(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 637 554 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
17.09.2014 Bulletin 2014/38

(21) Application number: **11815792.4**

(22) Date of filing: **03.11.2011**

(51) Int Cl.:
A61B 5/024 (2006.01) ***A61B 5/0205*** (2006.01)
A61B 5/021 (2006.01) ***H04B 13/00*** (2006.01)
A61B 5/00 (2006.01)

(86) International application number:
PCT/IB2011/054896

(87) International publication number:
WO 2012/063172 (18.05.2012 Gazette 2012/20)

(54) **SYSTEM AND METHOD FOR EXCHANGING DUTY-CYCLE INFORMATION IN WIRELESS NETWORKS**

SYSTEM UND VERFAHREN ZUM AUSTAUSCH VON SCHALTKREISINFORMATIONEN IN DRAHTLOSEN NETZWERKEN

SYSTÈME ET PROCÉDÉ POUR ÉCHANGER DES INFORMATIONS DE CYCLE D’UTILISATION DANS DES RÉSEAUX SANS FIL

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR

(30) Priority: **08.11.2010 US 410989 P**

(43) Date of publication of application:
18.09.2013 Bulletin 2013/38

(73) Proprietor: **Koninklijke Philips N.V.**
5656 AE Eindhoven (NL)

(72) Inventor: **PATEL, Maulin, Dahyabhai**
5656 AE Eindhoven (NL)

(74) Representative: **Steffen, Thomas**
Philips
Intellectual Property & Standards
P.O. Box 220
5600 AE Eindhoven (NL)

(56) References cited:
EP-A1- 2 227 065 **KR-A- 20100 076 414**
US-A1- 2003 228 875

- **WEI YE ET AL: "An energy-efficient MAC protocol for wireless sensor networks", PROCEEDINGS IEEE INFOCOM 2002. THE CONFERENCE ON COMPUTER COMMUNICATIONS. 21ST. ANNUAL JOINT CONFERENCE OF THE IEEE COMPUTER AND COMMUNICATIONS SOCIETIES. NEW YORK, NY, JUNE 23 - 27, 2002; [PROCEEDINGS IEEE INFOCOM. THE CONFERENCE ON COMPUTER COMMUNI, vol. 3, 23 June 2002 (2002-06-23), pages 1567-1576, XP010593724, DOI: 10.1109/INFCOM.2002.1019408 ISBN: 978-0-7803-7476-8**
- **PENG LIN ET AL: "Medium access control with a dynamic duty cycle for sensor networks", WIRELESS COMMUNICATIONS AND NETWORKING CONFERENCE, 2004. WCNC. 2004 IE EE ATLANTA, GA, USA 21-25 MARCH 2004, PISCATAWAY, NJ, USA,IEEE, vol. 3, 21 March 2004 (2004-03-21), pages 1534-1539, XP010708133, ISBN: 978-0-7803-8344-9**

EP 2 637 554 B1

Printed by Jouve, 75001 PARIS (FR)

Description

[0001] The present application relates to wireless devices. In particular, it relates to wireless sensor networks, such as body area networks (BANs) or patient area networks (PANs), which monitor a patient's physiological parameter and transmit a data regarding the sensed parameters to a control system.

[0002] Patients have traditionally been monitored using sensing units connected by wires to a base station. These wires inhibited the patient mobility and were labor intensive to install. To improve patient mobility, facilitate installation, and eliminate wire clutter, wireless sensing units have been developed. Certain patients require continuous monitoring of physiological parameters, such as ECG, SpO_2, blood pressure, blood sugar, or the like. Though well enough to move about the community, they were restricted to a hospital room, the hospital ward, a convalescent room, or their home to facilitate continuous monitoring of physiological parameters. To venture out of these areas, the patients would be unmonitored.

[0003] In order to continuously monitor patient physiological parameters without constraining their activities, it is desirable to be able to mount sensors on the body of the patient, which are light and compact as possible while also being capable of communicating wirelessly with each other and a base station. A body area network (BAN) includes multiple nodes which are typically sensors that can be either wearable or implantable in to the human body. The nodes monitor vital body parameters and/or movements, and communicate with each other over a wireless medium. The nodes can transmit physiological data from a body to a control unit from which the data can be forwarded, in real-time, to a hospital, clinic, or elsewhere over a local area network (LAN), wide area network (WAN), a cellular network, or the like.

[0004] The requirements for designing BANs include energy efficiency of the nodes while adhering to geopolitical regulatory requirements regarding the use of the radio spectrum. In the United States, the Federal Communication Commission (FCC) divides the communication frequency spectrum into many bands that have been allocated, leased or sold to specific users/industries (e.g. radio, television, satellite, cellular, etc.). The FCC sets and monitors the compliance with technical requirements in response to the increasing demand for spectrum access. Imposed restrictions include frequency band, bandwidth, duty-cycle limitations, maximum transmit power limitations, specific absorption rate, or the like.

[0005] To facilitate wireless medical devices, the FCC has allocated 401-406 MHz frequency band for Medical Device Radiocommunication (MedRadio) Service on a shared, secondary and non-interference basis. MedRadio bands are intended to be used for ultra-low power wireless communications involving implanted and body-worn medical devices used for diagnostic and therapeutic functions. Examples of medical devices implanted in human body that may use MedRadio bands for communication are cardiac defibrillators, pacemakers, nerve/brain stimulators, implanted drug pumps, or the like. Body-worn devices such as ECG, EMG, EEG and hearing aids may also use MedRadio bands for wireless communication.

[0006] The FCC has mandated that the transmission duty-cycle of MedRadio devices operating in either the 401-402 MHz or 405-406 MHz bands should not exceed 0.1% based on the total transmission time during a one-hour interval. The duty-cycle is defined as the ratio, expressed as a percentage, of the maximum transmitter "ON" time on one or more carrier frequencies, relative to a one hour period. In Europe, several other allocated bands have duty-cycle restrictions. For example, the industrial, scientific and medical (ISM) bands operating in the 433.05-434.79 MHz range has a duty-cycle restriction of 10%, the 868-868.6 MHz band has a duty-cycle restriction of 1%, and the 868.7-869.3 MHz band has a duty-cycle restriction of 0.1 %.

[0007] Recently, the FCC has issued a notice of proposed rule making to allow shared secondary usage of 2.36-2.40 GHz band for wireless Medical Body Area Networks (MBANs), FCC Notice of Proposed Rulemaking 09-57, June 2009. The MBANs are intended to support on-body medical devices used for diagnostic and therapeutic applications. In the notice, the FCC has sought to restrict the maximum duty-cycle of devices operating in MBANs to 25%.

[0008] In a typical communication session, e.g. using IEEE 802.11b MAC protocol, the sender transmits a *Request to Send* (RTS) message to a receiver. Upon reception of the RTS message, the receiver transmits a *Clear to Send* (CTS) message which silences other wireless nodes in its vicinity and enables the sender of the RTS message to begin data transfer. Upon receiving the CTS message, the sender transmits the data and upon error-free reception of the data the receiver transmits an *Acknowledgement* (ACK) message.

[0009] For each transmitter, it is straightforward to track its current duty-cycle, to suspend transmissions when the duty-cycle reaches the maximum limit, and to resume transmissions when the duty-cycle is within the acceptable limits. However, the sender may not be aware of the current duty-cycle of its intended receiver. The intended receiver may be inhibited from responding to the sender with a CTS or ACK message because the receiver has reached its duty-cycle limit. The sender may incorrectly conclude that the message has collided, the received message has errors, the receiver is out of range, the receiver is dead (i.e. battery depleted), the receiver is sleeping, or the like. The sender may retransmit the message or listen idly in anticipation of an incoming message. Consequently, the sender wastes valuable energy, bandwidth, duty-cycle, resources, and the like. For at least the shortcomings described above, it would be therefore advantageous to provide a solution for exchanging duty-cycle information between devices to support the requirements of applications.

[0010] In Ye et al., An Energy-Efficient MAC Protocol for Wireless Sensor Networks, IEEE INFOCOM 2002, S-MAC, a medium-access control (MAC) protocol designed for wireless sensor networks, is proposed. S-MAC uses three novel techniques to reduce energy consumption and support self-configuration.

[0011] In Lin et al., Medium Access Control With A Dynamic Duty Cycle For Sensor Networks, WCNC 2004 / IEEE Communications Society, a sensor medium access control protocol with dynamic duty cycle, DSMAC, is proposed. The protocol achieves a good tradeoff between energy conservation and latency without incurring much overhead. Moreover, DSMAC is able to adjust its duty cycle with varying traffic conditions without assuming any prior knowledge of application requirements.

[0012] In EP 2 227 065 Al A wireless sensor network of devices including a sensor and a coordinator is disclosed. The sensor comprises sensing means operable to detect a parameter, transmission and reception means, and sensor control means operable to control a sleep pattern of the sensor. The coordinator comprises transmission and reception means. The sensor transmission means is operable to transmit value information as to the parameter values and the coordinator transmission means is operable to transmit an indication of a suitable sensor sleep pattern taking into account the value information.

[0013] In KR 2010 0076414 A an operation method of a dynamic MAC protocol based on buffer occupancy ratio in a wireless sensor network is proposed.

[0014] The present application provides a new and improved system and method for exchanging duty-cycle information in wireless body area networks which overcomes the above-referenced problems and others.

[0015] In accordance with one aspect, a wireless medical device is presented. The wireless medical device comprises at least one of a sensor and an actuator. The sensor is configured to monitor physiological data of a patient while the actuator is configured to deliver therapy to the patient. The device includes a wireless transceiver configured to transmit and/or receive control packets (e.g. beacons) and/or information packets related to at least one of the monitored physiological data and delivered therapy. The wireless transceiver has to comply with predetermined duty-cycle limits which define a maximum transmission "ON" time within a predefined time window. A duty-cycle module is configured to determine duty-cycle parameters of the wireless transceiver according to the duty-cycle limit. A communication module is configured to control the transceiver to broadcast, unicast, and/or multicast at least one duty-cycle parameter when transmitting a control packet or an information packet or when acknowledging reception of an information packet from a neighboring wireless medical device.

[0016] In accordance with another aspect, a method for wirelessly transmitting medical information is presented. The method includes at least one of a monitoring physiological data of a patient and delivering therapy to the patient. Information packets related to at least one of the monitored physiological data and delivered therapy are wirelessly transmitted and/or received. The wireless transmission has a duty-cycle limit which defines a maximum transmission "on" time during a predefined time window. Duty-cycle related parameters of the wireless transmission are determined according to the duty-cycle limit. At least one duty-cycle parameter is broadcasted, unicasted, and/or multicasted when transmitting an information packet or control packet or when acknowledging receiving an information packet from a neighboring wireless medical device.

[0017] One advantage resides in improved regulatory compliance.

[0018] Another advantage resides in optimizing the transmission of critical medical information.

[0019] Still further advantages of the present invention will be appreciated to those of ordinary skill in the art upon reading and understanding the following detailed description.

[0020] The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE 1 is a diagrammatic illustration of a medical wireless network;

FIGURE 2 is a detailed illustration of one of the wireless medical devices of FIGURE 1;

FIGURE 3 is a diagrammatic illustration of the hub medical device of FIGURE 1; and,

FIGURE 4 is a flow chart illustrative of a method of operation.

[0021] With reference to FIGURE 1, a plurality of wireless medical devices includes a hub medical device **10** and a plurality of wireless medical devices **12** arranged approximate to a patient's body for monitoring and recording various physiological parameters, administering therapy, or the like. The wireless medical devices **12** communicate wirelessly to the hub medical device **10.** Various wireless medical devices are contemplated, such as an inner-ear sensor **14** connected to an associated electronic module **16** which is disposed at least partially in the patient's ear to measure temperature, blood pressure, pulse rate, or the like. As another example, the wireless medical devices **12** can include an ECG monitor having a plurality of ECG sensors or electrodes **18** connected to an electronic module **20** which measures and interprets the sensed signals. As another example, an SpO_2 sensor **22** senses blood oxygen and pulse rate, which are communicated by an associated electronics module **24.** As another example, an infusion pump or other actuator **26** injects or otherwise dispenses medications into the patient's body under the control of electrical signals from an associated electrical module **28.** Other wireless medical devices **12** which sense physiological parameters or deliver therapy includes pacemakers, hearing aids, vision aids, prosthetic limbs, artificial organs, and the like.

[0022] The wireless hub **10** conveys the received signals from the wireless medical devices **12** to other wireless medical devices **29,** such as computer workstations, cellular phones, personal digital assistants, tablet computers, and the like, via an infrastructure network **30.** Communications between the hub and the wireless network **30** can be via WiFi, via the internet, via cellular network, via relatively high power RF transmissions, or the like. The wireless medical devices **12** and the hub **10** may interact with one another in various configurations. For example, in a star network, each of the wireless medical devices **12** communicates directly with the hub medical device **10.** The hub device receives acknowledgment packets or beacon packets from the devices **12** to, for example, synchronize the devices in anticipation of sending and receiving information packets, control signals, and the like, from the hub **10.** In a mesh network, the devices **12** communicate directly with each other and the hub **10.** Some of the devices **12** may communicate directly with the hub **10,** may communicate indirectly with the hub via other devices, such as computers, PDA's, mobile phones, or the like. These other devices may communicate directly with the wireless medical devices **29** or indirectly via the infrastructure network **30** rather than via the hub **10.**

[0023] With reference to FIGURE 2, each wireless medical device **12** includes at least one of a sensor **14, 18, 22,** which monitors physiological data of the patient or an actuator **26** which delivers therapy to the patient. The electronics module **20, 24, 28,** associated with each sensor, actuator, or combination, includes a wireless transceiver **40** with a transmitter **42** and a receiver **44** which transmit and receive, respectively, information and/or control packets to/from at least one of the neighboring wireless medical device **12** and the wireless hub **10.** Each wireless transmitter **42** has a duty cycle limit which limits the transmitter "ON" time relative to a predefined time window. For example, a transmitter may be limited to a duty cycle of 25% over a one hour time window. This restricts the transmitter "ON" time to at most 900 seconds during any 1 hour time window.

[0024] A duty-cycle module **50** determines duty-cycle parameters of the wireless transceiver. The duty-cycle parameters include a current transmission duty-cycle which is computed by tracking the amount of time the transmitter is in "ON" state during a current time window, a remaining transmission duty-cycle which defines the available (for use) duty-cycle during the current time window, and an offset of time from current time when sufficient duty-cycle will be available.

[0025] A duty-cycle management module **52** determines a transmission mode for the transceiver **40** based on at least one of the current duty-cycle, remaining duty-cycle and time offset parameters of the wireless medical device and those of neighboring wireless medical devices. The transmission mode includes a fragmentation mode which fragments the information packets across a plurality of time windows such that the duty-cycle limit is not exceeded in a current time window. In a modulation mode, at least one of frequency and amplitude modulation parameters of the transceiver **40** are adjusted to reduce a transmission time of the packet such that the duty-cycle limit is not exceeded in a current time window. In a compression mode, the information packet is compressed to reduce the transmission time of the packet such that the duty-cycle limit is not exceeded in a current time window. In a delay mode, the transmission of the packet is delayed to a subsequent time window such that the duty-cycle limit is not exceeded in the current time window. In an aggregation mode, smaller packets are aggregated into a larger packet such that the duty-cycle limit is not exceeded in the current time window. In a priority mode, higher priority packets are transmitted in a current time window and lower priority information is transmitted in subsequent time windows such that the duty-cycle limit is not exceeded in the current time window.

[0026] A communication module **60** receives physiological information sensed by the sensor **14, 18, 22** via a sensor or actuator control module **62.** The control module **62** also communicates with the actuator **26** to control its operation in accordance with received information packets. The communication module packages the sensed information and other transmission information such as acknowledgments, and the like, into information packets. The communication module controls the transceiver to transmit the packets with a duty-cycle dictated by the duty-cycle module **50** and the duty-cycle management module **52.**

[0027] A memory **64** stores information for later transmission, information about other wireless medical devices in the body area network, such as remaining duty-cycle, and the like. For example, when other wireless medical devices have reached or are nearing their duty-cycle limit, they may cease to send acknowledgments. By keeping track of the remaining duty-cycle of other wireless medical devices, the communication module knows whether acknowledgment signals will be received and type of acknowledgement to be expected, whether modulation or spreading parameters will be changed, whether data will be compressed, how compressed the data may be, whether to expect communications on a different frequency band, a delay in communication and the length of the expected delay, or the like.

[0028] With reference to FIGURE 3, the hub medical device **10** includes a first transceiver **40'** which communicates with the other wireless medical devices of the body area network and a second transceiver **40"** which communicates with the infrastructure network **30.** The wireless hub may be connected with a physiological data sensor and/or an actuator like the other wireless medical devices, or may function merely as a central controller or coordinator and for transferring physiological and/or therapy related information to and from the network **30.** For communicating with the other wireless medical devices **12** of the body area network, the wireless hub **10** includes a duty-cycle module **50'** which determines the duty-cycle parameters and a duty-cycle management module **52'** which determines the transmission mode based on at least one of the current duty-cycle, remaining duty-cycle, and time offset parameters of itself and the other wireless medical devices. A communications module **60'** controls the transceiver **40'** to broadcast, unicast, and/or multicast at least one duty-cycle parameter when transmitting an information or control packet or when acknowledging receipt of an information packet in a transmission mode as indicated by the duty-cycle module **50'** and the duty-cycle management module **52".** If the hub unit **10** is connected with a sensor or actuator, then it also includes a sensor or actuator control module **62'.**

[0029] The wireless hub also includes a scheduling module **70** which schedules timeframes (a.k.a. superframes) of the wireless medical devices **12** according to duty-cycle parameters of the respective wireless medical devices **12.** The scheduling module controls the communication module **60'** and transceiver **40'** to transmit and receive packets in scheduled timeframes to and from the respective wireless medical devices **12.** The scheduling module **70** can receive the duty-cycle parameters directly from the communication module **60'** or from memory **64'.**

[0030] The wireless hub **10** also includes a communications module **60"** for controlling the transceiver **40"** to communicate with the network **30.** A duty-cycle module **50"** and a duty-cycle management module **52"** monitor the duty-cycle with which the transceiver **40"** is communicating with the network **30** relative to duty-cycle requirements and controls the duty-cycle accordingly as discussed above.

[0031] With reference to FIGURE 4, duty-cycle is defined as a percentage of time that the transmitter is in the "ON" state within a predefined window of time, e.g. in the past one hour. Each wireless device computes and tracks its own duty-cycle. The duty-cycle is computed over a sliding window of time by summing durations of the transmitter "ON" time within the window of time and converting the sum into a percentage relative to the duration of the time window. If the transmitter is ON for a total of 3.6 seconds in the past one hour (3600 seconds), then the current duty-cycle is 1%. If the transmitter has been silent for the past hour, then the current duty-cycle is 0%.

[0032] The duty cycle can be expressed in bits, symbols, time frames, or in other suitable units. At **102,** the duty-cycle parameters such as current duty-cycle, amount of remaining duty-cycle and time offset are calculated. The transmitter tracks the amount of time it spends in the "ON" state within the given time window to compute the duty cycle. In a packet/frame based radio, this can be computed per packet/frame basis just above the PHY layer. Thus, the duty-cycle information is readily available at the MAC layer.

[0033] A device might chose not to exhaust its entire transmission "ON" time in one session or with one neighboring device. Rather, the available duty-cycle may be divided among the neighboring devices and/or over multiple communication sessions. Hence, it is useful for the communicating wireless medical device to know how much time is available for the current session with a neighbor. For example, a device reserves 10% of the available time within a predefined window of time interval for communicating data frame transmissions to a neighbor and 5% of the available time for acknowledgments to frames received from that neighbor. Another 10% of the available time, for example, may be allocated for control or management frames, such as beacons. The device reserves the fraction of the duty cycle for intended purposes at **104.**

[0034] At **106,** each receiver receives the duty-cycle information of the neighboring wireless medical devices **12** with which it communicates. At **108,** the received duty cycle parameters of neighbors are stored in the memory. The device uses this tracked duty-cycle information in conjunction with its own current duty-cycle to optimize the available transmission times.

[0035] At **110,** each receiver determines an optimization transmission mode which optimizes transmission efficiency based on the predetermined duty-cycle requirements and the duty cycle information received at **106** from the neighboring wireless medical devices **12.**

[0036] Various optimization transmission modes include fragmenting the a large packet into smaller packets such that transmitting the smaller packets saves the duty cycle or prevents the duty cycle value to exceed the limit. Another option is for the transmitter to employ a higher order modulation technique, e.g., 16 QAM instead of QAM (or QPSK), to reduce the over-air transmission time such that the duty-cycle is conserved. As another option, the transmission of packet is delayed until a time when the packet transmission would not cause the duty-cycle limit to be exceeded. One optimization transmission mode prioritizes the information to be transmitted. Higher priority information is transmitted first if the duty-cycle is in short supply. Periodic housekeeping control messages are delayed when the duty-cycle is in short supply. If the pending high priority messages cannot be transmitted due to duty-cycle limit restrictions, then the transmitter indicates that it has pending high priority messages for the receiver and the offset time indicative of when transmissions will resume. Thus, the receiver can be ready to receive these messages by waking up at the indicated time and reserving the appropriate duty-cycle for acknowledgments. The duration of the packet can be reduced by stripping the optional control fields from the packet.

[0037] Another optimization mode includes a reservation mode in which the hub **10** or wireless medical devices **12** periodically advertise a poll message, or a beacon message, which indicates the amount transmit time is available, e.g., based on the current duty-cycle. In response to the poll or beacon message, the other wireless medical devices **12** may contend to transmit a reservation message to reserve a future timeframe to transmit data. Upcoming time windows are reserved for data transfer among neighboring devices such that duty cycle is not exceeded in the current time window in each of the devices.

[0038] Another optimization transmission mode is a compression mode in which the data can be compressed to save transmission time. Furthermore, the data can be aggregated to reduce the transmission time, e.g. instead of transmitting raw data, the data can be aggregated or filtered prior to transmission data. In an encoding mode, the coding scheme of the transmitter **42** is adjusted to encode more information in the current time window such that the duty-cycle limit is not exceeded. For example, when the available duty cycle is abundant then the coding rate of 1/3 can be employed by the transmitter which means fewer information bits and more redundant bits are transmitted. On the other hand when duty cycle is scarce, the coding rate can be adapted to 1/1 to transmit more information bits. A Frame aggregation mode can be employed to combine multiple short frames into one large frame to reduce overhead (i.e. PHY header and/or MAC header) and save duty-cycle.

[0039] In an acknowledgement mode, the acknowledgement policy is changed, e.g. from an individual acknowledgment to a cumulative acknowledgement policy, such that the duty-cycle limit is not exceeded in the current time window. For example, when the receiver is running short on remaining duty-cycle, the acknowledgment policy can be changed to a cumulative acknowledgement policy, where multiple received packets are cumulatively acknowledged, or an unacknowledged delivery policy, where received packets are not acknowledged rather than an individual acknowledgement policy where each data message is acknowledged individually. If a potential transmitter knows that the receiver is unable to transmit acknowledgments due to duty-cycle restrictions, then the transmitter delays its transmissions until a time when the receiver is able to acknowledge. Alternately, the transmitter would transmit the messages if it has not exceeded its duty-cycle limit, but it would expect acknowledgments at a later time. The sending device would not resend the transmitted packets in the absence of an acknowledgment for the appropriate duration.

[0040] In a retry mode, the retry limit for retransmissions of unacknowledged packets can be varied according to the available duty-cycle such that the duty-cycle limit is not exceeded in the current time window. For example, retransmission attempts can be limited to one attempt instead of up to three or more attempts when duty-cycle is sufficient yet still scarce.

[0041] In a spectrum mode, the frequency band of operation is switched to a less restrictive band such that information is transmitted while complying to the regulatory requirements. For example, when a group of the wireless medical devices **12** and/or hub **10** cannot continue packet exchanges due to duty-cycle restrictions, the devices **10, 12** can switch to another channel or frequency band which does not restrict the duty-cycle, or at least is less restrictive of duty-cycle. For example, a pair of medical devices communicating over a 2.36 GHz channel may decide to switch channels to 2.4 GHz ISM when the current duty-cycle approaches the regulatory limit. In the United States, the 2.36 GHz channel has a 25% duty-cycle limit imposed by the FCC; whereas, there is no restriction on duty-cycle in the 2.4 GHz ISM band. Due to the proximity of the 2.4 GHz ISM band and the 2.36 GHz band, the same radio transmitters and receivers can efficiently operate in both bands. In another embodiment, the hub **10** and wireless medical devices **12** includes a plurality of transmitters 42 each tuned to a unique frequency with a corresponding duty-cycle limit which is monitored by the duty-cycle module **50.**

[0042] In a channel bonding mode, multiple frequency channels are combined to increase the transmission rate of packets such that the duty cycle is not exceeded in the current time window. For example, the duty cycle is conserved by combining multiple frequency channels, such as 2.36 GHz and 2.4 GHz, to increase the transmission rate of packets. The channel bonding mode increases the amount of packet data which can be transmitted within a similar time window.

[0043] In a spreading mode, spreading parameters of the transceiver **40** are adjusted to reduce the transmission time of the packet such that the duty-cycle is conserved. For example, in a direct sequence spread spectrum technique, instead of encoding 4 data bits with a pseudonoise (PN) sequence of 32 chips, the transmitter can encode 4 data bits with a PN sequence of 16 chips thereby doubling the data transfer rate.

[0044] At **112,** the duty-cycle parameters, such as current duty-cycle, amount of remaining duty-cycle, and time offset, are inserted into the packet to be transmitted. In one embodiment, each packet begins with a PHY header followed by an MAC header. The additional duty-cycle related data in the MAC header, or in other suitable locations in the packet, informs the receiver, such as a neighboring wireless medical device or host device, the duration of the sender's transmitter can be in the "ON" state before it is forced to shut off. The current duty-cycle may be calculated assuming successful transmission of the packet on hand. The amount of remaining duty-cycle is indicative of the amount of duty-cycle available for the current communication session, including the entire sequence of packet exchanges.

[0045] At **114,** transmissions are intelligently scheduled according to the received duty cycle parameters of the devices **10, 12** of the BAN. By knowing the available duty-cycle information of its neighbors, one of the wireless medical devices **10, 12** can intelligently schedule its transmissions to that neighbor. If the neighbor has reached its duty-cycle limit, then transmissions to that neighbor are scheduled for a later time. In one embodiment, the hub device **10** receives and tracks the duty-cycle parameters from all of the wireless medical devices

12 and determines an intelligent schedule for transmissions with the available scheduling module **70.** In another embodiment, the wireless medical devices **12** perform the scheduling with the available duty-cycle management module **52.**

[0046] Before attempting to transmit a packet, the transmitter checks whether transmitting the packet at hand will cause the duty-cycle to exceed the predefined limit. If not, then the packet is transmitted at **116.**

[0047] The duty-cycle information can be used to schedule a sleep mode **118** where a sender or receiver enters a sleep mode to conserve battery life. If a wireless device **12** is unable to transmit due to available duty-cycle limitations, then it can put itself into a sleep mode until the time when it is allowed to transmit again, thereby saving energy. Alternatively, the hub device **10** can instruct the wireless medical device **12** to enter or schedule a sleep mode.

[0048] A frame of time, for example, a beacon period or a superframe, can be predefined according to regulatory requirements and all of the devices are synchronized to this timeframe. At **120,** the hub device **10** that communicates with the other wireless medical devices **12** of the body area network periodically advertises a poll message, or a beacon, which indicates the amount transmit time, e.g., based on the current duty-cycle, is available. In response to the poll or beacon message, the other wireless medical devices **12** may contend to transmit a reservation message to reserve a future timeframe to transmit data. During the active portion of the timeframe, the devices may exchange the messages and may reach the duty-cycle limit, causing them to cease further transmission until a new timeframe begins.

[0049] The invention has been described with reference to the preferred embodiments. Modifications and alterations may occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be constructed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.

Claims

1. A wireless medical device (12), comprising:

at least one of a sensor (14,18,22) configured to monitor physiological data of a patient and an actuator (26) configured to deliver therapy to the patient;

a wireless transceiver (16, 20, 24, 26) configured to transmit and/or receive information packets related to at least one of the monitored physiological data and delivered therapy, the wireless transceiver (16, 20, 24, 26) having a duty-cycle limit representing the maximum transmission "ON" time within a predefined time window;

a duty-cycle module (50) configured to determine duty-cycle parameters of the wireless transceiver (16, 20, 24, 26) according to the duty-cycle limit;

a communication module (60) configured to control the transceiver (16, 20, 24, 26) to broadcast at least one duty-cycle parameter when transmitting an information packet or when acknowledging receiving an information packet from a neighboring wireless medical device (12).

2. The wireless medical device (12) according to claim 1, wherein the communication module is configured to control the transceiver (16, 20, 24, 26) to receive at least one duty-cycle parameter from neighboring wireless medical devices (12).

3. The wireless medical device (12) according to either one of claims 1 and 2, wherein the duty-cycle parameters include at least one of:

a current transmission duty-cycle which defines the duty cycle within a current time window;

a remaining transmission duty-cycle which defines the available duty-cycle during the current time window; and

a time offset from the current time when sufficient duty cycle will become available.

4. The wireless medical device (12) according to either one of claims 2 and 3, further including:

a duty-cycle management module (52) configured to determine a transmission mode based on at least one of a current duty cycle, remaining duty cycle, and time offset parameters of the wireless medical device (12) and of the neighboring wireless medical devices (12).

5. The wireless medical device (12) according to claim 4, wherein the transmission mode includes:

a fragmentation mode which fragments the information packet across a plurality of time windows such that the duty-cycle limit is not exceeded in a current time window;

a modulation mode which adjusts one of frequency and amplitude modulation of the transceiver (16, 20, 24, 26) to reduce a transmission time of the information packet such that the duty-cycle limit is not exceeded in a current time window;

a compression mode which compresses the information packet to reduce a transmission time of the information packet such that the duty-cycle limit is not exceeded in a current time window;

a delay mode which delays the transmission of

the information packet to a subsequent time window such that the duty-cycle limit is not exceeded in the current time window;
a retry mode which varies retransmission attempts of unacknowledged packets such that the duty-cycle limit is not exceeded in the current time window;
an encoding mode which adjusts the coding scheme of the transceiver (16, 20, 24, 26) to encode information in the current time window such that the duty-cycle limit is not exceeded;
an acknowledgement mode which adjust the acknowledgement policy such that the duty-cycle limit is not exceeded in the current time window;
a frame aggregation mode which aggregates smaller information packets into a single larger information packet such that the duty-cycle limit is not exceeded in the current time window; and
a priority mode which transmits higher priority information packets in a current time window and transmits lower priority information in subsequent time windows such that the duty-cycle limit is not exceeded in the current time window.

6. The wireless medical device (12) according to either one of claims 4 and 5, wherein the duty-cycle management module (52) is configured to schedule a sleep duration which forces the transceiver (16, 20, 24, 26) into a lower power consumption state until sufficient duty-cycle is available for transmission.

7. The wireless medical device (12) according to claim 4, wherein the duty-cycle management module (52) is configured to adjust a transmission frequency of the wireless transceiver (16, 20, 24, 26) until sufficient duty-cycle is available for transmission.

8. The wireless medical device (12) according to any one of claims 4-7, wherein an information packet includes at least one of the monitored physiological data, actuator control signals, transmission mode, source address, destination address, frame type, payload, and error correction code.

9. A wireless body area network, comprising:

a plurality of wireless medical device (12) according to any one of claims 1-8; and
a wireless hub (10) configured to interface the plurality of wireless medical device (12) to a medical infrastructure network (30).

10. The wireless body area network according to claim 9, wherein the wireless hub (10) includes:

a wireless transceiver (16, 20, 24, 26) configured to receive the monitored physiological data from the at least one wireless medical device (12) and to transmit an actuator control signal to control an actuator to deliver therapy, the wireless transceiver (16, 20, 24, 26) having a predetermined duty-cycle limit representing the maximum transmission "ON" time within a predefined time window;
a scheduling module configured to schedule transmissions by the wireless medical devices (12) according to duty-cycle parameters of respective wireless medical devices (12); and
a control module configured to control the wireless medical devices to transmit and/or receive packets according to scheduled transmissions.

11. A method for a body area network, comprising:

creating a wireless body area network which includes a plurality of wireless medical devices (12) according to any one of claims 1-8 and at least one wireless hub (10) according to claims 9 and 10; and
interfacing the plurality of wireless medical devices (12) via the wireless hub to a medical infrastructure network (30).

12. A method for wirelessly transmitting medical information, comprising:

at least one of a monitoring physiological data of a patient and delivering therapy to the patient;
wirelessly transmitting and/or receiving information packets related to at least one of the monitored physiological data and delivered therapy, the wireless transmission having a duty-cycle limit representing the maximum transmission "ON" time within a predefined time window;
determining duty-cycle related parameters of the wireless transmission according to the duty-cycle limit;
broadcasting at least one duty-cycle parameter when transmitting an information packet or when acknowledging receiving an information packet from a neighboring wireless medical device (12).

13. The method according to claim 12, further including:

receiving at least one duty-cycle parameter from neighboring wireless medical devices (12).

14. The method according to either one of claims 12 and 13, wherein the duty-cycle parameters include at least one of:

a current transmission duty-cycle which defines the duty-cycle within a current time window;
a remaining transmission duty-cycle which defines the available duty-cycle during the current

time window; and
a time offset from the current time when sufficient duty cycle will become available.

15. A computer readable medium carrying a computer program which controls one or more processors to perform the method according to claims 11-14.

Patentansprüche

1. Drahtlose medizinische Vorrichtung (12), die Folgendes umfasst:

mindestens einen Sensor (14, 18, 22), der konfiguriert ist, um die physiologischen Daten eines Patienten zu überwachen, und ein Betätigungselement (26), das konfiguriert ist, um dem Patienten eine Therapie zu verabreichen;
einen drahtlosen Transceiver (16, 20, 24, 26), der konfiguriert, um Informationspakete zu senden und/oder zu empfangen, die sich auf mindestens entweder die physiologischen Daten oder die verabreichte Therapie beziehen, wobei der drahtlose Transceiver (16, 20, 24, 26) eine Arbeitszyklusgrenze hat, die die maximale Senden-"EIN"-Zeit innerhalb eines vordefinierten Zeitfensters darstellt;
ein Arbeitszyklusmodul (50), das konfiguriert ist, um Arbeitszyklusparameter des drahtlosen Transceivers (16, 20, 24, 26) entsprechend der Arbeitszyklusgrenze zu ermitteln;
ein Kommunikationsmodul (60), das konfiguriert ist, um den Transceiver (16, 20, 24, 26) so zu steuern, dass mindestens ein Arbeitszyklusparameter rundgesendet wird, wenn ein Informationspaket gesendet wird oder wenn der Empfang eines Informationspakets von einer benachbarten drahtlosen medizinischen Vorrichtung (12) bestätigt wird.

2. Drahtlose medizinische Vorrichtung (12) nach Anspruch 1, wobei das Kommunikationsmodul konfiguriert ist, um den Transceiver (16, 20, 24, 26) so zu steuern, dass er mindestens einen Arbeitszyklusparameter von benachbarten drahtlosen medizinischen Vorrichtungen (12) empfängt.

3. Drahtlose medizinische Vorrichtung (12) nach einem der Ansprüche 1 und 2, wobei die Arbeitszyklusparameter mindestens eines von Folgendem umfassen:

einen aktuellen Sendearbeitszyklus, der den Arbeitszyklus innerhalb eines aktuellen Zeitfensters definiert;
einen verbleibenden Sendearbeitszyklus, der den verfügbaren Arbeitzyklus während des aktuellen Zeitfensters definiert; und
einen Zeitversatz von der aktuellen Zeit, wenn ein ausreichender Arbeitszyklus verfügbar wird.

4. Drahtlose medizinische Vorrichtung (12) nach einem der Ansprüche 2 und 3, weiterhin Folgendes umfassend:

ein Arbeitszyklus-Managementmodul (52), das konfiguriert ist, um einen Sendemodus basierend auf mindestens entweder dem aktuellen Arbeitszyklus, dem verbleibenden Arbeitszyklus oder den Zeitversatzparametern der drahtlosen medizinischen Vorrichtung (12) und der benachbarten drahtlosen medizinischen Vorrichtungen (12) zu ermitteln.

5. Drahtlose medizinische Vorrichtung (12) nach Anspruch 4, wobei der Sendemodus Folgendes umfasst:

einen Fragmentierungsmodus, der die Informationspakete derartig über eine Vielzahl von Zeitfenstern fragmentiert, dass die Arbeitszyklusgrenze in einem aktuellen Zeitfenster nicht überschritten wird;
einen Modulationsmodus, der entweder die Frequenz- oder die Amplitudenmodulation des Transceivers (16, 20, 24, 26) anpasst, um eine Sendezeit der Informationspakete derartig zu verkürzen, dass die Arbeitszyklusgrenze in einem aktuellen Zeitfenster nicht überschritten wird;
einen Kompressionsmodus, der das Informationspaket komprimiert, um eine Sendezeit des Informationspakets derartig zu verkürzen, dass die Arbeitszyklusgrenze in einem aktuellen Zeitfenster nicht überschritten wird;
einen Verzögerungsmodus, der das Senden der Informationspakete bis zu einem nachfolgenden Zeitfenster aufschiebt, so dass die Arbeitszyklusgrenze in dem aktuellen Zeitfenster nicht überschritten wird;
einen Wiederholversuchmodus, der die erneuten Sendeversuche für nicht bestätigte Pakete derartig variiert, dass die Arbeitszyklusgrenze in dem aktuellen Zeitfenster nicht überschritten wird;
einen Codiermodus, der das Codierschema des Transceivers (16, 20, 24, 26) zum Codieren von Informationen in dem aktuellen Zeitfenster derartig anpasst, dass die Arbeitszyklusgrenze nicht überschritten wird;
einen Bestätigungsmodus, der die Bestätigungspolitik derartig anpasst, dass die Arbeitszyklusgrenze in dem aktuellen Zeitfenster nicht überschritten wird;
einen Rahmenzusammenstellungsmodus, der

kleinere Informationspakete derartig zu einem einzelnen größeren Informationspaket zusammenstellt, dass die Arbeitszyklusgrenze in dem aktuellen Zeitfenster nicht überschritten wird; und
einen Prioritätsmodus, der Informationspakete höherer Priorität in einem aktuellen Zeitfenster sendet und Informationspakete niedrigerer Priorität in nachfolgenden Zeitfenstem sendet, so dass die Arbeitszyklusgrenze in dem aktuellen Zeitfenster nicht überschritten wird.

6. Drahtlose medizinische Vorrichtung (12) nach einem der Ansprüche 4 und 5, wobei das Arbeitszyklus-Managementmodul (52) konfiguriert ist, um eine Schlafdauer zu planen, die den Transceiver (16, 20, 24, 26) in einen Status mit niedrigerem Energieverbrauch zwingt, bis genügend Arbeitszyklus für das Senden zur Verfügung steht.

7. Drahtlose medizinische Vorrichtung (12) nach Anspruch 4, wobei das Arbeitszyklus-Managementmodul (52) konfiguriert ist, um eine Sendefrequenz des drahtlosen Transceivers (16, 20, 24, 26) anzupassen, bis genügend Arbeitszyklus für das Senden zur Verfügung steht.

8. Drahtlose medizinische Vorrichtung (12) nach einem der Ansprüche 4 bis 7, wobei ein Informationspaket mindestens entweder die überwachten physiologischen Daten, Betätigungselement-Steuersignale, Sendemodus, Quellenadressen, Zieladressen, Rahmentyp, Nutzdatenvolumen oder Fehlerkorrekturcode umfasst.

9. Drahtloses Körpernetzwerk (Body Area Network, BAN), das Folgendes umfasst:

eine Vielzahl von drahtlosen medizinischen Vorrichtungen (12) nach einem der Ansprüche 1 bis 8; und
einen drahtlosen Hub (10), der konfiguriert ist, um die Vielzahl der drahtlosen medizinischen Vorrichtungen (12) mit einem medizinischen Infrastruktumetzwerk (30) zu verbinden.

10. Drahtloses Körpernetzwerk nach Anspruch 9, wobei der drahtlose Hub (10) Folgendes umfasst:

einen drahtlosen Transceiver (16, 20, 24, 26), der konfiguriert ist, um die überwachten physiologischen Daten von der mindestens einen drahtlosen medizinischen Vorrichtung (12) zu empfangen und ein Betätigungselement-Steuersignal zu senden, um ein Betätigungselement so zu steuern, dass eine Therapie verabreicht wird, wobei der drahtlose Transceiver (16, 20, 24, 26) eine vorgegebene Arbeitszyklusgrenze hat, die die maximale Senden-"EIN"-Zeit innerhalb eines vordefinierten Zeitfensters darstellt;
ein Planungsmodul, das konfiguriert ist, um Sendevorgänge durch die drahtlose medizinische Vorrichtung (12) entsprechend den Arbeitszyklusparametern der jeweiligen drahtlosen medizinischen Vorrichtungen (12) zeitlich zu planen; und
ein Steuermodul, das konfiguriert ist, um die drahtlosen medizinischen Vorrichtungen so zu steuern, dass sie Pakete entsprechend den geplanten Sendevorgängen senden und/oder empfangen.

11. Verfahren für ein Körpernetzwerk, das Folgendes umfasst:

Schaffen eines drahtlosen Körpernetzwerks, das eine Vielzahl von drahtlosen medizinischen Vorrichtungen (12) nach einem der Ansprüche 1 bis 8 und mindestens einen drahtlosen Hub (10) nach den Ansprüchen 9 und 10 umfasst; und
Verbinden der Vielzahl von drahtlosen medizinischen Vorrichtungen (12) über den drahtlosen Hub mit einem medizinischen Infrastrukturnetzwerk (30).

12. Verfahren zum drahtlosen Senden von medizinischen Informationen, das Folgendes umfasst:

mindestens entweder Überwachen der physiologischen Daten eines Patienten oder Verabreichen einer Therapie an den Patienten;
drahtloses Senden und/oder Empfangen von Informationspaketen, die sich auf mindestens entweder die physiologischen Daten oder die verabreichte Therapie beziehen, wobei das drahtlose Senden eine Arbeitszyklusgrenze hat, die die maximale Senden-"EIN"-Zeit innerhalb eines vordefinierten Zeitfensters darstellt;
Ermitteln von auf den Arbeitszyklus bezogenen Parametern des drahtlosen Sendevorgangs entsprechend der Arbeitszyklusgrenze;
Rundsenden von mindestens einem Arbeitszyklusparameter, wenn ein Informationspaket gesendet wird oder wenn der Empfang eines Informationspakets von einer benachbarten drahtlosen medizinischen Vorrichtung (12) bestätigt wird.

13. Verfahren nach Anspruch 12, das weiterhin Folgendes umfasst:

Empfangen von mindestens einem Arbeitszyklusparameter von benachbarten drahtlosen medizinischen Vorrichtungen (12).

14. Verfahren nach einem der Ansprüche 12 und 13, wobei die Arbeitszyklusparameter mindestens eines von Folgendem umfassen:

einen aktuellen Sendearbeitszyklus, der den Arbeitszyklus innerhalb eines aktuellen Zeitfensters definiert;
einen verbleibenden Sendearbeitszyklus, der den verfügbaren Arbeitzyklus während des aktuellen Zeitfensters definiert; und
einen Zeitversatz von der aktuellen Zeit, wenn ein ausreichender Arbeitszyklus verfügbar wird.

15. Computerlesbares Medium mit einem Computerprogramm, das einen oder mehrere Prozessoren steuert, um das Verfahren nach den Ansprüchen 11 bis 14 auszuführen.

Revendications

1. Dispositif médical sans fil (12), comprenant :

au moins l'un d'un capteur (14, 18, 22) configuré pour surveiller des données physiologiques d'un patient et d'un actionneur (26) configuré pour délivrer une thérapie au patient ;
un émetteur-récepteur sans fil (16, 20, 24, 26) configuré pour transmettre et/ou recevoir des paquets d'informations liés à au moins l'une des données physiologiques surveillées et de la thérapie délivrée, l'émetteur-récepteur sans fil (16, 20, 24, 26) ayant une limite de rapport cyclique représentant le temps d'activation de transmission maximal à l'intérieur d'une fenêtre de temps prédéfinie ;
un module de rapport cyclique (50) configuré pour déterminer des paramètres de rapport cyclique de l'émetteur-récepteur sans fil (16, 20, 24, 26) en fonction de la limite de rapport cyclique ;
un module de communication (60) configuré pour commander à l'émetteur-récepteur (16, 20, 24, 26) de diffuser au moins un paramètre de rapport cyclique lors de la transmission d'un paquet d'informations ou lors de l'accusé de réception d'un paquet d'informations en provenance d'un dispositif médical sans fil voisin (12).

2. Dispositif médical sans fil (12) selon la revendication 1, dans lequel le module de communication est configuré pour commander à l'émetteur-récepteur (16, 20, 24, 26) de recevoir au moins un paramètre de rapport cyclique en provenance de dispositifs médicaux sans fil voisins (12).

3. Dispositif médical sans fil (12) selon l'une des revendications 1 et 2, dans lequel les paramètres de rapport cyclique comprennent au moins l'un de :

un rapport cyclique de transmission en cours qui définit le rapport cyclique à l'intérieur d'une fenêtre de temps actuelle ;
un rapport cyclique de transmission restant qui définit le rapport cyclique disponible à l'intérieur de la fenêtre de temps actuelle ; et
un décalage de temps par rapport au temps actuel lorsqu'un rapport cyclique suffisant devient disponible.

4. Dispositif médical sans fil (12) selon l'une des revendications 2 et 3, comprenant en outre :

un module de gestion de rapport cyclique (52) configuré pour déterminer un mode de transmission sur la base d'au moins l'un d'un rapport cyclique en cours, d'un rapport cyclique restant et de paramètres de décalage de temps du dispositif médical sans fil (12) et des dispositifs médicaux sans fil voisins (12).

5. Dispositif médical sans fil (12) selon la revendication 4, dans lequel le mode de transmission comprend :

un mode de fragmentation qui fragmente le paquet d'informations à travers une pluralité de fenêtres de temps de sorte que la limite de rapport cyclique ne soit pas dépassée dans une fenêtre de temps actuelle ;
un mode de modulation qui ajuste l'une d'une modulation de fréquence et d'une modulation d'amplitude de l'émetteur-récepteur (16, 20, 24, 26) pour réduire un temps de transmission du paquet d'informations de sorte que la limite de rapport cyclique ne soit pas dépassée dans une fenêtre de temps actuelle ;
un mode de compression qui compresse le paquet d'informations pour réduire un temps de transmission du paquet d'informations de sorte que la limite de rapport cyclique ne soit pas dépassée dans une fenêtre de temps actuelle ;
un mode de retard qui retarde la transmission du paquet d'informations dans une fenêtre de temps suivante de sorte que la limite de rapport cyclique ne soit pas dépassée dans la fenêtre de temps actuelle ;
un mode de nouvelle tentative qui varie les tentatives de retransmission de paquets sans accusé de réception de sorte que la limite de rapport cyclique ne soit pas dépassée dans la fenêtre de temps actuelle ;
un mode de codage qui ajuste le schéma de codage de l'émetteur-récepteur (16, 20, 24, 26) pour coder des informations dans la fenêtre de temps actuelle de sorte que la limite de rapport cyclique ne soit pas dépassée ;

un mode d'accusé de réception qui ajuste la politique d'accusé de réception de sorte que la limite de rapport cyclique ne soit pas dépassée dans la fenêtre de temps actuelle ;
un mode d'agrégation de trames qui agrège de petits paquets d'informations en un grand paquet d'informations unique de sorte que la limite de rapport cyclique ne soit pas dépassée dans la fenêtre de temps actuelle ; et
un mode de priorité qui transmet des paquets d'informations de priorité supérieure dans une fenêtre de temps actuelle et qui transmet des informations de priorité inférieure dans des fenêtres de temps suivantes de sorte que la limite de rapport cyclique ne soit pas dépassée dans la fenêtre de temps actuelle.

6. Dispositif médical sans fil (12) selon l'une des revendications 4 et 5, dans lequel le module de gestion de rapport cyclique (52) est configuré pour ordonnancer une durée de veille qui force l'émetteur-récepteur (16, 20, 24, 26) à passer dans un état de faible consommation d'énergie jusqu'à ce qu'un rapport cyclique suffisant soit disponible pour une transmission.

7. Dispositif médical sans fil (12) selon la revendication 4, dans lequel le module de gestion de rapport cyclique (52) est configuré pour ajuster une fréquence de transmission de l'émetteur-récepteur sans fil (16, 20, 24, 26) jusqu'à ce qu'un rapport cyclique suffisant soit disponible pour une transmission.

8. Dispositif médical sans fil (12) selon l'une quelconque des revendications 4 à 7, dans lequel un paquet d'informations comprend au moins l'un de données physiologiques surveillées, de signaux de commande d'actionneur, d'un mode de transmission, d'une adresse de source, d'une adresse de destination, d'un type de trame, d'une charge utile et d'un code de correction d'erreur.

9. Réseau corporel sans fil, comprenant :

une pluralité de dispositifs médicaux sans fil (12) selon l'une quelconque des revendications 1 à 8 ; et
un concentrateur sans fil (10) configuré pour interfacer la pluralité de dispositifs médicaux sans fil (12) avec un réseau d'infrastructures médicales (30).

10. Réseau corporel sans fil selon la revendication 9, dans lequel le concentrateur sans fil (10) comprend :

un émetteur-récepteur sans fil (16, 20, 24, 26) configuré pour recevoir les données physiologiques surveillées à partir de l'au moins un dispositif médical sans fil (12) et pour transmettre un signal de commande d'actionneur pour commander à un actionneur de délivrer une thérapie, l'émetteur-récepteur sans fil (16, 20, 24, 26) ayant une limite de rapport cyclique prédéterminée représentant le temps d'activation de transmission maximal à l'intérieur d'une fenêtre de temps prédéfinie ;
un module d'ordonnancement configuré pour ordonnancer des transmissions par les dispositifs médicaux sans fil (12) en fonction de paramètres de rapport cyclique de dispositifs médicaux sans fil (12) respectifs ; et
un module de commande configuré pour commander aux dispositifs médicaux sans fil de transmettre et/ou de recevoir des paquets en fonction de transmissions ordonnancées.

11. Procédé pour un réseau corporel, comprenant :

la création d'un réseau corporel sans fil qui comprend une pluralité de dispositifs médicaux sans fil (12) selon l'une quelconque des revendications 1 à 8 et au moins un concentrateur sans fil (10) selon l'une des revendications 9 et 10 ; et
l'interfaçage de la pluralité de dispositifs médicaux sans fil (12) avec un réseau d'infrastructures médicales (30) par l'intermédiaire du concentrateur sans fil.

12. Procédé de transmission sans fil d'informations médicales, comprenant :

au moins l'une d'une surveillance de données physiologiques d'un patient et d'une livraison d'une thérapie au patient ;
la transmission et/ou la réception sans fil de paquets d'informations liés à au moins l'une des données physiologiques surveillées et de la thérapie délivrée, la transmission sans fil ayant une limite de rapport cyclique représentant le temps d'activation de transmission maximal à l'intérieur d'une fenêtre de temps prédéfinie ;
la détermination de paramètres de rapport cyclique de la transmission sans fil en fonction de la limite de rapport cyclique ;
la diffusion d'au moins un paramètre de rapport cyclique lors de la transmission d'un paquet d'informations ou lors de l'accusé de réception d'un paquet d'informations à partir d'un dispositif médical sans fil voisin (12).

13. Procédé selon la revendication 12, comprenant en outre :

la réception d'au moins un paramètre de rapport cyclique en provenance de dispositifs médicaux sans fil voisins (12).

14. Procédé selon l'une des revendications 12 et 13, dans lequel les paramètres de rapport cyclique comprennent au moins l'un de :

un rapport cyclique de transmission en cours qui définit le rapport cyclique à l'intérieur d'une fenêtre de temps actuelle ;
un rapport cyclique de transmission restant qui définit le rapport cyclique disponible à l'intérieur de la fenêtre de temps actuelle ; et
un décalage de temps par rapport au temps actuel lorsqu'un rapport cyclique suffisant devient disponible.

15. Support lisible par ordinateur portant un programme informatique qui commande à un ou plusieurs processeurs d'effectuer le procédé selon les revendications 11 à 14.

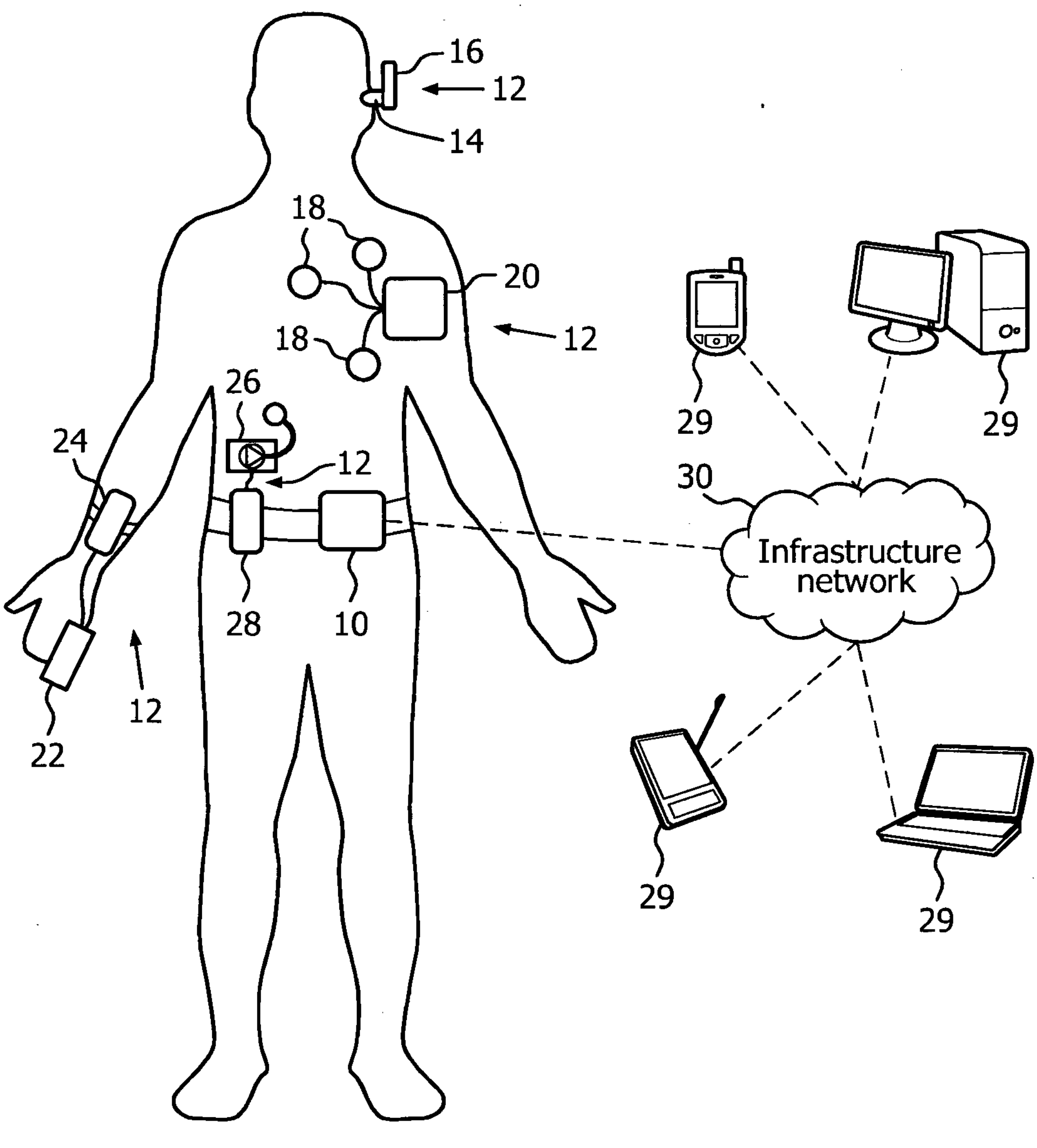
16
12
14
18
20
18
12
26
24
12
28
10
12
22
29
29
29
30
Infrastructure network
29
29

FIG. 1

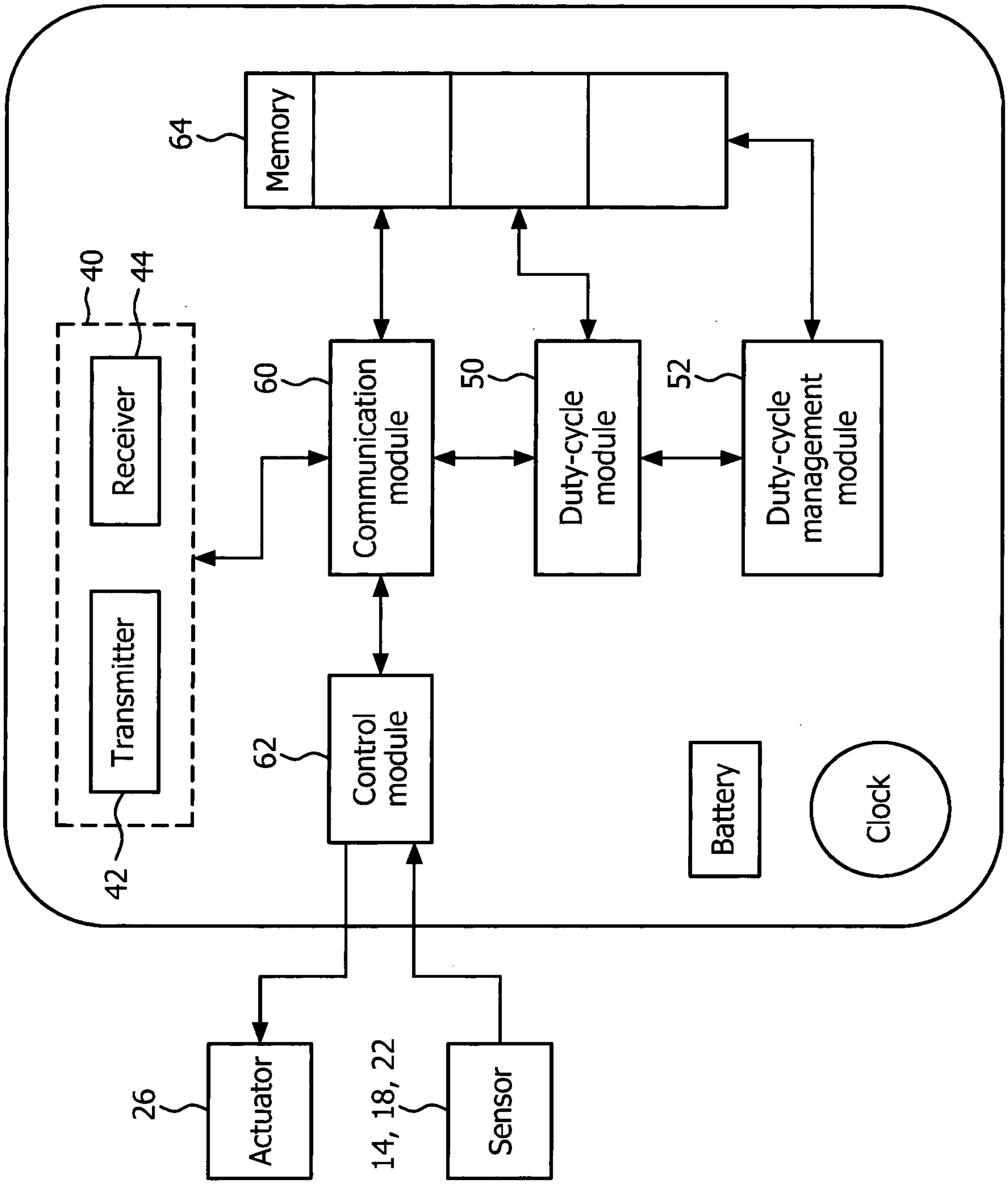
64
Memory
40
44
Receiver
Transmitter
42
60
Communication module
50
Duty-cycle module
52
Duty-cycle management module
62
Control module
Battery
Clock
26
Actuator
14, 18, 22
Sensor

FIG. 2

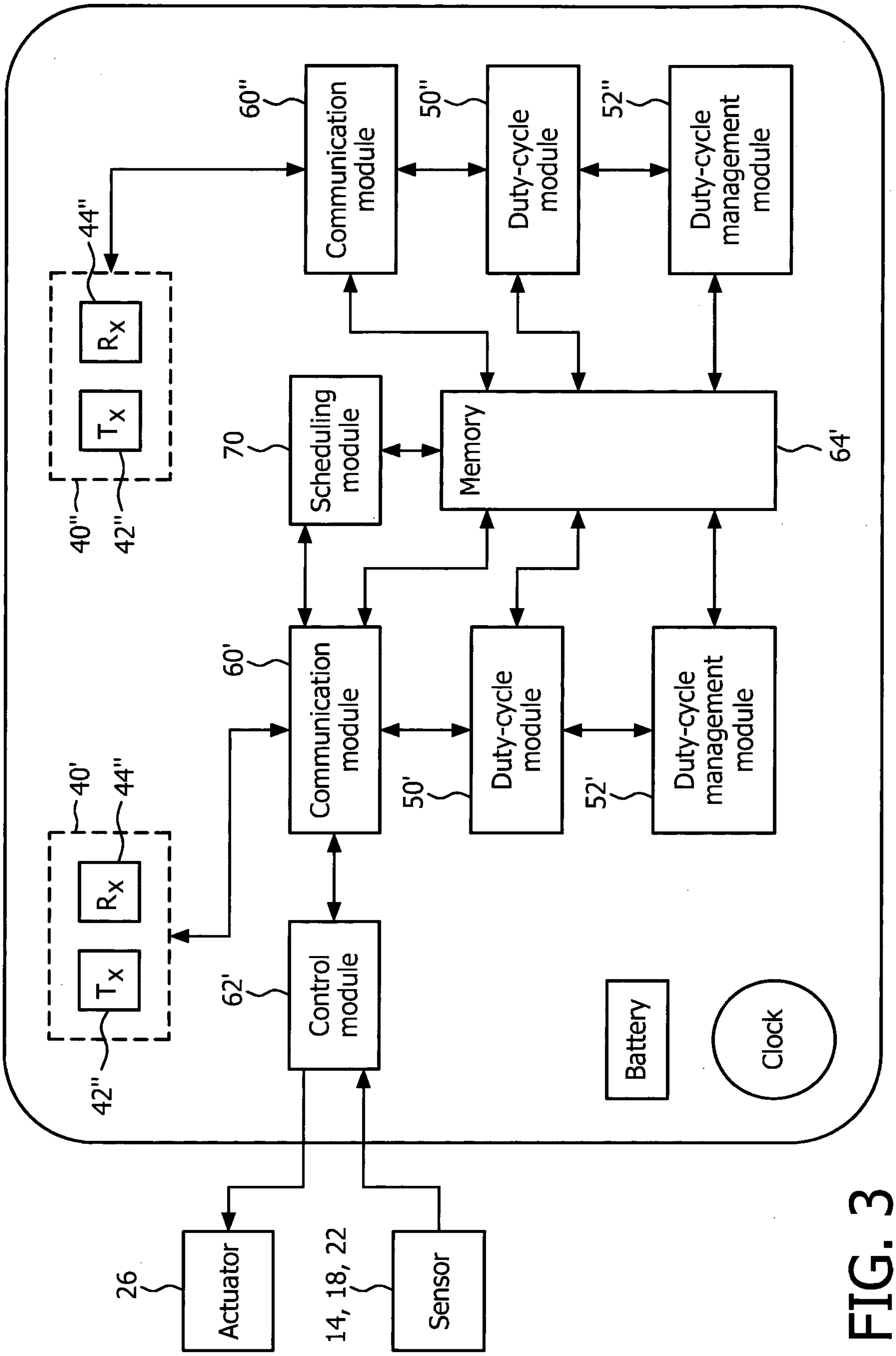
Communication module
60''
Duty-cycle module
50''
Duty-cycle management module
52''
44''
Rx
Tx
40''
42''
Scheduling module
70
Memory
64'
Communication module
60'
Duty-cycle module
50'
Duty-cycle management module
52'
40'
44''
Rx
Tx
42''
Control module
62'
Battery
Clock
Actuator
26
Sensor
14, 18, 22

FIG. 3

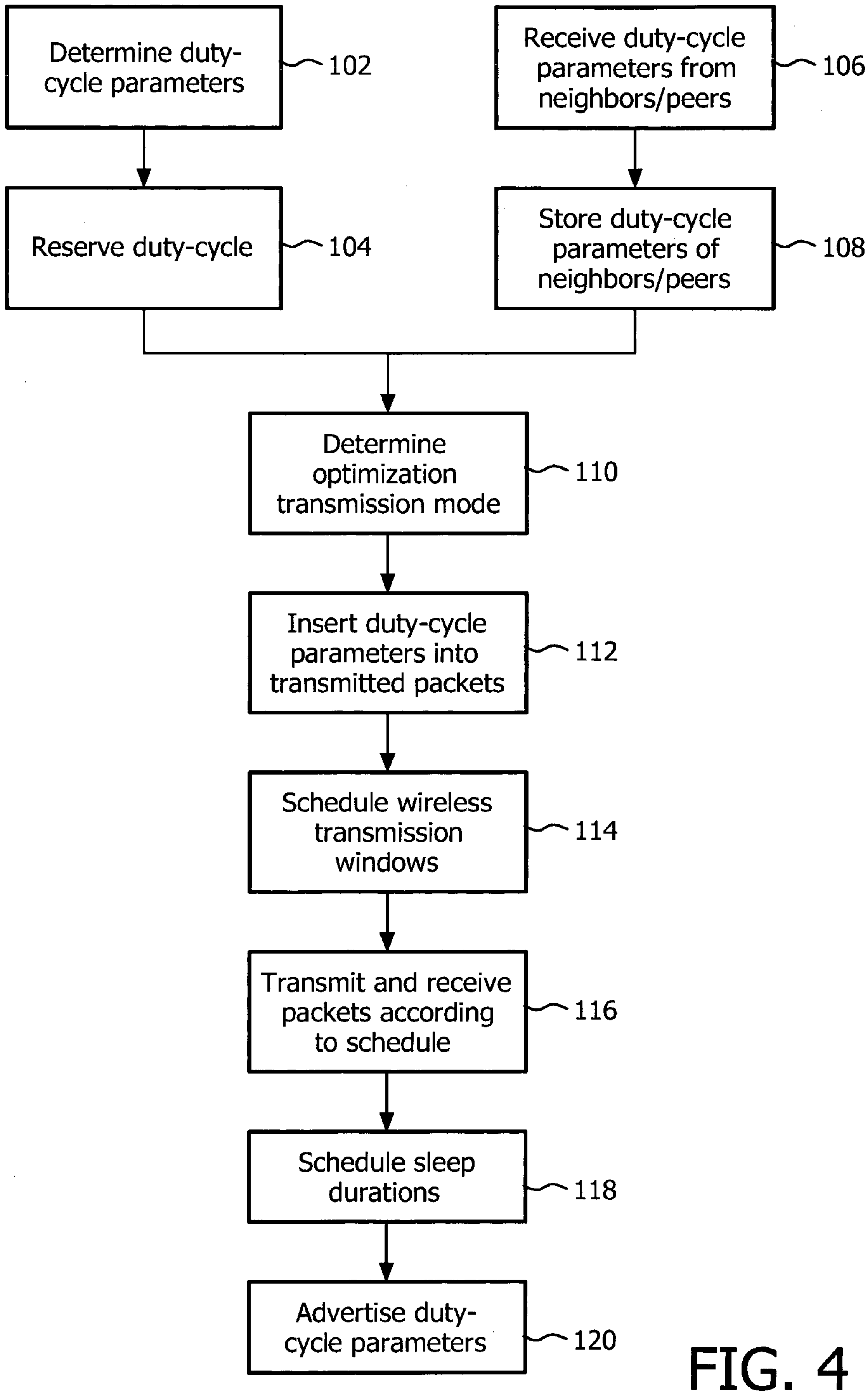
Determine duty-cycle parameters
102
Reserve duty-cycle
104
Receive duty-cycle parameters from neighbors/peers
106
Store duty-cycle parameters of neighbors/peers
108
Determine optimization transmission mode
110
Insert duty-cycle parameters into transmitted packets
112
Schedule wireless transmission windows
114
Transmit and receive packets according to schedule
116
Schedule sleep durations
118
Advertise duty-cycle parameters
120

FIG. 4

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- EP 2227065 A1 **[0012]**
- KR 20100076414 A **[0013]**

Non-patent literature cited in the description

- An Energy-Efficient MAC Protocol for Wireless Sensor Networks. **YE et al.** IEEE INFOCOM. 2002 **[0010]**
- Medium Access Control With A Dynamic Duty Cycle For Sensor Networks. **LIN et al.** WCNC. IEEE Communications Society, 2004 **[0011]**

专利名称(译)	用于在无线网络中交换占空比信息的系统和方法		
公开(公告)号	EP2637554B1	公开(公告)日	2014-09-17
申请号	EP2011815792	申请日	2011-11-03
[标]申请(专利权)人(译)	皇家飞利浦电子股份有限公司		
申请(专利权)人(译)	皇家飞利浦电子N.V.		
当前申请(专利权)人(译)	皇家飞利浦N.V.		
[标]发明人	PATEL MAULIN DAHYABHAI		
发明人	PATEL, MAULIN, DAHYABHAI		
IPC分类号	A61B5/024 A61B5/0205 A61B5/021 H04B13/00 A61B5/00		
CPC分类号	A61B5/0024 A61B5/02055 A61B5/021 A61B5/02438 A61B5/7232 A61B2560/0266 H04B13/005		
代理机构(译)	STEFFEN , THOMAS		
优先权	61/410989 2010-11-08 US		
其他公开文献	EP2637554A1		
外部链接	Espacenet		

摘要(译)

无线医疗设备（12）包括至少一个传感器（14,18,22），其监测患者的生理数据或致动器（26），其向患者递送治疗。无线收发器（40）发送和接收与监测的生理数据和所递送的治疗中的至少一个相关的信息包。无线收发器（40）具有占空比限制。占空比模块（50）根据占空比限制确定无线收发器（40）的占空比参数。通信模块（60）控制收发器（40）在发送信息包时或在确认从相邻无线医疗设备接收信息包时广播至少一个占空比参数。

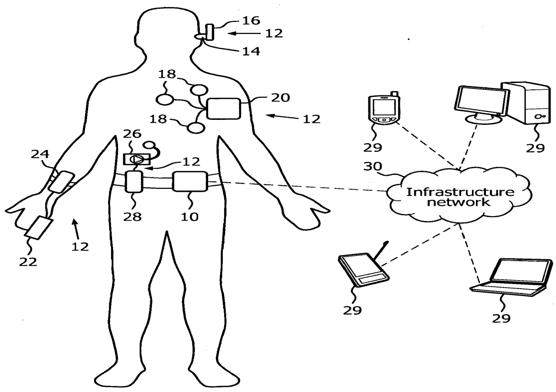

FIG. 1