

A MODULAR SYSTEM FOR WIRELESS COMMUNICATION

FIELD OF THE INVENTION

[0001] The present invention relates to wireless communication, and more particularly to a modular system and apparatus to manage sensors in wireless communication.

BACKGROUND

[0002] Technological developments in the field of Internet of things (IoT) have led to widespread use of electronic devices to monitor physical and environmental conditions in various segments, such as industrial, consumer segments, and the like. These electronic devices host sensors to monitor the physical and environmental conditions and generate sensor data. Each electronic device further wirelessly transmits the sensor data to a communication device, such as a network gateway.

[0003] Usually, a large number of electronic devices are deployed for monitoring. Transmission of the sensor data from such a large number of electronic devices makes the environment noisy and further results in data interference. To overcome loss of the sensor data due to the data interference, the electronic devices tend to re-transmit the sensor data, which leads to faster battery drainage and hence reduction of a lifespan of the electronic devices. Further, troubleshooting and configuring such a large number of the electronic devices is challenging and consumes lot of time. Typically, these electronic devices are designed and deployed for specific operational requirements. Therefore, when the operational requirements change, the electronic devices are required to be re-designed and re-deployed, which in turn increases the cost of infrastructure.

[0004] A known solution to overcome this problem is to design an electronic device that hosts multiple sensors for multiple operational requirements. In such electronic device, various sensors are pre-installed on a single printed circuit board (PCB), hence, one electronic device is capable of supporting multiple operational requirements. However, pre-installing multiple sensors on a single PCB makes the design of the electronic device inflexible, bulky, complex and very expensive. Further, not all of the sensors hosted by the electronic device are used at a given

time instant. Thus, the sensors that are not in use, merely occupy area on the PCB, and hence decrease an operational efficiency of the electronic device.

[0005] In light of the foregoing, there exists a need for a technical solution that is efficient, flexible, inexpensive, less bulky, and less complex, and offers multifunctional capabilities with easy deployment, troubleshooting, and lesser environmental noise.

SUMMARY

[0006] In an embodiment of the present invention, a system for wireless communication is provided. The system includes first and second sensors, first and second sensor modules, and first and second communication devices. The second communication device includes a first plurality of connectors, a communication bus, a processor, and a wireless transceiver. The first plurality of connectors include first and second connectors. The first and second sensors generate first and second sensor data, respectively. The first and second sensor modules are connected to the first and second sensors for receiving the first and second sensor data, respectively. The first communication device is connected to the second sensor module for receiving the second sensor data. The communication bus communicates with the first sensor module and the first communication device by way of the first and second connectors, respectively. The processor receives the first and second sensor data from the first sensor module and the first communication device, respectively, by way of the communication bus, and the first and second connectors. The wireless transceiver transmits the first and second sensor data to a third communication device.

[0007] In another embodiment of the present invention, an apparatus for wireless communication is provided. The apparatus includes a first plurality of connectors, a communication bus, a processor, and a wireless transceiver. The first plurality of connectors include first and second connectors. The communication bus communicates with a first sensor module and a first communication device by way of the first and second connectors, respectively. The processor receives first sensor data from the first sensor module by way of the communication bus and the first connector. The first sensor module is connected to a first sensor for receiving the first sensor data. The first sensor generates the first sensor data. The processor further receives second sensor data from the first communication device by way of the

communication bus and the second connector. The first communication device is connected to a second sensor module for receiving the second sensor data and the second sensor module is connected to a second sensor for receiving the second sensor data. The second sensor generates the second sensor data. The wireless transceiver transmits the first and second sensor data to a second communication device.

[0008] Various embodiments of the present invention provide a system and apparatus for wireless communication. The system includes first and second sensors, first and second sensor modules, and first and second communication devices. The first and second sensors are connected to the first and second sensor modules, respectively. The second communication device includes a first plurality of connectors, a communication bus, a processor, and a wireless transceiver. The first plurality of connectors further include first and second connectors. The second communication device further includes a first housing that encloses at least the communication bus, the processor, and the wireless transceiver. The first housing has a first plurality of slots for the first and second connectors. The first communication device further includes a second plurality of connectors that further include third and fourth connectors. The first communication device further includes a second housing that has a second plurality of slots for the third and fourth connectors. Based on operational requirements, the first and second sensor modules are connected to the second and first communication devices, respectively. The first sensor module is connected to the second communication device by way of the first connector and the second sensor module is connected to the first communication device by way of the fourth connector. The second connector of the second communication device is connected to the third connector of the first communication device by way of a wired connection interface.

[0009] The processor communicates with a mobile computing device for activating the first and second sensors. Thus, the first and second sensors generate first and second sensor data based on one or more physical or environmental conditions. Further, the first and second sensors communicate the first and second sensor data to the first and second sensor modules, respectively. Thus, the first and second sensor modules receive the first and second sensor data. The first communication device further receives the second sensor data from the second sensor module by way of the fourth connector. The first sensor module and the first communication device further communicate the first and second sensor data to the second communication device

by way of the first and second connectors. The communication bus communicates with the first and second connectors for receiving the first and second sensor data. The processor transmits the first and second sensor data to a third communication device by way of the wireless transceiver. The second communication device offers multifunctional capabilities by supporting various sensors based on operational requirements. Further, the first plurality of connectors of the second communication device are plug-and-play interfaces which enable the second communication device to connect to various sensors and the first communication device when required. Since, only the second communication device is enabled for wireless communication by using the wireless transceiver, environment noise is reduced in comparison to conventional wireless systems. Since, the first and second sensor modules are not pre-installed on the second communication device, the second communication device is flexible to be connected to any type of sensor module based on change of operational requirements.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] The accompanying drawings illustrate the various embodiments of systems, methods, and other aspects of the invention. It will be apparent to a person skilled in the art that the illustrated element boundaries (e.g., boxes, groups of boxes, or other shapes) in the figures represent one example of the boundaries. In some examples, one element may be designed as multiple elements, or multiple elements may be designed as one element. In some examples, an element shown as an internal component of one element may be implemented as an external component in another, and vice versa.

[0011] Various embodiments of the present invention are illustrated by way of example, and not limited by the appended figures, in which like references indicate similar elements:

[0012] FIG. 1 is a block diagram that illustrates a wireless communication system, in accordance with an embodiment of the present invention;

[0013] FIG. 2A is a block diagram that illustrates a front view of a first housing of a first communication device of the wireless communication system of FIG. 1, in accordance with an embodiment of the present invention;

[0014] FIG. 2B is a block diagram that illustrates a second housing of a sensor module of the wireless communication system of FIG. 1, in accordance with an embodiment of the present invention;

[0015] FIG. 2C is a block diagram that illustrates an attachment among first through fourth housings, in accordance with an embodiment of the present invention; and

[0016] FIG. 3 is a block diagram that illustrates system architecture of a computer system, in accordance with an embodiment of the present invention.

[0017] Further areas of applicability of the present invention will become apparent from the detailed description provided hereinafter. It should be understood that the detailed description of exemplary embodiments is intended for illustration purposes only and is, therefore, not intended to necessarily limit the scope of the invention.

DETAILED DESCRIPTION

[0018] The present invention is best understood with reference to the detailed figures and description set forth herein. Various embodiments are discussed below with reference to the figures. However, those skilled in the art will readily appreciate that the detailed descriptions given herein with respect to the figures are simply for explanatory purposes as the methods and systems may extend beyond the described embodiments. In one example, the teachings presented and the needs of a particular application may yield multiple alternate and suitable approaches to implement the functionality of any detail described herein. Therefore, any approach may extend beyond the particular implementation choices in the following embodiments that are described and shown.

[0019] References to “an embodiment”, “another embodiment”, “yet another embodiment”, “one example”, “another example”, “yet another example”, “for example”, and so on, indicate that the embodiment(s) or example(s) so described may include a particular feature, structure, characteristic, property, element, or limitation, but that not every embodiment or example necessarily includes that particular feature, structure, characteristic, property, element or limitation. Furthermore, repeated use of the phrase “in an embodiment” does not necessarily refer to the same embodiment.

[0020] Referring now to FIG. 1, a block diagram that illustrates a wireless communication system 100 in accordance with an embodiment of the present invention is shown. The wireless communication system 100 includes first through ninth sensors 102A-102I, first through eighth sensor modules 104A-104H, first through third communication devices 106-110, and a mobile computing device 112.

[0021] The first through ninth sensors 102A-102I generate sensor data by monitoring one or more physical or environmental conditions. For example, the first sensor 102A is a temperature sensor that generates sensor data by monitoring temperature conditions of the environment. Other examples of the first through ninth sensors 102A-102I include, but are not limited to, optical sensors, humidity sensors, pressure sensors, motion sensors, contact sensors, or any other type of sensor. In one scenario, the first through ninth sensors 102A-102I are of one type. For example, the first through ninth sensors 102A-102I are temperature sensors. In another scenario, the first through ninth sensors 102A-102I are of different types. For example, the first and second sensors 102A and 102B are optical sensors, the third sensor 102C is a motion sensor, the fourth and fifth sensors 102D and 102E are humidity sensors, the sixth and seventh sensors 102F and 102G are pressure sensors, and the eighth and ninth sensors 102H and 102I are contact sensors. In one embodiment, the first through ninth sensors 102A-102I are on-board sensors that are installed on one or more sensor modules, such as the first through eighth sensor modules 104A-104H. For example, the second sensor 102B is an on-board sensor that is installed on the second sensor module 104B. In another embodiment, the first through ninth sensors 102A-102I are off-board sensors that are connected to one or more sensor modules by way of an external wired connection. For example, the first sensor 102A is an off-board sensor that is connected to the first sensor module 104A by way of the external wired connection. Hereinafter, the sensor data generated by the first through fifth sensors 102A-102E is referred as first sensor data and the sensor data generated by the sixth through ninth sensors 102F-102I is referred as second sensor data.

[0022] The first through eighth sensor modules 104A-104H include suitable logic, circuitry, and/or interfaces for receiving the sensor data, such as the first and second sensor data, from one or more sensors, such as the first through ninth sensors 102A-102I. Each of the first through eighth sensor modules 104A-104H is connected to one or more sensors, such as the first

sensor through ninth sensors 102A-102I, for receiving the sensor data. For example, the first sensor module 104A is connected to the first sensor 102A, the second sensor module 104B is connected to the second sensor 102B, the third sensor module 104C is connected to the third and fourth sensors 102C and 102D, and the fourth sensor module 104D is connected to the fifth sensor 102E to receive the first sensor data. Further, the fifth sensor module 104E is connected to the sixth sensor 102F, the sixth sensor module 104F is connected to the seventh sensor 102G, the seventh sensor module 104G is connected to the eighth sensor 102H, and the eighth sensor module 104H is connected to the ninth sensor 102I to receive the second sensor data. In an embodiment, each of the first through eighth sensor modules 104A-104H includes a communication bus, such as an expansion bus, which is enabled with hot-swapping functionality such that the one or more sensors, such as the first through ninth sensors 102A-102I, may be connected or disconnected from each of the first through eighth sensor modules 104A-104H at any time instant without shutting down operations of the first through eighth sensor modules 104A-104H. For example, the fourth sensor 102D may be disconnected from the third sensor module 104C without shutting down the operations of the third sensor module 104C.

[0023] In one scenario, the one or more sensors, such as the first through ninth sensors 102A-102I, connected to the first through eighth sensor modules 104A-104H are of one type. For example, the third and fourth sensors 102C and 102D connected to the third sensor module 104C are temperature sensors. In another scenario, the one or more sensors, such as the first through ninth sensors 102A-102I, connected to the first through eighth sensor modules 104A-104H are of different types. For example, the third and fourth sensors 102C and 102D connected to the third sensor module 104C are temperature and humidity sensors, respectively. The first through eighth sensor modules 104A-104H are self-configurable sensor modules that automatically register and configure to a processor when they are connected to the processor. The first through eighth sensor modules 104A-104H have first through eight connectors 114A-114H, respectively. In one embodiment, the first through eight connectors 114A-114H are male electrical connectors, for example a male printed circuit board (PCB) connector. The first through eighth sensor modules 104A-104H can be connected to the first or second communication device 106 or 108 based on one or more operational requirements by way of the first through eight connectors 114A-114H, respectively. For example, the first through fourth sensor modules 104A-104D are connected to the first communication device 106 by way of the first through fourth connectors 114A-114D,

respectively, and the fifth through eighth sensor modules 104E-104H are connected to the second communication device 108 by way of the fifth through eighth connectors 114E-114H, respectively. The first through fourth sensor modules 104A-104D transmit the first sensor data to the first communication device 106 and the fifth through eighth sensor modules 104E-104H transmit the second sensor data to the second communication device 108.

[0024] The first communication device 106 is an apparatus to which various devices, such as the first through fourth sensor modules 104A-104D and the second communication device 108, are connected. The first communication device 106 provides wireless communication infrastructure to the various devices, which are connected to it. In one example, the first communication device 106 is a network hub. The first communication device 106 receives the sensor data, such as the first and second sensor data, from various devices, such as the first through fourth sensor modules 104A-104D and the second communication device 108, respectively. Further, the first communication device 106 processes and transmits the first and second sensor data to the third communication device 110. In an embodiment, the first communication device 106 supports a plug-and-play connection interface for connecting various devices, such as the first through fourth sensor modules 104A-104D and the second communication device 108. Therefore, based on the operational requirements, the first through fourth sensor modules 104A-104D and the second communication device 108 can be connected to the first communication device 106 at any time instant without re-configuring the first communication device 106. In an embodiment, the first communication device 106 is powered by a powering device (not shown), such as a battery, solar power cells, and the like. The powering device supplies power signals to the first communication device 106. The first communication device 106 includes a first processor 116A, a first memory 118A, ninth and tenth connectors 120A and 120B, eleventh through fourteenth connectors 122A-122D, a first bus 124A, and a wireless transceiver 126.

[0025] The first processor 116A executes instructions stored in the first memory 118A for receiving and processing the first and second sensor data. In an embodiment, the first processor 116A executes one or more control operations to control the first and second sensor data. Examples of the first processor 116A include a central processing unit (CPU), a general purpose processor (GPP), an application-specific integrated circuit (ASIC) processor, a reduced

instruction set computing (RISC) processor, a complex instruction set computing (CISC) processor, a field programmable gate array (FPGA), and the like.

[0026] The first memory 118A includes suitable logic, circuitry, and/or interfaces to store configuration details of various devices, such as the first through fourth sensor modules 104A-104D and the second communication device 108, which are connected to the first communication device 106. The first memory 118A further stores a set of instructions that enables the first processor 116A to process the first and second sensor data. The first memory 118A also stores the first and second sensor data received from the various devices, such as the first through fourth sensor modules 104A-104D and the second communication device 108, respectively. Examples of the first memory 118A include a random-access memory (RAM), a read-only memory (ROM), a removable storage drive, a hard disk drive (HDD), a flash memory, a solid-state memory, and the like.

[0027] The ninth and tenth connectors 120A and 120B connects the first communication device 106 with one or more devices, such as the second communication device 108 and the powering device (not shown). For example, the ninth connector 120A receives a wired connection interface 128 for connecting the second communication device 108 to the first communication device 106. In one example, the wired connection interface 128 is an RJ45 connection interface. In an embodiment, a user (not shown) may store the set of instructions by way of the tenth connector 120B in the first memory 118A. The first processor 116A may execute the set of instructions to process the first and second sensor data. Examples of the ninth and tenth connectors 120A and 120B include, but are not limited to, universal serial bus (USB) port, an RJ45 port, a serial port, a parallel port, an Ethernet port, and a video graphic array port. The ninth and tenth connectors 120A and 120B are communicatively coupled to the first bus 124A.

[0028] The eleventh through fourteenth connectors 122A-122D are connection interfaces that enable the first communication device 106 to connect to various devices, such as the first through fourth sensor modules 104A-104D. The eleventh through fourteenth connectors 122A-122D are plug-and-play connection interfaces. Thus, based on the operational requirements, the first through fourth sensor modules 104A-104D can be connected to the first communication device 106 by way of the eleventh through fourteenth connectors 122A-122D. In an example, the

eleventh through fourteenth connectors 122A-122D are female electrical connectors, such as female PCB connectors. The eleventh connector 122A receives the first connector 114A, the twelfth connector 122B receives the second connector 114B, the thirteenth connector 122C receives the third connector 114C, and the fourteenth connector 122D receives the fourth connector 114D. The eleventh through fourteenth connectors 122A-122D communicate with the first bus 124A. It will be apparent to a person skilled in the art that the scope of the eleventh through fourteenth connectors 122A-122D is not limited to be connected to the first through fourth connectors 114A-114D of the first through fourth sensor modules 104A-104C, respectively, as shown in FIG. 1.

[0029] The first bus 124A is a communication bus, such as an expansion bus, which enables the first processor 116A to communicate with various devices, such as the second communication device 108 and the first through fourth sensor modules 104A-104D, by way of the ninth connector 120A, and the eleventh through fourteenth connectors 122A-122D, respectively. The first bus 124A provides hot-swapping functionality to the first processor 116A. Thus, the first through fourth sensor modules 104A-104D and the second communication device 108 are connected or disconnected from the first communication device 106 at any time instant without shutting down the operations of the first communication device 106. In an embodiment, the first bus 124A provides separate transmission path to the sensor data, such as the first and second sensor data, and power signals received from the powering device (not shown). Examples of the first bus 124A include, but are not limited to, controller area network (CAN) bus, system management (SM) bus, and I2C bus.

[0030] The wireless transceiver 126 transmits the first and second sensor data to the third communication device 110 over a wireless communication network by using one or more wireless communication protocols. Examples of the wireless communication network include, but are not limited to, a Wi-Fi network, a light fidelity (Li-Fi) network, a satellite network, the internet, an infrared network, a radio frequency (RF) network, a Bluetooth network, or any combination thereof. Examples of the wireless transceiver 126 include an antenna, a radio frequency transceiver, a Bluetooth transceiver, and the like. In an embodiment, the wireless transceiver 126 may support communication over various frequency bands, such as 5.9GHz, 5GHz, 4.9GHz, 3.6GHz, 2.4GHz, 868MHz, 915MHz, and the like.

[0031] The second communication device 108 is a network node that relays data, such as the second sensor data, to the first communication device 106 by way of the wired connection interface 128. The second communication device 108 is connected to various sensor modules, such as the fifth through eighth sensor modules 104E-104H, for receiving the second sensor data. Further, the second communication device 108 transmits the second sensor data to the first communication device 106 by way of the wired connection interface 128. The second communication device 108 is not equipped with a wireless transceiver, such as the wireless transceiver 126, and hence it is unable to communicate with the third communication device 110 wirelessly. In an embodiment, the second communication device 108 receives power signals from the powering device (not shown). The second communication device 108 includes a second processor 116B, a second memory 118B, fifteenth and sixteenth connectors 120C and 120D, seventeenth through twentieth connectors 122E-122H, and a second bus 124B. The second processor 116B executes instructions stored in the second memory 118B for receiving and processing the second sensor data. The second memory 118B stores configuration details of the fifth through eighth sensor modules 104E-104H that are connected to the second communication device 108. In an embodiment, the second memory 118B also stores the second sensor data received from the fifth through eighth sensor modules 104E-104H. The fifteenth and sixteenth connectors 120C and 120D connect the second communication device 108 with the first communication device 106 and the powering device (not shown), respectively. The seventeenth through twentieth connectors 122E-122H are connection interfaces that enable the second communication device 108 to connect to the fifth through eighth sensor modules 104E-104H. The second bus 124B enables the second processor 116B to communicate with the fifth through eighth sensor modules 104E-104H and the first bus 124A of the first communication device 106 by way of the seventeenth through twentieth connectors 122E-122H and the fifteenth connector 120C, respectively.

[0032] It will be apparent to a person skilled in the art that the second processor 116B, the second memory 118B, the fifteenth and sixteenth connectors 120C and 120D, the seventeenth through twentieth connectors 122E-122H, and the second bus 124B are functionally similar to the first processor 116A, the first memory 118A, the ninth and tenth connectors 120A and 120B, the eleventh through fourteenth connectors 122A-122D, and the first bus 124A, respectively. Further, the scope of the second communication device 108 is not limited to be

connected to the fifth through eighth sensor modules 104E-104H, as shown in FIG. 1. In another embodiment, the second communication device 108 may be further connected to another network node that is functionally and structurally similar to the second communication device 108.

[0033] The third communication device 110 is a network gateway that provides system interoperability by performing one or more operations, such as protocol conversion. The third communication device 110 acts as an intermediary device that receives the first and second sensor data from the first communication device 106 and transmits the first and second sensor data to a remote server (not shown) through the internet or any other communication network. In an embodiment, the third communication device 110 processes the first and second sensor data for transmission. For example, the third communication device 110 performs protocol conversion on the first and second sensor data for transmission. Examples of the third communication device 110 include, but are not limited to, a mobile phone, a smartphone, a personal digital assistant (PDA), a tablet, a phablet, a laptop, a computer, or any other wireless communication device.

[0034] The mobile computing device 112 is a communication device of a user (not shown). The user may use the mobile computing device 112 to activate the first through ninth sensors 102A-102I for generating the first and second sensor data. In one example, the user may tap the mobile computing device 112 with the first communication device 106 for activating the first through fifth sensors 102A-102E and the second communication device 108 for activating the sixth through ninth sensors 102F-102I. In another example, the user may tap the mobile computing device 112 with the first communication device 106 for activating the first through ninth sensors 102A-102I. The mobile computing device 112 may communicate with the first or second communication device 106 or 108 by way of a short-range communication technology, such as Bluetooth low energy (BLE), Bluetooth, infrared, or Zigbee. Examples of the mobile computing device 112 include, but are not limited to, a mobile phone, a smartphone, a personal digital assistant (PDA), a tablet, a phablet, or any other portable communication device.

[0035] In operation, based on the operational requirements, the first through fourth sensor modules 104A-104D are connected to the first communication device 106 by way of the eleventh through fourteenth connectors 122A-122D and the first through fourth connectors

114A-114D. The eleventh through fourteenth connectors 122A-122D receive the first through fourth connectors 114A-114D, respectively. Further, the second communication device 108 is connected to the first communication device 106 by means of a daisy-chain connection between the ninth and fifteenth connectors 120A and 120C by way of the wired connection interface 128. The daisy-chain connection between the first communication device 106 and the second communication device 108 enables the first communication device 106 to expand a count of sensor modules that can be connected to the first communication device 106. For example, without the daisy-chain connection the first communication device 106 can accommodate a count of sensor modules, such as the first through fourth sensor modules 104A-104D, which is equal to a count of connectors, such as the eleventh through fourteenth connectors 122A-122D. However, the first communication device 106 expands the count of sensor modules it can accommodate by establishing the daisy-chain connection with the second communication device 108. Further, the fifth through eighth sensor modules 104E-104H are connected to the second communication device 108 by way of the seventeenth through twentieth connectors 122E-122H and the fifth through eighth connectors 114E-114H. The seventeenth through twentieth connectors 122E-122H receive the fifth through eighth connectors 114E-114H, respectively.

[0036] The first through eighth sensor modules 104A-104H automatically register and configure to the first and second processors 116A and 116B. During configuring, each of the first through eighth sensor modules 104A-104H transmit information pertaining to a type of sensors that are connected to the corresponding sensor module and a type of sensor data that is generated by the corresponding sensors to the first and second processors 116A and 116B. For example, the first sensor module 104A transmits information to the first processor 116A that the first sensor 102A is a temperature sensor and the first sensor data generated by the first sensor 102A is temperature data. In one embodiment, the first through eighth sensor modules 104A-104H further transmit control information for controlling the sensor data, such as the first and second sensor data, to the first and second processors 116A and 116B.

[0037] In one embodiment, the first and second communication devices 106 and 108 are enabled with one-tap connection facility for activating the first through ninth sensors 102A-102I. Thus, a user (not shown) taps the mobile computing device 112 with the first and second communication devices 106 and 108 to activate the first through ninth sensors 102A-102I. In

another embodiment, the first through ninth sensors 102A-102I are activated automatically, when the corresponding sensor modules are connected to the first or second communication device 106 or 108. For example, the first sensor 102A is activated automatically, when the first sensor module 104A is connected to the first communication device 106. After the activation, the first through fifth sensors 102A-102E generate the first sensor data and the sixth through ninth sensors 102F-102I generate the second sensor data.

[0038] The first through fourth sensor modules 104A-104D receive the first sensor data from the first through fifth sensors 102A-102E and the fifth through eighth sensor modules 104E-104H receive the second sensor data from the sixth through ninth sensors 102F-102I. The first through eighth sensor modules 104A-104H convert the first and second sensor data to a format that is compatible with the first and second communication devices 106 and 108. The communication bus of each of the fifth through eighth sensor modules 104E-104H communicates with the second bus 124B by way of the fifth through eighth connectors 114E-114H and the seventeenth through twentieth connectors 122E-122H to transmit the second sensor data to the second processor 116B. Thus, the second processor 116B receives the second sensor data by way of the second bus 124B.

[0039] The communication bus of each of the first through fourth sensor modules 104A-104D communicates with the first bus 124A by way of the first through fourth connectors 114A-114D and the eleventh through fourteenth connectors 122A-122D to transmit the first sensor data to the first processor 116A. Further, the second bus 124B communicates with the first bus 124A by way of the ninth and fifteenth connectors 120A and 120C to transmit the second sensor data to the first processor 116A. Hence, the first processor 116A receives the first and second sensor data by way of the first bus 124A. The first processor 116A processes the first and second sensor data and transmits it to the third communication device 110 by using the wireless transceiver 126. The third communication device 110 further processes the first and second sensor data and transmit it to a remote server (not shown) over the internet or any other communication network.

[0040] In an embodiment, based on the operational requirements, one or more of the first through eighth sensor modules 104A-104H may not be connected to the first and second communication devices 106 and 108. In an embodiment, the first communication device 106, the second communication device 108, the first through eighth sensor modules 104A-104H, and the

first through ninth sensors 102A-102I are pre-configured to automatically set-up in a hierarchical architecture, when a connection is established among them. It will be apparent to a person skilled in the art that the scope of the first and second communication devices 106 and 108 is not limited to have four connectors, *i.e.*, the eleventh through fourteenth connectors 122A-122D and the seventeenth through twentieth connectors 122E-122H, respectively. In another embodiment, the first and second communication devices 106 and 108 can have any number of connectors. Further, the wireless communication system 100 may include a plurality of first and second communication devices including the first and second communication devices 106 and 108, respectively, without deviating from the scope. In an embodiment, the ninth, tenth, fifteenth, and sixteenth connectors 120A, 120B, 120C and 120D are different from the eleventh through fourteenth connectors 122A-122D and the seventeenth through twentieth connectors 122E-122H.

[0041] Thus, the wireless communication system 100 provides a scalable solution to manage operational requirements of various segments. Unlike, conventional wireless communication systems which offer fixed multifunction capabilities by pre-installing multiple sensors on a single PCB, the wireless communication system 100 allows various types of sensor modules, such as the first through eighth sensor modules 104A-104H, each hosting different sensors to be connected to the first and second communication devices 106 and 108 based on the operational requirements. Thus, only those sensor modules, such as the first through eighth sensor modules 104A-104H, which meet the operational requirements, need to be connected. The eleventh through fourteenth connectors 122A-122D and the seventeenth through twentieth connectors 122E-122H of the first and second communication devices 106 and 108, respectively, support the plug-and-play connection interface which enables the first through eighth sensor modules 104A-104H to be connected to the first and second communication devices 106 and 108 at any time instant without affecting other operations. Hence, the wireless communication system 100 is flexible and offers multifunction capabilities. Further, the capability of the first and second communication devices 106 and 108 to accommodate multiple sensor modules, such as the first through eighth sensor modules 104A-104H, enables the wireless communication system 100 to meet changing operational requirements without re-designing and re-deploying the first and second communication devices 106 and 108.

[0042] In the wireless communication system 100, the second communication device 108, the first through eighth sensor modules 104A-104H, and the first through ninth sensors 102A-102I communicate with the first communication device 106 through the first and second buses 124A and 124B. Further, only the first communication device 106 is enabled to communicate wirelessly by using the wireless transceiver 126. Therefore, the wireless communication system 100 generates lesser environment noise in comparison to the conventional wireless systems in which various electronic devices transmit sensor data wirelessly to a network gateway. Since, the environment noise is less in the wireless communication system 100, data interference of the sensor data during transmission is also prevented, which in turn overcomes the requirement to re-transmit the sensor data. Hence, battery drainage due to re-transmission of the sensor data is also prevented which further leads to an increased lifespan of the first and second communication devices 106 and 108 in comparison to electronic devices of the conventional wireless systems.

[0043] Unlike the conventional wireless systems that are capable of hosting a fixed count of sensors, the wireless communication system 100 is scalable as the first communication device 106 expands a count of sensor modules it can accommodate by establishing the daisy-chain connection with the second communication device 108. The second communication device 108 can also be connected to another communication device (not shown) to further expand the count of sensor modules to be accommodated by the daisy-chain connection. In addition, the first and second buses 124A and 124B offers hot-swapping functionality to the first and second communication devices 106 and 108. Hence, the first through eighth sensor modules 104A-104H can be connected to the first and second communication devices 106 and 108 without shutting down their operations. Due to the plug-and-play connection interface of the first and second communication devices 106 and 108, troubleshooting of the wireless communication system 100 is easier in comparison to the conventional wireless systems. For example, in conventional wireless systems multiple sensors are pre-installed on a single PCB. Thus, a fault in one sensor can only be resolved by replacing the PCB, which in turn made troubleshooting very difficult and expensive. However, in the wireless communication system 100 if the first sensor 102A gets faulty, only the first sensor module 104A needs to be disconnected from the first communication device 106 by using the plug-and-play connection interface rather than replacing the first communication device 106. This makes troubleshooting in the wireless communication system

100 simpler and inexpensive. Further, in the wireless communication system 100, the first and second communication devices 106 and 108 are enabled with one-tap connection facility for activating the first through ninth sensors 102A-102I. The one-tap connection facility makes activation of the first through ninth sensors 102A-102I simple and less time consuming in comparison to manual activation of each individual sensor. Hence, the wireless communication system 100 improves the management of sensors, such as the first through ninth sensors 102A-102I, in comparison to the conventional wireless systems.

[0044] Referring now to FIG. 2A, a block diagram 200A that illustrates a front view of a first housing 202 of the first communication device 106 of the wireless communication system 100 of FIG. 1 in accordance with an embodiment of the present invention is shown. In an embodiment, the first housing 202 encloses the first communication device 106. For example, the first housing 202 encloses at least the first processor 116A, the first memory 118A, the first bus 124A, and the wireless transceiver 126. The first housing 202 has first through fourth slots 204A-204D for the eleventh through fourteenth connectors 122A-122D. In an embodiment, the first through fourth slots 204A-204D are parallel to each other and expose the eleventh through fourteenth connectors 122A-122D for communication with the first through fourth sensor modules 104A-104D. Each of the first through fourth slots 204A-204D supports a modular attachment of one sensor module, such as one of the first through fourth sensor modules 104A-104D. Further, the first housing 202 includes a covering 206 to enclose the wireless transceiver 126. The first housing 202 further includes fifth and sixth slots 208A and 208B for the ninth and tenth connectors 120A and 120B. The fifth and sixth slots 208A and 208B expose the ninth and tenth connectors 120A and 120B for communicating with the second communication device 108 and the powering device (not shown).

[0045] Referring now to FIG. 2B, a block diagram 200B that illustrates a second housing 210A of a sensor module, such as the first through eighth sensor modules 104A-104H, of the wireless communication system 100 of FIG. 1 in accordance with an embodiment of the present invention is shown. In one embodiment, the second housing 210A encloses the first sensor module 104A. Components of the first sensor module 104A are mounted on a PCB that is enclosed in the second housing 210A. The second housing 210A has a seventh slot 212 for the first connector 114A. Thus, the seventh slot 212 exposes the first connector 114A for

communicating with the first communication device 106. In an embodiment, the seventh slot 212 matches the first through fourth slots 204A-204D of the first housing 202 for attachment. In an embodiment, one or more sensors, such as the first through ninth sensors 102A-102I, are included in the second housing 210A. In another embodiment, the one or more sensors, such as the first through ninth sensors 102A-102I, are external to the second housing 210A. For example, the first sensor 102A is external to the second housing 210A and is connected to the first sensor module 104A by way of a wired connection interface.

[0046] Referring now to FIG. 2C, a block diagram 200C that illustrates an attachment among first through fourth housings 202, 210A, 210B and 214 in accordance with an embodiment of the present invention is shown. The third housing 210B is structurally and functionally similar to the second housing 210A and includes the eighth sensor module 104H. The third housing 210B has an eighth slot (not shown) for the eighth connector 114H. The fourth housing 214 of the second communication device 108 encloses the second processor 116B, the second memory 118B, and the second bus 124B. The fourth housing 214 has ninth through eleventh slots 204E-204G and a twelfth slot (not shown) for the seventeenth through twentieth connectors 122E-122H, respectively. Each of the ninth through eleventh slots 204E-204G and the twelfth slot supports a modular attachment of one sensor module, such as the fifth through eighth sensor modules 104E-104H. The fourth housing 214 further includes thirteenth and fourteenth slots 208C and 208D for the fifteenth and sixteenth connectors 120C and 120D of the second communication device 108.

[0047] In an embodiment, the second housing 210A is attached to the first housing 202 for connecting the first sensor module 104A to the first communication device 106. The first slot 204A receives the seventh slot 212 and thus, the first connector 114A is inserted into the eleventh connector 122A. Further, the fifth slot 208A exposing the ninth connector 120A and the thirteenth slot 208C exposing the fifteenth connector 120C are communicatively coupled by the wired connection interface 128 for establishing the daisy-chain connection between the first and second communication devices 106 and 108. The third housing 210B is attached to the fourth housing 214 for connecting the eighth sensor module 104H to the second communication device 108. The twelfth slot receives the eighth slot, and thus the eighth connector 114H is inserted into the twentieth connector 122H.

[0048] It will be apparent to a person skilled in the art that each of the second through seventh sensor modules 104B-104G is enclosed in a housing similar to the second or third housing 210A or 210B for attaching to the first or second communication device 106 and 108.

[0049] Referring now to FIG. 3, a block diagram that illustrates system architecture of a computer system 300 in accordance with an embodiment of the present invention is shown. An embodiment of present invention, or portions thereof, may be implemented as computer readable code on the computer system 300. In one example, the first through ninth sensors 102A-102I, the first through eighth sensor modules 104A-104H, the first through third communication devices 106-110, and the mobile computing device 112 of FIG. 1 may be implemented in the computer system 300 using hardware, software, firmware, non-transitory computer readable media having instructions stored thereon, or a combination thereof.

[0050] The computer system 300 includes a processor 302 that may be a special purpose or a general purpose processing device. The processor 302 may be a single processor, multiple processors, or combinations thereof. The processor 302 may have one or more processor “cores.” In one example, the processor 302 is an octa-core processor. In one embodiment, the processor 302 may correspond to the first or second processor 116A or 116B. Further, the processor 302 may be connected to a communication infrastructure 304, such as message queue, the first and second buses 124A and 124B, multi-core message-passing scheme, and the like. The computer system 300 further includes a memory 306. Examples of the memory 306 includes random access memory (RAM), read-only memory (ROM), a hard disk drive or a removable storage drive, such as a floppy disk drive, a magnetic tape drive, a compact disc, an optical disk drive, a flash memory, and the like. In an embodiment, the memory 306 may correspond to the first or second memory 118A or 118B.

[0051] The computer system 300 further includes an I/O port 308, a transceiver 310, and a communication interface 312. The I/O port 308 communicatively couples the computer system 300 to various input and output devices. Examples of the input devices may include a keyboard, a mouse, a joystick, a touchscreen, a microphone, and the like. Examples, of the output devices may include a display screen, a speaker, headphones, and the like. The transceiver 310 may allow the computer system 300 to transmit and receive data from various devices that are communicatively coupled to the computer system 300. In one embodiment, the transceiver 310 is

the wireless transceiver 126. The communication interface 312 may allow data to be transferred between the computer system 300 and various devices that are communicatively coupled to the computer system 300. Examples of the communication interface 312 may include, but are not limited to, a modem, a network interface, i.e., an Ethernet card, and a connector. In one embodiment, the communication interface 312 may correspond to the first through eighth connectors 114A-114H, the ninth and tenth connectors 120A and 120B, the eleventh through fourteenth connectors 122A-122D, the fifteenth and sixteenth connectors 120C and 120D, or the seventeenth through twentieth connectors 122E-122H. Data transferred via the communication interface 312 may correspond to signals, such as electronic, electromagnetic, optical, or other signals as will be apparent to a person skilled in the art. The signals may travel via a communications channel (not shown) which may be configured to transmit the signals to devices that are communicatively coupled to the computer system 300.

[0052] A person having ordinary skill in the art will appreciate that embodiments of the disclosed subject matter can be practiced with various computer system configurations, including multi-core multiprocessor systems, minicomputers, mainframe computers, computers linked or clustered with distributed functions, as well as pervasive or miniature computers that may be embedded into virtually any device. For instance, at least one processor such as the processor 302 and a memory such as the memory 306 implements the above described embodiments. Further, the operations may be described as a sequential process, however some of the operations may in fact be performed in parallel, concurrently, and/or in a distributed environment, and with program code stored locally or remotely for access by single or multiprocessor machines. In addition, in some embodiments the order of operations may be rearranged without departing from the spirit of the disclosed subject matter.

[0053] Techniques consistent with the present invention provide, among other features, apparatus and systems for wireless communication. While various exemplary embodiments of the disclosed system and method have been described above it should be understood that they have been presented for purposes of example only, not limitations. It is not exhaustive and does not limit the invention to the precise form disclosed. Modifications and variations are possible in light of the above teachings or may be acquired from practicing of the invention, without departing from the breadth or scope.

[0054] In the claims, the words ‘comprising’, ‘including’ and ‘having’ do not exclude the presence of other elements or steps than those listed in a claim. The terms “a” or “an,” as used herein, are defined as one or more than one. Unless stated otherwise, terms such as “first” and “second” are used to arbitrarily distinguish between the elements such terms describe. Thus, these terms are not necessarily intended to indicate temporal or other prioritization of such elements. The fact that certain measures are recited in mutually different claims does not indicate that a combination of these measures cannot be used to advantage.

[0055] While various embodiments of the present invention have been illustrated and described, it will be clear that the present invention is not limited to these embodiments only. Numerous modifications, changes, variations, substitutions, and equivalents will be apparent to those skilled in the art, without departing from the spirit and scope of the present invention, as described in the claims.

What is claimed is:

1. A modular system for wireless communication, comprising:
 - first and second sensors for generating first and second sensor data, respectively;
 - first and second sensor modules that are connected to the first and second sensors for receiving the first and second sensor data, respectively;
 - a first communication device that is connected to the second sensor module for receiving the second sensor data; and
 - a second communication device, wherein the second communication device comprises:
 - a first plurality of connectors including first and second connectors;
 - a communication bus that is configured to communicate with the first sensor module and the first communication device by way of the first and second connectors, respectively;
 - a processor that is configured to receive the first and second sensor data from the first sensor module and the first communication device, respectively, by way of the communication bus, and the first and second connectors; and
 - a wireless transceiver that is configured to transmit the first and second sensor data to a third communication device.
2. The modular system of claim 1, wherein the first communication device is connected to the second connector by way of a wired connection interface.
3. The modular system of claim 1, wherein the second communication device further comprises a first housing that encloses at least the communication bus, the processor, and the wireless transceiver, and wherein the first housing has a first plurality of slots for the first plurality of connectors.
4. The modular system of claim 3, wherein the first communication device comprises a second housing that has a second plurality of slots for a second plurality of connectors including third and fourth connectors.
5. The modular system of claim 3, wherein the first and second sensor modules are enclosed in second and third housings, respectively.

6. The modular system of claim 5, wherein the first sensor is included in the second housing.
7. The modular system of claim 5, wherein the first sensor is external to the second housing, and wherein the first sensor is connected to the first sensor module by way of a wired connection interface.
8. The modular system of claim 1, wherein the first communication device is a network node, and wherein the second communication device is a network hub, and wherein the third communication device is a network gateway.
9. The modular system of claim 1, wherein the processor is further configured to communicate with a mobile computing device over a wireless communication network for activating at least one of the first and second sensors.
10. The modular system of claim 1, wherein the communication bus is enabled with hot-swap functionality.
11. A modular apparatus for wireless communication, comprising:
 - a first plurality of connectors including first and second connectors;
 - a communication bus that is configured to communicate with a first sensor module and a first communication device by way of the first and second connectors, respectively;
 - a processor that is configured to:
 - receive first sensor data from the first sensor module by way of the communication bus and the first connector, wherein the first sensor module is connected to a first sensor for receiving the first sensor data, and wherein the first sensor generates the first sensor data; and
 - receive second sensor data from the first communication device by way of the communication bus and the second connector, wherein the first communication device is connected to a second sensor module for receiving the second sensor data, wherein the second sensor module is connected to a second sensor for receiving the second sensor data, and wherein the second sensor generates the second sensor data; and

a wireless transceiver that is configured to transmit the first and second sensor data to a second communication device.

12. The modular apparatus of claim 11, wherein the first communication device is connected to the second connector by way of a wired connection interface.
13. The modular apparatus of claim 11, further comprising a first housing that encloses at least the communication bus, the processor, and the wireless transceiver, wherein the first housing has a first plurality of slots for the first plurality of connectors.
14. The modular apparatus of claim 13, wherein the first communication device comprises a second housing that has a second plurality of slots for a second plurality of connectors including third and fourth connectors.
15. The modular apparatus of claim 13, wherein the first and second sensor modules are enclosed in second and third housings, respectively.
16. The modular apparatus of claim 15, wherein the first sensor is included in the second housing.
17. The modular apparatus of claim 15, wherein the first sensor is external to the second housing, and wherein the first sensor is connected to the first sensor module by way of a wired connection interface.
18. The modular apparatus of claim 11, wherein the second communication device is a network node, and wherein the second communication device is a network gateway.
19. The modular apparatus of claim 11, wherein the processor is further configured to communicate with a mobile computing device over a wireless communication network for activating at least one of the first and second sensors.
- 20.** The modular apparatus of claim 11, wherein the communication bus is enabled with hot-swap functionality.