ICM Development in HAPS

Interference Coordination Method
for Integrated HAPS-Terrestrial Networks

The Speakers

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Outline

1. HAPS, Terrestrial Networks, and Their System Model
2. Interference Analysis
3. Proposed Interference Coordination Method
4. Evaluation Results
5. Conclusions
6. Our Thoughts
7. Q&A

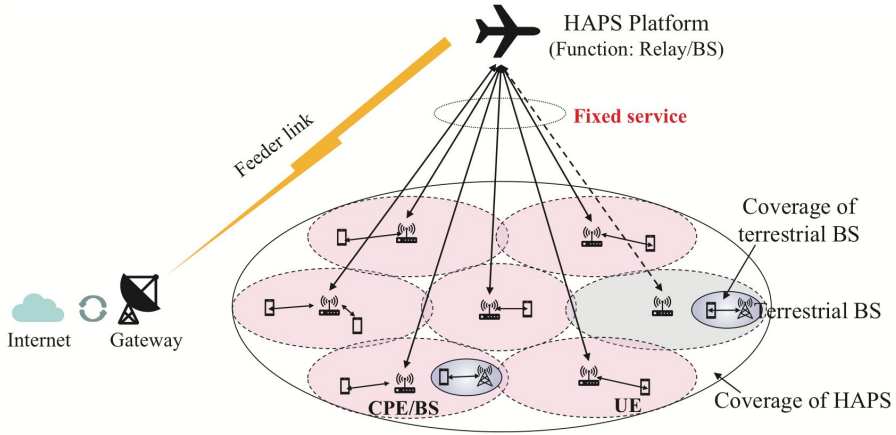
HAPS

- High Altitude Platform Station
- HAPS can be any Unmanned Aerial Vehicle (UAV) that fly or float in the stratosphere
- Typically at altitudes of around 20 km.
- HAPS system use solar power or an on-board energy source

Terrestrial Networks (TN)

- Ground-based cellular networks.
- Terrestrial networks consist of terrestrial base stations which randomly distributed within the coverage area of HAPS.

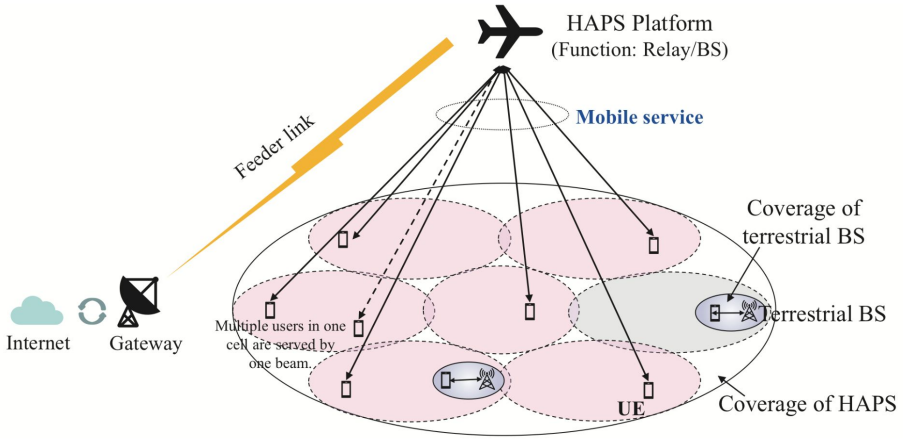
System Model of HAPS



- Case 1 - HAPS provides services for customer premise equipment (CPE) or terrestrial base stations (BS) on the ground and CPE/BS provide mobile services for user equipment (UE)

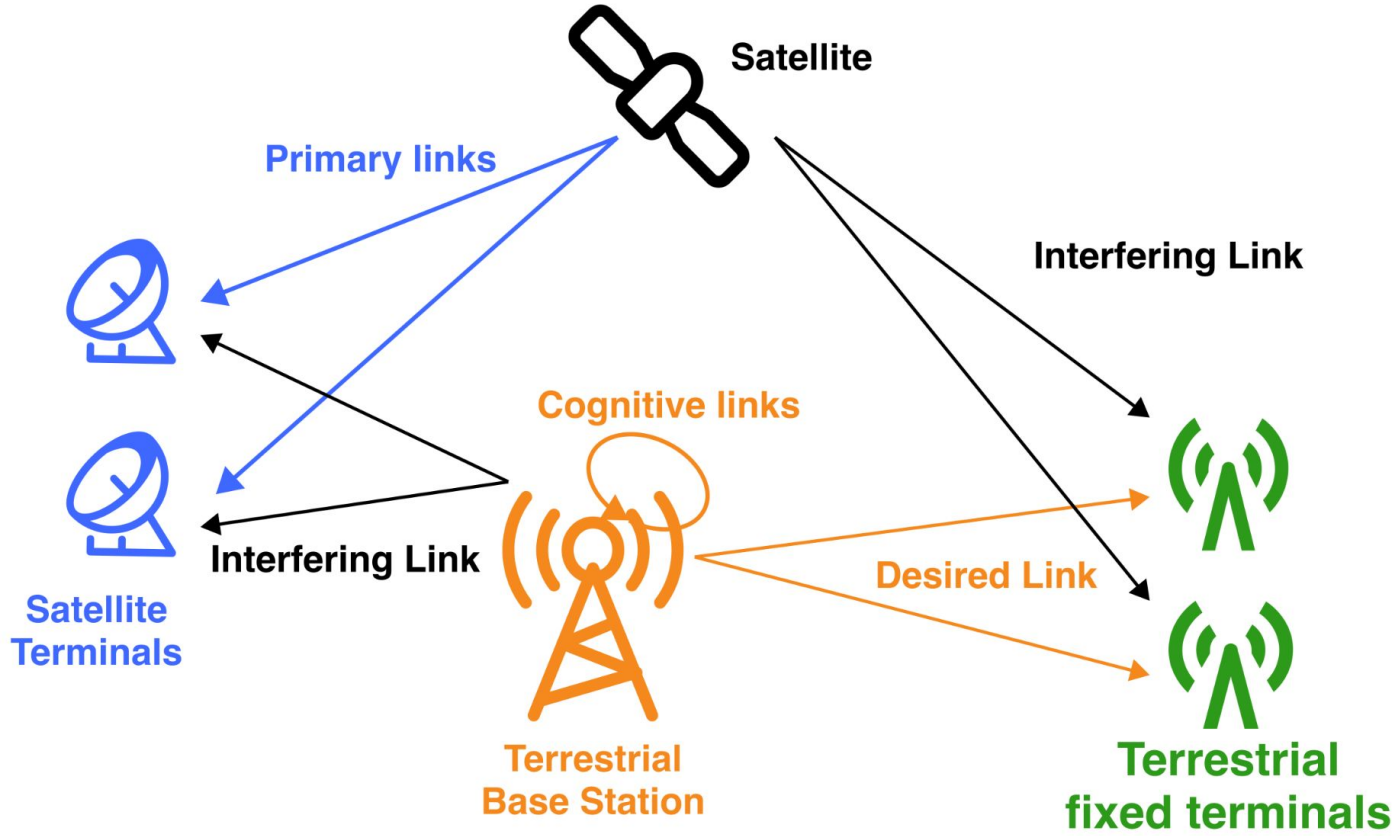
System Model of HAPS

- Case 2 - HAPS directly provides mobile services for UE on the ground



System model of TN

- Terrestrial networks have path loss and shadow fading, which are influenced by the scenario configuration
- Terrestrial Base Station can use fully dynamic beamforming and precoding schemes for better performance


Satellite
Primary links
Interfering Link
Cognitive links
Interfering Link
Desired Link
Satellite
Terminals
Terrestrial
Base Station
Terrestrial
fixed terminals

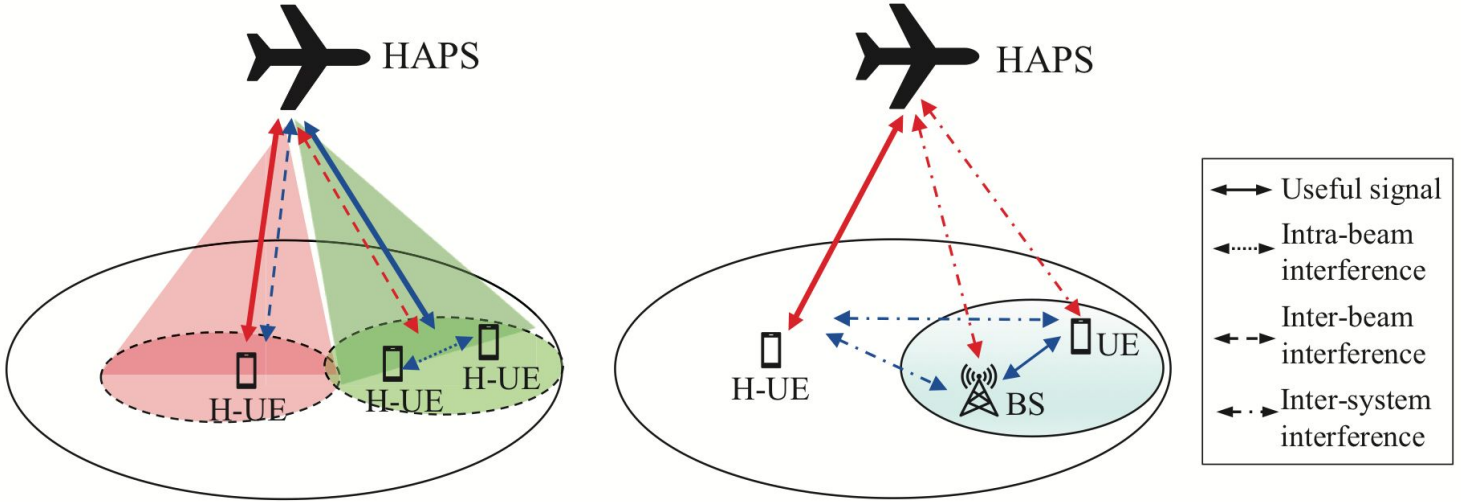
Interference Analysis

- The highlight of interference in integrated system is the interference from HAPS downlink to terrestrial downlink, especially to user equipment (UE)

- Multi-beam transmission in HAPS can cause inter-beam interference. And its will lead to intra-beam interference.

- This method goals is to achieve better resource utilization and performance by dynamically considering the changing traffic load in HAPS and terrestrial networks

Interference Analysis



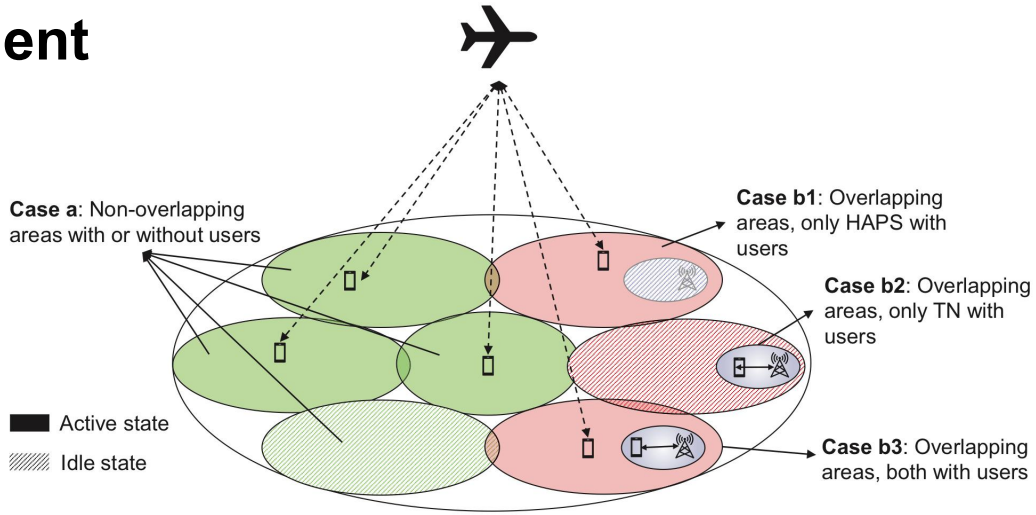
(a) Traditional interference in standalone HAPS system

(b) New interference in integrated HAPS-terrestrial system

The Proposed Method

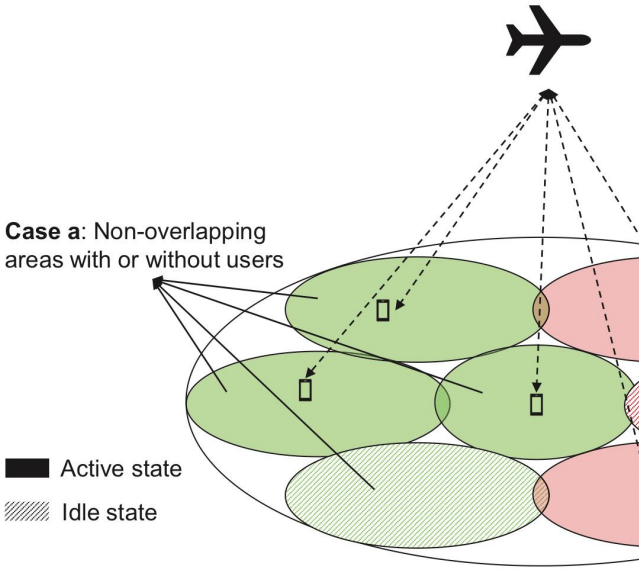
Traffic Load and Deployment

Different cases based on traffic distribution and deployment of integrated system



Liu, W., Hou, X., Chen, L., Hokazono, Y., & Zhao, J. (2022). Interference Coordination Method for Integrated HAPS-Terrestrial Networks. *2022 IEEE 95th Vehicular Technology Conference: (VTC2022-Spring)*. https://doi.org/10.1109/vtc2022-spring54318.2022.9860546

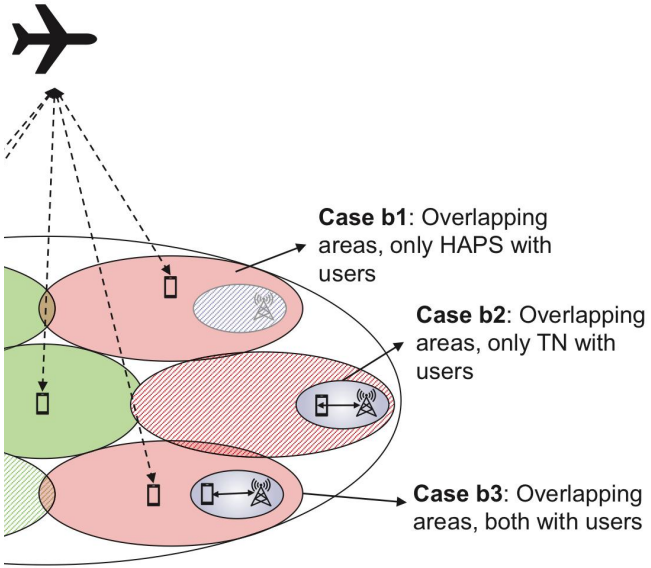
Case A: Non-overlapping Areas



- No overlaps between HAPS and TN coverage, only HAPS coverage is provided
- No interference

Case Bs: Overlapping Areas

- Their exist overlapping areas between HAPS and TN coverage
- Considering traffic distribution in HAPS and TN, this case is further divided into 3 subcases, B1 through B3



B-subcases

Subcase	Traffic Load	Condition	Consideration
B1	HAPS	Inter-system interference can be ignored; long distance between HAPS and TN	Turn TN base stations into idle state
B2	TN	No interference from HAPS to TN	Turn HAPS beam or CPE for the cell off
B3	HAPS and TN	● Inter-beam interference from HAPS cells ● Inter-system interference	Further analysis required (next page)

Case B3 Analysis: The Patterns

Pattern #	HAPS is active	TN is active	Coordination
1	✔	✔	✗ Both HAPS and TN serve users with same time-frequency resources
2	✔	✔	✔
3	✗	✔	✗
4	✔	✗	✗

Evaluation Results

Result	Proposed Method	Baseline 1 (Fixed Allocation)	Baseline 2 (Orthogonal Allocation)
Throughput (HAPS Users)	Higher	Lower	Higher
Throughput (Terrestrial Users)	Higher	Higher	Lower
Interbeam Interference	Mitigated	Ignored	Significant

Evaluation Results

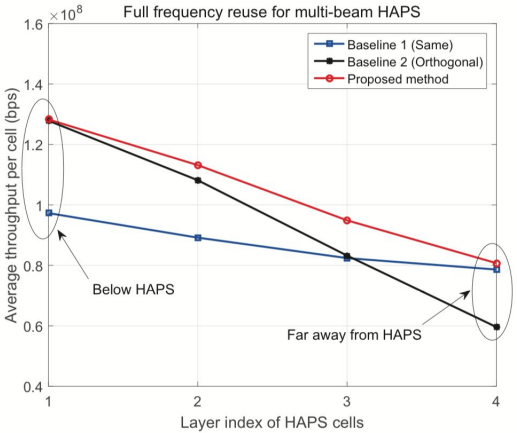


Fig. 6. Average throughput per cell versus different layer index of HAPS cells with full frequency reuse in HAPS.

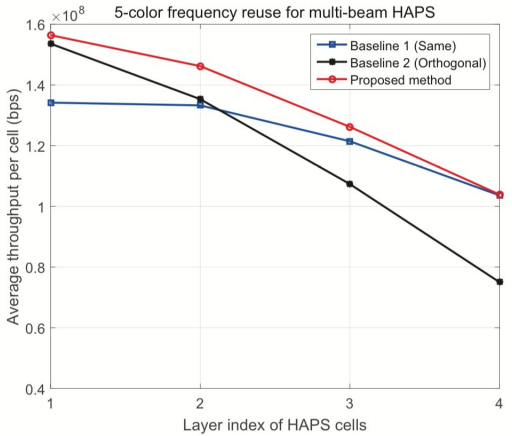


Fig. 7. Average throughput per cell versus different layer index of HAPS cells with 5-color frequency reuse in HAPS.

Conclusions

To coordinate HAPS and TN, we must take into account the inter-system interference.

The paper shows possible scenarios and proposed a method that can be used to determine the optimized pattern for distributing traffic between the two systems. The optimized pattern is the pattern such that throughput is at its maximum and is subject to the minimum data rate requirement.

The evaluation results show that this method improves performance by maximizing throughput when comparing to the current HAPS architecture.

Our Thoughts: Potsawat

The ICM method does help improve efficiency and traffic optimization between HAPS and TNs by distributing workload between the two.

Nevertheless, the evaluation results show that this method majorly covers particular regions with particular distance from HAPS cells. This may also mean the increased implementation cost in order to fairly provide service to users across a coverage area.

HAPS is meant to both improve performance, and reduce implementation and maintenance cost.

Our Thoughts: Sornsiri

The primary consideration from this paper is the reduction of resources used for data exchange in each time.

If this issues can be fixed, not only HAPS but the overall efficiency of the terrestrial network (NTN) will improve significantly.

This method could potentially lead to the development of 5G and 6G signal networks in the future.

References

[1] Wenjia Liu and others. “Interference Coordination Method for Integrated HAPS-Terrestrial Networks”. in 2022 IEEE 95th Vehicular Technology Conference: (VTC2022-Spring): 2022, pages 1–6. DOI: 10.1109/VTC2022-Spring54318.2022.9860546.

[2] GSMA. High Altitude Platform Systems. Tower in the Skies. version 2.0. 2022.

Q&A