華中科技大學

Huazhong University Of Science & Technology

Energy Efficient Technologies for Cooperative MIMO Mobile Communication Systems Based on Interference Coordination

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UK-China Science Bridge

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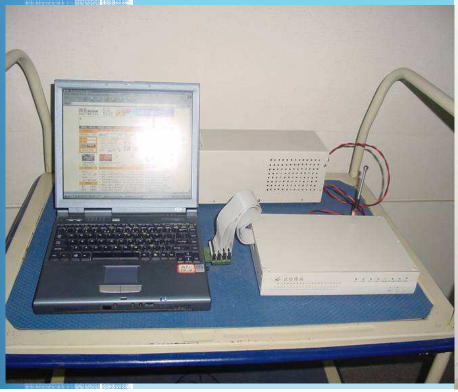
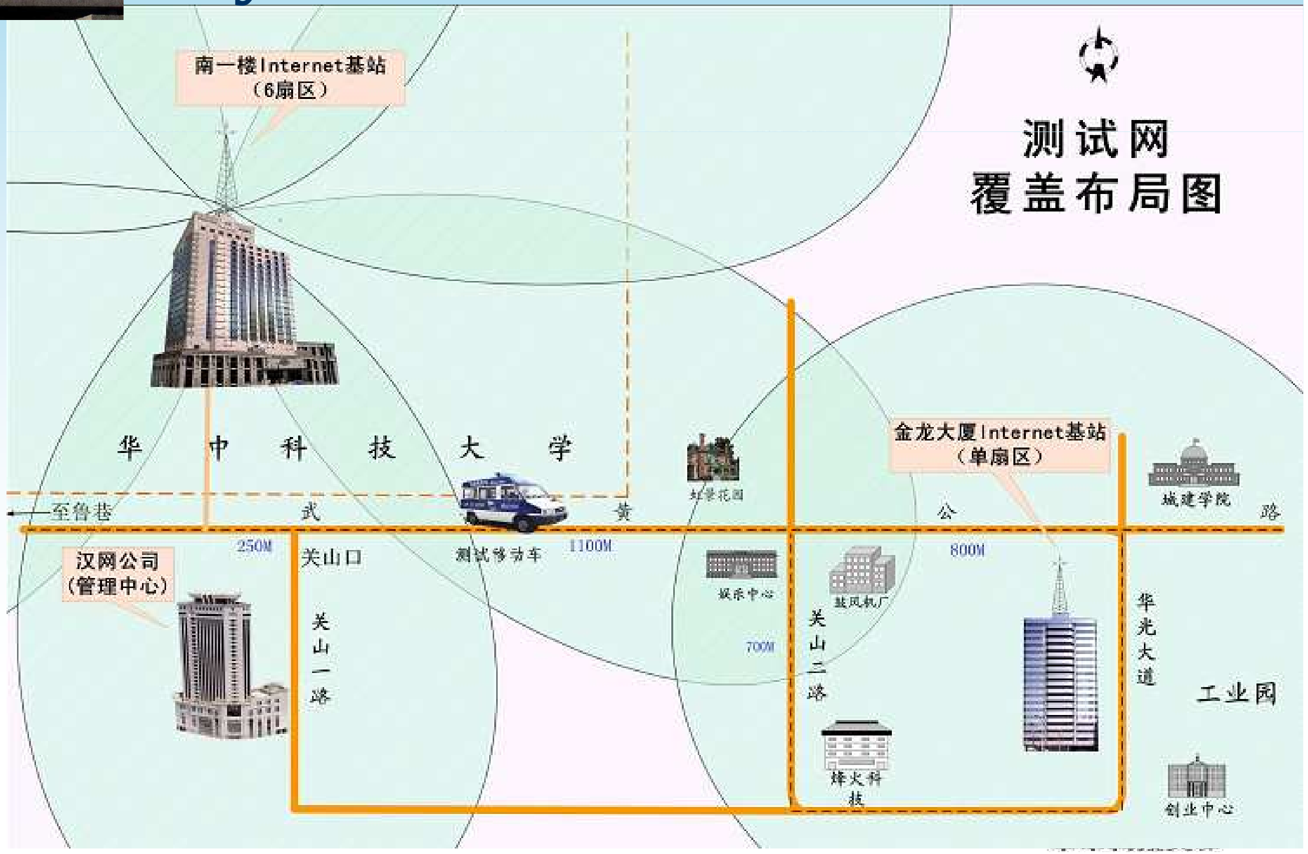


PDMA: *@2Mbps*
All-IP Cellular Mobile Communication Trial System by HUST in 2002



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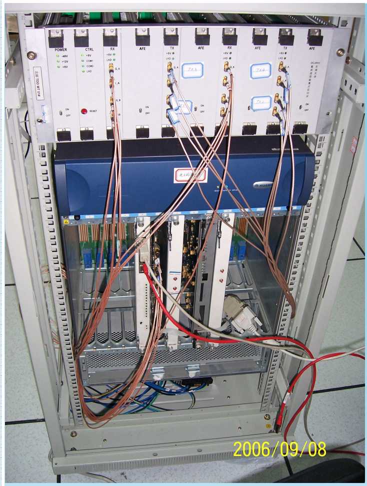
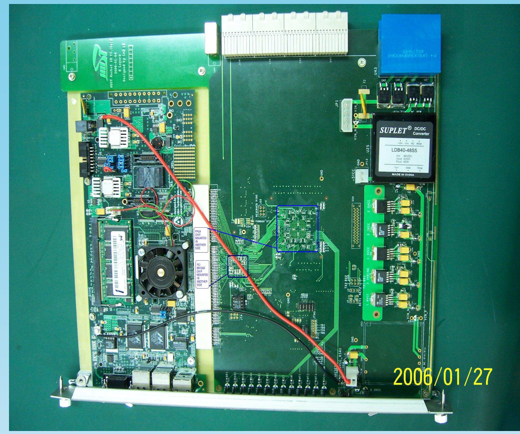
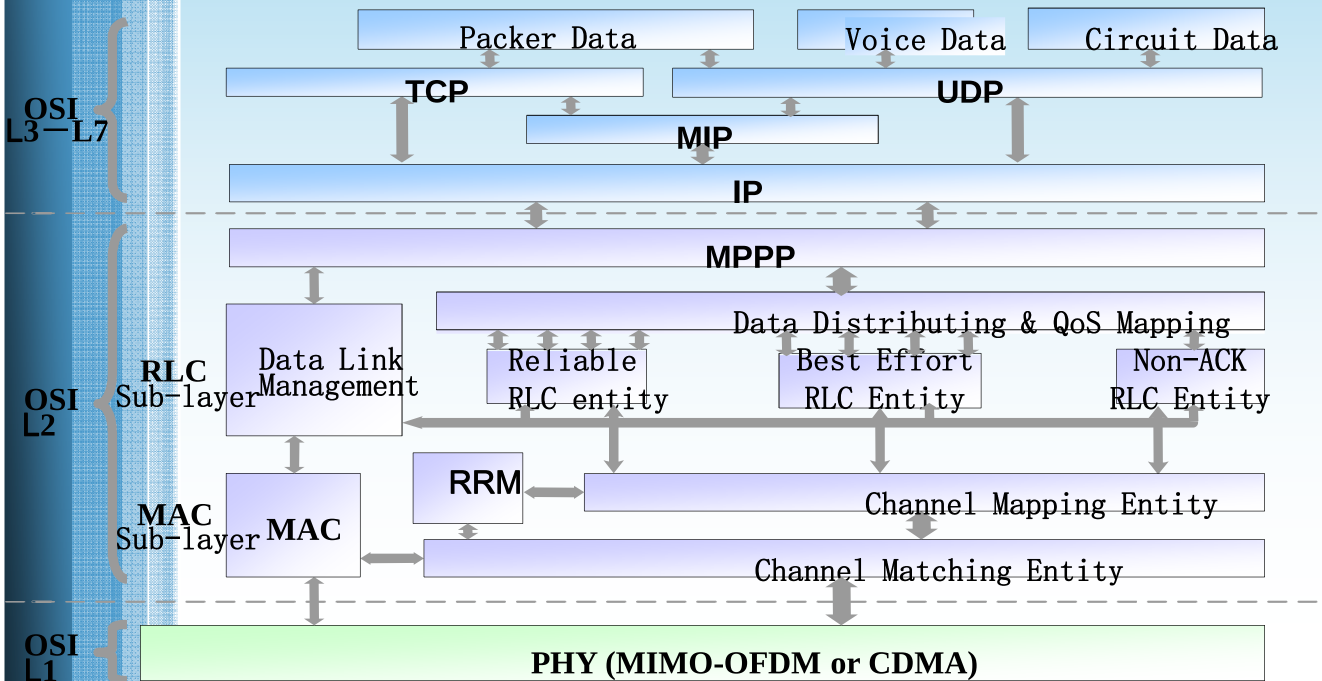


FuTURE/B3G Project





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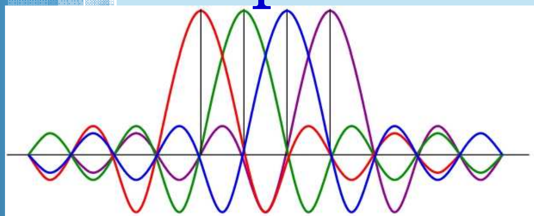
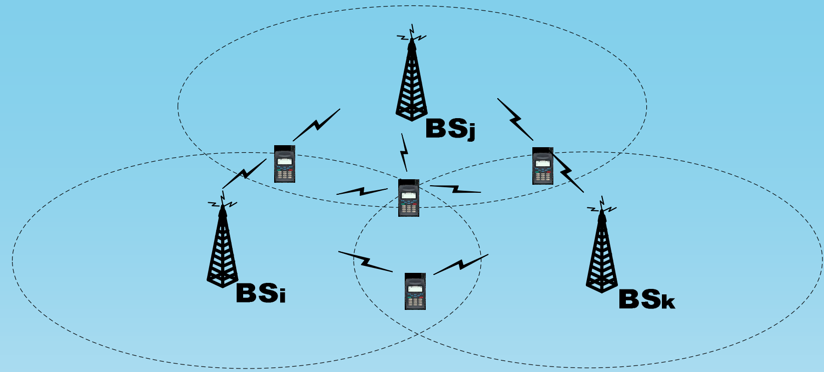
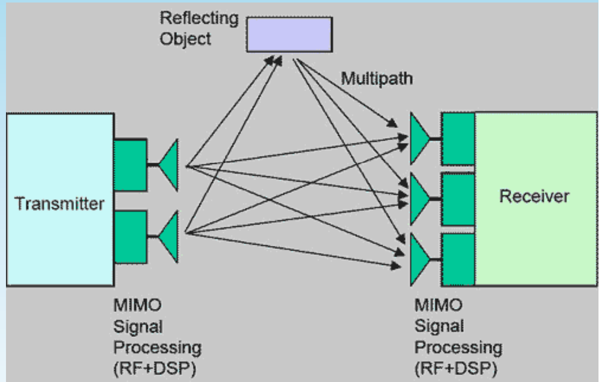
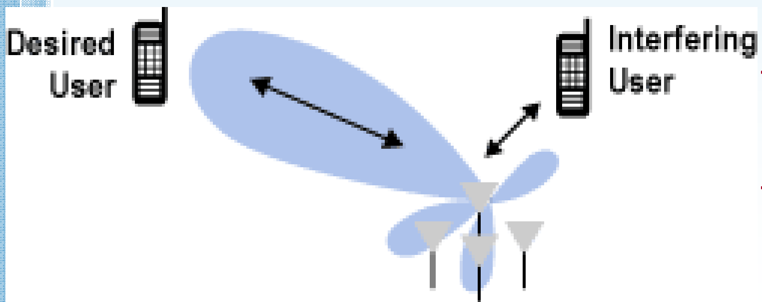
Orthogonal
Frequency
Division
Multiplexing





Interference
Coordination





Adaptive
Antenna
System

Multiple
Input
Multiple
Output

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PDMA project

- China MOST Key 863 Programme "Broadband wireless IP technology", 2000-2002;

FuTURE project

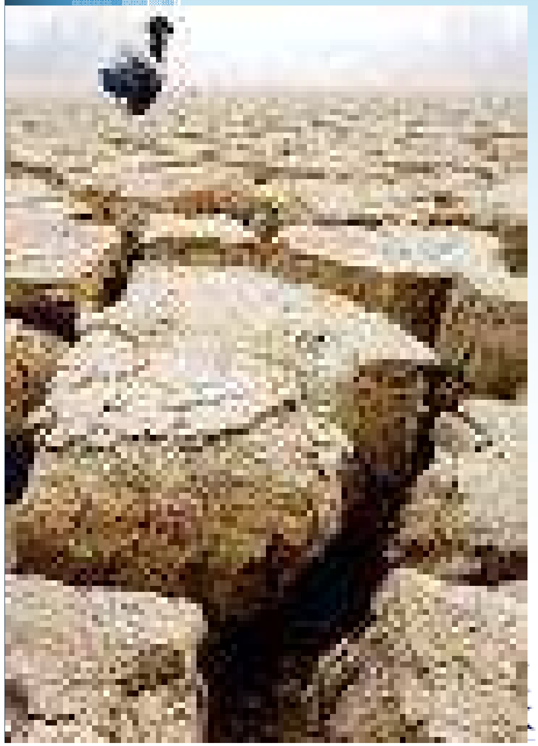
- China MOST Important 863 Programme "Research on wireless link technology for next generation cellular mobile communication system", 200-2003;
- China MOST Important 863 Programme "Design and testbed of TDD system protocol, adaptive link and coding", 200-2005;
- China NSFC Important Project "Adaptive air interface technology based on MIMO-OFDM", 2004-2008;

Current projects

- China MOST 863 Porgramme "Research on interference coordination technology for multi-user multi-antenna cellular networks", 2009-2010;
- China MOST international cooperative Programme "Cooperative communication technology in wireless networks", 2010-2012.

2.1 Background and Motivation-1

In China, the Telcom. Industry consumed **20** Billion kilowatt at 2008.



Until 2011, the China 3G mobile communication system will add 400,000 base stations. More base stations, more energy consumption?

2.1 Background and Motivation-2

- For the next generation mobile communication system, MIMO technology was widely accepted to improve the transmission rate and spectrum efficiency;
- Interference coordination technology is one of the key technologies to implement high transmission rate in the multi-cell MIMO cellular networks.
- How to trade off the energy efficiency and spectrum efficiency in the cellular networks based on interference coordination?

2.1 Background and Motivation-3

- Aim and objects:

  The ultimate aim of this project is investigate and develop various energy efficient techniques for cooperative MIMO systems with multiple cells based on the interference coordination.

- The measurable objectives

(1) Develop an interference model for cooperative MIMO systems with multiple cells based on the theory of alpha stable processes and analyse the system capacity;

(2) Investigate the impact of interference coordination techniques on the transmission energy efficiency of base stations in cooperative MIMO communication systems;

(3) Develop energy-efficient techniques for cooperative MIMO systems.

2.2 Research Programme - 1

Work Package 1 :**Interference modelling and capacity analysis of multi-cell cooperative MIMO networks**

- An analytical co-channel interference model has been proposed for a multi-cell cooperative cellular network with the Poisson spatial distribution of interfering transmitters.
- By adopting the theory of alpha-stable processes, a general method is proposed to derive the probability density function (PDF) of the aggregated interference power in a multi-cell cellular network.
- From the proposed co-channel interference model, we plan to derive the normalized average downlink capacity for the multi-cell cooperative cellular network.

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2.2 Research Programme - 2

Work Package 2: **Impact of interference coordination techniques on transmission energy efficiency in cooperative MIMO systems**

- We will apply our newly-developed analytical co-channel interference model to investigate the impact of interference coordination techniques on energy efficiency in cooperative MIMO systems.
- Some advanced numerical computation and approximation/ optimization techniques will be applied to obtain tighter performance bounds under different cooperative communication strategies.
- Depending on the work progress, the results will be summarized and a journal or conference paper will be prepared either during or shortly after the visit.

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2.2 Research Programme - 3

Work Package 3: Energy-efficient techniques for cooperative MIMO communication systems

- We will develop energy-efficient power control and traffic load balancing algorithms for cooperative MIMO systems by utilising advanced traffic engineering, optimisation, and approximation techniques.
- The aim is to reach the best trade-off between the transmission energy efficiency and the quality of service of cooperative MIMO systems.

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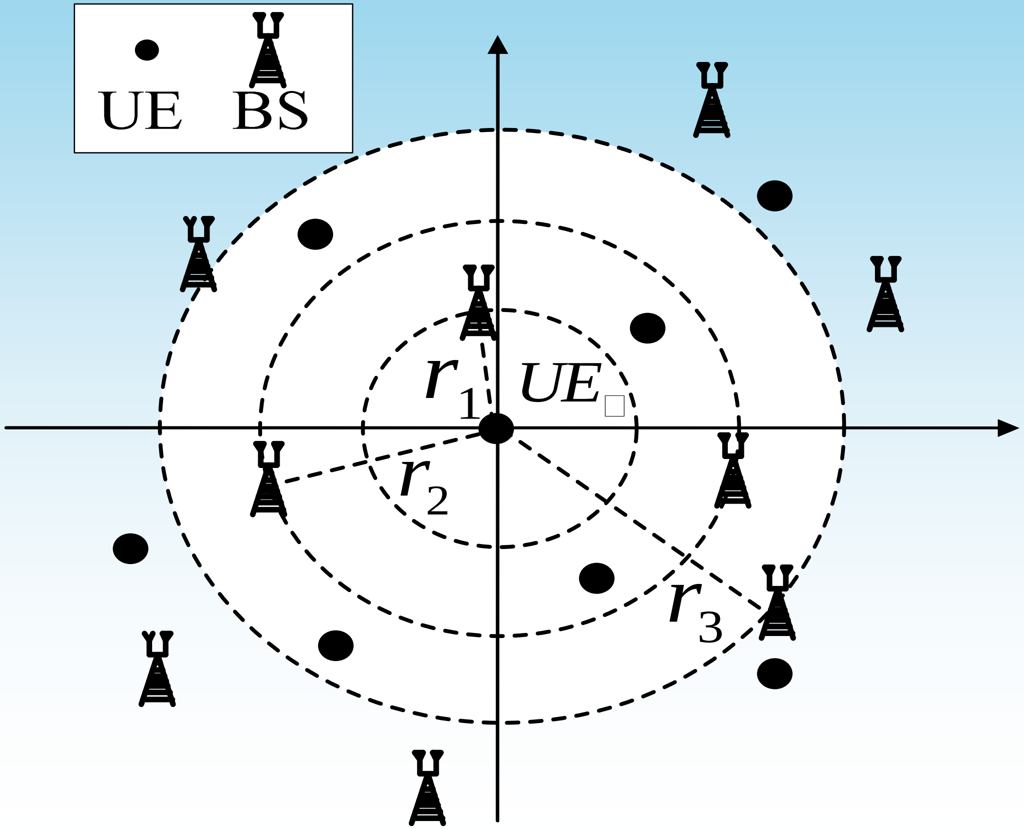
2.3 Research Results -1

- Interference model for multi-cell MIMO cellular network



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2.3 Research Results - 2

$$f_I(y) = \frac{1}{2\pi}\int_{-\infty}^{+\infty} \Phi_{P^{Rx}}(jw)\exp(-2\pi jwy)dw \quad (1a)$$

$$c = \left(\lambda_{BS} q \left(\frac{m\lambda}{\Omega} \right)^{-\alpha} \frac{\Gamma(\lambda+\alpha)\Gamma(N_t N_r m+\alpha)}{\Gamma(N_t N_r m)\Gamma(\lambda)} \right)^{\frac{1}{\alpha}} \quad (1e)$$

$$\Phi_{P^{Rx}}(j\omega) = \exp\left(-|c\omega|^{\alpha} \left[1 - jsign(\omega)\tan\left(\frac{\pi\alpha}{2} \right) \right] \right) \quad (1b)$$

$$q = \begin{cases} \frac{\pi\Gamma(2-\alpha)\cos(\pi\alpha/2)}{1-\alpha}, & \alpha \neq 1 \\ \frac{\pi^2}{2}, & \alpha = 1 \end{cases} \quad (1f)$$

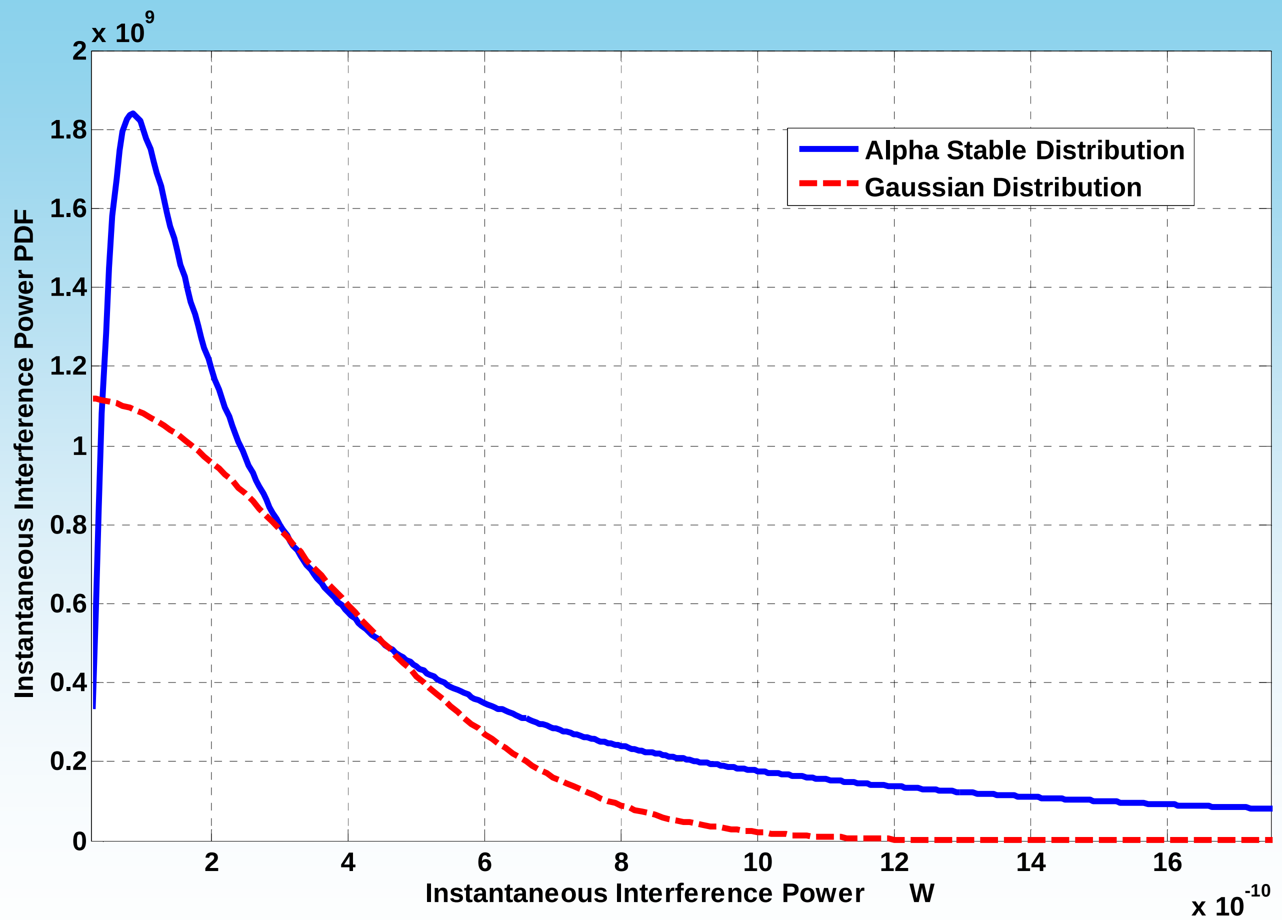
$$sign(\omega) = \begin{cases} 1, & \text{if } \omega > 0; \\ 0, & \text{if } \omega = 0; \\ -1 & \text{if } \omega < 0; \end{cases} \quad (1c)$$

$$\Omega = P_r \sqrt{\lambda + 1/\lambda} \quad (1g)$$

$$\alpha = \frac{2}{\sigma_r} \quad (1d)$$

$$\lambda = 1/(e^{(\sigma_{dB}/8.686)^2} - 1) \quad (1h)$$

2.3 Research Results - 3



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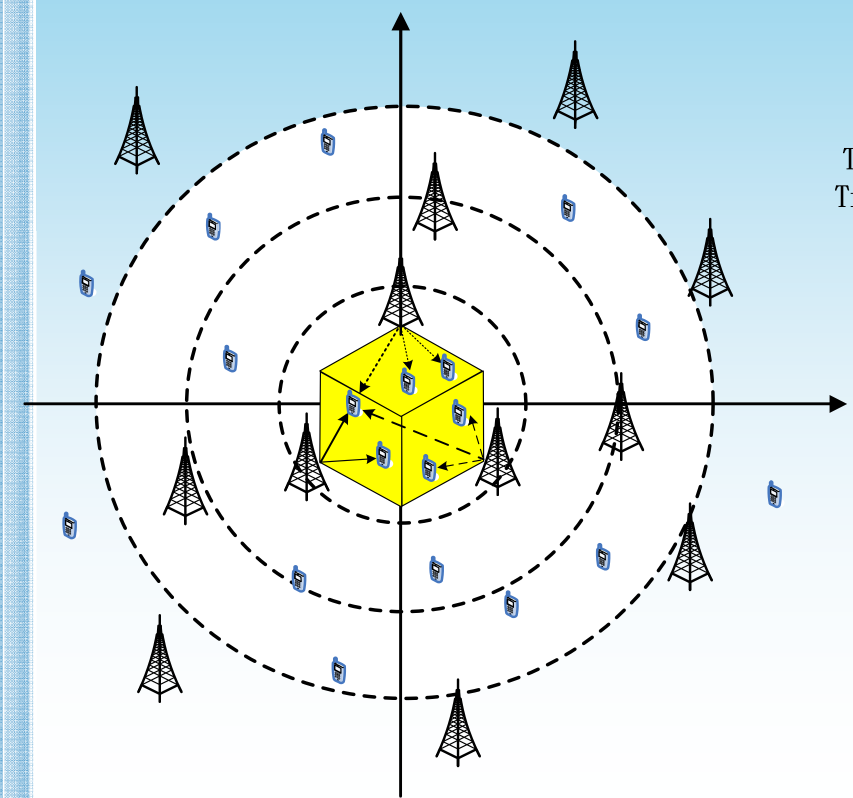
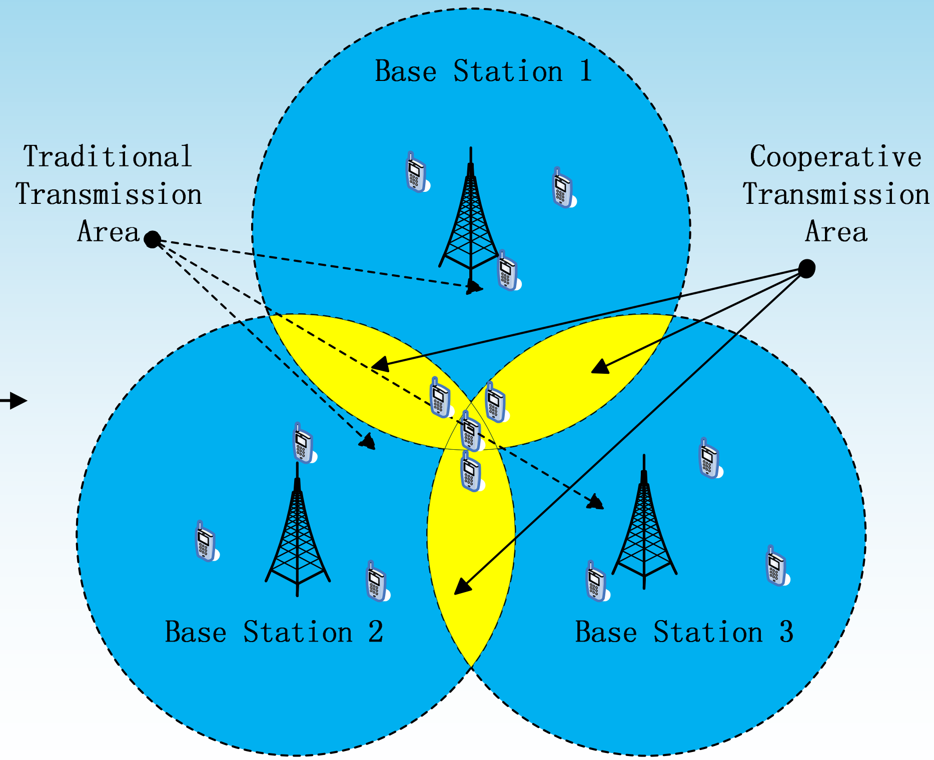
2.3 Research Results - 4

- Capacity model for multi-cell MIMO cellular network with co-channel interference





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2.3 Research Results - 5

$$C_{Aver} = \sqrt{\gamma^2 / 2\pi} \int_0^\infty \log_2(1+y) \left(\int_0^\infty e^{-\gamma^2/2z} z^{-1/2} f_d(yz)\, dz \right) dy \quad (2a)$$

$$\gamma = \lambda_{BS} \sqrt{2}\pi\Gamma(\frac{3}{2}) \left(\frac{m\lambda}{\Omega} \right)^{-\alpha} \frac{\Gamma(\lambda + \frac{1}{2})\Gamma(N_t N_r m + \frac{1}{2})}{\Gamma(N_t N_r m)\Gamma(\lambda)} \quad (2b)$$

$$\Gamma(\lambda) = \int_0^\infty t^{\lambda-1} e^{-t} dt \quad (2c)$$

$$\Omega = P_r \sqrt{\lambda + 1/\lambda} \quad (2d)$$

$$\lambda = 1/(e^{(\sigma_{dB}/8.686)^2} - 1) \quad 2(f)$$

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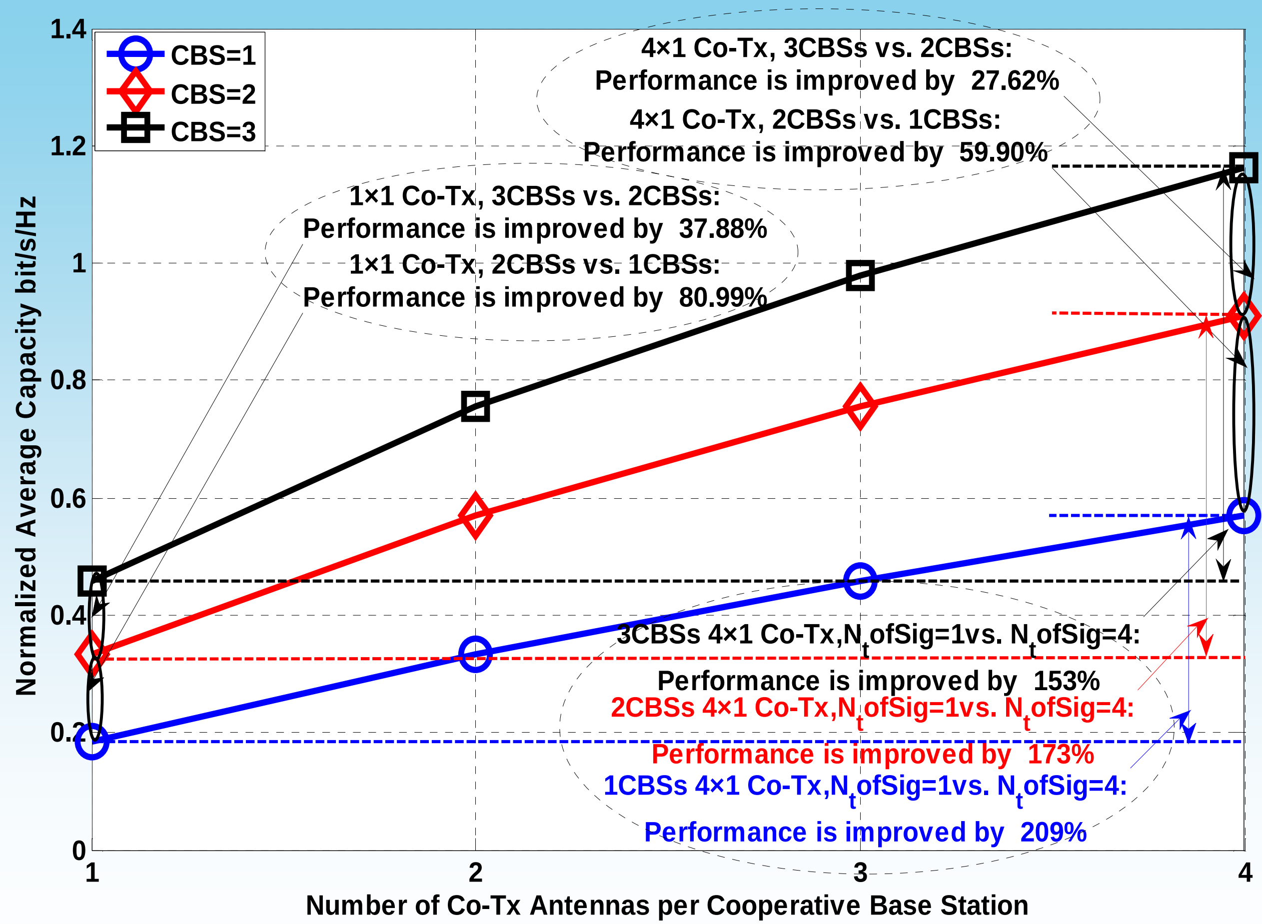
2.3 Research Results - 6



2.3 Research Results - 7

[1] Xiaohu Ge, Kun Huang, Cheng-Xiang Wang, Xuemin Hong, “Capacity Analysis of a Multi-Cell MIMO Cooperative Cellular Network with Co-Channel Interference ,” IEEE Trans. Wireless Communications, to be submitted;

Future research plan

- Based on this visit, the visiting fellowship and host researcher will fully appreciate the research strengths of two groups ;
- The visiting fellowship and host researcher plan to submit a joint research proposal to NSFC in the future, and such joint funding applications will be explored in the future from various resources in the UK and China;
- The visiting fellowship and host researcher plan to apply for a joint patent depending on the research outcome, which will hopefully be explored by UK and China industries in the near future.

Researcher Exchange

Our group are looking for visiting researcher to host at HUST

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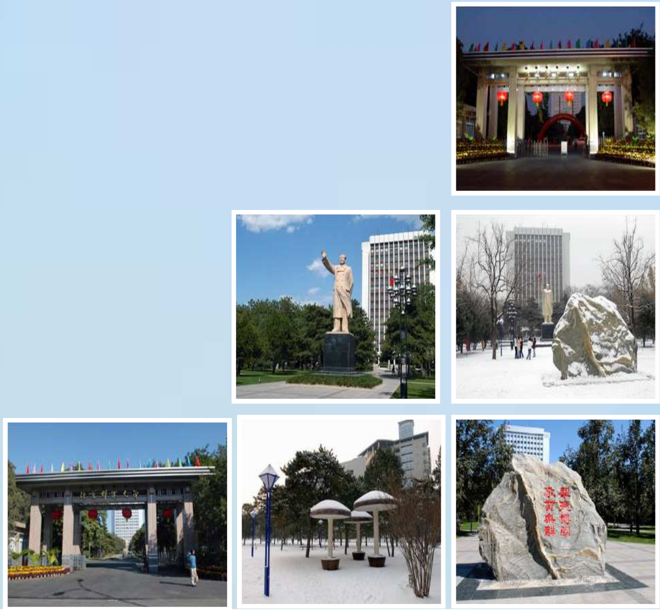
Thank You !



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