audio data may be received by the sounder, the actuator unit, the router, the control server, or any combination thereof, from external sources via the above networks. Furthermore, the source of the digital audio may a microphone serving as a sensor, either after processing, storing, delaying, or any other manipulation, or as originally received resulting 'door-phone' or 'intercom' functionality between a microphone and a sounder in the building.

In another example, the sounder simulates the voice of a human being or generates music, typically by using an electronic circuit having a memory for storing the sounds (e.g., music, song, voice message, etc.), a digital to analog converter **62** to reconstruct the electrical representation of the sound, and a driver for driving a loudspeaker, which is an electro-acoustic transducer that converts an electrical signal to sound. An example of a greeting card providing music and mechanical movement is disclosed in U.S. Patent Application No. 2007/0256337 to Segan entitled: "User Interactive Greeting Card", which is incorporated in its entirety for all purposes as if fully set forth herein.

In one example, the system is used for sound or music generation. For example, the sound produced can emulate the sounds of a conventional acoustical music instrument, such as a piano, tuba, harp, violin, flute, guitar and so forth. In one example, the sounder is an audible signaling device, emitting audible sounds that can be heard (having frequency components in the 20-20,000 Hz band). In one example the sound generated is music or song. The elements of the music such as pitch (which governs melody and harmony), rhythm (and its associated concepts tempo, meter, and articulation), dynamics, and the sonic qualities of timbre and texture, may be associated with the shape theme. For example, if a musical instrument shown in the picture, the music generated by that instrument will be played, e.g., drumming sound of drums and playing of a flute or guitar. In one example, a talking human voice is played by the sounder. The sound may be a syllable, a word, a phrase, a sentence, a short story or a long story, and can be based on speech synthesis or pre-recorded. Male or female voice can be used, further being young or old.

Some examples of toys that include generation of an audio signal such as music are disclosed in U.S. Pat. No. 4,496,149 to Schwartzberg entitled: "Game Apparatus Utilizing Controllable Audio Signals", in U.S. Pat. No. 4,516,260 to Breedlove et al. entitled: "Electronic Learning Aid or Game having Synthesized Speech", in U.S. Pat. No. 7,414,186 to Scarpa et al. entitled: "System and Method for Teaching Musical Notes", in U.S. Pat. No. 4,968,255 to Lee et al., entitled: "Electronic Instructional Apparatus", in U.S. Pat. No. 4,248,123 to Bunger et al., entitled: "Electronic Piano" and in U.S. Pat. No. 4,796,891 to Milner entitled: "Musical Puzzle Using Sliding Tiles", and toys with means for synthesizing human voice are disclosed in U.S. Pat. No. 6,527,611 to Cummings entitled: "Place and Find Toy", and in U.S. Pat. No. 4,840,602 to Rose entitled: "Talking Doll Responsive to External Signal", which are all incorporated in their entirety for all purposes as if fully set forth herein. A music toy kit combining music toy instrument with a set of construction toy blocks is disclosed in U.S. Pat. No. 6,132,281 to Klitsner et al. entitled: "Music Toy Kit" and in U.S. Pat. No. 5,349,129 to Wisniewski et al. entitled: "Electronic Sound Generating Toy", which are incorporated in their entirety for all purposes as if fully set forth herein.

A speech synthesizer used to produce natural and intelligible artificial human speech may be implemented in hardware, in software, or combination thereof. A speech synthesizer may be Text-To-Speech (TTS) based, that converts normal language text to speech, or alternatively (or in addition) may be based on rendering symbolic linguistic representation like phonetic transcription. A TTS typically involves two steps, the front-end where the raw input text is pre-processed to fully write-out words replacing numbers and abbreviations, followed by assigning phonetic transcriptions to each word (text-to-phoneme), and the back-end (or synthesizer) where the symbolic linguistic representation is converted to output sound.

The generating of synthetic speech waveform typically uses a concatenative or formant synthesis. The concatenative synthesis commonly produces the most natural-sounding synthesized speech, and is based on the concatenation (or stringing together) of segments of recorded speech. There are three main types of concatenative synthesis: Unit selection, diphone synthesis, and domain-specific synthesis. Unit selection synthesis is based on large databases of recorded speech including individual phones, diphones, half-phones, syllables, morphemes, words, phrases, and sentences, indexed based on the segmentation and acoustic parameters like the fundamental frequency (pitch), duration, position in the syllable, and neighboring phones. At run time, the desired target utterance is created by determining (typically using a specially weighted decision tree) the best chain of candidate units from the database (unit selection). Diphone synthesis uses a minimal speech database containing all the diphones (sound-to-sound transitions) occurring in a language, and at runtime, the target prosody of a sentence is superimposed on these minimal units by means of digital signal processing techniques such as linear predictive coding. Domain-specific synthesis is used where the output is limited to a particular domain, using concatenates prerecorded words and phrases to create complete utterances. In formant synthesis the synthesized speech output is created using additive synthesis and an acoustic model (physical modeling synthesis), rather than on using human speech samples. Parameters such as fundamental frequency, voicing, and noise levels are varied over time to create a waveform of artificial speech. The synthesis may further be based on articulatory synthesis where computational techniques for synthesizing speech are based on models of the human vocal tract and the articulation processes occurring there, or may be HMM-based synthesis which is based on hidden Markov models, where the frequency spectrum (vocal tract), fundamental frequency (vocal source), and duration (prosody) of speech are modeled simultaneously by HMMs and generated based on the maximum likelihood criterion. The speech synthesizer may further be based on the book entitled: "Development in Speech Synthesis", by Mark Tatham and Katherine Morton, published 2005 by John Wiley & Sons Ltd., ISBN: 0-470-85538-X, and on the book entitled: "Speech Synthesis and Recognition" by John Holmes and Wendy Holmes, 2nd Edition, published 2001 ISBN: 0-7484-0856-8, which are both incorporated in their entirety for all purposes as if fully set forth herein.

A speech synthesizer may be software based such as Apple VoiceOver utility which uses speech synthesis for accessibility, and is part of the Apple IOS operating system used on the iPhone, iPad and iPod Touch. Similarly, Microsoft uses SAPI 4.0 and SAPI 5.0 as part of Windows operating system. Similarly, hardware may be used, and may be based on an IC. A tone, voice, melody, or song hardware-based sounder typically contains a memory storing a digital representation of the pre-recorder or synthesized voice or music, a Digital to Analog (D/A) converter for creating an analog signal, a speaker and a driver for feeding the speaker. A sounder may be based on Holtek HT3834 CMOS VLSI

Integrated Circuit (IC) named '36 Melody Music Generator' available from Holtek Semiconductor Inc., headquartered in Hsinchu, Taiwan, and described with application circuits in a data sheet Rev. 1.00 dated Nov. 2, 2006, on EPSON 7910 series 'Multi-Melody IC' available from Seiko-Epson Corporation, Electronic Devices Marketing Division located in Tokyo, Japan, and described with application circuits in a data sheet PF226-04 dated 1998, on Magnevation SpeakJet chip available from Magnevation LLC and described in 'Natural Speech & Complex Sound Synthesizer', described in User's Manual Revision 1.0 Jul. 27, 2004, on Sensory Inc. NLP-5x described in the Data sheet "Natural Language Processor with Motor, Sensor and Display Control", P/N 80-0317-K, published 2010 by Sensory, Inc. of Santa-Clara, California, U.S.A., or on OPTi 82C931 'Plug and Play Integrated Audio Controller' described in Data Book 912-3000-035 Revision: 2.1 published on Aug. 1, 1997, which are all incorporated herein in their entirety for all purposes as if fully set forth herein. Similarly, a music synthesizer may be based on YMF721 OPL4-ML2 FM+Wavetable Synthesizer LSI available from Yamaha Corporation described in YMF721 Catalog No. LSI-4MF721A20, which is incorporated in its entirety for all purposes as if fully set forth herein.

An actuator may be used to generate an electric or magnetic field. An electromagnetic coil (sometimes referred to simply as a "coil") is formed when a conductor (usually an insulated solid copper wire) is wound around a core or form to create an inductor or electromagnet. One loop of wire is usually referred to as a turn, and a coil consists of one or more turns. Coils are often coated with varnish or wrapped with insulating tape to provide additional insulation and secure them in place. A completed coil assembly with taps is often called a winding. An electromagnet is a type of magnet in which the magnetic field is produced by the flow of electric current, and disappears when the current is turned off. A simple electromagnet consisting of a coil of insulated wire wrapped around an iron core. The strength of the magnetic field generated is proportional to the amount of current.

An actuator may be a display for presentation of visual data or information, commonly on a screen. A display is typically consists of an array of light emitters (typically in a matrix form), and commonly provides a visual depiction of a single, integrated, or organized set of information, such as text, graphics, image or video. A display may be a monochrome (a.k.a. black-and-white) type, which typically displays two colors, one for the background and one for the foreground. Old computer monitor displays commonly use black and white, green and black, or amber and black. A display may be a gray-scale type, which is capable of displaying different shades of gray, or may be a color type, capable of displaying multiple colors, anywhere from 16 to over many millions different colors, and may be based on Red, Green, and Blue (RGB) separate signals. A video display is designed for presenting video content. The screen is the actual location where the information is actually optically visualized by humans. The screen may be an integral part of the display. Alternatively or in addition, the display may be an image or video projector, that projects an image (or a video consisting of moving images) onto a screen surface, which is a separate component and is not mechanically enclosed with the display housing. Most projectors create an image by shining a light through a small transparent image, but some newer types of projectors can project the image directly, by using lasers. A projector may be based on an Eidophor, Liquid Crystal on Silicon (LCOS or LCOS), or LCD, or may use Digital Light Processing (DLP™) technology, and may further be MEMS based. A virtual retinal display, or retinal projector, is a projector that projects an image directly on the retina instead of using an external projection screen. Common display resolutions used today include SVGA (800×600 pixels), XGA (1024×768 pixels), 720p (1280×720 pixels), and 1080p (1920×1080 pixels). Standard-Definition (SD) standards, such as used in SD Television (SDTV), are referred to as 576i, derived from the European-developed PAL and SECAM systems with 576 interlaced lines of resolution; and 480i, based on the American National Television System Committee (ANTSC) NTSC system. High-Definition (HD) video refers to any video system of higher resolution than standard-definition (SD) video, and most commonly involves display resolutions of 1,280×720 pixels (720p) or 1,920×1,080 pixels (1080i/1080p). A display may be a 3D (3-Dimensions) display, which is the display device capable of conveying a stereoscopic perception of 3-D depth to the viewer. The basic technique is to present offset images that are displayed separately to the left and right eye. Both of these 2-D offset images are then combined in the brain to give the perception of 3-D depth. The display may present the information as scrolling, static, bold or flashing.

The display may be an analog display having an analog signal input. Analog displays arc commonly using interfaces such as composite video such as NTSC, PAL or SECAM formats. Similarly, analog RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART, S-video and other standard analog interfaces can be used. Alternatively or in addition, a display may be a digital display, having a digital input interface. Standard digital interfaces such as an IEEE1394 interface (a.k.a. FireWire™), may be used. Other digital interfaces that can be used are USB, SDI (Serial Digital Interface), HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video and DVB (Digital Video Broadcast). In some cases, an adaptor is required in order to connect an analog display to the digital data. For example, the adaptor may convert between composite video (PAL, NTSC) or S-Video and DVI or HDTV signal. Various user controls can be available to allow the user to control and effect the display operations, such as an on/off switch, a reset button and others. Other exemplary controls involve display associated settings such as contrast, brightness and zoom.

A display may be a Cathode-Ray Tube (CRT) display, which is based on moving an electron beam back and forth across the back of the screen. Such a display commonly comprises a vacuum tube containing an electron gun (a source of electrons), and a fluorescent screen used to view images. It further has a means to accelerate and deflect the electron beam onto the fluorescent screen to create the images Each time the beam makes a pass across the screen, it lights up phosphor dots on the inside of the glass tube, thereby illuminating the active portions of the screen. By drawing many such lines from the top to the bottom of the screen, it creates an entire image. A CRT display may be a shadow mask or an aperture grille type.

A display may be a Liquid Crystal Display (LCD) display, which utilize two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing a backlit light to pass through or blocking the light. In monochrome LCD images usually appear as blue or dark gray images on top of a grayish-white

background. Color LCD displays commonly use passive matrix and Thin Film Transistor (TFT) (or active-matrix) for producing color. Recent passive-matrix displays are using new CSTN and DSTN technologies to produce sharp colors rivaling active-matrix displays.

Some LCD displays use Cold-Cathode Fluorescent Lamps (CCFLs) for backlight illumination. An LED-backlit LCD is a flat panel display that uses LED backlighting instead of the cold cathode fluorescent (CCFL) backlighting, allowing for a thinner panel, lower power consumption, better heat dissipation, a brighter display, and better contrast levels. Three forms of LED may be used: White edge-LEDs around the rim of the screen, using a special diffusion panel to spread the light evenly behind the screen (the most usual form currently), an array of LEDs arranged behind the screen whose brightness are not controlled individually, and a dynamic "local dimming" array of LEDs that are controlled individually or in clusters to achieve a modulated backlight light pattern. A Blue Phase Mode LCD is an LCD technology that uses highly twisted cholesteric phases in a blue phase, in order to improve the temporal response of liquid crystal displays (LCDs).

A Field Emission Display (FED) is a display technology that uses large-area field electron emission sources to provide the electrons that strike colored phosphor, to produce a color image as an electronic visual display. In a general sense, a FED consists of a matrix of cathode ray tubes, each tube producing a single sub-pixel, grouped in threes to form red-green-blue (RGB) pixels. FEDs combine the advantages of CRTs, namely their high contrast levels and very fast response times, with the packaging advantages of LCD and other flat panel technologies. They also offer the possibility of requiring less power, about half that of an LCD system. FED display operates like a conventional cathode ray tube (CRT) with an electron gun that uses high voltage (10 kV) to accelerate electrons which in turn excite the phosphors, but instead of a single electron gun, a FED display contains a grid of individual nanoscopic electron guns. A FED screen is constructed by laying down a series of metal stripes onto a glass plate to form a series of cathode lines.

A display may be an Organic Light-Emitting Diode (OLED) display, a display device that sandwiches carbon-based films between two charged electrodes, one a metallic cathode and one a transparent anode, usually being glass. The organic films consist of a hole-injection layer, a hole-transport layer, an emissive layer and an electron-transport layer. When voltage is applied to the OLED cell, the injected positive and negative charges recombine in the emissive layer and create electro luminescent light. Unlike LCDs, which require backlighting, OLED displays are emissive devices-they emit light rather than modulate transmitted or reflected light. There are two main families of OLEDs: those based on small molecules and those employing polymers. Adding mobile ions to an OLED creates a light-emitting electrochemical cell or LEC, which has a slightly different mode of operation. OLED displays can use either Passive-Matrix (PMOLED) or active-matrix addressing schemes. Active-Matrix OLEDs (AMOLED) require a thin-film transistor backplane to switch each individual pixel on or off, but allow for higher resolution and larger display sizes.

A display may be an Electroluminescent Displays (ELDs) type, which is a flat panel display created by sandwiching a layer of electroluminescent material such as GaAs between two layers of conductors. When current flows, the layer of material emits radiation in the form of visible light. Electroluminescence (EL) is an optical and electrical phenomenon where a material emits light in response to an electric current passed through it, or to a strong electric field.

A display may be based on an Electronic Paper Display (EPD) (a.k.a. e-paper and electronic ink) display technology which is designed to mimic the appearance of ordinary ink on paper. Unlike conventional backlit flat panel displays which emit light, electronic paper displays reflect light like ordinary paper. Many of the technologies can hold static text and images indefinitely without using electricity, while allowing images to be changed later. Flexible electronic paper uses plastic substrates and plastic electronics for the display backplane.

An EPD may be based on Gyricon technology, using polyethylene spheres between 75 and 106 micrometres across. Each sphere is a janus particle composed of negatively charged black plastic on one side and positively charged white plastic on the other (each bead is thus a dipole). The spheres are embedded in a transparent silicone sheet, with each sphere suspended in a bubble of oil so that they can rotate freely. The polarity of the voltage applied to each pair of electrodes then determines whether the white or black side is face-up, thus giving the pixel a white or black appearance. Alternatively or in addition, an EPD may be based on an electrophoretic display, where titanium dioxide (Titania) particles approximately one micrometer in diameter are dispersed in hydrocarbon oil. A dark-colored dye is also added to the oil, along with surfactants and charging agents that cause the particles to take on an electric charge. This mixture is placed between two parallel, conductive plates separated by a gap of 10 to 100 micrometers. When a voltage is applied across the two plates, the particles will migrate electrophoretically to the plate bearing the opposite charge from that on the particles.

Further, an EPD may be based on Electro-Wetting Display (EWD), which is based on controlling the shape of a confined water/oil interface by an applied voltage. With no voltage applied, the (colored) oil forms a flat film between the water and a hydrophobic (water-repellent) insulating coating of an electrode, resulting in a colored pixel. When a voltage is applied between the electrode and the water, it changes the interfacial tension between the water and the coating. As a result the stacked state is no longer stable, causing the water to move the oil aside. Electrofluidic displays are a variation of an electrowetting display, involving the placing of aqueous pigment dispersion inside a tiny reservoir. Voltage is used to electromechanically pull the pigment out of the reservoir and spread it as a film directly behind the viewing substrate. As a result, the display takes on color and brightness similar to that of conventional pigments printed on paper. When voltage is removed liquid surface tension causes the pigment dispersion to rapidly recoil into the reservoir.

A display may be a Vacuum Fluorescent Display (VFD) that emits a very bright light with high contrast and can support display elements of various colors. VFDs can display seven-segment numerals, multi-segment alphanumeric characters or can be made in a dot-matrix to display different alphanumeric characters and symbols.

A display may be a laser video display or a laser video projector. A Laser display requires lasers in three distinct wavelengths—red, green, and blue. Frequency doubling can be used to provide the green wavelengths, and a small semiconductor laser such as Vertical-External-Cavity Surface-Emitting-Laser (VECSEL) or a Vertical-Cavity Surface-Emitting Laser (VCSEL) may be used. Several types of lasers can be used as the frequency doubled sources: fiber lasers, inter cavity doubled lasers, external cavity doubled

lasers, eVCSELs, and OPSLs (Optically Pumped Semiconductor Lasers). Among the inter-cavity doubled lasers VCSELs have shown much promise and potential to be the basis for a mass produced frequency doubled laser. A VECSEL is a vertical cavity, and is composed of two mirrors. On top of one of them is a diode as the active medium. These lasers combine high overall efficiency with good beam quality. The light from the high power IR-laser diodes is converted into visible light by means of extra-cavity waveguided second harmonic generation. Laser-pulses with about 10 KHz repetition rate and various lengths are sent to a Digital Micromirror Device where each mirror directs the pulse either onto the screen or into the dump.

A display may be a segment display, such as a numerical or an alphanumerical display that can show only digits or alphanumeric characters, commonly composed of several segments that switch on and off to give the appearance of desired glyph, The segments are usually single LEDs or liquid crystals, and may further display visual display material beyond words and characters, such as arrows, symbols, ASCII and non-ASCII characters. Non-limiting examples are Seven-segment display (digits only), Fourteen-segment display, and Sixteen-segment display. A display may be a dot matrix display, used to display information on machines, clocks, railway departure indicators and many other devices requiring a simple display device of limited resolution. The display consists of a matrix of lights or mechanical indicators arranged in a rectangular configuration (other shapes are also possible, although not common) such that by switching on or off selected lights, text or graphics can be displayed. A dot matrix controller converts instructions from a processor into signals which turns on or off the lights in the matrix so that the required display is produced.

In one non-limiting example, the display is a video display used to play a stored digital video, or an image display used to present stored digital images, such as photos. The digital video (or image) content can be stored in the display, the actuator unit, the router, the control server, or any combination thereof. Further, few video (or still image) files may be stored (e.g., representing different announcements or songs), selected by the control logic. Alternatively or in addition, the digital video data may be received by the display, the actuator unit, the router, the control server, or any combination thereof, from external sources via any one of the networks. Furthermore, the source of the digital video or image may an image sensor (or video camera) serving as a sensor, either after processing, storing, delaying, or any other manipulation, or as originally received, resulting Closed-Circuit Television (CCTV) functionality between an image sensor or camera and a display in the building, which may be used for surveillance in areas that may need monitoring such as banks, casinos, airports, military installations, and convenience stores.

In one non-limiting example, an actuator unit further includes a signal generator coupled between the processor and the actuator. The signal generator may be used to control the actuator, for example by providing an electrical signal affecting the actuator operation, such as changing the magnitude of the actuator affect or operation. Such a signal generator may be a digital signal generator, or may be an analog signal generator, having an analog electrical signal output. Analog signal generator may be a digital signal generator, which digital output is converted to analog signal using a digital to analog converter, as shown in actuator unit **60** shown in FIG. **6**, where two D/A converters **62***a* and **62***b* are connected to the computer **63** outputs, and where the analog outputs are coupled to respectively control the actuators **61***a* and **61***b*. The signal generator may be based on software (or firmware) stored in the unit and executed by the computer **63**, or may be a separated circuit or component connected between the computer **63** and the D/A converters **62***a* and **62***b*. In such an arrangement, the computer may be used to activate the signal generator, or to select a waveform or signal to be generated. In one non-limiting example, the signal generator serves as the actuator, for generating an electrical signal, such as voltage and current.

A signal generator (a.k.a. frequency generator) is an electronic device or circuit devices that can generate repeating or non-repeating electronic signals (typically voltage or current), having an analog output (analog signal generator) or a digital output (digital signal generator). The output signal may be based on an electrical circuit, or may be based on a generated or stored digital data. A function generator is typically a signal generator which produces simple repetitive waveforms. Such devices contain an electronic oscillator, a circuit that is capable of creating a repetitive waveform, or may use digital signal processing to synthesize waveforms, followed by a digital to analog converter, or DAC, to produce an analog output. Common waveforms are a sine wave, a sawtooth, a step (pulse), a square, and a triangular waveforms. The generator may include some sort of modulation functionality such as Amplitude Modulation (AM), Frequency Modulation (FM), or Phase Modulation (PM). An Arbitrary Waveform Generators (AWGs) are sophisticated signal generators which allow the user to generate arbitrary waveforms, within published limits of frequency range, accuracy, and output level. Unlike function generators, which are limited to a simple set of waveforms; an AWG allows the user to specify a source waveform in a variety of different ways. Logic signal generator (a.k.a. data pattern generator and digital pattern generator) is a digital signal generator that produces logic types of signals—that is logic 1's and 0's in the form of conventional voltage levels. The usual voltage standards are: LVTTL, LVCMOS.

In one non-limiting example, an actuator unit further includes an electrical switch (or multiple switches) coupled between the processor and the actuator. The electric switch may be used to activate the actuator, for example by completing an electrical circuit allowing current to flow to the actuator. Such arrangement is exampled regarding the actuator units **60***a*, **60***b*, **60***f* and **60***g*, respectively shown in FIGS. **6***a*, **6***b*, **6***e*, and **6***f*, connecting an electrical power source to a load. The load may be an actuator, and may be internal or external to the actuator unit, and may further be power fed from the same power source (and same power supply) of the actuator unit, or alternatively or in addition, a separate power source may be used to power the load or the actuator. The switch may be integrated with the actuator (if separated from the actuator unit), with the actuator unit, or any combination thereof. In the above examples, a controller can affect the actuator (or load) activation by sending the actuator unit a message to activate the actuator by powering it, or to deactivate the actuator operation by breaking the current floe thereto. In another non-limiting example, the actuator may be in two (or more) states, and the switch activates one or more of the states, or shifts the actuator between states. For example, an electric motor may have two speeds, controlled by a connected switch, which is under the controller control.

Any component that is designed to open (breaking, interrupting), close (making), or change one or more electrical circuits may serve as a switch, preferably under some type of external control. Preferably, the switch is an electromechanical device with one or more sets of electrical contacts

having two or more states. The switch may be a 'normally open' type, requiring actuation for closing the contacts, may be 'normally closed' type, where actuation affects breaking the circuit, or may be a changeover switch, having both types of contacts arrangements. A changeover switch may be either a 'make-before-break' or 'break-before-make' types. The switch contacts may have one or more poles and one or more throws. Common switches contacts arrangements include Single-Pole-Single-Throw (SPST), Single-Pole-Double-Throw (SPDT), Double-Pole-Double-Throw (DPDT), Double-Pole-Single-Throw (DPST), and Single-Pole-Changeover (SPCO). A switch may be electrically or mechanically actuated.

A relay is a non-limiting example of an electrically operated switch. A relay may be a latching relay, that has two relaxed states (bistable), and when the current is switched off, the relay remains in its last state. This is achieved with a solenoid operating a ratchet and cam mechanism, or by having two opposing coils with an over-center spring or permanent magnet to hold the armature and contacts in position while the coil is relaxed, or with a permanent core. A relay may be an electromagnetic relay, that typically consists of a coil of wire wrapped around a soft iron core, an iron yoke which provides a low reluctance path for magnetic flux, a movable iron armature, and one or more sets of contacts. The armature is hinged to the yoke and mechanically linked to one or more sets of moving contacts. It is held in place by a spring so that when the relay is de-energized there is an air gap in the magnetic circuit. In this condition, one of the two sets of contacts in the relay pictured is closed, and the other set is open. A reed relay is a reed switch enclosed in a solenoid, and the switch has a set of contacts inside an evacuated or inert gas-filled glass tube, which protects the contacts against atmospheric corrosion.

Alternatively or in addition, a relay may be a Solid State Relay (SSR), where a solid-state based component functioning as a relay, without having any moving parts. Alternatively or in addition, a switch may be implemented using an electrical circuit. For example, an open collector (or open drain) based circuit may be used. Further, an opto-isolator (a.k.a. optocoupler, photocoupler, or optical isolator) may be used to provide isolated signal transfer to the actuator. Further, a thyristor such as a Triode for Alternating Current (TRIAC) may be used for triggering power to an actuator.

A field unit may be a sensor unit such as sensor unit **50** shown above in FIG. **5**, including one or more sensors, or may be an actuator unit such as actuator unit **60** shown above in FIG. **6**, including one or more actuators, or may be a sensor/actuator unit such as sensor actuator unit **70** shown in FIG. **7**. Such a sensor/actuator **70** includes an analog sensor **51***a* connected via A/D converter **52***a*. Any number of sensors **51** of any type may be equally used. The sensor/actuator **70** further includes an analog actuator **61***a* connected via D/A converter **62***a*. Any number of actuators **61** of any type may be equally used. The sensors **51** and the actuators **61** are connected to a computer **71**, which communicates over the network medium via a suitable modem, such as wired modem (or transceiver) **72**, suitable for communication over the cable **79** terminated by connector **78**, which connects to the mating connector **77** in the sensor/actuator unit **70**. Similarly, sensor and actuator units or their functionalities may be integrated, and thus may share any resources. For example, both circuits may share a power source, a power supply or a power connector. Similarly, other electronic circuits mat be shared and used for both functionalities. Further, the same connector or connectors, as well as interfaces and other support circuits may be used by both functionalities. Furthermore, the associated components implementing these functionalities may be housed in the same enclosure, or may be mounted to the same surface. In one non-limiting example, the hardware relating to both functionalities may be integrated onto a single substrate (e.g., Silicon "die"), or as components mounted on the same PCB.

A non-limiting example of a power control field unit **70***a* is shown as part of arrangement **700***a* shown in FIG. **7***a*. Similar to arrangement **600***a* shown in FIG. **6***a*, a load **58** is powered from a power source **56***a* and can be turned on and off by the controlled switch **601** controlled by computer **71***a*. In addition, a current meter **57** is connected in series to measure the current or the power consumption of the load **58**.

A field unit may be powered, in whole or in part, from an AC or DC power source, which may be integrated with the unit enclosure, may be external to the unit enclosure, or any combination thereof. Typically, a power supply is connected to the power source to be power fed therefrom, and provides a single (or multiple) voltage as required by the field unit. Commonly, one or more regulated DC voltage is supplied by the power supply, which may be a linear or a switching type. The power supply outputs are commonly regulated to provide stable voltages (and/or currents, if applicable), under varying power source and load conditions. The power supply outputs are commonly protected against overload, for example by a fuse or a current limiter, and are commonly protected against overvoltage, over-current, or other instabilities and abnormal condition of the power source. Further, a power supply may also serve to provide electrical isolation, and further commonly filters an electrical noise between its inputs and outputs. A sensor may be power fed from the same power source or power supply powering the field unit circuits, or may use a dedicated power source or power supply, which may be internal or external to the field unit enclosure. An actuator may be power fed from the same power source or power supply powering the field unit circuits, or may use a dedicated power source or power supply, which may be internal or external to the field unit enclosure.

A field unit may be locally electrically powered from a power source integrated within the unit. Such a power source **56** is shown as part of the sensor unit **50** in FIG. **5**. Such power source **56** may be based on a battery. The battery may be a primary battery or cell, in which an irreversible chemical reaction generates the electricity, and thus the cell is disposable and cannot be recharged, and need to be replaced after the battery is drained. Such battery replacement may be expensive and cumbersome. Alternatively or in addition, a rechargeable (secondary) battery may be used, such as a nickel-cadmium based battery. In such a case, a battery charger is employed for charging the battery while it is in use or not in use. Various types of such battery chargers are known in the art, such as trickle chargers, pulse chargers and the like. The battery charger may be integrated with the field unit or be external to it. The battery may be a primary or a rechargeable (secondary) type, may include a single or few batteries, and may use various chemicals for the electrochemical cells, such as lithium, alkaline and nickel-cadmium. Common batteries are manufactured in pre-defined standard output voltages (1.5, 3, 4.5, 9 Volts, for example), as well as defined standard mechanical enclosures (usually defined by letters such as "A", "AA", "B", "C" sizes), and 'coin' type. In one embodiment the battery (or batteries) is held in a battery holder or compartment, and thus can be easily replaced.

In one non-limiting example, the field unit is locally energized using an electrical energy generator to locally generate electrical power for charging the rechargeable battery via a battery charger. Preferably, the generator is integrated within the field unit enclosure. Alternatively or in addition, the generator may directly feed the power consuming components in the field unit without using any electrical energy storage device such as a rechargeable battery. Such generator may be based on converting kinetic energy harvested from the field unit motion, which may be caused by a human or animal activity, to electrical energy. Such a generator is described in U.S. Pat. No. 7,692,320 to Lemieux entitled: "Electrical Energy Generator", in U.S. Pat. No. 5,578,877 to Tiemann entitled: "Apparatus for Converting Vibratory Motion to Electrical Energy", in U.S. Pat. No. 7,847,421 to Gardner et al. entitled: "System for Generating Electrical Energy from Ambient Motion" and in U.S. Patent Application No. 2007/0210580 to Roberts et al. entitled: "Electromechanical Generator for, and Method of, Converting Mechanical Vibrational Energy into Electrical Energy", as well as a battery-shaped generator described in U.S. Pat. No. 7,688,036 to Yarger et al. entitled: "System and Method for Storing Energy", which are all incorporated in their entirety for all purposes as if fully set forth herein. Using kinetic energy harvesting as an electrical power source may be useful in cased wherein the sensor in a field unit is involved in measuring motion (e.g., speed or acceleration). Another type of power source may use a solar or photovoltaic cell described above. In one non-limiting example, the same element may double as a sensor and as a power source. For example, a solar or photovoltaic cell may be used as a light sensor, simultaneously with serving as a power source, and an electromechanical generator, for example based on harvesting mechanical vibration energy, may at the same time be used to measure the mechanical vibrations (e.g., frequency or magnitude). Similarly, a thermoelectric device based on the Peltier effect may be used as a thermoelectric generator, in addition to being a temperature sensor, heater or a cooler.

In another non-limiting example, a field unit is powered from an external power source. Such implementation is exampled in the actuator unit **60** shown in FIG. **6**. The unit **60** is powered from a power supply **66** which is power fed from the common AC power supply via AC plug connector **68** and a power cord **67**, using the mains AC power (commonly 115VAC/60 Hz in North America or 220VAC/50 Hz in Europe) as the power source. The power supply commonly includes an AC/DC converter, for converting the AC voltage into the required low-level stabilized DC voltage or voltages, commonly suitable for power the digital circuits, such as 3.3VDC, 5VDC or 12VDC. Power supplies commonly include voltage stabilizers for ensuring that the output remains within certain limits under various load conditions, and typically employs a transformer, silicon diode bridge rectifier, reservoir capacitor and voltage regulator IC. Switched mode regulator supplies also include an inductor. In one embodiment, the power supply **66** is integrated into a single device or circuit, in order to share common circuits. Further, the power supply **66** may include a boost converter, such as a buck boost converter, charge pump, inverter and regulators as known in the art, as required for conversion of one form of electrical power to another desired form and voltage. While power supply **66** (either separated or integrated) can be an integral part and housed within the unit enclosure (together with the computer **63**), it may be enclosed as a separate housing connected via cable to the computer system enclosure. For example, a small outlet plug-in step-down transformer shape can be used (also known as wall-wart, "power brick", "plug pack", "plug-in adapter", "adapter block", "domestic mains adapter", "power adapter", or AC adapter). Further, power supply **66** may be a linear or switching type.

In one example, a field unit is powered by a power signal carried over the same wires or over the same cable used also for communication. For example, in the case of wired communication with a router, a gateway or another field unit, the same cable may be used for simultaneously carrying the digital data communication and the power signal. In one non-limiting example, the power is carried over dedicated and distinct wires, thus the power signal is carried separated from any other signals carried over the cable. Such configuration further requires the use of a cable and connectors having at least four contacts, where two (or more) are used for the power and at least two are used for the digital data signal (or for any other signal carried in the system).

In an alternative remote powering scheme, the power signal and the data signal (e.g., serial digital data signal) are concurrently carried together over the same wires, as exampled in the sensor/actuator unit **70** shown in FIG. **7**. This scheme makes use of a power/data splitter (PDS) **76** and a power/data combiner (PDC) circuit **86**, where the latter combines the power and data signals to a combined signal, and the first split a combined signal into its power and data signal components, as described in arrangement **80** in FIG. **8**. Such PDS or PDC circuits (e.g., PDC **86** and PDS **76** in FIG. **8**) commonly employ three ports designated as 'PD' **761** (stands for Power+Data), 'D' **763** (stands for Data only) and 'P' **762** (stands for Power only). The PDC **77** may be part of another device **81** such as a switch, a router or a gateway. In the PDS **76**, the cable **79** (carrying both power and data) is connected to port 'PD' **761***a*, which passes the a data signal received from, or transmitted to, the port 'D' **763***a* to or from the modem **72**, while the power signal carried over the cable **79** is split and supplied to port P **762***a* and connected to via the connection **75** to the power supply **73**, which in turn feeds power to the unit **70** electrical circuits. Similarly, the power signal fed by connection **82** to the power port P **762***b*, and the digital data signal carried over the connection **83** are combined in PDC **77** and connected via port 'PD' **761***b* to cable **79** via connectors **84** and its mating connector **85**. Thus, power signal transparently passes between ports 'PD' **761** and P **762**, while data signal (e.g., serial digital data signal) is transparently passed between ports 'PD' **761** and 'D' **763**. The power signal may be AC or DC, and the PDC **86** or the PDS **76** may each contain only passive components or alternatively may contain both active and passive electronic circuits.

In an alternative arrangement, the power and communication signals are carried over the wires in the cable using Frequency Division Multiplexing (FDM, a.k.a. Frequency Domain Multiplexing). In such an implementation, the power and the communications signals are carried each in its frequency band (or a single frequency) distinct from each other. For example, the power signal can be a DC (Direct Current) power (effectively 0 Hz), while the communication signal is carried over the 100 Hz-10 MHz (or 4-30 MHz) frequency band, which is distinct and above the DC power frequency. In this case, the component on each side may further include a low pass filter coupled between the connector and the transceiver (transmitter/receiver) for substantially passing only the power frequency, for powering the device from the power signal, or for injecting the power signal. Such device may also further include a high pass

filter coupled between the connector and the transceiver for substantially passing only the communication frequency band, for passing the communication signal between the connector and the transceiver. Another technique for carrying power and data signals over the same conductors is known as Power-over-Ethernet (POE) (i.e., Power over LAN—PoL) and standardized under IEEE 802.3af and IEEE 802.3at, also explained in U.S. Pat. No. 6,473,609 to Lehr et al. entitled: "Structure Cabling System", which is incorporated in its entirety for all purposes as if fully set forth herein, which describes a method to carry power over LAN wiring, using the spare pairs and the phantom mechanism. The latter makes use of center-tap transformers. The powering scheme may use the standards above, as well as using non-standard and proprietary powering schemes.

In one non-limiting example, the data and power signals are carried over the same wires using Frequency Division Multiplexing (FDM), where each signal is using a different frequency band, and wherein the frequency bands are spaced in frequency. For example, the power signal can be a DC signal (0 Hz), while the data signal will be carried over a band excluding the DC frequency. Similarly, the power signal can be an AC power signal, using a frequency above the frequency band used by the data signal. Separation or combining the power and data signals makes use of filters, passing or stopping the respective bands. A non-limiting example of a circuit **90** that may serve as a PDS **76** or as PDC **77** is shown in FIG. **9**, corresponding to the case wherein the power signal is a DC signal (OH), while the data signal is an AC signal carried over a band excluding the DC frequency. A capacitor **91***a*, which may be supplemented with another capacitor **91***b* is connected between the PD port **761** and the D port **763**, implementing a High Pass Filter (HPF) **92**. The HPF **92** substantially stops the DC power signal and substantially passes the data signal (or any AC signal) between the connected corresponding ports. An inductor **94***a*, which may be supplemented with another inductor **94***b* is connected between the PD port **761** and the P port **762**, implementing a Low Pass Filter (LPF) **93**. The LPF **93** substantially stops the data signal and substantially passes the DC power signal between the connected corresponding ports. Other passive or active implementations of the HPF **92** and LPF **93** can be equally used. Similarly, the power signal may be low-frequency power voltage, such as 50 Hz or 60 Hz.

Alternatively or in addition, the data and power signals are carried over the same wires using a split-tap transformer, as commonly known for powering an analog telephone set known as POTS (Plain Old Telephone Service and ISDN). A non-limiting example of a circuit **100** that may serve as a PDS **76** or as PDC **86** is shown in FIG. **8**, corresponding for example to the case wherein the power signal is a DC signal (0 Hz), while the data signal is an AC signal carried over a band excluding the DC frequency. A transformer **101** is connected between the PD port **761** and the D port **763**, where the primary side windings **103***a* and **103***b* connected to the PD port **761**, and the secondary winding **103***c* is connected to the D port **763**. The primary side is split to be formed of two windings **103***a* and **103***b*, connected together with capacitor **102**. The transformer substantially passes the data signal between PD port **761** and the D port **763**, while the DC power signal (or a low frequency AC signal) is blocked by the capacitor **102**. Any DC signal such as the DC power signal is substantially passed between the PD port **761** and the P port **762**.

In another alternative, the power signal is carried over a phantom channel between two pairs carrying the data signal or other signals. A non-limiting example of a of a circuit **110** that may serve as a PDS **76** or as PDC **86** is shown in FIG. **11**, corresponding for example to the case wherein the power signal is a DC signal (0 Hz), while the data signal is an AC signal carried over a band excluding the DC frequency. The transformers **111***a* and **111***b* are connected between the PD port **761** and the D port **763**, substantially passing data signals there between. The split-tap **122***b* (of the winding **122***a* of transformer **111***a*) and the split-tap **122***e* (of the winding **122***d* of transformer **111***b*) are connected to the P port **762**, allowing for DC power flow between the PD port **761** and the P port **762**. Such a phantom arrangement is used in communication based on IEEE802.3af or IEEE802.3at standards. Using the phantom channel for carrying power may be used in the case wherein at least four conductors are used as a connecting medium between modules.

In one non-limiting example, the same element is simultaneously used as both a sensor and as a power source. For example, a solar or photovoltaic cell may be doubly used as a sensor measuring the light intensity, for example by measuring the voltage or current output of the cell, and further the voltage or current generated are used to power in whole or part of the sensor unit or the field unit. Similarly, a dynamo, an alternator, an electric generator, or any other device that converts mechanical energy to electrical energy may be used, where the output power, voltage or current is used both as the sensor indicating the magnitude of the mechanical phenomenon, and also as the power source to power entire or part of the unit.

In one non-limiting example, the bus connecting to the field unit or to the processor is based on a LAN communication, such as Ethernet, and may be partly or in full in accordance with the IEEE802.3 standard. For example, Gigabit Ethernet (GbE or 1 GigE) may be used, describing various technologies for transmitting Ethernet frames at a rate of a gigabit per second (1,000,000,000 bits per second), as defined by the IEEE 802.3-2008 standard. There are five physical layer standards for gigabit Ethernet using optical fiber (1000BASE-X), twisted pair cable (1000BASE-T), or balanced copper cable (1000BASE-CX). The IEEE 802.3z standard includes 1000BASE-SX for transmission over multi-mode fiber, 1000BASE-LX for transmission over single-mode fiber, and the nearly obsolete 1000BASE-CX for transmission over balanced copper cabling. These standards use 8b/10b encoding, which inflates the line rate by 25%, from 1000 Mbit/s to 1250 Mbit/s, to ensure a DC balanced signal. The symbols are then sent using NRZ. The IEEE 802.3ab, which defines the widely used 1000BASE-T interface type, uses a different encoding scheme in order to keep the symbol rate as low as possible, allowing transmission over twisted pair. Similarly, The 10 gigabit Ethernet (10 GE or 10 GbE or 10 GigE may be used, which is a version of Ethernet with a nominal data rate of 10 Gbit/s (billion bits per second), ten times faster than gigabit Ethernet. The 10 gigabit Ethernet standard defines only full duplex point to point links which are generally connected by network switches. The 10 gigabit Ethernet standard encompasses a number of different physical layers (PHY) standards. A networking device may support different PHY types through pluggable PHY modules, such as those based on SFP+.

The powering scheme may be based on Power-over-Ethernet (POE), which describes a system to pass electrical power safely, along with data, on Ethernet cabling, and may use phantom configuration for carrying the power. The PoE technology and applications are described in the White Paper "All You Need To Know About Power over Ethernet (POE) and the IEEE 802.3af Standard", by PowerDsine

Ltd., 06-0002-082 20-May-4, and in U.S. Pat. No. 6,473,609 to Lehr et al. entitled: "Structure Cabling System", which are all incorporated in their entirety for all purposes as if fully set forth herein. The IEEE standard for PoE requires category 5 cable or higher for high power levels, but can operate with category 3 cable for low power levels. The power is supplied in common mode over two or more of the differential pairs of wires found in the Ethernet cables, and fed from a power supply within a PoE-enabled networking device such as an Ethernet switch, or can be injected into a cable run with a midspan power supply. The IEEE 802.3af-2003 PoE standard, which is incorporated in its entirety for all purposes as if fully set forth herein, provides up to 15.4 Watts of DC power (minimum 44 V DC and 350 mA) to each device. Only 12.95 Watts is assured to be available to the powered device as some power is dissipated in the cable. The updated IEEE 802.3at-2009 PoE standard, also known as PoE+ or PoE plus, and which is incorporated in its entirety for all purposes as if fully set forth herein, provides up to 25.5 Watts of power. In PoE environment, a powering unit (such as unit **81**) which may be a switch, a router or a gateway, may serve as a Power Sourcing Equipment (PSE) that provides ("sources") power on the Ethernet cable. A field unit (such as sensor/actuator unit **70**) consuming power from the LAN is referred to as a Powered Device (PD).

The controller functionality **147** may be integrated in the router **143** (corresponding for example to router **12** in FIG. **2**, router **40** in FIG. **4**, gateway **11** in FIG. **1**, or router **40***a* in FIGS. **4***a*-**4***d*), as shown in arrangement **145** in FIG. **14**. The router **143** is exampled having a port **146***a* for coupling to the control network **22** and a port **146***b* for connecting to control network **22***a*. The control network **22** couples field units **23***a*, **23***b* and **23***c* to each other and to the router **143**. The control network **22***a* couples field units **23***d*, **23***e* and **23***f* to each other and to the router **143**. A non-limiting example of data flow used for implementing a control system is shown in arrangement **145***a* in FIG. **14**. Data from a sensor in the field unit **23***f* is communicated to the router **143** over the communication path **144***d*, referring to the data transmitted from the field unit **23***f*, and carried (directly or via intervening devices) over the control network **22***a* to the port **146***b* of the router **143**. Similarly, data from a sensor in the field unit **23***c* is communicated to the router **143** over the communication path **144***b*, referring to the data transmitted from the field unit **23***c*, and carried over the control network **22** to the port **146***a* of the router **143**. The data received from the field units **23** in the router **143** is analyzed and processed, and based on control logic that may be embedded in the controller **147**, may generate a command for activating or triggering various actuators. For example, a command to an actuator in the field unit **23***a* is communicated from the router **143** over the communication path **144***a*, referring to the data transmitted from router **143** via the port **146***a*, and carried over the control network **22** the field unit **23***a*. Similarly, a command to an actuator in the field unit **23***e* is communicated from the router **143** over the communication path **144***c*, referring to the data transmitted from router **143** via the port **146***b*, and carried over the control network **22***a* the field unit **23***e*.

While a single sensor in a field unit is described, two or more sensors may equally be used in the same field unit **23**. Further, while two field units are described to send data to the router **143**, one, three or more field units may be part of the control system, each sending data from one or more sensors associated with it. Further, while two field units **23***c* and **23***f* are described, each communicating via the respective associated control network **22** and **22***a*, a single control network or multiple (three or more) control networks may be equally used. Further, while two field units are described to send data to the router **143**, one, three or more field units may be part of the control system, each sending data from one or more sensors associated with it. While a single actuator in a field unit is described, two or more actuators may equally be used in the same field unit **23**, with or without sensors associated with it. Further, while two field units are described to receive data from the router **143**, one, three or more field units may be part of the control system, each receiving data for activating or triggering one or more actuators associated with it. Further, while two field units **23***a* and **23***e* are described, each communicating via the respective associated control network **22** and **22***a*, a single control network or multiple (three or more) control networks may be equally used. Further, while two field units are described to receive data from the router **143**, one, three or more field units may be part of the control system, each receiving data for activating or triggering one or more actuators associated with it.

Alternatively or in addition, the controller **147** may be in part or in whole located external to the controlled premises **19**. Such an arrangement **150** is shown in FIG. **15**, where the controller **147** is integrated with the server **151**, which may correspond to the server **17** shown in FIG. **1**, the gateway server **24** shown in FIGS. **2**-**3**, or the gateway server **48** shown in FIGS. **4**-**4***c*. In such configuration, the router **21** may serve for relaying sensor data from the field units **23** to the controller **147**, and for relaying command data from the controller **147** to the field units **23** in the premises **19**. The router **21** may condition or otherwise manipulate the data in one or both directions. Arrangement **150***a* in FIG. **15***a* shows a non-limiting example of data paths in the arrangement **150**. The data path **152***d* describes the data flow from the field unit **23***f* via control network **22***a* to port **146***b* of the router **21**, which in turn transmits the data to the server **151** via the Internet **16**. Similarly, the data path **152***b* describes the data flow from the field unit **23***c* via control network **22** to port **146***a* of the router **21**, which in turn transmits the data to the server **151** via the Internet **16**. The command data is sent over the data path **152***c* from the server **151** via the Internet **16** to the field unit **23***e*, via the router **21** and control network **22***a*. Similarly, a command data may be sent over data path **152***a* from the server **151** via the Internet **16** to the field unit **23***a*, via the router **21** and control network **22**.

Alternatively or in addition, the controller functionality **147** may be in part or in whole located internal to the controlled premises **19**. In one non-limiting example, the controller **147** is integrated in a computer located inside the premises **19**, as shown in arrangement **160** in FIG. **16**. The controller **147** in shown integrated with a personal computer **161**. The computer **161** may be connected to the router **21** directly or via a network, such as via one of the control networks, or alternatively (or in addition) use another network, such as home network **14***a*, as shown in FIG. **16**, where the router **21** includes a port **146***a* connected to the home network **14***a*. Arrangement **160***a* shown in FIG. **16***a* shows example of the various data paths that may be used, such as the data path **162***d* coupling the field unit **23***f* to the computer **161** via the control network **22***a*, router **21** and the home network **14***a*, the data path **162***b* coupling the field unit **23***c* to the computer **161** via the control network **22**, router **21** and the home network **14***a*, the data path **162***c* coupling the computer **161** to the field unit **23***e* via the control network **22***a*, router **21** and the home network **14***a*, and the

data path **162***a* coupling the computer **161** to the field unit **23***a* via the control network **22**, router **21** and the home network **14***a*.

The controller functionality **147** may consist of, or include part or whole, of the flow chart **170** shown in FIG. **17**. At step 'Receive Sensor Data' **171**, data sent from one or more sensors (which are part of one or more field units) is received at the controller location. The sensor information is checked, processed, conditioned, or otherwise manipulated in step 'Sensor Conditioning' **172**. Other signal conditioning functionalities may also be applied in order to improve the handling of the sensor received data or for adapting it to the next step or manipulating, such as attenuation, delay, filtering, amplifying, digitizing, integration, derivation, and any other signal manipulation. The conditioning may include frequency related manipulation such as filtering, spectrum analysis or noise removal, smoothing or de-blurring in case of image enhancement, a compressor (or de-compressor) or a coder (or decoder) in case of compression or coding/decoding, a modulator or a demodulator in case or modulation, and an extractor for extracting or detecting a feature or parameter such as pattern recognition or correlation analysis. The 'Sensor conditioning' step **172** may apply linear or non-linear manipulations, and the manipulation may be time-related such as delaying, integration or rate-based manipulation. The sensors conditioned data serves as input to the step 'Logic' **173**, determining the output based on the sensors input according to a pre-determined logic function or algorithm. The control logic executed in step 'Logic' **173** outputs various actuators commands, which are conditioned in the 'Actuator Conditioning' step **174**, for proper operation of the specific actuators. The conditioning may include attenuation, delay, filtering, amplifying, time integration, derivation, and any other data manipulations as described above regarding the 'Sensor Conditioning' step **172**. The conditioned control commands are sent to the relevant actuators in the applicable field units in the step 'Send Actuator Command' **175**. While the flowchart **170** is exampled including both receiving data from sensors and activating actuators, a controller **143** may only receive data from various sensors in the field units (e.g., for logging purposes) while not activating any actuators, or only transmit commands to various actuators in the field units (e.g., according to time) regardless of any sensing information, or any combination thereof. Further, a controller **143** may use various control logic patterns at different times, where at one time the controller only receives data from the sensors, at another time the controller only transmit commands to the actuators, and yet at another time the controller does both functions.

In the 'Send Notification' step **178**, a message is sent to a user device to notify or alert a user. The notification may be sent periodically and include the system or any sub-system status, or may be sent upon an event, based on a predetermined condition or criteria. The message may be sent upon receiving a sensor data at 'Receive Sensor Data' step **171**, may include a notification of the event of receiving the sensor data, and may include the received sensor data. Alternatively or in addition the message may be sent before, in parallel to, or after the conditioning in step 'Sensor Conditioning' **172**, may include a notification of the event of conditioning the sensor data, and may include the sensor data before or after the conditioning of step **172**, or any other conditioning. Alternatively or in addition the message may be sent before, in parallel to, or after the control logic process execution in step 'Logic' **173**, may include a notification of the event of processing according to the logic of the sensor data, and may include the logic input or the logic output such as the actuator commands, or may use any other logic. Alternatively or in addition the message may be sent before, in parallel to, or after the conditioning and the generation of the actuator commands in step 'Actuator Conditioning' **174**, may include a notification of the event of the conditioning, and may include the actuator commands before or after the conditioning. The conditioning, logic or processing associated with the message sensing in step **178** may be the same, based on, or may be different from, the condition and logic used for the control itself, and may use the same of different predetermined criteria. For example, a message may be sent upon receiving sensor data above or below a threshold, or upon an actuator command that is above or below a threshold. Any event, notification, or alert may include a timestamp, which is a sequence of characters or encoded information identifying when a certain event occurred, usually giving date and time of day, sometimes accurate to a small fraction of a second. A notification may include a sensor data, such as the sensor or the associated field unit address (e.g., IP address) and location (e.g., kitchen, bedroom #1), the sensor type (e.g., temperature sensor) and make, the measured value (e.g. 25° C.), the sensor version or part-number, and the notification reason (e.g., periodic, pre-set time, above predetermined threshold). Similarly, a notification may include an actuator status or commands, such as the actuator or the associated field unit address (e.g., IP address) and location (e.g., kitchen, bedroom #1), the actuator type (e.g., heater) and make, the commanded value (e.g. 25° C.), the actuator version or part-number, and the notification reason (e.g., periodic, preset time, above predetermined threshold). Further, the notification may include an audio such as from a microphone serving as a sensor as in FIG. **19**, or a video or images, such as from a camera serving as a sensor as in FIG. **18**.

The notification or alert to the user device may be text based, such as an electronic mail (e-mail), website content, fax, or a Short Message Service (SMS). Alternatively or in addition, the notification or alert to the user device may be voice based, such as a voicemail, a voice message to a telephone device. Alternatively or in addition, the notification or the alert to the user device may activate a vibrator, causing vibrations that are felt by human body touching, or may be based on a Multimedia Message Service (MMS) or Instant Messaging (IM). The messaging, alerting, and notifications may be based on, include part of, or may be according to U.S. Patent Application No. 2009/0024759 to Mckibben et al. entitled: "System and Method for Providing Alerting Services", U.S. Pat. No. 7,653,573 to Hayes, Jr. et al. entitled: "Customer Messaging Service", U.S. Pat. No. 7,653,573 to Langseth. et al. entitled: "System and Method for a Subject-Based Channel Distribution of Automatic, Real-Time Delivery of Personalized Informational and Transactional Data", U.S. Pat. No. 7,334,001 to Eichstaedt et al. entitled: "Method and System for Data Collection for Alert Delivery", U.S. Pat. No. 7,136,482 to Wille entitled: "Progressive Alert Indications in a Communication Device", U.S. Patent Application No. 2007/0214095 to Adams et al. entitled: "Monitoring and Notification System and Method", U.S. Patent Application No. 2008/0258913 to Busey entitled: "Electronic Personal Alert System", or U.S. Pat. No. 7,557,689 to Seddigh et al. entitled: "Customer Messaging Service", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The information and the notification sent to the user device in 'Send Notification' step **178**, may be further logged or recorded in a data-base in 'Log' step **176**. The data

base may be accessed or sent in 'Send Log Information' step **177**. The logging and the storing the data base may be in the same user device receiving the notification in 'Send Notification' step **178**, or may be a distinct user device, and may be part of, or integrated with, any other device in the system.

The control logic **173** may be a Single-Input-Single-Output (SISO) which is based a single sensor and operative to control a single actuator. Alternatively or in addition, multiple sensors and actuators may be part of the control loop, referred to as Multi-Input-Multi-Output (MIMO). Similarly, SIMO and MISO control may be used as well. Further, the control may use linear or non-linear control schemes.

The control logic **173** may implement a sequential control (a.k.a. logic control), functioning much as a Programmable Logic Controller (PLC). Such sequential controllers commonly respond to various sensors by starting and stopping various operations, and typically make use of Boolean logic. Typically the system operation is based a state machine (or state diagram) and can be in various states (one state active at a time), and may transition from one state to another sequentially, or based on a transition condition, which are based on timing and data from the sensors. The system operation may be described or programmed graphically such as in a Ladder diagram (LD) or in a Function block diagram (FBD), or alternatively textually such as in Structured text (ST) and Instruction list (IL), as described for example in IEC 61131-3.

Alternatively or in addition, the control logic **173** implements an open-loop control, a feed-forward control, a closed-loop control or any combination thereof. In one non-limiting example, the controller **143** is a non-feedback controller, where the control logic **173** implemented as part of the controller flowchart **170** involves an open-loop control. In such a system, the control logic **173** does not use any feedback, such as from the various sensors, to determine the output commands to the actuators, but rather employs a pre-defined control mechanism. Unlike closed-control system, an open-loop system typically cannot engage in machine learning, cannot correct errors and does not compensate for any disturbances in the system. In some open-loop control systems, a human operator is involved in order to provide a 'feedback' for the system operation.

Alternatively or in addition, a non-feedback control, such as feed-forward control scheme may be used. In a typical feed-forward system, a measured disturbance is responded to in a pre-defined way, usually to maintain some desired state of the system in a changing environment. The disturbance is measured and fed forward to the control loop, so that corrective action can be initiated (without an actual feedback from the controlled element) in advance of the disturbance having an adverse effect on the system. The control systems may combine both feed-forward and feedback control, for better performance, such as the system disclosed in U.S. Pat. No. 7,499,239 to Chang entitled: "Feedforward Controller and Methods for Use Therewith", which is incorporated in its entirety for all purposes as if fully set forth herein. Such system is also described and analyzed in Ben-Gurion University Publication entitled: "Chapter 9—Feedforward Control" (pages 221-240) downloaded from http://www.bgu.ac.il/chem_eng/pages/Courses/oren%20courses/Chapter_9.pdf, which is incorporated in its entirety for all purposes as if fully set forth herein.

Alternatively or in addition, a closed-loop control is implemented by the controller **143**. In such a system, a physical phenomenon is sensed, measured, or detected by one or more sensors, and the logic **173** responses to the data received by commanding the activity of actuators, which directly or indirectly affects, change, regulate, or otherwise associated with, the sensed physical phenomenon. For example, the logic **173** may respond to a temperature sensor data by activating a heater or a cooler to change the measured temperature at that location. In one non-limiting example, a set-point or a reference value is defined which is (directly or indirectly) measured or sensed by one or more sensors, and the control loop is active to command the actuators to reach the set-point as measured by the sensors. The control loop may be a linear proportional only control loop, wherein the amount of the actuator control is proportional to the calculated deviation from a set-point, a PI (Proportional Integral) control, a Bistable control, a Hysteretic control, or a PID (Proportional, Integral and Derivative) control loop wherein the amount of the actuator command is calculated based on proportional, integral and derivative computations of the calculated deviation. Alternatively or in addition, the PID control loop may be based on the publication: "PID Control System Analysis, Design, and Technology" by Kiam Heong Ang, Gregory Chong, and Yun Li, published IEEE Transaction on Control System Technology, Vol. 13 No. 4, July 2005 (pp. 559-576), which is incorporated in its entirety for all purposes as if fully set forth herein.

Alternatively or in addition, the controller may employ a bang-bang control (a.k.a. on-off control), where one or more of the actuators may be only in two states, turned fully ON or turned fully OFF. Further, a sensor may be a switch-based sensor, having two states as well. For example, a thermostat is a simple negative-feedback control: when the temperature (the "process variable" or PV) goes below a set point (SP), the heater is switched on. Another example could be a pressure switch on an air compressor: when the pressure (PV) drops below the threshold (SP), the pump is powered. Refrigerators and vacuum pumps contain similar mechanisms operating in reverse, but still providing negative feedback to correct errors. A practical on-off control system is designed to include a hysteresis, usually in the form of an adjustable or programmable deadband, a region around the setpoint value in which no control action occurs.

The term 'random' herein is intended to cover not only pure random, non-deterministically generated signals, but also pseudo-random, deterministic signals such as the output of a shift-register arrangement provided with a feedback circuit as used to generate pseudo-random binary signals or as scramblers, and chaotic signals.

The system operation may involve randomness. For example, the control logic may use randomness in order to avoid predictability, or for having a statistical-based advantage. Randomness is commonly implemented by using random numbers, defined as a sequence of numbers or symbols that lack any pattern and thus appear random, are often generated by a random number generator, which may be included in one or more field units, in the router or gateway, or in the control server. A random number generator (having either analog or digital output) can be hardware based, using a physical process such as thermal noise, shot noise, nuclear decaying radiation, photoelectric effect or other quantum phenomena. Alternatively, or in addition, the generation of the random numbers can be software based, using a processor executing an algorithm for generating pseudo-random numbers which approximates the properties of random numbers. Such algorithm may be executed by a dedicated processor and firmware (or software), or may be integrated into one or more of the field units, in the router or gateway, or in the control server. Non-limiting examples of pseudo-

random numbers generators are described in U.S. Pat. No. 6,285,761 to Patel et al. entitled: "Method for Generating Pseudo-Random Numbers", in U.S. Pat. No. 7,512,645 to Pitz et al. entitled: "System and Method for Generating Pseudorandom Numbers", in U.S. Patent Application Publication No. 2005/0044119 to Langin-Hooper et al. entitled: "Pseudo-Random Number Generator", and in U.S. Patent Application Publication No. 2008/0263117 to Rose et al. entitled: "Initial Seed Management for Pseudorandom Number Generator", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The random signal generator may be hardware based, using a physical process such as thermal noise, shot noise, nuclear decaying radiation, photoelectric effect or other quantum phenomena, or can be software based, using a processor executing an algorithm for generating pseudo-random numbers which approximates the properties of random numbers. A non-limiting example of random number generators is disclosed in U.S. Pat. No. 7,124,157 to Ikake entitled: "Random Number Generator", in U.S. Pat. No. 4,905,176 to Schulz entitled: "Random Number Generator Circuit", in U.S. Pat. No. 4,853,884 to Brown et al. entitled: "Random Number Generator with Digital Feedback", and in U.S. Pat. No. 7,145,933 to Szajnowski entitled: "Method and Apparatus for generating Random signals", which are all incorporated in their entirety for all purposes as if fully set forth herein. The digital random signal generator may be based on 'True Random Number Generation IC RPG100/RPG100B' available from FDK Corporation and described in the data sheet 'Physical Random number generator RPG100.RPG100B' REV. 08 publication number HM-RAE106-0812, which is incorporated in its entirety for all purposes as if fully set forth herein.

The controller, the control logic, or the system operation may be based on, or involves, a fuzzy control, which is typically based on fuzzy logic. In fuzzy logic, the logical variables that take on continuous values between 0 and 1, in contrast to classical or digital logic, which operates on discrete values of either 1 or 0 (true or false respectively). The fuzzy logic has the advantage that the solution to the problem can be cast in terms that human operators can understand, so that their experience can be used in the design of the controller. This makes it easier to mechanize tasks that are already successfully performed by humans. Further, fuzzy logic is able to process incomplete data and provide approximate solutions to problems other methods find difficult to solve. The fuzzy logic or the fuzzy control may be in accordance with, or based on, the publication entitled: "Introduction to Fuzzy Control" by Marcelo Godoy Simoes, or the publication entitled: "Fuzzy Logic in Embedded Microcomputers and Control Systems" by Walter Banks and Gordon Hayward, published by the Byte Craft Limited, which are all incorporated in their entirety for all purposes as if fully set forth herein.

Alternatively or in addition, the control loop implementation may be based on, or be according to, the book entitled: "Sensors and Control Systems in manufacturing", Second Edition 2010, by Sabric Soloman, The McGraw-Hill Companies, ISBN: 978-0-07-160573-1, or according to the book entitled: "Fundamentals of Industrial Instrumentation and Process Control", by William C. Dunn, 2005, The McGraw-Hill Companies, ISBN: 0-07-145735-6, which are incorporated in their entirety for all purposes as if fully set forth herein.

The control loop may use a single fixed-value setpoint. Alternatively or addition, multiple setpoint values may be available as continuous or discrete values, to be selected by a human, which may be a tenant in the building. Further, a setpoint may be automatically set, such as being changed according to a pre-configured scheme. In one example, the value of the setpoint may be time dependent. For example, a first value may be automatically applied during day time, and a second value may be used during the night time. Similarly, a value of a setpoint may be dependent upon, and may be automatically changed or updated, based on TOD (Time-of-Day), day of the week, the month, the year and so forth. In such a case, the system may comprise hardware- or software-based timer, or may use an external timing source or signal for changing or selecting the setpoint value. Using multiple setpoint values is described for example in U.S. Pat. No. 8,214,070 to Grossmann et al. entitled: "Method and Device for Controlling an Actuator", which is incorporated in its entirety for all purposes as if fully set forth herein.

In one example, a setpoint affecting a control loop having a sensor (or sensors) and actuator (or actuators) for controlling a phenomenon, is selected by the control logic based on a sensor data that is not part of the control loop, and is not directly sensing or measuring the controlled phenomenon. For example, a temperature control system may have a low setpoint value such as 15° C. where there is no person in the building (or in a room) in order to preserve electricity or energy, and may have another setpoint value such as 25° C. when there is a person in the building (or in the room). An occupancy sensor, which is not part HVAC control loop including a thermostat and a heater, may be used to detect the presence of a person in the house, and then the control logic may automatically change the setpoint to the higher and more comfortable temperature. An example of adjusting a setpoint based on the state of occupancy is described in U.S. Pat. No. 8,180,492 to Steinberg entitled: "System and Method for Using a Networked Electronic Device as an Occupancy Sensor for an Energy Management System", which is incorporated in its entirety for all purposes as if fully set forth herein.

In one non-limiting example, one (or more) of the sensors in one or more of the field units may be, or may include, an image sensor, such as the sensor unit **50***f* shown in FIG. **5***f*. In such a case, information in the captured image may be extracted and used as part of the control loop. In one example, the field unit may include, be part of, or be integrated with, a digital camera. The digital camera may be a still camera primarily used to take photographs, or may be a video camera where video (and commonly audio) is captured and stored. Some digital cameras can capture and store both still and video images. The digital camera may be portable or may be fixed, such as in most surveillance applications.

The digital camera (or the field unit including an image sensor) may communicate the captured still image or video to the router (or other field units) via wireless communication. Digital cameras utilizing wireless communication are disclosed in U.S. Pat. No. 6,535,243 to Tullis entitled: "Wireless Hand-Held Digital Camera", U.S. Pat. No. 6,552,743 to Rissman entitled: "Digital Camera-Ready Printer", U.S. Pat. No. 6,788,332 to Cook entitled: "Wireless Imaging Device and System", and in U.S. Pat. No. 5,666,159 to Parulski et al. entitled: "Electronic Camera System with Programmable Transmission Capability", which are all incorporated in their entirety for all purposes as if fully set forth herein. A display system and method utilizing a cellular telephone having digital camera capability and a television linked directly over a UWB wireless signal is disclosed in U.S. Pat. No. 7,327,385 to Yamaguchi entitled: "Home Picture/Video Display System with Ultra Wide-Band Tech-

nology", which is incorporated in its entirety for all purposes as if fully set forth herein. In one embodiment, a WirelessHD standard based wireless communication is employed, which is based on the 7 GHz of continuous bandwidth around the 60 GHz radio frequency and allows for uncompressed, digital transmission.

The digital camera (or the field unit including an image sensor) may be connected via a conductive coupling (e.g., cable) to the router or to other field units. A tethered portable electronic camera connectable to a computer is disclosed in U.S. Pat. No. 5,402,170 to Parulski et al. entitled: "Hand-Manipulated Electronic Camera Tethered to a Personal Computer". A digital electronic camera which can accept various types of input/output cards or memory cards is disclosed in U.S. Pat. No. 7,432,952 to Fukuoka entitled: "Digital Image Capturing Device having an Interface for Receiving a Control Program", and the use of a disk drive assembly for transferring images out of an electronic camera is disclosed in U.S. Pat. No. 5,138,459 to Roberts et al., entitled: "Electronic Still Video Camera with Direct Personal Computer (PC) Compatible Digital Format Output", which are both incorporated in their entirety for all purposes as if fully set forth herein.

The connection of an image sensor unit (either a digital camera or a field unit) may be based on a standard video connection. In this case, the modem **64** and the associated connector are adapted to output this standard video signal. Such analog interfaces can be composite video such as NTSC, PAL or SECAM formats. Similarly, analog RGB, VGA (Video Graphics Array), SVGA (Super Video Graphics Array), SCART, S-video and other standard analog interfaces can be used. In case of a cable connection, the connector may be implemented as suitable standard analog video connector. For example, F-Type, BNC (Bayonet Neill-Concelman), RCA, and similar RF/coax connectors can be used. In one non-limiting example, the modem **64** and the related connector **65***b* are adapted to support the digital video interface. In one example, an IEEE1394 interface, also known as Fire Wire™, is used. Other digital interfaces that may be used are USB, SDI (Serial Digital Interface), FireWire, HDMI (High-Definition Multimedia Interface), DVI (Digital Visual Interface), UDI (Unified Display Interface), DisplayPort, Digital Component Video and DVB (Digital Video Broadcast).

In the case of image capturing application, the controller functionality **147** may consist of, or include part or whole, of the flow chart **180** shown in FIG. **18**. At step 'Receive Image Data' **181**, image data sent from one or more image sensors (which are part of one or more field units) is received at the controller location. The image sensor information is checked, processed, conditioned, or otherwise manipulated in step 'Image Processing' **182**. The image processing in this step may include frequency related manipulation such as filtering, spectrum analysis or noise removal, smoothing or de-blurring in case of image enhancement, a compressor (or de-compressor) or a coder (or decoder) in case of compression or coding/decoding, a modulator or a demodulator in case or modulation, and an extractor for extracting or detecting a feature or parameter such as pattern recognition or correlation analysis. In one non-limiting example, a decompression is performed in order to restore the original pre-compressed image, before the video compression such as in the video compressor **505** in the field unit **50***f* shown in FIG. **5***f*.

Other image processing functions may include adjusting color balance, gamma and luminance, filtering pattern noise, filtering noise using Wiener filter, changing zoom factors, recropping, applying enhancement filters, applying smoothing filters, applying subject-dependent filters, and applying coordinate transformations. Other enhancements in the image data may include applying mathematical algorithms to generate greater pixel density or adjusting color balance, contrast and/or luminance.

The 'Image Processing' step **182** may further include a face detection (also known as face localization), which includes an algorithm for identifying a group of pixels within a digitally-acquired image that relates to the existence, locations and sizes of human faces. Common face-detection algorithms focused on the detection of frontal human faces, and other algorithms attempt to solve the more general and difficult problem of multi-view face detection. That is, the detection of faces that are either rotated along the axis from the face of the observer (in-plane rotation), or rotated along the vertical or left-right axis (out-of-plane rotation), or both. Various face-detection techniques and devices (e.g., cameras) having face detection features are disclosed in U.S. Pat. No. 5,870,138 to Smith et al., entitled: "Facial Image Processing", in U.S. Pat. No. 5,987,154 to Gibbon et al., entitled: "Method and Means for Detecting People in Image Sequences", in U.S. Pat. No. 6,128,397 to Baluja et al., entitled: "Method for Finding All Frontal Faces in Arbitrarily Complex Visual Scenes", in U.S. Pat. No. 6,188,777 to Darrell et al., entitled: "Method and Apparatus for Personnel Detection and Tracking", in U.S. Pat. No. 6,282,317 to Luo et al., entitled: "Method for Automatic Determination of Main Subjects in Photographic Images", in U.S. Pat. No. 6,301,370 to Steffens et al., entitled: "Face Recognition from Video Images", in U.S. Pat. No. 6,332,033 to Qian entitled: "System for Detecting Skin-Tone Regions within an Image", in U.S. Pat. No. 6,404,900 to Qian et al., entitled: "Method for Robust Human Face Tracking in Presence of Multiple Persons", in U.S. U.S. Pat. No. 6,407,777 to DeLuca entitled: "Red-Eye Filter Method and Apparatus", in U.S. Pat. No. 7,508,961 to Chen et al., entitled: "Method and System for Face Detection in Digital Images", in U.S. Pat. No. 7,317,815 to Steinberg et al., entitled: "Digital Image Processing Composition Using Face Detection Information", in U.S. Pat. No. 7,315,630 to Steinberg et al., entitled: "Perfecting a Digital Image Rendering Parameters within Rendering Devices using Face Detection", in U.S. Pat. No. 7,110,575 to Chen et al., entitled: "Method for Locating Faces in Digital Color Images", in U.S. Pat. No. 6,526,161 to Yan entitled: "System and Method for Biometrics-Based Facial Feature Extraction", in U.S. Pat. No. 6,516,154 to Parulski et al., entitled: "Image Revising Camera and Method", in U.S. Pat. No. 6,504,942 to Hong et al., entitled: "Method and Apparatus for Detecting a Face-Like Region and Observer Tracking Display", in U.S. Pat. No. 6,501,857 to Gotsman et al., entitled: "Method and System for Detecting and Classifying Objects in an Image", and in U.S. Pat. No. 6,473,199 to Gilman et al., entitled: "Correcting Exposure and Tone Scale of Digital Images Captured by an Image Capture Device", which are all incorporated in their entirety for all purposes as if fully set forth herein. Another camera with human face detection means is disclosed in U.S. Pat. No. 6,940,545 to Ray et al., entitled: "Face Detecting Camera and Method", which is incorporated in its entirety for all purposes as if fully set forth herein. The image processing may use algorithms and techniques described in the book entitled: "The Image Processing Handbook", Sixth Edition, by John C. Russ, from CRC Press ISBN: 978-1-4398-4063-4, as well as algorithms and techniques described in U.S. Pat. Nos. RE 33,682, RE 31,370, 4,047,187, 4,317,991, 4,367,027, 4,638,364, 5,291,

234, 5,386,103, 5,488,429, 5,638, 136, 5,642,431, 5,710, 833, 5,724,456, 5,781,650, 5,812,193, 5,818,975, 5,835,616, 5,870,138, 5,978,519, 5,991,456, 6,097,470, 6, 101,271, 6,148,092, 6, 151,073, 6,192, 149, 6,249,315, 6,263, 113, 6,268,939, 6,393,148, 6,421,468, 6,438,264, 6,456,732, 6,459,436, 6,504,951, 7,466,866 and 7,508,961, which are all incorporated in their entirety for all purposes as if fully set forth herein.

The 'Image Processing' step **182** may further include an algorithm for motion detection by comparing the current image with a reference image and counting the number of different pixels, where the image sensor or the digital camera are assumed to be in a fixed location and thus assumed to capture the same image. Since images will naturally differ due to factors such as varying lighting, camera flicker, and CCD dark currents, pre-processing is useful to reduce the number of false positive alarms. More complex algorithms are necessary to detect motion when the camera itself is moving, or when the motion of a specific object must be detected in a field containing other movement which can be ignored.

The image processing may further include video enhancement such as video denoising, image stabilization, unsharp masking, and super-resolution. Further, the image processing may include a Video Content Analysis (VCA), where the video content is analyzed to detect and determine temporal events based on multiple images, and is commonly used for entertainment, healthcare, retail, automotive, transport, home automation, safety and security. VCA functionalities include Video Motion Detection (VMD), video tracking, and egomotion estimation, as well as identification, behavior analysis and other forms of situation awareness. A dynamic masking functionality involves the blocking a part of the video signal based on the signal itself, for example because of privacy concerns. An egomotion estimation functionality involves the determining of the location of a camera or estimating the camera motion relative to a rigid scene, by analyzing its output signal. Motion detection is used to determine the presence of a relevant motion in the observed scene, while object detection is used to determine the presence of a type of object or entity, for example a person or car, as well as fire and smoke detection. Similarly, Face recognition and Automatic Number Plate Recognition may be used to recognize, and therefore possibly identify persons or cars. Tamper detection is used to determine whether the camera or the output signal is tampered with, and video tracking is used to determine the location of persons or objects in the video signal, possibly with regard to an external reference grid. A pattern is defined as any form in an image having discernible characteristics that provide a distinctive identity when contrasted with other forms. Pattern recognition may also be used, for ascertaining differences, as well as similarities, between patterns under observation and partitioning the patterns into appropriate categories based on these perceived differences and similarities; and may include any procedure for correctly identifying a discrete pattern, such as an alphanumeric character, as a member of a predefined pattern category. Further, the video or image processing may use, or be based on, the algorithms and techniques disclosed in the book entitled: "Handbook of Image & Video Processing", edited by Al Bovik, by Academic Press ISBN: 0-12-119790-5, which is incorporated in its entirety for all purposes as if fully set forth herein.

In one example, the image processing may be used for non-verbal human control of the system, such as by hand posture or gesture recognition, typically involving movement of the hands, face, or other parts of the human body. The recognized hand posture or gesture is used as input by the control logic in the controller, and thus enables humans to interface with the machine (HMI) and interact naturally without any mechanical devices, and thus to impact the system operation and the actuators commands and operation. The image-based recognition may use a single camera, or may be based on a 3D representation, captured by 3-D stereo cameras that is using two cameras whose relations to one another are known, or alternatively by a depth-aware camera. The gesture recognition may be based on 3-D information of key elements of the body parts in order to obtain several important parameters, like palm position or joint angles, or alternatively (or in addition) may be appearance-based, where images or videos are used for direct interpretation.

The 3D model approach can use volumetric or skeletal models, or a combination of the two. Skeletal-based algorithms are based on using a simplified version of joint angle parameters along with segment lengths, known as a skeletal representation of the body, where a virtual skeleton of the person is computed and parts of the body are mapped to certain segments. The analysis is using the position and orientation of these segments and the relation between each one of them (for example the angle between the joints and the relative position or orientation). Appearance-based models derive the parameters directly from the images or videos using a template database. Some are based on the deformable 2D templates of the human parts of the body, particularly hands. Deformable templates are sets of points on the outline of an object, used as interpolation nodes for the object's outline approximation. The interpolation function may be linear, which performs an average shape from point sets, point variability parameters and external deformators. These template-based models are mostly used for hand-tracking, but could also be of use for simple gesture classification. A second approach in gesture detecting using appearance-based models uses image sequences as gesture templates. Parameters for this method are either the images themselves, or certain features derived from these, using only one (monoscopic) or two (stereoscopic) views. The technology, algorithm or techniques used for hand posture or gesture recognition may be based on the Brown University publication CS-99-11 entitled: "A survey of hand Posture and Gesture Recognition Techniques and Technology", by Joseph J. LaViola Jr., U.S. Pat. No. 5,047,952 to Kramer et al., entitled: "Communication System for Deaf, Deaf-Blind, or non-Vocal Individuals Using Instrumented Glove", U.S. Pat. No. 4,414,537 to Grimes, entitled: "Digital data Entry Glove Interface Device", U.S. Pat. No. 7,702,130 to Sung-Ho Im et al., entitled: "User interface apparatus using hand gesture recognition and method thereof", U.S. Pat. No. 7,598,942 to Underkoffler et al., entitled: "System and Method for Gesture Based Control System", U.S. Patent Application Publication No. 2011/0222726 to Ruan, entitled: "Gesture Recognition Apparatus, Method for Controlling Gesture Recognition Apparatus, and Control Program",", U.S. Patent Application Publication No. 2010/0211918 to Liang et al., entitled: "Web Cam Based User Interaction", U.S. Patent Application Publication No. 2007/0132725 to Kituara, entitled: "Electronic Appliance", U.S. Patent Application Publication No. 2012/0268373 to Grzesiak, entitled: "Method for Recognizing User's Gesture in Electronic Device", U.S. Pat. No. 5,652,849 to Conway et al., entitled: "Apparatus and Method for Remote Control Using a Visual Information Stream", U.S. Pat. No. 7,289,645 to Yamamoto et al., entitled: "Hand Pattern Switch

Device", U.S. Pat. No. 7,821,541 to Delcan, entitled: "Remote Control Apparatus Using Gesture Recognition", U.S. Pat. No. 5,454,043 to Freeman, entitled: "Dynamic and Static Hand Gesture Recognition Through Low-Level Image Analysis", or U.S. Pat. No. 5,046,022 to Conway et al., entitled: "Tele-Autonomous System and Method Employing Time/Position Synchrony/Desynchrony", which are all incorporated in their entirety for all purposes as if fully set forth herein.

In one non-limiting example, the control may be based on extracting the location of an identified element in the captured image. The element may be a human body part such as face, hand, and body contour. Example of a control systems which are based on the location of a human being by analyzing the human face location are described in U.S. Pat. No. 6,931,596 to Gutta et al., entitled: "Automatic Positioning of Display Depending upon the Viewer's Location" and in U.S. Patent Application Publication No. 2010/0295782 to Binder, entitled: "System and Method for Control Based on Face or Hand Gesture Detection", both incorporated in their entirety for all purposes as if fully set forth herein. Further, the control may be based on the number of identified elements in a captured image. For example, the number of human beings in a location may be determined by using image processing, such as face detection algorithms.

Any image processing functionality may be performed only as part of the 'Image Processing' step **182** executed as part of the controller functionality **147**. Alternatively, an image processing functionality may be performed only as part of the Image Processor **504** in the field unit **50***f* shown in FIG. **5***f*. Further, an image processing functionality may be split between the field unit **50***f* and the 'Image Processing' step **182** of the controller **147**. In another non-limiting example, some image processing functionality may be split between the field unit **50***f* and the controller **147**, where some functionalities will be executed (in whole or in part) in the field unit **50***f*, while other functionalities will be executed (in whole or in part) as part of the flow chart **180** as part of the controller **147**.

The information extracted from the received image serves as input to the step 'Logic' **183**, determining the output based on the sensors input according to a pre-determined logic function or algorithm. The 'Logic' step **183** may be identical, similar or different from the corresponding 'Logic' step **173** of the flowchart **170**. The control logic executed in step 'Logic' **183** outputs various actuators commands, which are conditioned in the 'Actuator Conditioning' step **174**, for proper operation of the specific actuators. The conditioning may include attenuation, delay, filtering, amplifying, time integration, derivation, and any other data manipulations as described above regarding the 'Sensor Conditioning' step **172**. The conditioned control commands are sent to the relevant actuators in the applicable field units in the step 'Send Actuator Command' **175**. While the flowchart **180** is exampled including both receiving data from sensors and activating actuators, a controller **143** may only receive data from various image sensors in the field units (e.g., for logging purposes) while not activating any actuators, or only transmit commands to various actuators in the field units (e.g., according to time) regardless of any sensing information, or any combination thereof. Further, a controller **143** may use various control logic patterns at different times, where at one time the controller only receives data from the image sensors, at another time the controller only transmit commands to the actuators, and yet at another time the controller does both functions. In one non-limiting example, the actuators are Pan, Tilt, and Zoom (PTZ) electric motors of the digital camera, and the commands are used to position the image sensor and the focus in order to obtain an image of a specific location or target.

In one non-limiting example, the information extracted from the captured image as part of the 'Image Processing' step **182**, detect an event that may impact the system operation. For example, in the case of an image processing that includes a face detection function, the first detection of a face is an event that may trigger one or more actuators into action (or to stop an activity) by the control logic. Similarly, the lack of detection of a human face may cause activation or deactivation of one or more actuators in the systems. Similarly, detection of a motion by the image processing may trigger actuators for an action, or may deactivate actuators, according to a pre-defined logic.

While flowchart **180** in FIG. **18** was described above where the sensors are image sensors only, additional sensors may be equally used in the control system. In such a case, the general flowchart **170** and the image-based flow chart **180** are integrated, and the combined 'Logic' step **173** uses both the non-related image sensor data (after conditioning in 'Sensor Conditioning' step **172**) and the image extracted data (after the 'Image Processing' step **182**), to determine the output and the commands to be sent to the actuators.

In one non-limiting example, one (or more) of the sensors in one or more of the field units may be, or may include, a sound or voice sensor, such as a microphone. In such a case, information in the captured voice may be extracted and used as part of the control loop. In one non-limiting example, the field unit may include, be part of, or be integrated with, a telephone.

In the case of voice capturing application, the controller functionality **147** may consist of, or include part or whole, of the flow chart **190** shown in FIG. **19**. At step 'Receive Voice Data' **191**, voice data sent from one or more microphones (which are part of one or more field units) is received at the controller location. The voice data is checked, processed, conditioned, or otherwise manipulated in step 'Voice Processing' **192**. The voice processing in this step may include frequency related manipulation such as filtering, spectrum analysis or noise removal, a compressor (or decompressor) or a coder (or decoder) in case of compression or coding/decoding, a modulator or a demodulator in case or modulation, and an extractor for extracting or detecting a feature or parameter such as pattern recognition or correlation analysis. In one non-limiting example, a decompression is performed in order to restore the original pre-compressed voice, before the voice compression executed in the field unit. The 'Voice Processing' step **192** may further include a voice recognition, which includes an algorithm for identifying the voice of a specific person.

Any voice processing functionality may be performed only as part of the 'Voice Processing' step **192** executed as part of the controller functionality **147**. Alternatively or in addition, a voice processing functionality may be performed as part of the field unit. Further, an image processing functionality may be split between the field unit and the 'Voice Processing' step **192** of the controller **147**. In another example, some voice processing functionality may be split between the field unit and the controller **147**, where some functionalities will be executed (in whole or in part) in the field unit, while other functionalities will be executed (in whole or in part) as part of the flow chart **190** as part of the controller **147**.

The information extracted from the received voice serves as input to the step 'Logic' **193**, determining the output based on the sensors input according to a pre-determined

logic function or algorithm. The 'Logic' step **193** may be identical, similar or different from the corresponding 'Logic' step **173** of the flowchart **170**. The control logic executed in step 'Logic' **193** outputs various actuators commands, which are conditioned in the 'Actuator Conditioning' step **174**, for proper operation of the specific actuators. The conditioning may include attenuation, delay, filtering, amplifying, time integration, derivation, and any other data manipulations as described above regarding the 'Sensor Conditioning' step **172**. The conditioned control commands are sent to the relevant actuators in the applicable field units in the step 'Send Actuator Command' **175**. While the flowchart **190** is exampled including both receiving data from sensors and activating actuators, a controller **143** may only receive data from various voice or sound sensors in the field units (e.g., for logging purposes) while not activating any actuators, or only transmit commands to various actuators in the field units (e.g., according to time) regardless of any sensing information, or any combination thereof. Further, a controller **143** may use various control logic patterns at different times, where at one time the controller only receives data from the voice sensors, at another time the controller only transmit commands to the actuators, and yet at another time the controller does both functions.

In one non-limiting example, the information extracted from the captured voice as part of the 'Voice Processing' step **192**, detect an event that may impact the system operation. For example, in the case of a voice processing that includes a voice recognition function, the detection of a specific human voice is an event that may trigger one or more actuators into action (or to stop an activity) by the control logic. Similarly, the lack of detection of a human voice may cause activation or deactivation of one or more actuators in the systems.

While flowchart **190** in FIG. **19** was described above where the sensors are only voice sensors, additional sensors may be equally used in the control system. In such a case, the general flowchart **170** and the voice-based flow chart **190** are integrated, and the combined 'Logic' step **173** uses both the non-related voice sensor data (after conditioning in 'Sensor Conditioning' step **172**) and the voice extracted data (after the 'Voice Processing' step **192**), to determine the output and the commands to be sent to the actuators.

A field unit (such as field unit **23** in FIG. **2**, sensor unit **50**-**50***e* in FIGS. **5**-**5***c*, or actuator unit **60**-**60***g* in FIGS. **6**-**6***f*), may be integrated, in part or in whole, in a router such as router **143** (corresponding for example to router **12** in FIG. **2**, router **40** in FIG. **4**, gateway **11** in FIG. **1**, or router **40***a* in FIGS. **4***a*-**4***d*). Alternatively or in addition, a router such as router **143** (corresponding for example to router **12** in FIG. **2**, router **40** in FIG. **4**, gateway **11** in FIG. **1**, or router **40***a* in FIGS. **4***a*-**4***d*) may be integrated, in part or in whole, in an appliance such as a home appliance. Further, a field unit (such as field unit **23** in FIG. **2**, sensor unit **50**-**50***e* in FIGS. **5**-**5***c*, or actuator unit **60**-**60***g* in FIGS. **6**-**6***f*), may be integrated, in part or in whole, in an appliance such as a home appliance. In such a case, the sensors or the actuators (or both) of the appliance, may serve as the sensors or actuators of the field unit, and handled as described herein. Home appliances are electrical and mechanical devices using technology for household use, such as food handling, cleaning, clothes handling, or environmental control. Appliances are commonly used in household, institutional, commercial or industrial setting, for accomplishing routine housekeeping tasks, and are typically electrically powered. The appliance may be a major appliance, also known as "White Goods", which is commonly large, difficult to move, and generally to some extent fixed in place (usually on the floor or mounted on a wall or ceiling), and is electrically powered from the AC power (mains) grid. Non-limiting examples of major appliances are washing machines, clothes dryers, dehumidifiers, conventional ovens, stoves, refrigerators, freezers, air-conditioners, trash compactors, furnaces, dishwasher, water heaters, microwave ovens and induction cookers. The appliance may be a small appliance, also known as "Brown Goods", which is commonly a small home appliance that is portable or semi-portable, and is typically a tabletop or a countertop type. Examples of small appliances are television sets, CD and DVD players, HiFi and home cinema systems, telephone sets and answering machines, and beverage making devices such as coffee-makers and iced-tea makers.

Some appliances main function is food storage, commonly refrigeration related appliances such as refrigerators and freezers. Other appliances main function is food preparation, such as conventional ovens (stoves) or microwave ovens, electric mixers, food processors, and electric food blenders, as well as beverage makers such as coffee-makers and iced-tea makers. Few food related appliances, commonly found in a home kitchen, are illustrated in FIG. **12**, showing a dishwasher **121**, a food processor **122**, a refrigerator **123**, an oven **124**, a mixer **125**, and a microwave oven **126**. Some appliances main function relates to cleaning, such as clothes cleaning. Clothes cleaning appliances examples are washing/laundry machines and clothes dryers. A vacuum cleaner is an appliance used to suck up dust and dirt, usually from floors and other surfaces. Few cleaning-related appliances are illustrated in FIG. **12***a*, showing a vacuum cleaner **127**, a cloth dryer **128** and a washing machine **129**, as well as a still digital camera **1210** and a digital video camera **1211**. Some appliances main function relates to temperature control, such as heating and cooling. Air conditioners and heaters, as well as HVAC (Heating, Ventilation and Air Conditioning) systems, are commonly used for climate control, usually for thermal comfort for occupants of buildings or other enclosures. Similarly, water heaters are used for heating water.

The system may be used for lighting control, moisture control, freeze control, pet feeding, propane gauge, interior and exterior cameras, security, smoke alarms, or health monitoring. In one non-limiting example, a field unit may be integrated with a smoke detector assembly, which is typically housed in a disk-shaped plastic enclosure, which may be about 150 millimeters (6 inch) in diameter and 25 millimeters (1 inch) thick, and is commonly mounted on a ceiling or on a wall.

The system may be used for building automation, or may be part of, integrated with, or coupled to a building automation system, such as the building automation system described in U.S. Pat. No. 6,967,565 to Lingemann entitled: "Building Automation System", which is incorporated in its entirety for all purposes as if fully set forth herein. A field unit, a sensor, or an actuator in the system may be part of, integrated with, coupled to, or used to control indoor or outdoor lighting, fans, sprinklers, pool/spa heaters and pumps, electronic drapes, windoware units, fireplaces, garage doors openers, electronic door locks, hot water heaters, fire detection and monitoring equipment, electronic gates, digital security cameras, motion sensors, flood monitors, humidifiers, home theater units, phone PBX, voice mail, intercom, door phone, aquarium sensors and heaters, sidewalk and driveway heaters, sprinklers, dampers, doorbells, lighting fixtures and fans. The system may further support, be part of, or be integrated with, a Building Auto-

mation System (BAS) standard, and may further be in part or in full in accordance with Cisco Validated Design document entitled: Building Automation System over IP (BAS/IP) Design and Implementation Guide" by Cisco Systems and Johnson Controls, which is incorporated in its entirety for all purposes as if fully set forth herein.

The system may be used for Remote Patient Monitoring (RPM), enabling monitoring of patients outside of conventional clinical settings (e.g., in their home), which may increase access to care and decrease healthcare delivery costs. The monitoring and trend analysis of physiological parameters, enable early detection of deterioration; thereby, reducing number of emergency department visits, hospitalizations, and duration of hospital stays. Physiological data such as blood pressure and subjective patient data are collected by sensors on peripheral devices such as blood pressure cuff, pulse oximeter, and glucometer. The data is transmitted to healthcare providers or third parties via various networks, and may be evaluated for potential problems by a healthcare professional or via a clinical decision support algorithm, and patient, caregivers, and health providers are immediately alerted if a problem is detected. As a result, timely intervention ensures positive patient outcomes. Other applications may provide education, test, and medication reminder alert, and may include Telesurgery (remote surgery), enabling medical doctors to perform surgery on a patient being physically at another location, Teleaudiology for providing audiological services, Teledentistry for remote dental care, consultation, education, or awareness, Teledermatology for exchanging information concerning skin conditions or tumors of the skin, Telepathology fort practicing pathology at a distance, Teleradiology for imaging and sending radiographic images, and Telecardiology where ECGs are transmitted for remote evaluation.

The term "outlet" herein denotes an electro-mechanical device, which facilitates easy, rapid connection and disconnection of external devices to and from wiring installed within a building. An outlet commonly has a fixed connection to the wiring, and permits the easy connection of external devices as desired, commonly by means of an integrated standard connector in a faceplate. The outlet is normally mechanically attached to, or mounted in, a wall or similar surface. Non-limiting examples of common outlets include: telephone outlets for connecting telephones and related devices; CATV outlets for connecting television sets, VCR's, and the like; outlets used as part of LAN wiring (i.e. "structured wiring") and electrical outlets for connecting power to electrical appliances. The term "wall" herein denotes any interior or exterior surface of a building, including, but not limited to, ceilings and floors, in addition to vertical walls. The term "building" herein includes any site, location, premises, or structure with a roof and walls, such as a house, school, store, or factory, including, without limitation, residential house, apartments, trailers, motor homes, offices, and businesses.

Outlets in general (to include LAN structured wiring, electrical power outlets, telephone outlets, and cable television outlets) are typically passive devices being part of the wiring system house infrastructure and solely serving the purpose of providing access to the in-wall wiring. However, there is a trend toward embedding active circuitry in the outlet in order to use them as part of the home/office network, and typically to provide a standard data communication interface. In most cases, the circuits added serve the purpose of adding data interface connectivity to the outlet, added to its basic passive connectivity function.

An outlet supporting both telephony and data interfaces for use with telephone wiring is disclosed in U.S. Pat. No. 6,549,616 to Binder entitled 'Telephone outlet for implementing a local area network over telephone lines and a local area network using such outlets', and in U.S. Pat. No. 6,216,160 to Dichter entitled 'Automatically configurable computer network', which are all incorporated in their entirety for all purposes as if fully set forth herein. A non-limiting example of home networking over CATV coaxial cables using outlets is described in U.S. Patent Application Publication No. 2002/0194383 to Cohen et al. entitled: 'Cableran Networking over Coaxial Cables', which is incorporated in its entirety for all purposes as if fully set forth herein. Such outlets are available as part of HomeRAN™ system from TMT Ltd. of Jerusalem, Israel. Outlets for use in conjunction with wiring carrying telephony, data and entertainment signals are disclosed in U.S. Patent Application Publication No. 2003/0099228 to Alcock entitled 'Local area and multimedia network using radio frequency and coaxial cable', which is incorporated in its entirety for all purposes as if fully set forth herein. Outlets for use with combined data and power using powerlines are described in U.S. Patent Application Publication No. 2003/0062990 to Schaeffer et al. entitled 'Powerline bridge apparatus', which is incorporated in its entirety for all purposes as if fully set forth herein. Such power outlets are available as part of PlugLAN™ by Asoka USA Corporation of San Carlos, CA USA.

While the active outlets have been described above with regard to networks formed over wiring used for basic services (e.g., telephone, CATV and power), it will be appreciated that the principle can be equally applied to outlets used in networks using dedicated wiring. In such a case, the outlet circuitry is used to provide additional interfaces to an outlet, beyond the basic service of single data connectivity interface. As a non-limiting example, it may be used to provide multiple data interfaces wherein the wiring supports single such data connection. An example of such an outlet is the Network Jack™ product family manufactured by 3Com™ of Santa-Clara, California, U.S.A. In addition, such outlets are described in U.S. Pat. No. 6,108,331 to Thompson entitled 'Single Medium Wiring Scheme for Multiple Signal Distribution in Building and Access Port Therefor', in U.S. Patent Application No. 2003/0112965 to McNamara et al. entitled 'Active Wall Outlet', and in U.S. Patent Application Publication No. 2005/0010954 to Binder entitled: "Modular Outlet", which are all incorporated in their entirety for all purposes as if fully set forth herein.

One approach to adding functionality to existing outlets is by using a plug-in module. Such plug-in modules are described in U.S. Patent Application Publication No. 2002/0039388 to Smart et al. entitled 'High data-rate powerline network system and method', U.S. Patent Application Publication No. 2002/0060617 to Walbeck et al. entitled 'Modular power line network adapter', and also in U.S. Patent Application Publication No. 2003/0062990 to Schaeffer, J R et al. entitled 'Powerline bridge apparatus', which are all incorporated in their entirety for all purposes as if fully set forth herein. Such modules using HomePlug™ technology are available from multiple sources such as part of PlugLink™ products by Asoka USA Corporation of San Carlos, California, U.S.A. (HomePlug is a trademark of HomePlug Powerline Alliance, Inc. of San Ramon, California, U.S.A.). Various types of snap-on devices are also described in U.S. Patent Application No. 2005/0180561, and in U.S. Patent Application Publication No. 2005/0180561 to Hazani, et al. entitled: "Outlet Add-On module", which are all incorpo-

rated in their entirety for all purposes as if fully set forth herein. A non-limiting example of a server-based automation system using outlets is described in U.S. Patent Application Publication No. 2005/0125083 to Kiko entitled: "Automation Apparatus and Methods", which is incorporated in its entirety for all purposes as if fully set forth herein.

In one non-limiting example, a sensor, an actuator, one or more field units, or the router are integrated with, or are part of, an outlet or a plug-in module. The outlet may be telephone, LAN (such as Structured Wiring based on Category 5, 6 or 7 wiring), AC power or CATV outlet. The field unit or the router may further communicate over the in-wall wiring connected to the outlet, such as telephone, AC power, LAN or CATV wiring. Further, the outlet associated sensor, actuator, one or more field units, or router may be powered from a power signal carried over the in-wall wiring, and may further communicate using the in-wall wiring as a network medium. For example, in the case of telephone wiring and telephone outlet, the powering may be carried over the telephone wire pair using the technique disclosed in U.S. Pat. No. 6,862,353 to Rabenko et al. entitled: "System and Method for Providing Power over a Home Phone Line Network", which teaches carrying AC power over telephone wiring carrying both telephony and data, by using a part of the spectrum not used by the other signals, or be based on U.S. Patent Application Publication No. 2004/0151305 to Binder, et al. entitled: "Method and System for Providing DC Power on Local Telephone Lines", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The system may be used for assistive domotics applications of home automation, making it possible for the elderly and disabled to remain at home, rather than moving to a healthcare facility, such as embedded health systems and private health networks. Embedded health systems integrate sensors and computers/microprocessors in appliances, furniture, and clothing for collecting data that is analyzed and can be used to diagnose diseases and recognize risk patterns. Private health networks typically implement wireless technology to connect portable devices and store data in a household health database. The system may provide both the elderly and disabled with many different types of emergency assistance systems, security features, fall prevention, automated timers, and alerts. The system may further allow for the individual to feel secure in their homes knowing that help is only minutes away, as well as making it possible for family members to monitor their loved ones from anywhere via an internet or other connection. The system may track the individual person location within the home, and may detect water on the floor, as well as a camera that allows the person to view who is at the door and let them in using a cell phone. The system may include devices worn around the neck or wrist, and may be connected to a control center that is 24-hour activated, and may analyze medical symptoms, medication allergies, and dispatch emergency services. The system generates alarms and alerts automatically if significant changes are observed in the user's vital signs. The system may implement medication dispensing devices in order to ensure that necessary medications are taken at appropriate times, and may use automated pill dispensers can dispense only the pills that are to be taken at that time and are locked; such as the versions that are available for Alzheimer's patients that have a lock on them. For diabetic patients a talking glucose monitor allows the patient to check their blood sugar level and take the appropriate injection, digital thermometers are able to recognize a fever and alert physicians, and blood pressure and pulse monitors may dispense hypertensive medications when needed. Other applications and advantages are described in the article entitled: "Smart Homes for Older People: Positive Aging in a Digital World" published in Future Internet 2012, which is incorporated in its entirety for all purposes as if fully set forth herein.

The system may be used in biometrics (a.k.a. biometric authentication) applications, where humans are identified by the control logic by their characteristics or traits sensed by the sensors. Biometrics may be used for identification and access control, as well as to identify individuals in groups that are under surveillance. Biometric identifiers or traits are typically distinctive, measurable physiological or behavioral characteristics used to identify, label and describe individuals. Behavioral biometrics relates to the behavior of a person, such as typing rhythm, gait, and voice, and physiological biometric would identify using voice, DNA, hand print or behavior. Biometrics may be based on sensors measuring or sensing a brain (electroencephalogram) or a heart (electrocardiogram) signals.

Many different aspects of human physiology, chemistry or behavior can be used for biometric authentication. Preferably, any person using a system should possess the trait; however the trait should be unique and sufficiently different for individuals in the relevant population such that they can be distinguished from one another. The control logic may accommodate both permanent traits that are reasonably invariant over time with respect to the specific matching algorithm, as well as traits that vary over time. Preferably the sensors easily acquire or measure the trait with accuracy, speed, and robustness, and in a form that permits subsequent processing and extraction of the relevant feature sets by the control logic, with minimal possibility of system circumvention such as by trait imitating using an artifact or substitute.

The system may be used for person verification purposes, where the system performs a one-to-one comparison of a captured biometric with a specific template stored in a biometric database that may be stored in the control server (or in any other device in the system or external to the system such as in another server), in order to verify the individual is the person they claim to be. Reference models for all the users are generated and stored in the biometric database. Then some samples are matched with reference models to generate the genuine and impostor scores and calculate the threshold. In the testing step, a smart card, username or ID number (e.g., PIN) is used to indicate which template should be used for comparison.

The system may be used for identification purposes, where the system performs a one-to-many comparison against a biometric database in an attempt to establish the identity of an unknown individual. The system succeeds in identifying the individual 'positive recognition' if the comparison of the biometric sample to a template in the database falls within a previously set threshold. A 'negative recognition' of the person means that the system establishes that the person is who he (implicitly or explicitly) denies to be, achieved through biometrics since other methods of personal recognition such as passwords, PINs or keys may be ineffective.

The system may be a multi-biometric system that uses multiple sensors or biometrics to overcome the limitations of unimodal biometric systems. For instance iris recognition systems can be compromised by aging irides and finger scanning systems by worn-out or cut fingerprints. Multi-biometric may obtain sets of information from the same sensors or markers (i.e., multiple images of an iris, or scans

of the same finger), or may be based on information from different biometrics such as requiring fingerprint scans, using voice recognition, and a spoken pass-code. Multi-biometric systems can integrate unimodal systems sequentially, simultaneously, a combination thereof, or in series, which refer to sequential, parallel, hierarchical and serial integration modes, respectively.

The information fusion may be broadly divided into three parts: pre-mapping fusion, midst-mapping fusion, and post-mapping fusion/late fusion. In pre-mapping fusion information can be combined at sensor level or feature level. Sensor-level fusion may be single sensor-multiple instances, intra-class multiple sensors, or inter-class multiple sensors. Feature-level fusion may be inter-class or intra-class type, the latter may be based on same sensor-same features, same sensor-different features, different sensors-same features, or different sensors-different features.

The system may be an adaptive biometric system capable of auto-updating the templates or models to the intra-class variation of the operational data, for solving the problem of limited training data and tracking the temporal variations of the input data through adaptation.

Soft biometrics traits are physical, behavioral, or adhered human characteristics, which have been derived from the way human beings commonly distinguish their peers (e.g., height, gender, hair color). Such traits include, but are not limited to, physical characteristics such as skin color, eye color, hair color, presence of beard, presence of mustache, height, and weight, behavioral characteristics such as gait and keystroke, and adhered human characteristics such as clothes color, tattoos, and accessories.

The system may be a security system, and may be according to, or based on, the system described in U.S. Pat. No. 5,510,765 to Madau, entitled: "Motor Vehicle Security Sensor System", in U.S. Pat. No. 6,934,426 to Rich et al., entitled: "Fiber Optic Security Sensor and System with Integrated Secure Data Transmission and Power Cables", in U.S. Pat. No. 7,843,336 to Kucharyson, entitled: "Self-Contained Wireless Security Sensor Collective System and Method", or in U.S. Patent Application Publication No. 2007/0164865 to Giasson et al., entitled: "Security Sensor System", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The system may be an environmental control system, and may be according to, or based on, the system described in U.S. Pat. No. 8,115,646 to Tanielian et al., entitled: "Environmental Sensor System", in U.S. Patent Application Publication No. 2010/0100327 to Jensen, entitled: "Environmental Sensing and Communication", in U.S. Patent Application Publication No. 2007/0004449 to Sham, entitled: "Mobile Communication Device with Environmental Sensors", or in U.S. Pat. No. 6,452,499 to Runge et al., entitled: "Wireless Environmental Sensor System", which are all incorporated in their entirety for all purposes as if fully set forth herein.

While some arrangements are exampled above where the router or gateway (such as router **40***a*), the field units (such as field units **23***a-f*), the sensors, and the actuators are located in the same building, it is apparent that this disclosure equally applies to any arrangement where one or more of these devices or elements is located in different buildings or external to the building. In one example, one or more of these devices or elements is located in the user premises, such as adjacent to the building, for example located on the roof, mounted on external walls, in the outdoor part of the premises such as garden, yard or garage. Further, one or more of these devices or elements is located remote from the user premises, such as in another street, neighborhood, city, region, state, or country. An example of such arrangement is described as arrangement **200** in FIG. **20**, showing two field units **23***g* and **23***h*, located externally from the building **19***a*. The router **40***a* is shown located in the building, connected to the server **48***a* similar to the arrangement **49** shown in FIG. **4**. In the example shown in arrangement **200**, the field unit **23***g* may communicate with WAN **46***a*. In such a case, the field unit **46***a* may communicate with the router **40***a* via the WAN **46***a*, as shown by the data path **201***a* shown in arrangement **200***a* in FIG. **20***a*. Alternatively or in addition, the field unit **23***a* may communicate with the server **48***a* via the WAN **46***a*, as shown by the data path **201***b* shown in arrangement **200***b* in FIG. **20***b*. Similarly, the field unit **23***h* is shown connected to the WAN **46***b*, which is distinct from the WAN **46***a* to which the router **40***a* is connected. In such a case, the field unit **23***h* may communicate with the router **40***a* via the WAN **46***a*, the Internet **16**, and WAN **46***a*, as shown by the data path **201***c* shown in arrangement **200***c* in FIG. **20***c*. Alternatively or in addition, the field unit **23***h* may communicate with the server **48***a* via the WAN **46***b* (and the Internet **16**), as shown by the data path **201***d* shown in arrangement **200***d* in FIG. **20***d*.

In the case each of the field unit **23***g* or **23***h* include a sensor, the sensor information may be part of the control logic executed by the controller as described above. In the case the controller is located inside the building such as in the router arrangement **145** shown in FIG. **14** above, the router **40***a* (serving also as the controller) may receive the sensor information directly from the field unit, such as described in arrangement **200***a*. Alternatively or in addition, the sensor information may be sent to the router **40***a* from the server **48***a* upon its receipt of such information, for example in the arrangement **200***d* described in FIG. **20***d*. Similarly, in the case the controller is part of the server **48***a*, sensor information reaching the router **40***a* is sent by the router **40***a* to the server **48***a* to be used as part of the control logic. Similarly, actuator commands from the controller are sent to the associated field unit via the server **48***a* or via the router **40***a*, as appropriate.

While some arrangements are exampled above regarding the Internet, it is apparent that this disclosure equally applies to any network such as a LAN (Local Area Network), a WAN (Wide Area Network), or a MAN (Metropolitan Area Network). Further, the arrangement equally applies to any digital data network connecting multiple devices, wherein multiple distinct communication paths may be formed between a sender and a receiver of the message. Further, non-packet based networks and networks which use protocols other than IP (e.g., cell-based networks such as ATM) may equally use the arrangement. In addition, while IP addresses have been exampled herein for identification of the entities involved in the communication (such as the source and ultimate destination computers and the intermediate servers), any other type of addresses or identifiers (involving any of the OSI layers) may be equally used. For example, MAC (Medium Access Control) address may be used as an alternative or in addition to the IP address.

The applications that can use the arrangement include Electronic Mail (E-Mail) and electronic commerce such as banking, shopping, products, or services purchase. Further, the arrangement may be used for carrying sensitive information such as passwords and public (or private) encryption keys. Messages carried according to the arrangement may include voice, text, images, video, facsimile, characters, numbers or any other digitally represented information. In one aspect, the messages are carrying multimedia informa-

tion, such as audio or video. The multimedia is carried as part of a one-way or interactive audio or video service. The arrangement may be equally used for carrying any real-time or near-real-time information. The carried audio may be speech or music, and may serve telephony such as VoIP or an Internet radio service. Similarly, the carried video may be part of video services over the Internet such as video conferencing and IPTV (IP Television).

There is a growing widespread use of the Internet for carrying multimedia, such as video and audio. Various audio services include Internet-radio stations and VoIP (Voice-over-IP). Video services over the Internet include video conferencing and IPTV (IP Television). In most cases, the multimedia service is a real-time (or near real-time) application, and thus sensitive to delays over the Internet. In particular, two-way services such a VoIP or other telephony services and video-conferencing are delay sensitive.

In addition to the equipment cost, the costs associated with the operation of the information device are as follows: a. Communication service. The costs associated with the communication sessions. b. ISP, in the case of using the Internet. c. Information service. The costs associated with operating the relay servers. In general, billing the user for communication services by the provider may be based on a one-time fee; a flat fee for a period (e.g., monthly); per communication session; per lengths of communication sessions or messages; or any combination of the above.

A Next Generation Network (NGN) is a packet based network which can provide services including telecommunication services and able to make use of multiple broadband, Quality of Service (QoS)-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. The NGN offers unrestricted access by users to different service providers. The NGN operator or any service provider using the NGN may offer gateway services based on the method described herein.

In one aspect the arrangement is used for security as part of cloud computing deployment. For example, messages exchanged between a cloud services provider and a user or as part of the cloud computing infrastructure. The cloud services may include Cloud Software as a Service (SaaS), Cloud Platform as a Service (PaaS) and Cloud Infrastructure as a Service (IaaS), and the method described herein may be used as part of the implementing security measures such as described in the publication "Security Guidance for Critical Areas of Focus in Cloud Computing V2.1", Prepared by the Cloud Security Alliance, December 2009, which is incorporated in its entirety for all purposes as if fully set forth herein.

FIG. **13** is a block diagram that illustrates a system **130** including a computer system **140** and the associated Internet **11** connection upon which an embodiment may be implemented. Such configuration is typically used for computers (hosts) connected to the Internet **11** and executing a server or a client (or a combination) software. A source computer such as laptop **12***a*, an ultimate destination computer **13***c* and relay servers **14***a*-**14***d* above, as well as any computer or processor described herein, may use the computer system configuration and the Internet connection shown in FIG. **13**. The system **140** may be used as a portable electronic device such as a notebook/laptop computer, a media player (e.g., MP3 based or video player), a cellular phone, a Personal Digital Assistant (PDA), an image processing device (e.g., a digital camera or video recorder), and/or any other handheld computing devices, or a combination of any of these devices. Note that while FIG. **13** illustrates various components of a computer system, it is not intended to represent any particular architecture or manner of interconnecting the components; as such details are not germane. It will also be appreciated that network computers, handheld computers, cell phones and other data processing systems which have fewer components or perhaps more components may also be used. The computer system of FIG. **13** may, for example, be an Apple Macintosh computer or Power Book, or an IBM compatible PC. Computer system **140** includes a bus **137**, an interconnect, or other communication mechanism for communicating information, and a processor **138**, commonly in the form of an integrated circuit, coupled with bus **137** for processing information and for executing the computer executable instructions. Computer system **140** also includes a main memory **134**, such as a Random Access Memory (RAM) or other dynamic storage device, coupled to bus **137** for storing information and instructions to be executed by processor **138**. Main memory **134** also may be used for storing temporary variables or other intermediate information during execution of instructions to be executed by processor **138**. Computer system **140** further includes a Read Only Memory (ROM) **136** (or other non-volatile memory) or other static storage device coupled to bus **137** for storing static information and instructions for processor **138**. A storage device **135**, such as a magnetic disk or optical disk, a hard disk drive for reading from and writing to a hard disk, a magnetic disk drive for reading from and writing to a magnetic disk, and/or an optical disk drive (such as DVD) for reading from and writing to a removable optical disk, is coupled to bus **137** for storing information and instructions. The hard disk drive, magnetic disk drive, and optical disk drive may be connected to the system bus by a hard disk drive interface, a magnetic disk drive interface, and an optical disk drive interface, respectively. The drives and their associated computer-readable media provide non-volatile storage of computer readable instructions, data structures, program modules and other data for the general purpose computing devices. Typically computer system **140** includes an Operating System (OS) stored in a non-volatile storage for managing the computer resources and provides the applications and programs with an access to the computer resources and interfaces. An operating system commonly processes system data and user input, and responds by allocating and managing tasks and internal system resources, such as controlling and allocating memory, prioritizing system requests, controlling input and output devices, facilitating networking and managing files. Non-limiting examples of operating systems are Microsoft Windows, Mac OS X, and Linux.

The term "processor" is meant to include any integrated circuit or other electronic device (or collection of devices) capable of performing an operation on at least one instruction including, without limitation, Reduced Instruction Set Core (RISC) processors, CISC microprocessors, Microcontroller Units (MCUs), CISC-based Central Processing Units (CPUs), and Digital Signal Processors (DSPs). The hardware of such devices may be integrated onto a single substrate (e.g., silicon "die"), or distributed among two or more substrates. Furthermore, various functional aspects of the processor may be implemented solely as software or firmware associated with the processor.

Computer system **140** may be coupled via bus **137** to a display **131**, such as a Cathode Ray Tube (CRT), a Liquid Crystal Display (LCD), a flat screen monitor, a touch screen monitor or similar means for displaying text and graphical data to a user. The display may be connected via a video adapter for supporting the display. The display allows a user

to view, enter, and/or edit information that is relevant to the operation of the system. An input device **132**, including alphanumeric and other keys, is coupled to bus **137** for communicating information and command selections to processor **138**. Another type of user input device is cursor control **133**, such as a mouse, a trackball, or cursor direction keys for communicating direction information and command selections to processor **138** and for controlling cursor movement on display **131**. This input device typically has two degrees of freedom in two axes, a first axis (e.g., x) and a second axis (e.g., y), that allows the device to specify positions in a plane.

The computer system **140** may be used for implementing the methods and techniques described herein. According to one embodiment, those methods and techniques are performed by computer system **140** in response to processor **138** executing one or more sequences of one or more instructions contained in main memory **134**. Such instructions may be read into main memory **134** from another computer-readable medium, such as storage device **135**. Execution of the sequences of instructions contained in main memory **134** causes processor **138** to perform the process steps described herein. In alternative embodiments, hardwired circuitry may be used in place of or in combination with software instructions to implement the arrangement. Thus, embodiments of the invention are not limited to any specific combination of hardware circuitry and software.

The term "computer-readable medium" (or "machine-readable medium") as used herein is an extensible term that refers to any medium or any memory, that participates in providing instructions to a processor, (such as processor **138**) for execution, or any mechanism for storing or transmitting information in a form readable by a machine (e.g., a computer). Such a medium may store computer-executable instructions to be executed by a processing element and/or control logic, and data which is manipulated by a processing element and/or control logic, and may take many forms, including but not limited to, non-volatile medium, volatile medium, and transmission medium. Transmission media includes coaxial cables, copper wire and fiber optics, including the wires that comprise bus **137**. Transmission media can also take the form of acoustic or light waves, such as those generated during radio-wave and infrared data communications, or other form of propagating signals (e.g., carrier waves, infrared signals, digital signals, etc.). Common forms of computer-readable media include, for example, a floppy disk, a flexible disk, hard disk, magnetic tape, or any other magnetic medium, a CD-ROM, any other optical medium, punch-cards, paper-tape, any other physical medium with patterns of holes, a RAM, a PROM, and EPROM, a FLASH-EPROM, any other memory chip or cartridge, a carrier wave as described hereinafter, or any other medium from which a computer can read.

Various forms of computer-readable media may be involved in carrying one or more sequences of one or more instructions to processor **138** for execution. For example, the instructions may initially be carried on a magnetic disk of a remote computer. The remote computer can load the instructions into its dynamic memory and send the instructions over a telephone line using a modem. A modem local to computer system **140** can receive the data on the telephone line and use an infrared transmitter to convert the data to an infrared signal. An infrared detector can receive the data carried in the infrared signal and appropriate circuitry can place the data on bus **137**. Bus **137** carries the data to main memory **134**, from which processor **138** retrieves and executes the instructions. The instructions received by main memory **134** may optionally be stored on storage device **135** either before or after execution by processor **138**.

Computer system **140** also includes a communication interface **141** coupled to bus **137**. Communication interface **141** provides a two-way data communication coupling to a network link **139** that is connected to a local network **111**. For example, communication interface **141** may be an Integrated Services Digital Network (ISDN) card or a modem to provide a data communication connection to a corresponding type of telephone line. As another non-limiting example, communication interface **141** may be a local area network (LAN) card to provide a data communication connection to a compatible LAN. For example, Ethernet based connection based on IEEE802.3 standard may be used such as 10/100BaseT, 1000BaseT (gigabit Ethernet), 10 gigabit Ethernet (10 GE or 10 GbE or 10 GigE per IEEE Std 802.3ae-2002as standard), 40 Gigabit Ethernet (40 GbE), or 100 Gigabit Ethernet (100 GbE as per Ethernet standard IEEE P802.3ba), as described in Cisco Systems, Inc. Publication number 1-587005-001-3 (6/99), "Internetworking Technologies Handbook", Chapter 7: "Ethernet Technologies", pages 7-1 to 7-38, which is incorporated in its entirety for all purposes as if fully set forth herein. In such a case, the communication interface **141** typically include a LAN transceiver or a modem, such as Standard Microsystems Corporation (SMSC) LAN91C111 10/100 Ethernet transceiver described in the Standard Microsystems Corporation (SMSC) data-sheet "LAN91C111 10/100 Non-PCI Ethernet Single Chip MAC+PHY" Data-Sheet, Rev. 15 (02-20-04), which is incorporated in its entirety for all purposes as if fully set forth herein.

In one non-limiting example, the communication is based on a LAN communication, such as Ethernet, and may be partly or in full in accordance with the IEEE802.3 standard. For example, Gigabit Ethernet (GbE or 1 GigE) may be used, describing various technologies for transmitting Ethernet frames at a rate of a gigabit per second (1,000,000,000 bits per second), as defined by the IEEE 802.3-2008 standard. There are five physical layer standards for gigabit Ethernet using optical fiber (1000BASE-X), twisted pair cable (1000BASE-T), or balanced copper cable (1000BASE-CX). The IEEE 802.32 standard includes 1000BASE-SX for transmission over multi-mode fiber, 1000BASE-LX for transmission over single-mode fiber, and the nearly obsolete 1000BASE-CX for transmission over balanced copper cabling. These standards use 8b/10b encoding, which inflates the line rate by 25%, from 1000 Mbit/s to 1250 Mbit/s, to ensure a DC balanced signal. The symbols are then sent using NRZ. The IEEE 802.3ab, which defines the widely used 1000BASE-T interface type, uses a different encoding scheme in order to keep the symbol rate as low as possible, allowing transmission over twisted pair. Similarly, The 10 gigabit Ethernet (10 GE or 10 GbE or 10 GigE may be used, which is a version of Ethernet with a nominal data rate of 10 Gbit/s (billion bits per second), ten times faster than gigabit Ethernet. The 10 gigabit Ethernet standard defines only full duplex point to point links which are generally connected by network switches. The 10 gigabit Ethernet standard encompasses a number of different physical layers (PHY) standards. A networking device may support different PHY types through pluggable PHY modules, such as those based on SFP+.

The powering scheme may be based on Power over Ethernet (POE), which describes a system to pass electrical power safely, along with data, on Ethernet cabling, and may use phantom configuration for carrying the power. The PoE technology and applications are described in the White

Paper "All You Need To Know About Power over Ethernet (POE) and the IEEE 802.3af Standard", by PowerDsine Ltd., 06-0002-082 20-May-4, and in U.S. Pat. No. 6,473,609 to Lehr et al. entitled: "Structure Cabling System", which are all incorporated in their entirety for all purposes as if fully set forth herein. The IEEE standard for PoE requires category 5 cable or higher for high power levels, but can operate with category 3 cable for low power levels. The power is supplied in common mode over two or more of the differential pairs of wires found in the Ethernet cables, and comes from a power supply within a PoE-enabled networking device such as an Ethernet switch or can be injected into a cable run with a midspan power supply. The IEEE 802.3af-2003 PoE standard, which is incorporated in its entirety for all purposes as if fully set forth herein, provides up to 15.4 Watts of DC power (minimum 44 V DC and 350 mA) to each device. Only 12.95 Watts is assured to be available to the powered device as some power is dissipated in the cable. The updated IEEE 802.3at-2009 PoE standard, also known as PoE+ or PoE plus, and which is incorporated in its entirety for all purposes as if fully set forth herein, provides up to 25.5 Watts of power. In PoE environment, a device may serve as a Power Sourcing Equipment (PSE) that provides ("sources") power on the Ethernet cable. A device consuming power from the LAN is referred to as a Powered Device (PD).

In the case of a dedicated or separated PCB or enclosure, the PCB or enclosure may be designed to be easily removable, for example by an end user. Such plug-in module is commonly designed to be installed and removed typically by respectively connecting or disconnecting the module connectors (pins, plugs, jacks, sockets, receptacles or any other types) to or from the mating connectors, commonly using human hand force and without any tool. The connection mechanical support may be based only on the connectors, or supplemented by guides, rails, or any other mechanical support. Such a plug-in module may be pluggable into a computer system, motherboard, an intermediary device, or a memory.

Discussions herein utilizing terms such as, for example, "processing," "computing," "calculating," "determining," "establishing", "analyzing", "checking", or the like, may refer to operation(s) and/or process(es) of a computer, a computing platform, a computing system, or other electronic computing device, that manipulate and/or transform data represented as physical (e.g., electronic) quantities within the computer's registers and/or memories into other data similarly represented as physical quantities within the computer's registers and/or memories or other information storage medium that may store instructions to perform operations and/or processes.

Throughout the description and claims of this specification, the word "couple", and variations of that word such as "coupling", "coupled" and "couplable", refer to an electrical connection (such as a copper wire or soldered connection), a logical connection (such as through logical devices of a semiconductor device), a virtual connection (such as through randomly assigned memory locations of a memory device) or any other suitable direct or indirect connections (including combination or series of connections), for example for allowing for the transfer of power, signal, or data, as well as connections formed through intervening devices or elements.

The arrangements and methods described herein may be implemented using hardware, software or a combination of both. The term "software integration" or any other reference to the integration of two programs or processes herein refers to software components (e.g., programs, modules, functions, processes etc.) that are (directly or via another component) combined, working or functioning together or form a whole, commonly for sharing a common purpose or set of objectives. Such software integration can take the form of sharing the same program code, exchanging data, being managed by the same manager program, executed by the same processor, stored on the same medium, sharing the same GUI or other user interface, sharing peripheral hardware (such as a monitor, printer, keyboard and memory), sharing data or a database, or being part of a single package. The term "hardware integration" or integration of hardware components herein refers to hardware components that are (directly or via another component) combined, working or functioning together or form a whole, commonly for sharing a common purpose or set of objectives. Such hardware integration can take the form of sharing the same power source (or power supply) or sharing other resources, exchanging data or control (e.g., by communicating), being managed by the same manager, physically connected or attached, sharing peripheral hardware connection (such as a monitor, printer, keyboard and memory), being part of a single package or mounted in a single enclosure (or any other physical collocating), sharing a communication port, or used or controlled with the same software or hardware. The term "integration" herein refers (as applicable) to a software integration, a hardware integration, or any combination thereof.

The term "message" is used generically herein to describe at least an ordered series of characters or bits intended to convey a package of information (or a portion thereof), which may be transferred from one point to another, such as by using communication via one or more communication mechanisms or by transferring among processes. The term "port" refers to a place of access to a device, electrical circuit or network, where energy or signal may be supplied or withdrawn. The term "interface" of a networked device refers to a physical interface, a logical interface (e.g., a portion of a physical interface or sometimes referred to in the industry as a sub-interface—for example, such as, but not limited to a particular VLAN associated with a network interface), and/or a virtual interface (e.g., traffic grouped together based on some characteristic—for example, such as, but not limited to, a tunnel interface). As used herein, the term "independent" relating to two (or more) elements, processes, or functionalities, refers to a scenario where one does not affect nor preclude the other. For example, independent communication such as over a pair of independent data routes means that communication over one data route does not affect nor preclude the communication over the other data routes.

As used herein, the term "Integrated Circuit" (IC) shall include any type of integrated device of any function where the electronic circuit is manufactured by the patterned diffusion of trace elements into the surface of a thin substrate of semiconductor material (e.g., Silicon), whether single or multiple die, or small or large scale of integration, and irrespective of process or base materials (including, without limitation Si, SiGe, CMOS and GAs) including without limitation applications specific integrated circuits (ASICs), field programmable gate arrays (FPGAs), digital processors (e.g., DSPs, CISC microprocessors, or RISC processors), so-called "system-on-a-chip" (SoC) devices, memory (e.g., DRAM, SRAM, flash memory, ROM), mixed-signal devices, and analog ICs. The circuits in an IC are typically contained in a silicon piece or in a semiconductor wafer, and commonly packaged as a unit. The solid-state circuits commonly include interconnected active and passive devices,

diffused into a single silicon chip. Integrated circuits can be classified into analog, digital and mixed signal (both analog and digital on the same chip). Digital integrated circuits commonly contain many of logic gates, flip-flops, multiplexers, and other circuits in a few square millimeters. The small size of these circuits allows high speed, low power dissipation, and reduced manufacturing cost compared with board-level integration. Further, a multi-chip module (MCM) may be used, where multiple integrated circuits (ICs), semiconductor dies, or other discrete components are packaged onto a unifying substrate, facilitating their use as a single component (as though a larger IC).

The term "computer" is used generically herein to describe any number of computers, including, but not limited to personal computers, embedded processing elements and systems, control logic, ASICs, chips, workstations, mainframes, etc. Any computer herein may consist of, or be part of, a handheld computer, including any portable computer which is small enough to be held and operated while holding in one hand or fit into a pocket. Such a device, also referred to as a mobile device, typically has a display screen with touch input and/or miniature keyboard. Non-limiting examples of such devices include Digital Still Camera (DSC), Digital video Camera (DVC or digital camcorder), Personal Digital Assistant (PDA), and mobile phones and Smartphones. The mobile devices may combine video, audio and advanced communication capabilities, such as PAN and WLAN. A mobile phone (also known as a cellular phone, cell phone and a hand phone) is a device which can make and receive telephone calls over a radio link whilst moving around a wide geographic area, by connecting to a cellular network provided by a mobile network operator. The calls are to and from the public telephone network which includes other mobiles and fixed-line phones across the world. The Smartphones may combine the functions of a personal digital assistant (PDA), and may serve as portable media players and camera phones with high-resolution touch-screens, web browsers that can access, and properly display, standard web pages rather than just mobile-optimized sites, GPS navigation, Wi-Fi and mobile broadband access. In addition to telephony, the Smartphones may support a wide variety of other services such as text messaging, MMS, email, Internet access, short-range wireless communications (infrared, Bluetooth), business applications, gaming and photography.

Some embodiments may be used in conjunction with various devices and systems, for example, a Personal Computer (PC), a desktop computer, a mobile computer, a laptop computer, a notebook computer, a tablet computer, a server computer, a handheld computer, a handheld device, a Personal Digital Assistant (PDA) device, a cellular handset, a handheld PDA device, an on-board device, an off-board device, a hybrid device, a vehicular device, a non-vehicular device, a mobile or portable device, a non-mobile or non-portable device, a wireless communication station, a wireless communication device, a wireless Access Point (AP), a wired or wireless router, a wired or wireless modem, a wired or wireless network, a Local Area Network (LAN), a Wireless LAN (WLAN), a Metropolitan Area Network (MAN), a Wireless MAN (WMAN), a Wide Area Network (WAN), a Wireless WAN (WWAN), a Personal Area Network (PAN), a Wireless PAN (WPAN), devices and/or networks operating substantially in accordance with existing IEEE 802.11, 802.11a, 802.11b, 802.11g, 802.11k, 802.11n, 802.11r, 802.16, 802.16d, 802.16c, 802.20, 802.21 standards and/or future versions and/or derivatives of the above standards, units and/or devices which are part of the above networks, one way and/or two-way radio communication systems, cellular radio-telephone communication systems, a cellular telephone, a wireless telephone, a Personal Communication Systems (PCS) device, a PDA device which incorporates a wireless communication device, a mobile or portable Global Positioning System (GPS) device, a device which incorporates a GPS receiver or transceiver or chip, a device which incorporates an RFID element or chip, a Multiple Input Multiple Output (MIMO) transceiver or device, a Single Input Multiple Output (SIMO) transceiver or device, a Multiple Input Single Output (MISO) transceiver or device, a device having one or more internal antennas and/or external antennas, Digital Video Broadcast (DVB) devices or systems, multi-standard radio devices or systems, a wired or wireless handheld device (e.g., BlackBerry, Palm Treo), a Wireless Application Protocol (WAP) device, or the like.

As used herein, the term "user device" is meant to include any device having a computer, a user interface, and a network interface. The network interface allows for communication over a network with other devices. The user interface (such as Graphical User Interface-GUI) allows for a human to interact with the device, to operate, control, or to output information to the user device, and to receive indications from the device. The user interface typically includes, or is based on, a Human Interface Device (HID), used to interact directly to receive input from humans, to provide output to humans, or both. Examples of HIDs that receive information from humans are keyboard, a pointing device such as a mouse, a trackball or a pointing stick, a joystick, a fingerprint scanner, a dance pad, a touch screen, a camera, a microphone, and a motion sensor (such as Wii™ remote), and such devices may include, or be based on, a sensor, such as any one of the sensors disclosed herein. The input may be based on a human touch, a human motion, a human voice, or a human gesture (such as hand gesture). Examples of HIDs that output information to humans are a display (for visual presentation), a speaker (for audio sounding), and a vibrator, and such devices may include, or be based on, an actuator, such as any one of the actuators disclosed herein. The HID, and the operation in USB environment, may be as described in the standard "HID Usage Tables" Version 1.12 Oct. 28, 2004) by the USB Implementers' Forum, which is incorporated in its entirety for all purposes as if fully set forth herein. The user device may communicate over any of the networks described herein via its network interface. A user device may consists of, comprises, be part of, or integrated with, a Digital Still Camera (DSC), a Digital video Camera (DVC or digital camcorder), a landline telephone set, a television set, a Personal Digital Assistant (PDA), a mobile phones, one way or two-way radio communication device, a pager, a cellular radio-telephone communication device, a cellular telephone handset, a wireless telephone, a Personal Communication Systems (PCS) device, a mobile or portable Global Positioning System (GPS) device, a Personal Computer (PC), a desktop computer, a mobile computer, a laptop computer, a notebook computer, a tablet computer, a server computer, or a handheld computer. Alternatively or in addition, a user device may consists of, comprises, be part of, or integrated with, a personal computer (such as the personal computer **18***a* shown in FIG. **5***i*), a home device (such as the home devices **15***a* and **15***b* shown in FIG. **5***i*), a field unit (such as the field units **23***a-c* shown in FIG. **5***i*), a router (such as the router **21** shown in FIG. **5***i*), an appliance, or a server (such as the server **24** shown in FIG. **5***i*). A user device may communi-

cate over a home network, a control network, the Internet, or any other network, for communication with another device in the system.

As used herein, the terms "program", "programmable", and "computer program" are meant to include any sequence or human or machine cognizable steps which perform a function. Such programs are not inherently related to any particular computer or other apparatus, and may be rendered in virtually any programming language or environment including, for example, C/C++, Fortran, COBOL, PASCAL, assembly language, markup languages (e.g., HTML, SGML, XML, VoXML), and the likes, as well as object-oriented environments such as the Common Object Request Broker Architecture (CORBA), Java™ (including J2ME, Java Beans, etc.) and the like, as well as in firmware or other implementations. Generally, program modules include routines, programs, objects, components, data structures, etc., that performs particular tasks or implement particular abstract data types.

The terms "task" and "process" are used generically herein to describe any type of running programs, including, but not limited to a computer process, task, thread, executing application, operating system, user process, device driver, native code, machine or other language, etc., and can be interactive and/or non-interactive, executing locally and/or remotely, executing in foreground and/or background, executing in the user and/or operating system address spaces, a routine of a library and/or standalone application, and is not limited to any particular memory partitioning technique. The steps, connections, and processing of signals and information illustrated in the figures, including, but not limited to any block and flow diagrams and message sequence charts, may typically be performed in the same or in a different serial or parallel ordering and/or by different components and/or processes, threads, etc., and/or over different connections and be combined with other functions in other embodiments, unless this disables the embodiment or a sequence is explicitly or implicitly required (e.g., for a sequence of reading the value, processing the value—the value must be obtained prior to processing it, although some of the associated processing may be performed prior to, concurrently with, and/or after the read operation). Where certain process steps are described in a particular order or where alphabetic and/or alphanumeric labels are used to identify certain steps, the embodiments of the invention are not limited to any particular order of carrying out such steps. In particular, the labels are used merely for convenient identification of steps, and are not intended to imply, specify or require a particular order for carrying out such steps. Furthermore, other embodiments may use more or less steps than those discussed herein. The invention may also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules may be located in both local and remote memory storage devices.

As used herein, the terms "network", "communication link" and "communications mechanism" are used generically to describe one or more networks, communications media or communications systems, including, but not limited to, the Internet, private or public telephone, cellular, wireless, satellite, cable, data networks. Data networks include, but not limited to, Metropolitan Area Networks (MANs), Wide Area Networks (WANs), Local Area Networks (LANs), Personal Area networks (PANs), WLANs (Wireless LANs), Internet, internets, NGN, intranets, Hybrid Fiber Coax (HFC) networks, satellite networks, and Telco networks. Communication media include, but not limited to, a cable, an electrical connection, a bus, and internal communications mechanisms such as message passing, interprocess communications, and shared memory. Such networks or portions thereof may utilize any one or more different topologies (e.g., ring, bus, star, loop, etc.), transmission media (e.g., wired/RF cable, RF wireless, millimeter wave, optical, etc.) and/or communications or networking protocols (e.g., SONET, DOCSIS, IEEE Std. 802.3, ATM, X.25, Frame Relay, 3GPP, 3GPP2, WAP, SIP, UDP, FTP, RTP/RTCP, H.323, etc.). While exampled herein with regard to secured communication between a pair of network endpoint devices (host-to-host), the described method can equally be used to protect the data flow between a pair of gateways or any other networking-associated devices (network-to-network), or between a network device (e.g., security gateway) and a host (network-to-host).

Some embodiments may be used in conjunction with one or more types of wireless communication signals and/or systems, for example, Radio Frequency (RF), Infra Red (IR), Frequency-Division Multiplexing (FDM), Orthogonal FDM (OFDM), Time-Division Multiplexing (TDM), Time-Division Multiple Access (TDMA), Extended TDMA (E-TDMA), General Packet Radio Service (GPRS), extended GPRS, Code-Division Multiple Access (CDMA), Wideband CDMA (WCDMA), CDMA 2000, single-carrier CDMA, multi-carrier CDMA, Multi-Carrier Modulation (MDM), Discrete Multi-Tone (DMT), Bluetooth®, Global Positioning System (GPS), Wi-Fi, Wi-Max, ZigBee™, Ultra-Wideband (UWB), Global System for Mobile communication (GSM), 2G, 2.5G, 3G, 3.5G, Enhanced Data rates for GSM Evolution (EDGE), or the like. Further, a wireless communication may be based on wireless technologies that are described in Chapter 20: "Wireless Technologies" of the publication number 1-587005-001-3 by Cisco Systems, Inc. (7/99) entitled: "Internetworking Technologies Handbook", which is incorporated in its entirety for all purposes as if fully set forth herein.

A wireless communication may be partly or in full in accordance with, or based on, the WiGig™ technology developed by the Wireless Gigabit Alliance (http://wirelessgigabitalliance.org), and standardized as IEEE 802.11ad, allowing multi-gigabit data rate and using the unlicensed 60 GHZ frequency band. The WiGig tri-band enabled in-room devices, which operate in the 2.4, 5 and 60 GHZ bands, supports data transmission rates up to 7 Gbit/s, and is based on, supplements and extends the 802.11 Media Access Control (MAC) layer and is thus backward compatible with the IEEE 802.11 standard. The specifications further supports protocol adaptation layers are being developed to support specific system interfaces including data buses for PC peripherals and display interfaces for HDTVs, monitors and projectors, and is based on phase array antenna beamforming, enabling robust communication at distances beyond 10 meters, while the beams can move within the coverage area through modification of the transmission phase of individual antenna elements. The WiGig technology is further described in the white paper entitled: "WiGig White Paper—Defining the Future of Multi-Gigabit Wireless Communications", published by WiGig Alliance, July 2010, which is incorporated in its entirety for all purposes as if fully set forth herein.

Alternatively or in addition, an in-room wireless communication may be in accordance with, or based on, the WirelessHD™ technology developed by the WirelessHD™ Consortium (http://www.wirelesshd.org) and standardized as IEEE 802.15.3c-2009, which based on a 7 GHZ channel

in the 60 GHz Extremely High Frequency radio band. It allows for either compressed (H.264) or uncompressed digital transmission of high-definition video and audio and data signals. The 1.1 version of the specification increases the maximum data rate to 28 Gbit/s, supports common 3D formats, 4K resolution, WPAN data, low-power mode for portable devices, and HDCP 2.0 content protection. The 60 GHz band usually requires line of sight between transmitter and receiver, and the WirelessHD specification ameliorates this limitation through the use of beam forming at the receiver and transmitter antennas to increase the signal's effective radiated power. The range obtained may be in-room, point-to-point, non line-of-sight (NLOS) at up to 10 meters. Further, The WirelessHD specification has provisions for content encryption via Digital Transmission Content Protection (DTCP) as well as provisions for network management. The WirelessHD™ technology is further described in the overview entitled: "WirelessHD Specifications Version 1.1 Overview", published by the WirelessHD consortium, May 2010, which is incorporated in its entirety for all purposes as if fully set forth herein.

Alternatively or in addition, a wireless communication may be in accordance with, or based on, the Wireless Home Digital Interface (WHDI™) technology developed by the WHDI™ Special Interest Group (http://www.whdi.org), and provides a high-quality, uncompressed wireless link which can support delivery of equivalent video data rates of up to 3 Gbps (including uncompressed 1080p) in a 40 MHz channel in the 5 GHz unlicensed band, conforming to FCC regulations. Equivalent video data rates of up to 1.5 Gbps (including uncompressed 1080i and 720p) can be delivered on a single 20 MHz channel in the 5 GHz unlicensed band, conforming to worldwide 5 GHz spectrum regulations. The range is beyond 100 feet, through walls, and latency is less than one millisecond. The WHDI™ technology is further described in the technical overview entitled: "Enabling Wireless uncompressed HDTV Connectivity with a Unique Video-Modem Approach" by Meir Feder, published by the AMIMON Ltd., which is incorporated in its entirety for all purposes as if fully set forth herein.

A wireless communication may use white spaces, which relates to the frequencies and frequency bands allocated between used or licensed radio frequency bands (or channels) to avoid interference or to serve as guard band. Further, white space refers to frequency bands between about 50 MHz and 700 MHz traditionally used for analog television broadcast, and were freed in the switchover to digital television. In the United States, full power analog television broadcasts, which operated between the 54 MHz and 806 MHZ (54-72, 76-88, 174-216, 470-608, and 614-806) television frequencies (Channels 2-69), ceased operating on Jun. 12, 2009 per a United States digital switchover mandate. At that time, full power TV stations were required to switch to digital transmission and operate only between 54 MHz and 698 MHz. The abandoned television frequencies are primarily covering TV channels 52 to 69 (698 to 806 MHZ), as well as unused television frequencies between 54 MHz and 698 MHZ (TV Channels 2-51). In the rest of the world, the abandoned television channels are VHF, and the resulting large VHF white spaces are being re-allocated for the worldwide (except the U.S.) digital radio standard DAB and DAB+, and DMB. A device intended to use these available channels is commonly referred to as a "White-Spaces Device" (WSD), and are typically designed to detect the presence of existing but unused areas of the airwaves, such as those reserved for analog television, and utilize these unused airwaves to transmit signals for communication application such as for Internet connectivity. The communication over white spaces may be partly or in full in accordance with, or based on, IEEE 802.11af or IEEE 802.22 standards (sometimes referred to as Super Wi-Fi standards).

The wireless communication over white spaces may be partly or in full in accordance with, or based on, Wireless Regional Area Network (WRAN) standard IEEE 802.22—"Standard for Wireless Regional Area Networks (WRAN)-Specific requirements—Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications: Policies and procedures for operation in the TV Bands", described in the article 'IEEE 802.22: An Introduction to the First Wireless Standard based on Cognitive Radios', by Carlos Cordeiro, Kiran Challapali, Dagnachew Birru, and Sai Shankar, published in the Journal of Communication, Vol. 1, No. 1, April 2006, and in the presentation 'IEEE 802.22 Wireless Regional Area Networks—Enabling Rural Broadband Wireless Access Using Cognitive Radio Technology', by Apruva N. Mody and Gerald Chouinard, Doc. #IEEE 802.22—10/0073r3 Jun. 2010, which are both incorporated in their entirety for all purposes as if fully set forth herein.

Such communication may use Cognitive Radio (CR) techniques to allow sharing of geographically unused spectrum formerly allocated to the Television Broadcast Service, on a non-interfering basis. Cognitive-based dynamic spectrum access is described, for example, in the document entitled: 'Dynamic Spectrum Access In IEEE 802.22-Based Cognitive Wireless Networks: A Game Theoretic Model for Competitive Spectrum Bidding and Pricing' by Dusit Niyato and Ekram Hossain, published IEEE Wireless Communication April 2009, which is incorporated in its entirety for all purposes as if fully set forth herein.

The communication may operate in a point to multipoint basis (P2MP), and the network may be formed by Base Stations (BS) and Customer-Premises Equipment (CPE), where the CPEs are communicating with a BS via a wireless link, while the BSs control the medium access for all the CPEs attached to it. The WRAN Base Stations may capable of performing a distributed sensing, where the CPEs are sensing the spectrum and are sending periodic reports to the BS informing it about what they sense, such that the BS, with the information gathered, may evaluate whether a change is necessary in the channel or channels used, or on the contrary, if it should stay transmitting and receiving in the same one. The PHY layer may use OFDMA as the modulation scheme and may use one TV channel (a TV channel typically has a bandwidth of 6 MHz; in some countries 7 or 8 MHz is used), and may use more than one channel using a Channel Bonding scheme.

In such environment, the gateway or router **21**, **40**, or **143** may serve as the base station, while the field units **23**, computer **161**, server **24**, or the home devices **15** functions as CPEs. Similarly, the gateway or router **21**, **40**, or **143** may serve as the CPE, while part or all of the field units **23**, computer **161**, server **24**, or the home devices **15** functions as BS.

The wireless communication may be partly or in full in accordance with, or based on, short-range communication such as Near Field Communication (NFC), having a theoretical working distance of 20 centimeters and a practical working distance of about 4 centimeters, and commonly used with mobile devices, such as smartphones. The NFC typically operates at 13.56 MHz as defined in ISO/IEC 18000-3 air interface and at data rates ranging from 106 Kbit/s to 424 Kbit/s. NFC commonly involves an initiator

and a target; the initiator actively generates an RF field that may power a passive target. NFC peer-to-peer communication is possible, provided both devices are powered. In NFC environment, the gateway or router **21**, **40**, or **143** may serve as the initiator, while the field units **23**, computer **161**, server **24**, or the home devices **15** functions as targets. Similarly, the gateway or router **21**, **40**, or **143** may serve as the target, while part or all of the field units **23**, computer **161**, server **24**, or the home devices **15** functions as initiators.

The NFC typically supports passive and active modes of operation. In passive communication mode, the initiator device provides a carrier field and the target device answers by modulating the existing field, and the target device may draw its operating power from the initiator-provided electromagnetic field, thus making the target device a transponder. In active communication mode, both devices typically have power supplies, and both initiator and target devices communicate by alternately generating their own fields where a device deactivates its RF field while it is waiting for data. NFC typically uses Amplitude-Shift Keying (ASK), and employs two different schemes to transfer data. At the data transfer rate of 106 Kbit/s, a modified Miller coding with 100% modulation is used, while in all other cases Manchester coding is used with a modulation ratio of 10%.

The NFC communication may be partly or in full in accordance with, or based on, NFC standards ISO/IEC 18092 or ECMA-340 entitled: "Near Field Communication Interface and Protocol-1 (NFCIP-1)", and ISO/IEC 21481 or ECMA-352 standards entitled: "Near Field Communication Interface and Protocol-2 (NFCIP-2)". The NFC technology is described in ECMA International white paper Ecma/TC32-TG19/2005/012 entitled: "Near Field Communication—White paper", in Rohde&Schwarz White Paper IMA182_4e entitled: "Near Field Communication (NFC) Technology and Measurements White Paper", and in Jan Kremer Consulting Services (JKCS) white paper entitled: "NFC—Near Field Communication—White paper", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The system **49***b* in FIG. **4***b* above shows two communication routes designated as routes **400***a* and **400***b* connecting the router **40***a* to servers **48***a* and **48***b*. Similarly, system **49***d* in FIG. **4***d* examples the connection of router **40***a* to the ISP server **47***a* via two communication routes, consisting of wired WAN **46***a* and wireless WAN **46***b*. The system **500***i* shown in FIG. **5***j* similarly shows two communication routes **500***g* and **500***h*, connecting the field unit **23***d* to router **21**. In the general case, any pair of devices in the system may communicate over two or more distinct or independent communication routes. Further, one, two, three or all of the communicating device pairs in the system may use two, three, or more distinct or independent alternative communication routes. The communication routes may involve direct communication between the pair of devices where the devices communicate directly with each other over a communication network. Alternatively or in addition, one or more of the alternative communication route use one or more intermediary device, acting as a repeater or a router. The intermediary device may be a dedicated device functioning as a traditional repeater, or alternatively a device in the system may double as a repeater. For example, while the arrangement **500***i* in FIG. **5***j* shows communication route **500***g* using network **22***a* and communication route **500***g* using network **22***b*, both routes directly connecting field unit **23***d* to the router **21**. In one example, a new communication route may be formed, where the field unit **23***b* also serves as a repeater for field unit **23***d*, and passes information between these two devices.

Multiple distinct or independent communication routes provide higher reliability such as avoiding single point of failure (SPOF), where in the case of any failure in one of the communication routes, the other routes may still provide the required connection and the system functionality is preserved, thus a therein renders the system fully functional, using a backup or fail-safe scheme. The operation of the redundant communication routes may be based on standby redundancy, (a.k.a. Backup Redundancy), where one of the data paths or the associated hardware is considered as a primary unit, and the other data path (or the associated hardware) is considered as the secondary unit, serving as back up to the primary unit. The secondary unit typically does not monitor the system, but is there just as a spare. The standby unit is not usually kept in sync with the primary unit, so it must reconcile its input and output signals on the takeover of the communication. This approach does lend itself to give a "bump" on transfer, meaning the secondary operation may not be in sync with the last system state of the primary unit. Such mechanism may require a watchdog, which monitors the system to decide when a switchover condition is met, and command the system to switch control to the standby unit. Standby redundancy configurations commonly employ two basic types, namely 'Cold Standby' and 'Hot Standby'.

In cold standby, the secondary unit is either powered off or otherwise non-active in the system operation, thus preserving the reliability of the unit. The drawback of this design is that the downtime is greater than in hot standby, because the standby unit needs to be powered up or activated, and brought online into a known state.

On hot standby, the secondary unit is powered up or otherwise kept operational, and can optionally monitor the system. The secondary unit may serve as the watchdog and/or voter to decide when to switch over, thus eliminating the need for an additional hardware for this job. This design does not preserve the reliability of the standby unit as well as the cold standby design. However, it shortens the downtime, which in turn increases the availability of the system. Some flavors of Hot Standby are similar to Dual Modular Redundancy (DMR) or Parallel Redundancy. The main difference between Hot Standby and DMR is how tightly the primary and the secondary are synchronized. DMR completely synchronizes the primary and secondary units.

While a redundancy of two was exampled above, where two data paths and two hardware devices were used, a redundancy involving three or more data paths or systems may be equally used. The term 'N' Modular Redundancy, (a.k.a. Parallel Redundancy) refers to the approach of having multiply units or data paths running in parallel. All units are highly synchronized and receive the same input information at the same time. Their output values are then compared and a voter decides which output values should be used. This model easily provides 'bumpless' switchovers. This model typically has faster switchover times than Hot Standby models, thus the system availability is very high, but because all the units are powered up and actively engaged with the system operation, the system is at more risk of encountering a common mode failure across all the units.

Deciding which unit is correct can be challenging if only two units are used. If more than two units are used, the problem is simpler, usually the majority wins or the two that agree win. In N Modular Redundancy, there are three main typologies: Dual Modular Redundancy, Triple Modular

Redundancy, and Quadruple Redundancy. Quadruple Modular Redundancy (QMR) is fundamentally similar to TMR but using four units instead of three to increase the reliability. The obvious drawback is the 4× increase in system cost.

Dual Modular Redundancy (DMR) uses two functional equivalent units, thus either can control or support the system operation. The most challenging aspect of DMR is determining when to switch over to the secondary unit. Because both units are monitoring the application, a mechanism is needed to decide what to do if they disagree. Either a tiebreaker vote or simply the secondary unit may be designated as the default winner, assuming it is more trustworthy than the primary unit. Triple Modular Redundancy (TMR) uses three functionally equivalent units to provide a redundant backup. This approach is very common in aerospace applications where the cost of failure is extremely high. TMR is more reliable than DMR due to two main aspects. The most obvious reason is that two "standby" units are used instead of just one. The other reason is that in a technique called diversity platforms or diversity programming may be applied. In this technique, different software or hardware platforms are used on the redundant systems to prevent common mode failure. The voter decides which unit will actively control the application. With TMR, the decision of which system to trust is made democratically and the majority rules. If three different answers are obtained, the voter must decide which system to trust or shut down the entire system, thus the switchover decision is straightforward and fast.

Another redundancy topology is 1:N Redundancy, where a single backup is used for multiple systems, and this backup is able to function in the place of any single one of the active systems. This technique offers redundancy at a much lower cost than the other models by using one standby unit for several primary units. This approach only works well when the primary units all have very similar functions, thus allowing the standby to back up any of the primary units if one of them fails.

While the redundant data paths have been exampled with regard to the added reliability and availability, redundant data paths may as well be used in order to provide higher aggregated data rate, allowing for faster response and faster transfer of data over the multiple data paths. Further, multiple communication routes may improve the delay through the system, in particular where the transfer delay is statistical and practically random, such as in packet-based delivery systems or over the Internet.

An example of part of a device **210** capable of communicating over three networks **211***a*, **221***b* and **211***c* is shown in FIG. **21**. The device may be any device, and in particular any one or more of the devices described herein such as the field unit **23**, the router **21** or the router **40**, or the home device **15**. The device **210** includes three interfaces **214***a*, **214***b*, and **214***c*, for respectively communicating over the networks **211***a*, **211***b*, and **211***c*. Each of the interfaces commonly includes all the components required for the communication over the respective network, and adapted to the specific network. The interface **214***a* includes network connection **212***a* connected to a modem **213***a* (or a transceiver in general). Similarly, the interface **214***b* includes a network connection **212***b* connected to a modem **213***b*, and the interface **214***c* includes network connection **212***c* connected to a modem **213***c*. In the case of a wired or a conductive medium, the network connection **212** is typically a connector, while in the case of a radio-frequency and over-the-air network, the network connection **212** is commonly an antenna. A packet (or any otherwise formatted digital data information piece) to be transmitted is received by the interface selector **215** via input **217**, which directs the packet to one of more of the network interfaces **214***a*, **214***b* and **214***c* to be sent over the respective networks **211***a*, **211***b*, and **211***c*. The interface selector **215** operation is controlled by the computer or processor **216**. The computer **216** may be in part or in whole a dedicated separated component, or may be the same computer used by the device **210** for other device functionalities, such as computer **53** in the sensor unit **50**, computer **63** in actuator unit **60**, computer **71** in field unit **70**, or controller **147** in router **143** described herein. While device **210** is exampled having three network interfaces **214**, two, four and any number of interfaces may be equally used for connecting to multiple networks **211**. The interface selector **215** may be hardware based, where the input **217** is a physical port or connection, or may be implemented in software or firmware executed by the computer **216** where the packet is received from other processes executed by the computer or processor **216**.

The networks **211***a*, **211***b*, and **211***c* may be similar, identical or different from each other. For example, networks **211***a* and **211***b* may use different, similar or the same type of medium, and may use different, similar or the same protocol for communication over the network medium. Similarly, networks **211***a* and **211***c* may use different, similar or the same type of medium, and may use different, similar or the same protocol for communication over the network medium. In the general case, some of the networks may be similar, identical or different from each other. The network interfaces **214***a*, **214***b*, and **214***c* may be (in part or in whole) similar, identical or different from each other. For example, network interfaces **214***a* and **214***b* may use different, similar or the same type of physical layer or other OSI layers, and may use different, similar or the same type of modem **213** or network connection **212**.

In one example, some of the networks may be wired (or otherwise conductive) while the other may be wireless (or otherwise using non-conductive propagation). Such example is shown in FIG. **22**, where networks **211***a* and **211***b* are wired networks, using wiring **222***a* and **222***b* respectively, while network **211***c* is a wireless over-the-air network using radio waves. In such scenario device **220** is used, where the generic network interface **214***a* is implemented as interface **224***a* having a wired modem **225***a* and connector **221***a* for connecting to the mating connector **223***a* attached to the wiring **222***a*. Similarly, the generic network interface **214***b* is implemented as interface **224***b* having a wired modem **225***b* and connector **221***b* for connecting to the mating connector **223***b* attached to the wiring **222***b*. The generic network interface **214***c* is implemented as interface **224***c* having a wireless modem **219** and an antenna **218** for transmitting to, and receiving from, the wireless network **211***c*. Similarly, all the networks may be wired networks, using different types of medium, such that one or more networks uses a coaxial cable (where the interface includes a coaxial connector and coaxial cable modem), one or more of the other networks are using twisted-pair (where the interface includes a cable connector and twisted-pair modem), while one or more of the other networks are using powerlines, telephone lines or similar, and the interfaces are using the appropriate connectors and modems. Further, all the networks may be wireless networks, using different types of non-conductive medium or different types of propagation technologies. For example, one or more networks uses a Radio Frequency (RF) propagation (where the interface includes an antenna and wireless modem), one or more of the other networks are using light propagation such as over

the air or fiber-optic cable (where the interface includes a light emitter and detector and an appropriate modem), while one or more of the other networks are using sound based propagation (where the interface includes a sound emitter such as a speaker and a microphone and an appropriate modem).

Similarly, all the networks may be the same type of geographical scale or coverage networks, such as NFC, PAN, LAN, MAN, or WAN types. Alternatively, multiple types of geographical scales or types may be used, such that one or more networks are PAN, one or more of the other networks are LAN, one or more of the other networks are WAN, and so forth. Similarly, the networks may all use the same type of modulation, such as Amplitude Modulation (AM), a Frequency Modulation (FM), or a Phase Modulation (PM). Alternatively, multiple types of modulations may be used, such that one or more networks use AM, one or more of the other networks use FM, one or more of the other networks use PM, and so forth. Similarly, the same of different line codes may be used among the networks. Further, the networks may all use the same type of duplexing, such as full-duplex, half-duplex or unidirectional. Alternatively, multiple types of modulations may be used, such that one or more networks use full-duplex communication, one or more of the other networks use half-duplex, one or more of the other networks are unidirectional, and so forth. Similarly, the same of different data rates may be used among the networks.

The networks may be circuit-switched based such as the PSTN, where typically two network nodes establish a dedicated communications channel (circuit) through the network before the nodes may communicate with each other. The circuit functions as if the nodes were physically connected as with an electrical circuit and guarantees the full bandwidth of the channel and remains connected for the duration of the communication session. In circuit switching, the bit delay is constant during a connection, as opposed to packet switching, where packet queues may cause varying and potentially indefinitely long packet transfer delays. Virtual circuit switching is a packet switching technology that emulates circuit switching, in the sense that the connection is established before any packets are transferred, and packets are delivered in order. The networks may be based on packet switching based where the data to be transmitted is divided into packets transmitted through the network independently. In packet switching, instead of being dedicated to one communication session at a time, the network links may be shared by packets from multiple competing communication sessions. Similarly, the networks may be a combination of circuit- and packet-based networks.

The networks may be private data networks where the medium or the equipment are owned by a private entity, or where the network is established, operated, or administered by a private administration, or may be public data networks, which were established or are operated for providing services to the public. Similarly, the networks may be a combination of private and public networks.

In one example, two or more network interfaces **214** communicate to the same network or to same network medium, providing redundancy by having multiple interfaces, which may function as redundant units. Such an example is shown in FIG. **22***a* as device **220***a*. Both network interfaces **224***a* and **224***b* are communicating over the same medium **222***a*, sharing the connector **221***a* for connecting to the same medium **222***a*. Both network interfaces may use the wiring **222***a* serving as the network medium simultaneously using the FDM technique (Frequency Division Multiplexing). In such configuration, the same network medium, such as the wiring **222***a* is used for carrying two or more distinct communication signals, each using a distinct frequency spectrum band. Such arrangement is shown as device **220***b* in FIG. **22***b*, based on device **220***a* in FIG. **22***a*. The network interfaces **224***a* and **224***b* are replaced with interfaces **226***a* and **226***b*, having filters **227***a* and **227***b* respectively connected between the respective modem and the shared connector **221***a*. The filters substantially pass part of the available frequency spectrum of the wiring **222***a*, allowing for concurrent transmission of two communication signals over the same physical medium. Alternatively, distinct modulation or coding may be used in order to carry two or more signals over the same medium. Similarly, a single antenna may be used as a network connection and shared by two more wireless modems, working on the same frequency band, distinct frequency bands, or a combination thereof. An example of sharing two communication signals over the same medium is described in U.S. Patent Application No. 2004/0032902 to Koifman et al., entitled: "Modem Channel Sharing Based on Frequency Division".

The flow chart **230** shown in FIG. **23** describes the packet handling in a multiple network connection device, such as device **210** shown in FIG. **21**. A packet to be sent is received by the interface selector **215** in step 'Receive Packet' **231**, for example via port **217**. In step 'Check Available Interfaces' **232** the interfaces that are available for transmission of the received packet are identified. For example, interfaces may not be available due to network or interface malfunction, or the interface may be busy in transmitting former packet or data. Similarly, in half-duplex connection, an interface may be in the state of receiving information, hence not available for transmission at the time of reception. Next, in 'Select Interface' **233** step, an interface to be used (or multiple interfaces) is selected out of the available interfaces. In step 'Send Packet' **234** the packet is directed and sent to the selected interface for being transmitted over the associated network.

In one example, the device may use a broadcast mechanism, where the packet is sent via all available interfaces, hence obviating the need for the 'Select Interface' **233** step. Similarly, two, three, or any other number of the available interfaces may be used to transmit the same packet. Such mechanism allows for fault tolerant transmission, since even in the case of communication failure of any one of parallel transmitted packet routes, one of the transmitted packets will arrive to the destination, thus enhancing the system reliability. Further, such arrangement allows for lower delay in the transmission, since the fastest communication route among those routes that are used will determine the transfer time. This may prove beneficial especially over the Internet or any other packet-based network, typically where transfer time is not guaranteed and is practically random.

Alternatively or in addition, the packet may be directed to be transmitted over a single network using a single interface. The selection mechanism may be designed for optimizing load balancing over the networks, for providing higher reliability, for reducing costs associated with the networks usage, allowing for higher total throughput and so forth. The selection of the interface to be used in the 'Select Interface' **233** step may use the cyclic assigning mechanism, where all interfaces are treated equally. For example, assuming three interfaces designated as #1, #2, and #3, the first packet will be directed to interface #1, the second packet to interface #2, the third packet to interface #3, the fourth packet again to interface #1, the fifth packet to interface #2, and so forth in a cyclic pattern. In the case one of the interfaces is or

becomes unavailable upon its turn, the 'next' interface is selected. In the case of two interfaces, the arriving packets to be sent are alternated between them. In the case when the interfaces have the same or similar data-rate capability, the selection mechanism is thus similar to, or the same as, common Time-Division Multiplexing (TDM) scheme, and the interface selector **215** effectively serves as a time-division multiplexer. The data-rate provided by the multiple network connections are thus aggregated to provide increased throughput.

In another alternative or in addition, the interface is randomly selected in the 'Select Interface' **233** step, allowing for 'fair' and evenly distributed workload over the available network and interfaces. The randomness may be based on a random number generated by a random number generator. The random number generator may be based on a physical process (such as thermal noise, shot noise, nuclear decaying radiation, photoelectric effect or other quantum phenomena), or on an algorithm for generating pseudo-random numbers.

Further alternatively or in addition, a priority may be assigned to each network interface. During operation in 'Select Interface' **233** step, the highest priority interface is assigned to the outgoing packet. In case that this highest priority interface is busy or otherwise unavailable, the second highest priority is used. The third priority interface will be used only in the case where the highest priority and the second in line interfaces are busy or otherwise unavailable. The priorities may be pre-set, fixed or adaptive and changing in time.

The selection of the interface to be used, or the priorities assigned to the network interfaces, may be based on the available networks attributes or their history. For example, based on the costs associated with the usage of a network, the higher cost network may have lower priority and less used than lower cost or free network. In another example, a high quality network, such as having a higher available bandwidth or throughput, lower communication errors or packet loss, lower hops to destination, or lower transfer delay time, is having higher priority that a lower quality network. The system may use Bit Error Rate (BER), Received Signal Strength Indicator (RSSI), Packet Loss Ratio (PLR), Cyclic Redundancy Check (CRC) and other indicators or measures associated with the communication channel associated with a network interface, and may be based on, use, or include the methodology and schemes described in RFC 2544 entitled: "Benchmarking Methodology for Network Interconnect Devices", and ITU-T Y.1564 entitled: "Ethernet Service Activation Test Methodology", which are both incorporated in their entirety for all purposes as if fully set forth herein. The network quality grade may be affected by the history of using such a network, for example in a pre-set period before the network interface selection process. In one example, the network interface where the last proper packet was received from may be selected as the interface to be used for the next packet to be transmitted. The system may further use, or be based on, the schemes and technologies described in U.S. Pat. No. 7,027,418 to Gan et al. entitled: "Approach for Selecting Communications Channels Based on Performance", which is incorporated in its entirety for all purposes as if fully set forth herein.

The selection of the interface to be used, or the priorities assigned to the network interfaces, may be based on the attributes of the packet to be sent. In one example, the selection scheme is based on the packet destination address, where the device assigns an outgoing interface according the destination address in the packet, which may be a MAC or IP (such as IPv4 or IPv6) address, based on routing tables. The routing tables may be fixed, or may change in time. The routing tables may be dynamically updated based on the interface from which a packet from the destination arrived in an earlier communication, similar to a common LAN switching, as described for example in U.S. Pat. No. 5,274,631 to Bhardwaj, entitled: "Computer Network Switching System", which is incorporated in its entirety for all purposes as if fully set forth herein.

Alternatively or in addition, the selection of the interface to be used, or the priorities assigned to the network interfaces, may be based on the information source or on the source address. The device may hold fixed or dynamic routing tables associating the various sources of information to the available network interfaces, such that when a packet is received, the data source is analyzed, and upon the stored routing table information, the packet is routed to the associated network interface. For example, a field unit may include, or may be connected to, four sensors designated as sensors #1, #2, #3, and #4, and may include three network interfaces, designated as #1, #2, and #3. The routing table may associate sensors #1 and #3 to interface #2, sensor #2 to interface #3, and sensor #4 to interface #1. Alternatively or in addition, the selection of the interface to be used, or the priorities assigned to the network interfaces, may be based on the type of information carried in the packet. For example, few types of information may be defined in the system, designated as types #1, #2, #3, and #4. For example, information type #1 may be associated with general management data, information type #2 may be associated with real time or time-sensitive information, information type #4 may be associated with images, and information type #4 may be associated with all other information types. The device may hold fixed or dynamic routing tables associating the various types of information to the available network interfaces, such that when a packet is received, the data type is analyzed, and upon the stored routing table information, the packet is routed to the associated network interface.

Each of the devices in the system, such as the router (such as router **40** in FIG. **4** or router **21** in FIG. **5***h*), the field unit (such as any of field units **23**), or the control server (such as server **24**), may be addressed in a digital data network. The address may be a digital address (typically a number) for uniquely identifying the device in one of the in-building (or in-vehicle) networks such as one of the control networks **22** or one of the home networks **14**, in the external network such as one of the WANs **46**, or in the Internet **16**. The address may be stored in a volatile or non-volatile memory in the addressable device. A device address may be global and recognized and used throughout the system, or may be used in a one or more networks, such as the networks coupled to the device and over which the device may communicate. In one example, the address may be used for identification in the network to which the device is coupled. Alternatively or in addition, the same address may be used for two or all the networks in the system. The address may be associated with the Media Access Control (MAC) layer of the OSI reference model (or layer 2), such as MAC-48, Extended Unique Identifier (EUI)-48, or EUI-64 addresses typically assigned by the Institute of Electrical and Electronics Engineers (IEEE) and described in the IEEE 802 standard, commonly used in Ethernet, 802.11 wireless networks, Bluetooth, IEEE 802.5 token ring, FDDI, and ITU-T G.hn. The address may be or locally administered addresses universally administered addresses, where the address is uniquely assigned to a device by its manufacturer. The MAC address may be a permanent and globally unique hardware-based identifica-

tion, commonly stored in a non-volatile memory in the device and programmed during manufacturing, however it may be possible to change the MAC address on modern hardware. Changing MAC addresses (known as MAC spoofing) may be used in network virtualization or in the process of exploiting security vulnerabilities.

Alternatively or in addition, a device may be addressable using a layer 3 addressing, such as IP address, which may be an IPv4 or IPv6 address, commonly software-based and assigned by the Internet Assigned Numbers Authority (IANA). The IP address may be permanently by fixed configuration of its hardware or software such as static IP address, typically manually assigned to a device by a human administrator. Alternatively or in addition, dynamic IP address may be used, where new address may be assigned either autonomously by a software in the device, or by another device via a communication interface (at the time or power-up or booting), such as an address assigned by a server or other device using Dynamic Host Configuration Protocol (DHCP). For example, the addresses of the field units may be assigned by the router, the in-building (or in-vehicle) computer **18**, or by the control server. Similarly, the address of the router may be assigned by the router or by the control server or by the in-building (or in-vehicle) computer **18**.

A device may be associated with multiple addresses. For example, a device may be addressed using multiple addresses, each relating to a different layer of the OSI model, such as a device having both a MAC and IP addresses. Alternatively or in addition, a device that may communicate directly or indirectly via few networks, may have a different addresses, each related and used in one of the networks. For example, in the case a device may communicate over multiple networks via different interfaces, a distinct address may be associated with each network interface. For example, the router **21** is shown in FIG. **16** enabled for communicating over control network **22** via interface **146***a*, over the control network **22***a* via interface **146***b*, over the home network **14***a* via interface **146***c*, and over the Internet **16**. In such a case, the router may be addressable by four different addresses, each associated with a distinct interface connected to a distinct network. Similarly, the device **210** is shown in FIG. **21** to communicate over networks **211***a*, **211***b*, and **211***c* via the respective network interfaces **214***a*, **214***b*, and **214***c*, and may thus be associated with three different addresses each relating to a respective network interface **214**. The network addresses may be an alternative or an addition to the address or addresses associated with the device itself.

In one example, the sensors and actuators are individually addressed in the system. The field unit **60***h* shown in FIG. **6***g* includes two actuators **61***a* and **61***b*. An address may be associated by each actuator **61**, and packets carrying commands to these actuators may be routed to the specific actuator identified by its address. These two actuator addresses may be in addition to two addresses associated with the network interfaces including the modems **54** and **64** of the field unit **60***h*. Similarly, each sensor in the system may be individually addressed, such as individually assigned addresses to sensors **51***a* and **51***b* shown as part of the field unit **50***g* in FIG. **5***g*. Any packet transmitted from the field unit **50***g* carrying a sensor data, may include the specific sensor address as its identifier as the data source. These two sensor addresses may be in addition to two addresses associated with the network interfaces including the modems **54** and **64** of the field unit **50***g*. In the case the sensor or the actuator is external to the field unit and connected thereto, the port or connection to the sensor or actuator will be associated with the individual address. Similarly, other components, interfaces, or ports of the devices in the system may be individually addressable, as an alternative or in addition to the other device address or addresses, and thus may serve as the destination or source addresses in the packets routed in the system. The sensors or actuators addresses, or the related connections or ports, may be uniquely assigned to during manufacturing, or may be assigned by the associated field unit, or a device communicating with the associated field unit.

While exampled above regarding a residential environment, in-building networks, and communication between in-building devices to devices external to the building, the system may equally apply to vehicular environment, such as in-vehicle communication, vehicle-to-vehicle (sometimes referred to as V2V) designed for automobiles to communicate to each other, and communication between the vehicle to stationary devices external to the vehicle such as communication with or via roadside units. A vehicle is typically a mobile unit designed or used to transport passengers or cargo between locations, such as bicycles, cars, motorcycles, trains, ships, aircrafts, boats, and spacecrafts. In such environment, one (or more) of the buildings **19** above is substituted by a vehicle, as schematically shown as arrangement **240** shown in FIG. **24**, where a car shape **241** is replacing the building **19** in the arrangement **20** of FIG. **2** above. Similarly, the building external computer or server **24** may be substituted with a roadside computer or server, or any intermediary device for connecting to a server or computer. The in-building networks **22** and **14** above may be substituted with in-vehicle networks, and the computers **18** may similarly be replaced with in-vehicle computers. The vehicle may be travelling on land, over or in liquid such as water, or may be airborne. The sensors may be used to sense a phenomenon in the vehicle, external to the vehicle, or in the surroundings around the vehicle. The actuators may affect the vehicle itself, such as the vehicle speed, path or direction, or may affect phenomenon external to the vehicle or in the surroundings around the vehicle.

The vehicle may be a land vehicle typically moving on the ground, using wheels, tracks, rails, or skies. The vehicle may be locomotion-based where the vehicle is towed by another vehicle or an animal. Propellers (as well as screws, fans, nozzles, or rotors) are used to move on or through a fluid or air, such as in watercrafts and aircrafts. The system described herein may be used to control, monitor or otherwise be part of, or communicate with, the vehicle motion system. Similarly, the system described herein may be used to control, monitor or otherwise be part of, or communicate with, the vehicle steering system. Commonly, wheeled vehicles steer by angling their front or rear (or both) wheels, while ships, boats, submarines, dirigibles, airplanes and other vehicles moving in or on fluid or air usually have a rudder for steering. The vehicle may be an automobile, defined as a wheeled passenger vehicle that carries its own motor, and primarily designed to run on roads, and have seating for one to six people. Typically automobiles have four wheels, and are constructed to principally transport of people.

Human power may be used as a source of energy for the vehicle, such as in non-motorized bicycles. Further, energy may be extracted from the surrounding environment, such as solar powered car or aircraft, a street car, as well as by sailboats and land yachts using the wind energy. Alternatively or in addition, the vehicle may include energy storage, and the energy is converted to generate the vehicle motion.

A common type of energy source is a fuel, and external or internal combustion engines are used to burn the fuel (such as gasoline, diesel, or ethanol) and create a pressure that is converted to a motion. Another common medium for storing energy are batteries or fuel cells, which store chemical energy used to power an electric motor, such as in motor vehicles, electric bicycles, electric scooters, small boats, subways, trains, trolleybuses, and trams. The system described herein may be used to control, monitor or otherwise be part of, or communicate with, the vehicle energy storage and conversion system. In automobiles and other vehicles, the system may be used for control, monitoring, or be part of, the Engine Control Unit (ECU), Transmission Control Unit (TCU), Anti-Lock Braking System (ABS), or Body Control Modules (BCM).

The system may employ vehicular communication systems, where vehicles may communicate and exchange information with other vehicles and with roadside units may allow for cooperation and may be effective in increasing safety such as sharing safety information, safety warnings, as well as traffic information, such as to avoid traffic congestion. In safety applications, vehicles that discover an imminent danger or obstacle in the road may inform other vehicles directly, via other vehicles serving as repeaters, or via roadside units. Further, the system may help in deciding right to pass first at intersections, and may provide alerts or warning about entering intersections, departing highways, discovery of obstacles, and lane change warnings, as well as reporting accidents and other activities in the road. The system may be used for traffic management, allowing for easy and optimal traffic flow control, in particular in the case of specific situations such as hot pursuits and bad weather. The traffic management may be in the form of variable speed limits, adaptable traffic lights, traffic intersection control, and accommodating emergency vehicles such as ambulances, fire trucks and police cars.

The vehicular communication systems may further be used to assist the drivers, such as helping with parking a vehicle, cruise control, lane keeping, and road sign recognition. Similarly, better policing and enforcement may be obtained by using the system for surveillance, speed limit warning, restricted entries, and pull-over commands. The system may be integrated with pricing and payment systems such as toll collection, pricing management, and parking payments. The system may further be used for navigation and route optimization, as well as providing travel-related information such as maps, business location, gas stations, and car service locations. Similarly, the system may be used for emergency warning system for vehicles, cooperative adaptive cruise control, cooperative forward collision warning, intersection collision avoidance, approaching emergency vehicle warning (Blue Waves), vehicle safety inspection, transit or emergency vehicle signal priority, electronic parking payments, commercial vehicle clearance and safety inspections, in-vehicle signing, rollover warning, probe data collection, highway-rail intersection warning, and electronic toll collection.

The in-vehicle internal networks that interconnect the various devices and components inside the vehicle may use any of the technologies and protocols described herein. Alternatively or in addition, a vehicle specialized networking may be used, sometimes referred to as 'vehicle buses'. Common protocols used by vehicle buses include a Control Area Network (CAN) and Local Interconnect Network (LIN). The CAN is described in the Texas Instrument Application Report No. SLOA101A entitled: "Introduction to the Controller Area Network (CAN)", and may be based on, or according to, ISO 11898 standards, ISO 11992-1 standard, SAE J1939 or SAE J2411 standards, which are all incorporated in their entirety for all purposes as if fully set forth herein. The LIN communication may be based on, or according to, ISO 9141, and is described in "LIN Specification Package—Revision 2.2A" by the LIN Consortium, which are all incorporated in their entirety for all purposes as if fully set forth herein. In one example, the DC power lines in the vehicle may also be used as the communication medium, as described for example in U.S. Pat. No. 7,010,050 to Maryanka, entitled: "Signaling over Noisy Channels", which is incorporated in its entirety for all purposes as if fully set forth herein.

The system may be integrated or communicating with, or connected to, the vehicle self-diagnostics and reporting capability, commonly referred to as On-Board Diagnostics (OBD), to a Malfunction Indicator Light (MIL), or to any other vehicle network, sensors, or actuators that may provide the vehicle owner or a repair technician access to health or state information of the various vehicle sub-systems and to the various computers in the vehicle. Common OBD systems, such as the OBD-II and the EOBD (European On-Board Diagnostics), employ a diagnostic connector, allowing for access to a list of vehicle parameters, commonly including Diagnostic Trouble Codes (DTCs) and Parameters IDentification numbers (PIDs). The OBD-II is described in the presentation entitled: "Introduction to On Board Diagnostics (II)" downloaded on 11/2012 from: http://groups.engin.umd.umich.edu/vi/w2_workshops/OBD_ganesan_w2.pdf, which is incorporated in its entirety for all purposes as if fully set forth herein. The diagnostic connector commonly includes pins that provide power for the scan tool from the vehicle battery, thus eliminating the need to connect a scan tool to a power source separately. The status and faults of the various sub-systems accessed via the diagnostic connector may include fuel and air metering, ignition system, misfire, auxiliary emission control, vehicle speed and idle control, transmission, and the on-board computer. The diagnostics system may provides access and information about the fuel level, relative throttle position, ambient air temperature, accelerator pedal position, air flow rate, fuel type, oxygen level, fuel rail pressure, engine oil temperature, fuel injection timing, engine torque, engine coolant temperature, intake air temperature, exhaust gas temperature, fuel pressure, injection pressure, turbocharger pressure, boost pressure, exhaust pressure, exhaust gas temperature, engine run time, NOx sensor, manifold surface temperature, and the Vehicle Identification Number (VIN). The OBD-II specifications defines the interface and the physical diagnostic connector to be according to the Society of Automotive Engineers (SAE) J1962 standard, the protocol may use SAE J1850 and may be based on SAE J1939 Surface Vehicle Recommended Practice entitled: "Recommended Practice for a Serial Control and Communication Vehicle Network" or SAE J1939-01 Surface Vehicle Standard entitled: "Recommended Practice for Control and Communication Network for On-Highway Equipment", and the PIDs are defined in SAE International Surface Vehicle Standard J1979 entitled: "E/E Diagnostic Test Modes", which are all incorporated in their entirety for all purposes as if fully set forth herein. Vehicle diagnostics systems are also described in the International Organization for Standardization (ISO) 9141 standard entitled: "Road vehicles—Diagnostic systems.", and the ISO 15765 standard entitled: "Road vehicles—Diagnostics on Controller Area Networks (CAN)", which are all incorporated in their entirety for all purposes as if fully set forth herein.

The physical layer of the in-vehicle network may be based on, or according to, J1939-11 Surface Vehicle Recommended Practice entitled: "Physical Layer, 250K bits/s, Twisted Shielded Pair" or J1939-15 Surface Vehicle Recommended Practice entitled: "Reduced Physical Layer, 250K bits/s, Un-Shielded Twisted Pair (UTP)", the data link may be based on, or according to, J1939-21 Surface Vehicle Recommended Practice entitled: "Data Link Layer", the network layer may be based on, or according to, J1939-31 Surface Vehicle Recommended Practice entitled: "Network Layer", the network management may be based on, or according to, J1939-81 Surface Vehicle Recommended Practice entitled: "Network Management", and the application layer may be based on, or according to, J1939-71 Surface Vehicle Recommended Practice entitled: "Vehicle Application Layer (through December 2004)", J1939-73 Surface Vehicle Recommended Practice entitled: "Application Layer—Diagnostics", J1939-74 Surface Vehicle Recommended Practice entitled: "Application—Configurable Messaging", or J1939-75 Surface Vehicle Recommended Practice entitled: "Application Layer—Generator Sets and Industrial", which are all incorporated in their entirety for all purposes as if fully set forth herein.

In one example, the router or a field unit is connected to, or communicating with, a diagnostic system (such as OBD-II) in a vehicle. Such communication may use OZEN Electronik EDBO/OBDII to RS-232 gateway P/N-OE90C4000, described in the data sheet "EDBO/OBDII to RS-232 gateway P/N-OE90C4000" by OZEN Electronik, which is incorporated in its entirety for all purposes as if fully set forth herein.

For example, the router or the field unit may connect to the diagnostic connector for accessing the various sensors or actuators coupled to the connector, or for accessing information available via the connector. Further, the router or the field unit may be powered in part or in whole from the power available at the diagnostics connector, and may communicate over (or be part of) the diagnostics network in the vehicle.

The system may be used to measure, sense, or analyze the changes over time of a controlled item **254**, and may use the arrangement **250** shown in FIG. **25**. The controlled item may be an environment, a phenomenon, or any controlled item. The actuator **251**, which corresponds to any actuator described herein, receives actuator command a(t) from the control logic **253** (preferably as an electrical signal), and in response to the actuator **251** characteristic c(t) impacts the controlled item **254** by an output u(t). The control logic **253** corresponds to, is based on, includes, or is part of, the logic **173** or any other control process described herein. The change in the controlled item **254** is measured by the sensor **252** as input y(t), which is impacted by the controlled item **254** transfer function p(t). The sensor **252** converts the sensed phenomenon y(t), and converts it to a signal f(t) using the sensor transfer function s(t). The signal (preferably an electrical signal) f(t) is sent to the control logic **253**. Assuming the elements are linear and time-invariant, then the system can be analyzed using Laplace transform, where A(s), C(s), U(s), P(s), Y(s), S(s), and F(s) are the respective transformed representations of a(t), c(t), u(t), p(t), y(t), s(t), and f(t) respectively, and where U(s)=A(s)*C(s), Y(s)=U(s)*P(s), and F(s)=Y(s)*S(s). In one example, the controlled item **254** is a temperature in a room, the actuator **251** is a heater for heating the room, and the sensor **252** is a temperature sensor measuring the temperature of the room, and the room temperature may be controlled in an open or closed loop by the control logic **253**, for example in order to achieve a pre-set temperature in the room.

By generating or excitation of an actuator command and measuring the resulting sensor output, the control logic **253** or the system in general may measure, sense, estimate, or analyze the behavior or characteristic p(t) of the controlled item **254**. Since P(s)=Y(s)/U(s)=F(s)/[S(s)*A(s)*C(s)], and since C(s) and S(s) are known as the transfer function of the actuator **251** and the sensor **252** respectively, and since A(s) is the activation or excitation signal and F(s) is the signal received from the actuator, P(s) can be calculated. The value of, or any change in P(s) over time, or any conditioning or manipulating of the calculated P(s) may be used as a sensor data in the system, and thus may be part of the system control logic. Such calculation may be used to sense or measure a phenomenon that is not directly measured or sensed by using a corresponding sensor. For example, the calculation may be used as a sensor data for other control loops in the system, for setpoint adjustment of other control loop, or used for user notification. The control logic may initiate such measurement cycle periodically, upon power up, upon the user control (for example via a user device), or as part of a regular control.

In one example, the controlled item **254** is a temperature in a room, the actuator **251** is a heater for heating the room, and the sensor **252** is a temperature sensor measuring the temperature of the room. The chart **260** in FIG. **26** shows the heater command a(t) in graph **261**, and graphs **262** shows the temperature sensor output f(t), along the time axis **263**. Before time point t1, the system is in a steady state, where the heater level of heating is a1 and the temperature measured is f1. For example, al may be zero (no heating), and the temperature f1 is corresponding to 20° C., which may be the environment temperature. At time point t1, the heater is activated (or the heating level increases) to constant level a2. As a response, the room temperature, as measured by the temperature sensor, will start to rise, as shown in graph **262***a*. The rate of rising is dependent upon the room isolation, other heat sources in the room, the room size and volume, and other parameters. For example, in the case the room isolation is affected by an open door or open window, the temperature rise may be at a lower rate, such as shown in graph **262***c*. Similarly, in the case a human enters the room (acting as a heat source), electrical equipment is turned on and dissipates heat, or the isolation is improved by closing a door, the rate of the temperature rise may be higher, such as in graph **262***b*. Hence, by analyzing the temperature change in the room versus the heater command, the room environment may be sensed, for example for sensing if the room door is open or closed, or serve as an occupancy sensor that a human is in the room, as a substitute (or in addition) to a direct and dedicated door or occupancy sensor. A simple analysis may include time measuring, such as checking the room measured temperature versus a threshold f2 **264**. In the case the door is half closed, the room temperature will rise according to graph **262***a*, crossing the threshold f2 occurs at time point t3. In the case the door is fully closed thus providing better isolation, the room temperature will rise according to graph **262***b*, crossing the threshold f2 occurs at time point t2, and in the case the door is open thus providing poor isolation, the room temperature will rise according to graph **262***c*, crossing the threshold f2 occurs at time point t4. The period measured from the heater excitation t1 to the various threshold f2 crossing points (such as t2-t1, t3-t1, and t4-t1) may serve as an indicator or sensor to the door status.

The arrangement **255** shown in FIG. **25***a* is a common closed loop control, where the control logic **258** (corre-

sponding to the control logic **253**) includes a reference input r(t), a subtractor **257**, and a control block **256**, which may for example be a PID unit for forming a PID closed loop. Similar to the above scenario, the p(t) may be estimated by measuring f(t) versus the excitation a(t). In one example, such a loop uses a bang-bang control, where the heater has a fixed single heating state, generating a set heat. Assuming that in order to keep a pre-set temperature in a room (e.g. 20° C.) the heater is operating, and the loop causes a duty cycle of the heater operation to be 50%. In the case the control loop raises the duty-cycle to 70% (with the same set point) it may indicate an open door or a human leaving the room. Similarly, in the case the control loop lowers the duty-cycle to 30% (with the same set point) it may indicate close door or a human entering the room.

To allow communications between devices, a computing or networking device preferably includes a network interface or an adapter, such as communication interface **141** or interface **214**. While the preferred embodiment contemplates that communications will be exchanged primarily via Ethernet, Internet or a broadband network, other means of exchanging communications are also contemplated. For example, a wireless access interface that receives and processes information exchanged via a wireless communications medium, such as, cellular communication technology, satellite communication technology, Bluetooth technology, WAP (Wireless Access Point) technology, or similar means of wireless communication can be utilized by the general purpose computing devices. Such an interface commonly includes a connector for wired or conductive medium, an antenna for over-the-air radio-frequency based communication and fiber-optic connector for fiber-optic cable based medium. A transceiver (transmitter/receiver set) is coupled to the connector or antenna, for transmitting to, and receiving from, the communication medium. A transmitter may be capable of operating at serial bit rates above 1 Gigabit/second, and a wired transmitter commonly uses differential signaling and low voltages for faster switching, such as MOS Current Mode Logic (MCML) based technology. The transmitter may use pre-emphasis or de-emphasis to shape the transmitted signal to compensate for expected losses and distortion. The line-code may employ self-clocking and other encoding schemes, and control information is transmitted along with the data for error detection, alignment, clock correction, and channel bonding. Some popular encoding schemes are 8B/10B, 64B/66B, and 64B/67B. A receiver is commonly designed to mate with the corresponding transmitter and to recover the data and clock from the received signals, and commonly use equalization, and may further include impedance matching termination. Phase Locked Loops (PLLs) are commonly used for clock reconstruction and for achieving a serial clock that is an exact multiple of the parallel data. The receiver commonly decodes the received signal, and detects encoding-based errors. The byte boundaries and other alignment schemes may also be performed by the receivers. A transceiver may include a modem (MOdulator-DEModulator), that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information, typically in order to produce a signal that can be transmitted easily over a communication medium and be decoded to reproduce the original digital data.

Any networking protocol may be utilized for exchanging information between the nodes in the network (e.g., field units, router or gateway, a PC) within the network (such as the Internet). For example, it is contemplated that communications can be performed using TCP/IP. Generally, HTTP and HTTPS are utilized on top of TCP/IP as the message transport envelope. These two protocols are able to deal with firewall technology better than other message management techniques. However, partners may choose to use a message-queuing system instead of HTTP and HTTPS if greater communications reliability is needed. A non-limiting example of a message queuing system is IBM's MQ-Series or the Microsoft Message Queue (MSMQ). The system described hereinafter is suited for both HTTP/HTTPS, message-queuing systems, and other communications transport protocol technologies. Furthermore, depending on the differing business and technical requirements of the various partners within the network, the physical network may embrace and utilize multiple communication protocol technologies.

The system may provide improved agility by allowing rapidly and inexpensively to provision infrastructure resources such as resources available at the remote control server, and may further provide easy accessibility to software in the control server, in the router, or in the field unit using Application Programming Interface (API). Using a cloud-based control server or using the system above may allow for reduced capital or operational expenditures. The users may further access the system using a web browser regardless of their location or what device they are using, and the virtualization technology allows servers and storage devices to be shared and utilization be increased.

The corresponding structures, materials, acts, and equivalents of all means plus function elements in the claims below are intended to include any structure, or material, 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. The present invention should not be considered limited to the particular embodiments described above, but rather should be understood to cover all aspects of the invention as fairly set out in the attached claims. Various modifications, equivalent processes, as well as numerous structures to which the present invention may be applicable, will be readily apparent to those skilled in the art to which the present invention is directed upon review of the present disclosure.

The control server **24** or **48** hardware, software, or functionality may be installed, operated, maintained, supported, or hosted by a business entity. The business entity may license or otherwise monetize the functionality as a service, similar to any SaaS business model. The service may be provided as a one-time, upfront fee paid license, or according to the usage of the control server. Further, the service may be charged per user, per time, per transaction or event, or per the communicated data amount. In one example, the business entity is the ISP that connects the building (or the vehicle) to the Internet (such as ISP server **47** operator), or the WAN provider, such as the telephone company ('Telco') or the CATV provider owning or operating the wiring of the external network such as WAN **46**. Similarly, a cellular network operator may be the business entity in the case the WAN **46** is based on cellular communication. Such Added Revenue Per User (ARPU) is beneficial to most communication service providers, since the additional revenues do not require any additional infrastructure investment. In one example, the communication service provider (such as the WAN **46** operator) may provide the router **40** for a nominal cost or even lower than nominal (e.g. free), wherein the ARPU covers the initial cost after a time. The control server

service may be billed as a one-time fee, a flat-fee per period (e.g., monthly or annually), per a communication session, per length of the communication sessions, per the amount of information transferred in a session, per type of communication sessions (e.g., status, control, or alert) or any combination thereof. The business method and the system may be based on, or comprise, the structure and functionalities described in U.S. Patent Application No. 2005/0216302 to Raji et al., entitled: "Business Method for Premises Management".

All publications, standards, patents, and patent applications cited in this specification are incorporated herein by reference as if each individual publication, patent, or patent application were specifically and individually indicated to be incorporated by reference and set forth in its entirety herein.

The invention claimed is:

1. A client device for use with a Wireless Local Area Network (WLAN) in a building and with a controlled device that comprises a second actuator in the building, the client device comprising:

a WLAN transceiver for communicating over the WLAN;

a microphone for capturing first and second human voice data; and

a first actuator in the client device,

wherein the client device is configured to:

sending, over the Internet via the WLAN, the captured first and second human voice data to an Internet-connected server device external to the building;

receiving, from the server device over the Internet via the WLAN, first and second messages, in response to the sending of the captured first and second human voice data;

operating the first actuator in response to the received first message; and

sending, to the controlled device over the WLAN, a control message in response to the received second message, and

wherein the client device is addressable in the WLAN and in the Internet using an Internet Protocol (IP) address.

2. The client device according to claim **1**, wherein the server device is configured for processing the first and second human voice data using a voice recognition algorithm for identifying a voice of a specific person.

3. The client device according to claim **1**, further comprising a sensor that outputs sensor data that responds to a physical phenomenon, wherein the client device is further configured for sending to the server device, via the WLAN over the Internet, the sensor data, and wherein the first message is received in response to the sent sensor data.

4. The client device according to claim **3**, wherein the sensor is a thermoelectric sensor that responds to a temperature or to a temperature gradient of an object using conduction, convection, or radiation, or wherein the sensor is a photoelectric sensor that responds to a visible or an invisible light or gamma rays.

5. The client device according to claim **1**, wherein each of the first and second actuators is configured for directly or indirectly affecting, changing, producing, or creating a physical phenomenon.

6. The client device according to claim **5**, wherein the physical phenomenon comprises temperature, humidity, pressure, audio, vibration, light, motion, sound, proximity, flow rate, electrical voltage, or electrical current.

7. The client device according to claim **1**, wherein the client device comprises multiple microphones, and wherein the capturing comprises capturing, by the multiple microphones in the client device, the first and second human voice data.

8. The client device according to claim **7**, wherein the multiple microphones are arranged as a directional microphones array operative to estimate a number, magnitude, frequency, Direction-Of-Arrival (DOA), distance, or speed of a phenomenon impinging the microphones array.

9. The client device according to claim **1**, wherein the microphone is an omnidirectional, unidirectional, or bidirectional microphone that is based on the sensing an incident sound-based motion of a diaphragm or a ribbon, or wherein the microphone comprises a condenser, an electret, a dynamic, a ribbon, a carbon, or a piezoelectric microphone.

10. The client device according to claim **1**, further comprising a volatile or non-volatile memory for storing the IP address.

11. The client device according to claim **1**, wherein the client device is further addressed by a Media Access Control (MAC) layer address that is MAC-48, Extended Unique Identifier (EUI) EUI-48, or EUI-64 address type.

12. The client device according to claim **1**, wherein the IP address is a static or dynamic Internet Protocol (IP) address that is IPv4 or IPv6 type address.

13. The client device according to claim **1**, wherein the WLAN is according to, or base on, Institute of Electrical and Electronics Engineers (IEEE) 802.11-2012, IEEE 802.11a, IEEE 802.11b, IEEE 802.11g, IEEE 802.11n, or IEEE 802.11ac.

14. The client device according to claim **1**, wherein the WLAN uses an unlicensed radio frequency band that is an Industrial, Scientific and Medical (ISM) radio band.

15. The client device according to claim **1**, further configured for communicating over a cellular telephone network that is a Third Generation (3G) network that uses Universal Mobile Telecommunications Client device (UMTS), Wideband Code Division Multiple Access (W-CDMA) UMTS, High Speed Packet Access (HSPA), UMTS Time-Division Duplexing (TDD), CDMA2000 1×RTT, Evolution-Data Optimized (EV-DO), or a Global Client device for Mobile communications (GSM), Enhanced Data rates for GSM Evolution (EDGE) EDGE-Evolution, or wherein the cellular telephone network is a Fourth Generation (4G) network that uses Evolved High Speed Packet Access (HSPA+), Mobile Worldwide Interoperability for Microwave Access (WiMAX), Long-Term Evolution (LTE), LTE-Advanced, Mobile Broadband Wireless Access (MBWA), or is based on IEEE 802.20-2008.

16. The client device according to claim **1**, wherein the controlled device is integrated in, is part of, or is entirely included in, a household appliance having a primary function.

17. The client device according to claim **16**, wherein the primary functionality of the appliance is associated with a food storage, handling, or preparation.

18. The client device according to claim **17**, wherein the primary function of the appliance is heating food, and wherein the appliance is a microwave oven, an electric mixer, a stove, an oven, or an induction cooker.

19. The client device according to claim **17**, wherein the appliance is a refrigerator, a freezer, a food processor, a dishwasher, a food blender, a beverage maker, a coffeemaker, or an iced-tea maker.

20. The client device according to claim **16**, wherein the primary function of the appliance is associated with an environmental control, and the appliance is part of a Heating, Ventilation and Air Conditioning (HVAC) system.

21. The client device according to claim **20**, wherein the primary function of the appliance is associated with a temperature control, and wherein the appliance is an air conditioner or a heater.

22. The client device according to claim **16**, wherein the primary function of the appliance is associated with cleaning, wherein the appliance primary function is associated with a clothes cleaning and the appliance is a washing machine, or wherein the appliance is a vacuum cleaner.

23. The client device according to claim **16**, wherein the appliance is an answering machine, a telephone set, a home cinema system, a High Fidelity (HiFi) system, a Compact Disc (CD) or Digital Video Disc (DVD) player, an electric furnace, a trash compactor, a smoke detector, a light fixture, or a dehumidifier.

24. The client device according to claim **1**, wherein the first actuator is an electric light source for converting an electrical energy into light that emits a visible or non-visible light for illumination or indication, and the non-visible light is infrared, ultraviolet, X-rays, or gamma rays.

25. The client device according to claim **24**, wherein the electric light source comprises a lamp, an incandescent lamp, a gas discharge lamp, a fluorescent lamp, a Solid-State Lighting (SSL), a Light Emitting Diode (LED), an Organic LED (OLED), a polymer LED (PLED), or a laser diode.

26. The client device according to claim **1**, wherein the first actuator is a motion actuator that causes a linear or rotary motion.

27. The client device according to claim **1**, wherein the first actuator is a sounder for converting an electrical energy to an omnidirectional, unidirectional, or bidirectional pattern emitted, audible or inaudible, sound waves.

28. The client device according to claim **27**, wherein the sounder comprises an electromagnetic loudspeaker, a piezoelectric speaker, an electrostatic loudspeaker (ESL), a ribbon or planar magnetic loudspeaker, or a bending wave loudspeaker, or wherein the sounder comprises an electric bell, a buzzer, a chime, a whistle, or a ringer.

29. The client device according to claim **27**, wherein the operating of the first actuator comprises playing a digital audio content that is pre-recorded or synthesized, or wherein the operating of the first actuator comprises simulating the voice of a human being or generating music, or wherein the operating of the first actuator comprises sounding a syllable, a word, a phrase, a sentence, a short story, or a long story, using male or female voice.

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