# METHODS AND APPARATUSES OF A MOBILITY ROBUSTNESS OPTIMIZATION (MRO) MECHANISM FOR A NON-TERRESTRIAL NETWORK (NTN)

## TECHNICAL FIELD

**[0001]** The present disclosure relates to wireless communications, and more specifically to methods and apparatuses of a mobility robustness optimization (MRO) mechanism for a non-terrestrial network (NTN).

## BACKGROUND

**[0002]** A wireless communications system may include one or multiple network communication devices, such as base stations, which may support wireless communications for one or multiple user communication devices, which may be otherwise known as user equipment (UE), or other suitable terminology. The wireless communications system may support wireless communications with one or multiple user communication devices by utilizing resources of the wireless communication system (e.g. time-domain resources (e.g. symbols, slots, subframes, frames, or the like) or frequency-domain resources (e.g. subcarriers, carriers, or the like). Additionally, the wireless communications system may support wireless communications across various radio access technologies including third generation (3G) radio access technology, fourth generation (4G) radio access technology, fifth generation (5G) radio access technology, among other suitable radio access technologies beyond 5G (e.g. sixth generation (6G)).

## SUMMARY

**[0003]** An article "a" before an element is unrestricted and understood to refer to "at least one" of those elements or "one or more" of those elements. The terms "a," "at least one," "one or more," and "at least one of one or more" may be interchangeable. As used herein, including in the claims, "or" as used in a list of items (e.g. a list of items prefaced by a phrase such as "at least one of" or "one or more of" or "one or both of") indicates an inclusive list such that, for example, a list of at least one of A, B, or C means A or B or C or AB or AC or BC or ABC (i.e. A and B and C). Also, as used herein, the phrase "based on" shall not be construed as a reference to a closed set of conditions. For example, an example step that is described as

"based on condition A" may be based on both a condition A and a condition B without departing from the scope of the present disclosure. In other words, as used herein, the phrase "based on" shall be construed in the same manner as the phrase "based at least in part on. Further, as used herein, including in the claims, a "set" may include one or more elements.

**[0004]** Some implementations of the present disclosure provide a user equipment (UE) for wireless communication. The UE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the UE to: obtain a first configuration used for the UE to store or report first information related with a mobility procedure in a non-terrestrial network (NTN); and store or report the first information.

**[0005]** In some implementations of the UE described herein, to obtain the first configuration, the processor of the UE is configured to: obtain the first configuration by pre-configuration; or receive the first configuration from a network equipment (NE).

**[0006]** In some implementations of the UE described herein, the first configuration includes one or more thresholds, and the one or more thresholds include at least one of the following: at least one first threshold related to a distance between the UE and a reference location of a source cell when a handover is initiated; at least one second threshold related to a distance between the UE and a moving reference location of the source cell when the handover is initiated; at least one third threshold related to a distance between the UE and the reference location of the source cell when the handover is successful; at least one fourth threshold related to a distance between the UE and the moving reference location of the source cell when the handover is successful; at least one fifth threshold related to a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated; at least one sixth threshold related to a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated; at least one seventh threshold related to a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful; at least one eighth threshold related to a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful; at least one ninth threshold related to time duration between when a location based conditional handover (CHO) execution condition configured for a cell is fulfilled and when a measurement based CHO execution condition configured for the cell is fulfilled; at least one timer T310 related

threshold; at least one timer T312 related threshold; or at least one timer T304 related threshold.

**[0007]** In some implementations of the UE described herein, the first information is stored upon at least one of the following: a satisfaction of at least one trigger condition associated with the one or more thresholds; or a successful completion of the handover.

**[0008]** In some implementations of the UE described herein, the satisfaction of the at least one trigger condition associated with the one or more thresholds includes at least one of the following: the distance between the UE and the reference location of the source cell when the handover is initiated is shorter than the at least one first threshold; the distance between the UE and the moving reference location of the source cell when the handover is initiated is shorter than the at least one second threshold; the distance between the UE and the reference location of the source cell when the handover is successful is shorter than the at least one third threshold; the distance between the UE and the moving reference location of the source cell when the handover is successful is shorter than the at least one fourth threshold; the distance between the UE and the reference location of the target cell or the candidate target cell when the handover is initiated is greater than the at least one fifth threshold; the distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is initiated is greater than the at least one sixth threshold; the distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful is greater than the at least one seventh threshold; the distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful is greater than the at least one eighth threshold; the time duration between when the location based CHO execution condition configured for the cell is fulfilled and when the measurement based CHO execution condition configured for the cell is fulfilled is greater than the at least one ninth threshold; a ratio between a value of elapsed running time of a timer T310 when the handover is initiated and a configured value of the timer T310 is greater than the at least one timer T310 related threshold; a ratio between a value of elapsed running time of a timer T312 when the handover is initiated and a configured value of the timer T312 is greater than the at least one timer T312 related threshold; or a ratio between a value of elapsed running time of a timer T304 and a configured value of the timer T304 is greater than the at least one timer T304 related threshold.

**[0009]** In some implementations of the UE described herein, the first information includes at least one of the following: a set of cell types of at least one cell; a distance between the UE and a reference location of a source cell when a handover is initiated; a distance between the UE and a moving reference location of the source cell when the handover is initiated; a distance between the UE and the reference location of the source cell when the handover is successful; a distance between the UE and the moving reference location of the source cell when the handover is successful; a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated; a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated; a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful; a cause value for the first information; at least one location based conditional handover (CHO) execution condition; a type of a firstly fulfilled CHO execution condition; a type of a secondly fulfilled CHO execution condition; a distance between the UE and the reference location of the source cell when a location based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the source cell when the location based CHO execution condition is fulfilled; a distance between the UE and the reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled; a distance between the UE and the reference location of the source cell when a measurement based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the source cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and the reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled; one or more measurement results of the source cell, or the target cell or the candidate target cell when the location based CHO execution condition is fulfilled; one or more measurement results of the source cell, or the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled; information

indicating whether a satellite switch with a re-synchronization procedure is configured; time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest radio resource control (RRC) reconfiguration message; time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest radio resource control (RRC) reconfiguration message; time duration between when the location based CHO execution condition configured for a cell is fulfilled and when the measurement based CHO execution condition configured for the cell is fulfilled; time elapsed between when the measurement based CHO execution condition is fulfilled and when the handover is successful; time elapsed between when the location based CHO execution condition is fulfilled and when the handover is successful; a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition; a radio link interruption since the handover is initiated or when the handover is successful; or information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

**[0010]** In some implementations of the UE described herein, the mobility procedure or the handover is performed in an ordinary handover procedure, a random access channel (RACH)-less handover procedure, a dual active protocol stack (DAPS) handover procedure, a conditional handover (CHO) procedure, another different mobility mechanism, or a combination thereof.

**[0011]** In some implementations of the UE described herein, the processor is configured to cause the UE to transmit optional UE capability information for supporting storage or report of the first information.

**[0012]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to: obtain a first configuration used for a user equipment (UE) to store or report first information related with a mobility procedure in a non-terrestrial network (NTN); and store or report the first information.

**[0013]** Some implementations of the present disclosure provide a method performed by a user equipment (UE) for wireless communication. The method includes: obtaining a first configuration used for the UE to store or report first information related with a mobility procedure in a non-terrestrial network (NTN); and storing or reporting the first information.

**[0014]** Some implementations of the present disclosure provide a network equipment (NE). The NE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the NE to receive first information related with a mobility procedure in a non-terrestrial network (NTN).

**[0015]** In some implementations of the NE described herein, the processor of the NE is configured to transmit, to a user equipment (UE), a first configuration used for the UE to store or report the first information.

**[0016]** In some implementations of the NE described herein, the first configuration includes one or more thresholds, and the one or more thresholds include at least one of the following: at least one first threshold related to a distance between the UE and a reference location of a source cell when a handover is initiated; at least one second threshold related to a distance between the UE and a moving reference location of the source cell when the handover is initiated; at least one third threshold related to a distance between the UE and the reference location of the source cell when the handover is successful; at least one fourth threshold related to a distance between the UE and the moving reference location of the source cell when the handover is successful; at least one fifth threshold related to a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated; at least one sixth threshold related to a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated; at least one seventh threshold related to a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful; at least one eighth threshold related to a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful; at least one ninth threshold related to time duration between when a location based conditional handover (CHO) execution condition configured for a cell is fulfilled and when a measurement based CHO execution condition configured for the cell is fulfilled; at least one timer T310 related threshold; at least one timer T312 related threshold; or at least one timer T304 related threshold.

**[0017]** In some implementations of the NE described herein, the first information includes at least one of the following: a set of cell types of at least one cell; a distance between a user equipment (UE) and a reference location of a source cell when a handover is initiated;

a distance between the UE and a moving reference location of the source cell when the handover is initiated; a distance between the UE and the reference location of the source cell when the handover is successful; a distance between the UE and the moving reference location of the source cell when the handover is successful; a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated; a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated; a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful; a cause value for the first information; at least one location based conditional handover (CHO) execution condition; a type of a firstly fulfilled CHO execution condition; a type of a secondly fulfilled CHO execution condition; a distance between the UE and the reference location of the source cell when a location based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the source cell when the location based CHO execution condition is fulfilled; a distance between the UE and the reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled; a distance between the UE and the reference location of the source cell when a measurement based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the source cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and the reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled; one or more measurement results of the source cell, or the target cell or the candidate target cell when the location based CHO execution condition is fulfilled; one or more measurement results of the source cell, or the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled; information indicating whether a satellite switch with a re-synchronization procedure is configured; time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest radio resource control (RRC) reconfiguration message;

time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest radio resource control (RRC) reconfiguration message; time duration between when the location based CHO execution condition configured for a cell is fulfilled and when the measurement based CHO execution condition configured for the cell is fulfilled; time elapsed between when the measurement based CHO execution condition is fulfilled and when the handover is successful; time elapsed between when the location based CHO execution condition is fulfilled and when the handover is successful; a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition; a radio link interruption since the handover is initiated or when the handover is successful; or information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

**[0018]** In some implementations of the NE described herein, the mobility procedure or the handover is performed in an ordinary handover procedure, a random access channel (RACH)-less handover procedure, a dual active protocol stack (DAPS) handover procedure, a conditional handover (CHO) procedure, another different mobility mechanism, or a combination thereof.

**[0019]** In some implementations of the NE described herein, the processor of the NE is configured to receive, from a user equipment (UE), optional UE capability information for supporting storage or report of the first information.

**[0020]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to receive first information related with a mobility procedure in a non-terrestrial network (NTN).

**[0021]** Some implementations of the present disclosure provide a method performed by a network equipment (NE). The method includes: receiving first information related with a mobility procedure in a non-terrestrial network (NTN).

**[0022]** Some implementations of the present disclosure provide a user equipment (UE) for wireless communication. The UE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the UE to: in response to

occurrence of a connection failure in a mobility procedure in a non-terrestrial network (NTN), store information related with the connection failure.

**[0023]** In some implementations of the UE described herein, the information related with the connection failure includes at least one of the following: a set of cell types of at least one cell; a distance between the UE and a reference location of a source cell when a handover is initiated; a distance between the UE and a moving reference location of the source cell when the handover is initiated; a distance between the UE and the reference location of the source cell when the connection failure happens; a distance between the UE and the moving reference location of the source cell when the connection failure happens; a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated; a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated; a distance between the UE and the reference location of the target cell or the candidate target cell when the connection failure happens; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the connection failure happens; at least one location based conditional handover (CHO) execution condition; a type of a firstly fulfilled CHO execution condition; or a type of a secondly fulfilled CHO execution condition; information indicating whether a satellite switch with a re-synchronization procedure is configured; information indicating whether a measurement based CHO execution condition configured for a cell is fulfilled when the connection failure happens; information indicating whether a location based CHO execution condition configured for the cell is fulfilled when the connection failure happens; a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition; a radio link interruption since the handover is initiated; or information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

**[0024]** In some implementations of the UE described herein, if the firstly fulfilled CHO execution condition is the location based CHO execution condition, and if only the location based CHO execution condition is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following: an identifier (ID) related to a first cell whose location based CHO execution condition is fulfilled but whose measurement based CHO execution condition is not fulfilled; a distance

between the UE and a reference location of a source cell when the location based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the source cell when the location based CHO execution condition is fulfilled; a distance between the UE and a reference location of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled; one or more measurement results of the source cell when the location based CHO execution condition is fulfilled; one or more measurement results of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled; time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest conditional reconfiguration; or time elapsed between when the location based CHO execution condition is fulfilled and when the connection failure happens.

**[0025]** In some implementations of the UE described herein, if the firstly fulfilled CHO execution condition is the measurement based CHO execution condition, and if only the measurement based CHO execution condition is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following: an identifier (ID) related to a second cell whose measurement based CHO execution condition is fulfilled but whose location based CHO execution condition is not fulfilled; a distance between the UE and a reference location of the source cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the source cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and a reference location of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled; one or more measurement results of the source cell when the measurement based CHO execution condition is fulfilled; one or more measurement results of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled; time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest conditional reconfiguration; or time elapsed between when the

measurement based CHO execution condition is fulfilled and when the connection failure happens.

**[0026]** In some implementations of the UE described herein, if both a location based CHO execution condition and a measurement based CHO execution condition are fulfilled before the connection failure happens: wherein the firstly fulfilled CHO execution condition is one of the location based CHO execution condition and the measurement based CHO execution condition, wherein the secondly fulfilled CHO execution condition is another one of the location based CHO execution condition and the measurement based CHO execution condition, and wherein the information related with the connection failure further includes at least one of the following: an identifier (ID) related to a third cell whose location based CHO execution condition is fulfilled and whose measurement based CHO execution condition is fulfilled; a distance between the UE and a reference location of a source cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the source cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and a reference location of the third cell or other candidate target cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the third cell or other candidate target cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and the reference location of the source cell when the secondly fulfilled CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the source cell when the secondly fulfilled CHO execution condition is fulfilled; a distance between the UE and the reference location of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled; one or more measurement results of the source cell when the firstly fulfilled CHO execution condition is fulfilled; one or more measurement results of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled; time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and a reception of a latest conditional reconfiguration; time elapsed between when the secondly fulfilled CHO execution condition is fulfilled and a reception of the latest conditional reconfiguration; time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and when the secondly fulfilled CHO execution

condition is fulfilled; time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and when the connection failure happens; or time elapsed between when the secondly fulfilled CHO execution condition is fulfilled and when the connection failure happens.

**[0027]** In some implementations of the UE described herein, the mobility procedure is an ordinary handover procedure, a random access channel (RACH)-less handover procedure, a dual active protocol stack (DAPS) handover procedure, a conditional handover (CHO) procedure, another different mobility mechanism, or a combination thereof.

**[0028]** In some implementations of the UE described herein, the processor of the UE is configured to report the information related with the connection failure, wherein the information related with the connection failure is reported via a radio link failure (RLF) report.

**[0029]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to: in response to occurrence of a connection failure in a mobility procedure in a non-terrestrial network (NTN), store information related with the connection failure.

**[0030]** Some implementations of the present disclosure provide a method performed by a user equipment (UE) for wireless communication. The method includes: in response to occurrence of a connection failure in a mobility procedure in a non-terrestrial network (NTN), storing information related with the connection failure.

**[0031]** Some implementations of the present disclosure provide a network equipment (NE). The NE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the NE to receive information related with a connection failure in a mobility procedure in a non-terrestrial network (NTN).

**[0032]** In some implementations of the NE described herein, the information related with the connection failure includes at least one of the following: a set of cell types of at least one cell; a distance between the UE and a reference location of a source cell when a handover is initiated; a distance between the UE and a moving reference location of the source cell when the handover is initiated; a distance between the UE and the reference location of the source cell when the connection failure happens; a distance between the UE and the moving

reference location of the source cell when the connection failure happens; a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated; a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated; a distance between the UE and the reference location of the target cell or the candidate target cell when the connection failure happens; a distance between the UE and the moving reference location of the target cell or the candidate target cell when the connection failure happens; at least one location based conditional handover (CHO) execution condition; a type of a firstly fulfilled CHO execution condition; or a type of a secondly fulfilled CHO execution condition; information indicating whether a satellite switch with a re-synchronization procedure is configured; information indicating whether a measurement based CHO execution condition configured for a cell is fulfilled when the connection failure happens; information indicating whether a location based CHO execution condition configured for the cell is fulfilled when the connection failure happens; a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition; a radio link interruption since the handover is initiated; or information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

**[0033]** In some implementations of the NE described herein, if the firstly fulfilled CHO execution condition is the location based CHO execution condition, and if only the location based CHO execution condition is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following: an identifier (ID) related to a first cell whose location based CHO execution condition is fulfilled but whose measurement based CHO execution condition is not fulfilled; a distance between the UE and a reference location of a source cell when the location based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the source cell when the location based CHO execution condition is fulfilled; a distance between the UE and a reference location of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled; one or more measurement results of the source cell when the location based CHO execution condition is fulfilled; one or more measurement results of the first cell or other candidate target cell when the location based CHO execution

condition is fulfilled; time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest conditional reconfiguration; or time elapsed between when the location based CHO execution condition is fulfilled and when the connection failure happens.

**[0034]** In some implementations of the NE described herein, if the firstly fulfilled CHO execution condition is the measurement based CHO execution condition, and if only the measurement based CHO execution condition is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following: an identifier (ID) related to a second cell whose measurement based CHO execution condition is fulfilled but whose location based CHO execution condition is not fulfilled; a distance between the UE and a reference location of the source cell when the e measurement based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the source cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and a reference location of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled; one or more measurement results of the source cell when the measurement based CHO execution condition is fulfilled; one or more measurement results of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled; time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest conditional reconfiguration; or time elapsed between when the measurement based CHO execution condition is fulfilled and when the connection failure happens.

**[0035]** In some implementations of the NE described herein, if both a location based CHO execution condition and a measurement based CHO execution condition are fulfilled before the connection failure happens: wherein the firstly fulfilled CHO execution condition is one of the location based CHO execution condition and the measurement based CHO execution condition, wherein the secondly fulfilled CHO execution condition is another one of the location based CHO execution condition and the measurement based CHO execution condition, and wherein the information related with the connection failure further includes at

least one of the following: an identifier (ID) related to a third cell whose location based CHO execution condition is fulfilled and whose measurement based CHO execution condition is fulfilled; a distance between the UE and a reference location of a source cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the source cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and a reference location of the third cell or other candidate target cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and a moving reference location of the third cell or other candidate target cell when the firstly fulfilled CHO execution condition is fulfilled; a distance between the UE and the reference location of the source cell when the secondly fulfilled CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the source cell when the secondly fulfilled CHO execution condition is fulfilled; a distance between the UE and the reference location of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled; a distance between the UE and the moving reference location of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled; one or more measurement results of the source cell when the firstly fulfilled CHO execution condition is fulfilled; one or more measurement results of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled; time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and a reception of a latest conditional reconfiguration; time elapsed between when the secondly fulfilled CHO execution condition is fulfilled and a reception of the latest conditional reconfiguration; time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and when the secondly fulfilled CHO execution condition is fulfilled; time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and when the connection failure happens; or time elapsed between when the secondly fulfilled CHO execution condition is fulfilled and when the connection failure happens.

**[0036]** In some implementations of the NE described herein, the mobility procedure is an ordinary handover procedure, a random access channel (RACH)-less handover procedure, a dual active protocol stack (DAPS) handover procedure, a conditional handover (CHO) procedure, another different mobility mechanism, or a combination thereof.

**[0037]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to receive information related with a connection failure in a mobility procedure in a non-terrestrial network (NTN).

**[0038]** Some implementations of the present disclosure provide a method performed by a network equipment (NE). The method includes: receiving information related with a connection failure in a mobility procedure in a non-terrestrial network (NTN).

**[0039]** Some implementations of the present disclosure provide a user equipment (UE) for wireless communication. The UE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the UE to: store non-terrestrial network (NTN) related information; and transmit the NTN related information, via a random access (RA) report.

**[0040]** In some implementations of the UE described herein, the NTN related information includes at least one of the following: a set of cell types of at least one cell of the UE; epoch time; ephemeris information; a scheduling offset used for timing relationships that are modified for NTN; a scheduling offset provided by a network equipment (NE) if downlink and uplink frame timing are not aligned at the NE; polarization information for a downlink transmission on a service link; polarization information for an uplink service link; validity duration configured by the NE for assistance information; a common timing advance (TA) value; a drift rate of the common TA value; drift rate variation of the common TA value; information indicating whether the UE is configured to report a TA value; or information indicating whether event-triggered reporting of the TA value is supported.

**[0041]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to: store non-terrestrial network (NTN) related information; and transmit the NTN related information, via a random access (RA) report.

**[0042]** Some implementations of the present disclosure provide a method performed by a user equipment (UE) for wireless communication. The method includes: storing non-terrestrial network (NTN) related information; and transmitting the NTN related information, via a random access (RA) report.

**[0043]** Some implementations of the present disclosure provide a network equipment (NE). The NE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the NE to receive a random access (RA) report including non-terrestrial network (NTN) related information.

**[0044]** In some implementations of the NE described herein, the NTN related information includes at least one of the following: a set of cell types of at least one cell of a user equipment (UE); epoch time; ephemeris information; a scheduling offset used for timing relationships that are modified for NTN; a scheduling offset provided by a network equipment (NE) if downlink and uplink frame timing are not aligned at the NE; polarization information for a downlink transmission on a service link; polarization information for an uplink service link; validity duration configured by the NE for assistance information; a common timing advance (TA) value; a drift rate of the common TA value; drift rate variation of the common TA value; information indicating whether the UE is configured to report a TA value; or information indicating whether event-triggered reporting of the TA value is supported.

**[0045]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to receive a random access (RA) report including non-terrestrial network (NTN) related information.

**[0046]** Some implementations of the present disclosure provide a method performed by a network equipment (NE). The method includes: receiving a random access (RA) report including non-terrestrial network (NTN) related information.

**[0047]** Some implementations of the present disclosure provide a user equipment (UE) for wireless communication. The UE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the UE to: store non-terrestrial network (NTN) related information of at least one cell of the UE; and transmit the NTN related information via or in mobility history information (MHI).

**[0048]** In some implementations of the UE described herein, the NTN related information includes at least one of the following: a set of cell identifiers (ID)s of the at least one cell; a set of cell types of the at least one cell; time duration when the UE stays in at least

one NTN cell; or time duration when the UE stays in at least one terrestrial network (TN) cell.

**[0049]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to: store non-terrestrial network (NTN) related information of at least one cell of the UE; and transmit the NTN related information via or in mobility history information (MHI).

**[0050]** Some implementations of the present disclosure provide a method performed by a user equipment (UE) for wireless communication. The method includes: storing non-terrestrial network (NTN) related information of at least one cell of the UE; and transmitting the NTN related information via or in mobility history information (MHI).

**[0051]** Some implementations of the present disclosure provide a network equipment (NE). The NE includes at least one memory; and at least one processor coupled to the at least one memory and configured to cause the NE to store user equipment (UE) history information, wherein the UE history information includes the NTN related information of at least one cell of a UE.

**[0052]** In some implementations of the NE described herein, the NTN related information includes at least one of the following: a set of cell identifiers (ID)s of the at least one cell; a set of cell types of the at least one cell; time duration when the UE stays in at least one NTN cell; or time duration when the UE stays in at least one terrestrial network (TN) cell.

**[0053]** Some implementations of the present disclosure provide a processor for wireless communication, comprising at least one controller coupled with at least one memory and configured to cause the processor to store user equipment (UE) history information, wherein the UE history information includes the NTN related information of at least one cell of a UE.

**[0054]** Some implementations of the present disclosure provide a method performed by a network equipment (NE). The method includes storing user equipment (UE) history information, wherein the UE history information includes the NTN related information of at least one cell of a UE.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0055]** Figure 1A illustrates an example of a Non-Terrestrial Network (NTN) in accordance with aspects of the present disclosure.

**[0056]** Figure 1B illustrates an example of timing relationship for collocated base station (BS) and NTN Gateway in accordance with aspects of the present disclosure.

**[0057]** Figure 1 illustrates an example of a wireless communications system in accordance with aspects of the present disclosure.

**[0058]** Figure 2 illustrates an example of a user equipment (UE) 200 in accordance with aspects of the present disclosure.

**[0059]** Figure 3 illustrates an example of a processor 300 in accordance with aspects of the present disclosure.

**[0060]** Figure 4 illustrates an example of a network equipment (NE) 400 in accordance with aspects of the present disclosure.

**[0061]** Figures 5-7 illustrates flowcharts of methods related to a MRO mechanism for NTN in accordance with some aspects of the present disclosure.

## DETAILED DESCRIPTION

**[0062]** The detailed description of the appended drawings is intended as a description of the preferred embodiments of the present disclosure and is not intended to represent the only form in which the present disclosure may be practiced. It should be understood that the same or equivalent functions may be accomplished by different embodiments that are intended to be encompassed within the spirit and scope of the present disclosure.

**[0063]** Reference will now be made in detail to some embodiments of the present disclosure, examples of which are illustrated in the accompanying drawings. To facilitate understanding, embodiments are provided under specific network architectures and new service scenarios, such as the 3rd generation partnership project (3GPP) 5G (NR), 3GPP long-term evolution (LTE) Release 8, and so on. It is contemplated that along with the developments of network architectures and new service scenarios, all embodiments in the present disclosure are also applicable to similar technical problems; and moreover, the

terminologies recited in the present disclosure may change, which should not affect the principles of the present disclosure.

**[0064]** Figure 1A illustrates an example of an NTN providing non-terrestrial NR access to the UE by means of an NTN payload and an NTN Gateway, depicting a service link between the NTN payload and a UE, and a feeder link between the NTN Gateway and the NTN payload.

**[0065]** The NTN payload transparently forwards the radio protocol received from the UE (via the service link) to the NTN Gateway (via the feeder link) and vice-versa. The following connectivity is supported by the NTN payload:

- An NTN gateway may serve multiple NTN payloads;
- An NTN payload may be served by multiple NTN gateways.

**[0066]** The NTN-payload may change the carrier frequency, before re-transmitting it on the service link, and vice versa (respectively on the feeder link).

**[0067]** Three types of service links may be supported:

- Earth-fixed: provisioned by beam(s) continuously covering the same geographical areas all the time (e.g. the case of GSO satellites);
- Quasi-Earth-fixed: provisioned by beam(s) covering one geographic area for a limited period and a different geographic area during another period (e.g. the case of NGSO satellites generating steerable beams);
- Earth-moving: provisioned by beam(s) whose coverage area slides over the Earth surface (e.g. the case of NGSO satellites generating fixed or non-steerable beams).

**[0068]** With NGSO satellites, a BS (e.g. gNB) can provide either quasi-Earth-fixed service link or Earth-moving service link, while the BS operating with GSO satellite can provide Earth fixed service link. The UE supporting NTN may be Global Navigation Satellite System (GNSS)-capable. In NTN, the distance may refer to Euclidean distance.

**[0069]** Regarding Timing and Synchronization, a downlink (DL) and an uplink (UL) are frame aligned at the uplink time synchronization reference point (RP) with an offset given by $N_{TA,offset}$ (see clause 4.2 of 3GPP standard document TS 38.213).

**[0070]** To accommodate the propagation delay in NTNs, several timing relationships are enhanced by a Common Timing Advance (Common TA) and two offsets $K_{\text{offset}}$ and $k_{\text{mac}}$:

- Common TA is a configured timing offset that is equal to the RTT between the RP and the NTN payload.
- $K_{\text{offset}}$ is a configured scheduling offset that needs to be larger or equal to the sum of the service link RTT and the Common TA.
- $k_{\text{mac}}$ is a configured offset that is approximately equal to the RTT between the RP and the gNB.

**[0071]** The scheduling offset $K_{\text{offset}}$ is used to allow the UE sufficient processing time between a downlink reception and an uplink transmission, see TS 38.213.

**[0072]** The offset $k_{\text{mac}}$ is used to delay the application of a downlink configuration indicated by a MAC CE command on PDSCH, see TS 38.213, and in estimation of UE-gNB RTT, see TS 38.321. It may be provided by the network when downlink and uplink frame timing are not aligned at the BS. The $k_{\text{mac}}$ is also used in the random access procedure, to determine the start time of RAR window/MsgB window after a Msg1/MsgA transmission (see TS 38.213).

**[0073]** The Service link RTT, Feeder link RTT, RP, Common TA, $k_{\text{mac}}$ and $T_{TA}$ are illustrated in Figure 1B.

**[0074]** The network may configure the HARQ operation as follows:

- For downlink, HARQ feedback can be enabled or disabled per HARQ process (as specified in clause 5.3.2.2 and clause 5.7 of TS 38.321). Disabling HARQ feedback allows scheduling a HARQ process before one HARQ RTT has elapsed since last scheduled.
- For uplink, HARQ mode (i.e. HARQ mode A or HARQ mode B) can be configured per HARQ process (as specified in clause 5.4.3.1 and clause 5.7 of TS 38.321). HARQ mode B allows scheduling a HARQ process before one HARQ RTT has elapsed since last scheduled.

**[0075]** For the HARQ processes configured with HARQ feedback enabled/disabled, it is up to network implementation to ensure a proper configuration of HARQ feedback (e.g.

either all enabled or all disabled) for HARQ processes used by an SPS configuration. For the HARQ processes configured with HARQ mode, it is up to network implementation to ensure a proper configuration of HARQ mode (e.g. either all HARQ mode A or all HARQ mode B) for HARQ processes used by a CG configuration.

**[0076]** Regarding Timing Advance and Frequency Pre-compensation, for the serving cell, the network broadcast valid ephemeris information and Common TA parameters. The UE shall have valid GNSS position as well as ephemeris and Common TA before connecting to an NTN cell. To achieve synchronization, before and during connection to an NTN cell, the UE shall compute the RTT between UE and the RP based on the GNSS position, the ephemeris, and the Common TA parameters (see clause 4.2 in TS 38.213), and autonomously pre-compensate the $T_{TA}$ for the RTT between the UE and the RP as illustrated in clause 4.3 of TS 38.211.

**[0077]** The UE shall compute the frequency Doppler shift of the service link, and autonomously pre-compensate for it in the uplink transmissions, by considering UE position and the ephemeris. If the UE does not have a valid GNSS position and/or valid ephemeris and Common TA, it shall not transmit until both are regained. In connected mode, the UE shall be able to continuously update the Timing Advance and frequency pre-compensation. The UE may be configured to report Timing Advance during Random Access procedures or in connected mode. In connected mode, event-triggered reporting of the Timing Advance is supported. While the pre-compensation of the instantaneous Doppler shift experienced on the service link is to be performed by the UE, the management of Doppler shift experienced over the feeder link and transponder frequency error is left to the network implementation.

**[0078]** In general, during mobility between NTN and Terrestrial Network (TN), a UE is not required to connect to both NTN and TN at the same time. NTN TN handover may refer to mobility in both directions, i.e. from NTN to TN (hand-in) and from TN to NTN (hand-out). A UE may support mobility between BSs operating with NTN payloads in different orbits (e.g., GSO, NGSO at different altitudes). RACH-less handover as specified in TS 38.32 may be supported in NTNs.

**[0079]** Regarding Conditional Handover (CHO) in NTN, NTN supports the following additional trigger conditions upon which a UE may execute CHO to a candidate cell, as defined in TS 38.331:

- the RRM measurement-based event A4;
- a time-based trigger condition; and/or
- a location-based trigger condition.

**[0080]** CondEvent D1 may be configured in a CHO procedure, CondEvent D1 is a location-based trigger condition or event, which is defined that: Distance between a UE and a reference location *referenceLocation1* becomes larger than configured threshold *distanceThreshFromReference1* and distance between UE and a reference location *referenceLocation2* of conditional reconfiguration candidate becomes shorter than configured threshold *distanceThreshFromReference2*. The details can refer to TS 38.331.

**[0081]** CondEvent D2 may be configured in a CHO procedure, CondEvent D2 is a location-based trigger condition or event, which is defined that: Distance between a UE and a moving reference location determined based on *referenceLocation1* becomes larger than configured threshold *distanceThreshFromReference1* and distance between UE and a moving reference location determined based on *referenceLocation2* of conditional reconfiguration candidate becomes shorter than configured threshold *distanceThreshFromReference2*. The details can refer to TS 38.331.

**[0082]** A time-based trigger condition/event or a location-based trigger condition/event is always configured together with one of the measurement-based trigger conditions (or radio link quality-based trigger conditions or events, e.g. CondEvent A3, CondEvent A4 or CondEvent A5) as defined in TS 38.331.

**[0083]** It is up to the UE's implementation how the UE evaluates the time-based trigger condition or location-based trigger condition together with the RRM measurement-based event.

**[0084]** Location may be defined by the distance between a UE and a reference location. Time may be defined by the time between T1 and T2, where T1 is an absolute time value and T2 is a duration started at T1. Time-based CHO can be performed via RACH-less.

**[0085]** Regarding satellite switch with re-sync, upon both hard and soft satellite switch over in the quasi-Earth fixed scenario with the same SSB frequency and the same BS, the satellite switch with re-sync procedure is supported. The satellite switch with re-sync avoids

a L3 mobility for UEs in the cell by maintaining the same PCI on the geographical area covered by quasi-Earth fixed beam. CHO can be configured simultaneously with the satellite switch with re-sync procedure. For soft satellite switch over, the UE can start synchronizing with the target satellite before the source satellite ends to serve the cell. It is not required for the UE to be connected to source satellite when the UE switches to target satellite.

**[0086]** Regarding an RLF report, one of the functions of MRO is to detect connection failures that occur due to Too Early or Too Late Handovers, or Handover to Wrong Cell. These problems are defined as follows:

- Intra-system Too Late Handover: an RLF occurs after the UE has stayed for a long period of time in the cell; the UE attempts to re-establish the radio link connection in a different cell.

- Intra-system Too Early Handover: an RLF occurs shortly after a successful handover from a source cell to a target cell or a handover failure occurs during the handover procedure; the UE attempts to re-establish the radio link connection in the source cell.

- Intra-system Handover to Wrong Cell: an RLF occurs shortly after a successful handover from a source cell to a target cell or a handover failure occurs during the handover procedure; the UE attempts to re-establish the radio link connection in a cell other than the source cell and the target cell.

**[0087]** In the definition above, the "successful handover" refers to the UE state, namely the successful completion of the RA procedure.

**[0088]** In case of CHO, the Too Late Handover, Too Early Handover and Handover to Wrong Cell in the definition above means Too Late CHO Execution, Too Early CHO Execution and CHO Execution to Wrong Cell.

**[0089]** Regarding a detection mechanism, a failure indication may be initiated after a UE attempts to re-establish the radio link connection at NG-RAN node B after a failure at NG-RAN node A. NG-RAN node B may initiate the Failure Indication procedure towards multiple NG-RAN nodes if they control cells which use the PCI signalled by the UE during the re-establishment procedure. The NG-RAN node receiving this selects the UE context that matches the received Failure Cell ID and C-RNTI, and, if available, uses the shortMAC-I to

confirm this identification, by calculating the shortMAC-I and comparing it to the received IE.

**[0090]** A failure indication may also be sent to the node last serving the UE when the NG-RAN node fetches the RLF REPORT from UE by triggering:

- The Failure Indication procedure over Xn interface.

- The Uplink RAN configuration transfer procedure and Downlink RAN configuration transfer procedure over NG.

**[0091]** In case of Too Early Handover or Handover to Wrong Cell, the NG-RAN node receiving the failure indication may inform the NG-RAN node controlling the cell where the mobility configuration caused the failure by means of the Handover Report procedure over Xn interface or the Uplink RAN Configuration Transfer procedure over NG. This may include the RLF report.

**[0092]** After an RLF or Handover failure, a UE will perform re-establishment in a cell. UE will store some information related with RLF failure and/or handover failure information. The UE stores the latest RLF Report, including RLF report until the RLF report is fetched by the network or for 48 hours after the connection failure is detected. For analysis of connection failures, the UE makes the RLF Report available to the network. The availability of an RLF Report may be indicated by the *RRCSetupComplete, RRCResumeComplete* or *RRCRe-establishmentComplete*, e.g. if the UE has failure related information available in VarRLF-Report, it can include rlf-InfoAvailable in the *RRCSetupComplete, RRCResumeComplete* or *RRCRe-establishmentComplete* message. The network may fetch information of an RLF report via UE Information Request/Response mechanism, i.e. the gNB may transmit *UEinformationrequest* to UE. Then, the UE will transmit *UEinformationresponse* including RLF-report to network. Network can optimize the mobility problem based on the response from UE.

**[0093]** Regarding a Successful Handover Report (SHR), one of the functions of MRO is to detect a sub-optimal successful handover event. The aim is to identify underlying conditions during successful ordinary handovers, successful DAPS handovers, or successful Conditional handovers.

**[0094]** For analysis of successful handover, the UE may collect SHR based on configuration by network, if stored, and makes the SHR available to the network as specified in TS 38.331.

**[0095]** For SHR collected during intra-NR handover, if the target NR node fetches the SHR from the UE and the trigger of SHR is timer T310 or T312, it may forward the information to the source NR node, i.e. the node handling the cell reported as source cell in this SHR, by using the ACCESS AND MOBILITY INDICATION message over Xn interface or by means of the Uplink RAN configuration transfer procedure and Downlink RAN configuration transfer procedure over NG.

**[0096]** If the NG-RAN node that fetches the SHR from the UE is neither the source node nor the target node of the handover, it forwards the information to the node(s) which configured the SHR trigger causing the SHR to be generated, by using the ACCESS AND MOBILITY INDICATION message over Xn interface or by means of the Uplink RAN configuration transfer procedure and Downlink RAN configuration transfer procedure over NG.

**[0097]** Upon retrieval of a SHR, the receiving node may analyze whether its mobility configuration needs adjustment.

**[0098]** In some cases, a UE may report UE history information (e.g. MHI) when connecting to a cell of the NG-RAN node, consisting of PCell mobility history information and optionally PSCell mobility history information, as specified in TS 38.331. When information needs to be discarded because the list is full, such information will be discarded in order of its position in the list, starting with the oldest cell record. If the list is full, and the UE history information from the UE is available, the UE history information from the UE should also be discarded.

**[0099]** In some cases, a NG-RAN node collects and stores UE History Information as long as a UE stays in one of its cells. In MR-DC case, the MN stores and correlates the UE History Information from a MN and SN(s) as long as the UE stays in MR-DC, forwards the UE History Information and optional UE History Information from the UE to its connected SNs. The resulting information is then used by SN for dual-connectivity operation. The SN

is in charge of collecting SCG UE history information and providing the collected information to the MN.

**[0100]** In general, NTN is a new feature introduced in 3GPP Rel-17 and Rel-18. To optimize NTN related configuration to improve mobility robustness, a MRO mechanism for NTN would be supported. Currently, details for a MRO mechanism for NTN including below issues need to be solved. In a mobility procedure in NTN, a near-failure successful handover may happen, and an issue is how to enable a network equipment (NE) to optimize mobility related configuration and/or mobility related threshold (e.g. reference signal received power (RSRP) or reference signal received quality (RSRQ) or signal to interference plus noise ratio (SINR) threshold to trigger an ordinary handover (i.e. a normal legacy handover) or a RACH-less handover procedure or a DAPS handover, or a location related threshold (e.g. distanceThreshFromReference1 or distanceThreshFromReference2) for triggering CHO execution). Issues of how to trigger storing or reporting a successful report for mobility in NTN (e.g. what is NTN specific trigger condition(s) for SHR), and what is successful mobility related information in NTN to be stored or reported by a UE have not been solved. In a mobility procedure in NTN, a connection failure may happen, to enable a NE to understand a failure for MRO optimization, an issue of what is failure related information in NTN to be stored or reported by a UE has not been solved. For mobility in RRC_IDLE or RRC_INACTIVE or RRC_CONNECTED state of a UE, the UE may perform an RA procedure towards a cell, and an RA report may be stored or reported by the UE, but an issue of what is NTN specific information to be stored or reported by the UE in an RA report has not been solved. In addition, an issue of what is NTN specific history information has not been solved.

**[0101]** Embodiments of the present disclosure aim to resolve the abovementioned issues. For example, some embodiments of the present disclosure provide a method to trigger a successful report in NTN. In some embodiments, NTN specific trigger condition(s) for a UE to log or store or generate a successful report for NTN are configured to the UE. For instance, the NTN specific trigger condition(s) may be distance threshold(s) regarding a distance between the UE and "a reference location or a moving reference location of a source cell (i.e. a serving cell)", or distance threshold(s) regarding a distance between the UE and "a reference location or a moving reference location of a target cell or a candidate target cell", when a

reception of the RRC reconfiguration message for mobility or when mobility is performed or when a mobility execution is successful, or a time threshold related to time duration between " when a location based CHO execution condition or event is satisfied (or fulfilled)" and "when a measurement based CHO execution condition or event is satisfied". The details of NTN specific trigger condition(s) can refer to Embodiment 1-1 as described below.

**[0102]** In some embodiments of the present disclosure, when NTN specific trigger condition(s) for a UE to log or store or generate a successful report for NTN is satisfied, the UE logs or stores or generates the successful report for NTN to include NTN specific information, e.g. including a distance between the UE and "a reference location or a moving reference location of a source cell," or a distance between the UE and "a reference location or a moving reference location of a target cell or a candidate target cell," when reception of the RRC reconfiguration message for mobility or when mobility is performed or when a mobility execution is successful or when a location based CHO execution condition or event is fulfilled or when measurement based CHO execution condition or event is fulfilled. The details of the NTN specific mobility information (e.g. included in the successful report) can refer to Embodiment 2-1 as described below.

**[0103]** Some other embodiments of the present disclosure provide a method to enhance a failure report in NTN. In some embodiments, NTN specific failure information may be stored or reported by a UE, e.g. in an RLF report. For example, the NTN specific failure information may include a distance between the UE and "a reference location or a moving reference location of a source cell," or a distance between the UE and "a reference location or a moving reference location of a target cell or a candidate target cell," when reception of the RRC reconfiguration message for mobility or when mobility is performed or when a connection failure occurs or when location based CHO execution condition or event is fulfilled or when measurement based CHO execution condition or event is fulfilled. The details of the NTN specific failure information (e.g. included in RLF report) can refer to Embodiment 2-2 as described below.

**[0104]** In the embodiments of the present disclosure, the mobility may be performed in an ordinary handover procedure (i.e. a normal or Rel-15 legacy handover), a RACH-less handover procedure, a DAPS handover procedure (e.g. a Rel-16 DAPS handover), a CHO procedure (e.g. a Rel-16 CHO), another different mobility mechanism (e.g. L1/L2-Triggered

Mobility (LTM) cell switch, or any new mobile technology or solution introduced by a subsequent standard), or a combination thereof.

**[0105]** Some embodiments of the present disclosure provide a method to enhance an RA report in NTN. For example, NTN specific information may be stored or reported by a UE in an RA report. The details of NTN specific information included in the RA report can refer to Embodiment 3 as described below.

**[0106]** Some embodiments of the present disclosure provide a method to enhance UE history information (UHI) or mobility history information (MHI) in NTN. For example, a UE may store or report NTN related information of at least one cell, e.g. in/via MHI. The network may store or record NTN related information of at least one cell, e.g. in/via UHI. In some embodiments of the present disclosure, MHI or UHI may include cell type (e.g. the cell is an NTN cell or the cell is a TN cell), the time duration or a percentage of time when the UE stays in the NTN cell, and etc. The details of MHI or UHI can refer to Embodiment 4-1 and Embodiment 4-2 as described below.

**[0107]** In some embodiments of the present disclosure, for SON enhancements for NTN, a new optional feature is introduced in SON reports. The new optional feature is optional without signalling, and it covers a SHR or an RLF report or an RA report. For a SHR for NTN, it is an optional feature without signalling. For an RLF report for NTN, it is an optional feature without signalling. For an RA report for NTN, it is an optional feature without signalling.

**[0108]** More details of the embodiments of the present disclosure will be illustrated in the following text in combination with the appended drawings.

**[0109]** Figure 1 illustrates an example of a wireless communications system 100 in accordance with aspects of the present disclosure. The wireless communications system 100 may include one or more NE 102, one or more UE 104, and a core network (CN) 106. The wireless communications system 100 may support various radio access technologies. In some implementations, the wireless communications system 100 may be a 4G network, such as an LTE network or an LTE-Advanced (LTE-A) network. In some other implementations, the wireless communications system 100 may be a NR network, such as a 5G network, a 5G-Advanced (5G-A) network, or a 5G ultrawideband (5G-UWB) network. In other

implementations, the wireless communications system 100 may be a combination of a 4G network and a 5G network, or other suitable radio access technology including Institute of Electrical and Electronics Engineers (IEEE) 802.11 (Wi-Fi), IEEE 802.16 (WiMAX), IEEE 802.20. The wireless communications system 100 may support radio access technologies beyond 5G, for example, 6G. Additionally, the wireless communications system 100 may support technologies, such as time division multiple access (TDMA), frequency division multiple access (FDMA), or code division multiple access (CDMA), etc.

**[0110]** The one or more NE 102 may be dispersed throughout a geographic region to form the wireless communications system 100. One or more of the NE 102 described herein may be or include or may be referred to as a network node, a base station, a network element, a network function, a network entity, a radio access network (RAN), a NodeB, an eNodeB (eNB), a next-generation NodeB (gNB), or other suitable terminology. An NE 102 and a UE 104 may communicate via a communication link, which may be a wireless or wired connection. For example, an NE 102 and a UE 104 may perform wireless communication (e.g. receive signaling, transmit signaling) over a Uu interface.

**[0111]** An NE 102 may provide a geographic coverage area for which the NE 102 may support services for one or more UEs 104 within the geographic coverage area. For example, an NE 102 and a UE 104 may support wireless communication of signals related to services (e.g. voice, video, packet data, messaging, broadcast, etc.) according to one or multiple radio access technologies. In some implementations, an NE 102 may be moveable, for example, a satellite associated with a non-terrestrial network (NTN). In some implementations, different geographic coverage areas associated with the same or different radio access technologies may overlap, but the different geographic coverage areas may be associated with different NE 102.

**[0112]** The one or more UE 104 may be dispersed throughout a geographic region of the wireless communications system 100. A UE 104 may include or may be referred to as a remote unit, a mobile device, a wireless device, a remote device, a subscriber device, a transmitter device, a receiver device, or some other suitable terminology. In some implementations, the UE 104 may be referred to as a unit, a station, a terminal, or a client, among other examples. Additionally, or alternatively, the UE 104 may be referred to as an

Internet-of-Things (IoT) device, an Internet-of-Everything (IoE) device, or machine-type communication (MTC) device, among other examples.

**[0113]** A UE 104 may be able to support wireless communication directly with other UEs 104 over a communication link. For example, a UE 104 may support wireless communication directly with another UE 104 over a device-to-device (D2D) communication link. In some implementations, such as vehicle-to-vehicle (V2V) deployments, vehicle-to-everything (V2X) deployments, or cellular-V2X deployments, the communication link may be referred to as a sidelink. For example, a UE 104 may support wireless communication directly with another UE 104 over a PC5 interface.

**[0114]** An NE 102 may support communications with the CN 106, or with another NE 102, or both. For example, an NE 102 may interface with other NE 102 or the CN 106 through one or more backhaul links (e.g. S1, N2, or network interface). In some implementations, the NE 102 may communicate with each other directly. In some other implementations, the NE 102 may communicate with each other or indirectly (e.g. via the CN 106. In some implementations, one or more NE 102 may include subcomponents, such as an access network entity, which may be an example of an access node controller (ANC). An ANC may communicate with the one or more UEs 104 through one or more other access network transmission entities, which may be referred to as a radio heads, smart radio heads, or transmission-reception points (TRPs).

**[0115]** The CN 106 may support user authentication, access authorization, tracking, connectivity, and other access, routing, or mobility functions. The CN 106 may be an evolved packet core (EPC), or a 5G core (5GC), which may include a control plane entity that manages access and mobility (e.g. a mobility management entity (MME), an access and mobility management functions (AMF)) and a user plane entity that routes packets or interconnects to external networks (e.g. a serving gateway (S-GW), a Packet Data Network (PDN) gateway (P-GW), or a user plane function (UPF)). In some implementations, the control plane entity may manage non-access stratum (NAS) functions, such as mobility, authentication, and bearer management (e.g. data bearers, signal bearers, etc.) for the one or more UEs 104 served by the one or more NE 102 associated with the CN 106.

**[0116]** The CN 106 may communicate with a packet data network over one or more backhaul links (e.g. via an S1, N2, or another network interface). The packet data network

may include an application server. In some implementations, one or more UEs 104 may communicate with the application server. A UE 104 may establish a session (e.g. a protocol data unit (PDU) session, or the like) with the CN 106 via an NE 102. The CN 106 may route traffic (e.g. control information, data, and the like) between the UE 104 and the application server using the established session (e.g. the established PDU session). The PDU session may be an example of a logical connection between the UE 104 and the CN 106 (e.g. one or more network functions of the CN 106).

**[0117]** In the wireless communications system 100, the NEs 102 and the UEs 104 may use resources of the wireless communications system 100 (e.g. time resources (e.g. symbols, slots, subframes, frames, or the like) or frequency resources (e.g. subcarriers, carriers)) to perform various operations (e.g. wireless communications). In some implementations, the NEs 102 and the UEs 104 may support different resource structures. For example, the NEs 102 and the UEs 104 may support different frame structures. In some implementations, such as in 4G, the NEs 102 and the UEs 104 may support a single frame structure. In some other implementations, such as in 5G and among other suitable radio access technologies, the NEs 102 and the UEs 104 may support various frame structures (i.e. multiple frame structures). The NEs 102 and the UEs 104 may support various frame structures based on one or more numerologies.

**[0118]** One or more numerologies may be supported in the wireless communications system 100, and a numerology may include a subcarrier spacing and a cyclic prefix. A first numerology (e.g. $\mu$=0) may be associated with a first subcarrier spacing (e.g. 15 kHz) and a normal cyclic prefix. In some implementations, the first numerology (e.g. $\mu$=0) associated with the first subcarrier spacing (e.g. 15 kHz) may utilize one slot per subframe. A second numerology (e.g. $\mu$=1) may be associated with a second subcarrier spacing (e.g. 30 kHz) and a normal cyclic prefix. A third numerology (e.g. $\mu$=2) may be associated with a third subcarrier spacing (e.g. 60 kHz) and a normal cyclic prefix or an extended cyclic prefix. A fourth numerology (e.g. $\mu$=3) may be associated with a fourth subcarrier spacing (e.g. 120 kHz) and a normal cyclic prefix. A fifth numerology (e.g. $\mu$=4) may be associated with a fifth subcarrier spacing (e.g. 240 kHz) and a normal cyclic prefix.

**[0119]** A time interval of a resource (e.g. a communication resource) may be organized according to frames (also referred to as radio frames). Each frame may have a duration, for

example, a 10 millisecond (ms) duration. In some implementations, each frame may include multiple subframes. For example, each frame may include 10 subframes, and each subframe may have a duration, for example, a 1 ms duration. In some implementations, each frame may have the same duration. In some implementations, each subframe of a frame may have the same duration.

**[0120]** Additionally or alternatively, a time interval of a resource (e.g. a communication resource) may be organized according to slots. For example, a subframe may include a number (e.g. quantity) of slots. The number of slots in each subframe may also depend on the one or more numerologies supported in the wireless communications system 100. For instance, the first, second, third, fourth, and fifth numerologies (i.e. $\mu$=0, $\mu$=1, $\mu$=2, $\mu$=3, $\mu$=4) associated with respective subcarrier spacings of 15 kHz, 30 kHz, 60 kHz, 120 kHz, and 240 kHz may utilize a single slot per subframe, two slots per subframe, four slots per subframe, eight slots per subframe, and 16 slots per subframe, respectively. Each slot may include a number (e.g. quantity) of symbols (e.g. OFDM symbols). In some implementations, the number (e.g. quantity) of slots for a subframe may depend on a numerology. For a normal cyclic prefix, a slot may include 14 symbols. For an extended cyclic prefix (e.g. applicable for 60 kHz subcarrier spacing), a slot may include 12 symbols. The relationship between the number of symbols per slot, the number of slots per subframe, and the number of slots per frame for a normal cyclic prefix and an extended cyclic prefix may depend on a numerology. It should be understood that reference to a first numerology (e.g. $\mu$=0) associated with a first subcarrier spacing (e.g. 15 kHz) may be used interchangeably between subframes and slots.

**[0121]** In the wireless communications system 100, an electromagnetic (EM) spectrum may be split, based on frequency or wavelength, into various classes, frequency bands, frequency channels, etc. By way of example, the wireless communications system 100 may support one or multiple operating frequency bands, such as frequency range designations FR1 (410 MHz – 7.125 GHz), FR2 (24.25 GHz – 52.6 GHz), FR3 (7.125 GHz – 24.25 GHz), FR4 (52.6 GHz – 114.25 GHz), FR4a or FR4-1 (52.6 GHz – 71 GHz), and FR5 (114.25 GHz – 300 GHz). In some implementations, the NEs 102 and the UEs 104 may perform wireless communications over one or more of the operating frequency bands. In some implementations, FR1 may be used by the NEs 102 and the UEs 104, among other equipment or devices for cellular communications traffic (e.g. control information, data). In some

implementations, FR2 may be used by the NEs 102 and the UEs 104, among other equipment or devices for short-range, high data rate capabilities.

**[0122]** FR1 may be associated with one or multiple numerologies (e.g. at least three numerologies). For example, FR1 may be associated with a first numerology (e.g. $\mu$=0), which includes 15 kHz subcarrier spacing; a second numerology (e.g. $\mu$=1), which includes 30 kHz subcarrier spacing; and a third numerology (e.g. $\mu$=2), which includes 60 kHz subcarrier spacing. FR2 may be associated with one or multiple numerologies (e.g. at least 2 numerologies). For example, FR2 may be associated with a third numerology (e.g. $\mu$=2), which includes 60 kHz subcarrier spacing; and a fourth numerology (e.g. $\mu$=3), which includes 120 kHz subcarrier spacing.

**[0123]** Figure 2 illustrates an example of a UE 200 in accordance with aspects of the present disclosure. The UE 200 may include a processor 202, a memory 204, a controller 206, and a transceiver 208. The processor 202, the memory 204, the controller 206, or the transceiver 208, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g. operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

**[0124]** The processor 202, the memory 204, the controller 206, or the transceiver 208, or various combinations or components thereof may be implemented in hardware (e.g. circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

**[0125]** The processor 202 may include an intelligent hardware device (e.g. a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 202 may be configured to operate the memory 204. In some other implementations, the memory 204 may be integrated into the processor 202. The processor 202 may be configured to execute computer-readable instructions stored in the memory 204 to cause the UE 200 to perform various functions of the present disclosure.

**[0126]** The memory 204 may include volatile or non-volatile memory. The memory 204 may store computer-readable, computer-executable code including instructions when executed by the processor 202 cause the UE 200 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 204 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

**[0127]** In some implementations, the processor 202 and the memory 204 coupled with the processor 202 may be configured to cause the UE 200 to perform one or more of the functions described herein (e.g. executing, by the processor 202, instructions stored in the memory 204).

**[0128]** For example, the processor 202 may support wireless communication at the UE 200 in accordance with examples as disclosed with respect to Figure 5. The UE 200 may be configured to support: a means for obtaining a configuration used for the UE 200 to store or report information related with mobility in an NTN; and a means for storing or reporting the information related with a mobility procedure in the NTN. For example, the information related with mobility in the NTN is reported by the UE 200 in a SHR or other named report or a new introduced report.

**[0129]** For example, the processor 202 may support wireless communication at the UE 200 which may be configured to support: in response to occurrence of a connection failure in a mobility procedure in an NTN, a means for storing information related with the connection failure. For example, the information related with the connection failure is reported by the UE 200 in an RLF report.

**[0130]** For example, the processor 202 may support wireless communication at the UE 200 in accordance with examples as disclosed with respect to Figure 6. The UE 200 may be configured to support: a means for storing NTN related information; and a means for transmitting the NTN related information, for example, via a random access (RA) report.

**[0131]** For example, the processor 202 may support wireless communication at the UE 200 in accordance with examples as disclosed with respect to Figure 7. The UE 200 may be configured to support: a means for storing NTN related information of at least one cell of the UE; and a means for transmitting the NTN related information via or in mobility history information (MHI).

**[0132]** The controller 206 may manage input and output signals for the UE 200. The controller 206 may also manage peripherals not integrated into the UE 200. In some implementations, the controller 206 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 206 may be implemented as part of the processor 202.

**[0133]** In some implementations, the UE 200 may include at least one transceiver 208. In some other implementations, the UE 200 may have more than one transceiver 208. The transceiver 208 may represent a wireless transceiver. The transceiver 208 may include one or more receiver chains 210, one or more transmitter chains 212, or a combination thereof. The means for receiving abovementioned in the processor 202 or the means for transmitting in the processor 202 may be implemented via at least one transceiver 208.

**[0134]** A receiver chain 210 may be configured to receive signals (e.g. control information, data, packets) over a wireless medium. For example, the receiver chain 210 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 210 may include at least one amplifier (e.g. a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 210 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 210 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

**[0135]** A transmitter chain 212 may be configured to generate and transmit signals (e.g. control information, data, packets). The transmitter chain 212 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation

(QAM). The transmitter chain 212 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 212 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

**[0136]** Figure 3 illustrates an example of a processor 300 in accordance with aspects of the present disclosure. The processor 300 may be an example of a processor configured to perform various operations in accordance with examples as described herein. The processor 300 may include a controller 302 configured to perform various operations in accordance with examples as described herein. The processor 300 may optionally include at least one memory 304, which may be, for example, an L1/L2/L3 cache. Additionally, or alternatively, the processor 300 may optionally include one or more arithmetic-logic units (ALUs) 306. One or more of these components may be in electronic communication or otherwise coupled (e.g. operatively, communicatively, functionally, electronically, electrically) via one or more interfaces (e.g. buses).

**[0137]** The processor 300 may be a processor chipset and include a protocol stack (e.g. a software stack) executed by the processor chipset to perform various operations (e.g. receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) in accordance with examples as described herein. The processor chipset may include one or more cores, one or more caches (e.g. memory local to or included in the processor chipset (e.g. the processor 300) or other memory (e.g. random access memory (RAM), read-only memory (ROM), dynamic RAM (DRAM), synchronous dynamic RAM (SDRAM), static RAM (SRAM), ferroelectric RAM (FeRAM), magnetic RAM (MRAM), resistive RAM (RRAM), flash memory, phase change memory (PCM), and others).

**[0138]** The controller 302 may be configured to manage and coordinate various operations (e.g. signaling, receiving, obtaining, retrieving, transmitting, outputting, forwarding, storing, determining, identifying, accessing, writing, reading) of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. For example, the controller 302 may operate as a control unit of the processor 300, generating control signals that manage the operation of various components

of the processor 300. These control signals include enabling or disabling functional units, selecting data paths, initiating memory access, and coordinating timing of operations.

**[0139]** The controller 302 may be configured to fetch (e.g. obtain, retrieve, receive) instructions from the memory 304 and determine subsequent instruction(s) to be executed to cause the processor 300 to support various operations in accordance with examples as described herein. The controller 302 may be configured to track memory address of instructions associated with the memory 304. The controller 302 may be configured to decode instructions to determine the operation to be performed and the operands involved. For example, the controller 302 may be configured to interpret the instruction and determine control signals to be output to other components of the processor 300 to cause the processor 300 to support various operations in accordance with examples as described herein. Additionally, or alternatively, the controller 302 may be configured to manage flow of data within the processor 300. The controller 302 may be configured to control transfer of data between registers, arithmetic logic units (ALUs), and other functional units of the processor 300.

**[0140]** The memory 304 may include one or more caches (e.g. memory local to or included in the processor 300 or other memory, such RAM, ROM, DRAM, SDRAM, SRAM, MRAM, flash memory, etc. In some implementations, the memory 304 may reside within or on a processor chipset (e.g. local to the processor 300). In some other implementations, the memory 304 may reside external to the processor chipset (e.g. remote to the processor 300).

**[0141]** The memory 304 may store computer-readable, computer-executable code including instructions that, when executed by the processor 300, cause the processor 300 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such as system memory or another type of memory. The controller 302 and/or the processor 300 may be configured to execute computer-readable instructions stored in the memory 304 to cause the processor 300 to perform various functions. For example, the processor 300 and/or the controller 302 may be coupled with or to the memory 304, the processor 300, the controller 302, and the memory 304 may be configured to perform various functions described herein. In some examples, the processor 300 may include multiple processors and the memory 304 may include multiple memories. One or

more of the multiple processors may be coupled with one or more of the multiple memories, which may, individually or collectively, be configured to perform various functions herein.

**[0142]** The one or more ALUs 306 may be configured to support various operations in accordance with examples as described herein. In some implementations, the one or more ALUs 306 may reside within or on a processor chipset (e.g. the processor 300). In some other implementations, the one or more ALUs 306 may reside external to the processor chipset (e.g. the processor 300). One or more ALUs 306 may perform one or more computations such as addition, subtraction, multiplication, and division on data. For example, one or more ALUs 306 may receive input operands and an operation code, which determines an operation to be executed. One or more ALUs 306 be configured with a variety of logical and arithmetic circuits, including adders, subtractors, shifters, and logic gates, to process and manipulate the data according to the operation. Additionally, or alternatively, the one or more ALUs 306 may support logical operations such as AND, OR, exclusive-OR (XOR), not-OR (NOR), and not-AND (NAND), enabling the one or more ALUs 306 to handle conditional operations, comparisons, and bitwise operations.

**[0143]** The processor 300 may support wireless communication in accordance with examples as disclosed herein.

**[0144]** In some implementations, the processor 300 may be configured to support a means for performing operations of a UE as described with respect to Figure 5. The processor 300 may be configured to or operable to support: a means for obtaining a configuration used for the processor 300 to store or report information related with a mobility procedure in an NTN; and a means for storing or reporting the information related with mobility in the NTN. For example, the information related with mobility in the NTN may be reported by the processor 300 in a SHR or other named report or a new introduced report.

**[0145]** In some implementations, the processor 300 may be configured to support a means for performing operations of a NE. The processor 300 may be configured to or operable to support a means for receiving information related with a mobility procedure in an NTN, e.g. via a SHR or other named report or a new introduced report.

**[0146]** In some implementations, the processor 300 may be configured to support a means for performing operations of a UE. The processor 300 may be configured to or

operable to support: in response to occurrence of a connection failure in a mobility procedure in an NTN, a means for storing information related with the connection failure. For example, the information related with the connection failure may be reported by the processor 300 in an RLF report.

**[0147]** In some implementations, the processor 300 may be configured to support a means for performing operations of a NE. The processor 300 may be configured to or operable to support a means for receiving information related with a connection failure in a mobility procedure in an NTN. For example, the information related with the connection failure is received via an RLF report.

**[0148]** In some implementations, the processor 300 may be configured to support a means for performing operations of a UE as described with respect to Figure 6. The processor 300 may be configured to or operable to support: a means for storing NTN related information; and a means for transmitting the NTN related information, via a random access (RA) report.

**[0149]** In some implementations, the processor 300 may be configured to support a means for performing operations of a NE. The processor 300 may be configured to or operable to support a means for receiving an RA report including NTN related information.

**[0150]** In some implementations, the processor 300 may be configured to support a means for performing operations of a UE as described with respect to Figure 7. The processor 300 may be configured to or operable to support: a means for storing NTN related information of at least one cell of the UE; and a means for transmitting the NTN related information via or in mobility history information (MHI).

**[0151]** In some implementations, the processor 300 may be configured to support a means for performing operations of a NE. The processor 300 may be configured to or operable to support: a means for storing UE history information, wherein the UE history information includes the NTN related information of at least one cell of a UE.

**[0152]** It should be appreciated by persons skilled in the art that the components in exemplary processor 300 may be changed, for example, some of the components in exemplary processor 300 may be omitted or modified or new component(s) may be added to

exemplary processor 300, without departing from the spirit and scope of the disclosure. For example, in some embodiments, the processor 300 may not include the ALUs 306.

**[0153]** Figure 4 illustrates an example of a NE 400 in accordance with aspects of the present disclosure. The NE 400 may include a processor 402, a memory 404, a controller 406, and a transceiver 408. The processor 402, the memory 404, the controller 406, or the transceiver 408, or various combinations thereof or various components thereof may be examples of means for performing various aspects of the present disclosure as described herein. These components may be coupled (e.g. operatively, communicatively, functionally, electronically, electrically) via one or more interfaces.

**[0154]** The processor 402, the memory 404, the controller 406, or the transceiver 408, or various combinations or components thereof may be implemented in hardware (e.g. circuitry). The hardware may include a processor, a digital signal processor (DSP), an application-specific integrated circuit (ASIC), or other programmable logic device, or any combination thereof configured as or otherwise supporting a means for performing the functions described in the present disclosure.

**[0155]** The processor 402 may include an intelligent hardware device (e.g. a general-purpose processor, a DSP, a CPU, an ASIC, an FPGA, or any combination thereof). In some implementations, the processor 402 may be configured to operate the memory 404. In some other implementations, the memory 404 may be integrated into the processor 402. The processor 402 may be configured to execute computer-readable instructions stored in the memory 404 to cause the NE 400 to perform various functions of the present disclosure.

**[0156]** The memory 404 may include volatile or non-volatile memory. The memory 404 may store computer-readable, computer-executable code including instructions when executed by the processor 402 cause the NE 400 to perform various functions described herein. The code may be stored in a non-transitory computer-readable medium such the memory 404 or another type of memory. Computer-readable media includes both non-transitory computer storage media and communication media including any medium that facilitates transfer of a computer program from one place to another. A non-transitory storage medium may be any available medium that may be accessed by a general-purpose or special-purpose computer.

**[0157]** In some implementations, the processor 402 and the memory 404 coupled with the processor 402 may be configured to cause the NE 400 to perform one or more of the functions described herein (e.g. executing, by the processor 402, instructions stored in the memory 404). For example, the processor 402 may support wireless communication at the NE 400 in accordance with examples as disclosed herein.

**[0158]** In some implementations, the NE 400 may be a network node and may be configured to or operable to support a means for receiving information related with a mobility procedure in an NTN, e.g. in a SHR or other named report or a new introduced report.

**[0159]** In some implementations, the NE 400 may be a network node and may be configured to or operable to support a means for receiving information related with a connection failure in a mobility procedure in an NTN, e.g. in an RLF report.

**[0160]** In some implementations, the NE 400 may be a network node and may be configured to or operable to support a means for receiving an RA report including NTN related information.

**[0161]** In some implementations, the NE 400 may be a network node and may be configured to or operable to support a means for storing UE history information, wherein the UE history information includes the NTN related information of at least one cell of a UE.

**[0162]** The controller 406 may manage input and output signals for the NE 400. The controller 406 may also manage peripherals not integrated into the NE 400. In some implementations, the controller 406 may utilize an operating system such as iOS®, ANDROID®, WINDOWS®, or other operating systems. In some implementations, the controller 406 may be implemented as part of the processor 402.

**[0163]** In some implementations, the NE 400 may include at least one transceiver 408. In some other implementations, the NE 400 may have more than one transceiver 408. The transceiver 408 may represent a wireless transceiver. The transceiver 408 may include one or more receiver chains 410, one or more transmitter chains 412, or a combination thereof. The means for receiving or the means for transmitting abovementioned in the processor 402 may be implemented via at least one transceiver 408.

**[0164]** A receiver chain 410 may be configured to receive signals (e.g. control information, data, packets) over a wireless medium. For example, the receiver chain 410 may include one or more antennas for receive the signal over the air or wireless medium. The receiver chain 410 may include at least one amplifier (e.g. a low-noise amplifier (LNA)) configured to amplify the received signal. The receiver chain 410 may include at least one demodulator configured to demodulate the receive signal and obtain the transmitted data by reversing the modulation technique applied during transmission of the signal. The receiver chain 410 may include at least one decoder for decoding the processing the demodulated signal to receive the transmitted data.

**[0165]** A transmitter chain 412 may be configured to generate and transmit signals (e.g. control information, data, packets). The transmitter chain 412 may include at least one modulator for modulating data onto a carrier signal, preparing the signal for transmission over a wireless medium. The at least one modulator may be configured to support one or more techniques such as amplitude modulation (AM), frequency modulation (FM), or digital modulation schemes like phase-shift keying (PSK) or quadrature amplitude modulation (QAM). The transmitter chain 412 may also include at least one power amplifier configured to amplify the modulated signal to an appropriate power level suitable for transmission over the wireless medium. The transmitter chain 412 may also include one or more antennas for transmitting the amplified signal into the air or wireless medium.

**[0166]** It should be appreciated by persons skilled in the art that the components in exemplary NE 400 may be changed, for example, some of the components in exemplary NE 400 may be omitted or modified or new component(s) may be added to exemplary NE 400, without departing from the spirit and scope of the disclosure. For example, in some embodiments, the NE 400 may not include the controller 406.

**[0167]** Figure 5 illustrates a flowchart of a method related to an NTN in accordance with some aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, aspects of operations 502 and 504 may be performed by UE 200 as described with reference to Figure 2. Each of operations 502 and 504 may be performed in accordance with examples as described herein.

**[0168]** At operation 502, the method may include obtaining, by a UE, a configuration (denoted as configuration #1 for simplicity) used for the UE to store or report information

(denoted as information #1) related with a mobility procedure in an NTN. For example, information #1 is related with a successful or near-failure successful mobility procedure in the NTN. In some embodiments of the method, the UE may obtain configuration #1 by pre-configuration, e.g. by a default manner. In some other embodiments, the UE may receive configuration #1 from a network equipment (NE).

**[0169]** For instance, the mobility procedure may be performed in an ordinary handover procedure (i.e. a normal or Rel-15 legacy handover), a RACH-less handover procedure, a DAPS handover procedure (e.g. a Rel-16 DAPS handover), a CHO procedure (e.g. a Rel-16 CHO), another different mobility mechanism (e.g. L1/L2-Triggered Mobility (LTM) cell switch, or any new mobile technology or solution introduced by a subsequent standard), or a combination thereof.

**[0170]** In some implementations of the method, configuration #1 includes at least one of the following one or more thresholds (denoted as Threshold(s) #A):

(1) At least one threshold (denoted as threshold #1) related to a distance between the UE and a reference location (e.g. referenceLocation1) of a source cell (or a serving cell) when a handover execution or mobility is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover). For example, the mobility or handover execution may be performed in an ordinary handover procedure, a RACH-less handover procedure, a DAPS handover procedure, a CHO procedure, another different mobility mechanism (e.g. an LTM cell switch, or any new mobile technology or solution introduced by a subsequent standard), or a combination thereof.

(2) At least one threshold (denoted as threshold #2) related to a distance between the UE and a moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover).

(3) At least one threshold (denoted as threshold #3) related to a distance between the UE and the reference location (e.g. referenceLocation1) of the source cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell).

(4) At least one threshold (denoted as threshold #4) related to a distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell).

(5) At least one threshold (denoted as threshold #5) related to a distance between the UE and a reference location (e.g. referenceLocation2) of a target cell or a candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover).

(6) At least one threshold (denoted as threshold #6) related to a distance between the UE and a moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover).

(7) At least one threshold (denoted as threshold #7) related to a distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell).

(8) At least one threshold (denoted as threshold #8) related to a distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell).

(9) At least one threshold (denoted as threshold #9) related to time duration between when a location based CHO execution condition (e.g. CondEvent D1 or CondEvent D2) configured for a cell (e.g. a target cell or a candidate target cell) is fulfilled and when a measurement based CHO execution condition (e.g. CondEvent A3, CondEvent A4 or CondEvent A5) configured for the cell (e.g. the target cell or the candidate target cell) is fulfilled. The location based CHO execution condition may also be named as "a location based CHO trigger condition" or “a location based CHO trigger event” or “a location

based CHO execution event" or the like. The measurement based CHO execution condition may also be named as "a measurement based CHO trigger condition," "a radio link quality based CHO execution condition," "a radio link quality based CHO trigger condition," or the like. The measurement based CHO execution condition may be named as "a measurement based CHO trigger event" or "a measurement based CHO execution event" or "a measurement based CHO trigger condition" or "a radio link quality based CHO execution condition" or "a radio link quality based CHO trigger condition" or "a radio link quality based CHO trigger event" or "a radio link quality based CHO execution event" or the like.

(10) At least one timer T310 related threshold, e.g. as legacy for SHR.

(11) At least one timer T312 related threshold, e.g. as legacy for SHR.

(12) At least one timer T304 related threshold, e.g. as legacy for SHR.

**[0171]** At operation 504, the method may include storing or reporting information #1 by the UE. In some implementations, information #1 may be stored by the UE upon at least one of the following:

(1) a successful completion of the mobility or handover execution; or

(2) a satisfaction of at least one trigger condition (denoted as Trigger Condition(s) #B) associated with Threshold(s) #A. In some embodiments, such satisfaction of Trigger Condition(s) #B includes at least one of the following:

1) the distance between the UE and the reference location (e.g. referenceLocation1) of the source cell (or serving cell) when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover) is shorter than threshold #1;

2) the distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover) is shorter than threshold #2;

3) the distance between the UE and the reference location (e.g. referenceLocation1) of the source cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell) is shorter than threshold #3;

4) the distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell) is shorter than threshold #4;

5) the distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover) is greater than threshold #5;

6) the distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover) is greater than threshold #6;

7) the distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell) is greater than threshold #7;

8) the distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell) is greater than threshold #8;

9) the time duration between when the location based CHO execution condition (e.g. CondEvent D1 or CondEvent D2) configured for the cell (e.g. a target cell or a candidate target cell) is fulfilled and when the measurement based CHO execution condition (i.e. a radio link quality based CHO execution condition) (e.g. CondEvent

A3, CondEvent A4 or CondEvent A5) configured for the cell (e.g. the target cell or the candidate target cell) is fulfilled is greater than threshold #9;

10) a ratio between a value of elapsed running time of a timer T310 when the mobility or handover execution is initiated (or when receiving the RRC reconfiguration message for mobility or handover) and a configured value of the timer T310 is greater than the at least one timer T310 related threshold;

11) a ratio between a value of elapsed running time of a timer T312 when the mobility or handover execution is initiated (or when receiving the RRC reconfiguration message for mobility or handover) and a configured value of the timer T312 is greater than the at least one timer T312 related threshold; or

12) a ratio between a value of elapsed running time of a timer T304 and a configured value of the timer T304 is greater than the at least one timer T304 related threshold.

**[0172]** In a specific embodiment of Figure 5 (denoted as Embodiment 1-1 for simplicity), for a near-failure successful case, NTN specific trigger condition(s) of a successful report (i.e. information #1) are designed. For example, the successful report may be a SHR or other named report or a new introduced report. In Embodiment 1-1, for the mobility (e.g. an ordinary handover, a RACH-less handover procedure, or a DAPS handover, or CHO, or other mobility mechanism) in NTN, trigger condition(s) for the UE to log or store or generate the successful report (e.g. a SHR or other named report or a new introduced report) for NTN, or log or store or generate successful mobility related information in NTN or information related with successful mobility in NTN, are configured to the UE. For example, the configuration for logging or storing or generating the successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN (i.e. configuration #1) includes one or more triggering conditions, e.g., Trigger Condition(s) #B associated with Threshold(s) #A as described above.

**[0173]** In Embodiment 1-1, the above NTN specific trigger condition(s) of the successful report (e.g. a threshold) may be configured in the UE by default or configured by the network (e.g. the source RAN node or the target RAN node). The threshold related to distance may be an absolute value, or a percentage value. For example, if the mobility is a CHO procedure in NTN, the above threshold related to distance may be an absolute value or a percentage

value. The percentage value may indicate a ratio of the threshold value over the location based triggering threshold (e.g. the location based triggering threshold may be distanceThreshFromReference1 or distanceThreshFromReference2) that configured for CHO execution condition, e.g. the percentage value can be 20%, 40%, 60% , 80% or other value. For another example, if the mobility is a normal/R15 legacy handover or a DAPS handover, the above threshold related to distance may be an absolute value.

**[0174]** Referring back to operation 504 of Figure 5, in some embodiments of the method, information #1 includes at least one of the following contents (denoted as Contents #A):

(1) a set of cell types of at least one cell, for instance, one or more cell types of a target cell, a source cell (or a serving cell), and/or a candidate target cell, for example, a cell type of a cell may be an NTN cell or a terrestrial Network (TN) cell;

(2) a distance between the UE and a reference location (e.g. referenceLocation1) of a source cell (or a serving cell) when a mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(3) a distance between the UE and a moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(4) a distance between the UE and the reference location (e.g. referenceLocation1) of the source cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell);

(5) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell);

(6) a distance between the UE and a reference location (e.g. referenceLocation2) of a target cell or a candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or

triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(7) a distance between the UE and a moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(8) a distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell);

(9) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is successful (or when the UE successfully accesses to the target cell);

(10) a cause value; for instance, a cause value for storing or reporting a successful report (e.g. a SHR), e.g. to indicate which trigger condition is fulfilled or indicate which triggering condition(s) for generating or logging the successful report (e.g. the SHR) was/were fulfilled, e.g. a cause value or a flag or an indication to indicate that the distance between UE and a reference location (e.g. referenceLocation1) of a source cell (or a serving cell) when mobility or handover execution is successful (or when the UE successfully accesses to the target cell) is shorter than a threshold; or, a cause value or a flag or an indication to indicate that the distance between UE and a reference location (e.g. referenceLocation2) of a target cell or a candidate target cell when mobility or handover execution is successful (or when the UE successfully accesses to the target cell) is larger than a threshold;

(11) at least one location based CHO execution (or trigger) condition (or event), e.g. the network configured or UE received location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2);

(12) at least one measurement based CHO execution (or trigger) condition (or event), e.g. the network configured or UE received measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3 or CondEventA4 or CondEventA5);

(13) a type of a firstly fulfilled CHO execution (or trigger) condition (or event), e.g. location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2), or radio link quality or measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3, CondEvent A4 or CondEvent A5);

(14) a type of a secondly fulfilled CHO execution (or trigger) condition (or event), e.g. location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2), or radio link quality or measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3, CondEvent A4 or CondEvent A5);

(15) a distance between the UE and the reference location (e.g. referenceLocation1) of the source cell when a location based CHO execution (or trigger) condition (or event) is fulfilled;

(16) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(17) a distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(18) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the location based CHO execution (or trigger) condition (or event)is fulfilled;

(19) a distance between the UE and the reference location (e.g. referenceLocation1) of the source cell when a measurement based CHO execution (or trigger) condition (or event)is fulfilled;

(20) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(21) a distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(22) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(23) one or more measurement results of the source cell, or the target cell or the candidate target cell, when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(24) one or more measurement results of the source cell, or the target cell or the candidate target cell, when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(25) information indicating whether a satellite switch with a re-synchronization procedure is configured, e.g. an indication concerning the satellite switch with re-sync procedure is configured, or an indication concerning the satellite switch with re-sync procedure is not configured;

(26) time elapsed between when the location based CHO execution (or trigger) condition (or event) is fulfilled and a reception of a latest RRC reconfiguration message or conditional reconfiguration;

(27) time elapsed between when the radio link quality or measurement based CHO execution (or trigger) condition (or event) is fulfilled and a reception of the latest RRC reconfiguration message or conditional reconfiguration;

(28) time duration between when the location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2) configured for a cell (e.g. a target cell or a candidate cell) is fulfilled and when the measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3, CondEvent A4 or CondEvent A5) configured for the cell (e.g. the target cell or the candidate cell) is fulfilled;

(29) time elapsed between when the measurement based CHO execution (or trigger) condition (or event)is fulfilled and when the mobility or handover execution is successful (or when the UE successfully access to the target cell);

(30) time elapsed between when the location based CHO execution (or trigger) condition (or event)is fulfilled and when the mobility or handover execution is successful (or when the UE successfully access to the target cell);

(31) a triggering sequential order for the location based CHO execution (or trigger) condition (or event) and the measurement based CHO execution (or trigger) condition (or event); or, an indication about whether radio link quality or measurement based CHO execution (or trigger) condition (or event) is triggered when location based CHO execution (or trigger) condition (or event) is triggered, or an indication about whether location based CHO execution (or trigger) condition (or event) is triggered when radio link quality or measurement based CHO execution (or trigger) condition (or event) is triggered;

(32) a radio link interruption since the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover) or when mobility or handover execution is successful (or when the UE successfully access to the target cell); or

(33) information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

**[0175]** In some implementations of Figure 5, information #1 may be named as or included in a successful report (e.g. a SHR or other named report or a new introduced report) for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN, or the like. In some other implementations of Figure 5, at least one of the above contents in information #1 (e.g. Contents #A), except the cause value e.g. which is for the successful report (e.g. the SHR) in Contents #A, can be stored or reported by the UE in an RA report or a connection establishment failure (CEF) report.

**[0176]** In a specific embodiment of Figure 5 (denoted as Embodiment 2-1), a successful report (e.g. a SHR or another named report or a new introduced report) for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN may be stored or reported by a UE. In particular, when at least one of Trigger Condition(s) #B associated with Threshold(s) #A as described above is fulfilled, and/or, mobility or

handover execution towards a target cell is successful, a UE logs or stores the successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN. For example, if at least one of Trigger Condition(s) #B associated with Threshold(s) #A is fulfilled, and/or, mobility or handover execution towards a target cell is successful, the UE logs or stores a SHR or other named report or a new introduced report for NTN. Then, the UE transmits the successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN to network.

**[0177]** In Embodiment 2-1, the successful report (e.g. a SHR or other named report or a new introduced report) for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN, may include at least one content of Contents #A as described above.

**[0178]** In Embodiment 2-1, based on the received successful report, the network (e.g. a NE) can optimize mobility related configuration(s) (e.g. ordinary handover related configuration(s) or CHO related configuration(s) or RACH-less handover related configuration(s) or any of configuration #1) and/or mobility related threshold(s) (e.g. threshold(s) to trigger ordinary handover or RACH-less handover, CHO related execution or trigger threshold(s)). For example, the network may optimize a RSRP or RSRQ or SINR threshold for triggering an ordinary handover or a RACH-less or a DAPS handover. Or, the network may optimize a location related threshold (e.g. distanceThreshFromReference1 or distanceThreshFromReference2) for triggering CHO execution.

**[0179]** Referring back to Figure 5, in some implementations, the UE may transmit optional UE capability information for supporting storage or report of information #1, e.g. optional UE capability information with or without signaling.

**[0180]** In a specific embodiment of Figure 5 of UE capability (denoted as Embodiment 1-2), since configuration(s) (e.g. Trigger Condition(s) #B as mentioned in Embodiment 1-1) for a UE to store or generate or report a successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN is required, the network (e.g. a NE) needs to know the UE capability, in order to configure proper configuration(s) to trigger the successful report in NTN. In Embodiment 1-2, the UE capability for storing or reporting the successful report for NTN, or successful mobility

related information in NTN, or information related with successful mobility in NTN may be an optional UE capability. Storing or reporting the successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN is optional, even if a UE supports to access NTN, and this capability is explicitly signalled to the network, i.e. explicit capability signalling is needed, or optional UE capability with signalling is needed.

**[0181]** In Embodiment 1-2, there may be following two options according to different embodiments, i.e. Option #a and Option #b as below.

(1) Option #a: Optional with capability signalling. In Option #a, storing or reporting the successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN is optional, and this capability is explicitly signalled by the UE to the network. A new UE capability bit (optional with signalling) may be introduced for supporting the storage and delivery of a successful report for NTN, or successful mobility related information in NTN, or information related with successful mobility in NTN, e.g. upon a request from the network. For instance, the new UE capability bit is introduced for a SHR or other named report or a new introduced report for NTN.

- For example, an optional UE capability indication is included for storing or reporting successful mobility related information in NTN, or information related with successful mobility in NTN, or include an optional UE capability indication for SHR for NTN, e.g. in a UE Capability Information message.
- For another example, the existing optional UE capability indication is reused for a successful handover (HO) report, i.e. success-HO-Report-r17, in a UE capability information message, for mobility in NTN.

(2) Option #b: Optional without capability signalling. In Option #b, storing or reporting successful mobility related information in NTN or information related with successful mobility in NTN is optional, and no explicit capability bit is signalled by the UE. In Option #b, an optional feature without signalling for a successful report (e.g. SHR) for NTN is introduced.

**[0182]** It should be noted that the method described in Figure 5 describes possible implementations, and that the operations and the steps may be rearranged or otherwise eliminated or modified and that other implementations are possible, without departing from the spirit and scope of the disclosure.

**[0183]** In accordance with some aspects of the present disclosure, a method related to an NTN may be implemented by a NE as described herein. In some implementations, aspects of the operations of the NE may be performed by NE 400 as described with reference to Figure 4. It should be noted that the method implemented by the NE herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise eliminated or modified and that other implementations are possible, without departing from the spirit and scope of the disclosure.

**[0184]** In particular, the method may include receiving, by a NE, information (e.g. information #1 as described in the embodiments of Figure 5) related with mobility in an NTN, e.g. successful mobility related information in the NTN. The information may include the same elements as those (e.g. Contents #A) of information #1 as described in the embodiments of Figure 5.

**[0185]** For instance, the NE may receive information #1 from a UE, from a third-party node, or from a target node (e.g. to which the target cell belongs) of the mobility. For example, the mobility may be performed in an ordinary handover procedure (i.e. a normal or Rel-15 legacy handover), a RACH-less handover procedure, a DAPS handover procedure (e.g. a Rel-16 DAPS handover), a CHO procedure (e.g. a Rel-16 CHO), another different mobility mechanism (e.g. LTM cell switch, or any new mobile technology or solution introduced by a subsequent standard), or a combination thereof.

**[0186]** In some implementations of the method, the NE may transmit, to the UE, a configuration (e.g. configuration #1 as described in the embodiments of Figure 5) used for the UE to store or report information #1. The configuration may include the same elements as those (e.g. Threshold(s) #A) of configuration #1 as described in the embodiments of Figure 5.

**[0187]** In some implementations of the method, the NE may receive, from the UE, optional UE capability information for supporting storage or report of information #1, e.g.

optional UE capability information with or without signaling. Details may refer to the embodiments of Figure 5 as described above.

**[0188]** In accordance with some other aspects of the present disclosure, a method related to an NTN may be implemented by a UE as described herein. In some implementations, aspects of the operations of the UE may be performed by UE 200 as described with reference to Figure 2. It should be noted that the method implemented by the UE herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise eliminated or modified and that other implementations are possible, without departing from the spirit and scope of the disclosure.

**[0189]** In particular, in response to occurrence of a connection failure in a handover procedure in an NTN, the method may include storing, by a UE, information related with the connection failure. For example, the connection failure may be a RLF in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received, or before mobility or handover execution is performed; or the connection failure may be a failure during mobility or handover execution; or the connection failure may a RLF occurring shortly after a successful mobility or handover execution. For instance, the handover procedure may be an ordinary handover procedure (i.e. a normal or Rel-15 legacy handover), a RACH-less handover procedure, a DAPS handover procedure (e.g. a Rel-16 DAPS handover), a CHO procedure (e.g. a Rel-16 CHO), another different mobility mechanism (e.g. LTM cell switch, or any new mobile technology or solution introduced by a subsequent standard), or a combination thereof.

**[0190]** In some implementations of the method, the UE may report the information related with the connection failure, e.g. via an RLF report or other report.

**[0191]** In some implementations of the method, the information related with the connection failure includes at least one of the following contents (denoted as Contents #B):

(1) a set of cell types of at least one cell, , for instance, one or more cell types of a target cell, a source cell (or a serving cell), and/or a candidate target cell, for example, a cell type of a cell may be an NTN cell or a terrestrial Network (TN) cell;

(2) a distance between the UE and a reference location (e.g. referenceLocation1) of a source cell when a mobility or handover execution is initiated or triggered (or when

reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(3) a distance between the UE and a moving reference location (e.g. determined based on referenceLocation1) of the source cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(4) a distance between the UE and the reference location (e.g. referenceLocation1) of the source cell when the connection failure happens (e.g. when RLF happens in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before mobility or handover execution is performed, or when mobility or handover execution failure happens (or when the UE fails to access to the target cell), or when an RLF occurs shortly after successful mobility or handover execution or access to the target cell);

(5) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation1) of the source cell when the connection failure happens (e.g. when RLF happens in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before mobility or handover execution is performed, or when mobility or handover execution failure happens (or when the UE fails to access to the target cell), or when an RLF occurs shortly after successful mobility or handover execution or access to the target cell);

(6) a distance between the UE and a reference location (e.g. referenceLocation2) of a target cell or a candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(7) a distance between the UE and a moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the mobility or handover execution is initiated or triggered (or when reconfiguration with sync for

mobility or cell change is initiated or triggered, or when reception of the RRC reconfiguration message for mobility or handover);

(8) a distance between the UE and the reference location (e.g. referenceLocation2) of the target cell or the candidate target cell when the connection failure happens (e.g. when RLF happens in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before mobility or handover execution is performed, or when mobility or handover execution failure happens (or when the UE fails to access to the target cell), or when an RLF occurs shortly after successful mobility or handover execution or access to the target cell);

(9) a distance between the UE and the moving reference location (e.g. determined based on referenceLocation2) of the target cell or the candidate target cell when the connection failure happens (e.g. when RLF happens in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before mobility or handover execution is performed, or when mobility or handover execution failure happens (or when the UE fails to access to the target cell), or when an RLF occurs shortly after successful mobility or handover execution or access to the target cell);

(10) at least one location based conditional handover (CHO) execution (or trigger) condition (or event), e.g. the NW configured/UE received location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2);

(11) at least one measurement based CHO execution (or trigger) condition (or event), e.g. the network configured or UE received measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3 or CondEventA4 or CondEventA5);

(12) a type of a firstly fulfilled CHO execution (or trigger) condition (or event), if any, e.g. location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2), or radio link quality/measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3, CondEvent A4 or CondEvent A5); or

(13) a type of a secondly fulfilled CHO execution (or trigger) condition (or event)if any, e.g. location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2), or radio link quality/measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3, CondEvent A4 or CondEvent A5);

(14) information indicating whether a satellite switch with a re-synchronization procedure is configured, e.g. an indication concerning the satellite switch with re-sync procedure is configured, or an indication concerning the satellite switch with re-sync procedure is not configured;

(15) information indicating whether a measurement based CHO execution (or trigger) condition (or event) configured for a cell is fulfilled when the connection failure happens (e.g. when an RLF happens in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before a mobility or handover execution is performed, or when a mobility or handover execution failure happens (or when the UE fails to access to the target cell), or when an RLF occurs shortly after a successful mobility or handover execution/access to the target cell) or when the UE performs an RRC re-establishment (the re-establishment cell may a source cell or another cell);

(16) information indicating whether a location based CHO execution (or trigger) condition (or event) configured for the cell is fulfilled when the connection failure happens (e.g. when an RLF happens in source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before a mobility or handover execution is performed, or when a mobility or handover execution failure happens (or when the UE fails to access to the target cell), or when an RLF occurs shortly after a successful mobility or handover execution/access to the target cell) or when the UE performs an RRC re-establishment (the re-establishment cell may a source cell or another cell);

(17) a triggering sequential order for the location based CHO execution (or trigger) condition (or event) and the measurement based CHO execution (or trigger) condition (or event); or, an indication about whether radio link quality/measurement based CHO execution (or trigger) condition (or event) is triggered when location based CHO execution (or trigger) condition (or event) is triggered, or an indication about whether location based CHO execution (or trigger) condition (or event) is triggered when radio link quality/measurement based CHO execution (or trigger) condition (or event)is triggered;

(18) a radio link interruption since the mobility or handover execution is initiated; or

(19) information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

**[0192]** In some implementations of the method, if the firstly fulfilled CHO execution (or trigger) condition (or event) is the location based CHO execution (or trigger) condition (or event), or if only the location based CHO execution (or trigger) condition (or event) (e.g. CondEvent D1 or CondEvent D2) is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following contents (denoted as Contents #C):

(1) an ID related to a cell (denoted as cell #1) whose location based CHO execution (or trigger) condition (or event) is fulfilled but whose measurement based CHO execution (or trigger) condition (or event) is not fulfilled;

(2) a distance between the UE and a reference location of a source cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(3) a distance between the UE and a moving reference location of the source cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(4) a distance between the UE and a reference location of cell #1 or other candidate target cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(5) a distance between the UE and a moving reference location of cell #1 or other candidate target cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(6) one or more measurement results of the source cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(7) one or more measurement results of cell #1 or other candidate target cell when the location based CHO execution (or trigger) condition (or event) is fulfilled;

(8) time elapsed between when the location based CHO execution (or trigger) condition (or event) is fulfilled and a reception of a latest conditional reconfiguration or conditional reconfiguration; or

(9) time elapsed between when the location based CHO execution (or trigger) condition (or event) is fulfilled and when the connection failure happens.

**[0193]** In some implementations of the method, if the firstly fulfilled CHO execution (or trigger) condition (or event) is the measurement based CHO execution (or trigger) condition (or event), or if only the radio link quality or measurement based CHO execution (or trigger) condition (or event) (e.g. CondEvent A3 or A4 or A5) is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following contents (denoted as Contents #D):

(1) an ID related to a cell (denoted as cell #2) whose measurement based CHO execution (or trigger) condition (or event) is fulfilled but whose location based CHO execution (or trigger) condition (or event) is not fulfilled;

(2) a distance between the UE and a reference location of the source cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(3) a distance between the UE and a moving reference location of the source cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(4) a distance between the UE and a reference location of cell #2 or other candidate target cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(5) a distance between the UE and a moving reference location of cell #2 or other candidate target cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(6) one or more measurement results of the source cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(7) one or more measurement results of the second cell or other candidate target cell when the measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(8) time elapsed between when the measurement based CHO execution (or trigger) condition (or event) is fulfilled and a reception of the latest conditional reconfiguration or conditional reconfiguration; or

(9) time elapsed between when the measurement based CHO execution (or trigger) condition (or event) is fulfilled and when the connection failure happens.

**[0194]** In some implementations of the method, if both a location based CHO execution (or trigger) condition (or event) and a measurement based CHO execution (or trigger) condition (or event) are fulfilled before the connection failure happens, (for instance, the firstly fulfilled CHO execution (or trigger) condition (or event) is one of the location based CHO execution (or trigger) condition (or event) and the measurement based CHO execution (or trigger) condition (or event), and the secondly fulfilled CHO execution condition is the other one of the location based CHO execution (or trigger) condition (or event) and the measurement based CHO execution (or trigger) condition (or event)), the information related with the connection failure further includes at least one of the following contents (denoted as Contents #E):

(1) an ID related to a cell (denoted as cell #3) whose location based CHO execution (or trigger) condition (or event) is fulfilled and whose measurement based CHO execution (or trigger) condition (or event) is fulfilled;

(2) a distance between the UE and a reference location of a source cell when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(3) a distance between the UE and a moving reference location of the source cell when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(4) a distance between the UE and a reference location of cell #3 or other candidate target cell when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(5) a distance between the UE and a moving reference location of cell #3 or other candidate target cell when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(6) a distance between the UE and the reference location of the source cell when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(7) a distance between the UE and the moving reference location of the source cell when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(8) a distance between the UE and the reference location of cell #3 or other candidate target cell when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(9) a distance between the UE and the moving reference location of cell #3 or other candidate target cell when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(10) one or more measurement results of the source cell when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(11) one or more measurement results of cell #3 or other candidate target cell when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(12) time elapsed between when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled and a reception of a latest RRC reconfiguration message or conditional reconfiguration;

(13) time elapsed between when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled and a reception of the latest RRC reconfiguration message or conditional reconfiguration;

(14) time elapsed between when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled and when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled;

(15) time elapsed between when the firstly fulfilled CHO execution (or trigger) condition (or event) is fulfilled and when the connection failure happens; or

(16) time elapsed between when the secondly fulfilled CHO execution (or trigger) condition (or event) is fulfilled and when the connection failure happens.

**[0195]** In some other implementations of the method implemented by the UE, at least one of the above contents in the information related with the connection failure, i.e. Contents #B, Contents #C, Contents #D, and/or Contents #E, can be stored or reported by the UE in an RA report or a connection establishment failure (CEF) report, rather than an RLF report.

**[0196]** In accordance with some aspects of the present disclosure, a method related to an NTN may be implemented by a NE as described herein. In some implementations, aspects of the operations of the NE may be performed by NE 400 as described with reference to Figure 4. It should be noted that the method implemented by the NE herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise eliminated or modified and that other implementations are possible, without departing from the spirit and scope of the disclosure.

**[0197]** In particular, the method may include receiving, by a NE, information related with a connection failure in a mobility or handover procedure in an NTN. For instance, the NE may receive information #1 from a UE (e.g. via an RLF report), from a third-party node, or from a source node (e.g. to which the source cell belongs) of the mobility or from a target node (e.g. to which the target cell belongs) of the mobility. The mobility or handover procedure may be an ordinary handover procedure, a RACH-less handover procedure, a DAPS handover procedure, a CHO procedure, another different mobility mechanism (e.g. LTM cell switch, or any new mobile technology or solution introduced by a subsequent standard), or a combination thereof. The information received by the NE may include the same contents as those (i.e. Contents #B, Contents #C, Contents #D, and/or Contents #E) of the information related with the connection failure stored or reported by the UE (e.g. via an RLF report) as described in the above method performed by the UE.

**[0198]** In a specific embodiment (denoted as Embodiment 2-2) of the present disclosure, for mobility in NTN, similar as legacy, a connection failure may happen. For example, an RLF may happen in a source cell/serving cell before the RRC reconfiguration message for mobility or handover is received or before a mobility or handover execution is performed, or a mobility or handover execution failure may happen (or the UE fails to access to the target cell), or an RLF may occur shortly after a successful mobility or handover execution or access to the target cell. For MRO purpose, a UE may store or log failure related information for mobility in NTN in a failure report (e.g. an RLF report or other named report or a new introduced report). The failure report or failure related information can include at least one content of Contents #B, Contents #C, Contents #D, and/or Contents #E as described above.

**[0199]** In Embodiment 2-2, based on the received failure report, the network (e.g. a NE) can optimize mobility related configuration and/or mobility related threshold (e.g. a RSRP

or RSRQ or SINR threshold to trigger a normal/R15 legacy handover or a DAPS handover, or location related threshold (e.g. distanceThreshFromReference1 or distanceThreshFromReference2) for triggering CHO execution).

**[0200]** Some aspects of the present disclosure refer to enhancements for Xn interface. In some embodiments, a SN STATUS TRANSFER message may include location related information (e.g. *referenceLocation1* which is contained in the *ReportConfigNR* IE as defined in TS 38.331, and/or, *referenceLocation2* which is contained in the *ReportConfigNR* IE as defined in TS 38.331, and/or, *distanceThreshFromReference1* which is contained in the *ReportConfigNR* IE as defined in TS 38.331, and/or, *distanceThreshFromReference2* which is contained in the *ReportConfigNR* IE as defined in TS 38.331). If such location related information is included in the SN STATUS TRANSFER message, a target NG-RAN node shall, if supported, store this information in the UE context, and use it for MRO, e.g. as specified in TS 38.300.

**[0201]** In some other embodiments, a HANDOVER REPORT message may include location related information (e.g. *referenceLocation1* which is contained in the *ReportConfigNR* IE as defined in TS 38.331, and/or, *referenceLocation2* which is contained in the *ReportConfigNR* IE as defined in TS 38.331, and/or, *distanceThreshFromReference1* which is contained in the *ReportConfigNR* IE as defined in TS 38.331, and/or, *distanceThreshFromReference2* which is contained in the *ReportConfigNR* IE as defined in TS 38.331). If such location related information is included in the HANDOVER REPORT message, a source node shall, if supported, use it for MRO, e.g. as specified in TS 38.300.

**[0202]** Figure 6 illustrates a further flowchart of a method related to an NTN in accordance with some aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, aspects of operations 602 and 604 may be performed by UE 200 as described with reference to Figure 2. Each of operations 602 and 604 may be performed in accordance with examples as described herein.

**[0203]** At operation 602, the method may include storing NTN related information by a UE. Such information may also be named as NTN specific information. At operation 602, the method may include transmitting the NTN related information by the UE, e.g. via an RA report.

**[0204]** For instance, the NTN related information may include at least one of the following contents (denoted as Contents #F):

(1) a set of cell types of at least one cell of the UE, for instance, one or more cell types of a target cell, a source cell (or a serving cell), and/or a candidate target cell , for example, a cell type of a cell may be an NTN cell or a terrestrial Network (TN) cell;

(2) epoch time, e.g. which may include sfn value and subFrameNR value (as defined in TS38.331);

(3) ephemeris information, e.g. which provides satellite ephemeris either in format of position and velocity state vector or in format of orbital parameters (as defined in TS38.331);

(4) a scheduling offset used for timing relationships that are modified for NTN (as defined in TS38.331), e.g. cellSpecificKoffset;

(5) a scheduling offset provided by a network equipment (NE) if downlink and uplink frame timing are not aligned at the NE (as defined in TS38.331), e.g. kmac;

(6) polarization information for a downlink transmission on a service link (as defined in TS38.331), e.g. ntn-PolarizationDL, which may include Right hand, Left hand circular polarizations (RHCP, LHCP) and Linear polarization;

(7) polarization information for an uplink service link, e.g. ntn-PolarizationUL (as defined in TS38.331);

(8) validity duration configured by the NE for assistance information(i.e. Serving and/or neighbour satellite ephemeris and Common TA parameters) which indicates the maximum time duration (from epochTime) during which the UE can apply assistance information without having acquired new assistance information (as defined in TS38.331), e.g. ntn-UlSyncValidityDuration;

(9) a common timing advance (TA) value, e.g. ta-Common, for example, Network-controlled common timing advanced value and it may include any timing offset considered necessary by the network (as defined in TS38.331);

(10) a drift rate of the common TA value (as defined in TS38.331), e.g. ta-CommonDrift;

(11) drift rate variation of the common TA value (as defined in TS38.331), e.g. ta-CommonDriftVariant;

(12) information indicating whether the UE is configured to report Timing Advance during Random Access due to RRC connection establishment or RRC connection resume or during RRC connection reestablishment, e.g. an indication concerning the UE is configured to report Timing Advance during Random Access due to RRC connection establishment or RRC connection resume or during RRC connection reestablishment, or an indication concerning the UE is not configured to report Timing Advance during Random Access due to RRC connection establishment or RRC connection resume or during RRC connection reestablishment; or

(13) information indicating whether event-triggered reporting of the Timing Advance is supported, for example, an indication concerning event-triggered reporting of the Timing Advance is supported, or an indication concerning event-triggered reporting of the Timing Advance is not supported.

**[0205]** In accordance with some aspects of the present disclosure, a method related to an NTN may be implemented by a NE as described herein. In particular, the method may include receiving, by a NE, an RA report including NTN related information. The NTN related information can include at least one content of Contents #F as described above. In some implementations, aspects of the operations of the NE may be performed by NE 400 as described with reference to Figure 4. It should be noted that the method implemented by the NE herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise eliminated or modified and that other implementations are possible, without departing from the spirit and scope of the disclosure.

**[0206]** In a specific embodiment of Figure 6 (denoted as Embodiment 3), for the serving cell, the network may broadcast valid ephemeris information and Common TA parameters. The UE shall have valid GNSS position as well as ephemeris and Common TA before connecting to an NTN cell. To achieve synchronization, before and during connection to an NTN cell, the UE shall compute the RTT between UE and a reference point (RP) based on the GNSS position, the ephemeris, and the Common TA parameters, and autonomously pre-compensate the $T_{TA}$ for the RTT between the UE and the RP.

**[0207]** In Embodiment 3, the UE may compute the frequency Doppler shift of the service link, and autonomously pre-compensate for it in the uplink transmissions, by considering UE position and the ephemeris. If the UE does not have a valid GNSS position and/or valid

ephemeris and Common TA, it shall not transmit until both are regained. In a connected mode, the UE shall be able to continuously update the Timing Advance and frequency pre-compensation. The UE may be configured to report Timing Advance during Random Access procedures or in the connected mode.

**[0208]** Embodiment 3 gives the solution about enhancements of RA report in NTN. The UE may store or report at least one of the above NTN related information (i.e. Contents #F) in an RA report. The granularity of the stored or reported information may be per RA attempt or per RA procedure or just for the last RA attempt or just for the first RA attempt or for partial RA attempts in an RA procedure.

**[0209]** In some other embodiments of the present disclosure, at least one of the above NTN related information (e.g. Contents #F) can be stored or reported by the UE in a CEF report, or in a successful report (e.g. the successful report may be SHR or other named report or a new introduced report), or in a failure report (e.g. an RLF report or other named report or a new introduced report), rather than an RA report.

**[0210]** Figure 7 illustrates another flowchart of a method related to an NTN in accordance with some aspects of the present disclosure. The operations of the method may be implemented by a UE as described herein. In some implementations, aspects of operations 702 and 704 may be performed by UE 200 as described with reference to Figure 2. Each of operations 702 and 704 may be performed in accordance with examples as described herein.

**[0211]** At operation 702, the method may include storing, by a UE, NTN related information of at least one cell of the UE. At operation 704, the method may include transmitting the NTN related information by the UE, e.g. the UE transmits the NTN related information via or in mobility history information (MHI). For instance, the NTN related information includes at least one of the following:

(1) a set of cell IDs of the at least one cell of the UE;

(2) a set of cell types of the at least one cell, for example, the cell type of a cell may be an NTN cell or a TN cell;

(3) time duration or percentage of time when the UE stays in at least one NTN cell; or

(4) time duration or percentage of time when the UE stays in at least one TN cell.

**[0212]** A specific embodiment of Figure 7 (denoted as Embodiment 4-1) gives a solution about enhancements for UE history information at UE side. In Embodiment 4-1, a UE may store or report NTN related information of at least one cell, e.g. in/via MHI. For example, the NTN related information of a cell includes at least one of: a cell ID, a cell type (e.g. the cell is an NTN cell or the cell is a TN cell), the time duration or percentage of time when the UE stays in the NTN cell, and the time duration or percentage of time when the UE stays in the TN cell.

**[0213]** In accordance with some aspects of the present disclosure, a method related to an NTN may be implemented by a NE as described herein. In some implementations, aspects of the operations of the NE may be performed by NE 400 as described with reference to Figure 4. It should be noted that the method implemented by the NE herein describes possible implementations, and that the operations and the steps may be rearranged or otherwise eliminated or modified and that other implementations are possible, without departing from the spirit and scope of the disclosure.

**[0214]** In particular, the method may include storing NTN related information by a NE. For example, UE history information (UHI) may include the NTN related information of at least one cell of a UE. For instance, the NTN related information includes at least one of the following:

(1) a set of cell IDs of the at least one cell;

(2) a set of cell types of the at least one cell, for example, the cell type of a cell may be an NTN cell or a TN cell;

(3) time duration or percentage of time when the UE stays in at least one NTN cell; or

(4) time duration or percentage of time when the UE stays in at least one TN cell.

**[0215]** A specific embodiment of the above method implemented by the NE (denoted as Embodiment 4-2) gives a solution about enhancements for UE history information at a network side. In Embodiment 4-2, the NE (i.e. the network) may store or record NTN related information of at least one cell, e.g. in/via UHI. For example, the NTN related information of a cell include at least one of: a cell ID, a cell type (e.g. the cell is an NTN cell or the cell

is a TN cell), the time duration or percentage of time when the UE stays in the NTN cell, and the time duration or percentage of time when the UE stays in the TN cell.

**[0216]** The description herein is provided to enable a person having ordinary skill in the art to make or use the disclosure. Various modifications to the disclosure will be apparent to a person having ordinary skill in the art, and the generic principles defined herein may be applied to other variations without departing from the scope of the disclosure. Thus, the disclosure is not limited to the examples and designs described herein but is to be accorded the broadest scope consistent with the principles and novel features disclosed herein.

CLAIMS

What is claimed:

1. A user equipment (UE) for wireless communication, comprising:

at least one memory; and

at least one processor coupled to the at least one memory and configured to cause the UE to:

obtain a first configuration used for the UE to store or report first information related with a mobility procedure in a non-terrestrial network (NTN); and

store or report the first information.

2. The UE of Claim 1, to obtain the first configuration, the processor of the UE is configured to:

obtain the first configuration by pre-configuration; or

receive the first configuration from a network equipment (NE).

3. The UE of Claim 1, wherein the first configuration includes one or more thresholds, and the one or more thresholds include at least one of the following:

at least one first threshold related to a distance between the UE and a reference location of a source cell when a handover is initiated;

at least one second threshold related to a distance between the UE and a moving reference location of the source cell when the handover is initiated;

at least one third threshold related to a distance between the UE and the reference location of the source cell when the handover is successful;

at least one fourth threshold related to a distance between the UE and the moving reference location of the source cell when the handover is successful;

at least one fifth threshold related to a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated;

at least one sixth threshold related to a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated;

at least one seventh threshold related to a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful;

at least one eighth threshold related to a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful;

at least one ninth threshold related to time duration between when a location based conditional handover (CHO) execution condition configured for a cell is fulfilled and when a measurement based CHO execution condition configured for the cell is fulfilled;

at least one timer T310 related threshold;

at least one timer T312 related threshold; or

at least one timer T304 related threshold.

4. The UE of Claim 3, wherein the first information is stored upon at least one of the following:

a satisfaction of at least one trigger condition associated with the one or more thresholds; or

a successful completion of the handover.

5. The UE of Claim 4, wherein the satisfaction of the at least one trigger condition associated with the one or more thresholds includes at least one of the following:

the distance between the UE and the reference location of the source cell when the handover is initiated is shorter than the at least one first threshold;

the distance between the UE and the moving reference location of the source cell when the handover is initiated is shorter than the at least one second threshold;

the distance between the UE and the reference location of the source cell when the handover is successful is shorter than the at least one third threshold;

the distance between the UE and the moving reference location of the source cell when the handover is successful is shorter than the at least one fourth threshold;

the distance between the UE and the reference location of the target cell or the candidate target cell when the handover is initiated is greater than the at least one fifth threshold;

the distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is initiated is greater than the at least one sixth threshold;

the distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful is greater than the at least one seventh threshold;

the distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful is greater than the at least one eighth threshold;

the time duration between when the location based CHO execution condition configured for the cell is fulfilled and when the measurement based CHO execution condition configured for the cell is fulfilled is greater than the at least one ninth threshold;

a ratio between a value of elapsed running time of a timer T310 when the handover is initiated and a configured value of the timer T310 is greater than the at least one timer T310 related threshold;

a ratio between a value of elapsed running time of a timer T312 when the handover is initiated and a configured value of the timer T312 is greater than the at least one timer T312 related threshold; or

a ratio between a value of elapsed running time of a timer T304 and a configured value of the timer T304 is greater than the at least one timer T304 related threshold.

6. The UE of Claim 1, wherein the first information includes at least one of the following:

a set of cell types of at least one cell;

a distance between the UE and a reference location of a source cell when a handover is initiated;

a distance between the UE and a moving reference location of the source cell when the handover is initiated;

a distance between the UE and the reference location of the source cell when the handover is successful;

a distance between the UE and the moving reference location of the source cell when the handover is successful;

a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated;

a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated;

a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful;

a cause value for the first information;

at least one location based conditional handover (CHO) execution condition;

a type of a firstly fulfilled CHO execution condition;

a type of a secondly fulfilled CHO execution condition;

a distance between the UE and the reference location of the source cell when a location based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the source cell when the location based CHO execution condition is fulfilled;

a distance between the UE and the reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled;

a distance between the UE and the reference location of the source cell when a measurement based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the source cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and the reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled;

one or more measurement results of the source cell, or the target cell or the candidate target cell when the location based CHO execution condition is fulfilled;

one or more measurement results of the source cell, or the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled;

information indicating whether a satellite switch with a re-synchronization procedure is configured;

time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest radio resource control (RRC) reconfiguration message;

time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest radio resource control (RRC) reconfiguration message;

time duration between when the location based CHO execution condition configured for a cell is fulfilled and when the measurement based CHO execution condition configured for the cell is fulfilled;

time elapsed between when the measurement based CHO execution condition is fulfilled and when the handover is successful;

time elapsed between when the location based CHO execution condition is fulfilled and when the handover is successful;

a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition;

a radio link interruption since the handover is initiated or when the handover is successful; or

information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

7. The UE of any of Claims 1-6, wherein the mobility procedure or the handover is performed in an ordinary handover procedure, a random access channel (RACH)-less handover procedure, a dual active protocol stack (DAPS) handover procedure, a conditional handover (CHO) procedure, another different mobility mechanism, or a combination thereof.

8. The UE of Claim 1, wherein the processor is configured to cause the UE to transmit optional UE capability information for supporting storage or report of the first information.

9. A network equipment (NE) for wireless communication, comprising:

at least one memory; and

at least one processor coupled with the at least one memory and configured to cause the NE to receive first information related with a mobility procedure in a non-terrestrial network (NTN).

10. The NE of Claim 9, wherein the processor of the NE is configured to transmit, to a user

equipment (UE), a first configuration used for the UE to store or report the first information.

11. The NE of Claim 10, wherein the first configuration includes one or more thresholds, and the one or more thresholds include at least one of the following:

at least one first threshold related to a distance between the UE and a reference location of a source cell when a handover is initiated;

at least one second threshold related to a distance between the UE and a moving reference location of the source cell when the handover is initiated;

at least one third threshold related to a distance between the UE and the reference location of the source cell when the handover is successful;

at least one fourth threshold related to a distance between the UE and the moving reference location of the source cell when the handover is successful;

at least one fifth threshold related to a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated;

at least one sixth threshold related to a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated;

at least one seventh threshold related to a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful;

at least one eighth threshold related to a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful;

at least one ninth threshold related to time duration between when a location based conditional handover (CHO) execution condition configured for a cell is fulfilled and when a measurement based CHO execution condition configured for the cell is fulfilled;

at least one timer T310 related threshold;

at least one timer T312 related threshold; or

at least one timer T304 related threshold.

12. The NE of Claim 9, wherein the first information includes at least one of the following:

a set of cell types of at least one cell;

a distance between a user equipment (UE) and a reference location of a source cell when a handover is initiated;

a distance between the UE and a moving reference location of the source cell when the handover is initiated;

a distance between the UE and the reference location of the source cell when the handover is successful;

a distance between the UE and the moving reference location of the source cell when the handover is successful;

a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated;

a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated;

a distance between the UE and the reference location of the target cell or the candidate target cell when the handover is successful;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the handover is successful;

a cause value for the first information;

at least one location based conditional handover (CHO) execution condition;

a type of a firstly fulfilled CHO execution condition;

a type of a secondly fulfilled CHO execution condition;

a distance between the UE and the reference location of the source cell when a location based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the source cell when the location based CHO execution condition is fulfilled;

a distance between the UE and the reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the location based CHO execution condition is fulfilled;

a distance between the UE and the reference location of the source cell when a measurement based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the source cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and the reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled;

one or more measurement results of the source cell, or the target cell or the candidate target cell when the location based CHO execution condition is fulfilled;

one or more measurement results of the source cell, or the target cell or the candidate target cell when the measurement based CHO execution condition is fulfilled;

information indicating whether a satellite switch with a re-synchronization procedure is configured;

time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest radio resource control (RRC) reconfiguration message;

time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest radio resource control (RRC) reconfiguration message;

time duration between when the location based CHO execution condition configured for a cell is fulfilled and when the measurement based CHO execution condition configured for the cell is fulfilled;

time elapsed between when the measurement based CHO execution condition is fulfilled and when the handover is successful;

time elapsed between when the location based CHO execution condition is fulfilled and when the handover is successful;

a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition;

a radio link interruption since the handover is initiated or when the handover is successful; or

information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

13. The NE of Claim 9, wherein the processor of the NE is configured to receive, from a user equipment (UE), optional UE capability information for supporting storage or report of the first information.

14. A user equipment (UE) for wireless communication, comprising:

at least one memory; and

at least one processor coupled to the at least one memory and configured to cause the UE to:

in response to occurrence of a connection failure in a mobility procedure in a non-terrestrial network (NTN), store information related with the connection failure.

15. The UE of Claim 14, wherein the information related with the connection failure includes at least one of the following:

a set of cell types of at least one cell;

a distance between the UE and a reference location of a source cell when a handover is initiated;

a distance between the UE and a moving reference location of the source cell when the handover is initiated;

a distance between the UE and the reference location of the source cell when the connection failure happens;

a distance between the UE and the moving reference location of the source cell when the connection failure happens;

a distance between the UE and a reference location of a target cell or a candidate target cell when the handover is initiated;

a distance between the UE and a moving reference location of the target cell or the candidate target cell when the handover is initiated;

a distance between the UE and the reference location of the target cell or the candidate target cell when the connection failure happens;

a distance between the UE and the moving reference location of the target cell or the candidate target cell when the connection failure happens;

at least one location based conditional handover (CHO) execution condition;

a type of a firstly fulfilled CHO execution condition; or

a type of a secondly fulfilled CHO execution condition;

information indicating whether a satellite switch with a re-synchronization procedure is configured;

information indicating whether a measurement based CHO execution condition configured for a cell is fulfilled when the connection failure happens;

information indicating whether a location based CHO execution condition configured for the cell is fulfilled when the connection failure happens;

a triggering sequential order for the location based CHO execution condition and the measurement based CHO execution condition;

a radio link interruption since the handover is initiated; or

information indicating that the radio link interruption is caused due to radio link quality or due to feeder link switch over.

16. The UE of Claim 15, if the firstly fulfilled CHO execution condition is the location based CHO execution condition, and if only the location based CHO execution condition is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following:

an identifier (ID) related to a first cell whose location based CHO execution condition is fulfilled but whose measurement based CHO execution condition is not fulfilled;

a distance between the UE and a reference location of a source cell when the location based CHO execution condition is fulfilled;

a distance between the UE and a moving reference location of the source cell when the location based CHO execution condition is fulfilled;

a distance between the UE and a reference location of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled;

a distance between the UE and a moving reference location of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled;

one or more measurement results of the source cell when the location based CHO execution condition is fulfilled;

one or more measurement results of the first cell or other candidate target cell when the location based CHO execution condition is fulfilled;

time elapsed between when the location based CHO execution condition is fulfilled and a reception of a latest conditional reconfiguration; or

time elapsed between when the location based CHO execution condition is fulfilled and when the connection failure happens.

17. The UE of Claim 15, if the firstly fulfilled CHO execution condition is the measurement based CHO execution condition, and if only the measurement based CHO execution

condition is fulfilled before the connection failure happens, the information related with the connection failure further includes at least one of the following:

an identifier (ID) related to a second cell whose measurement based CHO execution condition is fulfilled but whose location based CHO execution condition is not fulfilled;

a distance between the UE and a reference location of the source cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and a moving reference location of the source cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and a reference location of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled;

a distance between the UE and a moving reference location of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled;

one or more measurement results of the source cell when the measurement based CHO execution condition is fulfilled;

one or more measurement results of the second cell or other candidate target cell when the measurement based CHO execution condition is fulfilled;

time elapsed between when the measurement based CHO execution condition is fulfilled and a reception of the latest conditional reconfiguration; or

time elapsed between when the measurement based CHO execution condition is fulfilled and when the connection failure happens.

18. The UE of Claim 15, if both a location based CHO execution condition and a measurement based CHO execution condition are fulfilled before the connection failure happens:

wherein the firstly fulfilled CHO execution condition is one of the location based CHO execution condition and the measurement based CHO execution condition,

wherein the secondly fulfilled CHO execution condition is another one of the location based CHO execution condition and the measurement based CHO execution condition, and

wherein the information related with the connection failure further includes at least one of the following:

an identifier (ID) related to a third cell whose location based CHO execution condition is fulfilled and whose measurement based CHO execution condition is fulfilled;

a distance between the UE and a reference location of a source cell when the firstly fulfilled CHO execution condition is fulfilled;

a distance between the UE and a moving reference location of the source cell when the firstly fulfilled CHO execution condition is fulfilled;

a distance between the UE and a reference location of the third cell or other candidate target cell when the firstly fulfilled CHO execution condition is fulfilled;

a distance between the UE and a moving reference location of the third cell or other candidate target cell when the firstly fulfilled CHO execution condition is fulfilled;

a distance between the UE and the reference location of the source cell when the secondly fulfilled CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the source cell when the secondly fulfilled CHO execution condition is fulfilled;

a distance between the UE and the reference location of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled;

a distance between the UE and the moving reference location of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled;

one or more measurement results of the source cell when the firstly fulfilled CHO execution condition is fulfilled;

one or more measurement results of the third cell or other candidate target cell when the secondly fulfilled CHO execution condition is fulfilled;

time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and a reception of a latest conditional reconfiguration;

time elapsed between when the secondly fulfilled CHO execution condition is fulfilled and a reception of the latest conditional reconfiguration;

time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and when the secondly fulfilled CHO execution condition is fulfilled;

time elapsed between when the firstly fulfilled CHO execution condition is fulfilled and when the connection failure happens; or

time elapsed between when the secondly fulfilled CHO execution condition is fulfilled and when the connection failure happens.

19. A user equipment (UE) for wireless communication, comprising:

at least one memory; and

at least one processor coupled to the at least one memory and configured to cause the UE to:

store non-terrestrial network (NTN) related information; and

transmit the NTN related information, via a random access (RA) report.

20. The UE of Claim 19, wherein the NTN related information includes at least one of the following:

a set of cell types of at least one cell of the UE;

epoch time;

ephemeris information;

a scheduling offset used for timing relationships that are modified for NTN;

a scheduling offset provided by a network equipment (NE) if downlink and uplink frame timing are not aligned at the NE;

polarization information for a downlink transmission on a service link;

polarization information for an uplink service link;

validity duration configured by the NE for assistance information;

a common timing advance (TA) value;

a drift rate of the common TA value;

drift rate variation of the common TA value;

information indicating whether the UE is configured to report a TA value; or

information indicating whether event-triggered reporting of the TA value is supported.