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CELL FREE MASSIVE MIMO VS USER CENTRIC MASSIVE MIMO

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- **ABSTRACT**: This Poster notices the downlink data transmission portion for the User-Centric Massive MIMO systems, where a large number of APs at once is spread arbitrarily in an area to serve a smaller number of users. Channel estimates are obtained with use of Uplink pilot transmission which would then be useful to transmit information from APs to the users on performing conjugate beamforming towards the desired MS. We then compare the UC Massive MIMO approach to the Cell-Free Massive MIMO approach assuming that every AP doesn't serve all the MS, rather just the ones that have the high channel gains.

1. INTRODUCTION

- Massive MIMO is a reliable 5G wireless communication technology which includes deployment of multiple antennas at the Base Stations [3].
- In Cell Free Massive MIMO , Access Points are connected to a central processing unit through a backhaul network. The data which is to be transmitted to the mobile stations are sent to the access points. Neither the channel estimates or the beamforming vectors are transmitted through the backhaul network [2].
- In User-Centric Massive MIMO, Each access point doesn't serve all the Mobile Stations, rather just the ones that have the high channel gain. Thus, User-Centric Massive MIMO Provides better rate-per-user [1].

2. PROBLEM FORMUALATION

Comparing to the Small Cells Massive MIMO technique, In terms of 95%-likely per user rate, Cell-Free Massive MIMO gives superior execution but in Cell-Free approach, All Access Points employs Time-Division Duplex(TDD) operation, coordinate in phase through a backhaul network, where every user is served within the same time-frequency resource and hence causing a huge backhaul overhead. So A modern architecture has been presented that is User-Centric Massive MIMO which would require less backhaul overhead as well as will give more throughput in comparison to the Cell-Free approach and this could be accomplished in such a way that All Access Points serve specific Mobile Stations with strongest channel.

3. SYSTEM MODEL

An area with P mobile stations and Q access points have been considered. At first, In the training phase, Uplink Pilots are transmitted with the help of which Access Points calculates the channel estimates and arrange them in descending order of their strength. Thus, performs conjugate beamforming to send the data on the downlink. Lastly, uplink data transmission takes place from Mobile Stations to Access Points.

3.1. CHANNEL MODEL

$C_{p,q}=\beta_{p,q}^{1/2}s_{p,q}$ denotes the channel between the pth MS and qth AP where $\beta_{p,q}^{1/2}$ is a scalar coefficient which models the path loss in the channel. $s_{p,q}$ is a CN(0,1) random variable which represents small scale fading. $\beta_{p,q}^{1/2}=10^{PathL/10}10^{\sigma_{sd}corr_{p,q}/10}$ where $10^{\sigma_{sd}corr_{p,q}/10}$ represents the shadow fading with standard deviation σ_{sd}. $corr_{p,q}$ is the shadowing correlation coefficient. The three slope model for path loss is given as[1]:

$$\mathrm{PathL}_{p,q}=\begin{cases}-fsl-35\log_{10}(dis_{p,q}), & \text{if } dis_{p,q}>dis_1\\ -fsl-10\log_{10}\left(dis_1^{1.5}d_{p,q}^2\right), & \text{if } dis_0<dis_{p,q}\le dis_1\\ -fsl-10\log_{10}\left(dis_1^{1.5}dis_0^2\right), & \text{if } dis_{p,q}<dis_0\end{cases}$$

where $dis_{p,q}$ indicates the separation between the q-th access point and the p-th user, fsl is

$$fsl=46.3+33.9\log_{10}(fsl)-13.82\log_{10}(t_{\mathrm{AP}})$$
$$-[1.11\log_{10}(freq)-0.7]\,r_{\mathrm{MS}}+1.56\log_{10}(freq)-(0.8)$$

where *freq* represnts the frequency of carrier in MHz, t_{AP} & r_{MS} indicates the access point & heights of mobile stations and antenna, respectively.

4. THE COMMUNICATION PROCESS

1) Pilot-Matched (*PM*) Channel Estimation: The estimate, $\widehat{c}_{p,q}$ say, of the channel coefficient $c_{p,q}$ is formed as $\widehat{c}_{p,q}=\frac{1}{\sqrt{roh_p}}\phi_p^H\mathbf{r}_q$, with $(\cdot)^H$ denoting conjugate transpose.

2)Scalar LMMSE Channel Estimation [1][3]:

$$\widehat{c}_{p,q}=\frac{\sqrt{roh_p}\beta_{p,q}\phi_p^H\mathbf{r}_q}{\sum_{i=1}^{P}roh_i\beta_{i,q}\left|\phi_p^H\phi_i\right|^2+\sigma_n^2}$$

Uplink Training Phase

$$\gamma_p^{\mathrm{DL}}=\frac{\left|\sum_{q\in\mathcal{P}(p)}\sqrt{\eta_{p,q}^{\mathrm{DL}}}c_{p,q}\widehat{c}_{p,q}^{*}\right|^2}{\sigma_z^2+\sum_{i=1,i\neq p}^{P}\left|\sum_{q\in\mathcal{P}(i)}\sqrt{\eta_{i,q}^{\mathrm{DL}}}c_{p,q}\widehat{c}_{i,q}^{*}\right|^2}$$

The downlink rate for the p -th mobile station, assuming Gaussian data-symbols, $\mathcal{R}_p^{\mathrm{DL}}=BW\log_2(1+\gamma_p^{\mathrm{DL}})$, with BW the communication bandwidth.

Downlink Data Transmission

For the Cell-Free Massive MIMO Case:

2) CF Massive MIMO Architecture: The CF approach can be obtained as a special case of the UC approach by putting $num=P$, i.e., $\mathcal{P}(q)=\{1,\ldots,P\},\forall q$

5. PERFORMANCE ANALYSIS

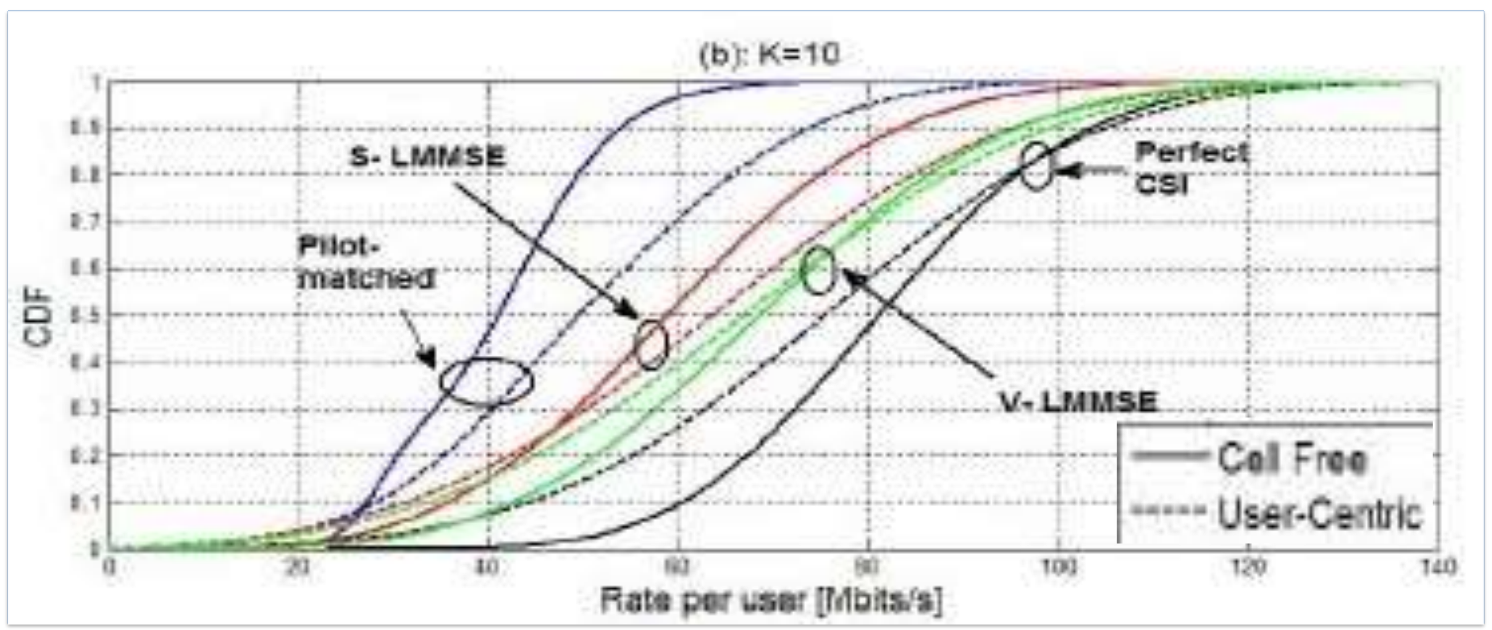

Fig.1. Downlink rate per user CDF. For the UC case [1] we have *P*= 10 and *num* = 2 and For the CF case num=P respectively.

Bandwidth=20MHz,Height(AP)=15m,Height(MS)=1.65m,σ_{sd}=8dB. For calculating Pathloss from 3.1, Three slope model is considered where dis_1=50m,dis_0=10m,δ=0.5,Area in which APs & MSs are distributed randomly=1km^2 ,Q=100,Pilot sequence length=P,P(uplink)=100mW., P(downlink)=200mW. For the case K = 10 with PM channel estimation, the downlink 95%-likely per-user rate is 22.34 (25.2) Mbit/s for the UC (CF) approach [1], i.e., the loss of the UC approach is about 11%; on the other hand, the UC approach outperforms the CF approach by 4% in terms of 90%-likely per-user rate, and by 21% in terms of median-rate [1].

6. FUTURE WORK

- It can be observed that with simple channel estimation methods, the User-Centric approach outflanks the Cell-Free one, except for few users having bad channel or low channel gain. The future work will be focused on the simulation based result for all of the different channel estimation techniques. These would be performed for the high density user along with the uplink data transmission phase of UC Massive MIMO to infer more important results.

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