UTC TRACEABILITY SUPPORT FOR TERMINAL DEVICES

TECHNICAL FIELD

Various example embodiments relate to wireless communications.

BACKGROUND

In a 5G communication system, terminal devices can be relatively time-synchronized to the 5G network or absolutely time-synchronized to the same global 5G clock (corresponding, e.g., to the coordinated universal time, UTC). The 5G clock may be delivered to the terminal devices, for example, via a ReferenceTimeInfo (RTI) information element (IE) that together with the estimation of the system frame number (SFN) reference, enables the terminal device to be absolute time synchronized to the 5G clock. However, the terminal device (or Device-Side Time Sensitive Networking Translator, DS-TT associated with the terminal device) is unable to ensure (metrological) traceability of its clock to UTC based on information received via the control plane.

SUMMARY

According to an aspect, there is provided the subject matter of the independent claims. Embodiments are defined in the dependent claims.

In one aspect, the present disclosure refers to a terminal device comprising, at least one processor, and at least one memory including computer program code, the at least one memory and the computer program code configured, with the at least one processor, to cause the terminal device at least to perform, receiving, from a serving access node of the terminal device, a first downlink radio resource control message comprising reference time information for a clock provided by the serving access node and traceability information for enabling traceability of the clock to a reference time standard, characterized in that the traceability information comprises at least information on a clock class indicative of a current synchronization status of the clock provided by the serving access node.

In another aspect, the present disclosure refers to an access node comprising, at least one processor, and at least one memory including computer program code, the at least one memory and the computer program code configured, with the at least one processor, to cause the access node at least to perform, receiving an uplink radio resource control message comprising an indication for preference for time traceability to a reference time standard for a terminal device from said terminal device or a request comprising said indication from a network function of a core network, determining traceability information for enabling traceability of the clock of an access node to the reference time standard based on said indication, and causing transmitting, from the access node to the terminal device, a first downlink radio resource control message comprising reference time information for the clock and the traceability information for the clock; characterized in that the traceability information comprises at least information on a clock class indicative of a current synchronization status of the clock provided by the serving access node.

One or more examples of implementations are set forth in more detail in the accompanying drawings and the description below. Other features will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

In the following, example embodiments will be described in greater detail with reference to the attached drawings, in which

Figure 1 illustrates an exemplified wireless communication system;

Figures 2 to 6, 7A and 7B illustrate exemplary processes according to embodiments; and

Figures 8 and 9 illustrate apparatuses according to embodiments.

DETAILED DESCRIPTION OF SOME EMBODIMENTS

The following embodiments are only presented as examples. Although the specification may refer to “an”, “one”, or “some” embodiment(s) and/or exam

CLAIMS

1. A terminal device comprising:

at least one processor; and

at least one memory including computer program code;

the at least one memory and the computer program code configured, with the at least one processor, to cause the terminal device at least to perform:

receiving, from a serving access node of the terminal device, a first downlink radio resource control message comprising reference time information for a clock provided by the serving access node and traceability information for enabling traceability of the clock to a reference time standard, characterized in that the traceability information comprises at least information on a clock class indicative of a current synchronization status of the clock provided by the serving access node.

2. The terminal device of claim 1, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the terminal device to perform:

storing at least the traceability information or a part thereof to the memory.

3. The terminal device according to claim 1, wherein the clock class is defined to have a value selected from a set of pre-defined values indicating different synchronization statuses of the clock, said set of pre-defined values comprising values indicative of one or more of the following:

the serving access node is locked to a primary reference clock;

the serving access node is in a holdover mode after losing the primary reference clock but still within a designated holdover specification; or

the serving access node is in the holdover mode and is no longer within the designated holdover specification.

4. The terminal device according to claim 3, wherein the designated holdover specification defines at least one or more pre-defined conditions for allowed clock drift.

5. The terminal device according to claim 1, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the terminal device to perform, before the receiving:

causing transmitting, from the terminal device to the serving access node, an uplink radio resource control message comprising an indication of preference for time traceability to the reference time standard.

6. The terminal device of claim 5, wherein the terminal device comprises a global positioning system receiver and the at least one memory and the computer program code are configured, with the at least one processor, to cause the terminal device to perform:

causing performing at least one global positioning system time measurement via the global positioning system receiver from at least one satellite;

receiving, before the transmitting, a SIB9 message from the serving access node, wherein the SIB9 message comprises at least time information acquired by the serving access node from at least one of said at least one satellite for determining a clock of the global positioning system, at least one identifier of said at least one of the at least one satellite and time offset information; and

estimating time uncertainty at the terminal device using a common-view method based on the SIB9 message received from the serving access node and results of said at least one global positioning system time measurement.

7. The terminal device of claim 5, wherein the terminal device comprises a global navigation satellite system receiver,

the uplink radio resource control message further comprises a request for global navigation satellite system common-view method information,

said request for global navigation satellite system common-view method information comprises at least information on a global navigation satellite system used by the terminal device and at least one identifier of at least one satellite observable by the terminal device,

the first downlink radio resource control message further comprises global navigation satellite system common-view method configuration information, said global navigation satellite system common-view method configuration information comprising at least global navigation satellite system time measurement timing information and information on at least one of the at

least one satellite observable by both the terminal device and the serving access node,

the global navigation satellite system common-view method information comprises at least information on global navigation satellite system time acquired by the serving access node from at least one of the at least one satellite and time offset and/or correction information,

wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the terminal device to perform:

causing performing, according to the global navigation satellite system time measurement timing information, at least one global navigation satellite system time measurement via the global navigation satellite system receiver using said at least one of the at least one satellite;

receiving, from the serving access node, a second downlink radio resource control message comprising the global navigation satellite system common-view method information comprising at least information on global navigation satellite system time acquired by the serving access node from the at least one of the at least one satellite and time offset and/or correction information; and

estimating time uncertainty at the terminal device using a common-view method based on the global navigation satellite system common-view method information received from the serving access node and results of said at least one GNSS time measurement.

8. The terminal device of claim 5, wherein the uplink radio resource control message comprises a long term evolution positioning protocol request for assistance data for forwarding to a location management function of a core network.

9. The terminal device of claim 5, wherein the terminal device comprises a global navigation satellite system receiver,

the uplink radio resource control message comprises a long term evolution positioning protocol request for assistance data for forwarding to a location management function of a core network,

the long term evolution positioning protocol request further comprises a request for global navigation satellite system common-view method

information of the serving access node of the terminal device, said request comprising at least information on a global navigation satellite system used by the terminal device and at least one identifier of at least one satellite observable by the terminal device,

the first downlink radio resource control message corresponds to a first long term evolution positioning protocol message originating from the location management function further comprising the global navigation satellite system common-view method configuration information, said global navigation satellite system common-view method configuration information comprising at least global navigation satellite system time measurement timing information and information on at least one of the at least one satellite observable by both the terminal device and the serving access node and

the at least one memory and the computer program code are configured, with the at least one processor, to cause the terminal device to perform:

causing performing, according to the global navigation satellite system time measurement timing information, at least one global navigation satellite system time measurement via the global navigation satellite system receiver using said at least one of the at least one satellite;

receiving, from the location management function via the serving access node, a second long term evolution positioning protocol message comprising at least the global navigation satellite system common-view method information comprising at least information on global navigation satellite system time acquired by the serving access node from the at least one of the at least one satellite and time offset and/or correction information; and

causing estimating time uncertainty of the clock at the terminal device using a common-view method based on the global navigation satellite system common-view method information and results of said at least one global navigation satellite system time measurement.

10. The terminal device according to any preceding claim, wherein the terminal device comprises or is connected to a 5G modem and/or a device-side time sensitive networking translator.

11. An access node comprising:

at least one processor; and

at least one memory including computer program code;

the at least one memory and the computer program code configured, with the at least one processor, to cause the access node at least to perform:

receiving an uplink radio resource control message comprising an indication for preference for time traceability to a reference time standard for a terminal device from said terminal device or a request comprising said indication from a network function of a core network;

determining traceability information for enabling traceability of the clock of an access node to the reference time standard based on said indication; and

causing transmitting, from the access node to the terminal device, a first downlink radio resource control message comprising reference time information for the clock and the traceability information for the clock;

characterized in that the traceability information comprises at least information on a clock class indicative of a current synchronization status of the clock provided by the serving access node.

12. The access node of claim 11, wherein the clock class is defined to have a value selected from a set of pre-defined values indicating different synchronization statuses of the clock, said set of pre-defined values comprising values indicative of one or more of the following:

the serving access node is locked to a primary reference clock;

the serving access node is in a holdover mode after losing the primary reference clock but still within a designated holdover specification; or

the serving access node is in the holdover mode and is no longer within the designated holdover specification.

13. The access node of claim 12, wherein the designated holdover specification defines at least one or more pre-defined conditions for allowed clock drift.

14. The access node according to any of claims 11 to 13, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the access node to perform, before the transmitting of the first downlink radio resource control message:

causing performing, in the access node, at least one global positioning system time measurement from at least one satellite; and

causing transmitting a SIB9 message from the access node to the terminal device, wherein the SIB9 message comprises at least time information acquired by the access node from at least one of said at least one satellite for determining a clock of the global positioning system, at least one identifier of said at least one of the at least one satellite and time offset information.

15. The access node according to any of claims 11 to 13, wherein the uplink radio resource control message or the request comprising said indication further comprises a request for global navigation satellite system common-view method information, said request for global navigation satellite system common view method information comprising at least information on a global navigation satellite system used by the terminal device and at least one identifier of at least one satellite observable by the terminal device, the at least one memory and the computer program code being configured, with the at least one processor, to cause the access node to perform:

determining global navigation satellite system common-view method configuration information for the terminal device based on the request for global navigation satellite system common-view method information, wherein the global navigation satellite system common-view method configuration information comprises at least global navigation satellite system time measurement timing information and information on at least one of the at least one satellite observable by both the terminal device and the serving access node;

including the global navigation satellite system common-view method configuration information in the first downlink radio resource control message;

causing performing, according to the global navigation satellite system time measurement timing information at the access node, at least one global navigation satellite system time measurement using said at least one of the at least one satellite; and

causing transmitting, to the terminal device, a second downlink radio resource control message comprising the global navigation satellite system common-view method information comprising at least information on global navigation satellite system time acquired by the access node from the at least one of the at least one satellite and time offset and/or correction information.

16. The access node according to any of claims 11 to 13, wherein the network function is a location management function and the at least one memory and the computer program code are configured, with the at least one processor, to cause the access node to perform:

receiving, from the location management function, said request comprising said indication, wherein said request further comprises a request for the global navigation satellite system common-view method information, said request for global navigation satellite system common-view method information comprising at least information on a global navigation satellite system used by the terminal device and at least one identifier of at least one satellite observable by the terminal device;

determining global navigation satellite system common-view method configuration information for the terminal device based on said request for the global navigation satellite system common-view method information, wherein the global navigation satellite system common-view method configuration information comprises at least global navigation satellite system time measurement timing information and information on at least one of the at least one satellite observable by both the terminal device and the serving access;

causing transmitting the reference time information, the traceability information and said global navigation satellite system common-view method in formation to the location management function;

causing forwarding, in response to receiving a first long term evolution positioning protocol message from the location management function, the first long term evolution positioning protocol message as the first downlink radio resource control message to the terminal device, wherein the first long term evolution positing protocol message comprises the global navigation satellite system common-view method configuration information;

causing performing, according to the global navigation satellite system time measurement timing information at the access node, at least one global navigation satellite system time measurement using said at least one of the at least one satellite;

causing transmitting, to the location management function, the global navigation satellite system common-view method information comprising at least information on global navigation satellite system time acquired by the access node from the at least one of the at least one satellite and time offset and/or correction information; and

causing forwarding, in response to receiving a second long term evolution positioning protocol message comprising the global navigation satellite system common-view method information from the location management function, the second long term evolution positioning protocol message as a second down link radio resource control message to the terminal device.

17. The access node according to any of claims 11 to 15, wherein the at least one memory and the computer program code are configured, with the at least one processor, to cause the access node to perform the receiving of the request comprising said indication from the network function, wherein the request is a time synchronization service request comprising the indication indicating the preference for the traceability to the reference time standard for the terminal device and the network function is an application function.

18. The access node according to any of claims 11 to 15, wherein the network function is an application function or a location management function.

19. The terminal device according to any of claims 1 to 10, wherein the reference time standard is coordinated universal time.

20. The access node according to any of claims 11 to 18, wherein the reference time standard is coordinated universal time.