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(54) Title: EVENT CLUSTERING FOR BLE-MESH DEVICES

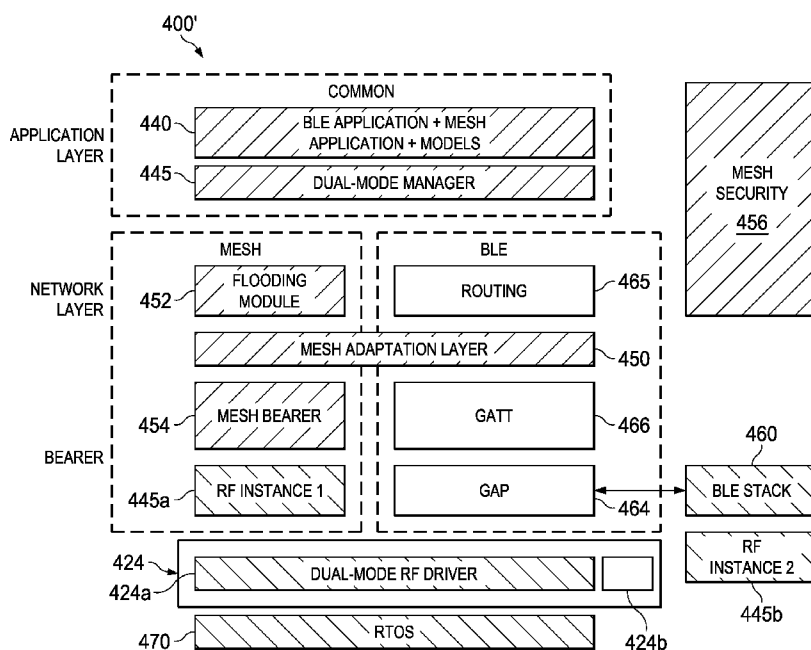


FIG. 4B

(57) **Abstract:** In described examples, a method of BLE-Mesh communications includes providing a dual-mode BLE-Mesh device (400') including dual-mode RF driver (424a), dual-mode manager (445), a BLE stack (460) for BLE operations, and a mesh stack (452, 454) for mesh operations in a BLE-mesh network having a BLE relay device and a functional end BLE device. The BLE-mesh device (400') has a periodic set of time indexed data slots common throughout the BLE-mesh network which provides a BLE event timeline for BLE connection events. The dual-mode BLE device (400') implements an event clustering algorithm (424b) that delays or advances mesh events with respect to a timing the BLE connection events for clustering together their respective occurrences into continuous BLE/Mesh events to reduce a duty cycle by reducing a number of transitions from active mode to sleep mode and from sleep mode to active mode. The BLE-Mesh device (400') communicates in the BLE-mesh network using the continuous BLE/Mesh events with

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(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

EVENT CLUSTERING FOR BLE-MESH DEVICES

[0001] This relates generally to wireless communications, and more particularly to Bluetooth Low Energy (BLE) automation mesh network (BLE-Mesh) communications.

BACKGROUND

[0002] BLE-Mesh is a wireless personal area network (WPAN) technology that uses a flooding-based protocol that with retransmission extends the range of BLE devices by including the ability to send messages to and amongst groups of devices. The devices in the BLE-Mesh network can support both BLE and BLE-mesh, but not necessarily both. A rebroadcasting mesh network works by flooding all messages to all nodes in the network through broadcasts.

[0003] The nodes in the mesh network all share a set of indexed data slots. Each time a device receives a broadcast message from another device in the mesh, the device repeats the message (rebroadcasts it), enabling its neighboring devices to ‘hear’ the new message. The neighboring devices rebroadcast this message to their neighbors, and the process is repeated until all devices in the mesh have received the same message. Flooding thus enables wireless devices to talk to each other without being within a direct radio range, as devices between them help by relaying the messages.

[0004] A typical WPAN has edge device(s) that are battery powered, relay devices that are always on as they are always in the listening mode, and functional end device(s), such as lights. Most BLE devices are battery powered so that power efficiency is generally an important consideration.

[0005] Smartphones and other some ‘legacy devices’ such as tablets and laptops support BLE, but do not currently support mesh formatted messaging. To enable such legacy devices to communicate with mesh devices, BLE connectivity needs to be enabled for mesh devices, creating the need for dual-mode BLE devices that provide both Mesh operations and BLE operations. However, adding this BLE-connectivity to mesh devices will significantly raise their power consumption, being a particular problem for battery-powered devices.

SUMMARY

[0006] In described examples, methods of BLE-Mesh communications include providing a dual-mode BLE-Mesh device including dual-mode RF driver, dual-mode manager, a BLE stack, and a mesh stack for mesh operations in a BLE-mesh network having a BLE relay device and a functional end BLE device. The dual-mode BLE-mesh device has a periodic set of time indexed data slots common throughout the BLE-mesh network, which provides a BLE event timeline for BLE connection events. The dual-mode BLE device implements an event clustering algorithm that delays or advances mesh events with respect to a timing the BLE connection events for clustering together their respective occurrences into continuous BLE/Mesh events to reduce a duty cycle by reducing a number of transitions from active mode to sleep mode and from sleep mode to active mode. The dual-mode BLE-Mesh device communicates in the BLE-mesh network using the continuous BLE/Mesh events with at least one mesh device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] FIG. 1 is a flowchart of an example method of BLE-Mesh communications, according to an example embodiment.

[0011] FIG. 2 shows an example timeline showing a BLE event timeline, friend (FR) low-power mesh edge Node (LPN) events timeline, and described clustering of mesh events with BLE connection events to reduce the number of wakeups and sleeps.

[0012] FIG. 3 shows an example timeline for a low power relay node including a BLE event timeline, relay events timeline, and described clustering of mesh relay events with the BLE connection events shown to reduce the number of wakeups and sleeps.

[0013] FIG. 4A is a block diagram schematic of an example described dual-mode BLE-Mesh device that can implement described event clustering for BLE-Mesh communications, according to an example embodiment.

[0014] FIG. 4B is a functional layer depiction of the dual-mode BLE-Mesh device shown in FIG. 4A including a dual-mode manager.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0015] The drawings are not necessarily drawn to scale. In the drawings, like reference numerals designate similar or equivalent elements. Some illustrated acts or events may occur in different order and/or concurrently with other acts or events. Furthermore, some illustrated acts or events are optional to implement a methodology in accordance with this description.

[0016] Also, the terms "coupled to" or "couples with" (and the like), as used herein without further qualification, describe either an indirect or direct electrical connection. Thus, if a first device "couples" to a second device, that connection can be through a direct electrical connection where only parasitics are in the pathway, or through an indirect electrical connection via intervening items including other devices and connections. For indirect coupling, the intervening item generally does not modify the information of a signal, but may adjust its current level, voltage level and/or power level.

[0017] Example embodiments recognize that dual-mode BLE devices providing both mesh operation and BLE operation, particularly those being battery powered, can benefit from a reduction in their power consumption. Example embodiments include techniques to cluster BLE events in time with mesh events for dual-mode BLE devices, which reduce a number of wakeups and likewise reduces a number of transitions from active to sleep and sleep to active, thereby lowering the device's power consumption.

[0018] FIG. 1 is a flowchart of an example method 100 of event clustering for BLE-Mesh communications, according to an example embodiment. BLE is used as the physical transport of the mesh network, referred herein as a BLE-mesh network, such as using the Bluetooth 4.1 specification. The BLE-mesh network environment includes a plurality of spaced apart dual-mode BLE-Mesh devices. A cluster of dual-mode BLE-enabled devices which are identifiable to one another may participate as routing nodes to provide range extension for any two participating BLE-mesh devices that would otherwise be out of the BLE transmission range from each other. The BLE-mesh network can be a secure network.

[0019] Step 101 comprises providing a dual-mode BLE-Mesh device including a BLE stack for BLE operations and a mesh stack for mesh operations in a BLE-mesh network having a least one BLE relay device and a functional end BLE device. The dual-mode BLE-Mesh device includes a dual-mode RF driver and a dual-mode manager. The dual-mode BLE-Mesh device has a periodic set of time indexed data slots that is common throughout the BLE-mesh network which provides a BLE event timeline for a plurality of BLE connection events. BLE connection events usually involve a periodic receive (Rx) and transmit (Tx) between a pair of dual-mode BLE-Mesh devices that occurs every connection interval time period. Other connection events can also occur defined in the BLE Special Interest Group (SIG) specification.

[0020] Step 102 comprises the dual-mode BLE device implementing an event clustering

algorithm that delays or advances a timing of mesh events with respect to a timing of instances of the BLE connection events for clustering together their respective occurrences into continuous BLE/Mesh events. (See FIG. 2 and FIG. 3 described hereinbelow for event clustering examples). The continuous BLE/Mesh events reduce a duty cycle of the device by reducing a number of transitions from active mode to sleep mode and from sleep mode to active mode. Duty cycle is the ratio of time in which the signal is active (in percentage). The formula is (duty cycle = (time signal is active/total period of signal) x 100%). For example, if a BLE device sends data for 1 ms then sleeps for 999 ms, then the (duty cycle = $(1/1000) \times 100$) = 0.1%.

[0021] Mesh events include FR LPN pinging (transmitting) and FR LPN receiving each involving mesh packets. Step 103 comprises the dual-mode BLE-Mesh device communicating in the BLE-mesh network using the continuous BLE/Mesh events with at least one mesh device.

[0022] FIG. 2 shows an example timeline 200 for a low-power FR edge node including a BLE event timeline 205 including periodic BLE events 205a1, 205a2 and 205a3, a FR LPN events timeline 210 including FR LPN receives 210a1, 210a2, and 210a3, and FR LPN pings 210b1, 210b2 and 210b3, and described positions of the respective pings and receives after clustering shown as 'with clustering' 215 to provide continuous BLE/Mesh events that reduce the number of wakeups and sleeps. According to the specification, a "friendship" is established between a FR relay device and an LPN. An edge device sends a ping with a FRND bit set, TTL=0, wakes up after FR Receive Delay (FRD), and is in scan state for FR Receive Window (FRW) duration. RF access for this ping and scan for FRW will be dedicated.

[0023] As shown in the leftmost clustering example ping 210b1 is time shifted now shown as 210b1' to cluster with the BLE event 205a1, in the center clustering example the receive 210a2 and pong 210b2 are both modified in time now shown as 210a2' and 210b2' to cluster before and after the BLE event 205a2 respectively, and in the rightmost clustering the receive 210a3 and ping 210b3 are both modified in time now shown as 210a3' and 210b3' to cluster after the BLE event 205a3.

[0024] FIG. 3 shows an example timeline 300 for a low power relay node including a BLE event timeline 305 including periodic BLE events 305a1, 305a2, and 305a3, a FR low-power mesh edge Node (LPN) events timeline 310 including Mesh receives 310a1, 310a2, and Mesh transmits 310b1, 310b2, and 310b3, and described clustering shown as 'with clustering' 315. Described clustering 315 has the Mesh transmits time shifted now shown as 310b1', 310b2', and

310b3' clustering with the BLE events 305a1, 305a2, and 305 a3 to reduce the number of wakeups and sleeps. Because this Example shows only Tx events postponed, it is applicable to current mesh routing nodes as well. The Mesh Tx events should generally be postponed only up within a threshold duration (the time between BLE connection events) to keep the impact of the timing change low.

[0025] FIG. 4A shows a system block diagram representation for an example dual-mode BLE-Mesh device 400 that generally conforms to the BLE communications standard. The dual-mode BLE-Mesh device 400 may be any device that can engage in BLE communications. Such devices may be, may include, or may be a part of, mobile phones such as smartphone, tablets, computers, personal digital assistants, and household items with communication capabilities such as door knobs, window blinds, and motion sensors. The dual-mode BLE-Mesh device 400 communicates in a BLE-mesh network along with as plurality of other BLE devices to a network (e.g., the Internet) that is coupled to a central authority database that is generally stored on a server.

[0026] The dual-mode BLE-Mesh device 400 comprises a controller 420 including a processor 425, a memory 422 including software 422a for a described event clustering for BLE-Mesh communications algorithm, and a transceiver 424 including a dual-mode RF driver 424a that is coupled to an antenna 428. The controller 420 implements a BLE stack for BLE operations and a mesh stack for mesh operations. The transceiver 424 is also shown including hardware comprising digital logic 424b that can be used as an alternative to software 422a for implementing a described event clustering for BLE-Mesh communications algorithm. The transceiver 424 includes a transmitter and a receiver. The transmitter generally comprises a media access control (MAC) module, an encoder, a modulator, an Inverse Fast Fourier Transform (IFFT) unit, a digital to analog conversion (DAC)/filter module, and an RF/antenna module. The receiver generally comprises an RF/antenna unit, an analog to digital conversion (ADC)/filter unit, a FFT unit, a demodulator, a decoder, and a MAC module.

[0027] The memory 422 is more generally configured to store information including data, instructions, or both. The memory 422 may be any storage medium accessible by the controller 420, such as a read only memory (ROM), a random access memory (RAM), a register, cache memory, or magnetic media device such as internal hard disks and removable disks. A phase lock loop (PLL) 432 is also provided for purposes including mixing and frequency synthesis.

[0028] The dual-mode BLE-Mesh device 400 is also shown including hardware comprising digital logic 434 that can also be for implementing a described event clustering for BLE-Mesh communications algorithm. However, as described hereinabove, the event clustering for BLE-Mesh communications algorithm may also be implemented by software.

[0029] The controller 420 is coupled to the memory 422 and to the transceiver 424. In some implementations, the transceiver 424 comprises baseband units (not shown) and analog units (not shown) to transmit and receive RF signals. The baseband unit may comprise hardware to perform baseband signal processing including digital signal processing, coding and decoding, modulation, and demodulation. The analog unit may comprise hardware to perform ADC, DAC, filtering, gain adjusting, up-conversion, and down-conversion. The analog unit may receive RF signals from an access point and down-convert the received RF signals to baseband signals to be processed by the baseband unit, or receive baseband signals from the baseband unit and up-convert the received baseband signals to RF wireless signals for uplink transmission. The analog unit comprises a mixer to up-convert the baseband signals and down-convert the RF signals with a carrier signal oscillated at the radio frequencies of the BLE-mesh network. The radio frequencies may be 2.4 GHz to 2.483-GHz frequency band for BLE communications, and a lower frequency such as about 1.0 to 1.5 GHz per the BLE standard (generally not sub-1 GHz for mesh communications), or other specifications depending on future radio access technology.

[0030] FIG. 4B is a functional layer depiction of the dual-mode BLE-Mesh device 400 shown in FIG. 4A now shown as 400' that includes an application layer including BLE applications, mesh application, models 440, and a dual-mode manager 445. All blocks above the dual-mode RF driver 424a are generally software (SW) running on the processor 425 shown in FIG. 4A in memory 422 (usually stored in flash RAM or ROM). Dual-mode BLE-Mesh device 400' implements simultaneous operation of the BLE and Mesh software (SW) stacks using the dual-mode RF driver 424a. An RF instance 1 445a exists for Mesh operations, and an RF instance 2 445b exists for BLE operations.

[0031] The dual-mode manager 445 handles RF access priorities based on the stack states, with generally three priority levels being dedicated, high, and normal. The Mesh adaptation layer 450 formats for BLE or Mesh accordingly and signals appropriate for the particular application. The dual-mode RF driver 424a includes driver Application Programming Interface (API) software and the radio itself in hardware. Also, a flooding module 452, Mesh bearer layer 454

and Mesh security 456 exist for mesh communications.

[0032] Dual-mode BLE-Mesh device 400' also includes BLE stack 460, Generic Access Profile (GAP) 464 which controls connections and advertising in Bluetooth, and Generic Attribute Profile (GATT) 466 which uses ATT to describe how data is exchanged from two connected devices for BLE. Dual-mode BLE-Mesh device 400' also includes a BLE routing block 465. The BLE routing block 465 is different from the flooding-based mesh. If routing is present, then each node maintains neighbor tables and messages that are sent via deterministic paths to reach a specific destination. In a flooding-based mesh, messages are broadcast to all devices across the network over multiple hops.

[0033] Dual-mode BLE-Mesh device 400' is also shown having a real-time operating system (RTOS) 470. RTOS 470 scales from a low-footprint, real-time preemptive multi-tasking kernel to a complete RTOS with additional middleware components including a power manager, TCP/IP and USB stacks, an embedded file system and device drivers.

[0034] Benefits of described event clustering include reducing the overall power consumption of nodes and the maintaining of interoperability. Described event clustering can be detected using a packet sniffer to detect transmission time-points with respect to BLE and mesh events. One can also use a power analyzer to determine the node activity for a described dual-mode BLE-Mesh device.

[0035] In at least one example, for a described dual-mode BLE-Mesh device having a 1 second connection interval using described clustering of mesh events and BLE connection events a power savings of 30% resulted. This result is for FR LPN devices only. For relay devices, with either power line or very long scans the power savings will be significantly less. For a 100 ms scan interval for mesh device operation, the power savings for a relay device would be about 0.7%.

[0036] Modifications are possible in the described embodiments, and other embodiments are possible, within the scope of the claims.

CLAIMS

What is claimed is:

1. A method of Bluetooth Low Energy (BLE)-Mesh communications, comprising:

providing a dual-mode BLE-Mesh device including dual-mode RF Driver, dual-mode manager and a BLE stack for BLE operations and a mesh stack for mesh operations in a BLE-mesh network having a least one BLE relay device and a functional end BLE device, wherein the dual-mode BLE-mesh device has a periodic set of time indexed data slots that is common throughout the BLE-mesh network which provides a BLE event timeline for a plurality of BLE connection events;

the dual-mode BLE-Mesh device implementing an event clustering algorithm that delays or advances a timing of mesh events with respect to a timing of instances of the BLE connection events for clustering together their respective occurrences into continuous BLE/Mesh events to reduce a duty cycle by reducing a number of transitions from active mode to sleep mode and from sleep mode to active mode, and

the dual-mode BLE-Mesh device communicating in the BLE-mesh network using the continuous BLE/Mesh events with at least one mesh device.

2. The method of claim 1, wherein for the delays, a delay time used is limited to a predetermined maximum duration that is $<$ a BLE connection period (T_{BP}).

3. The method of claim 1, wherein the dual-mode BLE-Mesh device is operating as a friend (FR) relay device with at least one associated low-power mesh edge Node (LPN), and wherein the BLE connection events have a BLE connection event absolute time (T_B) and a BLE connection period (T_{BP}).

4. The method of claim 3, wherein if friendship parameters are established between the LPN and the dual-mode BLE-Mesh device acting as the FR relay device, and wherein if a FR LPN ping has not been transmitted by the LPN to the FR relay device, the dual-mode BLE-Mesh device transmitting a ping at a next T_B minus ($-$) a Friend Receive Delay (FRD)th time instant, and wherein if the FR LPN ping has been sent, and if a time stamp (TS) at which the FR LPN ping was sent + FRD $\geq$ a next T_B , then setting a next FRD to the T_B , and

wherein if the friendship parameters are not established, checking the T_{BP} and negotiating with the LPN for the FRD to be equal to the T_B .

5. The method of claim 1, wherein the dual-mode BLE-Mesh device is battery powered.

6. The method of claim 1, wherein the dual-mode BLE-Mesh device is positioned as an edge device the BLE-mesh network.

7. A dual-mode BLE-Mesh device, comprising:

a controller comprising a processor coupled to a memory accessible by a transceiver, a dual-mode RF driver for driving the transceiver, the transceiver coupled to an antenna, the controller implementing an applications layer including BLE applications and Mesh Applications, a dual-mode manager, and a BLE stack for BLE operations and a mesh stack for mesh operations;

an event clustering algorithm that comprises software stored in the memory that is implemented by the processor or is implemented by hardware including digital logic, the algorithm:

delaying or advancing a timing of mesh events with respect to a timing of instances of BLE connection events for clustering together their respective occurrences into continuous BLE/Mesh events to reduce a duty cycle by reducing a number of transitions from active mode to sleep mode and from sleep mode to active mode, and

for the dual-mode BLE-Mesh device communicating in a BLE-mesh network using the continuous BLE/Mesh events with at least one mesh device.

8. The dual-mode BLE-Mesh Device of claim 7, wherein for the delaying, a delay time used is limited to a predetermined maximum duration that is $< T_{BP}$.

9. The dual-mode BLE-Mesh device claim 7, wherein the BLE-Mesh device is adapted to be configured to operate as a friend (FR) relay device with at least one associated low-power mesh edge Node (LPN), and wherein the BLE connection events have a BLE connection event absolute time (T_B) and a BLE connection period (T_{BP}).

10. The dual-mode BLE-Mesh device of claim 9, wherein if friendship parameters are established between the LPN and the dual-mode BLE-Mesh device acting as the FR relay device, and wherein if a FR LPN ping has not been transmitted by the LPN to the FR relay device, the dual-mode BLE-Mesh device transmitting a ping at a next T_B minus ($-$) a Friend Receive Delay (FRD)th time instant, and wherein if the FR LPN ping has been sent, and if a time stamp (TS) at which the FR LPN ping was sent + FRD $\geq$ a next T_B , then setting a next FRD to the T_B , and

wherein if the friendship parameters are not established, checking the T_{BP} and negotiating with the LPN for the FRD to be equal to the T_B .

11. The dual-mode BLE-Mesh device of claim 7, wherein the BLE-Mesh device includes a battery for battery powering.

12. The dual-mode BLE-Mesh device of claim 7, wherein the event clustering algorithm comprises the software stored in the memory that is implemented by the processor.

13. The dual-mode BLE-Mesh device of claim 7, wherein the event clustering algorithm is implemented by hardware including the digital logic.

14. A dual-mode BLE-Mesh device, comprising:

a controller comprising a processor coupled to a memory accessible by a transceiver, a dual-mode RF driver for driving the transceiver, the transceiver coupled to an antenna, the controller implementing a means for an applications layer including BLE applications and Mesh Applications, a means for a dual-mode manager, and a means for a BLE stack for BLE operations and a means for mesh stack for mesh operations;

a means for delaying or advancing a timing of mesh events with respect to a timing of instances of BLE connection events for clustering together their respective occurrences into continuous BLE/Mesh events to reduce a duty cycle by reducing a number of transitions from active mode to sleep mode and from sleep mode to active mode, and

a means for the dual-mode BLE-Mesh device communicating in a BLE-mesh network using the continuous BLE/Mesh events with at least one mesh device.

15. The dual-mode BLE-Mesh Device of claim 14, wherein for the means for delaying, a delay time used is limited to a predetermined maximum duration that is $<$ a BLE connection period (T_{BP}).

16. The dual-mode BLE-Mesh device claim 14, wherein the BLE-Mesh device is adapted to be configured to operate as a friend (FR) relay device with at least one associated low-power mesh edge Node (LPN), and wherein the BLE connection events have a BLE connection event absolute time (T_B) and a BLE connection period (T_{BP}).

17. The dual-mode BLE-Mesh device of claim 16, wherein if friendship parameters are established between the LPN and the dual-mode BLE-Mesh device acting as the FR relay device, and wherein if a FR LPN ping has not been transmitted by the LPN to the FR relay device, the dual-mode BLE-Mesh device having a means for transmitting a ping at a next T_B minus ($-$) a Friend Receive Delay (FRD)th time instant, and a means for wherein if the FR LPN ping has been sent, and if a time stamp (TS) at which the FR LPN ping was sent + FRD $\geq$ a next T_B ,

then setting a next FRD to the T_B , and

wherein if the friendship parameters are not established, a means for checking the T_{BP} and negotiating with the LPN for the FRD to be equal to the T_B .

18. The dual-mode BLE-Mesh device of claim 14, wherein the BLE-Mesh device includes a battery for battery powering.

19. The dual-mode BLE-Mesh device of claim 14, wherein the means for delaying or advancing the timing and the means for the dual-mode BLE-Mesh device communicating the BLE-mesh network comprises software stored in the memory that is implemented by the processor.

20. The dual-mode BLE-Mesh device of claim 14, wherein the wherein the means for delaying or advancing the timing and the means for the dual-mode BLE-Mesh device communicating the BLE-mesh network is implemented by hardware including digital logic.

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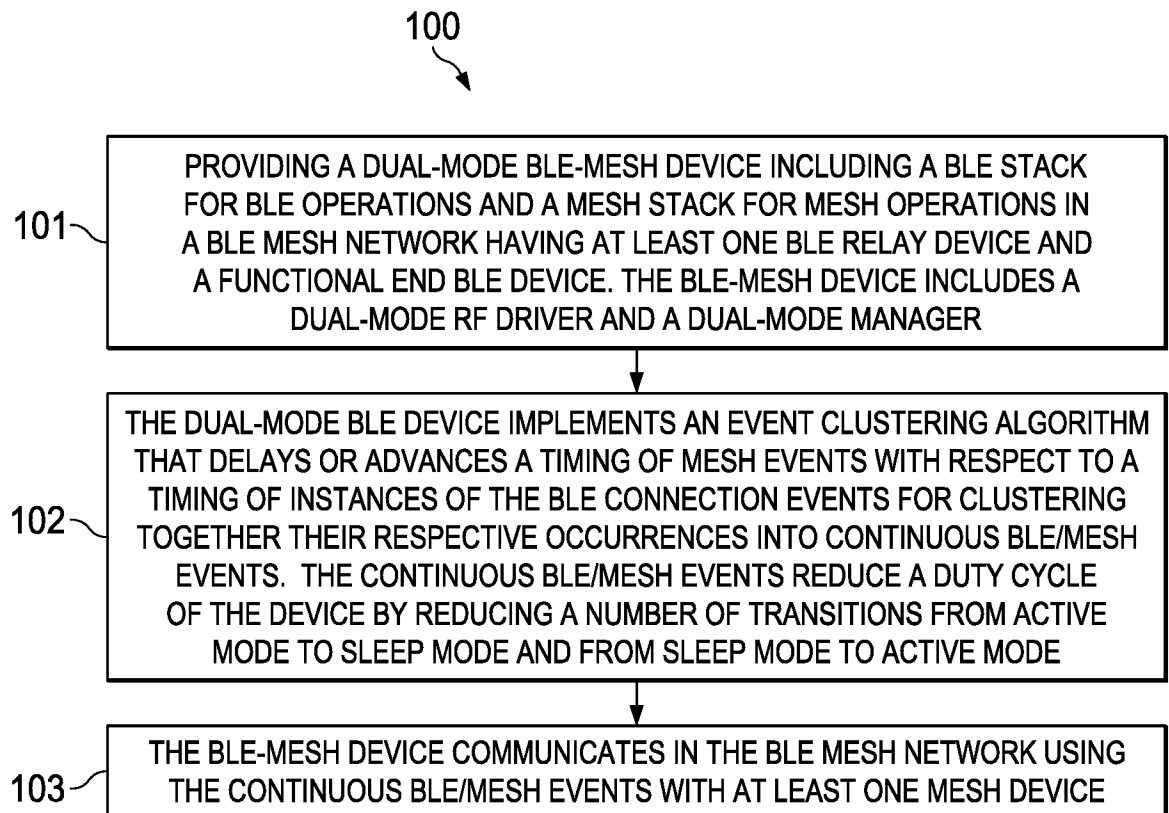


FIG. 1

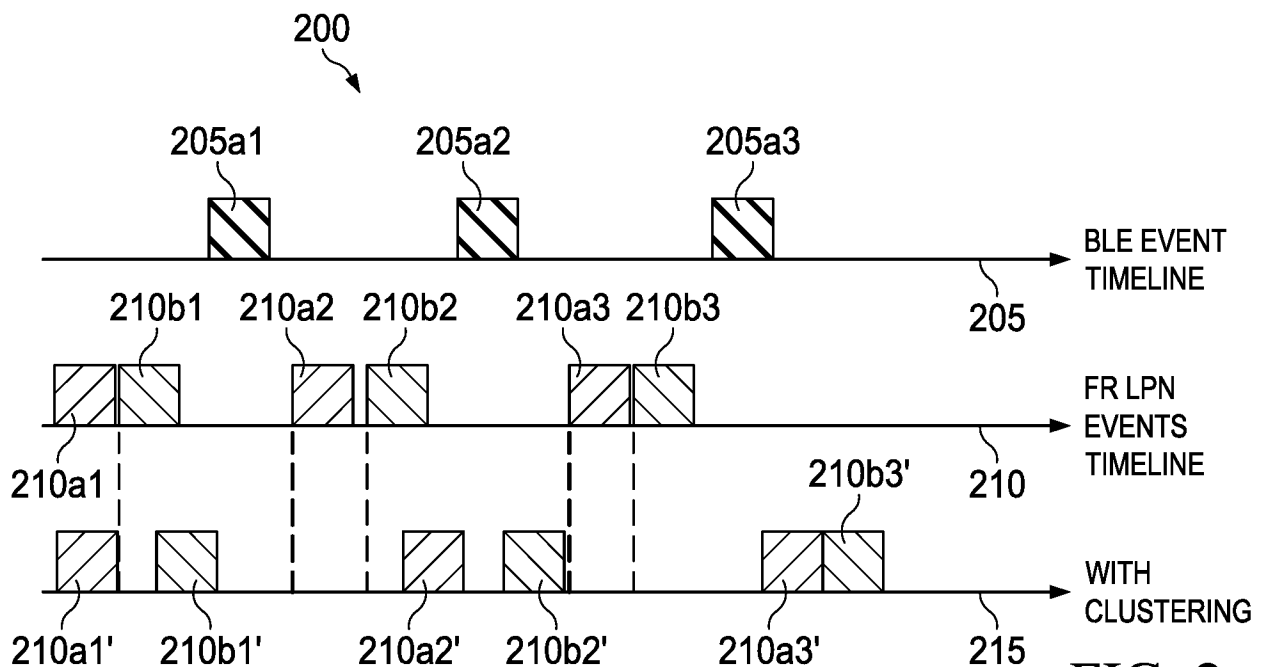
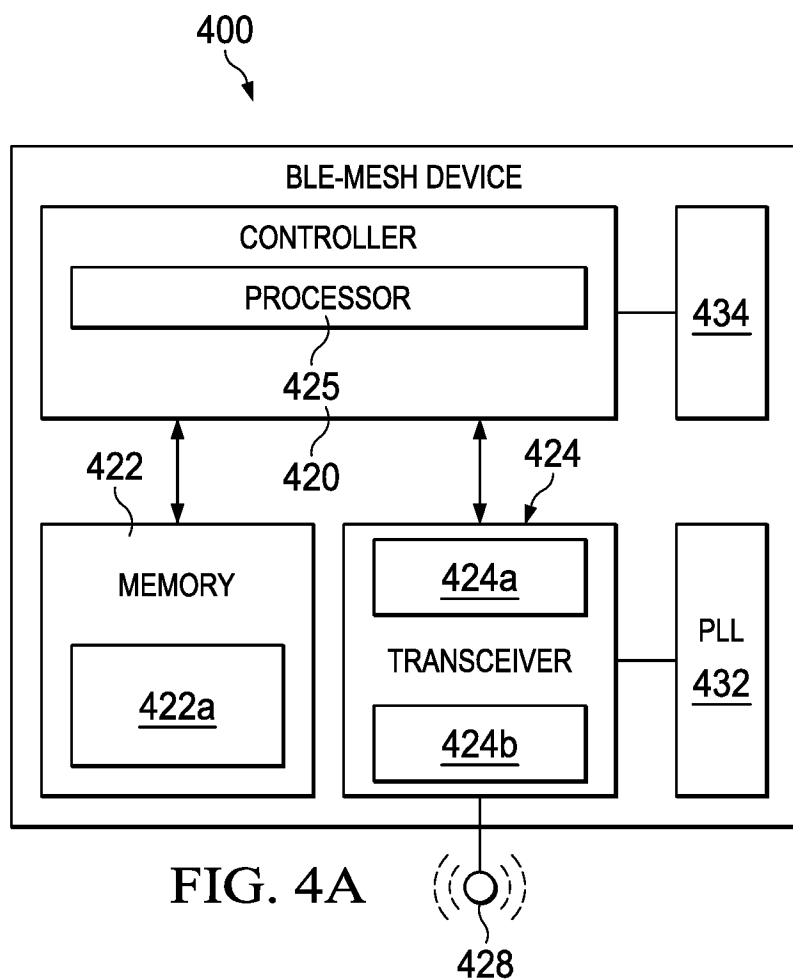
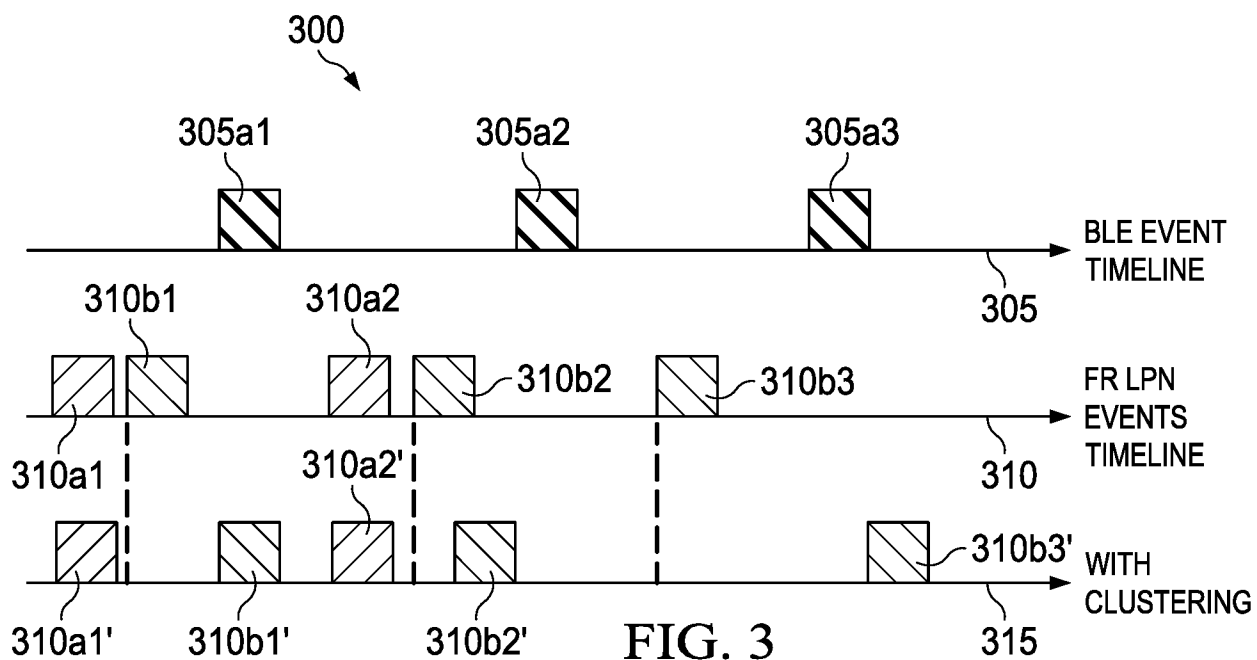


FIG. 2

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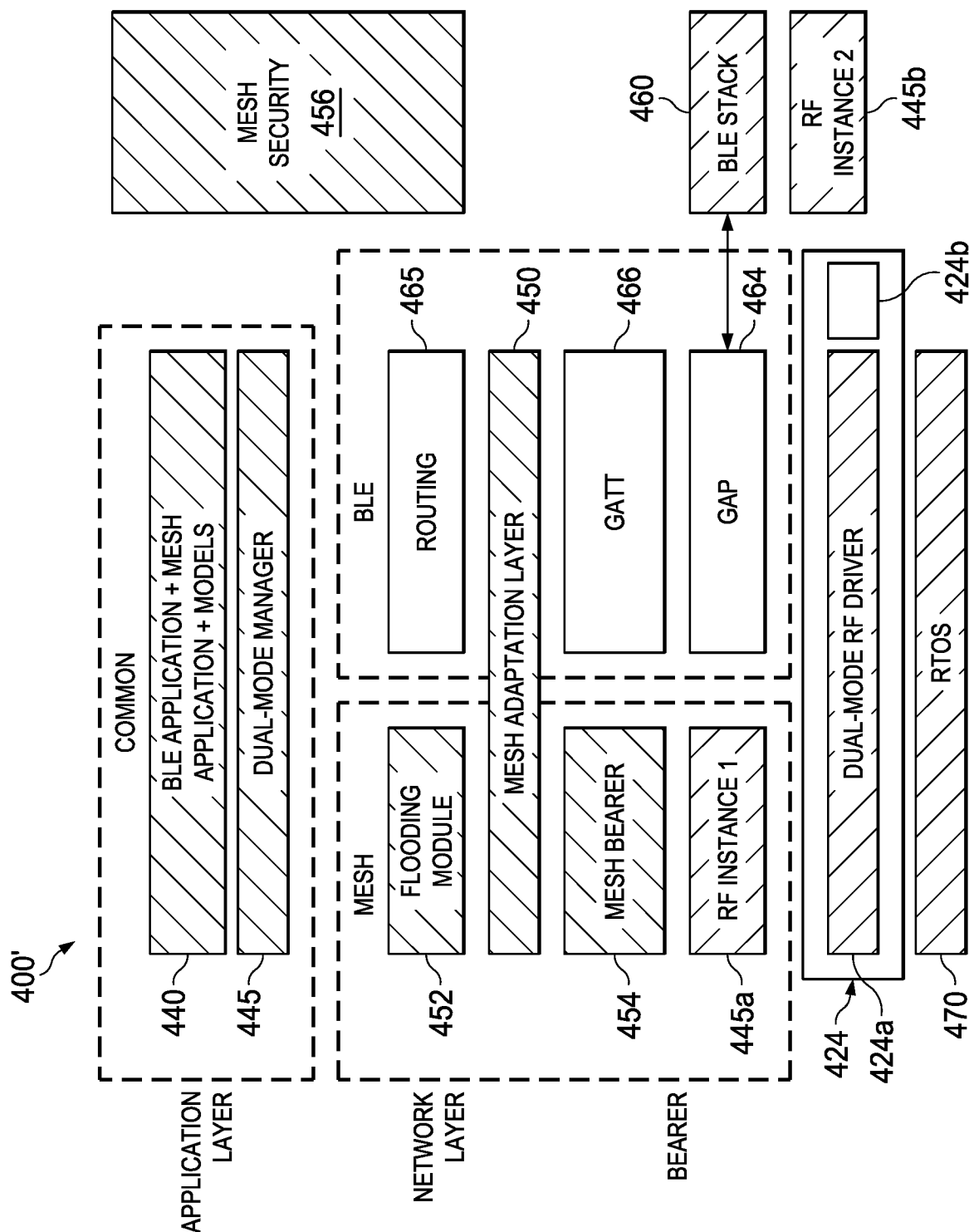


FIG. 4B

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US 2017/044215

A. CLASSIFICATION OF SUBJECT MATTER

H04W 4/06 (2009.01)**H04W 72/02 (2009.01)**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W 4/00-4/18, 8/00, 72/00-72/14

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

PatSearch (RUPTO internal), USPTO, PAJ, Esp@cenet, Information Retrieval System of FIPS

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2517086 B (CAMBRIDGE SILICON RADIO LIMITED) 17.06.2015, p.4, p.7, line 28 –p.8, line 10, p.8, lines 12-18, p.9, lines 1-8	1,5-7,11-14, 18-20
A		2,3,4,8,9,10,15,16,17
A	US 2011/0021142 A1 (PRASANNA DESAI et al) 27.01.2011	1-20



Further documents are listed in the continuation of Box C.



See patent family annex.

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“&” document member of the same patent family

Date of the actual completion of the international search

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