UNITED STATES PATENT AND TRADEMARK OFFICE

14/491,554 | EFACT.012C2:

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Application #	Attorney Docket #	Patent #	Status	Filing or 371 (c) date
14/491,554	EFACT.012C2	9,709,292 Issued - 07/18/2017	Patented Case - 06/28/2017	09/19/2014

Documents & transaction history

Documents

Mail room date	Doc code	Doc description	Pages	Quick download
09/19/2014	ADS	Application Data Sheet	6	
09/19/2014	SPEC	Specification	52	
09/19/2014	CLM	Claims	1	
09/19/2014	ABST	Abstract	1	
09/19/2014	DRW	Drawings-only black and white line drawings	47	
09/19/2014	OATH	Oath or Declaration filed	1	
09/19/2014	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
09/26/2014	WFEE	Fee Worksheet (SB06)	1	
09/26/2014	NTC.MISS.PRT	Notice to File Missing Parts	2	
09/26/2014	APP.FILE.REC	Filing Receipt	3	
12/19/2014	A.PE	Preliminary Amendment	1	
12/19/2014	SPEC	Specification	1	
12/19/2014	CLM	Claims	3	
12/19/2014	REM	Applicant Arguments/Remarks Made in an Amendment	5	

Exhibit 1006
IPR2023-00409
Ex. 1006.0001

Mail room date	Doc code	Doc description	Pages	Quick download
12/19/2014	PEFR	Applicant Response to Pre-Exam Formalities Notice	2	
12/19/2014	PA..	Power of Attorney	2	
12/19/2014	TRAN.LET	Transmittal Letter	2	
12/19/2014	IDS	Information Disclosure Statement (IDS) Form (SB08)	10	
12/19/2014	LET.	Miscellaneous Incoming Letter	2	
12/19/2014	SPEC	Specification	54	
12/19/2014	CLM	Claims	1	
12/19/2014	ABST	Abstract	1	
12/19/2014	REM	Applicant Arguments/Remarks Made in an Amendment	56	
12/19/2014	WFEE	Fee Worksheet (SB06)	2	
12/19/2014	N417	Electronic Filing System(EFS) Acknowledgment Receipt	4	
12/31/2014	WFEE	Fee Worksheet (SB06)	1	
12/31/2014	NT.INC.REPLY	Notice of Incomplete Reply	2	
12/31/2014	N570	Communication - Re: Power of Attorney (PTOL-308)	1	
02/27/2015	PEFR	Applicant Response to Pre-Exam Formalities Notice	1	
02/27/2015	SPEC	Specification	1	
02/27/2015	CLM	Claims	1	
02/27/2015	REM	Applicant Arguments/Remarks Made in an Amendment	1	
02/27/2015	SPEC	Specification	52	
02/27/2015	CLM	Claims	1	
02/27/2015	ABST	Abstract	1	
02/27/2015	REM	Applicant Arguments/Remarks Made in an Amendment	54	
02/27/2015	WFEE	Fee Worksheet (SB06)	2	
02/27/2015	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	
03/10/2015	WFEE	Fee Worksheet (SB06)	1	
03/10/2015	APP.FILE.REC	Filing Receipt	3	
06/18/2015	NTC.PUB	Notice of Publication	1	

Ex. 1006.0002

Mail room date	Doc code	Doc description	Pages	Quick download
11/16/2016	CTNF	Non-Final Rejection	9	
11/16/2016	892	List of references cited by examiner	1	
11/16/2016	1449	List of References cited by applicant and considered by examiner	10	
11/16/2016	BIB	Bibliographic Data Sheet	1	
11/16/2016	SRFW	Search information including classification, databases and other search related notes	1	
11/16/2016	FWCLM	Index of Claims	1	
02/15/2017	DIST.E.FILE	Terminal Disclaimer-Filed (Electronic)	2	
02/15/2017	WFEE	Fee Worksheet (SB06)	2	
02/15/2017	DISQ.E.FILE	Terminal Disclaimer-Electronic-Approved	1	
02/15/2017	N417	Electronic Filing System(EFS) Acknowledgment Receipt	2	
02/15/2017	A...	Amendment/Request for Reconsideration-After Non-Final Rejection	1	
02/15/2017	WFEE	Fee Worksheet (SB06)	2	
02/15/2017	N417	Electronic Filing System(EFS) Acknowledgment Receipt	4	
02/15/2017	IDS	Information Disclosure Statement (IDS) Form (SB08)	2	
02/15/2017	TRAN.LET	Transmittal Letter	2	
02/15/2017	FOR	Foreign Reference	14	
02/15/2017	NPL	Non Patent Literature	25	
02/15/2017	NPL	Non Patent Literature	6	
02/15/2017	NPL	Non Patent Literature	144	
02/15/2017	NPL	Non Patent Literature	151	
02/15/2017	REF.OTHER	Other reference-Patent/Application/Search Documents	5	
02/15/2017	NPL	Non Patent Literature	7	
02/15/2017	REM	Applicant Arguments/Remarks Made in an Amendment	8	
02/15/2017	CLM	Claims	4	
02/15/2017	WFEE	Fee Worksheet (SB06)	1	
03/13/2017	NOA	Notice of Allowance and Fees Due (PTOL-85)	5	

Ex. 1006.0003

Mail room date	Doc code	Doc description	Pages	Quick download
03/13/2017	892	List of references cited by examiner	1	
03/13/2017	1449	List of References cited by applicant and considered by examiner	2	
03/13/2017	SRFW	Search information including classification, databases and other search related notes	1	
03/13/2017	FWCLM	Index of Claims	1	
03/13/2017	SRNT	Examiner's search strategy and results	1	
03/13/2017	IIFW	Issue Information including classification, examiner, name, claim, renumbering, etc.	3	
06/07/2017	IFEE	Issue Fee Payment (PTO-85B)	1	
06/07/2017	TRAN.LET	Transmittal Letter	1	
06/07/2017	IDS	Information Disclosure Statement (IDS) Form (SB08)	1	
06/07/2017	NPL	Non Patent Literature	6	
06/07/2017	NPL	Non Patent Literature	3	
06/07/2017	WFEE	Fee Worksheet (SB06)	2	
06/07/2017	N417	Electronic Filing System(EFS) Acknowledgment Receipt	3	
06/12/2017	M327	Miscellaneous Communication to Applicant - No Action Count	1	
06/13/2017	1449	List of References cited by applicant and considered by examiner	3	
06/28/2017	ISSUE.NTF	Issue Notification	1	
01/14/2021	SES.LOSS.ELC	Notification of loss of entitlement to small entity status via Patent Application Information Retrieval (PAIR)	1	

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Ex. 1006.0004

PTO/AIA/14 (03-13)
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	EFACT.012C2
	Application Number	
Title of Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM	

The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76.
This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.

Secrecy Order 37 CFR 5.2

☐ Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)

Inventor Information:

Inventor 1 Remove

Legal Name

Prefix	Given Name	Middle Name	Family Name	Suffix
	John	Douglas	Steinberg	

Residence Information (Select One) ◉ US Residency ○ Non US Residency ○ Active US Military Service

City	Millbrae	State/Province	CA	Country of Residence i	US

Mailing Address of Inventor:

Address 1	873 Hacienda Way		
Address 2			
City	Millbrae	State/Province	CA
Postal Code	94030	Country i	US

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button. Add

Correspondence Information:

Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

☐ **An Address is being provided for the correspondence Information of this application.**

Customer Number	20995		
Email Address	efiling@knobbe.com	Add Email	Remove Email

Application Information:

Title of the Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM		
Attorney Docket Number	EFACT.012C2	Small Entity Status Claimed	☒
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	47	Suggested Figure for Publication (if any)	

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Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32).
Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	◉ Customer Number	○ US Patent Practitioner	○ Limited Recognition (37 CFR 11.9)
Customer Number	20995		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, or 365(c) or indicate National Stage entry from a PCT application. Providing this information in the application data sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

Prior Application Status	Pending		Remove
Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)
	Continuation of	14/048932	2013-10-08
Prior Application Status	Patented		Remove

Application Number	Continuity Type	Prior Application Number	Filing Date (YYYY-MM-DD)	Patent Number	Issue Date (YYYY-MM-DD)
14/048932	Continuation of	12/788246	2010-05-26	8556188	2013-10-15

Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the **Add** button. Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55(d). When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX) the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(h)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

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Title of Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM	

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Application Number	Country [i]	Filing Date (YYYY-MM-DD)	Access Code[i] (if applicable)

Additional Foreign Priority Data may be generated within this form by selecting the **Add** button. Add

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

☐ This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013.
NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.

Authorization to Permit Access:

☐ Authorization to Permit Access to the Instant Application by the Participating Offices

If checked, the undersigned hereby grants the USPTO authority to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the World Intellectual Property Office (WIPO), and any other intellectual property offices in which a foreign application claiming priority to the instant patent application is filed access to the instant patent application. See 37 CFR 1.14(c) and (h). This box should not be checked if the applicant does not wish the EPO, JPO, KIPO, WIPO, or other intellectual property office in which a foreign application claiming priority to the instant patent application is filed to have access to the instant patent application.

In accordance with 37 CFR 1.14(h)(3), access will be provided to a copy of the instant patent application with respect to: 1) the instant patent application-as-filed; 2) any foreign application to which the instant patent application claims priority under 35 U.S.C. 119(a)-(d) if a copy of the foreign application that satisfies the certified copy requirement of 37 CFR 1.55 has been filed in the instant patent application; and 3) any U.S. application-as-filed from which benefit is sought in the instant patent application.

In accordance with 37 CFR 1.14(c), access may be provided to information concerning the date of filing this Authorization.

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

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Title of Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM	

Applicant 1 Remove

If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.

Clear

(•) Assignee	( ) Legal Representative under 35 U.S.C. 117	( ) Joint Inventor
( ) Person to whom the inventor is obligated to assign.	( ) Person who shows sufficient proprietary interest	

If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:

Name of the Deceased or Legally Incapacitated Inventor :

If the Applicant is an Organization check here. [X]

Organization Name	EcoFactor, Inc.		
Mailing Address Information:			
Address 1	423 Broadway, #801		
Address 2			
City	Millbrae	**State/Province**	CA
Country [i]	US	Postal Code	94030
Phone Number		Fax Number	
Email Address			

Additional Applicant Data may be generated within this form by selecting the Add button. Add

Assignee Information including Non-Applicant Assignee Information:

Providing assignment information in this section does not subsitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.

Assignee 1

Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication . An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.

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	Application Number	
Title of Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM	

Prefix	**Given Name**	Middle Name	**Family Name**	Suffix

Mailing Address Information:

Address 1	
Address 2	

City		**State/Province**	
Country i		Postal Code	
Phone Number		Fax Number	
Email Address			

Additional Assignee Data may be generated within this form by selecting the Add button. Add

Signature:

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NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications

Signature	/John R. King/			Date (YYYY-MM-DD)	2014-09-19
First Name	John	Last Name	King	Registration Number	34362

Additional Signature may be generated within this form by selecting the Add button. Add

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The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

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2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.

3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.

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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.

6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).

7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.

8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.

9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Cross-Reference to Related Applications

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet, or any correction thereto, are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to the use of thermostatic HVAC and other energy management controls that are connected to a computer network. More specifically, the present invention pertains to the use of geographic movement of network-connected mobile devices to occupancy to inform an energy management system, to provide enhanced efficiency, and to verify demand response.

Description of the Related Art

[0003] Heating and cooling systems for buildings (heating, ventilation and cooling, or HVAC systems) have been controlled for decades by thermostats. At the most basic level, a thermostat includes a means to allow a user to set a desired temperature, a means to sense actual temperature, and a means to signal the heating and/or cooling devices to turn on or off in order to try to change the actual temperature to equal the desired temperature. The most basic versions of thermostats use components such as a coiled bi-metallic spring to measure actual temperature and a mercury switch that opens or completes a circuit when the spring coils or uncoils with temperature changes. More recently, electronic digital thermostats have become prevalent. These thermostats use solid-state devices such as thermistors or thermal diodes to measure temperature, and microprocessor-based circuitry to control the switch and to store and operate based upon user-determined protocols for temperature vs. time.

[0004] These programmable thermostats generally offer a very restrictive user interface, limited by the cost of the devices, the limited real estate of the small wall-mounted boxes, and the inability to take into account more than two variables: the desired temperature set by the user, and the ambient temperature sensed by the thermostat. Users can generally only set one series of commands per day, and in order to change one parameter (e.g., to change the late-night temperature) the user often has to cycle through several other parameters by repeatedly pressing one or two buttons.

[0005] Because the interface of programmable thermostats is so poor, the significant theoretical savings that are possible with them (sometimes cited as 25% of heating and cooling costs) are rarely realized. In practice, studies have found that more than 50% of users never program their thermostats at all. Significant percentages of the thermostats that are programmed are programmed sub-optimally, in part because, once programmed, people tend to not to re-invest the time needed to change the settings very often.

[0006] A second problem with standard programmable thermostats is that they represent only a small evolutionary step beyond the first, purely mechanical thermostats. Like the first thermostats, they only have two input signals - ambient temperature and the preset desired temperature. The entire advance with programmable thermostats is that they can shift between multiple present temperatures at different times without real-time involvement of a human being.

[0007] Because most thermostats control HVAC systems that do not offer infinitely variable output, traditional thermostats are designed to permit the temperature as seen by the thermostat to vary above and below the setpoint to prevent the HVAC system from constantly and rapidly cycling on and off, which is inefficient and harmful to the HVAC system. The temperature range in which the thermostat allows the controlled environment to drift is known as both the dead zone and, more formally, the hysteresis zone. The hysteresis zone is frequently set at +/- 1 degree Fahrenheit. Thus if the setpoint is 68 degrees, in the heating context the thermostat will allow the inside temperature to fall to 67 degrees before turning the heating system on, and will allow it to rise to 69 degrees before turning it off again.

Ex. 1006.0012

[0008] As energy prices rise, more attention is being paid to ways of reducing energy consumption. Because energy consumption is directly proportional to setpoint - that is, the further a given setpoint diverges from the balance point (the inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by virtually any strategy that over a given time frame lowers the average heating setpoint or raises the average cooling setpoint. Conventional programmable thermostats allow homeowners to save money and energy by pre-programming setpoint changes based upon comfort or schedule. For example, in the summer, allowing the setpoint to rise by several degrees (or even shutting off the air conditioner) when the home is unoccupied will generally save significantly on energy. But such thermostats have proven to be only minimally effective in practice. Because they have such primitive user interfaces, they are difficult to program, and so many users never bother at all, or set them up once and do not alter the programming even if their schedules change.

[0009] In the hotel industry, the heating and cooling decisions made in hundred or even thousands of individual rooms with independently controlled HVAC systems are aggregated into a single energy bill, so hotel owners and managers are sensitive to energy consumption by those systems. Hotel guests often turn the air conditioner to a low temperature setting and then leave the room for hours at a time, thereby wasting considerable energy. An approach commonly used outside of the United States to combat this problem is to use a keycard to control the HVAC system, such that guests place the keycard into a slot mounted on the wall near the door of the room which then triggers the lights and HVAC system to power up, and turn them off when the guest removes the card upon leaving the room. However, because most hotels give each guest two cards, it is easy to simply leave the extra card in the slot, thus defeating the purpose of the system. Recently, systems have been introduced in which a motion sensor is connected to the control circuitry for the HVAC system. If no motion is detected in the room for some predetermined interval, the system concludes that the room is unoccupied, and turns off the HVAC system or alters the setpoint to a more economical level. When the motion sensor detects motion (which is assumed to

coincide with the return of the guest), the HVAC system resets to the guest's chosen setting.

[0010] Adding occupancy detection capability to residential HVAC systems could also add considerable value in the form of energy savings without significant tradeoff in terms of comfort. But the systems used in hotels do not easily transfer to the single-family residential context. Hotel rooms tend to be small enough that a single motion sensor is sufficient to determine with a high degree of accuracy whether or not the room is occupied. A single motion sensor in the average home today would have limited value because there are likely to be many places one or more people could be home and active yet invisible to the motion sensor. The most economical way to include a motion sensor in a traditional programmable thermostat would be to build it into the thermostat itself. But thermostats are generally located in hallways, and thus are unlikely to be exposed to the areas where people tend to spend their time. Wiring a home with multiple motion sensors in order to maximize the chances of detecting occupants would involve considerable expense, both for the sensors themselves and for the considerable cost of installation, especially in the retrofit market. Yet if control is ceded to a single-sensor system that cannot reliably detect presence, the resulting errors would likely lead the homeowner to reject the system.

[0011] Although progress in residential HVAC control has been slow, tremendous technological change has come to the tools used for personal communication. When programmable thermostats were first offered, telephones were virtually all tethered by wires to a wall jack. But now a large percentage of the population carries at least one mobile device capable of sending and receiving voice or data or even video (or a combination thereof) from almost anywhere by means of a wireless network. These devices create the possibility that a consumer can, with an appropriate mobile device and a network-enabled HVAC system, control his or her HVAC system even when away from home. But systems that relay on active management decisions by consumers are likely to yield sub-optimal energy management outcomes, because consumers are unlikely to devote the attention and effort required to fully optimize energy use on a daily basis.

[0012] Many new mobile devices now incorporate another significant new technology – the ability to geolocate the device (and thus, presumably, the user of the device). One method of locating such devices uses the Global Positioning System (GPS). The GPS system uses a constellation of orbiting satellites with very precise clocks to triangulate the position of a device anywhere on earth based upon arrival times of signals received from those satellites by the device. Another approach to geolocation triangulates using signals from multiple cell phone towers. Such systems can enable a variety of so-called "location based services" to users of enabled devices. These services are generally thought of as aids to commerce like pointing users to restaurants or gas stations, etc.

[0013] It would be desirable to provide a system that could detect the location of regular occupants of a home or other structure without requiring the installation of additional hardware; that could accurately use such geospatial information in order to detect and predict occupancy, and could optimize energy consumption based upon dynamic and individually configurable heuristics.

SUMMARY OF THE INVENTION

[0014] In one embodiment, the invention comprises a thermostat attached to an HVAC system, a local network connecting the thermostat to a larger network such as the Internet, and one or more geolocation-enabled mobile devices attached to the network, and a server in bi-directional communication with a plurality of such thermostats and devices. The server pairs each thermostat with one or more geolocation-enabled mobile devices which are determined to be associated with the occupants of home in which the thermostat is located.

[0015] The server logs the ambient temperature sensed by each thermostat vs. time and the signals sent by the thermostats to their HVAC systems. The server also monitors and logs the geolocation data related to the geolocation-enabled mobile devices associated with each thermostat. Based on the locations and movement evidenced by geolocation data, the server instructs the thermostat to change temperature settings between those optimized for occupied and unoccupied states at the appropriate times based on the evolving geolocation data.

Ex. 1006.0015

[0016] One embodiment of the invention is directed to a method for varying temperature setpoints for an HVAC system. The method comprises determining the geographic location of a mobile electronic device that is connected to a network and associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices. In addition, the method comprises determining whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device and adjusting the temperature setpoint on said controller for an HVAC system for said structure based upon whether or not said structure is deemed to be occupied.

[0017] In another embodiment, the mobile electronic device is a telephone. In an additional embodiment, the networked mobile electronic device is a personal digital assistant. In a further embodiment, the mobile electronic device is connected to the Internet.

[0018] In one embodiment the method for determining the geographic location of a mobile electronic device uses the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0019] In yet another embodiment, the variation of temperature setpoints is logged to a database. In a further embodiment, the variation of temperature setpoints is initiated by a remote computer. In a different embodiment, the temperature setpoints are varied automatically. In a further embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

[0020] In one embodiment, a system for altering the setpoint on a thermostat for space conditioning of a structure comprises at least one said thermostat having at least one temperature setting associated with the presence of one or more occupants in said structure, and at least one temperature setting associated with the absence of occupants in said structure. The system also comprises one or more mobile electronic

devices having at least a user interface, where the mobile electronic devices and said thermostat are connected to a network and where the setpoint on said thermostat is adjusted between said temperature setting associated with the presence of one or more occupants in said structure and said temperature setting associated with the absence of occupants in said structure based upon the geographic location of said electronic device.

[0021] In a further embodiment, the mobile electronic device is a telephone. In yet another embodiment, the networked mobile electronic device is a personal digital assistant. In still a further embodiment, the mobile electronic device is connected to the Internet.

[0022] In one embodiment, the method for determining the geographic location of a mobile electronic device is the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0023] In a different embodiment, the variation of temperature setpoints is logged to a database. In another embodiment, the variation of temperature setpoints is initiated by a remote computer. In a further embodiment, the temperature setpoints are varied automatically. In still another embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figure 1 shows an example of an overall environment in which an embodiment of the invention may be used.

[0025] Figure 2 shows a high-level illustration of the architecture of a network showing the relationship between the major elements of one embodiment of the subject invention.

Ex. 1006.0017

[0026] Figures 3a and 3b show an embodiment of the website to be used as part of the subject invention.

[0027] Figure 4 shows a high-level schematic of the thermostat used as part of an embodiment of the subject invention.

[0028] Figure 5 shows one embodiment of the database structure used as part of an embodiment of the subject invention.

[0029] Figures 6a and 6b illustrate pages of a website that may be used with an embodiment of the subject invention.

[0030] Figure 7 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0031] Figure 8 is a flowchart that shows how the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device connected to the system.

[0032] Figures 9a and 9b show how comparing inside temperature against outside temperature and other variables permits calculation of dynamic signatures.

[0033] Figure 10 shows a flow chart for a high level version of the process of calculating the appropriate turn-on time in a given home.

[0034] Figure 11 shows a more detailed flowchart listing the steps in the process of calculating the appropriate turn-on time in a given home for a just-in-time event.

[0035] Figures 12a, 12b, 12c and 12d show the steps shown in the flowchart in Figure 11 in the form of a graph of temperature and time.

[0036] Figure 13 shows a table of some of the data used by an embodiment of the subject invention to predict temperatures.

[0037] Figure 14 shows an embodiment of the subject invention as applied in a specific home on a specific day.

[0038] Figure 15 shows an embodiment of the subject invention as applied in a different specific home on a specific day.

[0039] Figure 16 shows a table of predicted rates of change in temperature inside a given home for a range of temperature differentials between inside and outside.

[0040] Figure 17 shows how manual inputs can be recognized and recorded by an embodiment of the subject invention.

[0041] Figure 18 shows how an embodiment of the subject invention uses manual inputs to interpret manual overrides and make short-term changes in response thereto.

[0042] Figure 19 shows how an embodiment of the subject invention uses manual inputs to make long-term changes to interpretive rules and to setpoint scheduling.

[0043] Figure 20 shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event.

[0044] Figure 21(a) through 21(c) illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature.

[0045] Figure 22 is a flow chart illustrating the steps involved in generating a demand reduction event for a given subscriber.

[0046] Figure 23 is a flow chart illustrating the steps involved in confirming that a demand reduction event has taken place.

[0047] Figure 24 is a representation of the movement of messages and information between the components of an embodiment of the subject invention.

[0048] Figures 25a and 25b show graphical representations of inside and outside temperatures in two different homes, one with high thermal mass and one with low thermal mass.

[0049] Figures 26a and 26b show graphical representations of inside and outside temperatures in the same homes as in Figures 25a and 25b, showing the cycling of the air conditioning systems in those houses.

[0050] Figures 27a and 27b show graphical representations of inside and outside temperatures in the same home as in Figures 25a and 26a, showing the cycling of the air conditioning on two different days in order to demonstrate the effect of a change in operating efficiency on the parameters measured by the thermostat.

[0051] Figures 28a and 28b show the effects of employing a pre-cooling strategy in two different houses.

Ex. 1006.0019

[0052] Figures 29a and 29b show graphical representations of inside and outside temperatures in two different homes in order to demonstrate how the system can correct for erroneous readings in one house by referencing readings in another.

[0053] Figure 30 is a flowchart illustrating the steps involved in calculating the effective thermal mass of a home using an embodiment of the subject invention.

[0054] Figure 31 is a flowchart illustrating the steps involved in determining whether an HVAC system has developed a problem that impairs efficiency using an embodiment of the subject invention.

[0055] Figure 32 is a flowchart illustrating the steps involved in correcting for erroneous readings in one house by referencing readings in another using an embodiment of the subject invention.

[0056] Figure 33 shows the conventional programming of a programmable thermostat over a 24-hour period.

[0057] Figure 34 shows the programming of a programmable thermostat over a 24-hour period using ramped setpoints.

[0058] Figure 35 shows the steps required for the core function of the ramped setpoint algorithm.

[0059] Figure 36 shows a flowchart listing steps in the process of deciding whether to implement the ramped setpoint algorithm using an embodiment of the subject invention.

[0060] Figure 37 shows the browser as seen on the display of the computer used as part of an embodiment of the subject invention.

[0061] Figure 38 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0062] Figure 39 is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0063] **Figure 1** shows an example of an overall environment 100 in which an embodiment of the invention may be used. The environment 100 includes an

Ex. 1006.0020

interactive communication network 102 with computers 104 connected thereto. Also connected to network 102 are mobile devices 105, and one or more server computers 106, which store information and make the information available to computers 104 and mobile devices 105. The network 102 allows communication between and among the computers 104, mobile devices 105 and servers 106.

[0064] Presently preferred network 102 comprises a collection of interconnected public and/or private networks that are linked to together by a set of standard protocols to form a distributed network. While network 102 is intended to refer to what is now commonly referred to as the Internet, it is also intended to encompass variations which may be made in the future, including changes additions to existing standard protocols. It also includes various networks used to connect mobile and wireless devices, such as cellular networks.

[0065] When a user of an embodiment of the subject invention wishes to access information on network 102 using computer 104, the user initiates connection from his computer 104. For example, the user invokes a browser, which executes on computer 104. The browser, in turn, establishes a communication link with network 102. Once connected to network 102, the user can direct the browser to access information on server 106.

[0066] One popular part of the Internet is the World Wide Web. The World Wide Web contains a large number of computers 104 and servers 106, which store HyperText Markup Language (HTML) documents capable of displaying graphical and textual information. HTML is a standard coding convention and set of codes for attaching presentation and linking attributes to informational content within documents.

[0067] The servers 106 that provide offerings on the World Wide Web are typically called websites. A website is often defined by an Internet address that has an associated electronic page. Generally, an electronic page is a document that organizes the presentation of text graphical images, audio and video.

[0068] In addition to the Internet, the network 102 can comprise a wide variety of interactive communication media. For example, network 102 can include local area networks, interactive television networks, telephone networks, wireless data systems, two-way cable systems, and the like.

Ex. 1006.0021

[0069] In one embodiment, computers 104 and servers 106 are conventional computers that are equipped with communications hardware such as modem or a network interface card. The computers include processors such as those sold by Intel and AMD. Other processors may also be used, including general-purpose processors, multi-chip processors, embedded processors and the like.

[0070] Computers 104 can also be microprocessor- controlled home entertainment equipment including advanced televisions, televisions paired with home entertainment/media centers, and wireless remote controls.

[0071] Computers 104 may utilize a browser configured to interact with the World Wide Web. Such browsers may include Microsoft Explorer, Mozilla, Firefox, Opera or Safari. They may also include browsers or similar software used on handheld, home entertainment and wireless devices.

[0072] The storage medium may comprise any method of storing information. It may comprise random access memory (RAM), electronically erasable programmable read only memory (EEPROM), read only memory (ROM), hard disk, floppy disk, CD-ROM, optical memory, or other method of storing data.

[0073] Computers 104 and 106 may use an operating system such as Microsoft Windows, Apple Mac OS, Linux, Unix or the like.

[0074] Computers 106 may include a range of devices that provide information, sound, graphics and text, and may use a variety of operating systems and software optimized for distribution of content via networks.

[0075] Mobile devices 105 can also be handheld and wireless devices such as personal digital assistants (PDAs), cellular telephones and other devices capable of accessing the network. Mobile devices 105 can use a variety of means for establishing the location of each device at a given time. Such methods may include the Global Positioning System (GPS), location relative to cellular towers, connection to specific wireless access points, or other means

[0076] **Figure 2** illustrates in further detail the architecture of the specific components connected to network 102 showing the relationship between the major elements of one embodiment of the subject invention. Attached to the network are thermostats 108 and computers 104 of various users. Connected to thermostats 108

are HVAC units 110. The HVAC units may be conventional air conditioners, heat pumps, or other devices for transferring heat into or out of a building. Each user is connected to the server 106 via wired or wireless connection such as Ethernet or a wireless protocol such as IEEE 802.11, a gateway 110 that connects the computer and thermostat to the Internet via a broadband connection such as a digital subscriber line (DSL), cellular radio or other form of broadband connection to the World Wide Web. Server 106 contains the content to be served as web pages and viewed by computers 104, software to manage thermostats 108, as well as databases containing information used by the servers.

[0077] Also attached to the Network are cellular radio towers 120, or other means to transmit and receive wireless signals in communication with mobile devices 105. Such communication may use GPRS, GSM, CDMA, EvDO, EDGE or other protocols and technologies for connecting mobile devices to a network.

[0078] **Figures 3a** and **3b** shows a representative mobile device 105 from the front and back, respectively. The front of the device includes a display 202, and may include a physical keyboard 204. Alternatively, a virtual keyboard may be included in a display with touchscreen functionality. For devices with voice capabilities, such as a smart phone, a microphone 206 and speaker 208 enable audio communications. An antenna 210, which may be mounted entirely within the mobile device, aids wireless communications. Modules included within mobile device 105 but not visible from the outside may include memory cards, microprocessors, GPS receivers, battery, etc.

[0079] **Figure 4** shows a high-level block diagram of thermostat 108 used as part of an embodiment of the subject invention. Thermostat 108 includes temperature sensing means 252, which may be a thermistor, thermal diode or other means commonly used in the design of electronic thermostats. It includes a microprocessor 254, memory 256, a display 258, a power source 260, a relay 262, which turns the HVAC system on and off in response to a signal from the microprocessor, and contacts by which the relay is connected to the wires that lead to the HVAC system.

[0080] To allow the thermostat to communicate bi-directionally with the computer network, the thermostat also includes means 264 to connect the thermostat to a local computer or to a wireless network. Such means could be in the form of

Ethernet, wireless protocols such as IEEE 802.11, IEEE 802.15.4, Bluetooth, cellular systems such as CDMA, GSM and GPRS, or other wireless protocols. The thermostat 250 may also include controls 266 allowing users to change settings directly at the thermostat, but such controls are not necessary to allow the thermostat to function.

[0081] The data used to manage the subject invention is stored on one or more servers 106 within one or more databases. As shown in **Figure 5**, the overall database structure 300 may include temperature database 400, thermostat settings database 500, energy bill database 600, HVAC hardware database 700, weather database 800, user database 900, transaction database 1000, product and service database 1100, user location database 1200 and such other databases as may be needed to support these and additional features.

[0082] Users of connected thermostats 250 may create personal accounts. Each user's account will store information in database 900, which tracks various attributes relative to users of the site. Such attributes may include the make and model of the specific HVAC equipment in the user's home; the age and square footage of the home, the solar orientation of the home, the location of the thermostat in the home, the user's preferred temperature settings, whether the user is a participant in a demand response program, etc.

[0083] User personal accounts may also associate one or more mobile devices with such personal accounts. For mobile devices with the capability for geopositioning awareness, these personal accounts will have the ability log such positioning data over time in database 1200.

[0084] In one embodiment, a background application installed on mobile device 105 shares geopositioning data for the mobile device with the application running on server 106 that logs such data. Based upon this data, server 106 runs software that interprets said data (as described in more detail below). Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; or (b) transmit a message to mobile device 105 that asks the user if the server should change the current setpoint, alter the overall programming of the system

based upon a new occupancy pattern, etc. Such signalling activity may be conducted via email, text message, pop-up alerts, voice messaging, or other means.

[0085] **Figures 6a** and **6b** illustrate a website that may be provided to assist homeowners and others to interact with an embodiment of the subject invention. The website will permit thermostat users to perform through the web browser substantially all of the programming functions traditionally performed directly at the physical thermostat, such as temperature set points, the time at which the thermostat should be at each set point, etc. Preferably the website will also allow users to accomplish more advanced tasks such as allow users to program in vacation settings for times when the HVAC system may be turned off or run at more economical settings, and to set macros that will allow changing the settings of the temperature for all periods with a single gesture such as a mouse click.

[0086] As shown in **Figure 6a**, screen 351 of website 350 displays current temperature 352 as sensed by thermostat 108. Clicking on "up" arrow 354 raises the setpoint 358; clicking the down arrow 356 lowers setpoint 358. Screen 351 may also convey information about the outside weather conditions, such as a graphic representation 360 of the sun, clouds, etc. In homes with multiple thermostats, screen 351 may allow users to select different devices to adjust or monitor. Users will be able to use screen 351 by selecting, for example, master bedroom thermostat 362, living room thermostat 364, game room thermostat 366, or basement thermostat 368.

[0087] As shown in **Figure 6b**, screen 370 allows users to establish programming schedules. Row 372 shows a 24-hour period. Programming row 374 displays various programming periods and when they are scheduled, such as away setting 376, which begins at approximately 8AM and runs until approximately 5:30PM. When the away setting 376 is highlighted, the user can adjust the starting time and ending time for the setting by dragging the beginning time 378 to the left to choose an earlier start time, and dragging it to the right to make it later. Similarly, the user can drag ending time 380 to the left to make it earlier, and to the right to make it later. While away setting 376 is highlighted, the user can also change heating setpoint 382 by clicking on up arrow 384 or down arrow 386, and cooling setpoint 388 by clicking on up

Ex. 1006.0025

arrow 390 or down arrow 392. The user can save the program by clicking on save button 394.

[0088] **Figure 7** is a high-level flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 1302, mobile device 105 transmits geopositioning information to server 106 via the Internet. In step 1304 the server compares the latest geopositioning data point to previous data points in order to determine whether a change in location or vector of movement has occurred. In step 1306 the server evaluates the geopositioning data in order to determine whether the temperature settings for the HVAC system for the structure associated with the mobile device 105 should be optimized for an unoccupied structure, or for an occupied structure in light of the movement (or lack thereof) in the geopositioning data.

[0089] If the server 106 determines that the home should be in occupied or "home" mode, then in step 1308 the server queries database 300 to determine whether thermostat 108 is already set for home or away mode. If thermostat 108 is already in home mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 1310 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0090] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1316, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1312 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home.

[0091] If the user elects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and

Ex. 1006.0026

terminate. If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.

[0092] If the server 106 determines in step 1306 that the home should be in unoccupied or away mode, then in step 1350 the server queries database 300 to determine whether thermostat 108 is set for set for home or away mode. If thermostat 108 is already in away mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is occupied, then in step 1352 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0093] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1358, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when unoccupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1354 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate.

[0094] If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.If thermostat 108 is already in away mode, the program ends. If it was in home mode, then in step 1314 server 108 initiates a state change to put thermostat 108 in away mode. In either case, the server then in step 1316 writes the state change to database 300. In each case the server can also send a message to the person who owns the mobile device requesting, confirming or announcing the state change.

Ex. 1006.0027

[0095] **Figure 8** is a flowchart that shows one process by which an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device attached to the system. The process shown assumes (a) a static hierarchy of temperature preferences as between multiple occupants: that is, that for a given home/structure, mobile user #1's preferences will always control the outcome if mobile user #1 is present, that mobile user #2's preferences yield to #1's, but always prevail over user #3, etc; and (b) that there are no occupants to consider who are not associated with a mobile device. Other heuristics may be applied in order to account for more dynamic interactions of preferences.

[0096] In step 1402 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #1. In step 1404 server 106 uses current and recent coordinates to determine whether mobile user #1's "home" settings should be applied. If server 106 determines that User #1's home settings should be applied, then in step 1406 server 106 applies the correct setting and transmits it to the thermostat(s).

[0097] In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming. If after performing step 1404, the server concludes that mobile user #1's "home" settings should not be applied, then in step 1412 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #2.

[0098] In step 1414 server 106 uses current and recent coordinates to determine whether mobile user #2's "home" settings should be applied. If server 106 determines that User #2's home settings should be applied, then in step 1416 server 106 applies the correct setting and transmits it to the thermostat(s).

[0099] In step 1408, server 106 writes to database 300 the geospatial and other relevant information used to adjust the programming. If after performing step 1414, the server concludes that mobile user #2's "home" settings should not be applied, then in step 1422 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #N.

Ex. 1006.0028

[0100] In step 1424 server 106 uses current and recent coordinates to determine whether mobile user #N's "home" settings should be applied. If server 106 determines that User #N's home settings should be applied, then in step 1426 server 106 applies the correct setting and transmits it to the thermostat(s). In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming.

[0101] If none of the mobile devices associated with a given home or other structure report geospatial coordinates consistent with occupancy, then in step 1430 the server instructs the thermostat(s) to switch to or maintain the "away" setting.

[0102] One embodiment of the invention is capable of delivering additional benefits for homeowners in terms of increased comfort and efficiency. In addition to using the system to allow better signaling and control of the HVAC system, which relies primarily on communication running from the server to the thermostat, the bi-directional communication will also allow the thermostat 108 to regularly measure and send to the server information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0103] For example, **Figure 9a** shows a graph of inside temperature, outside temperature and HVAC activity for a 24 hour period. When outside temperature 1502 increases, inside temperature 1504 follows, but with some delay because of the thermal mass of the building, unless the air conditioning 1506 operates to counteract this effect. When the air conditioning turns on, the inside temperature stays constant (or rises at a much lower rate or even falls) despite the rising outside temperature. In this example, frequent and heavy use of the air conditioning results in only a very slight temperature increase inside the house of 4 degrees, from 72 to 76 degrees, despite the increase in outside temperature from 80 to 100 degrees.

[0104] **Figure 9b** shows a graph of the same house on the same day, but assumes that the air conditioning is turned off from noon to 7PM. As expected, the inside temperature 1504a rises with increasing outside temperatures 1502 for most of that period, reaching 88 degrees at 7PM. Because server 106 logs the temperature

Ex. 1006.0029

readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house.

[0105] The performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the rate at which the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc., the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0106] The ability to predict the rate of change in inside temperature in a given house under varying conditions may be applied by in effect holding the desired future inside temperature as a constraint and using the ability to predict the rate of change to determine when the HVAC system must be turned on in order to reach the desired temperature at the desired time. The ability of an HVAC system to vary turn-on time in order to achieve a setpoint with minimum energy use may be thought of as Just In Time (JIT) optimization.

[0107] **Figure 10** shows a flowchart illustrating the high-level process for controlling a just-in-time (JIT) event. In step 1512, the server determines whether a specific thermostat 108 is scheduled to run the preconditioning program. If, not, the program terminates. If it so scheduled, then in step 1514 the server retrieves the predetermined target time when the preconditioning is intended to have been completed (TT).

[0108] Using TT as an input, in step 1516 the server then determines the time at which the computational steps required to program the preconditioning event will be performed (ST). In step 1518, performed at start time ST, the server begins the process of actually calculating the required parameters, as discussed in greater detail below. Then in 1520 specific setpoint changes are transmitted to the thermostat so that the temperature inside the home may be appropriately changed as intended.

[0109] **Figure 11** shows a more detailed flowchart of the process. In step 1532, the server retrieves input parameters used to create a JIT event. These

Ex. 1006.0030

parameters include the maximum time allowed for a JIT event for thermostat 108 (MTI); the target time the system is intended to hit the desired temperature (TT); and the desired inside temperature at TT (TempTT). It is useful to set a value for MTI because, for example, it will be reasonable to prevent the HVAC system from running a preconditioning event if it would be expected to take 8 hours, which might be prohibitively expensive.

[0110] In step 1534, the server retrieves data used to calculate the appropriate start time with the given input parameters. This data includes a set of algorithmic learning data (ALD), composed of historic readings from the thermostat, together with associated weather data, such as outside temperature, solar radiation, humidity, wind speed and direction, etc; together with weather forecast data for the subject location for the period when the algorithm is scheduled to run (the weather forecast data, or WFD). The forecasting data can be as simple as a listing of expected temperatures for a period of hours subsequent to the time at which the calculations are performed, to more detailed tables including humidity, solar radiation, wind, etc. Alternatively, it can include additional information such as some or all of the kinds of data collected in the ALD.

[0111] In step 1536, the server uses the ALD and the WFD to create prediction tables that determine the expected rate of change or slope of inside temperature for each minute of HVAC cycle time (ΔT) for the relevant range of possible pre-existing inside temperatures and outside climatic conditions. An example of a simple prediction table is illustrated in Fig. 13.

[0112] In step 1538, the server uses the prediction tables created in step 1536, combined with input parameters TT and Temp(TT) to determine the time at which slope ΔT intersects with predicted initial temperature PT. The time between PT and TT is the key calculated parameter: the preconditioning time interval, or PTI.

[0113] In step 1540, the server checks to confirm that the time required to execute the pre-conditioning event PTI does not exceed the maximum parameter MTI. If PTI exceeds MTI, the scheduling routine concludes and no ramping setpoints are transmitted to the thermostat.

Ex. 1006.0031

[0114] If the system is perfect in its predictive abilities and its assumptions about the temperature inside the home are completely accurate, then in theory the thermostat can simply be reprogrammed once – at time PT, the thermostat can simply be reprogrammed to Temp(TT). However, there are drawbacks to this approach.

[0115] First, if the server has been overly conservative in its predictions as to the possible rate of change in temperature caused by the HVAC system, the inside temperature will reach TT too soon, thus wasting energy and at least partially defeating the purpose of running the preconditioning routine in the first place. If the server is too optimistic in its projections, there will be no way to catch up, and the home will not reach Temp(TT) until after TT. Thus it would be desirable to build into the system a means for self-correcting for slightly conservative start times without excessive energy use.

[0116] Second, the use of setpoints as a proxy for actual inside temperatures in the calculations is efficient, but can be inaccurate under certain circumstances. In the winter (heating) context, for example, if the actual inside temperature is a few degrees above the setpoint (which can happen when outside temperatures are warm enough that the home's natural "set point" is above the thermostat setting), then setting the thermostat to Temp(TT) at time PT will almost certainly lead to reaching TT too soon as well.

[0117] The currently preferred solution to both of these possible inaccuracies is to calculate and program a series of intermediate settings between Temp(PT) and Temp(TT) that are roughly related to ΔT.

[0118] Thus if MTI is greater than PTI, then in step 1542 the server calculates the schedule of intermediate setpoints and time intervals to be transmitted to the thermostat. Because thermostats cannot generally be programmed with steps of less than 1 degree F, ΔT is quantized into discrete interval data of at least 1 degree F each. For example, if Temp(PT) is 65 degrees F, Temp(TT) is 72 degrees F, and PT is 90 minutes, the thermostat might be programmed to be set at 66 for 10 minutes, 67 for 12 minutes, 68 for 15 minutes, etc.

[0119] The server may optionally limit the process by assigning a minimum programming interval (e.g., at least ten minutes between setpoint changes) to avoid

frequent switching of the HVAC system, which can reduce accuracy because of the thermostat's compressor delay circuit, which may prevent quick corrections. The duration of each individual step may be a simple arithmetic function of the time PTI divided by the number of whole-degree steps to be taken; alternatively, the duration of each step may take into account second order thermodynamic effects relating to the increasing difficulty of "pushing" the temperature inside a house further from its natural setpoint given outside weather conditions, etc. (that is, the fact that on a cold winter day it may take more energy to move the temperature inside the home from 70 degrees F to 71 than it does to move it from 60 degrees to 61).

[0120] In step 1544, the server schedules setpoint changes calculated in step 1542 for execution by the thermostat.

[0121] With this system, if actual inside temperature at PT is significantly higher than Temp(PT), then the first changes to setpoints will have no effect (that is, the HVAC system will remain off), and the HVAC system will not begin using energy, until the appropriate time, as shown in **Figure 12**. Similarly, if the server has used conservative predictions to generate ΔT, and the HVAC system runs ahead of the predicted rate of change, the incremental changes in setpoint will delay further increases until the appropriate time in order to again minimize unnecessary energy use, as shown in **Figure 11**.

[0122] **Figure 12(a)** through **12(d)** shows the steps in the preconditioning process as a graph of temperature and time. **Figure 12(a)** shows step 1532, in which inputs target time TT 1552, target temperature Temp(TT) 1554, maximum conditioning interval MTI 1556 and the predicted inside temperature during the period of time the preconditioning event is likely to begin Temp(PT) 1558 are retrieved.

[0123] **Figure 12(b)** shows the initial calculations performed in step 1538, in which expected rate of change in temperature ΔT 1560 inside the home is generated from the ALD and WFD using Temp(TT) 1554 at time TT 1552 as the endpoint.

[0124] **Figure 12(c)** shows how in step 1538 ΔT 1560 is used to determine start time PT 1562 and preconditioning time interval PTI 1564. It also shows how in step 1540 the server can compare PTI with MTI to determine whether or not to instantiate the pre-conditioning program for the thermostat.

Ex. 1006.0033

[0125] **Figure 12(d)** shows step 1542, in which specific ramped setpoints 1566 are generated. Because of the assumed thermal mass of the system, actual inside temperature at any given time will not correspond to setpoints until some interval after each setpoint change. Thus initial ramped setpoint 1216 may be higher than Temp(PT) 1558, for example.

[0126] **Figure 13** shows an example of the types of data that may be used by the server in order to calculate ΔT 1560. Such data may include inside temperature 1572, outside temperature 1574, cloud cover 1576, humidity 1578, barometric pressure 1580, wind speed 1582, and wind direction 1584.

[0127] Each of these data points should be captured at frequent intervals. In the preferred embodiment, as shown in **Figure 13**, the interval is once every 60 seconds.

[0128] **Figure 14** shows application of an embodiment of the subject invention in an actual house. Temperature and setpoints are plotted for the 4-hour period from 4AM to 8AM with temperature on the vertical axis and time on the horizontal axis. The winter nighttime setpoint 1592 is 60 degrees F; the morning setpoint temperature 1594 is 69 degrees F. The outside temperature 1596 is approximately 45 degrees F. The target time TT 1598 for the setpoint change to morning setting is 6:45AM. In the absence of embodiments of the subject invention, the homeowner could program the thermostat to change to the new setpoint at 6:45, but there is an inherent delay between a setpoint change and the response of the temperature inside the home. (In this home on this day, the delay is approximately fifty minutes.) Thus if the homeowner truly desired to achieve the target temperature at the target time, some anticipation would be necessary. The amount of anticipation required depends upon numerous variables, as discussed above.

[0129] After calculating the appropriate slope ΔT 1560 by which to ramp inside temperature in order to reach the target as explained above, the server transmits a series of setpoints 1566 to the thermostat because the thermostat is presumed to only accept discrete integers as program settings. (If a thermostat is capable of accepting finer settings, as in the case of some thermostats designed to operate in

Ex. 1006.0034

regions in which temperature is generally denoted in Centigrade rather than Fahrenheit, which accept settings in half-degree increments, tighter control may be possible.)

[0130] In any event, in the currently preferred embodiment of the subject invention, programming changes are quantized such that the frequency of setpoint changes is balanced between the goal of minimizing network traffic and the frequency of changes made on the one hand and the desire for accuracy on the other. Balancing these considerations may result in some cases in either more frequent changes or in larger steps between settings. As shown in Fig. 14, the setpoint "stairsteps" from 60 degrees F to 69 degrees F in nine separate setpoint changes over a period of 90 minutes.

[0131] Because the inside temperature 1599 when the setpoint management routine was instantiated at 5:04 AM was above the "slope" and thus above the setpoint, the HVAC system was not triggered and no energy was used unnecessarily heating the home before such energy use was required. Actual energy usage does not begin until 5:49 AM.

[0132] **Figure 15** shows application of an embodiment of the subject invention in a different house during a similar four hour interval. In **Figure 15**, the predicted slope ΔT 1560 is less conservative relative to the actual performance of the home and HVAC system, so there is no off cycling during the preconditioning event – the HVAC system turns on at approximately 4:35 AM and stays on continuously during the event. The home reaches the target temperature Temp(TT) roughly two minutes prior to target time TT.

[0133] **Figure 16** shows a simple prediction table. The first column 1602 lists a series of differentials between outside and inside temperatures. Thus when the outside temperature is 14 degrees and the inside temperature is 68 degrees, the differential is -54 degrees; when the outside temperature is 94 degrees and the inside temperature is 71 degrees, the differential is 13 degrees. The second column 1604 lists the predicted rate of change in inside temperature ΔT 1210 assuming that the furnace is running in terms of degrees Fahrenheit of change per hour. A similar prediction table will be generated for predicted rates of change when the air conditioner

Ex. 1006.0035

is on; additional tables may be generated that predict how temperatures will change when the HVAC system is off.

[0134] Alternatively, the programming of the just-in-time setpoints may be based not on a single rate of change for the entire event, but on a more complex multivariate equation that takes into account the possibility that the rate of change may be different for events of different durations.

[0135] The method for calculating start times may also optionally take into account not only the predicted temperature at the calculated start time, but may incorporate measured inside temperature data from immediately prior to the scheduled start time in order to update calculations, or may employ more predictive means to extrapolate what inside temperature based upon outside temperatures, etc.

[0136] An additional capability offered by an embodiment of the instant invention is the ability to adapt the programming of the HVAC control system based upon the natural behavior of occupants. Because an embodiment of the instant invention is capable of recording the setpoint actually used at a connected thermostat over time, it is also capable of inferring manual setpoint changes (as, for example, entered by pushing the "up" or "down" arrow on the control panel of the device) even when such overrides of the pre-set program are not specifically recorded as such by the thermostat.

[0137] In order to adapt programming to take into account the manual overrides entered into the thermostat, it is first necessary to determine when a manual override has in fact occurred. Most thermostats, including two-way communicating devices discussed herein, do not record such inputs locally, and neither recognize nor transmit the fact that a manual override has occurred. Furthermore, in a system as described herein, frequent changes in setpoints may be initiated by algorithms running on the server, thereby making it impossible to infer a manual override from the mere fact that the setpoint has changed. It is therefore necessary to deduce the occurrence of such events from the data that an embodiment of the subject invention does have access to.

[0138] **Figure 17** illustrates the currently preferred method for detecting the occurrence of a manual override event. In step 1702, the server retrieves the primary

data points used to infer the occurrence of a manual override from one or more databases in overall database structure 300. The data should include each of the following: for the most recent point at which it can obtain such data (time0) the actual setpoint as recorded at the thermostat at (A0); for the point immediately prior to time0 (time-1), the actual setpoint recorded for the thermostat (A-1); for time0 the setpoint as scheduled by server 106 according to the basic setpoint programming (S0), and for time-1 the setpoint as scheduled by server 106 according to the standard setpoint programming (S-1).

[0139] In step 1704, the server retrieves any additional automated setpoint changes C that have been scheduled for the thermostat by server 106 at time0. Such changes may include algorithmic changes intended to reduce energy consumption, etc.

[0140] In step 1706 the server calculates the difference (dA) between A0 and A-1; for example, if the actual setpoint is 67 degrees at T-1 and 69 at T0, dA is +2; if the setpoint at T-1 is 70 and the setpoint at T0 is 66, dA is –4.

[0141] In step 1708, the server performs similar steps in order to calculate dS, the difference between S0 and S-1. This is necessary because, for example, the setpoint may have been changed because the server itself had just executed a change, such as a scheduled change from "away" to "home" mode. In step 1710 the server evaluates and sums all active algorithms and other server-initiated strategies to determine their net effect on setpoint at time0. For example, if one algorithm has increased setpoint at time0 by 2 degrees as a short-term energy savings measure, but another algorithm has decreased the setpoint by one degree to compensate for expected subjective reactions to weather conditions, the net algorithmic effect sC is +1 degree.

[0142] In step 1712, the server calculates the value for M, where M is equal to the difference between actual setpoints dA, less the difference between scheduled setpoints dS, less the aggregate of algorithmic change sC.

[0143] In step 1714 the server evaluates this difference. If the difference equals zero, the server concludes that no manual override has occurred, and the routine terminates. But if the difference is any value other than zero, then the server concludes that a manual override has occurred. Thus in step 1716 the server logs the

Ex. 1006.0037

occurrence and magnitude of the override to one or more databases in overall database structure 300.

[0144] The process of interpreting a manual override is shown in **Figure 18**. Step 1802 is the detection of an override, as described in detail in **Figure 17**. In step 1804 the server retrieves the stored rules for the subject thermostat 108. Such rules may include weather and time-related inferences such as "if outside temperature is greater than 85 degrees and inside temperature is more than 2 degrees above setpoint and manual override lowers setpoint by 3 or more degrees, then revert to original setpoint in 2 hours," or "if heating setpoint change is scheduled from "away" to "home" within 2 hours after detected override, and override increases setpoint by at least 2 degrees, then change to "home" setting," or the like.

[0145] In step 1806 the server retrieves contextual data required to interpret the manual override. Such data may include current and recent weather conditions, current and recent inside temperatures, etc. This data is helpful because it is likely that manual overrides are at least in part deterministic: that is, that they may often be explained by such contextual data, and that such understanding can permit anticipation of the desire on the part of the occupants to override and to adjust programming accordingly, so as to anticipate and obviate the need for such changes. The amount of data may be for a period of a few hours to as long as several days or more. Recent data may be more heavily weighted than older data in order to assure rapid adaptation to situations in which manual overrides represent stable changes such as changes in work schedules, etc.

[0146] In step 1808 the server retrieves any relevant override data from the period preceding the specific override being evaluated that has not yet been evaluated by and incorporated into the long-term programming and rules engines as described below in **Figure 19**. In step 1810 the server evaluates the override and determines which rule, if any, should be applied as a result of the override.

[0147] In step 1812 the server determines whether to alter the current setpoint as a result of applying the rules in step 1810. If no setpoint change is indicated, then the routine ends. If a setpoint change is indicated, then in step 1814 the server transmits the setpoint change to the thermostat for execution in the home, and in

Ex. 1006.0038

step 1816 it records that change to one or more databases in overall database structure 300.

[0148] In order to ensure that both the stored rules for interpreting manual overrides and the programming itself continue to most accurately reflect the intentions of the occupants, the server will periodically review both the rules used to interpret overrides and the setpoint scheduling employed. **Figure 19** shows the steps used to incorporate manual overrides into the long-term rules and setpoint schedule. In step 1902 the server retrieves the stored programming for a given thermostat as well as the rules for interpreting overrides for that thermostat.

[0149] In step 1904 the server retrieves the recent override data as recorded in **Figures 17** and **18** to be evaluated for possible revisions to the rules and the programming. In step 1906 the server retrieves the contextual data regarding overrides retrieved in step 1904 (Because the process illustrated in **Figure 19** is not presently expected to be executed as a real-time process, and is expected to be run anywhere from once per day to once per month, the range and volume of contextual data to be evaluated is likely to be greater than in the process illustrated in **Figure 18**.

[0150] In step 1908 the server interprets the overrides in light of the existing programming schedule, rules for overrides, contextual data, etc. In step 1910 the server determines whether, as a result of those overrides as interpreted, the rules for interpreting manual overrides should be revised. If the rules are not to be revised, the server moves to step 1914. If the rules are to be revised, then in step 1912 the server revises the rules and the new rules are stored in one or more databases in overall database structure 300.

[0151] In step 1914 the server determines whether any changes to the baseline programming for the thermostat should be revised. If not, the routine terminates. If revisions are warranted, then in step 1916 the server retrieves from database 900 the permissions the server has to make autonomous changes to settings. If the server has been given permission to make the proposed changes, then in step 1918 the server revises the thermostat's programming and writes the changes to one or more databases in overall database structure 300.

Ex. 1006.0039

[0152] If the server has not been authorized to make such changes autonomously, then in step 1920 the server transmits the recommendation to change settings to the customer in the manner previously specified by the customer, such as email, text message, personalized website, etc.

[0153] Additional means of implementing an embodiment of the instant invention may be achieved using variations in system architecture. For example, much or even all of the work being accomplished by remote server 106 may also be done by thermostat 108 if that device has sufficient processing capabilities, memory, etc. Alternatively, these steps may be undertaken by a local processor such as a local personal computer, or by a dedicated appliance having the requisite capabilities, such as gateway 112.

[0154] An additional way in which an embodiment of the instant invention can reduce energy consumption with minimal impact on comfort is to vary the turn-on delay enforced by the thermostat after the compressor is turned off. Compressor delay is usually used to protect compressors from rapid cycling, which can physically damage them.

[0155] The ability to predict the rate of change in inside temperature in a given house under varying conditions may also be applied to permit calculation of the effect of different compressor delay settings on inside temperatures, HVAC cycling and energy consumption.

[0156] **Figure 20** shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event. In step 2002, server 106 retrieves parameters such as weather conditions, the current price per kilowatt-hour of electricity, and the state of the electric grid in terms of supply versus demand for the geographic area that includes a given home. In step 2004 server 106 determines whether to instantiate the compressor delay adjustment program for a certain group of homes in response to those conditions.

[0157] In step 2006, server 106 determines whether a specific home is subscribed to participate in compressor delay events. If a given home is eligible, then in step 2008 the server retrieves the parameters needed to specify the compressor delay routine for that home. These may include user preferences, such as the weather,

Ex. 1006.0040

time of day and other conditions under which the homeowner has elected to permit hysteresis band changes, the maximum length of compressor delay authorized, etc.

[0158] In step 2010 the appropriate compressor delay settings are determined, and in step 2012 the chosen settings are communicated to the thermostat. In step 2014 the server determines if additional thermostats in the given group must still be evaluated. If so, the server returns to step 2006 and repeats the subsequent steps with the next thermostat. If not, the routine ends.

[0159] **Figures 21(a)** through **21(c)** illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature. In **Figure 21(a)**, time is shown on the horizontal axis 2102, and temperature is shown on vertical axis 2104. The setpoint for thermostat 108 is 70 degrees F, which results in the cycling behavior shown for inside temperature 2106. Because compressor delay CD1 2108 is, at approximately 3 minutes, shorter than the natural duration of a compressor off cycle Off1 2110 at approximately 6 minutes for this particular house under the illustrated conditions, the compressor delay has no effect on the operation of the HVAC system.

[0160] Because the hysteresis band operates to so as to maintain the temperature within a range of plus or minus one degree of the setpoint, in the case of air conditioning the air conditioner will switch on when the inside temperature reaches 71 degrees, continue operating until it reaches 69 degrees, then shut off. The system will then remain off until it reaches 71 degrees again, at which time it will again switch on. The percentage of time during which inside temperature is above or below the setpoint will depend on conditions and the dynamic signature of the individual, home. Under the conditions illustrated, the average inside temperature AT1 2112 is roughly equal to the setpoint of 70 degrees.

[0161] **Figure 21(b)** shows how with the same environmental conditions as in **Figure 21(a)**, the cycling behavior of the inside temperature changes when the compressor delay is longer than the natural compressor off cycle Off1 2110. Extended compressor delay CD2 2114 allows inside temperature 2116 to climb above the range normally enforced by the hysteresis band. Because CD2 is roughly 8 minutes, under the given conditions the inside temperature climbs to approximately 72 degrees before

the compressor delay allows the air conditioner to restart and drive the inside temperature back down. But as before, the air conditioner shuts off when the inside temperature reaches 69 degrees. Thus the average temperature is increased from AT1 2112 to AT2 2118. This change will save energy and reduce cycling because it takes less energy to maintain a higher inside temperature with an air conditioner. However, the setpoint reported by the display of the thermostat will continue to be the occupant's chosen setpoint of 70 degrees.

[0162] **Figure 21(c)** shows how the same compressor delay can result in different thermal cycling with different weather conditions. The greater the amount by which outside temperature exceeds inside temperature in the air conditioning context, the more rapidly the inside temperature will increase during an off cycle, and the slower the air conditioner will be able to cool during the on cycle. Thus as compared to **Figure 21(b)**, when the inside temperature increased to roughly 72 degrees during the extended compressor delay of 8 minutes, a higher outside temperature will cause the inside temperature to increase faster, which results in a peak temperature of roughly 73 degrees, and in wider temperature cycling 2120. The average inside temperature consequently increases from AT(2) 2118 to AT(3) 2122.

[0163] It should be noted that the shape of the actual waveform will most likely not be sinusoidal, but for ease of illustration it is sometimes be presented as such in the figures.

[0164] Residential air conditioning is a major component of peak load. The traditional approach to dealing with high demand on hot days is to increase supply – build new powerplants, or buy additional capacity on the spot market. But because reducing loads has come to be considered by many to be a superior strategy for matching electricity supply to demand when the grid is stressed, the ability to shed load by turning off air conditioners during peak events has become a useful tool for managing loads. A key component of any such system is the ability to document and verify that a given air conditioner has actually turned off. Data logging hardware can accomplish this, but due to the cost is usually only deployed for statistical sampling. An embodiment of the instant invention provides a means to verify demand response without additional hardware such as a data logger.

Ex. 1006.0042

[0165] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures. This will permit remote verification of load shedding by the air conditioner without directly measuring or recording the electrical load drawn by the air conditioner.

[0166] **Figure 22** shows the steps followed in order to initiate air conditioner shutoff. When a summer peak demand situation occurs, the utility will transmit an email 2202 or other signal to server 106 requesting a reduction in load. Server 106 will determine 2204 if the user's house is served by the utility seeking reduction; determine 2206 if a given user has agreed to reduce peak demand; and determine 2208 if a reduction of consumption by the user is required or desirable in order to achieve the reduction in demand requested by the utility. The server will transmit 2210 a signal to the user's thermostat 108 signaling the thermostat to shut off the air conditioner 110.

[0167] **Figure 23** shows the steps followed in order to verify that the air conditioner has in fact been shut off. Server 106 will receive and monitor 2302 the temperature readings sent by the user's thermostat 108. The server then calculates 2304 the temperature reading to be expected for that thermostat given inputs such as current and recent outside temperature, recent inside temperature readings, the calculated thermal mass of the structure, temperature readings in other houses, etc. The server will compare 2306 the predicted reading with the actual reading. If the server determines that the temperature inside the house is rising at the rate predicted if the air conditioning is shut off, then the server confirms 2308 that the air conditioning has been shut off. If the temperature reading from the thermostat shows no increase, or significantly less increase than predicted by the model, then the server concludes

Ex. 1006.0043

2310 that the air conditioning was not switched off, and that no contribution to the demand response request was made.

[0168] For example, assume that on at 3PM on date Y utility X wishes to trigger a demand reduction event. A server at utility X transmits a message to the server at demand reduction service provider Z requesting W megawatts of demand reduction. The demand reduction service provider server determines that it will turn off the air conditioner at house A in order to achieve the required demand reduction. At the time the event is triggered, the inside temperature as reported by the thermostat in house A is 72 degrees F. The outside temperature near house A is 96 degrees Fahrenheit. The inside temperature at House B, which is not part of the demand reduction program, but is both connected to the demand reduction service server and located geographically proximate to House A, is 74F. Because the air conditioner in house A has been turned off, the temperature inside House A begins to rise, so that at 4PM it has increased to 79F. Because the server is aware of the outside temperature, which remains at 96F, and of the rate of temperature rise inside house A on previous days on which temperatures have been at or near 96F, and the temperature in house B, which has risen only to 75F because the air conditioning in house B continues to operate normally, the server is able to confirm with a high degree of certainty that the air conditioner in house A has indeed been shut off.

[0169] In contrast, if the HVAC system at house A has been tampered with, so that a demand reduction signal from the server does not actually result in shutting off the air conditioner in house A, when the server compares the rate of temperature change at house A against the other data points, the server will receive data inconsistent with the rate of increase predicted. As a result, it will conclude that the air conditioner has not been shut off in house A as expected, and may not credit house A with the financial credit that would be associated with demand reduction compliance, or may trigger a business process that could result in termination of house A's participation in the demand reduction program.

[0170] **Figure 24** illustrates the movement of signals and information between the components of one embodiment of the subject invention to trigger and verify a demand reduction response. Where demand response events are undertaken on

behalf of a utility by a third party, participants in the communications may include electric utility server 2400, demand reduction service server 106, and thermostat 108. In step 2402 the electric utility server 2400 transmits a message to demand reduction service server 106 requesting a demand reduction of a specified duration and size. Demand reduction service server 106 uses database 300 to determine which subscribers should be included in the demand reduction event. For each included subscriber, the server then sends a signal 2404 to the subscriber's thermostat 108 instructing it (a) to shut down at the appropriate time or (b) to allow the temperature as measured by the thermostat to increase to a certain temperature at the specified time, depending upon the agreement between the homeowner and the utility and/or demand reduction aggregator.

[0171] The server then receives 2406 temperature signals from the subscriber's thermostat. At the conclusion of the demand reduction event, the server transmits a signal 2408 to the thermostat permitting the thermostat to signal its attached HVAC system to resume cooling, if the system has been shut off, or to reduce the target temperature to its pre-demand reduction setting, if the target temperature was merely increased. If thermostat 108 is capable of storing scheduling information, these instructions may be transmitted prior to the time they are to be executed and stored locally. After determining the total number of subscribers actually participating in the DR event, the server then calculates the total demand reduction achieved and sends a message 2410 to the electric utility confirming such reduction.

[0172] Additional steps may be included in the process. For example, if the subscriber has previously requested that notice be provided when a peak demand reduction event occurs, the server will also send an alert, which may be in the form of an email or text message or an update to the personalized web page for that user, or both. If the server determines that a given home has (or has not) complied with the terms of its demand reduction agreement, the server may send a message to the subscriber confirming that fact.

[0173] It should also be noted that in some climate zones, peak demand events occur during extreme cold weather rather than (or in addition to) during hot

Ex. 1006.0045

weather. The same process as discussed above could be employed to reduce demand by shutting off electric heaters and monitoring the rate at which temperatures fall.

[0174] It should also be noted that the peak demand reduction service can be performed directly by an electric utility, so that the functions of server 106 can be combined with the functions of server 2400.

[0175] The system installed in a subscriber's home may optionally include additional temperature sensors at different locations within the building. These additional sensors may we connected to the rest of the system via a wireless system such as 802.11 or 802.15.4, or may be connected via wires. Additional temperature and/or humidity sensors may allow increased accuracy of the system, which can in turn increase user comfort, energy savings or both.

[0176] The bi-directional communication between server 106 and thermostat 108 will also allow thermostat 108 to regularly measure and send to server 106 information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0177] For example, **Figure 25a** shows a graph of inside temperature and outside temperature for a 24-hour period in House A, assuming no HVAC activity. House A has double-glazed windows and is well-insulated. When outside temperature 2502 increases, inside temperature 2504 follows, but with significant delay because of the thermal mass of the building.

[0178] **Figure 25b** shows a graph of inside temperature and outside temperature for the same 24-hour period in House B. House B is identical to House A except that it (i) is located a block away and (ii) has single-glazed windows and is poorly insulated. Because the two houses are so close to each other, outside temperature 2502 is the same in **Figure 25a** and **Figure 25b**. But the lower thermal mass of House B means that the rate at which the inside temperature 2506 changes in response to the changes in outside temperature is much greater.

[0179] The differences in thermal mass will affect the cycling behavior of the HVAC systems in the two houses as well. **Figure 26a** s hows a graph of inside

Ex. 1006.0046

temperature and outside temperature in House A for the same 24-hour period as shown in **Figure 6a**, but assuming that the air conditioning is being used to try to maintain an internal temperature of 70 degrees. Outside temperatures 2502 are the same as in **Figures 25a** and **25b**. Inside temperature 2608 is maintained within the range determined by thermostat 108 by the cycling of the air conditioner. Because of the high thermal mass of the house, the air conditioning does not need to run for very long to maintain the target temperature, as shown by shaded areas 2610.

[0180] **Figure 26b** shows a graph of inside temperature 2612 and outside temperature 2502 for the same 24-hour period in House B, assuming use of the air conditioning as in **Figure 26a**. Because of the lower thermal mass of House B, the air conditioning system in House B has to run longer in order to maintain the same target temperature range, as shown by shaded areas 2614.

[0181] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature and differences between inside and outside temperatures. Because the server 106 will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0182] The server will also record the responses of each house to changes in outside conditions and cycling behavior over time. That will allow the server to diagnose problems as and when they develop. For example, **Figure 27a** shows a graph of outside temperature 2702, inside temperature 2704 and HVAC cycle times 2706 in House A for a specific 24-hour period on date X. Assume that, based upon comparison of the performance of House A on date X relative to House A's historical performance, and in comparison to the performance of House A relative to other nearby houses on date X, the HVAC system in House A is presumed to be operating at normal

Ex. 1006.0047

efficiency, and that House A is in the 86th percentile as compared to those other houses.

[0183] **Figure 27b** shows a graph of outside temperature 2708, inside temperature 2710 and HVAC cycle times 2712 in House A for the 24-hour period on date X+1. House A's HVAC system now requires significantly longer cycle times in order to try to maintain the same internal temperature. If those longer cycle times were due to higher outside temperatures, those cycle times would not indicate the existence of any problems. But because server 106 is aware of the outside temperature, the system can eliminate that possibility as an explanation for the higher cycle times.

[0184] Because server 106 is aware of the cycle times in nearby houses, it can determine that, for example, on date X+1 the efficiency of House A is only in the 23rd percentile. The server will be programmed with a series of heuristics, gathered from predictive models and past experience, correlating the drop in efficiency and the time interval over which it has occurred with different possible causes. For example, a 50% drop in efficiency in one day may be correlated with a refrigerant leak, especially if followed by a further drop in efficiency on the following day. A reduction of 10% over three months may be correlated with a clogged filter. Based upon the historical data recorded by the server, the server 106 will be able to alert the homeowner that there is a problem and suggest a possible cause.

[0185] Because the system will be able to calculate effective thermal mass, it will be able to determine the cost effectiveness of strategies such as pre-cooling for specific houses under different conditions. **Figure 28a** shows a graph of outside temperature 2802, inside temperature 2804 and HVAC cycling times 2806 in House A for a specific 24-hour period on date Y assuming that the system has used a pre-cooling strategy to avoid running the air conditioning during the afternoon, when rates are highest. Because House A has high thermal mass, the house is capable of "banking" cooling, and energy consumed during off-peak hours is in effect stored, allowing the house to remain cool even when the system is turned off. Temperatures keep rising during the period the air conditioning is off, but because thermal mass is high, the rate of increase is low, and the house is still comfortable six hours later.

Ex. 1006.0048

[0186] Although the pre-cooling cycle time in a given home may be relatively long, the homeowner may still benefit if the price per kilowatt during the morning pre-cooling phase is lower than the price during the peak load period. **Figure 28b** shows a graph of the same outside temperature 2802 in House B as in House A in **Figure 28a** for the same 24-hour period and using the same pre-cooling strategy as shown by cycling times 2806. But because House B has minimal thermal mass, using additional electricity in order to pre-cool the house does not have the desired effect; inside temperature 2808 warms up so fast that the cooling that had been banked is quickly lost. Thus the system will recommend that House A pre-cool in order to save money, but not recommend pre-cooling for House B.

[0187] The system can also help compensate for anomalies such as measurement inaccuracies due to factors such as poor thermostat location. It is well known that thermostats should be placed in a location that will be likely to experience "average" temperatures for the overall structure, and should be isolated from windows and other influences that could bias the temperatures they "see." But for various reasons, not all thermostat installations fit that ideal. **Figure 29a** shows a graph of outside temperature 2902, the actual average inside temperature for the entire house 2904, and inside temperature as read by the thermostat 2906 in House C for a specific 24-hour period on September 15th, assuming that the thermostat is located so that for part of the afternoon on that day the thermostat is in direct sunlight.

[0188] Until the point at which the sun hits the thermostat, the average inside temperature and temperature as read by the thermostat track very closely. But when the direct sunlight hits the thermostat, the thermostat and the surrounding area can heat up, causing the internal temperature as read by the thermostat to diverge significantly from the average temperature for the rest of the house. A conventional thermostat has no way of distinguishing this circumstance from a genuinely hot day, and will both over-cool the rest of the house and waste considerable energy when it cycles the air conditioner in order to reduce the temperature as sensed by the thermostat.

[0189] If the air conditioning is turned off, this phenomenon will manifest as a spike in temperature as measured by the thermostat. If the air conditioning is turned on

Ex. 1006.0049

(and has sufficient capacity to respond to the distorted temperature signal caused by the sunlight), this phenomenon will likely manifest as relatively small changes in the temperature as sensed by the thermostat, but significantly increased HVAC usage (as well as excessively lowered temperatures in the rest of the house, but this result may not be directly measured in a single sensor environment).

[0190] An embodiment of the system, in contrast, has multiple mechanisms that will allow it to correct for such distortions. First, because an embodiment of the subject system compares the internal readings from House C with the external temperature, it will be obvious that the rise in temperature at 4:00PM is not correlated with a corresponding change in outside temperature. Second, because the system is also monitoring the readings from the thermostat in nearby House D, which (as shown in **Figure 29b**) is exposed to the same outside temperature 602, but has no sudden rise in measured internal afternoon temperature 2908, the system has further validation that the temperature increase is not caused by climatic conditions. And finally, because the system has monitored and recorded the temperature readings from the thermostat in House C for each previous day, and has compared the changing times of the aberration with the progression of the sun, the system can distinguish the patterns likely to indicate solar overheating from other potential causes.

[0191] **Figure 30** illustrates the steps involved in calculating comparative thermal mass, or the thermal mass index. In step 3002, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3004, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0192] In step 3006, the server retrieves data regarding recent temperature readings as recorded by the thermostat in home X. In step 3008, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its

Ex. 1006.0050

address, make, model and age of its furnace and air conditioning hardware, and other data.

[0193] In step 3010, the server retrieves the current inside temperature reading as transmitted by the thermostat. In step 3012, the server calculates the thermal mass index for the home under those conditions; that is, for example, it calculates the likely rate of change for internal temperature in home X from a starting point of 70 degrees when the outside temperature is 85 degrees at 3:00PM on August 10th when the wind is blowing at 5 mph from the north and the sky is cloudy. The server accomplishes this by applying a basic algorithm that weighs each of these external variables as well as variables for various characteristics of the home itself (such as size, level of insulation, method of construction, etc.) and data from other houses and environments.

[0194] **Figure 31** illustrates the steps involved in diagnosing defects in the HVAC system for specific home X. In step 3102, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3104, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0195] In step 3106, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3108, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data. In step 3110, the server retrieves comparative data from other houses that have thermostats that also report to the server.

[0196] Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses. In step 3112, the server

Ex. 1006.0051

calculates the current relative efficiency of home X as compared to other homes. Those comparisons will take into account differences in size, location, age, etc in making those comparisons.

[0197] The server will also take into account that comparative efficiency is not absolute, but will vary depending on conditions. For example, a house that has extensive south-facing windows is likely to experience significant solar gain. On sunny winter days, that home will appear more efficient than on cloudy winter days. That same house will appear more efficient at times of day and year when trees or overhangs shade those windows than it will when summer sun reaches those windows. Thus the server will calculate efficiency under varying conditions.

[0198] In step 3114 the server compares the HVAC system's efficiency, corrected for the relevant conditions, to its efficiency in the past. If the current efficiency is substantially the same as the historical efficiency, the server concludes 3116 that there is no defect and the diagnostic routine ends. If the efficiency has changed, the server proceeds to compare the historical and current data against patterns of changes known to indicate specific problems. For example, in step 3118, the server compares that pattern of efficiency changes against the known pattern for a clogged air filter, which is likely to show a slow, gradual degradation over a period of weeks or even months.

[0199] If the pattern of degradation matches the clogged filter paradigm, the server creates and transmits to the homeowner a message 3120 alerting the homeowner to the possible problem. If the problem does not match the clogged filter paradigm, the system compares 3122 the pattern to the known pattern for a refrigerant leak, which is likely to show a degradation over a period of a few hours to a few days. If the pattern of degradation matches the refrigerant leak paradigm, the server creates and transmits to the homeowner a message 3124 alerting the homeowner to the possible problem.

[0200] If the problem does not match the refrigerant leak paradigm, the system compares 3126 the pattern to the known pattern for an open window or door, which is likely to show significant changes for relatively short periods at intervals uncorrelated with climatic patterns. If the pattern of degradation matches the open

door/window paradigm, the server creates and transmits to the homeowner a message 3128 alerting the homeowner to the possible problem. If the problem does not match the refrigerant leak paradigm, the system continues to step through remaining know patterns N 3130 until either a pattern is matched 3132 or the list has been exhausted without a match 3134.

[0201] **Figure 32** illustrates the steps involved in diagnosing inaccurate thermostat readings due to improper location. In step 3202, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3204, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0202] In step 3206, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3208, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0203] In step 3210, the server retrieves comparative data from other houses that have thermostats that also report to the server. Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses.

[0204] In step 3212, the server calculates the expected thermostat temperature reading based upon the input data. In step 3214, the server compares the predicted and actual values. If the calculated and actual values are at least roughly equivalent, the server concludes 3216 that there is no thermostat-related anomaly. If the calculated and actual values are not roughly equivalent, the server retrieves additional historical information about past thermostat readings in step 3218.

Ex. 1006.0053

[0205] In step 3220, the server retrieves solar progression data, i.e., information regarding the times at which the sun rises and sets on the days being evaluated at the location of the house being evaluated, and the angle of the sun at that latitude, etc. In step 3222, the server compares the characteristics of the anomalies over time, to see if, for example, abnormally high readings began at 3:06 on June 5th, 3:09 on June 6th, 3:12 on June 7th, and the solar progression data suggests that at the house being analyzed, that sun would be likely to reach a given place in that house three minutes later on each of those days.

[0206] If the thermostat readings do not correlate with the solar progression data, the server concludes 3224 that the sun is not causing the distortion by directly hitting the thermostat. If the thermostat readings do correlate with solar progression, the server then calculates 3226 the predicted duration of the distortion caused by the sun.

[0207] In step 3228, the server calculates the appropriate setpoint information to be used by the thermostat to maintain the desired temperature and correct for the distortion for the expected length of the event. For example, if the uncorrected setpoint during the predicted event is 72 degrees, and the sun is expected to elevate the temperature reading by eight degrees, the server will instruct the thermostat to maintain a setpoint of 80 degrees. In step 3230, the server sends the homeowner a message describing the problem.

[0208] One or more embodiments of the invention may be used to implement additional energy savings by implementing small, repeated changes in setpoint. Because energy consumption is directly proportional to setpoint – that is, the further a given setpoint diverges from the balance point (the natural inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by any strategy that over a given time frame lowers the average heating setpoint or raises the cooling setpoint.

[0209] It is therefore possible to save energy by adopting a strategy that takes advantage of human insensitivity to slow temperature ramping by incorporating a user's desired setpoint within the range of the ramp, but setting the average target

temperature below the desired setpoint in the case of heating, and above it in the case of cooling. For example, a ramped summer setpoint that consisted of a repeated pattern of three phases of equal length set at 72°F, 73°F, and 74°F would create an effective average setpoint of 73°F, but would generally be experienced by occupants as yielding at least roughly equivalent comfort as in a room set at a constant 72°F. Energy savings resulting from this approach have been shown to be in the range of 4-6%.

[0210] Embodiments of the invention can automatically generate optimized ramped setpoints that could save energy without compromising the comfort of the occupants. It would also be advantageous to create a temperature control system that could incorporate adaptive algorithms that could automatically determine when the ramped setpoints should not be applied due to a variety of exogenous conditions that make application of such ramped setpoints undesirable.

[0211] **Figure 33** represents the conventional programming of a thermostat and the resulting behavior of a home's HVAC system in the air conditioning context. The morning setpoint 3302 of 74 degrees remains constant from midnight until 9:00AM, and the inside temperature 3304 varies more or less within the limits of the hysteresis band during that entire period. When the setpoint changes to 80 degrees 3306, the inside temperature 3308 varies within the hysteresis band around the new setpoint, and so on. Whether the average temperature is equal to, greater or less than the nominal setpoint will depend on weather conditions, the dynamic signature of the structure, and the efficiency and size of the HVAC system. But in most cases the average temperature will be at least roughly equivalent to the nominal setpoint.

[0212] **Figure 34** represents implementation of a three-phase ramped setpoint derived from the same user preferences as manifested by the settings shown in **Figure 33**. Thus the user-selected setpoint for the morning is still 74 degrees, and is reflected in the setpoint 3404 at the start of each three-step cycle, but because (in the air conditioning context) the setpoint requested by the user is the lowest of the three discrete steps, rather than the middle step, the average setpoint will be one degree higher 3402, and the resulting average inside temperature will be roughly one degree warmer than the average temperature without use of the ramped setpoints, thereby saving energy.

Ex. 1006.0055

[0213] In the currently preferred embodiment, the implementation of the ramped setpoints may be dynamic based upon both conditions inside the structure and other planned setpoint changes. Thus, for example, the ramped setpoints 3406, 3408 and 3410 may be timed so that the 9AM change in user-determined setpoint from 74 degrees to 80 degrees is in effect anticipated, and the period in which the air conditioner is not used can be extended prior to the scheduled start time for the less energy-intensive setpoint. Similarly, because the server 106 is aware that a lower setpoint will begin at 5PM. The timing can be adjusted to avoid excessively warm temperatures immediately prior to the scheduled setpoint change, which could cause noticeable discomfort relative to the new setpoint if the air conditioner is incapable of quickly reducing inside temperature on a given day based upon the expected slope of inside temperatures at that time 3412.

[0214] In order to implement such ramped setpoints automatically, algorithms may be created. These algorithms may be generated and/or executed as instructions on remote server 106 and the resulting setpoint changes can be transmitted to a given thermostat on a just-in-time basis or, if the thermostat 108 is capable of storing future settings, they may be transferred in batch mode to such thermostats. Basic parameters used to generate such algorithms include:

[0215] the number of discrete phases to be used;

[0216] the temperature differential associated with each phase; and

[0217] the duration of each phase

[0218] In order to increase user comfort and thus maximize consumer acceptance, additional parameters may be considered, including:

[0219] time of day

[0220] outside weather conditions

[0221] recent history of manual inputs

[0222] recent pre-programmed setpoint changes.

[0223] Time of day may be relevant because, for example, if the home is typically unoccupied at a given time, there is no need for perceptual programming. Outside weather is relevant because comfort is dependent not just on temperature as sensed by a thermostat, but also includes radiant differentials. On extremely cold days,

even if the inside dry-bulb temperature is within normal comfort range, radiant losses due to cold surfaces such as single-glazed windows can cause subjective discomfort; thus on such days occupants may be more sensitive to ramping. Recent manual inputs (e.g., programming overrides) may create situations in which exceptions should be taken; depending on the context, recent manual inputs may either suspend the ramping of setpoints or simply alter the baseline temperature from which the ramping takes place.

[0224] **Figure 35** shows the steps used in the core ramped setpoint algorithm in the context of a remotely managed thermostat system. In step 3502 the application determines whether to instantiate the algorithm based upon external scheduling criteria. In step 3504 the application running on a remote server retrieves from the thermostat the data generated by or entered into the thermostat, including current temperature settings, HVAC status and inside temperature. The algorithm performs preliminary logical tests at that point to determine whether further processing is required. For example, in the heating context, if the inside temperature as reported by the thermostat 108 is more than 1 degree higher than the current setpoint, the algorithm may determine that running the ramped setpoint program will have no effect and therefore terminate.

[0225] In step 3506 the algorithm advances to the next phase from the most recent phase; i.e., if the algorithm is just starting, the phase changes from "0" to "1"; if it has just completed the third phase of a three-phase ramp, the phase will change from "2" to "0". In step 3508 the application determines if the current phase is "0". If it is, then in step 3510 the algorithm determines whether current setpoint equals the setpoint in the previous phase. If so, which implies no manual overrides or other setpoint adjustments have occurred during the most recent phase, then in step 3512 the algorithm sets the new setpoint back to the previous phase "0" setpoint. If not, then in step 3514, the algorithm keeps the current temperature setting as setpoint for this new phase. In step 3516, the algorithm logs the resulting new setpoint as the new phase "0" setpoint for use in subsequent phases.

[0226] Returning to the branch after step 3508, if the current phase at that point is not phase "0", then in step 3520, the algorithm determines whether the current

setpoint is equal to the setpoint temperature in the previous phase. If not, which implies setpoints have been adjusted by the house occupants, thermostat schedules, or other events, then in step 3522, the application resets the phase to "0", resets the new setpoint associated with phase "0" to equal the current temperature setting, and sets the current setting to that temperature. Alternatively, if the current temperature setting as determined in step 3520 is equal to the setpoint in the previous phase, then in step 3524 new setpoint is made to equal current setpoint plus the differential associated with each phase change. In step 3526 the "previous-phase setpoint" variable is reset to equal the new setpoint in anticipation of its use during a subsequent iteration.

[0227] **Figure 36** shows one embodiment of the overall control application implementing the algorithm described in **Figure 35**. In step 3602, the control application retrieves the current setting from the thermostat. In step 3604, the setting is logged in database 300. In step 3606, the control program determines whether other algorithms that have higher precedence than the ramped setpoint algorithm are to be run. If another algorithm is to be run prior to the ramped setpoint algorithm, then the other program is executed in step 3608. If there are no alternate algorithms that should precede the ramped setpoint application then in step 1310, the control program determines whether the thermostat has been assigned to execute the ramped setpoint program. If not, the control program skips the remaining actions in the current iteration. If the program is set to run, then in step 3612 the algorithm retrieves from database 300 the rules and parameters governing the implementation of the algorithm for the current application of the program.

[0228] In step 3614, the algorithm determines whether one or more conditions that preclude application of the algorithm, such as extreme outside weather conditions, whether the home is likely to be occupied, etc. If any of the exclusionary conditions apply, the application skips execution of the ramped setpoint algorithm for the current iteration. If not, the application proceeds to step 3616 in which the application determines whether the setpoint has been altered by manual overrides, thermostat setback schedule changes, or other algorithms as compared to the previous value as stored in database 300. If setpoint has been altered, the application proceeds to step 3620 discussed below.

Ex. 1006.0058

[0229] In step 3618, the program described in **Figure 35** is executed. In step 3620, the application resets the phase to "0". Certain temperature setting variables are reset in anticipation of their use in subsequent phases. These variables include the new phase 0 temperature setting which is anchored to the current actual temperature setting, and the new previous-phase setpoint which will be used for identifying setpoint overrides in the subsequent phase.

[0230] In step 3622, the system records the changes to the thermostat settings to database 300. In step 3624, the system records the changes to the phase status of the algorithm to database 300. In step 3626, the application determines whether the new temperature setting differs from the current setting. If they are the same, the application skips applying changes to the thermostat. If they are different, then in step 3628, the application transmits revised settings to the thermostat. In step 3630, the application then hibernates for the specified duration until it is invoked again by beginning at step 3602 again.

[0231] An embodiment of the subject invention may also be used to detect occupancy through the use of software related to electronic devices located inside the conditioned structure, such as the browser running on computer or other device 104. **Figure 37** represents the screen of a computer or other device 104 using a graphical user interface connected to the Internet. The screen shows that a browser 3700 is displayed on computer 104. In one embodiment, a background application installed on computer 104 detects activity by a user of the computer, such as cursor movement, keystrokes or otherwise, and signals the application running on server 106 that activity has been detected. Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; (b) signal the background application running on computer 104 to trigger a software routine that instantiates a pop-up window 3702 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. The user can respond by clicking the cursor on "yes" button 3704 or "No" button 3706. Equilvalent means of signalling activity may be employed with interactive television programming, gaming systems, etc.

Ex. 1006.0059

[0232] **Figure 38** is a flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 3802, computer 104 transmits a message to server 106 via the Internet indicating that there is user activity on computer 104. This activity can be in the form of keystrokes, cursor movement, input via a television remote control, etc. In step 3804 the application queries database 300 to retrieve setting information for the HVAC system. In step 3806 the application determines whether the current HVAC program is intended to apply when the home is occupied or unoccupied.

[0233] If the HVAC settings then in effect are intended to apply for an occupied home, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 3808 the application will retrieve from database 300 the user's specific preferences for how to handle this situation. If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 3816, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 3810 the application transmits a command to computer 104 directing the browser to display a message informing the user that the current setting assumes an unoccupied house and asking the user in step 3812 to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 3814 the application will write to database 300 the fact that the users has so elected and terminate. If the user elects to change the setting, then in step 3816 the application transmits the revised setpoint to the thermostat. In step 3814 the application writes the updated setting information to database 300.

[0234] **Figure 39** is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system. In step 3902 computer 104 transmits to server 106 information regarding the type of

activity detected on computer 104. Such information could include the specific program or channel being watched if, for example, computer 104 is used to watch television. The information matching, for example, TV channel 7 at 4:00 PM on a given date to specific content may be made by referring to Internet-based or other widely available scheduling sources for such content. In step 3904 server 106 retrieves from database 300 previously logged data regarding viewed programs. In step 3906 server 106 retrieves previously stored data regarding the residents of the house.

[0235] For example, upon initiating the service, one or more users may have filled out online questionnaires sharing their age, gender, schedules, viewing preferences, etc. In step 3908, server 106 compares the received information about user activity to previously stored information retrieved from database 300 about the occupants and their viewing preferences. For example, if computer 104 indicates to server 106 that the computer is being used to watch golf, the server may conclude that an adult male is watching; if computer 104 indicates that it is being used to watch children's programming, server 106 may conclude that a child is watching.

[0236] In step 3910 the server transmits a query to the user in order to verify the match, asking, in effect, "Is that you Bob?" In step 3912, based upon the user's response, the application determines whether the correct user has been identified. If the answer is no, then the application proceeds to step 3916. If the answer is yes, then in step 3914 the application retrieves the temperature settings for the identified occupant. In step 3916 the application writes to database 300 the programming information and information regarding matching of users to that programming.

[0237] In an alternative embodiment, the application running on computer 104 may respond to general user inputs (that is, inputs not specifically intended to instantiate communication with the remote server) by querying the user whether a given action should be taken. For example, in a system in which the computer 104 is a web-enabled television or web-enabled set-top device connected to a television as a display, software running on computer 104 detects user activity, and transmits a message indicating such activity to server 106. The trigger for this signal may be general, such as changing channels or adjusting volume with the remote control or a power-on event. Upon receipt by server 106 of this trigger, server 106 transmits instructions to computer

104 causing it to display a dialog box asking the user whether the user wishes to change HVAC settings.

[0238] Additional functionality is also envisioned as part of different embodiments of the invention. For example, information from historic data may be used to predict how long it will take a user to reach home from the current coordinates, and the estimated arrival time may be used to calculate optimal cycling strategies for the HVAC system. In addition, information about traffic conditions may be integrated into these calculations, so that the geospatial data relative to mobile device 105 may indicate that a user is taking his or her normal route, but because of a traffic jam, is likely to come home later than would otherwise be expected. The characteristics of a given location may be used to infer arrival times as well. For example, if the geospatial data indicates that the user of mobile device 105 has arrived at the supermarket on his way home, a delay of 20 minutes is likely, whereas if the user has parked at a restaurant, the delay is likely to be one hour.

[0239] It is also possible to incorporate more sophisticated heuristics in incorporating the varying preferences of multiple occupants of a given home or other structure. For example, rules can be structured so that User #1's preferences control during the heating season, but not during the cooling season; User #2's preferences might control during certain times of the day but not others; User #3's preferences amy take precedence whenever they result in a more energy efficient strategy, but not when they result in increased energy use, and so on.

[0240] While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, that the invention may be carried out in other ways without departing from the true spirit and scope. These and other equivalents are intended to be covered by the following claims:

Ex. 1006.0062

WHAT IS CLAIMED IS:

1. A method for varying temperature setpoints for an HVAC system comprising:

accessing stored data comprising a plurality of internal temperature measurements taken within a structure and a plurality of outside temperature measurements relating to temperatures outside the structure;

using the stored data to predict a temperature inside the structure in response to at least changes in the outside temperatures;

determining with one or more computer processors, the geographic location of a mobile electronic device that is connected to a network;

associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices;

determining with one or more computer processors, whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device;

using route data to determine whether a user of the mobile electronic device is traveling to said structure;

using traffic data to predict a length of time for a user of said mobile device to reach said structure; and

adjusting with one or more computer processors, the temperature setpoint on said controller for an HVAC system for said structure based upon said predicted length of time for a user of the mobile device to reach said structure, said predicted temperature inside said structure, and whether or not said structure is deemed to be occupied.

Ex. 1006.0063

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

ABSTRACT OF THE DISCLOSURE

Embodiments of the invention comprise systems and methods for using the geographic location of networked consumer electronics devices as indications of occupancy of a structure for purposes of automatically adjusting the temperature setpoint on a thermostatic HVAC control. At least one thermostat is located inside a structure and is used to control an HVAC system in the structure. At least one mobile electronic device is used to indicate the state of occupancy of the structure. The state of occupancy is used to alter the setpoint on the thermostatic HVAC control to reduce unneeded conditioning of unoccupied spaces.

18896378
091614

Ex. 1006.0064

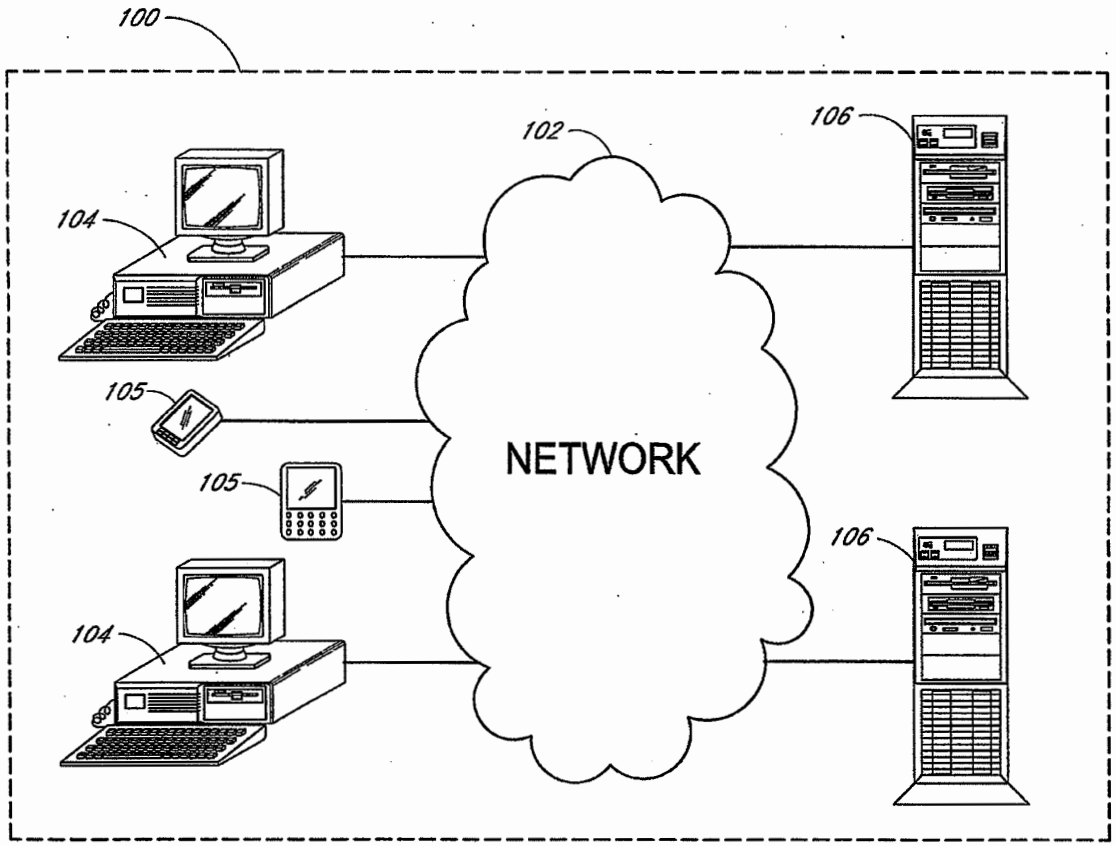


FIG. 1

Ex. 1006.0065

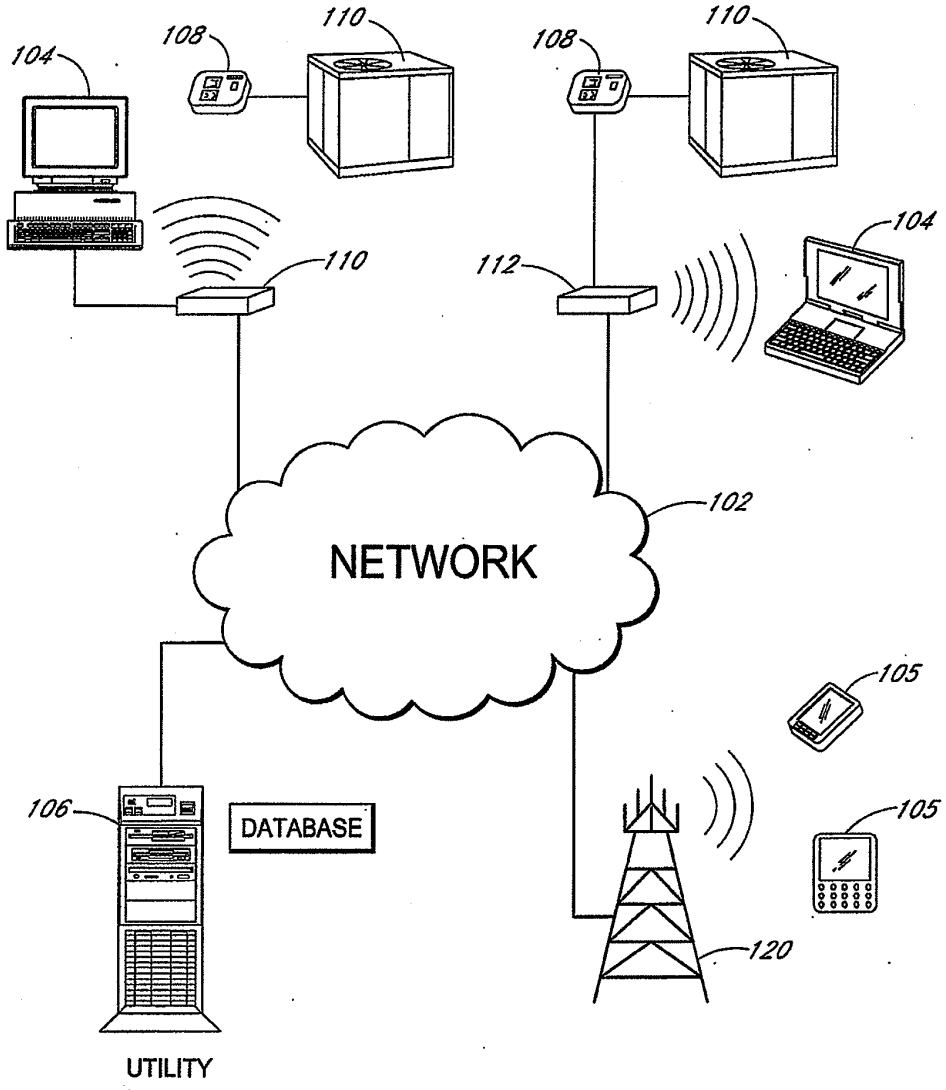

104
108
110
108
110
110
112
104
NETWORK
102
105
105
106
DATABASE
120
UTILITY

FIG. 2

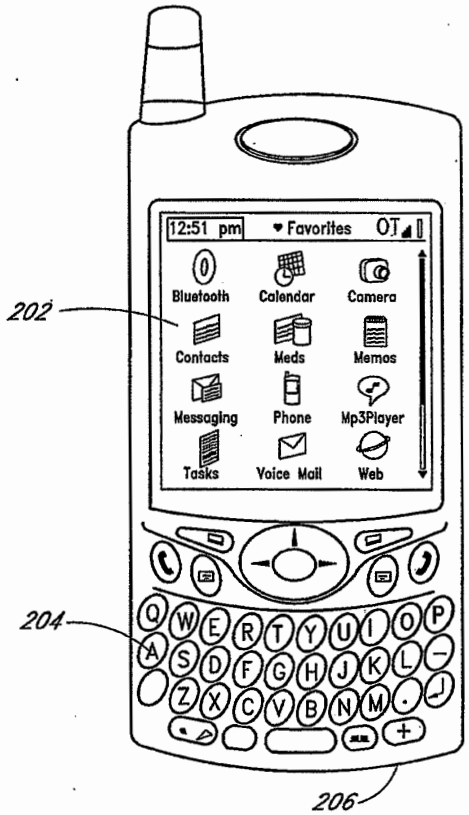


FIG. 3A

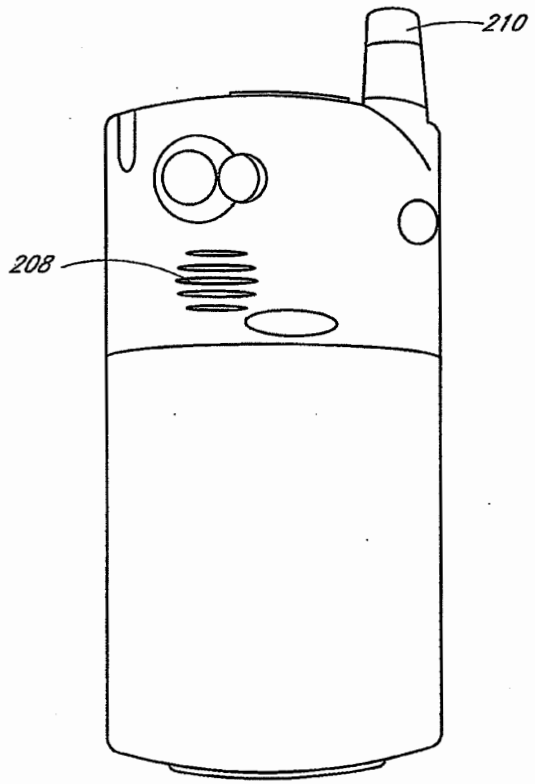


FIG. 3B

Ex. 1006.0067

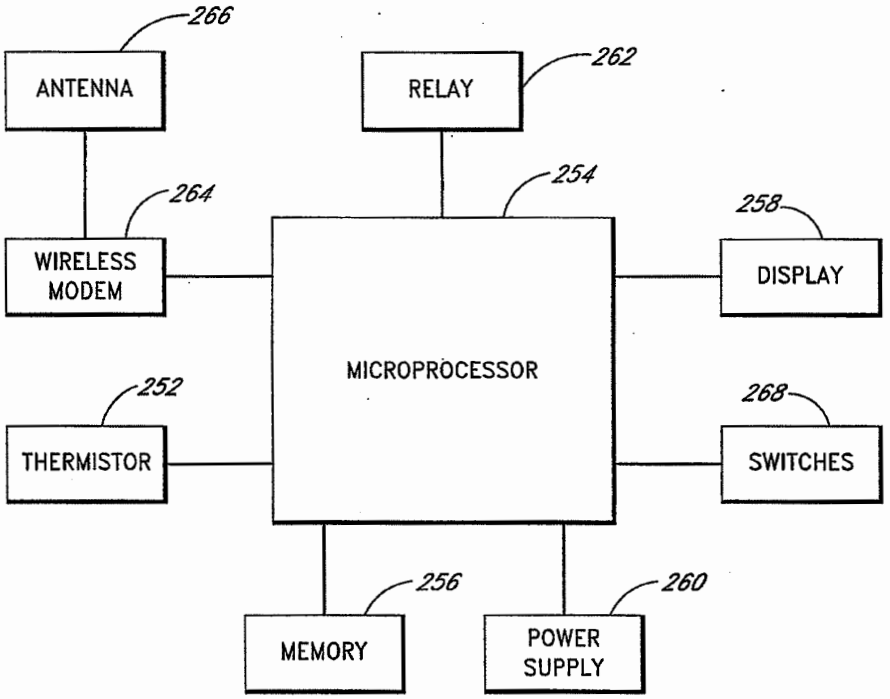

266
ANTENNA
262
RELAY
264
254
258
WIRELESS MODEM
DISPLAY
MICROPROCESSOR
252
268
THERMISTOR
SWITCHES
256
260
MEMORY
POWER SUPPLY

FIG. 4

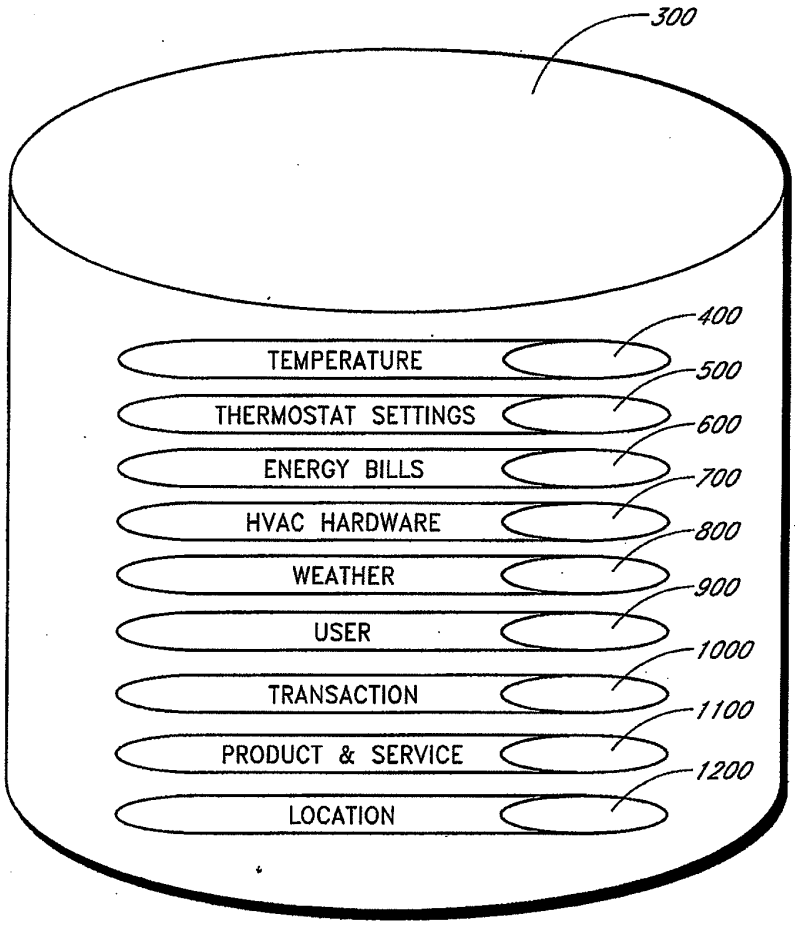

300
400
TEMPERATURE
500
THERMOSTAT SETTINGS
600
ENERGY BILLS
700
HVAC HARDWARE
800
WEATHER
900
USER
1000
TRANSACTION
1100
PRODUCT & SERVICE
1200
LOCATION

FIG. 5

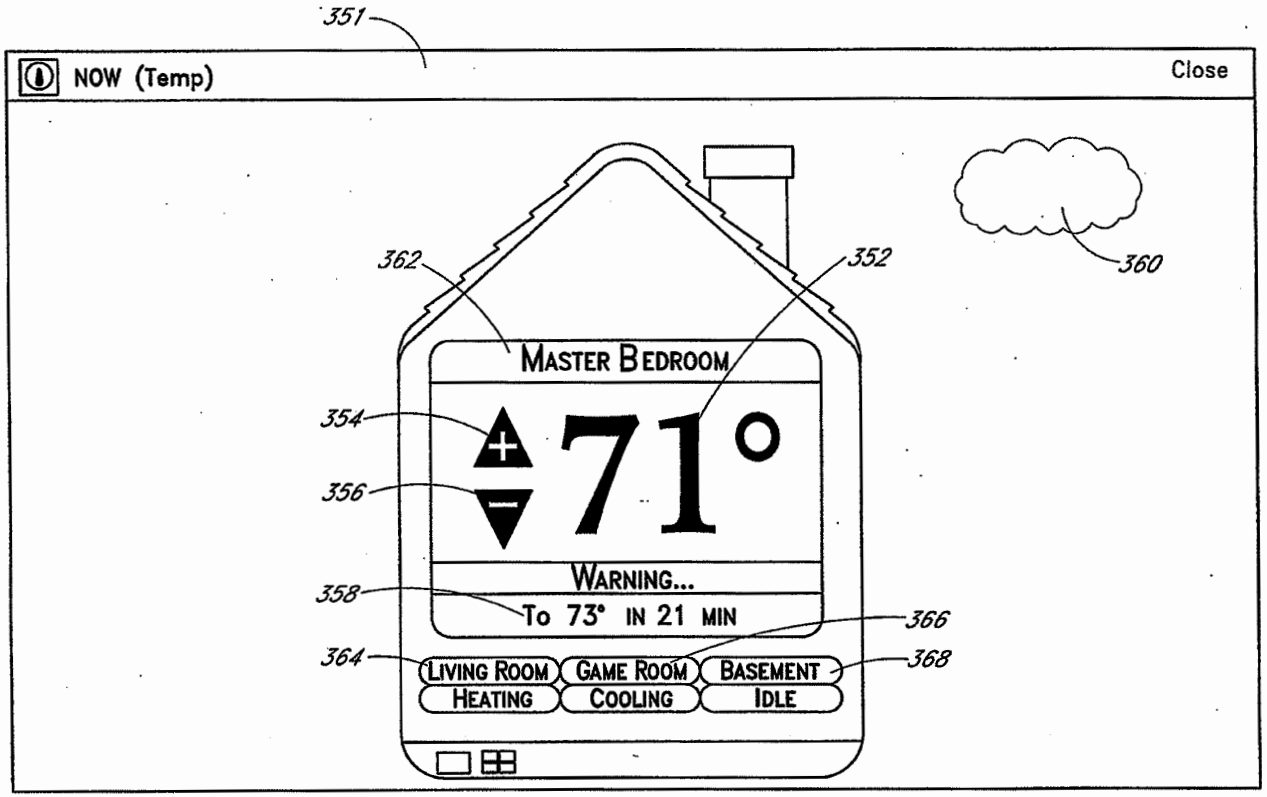

351
NOW (Temp)
Close
362
352
360
MASTER BEDROOM
354
71°
356
WARNING...
358
To 73° IN 21 MIN
366
364
LIVING ROOM
GAME ROOM
BASEMENT
368
HEATING
COOLING
IDLE

FIG. 6A

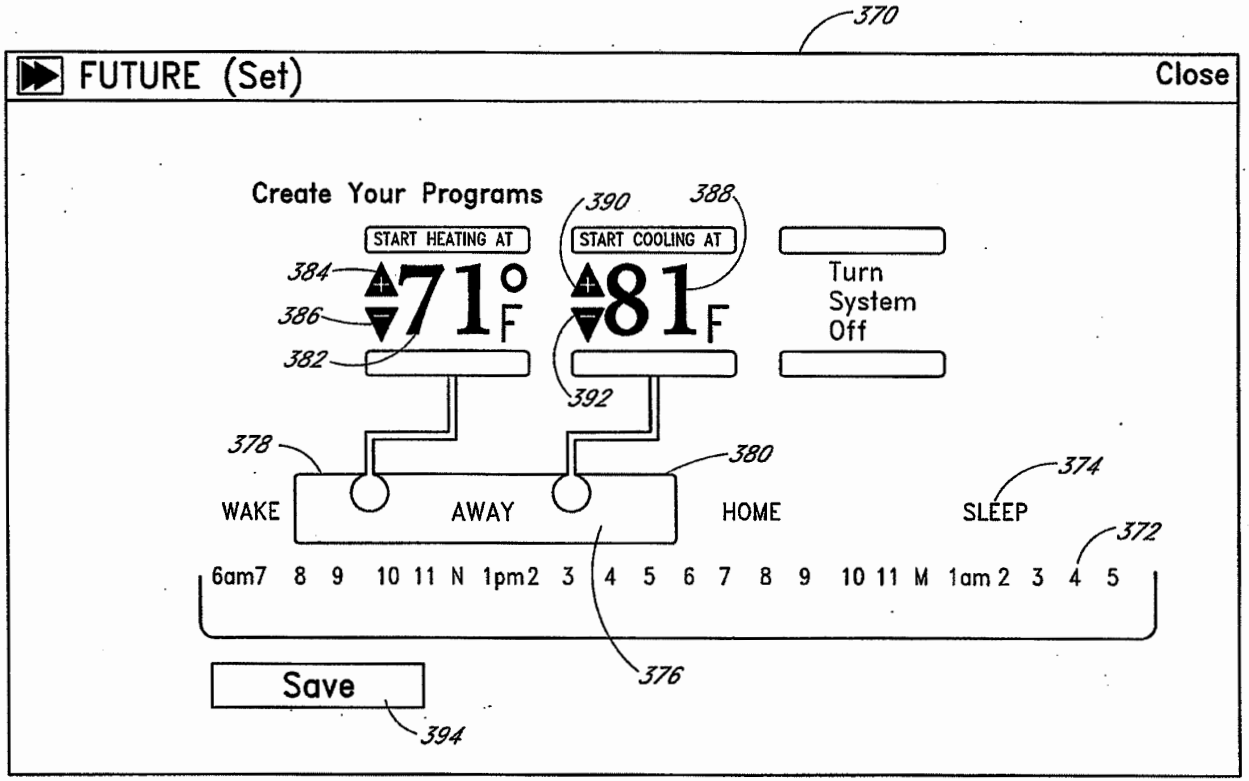


FIG. 6B

Ex. 1006.0071

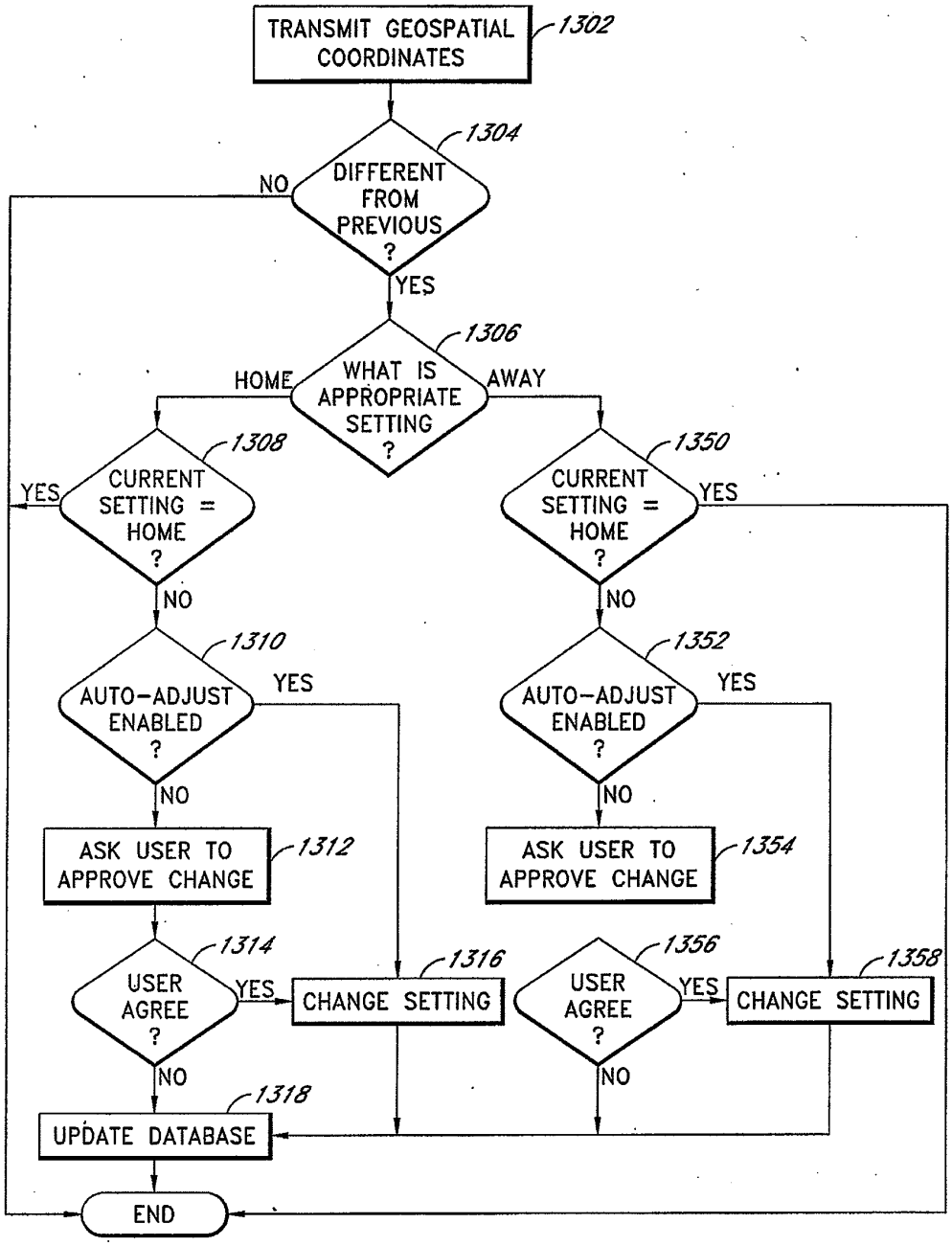

TRANSMIT GEOSPATIAL COORDINATES
1302
DIFFERENT FROM PREVIOUS ?
1304
NO
YES
WHAT IS APPROPRIATE SETTING ?
1306
HOME
AWAY
CURRENT SETTING = HOME ?
1308
YES
NO
AUTO-ADJUST ENABLED ?
1310
YES
NO
ASK USER TO APPROVE CHANGE
1312
USER AGREE ?
1314
YES
NO
CHANGE SETTING
1316
UPDATE DATABASE
1318
CURRENT SETTING = HOME ?
1350
YES
NO
AUTO-ADJUST ENABLED ?
1352
YES
NO
ASK USER TO APPROVE CHANGE
1354
USER AGREE ?
1356
YES
NO
CHANGE SETTING
1358
END

FIG. 7

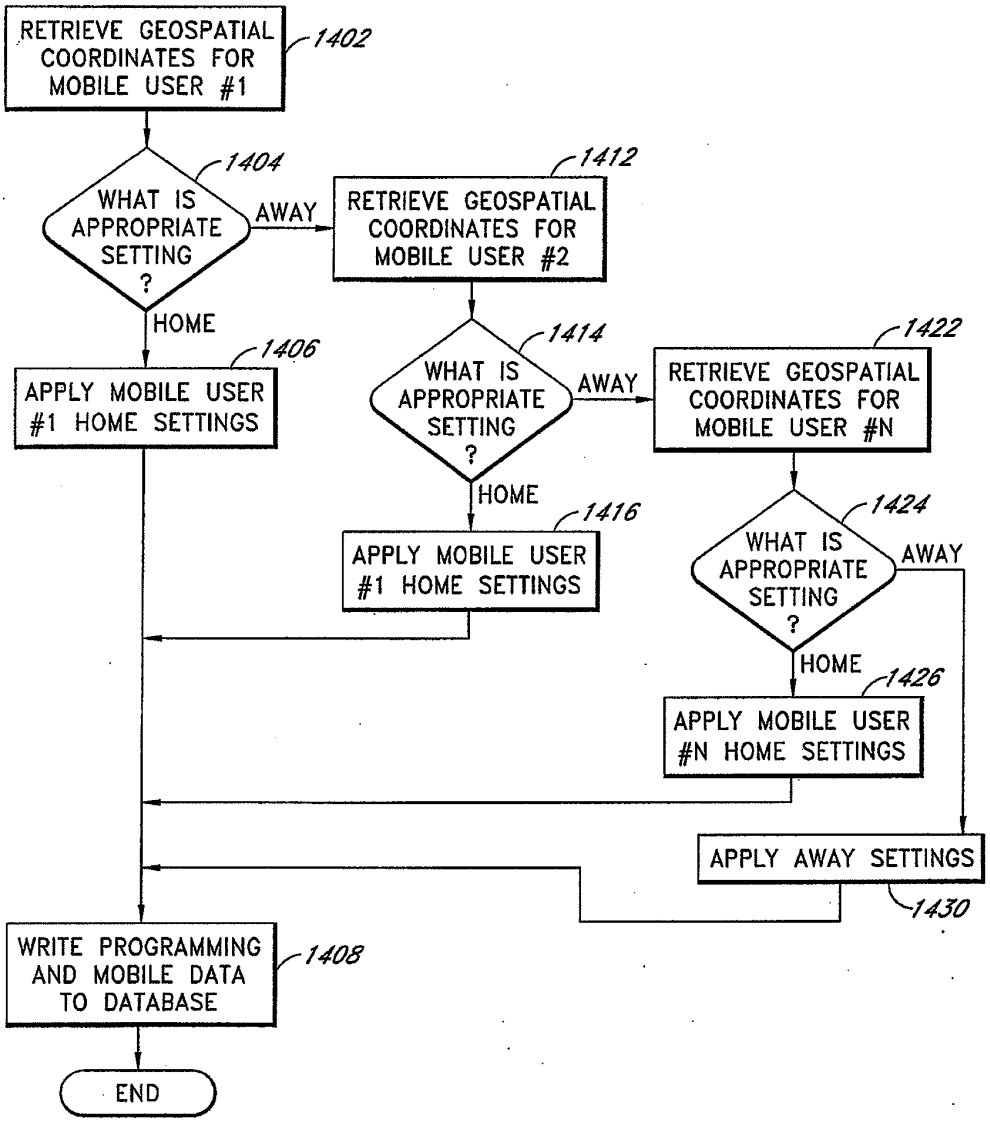

RETRIEVE GEOSPATIAL COORDINATES FOR MOBILE USER #1
1402
WHAT IS APPROPRIATE SETTING ?
1404
AWAY
HOME
APPLY MOBILE USER #1 HOME SETTINGS
1406
RETRIEVE GEOSPATIAL COORDINATES FOR MOBILE USER #2
1412
WHAT IS APPROPRIATE SETTING ?
1414
AWAY
HOME
APPLY MOBILE USER #1 HOME SETTINGS
1416
RETRIEVE GEOSPATIAL COORDINATES FOR MOBILE USER #N
1422
WHAT IS APPROPRIATE SETTING ?
1424
AWAY
HOME
APPLY MOBILE USER #N HOME SETTINGS
1426
APPLY AWAY SETTINGS
1430
WRITE PROGRAMMING AND MOBILE DATA TO DATABASE
1408
END

FIG. 8

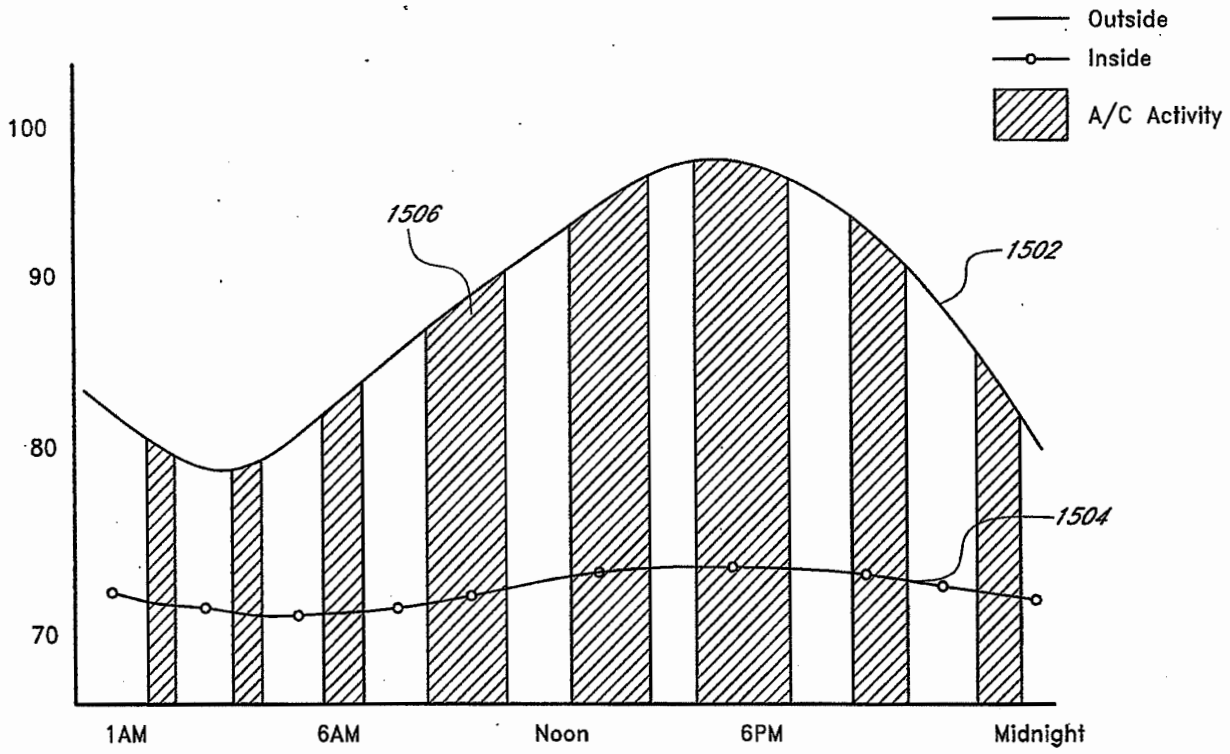

Outside
Inside
A/C Activity
100
90
80
70
1506
1502
1504
1AM
6AM
Noon
6PM
Midnight

FIG. 9A

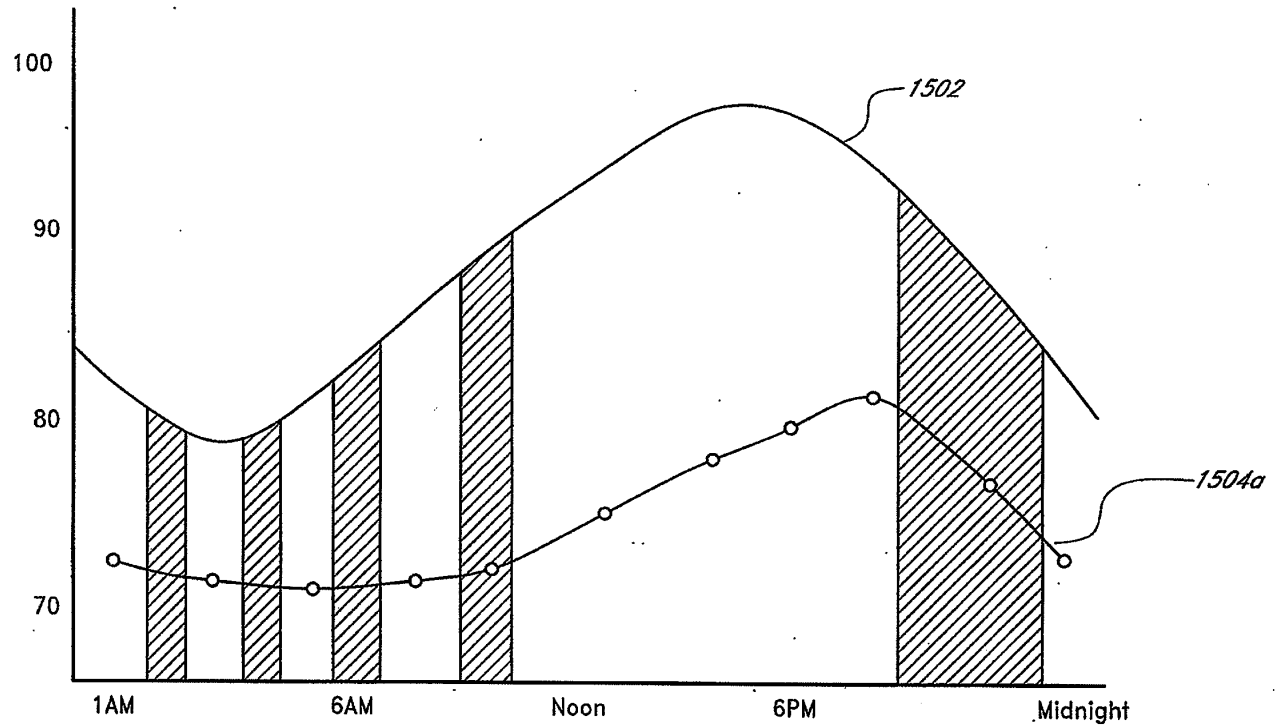


FIG. 9B

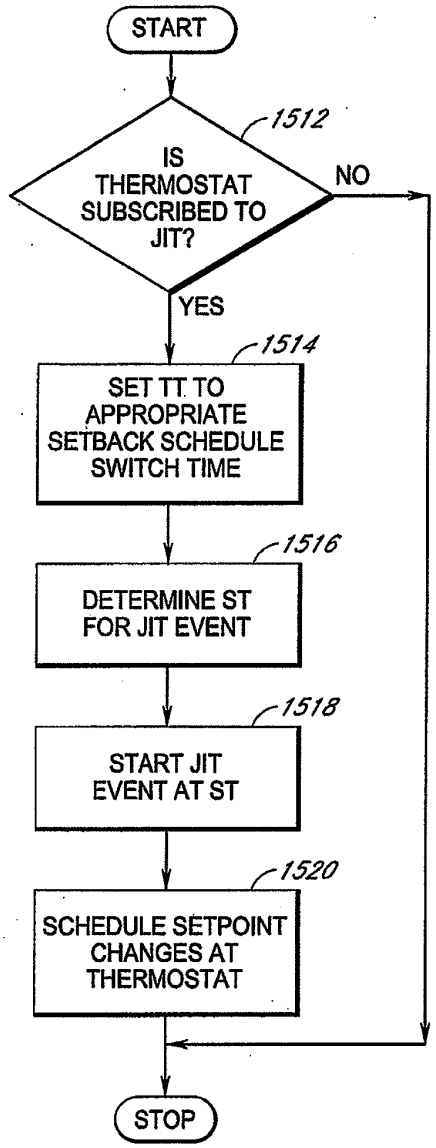

START
1512
IS THERMOSTAT SUBSCRIBED TO JIT?
NO
YES
1514
SET TT TO APPROPRIATE SETBACK SCHEDULE SWITCH TIME
1516
DETERMINE ST FOR JIT EVENT
1518
START JIT EVENT AT ST
1520
SCHEDULE SETPOINT CHANGES AT THERMOSTAT
STOP

FIG. 10

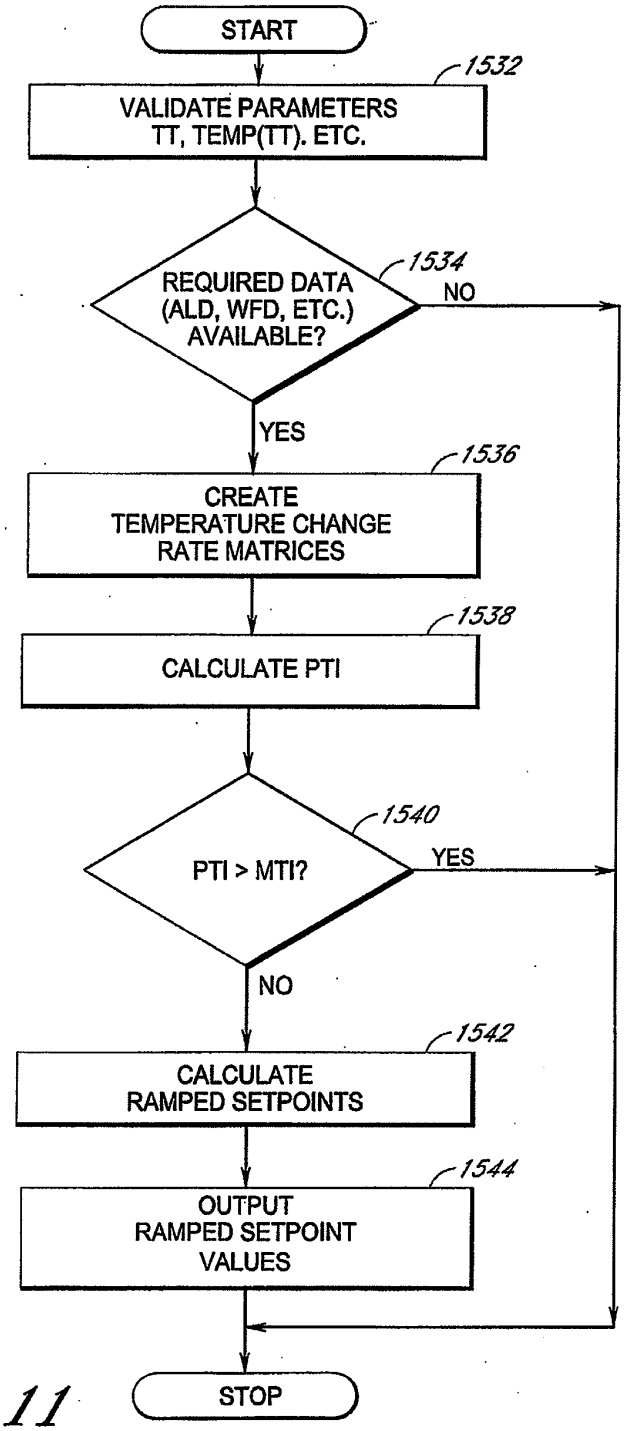

START
1532
VALIDATE PARAMETERS
TT, TEMP(TT). ETC.
1534
REQUIRED DATA
(ALD, WFD, ETC.)
AVAILABLE?
NO
YES
1536
CREATE
TEMPERATURE CHANGE
RATE MATRICES
1538
CALCULATE PTI
1540
PTI > MTI?
YES
NO
1542
CALCULATE
RAMPED SETPOINTS
1544
OUTPUT
RAMPED SETPOINT
VALUES
STOP

FIG. 11

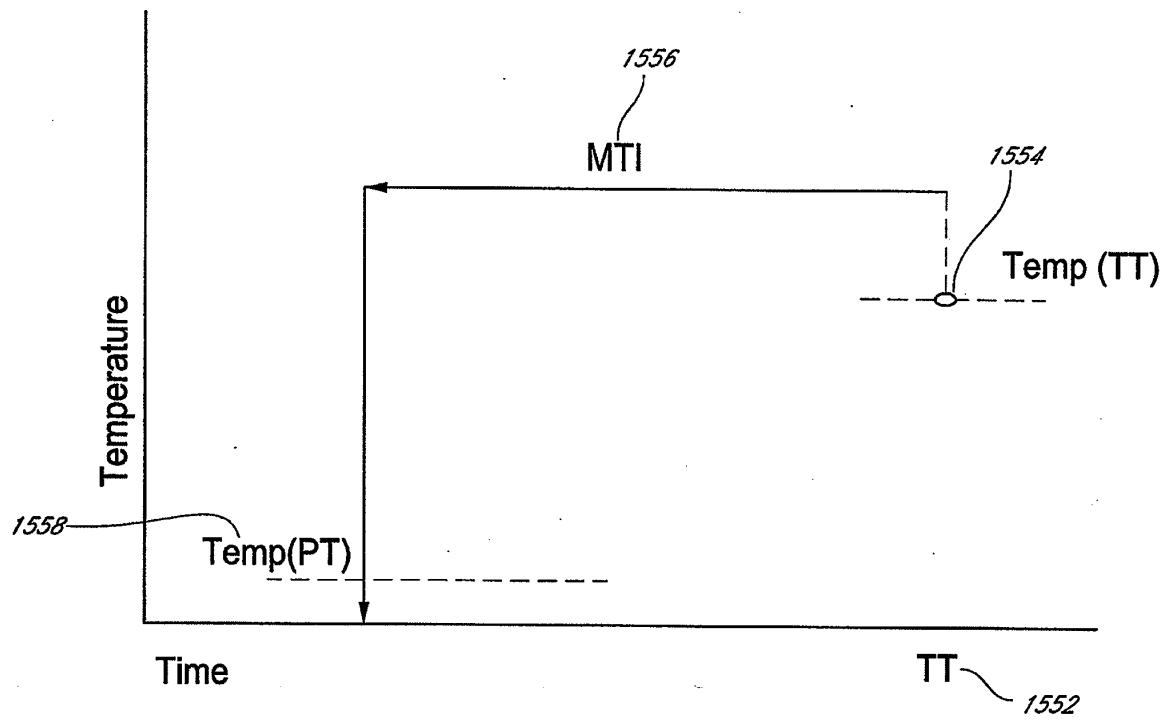


FIG. 12A

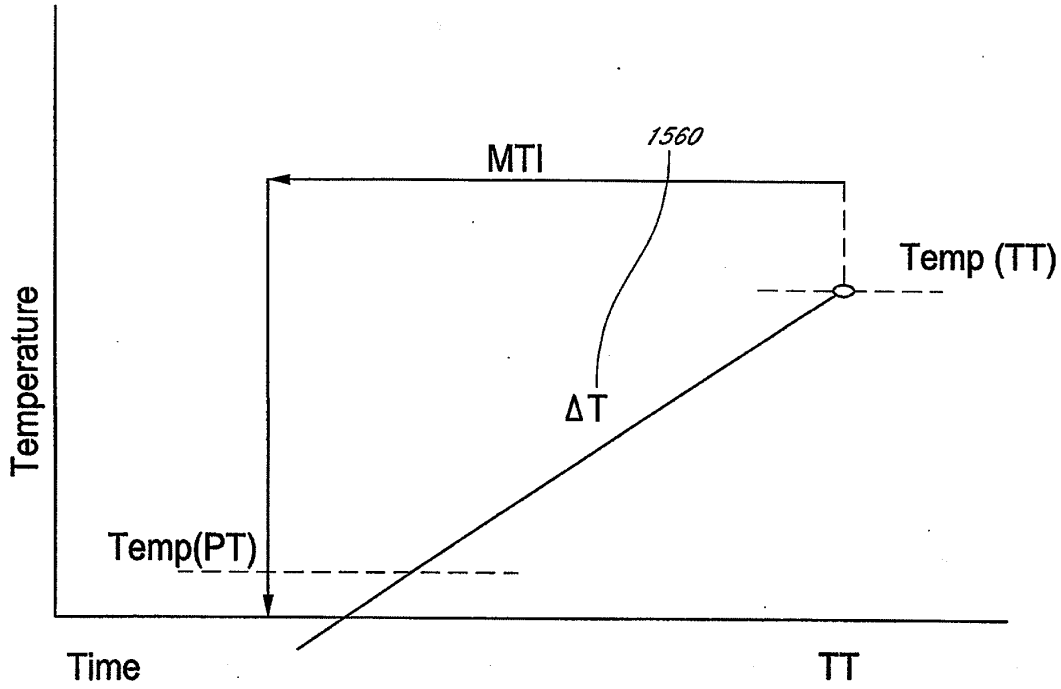


FIG. 12B

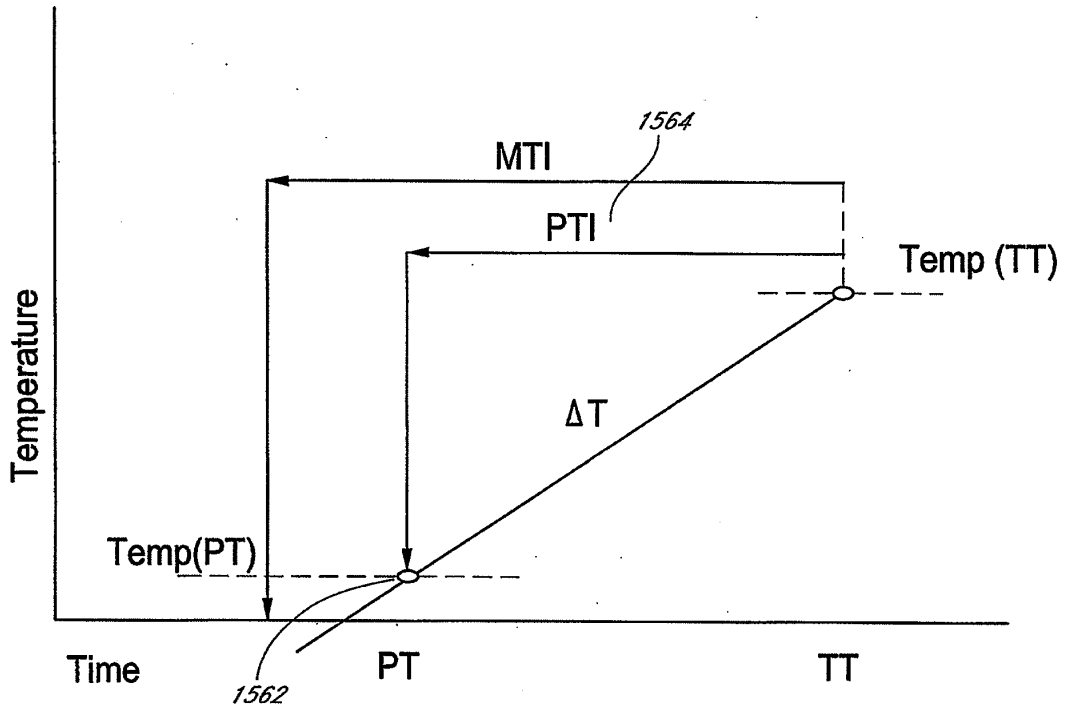


FIG. 12C

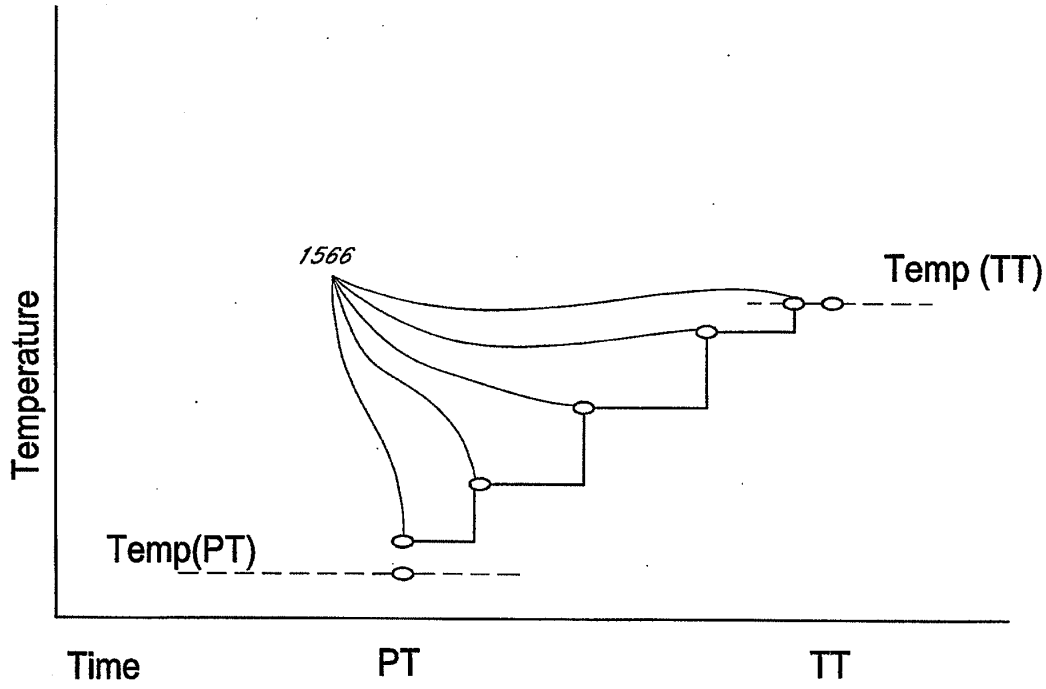


FIG. 12D

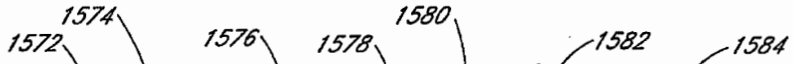


FIG. 13

Time	Temperature		Outside Conditions					Inside Conditions							
(hh24:mm)	Inside Temp.	Outside Temp.	Conditions	Humidity	Pressure	Wind Speed	Wind Direction	Cool Setting	Heat Setting	Hold Mode	Schd Setting	Schd Cool	Schd Heat	Hvac State	Hvac Mode
2009/04/10 11:00	69.70	54.00	Mostly Cloudy	74%	29.89in/ 1012.1hPa Steady	1.0mph 1.6kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:01	69.69	54.10	Overcast	74%	29.89in/ 1012.1hPa Rising	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:02	69.60	54.10	Overcast	74%	29.89in/ 1012.1hPa Steady	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:03	69.70	54.10	Overcast	74%	29.89in/ 1012.1hPa Rising	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:04	69.70	54.10	Overcast	74%	29.89in/ 1012.1hPa Steady	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:05	69.70	54.10	Overcast	74%	29.89in/ 1012.1hPa Rising	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:06	69.80	54.70	Overcast	72%	29.89in/ 1012.1hPa Steady	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:07	69.80	54.70	Overcast	72%	29.89in/ 1012.1hPa Rising	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:08	70.00	54.70	Overcast	72%	29.89in/ 1012.1hPa Steady	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:09	70.00	54.70	Overcast	72%	29.89in/ 1012.1hPa Rising	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat
2009/04/10 11:10	70.00	54.70	Overcast	72%	29.89in/ 1012.1hPa Steady	2.0mph 3.2kph	SE	80.00	71.00	Off	Out/Day	80.00	65.00	Heat	Heat

Ex. 1006.0082

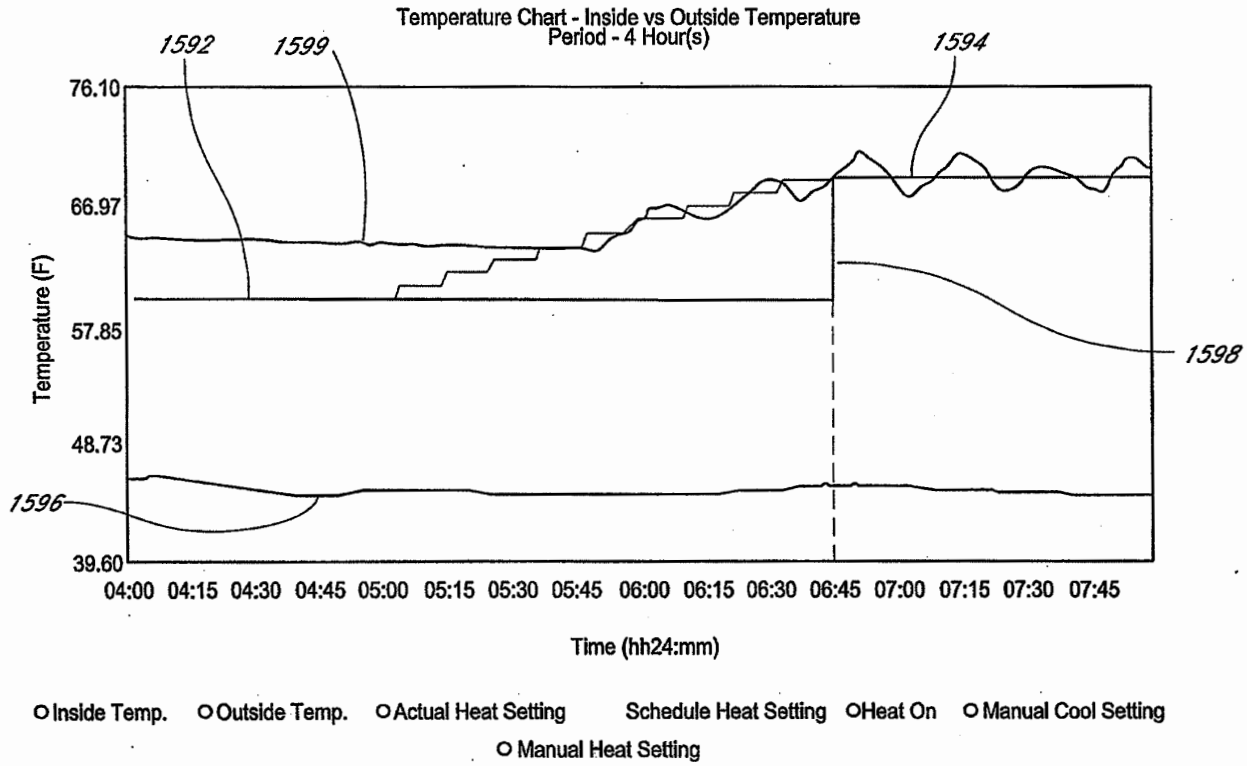


FIG. 14

Ex. 1006.0083

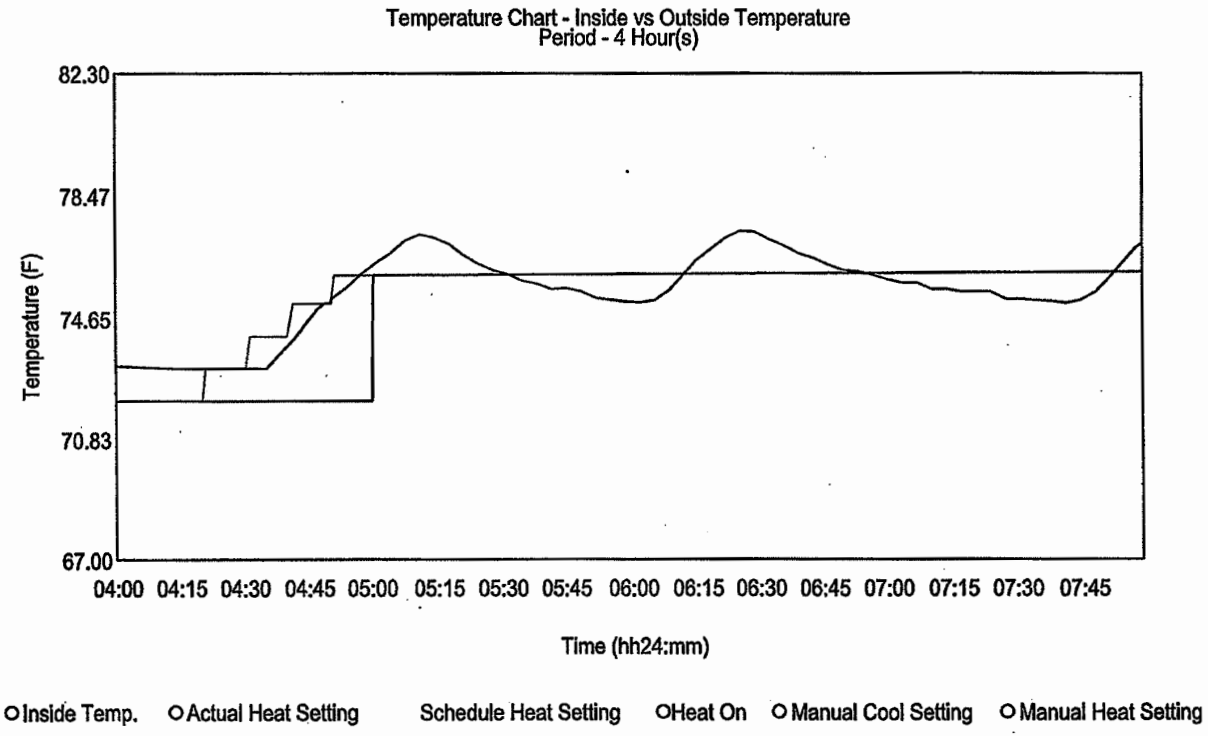

Temperature Chart - Inside vs Outside Temperature
Period - 4 Hour(s)
82.30
78.47
74.65
70.83
67.00
Temperature (F)
04:00 04:15 04:30 04:45 05:00 05:15 05:30 05:45 06:00 06:15 06:30 06:45 07:00 07:15 07:30 07:45
Time (hh24:mm)
Inside Temp.
Actual Heat Setting
Schedule Heat Setting
Heat On
Manual Cool Setting
Manual Heat Setting

FIG. 15

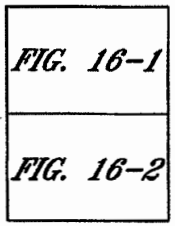


FIG. 16

1602 1604

FIG. 16-1

Outside/Inside Difference, Degrees F	Predicted Inside Temp Change, Degrees F/hour	Outside/Inside Difference, Degrees F	Predicted Inside Temp Change, Degrees F/hour	Outside/Inside Difference, Degrees F	Predicted Inside Temp Change, Degrees F/hour	Outside/Inside Difference, Degrees F	Predicted Inside Temp Change, Degrees F/hour
-99	-1.20945425	-49	0.61355475	1	2.43656376	51	4.25957277
-98	-1.17299407	-48	0.65001493	2	2.47302394	52	4.29603295
-97	-1.13653389	-47	0.68647511	3	2.50948412	53	4.33249313
-96	-1.10007371	-46	0.72293529	4	2.5459443	54	4.36895331
-95	-1.06361353	-45	0.75939547	5	2.58240448	55	4.40541349
-94	-1.02715335	-44	0.79585565	6	2.61886466	56	4.44187367
-93	-0.99069317	-43	0.83231583	7	2.65532484	57	4.47833385
-92	-0.95423299	-42	0.86877602	8	2.69178502	58	4.51479403
-91	-0.91777281	-41	0.9052362	9	2.7282452	59	4.55125421
-90	-0.88131263	-40	0.94169638	10	2.76470538	60	4.58771439
-89	-0.84485245	-39	0.97815656	11	2.80116556	61	4.62417457
-88	-0.80839227	-38	1.01461674	12	2.83762574	62	4.66063475
-87	-0.77193209	-37	1.05107692	13	2.87408592	63	4.69709493
-86	-0.73547191	-36	1.0542371	14	2.9105461	64	4.73355511
-85	-0.69901173	-35	1.12399728	15	2.94700628	65	4.77001529
-84	-0.66255155	-34	1.16045746	16	2.98346646	66	4.80647547
-83	-0.62609137	-33	1.19691764	17	3.01992664	67	4.84293565
-82	-0.58963119	-32	1.23337782	18	3.05638682	68	4.87939583
-81	-0.55317101	-31	1.269838	19	3.092847	69	4.91585601
-80	-0.51671083	-30	1.30629818	20	3.12930718	70	4.95231619
-79	-0.48025065	-29	1.34275836	21	3.16576736	71	4.98877637
-78	-0.44379047	-28	1.37921854	22	3.20222754	72	5.02523655

-77	-0.40733029	-27	1.41567872	23	3.23868772	73	5.06169673
-76	-0.37087011	-26	1.4521389	24	3.27514791	74	5.09815691
-75	-0.33440993	-25	1.48859908	25	3.31160809	75	5.13461709
-74	-0.29794975	-24	1.52505926	26	3.34806827	76	5.17107727
-73	-0.26148957	-23	1.56151944	27	3.38452845	77	5.20753745
-72	-0.22502939	-22	1.59797962	28	3.42098863	78	5.24399763
-71	-0.18856921	-21	1.6344398	29	3.45744881	79	5.28045781
-70	-0.15210903	-20	1.67089998	30	3.49390899	80	5.31691799
-69	-0.11564885	-19	1.70736016	31	3.53036917	81	5.35337817
-68	-0.07918867	-18	1.74382034	32	3.56682935	82	5.38983835
-67	-0.04272849	-17	1.78028052	33	3.60328953	83	5.42629853
-66	-0.00626831	-16	1.8167407	34	3.63974971	84	5.46275871
-65	0.03019187	-15	1.85320088	35	3.67620989	85	5.49921889
-64	0.06665205	-14	1.88966106	36	3.74913025	86	5.53567907
-63	0.10311223	-13	1.92612124	37	3.74913025	87	5.57213925
-62	0.13957241	-12	1.96258142	38	3.78559043	88	5.60859943
-61	0.17603259	-11	1.9990416	39	3.82205061	89	5.64505962
-60	0.21249277	-10	2.03550178	40	3.85851079	90	5.6815198
-59	0.24895295	-9	2.07196196	41	3.89497097	91	5.71797998
-58	0.28541313	-8	2.10842214	42	3.93143115	92	5.75444016
-57	0.32187331	-7	2.14488232	43	3.96789133	93	5.79090034
-56	0.35833349	-6	2.1813425	44	4.00435151	94	5.82736052
-55	0.39479367	-5	2.21780268	45	4.04081169	95	5.8638207
-54	0.43125385	-4	2.25426286	46	4.07727187	96	5.90028088
-53	0.46771403	-3	2.29072304	47	4.11373205	97	5.93674106
-52	0.50417421	-2	2.32718322	48	4.15019223	98	5.97320124
-51	0.54063439	-1	2.3636434	49	4.18665241	99	6.00966142
-50	0.57709457	0	2.40010358	50	4.22311259		

FIG. 16-2

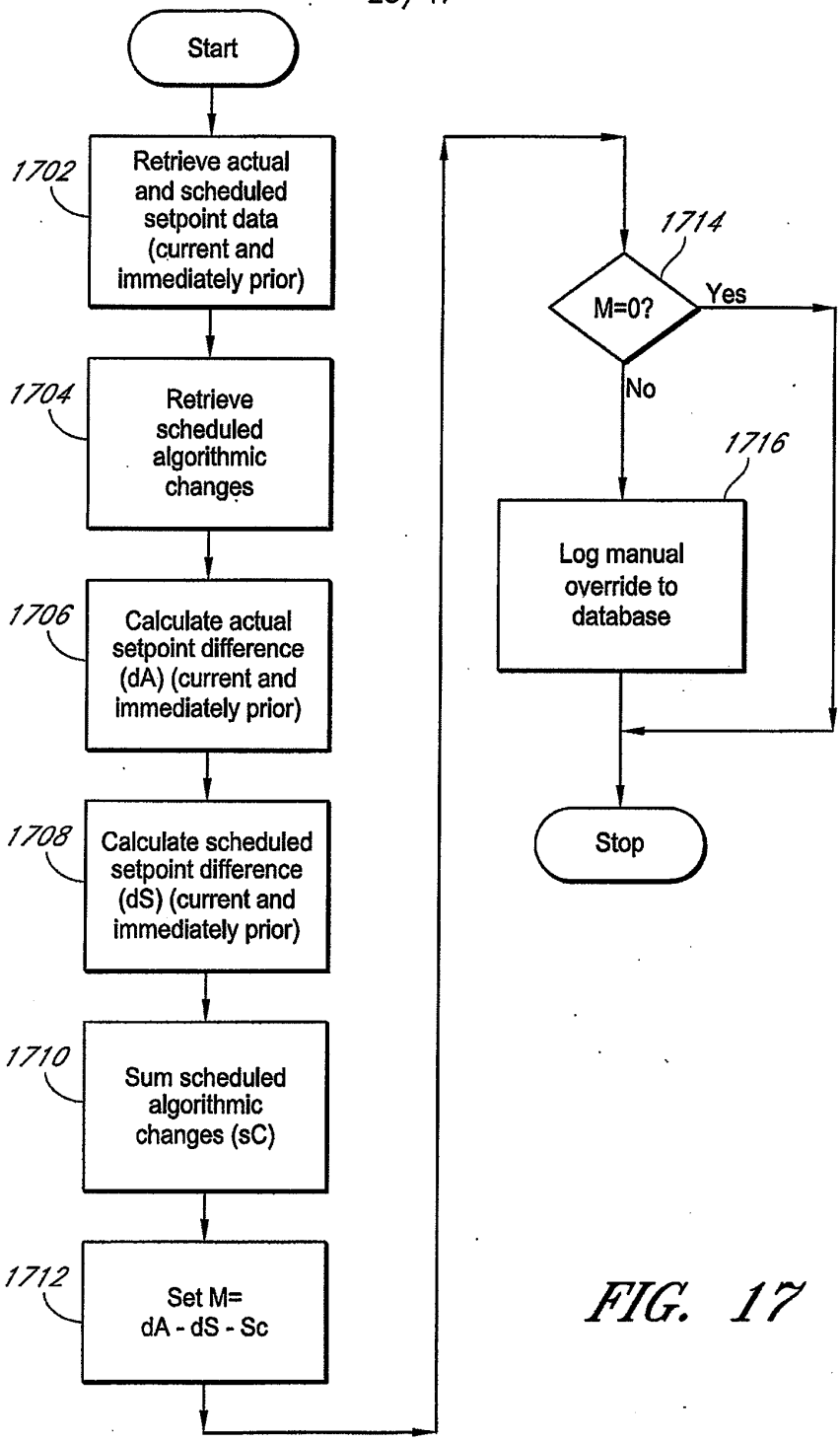

Start
1702
Retrieve actual and scheduled setpoint data (current and immediately prior)
1704
Retrieve scheduled algorithmic changes
1706
Calculate actual setpoint difference (dA) (current and immediately prior)
1708
Calculate scheduled setpoint difference (dS) (current and immediately prior)
1710
Sum scheduled algorithmic changes (sC)
1712
Set M= dA - dS - Sc
1714
M=0?
Yes
No
1716
Log manual override to database
Stop

FIG. 17

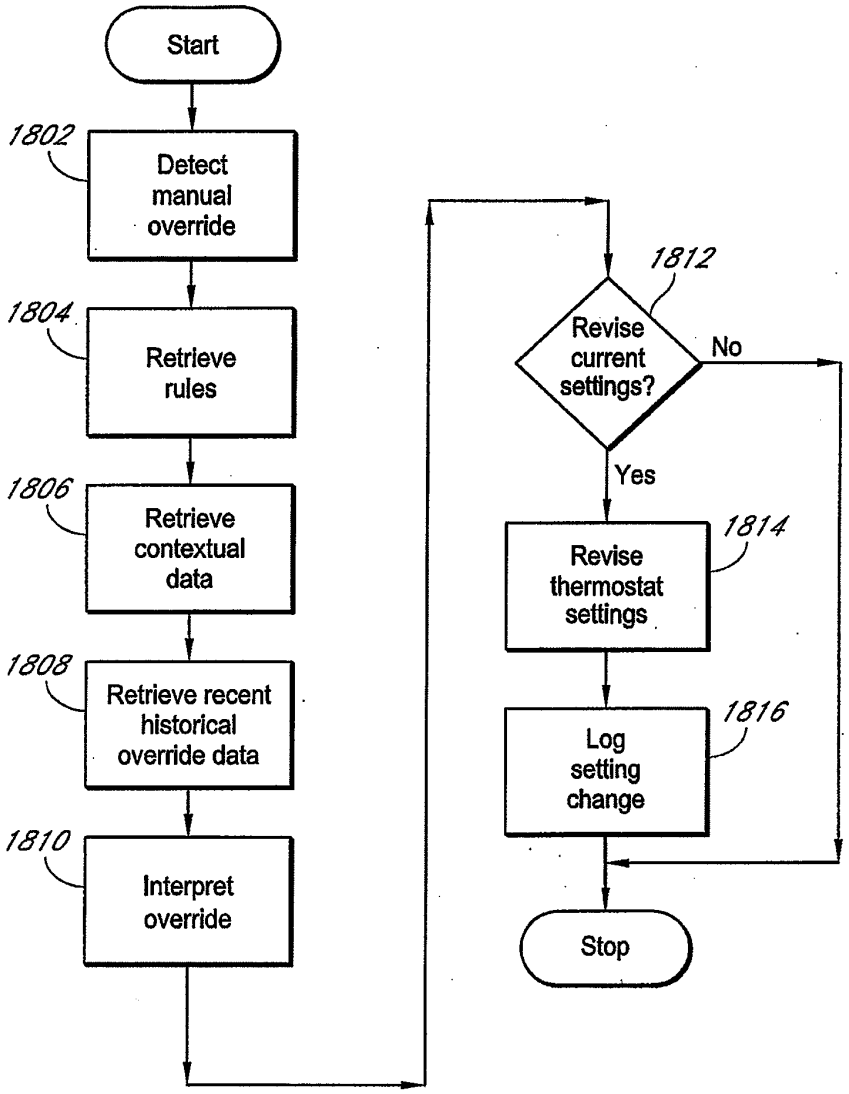

Start
1802
Detect manual override
1804
Retrieve rules
1806
Retrieve contextual data
1808
Retrieve recent historical override data
1810
Interpret override
1812
Revise current settings?
No
Yes
1814
Revise thermostat settings
1816
Log setting change
Stop

FIG. 18

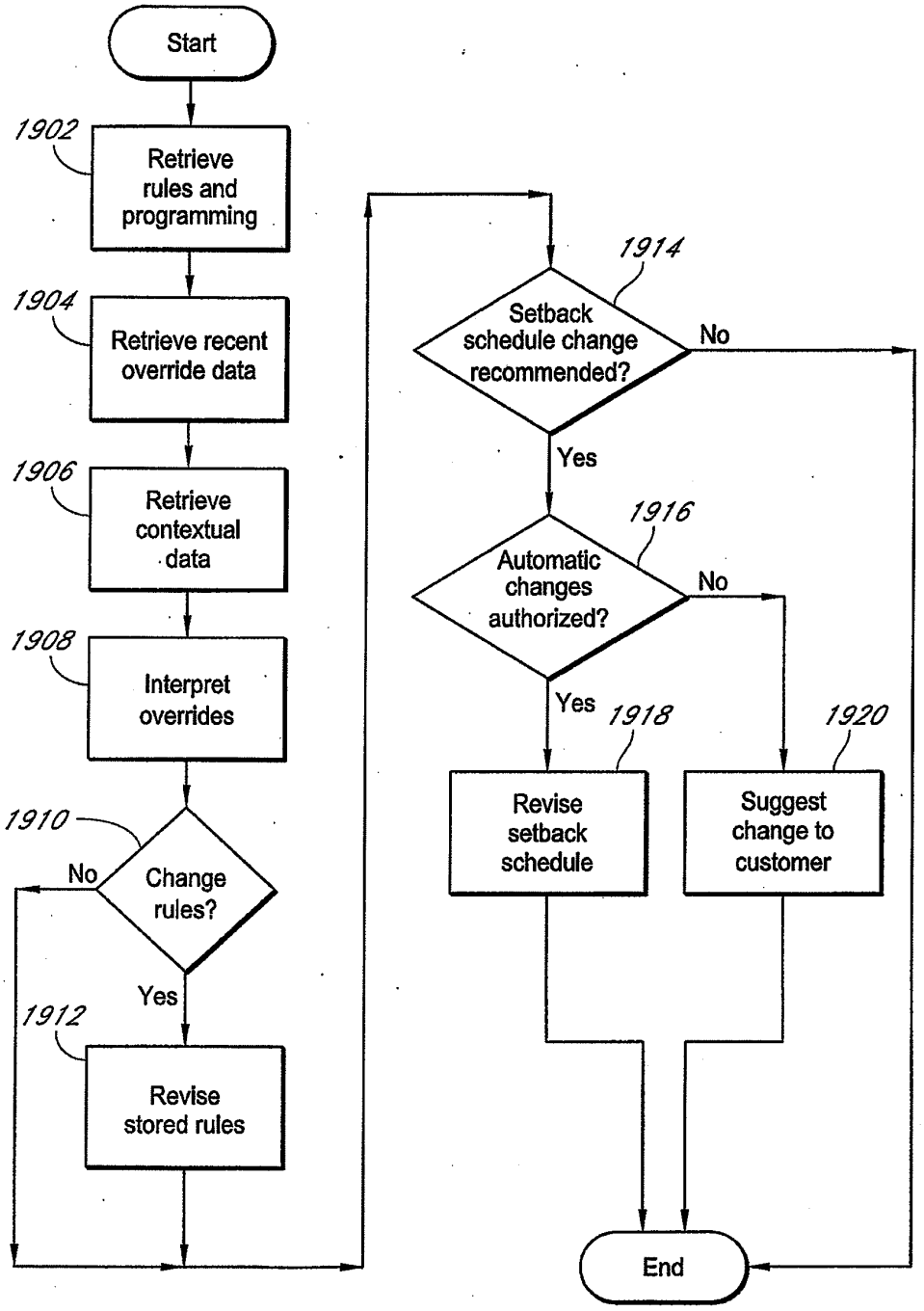

Start
1902
Retrieve rules and programming
1904
Retrieve recent override data
1906
Retrieve contextual data
1908
Interpret overrides
1910
Change rules?
No
Yes
1912
Revise stored rules
1914
Setback schedule change recommended?
No
Yes
1916
Automatic changes authorized?
No
Yes
1918
Revise setback schedule
1920
Suggest change to customer
End

FIG. 19

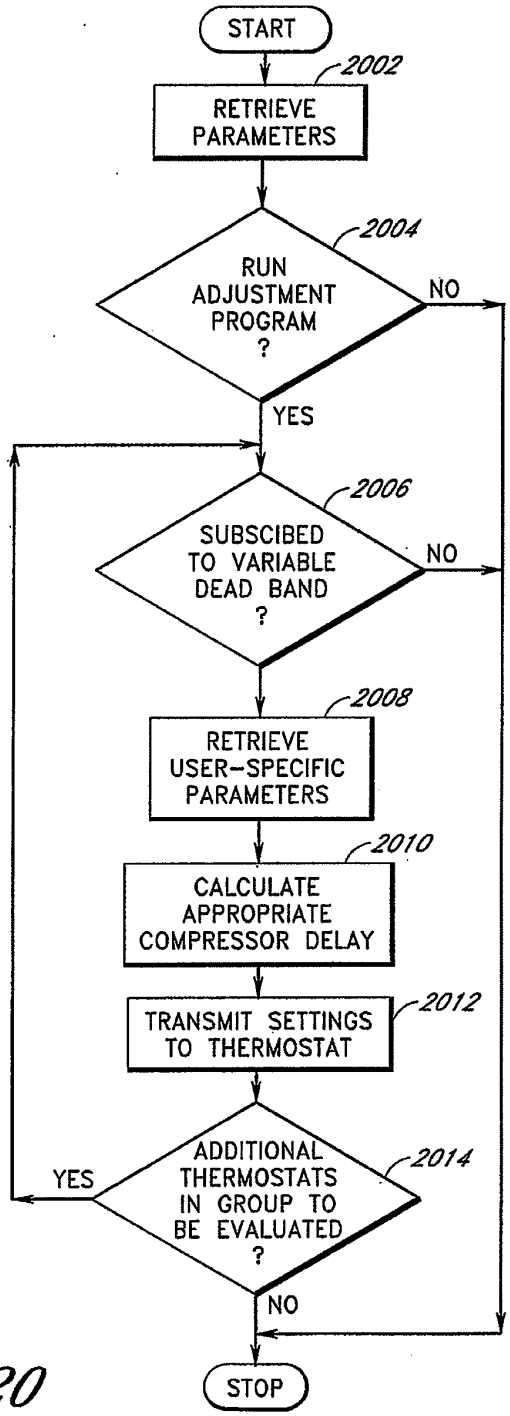

START
2002
RETRIEVE PARAMETERS
2004
RUN ADJUSTMENT PROGRAM ?
NO
YES
2006
SUBSCIBED TO VARIABLE DEAD BAND ?
NO
2008
RETRIEVE USER-SPECIFIC PARAMETERS
2010
CALCULATE APPROPRIATE COMPRESSOR DELAY
2012
TRANSMIT SETTINGS TO THERMOSTAT
2014
ADDITIONAL THERMOSTATS IN GROUP TO BE EVALUATED ?
YES
NO
STOP

FIG. 20

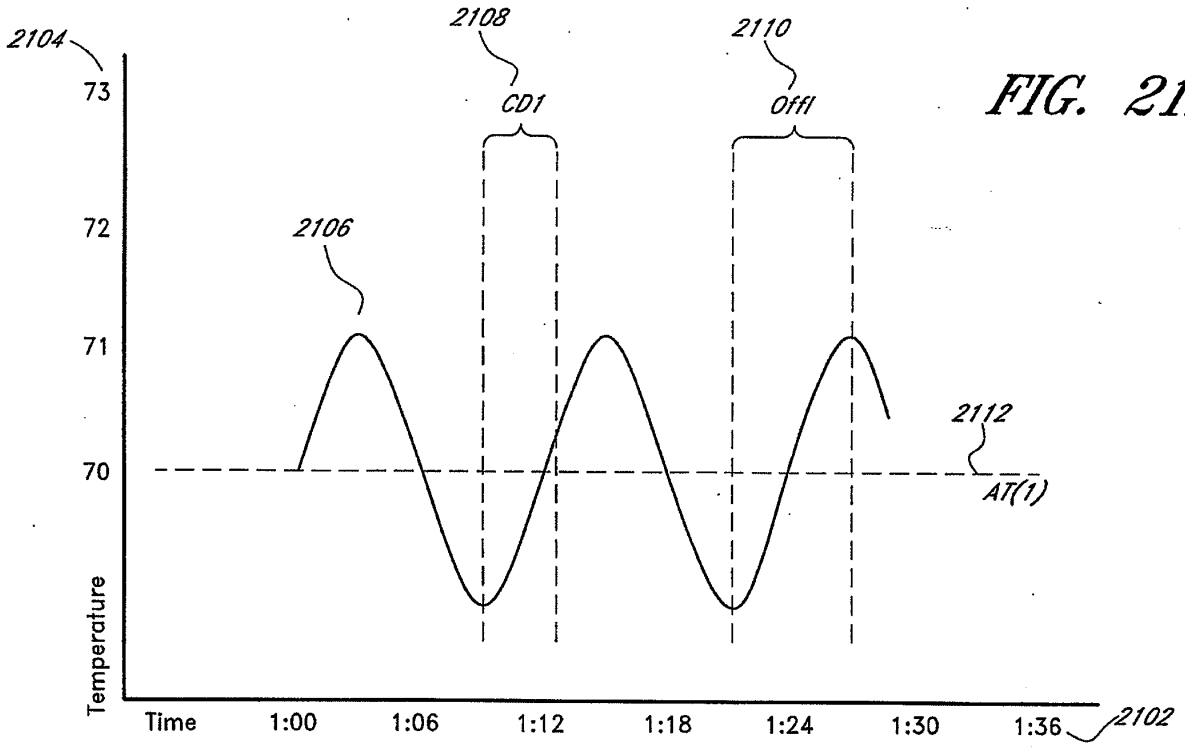

2104
2108
2110
CD1
Off1
73
72
71
70
2106
2112
AT(1)
Temperature
Time
1:00
1:06
1:12
1:18
1:24
1:30
1:36
2102

FIG. 21A

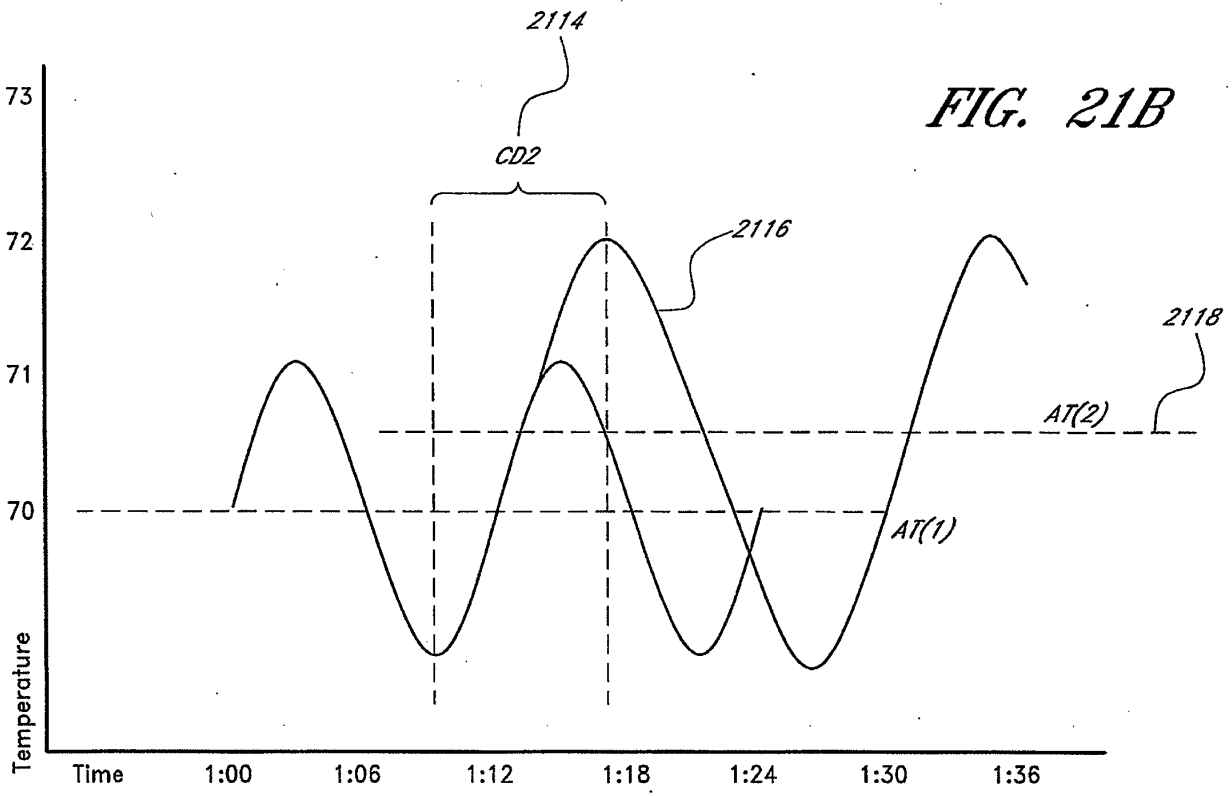

2114
CD2
2116
2118
AT(2)
AT(1)
73
72
71
70
Temperature
Time
1:00
1:06
1:12
1:18
1:24
1:30
1:36

FIG. 21B

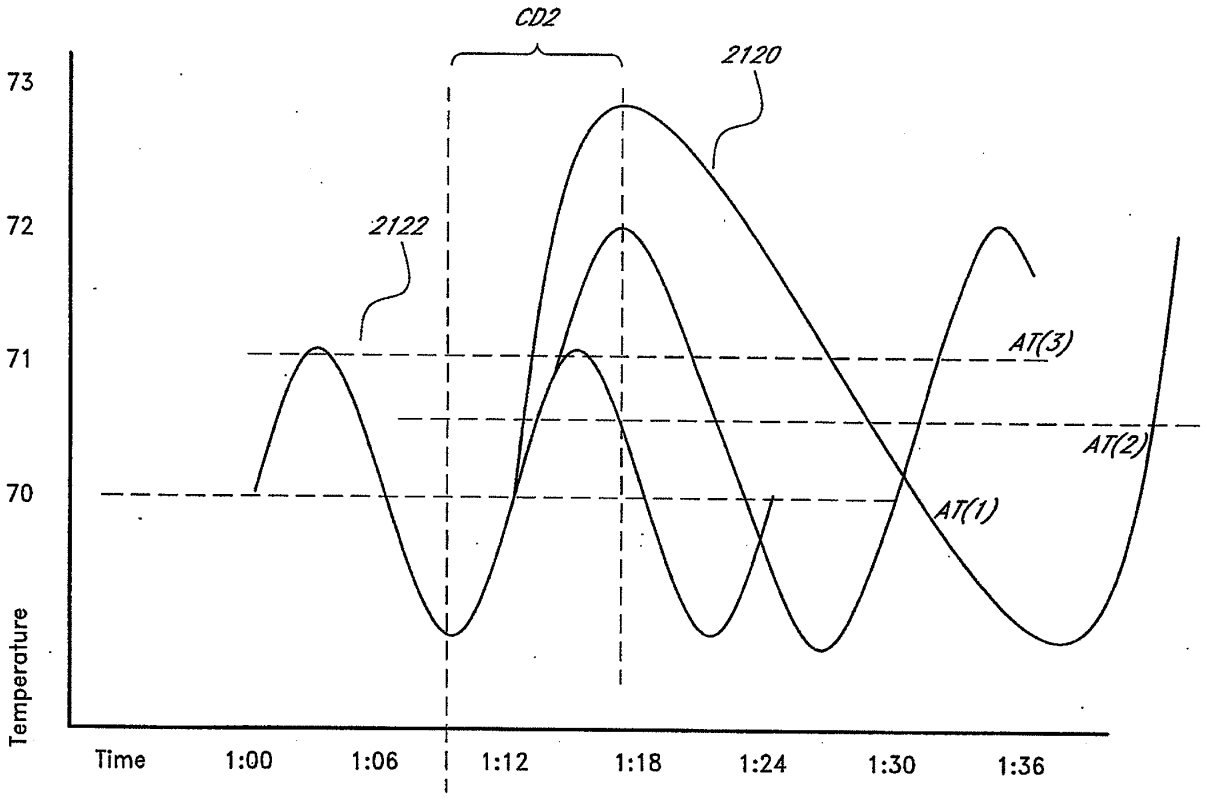


FIG. 21C

Ex. 1006.0093

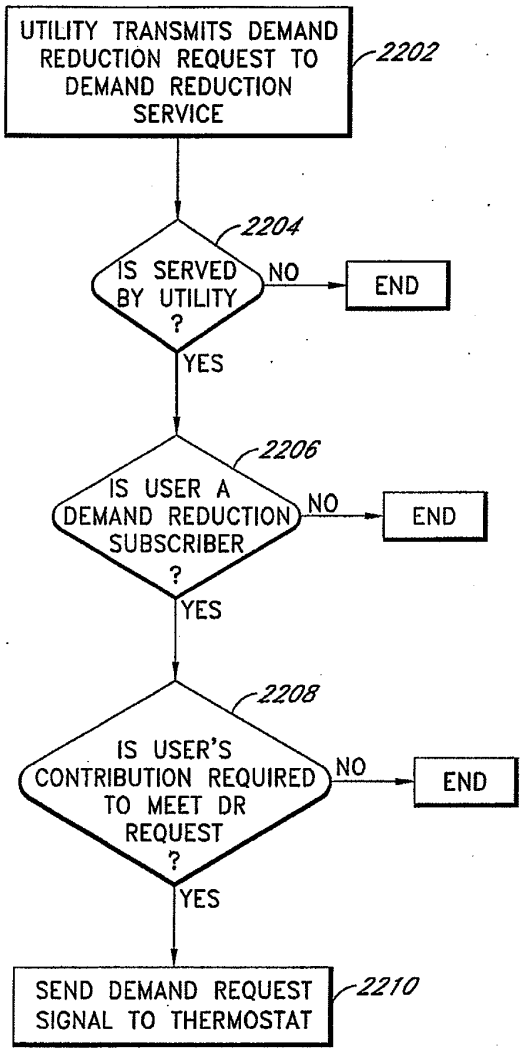

UTILITY TRANSMITS DEMAND REDUCTION REQUEST TO DEMAND REDUCTION SERVICE
2202
2204
IS SERVED BY UTILITY ?
NO
END
YES
2206
IS USER A DEMAND REDUCTION SUBSCRIBER ?
NO
END
YES
2208
IS USER'S CONTRIBUTION REQUIRED TO MEET DR REQUEST ?
NO
END
YES
SEND DEMAND REQUEST SIGNAL TO THERMOSTAT
2210

FIG. 22

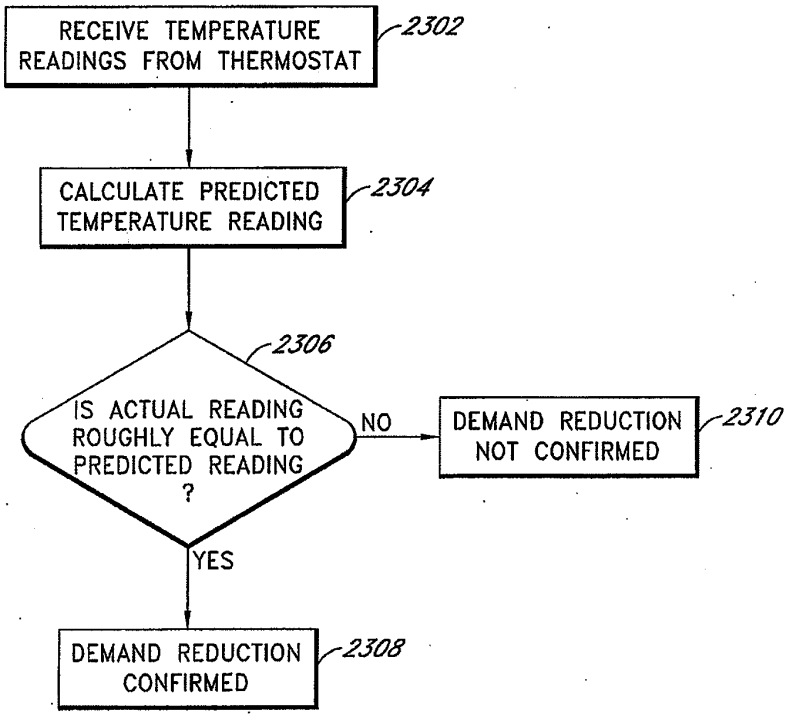

RECEIVE TEMPERATURE READINGS FROM THERMOSTAT
2302
CALCULATE PREDICTED TEMPERATURE READING
2304
2306
IS ACTUAL READING ROUGHLY EQUAL TO PREDICTED READING ?
NO
DEMAND REDUCTION NOT CONFIRMED
2310
YES
DEMAND REDUCTION CONFIRMED
2308

FIG. 23

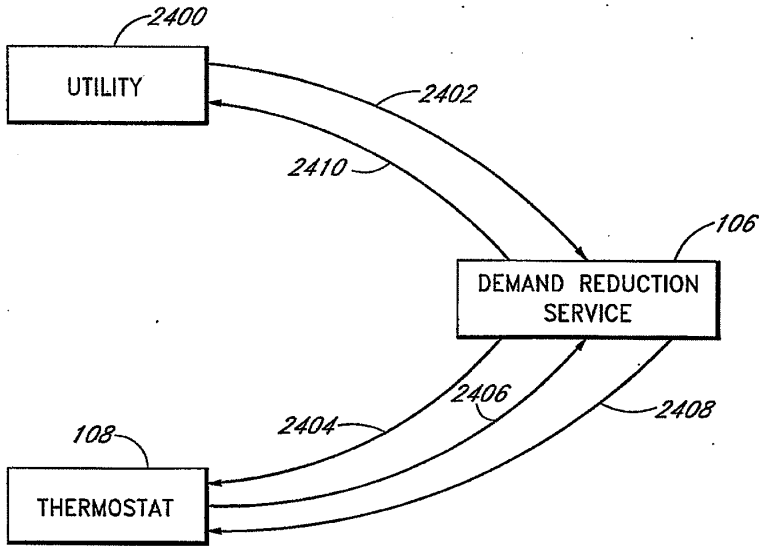

2400
UTILITY
2402
2410
106
DEMAND REDUCTION SERVICE
2406
2404
2408
108
THERMOSTAT

FIG. 24

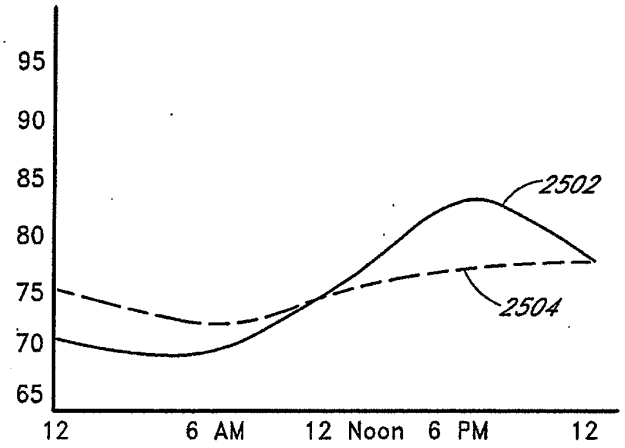


FIG. 25A

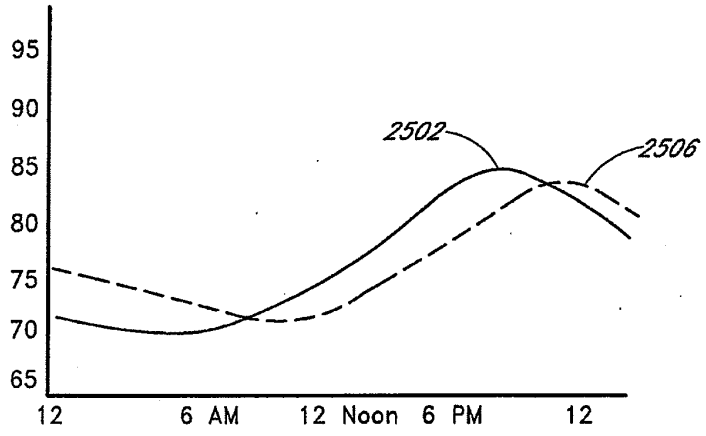


FIG. 25B

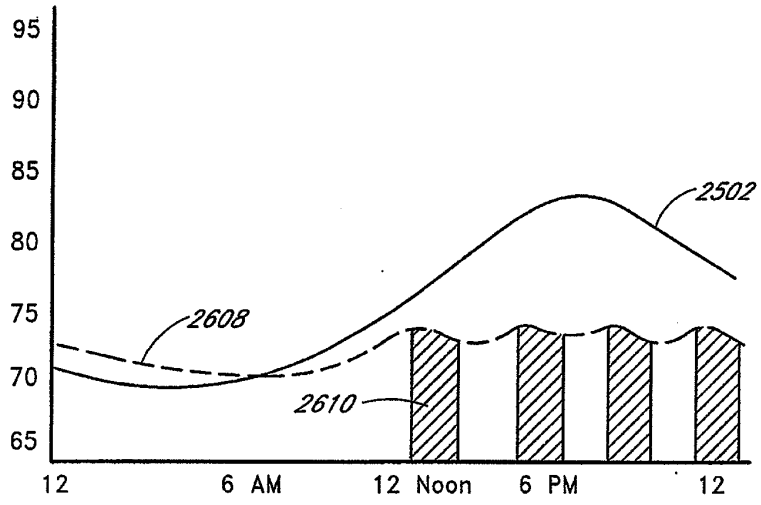


FIG. 26A

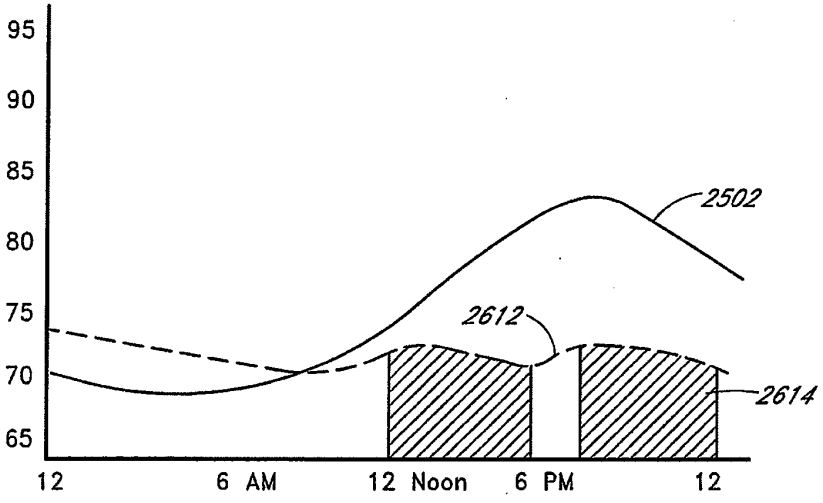


FIG. 26B

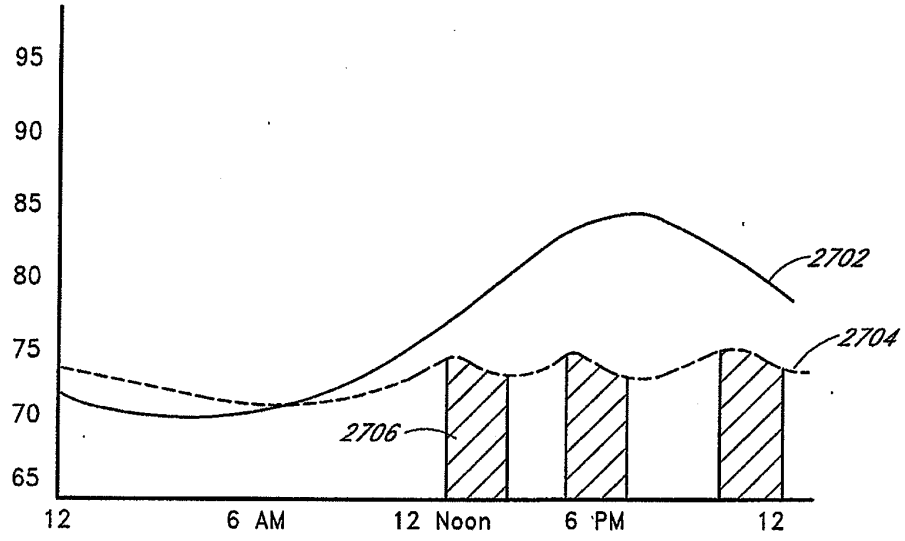


FIG. 27A

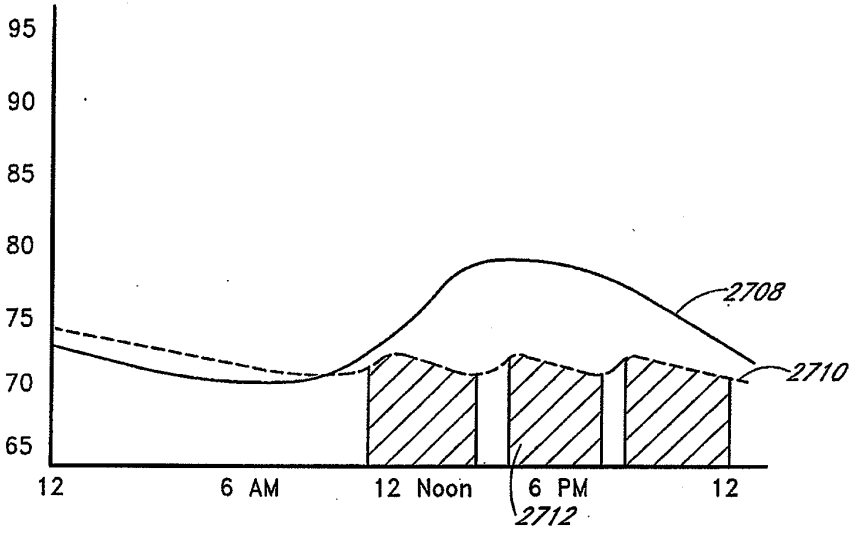


FIG. 27B

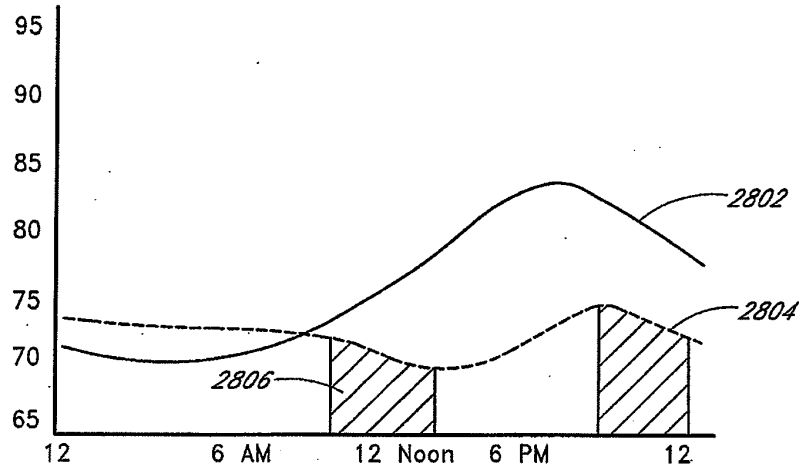


FIG. 28A

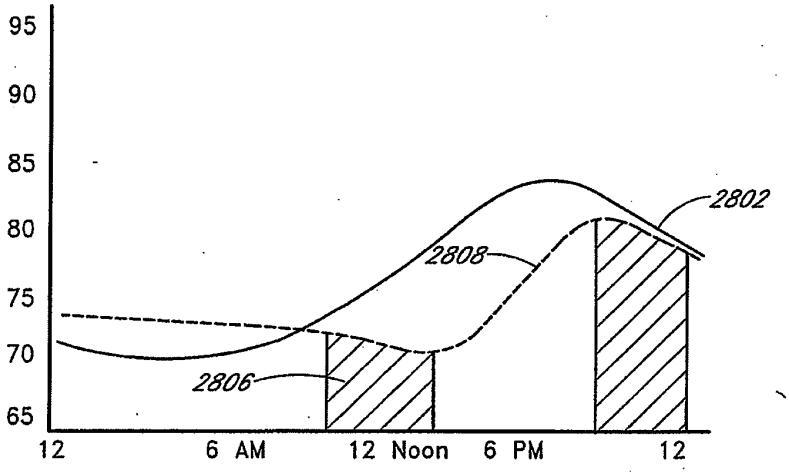


FIG. 28B

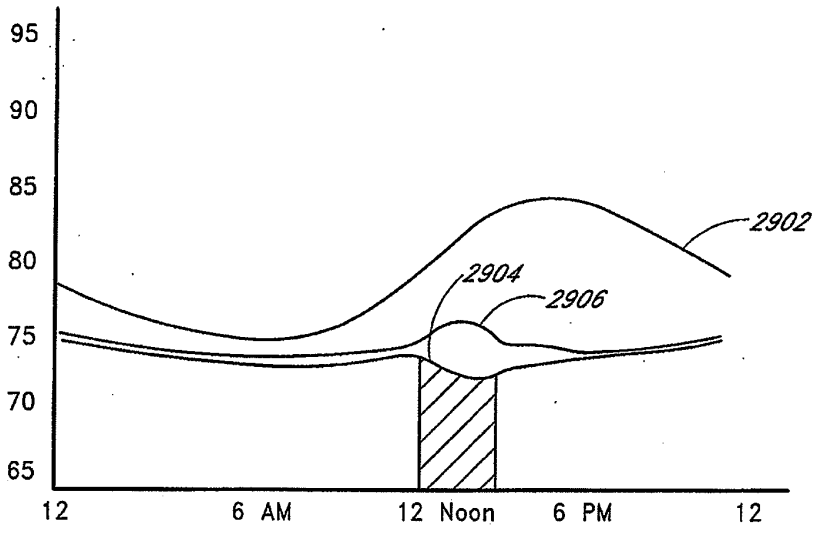


FIG. 29A

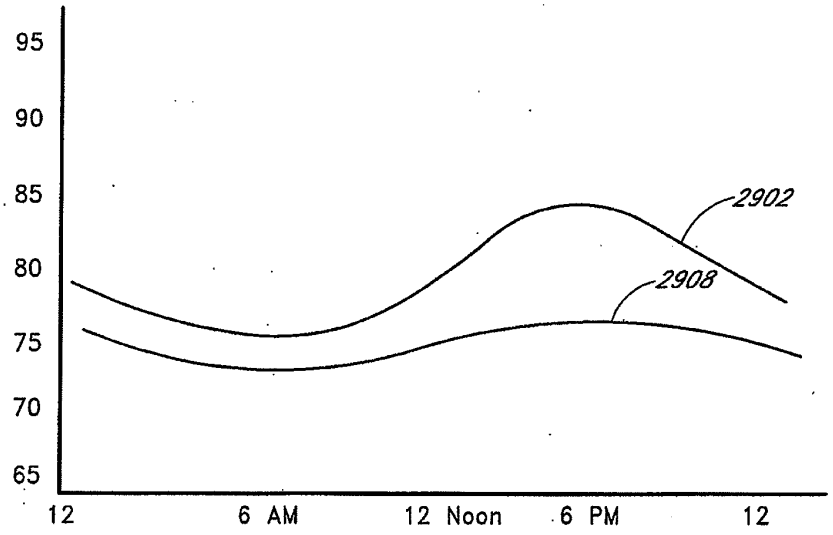


FIG. 29B

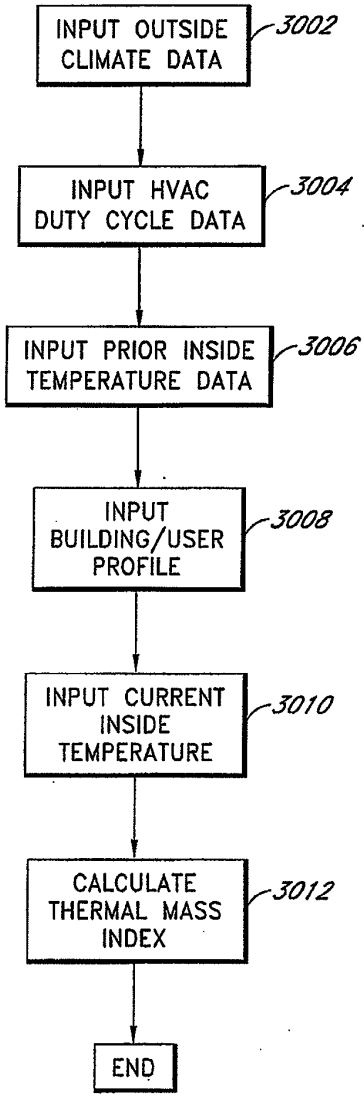

INPUT OUTSIDE CLIMATE DATA
3002
INPUT HVAC DUTY CYCLE DATA
3004
INPUT PRIOR INSIDE TEMPERATURE DATA
3006
INPUT BUILDING/USER PROFILE
3008
INPUT CURRENT INSIDE TEMPERATURE
3010
CALCULATE THERMAL MASS INDEX
3012
END

FIG. 30

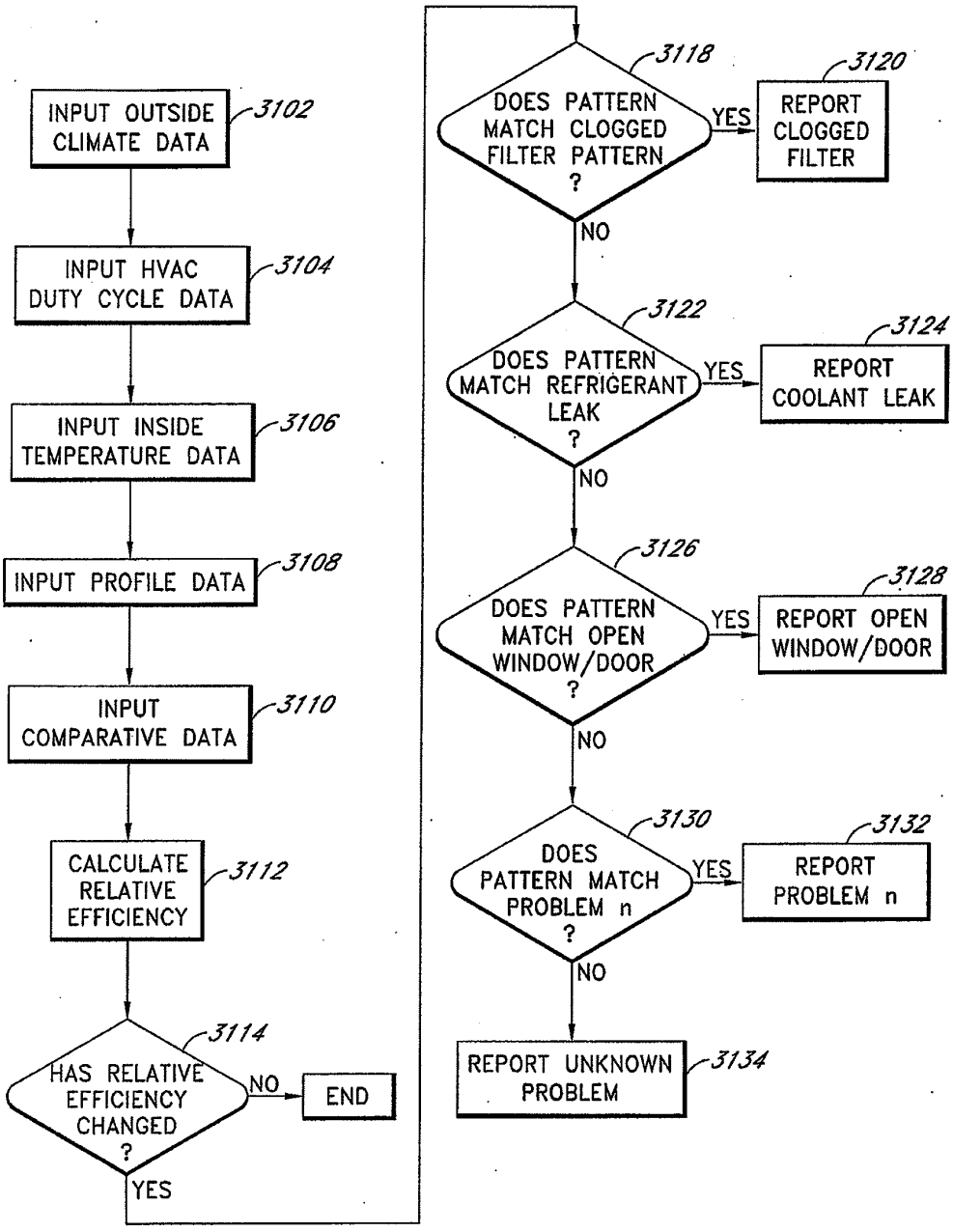

INPUT OUTSIDE CLIMATE DATA
3102
INPUT HVAC DUTY CYCLE DATA
3104
INPUT INSIDE TEMPERATURE DATA
3106
INPUT PROFILE DATA
3108
INPUT COMPARATIVE DATA
3110
CALCULATE RELATIVE EFFICIENCY
3112
HAS RELATIVE EFFICIENCY CHANGED ?
3114
NO
END
YES
DOES PATTERN MATCH CLOGGED FILTER PATTERN ?
3118
YES
REPORT CLOGGED FILTER
3120
NO
DOES PATTERN MATCH REFRIGERANT LEAK ?
3122
YES
REPORT COOLANT LEAK
3124
NO
DOES PATTERN MATCH OPEN WINDOW/DOOR ?
3126
YES
REPORT OPEN WINDOW/DOOR
3128
NO
DOES PATTERN MATCH PROBLEM n ?
3130
YES
REPORT PROBLEM n
3132
NO
REPORT UNKNOWN PROBLEM
3134

FIG. 31

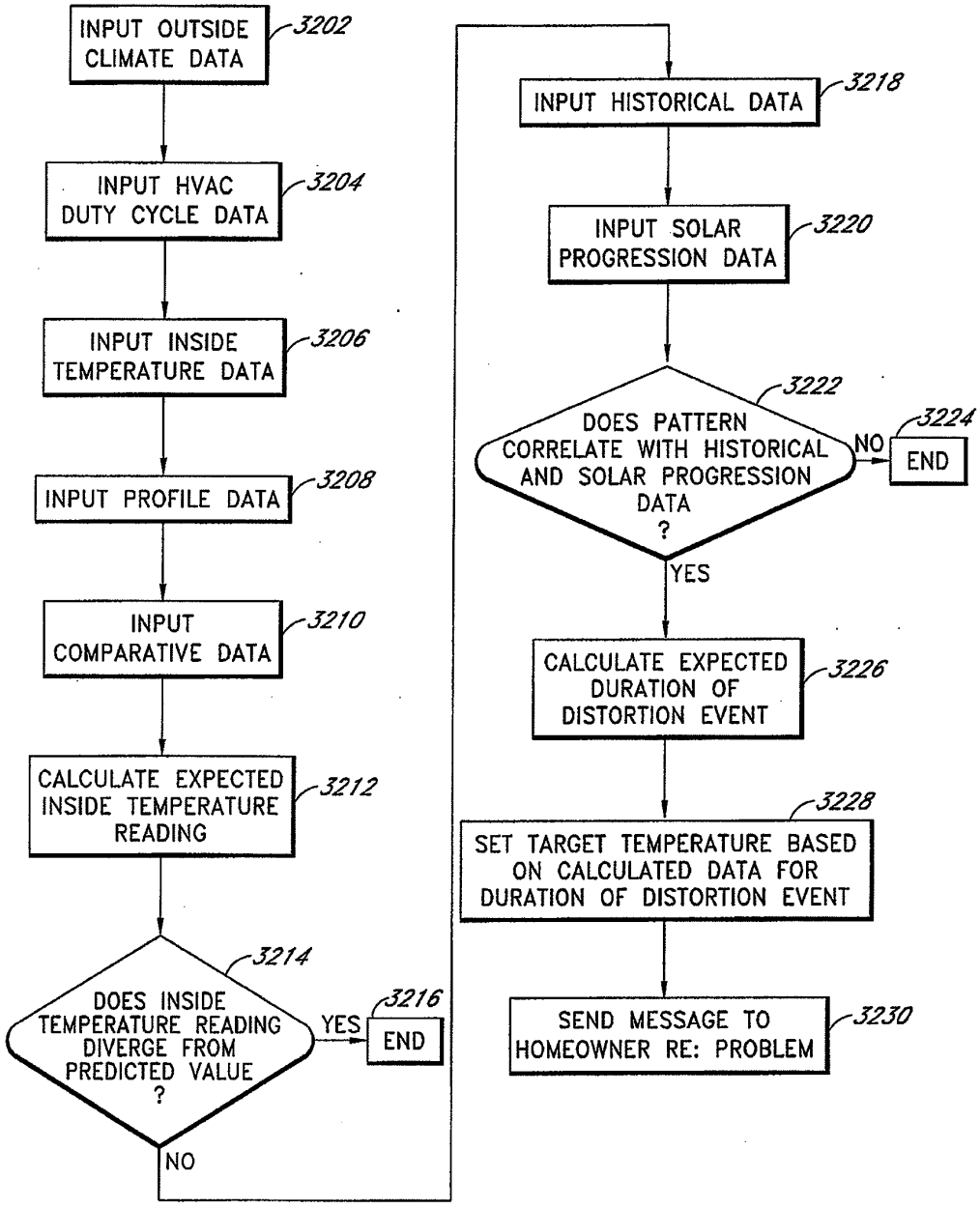

INPUT OUTSIDE CLIMATE DATA
3202
INPUT HVAC DUTY CYCLE DATA
3204
INPUT INSIDE TEMPERATURE DATA
3206
INPUT PROFILE DATA
3208
INPUT COMPARATIVE DATA
3210
CALCULATE EXPECTED INSIDE TEMPERATURE READING
3212
DOES INSIDE TEMPERATURE READING DIVERGE FROM PREDICTED VALUE ?
3214
YES
3216
END
NO
INPUT HISTORICAL DATA
3218
INPUT SOLAR PROGRESSION DATA
3220
DOES PATTERN CORRELATE WITH HISTORICAL AND SOLAR PROGRESSION DATA ?
3222
NO
3224
END
YES
CALCULATE EXPECTED DURATION OF DISTORTION EVENT
3226
SET TARGET TEMPERATURE BASED ON CALCULATED DATA FOR DURATION OF DISTORTION EVENT
3228
SEND MESSAGE TO HOMEOWNER RE: PROBLEM
3230

FIG. 32

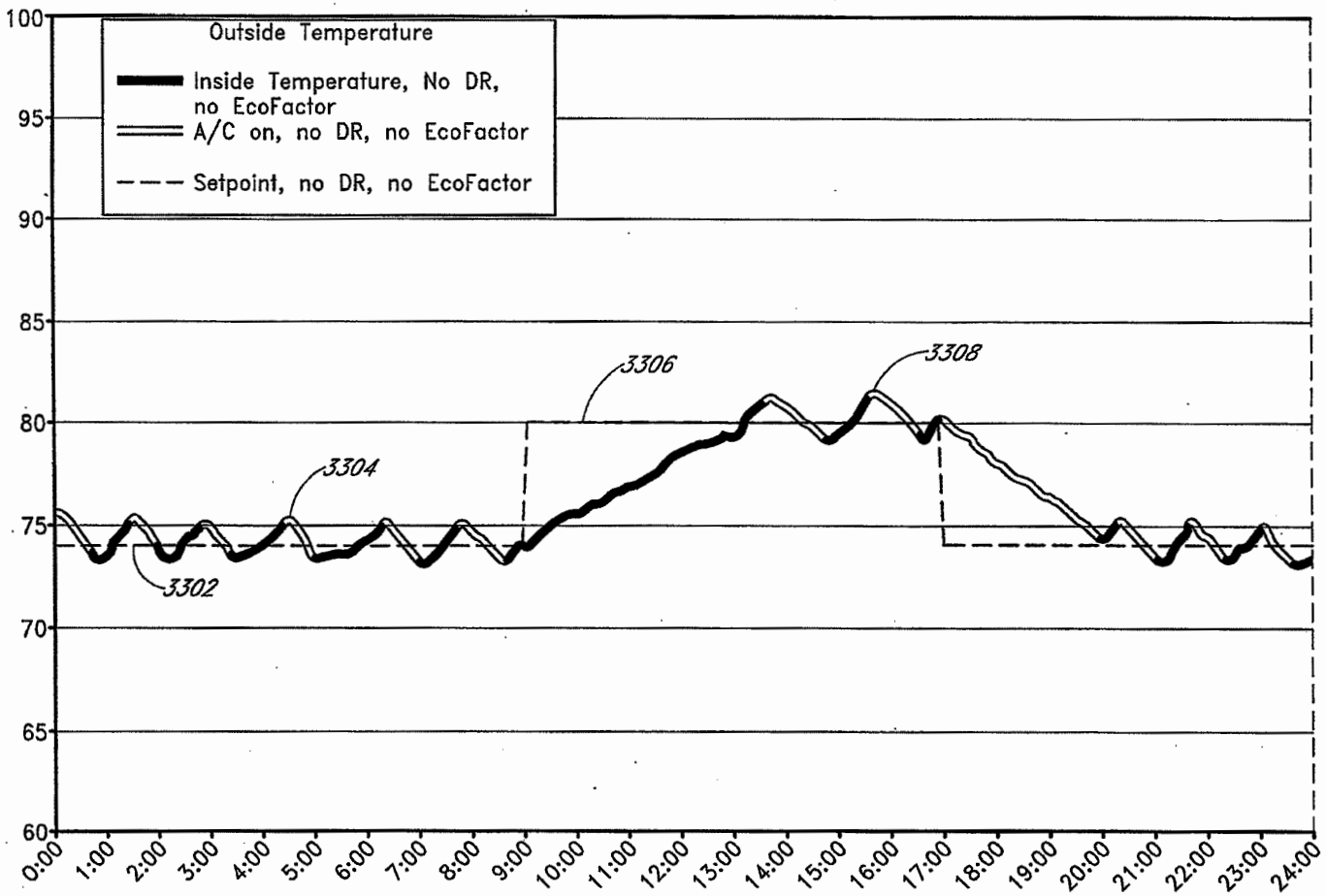

Outside Temperature
Inside Temperature, No DR, no EcoFactor
A/C on, no DR, no EcoFactor
Setpoint, no DR, no EcoFactor
100
95
90
85
80
75
70
65
60
0:00
1:00
2:00
3:00
4:00
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
22:00
23:00
24:00
3302
3304
3306
3308

FIG. 33

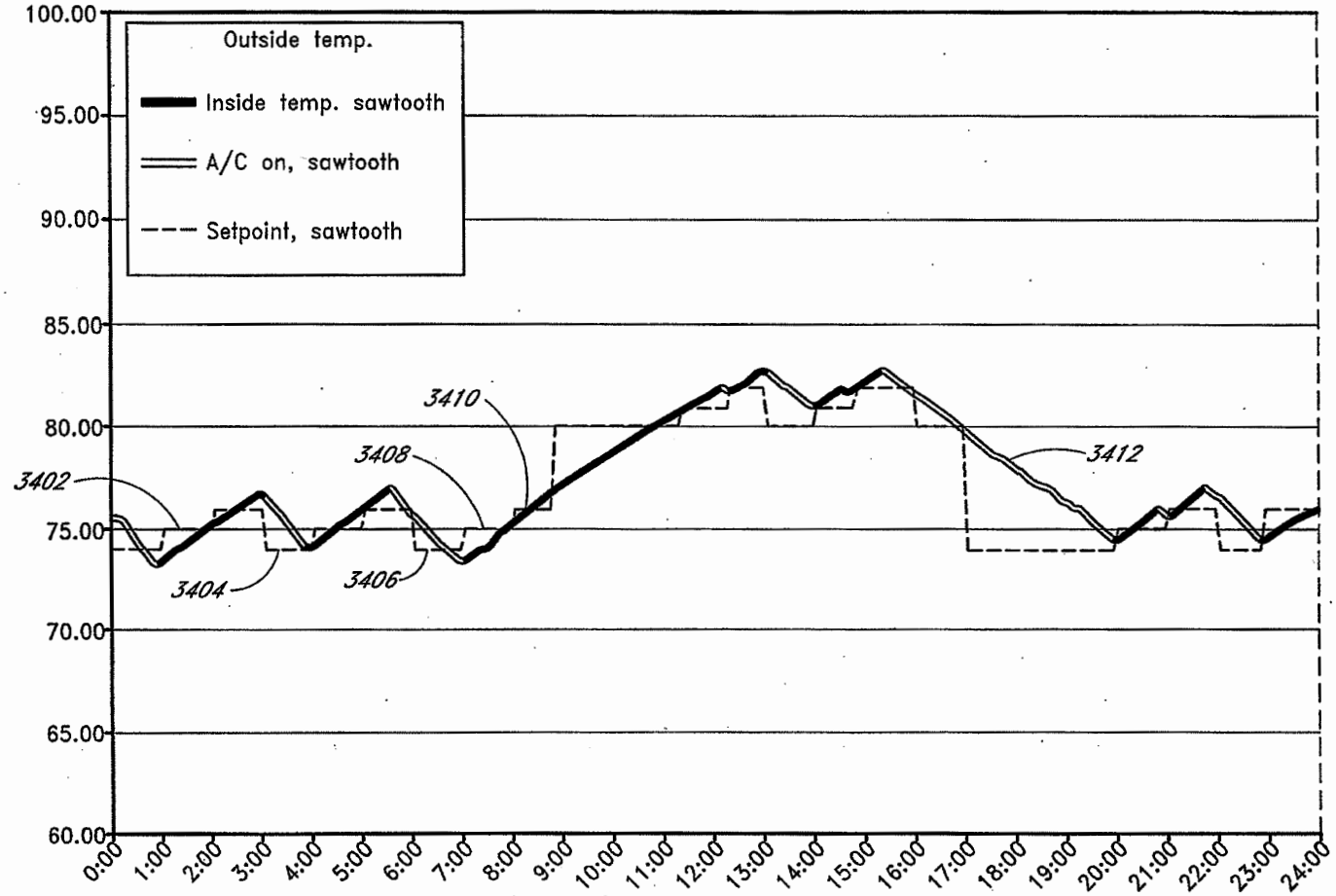


FIG. 34

Ex. 1006.0106

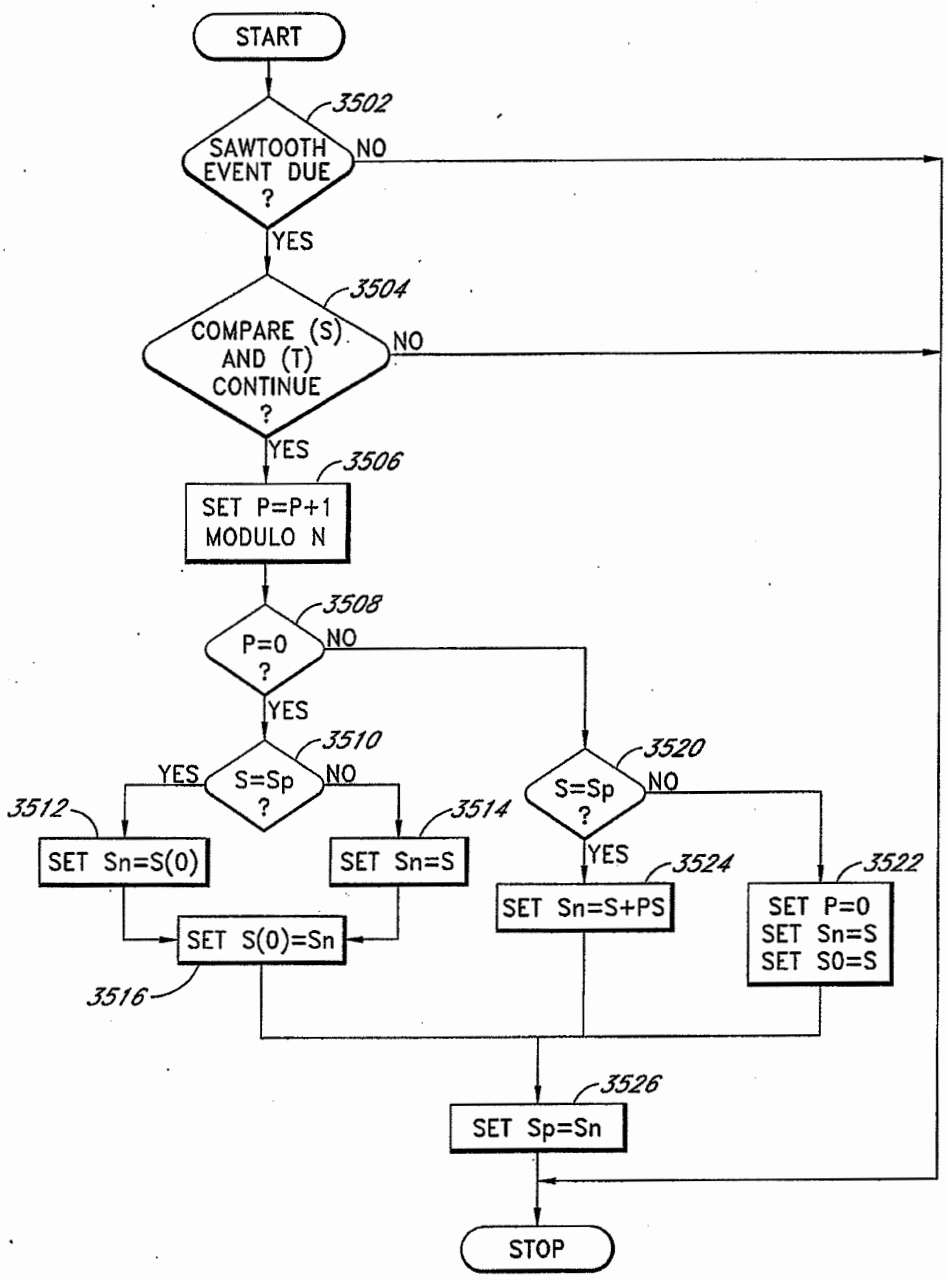

START
3502
SAWTOOTH EVENT DUE ?
NO
YES
3504
COMPARE (S) AND (T) CONTINUE ?
NO
YES
3506
SET P=P+1 MODULO N
3508
P=0 ?
NO
YES
3510
S=Sp ?
YES
NO
3512
SET Sn=S(0)
3514
SET Sn=S
3520
S=Sp ?
NO
YES
3524
SET Sn=S+PS
3522
SET P=0
SET Sn=S
SET S0=S
SET S(0)=Sn
3516
3526
SET Sp=Sn
STOP

FIG. 35

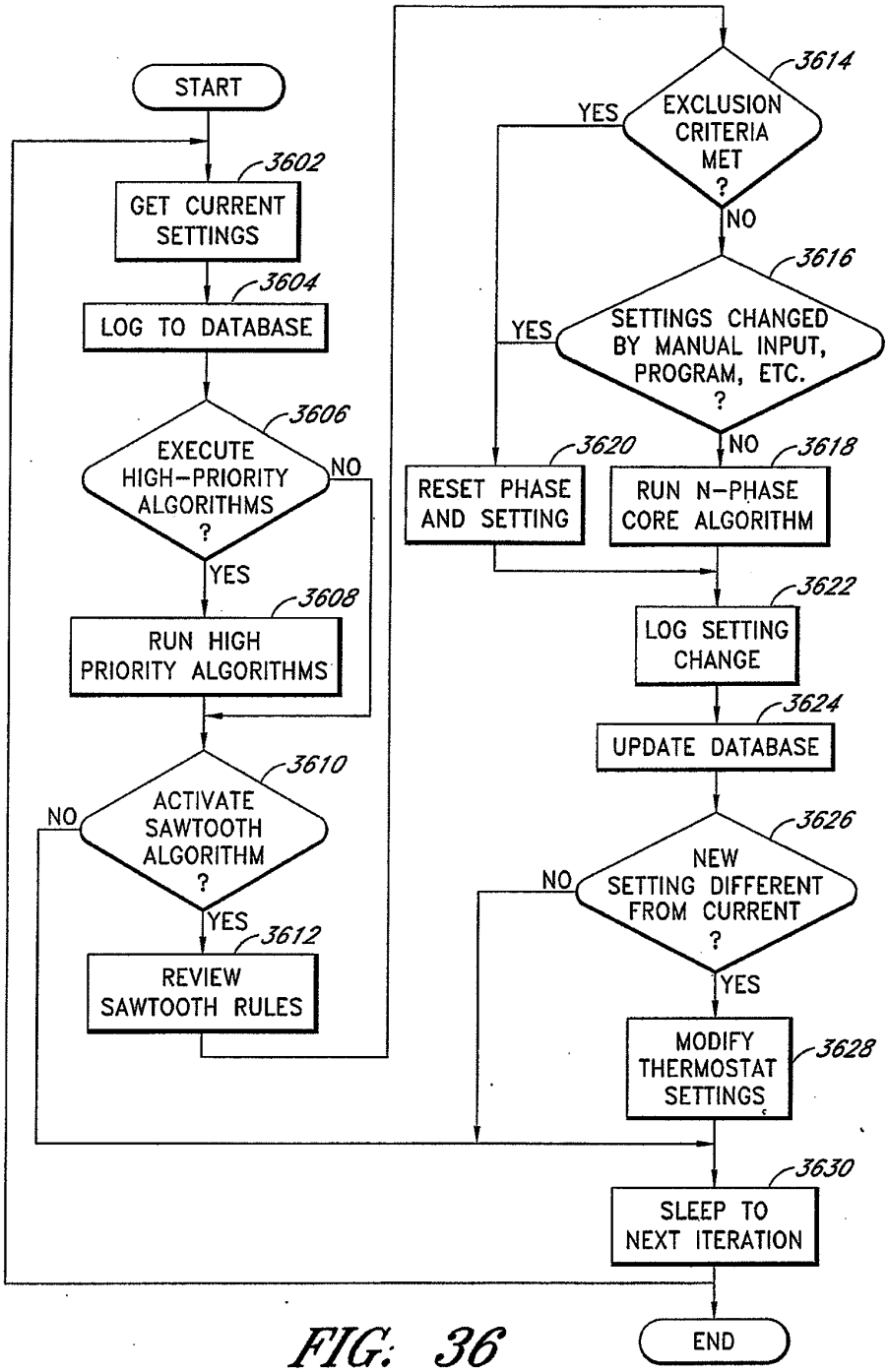

START
3602
GET CURRENT SETTINGS
3604
LOG TO DATABASE
3606
EXECUTE HIGH-PRIORITY ALGORITHMS ?
NO
YES
3608
RUN HIGH PRIORITY ALGORITHMS
3610
ACTIVATE SAWTOOTH ALGORITHM ?
NO
YES
3612
REVIEW SAWTOOTH RULES
3614
EXCLUSION CRITERIA MET ?
YES
NO
3616
SETTINGS CHANGED BY MANUAL INPUT, PROGRAM, ETC. ?
YES
NO
3620
RESET PHASE AND SETTING
3618
RUN N-PHASE CORE ALGORITHM
3622
LOG SETTING CHANGE
3624
UPDATE DATABASE
3626
NEW SETTING DIFFERENT FROM CURRENT ?
NO
YES
3628
MODIFY THERMOSTAT SETTINGS
3630
SLEEP TO NEXT ITERATION
END

FIG. 36

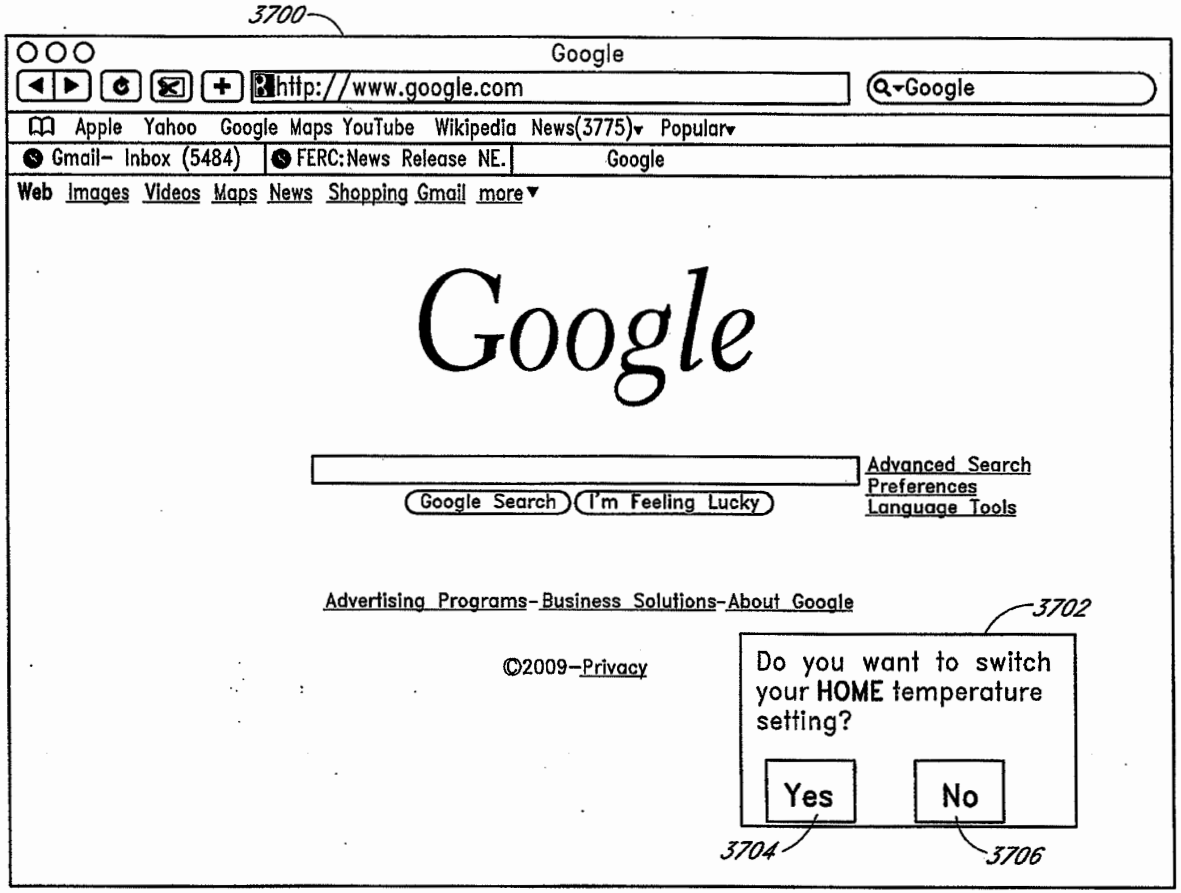

3700
Google
http://www.google.com
Google
Apple Yahoo Google Maps YouTube Wikipedia News(3775) Popular
Gmail- Inbox (5484)
FERC:News Release NE.
Google
Web Images Videos Maps News Shopping Gmail more
Google
Advanced Search
Preferences
Language Tools
Google Search
I'm Feeling Lucky
Advertising Programs-Business Solutions-About Google
©2009-Privacy
3702
Do you want to switch your HOME temperature setting?
Yes
No
3704
3706

FIG. 37

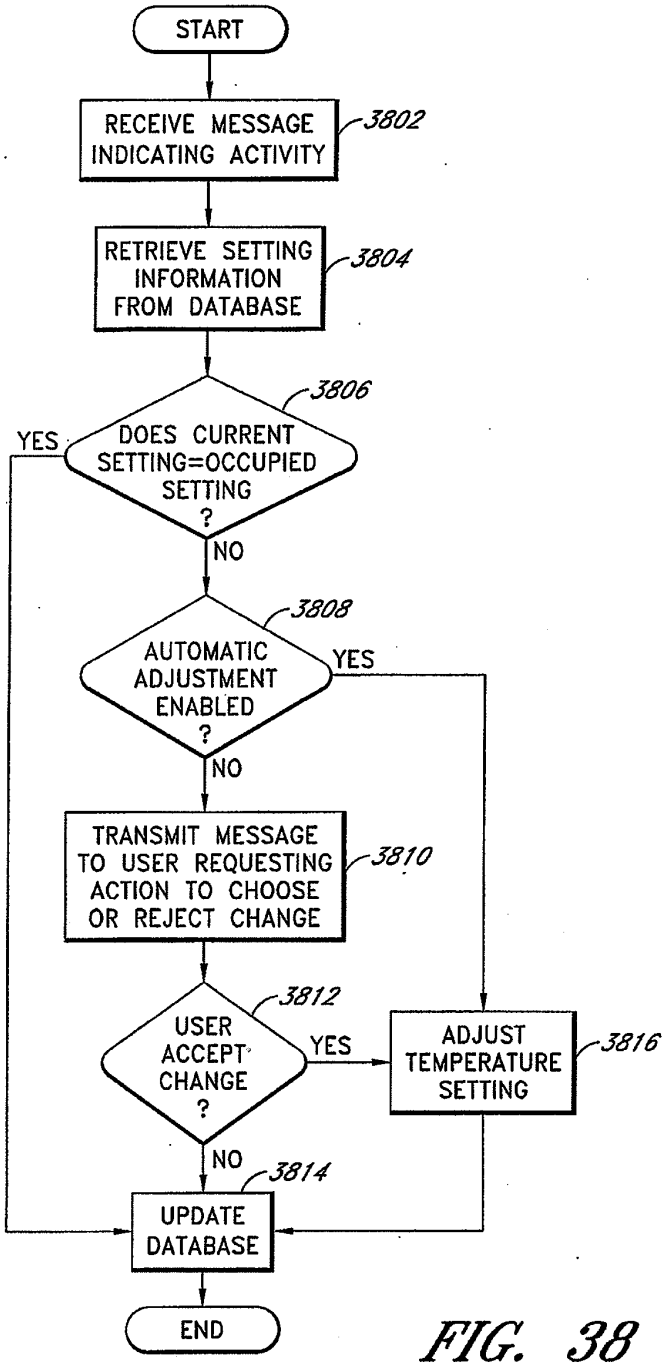

START
RECEIVE MESSAGE INDICATING ACTIVITY
3802
RETRIEVE SETTING INFORMATION FROM DATABASE
3804
3806
DOES CURRENT SETTING=OCCUPIED SETTING ?
YES
NO
3808
AUTOMATIC ADJUSTMENT ENABLED ?
YES
NO
TRANSMIT MESSAGE TO USER REQUESTING ACTION TO CHOOSE OR REJECT CHANGE
3810
3812
USER ACCEPT CHANGE ?
YES
NO
ADJUST TEMPERATURE SETTING
3816
3814
UPDATE DATABASE
END

FIG. 38

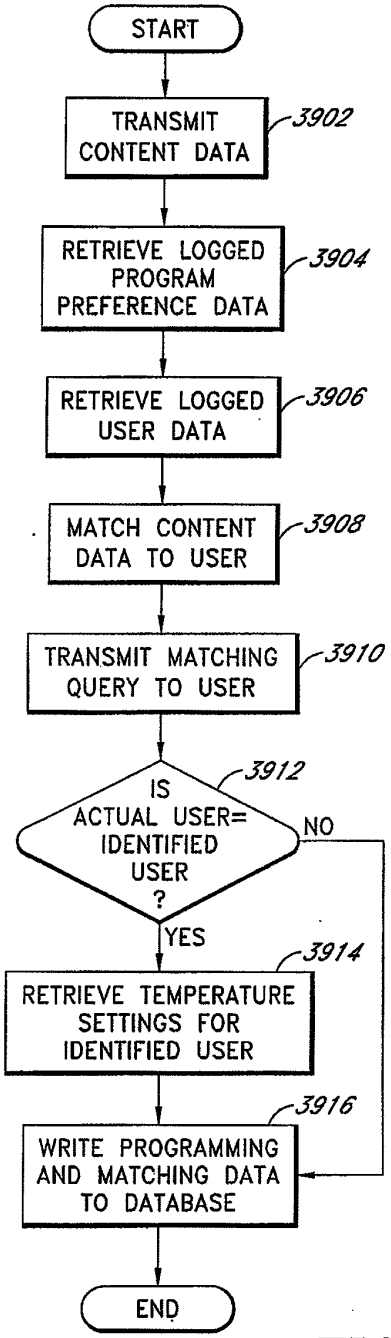

START
TRANSMIT CONTENT DATA
3902
RETRIEVE LOGGED PROGRAM PREFERENCE DATA
3904
RETRIEVE LOGGED USER DATA
3906
MATCH CONTENT DATA TO USER
3908
TRANSMIT MATCHING QUERY TO USER
3910
IS ACTUAL USER= IDENTIFIED USER ?
3912
NO
YES
RETRIEVE TEMPERATURE SETTINGS FOR IDENTIFIED USER
3914
WRITE PROGRAMMING AND MATCHING DATA TO DATABASE
3916
END

FIG. 39

PTO/AIA/01 (06-12)
Approved for use through 01/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)

Title of Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

As the below named inventor, I hereby declare that:

This declaration is directed to:

☐ The attached application, or

☒ United States application or PCT international application number 14/048932 filed on October 8, 2013.

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

WARNING:

Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: John Douglas Steinberg Date (Optional): 11/5/13

Signature: _____

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Electronic Acknowledgement Receipt

EFS ID:	20190998
Application Number:	14491554
International Application Number:	
Confirmation Number:	1254
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Customer Number:	20995
Filer:	John R. King/Tony Do
Filer Authorized By:	John R. King
Attorney Docket Number:	EFACT.012C2
Receipt Date:	19-SEP-2014
Filing Date:	
Time Stamp:	16:58:17
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	no

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Application Data Sheet	EFACT-012C2_ADS.pdf	1505410 389409b01407e50b32f28aed765e32e648e e0a29	no	6

Warnings:	
Information:	

2		EFACT-012C2_specification.pdf	3126019 f33b0ede94434f1541dc87319392601ed3fc6508	yes	54

Multipart Description/PDF files in .zip description		
Document Description	**Start**	**End**
Specification	1	52
Claims	53	53
Abstract	54	54

Warnings:

Information:

3	Drawings-only black and white line drawings	EFACT-012C2_drawings.pdf	901369 46119ce963d6ef574416adbdc0066e13b01baa44	no	47

Warnings:

Information:

4	Oath or Declaration filed	EFACT-012C2_declaration.pdf	82115 b73b0c9f0148949379ab77b27f00e1a909f1c569	no	1

Warnings:

Information:

Total Files Size (in bytes):	5614913

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

<u>New Applications Under 35 U.S.C. 111</u>
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

<u>National Stage of an International Application under 35 U.S.C. 371</u>
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

<u>New International Application Filed with the USPTO as a Receiving Office</u>
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/491,554

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	70		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	300		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	1 minus 20 =	*	x 40 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	1 minus 3 =	*	x 210 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	730		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2

CONFIRMATION NO. 1254

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

FORMALITIES LETTER

OC000000070973219

Date Mailed: 09/26/2014

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

Items Required To Avoid Abandonment:

An application number and filing date have been accorded to this application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee is missing.
- The application search fee must be submitted.
- The application examination fee must be submitted.

The application is informal since it does not comply with the regulations for the reason(s) indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125, is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). The specification, claims, and/or abstract page(s) submitted is not acceptable and cannot be scanned or properly stored because:
  - The application contains drawings, but the specification does not contain a brief description of the several views of the drawings as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9).

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

- Surcharge as set forth in 37 CFR 1.16(f) must be submitted.
  The surcharge is due for any one of:
  - late submission of the basic filing fee, search fee, or examination fee,
  - late submission of inventor's oath or declaration,
  - filing an application that does not contain at least one claim on filing, or
  - submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required within **TWO MONTHS** from the date of this Notice to avoid abandonment is/are itemized below. Small entity discount is in effect. If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- $ **70** basic filing fee.
- $ **70** surcharge.
- $ **300** search fee.
- $ **360** examination fee.
- $(**0**) previous unapplied payment amount.
- $ **800** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

/makanno/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/491,554	09/19/2014	3744	0.00	EFACT.012C2	1	1

CONFIRMATION NO. 1254

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

FILING RECEIPT

OC000000070973218

Date Mailed: 09/26/2014

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

John Douglas Steinberg, Millbrae, CA;

Applicant(s)

EcoFactor, Inc., Millbrae, CA

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 14/048,932 10/08/2013 PAT 8840033
which is a CON of 12/788,246 05/26/2010 PAT 8556188

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

If Required, Foreign Filing License Granted: 09/24/2014

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/491,554**

Projected Publication Date: To Be Determined - pending completion of Missing Parts

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****

Title

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Preliminary Class

236

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

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The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor	:	John Douglas Steinberg
App. No.	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Examiner	:	Unknown
Art Unit	:	3744
Conf. No.	:	1254

PRELIMINARY AMENDMENT

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Prior to examination of this application, Applicant respectfully submits the following amendments and comments.

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims which begins on page 3 of this paper.

Remarks/Arguments begin on page 6 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please enter the Substitute Specification submitted herewith into the application. Applicant has amended the Substitute Specification at paragraph 0039 to refer to Figures 16-1 and 16-2. Applicant submits that the Substitute Specification includes no new matter.

AMENDMENTS TO THE CLAIMS

Please cancel Claim 1 and add new Claims 2-21.

1. (Canceled)

2. (New) A method for adjusting at least one temperature setpoint of an HVAC system associated with a structure, the method comprising:

associating the at least one mobile electronic device with the structure;

receiving with one or more computer processors, the geographic location of the at least one mobile electronic device;

using traffic data to predict a length of time for a user of the at least one mobile electronic device to reach the structure; and

adjusting with one or more computer processors, at least one temperature setpoint of an HVAC system associated with the structure based upon the predicted length of time for a user of the mobile electronic device to reach the structure.

3. (New) The method of claim 2 further comprising using geospatial data associated with the mobile electronic device to increase the predicted length of time to reach the structure based on characteristics of a location the user has stopped at before reaching the structure.

4. (New) The method of claim 2 wherein the mobile electronic device is a telephone.

5. (New) The method of claim 2 wherein the mobile electronic device is connected to the Internet.

6. (New) The method of claim 2 wherein the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from the mobile electronic device.

7. (New) The method of claim 2 wherein the one or more processors comprise a remote server that is remotely located from the structure.

8. (New) The method of claim 2 wherein adjusting the at least one temperature setpoint is logged to a database.

9. (New) The method of claim in 2 wherein adjusting the at least one temperature setpoint is initiated by a remote computer.

10. (New) The method of claim 2 wherein adjusting the at least one temperature setpoint occurs automatically.

11. (New) The method of claim 2 wherein the user is prompted to confirm occupancy of the structure prior to adjustment of the at least one temperature setpoint.

12. (New) A system for adjusting at least one temperature setpoint of an HVAC system associated with a structure, the system comprising:

one or more computer processors that associate at least one mobile electronic device with the structure;

the one or more computer processors receive a geographic location of the at least one mobile electronic device;

the one or more computer processors use traffic data to predict a length of time for a user of the at least one mobile electronic device to reach the structure; and

the one or more computer processors adjust at least one temperature setpoint associated with the structure based upon the predicted length of time for a user of the mobile electronic device to reach the structure.

13. (New) The method of claim 12 wherein the one or more processors use geospatial data associated with the mobile electronic device to increase the predicted length of time to reach the structure based on characteristics of a location the user has stopped at before reaching the structure.

14. (New) The system of claim 12 wherein the mobile electronic device is a telephone.

15. (New) The system of claim 12 wherein the mobile electronic device is connected to the Internet.

16. (New) The system of claim 12 wherein the geographic location of the mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from the mobile electronic device.

17. (New) The system of claim 12 wherein the one or more computer processors comprise a remote server that is remotely located from the structure.

18. (New) The system of claim 12 wherein adjustment of the at least one temperature setpoint is logged to a database.

19. (New) The system of claim in 12 wherein adjustment of the at least one temperature setpoint is initiated by a remote computer.

20. (New) The system of claim 12 wherein the at least one temperature setpoint is adjusted automatically.

21. (New) The system of claim 12 wherein the user is prompted to confirm occupancy prior to adjustment of the at least one temperature setpoint.

REMARKS

In this amendment, Applicant has cancelled Claim 1 and added new Claims 2-12.

In addition, Applicant has submitted both a red-line copy and a clean copy of the Substitute Specification. Applicant has amended the Substitute Specification at paragraph 0039 to refer to Figures 16-1 and 16-2. Applicant submits that the Substitute Specification includes no new matter.

INFORMATION DISCLOSURE STATEMENT

Submitted concurrently herewith is an Information Disclosure Statement. Applicant respectfully requests the Examiner to consider the pending claims in connection with the cited references in order to make the references of record.

OTHER APPLICATIONS OF ASSIGNEE

Applicant wishes to draw the Examiner's attention to the following applications owned by of the present application's assignee:

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	60/963,183 Now Expired	08/03/07	EFACT.003PR	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	60/944,011 Now Expired	09/17/07	EFACT.005PR	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	12/183,990 Now Pat. 7,908,117	07/31/08	EFACT.003A	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	12/183,949 Now Pat. 7,908,116	07/31/08	EFACT.004A	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	12/211,733 Now Pat. 7,848,900	09/16/08	EFACT.005A	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	12/211,690 Now Pat. 8,019,567	09/16/08	EFACT.006A	System And Method For Evaluating Changes In The Efficiency Of An HVAC System

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	61/215,657 Now Expired	05/08/09	EFACT.009PR	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg	61/215,816 Now Expired	05/11/09	EFACT.008PR	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption
Steinberg et al.	61/215,999 Now Expired	05/12/09	EFACT.007PR	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Cheung et al.	12/498,142 Now Pat. 8,010,237	07/06/09	EFACT.010A	System And Method For Using Ramped Setpoint Temperature Variation With Networked Thermostats To Improve Efficiency
Steinberg	12/502,064 Now Pat. 8,180,492	07/13/09	EFACT.011A	System And Method For Using A Networked Electronic Device As An Occupancy Sensor For An Energy Management System
Steinberg et al.	12/773,690 Now Pat. 8,498,753	05/04/10	EFACT.009A	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg	12/774,580 Now Pat. 8,740,100	05/05/10	EFACT.008A	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption
Steinberg et al.	12/778,052 Now Pat. 8,596,550	05/11/10	EFACT.007A	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Steinberg	12/788,246 Now Pat. 8,556,188	05/26/10	EFACT.012A	System And Method For Using A Mobile Electronic Device To Optimize An Energy Management System
Steinberg	12/860,821 Now Pat. 8,090,477	08/20/10	EFACT.013A	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	12/959,225 Now Pat. 8,131,497	12/02/10	EFACT.005C1	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	13/037,162 Now Pat. 8,131,506	02/28/11	EFACT.004C1	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Cheung et al.	13/219,381 Published 2011/0307103	08/26/11	EFACT.010C1	System And Method For Using Ramped Setpoint Temperature Variation With Networked Thermostats To Improve Efficiency
Steinberg et al.	13/230,610 Now Pat. 8,423,322	09/12/11	EFACT.006C1	System And Method For Evaluating Changes In The Efficiency Of An HVAC System
Steinberg	13/329,117 Now Pat. 8,340,826	12/16/11	EFACT.013C1	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	13/409,697 Now Pat. 8,412,488	03/01/12	EFACT.004C2	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	13/409,729 Published 2012/0158350	03/01/12	EFACT.005C2	System And Method For Calculating The Thermal Mass Of A Building
Steinberg	13/470,074 Published 2012/0221151	05/11/12	EFACT.011C1	System And Method For Using A Wireless Device As A Sensor For An Energy Management System
Hublou et al.	13/523,697 Published 2013/0338837	06/14/12	EFACT.014A	System And Method For Optimizing Use Of Individual Hvac Units In Multi-Unit Chiller-Based Systems
Steinberg	13/725,447 Now Pat. 8,712,590	12/21/12	EFACT.013C2	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	13/852,577 Now Pat. 8,738,327	03/28/13	EFACT.004C3	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	13/858,710 Now Pat. 8,751,186	04/08/13	EFACT.005C3	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	13/861,189 Published 2013/0226502	04/11/13	EFACT.006C2	System And Method For Evaluating Changes In The Efficiency Of An HVAC System
Steinberg et al.	13/952,253 Published 2013/0310989	07/26/13	EFACT.009C1	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg	14/048,932 Now Pat. 8,840,033	10/08/13	EFACT.012C1	System And Method For Using A Mobile Electronic Device To Optimize An Energy Management System

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	14/082,675 Published 2014/0188290	11/18/13	EFACT.007C1	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Steinberg	14/263,762 Published 2014/0229018	04/28/14	EFACT.013C3	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	14/285,384	05/22/14	EFACT.004C4	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg	14/292,377	05/30/14	EFACT.008C1	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption
Steinberg	14/491,554	09/19/14	EFACT.012C2	System And Method For Using A Mobile Electronic Device To Optimize An Energy Management System
Steinberg et al.	14/527,433	10/29/14	EFACT.005C4	System And Method For Calculating The Thermal Mass Of A Building

Applicant notes that cited references, office actions, responses and notices of allowance currently exist or will exist for the above-referenced matters. Applicant also understands that the Examiner has access to sophisticated online Patent Office computing systems that provide ready access to the full file histories of these matters including, for example, specifications, drawings, pending claims, cited art, office actions, responses, declarations, and notices of allowance.

Rather than submit copies these file histories, Applicant respectfully requests that the Examiner continue to review these file histories online for past, current, and future information about these matters.

Also, if the Examiner cannot readily access these file histories, the Applicant would be pleased to provide any portion of any of the file histories at any time upon specific Examiner request.

NO DISCLAIMERS OR DISAVOWALS

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application.

Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution.

Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

CONCLUSION

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: 12-19-2014

By: John R. King

John R. King
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Attorney of Record
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19579667:ad
121814

Please Direct All Correspondence to Customer Number 20,995

RESPONSE TO FORMALITIES NOTICE

Inventor	:	John Douglas Steinberg
App. No.	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Art Unit	:	3744
Conf No.	:	1254

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The above-captioned application was filed lacking at least one item that would advance application to examination. Enclosed in compliance with 37 CFR 1.53(f) are the following.

(X) Preliminary Amendment.

(X) Copy of Power of Attorney from Parent Application.

(X) Information Disclosure Statement.

(X) Rescission of Any Prior Disclaimers and Request to Revisit Art.

(X) Substitute Specification (red-lined version).

(X) Substitute Specification (clean version).

The present application qualifies for small entity status under 37 CFR § 1.27.

(X) Fees will be paid via EFS Web. Any extension of time will be requested by payment of the appropriate extension fee.

Please Direct All Correspondence to Customer Number 20,995

The Commissioner is hereby authorized to charge any additional fees which may be required, now or in the future, or credit any overpayment, to Account No. 11-1410.

John R. King
Registration No. 34,362
Attorney of Record
Customer No. 20,995
(949) 760-0404

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Doc Code: PA..
Document Description: Power of Attorney

PTO/AIA/82A (07-13)
Approved for use through 11/30/2014. OMB 0651-0051
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

TRANSMITTAL FOR POWER OF ATTORNEY TO ONE OR MORE REGISTERED PRACTITIONERS

NOTE: This form is to be submitted with the Power of Attorney by Applicant form (PTO/AIA/82B) to identify the application to which the Power of Attorney is directed, in accordance with 37 CFR 1.5, unless the application number and filing date are identified in the Power of Attorney by Applicant form. If neither form PTO/AIA/82A nor form PTO/AIA82B identifies the application to which the Power of Attorney is directed, the Power of Attorney will not be recognized in the application.

Application Number	14/491,554
Filing Date	September 19, 2014
First Named Inventor	John Douglas Steinberg
Title	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Art Unit	3744
Examiner Name	Unknown
Attorney Docket Number	EFACT.012C2

SIGNATURE of Applicant or Patent Practitioner

Signature	John R. King	Date (Optional)	
Name	John R. King	Registration Number	34,362
Title (if Applicant is a juristic entity)	Attorney		
Applicant Name (if Applicant is a juristic entity)	EcoFactor, Inc.		

NOTE: This form must be signed in accordance with 37 CFR 1.33. See 37 CFR 1.4(d) for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

Doc Code: PA..
Document Description: Power of Attorney

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POWER OF ATTORNEY BY APPLICANT

I hereby revoke all previous powers of attorney given in the application identified in either the attached transmittal letter or the boxes below.

Application Number	Filing Date

(Note: The boxes above may be left blank if information is provided on form PTO/AIA/82A.)

☑ I hereby appoint the Patent Practitioner(s) associated with the following Customer Number as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above: 20995

OR

☐ I hereby appoint Practitioner(s) named in the attached list (form PTO/AIA/82C) as my/our attorney(s) or agent(s), and to transact all business in the United States Patent and Trademark Office connected therewith for the patent application referenced in the attached transmittal letter (form PTO/AIA/82A) or identified above. (Note: Complete form PTO/AIA/82C.)

Please recognize or change the correspondence address for the application identified in the attached transmittal letter or the boxes above to:

☑ The address associated with the above-mentioned Customer Number

OR

☐ The address associated with Customer Number:

OR

Firm or Individual Name					
Address					
City		State		Zip	
Country					
Telephone		Email			

I am the Applicant (if the Applicant is a juristic entity, list the Applicant name in the box):

EcoFactor, Inc.

☐ Inventor or Joint Inventor (title not required below)

☐ Legal Representative of a Deceased or Legally Incapacitated Inventor (title not required below)

☑ Assignee or Person to Whom the Inventor is Under an Obligation to Assign (provide signer's title if applicant is a juristic entity)

☐ Person Who Otherwise Shows Sufficient Proprietary Interest (e.g., a petition under 37 CFR 1.46(b)(2) was granted in the application or is concurrently being filed with this document) (provide signer's title if applicant is a juristic entity)

SIGNATURE of Applicant for Patent

The undersigned (whose title is supplied below) is authorized to act on behalf of the applicant (e.g., where the applicant is a juristic entity).

Signature		Date (Optional)	11/7/13
Name	John Douglas Steinberg		
Title	EVP of Business Development		

NOTE: Signature - This form must be signed by the applicant in accordance with 37 CFR 1.33. See 37 CFR 1.4 for signature requirements and certifications. If more than one applicant, use multiple forms.

☑ Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.131, 1.32, and 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

INFORMATION DISCLOSURE STATEMENT

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App. No.	:	14/491,554
Filed	:	September 19, 2014
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Examiner	:	Unknown
Art Unit	:	3744
Conf. No.	:	1254

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Listed references are of record in U.S. Patent Application No. 14/048,932, filed October 8, 2013, which is the parent of this continuation application, and is relied upon for an earlier filing date under 35 USC 120. Copies of the references are not submitted pursuant to 37 CFR 1.98(d).

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Timing of Disclosure

This Information Disclosure Statement is being filed before the receipt of a First Office Action on the merits, and presumably no fee is required. If a First Office Action on the merits was mailed before the mailing date of this Statement, the Commissioner

is authorized to charge the fee set forth in 37 CFR 1.17(p) to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: 12-19-2014

By: John R. King

John R. King
Registration No. 34,362
Attorney of Record
Customer No. 20995
(949) 760-0404

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121814

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 1 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	H2176	12/05/2006	Meyer et al.	
	2	13/470074	08/30/2012	Steinberg	
	3	13/523697	06/14/2012	Hublou et al.	
	4	13/725447	06/06/2013	Steinberg	
	5	13/852577	03/28/2013	Steinberg et al.	
	6	13/858710	09/05/2013	Steinberg et al.	
	7	13/861189	04/11/2013	Steinberg et al.	
	8	14/082,675 (EFACT.007C1)	11/18/2003	Steinberg et al.	
	9	14/263,762	04/28/2014	Steinberg	
	10	14/285,384	05/22/2014	Steinberg, et al.	
	11	14/292,377	05/30/2014	Steinberg	
	12	14/491,554	09/19/2014	Steinberg	
	13	14/527,433	10/29/2014	Steinberg, et al.	
	14	D 646,990	10/18/2011	Rhodes	
	15	D 659,560	05/15/2012	Rhodes	
	16	D 673,467	01/01/2013	Lee et al.	
	17	D 705,095 (EFACT.015DA)	05/20/2014	EcoFactor, Inc.	
	18	4,136,732	01/30/1979	Demaray et al.	
	19	4,341,345	07/27/1982	Hammer et al.	
	20	4,403,644	09/13/1983	Hebert	
	21	4,475,685	10/09/1984	Grimado et al.	
	22	4,655,279	04/07/1987	Harmon	
	23	4,674,027	06/16/1987	Beckey	
	24	5,124,502	06/23/1992	Nelson et al.	
	25	5,244,146	09/14/1993	Jefferson et al.	
	26	5,270,952	12/14/1993	Adams et al.	
	27	5,314,004	05/24/1994	Strand et al.	
	28	5,462,225	10/31/1995	Massara et al.	

Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

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	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 2 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	29	5,544,036	08/06/1996	Brown et al.	
	30	5,555,927	09/17/1996	Shah	
	31	5,572,438	11/05/1996	Ehlers et al.	
	32	5,682,949	11/04/1997	Ratcliffe et al.	
	33	5,717,609	02/10/1998	Packa et al.	
	34	5,725,148	03/10/1998	Hartman	
	35	5,729,474	03/17/1998	Hildebrand et al.	
	36	5,818,347	10/06/1998	Dolan et al.	
	37	5,977,964	11/02/1999	Williams et al.	
	38	6,079,626	06/27/2000	Hartman	
	39	6,115,713	09/05/2000	Pascucci et al.	
	40	6,145,751	11/14/2000	Ahmed	
	41	6,178,362	01/23/2001	Woolard et al.	
	42	6,260,765	07/17/2001	Natale et al.	
	43	6,241,156	06/05/2001	Kline et al.	
	44	6,351,693	02/26/2002	Monie	
	45	6,400,956	06/02/2002	Richton	
	46	6,400,996	06/04/2002	Hoffberg et al.	
	47	6,437,692	08/20/2002	Petite et al.	
	48	6,478,233	11/12/2002	Shah	
	49	6,480,803	11/12/2002	Pierret et al.	
	50	6,483,906	11/19/2002	Lggulden et al.	
	51	6,536,675	03/25/2003	Pesko et al.	
	52	6,542,076	04/01/2003	Joao	
	53	6,549,130	04/15/2003	Joao	
	54	6,574,537	06/02/2003	Kipersztok et al.	
	55	6,580,950	06/17/2003	Johnson	
	56	6,594,825	07/15/2003	Goldschmidtlki et al.	
	57	6,595,430	07/22/2003	Shah	

Examiner Signature	Date Considered

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PTO/SB/08 Equivalent

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	Art Unit	3744
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SHEET 3 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	58	6,598,056	07/22/2003	Hull et al.	
	59	6,619,555	09/16/2003	Rosen	
	60	6,622,097	09/16/2003	Hunter	
	61	6,622,115	09/16/2003	Brown et al.	
	62	6,622,925	09/23/2003	Carner et al.	
	63	6,622,926	09/23/2003	Sartain et al.	
	64	6,628,997	09/30/2003	Fox et al.	
	65	6,633,823	10/14/2003	Bartone et al.	
	66	6,643,567	11/04/2003	Kolk et al.	
	67	6,644,098	11/11/2003	Cardinale et al.	
	68	6,671,586	12/30/2003	Davis et al.	
	69	6,695,218	02/24/2004	Fleckenstein	
	70	6,726,113	04/27/2004	Guo	
	71	6,731,992	05/04/2004	Ziegler	
	72	6,734,806	05/11/2004	Cratsley	
	73	6,772,052	08/03/2004	Amundsen	
	74	6,785,592	08/31/2004	Smith	
	75	6,785,630	08/31/2004	Kolk	
	76	6,786,421	09/07/2004	Rosen	
	77	6,789,739	09/14/2004	Rosen	
	78	6,853,959	02/08/2005	Ikeda et al.	
	79	6,868,293	03/15/2005	Schurr	
	80	6,868,319	03/15/2005	Kipersztok et al.	
	81	6,882,712	04/19/2005	Iggulden et al.	
	82	6,889,908	05/10/2005	Crippen et al.	
	83	6,891,838	05/10/2005	Petite et al.	
	84	6,912,429	06/28/2005	Bilger	
	85	6,991,029	01/31/2006	Orfield et al.	
	86	7,009,493	03/07/2006	Howard	

Examiner Signature	Date Considered
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SHEET 4 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	87	7,031,880	04/18/2006	Seem et al.	
	88	7,039,532	05/02/2006	Hunter	
	89	7,061,393	06/13/2006	Buckingham et al.	
	90	7,089,088	08/08/2006	Terry et al.	
	91	7,130,719	10/31/2006	Ehlers et al.	
	92	7,130,832	10/31/2006	Bannai et al.	
	93	7,167,079	01/23/2007	Smyth et al.	
	94	7,187,986	03/06/2007	Johnson et al.	
	95	7,205,892	04/17/2007	Luebke et al.	
	96	7,215,746	05/08/2007	Iggulden et al.	
	97	7,216,015	05/08/2007	Poth Robert J.	
	98	7,231,424	06/11/2007	Bodin et al.	
	99	7,232,075	06/19/2007	Rosen	
	100	7,242,988	07/10/2007	Hoffberg et al.	
	101	7,260,823	08/21/2007	Schlack et al.	
	102	7,356,384	04/08/2008	Gull et al.	
	103	7,476,020	01/13/2009	Zufferey et al.	
	104	7,483,964	01/27/2009	Jackson et al.	
	105	7,644,869	01/12/2010	Hoglund et al.	
	106	7,702,424	04/20/2010	Cannon et al.	
	107	7,758,729	07/20/2010	DeWhitt	
	108	7,784,704	08/31/2010	Harter	
	109	7,848,900 (EFACT.005A)	12/07/2010	Steinberg et al.	
	110	7,869,904	01/11/2011	Cannon et al.	
	111	7,894,943	02/22/2011	Sloup et al.	
	112	7,908,116 (EFACT.004A)	03/15/2011	Steinberg et al.	
	113	7,908,117 (EFACT.003A)	03/15/2011	Steinberg et al.	
	114	8,010,237 (EFACT.010A)	08/30/2011	Cheung Leo et al.	

Examiner Signature	Date Considered

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U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	115	8,019,567 (EFACT.006A)	09/13/2011	Steinberg et al.	
	116	8,090,477 (EFACT.013A)	01/03/2012	Steinberg	
	117	8,131,497 (EFACT.005C1)	03/06/2012	Steinberg et al.	
	118	8,131,506 (EFACT.004C1)	03/06/2012	Steinberg et al.	
	119	8,180,492 (EFACT.011A)	05/15/2012	Steinberg	
	120	8,340,826 (EFACT.013C1)	12/25/2012	Steinberg et al.	
	121	8,412,488 (EFACT.004C2)	04/02/2013	Steinberg et al.	
	122	8,423,322 (EFACT.006C1)	04/16/2013	Steinberg et al.	
	123	8,457,797	06/04/2013	Imes et al.	
	124	8,556,188 (EFACT.012A)	10/15/2013	Steinberg	
	125	8,596,550 (EFACT.007A)	12/03/2013	Steinberg et al.	
	126	8,712,590 (EFACT.013C2)	04/29/2014	Steinberg	
	127	8,738,327 (EFACT.004C3)	05/27/2014	Steinberg, et al.	
	128	8,740,100 (EFACT.008A)	06/03/2014	Steinberg	
	129	8,751,186 (EFACT.005C3)	06/10/2014	Steinberg, et al.	
	130	8,840,033 (EFACT.012C1)	09/23/2014	EcoFactor, Inc.	
	131	8,886,488 (EFACT.005C2)	11/11/2014	Steinberg, et al.	
	132	2003/0040934	02/27/2003	Skidmore et al.	
	133	2004/0176880	09/09/2004	Obradovich et al.	
	134	2005/0222889	10/06/2005	Lai et al.	
	135	2005/0288822	12/29/2005	Rayburn	
	136	2006/0045105	03/02/2006	Dobosz et al.	
	137	2006/0214014	09/28/2006	Bash et al.	
	138	2007/0043477	02/22/2007	Elhers et al.	
	139	2007/0045431	03/03/2007	Chapman et al.	

Examiner Signature	Date Considered
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SHEET 6 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	140	2007/0146126	06/28/2007	Wang	
	141	2008/0083234	04/10/2008	Krebs et al.	
	142	2008/0198549	08/21/2008	Rasmussen et al.	
	143	2008/0281472	11/13/2008	Podgorny et al.	
	144	2009/0052859	02/26/2009	Greenberger et al.	
	145	2009/0099699	04/16/2009	Steinberg et al.	
	146	2009/0125151	05/14/2009	Steinberg et al.	
	147	2009/0240381	09/24/2009	Lane	
	148	2009/0281667	11/12/2009	Masui et al.	
	149	2010/0019052	01/28/2010	Yip	
	150	2010/0070086	03/18/2010	Harrod et al.	
	151	2010/0070089	03/18/2010	Harrod et al.	
	152	2010/0070093	03/18/2010	Harrod et al.	
	153	2010/0156608	06/24/2010	BAE et al.	
	154	2010/0162285	06/24/2010	Cohen et al.	
	155	2010/0211224	08/19/2010	Keeling et al.	
	156	2010/0235004	09/16/2010	Thind	
	157	2010/0318227	12/16/2010	Steinberg et al.	
	158	2011/0031323	02/10/2011	Nold et al.	
	159	2011/0046792	02/24/2011	Imes et al.	
	160	2011/0046798	02/24/2011	Imes et al.	
	161	2011/0046799	02/24/2011	Imes et al.	
	162	2011/0046800	02/24/2011	Imes et al.	
	163	2011/0046801	02/24/2011	Imes et al.	
	164	2011/0051823	03/03/2011	Imes et al.	
	165	2011/0054699	03/03/2011	Imes et al.	
	166	2011/0054710	03/03/2011	Imes et al.	
	167	2011/0173542	07/14/2011	Imes et al.	
	168	2011/0202185	08/18/2011	Imes et al.	

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INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 7 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	169	2011/0214060	09/01/2011	Imes et al.	
	170	2011/0224838	09/15/2011	Imes et al.	
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PTO/SB/08 Equivalent

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U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
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	211	WO 2013/187996	12/19/2013	EcoFactor, Inc.		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
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NON PATENT LITERATURE DOCUMENTS			
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant	:	John Douglas Steinberg
App. No	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Examiner	:	Unknown
Art Unit	:	3744

RESCISSION OF ANY PRIOR DISCLAIMERS AND REQUEST TO REVISIT ART

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

The claims of the present application are different and possibly broader in scope than any pending claims in any related application or issued claims in any related patent In particular, in one or more parent applications, including U.S. Patent Application No. 12/788,246, now U.S. Patent No. 8,556,188, issued October 15, 2013; and U.S. Patent Application No. 14/048,932, now U.S. Patent No. 8,840,033, issued September 23, 2014; Applicant amended claims and received allowance over at least U.S. Patent No. 8,386,082 and U.S. Publication No. 2011/0202181.

To the extent that any amendments or characterizations of the scope of any claim or referenced art could be construed as a disclaimer of any subject matter supported by the present disclosure, Applicant hereby rescinds and retracts such disclaimer. Accordingly, the above-listed references, or other listed or referenced art may need to be re-visited. To this end, Applicant would appreciate acknowledgement

of such reconsideration by Examiner initialization of at least the references listed in the attached Information Disclosure Statement Form PTO/SB/08.

In addition, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

Respectfully submitted,
KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: 12-19-2014

By: John R. King

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SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Cross-Reference to Related Applications

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet, or any correction thereto, are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to the use of thermostatic HVAC and other energy management controls that are connected to a computer network. More specifically, the present invention pertains to the use of geographic movement of network-connected mobile devices to occupancy to inform an energy management system, to provide enhanced efficiency, and to verify demand response.

Description of the Related Art

[0003] Heating and cooling systems for buildings (heating, ventilation and cooling, or HVAC systems) have been controlled for decades by thermostats. At the most basic level, a thermostat includes a means to allow a user to set a desired temperature, a means to sense actual temperature, and a means to signal the heating and/or cooling devices to turn on or off in order to try to change the actual temperature to equal the desired temperature. The most basic versions of thermostats use components such as a coiled bi-metallic spring to measure actual temperature and a mercury switch that opens or completes a circuit when the spring coils or uncoils with temperature changes. More recently, electronic digital thermostats have become prevalent. These thermostats use solid-state devices such as thermistors or thermal diodes to measure temperature, and microprocessor-based circuitry to control the switch and to store and operate based upon user-determined protocols for temperature vs. time.

[0004] These programmable thermostats generally offer a very restrictive user interface, limited by the cost of the devices, the limited real estate of the small wall-mounted boxes, and the inability to take into account more than two variables: the desired temperature set by the user, and the ambient temperature sensed by the thermostat. Users can generally only set one series of commands per day, and in order to change one parameter (e.g., to change the late-night temperature) the user often has to cycle through several other parameters by repeatedly pressing one or two buttons.

[0005] Because the interface of programmable thermostats is so poor, the significant theoretical savings that are possible with them (sometimes cited as 25% of heating and cooling costs) are rarely realized. In practice, studies have found that more than 50% of users never program their thermostats at all. Significant percentages of the thermostats that are programmed are programmed sub-optimally, in part because, once programmed, people tend to not to re-invest the time needed to change the settings very often.

[0006] A second problem with standard programmable thermostats is that they represent only a small evolutionary step beyond the first, purely mechanical thermostats. Like the first thermostats, they only have two input signals - ambient temperature and the preset desired temperature. The entire advance with programmable thermostats is that they can shift between multiple present temperatures at different times without real-time involvement of a human being.

[0007] Because most thermostats control HVAC systems that do not offer infinitely variable output, traditional thermostats are designed to permit the temperature as seen by the thermostat to vary above and below the setpoint to prevent the HVAC system from constantly and rapidly cycling on and off, which is inefficient and harmful to the HVAC system. The temperature range in which the thermostat allows the controlled environment to drift is known as both the dead zone and, more formally, the hysteresis zone. The hysteresis zone is frequently set at +/- 1 degree Fahrenheit. Thus if the setpoint is 68 degrees, in the heating context the thermostat will allow the

inside temperature to fall to 67 degrees before turning the heating system on, and will allow it to rise to 69 degrees before turning it off again.

[0008] As energy prices rise, more attention is being paid to ways of reducing energy consumption. Because energy consumption is directly proportional to setpoint - that is, the further a given setpoint diverges from the balance point (the inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by virtually any strategy that over a given time frame lowers the average heating setpoint or raises the average cooling setpoint. Conventional programmable thermostats allow homeowners to save money and energy by pre-programming setpoint changes based upon comfort or schedule. For example, in the summer, allowing the setpoint to rise by several degrees (or even shutting off the air conditioner) when the home is unoccupied will generally save significantly on energy. But such thermostats have proven to be only minimally effective in practice. Because they have such primitive user interfaces, they are difficult to program, and so many users never bother at all, or set them up once and do not alter the programming even if their schedules change.

[0009] In the hotel industry, the heating and cooling decisions made in hundred or even thousands of individual rooms with independently controlled HVAC systems are aggregated into a single energy bill, so hotel owners and managers are sensitive to energy consumption by those systems. Hotel guests often turn the air conditioner to a low temperature setting and then leave the room for hours at a time, thereby wasting considerable energy. An approach commonly used outside of the United States to combat this problem is to use a keycard to control the HVAC system, such that guests place the keycard into a slot mounted on the wall near the door of the room which then triggers the lights and HVAC system to power up, and turn them off when the guest removes the card upon leaving the room. However, because most hotels give each guest two cards, it is easy to simply leave the extra card in the slot, thus defeating the purpose of the system. Recently, systems have been introduced in which a motion sensor is connected to the control circuitry for the HVAC system. If no

motion is detected in the room for some predetermined interval, the system concludes that the room is unoccupied, and turns off the HVAC system or alters the setpoint to a more economical level. When the motion sensor detects motion (which is assumed to coincide with the return of the guest), the HVAC system resets to the guest's chosen setting.

[0010] Adding occupancy detection capability to residential HVAC systems could also add considerable value in the form of energy savings without significant tradeoff in terms of comfort. But the systems used in hotels do not easily transfer to the single-family residential context. Hotel rooms tend to be small enough that a single motion sensor is sufficient to determine with a high degree of accuracy whether or not the room is occupied. A single motion sensor in the average home today would have limited value because there are likely to be many places one or more people could be home and active yet invisible to the motion sensor. The most economical way to include a motion sensor in a traditional programmable thermostat would be to build it into the thermostat itself. But thermostats are generally located in hallways, and thus are unlikely to be exposed to the areas where people tend to spend their time. Wiring a home with multiple motion sensors in order to maximize the chances of detecting occupants would involve considerable expense, both for the sensors themselves and for the considerable cost of installation, especially in the retrofit market. Yet if control is ceded to a single-sensor system that cannot reliably detect presence, the resulting errors would likely lead the homeowner to reject the system.

[0011] Although progress in residential HVAC control has been slow, tremendous technological change has come to the tools used for personal communication. When programmable thermostats were first offered, telephones were virtually all tethered by wires to a wall jack. But now a large percentage of the population carries at least one mobile device capable of sending and receiving voice or data or even video (or a combination thereof) from almost anywhere by means of a wireless network. These devices create the possibility that a consumer can, with an appropriate mobile device and a network-enabled HVAC system, control his or her HVAC system even when away from home. But systems that relay on active

management decisions by consumers are likely to yield sub-optimal energy management outcomes, because consumers are unlikely to devote the attention and effort required to fully optimize energy use on a daily basis.

[0012] Many new mobile devices now incorporate another significant new technology – the ability to geolocate the device (and thus, presumably, the user of the device). One method of locating such devices uses the Global Positioning System (GPS). The GPS system uses a constellation of orbiting satellites with very precise clocks to triangulate the position of a device anywhere on earth based upon arrival times of signals received from those satellites by the device. Another approach to geolocation triangulates using signals from multiple cell phone towers. Such systems can enable a variety of so-called "location based services" to users of enabled devices. These services are generally thought of as aids to commerce like pointing users to restaurants or gas stations, etc.

[0013] It would be desirable to provide a system that could detect the location of regular occupants of a home or other structure without requiring the installation of additional hardware; that could accurately use such geospatial information in order to detect and predict occupancy, and could optimize energy consumption based upon dynamic and individually configurable heuristics.

SUMMARY OF THE INVENTION

[0014] In one embodiment, the invention comprises a thermostat attached to an HVAC system, a local network connecting the thermostat to a larger network such as the Internet, and one or more geolocation-enabled mobile devices attached to the network, and a server in bi-directional communication with a plurality of such thermostats and devices. The server pairs each thermostat with one or more geolocation-enabled mobile devices which are determined to be associated with the occupants of home in which the thermostat is located.

[0015] The server logs the ambient temperature sensed by each thermostat vs. time and the signals sent by the thermostats to their HVAC systems. The server also monitors and logs the geolocation data related to the geolocation-enabled mobile

devices associated with each thermostat. Based on the locations and movement evidenced by geolocation data, the server instructs the thermostat to change temperature settings between those optimized for occupied and unoccupied states at the appropriate times based on the evolving geolocation data.

[0016] One embodiment of the invention is directed to a method for varying temperature setpoints for an HVAC system. The method comprises determining the geographic location of a mobile electronic device that is connected to a network and associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices. In addition, the method comprises determining whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device and adjusting the temperature setpoint on said controller for an HVAC system for said structure based upon whether or not said structure is deemed to be occupied.

[0017] In another embodiment, the mobile electronic device is a telephone. In an additional embodiment, the networked mobile electronic device is a personal digital assistant. In a further embodiment, the mobile electronic device is connected to the Internet.

[0018] In one embodiment the method for determining the geographic location of a mobile electronic device uses the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0019] In yet another embodiment, the variation of temperature setpoints is logged to a database. In a further embodiment, the variation of temperature setpoints is initiated by a remote computer. In a different embodiment, the temperature setpoints are varied automatically. In a further embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

[0020] In one embodiment, a system for altering the setpoint on a thermostat for space conditioning of a structure comprises at least one said thermostat having at least one temperature setting associated with the presence of one or more occupants in said structure, and at least one temperature setting associated with the absence of occupants in said structure. The system also comprises one or more mobile electronic devices having at least a user interface, where the mobile electronic devices and said thermostat are connected to a network and where the setpoint on said thermostat is adjusted between said temperature setting associated with the presence of one or more occupants in said structure and said temperature setting associated with the absence of occupants in said structure based upon the geographic location of said electronic device.

[0021] In a further embodiment, the mobile electronic device is a telephone. In yet another embodiment, the networked mobile electronic device is a personal digital assistant. In still a further embodiment, the mobile electronic device is connected to the Internet.

[0022] In one embodiment, the method for determining the geographic location of a mobile electronic device is the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0023] In a different embodiment, the variation of temperature setpoints is logged to a database. In another embodiment, the variation of temperature setpoints is initiated by a remote computer. In a further embodiment, the temperature setpoints are varied automatically. In still another embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figure 1 shows an example of an overall environment in which an embodiment of the invention may be used.

[0025] Figure 2 shows a high-level illustration of the architecture of a network showing the relationship between the major elements of one embodiment of the subject invention.

[0026] Figures 3a and 3b show an embodiment of the website to be used as part of the subject invention.

[0027] Figure 4 shows a high-level schematic of the thermostat used as part of an embodiment of the subject invention.

[0028] Figure 5 shows one embodiment of the database structure used as part of an embodiment of the subject invention.

[0029] Figures 6a and 6b illustrate pages of a website that may be used with an embodiment of the subject invention.

[0030] Figure 7 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0031] Figure 8 is a flowchart that shows how the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device connected to the system.

[0032] Figures 9a and 9b show how comparing inside temperature against outside temperature and other variables permits calculation of dynamic signatures.

[0033] Figure 10 shows a flow chart for a high level version of the process of calculating the appropriate turn-on time in a given home.

[0034] Figure 11 shows a more detailed flowchart listing the steps in the process of calculating the appropriate turn-on time in a given home for a just-in-time event.

[0035] Figures 12a, 12b, 12c and 12d show the steps shown in the flowchart in Figure 11 in the form of a graph of temperature and time.

[0036] Figure 13 shows a table of some of the data used by an embodiment of the subject invention to predict temperatures.

[0037] Figure 14 shows an embodiment of the subject invention as applied in a specific home on a specific day.

[0038] Figure 15 shows an embodiment of the subject invention as applied in a different specific home on a specific day.

[0039] Figures 16-1 and 16-2 show a table of predicted rates of change in temperature inside a given home for a range of temperature differentials between inside and outside.

[0040] Figure 17 shows how manual inputs can be recognized and recorded by an embodiment of the subject invention.

[0041] Figure 18 shows how an embodiment of the subject invention uses manual inputs to interpret manual overrides and make short-term changes in response thereto.

[0042] Figure 19 shows how an embodiment of the subject invention uses manual inputs to make long-term changes to interpretive rules and to setpoint scheduling.

[0043] Figure 20 shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event.

[0044] Figure 21(a) through 21(c) illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature.

[0045] Figure 22 is a flow chart illustrating the steps involved in generating a demand reduction event for a given subscriber.

[0046] Figure 23 is a flow chart illustrating the steps involved in confirming that a demand reduction event has taken place.

[0047] Figure 24 is a representation of the movement of messages and information between the components of an embodiment of the subject invention.

[0048] Figures 25a and 25b show graphical representations of inside and outside temperatures in two different homes, one with high thermal mass and one with low thermal mass.

[0049] Figures 26a and 26b show graphical representations of inside and outside temperatures in the same homes as in Figures 25a and 25b, showing the cycling of the air conditioning systems in those houses.

[0050] Figures 27a and 27b show graphical representations of inside and outside temperatures in the same home as in Figures 25a and 26a, showing the cycling of the air conditioning on two different days in order to demonstrate the effect of a change in operating efficiency on the parameters measured by the thermostat.

[0051] Figures 28a and 28b show the effects of employing a pre-cooling strategy in two different houses.

[0052] Figures 29a and 29b show graphical representations of inside and outside temperatures in two different homes in order to demonstrate how the system can correct for erroneous readings in one house by referencing readings in another.

[0053] Figure 30 is a flowchart illustrating the steps involved in calculating the effective thermal mass of a home using an embodiment of the subject invention.

[0054] Figure 31 is a flowchart illustrating the steps involved in determining whether an HVAC system has developed a problem that impairs efficiency using an embodiment of the subject invention.

[0055] Figure 32 is a flowchart illustrating the steps involved in correcting for erroneous readings in one house by referencing readings in another using an embodiment of the subject invention.

[0056] Figure 33 shows the conventional programming of a programmable thermostat over a 24-hour period.

[0057] Figure 34 shows the programming of a programmable thermostat over a 24-hour period using ramped setpoints.

[0058] Figure 35 shows the steps required for the core function of the ramped setpoint algorithm.

[0059] Figure 36 shows a flowchart listing steps in the process of deciding whether to implement the ramped setpoint algorithm using an embodiment of the subject invention.

[0060] Figure 37 shows the browser as seen on the display of the computer used as part of an embodiment of the subject invention.

[0061] Figure 38 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0062] Figure 39 is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0063] **Figure 1** shows an example of an overall environment 100 in which an embodiment of the invention may be used. The environment 100 includes an interactive communication network 102 with computers 104 connected thereto. Also connected to network 102 are mobile devices 105, and one or more server computers 106, which store information and make the information available to computers 104 and mobile devices 105. The network 102 allows communication between and among the computers 104, mobile devices 105 and servers 106.

[0064] Presently preferred network 102 comprises a collection of interconnected public and/or private networks that are linked to together by a set of standard protocols to form a distributed network. While network 102 is intended to refer to what is now commonly referred to as the Internet, it is also intended to encompass variations which may be made in the future, including changes additions to existing standard protocols. It also includes various networks used to connect mobile and wireless devices, such as cellular networks.

[0065] When a user of an embodiment of the subject invention wishes to access information on network 102 using computer 104, the user initiates connection from his computer 104. For example, the user invokes a browser, which executes on computer 104. The browser, in turn, establishes a communication link with network 102. Once connected to network 102, the user can direct the browser to access information on server 106.

[0066] One popular part of the Internet is the World Wide Web. The World Wide Web contains a large number of computers 104 and servers 106, which store HyperText Markup Language (HTML) documents capable of displaying graphical and textual information. HTML is a standard coding convention and set of codes for attaching presentation and linking attributes to informational content within documents.

[0067] The servers 106 that provide offerings on the World Wide Web are typically called websites. A website is often defined by an Internet address that has an associated electronic page. Generally, an electronic page is a document that organizes the presentation of text graphical images, audio and video.

[0068] In addition to the Internet, the network 102 can comprise a wide variety of interactive communication media. For example, network 102 can include local area networks, interactive television networks, telephone networks, wireless data systems, two-way cable systems, and the like.

[0069] In one embodiment, computers 104 and servers 106 are conventional computers that are equipped with communications hardware such as modem or a network interface card. The computers include processors such as those sold by Intel and AMD. Other processors may also be used, including general-purpose processors, multi-chip processors, embedded processors and the like.

[0070] Computers 104 can also be microprocessor- controlled home entertainment equipment including advanced televisions, televisions paired with home entertainment/media centers, and wireless remote controls.

[0071] Computers 104 may utilize a browser configured to interact with the World Wide Web. Such browsers may include Microsoft Explorer, Mozilla, Firefox, Opera or Safari. They may also include browsers or similar software used on handheld, home entertainment and wireless devices.

[0072] The storage medium may comprise any method of storing information. It may comprise random access memory (RAM), electronically erasable programmable read only memory (EEPROM), read only memory (ROM), hard disk, floppy disk, CD-ROM, optical memory, or other method of storing data.

Ex. 1006.0160

[0073] Computers 104 and 106 may use an operating system such as Microsoft Windows, Apple Mac OS, Linux, Unix or the like.

[0074] Computers 106 may include a range of devices that provide information, sound, graphics and text, and may use a variety of operating systems and software optimized for distribution of content via networks.

[0075] Mobile devices 105 can also be handheld and wireless devices such as personal digital assistants (PDAs), cellular telephones and other devices capable of accessing the network. Mobile devices 105 can use a variety of means for establishing the location of each device at a given time. Such methods may include the Global Positioning System (GPS), location relative to cellular towers, connection to specific wireless access points, or other means

[0076] **Figure 2** illustrates in further detail the architecture of the specific components connected to network 102 showing the relationship between the major elements of one embodiment of the subject invention. Attached to the network are thermostats 108 and computers 104 of various users. Connected to thermostats 108 are HVAC units 110. The HVAC units may be conventional air conditioners, heat pumps, or other devices for transferring heat into or out of a building. Each user is connected to the server 106 via wired or wireless connection such as Ethernet or a wireless protocol such as IEEE 802.11, a gateway 110 that connects the computer and thermostat to the Internet via a broadband connection such as a digital subscriber line (DSL), cellular radio or other form of broadband connection to the World Wide Web. Server 106 contains the content to be served as web pages and viewed by computers 104, software to manage thermostats 108, as well as databases containing information used by the servers.

[0077] Also attached to the Network are cellular radio towers 120, or other means to transmit and receive wireless signals in communication with mobile devices 105. Such communication may use GPRS, GSM, CDMA, EvDO, EDGE or other protocols and technologies for connecting mobile devices to a network.

[0078] **Figures 3a** and **3b** shows a representative mobile device 105 from the front and back, respectively. The front of the device includes a display 202, and may

include a physical keyboard 204. Alternatively, a virtual keyboard may be included in a display with touchscreen functionality. For devices with voice capabilities, such as a smart phone, a microphone 206 and speaker 208 enable audio communications. An antenna 210, which may be mounted entirely within the mobile device, aids wireless communications. Modules included within mobile device 105 but not visible from the outside may include memory cards, microprocessors, GPS receivers, battery, etc.

[0079] **Figure 4** shows a high-level block diagram of thermostat 108 used as part of an embodiment of the subject invention. Thermostat 108 includes temperature sensing means 252, which may be a thermistor, thermal diode or other means commonly used in the design of electronic thermostats. It includes a microprocessor 254, memory 256, a display 258, a power source 260, a relay 262, which turns the HVAC system on and off in response to a signal from the microprocessor, and contacts by which the relay is connected to the wires that lead to the HVAC system.

[0080] To allow the thermostat to communicate bi-directionally with the computer network, the thermostat also includes means 264 to connect the thermostat to a local computer or to a wireless network. Such means could be in the form of Ethernet, wireless protocols such as IEEE 802.11, IEEE 802.15.4, Bluetooth, cellular systems such as CDMA, GSM and GPRS, or other wireless protocols. The thermostat 250 may also include controls 266 allowing users to change settings directly at the thermostat, but such controls are not necessary to allow the thermostat to function.

[0081] The data used to manage the subject invention is stored on one or more servers 106 within one or more databases. As shown in **Figure 5**, the overall database structure 300 may include temperature database 400, thermostat settings database 500, energy bill database 600, HVAC hardware database 700, weather database 800, user database 900, transaction database 1000, product and service database 1100, user location database 1200 and such other databases as may be needed to support these and additional features.

[0082] Users of connected thermostats 250 may create personal accounts. Each user's account will store information in database 900, which tracks various attributes relative to users of the site. Such attributes may include the make and model

of the specific HVAC equipment in the user's home; the age and square footage of the home, the solar orientation of the home, the location of the thermostat in the home, the user's preferred temperature settings, whether the user is a participant in a demand response program, etc.

[0083] User personal accounts may also associate one or more mobile devices with such personal accounts. For mobile devices with the capability for geopositioning awareness, these personal accounts will have the ability log such positioning data over time in database 1200.

[0084] In one embodiment, a background application installed on mobile device 105 shares geopositioning data for the mobile device with the application running on server 106 that logs such data. Based upon this data, server 106 runs software that interprets said data (as described in more detail below). Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; or (b) transmit a message to mobile device 105 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. Such signalling activity may be conducted via email, text message, pop-up alerts, voice messaging, or other means.

[0085] **Figures 6a** and **6b** illustrate a website that may be provided to assist homeowners and others to interact with an embodiment of the subject invention. The website will permit thermostat users to perform through the web browser substantially all of the programming functions traditionally performed directly at the physical thermostat, such as temperature set points, the time at which the thermostat should be at each set point, etc. Preferably the website will also allow users to accomplish more advanced tasks such as allow users to program in vacation settings for times when the HVAC system may be turned off or run at more economical settings, and to set macros that will allow changing the settings of the temperature for all periods with a single gesture such as a mouse click.

[0086] As shown in **Figure 6a**, screen 351 of website 350 displays current temperature 352 as sensed by thermostat 108. Clicking on “up” arrow 354 raises the

setpoint 358; clicking the down arrow 356 lowers setpoint 358. Screen 351 may also convey information about the outside weather conditions, such as a graphic representation 360 of the sun, clouds, etc. In homes with multiple thermostats, screen 351 may allow users to select different devices to adjust or monitor. Users will be able to use screen 351 by selecting, for example, master bedroom thermostat 362, living room thermostat 364, game room thermostat 366, or basement thermostat 368.

[0087] As shown in **Figure 6b**, screen 370 allows users to establish programming schedules. Row 372 shows a 24-hour period. Programming row 374 displays various programming periods and when they are scheduled, such as away setting 376, which begins at approximately 8AM and runs until approximately 5:30PM. When the away setting 376 is highlighted, the user can adjust the starting time and ending time for the setting by dragging the beginning time 378 to the left to choose an earlier start time, and dragging it to the right to make it later. Similarly, the user can drag ending time 380 to the left to make it earlier, and to the right to make it later. While away setting 376 is highlighted, the user can also change heating setpoint 382 by clicking on up arrow 384 or down arrow 386, and cooling setpoint 388 by clicking on up arrow 390 or down arrow 392. The user can save the program by clicking on save button 394.

[0088] **Figure 7** is a high-level flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 1302, mobile device 105 transmits geopositioning information to server 106 via the Internet. In step 1304 the server compares the latest geopositioning data point to previous data points in order to determine whether a change in location or vector of movement has occurred. In step 1306 the server evaluates the geopositioning data in order to determine whether the temperature settings for the HVAC system for the structure associated with the mobile device 105 should be optimized for an unoccupied structure, or for an occupied structure in light of the movement (or lack thereof) in the geopositioning data.

[0089] If the server 106 determines that the home should be in occupied or "home" mode, then in step 1308 the server queries database 300 to determine whether thermostat 108 is already set for home or away mode. If thermostat 108 is already in

home mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 1310 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0090] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1316, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1312 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home.

[0091] If the user elects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate. If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.

[0092] If the server 106 determines in step 1306 that the home should be in unoccupied or away mode, then in step 1350 the server queries database 300 to determine whether thermostat 108 is set for set for home or away mode. If thermostat 108 is already in away mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is occupied, then in step 1352 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0093] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds

to step 1358, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when unoccupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1354 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate.

[0094] If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.If thermostat 108 is already in away mode, the program ends. If it was in home mode, then in step 1314 server 108 initiates a state change to put thermostat 108 in away mode. In either case, the server then in step 1316 writes the state change to database 300. In each case the server can also send a message to the person who owns the mobile device requesting, confirming or announcing the state change.

[0095] **Figure 8** is a flowchart that shows one process by which an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device attached to the system. The process shown assumes (a) a static hierarchy of temperature preferences as between multiple occupants: that is, that for a given home/structure, mobile user #1's preferences will always control the outcome if mobile user #1 is present, that mobile user #2's preferences yield to #1's, but always prevail over user #3, etc; and (b) that there are no occupants to consider who are not associated with a mobile device. Other heuristics may be applied in order to account for more dynamic interactions of preferences.

[0096] In step 1402 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #1. In step 1404

server 106 uses current and recent coordinates to determine whether mobile user #1's "home" settings should be applied. If server 106 determines that User #1's home settings should be applied, then in step 1406 server 106 applies the correct setting and transmits it to the thermostat(s).

[0097] In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming. If after performing step 1404, the server concludes that mobile user #1's "home" settings should not be applied, then in step 1412 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #2.

[0098] In step 1414 server 106 uses current and recent coordinates to determine whether mobile user #2's "home" settings should be applied. If server 106 determines that User #2's home settings should be applied, then in step 1416 server 106 applies the correct setting and transmits it to the thermostat(s).

[0099] In step 1408, server 106 writes to database 300 the geospatial and other relevant information used to adjust the programming. If after performing step 1414, the server concludes that mobile user #2's "home" settings should not be applied, then in step 1422 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #N.

[0100] In step 1424 server 106 uses current and recent coordinates to determine whether mobile user #N's "home" settings should be applied. If server 106 determines that User #N's home settings should be applied, then in step 1426 server 106 applies the correct setting and transmits it to the thermostat(s). In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming.

[0101] If none of the mobile devices associated with a given home or other structure report geospatial coordinates consistent with occupancy, then in step 1430 the server instructs the thermostat(s) to switch to or maintain the "away" setting.

[0102] One embodiment of the invention is capable of delivering additional benefits for homeowners in terms of increased comfort and efficiency. In addition to using the system to allow better signaling and control of the HVAC system, which relies

primarily on communication running from the server to the thermostat, the bi-directional communication will also allow the thermostat 108 to regularly measure and send to the server information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0103] For example, **Figure 9a** shows a graph of inside temperature, outside temperature and HVAC activity for a 24 hour period. When outside temperature 1502 increases, inside temperature 1504 follows, but with some delay because of the thermal mass of the building, unless the air conditioning 1506 operates to counteract this effect. When the air conditioning turns on, the inside temperature stays constant (or rises at a much lower rate or even falls) despite the rising outside temperature. In this example, frequent and heavy use of the air conditioning results in only a very slight temperature increase inside the house of 4 degrees, from 72 to 76 degrees, despite the increase in outside temperature from 80 to 100 degrees.

[0104] **Figure 9b** shows a graph of the same house on the same day, but assumes that the air conditioning is turned off from noon to 7PM. As expected, the inside temperature 1504a rises with increasing outside temperatures 1502 for most of that period, reaching 88 degrees at 7PM. Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house.

[0105] The performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the rate at which the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc., the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0106] The ability to predict the rate of change in inside temperature in a given house under varying conditions may be applied by in effect holding the desired future inside temperature as a constraint and using the ability to predict the rate of change to determine when the HVAC system must be turned on in order to reach the desired temperature at the desired time. The ability of an HVAC system to vary turn-on time in order to achieve a setpoint with minimum energy use may be thought of as Just In Time (JIT) optimization.

[0107] **Figure 10** shows a flowchart illustrating the high-level process for controlling a just-in-time (JIT) event. In step 1512, the server determines whether a specific thermostat 108 is scheduled to run the preconditioning program. If, not, the program terminates. If it so scheduled, then in step 1514 the server retrieves the predetermined target time when the preconditioning is intended to have been completed (TT).

[0108] Using TT as an input, in step 1516 the server then determines the time at which the computational steps required to program the preconditioning event will be performed (ST). In step 1518, performed at start time ST, the server begins the process of actually calculating the required parameters, as discussed in greater detail below. Then in 1520 specific setpoint changes are transmitted to the thermostat so that the temperature inside the home may be appropriately changed as intended.

[0109] **Figure 11** shows a more detailed flowchart of the process. In step 1532, the server retrieves input parameters used to create a JIT event. These parameters include the maximum time allowed for a JIT event for thermostat 108 (MTI); the target time the system is intended to hit the desired temperature (TT); and the desired inside temperature at TT (TempTT). It is useful to set a value for MTI because, for example, it will be reasonable to prevent the HVAC system from running a preconditioning event if it would be expected to take 8 hours, which might be prohibitively expensive.

[0110] In step 1534, the server retrieves data used to calculate the appropriate start time with the given input parameters. This data includes a set of algorithmic learning data (ALD), composed of historic readings from the thermostat,

Ex. 1006.0169

together with associated weather data, such as outside temperature, solar radiation, humidity, wind speed and direction, etc; together with weather forecast data for the subject location for the period when the algorithm is scheduled to run (the weather forecast data, or WFD). The forecasting data can be as simple as a listing of expected temperatures for a period of hours subsequent to the time at which the calculations are performed, to more detailed tables including humidity, solar radiation, wind, etc. Alternatively, it can include additional information such as some or all of the kinds of data collected in the ALD.

[0111] In step 1536, the server uses the ALD and the WFD to create prediction tables that determine the expected rate of change or slope of inside temperature for each minute of HVAC cycle time (ΔT) for the relevant range of possible pre-existing inside temperatures and outside climatic conditions. An example of a simple prediction table is illustrated in Fig. 13.

[0112] In step 1538, the server uses the prediction tables created in step 1536, combined with input parameters TT and Temp(TT) to determine the time at which slope ΔT intersects with predicted initial temperature PT. The time between PT and TT is the key calculated parameter: the preconditioning time interval, or PTI.

[0113] In step 1540, the server checks to confirm that the time required to execute the pre-conditioning event PTI does not exceed the maximum parameter MTI. If PTI exceeds MTI, the scheduling routine concludes and no ramping setpoints are transmitted to the thermostat.

[0114] If the system is perfect in its predictive abilities and its assumptions about the temperature inside the home are completely accurate, then in theory the thermostat can simply be reprogrammed once – at time PT, the thermostat can simply be reprogrammed to Temp(TT). However, there are drawbacks to this approach.

[0115] First, if the server has been overly conservative in its predictions as to the possible rate of change in temperature caused by the HVAC system, the inside temperature will reach TT too soon, thus wasting energy and at least partially defeating the purpose of running the preconditioning routine in the first place. If the server is too optimistic in its projections, there will be no way to catch up, and the home will not

reach Temp(TT) until after TT. Thus it would be desirable to build into the system a means for self-correcting for slightly conservative start times without excessive energy use.

[0116] Second, the use of setpoints as a proxy for actual inside temperatures in the calculations is efficient, but can be inaccurate under certain circumstances. In the winter (heating) context, for example, if the actual inside temperature is a few degrees above the setpoint (which can happen when outside temperatures are warm enough that the home's natural "set point" is above the thermostat setting), then setting the thermostat to Temp(TT) at time PT will almost certainly lead to reaching TT too soon as well.

[0117] The currently preferred solution to both of these possible inaccuracies is to calculate and program a series of intermediate settings between Temp(PT) and Temp(TT) that are roughly related to ΔT.

[0118] Thus if MTI is greater than PTI, then in step 1542 the server calculates the schedule of intermediate setpoints and time intervals to be transmitted to the thermostat. Because thermostats cannot generally be programmed with steps of less than 1 degree F, ΔT is quantized into discrete interval data of at least 1 degree F each. For example, if Temp(PT) is 65 degrees F, Temp(TT) is 72 degrees F, and PT is 90 minutes, the thermostat might be programmed to be set at 66 for 10 minutes, 67 for 12 minutes, 68 for 15 minutes, etc.

[0119] The server may optionally limit the process by assigning a minimum programming interval (e.g., at least ten minutes between setpoint changes) to avoid frequent switching of the HVAC system, which can reduce accuracy because of the thermostat's compressor delay circuit, which may prevent quick corrections. The duration of each individual step may be a simple arithmetic function of the time PTI divided by the number of whole-degree steps to be taken; alternatively, the duration of each step may take into account second order thermodynamic effects relating to the increasing difficulty of "pushing" the temperature inside a house further from its natural setpoint given outside weather conditions, etc. (that is, the fact that on a cold winter

day it may take more energy to move the temperature inside the home from 70 degrees F to 71 than it does to move it from 60 degrees to 61).

[0120] In step 1544, the server schedules setpoint changes calculated in step 1542 for execution by the thermostat.

[0121] With this system, if actual inside temperature at PT is significantly higher than Temp(PT), then the first changes to setpoints will have no effect (that is, the HVAC system will remain off), and the HVAC system will not begin using energy, until the appropriate time, as shown in **Figure 12**. Similarly, if the server has used conservative predictions to generate ΔT, and the HVAC system runs ahead of the predicted rate of change, the incremental changes in setpoint will delay further increases until the appropriate time in order to again minimize unnecessary energy use, as shown in **Figure 11**.

[0122] **Figure 12(a)** through **12(d)** shows the steps in the preconditioning process as a graph of temperature and time. **Figure 12(a)** shows step 1532, in which inputs target time TT 1552, target temperature Temp(TT) 1554, maximum conditioning interval MTI 1556 and the predicted inside temperature during the period of time the preconditioning event is likely to begin Temp(PT) 1558 are retrieved.

[0123] **Figure 12(b)** shows the initial calculations performed in step 1538, in which expected rate of change in temperature ΔT 1560 inside the home is generated from the ALD and WFD using Temp(TT) 1554 at time TT 1552 as the endpoint.

[0124] **Figure 12(c)** shows how in step 1538 ΔT 1560 is used to determine start time PT 1562 and preconditioning time interval PTI 1564. It also shows how in step 1540 the server can compare PTI with MTI to determine whether or not to instantiate the pre-conditioning program for the thermostat.

[0125] **Figure 12(d)** shows step 1542, in which specific ramped setpoints 1566 are generated. Because of the assumed thermal mass of the system, actual inside temperature at any given time will not correspond to setpoints until some interval after each setpoint change. Thus initial ramped setpoint 1216 may be higher than Temp(PT) 1558, for example.

Ex. 1006.0172

[0126] **Figure 13** shows an example of the types of data that may be used by the server in order to calculate ΔT 1560. Such data may include inside temperature 1572, outside temperature 1574, cloud cover 1576, humidity 1578, barometric pressure 1580, wind speed 1582, and wind direction 1584.

[0127] Each of these data points should be captured at frequent intervals. In the preferred embodiment, as shown in **Figure 13**, the interval is once every 60 seconds.

[0128] **Figure 14** shows application of an embodiment of the subject invention in an actual house. Temperature and setpoints are plotted for the 4-hour period from 4AM to 8AM with temperature on the vertical axis and time on the horizontal axis. The winter nighttime setpoint 1592 is 60 degrees F; the morning setpoint temperature 1594 is 69 degrees F. The outside temperature 1596 is approximately 45 degrees F. The target time TT 1598 for the setpoint change to morning setting is 6:45AM. In the absence of embodiments of the subject invention, the homeowner could program the thermostat to change to the new setpoint at 6:45, but there is an inherent delay between a setpoint change and the response of the temperature inside the home. (In this home on this day, the delay is approximately fifty minutes.) Thus if the homeowner truly desired to achieve the target temperature at the target time, some anticipation would be necessary. The amount of anticipation required depends upon numerous variables, as discussed above.

[0129] After calculating the appropriate slope ΔT 1560 by which to ramp inside temperature in order to reach the target as explained above, the server transmits a series of setpoints 1566 to the thermostat because the thermostat is presumed to only accept discrete integers as program settings. (If a thermostat is capable of accepting finer settings, as in the case of some thermostats designed to operate in regions in which temperature is generally denoted in Centigrade rather than Fahrenheit, which accept settings in half-degree increments, tighter control may be possible.)

[0130] In any event, in the currently preferred embodiment of the subject invention, programming changes are quantized such that the frequency of setpoint

changes is balanced between the goal of minimizing network traffic and the frequency of changes made on the one hand and the desire for accuracy on the other. Balancing these considerations may result in some cases in either more frequent changes or in larger steps between settings. As shown in Fig. 14, the setpoint "stairsteps" from 60 degrees F to 69 degrees F in nine separate setpoint changes over a period of 90 minutes.

[0131] Because the inside temperature 1599 when the setpoint management routine was instantiated at 5:04 AM was above the "slope" and thus above the setpoint, the HVAC system was not triggered and no energy was used unnecessarily heating the home before such energy use was required. Actual energy usage does not begin until 5:49 AM.

[0132] **Figure 15** shows application of an embodiment of the subject invention in a different house during a similar four hour interval. In **Figure 15**, the predicted slope ΔT 1560 is less conservative relative to the actual performance of the home and HVAC system, so there is no off cycling during the preconditioning event – the HVAC system turns on at approximately 4:35 AM and stays on continuously during the event. The home reaches the target temperature Temp(TT) roughly two minutes prior to target time TT.

[0133] **Figure 16** shows a simple prediction table. The first column 1602 lists a series of differentials between outside and inside temperatures. Thus when the outside temperature is 14 degrees and the inside temperature is 68 degrees, the differential is -54 degrees; when the outside temperature is 94 degrees and the inside temperature is 71 degrees, the differential is 13 degrees. The second column 1604 lists the predicted rate of change in inside temperature ΔT 1210 assuming that the furnace is running in terms of degrees Fahrenheit of change per hour. A similar prediction table will be generated for predicted rates of change when the air conditioner is on; additional tables may be generated that predict how temperatures will change when the HVAC system is off.

[0134] Alternatively, the programming of the just-in-time setpoints may be based not on a single rate of change for the entire event, but on a more complex

multivariate equation that takes into account the possibility that the rate of change may be different for events of different durations.

[0135] The method for calculating start times may also optionally take into account not only the predicted temperature at the calculated start time, but may incorporate measured inside temperature data from immediately prior to the scheduled start time in order to update calculations, or may employ more predictive means to extrapolate what inside temperature based upon outside temperatures, etc.

[0136] An additional capability offered by an embodiment of the instant invention is the ability to adapt the programming of the HVAC control system based upon the natural behavior of occupants. Because an embodiment of the instant invention is capable of recording the setpoint actually used at a connected thermostat over time, it is also capable of inferring manual setpoint changes (as, for example, entered by pushing the "up" or "down" arrow on the control panel of the device) even when such overrides of the pre-set program are not specifically recorded as such by the thermostat.

[0137] In order to adapt programming to take into account the manual overrides entered into the thermostat, it is first necessary to determine when a manual override has in fact occurred. Most thermostats, including two-way communicating devices discussed herein, do not record such inputs locally, and neither recognize nor transmit the fact that a manual override has occurred. Furthermore, in a system as described herein, frequent changes in setpoints may be initiated by algorithms running on the server, thereby making it impossible to infer a manual override from the mere fact that the setpoint has changed. It is therefore necessary to deduce the occurrence of such events from the data that an embodiment of the subject invention does have access to.

[0138] **Figure 17** illustrates the currently preferred method for detecting the occurrence of a manual override event. In step 1702, the server retrieves the primary data points used to infer the occurrence of a manual override from one or more databases in overall database structure 300. The data should include each of the following: for the most recent point at which it can obtain such data (time0) the actual

setpoint as recorded at the thermostat at (A0); for the point immediately prior to time0 (time-1), the actual setpoint recorded for the thermostat (A-1); for time0 the setpoint as scheduled by server 106 according to the basic setpoint programming (S0), and for time-1 the setpoint as scheduled by server 106 according to the standard setpoint programming (S-1).

[0139] In step 1704, the server retrieves any additional automated setpoint changes C that have been scheduled for the thermostat by server 106 at time0. Such changes may include algorithmic changes intended to reduce energy consumption, etc.

[0140] In step 1706 the server calculates the difference (dA) between A0 and A-1; for example, if the actual setpoint is 67 degrees at T-1 and 69 at T0, dA is +2; if the setpoint at T-1 is 70 and the setpoint at T0 is 66, dA is –4.

[0141] In step 1708, the server performs similar steps in order to calculate dS, the difference between S0 and S-1. This is necessary because, for example, the setpoint may have been changed because the server itself had just executed a change, such as a scheduled change from "away" to "home" mode. In step 1710 the server evaluates and sums all active algorithms and other server-initiated strategies to determine their net effect on setpoint at time0. For example, if one algorithm has increased setpoint at time0 by 2 degrees as a short-term energy savings measure, but another algorithm has decreased the setpoint by one degree to compensate for expected subjective reactions to weather conditions, the net algorithmic effect sC is +1 degree.

[0142] In step 1712, the server calculates the value for M, where M is equal to the difference between actual setpoints dA, less the difference between scheduled setpoints dS, less the aggregate of algorithmic change sC.

[0143] In step 1714 the server evaluates this difference. If the difference equals zero, the server concludes that no manual override has occurred, and the routine terminates. But if the difference is any value other than zero, then the server concludes that a manual override has occurred. Thus in step 1716 the server logs the occurrence and magnitude of the override to one or more databases in overall database structure 300.

[0144] The process of interpreting a manual override is shown in **Figure 18**. Step 1802 is the detection of an override, as described in detail in **Figure 17**. In step 1804 the server retrieves the stored rules for the subject thermostat 108. Such rules may include weather and time-related inferences such as "if outside temperature is greater than 85 degrees and inside temperature is more than 2 degrees above setpoint and manual override lowers setpoint by 3 or more degrees, then revert to original setpoint in 2 hours," or "if heating setpoint change is scheduled from "away" to "home" within 2 hours after detected override, and override increases setpoint by at least 2 degrees, then change to "home" setting," or the like.

[0145] In step 1806 the server retrieves contextual data required to interpret the manual override. Such data may include current and recent weather conditions, current and recent inside temperatures, etc. This data is helpful because it is likely that manual overrides are at least in part deterministic: that is, that they may often be explained by such contextual data, and that such understanding can permit anticipation of the desire on the part of the occupants to override and to adjust programming accordingly, so as to anticipate and obviate the need for such changes. The amount of data may be for a period of a few hours to as long as several days or more. Recent data may be more heavily weighted than older data in order to assure rapid adaptation to situations in which manual overrides represent stable changes such as changes in work schedules, etc.

[0146] In step 1808 the server retrieves any relevant override data from the period preceding the specific override being evaluated that has not yet been evaluated by and incorporated into the long-term programming and rules engines as described below in **Figure 19**. In step 1810 the server evaluates the override and determines which rule, if any, should be applied as a result of the override.

[0147] In step 1812 the server determines whether to alter the current setpoint as a result of applying the rules in step 1810. If no setpoint change is indicated, then the routine ends. If a setpoint change is indicated, then in step 1814 the server transmits the setpoint change to the thermostat for execution in the home,

and in step 1816 it records that change to one or more databases in overall database structure 300.

[0148] In order to ensure that both the stored rules for interpreting manual overrides and the programming itself continue to most accurately reflect the intentions of the occupants, the server will periodically review both the rules used to interpret overrides and the setpoint scheduling employed. **Figure 19** shows the steps used to incorporate manual overrides into the long-term rules and setpoint schedule. In step 1902 the server retrieves the stored programming for a given thermostat as well as the rules for interpreting overrides for that thermostat.

[0149] In step 1904 the server retrieves the recent override data as recorded in **Figures 17** and **18** to be evaluated for possible revisions to the rules and the programming. In step 1906 the server retrieves the contextual data regarding overrides retrieved in step 1904 (Because the process illustrated in **Figure 19** is not presently expected to be executed as a real-time process, and is expected to be run anywhere from once per day to once per month, the range and volume of contextual data to be evaluated is likely to be greater than in the process illustrated in **Figure 18**.

[0150] In step 1908 the server interprets the overrides in light of the existing programming schedule, rules for overrides, contextual data, etc. In step 1910 the server determines whether, as a result of those overrides as interpreted, the rules for interpreting manual overrides should be revised. If the rules are not to be revised, the server moves to step 1914. If the rules are to be revised, then in step 1912 the server revises the rules and the new rules are stored in one or more databases in overall database structure 300.

[0151] In step 1914 the server determines whether any changes to the baseline programming for the thermostat should be revised. If not, the routine terminates. If revisions are warranted, then in step 1916 the server retrieves from database 900 the permissions the server has to make autonomous changes to settings. If the server has been given permission to make the proposed changes, then in step 1918 the server revises the thermostat's programming and writes the changes to one or more databases in overall database structure 300.

[0152] If the server has not been authorized to make such changes autonomously, then in step 1920 the server transmits the recommendation to change settings to the customer in the manner previously specified by the customer, such as email, text message, personalized website, etc.

[0153] Additional means of implementing an embodiment of the instant invention may be achieved using variations in system architecture. For example, much or even all of the work being accomplished by remote server 106 may also be done by thermostat 108 if that device has sufficient processing capabilities, memory, etc. Alternatively, these steps may be undertaken by a local processor such as a local personal computer, or by a dedicated appliance having the requisite capabilities, such as gateway 112.

[0154] An additional way in which an embodiment of the instant invention can reduce energy consumption with minimal impact on comfort is to vary the turn-on delay enforced by the thermostat after the compressor is turned off. Compressor delay is usually used to protect compressors from rapid cycling, which can physically damage them.

[0155] The ability to predict the rate of change in inside temperature in a given house under varying conditions may also be applied to permit calculation of the effect of different compressor delay settings on inside temperatures, HVAC cycling and energy consumption.

[0156] **Figure 20** shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event. In step 2002, server 106 retrieves parameters such as weather conditions, the current price per kilowatt-hour of electricity, and the state of the electric grid in terms of supply versus demand for the geographic area that includes a given home. In step 2004 server 106 determines whether to instantiate the compressor delay adjustment program for a certain group of homes in response to those conditions.

[0157] In step 2006, server 106 determines whether a specific home is subscribed to participate in compressor delay events. If a given home is eligible, then in step 2008 the server retrieves the parameters needed to specify the compressor

delay routine for that home. These may include user preferences, such as the weather, time of day and other conditions under which the homeowner has elected to permit hysteresis band changes, the maximum length of compressor delay authorized, etc.

[0158] In step 2010 the appropriate compressor delay settings are determined, and in step 2012 the chosen settings are communicated to the thermostat. In step 2014 the server determines if additional thermostats in the given group must still be evaluated. If so, the server returns to step 2006 and repeats the subsequent steps with the next thermostat. If not, the routine ends.

[0159] **Figures 21(a)** through **21(c)** illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature. In **Figure 21(a)**, time is shown on the horizontal axis 2102, and temperature is shown on vertical axis 2104. The setpoint for thermostat 108 is 70 degrees F, which results in the cycling behavior shown for inside temperature 2106. Because compressor delay CD1 2108 is, at approximately 3 minutes, shorter than the natural duration of a compressor off cycle Off1 2110 at approximately 6 minutes for this particular house under the illustrated conditions, the compressor delay has no effect on the operation of the HVAC system.

[0160] Because the hysteresis band operates to so as to maintain the temperature within a range of plus or minus one degree of the setpoint, in the case of air conditioning the air conditioner will switch on when the inside temperature reaches 71 degrees, continue operating until it reaches 69 degrees, then shut off. The system will then remain off until it reaches 71 degrees again, at which time it will again switch on. The percentage of time during which inside temperature is above or below the setpoint will depend on conditions and the dynamic signature of the individual, home. Under the conditions illustrated, the average inside temperature AT1 2112 is roughly equal to the setpoint of 70 degrees.

[0161] **Figure 21(b)** shows how with the same environmental conditions as in **Figure 21(a)**, the cycling behavior of the inside temperature changes when the compressor delay is longer than the natural compressor off cycle Off1 2110. Extended compressor delay CD2 2114 allows inside temperature 2116 to climb above the range

normally enforced by the hysteresis band. Because CD2 is roughly 8 minutes, under the given conditions the inside temperature climbs to approximately 72 degrees before the compressor delay allows the air conditioner to restart and drive the inside temperature back down. But as before, the air conditioner shuts off when the inside temperature reaches 69 degrees. Thus the average temperature is increased from AT1 2112 to AT2 2118. This change will save energy and reduce cycling because it takes less energy to maintain a higher inside temperature with an air conditioner. However, the setpoint reported by the display of the thermostat will continue to be the occupant's chosen setpoint of 70 degrees.

[0162] **Figure 21(c)** shows how the same compressor delay can result in different thermal cycling with different weather conditions. The greater the amount by which outside temperature exceeds inside temperature in the air conditioning context, the more rapidly the inside temperature will increase during an off cycle, and the slower the air conditioner will be able to cool during the on cycle. Thus as compared to **Figure 21(b)**, when the inside temperature increased to roughly 72 degrees during the extended compressor delay of 8 minutes, a higher outside temperature will cause the inside temperature to increase faster, which results in a peak temperature of roughly 73 degrees, and in wider temperature cycling 2120. The average inside temperature consequently increases from AT(2) 2118 to AT(3) 2122.

[0163] It should be noted that the shape of the actual waveform will most likely not be sinusoidal, but for ease of illustration it is sometimes be presented as such in the figures.

[0164] Residential air conditioning is a major component of peak load. The traditional approach to dealing with high demand on hot days is to increase supply – build new powerplants, or buy additional capacity on the spot market. But because reducing loads has come to be considered by many to be a superior strategy for matching electricity supply to demand when the grid is stressed, the ability to shed load by turning off air conditioners during peak events has become a useful tool for managing loads. A key component of any such system is the ability to document and verify that a given air conditioner has actually turned off. Data logging hardware can

accomplish this, but due to the cost is usually only deployed for statistical sampling. An embodiment of the instant invention provides a means to verify demand response without additional hardware such as a data logger.

[0165] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures. This will permit remote verification of load shedding by the air conditioner without directly measuring or recording the electrical load drawn by the air conditioner.

[0166] **Figure 22** shows the steps followed in order to initiate air conditioner shutoff. When a summer peak demand situation occurs, the utility will transmit an email 2202 or other signal to server 106 requesting a reduction in load. Server 106 will determine 2204 if the user's house is served by the utility seeking reduction; determine 2206 if a given user has agreed to reduce peak demand; and determine 2208 if a reduction of consumption by the user is required or desirable in order to achieve the reduction in demand requested by the utility. The server will transmit 2210 a signal to the user's thermostat 108 signaling the thermostat to shut off the air conditioner 110.

[0167] **Figure 23** shows the steps followed in order to verify that the air conditioner has in fact been shut off. Server 106 will receive and monitor 2302 the temperature readings sent by the user's thermostat 108. The server then calculates 2304 the temperature reading to be expected for that thermostat given inputs such as current and recent outside temperature, recent inside temperature readings, the calculated thermal mass of the structure, temperature readings in other houses, etc. The server will compare 2306 the predicted reading with the actual reading. If the

server determines that the temperature inside the house is rising at the rate predicted if the air conditioning is shut off, then the server confirms 2308 that the air conditioning has been shut off. If the temperature reading from the thermostat shows no increase, or significantly less increase than predicted by the model, then the server concludes 2310 that the air conditioning was not switched off, and that no contribution to the demand response request was made.

[0168] For example, assume that on at 3PM on date Y utility X wishes to trigger a demand reduction event. A server at utility X transmits a message to the server at demand reduction service provider Z requesting W megawatts of demand reduction. The demand reduction service provider server determines that it will turn off the air conditioner at house A in order to achieve the required demand reduction. At the time the event is triggered, the inside temperature as reported by the thermostat in house A is 72 degrees F. The outside temperature near house A is 96 degrees Fahrenheit. The inside temperature at House B, which is not part of the demand reduction program, but is both connected to the demand reduction service server and located geographically proximate to House A, is 74F. Because the air conditioner in house A has been turned off, the temperature inside House A begins to rise, so that at 4PM it has increased to 79F. Because the server is aware of the outside temperature, which remains at 96F, and of the rate of temperature rise inside house A on previous days on which temperatures have been at or near 96F, and the temperature in house B, which has risen only to 75F because the air conditioning in house B continues to operate normally, the server is able to confirm with a high degree of certainty that the air conditioner in house A has indeed been shut off.

[0169] In contrast, if the HVAC system at house A has been tampered with, so that a demand reduction signal from the server does not actually result in shutting off the air conditioner in house A, when the server compares the rate of temperature change at house A against the other data points, the server will receive data inconsistent with the rate of increase predicted. As a result, it will conclude that the air conditioner has not been shut off in house A as expected, and may not credit house A with the financial credit that would be associated with demand reduction compliance, or

may trigger a business process that could result in termination of house A's participation in the demand reduction program.

[0170] **Figure 24** illustrates the movement of signals and information between the components of one embodiment of the subject invention to trigger and verify a demand reduction response. Where demand response events are undertaken on behalf of a utility by a third party, participants in the communications may include electric utility server 2400, demand reduction service server 106, and thermostat 108. In step 2402 the electric utility server 2400 transmits a message to demand reduction service server 106 requesting a demand reduction of a specified duration and size. Demand reduction service server 106 uses database 300 to determine which subscribers should be included in the demand reduction event. For each included subscriber, the server then sends a signal 2404 to the subscriber's thermostat 108 instructing it (a) to shut down at the appropriate time or (b) to allow the temperature as measured by the thermostat to increase to a certain temperature at the specified time, depending upon the agreement between the homeowner and the utility and/or demand reduction aggregator.

[0171] The server then receives 2406 temperature signals from the subscriber's thermostat. At the conclusion of the demand reduction event, the server transmits a signal 2408 to the thermostat permitting the thermostat to signal its attached HVAC system to resume cooling, if the system has been shut off, or to reduce the target temperature to its pre-demand reduction setting, if the target temperature was merely increased. If thermostat 108 is capable of storing scheduling information, these instructions may be transmitted prior to the time they are to be executed and stored locally. After determining the total number of subscribers actually participating in the DR event, the server then calculates the total demand reduction achieved and sends a message 2410 to the electric utility confirming such reduction.

[0172] Additional steps may be included in the process. For example, if the subscriber has previously requested that notice be provided when a peak demand reduction event occurs, the server will also send an alert, which may be in the form of an email or text message or an update to the personalized web page for that user, or

both. If the server determines that a given home has (or has not) complied with the terms of its demand reduction agreement, the server may send a message to the subscriber confirming that fact.

[0173] It should also be noted that in some climate zones, peak demand events occur during extreme cold weather rather than (or in addition to) during hot weather. The same process as discussed above could be employed to reduce demand by shutting off electric heaters and monitoring the rate at which temperatures fall.

[0174] It should also be noted that the peak demand reduction service can be performed directly by an electric utility, so that the functions of server 106 can be combined with the functions of server 2400.

[0175] The system installed in a subscriber's home may optionally include additional temperature sensors at different locations within the building. These additional sensors may we connected to the rest of the system via a wireless system such as 802.11 or 802.15.4, or may be connected via wires. Additional temperature and/or humidity sensors may allow increased accuracy of the system, which can in turn increase user comfort, energy savings or both.

[0176] The bi-directional communication between server 106 and thermostat 108 will also allow thermostat 108 to regularly measure and send to server 106 information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0177] For example, **Figure 25a** shows a graph of inside temperature and outside temperature for a 24-hour period in House A, assuming no HVAC activity. House A has double-glazed windows and is well-insulated. When outside temperature 2502 increases, inside temperature 2504 follows, but with significant delay because of the thermal mass of the building.

[0178] **Figure 25b** shows a graph of inside temperature and outside temperature for the same 24-hour period in House B. House B is identical to House A except that it (i) is located a block away and (ii) has single-glazed windows and is

poorly insulated. Because the two houses are so close to each other, outside temperature 2502 is the same in **Figure 25a** and **Figure 25b**. But the lower thermal mass of House B means that the rate at which the inside temperature 2506 changes in response to the changes in outside temperature is much greater.

[0179] The differences in thermal mass will affect the cycling behavior of the HVAC systems in the two houses as well. **Figure 26a** shows a graph of inside temperature and outside temperature in House A for the same 24-hour period as shown in **Figure 6a**, but assuming that the air conditioning is being used to try to maintain an internal temperature of 70 degrees. Outside temperatures 2502 are the same as in **Figures 25a** and **25b**. Inside temperature 2608 is maintained within the range determined by thermostat 108 by the cycling of the air conditioner. Because of the high thermal mass of the house, the air conditioning does not need to run for very long to maintain the target temperature, as shown by shaded areas 2610.

[0180] **Figure 26b** shows a graph of inside temperature 2612 and outside temperature 2502 for the same 24-hour period in House B, assuming use of the air conditioning as in **Figure 26a**. Because of the lower thermal mass of House B, the air conditioning system in House B has to run longer in order to maintain the same target temperature range, as shown by shaded areas 2614.

[0181] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature and differences between inside and outside temperatures. Because the server 106 will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0182] The server will also record the responses of each house to changes in outside conditions and cycling behavior over time. That will allow the server to diagnose problems as and when they develop. For example, **Figure 27a** shows a graph of outside temperature 2702, inside temperature 2704 and HVAC cycle times 2706 in House A for a specific 24-hour period on date X. Assume that, based upon comparison of the performance of House A on date X relative to House A's historical performance, and in comparison to the performance of House A relative to other nearby houses on date X, the HVAC system in House A is presumed to be operating at normal efficiency, and that House A is in the 86th percentile as compared to those other houses.

[0183] **Figure 27b** shows a graph of outside temperature 2708, inside temperature 2710 and HVAC cycle times 2712 in House A for the 24-hour period on date X+1. House A's HVAC system now requires significantly longer cycle times in order to try to maintain the same internal temperature. If those longer cycle times were due to higher outside temperatures, those cycle times would not indicate the existence of any problems. But because server 106 is aware of the outside temperature, the system can eliminate that possibility as an explanation for the higher cycle times.

[0184] Because server 106 is aware of the cycle times in nearby houses, it can determine that, for example, on date X+1 the efficiency of House A is only in the 23rd percentile. The server will be programmed with a series of heuristics, gathered from predictive models and past experience, correlating the drop in efficiency and the time interval over which it has occurred with different possible causes. For example, a 50% drop in efficiency in one day may be correlated with a refrigerant leak, especially if followed by a further drop in efficiency on the following day. A reduction of 10% over three months may be correlated with a clogged filter. Based upon the historical data recorded by the server, the server 106 will be able to alert the homeowner that there is a problem and suggest a possible cause.

[0185] Because the system will be able to calculate effective thermal mass, it will be able to determine the cost effectiveness of strategies such as pre-cooling for specific houses under different conditions. **Figure 28a** shows a graph of outside

temperature 2802, inside temperature 2804 and HVAC cycling times 2806 in House A for a specific 24-hour period on date Y assuming that the system has used a pre-cooling strategy to avoid running the air conditioning during the afternoon, when rates are highest. Because House A has high thermal mass, the house is capable of "banking" cooling, and energy consumed during off-peak hours is in effect stored, allowing the house to remain cool even when the system is turned off. Temperatures keep rising during the period the air conditioning is off, but because thermal mass is high, the rate of increase is low, and the house is still comfortable six hours later.

[0186] Although the pre-cooling cycle time in a given home may be relatively long, the homeowner may still benefit if the price per kilowatt during the morning pre-cooling phase is lower than the price during the peak load period. **Figure 28b** shows a graph of the same outside temperature 2802 in House B as in House A in **Figure 28a** for the same 24-hour period and using the same pre-cooling strategy as shown by cycling times 2806. But because House B has minimal thermal mass, using additional electricity in order to pre-cool the house does not have the desired effect; inside temperature 2808 warms up so fast that the cooling that had been banked is quickly lost. Thus the system will recommend that House A pre-cool in order to save money, but not recommend pre-cooling for House B.

[0187] The system can also help compensate for anomalies such as measurement inaccuracies due to factors such as poor thermostat location. It is well known that thermostats should be placed in a location that will be likely to experience "average" temperatures for the overall structure, and should be isolated from windows and other influences that could bias the temperatures they "see." But for various reasons, not all thermostat installations fit that ideal. **Figure 29a** shows a graph of outside temperature 2902, the actual average inside temperature for the entire house 2904, and inside temperature as read by the thermostat 2906 in House C for a specific 24-hour period on September 15th, assuming that the thermostat is located so that for part of the afternoon on that day the thermostat is in direct sunlight.

[0188] Until the point at which the sun hits the thermostat, the average inside temperature and temperature as read by the thermostat track very closely. But when

the direct sunlight hits the thermostat, the thermostat and the surrounding area can heat up, causing the internal temperature as read by the thermostat to diverge significantly from the average temperature for the rest of the house. A conventional thermostat has no way of distinguishing this circumstance from a genuinely hot day, and will both over-cool the rest of the house and waste considerable energy when it cycles the air conditioner in order to reduce the temperature as sensed by the thermostat.

[0189] If the air conditioning is turned off, this phenomenon will manifest as a spike in temperature as measured by the thermostat. If the air conditioning is turned on (and has sufficient capacity to respond to the distorted temperature signal caused by the sunlight), this phenomenon will likely manifest as relatively small changes in the temperature as sensed by the thermostat, but significantly increased HVAC usage (as well as excessively lowered temperatures in the rest of the house, but this result may not be directly measured in a single sensor environment).

[0190] An embodiment of the system, in contrast, has multiple mechanisms that will allow it to correct for such distortions. First, because an embodiment of the subject system compares the internal readings from House C with the external temperature, it will be obvious that the rise in temperature at 4:00PM is not correlated with a corresponding change in outside temperature. Second, because the system is also monitoring the readings from the thermostat in nearby House D, which (as shown in **Figure 29b**) is exposed to the same outside temperature 602, but has no sudden rise in measured internal afternoon temperature 2908, the system has further validation that the temperature increase is not caused by climatic conditions. And finally, because the system has monitored and recorded the temperature readings from the thermostat in House C for each previous day, and has compared the changing times of the aberration with the progression of the sun, the system can distinguish the patterns likely to indicate solar overheating from other potential causes.

[0191] **Figure 30** illustrates the steps involved in calculating comparative thermal mass, or the thermal mass index. In step 3002, the server retrieves climate data related to home X. Such data may include current outside temperature, outside

temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3004, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0192] In step 3006, the server retrieves data regarding recent temperature readings as recorded by the thermostat in home X. In step 3008, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0193] In step 3010, the server retrieves the current inside temperature reading as transmitted by the thermostat. In step 3012, the server calculates the thermal mass index for the home under those conditions; that is, for example, it calculates the likely rate of change for internal temperature in home X from a starting point of 70 degrees when the outside temperature is 85 degrees at 3:00PM on August 10th when the wind is blowing at 5 mph from the north and the sky is cloudy. The server accomplishes this by applying a basic algorithm that weighs each of these external variables as well as variables for various characteristics of the home itself (such as size, level of insulation, method of construction, etc.) and data from other houses and environments.

[0194] **Figure 31** illustrates the steps involved in diagnosing defects in the HVAC system for specific home X. In step 3102, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3104, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

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[0195] In step 3106, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3108, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data. In step 3110, the server retrieves comparative data from other houses that have thermostats that also report to the server.

[0196] Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses. In step 3112, the server calculates the current relative efficiency of home X as compared to other homes. Those comparisons will take into account differences in size, location, age, etc in making those comparisons.

[0197] The server will also take into account that comparative efficiency is not absolute, but will vary depending on conditions. For example, a house that has extensive south-facing windows is likely to experience significant solar gain. On sunny winter days, that home will appear more efficient than on cloudy winter days. That same house will appear more efficient at times of day and year when trees or overhangs shade those windows than it will when summer sun reaches those windows. Thus the server will calculate efficiency under varying conditions.

[0198] In step 3114 the server compares the HVAC system's efficiency, corrected for the relevant conditions, to its efficiency in the past. If the current efficiency is substantially the same as the historical efficiency, the server concludes 3116 that there is no defect and the diagnostic routine ends. If the efficiency has changed, the server proceeds to compare the historical and current data against patterns of changes known to indicate specific problems. For example, in step 3118, the server compares that pattern of efficiency changes against the known pattern for a clogged air filter, which is likely to show a slow, gradual degradation over a period of weeks or even months.

[0199] If the pattern of degradation matches the clogged filter paradigm, the server creates and transmits to the homeowner a message 3120 alerting the homeowner to the possible problem. If the problem does not match the clogged filter paradigm, the system compares 3122 the pattern to the known pattern for a refrigerant leak, which is likely to show a degradation over a period of a few hours to a few days. If the pattern of degradation matches the refrigerant leak paradigm, the server creates and transmits to the homeowner a message 3124 alerting the homeowner to the possible problem.

[0200] If the problem does not match the refrigerant leak paradigm, the system compares 3126 the pattern to the known pattern for an open window or door, which is likely to show significant changes for relatively short periods at intervals uncorrelated with climatic patterns. If the pattern of degradation matches the open door/window paradigm, the server creates and transmits to the homeowner a message 3128 alerting the homeowner to the possible problem. If the problem does not match the refrigerant leak paradigm, the system continues to step through remaining know patterns N 3130 until either a pattern is matched 3132 or the list has been exhausted without a match 3134.

[0201] **Figure 32** illustrates the steps involved in diagnosing inaccurate thermostat readings due to improper location. In step 3202, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3204, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0202] In step 3206, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3208, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is

insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0203] In step 3210, the server retrieves comparative data from other houses that have thermostats that also report to the server. Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses.

[0204] In step 3212, the server calculates the expected thermostat temperature reading based upon the input data. In step 3214, the server compares the predicted and actual values. If the calculated and actual values are at least roughly equivalent, the server concludes 3216 that there is no thermostat-related anomaly. If the calculated and actual values are not roughly equivalent, the server retrieves additional historical information about past thermostat readings in step 3218.

[0205] In step 3220, the server retrieves solar progression data, i.e., information regarding the times at which the sun rises and sets on the days being evaluated at the location of the house being evaluated, and the angle of the sun at that latitude, etc. In step 3222, the server compares the characteristics of the anomalies over time, to see if, for example, abnormally high readings began at 3:06 on June 5th, 3:09 on June 6th, 3:12 on June 7th, and the solar progression data suggests that at the house being analyzed, that sun would be likely to reach a given place in that house three minutes later on each of those days.

[0206] If the thermostat readings do not correlate with the solar progression data, the server concludes 3224 that the sun is not causing the distortion by directly hitting the thermostat. If the thermostat readings do correlate with solar progression, the server then calculates 3226 the predicted duration of the distortion caused by the sun.

[0207] In step 3228, the server calculates the appropriate setpoint information to be used by the thermostat to maintain the desired temperature and correct for the distortion for the expected length of the event. For example, if the uncorrected setpoint during the predicted event is 72 degrees, and the sun is expected

to elevate the temperature reading by eight degrees, the server will instruct the thermostat to maintain a setpoint of 80 degrees. In step 3230, the server sends the homeowner a message describing the problem.

[0208] One or more embodiments of the invention may be used to implement additional energy savings by implementing small, repeated changes in setpoint. Because energy consumption is directly proportional to setpoint – that is, the further a given setpoint diverges from the balance point (the natural inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by any strategy that over a given time frame lowers the average heating setpoint or raises the cooling setpoint.

[0209] It is therefore possible to save energy by adopting a strategy that takes advantage of human insensitivity to slow temperature ramping by incorporating a user's desired setpoint within the range of the ramp, but setting the average target temperature below the desired setpoint in the case of heating, and above it in the case of cooling. For example, a ramped summer setpoint that consisted of a repeated pattern of three phases of equal length set at 72°F, 73°F, and 74°F would create an effective average setpoint of 73°F, but would generally be experienced by occupants as yielding at least roughly equivalent comfort as in a room set at a constant 72°F. Energy savings resulting from this approach have been shown to be in the range of 4-6%.

[0210] Embodiments of the invention can automatically generate optimized ramped setpoints that could save energy without compromising the comfort of the occupants. It would also be advantageous to create a temperature control system that could incorporate adaptive algorithms that could automatically determine when the ramped setpoints should not be applied due to a variety of exogenous conditions that make application of such ramped setpoints undesirable.

[0211] **Figure 33** represents the conventional programming of a thermostat and the resulting behavior of a home's HVAC system in the air conditioning context. The morning setpoint 3302 of 74 degrees remains constant from midnight until 9:00AM, and the inside temperature 3304 varies more or less within the limits of the

hysteresis band during that entire period. When the setpoint changes to 80 degrees 3306, the inside temperature 3308 varies within the hysteresis band around the new setpoint, and so on. Whether the average temperature is equal to, greater or less than the nominal setpoint will depend on weather conditions, the dynamic signature of the structure, and the efficiency and size of the HVAC system. But in most cases the average temperature will be at least roughly equivalent to the nominal setpoint.

[0212] **Figure 34** represents implementation of a three-phase ramped setpoint derived from the same user preferences as manifested by the settings shown in **Figure 33**. Thus the user-selected setpoint for the morning is still 74 degrees, and is reflected in the setpoint 3404 at the start of each three-step cycle, but because (in the air conditioning context) the setpoint requested by the user is the lowest of the three discrete steps, rather than the middle step, the average setpoint will be one degree higher 3402, and the resulting average inside temperature will be roughly one degree warmer than the average temperature without use of the ramped setpoints, thereby saving energy.

[0213] In the currently preferred embodiment, the implementation of the ramped setpoints may be dynamic based upon both conditions inside the structure and other planned setpoint changes. Thus, for example, the ramped setpoints 3406, 3408 and 3410 may be timed so that the 9AM change in user-determined setpoint from 74 degrees to 80 degrees is in effect anticipated, and the period in which the air conditioner is not used can be extended prior to the scheduled start time for the less energy-intensive setpoint. Similarly, because the server 106 is aware that a lower setpoint will begin at 5PM. The timing can be adjusted to avoid excessively warm temperatures immediately prior to the scheduled setpoint change, which could cause noticeable discomfort relative to the new setpoint if the air conditioner is incapable of quickly reducing inside temperature on a given day based upon the expected slope of inside temperatures at that time 3412.

[0214] In order to implement such ramped setpoints automatically, algorithms may be created. These algorithms may be generated and/or executed as instructions on remote server 106 and the resulting setpoint changes can be transmitted to a given

thermostat on a just-in-time basis or, if the thermostat 108 is capable of storing future settings, they may be transferred in batch mode to such thermostats. Basic parameters used to generate such algorithms include:

[0215] the number of discrete phases to be used;

[0216] the temperature differential associated with each phase; and

[0217] the duration of each phase

[0218] In order to increase user comfort and thus maximize consumer acceptance, additional parameters may be considered, including:

[0219] time of day

[0220] outside weather conditions

[0221] recent history of manual inputs

[0222] recent pre-programmed setpoint changes.

[0223] Time of day may be relevant because, for example, if the home is typically unoccupied at a given time, there is no need for perceptual programming. Outside weather is relevant because comfort is dependent not just on temperature as sensed by a thermostat, but also includes radiant differentials. On extremely cold days, even if the inside dry-bulb temperature is within normal comfort range, radiant losses due to cold surfaces such as single-glazed windows can cause subjective discomfort; thus on such days occupants may be more sensitive to ramping. Recent manual inputs (e.g., programming overrides) may create situations in which exceptions should be taken; depending on the context, recent manual inputs may either suspend the ramping of setpoints or simply alter the baseline temperature from which the ramping takes place.

[0224] **Figure 35** shows the steps used in the core ramped setpoint algorithm in the context of a remotely managed thermostat system. In step 3502 the application determines whether to instantiate the algorithm based upon external scheduling criteria. In step 3504 the application running on a remote server retrieves from the thermostat the data generated by or entered into the thermostat, including current temperature settings, HVAC status and inside temperature. The algorithm performs preliminary logical tests at that point to determine whether further processing is

required. For example, in the heating context, if the inside temperature as reported by the thermostat 108 is more than 1 degree higher than the current setpoint, the algorithm may determine that running the ramped setpoint program will have no effect and therefore terminate.

[0225] In step 3506 the algorithm advances to the next phase from the most recent phase; i.e., if the algorithm is just starting, the phase changes from "0" to "1"; if it has just completed the third phase of a three-phase ramp, the phase will change from "2" to "0". In step 3508 the application determines if the current phase is "0". If it is, then in step 3510 the algorithm determines whether current setpoint equals the setpoint in the previous phase. If so, which implies no manual overrides or other setpoint adjustments have occurred during the most recent phase, then in step 3512 the algorithm sets the new setpoint back to the previous phase "0" setpoint. If not, then in step 3514, the algorithm keeps the current temperature setting as setpoint for this new phase. In step 3516, the algorithm logs the resulting new setpoint as the new phase "0" setpoint for use in subsequent phases.

[0226] Returning to the branch after step 3508, if the current phase at that point is not phase "0", then in step 3520, the algorithm determines whether the current setpoint is equal to the setpoint temperature in the previous phase. If not, which implies setpoints have been adjusted by the house occupants, thermostat schedules, or other events, then in step 3522, the application resets the phase to "0", resets the new setpoint associated with phase "0" to equal the current temperature setting, and sets the current setting to that temperature. Alternatively, if the current temperature setting as determined in step 3520 is equal to the setpoint in the previous phase, then in step 3524 new setpoint is made to equal current setpoint plus the differential associated with each phase change. In step 3526 the "previous-phase setpoint" variable is reset to equal the new setpoint in anticipation of its use during a subsequent iteration.

[0227] **Figure 36** shows one embodiment of the overall control application implementing the algorithm described in **Figure 35**. In step 3602, the control application retrieves the current setting from the thermostat. In step 3604, the setting is logged in database 300. In step 3606, the control program determines whether other

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algorithms that have higher precedence than the ramped setpoint algorithm are to be run. If another algorithm is to be run prior to the ramped setpoint algorithm, then the other program is executed in step 3608. If there are no alternate algorithms that should precede the ramped setpoint application then in step 1310, the control program determines whether the thermostat has been assigned to execute the ramped setpoint program. If not, the control program skips the remaining actions in the current iteration. If the program is set to run, then in step 3612 the algorithm retrieves from database 300 the rules and parameters governing the implementation of the algorithm for the current application of the program.

[0228] In step 3614, the algorithm determines whether one or more conditions that preclude application of the algorithm, such as extreme outside weather conditions, whether the home is likely to be occupied, etc. If any of the exclusionary conditions apply, the application skips execution of the ramped setpoint algorithm for the current iteration. If not, the application proceeds to step 3616 in which the application determines whether the setpoint has been altered by manual overrides, thermostat setback schedule changes, or other algorithms as compared to the previous value as stored in database 300. If setpoint has been altered, the application proceeds to step 3620 discussed below.

[0229] In step 3618, the program described in **Figure 35** is executed. In step 3620, the application resets the phase to "0". Certain temperature setting variables are reset in anticipation of their use in subsequent phases. These variables include the new phase 0 temperature setting which is anchored to the current actual temperature setting, and the new previous-phase setpoint which will be used for identifying setpoint overrides in the subsequent phase.

[0230] In step 3622, the system records the changes to the thermostat settings to database 300. In step 3624, the system records the changes to the phase status of the algorithm to database 300. In step 3626, the application determines whether the new temperature setting differs from the current setting. If they are the same, the application skips applying changes to the thermostat. If they are different, then in step 3628, the application transmits revised settings to the thermostat. In step

3630, the application then hibernates for the specified duration until it is invoked again by beginning at step 3602 again.

[0231] An embodiment of the subject invention may also be used to detect occupancy through the use of software related to electronic devices located inside the conditioned structure, such as the browser running on computer or other device 104. **Figure 37** represents the screen of a computer or other device 104 using a graphical user interface connected to the Internet. The screen shows that a browser 3700 is displayed on computer 104. In one embodiment, a background application installed on computer 104 detects activity by a user of the computer, such as cursor movement, keystrokes or otherwise, and signals the application running on server 106 that activity has been detected. Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; (b) signal the background application running on computer 104 to trigger a software routine that instantiates a pop-up window 3702 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. The user can respond by clicking the cursor on "yes" button 3704 or "No" button 3706. Equilvalent means of signalling activity may be employed with interactive television programming, gaming systems, etc.

[0232] **Figure 38** is a flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 3802, computer 104 transmits a message to server 106 via the Internet indicating that there is user activity on computer 104. This activity can be in the form of keystrokes, cursor movement, input via a television remote control, etc. In step 3804 the application queries database 300 to retrieve setting information for the HVAC system. In step 3806 the application determines whether the current HVAC program is intended to apply when the home is occupied or unoccupied.

[0233] If the HVAC settings then in effect are intended to apply for an occupied home, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step

3808 the application will retrieve from database 300 the user's specific preferences for how to handle this situation. If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 3816, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 3810 the application transmits a command to computer 104 directing the browser to display a message informing the user that the current setting assumes an unoccupied house and asking the user in step 3812 to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 3814 the application will write to database 300 the fact that the users has so elected and terminate. If the user elects to change the setting, then in step 3816 the application transmits the revised setpoint to the thermostat. In step 3814 the application writes the updated setting information to database 300.

[0234] **Figure 39** is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system. In step 3902 computer 104 transmits to server 106 information regarding the type of activity detected on computer 104. Such information could include the specific program or channel being watched if, for example, computer 104 is used to watch television. The information matching, for example, TV channel 7 at 4:00 PM on a given date to specific content may be made by referring to Internet-based or other widely available scheduling sources for such content. In step 3904 server 106 retrieves from database 300 previously logged data regarding viewed programs. In step 3906 server 106 retrieves previously stored data regarding the residents of the house.

[0235] For example, upon initiating the service, one or more users may have filled out online questionnaires sharing their age, gender, schedules, viewing preferences, etc. In step 3908, server 106 compares the received information about

user activity to previously stored information retrieved from database 300 about the occupants and their viewing preferences. For example, if computer 104 indicates to server 106 that the computer is being used to watch golf, the server may conclude that an adult male is watching; if computer 104 indicates that it is being used to watch children's programming, server 106 may conclude that a child is watching.

[0236] In step 3910 the server transmits a query to the user in order to verify the match, asking, in effect, "Is that you Bob?" In step 3912, based upon the user's response, the application determines whether the correct user has been identified. If the answer is no, then the application proceeds to step 3916. If the answer is yes, then in step 3914 the application retrieves the temperature settings for the identified occupant. In step 3916 the application writes to database 300 the programming information and information regarding matching of users to that programming.

[0237] In an alternative embodiment, the application running on computer 104 may respond to general user inputs (that is, inputs not specifically intended to instantiate communication with the remote server) by querying the user whether a given action should be taken. For example, in a system in which the computer 104 is a web-enabled television or web-enabled set-top device connected to a television as a display, software running on computer 104 detects user activity, and transmits a message indicating such activity to server 106. The trigger for this signal may be general, such as changing channels or adjusting volume with the remote control or a power-on event. Upon receipt by server 106 of this trigger, server 106 transmits instructions to computer 104 causing it to display a dialog box asking the user whether the user wishes to change HVAC settings.

[0238] Additional functionality is also envisioned as part of different embodiments of the invention. For example, information from historic data may be used to predict how long it will take a user to reach home from the current coordinates, and the estimated arrival time may be used to calculate optimal cycling strategies for the HVAC system. In addition, information about traffic conditions may be integrated into these calculations, so that the geospatial data relative to mobile device 105 may indicate that a user is taking his or her normal route, but because of a traffic jam, is

likely to come home later than would otherwise be expected. The characteristics of a given location may be used to infer arrival times as well. For example, if the geospatial data indicates that the user of mobile device 105 has arrived at the supermarket on his way home, a delay of 20 minutes is likely, whereas if the user has parked at a restaurant, the delay is likely to be one hour.

[0239] It is also possible to incorporate more sophisticated heuristics in incorporating the varying preferences of multiple occupants of a given home or other structure. For example, rules can be structured so that User #1's preferences control during the heating season, but not during the cooling season; User #2's preferences might control during certain times of the day but not others; User #3's preferences amy take precedence whenever they result in a more energy efficient strategy, but not when they result in increased energy use, and so on.

[0240] While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, that the invention may be carried out in other ways without departing from the true spirit and scope. These and other equivalents are intended to be covered by the following claims:

WHAT IS CLAIMED IS:

1. A method for varying temperature setpoints for an HVAC system comprising:

accessing stored data comprising a plurality of internal temperature measurements taken within a structure and a plurality of outside temperature measurements relating to temperatures outside the structure;

using the stored data to predict a temperature inside the structure in response to at least changes in the outside temperatures;

determining with one or more computer processors, the geographic location of a mobile electronic device that is connected to a network;

associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices;

determining with one or more computer processors, whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device;

using route data to determine whether a user of the mobile electronic device is traveling to said structure;

using traffic data to predict a length of time for a user of said mobile device to reach said structure; and

adjusting with one or more computer processors, the temperature setpoint on said controller for an HVAC system for said structure based upon said predicted length of time for a user of the mobile device to reach said structure, said predicted temperature inside said structure, and whether or not said structure is deemed to be occupied.

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

ABSTRACT OF THE DISCLOSURE

Embodiments of the invention comprise systems and methods for using the geographic location of networked consumer electronics devices as indications of occupancy of a structure for purposes of automatically adjusting the temperature setpoint on a thermostatic HVAC control. At least one thermostat is located inside a structure and is used to control an HVAC system in the structure. At least one mobile electronic device is used to indicate the state of occupancy of the structure. The state of occupancy is used to alter the setpoint on the thermostatic HVAC control to reduce unneeded conditioning of unoccupied spaces.

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SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Cross-Reference to Related Applications

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet, or any correction thereto, are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to the use of thermostatic HVAC and other energy management controls that are connected to a computer network. More specifically, the present invention pertains to the use of geographic movement of network-connected mobile devices to occupancy to inform an energy management system, to provide enhanced efficiency, and to verify demand response.

Description of the Related Art

[0003] Heating and cooling systems for buildings (heating, ventilation and cooling, or HVAC systems) have been controlled for decades by thermostats. At the most basic level, a thermostat includes a means to allow a user to set a desired temperature, a means to sense actual temperature, and a means to signal the heating and/or cooling devices to turn on or off in order to try to change the actual temperature to equal the desired temperature. The most basic versions of thermostats use components such as a coiled bi-metallic spring to measure actual temperature and a mercury switch that opens or completes a circuit when the spring coils or uncoils with temperature changes. More recently, electronic digital thermostats have become prevalent. These thermostats use solid-state devices such as thermistors or thermal diodes to measure temperature, and microprocessor-based circuitry to control the switch and to store and operate based upon user-determined protocols for temperature vs. time.

[0004] These programmable thermostats generally offer a very restrictive user interface, limited by the cost of the devices, the limited real estate of the small wall-mounted boxes, and the inability to take into account more than two variables: the desired temperature set by the user, and the ambient temperature sensed by the thermostat. Users can generally only set one series of commands per day, and in order to change one parameter (e.g., to change the late-night temperature) the user often has to cycle through several other parameters by repeatedly pressing one or two buttons.

[0005] Because the interface of programmable thermostats is so poor, the significant theoretical savings that are possible with them (sometimes cited as 25% of heating and cooling costs) are rarely realized. In practice, studies have found that more than 50% of users never program their thermostats at all. Significant percentages of the thermostats that are programmed are programmed sub-optimally, in part because, once programmed, people tend to not to re-invest the time needed to change the settings very often.

[0006] A second problem with standard programmable thermostats is that they represent only a small evolutionary step beyond the first, purely mechanical thermostats. Like the first thermostats, they only have two input signals - ambient temperature and the preset desired temperature. The entire advance with programmable thermostats is that they can shift between multiple present temperatures at different times without real-time involvement of a human being.

[0007] Because most thermostats control HVAC systems that do not offer infinitely variable output, traditional thermostats are designed to permit the temperature as seen by the thermostat to vary above and below the setpoint to prevent the HVAC system from constantly and rapidly cycling on and off, which is inefficient and harmful to the HVAC system. The temperature range in which the thermostat allows the controlled environment to drift is known as both the dead zone and, more formally, the hysteresis zone. The hysteresis zone is frequently set at +/- 1 degree Fahrenheit. Thus if the setpoint is 68 degrees, in the heating context the thermostat will allow the

inside temperature to fall to 67 degrees before turning the heating system on, and will allow it to rise to 69 degrees before turning it off again.

[0008] As energy prices rise, more attention is being paid to ways of reducing energy consumption. Because energy consumption is directly proportional to setpoint - that is, the further a given setpoint diverges from the balance point (the inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by virtually any strategy that over a given time frame lowers the average heating setpoint or raises the average cooling setpoint. Conventional programmable thermostats allow homeowners to save money and energy by pre-programming setpoint changes based upon comfort or schedule. For example, in the summer, allowing the setpoint to rise by several degrees (or even shutting off the air conditioner) when the home is unoccupied will generally save significantly on energy. But such thermostats have proven to be only minimally effective in practice. Because they have such primitive user interfaces, they are difficult to program, and so many users never bother at all, or set them up once and do not alter the programming even if their schedules change.

[0009] In the hotel industry, the heating and cooling decisions made in hundred or even thousands of individual rooms with independently controlled HVAC systems are aggregated into a single energy bill, so hotel owners and managers are sensitive to energy consumption by those systems. Hotel guests often turn the air conditioner to a low temperature setting and then leave the room for hours at a time, thereby wasting considerable energy. An approach commonly used outside of the United States to combat this problem is to use a keycard to control the HVAC system, such that guests place the keycard into a slot mounted on the wall near the door of the room which then triggers the lights and HVAC system to power up, and turn them off when the guest removes the card upon leaving the room. However, because most hotels give each guest two cards, it is easy to simply leave the extra card in the slot, thus defeating the purpose of the system. Recently, systems have been introduced in which a motion sensor is connected to the control circuitry for the HVAC system. If no

motion is detected in the room for some predetermined interval, the system concludes that the room is unoccupied, and turns off the HVAC system or alters the setpoint to a more economical level. When the motion sensor detects motion (which is assumed to coincide with the return of the guest), the HVAC system resets to the guest's chosen setting.

[0010] Adding occupancy detection capability to residential HVAC systems could also add considerable value in the form of energy savings without significant tradeoff in terms of comfort. But the systems used in hotels do not easily transfer to the single-family residential context. Hotel rooms tend to be small enough that a single motion sensor is sufficient to determine with a high degree of accuracy whether or not the room is occupied. A single motion sensor in the average home today would have limited value because there are likely to be many places one or more people could be home and active yet invisible to the motion sensor. The most economical way to include a motion sensor in a traditional programmable thermostat would be to build it into the thermostat itself. But thermostats are generally located in hallways, and thus are unlikely to be exposed to the areas where people tend to spend their time. Wiring a home with multiple motion sensors in order to maximize the chances of detecting occupants would involve considerable expense, both for the sensors themselves and for the considerable cost of installation, especially in the retrofit market. Yet if control is ceded to a single-sensor system that cannot reliably detect presence, the resulting errors would likely lead the homeowner to reject the system.

[0011] Although progress in residential HVAC control has been slow, tremendous technological change has come to the tools used for personal communication. When programmable thermostats were first offered, telephones were virtually all tethered by wires to a wall jack. But now a large percentage of the population carries at least one mobile device capable of sending and receiving voice or data or even video (or a combination thereof) from almost anywhere by means of a wireless network. These devices create the possibility that a consumer can, with an appropriate mobile device and a network-enabled HVAC system, control his or her HVAC system even when away from home. But systems that relay on active

management decisions by consumers are likely to yield sub-optimal energy management outcomes, because consumers are unlikely to devote the attention and effort required to fully optimize energy use on a daily basis.

[0012] Many new mobile devices now incorporate another significant new technology – the ability to geolocate the device (and thus, presumably, the user of the device). One method of locating such devices uses the Global Positioning System (GPS). The GPS system uses a constellation of orbiting satellites with very precise clocks to triangulate the position of a device anywhere on earth based upon arrival times of signals received from those satellites by the device. Another approach to geolocation triangulates using signals from multiple cell phone towers. Such systems can enable a variety of so-called "location based services" to users of enabled devices. These services are generally thought of as aids to commerce like pointing users to restaurants or gas stations, etc.

[0013] It would be desirable to provide a system that could detect the location of regular occupants of a home or other structure without requiring the installation of additional hardware; that could accurately use such geospatial information in order to detect and predict occupancy, and could optimize energy consumption based upon dynamic and individually configurable heuristics.

SUMMARY OF THE INVENTION

[0014] In one embodiment, the invention comprises a thermostat attached to an HVAC system, a local network connecting the thermostat to a larger network such as the Internet, and one or more geolocation-enabled mobile devices attached to the network, and a server in bi-directional communication with a plurality of such thermostats and devices. The server pairs each thermostat with one or more geolocation-enabled mobile devices which are determined to be associated with the occupants of home in which the thermostat is located.

[0015] The server logs the ambient temperature sensed by each thermostat vs. time and the signals sent by the thermostats to their HVAC systems. The server also monitors and logs the geolocation data related to the geolocation-enabled mobile

devices associated with each thermostat. Based on the locations and movement evidenced by geolocation data, the server instructs the thermostat to change temperature settings between those optimized for occupied and unoccupied states at the appropriate times based on the evolving geolocation data.

[0016] One embodiment of the invention is directed to a method for varying temperature setpoints for an HVAC system. The method comprises determining the geographic location of a mobile electronic device that is connected to a network and associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices. In addition, the method comprises determining whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device and adjusting the temperature setpoint on said controller for an HVAC system for said structure based upon whether or not said structure is deemed to be occupied.

[0017] In another embodiment, the mobile electronic device is a telephone. In an additional embodiment, the networked mobile electronic device is a personal digital assistant. In a further embodiment, the mobile electronic device is connected to the Internet.

[0018] In one embodiment the method for determining the geographic location of a mobile electronic device uses the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0019] In yet another embodiment, the variation of temperature setpoints is logged to a database. In a further embodiment, the variation of temperature setpoints is initiated by a remote computer. In a different embodiment, the temperature setpoints are varied automatically. In a further embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

[0020] In one embodiment, a system for altering the setpoint on a thermostat for space conditioning of a structure comprises at least one said thermostat having at least one temperature setting associated with the presence of one or more occupants in said structure, and at least one temperature setting associated with the absence of occupants in said structure. The system also comprises one or more mobile electronic devices having at least a user interface, where the mobile electronic devices and said thermostat are connected to a network and where the setpoint on said thermostat is adjusted between said temperature setting associated with the presence of one or more occupants in said structure and said temperature setting associated with the absence of occupants in said structure based upon the geographic location of said electronic device.

[0021] In a further embodiment, the mobile electronic device is a telephone. In yet another embodiment, the networked mobile electronic device is a personal digital assistant. In still a further embodiment, the mobile electronic device is connected to the Internet.

[0022] In one embodiment, the method for determining the geographic location of a mobile electronic device is the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0023] In a different embodiment, the variation of temperature setpoints is logged to a database. In another embodiment, the variation of temperature setpoints is initiated by a remote computer. In a further embodiment, the temperature setpoints are varied automatically. In still another embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figure 1 shows an example of an overall environment in which an embodiment of the invention may be used.

[0025] Figure 2 shows a high-level illustration of the architecture of a network showing the relationship between the major elements of one embodiment of the subject invention.

[0026] Figures 3a and 3b show an embodiment of the website to be used as part of the subject invention.

[0027] Figure 4 shows a high-level schematic of the thermostat used as part of an embodiment of the subject invention.

[0028] Figure 5 shows one embodiment of the database structure used as part of an embodiment of the subject invention.

[0029] Figures 6a and 6b illustrate pages of a website that may be used with an embodiment of the subject invention.

[0030] Figure 7 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0031] Figure 8 is a flowchart that shows how the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device connected to the system.

[0032] Figures 9a and 9b show how comparing inside temperature against outside temperature and other variables permits calculation of dynamic signatures.

[0033] Figure 10 shows a flow chart for a high level version of the process of calculating the appropriate turn-on time in a given home.

[0034] Figure 11 shows a more detailed flowchart listing the steps in the process of calculating the appropriate turn-on time in a given home for a just-in-time event.

[0035] Figures 12a, 12b, 12c and 12d show the steps shown in the flowchart in Figure 11 in the form of a graph of temperature and time.

[0036] Figure 13 shows a table of some of the data used by an embodiment of the subject invention to predict temperatures.

[0037] Figure 14 shows an embodiment of the subject invention as applied in a specific home on a specific day.

[0038] Figure 15 shows an embodiment of the subject invention as applied in a different specific home on a specific day.

[0039] ~~Figure 16 shows~~ Figures 16-1 and 16-2 show a table of predicted rates of change in temperature inside a given home for a range of temperature differentials between inside and outside.

[0040] Figure 17 shows how manual inputs can be recognized and recorded by an embodiment of the subject invention.

[0041] Figure 18 shows how an embodiment of the subject invention uses manual inputs to interpret manual overrides and make short-term changes in response thereto.

[0042] Figure 19 shows how an embodiment of the subject invention uses manual inputs to make long-term changes to interpretive rules and to setpoint scheduling.

[0043] Figure 20 shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event.

[0044] Figure 21(a) through 21(c) illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature.

[0045] Figure 22 is a flow chart illustrating the steps involved in generating a demand reduction event for a given subscriber.

[0046] Figure 23 is a flow chart illustrating the steps involved in confirming that a demand reduction event has taken place.

[0047] Figure 24 is a representation of the movement of messages and information between the components of an embodiment of the subject invention.

[0048] Figures 25a and 25b show graphical representations of inside and outside temperatures in two different homes, one with high thermal mass and one with low thermal mass.

[0049] Figures 26a and 26b show graphical representations of inside and outside temperatures in the same homes as in Figures 25a and 25b, showing the cycling of the air conditioning systems in those houses.

[0050] Figures 27a and 27b show graphical representations of inside and outside temperatures in the same home as in Figures 25a and 26a, showing the cycling of the air conditioning on two different days in order to demonstrate the effect of a change in operating efficiency on the parameters measured by the thermostat.

[0051] Figures 28a and 28b show the effects of employing a pre-cooling strategy in two different houses.

[0052] Figures 29a and 29b show graphical representations of inside and outside temperatures in two different homes in order to demonstrate how the system can correct for erroneous readings in one house by referencing readings in another.

[0053] Figure 30 is a flowchart illustrating the steps involved in calculating the effective thermal mass of a home using an embodiment of the subject invention.

[0054] Figure 31 is a flowchart illustrating the steps involved in determining whether an HVAC system has developed a problem that impairs efficiency using an embodiment of the subject invention.

[0055] Figure 32 is a flowchart illustrating the steps involved in correcting for erroneous readings in one house by referencing readings in another using an embodiment of the subject invention.

[0056] Figure 33 shows the conventional programming of a programmable thermostat over a 24-hour period.

[0057] Figure 34 shows the programming of a programmable thermostat over a 24-hour period using ramped setpoints.

[0058] Figure 35 shows the steps required for the core function of the ramped setpoint algorithm.

[0059] Figure 36 shows a flowchart listing steps in the process of deciding whether to implement the ramped setpoint algorithm using an embodiment of the subject invention.

[0060] Figure 37 shows the browser as seen on the display of the computer used as part of an embodiment of the subject invention.

[0061] Figure 38 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0062] Figure 39 is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0063] **Figure 1** shows an example of an overall environment 100 in which an embodiment of the invention may be used. The environment 100 includes an interactive communication network 102 with computers 104 connected thereto. Also connected to network 102 are mobile devices 105, and one or more server computers 106, which store information and make the information available to computers 104 and mobile devices 105. The network 102 allows communication between and among the computers 104, mobile devices 105 and servers 106.

[0064] Presently preferred network 102 comprises a collection of interconnected public and/or private networks that are linked to together by a set of standard protocols to form a distributed network. While network 102 is intended to refer to what is now commonly referred to as the Internet, it is also intended to encompass variations which may be made in the future, including changes additions to existing standard protocols. It also includes various networks used to connect mobile and wireless devices, such as cellular networks.

[0065] When a user of an embodiment of the subject invention wishes to access information on network 102 using computer 104, the user initiates connection from his computer 104. For example, the user invokes a browser, which executes on computer 104. The browser, in turn, establishes a communication link with network 102. Once connected to network 102, the user can direct the browser to access information on server 106.

[0066] One popular part of the Internet is the World Wide Web. The World Wide Web contains a large number of computers 104 and servers 106, which store HyperText Markup Language (HTML) documents capable of displaying graphical and textual information. HTML is a standard coding convention and set of codes for attaching presentation and linking attributes to informational content within documents.

[0067] The servers 106 that provide offerings on the World Wide Web are typically called websites. A website is often defined by an Internet address that has an associated electronic page. Generally, an electronic page is a document that organizes the presentation of text graphical images, audio and video.

[0068] In addition to the Internet, the network 102 can comprise a wide variety of interactive communication media. For example, network 102 can include local area networks, interactive television networks, telephone networks, wireless data systems, two-way cable systems, and the like.

[0069] In one embodiment, computers 104 and servers 106 are conventional computers that are equipped with communications hardware such as modem or a network interface card. The computers include processors such as those sold by Intel and AMD. Other processors may also be used, including general-purpose processors, multi-chip processors, embedded processors and the like.

[0070] Computers 104 can also be microprocessor- controlled home entertainment equipment including advanced televisions, televisions paired with home entertainment/media centers, and wireless remote controls.

[0071] Computers 104 may utilize a browser configured to interact with the World Wide Web. Such browsers may include Microsoft Explorer, Mozilla, Firefox, Opera or Safari. They may also include browsers or similar software used on handheld, home entertainment and wireless devices.

[0072] The storage medium may comprise any method of storing information. It may comprise random access memory (RAM), electronically erasable programmable read only memory (EEPROM), read only memory (ROM), hard disk, floppy disk, CD-ROM, optical memory, or other method of storing data.

[0073] Computers 104 and 106 may use an operating system such as Microsoft Windows, Apple Mac OS, Linux, Unix or the like.

[0074] Computers 106 may include a range of devices that provide information, sound, graphics and text, and may use a variety of operating systems and software optimized for distribution of content via networks.

[0075] Mobile devices 105 can also be handheld and wireless devices such as personal digital assistants (PDAs), cellular telephones and other devices capable of accessing the network. Mobile devices 105 can use a variety of means for establishing the location of each device at a given time. Such methods may include the Global Positioning System (GPS), location relative to cellular towers, connection to specific wireless access points, or other means

[0076] **Figure 2** illustrates in further detail the architecture of the specific components connected to network 102 showing the relationship between the major elements of one embodiment of the subject invention. Attached to the network are thermostats 108 and computers 104 of various users. Connected to thermostats 108 are HVAC units 110. The HVAC units may be conventional air conditioners, heat pumps, or other devices for transferring heat into or out of a building. Each user is connected to the server 106 via wired or wireless connection such as Ethernet or a wireless protocol such as IEEE 802.11, a gateway 110 that connects the computer and thermostat to the Internet via a broadband connection such as a digital subscriber line (DSL), cellular radio or other form of broadband connection to the World Wide Web. Server 106 contains the content to be served as web pages and viewed by computers 104, software to manage thermostats 108, as well as databases containing information used by the servers.

[0077] Also attached to the Network are cellular radio towers 120, or other means to transmit and receive wireless signals in communication with mobile devices 105. Such communication may use GPRS, GSM, CDMA, EvDO, EDGE or other protocols and technologies for connecting mobile devices to a network.

[0078] **Figures 3a** and **3b** shows a representative mobile device 105 from the front and back, respectively. The front of the device includes a display 202, and may

include a physical keyboard 204. Alternatively, a virtual keyboard may be included in a display with touchscreen functionality. For devices with voice capabilities, such as a smart phone, a microphone 206 and speaker 208 enable audio communications. An antenna 210, which may be mounted entirely within the mobile device, aids wireless communications. Modules included within mobile device 105 but not visible from the outside may include memory cards, microprocessors, GPS receivers, battery, etc.

[0079] **Figure 4** shows a high-level block diagram of thermostat 108 used as part of an embodiment of the subject invention. Thermostat 108 includes temperature sensing means 252, which may be a thermistor, thermal diode or other means commonly used in the design of electronic thermostats. It includes a microprocessor 254, memory 256, a display 258, a power source 260, a relay 262, which turns the HVAC system on and off in response to a signal from the microprocessor, and contacts by which the relay is connected to the wires that lead to the HVAC system.

[0080] To allow the thermostat to communicate bi-directionally with the computer network, the thermostat also includes means 264 to connect the thermostat to a local computer or to a wireless network. Such means could be in the form of Ethernet, wireless protocols such as IEEE 802.11, IEEE 802.15.4, Bluetooth, cellular systems such as CDMA, GSM and GPRS, or other wireless protocols. The thermostat 250 may also include controls 266 allowing users to change settings directly at the thermostat, but such controls are not necessary to allow the thermostat to function.

[0081] The data used to manage the subject invention is stored on one or more servers 106 within one or more databases. As shown in **Figure 5**, the overall database structure 300 may include temperature database 400, thermostat settings database 500, energy bill database 600, HVAC hardware database 700, weather database 800, user database 900, transaction database 1000, product and service database 1100, user location database 1200 and such other databases as may be needed to support these and additional features.

[0082] Users of connected thermostats 250 may create personal accounts. Each user's account will store information in database 900, which tracks various attributes relative to users of the site. Such attributes may include the make and model

of the specific HVAC equipment in the user's home; the age and square footage of the home, the solar orientation of the home, the location of the thermostat in the home, the user's preferred temperature settings, whether the user is a participant in a demand response program, etc.

[0083] User personal accounts may also associate one or more mobile devices with such personal accounts. For mobile devices with the capability for geopositioning awareness, these personal accounts will have the ability log such positioning data over time in database 1200.

[0084] In one embodiment, a background application installed on mobile device 105 shares geopositioning data for the mobile device with the application running on server 106 that logs such data. Based upon this data, server 106 runs software that interprets said data (as described in more detail below). Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; or (b) transmit a message to mobile device 105 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. Such signalling activity may be conducted via email, text message, pop-up alerts, voice messaging, or other means.

[0085] **Figures 6a** and **6b** illustrate a website that may be provided to assist homeowners and others to interact with an embodiment of the subject invention. The website will permit thermostat users to perform through the web browser substantially all of the programming functions traditionally performed directly at the physical thermostat, such as temperature set points, the time at which the thermostat should be at each set point, etc. Preferably the website will also allow users to accomplish more advanced tasks such as allow users to program in vacation settings for times when the HVAC system may be turned off or run at more economical settings, and to set macros that will allow changing the settings of the temperature for all periods with a single gesture such as a mouse click.

[0086] As shown in **Figure 6a**, screen 351 of website 350 displays current temperature 352 as sensed by thermostat 108. Clicking on “up” arrow 354 raises the

setpoint 358; clicking the down arrow 356 lowers setpoint 358. Screen 351 may also convey information about the outside weather conditions, such as a graphic representation 360 of the sun, clouds, etc. In homes with multiple thermostats, screen 351 may allow users to select different devices to adjust or monitor. Users will be able to use screen 351 by selecting, for example, master bedroom thermostat 362, living room thermostat 364, game room thermostat 366, or basement thermostat 368.

[0087] As shown in **Figure 6b**, screen 370 allows users to establish programming schedules. Row 372 shows a 24-hour period. Programming row 374 displays various programming periods and when they are scheduled, such as away setting 376, which begins at approximately 8AM and runs until approximately 5:30PM. When the away setting 376 is highlighted, the user can adjust the starting time and ending time for the setting by dragging the beginning time 378 to the left to choose an earlier start time, and dragging it to the right to make it later. Similarly, the user can drag ending time 380 to the left to make it earlier, and to the right to make it later. While away setting 376 is highlighted, the user can also change heating setpoint 382 by clicking on up arrow 384 or down arrow 386, and cooling setpoint 388 by clicking on up arrow 390 or down arrow 392. The user can save the program by clicking on save button 394.

[0088] **Figure 7** is a high-level flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 1302, mobile device 105 transmits geopositioning information to server 106 via the Internet. In step 1304 the server compares the latest geopositioning data point to previous data points in order to determine whether a change in location or vector of movement has occurred. In step 1306 the server evaluates the geopositioning data in order to determine whether the temperature settings for the HVAC system for the structure associated with the mobile device 105 should be optimized for an unoccupied structure, or for an occupied structure in light of the movement (or lack thereof) in the geopositioning data.

[0089] If the server 106 determines that the home should be in occupied or "home" mode, then in step 1308 the server queries database 300 to determine whether thermostat 108 is already set for home or away mode. If thermostat 108 is already in

home mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 1310 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0090] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1316, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1312 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home.

[0091] If the user elects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate. If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.

[0092] If the server 106 determines in step 1306 that the home should be in unoccupied or away mode, then in step 1350 the server queries database 300 to determine whether thermostat 108 is set for set for home or away mode. If thermostat 108 is already in away mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is occupied, then in step 1352 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0093] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds

to step 1358, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when unoccupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1354 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate.

[0094] If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.If thermostat 108 is already in away mode, the program ends. If it was in home mode, then in step 1314 server 108 initiates a state change to put thermostat 108 in away mode. In either case, the server then in step 1316 writes the state change to database 300. In each case the server can also send a message to the person who owns the mobile device requesting, confirming or announcing the state change.

[0095] **Figure 8** is a flowchart that shows one process by which an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device attached to the system. The process shown assumes (a) a static hierarchy of temperature preferences as between multiple occupants: that is, that for a given home/structure, mobile user #1's preferences will always control the outcome if mobile user #1 is present, that mobile user #2's preferences yield to #1's, but always prevail over user #3, etc; and (b) that there are no occupants to consider who are not associated with a mobile device. Other heuristics may be applied in order to account for more dynamic interactions of preferences.

[0096] In step 1402 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #1. In step 1404

server 106 uses current and recent coordinates to determine whether mobile user #1's "home" settings should be applied. If server 106 determines that User #1's home settings should be applied, then in step 1406 server 106 applies the correct setting and transmits it to the thermostat(s).

[0097] In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming. If after performing step 1404, the server concludes that mobile user #1's "home" settings should not be applied, then in step 1412 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #2.

[0098] In step 1414 server 106 uses current and recent coordinates to determine whether mobile user #2's "home" settings should be applied. If server 106 determines that User #2's home settings should be applied, then in step 1416 server 106 applies the correct setting and transmits it to the thermostat(s).

[0099] In step 1408, server 106 writes to database 300 the geospatial and other relevant information used to adjust the programming. If after performing step 1414, the server concludes that mobile user #2's "home" settings should not be applied, then in step 1422 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #N.

[0100] In step 1424 server 106 uses current and recent coordinates to determine whether mobile user #N's "home" settings should be applied. If server 106 determines that User #N's home settings should be applied, then in step 1426 server 106 applies the correct setting and transmits it to the thermostat(s). In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming.

[0101] If none of the mobile devices associated with a given home or other structure report geospatial coordinates consistent with occupancy, then in step 1430 the server instructs the thermostat(s) to switch to or maintain the "away" setting.

[0102] One embodiment of the invention is capable of delivering additional benefits for homeowners in terms of increased comfort and efficiency. In addition to using the system to allow better signaling and control of the HVAC system, which relies

primarily on communication running from the server to the thermostat, the bi-directional communication will also allow the thermostat 108 to regularly measure and send to the server information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0103] For example, **Figure 9a** shows a graph of inside temperature, outside temperature and HVAC activity for a 24 hour period. When outside temperature 1502 increases, inside temperature 1504 follows, but with some delay because of the thermal mass of the building, unless the air conditioning 1506 operates to counteract this effect. When the air conditioning turns on, the inside temperature stays constant (or rises at a much lower rate or even falls) despite the rising outside temperature. In this example, frequent and heavy use of the air conditioning results in only a very slight temperature increase inside the house of 4 degrees, from 72 to 76 degrees, despite the increase in outside temperature from 80 to 100 degrees.

[0104] **Figure 9b** shows a graph of the same house on the same day, but assumes that the air conditioning is turned off from noon to 7PM. As expected, the inside temperature 1504a rises with increasing outside temperatures 1502 for most of that period, reaching 88 degrees at 7PM. Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house.

[0105] The performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the rate at which the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc., the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0106] The ability to predict the rate of change in inside temperature in a given house under varying conditions may be applied by in effect holding the desired future inside temperature as a constraint and using the ability to predict the rate of change to determine when the HVAC system must be turned on in order to reach the desired temperature at the desired time. The ability of an HVAC system to vary turn-on time in order to achieve a setpoint with minimum energy use may be thought of as Just In Time (JIT) optimization.

[0107] **Figure 10** shows a flowchart illustrating the high-level process for controlling a just-in-time (JIT) event. In step 1512, the server determines whether a specific thermostat 108 is scheduled to run the preconditioning program. If, not, the program terminates. If it so scheduled, then in step 1514 the server retrieves the predetermined target time when the preconditioning is intended to have been completed (TT).

[0108] Using TT as an input, in step 1516 the server then determines the time at which the computational steps required to program the preconditioning event will be performed (ST). In step 1518, performed at start time ST, the server begins the process of actually calculating the required parameters, as discussed in greater detail below. Then in 1520 specific setpoint changes are transmitted to the thermostat so that the temperature inside the home may be appropriately changed as intended.

[0109] **Figure 11** shows a more detailed flowchart of the process. In step 1532, the server retrieves input parameters used to create a JIT event. These parameters include the maximum time allowed for a JIT event for thermostat 108 (MTI); the target time the system is intended to hit the desired temperature (TT); and the desired inside temperature at TT (TempTT). It is useful to set a value for MTI because, for example, it will be reasonable to prevent the HVAC system from running a preconditioning event if it would be expected to take 8 hours, which might be prohibitively expensive.

[0110] In step 1534, the server retrieves data used to calculate the appropriate start time with the given input parameters. This data includes a set of algorithmic learning data (ALD), composed of historic readings from the thermostat,

Ex. 1006.0225

together with associated weather data, such as outside temperature, solar radiation, humidity, wind speed and direction, etc; together with weather forecast data for the subject location for the period when the algorithm is scheduled to run (the weather forecast data, or WFD). The forecasting data can be as simple as a listing of expected temperatures for a period of hours subsequent to the time at which the calculations are performed, to more detailed tables including humidity, solar radiation, wind, etc. Alternatively, it can include additional information such as some or all of the kinds of data collected in the ALD.

[0111] In step 1536, the server uses the ALD and the WFD to create prediction tables that determine the expected rate of change or slope of inside temperature for each minute of HVAC cycle time (ΔT) for the relevant range of possible pre-existing inside temperatures and outside climatic conditions. An example of a simple prediction table is illustrated in Fig. 13.

[0112] In step 1538, the server uses the prediction tables created in step 1536, combined with input parameters TT and Temp(TT) to determine the time at which slope ΔT intersects with predicted initial temperature PT. The time between PT and TT is the key calculated parameter: the preconditioning time interval, or PTI.

[0113] In step 1540, the server checks to confirm that the time required to execute the pre-conditioning event PTI does not exceed the maximum parameter MTI. If PTI exceeds MTI, the scheduling routine concludes and no ramping setpoints are transmitted to the thermostat.

[0114] If the system is perfect in its predictive abilities and its assumptions about the temperature inside the home are completely accurate, then in theory the thermostat can simply be reprogrammed once – at time PT, the thermostat can simply be reprogrammed to Temp(TT). However, there are drawbacks to this approach.

[0115] First, if the server has been overly conservative in its predictions as to the possible rate of change in temperature caused by the HVAC system, the inside temperature will reach TT too soon, thus wasting energy and at least partially defeating the purpose of running the preconditioning routine in the first place. If the server is too optimistic in its projections, there will be no way to catch up, and the home will not

reach Temp(TT) until after TT. Thus it would be desirable to build into the system a means for self-correcting for slightly conservative start times without excessive energy use.

[0116] Second, the use of setpoints as a proxy for actual inside temperatures in the calculations is efficient, but can be inaccurate under certain circumstances. In the winter (heating) context, for example, if the actual inside temperature is a few degrees above the setpoint (which can happen when outside temperatures are warm enough that the home's natural "set point" is above the thermostat setting), then setting the thermostat to Temp(TT) at time PT will almost certainly lead to reaching TT too soon as well.

[0117] The currently preferred solution to both of these possible inaccuracies is to calculate and program a series of intermediate settings between Temp(PT) and Temp(TT) that are roughly related to ΔT.

[0118] Thus if MTI is greater than PTI, then in step 1542 the server calculates the schedule of intermediate setpoints and time intervals to be transmitted to the thermostat. Because thermostats cannot generally be programmed with steps of less than 1 degree F, ΔT is quantized into discrete interval data of at least 1 degree F each. For example, if Temp(PT) is 65 degrees F, Temp(TT) is 72 degrees F, and PT is 90 minutes, the thermostat might be programmed to be set at 66 for 10 minutes, 67 for 12 minutes, 68 for 15 minutes, etc.

[0119] The server may optionally limit the process by assigning a minimum programming interval (e.g., at least ten minutes between setpoint changes) to avoid frequent switching of the HVAC system, which can reduce accuracy because of the thermostat's compressor delay circuit, which may prevent quick corrections. The duration of each individual step may be a simple arithmetic function of the time PTI divided by the number of whole-degree steps to be taken; alternatively, the duration of each step may take into account second order thermodynamic effects relating to the increasing difficulty of "pushing" the temperature inside a house further from its natural setpoint given outside weather conditions, etc. (that is, the fact that on a cold winter

day it may take more energy to move the temperature inside the home from 70 degrees F to 71 than it does to move it from 60 degrees to 61).

[0120] In step 1544, the server schedules setpoint changes calculated in step 1542 for execution by the thermostat.

[0121] With this system, if actual inside temperature at PT is significantly higher than Temp(PT), then the first changes to setpoints will have no effect (that is, the HVAC system will remain off), and the HVAC system will not begin using energy, until the appropriate time, as shown in **Figure 12**. Similarly, if the server has used conservative predictions to generate ΔT, and the HVAC system runs ahead of the predicted rate of change, the incremental changes in setpoint will delay further increases until the appropriate time in order to again minimize unnecessary energy use, as shown in **Figure 11**.

[0122] **Figure 12(a)** through **12(d)** shows the steps in the preconditioning process as a graph of temperature and time. **Figure 12(a)** shows step 1532, in which inputs target time TT 1552, target temperature Temp(TT) 1554, maximum conditioning interval MTI 1556 and the predicted inside temperature during the period of time the preconditioning event is likely to begin Temp(PT) 1558 are retrieved.

[0123] **Figure 12(b)** shows the initial calculations performed in step 1538, in which expected rate of change in temperature ΔT 1560 inside the home is generated from the ALD and WFD using Temp(TT) 1554 at time TT 1552 as the endpoint.

[0124] **Figure 12(c)** shows how in step 1538 ΔT 1560 is used to determine start time PT 1562 and preconditioning time interval PTI 1564. It also shows how in step 1540 the server can compare PTI with MTI to determine whether or not to instantiate the pre-conditioning program for the thermostat.

[0125] **Figure 12(d)** shows step 1542, in which specific ramped setpoints 1566 are generated. Because of the assumed thermal mass of the system, actual inside temperature at any given time will not correspond to setpoints until some interval after each setpoint change. Thus initial ramped setpoint 1216 may be higher than Temp(PT) 1558, for example.

Ex. 1006.0228

[0126] **Figure 13** shows an example of the types of data that may be used by the server in order to calculate ΔT 1560. Such data may include inside temperature 1572, outside temperature 1574, cloud cover 1576, humidity 1578, barometric pressure 1580, wind speed 1582, and wind direction 1584.

[0127] Each of these data points should be captured at frequent intervals. In the preferred embodiment, as shown in **Figure 13**, the interval is once every 60 seconds.

[0128] **Figure 14** shows application of an embodiment of the subject invention in an actual house. Temperature and setpoints are plotted for the 4-hour period from 4AM to 8AM with temperature on the vertical axis and time on the horizontal axis. The winter nighttime setpoint 1592 is 60 degrees F; the morning setpoint temperature 1594 is 69 degrees F. The outside temperature 1596 is approximately 45 degrees F. The target time TT 1598 for the setpoint change to morning setting is 6:45AM. In the absence of embodiments of the subject invention, the homeowner could program the thermostat to change to the new setpoint at 6:45, but there is an inherent delay between a setpoint change and the response of the temperature inside the home. (In this home on this day, the delay is approximately fifty minutes.) Thus if the homeowner truly desired to achieve the target temperature at the target time, some anticipation would be necessary. The amount of anticipation required depends upon numerous variables, as discussed above.

[0129] After calculating the appropriate slope ΔT 1560 by which to ramp inside temperature in order to reach the target as explained above, the server transmits a series of setpoints 1566 to the thermostat because the thermostat is presumed to only accept discrete integers as program settings. (If a thermostat is capable of accepting finer settings, as in the case of some thermostats designed to operate in regions in which temperature is generally denoted in Centigrade rather than Fahrenheit, which accept settings in half-degree increments, tighter control may be possible.)

[0130] In any event, in the currently preferred embodiment of the subject invention, programming changes are quantized such that the frequency of setpoint

changes is balanced between the goal of minimizing network traffic and the frequency of changes made on the one hand and the desire for accuracy on the other. Balancing these considerations may result in some cases in either more frequent changes or in larger steps between settings. As shown in Fig. 14, the setpoint "stairsteps" from 60 degrees F to 69 degrees F in nine separate setpoint changes over a period of 90 minutes.

[0131] Because the inside temperature 1599 when the setpoint management routine was instantiated at 5:04 AM was above the "slope" and thus above the setpoint, the HVAC system was not triggered and no energy was used unnecessarily heating the home before such energy use was required. Actual energy usage does not begin until 5:49 AM.

[0132] **Figure 15** shows application of an embodiment of the subject invention in a different house during a similar four hour interval. In **Figure 15**, the predicted slope ΔT 1560 is less conservative relative to the actual performance of the home and HVAC system, so there is no off cycling during the preconditioning event – the HVAC system turns on at approximately 4:35 AM and stays on continuously during the event. The home reaches the target temperature Temp(TT) roughly two minutes prior to target time TT.

[0133] **Figure 16** shows a simple prediction table. The first column 1602 lists a series of differentials between outside and inside temperatures. Thus when the outside temperature is 14 degrees and the inside temperature is 68 degrees, the differential is -54 degrees; when the outside temperature is 94 degrees and the inside temperature is 71 degrees, the differential is 13 degrees. The second column 1604 lists the predicted rate of change in inside temperature ΔT 1210 assuming that the furnace is running in terms of degrees Fahrenheit of change per hour. A similar prediction table will be generated for predicted rates of change when the air conditioner is on; additional tables may be generated that predict how temperatures will change when the HVAC system is off.

[0134] Alternatively, the programming of the just-in-time setpoints may be based not on a single rate of change for the entire event, but on a more complex

multivariate equation that takes into account the possibility that the rate of change may be different for events of different durations.

[0135] The method for calculating start times may also optionally take into account not only the predicted temperature at the calculated start time, but may incorporate measured inside temperature data from immediately prior to the scheduled start time in order to update calculations, or may employ more predictive means to extrapolate what inside temperature based upon outside temperatures, etc.

[0136] An additional capability offered by an embodiment of the instant invention is the ability to adapt the programming of the HVAC control system based upon the natural behavior of occupants. Because an embodiment of the instant invention is capable of recording the setpoint actually used at a connected thermostat over time, it is also capable of inferring manual setpoint changes (as, for example, entered by pushing the "up" or "down" arrow on the control panel of the device) even when such overrides of the pre-set program are not specifically recorded as such by the thermostat.

[0137] In order to adapt programming to take into account the manual overrides entered into the thermostat, it is first necessary to determine when a manual override has in fact occurred. Most thermostats, including two-way communicating devices discussed herein, do not record such inputs locally, and neither recognize nor transmit the fact that a manual override has occurred. Furthermore, in a system as described herein, frequent changes in setpoints may be initiated by algorithms running on the server, thereby making it impossible to infer a manual override from the mere fact that the setpoint has changed. It is therefore necessary to deduce the occurrence of such events from the data that an embodiment of the subject invention does have access to.

[0138] **Figure 17** illustrates the currently preferred method for detecting the occurrence of a manual override event. In step 1702, the server retrieves the primary data points used to infer the occurrence of a manual override from one or more databases in overall database structure 300. The data should include each of the following: for the most recent point at which it can obtain such data (time0) the actual

setpoint as recorded at the thermostat at (A0); for the point immediately prior to time0 (time-1), the actual setpoint recorded for the thermostat (A-1); for time0 the setpoint as scheduled by server 106 according to the basic setpoint programming (S0), and for time-1 the setpoint as scheduled by server 106 according to the standard setpoint programming (S-1).

[0139] In step 1704, the server retrieves any additional automated setpoint changes C that have been scheduled for the thermostat by server 106 at time0. Such changes may include algorithmic changes intended to reduce energy consumption, etc.

[0140] In step 1706 the server calculates the difference (dA) between A0 and A-1; for example, if the actual setpoint is 67 degrees at T-1 and 69 at T0, dA is +2; if the setpoint at T-1 is 70 and the setpoint at T0 is 66, dA is –4.

[0141] In step 1708, the server performs similar steps in order to calculate dS, the difference between S0 and S-1. This is necessary because, for example, the setpoint may have been changed because the server itself had just executed a change, such as a scheduled change from "away" to "home" mode. In step 1710 the server evaluates and sums all active algorithms and other server-initiated strategies to determine their net effect on setpoint at time0. For example, if one algorithm has increased setpoint at time0 by 2 degrees as a short-term energy savings measure, but another algorithm has decreased the setpoint by one degree to compensate for expected subjective reactions to weather conditions, the net algorithmic effect sC is +1 degree.

[0142] In step 1712, the server calculates the value for M, where M is equal to the difference between actual setpoints dA, less the difference between scheduled setpoints dS, less the aggregate of algorithmic change sC.

[0143] In step 1714 the server evaluates this difference. If the difference equals zero, the server concludes that no manual override has occurred, and the routine terminates. But if the difference is any value other than zero, then the server concludes that a manual override has occurred. Thus in step 1716 the server logs the occurrence and magnitude of the override to one or more databases in overall database structure 300.

[0144] The process of interpreting a manual override is shown in **Figure 18**. Step 1802 is the detection of an override, as described in detail in **Figure 17**. In step 1804 the server retrieves the stored rules for the subject thermostat 108. Such rules may include weather and time-related inferences such as "if outside temperature is greater than 85 degrees and inside temperature is more than 2 degrees above setpoint and manual override lowers setpoint by 3 or more degrees, then revert to original setpoint in 2 hours," or "if heating setpoint change is scheduled from "away" to "home" within 2 hours after detected override, and override increases setpoint by at least 2 degrees, then change to "home" setting," or the like.

[0145] In step 1806 the server retrieves contextual data required to interpret the manual override. Such data may include current and recent weather conditions, current and recent inside temperatures, etc. This data is helpful because it is likely that manual overrides are at least in part deterministic: that is, that they may often be explained by such contextual data, and that such understanding can permit anticipation of the desire on the part of the occupants to override and to adjust programming accordingly, so as to anticipate and obviate the need for such changes. The amount of data may be for a period of a few hours to as long as several days or more. Recent data may be more heavily weighted than older data in order to assure rapid adaptation to situations in which manual overrides represent stable changes such as changes in work schedules, etc.

[0146] In step 1808 the server retrieves any relevant override data from the period preceding the specific override being evaluated that has not yet been evaluated by and incorporated into the long-term programming and rules engines as described below in **Figure 19**. In step 1810 the server evaluates the override and determines which rule, if any, should be applied as a result of the override.

[0147] In step 1812 the server determines whether to alter the current setpoint as a result of applying the rules in step 1810. If no setpoint change is indicated, then the routine ends. If a setpoint change is indicated, then in step 1814 the server transmits the setpoint change to the thermostat for execution in the home,

and in step 1816 it records that change to one or more databases in overall database structure 300.

[0148] In order to ensure that both the stored rules for interpreting manual overrides and the programming itself continue to most accurately reflect the intentions of the occupants, the server will periodically review both the rules used to interpret overrides and the setpoint scheduling employed. **Figure 19** shows the steps used to incorporate manual overrides into the long-term rules and setpoint schedule. In step 1902 the server retrieves the stored programming for a given thermostat as well as the rules for interpreting overrides for that thermostat.

[0149] In step 1904 the server retrieves the recent override data as recorded in **Figures 17** and **18** to be evaluated for possible revisions to the rules and the programming. In step 1906 the server retrieves the contextual data regarding overrides retrieved in step 1904 (Because the process illustrated in **Figure 19** is not presently expected to be executed as a real-time process, and is expected to be run anywhere from once per day to once per month, the range and volume of contextual data to be evaluated is likely to be greater than in the process illustrated in **Figure 18**.

[0150] In step 1908 the server interprets the overrides in light of the existing programming schedule, rules for overrides, contextual data, etc. In step 1910 the server determines whether, as a result of those overrides as interpreted, the rules for interpreting manual overrides should be revised. If the rules are not to be revised, the server moves to step 1914. If the rules are to be revised, then in step 1912 the server revises the rules and the new rules are stored in one or more databases in overall database structure 300.

[0151] In step 1914 the server determines whether any changes to the baseline programming for the thermostat should be revised. If not, the routine terminates. If revisions are warranted, then in step 1916 the server retrieves from database 900 the permissions the server has to make autonomous changes to settings. If the server has been given permission to make the proposed changes, then in step 1918 the server revises the thermostat's programming and writes the changes to one or more databases in overall database structure 300.

[0152] If the server has not been authorized to make such changes autonomously, then in step 1920 the server transmits the recommendation to change settings to the customer in the manner previously specified by the customer, such as email, text message, personalized website, etc.

[0153] Additional means of implementing an embodiment of the instant invention may be achieved using variations in system architecture. For example, much or even all of the work being accomplished by remote server 106 may also be done by thermostat 108 if that device has sufficient processing capabilities, memory, etc. Alternatively, these steps may be undertaken by a local processor such as a local personal computer, or by a dedicated appliance having the requisite capabilities, such as gateway 112.

[0154] An additional way in which an embodiment of the instant invention can reduce energy consumption with minimal impact on comfort is to vary the turn-on delay enforced by the thermostat after the compressor is turned off. Compressor delay is usually used to protect compressors from rapid cycling, which can physically damage them.

[0155] The ability to predict the rate of change in inside temperature in a given house under varying conditions may also be applied to permit calculation of the effect of different compressor delay settings on inside temperatures, HVAC cycling and energy consumption.

[0156] **Figure 20** shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event. In step 2002, server 106 retrieves parameters such as weather conditions, the current price per kilowatt-hour of electricity, and the state of the electric grid in terms of supply versus demand for the geographic area that includes a given home. In step 2004 server 106 determines whether to instantiate the compressor delay adjustment program for a certain group of homes in response to those conditions.

[0157] In step 2006, server 106 determines whether a specific home is subscribed to participate in compressor delay events. If a given home is eligible, then in step 2008 the server retrieves the parameters needed to specify the compressor

delay routine for that home. These may include user preferences, such as the weather, time of day and other conditions under which the homeowner has elected to permit hysteresis band changes, the maximum length of compressor delay authorized, etc.

[0158] In step 2010 the appropriate compressor delay settings are determined, and in step 2012 the chosen settings are communicated to the thermostat. In step 2014 the server determines if additional thermostats in the given group must still be evaluated. If so, the server returns to step 2006 and repeats the subsequent steps with the next thermostat. If not, the routine ends.

[0159] **Figures 21(a)** through **21(c)** illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature. In **Figure 21(a)**, time is shown on the horizontal axis 2102, and temperature is shown on vertical axis 2104. The setpoint for thermostat 108 is 70 degrees F, which results in the cycling behavior shown for inside temperature 2106. Because compressor delay CD1 2108 is, at approximately 3 minutes, shorter than the natural duration of a compressor off cycle Off1 2110 at approximately 6 minutes for this particular house under the illustrated conditions, the compressor delay has no effect on the operation of the HVAC system.

[0160] Because the hysteresis band operates to so as to maintain the temperature within a range of plus or minus one degree of the setpoint, in the case of air conditioning the air conditioner will switch on when the inside temperature reaches 71 degrees, continue operating until it reaches 69 degrees, then shut off. The system will then remain off until it reaches 71 degrees again, at which time it will again switch on. The percentage of time during which inside temperature is above or below the setpoint will depend on conditions and the dynamic signature of the individual, home. Under the conditions illustrated, the average inside temperature AT1 2112 is roughly equal to the setpoint of 70 degrees.

[0161] **Figure 21(b)** shows how with the same environmental conditions as in **Figure 21(a)**, the cycling behavior of the inside temperature changes when the compressor delay is longer than the natural compressor off cycle Off1 2110. Extended compressor delay CD2 2114 allows inside temperature 2116 to climb above the range

normally enforced by the hysteresis band. Because CD2 is roughly 8 minutes, under the given conditions the inside temperature climbs to approximately 72 degrees before the compressor delay allows the air conditioner to restart and drive the inside temperature back down. But as before, the air conditioner shuts off when the inside temperature reaches 69 degrees. Thus the average temperature is increased from AT1 2112 to AT2 2118. This change will save energy and reduce cycling because it takes less energy to maintain a higher inside temperature with an air conditioner. However, the setpoint reported by the display of the thermostat will continue to be the occupant's chosen setpoint of 70 degrees.

[0162] **Figure 21(c)** shows how the same compressor delay can result in different thermal cycling with different weather conditions. The greater the amount by which outside temperature exceeds inside temperature in the air conditioning context, the more rapidly the inside temperature will increase during an off cycle, and the slower the air conditioner will be able to cool during the on cycle. Thus as compared to **Figure 21(b)**, when the inside temperature increased to roughly 72 degrees during the extended compressor delay of 8 minutes, a higher outside temperature will cause the inside temperature to increase faster, which results in a peak temperature of roughly 73 degrees, and in wider temperature cycling 2120. The average inside temperature consequently increases from AT(2) 2118 to AT(3) 2122.

[0163] It should be noted that the shape of the actual waveform will most likely not be sinusoidal, but for ease of illustration it is sometimes be presented as such in the figures.

[0164] Residential air conditioning is a major component of peak load. The traditional approach to dealing with high demand on hot days is to increase supply – build new powerplants, or buy additional capacity on the spot market. But because reducing loads has come to be considered by many to be a superior strategy for matching electricity supply to demand when the grid is stressed, the ability to shed load by turning off air conditioners during peak events has become a useful tool for managing loads. A key component of any such system is the ability to document and verify that a given air conditioner has actually turned off. Data logging hardware can

accomplish this, but due to the cost is usually only deployed for statistical sampling. An embodiment of the instant invention provides a means to verify demand response without additional hardware such as a data logger.

[0165] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures. This will permit remote verification of load shedding by the air conditioner without directly measuring or recording the electrical load drawn by the air conditioner.

[0166] **Figure 22** shows the steps followed in order to initiate air conditioner shutoff. When a summer peak demand situation occurs, the utility will transmit an email 2202 or other signal to server 106 requesting a reduction in load. Server 106 will determine 2204 if the user's house is served by the utility seeking reduction; determine 2206 if a given user has agreed to reduce peak demand; and determine 2208 if a reduction of consumption by the user is required or desirable in order to achieve the reduction in demand requested by the utility. The server will transmit 2210 a signal to the user's thermostat 108 signaling the thermostat to shut off the air conditioner 110.

[0167] **Figure 23** shows the steps followed in order to verify that the air conditioner has in fact been shut off. Server 106 will receive and monitor 2302 the temperature readings sent by the user's thermostat 108. The server then calculates 2304 the temperature reading to be expected for that thermostat given inputs such as current and recent outside temperature, recent inside temperature readings, the calculated thermal mass of the structure, temperature readings in other houses, etc. The server will compare 2306 the predicted reading with the actual reading. If the

server determines that the temperature inside the house is rising at the rate predicted if the air conditioning is shut off, then the server confirms 2308 that the air conditioning has been shut off. If the temperature reading from the thermostat shows no increase, or significantly less increase than predicted by the model, then the server concludes 2310 that the air conditioning was not switched off, and that no contribution to the demand response request was made.

[0168] For example, assume that on at 3PM on date Y utility X wishes to trigger a demand reduction event. A server at utility X transmits a message to the server at demand reduction service provider Z requesting W megawatts of demand reduction. The demand reduction service provider server determines that it will turn off the air conditioner at house A in order to achieve the required demand reduction. At the time the event is triggered, the inside temperature as reported by the thermostat in house A is 72 degrees F. The outside temperature near house A is 96 degrees Fahrenheit. The inside temperature at House B, which is not part of the demand reduction program, but is both connected to the demand reduction service server and located geographically proximate to House A, is 74F. Because the air conditioner in house A has been turned off, the temperature inside House A begins to rise, so that at 4PM it has increased to 79F. Because the server is aware of the outside temperature, which remains at 96F, and of the rate of temperature rise inside house A on previous days on which temperatures have been at or near 96F, and the temperature in house B, which has risen only to 75F because the air conditioning in house B continues to operate normally, the server is able to confirm with a high degree of certainty that the air conditioner in house A has indeed been shut off.

[0169] In contrast, if the HVAC system at house A has been tampered with, so that a demand reduction signal from the server does not actually result in shutting off the air conditioner in house A, when the server compares the rate of temperature change at house A against the other data points, the server will receive data inconsistent with the rate of increase predicted. As a result, it will conclude that the air conditioner has not been shut off in house A as expected, and may not credit house A with the financial credit that would be associated with demand reduction compliance, or

may trigger a business process that could result in termination of house A's participation in the demand reduction program.

[0170] **Figure 24** illustrates the movement of signals and information between the components of one embodiment of the subject invention to trigger and verify a demand reduction response. Where demand response events are undertaken on behalf of a utility by a third party, participants in the communications may include electric utility server 2400, demand reduction service server 106, and thermostat 108. In step 2402 the electric utility server 2400 transmits a message to demand reduction service server 106 requesting a demand reduction of a specified duration and size. Demand reduction service server 106 uses database 300 to determine which subscribers should be included in the demand reduction event. For each included subscriber, the server then sends a signal 2404 to the subscriber's thermostat 108 instructing it (a) to shut down at the appropriate time or (b) to allow the temperature as measured by the thermostat to increase to a certain temperature at the specified time, depending upon the agreement between the homeowner and the utility and/or demand reduction aggregator.

[0171] The server then receives 2406 temperature signals from the subscriber's thermostat. At the conclusion of the demand reduction event, the server transmits a signal 2408 to the thermostat permitting the thermostat to signal its attached HVAC system to resume cooling, if the system has been shut off, or to reduce the target temperature to its pre-demand reduction setting, if the target temperature was merely increased. If thermostat 108 is capable of storing scheduling information, these instructions may be transmitted prior to the time they are to be executed and stored locally. After determining the total number of subscribers actually participating in the DR event, the server then calculates the total demand reduction achieved and sends a message 2410 to the electric utility confirming such reduction.

[0172] Additional steps may be included in the process. For example, if the subscriber has previously requested that notice be provided when a peak demand reduction event occurs, the server will also send an alert, which may be in the form of an email or text message or an update to the personalized web page for that user, or

both. If the server determines that a given home has (or has not) complied with the terms of its demand reduction agreement, the server may send a message to the subscriber confirming that fact.

[0173] It should also be noted that in some climate zones, peak demand events occur during extreme cold weather rather than (or in addition to) during hot weather. The same process as discussed above could be employed to reduce demand by shutting off electric heaters and monitoring the rate at which temperatures fall.

[0174] It should also be noted that the peak demand reduction service can be performed directly by an electric utility, so that the functions of server 106 can be combined with the functions of server 2400.

[0175] The system installed in a subscriber's home may optionally include additional temperature sensors at different locations within the building. These additional sensors may we connected to the rest of the system via a wireless system such as 802.11 or 802.15.4, or may be connected via wires. Additional temperature and/or humidity sensors may allow increased accuracy of the system, which can in turn increase user comfort, energy savings or both.

[0176] The bi-directional communication between server 106 and thermostat 108 will also allow thermostat 108 to regularly measure and send to server 106 information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0177] For example, **Figure 25a** shows a graph of inside temperature and outside temperature for a 24-hour period in House A, assuming no HVAC activity. House A has double-glazed windows and is well-insulated. When outside temperature 2502 increases, inside temperature 2504 follows, but with significant delay because of the thermal mass of the building.

[0178] **Figure 25b** shows a graph of inside temperature and outside temperature for the same 24-hour period in House B. House B is identical to House A except that it (i) is located a block away and (ii) has single-glazed windows and is

poorly insulated. Because the two houses are so close to each other, outside temperature 2502 is the same in **Figure 25a** and **Figure 25b**. But the lower thermal mass of House B means that the rate at which the inside temperature 2506 changes in response to the changes in outside temperature is much greater.

[0179] The differences in thermal mass will affect the cycling behavior of the HVAC systems in the two houses as well. **Figure 26a** shows a graph of inside temperature and outside temperature in House A for the same 24-hour period as shown in **Figure 6a**, but assuming that the air conditioning is being used to try to maintain an internal temperature of 70 degrees. Outside temperatures 2502 are the same as in **Figures 25a** and **25b**. Inside temperature 2608 is maintained within the range determined by thermostat 108 by the cycling of the air conditioner. Because of the high thermal mass of the house, the air conditioning does not need to run for very long to maintain the target temperature, as shown by shaded areas 2610.

[0180] **Figure 26b** shows a graph of inside temperature 2612 and outside temperature 2502 for the same 24-hour period in House B, assuming use of the air conditioning as in **Figure 26a**. Because of the lower thermal mass of House B, the air conditioning system in House B has to run longer in order to maintain the same target temperature range, as shown by shaded areas 2614.

[0181] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature and differences between inside and outside temperatures. Because the server 106 will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0182] The server will also record the responses of each house to changes in outside conditions and cycling behavior over time. That will allow the server to diagnose problems as and when they develop. For example, **Figure 27a** shows a graph of outside temperature 2702, inside temperature 2704 and HVAC cycle times 2706 in House A for a specific 24-hour period on date X. Assume that, based upon comparison of the performance of House A on date X relative to House A's historical performance, and in comparison to the performance of House A relative to other nearby houses on date X, the HVAC system in House A is presumed to be operating at normal efficiency, and that House A is in the 86th percentile as compared to those other houses.

[0183] **Figure 27b** shows a graph of outside temperature 2708, inside temperature 2710 and HVAC cycle times 2712 in House A for the 24-hour period on date X+1. House A's HVAC system now requires significantly longer cycle times in order to try to maintain the same internal temperature. If those longer cycle times were due to higher outside temperatures, those cycle times would not indicate the existence of any problems. But because server 106 is aware of the outside temperature, the system can eliminate that possibility as an explanation for the higher cycle times.

[0184] Because server 106 is aware of the cycle times in nearby houses, it can determine that, for example, on date X+1 the efficiency of House A is only in the 23rd percentile. The server will be programmed with a series of heuristics, gathered from predictive models and past experience, correlating the drop in efficiency and the time interval over which it has occurred with different possible causes. For example, a 50% drop in efficiency in one day may be correlated with a refrigerant leak, especially if followed by a further drop in efficiency on the following day. A reduction of 10% over three months may be correlated with a clogged filter. Based upon the historical data recorded by the server, the server 106 will be able to alert the homeowner that there is a problem and suggest a possible cause.

[0185] Because the system will be able to calculate effective thermal mass, it will be able to determine the cost effectiveness of strategies such as pre-cooling for specific houses under different conditions. **Figure 28a** shows a graph of outside

temperature 2802, inside temperature 2804 and HVAC cycling times 2806 in House A for a specific 24-hour period on date Y assuming that the system has used a pre-cooling strategy to avoid running the air conditioning during the afternoon, when rates are highest. Because House A has high thermal mass, the house is capable of "banking" cooling, and energy consumed during off-peak hours is in effect stored, allowing the house to remain cool even when the system is turned off. Temperatures keep rising during the period the air conditioning is off, but because thermal mass is high, the rate of increase is low, and the house is still comfortable six hours later.

[0186] Although the pre-cooling cycle time in a given home may be relatively long, the homeowner may still benefit if the price per kilowatt during the morning pre-cooling phase is lower than the price during the peak load period. **Figure 28b** shows a graph of the same outside temperature 2802 in House B as in House A in **Figure 28a** for the same 24-hour period and using the same pre-cooling strategy as shown by cycling times 2806. But because House B has minimal thermal mass, using additional electricity in order to pre-cool the house does not have the desired effect; inside temperature 2808 warms up so fast that the cooling that had been banked is quickly lost. Thus the system will recommend that House A pre-cool in order to save money, but not recommend pre-cooling for House B.

[0187] The system can also help compensate for anomalies such as measurement inaccuracies due to factors such as poor thermostat location. It is well known that thermostats should be placed in a location that will be likely to experience "average" temperatures for the overall structure, and should be isolated from windows and other influences that could bias the temperatures they "see." But for various reasons, not all thermostat installations fit that ideal. **Figure 29a** shows a graph of outside temperature 2902, the actual average inside temperature for the entire house 2904, and inside temperature as read by the thermostat 2906 in House C for a specific 24-hour period on September 15th, assuming that the thermostat is located so that for part of the afternoon on that day the thermostat is in direct sunlight.

[0188] Until the point at which the sun hits the thermostat, the average inside temperature and temperature as read by the thermostat track very closely. But when

the direct sunlight hits the thermostat, the thermostat and the surrounding area can heat up, causing the internal temperature as read by the thermostat to diverge significantly from the average temperature for the rest of the house. A conventional thermostat has no way of distinguishing this circumstance from a genuinely hot day, and will both over-cool the rest of the house and waste considerable energy when it cycles the air conditioner in order to reduce the temperature as sensed by the thermostat.

[0189] If the air conditioning is turned off, this phenomenon will manifest as a spike in temperature as measured by the thermostat. If the air conditioning is turned on (and has sufficient capacity to respond to the distorted temperature signal caused by the sunlight), this phenomenon will likely manifest as relatively small changes in the temperature as sensed by the thermostat, but significantly increased HVAC usage (as well as excessively lowered temperatures in the rest of the house, but this result may not be directly measured in a single sensor environment).

[0190] An embodiment of the system, in contrast, has multiple mechanisms that will allow it to correct for such distortions. First, because an embodiment of the subject system compares the internal readings from House C with the external temperature, it will be obvious that the rise in temperature at 4:00PM is not correlated with a corresponding change in outside temperature. Second, because the system is also monitoring the readings from the thermostat in nearby House D, which (as shown in **Figure 29b**) is exposed to the same outside temperature 602, but has no sudden rise in measured internal afternoon temperature 2908, the system has further validation that the temperature increase is not caused by climatic conditions. And finally, because the system has monitored and recorded the temperature readings from the thermostat in House C for each previous day, and has compared the changing times of the aberration with the progression of the sun, the system can distinguish the patterns likely to indicate solar overheating from other potential causes.

[0191] **Figure 30** illustrates the steps involved in calculating comparative thermal mass, or the thermal mass index. In step 3002, the server retrieves climate data related to home X. Such data may include current outside temperature, outside

temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3004, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0192] In step 3006, the server retrieves data regarding recent temperature readings as recorded by the thermostat in home X. In step 3008, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0193] In step 3010, the server retrieves the current inside temperature reading as transmitted by the thermostat. In step 3012, the server calculates the thermal mass index for the home under those conditions; that is, for example, it calculates the likely rate of change for internal temperature in home X from a starting point of 70 degrees when the outside temperature is 85 degrees at 3:00PM on August 10th when the wind is blowing at 5 mph from the north and the sky is cloudy. The server accomplishes this by applying a basic algorithm that weighs each of these external variables as well as variables for various characteristics of the home itself (such as size, level of insulation, method of construction, etc.) and data from other houses and environments.

[0194] **Figure 31** illustrates the steps involved in diagnosing defects in the HVAC system for specific home X. In step 3102, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3104, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0195] In step 3106, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3108, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data. In step 3110, the server retrieves comparative data from other houses that have thermostats that also report to the server.

[0196] Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses. In step 3112, the server calculates the current relative efficiency of home X as compared to other homes. Those comparisons will take into account differences in size, location, age, etc in making those comparisons.

[0197] The server will also take into account that comparative efficiency is not absolute, but will vary depending on conditions. For example, a house that has extensive south-facing windows is likely to experience significant solar gain. On sunny winter days, that home will appear more efficient than on cloudy winter days. That same house will appear more efficient at times of day and year when trees or overhangs shade those windows than it will when summer sun reaches those windows. Thus the server will calculate efficiency under varying conditions.

[0198] In step 3114 the server compares the HVAC system's efficiency, corrected for the relevant conditions, to its efficiency in the past. If the current efficiency is substantially the same as the historical efficiency, the server concludes 3116 that there is no defect and the diagnostic routine ends. If the efficiency has changed, the server proceeds to compare the historical and current data against patterns of changes known to indicate specific problems. For example, in step 3118, the server compares that pattern of efficiency changes against the known pattern for a clogged air filter, which is likely to show a slow, gradual degradation over a period of weeks or even months.

[0199] If the pattern of degradation matches the clogged filter paradigm, the server creates and transmits to the homeowner a message 3120 alerting the homeowner to the possible problem. If the problem does not match the clogged filter paradigm, the system compares 3122 the pattern to the known pattern for a refrigerant leak, which is likely to show a degradation over a period of a few hours to a few days. If the pattern of degradation matches the refrigerant leak paradigm, the server creates and transmits to the homeowner a message 3124 alerting the homeowner to the possible problem.

[0200] If the problem does not match the refrigerant leak paradigm, the system compares 3126 the pattern to the known pattern for an open window or door, which is likely to show significant changes for relatively short periods at intervals uncorrelated with climatic patterns. If the pattern of degradation matches the open door/window paradigm, the server creates and transmits to the homeowner a message 3128 alerting the homeowner to the possible problem. If the problem does not match the refrigerant leak paradigm, the system continues to step through remaining know patterns N 3130 until either a pattern is matched 3132 or the list has been exhausted without a match 3134.

[0201] **Figure 32** illustrates the steps involved in diagnosing inaccurate thermostat readings due to improper location. In step 3202, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3204, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0202] In step 3206, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3208, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is

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insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0203] In step 3210, the server retrieves comparative data from other houses that have thermostats that also report to the server. Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses.

[0204] In step 3212, the server calculates the expected thermostat temperature reading based upon the input data. In step 3214, the server compares the predicted and actual values. If the calculated and actual values are at least roughly equivalent, the server concludes 3216 that there is no thermostat-related anomaly. If the calculated and actual values are not roughly equivalent, the server retrieves additional historical information about past thermostat readings in step 3218.

[0205] In step 3220, the server retrieves solar progression data, i.e., information regarding the times at which the sun rises and sets on the days being evaluated at the location of the house being evaluated, and the angle of the sun at that latitude, etc. In step 3222, the server compares the characteristics of the anomalies over time, to see if, for example, abnormally high readings began at 3:06 on June 5th, 3:09 on June 6th, 3:12 on June 7th, and the solar progression data suggests that at the house being analyzed, that sun would be likely to reach a given place in that house three minutes later on each of those days.

[0206] If the thermostat readings do not correlate with the solar progression data, the server concludes 3224 that the sun is not causing the distortion by directly hitting the thermostat. If the thermostat readings do correlate with solar progression, the server then calculates 3226 the predicted duration of the distortion caused by the sun.

[0207] In step 3228, the server calculates the appropriate setpoint information to be used by the thermostat to maintain the desired temperature and correct for the distortion for the expected length of the event. For example, if the uncorrected setpoint during the predicted event is 72 degrees, and the sun is expected

to elevate the temperature reading by eight degrees, the server will instruct the thermostat to maintain a setpoint of 80 degrees. In step 3230, the server sends the homeowner a message describing the problem.

[0208] One or more embodiments of the invention may be used to implement additional energy savings by implementing small, repeated changes in setpoint. Because energy consumption is directly proportional to setpoint – that is, the further a given setpoint diverges from the balance point (the natural inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by any strategy that over a given time frame lowers the average heating setpoint or raises the cooling setpoint.

[0209] It is therefore possible to save energy by adopting a strategy that takes advantage of human insensitivity to slow temperature ramping by incorporating a user's desired setpoint within the range of the ramp, but setting the average target temperature below the desired setpoint in the case of heating, and above it in the case of cooling. For example, a ramped summer setpoint that consisted of a repeated pattern of three phases of equal length set at 72°F, 73°F, and 74°F would create an effective average setpoint of 73°F, but would generally be experienced by occupants as yielding at least roughly equivalent comfort as in a room set at a constant 72°F. Energy savings resulting from this approach have been shown to be in the range of 4-6%.

[0210] Embodiments of the invention can automatically generate optimized ramped setpoints that could save energy without compromising the comfort of the occupants. It would also be advantageous to create a temperature control system that could incorporate adaptive algorithms that could automatically determine when the ramped setpoints should not be applied due to a variety of exogenous conditions that make application of such ramped setpoints undesirable.

[0211] **Figure 33** represents the conventional programming of a thermostat and the resulting behavior of a home's HVAC system in the air conditioning context. The morning setpoint 3302 of 74 degrees remains constant from midnight until 9:00AM, and the inside temperature 3304 varies more or less within the limits of the

hysteresis band during that entire period. When the setpoint changes to 80 degrees 3306, the inside temperature 3308 varies within the hysteresis band around the new setpoint, and so on. Whether the average temperature is equal to, greater or less than the nominal setpoint will depend on weather conditions, the dynamic signature of the structure, and the efficiency and size of the HVAC system. But in most cases the average temperature will be at least roughly equivalent to the nominal setpoint.

[0212] **Figure 34** represents implementation of a three-phase ramped setpoint derived from the same user preferences as manifested by the settings shown in **Figure 33**. Thus the user-selected setpoint for the morning is still 74 degrees, and is reflected in the setpoint 3404 at the start of each three-step cycle, but because (in the air conditioning context) the setpoint requested by the user is the lowest of the three discrete steps, rather than the middle step, the average setpoint will be one degree higher 3402, and the resulting average inside temperature will be roughly one degree warmer than the average temperature without use of the ramped setpoints, thereby saving energy.

[0213] In the currently preferred embodiment, the implementation of the ramped setpoints may be dynamic based upon both conditions inside the structure and other planned setpoint changes. Thus, for example, the ramped setpoints 3406, 3408 and 3410 may be timed so that the 9AM change in user-determined setpoint from 74 degrees to 80 degrees is in effect anticipated, and the period in which the air conditioner is not used can be extended prior to the scheduled start time for the less energy-intensive setpoint. Similarly, because the server 106 is aware that a lower setpoint will begin at 5PM. The timing can be adjusted to avoid excessively warm temperatures immediately prior to the scheduled setpoint change, which could cause noticeable discomfort relative to the new setpoint if the air conditioner is incapable of quickly reducing inside temperature on a given day based upon the expected slope of inside temperatures at that time 3412.

[0214] In order to implement such ramped setpoints automatically, algorithms may be created. These algorithms may be generated and/or executed as instructions on remote server 106 and the resulting setpoint changes can be transmitted to a given

thermostat on a just-in-time basis or, if the thermostat 108 is capable of storing future settings, they may be transferred in batch mode to such thermostats. Basic parameters used to generate such algorithms include:

[0215] the number of discrete phases to be used;

[0216] the temperature differential associated with each phase; and

[0217] the duration of each phase

[0218] In order to increase user comfort and thus maximize consumer acceptance, additional parameters may be considered, including:

[0219] time of day

[0220] outside weather conditions

[0221] recent history of manual inputs

[0222] recent pre-programmed setpoint changes.

[0223] Time of day may be relevant because, for example, if the home is typically unoccupied at a given time, there is no need for perceptual programming. Outside weather is relevant because comfort is dependent not just on temperature as sensed by a thermostat, but also includes radiant differentials. On extremely cold days, even if the inside dry-bulb temperature is within normal comfort range, radiant losses due to cold surfaces such as single-glazed windows can cause subjective discomfort; thus on such days occupants may be more sensitive to ramping. Recent manual inputs (e.g., programming overrides) may create situations in which exceptions should be taken; depending on the context, recent manual inputs may either suspend the ramping of setpoints or simply alter the baseline temperature from which the ramping takes place.

[0224] **Figure 35** shows the steps used in the core ramped setpoint algorithm in the context of a remotely managed thermostat system. In step 3502 the application determines whether to instantiate the algorithm based upon external scheduling criteria. In step 3504 the application running on a remote server retrieves from the thermostat the data generated by or entered into the thermostat, including current temperature settings, HVAC status and inside temperature. The algorithm performs preliminary logical tests at that point to determine whether further processing is

required. For example, in the heating context, if the inside temperature as reported by the thermostat 108 is more than 1 degree higher than the current setpoint, the algorithm may determine that running the ramped setpoint program will have no effect and therefore terminate.

[0225] In step 3506 the algorithm advances to the next phase from the most recent phase; i.e., if the algorithm is just starting, the phase changes from "0" to "1"; if it has just completed the third phase of a three-phase ramp, the phase will change from "2" to "0". In step 3508 the application determines if the current phase is "0". If it is, then in step 3510 the algorithm determines whether current setpoint equals the setpoint in the previous phase. If so, which implies no manual overrides or other setpoint adjustments have occurred during the most recent phase, then in step 3512 the algorithm sets the new setpoint back to the previous phase "0" setpoint. If not, then in step 3514, the algorithm keeps the current temperature setting as setpoint for this new phase. In step 3516, the algorithm logs the resulting new setpoint as the new phase "0" setpoint for use in subsequent phases.

[0226] Returning to the branch after step 3508, if the current phase at that point is not phase "0", then in step 3520, the algorithm determines whether the current setpoint is equal to the setpoint temperature in the previous phase. If not, which implies setpoints have been adjusted by the house occupants, thermostat schedules, or other events, then in step 3522, the application resets the phase to "0", resets the new setpoint associated with phase "0" to equal the current temperature setting, and sets the current setting to that temperature. Alternatively, if the current temperature setting as determined in step 3520 is equal to the setpoint in the previous phase, then in step 3524 new setpoint is made to equal current setpoint plus the differential associated with each phase change. In step 3526 the "previous-phase setpoint" variable is reset to equal the new setpoint in anticipation of its use during a subsequent iteration.

[0227] **Figure 36** shows one embodiment of the overall control application implementing the algorithm described in **Figure 35**. In step 3602, the control application retrieves the current setting from the thermostat. In step 3604, the setting is logged in database 300. In step 3606, the control program determines whether other

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algorithms that have higher precedence than the ramped setpoint algorithm are to be run. If another algorithm is to be run prior to the ramped setpoint algorithm, then the other program is executed in step 3608. If there are no alternate algorithms that should precede the ramped setpoint application then in step 1310, the control program determines whether the thermostat has been assigned to execute the ramped setpoint program. If not, the control program skips the remaining actions in the current iteration. If the program is set to run, then in step 3612 the algorithm retrieves from database 300 the rules and parameters governing the implementation of the algorithm for the current application of the program.

[0228] In step 3614, the algorithm determines whether one or more conditions that preclude application of the algorithm, such as extreme outside weather conditions, whether the home is likely to be occupied, etc. If any of the exclusionary conditions apply, the application skips execution of the ramped setpoint algorithm for the current iteration. If not, the application proceeds to step 3616 in which the application determines whether the setpoint has been altered by manual overrides, thermostat setback schedule changes, or other algorithms as compared to the previous value as stored in database 300. If setpoint has been altered, the application proceeds to step 3620 discussed below.

[0229] In step 3618, the program described in **Figure 35** is executed. In step 3620, the application resets the phase to "0". Certain temperature setting variables are reset in anticipation of their use in subsequent phases. These variables include the new phase 0 temperature setting which is anchored to the current actual temperature setting, and the new previous-phase setpoint which will be used for identifying setpoint overrides in the subsequent phase.

[0230] In step 3622, the system records the changes to the thermostat settings to database 300. In step 3624, the system records the changes to the phase status of the algorithm to database 300. In step 3626, the application determines whether the new temperature setting differs from the current setting. If they are the same, the application skips applying changes to the thermostat. If they are different, then in step 3628, the application transmits revised settings to the thermostat. In step

3630, the application then hibernates for the specified duration until it is invoked again by beginning at step 3602 again.

[0231] An embodiment of the subject invention may also be used to detect occupancy through the use of software related to electronic devices located inside the conditioned structure, such as the browser running on computer or other device 104. **Figure 37** represents the screen of a computer or other device 104 using a graphical user interface connected to the Internet. The screen shows that a browser 3700 is displayed on computer 104. In one embodiment, a background application installed on computer 104 detects activity by a user of the computer, such as cursor movement, keystrokes or otherwise, and signals the application running on server 106 that activity has been detected. Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; (b) signal the background application running on computer 104 to trigger a software routine that instantiates a pop-up window 3702 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. The user can respond by clicking the cursor on "yes" button 3704 or "No" button 3706. Equilvalent means of signalling activity may be employed with interactive television programming, gaming systems, etc.

[0232] **Figure 38** is a flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 3802, computer 104 transmits a message to server 106 via the Internet indicating that there is user activity on computer 104. This activity can be in the form of keystrokes, cursor movement, input via a television remote control, etc. In step 3804 the application queries database 300 to retrieve setting information for the HVAC system. In step 3806 the application determines whether the current HVAC program is intended to apply when the home is occupied or unoccupied.

[0233] If the HVAC settings then in effect are intended to apply for an occupied home, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step

3808 the application will retrieve from database 300 the user's specific preferences for how to handle this situation. If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 3816, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 3810 the application transmits a command to computer 104 directing the browser to display a message informing the user that the current setting assumes an unoccupied house and asking the user in step 3812 to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 3814 the application will write to database 300 the fact that the users has so elected and terminate. If the user elects to change the setting, then in step 3816 the application transmits the revised setpoint to the thermostat. In step 3814 the application writes the updated setting information to database 300.

[0234] **Figure 39** is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system. In step 3902 computer 104 transmits to server 106 information regarding the type of activity detected on computer 104. Such information could include the specific program or channel being watched if, for example, computer 104 is used to watch television. The information matching, for example, TV channel 7 at 4:00 PM on a given date to specific content may be made by referring to Internet-based or other widely available scheduling sources for such content. In step 3904 server 106 retrieves from database 300 previously logged data regarding viewed programs. In step 3906 server 106 retrieves previously stored data regarding the residents of the house.

[0235] For example, upon initiating the service, one or more users may have filled out online questionnaires sharing their age, gender, schedules, viewing preferences, etc. In step 3908, server 106 compares the received information about

user activity to previously stored information retrieved from database 300 about the occupants and their viewing preferences. For example, if computer 104 indicates to server 106 that the computer is being used to watch golf, the server may conclude that an adult male is watching; if computer 104 indicates that it is being used to watch children's programming, server 106 may conclude that a child is watching.

[0236] In step 3910 the server transmits a query to the user in order to verify the match, asking, in effect, "Is that you Bob?" In step 3912, based upon the user's response, the application determines whether the correct user has been identified. If the answer is no, then the application proceeds to step 3916. If the answer is yes, then in step 3914 the application retrieves the temperature settings for the identified occupant. In step 3916 the application writes to database 300 the programming information and information regarding matching of users to that programming.

[0237] In an alternative embodiment, the application running on computer 104 may respond to general user inputs (that is, inputs not specifically intended to instantiate communication with the remote server) by querying the user whether a given action should be taken. For example, in a system in which the computer 104 is a web-enabled television or web-enabled set-top device connected to a television as a display, software running on computer 104 detects user activity, and transmits a message indicating such activity to server 106. The trigger for this signal may be general, such as changing channels or adjusting volume with the remote control or a power-on event. Upon receipt by server 106 of this trigger, server 106 transmits instructions to computer 104 causing it to display a dialog box asking the user whether the user wishes to change HVAC settings.

[0238] Additional functionality is also envisioned as part of different embodiments of the invention. For example, information from historic data may be used to predict how long it will take a user to reach home from the current coordinates, and the estimated arrival time may be used to calculate optimal cycling strategies for the HVAC system. In addition, information about traffic conditions may be integrated into these calculations, so that the geospatial data relative to mobile device 105 may indicate that a user is taking his or her normal route, but because of a traffic jam, is

likely to come home later than would otherwise be expected. The characteristics of a given location may be used to infer arrival times as well. For example, if the geospatial data indicates that the user of mobile device 105 has arrived at the supermarket on his way home, a delay of 20 minutes is likely, whereas if the user has parked at a restaurant, the delay is likely to be one hour.

[0239] It is also possible to incorporate more sophisticated heuristics in incorporating the varying preferences of multiple occupants of a given home or other structure. For example, rules can be structured so that User #1's preferences control during the heating season, but not during the cooling season; User #2's preferences might control during certain times of the day but not others; User #3's preferences amy take precedence whenever they result in a more energy efficient strategy, but not when they result in increased energy use, and so on.

[0240] While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, that the invention may be carried out in other ways without departing from the true spirit and scope. These and other equivalents are intended to be covered by the following claims:

WHAT IS CLAIMED IS:

1. A method for varying temperature setpoints for an HVAC system comprising:

accessing stored data comprising a plurality of internal temperature measurements taken within a structure and a plurality of outside temperature measurements relating to temperatures outside the structure;

using the stored data to predict a temperature inside the structure in response to at least changes in the outside temperatures;

determining with one or more computer processors, the geographic location of a mobile electronic device that is connected to a network;

associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices;

determining with one or more computer processors, whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device;

using route data to determine whether a user of the mobile electronic device is traveling to said structure;

using traffic data to predict a length of time for a user of said mobile device to reach said structure; and

adjusting with one or more computer processors, the temperature setpoint on said controller for an HVAC system for said structure based upon said predicted length of time for a user of the mobile device to reach said structure, said predicted temperature inside said structure, and whether or not said structure is deemed to be occupied.

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

ABSTRACT OF THE DISCLOSURE

Embodiments of the invention comprise systems and methods for using the geographic location of networked consumer electronics devices as indications of occupancy of a structure for purposes of automatically adjusting the temperature setpoint on a thermostatic HVAC control. At least one thermostat is located inside a structure and is used to control an HVAC system in the structure. At least one mobile electronic device is used to indicate the state of occupancy of the structure. The state of occupancy is used to alter the setpoint on the thermostatic HVAC control to reduce unneeded conditioning of unoccupied spaces.

Ex. 1006.0260

Electronic Patent Application Fee Transmittal

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Filing Date:	19-Sep-2014
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First Named Inventor/Applicant Name:	John Douglas Steinberg
Filer:	John R. King/Amy Durrant
Attorney Docket Number:	EFACT.012C2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Utility filing Fee (Electronic filing)	4011	1	70	70
Utility Search Fee	2111	1	300	300
Utility Examination Fee	2311	1	360	360
Pages:				
Claims:				
Miscellaneous-Filing:				
Late Filing Fee for Oath or Declaration	2051	1	70	70
Petition:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				
Extension - 1 month with $0 paid	2251	1	100	100
Miscellaneous:				
		Total in USD ($)		**900**

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File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Applicant Response to Pre-Exam Formalities Notice	EFACT-012C2_response.pdf	49364 63806ac1fd74eb7b11b237d30362bc2c35766aa0	no	2
Warnings:					
Information:					
2		EFACT-012C2_prelamend.pdf	419314 b9d9588fc52e4227795e481c4e739f83e1743f3b	yes	10

Multipart Description/PDF files in .zip description

Document Description	Start	End
Preliminary Amendment	1	1
Specification	2	2
Claims	3	5
Applicant Arguments/Remarks Made in an Amendment	6	10

Warnings:					
Information:					
3	Power of Attorney	EFACT-012C2_poa.pdf	179650 f486c3f291ad2864a001b25bd70e6a87ec334ce4	no	2
Warnings:					
Information:					
4		EFACT-012C2_ids.pdf	701090 144c4eafe278b02d6c31b4a60245ab7f4b7b99a6	yes	12

Multipart Description/PDF files in .zip description

Document Description	Start	End
Transmittal Letter	1	2
Information Disclosure Statement (IDS) Form (SB08)	3	12

Warnings:

Information:					
5	Miscellaneous Incoming Letter	EFACT-012C2_rescission.pdf	62976 9077d50d116ece017bab0916700cd0c1e7e2d2e5	no	2
Warnings:					
Information:					
6		EFACT-012C2_subspec.pdf	2801685 9e41b6d49202e4ad65588e4ec094506f3c5c0373	yes	56

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	54
	Claims	55	55
	Abstract	56	56

Warnings:					
Information:					
7	Applicant Arguments/Remarks Made in an Amendment	EFACT-012C2_redlinespec.pdf	2802097 a5e416edfa9fbfd90c0d2735c30c95f0eb49bd67	no	56
Warnings:					
Information:					
8	Fee Worksheet (SB06)	fee-info.pdf	39333 4159781d96e65af02fa65a8f37f0c1c44674ffa3	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	7055509		

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National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/491,554

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	70		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	300		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 40 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*	x 210 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	730		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2

CONFIRMATION NO. 1254

20995
KNOBBE MARTENS OLSON & BEAR LLP
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IRVINE, CA 92614

FORMALITIES LETTER

OC000000072589325

Date Mailed: 12/31/2014

NOTICE OF INCOMPLETE REPLY (NONPROVISIONAL)

Filing Date Granted

The U.S. Patent and Trademark Office has received your reply on 12/19/2014 to the Notice to File Missing Parts (Notice) mailed 09/26/2014 and it has been entered into the nonprovisional application. The reply, however, does not include the following items required in the Notice. A complete reply must be timely filed to prevent ABANDONMENT of the above-identified application. Replies should be mailed to: Mail Stop Missing Parts, Commissioner for Patents, P.O. Box 1450, Alexandria VA 22313-1450.

Applicant is given **TWO MONTHS** from the date of the Notice to File Missing Parts (Notice) mailed 09/26/2014 within which to file all required items and pay any fees required below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

Items Required to Avoid Abandonment:

The required items noted below SHOULD be filed along with any items required above. The filing date of this nonprovisional application will be the date of receipt of the items required above.

The application is informal since it does not comply with the regulations for the reason(s) indicated below.

The required item(s) identified below must be timely submitted to avoid abandonment:

- A substitute specification in compliance with 37 CFR 1.52, 1.121(b)(3), and 1.125, is required. The substitute specification must be submitted with markings and be accompanied by a clean version (without markings) as set forth in 37 CFR 1.125(c) and a statement that the substitute specification contains no new matter (see 37 CFR 1.125(b)). The specification, claims, and/or abstract page(s) submitted is not acceptable and cannot be scanned or properly stored because:
  - The application contains drawings, but the specification does not contain a brief description of the several views of the drawings as required by 37 CFR 1.74 and 37 CFR 1.77(b)(9).

Applicant is cautioned that correction of the above items may cause the specification and drawings page count to exceed 100 pages. If the specification and drawings exceed 100 pages, applicant will need to submit the required application size fee.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be mailed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web, including a copy of this Notice and selecting the document description "Applicant response to Pre-Exam Formalities Notice". https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at http://www.uspto.gov/ebc.

If you are not using EFS-Web to submit your reply, you must include a copy of this notice.

/mtegene/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2

CONFIRMATION NO. 1254

20995
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2040 MAIN STREET
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POA ACCEPTANCE LETTER

OC000000072589274

Date Mailed: 12/31/2014

NOTICE OF ACCEPTANCE OF POWER OF ATTORNEY

This is in response to the Power of Attorney filed 12/19/2014.

The Power of Attorney in this application is accepted. Correspondence in this application will be mailed to the above address as provided by 37 CFR 1.33.

/mtegene/

Office of Data Management, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Inventor	:	John Douglas Steinberg
App. No.	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Examiner	:	Unknown
Art Unit	:	3744
Conf. No.	:	1254

RESPONSE TO NOTICE OF INCOMPLETE REPLY

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

Prior to examination of this application, Applicant respectfully submits the following amendments and comments.

Amendments to the Specification begin on page 2 of this paper.

Amendments to the Claims are reflected in the listing of claims which begins on page 3 of this paper.

Remarks/Arguments begin on page 4 of this paper.

AMENDMENTS TO THE SPECIFICATION

Please enter the Substitute Specification submitted herewith into the application. Applicant has amended the Substitute Specification at paragraph 0039 to clarify that Figure 16 includes Figures 16-1 and 16-2 and paragraph 0044 to refer to Figure 21b. Applicant submits that the Substitute Specification includes no new matter.

AMENDMENTS TO THE CLAIMS

Applicant has not amended the pending claims in this Response.

REMARKS

Applicant has submitted both a red-line copy and a clean copy of the Substitute Specification. Applicant has amended the Substitute Specification at paragraph 0039 to state that Figure 16 includes 16-1 and 16-2.

In addition, Applicant has amended paragraph 0044 to refer to Figure 21b.

Applicant submits that these changes do not add any new matter.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: 2-27-2015

By: John R. King

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121814

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Cross-Reference to Related Applications

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet, or any correction thereto, are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to the use of thermostatic HVAC and other energy management controls that are connected to a computer network. More specifically, the present invention pertains to the use of geographic movement of network-connected mobile devices to occupancy to inform an energy management system, to provide enhanced efficiency, and to verify demand response.

Description of the Related Art

[0003] Heating and cooling systems for buildings (heating, ventilation and cooling, or HVAC systems) have been controlled for decades by thermostats. At the most basic level, a thermostat includes a means to allow a user to set a desired temperature, a means to sense actual temperature, and a means to signal the heating and/or cooling devices to turn on or off in order to try to change the actual temperature to equal the desired temperature. The most basic versions of thermostats use components such as a coiled bi-metallic spring to measure actual temperature and a mercury switch that opens or completes a circuit when the spring coils or uncoils with temperature changes. More recently, electronic digital thermostats have become prevalent. These thermostats use solid-state devices such as thermistors or thermal diodes to measure temperature, and microprocessor-based circuitry to control the switch and to store and operate based upon user-determined protocols for temperature vs. time.

[0004] These programmable thermostats generally offer a very restrictive user interface, limited by the cost of the devices, the limited real estate of the small wall-mounted boxes, and the inability to take into account more than two variables: the desired temperature set by the user, and the ambient temperature sensed by the thermostat. Users can generally only set one series of commands per day, and in order to change one parameter (e.g., to change the late-night temperature) the user often has to cycle through several other parameters by repeatedly pressing one or two buttons.

[0005] Because the interface of programmable thermostats is so poor, the significant theoretical savings that are possible with them (sometimes cited as 25% of heating and cooling costs) are rarely realized. In practice, studies have found that more than 50% of users never program their thermostats at all. Significant percentages of the thermostats that are programmed are programmed sub-optimally, in part because, once programmed, people tend to not to re-invest the time needed to change the settings very often.

[0006] A second problem with standard programmable thermostats is that they represent only a small evolutionary step beyond the first, purely mechanical thermostats. Like the first thermostats, they only have two input signals - ambient temperature and the preset desired temperature. The entire advance with programmable thermostats is that they can shift between multiple present temperatures at different times without real-time involvement of a human being.

[0007] Because most thermostats control HVAC systems that do not offer infinitely variable output, traditional thermostats are designed to permit the temperature as seen by the thermostat to vary above and below the setpoint to prevent the HVAC system from constantly and rapidly cycling on and off, which is inefficient and harmful to the HVAC system. The temperature range in which the thermostat allows the controlled environment to drift is known as both the dead zone and, more formally, the hysteresis zone. The hysteresis zone is frequently set at +/- 1 degree Fahrenheit. Thus if the setpoint is 68 degrees, in the heating context the thermostat will allow the inside temperature to fall to 67 degrees before turning the heating system on, and will allow it to rise to 69 degrees before turning it off again.

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[0008] As energy prices rise, more attention is being paid to ways of reducing energy consumption. Because energy consumption is directly proportional to setpoint - that is, the further a given setpoint diverges from the balance point (the inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by virtually any strategy that over a given time frame lowers the average heating setpoint or raises the average cooling setpoint. Conventional programmable thermostats allow homeowners to save money and energy by pre-programming setpoint changes based upon comfort or schedule. For example, in the summer, allowing the setpoint to rise by several degrees (or even shutting off the air conditioner) when the home is unoccupied will generally save significantly on energy. But such thermostats have proven to be only minimally effective in practice. Because they have such primitive user interfaces, they are difficult to program, and so many users never bother at all, or set them up once and do not alter the programming even if their schedules change.

[0009] In the hotel industry, the heating and cooling decisions made in hundred or even thousands of individual rooms with independently controlled HVAC systems are aggregated into a single energy bill, so hotel owners and managers are sensitive to energy consumption by those systems. Hotel guests often turn the air conditioner to a low temperature setting and then leave the room for hours at a time, thereby wasting considerable energy. An approach commonly used outside of the United States to combat this problem is to use a keycard to control the HVAC system, such that guests place the keycard into a slot mounted on the wall near the door of the room which then triggers the lights and HVAC system to power up, and turn them off when the guest removes the card upon leaving the room. However, because most hotels give each guest two cards, it is easy to simply leave the extra card in the slot, thus defeating the purpose of the system. Recently, systems have been introduced in which a motion sensor is connected to the control circuitry for the HVAC system. If no motion is detected in the room for some predetermined interval, the system concludes that the room is unoccupied, and turns off the HVAC system or alters the setpoint to a more economical level. When the motion sensor detects motion (which is assumed to

coincide with the return of the guest), the HVAC system resets to the guest's chosen setting.

[0010] Adding occupancy detection capability to residential HVAC systems could also add considerable value in the form of energy savings without significant tradeoff in terms of comfort. But the systems used in hotels do not easily transfer to the single-family residential context. Hotel rooms tend to be small enough that a single motion sensor is sufficient to determine with a high degree of accuracy whether or not the room is occupied. A single motion sensor in the average home today would have limited value because there are likely to be many places one or more people could be home and active yet invisible to the motion sensor. The most economical way to include a motion sensor in a traditional programmable thermostat would be to build it into the thermostat itself. But thermostats are generally located in hallways, and thus are unlikely to be exposed to the areas where people tend to spend their time. Wiring a home with multiple motion sensors in order to maximize the chances of detecting occupants would involve considerable expense, both for the sensors themselves and for the considerable cost of installation, especially in the retrofit market. Yet if control is ceded to a single-sensor system that cannot reliably detect presence, the resulting errors would likely lead the homeowner to reject the system.

[0011] Although progress in residential HVAC control has been slow, tremendous technological change has come to the tools used for personal communication. When programmable thermostats were first offered, telephones were virtually all tethered by wires to a wall jack. But now a large percentage of the population carries at least one mobile device capable of sending and receiving voice or data or even video (or a combination thereof) from almost anywhere by means of a wireless network. These devices create the possibility that a consumer can, with an appropriate mobile device and a network-enabled HVAC system, control his or her HVAC system even when away from home. But systems that relay on active management decisions by consumers are likely to yield sub-optimal energy management outcomes, because consumers are unlikely to devote the attention and effort required to fully optimize energy use on a daily basis.

[0012] Many new mobile devices now incorporate another significant new technology – the ability to geolocate the device (and thus, presumably, the user of the device). One method of locating such devices uses the Global Positioning System (GPS). The GPS system uses a constellation of orbiting satellites with very precise clocks to triangulate the position of a device anywhere on earth based upon arrival times of signals received from those satellites by the device. Another approach to geolocation triangulates using signals from multiple cell phone towers. Such systems can enable a variety of so-called "location based services" to users of enabled devices. These services are generally thought of as aids to commerce like pointing users to restaurants or gas stations, etc.

[0013] It would be desirable to provide a system that could detect the location of regular occupants of a home or other structure without requiring the installation of additional hardware; that could accurately use such geospatial information in order to detect and predict occupancy, and could optimize energy consumption based upon dynamic and individually configurable heuristics.

SUMMARY OF THE INVENTION

[0014] In one embodiment, the invention comprises a thermostat attached to an HVAC system, a local network connecting the thermostat to a larger network such as the Internet, and one or more geolocation-enabled mobile devices attached to the network, and a server in bi-directional communication with a plurality of such thermostats and devices. The server pairs each thermostat with one or more geolocation-enabled mobile devices which are determined to be associated with the occupants of home in which the thermostat is located.

[0015] The server logs the ambient temperature sensed by each thermostat vs. time and the signals sent by the thermostats to their HVAC systems. The server also monitors and logs the geolocation data related to the geolocation-enabled mobile devices associated with each thermostat. Based on the locations and movement evidenced by geolocation data, the server instructs the thermostat to change temperature settings between those optimized for occupied and unoccupied states at the appropriate times based on the evolving geolocation data.

[0016] One embodiment of the invention is directed to a method for varying temperature setpoints for an HVAC system. The method comprises determining the geographic location of a mobile electronic device that is connected to a network and associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices. In addition, the method comprises determining whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device and adjusting the temperature setpoint on said controller for an HVAC system for said structure based upon whether or not said structure is deemed to be occupied.

[0017] In another embodiment, the mobile electronic device is a telephone. In an additional embodiment, the networked mobile electronic device is a personal digital assistant. In a further embodiment, the mobile electronic device is connected to the Internet.

[0018] In one embodiment the method for determining the geographic location of a mobile electronic device uses the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0019] In yet another embodiment, the variation of temperature setpoints is logged to a database. In a further embodiment, the variation of temperature setpoints is initiated by a remote computer. In a different embodiment, the temperature setpoints are varied automatically. In a further embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

[0020] In one embodiment, a system for altering the setpoint on a thermostat for space conditioning of a structure comprises at least one said thermostat having at least one temperature setting associated with the presence of one or more occupants in said structure, and at least one temperature setting associated with the absence of occupants in said structure. The system also comprises one or more mobile electronic

devices having at least a user interface, where the mobile electronic devices and said thermostat are connected to a network and where the setpoint on said thermostat is adjusted between said temperature setting associated with the presence of one or more occupants in said structure and said temperature setting associated with the absence of occupants in said structure based upon the geographic location of said electronic device.

[0021] In a further embodiment, the mobile electronic device is a telephone. In yet another embodiment, the networked mobile electronic device is a personal digital assistant. In still a further embodiment, the mobile electronic device is connected to the Internet.

[0022] In one embodiment, the method for determining the geographic location of a mobile electronic device is the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0023] In a different embodiment, the variation of temperature setpoints is logged to a database. In another embodiment, the variation of temperature setpoints is initiated by a remote computer. In a further embodiment, the temperature setpoints are varied automatically. In still another embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figure 1 shows an example of an overall environment in which an embodiment of the invention may be used.

[0025] Figure 2 shows a high-level illustration of the architecture of a network showing the relationship between the major elements of one embodiment of the subject invention.

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[0026] Figures 3a and 3b show an embodiment of the website to be used as part of the subject invention.

[0027] Figure 4 shows a high-level schematic of the thermostat used as part of an embodiment of the subject invention.

[0028] Figure 5 shows one embodiment of the database structure used as part of an embodiment of the subject invention.

[0029] Figures 6a and 6b illustrate pages of a website that may be used with an embodiment of the subject invention.

[0030] Figure 7 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0031] Figure 8 is a flowchart that shows how the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device connected to the system.

[0032] Figures 9a and 9b show how comparing inside temperature against outside temperature and other variables permits calculation of dynamic signatures.

[0033] Figure 10 shows a flow chart for a high level version of the process of calculating the appropriate turn-on time in a given home.

[0034] Figure 11 shows a more detailed flowchart listing the steps in the process of calculating the appropriate turn-on time in a given home for a just-in-time event.

[0035] Figures 12a, 12b, 12c and 12d show the steps shown in the flowchart in Figure 11 in the form of a graph of temperature and time.

[0036] Figure 13 shows a table of some of the data used by an embodiment of the subject invention to predict temperatures.

[0037] Figure 14 shows an embodiment of the subject invention as applied in a specific home on a specific day.

[0038] Figure 15 shows an embodiment of the subject invention as applied in a different specific home on a specific day.

[0039] Figure 16, which includes Figures 16-1 and 16-2, shows a table of predicted rates of change in temperature inside a given home for a range of temperature differentials between inside and outside.

Ex. 1006.0282

[0040] Figure 17 shows how manual inputs can be recognized and recorded by an embodiment of the subject invention.

[0041] Figure 18 shows how an embodiment of the subject invention uses manual inputs to interpret manual overrides and make short-term changes in response thereto.

[0042] Figure 19 shows how an embodiment of the subject invention uses manual inputs to make long-term changes to interpretive rules and to setpoint scheduling.

[0043] Figure 20 shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event.

[0044] Figure 21a, 21b, and 21c illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature.

[0045] Figure 22 is a flow chart illustrating the steps involved in generating a demand reduction event for a given subscriber.

[0046] Figure 23 is a flow chart illustrating the steps involved in confirming that a demand reduction event has taken place.

[0047] Figure 24 is a representation of the movement of messages and information between the components of an embodiment of the subject invention.

[0048] Figures 25a and 25b show graphical representations of inside and outside temperatures in two different homes, one with high thermal mass and one with low thermal mass.

[0049] Figures 26a and 26b show graphical representations of inside and outside temperatures in the same homes as in Figures 25a and 25b, showing the cycling of the air conditioning systems in those houses.

[0050] Figures 27a and 27b show graphical representations of inside and outside temperatures in the same home as in Figures 25a and 26a, showing the cycling of the air conditioning on two different days in order to demonstrate the effect of a change in operating efficiency on the parameters measured by the thermostat.

[0051] Figures 28a and 28b show the effects of employing a pre-cooling strategy in two different houses.

Ex. 1006.0283

[0052] Figures 29a and 29b show graphical representations of inside and outside temperatures in two different homes in order to demonstrate how the system can correct for erroneous readings in one house by referencing readings in another.

[0053] Figure 30 is a flowchart illustrating the steps involved in calculating the effective thermal mass of a home using an embodiment of the subject invention.

[0054] Figure 31 is a flowchart illustrating the steps involved in determining whether an HVAC system has developed a problem that impairs efficiency using an embodiment of the subject invention.

[0055] Figure 32 is a flowchart illustrating the steps involved in correcting for erroneous readings in one house by referencing readings in another using an embodiment of the subject invention.

[0056] Figure 33 shows the conventional programming of a programmable thermostat over a 24-hour period.

[0057] Figure 34 shows the programming of a programmable thermostat over a 24-hour period using ramped setpoints.

[0058] Figure 35 shows the steps required for the core function of the ramped setpoint algorithm.

[0059] Figure 36 shows a flowchart listing steps in the process of deciding whether to implement the ramped setpoint algorithm using an embodiment of the subject invention.

[0060] Figure 37 shows the browser as seen on the display of the computer used as part of an embodiment of the subject invention.

[0061] Figure 38 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0062] Figure 39 is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0063] **Figure 1** shows an example of an overall environment 100 in which an embodiment of the invention may be used. The environment 100 includes an

Ex. 1006.0284

interactive communication network 102 with computers 104 connected thereto. Also connected to network 102 are mobile devices 105, and one or more server computers 106, which store information and make the information available to computers 104 and mobile devices 105. The network 102 allows communication between and among the computers 104, mobile devices 105 and servers 106.

[0064] Presently preferred network 102 comprises a collection of interconnected public and/or private networks that are linked to together by a set of standard protocols to form a distributed network. While network 102 is intended to refer to what is now commonly referred to as the Internet, it is also intended to encompass variations which may be made in the future, including changes additions to existing standard protocols. It also includes various networks used to connect mobile and wireless devices, such as cellular networks.

[0065] When a user of an embodiment of the subject invention wishes to access information on network 102 using computer 104, the user initiates connection from his computer 104. For example, the user invokes a browser, which executes on computer 104. The browser, in turn, establishes a communication link with network 102. Once connected to network 102, the user can direct the browser to access information on server 106.

[0066] One popular part of the Internet is the World Wide Web. The World Wide Web contains a large number of computers 104 and servers 106, which store HyperText Markup Language (HTML) documents capable of displaying graphical and textual information. HTML is a standard coding convention and set of codes for attaching presentation and linking attributes to informational content within documents.

[0067] The servers 106 that provide offerings on the World Wide Web are typically called websites. A website is often defined by an Internet address that has an associated electronic page. Generally, an electronic page is a document that organizes the presentation of text graphical images, audio and video.

[0068] In addition to the Internet, the network 102 can comprise a wide variety of interactive communication media. For example, network 102 can include local area networks, interactive television networks, telephone networks, wireless data systems, two-way cable systems, and the like.

[0069] In one embodiment, computers 104 and servers 106 are conventional computers that are equipped with communications hardware such as modem or a network interface card. The computers include processors such as those sold by Intel and AMD. Other processors may also be used, including general-purpose processors, multi-chip processors, embedded processors and the like.

[0070] Computers 104 can also be microprocessor- controlled home entertainment equipment including advanced televisions, televisions paired with home entertainment/media centers, and wireless remote controls.

[0071] Computers 104 may utilize a browser configured to interact with the World Wide Web. Such browsers may include Microsoft Explorer, Mozilla, Firefox, Opera or Safari. They may also include browsers or similar software used on handheld, home entertainment and wireless devices.

[0072] The storage medium may comprise any method of storing information. It may comprise random access memory (RAM), electronically erasable programmable read only memory (EEPROM), read only memory (ROM), hard disk, floppy disk, CD-ROM, optical memory, or other method of storing data.

[0073] Computers 104 and 106 may use an operating system such as Microsoft Windows, Apple Mac OS, Linux, Unix or the like.

[0074] Computers 106 may include a range of devices that provide information, sound, graphics and text, and may use a variety of operating systems and software optimized for distribution of content via networks.

[0075] Mobile devices 105 can also be handheld and wireless devices such as personal digital assistants (PDAs), cellular telephones and other devices capable of accessing the network. Mobile devices 105 can use a variety of means for establishing the location of each device at a given time. Such methods may include the Global Positioning System (GPS), location relative to cellular towers, connection to specific wireless access points, or other means

[0076] **Figure 2** illustrates in further detail the architecture of the specific components connected to network 102 showing the relationship between the major elements of one embodiment of the subject invention. Attached to the network are thermostats 108 and computers 104 of various users. Connected to thermostats 108

are HVAC units 110. The HVAC units may be conventional air conditioners, heat pumps, or other devices for transferring heat into or out of a building. Each user is connected to the server 106 via wired or wireless connection such as Ethernet or a wireless protocol such as IEEE 802.11, a gateway 110 that connects the computer and thermostat to the Internet via a broadband connection such as a digital subscriber line (DSL), cellular radio or other form of broadband connection to the World Wide Web. Server 106 contains the content to be served as web pages and viewed by computers 104, software to manage thermostats 108, as well as databases containing information used by the servers.

[0077] Also attached to the Network are cellular radio towers 120, or other means to transmit and receive wireless signals in communication with mobile devices 105. Such communication may use GPRS, GSM, CDMA, EvDO, EDGE or other protocols and technologies for connecting mobile devices to a network.

[0078] **Figures 3a** and **3b** shows a representative mobile device 105 from the front and back, respectively. The front of the device includes a display 202, and may include a physical keyboard 204. Alternatively, a virtual keyboard may be included in a display with touchscreen functionality. For devices with voice capabilities, such as a smart phone, a microphone 206 and speaker 208 enable audio communications. An antenna 210, which may be mounted entirely within the mobile device, aids wireless communications. Modules included within mobile device 105 but not visible from the outside may include memory cards, microprocessors, GPS receivers, battery, etc.

[0079] **Figure 4** shows a high-level block diagram of thermostat 108 used as part of an embodiment of the subject invention. Thermostat 108 includes temperature sensing means 252, which may be a thermistor, thermal diode or other means commonly used in the design of electronic thermostats. It includes a microprocessor 254, memory 256, a display 258, a power source 260, a relay 262, which turns the HVAC system on and off in response to a signal from the microprocessor, and contacts by which the relay is connected to the wires that lead to the HVAC system.

[0080] To allow the thermostat to communicate bi-directionally with the computer network, the thermostat also includes means 264 to connect the thermostat to a local computer or to a wireless network. Such means could be in the form of

Ethernet, wireless protocols such as IEEE 802.11, IEEE 802.15.4, Bluetooth, cellular systems such as CDMA, GSM and GPRS, or other wireless protocols. The thermostat 250 may also include controls 266 allowing users to change settings directly at the thermostat, but such controls are not necessary to allow the thermostat to function.

[0081] The data used to manage the subject invention is stored on one or more servers 106 within one or more databases. As shown in **Figure 5**, the overall database structure 300 may include temperature database 400, thermostat settings database 500, energy bill database 600, HVAC hardware database 700, weather database 800, user database 900, transaction database 1000, product and service database 1100, user location database 1200 and such other databases as may be needed to support these and additional features.

[0082] Users of connected thermostats 250 may create personal accounts. Each user's account will store information in database 900, which tracks various attributes relative to users of the site. Such attributes may include the make and model of the specific HVAC equipment in the user's home; the age and square footage of the home, the solar orientation of the home, the location of the thermostat in the home, the user's preferred temperature settings, whether the user is a participant in a demand response program, etc.

[0083] User personal accounts may also associate one or more mobile devices with such personal accounts. For mobile devices with the capability for geopositioning awareness, these personal accounts will have the ability log such positioning data over time in database 1200.

[0084] In one embodiment, a background application installed on mobile device 105 shares geopositioning data for the mobile device with the application running on server 106 that logs such data. Based upon this data, server 106 runs software that interprets said data (as described in more detail below). Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; or (b) transmit a message to mobile device 105 that asks the user if the server should change the current setpoint, alter the overall programming of the system

Ex. 1006.0288

based upon a new occupancy pattern, etc. Such signalling activity may be conducted via email, text message, pop-up alerts, voice messaging, or other means.

[0085] **Figures 6a** and **6b** illustrate a website that may be provided to assist homeowners and others to interact with an embodiment of the subject invention. The website will permit thermostat users to perform through the web browser substantially all of the programming functions traditionally performed directly at the physical thermostat, such as temperature set points, the time at which the thermostat should be at each set point, etc. Preferably the website will also allow users to accomplish more advanced tasks such as allow users to program in vacation settings for times when the HVAC system may be turned off or run at more economical settings, and to set macros that will allow changing the settings of the temperature for all periods with a single gesture such as a mouse click.

[0086] As shown in **Figure 6a**, screen 351 of website 350 displays current temperature 352 as sensed by thermostat 108. Clicking on "up" arrow 354 raises the setpoint 358; clicking the down arrow 356 lowers setpoint 358. Screen 351 may also convey information about the outside weather conditions, such as a graphic representation 360 of the sun, clouds, etc. In homes with multiple thermostats, screen 351 may allow users to select different devices to adjust or monitor. Users will be able to use screen 351 by selecting, for example, master bedroom thermostat 362, living room thermostat 364, game room thermostat 366, or basement thermostat 368.

[0087] As shown in **Figure 6b**, screen 370 allows users to establish programming schedules. Row 372 shows a 24-hour period. Programming row 374 displays various programming periods and when they are scheduled, such as away setting 376, which begins at approximately 8AM and runs until approximately 5:30PM. When the away setting 376 is highlighted, the user can adjust the starting time and ending time for the setting by dragging the beginning time 378 to the left to choose an earlier start time, and dragging it to the right to make it later. Similarly, the user can drag ending time 380 to the left to make it earlier, and to the right to make it later. While away setting 376 is highlighted, the user can also change heating setpoint 382 by clicking on up arrow 384 or down arrow 386, and cooling setpoint 388 by clicking on up

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arrow 390 or down arrow 392. The user can save the program by clicking on save button 394.

[0088] **Figure 7** is a high-level flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 1302, mobile device 105 transmits geopositioning information to server 106 via the Internet. In step 1304 the server compares the latest geopositioning data point to previous data points in order to determine whether a change in location or vector of movement has occurred. In step 1306 the server evaluates the geopositioning data in order to determine whether the temperature settings for the HVAC system for the structure associated with the mobile device 105 should be optimized for an unoccupied structure, or for an occupied structure in light of the movement (or lack thereof) in the geopositioning data.

[0089] If the server 106 determines that the home should be in occupied or "home" mode, then in step 1308 the server queries database 300 to determine whether thermostat 108 is already set for home or away mode. If thermostat 108 is already in home mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 1310 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0090] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1316, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1312 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home.

[0091] If the user elects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and

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terminate. If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.

[0092] If the server 106 determines in step 1306 that the home should be in unoccupied or away mode, then in step 1350 the server queries database 300 to determine whether thermostat 108 is set for set for home or away mode. If thermostat 108 is already in away mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is occupied, then in step 1352 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0093] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1358, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when unoccupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1354 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate.

[0094] If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.If thermostat 108 is already in away mode, the program ends. If it was in home mode, then in step 1314 server 108 initiates a state change to put thermostat 108 in away mode. In either case, the server then in step 1316 writes the state change to database 300. In each case the server can also send a message to the person who owns the mobile device requesting, confirming or announcing the state change.

Ex. 1006.0291

[0095] **Figure 8** is a flowchart that shows one process by which an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device attached to the system. The process shown assumes (a) a static hierarchy of temperature preferences as between multiple occupants: that is, that for a given home/structure, mobile user #1's preferences will always control the outcome if mobile user #1 is present, that mobile user #2's preferences yield to #1's, but always prevail over user #3, etc; and (b) that there are no occupants to consider who are not associated with a mobile device. Other heuristics may be applied in order to account for more dynamic interactions of preferences.

[0096] In step 1402 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #1. In step 1404 server 106 uses current and recent coordinates to determine whether mobile user #1's "home" settings should be applied. If server 106 determines that User #1's home settings should be applied, then in step 1406 server 106 applies the correct setting and transmits it to the thermostat(s).

[0097] In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming. If after performing step 1404, the server concludes that mobile user #1's "home" settings should not be applied, then in step 1412 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #2.

[0098] In step 1414 server 106 uses current and recent coordinates to determine whether mobile user #2's "home" settings should be applied. If server 106 determines that User #2's home settings should be applied, then in step 1416 server 106 applies the correct setting and transmits it to the thermostat(s).

[0099] In step 1408, server 106 writes to database 300 the geospatial and other relevant information used to adjust the programming. If after performing step 1414, the server concludes that mobile user #2's "home" settings should not be applied, then in step 1422 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #N.

Ex. 1006.0292

[0100] In step 1424 server 106 uses current and recent coordinates to determine whether mobile user #N's "home" settings should be applied. If server 106 determines that User #N's home settings should be applied, then in step 1426 server 106 applies the correct setting and transmits it to the thermostat(s). In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming.

[0101] If none of the mobile devices associated with a given home or other structure report geospatial coordinates consistent with occupancy, then in step 1430 the server instructs the thermostat(s) to switch to or maintain the "away" setting.

[0102] One embodiment of the invention is capable of delivering additional benefits for homeowners in terms of increased comfort and efficiency. In addition to using the system to allow better signaling and control of the HVAC system, which relies primarily on communication running from the server to the thermostat, the bi-directional communication will also allow the thermostat 108 to regularly measure and send to the server information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0103] For example, **Figure 9a** shows a graph of inside temperature, outside temperature and HVAC activity for a 24 hour period. When outside temperature 1502 increases, inside temperature 1504 follows, but with some delay because of the thermal mass of the building, unless the air conditioning 1506 operates to counteract this effect. When the air conditioning turns on, the inside temperature stays constant (or rises at a much lower rate or even falls) despite the rising outside temperature. In this example, frequent and heavy use of the air conditioning results in only a very slight temperature increase inside the house of 4 degrees, from 72 to 76 degrees, despite the increase in outside temperature from 80 to 100 degrees.

[0104] **Figure 9b** shows a graph of the same house on the same day, but assumes that the air conditioning is turned off from noon to 7PM. As expected, the inside temperature 1504a rises with increasing outside temperatures 1502 for most of that period, reaching 88 degrees at 7PM. Because server 106 logs the temperature

Ex. 1006.0293

readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house.

[0105] The performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the rate at which the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc., the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0106] The ability to predict the rate of change in inside temperature in a given house under varying conditions may be applied by in effect holding the desired future inside temperature as a constraint and using the ability to predict the rate of change to determine when the HVAC system must be turned on in order to reach the desired temperature at the desired time. The ability of an HVAC system to vary turn-on time in order to achieve a setpoint with minimum energy use may be thought of as Just In Time (JIT) optimization.

[0107] **Figure 10** shows a flowchart illustrating the high-level process for controlling a just-in-time (JIT) event. In step 1512, the server determines whether a specific thermostat 108 is scheduled to run the preconditioning program. If, not, the program terminates. If it so scheduled, then in step 1514 the server retrieves the predetermined target time when the preconditioning is intended to have been completed (TT).

[0108] Using TT as an input, in step 1516 the server then determines the time at which the computational steps required to program the preconditioning event will be performed (ST). In step 1518, performed at start time ST, the server begins the process of actually calculating the required parameters, as discussed in greater detail below. Then in 1520 specific setpoint changes are transmitted to the thermostat so that the temperature inside the home may be appropriately changed as intended.

[0109] **Figure 11** shows a more detailed flowchart of the process. In step 1532, the server retrieves input parameters used to create a JIT event. These

Ex. 1006.0294

parameters include the maximum time allowed for a JIT event for thermostat 108 (MTI); the target time the system is intended to hit the desired temperature (TT); and the desired inside temperature at TT (TempTT). It is useful to set a value for MTI because, for example, it will be reasonable to prevent the HVAC system from running a preconditioning event if it would be expected to take 8 hours, which might be prohibitively expensive.

[0110] In step 1534, the server retrieves data used to calculate the appropriate start time with the given input parameters. This data includes a set of algorithmic learning data (ALD), composed of historic readings from the thermostat, together with associated weather data, such as outside temperature, solar radiation, humidity, wind speed and direction, etc; together with weather forecast data for the subject location for the period when the algorithm is scheduled to run (the weather forecast data, or WFD). The forecasting data can be as simple as a listing of expected temperatures for a period of hours subsequent to the time at which the calculations are performed, to more detailed tables including humidity, solar radiation, wind, etc. Alternatively, it can include additional information such as some or all of the kinds of data collected in the ALD.

[0111] In step 1536, the server uses the ALD and the WFD to create prediction tables that determine the expected rate of change or slope of inside temperature for each minute of HVAC cycle time (ΔT) for the relevant range of possible pre-existing inside temperatures and outside climatic conditions. An example of a simple prediction table is illustrated in Fig. 13.

[0112] In step 1538, the server uses the prediction tables created in step 1536, combined with input parameters TT and Temp(TT) to determine the time at which slope ΔT intersects with predicted initial temperature PT. The time between PT and TT is the key calculated parameter: the preconditioning time interval, or PTI.

[0113] In step 1540, the server checks to confirm that the time required to execute the pre-conditioning event PTI does not exceed the maximum parameter MTI. If PTI exceeds MTI, the scheduling routine concludes and no ramping setpoints are transmitted to the thermostat.

Ex. 1006.0295

[0114] If the system is perfect in its predictive abilities and its assumptions about the temperature inside the home are completely accurate, then in theory the thermostat can simply be reprogrammed once – at time PT, the thermostat can simply be reprogrammed to Temp(TT). However, there are drawbacks to this approach.

[0115] First, if the server has been overly conservative in its predictions as to the possible rate of change in temperature caused by the HVAC system, the inside temperature will reach TT too soon, thus wasting energy and at least partially defeating the purpose of running the preconditioning routine in the first place. If the server is too optimistic in its projections, there will be no way to catch up, and the home will not reach Temp(TT) until after TT. Thus it would be desirable to build into the system a means for self-correcting for slightly conservative start times without excessive energy use.

[0116] Second, the use of setpoints as a proxy for actual inside temperatures in the calculations is efficient, but can be inaccurate under certain circumstances. In the winter (heating) context, for example, if the actual inside temperature is a few degrees above the setpoint (which can happen when outside temperatures are warm enough that the home's natural "set point" is above the thermostat setting), then setting the thermostat to Temp(TT) at time PT will almost certainly lead to reaching TT too soon as well.

[0117] The currently preferred solution to both of these possible inaccuracies is to calculate and program a series of intermediate settings between Temp(PT) and Temp(TT) that are roughly related to ΔT.

[0118] Thus if MTI is greater than PTI, then in step 1542 the server calculates the schedule of intermediate setpoints and time intervals to be transmitted to the thermostat. Because thermostats cannot generally be programmed with steps of less than 1 degree F, ΔT is quantized into discrete interval data of at least 1 degree F each. For example, if Temp(PT) is 65 degrees F, Temp(TT) is 72 degrees F, and PT is 90 minutes, the thermostat might be programmed to be set at 66 for 10 minutes, 67 for 12 minutes, 68 for 15 minutes, etc.

[0119] The server may optionally limit the process by assigning a minimum programming interval (e.g., at least ten minutes between setpoint changes) to avoid

Ex. 1006.0296

frequent switching of the HVAC system, which can reduce accuracy because of the thermostat's compressor delay circuit, which may prevent quick corrections. The duration of each individual step may be a simple arithmetic function of the time PTI divided by the number of whole-degree steps to be taken; alternatively, the duration of each step may take into account second order thermodynamic effects relating to the increasing difficulty of "pushing" the temperature inside a house further from its natural setpoint given outside weather conditions, etc. (that is, the fact that on a cold winter day it may take more energy to move the temperature inside the home from 70 degrees F to 71 than it does to move it from 60 degrees to 61).

[0120] In step 1544, the server schedules setpoint changes calculated in step 1542 for execution by the thermostat.

[0121] With this system, if actual inside temperature at PT is significantly higher than Temp(PT), then the first changes to setpoints will have no effect (that is, the HVAC system will remain off), and the HVAC system will not begin using energy, until the appropriate time, as shown in **Figure 12**. Similarly, if the server has used conservative predictions to generate ΔT, and the HVAC system runs ahead of the predicted rate of change, the incremental changes in setpoint will delay further increases until the appropriate time in order to again minimize unnecessary energy use, as shown in **Figure 11**.

[0122] **Figure 12(a)** through **12(d)** shows the steps in the preconditioning process as a graph of temperature and time. **Figure 12(a)** shows step 1532, in which inputs target time TT 1552, target temperature Temp(TT) 1554, maximum conditioning interval MTI 1556 and the predicted inside temperature during the period of time the preconditioning event is likely to begin Temp(PT) 1558 are retrieved.

[0123] **Figure 12(b)** shows the initial calculations performed in step 1538, in which expected rate of change in temperature ΔT 1560 inside the home is generated from the ALD and WFD using Temp(TT) 1554 at time TT 1552 as the endpoint.

[0124] **Figure 12(c)** shows how in step 1538 ΔT 1560 is used to determine start time PT 1562 and preconditioning time interval PTI 1564. It also shows how in step 1540 the server can compare PTI with MTI to determine whether or not to instantiate the pre-conditioning program for the thermostat.

Ex. 1006.0297

[0125] **Figure 12(d)** shows step 1542, in which specific ramped setpoints 1566 are generated. Because of the assumed thermal mass of the system, actual inside temperature at any given time will not correspond to setpoints until some interval after each setpoint change. Thus initial ramped setpoint 1216 may be higher than Temp(PT) 1558, for example.

[0126] **Figure 13** shows an example of the types of data that may be used by the server in order to calculate ΔT 1560. Such data may include inside temperature 1572, outside temperature 1574, cloud cover 1576, humidity 1578, barometric pressure 1580, wind speed 1582, and wind direction 1584.

[0127] Each of these data points should be captured at frequent intervals. In the preferred embodiment, as shown in **Figure 13**, the interval is once every 60 seconds.

[0128] **Figure 14** shows application of an embodiment of the subject invention in an actual house. Temperature and setpoints are plotted for the 4-hour period from 4AM to 8AM with temperature on the vertical axis and time on the horizontal axis. The winter nighttime setpoint 1592 is 60 degrees F; the morning setpoint temperature 1594 is 69 degrees F. The outside temperature 1596 is approximately 45 degrees F. The target time TT 1598 for the setpoint change to morning setting is 6:45AM. In the absence of embodiments of the subject invention, the homeowner could program the thermostat to change to the new setpoint at 6:45, but there is an inherent delay between a setpoint change and the response of the temperature inside the home. (In this home on this day, the delay is approximately fifty minutes.) Thus if the homeowner truly desired to achieve the target temperature at the target time, some anticipation would be necessary. The amount of anticipation required depends upon numerous variables, as discussed above.

[0129] After calculating the appropriate slope ΔT 1560 by which to ramp inside temperature in order to reach the target as explained above, the server transmits a series of setpoints 1566 to the thermostat because the thermostat is presumed to only accept discrete integers as program settings. (If a thermostat is capable of accepting finer settings, as in the case of some thermostats designed to operate in

Ex. 1006.0298

regions in which temperature is generally denoted in Centigrade rather than Fahrenheit, which accept settings in half-degree increments, tighter control may be possible.)

[0130] In any event, in the currently preferred embodiment of the subject invention, programming changes are quantized such that the frequency of setpoint changes is balanced between the goal of minimizing network traffic and the frequency of changes made on the one hand and the desire for accuracy on the other. Balancing these considerations may result in some cases in either more frequent changes or in larger steps between settings. As shown in Fig. 14, the setpoint "stairsteps" from 60 degrees F to 69 degrees F in nine separate setpoint changes over a period of 90 minutes.

[0131] Because the inside temperature 1599 when the setpoint management routine was instantiated at 5:04 AM was above the "slope" and thus above the setpoint, the HVAC system was not triggered and no energy was used unnecessarily heating the home before such energy use was required. Actual energy usage does not begin until 5:49 AM.

[0132] **Figure 15** shows application of an embodiment of the subject invention in a different house during a similar four hour interval. In **Figure 15**, the predicted slope ΔT 1560 is less conservative relative to the actual performance of the home and HVAC system, so there is no off cycling during the preconditioning event – the HVAC system turns on at approximately 4:35 AM and stays on continuously during the event. The home reaches the target temperature Temp(TT) roughly two minutes prior to target time TT.

[0133] **Figure 16** shows a simple prediction table. The first column 1602 lists a series of differentials between outside and inside temperatures. Thus when the outside temperature is 14 degrees and the inside temperature is 68 degrees, the differential is -54 degrees; when the outside temperature is 94 degrees and the inside temperature is 71 degrees, the differential is 13 degrees. The second column 1604 lists the predicted rate of change in inside temperature ΔT 1210 assuming that the furnace is running in terms of degrees Fahrenheit of change per hour. A similar prediction table will be generated for predicted rates of change when the air conditioner

Ex. 1006.0299

is on; additional tables may be generated that predict how temperatures will change when the HVAC system is off.

[0134] Alternatively, the programming of the just-in-time setpoints may be based not on a single rate of change for the entire event, but on a more complex multivariate equation that takes into account the possibility that the rate of change may be different for events of different durations.

[0135] The method for calculating start times may also optionally take into account not only the predicted temperature at the calculated start time, but may incorporate measured inside temperature data from immediately prior to the scheduled start time in order to update calculations, or may employ more predictive means to extrapolate what inside temperature based upon outside temperatures, etc.

[0136] An additional capability offered by an embodiment of the instant invention is the ability to adapt the programming of the HVAC control system based upon the natural behavior of occupants. Because an embodiment of the instant invention is capable of recording the setpoint actually used at a connected thermostat over time, it is also capable of inferring manual setpoint changes (as, for example, entered by pushing the "up" or "down" arrow on the control panel of the device) even when such overrides of the pre-set program are not specifically recorded as such by the thermostat.

[0137] In order to adapt programming to take into account the manual overrides entered into the thermostat, it is first necessary to determine when a manual override has in fact occurred. Most thermostats, including two-way communicating devices discussed herein, do not record such inputs locally, and neither recognize nor transmit the fact that a manual override has occurred. Furthermore, in a system as described herein, frequent changes in setpoints may be initiated by algorithms running on the server, thereby making it impossible to infer a manual override from the mere fact that the setpoint has changed. It is therefore necessary to deduce the occurrence of such events from the data that an embodiment of the subject invention does have access to.

[0138] **Figure 17** illustrates the currently preferred method for detecting the occurrence of a manual override event. In step 1702, the server retrieves the primary

Ex. 1006.0300

data points used to infer the occurrence of a manual override from one or more databases in overall database structure 300. The data should include each of the following: for the most recent point at which it can obtain such data (time0) the actual setpoint as recorded at the thermostat at (A0); for the point immediately prior to time0 (time-1), the actual setpoint recorded for the thermostat (A-1); for time0 the setpoint as scheduled by server 106 according to the basic setpoint programming (S0), and for time-1 the setpoint as scheduled by server 106 according to the standard setpoint programming (S-1).

[0139] In step 1704, the server retrieves any additional automated setpoint changes C that have been scheduled for the thermostat by server 106 at time0. Such changes may include algorithmic changes intended to reduce energy consumption, etc.

[0140] In step 1706 the server calculates the difference (dA) between A0 and A-1; for example, if the actual setpoint is 67 degrees at T-1 and 69 at T0, dA is +2; if the setpoint at T-1 is 70 and the setpoint at T0 is 66, dA is –4.

[0141] In step 1708, the server performs similar steps in order to calculate dS, the difference between S0 and S-1. This is necessary because, for example, the setpoint may have been changed because the server itself had just executed a change, such as a scheduled change from "away" to "home" mode. In step 1710 the server evaluates and sums all active algorithms and other server-initiated strategies to determine their net effect on setpoint at time0. For example, if one algorithm has increased setpoint at time0 by 2 degrees as a short-term energy savings measure, but another algorithm has decreased the setpoint by one degree to compensate for expected subjective reactions to weather conditions, the net algorithmic effect sC is +1 degree.

[0142] In step 1712, the server calculates the value for M, where M is equal to the difference between actual setpoints dA, less the difference between scheduled setpoints dS, less the aggregate of algorithmic change sC.

[0143] In step 1714 the server evaluates this difference. If the difference equals zero, the server concludes that no manual override has occurred, and the routine terminates. But if the difference is any value other than zero, then the server concludes that a manual override has occurred. Thus in step 1716 the server logs the

Ex. 1006.0301

occurrence and magnitude of the override to one or more databases in overall database structure 300.

[0144] The process of interpreting a manual override is shown in **Figure 18**. Step 1802 is the detection of an override, as described in detail in **Figure 17**. In step 1804 the server retrieves the stored rules for the subject thermostat 108. Such rules may include weather and time-related inferences such as "if outside temperature is greater than 85 degrees and inside temperature is more than 2 degrees above setpoint and manual override lowers setpoint by 3 or more degrees, then revert to original setpoint in 2 hours," or "if heating setpoint change is scheduled from "away" to "home" within 2 hours after detected override, and override increases setpoint by at least 2 degrees, then change to "home" setting," or the like.

[0145] In step 1806 the server retrieves contextual data required to interpret the manual override. Such data may include current and recent weather conditions, current and recent inside temperatures, etc. This data is helpful because it is likely that manual overrides are at least in part deterministic: that is, that they may often be explained by such contextual data, and that such understanding can permit anticipation of the desire on the part of the occupants to override and to adjust programming accordingly, so as to anticipate and obviate the need for such changes. The amount of data may be for a period of a few hours to as long as several days or more. Recent data may be more heavily weighted than older data in order to assure rapid adaptation to situations in which manual overrides represent stable changes such as changes in work schedules, etc.

[0146] In step 1808 the server retrieves any relevant override data from the period preceding the specific override being evaluated that has not yet been evaluated by and incorporated into the long-term programming and rules engines as described below in **Figure 19**. In step 1810 the server evaluates the override and determines which rule, if any, should be applied as a result of the override.

[0147] In step 1812 the server determines whether to alter the current setpoint as a result of applying the rules in step 1810. If no setpoint change is indicated, then the routine ends. If a setpoint change is indicated, then in step 1814 the server transmits the setpoint change to the thermostat for execution in the home, and in

Ex. 1006.0302

step 1816 it records that change to one or more databases in overall database structure 300.

[0148] In order to ensure that both the stored rules for interpreting manual overrides and the programming itself continue to most accurately reflect the intentions of the occupants, the server will periodically review both the rules used to interpret overrides and the setpoint scheduling employed. **Figure 19** shows the steps used to incorporate manual overrides into the long-term rules and setpoint schedule. In step 1902 the server retrieves the stored programming for a given thermostat as well as the rules for interpreting overrides for that thermostat.

[0149] In step 1904 the server retrieves the recent override data as recorded in **Figures 17** and **18** to be evaluated for possible revisions to the rules and the programming. In step 1906 the server retrieves the contextual data regarding overrides retrieved in step 1904 (Because the process illustrated in **Figure 19** is not presently expected to be executed as a real-time process, and is expected to be run anywhere from once per day to once per month, the range and volume of contextual data to be evaluated is likely to be greater than in the process illustrated in **Figure 18**.

[0150] In step 1908 the server interprets the overrides in light of the existing programming schedule, rules for overrides, contextual data, etc. In step 1910 the server determines whether, as a result of those overrides as interpreted, the rules for interpreting manual overrides should be revised. If the rules are not to be revised, the server moves to step 1914. If the rules are to be revised, then in step 1912 the server revises the rules and the new rules are stored in one or more databases in overall database structure 300.

[0151] In step 1914 the server determines whether any changes to the baseline programming for the thermostat should be revised. If not, the routine terminates. If revisions are warranted, then in step 1916 the server retrieves from database 900 the permissions the server has to make autonomous changes to settings. If the server has been given permission to make the proposed changes, then in step 1918 the server revises the thermostat's programming and writes the changes to one or more databases in overall database structure 300.

Ex. 1006.0303

[0152] If the server has not been authorized to make such changes autonomously, then in step 1920 the server transmits the recommendation to change settings to the customer in the manner previously specified by the customer, such as email, text message, personalized website, etc.

[0153] Additional means of implementing an embodiment of the instant invention may be achieved using variations in system architecture. For example, much or even all of the work being accomplished by remote server 106 may also be done by thermostat 108 if that device has sufficient processing capabilities, memory, etc. Alternatively, these steps may be undertaken by a local processor such as a local personal computer, or by a dedicated appliance having the requisite capabilities, such as gateway 112.

[0154] An additional way in which an embodiment of the instant invention can reduce energy consumption with minimal impact on comfort is to vary the turn-on delay enforced by the thermostat after the compressor is turned off. Compressor delay is usually used to protect compressors from rapid cycling, which can physically damage them.

[0155] The ability to predict the rate of change in inside temperature in a given house under varying conditions may also be applied to permit calculation of the effect of different compressor delay settings on inside temperatures, HVAC cycling and energy consumption.

[0156] **Figure 20** shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event. In step 2002, server 106 retrieves parameters such as weather conditions, the current price per kilowatt-hour of electricity, and the state of the electric grid in terms of supply versus demand for the geographic area that includes a given home. In step 2004 server 106 determines whether to instantiate the compressor delay adjustment program for a certain group of homes in response to those conditions.

[0157] In step 2006, server 106 determines whether a specific home is subscribed to participate in compressor delay events. If a given home is eligible, then in step 2008 the server retrieves the parameters needed to specify the compressor delay routine for that home. These may include user preferences, such as the weather,

time of day and other conditions under which the homeowner has elected to permit hysteresis band changes, the maximum length of compressor delay authorized, etc.

[0158] In step 2010 the appropriate compressor delay settings are determined, and in step 2012 the chosen settings are communicated to the thermostat. In step 2014 the server determines if additional thermostats in the given group must still be evaluated. If so, the server returns to step 2006 and repeats the subsequent steps with the next thermostat. If not, the routine ends.

[0159] **Figures 21(a)** through **21(c)** illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature. In **Figure 21(a)**, time is shown on the horizontal axis 2102, and temperature is shown on vertical axis 2104. The setpoint for thermostat 108 is 70 degrees F, which results in the cycling behavior shown for inside temperature 2106. Because compressor delay CD1 2108 is, at approximately 3 minutes, shorter than the natural duration of a compressor off cycle Off1 2110 at approximately 6 minutes for this particular house under the illustrated conditions, the compressor delay has no effect on the operation of the HVAC system.

[0160] Because the hysteresis band operates to so as to maintain the temperature within a range of plus or minus one degree of the setpoint, in the case of air conditioning the air conditioner will switch on when the inside temperature reaches 71 degrees, continue operating until it reaches 69 degrees, then shut off. The system will then remain off until it reaches 71 degrees again, at which time it will again switch on. The percentage of time during which inside temperature is above or below the setpoint will depend on conditions and the dynamic signature of the individual, home. Under the conditions illustrated, the average inside temperature AT1 2112 is roughly equal to the setpoint of 70 degrees.

[0161] **Figure 21(b)** shows how with the same environmental conditions as in **Figure 21(a)**, the cycling behavior of the inside temperature changes when the compressor delay is longer than the natural compressor off cycle Off1 2110. Extended compressor delay CD2 2114 allows inside temperature 2116 to climb above the range normally enforced by the hysteresis band. Because CD2 is roughly 8 minutes, under the given conditions the inside temperature climbs to approximately 72 degrees before

Ex. 1006.0305

the compressor delay allows the air conditioner to restart and drive the inside temperature back down. But as before, the air conditioner shuts off when the inside temperature reaches 69 degrees. Thus the average temperature is increased from AT1 2112 to AT2 2118. This change will save energy and reduce cycling because it takes less energy to maintain a higher inside temperature with an air conditioner. However, the setpoint reported by the display of the thermostat will continue to be the occupant's chosen setpoint of 70 degrees.

[0162] **Figure 21(c)** shows how the same compressor delay can result in different thermal cycling with different weather conditions. The greater the amount by which outside temperature exceeds inside temperature in the air conditioning context, the more rapidly the inside temperature will increase during an off cycle, and the slower the air conditioner will be able to cool during the on cycle. Thus as compared to **Figure 21(b)**, when the inside temperature increased to roughly 72 degrees during the extended compressor delay of 8 minutes, a higher outside temperature will cause the inside temperature to increase faster, which results in a peak temperature of roughly 73 degrees, and in wider temperature cycling 2120. The average inside temperature consequently increases from AT(2) 2118 to AT(3) 2122.

[0163] It should be noted that the shape of the actual waveform will most likely not be sinusoidal, but for ease of illustration it is sometimes be presented as such in the figures.

[0164] Residential air conditioning is a major component of peak load. The traditional approach to dealing with high demand on hot days is to increase supply – build new powerplants, or buy additional capacity on the spot market. But because reducing loads has come to be considered by many to be a superior strategy for matching electricity supply to demand when the grid is stressed, the ability to shed load by turning off air conditioners during peak events has become a useful tool for managing loads. A key component of any such system is the ability to document and verify that a given air conditioner has actually turned off. Data logging hardware can accomplish this, but due to the cost is usually only deployed for statistical sampling. An embodiment of the instant invention provides a means to verify demand response without additional hardware such as a data logger.

Ex. 1006.0306

[0165] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures. This will permit remote verification of load shedding by the air conditioner without directly measuring or recording the electrical load drawn by the air conditioner.

[0166] **Figure 22** shows the steps followed in order to initiate air conditioner shutoff. When a summer peak demand situation occurs, the utility will transmit an email 2202 or other signal to server 106 requesting a reduction in load. Server 106 will determine 2204 if the user's house is served by the utility seeking reduction; determine 2206 if a given user has agreed to reduce peak demand; and determine 2208 if a reduction of consumption by the user is required or desirable in order to achieve the reduction in demand requested by the utility. The server will transmit 2210 a signal to the user's thermostat 108 signaling the thermostat to shut off the air conditioner 110.

[0167] **Figure 23** shows the steps followed in order to verify that the air conditioner has in fact been shut off. Server 106 will receive and monitor 2302 the temperature readings sent by the user's thermostat 108. The server then calculates 2304 the temperature reading to be expected for that thermostat given inputs such as current and recent outside temperature, recent inside temperature readings, the calculated thermal mass of the structure, temperature readings in other houses, etc. The server will compare 2306 the predicted reading with the actual reading. If the server determines that the temperature inside the house is rising at the rate predicted if the air conditioning is shut off, then the server confirms 2308 that the air conditioning has been shut off. If the temperature reading from the thermostat shows no increase, or significantly less increase than predicted by the model, then the server concludes

Ex. 1006.0307

2310 that the air conditioning was not switched off, and that no contribution to the demand response request was made.

[0168] For example, assume that on at 3PM on date Y utility X wishes to trigger a demand reduction event. A server at utility X transmits a message to the server at demand reduction service provider Z requesting W megawatts of demand reduction. The demand reduction service provider server determines that it will turn off the air conditioner at house A in order to achieve the required demand reduction. At the time the event is triggered, the inside temperature as reported by the thermostat in house A is 72 degrees F. The outside temperature near house A is 96 degrees Fahrenheit. The inside temperature at House B, which is not part of the demand reduction program, but is both connected to the demand reduction service server and located geographically proximate to House A, is 74F. Because the air conditioner in house A has been turned off, the temperature inside House A begins to rise, so that at 4PM it has increased to 79F. Because the server is aware of the outside temperature, which remains at 96F, and of the rate of temperature rise inside house A on previous days on which temperatures have been at or near 96F, and the temperature in house B, which has risen only to 75F because the air conditioning in house B continues to operate normally, the server is able to confirm with a high degree of certainty that the air conditioner in house A has indeed been shut off.

[0169] In contrast, if the HVAC system at house A has been tampered with, so that a demand reduction signal from the server does not actually result in shutting off the air conditioner in house A, when the server compares the rate of temperature change at house A against the other data points, the server will receive data inconsistent with the rate of increase predicted. As a result, it will conclude that the air conditioner has not been shut off in house A as expected, and may not credit house A with the financial credit that would be associated with demand reduction compliance, or may trigger a business process that could result in termination of house A's participation in the demand reduction program.

[0170] **Figure 24** illustrates the movement of signals and information between the components of one embodiment of the subject invention to trigger and verify a demand reduction response. Where demand response events are undertaken on

Ex. 1006.0308

behalf of a utility by a third party, participants in the communications may include electric utility server 2400, demand reduction service server 106, and thermostat 108. In step 2402 the electric utility server 2400 transmits a message to demand reduction service server 106 requesting a demand reduction of a specified duration and size. Demand reduction service server 106 uses database 300 to determine which subscribers should be included in the demand reduction event. For each included subscriber, the server then sends a signal 2404 to the subscriber's thermostat 108 instructing it (a) to shut down at the appropriate time or (b) to allow the temperature as measured by the thermostat to increase to a certain temperature at the specified time, depending upon the agreement between the homeowner and the utility and/or demand reduction aggregator.

[0171] The server then receives 2406 temperature signals from the subscriber's thermostat. At the conclusion of the demand reduction event, the server transmits a signal 2408 to the thermostat permitting the thermostat to signal its attached HVAC system to resume cooling, if the system has been shut off, or to reduce the target temperature to its pre-demand reduction setting, if the target temperature was merely increased. If thermostat 108 is capable of storing scheduling information, these instructions may be transmitted prior to the time they are to be executed and stored locally. After determining the total number of subscribers actually participating in the DR event, the server then calculates the total demand reduction achieved and sends a message 2410 to the electric utility confirming such reduction.

[0172] Additional steps may be included in the process. For example, if the subscriber has previously requested that notice be provided when a peak demand reduction event occurs, the server will also send an alert, which may be in the form of an email or text message or an update to the personalized web page for that user, or both. If the server determines that a given home has (or has not) complied with the terms of its demand reduction agreement, the server may send a message to the subscriber confirming that fact.

[0173] It should also be noted that in some climate zones, peak demand events occur during extreme cold weather rather than (or in addition to) during hot

Ex. 1006.0309

weather. The same process as discussed above could be employed to reduce demand by shutting off electric heaters and monitoring the rate at which temperatures fall.

[0174] It should also be noted that the peak demand reduction service can be performed directly by an electric utility, so that the functions of server 106 can be combined with the functions of server 2400.

[0175] The system installed in a subscriber's home may optionally include additional temperature sensors at different locations within the building. These additional sensors may we connected to the rest of the system via a wireless system such as 802.11 or 802.15.4, or may be connected via wires. Additional temperature and/or humidity sensors may allow increased accuracy of the system, which can in turn increase user comfort, energy savings or both.

[0176] The bi-directional communication between server 106 and thermostat 108 will also allow thermostat 108 to regularly measure and send to server 106 information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0177] For example, **Figure 25a** shows a graph of inside temperature and outside temperature for a 24-hour period in House A, assuming no HVAC activity. House A has double-glazed windows and is well-insulated. When outside temperature 2502 increases, inside temperature 2504 follows, but with significant delay because of the thermal mass of the building.

[0178] **Figure 25b** shows a graph of inside temperature and outside temperature for the same 24-hour period in House B. House B is identical to House A except that it (i) is located a block away and (ii) has single-glazed windows and is poorly insulated. Because the two houses are so close to each other, outside temperature 2502 is the same in **Figure 25a** and **Figure 25b**. But the lower thermal mass of House B means that the rate at which the inside temperature 2506 changes in response to the changes in outside temperature is much greater.

[0179] The differences in thermal mass will affect the cycling behavior of the HVAC systems in the two houses as well. **Figure 26a** shows a graph of inside

Ex. 1006.0310

temperature and outside temperature in House A for the same 24-hour period as shown in **Figure 6a**, but assuming that the air conditioning is being used to try to maintain an internal temperature of 70 degrees. Outside temperatures 2502 are the same as in **Figures 25a** and **25b**. Inside temperature 2608 is maintained within the range determined by thermostat 108 by the cycling of the air conditioner. Because of the high thermal mass of the house, the air conditioning does not need to run for very long to maintain the target temperature, as shown by shaded areas 2610.

[0180] **Figure 26b** shows a graph of inside temperature 2612 and outside temperature 2502 for the same 24-hour period in House B, assuming use of the air conditioning as in **Figure 26a**. Because of the lower thermal mass of House B, the air conditioning system in House B has to run longer in order to maintain the same target temperature range, as shown by shaded areas 2614.

[0181] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature and differences between inside and outside temperatures. Because the server 106 will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0182] The server will also record the responses of each house to changes in outside conditions and cycling behavior over time. That will allow the server to diagnose problems as and when they develop. For example, **Figure 27a** shows a graph of outside temperature 2702, inside temperature 2704 and HVAC cycle times 2706 in House A for a specific 24-hour period on date X. Assume that, based upon comparison of the performance of House A on date X relative to House A's historical performance, and in comparison to the performance of House A relative to other nearby houses on date X, the HVAC system in House A is presumed to be operating at normal

Ex. 1006.0311

efficiency, and that House A is in the 86th percentile as compared to those other houses.

[0183] **Figure 27b** shows a graph of outside temperature 2708, inside temperature 2710 and HVAC cycle times 2712 in House A for the 24-hour period on date X+1. House A's HVAC system now requires significantly longer cycle times in order to try to maintain the same internal temperature. If those longer cycle times were due to higher outside temperatures, those cycle times would not indicate the existence of any problems. But because server 106 is aware of the outside temperature, the system can eliminate that possibility as an explanation for the higher cycle times.

[0184] Because server 106 is aware of the cycle times in nearby houses, it can determine that, for example, on date X+1 the efficiency of House A is only in the 23rd percentile. The server will be programmed with a series of heuristics, gathered from predictive models and past experience, correlating the drop in efficiency and the time interval over which it has occurred with different possible causes. For example, a 50% drop in efficiency in one day may be correlated with a refrigerant leak, especially if followed by a further drop in efficiency on the following day. A reduction of 10% over three months may be correlated with a clogged filter. Based upon the historical data recorded by the server, the server 106 will be able to alert the homeowner that there is a problem and suggest a possible cause.

[0185] Because the system will be able to calculate effective thermal mass, it will be able to determine the cost effectiveness of strategies such as pre-cooling for specific houses under different conditions. **Figure 28a** shows a graph of outside temperature 2802, inside temperature 2804 and HVAC cycling times 2806 in House A for a specific 24-hour period on date Y assuming that the system has used a pre-cooling strategy to avoid running the air conditioning during the afternoon, when rates are highest. Because House A has high thermal mass, the house is capable of "banking" cooling, and energy consumed during off-peak hours is in effect stored, allowing the house to remain cool even when the system is turned off. Temperatures keep rising during the period the air conditioning is off, but because thermal mass is high, the rate of increase is low, and the house is still comfortable six hours later.

Ex. 1006.0312

[0186] Although the pre-cooling cycle time in a given home may be relatively long, the homeowner may still benefit if the price per kilowatt during the morning pre-cooling phase is lower than the price during the peak load period. **Figure 28b** shows a graph of the same outside temperature 2802 in House B as in House A in **Figure 28a** for the same 24-hour period and using the same pre-cooling strategy as shown by cycling times 2806. But because House B has minimal thermal mass, using additional electricity in order to pre-cool the house does not have the desired effect; inside temperature 2808 warms up so fast that the cooling that had been banked is quickly lost. Thus the system will recommend that House A pre-cool in order to save money, but not recommend pre-cooling for House B.

[0187] The system can also help compensate for anomalies such as measurement inaccuracies due to factors such as poor thermostat location. It is well known that thermostats should be placed in a location that will be likely to experience "average" temperatures for the overall structure, and should be isolated from windows and other influences that could bias the temperatures they "see." But for various reasons, not all thermostat installations fit that ideal. **Figure 29a** shows a graph of outside temperature 2902, the actual average inside temperature for the entire house 2904, and inside temperature as read by the thermostat 2906 in House C for a specific 24-hour period on September 15th, assuming that the thermostat is located so that for part of the afternoon on that day the thermostat is in direct sunlight.

[0188] Until the point at which the sun hits the thermostat, the average inside temperature and temperature as read by the thermostat track very closely. But when the direct sunlight hits the thermostat, the thermostat and the surrounding area can heat up, causing the internal temperature as read by the thermostat to diverge significantly from the average temperature for the rest of the house. A conventional thermostat has no way of distinguishing this circumstance from a genuinely hot day, and will both over-cool the rest of the house and waste considerable energy when it cycles the air conditioner in order to reduce the temperature as sensed by the thermostat.

[0189] If the air conditioning is turned off, this phenomenon will manifest as a spike in temperature as measured by the thermostat. If the air conditioning is turned on

Ex. 1006.0313

(and has sufficient capacity to respond to the distorted temperature signal caused by the sunlight), this phenomenon will likely manifest as relatively small changes in the temperature as sensed by the thermostat, but significantly increased HVAC usage (as well as excessively lowered temperatures in the rest of the house, but this result may not be directly measured in a single sensor environment).

[0190] An embodiment of the system, in contrast, has multiple mechanisms that will allow it to correct for such distortions. First, because an embodiment of the subject system compares the internal readings from House C with the external temperature, it will be obvious that the rise in temperature at 4:00PM is not correlated with a corresponding change in outside temperature. Second, because the system is also monitoring the readings from the thermostat in nearby House D, which (as shown in **Figure 29b**) is exposed to the same outside temperature 602, but has no sudden rise in measured internal afternoon temperature 2908, the system has further validation that the temperature increase is not caused by climatic conditions. And finally, because the system has monitored and recorded the temperature readings from the thermostat in House C for each previous day, and has compared the changing times of the aberration with the progression of the sun, the system can distinguish the patterns likely to indicate solar overheating from other potential causes.

[0191] **Figure 30** illustrates the steps involved in calculating comparative thermal mass, or the thermal mass index. In step 3002, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3004, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0192] In step 3006, the server retrieves data regarding recent temperature readings as recorded by the thermostat in home X. In step 3008, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its

address, make, model and age of its furnace and air conditioning hardware, and other data.

[0193] In step 3010, the server retrieves the current inside temperature reading as transmitted by the thermostat. In step 3012, the server calculates the thermal mass index for the home under those conditions; that is, for example, it calculates the likely rate of change for internal temperature in home X from a starting point of 70 degrees when the outside temperature is 85 degrees at 3:00PM on August 10th when the wind is blowing at 5 mph from the north and the sky is cloudy. The server accomplishes this by applying a basic algorithm that weighs each of these external variables as well as variables for various characteristics of the home itself (such as size, level of insulation, method of construction, etc.) and data from other houses and environments.

[0194] **Figure 31** illustrates the steps involved in diagnosing defects in the HVAC system for specific home X. In step 3102, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3104, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0195] In step 3106, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3108, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data. In step 3110, the server retrieves comparative data from other houses that have thermostats that also report to the server.

[0196] Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses. In step 3112, the server

Ex. 1006.0315

calculates the current relative efficiency of home X as compared to other homes. Those comparisons will take into account differences in size, location, age, etc in making those comparisons.

[0197] The server will also take into account that comparative efficiency is not absolute, but will vary depending on conditions. For example, a house that has extensive south-facing windows is likely to experience significant solar gain. On sunny winter days, that home will appear more efficient than on cloudy winter days. That same house will appear more efficient at times of day and year when trees or overhangs shade those windows than it will when summer sun reaches those windows. Thus the server will calculate efficiency under varying conditions.

[0198] In step 3114 the server compares the HVAC system's efficiency, corrected for the relevant conditions, to its efficiency in the past. If the current efficiency is substantially the same as the historical efficiency, the server concludes 3116 that there is no defect and the diagnostic routine ends. If the efficiency has changed, the server proceeds to compare the historical and current data against patterns of changes known to indicate specific problems. For example, in step 3118, the server compares that pattern of efficiency changes against the known pattern for a clogged air filter, which is likely to show a slow, gradual degradation over a period of weeks or even months.

[0199] If the pattern of degradation matches the clogged filter paradigm, the server creates and transmits to the homeowner a message 3120 alerting the homeowner to the possible problem. If the problem does not match the clogged filter paradigm, the system compares 3122 the pattern to the known pattern for a refrigerant leak, which is likely to show a degradation over a period of a few hours to a few days. If the pattern of degradation matches the refrigerant leak paradigm, the server creates and transmits to the homeowner a message 3124 alerting the homeowner to the possible problem.

[0200] If the problem does not match the refrigerant leak paradigm, the system compares 3126 the pattern to the known pattern for an open window or door, which is likely to show significant changes for relatively short periods at intervals uncorrelated with climatic patterns. If the pattern of degradation matches the open

Ex. 1006.0316

door/window paradigm, the server creates and transmits to the homeowner a message 3128 alerting the homeowner to the possible problem. If the problem does not match the refrigerant leak paradigm, the system continues to step through remaining know patterns N 3130 until either a pattern is matched 3132 or the list has been exhausted without a match 3134.

[0201] **Figure 32** illustrates the steps involved in diagnosing inaccurate thermostat readings due to improper location. In step 3202, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3204, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0202] In step 3206, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3208, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0203] In step 3210, the server retrieves comparative data from other houses that have thermostats that also report to the server. Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses.

[0204] In step 3212, the server calculates the expected thermostat temperature reading based upon the input data. In step 3214, the server compares the predicted and actual values. If the calculated and actual values are at least roughly equivalent, the server concludes 3216 that there is no thermostat-related anomaly. If the calculated and actual values are not roughly equivalent, the server retrieves additional historical information about past thermostat readings in step 3218.

Ex. 1006.0317

[0205] In step 3220, the server retrieves solar progression data, i.e., information regarding the times at which the sun rises and sets on the days being evaluated at the location of the house being evaluated, and the angle of the sun at that latitude, etc. In step 3222, the server compares the characteristics of the anomalies over time, to see if, for example, abnormally high readings began at 3:06 on June 5th, 3:09 on June 6th, 3:12 on June 7th, and the solar progression data suggests that at the house being analyzed, that sun would be likely to reach a given place in that house three minutes later on each of those days.

[0206] If the thermostat readings do not correlate with the solar progression data, the server concludes 3224 that the sun is not causing the distortion by directly hitting the thermostat. If the thermostat readings do correlate with solar progression, the server then calculates 3226 the predicted duration of the distortion caused by the sun.

[0207] In step 3228, the server calculates the appropriate setpoint information to be used by the thermostat to maintain the desired temperature and correct for the distortion for the expected length of the event. For example, if the uncorrected setpoint during the predicted event is 72 degrees, and the sun is expected to elevate the temperature reading by eight degrees, the server will instruct the thermostat to maintain a setpoint of 80 degrees. In step 3230, the server sends the homeowner a message describing the problem.

[0208] One or more embodiments of the invention may be used to implement additional energy savings by implementing small, repeated changes in setpoint. Because energy consumption is directly proportional to setpoint – that is, the further a given setpoint diverges from the balance point (the natural inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by any strategy that over a given time frame lowers the average heating setpoint or raises the cooling setpoint.

[0209] It is therefore possible to save energy by adopting a strategy that takes advantage of human insensitivity to slow temperature ramping by incorporating a user's desired setpoint within the range of the ramp, but setting the average target

temperature below the desired setpoint in the case of heating, and above it in the case of cooling. For example, a ramped summer setpoint that consisted of a repeated pattern of three phases of equal length set at 72°F, 73°F, and 74°F would create an effective average setpoint of 73°F, but would generally be experienced by occupants as yielding at least roughly equivalent comfort as in a room set at a constant 72°F. Energy savings resulting from this approach have been shown to be in the range of 4-6%.

[0210] Embodiments of the invention can automatically generate optimized ramped setpoints that could save energy without compromising the comfort of the occupants. It would also be advantageous to create a temperature control system that could incorporate adaptive algorithms that could automatically determine when the ramped setpoints should not be applied due to a variety of exogenous conditions that make application of such ramped setpoints undesirable.

[0211] **Figure 33** represents the conventional programming of a thermostat and the resulting behavior of a home's HVAC system in the air conditioning context. The morning setpoint 3302 of 74 degrees remains constant from midnight until 9:00AM, and the inside temperature 3304 varies more or less within the limits of the hysteresis band during that entire period. When the setpoint changes to 80 degrees 3306, the inside temperature 3308 varies within the hysteresis band around the new setpoint, and so on. Whether the average temperature is equal to, greater or less than the nominal setpoint will depend on weather conditions, the dynamic signature of the structure, and the efficiency and size of the HVAC system. But in most cases the average temperature will be at least roughly equivalent to the nominal setpoint.

[0212] **Figure 34** represents implementation of a three-phase ramped setpoint derived from the same user preferences as manifested by the settings shown in **Figure 33**. Thus the user-selected setpoint for the morning is still 74 degrees, and is reflected in the setpoint 3404 at the start of each three-step cycle, but because (in the air conditioning context) the setpoint requested by the user is the lowest of the three discrete steps, rather than the middle step, the average setpoint will be one degree higher 3402, and the resulting average inside temperature will be roughly one degree warmer than the average temperature without use of the ramped setpoints, thereby saving energy.

Ex. 1006.0319

[0213] In the currently preferred embodiment, the implementation of the ramped setpoints may be dynamic based upon both conditions inside the structure and other planned setpoint changes. Thus, for example, the ramped setpoints 3406, 3408 and 3410 may be timed so that the 9AM change in user-determined setpoint from 74 degrees to 80 degrees is in effect anticipated, and the period in which the air conditioner is not used can be extended prior to the scheduled start time for the less energy-intensive setpoint. Similarly, because the server 106 is aware that a lower setpoint will begin at 5PM. The timing can be adjusted to avoid excessively warm temperatures immediately prior to the scheduled setpoint change, which could cause noticeable discomfort relative to the new setpoint if the air conditioner is incapable of quickly reducing inside temperature on a given day based upon the expected slope of inside temperatures at that time 3412.

[0214] In order to implement such ramped setpoints automatically, algorithms may be created. These algorithms may be generated and/or executed as instructions on remote server 106 and the resulting setpoint changes can be transmitted to a given thermostat on a just-in-time basis or, if the thermostat 108 is capable of storing future settings, they may be transferred in batch mode to such thermostats. Basic parameters used to generate such algorithms include:

[0215] the number of discrete phases to be used;

[0216] the temperature differential associated with each phase; and

[0217] the duration of each phase

[0218] In order to increase user comfort and thus maximize consumer acceptance, additional parameters may be considered, including:

[0219] time of day

[0220] outside weather conditions

[0221] recent history of manual inputs

[0222] recent pre-programmed setpoint changes.

[0223] Time of day may be relevant because, for example, if the home is typically unoccupied at a given time, there is no need for perceptual programming. Outside weather is relevant because comfort is dependent not just on temperature as sensed by a thermostat, but also includes radiant differentials. On extremely cold days,

even if the inside dry-bulb temperature is within normal comfort range, radiant losses due to cold surfaces such as single-glazed windows can cause subjective discomfort; thus on such days occupants may be more sensitive to ramping. Recent manual inputs (e.g., programming overrides) may create situations in which exceptions should be taken; depending on the context, recent manual inputs may either suspend the ramping of setpoints or simply alter the baseline temperature from which the ramping takes place.

[0224] **Figure 35** shows the steps used in the core ramped setpoint algorithm in the context of a remotely managed thermostat system. In step 3502 the application determines whether to instantiate the algorithm based upon external scheduling criteria. In step 3504 the application running on a remote server retrieves from the thermostat the data generated by or entered into the thermostat, including current temperature settings, HVAC status and inside temperature. The algorithm performs preliminary logical tests at that point to determine whether further processing is required. For example, in the heating context, if the inside temperature as reported by the thermostat 108 is more than 1 degree higher than the current setpoint, the algorithm may determine that running the ramped setpoint program will have no effect and therefore terminate.

[0225] In step 3506 the algorithm advances to the next phase from the most recent phase; i.e., if the algorithm is just starting, the phase changes from "0" to "1"; if it has just completed the third phase of a three-phase ramp, the phase will change from "2" to "0". In step 3508 the application determines if the current phase is "0". If it is, then in step 3510 the algorithm determines whether current setpoint equals the setpoint in the previous phase. If so, which implies no manual overrides or other setpoint adjustments have occurred during the most recent phase, then in step 3512 the algorithm sets the new setpoint back to the previous phase "0" setpoint. If not, then in step 3514, the algorithm keeps the current temperature setting as setpoint for this new phase. In step 3516, the algorithm logs the resulting new setpoint as the new phase "0" setpoint for use in subsequent phases.

[0226] Returning to the branch after step 3508, if the current phase at that point is not phase "0", then in step 3520, the algorithm determines whether the current

setpoint is equal to the setpoint temperature in the previous phase. If not, which implies setpoints have been adjusted by the house occupants, thermostat schedules, or other events, then in step 3522, the application resets the phase to "0", resets the new setpoint associated with phase "0" to equal the current temperature setting, and sets the current setting to that temperature. Alternatively, if the current temperature setting as determined in step 3520 is equal to the setpoint in the previous phase, then in step 3524 new setpoint is made to equal current setpoint plus the differential associated with each phase change. In step 3526 the "previous-phase setpoint" variable is reset to equal the new setpoint in anticipation of its use during a subsequent iteration.

[0227] **Figure 36** shows one embodiment of the overall control application implementing the algorithm described in **Figure 35**. In step 3602, the control application retrieves the current setting from the thermostat. In step 3604, the setting is logged in database 300. In step 3606, the control program determines whether other algorithms that have higher precedence than the ramped setpoint algorithm are to be run. If another algorithm is to be run prior to the ramped setpoint algorithm, then the other program is executed in step 3608. If there are no alternate algorithms that should precede the ramped setpoint application then in step 1310, the control program determines whether the thermostat has been assigned to execute the ramped setpoint program. If not, the control program skips the remaining actions in the current iteration. If the program is set to run, then in step 3612 the algorithm retrieves from database 300 the rules and parameters governing the implementation of the algorithm for the current application of the program.

[0228] In step 3614, the algorithm determines whether one or more conditions that preclude application of the algorithm, such as extreme outside weather conditions, whether the home is likely to be occupied, etc. If any of the exclusionary conditions apply, the application skips execution of the ramped setpoint algorithm for the current iteration. If not, the application proceeds to step 3616 in which the application determines whether the setpoint has been altered by manual overrides, thermostat setback schedule changes, or other algorithms as compared to the previous value as stored in database 300. If setpoint has been altered, the application proceeds to step 3620 discussed below.

Ex. 1006.0322

[0229] In step 3618, the program described in **Figure 35** is executed. In step 3620, the application resets the phase to "0". Certain temperature setting variables are reset in anticipation of their use in subsequent phases. These variables include the new phase 0 temperature setting which is anchored to the current actual temperature setting, and the new previous-phase setpoint which will be used for identifying setpoint overrides in the subsequent phase.

[0230] In step 3622, the system records the changes to the thermostat settings to database 300. In step 3624, the system records the changes to the phase status of the algorithm to database 300. In step 3626, the application determines whether the new temperature setting differs from the current setting. If they are the same, the application skips applying changes to the thermostat. If they are different, then in step 3628, the application transmits revised settings to the thermostat. In step 3630, the application then hibernates for the specified duration until it is invoked again by beginning at step 3602 again.

[0231] An embodiment of the subject invention may also be used to detect occupancy through the use of software related to electronic devices located inside the conditioned structure, such as the browser running on computer or other device 104. **Figure 37** represents the screen of a computer or other device 104 using a graphical user interface connected to the Internet. The screen shows that a browser 3700 is displayed on computer 104. In one embodiment, a background application installed on computer 104 detects activity by a user of the computer, such as cursor movement, keystrokes or otherwise, and signals the application running on server 106 that activity has been detected. Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; (b) signal the background application running on computer 104 to trigger a software routine that instantiates a pop-up window 3702 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. The user can respond by clicking the cursor on "yes" button 3704 or "No" button 3706. Equilvalent means of signalling activity may be employed with interactive television programming, gaming systems, etc.

Ex. 1006.0323

[0232] **Figure 38** is a flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 3802, computer 104 transmits a message to server 106 via the Internet indicating that there is user activity on computer 104. This activity can be in the form of keystrokes, cursor movement, input via a television remote control, etc. In step 3804 the application queries database 300 to retrieve setting information for the HVAC system. In step 3806 the application determines whether the current HVAC program is intended to apply when the home is occupied or unoccupied.

[0233] If the HVAC settings then in effect are intended to apply for an occupied home, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 3808 the application will retrieve from database 300 the user's specific preferences for how to handle this situation. If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 3816, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 3810 the application transmits a command to computer 104 directing the browser to display a message informing the user that the current setting assumes an unoccupied house and asking the user in step 3812 to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 3814 the application will write to database 300 the fact that the users has so elected and terminate. If the user elects to change the setting, then in step 3816 the application transmits the revised setpoint to the thermostat. In step 3814 the application writes the updated setting information to database 300.

[0234] **Figure 39** is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system. In step 3902 computer 104 transmits to server 106 information regarding the type of

Ex. 1006.0324

activity detected on computer 104. Such information could include the specific program or channel being watched if, for example, computer 104 is used to watch television. The information matching, for example, TV channel 7 at 4:00 PM on a given date to specific content may be made by referring to Internet-based or other widely available scheduling sources for such content. In step 3904 server 106 retrieves from database 300 previously logged data regarding viewed programs. In step 3906 server 106 retrieves previously stored data regarding the residents of the house.

[0235] For example, upon initiating the service, one or more users may have filled out online questionnaires sharing their age, gender, schedules, viewing preferences, etc. In step 3908, server 106 compares the received information about user activity to previously stored information retrieved from database 300 about the occupants and their viewing preferences. For example, if computer 104 indicates to server 106 that the computer is being used to watch golf, the server may conclude that an adult male is watching; if computer 104 indicates that it is being used to watch children's programming, server 106 may conclude that a child is watching.

[0236] In step 3910 the server transmits a query to the user in order to verify the match, asking, in effect, "Is that you Bob?" In step 3912, based upon the user's response, the application determines whether the correct user has been identified. If the answer is no, then the application proceeds to step 3916. If the answer is yes, then in step 3914 the application retrieves the temperature settings for the identified occupant. In step 3916 the application writes to database 300 the programming information and information regarding matching of users to that programming.

[0237] In an alternative embodiment, the application running on computer 104 may respond to general user inputs (that is, inputs not specifically intended to instantiate communication with the remote server) by querying the user whether a given action should be taken. For example, in a system in which the computer 104 is a web-enabled television or web-enabled set-top device connected to a television as a display, software running on computer 104 detects user activity, and transmits a message indicating such activity to server 106. The trigger for this signal may be general, such as changing channels or adjusting volume with the remote control or a power-on event. Upon receipt by server 106 of this trigger, server 106 transmits instructions to computer

Ex. 1006.0325

104 causing it to display a dialog box asking the user whether the user wishes to change HVAC settings.

[0238] Additional functionality is also envisioned as part of different embodiments of the invention. For example, information from historic data may be used to predict how long it will take a user to reach home from the current coordinates, and the estimated arrival time may be used to calculate optimal cycling strategies for the HVAC system. In addition, information about traffic conditions may be integrated into these calculations, so that the geospatial data relative to mobile device 105 may indicate that a user is taking his or her normal route, but because of a traffic jam, is likely to come home later than would otherwise be expected. The characteristics of a given location may be used to infer arrival times as well. For example, if the geospatial data indicates that the user of mobile device 105 has arrived at the supermarket on his way home, a delay of 20 minutes is likely, whereas if the user has parked at a restaurant, the delay is likely to be one hour.

[0239] It is also possible to incorporate more sophisticated heuristics in incorporating the varying preferences of multiple occupants of a given home or other structure. For example, rules can be structured so that User #1's preferences control during the heating season, but not during the cooling season; User #2's preferences might control during certain times of the day but not others; User #3's preferences amy take precedence whenever they result in a more energy efficient strategy, but not when they result in increased energy use, and so on.

[0240] While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, that the invention may be carried out in other ways without departing from the true spirit and scope. These and other equivalents are intended to be covered by the following claims:

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WHAT IS CLAIMED IS:

1. A method for varying temperature setpoints for an HVAC system comprising:

accessing stored data comprising a plurality of internal temperature measurements taken within a structure and a plurality of outside temperature measurements relating to temperatures outside the structure;

using the stored data to predict a temperature inside the structure in response to at least changes in the outside temperatures;

determining with one or more computer processors, the geographic location of a mobile electronic device that is connected to a network;

associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices;

determining with one or more computer processors, whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device;

using route data to determine whether a user of the mobile electronic device is traveling to said structure;

using traffic data to predict a length of time for a user of said mobile device to reach said structure; and

adjusting with one or more computer processors, the temperature setpoint on said controller for an HVAC system for said structure based upon said predicted length of time for a user of the mobile device to reach said structure, said predicted temperature inside said structure, and whether or not said structure is deemed to be occupied.

Ex. 1006.0327

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

ABSTRACT OF THE DISCLOSURE

Embodiments of the invention comprise systems and methods for using the geographic location of networked consumer electronics devices as indications of occupancy of a structure for purposes of automatically adjusting the temperature setpoint on a thermostatic HVAC control. At least one thermostat is located inside a structure and is used to control an HVAC system in the structure. At least one mobile electronic device is used to indicate the state of occupancy of the structure. The state of occupancy is used to alter the setpoint on the thermostatic HVAC control to reduce unneeded conditioning of unoccupied spaces.

Ex. 1006.0328

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Cross-Reference to Related Applications

[0001] Any and all applications for which a foreign or domestic priority claim is identified in the Application Data Sheet, or any correction thereto, are hereby incorporated by reference under 37 CFR 1.57.

BACKGROUND OF THE INVENTION

Field of the Invention

[0002] This invention relates to the use of thermostatic HVAC and other energy management controls that are connected to a computer network. More specifically, the present invention pertains to the use of geographic movement of network-connected mobile devices to occupancy to inform an energy management system, to provide enhanced efficiency, and to verify demand response.

Description of the Related Art

[0003] Heating and cooling systems for buildings (heating, ventilation and cooling, or HVAC systems) have been controlled for decades by thermostats. At the most basic level, a thermostat includes a means to allow a user to set a desired temperature, a means to sense actual temperature, and a means to signal the heating and/or cooling devices to turn on or off in order to try to change the actual temperature to equal the desired temperature. The most basic versions of thermostats use components such as a coiled bi-metallic spring to measure actual temperature and a mercury switch that opens or completes a circuit when the spring coils or uncoils with temperature changes. More recently, electronic digital thermostats have become prevalent. These thermostats use solid-state devices such as thermistors or thermal diodes to measure temperature, and microprocessor-based circuitry to control the switch and to store and operate based upon user-determined protocols for temperature vs. time.

[0004] These programmable thermostats generally offer a very restrictive user interface, limited by the cost of the devices, the limited real estate of the small wall-mounted boxes, and the inability to take into account more than two variables: the desired temperature set by the user, and the ambient temperature sensed by the thermostat. Users can generally only set one series of commands per day, and in order to change one parameter (e.g., to change the late-night temperature) the user often has to cycle through several other parameters by repeatedly pressing one or two buttons.

[0005] Because the interface of programmable thermostats is so poor, the significant theoretical savings that are possible with them (sometimes cited as 25% of heating and cooling costs) are rarely realized. In practice, studies have found that more than 50% of users never program their thermostats at all. Significant percentages of the thermostats that are programmed are programmed sub-optimally, in part because, once programmed, people tend to not to re-invest the time needed to change the settings very often.

[0006] A second problem with standard programmable thermostats is that they represent only a small evolutionary step beyond the first, purely mechanical thermostats. Like the first thermostats, they only have two input signals - ambient temperature and the preset desired temperature. The entire advance with programmable thermostats is that they can shift between multiple present temperatures at different times without real-time involvement of a human being.

[0007] Because most thermostats control HVAC systems that do not offer infinitely variable output, traditional thermostats are designed to permit the temperature as seen by the thermostat to vary above and below the setpoint to prevent the HVAC system from constantly and rapidly cycling on and off, which is inefficient and harmful to the HVAC system. The temperature range in which the thermostat allows the controlled environment to drift is known as both the dead zone and, more formally, the hysteresis zone. The hysteresis zone is frequently set at +/- 1 degree Fahrenheit. Thus if the setpoint is 68 degrees, in the heating context the thermostat will allow the inside temperature to fall to 67 degrees before turning the heating system on, and will allow it to rise to 69 degrees before turning it off again.

Ex. 1006.0330

[0008] As energy prices rise, more attention is being paid to ways of reducing energy consumption. Because energy consumption is directly proportional to setpoint - that is, the further a given setpoint diverges from the balance point (the inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by virtually any strategy that over a given time frame lowers the average heating setpoint or raises the average cooling setpoint. Conventional programmable thermostats allow homeowners to save money and energy by pre-programming setpoint changes based upon comfort or schedule. For example, in the summer, allowing the setpoint to rise by several degrees (or even shutting off the air conditioner) when the home is unoccupied will generally save significantly on energy. But such thermostats have proven to be only minimally effective in practice. Because they have such primitive user interfaces, they are difficult to program, and so many users never bother at all, or set them up once and do not alter the programming even if their schedules change.

[0009] In the hotel industry, the heating and cooling decisions made in hundred or even thousands of individual rooms with independently controlled HVAC systems are aggregated into a single energy bill, so hotel owners and managers are sensitive to energy consumption by those systems. Hotel guests often turn the air conditioner to a low temperature setting and then leave the room for hours at a time, thereby wasting considerable energy. An approach commonly used outside of the United States to combat this problem is to use a keycard to control the HVAC system, such that guests place the keycard into a slot mounted on the wall near the door of the room which then triggers the lights and HVAC system to power up, and turn them off when the guest removes the card upon leaving the room. However, because most hotels give each guest two cards, it is easy to simply leave the extra card in the slot, thus defeating the purpose of the system. Recently, systems have been introduced in which a motion sensor is connected to the control circuitry for the HVAC system. If no motion is detected in the room for some predetermined interval, the system concludes that the room is unoccupied, and turns off the HVAC system or alters the setpoint to a more economical level. When the motion sensor detects motion (which is assumed to

coincide with the return of the guest), the HVAC system resets to the guest's chosen setting.

[0010] Adding occupancy detection capability to residential HVAC systems could also add considerable value in the form of energy savings without significant tradeoff in terms of comfort. But the systems used in hotels do not easily transfer to the single-family residential context. Hotel rooms tend to be small enough that a single motion sensor is sufficient to determine with a high degree of accuracy whether or not the room is occupied. A single motion sensor in the average home today would have limited value because there are likely to be many places one or more people could be home and active yet invisible to the motion sensor. The most economical way to include a motion sensor in a traditional programmable thermostat would be to build it into the thermostat itself. But thermostats are generally located in hallways, and thus are unlikely to be exposed to the areas where people tend to spend their time. Wiring a home with multiple motion sensors in order to maximize the chances of detecting occupants would involve considerable expense, both for the sensors themselves and for the considerable cost of installation, especially in the retrofit market. Yet if control is ceded to a single-sensor system that cannot reliably detect presence, the resulting errors would likely lead the homeowner to reject the system.

[0011] Although progress in residential HVAC control has been slow, tremendous technological change has come to the tools used for personal communication. When programmable thermostats were first offered, telephones were virtually all tethered by wires to a wall jack. But now a large percentage of the population carries at least one mobile device capable of sending and receiving voice or data or even video (or a combination thereof) from almost anywhere by means of a wireless network. These devices create the possibility that a consumer can, with an appropriate mobile device and a network-enabled HVAC system, control his or her HVAC system even when away from home. But systems that relay on active management decisions by consumers are likely to yield sub-optimal energy management outcomes, because consumers are unlikely to devote the attention and effort required to fully optimize energy use on a daily basis.

[0012] Many new mobile devices now incorporate another significant new technology – the ability to geolocate the device (and thus, presumably, the user of the device). One method of locating such devices uses the Global Positioning System (GPS). The GPS system uses a constellation of orbiting satellites with very precise clocks to triangulate the position of a device anywhere on earth based upon arrival times of signals received from those satellites by the device. Another approach to geolocation triangulates using signals from multiple cell phone towers. Such systems can enable a variety of so-called "location based services" to users of enabled devices. These services are generally thought of as aids to commerce like pointing users to restaurants or gas stations, etc.

[0013] It would be desirable to provide a system that could detect the location of regular occupants of a home or other structure without requiring the installation of additional hardware; that could accurately use such geospatial information in order to detect and predict occupancy, and could optimize energy consumption based upon dynamic and individually configurable heuristics.

SUMMARY OF THE INVENTION

[0014] In one embodiment, the invention comprises a thermostat attached to an HVAC system, a local network connecting the thermostat to a larger network such as the Internet, and one or more geolocation-enabled mobile devices attached to the network, and a server in bi-directional communication with a plurality of such thermostats and devices. The server pairs each thermostat with one or more geolocation-enabled mobile devices which are determined to be associated with the occupants of home in which the thermostat is located.

[0015] The server logs the ambient temperature sensed by each thermostat vs. time and the signals sent by the thermostats to their HVAC systems. The server also monitors and logs the geolocation data related to the geolocation-enabled mobile devices associated with each thermostat. Based on the locations and movement evidenced by geolocation data, the server instructs the thermostat to change temperature settings between those optimized for occupied and unoccupied states at the appropriate times based on the evolving geolocation data.

Ex. 1006.0333

[0016] One embodiment of the invention is directed to a method for varying temperature setpoints for an HVAC system. The method comprises determining the geographic location of a mobile electronic device that is connected to a network and associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices. In addition, the method comprises determining whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device and adjusting the temperature setpoint on said controller for an HVAC system for said structure based upon whether or not said structure is deemed to be occupied.

[0017] In another embodiment, the mobile electronic device is a telephone. In an additional embodiment, the networked mobile electronic device is a personal digital assistant. In a further embodiment, the mobile electronic device is connected to the Internet.

[0018] In one embodiment the method for determining the geographic location of a mobile electronic device uses the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0019] In yet another embodiment, the variation of temperature setpoints is logged to a database. In a further embodiment, the variation of temperature setpoints is initiated by a remote computer. In a different embodiment, the temperature setpoints are varied automatically. In a further embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

[0020] In one embodiment, a system for altering the setpoint on a thermostat for space conditioning of a structure comprises at least one said thermostat having at least one temperature setting associated with the presence of one or more occupants in said structure, and at least one temperature setting associated with the absence of occupants in said structure. The system also comprises one or more mobile electronic

devices having at least a user interface, where the mobile electronic devices and said thermostat are connected to a network and where the setpoint on said thermostat is adjusted between said temperature setting associated with the presence of one or more occupants in said structure and said temperature setting associated with the absence of occupants in said structure based upon the geographic location of said electronic device.

[0021] In a further embodiment, the mobile electronic device is a telephone. In yet another embodiment, the networked mobile electronic device is a personal digital assistant. In still a further embodiment, the mobile electronic device is connected to the Internet.

[0022] In one embodiment, the method for determining the geographic location of a mobile electronic device is the global positioning system. In another embodiment, the method for determining the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from said mobile electronic device. In a further embodiment, the mobile electronic device communicates with a remote server.

[0023] In a different embodiment, the variation of temperature setpoints is logged to a database. In another embodiment, the variation of temperature setpoints is initiated by a remote computer. In a further embodiment, the temperature setpoints are varied automatically. In still another embodiment, an occupant is prompted to confirm occupancy prior to adjustment of said temperature setpoint.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] Figure 1 shows an example of an overall environment in which an embodiment of the invention may be used.

[0025] Figure 2 shows a high-level illustration of the architecture of a network showing the relationship between the major elements of one embodiment of the subject invention.

Ex. 1006.0335

[0026] Figures 3a and 3b show an embodiment of the website to be used as part of the subject invention.

[0027] Figure 4 shows a high-level schematic of the thermostat used as part of an embodiment of the subject invention.

[0028] Figure 5 shows one embodiment of the database structure used as part of an embodiment of the subject invention.

[0029] Figures 6a and 6b illustrate pages of a website that may be used with an embodiment of the subject invention.

[0030] Figure 7 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0031] Figure 8 is a flowchart that shows how the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device connected to the system.

[0032] Figures 9a and 9b show how comparing inside temperature against outside temperature and other variables permits calculation of dynamic signatures.

[0033] Figure 10 shows a flow chart for a high level version of the process of calculating the appropriate turn-on time in a given home.

[0034] Figure 11 shows a more detailed flowchart listing the steps in the process of calculating the appropriate turn-on time in a given home for a just-in-time event.

[0035] Figures 12a, 12b, 12c and 12d show the steps shown in the flowchart in Figure 11 in the form of a graph of temperature and time.

[0036] Figure 13 shows a table of some of the data used by an embodiment of the subject invention to predict temperatures.

[0037] Figure 14 shows an embodiment of the subject invention as applied in a specific home on a specific day.

[0038] Figure 15 shows an embodiment of the subject invention as applied in a different specific home on a specific day.

[0039] Figure 16, which includes Figures 16-1 and 16-2, shows a table of predicted rates of change in temperature inside a given home for a range of temperature differentials between inside and outside.

Ex. 1006.0336

[0040] Figure 17 shows how manual inputs can be recognized and recorded by an embodiment of the subject invention.

[0041] Figure 18 shows how an embodiment of the subject invention uses manual inputs to interpret manual overrides and make short-term changes in response thereto.

[0042] Figure 19 shows how an embodiment of the subject invention uses manual inputs to make long-term changes to interpretive rules and to setpoint scheduling.

[0043] Figure 20 shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event.

[0044] Figure 21a, 21b, and 21c ~~21(a) through 21(c)~~ illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature.

[0045] Figure 22 is a flow chart illustrating the steps involved in generating a demand reduction event for a given subscriber.

[0046] Figure 23 is a flow chart illustrating the steps involved in confirming that a demand reduction event has taken place.

[0047] Figure 24 is a representation of the movement of messages and information between the components of an embodiment of the subject invention.

[0048] Figures 25a and 25b show graphical representations of inside and outside temperatures in two different homes, one with high thermal mass and one with low thermal mass.

[0049] Figures 26a and 26b show graphical representations of inside and outside temperatures in the same homes as in Figures 25a and 25b, showing the cycling of the air conditioning systems in those houses.

[0050] Figures 27a and 27b show graphical representations of inside and outside temperatures in the same home as in Figures 25a and 26a, showing the cycling of the air conditioning on two different days in order to demonstrate the effect of a change in operating efficiency on the parameters measured by the thermostat.

[0051] Figures 28a and 28b show the effects of employing a pre-cooling strategy in two different houses.

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[0052] Figures 29a and 29b show graphical representations of inside and outside temperatures in two different homes in order to demonstrate how the system can correct for erroneous readings in one house by referencing readings in another.

[0053] Figure 30 is a flowchart illustrating the steps involved in calculating the effective thermal mass of a home using an embodiment of the subject invention.

[0054] Figure 31 is a flowchart illustrating the steps involved in determining whether an HVAC system has developed a problem that impairs efficiency using an embodiment of the subject invention.

[0055] Figure 32 is a flowchart illustrating the steps involved in correcting for erroneous readings in one house by referencing readings in another using an embodiment of the subject invention.

[0056] Figure 33 shows the conventional programming of a programmable thermostat over a 24-hour period.

[0057] Figure 34 shows the programming of a programmable thermostat over a 24-hour period using ramped setpoints.

[0058] Figure 35 shows the steps required for the core function of the ramped setpoint algorithm.

[0059] Figure 36 shows a flowchart listing steps in the process of deciding whether to implement the ramped setpoint algorithm using an embodiment of the subject invention.

[0060] Figure 37 shows the browser as seen on the display of the computer used as part of an embodiment of the subject invention.

[0061] Figure 38 is a flowchart showing the steps involved in the operation of one embodiment of the subject invention.

[0062] Figure 39 is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0063] **Figure 1** shows an example of an overall environment 100 in which an embodiment of the invention may be used. The environment 100 includes an

interactive communication network 102 with computers 104 connected thereto. Also connected to network 102 are mobile devices 105, and one or more server computers 106, which store information and make the information available to computers 104 and mobile devices 105. The network 102 allows communication between and among the computers 104, mobile devices 105 and servers 106.

[0064] Presently preferred network 102 comprises a collection of interconnected public and/or private networks that are linked to together by a set of standard protocols to form a distributed network. While network 102 is intended to refer to what is now commonly referred to as the Internet, it is also intended to encompass variations which may be made in the future, including changes additions to existing standard protocols. It also includes various networks used to connect mobile and wireless devices, such as cellular networks.

[0065] When a user of an embodiment of the subject invention wishes to access information on network 102 using computer 104, the user initiates connection from his computer 104. For example, the user invokes a browser, which executes on computer 104. The browser, in turn, establishes a communication link with network 102. Once connected to network 102, the user can direct the browser to access information on server 106.

[0066] One popular part of the Internet is the World Wide Web. The World Wide Web contains a large number of computers 104 and servers 106, which store HyperText Markup Language (HTML) documents capable of displaying graphical and textual information. HTML is a standard coding convention and set of codes for attaching presentation and linking attributes to informational content within documents.

[0067] The servers 106 that provide offerings on the World Wide Web are typically called websites. A website is often defined by an Internet address that has an associated electronic page. Generally, an electronic page is a document that organizes the presentation of text graphical images, audio and video.

[0068] In addition to the Internet, the network 102 can comprise a wide variety of interactive communication media. For example, network 102 can include local area networks, interactive television networks, telephone networks, wireless data systems, two-way cable systems, and the like.

[0069] In one embodiment, computers 104 and servers 106 are conventional computers that are equipped with communications hardware such as modem or a network interface card. The computers include processors such as those sold by Intel and AMD. Other processors may also be used, including general-purpose processors, multi-chip processors, embedded processors and the like.

[0070] Computers 104 can also be microprocessor- controlled home entertainment equipment including advanced televisions, televisions paired with home entertainment/media centers, and wireless remote controls.

[0071] Computers 104 may utilize a browser configured to interact with the World Wide Web. Such browsers may include Microsoft Explorer, Mozilla, Firefox, Opera or Safari. They may also include browsers or similar software used on handheld, home entertainment and wireless devices.

[0072] The storage medium may comprise any method of storing information. It may comprise random access memory (RAM), electronically erasable programmable read only memory (EEPROM), read only memory (ROM), hard disk, floppy disk, CD-ROM, optical memory, or other method of storing data.

[0073] Computers 104 and 106 may use an operating system such as Microsoft Windows, Apple Mac OS, Linux, Unix or the like.

[0074] Computers 106 may include a range of devices that provide information, sound, graphics and text, and may use a variety of operating systems and software optimized for distribution of content via networks.

[0075] Mobile devices 105 can also be handheld and wireless devices such as personal digital assistants (PDAs), cellular telephones and other devices capable of accessing the network. Mobile devices 105 can use a variety of means for establishing the location of each device at a given time. Such methods may include the Global Positioning System (GPS), location relative to cellular towers, connection to specific wireless access points, or other means

[0076] **Figure 2** illustrates in further detail the architecture of the specific components connected to network 102 showing the relationship between the major elements of one embodiment of the subject invention. Attached to the network are thermostats 108 and computers 104 of various users. Connected to thermostats 108

are HVAC units 110. The HVAC units may be conventional air conditioners, heat pumps, or other devices for transferring heat into or out of a building. Each user is connected to the server 106 via wired or wireless connection such as Ethernet or a wireless protocol such as IEEE 802.11, a gateway 110 that connects the computer and thermostat to the Internet via a broadband connection such as a digital subscriber line (DSL), cellular radio or other form of broadband connection to the World Wide Web. Server 106 contains the content to be served as web pages and viewed by computers 104, software to manage thermostats 108, as well as databases containing information used by the servers.

[0077] Also attached to the Network are cellular radio towers 120, or other means to transmit and receive wireless signals in communication with mobile devices 105. Such communication may use GPRS, GSM, CDMA, EvDO, EDGE or other protocols and technologies for connecting mobile devices to a network.

[0078] **Figures 3a** and **3b** shows a representative mobile device 105 from the front and back, respectively. The front of the device includes a display 202, and may include a physical keyboard 204. Alternatively, a virtual keyboard may be included in a display with touchscreen functionality. For devices with voice capabilities, such as a smart phone, a microphone 206 and speaker 208 enable audio communications. An antenna 210, which may be mounted entirely within the mobile device, aids wireless communications. Modules included within mobile device 105 but not visible from the outside may include memory cards, microprocessors, GPS receivers, battery, etc.

[0079] **Figure 4** shows a high-level block diagram of thermostat 108 used as part of an embodiment of the subject invention. Thermostat 108 includes temperature sensing means 252, which may be a thermistor, thermal diode or other means commonly used in the design of electronic thermostats. It includes a microprocessor 254, memory 256, a display 258, a power source 260, a relay 262, which turns the HVAC system on and off in response to a signal from the microprocessor, and contacts by which the relay is connected to the wires that lead to the HVAC system.

[0080] To allow the thermostat to communicate bi-directionally with the computer network, the thermostat also includes means 264 to connect the thermostat to a local computer or to a wireless network. Such means could be in the form of

Ethernet, wireless protocols such as IEEE 802.11, IEEE 802.15.4, Bluetooth, cellular systems such as CDMA, GSM and GPRS, or other wireless protocols. The thermostat 250 may also include controls 266 allowing users to change settings directly at the thermostat, but such controls are not necessary to allow the thermostat to function.

[0081] The data used to manage the subject invention is stored on one or more servers 106 within one or more databases. As shown in **Figure 5**, the overall database structure 300 may include temperature database 400, thermostat settings database 500, energy bill database 600, HVAC hardware database 700, weather database 800, user database 900, transaction database 1000, product and service database 1100, user location database 1200 and such other databases as may be needed to support these and additional features.

[0082] Users of connected thermostats 250 may create personal accounts. Each user's account will store information in database 900, which tracks various attributes relative to users of the site. Such attributes may include the make and model of the specific HVAC equipment in the user's home; the age and square footage of the home, the solar orientation of the home, the location of the thermostat in the home, the user's preferred temperature settings, whether the user is a participant in a demand response program, etc.

[0083] User personal accounts may also associate one or more mobile devices with such personal accounts. For mobile devices with the capability for geopositioning awareness, these personal accounts will have the ability log such positioning data over time in database 1200.

[0084] In one embodiment, a background application installed on mobile device 105 shares geopositioning data for the mobile device with the application running on server 106 that logs such data. Based upon this data, server 106 runs software that interprets said data (as described in more detail below). Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; or (b) transmit a message to mobile device 105 that asks the user if the server should change the current setpoint, alter the overall programming of the system

based upon a new occupancy pattern, etc. Such signalling activity may be conducted via email, text message, pop-up alerts, voice messaging, or other means.

[0085] **Figures 6a** and **6b** illustrate a website that may be provided to assist homeowners and others to interact with an embodiment of the subject invention. The website will permit thermostat users to perform through the web browser substantially all of the programming functions traditionally performed directly at the physical thermostat, such as temperature set points, the time at which the thermostat should be at each set point, etc. Preferably the website will also allow users to accomplish more advanced tasks such as allow users to program in vacation settings for times when the HVAC system may be turned off or run at more economical settings, and to set macros that will allow changing the settings of the temperature for all periods with a single gesture such as a mouse click.

[0086] As shown in **Figure 6a**, screen 351 of website 350 displays current temperature 352 as sensed by thermostat 108. Clicking on "up" arrow 354 raises the setpoint 358; clicking the down arrow 356 lowers setpoint 358. Screen 351 may also convey information about the outside weather conditions, such as a graphic representation 360 of the sun, clouds, etc. In homes with multiple thermostats, screen 351 may allow users to select different devices to adjust or monitor. Users will be able to use screen 351 by selecting, for example, master bedroom thermostat 362, living room thermostat 364, game room thermostat 366, or basement thermostat 368.

[0087] As shown in **Figure 6b**, screen 370 allows users to establish programming schedules. Row 372 shows a 24-hour period. Programming row 374 displays various programming periods and when they are scheduled, such as away setting 376, which begins at approximately 8AM and runs until approximately 5:30PM. When the away setting 376 is highlighted, the user can adjust the starting time and ending time for the setting by dragging the beginning time 378 to the left to choose an earlier start time, and dragging it to the right to make it later. Similarly, the user can drag ending time 380 to the left to make it earlier, and to the right to make it later. While away setting 376 is highlighted, the user can also change heating setpoint 382 by clicking on up arrow 384 or down arrow 386, and cooling setpoint 388 by clicking on up

Ex. 1006.0343

arrow 390 or down arrow 392. The user can save the program by clicking on save button 394.

[0088] **Figure 7** is a high-level flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 1302, mobile device 105 transmits geopositioning information to server 106 via the Internet. In step 1304 the server compares the latest geopositioning data point to previous data points in order to determine whether a change in location or vector of movement has occurred. In step 1306 the server evaluates the geopositioning data in order to determine whether the temperature settings for the HVAC system for the structure associated with the mobile device 105 should be optimized for an unoccupied structure, or for an occupied structure in light of the movement (or lack thereof) in the geopositioning data.

[0089] If the server 106 determines that the home should be in occupied or "home" mode, then in step 1308 the server queries database 300 to determine whether thermostat 108 is already set for home or away mode. If thermostat 108 is already in home mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 1310 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0090] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1316, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1312 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home.

[0091] If the user elects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and

Ex. 1006.0344

terminate. If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.

[0092] If the server 106 determines in step 1306 that the home should be in unoccupied or away mode, then in step 1350 the server queries database 300 to determine whether thermostat 108 is set for set for home or away mode. If thermostat 108 is already in away mode, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is occupied, then in step 1352 the application will retrieve from database 300 the user's specific preferences for how to handle this situation.

[0093] If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 1358, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when unoccupied. If the user has previously specified that the application should not make such changes without further user input, then in step 1354 the application transmits a command to the location specified by the user (generally mobile device 105) directing the device display a message informing the user that the current setting assumes an unoccupied house and asking the user to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 1318 the application will write to database 300 the fact that the user has so elected and terminate.

[0094] If the user elects to change the setting, then in step 1316 the application transmits the revised setpoint to the thermostat. In step 1318 the application writes the updated setting information to database 300.If thermostat 108 is already in away mode, the program ends. If it was in home mode, then in step 1314 server 108 initiates a state change to put thermostat 108 in away mode. In either case, the server then in step 1316 writes the state change to database 300. In each case the server can also send a message to the person who owns the mobile device requesting, confirming or announcing the state change.

Ex. 1006.0345

[0095] **Figure 8** is a flowchart that shows one process by which an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the mobile device attached to the system. The process shown assumes (a) a static hierarchy of temperature preferences as between multiple occupants: that is, that for a given home/structure, mobile user #1's preferences will always control the outcome if mobile user #1 is present, that mobile user #2's preferences yield to #1's, but always prevail over user #3, etc; and (b) that there are no occupants to consider who are not associated with a mobile device. Other heuristics may be applied in order to account for more dynamic interactions of preferences.

[0096] In step 1402 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #1. In step 1404 server 106 uses current and recent coordinates to determine whether mobile user #1's "home" settings should be applied. If server 106 determines that User #1's home settings should be applied, then in step 1406 server 106 applies the correct setting and transmits it to the thermostat(s).

[0097] In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming. If after performing step 1404, the server concludes that mobile user #1's "home" settings should not be applied, then in step 1412 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #2.

[0098] In step 1414 server 106 uses current and recent coordinates to determine whether mobile user #2's "home" settings should be applied. If server 106 determines that User #2's home settings should be applied, then in step 1416 server 106 applies the correct setting and transmits it to the thermostat(s).

[0099] In step 1408, server 106 writes to database 300 the geospatial and other relevant information used to adjust the programming. If after performing step 1414, the server concludes that mobile user #2's "home" settings should not be applied, then in step 1422 server 106 retrieves the most recent geospatial coordinates from the mobile device 105 associated with mobile user #N.

Ex. 1006.0346

[0100] In step 1424 server 106 uses current and recent coordinates to determine whether mobile user #N's "home" settings should be applied. If server 106 determines that User #N's home settings should be applied, then in step 1426 server 106 applies the correct setting and transmits it to the thermostat(s). In step 1408, server 106 writes to database 300 the geospatial information used to adjust the programming.

[0101] If none of the mobile devices associated with a given home or other structure report geospatial coordinates consistent with occupancy, then in step 1430 the server instructs the thermostat(s) to switch to or maintain the "away" setting.

[0102] One embodiment of the invention is capable of delivering additional benefits for homeowners in terms of increased comfort and efficiency. In addition to using the system to allow better signaling and control of the HVAC system, which relies primarily on communication running from the server to the thermostat, the bi-directional communication will also allow the thermostat 108 to regularly measure and send to the server information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0103] For example, **Figure 9a** shows a graph of inside temperature, outside temperature and HVAC activity for a 24 hour period. When outside temperature 1502 increases, inside temperature 1504 follows, but with some delay because of the thermal mass of the building, unless the air conditioning 1506 operates to counteract this effect. When the air conditioning turns on, the inside temperature stays constant (or rises at a much lower rate or even falls) despite the rising outside temperature. In this example, frequent and heavy use of the air conditioning results in only a very slight temperature increase inside the house of 4 degrees, from 72 to 76 degrees, despite the increase in outside temperature from 80 to 100 degrees.

[0104] **Figure 9b** shows a graph of the same house on the same day, but assumes that the air conditioning is turned off from noon to 7PM. As expected, the inside temperature 1504a rises with increasing outside temperatures 1502 for most of that period, reaching 88 degrees at 7PM. Because server 106 logs the temperature

Ex. 1006.0347

readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house.

[0105] The performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the rate at which the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc., the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0106] The ability to predict the rate of change in inside temperature in a given house under varying conditions may be applied by in effect holding the desired future inside temperature as a constraint and using the ability to predict the rate of change to determine when the HVAC system must be turned on in order to reach the desired temperature at the desired time. The ability of an HVAC system to vary turn-on time in order to achieve a setpoint with minimum energy use may be thought of as Just In Time (JIT) optimization.

[0107] **Figure 10** shows a flowchart illustrating the high-level process for controlling a just-in-time (JIT) event. In step 1512, the server determines whether a specific thermostat 108 is scheduled to run the preconditioning program. If, not, the program terminates. If it so scheduled, then in step 1514 the server retrieves the predetermined target time when the preconditioning is intended to have been completed (TT).

[0108] Using TT as an input, in step 1516 the server then determines the time at which the computational steps required to program the preconditioning event will be performed (ST). In step 1518, performed at start time ST, the server begins the process of actually calculating the required parameters, as discussed in greater detail below. Then in 1520 specific setpoint changes are transmitted to the thermostat so that the temperature inside the home may be appropriately changed as intended.

[0109] **Figure 11** shows a more detailed flowchart of the process. In step 1532, the server retrieves input parameters used to create a JIT event. These

Ex. 1006.0348

parameters include the maximum time allowed for a JIT event for thermostat 108 (MTI); the target time the system is intended to hit the desired temperature (TT); and the desired inside temperature at TT (TempTT). It is useful to set a value for MTI because, for example, it will be reasonable to prevent the HVAC system from running a preconditioning event if it would be expected to take 8 hours, which might be prohibitively expensive.

[0110] In step 1534, the server retrieves data used to calculate the appropriate start time with the given input parameters. This data includes a set of algorithmic learning data (ALD), composed of historic readings from the thermostat, together with associated weather data, such as outside temperature, solar radiation, humidity, wind speed and direction, etc; together with weather forecast data for the subject location for the period when the algorithm is scheduled to run (the weather forecast data, or WFD). The forecasting data can be as simple as a listing of expected temperatures for a period of hours subsequent to the time at which the calculations are performed, to more detailed tables including humidity, solar radiation, wind, etc. Alternatively, it can include additional information such as some or all of the kinds of data collected in the ALD.

[0111] In step 1536, the server uses the ALD and the WFD to create prediction tables that determine the expected rate of change or slope of inside temperature for each minute of HVAC cycle time (ΔT) for the relevant range of possible pre-existing inside temperatures and outside climatic conditions. An example of a simple prediction table is illustrated in Fig. 13.

[0112] In step 1538, the server uses the prediction tables created in step 1536, combined with input parameters TT and Temp(TT) to determine the time at which slope ΔT intersects with predicted initial temperature PT. The time between PT and TT is the key calculated parameter: the preconditioning time interval, or PTI.

[0113] In step 1540, the server checks to confirm that the time required to execute the pre-conditioning event PTI does not exceed the maximum parameter MTI. If PTI exceeds MTI, the scheduling routine concludes and no ramping setpoints are transmitted to the thermostat.

Ex. 1006.0349

[0114] If the system is perfect in its predictive abilities and its assumptions about the temperature inside the home are completely accurate, then in theory the thermostat can simply be reprogrammed once – at time PT, the thermostat can simply be reprogrammed to Temp(TT). However, there are drawbacks to this approach.

[0115] First, if the server has been overly conservative in its predictions as to the possible rate of change in temperature caused by the HVAC system, the inside temperature will reach TT too soon, thus wasting energy and at least partially defeating the purpose of running the preconditioning routine in the first place. If the server is too optimistic in its projections, there will be no way to catch up, and the home will not reach Temp(TT) until after TT. Thus it would be desirable to build into the system a means for self-correcting for slightly conservative start times without excessive energy use.

[0116] Second, the use of setpoints as a proxy for actual inside temperatures in the calculations is efficient, but can be inaccurate under certain circumstances. In the winter (heating) context, for example, if the actual inside temperature is a few degrees above the setpoint (which can happen when outside temperatures are warm enough that the home's natural "set point" is above the thermostat setting), then setting the thermostat to Temp(TT) at time PT will almost certainly lead to reaching TT too soon as well.

[0117] The currently preferred solution to both of these possible inaccuracies is to calculate and program a series of intermediate settings between Temp(PT) and Temp(TT) that are roughly related to ΔT.

[0118] Thus if MTI is greater than PTI, then in step 1542 the server calculates the schedule of intermediate setpoints and time intervals to be transmitted to the thermostat. Because thermostats cannot generally be programmed with steps of less than 1 degree F, ΔT is quantized into discrete interval data of at least 1 degree F each. For example, if Temp(PT) is 65 degrees F, Temp(TT) is 72 degrees F, and PT is 90 minutes, the thermostat might be programmed to be set at 66 for 10 minutes, 67 for 12 minutes, 68 for 15 minutes, etc.

[0119] The server may optionally limit the process by assigning a minimum programming interval (e.g., at least ten minutes between setpoint changes) to avoid

frequent switching of the HVAC system, which can reduce accuracy because of the thermostat's compressor delay circuit, which may prevent quick corrections. The duration of each individual step may be a simple arithmetic function of the time PTI divided by the number of whole-degree steps to be taken; alternatively, the duration of each step may take into account second order thermodynamic effects relating to the increasing difficulty of "pushing" the temperature inside a house further from its natural setpoint given outside weather conditions, etc. (that is, the fact that on a cold winter day it may take more energy to move the temperature inside the home from 70 degrees F to 71 than it does to move it from 60 degrees to 61).

[0120] In step 1544, the server schedules setpoint changes calculated in step 1542 for execution by the thermostat.

[0121] With this system, if actual inside temperature at PT is significantly higher than Temp(PT), then the first changes to setpoints will have no effect (that is, the HVAC system will remain off), and the HVAC system will not begin using energy, until the appropriate time, as shown in **Figure 12**. Similarly, if the server has used conservative predictions to generate ΔT, and the HVAC system runs ahead of the predicted rate of change, the incremental changes in setpoint will delay further increases until the appropriate time in order to again minimize unnecessary energy use, as shown in **Figure 11**.

[0122] **Figure 12(a)** through **12(d)** shows the steps in the preconditioning process as a graph of temperature and time. **Figure 12(a)** shows step 1532, in which inputs target time TT 1552, target temperature Temp(TT) 1554, maximum conditioning interval MTI 1556 and the predicted inside temperature during the period of time the preconditioning event is likely to begin Temp(PT) 1558 are retrieved.

[0123] **Figure 12(b)** shows the initial calculations performed in step 1538, in which expected rate of change in temperature ΔT 1560 inside the home is generated from the ALD and WFD using Temp(TT) 1554 at time TT 1552 as the endpoint.

[0124] **Figure 12(c)** shows how in step 1538 ΔT 1560 is used to determine start time PT 1562 and preconditioning time interval PTI 1564. It also shows how in step 1540 the server can compare PTI with MTI to determine whether or not to instantiate the pre-conditioning program for the thermostat.

Ex. 1006.0351

[0125] **Figure 12(d)** shows step 1542, in which specific ramped setpoints 1566 are generated. Because of the assumed thermal mass of the system, actual inside temperature at any given time will not correspond to setpoints until some interval after each setpoint change. Thus initial ramped setpoint 1216 may be higher than Temp(PT) 1558, for example.

[0126] **Figure 13** shows an example of the types of data that may be used by the server in order to calculate ΔT 1560. Such data may include inside temperature 1572, outside temperature 1574, cloud cover 1576, humidity 1578, barometric pressure 1580, wind speed 1582, and wind direction 1584.

[0127] Each of these data points should be captured at frequent intervals. In the preferred embodiment, as shown in **Figure 13**, the interval is once every 60 seconds.

[0128] **Figure 14** shows application of an embodiment of the subject invention in an actual house. Temperature and setpoints are plotted for the 4-hour period from 4AM to 8AM with temperature on the vertical axis and time on the horizontal axis. The winter nighttime setpoint 1592 is 60 degrees F; the morning setpoint temperature 1594 is 69 degrees F. The outside temperature 1596 is approximately 45 degrees F. The target time TT 1598 for the setpoint change to morning setting is 6:45AM. In the absence of embodiments of the subject invention, the homeowner could program the thermostat to change to the new setpoint at 6:45, but there is an inherent delay between a setpoint change and the response of the temperature inside the home. (In this home on this day, the delay is approximately fifty minutes.) Thus if the homeowner truly desired to achieve the target temperature at the target time, some anticipation would be necessary. The amount of anticipation required depends upon numerous variables, as discussed above.

[0129] After calculating the appropriate slope ΔT 1560 by which to ramp inside temperature in order to reach the target as explained above, the server transmits a series of setpoints 1566 to the thermostat because the thermostat is presumed to only accept discrete integers as program settings. (If a thermostat is capable of accepting finer settings, as in the case of some thermostats designed to operate in

Ex. 1006.0352

regions in which temperature is generally denoted in Centigrade rather than Fahrenheit, which accept settings in half-degree increments, tighter control may be possible.)

[0130] In any event, in the currently preferred embodiment of the subject invention, programming changes are quantized such that the frequency of setpoint changes is balanced between the goal of minimizing network traffic and the frequency of changes made on the one hand and the desire for accuracy on the other. Balancing these considerations may result in some cases in either more frequent changes or in larger steps between settings. As shown in Fig. 14, the setpoint "stairsteps" from 60 degrees F to 69 degrees F in nine separate setpoint changes over a period of 90 minutes.

[0131] Because the inside temperature 1599 when the setpoint management routine was instantiated at 5:04 AM was above the "slope" and thus above the setpoint, the HVAC system was not triggered and no energy was used unnecessarily heating the home before such energy use was required. Actual energy usage does not begin until 5:49 AM.

[0132] **Figure 15** shows application of an embodiment of the subject invention in a different house during a similar four hour interval. In **Figure 15**, the predicted slope ΔT 1560 is less conservative relative to the actual performance of the home and HVAC system, so there is no off cycling during the preconditioning event – the HVAC system turns on at approximately 4:35 AM and stays on continuously during the event. The home reaches the target temperature Temp(TT) roughly two minutes prior to target time TT.

[0133] **Figure 16** shows a simple prediction table. The first column 1602 lists a series of differentials between outside and inside temperatures. Thus when the outside temperature is 14 degrees and the inside temperature is 68 degrees, the differential is -54 degrees; when the outside temperature is 94 degrees and the inside temperature is 71 degrees, the differential is 13 degrees. The second column 1604 lists the predicted rate of change in inside temperature ΔT 1210 assuming that the furnace is running in terms of degrees Fahrenheit of change per hour. A similar prediction table will be generated for predicted rates of change when the air conditioner

Ex. 1006.0353

is on; additional tables may be generated that predict how temperatures will change when the HVAC system is off.

[0134] Alternatively, the programming of the just-in-time setpoints may be based not on a single rate of change for the entire event, but on a more complex multivariate equation that takes into account the possibility that the rate of change may be different for events of different durations.

[0135] The method for calculating start times may also optionally take into account not only the predicted temperature at the calculated start time, but may incorporate measured inside temperature data from immediately prior to the scheduled start time in order to update calculations, or may employ more predictive means to extrapolate what inside temperature based upon outside temperatures, etc.

[0136] An additional capability offered by an embodiment of the instant invention is the ability to adapt the programming of the HVAC control system based upon the natural behavior of occupants. Because an embodiment of the instant invention is capable of recording the setpoint actually used at a connected thermostat over time, it is also capable of inferring manual setpoint changes (as, for example, entered by pushing the "up" or "down" arrow on the control panel of the device) even when such overrides of the pre-set program are not specifically recorded as such by the thermostat.

[0137] In order to adapt programming to take into account the manual overrides entered into the thermostat, it is first necessary to determine when a manual override has in fact occurred. Most thermostats, including two-way communicating devices discussed herein, do not record such inputs locally, and neither recognize nor transmit the fact that a manual override has occurred. Furthermore, in a system as described herein, frequent changes in setpoints may be initiated by algorithms running on the server, thereby making it impossible to infer a manual override from the mere fact that the setpoint has changed. It is therefore necessary to deduce the occurrence of such events from the data that an embodiment of the subject invention does have access to.

[0138] **Figure 17** illustrates the currently preferred method for detecting the occurrence of a manual override event. In step 1702, the server retrieves the primary

data points used to infer the occurrence of a manual override from one or more databases in overall database structure 300. The data should include each of the following: for the most recent point at which it can obtain such data (time0) the actual setpoint as recorded at the thermostat at (A0); for the point immediately prior to time0 (time-1), the actual setpoint recorded for the thermostat (A-1); for time0 the setpoint as scheduled by server 106 according to the basic setpoint programming (S0), and for time-1 the setpoint as scheduled by server 106 according to the standard setpoint programming (S-1).

[0139] In step 1704, the server retrieves any additional automated setpoint changes C that have been scheduled for the thermostat by server 106 at time0. Such changes may include algorithmic changes intended to reduce energy consumption, etc.

[0140] In step 1706 the server calculates the difference (dA) between A0 and A-1; for example, if the actual setpoint is 67 degrees at T-1 and 69 at T0, dA is +2; if the setpoint at T-1 is 70 and the setpoint at T0 is 66, dA is –4.

[0141] In step 1708, the server performs similar steps in order to calculate dS, the difference between S0 and S-1. This is necessary because, for example, the setpoint may have been changed because the server itself had just executed a change, such as a scheduled change from "away" to "home" mode. In step 1710 the server evaluates and sums all active algorithms and other server-initiated strategies to determine their net effect on setpoint at time0. For example, if one algorithm has increased setpoint at time0 by 2 degrees as a short-term energy savings measure, but another algorithm has decreased the setpoint by one degree to compensate for expected subjective reactions to weather conditions, the net algorithmic effect sC is +1 degree.

[0142] In step 1712, the server calculates the value for M, where M is equal to the difference between actual setpoints dA, less the difference between scheduled setpoints dS, less the aggregate of algorithmic change sC.

[0143] In step 1714 the server evaluates this difference. If the difference equals zero, the server concludes that no manual override has occurred, and the routine terminates. But if the difference is any value other than zero, then the server concludes that a manual override has occurred. Thus in step 1716 the server logs the

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occurrence and magnitude of the override to one or more databases in overall database structure 300.

[0144] The process of interpreting a manual override is shown in **Figure 18**. Step 1802 is the detection of an override, as described in detail in **Figure 17**. In step 1804 the server retrieves the stored rules for the subject thermostat 108. Such rules may include weather and time-related inferences such as "if outside temperature is greater than 85 degrees and inside temperature is more than 2 degrees above setpoint and manual override lowers setpoint by 3 or more degrees, then revert to original setpoint in 2 hours," or "if heating setpoint change is scheduled from "away" to "home" within 2 hours after detected override, and override increases setpoint by at least 2 degrees, then change to "home" setting," or the like.

[0145] In step 1806 the server retrieves contextual data required to interpret the manual override. Such data may include current and recent weather conditions, current and recent inside temperatures, etc. This data is helpful because it is likely that manual overrides are at least in part deterministic: that is, that they may often be explained by such contextual data, and that such understanding can permit anticipation of the desire on the part of the occupants to override and to adjust programming accordingly, so as to anticipate and obviate the need for such changes. The amount of data may be for a period of a few hours to as long as several days or more. Recent data may be more heavily weighted than older data in order to assure rapid adaptation to situations in which manual overrides represent stable changes such as changes in work schedules, etc.

[0146] In step 1808 the server retrieves any relevant override data from the period preceding the specific override being evaluated that has not yet been evaluated by and incorporated into the long-term programming and rules engines as described below in **Figure 19**. In step 1810 the server evaluates the override and determines which rule, if any, should be applied as a result of the override.

[0147] In step 1812 the server determines whether to alter the current setpoint as a result of applying the rules in step 1810. If no setpoint change is indicated, then the routine ends. If a setpoint change is indicated, then in step 1814 the server transmits the setpoint change to the thermostat for execution in the home, and in

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step 1816 it records that change to one or more databases in overall database structure 300.

[0148] In order to ensure that both the stored rules for interpreting manual overrides and the programming itself continue to most accurately reflect the intentions of the occupants, the server will periodically review both the rules used to interpret overrides and the setpoint scheduling employed. **Figure 19** shows the steps used to incorporate manual overrides into the long-term rules and setpoint schedule. In step 1902 the server retrieves the stored programming for a given thermostat as well as the rules for interpreting overrides for that thermostat.

[0149] In step 1904 the server retrieves the recent override data as recorded in **Figures 17** and **18** to be evaluated for possible revisions to the rules and the programming. In step 1906 the server retrieves the contextual data regarding overrides retrieved in step 1904 (Because the process illustrated in **Figure 19** is not presently expected to be executed as a real-time process, and is expected to be run anywhere from once per day to once per month, the range and volume of contextual data to be evaluated is likely to be greater than in the process illustrated in **Figure 18**.

[0150] In step 1908 the server interprets the overrides in light of the existing programming schedule, rules for overrides, contextual data, etc. In step 1910 the server determines whether, as a result of those overrides as interpreted, the rules for interpreting manual overrides should be revised. If the rules are not to be revised, the server moves to step 1914. If the rules are to be revised, then in step 1912 the server revises the rules and the new rules are stored in one or more databases in overall database structure 300.

[0151] In step 1914 the server determines whether any changes to the baseline programming for the thermostat should be revised. If not, the routine terminates. If revisions are warranted, then in step 1916 the server retrieves from database 900 the permissions the server has to make autonomous changes to settings. If the server has been given permission to make the proposed changes, then in step 1918 the server revises the thermostat's programming and writes the changes to one or more databases in overall database structure 300.

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[0152] If the server has not been authorized to make such changes autonomously, then in step 1920 the server transmits the recommendation to change settings to the customer in the manner previously specified by the customer, such as email, text message, personalized website, etc.

[0153] Additional means of implementing an embodiment of the instant invention may be achieved using variations in system architecture. For example, much or even all of the work being accomplished by remote server 106 may also be done by thermostat 108 if that device has sufficient processing capabilities, memory, etc. Alternatively, these steps may be undertaken by a local processor such as a local personal computer, or by a dedicated appliance having the requisite capabilities, such as gateway 112.

[0154] An additional way in which an embodiment of the instant invention can reduce energy consumption with minimal impact on comfort is to vary the turn-on delay enforced by the thermostat after the compressor is turned off. Compressor delay is usually used to protect compressors from rapid cycling, which can physically damage them.

[0155] The ability to predict the rate of change in inside temperature in a given house under varying conditions may also be applied to permit calculation of the effect of different compressor delay settings on inside temperatures, HVAC cycling and energy consumption.

[0156] **Figure 20** shows a flowchart illustrating the steps required to initiate a compressor delay adjustment event. In step 2002, server 106 retrieves parameters such as weather conditions, the current price per kilowatt-hour of electricity, and the state of the electric grid in terms of supply versus demand for the geographic area that includes a given home. In step 2004 server 106 determines whether to instantiate the compressor delay adjustment program for a certain group of homes in response to those conditions.

[0157] In step 2006, server 106 determines whether a specific home is subscribed to participate in compressor delay events. If a given home is eligible, then in step 2008 the server retrieves the parameters needed to specify the compressor delay routine for that home. These may include user preferences, such as the weather,

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time of day and other conditions under which the homeowner has elected to permit hysteresis band changes, the maximum length of compressor delay authorized, etc.

[0158] In step 2010 the appropriate compressor delay settings are determined, and in step 2012 the chosen settings are communicated to the thermostat. In step 2014 the server determines if additional thermostats in the given group must still be evaluated. If so, the server returns to step 2006 and repeats the subsequent steps with the next thermostat. If not, the routine ends.

[0159] **Figures 21(a)** through **21(c)** illustrate how changes in compressor delay settings affect HVAC cycling behavior by plotting time against temperature. In **Figure 21(a)**, time is shown on the horizontal axis 2102, and temperature is shown on vertical axis 2104. The setpoint for thermostat 108 is 70 degrees F, which results in the cycling behavior shown for inside temperature 2106. Because compressor delay CD1 2108 is, at approximately 3 minutes, shorter than the natural duration of a compressor off cycle Off1 2110 at approximately 6 minutes for this particular house under the illustrated conditions, the compressor delay has no effect on the operation of the HVAC system.

[0160] Because the hysteresis band operates to so as to maintain the temperature within a range of plus or minus one degree of the setpoint, in the case of air conditioning the air conditioner will switch on when the inside temperature reaches 71 degrees, continue operating until it reaches 69 degrees, then shut off. The system will then remain off until it reaches 71 degrees again, at which time it will again switch on. The percentage of time during which inside temperature is above or below the setpoint will depend on conditions and the dynamic signature of the individual, home. Under the conditions illustrated, the average inside temperature AT1 2112 is roughly equal to the setpoint of 70 degrees.

[0161] **Figure 21(b)** shows how with the same environmental conditions as in **Figure 21(a)**, the cycling behavior of the inside temperature changes when the compressor delay is longer than the natural compressor off cycle Off1 2110. Extended compressor delay CD2 2114 allows inside temperature 2116 to climb above the range normally enforced by the hysteresis band. Because CD2 is roughly 8 minutes, under the given conditions the inside temperature climbs to approximately 72 degrees before

the compressor delay allows the air conditioner to restart and drive the inside temperature back down. But as before, the air conditioner shuts off when the inside temperature reaches 69 degrees. Thus the average temperature is increased from AT1 2112 to AT2 2118. This change will save energy and reduce cycling because it takes less energy to maintain a higher inside temperature with an air conditioner. However, the setpoint reported by the display of the thermostat will continue to be the occupant's chosen setpoint of 70 degrees.

[0162] **Figure 21(c)** shows how the same compressor delay can result in different thermal cycling with different weather conditions. The greater the amount by which outside temperature exceeds inside temperature in the air conditioning context, the more rapidly the inside temperature will increase during an off cycle, and the slower the air conditioner will be able to cool during the on cycle. Thus as compared to **Figure 21(b)**, when the inside temperature increased to roughly 72 degrees during the extended compressor delay of 8 minutes, a higher outside temperature will cause the inside temperature to increase faster, which results in a peak temperature of roughly 73 degrees, and in wider temperature cycling 2120. The average inside temperature consequently increases from AT(2) 2118 to AT(3) 2122.

[0163] It should be noted that the shape of the actual waveform will most likely not be sinusoidal, but for ease of illustration it is sometimes be presented as such in the figures.

[0164] Residential air conditioning is a major component of peak load. The traditional approach to dealing with high demand on hot days is to increase supply – build new powerplants, or buy additional capacity on the spot market. But because reducing loads has come to be considered by many to be a superior strategy for matching electricity supply to demand when the grid is stressed, the ability to shed load by turning off air conditioners during peak events has become a useful tool for managing loads. A key component of any such system is the ability to document and verify that a given air conditioner has actually turned off. Data logging hardware can accomplish this, but due to the cost is usually only deployed for statistical sampling. An embodiment of the instant invention provides a means to verify demand response without additional hardware such as a data logger.

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[0165] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature. Because the server will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures. This will permit remote verification of load shedding by the air conditioner without directly measuring or recording the electrical load drawn by the air conditioner.

[0166] **Figure 22** shows the steps followed in order to initiate air conditioner shutoff. When a summer peak demand situation occurs, the utility will transmit an email 2202 or other signal to server 106 requesting a reduction in load. Server 106 will determine 2204 if the user's house is served by the utility seeking reduction; determine 2206 if a given user has agreed to reduce peak demand; and determine 2208 if a reduction of consumption by the user is required or desirable in order to achieve the reduction in demand requested by the utility. The server will transmit 2210 a signal to the user's thermostat 108 signaling the thermostat to shut off the air conditioner 110.

[0167] **Figure 23** shows the steps followed in order to verify that the air conditioner has in fact been shut off. Server 106 will receive and monitor 2302 the temperature readings sent by the user's thermostat 108. The server then calculates 2304 the temperature reading to be expected for that thermostat given inputs such as current and recent outside temperature, recent inside temperature readings, the calculated thermal mass of the structure, temperature readings in other houses, etc. The server will compare 2306 the predicted reading with the actual reading. If the server determines that the temperature inside the house is rising at the rate predicted if the air conditioning is shut off, then the server confirms 2308 that the air conditioning has been shut off. If the temperature reading from the thermostat shows no increase, or significantly less increase than predicted by the model, then the server concludes

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2310 that the air conditioning was not switched off, and that no contribution to the demand response request was made.

[0168] For example, assume that on at 3PM on date Y utility X wishes to trigger a demand reduction event. A server at utility X transmits a message to the server at demand reduction service provider Z requesting W megawatts of demand reduction. The demand reduction service provider server determines that it will turn off the air conditioner at house A in order to achieve the required demand reduction. At the time the event is triggered, the inside temperature as reported by the thermostat in house A is 72 degrees F. The outside temperature near house A is 96 degrees Fahrenheit. The inside temperature at House B, which is not part of the demand reduction program, but is both connected to the demand reduction service server and located geographically proximate to House A, is 74F. Because the air conditioner in house A has been turned off, the temperature inside House A begins to rise, so that at 4PM it has increased to 79F. Because the server is aware of the outside temperature, which remains at 96F, and of the rate of temperature rise inside house A on previous days on which temperatures have been at or near 96F, and the temperature in house B, which has risen only to 75F because the air conditioning in house B continues to operate normally, the server is able to confirm with a high degree of certainty that the air conditioner in house A has indeed been shut off.

[0169] In contrast, if the HVAC system at house A has been tampered with, so that a demand reduction signal from the server does not actually result in shutting off the air conditioner in house A, when the server compares the rate of temperature change at house A against the other data points, the server will receive data inconsistent with the rate of increase predicted. As a result, it will conclude that the air conditioner has not been shut off in house A as expected, and may not credit house A with the financial credit that would be associated with demand reduction compliance, or may trigger a business process that could result in termination of house A's participation in the demand reduction program.

[0170] **Figure 24** illustrates the movement of signals and information between the components of one embodiment of the subject invention to trigger and verify a demand reduction response. Where demand response events are undertaken on

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behalf of a utility by a third party, participants in the communications may include electric utility server 2400, demand reduction service server 106, and thermostat 108. In step 2402 the electric utility server 2400 transmits a message to demand reduction service server 106 requesting a demand reduction of a specified duration and size. Demand reduction service server 106 uses database 300 to determine which subscribers should be included in the demand reduction event. For each included subscriber, the server then sends a signal 2404 to the subscriber's thermostat 108 instructing it (a) to shut down at the appropriate time or (b) to allow the temperature as measured by the thermostat to increase to a certain temperature at the specified time, depending upon the agreement between the homeowner and the utility and/or demand reduction aggregator.

[0171] The server then receives 2406 temperature signals from the subscriber's thermostat. At the conclusion of the demand reduction event, the server transmits a signal 2408 to the thermostat permitting the thermostat to signal its attached HVAC system to resume cooling, if the system has been shut off, or to reduce the target temperature to its pre-demand reduction setting, if the target temperature was merely increased. If thermostat 108 is capable of storing scheduling information, these instructions may be transmitted prior to the time they are to be executed and stored locally. After determining the total number of subscribers actually participating in the DR event, the server then calculates the total demand reduction achieved and sends a message 2410 to the electric utility confirming such reduction.

[0172] Additional steps may be included in the process. For example, if the subscriber has previously requested that notice be provided when a peak demand reduction event occurs, the server will also send an alert, which may be in the form of an email or text message or an update to the personalized web page for that user, or both. If the server determines that a given home has (or has not) complied with the terms of its demand reduction agreement, the server may send a message to the subscriber confirming that fact.

[0173] It should also be noted that in some climate zones, peak demand events occur during extreme cold weather rather than (or in addition to) during hot

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weather. The same process as discussed above could be employed to reduce demand by shutting off electric heaters and monitoring the rate at which temperatures fall.

[0174] It should also be noted that the peak demand reduction service can be performed directly by an electric utility, so that the functions of server 106 can be combined with the functions of server 2400.

[0175] The system installed in a subscriber's home may optionally include additional temperature sensors at different locations within the building. These additional sensors may we connected to the rest of the system via a wireless system such as 802.11 or 802.15.4, or may be connected via wires. Additional temperature and/or humidity sensors may allow increased accuracy of the system, which can in turn increase user comfort, energy savings or both.

[0176] The bi-directional communication between server 106 and thermostat 108 will also allow thermostat 108 to regularly measure and send to server 106 information about the temperature in the building. By comparing outside temperature, inside temperature, thermostat settings, cycling behavior of the HVAC system, and other variables, the system will be capable of numerous diagnostic and controlling functions beyond those of a standard thermostat.

[0177] For example, **Figure 25a** shows a graph of inside temperature and outside temperature for a 24-hour period in House A, assuming no HVAC activity. House A has double-glazed windows and is well-insulated. When outside temperature 2502 increases, inside temperature 2504 follows, but with significant delay because of the thermal mass of the building.

[0178] **Figure 25b** shows a graph of inside temperature and outside temperature for the same 24-hour period in House B. House B is identical to House A except that it (i) is located a block away and (ii) has single-glazed windows and is poorly insulated. Because the two houses are so close to each other, outside temperature 2502 is the same in **Figure 25a** and **Figure 25b**. But the lower thermal mass of House B means that the rate at which the inside temperature 2506 changes in response to the changes in outside temperature is much greater.

[0179] The differences in thermal mass will affect the cycling behavior of the HVAC systems in the two houses as well. **Figure 26a** shows a graph of inside

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temperature and outside temperature in House A for the same 24-hour period as shown in **Figure 6a**, but assuming that the air conditioning is being used to try to maintain an internal temperature of 70 degrees. Outside temperatures 2502 are the same as in **Figures 25a** and **25b**. Inside temperature 2608 is maintained within the range determined by thermostat 108 by the cycling of the air conditioner. Because of the high thermal mass of the house, the air conditioning does not need to run for very long to maintain the target temperature, as shown by shaded areas 2610.

[0180] **Figure 26b** shows a graph of inside temperature 2612 and outside temperature 2502 for the same 24-hour period in House B, assuming use of the air conditioning as in **Figure 26a**. Because of the lower thermal mass of House B, the air conditioning system in House B has to run longer in order to maintain the same target temperature range, as shown by shaded areas 2614.

[0181] Because server 106 logs the temperature readings from inside each house (whether once per minute or over some other interval), as well as the timing and duration of air conditioning cycles, database 300 will contain a history of the thermal performance of each house. That performance data will allow the server 106 to calculate an effective thermal mass for each such structure – that is, the speed with the temperature inside a given building will change in response to changes in outside temperature and differences between inside and outside temperatures. Because the server 106 will also log these inputs against other inputs including time of day, humidity, etc. the server will be able to predict, at any given time on any given day, the rate at which inside temperature should change for given inside and outside temperatures.

[0182] The server will also record the responses of each house to changes in outside conditions and cycling behavior over time. That will allow the server to diagnose problems as and when they develop. For example, **Figure 27a** shows a graph of outside temperature 2702, inside temperature 2704 and HVAC cycle times 2706 in House A for a specific 24-hour period on date X. Assume that, based upon comparison of the performance of House A on date X relative to House A's historical performance, and in comparison to the performance of House A relative to other nearby houses on date X, the HVAC system in House A is presumed to be operating at normal

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efficiency, and that House A is in the 86th percentile as compared to those other houses.

[0183] **Figure 27b** shows a graph of outside temperature 2708, inside temperature 2710 and HVAC cycle times 2712 in House A for the 24-hour period on date X+1. House A's HVAC system now requires significantly longer cycle times in order to try to maintain the same internal temperature. If those longer cycle times were due to higher outside temperatures, those cycle times would not indicate the existence of any problems. But because server 106 is aware of the outside temperature, the system can eliminate that possibility as an explanation for the higher cycle times.

[0184] Because server 106 is aware of the cycle times in nearby houses, it can determine that, for example, on date X+1 the efficiency of House A is only in the 23rd percentile. The server will be programmed with a series of heuristics, gathered from predictive models and past experience, correlating the drop in efficiency and the time interval over which it has occurred with different possible causes. For example, a 50% drop in efficiency in one day may be correlated with a refrigerant leak, especially if followed by a further drop in efficiency on the following day. A reduction of 10% over three months may be correlated with a clogged filter. Based upon the historical data recorded by the server, the server 106 will be able to alert the homeowner that there is a problem and suggest a possible cause.

[0185] Because the system will be able to calculate effective thermal mass, it will be able to determine the cost effectiveness of strategies such as pre-cooling for specific houses under different conditions. **Figure 28a** shows a graph of outside temperature 2802, inside temperature 2804 and HVAC cycling times 2806 in House A for a specific 24-hour period on date Y assuming that the system has used a pre-cooling strategy to avoid running the air conditioning during the afternoon, when rates are highest. Because House A has high thermal mass, the house is capable of "banking" cooling, and energy consumed during off-peak hours is in effect stored, allowing the house to remain cool even when the system is turned off. Temperatures keep rising during the period the air conditioning is off, but because thermal mass is high, the rate of increase is low, and the house is still comfortable six hours later.

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[0186] Although the pre-cooling cycle time in a given home may be relatively long, the homeowner may still benefit if the price per kilowatt during the morning pre-cooling phase is lower than the price during the peak load period. **Figure 28b** shows a graph of the same outside temperature 2802 in House B as in House A in **Figure 28a** for the same 24-hour period and using the same pre-cooling strategy as shown by cycling times 2806. But because House B has minimal thermal mass, using additional electricity in order to pre-cool the house does not have the desired effect; inside temperature 2808 warms up so fast that the cooling that had been banked is quickly lost. Thus the system will recommend that House A pre-cool in order to save money, but not recommend pre-cooling for House B.

[0187] The system can also help compensate for anomalies such as measurement inaccuracies due to factors such as poor thermostat location. It is well known that thermostats should be placed in a location that will be likely to experience "average" temperatures for the overall structure, and should be isolated from windows and other influences that could bias the temperatures they "see." But for various reasons, not all thermostat installations fit that ideal. **Figure 29a** shows a graph of outside temperature 2902, the actual average inside temperature for the entire house 2904, and inside temperature as read by the thermostat 2906 in House C for a specific 24-hour period on September 15th, assuming that the thermostat is located so that for part of the afternoon on that day the thermostat is in direct sunlight.

[0188] Until the point at which the sun hits the thermostat, the average inside temperature and temperature as read by the thermostat track very closely. But when the direct sunlight hits the thermostat, the thermostat and the surrounding area can heat up, causing the internal temperature as read by the thermostat to diverge significantly from the average temperature for the rest of the house. A conventional thermostat has no way of distinguishing this circumstance from a genuinely hot day, and will both over-cool the rest of the house and waste considerable energy when it cycles the air conditioner in order to reduce the temperature as sensed by the thermostat.

[0189] If the air conditioning is turned off, this phenomenon will manifest as a spike in temperature as measured by the thermostat. If the air conditioning is turned on

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(and has sufficient capacity to respond to the distorted temperature signal caused by the sunlight), this phenomenon will likely manifest as relatively small changes in the temperature as sensed by the thermostat, but significantly increased HVAC usage (as well as excessively lowered temperatures in the rest of the house, but this result may not be directly measured in a single sensor environment).

[0190] An embodiment of the system, in contrast, has multiple mechanisms that will allow it to correct for such distortions. First, because an embodiment of the subject system compares the internal readings from House C with the external temperature, it will be obvious that the rise in temperature at 4:00PM is not correlated with a corresponding change in outside temperature. Second, because the system is also monitoring the readings from the thermostat in nearby House D, which (as shown in **Figure 29b**) is exposed to the same outside temperature 602, but has no sudden rise in measured internal afternoon temperature 2908, the system has further validation that the temperature increase is not caused by climatic conditions. And finally, because the system has monitored and recorded the temperature readings from the thermostat in House C for each previous day, and has compared the changing times of the aberration with the progression of the sun, the system can distinguish the patterns likely to indicate solar overheating from other potential causes.

[0191] **Figure 30** illustrates the steps involved in calculating comparative thermal mass, or the thermal mass index. In step 3002, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3004, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0192] In step 3006, the server retrieves data regarding recent temperature readings as recorded by the thermostat in home X. In step 3008, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its

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address, make, model and age of its furnace and air conditioning hardware, and other data.

[0193] In step 3010, the server retrieves the current inside temperature reading as transmitted by the thermostat. In step 3012, the server calculates the thermal mass index for the home under those conditions; that is, for example, it calculates the likely rate of change for internal temperature in home X from a starting point of 70 degrees when the outside temperature is 85 degrees at 3:00PM on August 10th when the wind is blowing at 5 mph from the north and the sky is cloudy. The server accomplishes this by applying a basic algorithm that weighs each of these external variables as well as variables for various characteristics of the home itself (such as size, level of insulation, method of construction, etc.) and data from other houses and environments.

[0194] **Figure 31** illustrates the steps involved in diagnosing defects in the HVAC system for specific home X. In step 3102, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3104, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0195] In step 3106, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3108, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data. In step 3110, the server retrieves comparative data from other houses that have thermostats that also report to the server.

[0196] Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses. In step 3112, the server

Ex. 1006.0369

calculates the current relative efficiency of home X as compared to other homes. Those comparisons will take into account differences in size, location, age, etc in making those comparisons.

[0197] The server will also take into account that comparative efficiency is not absolute, but will vary depending on conditions. For example, a house that has extensive south-facing windows is likely to experience significant solar gain. On sunny winter days, that home will appear more efficient than on cloudy winter days. That same house will appear more efficient at times of day and year when trees or overhangs shade those windows than it will when summer sun reaches those windows. Thus the server will calculate efficiency under varying conditions.

[0198] In step 3114 the server compares the HVAC system's efficiency, corrected for the relevant conditions, to its efficiency in the past. If the current efficiency is substantially the same as the historical efficiency, the server concludes 3116 that there is no defect and the diagnostic routine ends. If the efficiency has changed, the server proceeds to compare the historical and current data against patterns of changes known to indicate specific problems. For example, in step 3118, the server compares that pattern of efficiency changes against the known pattern for a clogged air filter, which is likely to show a slow, gradual degradation over a period of weeks or even months.

[0199] If the pattern of degradation matches the clogged filter paradigm, the server creates and transmits to the homeowner a message 3120 alerting the homeowner to the possible problem. If the problem does not match the clogged filter paradigm, the system compares 3122 the pattern to the known pattern for a refrigerant leak, which is likely to show a degradation over a period of a few hours to a few days. If the pattern of degradation matches the refrigerant leak paradigm, the server creates and transmits to the homeowner a message 3124 alerting the homeowner to the possible problem.

[0200] If the problem does not match the refrigerant leak paradigm, the system compares 3126 the pattern to the known pattern for an open window or door, which is likely to show significant changes for relatively short periods at intervals uncorrelated with climatic patterns. If the pattern of degradation matches the open

door/window paradigm, the server creates and transmits to the homeowner a message 3128 alerting the homeowner to the possible problem. If the problem does not match the refrigerant leak paradigm, the system continues to step through remaining know patterns N 3130 until either a pattern is matched 3132 or the list has been exhausted without a match 3134.

[0201] **Figure 32** illustrates the steps involved in diagnosing inaccurate thermostat readings due to improper location. In step 3202, the server retrieves climate data related to home X. Such data may include current outside temperature, outside temperature during the preceding hours, outside humidity, wind direction and speed, whether the sun is obscured by clouds, and other factors. In step 3204, the server retrieves HVAC duty cycle data for home X. Such data may include target settings set by the thermostat in current and previous periods, the timing of switch-on and switch-off events and other data.

[0202] In step 3206, the server retrieves data regarding current and recent temperature readings as recorded by the thermostat in home X. In step 3208, the server retrieves profile data for home X. Such data may include square footage and number of floors, when the house was built and/or renovated, the extent to which it is insulated, its address, make, model and age of its furnace and air conditioning hardware, and other data.

[0203] In step 3210, the server retrieves comparative data from other houses that have thermostats that also report to the server. Such data may include interior temperature readings, outside temperature for those specific locations, duty cycle data for the HVAC systems at those locations, profile data for the structures and HVAC systems in those houses and the calculated thermal mass index for those other houses.

[0204] In step 3212, the server calculates the expected thermostat temperature reading based upon the input data. In step 3214, the server compares the predicted and actual values. If the calculated and actual values are at least roughly equivalent, the server concludes 3216 that there is no thermostat-related anomaly. If the calculated and actual values are not roughly equivalent, the server retrieves additional historical information about past thermostat readings in step 3218.

Ex. 1006.0371

[0205] In step 3220, the server retrieves solar progression data, i.e., information regarding the times at which the sun rises and sets on the days being evaluated at the location of the house being evaluated, and the angle of the sun at that latitude, etc. In step 3222, the server compares the characteristics of the anomalies over time, to see if, for example, abnormally high readings began at 3:06 on June 5th, 3:09 on June 6th, 3:12 on June 7th, and the solar progression data suggests that at the house being analyzed, that sun would be likely to reach a given place in that house three minutes later on each of those days.

[0206] If the thermostat readings do not correlate with the solar progression data, the server concludes 3224 that the sun is not causing the distortion by directly hitting the thermostat. If the thermostat readings do correlate with solar progression, the server then calculates 3226 the predicted duration of the distortion caused by the sun.

[0207] In step 3228, the server calculates the appropriate setpoint information to be used by the thermostat to maintain the desired temperature and correct for the distortion for the expected length of the event. For example, if the uncorrected setpoint during the predicted event is 72 degrees, and the sun is expected to elevate the temperature reading by eight degrees, the server will instruct the thermostat to maintain a setpoint of 80 degrees. In step 3230, the server sends the homeowner a message describing the problem.

[0208] One or more embodiments of the invention may be used to implement additional energy savings by implementing small, repeated changes in setpoint. Because energy consumption is directly proportional to setpoint – that is, the further a given setpoint diverges from the balance point (the natural inside temperature assuming no HVAC activity) in a given house under given conditions, the higher energy consumption will be to maintain temperature at that setpoint), energy will be saved by any strategy that over a given time frame lowers the average heating setpoint or raises the cooling setpoint.

[0209] It is therefore possible to save energy by adopting a strategy that takes advantage of human insensitivity to slow temperature ramping by incorporating a user's desired setpoint within the range of the ramp, but setting the average target

temperature below the desired setpoint in the case of heating, and above it in the case of cooling. For example, a ramped summer setpoint that consisted of a repeated pattern of three phases of equal length set at 72°F, 73°F, and 74°F would create an effective average setpoint of 73°F, but would generally be experienced by occupants as yielding at least roughly equivalent comfort as in a room set at a constant 72°F. Energy savings resulting from this approach have been shown to be in the range of 4-6%.

[0210] Embodiments of the invention can automatically generate optimized ramped setpoints that could save energy without compromising the comfort of the occupants. It would also be advantageous to create a temperature control system that could incorporate adaptive algorithms that could automatically determine when the ramped setpoints should not be applied due to a variety of exogenous conditions that make application of such ramped setpoints undesirable.

[0211] **Figure 33** represents the conventional programming of a thermostat and the resulting behavior of a home's HVAC system in the air conditioning context. The morning setpoint 3302 of 74 degrees remains constant from midnight until 9:00AM, and the inside temperature 3304 varies more or less within the limits of the hysteresis band during that entire period. When the setpoint changes to 80 degrees 3306, the inside temperature 3308 varies within the hysteresis band around the new setpoint, and so on. Whether the average temperature is equal to, greater or less than the nominal setpoint will depend on weather conditions, the dynamic signature of the structure, and the efficiency and size of the HVAC system. But in most cases the average temperature will be at least roughly equivalent to the nominal setpoint.

[0212] **Figure 34** represents implementation of a three-phase ramped setpoint derived from the same user preferences as manifested by the settings shown in **Figure 33**. Thus the user-selected setpoint for the morning is still 74 degrees, and is reflected in the setpoint 3404 at the start of each three-step cycle, but because (in the air conditioning context) the setpoint requested by the user is the lowest of the three discrete steps, rather than the middle step, the average setpoint will be one degree higher 3402, and the resulting average inside temperature will be roughly one degree warmer than the average temperature without use of the ramped setpoints, thereby saving energy.

Ex. 1006.0373

[0213] In the currently preferred embodiment, the implementation of the ramped setpoints may be dynamic based upon both conditions inside the structure and other planned setpoint changes. Thus, for example, the ramped setpoints 3406, 3408 and 3410 may be timed so that the 9AM change in user-determined setpoint from 74 degrees to 80 degrees is in effect anticipated, and the period in which the air conditioner is not used can be extended prior to the scheduled start time for the less energy-intensive setpoint. Similarly, because the server 106 is aware that a lower setpoint will begin at 5PM. The timing can be adjusted to avoid excessively warm temperatures immediately prior to the scheduled setpoint change, which could cause noticeable discomfort relative to the new setpoint if the air conditioner is incapable of quickly reducing inside temperature on a given day based upon the expected slope of inside temperatures at that time 3412.

[0214] In order to implement such ramped setpoints automatically, algorithms may be created. These algorithms may be generated and/or executed as instructions on remote server 106 and the resulting setpoint changes can be transmitted to a given thermostat on a just-in-time basis or, if the thermostat 108 is capable of storing future settings, they may be transferred in batch mode to such thermostats. Basic parameters used to generate such algorithms include:

[0215] the number of discrete phases to be used;

[0216] the temperature differential associated with each phase; and

[0217] the duration of each phase

[0218] In order to increase user comfort and thus maximize consumer acceptance, additional parameters may be considered, including:

[0219] time of day

[0220] outside weather conditions

[0221] recent history of manual inputs

[0222] recent pre-programmed setpoint changes.

[0223] Time of day may be relevant because, for example, if the home is typically unoccupied at a given time, there is no need for perceptual programming. Outside weather is relevant because comfort is dependent not just on temperature as sensed by a thermostat, but also includes radiant differentials. On extremely cold days,

even if the inside dry-bulb temperature is within normal comfort range, radiant losses due to cold surfaces such as single-glazed windows can cause subjective discomfort; thus on such days occupants may be more sensitive to ramping. Recent manual inputs (e.g., programming overrides) may create situations in which exceptions should be taken; depending on the context, recent manual inputs may either suspend the ramping of setpoints or simply alter the baseline temperature from which the ramping takes place.

[0224] **Figure 35** shows the steps used in the core ramped setpoint algorithm in the context of a remotely managed thermostat system. In step 3502 the application determines whether to instantiate the algorithm based upon external scheduling criteria. In step 3504 the application running on a remote server retrieves from the thermostat the data generated by or entered into the thermostat, including current temperature settings, HVAC status and inside temperature. The algorithm performs preliminary logical tests at that point to determine whether further processing is required. For example, in the heating context, if the inside temperature as reported by the thermostat 108 is more than 1 degree higher than the current setpoint, the algorithm may determine that running the ramped setpoint program will have no effect and therefore terminate.

[0225] In step 3506 the algorithm advances to the next phase from the most recent phase; i.e., if the algorithm is just starting, the phase changes from "0" to "1"; if it has just completed the third phase of a three-phase ramp, the phase will change from "2" to "0". In step 3508 the application determines if the current phase is "0". If it is, then in step 3510 the algorithm determines whether current setpoint equals the setpoint in the previous phase. If so, which implies no manual overrides or other setpoint adjustments have occurred during the most recent phase, then in step 3512 the algorithm sets the new setpoint back to the previous phase "0" setpoint. If not, then in step 3514, the algorithm keeps the current temperature setting as setpoint for this new phase. In step 3516, the algorithm logs the resulting new setpoint as the new phase "0" setpoint for use in subsequent phases.

[0226] Returning to the branch after step 3508, if the current phase at that point is not phase "0", then in step 3520, the algorithm determines whether the current

setpoint is equal to the setpoint temperature in the previous phase. If not, which implies setpoints have been adjusted by the house occupants, thermostat schedules, or other events, then in step 3522, the application resets the phase to "0", resets the new setpoint associated with phase "0" to equal the current temperature setting, and sets the current setting to that temperature. Alternatively, if the current temperature setting as determined in step 3520 is equal to the setpoint in the previous phase, then in step 3524 new setpoint is made to equal current setpoint plus the differential associated with each phase change. In step 3526 the "previous-phase setpoint" variable is reset to equal the new setpoint in anticipation of its use during a subsequent iteration.

[0227] **Figure 36** shows one embodiment of the overall control application implementing the algorithm described in **Figure 35**. In step 3602, the control application retrieves the current setting from the thermostat. In step 3604, the setting is logged in database 300. In step 3606, the control program determines whether other algorithms that have higher precedence than the ramped setpoint algorithm are to be run. If another algorithm is to be run prior to the ramped setpoint algorithm, then the other program is executed in step 3608. If there are no alternate algorithms that should precede the ramped setpoint application then in step 1310, the control program determines whether the thermostat has been assigned to execute the ramped setpoint program. If not, the control program skips the remaining actions in the current iteration. If the program is set to run, then in step 3612 the algorithm retrieves from database 300 the rules and parameters governing the implementation of the algorithm for the current application of the program.

[0228] In step 3614, the algorithm determines whether one or more conditions that preclude application of the algorithm, such as extreme outside weather conditions, whether the home is likely to be occupied, etc. If any of the exclusionary conditions apply, the application skips execution of the ramped setpoint algorithm for the current iteration. If not, the application proceeds to step 3616 in which the application determines whether the setpoint has been altered by manual overrides, thermostat setback schedule changes, or other algorithms as compared to the previous value as stored in database 300. If setpoint has been altered, the application proceeds to step 3620 discussed below.

Ex. 1006.0376

[0229] In step 3618, the program described in **Figure 35** is executed. In step 3620, the application resets the phase to "0". Certain temperature setting variables are reset in anticipation of their use in subsequent phases. These variables include the new phase 0 temperature setting which is anchored to the current actual temperature setting, and the new previous-phase setpoint which will be used for identifying setpoint overrides in the subsequent phase.

[0230] In step 3622, the system records the changes to the thermostat settings to database 300. In step 3624, the system records the changes to the phase status of the algorithm to database 300. In step 3626, the application determines whether the new temperature setting differs from the current setting. If they are the same, the application skips applying changes to the thermostat. If they are different, then in step 3628, the application transmits revised settings to the thermostat. In step 3630, the application then hibernates for the specified duration until it is invoked again by beginning at step 3602 again.

[0231] An embodiment of the subject invention may also be used to detect occupancy through the use of software related to electronic devices located inside the conditioned structure, such as the browser running on computer or other device 104. **Figure 37** represents the screen of a computer or other device 104 using a graphical user interface connected to the Internet. The screen shows that a browser 3700 is displayed on computer 104. In one embodiment, a background application installed on computer 104 detects activity by a user of the computer, such as cursor movement, keystrokes or otherwise, and signals the application running on server 106 that activity has been detected. Server 106 may then, depending on context, (a) transmit a signal to thermostat 108 changing setpoint because occupancy has been detected at a time when the system did not expect occupancy; (b) signal the background application running on computer 104 to trigger a software routine that instantiates a pop-up window 3702 that asks the user if the server should change the current setpoint, alter the overall programming of the system based upon a new occupancy pattern, etc. The user can respond by clicking the cursor on "yes" button 3704 or "No" button 3706. Equilvalent means of signalling activity may be employed with interactive television programming, gaming systems, etc.

Ex. 1006.0377

[0232] **Figure 38** is a flowchart showing the steps involved in the operation of one embodiment of the subject invention. In step 3802, computer 104 transmits a message to server 106 via the Internet indicating that there is user activity on computer 104. This activity can be in the form of keystrokes, cursor movement, input via a television remote control, etc. In step 3804 the application queries database 300 to retrieve setting information for the HVAC system. In step 3806 the application determines whether the current HVAC program is intended to apply when the home is occupied or unoccupied.

[0233] If the HVAC settings then in effect are intended to apply for an occupied home, then the application terminates for a specified interval. If the HVAC settings then in effect are intended to apply when the home is unoccupied, then in step 3808 the application will retrieve from database 300 the user's specific preferences for how to handle this situation. If the user has previously specified (at the time that the program was initially set up or subsequently modified) that the user prefers that the system automatically change settings under such circumstances, the application then proceeds to step 3816, in which it changes the programmed setpoint for the thermostat to the setting intended for the house when occupied. If the user has previously specified that the application should not make such changes without further user input, then in step 3810 the application transmits a command to computer 104 directing the browser to display a message informing the user that the current setting assumes an unoccupied house and asking the user in step 3812 to choose whether to either keep the current settings or revert to the pre-selected setting for an occupied home. If the user selects to retain the current setting, then in step 3814 the application will write to database 300 the fact that the users has so elected and terminate. If the user elects to change the setting, then in step 3816 the application transmits the revised setpoint to the thermostat. In step 3814 the application writes the updated setting information to database 300.

[0234] **Figure 39** is a flowchart that shows how an embodiment of the invention can be used to select different HVAC settings based upon its ability to identify which of multiple potential occupants is using the computer attached to the system. In step 3902 computer 104 transmits to server 106 information regarding the type of

Ex. 1006.0378

activity detected on computer 104. Such information could include the specific program or channel being watched if, for example, computer 104 is used to watch television. The information matching, for example, TV channel 7 at 4:00 PM on a given date to specific content may be made by referring to Internet-based or other widely available scheduling sources for such content. In step 3904 server 106 retrieves from database 300 previously logged data regarding viewed programs. In step 3906 server 106 retrieves previously stored data regarding the residents of the house.

[0235] For example, upon initiating the service, one or more users may have filled out online questionnaires sharing their age, gender, schedules, viewing preferences, etc. In step 3908, server 106 compares the received information about user activity to previously stored information retrieved from database 300 about the occupants and their viewing preferences. For example, if computer 104 indicates to server 106 that the computer is being used to watch golf, the server may conclude that an adult male is watching; if computer 104 indicates that it is being used to watch children's programming, server 106 may conclude that a child is watching.

[0236] In step 3910 the server transmits a query to the user in order to verify the match, asking, in effect, "Is that you Bob?" In step 3912, based upon the user's response, the application determines whether the correct user has been identified. If the answer is no, then the application proceeds to step 3916. If the answer is yes, then in step 3914 the application retrieves the temperature settings for the identified occupant. In step 3916 the application writes to database 300 the programming information and information regarding matching of users to that programming.

[0237] In an alternative embodiment, the application running on computer 104 may respond to general user inputs (that is, inputs not specifically intended to instantiate communication with the remote server) by querying the user whether a given action should be taken. For example, in a system in which the computer 104 is a web-enabled television or web-enabled set-top device connected to a television as a display, software running on computer 104 detects user activity, and transmits a message indicating such activity to server 106. The trigger for this signal may be general, such as changing channels or adjusting volume with the remote control or a power-on event. Upon receipt by server 106 of this trigger, server 106 transmits instructions to computer

Ex. 1006.0379

104 causing it to display a dialog box asking the user whether the user wishes to change HVAC settings.

[0238] Additional functionality is also envisioned as part of different embodiments of the invention. For example, information from historic data may be used to predict how long it will take a user to reach home from the current coordinates, and the estimated arrival time may be used to calculate optimal cycling strategies for the HVAC system. In addition, information about traffic conditions may be integrated into these calculations, so that the geospatial data relative to mobile device 105 may indicate that a user is taking his or her normal route, but because of a traffic jam, is likely to come home later than would otherwise be expected. The characteristics of a given location may be used to infer arrival times as well. For example, if the geospatial data indicates that the user of mobile device 105 has arrived at the supermarket on his way home, a delay of 20 minutes is likely, whereas if the user has parked at a restaurant, the delay is likely to be one hour.

[0239] It is also possible to incorporate more sophisticated heuristics in incorporating the varying preferences of multiple occupants of a given home or other structure. For example, rules can be structured so that User #1's preferences control during the heating season, but not during the cooling season; User #2's preferences might control during certain times of the day but not others; User #3's preferences amy take precedence whenever they result in a more energy efficient strategy, but not when they result in increased energy use, and so on.

[0240] While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, that the invention may be carried out in other ways without departing from the true spirit and scope. These and other equivalents are intended to be covered by the following claims:

Ex. 1006.0380

WHAT IS CLAIMED IS:

1. A method for varying temperature setpoints for an HVAC system comprising:

accessing stored data comprising a plurality of internal temperature measurements taken within a structure and a plurality of outside temperature measurements relating to temperatures outside the structure;

using the stored data to predict a temperature inside the structure in response to at least changes in the outside temperatures;

determining with one or more computer processors, the geographic location of a mobile electronic device that is connected to a network;

associating said mobile electronic device to a structure having a known geographic location that contains one or more networked climate control devices;

determining with one or more computer processors, whether the location of said mobile electronic device indicates occupancy of said structure by a person associated with said mobile electronic device;

using route data to determine whether a user of the mobile electronic device is traveling to said structure;

using traffic data to predict a length of time for a user of said mobile device to reach said structure; and

adjusting with one or more computer processors, the temperature setpoint on said controller for an HVAC system for said structure based upon said predicted length of time for a user of the mobile device to reach said structure, said predicted temperature inside said structure, and whether or not said structure is deemed to be occupied.

Ex. 1006.0381

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

ABSTRACT OF THE DISCLOSURE

Embodiments of the invention comprise systems and methods for using the geographic location of networked consumer electronics devices as indications of occupancy of a structure for purposes of automatically adjusting the temperature setpoint on a thermostatic HVAC control. At least one thermostat is located inside a structure and is used to control an HVAC system in the structure. At least one mobile electronic device is used to indicate the state of occupancy of the structure. The state of occupancy is used to alter the setpoint on the thermostatic HVAC control to reduce unneeded conditioning of unoccupied spaces.

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Ex. 1006.0382

Electronic Patent Application Fee Transmittal

Application Number:	14491554
Filing Date:	19-Sep-2014
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Filer:	John R. King/Amy Durrant
Attorney Docket Number:	EFACT.012C2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension - 4 months with $0 paid	2254	1	1100	1100
Miscellaneous:				
		Total in USD ($)		**1100**

Electronic Acknowledgement Receipt

EFS ID:	21628115
Application Number:	14491554
International Application Number:	
Confirmation Number:	1254
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Customer Number:	20995
Filer:	John R. King/Kevin Kraus
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Attorney Docket Number:	EFACT.012C2
Receipt Date:	27-FEB-2015
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Payment was successfully received in RAM	$1100
RAM confirmation Number	5770
Deposit Account	111410
Authorized User	KNOBBE MARTENS OLSON AND BEAR

The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows:

Charge any Additional Fees required under 37 C.F.R. Section 1.16 (National application filing, search, and examination fees)

Charge any Additional Fees required under 37 C.F.R. Section 1.17 (Patent application and reexamination processing fees)

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		EFACT-012C2_response.pdf	63443 e4f84e4555bed5f972964b152b5bcbb087ea043f	yes	4

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Applicant Response to Pre-Exam Formalities Notice	1	1
	Specification	2	2
	Claims	3	3
	Applicant Arguments/Remarks Made in an Amendment	4	4

Warnings:

Information:

2		EFACT-012C2_cleanspec.pdf	3118319 542f929874553a45b635d73101a985a1c3024044	yes	54

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Specification	1	52
	Claims	53	53
	Abstract	54	54

Warnings:

Information:

3	Applicant Arguments/Remarks Made in an Amendment	EFACT-012C2_markedupspec.pdf	3124643 adca0bd7822f188098f2f18ac8e0d334cb4a8fa4	no	54

Warnings:

Information:

4	Fee Worksheet (SB06)	fee-info.pdf	30740 3fddae539e3de54d8f0c558acd290ebfa773ad63	no	2
Warnings:					
Information:					
			Total Files Size (in bytes):	6337145	

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

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If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number: 14/491,554

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY FEE($)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	70		N/A	
SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	300		N/A	
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	360		N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*	x 40 =	0.00	OR		
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*	x 210 =	0.00			
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			0.00			
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				0.00			
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	730		TOTAL	

APPLICATION AS AMENDED - PART II

AMENDMENT A

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	SMALL ENTITY RATE($)	SMALL ENTITY ADDITIONAL FEE($)	OR	OTHER THAN SMALL ENTITY RATE($)	OTHER THAN SMALL ENTITY ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

AMENDMENT B

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE($)	ADDITIONAL FEE($)	OR	RATE($)	ADDITIONAL FEE($)
Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
Application Size Fee (37 CFR 1.16(s))									
FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY.DOCKET.NO	TOT CLAIMS	IND CLAIMS
14/491,554	09/19/2014	3744	800	EFACT.012C2	20	2

CONFIRMATION NO. 1254

UPDATED FILING RECEIPT

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

OC000000073848591

Date Mailed: 03/10/2015

Receipt is acknowledged of this non-provisional patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF APPLICANT, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection. Please verify the accuracy of the data presented on this receipt. **If an error is noted on this Filing Receipt, please submit a written request for a Filing Receipt Correction. Please provide a copy of this Filing Receipt with the changes noted thereon. If you received a "Notice to File Missing Parts" for this application, please submit any corrections to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections**

Inventor(s)

John Douglas Steinberg, Millbrae, CA;

Applicant(s)

EcoFactor, Inc., Millbrae, CA

Power of Attorney: The patent practitioners associated with Customer Number 20995

Domestic Priority data as claimed by applicant

This application is a CON of 14/048,932 10/08/2013 PAT 8840033
which is a CON of 12/788,246 05/26/2010 PAT 8556188

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see http://www.uspto.gov for more information.) - None.
Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

If Required, Foreign Filing License Granted: 09/24/2014

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 14/491,554**

Projected Publication Date: 06/18/2015

Non-Publication Request: No

Early Publication Request: No
**** SMALL ENTITY ****

Title

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Preliminary Class

236

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at http://www.uspto.gov/web/offices/pac/doc/general/index.html.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, http://www.stopfakes.gov. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER

Title 35, United States Code, Section 184

Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

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The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign AssetsControl, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2

CONFIRMATION NO. 1254

20995
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

PUBLICATION NOTICE

OC000000075810147

Title:SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

Publication No.US-2015-0168001-A1
Publication Date:06/18/2015

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently http://www.uspto.gov/patft/.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Office of Public Records. The Office of Public Records can be reached by telephone at (703) 308-9726 or (800) 972-6382, by facsimile at (703) 305-8759, by mail addressed to the United States Patent and Trademark Office, Office of Public Records, Alexandria, VA 22313-1450 or via the Internet.

In addition, information on the status of the application, including the mailing date of Office actions and the dates of receipt of correspondence filed in the Office, may also be accessed via the Internet through the Patent Electronic Business Center at www.uspto.gov using the public side of the Patent Application Information and Retrieval (PAIR) system. The direct link to access this status information is currently http://pair.uspto.gov/. Prior to publication, such status information is confidential and may only be obtained by applicant using the private side of PAIR.

Further assistance in electronically accessing the publication, or about PAIR, is available by calling the Patent Electronic Business Center at 1-866-217-9197.

Office of Data Managment, Application Assistance Unit (571) 272-4000, or (571) 272-4200, or 1-888-786-0101

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2	1254

20995 7590 11/16/2016

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
NORMAN, MARC E	

ART UNIT	PAPER NUMBER
3744	

NOTIFICATION DATE	DELIVERY MODE
11/16/2016	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

jayna.cartee@knobbe.com
efiling@knobbe.com

Office Action Summary	**Application No.** 14/491,554	**Applicant(s)** STEINBERG, JOHN DOUGLAS	
	Examiner MARC NORMAN	**Art Unit** 3744	**AIA (First Inventor to File) Status** No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *3* MONTHS FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *2/27/15*.

☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims*

5)☒ Claim(s) *2-21* is/are pending in the application.

5a) Of the above claim(s) _____ is/are withdrawn from consideration.

6)☐ Claim(s) _____ is/are allowed.

7)☒ Claim(s) *2-21* is/are rejected.

8)☐ Claim(s) _____ is/are objected to.

9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

* If any claims have been determined allowable, you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

Application Papers

10)☐ The specification is objected to by the Examiner.

11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a)☐ All b)☐ Some** c)☐ None of the:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

** See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)

2) ☒ Information Disclosure Statement(s) (PTO/SB/08a and/or PTO/SB/08b) Paper No(s)/Mail Date _____.

3) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .

4) ☐ Other: _____.

The present application is being examined under the pre-AIA first to invent provisions.

Claim Rejections - 35 USC § 102

In the event the determination of the status of the application as subject to AIA 35 U.S.C. 102 and 103 (or as subject to pre-AIA 35 U.S.C. 102 and 103) is incorrect, any correction of the statutory basis for the rejection will not be considered a new ground of rejection if the prior art relied upon, and the rationale supporting the rejection, would be the same under either status.

The following is a quotation of the appropriate paragraphs of pre-AIA 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claim(s) 2-10 and 12-20 is/are rejected under pre-AIA 35 U.S.C. 102(e) as being anticipated by Imes (US 8,428,782 B2).

As per claims 2 and 12, Imes discloses a method/system for adjusting at least one temperature setpoint of an HVAC system associated with a structure, the method comprising: associating the at least one mobile electronic device with the structure (e.g., col. 20, line 67 - col. 21, line 1 regarding reporting device being associated with site); receiving with one or more computer processors, the geographic location of the at least one mobile electronic device (Step 344; col. 20, lines 46-50; etc.); using traffic data to predict a length of time for a user of the at

least one mobile electronic device to reach the structure (col. 21, lines 8-21); and adjusting with one or more computer processors, at least one temperature setpoint of an HVAC system associated with the structure based upon the predicted length of time for a user of the mobile electronic device to reach the structure (col. 21, lines 52-58, wherein the distance incorporates the traffic and time information as discussed at col. 21, lines 8-21).

As per claims 3 and 13, Imes discloses using geospatial data associated with the mobile electronic device to control (i.e., increase or decrease) the predicted length of time to reach the structure based on characteristics of a location (i.e, distance from the structure) the user has stopped at before reaching the structure.

As per claims 4 and 14, Imes discloses wherein the mobile electronic device is a telephone (col. 29, lines 3-4; etc.).

As per claims 5 and 15, Imes discloses wherein the mobile electronic device is connected to the Internet (col. 44, lines 55-61; etc.).

As per claims 6 and 16, Imes discloses wherein the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from the mobile electronic device (i.e., cell tower triangulation – col. 18, line 65; etc.).

As per claims 7 and 17, wherein the one or more processors comprise a remote server 204 that is remotely located from the structure 202 (Fig. 2).

As per claims 8 and 18, Imes discloses wherein adjusting the at least one temperature setpoint is logged to a database 224.

As per claims 9 and 19, Imes discloses wherein adjusting the at least one temperature setpoint is initiated by a remote computer 204.

As per claims 10 and 20, Imes discloses wherein adjusting the at least one temperature setpoint occurs automatically (according to the controls disclosed at col. 21, lines 52-57).

Claim Rejections - 35 USC § 103

The following is a quotation of pre-AIA 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under pre-AIA 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

Claims 11 and 21 is/are rejected under pre-AIA 35 U.S.C. 103(a) as being unpatentable over Imes (US 8,428,782 B2).

As per claims 11 and 21, Imes does not specifically prompting the user to confirm occupancy. However, user confirmation for automatic controls is considered a common

routine control expedient that would have been obvious to one of ordinary skill in the art to apply to the system of Imes for the general purpose of assuring the sensed conditions are accurate before changing the control settings.

Double Patenting

The nonstatutory double patenting rejection is based on a judicially created doctrine grounded in public policy (a policy reflected in the statute) so as to prevent the unjustified or improper timewise extension of the "right to exclude" granted by a patent and to prevent possible harassment by multiple assignees. A nonstatutory double patenting rejection is appropriate where the conflicting claims are not identical, but at least one examined application claim is not patentably distinct from the reference claim(s) because the examined application claim is either anticipated by, or would have been obvious over, the reference claim(s). See, e.g., *In re Berg*, 140 F.3d 1428, 46 USPQ2d 1226 (Fed. Cir. 1998); *In re Goodman*, 11 F.3d 1046, 29 USPQ2d 2010 (Fed. Cir. 1993); *In re Longi*, 759 F.2d 887, 225 USPQ 645 (Fed. Cir. 1985); *In re Van Ornum*, 686 F.2d 937, 214 USPQ 761 (CCPA 1982); *In re Vogel*, 422 F.2d 438, 164 USPQ 619 (CCPA 1970); *In re Thorington*, 418 F.2d 528, 163 USPQ 644 (CCPA 1969).

A timely filed terminal disclaimer in compliance with 37 CFR 1.321(c) or 1.321(d) may be used to overcome an actual or provisional rejection based on nonstatutory double patenting provided the reference application or patent either is shown to be commonly owned with the examined application, or claims an invention made as a result of activities undertaken within the scope of a joint research agreement. See MPEP § 717.02 for applications subject to examination under the first inventor to file provisions of the AIA as explained in MPEP § 2159. See MPEP

§§ 706.02(l)(1) - 706.02(l)(3) for applications not subject to examination under the first inventor to file provisions of the AIA. A terminal disclaimer must be signed in compliance with 37 CFR 1.321(b).

The USPTO Internet website contains terminal disclaimer forms which may be used. Please visit www.uspto.gov/patent/patents-forms. The filing date of the application in which the form is filed determines what form (e.g., PTO/SB/25, PTO/SB/26, PTO/AIA/25, or PTO/AIA/26) should be used. A web-based eTerminal Disclaimer may be filled out completely online using web-screens. An eTerminal Disclaimer that meets all requirements is auto-processed and approved immediately upon submission. For more information about eTerminal Disclaimers, refer to www.uspto.gov/patents/process/file/efs/guidance/eTD-info-I.jsp.

Claims 2-21 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-22 of U.S. Patent No. 8,556,188 B2. Although the claims at issue are not identical, they are not patentably distinct from each other because patented independent claims 1 and 12 disclose all of the limitations respective pending claims 2 and 12 regarding associating the mobile device with the structure, receiving the geographic location of the mobile device, using traffic data to predict length of time, and adjusting the setpoint based on the predicted length of time. Pending claims 2 and 12 appear to be a simple broadening of the patented claims. Patented claims 1 and 12 further disclose the limitations of pending claims 3 and 13 the controls being based a characteristic of a location (i.e., distance from structure) where a user is stopped. Pending claims 4-11 and 14-21 are disclosed in patented claims 2, 4, 6-11, 13, 15, and 17-22, respectively.

Claims 2-21 are rejected on the ground of nonstatutory double patenting as being unpatentable over claims 1-22 of U.S. Patent No. 8,840,033 B2. Although the claims at issue are not identical, they are not patentably distinct from each other because patented independent claims 1 and 12 disclose all of the limitations respective pending claims 2 and 12 regarding associating the mobile device with the structure, receiving the geographic location of the mobile device, using traffic data to predict length of time, and adjusting the setpoint based on the predicted length of time. Pending claims 2 and 12 appear to be a simple broadening of the patented claims. Patented claims 1 and 12 further disclose the limitations of pending claims 3 and 13 the controls being based a characteristic of a location (i.e., distance from structure) where a user is stopped. Pending claims 4-11 and 14-21 are disclosed in patented claims 2, 4, 6-11, 13, 15, and 17-22, respectively.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to MARC NORMAN whose telephone number is (571)272-4812. The examiner can normally be reached on Mon.-Fri., 8:30-5:00.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Alexandra Elve can be reached on 571-272-1173. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/MARC NORMAN/
Primary Examiner, Art Unit 3744

Notice of References Cited	Application/Control No. 14/491,554	Applicant(s)/Patent Under Reexamination STEINBERG, JOHN DOUGLAS	
	Examiner MARC NORMAN	Art Unit 3744	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
	A	US-				
	B	US-				
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 1 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	H2176	12/05/2006	Meyer et al.	
	2	13/470074	08/30/2012	Steinberg	
	3	13/523697	06/14/2012	Hublou et al.	
	4	13/725447	06/06/2013	Steinberg	
	5	13/852577	03/28/2013	Steinberg et al.	
	6	13/858710	09/05/2013	Steinberg et al.	
	7	13/861189	04/11/2013	Steinberg et al.	
	8	14/082,675 (EFACT.007C1)	11/18/2003	Steinberg et al.	
	9	14/263,762	04/28/2014	Steinberg	
	10	14/285,384	05/22/2014	Steinberg, et al.	
	11	14/292,377	05/30/2014	Steinberg	
	12	14/491,554	09/19/2014	Steinberg	
	13	14/527,433	10/29/2014	Steinberg, et al.	
	14	D 646,990	10/18/2011	Rhodes	
	15	D 659,560	05/15/2012	Rhodes	
	16	D 673,467	01/01/2013	Lee et al.	
	17	D 705,095 (EFACT.015DA)	05/20/2014	EcoFactor, Inc.	
	18	4,136,732	01/30/1979	Demaray et al.	
	19	4,341,345	07/27/1982	Hammer et al.	
	20	4,403,644	09/13/1983	Hebert	
	21	4,475,685	10/09/1984	Grimado et al.	
	22	4,655,279	04/07/1987	Harmon	
	23	4,674,027	06/16/1987	Beckey	
	24	5,124,502	06/23/1992	Nelson et al.	
	25	5,244,146	09/14/1993	Jefferson et al.	
	26	5,270,952	12/14/1993	Adams et al.	
	27	5,314,004	05/24/1994	Strand et al.	
	28	5,462,225	10/31/1995	Massara et al.	

Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 2 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	29	5,544,036	08/06/1996	Brown et al.	
	30	5,555,927	09/17/1996	Shah	
	31	5,572,438	11/05/1996	Ehlers et al.	
	32	5,682,949	11/04/1997	Ratcliffe et al.	
	33	5,717,609	02/10/1998	Packa et al.	
	34	5,725,148	03/10/1998	Hartman	
	35	5,729,474	03/17/1998	Hildebrand et al.	
	36	5,818,347	10/06/1998	Dolan et al.	
	37	5,977,964	11/02/1999	Williams et al.	
	38	6,079,626	06/27/2000	Hartman	
	39	6,115,713	09/05/2000	Pascucci et al.	
	40	6,145,751	11/14/2000	Ahmed	
	41	6,178,362	01/23/2001	Woolard et al.	
	42	6,260,765	07/17/2001	Natale et al.	
	43	6,241,156	06/05/2001	Kline et al.	
	44	6,351,693	02/26/2002	Monie	
	45	6,400,956	06/02/2002	Richton	
	46	6,400,996	06/04/2002	Hoffberg et al.	
	47	6,437,692	08/20/2002	Petite et al.	
	48	6,478,233	11/12/2002	Shah	
	49	6,480,803	11/12/2002	Pierret et al.	
	50	6,483,906	11/19/2002	Lggulden et al.	
	51	6,536,675	03/25/2003	Pesko et al.	
	52	6,542,076	04/01/2003	Joao	
	53	6,549,130	04/15/2003	Joao	
	54	6,574,537	06/02/2003	Kipersztok et al.	
	55	6,580,950	06/17/2003	Johnson	
	56	6,594,825	07/15/2003	Goldschmidtlki et al.	
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Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

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	Art Unit	3744
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SHEET 3 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
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	58	6,598,056	07/22/2003	Hull et al.	
	59	6,619,555	09/16/2003	Rosen	
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	61	6,622,115	09/16/2003	Brown et al.	
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	72	6,734,806	05/11/2004	Cratsley	
	73	6,772,052	08/03/2004	Amundsen	
	74	6,785,592	08/31/2004	Smith	
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	76	6,786,421	09/07/2004	Rosen	
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	78	6,853,959	02/08/2005	Ikeda et al.	
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U.S. PATENT DOCUMENTS					
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	87	7,031,880	04/18/2006	Seem et al.	
	88	7,039,532	05/02/2006	Hunter	
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	98	7,231,424	06/11/2007	Bodin et al.	
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	100	7,242,988	07/10/2007	Hoffberg et al.	
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	Art Unit	3744
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SHEET 5 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
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	115	8,019,567 (EFACT.006A)	09/13/2011	Steinberg et al.	
	116	8,090,477 (EFACT.013A)	01/03/2012	Steinberg	
	117	8,131,497 (EFACT.005C1)	03/06/2012	Steinberg et al.	
	118	8,131,506 (EFACT.004C1)	03/06/2012	Steinberg et al.	
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	120	8,340,826 (EFACT.013C1)	12/25/2012	Steinberg et al.	
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	122	8,423,322 (EFACT.006C1)	04/16/2013	Steinberg et al.	
	123	8,457,797	06/04/2013	Imes et al.	
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	125	8,596,550 (EFACT.007A)	12/03/2013	Steinberg et al.	
	126	8,712,590 (EFACT.013C2)	04/29/2014	Steinberg	
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	129	8,751,186 (EFACT.005C3)	06/10/2014	Steinberg, et al.	
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	135	2005/0288822	12/29/2005	Rayburn	
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	138	2007/0043477	02/22/2007	Elhers et al.	
	139	2007/0045431	03/03/2007	Chapman et al.	

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	Art Unit	3744
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SHEET 6 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	140	2007/0146126	06/28/2007	Wang	
	141	2008/0083234	04/10/2008	Krebs et al.	
	142	2008/0198549	08/21/2008	Rasmussen et al.	
	143	2008/0281472	11/13/2008	Podgorny et al.	
	144	2009/0052859	02/26/2009	Greenberger et al.	
	145	2009/0099699	04/16/2009	Steinberg et al.	
	146	2009/0125151	05/14/2009	Steinberg et al.	
	147	2009/0240381	09/24/2009	Lane	
	148	2009/0281667	11/12/2009	Masui et al.	
	149	2010/0019052	01/28/2010	Yip	
	150	2010/0070086	03/18/2010	Harrod et al.	
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	153	2010/0156608	06/24/2010	BAE et al.	
	154	2010/0162285	06/24/2010	Cohen et al.	
	155	2010/0211224	08/19/2010	Keeling et al.	
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	157	2010/0318227	12/16/2010	Steinberg et al.	
	158	2011/0031323	02/10/2011	Nold et al.	
	159	2011/0046792	02/24/2011	Imes et al.	
	160	2011/0046798	02/24/2011	Imes et al.	
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	162	2011/0046800	02/24/2011	Imes et al.	
	163	2011/0046801	02/24/2011	Imes et al.	
	164	2011/0051823	03/03/2011	Imes et al.	
	165	2011/0054699	03/03/2011	Imes et al.	
	166	2011/0054710	03/03/2011	Imes et al.	
	167	2011/0173542	07/14/2011	Imes et al.	
	168	2011/0202185	08/18/2011	Imes et al.	

Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

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SHEET 7 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
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	169	2011/0214060	09/01/2011	Imes et al.	
	170	2011/0224838	09/15/2011	Imes et al.	
	171	2011/0246898	10/06/2011	Imes et al.	
	172	2011/0253796	10/20/2011	Posa et al.	
	173	2011/0290893	12/01/2011	Steinberg	
	174	2011/0307101	12/15/2011	Imes et al.	
	175	2011/0307103 (EFACT.010C1)	12/15/2011	Cheung et al.	
	176	2012/0023225	01/26/2012	Imes et al.	
	177	2012/0046859	02/23/2012	Imes et al.	
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	182	2012/0093141	04/19/2012	Imes et al.	
	183	2012/0101637	04/26/2012	Imes et al.	
	184	2012/0135759	05/31/2012	Imes et al.	
	185	2011/0253796	10/20/2011	Posa et al.	
	186	2012/0215725	08/23/2012	Imes et al.	
	187	2012/0221151 (EFACT.011C1)	08/30/2012	Steinberg	
	188	2012/0221718	08/30/2012	Imes et al.	
	189	2012/0252430	10/04/2012	Imes et al.	
	190	2012/0324119	12/20/2012	Imes et al.	
	191	2013/0053054	02/28/2013	Lovitt et al.	
	192	2013/0054758	02/28/2013	Imes et al.	
	193	2013/0054863	02/28/2013	Imes et al.	
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U.S. PATENT DOCUMENTS					
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	197	2013/0226502 (EFACT.006C2)	08/29/2013	Steinberg, et al.	
	198	2013/0310989 (EFACT.009C1)	11/21/2013	Steinberg et al.	
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	200	2014/0039690 (EFACT.012C1)	02/06/2014	Steinberg	
	201	2014/0188290 (EFACT.007C1)	07/03/2014	EcoFactor, Inc.	

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Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	202	EP 0415747 A2	03/06/1991	Shaw et al.		
	203	JP 05-189659	07/30/1993	Hitachi Bill Shisetsu Eng. KK.		
	204	JP 2010-038377	02/18/2010	Mitsubishi Heavy Ind. Ltd.		
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	207	KR 10-1999-0070368	09/15/1999	Samsung Electronics Co. Ltd.		
	208	KR 10-2000-0059532	10/05/2000	Dang Hae System Co.		
	209	WO 2011/149600 (EFACT.012WO)	12/01/2011	EcoFactor, Inc.		
	210	WO 2012/024534 (EFACT.013WO)	02/23/2012	EcoFactor, Inc.		
	211	WO 2013/187996	12/19/2013	EcoFactor, Inc.		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
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	222	Gupta, et al., A Persuasive GPS-Controlled Thermostat System, MIT, 2008.	
	223	Honeywell Programmable Thermostat Owner's Guide, www.honeywell.com/yourhome, 2004.	
	224	Honeywell, "W7600/W7620 Controller Reference Manual, HW0021207, October, 1992.	
	225	Johnson Controls, "T600HCx-3 Single-Stage Thermostats", 2006.	
	226	Johnson Controls, Touch4 building automation system brochure, 2007.	
	227	Kilicotte, et al., "Dynamic Controls for Energy Efficiency and Demand Response: Framework Concepts and a New Construction Study Case in New York", Proceedings of the 2006 ACEEE Summer Study of Energy Efficiency in Buildings, Pacific Grove. CA, August 13-18, 2006	
	228	Krumm, et al., Learning Time-Based Presence Probabilities, June 2011.	
	229	Lin, et al., "Multi-Sensor Single-Actuator Control of HVAC Systems", 2002.	
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	232	Raji, "Smart Networks for Control", IEEE Spectrum, June 1994.	
	233	Scott, et al., Home Heating Using GPS-Based Arrival Prediction, 2010.	

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	234	Wang, et al., "Opportunities to Save Energy and Improve Comfort by Using Wireless Sensor Networks in Buildings," (2003), Center for Environmental Design Research.	
	235	Wetter, et al., A comparison of deterministic and probabilistic optimization algorithms for non-smooth simulation-based optimization, Building and Environment 39, 2004, Pages 989-999.	
	236	International Search Report and Written Opinion for PCT/US2013/035726 (EFACT.014WO), dated 8/6/13.	
	237	Written Opinion and Search Report for PCT/US2011/032537, dated 12/12/11 (our reference EFACT.012WO).	

19579915
121814

Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

*Examiner: Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.E.N/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

BIB DATA SHEET

CONFIRMATION NO. 1254

SERIAL NUMBER	FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
14/491,554	09/19/2014 RULE	236	3744	EFACT.012C2

APPLICANTS
EcoFactor, Inc., Millbrae, CA;

INVENTORS
John Douglas Steinberg, Millbrae, CA;

**** CONTINUING DATA ***************************
This application is a CON of 14/048,932 10/08/2013 PAT 8840033
which is a CON of 12/788,246 05/26/2010 PAT 8556188

**** FOREIGN APPLICATIONS ***************************

**** IF REQUIRED, FOREIGN FILING LICENSE GRANTED **** ** SMALL ENTITY **
09/24/2014

Foreign Priority claimed ☐ Yes ☑ No 35 USC 119(a-d) conditions met ☐ Yes ☑ No Verified and Acknowledged /MARC E NORMAN/ Examiner's Signature	☐ Met after Allowance Initials	STATE OR COUNTRY	SHEETS DRAWINGS	TOTAL CLAIMS	INDEPENDENT CLAIMS
		CA	47	20	2

ADDRESS

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614
UNITED STATES

TITLE

SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

FILING FEE RECEIVED		
800	FEES: Authority has been given in Paper No._____ to charge/credit DEPOSIT ACCOUNT No._____ for following:	☐ All Fees ☐ 1.16 Fees (Filing) ☐ 1.17 Fees (Processing Ext. of time) ☐ 1.18 Fees (Issue) ☐ Other _____ ☐ Credit

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	Art Unit
	MARC NORMAN	3744

CPC- SEARCHED		
Symbol	Date	Examiner
F24F 11/0034, 006, 0086; 2001/0058, 0071, 0075, 0091	10/20/16	MN
G05D 23/1905, 1951	10/20/16	MN
H04Q 9/00; 2209/40, 84	10/20/16	MN

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor name search	10/20/16	MN
reviewed prosecution of parent applications	10/20/16	MN

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	**Art Unit**
	MARC NORMAN	3744

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	10/20/2016								
	1	-								
	2	✓								
	3	✓								
	4	✓								
	5	✓								
	6	✓								
	7	✓								
	8	✓								
	9	✓								
	10	✓								
	11	✓								
	12	✓								
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	15	✓								
	16	✓								
	17	✓								
	18	✓								
	19	✓								
	20	✓								
	21	✓								

Doc Code: DIST.E.FILE **Document Description: Electronic Terminal Disclaimer - Filed**	PTO/SB/26 U.S. Patent and Trademark Office Department of Commerce

Electronic Petition Request	**TERMINAL DISCLAIMER TO OBVIATE A DOUBLE PATENTING REJECTION OVER A "PRIOR" PATENT**
Application Number	14491554
Filing Date	19-Sep-2014
First Named Inventor	John Steinberg
Attorney Docket Number	EFACT.012C2
Title of Invention	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

☒ Filing of terminal disclaimer does not obviate requirement for response under 37 CFR 1.111 to outstanding Office Action

☒ This electronic Terminal Disclaimer is not being used for a Joint Research Agreement.

Owner	Percent Interest
EcoFactor, Inc.	100%

The owner(s) with percent interest listed above in the instant application hereby disclaims, except as provided below, the terminal part of the statutory term of any patent granted on the instant application which would extend beyond the expiration date of the full statutory term of prior patent number(s)

8840033

8556188

as the term of said prior patent is presently shortened by any terminal disclaimer. The owner hereby agrees that any patent so granted on the instant application shall be enforceable only for and during such period that it and the prior patent are commonly owned. This agreement runs with any patent granted on the instant application and is binding upon the grantee, its successors or assigns.

In making the above disclaimer, the owner does not disclaim the terminal part of the term of any patent granted on the instant application that would extend to the expiration date of the full statutory term of the prior patent, "as the term of said prior patent is presently shortened by any terminal disclaimer," in the event that said prior patent later:
- expires for failure to pay a maintenance fee;
- is held unenforceable;
- is found invalid by a court of competent jurisdiction;
- is statutorily disclaimed in whole or terminally disclaimed under 37 CFR 1.321;
- has all claims canceled by a reexamination certificate;
- is reissued; or
- is in any manner terminated prior to the expiration of its full statutory term as presently shortened by any terminal disclaimer.

◉ Terminal disclaimer fee under 37 CFR 1.20(d) is included with Electronic Terminal Disclaimer request. ○ I certify, in accordance with 37 CFR 1.4(d)(4), that the terminal disclaimer fee under 37 CFR 1.20(d) required for this terminal disclaimer has already been paid in the above-identified application.	
Applicant claims the following fee status: ◉ Small Entity ○ Micro Entity ○ Regular Undiscounted I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.	
THIS PORTION MUST BE COMPLETED BY THE SIGNATORY OR SIGNATORIES I certify, in accordance with 37 CFR 1.4(d)(4) that I am: ◉ An attorney or agent registered to practice before the Patent and Trademark Office who is of record in this application Registration Number 34362 ○ A sole inventor ○ A joint inventor; I certify that I am authorized to sign this submission on behalf of all of the inventors as evidenced by the power of attorney in the application ○ A joint inventor; all of whom are signing this request	
Signature	/John R. King/
Name	John R. King

*Statement under 37 CFR 3.73(b) is required if terminal disclaimer is signed by the assignee (owner).
Form PTO/SB/96 may be used for making this certification. See MPEP § 324.

Electronic Patent Application Fee Transmittal

Application Number:	14491554
Filing Date:	19-Sep-2014
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Filer:	John R. King/Aimee Kazan
Attorney Docket Number:	EFACT.012C2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
STATUTORY OR TERMINAL DISCLAIMER	2814	1	160	160
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**160**

Doc Code: DISQ.E.FILE
Document Description: Electronic Terminal Disclaimer – Approved

Application No.: 14491554

Filing Date: 19-Sep-2014

Applicant/Patent under Reexamination: Steinberg

Electronic Terminal Disclaimer filed on February 15, 2017

☒ APPROVED

This patent is subject to a terminal disclaimer

☐ DISAPPROVED

Approved/Disapproved by: Electronic Terminal Disclaimer automatically approved by EFS-Web

U.S. Patent and Trademark Office

Electronic Acknowledgement Receipt	
EFS ID:	28369207
Application Number:	14491554
International Application Number:	
Confirmation Number:	1254
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Customer Number:	20995
Filer:	John R. King/Aimee Kazan
Filer Authorized By:	John R. King
Attorney Docket Number:	EFACT.012C2
Receipt Date:	15-FEB-2017
Filing Date:	19-SEP-2014
Time Stamp:	18:32:32
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$160
RAM confirmation Number	021617INTEFSW18323000
Deposit Account	111410
Authorized User	Aimee Kazan
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Electronic Terminal Disclaimer-Filed	eTerminal-Disclaimer.pdf	33592 52a5520644592912fc8680875a13603e0bbef3c9	no	2
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Information:					
2	Fee Worksheet (SB06)	fee-info.pdf	30810 1d59d840692c42f9290eb9ee2ca085ddf3871ff3	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	64402		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371
If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office
If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Inventor	:	John Douglas Steinberg
App. No.	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Examiner	:	Norman, Marc E.
Art Unit	:	3744
Conf. No.	:	1254

RESPONSE TO NOVEMBER 16, 2016 OFFICE ACTION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Office Action dated November 16, 2016, Applicant respectfully submits the following amendments and comments.

Amendments to the Claims are reflected in the listing of claims which begins on page 2 of this paper.

Remarks/Arguments begin on page 6 of this paper.

Electronic Patent Application Fee Transmittal

Application Number:	14491554
Filing Date:	19-Sep-2014
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Filer:	John R. King/Amy Durrant
Attorney Docket Number:	EFACT.012C2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
Extension-of-Time:				

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Miscellaneous:				
SUBMISSION- INFORMATION DISCLOSURE STMT	2806	1	90	90
		Total in USD ($)		**90**

Electronic Acknowledgement Receipt	
EFS ID:	28369065
Application Number:	14491554
International Application Number:	
Confirmation Number:	1254
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Customer Number:	20995
Filer:	John R. King/Heather OBrien
Filer Authorized By:	John R. King
Attorney Docket Number:	EFACT.012C2
Receipt Date:	15-FEB-2017
Filing Date:	19-SEP-2014
Time Stamp:	18:33:37
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$90
RAM confirmation Number	021617INTEFSW18342300
Deposit Account	111410
Authorized User	Heather OBrien
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1		EFACT-012C2_ids.pdf	133446 ca41e40a3a87a5cdd6ebc6282dfb84810cef0257	yes	4
	Multipart Description/PDF files in .zip description				
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	Transmittal Letter		1	2	
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Information:					
2	Foreign Reference	EFACT-012C2_REF36.pdf	608437 d05be00c699d0f48f61a6bb98353472655fe1a15	no	14
Warnings:					
Information:					
3	Non Patent Literature	EFACT-012C2_REF37.pdf	1850599 00e91324c416bd4bca91db81819094315b53183f	no	25
Warnings:					
Information:					
4	Non Patent Literature	EFACT-012C2_REF38.pdf	673773 badcbe5c07ee9977b87ef8c83d95d436b4e1ed19	no	6
Warnings:					
Information:					
5	Non Patent Literature	EFACT-012C2_REF39.pdf	4809309 1e9ad278700bd864befbc15997ee88b86b7a9c07	no	144
Warnings:					
Information:					

6	Non Patent Literature	EFACT-012C2_REF40.pdf	5299725 4c802a09e2b8b02bed05a454f8dda0ed0075ca4b	no	151
Warnings:					
Information:					
7	Non Patent Literature	EFACT-012C2_REF41.pdf	165146 dad7d4d27a22311233b28035de0d09349cdb0a5f	no	5
Warnings:					
Information:					
8	Non Patent Literature	EFACT-012C2_REF42.pdf	197869 bcd5c68163bdc614d339b3323838fbb7a10e34e2	no	7
Warnings:					
Information:					
9		EFACT-012C2_response.pdf	61905 ff0d6b2e385d893229db7d122e6a0da9e9255430	yes	13

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Applicant Arguments/Remarks Made in an Amendment	6	13
	Claims	2	5
	Amendment/Req. Reconsideration-After Non-Final Reject	1	1

Warnings:					
Information:					
10	Fee Worksheet (SB06)	fee-info.pdf	30758 e821609ac6975c89b68396753dbc27eaff85cb7e	no	2
Warnings:					
Information:					
		Total Files Size (in bytes):	13830967		

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111
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New International Application Filed with the USPTO as a Receiving Office
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PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Norman, Marc E.
SHEET 1 OF 2	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	12/805705	06/10/2010	Crabtree	
	2	13/729401	12/28/2012	Sloop	
	3	14/731,221	06/04/2015	Steinberg, et al.	
	4	4,451,879	05/29/1984	Welch et al.	
	5	4,675,828	06/23/1987	Winston	
	6	4,897,798	01/30/1990	Cler	
	7	5,279,458	01/18/1994	Dewolf et al.	
	8	5,348,078	09/20/1994	Dushane et al.	
	9	6,700,224	03/02/2004	Biskup, Sr.,	
	10	7,206,670	04/17/2007	Pimputkar, et al.	
	11	7,590,469	09/15/2009	Grohman	
	12	8,428,785	04/23/2013	Boucher et al.	
	13	8,498,753 (EFACT.009A)	07/30/2013	Steinberg et al.	
	14	8,850,348	09/30/2014	Fadell et al.	
	15	9,057,649 (EFACT.006C2)	06/16/2015	Steinberg, et al.	
	16	9,134,710 (EFACT.010C1)	09/15/2015	Cheung et al.	
	17	9,194,597 (EFACT.007C1)	11/24/2015	Steinberg, et al.	
	18	9,244,470 (EFACT.011C1)	01/26/2016	Steinberg	
	19	9,279,594 (EFACT.008C1)	03/08/2016	Steinberg	
	20	2004/0065095	04/08/2004	Osborne et al.	
	21	2006/0283965	12/21/2006	Mueller et al.	
	22	2009/0188985	07/30/2009	Scharing et al.	
	23	2012/0186774	07/26/2012	Matsuoka et al.	
	24	2013/0173064	07/04/2013	Fadell et al.	
	25	2013/0178985	07/11/2013	Lombard et al.	
	26	2014/0058567	02/27/2014	Matsuoka et al.	
	27	2014/0229018 (EFACT.013C3)	08/20/2014	Steinberg	

Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T[1] - Place a check mark in this area when an English language Translation is attached.

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT		
	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Norman, Marc E.
SHEET 2 OF 2	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	28	2014/0316581	10/26/2014	Fadell et al.	
	29	2016/0061474 (EFACT.010C2)	03/03/2016	Cheung et al.	
	30	2016/0091219 (EFACT.007C2)	03/31/2016	Steinberg et al.	
	31	2016/0097557 (EFACT.013C4)	04/07/2016	Steinberg	
	32	2016/0138822 (EFACT.011C2)	05/19/2016	Steinberg	
	33	2016/0238270	08/18/2016	Steinberg	
	34	2016/0258822	09/08/2016	Steinberg et al.	
	35	2016/0363337	12/15/2016	Steinberg et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	36	WO 2005/098331 A1	10/20/2005	Zip Ind Aust Pty Ltd.		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	37	CHENG et al., "Smart Sensors Enable Smart Air Conditioning Control", Sensors 2014, ISSN 1424-8220, June 24, 2014, 25 pages.	
	38	GUNES et al., "Improving Energy Efficiency and Thermal Comfort of Smart Buildings with HVAC Systems in the Presence of Sensor Faults", IEEE, August 24-26, 2015, 6 pages.	
	39	SIMMINI et al., Energy Efficient Control and Fault Detection for HVAC Systems, Univ. of Padova, XXVI Series, 2014, 144 pages.	
	40	SKLAVOUNOS, "Detection of Abnormal Situations and Energy Efficiency Control in Heating Ventilation and Air Conditioning (HVAC) Systems", Brunel University thesis, September 2015,151 pages.	
	41	International Preliminary Report on Patentability in PCT/US2013/035726 dated 12/16/2014 (EFACT.014WO).	
	42	Extended Search Report for European Application No. 13804057.1 dated June 1, 2016 (EFACT.014EP).	

25213396

Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T[1] - Place a check mark in this area when an English language Translation is attached.

INFORMATION DISCLOSURE STATEMENT

First Inventor	:	John Douglas Steinberg
App. No.	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Examiner	:	Norman, Marc E.
Art Unit	:	3744
Conf. No.	:	1254

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted.

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Timing of Disclosure

This Information Disclosure Statement is being filed after receipt of a First Office Action, but before the mailing date of a Final Action and before the mailing date of a Notice of Allowance. This Statement is accompanied by the fees set forth in 37 CFR 1.17(p).

The Commissioner is hereby authorized to charge any additional fees which may be required or to credit any overpayment to Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: February 15, 2017

By:/John R. King/
John R. King
Registration No. 34,362
Attorney of Record
Customer No. 20,995
(949) 760-0404

25213778

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
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20 October 2005 (20.10.2005)

PCT

(10) International Publication Number
WO 2005/098331 A1

(51) International Patent Classification[7]: F25B 49/02, F25D 11/00, 13/00, 29/00

(21) International Application Number: PCT/AU2005/000361

(22) International Filing Date: 15 March 2005 (15.03.2005)

(25) Filing Language: English

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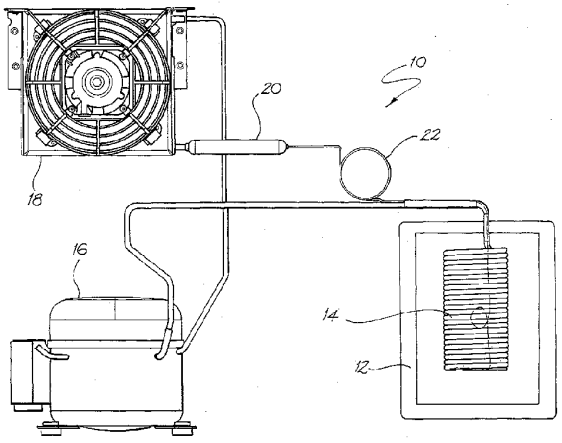
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Published:
— *with international search report*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: A METHOD OF OPERATING A WATER CHILLER



(57) Abstract: A method of operating a water chiller (10) having a water tank (12), a cold water tap, and a condenser and fan (18). The chiller avoids freezing of the water in the tank (12) by switching between 'normal' and 'protection' operating modes. The switching is initially triggered by checking the length of time since the cold water tap was last operated.

WO 2005/098331 A1

A METHOD OF OPERATING A WATER CHILLER

Field of the Invention

The present invention relates to a method of operating a water chiller.

The invention has been primarily developed in relation to a combined water chiller and boiling water heater unit and will be described hereinafter with reference to this application. However, it will be appreciated that the invention is not limited to this particular field of use and also suitable for use in a stand alone water chiller unit.

Background of the Invention

A known combined water chiller and boiling water heater unit provides instant boiling and instant chilled water from a single tap. The tap is typically mounted on a bench top or on a sink and the heater and chiller are housed together in a module, commonly in a cupboard under the sink. The unit includes a boiling water storage tank as well as a chilled water storage tank. An electronic controller controls both the boiling and chiller units.

The chiller unit has a complete refrigeration circuit which includes a compressor, a condenser, a fan and an evaporator. The chiller unit also has a chilled water tank with the evaporator (ie. cooling coil) and level and temperature sensors therein.

As per any refrigeration plant, to achieve cooling, heat must be removed. The refrigeration process involves the refrigerant being compressed through the compressor. This compression also raises the temperature of the refrigerant. The refrigerant then passes through a heat exchanger, known as a condenser, which cools the refrigerant. Thereafter the refrigerant passes through an evaporator which allows the refrigerant to expand causing the refrigerant to cool rapidly. This evaporator is submerged in the chilled water tank. As the water is hotter than the refrigerant, heat is removed from the water and passed into the refrigerant through the evaporator coils. The refrigerant then passes through the compressor again and the cycle starts over.

The heat is removed through a heat exchanger condenser that is force air cooled via an electric fan. The air is thus the cooling medium and its temperature rises. The effect of all of this is that the ambient air temperature within the unit, and within the cupboard, rises. Cupboards are often not well ventilated and as such the temperature of ambient air in the cupboard can rise noticeably. It follows that the hotter the ambient air, the less efficient the cooling process.

It should also be noted that water contracts in size as it cools to a temperature of 4 °C. As the water cools from 4 to 0 °C it expands again until the water is completely frozen. As water freezes the temperature remains constant at 0 °C until all the water has frozen and thereafter the temperature will continue to drop.

It is important that the water in the unit's chilled water tank is not allowed to freeze, as this can cause the tank to rupture.

A known approach to this issue has involved shutting down the compressor and indicating a fault if the compressor has been running continuously for one hour with no water being drawn off from the unit. This is based on the assumptions that, under normal circumstances, a compressor will normally only run for 5 to 10 minutes at a time if no new water is being introduced to the tank and that one hour continuous running is insufficient to completely freeze all of the water in the tank.

Units of this type suffer from the problem that: if the cupboard is not sufficiently ventilated; the incoming ambient water temperature is high; and the unit is required to work continuously due to the demands of chilled water, then this can result in the ambient air temperature inside the cupboard becoming so high that the chiller is only able to reduce the water temperature to about 7 or 8°C. Accordingly, the rate at which the unit is attempting to dissipate heat is the same rate at which the unit is absorbing heat. A state of equilibrium is thus reached and no further cooling of the water occurs. As a result, even if water is not being drawn off, the compressor runs continuously and upon reaching an hour the unit indicates a fault and shuts down. This results in a service call being required, which is both a cost and a source of dissatisfaction to the user.

Object of the Invention

It is the object of the present invention to substantially overcome at least ameliorate one or more of the above prior art deficiencies.

Summary of the Invention

Accordingly, in a first aspect, the present invention provides a method of operating a water chiller having: a water tank, a cold water tap, a condenser and a fan, the method including the following steps:

(a) monitoring a first predetermined time period since the cold water tap has been activated and if the first time period has not been reached then the chiller is said to be operating in normal mode and the method includes returning to step (a) or if the first

time period has been reached then the chiller is said to be operating in protection mode and the method includes proceeding to step (b);

(b) determining if the compressor is on or off and if the compressor is off then proceeding to step (c) or if the compressor is on then proceeding to step (e);

(c) determining if a predetermined high set point temperature for the water in the tank has been reached and if the high set point has been reached then proceeding to step (d) or if the high set point has not been reached then returning to step (b);

(d) turning the compressor on then returning to step (b);

(e) determining if a predetermined low set point temperature for the water in the tank has been reached and if the low set point has been reached then proceeding to step (f) and if the low set point has not been reached then proceeding to step (g);

(f) turning the compressor off, turning the fan on for a second predetermined time period and then returning to step (b);

(g) determining if a third predetermined time period has elapsed since the chiller entered the protection mode and if the third time period has been reached then proceeding to step (h) and if the third time period has not been reached then returning to step (b);

(h) determining if a fourth predetermined time period has elapsed and if the fourth time period has been reached then proceeding to step (i) or if the fourth time period has not been reached then returning to step (b);

(i) measuring the temperature of the water in the chiller at least three times at intervals of a fifth predetermined time period and calculating an first average temperature then proceeding to step (j);

(j) waiting for a sixth predetermined time period another then measuring the temperature of the water in the chiller and calculating a second average temperature for the last at least three measurements;

(k) comparing the first and second average temperatures and if the first average temperature is less than the second average temperature then returning to step (b) or if the first temperature is equal to or more than the second average temperature then proceeding to step (l);

(l) turning the compressor off and keeping the fan on then proceeding to step (m); and

(m) waiting for a seventh predetermined period of time before returning to step (b)

wherein if the cold water tap is activated when the chiller is in the protection mode then the chiller is altered to the normal mode.

The first, second, third, fourth, fifth, sixth and seventh predetermined time periods are preferably approximately 30, 5, 30, 5, 5, 5 and 30 minutes respectively.

The low set point and the high set point temperatures are preferably approximately 4.7 °C and 10.0 °C respectively.

Step (i) preferably includes measuring the temperature of the water in the chiller three times before calculating an average.

Brief Description of the Drawings

An embodiment of the invention will now be described, by way of an example only, with reference to the accompanying drawings in which:

Fig. 1 is a schematic diagram of the components of a water heater in accordance with an embodiment of the invention.

Fig. 2 is a logic diagram associated with an embodiment of a method for operating a heater according to the invention; and

Fig. 3 is a further logic diagram associated with the method set out in Fig. 2.

Detailed Description of the Preferred Embodiments

Referring firstly to Fig. 1, there is shown an embodiment of a water chiller 10 in accordance with an embodiment of the present invention. The chiller 10 forms a part of a combined boiling water heater and instant chilled water unit but the components of the boiling water heater are not shown for the sake of clarity.

The chiller 10 includes an insulated water tank 12 which has chilling evaporator coils 14 and a temperature sensor (not shown) therein. The tank 12 also has a cold water tap (not shown) to enable users to draw water from the tank 12. The chiller 10 also includes a PCB controller (not shown), a compressor 16, a condenser and fan 18, a filter dryer 20 and a capillary tube 22. The components of the chiller 10 are arranged to operate as per a normal refrigeration cycle.

Turning now to Fig. 2, there is shown a logic diagram associated with the initial steps of operating the chiller 10 in a manner which avoids freezing of water in the tank 12. When the chiller 10 is operating and there is no potential risk of the water in the tank 12 freezing, it is said to be operating in a 'normal' mode, as indicated at Step 30 of Fig. 2. The controller continuously checks the length of time since the cold water tap was last

operated, as shown in Step 32. As shown in Step 30, if the cold tap has been operated within the preceding 30 minutes, the unit continues to operate in the normal mode.

As shown in Step 34, if the cold tap has not been operated for 30 minutes or more then the chiller 10 switches to a 'protection' mode that has safeguards against freezing the water in the tank 12, as will be described below. However, as indicated at Step 36, if during any time the chiller 10 is operating in the protection mode and the cold tap is operated, it reverts to the normal mode, at Step 32, and the controller again begins checking for periods where the cold tap has not operated for 30 minutes.

The logic steps associated with the protection mode will now be described in relation to Fig. 3. As indicated at Step 40, the protection mode initially involves checking whether or not the compressor 16 is on. If the compressor 16 is not on, then the controller, as per Step 42, checks whether the water high set point temperature of 10.0 °C of the water in the tank 12 has been reached. If the water temperature is at or above 10.0 °C the compressor 16 is turned on, as indicated by Step 44, and the controller returns to Step 40 and checks whether or not the compressor 16 is on.

If the temperature of the water in the tank 12 has not reached 10.0 °C then the compressor 16 remains off and the controller returns to checking whether or not the compressor is on at Step 40.

If the compressor 16 is on then, as indicated at Step 46, the controller checks as to whether or not the water in the tank 12 has reached the low set point temperature of 4.7°C. If this is the case then, as indicated at Step 48, the compressor 16 is turned off and the fan is operated for a further 5 minutes to remove the heat soak that occurs. The controller then returns to Step 40 and continues to check whether or not the compressor 16 is on.

If the temperature of the water in the tank 12 has not reached the low set point of 4.7°C then, as indicated in Step 50, the controller checks whether or not 30 minutes has elapsed since entering the protection mode. If not, the controller returns to Step 40. If yes, then the controller proceeds to Step 52 and waits for a further 5 minutes before, at Step 54, it measures the temperature of the water in the tank 12. A new reading of the water temperature is taken every subsequent 5 minutes and, after three readings, an average of those three readings is calculated. After a further five minutes another reading is taken and the new moving average is compared to the previous average, as indicated at Step 56.

If the new average is less than the previous average it means that the chiller 10 is still chilling down and the normal operation continues. However, if the new average is the same or higher than the previous average it means that no more cooling is occurring. There are two main reasons that could lead to this occurring. The first is that the ambient temperature of the air has reached a point in which the chiller 10 is operating at equilibrium and is to not to take any further heat out of the water. The second reason may be a failure of the controller or the temperature sensor probe.

Normally, as previously described in relation to Step 48, when the water is cooled to 4.7°C the compressor 16 is turned off. The cooling fan 18 then continues to run for a further 5 minutes to remove the heat soak that occurs. If however the controller or the temperature sensor probe fails, the water may be continued to be cooled down past the 4.7 °C set point. If this occurs then the water starts to freeze and 0 °C and remains at this temperature until all of the water is frozen. However, the chiller 10 will recognise that the temperature is not dropping and will shut down the compressor 16 and turn on the fan 18, as indicated at Step 58.

As indicated at Step 60, prior to a complete freeze of the water in the tank 12, the fan 18 is kept running for 30 minutes after the compressor 16 has been shut down in order to clear any residual ambient heat in the chiller 10 and the cupboard. Thereafter, the chiller 10 returns to the normal mode of operation. Typically, the excess heat mode described above may occur after the chiller 10 has been operating continuously during the day and at the end of the day when the users have departed, the cupboard is too hot for the chilled water's lower set point temperature to be reached.

The method described above advantageously allows the heat in the cupboard to be dissipated in the evening and allows the chiller 10 to cool down to the point where the next day it is ready to function in the normal operating mode. Further, the controller also includes provision to supply a warning message if the overheating protection mode regularly occurs to indicate that the cupboard ventilation is inadequate and needs attention.

Although the invention has been described with reference to a preferred embodiment, it will be appreciated for those skilled in the art that the invention may be embodied in many other forms.

Claims:

1. A method of operating a water chiller having: a water tank, a cold water tap, a condenser and a fan, the method including the following steps:

(b) monitoring a first predetermined time period since the cold water tap has been activated and if the first time period has not been reached then the chiller is said to be operating in normal mode and the method includes returning to step (a) or if the first time period has been reached then the chiller is said to be operating in protection mode and the method includes proceeding to step (b);

(b) determining if the compressor is on or off and if the compressor is off then proceeding to step (c) or if the compressor is on then proceeding to step (e);

(c) determining if a predetermined high set point temperature for the water in the tank has been reached and if the high set point has been reached then proceeding to step (d) or if the high set point has not been reached then returning to step (b);

(d) turning the compressor on then returning to step (b);

(e) determining if a predetermined low set point temperature for the water in the tank has been reached and if the low set point has been reached then proceeding to step (f) and if the low set point has not been reached then proceeding to step (g);

(f) turning the compressor off, turning the fan on for a second predetermined time period and then returning to step (b);

(g) determining if a third predetermined time period has elapsed since the chiller entered the protection mode and if the third time period has been reached then proceeding to step (h) and if the third time period has not been reached then returning to step (b);

(h) determining if a fourth predetermined time period has elapsed and if the fourth time period has been reached then proceeding to step (i) or if the fourth time period has not been reached then returning to step (b);

(i) measuring the temperature of the water in the chiller at least three times at intervals of a fifth predetermined time period and calculating an first average temperature then proceeding to step (j);

(j) waiting for a sixth predetermined time period another then measuring the temperature of the water in the chiller and calculating a second average temperature for the last at least three measurements;

(k) comparing the first and second average temperatures and if the first average temperature is less than the second average temperature then returning to step (b) or if the first temperature is equal to or more than the second average temperature then proceeding to step (l);

(l) turning the compressor off and keeping the fan on then proceeding to step (m); and

(m) waiting for a seventh predetermined period of time before returning to step (b)

wherein if the cold water tap is activated when the chiller is in the protection mode then the chiller is altered to the normal mode.

2. The method as claimed in claim 1, wherein the first, second, third, fourth, fifth, sixth and seventh predetermined time periods are approximately 30, 5, 30, 5, 5, 5 and 30 minutes respectively.

3. The method as claimed in claim 1 or 2, wherein the low set point and the high set point temperatures are approximately 4.7 °C and 10.0 °C respectively.

4. The method as claimed in claim 1, 2 or 3, wherein step (i) includes measuring the temperature of the water in the chiller three times before calculating an average.

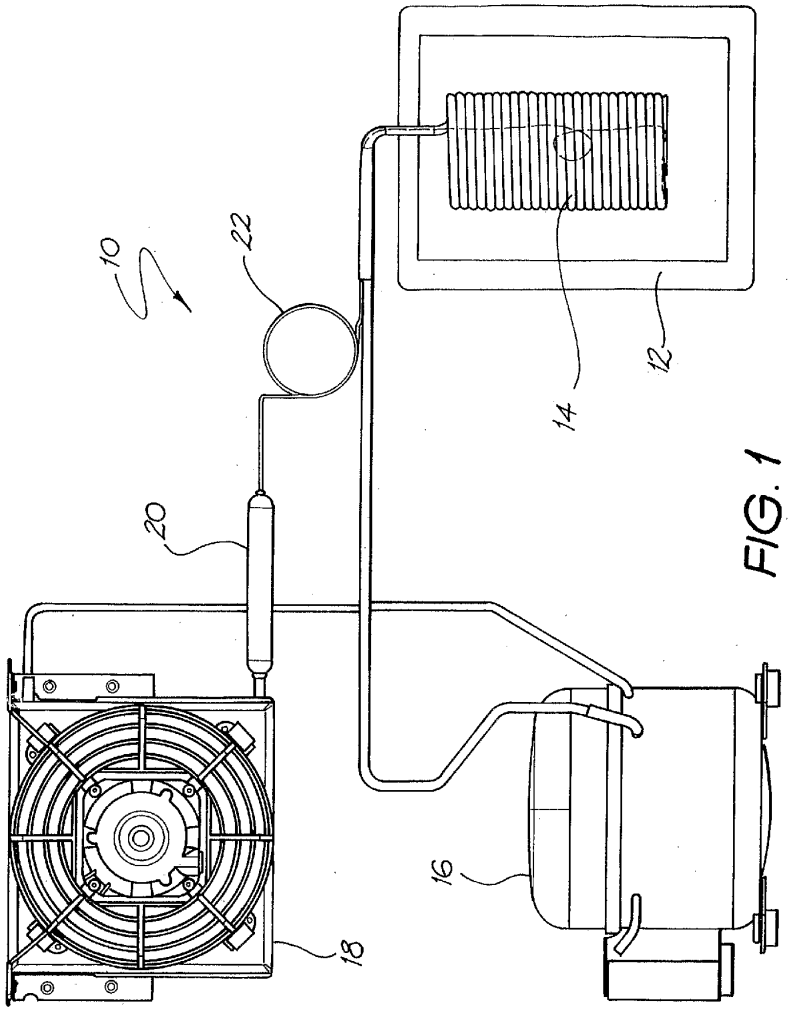


FIG. 1

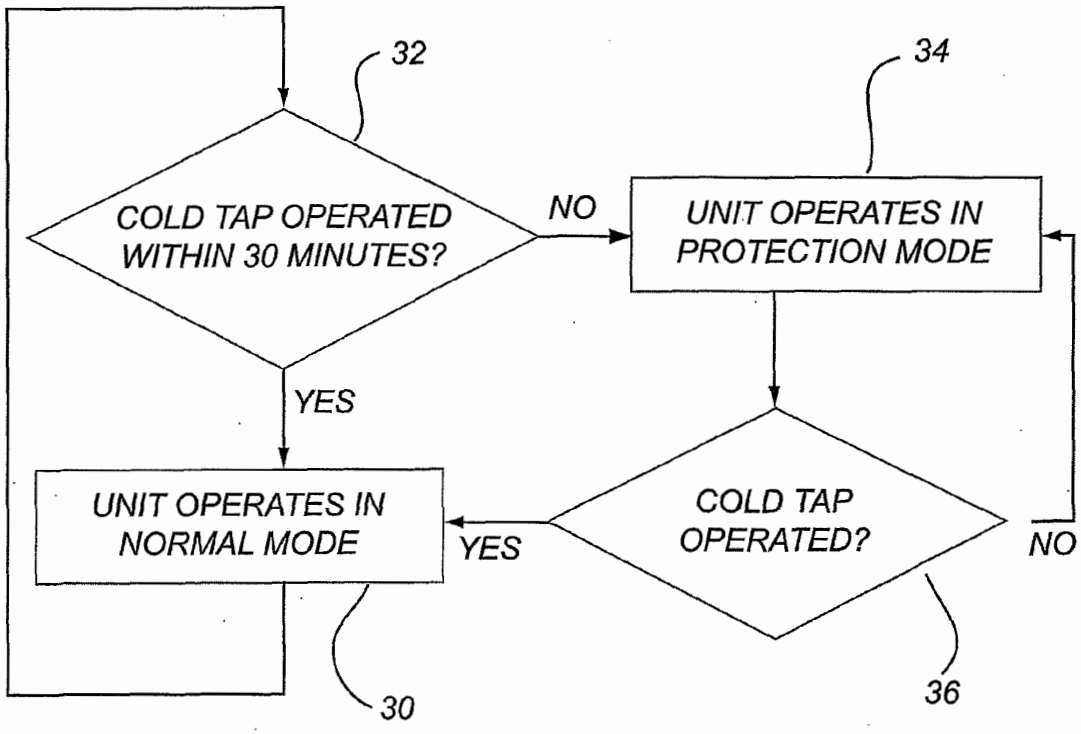

32
34
COLD TAP OPERATED WITHIN 30 MINUTES?
NO
UNIT OPERATES IN PROTECTION MODE
YES
UNIT OPERATES IN NORMAL MODE
YES
COLD TAP OPERATED?
NO
30
36

FIG. 2

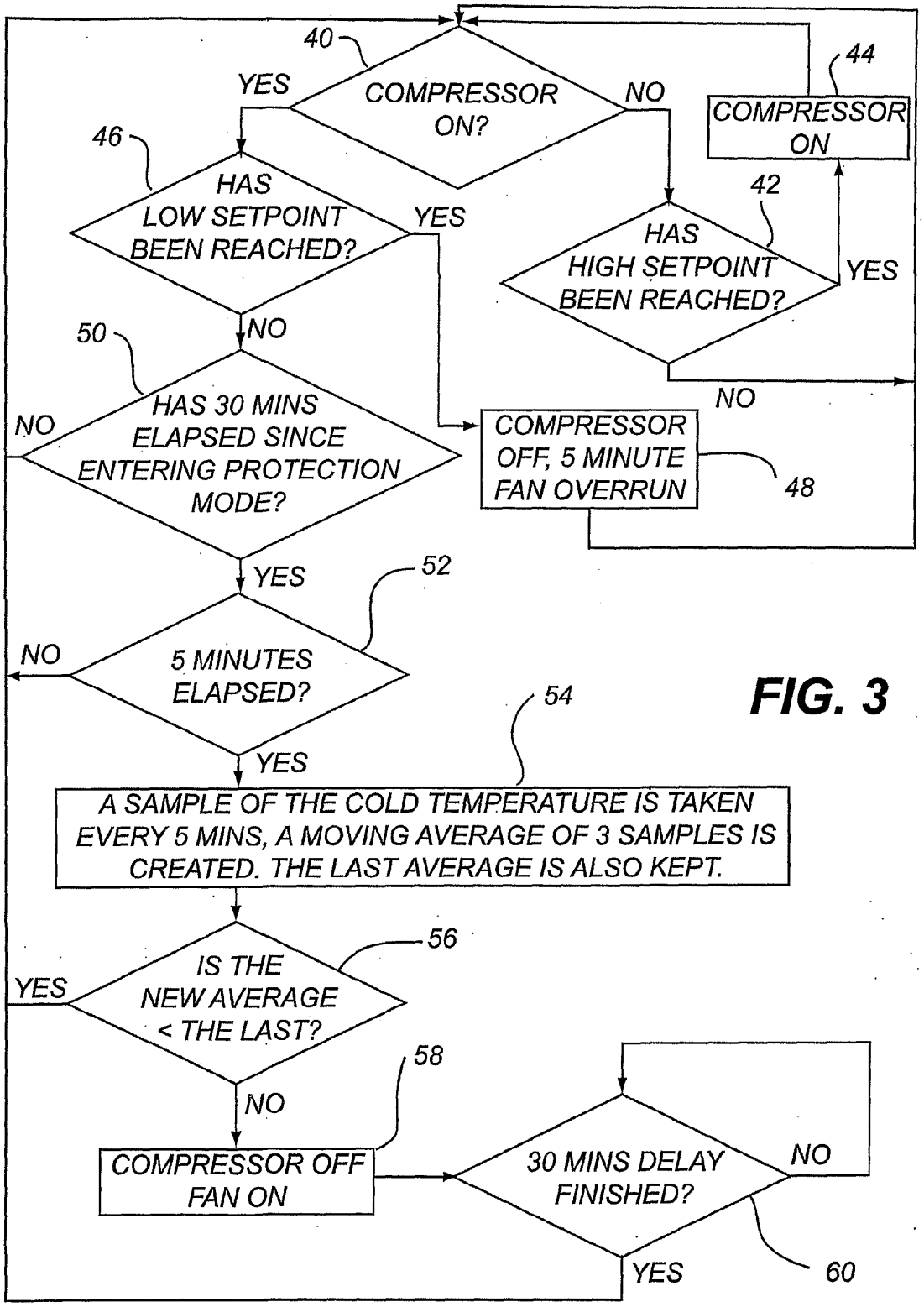

40
COMPRESSOR ON?
YES
NO
44
COMPRESSOR ON
46
HAS LOW SETPOINT BEEN REACHED?
YES
42
HAS HIGH SETPOINT BEEN REACHED?
YES
NO
NO
50
HAS 30 MINS ELAPSED SINCE ENTERING PROTECTION MODE?
NO
COMPRESSOR OFF, 5 MINUTE FAN OVERRUN
48
YES
52
5 MINUTES ELAPSED?
NO
YES
54
A SAMPLE OF THE COLD TEMPERATURE IS TAKEN EVERY 5 MINS, A MOVING AVERAGE OF 3 SAMPLES IS CREATED. THE LAST AVERAGE IS ALSO KEPT.
56
IS THE NEW AVERAGE < THE LAST?
YES
NO
58
COMPRESSOR OFF FAN ON
30 MINS DELAY FINISHED?
NO
YES
60

FIG. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU2005/000361

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: F25B 49/02; F25D 11/00, 13/00, 29/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI: F25+/IC; F25B 49/02; F25D 11/00, 13/00, 29/00 & keywords - freez+, water chill+

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2001/079733 A (ZIP HEATERS (AUSTRALIA) PTY LIMITED) 25 October 2001 Whole document	1-4
A	EP 0967449 A (DANFOSS A/S) 29 December 1999 Whole document	1-4
A	US 5224355 A (SO et al) 6 July 1993 Whole document	1-4
A	Patent Abstracts of Japan, JP 2002-318050 A (MIURA CO LTD) 31 October 2002 Abstract	1-4

☐ Further documents are listed in the continuation of Box C ☒ See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 May 2005	19 MAY 2005
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **Tharu Fernando** Telephone No : (02) 6283 2486

Form PCT/ISA/210 (second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/AU2005/000361

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	2001079733	AU	48148/01				
EP	0967449	BR	9903275	CN	1240924	US	6138465
US	5224355	JP	2539569	KR	9402232		
JP	2002318050	NONE					

Due to data integration issues this family listing may not include 10 digit Australian applications filed since May 2001.

END OF ANNEX

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter I of the Patent Cooperation Treaty)

(PCT Rule 44*bis*)

Applicant's or agent's file reference EFACT014WO	**FOR FURTHER ACTION**	See item 4 below
International application No. PCT/US2013/035726	International filing date *(day/month/year)* 09 April 2013 (09.04.2013)	Priority date *(day/month/year)* 14 June 2012 (14.06.2012)
International Patent Classification (8th edition unless older edition indicated) See relevant information in Form PCT/ISA/237		
Applicant ECOFACTOR, INC.		

1. This international preliminary report on patentability (Chapter I) is issued by the International Bureau on behalf of the International Searching Authority under Rule 44 *bis*.1(a).

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   In the attached sheets, any reference to the written opinion of the International Searching Authority should be read as a reference to the international preliminary report on patentability (Chapter I) instead.

3. This report contains indications relating to the following items:

☒	Box No. I	Basis of the report
☐	Box No. II	Priority
☐	Box No. III	Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
☐	Box No. IV	Lack of unity of invention
☒	Box No. V	Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
☐	Box No. VI	Certain documents cited
☐	Box No. VII	Certain defects in the international application
☐	Box No. VIII	Certain observations on the international application

4. The International Bureau will communicate this report to designated Offices in accordance with Rules 44*bis*.3(c) and 93*bis*.1 but not, except where the applicant makes an express request under Article 23(2), before the expiration of 30 months from the priority date (Rule 44*bis* .2).

	Date of issuance of this report 16 December 2014 (16.12.2014)
The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland Facsimile No. +41 22 338 82 70	Authorized officer Nora Lindner e-mail: pt05.pct@wipo.int

Form PCT/IB/373 (January 2004)

PATENT COOPERATION TREATY

From the
INTERNATIONAL SEARCHING AUTHORITY

To:
KING, JOHN, R.

KNOBBE, MARTENS, OLSON & BEAR, LLP 2040 MAIN STREET, 14TH FLOOR IRVINE CA 92614 USA

PCT

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

(PCT Rule 43bis.1)

Date of mailing *(day/month/year)*	**06 undefined 2013 (06.08.2013)**
Applicant's or agent's file reference: EFACT014WO	**FOR FURTHER ACTION** See paragraph 2 below

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/US2013/035726	**09 April 2013 (09.04.2013)**	14 June 2012 (14.06.2012)

International Patent Classification (IPC) or both national classification and IPC

F24F 11/02(2006.01)i, G05D 23/00(2006.01)i, G06Q 50/06(2012.01)i

Applicant
ECOFACTOR, INC.

1. This opinion contains indications relating to the following items:

- ☒ Box No. I Basis of the opinion
- ☐ Box No. II Priority
- ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- ☐ Box No. IV Lack of unity of invention
- ☒ Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- ☐ Box No. VI Certain documents cited
- ☐ Box No. VII Certain defects in the international application
- ☐ Box No. VIII Certain observations on the international application

2. **FURTHER ACTION**

If a demand for international preliminary examination is made, this opinion will be considered to be a written opinion of the International Preliminary Examining Authority ("IPEA") except that this does not apply where the applicant chooses an Authority other than this one to be the IPEA and the chosen IPEA has notified the International Bureau under Rule 66.1bis(b) that written opinions of this International Searching Authority will not be so considered.

If this opinion is, as provided above, considered to be a written opinion of the IPEA, the applicant is invited to submit to the IPEA a written reply together, where appropriate, with amendments, before the expiration of 3 months from the date of mailing of Form PCT/ISA/220 or before the expiration of 22 months from the priority date, whichever expires later.
For further options, see Form PCT/ISA/220.

Name and mailing address of the ISA/KR	Date of completion of this opinion	Authorized officer
Korean Intellectual Property Office 189 Cheongsa-ro, Seo-gu, Daejeon Metropolitan City, 302-701, Republic of Korea Facsimile No. +82-42-472-7140	05 August 2013 (05.08.2013)	KIM Jin Ho Telephone No. +82-42-481-8699

Form PCT/ISA/237 (cover sheet) (July 2011)

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/035726

Box No. I Basis of this opinion

1. With regard to the **language**, this opinion has been established on the basis of :

   ☒ the international application in the language in which it was filed

   ☐ a translation of the international application into _____ , which is the language of a translation furnished for the purposes of international search (Rules 12.3(a) and 23.1(b))

2. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 43*bis*.1(a))

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, this opinion has been established on the basis of:

   a. a sequence listing filed or furnished
      ☐ on paper
      ☐ in electronic form

   b. time of filing or furnishing
      ☐ contained in the international application as filed.
      ☐ filed together with the international application in electronic form.
      ☐ furnished subsequently to this Authority for the purposes of search.

4. ☐ In addition, in the case that more than one version or copy of a sequence listing has been filed or furnished, the required statements that the information in the subsequent or additioanl copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.

5. Additional comments:

WRITTEN OPINION OF THE INTERNATIONAL SEARCHING AUTHORITY

International application No.
PCT/US2013/035726

Box No. V Reasoned statement under Rule 43bis.1(a)(i) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-18	YES
	Claims	NONE	NO
Inventive step (IS)	Claims	1-18	YES
	Claims	NONE	NO
Industrial applicability (IA)	Claims	1-18	YES
	Claims	NONE	NO

2. Citations and explanations :

Reference is made to the following documents:

D1: JP 2010-286218 A (MITSUBISHI HEAVY IND. LTD.) 24 December 2010
D2: KR 10-1999-0070368 A (SAMSUNG ELECTRONICS CO., LTD.) 15 September 1999
D3: JP 05-189659 A (HITACHI BILL SHISETSU ENG. KK.) 30 July 1993
D4: JP 2010-038377 A (MITSUBISHI HEAVY IND. LTD.) 18 February 2010
D5: S 6786421 B2 (ROSEN, HOWARD) 07 September 2004

1. Novelty and Inventive Step

1.1 Independent claim 1

None of the documents D1-D5 teach or fairly suggest a system for allocating the cost of operating an HVAC system comprising a thermostatic controller configured to turn on or off a first component associated with an individual unit of occupancy based on temperature reading from an inside of the individual unit of occupancy. Accordingly, claim 1 is not anticipated by any of the documents, nor is it obvious to a person skilled in the art by the documents, taken alone or in combination. Therefore, claim 1 is novel and involves an inventive step under PCT Article 33(2) and (3).

1.2 Dependent claims 2-9

Claims 2-9 are directly or indirectly dependent on claim 1 and therefore meet the requirements of PCT Article 33(2) and (3).

Continued on Supplemental Box

Ex. 1006.0451

Supplemental Box

In case **the space in any of the preceding boxes is not sufficient.**
Continuation of : Box No. V

1.3 Independent claim 10

Claim 10 concerns a method for allocating the cost of operating an HVAC system, but it has the same technical features as claim 1. Thus, the same reasoning applies to claim 10. Therefore, claim 10 is novel and involves an inventive step under PCT Article 33(2) and (3).

1.4 Dependent claims 11-18

Claims 11-18 are directly or indirectly dependent on claim 10 and therefore meet the requirements of PCT Article 33(2) and (3).

2. Industrial Applicability

Claims 1-18 meet the requirement of industrial applicability under PCT Article 33(4).

REMARKS

The November 16, 2016 Office Action was based upon pending Claims 2-21. This Amendment amends Claims 2 and 12. Thus, after entry of this Amendment, Claims 2-21 are pending and presented for further consideration.

ISSUES RAISED IN THE OFFICE ACTION

The pending claims were rejected under obviousness-type double patenting.

Claims 2-10 and 12-20 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 8,428,782 to Imes (hereinafter "Imes").

Claims 11 and 21 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Imes.

REJECTION OF CLAIMS FOR OBVIOUSNESS-TYPE DOUBLE PATENTING

The Examiner rejected the pending claims under obviousness-type double patenting as being unpatentable over the claims of U.S. Patent Nos. 8,556,188 and 8,840,033.

In response, Applicant submits herewith a Terminal Disclaimer in compliance with 37 C.F.R. §1.321(b) and (c). Accordingly, Applicant respectfully requests that the obviousness-type double patenting rejection be withdrawn.

REJECTION OF CLAIMS 2-10 AND 12-20 UNDER 35 U.S.C. § 102(e)

Claims 2-10 and 12-20 were rejected under 35 U.S.C. § 102(e) as being anticipated by U.S. Patent No. 8,428,782 to Imes.

Claims 2 and 12

Applicant submits that amended Claims 2 and 12 are different than the cited references for at least the following reasons:

1) Obtaining a measurement from within the structure and predicting a length of time to reach a desired temperature; and

2) Adjusting the temperature setpoint of an HVAC system based at least in part on the predicted length of time to reach the desired temperature, and upon the predicted length of time for a user to reach the structure.

Imes in contrast fails to teach these concepts. In particular, Imes does not predict a length of time that is needed for a structure to reach a desired temperature.

In addition, Imes does not adjust the temperature setpoint of an HVAC system based on a) the predicted length of time that is needed for a structure to reach a desired temperature and b) upon the predicted length of time for a user of a mobile device to reach the structure.

Accordingly, Applicant respectfully submits that amended Claims 2 and 3 are patentable in light of Imes.

Claims 3-10

Claims 3-10 depend from amended Claim 2 and are believed to be patentable for the same reasons articulated above with respect to amended Claim 2, and because of the additional features recited therein.

Claims 13-21

Claims 13-20 depend from amended Claim 12 and are believed to be patentable for the same reasons articulated above with respect to amended Claim 12, and because of the additional features recited therein.

REJECTION OF CLAIMS 11 AND 21 UNDER 35 U.S.C. § 103(a)

Claims 11 and 21 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Imes.

Claim 11

Applicant notes that Claim 11 depends from amended Claim 2 and is believed to be patentable for the same reasons articulated above with respect to amended Claim 2, and because of the additional features recited therein.

Claim 21

Applicant notes that Claim 21 depends from amended Claim 12 and is believed to be patentable for the same reasons articulated above with respect to amended Claim 12, and because of the additional features recited therein.

OTHER APPLICATIONS OF ASSIGNEE

Applicant wishes to draw the Examiner's attention to the following applications owned by of the present application's assignee:

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	60/963,183 Now Expired	08/03/07	EFACT.003PR	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	60/944,011 Now Expired	09/17/07	EFACT.005PR	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	12/183,949 Now Pat. 7,908,116	07/31/08	EFACT.004A	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	12/183,990 Now Pat. 7,908,117	07/31/08	EFACT.003A	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	12/211,690 Now Pat. 8,019,567	09/16/08	EFACT.006A	System And Method For Evaluating Changes In The Efficiency Of An HVAC System
Steinberg et al.	12/211,733 Now Pat. 7,848,900	09/16/08	EFACT.005A	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	61/215,657 Now Expired	05/08/09	EFACT.009PR	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg	61/215,816 Now Expired	05/11/09	EFACT.008PR	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	61/215,999 Now Expired	05/12/09	EFACT.007PR	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Cheung et al.	12/498,142 Now Pat. 8,010,237	07/06/09	EFACT.010A	System And Method For Using Ramped Setpoint Temperature Variation With Networked Thermostats To Improve Efficiency
Steinberg	12/502,064 Now Pat. 8,180,492	07/13/09	EFACT.011A	System And Method For Using A Networked Electronic Device As An Occupancy Sensor For An Energy Management System
Steinberg et al.	12/773,690 Now Pat. 8,498,753	05/04/10	EFACT.009A	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg	12/774,580 Now Pat. 8,740,100	05/05/10	EFACT.008A	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption
Steinberg et al.	12/778,052 Now Pat. 8,596,550	05/11/10	EFACT.007A	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Steinberg	12/788,246 Now Pat. 8,556,188	05/26/10	EFACT.012A	System And Method For Using A Mobile Electronic Device To Optimize An Energy Management System
Steinberg	12/860,821 Now Pat. 8,090,477	08/20/10	EFACT.013A	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	12/959,225 Now Pat. 8,131,497	12/02/10	EFACT.005C1	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	13/037,162 Now Pat. 8,131,506	02/28/11	EFACT.004C1	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Cheung et al.	13/219,381 Now Pat. 9,134,710	08/26/11	EFACT.010C1	System And Method For Using Ramped Setpoint Temperature Variation With Networked Thermostats To Improve Efficiency

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	13/230,610 Now Pat. 8,423,322	09/12/11	EFACT.006C1	System And Method For Evaluating Changes In The Efficiency Of An HVAC System
Steinberg	13/329,117 Now Pat. 8,340,826	12/16/11	EFACT.013C1	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	13/409,697 Now Pat. 8,412,488	03/01/12	EFACT.004C2	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	13/409,729 Now Pat. 8,886,488	03/01/12	EFACT.005C2	System And Method For Calculating The Thermal Mass Of A Building
Steinberg	13/470,074 Now Pat. 9,244,470	05/11/12	EFACT.011C1	System And Method For Using A Wireless Device As A Sensor For An Energy Management System
Hublou et al.	13/523,697 Published 2013/0338837	06/14/12	EFACT.014A	System And Method For Optimizing Use Of Individual HVAC Units In Multi-Unit Chiller-Based Systems
Steinberg	13/725,447 Now Pat. 8,712,590	12/21/12	EFACT.013C2	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	13/852,577 Now Pat. 8,738,327	03/28/13	EFACT.004C3	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg et al.	13/858,710 Now Pat. 8,751,186	04/08/13	EFACT.005C3	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	13/861,189 Now Pat. 9,057,649	04/11/13	EFACT.006C2	System And Method For Evaluating Changes In The Efficiency Of An HVAC System
Steinberg et al.	13/952,253 Abandoned	07/26/13	EFACT.009C1	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg	14/048,932 Now Pat. 8,840,033	10/08/13	EFACT.012C1	System And Method For Using A Mobile Electronic Device To Optimize An Energy Management System

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg et al.	14/082,675 Now Pat. 9,194,597	11/18/13	EFACT.007C1	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Steinberg	14/263,762 Now Pat. 9,188,994	04/28/14	EFACT.013C3	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg et al.	14/285,384 Published 2015/0043615	05/22/14	EFACT.004C4	System And Method For Using A Network Of Thermostats As Tool To Verify Peak Demand Reduction
Steinberg	14/292,377 Now Pat. 9,279,594	05/30/14	EFACT.008C1	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption
Steinberg	14/491,554 Published 2015/0168001	09/19/14	EFACT.012C2	System And Method For Using A Mobile Electronic Device To Optimize An Energy Management System
Steinberg et al.	14/527,433 Abandoned	10/29/14	EFACT.005C4	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	14/731,221 Published As 2015/0345822	06/04/15	EFACT.006C3	System And Method For Evaluating Changes In The Efficiency Of An HVAC System
Cheung et al.	14/842,134 Published As 2016/0061474	09/01/15	EFACT.010C2	System And Method For Using Ramped Setpoint Temperature Variation With Networked Thermostats To Improve Efficiency
Steinberg et al.	14/878,872 Published As 2016/0091219	10/08/15	EFACT.007C2	System, Method And Apparatus For Identifying Manual Inputs To And Adaptive Programming Of A Thermostat
Steinberg	14/920,063 Published As 2016/0097557	10/22/15	EFACT.013C4	System And Method For Optimizing Use Of Plug-In Air Conditioners And Portable Heaters
Steinberg	15/002,791 Published As 2016/0138822	01/21/16	EFACT.011C2	System And Method For Using A Wireless Device As A Sensor For An Energy Management System

Inventors	Appl. No.	Filing Date	Attorney Docket No.	Title
Steinberg	15/047352 Published As 2016/0238270	02/18/16	EFACT.008C2	System, Method And Apparatus For Dynamically Variable Compressor Delay In Thermostat To Reduce Energy Consumption
Steinberg et al.	15/060,226 Published As 2016/0258822	03/03/16	EFACT.005C5	System And Method For Calculating The Thermal Mass Of A Building
Steinberg et al.	15/097,078	04/12/16	EFACT.009C2	System, Method And Apparatus For Just-In-Time Conditioning Using A Thermostat
Steinberg et al.	15/426,882	02/07/17	EFACT.005C6	System And Method For Calculating The Thermal Mass Of A Building

Applicant notes that cited references, office actions, responses and notices of allowance currently exist or will exist for the above-referenced matters. Applicant also understands that the Examiner has access to sophisticated online Patent Office computing systems that provide ready access to the full file histories of these matters including, for example, specifications, drawings, pending claims, cited art, office actions, responses, declarations, and notices of allowance.

Rather than submit copies these file histories, Applicant respectfully requests that the Examiner continue to review these file histories online for past, current, and future information about these matters. Also, if the Examiner cannot readily access these file histories, the Applicant would be pleased to provide any portion of any of the file histories at any time upon specific Examiner request.

SUPPLEMENTAL INFORMATION DISCLOSURE STATEMENT

Submitted concurrently herewith is a Supplemental Information Disclosure Statement citing references for consideration. Applicant respectfully requests the Examiner to consider the pending claims in connection with these references in order to make the references of record.

NO DISCLAIMERS OR DISAVOWALS

Although the present communication may include alterations to the application or claims, or characterizations of claim scope or referenced art, Applicant is not conceding in this application that previously pending claims are not patentable over the cited references. Rather, any alterations or characterizations are being made to facilitate expeditious prosecution of this application.

Applicant reserves the right to pursue at a later date any previously pending or other broader or narrower claims that capture any subject matter supported by the present disclosure, including subject matter found to be specifically disclaimed herein or by any prior prosecution. Accordingly, reviewers of this or any parent, child or related prosecution history shall not reasonably infer that Applicant has made any disclaimers or disavowals of any subject matter supported by the present application.

CONCLUSION

Applicant has endeavored to address all of the Examiner's concerns as expressed in the outstanding Office Action. In light of the above remarks, reconsideration and withdrawal of the outstanding rejections is specifically requested.

Please charge any additional fees, including any fees for additional extension of time, or credit overpayment to Deposit Account No. 11-1410.

Respectfully submitted,

KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: February 15, 2017

By:/John R. King/
John R. King
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AMENDMENTS TO THE CLAIMS

Please amend Claims 2 and 12 as indicated below.

1. (Canceled)

2. (Currently Amended) A method for adjusting at least one temperature setpoint of an HVAC system associated with a structure, the method comprising:

associating the at least one mobile electronic device with the structure;

receiving with one or more computer processors, the geographic location of the at least one mobile electronic device;

receiving with one or more computer processors, at least a measurement of a temperature obtained from within the structure and predicting a length of time to reach a desired temperature;

using traffic data to predict a length of time for a user of the at least one mobile electronic device to reach the structure; and

adjusting with one or more computer processors, at least one temperature setpoint of an HVAC system associated with the structure based at least in part upon the predicted length of time to reach the desired temperature and upon the predicted length of time for a user of the mobile electronic device to reach the structure.

3. (Previously Presented) The method of claim 2 further comprising using geospatial data associated with the mobile electronic device to increase the predicted length of time to reach the structure based on characteristics of a location the user has stopped at before reaching the structure.

4. (Previously Presented) The method of claim 2 wherein the mobile electronic device is a telephone.

5. (Previously Presented) The method of claim 2 wherein the mobile electronic device is connected to the Internet.

6. (Previously Presented) The method of claim 2 wherein the geographic location of a mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from the mobile electronic device.

7. (Previously Presented) The method of claim 2 wherein the one or more processors comprise a remote server that is remotely located from the structure.

8. (Previously Presented) The method of claim 2 wherein adjusting the at least one temperature setpoint is logged to a database.

9. (Previously Presented) The method of claim in 2 wherein adjusting the at least one temperature setpoint is initiated by a remote computer.

10. (Previously Presented) The method of claim 2 wherein adjusting the at least one temperature setpoint occurs automatically.

11. (Previously Presented) The method of claim 2 wherein the user is prompted to confirm occupancy of the structure prior to adjustment of the at least one temperature setpoint.

12. (Currently Amended) A system for adjusting at least one temperature setpoint of an HVAC system associated with a structure, the system comprising:

one or more computer processors that associate at least one mobile electronic device with the structure;

the one or more computer processors receive a geographic location of the at least one mobile electronic device;

the one or more computer processors receive at least a measurement of a temperature obtained from within the structure and predict a length of time to reach a desired temperature;

the one or more computer processors use traffic data to predict a length of time for a user of the at least one mobile electronic device to reach the structure; and

the one or more computer processors adjust at least one temperature setpoint associated with the structure based at least in part upon the predicted length of time to reach the desired temperature, and at least in part upon the predicted length of time for a user of the mobile electronic device to reach the structure.

13. (Previously Presented) The method of claim 12 wherein the one or more processors use geospatial data associated with the mobile electronic unit to increase the predicted length of time to reach the structure based on characteristics of a location the user has stopped at before reaching the structure.

14. (Previously Presented) The system of claim 12 wherein the mobile electronic device is a telephone.

15. (Previously Presented) The system of claim 12 wherein the mobile electronic device is connected to the Internet.

16. (Previously Presented) The system of claim 12 wherein the geographic location of the mobile electronic device is based upon estimation of the distance between the mobile electronic device and one or more antennas used to receive radio signals from the mobile electronic device.

17. (Previously Presented) The system of claim 12 wherein the one or more computer processors comprise a remote server that is remotely located from the structure.

18. (Previously Presented) The system of claim 12 wherein adjustment of the at least one temperature setpoint is logged to a database.

19. (Previously Presented) The system of claim in 12 wherein adjustment of the at least one temperature setpoint is initiated by a remote computer.

20. (Previously Presented) The system of claim 12 wherein the at least one temperature setpoint is adjusted automatically.

21. (Previously Presented) The system of claim 12 wherein the user is prompted to confirm occupancy prior to adjustment of the at least one temperature setpoint.

PTO/SB/06 (09-11)
Approved for use through 1/31/2014. OMB 0651-0032
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
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PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 14/491,554	Filing Date 09/19/2014	☐ To be Mailed

ENTITY: ☐ LARGE ☒ SMALL ☐ MICRO

APPLICATION AS FILED – PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE ($)	FEE ($)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 =	*	X $ =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 =	*	X $ =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is $310 ($155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED – PART II

AMENDMENT **02/15/2017**

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	* 20	Minus	** 20	= 0	X $40 =	0
Independent (37 CFR 1.16(h))	* 2	Minus	***3	= 0	X $210 =	0
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	0

AMENDMENT

	(Column 1) CLAIMS REMAINING AFTER AMENDMENT		(Column 2) HIGHEST NUMBER PREVIOUSLY PAID FOR	(Column 3) PRESENT EXTRA	RATE ($)	ADDITIONAL FEE ($)
Total (37 CFR 1.16(i))	*	Minus	**	=	X $ =	
Independent (37 CFR 1.16(h))	*	Minus	***	=	X $ =	
☐ Application Size Fee (37 CFR 1.16(s))						
☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))						
					TOTAL ADD'L FEE	

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.

LIE
SHIRELL M. CARMICHAEL

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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NOTICE OF ALLOWANCE AND FEE(S) DUE

20995 7590 03/13/2017

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EXAMINER	
NORMAN, MARC E	
ART UNIT	PAPER NUMBER
3744	

DATE MAILED: 03/13/2017

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2	1254

TITLE OF INVENTION: SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	06/13/2017

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 1/2 the amount of undiscounted fees, and micro entity fees are 1/2 the amount of small entity fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

Ex. 1006.0466

PART B - FEE(S) TRANSMITTAL

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or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20995 7590 03/13/2017
KNOBBE MARTENS OLSON & BEAR LLP
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IRVINE, CA 92614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2	1254

TITLE OF INVENTION: SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	06/13/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS
NORMAN, MARC E	3744	236-051000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
- ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
1 _____
2 _____
3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE (B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The director is hereby authorized to charge the required fee(s), any deficiency, or credits any overpayment, to Deposit Account Number _____ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ Applicant certifying micro entity status. See 37 CFR 1.29 — NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
- ❑ Applicant asserting small entity status. See 37 CFR 1.27 — NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
- ❑ Applicant changing to regular undiscounted fee status. — NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____ Date _____

Typed or printed name _____ Registration No. _____

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Ex. 1006.0467

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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2	1254

20995 7590 03/13/2017

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
NORMAN, MARC E	

ART UNIT	PAPER NUMBER
3744	

DATE MAILED: 03/13/2017

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 14/491,554	Applicant(s) STEINBERG, JOHN DOUGLAS	
	Examiner MARC NORMAN	Art Unit 3744	AIA (First Inventor to File) Status No

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *amendment filed 2/15/17*.
   ☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on_____.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *2-21*. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

   Certified copies:

   a) ☐ All b) ☐ Some *c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
4. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
5. ☐ Examiner's Amendment/Comment
6. ☐ Examiner's Statement of Reasons for Allowance
7. ☐ Other _____.

/MARC NORMAN/
Primary Examiner, Art Unit 3744

Notice of References Cited	Application/Control No. 14/491,554	Applicant(s)/Patent Under Reexamination STEINBERG, JOHN DOUGLAS	
	Examiner MARC NORMAN	Art Unit 3744	Page 1 of 1

U.S. PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
*	A	US-2013/0073094 A1	03-2013	Knapton; Cary	F24F11/0034	700/278
	B	US-				
	C	US-				
	D	US-				
	E	US-				
	F	US-				
	G	US-				
	H	US-				
	I	US-				
	J	US-				
	K	US-				
	L	US-				
	M	US-				

FOREIGN PATENT DOCUMENTS

*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Country	Name	CPC Classification
	N					
	O					
	P					
	Q					
	R					
	S					
	T					

NON-PATENT DOCUMENTS

*		Include as applicable: Author, Title Date, Publisher, Edition or Volume, Pertinent Pages)
	U	
	V	
	W	
	X	

*A copy of this reference is not being furnished with this Office action. (See MPEP § 707.05(a).)
Dates in MM-YYYY format are publication dates. Classifications may be US or foreign.

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Norman, Marc E.
SHEET 1 OF 2	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	12/805705	06/10/2010	Crabtree	
	2	13/729401	12/28/2012	Sloop	
	3	14/731,221	06/04/2015	Steinberg, et al.	
	4	4,451,879	05/29/1984	Welch et al.	
	5	4,675,828	06/23/1987	Winston	
	6	4,897,798	01/30/1990	Cler	
	7	5,279,458	01/18/1994	Dewolf et al.	
	8	5,348,078	09/20/1994	Dushane et al.	
	9	6,700,224	03/02/2004	Biskup, Sr.,	
	10	7,206,670	04/17/2007	Pimputkar, et al.	
	11	7,590,469	09/15/2009	Grohman	
	12	8,428,785	04/23/2013	Boucher et al.	
	13	8,498,753 (EFACT.009A)	07/30/2013	Steinberg et al.	
	14	8,850,348	09/30/2014	Fadell et al.	
	15	9,057,649 (EFACT.006C2)	06/16/2015	Steinberg, et al.	
	16	9,134,710 (EFACT.010C1)	09/15/2015	Cheung et al.	
	17	9,194,597 (EFACT.007C1)	11/24/2015	Steinberg, et al.	
	18	9,244,470 (EFACT.011C1)	01/26/2016	Steinberg	
	19	9,279,594 (EFACT.008C1)	03/08/2016	Steinberg	
	20	2004/0065095	04/08/2004	Osborne et al.	
	21	2006/0283965	12/21/2006	Mueller et al.	
	22	2009/0188985	07/30/2009	Scharing et al.	
	23	2012/0186774	07/26/2012	Matsuoka et al.	
	24	2013/0173064	07/04/2013	Fadell et al.	
	25	2013/0178985	07/11/2013	Lombard et al.	
	26	2014/0058567	02/27/2014	Matsuoka et al.	
	27	2014/0229018 (EFACT.013C3)	08/20/2014	Steinberg	

Examiner Signature	/MARC E NORMAN/	Date Considered	03/01/2017

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.E.N/

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Norman, Marc E.
SHEET 2 OF 2	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	28	2014/0316581	10/26/2014	Fadell et al.	
	29	2016/0061474 (EFACT.010C2)	03/03/2016	Cheung et al.	
	30	2016/0091219 (EFACT.007C2)	03/31/2016	Steinberg et al.	
	31	2016/0097557 (EFACT.013C4)	04/07/2016	Steinberg	
	32	2016/0138822 (EFACT.011C2)	05/19/2016	Steinberg	
	33	2016/0238270	08/18/2016	Steinberg	
	34	2016/0258822	09/08/2016	Steinberg et al.	
	35	2016/0363337	12/15/2016	Steinberg et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	36	WO 2005/098331 A1	10/20/2005	Zip Ind Aust Pty Ltd.		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	37	CHENG et al., "Smart Sensors Enable Smart Air Conditioning Control", Sensors 2014, ISSN 1424-8220, June 24, 2014, 25 pages.	
	38	GUNES et al., "Improving Energy Efficiency and Thermal Comfort of Smart Buildings with HVAC Systems in the Presence of Sensor Faults", IEEE, August 24-26, 2015, 6 pages.	
	39	SIMMINI et al., Energy Efficient Control and Fault Detection for HVAC Systems, Univ. of Padova, XXVI Series, 2014, 144 pages.	
	40	SKLAVOUNOS, "Detection of Abnormal Situations and Energy Efficiency Control in Heating Ventilation and Air Conditioning (HVAC) Systems", Brunel University thesis, September 2015,151 pages.	
	41	International Preliminary Report on Patentability in PCT/US2013/035726 dated 12/16/2014 (EFACT.014WO).	
	42	Extended Search Report for European Application No. 13804057.1 dated June 1, 2016 (EFACT.014EP).	

25213396

Examiner Signature	/MARC E NORMAN/	Date Considered	03/01/2017

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.E.N/

Search Notes	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	Art Unit
	MARC NORMAN	3744

CPC- SEARCHED		
Symbol	Date	Examiner
F24F 11/0034, 006, 0086; 2001/0058, 0071, 0075, 0091	10/20/16	MN
G05D 23/1905, 1951	10/20/16	MN
H04Q 9/00; 2209/40, 84	10/20/16	MN
updated above	3/1/17	MN

CPC COMBINATION SETS - SEARCHED		
Symbol	Date	Examiner

US CLASSIFICATION SEARCHED			
Class	Subclass	Date	Examiner

SEARCH NOTES		
Search Notes	Date	Examiner
Inventor name search	10/20/16	MN
reviewed prosecution of parent applications	10/20/16	MN

INTERFERENCE SEARCH			
US Class/ CPC Symbol	US Subclass / CPC Group	Date	Examiner
	EAST interference search (see attached)	3/1/17	MN

Index of Claims	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	**Art Unit**
	MARC NORMAN	3744

✓	Rejected	-	Cancelled	N	Non-Elected	A	Appeal
=	Allowed	÷	Restricted	I	Interference	O	Objected

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47

CLAIM		DATE								
Final	Original	10/20/2016	03/01/2017							
	1	-	-							
	2	✓	=							
	3	✓	=							
	4	✓	=							
	5	✓	=							
	6	✓	=							
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	18	✓	=							
	19	✓	=							
	20	✓	=							
	21	✓	=							

EAST Search History

EAST Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	Time Stamp
S1	157	(temperature adj2 (setpoint or (set adj point))) and (predict$3 near3 time) and traffic	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 13:09
S2	12	(temperature adj2 (setpoint or (set adj point))) and (predict$3 near3 time near3 temperature) and traffic	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 13:09
S3	0	((temperature adj2 (setpoint or (set adj point))) and (predict$3 near3 time near3 temperature) and traffic).clm.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 13:10
S4	0	(temperature adj2 (setpoint or (set adj point))) and (predict$3 near3 time near3 temperature) and (traffic near3 time)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 13:21
S5	1	(temperature adj2 (setpoint or (set adj point))) and (predict$3 near3 time near3 temperature) and (traffic with time)	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 13:21
S6	6258	f24f11/0034,006,0086.cpc.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 13:22
S7	3429	f24f2011/0058,0071,0075,0091.cpc.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 14:08
S8	1134	g05d23/1905,1951.cpc.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 14:10
S9	7351	(h04q9/00 or ho4q2209/40,84).cpc.	US-PGPUB; USPAT; EPO; JPO; DERWENT	OR	ON	2017/03/01 15:15

3/1/2017 4:03:47 PM
C:\Users\mnorman1\Documents\EAST\Workspaces\14491554int.wsp

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	**Art Unit**
	MARC NORMAN	3744

CPC						
Symbol					**Type**	**Version**
F24F		11	/	0034	F	2013-01-01
H04Q		9	/	00	I	2013-01-01
H04Q		2209	/	40	A	2013-01-01
H04Q		2209	/	84	A	2013-01-01
G05D		23	/	1951	I	2013-01-01
G05D		23	/	1905	I	2013-01-01
F24F		11	/	006	I	2013-01-01
F24F		11	/	0086	I	2013-01-01
F24F		2011	/	0071	A	2013-01-01
F24F		2011	/	0075	A	2013-01-01
F24F		2011	/	0091	A	2013-01-01
F24F		2011	/	0058	A	2013-01-01
			/			
			/			
			/			

CPC Combination Sets							
Symbol				**Type**	**Set**	**Ranking**	**Version**
			/				
			/				

NONE		**Total Claims Allowed:**	
(Assistant Examiner)	(Date)	20	
/MARC NORMAN/ Primary Examiner.Art Unit 3744	03/01/2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	**Art Unit**
	MARC NORMAN	3744

US ORIGINAL CLASSIFICATION		INTERNATIONAL CLASSIFICATION										
CLASS	SUBCLASS	CLAIMED					NON-CLAIMED					
		F	2	4	F	11 / 00 (2006.01.01)						
CROSS REFERENCE(S)		G	0	5	D	23 / 19 (2006.01.01)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)											

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/MARC NORMAN/ Primary Examiner.Art Unit 3744	03/01/2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

Issue Classification	Application/Control No.	Applicant(s)/Patent Under Reexamination
	14491554	STEINBERG, JOHN DOUGLAS
	Examiner	**Art Unit**
	MARC NORMAN	3744

☒ Claims renumbered in the same order as presented by applicant ☐ CPA ☒ T.D. ☐ R.1.47

Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original	Final	Original

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	20	
/MARC NORMAN/ Primary Examiner.Art Unit 3744	03/01/2017	O.G. Print Claim(s)	O.G. Print Figure
(Primary Examiner)	(Date)	1	1

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20995 7590 03/13/2017
KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission
I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2	1254

TITLE OF INVENTION: SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	SMALL	$480	$0	$0	$480	06/13/2017

EXAMINER	ART UNIT	CLASS-SUBCLASS
NORMAN, MARC E	3744	236-051000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,
(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

1 Knobbe, Martens,
2 Olson & Bear, LLP
3

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE: EcoFactor, Inc.

(B) RESIDENCE: (CITY and STATE OR COUNTRY): Redwood City, CA

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☒ Corporation or other private group entity ☐ Government

4a. The following fee(s) are submitted:
☒ Issue Fee
☐ Publication Fee (No small entity discount permitted)
☐ Advance Order - # of Copies _____

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
☐ A check is enclosed.
☐ Payment by credit card. Form PTO-2038 is attached.
☒ The director is hereby authorized to charge ~~the required fee(s),~~ any deficiency, or credits any overpayment, to Deposit Account Number 11-1410 (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
☐ Applicant certifying micro entity status. See 37 CFR 1.29
NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.
☐ Applicant asserting small entity status. See 37 CFR 1.27
NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.
☐ Applicant changing to regular undiscounted fee status.
NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /John R. King/ Date June 7, 2017
Typed or printed name John R. King Registration No. 34,362

PTOL-85 Part B (10-13) Approved for use through 10/31/2013. OMB 0651-0033 U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE

Ex. 1006.0480

INFORMATION DISCLOSURE STATEMENT

First Inventor	:	John Douglas Steinberg
App. No.	:	14/491,554
Filed	:	September 19, 2014
For	:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
Examiner	:	Norman, Marc E.
Art Unit	:	3744
Conf. No.	:	1254

Mail Stop Issue Fee
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

References and Listing

Pursuant to 37 CFR 1.56, an Information Disclosure Statement listing references is provided herewith. Copies of any listed foreign and non-patent literature references are being submitted.

No Disclaimers

To the extent that anything in the Information Disclosure Statement or the listed references could be construed as a disclaimer of any subject matter supported by the present application, Applicant hereby rescinds and retracts such disclaimer.

Timing of Disclosure

This Information Disclosure Statement is being filed after the mailing date of a final action or after the mailing date of a Notice of Allowance. Please place these references in the file in accordance with 37 CFR 1.97(i).

Respectfully submitted,
KNOBBE, MARTENS, OLSON & BEAR, LLP

Dated: June 7, 2017

By:/John R. King/
John R. King
Registration No. 34,362
Registered Practitioner
Customer No. 20,995
(949) 760-0404

26073668

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Norman, Marc E.
SHEET 1 OF 1	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	2009/0005070	01/01/2009	Forstall et al.	
	2	2015/0025691	01/22/2015	Fadell et al.	
	3	2015/0043615 (EFACT.004C4)	02/12/2015	Steinberg et al.	
	4	2015/0120235 (EFACT.005C4)	04/30/2015	Steinberg et al.	
	5	2015/0142180	05/21/2015	Matsuoka et al.	

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	**T**[1]

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	**T**[1]
	6	Office Action in Canadian Application No. 2800491, dated December 7, 2016 (EFACT.012CA).	
	7	Examination Report in Australian Application No. 2013274827, dated April 11, 2017 (EFACT.014AU).	

26073623

Examiner Signature	Date Considered
***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.	

T[1] - Place a check mark in this area when an English language Translation is attached.

Electronic Patent Application Fee Transmittal

Application Number:	14491554
Filing Date:	19-Sep-2014
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Filer:	John R. King/Amy Durrant
Attorney Docket Number:	EFACT.012C2

Filed as Small Entity

Filing Fees for Utility under 35 USC 111(a)

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Basic Filing:				
Pages:				
Claims:				
Miscellaneous-Filing:				
Petition:				
Patent-Appeals-and-Interference:				
Post-Allowance-and-Post-Issuance:				
UTILITY APPL ISSUE FEE	2501	1	480	480

Description	Fee Code	Quantity	Amount	Sub-Total in USD($)
Extension-of-Time:				
Miscellaneous:				
			Total in USD ($)	**480**

Electronic Acknowledgement Receipt	
EFS ID:	29427640
Application Number:	14491554
International Application Number:	
Confirmation Number:	1254
Title of Invention:	SYSTEM AND METHOD FOR USING A MOBILE ELECTRONIC DEVICE TO OPTIMIZE AN ENERGY MANAGEMENT SYSTEM
First Named Inventor/Applicant Name:	John Douglas Steinberg
Customer Number:	20995
Filer:	John R. King/Tony Do
Filer Authorized By:	John R. King
Attorney Docket Number:	EFACT.012C2
Receipt Date:	07-JUN-2017
Filing Date:	19-SEP-2014
Time Stamp:	17:39:11
Application Type:	Utility under 35 USC 111(a)

Payment information:

Submitted with Payment	yes
Payment Type	CARD
Payment was successfully received in RAM	$480
RAM confirmation Number	060817INTEFSW17400400
Deposit Account	111410
Authorized User	tony do
The Director of the USPTO is hereby authorized to charge indicated fees and credit any overpayment as follows: 37 CFR 1.16 (National application filing, search, and examination fees) 37 CFR 1.17 (Patent application and reexamination processing fees)	

File Listing:

Document Number	Document Description	File Name	File Size(Bytes)/ Message Digest	Multi Part /.zip	Pages (if appl.)
1	Issue Fee Payment (PTO-85B)	EFACT-012C2_issuefee.pdf	85873 173675a5c71cf49739adeaf897520adde97d1509	no	1
Warnings:					
Information:					
2		EFACT-012C2_IDS.pdf	68231 62af70f1194f0d350404f3631b31bc49ae18486d	yes	2

	Multipart Description/PDF files in .zip description		
	Document Description	**Start**	**End**
	Transmittal Letter	1	1
	Information Disclosure Statement (IDS) Form (SB08)	2	2

Warnings:					
Information:					
3	Non Patent Literature	EFACT-012C2_ref6.pdf	321513 856de7aef4af43e9a9c6d6fd431a9ba261d2bda1	no	6
Warnings:					
Information:					
4	Non Patent Literature	EFACT-012C2_ref7.pdf	159588 3c81407a4453d13172090219487e53b6e143ebf9	no	3
Warnings:					
Information:					
5	Fee Worksheet (SB06)	fee-info.pdf	30722 4caa286fce128c57df5e82dfc1113bc07456c12a	no	2
Warnings:					
Information:					

Total Files Size (in bytes):	665927

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for a filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
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Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	09/19/2014	John Douglas Steinberg	EFACT.012C2	1254

7590 06/12/2017

KNOBBE MARTENS OLSON & BEAR LLP
2040 MAIN STREET
FOURTEENTH FLOOR
IRVINE, CA 92614

EXAMINER	
NORMAN, MARC E	

ART UNIT	PAPER NUMBER
3744	

NOTIFICATION DATE	DELIVERY MODE
06/12/2017	ELECTRONIC

NOTICE OF NON-COMPLIANT INFORMATION DISCLOSURE STATEMENT

An Information Disclosure Statement (IDS) filed 06.07.2017 in the above-identified application fails to meet the requirements of 37 CFR 1.97(d) for the reason(s) specified below. Accordingly, the IDS will be placed in the file, but the information referred to therein has not been considered.

The IDS is not compliant with 37 CFR 1.97(d) because:

☒ The IDS lacks a statement as specified in 37 CFR 1.97(e).

☐ The IDS lacks the fee set forth in 37 CFR 1.17(p).

☐ The IDS was filed after the issue fee was paid. Applicant may wish to consider filing a petition to withdraw the application from issue under 37 CFR 1.313(c) to have the IDS considered. See MPEP 1308.

/bc/ Bernice Crittenden

571-272-4200 or 1-888-786-0101
Application Assistance Unit
Office of Data Management

FORM PTOM327-B (Rev. 02/08)

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 8 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	197	2013/0226502 (EFACT.006C2)	08/29/2013	Steinberg, et al.	
	198	2013/0310989 (EFACT.009C1)	11/21/2013	Steinberg et al.	
	199	2013/0338837 (EFACT.014A)	12/19/2013	Hublou et al.	
	200	2014/0039690 (EFACT.012C1)	02/06/2014	Steinberg	
	201	2014/0188290 (EFACT.007C1)	07/03/2014	~~EcoFactor, Inc.~~ Steinberg et al.	

Change(s) applied to document, /S.J.W./ 3/17/2017

FOREIGN PATENT DOCUMENTS						
Examiner Initials	Cite No.	Foreign Patent Document *Country Code-Number-Kind Code* Example: JP 1234567 A1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear	T[1]
	202	EP 0415747 A2	03/06/1991	Shaw et al.		
	203	JP 05-189659	07/30/1993	Hitachi Bill Shisetsu Eng. KK.		
	204	JP 2010-038377	02/18/2010	Mitsubishi Heavy Ind. Ltd.		
	205	JP 2010-286218	12/24/2010	Mitsubishi Heavy Ind. Ltd.		
	206	KR 10-1994-0011902	06/22/1994	Koryo Digital Elect. Co.		
	207	KR 10-1999-0070368	09/15/1999	Samsung Electronics Co. Ltd.		
	208	KR 10-2000-0059532	10/05/2000	Dang Hae System Co.		
	209	WO 2011/149600 (EFACT.012WO)	12/01/2011	EcoFactor, Inc.		
	210	WO 2012/024534 (EFACT.013WO)	02/23/2012	EcoFactor, Inc.		
	211	WO 2013/187996	12/19/2013	EcoFactor, Inc.		

NON PATENT LITERATURE DOCUMENTS			
Examiner Initials	Cite No.	Include name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazine, journal, serial, symposium, catalog, etc.), date, page(s), volume-issue number(s), publisher, city and/or country where published.	T[1]
	212	ARENS, et al, "How Ambient Intelligence Will Improve Habitability and Energy Efficiency in Buildings", 2005, research paper, Center for the Built Environment, Controls and Information Technology.	
	213	Bourhan, et al., "Cynamic model of an HVAC system for control analysis", Elsevier 2004.	
	214	Brush, et al., Preheat – Controlling Home Heating with Occupancy Prediction, 2013.	

Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.E.N/

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 5 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	115	8,019,567 (EFACT.006A)	09/13/2011	Steinberg et al.	
	116	8,090,477 (EFACT.013A)	01/03/2012	Steinberg	
	117	8,131,497 (EFACT.005C1)	03/06/2012	Steinberg et al.	
	118	8,131,506 (EFACT.004C1)	03/06/2012	Steinberg et al.	
	119	8,180,492 (EFACT.011A)	05/15/2012	Steinberg	
	120	8,340,826 (EFACT.013C1)	12/25/2012	Steinberg et al.	
	121	8,412,488 (EFACT.004C2)	04/02/2013	Steinberg et al.	
	122	8,423,322 (EFACT.006C1)	04/16/2013	Steinberg et al.	
	123	8,457,797	06/04/2013	Imes et al.	
	124	8,556,188 (EFACT.012A)	10/15/2013	Steinberg	
	125	8,596,550 (EFACT.007A)	12/03/2013	Steinberg et al.	
	126	8,712,590 (EFACT.013C2)	04/29/2014	Steinberg	
	127	8,738,327 (EFACT.004C3)	05/27/2014	Steinberg, et al.	
	128	8,740,100 (EFACT.008A)	06/03/2014	Steinberg	
Change(s) applied to document, /S.J.W./ 3/17/2017	**129**	8,751,186 (EFACT.005C3)	06/10/2014	Steinberg, et al.	
	130	8,840,033 (EFACT.012C1)	09/23/2014	~~EcoFactor, Inc.~~ Steinberg	
	131	8,886,488 (EFACT.005C2)	11/11/2014	Steinberg, et al.	
	132	2003/0040934	02/27/2003	Skidmore et al.	
	133	2004/0176880	09/09/2004	Obradovich et al.	
	134	2005/0222889	10/06/2005	Lai et al.	
	135	2005/0288822	12/29/2005	Rayburn	
	136	2006/0045105	03/02/2006	Dobosz et al.	
	137	2006/0214014	09/28/2006	Bash et al.	
	138	2007/0043477	02/22/2007	Elhers et al.	
	139	2007/0045431	03/03/2007	Chapman et al.	

Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.E.N/

PTO/SB/08 Equivalent

INFORMATION DISCLOSURE STATEMENT BY APPLICANT	Application No.	14/491554
	Filing Date	September 19, 2014
	First Named Inventor	John Douglas Steinberg
	Art Unit	3744
(Multiple sheets used when necessary)	Examiner	Unknown
SHEET 1 OF 10	Attorney Docket No.	EFACT.012C2

U.S. PATENT DOCUMENTS					
Examiner Initials	Cite No.	Document Number *Number - Kind Code (if known)* Example: 1,234,567 B1	Publication Date MM-DD-YYYY	Name	Pages, Columns, Lines Where Relevant Passages or Relevant Figures Appear
	1	H2176	12/05/2006	Meyer et al.	
	2	13/470074	08/30/2012	Steinberg	
	3	13/523697	06/14/2012	Hublou et al.	
	4	13/725447	06/06/2013	Steinberg	
	5	13/852577	03/28/2013	Steinberg et al.	
	6	13/858710	09/05/2013	Steinberg et al.	
	7	13/861189	04/11/2013	Steinberg et al.	
	8	14/082,675 (EFACT.007C1)	11/18/2003	Steinberg et al.	
	9	14/263,762	04/28/2014	Steinberg	
	10	14/285,384	05/22/2014	Steinberg, et al.	
	11	14/292,377	05/30/2014	Steinberg	
	12	14/491,554	09/19/2014	Steinberg	
	13	14/527,433	10/29/2014	Steinberg, et al.	
	14	D 646,990	10/18/2011	Rhodes	
	15	D 659,560	05/15/2012	Rhodes	
Change(s) applied	16	D 673,467	01/01/2013	Lee et al.	
to document,	17	D 705,095 (EFACT.015DA)	05/20/2014	~~EcoFactor, Inc.~~ Steinberg,	et al.
/S.J.W./	18	4,136,732	01/30/1979	Demaray et al.	
3/17/2017	19	4,341,345	07/27/1982	Hammer et al.	
	20	4,403,644	09/13/1983	Hebert	
	21	4,475,685	10/09/1984	Grimado et al.	
	22	4,655,279	04/07/1987	Harmon	
	23	4,674,027	06/16/1987	Beckey	
	24	5,124,502	06/23/1992	Nelson et al.	
	25	5,244,146	09/14/1993	Jefferson et al.	
	26	5,270,952	12/14/1993	Adams et al.	
	27	5,314,004	05/24/1994	Strand et al.	
	28	5,462,225	10/31/1995	Massara et al.	

Examiner Signature	/MARC E NORMAN/	Date Considered	10/20/2016

***Examiner:** Initial if reference considered, whether or not citation is in conformance with MPEP 609. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

T[1] - Place a check mark in this area when an English language Translation is attached.

ALL REFERENCES CONSIDERED EXCEPT WHERE LINED THROUGH. /M.E.N/

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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Address: COMMISSIONER FOR PATENTS
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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
14/491,554	07/18/2017	9709292	EFACT.012C2	1254

20995 7590 06/28/2017

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ISSUE NOTIFICATION

The projected patent number and issue date are specified above.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment is 294 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Data Management (ODM) at (571)-272-4200.

APPLICANT(s) (Please see PAIR WEB site http://pair.uspto.gov for additional applicants):

John Douglas Steinberg, Millbrae, CA;
EcoFactor, Inc., Millbrae, CA;

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APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY.DOCKET NO./TITLE	REQUEST ID
14/491,554	09/19/2014	EcoFactor, Inc.	EFACT.012C2	129156

Acknowledgement of Loss of Entitlement to Entity Status Discount

The entity status change request below filed through Private PAIR on 01/14/2021 has been accepted.

CERTIFICATIONS:

Change of Entity Status:

X Applicant changing to regular undiscounted fee status.

NOTE: Checking this box will be taken to be notification of loss of entitlement to small or micro entity status, as applicable.

This portion must be completed by the signatory or signatories making the entity status change in accordance with 37 CFR 1.4(d)(4).

Signature:	/John R. King/
Name:	John R. King
Registration Number:	34362