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(54) **REAL-TIME DATA DISTRIBUTION SYSTEM FOR PATIENT MONITORING DEVICES, CARDIAC DEFIBRILLATORS AND ASSOCIATED INFORMATION DELIVERY SYSTEMS**

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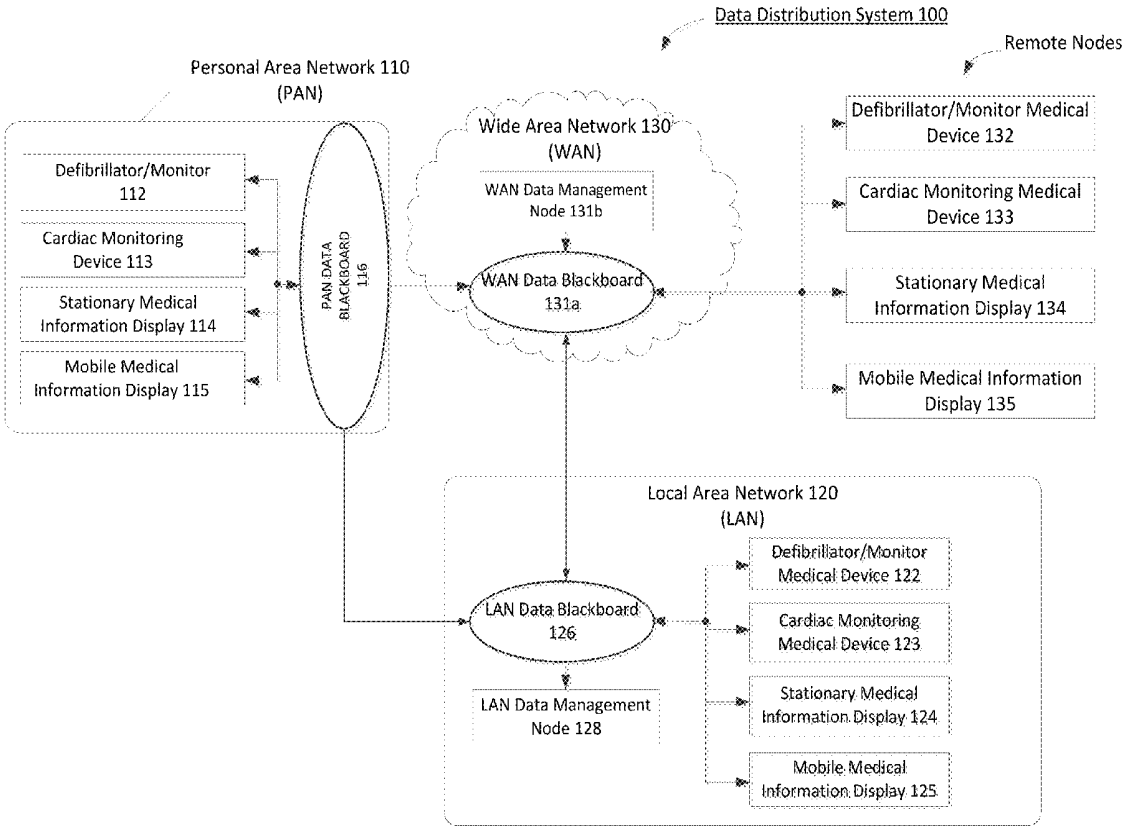
(57) **ABSTRACT**

A data distribution system in comprises software application nodes that utilize a publish-subscribe communication mechanism for distribution of data in real-time or near real-time within a personal area network (PAN), local area network (LAN), or wide-area network (WAN) configuration. The distributed system communication software application nodes reside in medical devices, such as monitoring devices and cardiac defibrillators, and associated patient information delivery systems and patient data management systems comprising medical software installed on servers and end-user computing devices, including mobile devices.



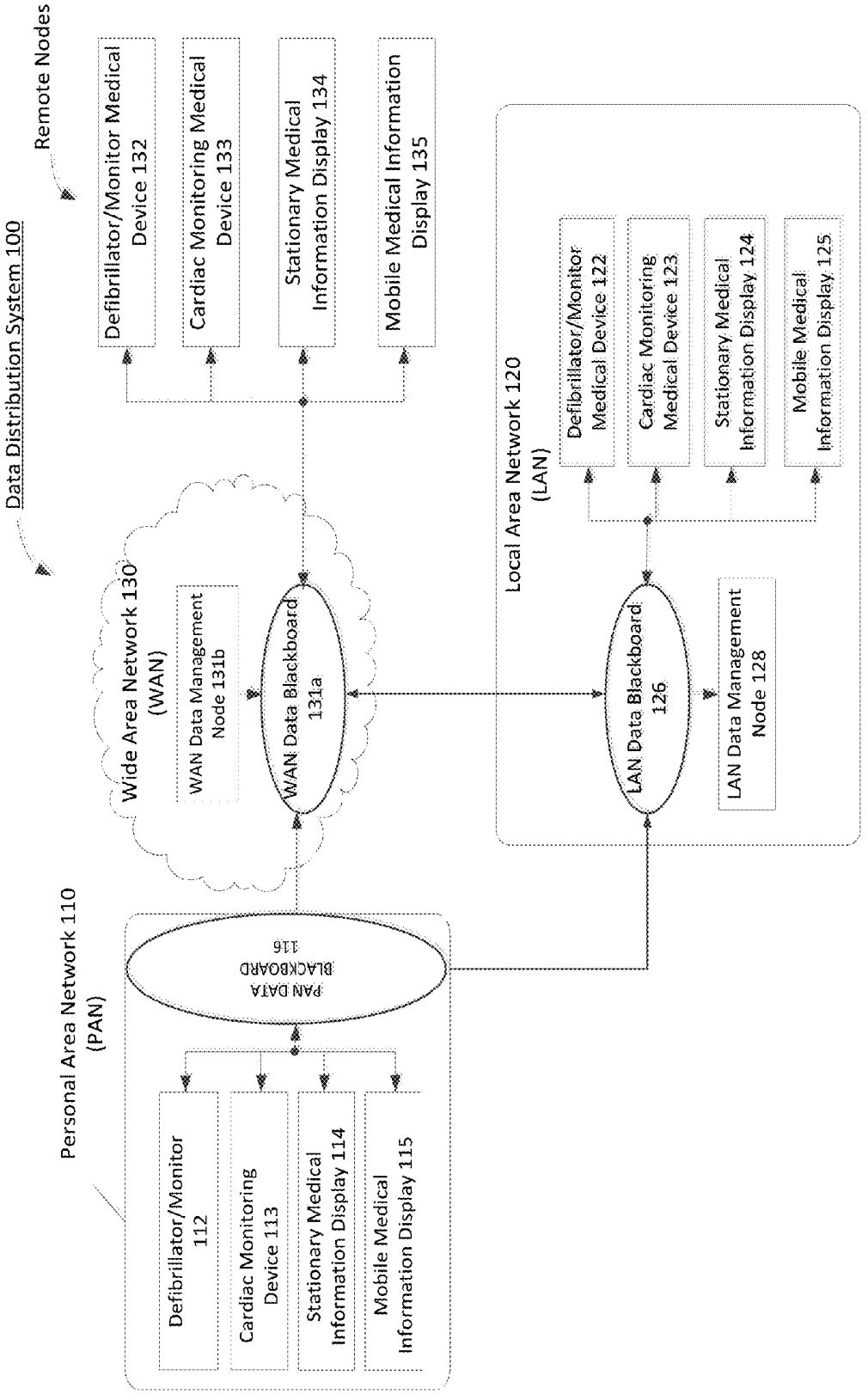

Data Distribution System 100
Remote Nodes
Defibrillator/Monitor Medical Device 132
Cardiac Monitoring Medical Device 133
Stationary Medical Information Display 134
Mobile Medical Information Display 135
Wide Area Network 130 (WAN)
WAN Data Management Node 131b
WAN Data Blackboard 131a
Local Area Network 120 (LAN)
Defibrillator/Monitor Medical Device 122
Cardiac Monitoring Medical Device 123
Stationary Medical Information Display 124
Mobile Medical Information Display 125
LAN Data Blackboard 126
LAN Data Management Node 128
Personal Area Network 110 (PAN)
PAN DATA BLACKBOARD 116
Defibrillator/Monitor 112
Cardiac Monitoring Device 113
Stationary Medical Information Display 114
Mobile Medical Information Display 115

FIGURE 1

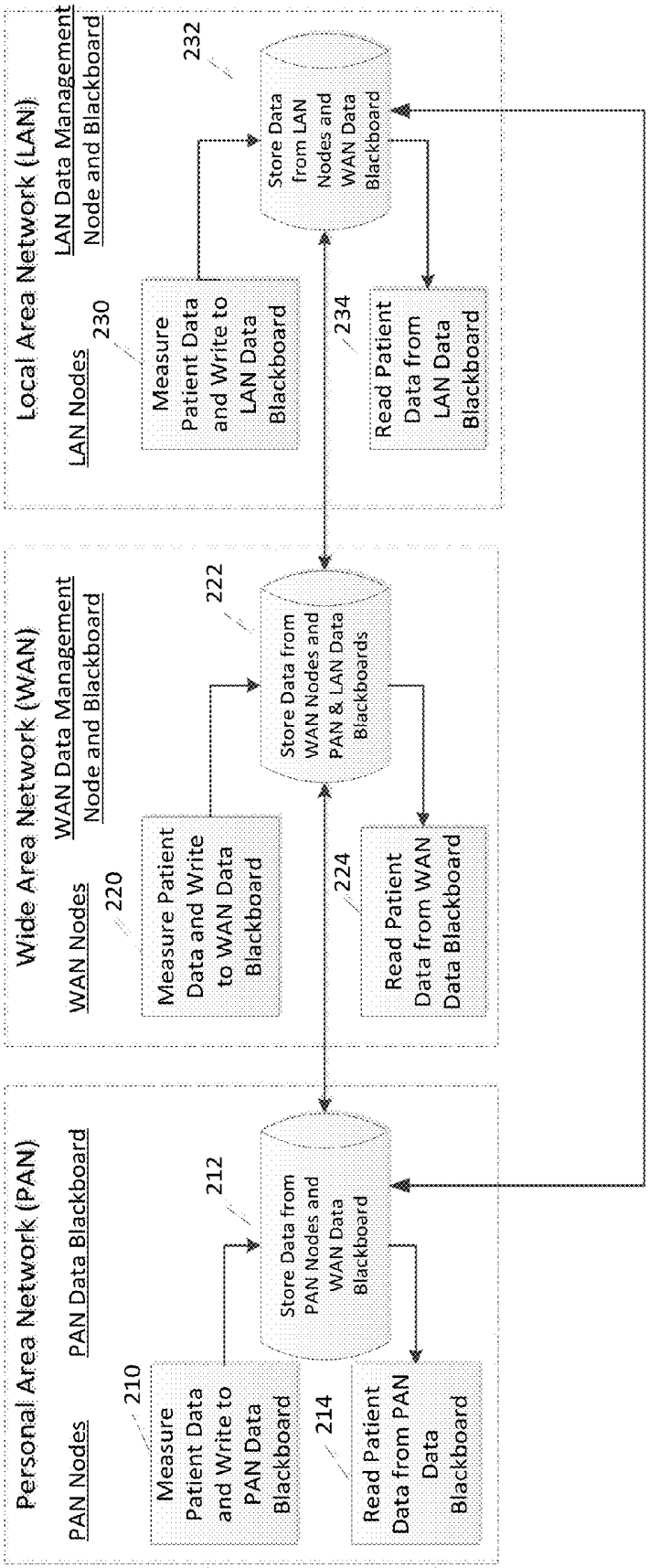

Personal Area Network (PAN)
PAN Nodes
PAN Data Blackboard
210
Measure Patient Data and Write to PAN Data Blackboard
212
Store Data from PAN Nodes and WAN Data Blackboard
214
Read Patient Data from PAN Data Blackboard
Wide Area Network (WAN)
WAN Nodes
WAN Data Management Node and Blackboard
220
Measure Patient Data and Write to WAN Data Blackboard
222
Store Data from WAN Nodes and PAN & LAN Data Blackboards
224
Read Patient Data from WAN Data Blackboard
Local Area Network (LAN)
LAN Nodes
LAN Data Management Node and Blackboard
230
Measure Patient Data and Write to LAN Data Blackboard
232
Store Data from LAN Nodes and WAN Data Blackboard
234
Read Patient Data from LAN Data Blackboard

FIGURE 2

REAL-TIME DATA DISTRIBUTION SYSTEM FOR PATIENT MONITORING DEVICES, CARDIAC DEFIBRILLATORS AND ASSOCIATED INFORMATION DELIVERY SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims benefit under 35 U.S.C. §119(e) of Provisional U.S. patent application No. 61/871,271, filed Aug. 28, 2013, the contents of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates generally to medical devices including defibrillators, and more particularly to a data distribution system configured to distribute patient medical data in real-time or near real-time.

SUMMARY

[0003] A data distribution system in accordance with an illustrative embodiment comprises a personal area network (PAN) comprising a first PAN node and a second PAN node, and a PAN data blackboard, wherein the first PAN node comprises a first medical device configured for monitoring a first patient. In addition, the inventive system may include a wide area network (WAN) comprising a WAN data blackboard coupled to the PAN data blackboard, and a WAN data management node. The PAN data blackboard is configured to provide a data storage space shared among the first and second PAN nodes. In the illustrative embodiment, data blackboards are used in PAN, LAN, and WAN communications, and a separate blackboard is used for each type of communication.

[0004] In the illustrative embodiment, the first PAN node is configured as publisher node, whereby the first PAN node writes data to the PAN data blackboard, and the second PAN node is configured as a subscriber node, whereby the second PAN node reads data from the PAN data blackboard. The data distribution system of the illustrative embodiment also includes a local area network (LAN) comprising a first LAN node, a second LAN node, a LAN data blackboard, and a LAN data management node. As discussed below, a WAN data blackboard may also be used for WAN communications.

[0005] Other features of the illustrative embodiment are described below.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] FIG. **1** is a block diagram of an illustrative embodiment of a data distribution system in accordance with the present invention.

[0007] FIG. **2** is a flowchart of a medical data monitoring and distribution method in accordance with the present invention.

DETAILED DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

[0008] Data Distribution System and Method

[0009] An illustrative embodiment of a data distribution system in accordance with the present invention comprises software application nodes that utilize a publish-subscribe communication mechanism for distribution of data in real-time or near real-time within a personal area network (PAN), local area network (LAN), or wide-area network (WAN) configuration. The distributed system communication software application nodes reside in medical devices, such as monitoring devices and cardiac defibrillators, and associated patient information delivery systems and patient data management systems comprising medical software installed on servers and end-user computing devices, including mobile devices.

[0010] Referring to FIG. **1**, in the illustrative embodiment, the data distribution system **100** may include or employ a personal area network (PAN) **110**, a local area network (LAN) **120**, and/or a wide area network (WAN) **130**. The PAN **110** includes various nodes, including a defibrillator/monitor **112**, a cardiac monitoring device **113**, a stationary medical information display **114**, and a mobile medical information display **115**. It will be understood by those skilled in the art that these are just exemplary medical sensing or display devices, and that a given system may include only a subset of these or all of these plus additional nodes. The nodes are operatively connected to a PAN data blackboard **116**. Each of the various nodes can be configured as a "publisher" or "subscriber" of data (or both), and the PAN data blackboard and the other blackboards (i.e., **126** and **131***a*) provide a data space that can be shared by the connected publisher and subscriber nodes. As used herein, the term "blackboard" refers to a shared memory structure.

[0011] Similarly, the LAN **120** includes various nodes including a defibrillator/monitor medical device **122**, a cardiac monitoring device **123**, a stationary medical information display **124**, and a mobile medical information display **125**. Here again, it will be understood by those skilled in the art that these are just exemplary medical sensing or display devices, and that a given system may include only a subset of these or all of these plus additional nodes. The nodes are operatively connected to a LAN data blackboard **126**, and the LAN data blackboard **126** is connected to a LAN data management node **128**. The LAN data management node **128** (as well as the WAN data management node **133**) is configured to mediate the communication channels, ensuring subscribers have access to published data they are entitled to access, and do not have access to published data they are not entitled to access. The data management nodes may also perform certain processor intensive activities (in other words, data analytics) and long term data storage tasks.

[0012] Finally, referring to FIG. **1**, the WAN **130** includes the WAN data blackboard **13** la and the WAN data management node **131***b*, and is operatively connected to various nodes, e.g., a defibrillator/monitor medical device **132**, a cardiac monitoring device **133**, a stationary medical information display **134**, and a mobile medical information display **135**. It should be noted that the number of subscribers/publishers, including medical device nodes, is limited by the available resource on the particular network configuration. For example, a single PAN may support approximately 5-10 devices depending on wireless capability, bandwidth, memory constraints at each node, processing constraints at each node, etc. On the other hand, a single LAN may support hundreds of devices (concurrently), and a WAN may support thousands of devices (concurrently).

[0013] The overall data distribution system **100** can:

[0014] Be localized to devices connected in an ad-hoc personal area network (PAN).

[0015] Be geographically dispersed via a wide area network (WAN), i.e., by way of wired or wireless connections of nodes over the Internet.

[0016] Be a local area network (LAN) or virtualized local area network (VLAN) of wired or wirelessly connected nodes.

[0017] Comprise various computing hardware and operating systems.

[0018] Enable all nodes to publish information to other nodes and subscribe to information from other nodes.

[0019] Ensure multiple subscriber nodes can receive medical event information that is published just once by another node.

[0020] Medical Data Monitoring and Distribution Method

[0021] FIG. **2** depicts an illustrative embodiment of a medical data monitoring and distribution method in accordance with the present invention. As discussed above, the inventive system operates according to a method in which a first node of a personal area network (PAN) is used to monitor a first patient and write medical data to a PAN data blackboard. A second PAN node, which may be contained within in a second medical device, reads data from the PAN data blackboard. Moreover, as discussed, the PAN data blackboard may be coupled to a WAN data blackboard, which may in turn be coupled to a remote LAN data blackboard, and both the WAN and LAN data blackboards may be coupled to respective medical devices and nodes.

[0022] As shown in FIG. **2**, in a PAN, a first PAN node measures patient data and writes this data to the PAN data blackboard (step **210**). The PAN data blackboard stores the data and may also store selected data from the WAN data blackboard (step **212**); and a second LAN node reads selected data from the PAN data blackboard (step **214**).

[0023] Similarly, in a WAN, a first WAN node measures patient data and writes this data to the WAN data blackboard (step **220**), and the WAN data blackboard stores the data and may also store selected data from the PAN and LAN data blackboards (step **222**). A second WAN node may be deployed to read selected data from the WAN data blackboard (step **224**).

[0024] Finally, in the LAN (far right box of FIG. **2**), a first LAN node measures patient data and writes this data to the LAN data blackboard (step **230**). The LAN data blackboard stores the data and may also store selected data from the WAN data blackboard (step **232**); and a second LAN node reads selected data from the LAN data blackboard (step **234**).

[0025] Further Details of Illustrative Uses

[0026] The inventive data distribution system and method may be used to:

[0027] Distribute medical event information between local and remote nodes in the data distribution system. Such medical event information can include data, audio and video streams, and consumable electronic object formats.

[0028] Distribute information for shared viewing of information that is continuously updated (i.e., in "real-time" or by "live streaming") on one or more subscribing nodes when changed on the publisher node. For example, an ECG lead sensor reading may be distributed every 0.25 ms, or updated on a discrete interval, or may be considered a "batch" mode operation where information is bundled periodically on a publisher node and broadcast to subscriber nodes. For example, a sync timer may be used, or an intermittent event; for example, a lead placement indicator may be used.

[0029] Distribute software and configuration updates within the data distribution system.

[0030] Distribute commands between local and remote nodes in the data distribution system. A distributed command is an instruction by one node to one or more other nodes to perform an action. An example is a command to start a timer, silence an alarm, etc.

[0031] Conduct remote diagnostics of equipment.

[0032] Distribute algorithms for processing ("analytics") across nodes of the data distribution system.

[0033] Data Blackboard (see elements **116**, **126**, and **131***a* in FIG. **1**)—a data space shared among connected publisher and subscriber nodes to enable publication (write) and subscription (read).

[0034] Node (see elements **112-115**, **122-125**, and **132-135** of FIG. **1**)—each node is a publisher/subscriber of a Data Blackboard. Node Types may include Information Management System, Defibrillator/Monitor, Monitoring Device, Stationary Medical Information Display, Mobile Medical Information Display.

[0035] PAN Data Distribution System: nodes dynamically form a wireless personal area network based on close proximity (e.g., patient home, military battle field, movie theater) sharing a Data Blackboard for point-to-point publish-subscribe communication within the PAN. Many PAN instances may exist concurrently.

[0036] LAN Data Distribution System: wired and wireless nodes participate in a local area network. Wireless nodes join the network via one or more network access points. LAN nodes participate in publish-subscribe communication using LAN network infrastructure. LANs are created for organizational entities such as a patient care facility (e.g., Hospital, Emergency Room), or patient care organization (e.g., Hospital Network)

[0037] WAN Data Distribution System: Servers residing in data centers enable publishers and subscribers to span a broader geographic spectrum than a PAN or LAN. The WAN servers bridge the communication between PAN and LAN nodes, as well as publish-subscribe nodes connected directly.

[0038] Each Data Blackboard selectively synchronizes data with other Data Blackboards, thereby enabling communication with nodes connected to another bus. The Data Management Nodes mediate the communication channels, ensuring subscribers have access to published data they are entitled to access, and do not have access to published data they are not entitle to access. The Data Management Nodes may also offload processor intensive activities and long term data storage requirements from other Data Distribution System nodes.

[0039] Further Illustrative Details of How it Works

Node Capability:

[0040] Each node in the distributed system has the capability to both publish (provide data) and subscribe (consume data). The communication nodes participate in the distributed system as either publishers, or subscribers, or both.

[0041] A subscriber may perform content filtering on published streams. In other words, a subscriber can be

selective regarding what it receives from a publisher. In other words, a publisher may publish more than the subscriber receives.

Data Types:

[0042] Each node publishes and\or subscribes to a data channel for exchange of discrete data, audio and video streams, and binary objects.

Data Sources:

[0043] The data source for publication may be bio-sensors, medical information systems, externally connected medical device accessories, user entered information, and/or the results from algorithms/processor intensive activities/data summarization of a node.

Communication Channel Types:

[0044] Distributed system nodes may communicate in the data distribution system via wired network connection or wireless network connection. Wireless network connections include Wi-Fi™, Wi-Fi Direct™ and Bluetooth® Standard, Bluetooth® PAN, and Cellular.

Communication Channel Middleware:

[0045] The data distribution system may include messaging middleware that enables the publishers and subscribers to function autonomously (i.e., "decoupled").

Communication Protocol and Data Format Standards

[0046] The Data Distribution System may implement a standard messaging protocol for publish-subscribe communications such as Message Queuing for Telemetry Transport (MQTT) or Advanced Message Queuing Protocol.

[0047] The Data Distribution System may alternatively comprise shared data spaces, which also decouples publishers and subscribers. A standard protocol for distributed data communication using shared data spaces is the Object Management Group Data-Distribution Service for Real-Time Systems (DDS).

[0048] Other standard protocols for communication are UDP and TCP/IP

[0049] Data payload may employ data format and\or semantics as defined by the following standards: IEEE 11073, HL7, IHE Domains such as Infrastructure, PCD, and the IHE CDA\CCD, and NEMSIS XML.

Communication Attributes:

[0050] Published data is persistent; a "late" subscriber may obtain published data for a defined interval following its publication.

[0051] Publication is reliable; a publisher will postpone publication until a lost connection is restored or an unavailable connection becomes available.

[0052] The publication is auto-scaled (also "auto-adjusted) based on available bandwidth, thereby reducing or increasing the amount or frequency of data, or selectively eliminating lower-priority data to give bandwidth for higher priority data.

[0053] The publication/subscription capability on each node minimizes bandwidth requirement and battery consumption, thereby allowing interconnected mobile battery powered nodes.

[0054] Publication may be multi-cast (many publishers, many subscribers) or unicast (one publisher, one subscriber).

Communication Isolation

[0055] The Data Distribution System enforces constraints necessarily to ensure data privacy and to enable nodes to operate within resource limitations (memory, storage, battery, etc.); publishers are necessarily constrained by where to publish, when to publish, and what to publish. Subscribers are constrained by which publications they have access to, when they receive the publication, and how much they can receive due to limited subscriber resources (memory, storage, battery, etc.).

Communication Sustainability across Networks

[0056] Distributed system nodes may participate in publish-subscribe communications over several network interfaces concurrently or serially.

[0057] The data distribution system enables a bridge for communications across network interfaces, allowing publishers and subscribers to reside on separate networks.

[0058] Distributed system nodes including publishers and subscribers may switch network connections, allowing a subscriber to continue to receive data from a publisher after the switchover.

[0059] Distributed system nodes may implement a priority scheme to expedite a connection switch based on connection speed, connection strength, or service discovery\accessibility.

[0060] Conclusion

[0061] One skilled in the art will appreciate that the present teachings can be practiced with embodiments other than those disclosed above. The disclosed embodiments are presented for purposes of illustration and not limitation. The scope of protection of the following claims is limited only by the claims themselves and not by the above description.

We claim:

1. A data distribution system, comprising:

a personal area network (PAN) (**110**) comprising a first PAN node (**112**) and a second PAN node (**113**), and a PAN data blackboard (**116**) coupled to the first and second PAN nodes, wherein the first PAN node comprises a first medical device configured for monitoring a first patient;

wherein the PAN data blackboard is configured to provide a data storage space shared among the first and second PAN nodes.

2. The data distribution system recited in claim **1**, further comprising a wide area network (WAN) (**130**) comprising a WAN data blackboard (**131***a*) coupled to the PAN data blackboard, and a WAN data management node (**133**) coupled to the WAN data blackboard; and wherein the first PAN node is configured as publisher node, whereby the first PAN node writes data to the PAN data blackboard; and the second PAN node is configured as a subscriber node, whereby the second PAN node reads data from the PAN data blackboard.

3. The data distribution system recited in claim **2**, further comprising a local area network (LAN) (**120**), the LAN comprising:

a first LAN node (**122**);

a second LAN node (**123**);

a LAN data blackboard (**126**) coupled to the first and second LAN nodes and to the WAN data blackboard (via Bridge); and

a LAN data management node (**128**) coupled to the LAN data blackboard.

4. The data distribution system recited in claim **3**, wherein the first LAN node comprises a second medical device configured for monitoring a second patient and providing measured patient data to the LAN data blackboard; wherein the LAN data blackboard is configured to provide a data storage space shared among the first and second LAN nodes; wherein the first LAN node is configured as publisher node, whereby the first LAN node writes data to the LAN data blackboard; and wherein the second LAN node is configured as a subscriber node, whereby the second LAN node reads data from the LAN data blackboard.

5. The data distribution system recited in claim **4**, further comprising a first WAN node (**132**) and a second WAN node (**134**, **135**).

6. The data distribution system recited in claim **5**, wherein the WAN data blackboard is configured to provide a data storage space shared among the first and second WAN nodes;

wherein the first WAN node is configured as publisher node, whereby the first WAN node writes data to the WAN data blackboard; and wherein the second WAN node is configured as a subscriber node, whereby the second WAN node reads data from the WAN data blackboard.

7. The data distribution system recited in claim **6**, wherein the first PAN node comprises a first software application node residing in the first medical device, and the second PAN node comprises a second software application node residing in the second medical device.

8. The data distribution system recited in claim **7**, wherein the first LAN node comprises a third software application node residing in a third medical device, and the second PAN node comprises a forth software application node residing in fourth medical device.

9. The data distribution system recited in claim **8**, wherein the first WAN node comprises a fifth software application node residing in a fifth medical device configured for monitoring a third patient, and wherein the second WAN node comprises a sixth software application node residing in a display device.

10. The data distribution system recited in claim **9**, wherein at least one of the first, second, third, fourth, or fifth medical devices is a cardiac defibrillator or cardiac monitoring device.

11. A medical data monitoring and distribution method, comprising:

in a personal area network (PAN) comprising a first PAN node within a first medical device and a second PAN node in a second medical device, and a PAN data blackboard, employing the first PAN node and first medical device to monitor a first patient and to write medical data concerning the first patient to the PAN data blackboard; and

in a wide area network (WAN) comprising a WAN data blackboard coupled to the PAN data blackboard, using the WAN data blackboard to read said data concerning the first patient from the PAN data blackboard.

12. The medical data monitoring and distribution method recited in claim **11**, wherein the first PAN node writes data to the PAN data blackboard; and the second PAN node reads data from the PAN data blackboard.

13. The medical data monitoring and distribution method recited in claim **12**, further comprising coupling a local area network (LAN) to the WAN, wherein the LAN comprises a first LAN node, a second LAN node, a LAN data blackboard, and a LAN data management node.

14. The medical data monitoring and distribution method recited in claim **13**, wherein the first LAN node comprises a second medical device configured for monitoring a second patient and providing measured patient data to the LAN data blackboard; wherein the first LAN node writes data to the LAN data blackboard; and wherein the second LAN node reads data from the LAN data blackboard.

15. The medical data monitoring and distribution method recited in claim **14**, further comprising coupling a first WAN node and a second WAN node to the WAN data blackboard.

16. The medical data monitoring and distribution method recited in claim **15**, wherein the WAN data blackboard is configured to provide a data storage space shared among the first and second WAN nodes; wherein the first WAN node writes data to the WAN data blackboard; and

wherein the second WAN node reads data from the WAN data blackboard.

17. The medical data monitoring and distribution method recited in claim **16**, wherein the first PAN node comprises a first software application node residing in the first medical device, and the second PAN node comprises a second software application node residing in the second medical device.

18. The medical data monitoring and distribution method recited in claim **17**, wherein the first LAN node comprises a third software application node residing in a third medical device, and the second PAN node comprises a forth software application node residing in fourth medical device.

19. The medical data monitoring and distribution method recited in claim **18**, wherein the first WAN node comprises a fifth software application node residing in a fifth medical device configured for monitoring a third patient, and wherein the second WAN node comprises a sixth software application node residing in a display device.

20. The medical data monitoring and distribution method recited in claim **19**, wherein at least one of the first, second, third, fourth, or fifth medical devices is a cardiac defibrillator or cardiac monitoring device.

* * * * *

专利名称(译)	用于患者监测设备，心脏除颤器和相关信息传递系统的实时数据分布系统		
公开(公告)号	US20150067021A1	公开(公告)日	2015-03-05
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申请(专利权)人(译)	生理控制，INC.		
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优先权	61/871271 2013-08-28 US		
其他公开文献	US10257287		
外部链接	Espacenet USPTO		

摘要(译)

一种数据分发系统，包括软件应用节点，其利用发布 - 订阅通信机制在个人区域网（PAN），局域网（LAN）或广域内实时或接近实时地分发数据。网络（WAN）配置。分布式系统通信软件应用节点驻留在医疗设备中，例如监视设备和心脏除颤器，以及相关的患者信息传递系统和患者数据管理系统，其包括安装在服务器和终端用户计算设备（包括移动设备）上的医疗软件。