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(71) Applicant: **SHENZHEN TCL NEW TECHNOLOGY CO., LTD.** [CN/CN]; 9th Floor, Building D4, TCL International E City No. 1001, Zhongshan Park Road, Xili Street, Nanshan District, Shenzhen, Guangdong 518052 (CN).

(72) Inventor: **LIU, Kai**; 9th Floor, Building D4, TCL International E City No. 1001, Zhongshan Park Road, Xili Street, Nanshan District, Shenzhen, Guangdong 518052 (CN).

(74) Agent: **PURPLEVINE INTELLECTUAL PROPERTY (SHENZHEN) CO., LTD.**; 2901, Block C, China Resources Land Building, Dachong Community, Yuehai Street, Nanshan District, Shenzhen, Guangdong 518052 (CN).

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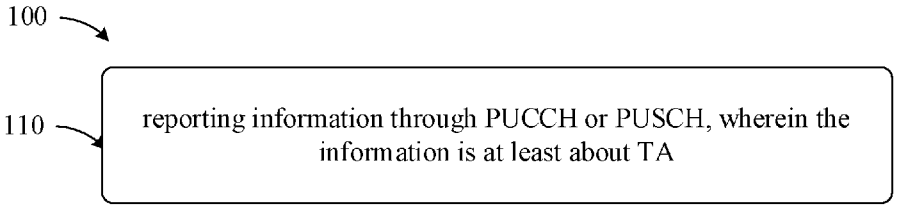

FIG. 7

(57) Abstract: A method of reporting timing information and a method of timing information indication in multiple transmission-reception point (multi-TRP) scenario and related devices are provided. The method of reporting timing information, performed by a user equipment (UE), including reporting information through physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH), wherein the information is at least about timing advance (TA). The report information can help TRPs to schedule UL transmission better to avoid UL transmission overlapping.

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METHOD OF REPORTING TIMING INFORMATION AND METHOD OF TIMING INFORMATION INDICATION IN MULTI-TRP SCENARIO AND RELATED DEVICES

TECHNICAL FIELD

The present application relates to wireless communication technologies, and more particularly, to a method of reporting timing information and a method of timing information indication in multiple transmission-reception point (multi-TRP) scenario and related devices such as a user equipment (UE) and a TRP.

BACKGROUND ART

Wireless communication systems, such as the third-generation (3G) of mobile telephone standards and technology are well known. Such 3G standards and technology have been developed by the Third Generation Partnership Project (3GPP). The 3rd generation of wireless communications has generally been developed to support macro-cell mobile phone communications. Communication systems and networks have developed towards being a broadband and mobile system. In cellular wireless communication systems, user equipment (UE) is connected by a wireless link to a radio access network (RAN). The RAN includes a set of base stations (BSs) which provide wireless links to the UEs located in cells covered by the base stations, and an interface to a core network (CN) which provides overall network control. The RAN and CN each conducts respective functions in relation to the overall network.

The 3GPP has developed the so-called Long-Term Evolution (LTE) system, namely, an Evolved Universal Mobile Telecommunication System Territorial Radio Access Network (E-UTRAN), for a mobile access network where one or more macro-cells are supported by base station knowns as an eNodeB or eNB (evolved NodeB). More recently, LTE is evolving further towards the so-called 5G or NR (new radio) systems where one or more cells are supported by base stations known as a next generation Node B called gNodeB (gNB).

The 5G New Radio (NR) standard will support a multitude of different services each with very different requirements. These services include Enhanced Mobile Broadband (eMBB) for high data rate transmission, Ultra-Reliable Low Latency Communication (URLLC) for devices requiring low latency and high link reliability and Massive Machine-Type Communication (mMTC) to support a large number of low-power devices for a long life-time requiring highly energy efficient communication.

Multiple-input multiple-output (MIMO) is an effective approach to enhance the capacity of a radio link due to the multiplexing of both transmit and receive antennas. MIMO refers to a practical technique for sending and receiving more than one data signal simultaneously over the same radio channel, which improves the performance of spectral efficiency greatly. Below a quick overview is given about what progress has been achieved to enable the use of multi-TRP transmission which is one of the key technology of MIMO in an efficient manner.

MIMO is one of the key technologies in NR systems and is successful in commercial deployment. In the communication system of MIMO, both UE and base station comprise of a large number of antenna elements. Especially for base station, these antenna elements can be distributed in different panels, as shown in FIG. 1. Each panel is placed at different position such that base station can communicate with UE better. Specifically, panels at different positions are named as multi-TRP in current spec. Both DL and UL channels can benefit from multi-TRP transmission by leveraging spatial diversity to improve the throughput and reliability of transmission in case of unpredictable blockage between a TRP and a UE, especially in FR2.

In multi-TRP scenario, UE can receive DL signals from different TRPs or transmit UL signals to different TRPs. However, as shown in FIG. 2, different distances from UE to different TRPs result in different reception times of UL

signals for different TRPs. In current spec, each UE maintains only one timing advance (TA) value in spite of multi-TRP. Maintaining only one TA value means that UE transmitting different UL signals to different TRPs is the same time in advance. UL signal transmission with the same time in advance may lower performance of UL signals due to lower orthogonality with other UL signals transmitted by another UE.

In Rel-18 WID, two TA values are introduced in multi-TRP scenario. Two TAs can let UE transmit different UL signals to different TRPs at different time in advance. Two TAs can make sure the performance of UL signals. However, two TAs also lead to some problems, such as UL transmission overlapping, UL resource multiplexing and so on.

Related arts:

In current spec, the time quantity of UL TA is calculated by $T_{TA} = (N_{TA} + N_{TA,offset})T_c$, where $N_{TA,offset}$ is provided by the higher parameter *n-TimingAdvanceOffset*, N_{TA} is indicated by the absolute or relative TAC (timing advance command) MAC CE indirectly, and $T_c = 0.509$ ns. The absolute TAC MAC CE indicates $T_A = 0,1,2,\ldots,3846$ and $N_{TA} = T_A \cdot 16 \cdot 64 / 2^{\mu}$ for SCS of $2^{\mu} \cdot 15$ kHz. The relative TAC MAC CE indicates adjustment of N_{TA_old} to N_{TA_new} by $T_A = 0,1,2,\ldots,63$ and $N_{TA\_new} = N_{TA\_old} + (T_A - 31) \cdot 16 \cdot 64 / 2^{\mu}$ for SCS of $2^{\mu} \cdot 15$ kHz. The TAC field is 12 bits or 6 bits in the absolute or relative TAC MAC CE.

In current spec, the duration time of a cyclic prefix for SCS of $2^{\mu} \cdot 15$ kHz can be calculated by $T_{CP} = N_{CP} \cdot T_C$ where the formula of N_{CP} is shown below.

$$N_{CP,l}^{\mu} = \begin{cases} 512\kappa \cdot 2^{-\mu} & extended\ cyclic\ prefix \\ 144\kappa \cdot 2^{-\mu} + 16\kappa & nomal\ cyclic\ prefix,\ \ l = 0\ or\ l = 7 \\ 144\kappa \cdot 2^{-\mu} & nomal\ cyclic\ prefix,\ \ l \neq 0\ and\ l \neq 7 \end{cases}$$

In 3rd Generation Partnership Project (3GPP) RAN1#109-e meeting, the related agreements are shown as follows.

Agreement

Enhancement on two TAs for UL multi-DCI for multi-TRP operation is supported in Rel-18.

Note 1: whether (1) the network signals two TACs or (2) the network signals one TAC and the UE deriving the second TA can be further studied.

Note 2: evaluations can be considered on as-needed basis.

Agreement

For multi-DCI multi-TRP operation with two TAs, study the following alternatives:

- Alt 1: two reference timings are considered
- Alt 2: one reference timing is considered

Note: reference timing above is the timing of the DL reception

Agreement

For multi-DCI multi-TRP operation with two TAs, study the following alternatives further in Rel-18:

- Alt 1: one *n-TimingAdvanceOffset* value per serving cell
- Alt 2: two *n-TimingAdvanceOffset* value per serving cell

In 3rd Generation Partnership Project (3GPP) RAN1#110-e meeting, the related agreements are shown as follows.

Agreement

For multi-DCI based multi-TRP operation with two TAs, study how to handle overlapping part between two UL transmissions associated with two TAs, where the study includes:

- whether to introduce scheduling restriction in overlapping part
- whether to introduce dropping rules

- whether specification impact is needed, or if the issue can be handled via implementation
- whether to allow overlapped transmission in case the UE supports STxMP transmission (if STxMP feature is agreed in NR Rel-18)

Agreement

For multi-DCI multi-TRP operation with two TAs, up to two n-TimingAdvanceOffset value per serving cell is supported

Some Tdocs present that time duration of the DL time offset is not larger than that of a cyclic prefix (CP).

SUMMARY

The objective of the present application is to provide a method of reporting timing information and a method of timing information indication in multi-TRP scenario and related devices for solving issues in the prior arts, scheduling UL transmission better, avoiding UL transmission overlapping, or providing a good communication performance.

In a first aspect, an embodiment of the present application provides a method of reporting timing information in multi-TRP scenario, performed by a user equipment (UE) in a network, the method including: reporting information through physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH), wherein the information is at least about timing advance (TA).

In a second aspect, an embodiment of the present application provides a method of timing information indication in multi-TRP scenario, performed by a TRP in a network, the method including: by transmitting a signaling to a user equipment (UE), informing the UE to report information at least about timing advance (TA).

In a third aspect, an embodiment of the present application provides a method of reporting timing information in multi-TRP scenario, performed by a user equipment (UE) in a network, the method including: reporting information through physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH), wherein the information is at least about a difference between two downlink (DL) reception timings corresponding to a first TRP and a second TRP.

In a fourth aspect, an embodiment of the present application provides a method of timing information indication in multi-TRP scenario, performed by a TRP in a network, the method including: by transmitting a signaling to a user equipment (UE), informing the UE to report information at least about a difference between two downlink (DL) reception timings corresponding to different TRPs.

In a fifth aspect, an embodiment of the present application provides a UE, including a processor and a transmitter, wherein the processor is configured to call and run program instructions stored in a memory, to cooperate with the transmitter to execute the method of any of the first aspect and the third aspect.

In a sixth aspect, an embodiment of the present application provides a TRP, including a processor and a transmitter, wherein the processor is configured to call and run program instructions stored in a memory, to cooperate with the transmitter to execute the method of any of the second aspect and the fourth aspect.

In a seventh aspect, an embodiment of the present application provides a computer readable storage medium provided for storing a computer program, which enables a computer to execute the method of any of the first to the fourth aspects.

In an eighth aspect, an embodiment of the present application provides a computer program product, which includes computer program instructions enabling a computer to execute the method of any of the first to the fourth aspects.

In a ninth aspect, an embodiment of the present application provides a computer program, when running on a computer, enabling the computer to execute the method of any of the first to the fourth aspects.

DESCRIPTION OF DRAWINGS

In order to more clearly illustrate the embodiments of the present application or related art, the following figures that will be described in the embodiments are briefly introduced. It is obvious that the drawings are merely some embodiments of the present application, a person having ordinary skill in this field can obtain other figures according to these figures without paying the premise.

FIG. 1 is a schematic diagram illustrating a multi-TRP scenario.

FIG. 2 is a schematic diagram illustrating distances from different TRPs in a multi-TRP scenario.

FIG. 3 is a schematic diagram illustrating a solution to avoid UL transmission overlapping in a multi-TRP scenario according to the present application.

FIG. 4 is a schematic diagram illustrating UL transmission overlapping that is not avoided even if the solution in FIG. 3 is applied.

FIG. 5 is a schematic diagram illustrating another solution to avoid UL transmission overlapping in a multi-TRP scenario according to the present application.

FIG. 6 is a schematic block diagram illustrating a communication network system according to an embodiment of the present application.

FIG. 7 is a flowchart of a method of reporting timing information in multi-TRP scenario according to a first embodiment of the present application.

FIG. 8 is a schematic diagram illustrating a first example of TA reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 9 is a schematic diagram illustrating a second example of TA reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 10 is a schematic diagram illustrating a third example of TA reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 11 is a schematic diagram illustrating a fourth example of TA reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 12 is a schematic diagram illustrating a first example of TA reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 13 is a schematic diagram illustrating a second example of TA reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 14 is a schematic diagram illustrating a third example of TA reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 15 is a schematic diagram illustrating a fourth example of TA reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 16 is a flowchart of a method of timing information indication in multi-TRP scenario according to a second embodiment of the present application.

FIG. 17 is a flowchart of a method of reporting timing information in multi-TRP scenario according to a third embodiment of the present application.

FIG. 18 is a schematic diagram illustrating a first example of DL reception timing reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 19 is a schematic diagram illustrating a second example of DL reception timing reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 20 is a schematic diagram illustrating a third example of DL reception timing reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 21 is a schematic diagram illustrating a fourth example of DL reception timing reporting in multi-TRP scenario according to an embodiment of the present application.

FIG. 22 is a schematic diagram illustrating a first example of DL reception timing reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 23 is a schematic diagram illustrating a second example of DL reception timing reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 24 is a schematic diagram illustrating a third example of DL reception timing reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 25 is a schematic diagram illustrating a fourth example of DL reception timing reporting in multi-TRP scenario (a) with a time difference less than processing time and (b) with a time difference greater than processing time according to an embodiment of the present application.

FIG. 26 is a flowchart of a method of timing information indication in multi-TRP scenario according to a fourth embodiment of the present application.

DETAILED DESCRIPTION OF EMBODIMENTS

Embodiments of the disclosure are described in detail with the technical matters, structural features, achieved objects, and effects with reference to the accompanying drawings as follows. Specifically, the terminologies in the embodiments of the present application are merely for describing the purpose of the certain embodiment, but not to limit the disclosure.

In 3GPP RAN1#110 meeting, some companies propose a method of scheduling constraints in time domain to avoid UL transmission overlapping. For example, as shown in FIG. 3, UL1 and UL2 are scheduled by network in two consecutive time units respectively. After a UE transmits UL1 with TA1, a UE starts to transmit UL2 with TA2. If TA2 is larger than TA1, the starting of UL2 transmission overlaps with the duration of UL1. The overlapping time can be calculated by the difference between the two TAs. However, for multi-TRP with a non-idea backhaul, one of TRPs only knows its own TA but cannot know the TA corresponding to the other TRP. Nevertheless, a UE can know both two TAs corresponding to different TRPs. In the present application, a UE reports the TA corresponding to a TRP to the other TRP such that TRPs can calculate the overlapping time and schedule UL resources properly to avoid this. For example, as shown in FIG. 3, if a UE reports TA2 to TRP1, after TRP1 calculates $\Delta t_{\text{overlapping}}$ and schedules UL1 $\Delta t_{\text{overlapping}}$ early, UL1 do not overlap with UL2.

On the other hand, for multi-TRP with a non-idea synchronization, the additional error will be introduced for DL Tx, because the DL timing offset may be unfortunately compensated along with propagation delay. The additional error may also result in UL transmission overlapping even if the above-mentioned proper scheduling is adopted. For example, as shown in FIG. 4, the time in TRP2 is $\Delta t_{\text{DL,TRP}}$ earlier than TRP1. This earlier time $\Delta t_{\text{DL,TRP}}$ results in

overlapping between UL1 and UL2. The overlapping time is $\Delta t_{DL,TRP}$. If TRP2 knows the time, TRP2 can adjust the DL timing to avoid overlapping. However, for multi-TRP with a non-idea backhaul, one of TRPs only knows its own DL timing but cannot know the DL timing corresponding to the other TRP.

In 3GPP RAN1#109-e meeting, some companies present the DL timing offset can be calculated by the difference between two TAs and the difference between two DL reception timings, as shown in FIG. 5. The two DL reception timings from two TRPs can be measured by UE. However, for multi-TRP with a non-idea backhaul, one of TRPs only knows its own TA and DL timing but cannot know the TA and the DL reception timing corresponding to the other TRP. Nevertheless, a UE can know both two TAs and DL reception timings corresponding to different TRPs. In the present application, a UE reports the TA and the DL reception timing corresponding to a TRP to the other TRP such that TRPs can calculate the DL timing offset and schedule DL resources properly to avoid UL transmission overlapping. For example, as shown in FIG. 5, if a UE reports TA2 and $\Delta t_{DL,UE}$ to TRP1, after TRP1 calculates $\Delta t_{DL,TRP}$ and schedules DL1 $\Delta t_{DL,TRP}$ later, UL1 does not overlap with UL2.

The main idea of this disclosure is to provide some solutions to reporting information about a TA and a DL reception timing. A UE can report the information to different TRPs through PUCCH or PUSCH. A TRP can transmit a command to indicate UE to report the information. The report timing should consider the treating information time and preparing UL signal time. The report information can help TRPs to schedule UL transmission better to avoid UL transmission overlapping.

FIG. 6 illustrates that, in some embodiments, one or more user equipments (UEs) 10, a first transmission/reception point (TRP) 20 and a second TRP 30 for wireless communication in a communication network system according to an embodiment of the present application are provided. The communication network system includes the one or more UEs 10, the first TRP 20 and the second TRP 30. The one or more UEs 10 may include a memory 12, a transceiver 13, and a processor 11 coupled to the memory 12 and the transceiver 13. The first TRP 20 may include a memory 22, a transceiver 23, and a processor 21 coupled to the memory 22 and the transceiver 23. The second TRP 30 may include a memory 32, a transceiver 33, and a processor 31 coupled to the memory 32 and the transceiver 33. The processor 11 or 21 or 31 may be configured to implement proposed functions, procedures and/or methods described in this description. Layers of radio interface protocol may be implemented in the processor 11 or 21 or 31. The memory 12 or 22 or 32 is operatively coupled with the processor 11 or 21 or 31 and stores a variety of information to operate the processor 11 or 21 or 31. The transceiver 13 or 23 or 33 is operatively coupled with the processor 11 or 21 or 31, and the transceiver 13 or 23 or 33 transmits and/or receives a radio signal.

The processor 11 or 21 or 31 may include application-specific integrated circuit (ASIC), other chipset, logic circuit and/or data processing device. The memory 12 or 22 or 32 may include read-only memory (ROM), random access memory (RAM), flash memory, memory card, storage medium and/or other storage device. The transceiver 13 or 23 or 33 may include baseband circuitry to process radio frequency signals. When the embodiments are implemented in software, the techniques described herein can be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. The modules can be stored in the memory 12 or 22 or 32 and executed by the processor 11 or 21 or 31. The memory 12 or 22 or 32 can be implemented within the processor 11 or 21 or 31 or external to the processor 11 or 21 or 31 in which case those can be communicatively coupled to the processor 11 or 21 or 31 via various means as is known in the art.

FIG. 7 is a flowchart of a method of reporting timing information in multi-TRP scenario according to a first embodiment of the present application. Rreferring to FIG. 7 in conjunction with FIG. 6, the method 100 includes the following. In Step 110, the UE reports information to a TRP through physical uplink control channel (PUCCH) or

physical uplink shared channel (PUSCH), wherein the information is at least about timing advance (TA). The TRP receives this information and schedule UL transmission based on this information. For instance, the information is at least about the TA corresponds to a TRP, and the information is reported to the other TRP. With this method, the timing information (i.e., the TA) is reported to TRP(s) by the UE. The report information can help TRPs to schedule UL transmission better to avoid UL transmission overlapping.

In some embodiments, in the case of reporting the information through PUCCH, the reporting step includes: reporting the information by using PUCCH resources, wherein the PUCCH resources are periodic. Further, the reporting step may include: reporting an old one of the information before the time the UE receives a timing advance command (TAC) or the information is updated; and reporting a new one of the information after the time the UE receives the TAC or the information is updated.

In some embodiments, the reporting step includes: reporting the information when the information is updated. In the case of reporting the information through PUCCH, the reporting step includes: reporting the information at a time point, which is a nearest time after the UE receives a TAC or the information is updated, and at the time point there is a PUCCH resource. In the case of reporting the information through PUSCH, the reporting step includes: reporting the information by using a PUSCH scheduled after a scheduling request (SR). Further, the reporting step may include: transmitting the SR at a time point, which is a nearest time after the time the UE receives a TAC or the information is updated, and at the time point there is a PUCCH; monitoring an uplink grant or scheduling after transmitting the SR; and reporting the information carried on the PUSCH indicated by the uplink grant. Further, the reporting step may include: reporting the information at a time point after the UE receives a TAC or the information is updated, and at the time point there is a PUSCH resource.

In some embodiments, the reporting step includes: if a time difference between a TAC updating the information and a UL signal for carrying or scheduling the information is larger than total time of treating the TAC and preparing the UL signal, reporting the information through the UL signal. Further, if the time difference between the TAC updating the information and the UL signal for carrying or scheduling the information is less than the total time of treating the TAC and preparing the UL signal, the information is not reported through the UL signal. In some embodiments, an absolute TA is reported by the UE, or a difference between two absolute TAs corresponding to different TRPs is reported by the UE, or a relative TA is reported by the UE.

In an embodiment, a report about a TA is proposed. A UE can report information about a TA corresponding to a TRP to the other TRP through PUCCH or PUSCH.

In a possible implementation, a UE reports a TA corresponding to a TRP to the other TRP periodically through PUCCH. As shown in FIG. 8, a UE is configured specific periodic PUCCH resources for reporting TA. At time t_{offset1}, $t_{\text{offset1}}+T_1$, $t_{\text{offset1}}+2T_1$, …, a UE reports TA2 to TRP1 periodically. At time t_{offset2}, $t_{\text{offset2}}+T_2$, $t_{\text{offset2}}+2T_2$, …, a UE reports TA1 to TRP2 periodically. At time t_{TAC1}, a UE receives TAC1, which updates TA1. Before time t_{TAC1} (e.g., t_{offset2}, $t_{\text{offset2}}+T_2$), a UE reports old TA1 to TRP2. After time t_{TAC1} (e.g., $t_{\text{offset2}}+2T_2$), a UE reports new TA1 to TRP2. At time t_{TAC2}, a UE receives TAC2, which updates TA2. Before time t_{TAC2} (e.g., t_{offset1}), a UE reports old TA2 to TRP1. After time t_{TAC2} (e.g., $t_{\text{offset1}}+T_1$, $t_{\text{offset1}}+2T_1$), a UE reports new TA2 to TRP1.

In a possible implementation, a UE reports a TA corresponding to a TRP to the other TRP through PUCCH when the TA is updated. As shown in FIG. 9, a UE is configured specific periodic PUCCH resources for reporting TA. At time t_{TAC1}, a UE receives TAC1 which updates TA1. Then the UE reports TA1 to TRP2 at time $t_{\text{offset2}}+2T_2$, which is the nearest time after t_{TAC1} and at which there is a PUCCH resource related to TRP2. While at time t_{offset2} and $t_{\text{offset2}}+T_2$, there are PUCCH resources, which can be utilized to transmit TA1, but TA1 is not updated, so a UE does not report

TA1 to TRP2. At time t_{TAC2}, a UE receives TAC2, which updates TA2. Then a UE reports TA2 to TRP1 at time $t_{offset1}+T_1$, which is the nearest time after t_{TAC2} and at which there is a PUCCH resource related to TRP1. While at time $t_{offset1}$ and $t_{offset1}+2T_1$, there are PUCCH resources, which can be utilized to transmit TA2, but TA2 is not updated, so a UE does not report TA2 to TRP1. This mechanism can save UL resources.

In a possible implementation, a UE reports a TA corresponding to a TRP to the other TRP through PUSCH. As shown in FIG. 10, a UE is configured specific SR resources for requesting UL resources to report a TA. At time t_{TAC1}, a UE receives TAC1 which updates TA1. The UE transmits SR2 to TRP2 for requesting PUSCH resources at the time $t_{offset2}+2T_2$ which is the nearest time after t_{TAC1} and at which there is a PUCCH resource related to TRP2. After the UE receives UL grant 2, the UE reports TA1 to TRP2 carried by PUSCH. At time t_{TAC2}, a UE receives TAC2 which updates TA2. The UE transmits SR1 to TRP1 for requesting PUSCH resources at the time $t_{offset1}+T_1$ which is the nearest time after t_{TAC2} and at which there is a PUCCH resource related to TRP1. After the UE receives UL grant 1, the UE reports TA2 to TRP1 carried by PUSCH.

In a possible implementation, a UE reports a TA corresponding to a TRP to the other TRP through PUSCH. As shown in FIG. 11, at time t_{TAC1}, a UE receives TAC1 which updates TA1. If there is PUSCH resource transmitted to TRP2 at time $t_{offset2}$ which is after time t_{TAC1}, the UE reports TA1 to TRP2 carried by PUSCH. At time t_{TAC2}, a UE receives TAC2 which updates TA2. If there is PUSCH resource transmitted to TRP1 at time $t_{offset1}$ which is after time t_{TAC2}, the UE reports TA2 to TRP1 carried by PUSCH.

In an embodiment, the restriction of report time for information about a TA is proposed. If time difference between a TAC updating a TA and a UL signal for carrying or scheduling the TA is larger than the total time of treating this TAC and preparing this UL signal, a UE reports information about the TA corresponding to a TRP to the other TRP through this UL signal. The time of treating a TAC and preparing a UL signal can be pre-defined or dependent on UE capability.

In a possible implementation, if time difference between a TAC updates a TA and a PUCCH carrying the TA is less than the total time of treating this TAC and preparing this PUCCH, a UE reports an old TA corresponding to a TRP to the other TRP through this PUCCH. For example, as shown in FIG. 12(a), if Δt_1 is less than the total time of treating TAC2 and preparing PUCCH, a UE reports old TA2 to TRP1 through PUCCH at time $t_{offset1}+T_1$ in spite of TA2 updated by TAC2. However, the UE can report new TA2 at time $t_{offset1}+2T_1$ if time difference between TAC2 and the next PUCCH is larger than the total time of treating TAC and preparing PUCCH. If time difference between a TAC updating a TA and a PUCCH carrying the TA is larger than the total time of treating TAC and preparing PUCCH, a UE reports a new TA corresponding to a TRP to the other TRP through this PUCCH. For example, as shown in FIG. 12(b), if Δt_1 is larger than the total time of treating TAC2 and preparing PUCCH, a UE reports new TA2 to TRP1 through PUCCH at time $t_{offset1}+T_1$.

In a possible implementation, if time difference between a TAC updating a TA and a PUCCH is less than the total time of treating this TAC and preparing this PUCCH, a UE does not report a TA corresponding to a TRP to the other TRP. For example, as shown in FIG. 13(a), if Δt_1 is less than the total time of treating TAC2 and preparing PUCCH, a UE does not report TA2 to TRP1 at time $t_{offset1}+T_1$ in spite of TA2 updated by TAC2. However, the UE can report TA2 at time $t_{offset1}+2T_1$ if time difference between TAC2 and the next PUCCH is larger than the total time of treating TAC and preparing PUCCH. If time difference between a TAC updating a TA and a PUCCH is larger than the total time of treating this TAC and preparing this PUCCH, a UE reports a TA corresponding to a TRP to the other TRP through this PUCCH. For example, as shown in FIG. 13(b), if Δt_1 is larger than the total time of treating TAC2 and preparing PUCCH, a UE reports TA2 to TRP1 at time $t_{offset1}+T_1$ through PUCCH.

In a possible implementation, if time difference between a TAC updating a TA and a PUCCH for carrying a PUSCH SR is less than the total time of treating this TAC and preparing this PUCCH, a UE does not transmit SR and does not report a TA. For example, as shown in FIG. 14(a), if Δt_1 is less than the total time of treating TAC2 and preparing PUCCH, a UE does not transmit SR1 to TRP1 at time $t_{offset1}+T_1$ in spite of TA2 updated by TAC2. However, the UE can transmit SR1 at time $t_{offset1}+2T_1$ if time difference between TAC2 and the next PUCCH is larger than the total time of treating TAC and preparing PUCCH. If time difference between TAC updating a TA and PUCCH for carrying a PUSCH SR is larger than the total time of treating this TAC and preparing this PUCCH, a UE transmits SR through this PUCCH. For example, as shown in FIG. 14(b), if Δt_1 is larger than the total time of treating TAC2 and preparing PUCCH, a UE transmits SR1 to TRP1 through PUCCH at time $t_{offset1}+T_1$. After the UE receives UL grant 1, the UE reports TA2 to TRP1 carried by PUSCH.

In a possible implementation, if time difference between a TAC updating a TA and a PUSCH is less than the total time of treating this TAC and preparing this PUSCH, a UE transmits PUSCH but does not report a TA. For example, as shown in FIG. 15(a), if Δt_1 is less than the total time of treating TAC2 and preparing PUSCH, a UE transmits PUSCH but does not report TA2 at time $t_{offset1}$ in spite of TA2 updated by TAC2. However, the UE can report TA2 at time $t_{offset2}$ if time difference between TAC2 and the next PUSCH is larger than the total time of treating TAC and preparing PUSCH. If time difference between TAC updating a TA and PUSCH for carrying the TA is larger than the total time of treating this TAC and preparing this PUSCH, a UE reports TA2 through this PUSCH. For example, as shown in FIG. 15(b), if Δt_1 is larger than the total time of treating TAC2 and preparing PUSCH, a UE reports TA2 to TRP1 through PUSCH at time $t_{offset1}$.

FIG. 16 is a flowchart of a method of timing information indication in multi-TRP scenario according to a second embodiment of the present application. Rreferring to FIG. 16 in conjunction with FIG. 6, the method 200 includes the following. In Step 210, by transmitting a signaling to a user equipment (UE), a TRP informs the UE to report information at least about timing advance (TA). That is, upon reception of the signaling from the TRP, the UE reports the information. For instance, the information is at least about the TA corresponding to the other TRP. The signaling is used to inform the UE to report the information to the TRP. This facilitates the reporting of timing information (i.e., the TA). With this method, the report information can help TRPs to schedule UL transmission better to avoid UL transmission overlapping.

In some embodiments, the method further includes: flushing a timer in the TRP when the TRP receives the information from the UE; and performing the informing step when the timer expires.

In some embodiments, a field in a downlink (DL) downlink control information (DCI) is used to inform whether the UE reports the information through physical uplink control channel (PUCCH). Further, the information is multiplexing with hybrid automatic repeat request-acknowledgement (HARQ-ACK) information. In some embodiments, a field in a DCI is used to inform whether the UE reports the information through physical uplink shared channel (PUSCH). Further, the information is multiplexing with UL data. In some embodiments, a field in a DL/UL DCI is used, in which one or more bits in the field are used to inform whether the UE reports the information and one ore more bits in the field are used to indicate a PUCCH resource.

In some embodiments, a special DL DCI is used to inform whether the UE reports the information, and wherein the special DL DCI does not schedule PDSCH such that the UE does not feed back HARQ-ACK in PUCCH indicated by the special DL DCI. In some embodiments, a special UL DCI is used to inform whether the UE reports the information, and the information is reported through PUSCH whose frequency resource allocation and time resource allocation is indicated by the special UL DCI. In some embodiments, a medium access control (MAC) control element

(CE) is used to inform the UE to report the information. Further, the MAC CE includes a field with at least one of time offset information or PUCCH resource information.

In some embodiments, the TRP receives an absolute TA reported by the UE, or the TRP receives a difference between two absolute TAs corresponding to different TRPs reported by the UE, or the TRP receives a relative TA reported by the UE.

In an embodiment, a timer related to TA at TRP side is proposed. A TRP maintains a timer related to TA which corresponds to the other TRP and is reported by a UE. When a TRP receives TA corresponding to the other TRP, the TRP flushes the timer immediately. When the timer is overtime, the TRP transmits a command to UE to indicate UE to report TA corresponding to the other TRP.

In a possible implementation, a new field (X bits) is appended in a DL DCI (e.g., DCI format 1_1, DCI format 1_2) as a command to indicate whether a UE reports a TA through PUCCH. For example, assuming X = 1, if the timer in the first TRP is overtime, the first TRP transmits a DL DCI to a UE where the command is '1'. When a UE receives a DL DCI from the first TRP where the command is '1', the UE reports a TA corresponding to the second TRP to the first TRP through PUCCH which is indicated by the PUCCH resource indicator field in the DL DCI. In this PUCCH, the TA is multiplexing with HARQ-ACK information which is an acknowledgement to PDSCH scheduling by the DL DCI. When a UE receives a DL DCI from the first TRP where the command is '0', the UE does not report a TA.

In a possible implementation, a new field (X bits) is appended in a UL DCI (e.g., DCI format 0_1, DCI format 0_2) as a command to indicate whether a UE reports a TA through PUSCH. For example, assuming X = 1, if the timer in the first TRP is overtime, the first TRP transmits a UL DCI to a UE where the command is '1'. When a UE receives a UL DCI from the first TRP where the command is '1', the UE reports a TA corresponding to the second TRP to the first TRP through PUSCH whose frequency resource allocation and time resource allocation is indicated by the UL DCI. In this PUSCH, the TA is multiplexing with UL data. When a UE receives a UL DCI from the first TRP where the command is '0', the UE does not report a TA.

In a possible implementation, a new field (X bits) is appended in a DL/UL DCI as a command where the former X_1 bits is used to indicate whether a UE reports a TA and the latter (X-X_1) bits is used to indicate which PUCCH resource for TA reporting. For example, assuming X = 4 and X_1 = 1, if the timer in the first TRP is overtime, the first TRP transmits a DL/UL DCI to a UE where the command is '1000'. When a UE receives a DL/UL DCI from the first TRP where the command is '1000', the UE reports a TA corresponding to the second TRP to the first TRP through the first PUCCH resource. The PUCCH is located at the Nth time units after UE receives DL/UL DCI. The N can be predefined or dependent on the UE capability. When a UE receives a DL/UL DCI from the first TRP where the command is '0000', the UE does not report a TA.

In a possible implementation, a special DL DCI serves as a command used to indicate whether a UE reports a TA through PUCCH. In this special DL DCI, the HRAQ process number field, the redundancy version field, the modulation and coding scheme field, and/or the frequency domain resource assignment field are set to be all '0's, all '0's, all '1's, and/or all'0's, respectively. Meanwhile, this specific DL DCI is scrambled by specific RNTI. This special DL DCI does not schedule PDSCH such that a UE does not feedback HARQ-ACK in the PUCCH indicated by this DL DCI. For example, if the timer in the first TRP is overtime, the first TRP transmits this special DL DCI to a UE. When a UE receives the special DL DCI from the first TRP, the UE reports a TA corresponding to the second TRP to the first TRP through PUCCH, which is indicated by the PUCCH resource indicator field in the DL DCI. This PUCCH only carries TA.

In a possible implementation, a special UL DCI serves as a command used to indicate whether a UE reports a TA through PUSCH. In this special UL DCI, the HRAQ process number field, the redundancy version field, and/or the modulation and coding scheme field are set to be all '0's, all '0's, and/or all '1's, respectively. Meanwhile, this specific UL DCI is scrambled by specific RNTI. For example, if the timer in the first TRP is overtime, the first TRP transmits this special UL DCI to a UE. When a UE receives the special UL DCI from the first TRP, the UE reports a TA corresponding to the second TRP to the first TRP through PUSCH whose frequency resource allocation and time resource allocation is indicated by this special UL DCI. This PUSCH only carries TA information.

In a possible implementation, a MAC CE as a command to indicate whether a UE reports a TA through PUCCH. In this MAC CE, there is/are a time offset indicator field and/or a PUCCH resource indicator field. The time offset indicator field indicates when a UE can report a TA. The PUCCH resource indicator field indicates which resource can be used for reporting TA. Meanwhile, network allocates a new LCID for this MAC CE.

In an embodiment, the content of report information about TA is proposed.

In a possible implementation, a UE reports an absolute TA corresponding to a TRP to the other TRP. If the absolute TA1 maintained by a UE is N_{TA1}, the UE reports M_{TA} to TRP2 according to $M_{TA1} = N_{TA} / 16 / 64 \cdot 2^{\mu}$ for SCS of $2^{\mu} \cdot 15$ kHz. TRP2 obtains the absolute TA1 according to $N_{TA1} = M_{TA} \cdot 16 \cdot 64 / 2^{\mu}$. If the report is carried by PUCCH, 12 bits is proposed to bear $M_{TA1} = 0,1,2,\ldots,4095$. If the report is carried PUSCH, a MAC CE at least with the M_{TA} field is proposed.

In a possible implementation, a UE reports the difference of two absolute TAs corresponding to two TRPs to a TRP. If the absolute TA1 and absolute TA2 maintained by a UE are N_{TA1} and N_{TA2}, the UE reports M_{TA} to TRP2 according to $M_{TA} = (N_{TA1} - N_{TA2}) / 16 / 64 \cdot 2^{\mu}$ for SCS of $2^{\mu} \cdot 15$ kHz. TRP2 obtains the absolute TA1 according to $N_{TA1} = N_{TA2} + M_{TA} \cdot 16 \cdot 64 / 2^{\mu}$ for SCS of $2^{\mu} \cdot 15$ kHz. To bear $M_{TA} = 0,1,2,\ldots,4095$, 12 bits is needed. If the report is carried by PUCCH, 12 bits is proposed to bear $M_{TA} = 0,1,2,\ldots,4095$. If the report is carried PUSCH, a MAC CE at least with the M_{TA} field is proposed.

In a possible implementation, a UE reports a relative TA corresponding to a TRP to the other TRP. When a UE receives a relative TAC1 carrying $T_{A,1}$ from TRP1, the UE directly reports $M_{TA} = T_{A,1}$ to TRP2. TRP2 obtains the new absolute TA1 according to $N_{TA1\_new} = N_{TA1\_old} + (T_{A,1} - 31) \cdot 16 \cdot 64 / 2^{\mu}$ for SCS of $2^{\mu} \cdot 15$ kHz where N_{TA1_old} is the old absolute TA1 maintained by TRP2. To bear $M_{TA} = 0,1,2,\ldots,63$, 6 bits is needed. If the report is carried by PUCCH, 6 bits is proposed to bear $M_{TA} = 0,1,2,\ldots,63$. If the report is carried PUSCH, a MAC CE at least with the M_{TA1} field is proposed.

FIG. 17 is a flowchart of a method of reporting timing information in multi-TRP scenario according to a third embodiment of the present application. Rreferring to FIG. 17 in conjunction with FIG. 6, the method 300 includes the following. In Step 310, the UE reports information through physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH), wherein the information is at least about a difference between two downlink (DL) reception timings corresponding to a first TRP and a second TRP. TRP(s) (e.g., the first TRP and/or the second TRP) receives this information and schedule UL transmission based on this information. With this method, the timing information (i.e., the difference between the two DL reception timings) corresponding to two TRPs is reported by the UE. The report information can help TRPs to schedule UL transmission better to avoid UL transmission overlapping.

In some embodiments, in the case of reporting the information through PUCCH, the reporting step includes: reporting the information by using configured PUCCH resources related to the first TRP; or reporting the information by using configured PUCCH resources related to the second TRP. In some embodiments, the reporting step includes:

reporting an old one of the information before the information has a change; and reporting a new one of the information after the information has a change.

In some embodiments, the reporting step includes: reporting the information when the information has a change. In the case of reporting the information through PUCCH, the reporting step includes: reporting the information at a time point, which is a nearest time after the information has a change, and at the time point there is a PUCCH resource. In the case of reporting the information through PUSCH, the reporting step includes: reporting the information by using a PUSCH scheduled after a scheduling request (SR). Further, the reporting step may include: transmitting the SR at a time point, which is a nearest time after the time the information has a change, and at the time point there is a PUCCH; monitoring an uplink grant or scheduling after transmitting the SR; and reporting the information carried on the PUSCH indicated by the uplink grant. Further, the reporting step may include: reporting the information after the time the information has a change, and after the time there is a PUSCH resource avaliable for the reporting.

In some embodiments, the reporting step includes: if a time difference between the time the information has a change and a UL signal for carrying or scheduling the information is larger than total time of preparing the UL signal, reporting the information through the UL signal. Further, if the time difference between the time the information has a change and the UL signal for carrying or scheduling the information is less than the total time of preparing the UL signal, the information is not reported through the UL signal. In some embodiments, the information reported by the UE adopts granularity of timing advance (TA).

In an embodiment, a report about the difference between two DL reception timings ($\Delta t_{DL,UE}$) is proposed. A UE can report information about $\Delta t_{DL,UE}$ through PUCCH or PUSCH.

In a possible implementation, a UE reports $\Delta t_{DL,UE}$ periodically through PUCCH. As shown in FIG. 18, a UE is configured specific periodic PUCCH resources for reporting $\Delta t_{DL,UE}$. At time $t_{offset1}$, $t_{offset1}+T_1$, $t_{offset1}+2T_1$, …, a UE reports $\Delta t_{DL,UE}$ to TRP1 periodically. At time $t_{offset2}$, $t_{offset2}+T_2$, $t_{offset2}+2T_2$, …, a UE reports $\Delta t_{DL,UE}$ to TRP2 periodically. At time t_{DL1}, a UE realizes that $\Delta t_{DL,UE}$ has a change by measuring DL signals/channels from different TRPs. Before time t_{DL1} (e.g., $t_{offset1}$ or $t_{offset2}$), a UE reports old $\Delta t_{DL,UE}$ to TRP1 or TRP2, respectively. After time t_{DL1} (e.g., $t_{offset1}+T_1$, $t_{offset1}+2T_1$ or $t_{offset2}+T_2$, $t_{offset2}+2T_2$), a UE reports new $\Delta t_{DL,UE}$ to TRP1 or TRP2, respectively.

In a possible implementation, a UE reports $\Delta t_{DL,UE}$ through PUCCH only when $\Delta t_{DL,UE}$ is changed. As shown in FIG. 19, a UE is configured specific periodic PUCCH resources for reporting $\Delta t_{DL,UE}$. At time t_{DL1}, a UE realizes that $\Delta t_{DL,UE}$ has a change by measuring DL signals/channels from different TRPs. Then the UE reports $\Delta t_{DL,UE}$ to TRP1 or TRP2 at time $t_{offset1}+T_1$ or $t_{offset2}+T_2$ which are the nearest time after t_{DL1} and at which there is a PUCCH resource related to TRP1 or TRP2, respectively. While at time $t_{offset1}+2T_1$ or $t_{offset2}+2T_2$, there are PUCCH resources which can be utilized to transmit $\Delta t_{DL,UE}$, but $\Delta t_{DL,UE}$ is not changed, so a UE does not report $\Delta t_{DL,UE}$ to TRP1 or TRP2, respectively. This mechanism can save UL resources.

In a possible implementation, a UE reports $\Delta t_{DL,UE}$ through PUSCH. As shown in FIG. 20, a UE is configured specific SR resources for requesting UL resources to report $\Delta t_{DL,UE}$. At time t_{DL1}, a UE realize that $\Delta t_{DL,UE}$ have a change by measuring DL signals/channels from different TRPs. The UE transmits SR1 or SR2 to TRP1 or TRP2 for requesting PUSCH resources at the time $t_{offset1}+T_1$ or $t_{offset2}+T_2$ which is the nearest time after t_{DL1} and at which there is a PUCCH resource related to TRP1 or TRP2, respectively. After the UE receives UL grant 1 or UL grant 2, the UE reports $\Delta t_{DL,UE}$ to TRP1 or TRP2 carried by PUSCH, respectively.

In a possible implementation, a UE reports $\Delta t_{DL,UE}$ through PUSCH. As shown in FIG. 21, at time t_{DL1}, a UE realizes that $\Delta t_{DL,UE}$ has a change by measuring DL signals/channels from different TRPs. If there is PUSCH resource transmitted to TRP2 at time $t_{offset2}$ which is after time t_{DL1}, the UE reports $\Delta t_{DL,UE}$ to TRP2 carried by PUSCH. If there

is PUSCH resource transmitted to TRP1 at time $t_{offset1}$ which is after time t_{DL1}, the UE reports $\Delta t_{DL,UE}$ to TRP1 carried by PUSCH.

In an embodiment, the restriction of report time for information about a DL reception timing is proposed. If time difference between $\Delta t_{DL,UE}$ change and a UL signal for carrying or scheduling $\Delta t_{DL,UE}$ is larger than the total time of preparing this UL signal, a UE reports $\Delta t_{DL,UE}$ to TRPs, respectively. The time of preparing a UL signal can be pre-defined or dependent on UE capability.

In a possible implementation, if time difference between $\Delta t_{DL,UE}$ change and a PUCCH carrying $\Delta t_{DL,UE}$ is less than the time of preparing this PUCCH, a UE reports old $\Delta t_{DL,UE}$ through this PUCCH to TRPs. For example, as shown in FIG. 22(a), if Δt_1 is less than the time of preparing PUCCH, a UE reports old $\Delta t_{DL,UE}$ to TRP1 through this PUCCH at time $t_{offset1}+T_1$ in spite of $\Delta t_{DL,UE}$ change. However, the UE can report new $\Delta t_{DL,UE}$ at time $t_{offset1}+2T_1$ if time difference between Δt_1 and the next PUCCH is larger than the time of preparing PUCCH. If time difference between $\Delta t_{DL,UE}$ change and a PUCCH carrying $\Delta t_{DL,UE}$ is larger than the time of preparing this PUCCH, a UE reports a new $\Delta t_{DL,UE}$ to two TRPs. For example, as shown in FIG. 22(b), if Δt_1 is larger than the time of preparing PUCCH, a UE reports new $\Delta t_{DL,UE}$ to TRP1 through this PUCCH at time $t_{offset1}+T_1$.

In a possible implementation, if time difference between $\Delta t_{DL,UE}$ change and a PUCCH is less than the time of preparing PUCCH, a UE does not report $\Delta t_{DL,UE}$ to TRPs. For example, as shown in FIG. 23(a), if Δt_1 is less than the time of preparing PUCCH, a UE does not report $\Delta t_{DL,UE}$ to TRP1 at time $t_{offset1}+T_1$ in spite of $\Delta t_{DL,UE}$ change. However, the UE can report $\Delta t_{DL,UE}$ at time $t_{offset1}+2T_1$ if time difference between $\Delta t_{DL,UE}$ change and the next PUCCH is larger than the time of preparing PUCCH. If time difference between $\Delta t_{DL,UE}$ change and a PUCCH is larger than the time of preparing this PUCCH, a UE reports $\Delta t_{DL,UE}$ to TRPs through this PUCCH. For example, as shown in FIG. 23(b), if Δt_1 is larger than the time of preparing this PUCCH, a UE reports $\Delta t_{DL,UE}$ to TRP1 at time $t_{offset1}+T_1$ through this PUCCH.

In a possible implementation, if time difference between $\Delta t_{DL,UE}$ change and a PUCCH for carrying a PUSCH SR is less than the time of preparing this PUCCH, a UE does not transmit SR and does not report $\Delta t_{DL,UE}$. For example, as shown in FIG. 24(a), if Δt_1 is less than the total time of preparing PUCCH, a UE does not transmit SR1 to TRP1 at time $t_{offset1}+T_1$ in spite of $\Delta t_{DL,UE}$ change. However, the UE can transmit SR1 to TRP1 at time $t_{offset1}+2T_1$ if time difference between $\Delta t_{DL,UE}$ change and the next PUCCH is larger than the total time of treating TAC and preparing PUCCH. If time difference between $\Delta t_{DL,UE}$ change and a PUCCH for carrying a PUSCH SR is larger than the time of preparing this PUCCH, a UE transmits SR through this PUCCH. For example, as shown in FIG. 24(b), if Δt_1 is larger than the time of preparing PUCCH, a UE transmits SR1 to TRP1 through PUCCH at time $t_{offset1}+T_1$. After the UE receives UL grant 1, the UE reports $\Delta t_{DL,UE}$ to TRP1 carried by PUSCH.

In a possible implementation, if time difference between $\Delta t_{DL,UE}$ change and a PUSCH is less than the time of preparing this PUSCH, a UE transmits PUSCH but does not report $\Delta t_{DL,UE}$. For example, as shown in FIG. 25(a), if Δt_1 is less than the total time of preparing PUSCH, a UE transmits PUSCH to TRP1 and does not report $\Delta t_{DL,UE}$ at time $t_{offset1}$ in spite of $\Delta t_{DL,UE}$ change. However, the UE can report $\Delta t_{DL,UE}$ to TRP1 at time $t_{offset2}$ if time difference between $\Delta t_{DL,UE}$ change and the next PUSCH is larger than the total time of treating TAC and preparing PUSCH. If time difference between $\Delta t_{DL,UE}$ change and a PUSCH is larger than the time of preparing this PUSCH, a UE reports $\Delta t_{DL,UE}$ through this PUSCH. For example, as shown in FIG. 25(b), if Δt_1 is larger than the time of preparing PUSCH, a UE reports $\Delta t_{DL,UE}$ through PUSCH at time $t_{offset1}$.

FIG. 26 is a flowchart of a method of timing information indication in multi-TRP scenario according to a fourth embodiment of the present application. Rreferring to FIG. 26 in conjunction with FIG. 6, the method 400 includes the

following. In Step 410, by transmitting a signaling to a user equipment (UE), a TRP informs the UE to report information at least about a difference between two downlink (DL) reception timings corresponding to different TRPs. That is, upon reception of the signaling from the TRP, the UE reports the information. The signaling is used to inform the UE to report the information to the TRP. This facilitates the reporting of timing information (i.e., the difference between the two DL reception timings). With this method, the report information can help TRPs to schedule UL transmission better to avoid UL transmission overlapping.

In some embodiments, the method further includes: flushing a timer in the TRP when the TRP receives the information from the UE; and performing the informing step when the timer expires.

In some embodiments, a field in a DL downlink control information (DCI) is used to inform whether the UE reports the information through physical uplink control channel (PUCCH). Further, the information is multiplexing with hybrid automatic repeat request-acknowledgement (HARQ-ACK) information. In some embodiments, a field in an uplink (UL) DCI is used to inform whether the UE reports the information through physical uplink shared channel (PUSCH). Further, the information is multiplexing with UL data. In some embodiments, a field in a DL/UL DCI is used, in which one ore more bits in the field are used to inform whether the UE reports the information and one ore more bits in the field are used to indicate which PUCCH resource is used for the reporting.

In some embodiments, a special DL DCI is used to inform whether the UE reports the information, and wherein the special DL DCI does not schedule PDSCH such that the UE does not feed back HARQ-ACK in PUCCH indicated by the special DL DCI. In some embodiments, a special UL DCI is used to inform whether the UE reports the information, and the information is reported through PUSCH whose frequency resource allocation and time resource allocation is indicated by the special UL DCI. In some embodiments, a medium access control (MAC) control element (CE) is used to inform the UE to report the information. Further, the MAC CE includes a field with at least one of a time offset indicator field or a PUCCH resource indicator field.

In some embodiments, the TRP receives the information that adopts granularity of timing advance (TA).

In an embodiment, a timer related to the difference between two DL reception timings ($\Delta t_{DL,UE}$) at TRP side is proposed. A TRP maintains a timer related to $\Delta t_{DL,UE}$ which is reported by a UE. When a TRP receives $\Delta t_{DL,UE}$, the TRP flushes the timer immediately. When the timer is overtime, the TRP transmits a command to UE to indicate UE to report $\Delta t_{DL,UE}$.

In a possible implementation, a new field (X bits) is appended in a DL DCI (e.g., DCI format 1_1, DCI format 1_2) as a command to indicate whether a UE reports $\Delta t_{DL,UE}$ through PUCCH. For example, assuming X = 1, if the timer in the first TRP is overtime, the first TRP transmits a DL DCI to a UE where the command is '1'. When a UE receives a DL DCI from the first TRP where the command is '1', the UE reports $\Delta t_{DL,UE}$ to the first TRP through PUCCH which is indicated by the PUCCH resource indicator field in the DL DCI. In this PUCCH, $\Delta t_{DL,UE}$ is multiplexing with HARQ-ACK information which is an acknowledgement to PDSCH scheduling by the DL DCI. When a UE receives a DL DCI from the first TRP where the command is '0', the UE does not report $\Delta t_{DL,UE}$.

In a possible implementation, a new field (X bits) is appended in a UL DCI (e.g., DCI format 0_1, DCI format 0_2) as a command to indicate whether a UE reports $\Delta t_{DL,UE}$ through PUSCH. For example, assuming X = 1, if the timer in the first TRP is overtime, the first TRP transmits a UL DCI to a UE where the command is '1'. When a UE receives a UL DCI from the first TRP where the command is '1', the UE reports $\Delta t_{DL,UE}$ to the first TRP through PUSCH whose frequency resource allocation and time resource allocation is indicated by the UL DCI. In this PUSCH, $\Delta t_{DL,UE}$ is multiplexing with UL data. When a UE receives a UL DCI from the first TRP where the command is '0', the UE does not report $\Delta t_{DL,UE}$.

In a possible implementation, a new field (X bits) is appended in a DL/UL DCI as a command where the former X_1 bits is used to indicate whether a UE reports a TA and the latter (X-X_1) bits is used to indicate which PUCCH resource for $\Delta t_{DL,UE}$ reporting. For example, assuming X = 4 and X_1 = 1, if the timer in the first TRP is overtime, the first TRP transmits a DL/UL DCI to a UE where the command is '1000'. When a UE receives a DL/UL DCI from the first TRP where the command is '1000', the UE reports $\Delta t_{DL,UE}$ to the first TRP through the first PUCCH resource. The PUCCH is located at the Nth time units after UE receives DL/UL DCI. The N can be predefined or dependent on the UE capability. When a UE receives a DL/UL DCI from the first TRP where the command is '0000', the UE does not report $\Delta t_{DL,UE}$.

In a possible implementation, a special DL DCI as a command is used to indicate whether a UE reports a TA through PUCCH. In this special DL DCI, the HRAQ process number field, the redundancy version field, the modulation and coding scheme field, and/or the frequency domain resource assignment field are set to be all '0's, all '0's, all '1's, and/or all'0's, respectively. Meanwhile, this specific DL DCI is scrambled by specific RNTI. This special DL DCI does not schedule PDSCH such that a UE does not feedback HARQ-ACK in the PUCCH indicated by this DL DCI. For example, if the timer in the first TRP is overtime, the first TRP transmits this special DL DCI to a UE. When a UE receives the special DL DCI from the first TRP, the UE reports a TA corresponding to the second TRP to the first TRP through PUCCH, which is indicated by the PUCCH resource indicator field in the DL DCI. This PUCCH only carries TA information.

In a possible implementation, a special UL DCI as a command is used to indicate whether a UE reports $\Delta t_{DL,UE}$ through PUSCH. In this special UL DCI, the HRAQ process number field, the redundancy version field, and/or the modulation and coding scheme field are set to be all '0's, all '0's, and/or all '1's, respectively. Meanwhile, this specific UL DCI is scrambled by specific RNTI. For example, if the timer in the first TRP is overtime, the first TRP transmits this special UL DCI to a UE. When a UE receives the special UL DCI from the first TRP, the UE reports $\Delta t_{DL,UE}$ to the first TRP through PUSCH whose frequency resource allocation and time resource allocation is indicated by this special UL DCI. This PUSCH only carries $\Delta t_{DL,UE}$.

In a possible implementation, a MAC CE as a command to indicate whether a UE reports $\Delta t_{DL,UE}$ through PUCCH. In this MAC CE, there is/are a time offset indicator field and/or a PUCCH resource indicator field. The time offset indicator field indicates when a UE can report $\Delta t_{DL,UE}$. The PUCCH resource indicator field indicates which resource can be used for reporting $\Delta t_{DL,UE}$. Meanwhile, network allocates a new LCID for this MAC CE.

In an embodiment, an estimation method of report granularity and quantization parameter of the difference between two DL reception timings is proposed. The report granularity can adopt the granularity of TA. The quantization parameter can be determined by a DL timing offset and two TAs.

In current spec, the method of TA adjustment is to adjust the quantization parameter M_{TA} according to $T_{TA} = M_{TA} \cdot 16 \cdot 64 / 2^{\mu} \cdot T_c$ for SCS of $2^{\mu} \cdot 15$ kHz. Therefore, the granularity of the TA adjustment is $16 \cdot 64 / 2^{\mu} \cdot T_c$. To align with TA, the difference between two DL reception timings corresponding to different TRPs ($\Delta t_{DL,UE}$) should also adopt this granularity. According to the formula in FIG. 5, $\Delta t_{DL,UE}$ can be calculated by a DL timing offset and two TAs, where DL timing offset is not larger than the duration time of a CP (T_{CP}). The quantization parameter M_{CP} of a CP can be calculated by $M_{CP} = T_{CP} / 16 / 64 \cdot 2^{\mu} / T_c$, whose values for SCS of $2^{\mu} \cdot 15$ kHz are shown in Table 1. Therefore, the quantization parameter $M_{DL,UE}$ of $\Delta t_{DL,UE}$ can be ($M_{TA} / 2 + M_{CP}$).

Table 1. The quantization parameters of a cyclic prefix.

Numerology (μ)	SCS (kHz)	M_{CP} of Normal CP (long)	M_{CP} of Normal CP (short)	M_{CP} of Extend CP

0	15	9	10	-
1	30	9	11	-
2	60	9	13	32
3	120	9	17	-
4	240	9	25	-

A UE can obtain $\Delta t_{DL,UE}$ by measuring DL signals/channels corresponding to different TRPs. Then, the UE calculates $M_{DL,UE}$ according to the formula $M_{DL,UE} = \Delta t_{DL,UE} / 16 / 64 \cdot 2^{\mu} / T_c$, and reports $M_{DL,UE}$ to TRPs. When TRPs receive $M_{DL,UE}$, TRPs obtain $\Delta t_{DL,UE}$ according to the formula $\Delta t_{DL,UE} = M_{DL,UE} \cdot 16 \cdot 64 / 2^{\mu} \cdot T_c$. If the report is carried by PUCCH, 11 bits is proposed to bear $M_{DL,UE} = 0,1,2,\ldots,2048$. If the report is carried by PUSCH, a MAC CE at least with the $M_{DL,UE}$ field is proposed.

Commercial interests for some embodiments are as follows. 1. Solving issues in the prior art. 2. Scheduling UL transmission better. 3. Avoiding UL transmission overlapping. 4. Providing a good communication performance. Some embodiments of the present application are used by 5G-NR chipset vendors, V2X communication system development vendors, automakers including cars, trains, trucks, buses, bicycles, moto-bikes, helmets, and etc., drones (unmanned aerial vehicles), smartphone makers, communication devices for public safety use, AR/VR device maker for example gaming, conference/seminar, education purposes. Some embodiments of the present application are a combination of “techniques/processes” that can be adopted in 3GPP specification to create an end product. Some embodiments of the present application could be adopted in the 5G NR unlicensed band communications. Some embodiments of the present application propose technical mechanisms.

The embodiment of the present application further provides a computer readable storage medium for storing a computer program. The computer readable storage medium enables a computer to execute corresponding processes implemented by the UE/base station (BS)/TRP in each of the methods of the embodiment of the present application. For brevity, details will not be described herein again.

The embodiment of the present application further provides a computer program product including computer program instructions. The computer program product enables a computer to execute corresponding processes implemented by the UE/BS/TRP in each of the methods of the embodiment of the present application. For brevity, details will not be described herein again.

The embodiment of the present application further provides a computer program. The computer program enables a computer to execute corresponding processes implemented by the UE/BS/TRP in each of the methods of the embodiment of the present application. For brevity, details will not be described herein again.

A person of ordinary skill in the art may be aware that, in combination with the examples described in the embodiments disclosed in this specification, units and algorithm steps may be implemented by electronic hardware or a combination of computer software and electronic hardware. Whether the functions are performed by hardware or software depends on particular applications and design constraint conditions of the technical solutions. A person skilled in the art may use different approaches to implement the described functions for each particular application, but it should not be considered that the implementation goes beyond the scope of the present application.

While the present application has been described in connection with what is considered the most practical and preferred embodiments, it is understood that the present application is not limited to the disclosed embodiments but is intended to cover various arrangements made without departing from the scope of the broadest interpretation of the appended claims.

CLAIMS

1. A method of reporting timing information in multiple transmission-reception point (multi-TRP) scenario, performed by a user equipment (UE) in a network, the method comprising:

reporting information through physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH), wherein the information is at least about timing advance (TA).

2. The method of claim 1, wherein in the reporting step, the information is at least about the TA corresponds to a TRP, and the information is reported to the other TRP.

3. The method of claim 1, wherein in the case of reporting the information through PUCCH, the reporting step comprises:

reporting the information by using PUCCH resources, wherein the PUCCH resources are periodic.

4. The method of claim 3, wherein the reporting step comprises:

reporting an old one of the information before the time the UE receives a timing advance command (TAC) or the information is updated; and

reporting a new one of the information after the time the UE receives the TAC or the information is updated.

5. The method of claim 1, wherein the reporting step comprises:

reporting the information when the information is updated.

6. The method of claim 5, wherein in the case of reporting the information through PUCCH, the reporting step comprises:

reporting the information at a time point, which is a nearest time after the UE receives a TAC or the information is updated, and at the time point there is a PUCCH resource.

7. The method of claim 5, wherein in the case of reporting the information through PUSCH, the reporting step comprises:

reporting the information by using a PUSCH scheduled after a scheduling request (SR).

8. The method of claim 7, wherein the reporting step comprises:

transmitting the SR at a time point, which is a nearest time after the time the UE receives a TAC or the information is updated, and at the time point there is a PUCCH;

monitoring an uplink grant or scheduling after transmitting the SR; and

reporting the information carried on the PUSCH indicated by the uplink grant.

9. The method of claim 5, wherein the reporting step comprises:

reporting the information at a time point after the UE receives a TAC or the information is updated, and at the time point there is a PUSCH resource.

10. The method of any of claims 1 to 9, wherein the reporting step comprises:

if a time difference between a TAC updating the information and a UL signal for carrying or scheduling the information is larger than total time of treating the TAC and preparing the UL signal, reporting the information through the UL signal.

11. The method of claim 10, wherein if the time difference between the TAC updating the information and the UL signal for carrying or scheduling the information is less than the total time of treating the TAC and preparing the UL signal, the information is not reported through the UL signal.

12. The method of claim 1, wherein an absolute TA is reported by the UE, or a difference between two absolute TAs corresponding to different TRPs is reported by the UE, or a relative TA is reported by the UE.

13. A method of timing information indication in multiple transmission-reception point (multi-TRP) scenario,

performed by a TRP in a network, the method comprising:

by transmitting a signaling to a user equipment (UE), informing the UE to report information at least about timing advance (TA).

14. The method of claim 13, wherein the signaling is used to inform the UE to report the information to the TRP, and wherein the information is at least about the TA corresponding to the other TRP.

15. The method of claim 13, further comprising:

flushing a timer in the TRP when the TRP receives the information from the UE; and

performing the informing step when the timer expires.

16. The method of claim 13, wherein a field in a downlink (DL) downlink control information (DCI) is used to inform whether the UE reports the information through physical uplink control channel (PUCCH).

17. The method of claim 16, wherein the information is multiplexing with hybrid automatic repeat request-acknowledgement (HARQ-ACK) information.

18. The method of claim 13, wherein a field in a DCI is used to inform whether the UE reports the information through physical uplink shared channel (PUSCH).

19. The method of claim 18, wherein the information is multiplexing with UL data.

20. The method of claim 13, wherein a field in a DL/UL DCI is used, in which one ore more bits in the field are used to inform whether the UE reports the information and one ore more bits in the field are used to indicate a PUCCH resource.

21. The method of claim 13, wherein a special DL DCI is used to inform whether the UE reports the information, and wherein the special DL DCI does not schedule PDSCH such that the UE does not feed back HARQ-ACK in PUCCH indicated by the special DL DCI.

22. The method of claim 13, wherein a special UL DCI is used to inform whether the UE reports the information, and the information is reported through PUSCH whose frequency resource allocation and time resource allocation is indicated by the special UL DCI.

23. The method of claim 13, wherein a medium access control (MAC) control element (CE) is used to inform the UE to report the information.

24. The method of claim 23, wherein the MAC CE comprises a field with at least one of time offset information or PUCCH resource information.

25. The method of claim 13, wherein the TRP receives an absolute TA reported by the UE, or the TRP receives a difference between two absolute TAs corresponding to different TRPs reported by the UE, or the TRP receives a relative TA reported by the UE.

26. A method of reporting timing information in multiple transmission-reception point (multi-TRP) scenario, performed by a user equipment (UE) in a network, the method comprising:

reporting information through physical uplink control channel (PUCCH) or physical uplink shared channel (PUSCH), wherein the information is at least about a difference between two downlink (DL) reception timings corresponding to a first TRP and a second TRP.

27. The method of claim 26, wherein in the case of reporting the information through PUCCH, the reporting step comprises:

reporting the information by using configured PUCCH resources related to the first TRP; or

reporting the information by using configured PUCCH resources related to the second TRP.

28. The method of claim 26, wherein the reporting step comprises:

reporting an old one of the information before the information has a change; and

reporting a new one of the information after the information has a change.

29. The method of claim 26, wherein the reporting step comprises:

reporting the information when the information has a change.

30. The method of claim 29, wherein in the case of reporting the information through PUCCH, the reporting step comprises:

reporting the information at a time point, which is a nearest time after the information has a change, and at the time point there is a PUCCH resource.

31. The method of claim 29, wherein in the case of reporting the information through PUSCH, the reporting step comprises:

reporting the information by using a PUSCH scheduled after a scheduling request (SR).

32. The method of claim 31, wherein the reporting step comprises:

transmitting the SR at a time point, which is a nearest time after the time the information has a change, and at the time point there is a PUCCH;

monitoring an uplink grant or scheduling after transmitting the SR; and

reporting the information carried on the PUSCH indicated by the uplink grant.

33. The method of claim 29, wherein the reporting step comprises:

reporting the information after the time the information has a change, and after the time there is a PUSCH resource avaliable for the reporting.

34. The method of any of claims 26 to 33, wherein the reporting step comprises:

if a time difference between the time the information has a change and a UL signal for carrying or scheduling the information is larger than total time of preparing the UL signal, reporting the information through the UL signal.

35. The method of claim 34, wherein if the time difference between the time the information has a change and the UL signal for carrying or scheduling the information is less than the total time of preparing the UL signal, the information is not reported through the UL signal.

36. The method of claim 26, wherein the information reported by the UE adopts granularity of timing advance (TA).

37. A method of timing information indication in multiple transmission-reception point (multi-TRP) scenario, performed by a TRP in a network, the method comprising:

by transmitting a signaling to a user equipment (UE), informing the UE to report information at least about a difference between two downlink (DL) reception timings corresponding to different TRPs.

38. The method of claim 37, wherein the signling is used to inform the UE to report the information to the TRP.

39. The method of claim 37, further comprising:

flushing a timer in the TRP when the TRP receives the information from the UE; and

performing the informing step when the timer expires.

40. The method of claim 37, wherein a field in a DL downlink control information (DCI) is used to inform whether the UE reports the information through physical uplink control channel (PUCCH).

41. The method of claim 40, wherein the information is multiplexing with hybrid automatic repeat request-acknowledgement (HARQ-ACK) information.

42. The method of claim 37, wherein a field in an uplink (UL) DCI is used to inform whether the UE reports the information through physical uplink shared channel (PUSCH).

43. The method of claim 42, wherein the information is multiplexing with UL data.

44. The method of claim 37, wherein a field in a DL/UL DCI is used, in which one ore more bits in the field are used to inform whether the UE reports the information and one ore more bits in the field are used to indicate which PUCCH resource is used for the reporting.

45. The method of claim 37, wherein a special DL DCI is used to inform whether the UE reports the information, and wherein the special DL DCI does not schedule PDSCH such that the UE does not feed back HARQ-ACK in PUCCH indicated by the special DL DCI.

46. The method of claim 37, wherein a special UL DCI is used to inform whether the UE reports the information, and the information is reported through PUSCH whose frequency resource allocation and time resource allocation is indicated by the special UL DCI.

47. The method of claim 37, wherein a medium access control (MAC) control element (CE) is used to inform the UE to report the information.

48. The method of claim 47, wherein the MAC CE comprises a field with at least one of a time offset indicator field or a PUCCH resource indicator field.

49. The method of claim 37, wherein the TRP receives the information that adopts granularity of timing advance (TA).

50. A user equipment (UE), comprising a processor and a transmitter, wherein the processor is configured to call and run program instructions stored in a memory, to cooperate with the transmitter to execute the method of any of claims 1 to 12.

51. A transmission-reception point (TRP), comprising a processor and a transmitter, wherein the processor is configured to call and run program instructions stored in a memory, to cooperate with the transmitter to execute the method of any of claims 13 to 25.

52. A user equipment (UE), comprising a processor and a transmitter, wherein the processor is configured to call and run program instructions stored in a memory, to cooperate with the transmitter to execute the method of any of claims 26 to 36.

53. A transmission-reception point (TRP), comprising a processor and a transmitter, wherein the processor is configured to call and run program instructions stored in a memory, to cooperate with the transmitter to execute the method of any of claims 37 to 49.

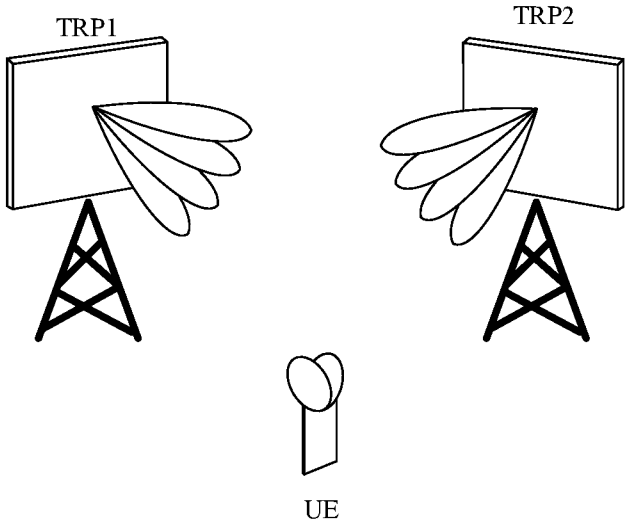


FIG. 1

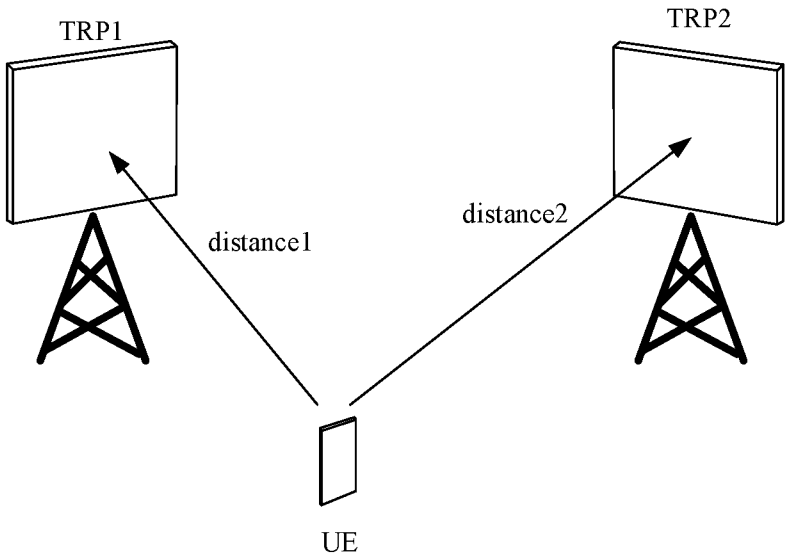
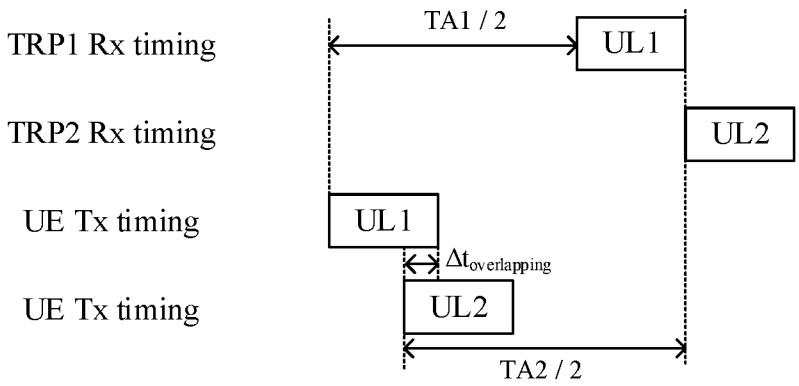


FIG. 2



$\Delta t_{overlapping} = (TA2 - TA1)/2$

FIG. 3

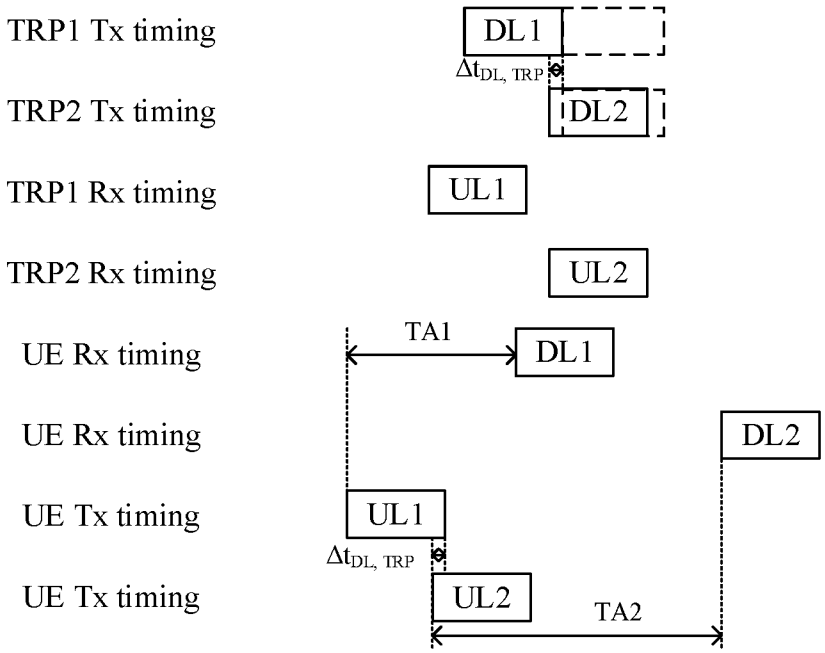
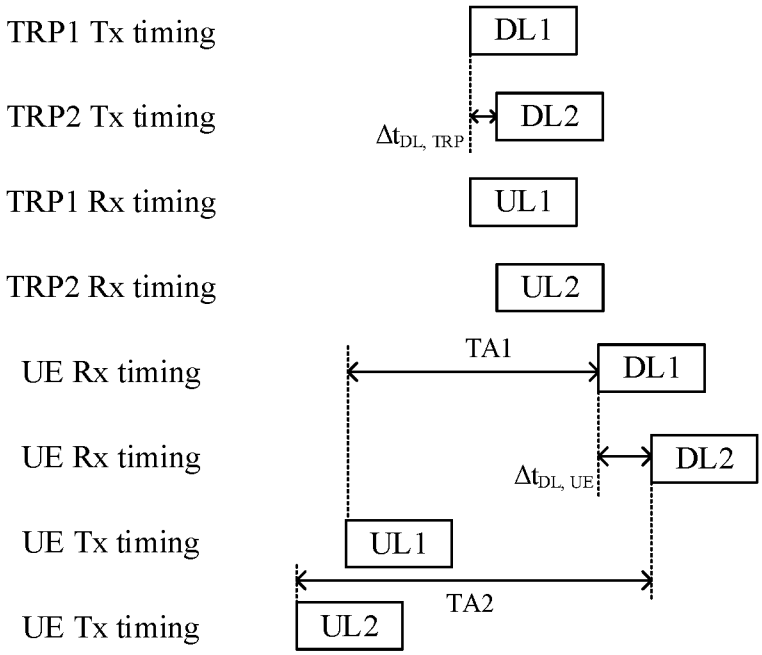


FIG. 4



$$\Delta t_{DL, TRP} = \Delta t_{DL, UE} - (TA2 - TA1)/2$$

FIG. 5

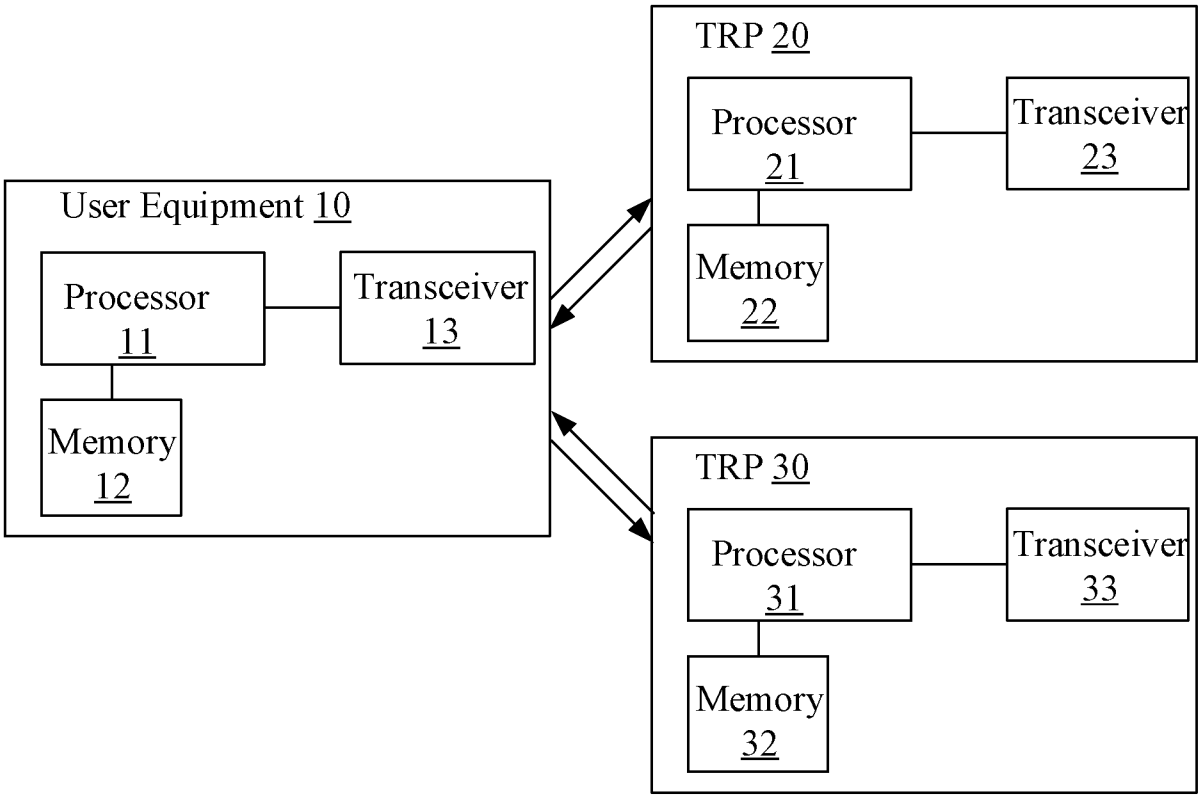

TRP 20
Processor 21
Transceiver 23
Memory 22
User Equipment 10
Processor 11
Transceiver 13
Memory 12
TRP 30
Processor 31
Transceiver 33
Memory 32

FIG. 6

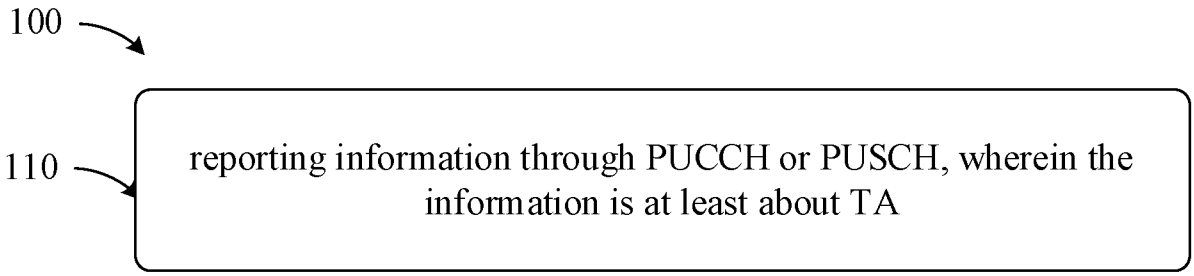

100
110
reporting information through PUCCH or PUSCH, wherein the information is at least about TA

FIG. 7

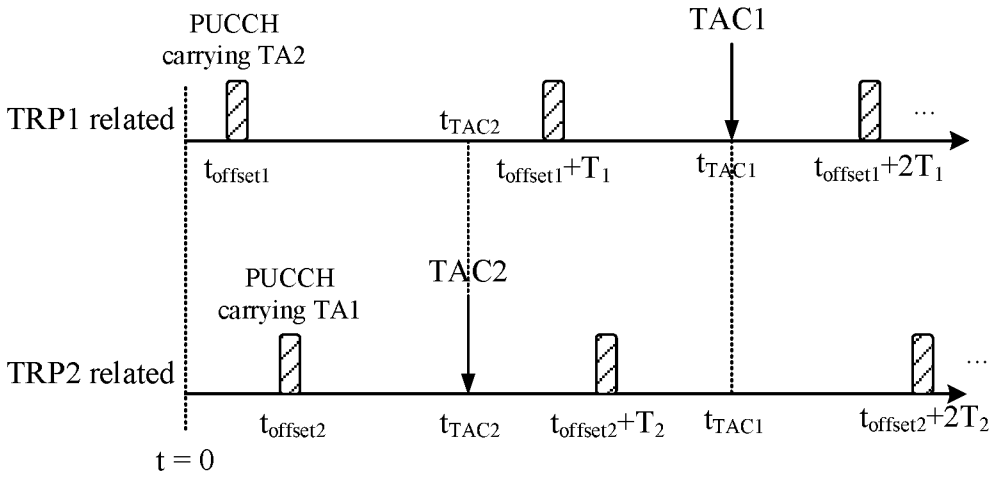

PUCCH
carrying TA2
TAC1
TRP1 related
t_{TAC2}
$t_{offset1}$
$t_{offset1}+T_1$
t_{TAC1}
$t_{offset1}+2T_1$
PUCCH
carrying TA1
TAC2
TRP2 related
$t_{offset2}$
t_{TAC2}
$t_{offset2}+T_2$
t_{TAC1}
$t_{offset2}+2T_2$
t = 0

FIG. 8

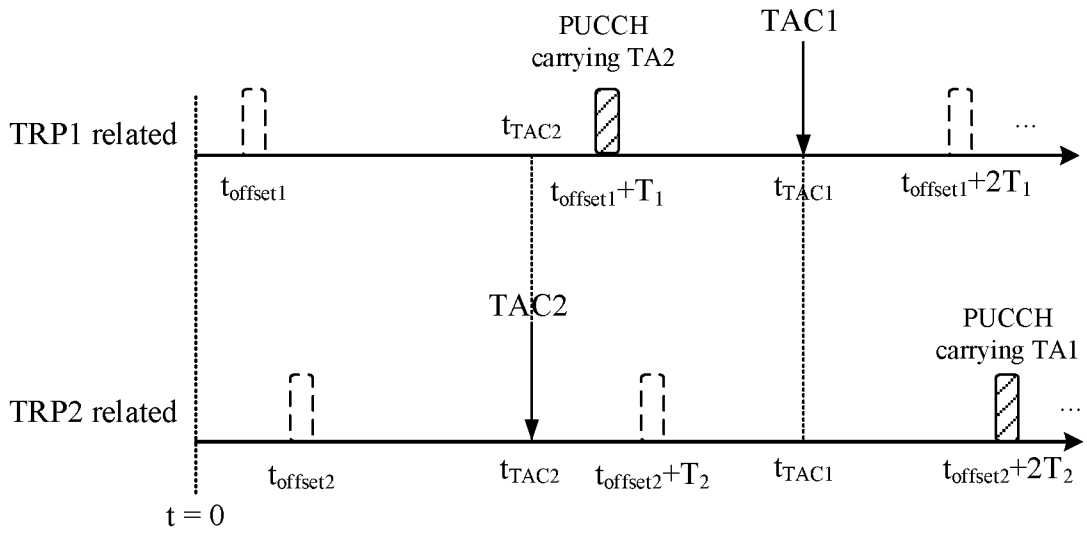

PUCCH
carrying TA2
TAC1
TRP1 related
t_{TAC2}
$t_{offset1}$
$t_{offset1}+T_1$
t_{TAC1}
$t_{offset1}+2T_1$
TAC2
PUCCH
carrying TA1
TRP2 related
$t_{offset2}$
t_{TAC2}
$t_{offset2}+T_2$
t_{TAC1}
$t_{offset2}+2T_2$
t = 0

FIG. 9

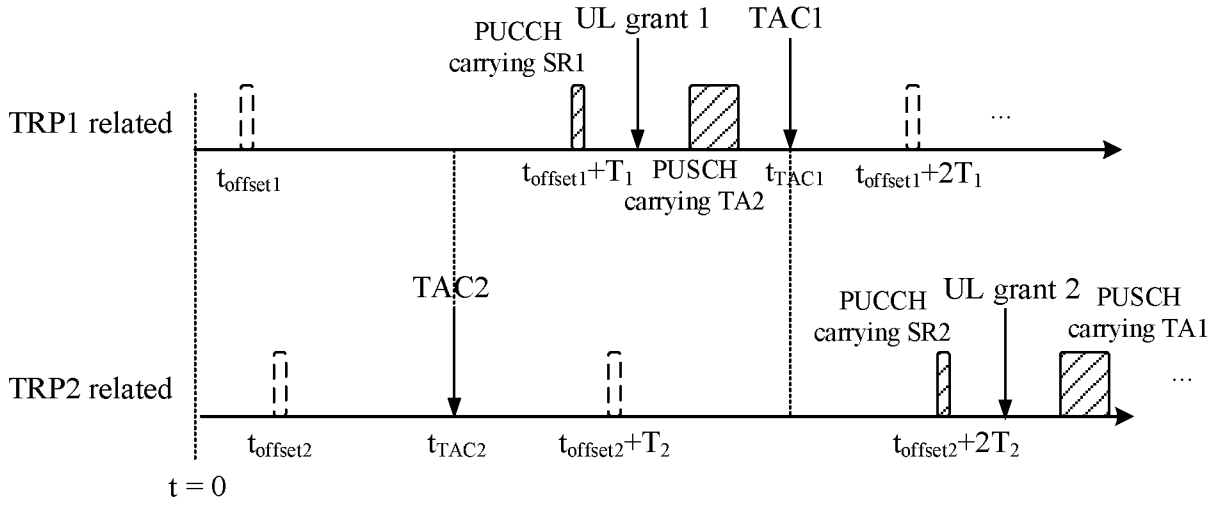

PUCCH carrying SR1
UL grant 1
TAC1
TRP1 related
...
$t_{offset1}$
$t_{offset1}+T_1$
PUSCH carrying TA2
t_{TAC1}
$t_{offset1}+2T_1$
TAC2
PUCCH carrying SR2
UL grant 2
PUSCH carrying TA1
TRP2 related
...
$t_{offset2}$
t_{TAC2}
$t_{offset2}+T_2$
$t_{offset2}+2T_2$
t = 0

FIG. 10

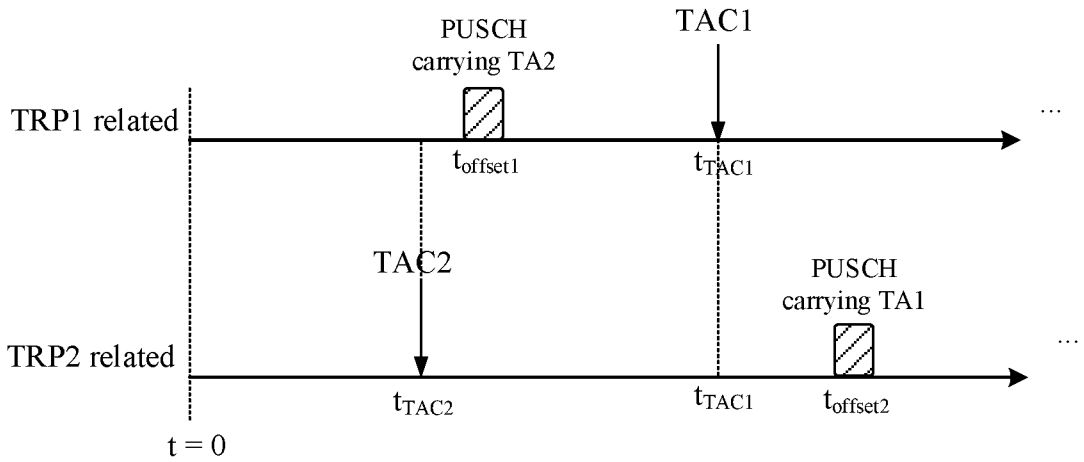

PUSCH carrying TA2
TAC1
TRP1 related
...
$t_{offset1}$
t_{TAC1}
TAC2
PUSCH carrying TA1
TRP2 related
...
t_{TAC2}
t_{TAC1}
$t_{offset2}$
t = 0

FIG. 11

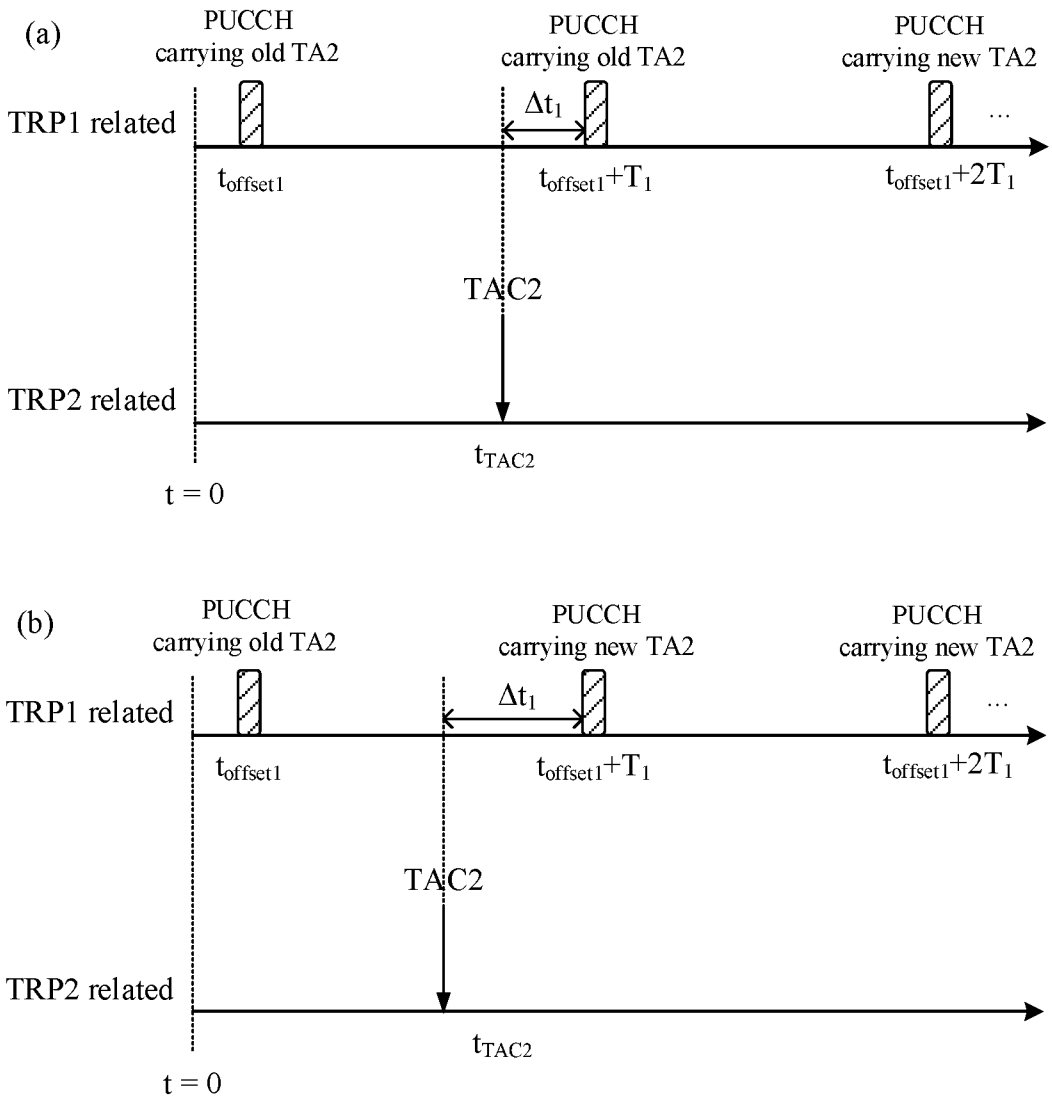

(a)
PUCCH carrying old TA2
PUCCH carrying old TA2
PUCCH carrying new TA2
TRP1 related
Δt1
...
toffset1
toffset1+T1
toffset1+2T1
TAC2
TRP2 related
tTAC2
t = 0
(b)
PUCCH carrying old TA2
PUCCH carrying new TA2
PUCCH carrying new TA2
TRP1 related
Δt1
...
toffset1
toffset1+T1
toffset1+2T1
TAC2
TRP2 related
tTAC2
t = 0

FIG. 12

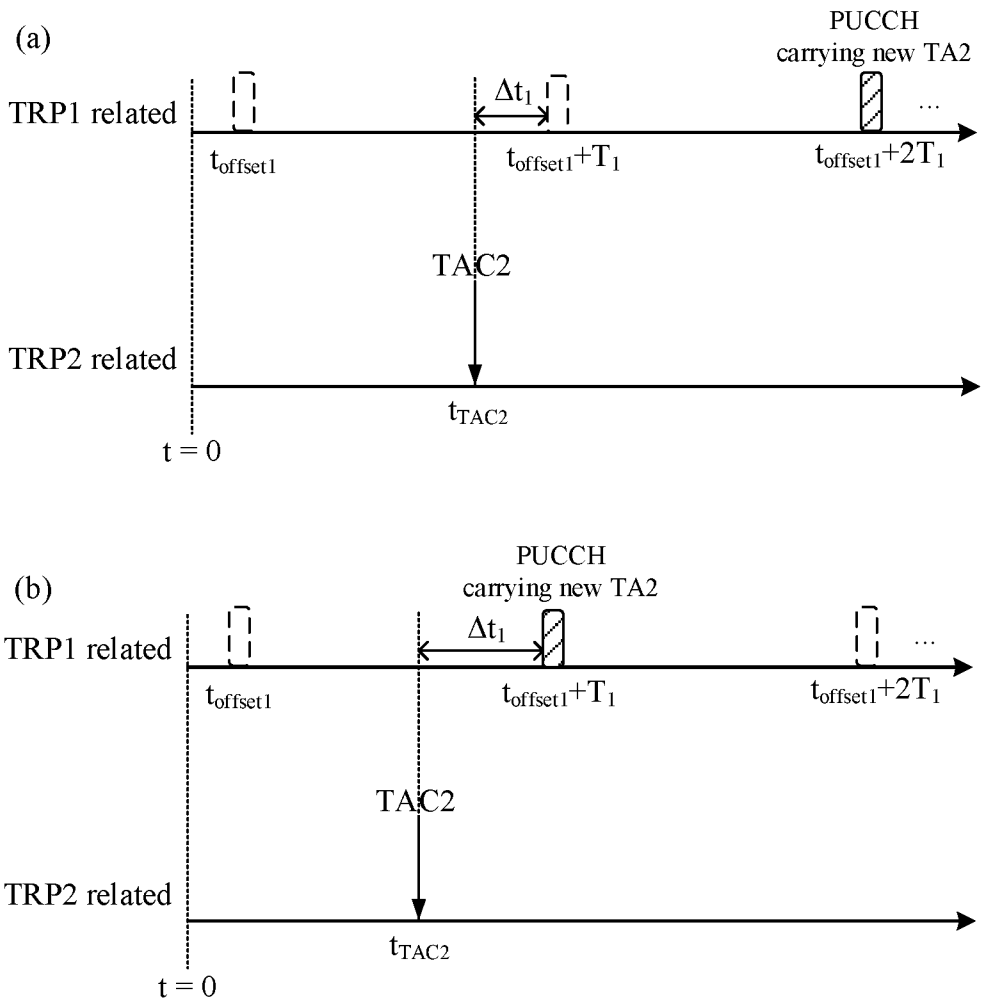

(a)
PUCCH
carrying new TA2
TRP1 related
Δt1
...
toffset1
toffset1+T1
toffset1+2T1
TAC2
TRP2 related
tTAC2
t = 0
(b)
PUCCH
carrying new TA2
TRP1 related
Δt1
...
toffset1
toffset1+T1
toffset1+2T1
TAC2
TRP2 related
tTAC2
t = 0

FIG. 13

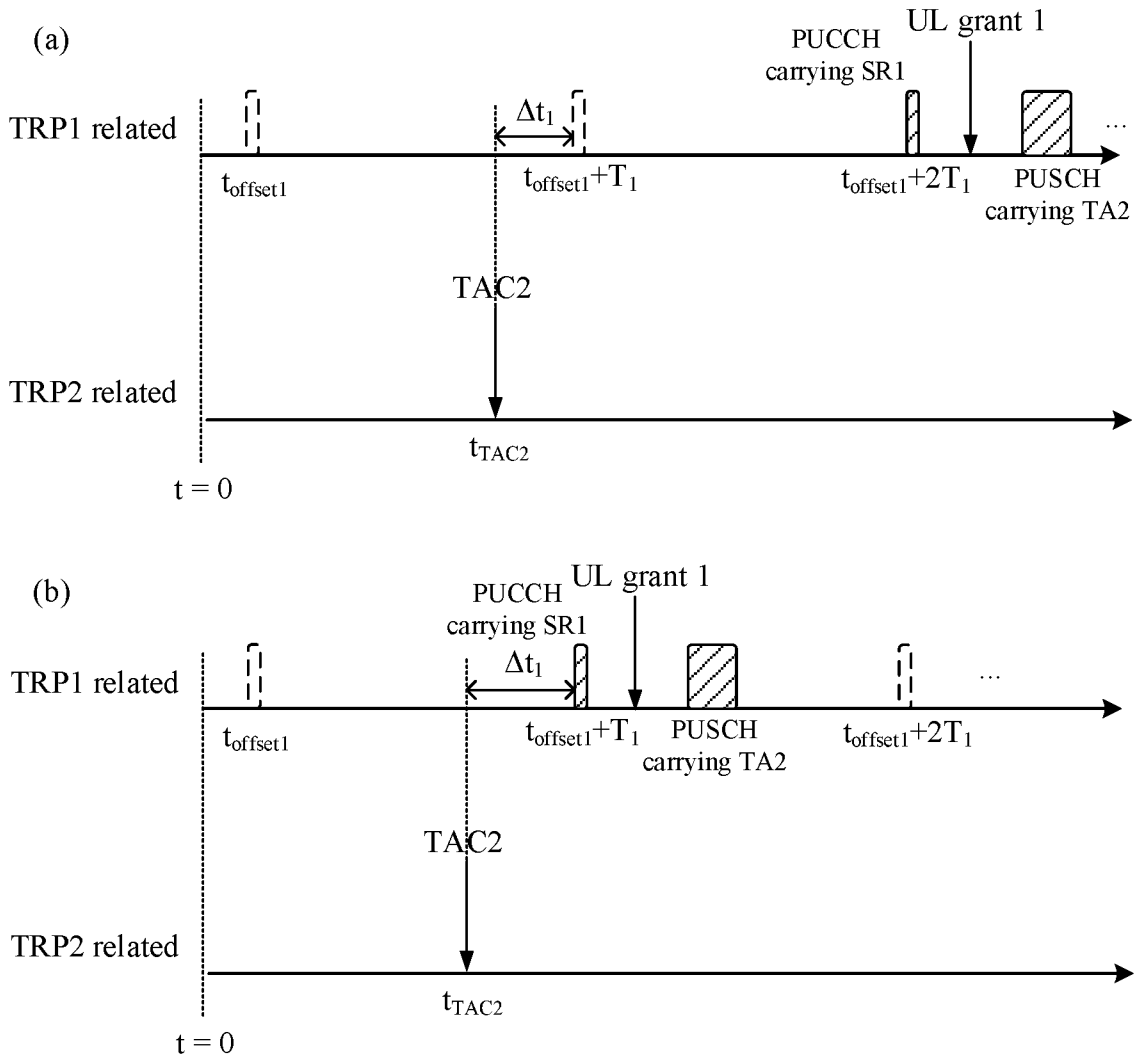

(a)
PUCCH carrying SR1
UL grant 1
TRP1 related
Δt1
...
toffset1
toffset1+T1
toffset1+2T1
PUSCH carrying TA2
TAC2
TRP2 related
tTAC2
t = 0
(b)
PUCCH carrying SR1
UL grant 1
TRP1 related
Δt1
...
toffset1
toffset1+T1
PUSCH carrying TA2
toffset1+2T1
TAC2
TRP2 related
tTAC2
t = 0

FIG. 14

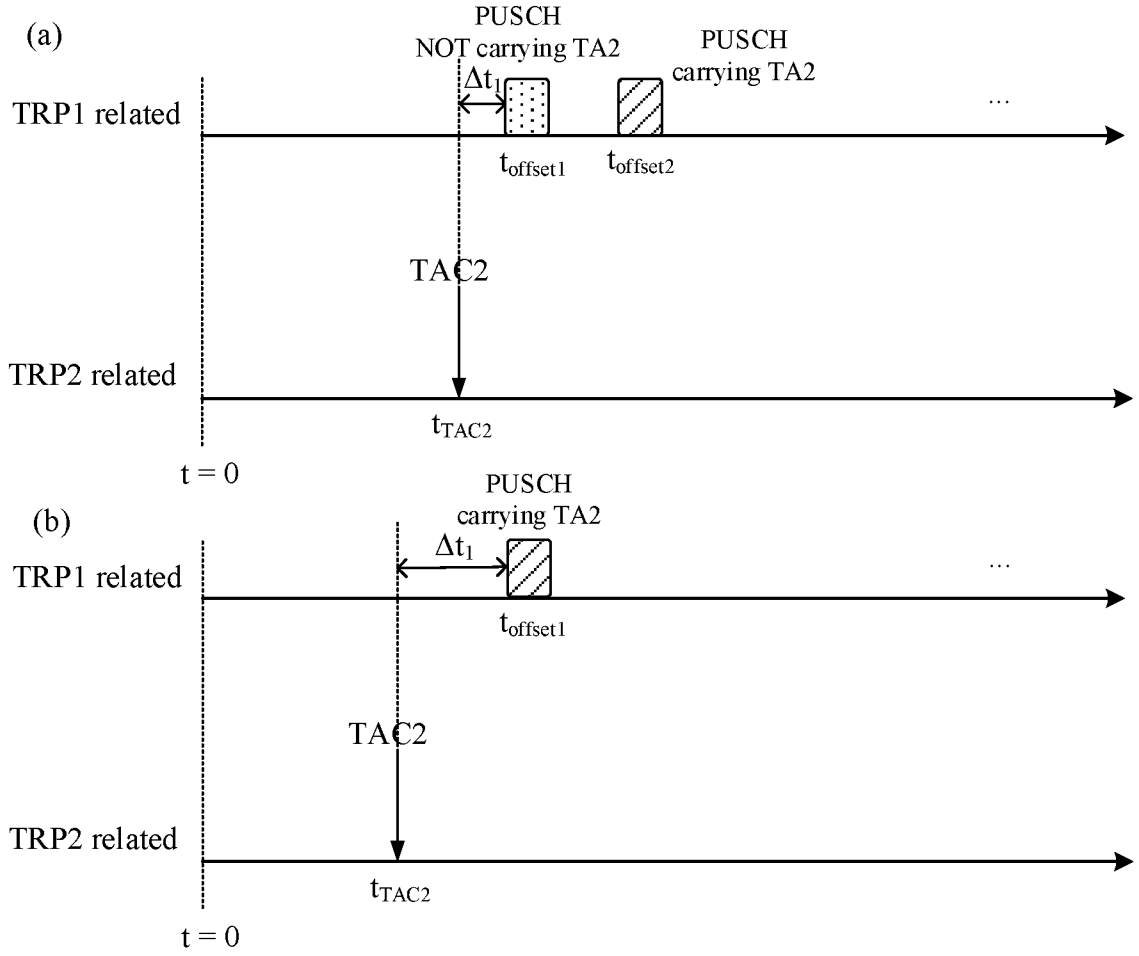


FIG. 15

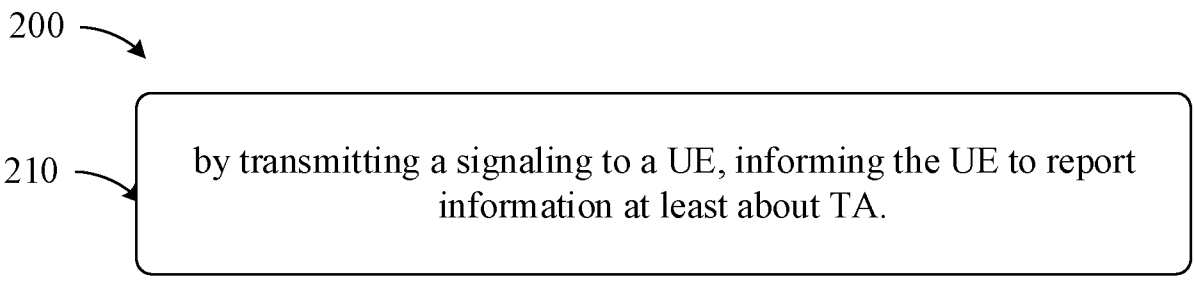


FIG. 16

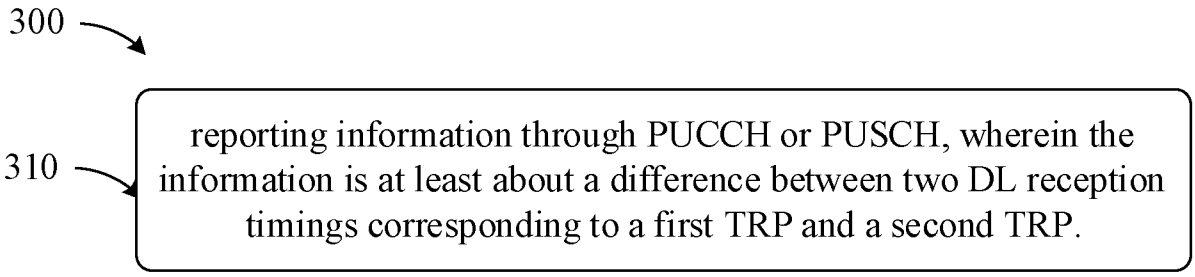


FIG. 17

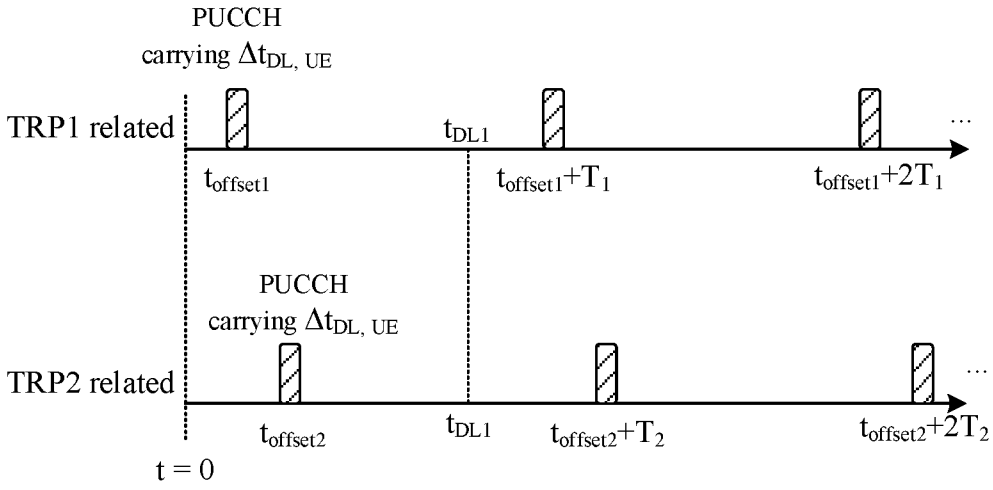


FIG. 18

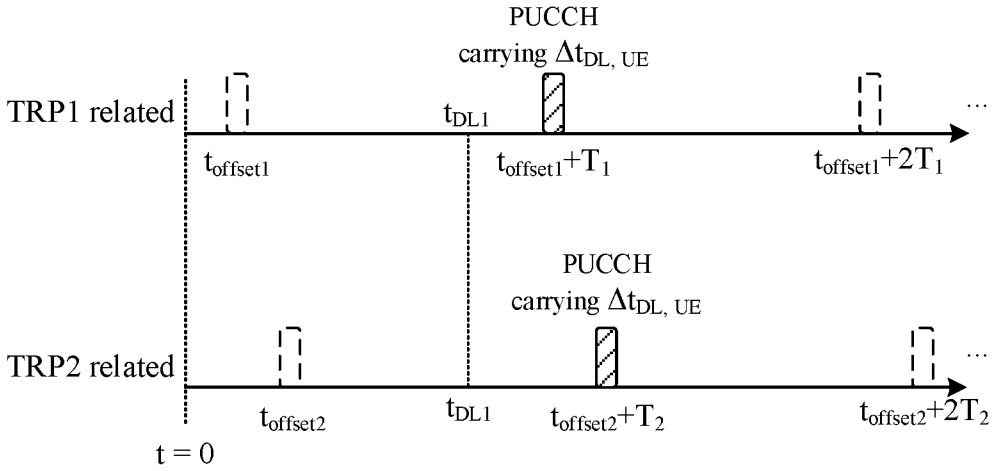


FIG. 19

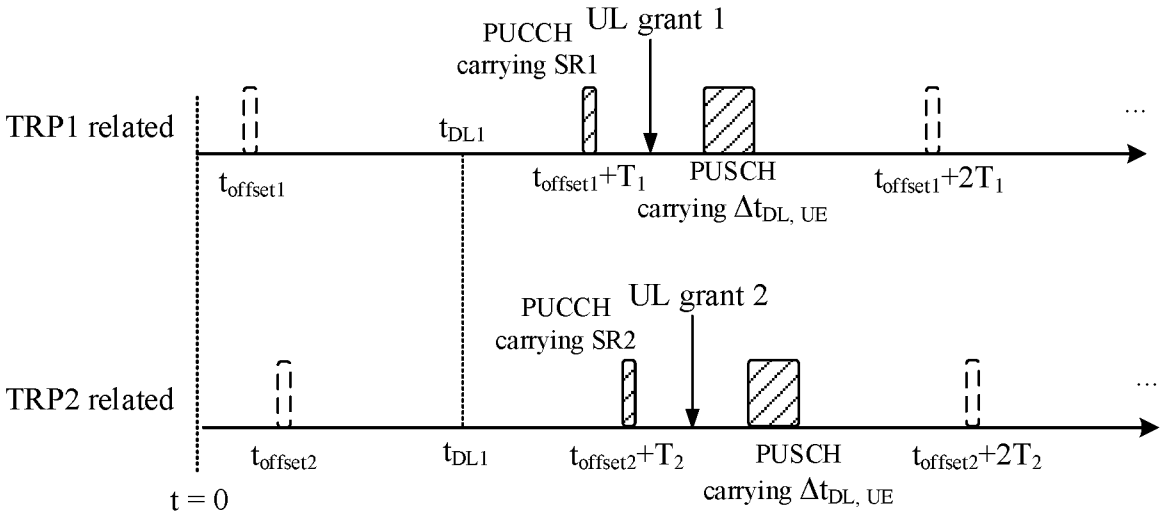


FIG. 20

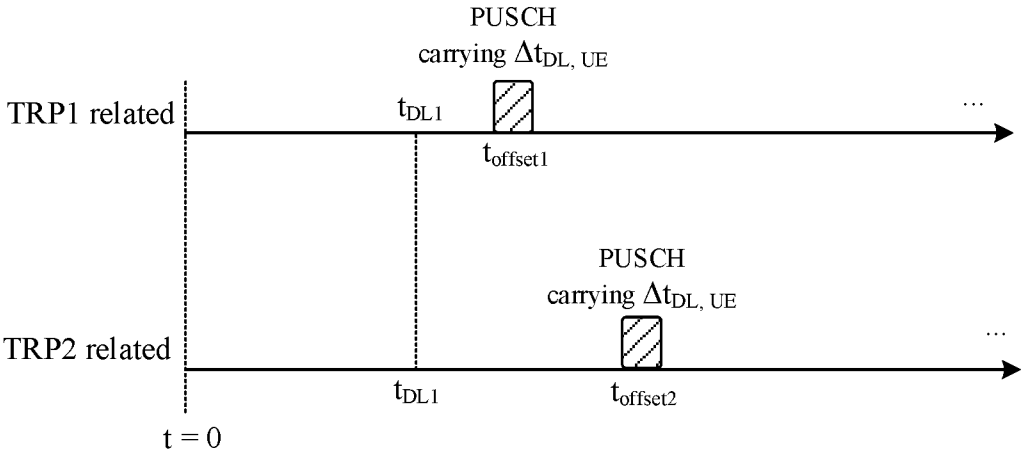

PUSCH
carrying $\Delta t_{DL, UE}$
TRP1 related
t_{DL1}
$t_{offset1}$
PUSCH
carrying $\Delta t_{DL, UE}$
TRP2 related
t_{DL1}
$t_{offset2}$
t = 0

FIG. 21

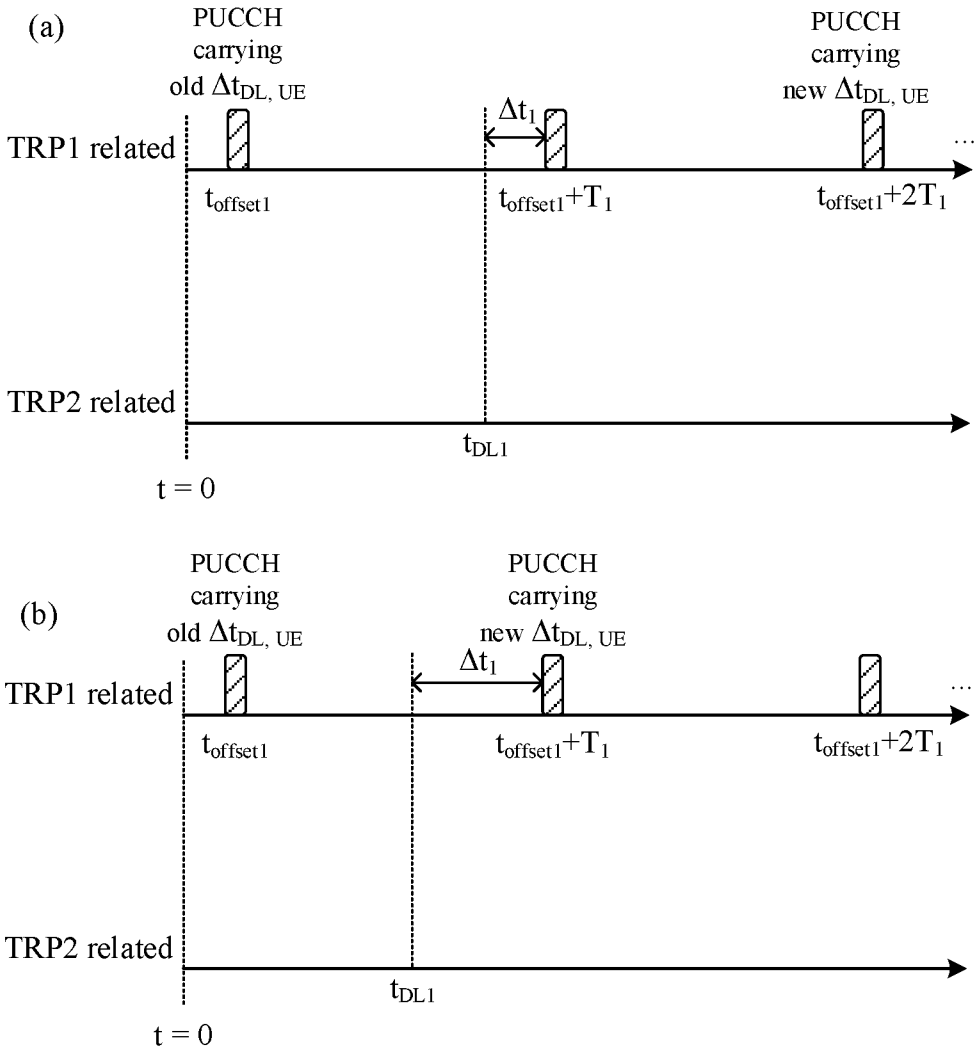

(a)
PUCCH
carrying
old $\Delta t_{DL, UE}$
PUCCH
carrying
new $\Delta t_{DL, UE}$
Δt_1
TRP1 related
$t_{offset1}$
$t_{offset1}+T_1$
$t_{offset1}+2T_1$
TRP2 related
t_{DL1}
t = 0
(b)
PUCCH
carrying
old $\Delta t_{DL, UE}$
PUCCH
carrying
new $\Delta t_{DL, UE}$
Δt_1
TRP1 related
$t_{offset1}$
$t_{offset1}+T_1$
$t_{offset1}+2T_1$
TRP2 related
t_{DL1}
t = 0

FIG. 22

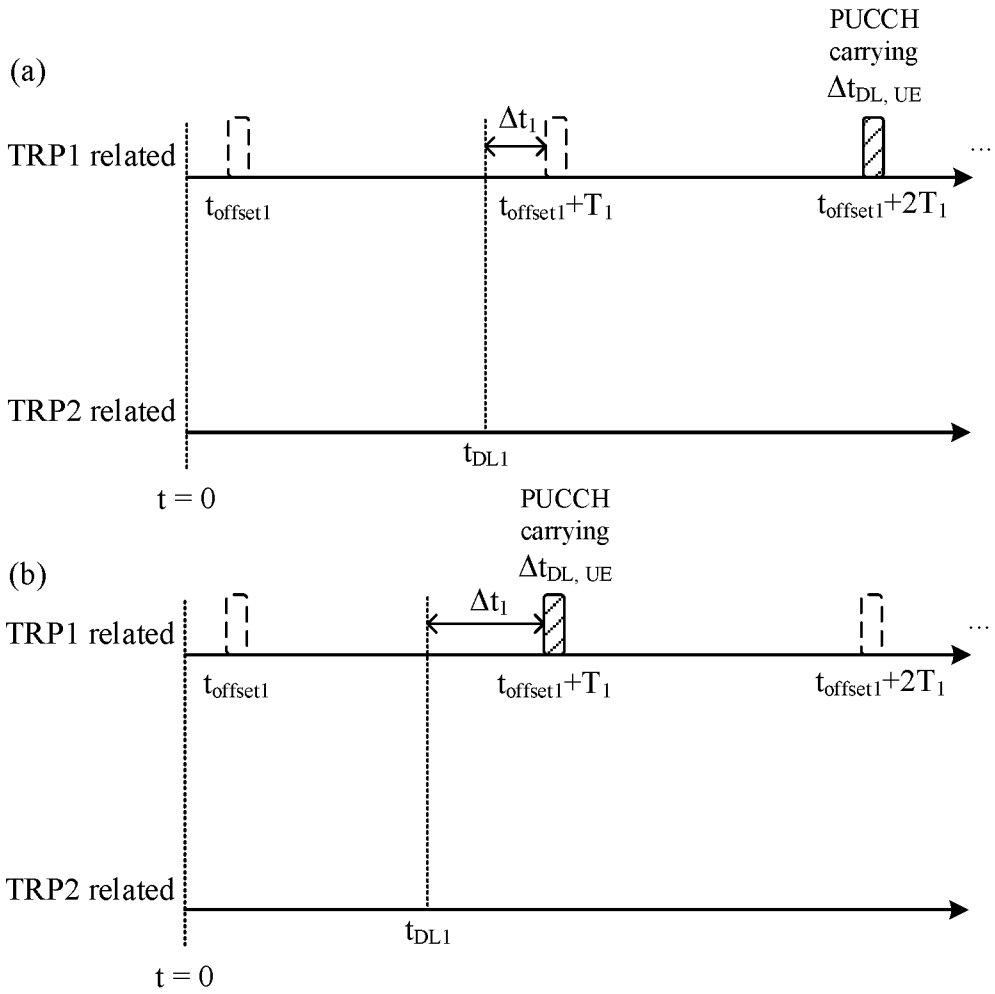

(a)
PUCCH carrying $\Delta t_{DL, UE}$
Δt_1
TRP1 related
$t_{offset1}$
$t_{offset1}+T_1$
$t_{offset1}+2T_1$
...
TRP2 related
t_{DL1}
t = 0
(b)
PUCCH carrying $\Delta t_{DL, UE}$
Δt_1
TRP1 related
$t_{offset1}$
$t_{offset1}+T_1$
$t_{offset1}+2T_1$
...
TRP2 related
t_{DL1}
t = 0

FIG. 23

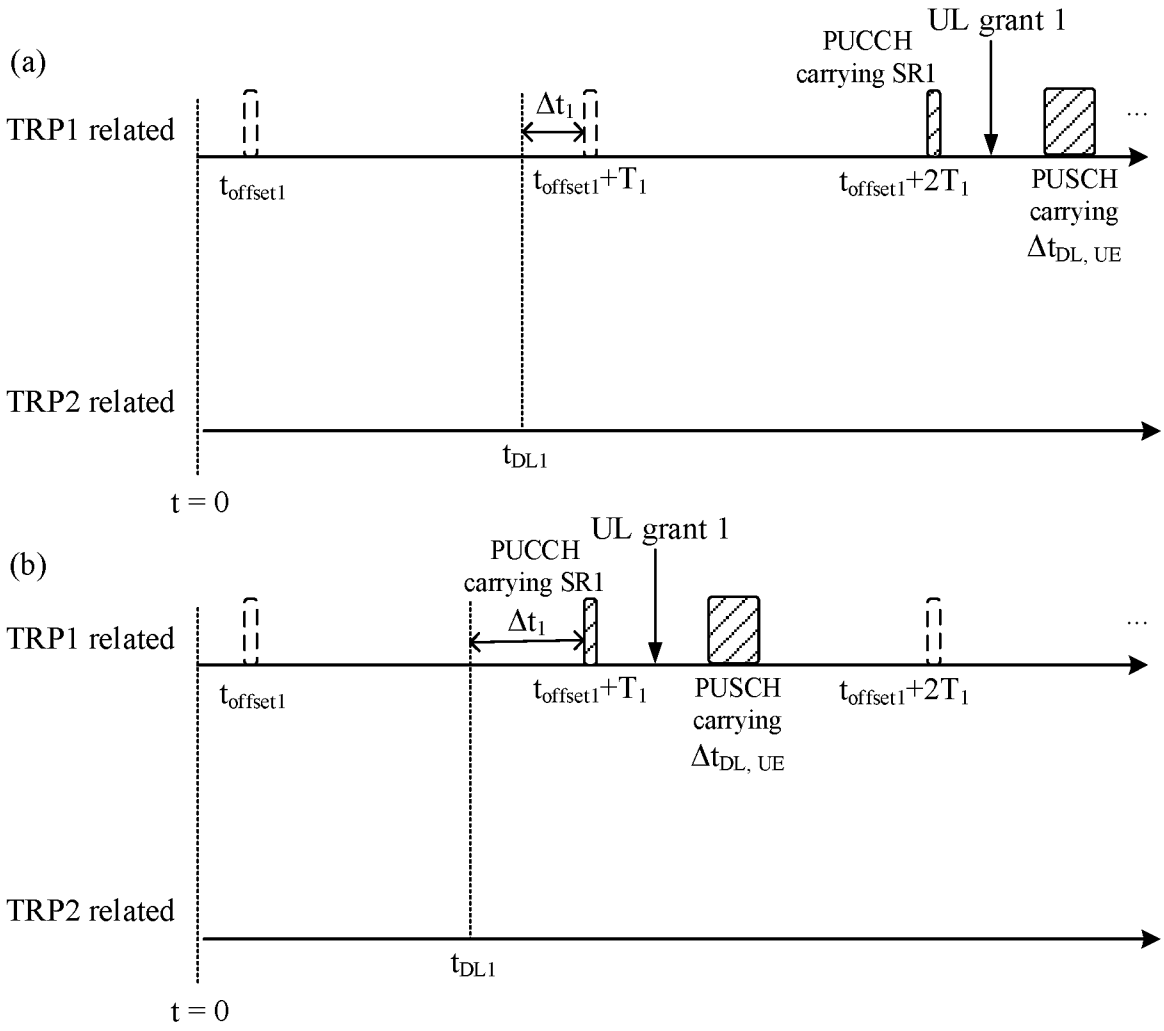

(a)
TRP1 related
TRP2 related
UL grant 1
PUCCH carrying SR1
Δt_1
$t_{offset1}$
$t_{offset1}+T_1$
$t_{offset1}+2T_1$
PUSCH carrying $\Delta t_{DL, UE}$
t_{DL1}
t = 0
(b)
TRP1 related
TRP2 related
UL grant 1
PUCCH carrying SR1
Δt_1
$t_{offset1}$
$t_{offset1}+T_1$
PUSCH carrying $\Delta t_{DL, UE}$
$t_{offset1}+2T_1$
t_{DL1}
t = 0

FIG. 24

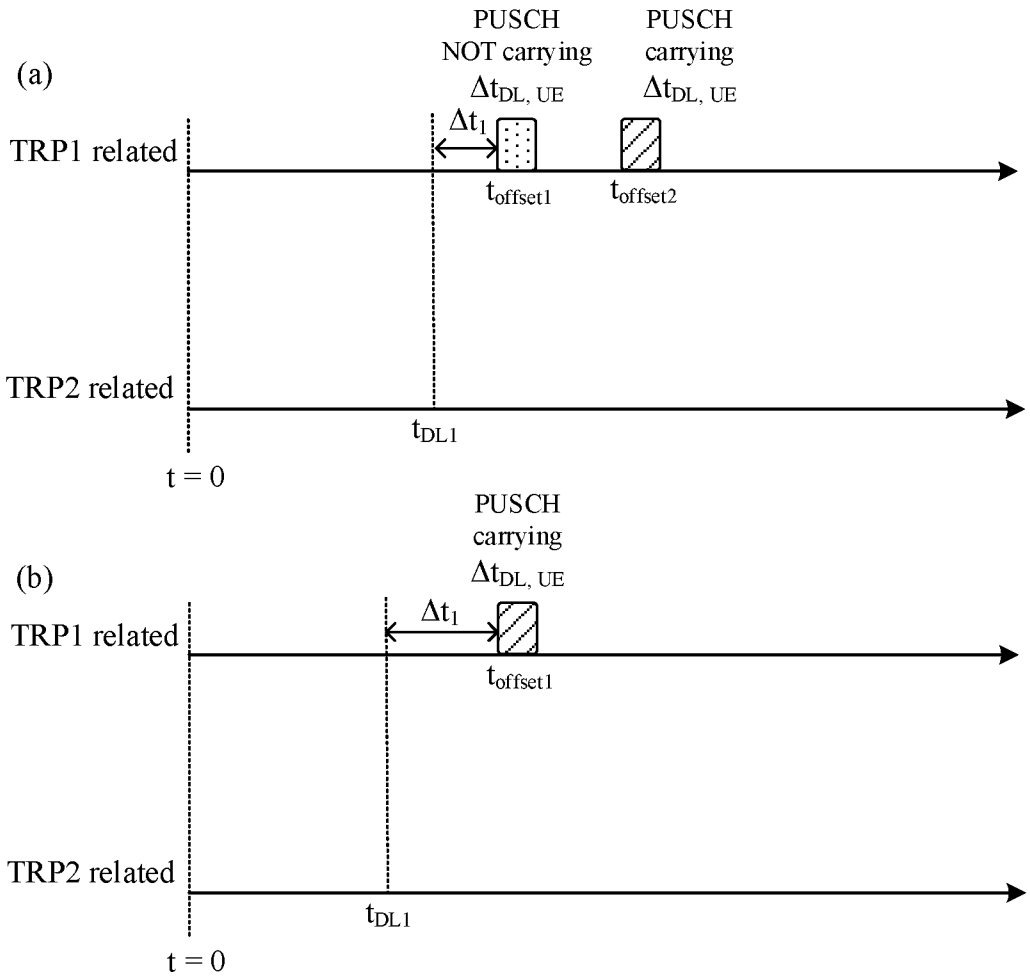

(a)
PUSCH NOT carrying $\Delta t_{DL, UE}$
PUSCH carrying $\Delta t_{DL, UE}$
Δt_1
TRP1 related
$t_{offset1}$
$t_{offset2}$
TRP2 related
t_{DL1}
t = 0
(b)
PUSCH carrying $\Delta t_{DL, UE}$
Δt_1
TRP1 related
$t_{offset1}$
TRP2 related
t_{DL1}
t = 0

FIG. 25

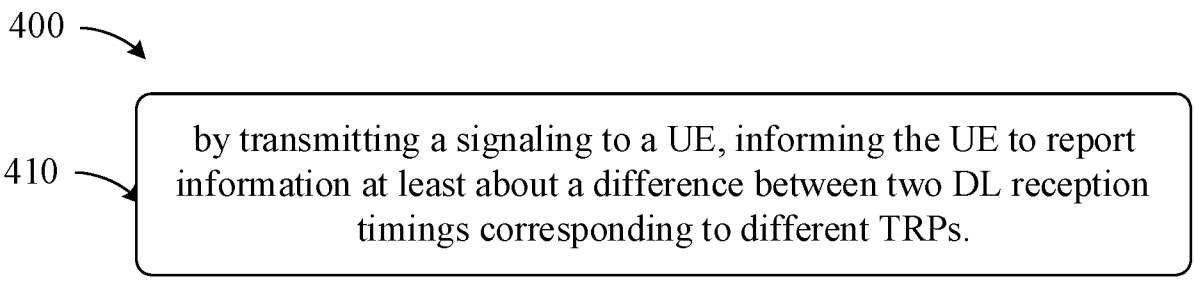

400
410
by transmitting a signaling to a UE, informing the UE to report information at least about a difference between two DL reception timings corresponding to different TRPs.

FIG. 26

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2022/123308

A. CLASSIFICATION OF SUBJECT MATTER

H04L5/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: H04W H04L H04B

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

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

CNABS,CNKI,VEN,VCN,3GPP: multi, multiple, TRP, mTRP, m-TRP, PUSCH, PUCCH, timing advance, TA, report, DL timing, DL reception timings, difference

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2020194103 A1 (NOKIA TECHNOLOGIES OY) 01 October 2020 (2020-10-01) description, paragraphs 30-78	1-53
X	NOKIA et al. "Enhancements on Multi-TRP/Panel Transmission" *3GPP TSG RAN WG1 #97 Meeting R1-1907316,* 17 May 2019 (2019-05-17), sections 1-3	1-53
A	ERICSSON. "Our views on Rel-18 MIMO WI content" *3GPP TSG-RAN WG1 Meeting #106b-e Tdoc R1-2109836,* 19 October 2021 (2021-10-19), the whole document	1-53
A	OPPO. "Two TAs for multi-DCI" *3GPP TSG RAN WG1 #109-e R1-2203954,* 20 May 2022 (2022-05-20), the whole document	1-53
A	QUALCOMM INCORPORATED. "Supporting two TAs for multi-DCI based mTRP" *3GPP TSG-RAN WG1 Meeting #109-e R1-2205015,* 20 May 2022 (2022-05-20), the whole document	1-53

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
01 June 2023	**07 June 2023**

Name and mailing address of the ISA/CN	Authorized officer
CHINA NATIONAL INTELLECTUAL PROPERTY ADMINISTRATION **6, Xitucheng Rd., Jimen Bridge, Haidian District, Beijing 100088, China**	**ZHANG,Fan** Telephone No. **(+86) 010-53961651**

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2021008673 A1 (NOKIA TECHNOLOGIES OY) 21 January 2021 (2021-01-21) the whole document	1-53

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2022/123308

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
WO 2020194103 A1	01 October 2020	EP 3949219 A1	09 February 2022
		US 2022182957 A1	09 June 2022
		CN 113647046 A	12 November 2021
WO 2021008673 A1	21 January 2021	US 2022248358 A1	04 August 2022