# User Association in mm-Wave MIMO Network

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## Introduction

Due to global bandwidth shortage and increasing demand for higher data rates, migrating to a new frequency band is inevitable for the next generation of wireless networks. Millimeter wave (mmWave) frequency band is a promising candidate for this end as it provides:

- Huge amount of spectrum (30-300 GHz)
- Higher BW (> 1 GHz)
- Multiple Gbps data rates

## Problem Definition

**Heterogeneous wireless networks**

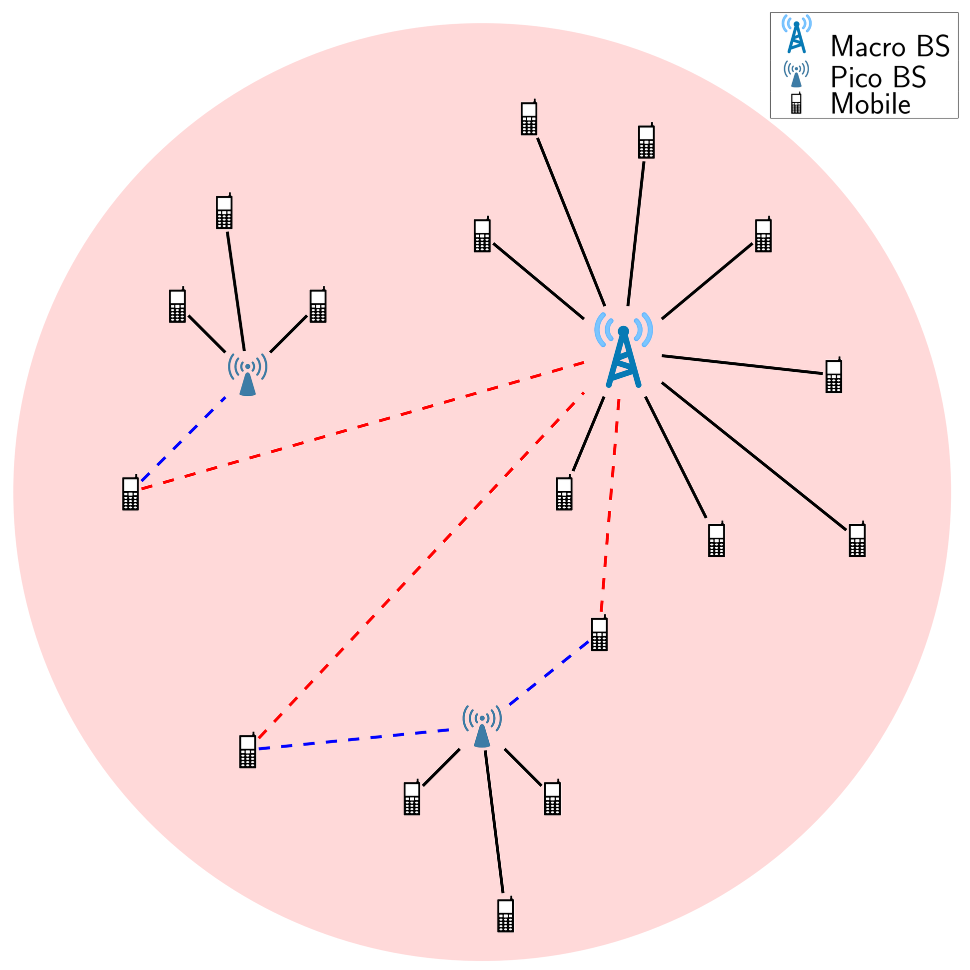
- Ultra-dense structure with multi-tier cells
- Short-range communications

**User Association (UA)**

- Problem of assigning user-BS connections

**Two approaches**

- Max-SINR UA (suboptimal)
- Load-aware UA (optimal)




## Objectives

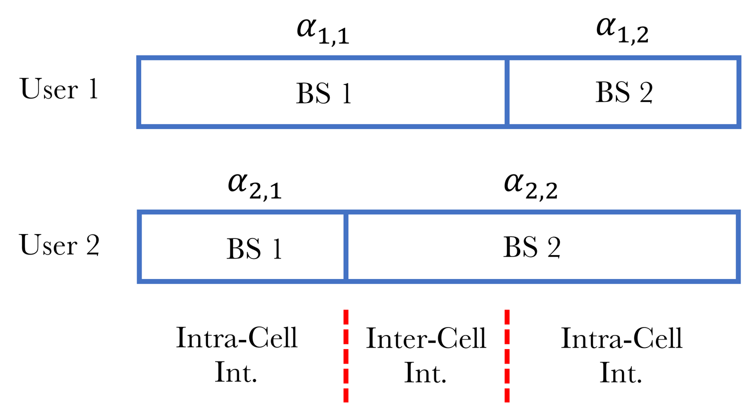
The goal of this research is to design a load-aware user UA algorithm for mmWave MIMO network. The algorithm should be able to improve the network performance by moving the traffic of congested macro BSs to lightly-loaded small BSs.

## Solution Approach

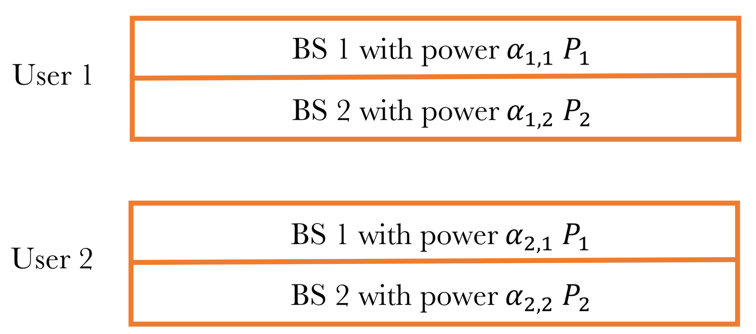
We use a 3GPP-style 3D mmWave channel model developed based on a ray-tracing study [1]. Also, we introduce two new association models. For each model we need to define and solve a different optimization problem to find optimal association coefficients ($\alpha_{k,j}$). In the literature, the optimization problem is usually solved while considering instantaneous user rates independent of association coefficients [2]. In this case, the interference from all base stations is assumed to be present all the time (full interference), which is not a realistic assumption. Our preliminary simulation results show that the association-dependent models result in a higher network sum rate compared to the full interference model.

**Association models**

- Time Fractional Association (TFA)




- Power Fractional Association (PFA)




## User Association: Max-SINR vs. Load-aware (*i.i.d. channel*)

- $K = 40$
- $J = 10$
- $S(1) = 10$
- $S(j) = 4$, for $j = 2, \cdots, 10$
- $\alpha_{k,j} \in [0 \;\; 0.15)$
- $\alpha_{k,j} \in [0.15 \;\; 0.5)$
- $\alpha_{k,j} \in [0.5 \;\; 0.75)$
- $\alpha_{k,j} \in [0.75 \;\; 1]$

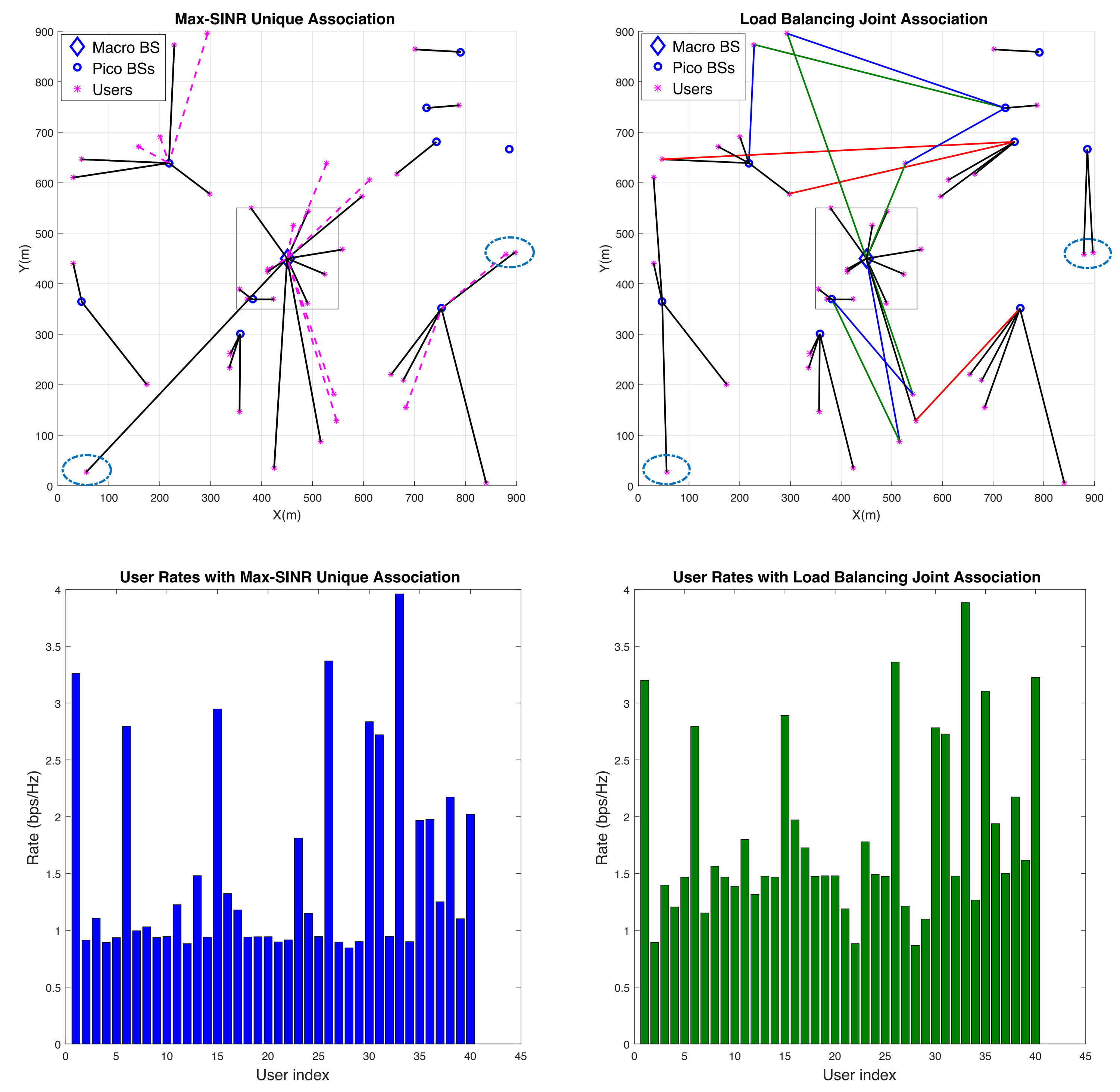
Max-SINR

- SUM Rate = 60.2 bps/Hz
- Average Rate = 1.5 bps/Hz

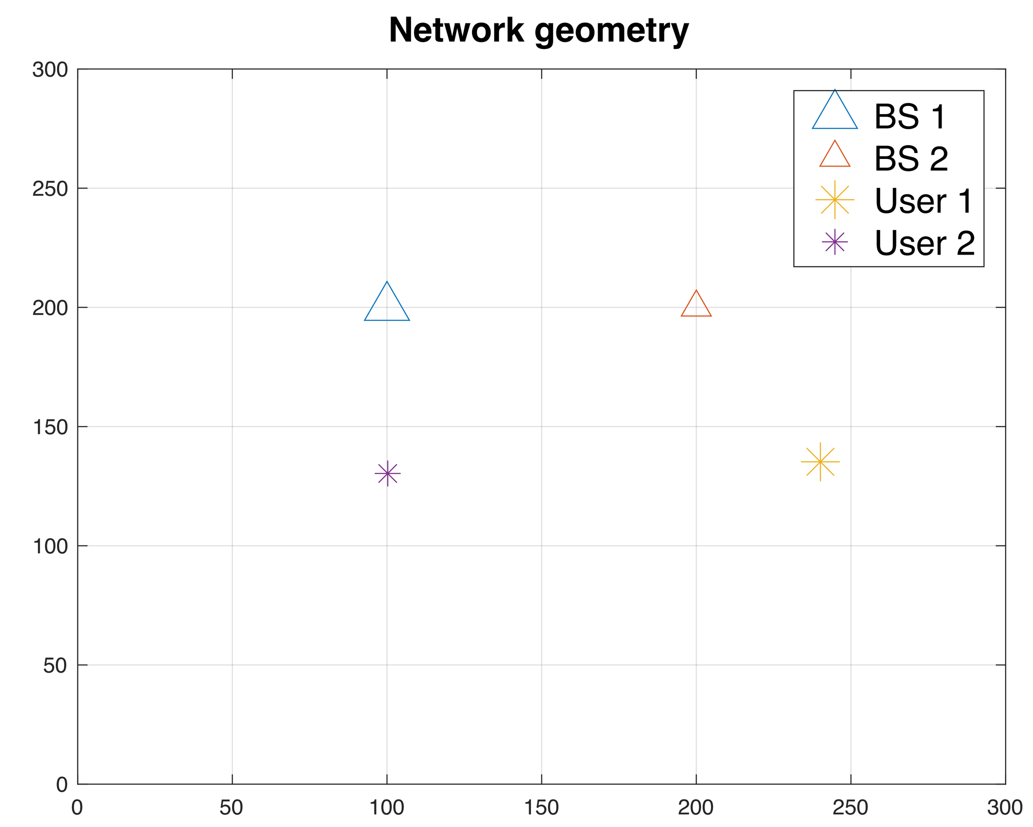
Load Balancing

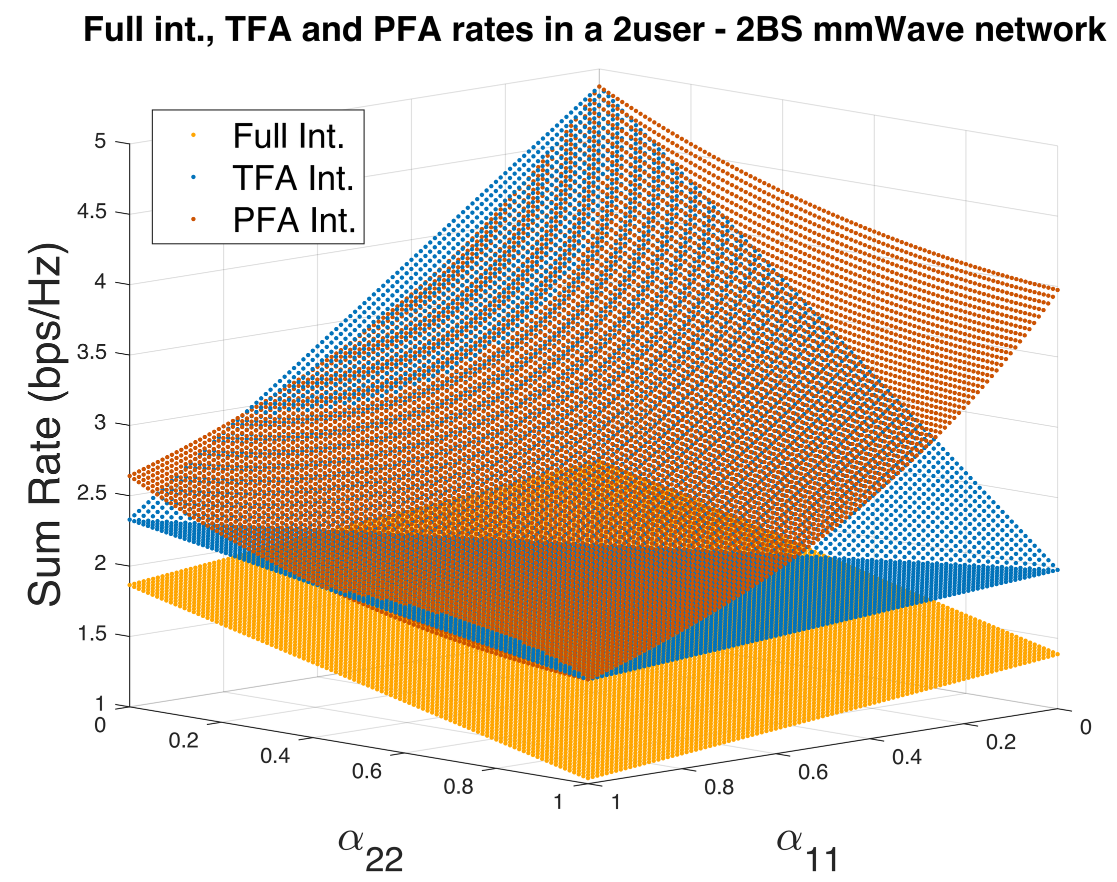
- SUM Rate = 72.66 bps/Hz
- Average Rate = 1.81 bps/Hz

Rate improvement: 20%




## Comparison of Interference Models (*mmWave channel*)




## References

[1] T. A. Thomas, et. al., 3D mmWave Channel Model Proposal, IEEE 2014 80th VTC.

[2] D. Bethanabhotla, et. al., "Optimal User-Cell Association for Massive MIMO Wireless Networks," IEEE Trans. Wirele. Commun., vol. 15, no. 3, 2016.

## Future Research

High path loss is a big challenge at mmWave frequencies. However, large antenna arrays can be implemented at mmWave systems due to the very short wavelengths, and we can apply beamforming techniques to combat path loss. Considering beamforming, the next step is to design an association algorithm to achieve a network with balanced load and highest throughput.

## Contact Information

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