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(54) **MEDICAL SIGNAL PROCESSING SYSTEM WITH DISTRIBUTED WIRELESS SENSORS**

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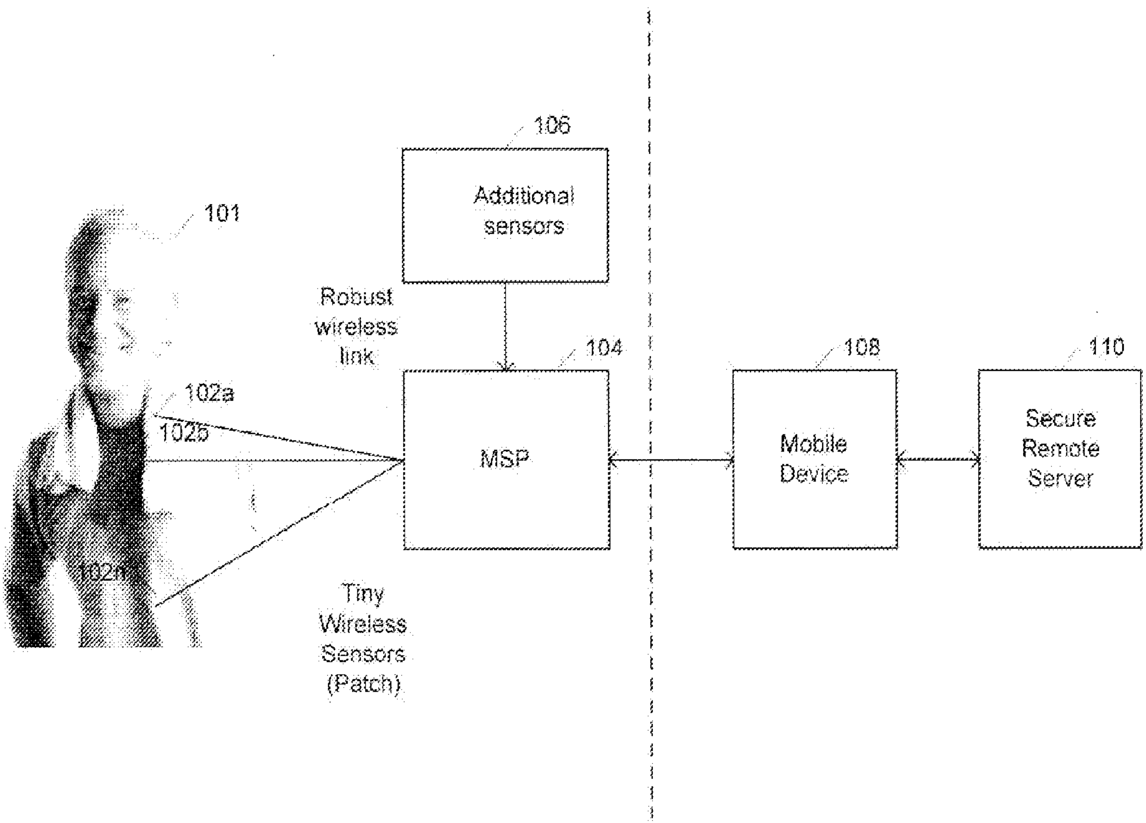
(57) **ABSTRACT**

A wireless medical signal processing system for health monitoring is disclosed which achieves high wireless link reliability/security, low power dissipation, compactness, low cost and supports a variety of sensors for various physiological parameters. The system includes a medical signal processor which communicates with a wireless distributed sensor system as its peripheral for detecting physiological parameters of the person and for providing signals indicative thereof. The medical signal processor wirelessly receives the signals from the distributed wireless sensor system in a multiplexed fashion and processes the signals to provide an indication of the health of the person. The indication of health could relate to a disease state, general health or fitness level of a person. The system also includes a mobile device for receiving the indication of the health of the person to allow for a diagnosis or treatment of the person.



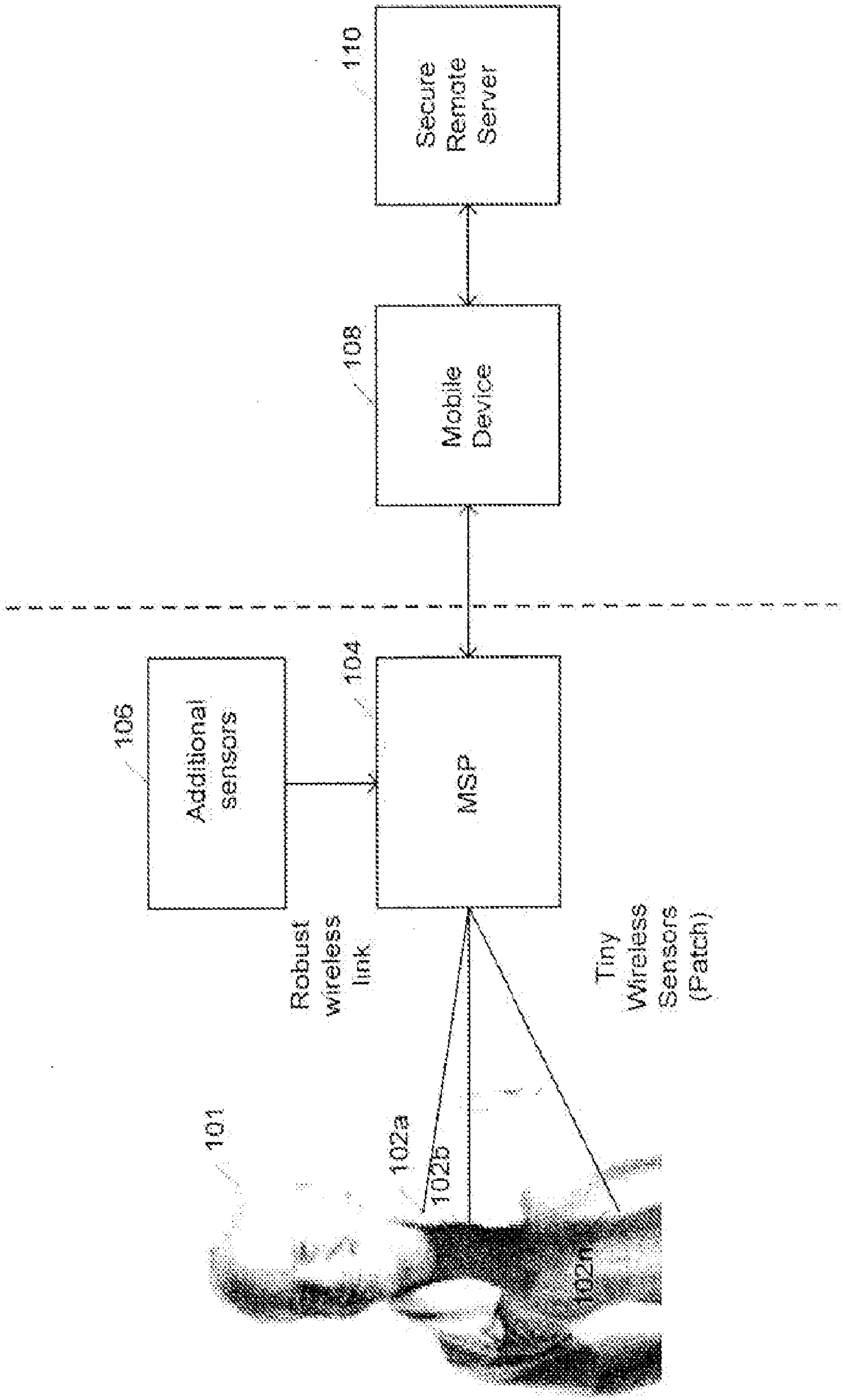
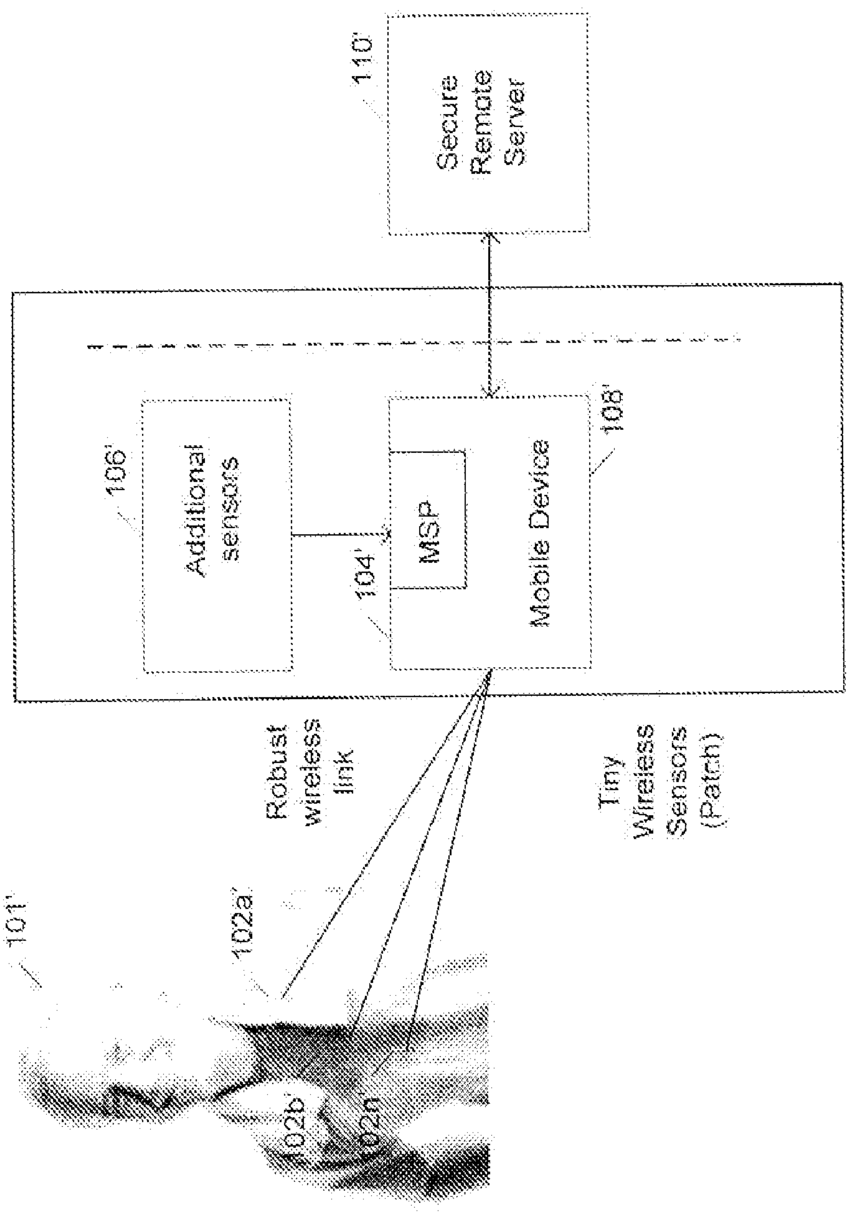

110
Secure Remote Server
108
Mobile Device
106
Additional sensors
104
MSP
Robust wireless link
Tiny Wireless Sensors (Patch)
101
102a
102b
102n

Figure 1A



110'
Secure Remote Server
106'
Additional sensors
104'
MSP
Mobile Device
108'
Robust wireless link
Tiny Wireless Sensors (Patch)
101'
102a'
102b'
102n'

Figure 1B

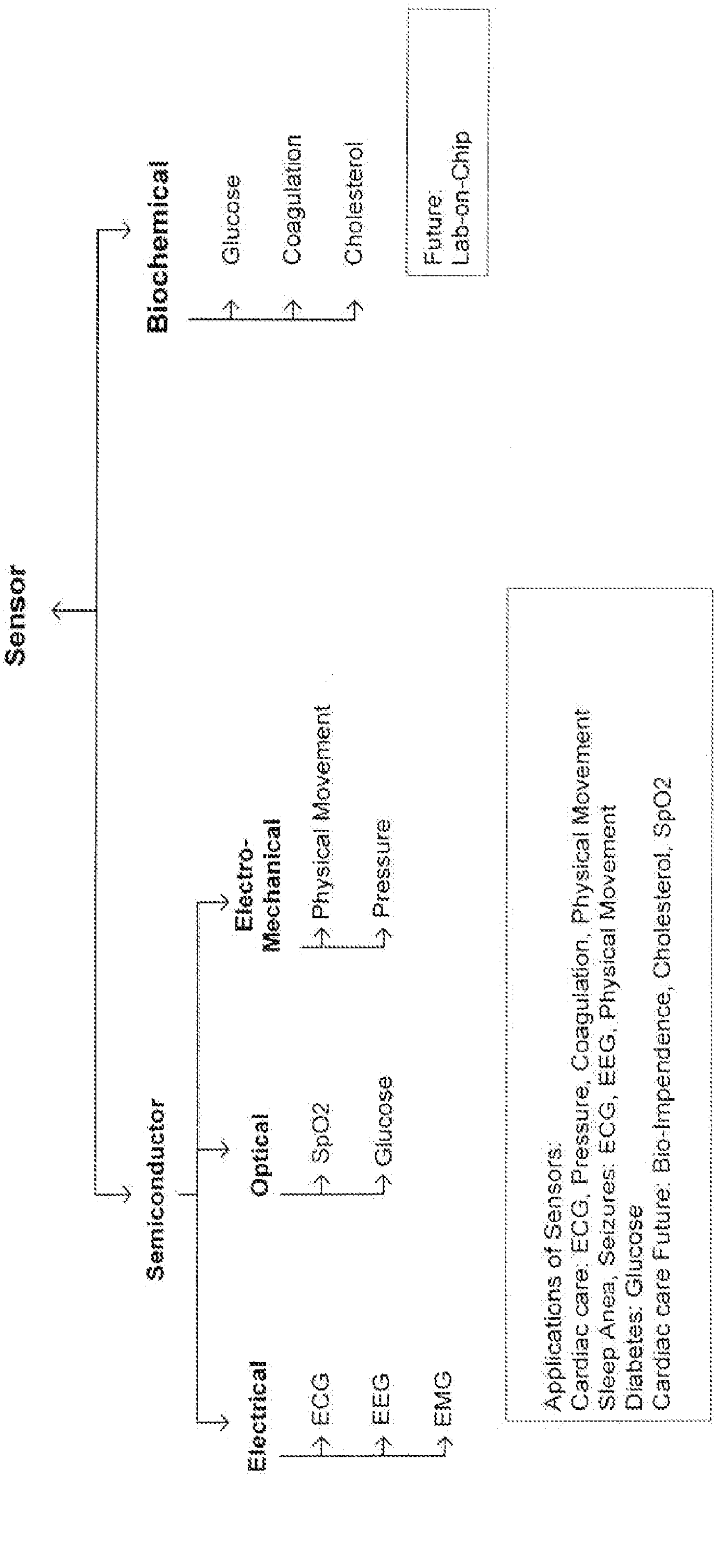

Sensor
Semiconductor
Biochemical
Electrical
ECG
EEG
EMG
Optical
SpO2
Glucose
Electro-
Mechanical
Physical Movement
Pressure
Glucose
Coagulation
Cholesterol
Future:
Lab-on-Chip
Applications of Sensors:
Cardiac care: ECG, Pressure, Coagulation, Physical Movement
Sleep Anea, Seizures: ECG, EEG, Physical Movement
Diabetes: Glucose
Cardiac care Future: Bio-Impendence, Cholesterol, SpO2

Figure 2

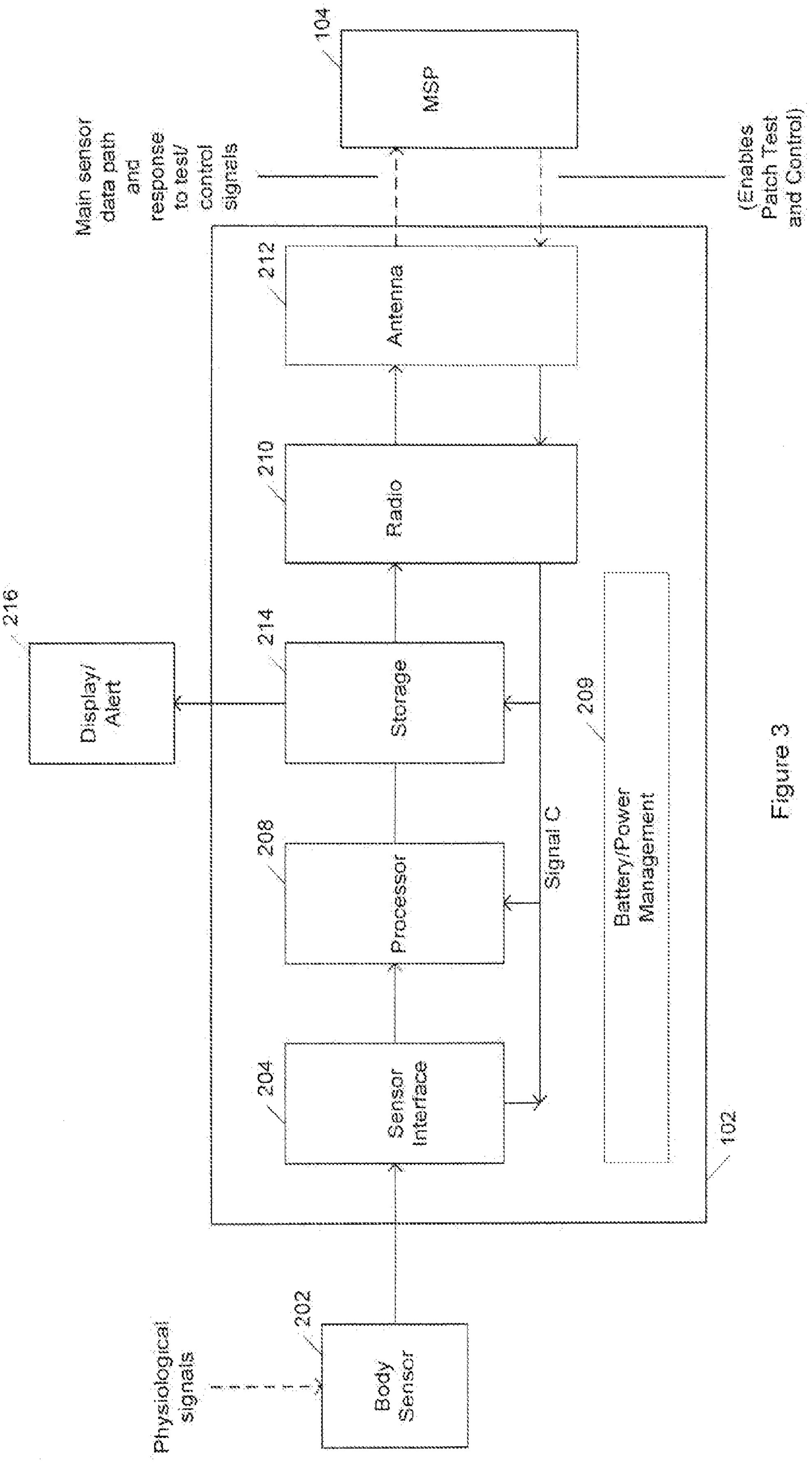
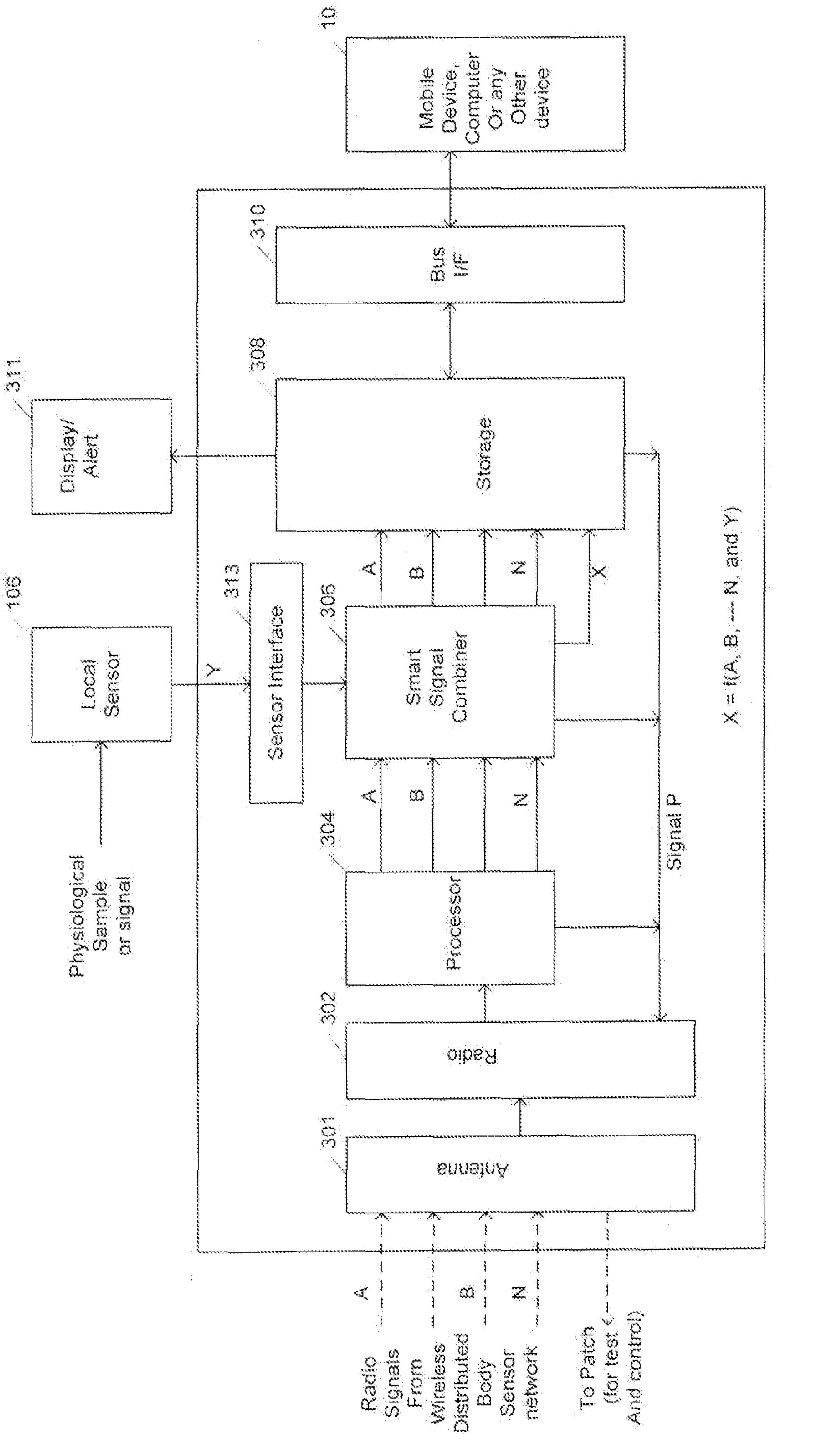
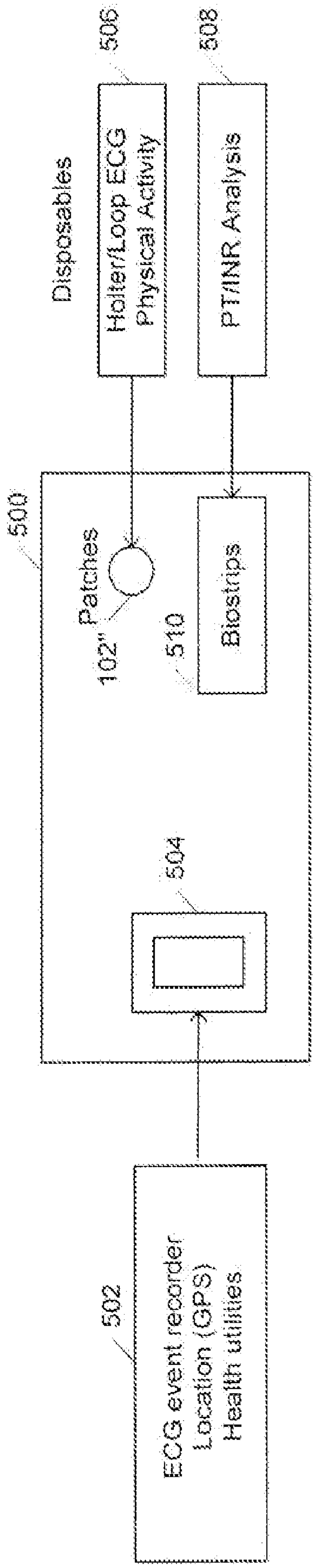

104
MSP
Main sensor data path and response to test/ control signals
(Enables Patch Test and Control)
212
Antenna
210
Radio
216
Display/ Alert
214
Storage
209
Battery/Power Management
Signal C
208
Processor
204
Sensor Interface
102
202
Body Sensor
Physiological signals

Figure 3


10
Mobile Device, Computer Or any Other device
310
Bus I/F
308
Storage
311
Display/ Alert
106
Local Sensor
Physiological Sample or signal
Y
313
Sensor Interface
306
Smart Signal Combiner
A
B
N
X
X = f(A, B, --- N, and Y)
304
Processor
Signal P
302
Radio
301
Antenna
Radio Signals From Wireless Distributed Body Sensor network
To Patch (for test And control)

104

Figure 4



Disposables
506
Holter/Loop ECG
Physical Activity
508
PT/INR Analysis
500
Patches
102"
510
Biostrips
504
502
ECG event recorder
Location (GPS)
Health utilities

Figure 5

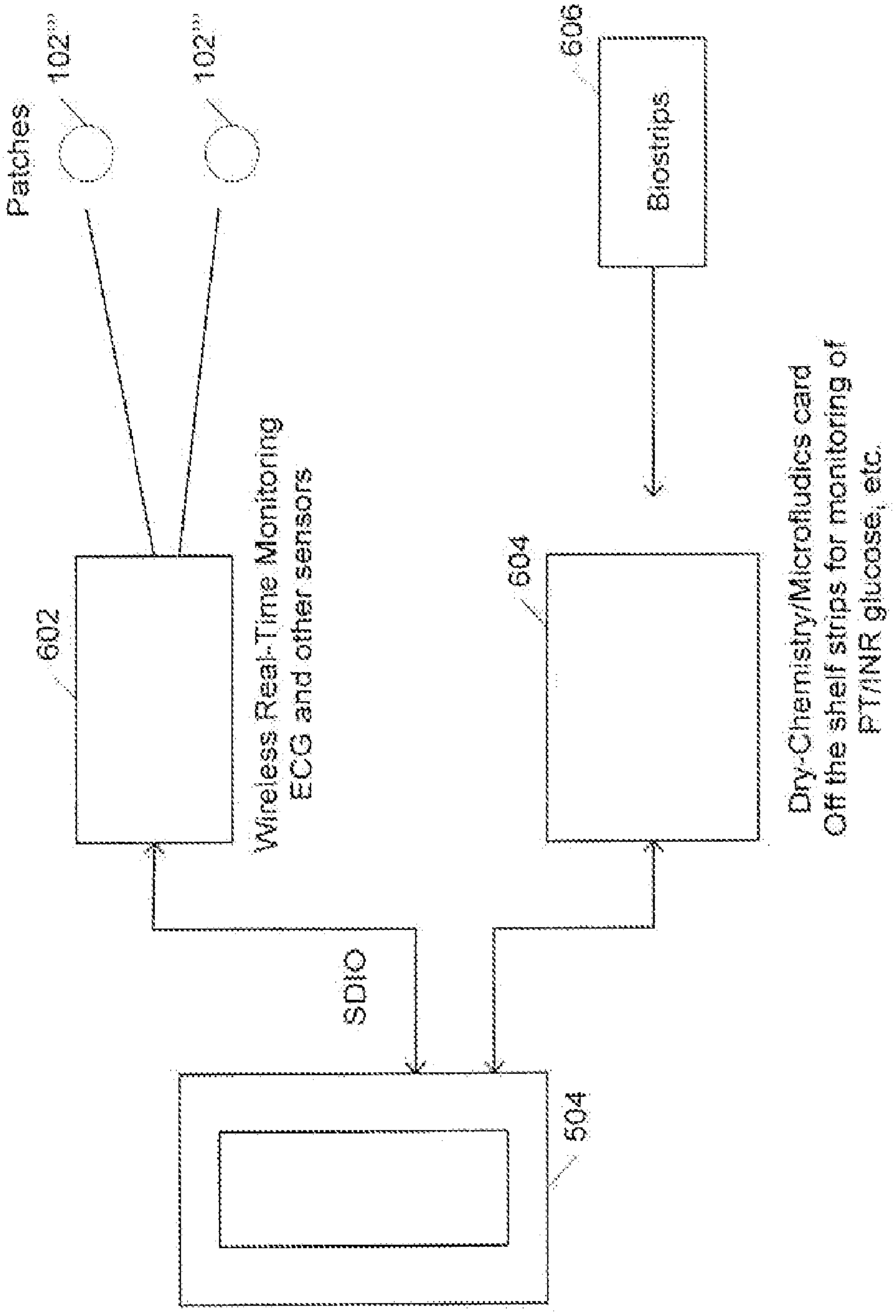

Patches
102'''
102'''
602
Wireless Real-Time Monitoring
ECG and other sensors
606
Biostrips
604
Dry-Chemistry/Microfludics card
Off the shelf strips for monitoring of
PT/INR glucose, etc.
SDIO
504

Figure 6

MEDICAL SIGNAL PROCESSING SYSTEM WITH DISTRIBUTED WIRELESS SENSORS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] Under 35 U.S.C. 119, this application is a Non-Provisional application of U.S. Provisional Application No. 60/776,590, filed Feb. 24, 2006 and U.S. Provisional Application No. 60/810,742, filed Jun. 1, 2006, all of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present invention relates generally for health monitoring and more particularly to a health monitoring system that utilizes a medical signal processor with a wireless distributed sensor system.

BACKGROUND OF THE INVENTION

[0003] Monitoring the health of people has always been important. As the population ages and more people advance in age health monitoring systems become more significant to maintaining a healthy lifestyle and disease management. Remote health monitoring makes it easier and cost effective to monitor the health of vast populations. Wireless systems are the most desired approach to enable remote health monitoring. Therefore, a variety of wireless health monitoring systems have been introduced over the years.

[0004] Conventional wireless health monitoring systems are bulky, expensive, have inadequate wireless link reliability and have high power dissipation which severely limits their applications, particularly to monitor wide ranging physiological parameters in high volumes for large populations. Accordingly, what is desired is a system that addresses the above-identified issues.

SUMMARY OF THE INVENTION

[0005] A wireless medical signal processing system for health monitoring is disclosed which achieves high wireless link reliability/security, low power dissipation, compactness, low cost and supports a variety of sensors for various physiological parameters. The system includes a medical signal processor which communicates with a wireless distributed sensor system as its peripheral for detecting physiological parameters of the person and for providing signals indicative thereof. The medical signal processor wirelessly receives the signals from the distributed wireless sensor system in a multiplexed fashion and processes the signals to provide an indication of the health of the person. The indication of health could relate to a disease state, general health or fitness level of a person. The system also includes a mobile device for receiving the indication of the health of the person to allow for a diagnosis or treatment of the person, and a secure server for securely storing the at least one indication of health. The core processing resources of the medical signal processor allows wireless distributed sensors to be ultra reliable/secure, ultra low power, ultra small and low cost. The peripheral wireless sensors can be a within a reasonable range of medical signal processor, such as within a typical home.

[0006] A distributed sensor based mobile/remote monitoring system for the management of various types of diseases is disclosed. The system is capable of continuously monitoring a variety of parameters relating to the state of various diseases. The parameter monitoring can be continuous, periodic or episodic. The system is capable of continuous monitoring of given parameters from a few seconds to many days. A system to manage a particular type of disease or meet a health objective can be defined by selecting the appropriate parameters for that disease.

BRIEF DESCRIPTION OF DRAWINGS

[0007] FIG. **1**A is a block diagram of a first embodiment of a general architecture of wireless health monitoring system in accordance with the present invention.

[0008] FIG. **1**B is a block diagram of a second embodiment of a general architecture of a wireless health monitoring system in accordance with the present invention.

[0009] FIG. **2** illustrates examples of various sensors that can be included in a distributed sensor network.

[0010] FIG. **3** illustrates a block diagram of a wireless patch in accordance with the present invention.

[0011] FIG. **4** illustrates a block diagram of a medical signal processor in accordance with the present invention.

[0012] FIG. **5** is a block diagram of a cardiac care product in accordance with the present invention.

[0013] FIG. **6** is a block diagram of an implementation of a mobile device utilized with the cardiac care product of FIG. **5**.

DETAILED DESCRIPTION

[0014] The present invention relates generally to health monitoring and more particularly to a health monitoring system that utilizes a medical signal processor with a wireless distributed sensor system. The following description is presented to enable one of ordinary skill in the art to make and use the invention and is provided in the context of a patent application and its requirements. Various modifications to the preferred embodiments and the generic principles and features described herein will be readily apparent to those skilled in the art. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features described herein.

[0015] To describe the feature of the medical signal processing system in more detail, refer now to the following description in conjunction with the accompanying figures.

[0016] FIG. **1**A is a first embodiment of a general architecture of a wireless medical signal processing system **100** in accordance with the present invention. The system **100** is centered around a medical signal processor **104** that has a wireless distributed sensor network as its peripheral. The distributed sensor network includes a plurality of patches **102***a*-**102***n* on a person **101**. The patches **102***a*-**102***n* can be internal to the body, coupled to the exterior of the body embedded in the garments or can be in close proximity of the body by some other means. The patches communicate wirelessly with MSP **104**. The MSP **104** also includes its internal/local sensors **106**, which can engage the body of the person, which are also part of the distributed sensor system. The medical signal processor (MSP) **104** in turn communicates with a mobile device **108**. The mobile device **108** in turn communicates with a secure server **110** via a wireless or wired network. In this embodiment, the MSP **104** is a separate component from the mobile device **108**. However, one of ordinary skill in the art readily recognizes that the MSP **104** could be incorporated into the mobile device as shown in FIG. **1**B which is a second embodiment of the system **100'**. The MSP **104** also includes sensors **106**, which can engage the body of the person, which are also part of the distributed sensor network. The MSP **104** has the ability to absorb significant processing burden from all of its distributed sensors to form a reliable wireless link with them. The MSP **104** also has the ability to communicate with all of its distributed sensors through a wireless uplink. It allows the MSP **104** to use its internal resources to monitor, control and dictate various performance factors of the distributed sensors to achieve the performance balance needed for any given application. The MSP **104** also can perform various house keeping functions for the overall medical signal processing system.

[0017] The mobile device **108** could be, for example, a cellular telephone, laptop, notebook, a smart phone, a PDA, a custom medical device or any mobile device which can communicate with the server over a network. Each component of the health monitoring system **100** will now be described in detail in conjunction with the accompanying figures.

Medical Signal Processing System

[0018] As discussed above, the medical signal processing system as shown in FIGS. **1**A and **1**B can include a variety of sensors—either directly integrated in the medical signal processor **104**, or linked to the medical signal processor **104** via a wireless link as patches **102** on the body of a user. Examples of various sensors that can be included in the distributed sensor system are shown in FIG. **2**. Out of these examples, certain sensors can be chosen for implementation as patches **102**. Other sensors can be chosen for integration within the MSP **104**. In this way, a variety of systems can be designed for the management of diseases, health and fitness, by choosing the sensors that monitor the appropriate parameters associated with target applications.

[0019] Modes of Operation: By using the distributed sensor network, the system of FIGS. **1**A and **1**B can monitor parameters in different ways. For example, by wearing patches on the body, the monitoring can be done continuously—continuously data flowing from sensors in to the mobile device to the secure server. Patches can also be used for periodic or episodic monitoring. In a stand-alone mode, monitoring is normally done in an episodic or periodic mode by using the MSP **104** and sensors **106**. For example, a cardiac rhythm can be directly monitored by pressing the MSP **104** against the body by using a built in ECG sensor. Another example of this stand-alone mode is glucose, cholesterol or blood coagulation monitoring. A drop of blood can be placed on a biochemical sensor that is built into the MSP **104** which can be converted to electrical signal by MSP for further processing. The glucose, cholesterol or blood coagulation rate reading will be registered in the database on MSP **104** and/or mobile device **108** and/or the secure server **108**.

Wearable Wireless Patches **102**

[0020] Patches **102** are integrated circuit technology driven miniature wireless devices that can be conveniently attached to the body. Patches can also be designed for implanting within the body of a person. To achieve compactness, the patches **102** are designed using custom ASIC and a compact multi-chip module. The patches can be further simplified by leveraging the resources of MSP **104**. The patch **102** in a preferred embodiment has two main parts: sensor circuits, and a wireless radio core for the transmission of sensor data to other devices. In addition, it has a signal processor and power management circuits to achieve very low power dissipation. The sensor circuits can be directly incorporated in the custom ASIC and/or patch can also include a stand-alone sensor device whose data can be transmitted to other devices using the wireless radio or ASIC on the patch. In a preferred embodiment, a person can wear a patch **102** for several days for continuous monitoring without changing or recharging the power source. Patches **102** can have the ability to receive wireless signals from the MSP **104** to enhance its own power dissipation and improve its own wireless link reliability, based on the MSP's **104** monitoring of radio environment and application requirements. The patches **102** can also receive test/control signals from the MSP **104** to get authenticated and to check its own functionality.

[0021] FIG. **3** illustrates a wireless patch **102** utilized in accordance with the present invention. The wireless patch **102** receives signals from a body sensor **202** via a sensor interface **204**. The patch **102** may receive signals from a body it is either in contact with, or in close proximity of. The sensor interface **204** can receive electrical signals or other signals representative of different physiological parameters of the body. The output from the sensor interface **204** is provided to a processor **208** which processes the signal to perform various functions such as compression to reduce the data rate, encoding to achieve high reliability and manage buffering to vary duty cycle of radio. The processed data is presented to a storage element **214**. The data from the storage element **214** is provided to a radio **210** which outputs the signal to a signal antenna **212**. The storage element **214** can be adapted to be coupled to a local display/alert **216**. A power source **209** provides power and power management to all elements of the patch **102**. As shown, a wireless path through radio/antenna **210**/**212** also exists to receive test and control signals from the MSP **104** as discussed above. As shown, all resources of the patch **102** can be controlled by the MSP **104** by a signal C, wirelessly coming to patch **102** from the MSP **104**.

[0022] Accordingly, by leveraging the information sent by MSP **104** via signal C, patches can dynamically alter the performance of their various functional blocks to choose trade off among high reliability, high security, low power and low cost for given applications of health monitoring.

[0023] In summary, the trade off is possible due to any of or any combination of the following features:

[0024] a. A sensor interface to connect to a variety of physiological sensors

[0025] b. A radio subsystem that can support a variety of communication schemes (e.g. different modulations including analog modulation, various codings, various data rates) to wirelessly communicate with a medical signal processor which is within a reasonable range, such as within a typical house

[0026] c. A processor to support a variety of wireless communication schemes for radio system

[0027] d. A processor that can implement various authentication and security schemes as desired by application

[0028] e. Means to wirelessly receive a variety of test signals from a medical signal processor

[0029] f. Means to run test signal though its data paths and generate output signals in response

[0030] g. Means to wirelessly send resulting output signals back to medical signal processor

[0031] h. Means to receive various control signals to reconfigure its various functional blocks

[0032] i. Reconfigurable internal blocks to alter data rates, radio scheme, communication algorithm, power dissipation levels, etc.

[0033] j. sensors that can receive body's electrical physiological signals

[0034] k. Encapsulation in a packaging material that can also provide a body interface

[0035] l. Using its radio, generation of a RF beam that can be directed towards a part of person's body to probe internal parts

[0036] m. Means to receive the RF signals scattered by body that can be analyzed to get information about the internals of the body

[0037] n. Means to bring the device in a close proximity of body

[0038] o. Means to attach the device to body

[0039] p. Means to analyze and display the sensor data

[0040] q. Means to alert a person as needed

[0041] r. For ultra high reliability, ability of patches to wirelessly communicate with each other in case of loss of link by a patch to medical signal processor

Medical Signal Processor (MSP) **104**

[0042] The medical signal processor (MSP) **104** collects and receives data from the one or more of the distributed sensors (internal or external), and aggregates and processes this data. In addition, the MSP **104** can reliably transmit it to mobile device **100** in such a way that mobile device **100** in turn can transmit the data to a remote server system over wireless, cellular, or any type of wide area network (WAN).

[0043] The MSP **104** may have one or more of the following features:

[0044] 1. to collect data from its internal/local sensors

[0045] 2. radio/processors to receive data from external wireless sensors that are within a reasonable range, such as within a typical house

[0046] 3. means to process and aggregate the sensor data based on an algorithm that can be programmed in MSP **104** to determine a diseases state and/or health state and/or fitness state

[0047] 4. means to attach or connect or plug in to a mobile device

[0048] 5. means to generate an alert based on the determination of the state of disease, health or fitness

[0049] 6. means to locally display collected raw sensor data or processed data

[0050] 7. means for transmission of collected raw sensor data or processed data to a remote server either directly or via a mobile device

[0051] 8. means to enable continuous reliable transmission of sensor data over a cellular or wide area network

[0052] 9. user interface to control the operation of monitoring system

[0053] 10. means of a regular cell phone device (voice, data and image communication, display, keypad, etc.)

[0054] In addition to collecting and processing the data from all of its peripheral patches/sensors, the MSP **104** also has various means to wirelessly monitor and control all of its peripheral patches/sensors through a wireless uplink with them. Essentially, the MSP **104** becomes an integral part of the wireless medical signal processing system to achieve the overall requirements of the system—a major requirement being patches to be ultra reliable/secure, ultra low power, ultra small and low cost. The overall functionality of the system is asymmetrically partitioned between the patches **102** and MSP **104** to achieve these critical patch requirements.

[0055] Accordingly, MSP **104** may have the following features to achieve the system objectives:

[0056] 1. means to act as a master of the overall system and patches/sensors to be its slaves

[0057] 2. means to manage a distributed network of patches/sensors

[0058] 3. means to authenticate, test and control the functionality of all of its peripheral patches/sensors

[0059] 4. means to monitor/dictate the wireless link performance of its peripheral patches/sensors

[0060] 5. means to monitor/dictate the power dissipation of its peripheral patches/sensors

[0061] 6. means to dictate the degree of reliability of all of its peripheral sensors/patches

[0062] 7. means to allow peripheral sensors/patches to use a very simple radio and have its own signal processor to complete the radio processing for patches/sensors

[0063] 8. means to recreate the original sensor data if data has been compressed on the sensor/patches

[0064] 9. means to monitor radio environment.

[0065] 10. Radio to work with multiple communication schemes including digital and analog modulation

[0066] The MSP **104** can control the functionality and performance of its peripheral/patches based on the requirement defined for the overall system. The system performance can be dynamically adjusted, for example, due to a change in radio environment or a change in person's condition as monitored by the MSP **104**.

[0067] FIG. **4** illustrates an MSP **104** in accordance with the present invention. An antenna **301** and a radio **302** within the MSP **104** receives a plurality of data signals (signals A-N) from the distributed sensor network. The radio **302** then provides these signals to a signal processor **304**. The processor **304** then decodes the signals received by the radio **302**. The decoded signals are then provided to a smart signal combiner **306**, in a multiplexed or parallel fashion.

[0068] The smart signal combiner **306** includes a means for programming an algorithm for combining the signals to provide an indication of a state of the body. For example, certain sensor parameters taken together might indicate a disease state and/or heath state and/or fitness state of an individual.

[0069] The smart signal combiner **306** may also receive a signal Y from the local sensors **106'** in the MSP **104**. The signal Y represents either one signal from one local sensor or a plurality of signals from a plurality of local sensors. The smart signal combiner **306** also provides a signal (X) that is a parameter, relating to a state that has been measured utilizing a single sensor output or by combining the outputs of multiple sensors. This state is a result of one or several physiological parameters of the body and the signal X may be a function, computed over time, of one, all or a set of those sensor outputs (signals A-N) and sensor signals.

[0070] These various signals (A, B, . . . N, Y, X) are provided to a storage element **308** by the smart signal combiner **306**. The storage element **308** may be any type of memory that can be utilized in integrated circuits. The storage element **308** can be adapted to be coupled to a local display/alert device **311** via the sensor interface **313**. The data can then be retrieved by the mobile device from the storage element **308** via a bus interface **310**. As before mentioned, the MSP **104** can either be part of the mobile device **108** or a stand alone device.

[0071] All these resources enable MSP **104** to act as a stand-alone device to provide the needed information locally to concerned parties or it can transmit the information to a remote secure server for further processing and access. The information can be used locally, or remotely, to diagnose/treat a disease or for general health/fitness management of a person. As shown, MSP **104** also has a wireless path to communicate with patches/sensors to monitor and control their performance. In a control mode, radio **302** operates in an uplink mode by sending test/control data via signal P over the wireless link. This control mode is activated when the MSP **104** needs to test, monitor and/or control its peripheral patches/sensors via the processor **304**. The processor **304** should be for example, a microprocessor with signal processing capability that executes the various functions.

[0072] The processor **304** can utilize other resources such as smart signal processor **306** and storage **308** to carry out its control/test related and general processing tasks. In the control mode, for example, the processor **304** can generate test signals and send to a patch **102**, and analyze the signals received from the patch **102** to estimate its wireless link performance. If needed, the MSP **104** can then send control signals to alter the wireless link performance by changing certain parameters relating to radio functions of the patch **102**, for example by instructing signal processor **208** and radio **210**. In some implementations, some of the internal blocks of MSP **104**, such as processor **304**, smart signal processor **306** and storage **308** can be implemented in software. This implementation is likely when MSP **104** functionality is embodied within a mobile device, computer, a custom medical device, or any other device.

[0073] The functionality of MSP **104** allows its distributed sensors (patches) to maintain high wireless reliability, high security, low power and low cost. Furthermore, the versatility of MSP **104** allows it to create a variety of different types of medical systems. To allow this functionality and versatility, in summary, it can include any of or any combination of the following features:

[0074] a. Means to wirelessly communicate with a plurality of peripheral wireless physiological sensors in a multiplexed fashion that are within a reasonable range, such as within a typical house

[0075] b. Means to manage a network of plurality of said sensors as their master

[0076] c. Means to display health state information or the data received from peripheral sensors

[0077] d. Means to alert a person about health state

[0078] e. Means to connect to a mobile device to exchange information with it and to communicate with a remote server through mobile device's connectivity to a wide area network

[0079] f. Partitioning of its functions between hardware and software to allow its integration within a mobile device

[0080] g. Means to wirelessly send a variety of test signals to its peripheral sensors and analyze the received signals to monitor the proper functioning of the sensors and their various internal functional blocks

[0081] h. Means to send various control signals to peripheral sensors to configure their various functional blocks:

[0082] i. Means to monitor peripheral sensors to determine their respective power dissipation rates and the state of their power sources; to supervise power management

[0083] j. Means to monitor surrounding radio environment to determine an optimum wireless communication scheme at any given instance

[0084] k. Means to instruct peripheral sensors to utilize a particular radio/communication mode for reliable operation

[0085] l. Means to authenticate peripheral sensors

[0086] m. Means to monitor various security aspects of peripheral sensors

[0087] n. Means to allow coupling to local sensors through a wired connection

[0088] o. A processor to support the execution of a variety of communication algorithms/schemes to allow peripheral sensor to use the simplest possible communication scheme for a given application to minimize sensor's power and resource requirements by absorbing the burden of processing (asymmetric communication scheme)

[0089] p. A smart signal combiner that can be programmed to run needed algorithms to (i) analyze signals from one or more peripheral sensors over time, and/or (ii) combine signals from a plurality of peripheral sensors; to determine a health state

[0090] q. Storage media to store the health state information and/or raw data received from peripheral sensors

Mobile Device **108**

[0091] The mobile device **108** could be, for example, a cellular telephone, laptop, notebook, a smart phone, a PDA, a custom medical device or any mobile device which can communicate with the server over a wide area network and/or Internet. The mobile device **108** can also be a regular cell phone handset, which has been modified to include the appropriate features and means to work with MSP **104**. The mobile device **108** communicates with the MSP **104**. In one embodiment, the MSP can be built within mobile device **108** as part of the mobile device design. In this mode, many internal functions of MSP can be implemented in software. In most cases, MSP's radio system and sensor interfaces will remain intact in hardware.

Secure Server **110**

[0092] The secure server **110** receives data from distributed sensors over a cellular telephony network, any type of wide area network or Internet via MSP **104** and the mobile device **108**. The server **110** further processes the received data from the mobile device and stores it in a secure location. The server **110** may also contain various types of software programs, including software to manage health information databases (such as electronic medical records, computerized purchase orders and computerized prescription systems). The secure server **110** may also have the middleware to process/link sensor data to such health information databases.

[0093] The data stored on the secure server **110** may be accessed by a healthcare provider, caregiver or patient via the Internet by using any type of terminal device such as computer, mobile device, cell phone, smart phone or personal data assistant (PDA).

[0094] The health monitoring system in accordance with the present invention supports many classes of sensors for physiological data collection, such as:

[0095] 1. The health monitoring system supports many classes of sensors for physiological data collection, such as:

[0096] (a) Sensors (either patches **102** or sensors **106**) contacting the body **101** through gels, etc.

[0097] (b) Patches **102** embedded within the body **101** through surgical procedures.

[0098] (c) Patches **102** probing the body **101** through micro-needle based skin punctures.

[0099] (d) Sensors in close proximity of the body **101**—e.g., probing using a microwave or optical beam.

[0100] (e) Sensors embedded in the MSP **104** or mobile device **108** for periodic or occasional use.

[0101] (f) Sensors that can read biochemical micro-fluidic test strips (e.g. glucose, blood coagulation rate) via electrical or optical sensor

[0102] 2. The health monitoring system in accordance with the present invention can support one of these sensors and/or patches or multiple sensors and/or patches from multiple classes.

[0103] 3. The MSP **104** has the ability to collect data in real time from many such sensors and/or patches and to apply a chosen algorithm to combine signals from various sensors and/or patches to determine or predict a physiological or disease state.

[0104] 4. The MSP **104** can store data for local use and/or transmit in real time to a remote server for use by clinicians and other parties. If desired, some of the MSP **104** functions can be implemented on a remote sensor.

[0105] 5. As stated above, one function of the MSP **104** is physiological data processing.

[0106] 6. The second function of MSP **104** is to manage all patches and/or sensors for optimal functionality—managing authentication/security functions, monitor and enhance the radio transmission performance of patches and/or sensors to increase link reliability, monitor and minimize power dissipation by patches and/or sensors.

[0107] The health monitoring system in accordance with the present invention can be utilized in a variety of environments. One example is the cardiac disease management system. To describe the features of such a system refer now to the following description in conjunction with the accompanying figures.

A Mobile/Remote Monitoring System for Cardiac Disease Management

[0108] An embodiment of a cardiac disease care product in accordance with the present invention is described herein below. FIG. **5** is a block diagram of a cardiac care product in accordance with the present invention. The cardiac care product includes a mobile device **504** which utilizes patches **102**" and biostrips as sensors **510**. The mobile device **504** includes an ECG event recorder **502**, a geographic positioning system (GPS) and health utilities. The patches may include a holter mechanism and a loop ECG monitor **506** as well as accelerometers for detecting physical activity. The biostrips **510**, which are basically microfluidic test strips, may be utilized, for example, for anticoagulation analysis of the blood (PT/INR).

[0109] FIG. **6** is a block diagram of one implementation of a mobile device utilized with the cardiac care product of FIG. **5**. The mobile device **504** may receive a first SD (Secure Digital) card **602** that includes wireless real-time monitoring system. The SD card **602** receives data from patches **102**"" and other sensors. The mobile device **504** also may receive a second SD card **604** that monitors PT/INR, glucose and the like. The second SD card receives its data via biostrips **606** that can be activated by a drop of patient's blood, for example. The PT/INR and/or glucose reading is obtained by building an electrical or optical reader on the second SD card that can read the biostrips. The cardiac care product can be used for the management of various cardiac diseases, including arrhythmia. In an embodiment, this cardiac care product monitors the following parameters:

[0110] 1. ECG signals (time duration programmable—few seconds to few weeks)

[0111] 2. Pulse and respiration

[0112] 3. Patient's physical movement

[0113] 4. Blood coagulation analysis for drug therapy for the treatment of arrhythmia

[0114] 5. A mobile, integrated system for remote cardiac care is provided—It is a system that is useful for diagnosis and treatment of various cardiac diseases.

[0115] 6. Its core functions are listed below:

[0116] (a) Wireless AECG—duration programmable from a few seconds to 30 days to serve a variety of functions including holter monitoring, cardiac event monitoring, cardiac loop monitoring (wireless ECG sensor patches and receiver)

[0117] (b) PT/INR based blood anticoagulation analysis (dry chemistry microfluidic strip and optical/electrical reader/sensor)

[0118] 7. Its auxiliary functions are listed below:

[0119] (a).Patient activity recording (accelerometer sensor)

[0120] (b).Patient location information (GPS)

[0121] (c).Ability to connect to an implanted wireless pacemaker

[0122] (d).Medication schedules (software)

[0123] (e).Doctor visit and treatment schedule (software)

[0124] 8. Microfluidic biostrip/reader concept can also be used for glucose monitoring

[0125] 9. The system can be built by integrating the electronics inside a mobile device/computer or an attachment to a mobile device/computer. The mobile device **504** may or may not be connected to a remote server through a network.

[0126] The sensors for parameter monitoring may be distributed between the patches **102**"" and the mobile device **504** as follows:

Patches **102**

[0127] The patches **102**"" have sensors to continuously monitor ECG, pulse, respiration and patient's physical movement. ECG function can be programmed to work in any mode as prescribed by a physician, such as:

[0128] (a) Continuous ECG: for any amount of time (e.g. 24 Hrs, 48 Hrs, seven days, thirty days).

[0129] (b) ECG Loop recorder: Shorter time recordings with continuous overwriting

[0130] Patient's physical movement data is recorded along with ECG data on a continuous basis. In addition, pulse and respiration are recorded as desired.

MSP **104**

[0131] In a stand-alone mode, the mobile device **504** has the means to monitor a few different parameters as below:

[0132] (a) ECG Event Recording: Via built-in ECG sensor, mobile device **504** is able to record ECG signals for any duration as desired. In this mode, the mobile device **504** is directly held to the body **101**.

[0133] (b) Biochemical parameters: The mobile device **504** has a built in biochemical sensor, electrical sensor and an optical sensor. Any of these sensors can be used to read certain parameters relating to disease management. For example, the MSP **104** can register blood coagulation readings for PT/INR (Prothrombin Time/International Test Ratio) analysis for Warfarin drug therapy. For this application, a test strip with a blood drop mixed with a chemical reagent can be inserted into the MSP **104** to determine blood anticoagulation rate for PT/INR analysis.

CONCLUSION

[0134] A distributed sensor based mobile/remote monitoring system for the management of various types of diseases is disclosed. The system is capable of continuously monitoring a variety of parameters relating to the state of various diseases. The parameter monitoring can be continuous, periodic or episodic. Some of the parameters that can be monitored by the system are ECG (electrocardiograph), EEG (electroencephalograph), EMG (Electromyography), blood glucose, pulse, respiration, blood pressure, temperature, SpO2, body fluid density, blood density, patient physical movement and patient physical location. A system to manage a particular type of disease can be defined by selecting the appropriate parameters for that disease. The system can be applied to manage many type of diseases and conditions, such as—arrhythmia, heart failure, coronary heart disease, diabetes, sleep apnea, seizures, asthma, COPD (Chronic Obstructive Pulmonary Disease), pregnancy complications, wound state, etc.

[0135] An innovative technology base is needed to address wide ranging applications and to meet critical requirements for the mass market—high reliability, high security, low power, small form factor and low cost. The technology disclosed meets this goal. The technology involves a medical signal processor (MSP) closely supervising all aspects of functionality of its peripheral wireless patches to help achieve the objectives. The patches are simple while the medical signal processor (MSP) has all the smarts to work with patches. It results in asymmetric processing load on MSP and patches—patches are simple and reconfigurable and MSP has the complexity to take the processing burden from them for wireless communication link, and processing load to supervise patches. Both the MSP and the patches have various resources to build complete self contained systems to determine a health state of a person from sensor physiological data and to display and/or send data to another device for further processing.

[0136] Although the present invention has been described in accordance with the embodiments shown, one of ordinary skill in the art will readily recognize that there could be variations to the embodiments and those variations would be within the spirit and scope of the present invention. Accordingly, many modifications may be made by one of ordinary skill in the art without departing from the spirit and scope of the appended claims.

1.-**65**. (canceled)

66. A system for wireless healthcare monitoring comprising:

(a) a physiological signal monitoring patch comprising a sensor interface that receives signals from sensors coupled to the sensor interface, a signal processor coupled to the sensor interface, a storage element coupled to the signal processor, a radio coupled to the storage element, an antenna coupled to the radio, power dissipation management circuits coupled to the processor, and a battery that provides power to the patch; and

(b) a medical signal processor comprising an antenna that receives data from the patch, a radio coupled to the antenna, a storage element coupled to the radio, a processor coupled to the storage element, power dissipation management circuits, and a bus interface that communicates with a device.

67. The system of claim **66** wherein the medical signal processor is incorporated into the device.

68. The system of claim **66** wherein the medical signal processor is a stand-alone unit that is connected to the device.

69. The system of claim **67** wherein the device is a mobile device, smart phone, personal digital assistant, or medical device.

70. The system of claim **66** wherein the patch comprises a custom ASIC wherein the custom ASIC comprises the sensor interface.

71. The system of claim **66** wherein the processor in the patch performs compression to reduce data rate, performs encoding to achieve high reliability, and/or manages buffering to vary the duty cycle of the radio in the patch.

72. The system of claim **66** wherein the medical signal processor decodes the signal received from the patch.

73. The system of claim **66** wherein the medical signal processor authenticates, tests, and/or controls the functionality of one or more patches in the system.

74. The system of claim **66** wherein the medical signal processor dictates the power dissipation of the patches.

75. The system of claim **66** wherein the medical signal processor sends control signals to alter wireless link performance by changing parameters relating to radio functions by instructing the signal processor and/or the radio on the patch.

76. The system of claim **66** wherein the medical signal processor instructs patches to utilize a particular radio or communication scheme.

77. The system of claim **66** wherein the system further comprises a secure server with which the device communicates.

78. The system of claim **77** wherein the secure server links the sensor data with other health information.

79. The system of claim **66** wherein the physiological signals are monitored continuously, periodically, or episodically.

80. A system for wireless healthcare monitoring comprising:

(a) a physiological signal monitoring patch comprising a sensor interface that receives signals from sensors coupled to the patch, a signal processor coupled to the sensor interface, a storage element coupled to the signal processor, a radio coupled to the storage element, an antenna coupled to the radio, power dissipation management circuits coupled to the processor, and a battery that provides power to the patch; and

(b) a medical signal processor comprising an antenna that receives data from the patch, a radio coupled to the antenna, a storage element coupled to the radio, a processor coupled to the storage element, a storage element for storing data relating to the signals, power dissipation management circuits, and a signal combiner that decodes signals received from the processor to provide an indication of a state of a body.

81. The system of claim **80** wherein the signal combiner also receives signals from at least one local sensor connected to the medical signal processor.

82. The system of claim **80** wherein multiple sensor parameters taken together indicate a disease state, heath state, and/or fitness state of an individual.

83. The system of claim **66** or **80** wherein the system monitors ECG (electrocardiograph), EEG (electroencephalograph), EMG (Electromyography), blood glucose, pulse, respiration, blood pressure, temperature, SpO2, body fluid density, blood density, patient physical movement, patient physical location, or a combination thereof.

84. The system of claim **66** or **80** wherein the system monitors arrhythmia, heart failure, coronary heart disease, diabetes, sleep apnea, seizures, asthma, COPD (Chronic Obstructive Pulmonary Disease), pregnancy complications, wound state, or a combination thereof.

85. A patch for monitoring physiological signals comprising a sensor interface that receives signals from one or more sensors coupled to the sensor interface, a signal processor coupled to the sensor interface, a storage element coupled to the signal processor, a radio coupled to the storage element, an antenna coupled to the radio that sends and/or receives wireless signals, power dissipation management circuits coupled to the processor, and a battery that provides power to the patch; wherein the patch comprises a custom ASIC wherein the custom ASIC comprises the sensor interface, the signal processor, and the radio.

86. The patch of claim **85** wherein the physiological signals are ECG signals.

87. The patch of claim **86** wherein the patch measures ECG for 24 hours or more.

88. The patch of claim **66** wherein the patch monitors ECG (electrocardiograph), EEG (electroencephalograph), EMG (Electromyography), blood glucose, pulse, respiration, blood pressure, temperature, SpO2, body fluid density, blood density, patient physical movement, patient physical location or a combination thereof.

89. The patch of claim **85** wherein the patch monitors arrhythmia, heart failure, coronary heart disease, diabetes, sleep apnea, seizures, asthma, COPD (Chronic Obstructive Pulmonary Disease), pregnancy complications, wound state, or a combination thereof.

90. A patch for monitoring physiological signals comprising a sensor interface that receives signals from sensors coupled to the sensor interface, a signal processor coupled to the sensor interface, a storage element coupled to the signal processor, a radio coupled to the storage element, an antenna coupled to the radio that communicates wireless signals, power dissipation management circuits coupled to the processor, and a battery that provides power to the patch; wherein the patch is designed to be controlled by wirelessly communicated instructions.

91. The patch of claim **90** wherein the patch measures ECG, EMG, EEG signals, or a combination thereof.

92. A method for wireless healthcare monitoring of an individual comprising:

(a) sending a data signal from a physiological signal monitoring patch; wherein the patch comprises a sensor interface that receives physiological signals from sensors coupled to the sensor interface, a signal processor coupled to the sensor interface, a storage element coupled to the signal processor, a radio coupled to the storage element, an antenna coupled to the radio;

(b) managing power dissipation in the patch with management circuits on the patch coupled to the processor, wherein the patch comprises a battery that provides power to the patch;

(c) receiving the data signal at a medical signal processor comprising an antenna that receives the data signal from the patch, a radio coupled to the antenna, a storage element coupled to the radio, a processor coupled to the storage element, and power dissipation management circuits, and

(d) sending processed data from the medical signal processor to a device through a bus interface.

93. The method of claim **92** wherein the medical signal processor is incorporated into the device.

94. The method of claim **92** wherein the medical signal processor is a stand-alone device that is connected to the device.

95. The method of claim **93** wherein the device is a mobile device, smart phone, personal digital assistant, or medical device.

96. The method of claim **92** wherein the patch comprises a custom ASIC wherein the custom ASIC comprises the sensor interface.

97. The method of claim **92** wherein the processor in the patch performs compression to reduce data rate, performs encoding to achieve high reliability, and/or manages buffering to vary the duty cycle of the radio in the patch.

98. The method of claim **92** wherein the medical signal processor decodes the signal received from the patch.

99. The method of claim **92** wherein the medical signal processor authenticates, tests, and/or controls the functionality of the patch.

100. The method of claim **92** wherein the medical signal processor dictates the power dissipation of the patches.

101. The method of claim **92** wherein the medical signal processor sends control signals to alter the wireless link performance by changing certain parameters relating to radio functions by instructing the signal processor and/or the radio on the patch.

102. The method of claim **92** wherein the medical signal processor instructs patches to utilize a particular radio or communication scheme.

103. A method for wireless healthcare monitoring comprising:

(a) sending data from a physiological signal monitoring patch comprising a sensor interface that receives signals from sensors coupled to the patch, a signal processor coupled to the sensor interface, a storage element coupled to the signal processor, a radio coupled to the storage element, an antenna coupled to the radio;

(b) managing power dissipation on the patch with power management circuits coupled to the processor, wherein the patch comprises a battery that provides power to the patch;

(c) receiving the data at a medical signal processor comprising an antenna that receives data from the patch, a radio coupled to the antenna, a storage element coupled to the radio, a processor coupled to the storage element, a storage element for storing data relating to the signals, power dissipation management circuits; and

(d) combining the data on a signal combiner that decodes signals received from the processor to provide an indication of a state of a body.

104. The method of claim **103** wherein the signal combiner also receives signals from at least one local sensor connected to the medical signal processor.

105. The method of claim **103** wherein certain sensor parameters taken together indicate a disease state, heath state, and/or fitness state of an individual.

106. The method of claim **92** or **103** wherein physiological signal is related to ECG (electrocardiograph), EEG (electroencephalograph), EMG (Electromyography), blood glucose, pulse, respiration, blood pressure, temperature, SpO2, body fluid density, blood density, patient physical movement or patient physical location or a combination thereof.

107. The method of claim **92** or **103** wherein the method is used to monitor arrhythmia, heart failure, coronary heart disease, diabetes, sleep apnea, seizures, asthma, COPD (Chronic Obstructive Pulmonary Disease), pregnancy complications, wound state, or a combination thereof.

* * * * *

patsnap

专利名称(译)	具有分布式无线传感器的医疗信号处理系		
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摘要(译)

公开了一种用于健康监测的无线医疗信号处理系统，其实现了高无线链路可靠性/安全性，低功耗，紧凑性，低成本并且支持用于各种生理参数的各种传感器。该系统包括医疗信号处理器，该医疗信号处理器与无线分布式传感器系统通信，作为其外围设备，用于检测人的生理参数并提供指示其的信号。医疗信号处理器以多路复用的方式无线地接收来自分布式无线传感器系统的信号，并处理这些信号以提供人的健康状况的指示。健康指示可能与疾病状态，一般健康状况或一个人的健康水平有关。该系统还包括移动设备，用于接收人的健康状况的指示以允许对该人进行诊断或治疗。