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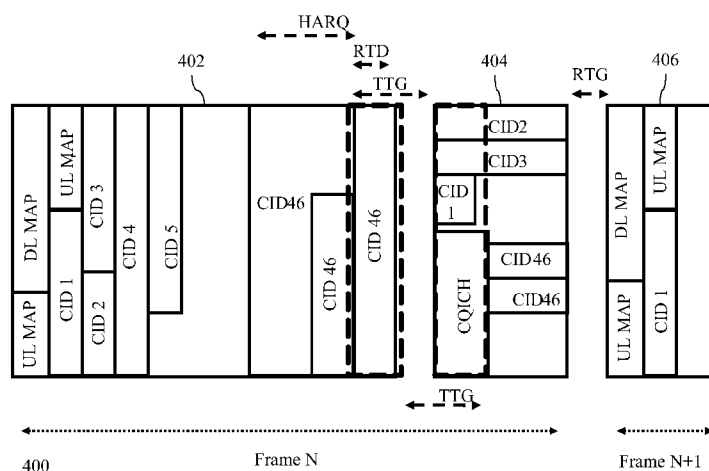


FIG. 4

(57) Abstract: A method and system for managing a communication between a base station (102) and plurality of subscriber stations (104, 106, 108 and 110) is disclosed. The method includes determining (504) whether a Round Trip Delay (RTD) component is greater than the duration of a data slot for at least one subscriber station of the plurality of subscriber stations. The RTD component is a part of a Transmit/receive Transition Gap (TTG) of the base station. The method also includes scheduling (506) the data slot for the at least one subscriber station using the RTD component of the base station when the duration of the RTD component is greater than the duration of the data slot for the at least one subscriber station.

METHOD AND SYSTEM FOR MANAGING COMMUNICATION BETWEEN A BASE STATION AND SUBSCRIBER STATIONS

FIELD OF THE INVENTION

[0001] This invention relates generally to communication networks, and more specifically, to a method and system for managing communication between a base station and subscriber stations in a communication network.

BACKGROUND OF THE INVENTION

[0002] Communication networks are becoming increasingly popular with the increase in the need for communication and information exchange. A typical communication network includes numerous base stations and subscriber stations. These subscriber stations exchange information with each other via base stations. The subscriber stations exchange data with a base station in a series of frames. Each frame includes, for example, an uplink data frame of data and a downlink data frame of data. The uplink data frame can be defined as a sub-frame, during which the subscriber stations send data to the base station. The downlink data frame can be defined as a sub-frame, during which the base station sends data to the subscriber stations. A typical base station communicates with the subscriber stations by allocating respective data slots to different subscriber stations. These data slots are allocated in the downlink data frame as well as in the uplink data frame.

[0003] Generally, base stations and subscriber stations comply with the Institute of Electrical and Electronics Engineers (IEEE) standards 802.16-2004 and/or 802.16-2005. According to section 8.4.4.2 of the IEEE standard 802.16-2004, a Transmit/receive Transition Gap (TTG) and a Receive/transmit Transition Gap (RTG) needs to be inserted between the downlink data frame and uplink data frame, and also at the end of each frame. According to these standards, a base station should not transmit information to a subscriber station later than (Subscriber Station Receive/Transmit Turnaround Gap + Round Trip Delay) before the beginning of the

first scheduled uplink allocation in any uplink data frame. Further, the base station should not transmit downlink information to the subscriber station earlier than (Subscriber Station Transmit/Receive Turnaround Gap-RTD) after the end of the allocation in the last uplink data frame.

[0004] According to the specifications of the IEEE standards 802.16-2004 and 802.16-2005, TTG is equal to the sum of SSRTG (Subscriber Station Receive/Transmit Turnaround Gap) and RTD (Round Trip Delay). SSRTG and SSTTG (Subscriber Station Transmit/receive Transition Gap) are parameters provided by the subscriber station to the base station when the subscriber station enters the communication network. TTG is a pre-configured value set that corresponds to the base station. The RTD component is a major portion of the TTG. The RTD cannot be changed once the SSRTG has been reported to a base station by a subscriber station. Therefore, bandwidth may be wasted by subscriber stations that are close to the base station, as well as by subscriber stations that are moving closer to the base station, resulting in a decrease in data throughput for the corresponding communication network.

BRIEF DESCRIPTION OF THE FIGURES

[0005] The accompanying figures, where like reference numerals refer to identical or functionally similar elements throughout the separate views, and which, together with the detailed description below, are incorporated in and form part of the specification, serve to further illustrate various embodiments and explain various principles and advantages, all in accordance with the present invention.

[0006] **FIG. 1** illustrates an exemplary communication network, in accordance with an embodiment of the present invention;

[0007] **FIG. 2** is a block diagram illustrating a base station for managing communication with a plurality of subscriber stations, in accordance with an embodiment of the present invention;

[0008] **FIG. 3** is a block diagram illustrating a subscriber station for managing communication with a base station, in accordance with an embodiment of the present invention;

[0009] **FIG. 4** is a schematic diagram illustrating an architecture of frame structure for managing communication between a base station and a plurality of subscriber stations, in accordance with an embodiment of the present invention;

[0010] **FIG. 5** is a flow diagram illustrating a method for managing communication between a base station and a plurality of subscriber stations, in accordance with an embodiment of the present invention; and

[0011] **FIG. 6** is a detailed flow diagram illustrating a method for managing communication between a base station and a plurality of subscriber stations, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION

[0012] For one embodiment, a method for managing communication between a base station and a plurality of subscriber stations is provided. The method includes determining whether a Round Trip Delay (RTD) component is greater than the duration of a data slot for at least one subscriber station of the plurality of subscriber stations. The RTD component is a part of a Transmit/receive Transition Gap (TTG) of the base station. The method also includes scheduling the data slot for the at least one subscriber station by using the RTD component when the duration of the RTD component is greater than the duration of the data slot for the at least one subscriber station.

[0013] For another embodiment, a base station is provided. The base station includes a scheduling module and a transceiver module. The scheduling module is adapted to schedule a data slot for at least one subscriber station of a plurality of subscriber stations. The scheduling module uses a Round Trip Delay (RTD) component of a Transmit/receive Transition Gap (TTG) of the base station, to

schedule the data slot for the at least one subscriber station. The transceiver module is adapted to communicate with the at least one subscriber station, based on the scheduling of the data slot for the at least one subscriber station performed by the scheduling module.

[0014] For yet another embodiment, a subscriber station is provided. The subscriber station includes a transceiver module that is adapted to communicate with a base station. The communication can be scheduled to be exchanged in the Round Trip Delay (RTD) component, which is a part of a Transmit/receive Transition Gap (TTG) of the base station.

[0015] Before describing in detail the particular method and system for managing a communication between a base station and a plurality of subscriber stations, in accordance with various embodiments of the present invention, it should be observed that the present invention resides primarily in combinations of method steps related to the method for managing communication between the base station and the plurality of subscriber stations. Accordingly, the method steps have been represented, where appropriate, by conventional symbols in the drawings, showing only those specific details that are pertinent for an understanding of the present invention, so as not to obscure the disclosure with details that will be readily apparent to those with ordinary skill in the art, having the benefit of the description herein.

[0016] In this document, relational terms such as first and second, and the like, may be used solely to distinguish one entity or action from another entity or action, without necessarily requiring or implying any actual such relationship or order between such entities or actions. The terms "comprises," "comprising", or any other variation thereof, are intended to cover a non-exclusive inclusion, such that a process, method, article or apparatus that comprises a list of elements does not include only those elements but may include other elements not expressly listed or inherent to such a process, method, article or apparatus. An element preceded by "comprises ... a" does not, without more constraints, preclude the existence of additional identical elements in the process, method, article or apparatus that comprises the element.

[0017] The term "another", as used in this document, is defined as at least a second or more. The term "includes", as used herein, is defined as comprising.

[0018] **FIG. 1** illustrates an exemplary communication network **100**, in accordance with one embodiment of the present invention. The communication network **100** can include one or more base stations and a plurality of subscriber stations. Examples of the communication network **100** include, but are not limited to, an Institute of Electrical and Electronics Engineers (IEEE) 802.16-based broadband wireless access network, an Advanced Mobile Phone Systems (AMPS) network, a Global System for Mobile (GSM) communications network, a Digital Cellular Systems (DCS) network, a Universal Mobile Telecommunications Systems (UMTS) network, a Code Division Multiple Access (CDMA) network, and the Internet. For the purpose of this description, the communication network **100** is shown to include a base station **102**, a subscriber station **104**, a subscriber station **106**, a subscriber station **108**, and a subscriber station **110**. Examples of the subscriber stations **104**, **106**, **108** and **110** include, but are not limited to, cellular phones, laptop computers, personal digital assistants (PDAs), Internet Protocol (IP)-enabled phones, voice-messaging systems, audio broadcast systems, video broadcast systems, portable gaming systems, and conferencing systems. For example, each of the subscriber stations **104**, **106**, **108** and **110** exchange data packets with the base stations in a series of frames. Data slot is allocated for the subscriber stations **104**, **106**, **108** and **110** in each frame. The frames can include one or more sub-frames that are referred to as a downlink data frame and an uplink data frame. The downlink data frame includes the data slots corresponding to the each of the plurality of subscriber stations **104**, **106**, **108** and **110**. These data slots contain information that is to be sent to the subscriber stations **104**, **106**, **108** and **110** from the base station **102**. For example, the uplink data frame includes the data slots corresponding to each of the plurality of subscriber stations **104**, **106**, **108** and **110**. These data slots include information that is to be sent to the base station **102** from the subscriber stations **104**, **106**, **108** and **110**. Each of the subscriber stations **104**, **106**, **108** and **110** exchange data with the base station **102** in their respective data slots in the uplink data frame and the downlink data frame. The allocation of the frames for each of the subscriber stations is explained further in conjunction with **FIG. 4**.

[0019] **FIG. 2** is a block diagram illustrating the base station **102** for managing communication with the plurality of subscriber stations **104**, **106**, **108** and **110**, in accordance with one embodiment of the present invention. The base station **102** includes a scheduling module **202**, a transceiver module **204**, a processor module **206**, a first memory unit **208**, and a second memory unit **210**. The scheduling module **202** includes a downlink scheduling module **212** and an uplink scheduling module **214**. The downlink scheduling module **212** schedules data slots for the at least one subscriber station in a downlink data frame. The downlink scheduling module **212** is configured such that it can schedule at least one data slot for a subscriber station by using the Round Trip Delay (RTD) component of the Transmit/receive Transition Gap (TTG) of the base station **102**. The scheduling of the at least one data slot is explained in detail in conjunction with **FIG. 4**. The uplink scheduling module **214** schedules a data slot for the at least one subscriber in an uplink data frame. The uplink scheduling module **214** is configured such that it can schedule at least one data slot for a subscriber station by using the RTD component of the TTG of the base station **102**.

[0020] The transceiver module **204** is adapted to communicate with the subscriber stations **104**, **106**, **108** and **110**, based on the scheduling of the respective data slots for the subscriber stations **104**, **106**, **108** and **110**. It will be apparent to a person ordinarily skilled in the art that the transceiver module **204** can be a combination of a receiver and a transmitter or can be a single entity with a receiver and a transmitter. The downlink scheduling module **212** and uplink scheduling module **214** work in conjunction with the processor module **206**. The processor module **206** determines whether the duration of the RTD component of the TTG of the base station **102** for a subscriber station is greater than the duration of the data slot required for the subscriber station. The processor module **206** is also adapted to maintain a gap between the data slots for the subscriber station in the uplink data frame and the data slots in the downlink data frame so that they are equal to the TTG.

[0021] The working of the base station **102** is explained with the following example, for clarity. Consider a situation in which the duration of the data slot for a subscriber station is 20 μ s, the TTG of the base station is 80 μ s, the SSRTG is equal

to 50 μ s. As a result, the RTD is equal to 30 μ s ($RTD = TTG - SSRTG$). In this event, the duration of the RTD component (30 μ s) is greater than the data slot (20 μ s) for the subscriber station **104**. Therefore, data slots for the subscriber station can be inserted in the uplink data frame and the downlink data frame, maintaining a gap of 50 μ s, which is equal to the SSRTG. In other words, the duration of RTD (30 μ s) can be utilized to insert an additional data slot for the subscriber station in either the uplink data frame or the downlink data frame.

[0022] In one embodiment, the minimum gap required between the data slot of the subscriber station in the uplink data frame and the downlink data frame can be maintained with the help of the first memory unit **208** and the second memory unit **210**. The first memory unit **208** is used to store downlink scheduling information. The downlink data frame-scheduling information refers to the scheduling of data slots for one or more subscriber stations of the plurality of subscriber stations in the downlink data frame. The second memory unit **210** is used to store uplink scheduling information. The uplink data frame-scheduling information refers to the scheduling of a set of data slots for the one or more subscriber stations of the plurality of subscriber stations in the uplink data frame. The first memory unit **208** and the second memory unit **210** communicate the uplink scheduling information and the downlink scheduling information to the processor module **206**. The processor module **206** maintains a minimum gap of TTG between the data slots for every subscriber station in the uplink data frame and the downlink data frame, based on the uplink scheduling information and the downlink scheduling information. In one embodiment, the first memory unit **208** and the second memory unit **210** can be integrated and can store the uplink scheduling information and the downlink scheduling information. In some embodiments, the base station **102** communicates with the subscriber stations **104**, **106**, **108** and **110**, in compliance with, but not limited to, IEEE standards 802.16-2004 and/or 802.16-2005.

[0023] **FIG. 3** is a block diagram illustrating the subscriber station **104** for managing a communication with the base station **102**, in accordance with one embodiment of the present invention. The subscriber station **104** includes a transceiver module **302**, which exchanges data with the base station **102**. The

transceiver module **302** can be adapted to exchange the data with the base station **102** when the data is scheduled to be exchanged in the RTD component of the TTG gap of the base station. For one embodiment, the transceiver module **302** includes a receiver module **304** and a transmitter module **306**.

[0024] The receiver module **304** is configured to receive the data from the base station **102** such that it can receive the data that is scheduled to be sent in the downlink data frame by using the RTD component of the TTG of the base station **102**. The transmitter module **306** is configured to transmit data to the base station **102**. Moreover, the transmitter module **306** is configured such that the data sent by it can be received by the base station **102** in an uplink data frame by using the RTD component of the TTG of the base station **102**. The receiver module **304** and the transmitter module **306** operates in coordination with each other, to maintain that the gap between the data received by the receiver module **304** and the data transmitted by the transmitter module **306** is at least equal to the TTG of the base station **102**. In some embodiments, the subscriber station **104** communicates with the base station **102**, in compliance with, but not limited to, IEEE standard 802.16-2004 and/or IEEE standard 802.16-2005.

[0025] **FIG. 4** is a schematic diagram illustrating an architecture **400** of the frame structure for managing communication between the base station **102** and the plurality of subscriber stations **104**, **106**, **108** and **110**, in accordance with one embodiment of the present invention. The architecture **400** represents the architecture of the two generic frames N and $N+1$ corresponding to the base station **102**, where N is an integer number and is greater than zero. Frame N includes a downlink data frame **402** and an uplink data frame **404**. For the purpose of this description, frame $N+1$ is shown to include a downlink data frame **406** only. The downlink data frame **402** includes an Up Link (UL) map, a Down Link (DL) map, and several data bursts with different Connection Identifiers (CIDs). The UL map describes a Medium Access Control (MAC) message that defines the UL data burst locations in the UL data frame for subscribers identified by CIDs. The DL map describes a MAC message that defines the DL data burst locations in the DL data frame for subscribers identified by CIDs.

[0026] The several CIDs represent the respective CIDs for each of the subscriber stations associated with the base station **102**. CID is a term used in IEEE 802.16 networks to specify a unidirectional MAC-layer address that identifies a connection between a base station and a subscriber station. As shown in **FIG. 4**, the downlink data frame **402** includes CID1, CID2, CID3, CID4 and CID5 to CID46, where CID_i represents the CID allocation of i^{th} subscriber station ($i \geq 1$ and i is an integer). CID_i represents the connection between the i^{th} subscriber station and the base station **102** through which the data packets are routed.

[0027] As shown in **FIG. 4**, the uplink data frame **404** occurs subsequent to the downlink data frame **402**. The uplink data frame **404** includes a Channel Quality Information Channel (CQICH) control field and uplink data bursts for CID1, CID2, and CID3 to CID46. It will be apparent to a person ordinarily skilled in the art (from **FIG. 4**) that the minimum gap between the boundaries of the data bursts for CID 46 in the downlink data frame **402** and the uplink data frame **404** is the TTG, which is a prerequisite according to IEEE 802. 16. 2004. For example, the data slots for the CID 46 in the downlink data frame **402** and the uplink data frame **404** are allocated in a way that the RTD gap is utilized to insert a data slot for the CID 46. In addition, the minimum gap criterion is also fulfilled for the 46^{th} subscriber station. For example, the gap between the CIDs in the uplink data frame and the down link data frame for a subscriber station should be TTG. In other words, the RTD gap is re-used for data transmission. From the description given above, it will be apparent to a person ordinarily skilled in the art that if the data slots for a subscriber station in the downlink data frame and in the uplink data frame are arranged, so that the gap between them is equal or more than the RTD time, the base station and/or subscriber stations can re-use the RTD time for data-burst transmission.

[0028] The frame N+1 **406** shown in **FIG. 4** includes a UL map, a DL map and a CID1. The duration between the frame N and the frame N+1 is represented as the RTG (Receive/Transmit Transition Gap). For one embodiment, the frame N+1 is a downlink data frame. It will be apparent to person skilled in the art that there will be an uplink data frame subsequent to the downlink data frame for the frame N+1 **406** (not shown in **FIG. 4**).

[0029] **FIG. 5** is a flow diagram illustrating a method for managing communication between the base station **102** and the plurality of subscriber stations **104, 106, 108** and **110**, in accordance with one embodiment of the present invention. The method for managing the communication between the base station **102** and the subscriber stations **104, 106, 108** and **110** is initiated at step **502**. At step **504**, it is determined whether an RTD component is greater than a data slot of a subscriber station of the subscriber stations **104, 106, 108** and **110**. The RTD component is a part of the TTG of the base station **102**. At step **506**, the data slots for the subscriber station are scheduled in the downlink data frame **402** and the uplink data frame **404**. In one embodiment, the scheduling of the data slots for the subscriber station is carried out, based on the condition that the RTD component is greater than the data slot required for the subscriber station. The data slots for the subscriber station are scheduled by using the RTD component. At step **508**, the method for managing communication between a base station and a plurality of subscriber stations is terminated.

[0030] **FIG. 6** is a detailed flow diagram illustrating a method for managing communication between a base station and a plurality of subscriber stations, in accordance with one embodiment of the present invention. The method is initiated at step **602**. The step **604** being performed for managing the communication between the base station **102** and the plurality of subscriber stations **104, 106, 108** and **110** is the same as the step **504**, as discussed in conjunction with **FIG. 5**. At step **606**, the data slots for the subscriber station are allocated in the uplink data frame and the downlink data frame. The scheduling of the data slots for the subscriber station in the downlink data frame is performed in coordination with the scheduling in the uplink data frame. At step **608**, a gap is maintained between the data slots for the subscriber station in the uplink data frame **404** and the downlink data frame **402**, which is at least equal to the TTG of the base station. In some embodiments, the communication between the base station **102** and the subscriber stations **104, 106, 108** and **110** is in compliance with at least IEEE standards 802.16-2004 or 802.16-2005. At step **610**, a method for managing communication between a base station and a plurality of subscriber stations is terminated.

[0031] The method given above is explained with the following example, for added clarity. Consider an exemplary case in which the duration of a data slot required for a subscriber station is 20 μ s and the TTG of the base station is 80 μ s (the SSRTG is equal to 50 μ s and the RTD is equal to 30 μ s). In this case, the duration of the RTD component (30 μ s) is greater than the data slot (20 μ s) required for the subscriber station **104**. The data slots for the subscriber station can be inserted in the uplink data frame and the downlink data frame while maintaining a gap of 50 μ s, which is equal to the SSRTG. In other words, the duration of RTD (30 μ s) can be utilized to insert an additional data slot for the subscriber station in either the uplink data frame or the downlink data frame.

[0032] Various embodiments, as described above, provide a method and system for managing communication between a base station and a plurality of subscriber stations. Embodiments of the present invention enable an increase in the available bandwidth and the system throughput by creating additional data slots in the transmitting data frames. Embodiments of the present invention may be implemented without any change in the IEEE standard 802.16-2004 or IEEE standard 802.16-2005.

[0033] In the foregoing specification, the invention and its benefits and advantages have been described with reference to specific embodiments. However, one with ordinary skill in the art would appreciate that various modifications and changes can be made without departing from the scope of the present invention, as set forth in the claims below. Accordingly, the specification and figures are to be regarded in an illustrative rather than a restrictive sense, and all such modifications are intended to be included within the scope of the present invention. The benefits, advantages, solutions to problems and any element(s) that may cause any benefit, advantage or solution to occur or become more pronounced are not to be construed as critical, required or essential features or elements of any or all of the claims. The invention is defined solely by the appended claims, including any amendments made during the pendency of this application and all equivalents of those claims, as issued.

[0034] What is claimed is:

CLAIMS

1. A method for managing a communication between a base station and a plurality of subscriber stations, the method comprising:
 - determining whether a Round Trip Delay (RTD) component is greater than a duration of a data slot for at least one subscriber station of the plurality of subscriber stations, wherein the RTD component is a part of a Transmit/receive Transition Gap (TTG) of the base station; and
 - scheduling the data slot for the at least one subscriber station using the RTD component when the duration of the RTD component is greater than the duration of the data slot for the at least one subscriber station.
2. The method as recited in claim 1, wherein scheduling the data slot for the at least one subscriber station comprises allocating the data slot in one of a downlink data frame and an uplink data frame.
3. A base station comprising:
 - a scheduling module, the scheduling module adapted to schedule a data slot for at least one subscriber station of a plurality of subscriber stations using a Round Trip Delay (RTD) component, wherein the RTD component is a part of a Transmit/receive Transition Gap (TTG) of the base station; and
 - a transceiver module, the transceiver module adapted to communicate with the at least one subscriber station based on the scheduling of the data slot for the at least one subscriber station.
4. The base station as recited in claim 3, wherein the scheduling module comprises:
 - a downlink scheduling module, the downlink scheduling module adapted to schedule the data slot for the at least one subscriber station in a downlink data frame using the RTD component of the base station.

5. The base station as recited in claim 3, wherein the scheduling module comprises:
 - an uplink scheduling module, the uplink scheduling module adapted to schedule the data slot for the at least one subscriber station in an uplink data frame using the RTD component of the base station.
6. The base station as recited in claim 3 further comprising:
 - a processor module, the processor module adapted to determine whether a duration of the RTD component is greater than a duration of the data slot for the at least one subscriber station.
7. The base station as recited in claim 3 further comprising a first memory unit to store downlink data frame scheduling information, wherein the downlink data frame scheduling information includes scheduling of a set of data slots for one or more subscriber stations of the plurality of subscriber stations in a downlink data frame.
8. A subscriber station comprising:
 - a transceiver module, the transceiver module adapted to exchange data with a base station, wherein the data is scheduled to be exchanged in a Round Trip Delay (RTD) component, wherein the RTD component is a part of a Transmit/receive Transition Gap (TTG) of the base station.
9. The subscriber station as recited in claim 8, wherein the transceiver module comprises:
 - a receiver module, the receiver module adapted to receive a downlink portion of the data from the base station, wherein the downlink portion of the data is scheduled in a downlink data frame based on the RTD component of the base station; and
 - a transmitter module, the transmitter module adapted to transmit an uplink portion of the data to the base station, wherein the data is scheduled in an uplink data frame based on the RTD component of the base station.

10. The subscriber station as recited in claim 9, wherein a gap between the downlink portion of the data received by the receiver module and the uplink portion of the data transmitted by the transmitter module is at least equal to the TTG of the base station.

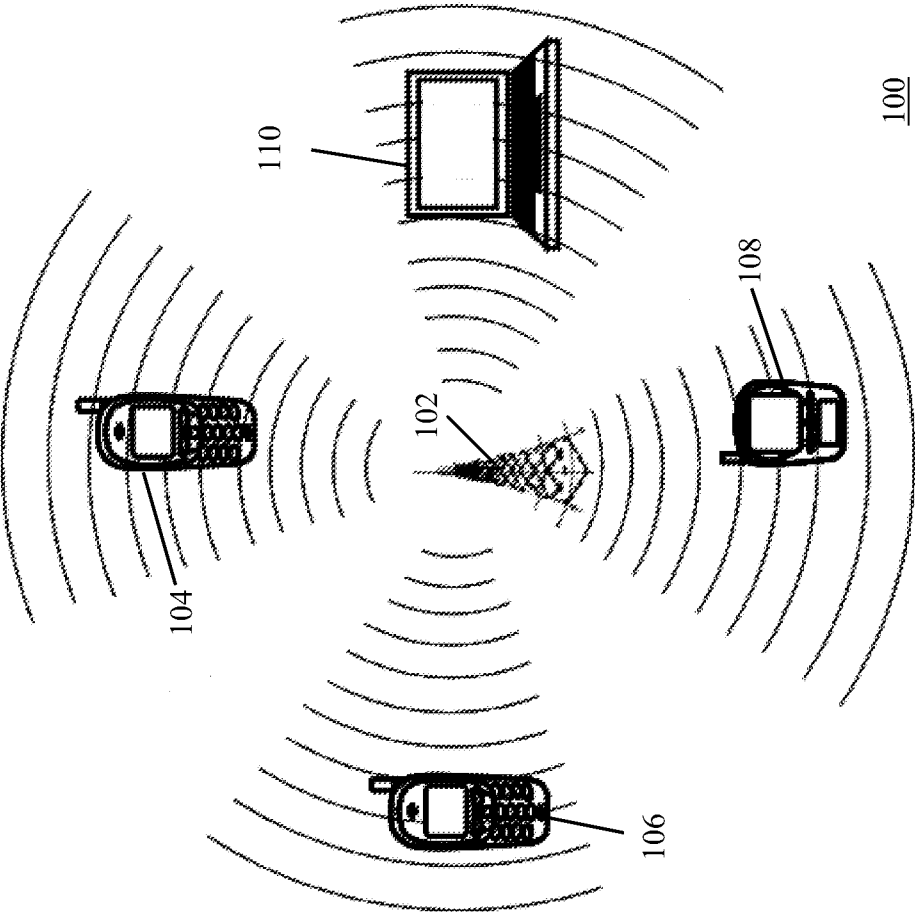


FIG. 1

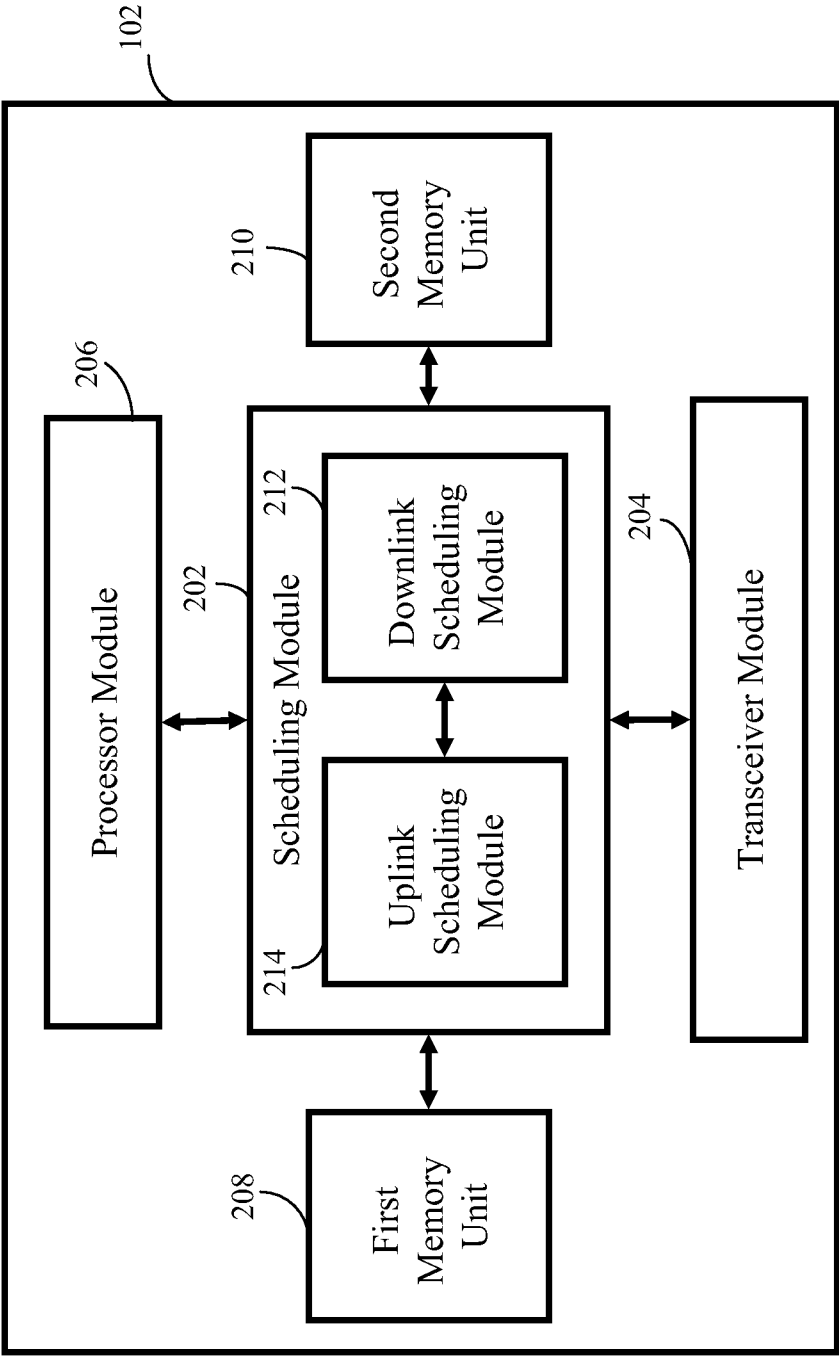


FIG. 2

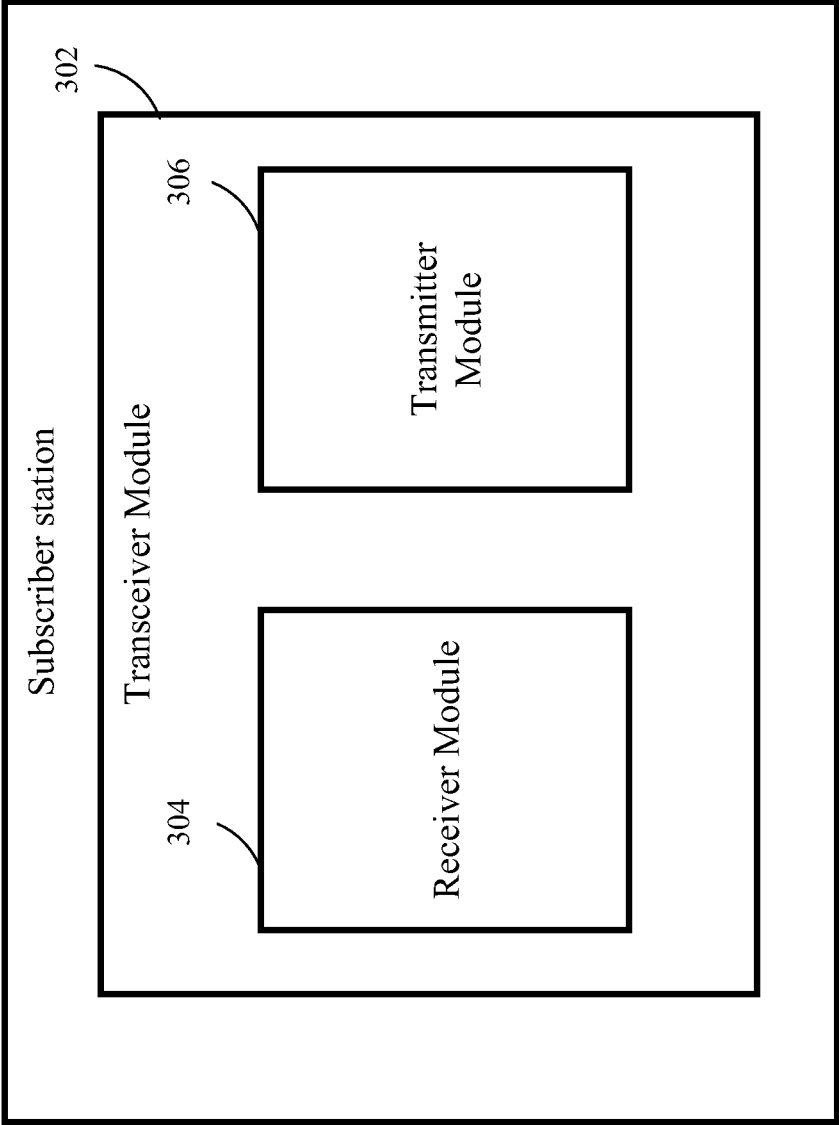
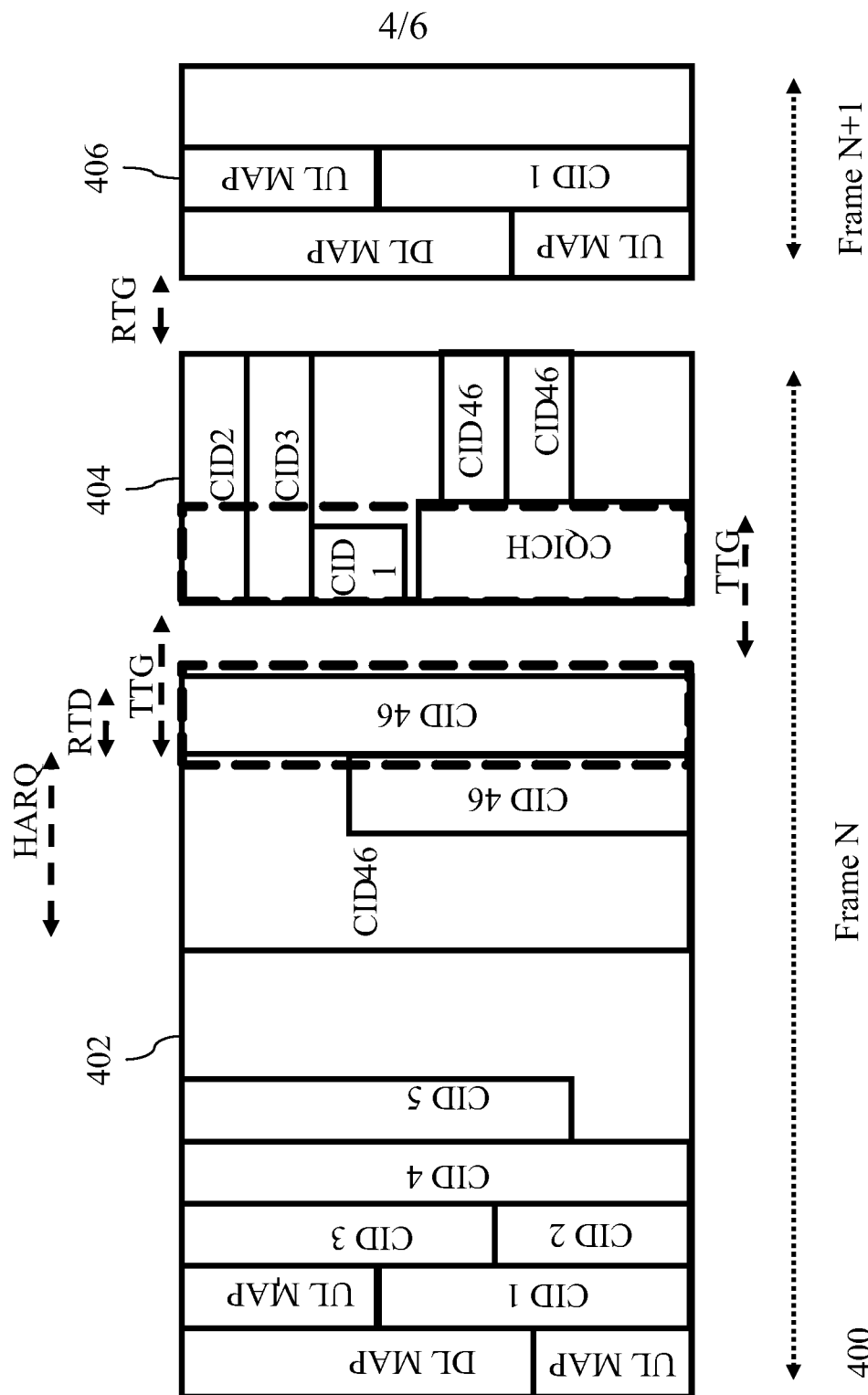


FIG. 3



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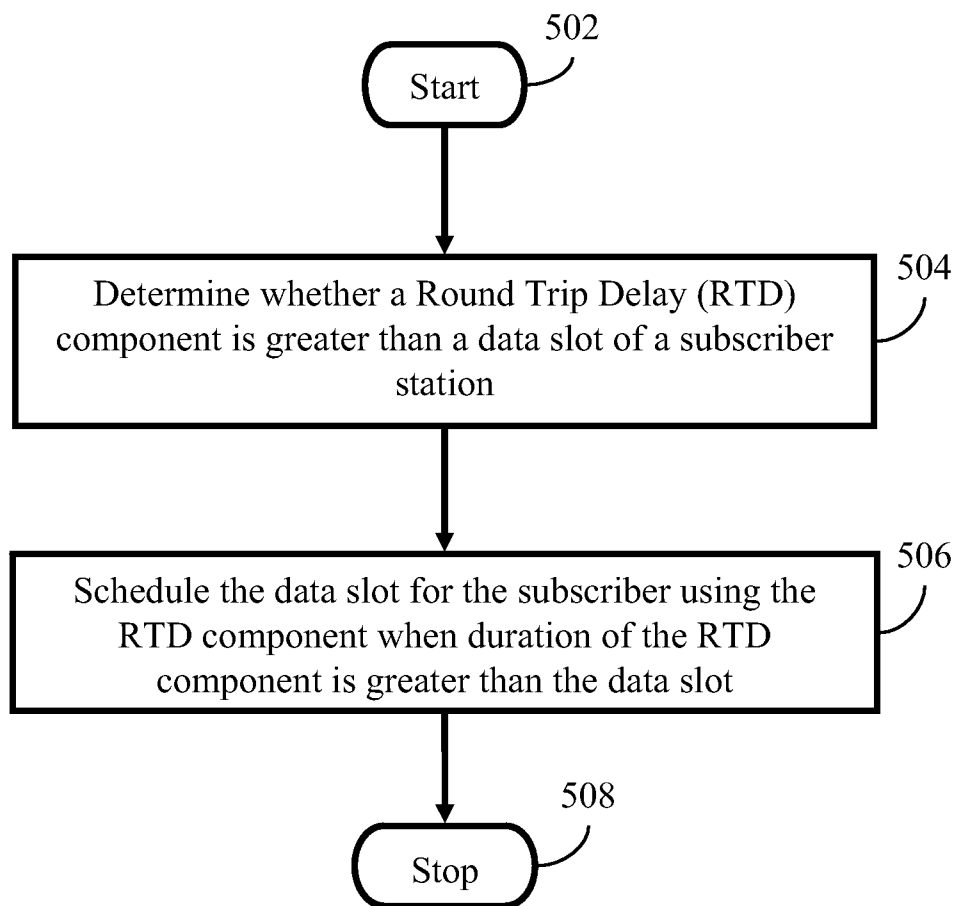


FIG. 5

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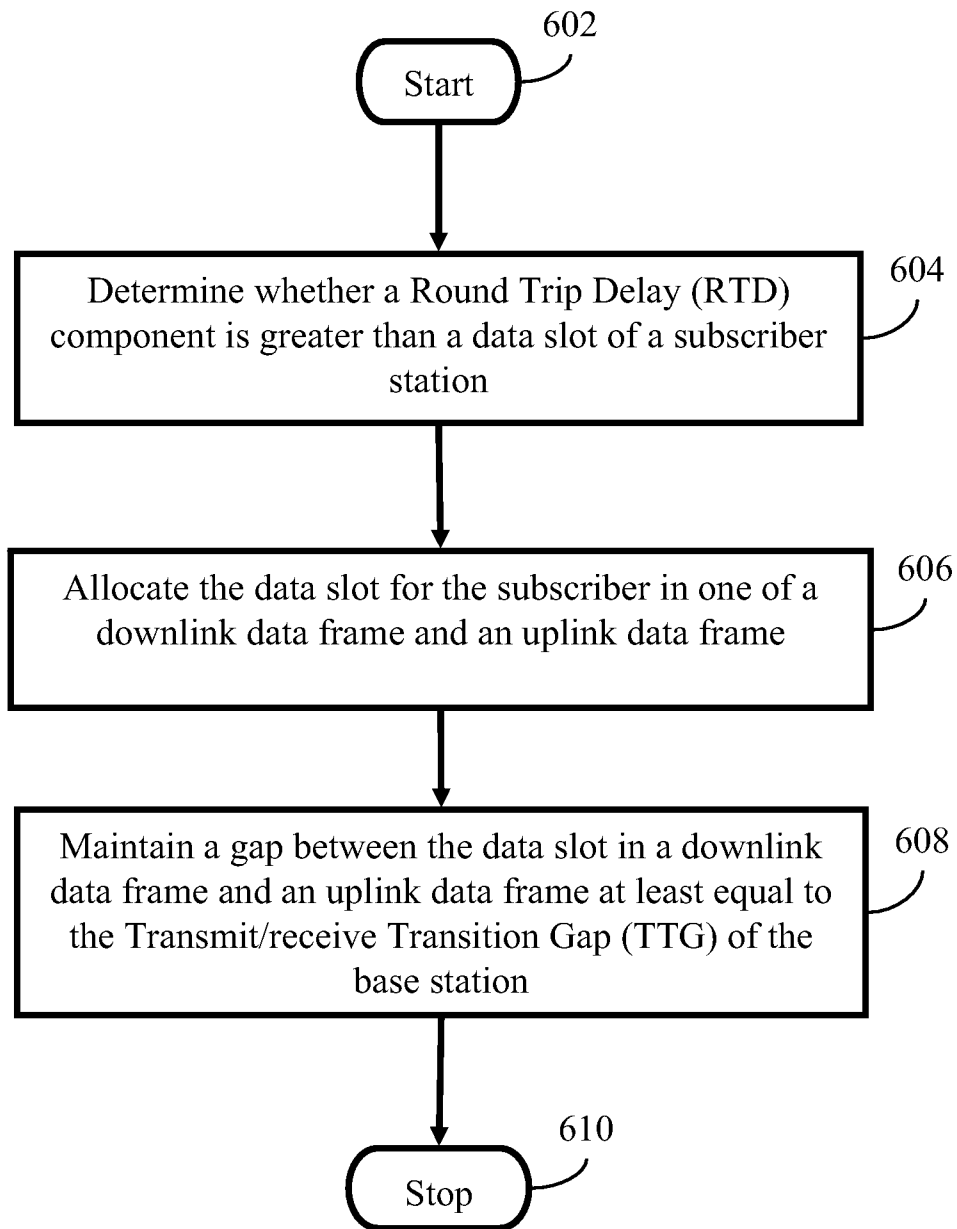


FIG. 6