An Enhancement of the Location-based Measurement Initiation in an Earth-moving Cell

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***Abstract*—Recently, location-based measurement initiation in an Earth-moving cell is adopted in 3rd generation partnership project new radio non-terrestrial network standard Release 18. In this paper, we propose an enhancement of the location-based measurement initiation. Through computer simulations, we show that the proposal is an appealing enhancement that can provide a user equipment with more power saving while supporting mobility in idle or inactive mode.**

***Index Terms*—Non-terrestrial network, Earth-moving cell, location-based measurement initiation, distance threshold.**

I. Introduction

The first global 5G new radio (NR) was standardized in 3rd generation partnership project (3GPP) Release 15 [1]. Due to the potential of connecting user equipments (UEs) anywhere outside of terrestrial network (TN) coverage, enabling 3GPP NR systems to support non-terrestrial networks (NTNs) has been one of key items since Release 15 [2]. NTN scenarios and channel models were studied in Release 15. In Release 16, the minimum NR functions required for NTN implementations were studied. Based on these studies, normative specifications were developed in Release 17. Currently, 3GPP is developing Release 18 NR NTN specifications for coverage enhancement, support of deployment in above 10 GHz band, network-verified UE location, and enhancements of mobility [3].

One of the main objectives of the enhancements of mobility in the Releases 18 NR NTN is to specify cell reselection enhancements for an Earth-moving cell (EMC) [4, Sec. 16.14.1, p. 178]. The cell reselection is the mechanism supporting the mobility of a UE in idle or inactive mode by enabling it to find and select the best cell to camp on [5]. The baselines for the enhancements are the time-based and the location-based measurement initiation for a quasi-Earth fixed cell (QEFC) [6, Sec. 3.1] in the Release 17 NR NTN [7], which is summarized in the next section. The Release 17 time-based measurement initiation was basically reused for an EMC. On the other hand, to take into account the movement of an EMC, the current location of the EMC is derived in the Release 18 location-based measurement initiation [8, Sec. 8.7.4.1.2, p. 47].

In this paper, regarding the enhancements of mobility in the Release 18 NR NTN, we propose an enhancement of the location-based measurement initiation. The enhancement is motivated by the observation that measurement initiation is not necessary for a UE who is getting closer to the center of the camp-on EMC. The proposed enhancement does not require more information than the existing location-based measurement initiation while supporting the mobility of the UEs in idle or inactive mode. Computer simulations are conducted to validate the proposed enhancement by evaluating its performance in terms of mean accumulated measurement time.

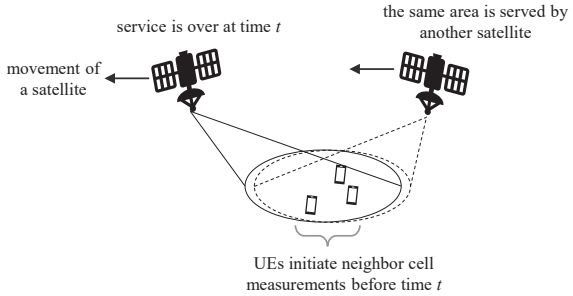

Fig. 1. The time-based measurement initiation for a quasi-Earth fixed cell.

The rest of this paper is organized as follows. Section II summarizes the time-based and the location-based measurement initiation in the Release 17 NR NTN. The enhancements of these two measurement initiations in the Release 18 NR NTN are introduced in Section Section III. The proposed enhancement is described in Section IV, and its performance evaluation results are presented in Section V.

II. Measurement Initiation for Cell Reselection in the Release 17 NR NTN

A. The Release 17 Time-based Measurement Initiation

For QEFCs, time-based measurement initiation for UEs in idle or inactive mode is adopted as an optional feature in the Release 17 NR NTN [7]. The QEFC refers to an NTN cell of which geographic area on the Earth is served by a satellite using steerable beam(s) during a limited time period. As shown in Fig. 1, when the service provided by one satellite for the area is over, the same area is served by another satellite during another limited time period. If a UE supports the time-based measurement initiation, it is necessary for the UE to initiate neighbor cell measurement before the broadcasted service stop time of the serving satellite. Otherwise, the UE may not have enough time for reselecting the best neighbor cell, because the service cell quality is highly likely to be good enough until the service is over and thus the UE would not initiate the measurement.

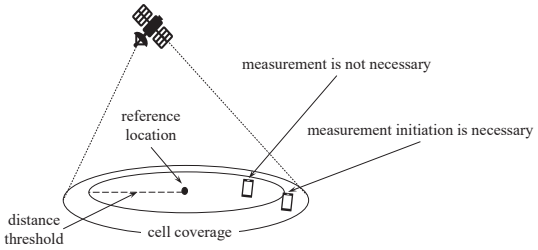

Fig. 2. The location-based measurement initiation.

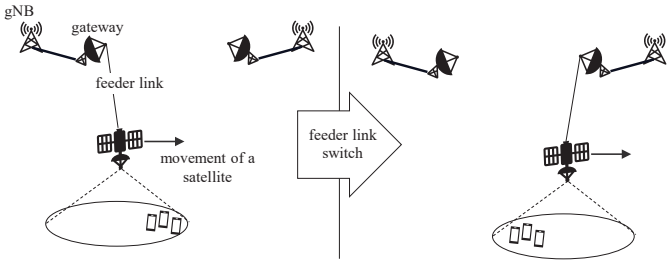

Fig. 3. Example feeder link switch.

B. The Release 17 Location-based Measurement Initiation

Location-based measurement initiation for UEs in idle or inactive mode is also adopted as an optional feature in 3GPP Release 17. In terrestrial network, the downlink signal strength at the cell edge is significantly weaker than at the cell center. On the other hand, in NTN, the difference in the downlink signal strength between the cell center and the cell edge is not large, which is referred to as "flat pancake" nature of the satellite cell's signal spread [9, Sec. 2.1.2]. Thus, neighbor cell measurement for cell reselection may not be initiated by a UE even at the cell edge. This is because a UE may not initiate the measurement if the downlink signal strength is good enough.

To solve this problem, as shown in Fig. 2, a UE in accordance with Release 17 initiates the measurement if its distance from the reference location [6, Sec. 5.2.4.7.0] is longer than the distance threshold [6, Sec. 5.2.4.7.0] that is broadcasted as system information. The reference location is not the cell center but is considered as a location in vicinity of the cell center. It is also broadcasted with the distance threshold.

Since the measurement may not be initiated if a UE is inside the circle specified by the reference location and the distance threshold, the location-based measurement initiation can provides the UE with considerable power savings while supporting mobility in idle or inactive mode.

III. Measurement Initiation for Cell Reselection in the Release 18 NR NTN

One of distinctive feature of the Release 18 NR NTN [3] is support of an EMC. In Release 17, an Earth-fixed cell and a QEFC are considered. This section provides the enhancements of the two measurement initiations adopted for an EMC in the Release 18 NR NTN.

A. The Release 18 Time-based Measurement Initiation

In Release 18, the time-based measurement initiation in Release 17 is used as it is to address feeder-link switch case for the cell reselection in an EMC [8, Sec. 7.7.4.1.2]. As shown in Fig. 3, the feeder link switch refers to the switch of the feeder link between different gateway toward the same satellite [10, Sec. 8.7], where feeder link is defined as the wireless link between the NTN gateway and the NTN payload in the satellite [4, Sec. 3.2]. Note that the gNodeBs (gNBs) before and after the switch are different.

B. The Release 18 Location-based Measurement Initiation

Recently, reuse of the location-based measurement initiation in an EMC was agreed in 3GPP [11, Sec. 8.7.4.1.1, p. 41]. However, due to the nature of movement inherent in an EMC, the location-based measurement initiation could not be reused as it was in Release 17.

Since an EMC on the Earth surface is constantly moving, the reference location cannot be used as it broadcasted. With the assumption that only a fixed or a non-steerable beam is used in an EMC [11, Sec. 8.7.4.1.1, p. 41], the reference location for the EMC is obtained by deriving the trajectory of the satellite ephemeris [8, Sec. 8.7.4.1.2, p. 47]. Even though the derivation is controversial due to concerns on the obtainable accuracy [12], the broadcasted ephemeris information of the satellite and the time of broadcast are used in the derivation, which provides a rough accuracy.

IV. The Proposed Enhancement of the Location-based Measurement Initiation in an EMC

Taking into account the nature of movement in an EMC, an enhancement of the Release 18 location-based measurement initiation in an EMC is proposed in this paper. We propose that neighbor cell measurements be unnecessary for the UE that is getting closer to the derived reference location even if the distance between it and the derived reference location is longer than the distance threshold. In other words, according to our proposal, the neighbor cell measurement is necessary for a UE only when the distance from the derived reference location is longer than the distance threshold and the distance is expected to increase.

Our proposal is justified by the fact that the measurement initiation is unnecessary for the UEs that are getting closer to the reference location. This is because the downlink signal strength becomes stronger as a UE is getting closer to the reference location and thus reselection is less likely to be needed. In addition, note that the proposal can be implemented using the same information required in the Release 18 location-based measurement initiation in an EMC.

V. Simulation Results

Computer simulations were conducted to evaluate the performance of the proposed scheme. As a measure of performance, we used mean accumulated measurement time. Accumulated measurement time is defined as the accumulated time spent by a UE in neighbor cell measurement during a simulation. Thus, the mean accumulated measurement time is

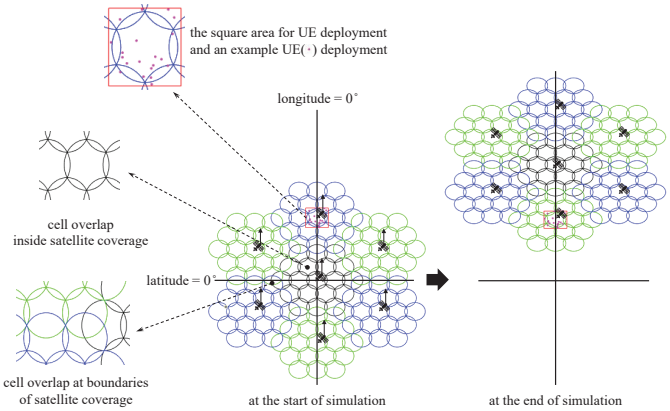

Fig. 4. The simulation scenario based on [13].

obtained by averaging the accumulated measurement times of all UEs.

We adopted the simulation scenario for an EMC presented in [13], which is shown in Fig. 4. The simulation parameters were the same as those used in [13] except the initial location of the square area for UE deployment and simulation time. The center of the square area was set to coincide with the center of the center cell served by the satellite at the highest latitude. The simulation was over when the center of the square area coincided with the center of the center cell served by the satellite at the lowest latitude. An ideal wireless channel was assumed. Perfect derivation of reference location by each UE is assumed.

Fig. 5 shows the mean accumulated measurement time of not only the proposed but also two other neighbor cell measurement schemes: Always-on and Rel.18. In Always-on, UE always performs neighbor cell measurement, and thus mean accumulated measurement time is equal to the simulation time. Rel.18 denotes the measurement scheme in accordance with the current Release 18 location-based measurement initiation in an EMC. The lower the mean accumulated measurement time, the larger the obtainable power savings. The normalized distance threshold in Fig. 5 is defined as the ratio of the distance threshold to the cell radius. Each point on the plots in the figure was obtained by averaging 50 Monte Carlo simulation runs.

From Fig. 5, we can observe that the mean accumulated measurement times of both the proposed and Rel.18 decrease as the normalized distance threshold increases. This is because the region where the measurement is not necessary increases as the normalized distance threshold increases. Another observation is that the difference in the mean accumulated measurement times of the proposed and Rel.18 becomes larger as the normalized distance threshold decrease. This is because the ring-shaped region in Fig. 2 increases as the normalized distance threshold decrease, which gives more opportunities of avoiding the measurements to UEs in accordance with the proposed enhancement.

It is worth noting that the proposed scheme outperforms other ones with no additional information.

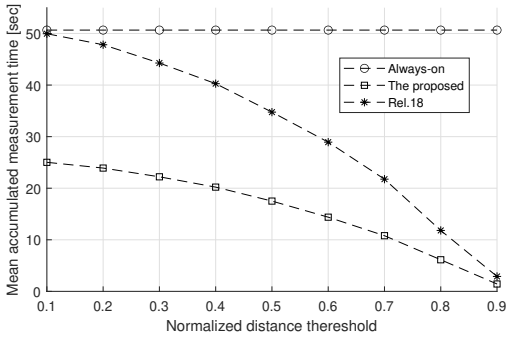

Fig. 5. The mean accumulated measurement time of the investigated schemes.

VI. Conclusions

In this paper, an enhancement of the Release 18 location-based measurement initiation in an EMC was proposed. Compared with the current Release 18 location-based measurement initiation in an EMC, the proposed scheme requires no additional information. On the other hand, as we observed in the simulation results, it can provides a significantly smaller mean accumulated measurement time, which leads to significantly better power savings in a UE. Therefore, the proposal is an appealing enhancement of the current Release 18 location-based measurement initiation in an EMC.

Acknowledgment

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