

WIRELESS RELAY MODULE FOR MONITORING NETWORK STATUS

RELATED APPLICATION

[001] This application is a continuation-in-part application of co-pending U.S. Patent Application Ser. No. 13/241,620 entitled "Wireless Relay Module for Remote Monitoring Systems" filed September 23, 2011, which is a continuation-in-part application of co-pending U.S. Patent Application Ser. No. 13/006,769 entitled "Wireless Relay Module for Remote Monitoring Systems" filed January 14, 2011, each of which shares an assignee-in-common with the present application and is incorporated by reference in its entirety herein for all purposes. This application is also related to U.S. Application Ser. No. 13/006,784, entitled "Medical Device Wireless Network Architectures" filed January 14, 2011, which shares an assignee-in-common with the present application is incorporated by reference in its entirety herein for all purposes.

FIELD OF THE INVENTION

[002] The present application is directed to a wireless relay module for communicating between a series of medical devices and remote monitoring devices, and more particularly, to a wireless relay module for receiving communications from and transmitting communications to medical devices via one or more wireless relay networks, for transferring the communications received from the remote monitoring devices via one or more internet-accessible wireless communications networks, and for monitoring the status of the networks.

BACKGROUND OF THE INVENTION

[003] In critical care and home care health service centers including hospitals, clinics, assisted living centers and the like, care giver-patient interaction time is at a premium. Moreover, response times by care givers to significant health conditions and events can be critical. Systems of centralized monitoring have been developed to better manage care giver time and patient interaction. In such systems, physiological data from each patient is transmitted to a

centralized location. At this centralized location, a single or small number of technicians monitor all of this patient information to determine patient status. Information indicating a patient alarm condition will cause the technicians and/or system to communicate with local care givers to provide immediate patient attention, for example via wireless pagers and/or cell phones, and/or by making a facility-wide audio page.

[004] Implementing such centralized monitoring systems using wireless networks may present a number of difficulties. In order to effectively monitor patient status using information provided by a variety of medical devices that may be dynamically assigned to patients in a variety of rooms and on a variety of floors in a facility, it would be desirable to establish communications between the medical devices and the centralized location by means of a local area network such as, for example, a “WiFi” network based on IEEE 802.11 standards. However, as such networks are typically already in place in facilities to support a variety of other functions (for example, physician access to electronic medical records (EMRs), facility administrative systems and other functions), it is often undesirable to secure sufficient local area network access for the purpose of providing centralized monitoring. Moreover, when a patient is located remotely from a critical care health service center (for example, at home), access to traditional local area network facilities such as a WiFi network may be unavailable or not sufficiently reliable to support critical care monitoring applications.

[005] As an alternative to conventional WiFi or IEEE 802.11-based local area networks, ZIGBEE networks based on the IEEE 802.15.4 standard for wireless personal area networks have been used for collecting information from a variety of medical devices in accordance with IEEE 11073 Device Specializations for point-of-care medical device communication, including for example pulse oximeters, blood pressure monitors, pulse monitors, weight scales and glucose meters . See, e.g., *ZIGBEE Wireless Sensor Applications for Health, Wellness and Fitness*, the ZIGBEE Alliance, March 2009, which is incorporated by reference herein in its entirety. ZIGBEE networks provide the advantage of being dynamically configurable, for example, in “self-healing” mesh configurations, and operating with low power requirements (enabling, for example, ZIGBEE transceivers to be integrally coupled to the medical devices under battery power). However, transmission ranges between individual ZIGBEE transceivers are generally limited to no more than several hundred feet. As a consequence, such networks are unusable for centralized monitoring locations located off-site.

Also, in accordance with applicable patient data privacy provisions of the Health Insurance Portability and Accountability Act of 1996 (HIPAA), communication of information between the monitored medical devices and the central monitoring location must be done securely.

SUMMARY OF THE INVENTION

[006] The present invention is directed to a wireless relay module for providing networked communications between a series of medical devices and remote monitoring devices. In accordance with an embodiment of the invention, one or more medical devices (including but not limited to including for example, respirators, enteral feeding devices, pulse oximeters, blood pressure monitors, pulse monitors, weight scales and glucose meters) are provided at a patient facility. An interface circuit is coupled to each medical device, and is configured for communicating with one of a plurality of the wireless relay modules via one of a plurality wireless relay networks. The wireless relay modules are advantageously further configured to communicate with a remote monitoring device over one or more internet-accessible wireless communication networks, and preferably, wireless wide-area networks (WWAN) such as a mobile telephone data network (including for example, based on a Global System for Mobile Communications (GSM) or Code Division Multiple Access (CDMA) cellular network or associated wireless data channels, or WiMAX networks). Also, for compliance for example with HIPAA regulations, communications over each of the wireless networks are preferably conducted securely using, for example, encryption of data and/or commands.

[007] Each of the wireless relay modules includes a receiver capable of wirelessly receiving medical device data from at least one medical device via the wireless relay network, a first transmitter capable of wirelessly transmitting medical device data to another one of the wireless relay modules over the wireless relay network, a second transmitter capable of wirelessly transmitting data over an internet-accessible wireless communications network, and a controller coupled to the first and second transmitters. "Medical device data" as generally used herein means data from or about the medical device including, for example, medical device identification, medical device software, medical device settings or status information (including alarm information and/or alarm priority), patient identification information, patient personal identification number(s) "PIN(s)", patient prescriptions, and/or patient medical and/or

physiological data as is collected, produced and/or generated by at least one of the medical device and patient identification device; as well as wireless relay network information such as location or status information.

[008] The controller is configured to facilitate communication and management of information transfer. For example, a first status module can determine an access status of the internet-accessible wireless communications network, and the controller can select one of the first or second transmitters based on that status and routing criteria. A second status module can determine a status of communications over the wireless relay module. For example, when the status indicates that the internet-accessible wireless communications network is accessible to the wireless relay module, the controller in accordance with the status selects the second transmitter for transmitting medical device data via the internet-accessible wireless communications network.

[009] When the status indicates that the internet-accessible wireless communications network is not accessible to the wireless relay module, the controller selects the first transmitter for transmitting the medical device data to another wireless relay module. The another or second wireless relay module may then access the internet-accessible wireless communications network. In this manner, another attempt to transmit the medical device data over one of the internet-accessible wireless communication networks can be made by this another wireless relay module (and potentially additional ones of the wireless relay modules) until a successful transmission over the internet-accessible wireless communications network is achieved. It should be understood that, consistent with the aspects described within the present disclosure, additional receivers and transmitters may be employed in the module to communicate with different medical devices over different wireless relay networks.

[0010] Each of the plurality of wireless relay modules may also include additional receivers for receiving communications from the internet-accessible wireless communications networks.

[0011] Further consistent with one or more embodiments of the present invention, information indicative of a status of network communications of at least one of the wireless relay network and the internet-accessible wireless communications network can be transmitted to at least one of the medical devices and/or to a device in communication with one of the internet-accessible wireless communication networks. The wireless relay module may include a display

having an indicator of status of network communications. The display may further include an indicator of the status of accessibility of communications over the internet-accessible wireless communications network and/or an indicator representative of a status of the wireless relay network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] The invention will become more readily apparent from the Detailed Description of the Invention, which proceeds with reference to the drawings, in which:

[0013] FIG. 1 presents a block diagram of an exemplary medical device network architecture that incorporates a wireless relay module according to the present invention;

[0014] FIG. 2 presents a block diagram further illustrating exemplary wireless network components of the architecture according to FIG. 1;

[0015] FIG. 3(a) presents a schematic diagram illustrating an exemplary wireless relay module according to the present invention;

[0016] FIGs. 3(b)-3(d) present schematic diagrams respectively illustrating top, front and side views of an embodiment of the wireless relay module of FIG. 3(a);

[0017] FIG. 3(e) illustrates an exemplary control panel for the wireless relay module according to the present invention;

[0018] FIG. 4(a) - 4(d) present flow diagrams illustrating exemplary methods of operation for the wireless relay module according to the present invention;

[0019] FIG. 5 presents a flow diagram illustrating another exemplary method of operation for the wireless relay module according to the present invention;

[0020] FIG. 6 presents a schematic diagram illustrating an alternative exemplary wireless relay module to that depicted in FIG. 3(a) according to the present invention; and

[0021] FIG. 7 presents a flow diagram illustrating yet another exemplary method of operation for the wireless relay module according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0022] Reference will now be made in detail to exemplary embodiments for carrying out the invention. Examples of these exemplary embodiments are illustrated in the

accompanying drawings. While the invention is described in conjunction with these embodiments, it will be understood that it is not intended to limit the invention to the described embodiments. Rather, the invention is also intended to cover alternatives, modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

[0023] In the following description, specific details are set forth in order to provide a thorough understanding of the present invention. The present invention may be practiced without some or all of these specific details. In other instances, well-known aspects have not been described in detail in order not to unnecessarily obscure the present invention.

[0024] For the purpose of illustrating the present invention, exemplary embodiments are described with reference to FIGs. 1-7.

[0025] In this specification and the appended claims, the singular forms "a," "an," and "the" include plural references unless the context clearly dictates otherwise. Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs.

[0026] A diagram of an exemplary architecture 100 for a system for monitoring medical devices in accordance with the present invention is illustrated in FIG. 1. One or more medical devices 10 are provided at a patient facility 20 for monitoring the medical condition and/or administering medical treatment to one or more patients. Patient facility 20 may comprise a critical care health service center (for example, including hospitals, clinics, assisted living centers and the like) servicing a number of patients, a home facility for servicing one or more patients, or a personal enclosure (for example, a backpack) that may be attached to or worn by an ambulatory patient.

[0027] Associated with each medical device 10 is an interface circuit 15 that includes one or more of a transmitter and/or a receiver in the form of, for example, a transceiver, for respectively transmitting and receiving signals in a facility-oriented wireless network such as, for example, a Low-Rate Wireless Personal Area Networks or "LR-WPAN," ZIGBEE network or another low-power personal area network such as a low power BLUETOOTH network, existing or presently under development or consideration. See, e.g., Houda Labiod et al., *Wi-Fi, Bluetooth, Zigbee and WiMax*, Springer 2010, which is incorporated by reference herein in its entirety. It should be understood that interface circuit 15 may be contained within or disposed

external to medical device 10 in accordance with the present invention. Also provided within the patient facility 20 are one or more relay modules 30, 30a.

[0028] Each of the relay modules 30, 30a includes at least one transceiver configured to communicate with other relay modules 30, 30a in the wireless relay network 16. Relay modules 30a further include at least a second transceiver for communicating over the WWAN with the access point 40. As further described in greater detail with regard to FIG. 3(a), each module 30a includes a first transceiver 31 having a respective receiver and transmitter for receiving signals from and transmitting signals to the interface circuits 15 in one or more of the facility-oriented wireless networks. Each relay module 30a, as depicted in FIG. 3(a), further includes a second transceiver 32 having a respective receiver and transmitter for wirelessly transmitting signals to and receiving signals from an access point 40 via a wireless wide-area network or "WWAN".

[0029] Suitable WWANs for use with the present invention include, for example, networks based on a Global System for Mobile Communications (GSM) or Code Division Multiple Access (CDMA) cellular network or associated with the 2G, 3G, 3G Long Term Evolution, 4G, WiMAX cellular wireless standards of the International Telecommunication Union Radiocommunication Sector (ITU-R). See, e.g., Vijay Garg, *Wireless Communications & Networking*, Morgan Kaufmann 2007, which is incorporated by reference herein in its entirety. Additional suitable exemplary WWANs include metropolitan area networks (MANs), campus area networks (CANs), local area networks (LANs), home area networks (HANs), personal area networks (PANs) and body area networks (BANs). It should be readily understood that the relay module 30a may include additional transceivers for communicating with additional WWANs or additional facility-oriented wireless networks as described in greater detail with respect to FIG. 6.

[0030] For compliance with HIPAA regulations, communications over each of the facility-oriented wireless network and WWAN are preferably conducted securely using encryption based upon, for example, any of a Secure Sockets Layer (SSL) protocol and a Transport Layer Security (TLS) protocol.

[0031] As illustrated in FIG. 1, a suitable access point 40 useable with the present invention may include an inbound web server 41 that incorporates or otherwise has access to a transceiver (not shown) for communicating with the relay modules 30a over a particular

WWAN. Medical device data received by the inbound web server 41 over the WWAN is forwarded to a secure data storage server 42, which is configured for example to log the received data in association with identification information of the associated medical devices. "Medical device data" as generally used herein means data from or about the medical device including, for example, medical device identification, medical device software, medical device settings or status information (including alarm information and/or alarm priority), patient identification information, patient personal identification number(s) "PIN(s)", patient prescriptions, and/or patient medical and/or physiological data as is collected, produced and/or generated by at least one of the medical device and patient identification device; as well as wireless relay network information such as location or status information.

[0032] Referring once more to FIG. 1, an outbound web server 43 is configured, for example, to receive and qualify data retrieval requests submitted by one or more of remote monitoring devices 61, 62 and 63 over a broad-band network 50 (for example, over the Internet), to request associated medical device data to be retrieved from the secure data storage server 42, and to format and transmit the retrieved data or portion thereof to the one or more remote monitoring devices 61, 62 and 63 for display on associated device displays. It should be understood that any architecture for the access point 40 that enables the receipt, storage and retrieval of medical device data on a device display of the one or more remote monitoring devices 61, 62 and 63 is suitable for use in conjunction with the present invention. Variations of the exemplary architecture may involve utilizing a web server integrated with a data storage server.

[0033] FIG. 2 presents a block diagram that further illustrates exemplary components of the inventive architecture that are located within or otherwise associated with the patient facility 20. In FIG. 2, a number of interface circuits 15 and relay modules 30, 30a are arranged in a single wireless relay network 16 within the patient facility 20 for illustration purposes only. It should be understood that other interface circuits 15 and relay modules 30, 30a may communicate over other wireless relay networks similar to network 16 in the patient facility 20. In FIG. 2, the interface circuits 15 and relay modules 30, 30a are configured to communicate with one another via associated wireless links. In a preferred embodiment of the present invention represented in FIG. 2, the network 16 is a self-configurable mesh network and can also be a self-healing mesh network such as a ZIGBEE compliant-mesh network based on the IEEE

802.15.4 standard. However, the wireless relay network 16 or additional wireless relay networks in the patient facility may be organized according to a variety of other wireless local area network (WLAN) or WPAN formats including, for example, WiFi WLANs based on the IEEE 802.11 standard and BLUETOOTH WPANs based on the IEEE 802.15.1 standard.

[0034] In the illustrated wireless relay network 16, each of the interface circuits 15 includes a communications interface such as, for example, a wired communications interface, to an associated medical device 10. As previously stated, each of the relay modules 30, 30a includes at least one transceiver configured to communicate with other relay modules 30, 30a in the wireless relay network 16. Relay modules 30a further include at least a second transceiver for communicating over the WWAN with the access point 40.

[0035] The use of a ZIGBEE mesh network for network 16 provides the advantages of being self-configurable when one or more interface circuits 15 and/or relay modules 30, 30a are added to the network, and self-healing when one or more interface circuits 15 and/or relay modules 30, 30a are removed from or otherwise disabled in the network. Sub-groupings of the interface circuits 15 and relay modules 30, 30a may be provided in a defined geographic space (for example, on an individual floor or within a region of a floor in a multi-floor home or care facility).

[0036] FIG. 3(a) provides a block diagram illustrating exemplary components of relay module 30a. The relay module 30a of FIG. 3(a) includes a first transceiver 31 for wirelessly communicating with interface circuits 15 and other relay modules 30, 30a in the WLAN or WPAN network 16 of FIG. 2 via an antenna 31a. The relay module 30a further includes a second transceiver 32 for wirelessly communicating with the access point 40 over the WWAN via an antenna 32a. Each of the transceivers 31, 32 is in communication with a data processing circuit 33, which is configured to operate under the control of a controller, e.g., processor 34, to accept data received by the transceivers 31, 32 and store the received data in a memory such as buffer element 35a. In addition, the data processing circuit 33 is further configured to retrieve data from the buffer element 35a under the direction of the processor 34 and provide the retrieved data to a selected one of the transceiver 31 or transceiver 32 for transmission. In order to make a selection, the processor 34 is configured to communicate with respective status modules 31b, 32b of the transceivers 31, 32 in order to determine a communications status of each of the transceivers 31, 32. One or more of the data processing

circuit 33 and/or controller 34 may also preferably include commercially available encryption circuitry for encrypting data to be sent by the transceivers 31, 32 and to decrypt data received by the transceivers 31, 32, in accordance for example with HIPAA requirements.

[0037] The processor 34 is also preferably in communication with a memory 35b for storing an operating program of the processor 34 and/or data stored by and/or retrieved by the processor 34. The processor 34 is also in communication with an input/output circuit 36, which provides signals to one or more display elements of the relay module 30a, for example, for indicating a start-up or current status of the relay module 30a, including communication or connection status with the WLAN or WPAN network 16 and WWAN. Input/output circuit 36 may also be configured to provide signals to indicate an A/C power loss, and or to be responsive to signals provided by one or more input devices provided in proximity to the one or more display elements.

[0038] Relay module 30a may preferably be provided as a small physical enclosure with an integral power plug and power supply circuit, such that the relay module 30a may be directly plugged into and supported by a conventional wall outlet providing commercial alternating current AC power. Relay module 30a may also preferably include a subsystem battery back-up circuit (not shown) to provide uninterrupted power in the event of external power outage of short duration. Battery back-up may also be advantageous, for example, for using the relay module 30a in an ambulatory mode that enables the patient to move within and potentially at a distance from the facility 20. In this configuration of facility 20, for example, any of the medical device 10, the interface circuit 15 and relay module 30a may be conveniently carried in a mobile platform such as any patient-wearable backpack, vehicle or other transport vessel.

[0039] It is possible for the relay module 30 to have a substantially similar configuration as the relay module 30a but excluding the transceiver for communicating over the WWAN with the access point 40.

[0040] FIGs. 3(b)-3(d) respectively illustrate top, front and side views of an exemplary module configuration 37 for the relay module 30a. Configuration 37 includes a housing 37a, which is shown in FIGs. 3(b)-3(d) configured essentially as a rectangular box or prism. It should however be noted that the housing may alternatively be configured in any of a variety of three-dimensional shapes having a sufficient interior volume for housing the

associated circuits, having a sufficient area 37c on a front panel 37b of the housing 37a for locating a control panel 38 (as further illustrated in FIG. 3(e)), and having a sufficient area on a rear panel 37d for providing a receptacle support 37e and power plug 37f for supportably plugging the module configuration 37 into a conventional power outlet or socket. The power plug 37f may also be provided in a modular and replaceable removable configuration enabling power plugs 37f to be configured according to a variety of national or international standards.

[0041] FIG. 3(e) illustrates an exemplary control panel 38 of module configuration 37 that may constitute a portion of the one or more display elements. The exemplary control panel 38 preferably includes, for example, a power switch 38a for powering and/or de-powering the module configuration 37 after it has been connected to a power supply, e.g., plugged into the conventional wall outlet or equipped with a charged battery back-up subsystem. In addition, the control panel 38 preferably includes an alarm switch 38b which allows a user to mute and/or de-mute an audible alarm (for example, a conventional buzzer, bell or audible sound generator and associated loudspeaker, not shown) which is coupled to an alarm circuit (not shown) that is configured to issue an alarm, when, for example, external AC power to the module configuration 37 has been interrupted. The control panel 38 also includes one or more power indicators 38c which may preferably be provided as one or more light-emitting diode (LED) indicator segments which are activated when external power has been provided to the module configuration 37. Optionally, the indicator 38c may be intermittently or periodically activated when AC power is lost (for example, by means of back-up battery power) to signal the loss of AC power.

[0042] The exemplary control panel 38 of FIG. 3(e) also includes a battery indicator 38d to indicate a status of the subsystem battery back-up circuit. For example, and as illustrated in FIG. 3(e), the battery indicator 38d may preferably include indicator segments 38h which may be selectively activated to indicate a capacity of the back-up battery. Indicator segments 38h may also be preferably provided as LED segments, or as one or more multicolor LEDs for which color is indicative of capacity. If implemented as individual segments 38h, the segments 38h may, for example, be activated to indicate that the back-up battery is fully charged, and ones of the segments 38h may be progressively deactivated (for example, proceeding downwardly from an uppermost one of the segments 38h) as battery power is drawn down. In the event that remaining battery power is insufficient to operate the module configuration 37,

each of the segments 38h may be deactivated. Alternatively, the indicator segments 38h may be provided as one or more multicolor LED segments (for example, red, yellow and green). In operation, it is possible for all LED segments 38h to be illuminated as green indicated a full backup battery charge and then progressively, sequentially deactivated as battery charge levels are reduced to a first low power threshold. Then, the LED segments 38h may progressively, sequentially illuminated red as power is further diminished so that all LED segments are illuminated red when battery power is no longer sufficient to power the module configuration 37.

[0043] As further illustrated in FIG. 3(e), the control panel 38 may further include a relay module network indicator 38e to indicate a status of the portion of the WLAN or WPAN network 16 used to provide communications between the relay module 30a and its associated interface circuits 15 and medical devices 10. This relay module network status indicator 38e is preferably backlit with one or more multi-color LEDs to indicate a relative “health” of the associated portion of the network (for example, using “green” to indicate a healthy(e.g., level of accessibility) network, “yellow” to indicate a network having one or more issues but still operable, and “red” to indicate a network that is inoperative and indicating an alarm condition). Optionally, the indicator element 38e may be intermittently or periodically activated when the portion of the WLAN or WPAN network 16 that provides communications between the relay module 30a and its associated interface circuits 15 and medical devices 10 has relatively poor communications between these devices, or is unavailable to support such communications. In addition, an audible alarm (for example, a conventional buzzer, bell or audible sound generator and associated loudspeaker, not shown) may be initiated under such conditions.

[0044] Indicator elements 38f may also be provided, for example, in an array to indicate the status of individual communications with medical devices 10 and or other relay modules 30, 30a. For example, the indicator elements may preferably be provided with multi-color LEDs 38g capable, for example, of illuminating a green segment for a healthy a communications path, a yellow segment for operative communication path with issues, and a red segment to indicate a communications path that is inoperative. Alternatively, individual red, yellow and green LEDs may be used in place of the multi-color LEDs.

[0045] A WWAN indicator 38j may preferably be provided to indicate a status of access to the WWAN network (using “green” to indicate a healthy network, “yellow” to indicate a network having one or more issues but still operable, and “red” to indicate a network that is

inoperative and indicating an alarm condition). As depicted in FIG. 3(e), the indicator 38j may preferably be backlit with one or more multicolor LEDs. Optionally, the indicator element 38j may be intermittently or periodically activated, for example, when a signal strength of the WWAN network available to the module configuration 37 is too low to support communications, or is unavailable to support such communications. In addition, the audible alarm may be initiated under such conditions.

[0046] Finally, the control panel may include a WLAN/WPAN indicator 38i to indicate an overall health of the entire WLAN/WPAN (or at least of the portion available to provide an alternate path for the relay module 30a to the WWAN network). The WLAN/WPAN indicator 38i may preferably indicate an overall status of the WLAN/WPAN (using “green” to indicate a healthy network, “yellow” to indicate a network having one or more issues but still operable, and “red” to indicate a network that is inoperative and indicating an alarm condition). As depicted in FIG. 3(e), the indicator 38i may preferably be backlit with one or more multicolor LEDs. Optionally, the indicator element 38i may be intermittently or periodically activated when the signal strength of the WLAN network available to the module configuration 37 is too low or insufficient to support communications. In addition, the audible alarm may be initiated under such conditions.

[0047] As previously indicated, the alarm switch 38b may be configured to allow a user to mute and/or un-mute one or more of the audible alarms entirely, or for a specified time period (similarly to a conventional clock alarm “snooze function) indicators of the module configuration 37 such as indicators 38a-38j may preferably be electrically connected to the input-output circuit 36 depicted in FIG. 3(a).

[0048] In addition, it is possible for the wireless relay module 30a to employ, for example, hardware or software to implement an International Telecommunication Standardization Sector (ITU-T) H.323 codec to enable voice and/or video communications between a caregiver located proximate the wireless relay module and a remote technician. In such an embodiment, the wireless relay module control panel 38 may optionally include microphone and speaker elements (not shown) coupled to the codec for enabling the module configuration 37 to be operated in a voice communication mode to allow for voice communication, for example, between the caregiver and a help desk technician in event of a trouble condition reported by one of the medical devices 10. Alternatively or in addition, the

control panel 38 may include one or more of a camera element (not shown) and/or a display element (not shown) coupled to the codec to be operated in a visual communication mode. For example, the camera element may be used to transfer images from displays of one or more medical devices 10 to one of the remote monitoring devices 61, 62 and 63 of FIG. 1.

[0049] FIG. 4(a) presents a flow diagram 400 illustrating an exemplary method of operation for the architecture according to FIG. 1 and relay module 30, 30a components of FIGs. 2 and 3(a), relating to the transmission of medical device data obtained from a medical device 10 to the access point 40. First, at step 402 of the method 400, the medical device data is received at a first one of the relay modules 30a from one of the interface circuits 15 and/or other relay modules 30, 30a over the wireless relay network 16. At step 404, the processor 34 of the one relay module 30a determines whether the WWAN is accessible by that relay module 30a.

[0050] The determination of step 404 may be carried out in a variety of manners. For example, the processor 34 may interrogate the status module 32b of the transceiver 32 at the time of or after the receipt of the medical device data to determine a status parameter indicative of access for the transceiver 32 to the WWAN (for example, access for transceiver 37 to the WWAN may be determined as the result of the transceiver 32 detecting an access signal of the WWAN having sufficient signal strength for maintaining data communication at a desired quality level). Alternatively, the processor 34 may interrogate the status module 32b at a different time including, for example, at system start-up and/or periodically (for example, hourly), and maintain a status indicator such as in the buffer 35a or another storage element to be retrieved at the time of or after receipt of the medical device data. In yet another alternative, the relay module 30, 30a may be assigned a predetermined, fixed role within the network 16. For example, relay modules 30a in the network 16 may be assigned a data routing assignments by a controller or controlling relay module or modules. By definition, the WWAN status for relay module 30 that does not possess WWAN access capability shall have a fixed status of "WWAN inaccessible."

[0051] If, as provided for in step 404, the status module 32b indicates that the WWAN is accessible by the transceiver 32, the processor 34 will proceed to step 406 to instruct the data processing circuit 33 of the relay module 30a to retrieve the medical device data from the buffer 35a (as necessary) and forward the medical device data to the transceiver 32 for transmission to the access point 40 over the WWAN.

[0052] Alternatively, in step 404, the status module 32b may indicate that the WWAN is not accessible by the transceiver 32. For example, if the relay module 30a is located on a basement floor of the building in an area that is substantially shielded with respect to WWAN signals, the WWAN may not be accessible to the one relay module 30a. In this event, at step 408, the processor 34 determines whether a second relay module 30a is accessible via the WLAN or WPAN. Again, this determination may be made in a variety of manners including by instructing the transceiver 31 to send a handshake signal transmission directed to a second relay module 30a and to listen for a reply therefrom, or by retrieving a stored status indicator for the second relay module 30a.

[0053] If the second relay module 30a is accessible, then the processor 34 instructs the data processing circuit 33 of the one relay module 30a to retrieve the medical device data from the buffer 35a (as necessary) and forward the medical device data to the transceiver 31 for transmission to the second relay module 30a over the WLAN or WPAN at step 410. Alternatively, if the second relay module 30a is inaccessible in step 408, this portion of the process 400 may preferably be repeated to search for a further relay module 30a that is accessible. Alternatively, or in the event that no other relay module 30a is available, the processor 34 of the one relay module 30a may preferably issue an alarm notification at step 412. Exemplary alarm notifications may include, for example, (i) one or more of local visual and audio alarms as directed by processor 34 via the input/output circuit 36 of the one relay module 30a, (ii) alarm messages directed by the processor 34 to another accessible WPAN, WLAN or WWAN via one or more of the transceivers 31, 32, and/or (iii) alarm messages generated by the the inbound web server 41 of the access point 40 of FIG. 1 after a specified time period has been exceeded during which a handshake signal of the relay module 30a is due, but not received, at the inbound web server 41 from the wireless relay module 30a.

[0054] As previously described with reference to the control panel 38 of the relay module configuration 37 of FIG. 3(e), the relay module 30a is preferably provided with a relay module network indicator 38e to indicate a status of the portion of the WLAN or WPAN network 16 of FIGs. 1, 2 used to provide communications between the relay module 30a and its associated interface circuits 15 and medical devices 10. FIG. 4(b) presents a flow diagram illustrating an exemplary method of operation 420 for generating the status information needed by network indicator 38e of FIG. 3(e).

[0055] At steps 421, 422 of FIG. 4(b), the processor 34 of FIG. 3(a) is instructed to retrieve a current module performance measure or history, for example, from the memory 35b for each medical device 15 accessible to the relay module 30a via the WLAN/WPAN network 16. Performance measures may, for example, include a measured signal strength, noise, bit rate, error rate, packet discard rate, occupancy, availability and the like as are conventionally measured for WLAN/WPAN networks. See, e.g., Pinto, *WMM - Wireless Mesh Monitoring*, Technical Report, INESC-ID, 2009, which is incorporated by reference in its entirety herein for all purposes. Measured performance may in addition take certain environmental information into account. For example, relatively elevated ambient operating temperature of the relay module 30a, and the like, which may lead to possible corruption of data from the medical device caused by such elevated ambient temperature.

[0056] At step 423, if the performance history is not sufficiently current (for example, as indicated by timestamp data) and/or missing, the processor 34 at step 424 employs conventional means in the transceiver 31 (for example, via status module 31b) to obtain current performance measures by transmitting a request to and receiving current performance data from the interface circuit 15 of the associated medical device 10, and preferably stores the current performance measures as part of the performance history in the memory 35b. Currency may preferably be determined according to system performance, regulatory and/or other requirements for individual performance measures in prescribed time intervals (for example, for an interval older than 5 seconds, older than 1 minute, older than the most recent each hour, or the like), which may be stored in the memory 35b for retrieval and reference by the processor 34.

[0057] After determining at steps 423 and 425 that current performance data has been obtained for each medical device accessible to the relay module 30a, the processor 34 at step 426 determines a current module status as a function of the current performance data and the performance history. For example, if the current performance data indicate that each medical device 10 is currently accessible to the relay module 30a, the module performance history indicates that the medical devices have been consistently accessible to the relay module 30a for a predetermined time (for example, over a period of several hours), and throughput and/or occupancy are within predetermined limits, the processor 34 may determine that the wireless relay network 16 is "healthy" (indicated, for example, at step 427 by illuminating a green LED segment of indicator 38e).

[0058] If the current performance data indicate that each medical device 10 is currently accessible to the relay module 30a, but one or more of the devices 10 have a recent performance history where one or more of throughput and/or occupancy were outside of the predetermined limits, the processor 34 may determine a status of “partially accessible” (indicated, for example, at step 427 by illuminating a yellow LED segment of indicator 38 e). If one or more of the medical devices 10 are presently inaccessible to the relay module 30a, the processor 34 may determine a status of “inaccessible” (indicated, for example, at step 427 by illuminating a red LED segment of indicator 38 e). At step 428, it may be determined by the processor 34 for example in view of “partially accessible” or “inaccessible” statuses that an alarm condition has been generated, causing the processor 34 to present an alarm (for example, by causing the yellow or red LED segments to be illuminated in a blinking fashion, and/or by providing one or more audible alarms as previously described. As an alternative to displaying display status information at step 427, the processor 34 may cause the transceiver 31 to transmit the status information to one or more of the medical devices 10, or may cause the transceiver 32 to transmit the status information to a device in communication with the WWAN.

[0059] With further reference to FIG. 1, FIG. 3(e), FIG. 4(c) presents a flow diagram illustrating an exemplary method of operation 440 for generating the status information indicated by WWAN indicator 38j of FIG. 3(e). At steps 441, 442 of FIG. 4(c), the processor 34 of FIG. 3(a) retrieves a WWAN performance history, for example, from the memory 35b as to the status of the WWAN network 44. Performance measures may, for example, include a measured signal strength, noise, bit rate, error rate, call set up time, dropped call rate, occupancy and network availability and the like as are conventionally measured for WWAN/cellular networks for example, via the status module 32b of FIG. 3(a)). See, e.g., Mike P. Wittie, et al., *MIST: Cellular Data Network Measurement for Mobile Applications*, Broadband Communications, Networks and Systems Fourth International Conference, IEEE, 2007, which is incorporated by reference in its entirety herein for all purposes. At step 443, if the performance history is not sufficiently current (for example, as indicated by timestamp data), the processor 34 at step 444 employs conventional means in the transceiver 32 to obtain current performance measures by transmitting a request to and receiving data from the access point 40 of FIG. 1, and preferably stores the current performance measures as part of the performance history in the memory 35b. Alternatively, if the access point 40 and/or another device in communication with

the WWAN 44 collects performance measurement data for the WWAN, the transceiver 32 may transmit a request to the access point 40 and/or other device to retrieve the performance data.

[0060] After determining at step 443 that the WWAN performance data is current, the processor 34 at step 445 determines a current WWAN status as a function of the current performance data and the performance history. For example, if the current performance data indicate that the WWAN 44 is currently accessible to the relay module 30a, the module performance history indicates that the WWAN 44 has been accessible to the relay module 30a for a predetermined time (for example, several hours), and throughput and/or occupancy are within predetermined limits, the processor 34 may determine that the WWAN 44 is “healthy” (indicated, for example, at step 446 by illuminating a green LED segment of the WWAN indicator 38j).

[0061] If the current performance data indicate that the WWAN 44 is currently accessible to the relay module 30a, but has a history where one or more of throughput and/or occupancy was outside of the predetermined limits, the processor 34 may determine a status of “partially accessible” (indicated, for example, at step 446 by illuminating a yellow LED segment of the WWAN indicator 38j).

[0062] If the WWAN 44 is presently inaccessible to the relay module 30a, the processor 34 may determine a status of “inaccessible” (indicated, for example, at step 446 by illuminating a red LED segment of the WWAN indicator 38j). At step 447, which may be performed before or concurrently with step 446, it may be determined by the processor 34 for example in view of “partially accessible” or “inaccessible” statuses that an alarm condition has been generated, causing the processor 34 to present an alarm (for example, by causing the yellow or red LED segments to be illuminated in a blinking fashion, and/or by providing one or more audible alarms as previously described. As an alternative or in addition to displaying display status information at step 446, the processor 34 may cause the transceiver 31 to transmit the status information to one or more of the medical devices 10, or may cause the transceiver 32 to transmit the status information to a device in communication with the WWAN.

[0063] With reference once again to FIG. 3(e), FIG. 4(d) presents a flow diagram illustrating an exemplary method of operation 460 for generating the status information needed by WLAN/WPAN indicator 38i of FIG. 3(e) to indicate an overall health of the entire WLAN/WPAN (or at least of the portion available to provide an alternate path for the relay

module 30a to the WWAN network). At steps 461, 462 and 464 of FIG. 4(d), the processor 34 of FIG. 3(a) retrieves current module performance history from the memory 35b for communications with each other relay module that is accessible to the relay module 30a via the WLAN/WPAN network 16 ("neighbor module").

[0064] As previously described, performance measures may, for example, include a measured signal strength, noise, bit rate, error rate, occupancy, availability, path usage and the like as are conventionally measured for WLAN/WPAN networks (using, for example, the status module 31b of FIG. 3(a)). In addition, at step 463, the processor operates the transceiver 31 to request that each neighbor module provide a WWAN status (prepared, for example, according to the method described with reference to FIG. 4(c)).

[0065] At step 465, if the performance history relative to the neighbor modules is not sufficiently current (for example, as indicated by timestamp data) and/or missing, the processor 34 at step 466 employs conventional means in the transceiver 31 to obtain current performance measures by transmitting data to and receiving data from the neighbor modules, and preferably stores the current performance measures as part of the performance history in the memory 35b. In addition, current performance measures may be obtained with respect to other neighboring devices, for example, having known or discernible performance (for example, network "beacons").

[0066] After determining at step 467 that current performance data has been obtained for each neighbor module accessible to the relay module 30a, the processor 34 at step 468 determines a current module status as a function of the current neighbor module performance data (including neighbor module WWAN status) and the neighbor module performance history. For example, if the current performance data indicate that each neighbor module 30a is currently accessible to the relay module 30a and has a WWAN status of "accessible", the module performance history indicates that the neighbor modules 30a have been accessible to the relay module 30a for a predetermined period of time, and throughput and/or occupancy are within predetermined limits, the processor 34 may determine a status of "fully accessible" (indicated, for example, at step 469 by illuminating a green LED segment of WLAN/WPAN indicator 38i).

[0067] If the current performance data indicate that each neighbor module 30a is currently accessible to the relay module 30a, but one or more of the neighbor modules 20a have a

recent performance history where WWAN status was inaccessible, the processor 34 may determine a status of “partially accessible” (indicated, for example, at step 469 by illuminating a yellow LED segment of WLAN/WPAN indicator 38i). If at least two of the neighbor modules 30a are not presently accessible to the relay module 30a, the processor 34 may determine a status of “inaccessible” (indicated, for example, at step 469 by illuminating a red LED segment of WLAN/WPAN indicator 38i). At step 470, it may be determined by the processor 34 for example in view of “partially accessible” or “inaccessible” statuses that an alarm condition has been generated, causing the processor 34 to present an alarm (for example, by causing the yellow or red LED segments to be illuminated in a blinking fashion, and/or by providing one or more audible alarms as previously described. As an alternative to displaying display status information at step 469, the processor 34 may cause the transceiver 31 to transmit the status information to one or more of the medical devices 10, or may cause the transceiver 32 to transmit the status information to a device in communication with the WWAN.

[0068] FIG. 5 presents a flow diagram 500 illustrating another exemplary method of operation 500 for the architecture according to FIG. 1, relating to the transmission of a message from the access point 40 to be received by one of the medical devices 10. This enables the access point 40, for example, to communicate with medical devices in order to download new firmware or software, to respond to error messages initiated by the medical devices (for example, to re-set a device or remove it from service, or to run device diagnostics), and to operate the medical device (for example, to adjust a flow rate on a feeding pump).

[0069] At step 502 of the method 500, the message is received at the first one of the relay modules 30a from the access point 40 via a WWAN. At step 504, the one relay module 30a determines whether the message is intended to reach one of the interface circuits 15 and/or other relay modules 30, 30a located in the facility 20. This may be accomplished, for example, by maintaining a list of active devices 15 and modules 30, 30a in the buffer 35a or in a manner otherwise accessible to the one relay module 30a, or coding an identifier of the device 15 or module 30, 30a to include an identity of the facility 20 that is stored in the buffer 35a or is otherwise identifiable to the one relay module 30a.

[0070] If the one relay module 30a determines at step 506 that the device 15 or module 30, 30a is not located in the facility, the one relay module 30 may preferably proceed to discard the message at step 508, and/or alternatively alert the access point 40 with a non-delivery

message. If the interface device 15 is located in the facility 20, the one relay module 30a determines at step 510 whether the device 15 or relay module 30, 30a is accessible to the one relay module 30a via the WLAN or WPAN 16 (for example, by consulting a list stored in the buffer 35a or that is otherwise accessible to the one relay module 30a, or by instructing the transceiver 31 to send a handshake transmission directed to the interface device 15a, 15b and to listen for a reply).

[0071] If the one relay module 30a determines at step 512 that the device 15 or relay module 30, 30a is accessible, then at step 514, it transmits the message via network 16 to that device 15 or relay module 30, 30a via the transceiver 31. In this case, the message may again be broadcasted to all devices 15 and modules 30, 30a in communication with the one relay module 30a, and each device 15 or module 30, 30a may decide to act on or ignore the message (for example, by matching to an associated device ID or other identifier in the message). If the one relay module 30a alternatively determines at step 512 that the device or relay module is not accessible, then it proceeds at step 516 to determine whether a second relay module 30, 30a is accessible via the WLAN or WPAN (for example, by instructing the transceiver 31 to send a handshake transmission directed to the second relay module and to listen for a reply). If the second relay module 30, 30a is available, then the one relay module 30a forwards the message to the transceiver 31 for transmission to the second relay module 30, 30a over the WLAN or WPAN. If the second relay module 30, 30a is inaccessible, then this portion of the process 500 may preferably be repeated to search for a third relay module 30, 30a that is accessible. Alternatively, or in the event that no other relay module 30, 30a is available, the one relay module 30a may preferably issue an alarm notification at step 522, preferably in one of the same manners described above in reference to the method 400 of FIG. 4(a).

[0072] As illustrated for example in FIG. 2, each relay module 30, 30a is capable of communicating with a number of medical devices 10 over a period of time. It is possible that communications with some of the medical devices 10 are more time-critical with regard to patient safety than other. For example, consider communications with medical devices 10 including each of a thermometer, a feeding pump, a patient electrode, and a ventilator. In this case, communications with the ventilator would likely be most time-critical among the three medical devices, while communications with the thermometer might be least critical among the three medical devices.

[0073] In accordance with the IEEE 802.14.15 standard, if the wireless relay network 16 is a ZIGBEE mesh network, then there is little risk that communications from more than one medical device will contend for simultaneous access to the wireless relay network 16. The network 16 operates with a protocol in which a transmitting device checks for energy on a wireless bus component of the network 16. If the bus is in use, the transmitting device waits a preselected amount of time before checking again (for example, 10 to 20 milliseconds), and only proceeds to transfer data when the energy level suggests that no other transmission is actively underway on the wireless bus. Nevertheless, for circumstances in which data packets transmitted by the medical devices 10 arrive at a relay module 30, 30a at nearly at the same time, there may be a need to manage an order of delivery by the relay module 30, 30a.

[0074] For example, consider a medical device data packet from a ventilator indicating disconnection from a comatose patient, with possible fatality. In this case, the ventilator should be assigned priority for transmitting to one or more of remote monitoring devices 61, 62 and 63, while medical device data transmissions from a thermometer and a pump are discontinued until a response to the medical device data packet transmitted by the ventilator is received from one of the remote monitoring devices 61, 62 and 63. For example, the ventilator might be assigned a priority of 1, while the feeding pump is assigned a priority of 2 and the thermometer is assigned a priority of 3. The assigned priority is preferably indicated in each data packet transmitted by and to the medical devices, for example, as a "priority nibble."

[0075] With reference to FIG. 3(a), the processor 34 may be configured to read the priority nibble from each received data packet, and to instruct the data processing circuit 33 to place the data packet at a logical position in the buffer element 35a based upon the priority designation. For example, critical data packets (for example, data packets including an indication of a life threatening condition) for the ventilator would be positioned for first retrieval and transmission by the relay module 30, 30a, and other data packets are positioned in order according to their priority.

[0076] In addition, under circumstances where urgent commands may need to be transmitted by one of the remote monitoring devices 61, 62 and 63 anticipated based on an urgent data packet (for example, a data packet including an alarm) from the ventilator, the wireless relay module 30, 30a may in addition discontinue reception of any new medical device

information from other medical devices until the urgent commands are relayed and an associated alarm condition has been terminated or released.

[0077] The novel wireless relay module disclosed herein for providing networked communications between a series of medical devices and a remote monitoring device provides a number of distinct advantages in comparison to other monitoring systems. By employing wireless relay networks such as ZIGBEE networks based on the IEEE 802.15.4 standard, for wireless communications between the medical devices 10 and relay modules 30, 30a in accordance with one embodiment of the invention, power and size requirements can be minimized so that the interface circuits 15 can be easily and inexpensively applied to and/or integrated with the medical devices 10.

[0078] By introducing relay modules 30a that are part of the wireless relay networks and are directly able to access off-site monitoring devices via a WWAN, access to and reliance on existing and potentially unreliable LAN facilities at a facility can be avoided. By incorporating relay features into the relay modules 30, 30a that relay communications from a first relay module 30a to a second relay module 30, 30a in the event that WWAN access to the first relay module 30a has been compromised, the present invention improves reliability and enables the use of conventional, low-cost cellular transceivers in the relay modules 30a for accessing the WWAN.

[0079] FIG. 6 depicts a block diagram illustrating exemplary components of an alternative configuration for the relay module 30a to the configuration of relay module 30a depicted in FIG 3(a). Identical reference numbers in FIGS. 3(a) and (6) refer to identical components, for example, transceivers 31 and 32, data processing circuit 33, buffer 35a, memory 35b and processor 34. In FIG. 6, as in FIG. 3(a), the relay module 30a includes transceiver 31 for wirelessly communicating with interface circuits 15 (shown in FIGs. 1 and 2) and other relay modules 30, 30a in a particular WLAN or WPAN network 16 (shown in FIG. 2) via antenna 31a. Also, in FIG. 6, as in FIG. 3(a), the relay module 30a further includes a transceiver 32 for wirelessly communicating with the access point 40 over a particular WWAN (shown in FIG. 2) via an antenna 32a.

[0080] Added components to the relay module 30a in FIG. 6 not present in FIG. 3(a) include an additional transceiver 31c, similar to transceiver 31, for wirelessly communicating via antenna 31d with interface circuits and other relay modules capable of

communicating over a different WLAN or WPAN network than the network used by transceiver 31. Correspondingly, the relay module 30a in FIG. 6 includes yet a further transceiver 32c, similar to transceiver 32, for wirelessly communicating via antenna 38d with an access point over a different WWAN than the WWAN used by transceiver 32.

[0081] Each of the transceivers 31, 32, 31c and 32c is in communication with data processing circuit 33, which is configured to operate under the control of processor 34 to accept data received by the transceivers 31, 32, 31c and 32c and store the received data in buffer element 35a. In addition, the data processing circuit 33 is further configured to retrieve data from buffer element 35a under the direction of processor 34 and provide the retrieved data to a selected one of the transceivers 31, 32, 31c and 32c for transmission. In order to make a selection, the processor 34 is configured to communicate with respective status modules 31b, 32b, 31c and 32e of respective transceivers 31, 32, 31c and 32c in order to determine a communications status of the transceivers 31, 32, 31c and 32c. It should be understood that the data processing circuit 33 and processor 34 may be implemented as separate integrated circuits or chip sets or their functions may be combined and implemented on single integrated circuits or chip set

[0082] The processor 34 is also preferably in communication with an input/output circuit 36, which provides signals to one or more display elements of the relay module 30a, for example, for indicating a start-up or current status of the relay module 30a, including communication or connection status with the WLAN or WPAN networks and WWANs networks. Input/output circuit 36 may also be configured to provide signals to indicate an A/C power loss, and or to be responsive to signals provided by one or more input devices provided in proximity to the one or more display elements.

[0083] A control panel useable for the module 30a of FIG. 6 may be substantially similar to the control panel 38 depicted in FIG. 3(e) with corresponding multiple indicators 38e for indicating the status of the different WLAN or WPAN networks, and/or multiple indicators 38j for indicating the status of the different WWANs.

[0084] The relay module 30a configuration of FIG. 6 may be operated in a substantially similar manner to the relay module 30a configuration of FIG 3a employing, for example, corresponding methods of operation to those depicted in FIGS. 4 and 5 incorporating the use of a plurality of WWANs or WLAN or WPAN networks. However, in performing

methods of operation for the relay module 30a of FIG. 6, the depicted steps in FIGs. 4 and 5 may be employed with the further transceiver selections of the additional transceivers 37 and 38. For example, FIG. 7 depicts a method of operation 600 for the relay module 30a configuration of FIG. 6 that is analogous to the method 400 of FIG. 4(a) for the relay module 30a configuration of FIG. 3(a). Methods 400 and 600 include substantially identical steps except method 600 substitutes steps 604 and 606 for steps 404 and 406 of method 400. These substituted steps 604 and 606 are similar to the corresponding steps 404 and 406 expanded to utilize the additional transceivers 37 and 38 of FIG. 6.

[0085] Referring to FIG. 7, after medical device data is received over a WLAN or PLAN network by transceivers 31 or 37 of FIG. 6 in step 402, the relay module 30a determines if any WWAN is accessible by transceivers 32 or 38. If no WWAN is accessible the method 600 then continues to step 408 and performs substantially the same operations as described with respect to steps 408, 410 and 412 in FIG. 4(a). Otherwise, if a WWAN is determined accessible in step 604 of FIG. 7, the method 600 proceeds to step 606. In step 606, the method 600 transmits the medical data over the available WWAN via transceiver 32 or 38 to the appropriate access point.

[0086] Moreover, to the extent to that in step 604 of FIG. 7 there are more than one WWAN accessible then in step 606 the controller 33 in FIG. 6 must determine which one of the accessible WWANs the medical data should be transmitted over by either of transceivers 32 or 38. Such determination can be made by many different criteria or rules including, for example, based upon signal strength, cost, time of day, day of week or preferences of a network manager or other user.

[0087] It is possible to limit the configuration of cellular transceivers to just the relay modules 30a in a facility, instead of modules 30 and 30a. In addition, by providing the relay modules 30a in a compact enclosure, the relay modules 30a are easily connected to reliable commercial power sources and easily moved when needed to reconfigure the wireless relay networks according to facilities changes. The portability for ambulatory use that is provided by battery back-up is an additional advantage.

[0088] It should of course, be understood that while the present invention has been described with respect to disclosed embodiments, numerous variations are possible without departing from the spirit and scope of the present invention as defined in the claims. For

example, the present invention may be based on any of a number of current and future WPAN, WLAN and WWAN standards beyond those explicitly described herein. It should also be understood that it is possible to use exclusively relay modules 30a in the WLAN or WPAN network 16 of FIGs. 1 and 2, with transceivers for communicating with other relay modules as well as over the WWAN.

[0089] In addition, respective interface circuits useable with the present invention may include components of and perform the functions of the module 30 to provide greater flexibility in accordance with the present invention. Further, numerous configurations of components for relay module 30a are useable with the present invention beyond the components shown in FIG. 3. For instance, an input-output buffer may be used with respective switches under control of a processor for directing medical device data to transceivers 31, 32, 37 or 38 as needed. Moreover, it is intended that the scope of the present invention include all other foreseeable equivalents to the elements and structures as described herein and with reference to the drawing figures. Accordingly, the invention is to be limited only by the scope of the claims and their equivalents.

We claim:

1. A wireless relay module comprising:
 - a first receiver capable of wirelessly receiving medical device data over a wireless relay network from at least one medical device;
 - a first transmitter capable of wirelessly transmitting the medical device data over the wireless relay network; and
 - a second transmitter capable of wirelessly transmitting the medical device data over an internet-accessible wireless communications network;
 - a controller coupled to the first and second transmitters, said controller capable of controlling said wireless relay module to select one of said first or second transmitter for transmitting medical device data received by said first receiver, wherein said first transmitter is further capable of transmitting information to the at least one medical device indicative of a status of network communications of at least one of the wireless relay network and the internet-accessible wireless communications network.
2. The wireless relay module of claim 1, further comprising:
 - a display having a first indicator indicative of status of network communications.
3. The wireless relay module of claim 2, further comprising:
 - a second receiver capable of receiving data over the internet-accessible wireless communications network.
4. The wireless relay module of claim 2, further comprising:
 - a status module coupled to the second transmitter and controller, said status module capable of determining a status of accessibility of communications over said internet-accessible wireless communications network and providing said status of accessibility to the controller.

5. The wireless relay module of claim 4, wherein said display further comprises a second indicator representative of the status of accessibility of communications over said internet-accessible wireless communications network.

6. The wireless relay module of claim 2, wherein said display further comprises a second indicator representative of a status of the wireless relay network.

7. The wireless relay module of claim 1 wherein said wireless relay network is at least one of a ZIGBEE network or a relay-enabled Bluetooth network.

8. The wireless relay module of claim 1, wherein the internet-accessible wireless communications network is a mobile communications network.

9. A wireless relay module comprising:

- a first receiver capable of wirelessly receiving medical device data over a wireless relay network from at least one medical device;

- a first transmitter capable of wirelessly transmitting the medical device data to a second wireless relay module over the wireless relay network;

- a second transmitter capable of wirelessly transmitting the medical device data over an internet-accessible wireless communications network;

- a controller coupled to the first and second transmitters, said controller capable of controlling said wireless relay module to select one of said first or second transmitter for transmitting the medical device data received by said first receiver, and

- a display coupled to the controller, said display capable of displaying information indicative of status of network communications of at least one of the wireless relay network and the internet-accessible wireless communications network.

10. The wireless relay module of claim 9, further comprising:

- a first status module coupled to the second transmitter and controller, said first status module capable of determining a status of potential communications over said internet-accessible

wireless communications network and providing said potential communications status to the controller for selecting said first or second transmitter based on said status.

11. The wireless relay module of claim 10, wherein said display is further capable of providing a status indication of a determined status of potential communications over said internet-accessible wireless communications network.

12. The wireless relay module of claim 10, further comprising a second status module coupled to the first transmitter, the second status module capable of determining a status of communications over said wireless relay network.

13. The wireless relay module of claim 12, wherein said display is further capable of providing a status indication of potential communications over said wireless relay network.

14. The wireless relay module of claim 13 wherein said wireless relay network is at least one of a ZIGBEE network and a relay-enabled Bluetooth network.

15. The wireless relay module of claim 9, wherein said an internet-accessible wireless communications network is a mobile communications network.

16. The wireless relay module of claim 9 wherein said first transmitter is further capable of transmitting information to the at least one medical device indicative of status of network communications of at least one of the wireless relay network and the internet-accessible wireless communications network.

17. A process for operating a relay module in a medical device wireless network, comprising the steps of:

receiving medical device data from at least one medical device over a wireless relay network;

determining a status of an internet-accessible wireless communications network in communication with a first transmitter of said relay module;

transmitting said medical device data from said at least one medical device over said communications network by said first transmitter if said determined status satisfies a particular criteria;

transmitting said medical device data from said at least one medical device by a second transmitter in communication with the wireless relay network to a second relay module over the wireless relay network if said determined status fails to satisfy the particular criteria; and

determining information indicative of status of network communications of at least one of the wireless relay network and the internet-accessible wireless communications network.

18. The process of claim 17 further comprising the step of:

displaying the determined information indicative of status of network communications.

19. The process of claim 17 further comprising the step of:

transmitting the determined information indicative of status of network communications to the at least one medical device.

20. The process of claim 17 further comprising the step of:

transmitting the determined information indicative of status of network communications via the first transmitter to a device in communication with the internet-accessible wireless communications network.