

[0001] METHOD OF MAINTAINING TIME ALIGNMENT WITH MULTIPLE
UPLINK CARRIERS

[0002] FIELD OF INVENTION

[0003] This application is related to wireless communications.

[0004] BACKGROUND

[0005] In a Long Term Evolution (LTE) wireless system, the network configures the wireless transmit/receive unit (WTRU) with uplink (UL) and downlink (DL) resources on a single UL and single DL carrier, respectively. In order to utilize these resources, the WTRU is expected to be in sync with the network on these carriers. UL synchronization is initially achieved using random access channel (RACH) procedure and the WTRU is considered to be UL time aligned with the network. The WTRU has a configurable timer, timeAlignmentTimer (TAT), which is used to maintain timing alignment with the network.

[0006] Currently, the timing advance (TA) value used by the WTRU for UL time alignment is provided by the network in either the RACH response to the WTRU's RACH request message, or by using a TA command medium access control (MAC) control element (CE). The WTRU uses this TA value for UL time alignment. Because there is only one UL carrier assigned to the WTRU, the WTRU starts and restarts the TAT associated with this carrier.

[0007] Operation of a WTRU with multiple carriers in an LTE system, or carrier aggregation, is advantageous. The main objective of carrier aggregation is to increase the maximum throughput and peak data rate of a WTRU. Ideally, the WTRU would be allowed to operate with multiple UL and DL carriers in connected mode.

[0008] A WTRU configured to operate with multiple carriers in connected mode may consist of different UL carriers or a group of UL carriers sharing different TAs.

Accordingly, the WTRU needs to establish timing alignment with each of these carriers or group of carriers.

[0009] It is desirable to allow the WTRU and network to agree on which UL carriers should share the same TA and determine how the network communicates the TA values associated with these carriers or group of carriers to the WTRU. It is also desirable to determine what actions need to be taken when loss of synchronization occurs due to expiration of the TA timer for a group of UL carriers.

[0010] SUMMARY

[0011] A method and apparatus are disclosed for use in a WTRU for maintaining TA with multiple UL carriers wherein a group of carriers is defined. Additionally, a method is disclosed for allowing a WTRU and network to agree on which UL carriers should share the same TA and how the network communicates to the WTRU the TA values associated with specific carriers or groups of carriers. The disclosed method also addresses what actions need to be taken when loss of synchronization occurs due to expiration of the TA timer for a group of UL carriers.

[0012] BRIEF DESCRIPTION OF THE DRAWINGS

[0013] A more detailed understanding may be had from the following description, given by way of example in conjunction with the accompanying drawings wherein:

[0014] Figure 1 shows an LTE wireless communication system/access network; and

[0015] Figure 2 shows an example block diagram of an LTE wireless communication system including the WTRU, the evolved Node-B (eNB), and the Mobility Management Entity (MME)/Serving GateWay (S-GW).

[0016] DETAILED DESCRIPTION

[0017] When referred to hereafter, the terminology "WTRU" includes but is not limited to a user equipment (UE), a mobile station, a fixed or mobile subscriber unit, a pager, a cellular telephone, a personal digital assistant (PDA), a computer, or any other type of device capable of operating in a wireless environment. When referred to hereafter, the terminology "base station" includes but is not limited to a Node-B, a site controller, an access point (AP), or any other type of interfacing device capable of operating in a wireless environment.

[0018] Figure 1 shows an LTE wireless communication system/access network 200 that includes an Evolved-Universal Terrestrial Radio Access Network (E-UTRAN) 205. The E-UTRAN 205 includes a WTRU 210 and several eNBs 220. The WTRU 210 is in communication with an eNB 220. The eNBs 220 interface with each other using an X2 interface. Each of the eNBs 220 interface with a MME/S-GW 230 through an S1 interface. Although a single WTRU 210 and three eNBs 220 are shown in Figure 1, it should be apparent that any combination of wireless and wired devices may be included in the wireless communication system access network 200.

[0019] Figure 2 is an example block diagram of an LTE wireless communication system 300 including the WTRU 210, the eNB 220, and the MME/S-GW 230. As shown in Figure 2, the WTRU 210, the eNB 220 and the MME/S-GW 230 are configured to perform methods of maintaining time alignment with multiple uplink carriers.

[0020] In addition to the components that may be found in a typical WTRU, the WTRU 210 includes a processor 316 with an optional linked memory 322, at least one transceiver 314, an optional battery 320, and an antenna 318. The processor 316 is configured to perform a method of maintaining time alignment with multiple uplink carriers. The transceiver 314 is in communication with the processor 316 and the antenna 318 to facilitate the transmission and reception of wireless communications. In case a battery 320 is used in the WTRU 210, it powers the transceiver 314 and the processor 316.

[0021] In addition to the components that may be found in a typical eNB, the eNB 220 includes a processor 317 with an optional linked memory 315, transceivers 319, and antennas 321. The processor 317 is configured to perform a method of maintaining time alignment with multiple uplink carriers. The transceivers 319 are in communication with the processor 317 and antennas 321 to facilitate the transmission and reception of wireless communications. The eNB 220 is connected to the MME/S-GW 230 which includes a processor 333 with an optional linked memory 334.

[0022] A WTRU may be constrained by its implementation to operate with a single TA for a group of UL carriers which it is operating with at a given time. This is typical if these UL carriers are within the same frequency band and are transmitted using a common radio frequency (RF) module. A group of carriers operating with the same TA is referred to as a UL control carrier (CC) set.

[0023] The simplest way of defining UL CC sets that require minimum signaling is to determine that all UL carriers which are part of the same frequency band are part of the same UL CC set. Alternatively, UL carriers that are not part of the same frequency band are not part of the same UL CC set. Using this approach, both the WTRU and the network know in advance which UL carriers belong to the same UL CC set.

[0024] Alternatively, the definition of a UL CC set may depend on the WTRU capability. To allow the network to be aware of which UL carriers may be transmitted with different TAs, the WTRU includes this information as part of its E-UTRAN capabilities.

[0025] The possibility of being able to operate with multiple TAs is likely to be linked to the frequency bands that the WTRU is supporting. One possibility to transfer this information is to define the capability as a single information element (multipleTAsupport) with an encoding. Using encoding, codepoint 0 indicates the WTRU is not capable of supporting multiple TAs. Codepoint 1 indicates the WTRU is capable of operating with different TAs if UL carriers are not in the same band.

Codepoint 2 indicates the WTRU is fully capable of operating with different TAs for any pair of UL carriers. However, codepoint 2 may not exist if the use of different TAs within the same band is never supported.

[0026] The network may define sets of UL carriers that use the same TA (UL CC sets) and provide the information to the WTRU. The network may include UL carriers from different bands in the same UL CC set, even if the WTRU is capable of operating with different TAs for UL carriers in different bands.

[0027] One way of identifying UL carriers that use the same TA is to define a group index of a few bits for each UL CC set, which can possibly be a single bit if there is a maximum of two UL CC sets. The WTRU may obtain the group index of the UL CC set to which an UL carrier belongs when this UL carrier is being configured by the network (in the radio resource control (RRC) message). Alternatively, the group index may be broadcast in the system information of a paired DL carrier. A group index may also be associated to a frequency band, if the operation with multiple TAs within a band is not supported.

[0028] The WTRU may also obtain the DL carrier or set of DL carriers that should be used as a reference for the TA for each UL carrier or UL CC set. The DL carrier, which may be used as a reference for the TA, may also implicitly be the DL carrier from which the message containing the TA value is transmitted.

[0029] The following embodiments describe methods used by the WTRU to apply different TA values for different UL CC sets. Each UL CC set may operate with a separate TAT.

[0030] In one embodiment, initial timing alignment is achieved using RACH procedure and the TA value is provided by the network to the WTRU using the RACH response message.

[0031] In an UL CC set where all the carriers or a subset of carriers of the set are configured for RACH, the WTRU may select one of the carriers that may be used for RACH and trigger the random access (RA) procedure.

[0032] The TA command, which is received in the RA response message, is used to apply the TA value to each UL carrier of the UL CC set, and the WTRU starts or restarts the TAT associated with the UL CC set.

[0033] If only one carrier in the UL CC set is configured for RACH, the WTRU triggers RA procedure on this carrier, applies the TA value obtained in the corresponding RA response message to each UL carrier of the UL CC set, and starts or restarts the TAT associated with the UL CC set.

[0034] In another embodiment, the timing alignment is maintained by the WTRU based on the TA value received from the network either through an existing MAC CE or any other form of signaling described below.

[0035] The WTRU may determine which UL CC set the TA value applies to based on which DL carrier the command, which may be a TA command MAC CE, was transmitted from. For instance, the UL CC set, which the TA value applies, may be determined as the one to which the UL carrier paired to this DL carrier belongs. In case a UL CC set corresponds to a frequency band, the TA value applies to the UL CC set in the same band as the DL carrier from which the command is transmitted. Alternatively, the correspondence between a DL carrier and an UL CC set may be explicitly signaled.

[0036] The WTRU may determine which UL CC set the TA value applies to based on the group index which is explicitly provided in the command. For instance, the two spare bits of the existing TA command MAC CE may be used, or a new type of MAC CE, including the group index may be defined. When a TA command MAC CE is received, the WTRU identifies the UL CC set using the group index and starts or restarts the TAT for the corresponding UL CC set.

[0037] The network may use any other form of dedicated signaling to provide the WTRU with the TA value. The network shall embed the CC group index in this message to indicate which UL CC set is associated with this TA value.

[0038] In another embodiment, any of the following mechanisms may be used to re-establish UL timing alignment upon expiry of an UL CC set's TAT. The WTRU may follow the same procedure as initial TA establishment as described above. Re-acquiring the TA is done if and when necessary.

[0039] The WTRU may determine, based on the group index provided in dedicated signaling, which RACH resources to use to re-establish the corresponding UL CC set's TA. The WTRU may then repeat the RA procedure as described above.

[0040] The network may use the existing TA command MAC CE or any other form of dedicated signaling to provide the TA value previously used for the corresponding UL CC set. The network may use this mechanism within a reasonable amount of time after the expiry of the TAT. The reasonable amount of time may be determined by a newly defined timer. The WTRU may use this TA value to start or restart the corresponding TAT without the necessity to perform a RA procedure for this UL CC set.

[0041] Upon expiration of the TAT for a specific UL CC set, the following actions may be taken by the WTRU. All hybrid automatic repeat request (HARQ) buffers of the UL shared channel (UL-SCH) of each UL carrier part of the UL CC set are flushed. Any physical uplink control channel (PUCCH) or sounding reference signal (SRS) configuration on an UL carrier part of the UL CC set is released. Any UL grant applicable to an UL carrier part of the UL CC set is cleared. In addition, any DL assignment for which feedback would be provided by an UL carrier part of the UL set is cleared. The physical uplink shared channel (PUSCH) configuration on each UL carrier part of the UL CC set is released. Optionally, this does not apply to certain UL carriers, such as the UL carrier corresponding to the special cell. The PUSCH on each UL carrier part of the UL CC set is deactivated. Optionally, this does not apply to certain UL carriers, such as the UL carrier corresponding to the special cell. The PUSCH on these carriers may be reactivated upon subsequent reception of a TA command applicable to the UL CC set.

[0042] Suitable processors include, by way of example, a general purpose processor, a special purpose processor, a conventional processor, a digital signal processor (DSP), a plurality of microprocessors, one or more microprocessors in association with a DSP core, a controller, a microcontroller, Application Specific Integrated Circuits (ASICs), Application Specific Standard Products (ASSPs); Field Programmable Gate Arrays (FPGAs) circuits, any other type of integrated circuit (IC), and/or a state machine.

[0043] A processor in association with software may be used to implement a radio frequency transceiver for use in a WTRU, UE, terminal, base station, MME or Evolved Packet Core (EPC), or any host computer. The WTRU may be used in conjunction with modules, implemented in hardware and/or software including a Software Defined Radio (SDR), and other components such as a camera, a video camera module, a videophone, a speakerphone, a vibration device, a speaker, a microphone, a television transceiver, a hands free headset, a keyboard, a Bluetooth® module, a frequency modulated (FM) radio unit, a Near Field Communication (NFC) Module, a liquid crystal display (LCD) display unit, an organic light-emitting diode (OLED) display unit, a digital music player, a media player, a video game player module, an Internet browser, and/or any Wireless Local Area Network (WLAN) or Ultra Wide Band (UWB) module.

[0044] Although features and elements are described above in particular combinations, each feature or element may be used alone without the other features and elements or in various combinations with or without other features and elements. The methods or flow charts provided herein may be implemented in a computer program, software, or firmware incorporated in a computer-readable storage medium for execution by a general purpose computer or a processor. Examples of computer-readable storage mediums include a read only memory (ROM), a random access memory (RAM), a register, cache memory, semiconductor memory devices, magnetic

media such as internal hard disks and removable disks, magneto-optical media, and optical media such as CD-ROM disks, and digital versatile disks (DVDs).

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CLAIMS

What is claimed is:

1. A method for use in a wireless transmit/receive unit (WTRU), the method comprising:
maintaining time alignment (TA) with multiple uplink (UL) carriers.
2. The method of claim 1 wherein the WTRU may be constrained to operate with a single TA for a group of UL carriers which it is operating with at a given time.
3. The method as in any one of claims 1-2 wherein the group of carriers operating with the same TA is defined as a UL control carrier (CC) set.
4. The method as in any one of claims 1-3 wherein UL carriers, which are part of the same frequency band, are part of the same UL CC set.
5. The method as in any one of claims 1-3 wherein UL carriers, which are not part of the same frequency band, are not part of the same UL CC set.
6. The method as in any one of claims 1-5 wherein both the WTRU and network know in advance which UL carriers belong to the same UL CC set.
7. The method as in any one of claims 1-6 wherein a UL CC set may depend on the WTRU capability, further comprising:
allowing the network to be aware of which UL carriers may be transmitted with different TAs; and
including information regarding the UL carriers and TAs as part of its evolved universal terrestrial radio access network (E-UTRAN) capabilities.

8. The method as in any one of claims 1-7 wherein the ability to operate with multiple TAs is likely to be linked to the frequency bands which the WTRU is supporting.

9. The method as in any one of claims 1-8, further comprising:
transferring the information regarding the UL carriers and TAs by
defining the capability as a single information element with an encoding;
using multipleTAsupport as a single information element;
using codepoint 0 to indicate the WTRU is not capable of supporting
multiple TAs;
using codepoint 1 to indicate the WTRU is capable of operating with
different TAs if UL carriers are not in same band; and
using codepoint 2 to indicate the WTRU is fully capable of operating with
different TAs for any pair of UL carriers.

10. The method of claim 9 wherein codepoint 2 may not exist if the use of different TAs within the same band is never supported.

11. The method as in any one of claims 1-10 wherein the network may define sets of UL carriers that use the same TA, or UL CC sets, and provide the information to the WTRU.

12. The method as in any one of claims 1-11 wherein the network may include UL carriers from different bands in the same UL CC set even if the WTRU is capable of operating with different TAs for UL carriers in different bands.

13. The method as in any one of claims 1-12, further comprising:

identifying UL carriers that use the same TA to define a group index of a few bits for each UL CC set.

14. The method of claim 13 wherein a single bit may be used if there is a maximum of two UL CC sets.

15. The method of claim 13 wherein the WTRU may obtain the group index of the UL CC set to which an UL carrier belongs when this UL carrier is being configured by the network in the radio resource control (RRC) message.

16. The method of claim 13 wherein the group index may be broadcast in the system information of a paired downlink (DL) carrier.

17. The method of claim 13 wherein a group index may be associated to a frequency band, if the operation with multiple TAs within a band is not supported.

18. The method of claim 13 wherein the WTRU may also obtain the downlink (DL) carrier, or set of DL carriers, that may be used as a reference for the TA, for each UL carrier or UL CC set.

19. The method of claim 13 wherein the downlink (DL) carrier to be used as a reference for the TA is implicitly the DL carrier from which the message containing the TA value is transmitted.

20. The method as in any one of claims 1-19, further comprising:
applying different TA values for different UL CC sets; and
operating each UL CC set with a separate timeAlignmentTimer (TAT).

21. The method of claim 20 wherein initial timing alignment is achieved using random access channel (RACH) procedure and providing the TA value by the network to the WTRU using the RACH response message.

22. The method as in any one of claims 20-21 wherein in an UL CC set, in which all the carriers or a subset of carriers of the set are configured for RACH, the WTRU may select one of the carriers that may be used for RACH and trigger the random access (RA) procedure.

23. The method as in any one of claims 20-21 wherein the TA command received in the random access (RA) response message is used to apply the TA value to each UL carrier of the UL CC set, and the WTRU starts or restarts the TAT associated with the UL CC set.

24. The method as in any one of claims 20-23 wherein, if only one carrier in the UL CC set is configured for RACH, the WTRU:
triggers RA procedure on this carrier;
applies the TA value obtained in the corresponding RA response message to each UL carrier of the UL CC set; and
starts or restarts the TAT associated with the UL CC set.

25. The method as in any one of claims 1-24 wherein the timing alignment is maintained by the WTRU based on the TA value received from the network, either through an existing medium access control (MAC) control element (CE) or any other form of signaling.

26. The method of claim 25 wherein the WTRU may determine which UL CC set the TA value applies to based on which DL carrier the command was transmitted from.

27. The method as in any one of claims 25-26 wherein the command may be a TA command MAC CE.

28. The method as in any one of claims 25-27 wherein the UL CC set the TA value applies may be determined as the one to which the UL carrier paired to this DL carrier belongs.

29. The method as in any one of claims 25-28 wherein if a UL CC set corresponds to a frequency band, the TA value applies to the UL CC set in the same band as the DL carrier from which the command is transmitted.

30. The method as in any one of claims 25-29 wherein the correspondence between a DL carrier and an UL CC set may be explicitly signaled.

31. The method of claim 25 wherein the WTRU may determine which UL CC set the TA value applies to based on the group index being explicitly provided in the command.

32. The method of claim 31 wherein the two spare bits of the existing TA command MAC CE may be used, or a new type of MAC CE, including the group index may be defined.

33. The method of claim 31 wherein when a TA command MAC CE is received, the WTRU identifies the UL CC set using the group index and starts or restarts the TAT for the corresponding UL CC set.

34. The method of claim 25 wherein the network may use any form of dedicated signaling to provide the WTRU with the TA value.

35. The method of claim 34 wherein the network shall embed the CC group index in this message to indicate which UL CC set is associated with this TA value.

36. The method as in any one of claims 1-35, further comprising:
re-establishing UL timing alignment upon expiry of an UL CC set's TAT.

37. The method of claim 36 wherein the WTRU may follow the same procedure as initial TA establishment and re-acquiring the TA is done if and when necessary.

38. The method of claim 36 wherein the WTRU may determine which RACH resources to use to re-establish the corresponding UL CC set's TA based on the group index provided in dedicated signaling.

39. The method of claim 38 wherein the WTRU may then repeat the RA procedure.

40. The method of claim 36 wherein the network may use the existing TA command MAC CE, or any other form of dedicated signaling, to provide the TA value previously used for the corresponding UL CC set.

41. The method of claim 40 wherein the network may use this mechanism within a reasonable amount of time after the expiry of the TAT.

42. The method of claim 41 wherein a new timer may be defined for the reasonable amount of time.

43. The method of claim 41 wherein the WTRU may use this TA value to start or restart the corresponding TAT without performing an RA procedure for this UL CC set.

44. The method as in any one of claims 1-43 wherein upon expiration of the TAT for a specific UL CC set, the WTRU may:

flush all hybrid automatic repeat request (HARQ) buffers of the UL shared channel (UL-SCH) of each UL carrier part of the UL CC set;

release any physical uplink control channel (PUCCH) or sounding reference signal (SRS) configuration on an UL carrier part of the UL CC set;

clear any UL grant applicable to an UL carrier part of the UL CC set;

clear any DL assignment for which feedback would be provided by an UL carrier part of the UL set;

release the physical uplink shared channel (PUSCH) configuration on each UL carrier part of the UL CC set, although this does not apply to certain UL carriers, such as the UL carrier corresponding to the special cell; or

deactivate the PUSCH on each UL carrier part of the UL CC set, although this does not apply to certain UL carriers, such as the UL carrier corresponding to the special cell.

45. The method of claim 44 wherein the PUSCH on these carriers may be reactivated upon subsequent reception of a TA command applicable to the UL CC set.

46. A wireless transmit/receive unit (WTRU) for use in wireless communications, the WTRU configured to perform the method of any one of claims 1 - 45.

47. A base station for use in wireless communications, the base station configured to perform the method of any one of claims 1 - 45.

48. An integrated circuit configured to perform the method of any one of claims 1 - 45.

ABSTRACT

A method and apparatus are disclosed for use in a wireless transmit/receive unit (WTRU) for maintaining timing advance (TA) with multiple uplink (UL) carriers wherein a group of carriers is defined. Additionally, a method is disclosed for allowing a WTRU and network to agree on which UL carriers should share the same TA and how the network communicates to the WTRU the TA values associated with specific carriers or group of carriers. The disclosed method also addresses what actions need to be taken when loss of synchronization occurs due to expiration of the TA timer for a group of UL carriers.

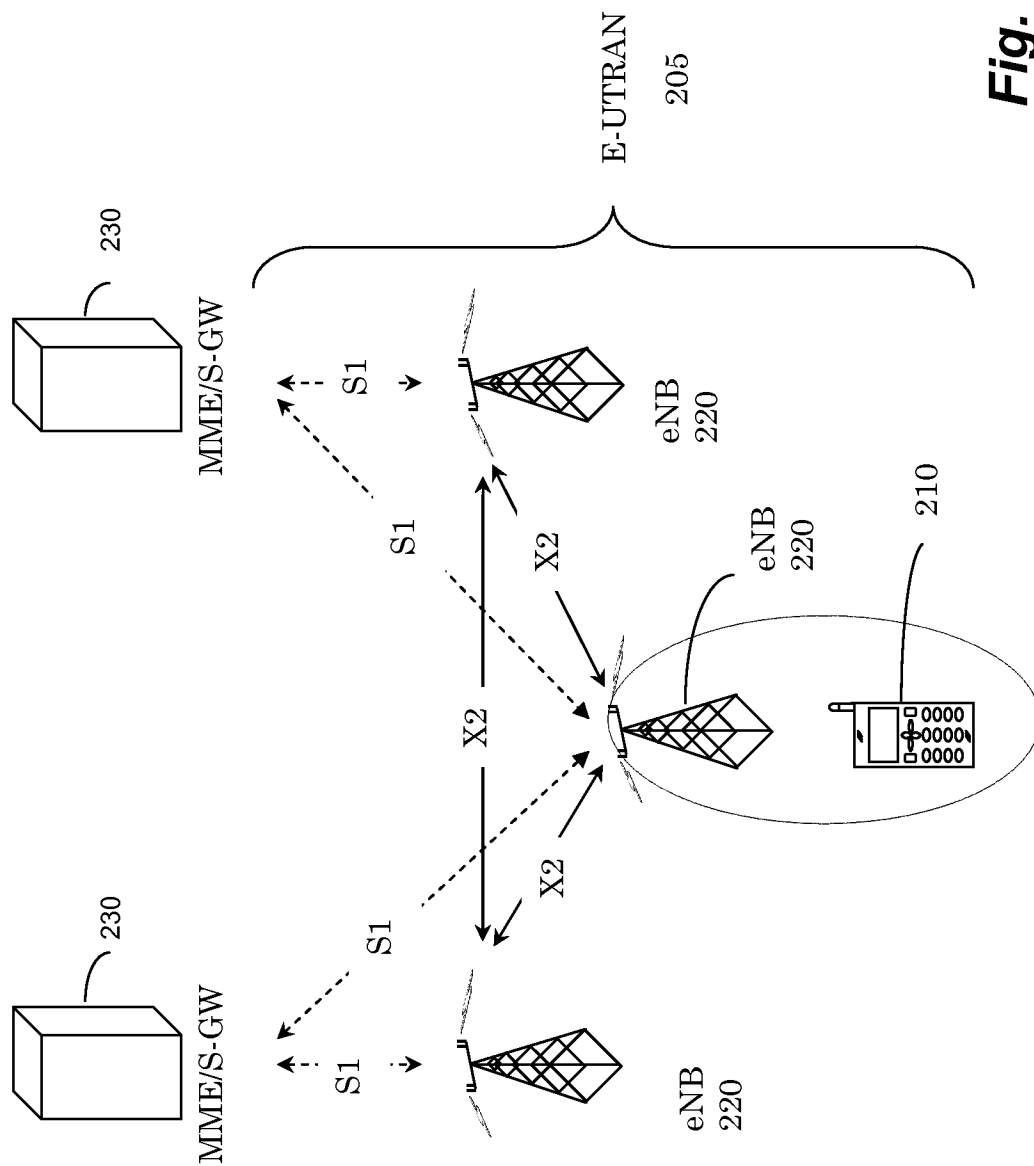


Fig. 1

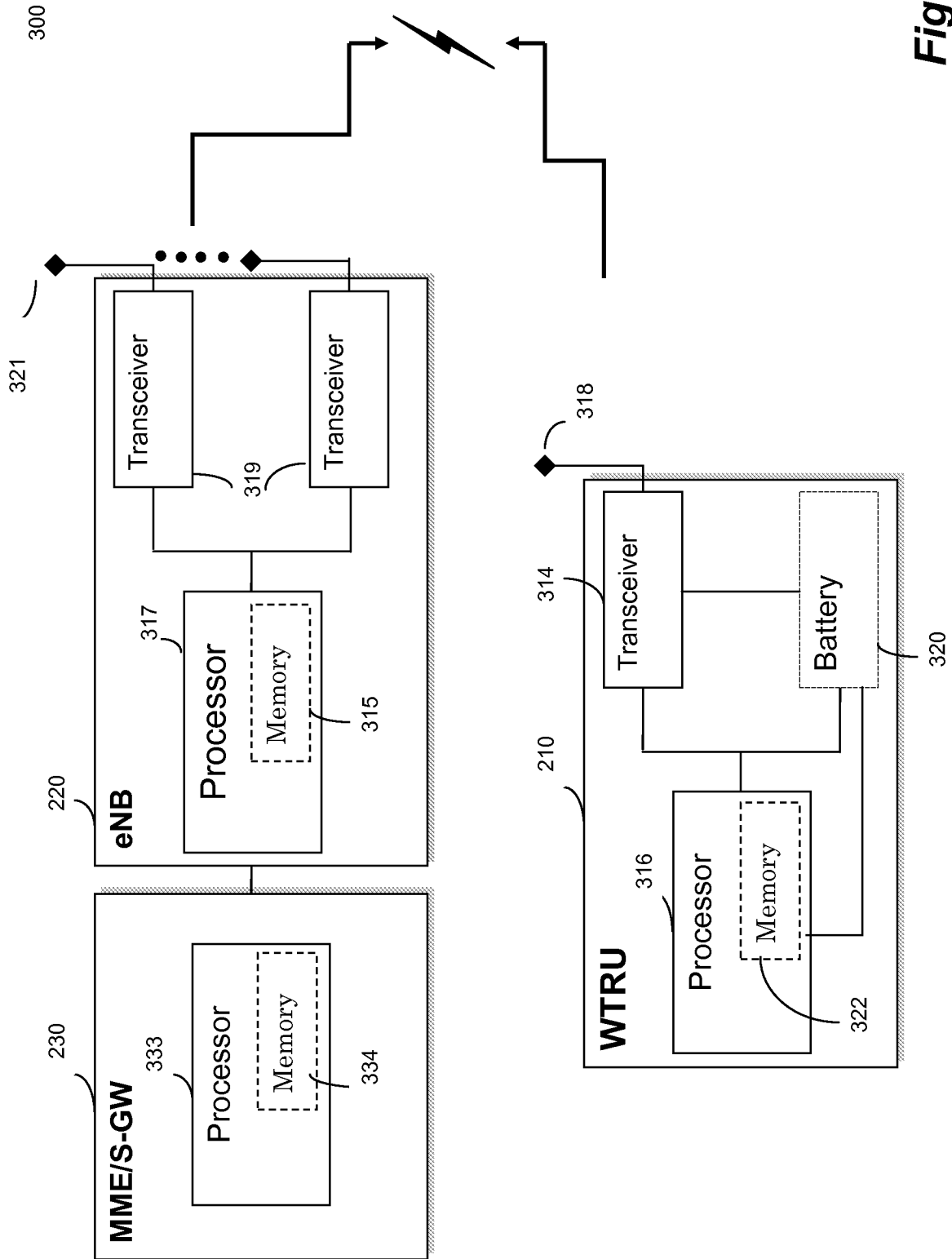


Fig. 2