



Ubiquitous cell-free Massive MIMO Communications

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WindMill study-group 11 Nov. 2020



This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie Grant Agreement No 813999.



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Introduction and Motivation

- From 1G to 4G cellular networks, the massive traffic growth has been managed by:
 - Wider bandwidths,
 - Refined radio interfaces,
 - Network densification
 - Increasing the number of antennas per site
 - Deploying smaller and smaller cells



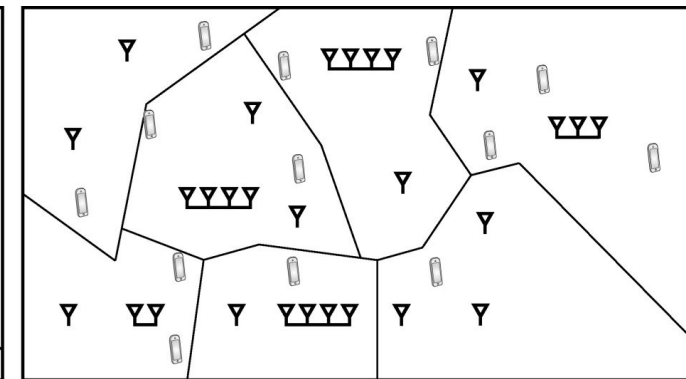
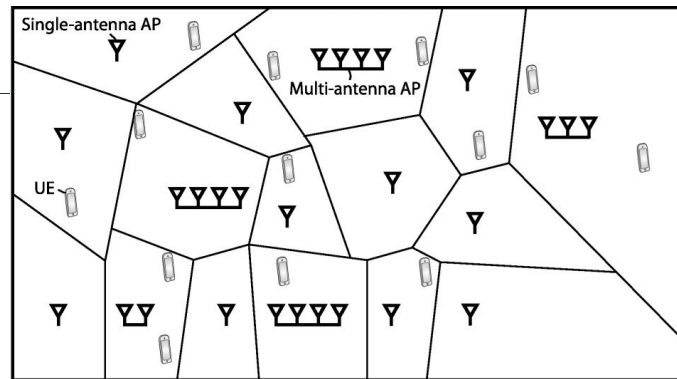
Introduction and Motivation

Inter-cell interference

Network-Centric

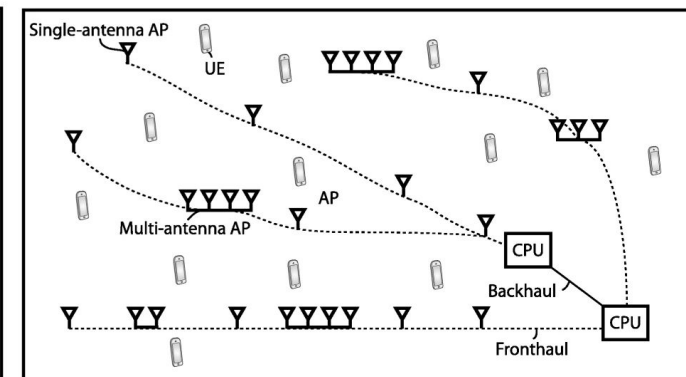
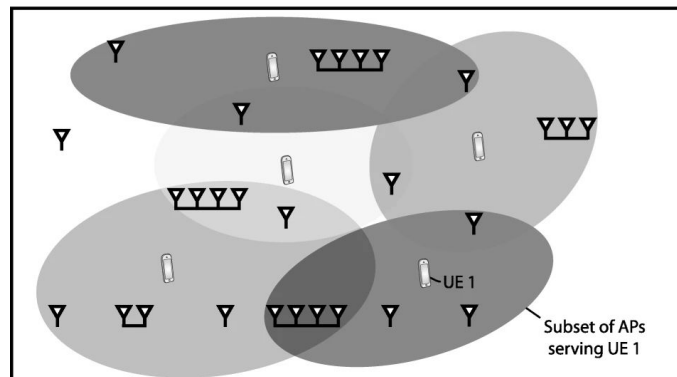
Inter-cluster interference & high backhaul

Conventional cellular network:
each UE is connected to only one AP



Network-centric implementation of CoMP-JT:
APs in a cluster cooperate to serve the UEs residing in their joint coverage area

User-centric implementation of CoMP-JT:
each UE communicates with its closest APs



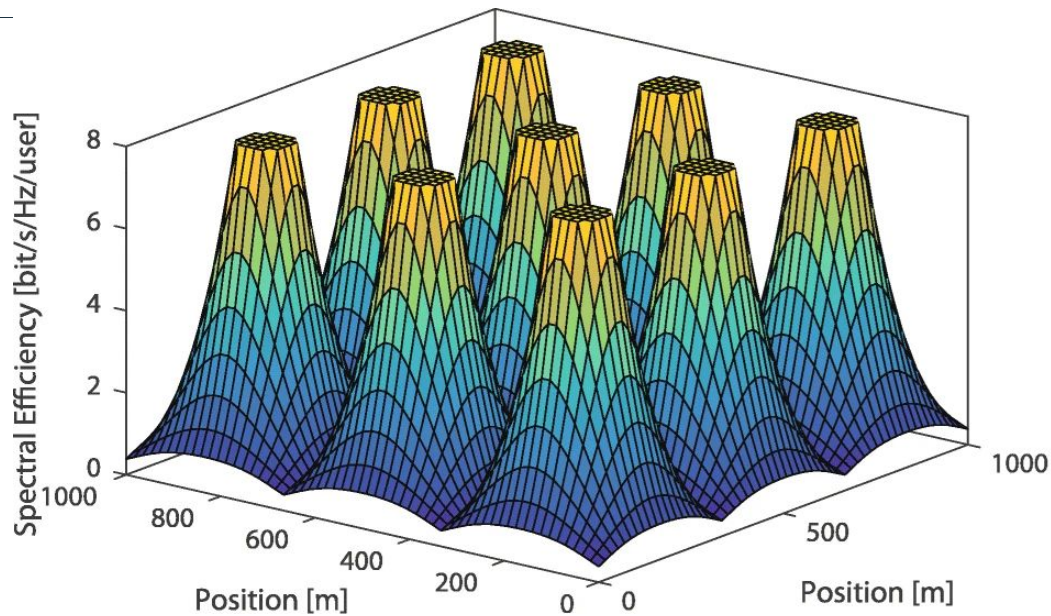
Cell-free Massive MIMO network:
a way to implement a user-centric network

User-Centric

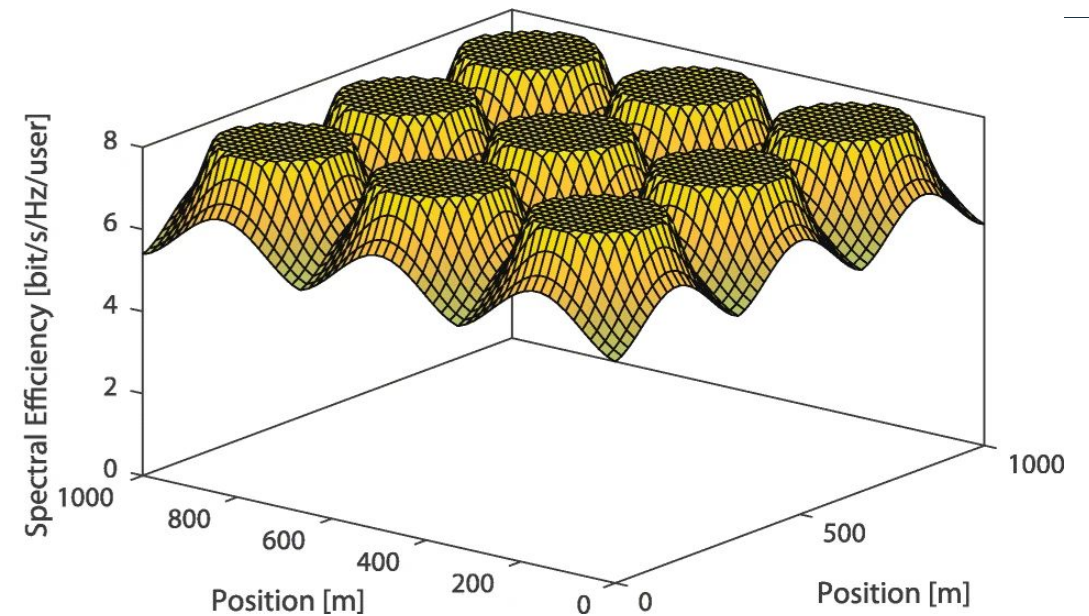


Cell-free vs. Cellular Networks

Data coverage



Cellular network

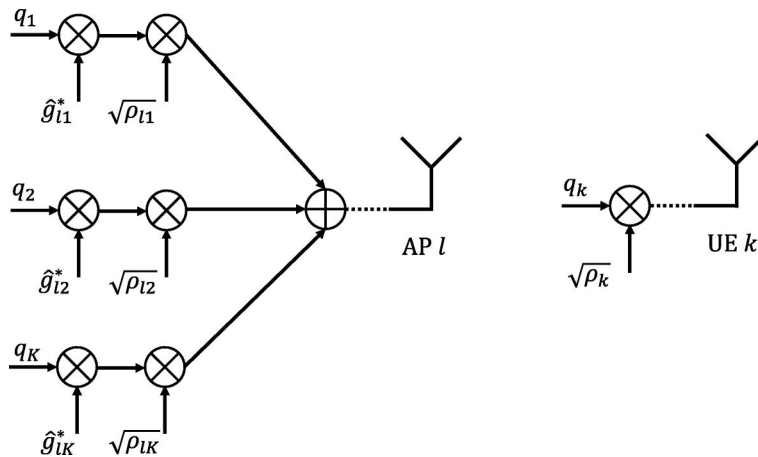


Cell-free Massive MIMO network

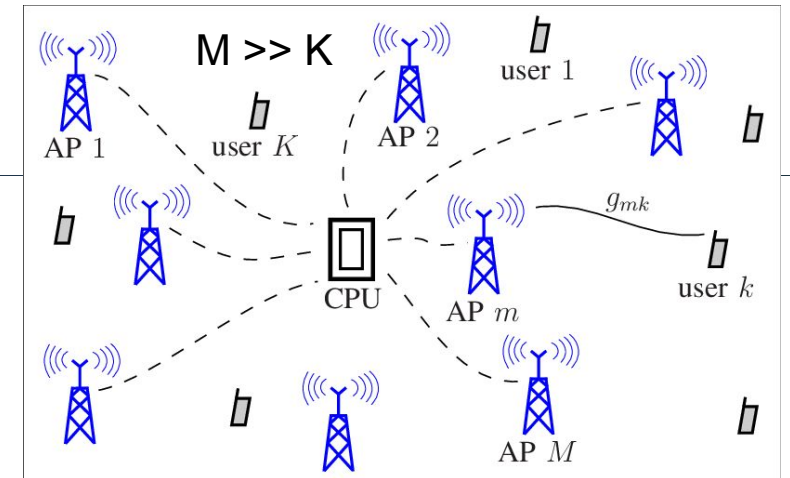
System operation

- **Channel coherence interval:**
 - time-frequency interval during which the channel can be approximately considered as *static*
 - Determined by: propagation environment, UE mobility, and carrier frequency

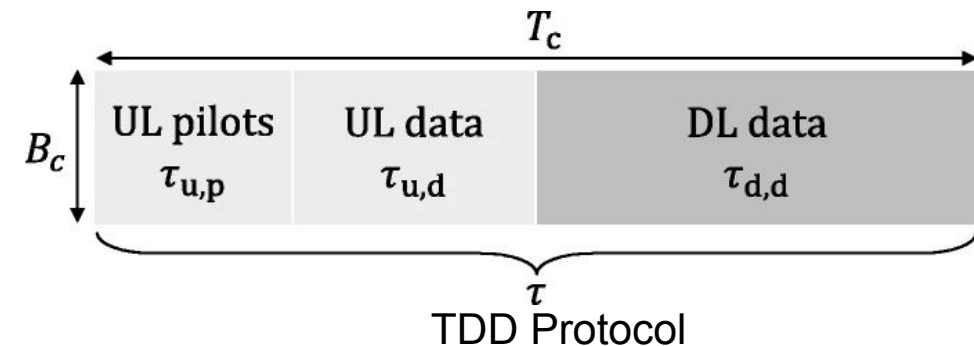
- **Pilot Contamination**



Maximum-ratio (MR) precoding



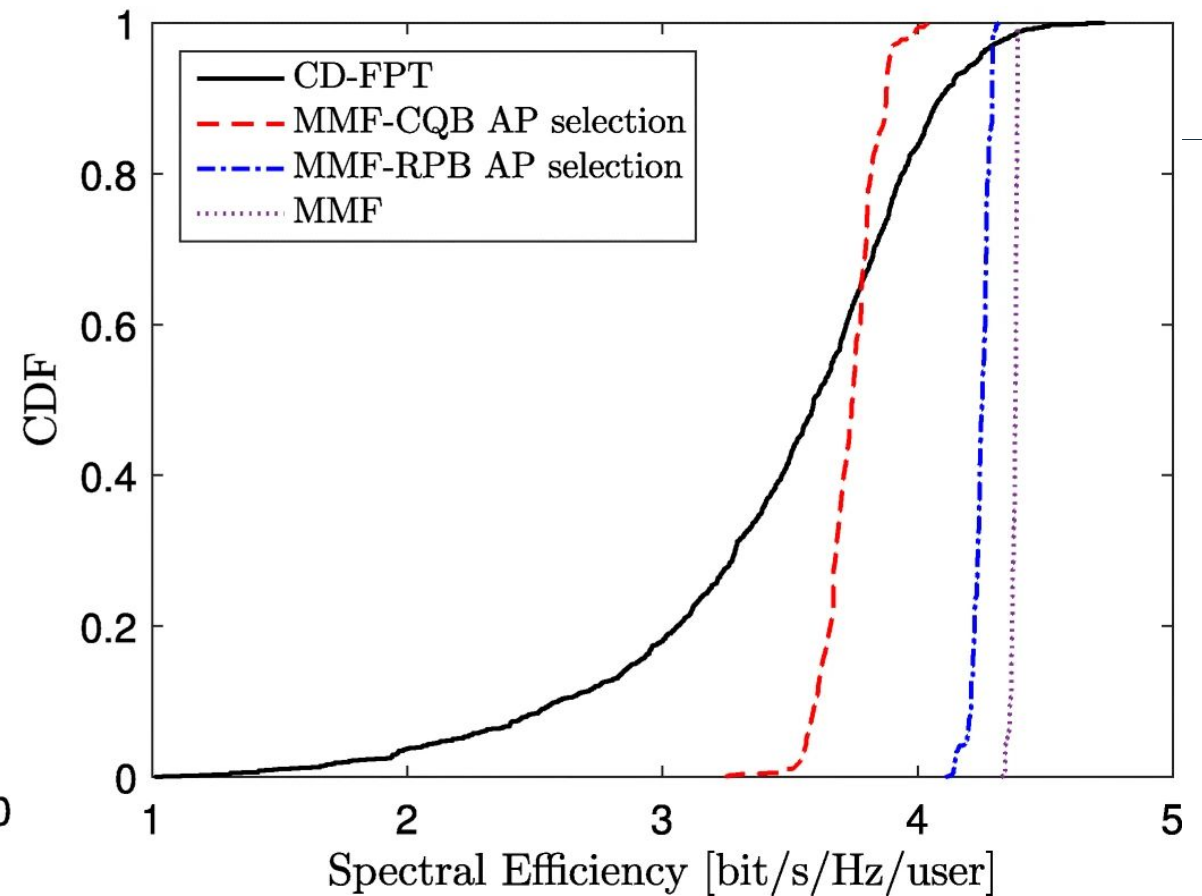
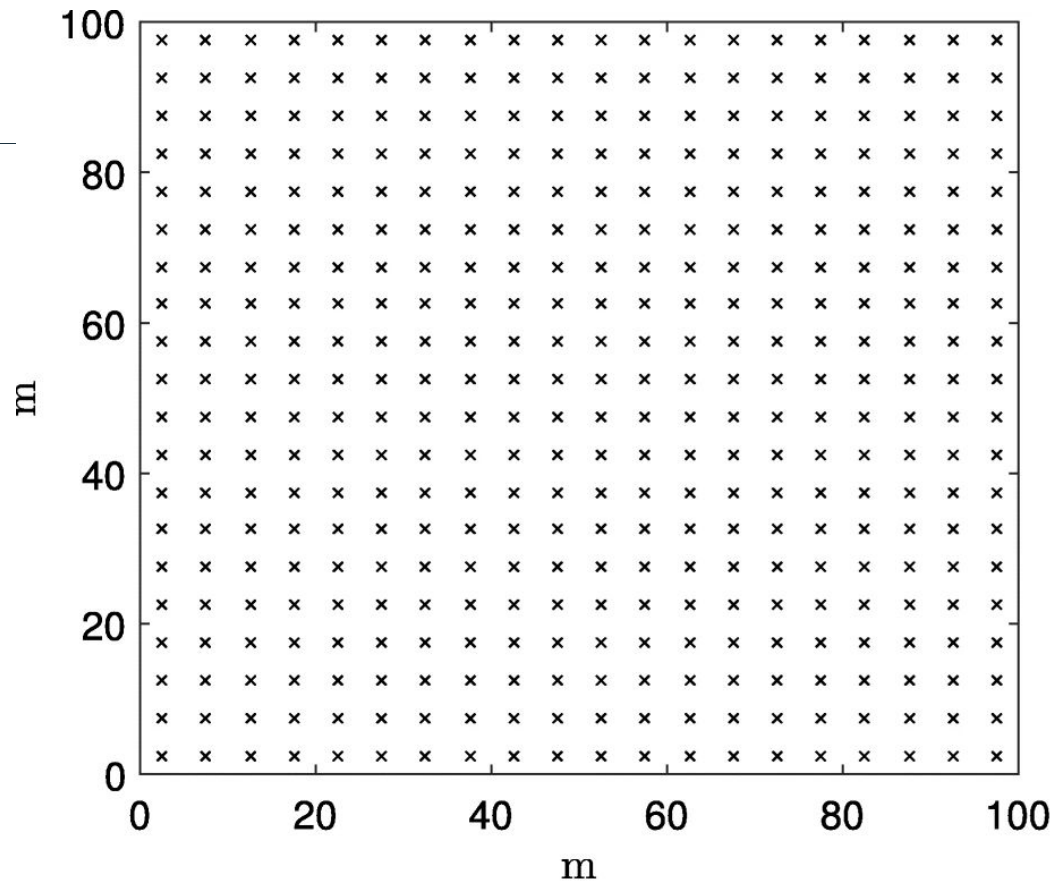
Ngo, Hien Quoc, et al. "Cell-free massive MIMO versus small cells." *IEEE Transactions on Wireless Communications* 16.3 (2017): 1834-1850.



Power Control

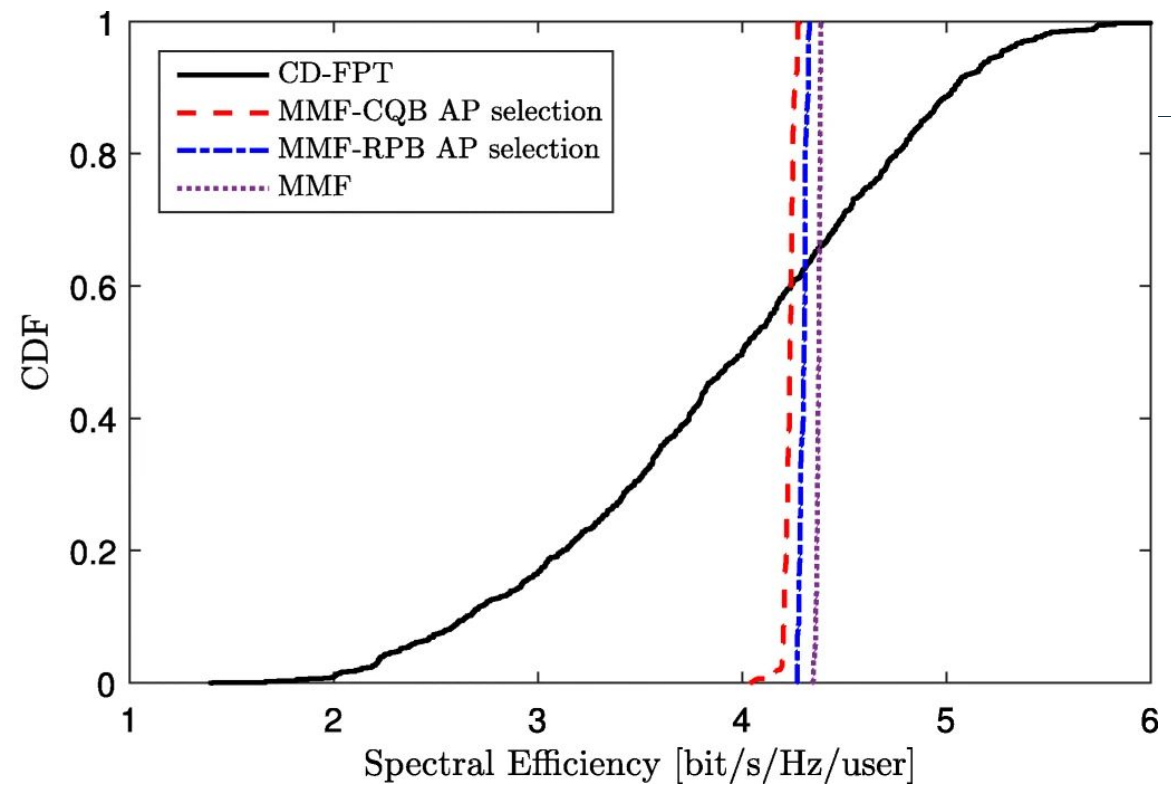
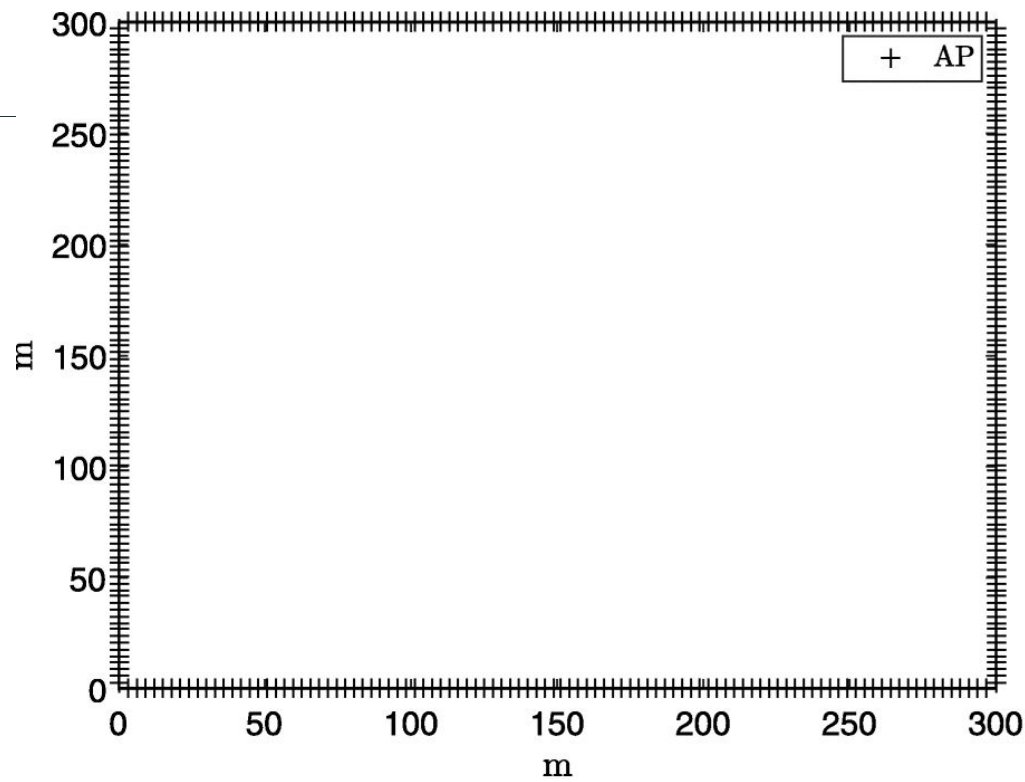
- **Channel-dependent full power transmission (CD-FPT)**
 - All APs transmit with full power
 - Power-control coefficients for a given AP m are the same for all k
- **Max-min fairness (MMF) power control**
 - All the APs are involved in coherently serving a given UE
 - Power control coefficients are chosen to maximize the minimum spectral efficiency of the network
- **Max-min fairness power control with received-power-based AP selection (MMF-RPB AP selection)**
 - Only a subset of APs serves a given UE k
 - The subset consists of the APs that contribute at least $\alpha\%$ of the power assigned to UE k
- **Max-min fairness power control with channel quality-based AP selection (MMF-CQB AP selection)**
 - This method selects the APs with the best channel quality towards UE k

Performance of cell-free Massive MIMO



$L = 400$, $K = 20$, bandwidth $B = 20$ MHz, and max per-AP power 200 mW

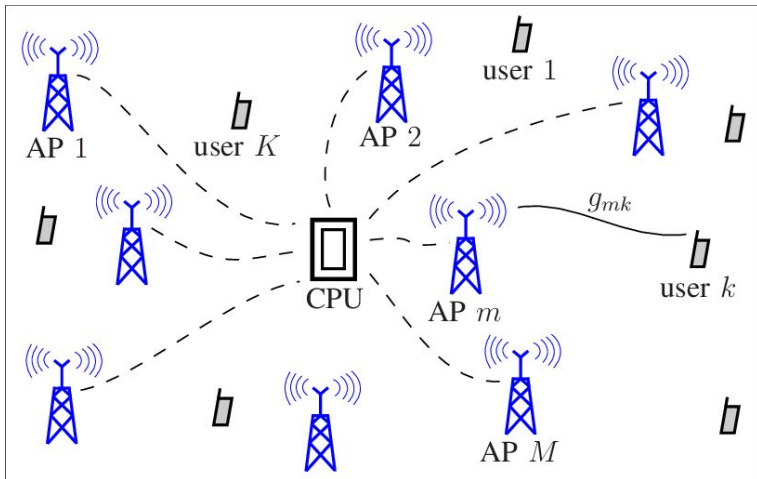
Performance of cell-free Massive MIMO



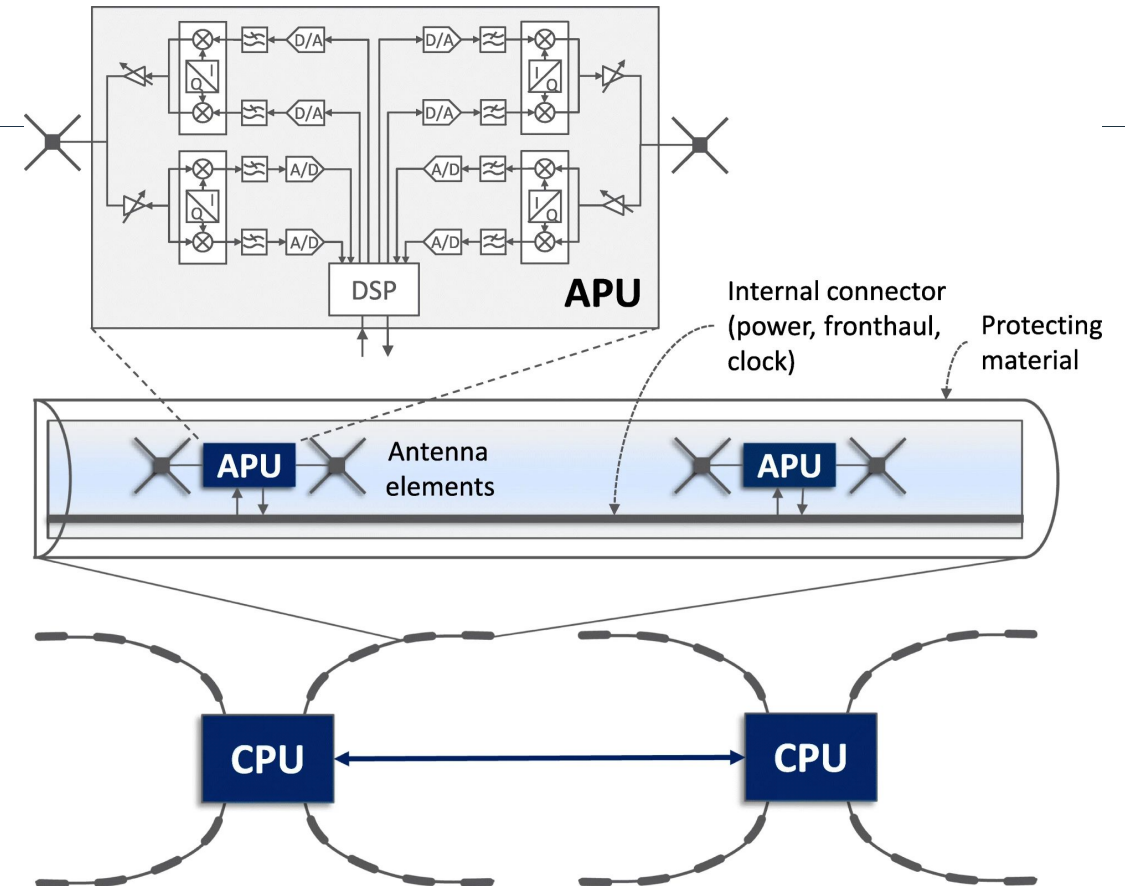
$L = 400$, $K = 20$, bandwidth $B = 20$ MHz, and max per-AP power 400 mW

Practical deployment issues

- The cost and complexity of deployment
- Limited capacity of back/front-haul connections
- Network synchronization



Ngo, Hien Quoc, et al. "Cell-free massive MIMO versus small cells." *IEEE Transactions on Wireless Communications* 16.3 (2017): 1834-1850.





Radio stripe system



<https://teletime.com.br/01/03/2019/ericsson-lanca-conceito-de-fitocell-no-mwc-2019/>



Open challenges

- **Power control**

- New PC algorithms are needed to balance fairness, latency, and network throughput, while permitting a distributed implementation

- **Distributed signal processing**

- In MR precoding/detection and synchronization can be distributed
 - But, data encoding/decoding must be carried out at CPUs

- **Resource allocation and broadcasting**

- New scheduling, pilot allocation, random access and ... should be designed for cell-free

- **What else**

- Channel modeling, DL channel estimation, Prototype development, ...



THANK YOU!

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Beneficiaries



Partner organisations



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