US 20170118732A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2017/0118732 A1

Norair (43) Pub. Date: Apr. 27, 2017

(54) METHOD AND APPARATUS FOR RAPID GROUP SYNCHRONIZATION

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(21) Appl. No.: **15/399,251**

(22) Filed: **Jan. 5, 2017**

Related U.S. Application Data

(63) Continuation of application No. 15/157,445, filed on May 18, 2016, now abandoned, which is a continuation of application No. 15/012,888, filed on Feb. 2, 2016, now abandoned, which is a continuation of application No. 14/886,151, filed on Oct. 19, 2015, now abandoned, which is a continuation of application No. 14/324,411, filed on Jul. 7, 2014, now Pat. No. 9,166,894, which is a continuation of application No. 13/408,457, filed on Feb. 29, 2012, now Pat. No. 8,774,096.

(60) Provisional application No. 61/464,376, filed on Mar. 2, 2011.

Publication Classification

(51) **Int. Cl.**

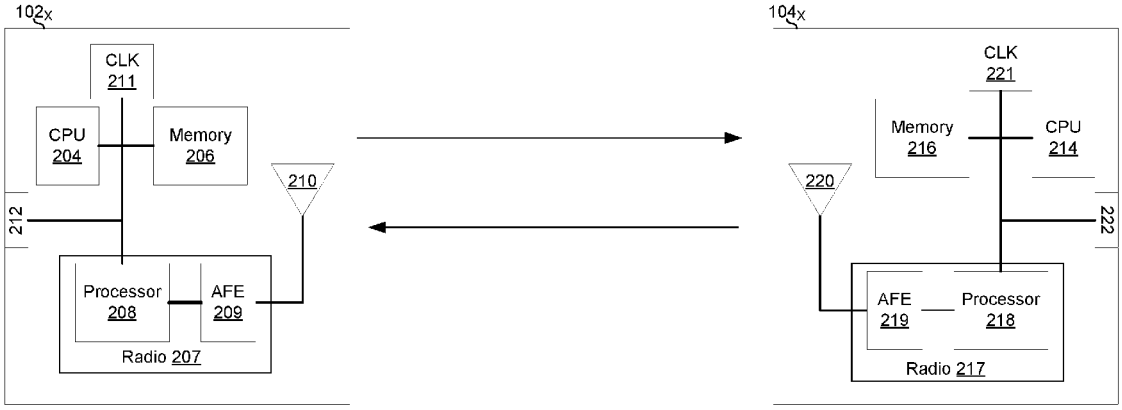
H04W 56/00	(2006.01)
H04W 28/04	(2006.01)
H04W 40/02	(2006.01)
H04W 72/04	(2006.01)

(52) **U.S. Cl.**

CPC ***H04W 56/002*** (2013.01); ***H04W 72/0446*** (2013.01); ***H04W 28/044*** (2013.01); ***H04W 40/023*** (2013.01)

(57) **ABSTRACT**

A first device of a network may decide to transmit a flood of packets that is longer in duration than the maximum amount of time that the first device can continuously transmit. The first device may coordinate with one or more second devices of the network such that each of the one or more second devices transmits a respective second portion of the flood of packets following transmission of a first portion of the flood of packets by the first network device. The packets may advertise a pending network event that is to occur at a time indicated by the contents of the packets. The first device may select the one or more second devices from a plurality of devices based on a location of the one or more second devices and/or how many third devices are in the network.



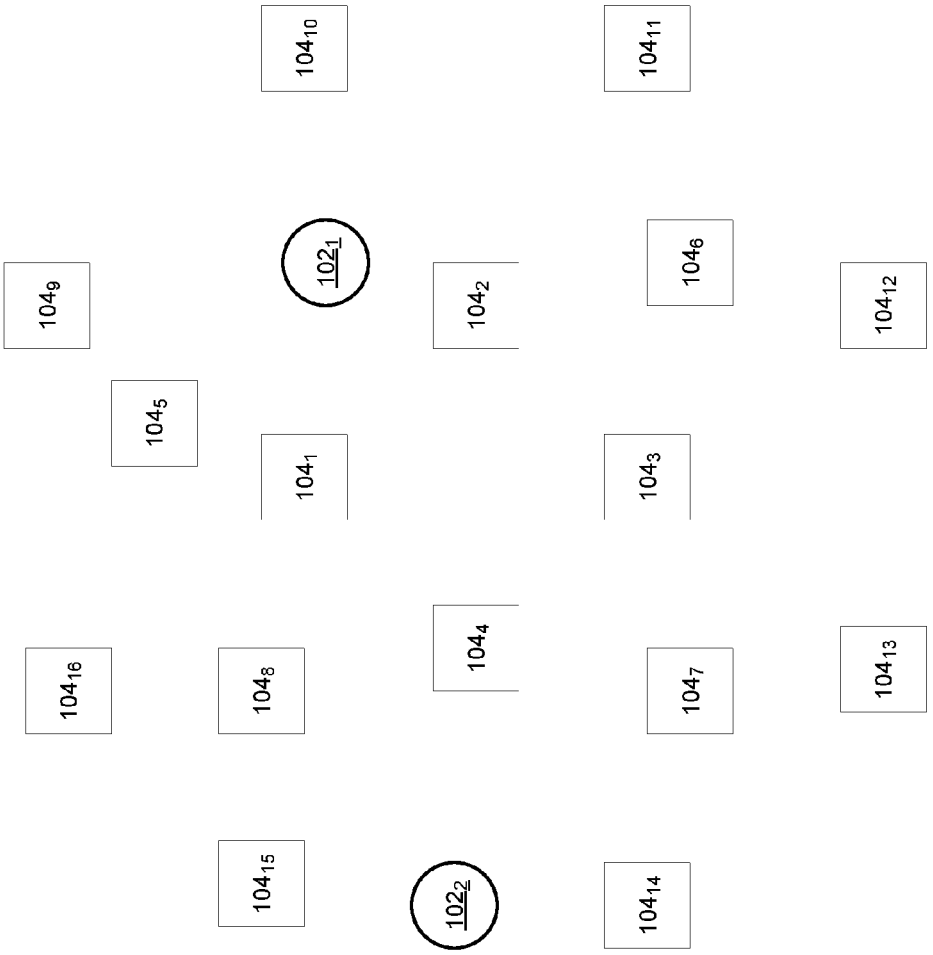

104_{10}
104_{11}
102_1
104_9
104_2
104_6
104_{12}
104_5
104_1
104_3
104_4
104_{16}
104_8
104_7
104_{13}
104_{15}
102_2
104_{14}

FIG. 1

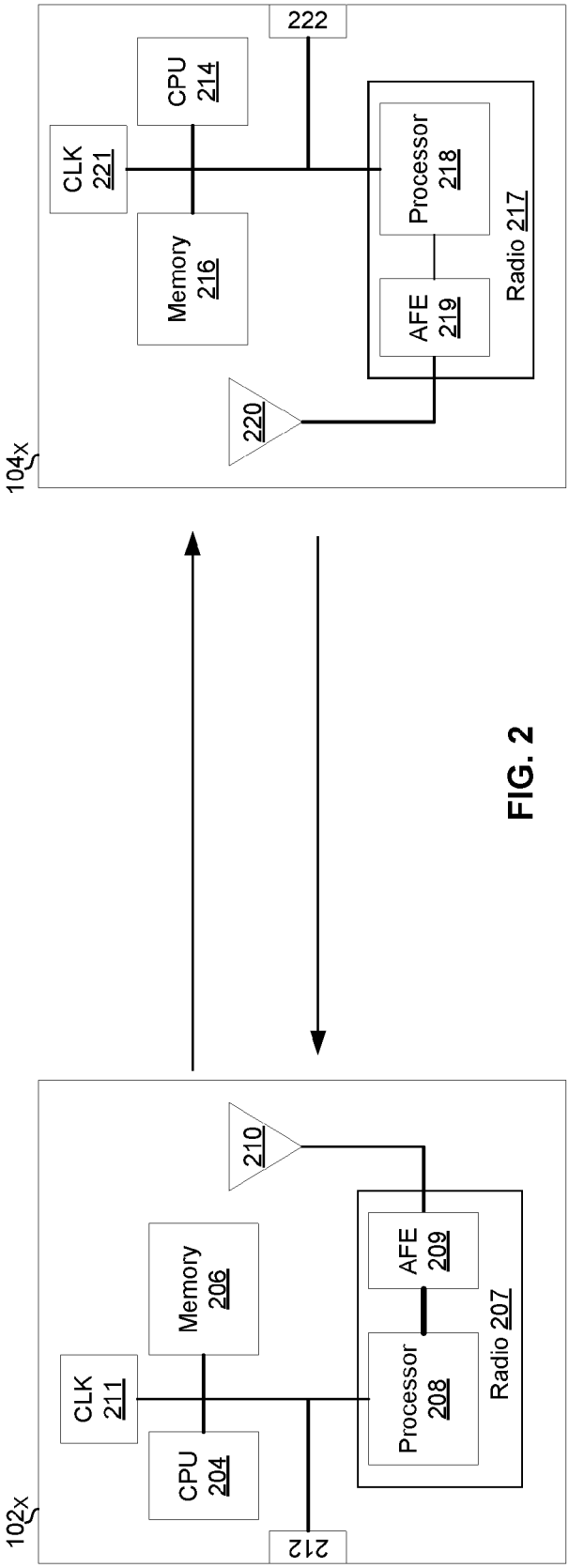

104x
222
CPU 214
CLK 221
Memory 216
Processor 218
AFE 219
Radio 217
220
102x
210
Memory 206
CLK 211
CPU 204
AFE 209
Processor 208
Radio 207
212

FIG. 2

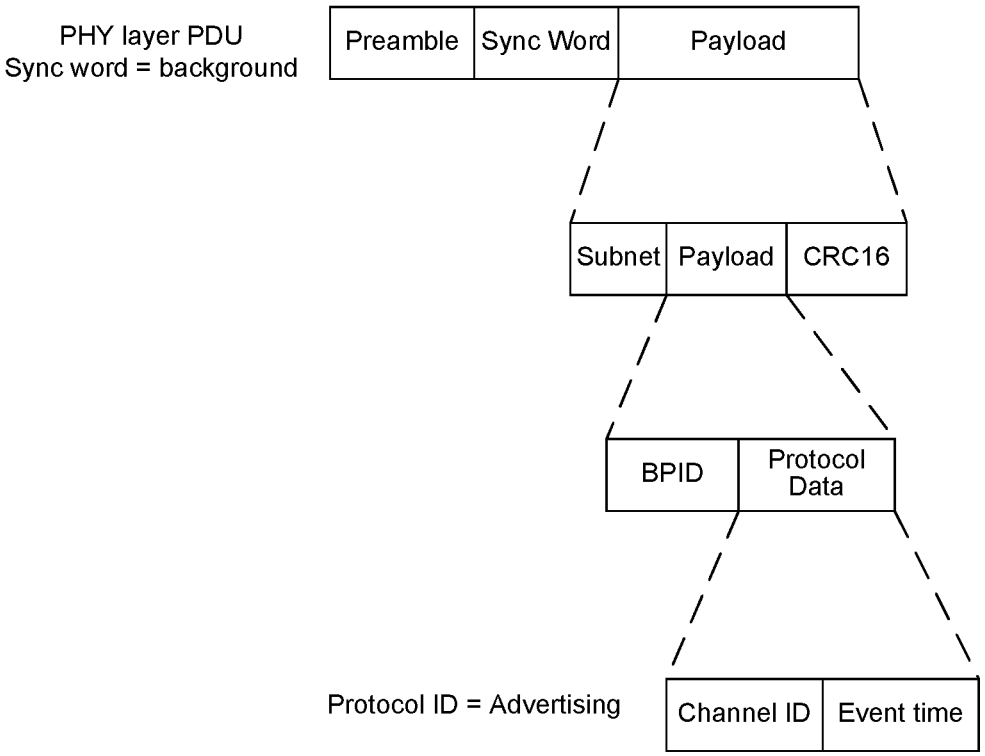

PHY layer PDU
Sync word = background
Preamble
Sync Word
Payload
Subnet
Payload
CRC16
BPID
Protocol Data
Protocol ID = Advertising
Channel ID
Event time

FIG. 3A

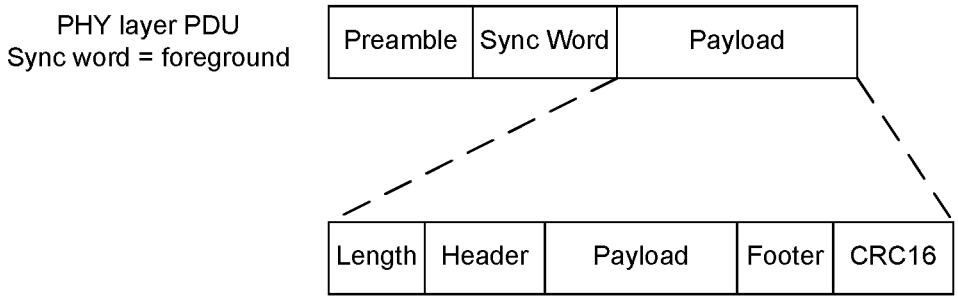

PHY layer PDU
Sync word = foreground
Preamble
Sync Word
Payload
Length
Header
Payload
Footer
CRC16

FIG. 3B

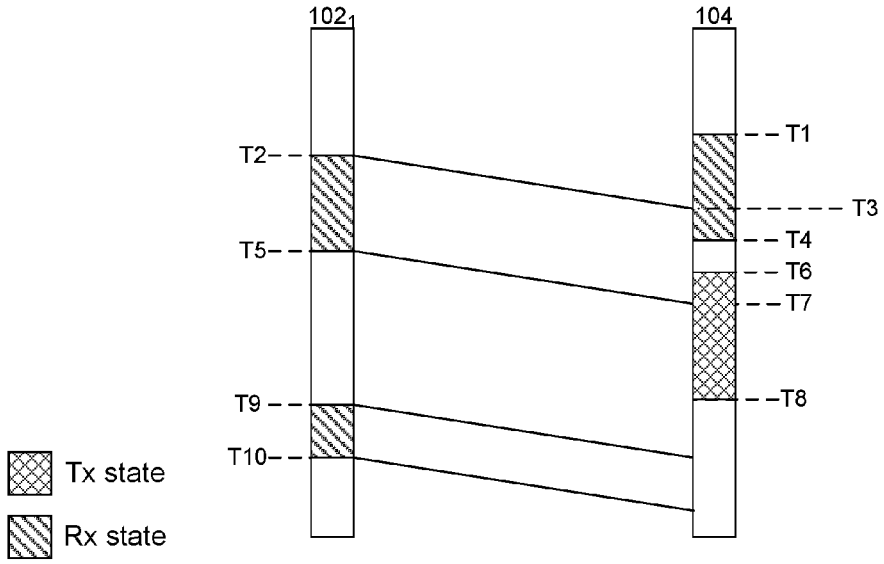

102₁
104
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
Tx state
Rx state

FIG. 4A

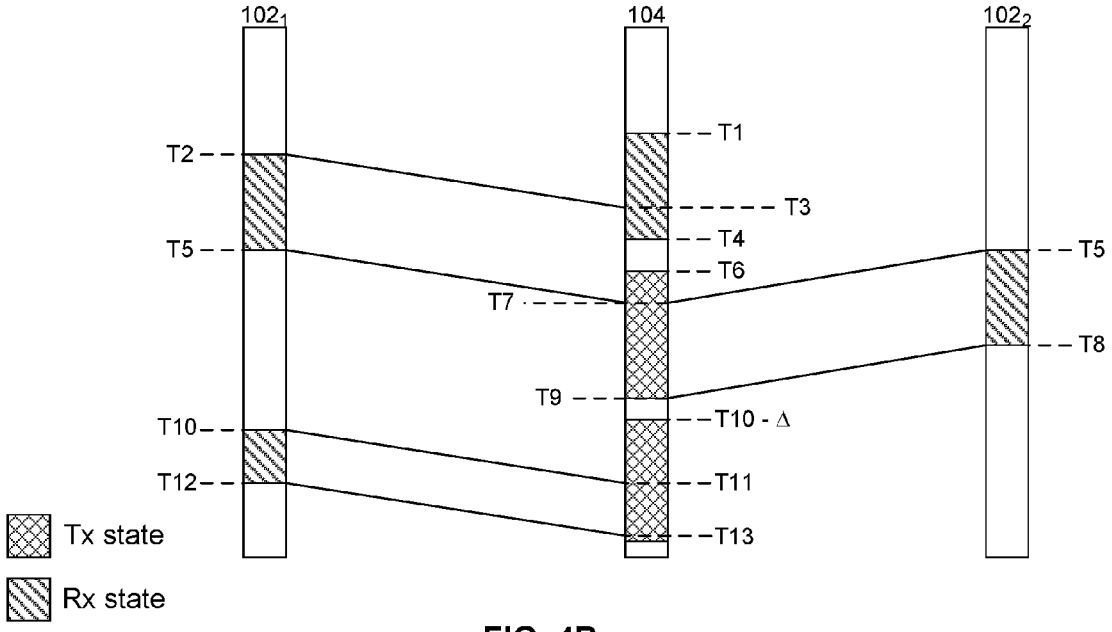

102₁
104
102₂
T1
T2
T3
T4
T5
T6
T7
T5
T8
T9
T10 - Δ
T10
T11
T12
T13
Tx state
Rx state

FIG. 4B

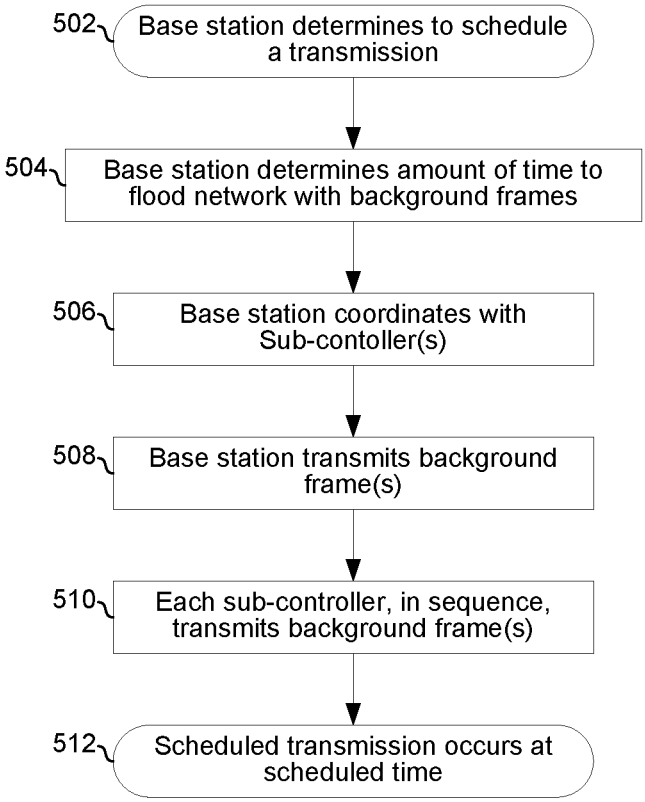

502
Base station determines to schedule a transmission
504
Base station determines amount of time to flood network with background frames
506
Base station coordinates with Sub-contoller(s)
508
Base station transmits background frame(s)
510
Each sub-controller, in sequence, transmits background frame(s)
512
Scheduled transmission occurs at scheduled time

FIG. 5

METHOD AND APPARATUS FOR RAPID GROUP SYNCHRONIZATION

CLAIM OF PRIORITY

[0001] This patent application is a continuation of U.S. application Ser. No. 15/157,445 filed May 18, 2016, which is a continuation of U.S. application Ser. No. 15/012,888 filed Feb. 2, 2016, which is a continuation of U.S. application Ser. No. 14/886,151 filed Oct. 19, 2015, which is a continuation of U.S. application Ser. No. 14/324,411, filed Jul. 7, 2014 (now Pat. No. 9,166,894), which is a continuation of U.S. application Ser. No. 13/408,457, filed Feb. 29, 2012 (now Pat. No. 8,774,096), which makes reference to, claims priority to and claims benefit from U.S. Provisional Patent Application Ser. No. 61/464,376 entitled "Advanced Communication System for Wide-area Low Power Wireless Applications and Active RFID" and filed on Mar. 2, 2011.

[0002] Each of above-referenced documents is hereby incorporated herein by reference in its entirety.

INCORPORATION BY REFERENCE

[0003] This patent application also makes reference to:

[0004] U.S. Provisional Patent Application Ser. No. 61/464,376 titled "Advanced Communication System for Wide-Area Low Power Wireless Applications and Active RFID" and filed on Mar. 2, 2011, now expired;

[0005] U.S. Provisional Patent Application Ser. No. 61/572,390 titled "System for Adding Dash7-Based Applications Capability to a Smartphone" and filed on Jul. 15, 2011, now expired;

[0006] U.S. Pat. No. 8,976,691 titled "Method and Apparatus for Adaptive Searching of Distributed Datasets" and filed on Oct. 6, 2011;

[0007] U.S. Pat. No. 9,042,353 titled "Method and Apparatus for Low-Power, Long-Range Networking" and filed on Oct. 6, 2011;

[0008] U.S. Pat. No. 8,718,551 titled "Method and Apparatus for a Multi-band, Multi-mode Smartcard" and filed on Oct. 11, 2011;

[0009] U.S. patent application Ser. No. 13/270,959 titled "Method and Apparatus for an Integrated Antenna" and filed on Oct. 11, 2011;

[0010] U.S. patent application Ser. No. 13/289,054 titled "Method and Apparatus for Electronic Payment" and filed on Nov. 4, 2011;

[0011] U.S. patent application Ser. No. 13/289,050 titled "Method And Apparatus For Tire Pressure Monitoring" filed on Nov. 4, 2011;

[0012] U.S. Pat. No. 8,622,312 titled "Method and Apparatus for Interfacing with a Smartcard" and filed on Nov. 16, 2011;

[0013] U.S. Pat. No. 9,104,548 titled "Method and Apparatus for Memory Management" and filed on Jan. 20, 2012;

[0014] U.S. patent application Ser. No. 13/354,615 titled "Method and Apparatus for Discovering, People, Products, and/or Services via a Localized Wireless Network" and filed on Jan. 20, 2012;

[0015] U.S. Pat. No. 8,909,865 titled "Method and apparatus for Plug and Play, Networkable ISO 18000-7 Connectivity" and filed on Feb. 15, 2012;

[0016] U.S. Patent Publication No. 2012/0209716 titled "Method and Apparatus for Serving Advertisements in a Low-Power Wireless Network" and filed on Feb. 15, 2012;

[0017] U.S. patent application Ser. No. 13/408,440 titled "Method and Apparatus for Forward Error Correction (FEC) in a Resource-Constrained Network" and filed on Feb. 29, 2012, now abandoned;

[0018] U.S. Pat. No. 8,867,370 titled "Method and Apparatus for Adaptive Traffic Management in a Resource-Constrained Network" and filed on Feb. 29, 2012;

[0019] U.S. Pat. No. 9,191,340 titled "Method and Apparatus for Dynamic Media Access Control in a Multiple Access System" and filed on Feb. 29, 2012;

[0020] U.S. Patent Publication No. 2012/0226822 titled "Method and Apparatus for Addressing in a Resource-Constrained Network" and filed on Feb. 29, 2012;

[0021] U.S. Pat. No. 8,885,586 titled "Method and Apparatus for Query-Based Congestion Control" and filed on Feb. 29, 2012; and

[0022] U.S. Pat. No. 9,154,392 titled "Method and Apparatus for Power Autoscaling in a Resource-Constrained Network" and filed on Feb. 29, 2012.

[0023] Each of the above-referenced applications is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0024] Certain embodiments of the invention relate to networking. More specifically, certain embodiments of the invention relate to a method and apparatus for rapid group synchronization.

BACKGROUND OF THE INVENTION

[0025] Existing methods and systems for synchronizing wireless devices are time and power intensive. Further limitations and disadvantages of conventional and traditional approaches will become apparent to one of skill in the art, through comparison of such systems with some aspects of the present invention as set forth in the remainder of the present application with reference to the drawings.

BRIEF SUMMARY OF THE INVENTION

[0026] A system and/or method is provided for rapid group synchronization, substantially as illustrated by and/or described in connection with at least one of the figures, as set forth more completely in the claims.

[0027] These and other advantages, aspects and novel features of the present invention, as well as details of an illustrated embodiment thereof, will be more fully understood from the following description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. **1** depicts an exemplary wireless communication network in which network communications may be scheduled as needed and/or on-demand.

[0029] FIG. **2** depicts exemplary communication devices which may support rapid group synchronization.

[0030] FIG. **3**A illustrates an exemplary physical layer PDU utilized for synchronizing network devices and scheduling network events.

[0031] FIG. **3**B illustrates an exemplary physical layer PDU utilized for data communication.

[0032] FIG. **4**A is a diagram illustrating scheduling of a network communication via communications from a single requesting device.

[0033] FIG. **4**B is a diagram illustrating scheduling of a network communication via communications from a single requesting device.

[0034] FIG. **5** is a flowchart illustrating exemplary steps for event scheduling in a network comprising a plurality of resource-constrained devices.

DETAILED DESCRIPTION OF THE INVENTION

[0035] As utilized herein the terms "circuits" and "circuitry" refer to physical electronic components (i.e. hardware) and any software and/or firmware ("code") which may configure the hardware, be executed by the hardware, and or otherwise be associated with the hardware. As utilized herein, "and/or" means any one or more of the items in the list joined by "and/or". As an example, "x and/or y" means any element of the three-element set {(x), (y), (x, y)}. As another example, "x, y, and/or z" means any element of the seven-element set {(x), (y), (z), (x, y), (x, z), (y, z), (x, y, z)}. As utilized herein, the terms "block" and "module" refer to functions than can be implemented in hardware, software, firmware, or any combination of one or more thereof. As utilized herein, the term "exemplary" means serving as a non-limiting example, instance, or illustration. As utilized herein, the terms "e.g.," and "for example" introduce a list of one or more non-limiting examples, instances, or illustrations.

[0036] FIG. **1** depicts an exemplary wireless communication network in which network communications may be scheduled as needed and/or on-demand. Referring to FIG. **1**, the network comprises base stations/sub-controllers $\mathbf{102}_1$ and $\mathbf{102}_2$, and endpoints $\mathbf{104}_1$-$\mathbf{104}_{16}$.

[0037] Each of the devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may be, for example, a base station or a network sub-controller and may comprise circuitry for communicating wirelessly, and managing overall synchronization and access to the wireless network within the cell **108**. The devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may transmit and receive wireless signals in accordance with any one or more protocols. Such protocols may include, for example, protocols defined in the ISO 18000-7 standard, and/or protocols described in the above-incorporated U.S. Provisional Patent Application No. 61/464,376 filed on Mar. 2, 2011. An exemplary device **102** is described below with respect to FIG. **2**.

[0038] Each of the endpoints $\mathbf{104}_1$-$\mathbf{104}_{15}$ may comprise circuitry for communicating wirelessly. Each of the devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may communicate with in-range endpoints in accordance with any one or more protocols. Such protocols may include, for example, protocols defined in the ISO 18000-7 standard, and/or protocols described in the above-incorporated U.S. Provisional Patent Application No. 61/464,376 filed on Mar. 2, 2011. An exemplary endpoint **104** is described below with respect to FIG. **2**.

[0039] In operation, the devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may send two types of protocol data units (PDUs) to the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$. A first type of PDU (referred to herein as a "background frame") may be utilized for scheduling the occurrence of events in the network, (e.g., with reference to the common network time and/or common time base), and/or for other network communications. A second type of PDU (referred to herein as a "foreground frame") may be utilized for data exchanges and/or other network communications.

[0040] The devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may comprise clocks which may be utilized for scheduling communications and/or other events in the network. Generally speaking, transmissions in the network may be coordinated utilizing collision detection and/or collision avoidance, rather than a "fully-managed" or "time-slotted" scheme. As a result, at any given time, one or more of the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$ may be transmitting on the medium, one or more of the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$ may be listening on the medium, and one or more of the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$ may be in a low-power or powered-down state. Consequently, reliably synchronizing all of the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$ may require the transmission of multiple background frames in succession. That is, the more background frames that are consecutively sent, the more likely it may be that any or all devices $\mathbf{104}_1$-$\mathbf{104}_{15}$ have successfully received one of the background frames.

[0041] Each of the devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may, however, be limited in how many consecutive background frames it can send. Accordingly, aspects of the invention may enable the devices $\mathbf{102}_1$-$\mathbf{102}_2$ to coordinate a flood of background frames where a transmission of one or more background packets on a particular channel by device $\mathbf{102}_1$ is followed immediately (or as nearly immediately as may be possible or permitted) by a transmission of one or more background packets on the same channel by device $\mathbf{102}_2$. In this manner, a flood of background packets twice as long as may be sent by device $\mathbf{102}_1$ or $\mathbf{102}_2$ alone may be achieved. For even longer floods, the devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may coordinate with additional devices **102** (not shown) and/or the devices $\mathbf{102}_1$ and $\mathbf{102}_2$ may continue to alternate transmissions back-to-back for as long as may be desired.

[0042] FIG. **2** depicts exemplary communication devices which may support rapid group synchronization. Shown in FIG. **2** are details of an exemplary first device $\mathbf{102}_x$ (which may generically represent each of the devices $\mathbf{102}_1$ and $\mathbf{102}_2$), and details of an exemplary second device $\mathbf{104}_x$ (which generically represents each of the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$).

[0043] The CPU **204** may comprise circuitry operable to control operation of the first device **102**. The CPU **204** may, for example, execute an operating system and/or other programs such (e.g., programs that enable a user interface of the device **102**). The CPU **204** may generate one or more control signals for controlling the operation of the device **102**. The CPU **204** may, for example, control a mode of operation of the device **102**.

[0044] The CPU **214** may comprise circuitry operable to control operation of the second device **104**. In some instances, the CPU **214** may be substantially similar to the CPU **204**. In instances that the device **102** is less resource-constrained device, such as a base station or network controller, and the device **104** is more resource-constrained device, such as a battery-powered tag or a smartcard as described in above-incorporated U.S. patent application having Ser. No. 13/270,802, the CPU **204** may be less-complex (e.g., comprise fewer gates, utilize less power, utilize less memory, etc.) than the CPU **214**. In one embodiment, for example, the CPU **204** may comprise a RISC or ARM processor, and the CPU **214** may comprise a state-machine having a relatively small number of states (e.g., four states).

[0045] The radio **207** may comprise a processor **208** and an analog front-end (AFE) **209**. The processor **208** may comprise circuitry operable to interface with the AFE **209** to

receive and transmit data, and to process received and to-be-transmitted data. For transmission, the processor **208** may be operable to receive data from the CPU **204** and/or memory **206**, encode, packetize, and/or otherwise process the data to prepare it for transmission in accordance with one or more wireless protocols, and output the data to the AFE **209** for transmission. For reception, the processor **208** may be operable to receive data via the AFE **209**, process the received data and output received data to the memory **206** and/or the CPU **204**. Exemplary protocols which may be supported by the second device **104** include the ISO 18000-7 standard, and protocols described in the above-incorporated U.S. Provisional Patent Application having Ser. No. 61/464,376 filed on Mar. 2, 2011.

[0046] The radio **217** may comprise a processor **218** and an analog front-end (AFE) **219**. The baseband processor **218** may comprise circuitry operable to interface with the AFE **219** to receive and transmit data, and to process received and to-be-transmitted data. In some instances, the baseband processor **218** may be substantially similar to the baseband processor **208**. In instances that the device **102** is less-resource-constrained device, such as a base station or network controller, and the device **104** is a more-resource-constrained device, such as a battery-powered tag, the baseband processor **218** may be less-complex (e.g., comprise fewer gates, utilize less power, utilize less memory, etc.) than the baseband processor **208**. In one embodiment, for example, the baseband processor **208** may be operable to implement more complex signal processing algorithms (e.g., FEC decoding) than the baseband processor **218**.

[0047] The analog front-end (AFE) **209** may comprise circuitry suitable for processing received and/or to-be-transmitted data in the analog domain. For transmission, the AFE **209** may receive digital data from the baseband processor **208**, process the data to generate corresponding RF signals, and output the RF signals to the antenna **210**. For reception, the AFE **209** may receive RF signals from the antenna **210**, process the RF signals to generate corresponding digital data, and output the digital data to the baseband processor **209**. In some instances, the AFE **219** may be substantially similar to the AFE **209**. In instances that the device **102** is less-resource-constrained device, such as a base station or network controller, and the device **104** is a more-resource-constrained device, such as a battery-powered tag, the AFE **219** may be less-complex (e.g., comprise fewer gates, utilize less power, utilize less memory, etc.) than the AFE **209**. In one embodiment, for example, the AFE **209** may comprise a more-sensitive receiver, a more powerful transmitter than the AFE **219**.

[0048] Circuitry of the memory **206** may comprise one or more memory cells and may be operable to store data to the memory cell(s) and read data from the memory cell(s). The one or more memory cell may comprise one or more volatile memory cells and/or one or more non-volatile memory cells. The memory **206** may store data arranged, for example, as an indexed short file block (ISFB) and/or indexed short file series block (ISFSB) as described in the above-incorporated U.S. Provisional Patent Application having Ser. No. 61/464,376.

[0049] Circuitry of the memory **216** may comprise one or more memory cells and may be operable to read data from the memory cell(s) and/or store data to the memory cell(s). The memory **216** may store data arranged, for example, as an indexed short file block (ISFB) and/or indexed short file series block (ISFSB) as described in the above-incorporated U.S. Provisional Patent Application having Ser. No. 61/464,376. In some instances, the memory **216** may be substantially similar to the memory **206**. In instances that the device **104** is resource-constrained, the memory **216** may be less-complex (e.g., comprise fewer gates, utilize less power, etc.) than the memory **206**.

[0050] Each of the clocks **211** and **221** may be operable to generate one or more oscillating signals which may be utilized to control synchronous circuitry of the device **100**. Each of the clocks **211** and **221** may comprise, for example, one or more crystal oscillators, phase-locked loops, and/or direct digital synthesizers. Each of the clocks **211** and **221** may also comprise a "date/time" or "real-time" clock operable to keep track of time of day, day of week, day of month, month, and/or year.

[0051] The interfaces **212** and **222** may enable configuring and/or programming the devices **102** and **104**, respectively. In an exemplary embodiment, one or more values of one or more timing parameters may be programmed via the programming interfaces **212** and/or **222**.

[0052] Each of the antennas **210** and **220** may be operable to transmit and receive electromagnetic signals in one or more frequency bands. In an embodiment of the invention, the antennas **210** and **220** may be operable to transmit and receive signals in the ISM frequency band centered at 433.92 MHz.

[0053] In operation, the device $\mathbf{102}_X$ may decide to (or be instructed to) schedule a network communication (e.g., schedule a search of the devices $\mathbf{104}_1$-$\mathbf{104}_{15}$) to occur at time T, where T may be referenced to a common time base (e.g., ticks of a fixed-frequency oscillator) and/or to a real-time clock. For example, the device $\mathbf{102}_X$ may generate a background frame that instructs destination devices (i.e. devices for which the frame is destined) receiving the background frame to be prepared (e.g., have their receivers on and listening to a particular channel) to receive a search request at time T. From time $T-2\Delta$ until time $T+\Delta$, where Δ is some positive value, the device $\mathbf{102}_X$ may transmit the generated background frame one or more times in succession. The amount of time between transmissions of the background frame may be as short as is permissible and/or allowed. If, during the time period from time $T-2\Delta$ to time $T+\Delta$, the device $\mathbf{104}_X$ was listening to the channel(s) on which the background frame was transmitted, then the device may have received the background frame, and scheduled itself to turn on the receive portion of its radio **217** at time $T-\alpha$ (where a is the amount of time that it takes the receiver to power-up and stabilize)

[0054] If, on the other hand, the device $\mathbf{104}_X$ was not receiving during the period from time $T-2\Delta$ to time $T+\Delta$, (e.g., because its receiver was off and/or it was busy transmitting), then the clock **221** may have failed to schedule the reception of the request at time $T-\alpha$. Consequently, the device $\mathbf{104}_X$ may miss the search request and the results of search may be sub-optimal.

[0055] FIG. **3**A illustrates an exemplary physical layer PDU utilized for synchronizing network devices and scheduling network events. The physical layer frame comprises a preamble, a sync word, and a payload. The preamble may be utilized for phase and/or frequency locking the receive circuitry of the device receiving the PDU. The sync word may identify whether the PDU contains a background frame

or a foreground frame. In the case of FIG. **3**A, the sync word may indicate that the PDU contains a background frame.

[0056] The payload comprises a data link layer (OSI layer **2**) PDU; in this case, a background frame. The background frame comprises a subnet field, a background protocol ID (BPID) field, and a CRC field. The subnet field may be a value utilized for packet filtering. Specifically, devices which have a device subnet specifier that does not match the value in the subnet field of the frame may ignore/discard the frame. The CRC field may be utilized for performing error detection and/or correction on the received PDU.

[0057] The payload comprises a background protocol ID (BPID) field and protocol data. The BPID may indicate which background frame protocol(s) is to be utilized for parsing and/or processing the received frame. In the case of FIG. **3**A, the background protocol is an advertising protocol, and the protocol data comprises a channel ID field and an event time field. For each devices $\mathbf{104}_X$ that received the frame and determined that it was a valid destination of the frame, the event time field may indicate a time at which the device should prepare to receive a transmission and the channel ID field may indicate a channel on which the device $\mathbf{104}_X$ should prepare to receive the transmission. The event time field may be formatted as amount of time until the event and/or real-time at which the event will occur.

[0058] FIG. **3**B illustrates an exemplary physical layer PDU utilized for data communication. The physical layer frame comprises a preamble, a sync word, and a payload. The payload comprises a data link layer (OSI layer **2**) PDU, in this case, a foreground frame. The foreground frame comprises a length field, a header field, a payload, a footer, and a cyclic redundancy check field. The payload may comprise, for example, a network layer (OSI layer **3**) PDU. The headers field may comprise, for example, TxEIRP field, a subnet field, a frame control field, a data link layer security (DLLS) code, DLLS initialization data, a dialog identifier, a flags field, a source ID, and a target ID. The frame control field comprises a listen flag, a DLLS flag, an enable addressing flag, a frame continuity flag, a CRC32 flag, a not mode 2 flag, and a mode 2 frame type flag. The flags field comprises an addressing option flag, a virtual ID flag, a network layer security flag, and application flags.

[0059] FIG. **4**A is a diagram illustrating scheduling of a network communication via communications from a single requesting device. From time instant T**2** to time instant T**5**, the device **102** may begin transmitting background frames to schedule a search at time instant T**9**. The background frames may arrive at the device **104** from time instant T**3** until time instant T**7**. The device **104**, however, may be transmitting from time instant T**1** to time instant T**4** and may not begin receiving until T**6**. As a result, the device **104** may not successfully receive one of the background packets transmitted by the device $\mathbf{102}_1$ from time instant T**2** to T**5**. Consequently, the device **104** may not schedule reception of the search request at time instant T**9**, and may not participate in the search. Had the device **1021** transmitted background packets (e.g., until time instant T**8**) perhaps the device **104** would have successfully received the background frame, but the device **1021** may be prevented from transmitting longer than the duration of T**5**-T**2**.

[0060] FIG. **4**B is a diagram illustrating scheduling of a network communication via communications from a single requesting device. From time instant T**2** to time instant T**5**, the device **102** may begin transmitting background frames to schedule a search at time instant T**10**. The background frames may arrive at the device **104** from time instant T**3** until time instant T**7**. The device **104**, however, may be transmitting from time instant T**1** to time instant T**4** and may not begin receiving until T**6**. As a result, the device **104** may not successfully receive one of the background packets transmitted by the device $\mathbf{102}_1$ from time instant T**2** to T**5**. In contrast to FIG. **4**A, however, at time instant T**5** the device $\mathbf{102}_2$ may begin transmitting the background frame, and the transmissions may arrive at device **104** between time instants T**7** and T**9**. The device **104** may successfully receive one of the background frames transmitted between time instants T**5** and T**8** and may, consequently, schedule reception of the search to be transmitted at time instant T**10**. Accordingly, at time instant T**10**−Δ, the device **104** may power-up its receiver, and may receive the search request from time instant T**11** to T**13**.

[0061] FIG. **5** is a flowchart illustrating exemplary steps for event scheduling in a network comprising a plurality of resource-constrained devices. The exemplary steps begin with step **502** in which a base station (e.g., device $\mathbf{102}_1$) determines to schedule a network transmission. The network transmission may be, for example, a search request.

[0062] In step **504**, the base station may determine an amount of time for which to transmit background frames advertising the scheduled network transmission. The duration of the flood of background frames may be determined based on a variety of factors such as, for example: how many devices **104** are present in the network, a distance to one or more of the devices **104**, how frequently the devices **104** typically transmit, how frequently the devices **104** typically perform a channel scan, power and/or sources available to the base station (e.g., if it is running on battery power it may want to reduce the length of the flood), and/or amount of time until the scheduled event.

[0063] In step **506**, the base station may coordinate with sub-controllers (e.g., device $\mathbf{102}_2$) in the network to transmit the flood of background frames. The sub-stations may enlist other devices to participate in the flood because, for example, the flood will be longer than the base station can transmit (e.g., because of technical and/or regulatory limitations). The sub-stations may enlist other devices to participate in the flood because, for example, the large number of devices **104** in the network makes it unlikely that greater than a threshold percentage (which may be configurable and/or vary with the circumstances of the scheduled transmission) of the devices **104** will receive the background frames if the duration of the flood is limited to the maximum duration of continuous transmission by the base station. The sub-stations may enlist other devices to participate in the flood because of the distance between the base station and one or more devices in the network. For example, based on past communications with the sub-controller and/or the devices **104**, the base station may be aware that the sub-controller may be closer to one or more devices **104** and thus enable more reliably reaching those one or more devices. In an exemplary embodiment, the base station may coordinate with the sub-controller(s) via a different protocol (wired, wireless, or optical) than the protocol utilized for communicating with the devices **104**. For example, the base station and sub-controller(s) may have wired connections to a LAN or the Internet.

[0064] In step **508**, the base station may transmit its portion of the background frames. Devices which perform a

channel scan during this time period may successfully receive one or more of the background frames and may schedule reception of the pending transmission being advertised in the background frames. Devices which do not perform a channel scan during this time period may not receive one or more of the background frames and, consequently, may not schedule reception of the pending transmission being advertised in the background frames.

[0065] In step **510**, the sub-controllers with which the base station coordinated in step **506** may, sequentially in turn, transmit its share of the background frames. Devices which perform a channel scan during this time period (which may include devices which did not perform a channel scan during step **508**) may successfully receive one or more of the background frames and may schedule reception of the pending transmission being advertised in the background frames.

[0066] In another embodiment of the invention, the coordinating of the sub-controllers may comprise controlling their transmit strength such that their transmissions are non-overlapping. In this manner, all of the sub-controllers could transmit the flood concurrently.

[0067] In step **512**, the scheduled transmission (e.g., a search request as described in above-incorporated U.S. patent application Ser. No. 13/267,640) may take place at the scheduled time. In an exemplary embodiment, the scheduled transmission may be transmitted only by the base station. In another exemplary embodiment, the request may be transmitted concurrently by a plurality of sub-controllers each of which has had its transmit power and/or transmit channel configured to not overlap with other ones of the sub-controllers (i.e., so the packets from the various sub-controllers does not collide).

[0068] In an exemplary embodiment of the invention, a first device $\mathbf{102}_1$ of a network may decide to transmit a flood of packets that is longer in duration than the maximum amount of time that the first device can continuously transmit. The first device $\mathbf{102}_1$ may coordinate with one or more second devices $\mathbf{102}_2$-$\mathbf{102}_N$ (where N is an integer greater than 1) of the network such that each of the one or more second devices **102** transmits a respective second portion of the flood of packets following transmission of a first portion of the flood of packets by the first network device $\mathbf{102}_1$. The packets may advertise a pending network event that is to occur at a time indicated by the contents of the packets (e.g., by an event time field). The network event comprises the transmission of a search request. The packets may contain a channel identifier field that indicates a channel on which the search request will be transmitted. The device $\mathbf{102}_1$ may select the one or more second devices $\mathbf{102}_2$-$\mathbf{102}_N$ from a plurality of devices based on a location of the one or more second devices $\mathbf{102}_2$-$\mathbf{102}_N$. The device $\mathbf{102}_1$ may select the one or more second network devices from a plurality of devices based on how many third devices **104** are in the network. The plurality of second devices $\mathbf{102}_2$-$\mathbf{102}_N$ may concurrently transmit their respective portions of the flood. A transmit power utilized by each of the one or more second devices for transmitting its respective portion of the flood may be controlled to avoid collisions between packets of the flood. Each one of the plurality of second devices $\mathbf{102}_2$-$\mathbf{102}_N$ may transmit its respective portion of the flood on a channel that is different than a channel utilized by each other one of the plurality of second devices $\mathbf{102}_2$-$\mathbf{102}_N$ for transmitting their respective portions of the flood. The packets may be background frames comprising a subnet field, a background protocol identifier field, a channel identifier field, and an event time field.

[0069] Other embodiments of the invention may provide a non-transitory computer readable medium and/or storage medium, and/or a non-transitory machine readable medium and/or storage medium, having stored thereon, a machine code and/or a computer program having at least one code section executable by a machine and/or a computer, thereby causing the machine and/or computer to perform the steps as described herein for rapid group synchronization.

[0070] Accordingly, the present invention may be realized in hardware, software, or a combination of hardware and software. The present invention may be realized in a centralized fashion in at least one computing system, or in a distributed fashion where different elements are spread across several interconnected computing systems. Any kind of computing system or other apparatus adapted for carrying out the methods described herein is suited. A typical combination of hardware and software may be a general-purpose computing system with a program or other code that, when being loaded and executed, controls the computing system such that it carries out the methods described herein. Another typical implementation may comprise an application specific integrated circuit or chip.

[0071] The present invention may also be embedded in a computer program product, which comprises all the features enabling the implementation of the methods described herein, and which when loaded in a computer system is able to carry out these methods. Computer program in the present context means any expression, in any language, code or notation, of a set of instructions intended to cause a system having an information processing capability to perform a particular function either directly or after either or both of the following: a) conversion to another language, code or notation; b) reproduction in a different material form.

[0072] While the present invention has been described with reference to certain embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted without departing from the scope of the present invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the present invention without departing from its scope. Therefore, it is intended that the present invention not be limited to the particular embodiment disclosed, but that the present invention will include all embodiments falling within the scope of the appended claims.

What is claimed is:

1. A method comprising:

in a first device of a network:

deciding to transmit a flood of packets that is longer in duration than the maximum amount of time that said first device can continuously transmit;

coordinating with one or more second devices of said network such that each of said one or more second devices transmits a respective second portion of said flood of packets following transmission of a first portion of said flood of packets by said first network device.

2. The method of claim **1**, wherein said packets advertise a pending network event that is to occur at a time indicated by the contents of said packets.

3. The method of claim 2, wherein said network event comprises the transmission of a search request.

4. The method of claim 3, wherein said packets contain a channel identifier field that indicates a channel on which said search request will be transmitted.

5. The method of claim 1, comprising selecting said one or more second devices from a plurality of devices based on a location of said one or more second devices.

6. The method of claim 1, comprising selecting said one or more second network devices from a plurality of devices based on how many third devices are in said network.

7. The method of claim 1, wherein:

said one or more second devices is a plurality of second devices; and

said plurality of second devices concurrently transmit their said respective portions of said flood.

8. The method of claim 7, wherein a transmit power utilized by each of said one or more second devices for transmitting its said respective portion of said flood is controlled to avoid collisions between packets of said flood.

9. The method of claim 7, wherein each one of said plurality of second devices transmits its said respective portion of said flood on a channel that is different than a channel utilized by each other one of said plurality of second devices for transmitting their said respective portions of said flood.

10. The method of claim 1, wherein said packets are background frames comprising a subnet field, a background protocol identifier field, a channel identifier field, and an event time field.

11. A system comprising:

a first device of a network, said first device being operable to:

decide to transmit a flood of packets that is longer in duration than the maximum amount of time that said first device can continuously transmit;

coordinate with one or more second devices of said network such that each of said one or more second devices transmits a respective second portion of said flood of packets following transmission of a first portion of said flood of packets by said first network device.

12. The system of claim 11, wherein said packets advertise a pending network event that is to occur at a time indicated by the contents of said packets.

13. The system of claim 12, wherein said network event comprises the transmission of a search request.

14. The system of claim 13, wherein said packets contain a channel identifier field that indicates a channel on which said search request will be transmitted.

15. The system of claim 11, wherein said first device is operable to select said one or more second devices from a plurality of devices based on a location of said one or more second devices.

16. The system of claim 11, wherein said first network device is operable to select said one or more second network devices from a plurality of devices based on how many third devices are in said network.

17. The system of claim 11, wherein:

said one or more second devices is a plurality of second devices; and

said plurality of second devices concurrently transmit their said respective portions of said flood.

18. The system of claim 17, wherein a transmit power utilized by each of said one or more second devices for transmitting its said respective portion of said flood is controlled to avoid collisions between packets of said flood.

19. The system of claim 17, wherein each one of said plurality of second devices transmits its said respective portion of said flood on a channel that is different than a channel utilized by each other one of said plurality of second devices for transmitting their said respective portions of said flood.

20. The system of claim 11, wherein said packets are background frames comprising a subnet field, a background protocol identifier field, a channel identifier field, and an event time field.

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