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# A non-stationary channel model for 5G massive MIMO system

**Key words:** Massive MIMO; Spherical wave-front assumption; Non-stationary property; Birth-death process; Visibility region method

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# Motivation

- Massive multiple-input multiple-output (MIMO) has been proposed as one of the essential candidate technologies for the fifth generation (5G) wireless communication networks.
- For MIMO system design and performance evaluation, an accurate small-scale fading MIMO channel model is indispensable. However, according to the channel measurements, some new characteristics that make the conventional MIMO channel models not effective for application to model massive MIMO channels directly.

# Main idea

- The proposed channel model for massive multiple-input multiple-out (MIMO) communication systems incorporates the spherical wave-front assumption and non-stationary properties of clusters on both the array and time axes.
- A novel visibility region method is proposed to capture the non-stationary properties of clusters at the receiver side. Combined with the birth-death process, a cluster evolution algorithm is proposed.
- Corresponding to the theoretical model, a simulation model with a finite number of rays that capture channel characteristics as accurately as possible is proposed.

# Method

1. Derive expressions of calculating AoA shifts, Doppler frequencies, and channel coefficients under the spherical wave-front assumption.
2. Propose a cluster evolution algorithm to describe cluster evolution.
3. Propose a corresponding simulation model for the theoretical model with a finite number of rays.
4. Investigate the impacts of the spherical wave-front assumption and cluster evolution on the statistical properties of our proposed model.

# Major results

- Our proposed channel model can describe the ray evolution on the array axis and power deviation of rays within the cluster for different antenna pairs.



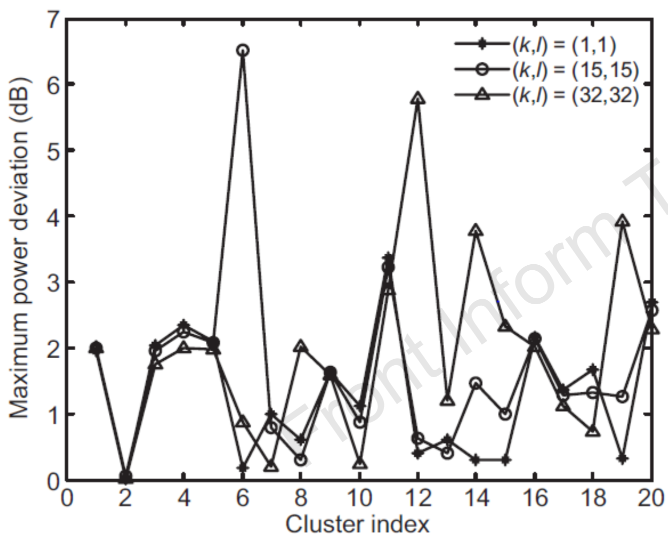


**Fig. 4 An example of maximum power deviation of rays within the cluster**

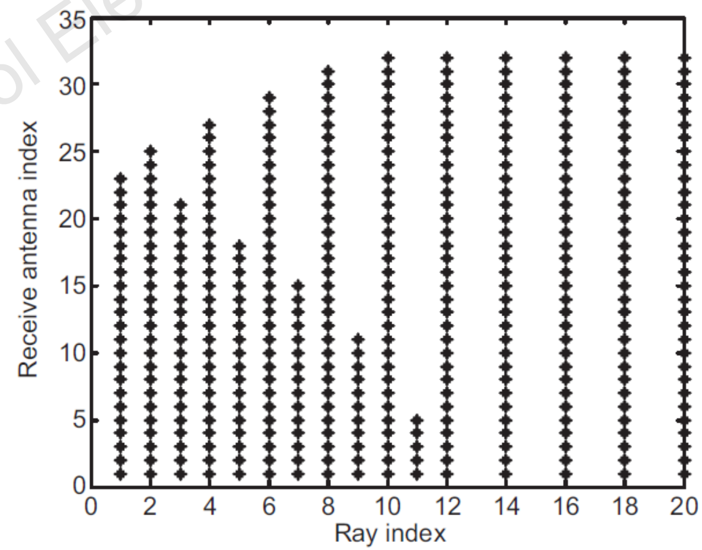


**Fig. 5 An example of ray evolution on the receive antenna array (The asterisk '*' symbol in the two-dimensional plane means its corresponding antenna element observes its corresponding ray element)**

# Major results

- The impacts of cluster evolution and spherical wave-front assumption on the statistical properties of the channel model are investigated.



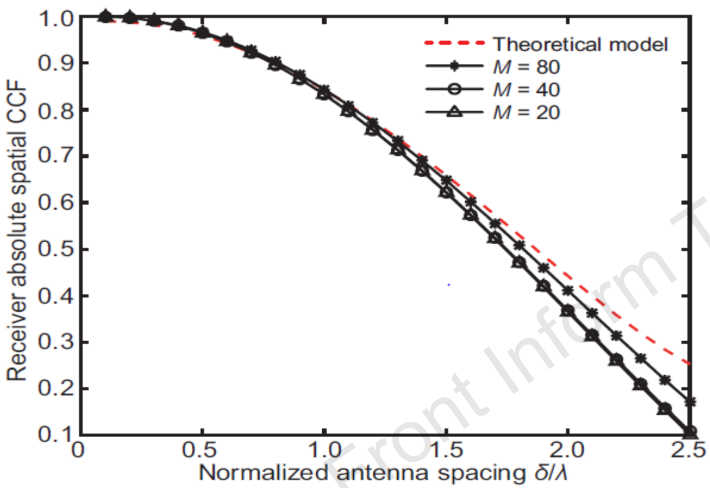


**Fig. 6** **Absolute receiver spatial CCF $|\rho_{11,12,1}(0,\delta_\mathrm{R};t)|$ of the proposed channel model in terms of the number of rays at the receiver side ($M_\mathrm{R}=32$, $M_\mathrm{T}=1$, $t=1$ s, $D=150$ m, $b=1$, $\mu=0$, $\beta_\mathrm{T}=\beta_\mathrm{R}=\pi/2$, $\lambda=0.15$ m, $f_{\max}=66.66$ Hz , $\theta_v=\pi/3$, NLOS)**

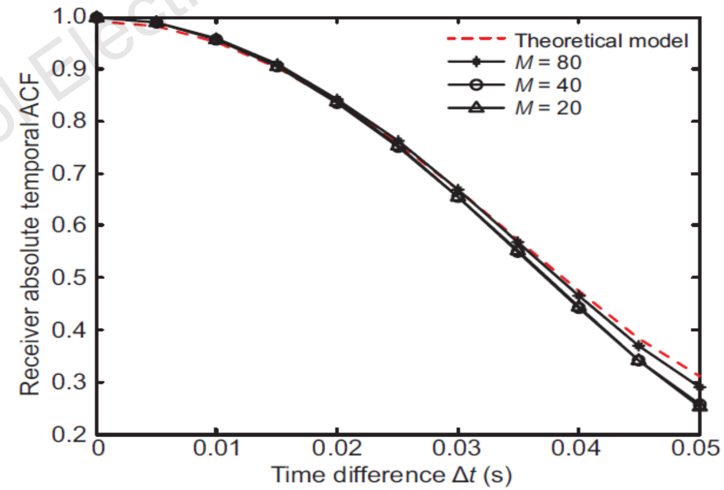


**Fig. 8** **Absolute receiver temporal ACF $|\rho_{11,1}(\Delta t;t)|$ of the proposed channel model in terms of the number of rays within the cluster at the receiver side ($M_\mathrm{R}=32$, $M_\mathrm{T}=32$), $t=1$ s, $D=150$ m, $b=1$, $\mu=0$, $\beta_\mathrm{T}=\beta_\mathrm{R}=\pi/2$, $\lambda=0.15$ m, $f_{\max}=66.66$ Hz, $V_c=1$ m/s, $\theta_{c,n}=\pi/3$, $\theta_v=\pi/3$, NLOS)**

# Conclusions

- In this paper, a novel theoretical non-stationary channel model reflecting the spherical wave-front assumption and cluster evolution on both the array and time axes is proposed for massive MIMO.
- A novel cluster evolution algorithm is presented to models cluster evolution on both the array and time axes
- The impacts of cluster evolution and the spherical wave-front assumption on the statistical properties of the channel model are investigated, and numerical analysis shows that our proposed channel model can serve as a design framework to model massive MIMO channels.