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**Welcome UK Delegation to Xidian University  
for  
UK-China Science Bridges: R&D on 4G  
Wireless Mobile Communications**

# The State Key Lab. of Integrated Service Network Xidian University



# Outlines

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- **Overview of the Lab.**
- **Some Achievements**
- **Current Projects**
- **Academic Exchange**
- **Visiting Projects**

- **1989: The project to establish the Lab. proved**
- **1991: Construction started**
- **1995.10: Passed the State check and started open operation**
- **2002: Passed the State evaluation**
- **2007: Passed the State evaluation**

**Supported by Xidian University**

# Mission of ISN Lab.

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**To study the theory and key technologies on new types of Communication Networks, such as**

- **New concept and scheme for communication networks**
- **Channel and network Coding**
- **High performance image and video compress coding**
- **High speed and efficient information transmission**
- **Information security**
- **Special private communication system**

## **65 Members are divided into:**

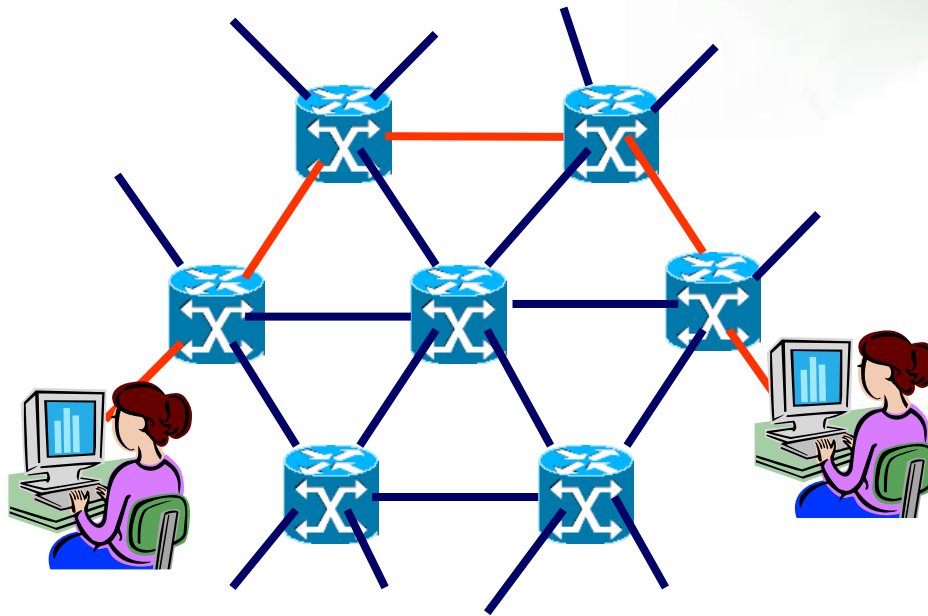
- **Broadband Wireless Communications;**
- **Channel and Network Coding;**
- **Video and Image Coding;**
- **Private Communications;**
- **Satellite Communications;**
- **Network and Routing;**
- **Multi Media Communications;**
- **Quantum Communications;**
- **Information and Network Security**

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# Some Achievements

# T-bits Router Switch Fabric

## ➤ ATM Switch → Routers

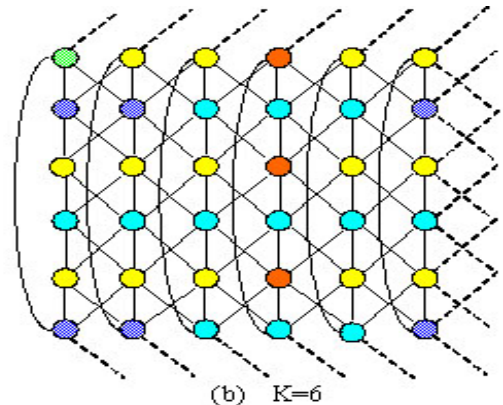
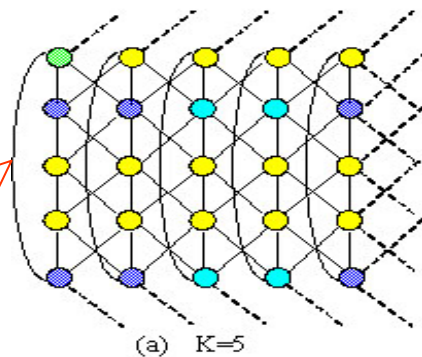




# T-bits Router Switch Fabric

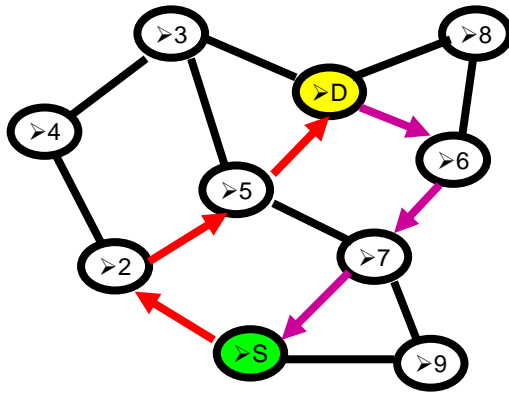
➤ For T-bits router, 2D3C ( 2 Degree 3 Cycle ) Switch Fabric is proposed.

➤ 这种网络为平面结构，便于工程实现，**具有良好的可扩展性**，其性能可与传统 3D Torus 或超立方体等高维网络相媲美。

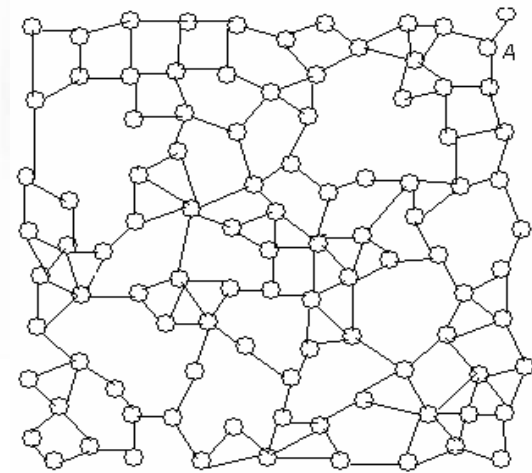


➤ Two kinds of 2D3C networks

# Ad Hoc Network

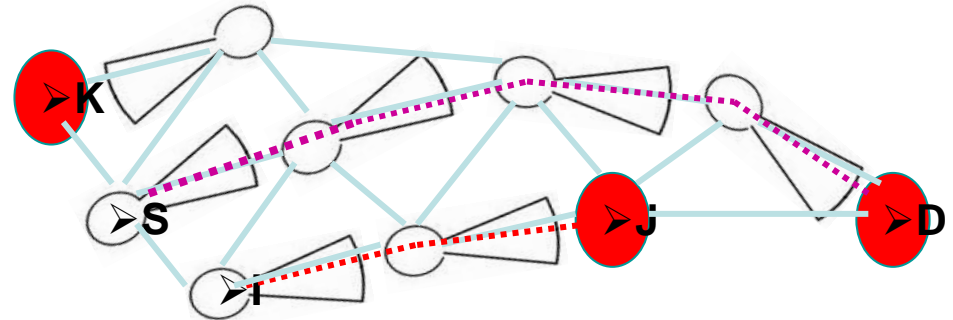


➤ Tens nodes

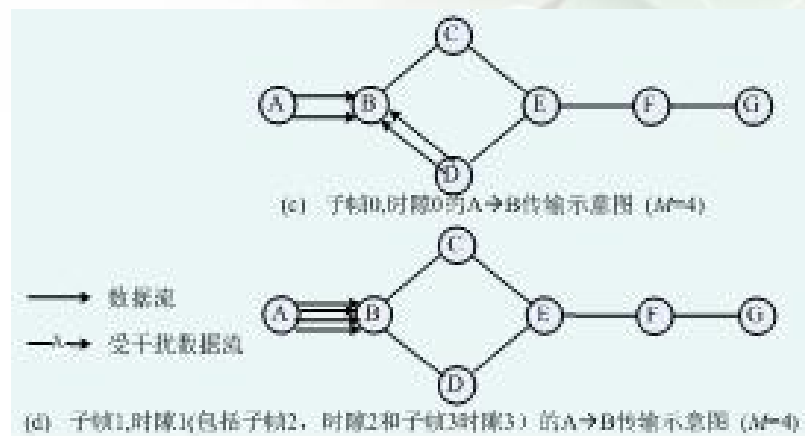
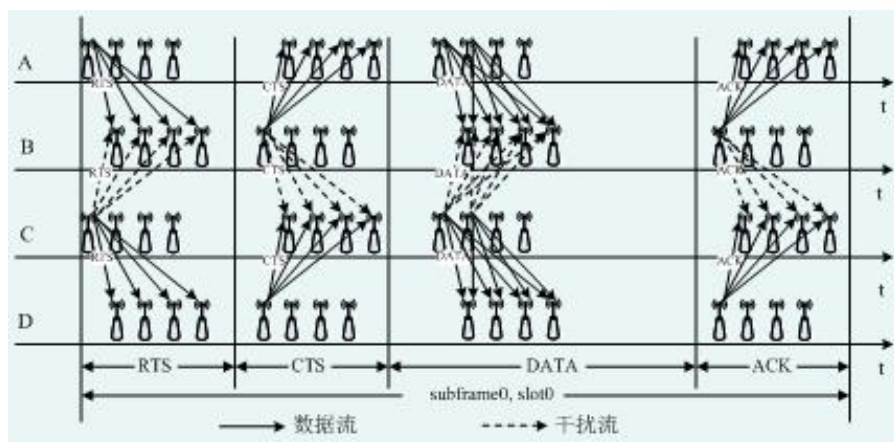


➤ Hundreds nodes

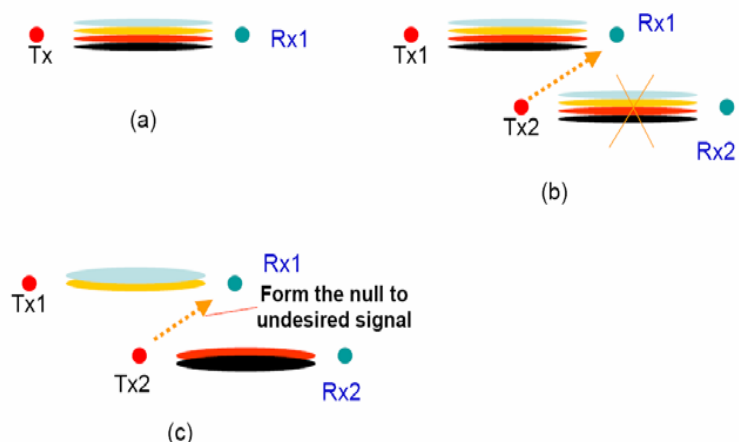
- How to route efficiently?
- How to support new technologies, such as smart antenna and MIMO?



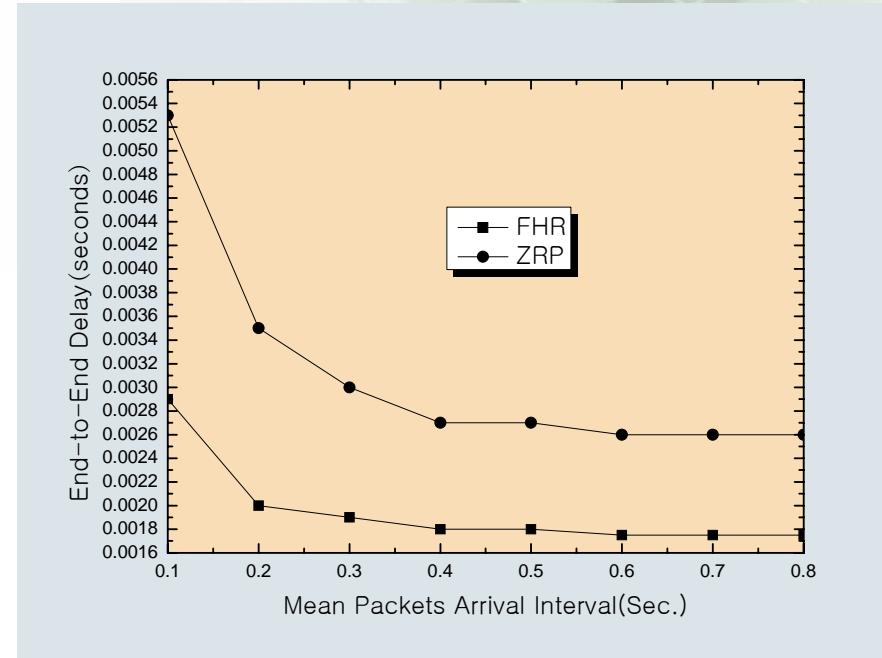
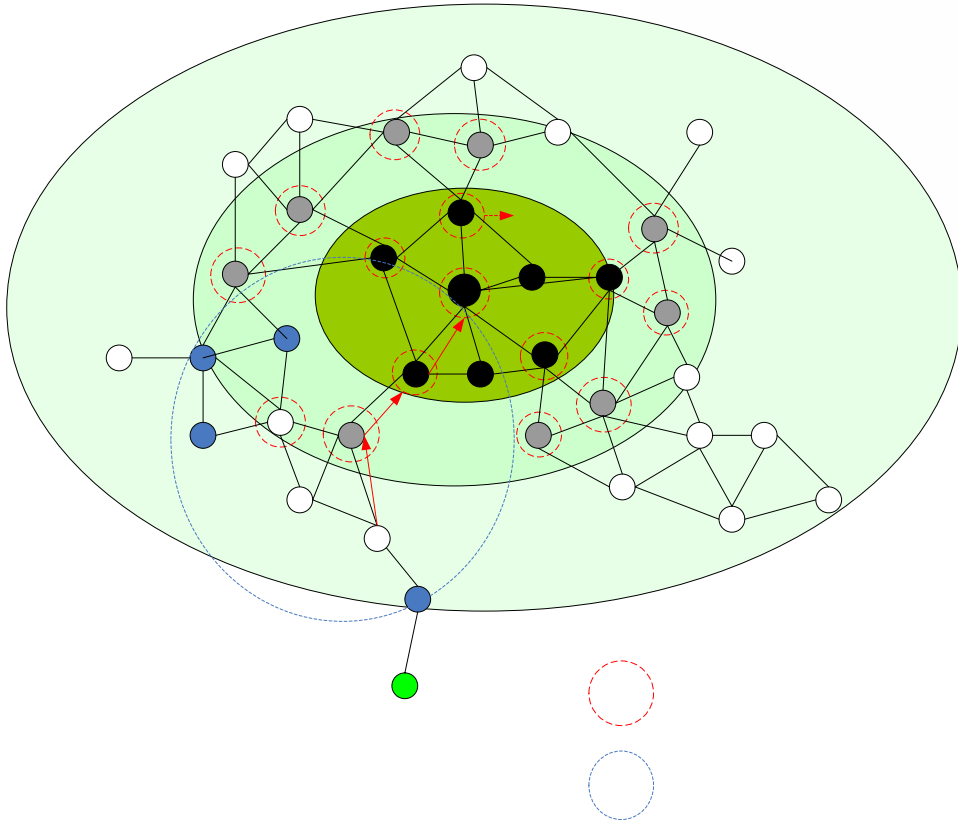
## ➤ New MAC Protocol with the combination of MIMO and TDMA (MIMO-TTR-TDMA)。



## ➤ (Typical Example for 4x4 MIMO and TDMA)

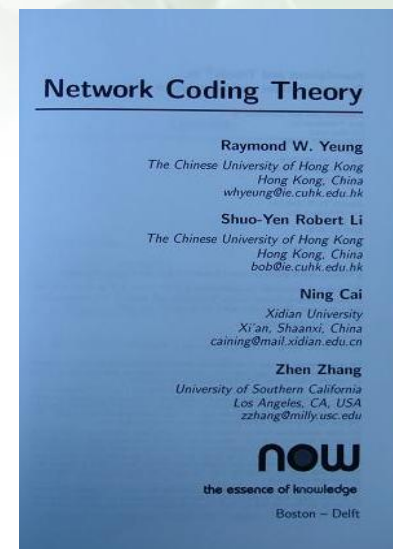
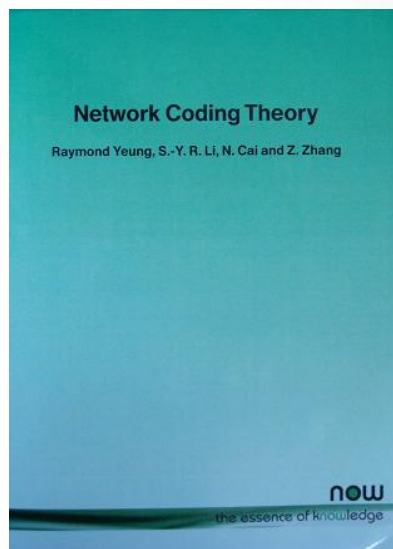
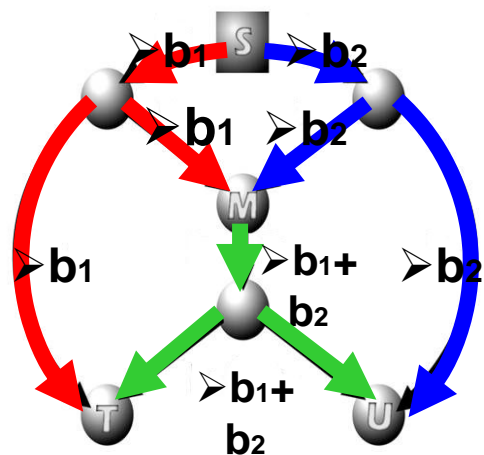


# Large Scale Ad hoc Routing

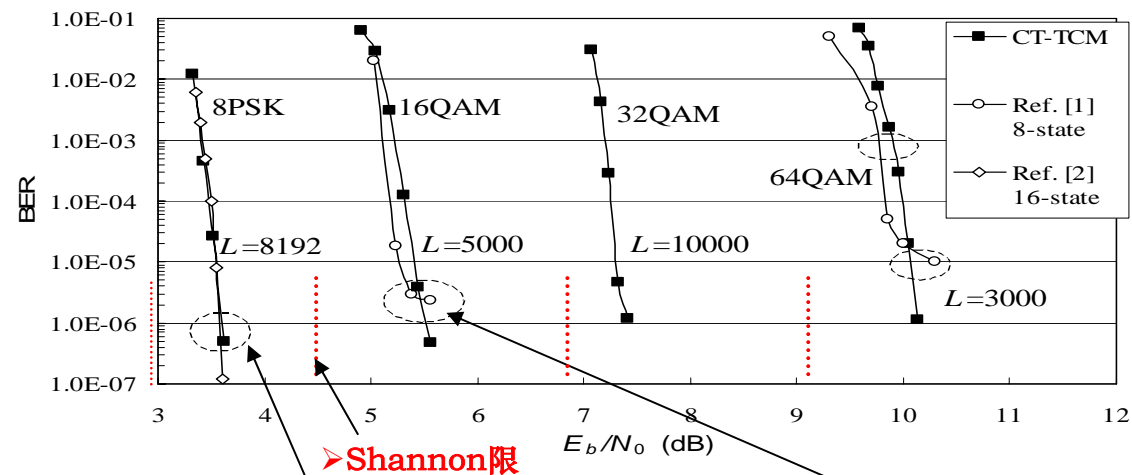
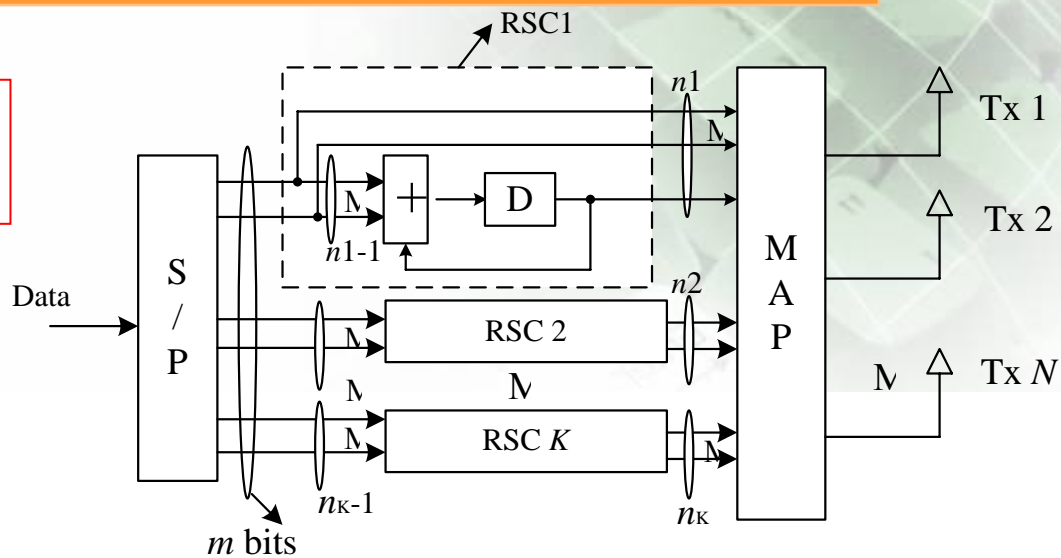


广播RREQ

➤ Fuzzy Hybrid Routing-----Based on Hierarchical and Fish Eye Technologies to reduce the overhead.



## • STTC



➤ Shannon限

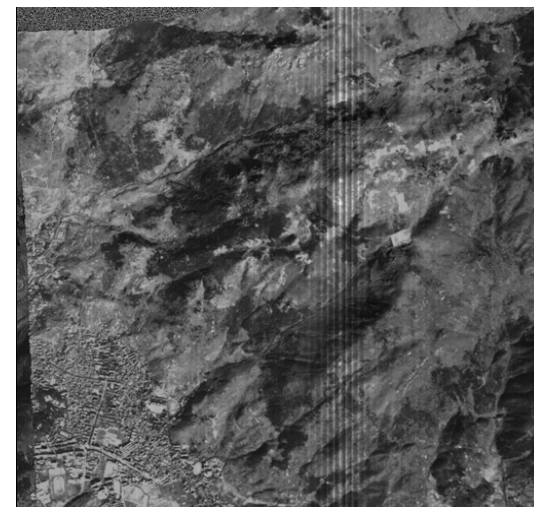
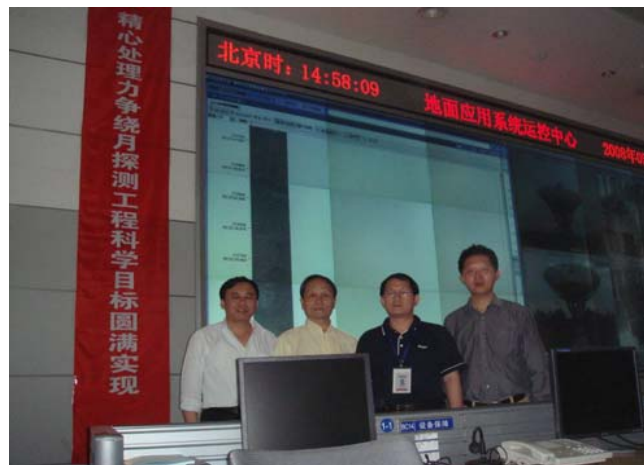
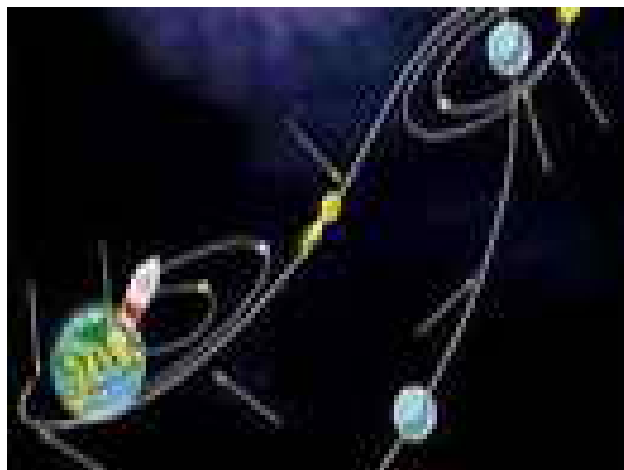
➤ 复杂度降低12倍

➤ 复杂度降低 6 倍

## • CT-TCM



- **Distortionless Image Compress Coding**
- **Concomitant Satellite Image System of “Shen’Zhou” Space Shuttle No.7**
- **Image System of Moon Exploring Satellite**



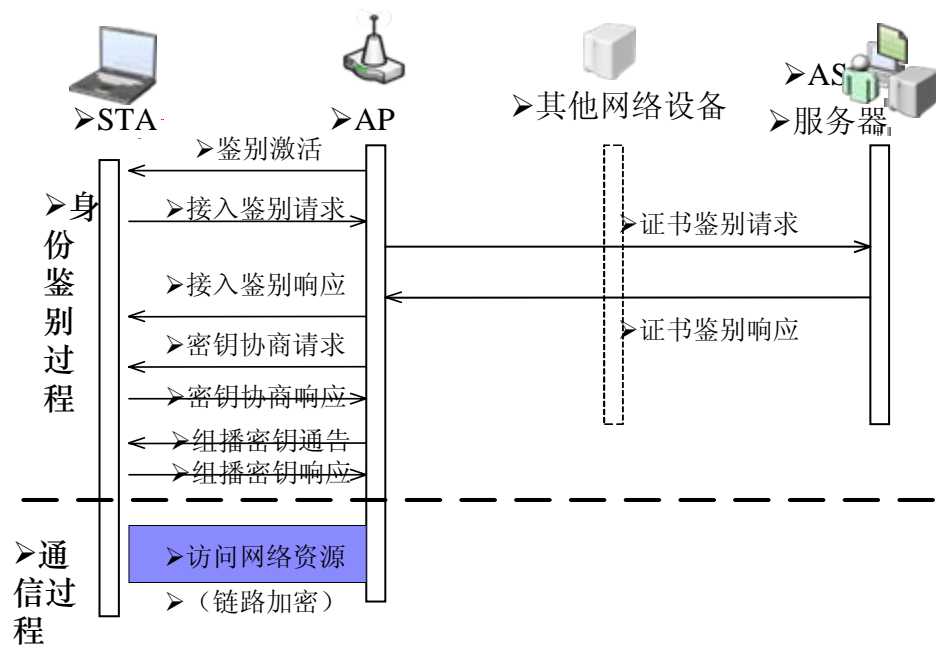
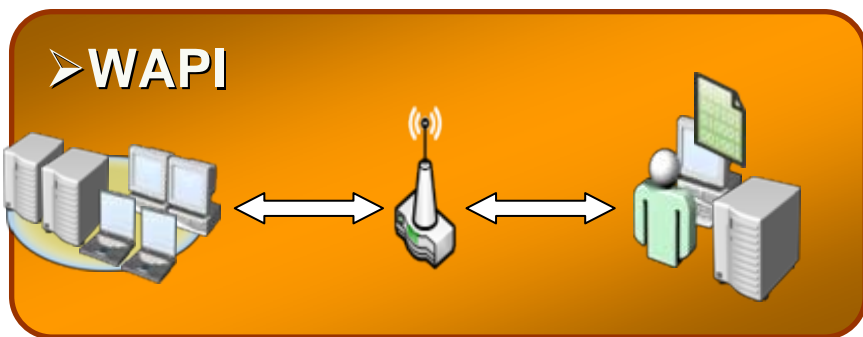
## ➤ WAPI: Wireless Authentication and Privacy Infrastructure

### ➤ ( Competition with IEEE 802.11i )

➤ The China National Standard

➤ Supported by Sony and Motorola

➤ Will be the international Std.





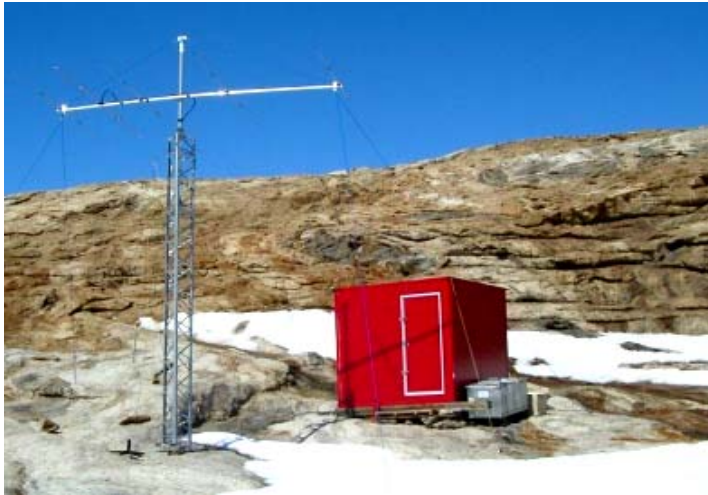
# Meteor Burst Communication System



➤ Using the ionization aerosphere after meteor trail to relay the radio wave for about km communications



# Meteor Burst Communication System



➤ **South Pole Experiments cooperated with Japan**

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# Current Projects

## China Special R&D Project:

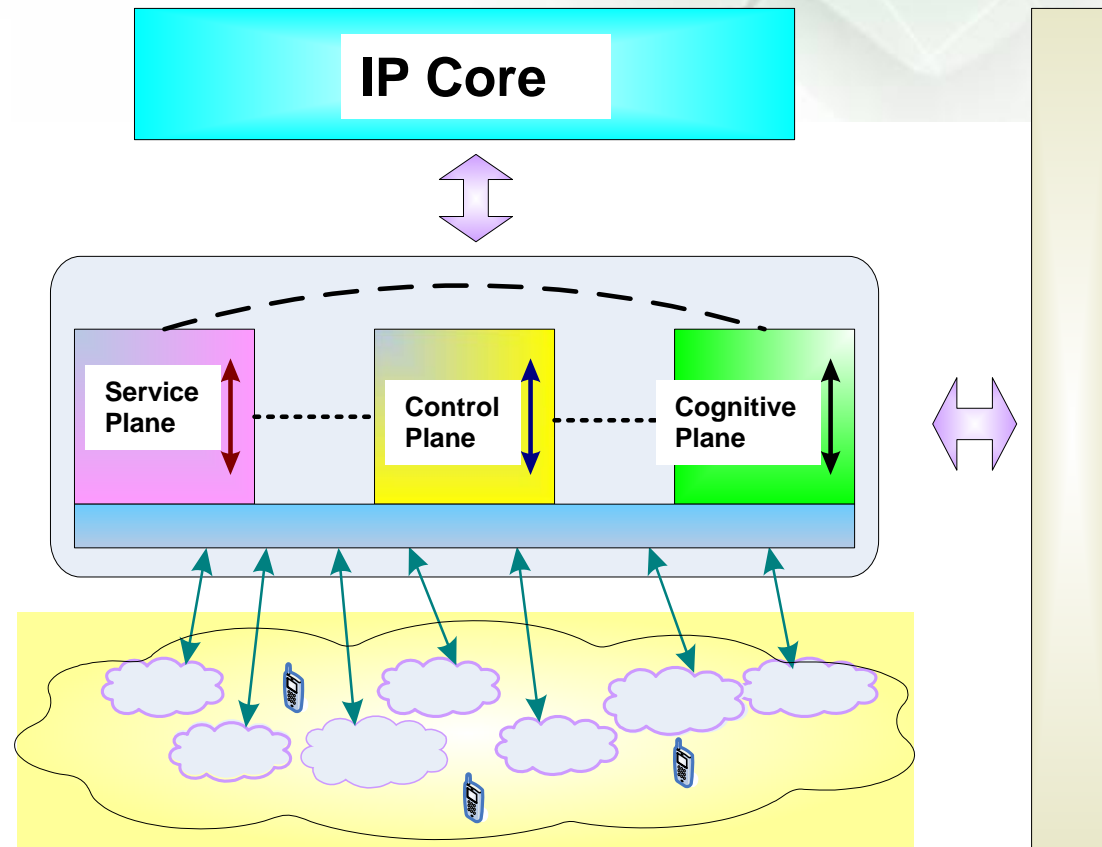
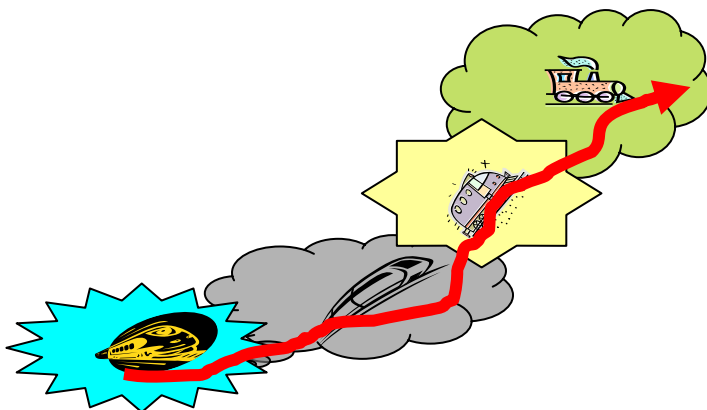
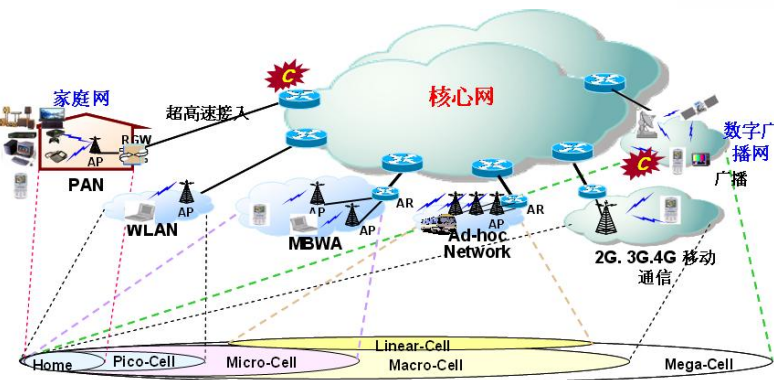
**New Generation Broadband Wireless Mobile Communication Networks**

- **TD-LTE Technologies (Relay)**
- **IMT-advanced Technologies (EMIMO, Coding, CR)**
- **Self-organizing Network Technologies**

## 973 Project:

### Cognitive Wireless Networks

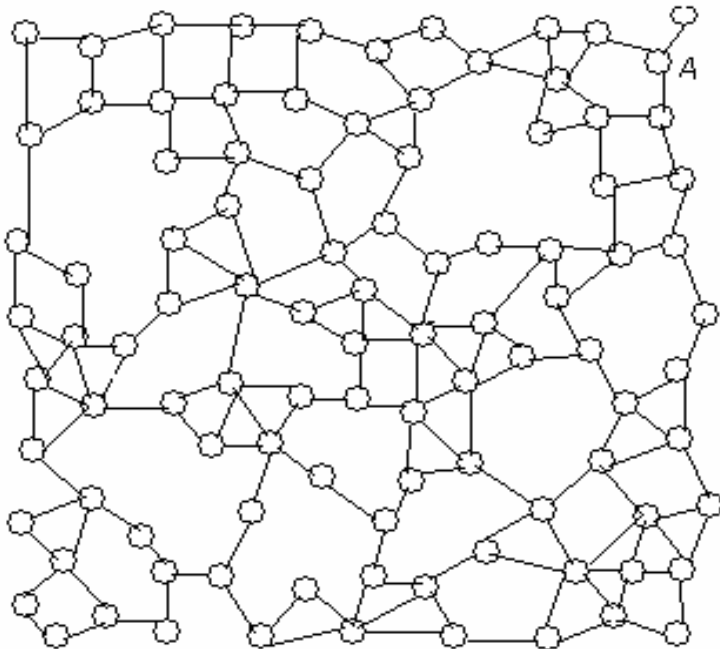
➤ To explore any available resources to enhance the wireless network capacity and meet the E2E QoS



# Current Projects

## Outstanding Youth Science Fund:

### Large Scale Ad hoc Networks



- **Network Capacity and Routing algorithms for thousands of nodes**
- **Enhancing the network capabilities by using MIMO, Smart Antenna, Cognitive Technologies**



# Current Projects

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## NSFC Key Projects:

- Key Technologies on Deep Space Communication System (**Long Delay Tolerated Communication Protocols and Information Transmission and Image Coding**)
- Network Coding
- IP network measurement

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# Academic Exchange



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- **“111 Discipline Innovation and Intellectuality Introduction Base”** for Fundamental Theory and Technologies for Modern Wireless Information Networks

<b>Academic Leaders</b>	<b>Long Term Visitors</b>	<b>Short Term Visitors</b>
<p><b>James L. Massey</b></p> <p><b>Kang G. Shin</b></p>	<p><b>Yuguang Fang</b></p> <p><b>Thomas F. La Porta</b></p> <p><b>Raymond Wai-Ho Yeung</b></p> <p><b>Chung-Chieh Kuo</b></p> <p><b>Michael Orchard</b></p> <p><b>Mukesh Singhal</b></p>	<p><b>Sartaj K Sahni</b></p> <p><b>Jiangzhou Wang</b></p> <p><b>Xuemin Shen</b></p> <p><b>Weihua Zhuang</b></p> <p><b>Kai-Kuang Ma</b></p> <p><b>Bazhong Shen</b></p> <p><b>Hongren Wu</b></p> <p><b>Heung-Gyoon Ryu</b></p> <p><b>Ali A. Rezazadeh</b></p> <p><b>Ebroul Izquierdo</b></p>

# Visiting Projects

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- **Ad Hoc Network and Cognitive Radio**
- **Broadband Wireless Access and MIMO**
- **Techniques in LTE-Advanced**
- **Multi-User MIMO and CoMP**

# Visiting Projects

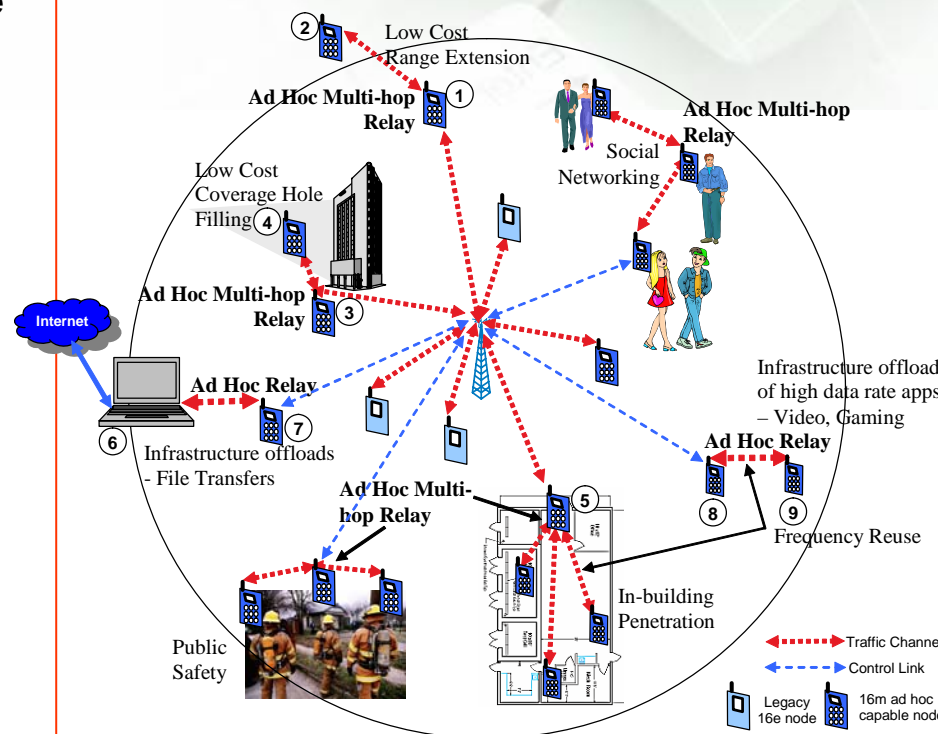
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➤ PI: Prof. Jiandong LI  
➤ & Prof. Min Sheng

- **Ad Hoc Network and Cognitive Radio**
- **Broadband Wireless Access and MIMO**
- **Techniques in LTE-Advanced**
- **Multi-User MIMO and Comp**

## Usage Models

- Coverage/Range Extension
  - Micro-holes/shadowing/fringe coverage
  - Improved throughput
- In-building Penetration
  - Multi-hop relay from fixed “seed”
  - Improved service availability
- Infrastructure Offloading
  - BS controlled P2P file transfers, gaming, video streaming
  - Improved network efficiency
- Unique Application Support
  - BS controlled Social Networking, Public Safety
- Improved Frequency Reuse
  - Improved network efficiency



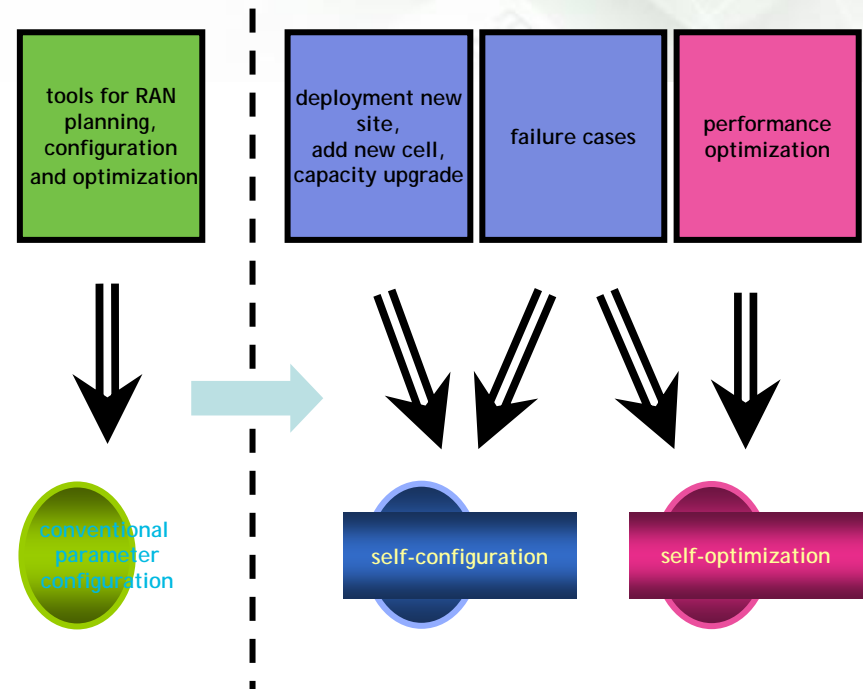
## ➤ Self Organizing and Optimizing Networks

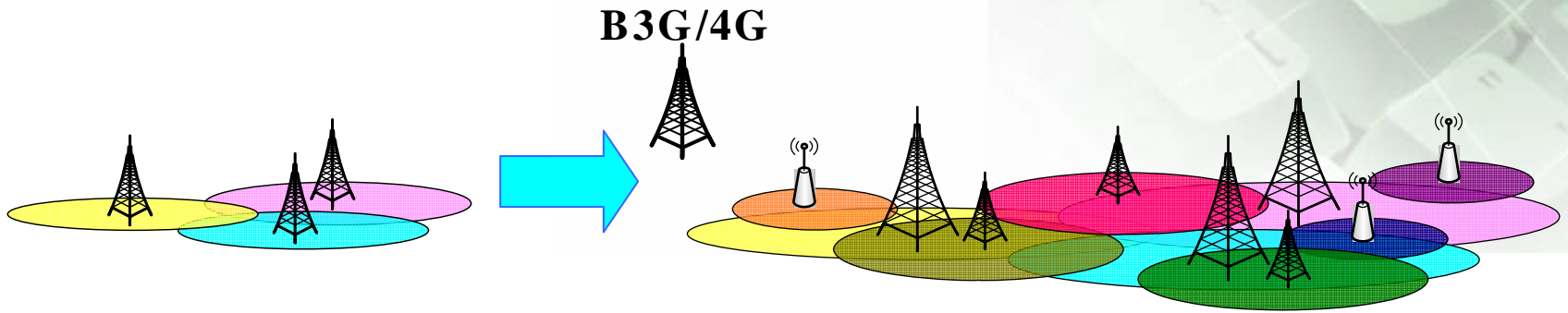
### ■ RAN optimization use cases

- Cell outage compensation
- LTE handover parameter optimization
- Interference optimization for LTE
- Load balancing for LTE

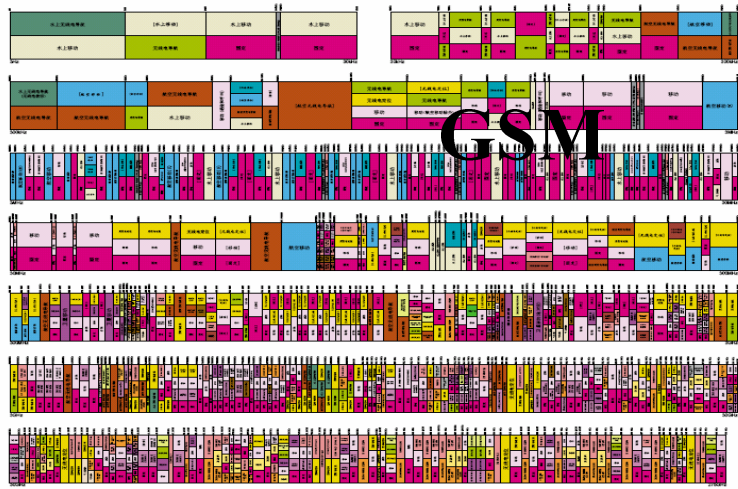
### ■ QoS optimization use cases

- Scheduler operation optimization for LTE
- MIMO Mode Selection Optimization for LTE





➤ Heterogeneous networks coexist



➤ Spectrum "scarcity"  
GSM

- Resource Definition
- Resource Mobility Control
- Resource Allocation and Adaptive Decision
- United Inter-network Resource Management

# Visiting Projects

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- Ad Hoc Network and Cognitive Radio
- **Broadband Wireless Access and MIMO**
- Techniques in LTE-Advanced
- Multi-User MIMO and CoMP



➤ **PI: Hailing Zhang**

Hailin Zhang

9 academic staff  
over 10 PhD students

Liqiang Zhao  
Yongzhao Li

Xiaofeng Lu  
Yi Liu

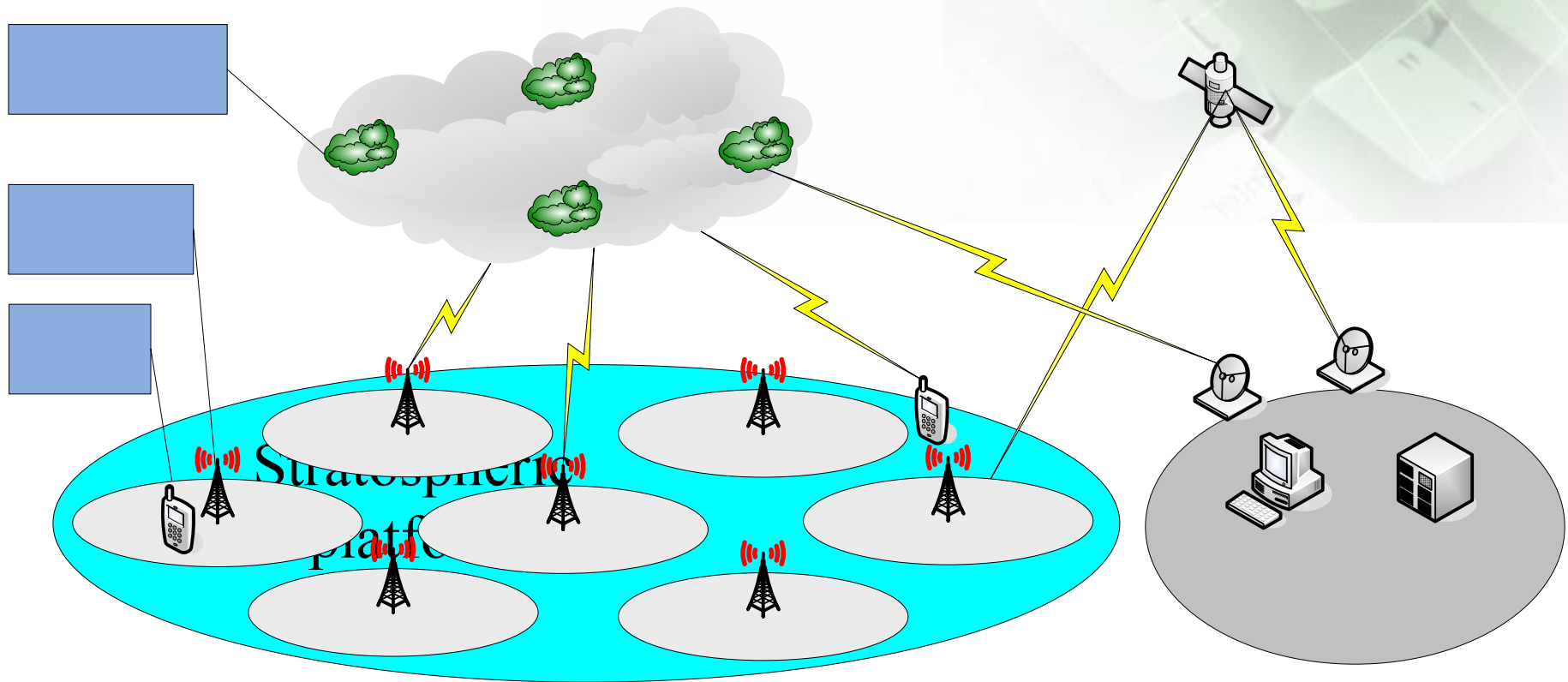
Depin Wu  
Longwei Liu  
Meixia Hu

Broadband Wireless Access  
Cooperative Communication

MIMO Technologies

Engineering Implementation

# Broadband Wireless Access Systems in Near Space



Ground  
base-station

- **Broadband wireless PMP/Mesh access structure is proposed.**
- **Demonstration prototype of broadband wireless PMP/Mesh hybrid network is under investigation.**
- **Layered network topology and active/on-demand routing protocols are investigated.**
- **The frame format which supports PMP/Mesh hybrid access are proposed.**
- **Synchronization strategy and uplink channel estimation strategy for PMP/Mesh broadband wireless access network are proposed.**

- **Purpose**

- performance: approaching MLD performance
- complexity: reduced and easy for accomplishing in engineering

- **Hold Partial ML (HPML) algorithm**

- Firstly, select  $d$  columns of  $H$ , whose MSEs are the largest ones.
- Secondly, detect the residue  $M-d$  columns by ZF-DFE or MMSE-DFE to form one candidate for each  $M$ -layer signal vector.
- Finally, detect the transmitted signals by using partial ML from the candidate set of combined  $M$ -layer signal vectors.

- **Close-loop MIMO-OFDM transmitting can achieve a high performance, which need channel information at the transmitter. With limited feedback, we proposed precoding schemes.**
  - **The codebook is constructed using Lloyd vector quantization method.**
  - **The strategy for selecting the precoding matrix is proposed aiming at capacity maximization.**
  - **An interpolation scheme is also proposed to further reduce feedback cost.**

# Visiting Projects

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- Ad Hoc Network and Cognitive Radio
- Broadband Wireless Access and MIMO
- **Techniques in LTE-Advanced**
- Multi-User MIMO and Comp

➤ **PI: Prof. Jianhua Ge**

## □ Precoding

- Precoding matrix selection criteria and comparison among them
- Feedback reduction
- Feedback error
- Precoding based on partial channel information
  - What to feedback, mean or variance or both?
  - The design of codebook
- Precoding based on fixed channel parameters

## □ Beamforming

- Beamforming for interference cancellation, MIMO for diversity

## ❑ Antenna selection

- Comparison between different criteria and searching methods
- Pragmatic low-complexity technique

## ❑ Space-time coding (STC)

- Comparison between typical LD codes (including STTD/DSTTD/SM and new code like twisted STTD) which focus on 2~4 Tx antennas
  - with/without channel coding
  - different channel models, e.g. independent/correlated channels
- New low-complexity LD code
- Pragmatic low-complexity STF codes
- Evaluation of typical II-type STCs at high mobility



## □ Channel estimation

- Comparison of imbedded training sequence with time-division training sequence in terms of performance, bandwidth efficiency and complexity
- Channel correlation estimation in OFDM systems: precoding?

## □ MIMO detection

- Impact of inter-cell co-channel interference on MIMO performance (SM, STC)
- Inter-cell interference cancellation
- PHY/MAC joint design: Resource allocation, power/rate allocation
- Interleaved Division Multiple Access (IDMA)
- Blind Equalization and Turbo Equalization

## □ Coordinated multiple point (CoMP)

- Network framework supports the cooperation between base stations (BS), users, BS and relay, user and relay
- interference cancellation at the cell edge
- Virtual and adaptive MIMO
- Joint resource allocation and cooperative node
- Cooperative multi-point access

## □ Relay

- Network framework supports relay transmission
- Relay selection and wireless resource allocation

- TD-LTE link level software platforms
- User cooperation software platforms
- User cooperation hardware platforms



# Visiting Projects

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- Ad Hoc Network and Cognitive Radio
- Broadband Wireless Access and MIMO
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- Multi-User MIMO and CoMP

➤ PI: Dr. Xiaohui LI

- **Research Interests**

- **Broadband wireless access**
- **Radio resource management**
- **MIMO and Multi-user MIMO**

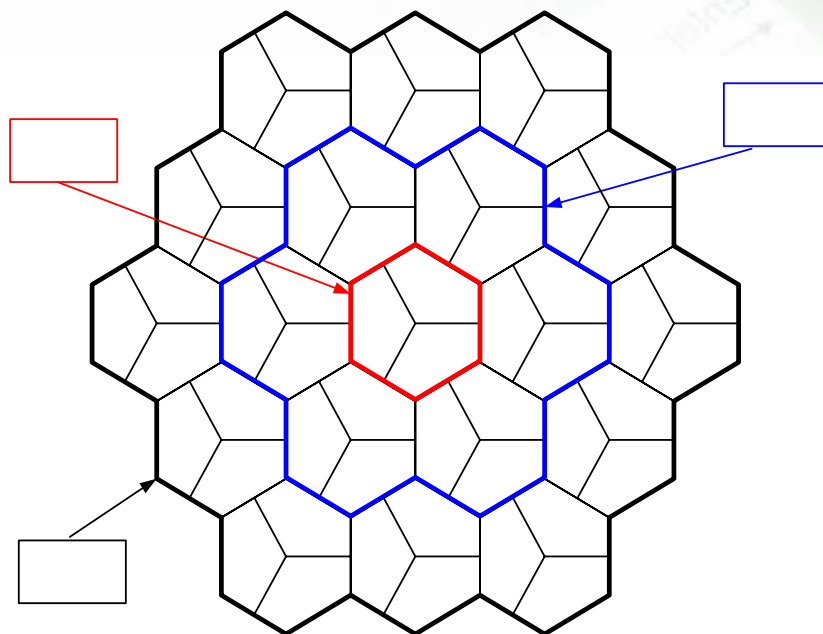
# Multuser MIMO

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- **Research on MIMO systems**
  - Antenna selection---->improve the capacity
    - Modified G-Circle Algorithm
  - Multi-user scheduling----->tradeoff between the capacity and the fairness
    - Particle Swarm Algorithm
  - MIMO Detection----->Improve the BER performance
    - Modified QRD-M Algorithm

# System level platform

- **Development of 3G Long Term Evolution Advanced (LTE-A)**





# CoMP for LTE-A

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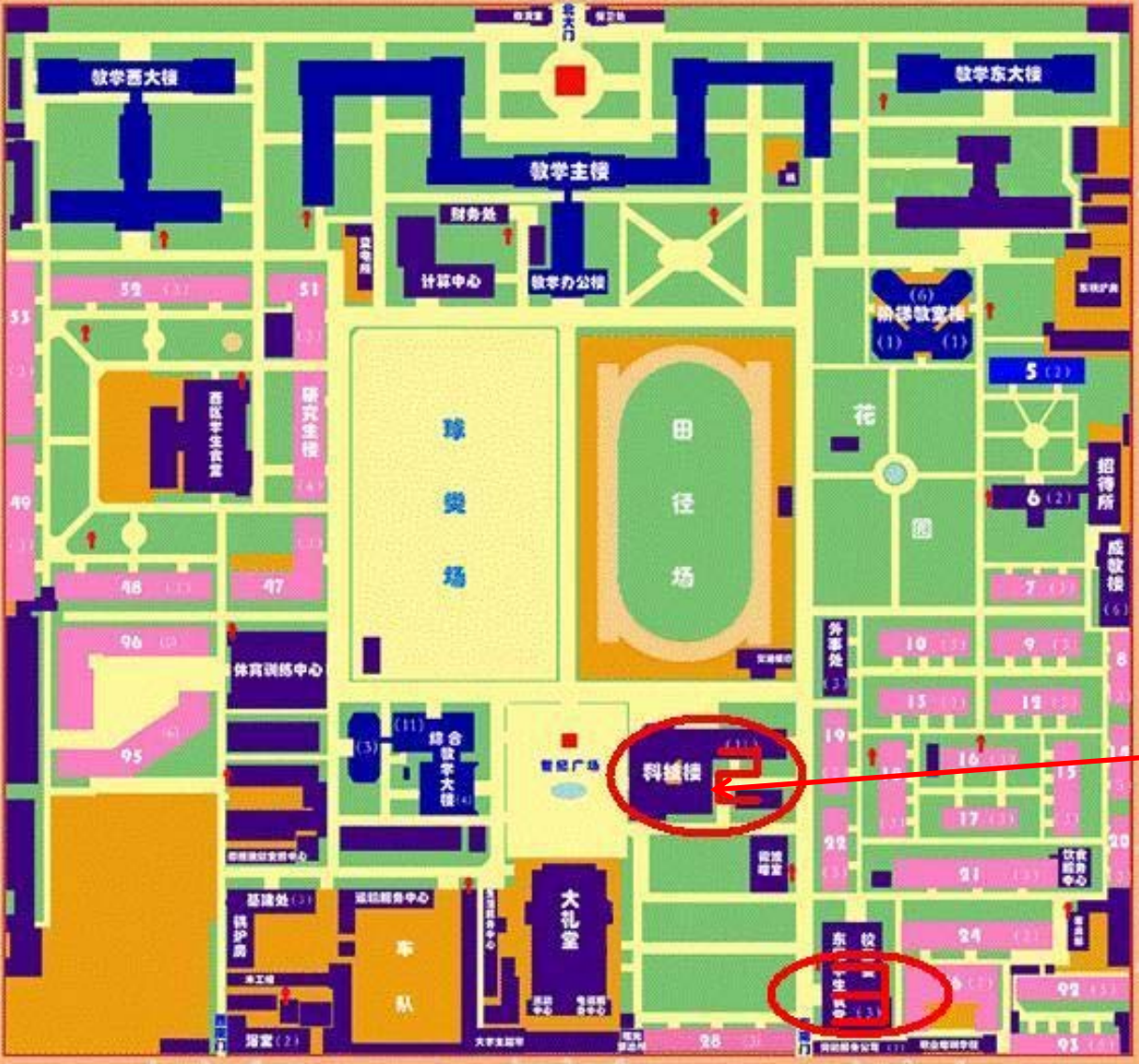
- **Aimed at improve the system throughput**
  - Link level simulation and system level simulation with/without CoMP (Coordinated Multiple Point transmission/reception)
  - Cell(s) selection for users
  - Inter-cell power control technologies
  - Inter-cell Interference Co-ordination (ICIC)

➤ 1.5 km ahead

➤ “Haidu”  
Restaurant for  
dinner



### 西安电子科技大学平面图



➤ We are here!

Visiting  
Locations

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***Thanks!***

谢谢!