Location-based Trigger Conditions for Handover in Non-Terrestrial Network

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***Abstract*— The Non-Terrestrial Network (NTN), as defined in the 3GPP Release 17 specifications, supports either time-based or location-based trigger conditions, configured in conjunction with one of the measurement-based trigger conditions defined for conditional handover in a terrestrial network (TN). The NTN mobility support, as defined in the Release 17 (Rel-17) specifications, was designed to minimize impacts on the existing New Radio (NR) based TN specifications, prioritizing urgent commercial deployments in the first release to support them. Performance enhancement is now being addressed in the Rel-18 NTN standardization. In this context, this paper proposes an enhanced location-based trigger condition to efficiently support NTN mobility in realistic deployment environments.**

Keywords*— *Non-Terrestrial Network, Measurement based Trigger Condition, Location-based Trigger Condition, Handover, Mobility

I. INTRODUCTION

The satellite communication is the key infrastructure of 6G communication that provides 3 dimensional (3D) services via an integrated satellite-terrestrial network. In particular, low earth orbit (LEO) based satellite communication could provide high-speed and low-latency services to land shadow areas such as islands, mountains and deserts, as well as sea and aircraft. On the other hand, with the miniaturization of communication equipment and the reduction in the cost of manufacturing and launching satellite, it become possible for satellite networks to be cost-effectively deployed with competitiveness compared to terrestrial networks. The 3GPP is in the process of standardizing non-terrestrial network (NTN) technology to integrate all wireless access and networking technologies into one 5G/6G technology by including satellite networks in the 3GPP 5G/6G standards. The features addressing NTN aspects was included in the Release 17 (Rel-17) specifications of the 3GPP.

Conditional Handover (CHO) within the terrestrial network (TN) is characterized by the UE performing a handover once specific handover execution conditions are fulfilled. Upon reception of the CHO configuration, the UE initiates the assessment of launch conditions, ceasing this evaluation process once the handover is executed. While the fundamental principles of CHO within the TN remain consistent, these same principles are generally applicable to the Rel-17 NTN. However, it's crucial to consider the following additional aspects specific to NTN environments:

- The increased UE measurement error can be attributed to the limited fluctuation observed in the reference signal received power (RSRP). This phenomenon is especially prominent within NTN environments
- NTN scenarios might experience an elevated occurrence of handovers, often leading to unwarranted handover events. The environment's unique characteristics can contribute to this issue.
- The prevalence of low downlink signal-to-interference-and-noise ratio (SINR) values can result in recurrent radio link failures, a phenomenon exacerbated within NTN settings).

Taking into account the unique characteristics of NTN environments, the Non-Terrestrial Network (NTN), as defined in the 3GPP Release 17 specifications, offers support for trigger conditions based on time or location. These conditions are configured alongside measurement-based triggers, as established for conditional handover within terrestrial networks (TN). The NTN mobility support outlined in the Release 17 (Rel-17) specifications was intentionally structured to minimize any potential impacts on the existing New Radio (NR) based TN specifications. The primary focus was on facilitating urgent implementation and deployment rather than developing into performance optimization considerations. Subsequently, performance enhancement efforts are now directed toward the Rel-18 NTN standardization. This upcoming standardization phase aims to address the following key aspects for improving NTN performance:

- Support of earth moving cell
- Performance enhancement of CHO
- Solutions to reduce signal overhead and random access saturation due to the occurrence of many handovers at the same time.

In this regard, this paper proposes an enhanced location-based trigger condition for the support of the efficiency of NTN handover processes.

II. ENHANCED LOCATION-BASED TRIGGERING CONDITIONS FOR NTN HANDOVER

Within the 3GPP Release 17 NTN standard, notable additions include Event D1 and Event T1, both representing location-based and time-based event conditions. These events serve as measurement reporting triggers to facilitate the handover support of earth fixed cells. Specifically, this section outlines the measurement reporting trigger conditions for the location-based Event D1 as defined in the 3GPP Release 17 NTN standard. The conditions are as follows:

- The UE should enter the measurement report event when both conditions D1-1 and D1-2 are satisfied.
- The UE should stop the measurement report event when one of the conditions D1-3 or D1-4 is satisfied.
- Event D1-1: Ml1 – Hys > Thresh1
- Event D1-2: Ml2 + Hys < Thresh2
- Event D1-3: Ml1 + Hys < Thresh1
- Event D1-4: Ml2 - Hys > Thresh2

where Ml1, Ml2, Hys, Thresh 1 and Thresh 2 represent the distance between the UE and the reference location parameter 1 for this event (i.e. referenceLocation1 defined in reportConfigNR for this event), the distance between the UE and the reference location parameter 2 for this event (i.e. referenceLocation2 defined in reportConfigNR for this event),

the hysteresis parameter for this event, the distanceThreshFromReference1 parameter from the reference location 1, the distanceThreshFromReference2 parameter from the reference location 2. Figure 1 shows the location-based triggering areas in the Event D1 of 3GPP Release 17 NTN and the event triggering occurs in the area with white circles. As depicted in Figure 1, the measurement reporting trigger conditions established for the location-based Event D1 within the 3GPP Release 17 NTN standard exhibit effective performance within satellite beams characterized by circular shapes. However, certain challenges emerge when dealing with more complex and realistic beam shapes, such as elliptical satellite beams or beams elongated at low elevation angles. In Figure 1(b), an issue arises where event triggering fails to transpire within the region demarcated by grey circles, which would otherwise be a viable candidate area for initiating measurement reporting within the context of NTN handover. This limitation hampers the NTN handover procedure, particularly given that the event triggering is confined to a narrow area. The result reduces operational efficiency for the NTN handover process.

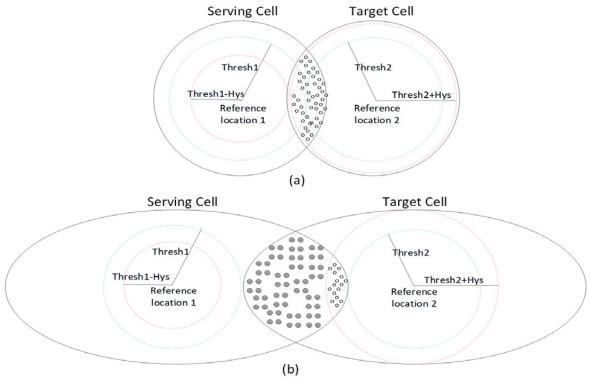

Fig. 2. Location-based triggering areas in the Event D1 of Rel-7 NTN

To address the challenge of achieving efficient measurement reporting triggering events within realistic satellite beam shapes, we have made modifications to the conventional measurement reporting trigger conditions of the location-based Event D1 within the 3GPP Release 17 NTN standard. The revised conditions are outlined as follows:

- The UE should enter the measurement report event when both conditions D1-1 and D1-2 are satisfied.
- The UE should stop the measurement report event when one of the conditions D1-3 or D1-4 is satisfied.
- Event D1-1: Ml1 – Hys(UE_pos) > Thresh1(UE_pos)
- Event D1-2: Ml2 + Hys(UE_pos) < Thresh2(UE_pos)
- Event D1-3: Ml1 + Hys(UE_pos) < Thresh1(UE_pos)
- Event D1-4: Ml2 - Hys(UE_pos) > Thresh2(UE_pos)

where Hys(UE_pos), Thresh 1(UE_pos) and Thresh 2(UE_pos) represent hysteresis parameter from the reference location to the UE direction calculated based on the Hys parameter (defined in reportConfigNR for this event) from the reference location 1 to the specific location direction, a threshold distance from reference location 1 in the direction of the UE calculated based on the distanceThreshFromReference1 parameter in the direction of a specific location from reference location 1, and a threshold distance from reference location 2 in the direction of the UE calculated based on the distanceThreshFromReference2 parameter in the direction of a specific location from reference location 2.

The key distinction between the conventional and proposed triggering conditions lies in the adaptability of certain parameters. In the proposed scheme, the Hysteresis (Hys), Threshold 1 (Thresh1), and Threshold 2 (Thresh2) parameters are not static values but rather variable values contingent on the UE's location. This adjustment addresses the challenge posed by realistic satellite beam shapes. As evident in Figure 2, the proposed scheme's triggering event can take place throughout all areas within the candidate region designated for the measurement reporting of NTN handover. This enhancement signifies a significant improvement, as event triggering is no longer confined to limited regions. The proposed approach yields a more comprehensive and efficient measurement reporting process for NTN handover scenarios.

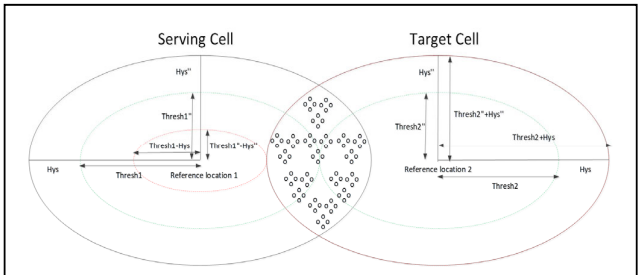

Fig. 1. Location-based triggering areas in the proposed scheme

TABLE I. LOCATION-BASED TRIGGERING AREAS TO CADIDATE AREA RATIO

	Conventional scheme	**Proposed scheme**
Cell type	• Elliptical shape (Semi-major axis: 120 km, Semi-minor axis: 100 km) • Distance between serving cell and target cell: 180 km	
Event D1 triggering parameters	• Thresh1: 90 km • Hys: 10 km • Thresh2: 90 km	• Thresh1': 90 km • Hys': 10 km • Thresh2': 90 km • Thresh1": 105 • Hys"15km • Thresh2": 105
Candiate Areas	• 1962 km^2	
Triggering Areas	• 587 km^2	• 1916 km^2
Triggering to Cadidate areas ratio	• 30 %	• 100 %

III. CONCLUSION

This paper introduced a refined location-based trigger condition, aiming to facilitate the efficient support of Non-Terrestrial Network (NTN) mobility within practical deployment environments.

ACKNOWLEDGMENT

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