Spatial Channel Models

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Victoria University of Wellington

Robert Reid, 300385028

***Abstract*—To evaluate the performance of single users a in multi-user multiple-input-multiple-output system, we investigate the performance of different channel models and the capacity. The two spatial models that are to be simulated are the cluster ray-based channel and the classical Kronecker correlated fading model. The key aspects that are to be analysed are derived from the Signal-to-interference-plus-noise ratio, which produces the spectral efficiency of the cell. We also present the process of modelling these channels and how it has been mathematically modelled. Using these models we present the relationship between the efficiency and the signal-to-noise-ratio, and compare probability that an efficiency value will be greater than a certain value. During this investigation we also simulate the affects of having large arrays of transmit antennas, and discuss how it affects the performance. We demonstrate in the ray-based model how the performance increases with an increase in antennas and how zero force processing is better than maximum ration combining processing techniques. Additionally demonstrating in the Kronecker model that increasing the antennas reaches a saturation point, also showing that the ZF processing technique excels.**

Table I

Parameters of Numerical Values

Parameter	**Value**
cell radius, r	100 m
exclusion radius, r_o	10 m
median SNR value	0 dB
pathloss, Γ	3.2
shadow fading SD σ_{sf}	8.2 dB
link gain reference. distance d_o	1 m
antenna spacing δ	0.5
number of clusters, C	3
number of subrays, S	16
number of antennas, M	15, 100, 150, 500
cluster angle mean, μ_c	0
cluster angle variance, σ_c^2	14.4^{o2}
subray angle variance, σ_s^2	1.28^{o2}
Transmit power, ρ_{ul}	70.5 dB
number of users, L	10

I. Introduction

To investigate wireless networks we develop channel models that account for variations in 5$^{\text{th}}$ Generation wireless systems have a growing interest in Massive Distributed MI-MO that is aimed to increase the data rates up to 5 Gbps, with a network latency under a millisecond and also increase the capacity and efficiency by a factor of 1000 [1]. This is very necessary with growing demands for higher data rates and user density increasing. The previous generation of wireless communication required high-powered cell towers to radiate signals over long distances, while 5G will be transmitted via large quantities of small cell stations located around dense areas, positioned on buildings and light poles. The problem with just increasing the number of MI-MO streams from a single base station is the channels become too correlated. By distributing the antennas and increasing the spatial separation, the performance improves. This uses an increased frequency like those used in broadband although the major trade-off is that it is more susceptible to wall loss. Multiple antennas are to communicate with one user at a time to assure connection and minimise fading.

The focus on this paper is to model and simulate the performance of a channel in a single cell, using up-link linear receiving and down-link linear precoding techniques and observe how the distribution of antennas affects the performance. The transmitting antennas are to be distributed geographically in circle array around the center of the cell, assuming they are connected via fiber optics with negligible delay and infinite bandwidth. The capacity of the systems is to be determined from the simulation by varying the signal-to-noise ratio, and comparing the different plots.

II. System Model

The model is to determine the maximum achievable rate for the channel, by observing the systems ergodic sum spectral efficiency, where the model is derived from prior research, for 4 users, K, in a cell. In this system the number of users, M, will be 6 which is the same as the model investigated [2][3]. This uses the equations II-.4 and II-.6 below where the SINR is the variable.

$$h_l = \sum_{c=1}^{C}\sum_{s=1}^{S}\gamma_{c,s}^{(l)} a(\phi_{c,s}^{(l)}) \quad \text{(II-.1)}$$

$$W^{MRC} = H \quad \text{(II-.2)}$$

$$W^{ZF} = H(H^H H)^{-1} \quad \text{(II-.3)}$$

$$\beta^{(l)} = AX_l(\frac{d_l}{d_o})^{-\Gamma} \quad \text{(II-.4)}$$

$$SINR_l = \frac{p_{ul}|w_l^H h_l|^2}{p_{ul}\sum_{l'=l}^{L}|w_l^H h_{l'}|^2 + \sigma_n^2||w_l||^2} \quad \text{(II-.5)}$$

$$E[SE_{sum}] = E\Big[\sum_{l=1}^{L} SE_l] \quad \text{(II-.6)}$$

III. Conclusion

We have presented a study of the distributed antenna performance for different linear precoders. We have shown that the increase in the distribution of antennas increases the performance as the channels become less correlated and distance decrease. With analysis and simulation, we have shown how much the system is expected to improve using a known model. Furthermore, we have shown how the sum capacity of the system relates to the signal-to-noise ratio of the power transmitted.

References

[1] 5G live test demo: Multipoint Connectivity with Distributed MIMO
https://www.youtube.com/watch?v=jCO68dPoNwA
https://www.ericsson.com/en/press-releases/2015/5/new-5g-innovations-boost-mobile-data-speeds

[2] Tataria, Harsh. (2017). Analysis of Multiuser Cellular Systems in Heterogeneous Channels

[3] Hien Quoc Ngo. (2015). Massive MIMO: Fundamentals and System Designs