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Timing Synchronization For Handover In Non-Terrestrial Network Communications

Abstract

Various solutions for uplink synchronization in non-terrestrial network (NTN) communications are proposed. An apparatus implemented in a user equipment (UE) receives a system information block (SIB) of a target cell via a non-terrestrial (NT) network node of the NTN. The apparatus obtains an explicit epoch time from the SIB of the target cell. Then, the apparatus performs an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.

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Background/Summary

CROSS REFERENCE TO RELATED PATENT APPLICATION(S) [0001] The present disclosure is a continuation of U.S. Patent Application No. 17/865, 147, filed 14 Jul. 2022 and claiming the priority benefit of U.S. Provisional Patent Application No. 63/245,233, filed 17 Sep. 2021. Contents of the aforementioned applications are herein incorporated by reference in their entirety.

TECHNICAL FIELD
[0002] The present disclosure is generally related to mobile communications and, more particularly, to timing synchronization for handover in non-terrestrial network (NTN) communications.
BACKGROUND
[0003] Unless otherwise indicated herein, approaches described in this section are not prior art to the claims listed below and are not admitted as prior art by inclusion in this section.
[0004] There is increasing interest and participation in 3GPP from the satellite communication industry, with companies and organizations convinced of the market potential for an integrated satellite and terrestrial network infrastructure in the context of 3GPP 5G. Satellites refer to Spaceborne vehicles in Low Earth Orbits (LEO), Medium Earth Orbits (MEO), Geostationary Earth Orbit (GEO) or in Highly Elliptical Orbits (HEO). 5G standards make Non-Terrestrial Networks (NTN)—including satellite segments—a recognized part of 3GPP 5G connectivity infrastructure. A low Earth orbit is an Earth-centered orbit with an altitude of 2,000 km or less, or with at least 11.25 periods per day and an eccentricity less than 0.25. Most of the manmade objects in outer space are in LEO. LEO satellites orbit around the earth at a high speed (mobility), but over a predictable or deterministic orbit.
[0005] In 4G Long-Term Evolution (LTE) and 5G new radio (NR) networks, an evolved universal terrestrial radio access network (E-UTRAN) includes a plurality of base stations, e.g., evolved Node-Bs (eNodeBs) communicating with a plurality of mobile stations referred as user equipment (UEs). In 5G New Radio (NR), the base stations are also referred to as gNodeBs or gNBs. For UEs in RRC Idle mode mobility, cell selection is the procedure through which a UE selects a specific cell for initial registration after power on, and cell reselection is the mechanism to change cell after UE is camped on a cell and stays in idle mode. For UEs in RRC Connected mode mobility, handover is the procedure through which a UE hands over an ongoing session from the source gNB to a neighboring target gNB.
[0006] Mobility in LEO satellite-based NTN can be quite different from terrestrial networks. In terrestrial networks, cells are fixed but UEs may move in different trajectories. On the other hand, in NTN, most of the LEO satellites travel at some speed relative to the earth's ground, while the UE movements are relatively slow and negligible. For LEO satellites, the cells are moving over time, albeit in a predictable manner. Hence, LEO satellites can estimate the target cell based on its own movement speed, direction and height from the ground, instead of relying on UE's measurement reports. Once the LEO satellite moves to a new cell, most (if not all) of the UEs will be handed over to the same target cell. The network can estimate UEs' locations by using Global Navigation Satellite System (GNSS) or by capturing location information from the core networks.
[0007] Handover process in NR-based LEO-NTN involve frequent, periodic handover messages. Naturally, UE's measurement-report (MR) based traditional handover will incur frequent, heavy signaling overhead as the network needs to process MR, trigger HO decision and continue HO signaling in every few seconds. System information block (SIB) may be used in NTN for serving

satellite/gNB synchronization. NTN synchronization SIB will contain ephemeris information such as satellite position vector, satellite velocity vector, orbital parameters.

[0008] During handover, in order to reduce the interruption, the UE is not expected to decode the SIB information. The satellite-assisted system information broadcast on SIB is provided to the UE through the radio resource control (RRC) configuration during handover procedure. However, if the target cell is NTN and if the NTN SIB uses implicit time reference for the validity of the content or epoch time, which requires DL reception, then forwarding the NTN SIB as it is will not allow the UE to synchronize its UL and transmit the RACH preamble. Hence, the time information of target cell needs to be explicitly forwarded to the UE before handover process in NR-NTN is initiated.

SUMMARY

[0009] The following summary is illustrative only and is not intended to be limiting in any way. That is, the following summary is provided to introduce concepts, highlights, benefits and advantages of the novel and non-obvious techniques described herein. Select implementations are further described below in the detailed description. Thus, the following summary is not intended to identify essential features of the claimed subject matter, nor is it intended for use in determining the scope of the claimed subject matter.

[0010] An objective of the present disclosure is to propose solutions or schemes that address the aforementioned issues. More specifically, various schemes proposed in the present disclosure are believed to address issues pertaining to uplink synchronization with target cell during handover procedure in NTN communications.

[0011] In one aspect, a method may involve an apparatus obtaining a carrier frequency of a non-terrestrial network (NTN). The method may also involve the apparatus receiving a system information block (SIB) of a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN). The method may also involve the apparatus obtaining an explicit epoch time from the SIB of the target cell. The method may also involve the apparatus performing an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.

[0012] In another aspect, an apparatus may include a transceiver and a processor coupled to the transceiver. The transceiver may be configured to wirelessly communicate with a non-terrestrial network (NTN). The processor may be configured to receive, via the transceiver, a system information block (SIB) of a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN). The processor may also obtain an explicit epoch time from the SIB of the target cell. The processor may also perform an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.

[0013] In another aspect, an apparatus may include a transceiver and a processor coupled to the transceiver. The transceiver may be configured to wirelessly communicate with a non-terrestrial network (NTN). The processor may be configured to receive, via the transceiver, a system information block (SIB) from a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN). The processor may also decode the SIB to obtain an explicit epoch time of the target cell before completing a handover procedure. The processor may also perform an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.

[0014] It is noteworthy that, although description provided herein may be in the context of certain radio access technologies, networks and network topologies such as Long-Term Evolution (LTE), LTE-Advanced, LTE-Advanced Pro, 5th Generation (5G), New Radio (NR), Internet-of-Things (IoT), Narrow Band Internet of Things (NB-IoT), Industrial Internet of Things (IIoT), non-terrestrial network (NTN) and 6th Generation (6G), the proposed concepts, schemes and any variation(s)/derivative(s) thereof may be implemented in, for and by other types of radio access

technologies, networks and network topologies. Thus, the scope of the present disclosure is not limited to the examples described herein.

Description

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] The accompanying drawings are included to provide a further understanding of the disclosure and are incorporated in and constitute a part of the present disclosure. The drawings illustrate implementations of the disclosure and, together with the description, serve to explain the principles of the disclosure. It is appreciable that the drawings are not necessarily in scale as some components may be shown to be out of proportion than the size in actual implementation in order to clearly illustrate the concept of the present disclosure.

[0016] FIG. **1** is a diagram of an example network environment in which various proposed schemes in accordance with the present disclosure may be implemented.

[0017] FIG. **2** is a block diagram of an example communication system in accordance with an implementation of the present disclosure.

[0018] FIG. **3** is a flowchart of an example process in accordance with an implementation of the present disclosure.

[0019] FIG. **4** is a flowchart of an example process in accordance with an implementation of the present disclosure.

DETAILED DESCRIPTION OF PREFERRED IMPLEMENTATIONS

[0020] Detailed embodiments and implementations of the claimed subject matters are disclosed herein. However, it shall be understood that the disclosed embodiments and implementations are merely illustrative of the claimed subject matters which may be embodied in various forms. The present disclosure may, however, be embodied in many different forms and should not be construed as limited to the exemplary embodiments and implementations set forth herein. Rather, these exemplary embodiments and implementations are provided so that description of the present disclosure is thorough and complete and will fully convey the scope of the present disclosure to those skilled in the art. In the description below, details of well-known features and techniques may be omitted to avoid unnecessarily obscuring the presented embodiments and implementations.

Overview

[0021] Implementations in accordance with the present disclosure relate to various techniques, methods, schemes and/or solutions pertaining to uplink synchronization with target cell during handover procedure in NTN communications. According to the present disclosure, a number of possible solutions may be implemented separately or jointly. That is, although these possible solutions may be described below separately, two or more of these possible solutions may be implemented in one combination or another.

[0022] FIG. **1** illustrates an exemplary network environment **100** that supports efficient

[0023] handover procedure in Low Earth Orbit (LEO) Non-Terrestrial Network (NTN) in accordance with the present disclosure may be implemented. NR wireless communication system **100** involves at least one non-terrestrial (NT) network node **120** (e.g., a satellite), at least one user equipment (UE) **110**, and a plurality of terrestrial network nodes **131**, **132** (e.g., a gateway, base station, eNB, gNB or transmission/reception point (TRP)), which may be a part of a wireless communication network (e.g., an LTE network, a 5G network, an NR network, an loT network, an NB-IoT network, an IIoT network, an NTN network or a 6G network).

[0024] UE **110** may be far from terrestrial network nodes **131**, **132** (e.g., not within the communication range of terrestrial network nodes **131**, **132**) and not able to communicate with terrestrial network nodes **131**, **132** directly. Via NTN, UE **110** may be able to transmit/receive signals to/from NT network node **120**. NT network node **120** may relay/transfer signals/data from

UE **110** to one of the terrestrial network nodes **131**, **132**. Thus, one of the terrestrial network nodes **131**, **132** may be able to communicate with UE **110** via NT network node **120**. In the example of FIG. **1**, the NT network node **120** orbit around the earth at a high speed (mobility), but over a predictable or deterministic orbit, and UE **110** is initially served in a terrestrial network node **131** (hereinafter source cell **131**). Once the NT network node **120** moves to a new cell, the UE **110** will be handed over to a terrestrial network node **132** (hereinafter target cell **132**).
[0025] For NT network node **120**, the terrestrial network nodes **131**, **132** are moving over time, albeit in a predictable manner. Hence, NT network node **120** can estimate the target cell based on its own movement speed, direction and height from the ground, instead of relying on UE's measurement reports. Once the NT network node **120** moves to a new cell, most (if not all) of the UEs will be handed over to the same target cell. The network can estimate UEs' locations by using Global Navigation Satellite System (GNSS) or by capturing location information from the core networks.
[0026] For UE **110** in RRC Connected mode mobility, handover is the procedure through which the UE **110** hands over an ongoing session from the source cell **131** to a neighboring target cell **132**. Before handing over to the target cell **132**, the UE **110** needs to obtain the system information (e.g., master information block (MIB) and system information block (SIB)) of the target cell **132**. SIB maybe used in NTN for synchronization with the terrestrial network nodes **131**, **132**.
[0027] During handover, in order to reduce the interruption, the UE is not expected to decode the SIB. The source cell **131** provides the RRC configuration to the UE **110** by forwarding the RRCReconfiguration message received in the HANDOVER REQUEST ACKNOWLEDGE. The RRCReconfiguration message includes at least cell ID and all information required to access the target cell **132** so that the UE **110** can access the target cell **132** without reading system information. However, if the SIB uses implicit time reference for the validity of the content or epoch time, then forwarding the NTN SIB as it is will not allow the UE **110** to synchronize its UL to the target cell **132** and transmit the RACH preamble. Under the circumstances, UE **110** may need to a downlink reception for UL timing synchronization.
[0028] In view of the above, the present disclosure proposes a number of schemes pertaining to uplink synchronization with target cell during handover procedure in NTN communications with respect to the UE **110**, NT network node **120** and terrestrial network node **130**. Under various proposed schemes in accordance with the present disclosure, each of the UE **110**, the NT network node **120** and the terrestrial network node **130** may be configured to perform operations pertaining to system information block (SIB) and explicit epoch time for uplink synchronization with target cell during handover procedure in NTN communications, as described below.
[0029] Under a proposed scheme, UE **110** may receive a SIB of a target cell via the NT network node of NTN. Additionally, UE **110** may obtain an explicit epoch time from the SIB of the target cell. Then, UE **110** may perform UL synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.
[0030] In some implementations, UE **110** may obtain the SIB of the target cell **132** from the source cell **131**. Specifically, when the NT network node **120** moves to the target cell **132**, the target cell **132** may transmit its SIB to the source cell **131**. Since the UE **110** is still served by the source cell **131** and in RRC Connected mode, the source cell **131** may transmit RRC configuration signal (e.g., RRCConfiguration message) configuring the SIB of the target cell **132** to the NT network node **120**. Then, the NT network node **120** will forward the RRC configuration signal to the UE **110**.
[0031] SIB includes at least the explicit epoch time of the target cell **132** and the satellite ephemeris of the NT network node **120**. The satellite ephemeris includes at least one of a satellite position vector, a satellite velocity vector, a feeder link timing advance (TA) parameter, a feeder link delay parameter, a plurality of satellite orbital parameters and trajectory information. The satellite position vector and the satellite velocity vector are in earth-centered, earth-fixed (ECEF) coordinate system or another frame of reference. In some implementations, SIB information can include as

well other information such as the feeder link delay or timing advance, but not limited thereto.

[0032] The explicit epoch time may be a downlink (DL) timing of the target cell and may include one of a system frame number (SFN), a subframe index, a slot index, a symbol number, coordinated universal time (UTC) or any combinations thereof, but not limited thereto. In some implementations, UL timing may also be used. Once the explicit epoch time is obtained, the UE **110** may synchronize its uplink transmit time with the target cell **132** and perform the handover procedure by handing over from the source cell **131** to the target cell **132** according to the SIB.

[0033] Since the UE **110** does not decode the SIB, a handover interruption time during the handover procedure is a sum of at least one of a cell searching time for searching the target cell, an interruption uncertainty time in acquiring a first available PRACH occasion in the target cell, a processing time, a timing information acquiring time, and a synchronization signal block (SSB) post-processing time, and may be calculated as T.sub.interrupt=T.sub.search+T.sub.IU+T.sub.processing+T.sub.Δ+T.sub.margin_ms. T.sub.interrupt denotes the handover interruption time. T.sub.search denotes the cell searching time which is the time required to search the target cell **132** when the handover command is received by the UE **110**. T.sub.IU denotes the interruption uncertainty time which is the interruption uncertainty in acquiring the first available PRACH occasion in the new cell. T.sub.processing denotes the processing time for UE processing, and the processing time can be up to **20** ms. T.sub.α denotes the timing information acquiring time which is time for fine time tracking and acquiring full timing information of the target cell **132**. T.sub.margin_ms denotes the SSB post-processing time.

[0034] Under another proposed scheme, the UE **110** may receive the SIB from the target cell **132** via the NT network node **120**. Then, the UE **110** may decode the SIB before completing a handover procedure. In detail, the target cell **132** may broadcast the SIB, and the NT network node **120** forwards the SIB to the UE **110**. In order to access the target cell **132**, the UE **110** has to decode the SIB. Therefore, the handover interruption time is a sum of at least one of a cell searching time for searching the target cell, an interruption uncertainty time in acquiring a first available PRACH occasion in the target cell, a processing time, a timing information acquiring time, a SIB decoding time, and a synchronization signal block (SSB) post-processing time, and may be calculated as T.sub.interrupt=T.sub.search+T.sub.IU+T.sub.processing+T.sub.α+T.sub.SIB+T.sub.margin_ms. T.sub.SIB denotes the SIB decoding time which is the time for the UE **110** to decode the SIB. The SIB decoding time is determined from a system information scheduling.

Illustrative Implementations

[0035] FIG. **2** illustrates an example communication system **200** having an example communication apparatus **210** and an example network apparatus **220** in accordance with an implementation of the present disclosure. Each of communication apparatus **210** and network apparatus **220** may perform various functions to implement schemes, techniques, processes and methods described herein pertaining to system information block (SIB) and explicit epoch time for uplink synchronization with target cell during handover procedure in NTN communications, including scenarios/schemes described above as well as processes **300** and **400** described below.

[0036] Communication apparatus **210** may be a part of an electronic apparatus, which may be a UE such as a portable or mobile apparatus, a wearable apparatus, a wireless communication apparatus or a computing apparatus. For instance, communication apparatus **210** may be implemented in a smartphone, a smartwatch, a personal digital assistant, a digital camera, or a computing equipment such as a tablet computer, a laptop computer or a notebook computer. Communication apparatus **210** may also be a part of a machine type apparatus, which may be an IoT, NB-IoT, IIoT or NTN apparatus such as an immobile or a stationary apparatus, a home apparatus, a wire communication apparatus or a computing apparatus. For instance, communication apparatus **210** may be implemented in a smart thermostat, a smart fridge, a smart door lock, a wireless speaker or a home control center.

[0037] Alternatively, communication apparatus **210** may be implemented in the form of one or more integrated-circuit (IC) chips such as, for example and without limitation, one or more single-core processors, one or more multi-core processors, one or more reduced-instruction set computing (RISC) processors, or one or more complex-instruction-set-computing (CISC) processors. Communication apparatus **210** may include at least some of those components shown in FIG. **2** such as a processor **212**, for example. Communication apparatus **210** may further include one or more other components not pertinent to the proposed scheme of the present disclosure (e.g., internal power supply, display device and/or user interface device), and, thus, such component(s) of communication apparatus **210** are neither shown in FIG. **2** nor described below in the interest of simplicity and brevity.

[0038] Network apparatus **220** may be a part of an electronic apparatus/station, which may be a network node such as a base station, a small cell, a router, a gateway or a satellite. For instance, network apparatus **220** may be implemented in an eNodeB in an LTE, in a gNB in a 5G, NR, 6G, IoT, NB-IoT, IIoT, or in a satellite in an NTN network. Alternatively, network apparatus **220** may be implemented in the form of one or more IC chips such as, for example and without limitation, one or more single-core processors, one or more multi-core processors, or one or more RISC or CISC processors. Network apparatus **220** may include at least some of those components shown in FIG. **2** such as a processor **222**, for example. Network apparatus **220** may further include one or more other components not pertinent to the proposed scheme of the present disclosure (e.g., internal power supply, display device and/or user interface device), and, thus, such component(s) of network apparatus **220** are neither shown in FIG. **2** nor described below in the interest of simplicity and brevity.

[0039] In one aspect, each of processor **212** and processor **222** may be implemented in the form of one or more single-core processors, one or more multi-core processors, or one or more CISC processors. That is, even though a singular term “a processor” is used herein to refer to processor **212** and processor **222**, each of processor **212** and processor **222** may include multiple processors in some implementations and a single processor in other implementations in accordance with the present disclosure. In another aspect, each of processor **212** and processor **222** may be implemented in the form of hardware (and, optionally, firmware) with electronic components including, for example and without limitation, one or more transistors, one or more diodes, one or more capacitors, one or more resistors, one or more inductors, one or more memristors and/or one or more varactors that are configured and arranged to achieve specific purposes in accordance with the present disclosure. In other words, in at least some implementations, each of processor **212** and processor **222** is a special-purpose machine specifically designed, arranged and configured to perform specific tasks including power consumption reduction in a device (e.g., as represented by communication apparatus **210**) and a network (e.g., as represented by network apparatus **220**) in accordance with various implementations of the present disclosure.

[0040] In some implementations, communication apparatus **210** may also include a transceiver **216** coupled to processor **212** and capable of wirelessly transmitting and receiving data. In some implementations, communication apparatus **210** may further include a memory **214** coupled to processor **212** and capable of being accessed by processor **212** and storing data therein. In some implementations, network apparatus **220** may also include a transceiver **226** coupled to processor **222** and capable of wirelessly transmitting and receiving data. In some implementations, network apparatus **220** may further include a memory **224** coupled to processor **222** and capable of being accessed by processor **222** and storing data therein. Accordingly, communication apparatus **210** and network apparatus **220** may wirelessly communicate with each other via transceiver **216** and transceiver **226**, respectively.

[0041] Each of communication apparatus **210** and network apparatus **220** may be a communication entity capable of communicating with each other using various proposed schemes in accordance with the present disclosure. To aid better understanding, the following description of the operations, functionalities and capabilities of each of communication apparatus **210** and network apparatus **220** is provided in the context of a mobile communication environment in which communication apparatus **210** is implemented in or as a communication apparatus or a UE (e.g., UE **110**) and network apparatus **220** is implemented in or as a network node or base station (e.g., NT network node **120** or terrestrial network node **130**) of a communication network (e.g., network **120**). It is also noteworthy that, although the example implementations described below are provided in the context of NTN communications, the same may be implemented in other types of networks.

[0042] Under various proposed scheme in accordance with the present disclosure pertaining to system information block (SIB) and explicit epoch time for uplink synchronization with target cell during handover procedure in NTN communications, processor **212** of the communication apparatus **210** implemented in or as UE **110** may receive SIB of the target cell via the NT network node of NTN. Processor **212** may obtain, via the transceiver **216**, explicit epoch time from the SIB of the target cell. Processor **212** may perform UL synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time. The explicit epoch time includes one of a system frame number (SFN), a subframe index, a slot index, a symbol number, coordinated universal time (UTC) or any combinations thereof.

[0043] The SIB includes a satellite ephemeris of the NT network node. The satellite ephemeris includes at least one of a satellite position vector, a satellite velocity vector, a feeder link timing advance (TA) parameter, a feeder link delay parameter, a plurality of satellite orbital parameters and trajectory information. The satellite position vector and the satellite velocity vector are in earth-centered, earth-fixed (ECEF) coordinate system or another frame of reference.

[0044] In some implementation, processor **212** may receive a radio resource control (RRC) configuration signal configuring the SIB from a source cell.

[0045] In some implementation, processor **212** may perform a handover procedure by handing over from the source cell to the target cell according to the SIB

[0046] Under various proposed scheme in accordance with the present disclosure pertaining to SIB and explicit epoch time for uplink synchronization with target cell during handover procedure in NTN communications, processor **212** of the communication apparatus **210** implemented in or as UE **110** may receive, via the transceiver, the SIB from the target cell via the NT network node of NTN and decode the SIB to obtain an explicit epoch time of the target cell before completing a handover procedure. The processor may perform UL synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.

[0047] The handover interruption time is a sum of at least one of a cell searching time for searching the target cell, an interruption uncertainty time in acquiring a first available PRACH occasion in the target cell, a processing time, a timing information acquiring time, a SIB decoding time, and a synchronization signal block (SSB) post-processing time.

[0048] The SIB decoding time is determined from a system information scheduling.

Illustrative Processes

[0049] FIG. **3** illustrates an example process **300** in accordance with an implementation of the present disclosure. Process **300** may be an example implementation of schemes described above, whether partially or completely, with respect to the system information block (SIB) and explicit epoch time for uplink synchronization with target cell during handover procedure with the present disclosure. Process **300** may represent an aspect of implementation of features of communication apparatus **210**. Process **300** may include one or more operations, actions, or functions as illustrated by one or more of blocks **310**, **320**, and **330**.

[0050] Although illustrated as discrete blocks, various blocks of process **300** may be divided into additional blocks, combined into fewer blocks, or eliminated, depending on the desired implementation. Moreover, the blocks of process **300** may executed in the order shown in FIG. **3** or, alternatively, in a different order. Process **300** may be implemented by communication apparatus **210** or any suitable UE or machine type devices. Solely for illustrative purposes and without limitation, process **300** is described below in the context of communication apparatus **210**.

[0051] Process **300** may begin at block **310**. At block **310**, process **300** may involve processor **212** of communication apparatus **210** receiving a system information block (SIB) of a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN). Process **300** may proceed from block **310** to block **320**.
[0052] At block **320**, process **300** may involve processor **212** obtaining an explicit epoch time from the SIB of the target cell. Process **300** may proceed from block **320** to block **330**.
[0053] At block **330**, process **300** may involve processor **212** performing an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.
[0054] In some implementations, in receiving the SIB, process **300** may involve processor **212** performing certain operations. For instance, process **300** may involve processor **212** receiving a radio resource control (RRC) configuration signal configuring the SIB from a source cell.
[0055] In some implementations, the explicit epoch time includes one of a system frame number (SFN), a subframe index, a slot index, a symbol number, coordinated universal time (UTC) or any combinations thereof.
[0056] In some implementations, the SIB includes a satellite ephemeris of the NT network node. The satellite ephemeris comprises at least one of a satellite position vector, a satellite velocity vector, a feeder link timing advance (TA) parameter, a feeder link delay parameter, a plurality of satellite orbital the satellite position vector and the satellite velocity vector are in earth-centered, earth-fixed (ECEF) coordinate system or another frame of reference. parameters and trajectory information.
[0057] FIG. **4** illustrates an example process **400** in accordance with an implementation of the present disclosure. Process **400** may be an example implementation of schemes described above, whether partially or completely, with respect to the SIB and explicit epoch time for uplink synchronization with target cell during handover procedure with the present disclosure. Process **400** may represent an aspect of implementation of features of communication apparatus **210**. Process **400** may include one or more operations, actions, or functions as illustrated by one or more of blocks **410**, **420** and **430**.
[0058] Although illustrated as discrete blocks, various blocks of process **400** may be divided into additional blocks, combined into fewer blocks, or eliminated, depending on the desired implementation. Moreover, the blocks of process **400** may executed in the order shown in FIG. **4** or, alternatively, in a different order. Process **400** may be implemented by communication apparatus **210** or any suitable UE or machine type devices. Solely for illustrative purposes and without limitation, process **400** is described below in the context of communication apparatus **210**.
[0059] Process **400** may begin at block **410**. At block **410**, process **400** may involve processor **212** of communication apparatus **210** receiving the SIB from the target cell via the NT network node of the NTN. Process **400** may proceed from block **410** to block **420**.
[0060] At block **420**, process **400** may involve processor **212** decoding the SIB to obtain an explicit epoch time of the target cell before completing a handover procedure. Process **400** may proceed from block **420** to block **430**.
[0061] At block **430**, process **400** may involve processor **212** performing an uplink synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time.
[0062] In some implementations, a handover interruption time is a sum of at least one of a cell searching time for searching the target cell, an interruption uncertainty time in acquiring a first available PRACH occasion in the target cell, a processing time, a timing information acquiring time, a SIB decoding time, and a synchronization signal block (SSB) post-processing time.
[0063] In some implementations, the SIB decoding time is determined from a system information scheduling.
Additional Notes
[0064] The herein-described subject matter sometimes illustrates different components contained

within, or connected with, different other components. It is to be understood that such depicted architectures are merely examples, and that in fact many other architectures can be implemented which achieve the same functionality. In a conceptual sense, any arrangement of components to achieve the same functionality is effectively "associated" such that the desired functionality is achieved. Hence, any two components herein combined to achieve a particular functionality can be seen as "associated with" each other such that the desired functionality is achieved, irrespective of architectures or intermedial components. Likewise, any two components so associated can also be viewed as being "operably connected", or "operably coupled", to each other to achieve the desired functionality, and any two components capable of being so associated can also be viewed as being "operably couplable", to each other to achieve the desired functionality. Specific examples of operably couplable include but are not limited to physically mateable and/or physically interacting components and/or wirelessly interactable and/or wirelessly interacting components and/or logically interacting and/or logically interactable components.

[0065] Further, with respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

[0066] Moreover, it will be understood by those skilled in the art that, in general, terms used herein, and especially in the appended claims, e.g., bodies of the appended claims, are generally intended as "open" terms, e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc. It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to implementations containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an," e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more;" the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number, e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations. Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention, e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc. In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention, e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc. It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

[0067] From the foregoing, it will be appreciated that various implementations of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various implementations disclosed herein are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

Claims

1. A method, comprising: receiving, by a processor of an apparatus, information of a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN); obtaining, by the processor, an explicit epoch time from the information; and performing, by the processor, an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time, wherein the explicit epoch time comprises a reference time of the target cell, a system frame number (SFN) and a subframe index number.
2. The method of claim 1, further comprising: receiving, by the processor, a radio resource control (RRC) configuration signal from a source cell configuring a system information block (SIB) which contains the information.
3. The method of claim 2, further comprising: performing, by the processor, a handover procedure by handing over from the source cell to the target cell according to the SIB.
4. The method of claim 2, wherein the explicit epoch time further comprises one of a slot index, a symbol number, coordinated universal time (UTC) or any combinations thereof.
5. The method of claim 2, wherein the SIB comprises a satellite ephemeris of the NT network node.
6. The method of claim 5, wherein the satellite ephemeris comprises at least one of a satellite position vector, a satellite velocity vector, a feeder link timing advance (TA) parameter, a feeder link delay parameter, a plurality of satellite orbital parameters and trajectory information.
7. The method of claim 6, wherein the satellite position vector and the satellite velocity vector are in earth-centered, earth-fixed (ECEF) coordinate system or another frame of reference.
8. A method, comprising: receiving, by a processor of an apparatus, information from a target cell via a non-terrestrial (NT) network node from a non-terrestrial network (NTN); decoding, by the processor, the information to obtain an explicit epoch time of the target cell before completing a handover procedure; and performing, by the processor, an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time, wherein the explicit epoch time comprises a reference time of the target cell, a system frame number (SFN) and a subframe index number.
9. The method of claim 8, wherein a handover interruption time is a sum of at least one of a cell searching time for searching the target cell, an interruption uncertainty time in acquiring a first available PRACH occasion in the target cell, a processing time, a timing information acquiring time, a system information block (SIB) decoding time, and a synchronization signal block (SSB) post-processing time.
10. An apparatus, comprising: a transceiver configured to wirelessly communicate with a non-terrestrial network (NTN); and a processor coupled to the transceiver and configured to perform operations comprising: receiving, via the transceiver, information of a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN); obtaining an explicit epoch time from the information of the target cell; and performing an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time, wherein the explicit epoch time comprises a reference time of the target cell, a system frame number (SFN) and a subframe index number.
11. The apparatus of claim 10, wherein the processor further performs operations comprising: receiving, via the transceiver, a radio resource control (RRC) configuration signal from a source cell configuring a system information block (SIB) which contains the information.
12. The apparatus of claim 11, wherein the processor further performs operations comprising:

performing a handover procedure by handing over from the source cell to the target cell according to the SIB.

13. The apparatus of claim 11, wherein the explicit epoch time further comprises one of a slot index, a symbol number, coordinated universal time (UTC) or any combinations thereof.

14. The apparatus of claim 11, wherein the SIB comprises a satellite ephemeris of the NT network node.

15. The apparatus of claim 14, wherein the satellite ephemeris comprises at least one of a satellite position vector, a satellite velocity vector, a feeder link timing advance (TA) parameter, a feeder link delay parameter, a plurality of satellite orbital parameters and trajectory information.

16. The apparatus of claim 15, wherein the satellite position vector and the satellite velocity vector are in earth-centered, earth-fixed (ECEF) coordinate system or another frame of reference.

17. An apparatus, comprising: a transceiver configured to wirelessly communicate with a non-terrestrial network (NTN); and a processor coupled to the transceiver and configured to perform operations comprising: receiving, via the transceiver, information from a target cell via a non-terrestrial (NT) network node of a non-terrestrial network (NTN); decoding the information to obtain an explicit epoch time of the target cell before completing a handover procedure; and performing an uplink (UL) synchronization with the target cell through adjusting an uplink transmit time according to the explicit epoch time, wherein the explicit epoch time comprises a reference time of the target cell, a system frame number (SFN) and a subframe index number.

18. The apparatus of claim 17, wherein a handover interruption time is a sum of at least one of a cell searching time for searching the target cell, an interruption uncertainty time in acquiring a first available PRACH occasion in the target cell, a processing time, a timing information acquiring time, a system information block (SIB) decoding time, and a synchronization signal block (SSB) post-processing time.