Multi-Connectivity in B5G and 6G Non-Terrestrial Networks

"Advanced Multi-Connectivity activation and traffic splitting boost users' throughputs!"

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Abstract

Thanks to the recent standardization and deployment activities, the 5G Non-Terrestrial Networks (NTNs) can be seen to complement the 5G Terrestrial Networks (TNs), instead of competing with them. The 5G NTNs can be used to provide 5G access, for example, for load balancing, in case of emergencies or in areas where deploying TNs is not possible. To use the scarce spectrum resources more efficiently, bandwidth-efficient techniques should be used. Multi-Connectivity (MC), where a user can be connected to multiple Next Generation NodeBs (gNBs) simultaneously is one such technique. In this poster, adaptive MC activation and traffic split algorithms for NTNs are introduced.

Introduction

- In MC, a User Equipment (UE) can receive transmissions from multiple gNBs. In practice, the number of connections per user is limited due to the hardware requirements.
- MC is specified for TNs [1] but not for NTNs.

➔ Research is needed!

- Many interesting questions arise in this setting. In this work, the following are investigated:
  - When to activate MC for a UE?
  - How to split the data between the transmitting nodes?

The Multi-Connectivity Algorithms

Secondary Node Addition

- Need for MC for a UE is determined by transmission (Tx) buffer size occupancy at the current serving gNB.
- Criteria for a gNB to be a candidate Secondary Node (SN) for a UE is determined by signal strength measurements.
- If the above criteria are satisfied, the Master Node (MN) can request the candidate to be a SN for the UE.
- The candidate can reject the request if it is too loaded.
- Time intervals between accepting the requests/sending them are utilized to give time to adapt to the changing load conditions.
- The Tx buffer and load sizes are filtered to account for possibly quickly varying values. [2]

Traffic Splitting

- After the SN addition, the traffic is split between the MN/SN.
- In the developed algorithm, it is done based on data requests.
- The SN sends data requests to the MN.
- The amount of data to request is computed using Shannon's formula.

Methods

- The simulations are run with a 5G NTN System Level Simulator (SLS) [4].
- MC is implemented in the simulator according to [1].
- The simulation scenario consists of
  - two transparent payload LEO satellites, each with seven beams and partially overlapping coverage
  - 10 UEs placed around the first satellite's beams
  - UEs have Constant Bit Rate (CBR) traffic with User Datagram Protocol (UDP).
- For the SN addition, the simulations are run with a standard SN addition algorithm (only considers the signal strength for the MC activation criteria) and with the adaptive SN addition algorithm.
- For the traffic split, the simulations are run with a standard traffic split algorithm (splits the data evenly between the MN and SN) and with the data request algorithm.

Results

Fig. 1. shows that the standard MC activation algorithm suboptimally keeps adding secondary connections. Fig. 2. shows the average per-user throughputs when the threshold for SN addition is -111 dBm (which gave the best performance for each algorithm combination). The combination of the developed SN addition and traffic split algorithms gave the best performance.

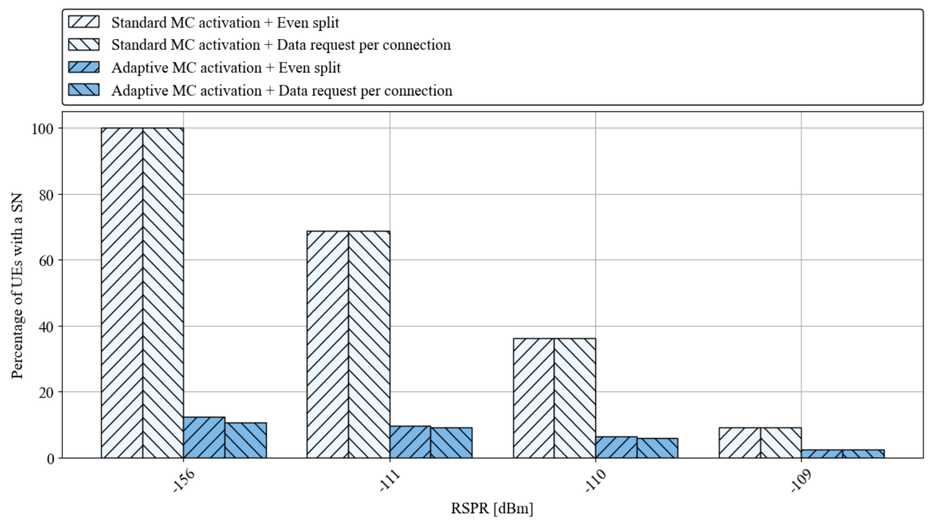

Fig. 1. Percentage of UEs with a SN for different SN addition thresholds.

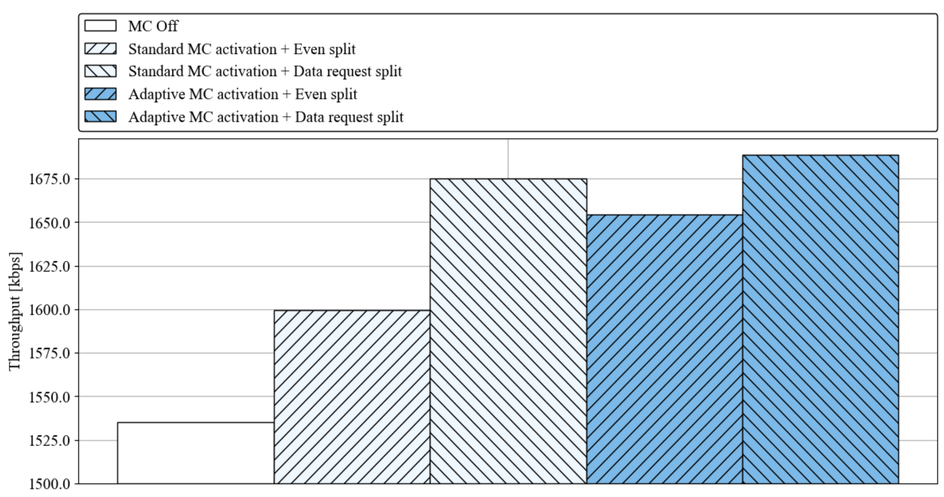

Fig. 2. Average per user throughputs with -111 dBm SN addition threshold.

Conclusions and Future Work

In this poster, MC in the NTN setting was discussed. Adaptive MC activation and traffic split algorithms were introduced. By means of system simulations, it was confirmed that the developed algorithms performed better in terms of throughput enhancement than the standard algorithms. Future work includes incorporating machine learning into the traffic split problem. Furthermore, new scenarios and requirements for the UE need research.

Acknowledgment

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For the publications etc., see:

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