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(54) BODY AREA NETWORK COMMUNICATION COLLISION AVOIDANCE CONCEPT FOR MEDICAL SYSTEMS

(57) The present disclosure relates to a medical system (1), comprising a plurality of devices (10, 20, 30) forming nodes of a network, wherein each device (10, 20, 30) of said plurality of devices is configured to communicate with another device in a wireless fashion by receiving a message from another device in the network or by transmitting a message to another device in the network, and wherein a priority is assigned to each device (10, 20, 30), wherein as long as no other transmission of a message is ongoing in the network, each device (10, 20, 30) is configured to initiate a transmission of a message by transmitting a start signal (SI, S2, S3), wherein the higher the priority of the respective device (10, 20, 30), the higher the duration (D1, D2, D3) of the start signal (SI, S2, S3) allocated to the respective device (10, 20, 30), and wherein in case several devices in the network simultaneously initiate a transmission of a message by transmitting a start signal, a permission to transmit a message is automatically granted to the device in the network with the highest priority. Furthermore, the present disclosure relates to a method of communicating in a medical system/network.

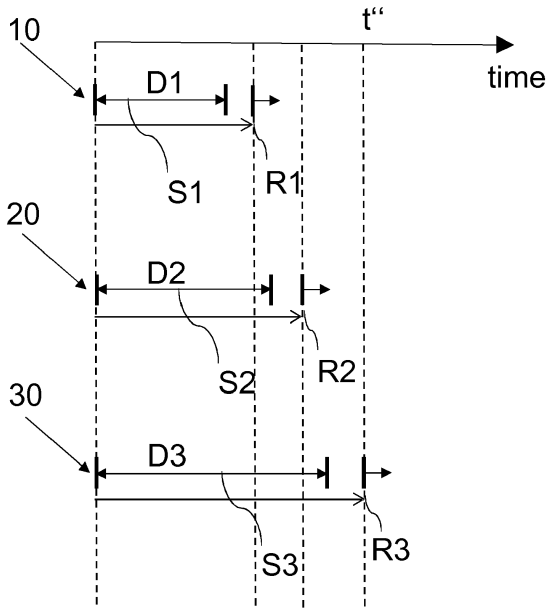

Fig. 2

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Description

[0001] The present invention relates to a medical system utilizing a network, particularly a body are network (BAN).

[0002] In the framework of the present invention, a body area network (BAN), is a network of devices capable of performing wireless communication within a body area of a patient. The respective device can be an implantable device that is positioned inside the patient's body or a device positioned outside the patient's body. A device positioned outside the person's body may be configured to be worn by the patient and may be arranged on the person's body. The devices of the BAN may communicate via wireless (particularly short-range) radio communication. Particularly, IEEE 802.15 formally defines a BAN as a communication standard optimized for low power devices and operation on, in or around the human body (but not limited to humans) to serve a variety of applications including medical, consumer electronics/personal entertainment and other.

[0003] In a network or BAN working in half-duplex mode, two parties (e.g. devices) can communicate with each other, but not simultaneously (i.e. the communication is one direction at a time). In case such a network/BAN shall be used for the communication between (e.g. implantable) medical devices, it needs to facilitate the exchange of information in a reliable and timely fashion.

[0004] The communication between devices can be made reliable by implementing a transmit/response scheme where the transmitting party repeats the transmission until it receives an acknowledging response from the addressed party.

[0005] Existing solutions do not handle time critical communication in a reliable timely manner. Half duplex body area networks such as envisioned for the communication between implantable medical devices may need the ability to prevent the collision of transmissions from separate devices when started accidentally at the same time. The collision of the transmission of information may or may not be critical.

[0006] If the information to be transmitted is not time critical, the transmission can be made reliable by implementing the transmit/response scheme where the transmitting party repeats the transmission until it receives an acknowledging response from the addressed party. If the information to be transmitted by one device is time critical for another device such as in the synchronization of intracardiac pacemaker activities implanted in different heart chambers, the repeated transmission until an acknowledging response is observed may not be sufficient. Time critical information needs a communication concept that prevents the potential collision of transmissions.

[0007] Therefore, it is an objective to provide a medical system comprising communication concept that prevents the collision of transmissions in a network, particularly in case the network (e.g. BAN) operates in half duplex mode.

[0008] A medical system having the features of claim 1 and a method with the features of claim 13 are provided. Further embodiments are stated in the dependent claims.

[0009] In one aspect, a medical system is disclosed which comprises a plurality of devices forming nodes of a network provided by the medical system, wherein each device of said plurality of devices is configured to communicate with another device of said plurality of devices via the network in a wireless fashion by receiving a message from another device in the network or by transmitting a message to another device in the network, and wherein a priority is assigned to each device, wherein as long as no other transmission of a message is ongoing in the network, each device is configured to initiate a transmission of a message by transmitting a start signal, wherein the higher the priority of the respective device, the higher the duration of the start signal allocated to the respective device, and wherein in case several devices in the network simultaneously initiate a transmission of a message by transmitting a start signal, a permission to transmit a message is automatically granted to the device in the network with the highest priority.

[0010] In another aspect, a method for wireless communication between devices of a medical system is provided, wherein the devices form nodes of a network, and wherein the method comprises the steps of:

- assigning a priority to each device,
- allowing each device in the network to initiate a transmission of a message by transmitting a start signal as long as no other transmission of a message is ongoing in the network, wherein the higher the priority of the respective device, the higher a duration of the start signal allocated to the respective device, and
- in case several devices in the network simultaneously initiate a transmission by transmitting a start signal, granting a permission to transmit a message to the device in the network having the highest priority.

[0011] The disclosure thus provides a novel concept to prevent communication collisions in networks such as body area networks, particularly in case the network/BAN comprises half duplex communication.

[0012] According to an embodiment, the network is a body area network (BAN) (e.g.as defined above).

[0013] Furthermore, according to an embodiment of the system, wherein the devices are configured to communicate with one another via the network in half-duplex mode.

[0014] Further, according to an embodiment, each device is configured to be in a receiving mode in which the respective device is able to receive a message from another device and is able to transmit a message of its own and is not inhibited by an ongoing or initiated message of another device of the network. Start sending a start signal might be inhibited by an already ongoing start sig-

nal or a message from another device.

[0015] Furthermore, according to an embodiment of the system, the respective device is configured to return into the receiving mode for a pre-defined time period after having transmitted a start signal, wherein in case the respective device receives a start signal from another device during this time period, the respective device is configured to postpone transmission of its own message until the ongoing transmission of the start signal from the other device ends, and wherein the respective device is configured to transmit its own message in case the respective device sees no ongoing transmission of a start signal from a different device after its own start signal has ended.

[0016] Further, according to an embodiment of the system, no two devices of the network comprise the same start signal duration.

[0017] Furthermore, in an embodiment, a difference between the durations of each two start signals is larger than a transition time from transmission to receiving mode of a device among the plurality of devices that comprises the longest transition time.

[0018] Furthermore, according to an embodiment of the system, the plurality of devices comprises at least a first and a second medical device, wherein particularly the first device is an implantable medical device, and wherein particularly the second medical device is an implantable medical device.

[0019] Furthermore, according to an embodiment, the first device is an implantable intracardiac pacemaker that is configured to be implanted in the heart of a patient. Further, according to an embodiment, the second device is an implantable intracardiac pacemaker that is configured to be implanted in the heart of a patient. Alternatively, the second device can be a sensor. The sensor may be configured to measure a blood pressure of a patient or the sensor can be a loop recorder configured to measure an ECG.

[0020] Particularly, the first device is an intracardiac pacemaker configured to be implanted in the right ventricle of the patient. Furthermore, particularly, in case the second device is an intracardiac pacemaker, the latter is preferably configured to be implanted in the right atrium, in the left atrium or in the left ventricle of the patient.

[0021] According to a further embodiment, the plurality of devices further comprises a third medical device, wherein particularly the third medical device is an implantable medical device. The third medical device can be an intracardiac pacemaker, the latter may be configured to be implanted in the right atrium, in the left atrium or in the left ventricle of the patient. Also, the third medical device may be a sensor (e.g. configured to measure a blood pressure of a patient) or a loop recorder.

[0022] The plurality of devices may also comprise more than three medical devices.

[0023] Furthermore, in an embodiment of the method, the method comprises the further step of sending the message from the device having the highest priority and receiving the message by another device in the network in half-duplex mode.

[0024] Further, according to an embodiment of the method, the method comprises the further step of maintaining each device in the network in a receiving mode in which the respective device is able to receive a transmission of a message from another device and is able to transmit a message of its own and is not inhibited by an ongoing or initiated message of another device of the network.

[0025] Furthermore, according to an embodiment of the method, the method comprises the further steps of prompting the respective device to return into the receiving mode for a pre-defined time period after having transmitted a start signal, and postponing a transmission of a message of the respective device when the respective device sees a start signal from another device during this time period, and allowing the respective device to transmit its own message in case the respective device sees no ongoing transmission of a start signal from a different device after its own start signal has ended.

[0026] Furthermore, according to an embodiment of the method, no two devices of the network comprise the same start signal duration. Particularly, a difference between the durations of each two start signals is larger than a transition time from transmission to receiving mode of a device among the plurality of devices that comprises the longest transition time. Particularly, the method according to the present disclosure can be conducted with the first device, second device, and particularly third device described above. All features disclosed herein with regard to the system can be applied to the method and vice versa.

[0027] In the following, embodiments, features and advantages of the present invention shall be described with reference to the Figures, wherein

Fig. 1 shows a schematical illustration of an embodiment of a medical system comprising medical devices forming nodes of a network, particularly of a BAN; and

Fig. 2 shows a schematical illustration of transmitting a message in the medical system shown in Fig. 1.

[0028] Fig. 1 shows in conjunction with Fig. 2 an embodiment of a medical system 1 which comprises at least a first and a second device 10, 20.

[0029] Particularly, in an embodiment, the first device 10 can be an intracardiac pacemaker implanted in the right ventricle of a patient, wherein the second device can be an intracardiac pacemaker implanted in the right atrium of the patient. According to another example, the first device 10 can be an intracardiac pacemaker implanted in the right ventricle, and the second device can be an intracardiac pacemaker implanted in the left ventricle. Furthermore, according to an alternative example, the

first device can be an intracardiac pacemaker implanted in the right ventricle, whereas the second device 20 can be a sensor, e.g. configured to measure blood pressure of the patient.

[0030] In the following, for describing the communication among the devices in a medical system 1, a third device 30 is considered forming a node of the network, too.

[0031] Particularly, for enabling communication e.g. in the medical system 1/network shown in Fig. 1, preferably a physical layer is defined to determine the beginning of a data transmission, e.g. in form of a start signal S1, S2, S3 as well as a signal pattern to define the logical bit values of the actual digital data transmission which is denoted as a message herein. Particularly, the communication is based on the duration D1, D2, D3 of the start signal S1, S2, S3 to be dependent on a priority scheme assigned to all the devices 10, 20, 30 communicating within the same network, which particularly is a BAN.

[0032] Any device 10, 20, 30 that takes part in the information exchange within the same network/BAN needs to be always in the message receiving mode R1, R2, R3 unless it is granted permission to transmit its own message. After transmitting, the device 10, 20, 30 preferably needs to return to the receiving mode R1, R2, R3 as soon as possible.

[0033] As long as no other transmission is ongoing any device 10, 20, 30 may initiate a transmission by transmitting a start signal S1, S2, S3. The duration D1, D2, D3 of the start signal S1, S2, S3 for each device 10, 20, 30 is dependent on the priority assigned to the device 10, 20, 30. By starting to transmit a start signal S1, S2, S3 the device 10, 20, 30 indicates the intention to transmit information (i.e. a message).

[0034] After transmitting the start signal S1, S2, S3 the transmitting device 10, 20, 30 needs to first return into receiving mode R1, R2, R3 for a limited amount of time. If at this time the device 10, 20, 30 sees an incoming transmission (receiving an ongoing start signal from a different device), the device 10, 20, 30 needs to postpone its own message transmission until the ongoing message/start signal transmission stops. If the device 10, 20, 30 sees no ongoing transmission of a start signal S1, S2, S3 from a different device 10, 20, 30 after its own start signal S1, S2, S3 ended, the device 10, 20, 30 is allowed to transmit its information.

[0035] If several devices 10, 20, 30 initiate simultaneously the transmission of the start signal S1, S2, S3, a situation that is shown in Fig. 2, the permission to send is granted automatically to the device with the higher priority by the proposed implementation of the start signal S1, S2, S3. The priority scheme assigned to each device 10, 20, 30 within the same network (e.g. BAN) defines the duration D1, D2, D3 of the allowed transmission of the start signal S1, S2, S3. The device 30 with the highest priority is allocated the longest duration of the start signal D3 and the device 10 with the lowest priority is allocated the shortest duration D1 of the start signal S1. Preferably, no two devices 10, 20, 30 must have the same start signal duration D1, D2, D3 assigned if working in the same network, e.g. BAN. The incremental differences in the start signal duration D1, D2, D3 needs to be longer than the transition time from transmission to receiving of the device 10, 20, 30 with the longest transition time to ensure that each device 10, 20, 30 will be able to see the ongoing start signal of a higher priority device.

[0036] Particularly, as shown in Fig. 2 as an example, the first device 10 comprises the lowest priority (and consequently shortest start signal duration D1) and the third device 30 the highest priority (longest start signal duration D3), wherein the second device 20 comprises a priority in between the lowest and highest priority (duration D1 between D2 and D3). All three devices 10, 20, 30 initiate the transmission of their respective start signal S1, S2, S3 at the same time to request the transmission of a message, respectively.

[0037] The first device 10 comprises the lowest priority and therefore returns to the receiving mode R1 at time t first, wherein the first device 10 then sees the incoming start signals S2, S3 from the higher priority second and third devices 20, 30 and therefore postpones transmission of its message to wait for the incoming messages.

[0038] Furthermore, the second device 20 returns to the receiving mode R1 after the first device 10 at time t' and then sees an incoming start signal S3 from the higher priority third device 30. Consequently, the second device 20 postpones its transmission of a message and waits for the incoming message of the third device 30.

[0039] Finally, the highest priority third device 30, after having transmitted its start signal S3, returns to the receiving mode R3 after the other two devices 10, 20 at time t" and therefore sees no incoming start signals S1, S2. Therefore, the third device 30 is automatically allowed to start transmission of its message.

[0040] Particularly, one advantage of the present disclosure may be the ability to avoid lengthy arbitration schemes in order to prevent the loss of information due to information transmission collisions in a network, particularly in a body area network (BAN), operating e.g. in the half duplex mode.

Claims

1. A medical system (1), comprising a plurality of devices (10, 20, 30) forming nodes of a network, wherein each device (10, 20, 30) of said plurality of devices is configured to communicate with another device of the network in a wireless fashion by receiving a message from another device in the network or by transmitting a message to another device in the network, and wherein a priority is assigned to each device (10, 20, 30), wherein as long as no other transmission of a message is ongoing in the network, each device (10, 20, 30) is configured to initiate a transmission of a message by transmitting a start signal

(S1, S2, S3), wherein the higher the priority of the respective device (10, 20, 30), the higher the duration (D1, D2, D3) of the start signal (S1, S2, S3) allocated to the respective device (10, 20, 30), and wherein in case several devices in the network simultaneously initiate a transmission of a message by transmitting a start signal, a permission to transmit a message is automatically granted to the device in the network with the highest priority.

2. The medical system according to claim 1, wherein the network is a body area network.

3. The medical system according to claim 1 or 2, wherein the devices (10, 20, 30) are configured to communicate with one another in half-duplex mode.

4. The medical system according to one of the preceding claims, wherein each device (10, 20, 30) is configured to be in a receiving mode (R1, R2, R3) in which the respective device (10, 20, 30) is able to receive a message from another device and is able to transmit a message of its own and is not inhibited by an ongoing or initiated message of another device of the network.

5. The medical system according to claim 4, wherein the respective device (10, 20, 30) is configured to return into the receiving mode (R1, R2, R3) for a predefined time period after having transmitted a start signal (S1, S2, S3), wherein in case the respective device (10, 20, 30) sees a start signal (S1, S2, S3) from another device during this time period, the respective device (10, 20, 30) is configured to postpone transmission of its own message until the ongoing transmission of the start signal from the other device ends, and wherein the respective device (10, 20, 30) is configured to transmit its own message in case the respective device (10, 20, 30) sees no ongoing transmission of a start signal from a different device after its own start signal has ended.

6. The medical system according to one of the preceding claims, wherein no two devices (10, 20, 30) of the network comprise the same start signal duration (D1, D2, D3).

7. The medical system according to one of the preceding claims, wherein a difference between the durations (D1, D2, D2) of each two start signals (S1, S2, S3) is larger than a transition time from transmission to receiving mode (R1, R2, R3) of a device among the plurality of devices (10, 20, 30) that comprises the longest transition time.

8. The medical system according to one of the preceding claims, wherein the plurality of devices comprises at least a first and a second medical device (10, 20).

9. The medical system according to claim 8, wherein the first device (10) is an intracardiac pacemaker, and/or wherein the second device (20) is an intracardiac pacemaker or a sensor configured to measure a blood pressure of a patient.

10. The medical system according to claim 9, wherein the first device (10) is an intracardiac pacemaker configured to be implanted in the right ventricle of the patient.

11. The medical system according to claim 9 or 10, wherein the second device (20) is an intracardiac pacemaker configured to be implanted in the right atrium or in the left ventricle of the patient.

12. The medical system according to one of the claims 8 to 11, wherein the plurality of devices further comprises a third medical device (30).

13. A method for wireless communication between devices (10, 20, 30) of a medical system (1), wherein the devices (10, 20, 30) form nodes of a network, and wherein the method comprises the steps of:

- assigning a priority to each device (10, 20, 30),
- allowing each device (10, 20, 30) in the network to initiate a transmission of a message by transmitting a start signal (S1, S2, S3) as long as no other transmission of a message is ongoing in the network, wherein the higher the priority of the respective device (10, 20, 30), the higher a duration (D1, D2, D3) of the start signal (S1, S2, S3) allocated to the respective device (10, 20, 30), and
- in case several devices (10, 20, 30) in the network simultaneously initiate a transmission by transmitting a start signal (S1, S2, S3), granting a permission to transmit a message to the device (10, 20, 30) in the network having the highest priority.

14. The method according to claim 13, wherein the method comprises the further step of maintaining each device (10, 20, 30) in the network in a receiving mode (R1, R2, R3) in which the respective device (10, 20, 30) is able to receive a transmission of a message from another device and is able to transmit a message of its own and is not inhibited by an ongoing or initiated message of another device of the network.

15. The method according to claim 14, wherein the method comprises the further steps of prompting the respective device (10, 20, 30) to return into the receiving mode (R1, R2, R3) for a pre-defined time period after having transmitted a start signal (S1, S2, S3), and postponing a transmission of a message of the respective device (10, 20, 30) when the respective

device (10, 20, 30) sees a start signal (S1, S2, S3) from another device during this time period, and allowing the respective device (10, 20, 30) to transmit its own message in case the respective device (10, 20, 30) sees no ongoing transmission of a start signal (S1, S2, S3) from a different device after its own start signal has ended.

16. The method according to one of the claims 13 to 15, wherein no two devices (10, 20, 30) of the network comprise the same start signal duration (D1, D2, D3).

17. The method according to one of the claims 13 to 16, wherein a difference between the durations (D1, D2, D3) of each two start signals (S1, S2, S3) is larger than a transition time from transmission to receiving mode (R1, R2, R3) of a device among the plurality of devices that comprises the longest transition time.

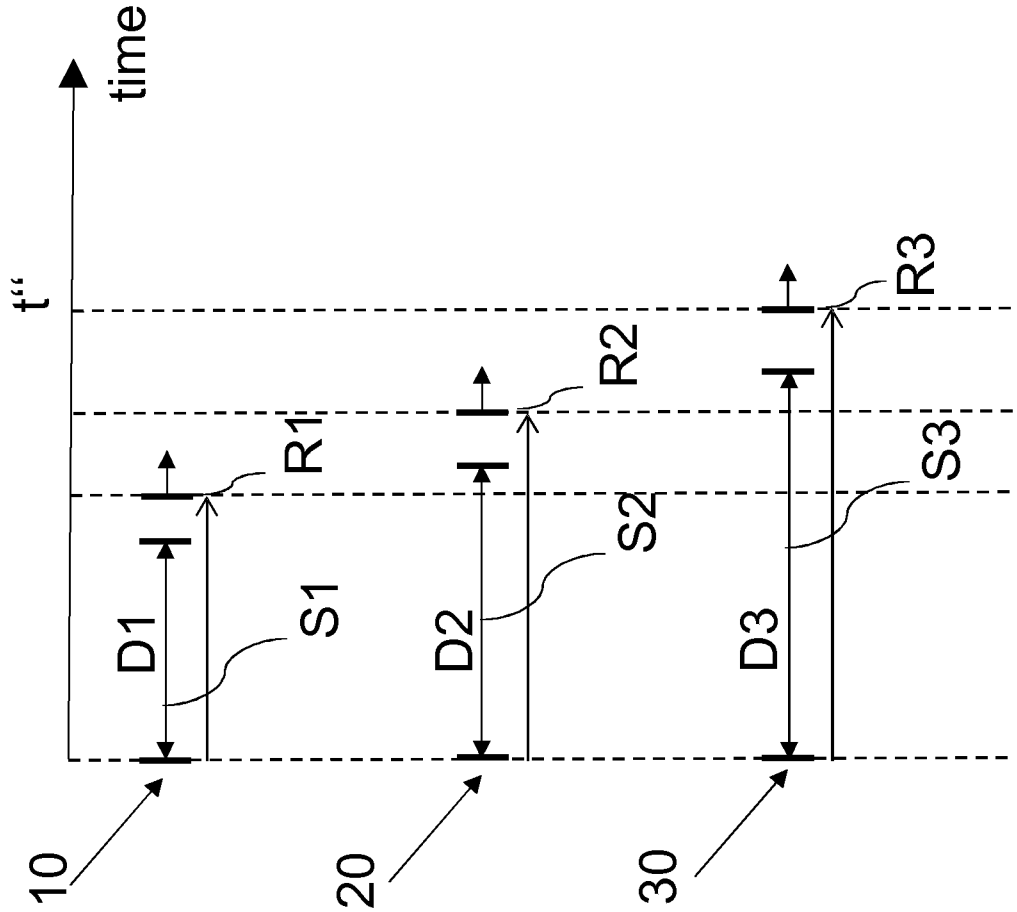

Fig. 2

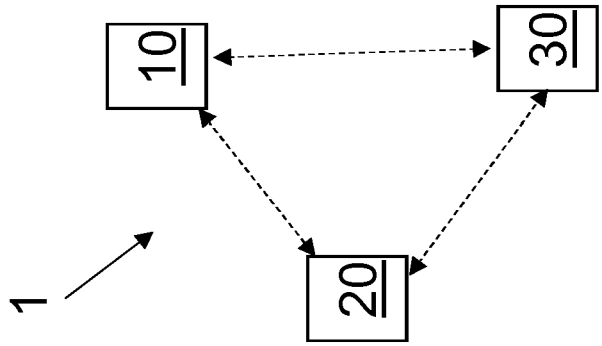

Fig. 1

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EUROPEAN SEARCH REPORT

Application Number
EP 19 15 2531

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2016/183285 A1 (MATSUO RYOKO [JP] ET AL) 23 June 2016 (2016-06-23) * paragraphs [0003], [0004], [0037], [0038] * -----	1-17	INV. H04W74/08 A61B5/00 H04W4/80
A	US 2011/182223 A1 (PATEL MAULIN D [US] ET AL) 28 July 2011 (2011-07-28) * abstract * * paragraphs [0003], [0004], [0007] * -----	1-17	ADD. H04W84/18
A	INES SLAMA ET AL: "A Free Collision and Distributed Slot Assignment Algorithm for Wireless Sensor Networks", 2008 IEEE GLOBAL TELECOMMUNICATIONS CONFERENCE : [IEEE GLOBECOM 2008] ; NEW ORLEANS, LOUISIANA, 30 NOVEMBER 2008 - 04 DECEMBER 2008, IEEE, PISCATAWAY, NJ, USA, 30 November 2008 (2008-11-30), pages 1-6, XP031369761, ISBN: 978-1-4244-2324-8 * abstract * * Sections II, III * -----	1-17	TECHNICAL FIELDS SEARCHED (IPC) H04W A61B
A	YU-SHIANG WONG ET AL: "On Alleviating Starvation in Wireless Sensor Networks", ICC 2011 - 2011 IEEE INTERNATIONAL CONFERENCE ON COMMUNICATIONS - 5-9 JUNE 2011 - KYOTO, JAPAN, IEEE, PISCATAWAY, NJ, USA, 5 June 2011 (2011-06-05), pages 1-5, XP031908921, DOI: 10.1109/ICC.2011.5963194 ISBN: 978-1-61284-232-5 * abstract * * Section II * -----	1-17	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	6 June 2019	Nogueroles Petersen

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 15 2531

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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06-06-2019

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

专利名称(译)	医疗系统的身体通信冲突规避概念		
公开(公告)号	EP3672350A1	公开(公告)日	2020-06-24
申请号	EP2019152531	申请日	2019-01-18
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当前申请(专利权)人(译)	BIOTRONIK SE & CO.KG		
发明人	HUEGERICH, BURKHARD		
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CPC分类号	A61B5/0024 H04W4/80 H04W74/0808 H04W84/18		
优先权	62/780952 2018-12-18 US		
外部链接	Espacenet		

摘要(译)

本公开涉及一种医疗系统（1），包括形成网络节点的多个设备（10、20、30），其中所述多个设备中的每个设备（10、20、30）被配置为与之通信。 通过从网络中的另一设备接收消息或通过向网络中的另一设备发送消息来以无线方式另一设备，并且其中优先级被分配给每个设备（10、20、30），其中只要 在网络中正在进行消息的其他传输，每个设备（10、20、30）被配置为通过传输开始信号（S1，S2，S3）来发起消息的传输，其中各个设备的优先级越高 设备（10、20、30），分配给相应设备（10、20、30）的启动信号（SI，S2，S3）的持续时间（D1，D2，D3）越高，其中，如果有多个设备 在网络中，通过同时发送开始信号，允许发送消息， 会自动授予网络中具有最高优先级的设备。 此外，本公开涉及一种在医疗系统/网络中进行通信的方法。

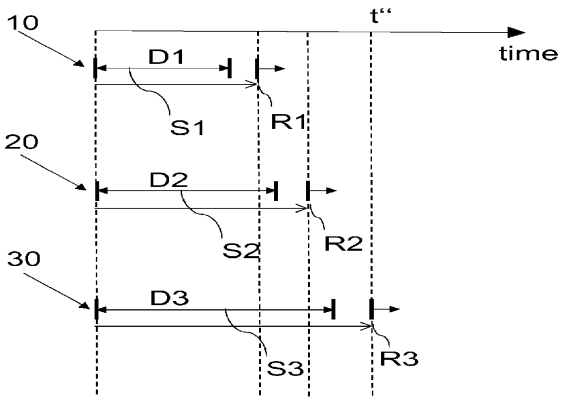

Fig. 2