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(54) **SYSTEM AND METHOD FOR STORING AND FORWARDING DATA FROM A VITAL-SIGNS MONITOR**

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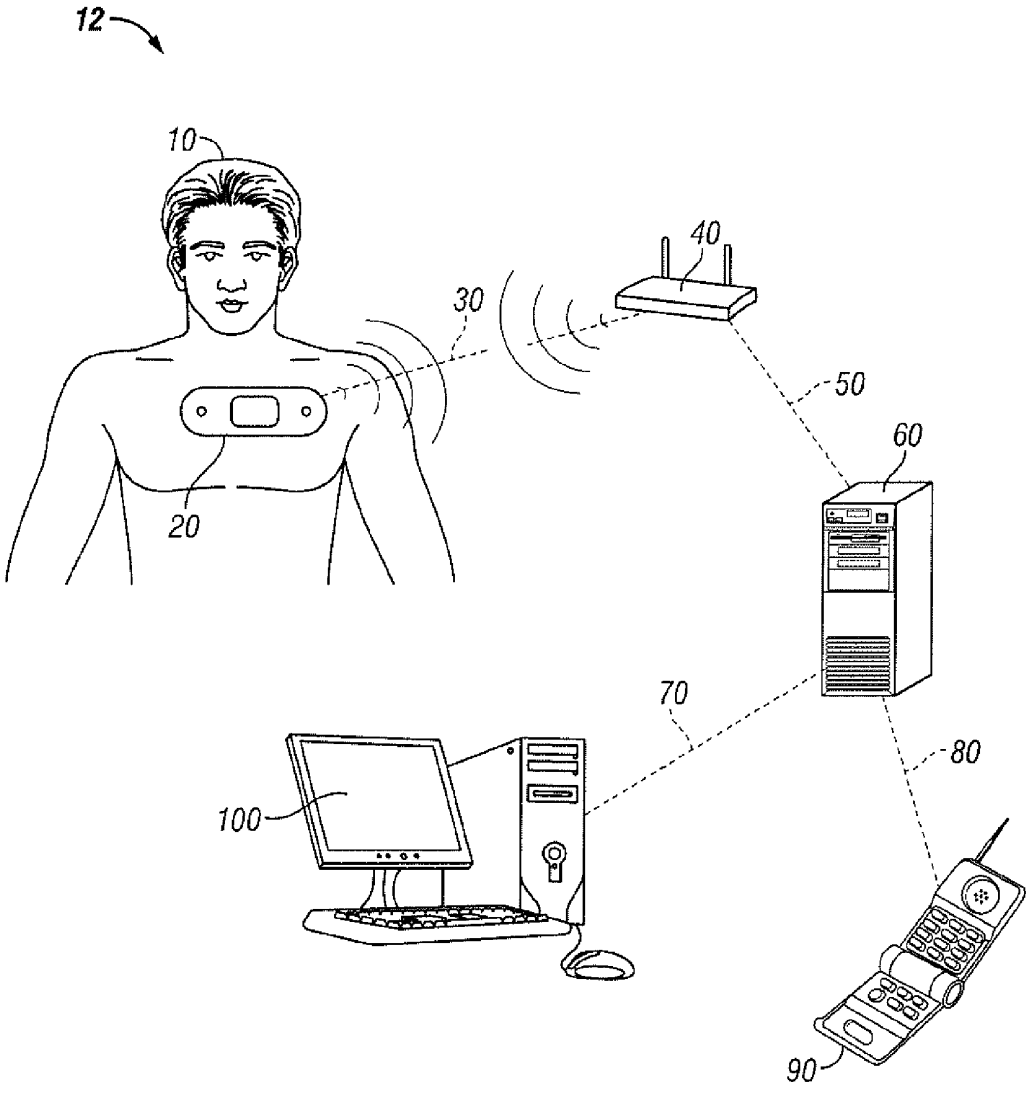
(57) **ABSTRACT**

A vital-signs patch for a patient monitoring system that includes a housing containing a sensor that makes physiological measurements of a patient, a transmitter, a receiver, a memory, and a processor. The processor periodically takes a measurement from the sensor, converts the measurement to a data record, and stores the data record in the memory. Upon receipt of a signal from another device, the processor retrieves at least a portion of the data record, converts the retrieved portion of the data record to a vital-sign signal, and causes the transmitter to transmit the vital-sign signal to the other device.



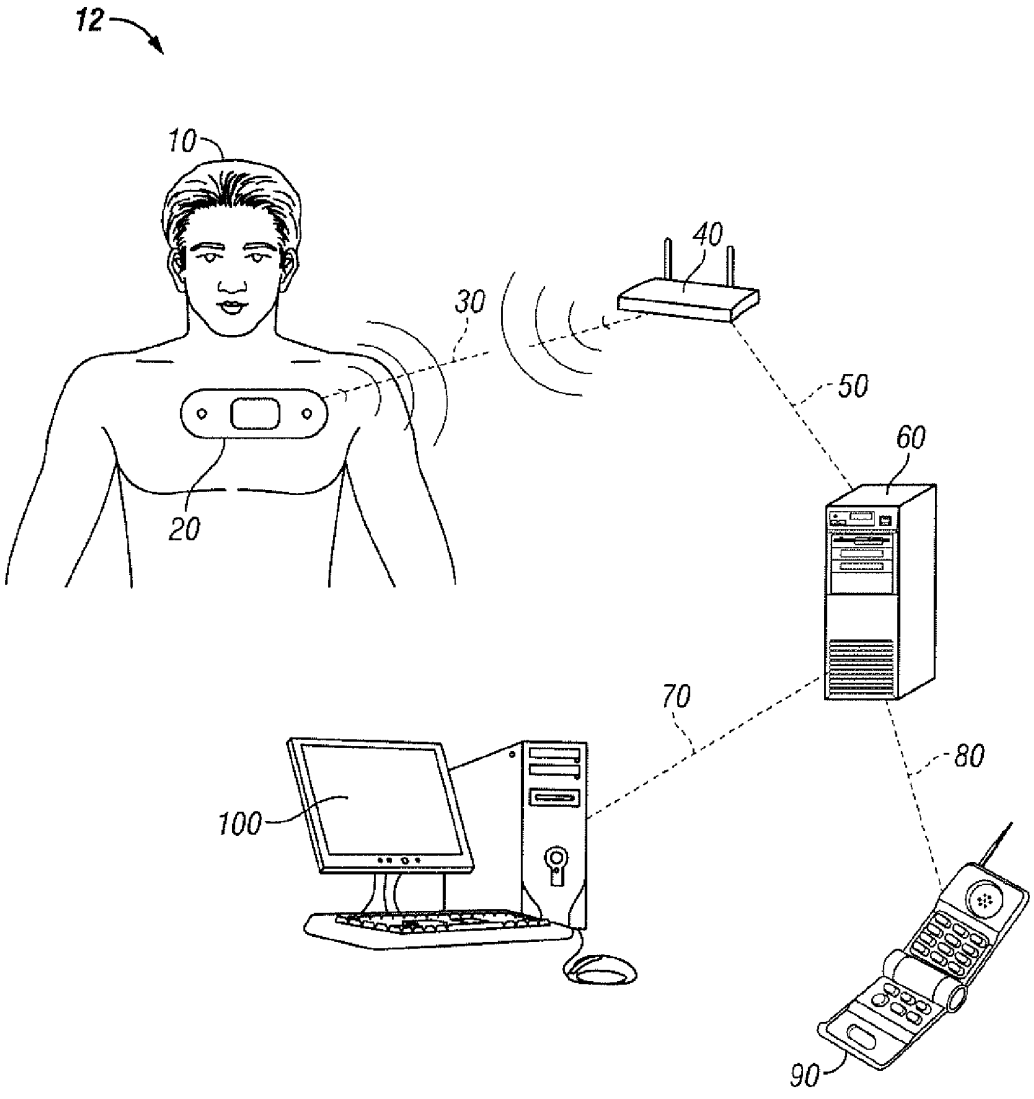


FIG. 1

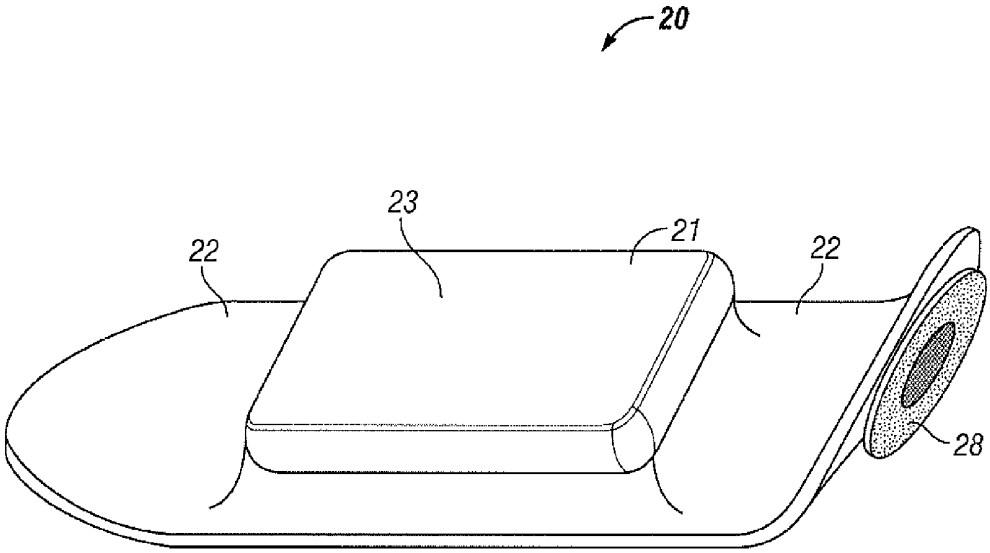


FIG. 2A

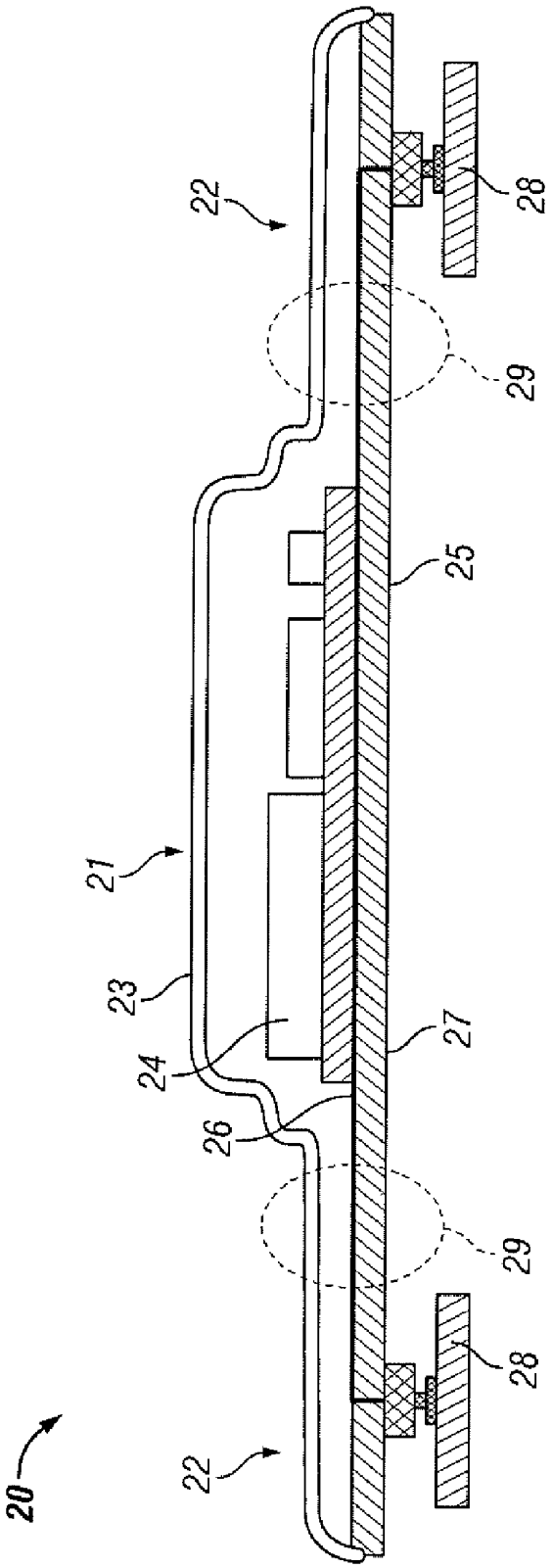


FIG. 2B

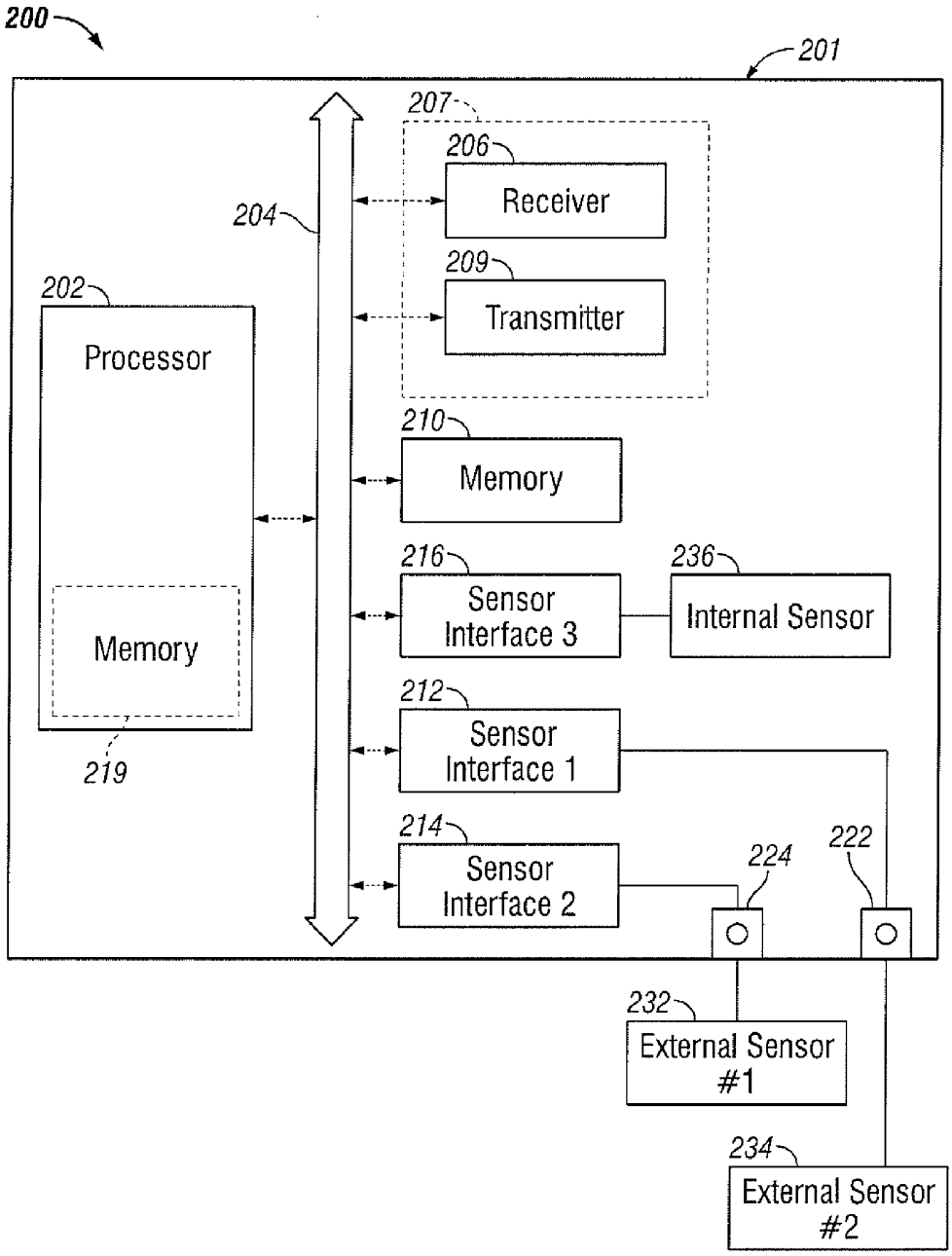

200
201
207
206
Receiver
204
209
Transmitter
202
Processor
210
Memory
216
Sensor Interface 3
236
Internal Sensor
Memory
219
212
Sensor Interface 1
214
Sensor Interface 2
224
222
232
External Sensor #1
234
External Sensor #2

FIG. 2C

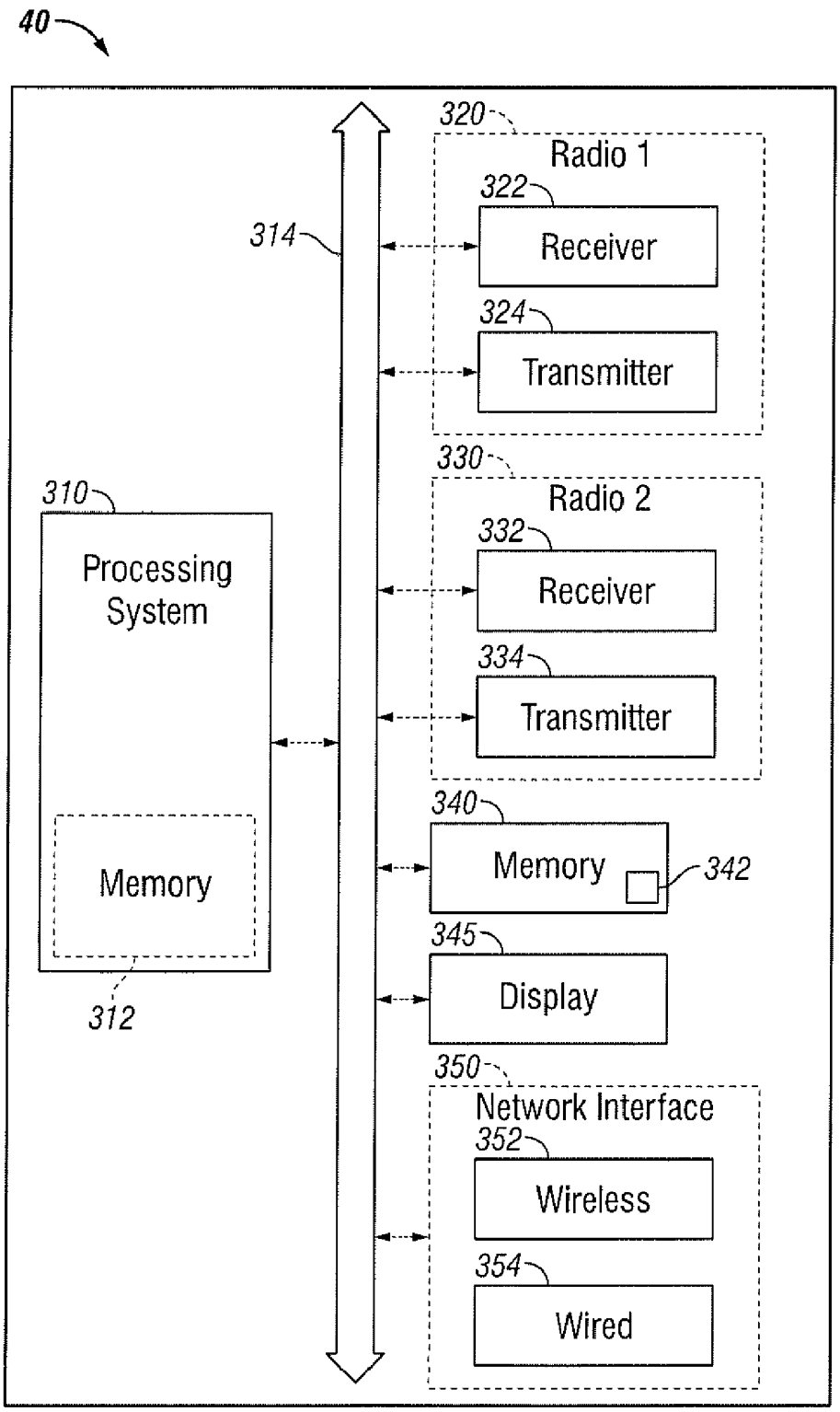

40
320
Radio 1
322
Receiver
314
324
Transmitter
330
Radio 2
310
332
Processing System
Receiver
334
Transmitter
340
Memory
342
Memory
345
Display
312
350
Network Interface
352
Wireless
354
Wired

FIG. 3A

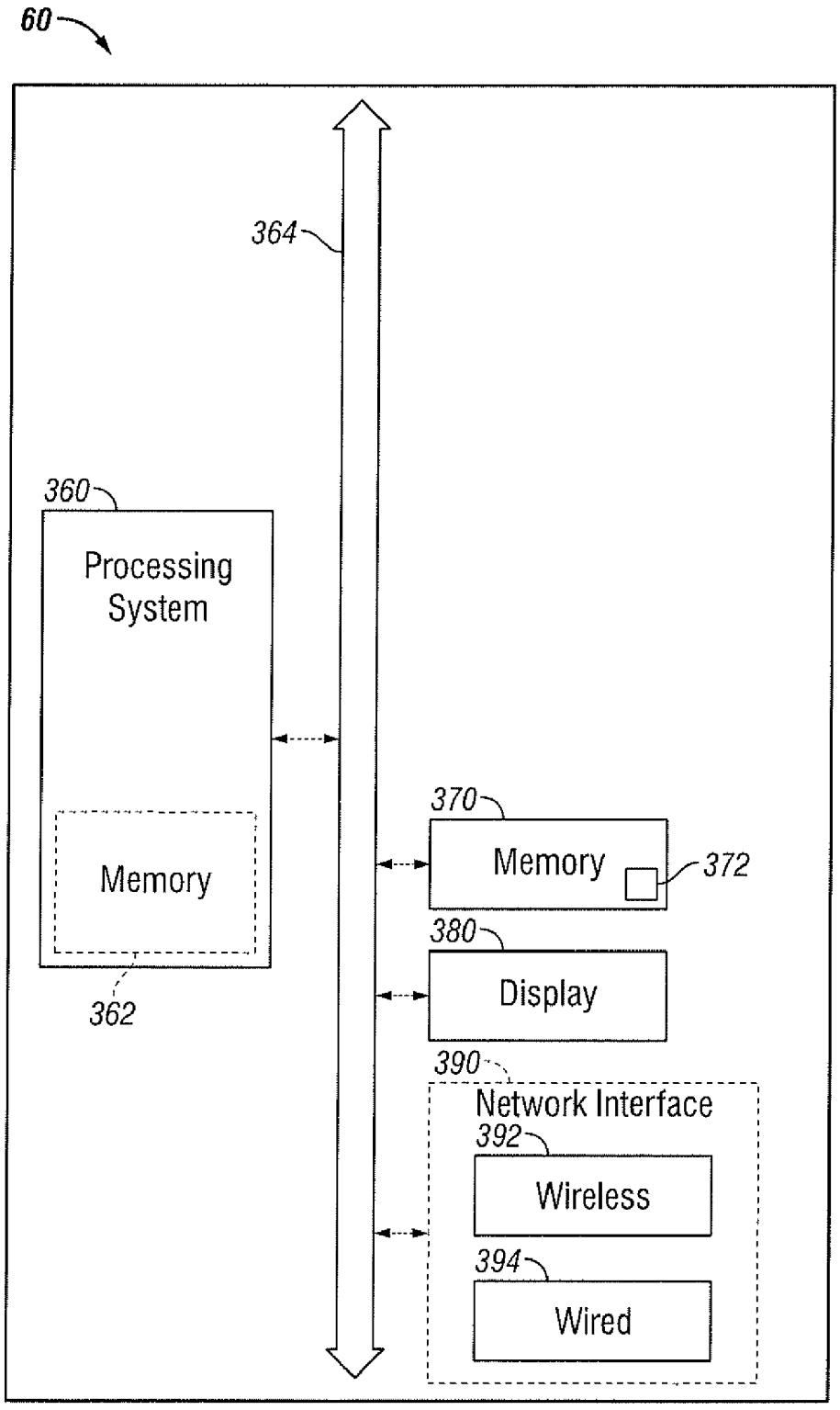

60
364
360
Processing System
Memory
362
370
Memory
372
380
Display
390
Network Interface
392
Wireless
394
Wired

FIG. 3B

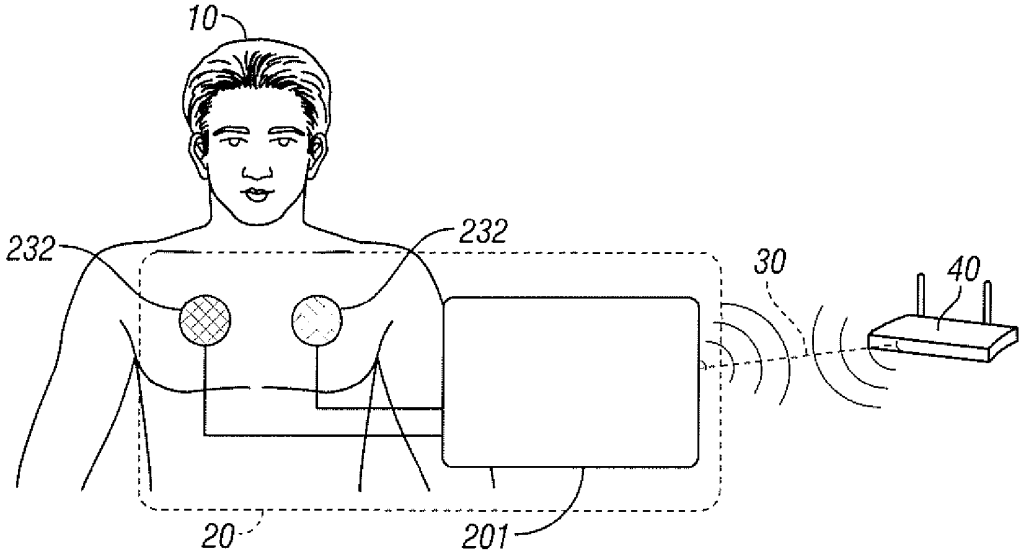


FIG. 4

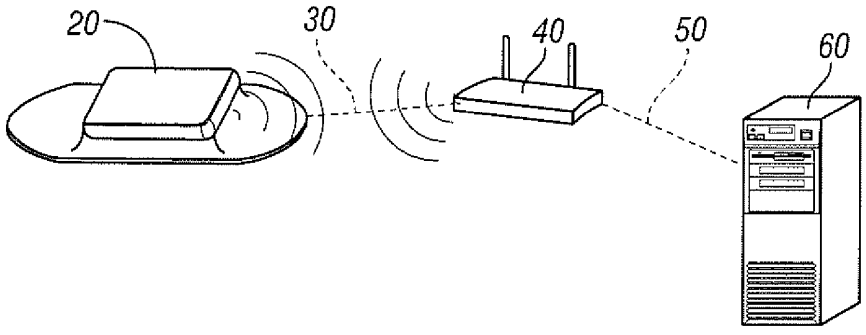


FIG. 5

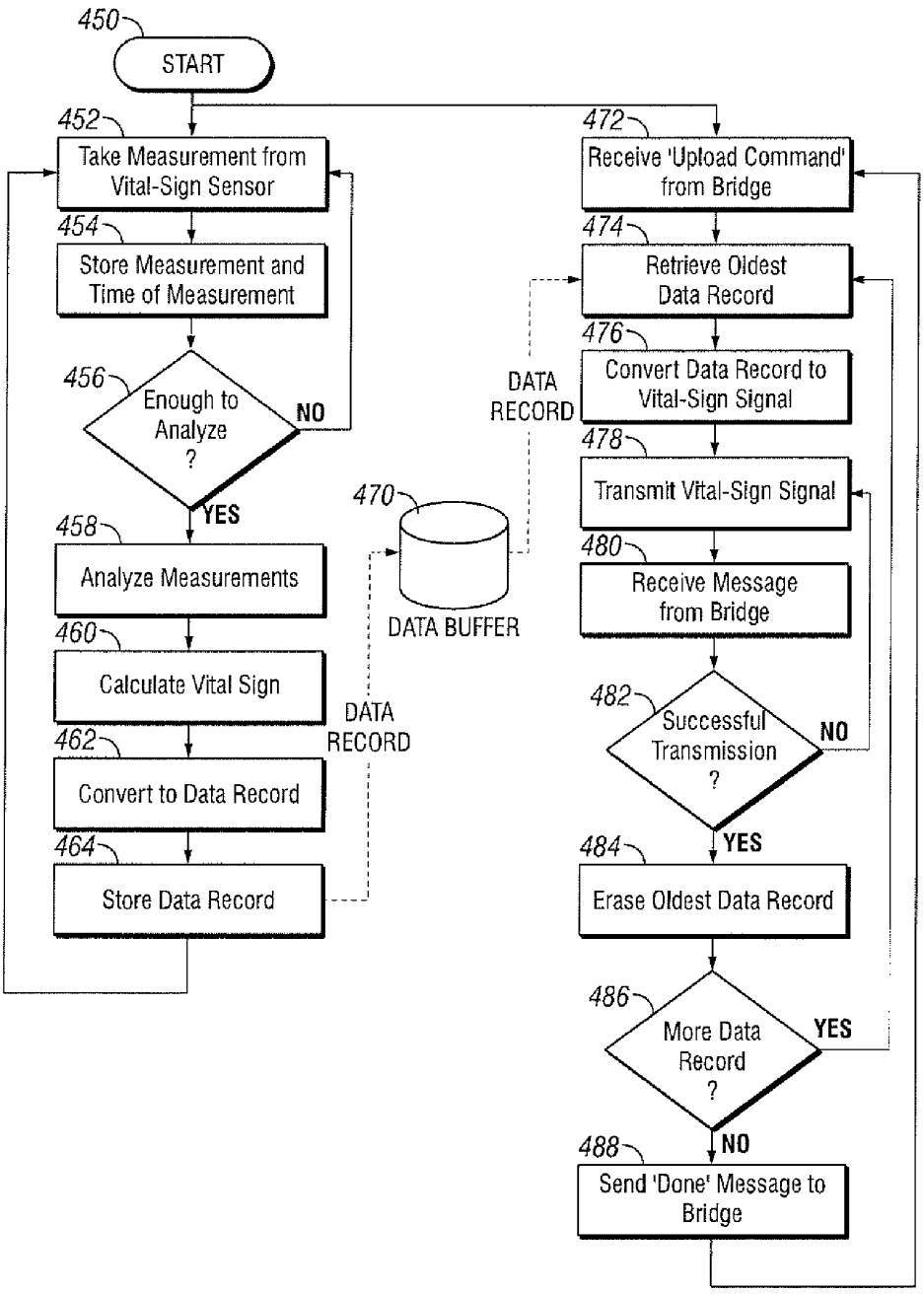

450
START
452
Take Measurement from Vital-Sign Sensor
454
Store Measurement and Time of Measurement
456
Enough to Analyze ?
NO
YES
458
Analyze Measurements
460
Calculate Vital Sign
462
Convert to Data Record
464
Store Data Record
470
DATA BUFFER
DATA RECORD
DATA RECORD
472
Receive 'Upload Command' from Bridge
474
Retrieve Oldest Data Record
476
Convert Data Record to Vital-Sign Signal
478
Transmit Vital-Sign Signal
480
Receive Message from Bridge
482
Successful Transmission ?
NO
YES
484
Erase Oldest Data Record
486
More Data Record ?
YES
NO
488
Send 'Done' Message to Bridge

FIG. 6

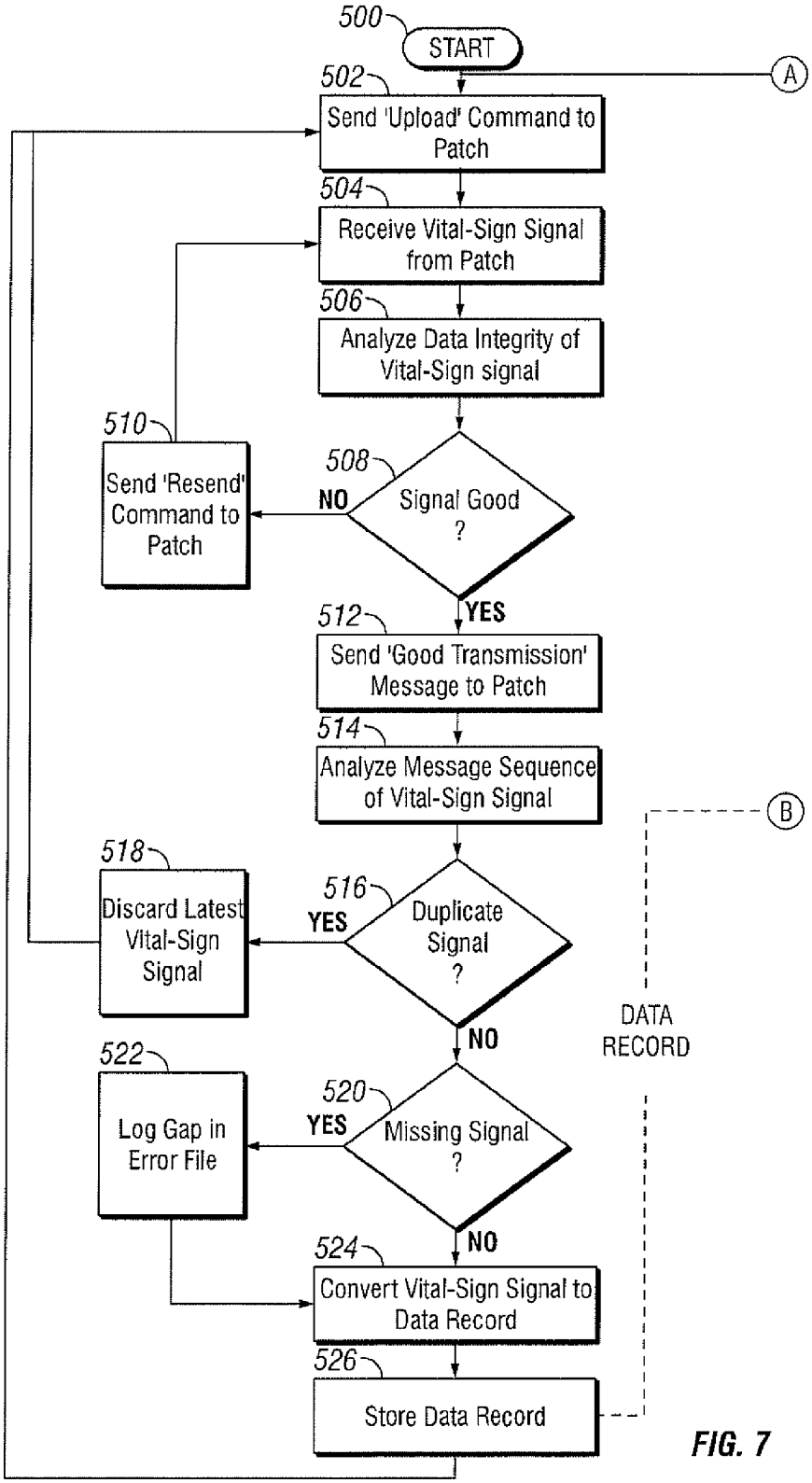

500
START
A
502
Send 'Upload' Command to Patch
504
Receive Vital-Sign Signal from Patch
506
Analyze Data Integrity of Vital-Sign signal
508
Signal Good ?
NO
510
Send 'Resend' Command to Patch
YES
512
Send 'Good Transmission' Message to Patch
514
Analyze Message Sequence of Vital-Sign Signal
B
516
Duplicate Signal ?
YES
518
Discard Latest Vital-Sign Signal
NO
DATA RECORD
520
Missing Signal ?
YES
522
Log Gap in Error File
NO
524
Convert Vital-Sign Signal to Data Record
526
Store Data Record

FIG. 7

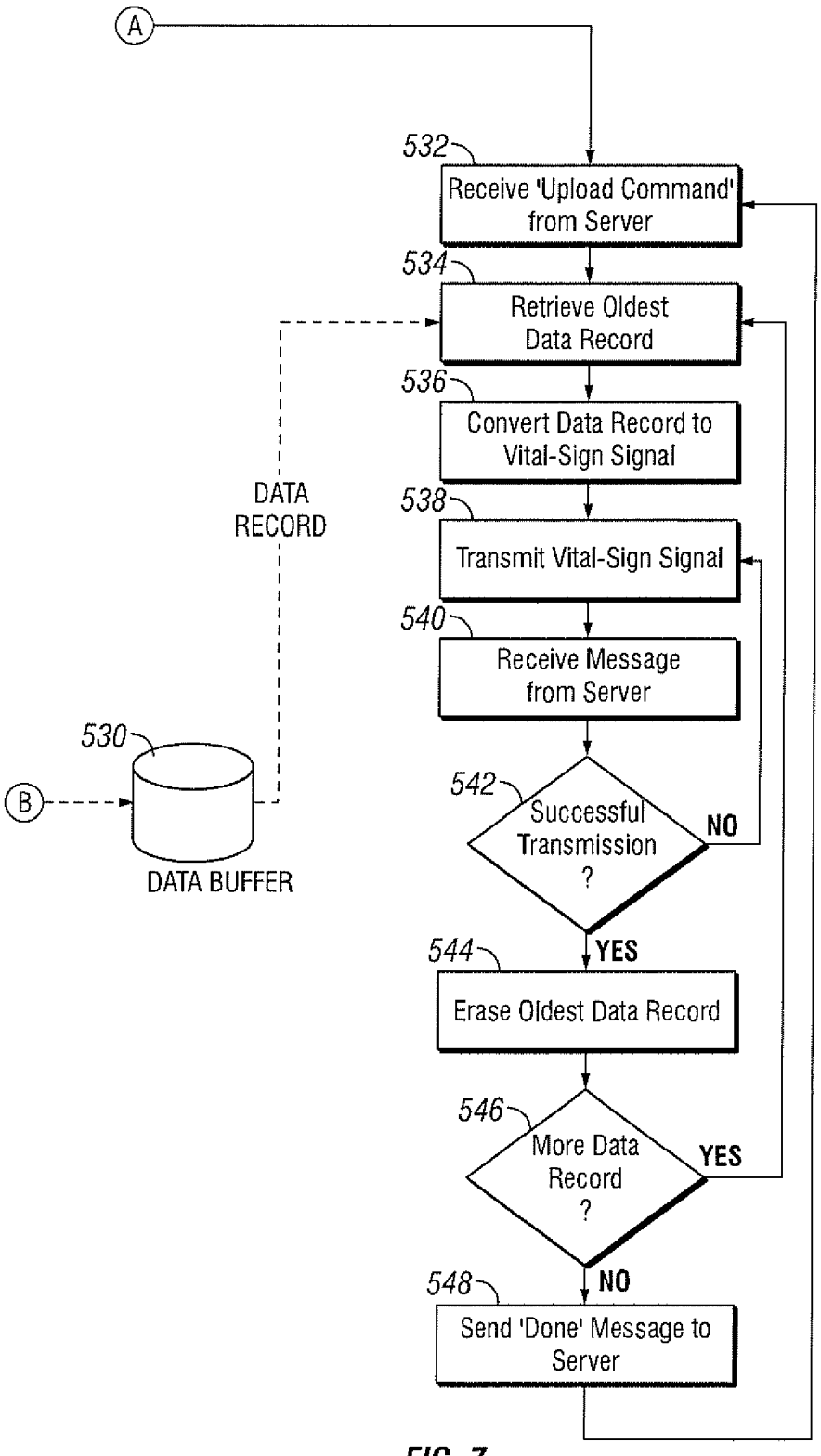


FIG. 7
(Continued)

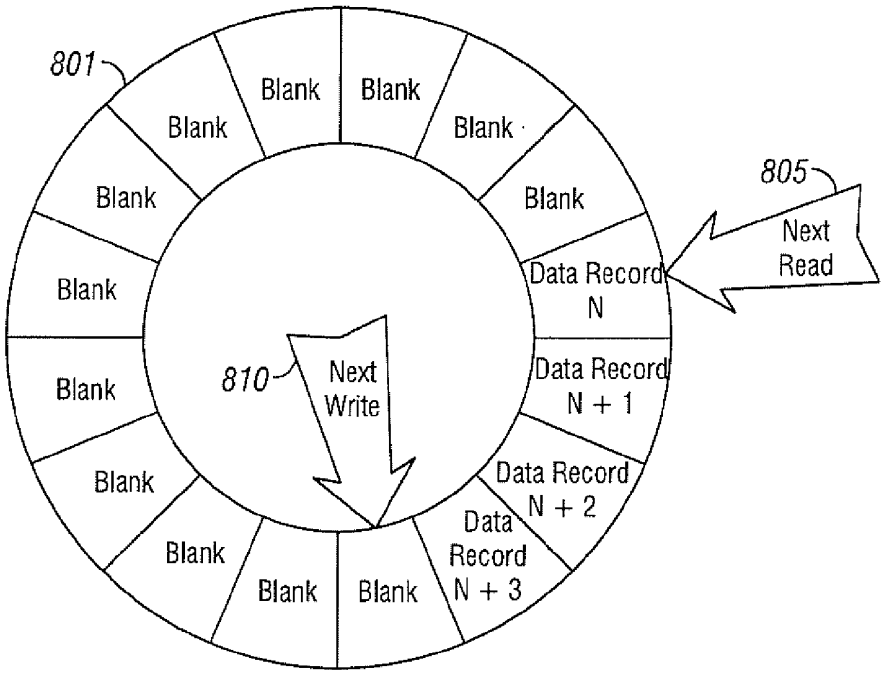

801
Blank
Blank
Blank
Blank
Blank
Blank
Blank
Blank
Blank
Blank
Blank
Blank
805
Next
Read
Data Record
N
Data Record
N + 1
Data Record
N + 2
Data
Record
N + 3
810
Next
Write

FIG. 8A

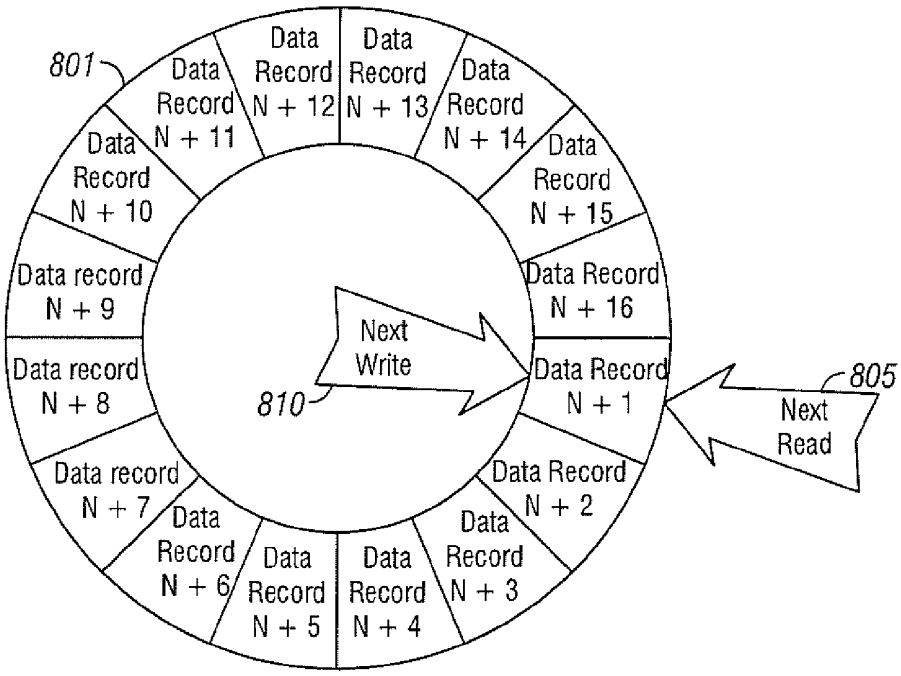

801
Data
Record
N + 12
Data
Record
N + 13
Data
Record
N + 14
Data
Record
N + 15
Data Record
N + 16
Data Record
N + 1
Data Record
N + 2
Data
Record
N + 3
Data
Record
N + 4
Data
Record
N + 5
Data
Record
N + 6
Data record
N + 7
Data record
N + 8
Data record
N + 9
Data
Record
N + 10
Data
Record
N + 11
805
Next
Read
810
Next
Write

FIG. 8B

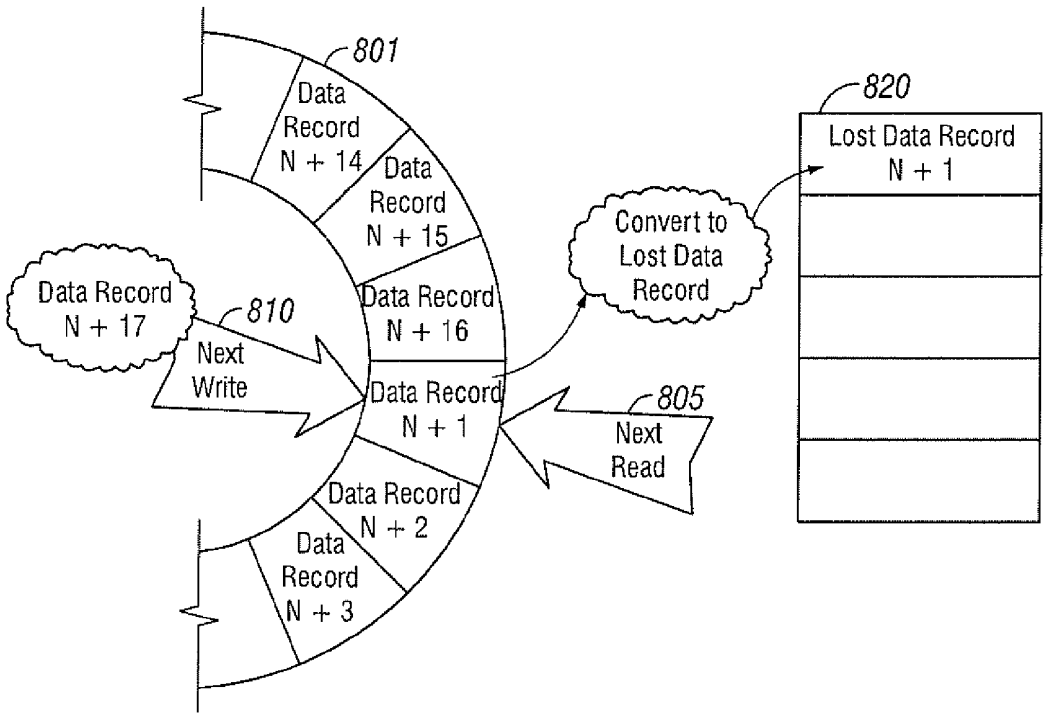

801
Data Record N + 14
Data Record N + 15
Data Record N + 16
Data Record N + 1
Data Record N + 2
Data Record N + 3
Data Record N + 17
810
Next Write
805
Next Read
Convert to Lost Data Record
820
Lost Data Record N + 1

FIG. 9A

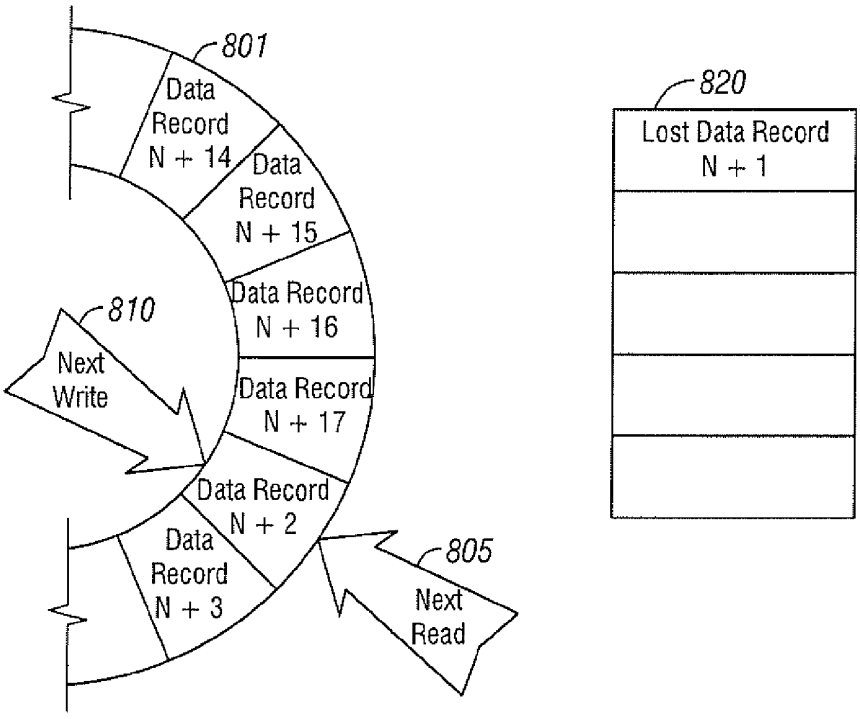

801
Data Record N + 14
Data Record N + 15
Data Record N + 16
Data Record N + 17
Data Record N + 2
Data Record N + 3
810
Next Write
805
Next Read
820
Lost Data Record N + 1

FIG. 9B

SYSTEM AND METHOD FOR STORING AND FORWARDING DATA FROM A VITAL-SIGNS MONITOR

CROSS-REFERENCES TO RELATED APPLICATIONS

[0001] The following applications disclose certain common subject matter with the present application: A Vital-Signs Monitor with Encapsulation Arrangement, docket number 080624-0612; A Vital-Signs Monitor with Spaced Electrodes, docket number 080624-0623; A Vital-Signs Patch Having a Strain Relief, docket number 080624-0624; A Temperature Probe Suitable for Axillary Reading, docket number 080624-0625; System and Method for Monitoring Body Temperature of a Person, docket number 080624-0626; System and Method for Saving Battery Power in a Vital Signs Monitor, docket number 080624-0628; A System and Method for Conserving Battery Power in a Patient Monitoring System, docket number 080624-0629; A System and Method for Saving Battery Power in a Patient Monitoring System, docket number 080624-0630; A System And Method for Tracking Vital-Signs Monitor Patches, Docket Number 080624-0631; A System And Method for Reducing False Alarms Associated with Vital-Signs Monitoring, Docket Number 080624-0632; A System And Method for Location Tracking of Patients in a Vital-Signs Monitoring System, Docket Number 080624-0633; A System And Method for Reducing False Alarms Based on Motion and Location Sensing, Docket Number 080624-0634; all of the listed applications filed on _____.

BACKGROUND

[0002] 1. Field

[0003] The present disclosure generally relates to systems and methods of physiological monitoring, and, in particular, relates to monitoring of vital signs of patients in hospitals.

[0004] 2. Description of the Related Art

[0005] Some of the most basic indicators of a person's health are those physiological measurements that reflect basic body functions and are commonly referred to as a person's "vital signs." The four measurements commonly considered to be vital signs consider oxygen saturation (S_{02}) to be a "fifth vital sign" particularly for pediatric or geriatric cases. Some or all of these measurements may be performed routinely upon a patient when they arrive at a healthcare facility, whether it is a routine visit to their doctor or arrival at an Emergency Room (ER).

[0006] Vital signs are frequently taken by a nurse using basic tools including a thermometer to measure body temperature, a sphygmomanometer to measure blood pressure, and a watch to count the number of breaths or the number of heart beats in a defined period of time which is then converted to a "per minute" rate. If a patient's pulse is weak, it may not be possible to detect a pulse by hand and the nurse may use a stethoscope to amplify the sound of the patient's heart beat so that she can count the beats. Oxygen saturation of the blood is most easily measured with a pulse oximeter.

[0007] When a patient is admitted to a hospital, it is common for vital signs to be measured and recorded at regular intervals during the patient's stay to monitor their condition. A typical interval is 4 hours, which leads to the undesirable requirement for a nurse to awaken a patient in the middle of the night to take vital sign measurements.

[0008] When a patient is admitted to an ER, it is common for a nurse to do a "triage" assessment of the patient's condition that will determine how quickly the patient receives treatment. During busy times in an ER, a patient who does not appear to have a life-threatening injury may wait for hours until more-serious cases have been treated. While the patient may be reassessed at intervals while awaiting treatment, the patient may not be under observation between these reassessments.

[0009] Measuring certain vital signs is normally intrusive at best and difficult to do on a continuous basis. Measurement of body temperature, for example, is commonly done by placing an oral thermometer under the tongue or placing an infrared thermometer in the ear canal such that the tympanic membrane, which shared blood circulation with the brain, is in the sensor's field of view. Another method of taking a body temperature is by placing a thermometer under the arm, referred to as an "axillary" measurement as axilla is the Latin word for armpit. Skin temperature can be measured using a stick-on strip that may contain panels that change color to indicate the temperature of the skin below the strip.

[0010] Measurement of respiration is easy for a nurse to do, but relatively complicated for equipment to achieve. A method of automatically measuring respiration is to encircle the upper torso with a flexible band that can detect the physical expansion of the rib cage when a patient inhales. An alternate technique is to measure a high-frequency electrical impedance between two electrodes placed on the torso and detect the change in impedance created when the lungs fill with air. The electrodes are typically placed on opposite sides of one or both lungs, resulting in placement on the front and back or on the left and right sides of the torso, commonly done with adhesive electrodes connected by wires or by using a torso band with multiple electrodes in the strap.

[0011] Measurement of pulse is also relatively easy for a nurse to do and intrusive for equipment to achieve. A common automatic method of measuring a pulse is to use an electrocardiograph (ECG or EKG) to detect the electrical activity of the heart. An EKG machine may use 12 electrodes placed at defined points on the body to detect various signals associated with the heart function. Another common piece of equipment is simply called a "heart rate monitor." Widely sold for use in exercise and training, heart rate monitors commonly consist of a torso band, in which are embedded two electrodes held against the skin and a small electronics package. Such heart rate monitors can communicate wirelessly to other equipment such as a small device that is worn like a wristwatch and that can transfer data wirelessly to a PC.

[0012] Nurses are expected to provide complete care to an assigned number of patients. The workload of a typical nurse is increasing, driven by a combination of a continuing shortage of nurses, an increase in the number of formal procedures that must be followed, and an expectation of increased documentation. Replacing the manual measurement and logging of vital signs with a system that measures and records vital signs would enable a nurse to spend more time on other activities and avoid the potential for error that is inherent in any manual procedure.

SUMMARY

[0013] For some or all of the reasons listed above, there is a need for a hospital to be able to continuously monitor its patients in different settings within the hospital. In addition, it

is desirable for this monitoring to be done with limited interference with a patient's mobility or interfering with their other activities.

[0014] Embodiments of the patient monitoring system disclosed herein measure certain vital signs of a patient, which include respiratory rate, pulse rate, and body temperature, on a regular basis and compare these measurements to preset limits.

[0015] In certain aspects of the present disclosure, a vital-signs patch is disclosed. The patch includes a housing containing at least one sensor configured to make physiology of a patient, a transmitter, a receiver, a memory, and a processor. The processor periodically takes a measurement from the sensor, converts the measurement to a data record, and stores the data record in the memory. Upon receipt of a signal from a second device via the receiver, the processor retrieves at least a portion of the data record, configures the retrieved portion of the data record into a vital-sign signal, and causes the transmitter to transmit the vital-sign signal to the other device.

[0016] In certain aspects of the present disclosure, a bridge is disclosed. The bridge includes first and second receivers, first and second transmitters, a memory, and a processor. The processor periodically causes the first transmitter to transmit a signal to a first device that will cause the first device to transmit a vital-sign signal, receives a vital-sign signal from the first device via the first transmitter, converts the vital sign signal to a data record, and stores the data record in the memory. Upon receipt of a signal from a second device via the second receiver, the processor retrieves at least a portion of the data record from the memory, configures the retrieved portion of the data record into a data signal, and causes the transmitter to transmit the data signal.

[0017] In one aspect of the present disclosure, a method of storing and forwarding vital sign data is disclosed. The method includes receiving at a second device vital-sign data from a first device, storing the vital-sign data, listening for a signal from a third device until the signal is received, retrieving at least a portion of the vital-sign data from storage, and transmitting the retrieved portion of the vital-sign data to the third device.

[0018] It is understood that other configurations of the subject technology will become readily apparent to those skilled in the art from the following detailed description, wherein various configurations of the subject technology are shown and described by way of illustration. As will be realized, the subject technology is capable of other and different configurations and its several details are capable of modification in various other respects, all without departing from the scope of the subject technology. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The accompanying drawings, which are included to provide further understanding and are incorporated in and constitute a part of this specification, illustrate disclosed embodiments and together with the description serve to explain the principles of the disclosed embodiments. In the drawings:

[0020] FIG. **1** is a diagram illustrating an exemplary embodiment of a patient monitoring system according to certain aspects of the present disclosure.

[0021] FIG. **2**A is a perspective view of the vital-signs monitor patch of FIG. **1** according to certain aspects of the present disclosure.

[0022] FIG. **2**B is a cross-section of the vital-signs monitor patch of FIG. **1** according to certain aspects of the present disclosure.

[0023] FIG. **2**C is a functional block diagram illustrating exemplary electronic and sensor components of the vital-signs monitor patch of FIG. **1** according to certain aspects of the present disclosure.

[0024] FIG. **3**A is a functional schematic diagram of the bridge according to certain aspects of the subject disclosure.

[0025] FIG. **3**B is a functional schematic diagram of an embodiment of the surveillance server according to certain aspects of the present disclosure.

[0026] FIG. **4** is a diagram illustrating a store-and-forward system implemented for the vital-signs patch according to certain aspects of the subject disclosure.

[0027] FIG. **5** is a diagram illustrating a store-and-forward system implemented for the bridge according to certain aspects of the subject disclosure.

[0028] FIG. **6** is a flowchart showing a store-and-forward methodology implemented for the vital-signs patch according to certain aspects of the subject disclosure.

[0029] FIG. **7** is a flowchart showing a store-and-forward methodology implemented for the bridge according to certain aspects of the subject disclosure.

[0030] FIGS. **8**A and **8**B are diagrams that illustrate the function of a circular data buffer according to certain aspects of the subject disclosure.

[0031] FIGS. **9**A and **9**B are diagrams that illustrate a process for managing circular buffer overflow using lost data records according to certain aspects of the subject disclosure.

DETAILED DESCRIPTION

[0032] Periodic monitoring of patients in a hospital is desirable at least to ensure that patients do not suffer an un-noticed sudden deterioration in their condition or a secondary injury during their stay in the hospital. It is impractical to provide continuous monitoring by a clinician and cumbersome to connect sensors to a patient, which are then connected to a fixed monitoring instrument by wires. Furthermore, systems that sound an alarm when the measured value exceeds a threshold value may sound alarms so often and in situations that are not truly serious that such alarms are ignored by clinicians.

[0033] Measuring vital signs is difficult to do on a continuous basis. Accurate measurement of cardiac pulse, for example, can be done using an electrocardiograph (ECG or EKG) to detect the electrical activity of the heart. An EKG machine may use up to 12 electrodes placed at various points on the body to detect various signals associated with the cardiac function. Another common piece of equipment is termed a "heart rate monitor." Widely sold for use in exercise and physical training, heart rate monitors may comprise a torso band in which are embedded two electrodes held against the skin and a small electronics package. Such heart rate monitors can communicate wirelessly to other equipment such as a small device that is worn like a wristwatch and that can transfer data wirelessly to a personal computer (PC).

[0034] Monitoring of patients that is referred to as "continuous" is frequently periodic, in that measurements are taken at intervals. In many cases, the process to make a single measurement takes a certain amount of time, such that even

back-to-back measurements produce values at an interval equal to the time that it takes to make the measurement. For the purpose of vital sign measurement, a sequence of repeated measurements can be considered to be "continuous" when the vital sign is not likely to change an amount that is of clinical significance within the interval between measurements. For example, a measurement of blood pressure every 10 minutes may be considered "continuous" if it is considered unlikely that a patient's blood pressure can change by a clinically significant amount within 10 minutes. The interval appropriate for measurements to be considered continuous may depend on a variety of factors including the type of injury or treatment and the patient's medical history. Compared to intervals of 4-8 hours for manual vital sign measurement in a hospital, measurement intervals of 30 minutes to several hours may still be considered "continuous."

[0035] Certain exemplary embodiments of the present disclosure include a system that comprises a vital-signs monitor patch that is attached to the patient, and a bridge that communicates with monitor patches and links them to a central server that processes the data, where the server can send data and alarms to a hospital system according to algorithms and protocols defined by the hospital.

[0036] The construction of the vital-signs monitor patch is described according to certain aspects of the present disclosure. As the patch may be worn continuously for a period of time that may be several days, as is described in the following disclosure, it is desirable to encapsulate the components of the patch such that the patient can bathe or shower and engage in their normal activities without degradation of the patch function. An exemplary configuration of the construction of the patch to provide a hermetically sealed enclosure about the electronics is disclosed.

[0037] In the following detailed description, numerous specific details are set forth to provide a full understanding of the present disclosure. It will be apparent, however, to one ordinarily skilled in the art that embodiments of the present disclosure may be practiced without some of the specific details. In other instances, well-known structures and techniques have not been shown in detail so as not to obscure the disclosure.

[0038] FIG. **1** discloses a vital sign monitoring system according to certain embodiments of the present disclosure. The vital sign monitoring system **12** includes vital-signs monitor patch **20**, bridge **40**, and surveillance server **60** that can send messages or interact with peripheral devices exemplified by mobile device **90** and workstation **100**.

[0039] Monitor patch **20** resembles a large adhesive bandage and is applied to a patient **10** when in use. It is preferable to apply the monitor patch **20** to the upper chest of the patient **10** although other locations may be appropriate in some circumstances. Monitor patch **20** incorporates one or more electrodes (not shown) that are in contact with the skin of patient **10** to measure vital signs such as cardiac pulse rate and respiration rate. Monitor patch **20** also may include other sensors such as an accelerometer, temperature sensor, or oxygen saturation sensor to measure other characteristics associated with the patient. These other sensors may be internal to the monitor patch **20** or external sensors that are operably connected to the monitor patch **20** via a cable or wireless connection. Monitor patch **20** also includes a wireless transmitter that can both transmit and receive signals. This transmitter is preferably a short-range, low-power radio frequency (RF) device operating in one of the unlicensed radio bands. One band in the United States (US) is, for example, centered at 915 MHz and designated for industrial, scientific and medical (ISM) purposes. An example of an equivalent band in the European Union (EU) is centered at 868 MHz. Other frequencies of operation may be possible dependent upon the International Telecommunication Union (ITU), local regulations and interference from other wireless devices.

[0040] Surveillance server **60** may be a standard computer server connected to the hospital communication network and preferably located in the hospital data center or computer room, although other locations may be employed. The server **60** stores and processes signals related to the operation of the patient monitoring system **12** disclosed herein including the association of individual monitor patches **20** with patients **10** and measurement signals received from multiple monitor patches **20**. Hence, although only a single patient **10** and monitor patch **20** are depicted in FIG. **1**, the server **60** is able to monitor the monitor patches **20** for multiple patients **10**.

[0041] Bridge **40** is a device that connects, or "bridges", between monitor patch **20** and server **60**. Bridge **40** communicates with monitor patch **20** over communication link **30** operating, in these exemplary embodiments, at approximately 915 MHz and at a power level that enables communication link **30** to function up to a distance of approximately 10 meters. It is preferable to place a bridge **40** in each room and at regular intervals along hallways of the healthcare facility where it is desired to provide the ability to communicate with monitor patches **20**. Bridge **40** also is able to communicate with server **60** over network link **50** using any of a variety of computer communication systems including hardwired and wireless Ethernet using protocols such as 802.11a/b/g or 802.3af. As the communication protocols of communication link **30** and network link **50** may be very different, bridge **40** provides data buffering and protocol conversion to enable bidirectional signal transmission between monitor patch **20** and server **60**.

[0042] While the embodiments illustrated by FIG. **1** employ a bridge **20** to provide communication link between the monitor patch **20** and the server **60**, in certain alternative embodiments, the monitor patch **20** may engage in direct wireless communication with the server **60**. In such alternative embodiments, the server **60** itself or a wireless modem connected to the server **60** may include a wireless communication system to receive data from the monitor patch **20**.

[0043] In use, a monitor patch **20** is applied to a patient **10** by a clinician when it is desirable to continuously monitor basic vital signs of patient **10** while patient **10** is, in this embodiment, in a hospital. Monitor patch **20** is intended to remain attached to patient **10** for an extended period of time, for example, up to 5 days in certain embodiments, limited by the battery life of monitor patch **20**. In some embodiments, monitor patch **20** is disposable when removed from patient **10**.

[0044] Server **60** executes analytical protocols on the measurement data that it receives from monitor patch **20** and provides this information to clinicians through external workstations **100**, preferably personal computers (PCs), laptops, or smart phones, over the hospital network **70**. Server **60** may also send messages to mobile devices **90**, such as cell phones or pagers, over a mobile device link **80** if a measurement signal exceeds specified parameters. Mobile device link **80** may include the hospital network **70** and internal or external wireless communication systems that are capable of sending messages that can be received by mobile devices **90**.

[0045] FIG. **2**A is a perspective view of the vital-signs monitor patch **20** shown in FIG. **1** according to certain aspects of the present disclosure. In the illustrated embodiment, the monitor patch **20** includes component carrier **23** comprising a central segment **21** and side segments **22** on opposing sides of the central segment **21**. In certain embodiments, the central segment **21** is substantially rigid and includes a circuit assembly (**24**, FIG. **2**B) having electronic components and battery mounted to a rigid printed circuit board (PCB). The side segments **22** are flexible and include a flexible conductive circuit (**26**, FIG. **2**B) that connect the circuit assembly **24** to electrodes **28** disposed at each end of the monitor patch **20**, with side segment **22** on the right shown as being bent upwards for purposes of illustration to make one of the electrodes **28** visible in this view.

[0046] FIG. **2**B is a cross-sectional view of the vital-signs patch **20** shown in FIGS. **1** and **2**A according to certain aspects of the present disclosure. The circuit assembly **24** and flexible conductive circuit **26** described above can be seen herein. The flexible conductive circuit **26** operably connects the circuit assembly **24** to the electrodes **28**. Top and bottom layers **23** and **27** form a housing **25** that encapsulate circuit assembly **28** to provide a water and particulate barrier as well as mechanical protection. There are sealing areas on layers **23** and **27** that encircles circuit assembly **28** and is visible in the cross-section view of FIG. **2**B as areas **29**. Layers **23** and **27** are sealed to each other in this area to form a substantially hermetic seal. Within the context of certain aspects of the present disclosure, the term 'hermetic' implies that the rate of transmission of moisture through the seal is substantially the same as through the material of the layers that are sealed to each other, and further implies that the size of particulates that can pass through the seal are below the size that can have a significant effect on circuit assembly **24**. Flexible conductive circuit **26** passes through portions of sealing areas **29** and the seal between layers **23** and **27** is maintained by sealing of layers **23** and **27** to flexible circuit assembly **28**. The layers **23** and **27** are thin and flexible, as is the flexible conductive circuit **26**, allowing the side segment **22** of the monitor patch **20** between the electrodes **28** and the circuit assembly **24** to bend as shown in FIG. **2**A.

[0047] FIG. **2**C is a functional block diagram **200** illustrating exemplary electronic and sensor components of the monitor patch **20** of FIG. **1** according to certain aspects of the present disclosure. The block diagram **200** shows a processing and sensor interface module **201** and external sensors **232**, **234** connected to the module **201**. In the illustrated example, the module **201** includes a processor **202**, a wireless transceiver **207** having a receiver **206** and a transmitter **209**, a memory **210**, a first sensor interface **212**, a second sensor interface **214**, a third sensor interface **216**, and an internal sensor **236** connected to the third sensor interface **216**. The first and second sensor interfaces **212** and **214** are connected to the first and second external sensors **232**, **234** via first and second connection ports **222**, **224**, respectively. In certain embodiments, some or all of the aforementioned components of the module **201** and other components are mounted on a PCB.

[0048] Each of the sensor interfaces **212**, **214**, **216** can include one or more electronic components that are configured to generate an excitation signal or provide DC power for the sensor that the interface is connected to and/or to condition and digitize a sensor signal from the sensor. For example, the sensor interface can include a signal generator for generating an excitation signal or a voltage regulator for providing power to the sensor. The sensor interface can further include an amplifier for amplifying a sensor signal from the sensor and an analog-to-digital converter for digitizing the amplified sensor signal. The sensor interface can further include a filter (e.g., a low-pass or bandpass filter) for filtering out spurious noises (e.g., a 60 Hz noise pickup).

[0049] The processor **202** is configured to send and receive data (e.g., digitized signal or control data) to and from the sensor interfaces **212**, **214**, **216** via a bus **204**, which can be one or more wire traces on the PCB. Although a bus communication topology is used in this embodiment, some or all communication between discrete components can also be implemented as direct links without departing from the scope of the present disclosure. For example, the processor **202** may send data representative of an excitation signal to the sensor excitation signal generator inside the sensor interface and receive data representative of the sensor signal from the sensor interface, over either a bus or direct data links between processor **202** and each of sensor interface **212**, **214**, and **216**.

[0050] The processor **202** is also capable of communication with the receiver **206** and the transmitter **209** of the wireless transceiver **207** via the bus **204**. For example, the processor **202** using the transmitter and receiver **209**, **206** can transmit and receive data to and from the bridge **40**. In certain embodiments, the transmitter **209** includes one or more of a RF signal generator (e.g., an oscillator), a modulator (a mixer), and a transmitting antenna; and the receiver **206** includes a demodulator (a mixer) and a receiving antenna which may or may not be the same as the transmitting antenna. In some embodiments, the transmitter **209** may include a digital-to-analog converter configured to receive data from the processor **202** and to generate a base signal; and/or the receiver **206** may include an analog-to-digital converter configured to digitize a demodulated base signal and output a stream of digitized data to the processor **202**. In other embodiments, the radio may comprise a direct sequence radio, a software-defined radio, or an impulse spread spectrum radio.

[0051] The processor **202** may include a general-purpose processor or a specific-purpose processor for executing instructions and may further include a memory **219**, such as a volatile or non-volatile memory, for storing data and/or instructions for software programs. The instructions, which may be stored in a memory **219** and/or **210**, may be executed by the processor **202** to control and manage the wireless transceiver **207**, the sensor interfaces **212**, **214**, **216**, as well as provide other communication and processing functions.

[0052] The processor **202** may be a general-purpose microprocessor, a microcontroller, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), a Programmable Logic Device (PLD), a controller, a state machine, gated logic, discrete hardware components, or any other suitable device or a combination of devices that can perform calculations or other manipulations of information.

[0053] Information, such as program instructions, data representative of sensor readings, preset alarm conditions, threshold limits, may be stored in a computer or processor readable medium such as a memory internal to the processor **202** (e.g., the memory **219**) or a memory external to the processor **202** (e.g., the memory **210**), such as a Random Access Memory (RAM), a flash memory, a Read Only Memory (ROM), a Programmable Read-Only Memory (PROM), an Erasable PROM (EPROM), registers, a hard disk, a removable disk, or any other suitable storage device.

[0054] In certain embodiments, the internal sensor **236** can be one or more sensors configured to measure certain properties of the processing and sensor interface module **201**, such as a board temperature sensor thermally coupled to a PCB. In other embodiments, the internal sensor **236** can be one or

more sensors configured to measure certain properties of the patient **10**, such as a motion sensor (e.g., an accelerometer) for measuring the patient's motion or position with respect to gravity.

[0055] The external sensors **232**, **234** can include sensors and sensing arrangements that are configured to produce a signal representative of one or more vital signs of the patient to which the monitor patch **20** is attached. For example, the first external sensor **232** can be a set of sensing electrodes that are affixed to an exterior surface of the monitor patch **20** and configured to be in contact with the patient for measuring the patient's respiratory rate, and the second external sensor **234** can include a temperature sensing element (e.g., a thermocouple or a thermistor or resistive thermal device (RTD)) affixed, either directly or via an interposing layer, to skin of the patient **10** for measuring the patient's body temperature. In other embodiments, one or more of the external sensors **232**, **234** or one or more additional external sensors can measure other vital signs of the patient, such as blood pressure, pulse rate, or oxygen saturation.

[0056] FIG. **3**A is a functional block diagram illustrating exemplary electronic components of bridge **40** of FIG. **1** according to one aspect of the subject disclosure. Bridge **40** includes a processor **310**, radio **320** having a receiver **322** and a transmitter **324**, radio **330** having a receiver **332** and a transmitter **334**, memory **340**, display **345**, and network interface **350** having a wireless interface **352** and a wired interface **354**. In some embodiments, some or all of the aforementioned components of module **300** may be integrated into single devices or mounted on PCBs.

[0057] Processor **310** is configured to send data to and receive data from receiver **322** and transmitter **324** of radio **320**, receiver **332** and transmitter **334** of radio **330** and wireless interface **352** and wired interface **354** of network interface **350** via bus **314**. In certain embodiments, transmitters **324** and **334** may include a radio frequency signal generator (oscillator), a modulator, and a transmitting antenna, and the receivers **322** and **332** may include a demodulator and antenna which may or may not be the same as the transmitting antenna of the radio. In some embodiments, transmitters **324** and **334** may include a digital-to-analog converter configured to convert data received from processor **310** and to generate a base signal, while receivers **322** and **332** may include analog-to-digital converters configured to convert a demodulated base signal and sent a digitized data stream to processor **310**.

[0058] Processor **310** may include a general-purpose processor or a specific-purpose processor for executing instructions and may further include a memory **312**, such as a volatile or non-volatile memory, for storing data and/or instructions for software programs. The instructions, which may be stored in memories **312** or **340**, may be executed by the processor **310** to control and manage the transceivers **320**, **330**, and **350** as well as provide other communication and processing functions.

[0059] Processor **310** may be a general-purpose microprocessor, a microcontroller, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), a Programmable Logic Device (PLD), a controller, a state machine, gated logic, discrete hardware components, or any other suitable device or a combination of devices that can perform calculations or other manipulations of information.

[0060] Information such as data representative of sensor readings may be stored in memory **312** internal to processor **310** or in memory **340** external to processor **310** which may be a Random Access Memory (RAM), flash memory, Read Only Memory (ROM), Programmable Read Only Memory (PROM), Erasable Programmable Read Only Memory (EPROM), registers, a hard disk, a removable disk, a Solid State Memory (SSD), or any other suitable storage device.

[0061] Memory **312** or **340** can also store a list or a database of established communication links and their corresponding characteristics (e.g., signal levels) between the bridge **40** and its related monitor patches **20**. In the illustrated example of FIG. **3**A, the memory **340** external to the processor **310** includes such a database **342**; alternatively, the memory **312** internal to the processor **310** may include such a database.

[0062] FIG. **3**B is a functional block diagram illustrating exemplary electronic components of server **60** of FIG. **1** according to one aspect of the subject disclosure. Server **60** includes a processor **360**, memory **370**, display **380**, and network interface **390** having a wireless interface **392** and a wired interface **394**. Processor **360** may include a general-purpose processor or a specific-purpose processor for executing instructions and may further include a memory **362**, such as a volatile or non-volatile memory, for storing data and/or instructions for software programs. The instructions, which may be stored in memories **362** or **370**, may be executed by the processor **360** to control and manage the wireless and wired network interfaces **392**, **394** as well as provide other communication and processing functions.

[0063] Processor **360** may be a general-purpose microprocessor, a microcontroller, a Digital Signal Processor (DSP), an Application Specific Integrated Circuit (ASIC), a Field Programmable Gate Array (FPGA), a Programmable Logic Device (PLD), a controller, a state machine, gated logic, discrete hardware components, or any other suitable device or a combination of devices that can perform calculations or other manipulations of information.

[0064] Information such as data representative of sensor readings may be stored in memory **362** internal to processor **360** or in memory **370** external to processor **360** which may be a Random Access Memory (RAM), flash memory, Read Only Memory (ROM), Programmable Read Only Memory (PROM), Erasable Programmable Read Only Memory (EPROM), registers, a hard disk, a removable disk, a Solid State Memory (SSD), or any other suitable storage device.

[0065] Memory **362** or **370** can also store a database of communication links and their corresponding characteristics (e.g., signal levels) between monitor patches **20** and bridges **40**. In the illustrated example of FIG. **3**B, the memory **370** external to the processor **360** includes such a database **372**; alternatively, the memory **362** internal to the processor **360** may include such a database.

[0066] FIG. **4** graphically illustrates a "store-and-forward" data transfer of vital sign measurements taken by the vital-sign patch **20** from, in this example, electrodes **232** by module **201** of patch **20** and forwarded from patch **20** to bridge **40**. Some existing wireless devices that monitor vital signs such as cardiac pulse broadcast each measurement at the time the measurement was taken without confirmation that the data was received intact. In the embodiment described in FIG. **4**, measurements are taken at regular intervals at the patient **10** while the vital sign signal transfer from patch **20** to bridge **40** over communication link **30** is at irregular intervals which are controlled by bridge **40** and which are not synchronized with the measurement intervals. Similarly, FIG. **5** graphically illustrates the "store-and-forward" transfer of vital sign signals received by bridge **40** from patch **20** over communication link **30** and then forwarded to server **60** over network link **50**. There is no requirement that the transfer of data from bridge **40** to server **60** over network link **50** be synchronized with the transfer of data from patch **20** over communication link **30** to bridge **40**.

[0067] FIG. **6** is a flowchart that illustrates an exemplary store-and-forward methodology as implemented for the vital-signs patch according to certain embodiments of the present disclosure. As will be apparent to one of ordinary skill in the art, there are numerous variations of the principles disclosed in this specific example and in the examples that follow. Steps may be performed in a different order, some steps omitted, other steps added, and the logic flow may be varied without departing from the scope of the subject disclosure.

[0068] The process of FIG. **6** starts at step **450** when patch **20** is applied to a patient and activated. In this example, the sensor will be a pair of electrodes **28** (FIG. **2**B) and the vital sign of interest is respiration, although patch **20** may have other sensors and may be measuring other vital signs instead of or in addition to respiration. Processor **202** of patch **20** takes a voltage measurement from the electrodes in step **452** and the measurement and the time at which the measurement was taken are stored in memory **202** in step **454**. As determining the rate of respiration requires a series of measurements that are evaluated as a set, step **456** branches back to step **452** at this point. After a sufficient number of measurements are recorded, step **456** will branch to step **458** where the data is analyzed, in this example to find two successive peaks in the measurements, and the respiration rate is calculated, in this example, from the time interval between these peaks, in step **460**. This calculated value is converted to a data record in step **462**, in this example, by storing a record sequence number, the time of the second peak value, and the calculated respiration rate in a defined data structure, and in step **464** the data record is stored in data buffer **470** located, in this example, in memory **202**.

[0069] In parallel with the process of steps **452** through **464**, a second process of steps **472** through **488** is being independently executed. Patch **20** is listening with receiver **206** for a signal from bridge **40**. Upon receipt in step **472** of an 'upload' command from bridge **40**, this second process is initiated. Patch processor **20** will retrieve the oldest data record, as indicated in this example by the sequence number assigned in the first process, from data buffer **470** in step **474**. The data record is converted in step **476** to a vital-sign signal according to the communication protocol of link **30** and transmitted to bridge **40** in step **480**. Patch **20** then waits for a signal from bridge **40** as to whether the transmission was successful. If the message from the bridge is that the transmission was not correctly received, step **482** will branch back to step **478** and resend the same vital-sign signal. If the message from the bridge is that the transmission was successful, step **482** will bridge to step **484** where the data record associated with the transmission, which is the oldest record in data buffer **470**, is erased. If more data records are available to transmit, step **486** branches back to step **474** to process the next-oldest record. If there are no more records ready to transmit, patch **20** sends a 'done" message to bridge **40** and returns to step **472** to await the next 'upload' command.

[0070] A patch **20** may lose communication with bridge **40**, for example, when a patient travels to a part of the hospital where there are no bridges **40**. If a patch **20** is out of communication with any bridge **40** for a period of time exceeding the measurement interval of step **452**, then patch **20** will continue to make and store vital sign measurements following the loop **452-456-464-452**. In some embodiments, patch **20** may comprise enough memory to hold several hours of vital sign measurements.

[0071] It can be seen that there is potential for a delay between the completion of a measurement by patch **20** of the vitals signs of a patient **10** and the successful transmission of the data from this measurement to bridge **40**. This delay may be due to the periodic nature of communication between patch **20** and bridge **40** as designed into the protocol of communication link **30** or by travel by patient **10** out of the range of bridge **40**.

[0072] FIG. **7** is a flowchart that illustrates an embodiment of the store-and-forward methodology as implemented for the bridge. As will be apparent to one of ordinary skill in the art, there are numerous variations of the principles disclosed in this specific example. Steps may be performed in a different order, some steps omitted, other steps added, and the logic flow may be varied without departing from the scope of the subject disclosure.

[0073] In this example, the process starts at step **500** and proceeds to step **502** where bridge **40** sends an 'upload' command to patch **20**. Bridge **40** then receives a vital-sign signal from patch **20** in step **504**. In this example, the vital-sign signal is structured as a data packet that includes a packet identification value and a data integrity value.

[0074] The packet identification value may be unique over some duration of activity such that the system can determine whether a received data packet is a duplicate of a packet previously received (i.e. two packets have the same packet identification value) or whether a data packet has been missed (i.e. there is a gap in the sequence of packet identification values). For example, the packet identification value may be a numeric string composed of the serial number of patch **20** followed by a sequence number where the sequence number is, in this example, incremented by one for each new packet that is sent. If a packet is retransmitted, the same sequence number is used as was used for the initial transmission.

[0075] The data integrity value may be a Cyclic Redundancy Check (CRC) value or other error-detection value that is used to verify that the packet has been received without corruption at an acceptable level of certainty. Use of a CRC value to verify the integrity of a data signal is well known in the art. As a data integrity check of this type may not provide 100% certainty that an error in transmission has not occurred, other types of error-detection algorithms may be used to provide a higher degree of assurance that the signal has not been corrupted in transit.

[0076] In step **506**, bridge **40** analyzes the data integrity of the vital-sign signal data packet using the CRC value. If an error in the data packet is detected, step **508** branches to step **510** where bridge **40** sends a 'resend' command to patch **20** and the process reverts to step **504**. If no error is detected in the vital-sign signal, step **508** branches to step **512** where bridge **40** sends a "good transmission' signal to patch **20** and proceeds to step **514** where the message sequence is evaluated. If the sequence number indicates that this vital-sign signal is a duplicate of a previous successfully-received signal, step **516** branches to step **518** where this signal is discarded and the process reverts to step **502**. If the sequence number indicates that a vital-sign signal was lost, in this example by a gap between the message sequence number of this vital-sign signal and the message sequence number of the last signal, step **520** branches to step **522** which logs the gap. Regardless of a gap, the process then reaches step **524** where the vital-sign signal is converted to a data record and stored in step **526** in data buffer **530**.

[0077] In parallel with the process of steps **502** through **526**, a second process of steps **532** through **548** is being independently executed. In step **532**, bridge **40** is listening for an upload command from server **60**. This step may be implemented in a number of configurations according to the protocol of network link **50**, some of which include actions by the bridge to determine whether it is appropriate to initiate a transmission, without departing from the scope of the subject

disclosure. Upon determination that it is appropriate to send data to the server, the process moves to step **534** where the oldest data record is retrieved from data buffer **530**. The data record is converted to a vital-signs signal according to the protocol of network link **50** in step **536** and transmitted to server **60** in step **538**. Bridge **40** then waits for a signal from the server in step **540** as to whether the transmission was successfully received. If the transmission was not successfully received, step **542** branches back to step **538** and resends the same signal. If the signal was successfully received, step **542** branches to step **544** and erases the oldest data record, which was associated with the signal just sent. If there are more data records available to transmit, step **546** branches to step **534** and retrieves the next-oldest record. If there are no more records ready to transmit, step **546** branches to step **548** and sends a 'done' message to the server, according to the protocol of network link **50**, and returns to step **532** to await initiation of the next upload sequence.

[0078] FIGS. **8**A and **8**B illustrate the configuration and use of a circular data buffer **801** in certain embodiments of the present disclosure. In this example, data buffer **801**, located in memory **202**, is able to store **16** data records but a data buffer may be of any size, limited only by the available storage capacity of the device. Circular data buffers are especially advantageous where the storage capacity is limited, such as in an embedded microprocessor system. The depiction of data buffer **801** as a circle of storage locations is intended to assist in understanding, as the designation of the storage locations has no physical significance.

[0079] In FIG. **8**A, data records are stored in sequential locations in data buffer **801** and each data record has a number associated with the sequence in which the records were stored. In this example, the oldest data record is number "N" and the latest record is "N+3". Two pointers are associated with data buffer **801**. The 'next write' pointer **810** indicates which storage location of data buffer **801** will be used for the next data record to be received. The 'next read' pointer **805** indicates the storage location of data buffer **801** that contains the oldest data record that is the data record that will be transmitted first. The number of records from the 'next read' pointer **805** to the 'next write' pointer **810** indicates the amount of data currently stored in data buffer **801**. In this example, there are 4 records in data buffer **801**, which has a capacity of 16, so the buffer is 25% full.

[0080] In normal operation, storage of new data records and reading of old data records happen independently. New data records may be received asynchronously from data records being read. For example, a new data record may be received at a fixed time interval while data records may be read in groups at irregular intervals. During times when more new data records are received than old data records are read, data buffer **801** will become increasingly full. During times when more data records are read than new data records are received, data buffer **801** will become increasingly empty until there are no data records stored in data buffer **801**. It is desirable to select the size of data buffer **801** to be large enough to store the largest number of data records that might accumulate.

[0081] In FIG. **8**B, circular data buffer **801** is full. This may occur when there is an interruption in the reading of data records for a period of time longer than anticipated by the software programmer. In this example, the oldest existing data record is "N+1" and the last record stored is "N+16". After record "N+16" was received and stored, the 'next read' pointer **810** and 'next write' pointer **805** both indicate the same record. When the next record is received, it would be stored in the same location as currently occupied by record "N+1", erasing record "N+1" resulting in loss of the data in data record "N+1". This is termed "circular buffer overflow."

[0082] FIGS. **9**A and **9**B describe an exemplary embodiment of a method of handling circular buffer overflow according to certain embodiments of the present disclosure. In FIG. **9**A, data record "N+17" has been received but is not yet written into data buffer **801**. The processor first reads data record "N+1" and extracts key information such as the time of the reading and whether the reading is within limits. This key information is stored as a "lost data record" in array **820** which occupies a separate area of memory **202**. The lost data record is much smaller than the data record from which it is created, possibly as small as a single bit depending on how much information the programmer wishes to retain. Once lost data record "N+1" is created, the 'next read' pointer **805** is reset to indicate data record "N+2" and then data record "N+17" is written into the buffer location occupied by data record "N+1". FIG. **9**B illustrates the configuration of the buffer at the end of the storage operation, with the oldest record in the buffer now being data record "N+2" and the newest record being data record "N+17", both the 'next write' pointer **810** and 'next read' pointer **805** indicating the buffer location occupied by data record "N+2", and with a separate lost data record "N+1" stored in the first location of array **820**.

[0083] Alternate forms of a lost data record may be a single register that stores the number of data records that have been overwritten, or a pair of registers that store the number of overwritten records that were within limits and that exceeded limits. The advantage of these alternate methods is that they occupy a very small and fixed amount of memory while being able to handle a relatively large number of lost data records, up to the allocated size of the registers. The disadvantage is that the amount of information retained regarding the values of the lost data records is very small.

[0084] It can be seen that the disclosed embodiments of the vital-signs monitor patch provide a mobile solution to monitoring the vital signs of a patient. The design of the vital-signs monitor patch frees nurses, or other caregivers, from the task of repetitively measuring the vital signs of their patients, allowing the caregivers to spend more time on other duties. The ability to continuously monitor a patient's vital signs using a monitor patch, together with the rest of the patient monitoring system, increases the ability of the nurse to respond quickly to a sudden change in a patient's condition, resulting in improved care for the patient.

[0085] The store-and-forward capability of the patch enables the patch to accumulate vital-sign measurements while the patient is out of range of a bridge and, up to certain interval of time out of communication, transfer this data to the rest of the patient monitoring system without loss of data taken during the time out of communication. Furthermore, in cases where the patient is out of range of a bridge for a period of time exceeding the storage limits of the patch, a reduced amount of information related to the oldest measurements is retained and, when the patch regains a communication link to the rest of the patient monitoring system, information is sent to the system regarding the lost measurements in addition to the complete records of the latest measurements. Furthermore, because the data is stored, the data can be retained by the patch until the bridge confirms that the data was received intact and if a data transfer was corrupted, the same data can be resent. This retention of data until receipt is confirmed increases the reliability of the communication link between the patch and bridge.

[0086] The store-and-forward capability of the bridge enables the bridge to receive data from each patch to which the bridge is assigned at times determined by the bridge. The

time at which this same information is transferred from the bridge to the server can be selected by the server to optimize other characteristics of the system, such as load management of the server-to-bridge communication link. This decoupling of the timing of the patch-to-bridge data transfer from the bridge-to-server data transfer increases the reliability of the end-to-end linkage from a patch to the server as the transfer over each link can be verified without impact to the next link of the transfer chain.

[0087] The previous description is provided to enable any person skilled in the art to practice the various aspects described herein. While the foregoing has described what are considered to be the best mode and/or other examples, it is understood that various modifications to these aspects will be readily apparent to those skilled in the art, and the generic principles defined herein may be applied to other aspects. Thus, the claims are not intended to be limited to the aspects shown herein, but is to be accorded the full scope consistent with the language claims, wherein reference to an element in the singular is not intended to mean "one and only one" unless specifically so stated, but rather "one or more." Unless specifically stated otherwise, the term "some" refers to one or more. Pronouns in the masculine (e.g., his) include the feminine and neuter gender (e.g., her and its) and vice versa. Headings and subheadings, if any, are used for convenience only and do not limit the invention.

[0088] It is understood that the specific order or hierarchy of steps in the processes disclosed is an illustration of exemplary approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the processes may be rearranged. Some of the steps may be performed simultaneously. The accompanying method claims present elements of the various steps in a sample order, and are not meant to be limited to the specific order or hierarchy presented.

[0089] Terms such as "top," "bottom," "front," "rear" and the like as used in this disclosure should be understood as referring to an arbitrary frame of reference, rather than to the ordinary gravitational frame of reference. Thus, a top surface, a bottom surface, a front surface, and a rear surface may extend upwardly, downwardly, diagonally, or horizontally in a gravitational frame of reference.

[0090] A phrase such as an "aspect" does not imply that such aspect is essential to the subject technology or that such aspect applies to all configurations of the subject technology. A disclosure relating to an aspect may apply to all configurations, or one or more configurations. A phrase such as an aspect may refer to one or more aspects and vice versa. A phrase such as an "embodiment" does not imply that such embodiment is essential to the subject technology or that such embodiment applies to all configurations of the subject technology. A disclosure relating to an embodiment may apply to all embodiments, or one or more embodiments. A phrase such an embodiment may refer to one or more embodiments and vice versa.

[0091] The word "exemplary" is used herein to mean "serving as an example or illustration." Any aspect or design described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other aspects or designs.

[0092] All structural and functional equivalents to the elements of the various aspects described throughout this disclosure that are known or later come to be known to those of ordinary skill in the art are expressly incorporated herein by reference and are intended to be encompassed by the claims. Moreover, nothing disclosed herein is intended to be dedicated to the public regardless of whether such disclosure is explicitly recited in the claims. No claim element is to be construed under the provisions of 35 U.S.C. §112, sixth paragraph, unless the element is expressly recited using the phrase "means for" or, in the case of a method claim, the element is recited using the phrase "step for." Furthermore, to the extent that the term "include," "have," or the like is used in the description or the claims, such term is intended to be inclusive in a manner similar to the term "comprise" as "comprise" is interpreted when employed as a transitional word in a claim.

What is claimed is:

1. A vital-signs patch for a patient monitoring system, the patch comprising:

a patch housing configured for wearing by a patient, the housing containing:

at least one sensor configured to make physiological measurements of a patient;

a transmitter configured to transmit signals to another device;

a receiver configured to receive signals from the other device;

a memory configured to store executable instructions and data records; and

a processor operably connected to the sensor, transmitter, receiver, and memory, and configured to execute the instructions;

wherein the processor is configured to periodically take at least one measurement from the sensor, convert the measurement to a data record, and store the data record in the memory; and

wherein the processor is further configured to receive signals from the other device via the receiver and in response to receipt of the signals:

retrieve at least a portion of the data record,

configure the retrieved portion of the data record into a vital-sign signal, and

cause the transmitter to transmit the vital-sign signal to the other device.

2. The vital-signs patch of claim **1** wherein the physiological measurements of a patient include measurements of at least one of the set of body temperature, cardiac pulse rate, respiration rate, and blood pressure.

3. The vital-signs patch of claim **2** wherein the sensor comprises one or more electrodes.

4. The vital-signs patch of claim **1** wherein the vital-sign signal is in the form of a data packet, wherein the data packet comprises a data packet identification value and a data integrity value.

5. The vital-signs patch of claim **1** wherein the processor is configured to store the data records from the successive vital-sign measurements as successive data records.

6. The vital-signs patch of claim **5** wherein the processor is configured to retain each data record in memory until a signal indicating a successful transmission of the data record is received from the other device, whereupon the processor is configured to erase the data record.

7. The vital-signs device of claim **5** wherein the successive data records are stored in a circular buffer within the memory.

8. The vital-signs device of claim **7** wherein when the circular buffer becomes full of data records and it is desired to store a new data record, the processor is configured to create a lost-data record that comprises information regarding the oldest data record, store the lost data record outside of the circular buffer, and then overwrite the oldest data record with the new data record.

9. A bridge in a patient monitoring system, the bridge comprising:

a first receiver configured to receive signals from a first device;

a first transmitter configured to transmit signals to the first device;

a second receiver configured to receive signals from a second device;

a second transmitter configured to transmit signals to the second device;

a memory configured to store executable instructions and data records; and

a processor operably connected to the receivers , transmitters, and memory and configured to execute the instructions;

wherein the processor is configured to periodically cause the first transmitter to transmit a signal to the first device that will cause the first device to transmit a vital-sign signal, receive the vital-sign signal from the first device via the first receiver, convert the vital-sign signal to a data record, and store the data record in the memory; and

wherein the processor is further configured to receive upload signals from the second device via the second receiver and in response to the receipt of upload signals from the second device:

retrieve at least a portion of the data record from the memory,

configure the retrieved portion of the data record into a data signal, and

cause the second transmitter to transmit the data signal.

10. The bridge of claim **9** wherein the first receiver comprises a wireless radio frequency receiver, the first transmitter comprises a wireless radio frequency transmitter, and wherein both the second transmitter and second receiver comprise an interface to a communication network wherein the second transmitter and second receiver communicate with the second device over an Ethernet network.

11. The bridge of claim **9** wherein the vital sign signal is received in the form of a data packet, wherein the data packet comprises a data packet identification value and a data integrity value, and wherein the processor is configured to use the data packet identification value to verify that the data packet is not a duplicate of a previously received packet, and wherein the processor is further configured to use the data integrity value to verify the integrity of the data packet.

12. The bridge of claim **9** wherein the processor is configured to store the data records from the successive vital-sign measurements as successive data records.

13. The bridge of claim **12** wherein the processor is configured to retain each data record in memory until a signal indicating a successful transmission of the data record is received from the second device, whereupon the processor is configured to erase the data record.

14. The bridge of claim **12** wherein the successive data records are stored in a circular buffer within the memory.

15. The bridge of claim **14** wherein when the circular buffer becomes full of data records and it is desired to store a new data record, the processor is configured to create a lost-data record that comprises information regarding the oldest data record, store the lost data record outside of the circular buffer, and then overwrite the oldest data record with the new data record.

16. A method of storing and forwarding vital-sign data comprising the steps of:

receiving at a second device vital-sign data from a first device;

storing the vital-sign data;

listening for a signal from a third device until the signal is received;

retrieving at least a portion of the vital-sign data from storage; and

transmitting the retrieved portion of the vital-sign data to the third device.

17. The method of claim **16** further comprising the steps of:

retaining the vital-sign data until a signal is received from the third device confirming that the vital-sign data was successfully received by the third device; and

erasing the vital-sign data from storage.

18. The method of claim **16** wherein the vital-sign data from the first device includes physiological measurements related to at least one of the set of body temperature, cardiac pulse rate, respiration rate, and blood pressure.

19. The method of claim **16** wherein the first device is a sensor.

20. The method of claim **16** wherein the vital-sign data received from the first device is in the form of a data packet that comprises a data packet identification value and a data integrity value, and wherein the method further comprises the steps of:

using the data packet identification value to determine if the data packet is a duplicate of a previously received packet;

discarding the data packet if it is a duplicate;

using the data integrity value to verify the integrity of the data packet; and

transmitting a request to the first device to retransmit the data packet if the integrity of the received data packet has been corrupted.

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专利名称(译)	用于存储和转发来自生命体征监视器的数据的系统和方法		
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摘要(译)

用于患者监测系统的生命体征贴片，其包括壳体，壳体包含对患者进行生理测量的传感器，发射器，接收器，存储器和处理器。处理器定期从传感器获取测量值，将测量值转换为数据记录，并将数据记录存储在存储器中。在从另一个设备接收到信号时，处理器检索数据记录的至少一部分，将检索到的数据记录部分转换为生命体征信号，并使发射器将生命体征信号发送给另一个。设备。