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(54) WIRELESS DATA COMMUNICATION FOR A MEDICAL DEVICE NETWORK THAT SUPPORTS A PLURALITY OF DATA COMMUNICATION MODES

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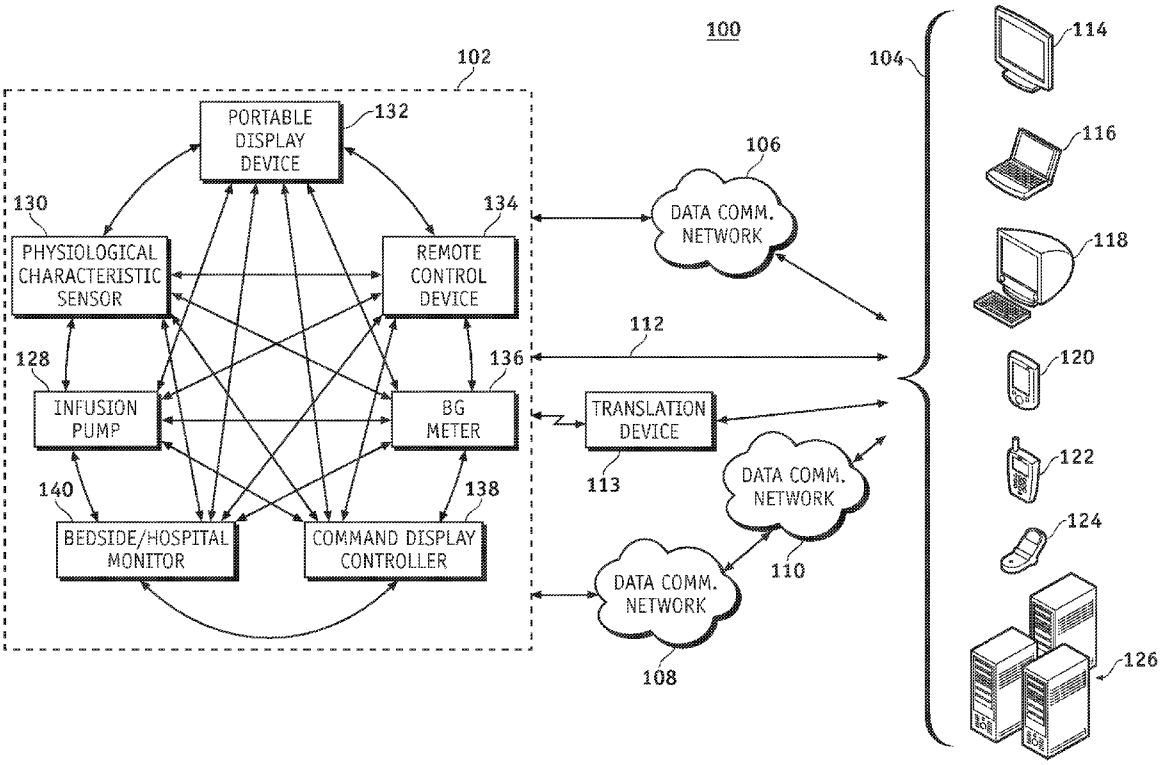
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G08B 1/08 (2006.01)

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(57) **ABSTRACT**

A fluid infusion system as described herein includes a number of local "body network" devices, such as an infusion pump, a handheld monitor or controller, a physiological sensor, and a bedside or hospital monitor. The body network devices can be configured to support communication of status data, physiological information, alerts, control signals, and other information between one another. In addition, the body network devices can be configured to support networked communication of status data, physiological information, alerts, control signals, and other information between the body network devices and "external" devices, systems, or communication networks. The networked medical devices are configured to support a variety of wireless data communication protocols for efficient communication of data within the medical device network. In addition, the wireless medical devices may be configured to support a number of dynamically adjustable wireless data communication modes to react to current operating conditions, application-specific data content, or other criteria.



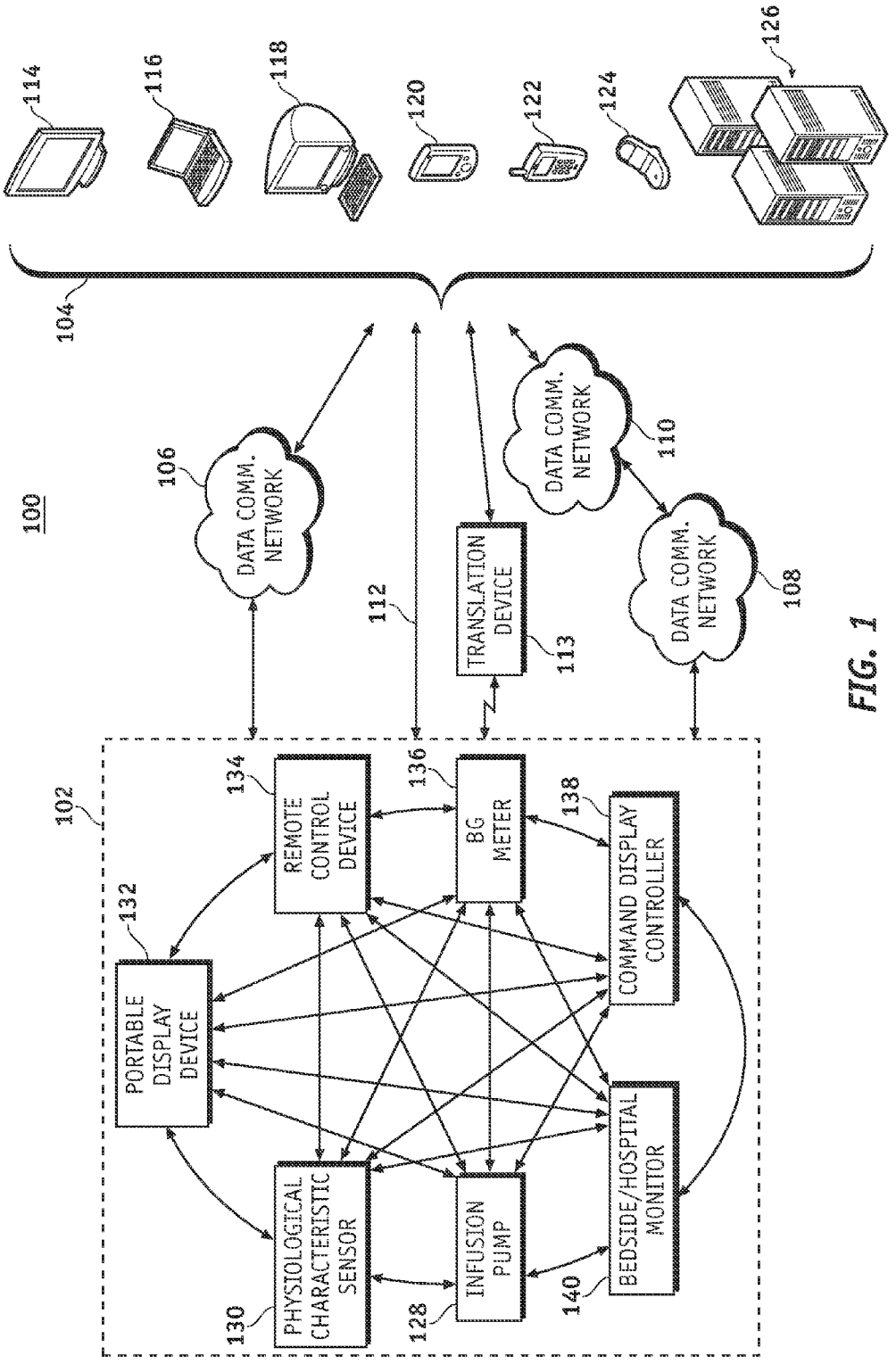

100
102
104
106
DATA COMM. NETWORK
108
DATA COMM. NETWORK
110
DATA COMM. NETWORK
112
113
TRANSLATION DEVICE
114
116
118
120
122
124
126
128
130
PHYSIOLOGICAL CHARACTERISTIC SENSOR
132
PORTABLE DISPLAY DEVICE
134
REMOTE CONTROL DEVICE
136
BG METER
138
COMMAND DISPLAY CONTROLLER
140
BEDSIDE/HOSPITAL MONITOR
INFUSION PUMP

FIG. 1

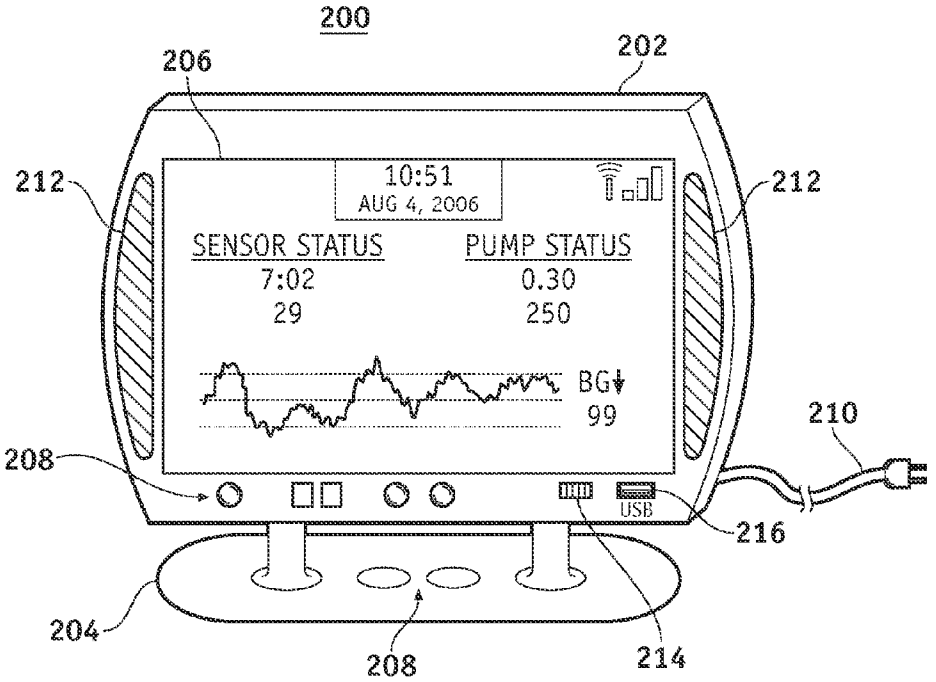

200
206
202
212
212
10:51
AUG 4, 2006
SENSOR STATUS
PUMP STATUS
7:02
0.30
29
250
BG
99
210
208
USB
216
204
208
214

FIG. 2

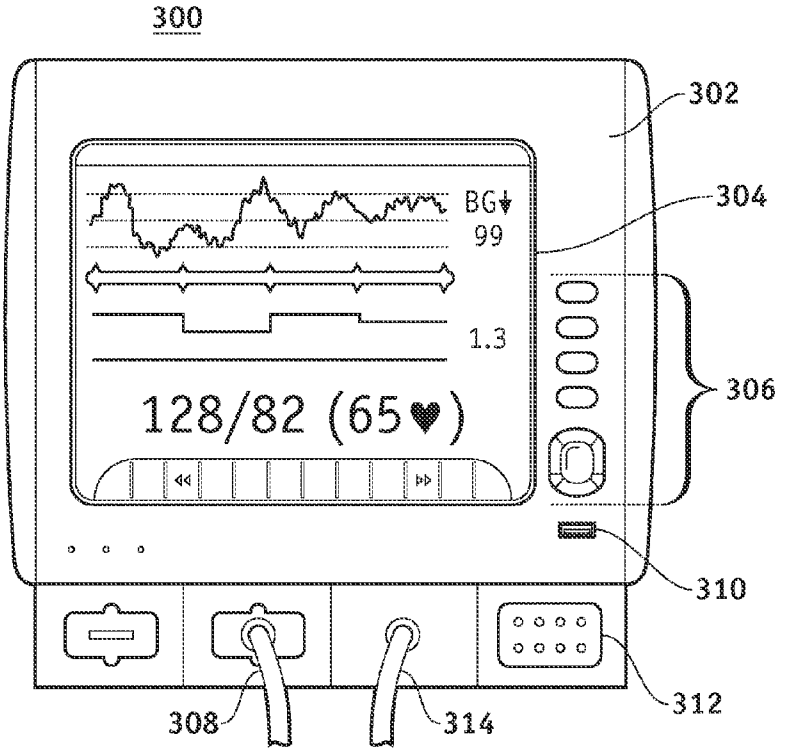

300
302
304
BG
99
1.3
128/82 (65♥)
306
310
308
314
312

FIG. 3

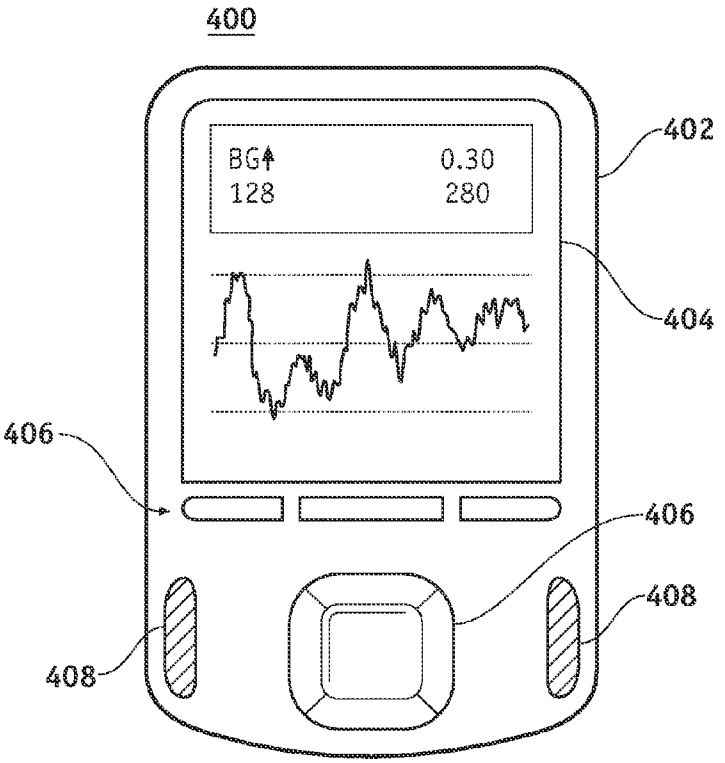

400
BG↑ 0.30
128 280
402
404
406
406
408
408

FIG. 4A

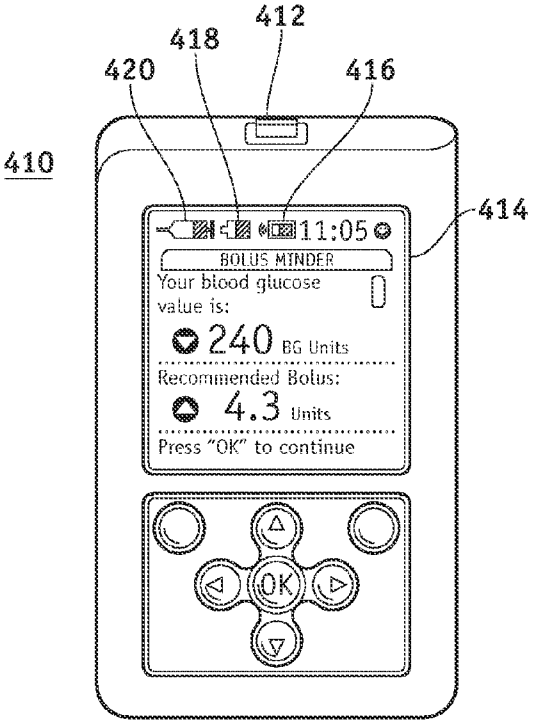

412
418
420
416
410
414
11:05
BOLUS MINDER
Your blood glucose value is:
240 BG Units
Recommended Bolus:
4.3 Units
Press "OK" to continue
OK

FIG. 4B

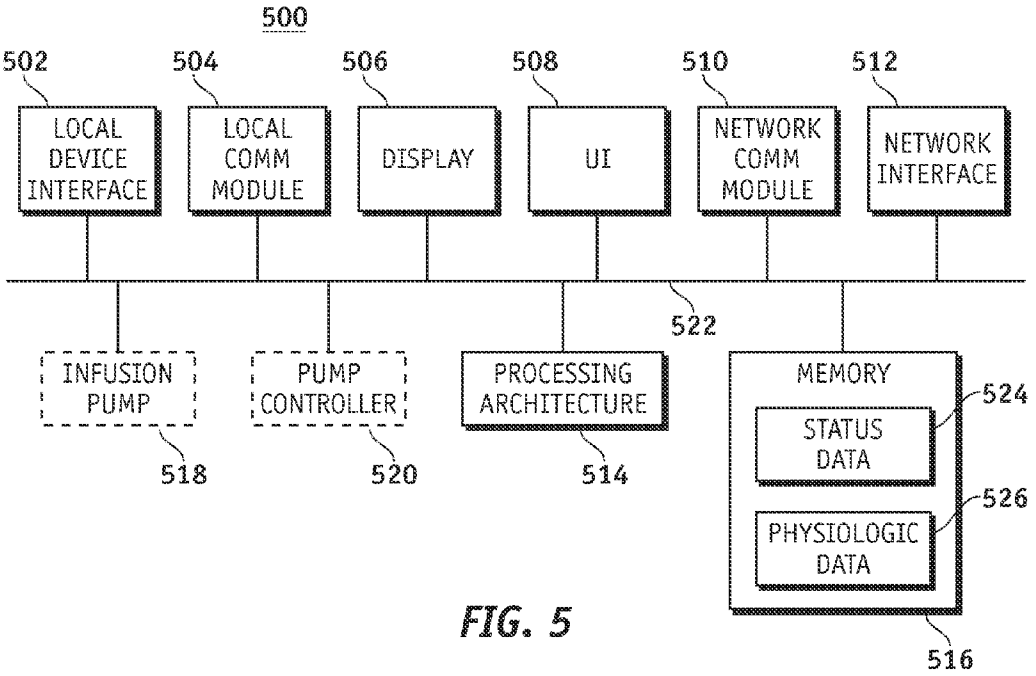

500
502
LOCAL DEVICE INTERFACE
504
LOCAL COMM MODULE
506
DISPLAY
508
UI
510
NETWORK COMM MODULE
512
NETWORK INTERFACE
522
INFUSION PUMP
518
PUMP CONTROLLER
520
PROCESSING ARCHITECTURE
514
MEMORY
524
STATUS DATA
526
PHYSIOLOGIC DATA
516

FIG. 5

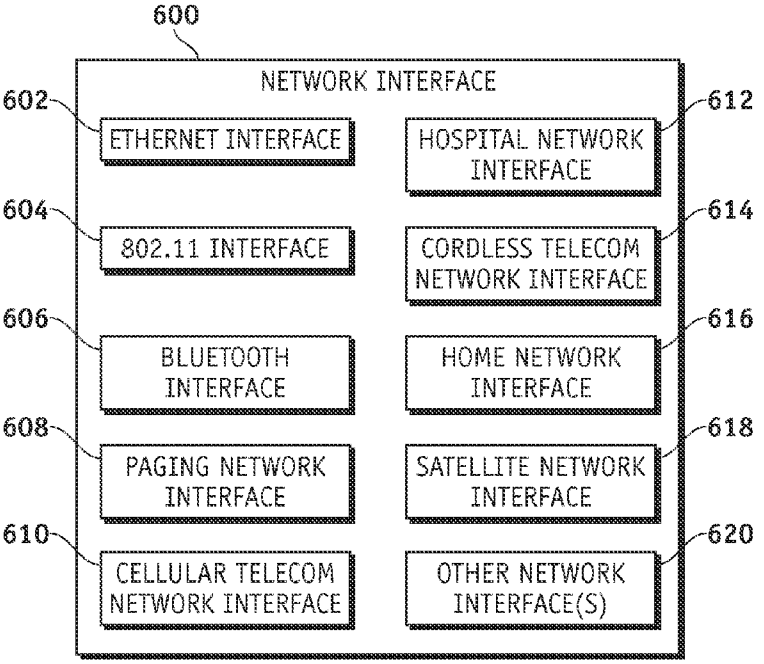

600
NETWORK INTERFACE
602
ETHERNET INTERFACE
604
802.11 INTERFACE
606
BLUETOOTH INTERFACE
608
PAGING NETWORK INTERFACE
610
CELLULAR TELECOM NETWORK INTERFACE
612
HOSPITAL NETWORK INTERFACE
614
CORDLESS TELECOM NETWORK INTERFACE
616
HOME NETWORK INTERFACE
618
SATELLITE NETWORK INTERFACE
620
OTHER NETWORK INTERFACE(S)

FIG. 6

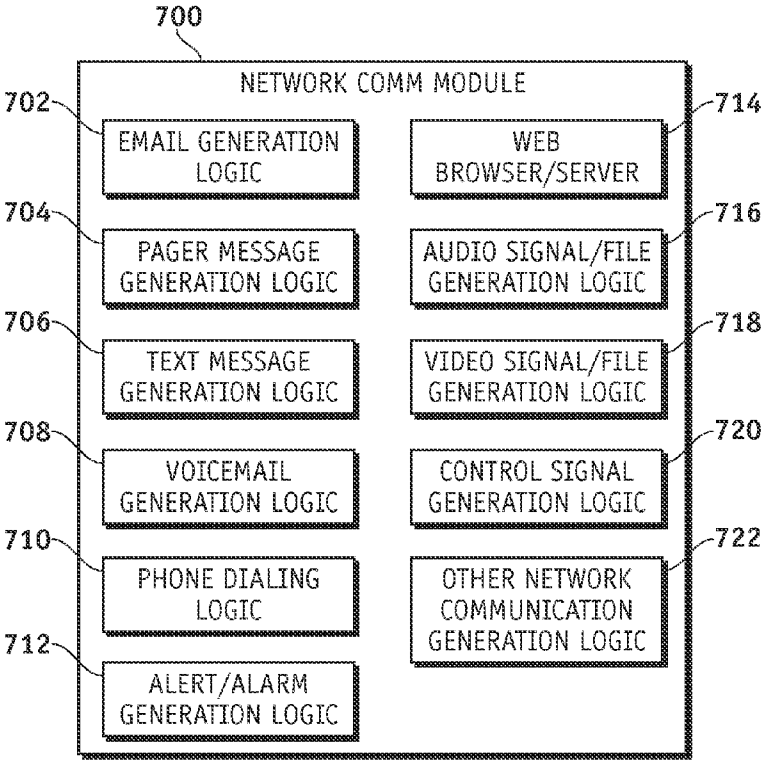

700
NETWORK COMM MODULE
702
EMAIL GENERATION LOGIC
704
PAGER MESSAGE GENERATION LOGIC
706
TEXT MESSAGE GENERATION LOGIC
708
VOICEMAIL GENERATION LOGIC
710
PHONE DIALING LOGIC
712
ALERT/ALARM GENERATION LOGIC
714
WEB BROWSER/SERVER
716
AUDIO SIGNAL/FILE GENERATION LOGIC
718
VIDEO SIGNAL/FILE GENERATION LOGIC
720
CONTROL SIGNAL GENERATION LOGIC
722
OTHER NETWORK COMMUNICATION GENERATION LOGIC

FIG. 7

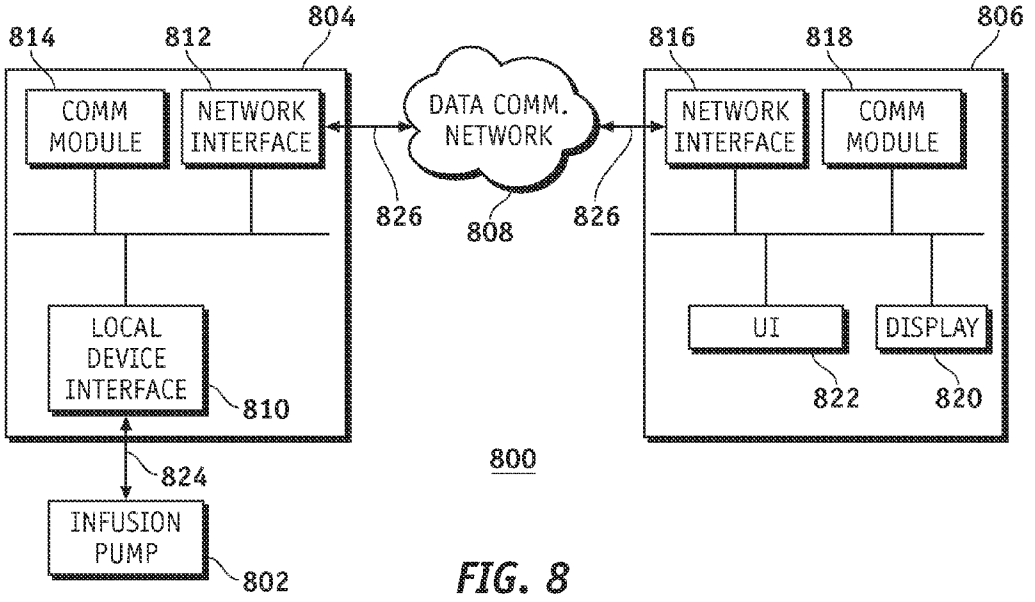

814
812
804
COMM MODULE
NETWORK INTERFACE
LOCAL DEVICE INTERFACE
810
824
INFUSION PUMP
802
DATA COMM. NETWORK
826
808
826
816
818
806
NETWORK INTERFACE
COMM MODULE
UI
DISPLAY
822
820
800

FIG. 8

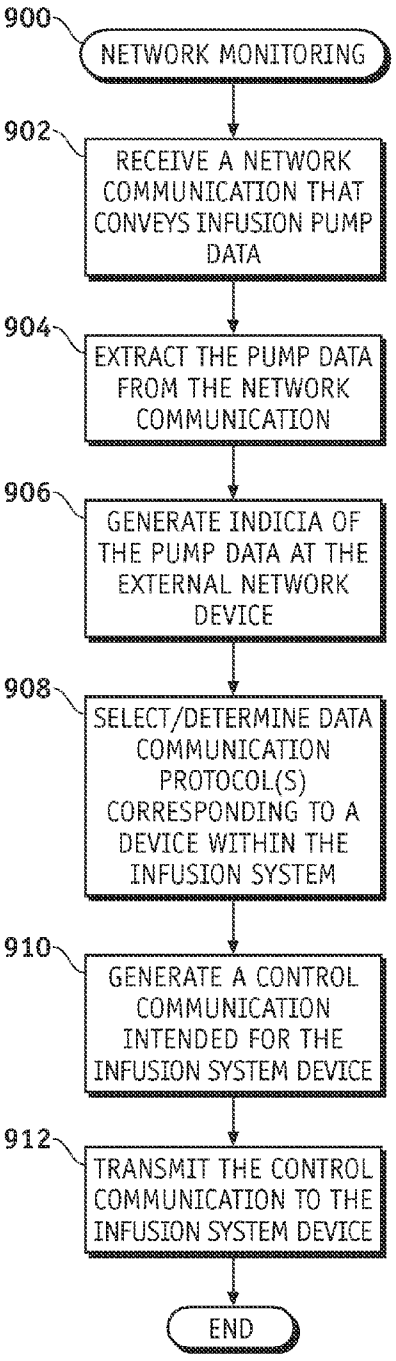

900
NETWORK MONITORING
902
RECEIVE A NETWORK COMMUNICATION THAT CONVEYS INFUSION PUMP DATA
904
EXTRACT THE PUMP DATA FROM THE NETWORK COMMUNICATION
906
GENERATE INDICIA OF THE PUMP DATA AT THE EXTERNAL NETWORK DEVICE
908
SELECT/DETERMINE DATA COMMUNICATION PROTOCOL(S) CORRESPONDING TO A DEVICE WITHIN THE INFUSION SYSTEM
910
GENERATE A CONTROL COMMUNICATION INTENDED FOR THE INFUSION SYSTEM DEVICE
912
TRANSMIT THE CONTROL COMMUNICATION TO THE INFUSION SYSTEM DEVICE
END

FIG. 9

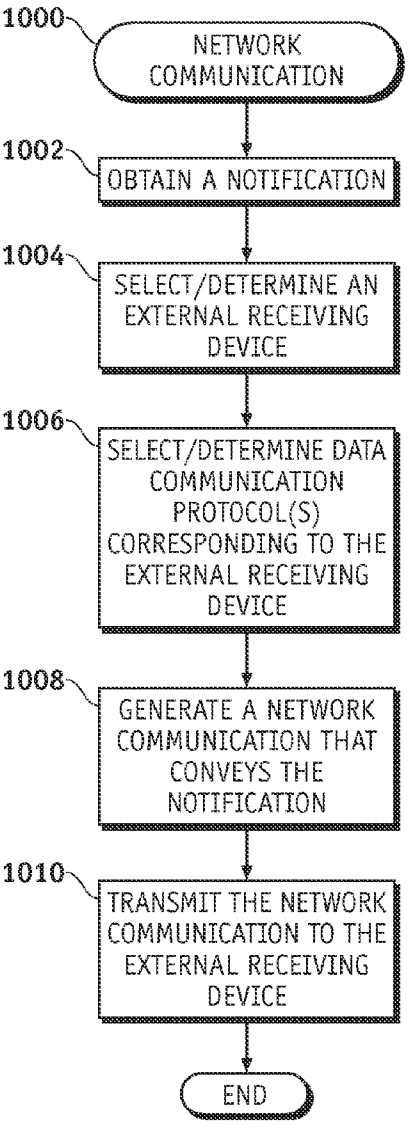

1000
NETWORK COMMUNICATION
1002
OBTAIN A NOTIFICATION
1004
SELECT/DETERMINE AN EXTERNAL RECEIVING DEVICE
1006
SELECT/DETERMINE DATA COMMUNICATION PROTOCOL(S) CORRESPONDING TO THE EXTERNAL RECEIVING DEVICE
1008
GENERATE A NETWORK COMMUNICATION THAT CONVEYS THE NOTIFICATION
1010
TRANSMIT THE NETWORK COMMUNICATION TO THE EXTERNAL RECEIVING DEVICE
END

FIG. 10

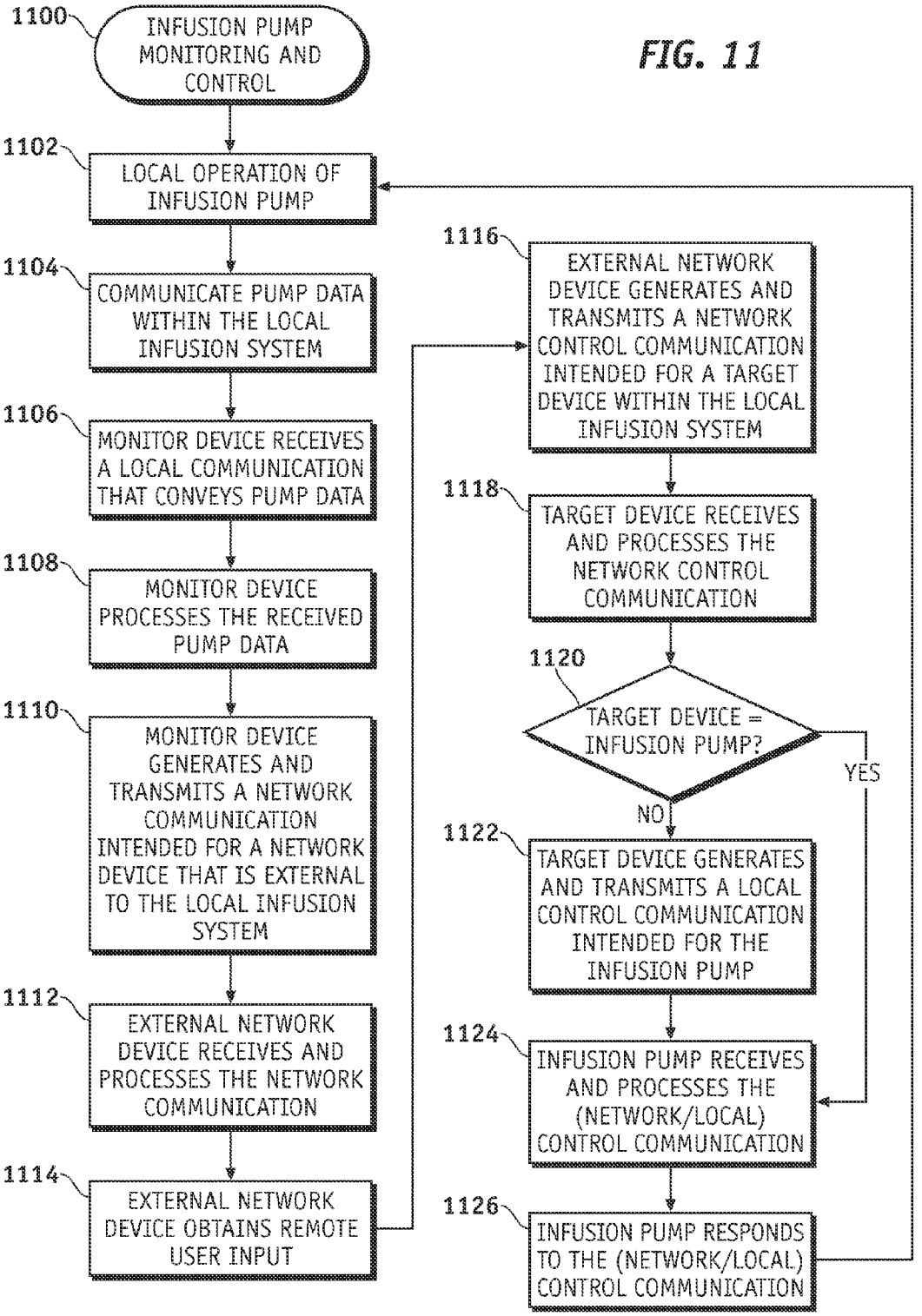

1100
INFUSION PUMP MONITORING AND CONTROL
1102
LOCAL OPERATION OF INFUSION PUMP
1104
COMMUNICATE PUMP DATA WITHIN THE LOCAL INFUSION SYSTEM
1106
MONITOR DEVICE RECEIVES A LOCAL COMMUNICATION THAT CONVEYS PUMP DATA
1108
MONITOR DEVICE PROCESSES THE RECEIVED PUMP DATA
1110
MONITOR DEVICE GENERATES AND TRANSMITS A NETWORK COMMUNICATION INTENDED FOR A NETWORK DEVICE THAT IS EXTERNAL TO THE LOCAL INFUSION SYSTEM
1112
EXTERNAL NETWORK DEVICE RECEIVES AND PROCESSES THE NETWORK COMMUNICATION
1114
EXTERNAL NETWORK DEVICE OBTAINS REMOTE USER INPUT
1116
EXTERNAL NETWORK DEVICE GENERATES AND TRANSMITS A NETWORK CONTROL COMMUNICATION INTENDED FOR A TARGET DEVICE WITHIN THE LOCAL INFUSION SYSTEM
1118
TARGET DEVICE RECEIVES AND PROCESSES THE NETWORK CONTROL COMMUNICATION
1120
TARGET DEVICE = INFUSION PUMP?
YES
NO
1122
TARGET DEVICE GENERATES AND TRANSMITS A LOCAL CONTROL COMMUNICATION INTENDED FOR THE INFUSION PUMP
1124
INFUSION PUMP RECEIVES AND PROCESSES THE (NETWORK/LOCAL) CONTROL COMMUNICATION
1126
INFUSION PUMP RESPONDS TO THE (NETWORK/LOCAL) CONTROL COMMUNICATION

FIG. 11

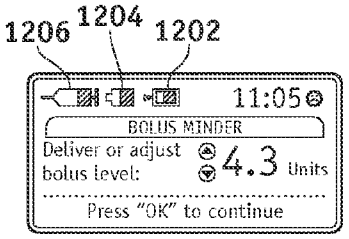


FIG. 12

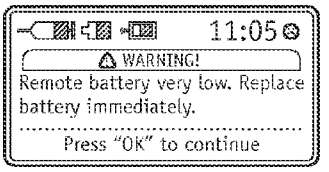


FIG. 13

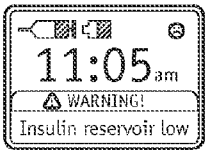


FIG. 14

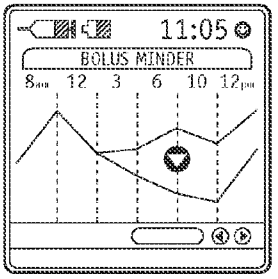


FIG. 15

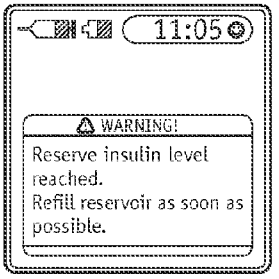


FIG. 16

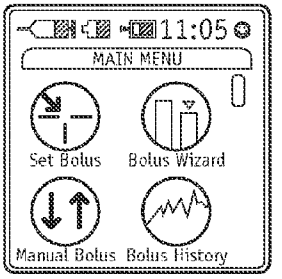


FIG. 17

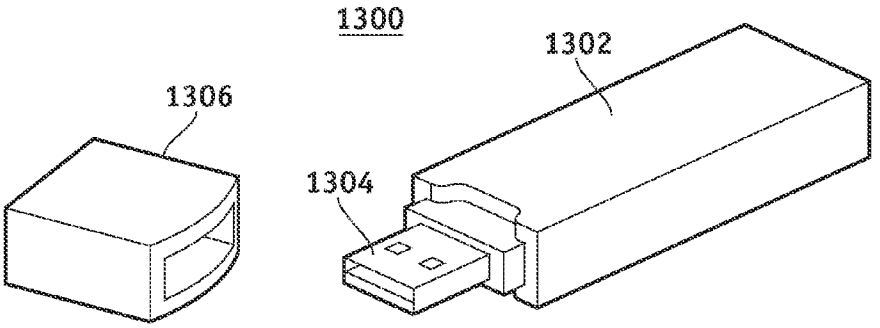

1300
1302
1306
1304

FIG. 18

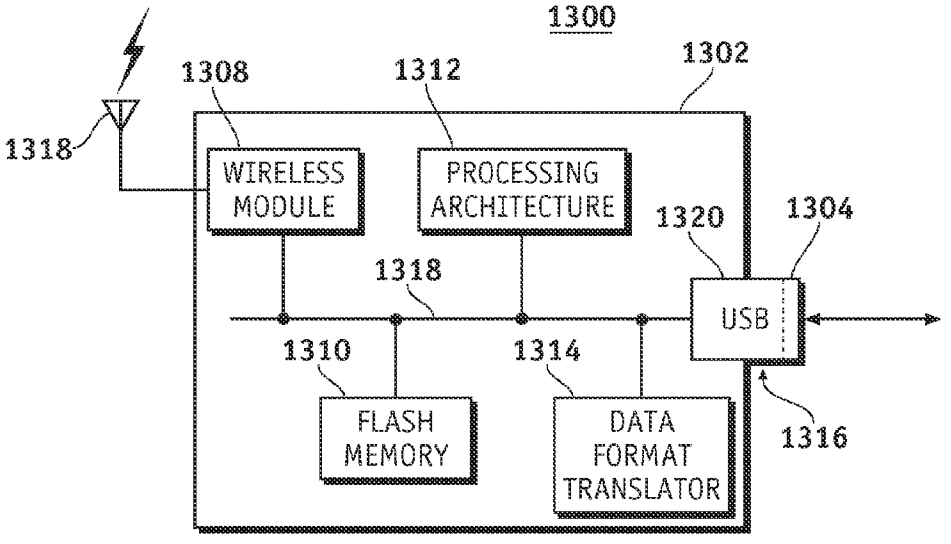

1300
1308
1312
1302
1318
WIRELESS MODULE
PROCESSING ARCHITECTURE
1320
1304
1318
USB
1310
1314
FLASH MEMORY
DATA FORMAT TRANSLATOR
1316

FIG. 19

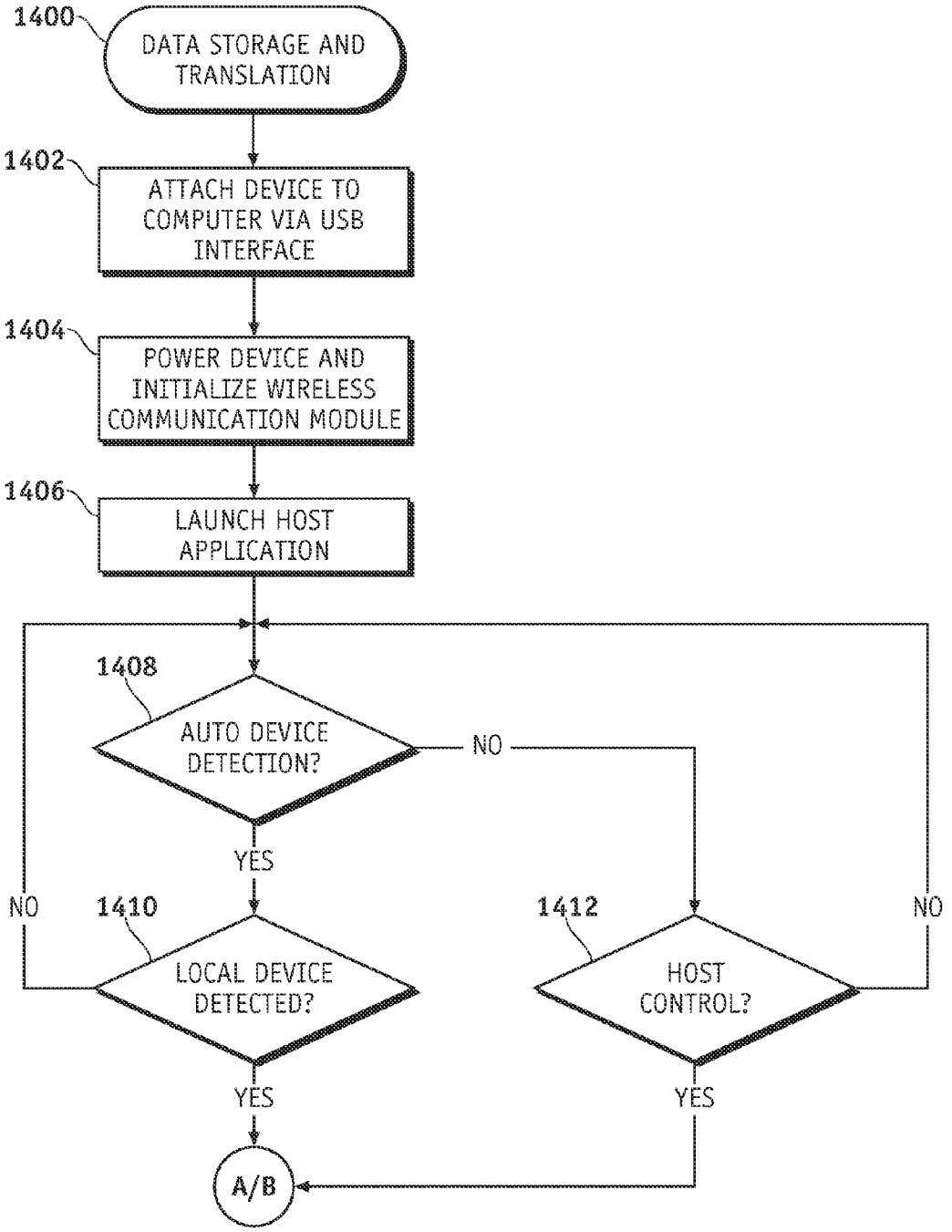

1400
DATA STORAGE AND TRANSLATION
1402
ATTACH DEVICE TO COMPUTER VIA USB INTERFACE
1404
POWER DEVICE AND INITIALIZE WIRELESS COMMUNICATION MODULE
1406
LAUNCH HOST APPLICATION
1408
AUTO DEVICE DETECTION?
NO
YES
NO
1410
LOCAL DEVICE DETECTED?
1412
HOST CONTROL?
NO
YES
YES
A/B

FIG. 20A

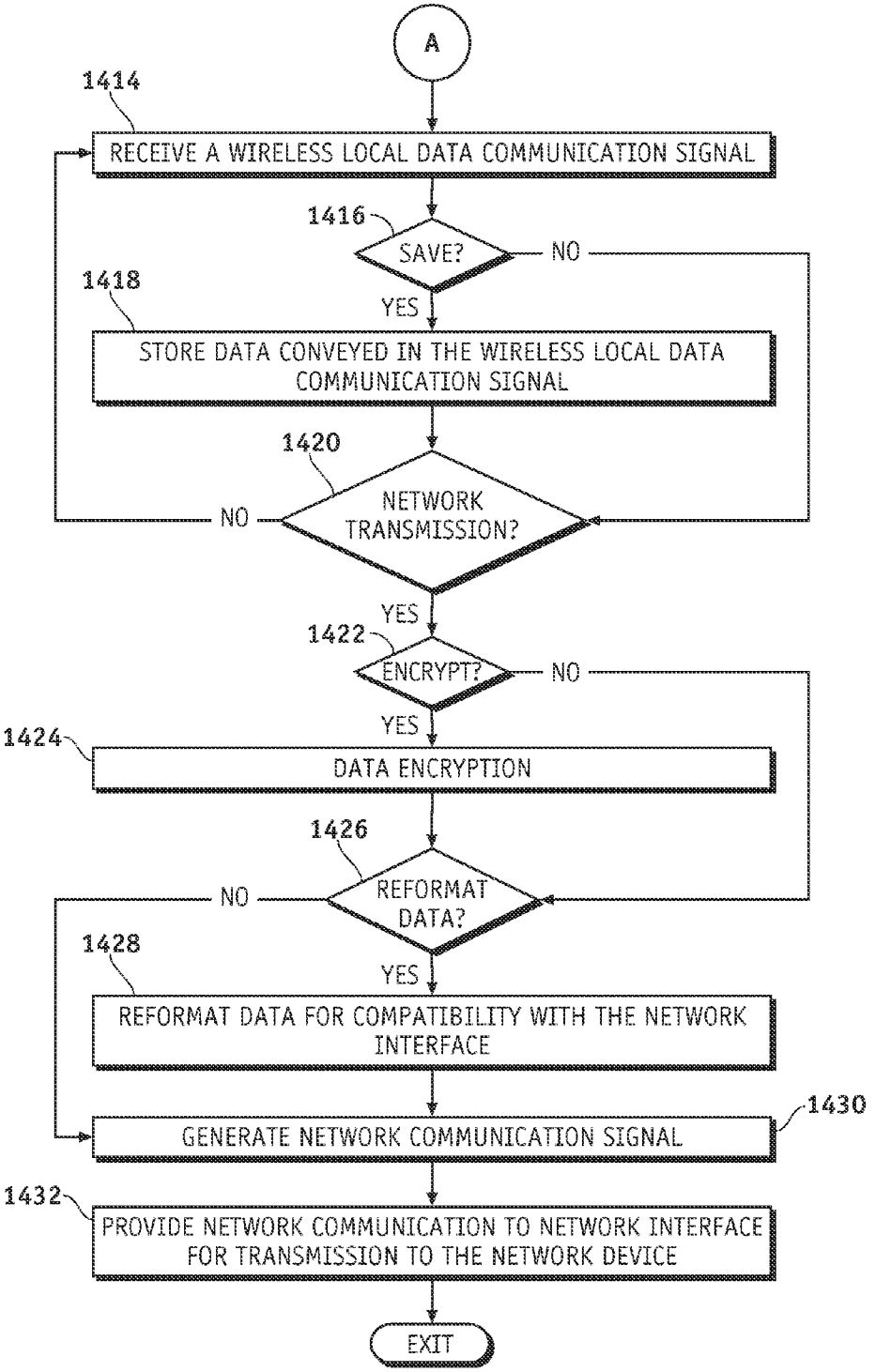

A
1414
RECEIVE A WIRELESS LOCAL DATA COMMUNICATION SIGNAL
1416
SAVE?
NO
YES
1418
STORE DATA CONVEYED IN THE WIRELESS LOCAL DATA COMMUNICATION SIGNAL
1420
NETWORK TRANSMISSION?
NO
YES
1422
ENCRYPT?
NO
YES
1424
DATA ENCRYPTION
1426
REFORMAT DATA?
NO
YES
1428
REFORMAT DATA FOR COMPATIBILITY WITH THE NETWORK INTERFACE
1430
GENERATE NETWORK COMMUNICATION SIGNAL
1432
PROVIDE NETWORK COMMUNICATION TO NETWORK INTERFACE FOR TRANSMISSION TO THE NETWORK DEVICE
EXIT

FIG. 20B

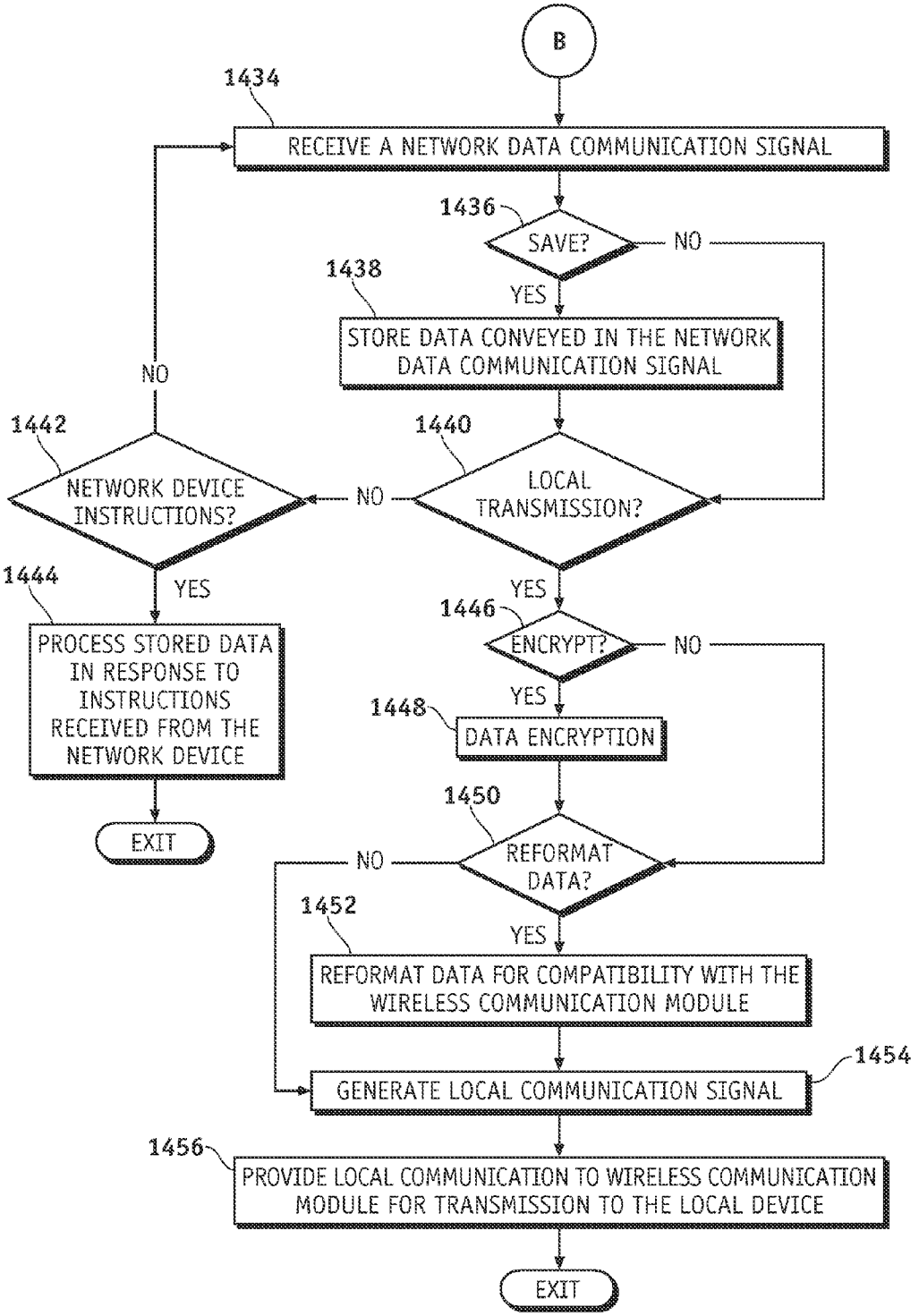

B
1434
RECEIVE A NETWORK DATA COMMUNICATION SIGNAL
1436
SAVE?
NO
YES
1438
STORE DATA CONVEYED IN THE NETWORK DATA COMMUNICATION SIGNAL
NO
1442
NETWORK DEVICE INSTRUCTIONS?
NO
1440
LOCAL TRANSMISSION?
1444
YES
YES
1446
ENCRYPT?
NO
PROCESS STORED DATA IN RESPONSE TO INSTRUCTIONS RECEIVED FROM THE NETWORK DEVICE
YES
1448
DATA ENCRYPTION
1450
EXIT
NO
REFORMAT DATA?
1452
YES
REFORMAT DATA FOR COMPATIBILITY WITH THE WIRELESS COMMUNICATION MODULE
1454
GENERATE LOCAL COMMUNICATION SIGNAL
1456
PROVIDE LOCAL COMMUNICATION TO WIRELESS COMMUNICATION MODULE FOR TRANSMISSION TO THE LOCAL DEVICE
EXIT

FIG. 20C

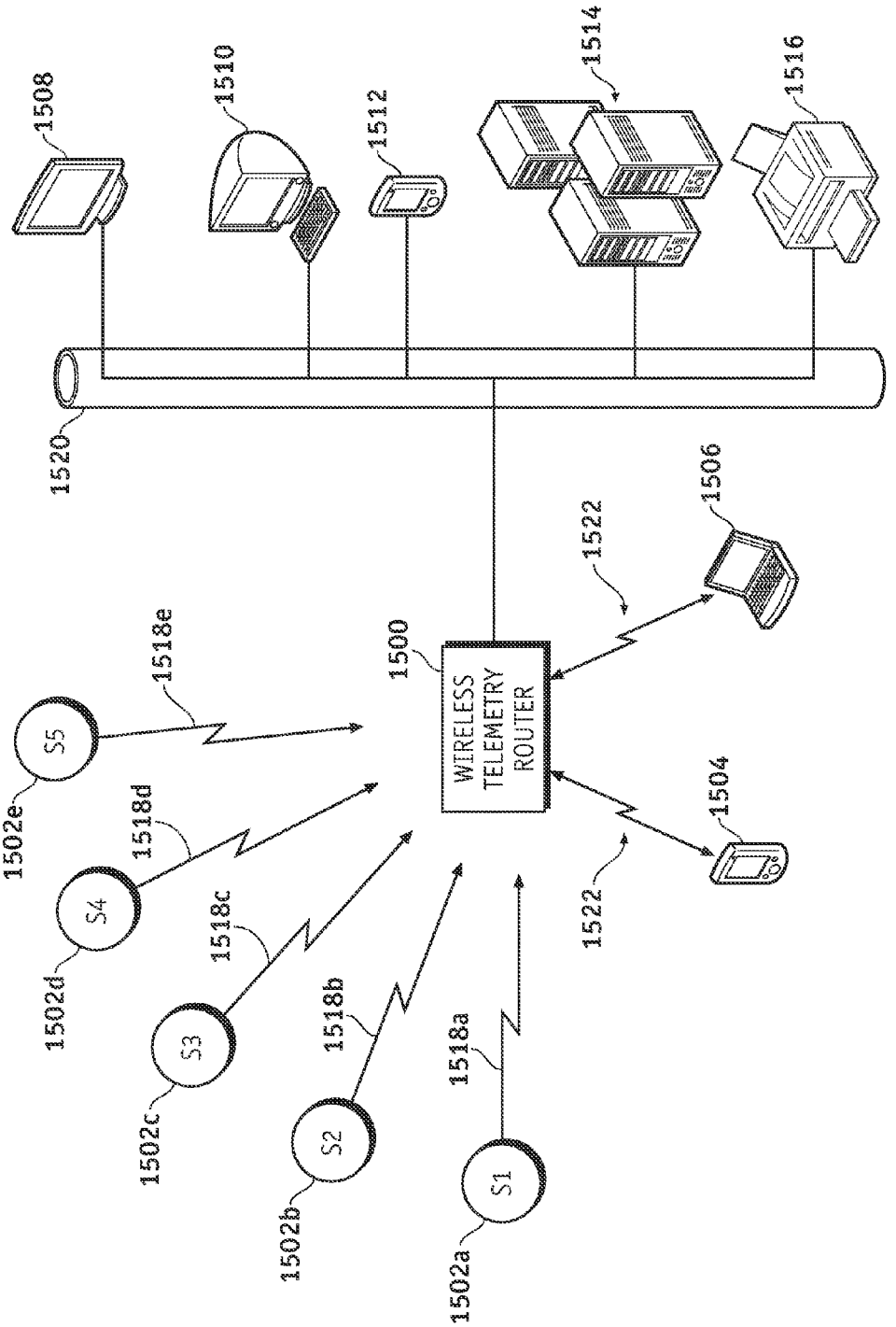

1508
1510
1512
1514
1516
1520
1506
1522
1500
WIRELESS TELEMETRY ROUTER
1518e
S5
1502e
1518d
S4
1502d
1518c
S3
1502c
1518b
S2
1502b
1518a
S1
1502a
1504
1522

FIG. 21

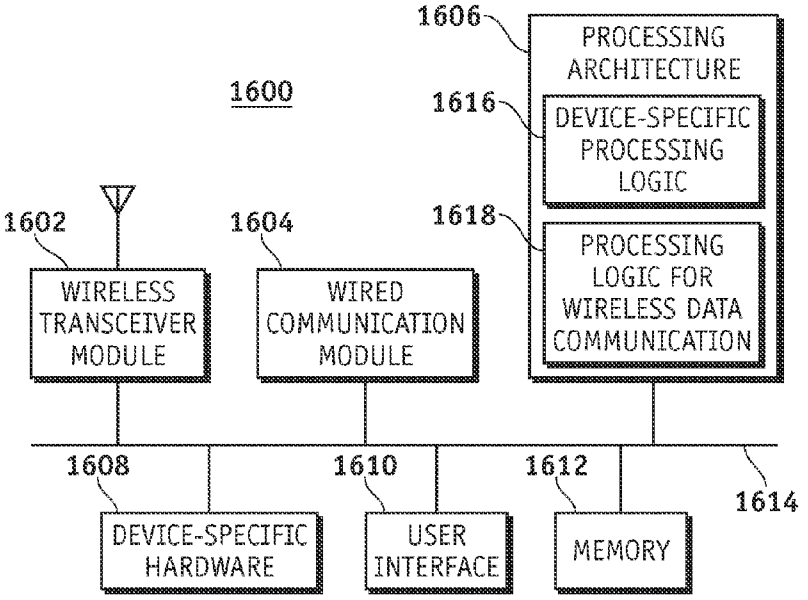

1600
1602
WIRELESS TRANSCEIVER MODULE
1604
WIRED COMMUNICATION MODULE
1606
PROCESSING ARCHITECTURE
1616
DEVICE-SPECIFIC PROCESSING LOGIC
1618
PROCESSING LOGIC FOR WIRELESS DATA COMMUNICATION
1608
DEVICE-SPECIFIC HARDWARE
1610
USER INTERFACE
1612
MEMORY
1614

FIG. 22

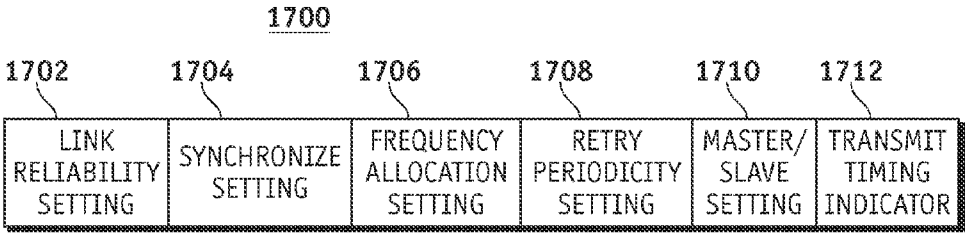

1700
1702
LINK RELIABILITY SETTING
1704
SYNCHRONIZE SETTING
1706
FREQUENCY ALLOCATION SETTING
1708
RETRY PERIODICITY SETTING
1710
MASTER/ SLAVE SETTING
1712
TRANSMIT TIMING INDICATOR

FIG. 23

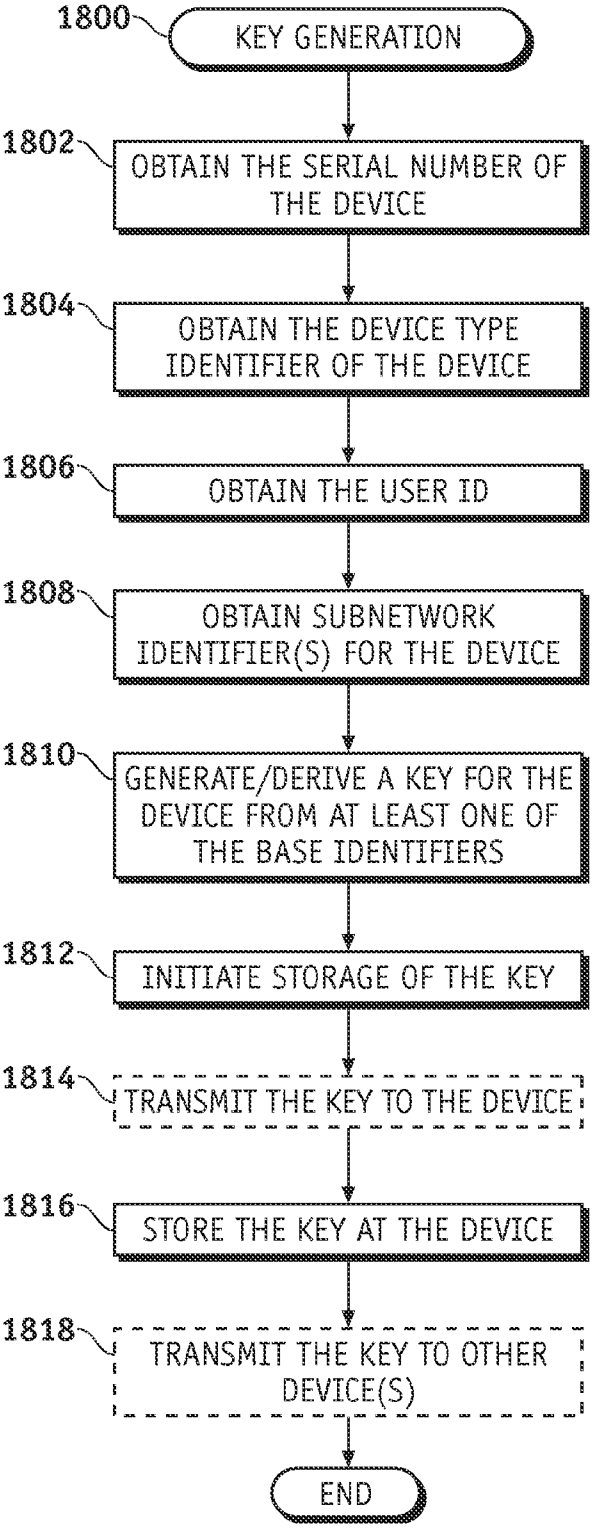

1800
KEY GENERATION
1802
OBTAIN THE SERIAL NUMBER OF THE DEVICE
1804
OBTAIN THE DEVICE TYPE IDENTIFIER OF THE DEVICE
1806
OBTAIN THE USER ID
1808
OBTAIN SUBNETWORK IDENTIFIER(S) FOR THE DEVICE
1810
GENERATE/DERIVE A KEY FOR THE DEVICE FROM AT LEAST ONE OF THE BASE IDENTIFIERS
1812
INITIATE STORAGE OF THE KEY
1814
TRANSMIT THE KEY TO THE DEVICE
1816
STORE THE KEY AT THE DEVICE
1818
TRANSMIT THE KEY TO OTHER DEVICE(S)
END

FIG. 24

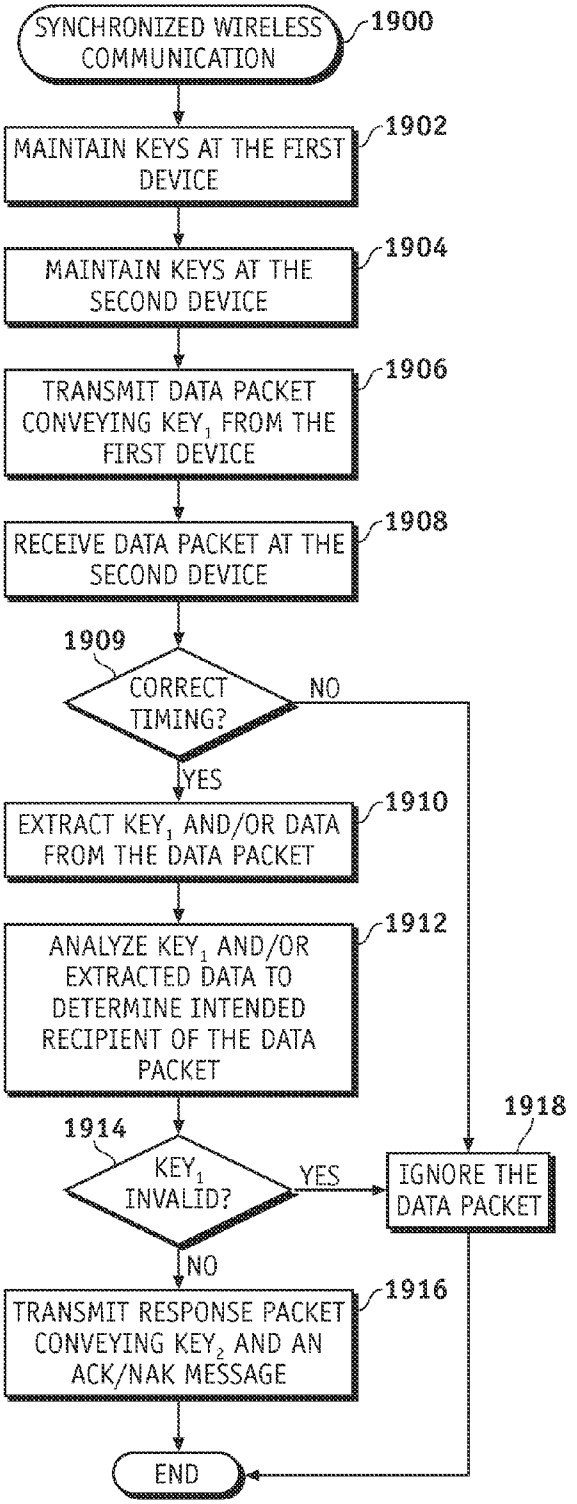

SYNCHRONIZED WIRELESS COMMUNICATION
1900
MAINTAIN KEYS AT THE FIRST DEVICE
1902
MAINTAIN KEYS AT THE SECOND DEVICE
1904
TRANSMIT DATA PACKET CONVEYING KEY1 FROM THE FIRST DEVICE
1906
RECEIVE DATA PACKET AT THE SECOND DEVICE
1908
1909
CORRECT TIMING?
NO
YES
EXTRACT KEY1 AND/OR DATA FROM THE DATA PACKET
1910
ANALYZE KEY1 AND/OR EXTRACTED DATA TO DETERMINE INTENDED RECIPIENT OF THE DATA PACKET
1912
1914
KEY1 INVALID?
YES
1918
IGNORE THE DATA PACKET
NO
TRANSMIT RESPONSE PACKET CONVEYING KEY2 AND AN ACK/NAK MESSAGE
1916
END

FIG. 25

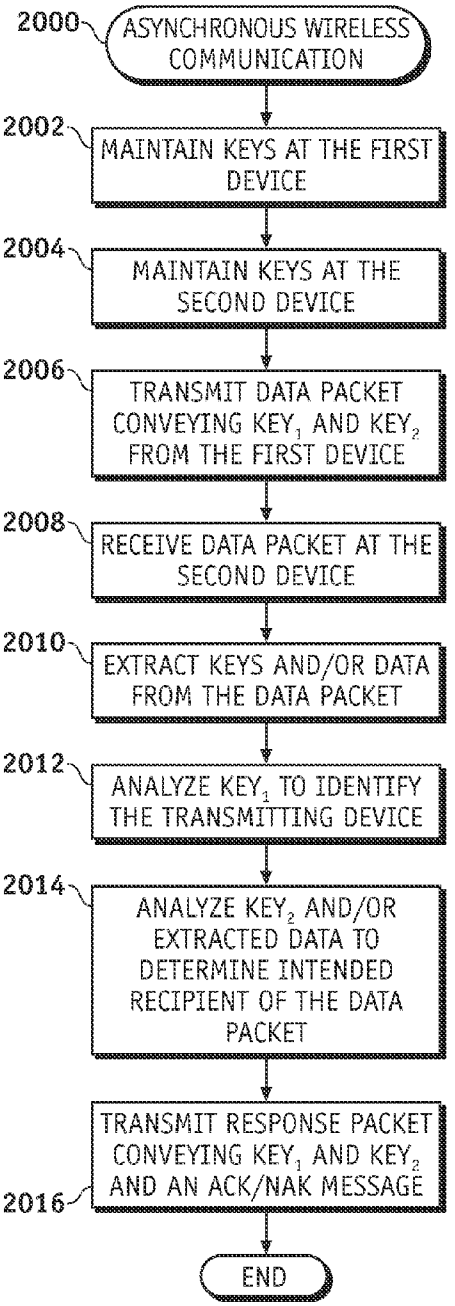

2000
ASYNCHRONOUS WIRELESS COMMUNICATION
2002
MAINTAIN KEYS AT THE FIRST DEVICE
2004
MAINTAIN KEYS AT THE SECOND DEVICE
2006
TRANSMIT DATA PACKET CONVEYING KEY1 AND KEY2 FROM THE FIRST DEVICE
2008
RECEIVE DATA PACKET AT THE SECOND DEVICE
2010
EXTRACT KEYS AND/OR DATA FROM THE DATA PACKET
2012
ANALYZE KEY1 TO IDENTIFY THE TRANSMITTING DEVICE
2014
ANALYZE KEY2 AND/OR EXTRACTED DATA TO DETERMINE INTENDED RECIPIENT OF THE DATA PACKET
TRANSMIT RESPONSE PACKET CONVEYING KEY1 AND KEY2 AND AN ACK/NAK MESSAGE
2016
END

FIG. 27

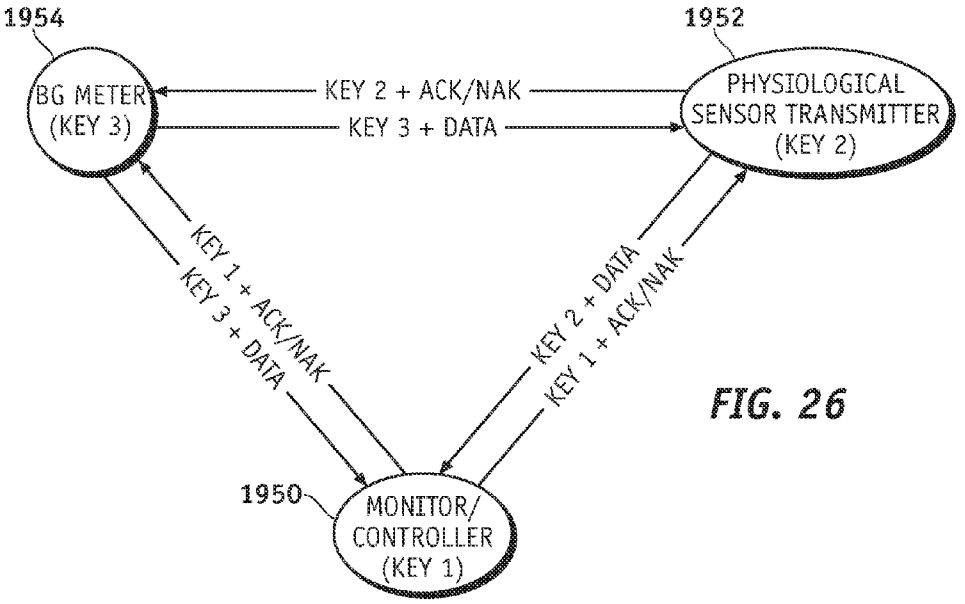

1954
1952
BG METER
(KEY 3)
KEY 2 + ACK/NAK
KEY 3 + DATA
PHYSIOLOGICAL
SENSOR TRANSMITTER
(KEY 2)
KEY 1 + ACK/NAK
KEY 3 + DATA
KEY 2 + DATA
KEY 1 + ACK/NAK
1950
MONITOR/
CONTROLLER
(KEY 1)

FIG. 26

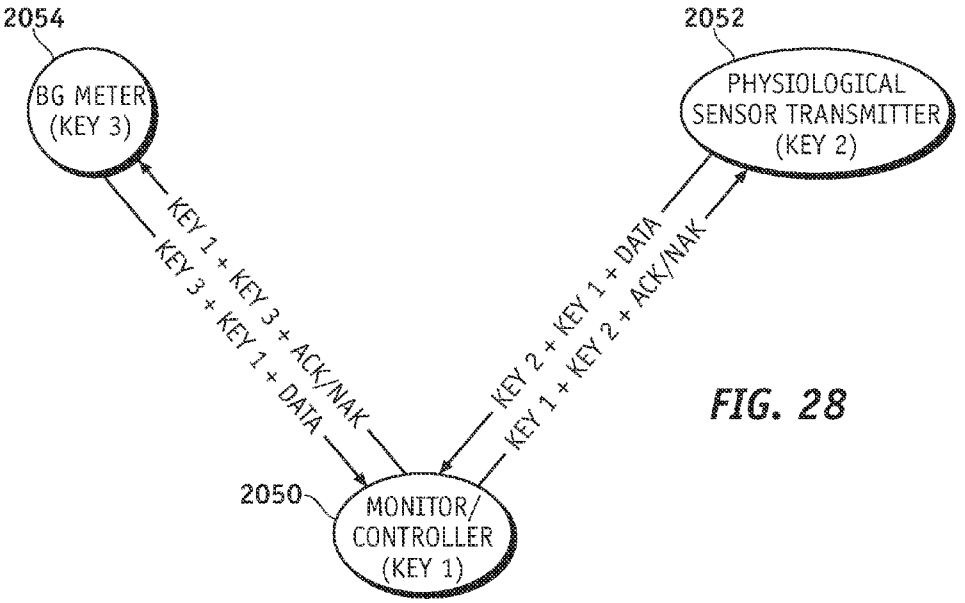

2054
2052
BG METER
(KEY 3)
PHYSIOLOGICAL
SENSOR TRANSMITTER
(KEY 2)
KEY 1 + KEY 3 + ACK/NAK
KEY 3 + KEY 1 + DATA
KEY 2 + KEY 1 + DATA
KEY 1 + KEY 2 + ACK/NAK
2050
MONITOR/
CONTROLLER
(KEY 1)

FIG. 28

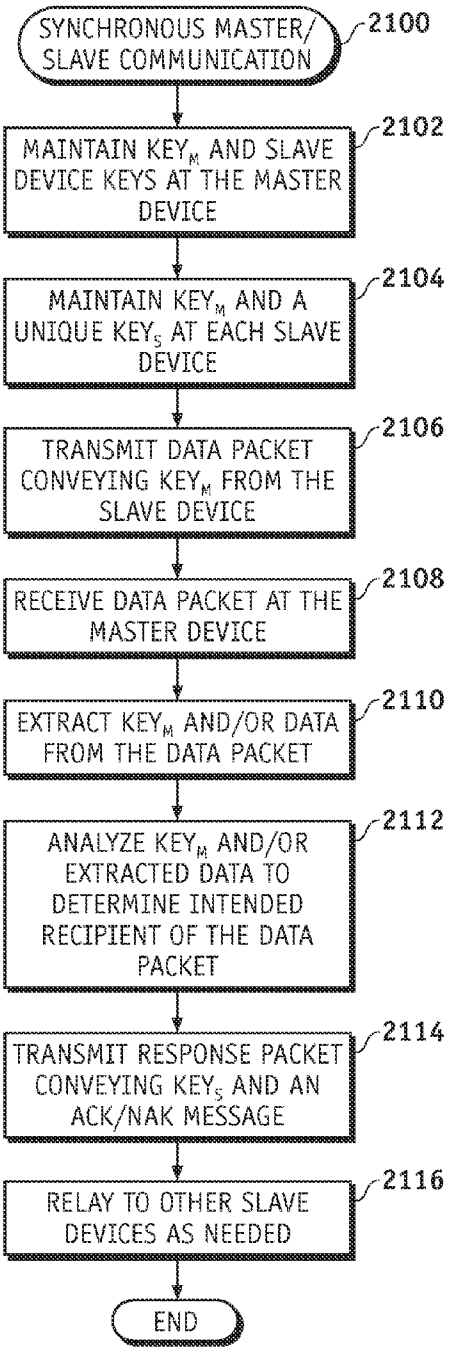

SYNCHRONOUS MASTER/ SLAVE COMMUNICATION
2100
MAINTAIN KEY_M AND SLAVE DEVICE KEYS AT THE MASTER DEVICE
2102
MAINTAIN KEY_M AND A UNIQUE KEY_S AT EACH SLAVE DEVICE
2104
TRANSMIT DATA PACKET CONVEYING KEY_M FROM THE SLAVE DEVICE
2106
RECEIVE DATA PACKET AT THE MASTER DEVICE
2108
EXTRACT KEY_M AND/OR DATA FROM THE DATA PACKET
2110
ANALYZE KEY_M AND/OR EXTRACTED DATA TO DETERMINE INTENDED RECIPIENT OF THE DATA PACKET
2112
TRANSMIT RESPONSE PACKET CONVEYING KEY_S AND AN ACK/NAK MESSAGE
2114
RELAY TO OTHER SLAVE DEVICES AS NEEDED
2116
END

FIG. 29

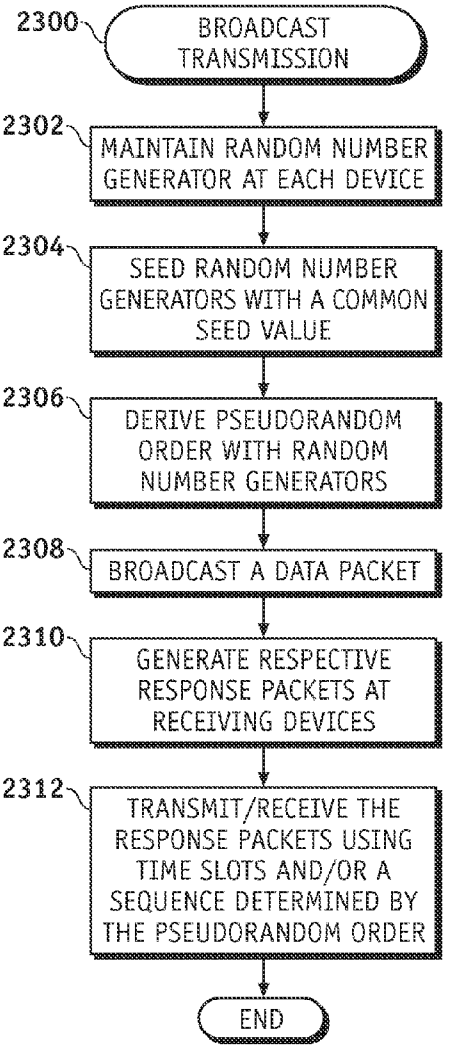

2300
BROADCAST TRANSMISSION
2302
MAINTAIN RANDOM NUMBER GENERATOR AT EACH DEVICE
2304
SEED RANDOM NUMBER GENERATORS WITH A COMMON SEED VALUE
2306
DERIVE PSEUDORANDOM ORDER WITH RANDOM NUMBER GENERATORS
2308
BROADCAST A DATA PACKET
2310
GENERATE RESPECTIVE RESPONSE PACKETS AT RECEIVING DEVICES
2312
TRANSMIT/RECEIVE THE RESPONSE PACKETS USING TIME SLOTS AND/OR A SEQUENCE DETERMINED BY THE PSEUDORANDOM ORDER
END

FIG. 32

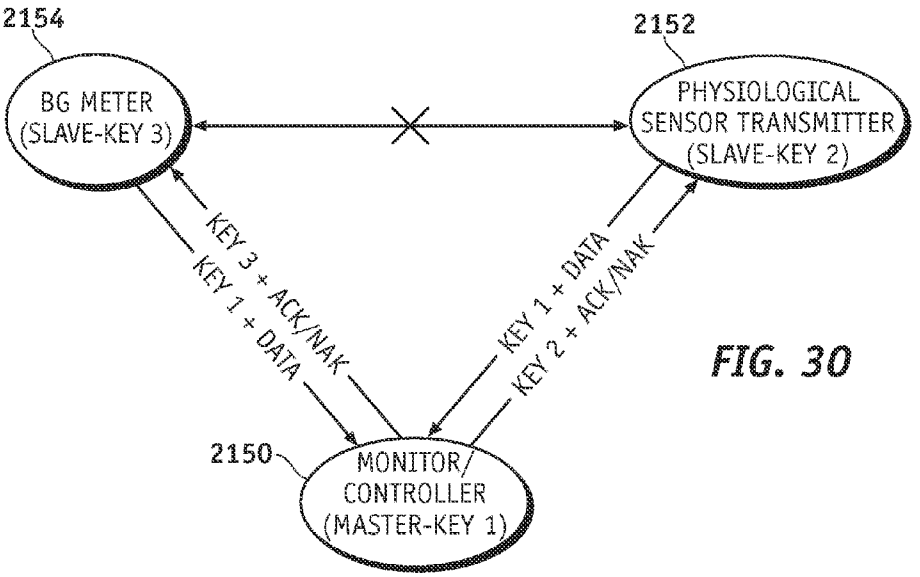


FIG. 30

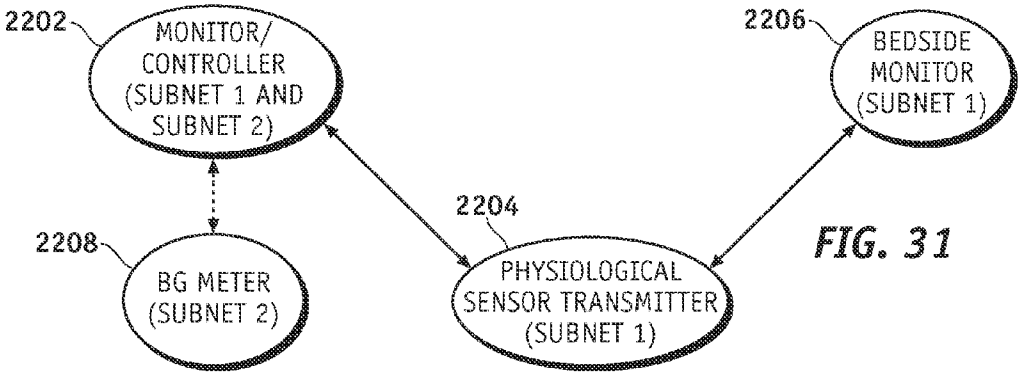


FIG. 31

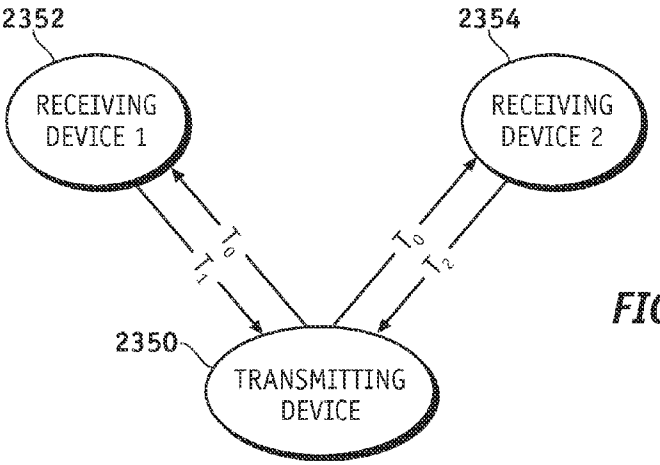


FIG. 33

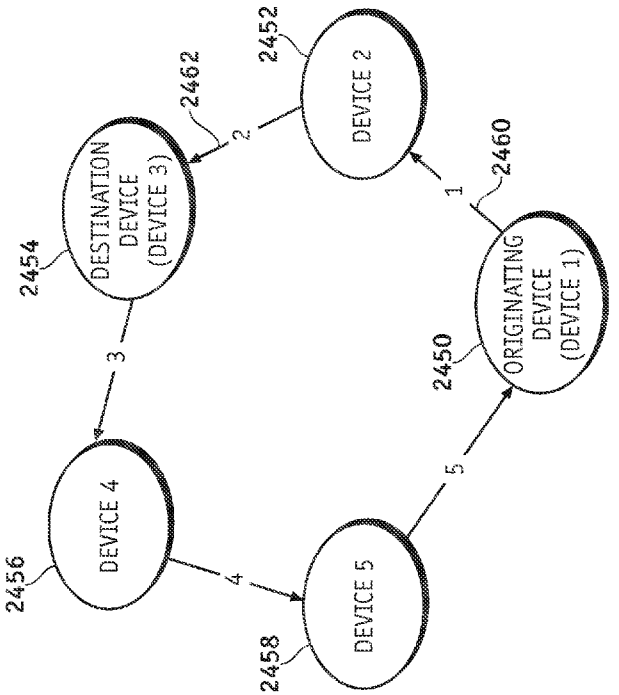


FIG. 35A

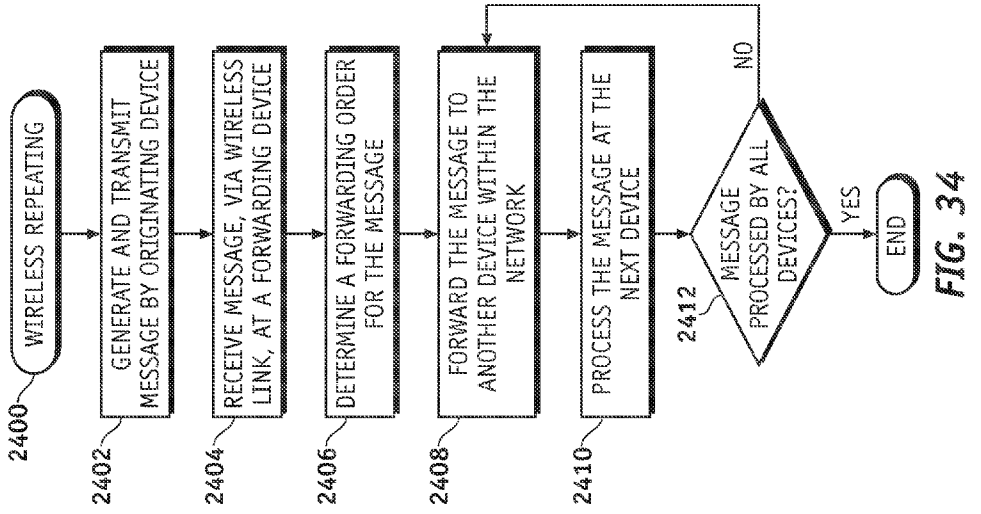


FIG. 34

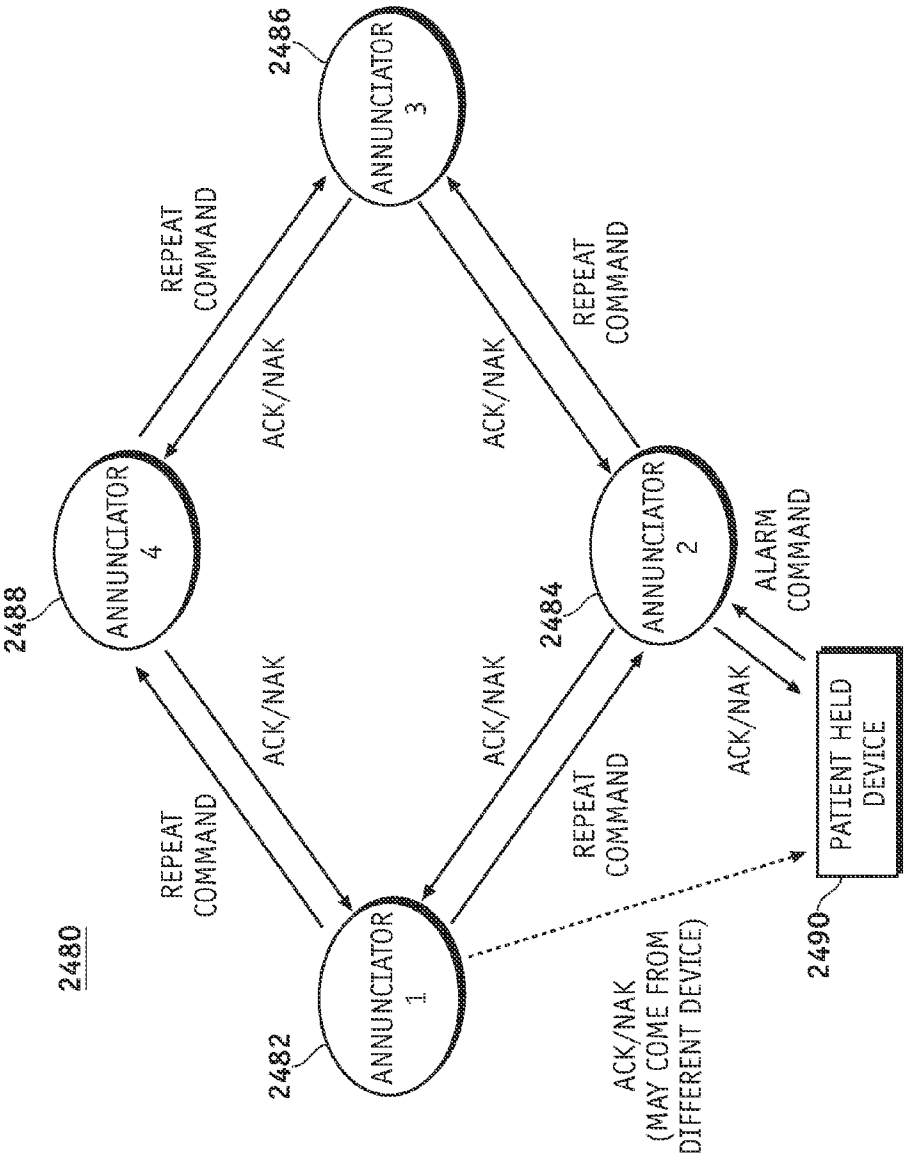

2480
2482
ANNUNCIATOR 1
2484
ANNUNCIATOR 2
2486
ANNUNCIATOR 3
2488
ANNUNCIATOR 4
2490
PATIENT HELD DEVICE
REPEAT COMMAND
ACK/NAK
ACK/NAK
REPEAT COMMAND
REPEAT COMMAND
ACK/NAK
ACK/NAK
REPEAT COMMAND
ACK/NAK
ALARM COMMAND
ACK/NAK (MAY COME FROM DIFFERENT DEVICE)

FIG. 35B

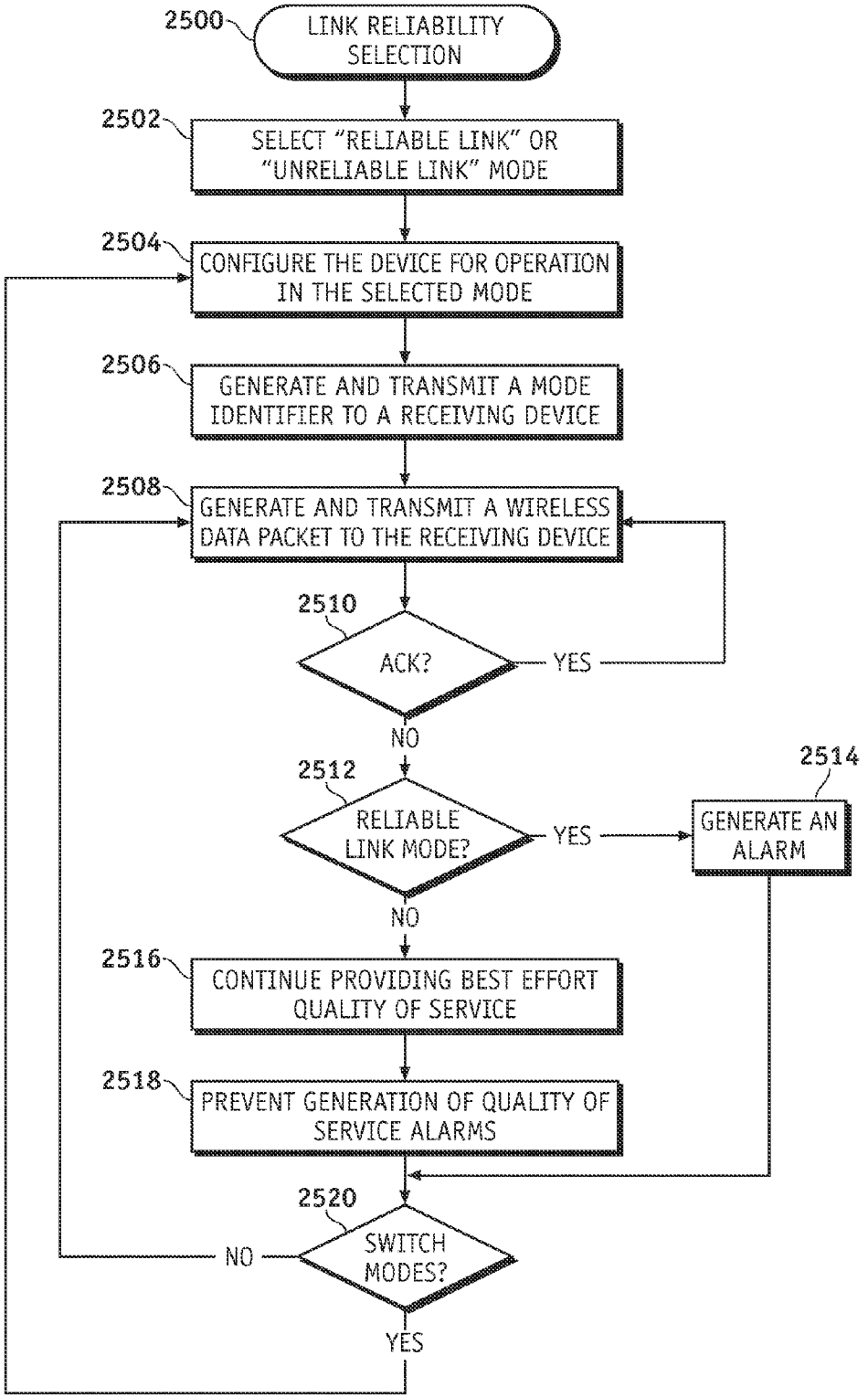

2500
LINK RELIABILITY SELECTION
2502
SELECT "RELIABLE LINK" OR "UNRELIABLE LINK" MODE
2504
CONFIGURE THE DEVICE FOR OPERATION IN THE SELECTED MODE
2506
GENERATE AND TRANSMIT A MODE IDENTIFIER TO A RECEIVING DEVICE
2508
GENERATE AND TRANSMIT A WIRELESS DATA PACKET TO THE RECEIVING DEVICE
2510
ACK?
YES
NO
2512
RELIABLE LINK MODE?
YES
2514
GENERATE AN ALARM
NO
2516
CONTINUE PROVIDING BEST EFFORT QUALITY OF SERVICE
2518
PREVENT GENERATION OF QUALITY OF SERVICE ALARMS
2520
SWITCH MODES?
NO
YES

FIG. 36

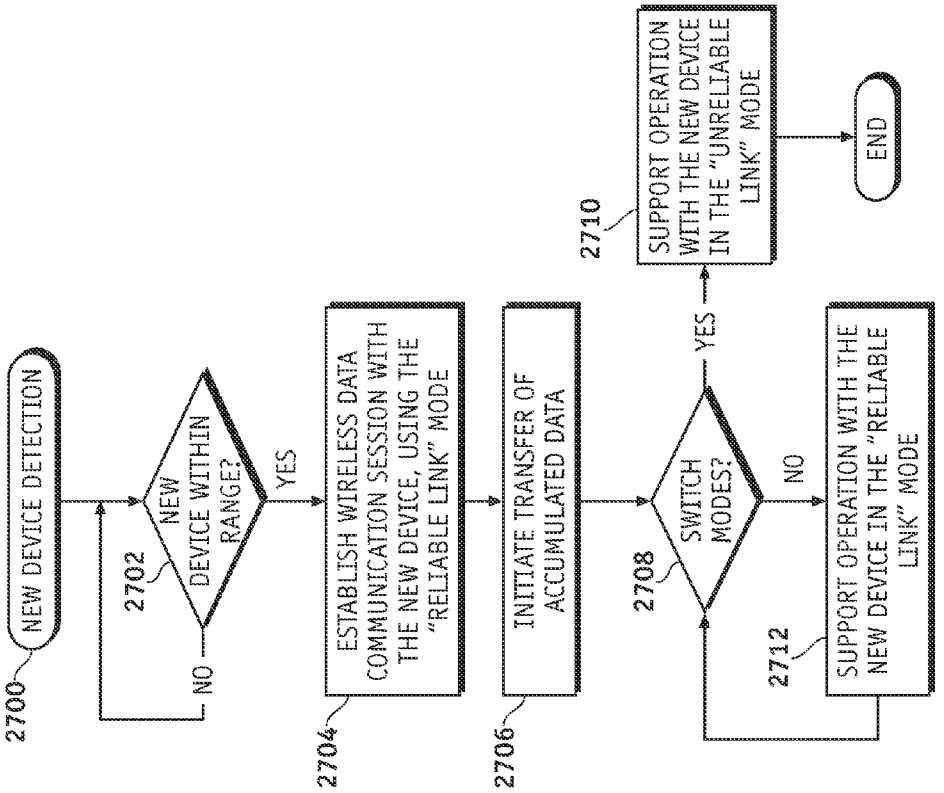

2700
NEW DEVICE DETECTION
2702
NEW DEVICE WITHIN RANGE?
NO
YES
2704
ESTABLISH WIRELESS DATA COMMUNICATION SESSION WITH THE NEW DEVICE, USING THE "RELIABLE LINK" MODE
2706
INITIATE TRANSFER OF ACCUMULATED DATA
2708
SWITCH MODES?
NO
YES
2710
SUPPORT OPERATION WITH THE NEW DEVICE IN THE "UNRELIABLE LINK" MODE
END
2712
SUPPORT OPERATION WITH THE NEW DEVICE IN THE "RELIABLE LINK" MODE

FIG. 38

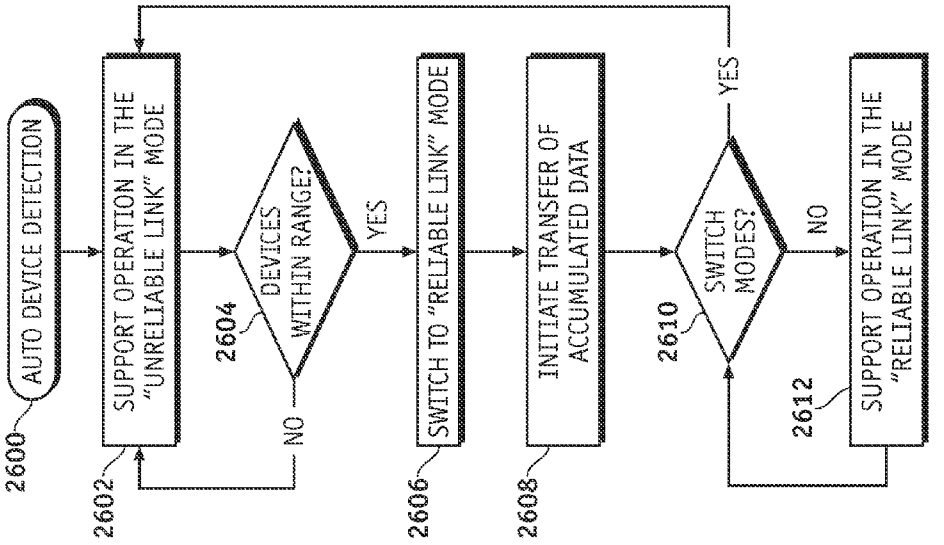

2600
AUTO DEVICE DETECTION
2602
SUPPORT OPERATION IN THE "UNRELIABLE LINK" MODE
2604
DEVICES WITHIN RANGE?
NO
YES
2606
SWITCH TO "RELIABLE LINK" MODE
2608
INITIATE TRANSFER OF ACCUMULATED DATA
2610
SWITCH MODES?
NO
YES
2612
SUPPORT OPERATION IN THE "RELIABLE LINK" MODE

FIG. 37

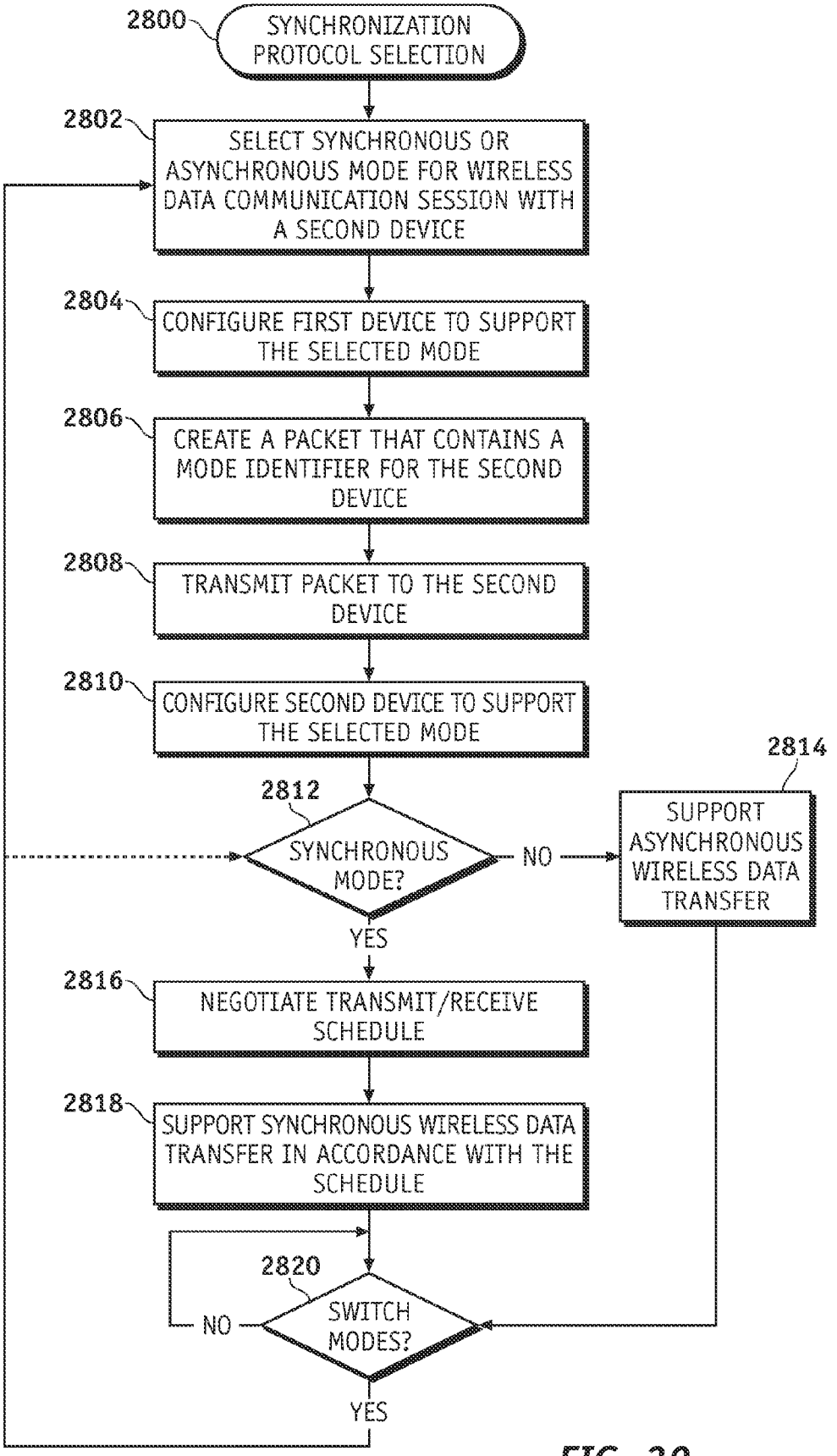

2800
SYNCHRONIZATION PROTOCOL SELECTION
2802
SELECT SYNCHRONOUS OR ASYNCHRONOUS MODE FOR WIRELESS DATA COMMUNICATION SESSION WITH A SECOND DEVICE
2804
CONFIGURE FIRST DEVICE TO SUPPORT THE SELECTED MODE
2806
CREATE A PACKET THAT CONTAINS A MODE IDENTIFIER FOR THE SECOND DEVICE
2808
TRANSMIT PACKET TO THE SECOND DEVICE
2810
CONFIGURE SECOND DEVICE TO SUPPORT THE SELECTED MODE
2812
SYNCHRONOUS MODE?
NO
2814
SUPPORT ASYNCHRONOUS WIRELESS DATA TRANSFER
YES
2816
NEGOTIATE TRANSMIT/RECEIVE SCHEDULE
2818
SUPPORT SYNCHRONOUS WIRELESS DATA TRANSFER IN ACCORDANCE WITH THE SCHEDULE
2820
SWITCH MODES?
NO
YES

FIG. 39

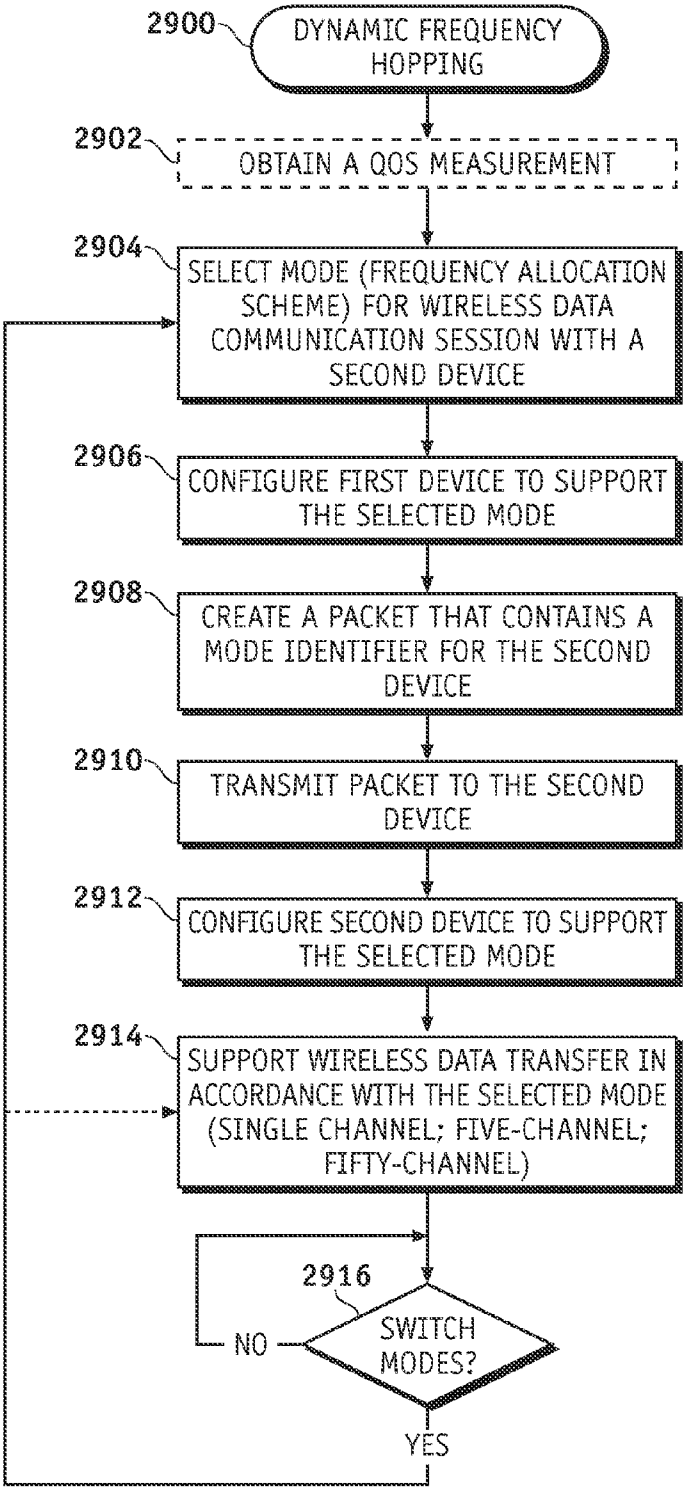

2900
DYNAMIC FREQUENCY HOPPING
2902
OBTAIN A QOS MEASUREMENT
2904
SELECT MODE (FREQUENCY ALLOCATION SCHEME) FOR WIRELESS DATA COMMUNICATION SESSION WITH A SECOND DEVICE
2906
CONFIGURE FIRST DEVICE TO SUPPORT THE SELECTED MODE
2908
CREATE A PACKET THAT CONTAINS A MODE IDENTIFIER FOR THE SECOND DEVICE
2910
TRANSMIT PACKET TO THE SECOND DEVICE
2912
CONFIGURE SECOND DEVICE TO SUPPORT THE SELECTED MODE
2914
SUPPORT WIRELESS DATA TRANSFER IN ACCORDANCE WITH THE SELECTED MODE (SINGLE CHANNEL; FIVE-CHANNEL; FIFTY-CHANNEL)
2916
SWITCH MODES?
NO
YES

FIG. 40

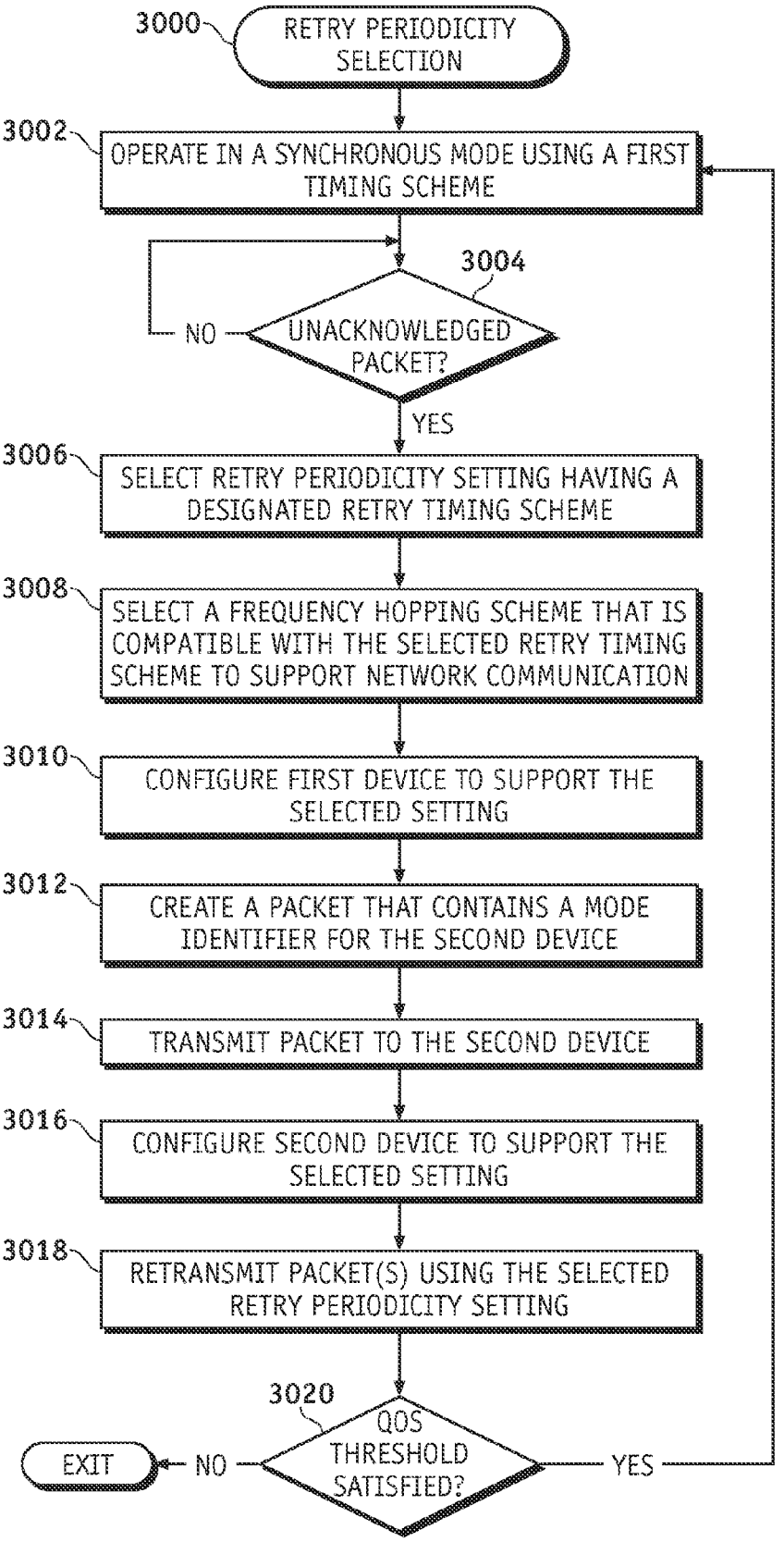

3000
RETRY PERIODICITY SELECTION
3002
OPERATE IN A SYNCHRONOUS MODE USING A FIRST TIMING SCHEME
3004
UNACKNOWLEDGED PACKET?
NO
YES
3006
SELECT RETRY PERIODICITY SETTING HAVING A DESIGNATED RETRY TIMING SCHEME
3008
SELECT A FREQUENCY HOPPING SCHEME THAT IS COMPATIBLE WITH THE SELECTED RETRY TIMING SCHEME TO SUPPORT NETWORK COMMUNICATION
3010
CONFIGURE FIRST DEVICE TO SUPPORT THE SELECTED SETTING
3012
CREATE A PACKET THAT CONTAINS A MODE IDENTIFIER FOR THE SECOND DEVICE
3014
TRANSMIT PACKET TO THE SECOND DEVICE
3016
CONFIGURE SECOND DEVICE TO SUPPORT THE SELECTED SETTING
3018
RETRANSMIT PACKET(S) USING THE SELECTED RETRY PERIODICITY SETTING
3020
QOS THRESHOLD SATISFIED?
NO
YES
EXIT

FIG. 41

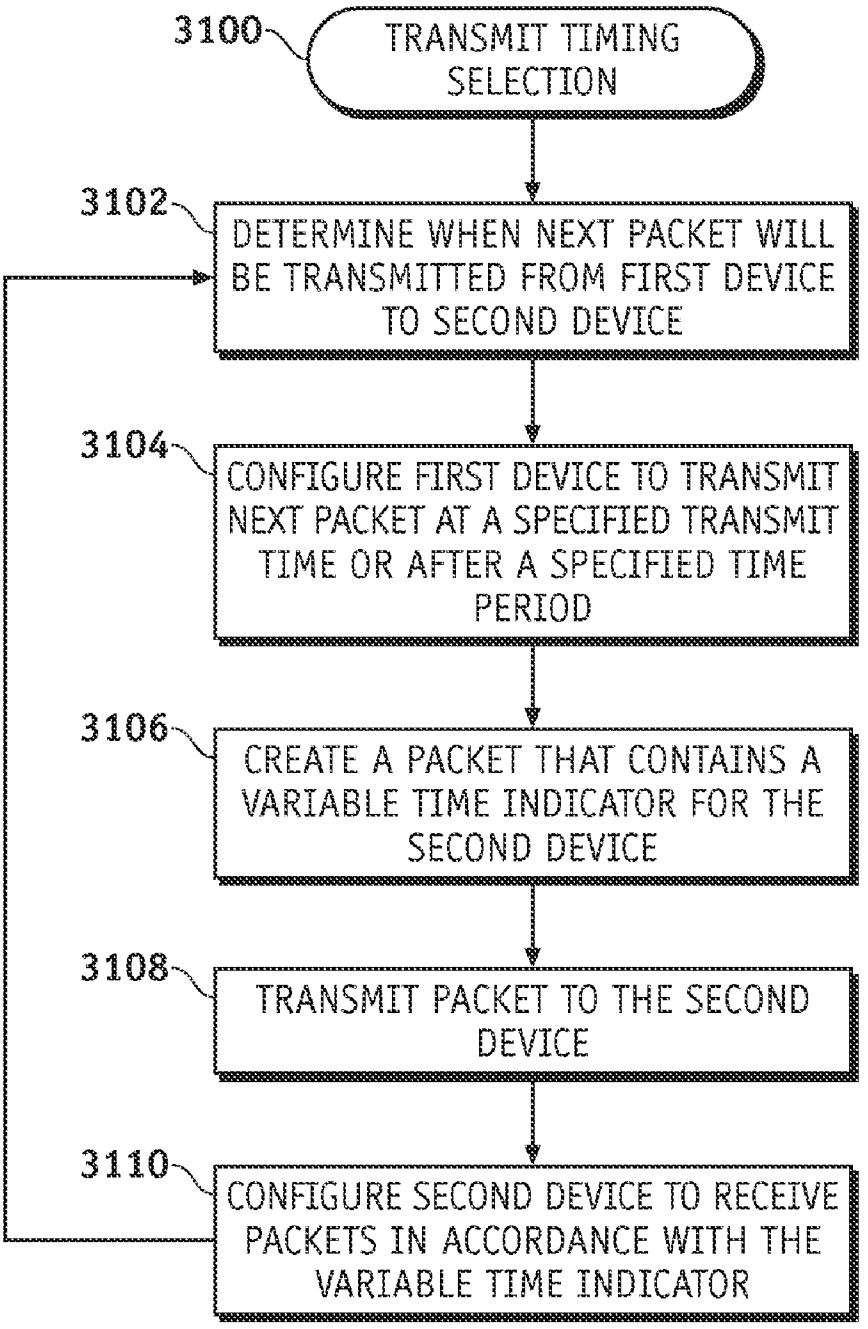

3100
TRANSMIT TIMING SELECTION
3102
DETERMINE WHEN NEXT PACKET WILL BE TRANSMITTED FROM FIRST DEVICE TO SECOND DEVICE
3104
CONFIGURE FIRST DEVICE TO TRANSMIT NEXT PACKET AT A SPECIFIED TRANSMIT TIME OR AFTER A SPECIFIED TIME PERIOD
3106
CREATE A PACKET THAT CONTAINS A VARIABLE TIME INDICATOR FOR THE SECOND DEVICE
3108
TRANSMIT PACKET TO THE SECOND DEVICE
3110
CONFIGURE SECOND DEVICE TO RECEIVE PACKETS IN ACCORDANCE WITH THE VARIABLE TIME INDICATOR

FIG. 42

WIRELESS DATA COMMUNICATION FOR A MEDICAL DEVICE NETWORK THAT SUPPORTS A PLURALITY OF DATA COMMUNICATION MODES

CROSS-REFERENCE TO RELATED APPLICATION(S)

[0001] This application is a continuation-in-part of U.S. patent application Ser. No. 11/413,956, filed Apr. 28, 2006.

TECHNICAL FIELD

[0002] Embodiments of the present invention relate generally to medical devices and medical device networks, such as infusion systems that deliver fluids into a patient's body. More particularly, embodiments of the present invention relate to systems and techniques related to wireless data communication protocols, and wireless data communication features suitable for use in a medical device network environment.

BACKGROUND

[0003] Portable medical devices having wireless data communication capabilities are becoming increasingly popular, especially for patients that have conditions that must be monitored on a continuous or frequent basis. For example, diabetics are usually required to modify and monitor their daily lifestyle to keep their body in balance, in particular, their blood glucose ("BG") levels. Individuals with Type 1 diabetes and some individuals with Type 2 diabetes use insulin to control their BG levels. To do so, diabetics routinely keep strict schedules, including ingesting timely nutritious meals, partaking in exercise, monitoring BG levels daily, and adjusting and administering insulin dosages accordingly. Diabetics may utilize wireless medical devices that are deployed in a network environment in a manner that facilitates data communication between two or more separate devices.

[0004] The prior art includes a number of insulin pump systems that are designed to deliver accurate and measured doses of insulin via infusion sets (an infusion set delivers the insulin through a small diameter tube that terminates at a cannula inserted under the patient's skin). In lieu of a syringe, the patient can simply activate the insulin pump to administer an insulin bolus as needed, for example, in response to the patient's current BG level. A patient can measure his BG level using a BG measurement device, such as a test strip meter, a continuous glucose measurement system, or the like. BG measurement devices use various methods to measure the BG level of a patient, such as a sample of the patient's blood, a sensor in contact with a bodily fluid, an optical sensor, an enzymatic sensor, or a fluorescent sensor. When the BG measurement device has generated a BG measurement, the measurement is displayed on the BG measurement device. A continuous glucose monitoring system can monitor the patient's BG level in real time.

[0005] Insulin pumps and continuous glucose monitoring devices may also be configured to communicate with remote control devices, monitoring or display devices, BG meters, and other devices associated with such an infusion system. Individual devices within conventional infusion systems may be configured to support a limited amount of wired or wireless data communication to support the operation of the infusion system. For example, a continuous glucose monitoring sensor may include a wireless radio frequency ("RF") transmitter that communicates with a BG monitor device within the infusion system. As another example, the infusion system may include a handheld remote control that communicates with the infusion pump device using wireless techniques. Conventional infusion systems, however, operate in a somewhat isolated and local manner in that the routing of control signals, monitoring signals, patient status information, physiologic data, alerts, activation instructions, programming signals, and other data communication generally occurs within the limited short range and local operating environment of the infusion system itself. Moreover, many conventional infusion systems do not take advantage of certain protocols that facilitate efficient and effective wireless data communication between devices arranged in a network.

BRIEF SUMMARY

[0006] An embodiment of a medical device system as described here includes wireless devices that are configured to support a number of RF data communication protocols, techniques, and technologies that enable efficient routing of system data over wireless links. The medical device system includes a plurality of devices arranged in a wireless network topology (and/or in a wired network topology). Moreover, a wireless medical device in the "local" or "body" area network can be suitably configured to communicate with one or more external network devices, such as networked computers, cellular telephones, personal digital assistants, hospital monitoring equipment, pager devices, or the like. Wireless network communications within the medical device network may convey device status information, physiologic patient data, alerts, and/or alarms. Moreover, wireless network communications within the medical device network may convey data that originates from external devices outside the local system environment, such as device programming instructions, device actuation instructions, calibration parameters, alert/alarm enable or disable signals, and/or other control parameters to the local system devices.

[0007] A number of desirable RF operating features may be carried out by an embodiment of a communication method for a medical device system. The method involves: supporting a first wireless data communication mode between a first device in the medical device system and a second device in the medical device system; supporting a second wireless data communication mode between the first device and the second device; in the first wireless data communication mode, generating an alarm in response to an unacknowledged wireless data packet; and in the second wireless data communication mode, providing a best effort quality of service between the first device and the second device regardless of wireless data packet acknowledgement status.

[0008] In addition, an embodiment of a medical device system may employ a wireless data communication signal having data fields transmitted over a wireless data communication channel between a first device in a medical device system and a second device in the medical device system. The wireless data communication signal includes a data field including data representing a selected one of a plurality of supported wireless data communication modes, each of the supported wireless data communication modes correspond-

ing to a different set of RF link characteristics for the wireless data communication channel.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] A more complete understanding of the present invention may be derived by referring to the detailed description and claims when considered in conjunction with the following figures, wherein like reference numbers refer to similar elements throughout the figures.

[0010] FIG. **1** is a schematic representation of a network-based infusion system configured in accordance with an example embodiment of the invention;

[0011] FIG. **2** is a front view of a bedside infusion system monitor configured in accordance with an example embodiment of the invention;

[0012] FIG. **3** is a front view of a hospital infusion system monitor configured in accordance with an example embodiment of the invention;

[0013] FIG. **4**A is a front view of a handheld infusion system monitor/controller configured in accordance with example embodiment of the invention;

[0014] FIG. **4**B is a front view of a handheld infusion system monitor/controller configured in accordance with another example embodiment of the invention;

[0015] FIG. **5** is a schematic representation of an infusion system monitor configured in accordance with an example embodiment of the invention;

[0016] FIG. **6** is a schematic representation of a network interface suitable for use with the infusion system monitor depicted in FIG. **5**;

[0017] FIG. **7** is a schematic representation of a network communication module suitable for use with the infusion system monitor depicted in FIG. **5**;

[0018] FIG. **8** is a schematic representation of a network-based infusion system configured in accordance with an example embodiment of the invention;

[0019] FIG. **9** is a flow chart that depicts an example network-based infusion system monitoring process;

[0020] FIG. **10** is a flow chart that depicts an example network-based infusion system communication process;

[0021] FIG. **11** is a flow chart that depicts an example network-based infusion pump monitoring and control process;

[0022] FIGS. **12-17** are screen shots that may be generated by monitor devices, controller devices, network devices, display devices, and/or other infusion system devices configured in accordance with example embodiments of the invention;

[0023] FIG. **18** is a perspective view of a data communication translation device configured in accordance with an example embodiment of the invention;

[0024] FIG. **19** is a schematic representation of a data communication translation device configured in accordance with an example embodiment of the invention;

[0025] FIG. **20** is a flow chart that depicts an example data storage and translation process;

[0026] FIG. **21** is a schematic representation of an example network deployment of a wireless telemetry router configured in accordance with an example embodiment of the invention;

[0027] FIG. **22** is a schematic and generalized representation of a medical device having wireless data communication and wireless networking capabilities;

[0028] FIG. **23** is a diagram of a portion of a data packet that contains data fields representing different dynamic link parameters corresponding to supported wireless data communication modes;

[0029] FIG. **24** is a flow chart that illustrates an exemplary key generation process;

[0030] FIG. **25** is a flow chart that illustrates a synchronized wireless communication process suitable for use in a wireless medical device network;

[0031] FIG. **26** is a diagram that depicts data packet exchanges in accordance with the process shown in FIG. **25**;

[0032] FIG. **27** is a flow chart that illustrates an asynchronous wireless communication process suitable for use in a wireless medical device network;

[0033] FIG. **28** is a diagram that depicts data packet exchanges in accordance with the process shown in FIG. **27**;

[0034] FIG. **29** is a flow chart that illustrates a synchronous master-slave wireless communication process suitable for use in a wireless medical device network;

[0035] FIG. **30** is a diagram that depicts data packet exchanges in accordance with the process shown in FIG. **29**;

[0036] FIG. **31** is a diagram that depicts two subnetworks of wireless medical devices in a medical device network;

[0037] FIG. **32** is a flow chart that illustrates a broadcast transmission process suitable for use in a wireless medical device network;

[0038] FIG. **33** is a diagram that depicts data packet exchanges in accordance with the process shown in FIG. **32**;

[0039] FIG. **34** is a flow chart that illustrates a wireless repeating process suitable for use in a wireless medical device network;

[0040] FIG. **35**A is a diagram that depicts data packet exchanges in accordance with the process shown in FIG. **34**;

[0041] FIG. **35**B is a diagram that represents a wireless annunciating and repeating process and system;

[0042] FIG. **36** is a flow chart that illustrates a link reliability selection process suitable for use in a wireless medical device network;

[0043] FIG. **37** is a flow chart that illustrates an auto device detection process suitable for use in a wireless medical device network;

[0044] FIG. **38** is a flow chart that illustrates a new device detection process suitable for use in a wireless medical device network;

[0045] FIG. **39** is a flow chart that illustrates a synchronization protocol selection process suitable for use in a wireless medical device network;

[0046] FIG. **40** is a flow chart that illustrates a dynamic frequency hopping process suitable for use in a wireless medical device network;

[0047] FIG. **41** is a flow chart that illustrates a retry periodicity selection process suitable for use in a wireless medical device network; and

[0048] FIG. **42** is a flow chart that illustrates a transmit timing selection process suitable for use in a wireless medical device network.

DETAILED DESCRIPTION

[0049] The following detailed description is merely illustrative in nature and is not intended to limit the embodiments of the invention or the application and uses of such embodiments. Furthermore, there is no intention to be bound by any

expressed or implied theory presented in the preceding technical field, background, brief summary or the following detailed description.

[0050] Embodiments of the invention may be described herein in terms of functional and/or logical block components and various processing steps. It should be appreciated that such block components may be realized by any number of hardware, software, and/or firmware components configured to perform the specified functions. For example, an embodiment of the invention may employ various integrated circuit components, e.g., memory elements, digital signal processing elements, logic elements, look-up tables, or the like, which may carry out a variety of functions under the control of one or more microprocessors or other control devices. In addition, those skilled in the art will appreciate that embodiments of the present invention may be practiced in conjunction with any number of data transmission protocols and that the system described herein is merely one example embodiment of the invention.

[0051] For the sake of brevity, conventional techniques related to infusion system operation, insulin pump and/or infusion set operation, blood glucose sensing and monitoring, signal processing, data transmission, signaling, network control, and other functional aspects of the systems (and the individual operating components of the systems) may not be described in detail here. Examples of infusion sets that may be used as a delivery device are described in, but not limited to, U.S. Patents: U.S. Pat. Nos. 4,723,947; 4,755,173; 5,176,662; 5,584,813; 6,056,718; 6,461,329; 6,475,195; 6,520,938; 6,585,695; 6,591,876; and 6,607,509, which are herein incorporated by reference. Examples of infusion pumps and/or communication options may be of the type described in, but not limited to, U.S. Patents: U.S. Pat. Nos. 4,562,751; 4,685,903; 5,080,653; 5,505,709; 5,097,122; 6,554,798; 6,558,320; 6,558,351; 6,641,533; 6,659,980; 6,752,787; 6,817,990; and 6,932,584, which are herein incorporated by reference. Examples of glucose sensing and/or monitoring devices maybe be of the type described in, but not limited to, U.S. Patents: U.S. Pat. Nos. 6,484,045; 6,809,653; 6,892,085; and 6,895,263, which are herein incorporated by reference. Furthermore, the connecting lines shown in the various figures contained here are intended to represent example functional relationships and/or physical couplings between the various elements. It should be noted that many alternative or additional functional relationships or physical connections may be present in an embodiment.

[0052] The following description may refer to elements or nodes or features being "connected" or "coupled" together. As used herein, unless expressly stated otherwise, "connected" means that one element/node/feature is directly joined to (or directly communicates with) another element/node/feature, and not necessarily mechanically. Likewise, unless expressly stated otherwise, "coupled" means that one element/node/feature is directly or indirectly joined to (or directly or indirectly communicates with) another element/node/feature, and not necessarily mechanically. Thus, although each of the schematic block diagrams depicts one example arrangement of elements, additional intervening elements, devices, features, or components may be present in an embodiment of a device, system, or network.

[0053] FIG. **1** is a schematic representation of a network-based medical device system **100** configured in accordance with an example embodiment of the invention. In this example, system **100** is an insulin infusion system that controls the infusion of insulin into the body of a user. Aspects of the invention, however, may also be utilized in the context of other medical device systems. Briefly, system **100** includes a local infusion system **102** having one or more local devices that communicate (unidirectional or bidirectional) with one or more network devices **104**. As used here, network devices **104** are "external" to local infusion system **102** because they need not utilize the local data communication protocols and techniques employed within local infusion system **102**, and because they need not be in close physical proximity to the local devices within local infusion system **102**. The manner in which a given local device within local infusion system **102** communicates with a given network device **104** may vary depending upon the particular configuration of system **100**, the characteristics of that local device, and the characteristics of that network device **104**. For example, network communications may be routed using one data communication network **106**, using a plurality of data communication networks **108**/**110**, using a direct wireless or wired connection **112**, or the like. In one example embodiment, data from wireless devices within local infusion system **102** (and/or data from wireless devices associated with different local infusion systems) may be collected by a wireless telemetry router device that serves as an interface to one or more network devices **104**. One example wireless telemetry router device is described in more detail below in connection with FIG. **21**.

[0054] Data communicated within local infusion system **102** and/or between devices within local infusion system **102** and network devices **104** may include or represent, without limitation: physiologic patient data, device status information, time and date information, alarm/alert status, and other information related to the operation, status, or condition of the patient, related to any of the devices within local infusion system **102**, or related to local infusion system **102** itself. For example, such data may include or represent bolus information, basal information, or sensor information. Such data may also include or represent information entered by the patient, a caregiver, or another person having access to a local device or a network device **104**, such as, without limitation: reminders; event markers (for meals, exercise, or the like); alarms; notifications; or the like.

[0055] In one embodiment, devices within local infusion system **102** can communicate with network devices **104** via a suitably configured translation device, system, or application **113**. For example, such a translation device **113** may be configured to communicate with devices within local infusion system **102** using a suitable RF data communication protocol (which may be published or proprietary), while coupling to one or more network devices **104** via a standardized data communication interface such as USB, IEEE 1394, or the like. The translation device **113** may also be provisioned with flash memory capability such that patients or caregivers can save data received from a device in a portable storage device and physically transport the storage device to any compatible computing device, e.g., a personal computer at a doctor's office. One example translation device is described in more detail below in connection with FIGS. **18**-**20**.

[0056] As used here, a "data communication network" represents any number of physical, virtual, or logical components, including hardware, software, firmware, and/or processing logic configured to support data communication between an originating component and a destination com-

ponent, where data communication is carried out in accordance with one or more designated communication protocols over one or more designated communication media. Communication hardware utilized by a data communication network may include a mechanically detachable unit such as an SDIO, a USB ready wireless module, or the like. For example, data communication network **106** may include, without limitation: a computer network such as a local area network or a wide area network; a pager network; a cellular telecommunication network; a cordless telephone system; an 802.11 network (WiFi); an 802.16 network (WiMAX); the Internet; IEEE P1901 BPL (Broadband over Power Lines); a hospital data communication network (WMTS or other); a home network, such as a home control network, a home security system, or a home alarm system; the public switched telephone network; a satellite communication network; or the like. In embodiments, network communications between local infusion system **102** and network devices **104** may be routed by two or more different types of data communication networks using known or proprietary network interfacing techniques.

[0057] The flexible nature of network-based infusion system **100** is illustrated in FIG. **1**, which depicts local infusion system **102** in communication with a variety of external and remote network devices **104**. In an embodiment, local devices within local infusion system **102** may be suitably configured to support the transmission of network communications to: a stationary monitor device **114**, such as a bedside monitor or a piece of hospital monitoring equipment; a portable computer **116**, such as a laptop PC, a palmtop PC, or a tablet PC; a stationary computer **118**, such as a desktop PC; a personal digital assistant **120**, which may also be a portable email device; a smart phone **122**, which may also be a portable email device; a wireless phone **124**, such as a cellular phone or a cordless phone; one or more additional computing devices or databases **126**; or the like. As described in more detail below, these local devices need not communicate only via a local network interface and such devices may communicate using other means. The above list of possible network devices **104** is not exhaustive, and an implementation of system **100** can be designed to accommodate network communication with other network systems, equipment, computing devices, components, and elements that are external to local infusion system **102**.

[0058] In one embodiment, local infusion system **102** is realized as an insulin infusion system that is locally controlled and monitored by the patient. In this example, local infusion system **102** includes at least an infusion pump **128**. Local infusion system **102** may also include any of the following components, without limitation: a physiological characteristic sensor **130**, such as a continuous glucose sensor (which may include a wireless transmitter); a portable display device **132**; a remote control device **134**; a BG meter **136** or other physiological characteristic meter; a command display controller **138** for infusion pump **128**; and a monitor device **140**, which may be realized as a bedside monitor or a hospital monitor. Each of these local devices is described in more detail below.

[0059] As depicted in FIG. **1**, these local devices may be configured to transmit and receive local communications within local infusion system **102**, where such local communications are transmitted and received in accordance with one or more specified local data communication protocols. For example, local communications may be exchanged between local devices using one or more wireless data communication protocols (which may leverage RF, infrared, magnetic induction, or other wireless techniques) and/or using one or more wired data communication protocols. Local infusion system **102** may be flexibly configured such that any given local device can communicate with any other local device, and a communication link or path between two local devices may be unidirectional or bidirectional. FIG. **1** depicts an example embodiment where each communication link or path is bidirectional (represented by double headed arrows).

[0060] Infusion pump **128** is configured to deliver fluid, such as insulin, into the body of a user via, for example, an infusion set. In accordance with one example embodiment, infusion pump **128** serves as a central hub, and most of the processing logic and intelligence for local infusion system resides at infusion pump **128**. In some embodiments, the local medical device system need not include infusion pump **128**, for example, monitoring systems utilized in conjunction with traditional insulin injection therapy. Moreover, infusion pump **128** need not include a display. In an embodiment that lacks a display, portable display device **132**, remote control device **134**, command display controller **138**, or any other device within local infusion system **102** may serve as a remote display for infusion pump **128**. Other options for a remote display include, but are not limited to, any of the network devices **104** described above, e.g., wireless phone **124**, monitor device **114**, portable computer **116**, or personal digital assistant **120**.

[0061] In practice, operation of infusion pump **128** may be remotely controlled by command display controller **138** (which may be realized as a handheld monitor/controller for infusion pump **128**), by remote control device **134**, and/or by or monitor **140**. In one example embodiment, BG meter **136** may include the functionality of a controller device such that both components share a single housing. One such BG meter is described in U.S. patent application Ser. No. 11/204,667, titled "Controller Device for an Infusion Pump," the content of which is incorporated by reference herein. Control of infusion pump **128** may also be possible via a suitably configured user interface located at infusion pump **128** itself.

[0062] Local infusion system **102** may also include physiologic characteristic sensor **130**, which is suitably configured to measure a physiologic characteristic of the patient. In addition, sensor **130** may include processing and control logic that enables it to control the operation of infusion pump **128**. Such control may be responsive to measurements obtained by sensor **130**. In the example system described here, sensor **130** is a continuous BG sensor that measures the BG level of the patient in real time. Sensor **130** may include a wireless transmitter that facilitates transmission of physiologic data of the user to other devices within local infusion system **102**. Alternatively, sensor **130** may be directly wired to a monitor/user interface. Sensor **130** may also be linked to monitor **140** so that monitoring and programming of medication delivery may be performed remotely. Alternatively sensor **130** may communicate directly with devices in the external network space, e.g., via Bluetooth, ZigBee or the like.

[0063] Local devices can process the received sensor data in an appropriate manner. For example, portable display device **132**, remote control device **134**, BG meter **136**, command display controller **138**, monitor **140**, or infusion pump **128** may display the current BG level derived from the

received sensor data and/or generate an alert or otherwise indicate low or high BG levels. As another example, BG meter **136** or infusion pump **128** may process the received sensor data for purposes of calibration. As yet another example, infusion pump **128** may be configured to activate its infusion mechanism in response to the received sensor data. Moreover, sensor data could be processed in one or more of the local devices and/or in one or more of network devices **104**. In this regard, system **100** may utilize distributed processing techniques for the handling of sensor data.

[0064] Any of the devices within local infusion system **102** may include a display and related processing logic that facilitates the display of physiologic patient data, device status information, time and date information, alarm/alert status, and other information related to the operation, status, or condition of the patient, related to any of the devices within local infusion system **102**, or related to local infusion system **102** itself. Portable display device **132** may be realized as a small device having limited functionality. In this regard, portable display device **132** may be incorporated into a key fob, a carabiner, a pendant, an insulin pen, a credit card display, or the like. Other local devices may have expanded display capabilities related to the specific functionality of such devices. For example, BG meter **136** may include display features that are specific to its metering functionality.

[0065] BG meter **136** is generally configured to measure the BG level of a user by analyzing a blood sample. For example, BG meter **136** may include a receptacle for receiving a blood sample test strip. In this regard, the user inserts a test strip into the BG meter **136**, which analyzes the sample and displays a BG level corresponding to the test strip sample. BG meter **136** may be configured to generate a local communication, which conveys the measured BG level, for transmission to other local devices within local infusion system **102**. Depending upon the specific application, BG meter **136** may also include the functionality of a monitoring device for infusion pump **128** and/or the functionality of a controller device for infusion pump **128**.

[0066] Command display controller **138** is preferably realized as a handheld monitor/controller device that, although physically separate from infusion pump **128**, enables the user to monitor and control the operation of infusion pump **128**. This allows the user to operate infusion pump **128** without physically handling the device. As described in more detail below, command display controller **138** includes a communication module for transmitting local communications or commands to infusion pump **128**. In further embodiments, command display controller **138** may receive local communications sent from infusion pump **128** or other components within local infusion system **102**. In example embodiments, command display controller **138** also includes a network communication module for handling network communications to and from network devices that are external to local infusion system **102**. Further, command display controller **138** may include one or more user input elements on its housing, such as keys, buttons, or the like, which accommodate user inputs. In embodiments, command display controller **138** includes a display on its housing, which may be configured to concurrently reproduce at least a portion of the information displayed on infusion pump **128**.

[0067] Monitor **140**, which may be realized as a bedside monitor for personal use or as a hospital monitor for caregiver use, enables remote monitoring of infusion pump **128** (and possibly other devices within local infusion system **102**). Monitor **140** and other monitors described herein may be utilized in applications that do not utilize infusion pump **128**; for example, applications that monitor patient data (such as glucose levels). In addition, monitor **140** may be suitably configured to enable remote programming and control of infusion pump **128** and/or other devices within local infusion system **102**. In this regard, a "monitor" as used herein can generally refer to a monitor-only device or a monitor-controller device. In practice, monitor **140** is a relatively large device in comparison to portable or handheld devices of infusion system **102**. In contrast to remote control device **134**, portable display device **132**, and command display controller **138**, monitor **140** is intended to be somewhat stationary and not carried by the user. For example, a bedside monitor may be located on a nightstand beside the patient's bed, while a hospital monitor may be located on a medical equipment cart or stand in the patient's room. In contrast to the smaller portable devices of local infusion system **102**, monitor **140** preferably includes a large and easy to read display element, which may be configured to concurrently reproduce at least a portion of the information displayed on infusion pump **128**.

[0068] As described above in connection with command display controller **138**, monitor **140** may also be configured to allow the user to remotely operate infusion pump **128**. Monitor **140** may include a communication module for receiving and/or transmitting local communications within local infusion system **102**. Moreover, monitor **140** may include a network communication module for handling network communications to and from network devices that are external to local infusion system **102**. Further, monitor **140** may include one or more user input elements on its housing, such as keys, buttons, or the like, which accommodate user inputs.

[0069] As shown in FIG. **1**, local infusion system **102** is capable of establishing many potential communication paths between the local devices. In embodiments, a controller device (e.g., remote control device **134**, command display controller **138**, or monitor **140**) may serve as a translator between infusion pump **128** and the other components of local infusion system **102**, such as BG meter **136**. For example, the controller device may have the ability to determine how best to translate data received from infusion pump **128** for compatibility with the display requirements of a destination device within local infusion system **102**. As depicted in FIG. **1**, infusion pump **128** may communicate directly with BG meter **136**. In some embodiments, local infusion system **102** may include multiple controllers that can communicate with infusion pump **128**. In other embodiments, only one controller device can communicate with infusion pump **128** at any given moment. The controller device functionality may also be integrated into infusion pump **128** in some embodiments. In yet another embodiment, BG meter **136** may be integrated into the controller device such that both features share a single device housing.

[0070] FIG. **2** is a front view of an example bedside monitor **200** configured in accordance with an example embodiment of the invention. Referring to FIG. **1**, bedside monitor **200** may be deployed in local infusion system **102** (as monitor **140**) and/or as a network device **104** (e.g., as monitor **114**). Bedside monitor **200** may, but need not, be utilized to monitor the activity of an insulin infusion pump. Bedside monitor **200** generally includes a housing **202**, a

stand **204** that supports housing **202**, a display element **206**, and user interface features **208**. Embodiments of bedside monitor **200** may include an AC power plug **210**, one or more speakers **212**, one or more local device interfaces **214**, and one or more network interfaces **216**.

[0071] As mentioned above, bedside monitor **200** is intended to be used as a somewhat stationary fixture placed in a suitable location, such as on the patient's nightstand. In other words, bedside monitor **200** is not designed to be a portable or handheld component. Therefore, housing **202** may be sized to accommodate a relatively large display element **206**, which may utilize any known display technology (e.g., a cathode ray tube, an LCD panel, or a plasma panel). The size of display element **206** may vary to suit the needs of the particular application; typical sizes can range from 10 diagonal inches to 20 diagonal inches. Housing **202** may also be configured to accommodate integral speakers **212**, which can be activated to generate alarm or alert notifications. Housing **202** may also be designed to accommodate user interface features **208** as shown in FIG. **2**. Stand **204** is suitably configured to support housing **202** and to provide a stable mounting location for bedside monitor **200**. In the example embodiment shown in FIG. **2**, stand **204** is also configured to accommodate one or more user interface features **208**. User interface features **208** may include a keypad, keys, buttons, switches, knobs, a touchpad, a joystick, a pointing device, a virtual writing tablet, or any device, component, or function that enables the user to select options, input information, or otherwise control the operation of bedside monitor **200**.

[0072] Bedside monitor **200** may include processing logic, a display driver, and memory (not shown in FIG. **2**) that is suitably configured to display information on display element **206**. In embodiments, bedside monitor **200** functions to display information requested by the user, to display information related to an instructed act that was undertaken by the infusion pump, or to display status data for the infusion pump, such as, for example, BG levels, BG trends or graphs, or fluid delivery information. Bedside monitor **200** may be configured to display information conveyed in local communications received from an infusion pump or from any device within the local infusion system. At any moment, display element **206** may show substantially the same information as shown on the infusion pump; the two displays may mimic one another so that the user may choose to conveniently view the selected information from bedside monitor **200** rather than from the infusion pump, which is usually attached to the patient's body through an infusion set. Display element **206** may also include a backlight to facilitate viewing. The backlight may be a user programmable multi-color backlight that additionally performs the function of a visual indicator by flashing colors appropriate to the level of an alert or alarm. The backlight may also have variable intensity (automatic or manual) to accommodate user preferences and/or to indicate different alert or alarm status.

[0073] As described in more detail below, bedside monitor **200** may include one or more communication modules (not shown in FIG. **2**) that facilitate data communication between bedside monitor **200** and other local devices within the local infusion system and/or data communication between bedside monitor **200** and network devices that are external to the local infusion system. For example, a local communication module may cooperate with a local device interface to receive local communications from local devices and/or to transmit local communications to local devices. The local communication module and local device interface may be configured to support wireless and/or wired data communication protocols. In an embodiment, local device interface **214** may represent a physical interface (such as a plug, a jack, a connector, a USB port, etc.) that facilitates connection to a data communication cable or any suitably configured physical component that establishes a communication link to a local device. As another example, a network communication module may cooperate with a network interface to receive network communications from network devices and/or to transmit network communications to network devices. The network communication module and network interface may be configured to support wireless and/or wired data communication protocols. In an embodiment, network interface **216** may represent a physical interface (such as a plug, a jack, a connector, a USB port, etc.) that accommodates a data communication cable or any suitably configured physical component that establishes a communication link to a network device. Bedside monitor **200** may also utilize one or more wireless local device interfaces and one or more wireless network interfaces, however, such wireless interfaces may not be visible from points outside housing **202**.

[0074] FIG. **3** is a front view of an example hospital monitor **300** configured in accordance with an example embodiment of the invention. Hospital monitor **300** is similar to bedside monitor **200**, and both monitors include some shared features and functionality. For the sake of brevity, such common features and functions will not be redundantly described here. Hospital monitor **300** is generally configured to display and/or process information in an appropriate manner. Such information may be, for example, alarms, alerts, or any of the information or data types described above with respect to FIG. **1**, regardless of the location or device that originally generated or processed such information/data. Generally, referring to FIG. **1**, hospital monitor **300** may be deployed in local infusion system **102** (as monitor **140**) and/or as a network device **104** (e.g., as monitor **114**). Hospital monitor **300** generally includes a housing **302**, a display element **304**, user interface features **306**, an AC power plug **308**, one or more speakers (hidden from view in FIG. **3**), one or more local device interfaces **310**, and one or more network interfaces **312**. In this example embodiment, hospital monitor **300** also includes an integrated infusion pump that delivers fluid to the patient via a delivery tube **314**.

[0075] Hospital monitor **300** is intended to be used as a somewhat stationary fixture placed in a suitable location, such as on a cart or an equipment rack in the patient's room. In other words, hospital monitor **300** is not designed to be a portable or handheld component. Hospital monitor **300** is suitably configured to operate substantially as described above with respect to bedside monitor **200**. In contrast to bedside monitor **200**, however, hospital monitor **300** may include an infusion pump and control features related to the operation of the infusion pump. Moreover, hospital monitor **300** may employ a network communication module and a network interface that cooperate to receive network communications from hospital network devices and/or to transmit network communications to hospital network devices. As used here, a "hospital network" refers to any number of physical or logical components, including hardware, soft-

ware, firmware, and/or processing logic configured to support data communication between an originating component and a destination component, where data communication is carried out in accordance with one or more communication protocols that are reserved for, or utilized in, hospital environments.

[0076] FIG. **4**A is a front view of a handheld monitor/controller **400** configured in accordance with an example embodiment of the invention. Handheld monitor/controller **400** is similar to bedside monitor **200**, and both monitors include some shared features and functionality. For the sake of brevity, such common features and functions will not be redundantly described here. Referring to FIG. **1**, handheld monitor/controller **400** may be deployed in local infusion system **102** (as command display controller **138** or remote control device **134**) and/or as a network device **104** (e.g., as personal digital assistant **120**). Handheld monitor/controller **400** generally includes a housing **402**, a display element **404**, user interface features **406**, one or more speakers **408**, one or more local device interfaces (not shown), and one or more network interfaces (not shown).

[0077] Handheld monitor/controller **400** is intended to be used as a portable and mobile device that can be carried by the user. In particular embodiments, handheld monitor/controller **400** supports wireless communication with the patient's infusion pump, and the telemetry range of handheld monitor/controller **400** is localized. Handheld monitor/controller **400** is suitably configured to operate substantially as described above in connection with bedside monitor **200**. Although the example embodiment utilizes a wireless local device interface and a wireless network interface, handheld monitor/controller **400** may also include wired interfaces to accommodate direct physical connections to other devices within the local infusion system and/or to network devices external to the local infusion system.

[0078] The power of handheld monitor/controller **400** (and of the other portable devices discussed here) may be provided by a battery. The battery may be a single use or a rechargeable battery. Where the battery is rechargeable, there may be a connector or other interface on handheld monitor/controller **400** for attaching the device to an electrical outlet, docking station, portable recharger, or so forth to recharge the battery while the battery remains in housing **402**. It is also possible that a rechargeable battery may be removable from housing **402** for external recharging. In practice, however, the rechargeable battery may be sealed into housing **402** to create a more water resistant or waterproof component. In further embodiments, handheld monitor/controller **400** may be adapted to accommodate more than one type of battery. For example, handheld monitor/controller **400** may be configured to accommodate a rechargeable battery and (for backup or emergency purposes) a readily available battery type, such as a AA battery, a AAA battery, or a coin cell battery.

[0079] FIG. **4**B is a front view of a handheld monitor/controller **410** configured in accordance with another example embodiment of the invention. Handheld monitor/controller **410** is similar to handheld monitor/controller **400**, and both devices include some shared features and functionality. For the sake of brevity, such common features and functions will not be redundantly described here.

[0080] Handheld monitor/controller **410** preferably includes wireless data communication functionality that enables it to handle wireless local communications and/or wireless network communications. In addition, handheld monitor/controller **410** may include a wired or cabled network interface **412**, which may be realized as a cable connector, jack, plug, or receptacle. FIG. **4**B depicts example content displayed on a display element **414** of handheld monitor/controller **410**. This content represents one particular "screen shot" for handheld monitor/controller **410**; in practice any number of different display screens can be generated to suit the intended functionality and features of the device. The example screen shot of FIG. **4**B includes a clock display, an RF quality indicator **416**, a battery indicator **418**, a fluid level indicator **420** that represents the amount of fluid remaining in the infusion pump, a current BG value for the patient (**240** in this example), and a recommended bolus (**4.3** units in this example). Handheld monitor/controller **410** may also display one or more prompts that provide guidance or instruction to the user. In this example, display element **414** includes the prompt: "Press 'OK' to Continue". The user can press "OK" to display other options, such as an activation request that controls the infusion pump to administer the recommended bolus.

[0081] FIG. **5** is a schematic representation of a medical device system monitor **500** configured in accordance with an example embodiment of the invention. Monitor **500** represents a generalized embodiment that may be realized as a bedside monitor, a hospital monitor, or a handheld monitor/controller, depending upon its specific configuration. In this example, monitor **500** generally includes a local device interface **502**, a local communication module **504**, a display element **506**, one or more user interface features **508**, a network communication module **510**, a network interface **512**, a processing architecture **514**, and a suitable amount of memory **516**. If monitor **500** is implemented as a hospital monitor, then it may also include an infusion pump **518** and a pump controller **520** that controls the operation of infusion pump **518** (these elements are depicted in dashed lines to indicate their optional nature). The elements of monitor **500** may be coupled together via a bus **522** or any suitable interconnection architecture.

[0082] Those of skill in the art will understand that the various illustrative blocks, modules, circuits, and processing logic described in connection with monitor **500** (and other devices, elements, and components disclosed here) may be implemented in hardware, computer software, firmware, or any combination of these. To clearly illustrate this interchangeability and compatibility of hardware, firmware, and software, various illustrative components, blocks, modules, circuits, and processing steps may be described generally in terms of their functionality. Whether such functionality is implemented as hardware, firmware, or software depends upon the particular application and design constraints imposed on the embodiment. Those familiar with the concepts described here may implement such functionality in a suitable manner for each particular application, but such implementation decisions should not be interpreted as causing a departure from the scope of the present invention.

[0083] Referring again to FIG. **5**, display element **506** and user interface features **508** were described above in connection with bedside monitor **200**, hospital monitor **300**, and handheld monitor/controller **400**. Briefly, display element **506** is suitably configured to enable monitor **500** to display physiologic patient data, local device status information, clock information, alarms, alerts, and any information/data

received or processed by monitor **500**. For example, display element **506** may be controlled to indicate an alert or alarm status when monitor **500** receives an incoming communication (from a local device within the infusion system or from a network device external to the infusion system) that conveys an alert signal or an alarm signal. User interface features **508** enable the user to control the operation of monitor **500**. In one example embodiment, user interface features **508** enable the user to control the operation of one or more additional devices within the local infusion system, for example, an infusion pump. Moreover, monitor **500** may be configured such that user interface features **508** can be manipulated to control the operation of one or more network devices that are external to the local infusion system.

[0084] Processing architecture **514** may be implemented or performed with a general purpose processor, a content addressable memory, a digital signal processor, an application specific integrated circuit, a field programmable gate array, any suitable programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination designed to perform the functions described here. A processor may be realized as a microprocessor, a controller, a microcontroller, or a state machine. Moreover, a processor may be implemented as a combination of computing devices, e.g., a combination of a digital signal processor and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a digital signal processor core, or any other such configuration.

[0085] In practice, processing architecture **514** may be suitably configured to interpret and process incoming information, data, and content that is conveyed in local communications received from a transmitting device within the local infusion system. Referring to FIG. **1**, the transmitting device may be any of the devices within local infusion system **102**, including another monitor device. Such incoming information may include, without limitation: physiologic data of the user, such as a BG level (a calibrated reading or a raw measured value); status information of the transmitting local device (e.g., a battery life indication, a power on/off status, a transmit signal power level, diagnostic information indicating results of self tests); an alert signal related to operation of the transmitting local device (e.g., a low battery alert, an out of range alert, a calibration reminder); a basal rate of fluid delivered to the user by an infusion pump; bolus information for a bolus of fluid delivered to the user by an infusion pump; advisory information for the patient (e.g., a notification to place an order for supplies, a reminder to schedule a doctor's appointment, a reminder to schedule or automatically execute a data download for analysis by a caregiver, a notification to perform routine diagnostics, either manually or remotely via a network connection); or the like.

[0086] Processing architecture **514** may also be configured to interpret and process incoming information, data, and content that is conveyed in network communications generated by an originating device that is external to the local infusion system. Referring to FIG. **1**, the originating device may be any network device **104**, including a networked monitor device. Such incoming network information may include, without limitation: programming data for a local device within the infusion system; an activation instruction for an infusion pump or another local device within the infusion system; a status request for a local device within the infusion system; a request for physiologic data of the user; an alert or alarm enable or disable instruction for a local device within the infusion system (which may be processed by monitor **500** and/or routed by monitor **500** to the appropriate local device); advisory information for the patient (e.g., a notification to place an order for supplies, a reminder to schedule a doctor's appointment, a reminder to schedule or automatically execute a data download for analysis by a caregiver, a notification to perform routine diagnostics, either manually or remotely via a network connection); or the like.

[0087] Memory **516** may be realized as RAM memory, flash memory, EPROM memory, EEPROM memory, registers, a hard disk, a removable disk, a CD-ROM, or any other form of storage medium known in the art. In this regard, memory **516** can be coupled to processing architecture **514** such that processing architecture **514** can read information from, and write information to, memory **516**. In the alternative, memory **516** may be integral to processing architecture **514**. As an example, processing architecture **514** and memory **516** may reside in an ASIC. In this example, memory **516** may be utilized to store device status data **524** and/or physiologic data **526** of the user, where such data is communicated to monitor **500** via local communications, network communications, or directly (for example, if monitor **500** is configured to receive BG data directly from a test strip or via direct user input).

[0088] Monitor **500** may be configured to communicate with a remote database or databank that is accessible via a network connection. Referring to FIG. **1**, for example, a network device **104** in system **100** may be realized as a network database **126** that provides data to monitor **500**. In such an embodiment, monitor **500** can download data from the remote database as necessary, store it in memory **516** if needed, or otherwise process the downloaded data in an appropriate manner.

[0089] An embodiment of monitor **500** may employ any number of local communication modules **504** and any number of local device interfaces **502**. For simplicity, the example described here employs one local communication module **504** and one local device interface **502**. Local communication module **504** and local device interface **502** are suitably configured to support local communications between monitor **500** and devices within the local infusion system (e.g., any of the devices in infusion system **102** shown in FIG. **1**). Depending upon the particular implementation, local communication module **504** and local device interface **502** may be configured to support unidirectional communication from monitor **500** to one or more local devices, unidirectional communication from one or more local devices to monitor **500**, or bidirectional communication between monitor **500** and one or more local devices. Thus, local device interface **502** may be configured to receive a local communication from a transmitting device within the local infusion system, and/or to transmit a local communication to a receiving device within the local infusion system. Moreover, depending upon the particular implementation, local communication module **504** and local device interface **502** may be configured to support wireless data communication, wired/cabled data communication, or both.

[0090] For wireless transmissions of local communications, local communication module **504** and local device interface **502** support one or more wireless data communi-

cation protocols that are also supported by the local device (s) communicating with monitor **500**. Any number of suitable wireless data communication protocols, techniques, or methodologies may be supported by monitor **500**, including, without limitation: RF; IrDA (infrared); Bluetooth; ZigBee (and other variants of the IEEE 802.15 protocol); IEEE 802.11 (any variation); IEEE 802.16 (WiMAX or any other variation); Direct Sequence Spread Spectrum; Frequency Hopping Spread Spectrum; cellular/wireless/cordless telecommunication protocols; wireless home network communication protocols; paging network protocols; magnetic induction; satellite data communication protocols; wireless hospital or health care facility network protocols such as those operating in the WMTS bands; GPRS; and proprietary wireless data communication protocols such as variants of Wireless USB. In an embodiment, a wireless local device interface **502** may include or be realized as hardware, software, and/or firmware, such as an RF front end, a suitably configured radio module (which may be a stand alone module or integrated with other or all functions of the device), a wireless transmitter, a wireless receiver, a wireless transceiver, an infrared sensor, an electromagnetic transducer, or the like.

[0091] For transmissions of local communications over a cable, a wired connection, or other physical link, local communication module **504** and local device interface **502** support one or more wired/cabled data communication protocols that are also supported by the local device(s) communicating with monitor **500**. Any number of suitable data communication protocols, techniques, or methodologies may be supported by monitor **500**, including, without limitation: Ethernet; home network communication protocols; USB; IEEE 1394 (Firewire); hospital network communication protocols; and proprietary data communication protocols. In an embodiment, a wired/cabled local device interface **502** may include or be realized as hardware, software, and/or firmware, such as a suitably configured and formatted port, connector, jack, plug, receptacle, socket, adaptor, or the like.

[0092] An embodiment of monitor **500** may employ any number of network communication modules **510** and any number of network interfaces **512**. For simplicity, the described example employs one network communication module **510** and one network interface **512**. Network communication module **510** and network interface **512** are suitably configured to support network communications between monitor **500** and network devices that are external to the local infusion system (e.g., one or more of the network devices **104** shown in FIG. **1**). Depending upon the particular implementation, network communication module **510** and network interface **512** may be configured to support unidirectional communication from monitor **500** to one or more network devices, unidirectional communication from one or more network devices to monitor **500**, or bidirectional communication between monitor **500** and one or more network devices. Thus, network device interface **512** may be configured to receive an incoming network communication from an originating network device, and/or to enable transmission of an outgoing network communication to a receiving network device. Moreover, depending upon the particular implementation, network communication module **510** and network interface **512** may be configured to support wireless data communication, wired/cabled data communication, or both.

[0093] For wireless transmissions of network communications, network communication module **510** and network interface **512** support one or more wireless data communication protocols that are also supported by the network device(s) communicating with monitor **500**. Any number of suitable wireless data communication protocols, techniques, or methodologies may be supported by monitor **500**, including, without limitation, the wireless protocols listed above. In an embodiment, a wireless network interface **512** may include or be realized as hardware, software, and/or firmware, as described above for a wireless local device interface **502**.

[0094] For transmissions of network communications over a cable, a wired connection, or other physical link, network communication module **510** and network interface **512** support one or more wired/cabled data communication protocols that are also supported by the network device(s) communicating with monitor **500**. Any number of suitable data communication protocols, techniques, or methodologies may be supported by monitor **500**, including, without limitation, the wired or cable based protocols listed above. In an embodiment, a wired/cabled network interface **512** may include or be realized as hardware, software, and/or firmware, as described above for a wired/cabled local device interface **502**.

[0095] FIG. **6** is a schematic representation of a generalized network interface **600** suitable for use with monitor **500**. For ease of description, network interface **600** is depicted as a general interface that includes a number of wireless and wired/cabled data communication aspects. Network interface **600** need not include multiple interfaces as depicted in FIG. **6** and, indeed, an embodiment may utilize only one specific type of interface. Network interface **600** generally includes an Ethernet interface **602**, an 802.11 interface **604**, a Bluetooth interface **606**, a paging network interface **608**, a cellular telecommunication network interface **610**, a hospital network interface **612**, a cordless telecommunication network interface **614**, a home network interface **616**, a satellite network interface **618**, and other network interfaces **620**.

[0096] Ethernet interface **602** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to accommodate Ethernet compliant network data communications with one or more network devices. For example, Ethernet interface **602** may include a T-568A Ethernet connector, a T-568B Ethernet connector, an RJ-45 connector, or any connector that is compatible with Ethernet cables.

[0097] 802.11 interface **604** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to accommodate 802.11 compliant network data communications with one or more network devices. For example, 802.11 interface **604** may include an appropriate radio module, an 802.11 transceiver card, an RF front end, an RF antenna, and/or 802.11 access point functionality.

[0098] Bluetooth interface **606** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to support Bluetooth compliant network data communications with one or more network devices. For

example, Bluetooth interface **606** may include an appropriate radio module, a Bluetooth transceiver, an RF front end, and/or an RF antenna.

[0099] Paging network interface **608** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to support network communications in compliance with a paging network protocol. For example, paging network interface **608** may include an appropriate radio module, a transceiver card, an RF front end, and/or an RF antenna.

[0100] Cellular telecommunication network interface **610** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to accommodate network communications in compliance with a cellular telecommunication protocol (e.g., CDMA, GSM, or the like). For example, cellular telecommunication network interface **610** may include an appropriate radio module, a transceiver card, an RF front end, and/or an RF antenna.

[0101] Hospital network interface **612** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to support network communications in compliance with a hospital network protocol. In embodiments, the hospital network protocol may be a wireless data communication protocol or a wired/cabled data communication protocol. In this regard, a wireless hospital network interface **612** may include an appropriate radio module, a transceiver card, an RF front end, an RF antenna, an infrared transmitter, an infrared sensor, a magnetic induction transducer, or the like. Depending upon the particular deployment, a wireless hospital network interface **612** may be compliant with any of the other wireless/cordless data communication protocols described here. A wired/cabled hospital network interface **612** may include suitably configured connectors, sockets, jacks, plugs, or adaptors. Moreover, depending upon the particular application, a wired/cabled hospital network interface **612** may be compliant with any of the other wired/cabled data communication protocols described here.

[0102] Cordless telecommunication network interface **614** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to support network communications in compliance with a cordless telecommunication protocol. Such protocols are commonly used in household cordless telephone systems. In practice, cordless telecommunication network interface **614** may include an appropriate radio module, a cordless telephone base station, a transceiver card, an RF front end, and/or an RF antenna.

[0103] Home network interface **616** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to support network communications in compliance with a home network protocol. Such home network protocols may be utilized in the context of a home control system, a home computing network that leverages existing telephone wires or existing AC power lines, a home security or alarm system, a home entertainment system, or the like. In embodiments, the home network protocol may be a wireless data communication protocol or a wired/cabled data communication protocol. In this regard, a wireless home network interface **616** may include an appropriate radio module, a transceiver base station, a transceiver card, an RF front end, an RF antenna, an infrared transmitter, an infrared sensor, a magnetic induction transducer, or the like. Depending upon the particular deployment, a wireless home network interface **616** may be compliant with any of the other wireless/cordless data communication protocols described here. A wired/cabled home network interface **616** may include suitably configured connectors, sockets, jacks, plugs, or adaptors. Moreover, depending upon the particular application, a wired/cabled home network interface **616** may be compliant with any of the other wired/cabled data communication protocols described here.

[0104] Satellite network interface **618** may include or be realized as hardware, software, and/or firmware that is suitably configured to cooperate with network communication module **510** to accommodate network communications in compliance with a satellite data communication protocol. For example, satellite network interface **618** may include an appropriate radio module, a transceiver card, an RF front end, and/or an RF antenna. Alternatively (or additionally), satellite network interface **618** may include suitably configured connectors, sockets, jacks, plugs, or adaptors that facilitate wired/cabled connection to a separate piece of satellite network equipment, e.g., a satellite dish or a satellite transceiver module.

[0105] In practice, network interface **600** may utilize any number of network interfaces **620** other than the specific types described above. Such other network interfaces **620** can be suitably configured to support network communications in accordance with existing data communication protocols, whether publicly known or proprietary. Moreover, other network interfaces **620** enable network interface **600** to support wireless or wired data communication protocols that may be developed in the future.

[0106] FIG. **7** is a schematic representation of a network communication module **700** suitable for use with monitor **500**. For ease of description, network communication module **700** is depicted as a general module that includes processing logic for handling different types of network communications. In practice, network communication module **700** need not support different modes of network communications as depicted in FIG. **7** and, indeed, an embodiment may process only one specific network communication format or type. Network communication module **700** generally includes email generation logic **702**, pager message generation logic **704**, text message generation logic **706**, voicemail generation logic **708**, phone dialing logic **710**, alert/alarm generation logic **712**, a web browser/server **714**, audio signal/file generation logic **716**, video signal/file generation logic **718**, control signal generation logic **720**, and other network communication generation logic **722**.

[0107] Email generation logic **702** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as email. For example, email generation logic **702** may generate automatic or user-created email that conveys notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for a destination network device. In embodiments, email generation logic **702** may be compatible with any suitable email system or technology, including web-based email systems.

[0108] Pager message generation logic **704** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as

pager messages. For example, pager message generation logic **704** may generate automatic or user-created pager messages that convey notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for a pager device or any compatible destination network device. In embodiments, pager message generation logic **704** may be compatible with any suitable pager system or technology, including web-based paging systems.

[0109] Text message generation logic **706** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as text messages. Such text messages may be carried over existing cellular telephone networks, existing pager networks, the Internet, local area networks, hospital networks, home networks, or the like. For example, text message generation logic **706** may generate automatic or user-created text messages that convey notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for any compatible destination network device. In embodiments, text message generation logic **706** may be compatible with any suitable text messaging application or technology.

[0110] Voicemail generation logic **708** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as voicemail messages. For example, voicemail message generation logic **708** may generate automatic or user-created voicemail messages that convey notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for any compatible destination network device. In embodiments, such voicemail messages can be generated as audio files suitable for transmission as electronic attachments. Upon receipt, the destination network device can play the voicemail message using an appropriate playback mechanism, multimedia application, or the like. In embodiments, voicemail generation logic **708** may be compatible with any suitable voice messaging, telephone system, or multimedia application.

[0111] Phone dialing logic **710** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as an outgoing telephone call. For example, phone dialing logic **710** may be configured to dial (automatically or in response to user interaction) an outgoing telephone number as needed to convey notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for any compatible destination network device. Phone dialing logic **710** may also cooperate with one or more of the other logical components of network communication module **700**, for example, voicemail generation logic **708**, to facilitate transmission of certain network communications. In embodiments, phone dialing logic **710** may be compatible with any suitable telephone system or application.

[0112] Alert/alarm generation logic **712** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate alerts and/or alarms intended for distribution to network devices. For example, alert/alarm generation logic **712** may generate automatic or user-created alerts or alarms that indicate any of the following, without limitation: battery status of a device within the local infusion system; when a physiologic characteristic of the patient crosses a predetermined threshold value; when a telemetered device within the local infusion system is out of range of the monitor; a scheduled calibration for a piece of equipment within the local infusion system; or any scheduled event related to the operation of the infusion system. In embodiments, alert/alarm generation logic **712** may cooperate with one or more of the other logical components of network communication module **700**, for example, text message generation logic **706**, to facilitate the formatting and network transmission of alerts and alarms. Upon receipt, the destination network device can generate an alert/alarm using an appropriate playback mechanism, multimedia application, an illuminating element, a speaker, or the like.

[0113] Web browser/server **714** represents a software application that is configured to generate network communications as markup language documents, e.g., HTML documents. Moreover, web browser/server **714** may include conventional web browsing capabilities that enable the monitor device to access web pages via the Internet. In this regard, web browser/server **714** may cooperate with one or more of the other logical components of network communication module **700**, for example, email generation logic **702** or text message generation logic **706**, to facilitate the transmission and receipt of certain network communications. Web browser applications and web server applications are well known and, therefore, will not be described in detail here.

[0114] Audio signal/file generation logic **716** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as audio signals and/or audio files. The audio signals or files may be pre-programmed into the monitor device (or into the device that creates the audio signals or files). Alternatively, the audio signals or files may be created by a user of the monitor device (or by a user of the device in communication with the monitor device). For example, audio signal/file generation logic **716** may generate automatic or user-created audio signals or audio files that convey notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for any compatible destination network device. Audio-based alerts/alarms may be automatically initiated by the monitor device or by a device in communication with the monitor device. Alternatively, audio-based alerts/alarms may be initiated by a user, patient, or caregiver at the monitor device or at a device in communication with the monitor device. Upon receipt, the destination network device can play the audio signals or audio files using an appropriate playback mechanism, multimedia application, or the like.

[0115] As used here, an audio signal may be a streaming audio signal, a broadcast radio signal, or a control signal that initiates the generation of audio at the destination network device, while an audio file represents a file that is received and interpreted by the destination network device (which then executes the audio file to generate audio). For example, audio signal/file generation logic **716** may be configured to generate MP3 audio files, WMA audio files, or the like. In this regard, audio signal/file generation logic **716** may cooperate with one or more of the other logical components of network communication module **700**, for example, voicemail generation logic **708** or alert/alarm generation logic **712**, to facilitate the transmission and receipt of certain network communications.

[0116] Video signal/file generation logic **718** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as video signals and/or video files. The video signals or files

may be pre-programmed into the monitor device (or into the device that creates the audio signals or files). Alternatively, the video signals or files may be created by a user of the monitor device (or by a user of the device in communication with the monitor device). For example, video signal/file generation logic **718** may generate automatic or user-created video signals or video files that convey notifications, alerts, alarms, status reports, physiologic data, or other information that is intended for any compatible destination network device. Video-based alerts/alarms may be automatically initiated by the monitor device or by a device in communication with the monitor device. Alternatively, video-based alerts/alarms may be initiated by a user, patient, or caregiver at the monitor device or at a device in communication with the monitor device. Upon receipt, the destination network device can play the video signals or video files using an appropriate playback mechanism, multimedia application, or the like.

[0117] As used here, a video signal may be a streaming video signal, a broadcast video signal, or a control signal that initiates the generation of video at the destination network device, while a video file represents a file that is received and interpreted by the destination network device (which then executes the video file to generate video). For example, video signal/file generation logic **718** may be configured to generate MPEG video files, JPG image files, or the like. In this regard, video signal/file generation logic **718** may cooperate with one or more of the other logical components of network communication module **700**, for example, alert/alarm generation logic **712**, to facilitate the transmission and receipt of certain network communications.

[0118] Control signal generation logic **720** may include or be realized as hardware, software, and/or firmware that is suitably configured to generate network communications as control signals for the receiving network device. For example, control signal generation logic **720** may generate automatic or user-created control signals that initiate the generation of notifications, alerts, alarms, displays, or otherwise control the operation of any compatible destination network device. Upon receipt of such a control signal, a destination network device will respond in a suitable manner—activating a display, activating a vibrating element, activating an illumination element, generating an audio or video response, or the like. In embodiments, control signal generation logic **720** may cooperate with one or more of the other logical components of network communication module **700**, for example, alert/alarm generation logic **712**, to facilitate the formatting and network transmission of control signals.

[0119] In practice, network communication module **700** may utilize other network communication generation logic **722** in lieu of, or in addition to, the specific types described above. Such other logical components can be suitably configured to generate network communications in various existing formats, whether publicly known or proprietary. Moreover, such other logical components enable network communication module **700** to support additional formats that may be developed in the future.

[0120] FIG. **8** is a schematic representation of a network-based medical device system **800** configured in accordance with an example embodiment of the invention. System **800** represents one simple implementation of a system that might utilize some of the devices, techniques, and methodologies described here. A vast number of alternative configurations may be constructed and operated within the scope of the invention. For example, although system **800** is described below in the context of an infusion pump, the infusion pump is not a requirement for embodiments of the invention.

[0121] Network-based infusion system **800** generally includes an infusion pump **802**, a monitor device **804** (or any suitable local device that is defined to be within a local infusion system), and a network device **806**. In this example embodiment, monitor device **804** and network device **806** communicate with each other via any number of network communication links established in a data communication network **808**. Moreover, although not a requirement, FIG. **8** depicts bidirectional communications between monitor device **804** and network device **806**. Network device **806** may be, for example, a network-based monitor, a networked computer, a cellular telephone or other mobile computing device, any network device **104** described in connection with FIG. **1**, or any network-based device described elsewhere. Data communication network **808** may be (or include), for example, the Internet, a cellular telecommunication network, a paging system network, a local or wide area network, any wireless or wired network described in connection with FIG. **1**, or any network described elsewhere.

[0122] As described in more detail in connection with FIG. **5**, monitor **804** may include a local device interface **810**, a network interface **812**, and one or more suitable communication modules **814** (e.g., a local communication module and/or a network communication module). Network device **806** may include a network interface **816**, which is configured for compatibility with network interface **812**, one or more suitably configured communication modules **818**, a display element **820**, and user interface features **822**. Network interface **816** may be configured as described above in connection with network interface **512** and in connection with network interface **600**. Communication module(s) **818** may be configured as described above in connection with network communication module **510** and in connection with network communication module **700**. Communication module(s) **818** are configured to enable network device **806** to receive, process, and interpret network communications received from monitor device **804**. In addition, communication module(s) **818** may be configured to enable network device **806** to process, generate, and transmit outgoing network communications intended for monitor device **804**. User interface features **822** and display element **820** enable a user of network device **806** to remotely view data that might be displayed at infusion pump **802** or monitor device **804**, remotely control monitor device **804** or infusion pump **802**, and/or remotely program or modify operating parameters of monitor device **804** or infusion pump **802**.

[0123] In some embodiments of network-based infusion system **800**, infusion pump **802** and monitor device **804** communicate using a first data communication protocol, while monitor device **804** and network device **806** communicate using a second data communication protocol (or a combination of protocols). Local communications between infusion pump **802** and monitor device **804** are carried over one or more local communication links **824**, which may be wireless or wired. Network communications between monitor device **804** and network device **806** are carried over one or more network communication links **826**, which may be wireless or wired. For example, infusion pump **802** may transmit local communications (such as pump status infor-

mation) to monitor device **804**, where the local communications are transmitted in accordance with a Bluetooth data communication protocol. Moreover, infusion pump **802** may receive incoming data from monitor device **804** using the same Bluetooth protocol. In contrast, monitor device **804** may transmit network communications (such as pump status information, alerts, or patient data) to network device **806**, where the network communications are transmitted in accordance with a cellular telecommunication protocol such as CDMA. Similarly, monitor device **804** may receive incoming data from network device **806** using the same CDMA protocol.

[0124] FIG. **9** is a flow chart that depicts an example network-based medical device system monitoring process **900**. The various tasks performed in connection with process **900** may be performed by software, hardware, firmware, or any combination. For illustrative purposes, the following description of process **900** may refer to elements mentioned above in connection with FIGS. **1-8**. In embodiments, portions of process **900** may be performed by different elements of the described system, e.g., a network device or a functional element or operating component. It should be appreciated that process **900** may include any number of additional or alternative tasks, the tasks shown in FIG. **9** need not be performed in the illustrated order, and process **900** may be incorporated into a more comprehensive procedure or process having additional functionality not described in detail here.

[0125] Monitoring process **900** may be performed by a network device that is external to a local infusion system having an infusion pump that controls the infusion of fluid into the body of a user. Process **900** may begin when the network device receives (task **902**) a network communication that conveys pump data associated with the local infusion pump. The network communication may be generated by (or originate at) any transmitting device within the local infusion system, such as a bedside monitor device, a hospital monitor device, a physiological characteristic meter, a remote controller, a handheld monitor/controller, the infusion pump itself, or the like. The pump data may include any information or content related to the operation, control, programming, or status of the infusion pump and/or the transmitting device, including, without limitation: physiologic data of the user/patient, alarms, alerts, graph or chart data, a basal rate of fluid delivered by the infusion pump, bolus information for a bolus of fluid delivered by the infusion pump, or any suitably formatted text, audio, or visual information. As described above in connection with FIG. **5** and FIG. **6**, the network device may receive the network communication in compliance with one or more appropriate data communication protocols, including, without limitation: an Ethernet protocol, an IEEE 802.11 protocol (any variant), a Bluetooth protocol, a paging network protocol, a cellular telecommunication protocol (e.g., CDMA or GSM), a cordless telecommunication protocol, a home network data communication protocol, a satellite data communication protocol, a hospital network protocol, or any suitable wireless or wired/cabled data communication protocol that enables the network device to receive network communications via a wireless, cabled, and/or wired communication link.

[0126] In practice, the network device processes the received network communication and extracts (task **904**) the pump data from the network communication. Task **904** may be performed by a suitably configured communication module and/or a suitably configured processing architecture resident at the network device. In response to such processing, the network device may generate (task **906**) indicia of the pump data for display, playback, broadcast, or rendering at the network device. In connection with task **906**, the network device may: generate indicia of received physiologic data; generate indicia of local device status information; generate indicia of an alert or an alarm; generate indicia of a basal rate of fluid delivery; generate indicia of bolus information; or the like. In embodiments, the network device may generate indicia of the pump data in any suitable manner, including, without limitation: generating an audible representation of the pump data, such as an audible alarm, alert, recording, or audio signal; generating a visual representation of the pump data, such as a graph or a text display; activating an illumination element of the network device, e.g., an indicator light or a flashing display screen; or activating a vibration element of the network device.

[0127] Monitoring process **900** assumes that the network device can transmit network communications back to a device within the local infusion system. In this regard, process **900** may select or determine (task **908**) one or more data communication protocols corresponding to a local device within the infusion system. Task **908** may be performed to ensure that the network device utilizes an appropriate protocol for compatible communication with the local device. The network device may also obtain or generate an instruction or programming parameter intended for the infusion pump or another local device within the infusion system. Such instructions or programming parameters may be generated by the network device or obtained from an operator of the network device. The network device may be configured to generate (task **910**) a suitably configured control communication that conveys the instruction or programming parameter. Depending upon the particular system deployment and the specific operating conditions, an example control communication may include, without limitation: an alert disable instruction; an activation instruction for the infusion pump or any local device; a programming parameter for the infusion pump or any local device; or the upload of software programs (main application code or auxiliary function code such as motor control, RF telemetry code, or the like). Eventually, the network device can transmit (task **912**) the control communication in an appropriate format and in compliance with the particular data communication protocol utilized for the communication session with the local device. Upon receipt, the receiving local device can process the control communication in an appropriate manner.

[0128] In alternate embodiments of the invention, monitoring process **900** can be modified for use in connection with a medical device system that does not include an infusion pump. For example, the tasks of process **900** may be performed in an equivalent manner to receive and process a network communication that conveys patient data, monitor data, or other medical device information that might originate at a device within the local system, and such data need not include pump data.

[0129] FIG. **10** is a flow chart that depicts an example network-based medical device system communication process **1000**. The various tasks performed in connection with process **1000** may be performed by software, hardware, firmware, or any combination of these. For illustrative

purposes, the following description of process **1000** may refer to elements mentioned above in connection with FIGS. **1-8**. In embodiments, portions of process **1000** may be performed by different elements of the described system, e.g., a local device within an infusion system or a functional element or operating component. It should be appreciated that process **1000** may include any number of additional or alternative tasks, the tasks shown in FIG. **10** need not be performed in the illustrated order, and process **1000** may be incorporated into a more comprehensive procedure or process having additional functionality not described in detail here.

[0130] Network communication process **1000** may be performed by a transmitting device that is within a local medical device system, e.g., an infusion system having an infusion pump that controls the infusion of fluid into the body of a user. For example, the transmitting device may be any local device within the local infusion system, such as a bedside monitor device, a hospital monitor device, a physiological characteristic meter, a physiological characteristic sensor transmitter, a remote controller, a handheld monitor/controller, the infusion pump itself, or the like. Process **1000** may begin when the transmitting device obtains (either internally, from another device, or from a user) or generates a notification (task **1002**) related to the operation of the infusion pump and/or related to the operation of another local device. As used here, a notification may be any signal, alert, alarm, content, data, or information that is intended to be forwarded to another device, or is utilized as a prompt or a trigger to invoke a response by the transmitting device.

[0131] Network communication process **1000** may select or determine (task **1004**) an external receiving device, which will be a network device in this example, that represents the intended recipient of the notification. In addition, process **1000** may select or determine (task **1006**) one or more data communication protocols corresponding to the intended external receiving device. Task **1006** may be performed to ensure that the local transmitting device utilizes an appropriate protocol for compatible communication with the network device. As described above in connection with FIG. **5** and FIG. **6**, the local device may transmit network communications in compliance with one or more appropriate data communication protocols, including, without limitation: an Ethernet protocol, an IEEE 802.11 protocol (any variant), a Bluetooth protocol, a paging network protocol, a cellular telecommunication protocol (e.g., CDMA or GSM), a cordless telecommunication protocol, a home network data communication protocol, a satellite data communication protocol, a hospital network protocol, or any suitable wireless or wired/cabled data communication protocol that enables the local device to transmit network communications via a wireless, cabled, and/or wired communication link.

[0132] The local transmitting device may then generate (task **1008**) a network communication that conveys the notification, where the network communication is compatible with the selected data communication protocol. In accordance with embodiments, the network communication may include any information or content related to the operation, control, programming, or status of the infusion pump and/or the transmitting device, including, without limitation: physiologic data of the user/patient, alarms, alerts, graph or chart data, a basal rate of fluid delivered by the infusion pump, bolus information for a bolus of fluid delivered by the infusion pump, or any suitably formatted text, audio, or visual information. As described above in connection with FIG. **7**, the network communication may be formatted as (or include) different message types, file types, or signal types, including, without limitation: an email message; a pager message; a text message; a voicemail message; an outgoing telephone call to the receiving network device; a markup language document, such as a web page; an audio signal; an audio file; a video signal; or a video file.

[0133] Eventually, the local transmitting device transmits (task **1010**) the network communication to the external receiving device. The local device transmits the network communication in accordance with the network data communication protocol selected during task **1006**. In one example, the network communication is conveyed in an outgoing telephone call, and the local transmitting devices transmits the network communication by initiating an outgoing telephone call to the destination network device. In other example embodiments, task **1010** represents the transmission of a message, file, and/or signal having a specified type and format. Upon receipt of the network communication, the destination network device can process the notification in an appropriate manner.

[0134] In alternate embodiments of the invention, process **1000** can be modified for use in connection with a medical device system that does not include an infusion pump. For example, the tasks of process **1000** may be performed in an equivalent manner to process and transmit a network communication that conveys patient data, monitor data, or other medical device information that might originate at a device within the local system, and such information need not include pump data.

[0135] FIG. **11** is a flow chart that depicts an example network-based infusion pump monitoring and control process **1100**. Process **1100** represents one example technique for operating a network-based infusion pump system. A system may be able to support any number of alternative techniques and methodologies, and the following description of process **1100** is not intended to limit the scope or application of the invention in any way. The various tasks performed in connection with process **1100** may be performed by software, hardware, firmware, or any combination. For illustrative purposes, the following description of process **1100** may refer to elements mentioned above in connection with FIGS. **1-8**. In embodiments, portions of process **1100** may be performed by different elements of the described system, e.g., a local device, an infusion pump, a network device or any functional element or operating component. It should be appreciated that process **1100** may include any number of additional or alternative tasks, the tasks shown in FIG. **11** need not be performed in the illustrated order, and process **1100** may be incorporated into a more comprehensive procedure or process having additional functionality not described in detail here.

[0136] Infusion pump monitoring and control process **1100** is performed in conjunction with the normal local operation of an infusion pump (task **1102**). Process **1100** preferably supports the communication of pump data within the local infusion system (task **1104**), as described in detail above. In particular, task **1104** may correspond to the transmission of pump data from the infusion pump to a monitor device within the local infusion system, the transmission of pump data between local devices other than the

infusion pump, or the like. In this example, a local monitor device receives a local communication that conveys pump data (task **1106**). The local monitor device may be a bedside monitor, a hospital monitor, a handheld monitor/controller, or any suitably configured local device as described above. If necessary, the local monitor device processes the received pump data (task **1108**) to determine how best to respond.

[0137] In this example, the local monitor device generates and transmits a network communication in response to the received pump data (task **1110**). The network communication may be intended for any compatible network device that is external to the local infusion system. As described above, the network communication is preferably generated in accordance with a selected network data communication protocol that is also supported by the destination network device. Infusion pump monitoring and control process **1100** assumes that the external network device receives and processes (task **1112**) the network communication in an appropriate manner. For example, the network device may generate an alert or an alarm that originated at the infusion pump.

[0138] In response to the network communication (e.g., an alert in this example), the network device may obtain a remote user input (task **1114**). In this regard, a remote user input may correspond to manipulation of user interface features located at the network device. For example, the user of the network device may elect to disable the alert by engaging a "DISABLE" button on the network device. As another example, the user of the network device may elect to remotely administer a bolus by engaging an "ACTIVATE" button on the network device. In response to the remote user input, the network device may generate and transmit (task **1116**) a suitably configured network control communication that is intended for a target device within the local infusion system. This control communication is formatted for compliance with a particular data communication protocol that is also supported by the target device. The target device may, but need not be, the same local device that transmitted (or originated) the local communication received during task **1106**.

[0139] Infusion pump monitoring and control process **1100** assumes that the intended target device receives and processes (task **1118**) the network control communication in an appropriate manner. Generally, the target device processes the received control communication to determine how best to respond. If the target device is the infusion pump, then process **1100** may proceed to a task **1124**. If not, then process **1100** may proceed to a task **1122**. During task **1122**, the target device may generate and transmit a local control communication that is intended for the infusion pump. The target device generates and transmits the local control communication in accordance with a data communication protocol that is supported within the local infusion system. As an example, task **1122** can be performed when the target device is a local monitor device that locally communicates with the infusion device. Eventually, the infusion pump receives and processes (task **1124**) the network or local control communication in an appropriate manner. In this regard, task **1124** is performed in response to the remote user input obtained at the network device during task **1114**. In embodiments, the local infusion pump will respond to the control communication (task **1126**) in a suitable manner. For example, the infusion pump may react in the following manner, without limitation: disable an alarm or an alert; update its software or firmware; modify its basal rate; activate its pump to administer a bolus; generate a local alert/alarm; perform a calibration routine; or the like.

[0140] In this example embodiment, infusion pump monitoring and control process **1100** enables continuous or periodic monitoring and control of the infusion pump. Accordingly, FIG. **11** depicts process **1100** as a loop, where task **1126** leads back to task **1102** for purposes of continued local operation of the infusion pump.

[0141] FIGS. **12-17** are screen shots that may be generated by monitor devices, controller devices, network devices, display devices, and/or other infusion system devices configured in accordance with example embodiments of the invention. For example, the content of these screen shots may be displayed by bedside monitor **200** (see FIG. **2**), by hospital monitor **300** (see FIG. **3**), by handheld monitor/controllers **400** and **410** (see FIG. **4**), by any of the local devices within local infusion system **102** (see FIG. **1**), and/or by any of the network devices **104** utilized by network-based infusion system **100** (see FIG. **1**).

[0142] FIG. **12** is a screen shot that is suitable for use with a relatively small device, such as a handheld monitor, a personal digital assistant, a wireless phone, a key fob remote control, or the like. This screen shot includes a clock display, an RF quality indicator **1202**, a battery indicator **1204**, a fluid level indicator **1206** that represents the amount of fluid remaining in the infusion pump, and a recommended bolus (4.3 units in this example). This screen shot also includes the prompt: "Press 'OK' to Continue". The user can press "OK" to display other options, such as an activation request that controls the infusion pump to administer the recommended bolus.

[0143] FIG. **13** is another screen shot that is suitable for use with a relatively small device. This screen shot includes a warning display, which may be accompanied by a suitably generated alert or alarm. Here, the warning includes text that indicates a low battery condition and a reminder to replace the battery. In example embodiments of the invention, such a warning may be associated with the battery in the device that actually displays the warning, or it may be associated with the battery in a remote device being monitored by the device that actually displays the warning. In this regard, this screen shot may be displayed at a network monitor device, where the low battery warning indicates that the battery in the local infusion pump device is low.

[0144] FIG. **14** is a screen shot that is suitable for use with a small form factor device, such as a remote control, a watch sized monitor, a portable display-only device, or the like. This screen shot includes a clock display, which is proportionately large for readability. This screen shot also includes a warning display, which may be accompanied by a suitably generated alert or alarm. Here, the warning includes text that indicates a low insulin reservoir condition for the monitored infusion pump. In example embodiments, this screen shot can be displayed on the infusion pump itself, on a remote device within the local infusion system, and/or on a network-based monitoring device.

[0145] FIGS. **15-17** are various screen shots that are suitable for use with a relatively small device, such as a personal digital assistant, a wireless phone, or a pager device. The example screen shot of FIG. **15** includes historical BG data for the patient, rendered in a graph format, and a clock display. The screen shot of FIG. **16** includes a warning related to a low level in the insulin reservoir of the

insulin pump, along with a clock display. The screen shot of FIG. **17** represents a "Main Menu" display for the device, where the menu includes a number of options for the user. For example, the device may display selectable menu icons, including, without limitation: a "Set Bolus" icon; a "Bolus Wizard" icon; a "Manual Bolus" icon; and a "Bolus History" icon. Selection of a given icon may cause the device to generate a new display screen that provides additional information or options related to the selected feature or function. For example, the "Set Bolus" icon enables the user to program the device for a specific bolus value or values that can be activated during use; the default values could be assigned to correspond to various meal carbohydrate values commonly consumed by the user, the "Bolus Wizard" icon launches a feature that enables the user to calculate a bolus of insulin that is appropriate for the patient's current condition, the "Manual Bolus" icon enables the user to deviate from the default bolus value(s), and the "Bolus History" icon launches a display (such as a graph, a chart, or a report) of past bolus deliveries by the infusion pump.

[0146] Again, the specific display formats, screen shot contents, display menu trees, and other display characteristics and features may vary depending upon the particular device configuration, whether the device is a network device or a local device within the infusion system, and/or whether the device is a wireless device. The example screen shots depicted in the various figures are not intended to limit or restrict the scope or application of any embodiment of the invention.

[0147] As mentioned above with regard to network-based infusion system **100** (see FIG. **1**), a data communication translation device **113** may be utilized to facilitate communication between a wireless local device and a network device **104**, such as a personal computer, a networked hospital computer, a caregiver office computer, or the like. FIG. **18** is a perspective view of a data communication translation device **1300** configured in accordance with one possible embodiment of the invention. In this embodiment, translation device **1300** is a relatively small and portable device that provides wireless bridge and memory storage functionality. Translation device **1300** may be conveniently sized such that it can be easily carried by a patient or a caregiver. In certain embodiments, translation device **1300** is small enough to be carried in a pocket.

[0148] Translation device **1300** includes a housing **1302** that encloses a number of functional components that are described in more detail below. This example embodiment includes a universal serial bus ("USB") connector **1304** that serves as a network interface port for translation device **1300**. The network interface port can alternately be a IEEE 1394 port, a serial port, a parallel port, or the like. USB connector **1304** is configured for physical and electrical compliance with known USB specifications; such specifications will not be described in detail herein. Alternate embodiments may utilize different network interface configurations and, therefore, different network interface connectors, ports, couplers, or the like. USB connector **1304** is merely one suitable implementation of such a network interface, and embodiments of the invention are not limited to USB deployments.

[0149] Translation device **1300** may also include a removable cover **1306** that protects USB connector **1304** when translation device **1300** is not connected to a network device. Cover **1306** may be designed to snap onto USB connector **1304** and/or housing **1302** in a manner that allows the user to remove and replace cover **1306** by hand.

[0150] FIG. **19** is a schematic representation of one example embodiment of translation device **1300**. In this example, translation device **1300** generally includes housing **1302**, a network interface port (e.g., USB connector **1304**), a wireless communication module **1308**, a memory element **1310**, a processing architecture **1312**, a data format translator **1314**, and a network interface **1316** (e.g., a USB interface). The elements of translation device **1300** may be coupled together via a bus **1318** or any suitable interconnection architecture. In example embodiments, housing **1302** encloses wireless communication module **1308**, memory element **1310**, processing architecture **1312**, and data format translator **1314**. Depending upon the particular implementation, housing **1302** may also enclose at least a portion of network interface **1316**.

[0151] Processing architecture **1312** may be implemented or performed with a general purpose processor, a content addressable memory, a digital signal processor, an application specific integrated circuit, a field programmable gate array, any suitable programmable logic device, discrete gate or transistor logic, discrete hardware components, or any combination designed to perform the functions described here. A processor may be realized as a microprocessor, a controller, a microcontroller, or a state machine. Moreover, a processor may be implemented as a combination of computing devices, e.g., a combination of a digital signal processor and a microprocessor, a plurality of microprocessors, one or more microprocessors in conjunction with a digital signal processor core, or any other such configuration. In an example embodiment of translation device **1300**, data format translator **1314** may be implemented in processing architecture **1312** (even though FIG. **19** depicts the two as separate logical elements).

[0152] In practice, processing architecture **1312** is configured to support the various tasks, functions, and operations of translation device **1300**. For example, processing architecture **1312** may be suitably configured to interpret and process incoming information, data, and content that is conveyed in local communications received from a transmitting device within the local infusion system. Likewise, processing architecture **1312** may be suitably configured to interpret and process incoming information, data, and content that is conveyed in network communications received from a network device external to the local infusion system. Processing architecture **1312** may also be configured to manage storage and retrieval of data in memory element **1310**. Moreover, processing architecture **1312** may be configured to process data in response to instructions received from a network device via network interface **1316** and/or in response to instructions received from a local device via wireless communication module **1308**.

[0153] In one embodiment, memory element **1310** can be a powered memory arrangement that utilizes a backup battery to maintain its storage ability. In the example embodiment, memory element **1310** is realized as nonvolatile flash memory having a suitable amount of storage capacity. The design and configuration of flash memory, its selection circuitry, and its program/erase control circuitry are generally known, and such conventional aspects of memory element **1310** will not be described in detail here. In alternate embodiments, memory element **1310** may utilize EEPROM memory, random access memory, registers, a

small scale hard disk, a removable media, or the like. In this regard, memory element **1310** can be coupled to processing architecture **1312** such that processing architecture **1312** can read information from, and write information to, memory element **1310**. In the alternative, memory element **1312** and processing architecture **1312** may be realized as an integrated unit. As an example, processing architecture **1312** and memory element **1310** may reside in an ASIC. As described in more detail below, memory element **1310** can be utilized to store data conveyed in wireless signals received from a local device within an infusion system. In addition, memory element **1310** can be utilized to store data conveyed in network communication signals received from a network device external to the infusion system. Such data may include local device status data, physiologic data of the user, sensor data, alerts/alarms, control data from the network device, operating instructions for translation device **1300**, any of the local data types or content described herein, and/or any of the network data types or content described herein.

[0154] Wireless communication module **1308** is suitably configured to support wireless data communication with a device within an infusion system, e.g., any of the local devices mentioned in the above description of infusion system **100** (see FIG. **1**). For example, the local device may be an infusion pump or a monitor device for an infusion pump. Depending upon the particular implementation, wireless communication module **1308** may be configured to support unidirectional communication from local devices, or bidirectional communication between translation device **1300** and local devices. Thus, wireless communication module **1308** may be configured to receive local communication signals from a transmitting device within the local infusion system, and/or to transmit local communication signals to a receiving device within the local infusion system.

[0155] Wireless communication module **1308** may include or be realized as a radio module that supports one or more wireless data communication protocols and one or more wireless data transmission schemes. In an embodiment, wireless communication module **1308** may include or be realized as hardware, software, and/or firmware, such as an RF front end, a suitably configured radio module (which may be a stand alone module or integrated with other or all functions of translation device **1300**), a wireless transmitter, a wireless receiver, a wireless transceiver, an infrared sensor, an electromagnetic transducer, or the like. In this example, translation device **1300** includes an antenna **1318** coupled to wireless communication module **1308**. Antenna **1318**, which may be located inside or outside of housing **1302** (or partially inside and partially outside of housing **1302**), is appropriately configured in accordance with the particular design of wireless communication module **1308**.

[0156] For wireless transmissions of local communications, wireless communication module **1308** supports one or more wireless data communication protocols that are also supported by the local device(s) communicating with translation device **1300**. Any number of suitable wireless data communication protocols, techniques, or methodologies may be supported by wireless communication module **1308** and translation device **1300**, including, without limitation: RF; IrDA (infrared); Bluetooth; ZigBee (and other variants of the IEEE 802.15 protocol); IEEE 802.11 (any variation); IEEE 802.16 (WiMAX or any other variation); Direct Sequence Spread Spectrum; Frequency Hopping Spread Spectrum; cellular/wireless/cordless telecommunication protocols; wireless home network communication protocols; paging network protocols; magnetic induction; satellite data communication protocols; wireless hospital or health care facility network protocols such as those operating in the WMTS bands; GPRS; and proprietary wireless data communication protocols such as variants of Wireless USB.

[0157] Network interface **1316** is generally configured to support transmission of network communications between translation device **1300** and one or more network devices. Network interface **1316** may include interface logic **1320** and network interface port **1304**. Interface logic **1320** may be implemented in processing architecture **1312** (even though FIG. **19** depicts the two as separate logical elements). In this example embodiment, network interface **1316** is a USB interface, interface logic **1320** is compatible with USB specifications and requirements, and network interface port **1304** is a USB port or connector. As mentioned above, however, alternate embodiments may utilize different network interface configurations (for example, IEEE 1394) and, therefore, different network interface connectors, ports, couplers, or the like.

[0158] Network interface **1316** is suitably configured to support data communication with a device external to the infusion system, e.g., any of the network devices **104** mentioned in the above description of infusion system **100** (see FIG. **1**). For example, the network device may be a personal computer having a suitable host application that can be manipulated to manage communication with translation device **1300**. The personal computer may be owned by the patient, located in a caregiver facility, located in a hospital, located in a device manufacturer facility, or elsewhere. In example embodiments, the host application may be realized as software that is designed to provide monitoring, diagnostic services, patient data analysis, medical device programming, and/or other functions associated with one or more devices within the local infusion system. Depending upon the particular implementation, network interface **1316** may be configured to support unidirectional communication from translation device **1300**, or bidirectional communication between translation device **1300** and network devices. Thus, network interface **1316** may be configured to receive network communication signals from a transmitting network device, and/or to transmit network communication signals to a receiving network device.

[0159] For transmission of network communication signals over a cable, a wired connection, a direct connection, or other physical link, network interface **1316** supports one or more wired/cabled data communication protocols that are also supported by the network device(s) communicating with translation device **1300**. Any number of suitable data communication protocols, techniques, or methodologies may be supported by network interface **1316** and translation device **1300**, including, without limitation: Ethernet; home network communication protocols; USB; IEEE 1394 (Firewire); hospital network communication protocols; and proprietary data communication protocols.

[0160] For wireless transmission of network communication signals, network interface **1316** supports one or more wireless data communication protocols that are also supported by the network device(s) communicating with translation device **1300**. Any number of suitable wireless data communication protocols, techniques, or methodologies may be supported by network interface **1316** and translation

device **1300**, including, without limitation: RF; IrDA (infrared); Bluetooth; ZigBee (and other variants of the IEEE 802.15 protocol); IEEE 802.11 (any variation); IEEE 802.16 (WiMAX or any other variation); Direct Sequence Spread Spectrum; Frequency Hopping Spread Spectrum; cellular/wireless/cordless telecommunication protocols; wireless home network communication protocols; paging network protocols; magnetic induction; satellite data communication protocols; wireless hospital or health care facility network protocols such as those operating in the WMTS bands; GPRS; and proprietary wireless data communication protocols such as variants of Wireless USB.

[0161] In connection with wireless data transmissions, translation device **1300** may be configured to perform dynamic frequency hopping to optimize its operation, to conserve battery life for battery-powered wireless devices, and/or to provide flexibility in the complexity of the devices with which it communicates. For example, wireless communication module **1308** may be designed to dynamically accommodate 5-channel (low power) devices and 50-channel (high power) devices. In this context, translation device **1300** may utilize a low power mode to conserve battery power when a high quality wireless link has been established. On the other hand, translation device **1300** may switch to a high power mode in response to increased packet loss, increased collision, or a generally poor quality of service.

[0162] In connection with wireless data transmissions, translation device **1300** may also be configured to support a retry periodicity for synchronous links having a designated transmission periodicity. For example, during normal operation, a synchronous wireless link may communicate one packet per minute. Translation device **1300** can be configured to initiate a retry procedure in response to a missed packet. In this regard, translation device **1300** can support retry transmissions (i.e., retransmission of the missed packet) that occur at a higher rate than the normal operating mode. For example, retry packet transmissions may occur every 20 seconds rather than once a minute. In practice, translation device **1300** and the wireless device may adapt their frequency hopping scheme to accommodate the retry packets, and resume their normal frequency hopping scheme thereafter.

[0163] Data format translator **1314**, which may be realized as hardware, software, firmware, or any combination thereof, is suitably configured to reformat data between wireless communication module **1308** and network interface **1316**. Depending upon the particular implementation, such reformatting may occur for data received via wireless communication module **1308**, for data received via network interface **1316**, or both. For example, it may be desirable for translation device **1300** to receive a wireless communication signal at wireless communication module **1308**, extract data from the wireless communication signal, and process the extracted data in an appropriate manner such that the extracted data can be conveyed in a network communication signal to be provided by network interface **1316**. Likewise, it may be desirable for translation device **1300** to receive a network communication signal at network interface **1316**, extract data from the network communication signal, and process the extracted data in an appropriate manner such that the extracted data can be conveyed in a wireless communication signal to be provided by wireless communication module **1308**.

[0164] Translation device **1300** may be configured to encrypt data between wireless communication module **1308** and network interface **1316**. Encrypting data may be desirable for ensure that confidential or sensitive information remains protected. In this example, data format translator **1314** may be configured to perform data encryption using one or more known or proprietary encryption schemes. Alternatively, translation device **1300** may include a separate encryption engine or module that performs the data encryption. Depending upon the specific implementation, data encryption may be applied to the extracted data (or any portion thereof), to the sensitive/confidential data (or any portion thereof), and/or to the entire communication signal (or any portion thereof).

[0165] Translation device **1300** provides a wireless bridge between a local device and a network device, and translation device **1300** can support a range of data transmission and data storage features. In this regard, FIG. **20** is a flow chart that depicts an example data storage and translation process **1400** that may be supported by translation device **1300**. The various tasks performed in connection with process **1400** may be performed by software, hardware, firmware, or any combination. For illustrative purposes, the following description of process **1400** may refer to elements mentioned above in connection with FIGS. **18** and **19**. In practice, portions of process **1400** may be performed by different elements of the described system, e.g., wireless communication module **1308**, memory element **1310**, processing architecture **1312**, or network interface **1316**. It should be appreciated that process **1400** may include any number of additional or alternative tasks, the tasks shown in FIG. **20** need not be performed in the illustrated order, and process **1400** may be incorporated into a more comprehensive procedure or process having additional functionality not described in detail here.

[0166] Data storage and translation process **1400** may begin when the translation device is attached to a network device via the network interface of the translation device (task **1402**). In this example, task **1402** is associated with the coupling of a USB-compatible translation device to a personal computer via the USB interface of the translation device. In response to this attachment, process **1400** powers the translation device and initializes the wireless communication module (task **1404**). In accordance with conventional methodologies, the USB interface provides operating power from the computer to the translation device, and such operating power may be utilized to energize the wireless communication module and other functional elements of the translation device. In this example, the computer detects the mounting of the translation device and responds by automatically launching its host application (task **1406**). Alternatively, the computer may prompt the user to manually launch the host application.

[0167] The translation device may be configured to support an auto-detect or standby mode, during which the translation device "listens" for compatible local devices that come within wireless transmission range. Such an auto device detection mode may be desirable to enable the system to accommodate intermittent or unreliable links by delaying wireless transmission of data until a link of sufficient strength is established. Such an auto device detection mode may also be desirable in a caregiver office environment to enable the system to download data (automatically or upon patient approval) whenever a patient enters the waiting

room. Alternatively, the auto device detection mode may also be desirable in a user's home or other such environment to enable the system to automatically, or upon patient approval, download data directly into a central depository or into a temporary holding area, such as a PC, and then transfer the data to a central depository, such as a web server, or a hospital database. If the auto device detection mode is active (query task **1408**), then the translation device may check to determine whether a local device has been detected (query task **1410**). If the translation device detects a local device within range, then data storage and translation process **1400** may continue as described below. Otherwise, the translation device may idle until it detects a local device within range, or process **1400** may be re-entered at query task **1408**. If the auto device detection mode is inactive, or if the translation device does not support the auto device detection mode, then query task **1408** may lead to a query task **1412**.

[0168] Data storage and translation process **1400** may perform query task **1412** to determine whether a user of the host application has assumed control over the translation device. If host control is not initiated, then process **1400** may be re-entered at query task **1408**. Alternatively, if host control is not initiated, then process **1400** may idle until host control occurs. If, however, host control is initiated, then process **1400** may continue as described below.

[0169] Depending upon the implementation and the application, the translation device may receive and process data from a wireless local device and/or receive and process data from a network device. For ease of description, data storage and translation process **1400** is arbitrarily and artificially separated into sub-process A (relating to the handling of incoming wireless communication signals) and sub-process B (relating to the handling of incoming network communication signals). An embodiment of the translation device may be suitably configured to carry out both sub-processes concurrently or in a synchronous manner that avoids transmit/receive clashes. Either or both of these sub-processes may follow query task **1410** or query task **1412**, as indicated in FIG. **20**A.

[0170] Referring to sub-process A (see FIG. **20**B), the translation device may receive a wireless local data communication signal from a local device within the infusion system (task **1414**). In one example embodiment, during an initial handshaking or packet exchange routine, the device initiating contact indicates whether the transmission is a one-time packet (which could be sent as often as required) or a synchronous-link packet that requires time synchronization of packets sent and received between the two communicating devices. If data conveyed in the received wireless local data communication signal is to be saved (query task **1416**), then the translation device may extract and store the data in its resident memory element (task **1418**). Following the data storage of task **1418**, data storage and translation process **1400** may proceed to a query task **1420**. If data conveyed in the wireless local data communication signal is not to be saved, then process **1400** may bypass task **1418** and proceed to query task **1420**.

[0171] Query task **1420** may determine whether the translation device is to perform network transmission of data. The translation device may be suitably configured to support network transmission of data stored in the memory element and/or network transmission of data that need not be stored in the memory element. For example, the translation device may be configured to process data stored in the memory element for transmission to a network device that is external to the infusion system. In this example, such network transmission corresponds to transmission of data from the translation device to the host computer via the USB interface. If network transmission has not been initiated, then data storage and translation process **1400** may be re-entered at task **1414** to allow the translation device to continue receiving wireless communication signals. If, however, network transmission has been initiated, then process **1400** may proceed to a query task **1422**.

[0172] Query task **1422** determines whether the translation device is to perform data encryption. The translation device may be suitably configured to encrypt data conveyed in wireless local data communication signals, to encrypt data conveyed in network communication signals, and/or to encrypt data stored in the memory element. For example, the translation device may encrypt data stored in the memory element for encrypted transmission to the network device, which is compatibly configured to decrypt the data. If encryption is to be performed, then data storage and translation process **1400** performs data encryption (task **1424**) using any suitable data encryption technique. After process **1400** performs encryption, it may lead to a query task **1426**. If the data will not be encrypted, then process **1400** may bypass task **1424** and proceed to query task **1426**.

[0173] Query task **1426** determines whether the translation device is to reformat data for transmission to the network device. For example, data storage and translation process **1400** may reformat data conveyed in the wireless local data communication signal for compatibility with the network interface (task **1428**). Process **1400** may additionally (or alternatively) reformat data that has been stored in the memory element. Such reformatting may be desirable to enable the network interface to provide network communications to the network device, where the network communications convey the reformatted data. After reformatting data in a desired manner, the translation device can generate a network communication signal (task **1430**). Task **1430** may also be performed if query task **1426** determines that reformatting is unnecessary or undesired. In this example, the network communication signal includes data that was conveyed in the wireless local data communication signal and/or data retrieved from the memory element.

[0174] Eventually, data storage and translation process **1400** provides the network communication signal (generated during task **1430**) to the network interface for transmission to the network device (task **1432**). In the example embodiment, task **1432** results in the transmission of data to the host computer via the USB interface. Following task **1432**, process **1400** may exit or it may be re-entered at a designated point, such as query task **1408**.

[0175] Referring to sub-process B (see FIG. **20**C), the translation device may receive a network data communication signal from a network device that is external to the infusion system (task **1434**). In one example embodiment, during an initial handshaking or packet exchange routine, the device initiating contact indicates whether the transmission is a one-time packet (which could be sent as often as required) or a synchronous-link packet that requires time synchronization of packets sent and received between the two communicating devices. If data conveyed in the network data communication signal is to be saved (query task **1436**), then the translation device may extract and store the

data in its resident memory element (task **1438**). Thereafter, data storage and translation process **1400** may proceed to a query task **1440**. If data conveyed in the network data communication signal is not to be saved, then process **1400** may bypass task **1438** and proceed to query task **1440**.

[0176] Query task **1440** may determine whether the translation device is to perform local transmission of data. The translation device may be suitably configured to support local transmission of data stored in the memory element and/or local transmission of data that need not be stored in the memory element. For example, the translation device may be configured to process data stored in the memory element for transmission to a local device within the infusion system. In this example, such local transmission corresponds to transmission of data from the translation device to a local device via the wireless communication module. If local transmission has not been initiated, then data storage and translation process **1400** may check whether the received network data communication signal conveys operating or control instructions from the network device (query task **1442**). If so, then the translation device may process data stored in the memory element in response to such instructions (task **1444**). These instructions may include or indicate a request for certain data stored at the translation device, a request for the translation device to obtain data from a local device, programming or configuration data for the translation device and/or a local device, or the like. Following task **1444**, process **1400** may exit or it may be re-entered at a designated point, such as task **1434** or query task **1408**.

[0177] If query task **1440** determines that local transmission has been initiated, then data storage and translation process **1400** may proceed to a query task **1446**. Query task **1446** determines whether the translation device is to perform data encryption as described previously. For example, the translation device may encrypt data conveyed in the received network data communication signal and/or data stored in the memory element for encrypted transmission to the wireless local device, which is compatibly configured to decrypt the data. If encryption is to be performed, then process **1400** performs data encryption (task **1448**) using any suitable data encryption technique. After process **1400** encrypts the data, it may proceed to a query task **1450**. If the data will not be encrypted, then process **1400** may bypass task **1448** and proceed to query task **1450**.

[0178] Query task **1450** determines whether the translation device is to reformat data for transmission to the wireless local device. For example, data storage and translation process **1400** may reformat data conveyed in the network data communication signal for compatibility with the wireless data communication module (task **1452**). Process **1400** may additionally (or alternatively) reformat data that has been stored in the memory element. Such reformatting may be desirable to enable the wireless communication module to provide local wireless communication signals to the local device(s), where the wireless signals convey the reformatted data. After reformatting data in a desired manner, the translation device can generate a local communication signal (task **1454**). Task **1454** may also be performed if query task **1450** determines that reformatting is unnecessary or undesired. In this example, the local communication signal is a wireless signal that includes data that was conveyed in the network data communication signal and/or data retrieved from the memory element.

[0179] Eventually, data storage and translation process **1400** provides the local communication signal (generated during task **1454**) to the wireless communication module for transmission to the local device (task **1456**). In the example embodiment, task **1456** results in the wireless transmission of data to a local device via the wireless communication module. Following task **1456**, process **1400** may exit or it may be re-entered at a designated point, such as query task **1408**.

[0180] Translation device **1300**, data storage and translation process **1400**, and other processes supported by translation device **1300** provide added flexibility and convenience for users of the infusion system. For example, translation device **1300** can support the downloading of history data from an infusion pump or an infusion pump monitor with automatic storage to its internal flash memory. Such downloading may be driven by the host application—the host computer can command translation device **1300** to download data to the flash memory—for retrieval and analysis at a later date by the patient's caregiver. Patient history data may be encrypted such that only an authorized caregiver computer system can access the history files. Alternatively, the history files could be read-only by the patient, with read/write access provided to the caregiver. In example embodiments, the host application may be configured to detect whether the patient or a caregiver is communicating with the local device via translation device **1300**. Consequently, translation device **1300** may be configured to support patient-specific and/or caregiver-specific functions and operations if so desired.

[0181] Depending upon the given deployment of an infusion system, it may be desirable to collect data from a plurality of local devices such that the collected data can be stored, processed, routed, or otherwise managed in an controlled manner. In this regard, FIG. **21** is a schematic representation of an example network deployment of a wireless telemetry router **1500** configured in accordance with an example embodiment of the invention. Wireless telemetry router **1500** may be deployed in a medical device system such as network-based infusion system **100** (see FIG. **1**). Wireless telemetry router **1500** is suitably configured to communicate with a plurality of wireless devices within a local medical device system, such as a local infusion system. Wireless telemetry router **1500** is also configured to communicate with one or more network devices, which may be external to the local medical device system. For example, wireless telemetry router **1500** may communicate with network devices coupled to wireless telemetry router **1500** via an Ethernet connection and/or via wireless links.

[0182] The flexible nature of the example environment is depicted in FIG. **21**, which depicts wireless telemetry router **1500** in communication with a variety of devices. In an example embodiment, wireless telemetry router **1500** may be suitably configured to communicate with one or more of the following devices, without limitation: a plurality of physiological characteristic sensor transmitters **1502**, a wireless personal digital assistant **1504**, a wireless laptop computer **1506**, a network monitor **1508**, a network computer **1510**, a network personal digital assistant **1512**, a network hospital management system **1514**, and a network printer **1516**. Wireless telemetry router **1500** may also be configured to support communication with the various local devices and network devices mentioned in the above description of infusion system **100**.

[0183] Although FIG. **21** depicts five physiological characteristic sensor transmitters **1502**, wireless telemetry router **1500** can support any number of sensor transmitters (limited only by practical operating restrictions such as bandwidth, available power, transmission range, etc.). Each physiological characteristic sensor transmitter **1502** is suitably configured to measure a physiologic characteristic of a patient. In the example infusion system described here, each sensor transmitter **1502** is a continuous glucose (e.g., blood glucose) sensor transmitter that measures the glucose level of a patient in real time. Each sensor transmitter **1502** may be realized in a form that is intended to be worn by the patient, attached to the patient's skin, implanted within the patient's body, or the like. Each sensor transmitter **1502** includes a wireless transmitter that facilitates transmission of physiologic sensor data of the user to wireless telemetry router **1500** and possibly other devices within the local infusion system.

[0184] Wireless telemetry router **1500** may be deployed in any environment where physiological characteristic sensor transmitters **1502** might come in range. Wireless telemetry router **1500** can support a system where a plurality of sensor transmitters **1502** are used by one person and/or a system that contemplates more than one person (each using only one sensor transmitter **1502**). Moreover, wireless telemetry router **1500** can be suitably configured to support different types of sensor transmitters, and the example environment depicted in FIG. **21** need not be limited to an insulin infusion system or any specific type of medical device system. Example applications of wireless telemetry router **1500** include the following, without limitation: one patient having multiple sensor transmitters **1502**, each being configured to provide data indicative of a different physiologic characteristic; a home deployment where more than one member of a family uses a sensor transmitter **1502**; a school deployment where it may be desirable to monitor the physiologic data for any number of students; a hospital deployment where it may be desirable to monitor physiologic data for any number of patients; or a caregiver office environment where it may be desirable to identify specific sensor transmitters **1502** for purposes of patient identification and/or to obtain data from sensor transmitters **1502**.

[0185] Physiological characteristic sensor transmitters **1502** and wireless telemetry router **1500** are suitably configured to support wireless data communication via respective wireless links **1518**, which may be unidirectional (as shown) or bidirectional, depending upon the particular system and/or the specific type of sensor transmitters **1502**. Accordingly, wireless telemetry router **1500** includes a suitably configured wireless communication module that is capable of supporting multiple sensor transmitters **1502**.

[0186] Although not a requirement of the system, wireless links **1518** may be established using the same wireless data communication protocol and wireless data transmission scheme. Wireless telemetry router **1500** may utilize any number of suitable wireless data communication protocols, techniques, or methodologies for wireless links **1518**, including, without limitation: RF; IrDA (infrared); Bluetooth; ZigBee (and other variants of the IEEE 802.15 protocol); IEEE 802.11 (any variation); IEEE 802.16 (WiMAX or any other variation); Direct Sequence Spread Spectrum; Frequency Hopping Spread Spectrum; cellular/wireless/cordless telecommunication protocols; wireless home network communication protocols; paging network protocols; magnetic induction; satellite data communication protocols; wireless hospital or health care facility network protocols such as those operating in the WMTS bands; GPRS; and proprietary wireless data communication protocols such as variants of Wireless USB. In the example embodiment, wireless links **1518** are carried over the 900-930 MHz band that is reserved for industrial, scientific, and medical equipment use. As another example, wireless links **1518** in a hospital implementation may utilize the WMTS bands that are reserved for hospital applications. Packaging of sensor data, error detection, security, sensor transmitter identification, and other sensor data processing techniques may be governed by known or proprietary protocols.

[0187] Wireless telemetry router **1500** may be configured to communicate with network devices via Ethernet connectivity (or via any suitable data communication methodology). FIG. **21** depicts an Ethernet data communication architecture **1520** that links wireless telemetry router **1500** to network monitor **1508**, network computer **1510**, network personal digital assistant **1512**, network hospital management system **1514**, and network printer **1516**. Of course, these example network devices are not exhaustive, and embodiments of the invention are not limited to these examples. A given link between wireless telemetry router **1500** and a network device may be unidirectional (in either direction) or bidirectional, depending upon the particular system and/or the specific type of network device. For example, the link from wireless telemetry router **1500** to network printer **1516** may be unidirectional, the link from wireless telemetry router **1500** to network monitor **1508** may be unidirectional, and other links may be bidirectional.

[0188] Wireless telemetry router **1500** may be configured to support wireless communication with compatible wireless devices, such as wireless personal digital assistant **1504** and wireless laptop computer **1506**. Accordingly, wireless telemetry router **1500** includes a suitably configured wireless communication module, which may (but need not) be distinct from the wireless communication module that receives wireless links **1518**. In this regard, FIG. **21** depicts wireless links **1522** between wireless telemetry router **1500** and these wireless devices. A given wireless link **1522** between wireless telemetry router and a wireless device may be unidirectional in either direction or bidirectional (as shown in FIG. **21**), depending upon the particular system and/or the specific type of wireless device. In practice, wireless links **1522** enable wireless telemetry router **1500** to communicate directly with wireless devices while bypassing the network (i.e., without having to traverse Ethernet data communication architecture **1520**).

[0189] Although not a requirement of the system, wireless links **1522** may be established using the same wireless data communication protocol and wireless data transmission scheme. In this example, wireless telemetry router **1500** utilizes one wireless data communication technique for wireless links **1522** and a different wireless data communication technique for wireless links **1518**. Wireless telemetry router **1500** may utilize any number of suitable wireless data communication protocols, techniques, or methodologies for wireless links **1522**, including, without limitation: RF; IrDA (infrared); Bluetooth; ZigBee (and other variants of the IEEE 802.15 protocol); IEEE 802.11 (any variation); IEEE 802.16 (WiMAX or any other variation); Direct Sequence Spread Spectrum; Frequency Hopping Spread Spectrum; cellular/wireless/cordless telecommunication protocols;

wireless home network communication protocols; paging network protocols; magnetic induction; satellite data communication protocols; wireless hospital or health care facility network protocols such as those operating in the WMTS bands; GPRS; and proprietary wireless data communication protocols such as variants of Wireless USB. Packaging of data, error detection, security, and other data processing techniques may be governed by known or proprietary protocols.

[0190] In one example embodiment, wireless telemetry router **1500** includes an HTML-based setup, management, and control interface that can be accessed via any authorized computer or device having HTML browser capabilities and connectivity to wireless telemetry router **1500**. For example, an administrator may be able to access wireless telemetry router **1500** via the Internet and a conventional web browser application residing on wireless personal digital assistant **1504**, wireless laptop computer **1506**, network computer **1510**, or network personal digital assistant **1512**. The control interface may be provided as one or more HTML pages that reside in the firmware/software of wireless telemetry router **1500**. The control interface can be accessed using an IP address and/or a network interface card that is unique to that particular wireless telemetry router **1500**. Password and firewall protection may be implemented to provide protection against external misuse or data theft.

[0191] In connection with a setup procedure, wireless telemetry router **1500** may be provided with sensor identifiers for the respective physiological characteristic sensor transmitters **1502**. The sensor identifiers may be, for example, the serial numbers of sensor transmitters **1502** or any information that uniquely distinguishes the different sensor transmitters **1502** within the operating environment. In example embodiments, wireless communication signals generated by an originating sensor transmitter **1502** conveys the corresponding sensor identifier. Wireless telemetry router **1500** can then process the sensor identifiers in a suitable manner. For example, wireless telemetry router **1500** may receive a wireless communication signal from an originating sensor transmitter **1502**, obtain or extract the sensor identifier for that wireless communication signal, and process the sensor data conveyed in that wireless communication signal in a manner that is determined, governed, or dictated by the particular sensor identifier. This technique enables wireless telemetry router **1500** to identify the originating sensor transmitter **1502**, the originating patient, the sensor transmitter type, or other pertinent information. Wireless telemetry router **1500** may then process, store, and/or route the sensor data in an appropriate manner. As another example, wireless telemetry router **1500** may receive a first wireless communication signal from a first sensor transmitter **1502***a*, receive a second wireless communication signal from a second sensor transmitter **1502***b*, obtain or extract the two respective sensor identifiers (which should be different), and process the sensor data conveyed in the two wireless communication signals in a synchronized manner that is determined, governed, or dictated by the sensor identifiers. This technique enables wireless telemetry router **1500** to prioritize the receipt, processing, storage, and/or transmission of sensor data depending upon the originating source.

[0192] In connection with a setup procedure, wireless telemetry router **1500** may be provided with network identifiers (e.g., IP addresses or network interface card identifiers) for the various destination network devices. Such network identifiers enable wireless telemetry router **1500** to determine how to process, handle, store, or route the received sensor data. In this regard, wireless telemetry router **1500** may, for example, maintain or access a lookup table (or any suitable memory or database structure) that contains the different sensor identifiers and a corresponding list of destination network identifiers for each sensor identifier. This lookup table may also include corresponding processing instructions for each sensor identifier.

[0193] Wireless telemetry router **1500** is generally configured to receive sensor data and route the sensor data to one or more destination network devices. In this example, wireless telemetry router **1500** receives a plurality of wireless communication signals from a plurality of physiological characteristic sensor transmitters **1502**, where each wireless communication signal conveys sensor data generated by a respective sensor transmitter **1502**. As mentioned above, each wireless communication signal may also convey a sensor identifier that uniquely identifies the originating sensor transmitter **1502**. Wireless telemetry router **1500** can then process the received information in an appropriate manner, depending upon the particular application and the identity of the originating sensor transmitter **1502**.

[0194] Wireless telemetry router **1500** may perform one or more operations on the received sensor data, including, without limitation: storing at least some of the sensor data (at wireless telemetry router **1500** itself or at a network device that is coupled to wireless telemetry router **1500**); forward at least some of the sensor data to a destination network device; reformat data conveyed in the wireless communication signals for compatibility with a designated network data communication protocol; or process at least some of the sensor data. In example embodiments, wireless telemetry router **1500** may include some functionality and processing intelligence that might normally be found elsewhere in the system environment. For example, wireless telemetry router **1500** may be configured to receive uncalibrated physiologic characteristic data, such as an uncalibrated patient glucose level, and calibrate the data before routing it to the destination network device.

[0195] In connection with its routing function, wireless telemetry router **1500** may generate a network communication that complies with a specified network data communication protocol. The network communication conveys sensor data, which may include stored sensor data, real-time sensor data that is being immediately routed, or a combination thereof. Wireless telemetry router **1500** can then transmit the network communication to one or more network devices. Wireless telemetry router **1500** transmits the network communication in accordance with the selected network data communication protocol and in accordance with the selected data transmission technique. For example, wireless telemetry router **1500** may function as a translation device between data received on wireless links **1518** (using one protocol and transmission scheme combination) and data transmitted over Ethernet data communication architecture **1520** (using another protocol and transmission scheme combination). As another example, wireless telemetry router **1500** may function as a translation device between data received on wireless links **1518** (using one protocol and transmission scheme combination) and data transmitted over wireless links **1522** (using another protocol and transmission scheme combination).

[0196] Wireless telemetry router **1500** may also be configured to generate warning, error, alarm, and alert information ("diagnostic information"), which may be routed using the techniques described above. The diagnostic information may be displayed or rendered at wireless telemetry router **1500** itself and/or routed for display or rendering at a network device. The diagnostic information may include, without limitation: information related to the operation or status of wireless telemetry router **1500**; information related to the operation or status of physiological characteristic sensor transmitters **1502**; information related to the operation or status of a network device; or any of the notifications, alerts, alarms, or status reports described in more detail above.

[0197] Wireless Medical Device Network Protocols and Features

[0198] Medical devices, including any of the devices described above, may be suitably configured to support wireless data communication within a network environment. Unless otherwise specified, the following examples assume that wireless data is transferred between the medical devices using suitably formatted data packets, and that communication between the medical devices is bi-directional (half-duplex or full-duplex). Generally, a network of medical devices includes any number (N) of devices, and a subnetwork of medical devices within the network includes any subset of the N devices. A given device within the network may be common to more than one subnetwork, i.e., subnetworks need not be mutually exclusive.

[0199] As described above, a fluid infusion system is one example of a medical device network having wireless medical devices, where a network device may be, without limitation: an infusion pump; a physiological characteristic sensor transmitter; a portable display device; a remote controller; a physiological characteristic meter; a controller; a monitor device; a data translation device; a wireless telemetry router; or the like. FIG. **22** is a schematic and generalized representation of a medical device **1600** having wireless data communication and wireless networking capabilities. Device **1600** may represent any of the wireless medical devices described above. Accordingly, device **1600** may include a number of additional and/or alternative components that are specific to its particular application and functionality. Generally, device **1600** may include a wireless transceiver module **1602**, a wired communication module **1604**, a processing architecture **1606**, device-specific hardware **1608**, a user interface **1610**, and an appropriate amount of memory **1612**. The elements of device **1600** may be coupled together via a bus **1614** or any suitable interconnection architecture.

[0200] Wireless transceiver module **1602** is suitably configured to transmit and receive wireless data communication signals using appropriate wireless data communication links. The wireless signals include data fields that include data representing the desired information to be transferred within the medical device network. In certain embodiments, the wireless signals convey data packets that include the desired data fields. In this regard, FIG. **23** is a diagram of a portion of a data packet **1700** that contains data fields representing different dynamic link parameters corresponding to supported wireless data communication modes. An embodiment of medical device **1600** may be configured to process dynamic link parameters related to: a link reliability setting **1702**; a synchronize setting **1704**; a frequency allocation setting **1706**; a retry periodicity setting **1708**; a master/slave setting **1710**; and/or a transmit timing indicator **1712**. Any of these link parameters can be dynamically updated during a wireless data communication session. Moreover, data packet **1700** need not convey all of these dynamic link parameters; FIG. **23** depicts a full-featured version for ease of description. Each of these link parameters is described in more detail below.

[0201] Wireless transceiver module **1602** can transmit (and/or receive) wireless signals over wireless communication channels established between medical device **1600** and other compatible medical devices in the medical device network. Wireless transceiver module **1602** may include a wireless receiver module and a wireless transmitter module integrated together as a wireless (RF) radio module. Alternatively, medical device **1600** may utilize distinct wireless receiver and wireless transmitter modules. Wireless transceiver module **1602** may be configured as described above for wireless module **1308** (see FIG. **19**).

[0202] Medical device **1600** may also be capable of supporting data communication via a wired or cabled link using wired communication module **1604**. Accordingly, wired communication module **1604** may utilize hardware, software, firmware, processing logic, or any combination thereof, to provide the desired wired interface for medical device **1600**. Wired communication module **1604** may be suitably configured to support any of the wired data communication protocols described above (see, for example, the description of monitor **500**).

[0203] Processing architecture **1606** is generally configured as described above (see, for example, the description of processing architecture **514**). For this generalized medical device **1600**, processing architecture **1606** may include device-specific processing logic **1616** and processing logic **1618** for the particular wireless data communication modes supported by device **1600**. The device-specific processing logic **1616** represents the processing capabilities that relate to the operation and functionality of device **1600**. For example, if device **1600** is an infusion pump, then device-specific processing logic **1616** will include instructions related to pump operations. On the other hand, if device **1600** is a patient monitor, then device-specific processing logic **1616** will include instructions related to monitor operations. Processing logic **1618** represents various instructions, control logic, and processing capabilities related to the different wireless data communication protocols, wireless data transmission protocols, and dynamic wireless link parameters described here. In practice, some of the processing logic **1618** may (but need not) also be device-specific.

[0204] Device-specific hardware **1608** represents hardware and/or firmware that relate to the particular operation and functionality of medical device **1600**. For example, if device **1600** is an infusion pump, then device-specific hardware **1608** will include the pump mechanism. On the other hand, if device **1600** is a BG meter, then device-specific hardware **1608** may include a receptacle for a blood sample strip or stick.

[0205] User interface **1610** may include any number of features that allow user interaction with medical device **1600**. User interface **1610** may include any of the user interface elements described previously (see, for example, the description of user interface **208**).

[0206] Memory **1612** may be realized as described above for memory **516**. Memory **1612** can be coupled to process-

ing architecture **1606** such that processing architecture **1606** can read information from, and write information to, memory **1612**. In the alternative, memory **1612** may be integral to processing architecture **1606**. As an example, processing architecture **1606** and memory **1612** may reside in an ASIC. Memory **1612** is generally configured to store device-specific data and any data necessary to support the different wireless data communication modes described in more detail below.

[0207] Medical device **1600** (and/or a network of medical devices **1600**) is suitably configured to perform the various processes described here. A given process may be performed by software, hardware, firmware, or any combination. In embodiments, portions of a given process may be performed by different elements of the described system or device. Moreover, it should be appreciated that a described process may include any number of additional or alternative tasks, the tasks shown in the figures need not be performed in the illustrated order, and a described process may be incorporated into a more comprehensive procedure or process having additional functionality not described in detail here.

[0208] A medical device network as described herein includes any number of wireless medical devices configured to communicate with each other using wireless data communication links. To facilitate such data transfer, each device in the network is identified using a key that is unique within the network environment (and possibly unique beyond the network environment). In this regard, FIG. **24** is a flow chart that illustrates an exemplary key generation process **1800** that can be used to derive the keys for the devices. Once a key is generated for a device, that device is configured, initialized, or set up for operation in the medical device network using its unique key.

[0209] Key generation process **1800** can be utilized to generate device keys from at least one base identifier for the device, where a "base identifier" is any value, quantity, bit string, or character string that is associated with the device and/or with characteristics of deployment of the device within the medical device network. Accordingly, process **1800** may begin by obtaining one or more of such base identifiers (tasks **1802**, **1804**, **1806**, **1808**). In an embodiment where the device itself generates the key, a base identifier may be obtained from the memory of the device itself, via a user interface of the device, or it may be received from another device in the medical device network. In an embodiment where a programming device generates the key, a base identifier may be obtained from the medical device, from the memory of the programming device, or from another device in the medical device network.

[0210] The serial number of the medical device may be used as one base identifier in key generation process **1800**. Accordingly, process **1800** may obtain a serial number for the device (task **1802**). In practice, a serial number may or may not be unique across different device types, however, it should be unique for a given device type. As used here, a "device type" represents a grouping or categorization of medical devices that might be used in a medical device network. For example, the device type may identify the primary function of a device: infusion pumps may be a first device type; BG sensor transmitters may be a second device type; BG meters may be a third device type; etc. The device type may be used as another base identifier in process **1800**. Accordingly, process **1800** may obtain a device type identifier for the device (task **1804**).

[0211] Yet another suitable base identifier is a user identifier for the user of the device, where the user identifier may identify a patient-user of the device, a caregiver-user of the device, a parent-user of the device, or the like. Accordingly, key generation process **1800** may obtain a user identifier for a user of the device (task **1806**). In practice, the user identifier can be employed to distinguish different user classes from one another (for example, a patient-user may have different access rights than a caregiver-user). The user identifier could be identical to (or derived from) a customer ID that is assigned when an order for the medical device is placed. Alternatively, the user identifier could be programmed by the patient as a personalized ID. One application of this user identifier could be to provide limited access to a caregiver for certain functions such as data downloads. Since it would be used in conjunction with the device serial number, the user identifier may be realized as a relatively small string to differentiate between the different user classes. For example, in the case of a patient versus caregiver scenario, one bit would be sufficient to distinguish between the two user classes.

[0212] Yet another suitable base identifier could be one that distinguishes subnetworks within the medical device network. Subnetworks may be established to restrict the amount of wireless transmissions in the network; devices may be configured such that they only communicate with other devices within a designated subnetwork. For this example, a particular subnetwork identifier will be common to a subset of devices in the medical device network. For a network of N medical devices, the subnetwork identifier should be large enough to accommodate N−1 different subnetworks. Accordingly, key generation process **1800** may obtain one or more subnetwork identifiers for the device (task **1808**). Of course, if the network does not support subnetworks, then task **1808** will be omitted.

[0213] After the base identifier(s) have been obtained, the key for the device can be generated/derived from one or more of the base identifiers (task **1810**). In certain embodiments, task **1810** derives the key from a plurality of base identifiers. The base identifiers may serve as inputs to a suitably designed algorithm that generates the unique key as an output. In practical embodiments, a key is realized as a string of bits having an appropriate length. The number of bits assigned to the various base identifiers and to the computed key would be sufficiently large to accommodate the number of systems expected to be produced over time, thus ensuring uniqueness. Keys remain fixed once they are generated unless otherwise updated to reflect a change in one or more of the base identifiers or to reflect a network or device reconfiguration.

[0214] Key generation process **1800** may also initiate storage of the key at the device (task **1812**). In an embodiment where the device itself generates the key, task **1812** will be performed by the device. In an embodiment where a programming device generates the key, task **1812** will be performed by the programming device. In such an embodiment, process **1800** may transmit the key from the programming device to the device (task **1814**) for storage at the device. Task **1814** is depicted in dashed lines to indicate its optional nature. In response to task **1812**, the device stores the key in its internal memory (task **1816**). In certain embodiments, process **1800** may also transmit the key to one or more other devices in the medical device network (task **1818**). Task **1818** is depicted in dashed lines to indicate its

optional nature. Depending upon the embodiment, task **1818** may be performed by the device itself and/or by a programming device. For example, task **1818** may transmit the key to all other devices in the network. As an alternative example, task **1818** may transmit the key to a designated master device in the network.

[0215] In various embodiments, each medical device would have the capability of being programmed with the keys of other devices in the network. A device may also be capable of receiving one or more of the base identifiers from another device in the network. The programming can be performed manually using a suitably equipped computer device (e.g., a personal computer), via local or portable memory storage, using network access, using a wireless PDA, or using any device having the desired functionality and user interface features. Indeed, any device within the network may be configured to support such programming features. Alternatively, keys and/or base identifiers can be preloaded into a device at the factory or at a caregiver office.

[0216] Keys and/or base identifiers may be exchanged by wireless medical devices in the network using an appropriate "marrying" function. For example, a marrying function may be manually initialized such that a first device queries a second device for data; the first device can store the data after it receives it. This marrying function may be initialized via capacitive sensing between the two devices. Once the marrying function is initialized, the data can be exchanged via: the capacitive connection itself, RFID transmissions; proprietary or other RF transmissions per a network communication protocol; or some other RF data communication protocol such as Bluetooth, ZigBee, etc.

[0217] The two devices in question could also connect via magnetic sensing and then trade information as described in the preceding paragraph. The data may also be transferred using the magnetic connection. The two devices in question could also connect via optical sensing (e.g., IR) and then trade data as described in the preceding paragraph. The data may also be transferred using the optical connection.

[0218] A wireless medical device network can handle wireless network communications using different protocols to suit the needs of the particular application, network topology, operating conditions, or the like. Moreover, the medical devices may utilize device keys when processing wireless data packets within the medical device network. The device keys may serve as identifiers to distinguish different protocols, device features, and/or other variable characteristics (described in more detail below). For example, the keys may be used in connection with the various processes depicted in FIGS. **25-30**.

[0219] FIG. **25** is a flow chart that illustrates a synchronized wireless communication process **1900** suitable for use in a wireless medical device network, and FIG. **26** is a diagram that depicts data packet exchanges in accordance with process **1900**. This example assumes that each wireless medical device in the network has knowledge of the keys of the other devices. In this regard, each device may store a table of the keys utilized within the medical device network. Moreover, this example assumes that the devices communicate wireless data packets using a synchronized data communication protocol. The simple example shown in FIG. **26** includes three medical devices configured to operate in a wireless network topology: a monitor/controller **1950** that is identified by KEY**1**; a physiological sensor transmitter **1952** that is identified by KEY**2**; and a BG meter **1954** that is identified by KEY**3**. In practice, any device may be capable of sending data to another device and, in response, receiving an acknowledgement or a negative acknowledgement. The following example has been simplified for ease of description.

[0220] In connection with synchronized wireless communication process **1900**, all of the device keys are maintained at a first device (task **1902**), which serves as the transmitting device in this example, and all of the device keys are maintained at a second device (task **1904**), which serves as the receiving device in this example. In practice, each data packet transmitted by a device in the network will include the key of the transmitting device. Thus, the first device transmits a data packet intended for the second device (task **1906**), and that data packet conveys a quantity of data along with the key for the first device, i.e., the "first key." The quantity of data represents any non-overhead data of interest. During normal operation, the first device will transmit packets according to a negotiated synchronous transmit schedule such that the second device will expect to receive packets from the first device at certain designated times.

[0221] The data packet transmitted at task **1906** is received by the second device (task **1908**), and the second device determines whether the timing of the received data packet is in accordance with the particular synchronization settings (query task **1909**). In other words, the second device checks whether the timing and synchronization of the received data packet is correct or as anticipated. If so, then the received data packet was actually intended for the second device. If not, then the received data packet can be ignored (task **1918**). If the timing characteristics of the received data packet are correct, then the second device processes the received packet to extract the first key and/or to extract the non-overhead data (task **1910**). The second device can then analyze the extracted key and/or the extracted non-overhead data to determine whether the data packet was intended for the second device (task **1912**). As mentioned above, the devices exchange data in a synchronous manner. Therefore, the second device will expect to receive data from the first device (and possibly other devices in the network) in accordance with a designated time schedule. If the extracted key does not match the anticipated key (the first key in this example), then the second device will determine that the received packet was not intended for it. In practice, two things need to happen for the second device to either ACK or NAK. First, the time the message was received must correspond to the synchronized setting. If not, the second device should not be "listening" for the message and no NAK will be sent. Second, if the message is intended for the second device based on the synchronized timing but the data is corrupted or is valid data that is meant for another device, then a NAK will be sent. Thus, a NAK is generated in response to corrupt or invalid data if the timing is correct. If the timing is not correct, then the received message can be ignored. Additionally or alternatively, if the extracted non-overhead data has unexpected characteristics, then the second device will determine that the received packet was not intended for it. Under normal conditions, the non-overhead data may have certain trending characteristics that do not change very rapidly. If the extracted non-overhead data has unusually abrupt transitions or unintelligible content, then the second device might assume that the received packet was erroneously received.

[0222] In some embodiments, medical devices in the network may designate certain devices keys as invalid keys, where an invalid key corresponds to an unsupported or blocked device. For example, if the second device designates the first key as a valid key (query task **1914**), then the second device can support wireless data communication with the first device. Accordingly, the second device can generate and transmit a suitable response packet (task **1916**) intended for the first device. The response packet conveys the key for the second device, i.e., the "second key," along with an acknowledgement message (ACK) or a negative acknowledgement message (NAK). If, for example, the second device determines that the received packet was not actually intended for it, then the response packet may include a NAK. If, however, query task **1914** determines that the first key is an invalid key, then the second device may simply ignore the received packet (task **1918**) without taking any further action.

[0223] Referring to FIG. **26**, BG meter **1954** transmits a packet containing KEY**3** and a data payload to monitor/controller **1950**, which then responds with a packet containing KEY**1** and an ACK or a NAK message. A similar transmit/response scheme may be followed for a data payload transmitted from physiological sensor transmitter **1952** to monitor/controller **1950**, and for a data payload transmitted from BG meter **1954** to physiological sensor transmitter **1952**. The timing of the transmit and response packets between the various medical devices is governed by the negotiated synchronous timing scheme.

[0224] FIG. **27** is a flow chart that illustrates an asynchronous wireless communication process **2000** suitable for use in a wireless medical device network, and FIG. **28** is a diagram that depicts data packet exchanges in accordance with process **2000**. This example assumes that each wireless medical device in the network has knowledge of the keys of the other devices. Moreover, this example assumes that the devices communicate wireless data packets using an asynchronous data communication protocol. The simple example shown in FIG. **28** includes three medical devices configured to operate in a wireless network topology: a monitor/controller **2050** that is identified by KEY**1**; a physiological sensor transmitter **2052** that is identified by KEY**2**; and a BG meter **2054** that is identified by KEY**3**. In practice, any device may be capable of sending data to another device and, in response, receiving an acknowledgement or a negative acknowledgement. The following example has been simplified for ease of description.

[0225] In connection with asynchronous wireless communication process **2000**, all of the device keys are maintained at a first device (task **2002**), which serves as the transmitting device in this example, and all of the device keys are maintained at a second device (task **2004**), which serves as the receiving device in this example. In practice, each data packet transmitted by a device in the network will include the key of the transmitting device and the key of the intended receiving device. Thus, the first device transmits a data packet intended for the second device (task **2006**), and that data packet conveys a quantity of data along with the key for the first device, i.e., the "first key," and the key for the second device, i.e., the "second key." The quantity of data represents any non-overhead data of interest.

[0226] The data packet transmitted at task **2006** is received by the second device (task **2008**), and the second device processes the received packet to extract the keys and/or to extract the non-overhead data (task **2010**). The second device can then analyze the first key to identify the transmitting device (task **2012**). For example, the second device may look up the extracted key in a table to determine the origin of the received packet. This may be desirable in embodiments where subsequent processing of the received packet is dependent upon the identity of the transmitting device. The second device may also analyze the extracted second key and/or the extracted non-overhead data to determine whether the data packet was intended for the second device (task **2014**). If the extracted second key does not match the key of the second device, then the second device will determine that the received packet was not intended for it. If the received key is a valid key for a device in the network then the second device can ignore the message, understanding that the intended receiving device will either ACK or NAK. If, however, the received key is invalid for any device in the network, then the second device will generate a NAK. Additionally or alternatively, if the extracted non-overhead data has unexpected characteristics (as described above), then the second device will determine that the received packet was not intended for it.

[0227] Eventually, the second device can generate and transmit a suitable response packet (task **2016**) intended for the first device. The response packet conveys the first key, the second key, and an ACK/NAK message. If, for example, the second device determines that the received packet was not actually intended for it, then the response packet may include a NAK.

[0228] Referring to FIG. **28**, BG meter **2054** transmits a packet containing KEY**3**, KEY**1**, and a data payload to monitor/controller **2050**, which then responds with a packet containing KEY**1**, KEY**3**, and an ACK or a NAK message. A similar transmit/response scheme may be followed for a data payload transmitted from physiological sensor transmitter **2052** to monitor/controller **2050**. The transmission of both originating and destination keys in the above manner facilitates asynchronous packet transmission within the medical device network.

[0229] In another embodiment of a medical device network, one device (usually the monitor/controller or the infusion pump in a fluid infusion system) is designated as the master device and all other devices are designated as slave devices. The master device has knowledge of the keys for all of the devices in the network, while each slave device has knowledge of only its own key and the key for the master device. In this regard, FIG. **29** is a flow chart that illustrates a synchronous master-slave wireless communication process **2100** suitable for use in a wireless medical device network, and FIG. **30** is a diagram that depicts data packet exchanges in accordance with process **2100**. This example assumes that the devices communicate wireless data packets using a synchronized data communication protocol. The simple example shown in FIG. **30** includes three medical devices configured to operate in a wireless network topology: a monitor/controller **2150** that is identified by KEY**1**; a physiological sensor transmitter **2152** that is identified by KEY**2**; and a BG meter **2154** that is identified by KEY**3**. Here, monitor/controller **2150** is the master device. In practice, any device may be capable of sending data to another device and, in response, receiving an acknowledgement or a negative acknowledgement. The following example has been simplified for ease of description.

[0230] In connection with process **2100**, all of the device keys, including the master device key (KEY_M) and each slave device key (KEY_S), are maintained at the master device (task **2102**), which serves as the receiving device in this example. In addition, the master device key and the respective slave device key is maintained at each slave device within the medical device network (task **2104**). In this example, one of the slave devices serves as the transmitting device. In practice, each data packet transmitted by a slave device in the network will include the key of the master device, and need not include any other key. Thus, the slave device transmits a data packet intended for the master device (task **2106**), and that data packet conveys a quantity of data along with the key for the master device, i.e., the "master key." The quantity of data represents any non-overhead data of interest. During normal operation, the slave device will transmit packets according to a negotiated synchronous transmit schedule such that the master device will expect to receive packets from the slave device at certain designated times.

[0231] The data packet transmitted at task **2106** is received by the master device (task **2108**), and the master device processes the received packet to extract the master key and/or to extract the non-overhead data (task **2110**). The master device can then analyze the extracted master key and/or the extracted non-overhead data to determine whether the data packet was intended for the master device (task **2112**). As mentioned above, the devices exchange data in a synchronous manner. Therefore, the master device will expect to receive data from the slave device (and possibly other devices in the network) in accordance with a designated time schedule. If the extracted master key does not match the anticipated key (KEY**1** in this example), then the master device will determine that the received packet was not intended for it. Additionally or alternatively, if the extracted non-overhead data has unexpected characteristics (described above), then the master device will determine that the received packet was not intended for it.

[0232] Eventually, the master device can generate and transmit a suitable response packet (task **2114**) intended for the slave device. The response packet conveys the key for the slave device and an ACK/NAK message. If, for example, the master device determines that the received packet was not actually intended for it, then the response packet may include a NAK.

[0233] The master device, which functions as a communication coordinator or a hub in this example, may relay data (after appropriate data re-formatting if required) to other slave devices as needed (task **2116**). For example, BG meter **2154** can send data to monitor/controller **2150**, which may then forward the data to physiological sensor transmitter **2152**. Data packets transmitted by the master device may convey any type of data. For example, a data packet transmitted by the master device may convey a master clock time to which the other devices synchronize.

[0234] Referring to FIG. **30**, BG meter **2154** transmits a packet containing KEY**1** (the master key) and a data payload to monitor/controller **2150**, which then responds with a packet containing KEY**3** (the slave key for BG meter **2154**) and an ACK or a NAK message. Alternatively, the response packet need not include any keys; the specific response time slot would identify the responding device to the originating device. A similar transmit/response scheme may be followed for a data payload transmitted from physiological sensor transmitter **2152** to monitor/controller **2150**. Notably, under this master-slave scheme physiological sensor transmitter **2152** and BG meter **2154** are unable to directly communicate wireless data packets between one another; they communicate with each other indirectly via the master device. The timing of the transmit and response packets between the various medical devices is governed by the negotiated synchronous timing scheme.

[0235] Notably, for synchronized communications, the ACK/NAK packet need not require the key of the transmitting device. Moreover, asynchronous communication can be supported in a system embodiment where the transmitting device sends its key along with the ACK/NAK packet. In such an embodiment the transmission of the responding device key identifies the responding device to the master device in a manner that need not rely on any synchronized timing.

[0236] Depending upon the network deployment, it may not be necessary for each medical device in the network to be able to communicate with all other medical devices in the network. It may be desirable for a device to communicate with only a subset of the devices within the network. In this regard, FIG. **31** is a diagram that depicts two subnetworks of wireless medical devices in a medical device network. In this simplified example, the network includes a monitor/controller **2202**, a physiological sensor transmitter **2204**, a bedside monitor **2206**, and a BG meter **2208**. Subnetwork one includes monitor/controller **2202**, physiological sensor transmitter **2204**, and bedside monitor **2206**, and subnetwork two includes monitor/controller **2202** and BG meter **2208**. Each device may be associated with one or more codes or suitably formatted subnetwork indicators that identify the different subnetworks to which that device belongs. Thus, in this example, monitor/controller **2202** would have two different subnetwork identifiers.

[0237] In practice, different subnetworks within the medical device network may utilize different synchronized timing schemes to avoid packet collisions. In certain embodiments, the medical device network may be configured to adjust the different synchronized timing schemes to enable concurrent operation of the various subnetworks (e.g., avoid simultaneous packet transmissions for devices that are common to multiple subnetworks). To improve efficiency and to reduce unnecessary packet transmissions, medical devices in one subnetwork may be configured to avoid communication with medical devices in other subnetworks, and vice versa. This functionality can be achieved in one embodiment in the following manner. Devices in a given subnetwork maintain a list of valid device keys corresponding to other devices in the subnetwork, and maintain a list of invalid device keys corresponding to devices that are not in the subnetwork. Consequently, packets received by devices within the subnetwork must be associated with a valid device key, otherwise the received packets are discarded or ignored.

[0238] In some network deployments, it may be possible for a wireless medical device to perform a broadcast transmission of data packets for potential reception by a plurality of destination devices in the network. In this case, the receiving devices will respond (ACK/NAK) either in a specified predetermined sequence or in a pseudorandom order. In the event of a NAK or no response from one or more receiving devices, the transmitting device can retransmit the packet to all devices and await ACK/NAK

messages again. Such re-transmissions can be repeated for a predetermined number of retry attempts before alerting the user.

[0239] FIG. **32** is a flow chart that illustrates a broadcast transmission process **2300** suitable for use in a wireless medical device network, and FIG. **33** is a diagram that depicts data packet exchanges in accordance with process **2300**. This example assumes that the network devices are configured to communicate data in a synchronized manner using a common carrier frequency. At least the following two scenarios are also possible. First, devices within the "repeater" network can be at the same frequency but each device can communicate at a different frequency with a patient-held device. Second, devices within the network can be at different frequencies as long as at least a pair of devices are at the same frequency to allow communication. In FIG. **33**, the transmitting device **2350** is configured to broadcast wireless data packets to a plurality of receiving devices, including a first receiving device **2352** and a second receiving device **2354**.

[0240] In connection with broadcast transmission process **2300**, an instantiation of a random number generator is maintained at each device (task **2302**). Referring to FIG. **22**, a random number generator may be realized in, for example, processing logic **1618** of the respective device. The "same" random number generator is operable at each device such that, if seeded with the same value, each instantiation of the random number generator will generate the same sequence of pseudorandom numbers. Accordingly, process **2300** may seed each instantiation of the random number generator with a suitable common seed value (task **2304**) as an initialization step. This enables process **2300** to derive a pseudorandom order at the devices using the random number generators (task **2306**), where the pseudorandom order is derived in response to the common seed value.

[0241] A transmitting device then broadcasts a data packet to a plurality of other devices in the wireless medical device network (task **2308**) using an appropriate wireless data transmission protocol. FIG. **33** depicts this broadcast transmission occurring at time T_0. Assuming that multiple devices receive the broadcast packet, the receiving devices will generate respective response packets (task **2310**) for transmission back to the transmitting device. Thereafter, the receiving devices will transmit the response packets (and the originating device will receive the response packets) using time slots and/or using a sequence that is determined by the pseudorandom order (task **2312**). In one embodiment, the pseudorandom order (which will be shared with the network devices) is utilized to derive different response time slots for the receiving devices; each receiving device will have a pseudorandomly designated time slot for transmitting its response packet. In another embodiment, the pseudorandom order is utilized to derive a transmit sequence for the receiving devices; each receiving device will transmit its response packet in a designated sequential order. FIG. **33** depicts the response for first receiving device **2352** being transmitted at time T_1 and the response for second receiving device **2354** being transmitted at time T_2.

[0242] Thus, the transmitting device receives the response packets in a pseudorandom order that is based upon the common seed value for the random number generators. Since the transmitting device also maintains an instantiation of the random number generator (having the same seed value), it can correlate the received response packets to the receiving devices. In this manner, the transmitting device can resolve the identities of the receiving devices and process the respective response packets accordingly.

[0243] A wireless medical device may be suitably configured to function as a "repeater" in order to transmit messages over a longer range. In practice, such a repeater device might be realized with a relatively stationary device such as a bedside monitor or a remote annunciator. A medical device network may include any number of repeater devices configured to forward wireless messages within the network environment. In addition, this repeater device may serve as a translation device, connected via a USB link to a PC. In this case the repeater device may be capable of operating off the power provided by the USB interface when connected to a PC, or through an AC adapter providing power through the physical USB connector. Alternatively, such a repeater/translation device could be configured to directly communicate with the Internet (using any appropriate data communication technique or technology), in which case it would have its own IP address.

[0244] FIG. **34** is a flow chart that illustrates a wireless repeating process **2400** suitable for use in a wireless medical device network, and FIG. **35**A is a diagram that depicts data packet exchanges in accordance with process **2400**. The example depicted in FIG. **35**A includes an originating device **2450** (i.e., the first device), a second device **2452**, a destination device **2454** (i.e., the third device), a fourth device **2456**, and a fifth device **2458**. Here, originating device **2450** transmits a wireless message or data packet that is intended for destination device **2454**. Process **2400**, or an equivalent variant thereof, is used to forward the message to destination device **2454**.

[0245] Wireless repeating process **2400** may begin with an originating device generating a message that is intended for a destination device (task **2402**). In this embodiment, the message is conveyed using wireless data packets, and the originating device transmits the message using a suitable wireless data communication link. The message may include or convey any type of data, including, without limitation: alarms for the medical device network; status information; user reminders; patient data; or any of the data types described above.

[0246] The originating device may be configured to transmit messages in accordance with a predetermined ordered sequence, a pseudorandom sequence, or any suitable sequence for a plurality of devices within the medical device network. In the example shown in FIG. **35**A, the ordered sequence corresponds to a "circular" path that follows the device numbers. Thus, if fourth device **2456** is the originating device, then the ordered sequence is as follows: fifth device **2458**; first device **2450**; second device **2452**; third device **2454**; fourth device **2456**. If second device **2452** is the originating device, then the ordered sequence is as follows: third device **2454**; fourth device **2456**; fifth device **2458**; first device **2450**; second device **2452**. The sequence of devices in the medical device network may also represent a forwarding order for wireless packets routed throughout the network. In practice, the forwarding order may take any desired path, and one or more devices in the network may be omitted from the path. Moreover, the forwarding path may return to a device in the network for the sake of redundancy.

[0247] For purposes of this example, first device **2450** is the originating device and, therefore, task **2402** transmits the message from first device **2450** to second device **2452** via a

wireless data communication link **2460**. Under normal operating conditions, second device **2452** will receive the message via wireless data communication link **2460**. This example assumes that the message is intended for third device **2454** (i.e., the destination device). Accordingly, second device **2452** serves as a repeater/forwarding device for the message. If, however, the message is intended for second device **2452**, then the message need not be forwarded within the medical device network.

[0248] The receiving device (the second device **2452** in this example) may process the message and/or overhead data associated with the message to determine the desired forwarding order for the message (task **2406**). As mentioned above, the forwarding order represents a sequence of devices in the medical device network and the forwarding order may be based upon the location of the destination device within the medical device network. For example, a device may determine the forwarding order in a manner that favors paths having less "hops" between wireless devices in the network. In this embodiment, the forwarding order is fixed for a given network topology and the receiving device may consult a stored device sequence to determine the identity of the forward-to device.

[0249] The receiving device will then format the received message (if necessary) for forwarding, and forward the received message within the medical device network in an appropriate manner that is intended to reach the destination device. The receiving device will forward the message to another device in the network via a wireless data communication link (task **2408**). Depending upon the network topology and the forwarding order, this other device may be the destination device itself or an intermediate device located "before" the destination device. FIG. **35**A depicts an example where second device **2452** forwards its received message to third device **2454** via a wireless data communication link **2462**. Here, third device **2454** is the intended destination device.

[0250] Generally, the forwarded message can be processed (task **2410**) by each device as it progresses through the medical device network. If necessary, the devices can extract the payload data and process that data in an appropriate manner. Alternatively, the devices may analyze overhead data for purposes of message forwarding. In this example, wireless repeating process **2400** forwards the message within the medical device network until each of the devices has processed the message. This may occur even if the intended destination device has already received and processed the message. Accordingly, if the message has not been processed by all devices (query task **2412**), then process **2400** may be re-entered at task **2408** to initiate additional forwarding of the message. Otherwise, process **2400** ends. Referring to FIG. **35**A, the message may be forwarded from third device **2454** to fourth device **2456**, from fourth device **2456** to fifth device **2458**, and from fifth device **2458** back to first device **2450**. First device **2450** may be suitably configured to recognize that it originated the message and, therefore, to disregard the message without forwarding it.

[0251] Wireless repeating process **2400** can be modified to accommodate the situation where a common message (e.g., an alarm message generated by a monitor device) is detected and forwarded by multiple devices. For instance, one of the devices in the medical device network may be a designated "broadcasting device" for a given message that is intended for a plurality of destination devices in the network. In practice, the broadcast message can be wirelessly received by one or more destination devices in the network. When this occurs, any destination device that has received the broadcast message can then wirelessly forward the message to one or more other destination devices. Notably, the common broadcast message can be concurrently forwarded using different forwarding paths within the medical device network. However, each device may have suitably configured processing logic that enables it to determine whether or not it has already received the forwarded message. If a device determines that it has already received (and forwarded) the common message, then it can choose to ignore it.

[0252] The broadcast message may convey an alarm for the medical device network. If so, then it is possible for each destination device that receives the alarm message to generate an alarm indication in response to the alarm message. This alarm indication may be an audible and/or visual indication, depending upon the desired configuration and user preferences. In certain embodiments, the wireless repeating technique described herein can also be utilized to handle alarm termination (silencing) messages. For example, an alarm termination message may be generated at a first device within the medical device network in any suitable manner (usually in response to user interaction with the device). The alarm termination message may be processed by the first device such that the alarm at the first device is terminated. In addition, the first device may wirelessly forward the alarm termination message to one or more destination devices within the network, with the goal of terminating the related alarms at the other devices. Thus, the forwarded alarm termination message can be wirelessly received at another device, which then terminates its alarm in response to the forwarded alarm termination message. The alarm termination message may be forwarded in this manner until all alarms are silenced.

[0253] A patient-held or patient-worn device may also be considered to be part of the medical device network and, therefore, subject to the message forwarding and repeating techniques described herein. For example, silencing an alarm at a repeater/annunciator device within the network may cause that device to generate (or forward) an alarm termination message for the patient device. Upon receipt of the alarm termination message, the patent device will terminate its alarm (if it is still active). Similarly, silencing an alarm at a patient device may cause the patient device to generate (or forward) an alarm termination message for one or more destination devices within the medical device network. Thereafter, the alarm termination message can be forwarded/broadcast within the network in the manner described above.

[0254] A device in the network may also be configured to not sound an alarm. This can be performed on a pre-programmed time schedule, such as night versus day, or as required at any time. In the latter scenario, to prevent accidentally silencing a device permanently, the device may be designed to switch to the pre-programmed mode at the prescribed time.

[0255] FIG. **35**B is a diagram that illustrates a wireless annunciating and repeating system **2480**, which may be realized in the context of a wireless medical device network. Process **2400** described above may be modified in an appropriate manner to support the operation of system **2480**.

Here, system **2480** includes four annunciator/repeater devices (identified by reference numbers **2482**, **2484**, **2486**, and **2488**). A given annunciator/repeater may be a full function device such as a bedside monitor, or a reduced function device with or without a user interface. Any number of these devices can be used in a wireless repeater network. The example depicted in FIG. **35**B includes a patient-held device **2490** that transmits a message, typically an alarm or alert, that is received by annunciator/repeater **2484**. Note that one or more of the annunciator/repeater devices can receive the message as the location of patient-held device **2490** is not known to the annunciator/repeater devices.

[0256] Here, annunciator/repeater **2484** forwards (repeats) the message to the next device in the link, and so on. Each annunciator/repeater device can sound the appropriate alarm/alert as the location of the caregiver is unknown. The receiving annunciator/repeater device may respond with an ACK or NAK to the transmitting annunciator/repeater device. The patient-held device **2490** will be capable of listening for, and responding to ACK/NAK commands. Moreover, patient-held device may not be in the same location during the period that the messages are being transmitted and, therefore, it is preferably configured to be able to communicate with each annunciator/repeater device in the chain. In FIG. **35**B, patient-held device **2490** receives the ACK/NAK message annunciator/repeater **2482**. The alarm can be silenced (temporarily or permanently) at the annunciator/repeater device. In this regard, a silence message will be transmitted by each annunciator/repeater device to the next one in the chain. In addition, patient-held device **2490** will be capable of listening for, and responding to, the alarm silence command by temporarily halting the alarm until the alarm-causing condition is addressed on patient-held device **2490**.

[0257] The repeating/forwarding function can be served by a proprietary protocol or by a commercially available protocol such as ZigBee, Bluetooth, WiFi, and the like. Further, the protocol for the network of annunciator/repeater devices can be designed to be self-healing, allowing the networked annunciator/repeater devices to maintain connectivity if any annunciator/repeater device malfunctions, as is the case in a self-healing mesh network. Furthermore, the network protocol will be capable of determining which device malfunctioned and will be configured to sound an alarm via one of the other annunciator/repeater devices. The annunciator/repeater devices may also be equipped with another communication protocol such as Bluetooth, WiFi, or cellular, to forward a message to a device not inherently part of the repeater network or patient-held device **2490**. One suitable example is when a patient-held device transmits a message via a first telemetry to the annunciator/repeater network, which uses a second telemetry to forward that message within the annunciator/repeater network, and one designated annunciator/repeater also forwards the message via a third telemetry (which may be the same as the second or first telemetry) to another device such as a cell phone.

[0258] In the repeater network, even though the location of the patient-held device is unknown, it is possible to determine which repeater in the chain is closest to the patient-held device by virtue of the signal strength received. The device that has the highest signal strength would initiate the forwarding of the message to the next repeater in the chain. This would mean that the repeater network devices are in regular communication with each other, which would be the case regardless to ensure a device in the chain has not failed.

[0259] Alternatively, message forwarding may be triggered if a device in the chain obtains a received signal strength measurement that exceeds a preset threshold. In this regard, if a device receives a message having at least the threshold signal strength, then the device can initiate the forwarding of the message. If two or more devices all receive a message with the same signal strength, then the forwarding scheme could switch to one of the schemes described above.

[0260] A device for a medical device network may be suitably configured in a manner that combines the functionality of a wireless repeater/annunciator and a data communication translation device (see FIGS. **18-20** and related description). Such a device may be powered by a USB connection when coupled to a computer, by a conventional household AC supply, or by an AC or DC adapter having a USB connector. This device may be configured as a full-featured component (e.g., a bedside or hospital monitor as described above), or as a reduced-featured component having a minimal or no user interface. For example, a minimal user interface may include an alarm silence/termination button and perhaps a volume control element for audio alarms. In practice, such a combined device could be programmable via a personal computer or other suitable computing device (using, for example, a USB connection).

[0261] An embodiment of a wireless medical device as described herein can be configured to support both reliable wireless links (where missing or unacknowledged packets result in the generation of alarms) and unreliable wireless links (where missing or unacknowledged packets do not result in the generation of alarms) in a dynamically switching manner and in response to various criteria. In practice, unreliable links may be associated with a "best effort" quality of service. One example of a dynamically switchable wireless link is the wireless link between an infusion pump and a bedside monitor for the pump. Although this link may be a reliable link while the patient is asleep and in close proximity to the bedside monitor, during the day the link could switch to a best effort link to accommodate periods of time when the patient might be outside of the reliable range of the bedside monitor. When the patient (and the infusion pump) returns within range of the bedside monitor, the link can switch back to a reliable link and accumulated patient data can be transferred in a batch mode.

[0262] For example, FIG. **36** is a flow chart that illustrates a link reliability selection process **2500** suitable for use in a wireless medical device network. Process **2500** may be performed by wireless medical devices that are configured to support both reliable links and unreliable links. Process **2500** may begin by selecting the "reliable link" mode or the "unreliable link" mode (task **2502**). Task **2502** may be responsive to a selection made by a user of the medical device system, the selection may be automatically initiated by the medical device in response to current operating conditions, or the selection may be made by another device in the system and communicated to the transmitting device. For example, the particular wireless data communication mode may be selected in response to: (1) a priority associated with data to be transferred between the devices; (2) a data type category associated with data to be transferred between the devices; (3) a predetermined schedule; (4)

transmit power criteria; and/or (5) a quality of service measurement for a wireless data communication session between the devices. Regarding item (1), the reliable link mode can be selected for data marked with a relatively high priority, while the unreliable link mode can be selected for data marked with a relatively low priority. Regarding item (2), the reliable link mode can be selected for urgent or time-sensitive items such as alarms and event markers, while the unreliable link mode can be selected for background or device status information. Regarding item (3), the reliable link mode can be selected during normal sleeping hours, while the unreliable link mode can be selected during normal working hours. Regarding item (4), the reliable link mode can be selected for relatively high power transmissions, while the unreliable link mode can be selected for relatively low power transmissions. Regarding item (5), the reliable link mode can be selected when the wireless channel between the devices is of relatively high quality, while the unreliable link mode can be selected when the wireless channel between the devices is of relatively low quality. Of course, the dynamic selection of the wireless data communication mode need not be restricted to these examples, and an embodiment of the medical device system may utilize different criteria that governs the selection made during task **2502**.

[0263] After the link reliability mode has been selected, the transmitting device is configured to support operation in the selected mode (task **2504**). In this regard, the transmitting device is configured to support either of the dynamically selectable modes (the reliable link mode or the unreliable link mode in this example). Link reliability selection process **2500** may also generate and transmit a mode identifier to the receiving device (task **2506**). The mode identifier designates or identifies the selected wireless data communication mode, and the mode identifier prompts the receiving device to configure itself to support the selected mode (as designated by the mode identifier). In this example where only two different link reliability modes are available, the mode identifier can simply be a one-bit flag that is transmitted in an appropriate format. The mode identifier may be transmitted as overhead in a data packet or transmitted in at least one initial bonding packet (packets that are sent at the beginning of a wireless data communication session).

[0264] Once the wireless medical devices are operating in the selected link reliability mode, a transmitting device can generate and transmit a wireless data packet to a receiving device (task **2508**). If the transmitting device receives an acknowledgement (ACK) of the transmitted data packet (query task **2510**), then task **2508** may be re-entered to enable the continued transmission of additional wireless data packets using the selected mode. If the transmitting device does not receive an ACK message for the transmitted data packet, then it may check to determine whether the reliable link mode is currently active (query task **2512**). If the devices are currently operating in the reliable link mode, then an appropriate alarm is generated (task **2514**) to notify the user that a wireless data packet may have been missed or that the wireless link has become unreliable. In practice, task **2514** may be delayed until a specified number of data packets have been transmitted without acknowledgment.

[0265] If query task **2512** determines that the unreliable link mode is currently active, then the devices will continue providing a best effort quality of service (task **2516**) regardless of the wireless data packet acknowledgement status. In other words, the unreliable link mode tolerates unacknowledged packets and the devices need not take any special action in response to unacknowledged packets. Indeed, the devices might be suitably configured to prevent the generation of quality of service alarms (task **2518**) while operating in the unreliable link mode. This feature ensures that alarms are not generated for low priority data items.

[0266] In this example, the devices are capable of dynamically switching between the different wireless data communication modes, and such dynamic switching may occur during a wireless data communication session between the devices. Accordingly, if one or both of the devices decide to switch modes (query task **2520**), then link reliability process **2500** may be re-entered at task **2504** to reconfigure a transmitting device for operation in the newly selected mode. If the current mode is not switched, then process **2500** may be re-entered at task **2508**.

[0267] Wireless medical devices in the system may be configured to automatically switch from the unreliable link mode to the reliable link mode when they become within a certain range of each other. For example, FIG. **37** is a flow chart that illustrates an auto device detection process **2600** suitable for use in a wireless medical device network. Process **2600** assumes that the devices are already supporting operation in the unreliable link mode (task **2602**). If one (or both) of the devices automatically detects that the devices are within range for the reliable link mode (query task **2604**), then the devices can switch to the reliable link mode (task **2606**). Otherwise, the devices can continue operating in the unreliable link mode.

[0268] Upon switching from the unreliable link mode to the reliable link mode, auto device detection process **2600** may initiate the transfer of accumulated data (task **2608**), which may have collected at one or both devices. This enables the devices to be updated with "fill-in" data that may have been missed while the devices were operating in the unreliable link mode. As described above in the context of link reliability selection process **2500**, the wireless medical devices may be configured to dynamically switch between the reliable link mode and the unreliable link mode. Accordingly, if the current mode is switched (query task **2610**), then process **2600** may be re-entered at task **2602** to support operation in the unreliable link mode. Otherwise, process **2600** can continue to support operation in the reliable link mode (task **2612**) until the wireless data communication session ends or until the mode is switched.

[0269] A wireless medical device in the system may also be configured to automatically detect the presence of new compatible devices when they are within a certain range of the existing device. For example, FIG. **38** is a flow chart that illustrates a new device detection process **2700** suitable for use in a wireless medical device network. Process **2700** assumes that a first device is already active in the medical device network. If the first device automatically detects that a new device is within range for the reliable link mode (query task **2702**), then process **2700** establishes a wireless data communication session between the first device and the new device (task **2704**); the wireless data communication session uses the reliable link mode for wireless data transfer between the two devices.

[0270] After detecting and connecting with the new device, new device detection process **2700** may initiate the transfer of accumulated data (task **2706**), which may be stored at the new device. This enables the first device to be

updated with "fill-in" data for the new device. As described above in the context of link reliability selection process **2500**, the wireless medical devices may be configured to dynamically switch between the reliable link mode and the unreliable link mode. Accordingly, if the current mode is switched (query task **2708**), then process **2700** may cause the devices to be reconfigured to support operation in the unreliable link mode (task **2710**) until the wireless data communication session ends or until the mode is again switched. Otherwise, process **2700** can continue to support operation in the reliable link mode (task **2712**) until the wireless data communication session ends or until the mode is switched.

[0271] A wireless medical device in the system may also be configured to select between a synchronous wireless data communication mode or an asynchronous wireless data communication mode for a given data communication session with another device. In the asynchronous mode, wireless data packets can be transmitted at arbitrary times; in the synchronous mode, wireless data packets are sent and received in accordance with a specified synchronization scheme.

[0272] FIG. **39** is a flow chart that illustrates a synchronization protocol selection process **2800** suitable for use in a wireless medical device network. Process **2800** may be performed by wireless medical devices that are configured to support both synchronous and asynchronous data communication protocols. Process **2800** may begin by selecting the synchronous mode or the asynchronous mode for a wireless data communication session with a device (task **2802**). Task **2802** may be responsive to a selection made by a user of the medical device system, the selection may be automatically initiated by the transmitting medical device in response to current operating conditions, or the selection may be made by another device in the system and communicated to the transmitting medical device. For example, the particular wireless data communication mode may be selected in response to: (1) a priority associated with data to be transferred between the devices; (2) a data type category associated with data to be transferred between the devices; (3) a predetermined schedule; (4) transmit power criteria; and/or (5) a quality of service measurement for a wireless data communication session between the devices. These items were described above in the context of link reliability selection process **2500**. The selection of the wireless data communication mode need not be restricted to these examples, and an embodiment of the medical device system may utilize different criteria that governs the selection made during task **2802**.

[0273] After the synchronize mode has been selected, the transmitting device is configured to support operation in the selected mode (task **2804**). In this regard, the transmitting device is configured to support either of the dynamically selectable modes (the synchronous mode or the asynchronous mode in this example). Synchronization protocol selection process **2800** may also create a packet that contains a mode identifier for processing by the receiving device (task **2806**). The mode identifier designates or identifies the synchronous mode or the asynchronous mode, and the mode identifier prompts the receiving device to configure itself to support the selected mode (as designated by the mode identifier). In this example where only two different synchronize settings are available, the mode identifier can simply be a one-bit flag that is transmitted in an appropriate format. The transmitting device transmits the packet with the mode identifier to the receiving device (task **2808**). In practice, the mode identifier may be transmitted as overhead in a data packet or transmitted in at least one initial bonding packet. Upon receipt of this packet, the receiving device is configured to support the selected mode (task **2810**).

[0274] If the selected mode is the asynchronous mode (the "NO" branch of query task **2812**), then the wireless medical devices will operate in a manner that supports asynchronous wireless data transfer (task **2814**). Otherwise, if the selected mode is the synchronous mode, then the devices may negotiate or select a suitable transmit/receive schedule for data transferred between the devices (task **2816**). In addition, the wireless medical devices will operate in a manner that supports synchronous wireless data transfer in accordance with the negotiated transmit/receive schedule (task **2818**). This schedule may designate specific transmit and receive time slots for the two devices such that each device will know when to transmit a packet to the other device, and when to expect to receive a packet from the other device.

[0275] In this example, the devices are capable of dynamically switching between the synchronous and asynchronous modes, and such dynamic switching may occur during a wireless data communication session between the devices. Accordingly, if one or both of the devices decide to switch modes (query task **2820**), then synchronization protocol selection process **2800** may be re-entered at task **2802** (or possibly task **2812**) to reconfigure the devices to support the new mode. Otherwise, query task **2820** may be re-entered so that process **2800** can continue monitoring for a mode switching instruction.

[0276] A wireless medical device in the system may also be configured to select a frequency allocation scheme for a given wireless data communication session with another device. This feature allows for flexibility in the complexity of the devices in the medical device network. An embodiment may be configured to support any number of different frequency allocation schemes and to choose one of the schemes for use with any given wireless data communication link. As one non-limiting example, the device can select from the following options: a single frequency/channel mode; a five frequency/channel, low power mode; and a fifty frequency/channel, high power mode. In connection with an infusion system, the wireless link between a physiological sensor transmitter and an infusion pump may utilize the five frequency/channel mode to conserve battery power, however, during times of increased packet loss or collision, the devices may switch to the fifty frequency/channel mode to achieve increased transmit power.

[0277] FIG. **40** is a flow chart that illustrates a dynamic frequency hopping process **2900** suitable for use in a wireless medical device network. Process **2900** may be performed by wireless medical devices that are configured to support a plurality of different frequency allocation (e.g., frequency hopping) schemes. In connection with process **2900**, the wireless medical device may obtain a quality of service measurement for a current wireless data communication session with another device (task **2902**). Task **2902** is depicted in dashed lines to indicate its optional nature; the quality of service measurement represents an optional parameter that can be utilized to govern the selection of the frequency allocation scheme.

[0278] Dynamic frequency hopping process **2900** is utilized to select (task **2904**) a desired wireless data commu-

nication mode from a plurality of supported modes, where each supported mode corresponds to a different frequency allocation scheme. Task **2904** may be responsive to a selection made by a user of the medical device system, the selection may be automatically initiated by the transmitting medical device in response to current operating conditions, or the selection may be made by another device in the system and communicated to the transmitting medical device. For example, the particular frequency allocation scheme may be selected in response to: (1) a priority associated with data to be transferred between the devices; (2) a data type category associated with data to be transferred between the devices; (3) a predetermined schedule; (4) transmit power criteria; and/or (5) a quality of service measurement for a wireless data communication session between the devices. These items were described above in the context of link reliability selection process **2500**. The selection of the frequency allocation scheme need not be restricted to these examples, and an embodiment of the medical device system may utilize different criteria that governs the selection made during task **2904**.

[0279] After the frequency allocation scheme has been selected, the transmitting device is configured (setup) to support operation in the selected mode (task **2906**). In this regard, the transmitting device is able to support any of a plurality of frequency allocation schemes in a dynamically selectable manner—the single frequency/channel mode, the five frequency/channel mode, or the fifty frequency/channel mode in this example. Dynamic frequency hopping process **2900** may also create a packet that contains a mode identifier for processing by the receiving device (task **2908**). The mode identifier designates or identifies the selected operating mode, and the mode identifier prompts the receiving device to configure itself to support the selected mode (as designated by the mode identifier). In this example where three different frequency allocation schemes are available, the mode identifier can be a two-bit flag that is transmitted in an appropriate format. The transmitting device transmits the packet containing the mode identifier to the receiving device (task **2910**). In practice, the mode identifier may be transmitted as overhead in a data packet or transmitted in at least one initial bonding packet. Upon receipt of this packet, the receiving device is configured (setup) to support the selected mode (task **2912**).

[0280] Eventually, both devices are setup to support wireless data transfer in accordance with the selected wireless data communication mode and in accordance with the designated frequency allocation scheme (task **2914**). In this example, the devices are capable of dynamically switching between the different modes, and such dynamic switching may occur during a wireless data communication session between the devices. Accordingly, if one or both of the devices decide to switch modes (query task **2916**), then dynamic frequency hopping process **2900** may be re-entered at task **2904** (or possibly task **2914**) to reconfigure the devices to support the new mode. Otherwise, query task **2916** may be re-entered so that process **2900** can continue monitoring for a mode switching instruction.

[0281] In practice, synchronous wireless links operate with a designated transmission periodicity (e.g., sixty seconds per packet). The transmitting device can retransmit (retry) a packet if that packet was missed or unacknowledged. Moreover, the two devices may follow a particular retry synchronization scheme where retry packets are sent with a designated retry periodicity (e.g., twenty seconds per retry packet). In this regard, a wireless medical device as described herein may also be configured to adjust its packet retransmission (retry) settings for synchronous links. For example, the device can select a particular retry periodicity based upon current operating conditions and/or characteristics of the data to be transferred. The selection may be governed by various criteria such as data transmission reliability, power saving, available bandwidth, or the like. Moreover, both devices can adapt their frequency hopping scheme in a negotiated manner (for example, as described above in the context of dynamic frequency hopping process **2900**) for retry packets and, once the nominal quality of service is resumed for the wireless link, revert back to the baseline frequency hopping scheme.

[0282] FIG. **41** is a flow chart that illustrates a retry periodicity selection process **3000** suitable for use in a wireless medical device network. Process **3000** may be performed by wireless medical devices that are configured to support a plurality of different retry periodicity settings. Process **3000** begins with the devices operating in a synchronous wireless data communication mode (task **3002**) during which wireless data packets are exchanged in accordance with a first timing scheme. For this example, the first timing scheme represents the normal packet transmission periodicity associated with normal operating conditions and at least a nominal quality of service for the wireless link utilized by the devices. Thus, the first timing scheme corresponds to a first transmit/receive period for the devices. This normal operating mode is maintained until the occurrence of an unacknowledged data packet (query task **3004**). In this regard, the transmitting device may receive a NAK message that indicates an unacknowledged data packet, the transmitting device may receive a retry request from the receiving device, or the transmitting device may assume that a transmitted data packet was not received if the transmitting device does not receive some type of response message within a certain time period.

[0283] If a data packet remains unacknowledged (query task **3004**), then retry periodicity selection process **3000** selects (task **3006**) a desired retry periodicity setting from a plurality of supported settings, where each supported setting corresponds to a respective retry timing scheme that is different than the first (normal) transmission timing scheme. In practical embodiments, each retry periodicity setting corresponds to a different transmit/receive period that is shorter than the first transmit/receive period utilized for packet transmissions under normal conditions. Task **3006** may be responsive to a selection made by a user of the medical device system, the selection may be automatically initiated by the transmitting medical device in response to current operating conditions, or the selection may be made by another device in the system and communicated to the transmitting medical device. For example, the particular retry periodicity setting may be selected in response to: (1) a priority associated with data to be transferred between the devices; (2) a data type category associated with data to be transferred between the devices; (3) a predetermined schedule; (4) transmit power criteria; and/or (5) a quality of service measurement for a wireless data communication session between the devices. These items were described above in the context of link reliability selection process **2500**. Alternatively, the retry periodicity setting may be selected in response to the number of retry attempts that

have been performed for the data packet. For example, the length of the retry period may decrease in proportion to the number of failed packet transmission attempts such that the frequency of retry packet transmissions increases until one has been acknowledged or until the transmitter decides to no longer make any retry attempts. The selection of the retry periodicity setting need not be restricted to these examples, and an embodiment of the medical device system may utilize different criteria that governs the selection made during task **3006**.

[0284] Assuming that the devices are communicating using a synchronous wireless data communication protocol, it may be necessary to select an appropriate frequency hopping scheme (from a plurality of supported frequency hopping schemes) that is compatible with the selected retry timing scheme (task **3008**). For example, dynamic frequency hopping process **2900**, or a suitable variant thereof, can be utilized in connection with task **3008**. The selection of an appropriate frequency allocation scheme enables the devices to support network communication using the designated retry periodicity setting.

[0285] After the retry periodicity setting and the frequency hopping scheme have been selected, the transmitting device is configured (setup) to support operation in the selected mode (task **3010**). In this regard, the transmitting device is able to support any of a plurality of retry timing schemes in a dynamically selectable manner. Retry periodicity selection process **3000** may also create a packet that contains a mode identifier for processing by the receiving device (task **3012**). The mode identifier designates or identifies the selected retry periodicity setting, and the mode identifier prompts the receiving device to configure itself to support the selected mode (as designated by the mode identifier). The transmitting device transmits the packet containing the mode identifier to the receiving device (task **3014**). In practice, the mode identifier may be transmitted as overhead in a data packet or transmitted in a packet that conveys dynamic link parameters without any payload data. Upon receipt of this packet, the receiving device is configured (setup) to support the selected mode (task **3016**).

[0286] Eventually, both devices are setup to support the designated retry timing scheme. Accordingly, the transmitting device can retransmit at least one wireless data packet using the designated retry periodicity setting (task **3018**). In this example, if one or both devices detect an operating condition that satisfies a quality of service threshold (query task **3020**), then retry periodicity selection process **3000** may be re-entered at task **3002** such that the normal timing scheme and the baseline retry timing scheme are again utilized for subsequently transmitted data packets. In other words, the system switches back to the first timing scheme and switches back to its nominal retry periodicity setting. If the threshold quality of service is not satisfied (query task **3020**), then process **3000** may exit or otherwise proceed in an appropriate manner. For example, query task **3004** may be re-entered to enable dynamic adjustment of the retry timing scheme. Alternatively, the current retry timing scheme may be maintained for a period of time or until the quality of service improves or degrades by a specified amount.

[0287] A wireless medical device as described herein may also be configured to provide varying time periods between transmissions based upon various criteria such as, without limitation: the particular physiological data (e.g., rising or falling trends), failure to respond to an alert, failure to notice a change in physiological parameters, or the like. The transmitted packet could provide a field for notifying the receiving device of the desired time period after which the next data packet will be transmitted. This could be implemented using a time differential or a specified time, assuming that both devices are synchronized with a common clock. Alternatively, time synchronization with a common clock may not be necessary if a time stamp is sent with the data. In that case, the resolution of the time (e.g., microseconds) needs to be the same in order to know when to expect the next data packet.

[0288] For example, FIG. **42** is a flow chart that illustrates a transmit timing selection process **3100** suitable for use in a wireless medical device network. Process **3100** assumes that the wireless medical devices exchange data in a synchronous manner. Process **3100** may be performed by wireless medical devices that are configured to support a variable transmit/receive timing scheme. In connection with process **3100**, the transmitting device dynamically determines when the next wireless data packet will be transmitted to the receiving device (task **3102**). The transmitting device may then generate or select a variable time indicator that indicates when the next data packet will be transmitted over the wireless data communication channel. In one embodiment, the variable time indicator indicates a specific transmit time for the next packet. In another embodiment, the variable time indicator indicates a specific time period, where the next data packet will be transmitted after the specified time period.

[0289] The selection of the variable time indicator may be responsive to a selection made by a user of the medical device system, the selection may be automatically initiated by the transmitting medical device in response to current operating conditions, or the selection may be made by another device in the system and communicated to the transmitting medical device. For example, the particular variable time indicator may be selected in response to: (1) a priority associated with data to be transferred between the devices; (2) a data type category associated with data to be transferred between the devices; (3) a predetermined schedule; (4) transmit power criteria; and/or (5) a quality of service measurement for a wireless data communication session between the devices. These items were described above in the context of link reliability selection process **2500**. Alternatively, the variable time indicator may be selected in response to trending characteristics in the data transferred between the devices. For example, if the trending characteristics represent a relatively high rate of change in the data transferred between the devices, the variable time indicator may indicate a relatively short time period corresponding to when the next data packet will be transmitted. On the other hand, if the trending characteristics represent a relatively low rate of change in the data transferred between the devices, the variable time indicator may indicate a relatively long time period corresponding to when the next data packet will be transmitted. Of course, the selection of the variable time indicator need not be restricted to these examples, and an embodiment of the medical device system may utilize different criteria that governs the selection of the variable time indicator. One practical benefit of this scheme is to lower the power consumption by reducing RF "on" time. Other practical benefits may also be derived from this scheme.

[0290] After the variable time indicator has been selected, the transmitting device configures itself to transmit the next data packet at the specified transmit time or after the specified time period, as designated by the variable time indicator (task **3104**). Transmit timing selection process **3100** may also create a packet that contains the variable time indicator for processing by the receiving device (task **3106**), and transmit that packet to the receiving device (task **3108**). In practice, the variable time indicator may be transmitted as overhead in a data packet, transmitted in at least one initial bonding packet, or transmitted in a packet that conveys dynamic link parameters without any payload data. The variable time indicator prompts the receiving device to configure itself to receive the next data packet as designated by the variable time indicator. Accordingly, upon receipt of this packet, the receiving device is configured (setup) in response to the variable time indicator (task **3110**).

[0291] The transmitting device can adjust the transmit time for subsequent packets in a dynamic manner. Accordingly, FIG. **42** depicts task **3110** leading back to task **3102**. Notably, the timing need not be adjusted for each transmitted packet, and transmit timing selection process **3100** may preserve a selected transmit timing scheme for any number of packet transmissions before altering the current timing scheme.

[0292] In an alternate embodiment, the receiving (second) device receives data packets from the first device, performs data analysis, and, in response thereto, determines a time period or a specific time for the next data packet transmission. Thereafter, the receiving device will generate and send an ACK message back to the transmitting (first) device, with the selected time period or specific time corresponding to the next transmission. In practice, the selected time period or specific time for the next transmission may be conveyed in the ACK message itself or in a separate data packet.

[0293] Referring again to FIG. **23**, one or more of the dynamic link parameters described above can be transmitted via a wireless data communication signal having data fields arranged in a suitably formatted data packet **1700**. In this context, the dynamic link parameters are any of the various mode identifiers and variables that result in adjustments in the wireless data communication protocols/links used between the wireless medical devices.

[0294] Data packet **1700** may, for example, be an initial bonding packet that is used to initiate a wireless data communication session between two devices. As mentioned previously, data packet **1700** may include data or data fields corresponding to one or more of the following dynamic link parameters: a link reliability setting **1702**; a synchronize setting **1704**; a frequency allocation setting **1706**; a retry periodicity setting **1708**; a master/slave setting **1710**; and/or a transmit timing indicator **1712**. Depending upon the particular system application, one or more of these link parameters can be dynamically updated during a wireless data communication session. The data contained in data packet **1700** represents a selected one of a plurality of supported wireless data communication modes, where each mode corresponds to a different set of wireless or RF link characteristics for the wireless data communication channel between the devices.

[0295] For the example described here, the data fields shown in FIG. **23** correspond to various parameters and indicators described above. Thus, link reliability setting **1702** designates either the reliable link mode or the unreliable link mode, as described in more detail above in the context of link reliability selection process **2500** (see FIG. **36**). In addition, synchronize setting **1704** designates either the synchronous wireless data communication mode or the asynchronous wireless data communication mode, as described in more detail above in the context of synchronization protocol selection process **2800** (see FIG. **39**). For the example described here, frequency allocation setting **1706** designates one of the plurality of supported frequency hopping schemes, as described in more detail above in the context of dynamic frequency hopping process **2900** (see FIG. **40**). Moreover, retry periodicity setting **1708** designates one of the plurality of supported retry timing schemes, as described in more detail above in the context of retry periodicity selection process **3000** (see FIG. **41**). For the example described here, master/slave setting **1710** designates a master device status or a slave device status for a device that originates data packet **1700**, as described in more detail above in the context of master-slave communication process **2100** (see FIG. **29** and FIG. **30**). In addition, transmit timing indicator **1712** designates when the next packet will be transmitted, as described in more detail above in the context of transmit timing selection process **3100** (see FIG. **42**).

[0296] While at least one example embodiment has been presented in the foregoing detailed description, it should be appreciated that a vast number of variations exist. It should also be appreciated that the example embodiment or embodiments described herein are not intended to limit the scope, applicability, or configuration of the invention in any way. Rather, the foregoing detailed description will provide those skilled in the art with a convenient road map for implementing the described embodiment or embodiments. It should be understood that various changes can be made in the function and arrangement of elements without departing from the scope of the invention, where the scope of the invention is defined by the claims, which includes known equivalents and foreseeable equivalents at the time of filing this patent application.

What is claimed is:

1. A communication method for a medical device system, the method comprising:

supporting a first wireless data communication mode between a first device in the medical device system and a second device in the medical device system;

supporting a second wireless data communication mode between the first device and the second device;

in the first wireless data communication mode, generating an alarm in response to an unacknowledged wireless data packet; and

in the second wireless data communication mode, providing a best effort quality of service between the first device and the second device regardless of wireless data packet acknowledgement status.

2. A method according to claim **1**, further comprising selecting the first wireless data communication mode or the second wireless data communication mode in response to a priority associated with data to be transferred between the first device and the second device.

3. A method according to claim **1**, further comprising selecting the first wireless data communication mode or the second wireless data communication mode in response to a data type category associated with data to be transferred between the first device and the second device.

4. A method according to claim 1, further comprising selecting the first wireless data communication mode or the second wireless data communication mode in response to a predetermined schedule.

5. A method according to claim 1, further comprising dynamically switching between the first wireless data communication mode and the second wireless data communication mode during a wireless data communication session between the first device and the second device.

6. A method according to claim 1, further comprising preventing generation of quality of service alarms while in the second data communication mode.

7. A method according to claim 1, further comprising the first device transmitting a mode identifier to the second device, wherein the mode identifier designates the first wireless data communication mode or the second wireless data communication mode, and wherein the mode identifier prompts the second device to configure itself to support the first wireless data communication mode or the second wireless data communication mode as designated by the mode identifier.

8. A method according to claim 7, wherein the transmitting step transmits the mode identifier in at least one initial bonding packet.

9. A method according to claim 1, further comprising:

in the second wireless data communication mode, the first device automatically detecting when the second device is within range for the first wireless data communication mode; and

switching to the first wireless data communication mode in response to the detecting step.

10. A method according to claim 1, further comprising:

in the second wireless data communication mode, the first device automatically detecting when a compatible device is within range for the first wireless data communication mode; and

establishing, in response to the detecting step, a wireless data communication session between the first device and the compatible device, wherein the wireless data communication session uses the first wireless data communication mode.

11. A method according to claim 10, further comprising initiating, after establishing the wireless data communication session, a transfer of accumulated patient data between the first device and the compatible device.

12. A wireless data communication signal having data fields transmitted over a wireless data communication channel between a first device in a medical device system and a second device in the medical device system, the wireless data communication signal comprising a data field including data representing a selected one of a plurality of supported wireless data communication modes, each of the supported wireless data communication modes corresponding to a different set of radio frequency (RF) link characteristics for the wireless data communication channel.

13. A wireless data communication signal according to claim 12, wherein:

the data field includes data representing a link reliability setting;

the link reliability setting designates a first wireless data communication mode or a second wireless data communication mode;

in the first wireless data communication mode, the medical device system generates an alarm in response to an unacknowledged wireless data packet; and

in the second wireless data communication mode, the medical device system provides a best effort quality of service between the first device and the second device regardless of wireless data packet acknowledgement status.

14. A wireless data communication signal according to claim 12, wherein:

the data field includes data representing a synchronize setting; and

the synchronize setting designates a synchronous wireless data communication mode or an asynchronous wireless data communication mode.

15. A wireless data communication signal according to claim 12, wherein:

the data field includes data representing a frequency allocation setting; and

the frequency allocation setting designates one of a plurality of supported frequency hopping schemes.

16. A wireless data communication signal according to claim 12, wherein:

the data field includes data representing a retry periodicity setting; and

the retry periodicity setting designates one of a plurality of supported retry timing schemes.

17. A wireless data communication signal according to claim 12, wherein:

the data field includes data representing a master/slave setting; and

the master/slave setting designates a master device status or a slave device status for a device that originates the wireless data communication signal.

18. A wireless data communication signal according to claim 12, wherein the data field is dynamically updateable during a wireless data communication session between the first device and the second device.

19. A wireless data communication signal according to claim 18, wherein the data field is dynamically updateable in response to a priority associated with data to be transferred between the first device and the second device.

20. A wireless data communication signal according to claim 18, wherein the data field is dynamically updateable in response to a data type category associated with data to be transferred between the first device and the second device.

21. A wireless data communication signal according to claim 18, wherein the data field is dynamically updateable in response to a predetermined schedule.

22. A wireless data communication signal according to claim 18, wherein the data field is dynamically updateable in response to a transmit power criteria.

23. A wireless data communication signal according to claim 18, wherein the data field is dynamically updateable in response to a quality of service measurement.

24. A wireless data communication signal according to claim 18, wherein the data field is dynamically updateable in response to an unacknowledged wireless data packet.

25. A wireless data communication signal according to claim 12, wherein the data field is transmitted in at least one initial bonding packet.

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