Design of 5G Non-Terrestrial Network Handover using Transparent Satellite

Kyung-Rak LEE
Satellite Communication Infra Research Section
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
krlee@etri.re.kr

Hee-Wook Kim
Satellite Communication Infra Research Section
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
prince304@etri.re.kr

Joon-Gyu Ryu
Satellite Communication Infra Research Section
Electronics and Telecommunications Research Institute
Daejeon, Republic of Korea
jgryurt@etri.re.kr

Jin-Young Kang
Semicolon Inc.
Seoul, Republic of Korea
jinyoung.kang@semicoloner.com

***Abstract*— Deploying actual satellites into space and conducting verification entail significant costs, time, and various challenges. In this paper, we aim to address these problems by developing a platform that simulates networks using terrestrial networks and satellite systems. The focus is particularly on simulating Terrestrial Network (TN) to Non Terrestrial Network (NTN) handover technology. This approach is devised to overcome the constraints of physically deploying and testing satellites, avoiding the high costs and time associated with space deployment. It aims to create a simulation environment for evaluating network behavior and performance without the need for costly and time-consuming space deployment.**

Keywords—5G NR, Handover, Non Terrestrial Network, Transparent satellite

I. INTRODUCTION

Recently, the international wireless communication standardization organization, 3GPP, has been establishing standards for Non-Terrestrial Networks (NTN) based on NR (New Radio). This can be seen as a very early stage of constructing integrated Terrestrial Networks (TN) and NTN, and currently, there is active discussion on the details in Rel.18. With the advancement of communication technologies utilizing low Earth orbit satellites (LEO), the standardization of integrated TN/NTN is expected to continue to 6G communications. [1][2].

The Electronics and Telecommunications Research Institute (ETRI) is engaged in the development of a multilayered network using both terrestrial networks (e.g., mobile communication networks) and satellite systems, reflecting the content of the 5G standards (Rel. 17 and above). However, the practical deployment and validation of satellites in space involve significant costs and time, along with various challenging issues. To overcome these problems, as the initial step in developing a multilayered network, ETRI is working on the development of a simulation platform for TN/NTN handover to estimate and comprehend achievable network performance. In this paper, the structure of the in-progress TN/NTN handover simulation platform is described, along with the sequence flow and visualization aspects.

II. MULTILAYERED NETWORK UTILIZING TERRESTRIAL NETWORKS AND SATELLITE SYSTEMS

A. Structure of the TN/NTN Handover Simulation Platform

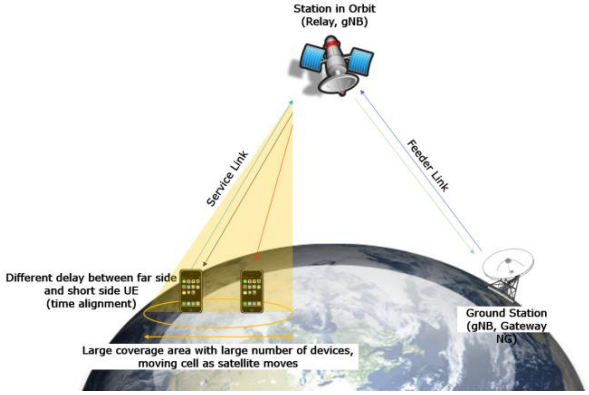

fig. 1. Example network configuration for simulating a multilayered network using terrestrial network and satellite system

This simulation platform is composed of two modules: first module is for simulating the handover scheme between gNBs using NR and satellite. The other module is for managing a mobility of LEO satellites. The handover module within the simulation platform supports the inter-gNB handover functionalities based on 3GPP Rel.17 and some aspects of NTN handover from Rel.18. Also, the handover simulation module utilizing NR-based inter-gNB handover allows a flexible provision of simulation parameters such as the number of gNBs and User Equipment (UEs), distance between gNBs, UE speed, Radio Resource Control (RRC) parameters, and etc [3].

The LEO satellite module in the simulation platform determines the orbits of LEO satellites and the number of satellites per orbit. It is assumed that LEO satellites are transparent satellite. Therefore, notes that the satellites within the same orbit communicate with each other only through ground gateways.

B. Sequence Flow of the TN/NTN Handover Simulation Platform

In our TN/NTN simulation platform, it is assumed that a gNBs control two distinct LEO satellites with different IDs, thus a physical gNB needs a logical sub-gNB group corresponding to individual satellite. In our testbed, the

physical gNB has two logical sub gNBs, named logical gNB1 and logical gNB2. Initially, Sat1 is connected to logical gNB1, while Sat2 is connected to logical gNB2. It is assumed that UEs utilize the service link of Sat1. Fig.2 shows the handover sequence flow using transparent satellite with proposed logical gNBs.

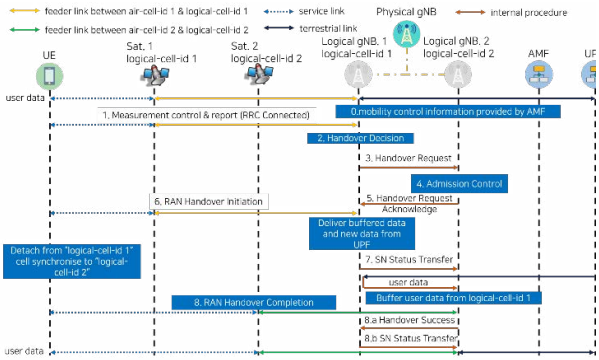

fig. 2. Sequence Flow of the Developing TN/NTN Handover Simulation

The fundamental procedures are as follows.

1) STEP 0.

- The authentication procedure of the UE for connecting to the network (Registration Area).
- Defining and controlling policies applied during UE transitions or movements to a specific network (Mobility Management).

2) STEP 1.

- Received signal quality based Measurement Control & Reporting

3) STEP 2.

- Performing A-Event based on the measurement Report transmitted by the UE.

4) STEP 5.

- Logical gNB2 indicates handover preparation in L1/L2.
- This message includes RRC messages to be sent to the UE for handover execution.

5) STEP 6.

- Logical gNB1 sends an RRC reconfiguration message to trigger handover to the UE.
- This message contains information required to access logical gNB2 (sat2)

6) STEP 8.

- The UE synchronizes with Sat2 and sends the RRC Reconfiguration Complete message to Logical gNB2 to finalize the RRC handover procedure.

III. VISUALIZATION OF THE TN/NTN HANDOVER SIMULATION PLATFORM

Currently, open-source visualization tools related to satellite simulation are widely recognized, such as the MATLAB-based System Tool Kit (STK) and NASA's internally developed General Mission Analysis Tool (GMAT). However, both of these tools are tied to specific programming languages. Therefore, our intention is to develop simulation visualization independently, using the CESIUM library, which enables visualization without language dependencies. Fig. 3 demonstrates the simulation of the connectivity between ground stations and satellites over time using the CESIUM library.

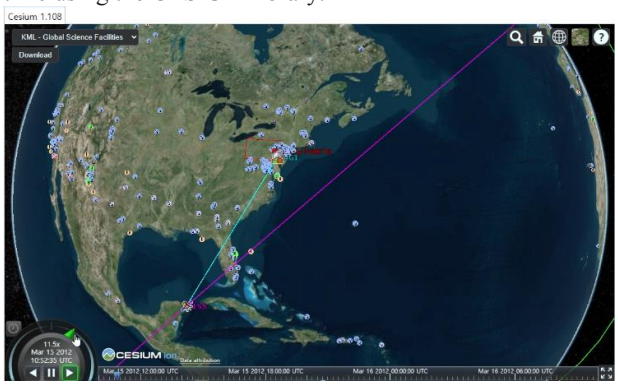

fig. 3. Visualization using CESIUM

IV. CONCLUSIONS

In this paper, we discussed the structure of the ongoing TN/NTN handover simulation platform development, presented a new sequence flow, and outlined the visualization plan. Moving forward, we aim to strengthen the logic for handover simulation and plan to integrate with CESIUM for visualization purposes.

ACKNOWLEDGMENT

This work was supported by the Institute of Information & communications Technology Planning & Evaluation (IITP) grant funded by the Korea government (MSIT) (No. 2021-0-00847, Development of 3D Spatial Satellite Communications Technology).

REFERENCES

[1] M. Giordani and M. Zorzi "Non-terrestrial networks in the 6G era: Challenges and opportunities" IEEE Netw. vol. 35 no. 2 pp. 244-251 Mar./Apr. 2021.

[2] *S. Kota and G. Giambene "6G integrated non-terrestrial networks: Emerging technologies and challenges" Proc. IEEE Int. Conf. Commun. Workshops (ICC Workshops) pp. 1-6 Jun. 2021.*

[3] J. Puttonen L. Sormunen H. Martikainen S. Rantanen and J. Kurjenniemi "A System Simulator for 5G Non-Terrestrial Network Evaluations" International Symposium on a World of Wireless Mobile and Multimedia Networks (WoWMoM) pp. 292-297 2021.