DATA-AIDED FAST BEAMFORMING SELECTION FOR 5G

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Introduction

Problem: How to minimize the negative impact of the beam search, for millimeter wave codebook-based beamforming systems?

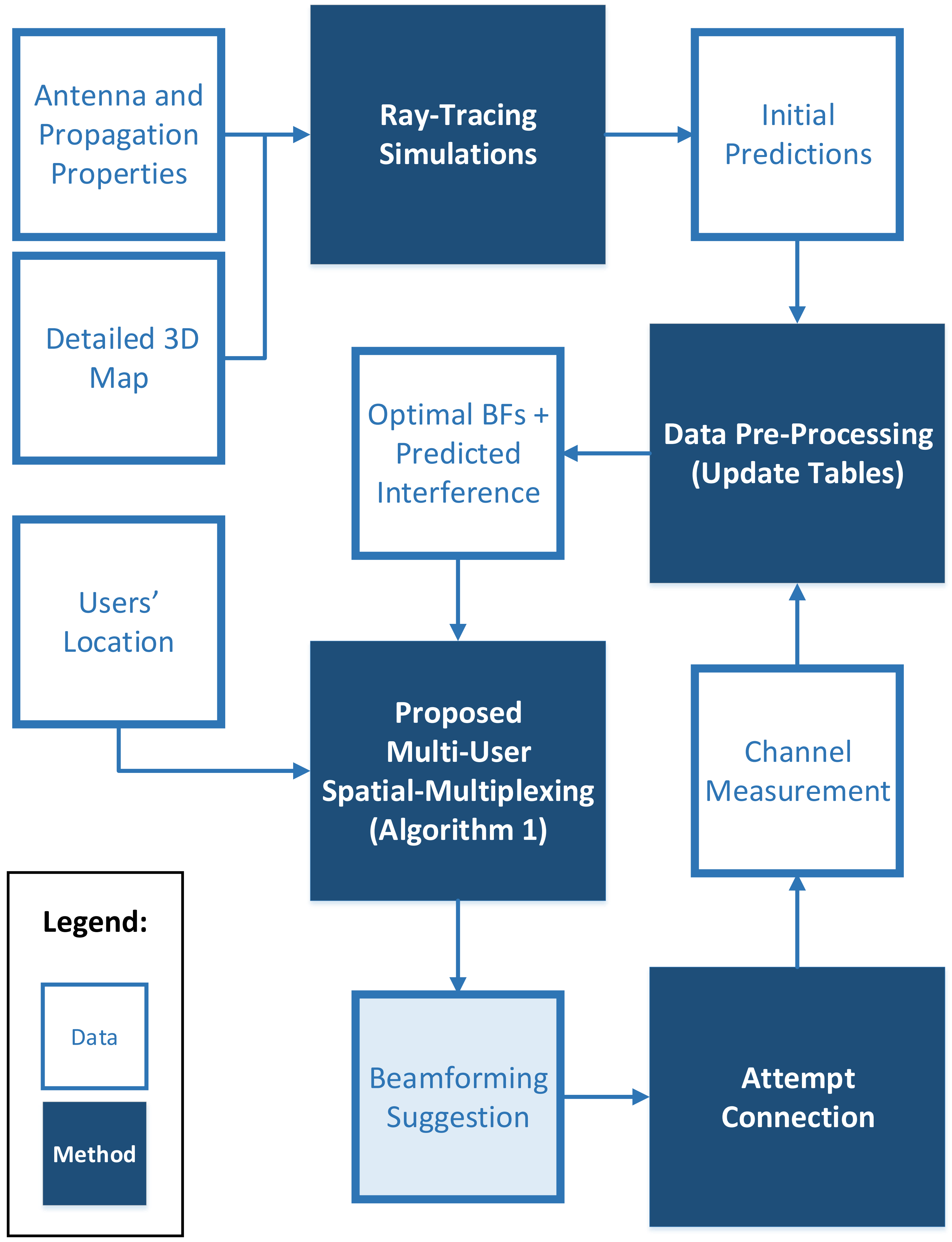
Motivation

- 5G critical enabler: Millimeter wave (mmWave) frequencies with MIMO antennas and beamforming;
- Beamforming: through CSI or codebook-based;
- Codebook beamforming: conceptually simpler, but usually rely on brute-force search;
- Unfit for big codebooks with narrow beams (required to extract the advantages of massive MIMO arrays).

Proposed Approach

- The mmWave propagation is defined by the surrounding obstacles;
- Urban 5G base stations: most obstacles are static for a significant amount of time (buildings);
- A static receiver should measure roughly the same average received power for each codebook entry;
- We propose to use the device position to predict the most suitable codebook entries.

Proposed System



- The proposed multi-user spatial-multiplexing method gives beamforming suggestions, maximizing the received power at each user, while holding down the unwanted interference;

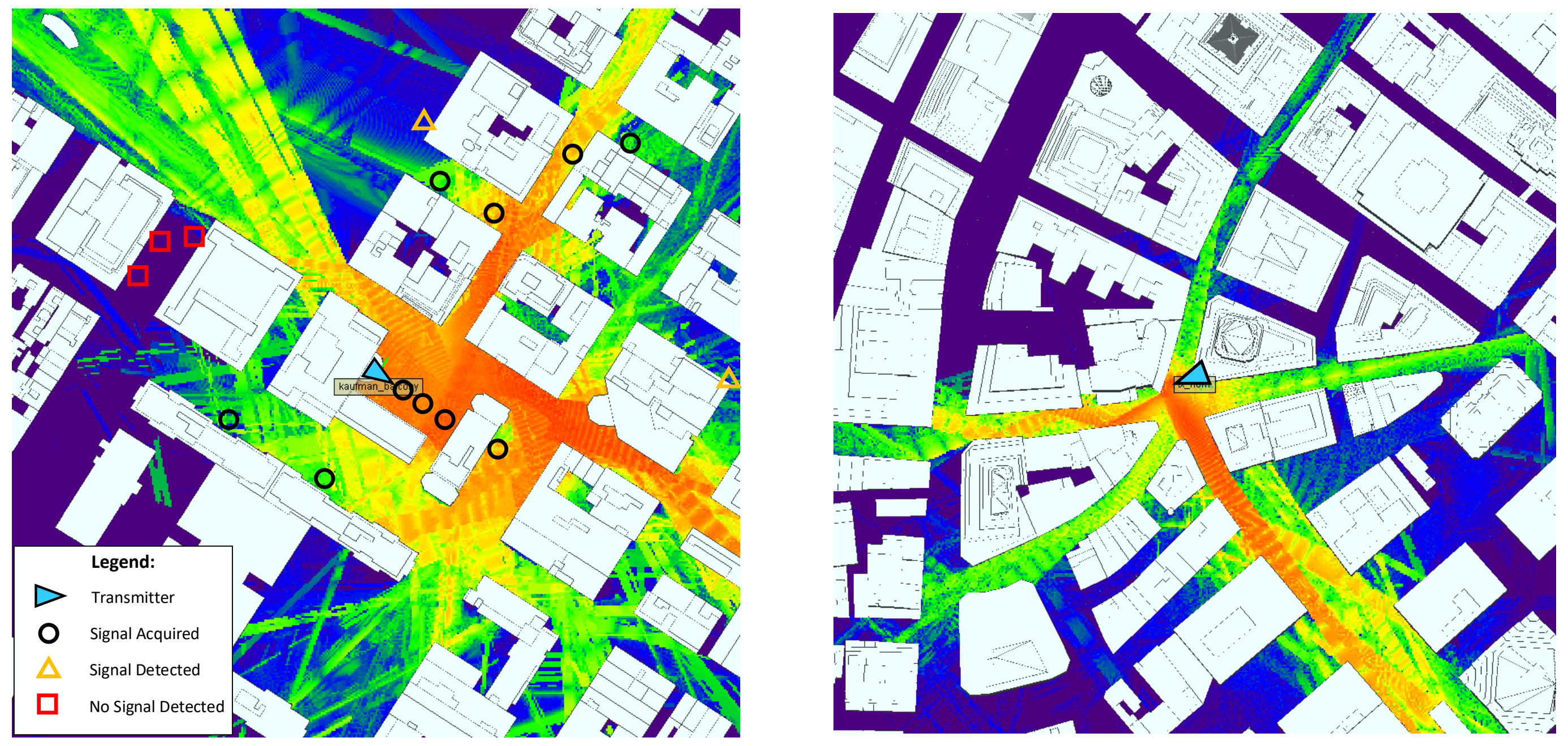
$$\begin{aligned} \underset{\mathbf{F}}{\text{maximize}} \quad & \text{trace}(\hat{\mathbf{H}}\mathbf{F}) \\ \text{subject to:} \quad & \mathbf{f}(i) \in \mathbf{C}, \\ & (\hat{\mathbf{H}}\mathbf{F})_{i,j} < I_{th},\ i \neq j, \\ & (\hat{\mathbf{H}}\mathbf{F})_{i,j} \geq P_{th},\ i = j, \end{aligned}$$

- For each suggestion, there is a connection attempt;
- Through the connection attempt, the data table is updated;
- The data table keeps up-to-date information regarding the expected power for any codebook/position combination;
- To meet the latency requirements: the users are evaluated sequentially, avoiding jointly optimization.

Simulation Results

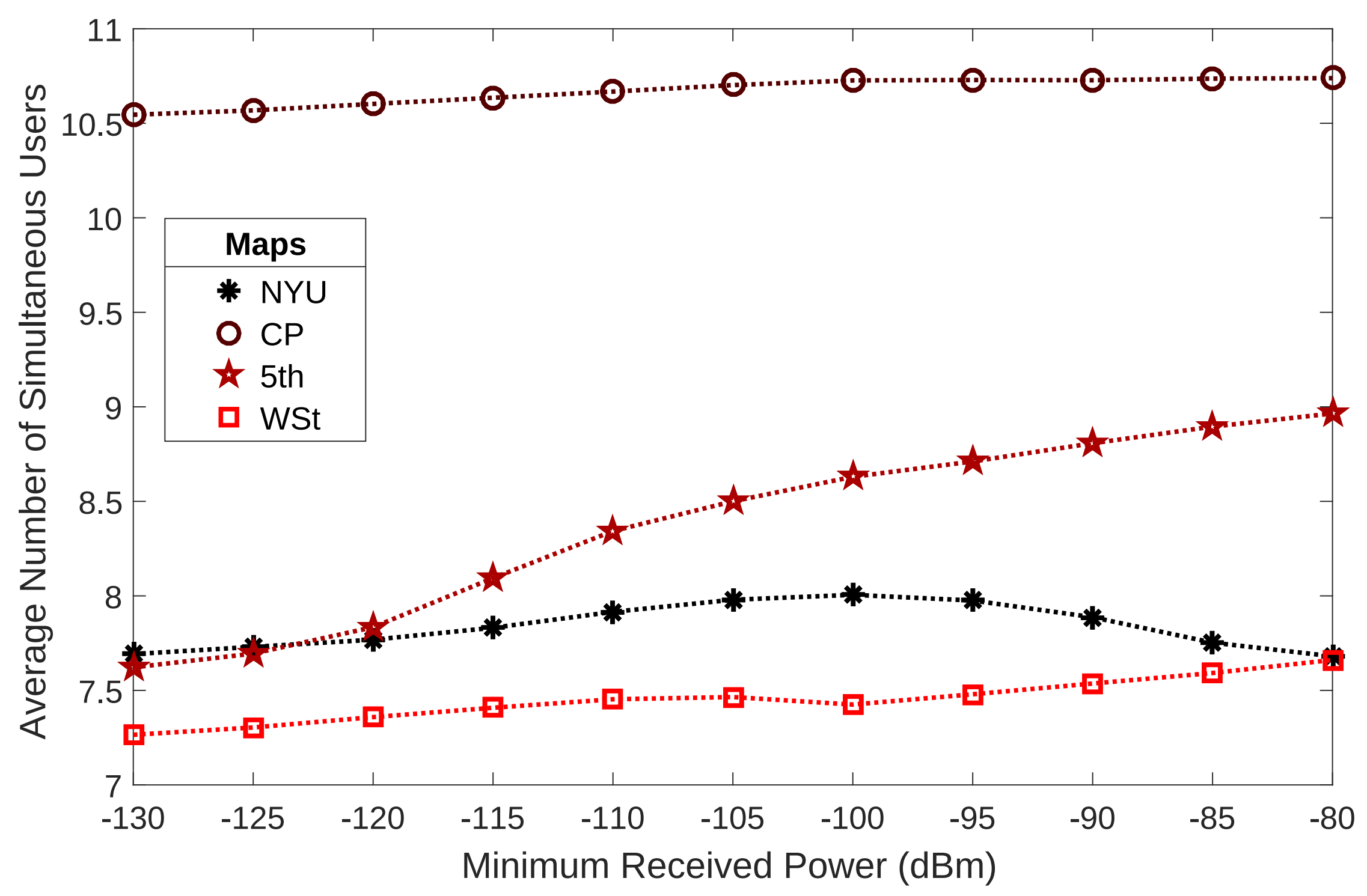
Ray-Tracing Simulations

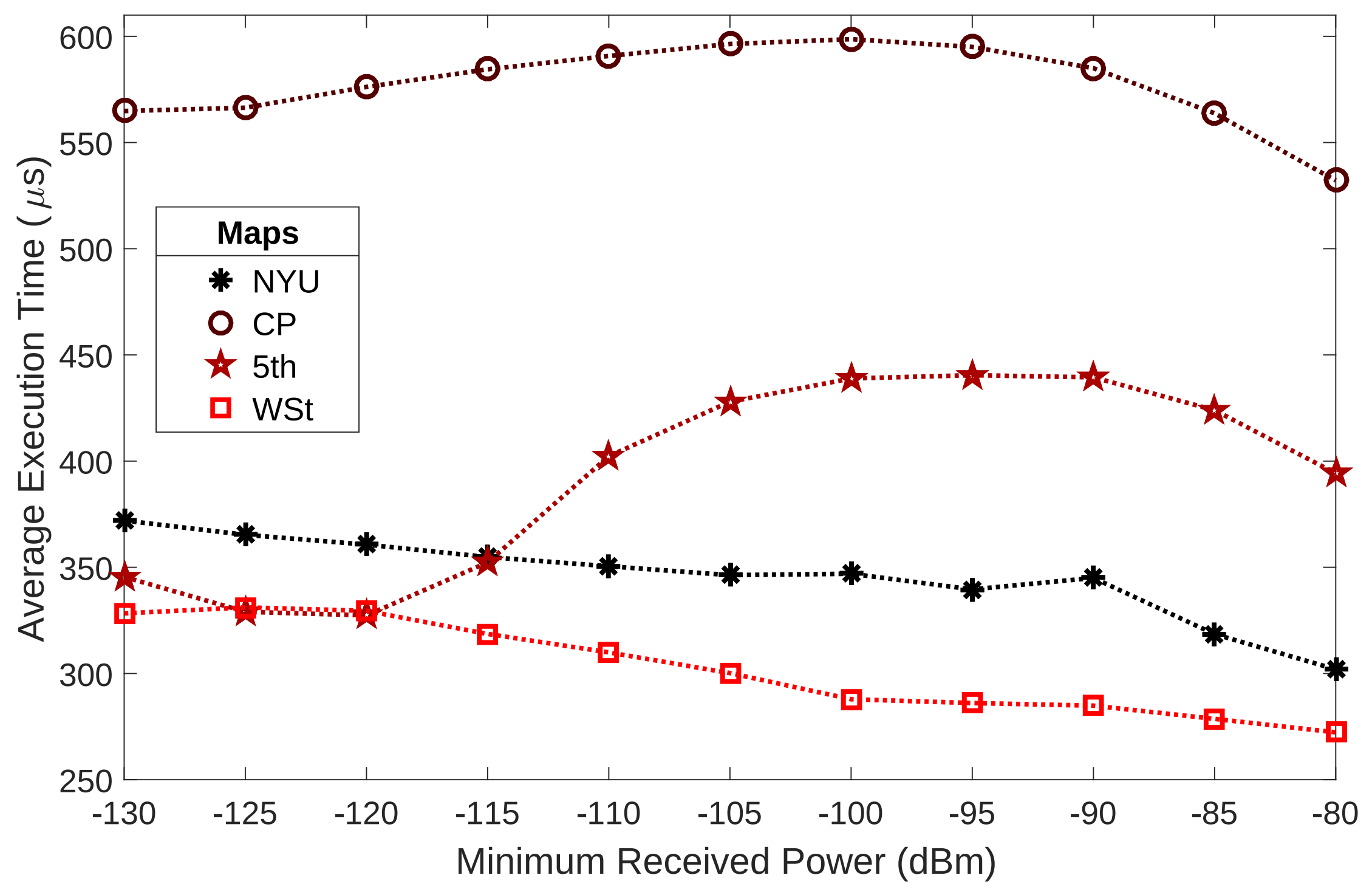
Parameter Name	Value
Carrier Frequency	28 GHz
Transmit Power	30 dBm
Max. Tx. Gain	24.5 dBi (horn antenna)
HPBW	10.9°
Downtilt	10°
Codebook Size	16 (150° arc with 10° between entries)
Saved BF	4 (per receiver location)
Receiver Grid Size	160801 (400 × 400 m, 1 m between receiver)
# of Executions	10^6



- Four simulated areas, using ray-tracing and accurate 3D maps, with disparate layouts;
- Different layouts present distinct characteristics (*e.g.*, in open areas it is easier to separate the beams);
- The ray-tracing simulations matched the experimental measurements at the NYU campus.

Proposed System Simulations





Conclusions: With quick and adequate suggestions, the proposed system should greatly reduce the search space. Thus, bigger codebooks and higher area spectral efficiency become possible.

Acknowledgements

This work was supported by the Portuguese Foundation for Science and Technology (FCT) under Grant SFRH/BD/103960/2014 and also under Project UID/CEC/50021/2013