Dynamic Spectrum Coordination Mechanism for Spectrum Sharing between 6G NTN and TN

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Abstract

In sixth generation (6G), Non-Terrestrial Network (NTN) and Terrestrial Network (TN) coordination can meet the requirement of extensive coverage in mobile cellular networks and significantly enhance spectral efficiency. This survey paper explores the outcomes of previously proposed spectrum sharing techniques and mechanisms. Additionally, a Dynamic Spectrum Coordination Mechanism (DSCM) is proposed for future studies, focusing on the implementation of spectrum sensing techniques within the reverse pairing mechanism of Low Earth Orbit (LEO) satellites and TN Base Stations (gNBs). This innovative approach aims to optimize spectrum utilization and improve network performance.

Keywords –6G-NTN, C-DSS, DASS, LEO, Spectrum Sensing.

Ⅰ. Introduction

The growing demand for high throughput and coverage extension, spectrum scarcity has become a primary concern for mobile operators. In previous years significant research has been done on spectrum sharing in terrestrial systems.

In 6G focus is shifted more towards replacing terrestrial components with non-terrestrial components, and it act as a complement in the network while meantime making it more complex.

While efforts to coordinate device and gNB segments continue, the current separation of spectrum between TN and NTN imposes constraints on spectral efficiency improvement. Integrating spectrum sharing between TN and NTN systems holds promise for optimizing spectrum utilization [1]. With spectrum sharing, the same spectrum can be used for NTN and TN, particularly enhancing the re-use of lower frequency bands. However, this integration may lead to increased congestion and interference within the shared spectrum. Consequently, more effective spectrum management and interference mitigation techniques are required [2].

The rest of the paper is as follows. Section II presents an overview of TN-NTN spectrum sharing mechanisms. Section III overviews the 6G-NTN spectrum utilization schemes. Section IV presents the proposed spectrum sharing mechanism DSCM, spectrum sharing technique to be used in conjunction with reverse pairing scheme. Finally, section V presents the conclusions.

Ⅱ. Overview of TN-NTN Spectrum Sharing Mechanisms

In this section, we discuss two possible spectrum sharing methods.

A. Normal Spectrum Sharing

In the normal pairing mode, both NTN and TN utilize the same frequencies for their downlink (DL) and uplink (UL) operations, respectively. Interferences are generated by TN and NTN user equipment's (UEs) to the LEO Satellite and terrestrial gNBs respectively, degrading the spectral efficiency [1].

B. Reverse Spectrum Sharing

This spectrum pairing method transmits in the UL using the same spectrum that TN uses for the DL, and vice versa. This configuration results in interference to the satellite receiver from base stations when TN operates in the DL as shown in Figure 1 [1]. In the current spectrum sharing regulations, due to Frequency Division Duplex (FDD) it has restrictions in implementing this pairing mechanism. However, it's more favorable than normal spectrum sharing.

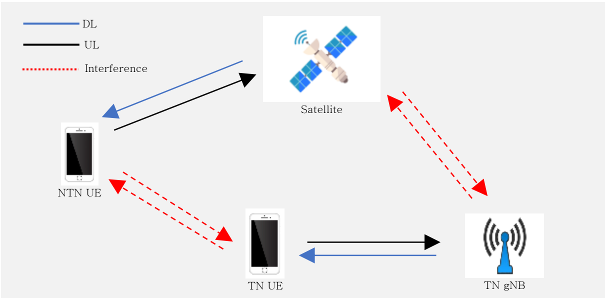

Fig.1. Reverse Pairing.

III. 6G-NTN Spectrum Utilization Schemes

Numerous spectrum utilization schemes introduced recently, specifically for NTN. Table 1 provides a summary of the spectrum utilization schemes that could be deployed in coordinated networks i.e., TN and NTN.

A. Coordinated Dynamic Spectrum Sharing (C-DSS)

In this C-DSS architecture, a centralized approach coordinates spectrum sharing between TN and NTN

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operators. The Spectrum Management Server (SMS) system allocates data resource blocks for each network based on load information received as input as shown in Figure 2. The SMS calculates total network load and assigns resource blocks (RBs) ranges for TN and NTN networks accordingly [2].

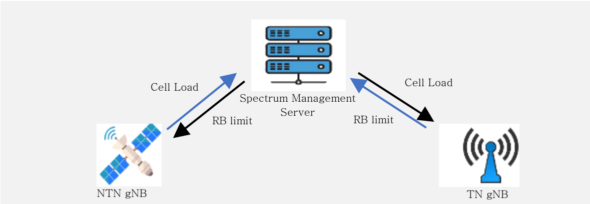

Fig.2. SMS Architecture.

In low demand areas the primary users are not affected negatively but in high demand areas the TN suffers inevitably.

B. Database Assisted Spectrum Sharing (DASS)

The fundamental concept of a spectrum database approach is that secondary devices can only access the spectrum after receiving confirmation from the database that the intended channel is available at

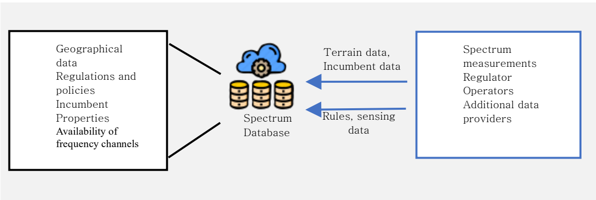

Fig.3. Spectrum Database Model.

their location. The spectrum database model, outlined in Figure 3, illustrates the information storage and sharing capabilities of the model, as well as the various information sources involved.

Operators may not be willing to provide data for this reason, there is need for third party involvement and it's a trivial task and it may take years in implementing this spectrum sharing scheme [3]

IV. Proposed Dynamic Spectrum Coordination Mechanism (DSCM)

The innovative approach is to develop a dynamic spectrum sharing mechanism that integrates spectrum sensing and waveform notching with reverse spectrum sharing. In this approach, the system continuously monitors the available spectrum using spectrum sensing techniques. If there is unused spectrum available, then system detects the location of the communication signal in the frequency spectrum and inserts "notches" or frequency nulls into its transmitted waveform at those frequencies. This action effectively reduces or eliminates the power of the NTN signal in those specific frequency regions, minimizing interference with the TN system.

However, if the spectrum becomes scarce or unavailable, the system continues working into reverse pairing mode, where the LEO satellite and terrestrial base stations engage in spectrum sharing. This standby mode, where spectrum sensing and waveform notching are on standby, ensures efficient spectrum utilization and maintains uninterrupted communication even in challenging spectrum conditions. By incorporating this dynamic spectrum management strategy, we can maximize spectral efficiency and ensure reliable connectivity in both TN and NTN.

Table 1. Spectrum Sharing Techniques in 6G NTN.

Spectrum Sharing Techniques	Description
Coordinated Dynamic spectrum Sharing (C-DSS)	• Spectrum management server • Resource blocks allocation depending on the cell load • TN UEs primary users and NTN UEs secondary users
Database Assisted spectrum Sharing (DASS)	• Spectrum database model • Gather occupancy information from frequency channels to allocate resources • Radio Environment Map (REM) proposed

V. Conclusions

In this paper, different techniques and mechanisms for spectrum sharing between TN-NTN have been studied. A proposed DSCM approach, implementation of spectrum sensing technique in coordination with reverse pairing mechanism offers a promising solution for optimizing spectrum utilization and minimizing interference between TN gNBs and LEO as a result improving overall network performance in 6G mobile networks. Further research and development in this area is crucial for realizing the full potential of spectrum sharing in NTN and TN integrated systems.

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