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(12) **United States Patent**
Ambrosio et al.

(10) **Patent No.: US 8,266,075 B2**
(45) **Date of Patent: Sep. 11, 2012**

(54) **ELECTRIC VEHICLE CHARGING TRANSACTION INTERFACE FOR MANAGING ELECTRIC VEHICLE CHARGING TRANSACTIONS**

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(73) Assignee: **International Business Machines Corporation**, Armonk, NY (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 823 days.

(21) Appl. No.: **12/139,574**

(22) Filed: **Jun. 16, 2008**

(65) **Prior Publication Data**

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(51) **Int. Cl.**
H02J 7/00 (2006.01)
G01R 11/56 (2006.01)

(52) **U.S. Cl.** **705/412**; 705/30; 705/17; 705/14.38; 320/109

(58) **Field of Classification Search** ..... None
See application file for complete search history.

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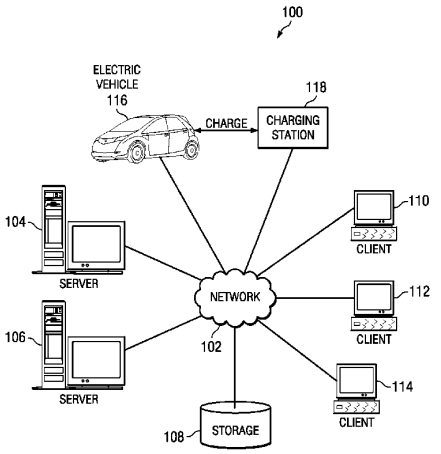
Primary Examiner — Faris Almatrahi
(74) *Attorney, Agent, or Firm* — Yee & Associates, P.C.; David A. Mims, Jr.

(57) **ABSTRACT**

Illustrative embodiments manage an electric vehicle charging transaction. A set of principals associated with the electric vehicle charging transaction is identified. Electric vehicle charging information is retrieved from a set of sources. An energy transaction plan is generated using the electric vehicle charging information. A charging phase of the electric vehicle charging transaction is initiated for an electric vehicle connected to a charging station in accordance with the energy transaction plan. The charging phase comprises at least one of charging the electric vehicle with electricity, storing electricity in an electric storage mechanism associated with the electric vehicle, and removing electricity from the electric storage mechanism to de-charge the electric vehicle. In response to completion of the charging phase, the process then settles the financial obligations of a subset of principals in accordance with the energy transaction plan.

10 Claims, 13 Drawing Sheets



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2009/0021213	A1*	1/2009	Johnson	320/109
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2009/0066287	A1	3/2009	Pollack et al.	
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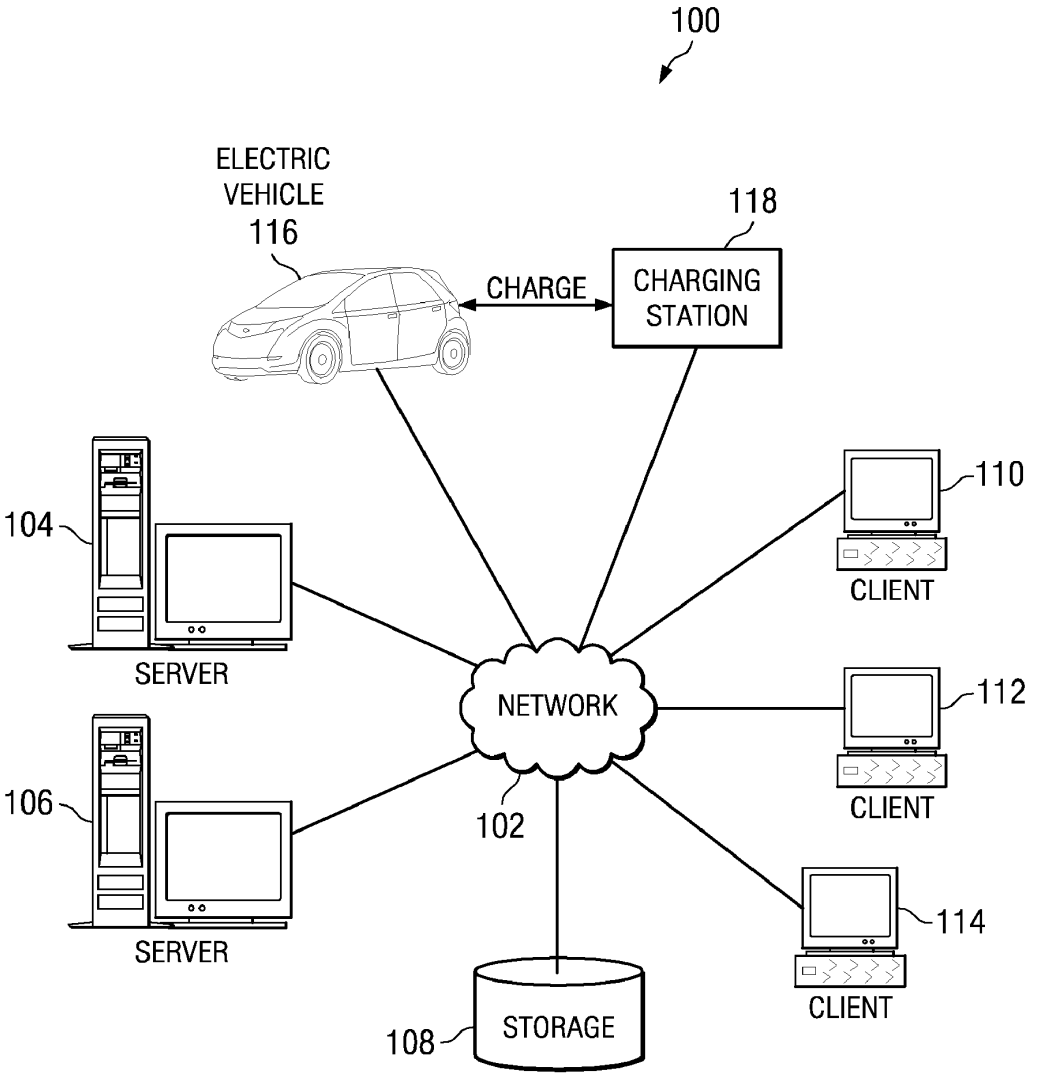
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ELECTRIC
VEHICLE
116
118
CHARGE
CHARGING
STATION
104
SERVER
110
CLIENT
NETWORK
112
CLIENT
106
SERVER
102
114
CLIENT
108
STORAGE

FIG. 1

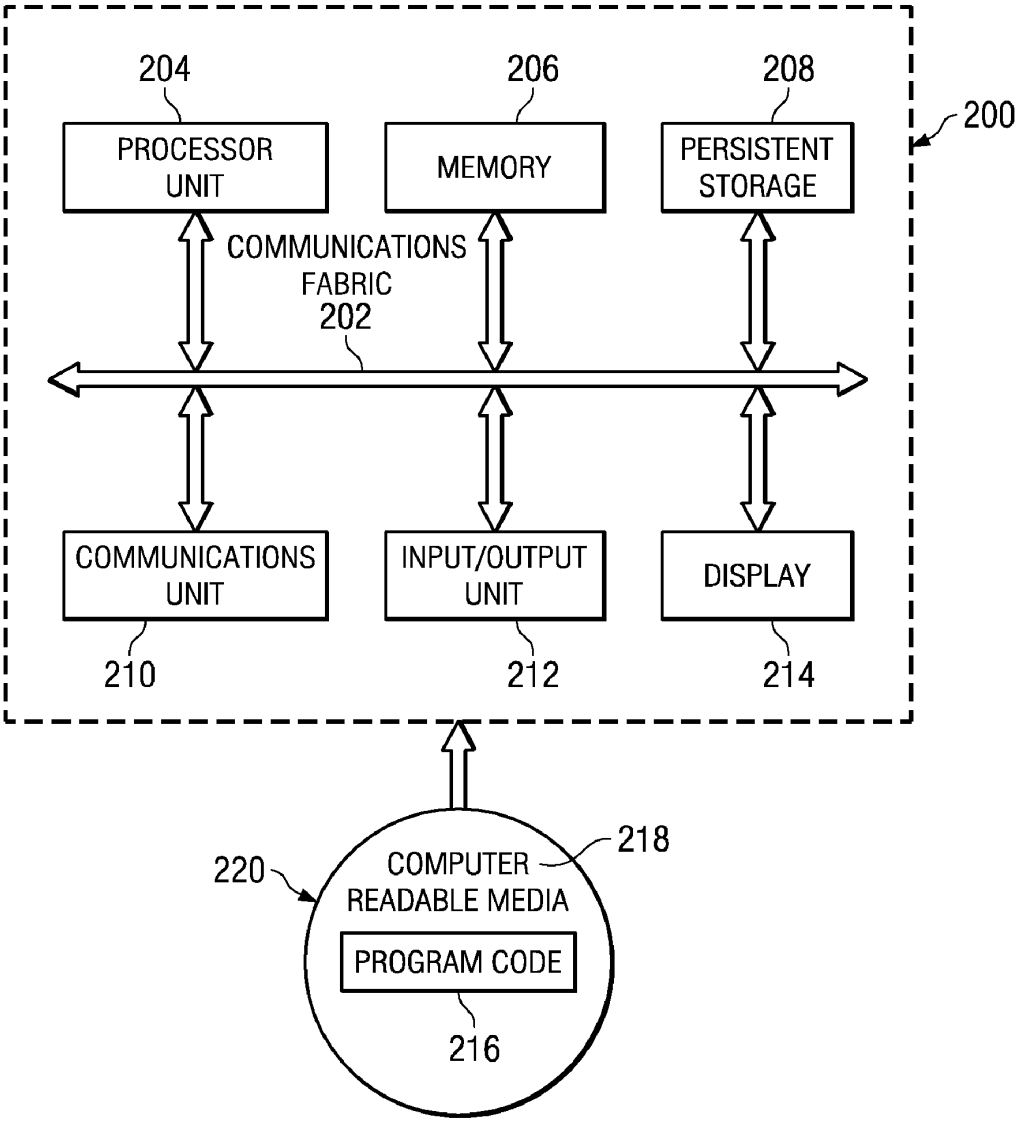
204
206
208
200
PROCESSOR UNIT
MEMORY
PERSISTENT STORAGE
COMMUNICATIONS FABRIC
202
COMMUNICATIONS UNIT
INPUT/OUTPUT UNIT
DISPLAY
210
212
214
220
218
COMPUTER READABLE MEDIA
PROGRAM CODE
216

FIG. 2

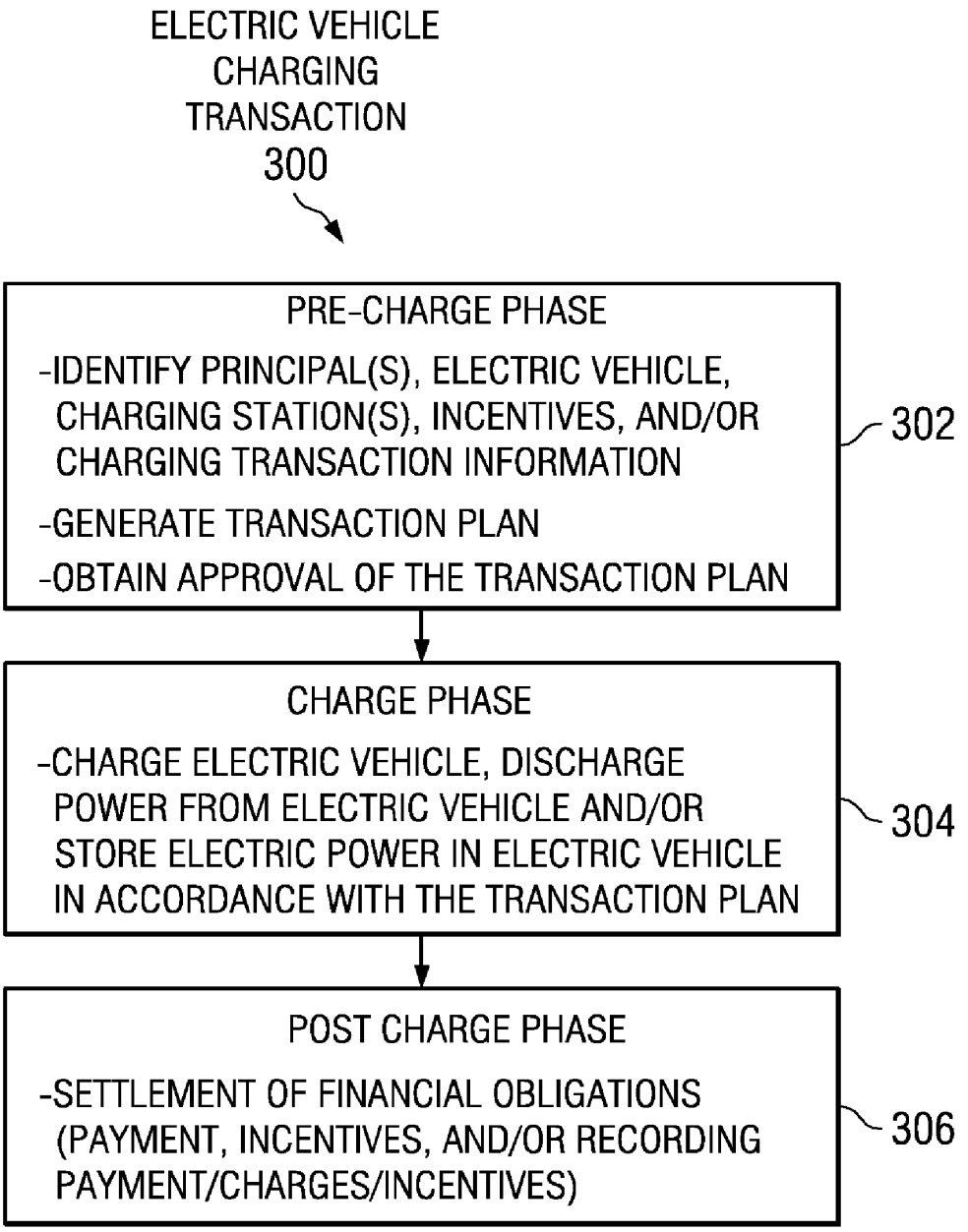
ELECTRIC VEHICLE
CHARGING
TRANSACTION
300
PRE-CHARGE PHASE
-IDENTIFY PRINCIPAL(S), ELECTRIC VEHICLE, CHARGING STATION(S), INCENTIVES, AND/OR CHARGING TRANSACTION INFORMATION
-GENERATE TRANSACTION PLAN
-OBTAIN APPROVAL OF THE TRANSACTION PLAN
302
CHARGE PHASE
-CHARGE ELECTRIC VEHICLE, DISCHARGE POWER FROM ELECTRIC VEHICLE AND/OR STORE ELECTRIC POWER IN ELECTRIC VEHICLE IN ACCORDANCE WITH THE TRANSACTION PLAN
304
POST CHARGE PHASE
-SETTLEMENT OF FINANCIAL OBLIGATIONS (PAYMENT, INCENTIVES, AND/OR RECORDING PAYMENT/CHARGES/INCENTIVES)
306

FIG. 3

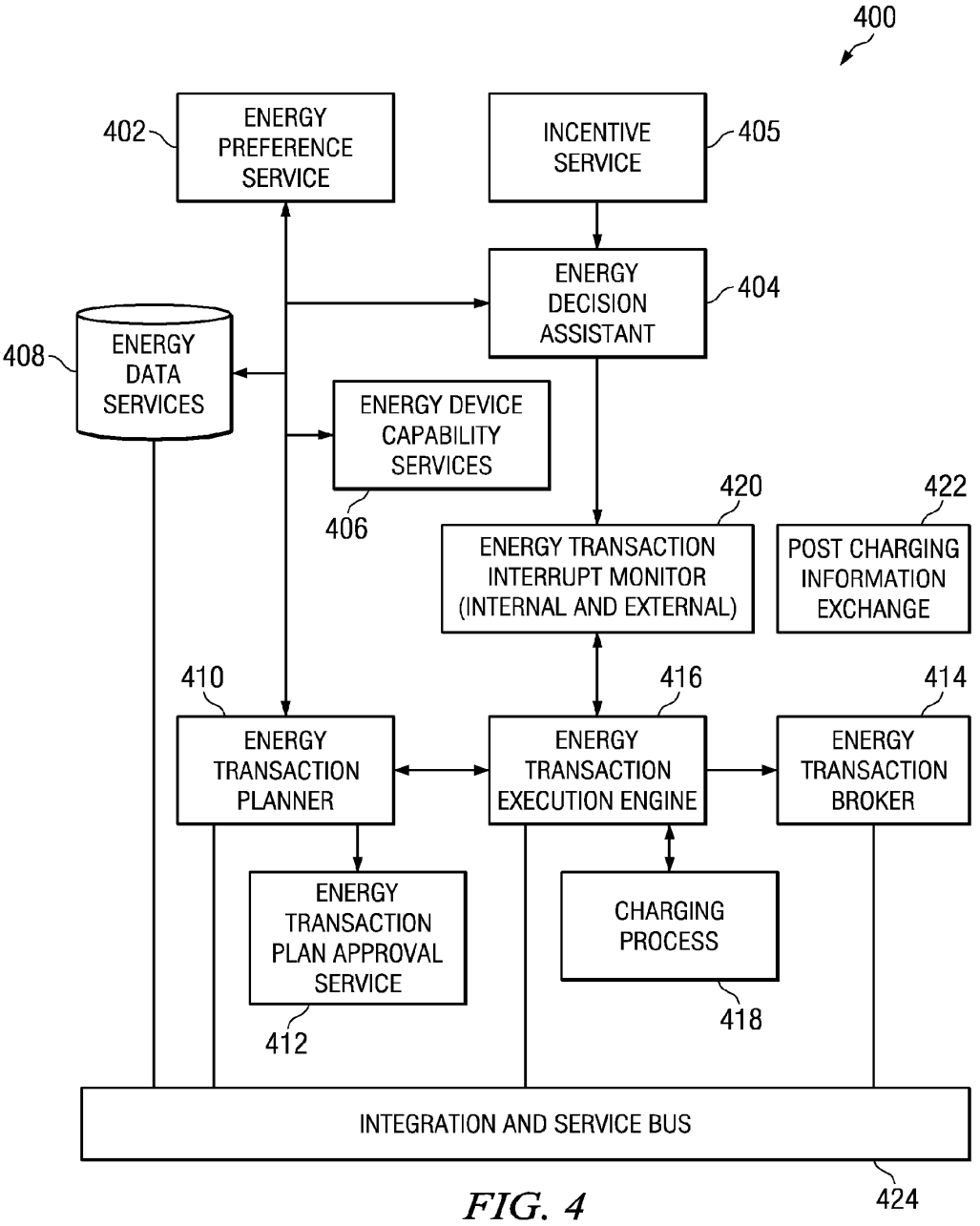
400
402
ENERGY PREFERENCE SERVICE
INCENTIVE SERVICE
405
ENERGY DECISION ASSISTANT
404
408
ENERGY DATA SERVICES
ENERGY DEVICE CAPABILITY SERVICES
406
420
422
ENERGY TRANSACTION INTERRUPT MONITOR (INTERNAL AND EXTERNAL)
POST CHARGING INFORMATION EXCHANGE
410
416
414
ENERGY TRANSACTION PLANNER
ENERGY TRANSACTION EXECUTION ENGINE
ENERGY TRANSACTION BROKER
ENERGY TRANSACTION PLAN APPROVAL SERVICE
CHARGING PROCESS
412
418
INTEGRATION AND SERVICE BUS
424

FIG. 4

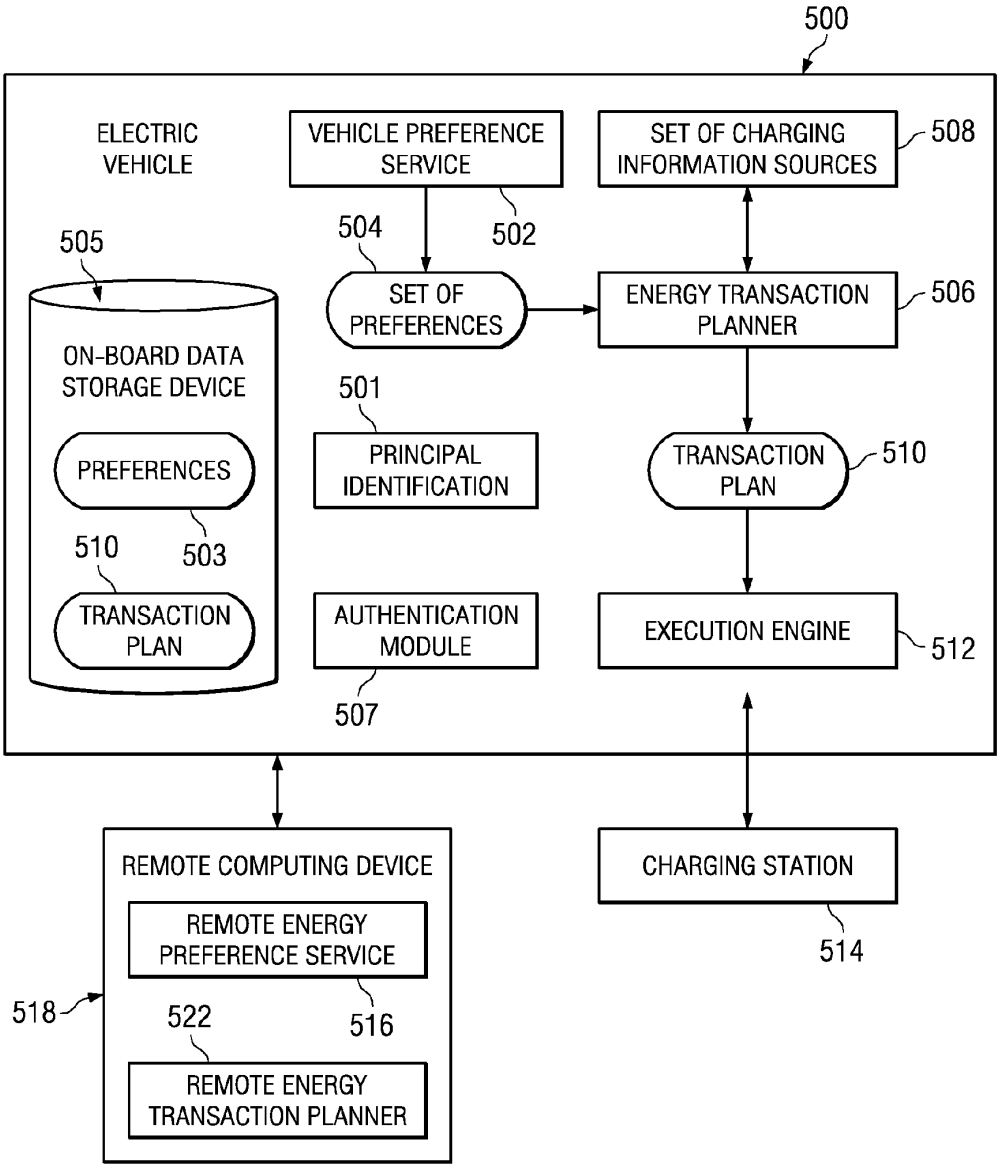
500
ELECTRIC VEHICLE
VEHICLE PREFERENCE SERVICE
SET OF CHARGING INFORMATION SOURCES
508
505
504
502
SET OF PREFERENCES
ENERGY TRANSACTION PLANNER
506
ON-BOARD DATA STORAGE DEVICE
501
PREFERENCES
PRINCIPAL IDENTIFICATION
TRANSACTION PLAN
510
510
503
TRANSACTION PLAN
AUTHENTICATION MODULE
EXECUTION ENGINE
512
507
REMOTE COMPUTING DEVICE
CHARGING STATION
REMOTE ENERGY PREFERENCE SERVICE
514
518
522
516
REMOTE ENERGY TRANSACTION PLANNER

FIG. 5

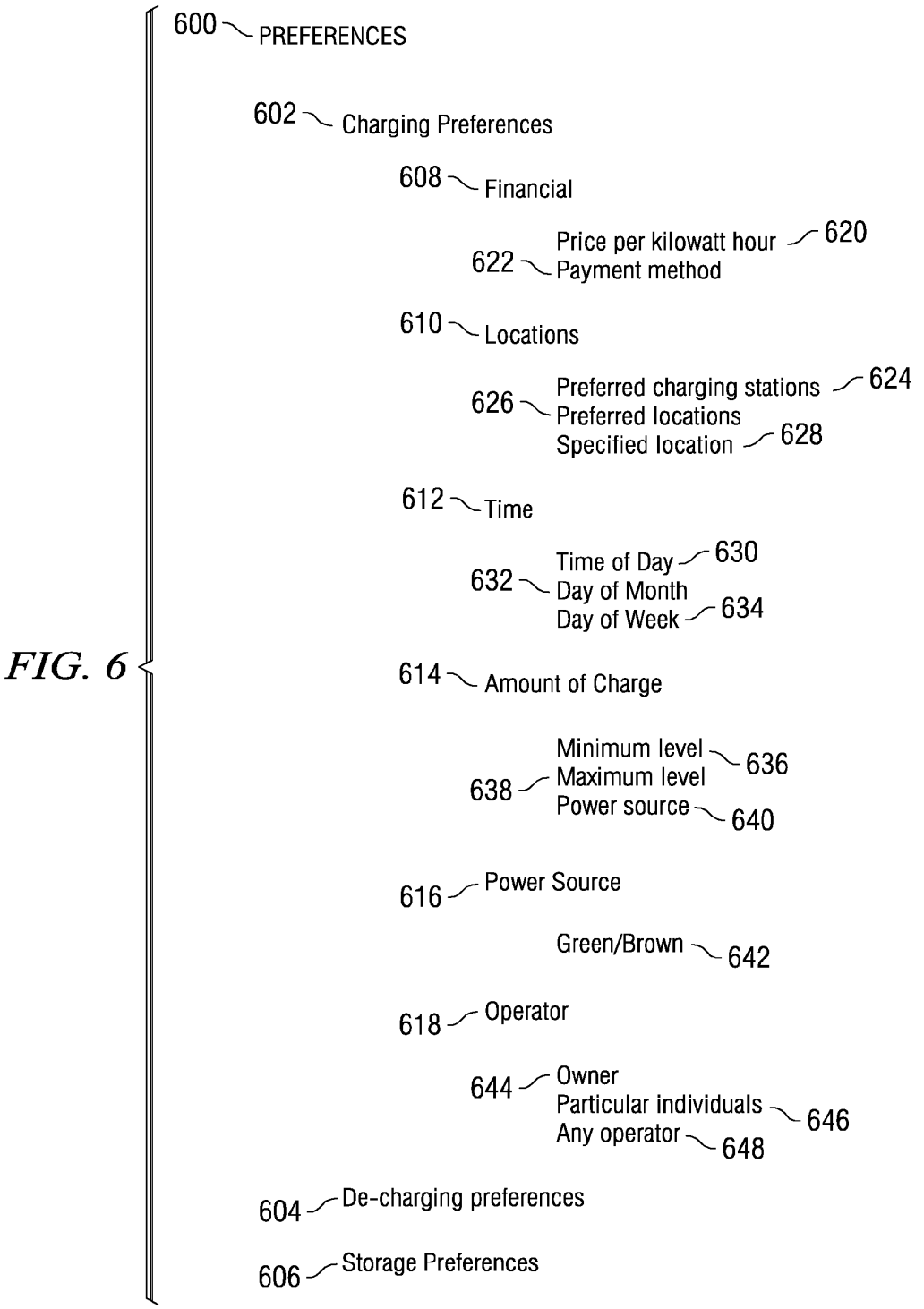
600 PREFERENCES
602 Charging Preferences
608 Financial
622
Price per kilowatt hour 620
Payment method
610 Locations
626
Preferred charging stations 624
Preferred locations
Specified location 628
612 Time
632
Time of Day 630
Day of Month
Day of Week 634
614 Amount of Charge
638
Minimum level 636
Maximum level
Power source 640
616 Power Source
Green/Brown 642
618 Operator
644
Owner
Particular individuals 646
Any operator 648
604 De-charging preferences
606 Storage Preferences

FIG. 6

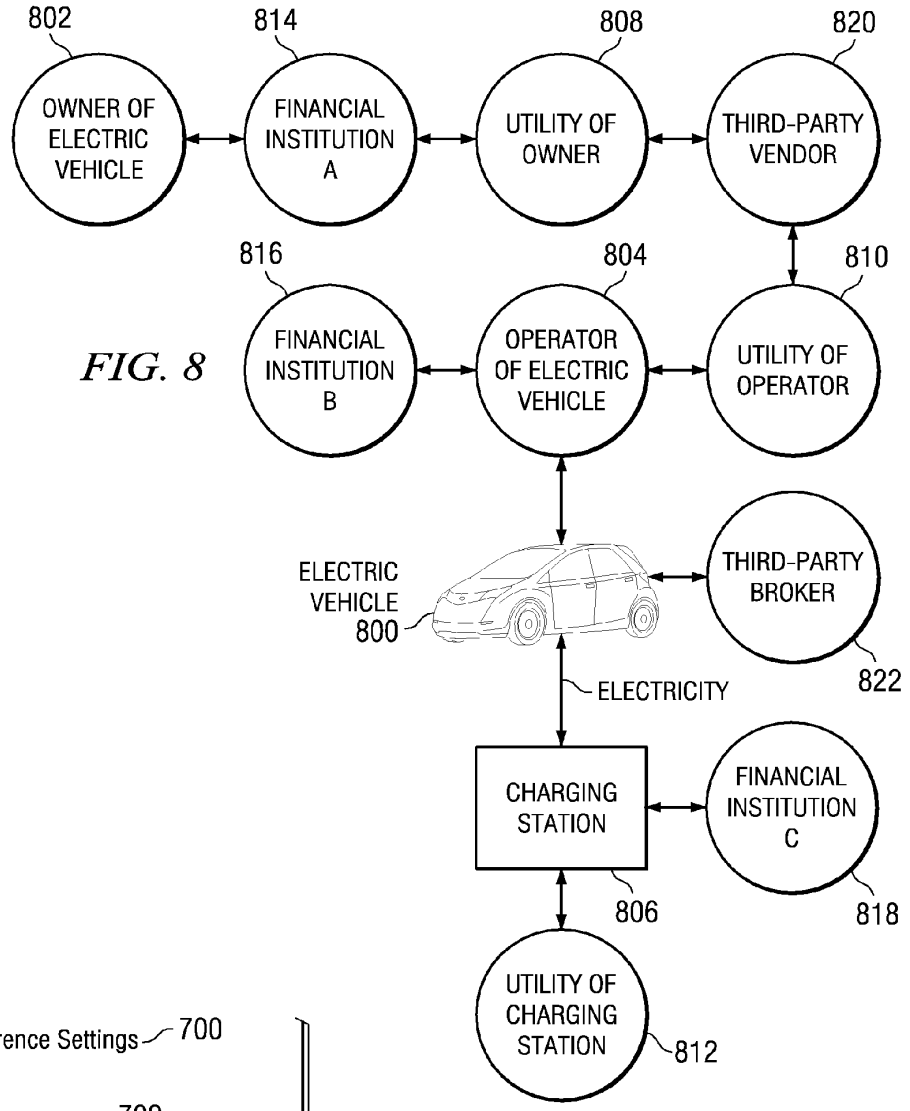
802
OWNER OF ELECTRIC VEHICLE
814
FINANCIAL INSTITUTION A
808
UTILITY OF OWNER
820
THIRD-PARTY VENDOR
816
FINANCIAL INSTITUTION B
804
OPERATOR OF ELECTRIC VEHICLE
810
UTILITY OF OPERATOR
ELECTRIC VEHICLE
800
THIRD-PARTY BROKER
822
ELECTRICITY
CHARGING STATION
806
FINANCIAL INSTITUTION C
818
UTILITY OF CHARGING STATION
812

FIG. 8

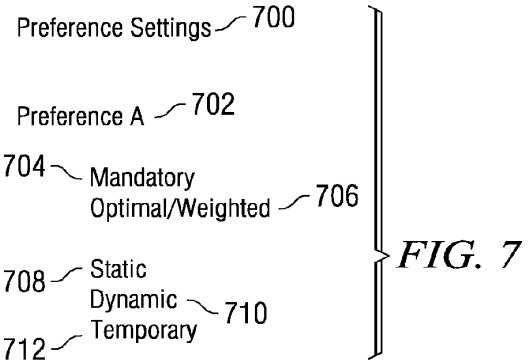
Preference Settings 700
Preference A 702
704 Mandatory
Optimal/Weighted 706
708 Static
Dynamic 710
712 Temporary

FIG. 7

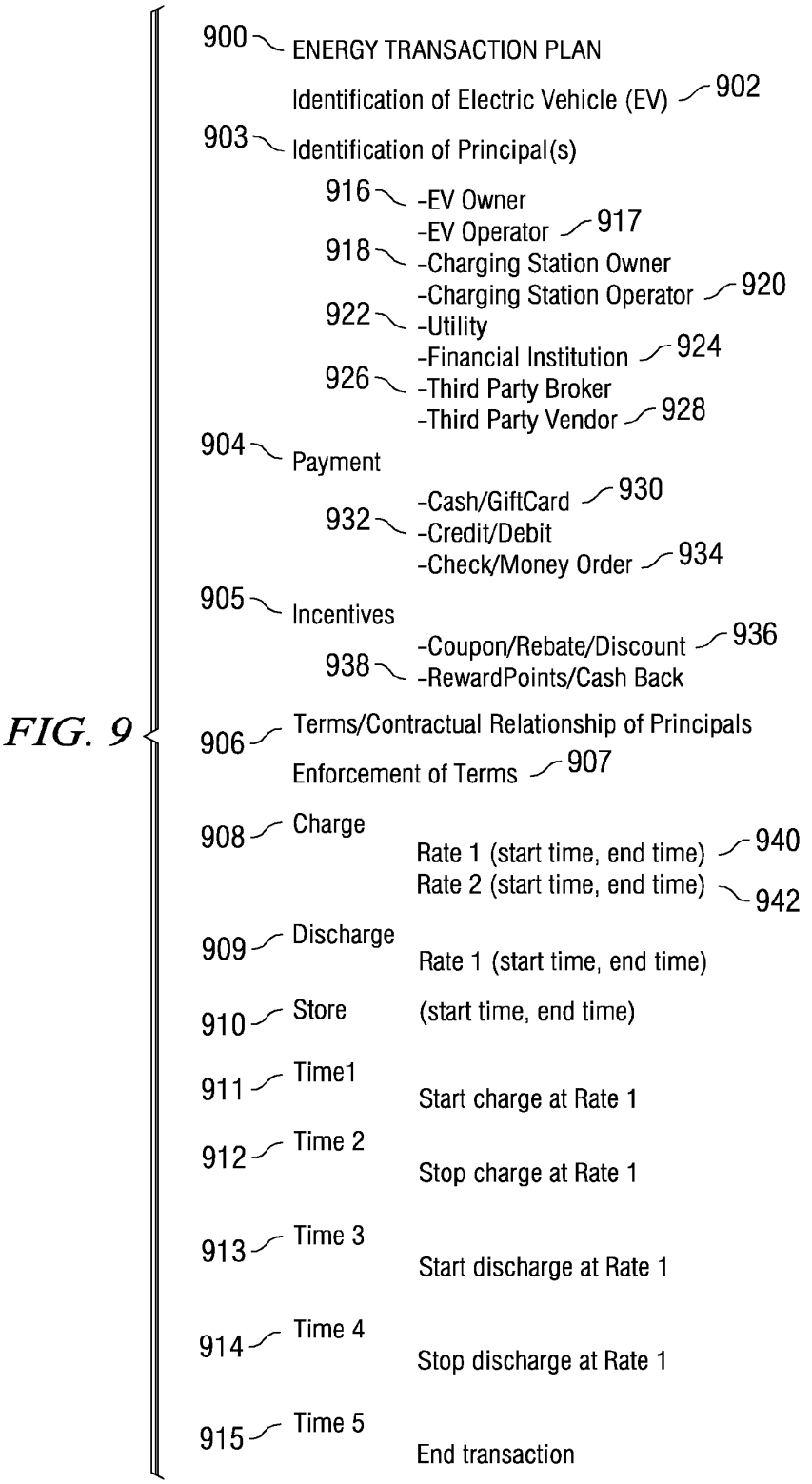
900 ENERGY TRANSACTION PLAN
Identification of Electric Vehicle (EV) 902
903 Identification of Principal(s)
916 -EV Owner
-EV Operator 917
918 -Charging Station Owner
-Charging Station Operator 920
922 -Utility
-Financial Institution 924
926 -Third Party Broker
-Third Party Vendor 928
904 Payment
-Cash/GiftCard 930
932 -Credit/Debit
-Check/Money Order 934
905 Incentives
-Coupon/Rebate/Discount 936
938 -RewardPoints/Cash Back
906 Terms/Contractual Relationship of Principals
Enforcement of Terms 907
908 Charge
Rate 1 (start time, end time) 940
Rate 2 (start time, end time) 942
909 Discharge
Rate 1 (start time, end time)
910 Store
(start time, end time)
911 Time1
Start charge at Rate 1
912 Time 2
Stop charge at Rate 1
913 Time 3
Start discharge at Rate 1
914 Time 4
Stop discharge at Rate 1
915 Time 5
End transaction

FIG. 9

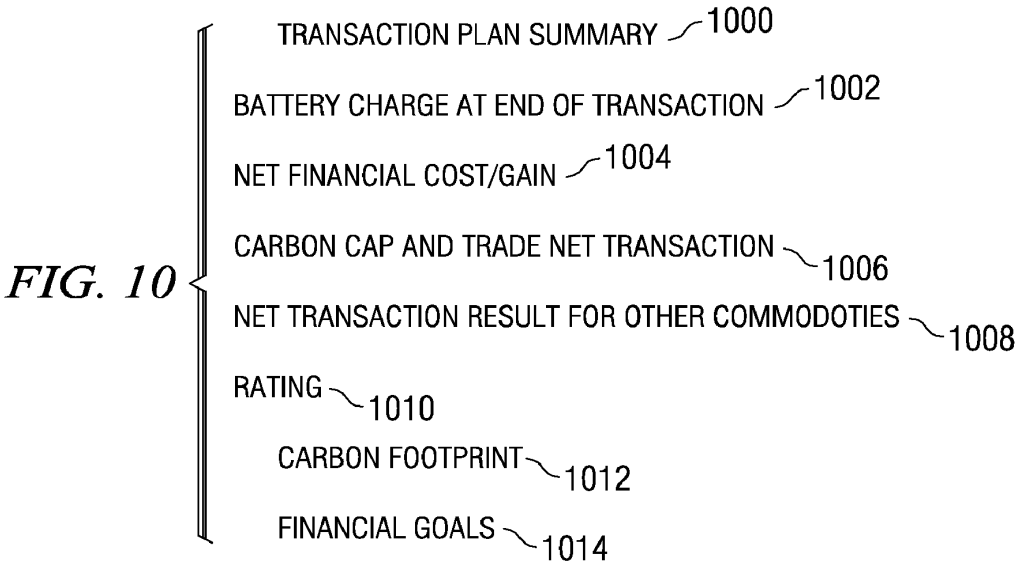
TRANSACTION PLAN SUMMARY 1000
BATTERY CHARGE AT END OF TRANSACTION 1002
NET FINANCIAL COST/GAIN 1004
CARBON CAP AND TRADE NET TRANSACTION 1006
NET TRANSACTION RESULT FOR OTHER COMMODOTIES 1008
RATING 1010
CARBON FOOTPRINT 1012
FINANCIAL GOALS 1014

FIG. 10

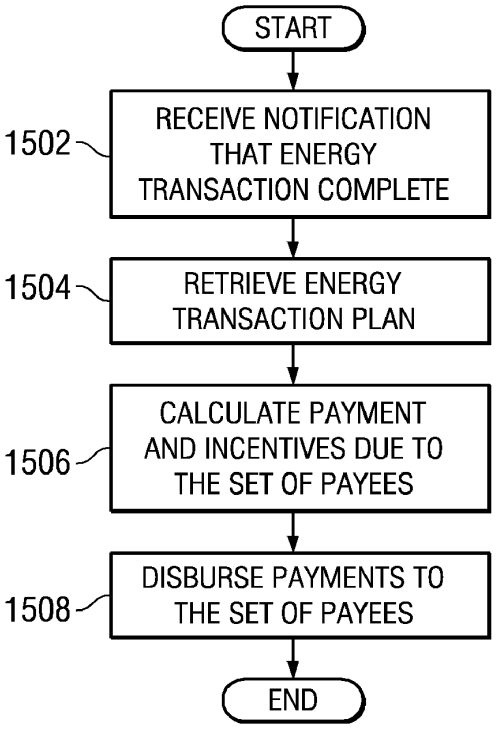
START
1502
RECEIVE NOTIFICATION THAT ENERGY TRANSACTION COMPLETE
1504
RETRIEVE ENERGY TRANSACTION PLAN
1506
CALCULATE PAYMENT AND INCENTIVES DUE TO THE SET OF PAYEES
1508
DISBURSE PAYMENTS TO THE SET OF PAYEES
END

FIG. 15

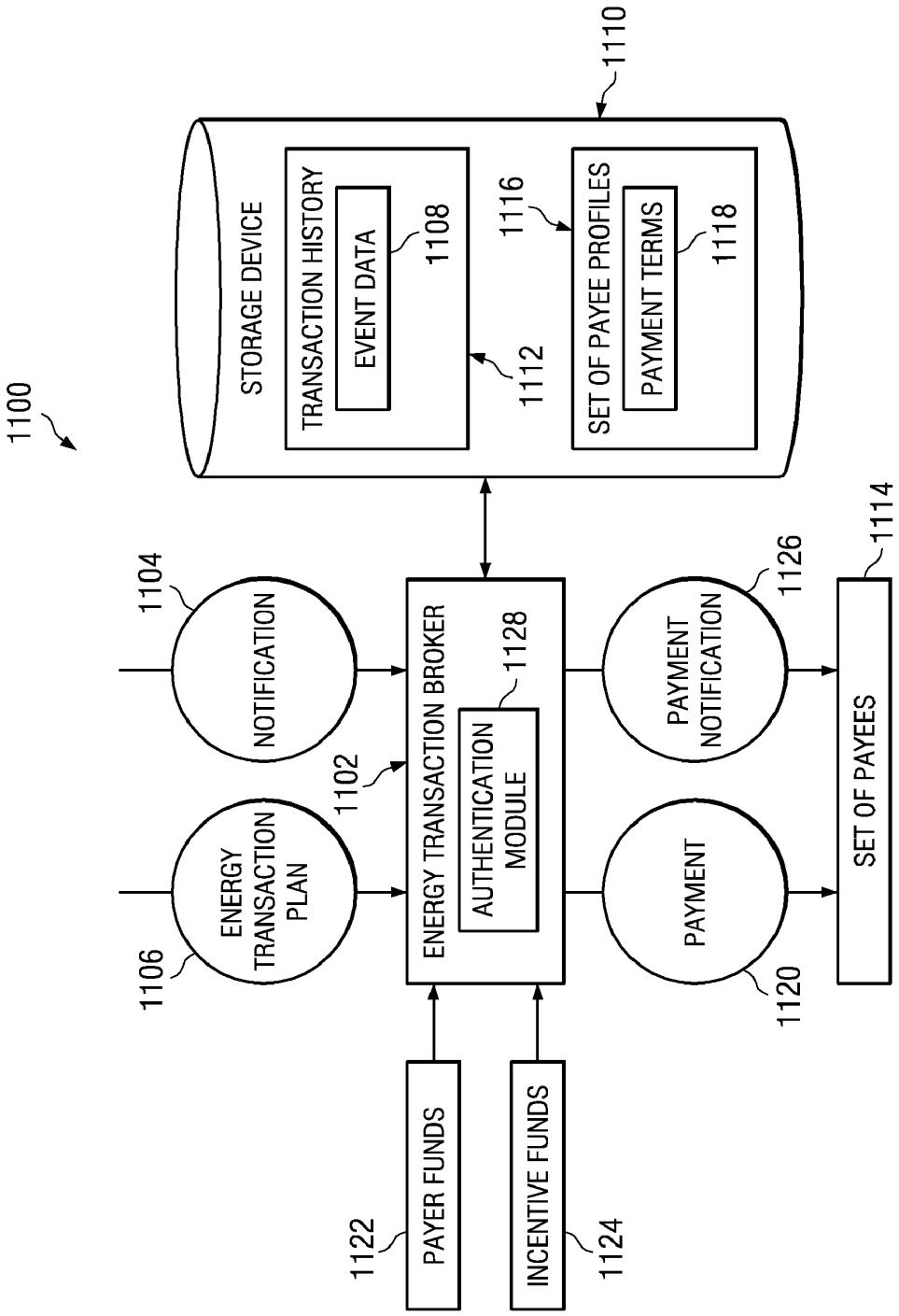
1100
1110
STORAGE DEVICE
TRANSACTION HISTORY
EVENT DATA
1108
1112
1116
SET OF PAYEE PROFILES
PAYMENT TERMS
1118
1104
NOTIFICATION
1106
ENERGY TRANSACTION PLAN
1102
ENERGY TRANSACTION BROKER
AUTHENTICATION MODULE
1128
1126
PAYMENT NOTIFICATION
PAYMENT
1120
1114
SET OF PAYEES
1122
PAYER FUNDS
INCENTIVE FUNDS
1124

FIG. 11

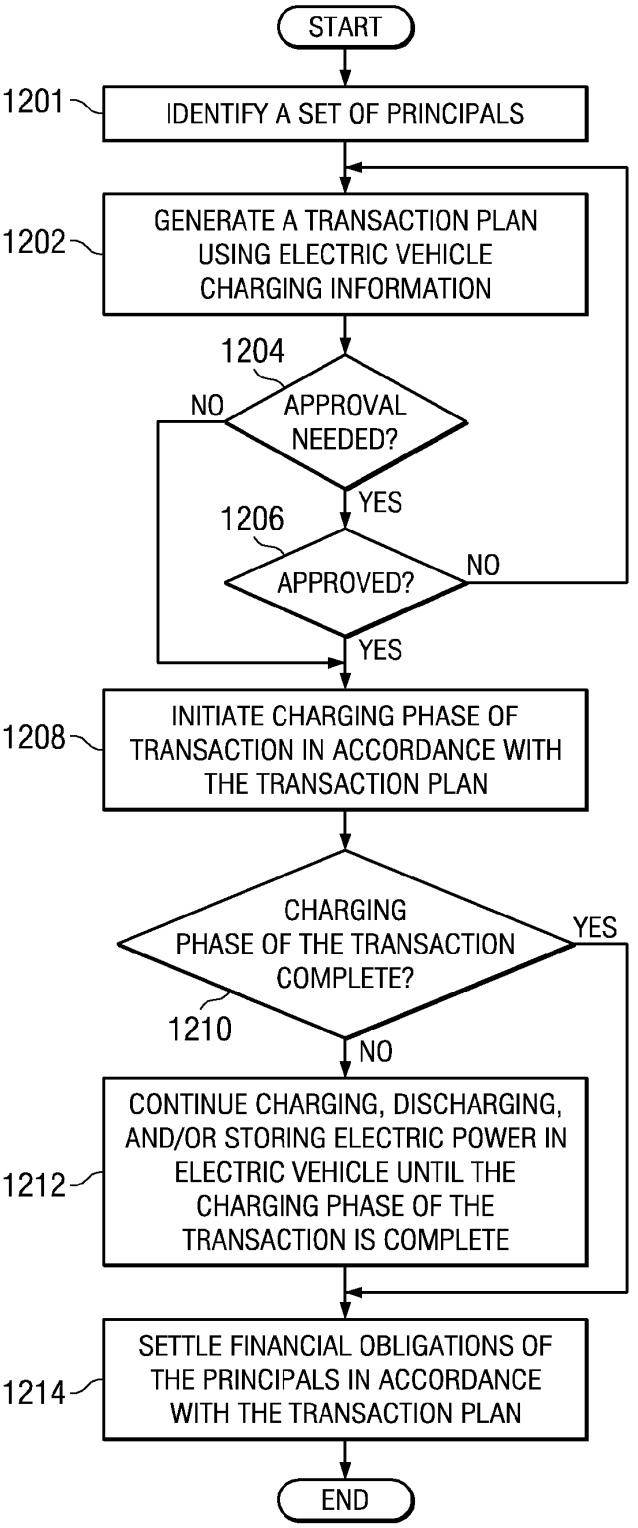
START
1201
IDENTIFY A SET OF PRINCIPALS
1202
GENERATE A TRANSACTION PLAN USING ELECTRIC VEHICLE CHARGING INFORMATION
1204
APPROVAL NEEDED?
NO
YES
1206
APPROVED?
NO
YES
1208
INITIATE CHARGING PHASE OF TRANSACTION IN ACCORDANCE WITH THE TRANSACTION PLAN
CHARGING PHASE OF THE TRANSACTION COMPLETE?
YES
1210
NO
1212
CONTINUE CHARGING, DISCHARGING, AND/OR STORING ELECTRIC POWER IN ELECTRIC VEHICLE UNTIL THE CHARGING PHASE OF THE TRANSACTION IS COMPLETE
1214
SETTLE FINANCIAL OBLIGATIONS OF THE PRINCIPALS IN ACCORDANCE WITH THE TRANSACTION PLAN
END

FIG. 12

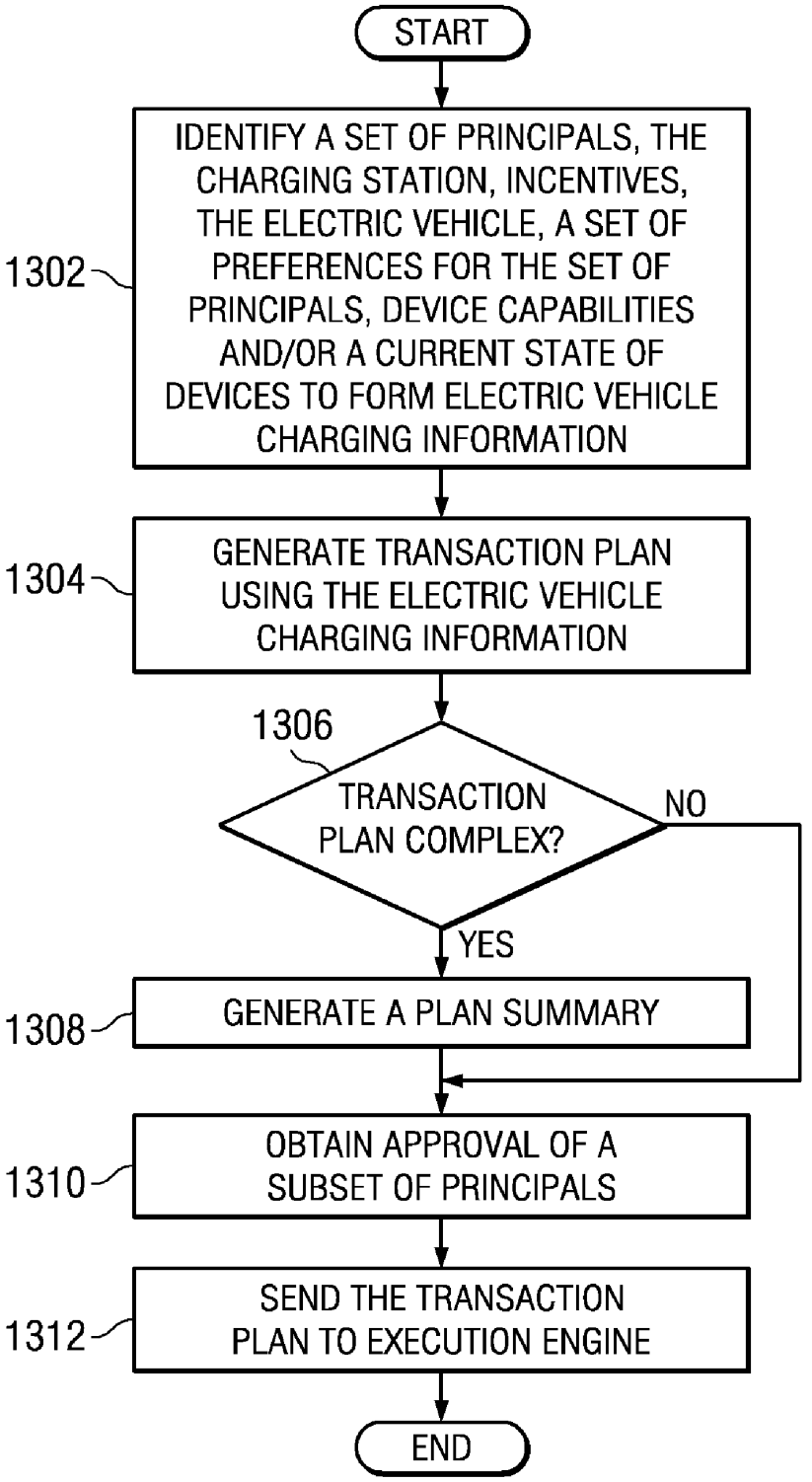
START
IDENTIFY A SET OF PRINCIPALS, THE CHARGING STATION, INCENTIVES, THE ELECTRIC VEHICLE, A SET OF PREFERENCES FOR THE SET OF PRINCIPALS, DEVICE CAPABILITIES AND/OR A CURRENT STATE OF DEVICES TO FORM ELECTRIC VEHICLE CHARGING INFORMATION
1302
GENERATE TRANSACTION PLAN USING THE ELECTRIC VEHICLE CHARGING INFORMATION
1304
1306
TRANSACTION PLAN COMPLEX?
NO
YES
GENERATE A PLAN SUMMARY
1308
OBTAIN APPROVAL OF A SUBSET OF PRINCIPALS
1310
SEND THE TRANSACTION PLAN TO EXECUTION ENGINE
1312
END

FIG. 13

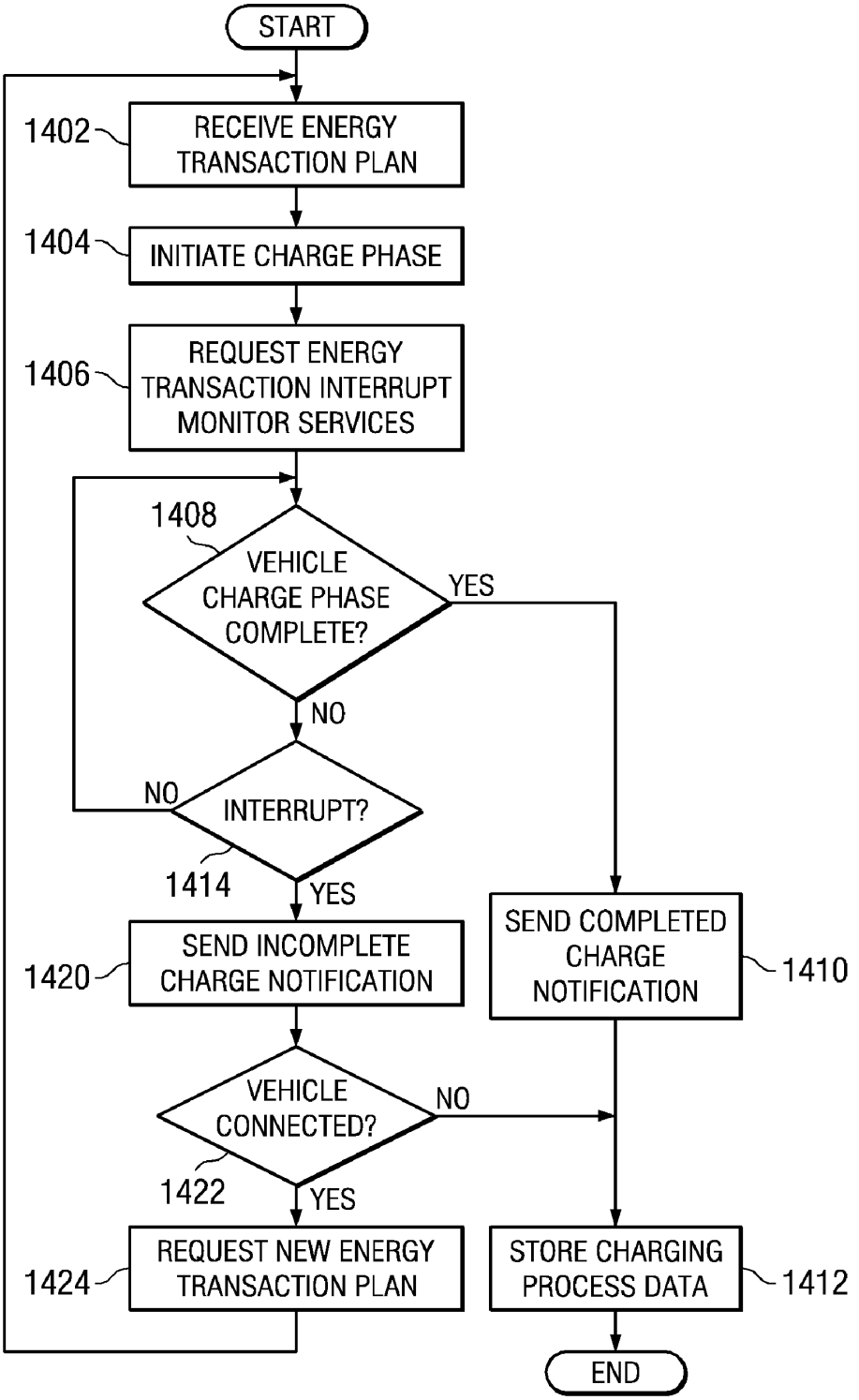
START
1402
RECEIVE ENERGY TRANSACTION PLAN
1404
INITIATE CHARGE PHASE
1406
REQUEST ENERGY TRANSACTION INTERRUPT MONITOR SERVICES
1408
VEHICLE CHARGE PHASE COMPLETE?
YES
NO
NO
INTERRUPT?
1414
YES
1420
SEND INCOMPLETE CHARGE NOTIFICATION
SEND COMPLETED CHARGE NOTIFICATION
1410
VEHICLE CONNECTED?
NO
1422
YES
1424
REQUEST NEW ENERGY TRANSACTION PLAN
STORE CHARGING PROCESS DATA
1412
END

FIG. 14

ELECTRIC VEHICLE CHARGING TRANSACTION INTERFACE FOR MANAGING ELECTRIC VEHICLE CHARGING TRANSACTIONS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention is related generally to an improved data processing system, and in particular, to a method and apparatus for managing electric vehicle charging transactions. More particularly, the present invention is directed to a computer implemented method, apparatus, and computer usable program code for managing multiple aspects of electric vehicle charging transactions.

2. Description of the Related Art

Electric vehicles (EV) can be divided into two categories: totally electric vehicles (TEV) and plug-in hybrid electric vehicles (PHEV). Plug-in hybrid vehicles utilize two or more power sources to drive the vehicle. With the increasing costs of fossil fuels and concern over reliance on non-renewable resources, electric vehicles are poised to become a critical component of transportation systems throughout the world. Gasoline powered vehicles utilize the explosive power of a mixture of gasoline and air to propel the vehicle. In contrast, electric vehicles rely in whole or in part on electric power to drive the vehicle.

Electric vehicles contain electric storage mechanisms, such as batteries, to store electricity until it is needed to power the electric vehicle. The electric storage mechanisms require periodic charging to replenish the electric charge for continued operation. The electricity used to charge the electric storage mechanisms may be provided by any type of on-vehicle power generation and charging mechanism. The on-vehicle power generation and charging mechanisms may include consumptive power generation systems and/or non-consumptive power generation systems, such as, without limitation, fuel cells, gasoline powered combustion engines, bio-diesel powered engines, solar powered generators and regenerative braking systems.

In totally electric vehicles and plug-in hybrid electric vehicles, charging of the electric vehicles can also be accomplished by plugging the electric vehicle into an off-vehicle charging station. The off-vehicle charging station provides an external source of electricity, such as, an electric power grid. Totally electric vehicles require this type of off-vehicle charging in all cases. Off-vehicle charging is also likely to be significantly less expensive for plug-in hybrid electric vehicles than on-vehicle charging given currently available technology. Consequently off-vehicle charging may be the preferred charging mode for electric vehicle owners.

The power stored in the electric storage mechanisms on the electric vehicles and on-vehicle power generation mechanisms may be used to provide electricity back to the electricity grid. For electric vehicles to be used as suppliers of electric power to an electric power grid, electric vehicles are connected to an off-vehicle infrastructure which can efficiently consume the electricity generated or stored by the electric vehicle. To date, electric vehicle manufacturers and electric utility companies have only planned and provided infrastructure and methods for the most rudimentary charging scenario in which the electric vehicle is plugged into a common electric outlet.

BRIEF SUMMARY OF THE INVENTION

According to one embodiment of the present invention, a computer implemented method, apparatus, and computer

program product is provided for managing an electric vehicle charging transaction. A set of principals associated with the electric vehicle charging transaction is identified. A principal in the set of principals is an entity having an interest in the electric vehicle charging transaction. Electric vehicle charging information is retrieved from a set of sources. An energy transaction plan is generated using the electric vehicle charging information. A charging phase of the electric vehicle charging transaction is initiated for an electric vehicle connected to a charging station in accordance with the energy transaction plan. The charging phase comprises at least one of charging the electric vehicle with electricity, storing electricity in an electric storage mechanism associated with the electric vehicle, and removing electricity from the electric storage mechanism to de-charge the electric vehicle. In response to completion of the charging phase, the process settles the financial obligations of a subset of principals in the set of principals in accordance with the energy transaction plan.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

FIG. **1** is a block diagram of a network of data processing systems in which illustrative embodiments may be implemented;

FIG. **2** is a block diagram of a data processing system in which illustrative embodiments may be implemented;

FIG. **3** is a block diagram illustrating phases of an electric vehicle charging transaction in accordance with an illustrative embodiment;

FIG. **4** is a block diagram of an energy transaction infrastructure in accordance with an illustrative embodiment;

FIG. **5** is a block diagram illustrating a pre-charge phase of a charging transaction in accordance with an illustrative embodiment;

FIG. **6** is a block diagram of vehicle preferences in accordance with an illustrative embodiment;

FIG. **7** is a block diagram of preference settings in accordance with an illustrative embodiment;

FIG. **8** is a block diagram of parties to an electric vehicle charging transaction in accordance with an illustrative embodiment;

FIG. **9** is a block diagram of a set of fields in an energy transaction plan in accordance with an illustrative embodiment;

FIG. **10** is a block diagram of a set of fields in an energy transaction plan summary in accordance with an illustrative embodiment;

FIG. **11** is a block diagram of a post-charge process for brokering electric vehicle charge transactions in accordance with an illustrative embodiment;

FIG. **12** is a flowchart illustrating an electric vehicle charging transaction in accordance with an illustrative embodiment;

FIG. **13** is a flowchart illustrating a process for a pre-charge phase of a charging transaction in accordance with an illustrative embodiment;

FIG. **14** is a flowchart illustrating a process for a charging phase and a post charging phase of an electric vehicle charging transaction in accordance with an illustrative embodiment; and

FIG. **15** is a flowchart of a process for a post-charge process in an electric vehicle charge transaction in accordance with an illustrative embodiment.

DETAILED DESCRIPTION OF THE INVENTION

As will be appreciated by one skilled in the art, the present invention may be embodied as a system, method, or computer

program product. Accordingly, the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a "circuit," "module" or "system." Furthermore, the present invention may take the form of a computer program product embodied in any tangible medium of expression having computer-usable program code embodied in the medium.

Any combination of one or more computer-usable or computer-readable medium(s) may be utilized. The computer-usable or computer-readable medium may be, for example but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, device, or propagation medium. More specific examples (a non-exhaustive list) of the computer-readable medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CDROM), an optical storage device, a transmission media such as those supporting the Internet or an intranet, or a magnetic storage device. Note that the computer-usable or computer-readable medium could even be paper or another suitable medium upon which the program is printed, as the program can be electronically captured, via, for instance, optical scanning of the paper or other medium, then compiled, interpreted, or otherwise processed in a suitable manner, if necessary, and then stored in a computer memory. In the context of this document, a computer-usable or computer-readable medium may be any medium that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device. The computer-usable medium may include a propagated data signal with the computer-usable program code embodied therewith, either in baseband or as part of a carrier wave. The computer-usable program code may be transmitted using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc.

Computer program code for carrying out operations of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a standalone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through any type of network, including a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

The present invention is described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions.

These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks. These computer program instructions may also be stored in a computer-readable medium that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable medium produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

With reference now to the figures, and in particular, with reference to FIGS. **1-2**, exemplary diagrams of data processing environments are provided in which illustrative embodiments may be implemented. It should be appreciated that FIGS. **1-2** are only exemplary and are not intended to assert or imply any limitation with regard to the environments in which different embodiments may be implemented. Many modifications to the depicted environments may be made.

FIG. **1** depicts a pictorial representation of a network of data processing system in which illustrative embodiments may be implemented. Network data processing system **100** is a network of computers in which the illustrative embodiments may be implemented. Network data processing system **100** contains network **102**, which is the medium used to provide communications links between various devices and computers connected together within network data processing system **100**. Network **102** may include connections, such as wire, wireless communication links, or fiber optic cables.

In the depicted example, server **104** and server **106** connect to network **102** along with storage unit **108**. In addition, clients **110**, **112**, and **114** connect to network **102**. Clients **110**, **112**, and **114** may be, for example, personal computers or network computers. In the depicted example, server **104** provides data, such as boot files, operating system images, and applications to clients **110**, **112**, and **114**. Clients **110**, **112**, and **114** are clients to server **104** in this example. Network data processing system **100** may include additional servers, clients, and other devices not shown.

Electric vehicle **116** is any vehicle that utilizes electric power in whole or in part to drive the vehicle that is capable of being plugged into charging station **118**. Electric vehicle **116** may be a totally electric vehicle or a plug-in hybrid electric vehicle. The plug-in electric hybrid vehicle may be a gasoline/electric hybrid, a natural gas/electric hybrid, a diesel/electric hybrid, a biodiesel/electric hybrid, or any other type of plug-in electric hybrid. Electric vehicle **116** may optionally include an on-vehicle power generation mechanism such as, but without limitation, solar power electric generators, gasoline powered electric generators, biodiesel powered electric generator, or any other type of on-vehicle electric power generation mechanism. Electric vehicle **116** in this embodiment includes an electric vehicle charging transaction interface (not shown) for managing multiple aspects of charging transactions.

Charging station **118** is any station, kiosk, garage, power outlet, or other facility for providing electricity to electric

vehicle **116**. Electric vehicle **116** receives electricity from, or provides electricity to, an electric grid at charging station **118**. In other words, electric charge may flow from an electric grid through charging station **118** to electric vehicle **116** or the electric charge may flow from electric vehicle **116** back into the electric grid through charging station **118**. Charging station **118** is a selected charge/discharge site, such as an outlet or kiosk, for providing electric vehicle **116** with access to the electric grid. For example, and without limitation, charging station **118** may be a power outlet in a privately owned garage, an electric outlet in a docking station in a commercially owned electric vehicle charging kiosk, or a power outlet in a commercially owned garage.

Electric vehicle **116** connects to charging station **118** via an electrical outlet or other electricity transfer mechanism. The electricity may also be optionally transferred via wireless energy transfer, also referred to as wireless power transfer, in which electrical energy is transferred to a load, such as electric vehicle **116**, without interconnecting wires. The electricity may flow from charging station **118** into electric vehicle to charge electric vehicle **116**. The electricity may also flow from electric vehicle **116** into charging station **118** to sell electricity back to the power grid.

Electric vehicle **116** and charging station **118** are optionally connected to network **102**. Electric vehicle **116** and charging station **118** send and receive data associated with the charging of electric vehicle, the capabilities of electric vehicle, the capabilities of charging station **118**, the current charge stored in electric vehicle, the rate of charging electric vehicle, the price of electricity received from a power grid, identity of the owner and/or operator of electric vehicle **116** and/or any other data relevant to charging or de-charging electric vehicle **116** over network **102**.

In the depicted example, network data processing system **100** is the Internet with network **102** representing a worldwide collection of networks and gateways that use the Transmission Control Protocol/Internet Protocol (TCP/IP) suite of protocols to communicate with one another. At the heart of the Internet is a backbone of high-speed data communication lines between major nodes or host computers, consisting of thousands of commercial, governmental, educational and other computer systems that route data and messages. Of course, network data processing system **100** also may be implemented as a number of different types of networks, such as for example, an intranet, a local area network (LAN), or a wide area network (WAN). FIG. **1** is intended as an example, and not as an architectural limitation for the different illustrative embodiments.

With reference now to FIG. **2**, a block diagram of a data processing system is shown in which illustrative embodiments may be implemented. Data processing system **200** is an example of a computer, such as server **104** or client **110** in FIG. **1**, in which computer-usable program code or instructions implementing the processes may be located for the illustrative embodiments. Data processing system **200** may also be implemented as a computing device on-board an electric vehicle, such as electric vehicle **116** in FIG. **1**.

In this illustrative example, data processing system **200** includes communications fabric **202**, which provides communications between processor unit **204**, memory **206**, persistent storage **208**, communications unit **210**, input/output (I/O) unit **212**, and display **214**. Processor unit **204** serves to execute instructions for software that may be loaded into memory **206**. Processor unit **204** may be a set of one or more processors or may be a multi-processor core, depending on the particular implementation. Further, processor unit **204** may be implemented using one or more heterogeneous processor systems in which a main processor is present with secondary processors on a single chip. As another illustrative example, processor unit **204** may be a symmetric multi-processor system containing multiple processors of the same type.

Memory **206**, in these examples, may be, for example, a random access memory or any other suitable volatile or non-volatile storage device. Persistent storage **208** may take various forms depending on the particular implementation. For example, persistent storage **208** may contain one or more components or devices. In another example, persistent storage **208** may be a hard drive, a flash memory, a rewritable optical disk, a rewritable magnetic tape, or some combination of the above. The media used by persistent storage **208** also may be removable. For example, a removable hard drive may be used for persistent storage **208**.

Communications unit **210**, in these examples, provides for communications with other data processing systems or devices. In these examples, communications unit **210** is a network card. Communications unit **210** may provide communications through the use of either or both physical and wireless communications links.

Input/output unit **212** allows for input and output of data with other devices that may be connected to data processing system **200**. For example, input/output unit **212** may provide a connection for user input through a keyboard and mouse. Further, input/output unit **212** may send output to a printer. Display **214** provides a mechanism to present information to a user. The information may be presented in a visual or graphical format on a display, in an audio format, presented as a combination of audio and visual content, presented in a raised format that can be read by the blind, or in any other format.

Instructions for the operating system and applications or programs are located on persistent storage **208**. These instructions may be loaded into memory **206** for execution by processor unit **204**. The processes of the different embodiments may be performed by processor unit **204** using computer implemented instructions, which may be located in a memory, such as memory **206**. These instructions are referred to as program code, computer-usable program code, or computer-readable program code that may be read and executed by a processor in processor unit **204**. The program code in the different embodiments may be embodied on different physical or tangible computer-readable media, such as memory **206** or persistent storage **208**.

Program code **216** is located in a functional form on computer-readable media **218** that is selectively removable and may be loaded onto or transferred to data processing system **200** for execution by processor unit **204**. Program code **216** and computer-readable media **218** form computer program product **220** in these examples. In one example, computer-readable media **218** may be in a tangible form, such as, for example, an optical or magnetic disc that is inserted or placed into a drive or other device that is part of persistent storage **208** for transfer onto a storage device, such as a hard drive that is part of persistent storage **208**. In a tangible form, computer-readable media **218** also may take the form of a persistent storage, such as a hard drive, a thumb drive, or a flash memory that is connected to data processing system **200**. The tangible form of computer-readable media **218** is also referred to as computer-recordable storage media. In some instances, computer-recordable media **218** may not be removable.

Alternatively, program code **216** may be transferred to data processing system **200** from computer-readable media **218** through a communications link to communications unit **210** and/or through a connection to input/output unit **212**. The

communications link and/or the connection may be physical or wireless in the illustrative examples. The computer-readable media also may take the form of non-tangible media, such as communications links or wireless transmissions containing the program code.

The different components illustrated for data processing system **200** are not meant to provide architectural limitations to the manner in which different embodiments may be implemented. The different illustrative embodiments may be implemented in a data processing system including components in addition to or in place of those illustrated for data processing system **200**. Other components shown in FIG. **2** can be varied from the illustrative examples shown.

As one example, a storage device in data processing system **200** is any hardware apparatus that may store data. Memory **206**, persistent storage **208**, and computer-readable media **218** are examples of storage devices in a tangible form.

In another example, a bus system may be used to implement communications fabric **202** and may be comprised of one or more buses, such as a system bus or an input/output bus. Of course, the bus system may be implemented using any suitable type of architecture that provides for a transfer of data between different components or devices attached to the bus system. Additionally, a communications unit may include one or more devices used to transmit and receive data, such as a modem or a network adapter. Further, a memory may be, for example, memory **206** or a cache such as found in an interface and memory controller hub that may be present in communications fabric **202**.

Currently, electric vehicle manufacturers and electric utility companies have only planned and provided infrastructure for the most rudimentary charging scenarios, such as, merely plugging the electric vehicle into a common electric outlet that is owned by the owner and operator of the electric vehicle. The illustrative embodiments recognize that charging electric vehicles will frequently be conducted under much broader and more complex sets of circumstances than this simple scenario and infrastructure is needed to accommodate these complex transactions. For example, owners and operators of electric vehicles will frequently be required to charge their electric vehicle at a charging station that is remote from the home of the electric vehicle owner. In most circumstances, it is unlikely that the electric vehicle owner will own the off-vehicle charging stations from which the owner obtains electricity to recharge the electric vehicle. In such a situation, the owner or operator of the electric vehicle will likely be required to pay for the charge obtained from the off-vehicle charging station.

The illustrative embodiments recognize that the charging transactions by which electric vehicles obtain electricity from an off-vehicle charging station to charge the electric vehicle requires a much more complete, flexible, and interoperable system governing all aspects of the charging transaction. Electric vehicle charging transactions can be divided into the pre-charge phase, the charge phase, and the post-charge phase.

Therefore, one embodiment provides a computer implemented method, apparatus, and computer program product for managing an electric vehicle charging transaction. A set of principals associated with the electric vehicle charging transaction is identified. A principal in the set of principals is an entity having an interest in the electric vehicle charging transaction. Electric vehicle charging information is retrieved from a set of sources. An energy transaction plan is generated using the electric vehicle charging information. A charging phase of the electric vehicle charging transaction is initiated for an electric vehicle connected to a charging station in accordance with the energy transaction plan. The charging phase comprises at least one of charging the electric vehicle with electricity, storing electricity in an electric storage mechanism associated with the electric vehicle, and removing electricity from the electric storage mechanism to de-charge the electric vehicle. In response to completion of the charging phase, the financial obligations of a subset of principals in the set of principals are settled in accordance with the energy transaction plan.

FIG. **3** is a block diagram illustrating phases of an electric vehicle charging transaction in accordance with an illustrative embodiment. Electric vehicle charging transaction **300** comprises pre-charge phase **302**, charge phase **304**, and post-charge phase **306**. During pre-charge phase **302** the charging transaction interface identifies a set of one or more principals associated with the electric vehicle charging transaction. Each principal in the set of identified principals is an entity having an interest in the charging transaction for the electric vehicle. A charging transaction is a transaction associated with at least one of charging the electric vehicle, storing electric power in an electric storage mechanism associated with the electric vehicle, and de-charging the electric vehicle. The electric vehicle is identified by the charging transaction interface. The electric vehicle may be identified using a vehicle identification number (VIN) or any other type of identifier. The charging transaction interface may also identify one or more charging stations within a given vicinity of the electric vehicle, a charging station at which the electric vehicle is docked or connected, available incentives, and/or charging transaction information. The charging transaction information may include, without limitation, a set of preferences for the set of principals, information describing the capabilities of devices associated with the electric vehicle and/or the charging station(s), and/or information describing the current state of devices associated with the electric vehicle and/or the charging station(s).

During pre-charge phase **302** all parties are presented with the conditions governing the charging transaction and agree to the conditions relevant to their role in the charging transaction prior to the charge phase commencing. There may be special circumstances in the terms and conditions which should be presented in standard formats that are universally understood and which can be readily communicated and agreed upon by all parties.

During pre-charge phase **302** an energy transaction plan is generated to manage the aspects of the charging transaction. If approval of the transaction plan is needed, the charging transaction interface also obtains approval of the transaction plan during pre-charge phase **302**. Thus, during pre-charge phase **302** of decision enablement, a charging plan is generated and all parties are presented with the conditions governing the charging transaction.

During charging phase **304**, electricity flows to the electric vehicle, electricity flows from the electric vehicle, and/or electricity is stored in the electric vehicle for some period of time. Operational and financial parameters may be conveyed for an optimum charge transaction. A dynamic representation of an electric vehicle's capability to consume charge may be monitored at all time during charge phase **304** to ensure the electric vehicle is not harmed or that the protections of the charging system are preserved. Electricity metering of power flow may be conducted and reported. Standards representing acceptable charging voltage and amperage ranges, for example, may be communicated and maintained for a safe charging transaction to occur.

Finally, during post-charge phase **306** of the transaction, the charging transaction interface performs an analysis to

settle the financial obligations of the principals and apply any applicable incentives on the part of one or more principals involved in the transaction. Post-charge phase **306** may include payment to one or more principals, applying incentives to the current transaction, issuing coupons, credits, gift cards, or other incentives to be used in the future, and/or recording the payments, charges, and incentives. All data pertinent to the financial transaction is conveyed and recorded.

Various programs may be available to encourage specific behaviors on the part of consumers. For example, there may be reduced electricity rates available if the electric vehicle charging is conducted during off-peak times when electricity usage across the power grid is lower. Data pertinent to these programs may be authenticated, accumulated, and analyzed for more effective business processing.

FIG. **4** is a block diagram of a charging transaction interface infrastructure in accordance with an illustrative embodiment. Electric vehicle charging transaction interface infrastructure **400** is an infrastructure for managing all phases of an electric vehicle charging transaction. During the pre-charge phase, all parties of the transaction are presented with the conditions governing the charging transaction. The parties may include, without limitation, the owner of the electric vehicle to be charged, the operator of the electric vehicle, the owner of the charging station, and an electric utility company providing electricity to an electric power grid associated with the charging station. Parties agree to conditions relevant to their role in the transaction prior to the charge commencing. There are likely to be many special circumstances in the terms and conditions which are presented in standard formats which are universally understood and which can be readily communicated and agreed upon by all parties.

During the pre-charge phase, electric vehicle energy transaction infrastructure **400** utilizes energy preference service **402**, energy decision assistant **404**, incentive service **405**, energy device capability services **406**, energy data services **408**, energy transaction planner **410**, and optionally, energy transaction plan approval service **412** to generate a plan governing the charging transaction to the parties involved in the transaction.

Energy preference service **402** is a software component that generates, stores, and retrieves preference information associated with an electric vehicle and the preference information associated with the parties to the transaction. Preferences may include, without limitation, a maximum price per kilowatt hour of electricity to be paid by a party, a location where charging may occur, a location where charging may not occur, a rate of charging the electric vehicle, a minimum amount of charge, or any other preferences associated with charging an electric vehicle. The preferences may be pre-generated by one or more of the parties to the transaction.

Energy decision assistant **404** is an optional service that provides real-time options and trade-offs for a particular trip. For example, energy decision assistant **404** may monitor available incentives, weather conditions, a travel route, traffic information, and other real-time data to identify the best electric vehicle charging options for a particular trip.

Incentive service **405** receives offers of incentives from third party vendors. The incentives may be offers of discounts, rebates, rewards, and/or other incentives associated with charging an electric vehicle to encourage an operator of the electric vehicle to perform one or more behaviors associated with charging the electric vehicle. For example, and without limitation, an incentive may offer to charge the electric vehicle for free at a particular charging station if the owner or operator of the electric vehicle purchases one or more products from the third party vendor. Incentives service **405** provides information describing current incentives to energy transaction planner **410**. In one embodiment, incentives service **405** provides the information describing the incentives to energy decision assistant **404**. Energy decision assistant **404** then provides the incentives information to energy transaction planner **410**.

Energy device capability service **406** is a software component that identifies and validates device capabilities. For example, and without limitation, energy device capability service **406** may include information describing the charging capabilities of the charging station, the charging requirements of the electric vehicle, the maximum storage capacity of the electric vehicle's on-vehicle storage mechanisms, the existing amount of charge in the electric vehicle, the number of amps of electricity the charging station is capable of providing, and any other information associated with the capabilities and requirements of the electric vehicles and the charging station.

Energy data services **408** are a set of one or more third party data sources providing information relevant to the energy transaction. Energy data services **408** may include, without limitation, weather information sources, traffic information sources, map and travel information sources, charging station price information sources, or any other third party information sources.

Energy transaction planner **410** is an application that creates a transaction plan for governing the electric vehicle charging transaction based on preferences of one or more principals. Energy transaction plan approval service **412** approves the transaction plan and validates with energy transaction broker **414**. Energy transaction plan approval service **412** may be required to notify one or more parties of the terms of the transaction and obtain approval of one or more of the terms from the party. For example, and without limitation, if an operator of the electric vehicle is not the owner of the electric vehicle, energy transaction plan approval service **412** may require approval from the owner of the vehicle before allowing the vehicle to receive power at a charging station if the charging station and/or a utility will charge the owner of the electric vehicle a fee for the charging transaction. If approval is required, energy transaction planner **410** sends the transaction plan to energy transaction plan approval service **412**. If energy transaction plan approval service **412** sends an approval back to energy transaction planner **410**, the transaction plan is an approved transaction plan that is ready to be sent to execution engine **416** for execution.

In this example, the charging phase begins when energy transaction execution engine **416** receives the transaction plan generated by energy transaction planner **410** and a request to begin charging the electric vehicle. Energy transaction execution engine **416** monitors and logs the health and safety of charging process **418** and receives requests from energy transaction interrupt monitor **420**. During charging process **418**, electricity flows into the electric vehicle or out of the electric vehicle and back into the power grid. Energy transaction interrupt monitor **420** monitors data transmissions to detect interrupt conditions that may terminate the flow of electric power to or from a vehicle. The interrupts may originate from the power grid, suppliers, and/or vehicles. For example, if a price of energy exceeds a predefined threshold in violation of a user-selected preference, energy transaction interrupt monitor **420** detects this interrupt condition and initiates appropriate actions to handle the cessation of electric power flow to the electric vehicle.

The post-charge phase includes payment of the appropriate parties for the energy transaction in accordance with the

energy transaction plan governing the transaction. Energy transaction broker **414** supports settling an electric vehicle charging and discharge transaction independent of electricity supplier, parking space supplier, electrical infrastructure supplier, taxing authority, incentive provider, or other interested party. Elements include pricing schedules, time based pricing, facility recovery, tax collection, incentives, and/or fixed plans. Energy transaction broker **414** may also be used by energy transaction approval service **412** to validate the financial elements of the energy transaction plan prior to plan approval and prior to charging the electric vehicle.

The post-charge phase may also optionally include analysis of the completed energy transaction to provide incentives, redeem credits or benefits, and induce specific behaviors by one or more parties involved in the charging transaction. Various programs may be available to encourage specific behaviors on the part of consumers. For example, a vehicle owner or user may receive reduced electricity rates if vehicle charging is conducted during off-peak times, such as during the night rather than during daylight hours when electricity usage is higher. Post charging information exchange **422** accumulates data pertinent to these incentives or redemption programs, authenticates the incentives data, and analyzes the incentives data to identify the most effective business process and optimize incentives for the parties.

During this charging phase, payment or fees for the charge are also recorded. Operational and financial parameters are conveyed for an optimum charge to occur. For example, a dynamic representation of an electric vehicle's capability to consume charge should be understood at all times during the charging process to ensure the vehicle is not damaged or that the protections of the charging system are preserved. Electricity metering of the power flow may also be conducted and reported. Standards representing the acceptable charging voltage and amperage ranges, for example may be communicated and maintained for a safe charging transaction to occur. All data pertinent to the financial transaction is conveyed and recorded.

The components shown in FIG. **4** may be implemented on a data processing system associated with an electric vehicle. In such case, the components communicate and transfer data using integration and service bus **424**. Integration and service bus **424** is an internal communication system within the electric vehicle, such as any wired or wireless communications system. A wired communications system includes, without limitation, a data bus or a universal serial bus (USB). If one or more components shown in FIG. **4** are located remotely, the components may transfer data using any type of wired or wireless network connection to connect to a network, such as network **102** in FIG. **1**. A wireless network connection may be implemented over a cell-phone network, satellite, two-way radio, WiFi networks, or any other type of wireless network.

Additional charging infrastructure may also be provided to meter electricity at the point of charge, identify the various parties involved in the transaction, and provide flexible business rules governing the flow of funds between those parties.

Turning now to FIG. **5**, a block diagram illustrating a pre-charge phase of a charging transaction is shown in accordance with an illustrative embodiment. Electric vehicle **500** is an electric vehicle that relies in whole or in part on electricity to drive the vehicle, such as, without limitation, electric vehicle **116** in FIG. **1**.

Principal identification **501** includes software and/or hardware to identify a principal associated with electric vehicle **500**. Principal identification **501** may include a badge reader, a radio frequency identification tag reader, a biometric device, a prompt requesting a password and/or user login, or any other type of identification mechanism. The biometric device may include, without limitation, a fingerprint scanner, a thumbprint scanner, a palm scanner, a voice print analysis tool, a retina scanner, an iris scanner, a device for reading deoxyribonucleic acid (DNA) patterns of the user, or any other type of biometric identification device.

Likewise, the identification of the user may include, without limitation, a user name, a password, a personal identification (PIN) number, an identifier, a fingerprint, a thumbprint, a retinal scan, an iris scan, or any other type of identification. The identification is associated with the set of preferences to map the set of preferences with the identification of the user that created the set of preferences. In another embodiment, security authentication, authorization, and/or identification information for the principal's identity may also be provided. The identification of the principal may also be accomplished via the driver preference settings available on electric vehicle **500**.

Vehicle preference service **502** is a software component for creating, managing, storing, and retrieving preferences for one or more principals, such as energy preference service **402** in FIG. **4**. In this example, vehicle preference service **502** is included within or bolted on electric vehicle **500**. Vehicle preference service **502** may be a system incorporated within electric vehicle **500** or added onto electric vehicle **500** as an after-market component. Vehicle preference service **502** responds to user input and requests or prompts users to enter preferences **503** through a user input/output device, such as without limitation, a graphical user interface, a command line interface, a menu driven interface, a keyboard, a mouse, a touch screen, a voice-recognition system, or any other type of input/output device. Vehicle preference service **502** may request an identity of a principal using the user input/output device. Vehicle preference service **502** may also obtain the identity of the principal from principal identification **501**.

Preferences **503** are choices for managing, governing, and/or controlling the manner in which electric vehicle **500** is charged with electric power at charging station **514**, de-charged, or used for storage of electric power. De-charging refers to removing or drawing electric power from electric vehicle **500** and returning the electric power to a power grid. A preference specifies a parameter of the charging transaction that is to be minimized, maximized, or optimized. A parameter of the charging transaction is any feature of the charging transaction, such as, without limitation, a rate of charging, a length of time for charging, a time to begin charging, a time to cease charging, a maximum level of charge, a minimum level of charge, or any other aspect of the charging transaction.

It will be appreciated by one skilled in the art that the words "optimize", "optimization" and related terms are terms of art that refer to improvements in speed, efficiency, accuracy, quality, and/or improvement of one or more parameters of electric vehicle charging transactions, and do not purport to indicate that any parameter of the charging transaction has achieved, or is capable of achieving, an "optimal" or perfectly speedy, perfectly efficient, and/or completely optimized.

Each preference may optionally be associated with a weighting value. For example, a preference may specify that charging at charging stations that obtain power from environmentally friendly, "green", wind farms is to be maximized or given a higher weighting value while charging at charging stations that obtain power from "brown", coal powered plants that may be harmful to the environment and should be minimized or given a lower weighting value. Brown energy refers to power generated from polluting sources, as opposed to green energy that is produced from renewable or less polluting energy sources.

Preferences **503** may also specify the price per kilowatt hour the user is willing to pay to charge the electric vehicle, identify certain charging stations the user prefers to fully charge electric vehicle **500** and identify other charging stations at which the user prefers to partially charge electric vehicle **500**, perhaps due to proximity to the user's home or due to the source of the electricity. For example, preferences may indicate that charging when the price per kilowatt hour is less than thirteen cents is to be maximized and charging when prices are higher than thirteen cents per kilowatt hour is to be minimized or prohibited all together. In another example, preferences **503** may specify a limit, such as, without limitation, buy electricity up to a certain price or optimize the cost of the return trip home given the current prices of gas and electricity.

Preferences **503** may be static, dynamic, or temporary preferences. A static preference, also referred to as a default preference, is a preference that is effective until the user changes the preference. A dynamic preference is a preference that does not have a predetermined value. A dynamic preference requires a user to enter a value for the dynamic preference in real time as the set of preferences are needed for a particular charging transaction. Thus, if a preference specifying whether an operator of the vehicle is to be allowed to charge electric vehicle **500** is a dynamic preference, the principal is always prompted to enter a preference value indicating whether a particular operator of electric vehicle **500** is authorized to charge electric vehicle **500**. A user may choose to make a preference for operator charging electric vehicle **500** a dynamic preference so that the owner of electric vehicle **500** will always be informed of who is attempting to charge electric vehicle **500** and have the option of preventing the charging of electric vehicle **500** in real time prior to commencing of the charging transaction.

A temporary preference is a preference that is only valid for a predetermined period of time, a predetermined number of transactions, or under predetermined conditions. When the period of time expires or the number of transactions is used, the temporary preference is invalid and no longer used. For example, a user may set a temporary preference that indicates no charging is to be performed for the next ten minutes at the charging station where the user is parked because the user is only going to be parked for five minutes. At the end of the ten minute time period, the temporary preference expires and electric vehicle **500** can begin charging if electric vehicle **500** is still parked at the charging station.

Preferences **503** are preference selections chosen by one or more users. A set of preferences may be stored for each user in a plurality of principals. For example, if electric vehicle **500** is owned and operated by a single person, preferences **503** may only contain a set of preferences for the person that is the owner and operator. However, if electric vehicle **500** is owned by a company that frequently loans electric vehicles to employees, preferences **503** may include a set of preferences for the owner and a set of preferences for each employee that borrows electric vehicle **500**. In such a case, vehicle preference service **502** may create, store, and manage hundreds of sets of preferences for hundreds of principals.

Vehicle preference service **502** stores preference **503** selected by one or more principals in data storage device **505**. Data storage device **505** may be implemented as any type of known or available device for storing data, such as, without limitation, a hard drive, a flash memory, a main memory, read only memory (ROM), a random access memory (RAM), a magnetic or optical disk drive, tape, or any other type of data storage device. Data storage may be implemented in a single data storage device or a plurality of data storage devices. In this example, data storage device **505** is located on-board electric vehicle **500**. However, data storage device **505** may also be located remotely from electric vehicle **500** or on a removable data storage device.

Vehicle preference service **502** receives requests for set of preferences **504** from energy transaction planner **506**. Set of preferences **504** is a set of preferences of interest in a particular charging transaction. Energy transaction planner **506** is a component for generating an energy transaction plan to manage the charging of an electric vehicle connected to an electric grid in accordance with the preferences of one or more parties to the electric vehicle charging transaction, such as energy transaction planner **410** in FIG. **4**.

When energy transaction planner **506** is engaged to create a transaction plan to govern an electric vehicle charging transaction for electric vehicle **400**, energy transaction planner **506** sends a request that contains at least the identity of one or more principals and a description of the specific preferences that are required by energy transaction planner **506**. For example, energy transaction planner **506** may only need charging related preferences if the charging station is incapable of providing discharge or store services. The messages sent between vehicle preference service **502** and energy transaction planner **506** may be authenticated and/or encrypted by authentication module **507**.

Authentication module **507** comprises any type of known or available encryption technology and/or security protocols, such as, without limitation, public/private key exchange. Authentication module **507** may be used to authenticate vehicle preference service **502** itself or authenticate tokens provided by vehicle preference service **502** for each of the principals for which vehicle preference service **502** is providing preferences to energy transaction planner **506**.

In response to receiving the request from energy transaction planner **506**, vehicle preference service **502** retrieves the one or more preferences in set of preferences **504** from the plurality of preferences stored in data storage device **505** that are responsive to the request.

Energy transaction planner **506** also requests other charging information from set of charging information sources **508**. Set of charging information sources may include, without limitation, an energy device capability service, such as energy device capabilities services **406** in FIG. **4**, and/or an energy data service, such as energy data services **408** in FIG. **4**. The charging information may include information describing the capabilities of devices and/or current state of devices associated with electric vehicle **400** and/or charging station **514**, as well as any other information relevant to the charging transaction. Energy transaction planner **506** utilizes set of preferences **504** and/or any other available charging information from set of charging information sources **508** to generate transaction plan **510**. Energy transaction plan **510** is then sent to execution engine **512** for implementation during the charging phase of the charging transaction. Energy transaction planner **506** may also save a copy of transaction plan **510** in data storage device **508**.

Energy transaction plan **510** is a plan that manages every aspect of charging electric vehicle **500**, using electric vehicle **500** as a temporary electric storage device, discharging/selling electric power back to the electric grid, or any combination of charging, de-charging, or storing. For example, and without limitation, energy transaction plan **510** may involve charging electric vehicle **500** for two hours, storing the electricity for one hour, de-discharging/selling electricity back to the grid for thirty minutes, waiting two hours and then charging again for one more hour.

Energy transaction plan **510** is created to meet the needs of all the identified principals, is consistent with the capabilities of the physical components of electric vehicle **500**, charging station **514**, and the electric power grid. Charging station **514** is a station or kiosk for permitting electric vehicle **500** to connect to an electric grid to charge or de-charge electric vehicle, such as charging station **118** in FIG. **1**.

To construct energy transaction plan **510**, a number of the following entities should be specified: a user paying for the charging transaction, the electric vehicle to be charged, the electric vehicle owner, the supplier of electricity, such as a utility, the owner of the charging station or outlet, and additional information related to incentives or credits, such as, for example, a clean energy generation source. In addition, energy transaction plan **510** optionally determines the contractual relationships between all principals. Energy transaction plan **510** includes an identification of electric vehicle **500**, an identification of the principal paying for the charging and/or the principal that is to be paid for storing electric power or de-charging electric vehicle **500**. Energy transaction plan **510** may specify method of payment, amount of payment, incentives, terms of the transaction, and enforcement of the terms of the charging transaction.

In this example, energy transaction planner **506** obtains set of preferences **504** from vehicle preference service **502** that is located on-board electric vehicle **500**. However, energy transaction planner **506** may optionally receive some preferences, or all preferences, from one or more remote energy preference services, such as remote energy preference service **516** on remote computing device **518**. Likewise, in the example shown in FIG. **4**, energy transaction planner **506** is an on-vehicle component that is attached, coupled to, or located on electric vehicle **500**. However, in another embodiment, vehicle preference service **502** may receive requests for preferences from remote energy transaction planner **522** that is located on remote computing device **518** that is remote from electric vehicle **500**. Electric vehicle **500** communicates with remote energy preference service **516** and/or remote energy transaction planner **522** on remote computing device **518** over a network via a network interface. The network interface is any type of network access software known or available for allowing electric vehicle **500** to access a network, such as network **102** in FIG. **1**. Vehicle preference service **502** utilizes the network connection to send set of preferences **504** to remote energy transaction planner **522** on remote computing device **518**. Likewise, energy transaction planner **506** may use the network connection to request preferences from one or more remote energy preference services.

A secure connection may be established between electric vehicle **500** and remote computing device **518** using any wired or wireless communications method, such as, without limitation, Wi-Fi, Bluetooth, telephone network, or any other network connection. The remote computing device **518** may be any type of computing device, such as, without limitation, a desk top computer, a laptop computer, a personal digital assistant (PDA), or a smart phone.

Referring to FIG. **6**, a block diagram of vehicle preferences is shown in accordance with an illustrative embodiment. Preferences **600** are types of preferences that may be included within preferences for one or more users, such as preferences **420** in FIG. **4**. Preferences **600** may be charging preferences **602** for governing energy transaction to charge an energy storage device associated with the electric vehicle, de-charging preferences **604** for governing energy transactions for de-charging or depleting the energy stored in an energy storage device, or storage preferences **606** for governing the storage of electricity in the electric vehicle's energy storage mechanisms.

A user may wish to de-charge or transfer power from the electric vehicle to a charging station if the price of the electricity is higher than when the electricity was purchased and stored in the electric vehicle. For example, if a user charges an electric vehicle at night when the price of the electricity is only nine cents per kilowatt hour, the user may wish to de-charge or provide electricity from the electric vehicle back to the charging station at noon when the price per kilowatt hour is fifteen cents because the user is able to make a profit from storing the electricity in the electric vehicle until the price of electricity increases and then selling the electricity back to the electric grid.

Some examples of charging preferences include, without limitation, financial **608**, locations **610**, time **612**, amount of charge **614**, power source **616**, and/or operator **618**. For example, financial **608** preferences may specify price per kilowatt hour **620** that the user is willing to pay to charge the electric vehicle or payment method **622** for purchasing the electricity from the charging station and/or the electricity grid. Payment method **622** may include, without limitation, credit cards, cash, debit card, credit, or any other type of payment. The payment type preferences may even specify a particular credit card or bank account for debit to pay for the charging transaction.

Locations **610** preferences may specify preferred charging station **624**, preferred locations **626** of the charging stations, and/or specified locations **628** for charging. For example, the user may specify that any time the electric vehicle is parked at a charging station that is at a specified location, the electric vehicle is not to be charged at all, to be charged to a particular charge level, or to be fully charged. The user may wish to set these preferences because the charging stations are a given distance from the user's home or workplace, due to past service received at the charging station, or any other factors.

Time **612** preferences may specify, without limitation, time of day **630** for charging the vehicle, time of day to stop charging the vehicle, day of month **632** for charging, and/or day of the week **634** for charging the electric vehicle.

Amount of charge **614** preferences may specify minimum level **636** of charge in the electric vehicle's storage device, a maximum level of charge **638**, or specify different levels of charge depending on power source **640** of the electricity used to charge the electric vehicle. If the power source is a "green" source, such as solar power, the user may specify a higher charge level than if the power source is a more environmentally harmful, or "brown" power source, such as coal or oil.

Power source **616** preferences specify types of power sources that are acceptable or preferred and/or provide weighting values for different power sources. The power sources may be identified as "green" or "brown" **642**. The power sources may also be identified specifically by the type of power source, such as wind, solar, coal, oil, and so forth.

Operator **618** preferences are preferences for allowing particular operators to charge the electric vehicle. Owner **644** is a preference that permits an owner to charge, particular individuals **646** permits identified individuals to charge the vehicle, and any operator **648** is a preference that permits anyone to charge the electric vehicle. The operator **618** preference may permit a user to prevent or impede theft of the electric vehicle. For example, if a user sets owner **644** as a mandatory preference that only permits the owner to charge the electric vehicle, a thief would not be permitted to recharge the electric vehicle. Therefore, a thief may not be able to

transport the electric vehicle very far from the location at which the electric vehicle was stolen.

The preferences described for charging preferences **602** are only examples of some preferences that may be used. A vehicle preference service is not required to utilize all of the preferences shown in FIG. **6**. Moreover, a vehicle preference service may utilize other preferences not shown in FIG. **6** without departing from the scope of the embodiments. Finally, the preferences shown for charging preferences **602** may also be used as preferences for de-charging preferences **604** and/or storage preferences **606**, in addition to other preferences not shown. For example, de-charging preferences **604** may include operator **618** preferences specifying operators that are permitted to de-charge or sell power back to the electric grid, financial **608** specifying prices at which the electricity may be transferred from the electric vehicle and sold back to the electric grid, time **612** when de-charging may occur, amount of charge **614** levels for de-charging, and power source **616** of the power that is de-charged.

FIG. **7** is a block diagram of preference settings in accordance with an illustrative embodiment. Preference settings **700** are settings that may be appended to a preference, such as preference A **702**. Preference A **702** may be any type of preference, such as, without limitation, financial, locations, time, amount of charge, power source, operator, or any other preferences. Mandatory **704** specifies that the requirements of a particular preference must be met or a charging transaction will not be permitted. For example, if a user sets an operator preference indicating that only the owner is permitted to charge the electric vehicle and the user sets the preference to mandatory, only the owner will be permitted to initiate charging of the electric vehicle. Any other operator of the electric vehicle will not be permitted to charge the electric vehicle unless the owner changes the preference settings.

Optional/weighted **706** is a setting that indicates that a preference is preferred or desirable, but not mandatory. For example, the user may specify that "green" power sources, such as wind and solar power sources, are preferred but not mandatory. In such cases, the energy transaction planner may still permit charging of the electric vehicle at charging stations that utilize electricity provided by coal powered electric generators. The weighting value permits a user to indicate how strongly the user wants a particular preference to be minimized, maximized, or optimized. In the example above, the user may indicate a high weighting value in favor of wind and solar power, a medium weighting value for nuclear power plants, and a low weighting value for coal power plants. The energy transaction planner may then use the weighting value to determine how much to charge or de-charge the electric vehicle or whether to charge or de-charge the electric vehicle at all.

Static **708** indicates that a preference is a default preference that should be used in all cases. A static preference does not change from one charging transaction to the next charging transaction. Dynamic **710** setting indicates that a user wants to provide or select a value or choice for this preference every time a charging transaction plan is generated. A dynamic preference is selected in real time as the charging transaction is commencing. Temporary **712** indicates that a temporary preference value is to be used in place of a static preference for a limited period of time. For example, a user may wish to override a static preference that the electric vehicle should always be fully charged at a particular charging station with a temporary preference indicating that the electric vehicle is not to be charged because the user will only be parked at the charging station for a few minutes.

Turning now to FIG. **8**, a block diagram of parties to an electric vehicle charging transaction is depicted in accordance with an illustrative embodiment. Each party may have a set of preferences for charging the electric vehicle that is managed by the vehicle preference service. A principal is any entity that may have an interest or role in the energy transaction for charging an electric vehicle, including but not limited to, the vehicle operator, owner of the electric vehicle, the owner of the charging station, the operator of the charging station, financial institutions associated with one or more of the parties, utilities associated with one or more of the principals, or third parties having an interest in the charging transaction. FIG. **8** illustrates the different relationships between principals. Any one or more of the principals shown in FIG. **8** may have preferences stored in the on-vehicle preference service.

Electric vehicle **800** is a vehicle that relies in whole or in part on electric power to drive the vehicle, such as electric vehicle **118** in FIG. **1** or electric vehicle **400** in FIG. **4**. Owner of electric vehicle **802** is a principal that creates a set of preferences in vehicle preference service on electric vehicle **800**. Operator of electric vehicle **804** is a principal that may be the owner or only someone that has borrowed electric vehicle **800**. Each operator may optionally create their own set of preferences in the vehicle preference service on electric vehicle. Charging station **806** is a station or kiosk at which electric vehicle obtains charge or de-charges to provide electricity back to the electric grid, such as charging station **118** in FIG. **1** or charging station **514** in FIG. **4**. Charging station **806** may also have a set of preferences for governing the charging of electric vehicle **800**. Each party may have a utility associated with the party. A utility refers to a provider of electric power. A utility typically provides electric power to a charging station via an electric power grid. Each utility may also have preferences for governing the charging transaction. For example, utility of owner **808**, utility of operator **810**, and utility of charging station **812** may each be parties with an interest in the charging transaction and preferences for governing the charging of electric vehicle **800**.

Each party may also have a financial institution for paying for the electricity purchased, or for being reimbursed for electricity provided back to the electric grid. A financial institution may be a bank, a credit card company, a broker, a lender, or any other financial institution. For example, financial institution A **814** may be associated with owner of electric vehicle **802**, financial institution B **816** may be associated with operator of electric vehicle **804**, and financial institution C **818** may be associated with charging station **806**. Each of these financial institutions may have preferences for controlling how amounts due are received, how charges of payments are received and accepted, how credits are issued and received, and other aspects of financial transactions associated with charging electric vehicle **800**.

Third party vendor **820** is a third party that is not associated with charging station **806** or electric vehicle **800**. For example, and without limitation, third party vendor **820** may be a grocery store, a convenience store, a car wash, a repair shop, or any other type of vendor. Third party broker **822** is a third party that may provide financing or manage financial transactions associated with charging electric vehicle **800**.

Each of the parties shown in FIG. **8** may optionally have preferences, constraints, limitations, or requirements associated with charging electric vehicle **800**. The vehicle preference service on electric vehicle **800** may optionally store, manage, and retrieve some or all of these preferences, constraints, limitations, and requirements in data storage device on electric vehicle **800**. The vehicle preference service

retrieves the information of interest that is responsive to a request by an energy transaction planner and sends the preferences of interest to the energy transaction planner for use in generating a plan to govern the charging of electric vehicle **800** at charging station **806**.

FIG. **9** is a block diagram of a set of fields in an energy transaction plan in accordance with an illustrative embodiment. Energy transaction plan **900** is a plan for managing an electric vehicle charging transaction, such as energy transaction plan **424** in FIG. **4**. Energy transaction plan **900** defines an energy transfer transaction encompassing the charge, discharge, and storage of electric energy in an electric vehicle and the incumbent financial exchanges related to those energy exchanges and storage of electric power in the electric vehicle. Energy transaction plan **900** may include, without limitation, identification of electric vehicle **902**; identification of principal(s) **903**; payment **904** terms; incentives **905**; terms/contractual relationship of the principals **906**; enforcement of terms **907**; charge **908**, discharge **909**, store **910**, and/or a series of time fields indicating the electric flow direction at each time mark, such as, without limitation, time **1 911**, time **2 912**, time **3 913**, time **4 914**, and/or time **5 915**.

Identification of principal(s) **903** identifies one or more principals for a particular charging transaction, such as, without limitation, electric vehicle (EV) owner **916**; electric vehicle operator **917**; charging station owner **918**; charging station operator **920**; utility **922** of the owner; operator; or charging station; financial institution **924** of the owner; operator; or utility; third party broker **926**; and/or a third party vendor **928**. Payment **904** may specify the type of payment method, such as, without limitation, cash/gift card **930**; credit/debit **932**; and/or check/money order **934**. Incentives **905** are terms in energy transaction plan **900** associated with coupons/rebates/discounts **936**, and/or reward points/cash back **938**, or any other rewards, discounts, rebates, coupons, or other benefits.

Charge **908** orders the flow direction of electricity from the charging station into the electric vehicle during one or more specified time intervals. Rate **1 940** is a first time interval during which the electric vehicle receives electricity from the charging station at a specified rate of electricity flow. Rate **2 942** is a second time interval during which the electric vehicle receives electricity from the charging station at a specified rate. Discharge **909** indicates each time interval during which electricity flows out of the electric vehicle and back into the electric grid through the charging station. Store **910** indicates time intervals during which electricity is neither flowing into the electric vehicle nor flowing out of the electric vehicle's electricity storage mechanisms. In other words, during the one or more time intervals indicated in store **910**, the electric vehicle stores electricity in the electric vehicle's storage mechanisms without charging or discharging power.

The time intervals **911-915** optionally indicate start and end times for charging, discharging, and/or storing. Energy transaction plan **900** may have multiple charge, discharge or store time windows. In this example, and without limitation, time **1 911** starts charging the electric vehicle at a given rate of electricity flow until time **2 912**. At time **2 912**, charging stops. At time **3 913**, the electric vehicle begins discharging power back to the electric grid and continues discharging electricity until time **4 914**. Time **5 915** indicates a time when the electric vehicle charging transaction ends. However, the embodiments are not limited to this example. The field for time **1 911** may have been an entry for discharging the electric vehicle instead of charging. The field for time **4 914** may be a field for storing electric power.

Fields **908-915** are examples of charging transaction time driven event sequences. The time intervals may be any standard clock time, such as Greenwich Mean Time, Central Time, Pacific Time, an internal clock time for the electric vehicle, or any other standard clock time. In another embodiment, the time may be a time relative to beginning the electric vehicle charging transaction. For example, instead of charge **908** stating that charging begins at 2:24 p.m. and ends at 4:24 p.m., charge **908** may state that charging begins when the charging transaction begins and ends two hours later, regardless of what time it may be.

Energy transaction plan **900** is not required to include every field shown in FIG. **9**. For example, and without limitation, energy transaction plan **900** may include fields for charge **908**, discharge **909**, and store **910** but omit fields for time entries, such as time **1** to time **5 911-915**. In addition, energy transaction plan **900** may include additional fields not shown in FIG. **9**. For example, energy transaction plan may include a time **5** to begin storing electricity, time **6** to stop storing, time **7** to charge, time **8** to stop charging, time **9** to discharge, time **10** to stop discharging, and time **11** to end the transaction. In other words, energy transaction plan **900** may include any number of fields and any combination of fields to provide terms for charging, discharging, and/or storing electricity in an electric vehicle.

FIG. **10** is a block diagram of a set of fields in an energy transaction plan summary in accordance with an illustrative embodiment. Transaction plan summary **1000** is an example of fields that may be provided in a summary of a proposed energy transaction plan generated by an energy transaction plan approval service, such as plan summary **414** in FIG. **4**. Battery charge at end of transaction **1002** is a field that summarizes the anticipated amount of charge in one or more electric power storage mechanisms on-board an electric vehicle at the end of an electric vehicle charging transaction. Net financial cost/gain **1004** is a field that provides an anticipated net cost for electric power or an anticipated net financial gain at the end of the electric vehicle charging transaction. A net financial gain may occur where the electric vehicle purchases electricity for storage on the electric vehicle when rates for electricity are low and then sells the electricity back to the power grid during peak electric power utilization when the price of electricity is higher.

A carbon cap and trade system is a system in which those who produce carbon emissions below a certain level obtain carbon credits that may then be sold to those who produce carbon emissions above that level. Carbon cap and trade net transaction **1006** is a field indicating the amount of carbon credits that may have been earned. Net transaction result for other commodities **1008** is a field for indicating net gains or losses associated with other commodities. For example, net transaction result for other commodities **1008** may indicate a number of reward points earned by the user, discounts on other commodities such as car wash, oil change, or other vehicle maintenance privileges, reduction of parking fees, or other commodities. Rating **1010** indicates a rating for certain goals of a user. For example, carbon footprint **1012** rating indicates how well the electric vehicle's carbon emissions rate on a carbon footprint scale. Financial goals **1014** indicates a rating for how the actual financial costs/gains of the electric vehicle charging transaction(s) rate in accordance with the user's selected preferences.

Transaction plan summary **1000** is only an example and not intended as a limitation. A transaction plan summary may include more fields than is shown in FIG. **10** or fewer fields than is depicted in FIG. **10**.

FIG. **11** is a block diagram of a post-charge process for brokering electric vehicle charge transactions in accordance with an illustrative embodiment. Post charge system **1100** is a system for processing data, such as network data processing system **100** in FIG. **1** and electric vehicle charging transaction infrastructure **300** in FIG. **3**.

Energy transaction broker **1102** is an energy transaction broker such as energy transaction broker **414** in FIG. **4**. Energy transaction broker **1102** is configured for brokering settlement of payments in a charging transaction. The process of brokering the settlement of a charging transaction includes identifying a set of payees' entitled payment, calculating a payment owed, and disbursing the payment according to payment terms. In addition, the settlement process may require applying incentive funds to offset an amount owed by the party charging an electric vehicle.

Energy transaction broker **1102** initiates the settlement process in response to receiving notification **1104** indicating that a charging transaction has been completed. Energy transaction broker **1102** may receive notification **1104** from an execution engine, such as energy transaction execution engine **416** in FIG. **4**. After receiving notification **1104**, energy transaction broker **1102** retrieves energy transaction plan **1106**. Energy transaction plan **1106** is a plan for controlling and managing multiple aspects of the charging transaction, such as transaction plan **510** in FIG. **5**. Energy transaction plan **1106** may indicate the location of the charging station, the date of the charging transaction, a length of time that the electric vehicle was at the charging station, an amount of electricity that was transmitted between the electric vehicle and the charging station, the variable rate of the cost of electricity during the charging transaction, the utility provider responsible for providing electricity, and any other information that may be related to the charging transaction or relevant for brokering the settlement of a charging transaction.

Energy transaction broker **1102** extracts event data **1108** from energy transaction plan **1106**. Event data **1108** may include, for example, unique identifiers included in energy transaction plan **1106**, prices, quantities of energy transferred, or any other categories of information related to a charging transaction. Event data **1108** may be stored in storage device **1110** and aggregated over time. Storage device **1110** is a device for storing data. Storage device **1110** may include, for example, a hard drive, flash drive, remote server, or any other device for storing data.

Aggregated event data **1108** forms transaction history **1112**. Transaction history **1112** is a collection of event data recorded over time. Transaction history **1112** may be used for auditing past charging transactions, or mined for relevant information for performing data analysis. The results of the data analysis may be used to provide incentives, recommendations for optimizing energy consumption, or other selected outcomes or tasks.

Event data **1108** may also be used for identifying set of payees **1114**. Set of payees **1114** is one or more principals, such as, for example, a utility company, a point of service entity providing a charging station, a government entity specifying a tax applicable to a charging transaction, or any other party participating in a charging transaction. Set of payees **1114** may be identified from event data **1108** by correlating a unique identifier assigned to a payee with a payee profile from set of payee profiles **1116**.

Set of payee profiles **1116** is one or more profiles corresponding to set of payees **1106**. Each profile from set of payee profiles **1116** includes information relating to a single payee from set of payees **1114**. Energy transaction broker **1102** may identify set of payees **1114** by correlating payee identifiers from event data **1108** with payee identifiers from profiles of set of payee profiles **1116**. In this manner, energy transaction broker **1102** may quickly and easily locate information, instructions, or preferences that facilitate the settlement of a charging transaction for the benefit of each payee in set of payees **1114**.

Set of payee profiles **1116** may also include payment terms **1118**. Payment terms **1118** are terms to which a payee has agreed and which govern the settlement of a charging transaction. For example, payment terms **1118** may provide an algorithm for calculating the portion of payment **1120** due to the payee, establish the time and manner in which payment **1120** is made, or an account into which payment **1120** is deposited. Thus, if a payee is a government entity, payment terms **1118** may specify that payment **1120** is based on a rate of an excise tax applicable to all charging transactions.

Payment **1120** may be any medium of exchange, such as, without limitation, coins, paper money, demand deposits, credit, or other forms of money. Payment **1120** may be made with funds from payer funds **1122** and/or incentive funds **1124**. Payer funds **1122** is a fund supplied by a payee, such as, without limitation, a bank account debit card, a check, money order, or some other acceptable form of payment. Incentive funds **1124** is a fund established by a payee or a third party entity. For example, without limitation, set of payees **1114** may include a point of service entity providing a charging station at which a charging transaction may occur. Incentive funds **1124** are applied to payment **1120** and reduce the amount of money that energy transaction broker **1102** uses from payer funds **1122**.

After payment **1120** is made to set of payees **1114**, energy transaction broker **1102** sends payment notification **1126** to set of payees informing set of payees **1114** that payment **1120** has been disbursed, thus signaling the completion of a charging transaction. Payment notification **1126** may provide details such as, for example, a time at which the disbursement was made, the account into which payment **1120** was deposited, a unique identifier associated with the user from which payer funds **1122** is associated, the amount of the disbursement, or any other relevant information. The payment notification **1126** may include an incentive for future use on a future charging transaction and/or an incentive offering other related or unrelated goods and services.

Authentication module **1128** is a software component for authenticating energy transaction plan **1106** using currently available or later developed authentication algorithms. Authentication module **1128** may also implement encryption technologies for protecting energy transaction plan **1106** or other forms of protected data. Authentication module **1128** insures that only those entities having the proper authorization receive payment **1120**, payment notification **1126**, or other forms of protected information.

Turning now to FIG. **12**, a flowchart illustrating an electric vehicle charging transaction is shown in accordance with an illustrative embodiment. FIG. **12** is implemented by a software component for managing an electric vehicle charging transaction, such as electric vehicle charging transaction infrastructure **400** in FIG. **4**.

The process begins by identifying a set of principals (step **1201**) and generating a transaction plan using electric vehicle charging information (step **1202**). The charging information may include, without limitation, preferences, device capabilities information, and information describing the current state of devices. A determination is made as to whether approval by one or more principals is needed (step **1204**). If approval is needed, a determination is made as to whether approval is received (step **1206**). In one embodiment, the transaction plan

and/or a summary of the transaction plan is presented to one or more principals with a request for approval. If the one or more principals indicate approval of the transaction plan, the process determines that the transaction plan is approved. If approval is not received, a new transaction plan is generated at step **1202** and a new determination is made as to whether approval is needed at step **1204** and whether the transaction plan is approved at step **1206**.

If the transaction plan is approved at step **1206**, the charging phase of the charging transaction is initiated (step **1208**). A determination is made as to whether the charging phase of the charging transaction is complete (step **1210**). If the charging phase is not complete, the charging, discharging, and/or storing of electric power in the electric vehicle continues until the charging phase is complete (step **1212**). Once the charging phase is complete, the financial obligations of the principals are settled in accordance with the transaction plan (step **1214**) with the process terminating thereafter.

In another embodiment, the charging phase may be interrupted if an interrupt condition is detected. An interrupt condition may include a disconnection from the electric grid, a failure in a device associated with the electric vehicle or the charging station, or any other event causing an interruption in the charging phase.

FIG. **13** is a flowchart illustrating a process for a pre-charge phase of a charging transaction in accordance with an illustrative embodiment. The process in FIG. **13** may be implemented software for generating a customized, energy transaction plan, such as energy transaction planner **410** in FIG. **4** or energy transaction planner **506** in FIG. **5**.

The energy transaction planner identifies a set of principals, the charging station, applicable incentives, the electric vehicle, a set of preferences for the set of principals, device capabilities, and/or a current state of devices to form electric vehicle charging information (step **1302**). The energy transaction planner generates a transaction plan using the electric vehicle charging information (step **1304**). The energy transaction planner makes a determination as to whether the transaction plan is complex (step **1306**). If the plan is complex, the energy transaction planner generates a plan summary (step **1308**). The energy transaction planner then obtains approval of the plan from a subset of principals (step **1310**). This subset of principals may include no principals, a single principal, or two or more principals. In other words, the subset of principals may be a null set having no members. The energy transaction planner may send the transaction plan and/or the transaction plan summary to each principal in the subset of principals for approval. The energy transaction planner then sends the approved transaction plan to an execution engine for implementation during a charging phase (step **1312**) with the process terminating thereafter. In another embodiment, steps **1304-1310** may be omitted if approval of the transaction plan is not needed.

FIG. **14** is a flowchart illustrating a process for a charging phase and a post charging phase of an electric vehicle charging transaction in accordance with an illustrative embodiment. The process begins by receiving an energy transaction plan (step **1402**) from an energy transaction planner, such as energy transaction planner **410** in FIG. **4**. The process then initiates a charging phase of a charging transaction (step **1404**). In response to initiating the charging phase, the execution engine may trigger charging, discharging, or storing electricity in the electric vehicle.

The process requests energy transaction interrupt monitor services (step **1406**). The energy transaction interrupt monitor is an energy transaction interrupt monitor such as energy transaction interrupt monitor **420** in FIG. **4**. The process then makes the determination as to whether the charging phase is complete (step **1408**). If the process makes the determination that the charging process is complete, then the process sends a completed charge notification for transmission (step **1410**). The process then stores the charging process data (step **1412**) and terminates thereafter.

Returning now to step **1408**, if the process makes the determination that the vehicle charge is not complete, the process makes the determination as to whether an interruption is detected (step **1414**). If an interruption is not detected, then the process returns to step **1408**. However, if the process makes the determination that an interruption is detected, then the process sends an incomplete charge notification (step **1420**) and makes a determination as to whether the electric vehicle is still connected to the charging station (step **1422**). If the electric vehicle is still connected to the charging station, the process requests a new energy transaction plan (step **1424**) and returns to step **1402**. The new energy transaction plan may be requested from an energy transaction planner such as energy transaction planner **410** in FIG. **4**.

FIG. **15** is a flowchart of a process for a post-charge process in an electric vehicle charge transactions. The process in FIG. **15** may be implemented by software, such as energy transaction broker **402** in FIG. **4**.

The process begins by receiving a notification that the energy transaction is complete (step **1502**). Thereafter, the energy transaction plan is retrieved (step **1504**). The energy transaction plan may be retrieved from an energy transaction execution engine such as energy transaction execution engine **416** in FIG. **4**. A payment due to a set of payees is calculated (step **1506**). The payment is disbursed to the set of payees (step **1508**) and the process terminates.

In one embodiment, before the payments are disbursed to the set of payees, the process may authenticate the energy transaction plan. Authentication may be achieved by implementing, for example, the use of passwords, encryption, or any other currently existing or later developed mechanism.

According to one embodiment of the present invention, a computer implemented method, apparatus, and computer program product is provided for managing an electric vehicle charging transaction. A set of principals associated with the electric vehicle charging transaction is identified. A principal in the set of principals is an entity having an interest in the electric vehicle charging transaction. Electric vehicle charging information is retrieved from a set of sources. An energy transaction plan is generated using the electric vehicle charging information. A charging phase of the electric vehicle charging transaction is initiated for an electric vehicle connected to a charging station in accordance with the energy transaction plan. The charging phase comprises at least one of charging the electric vehicle with electricity, storing electricity in an electric storage mechanism associated with the electric vehicle, and removing electricity from the electric storage mechanism to de-charge the electric vehicle. In response to completion of the charging phase, the process settles the financial obligations of a subset of principals in the set of principals in accordance with the energy transaction plan.

The electric vehicle charging transaction interface may be used to govern all aspects of an electric vehicle charging transaction. The electric vehicle charging transaction interface may also be used with additional infrastructure to provide electricity metering at the point of charge, identification of the various parties involved in the transaction, and flexible business rules governing the flow of funds between those parties.

The electric vehicle charging transaction interface permits a driver of an electric vehicle to plug his vehicle in at any

location that has an electric outlet for charging and automatically identify the financial account responsible for settling the cost of charging the vehicle. The electric vehicle charging transaction interface identifies all parties that will be responsible for paying for a charging transaction and establishing a transaction plan to govern the charging transaction in accordance with the parties preferences and agreements.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

The terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. As used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, integers, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, and/or groups thereof.

The corresponding structures, materials, acts, and equivalents of all means or step plus function elements in the claims below are intended to include any structure, material, or act for performing the function in combination with other claimed elements as specifically claimed. The description of the present invention has been presented for purposes of illustration and description, but is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art without departing from the scope and spirit of the invention. The embodiment was chosen and described in order to best explain the principles of the invention and the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

The invention can take the form of an entirely hardware embodiment, an entirely software embodiment or an embodiment containing both hardware and software elements. In a preferred embodiment, the invention is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

Furthermore, the invention can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer-readable medium can be any tangible apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

The medium can be an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk and an optical disk. Current examples of optical disks include compact disk-read only memory (CD-ROM), compact disk-read/write (CD-R/W) and DVD.

A data processing system suitable for storing and/or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution.

Input/output or I/O devices (including but not limited to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers.

Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems, cable modem and Ethernet cards are just a few of the currently available types of network adapters.

The description of the present invention has been presented for purposes of illustration and description, and is not intended to be exhaustive or limited to the invention in the form disclosed. Many modifications and variations will be apparent to those of ordinary skill in the art. The embodiment was chosen and described in order to best explain the principles of the invention, the practical application, and to enable others of ordinary skill in the art to understand the invention for various embodiments with various modifications as are suited to the particular use contemplated.

What is claimed is:

1. An electric vehicle charging transaction interface comprising:

a principal identification component, wherein the principal identification component identifies a set of principals associated with the electric vehicle charging transaction, wherein a principal in the set of principals is an entity having an interest in the electric vehicle charging transaction;

an energy transaction planner, wherein the energy transaction planner generates an energy transaction plan using electric vehicle charging information, wherein the electric vehicle charging information is received from a set of sources;

an execution engine, wherein the execution engine initiates a charging phase of the electric vehicle charging transaction for an electric vehicle connected to a charging station in accordance with the energy transaction plan, wherein the charging phase comprises at least one of charging the electric vehicle with electricity, storing electricity in an electric storage mechanism associated with the electric vehicle, and removing electricity from the electric storage mechanism to de-charge the electric vehicle;

a vehicle preference service, wherein the electric vehicle charging information comprises a set of preferences, wherein the set of preferences comprises a subset of

preferences for each principal in the set of principals, wherein a preference in the set of preferences specifies a parameter of the charging transaction that is to be minimized, maximized, or optimized, and wherein the vehicle preference service sends the set of preferences to the energy transaction planner to form the electric vehicle charging information; and

an energy transaction broker, wherein the energy transaction broker settles financial obligations of a subset of principals in the set of principals in accordance with the energy transaction plan in response to completion of the charging phase.

2. The electric vehicle charging transaction interface of claim **1** further comprising:

an energy transaction plan approval service, wherein the energy transaction plan approval service receives the energy transaction plan and obtains approval of the energy transaction plan from a subset of principals in the set of principals.

3. The electric vehicle charging transaction interface of claim **1** further comprising:

an energy transaction plan approval service, wherein the energy transaction plan approval service generates a summary of the energy transaction plan in response to a determination that the energy transaction plan is a complex plan and sends the summary of the energy transaction plan with a request for approval of the energy transaction plan to a subset of principals in the set of principals for approval.

4. The electric vehicle charging transaction interface of claim **1** wherein the electric vehicle charging information comprises information describing capabilities of devices associated with the electric vehicle and information describing a current state of the devices associated with the electric vehicle.

5. The electric vehicle charging transaction interface of claim **1** further comprising:

an interrupt monitor, wherein the interrupt monitor detects an interrupt condition, sends an incomplete charge notification to an execution engine; and requests a new energy transaction plan in response to a determination that the electric vehicle is still connected to the charging station.

6. A computer implemented method for providing a charging transaction interface, the computer implemented method comprising:

identifying a set of principals associated with an electric vehicle charging transaction in a principal identification component, wherein a principal in the set of principals is an entity having an interest in the electric vehicle charging transaction;

generating an energy transaction plan in an energy transaction planner, wherein the energy transaction planner uses electric vehicle charging information received from a set of sources;

initiating a charging phase of the electric vehicle charging transaction for an electric vehicle connected to a charging station with an execution engine, wherein the execution engine initiates the charging phase in accordance with the energy transaction plan, wherein the charging phase comprises at least one of charging the electric vehicle with electricity, storing electricity in an electric storage mechanism associated with the electric vehicle, and removing electricity from the electric storage mechanism to de-charge the electric vehicle;

sending a set of preferences to the energy transaction planner to form the electric vehicle charging information using a vehicle preference service, wherein the electric vehicle charging information comprises a set of preferences, wherein the set of preferences comprises a subset of preferences for each principal in the set of principals, and wherein a preference in the set of preferences specifies a parameter of the charging transaction that is to be minimized, maximized, or optimized; and

settling financial obligations of a subset of principals in the set of principals in accordance with the energy transaction plan in response to completion of the charging phase in an energy transaction broker.

7. The computer implemented method of claim **6** further comprising:

receiving the energy transaction plan at an energy transaction plan approval service to obtain approval of the energy transaction plan from a subset of principals in the set of principals.

8. The computer implemented method of claim **6** further comprising:

generating a summary of the energy transaction plan using an energy transaction plan approval service, wherein the energy transaction plan approval service generates the summary in response to a determination that the energy transaction plan is a complex plan and sends the summary of the energy transaction plan with a request for approval of the energy transaction plan to a subset of principals in the set of principals for approval.

9. The computer implemented method of claim **6** wherein the electric vehicle charging information comprises information describing capabilities of devices associated with the electric vehicle and information describing a current state of the devices associated with the electric vehicle.

10. The computer implemented method of claim **6** further comprising:

detecting an interrupt condition using an interrupt monitor, wherein the interrupt monitor sends an incomplete charge notification to an execution engine; and

requesting a new energy transaction plan, by the interrupt monitor, in response to a determination that the electric vehicle is still connected to the charging station.

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