Overview of the FuTURE Project in China

Dr Cheng-Xiang Wang

Heriot-Watt University, Edinburgh, UK
School of Engineering & Physical Sciences
Electrical, Electronic and Computer Engineering

The Edinburgh Research Partnership in Engineering and Mathematics (ERPem)
Joint Research Institute for Signal and Image Processing (JRI-SIP)

Phone: +44-131-4513329
Fax: +44-131-4514155
E-mail: cheng-xiang.wang@hw.ac.uk
URL: http://www.ece.eps.hw.ac.uk/~cxwang/

Outline

I. Background of FuTURE

II. FuTURE FDD Demonstrator at SEU

III. FuTURE TDD Demonstrator at BUPT

IV. Summary

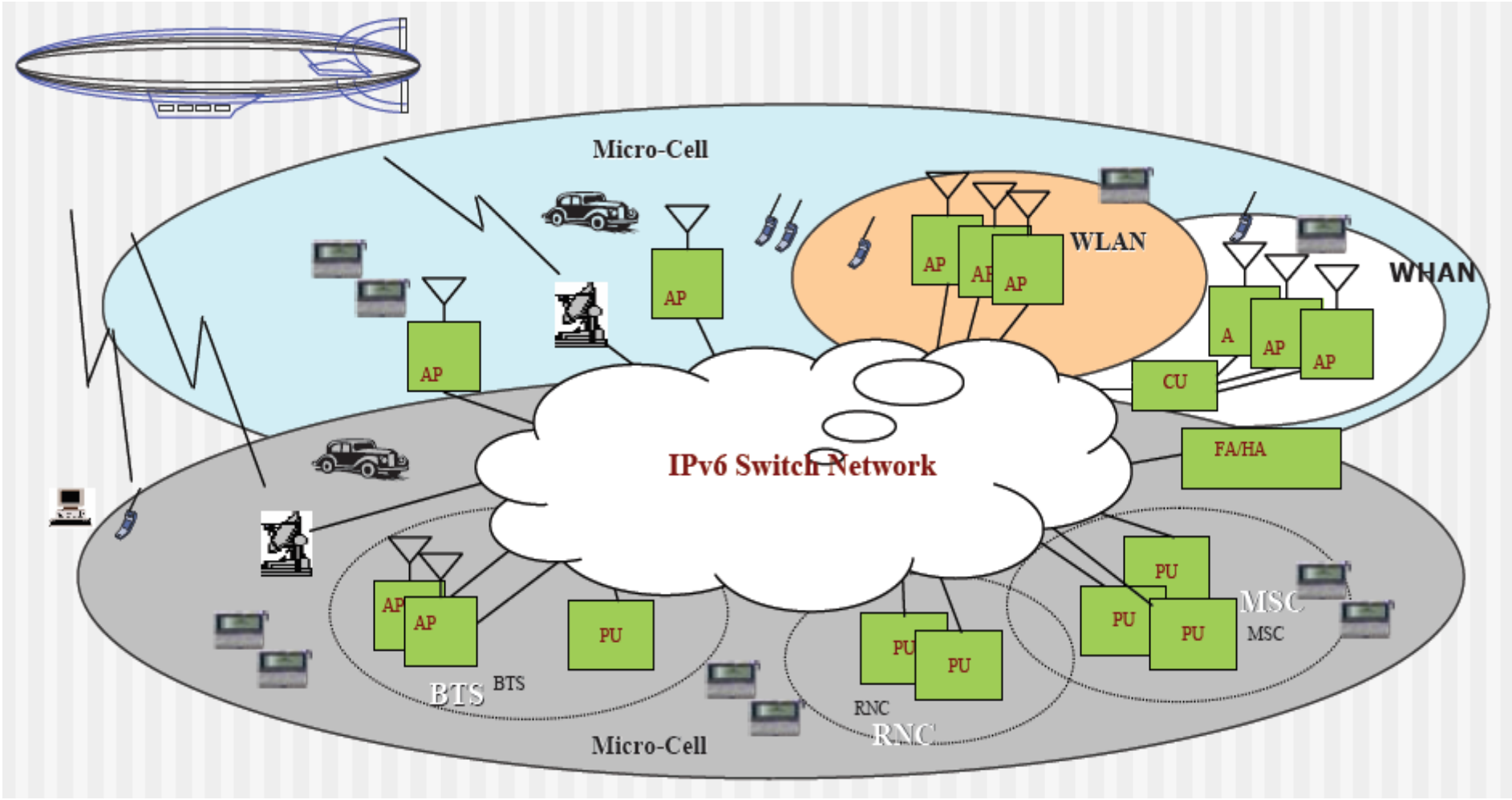
Acknowledgement:

The slides here are largely based on the presentation slides by Prof. Xiaohu You from Southeast University (SEU) and Prof. Ping Zhang & Dr Qimei Cui from Beijing University of Posts and Telecommunications (BUPT).

I. Background of FuTURE

- **FuTURE** – Future Technologies for Universal Radio Environment
- The FuTURE was launched as part of China's 863 high-tech Program in wireless communications area for the 10th five-years plan (2001-2005)
- The **Mission** of the FuTURE is to establish a universal radio experiment environment that can meet the application demands and technique trends headed for the years around 2010.
- Nearly 20 domestic universities, research institutes, manufacturers and multinational companies have been involved as partners.
- The FuTURE integrate layered wireless communications systems via IPv6 core networks:
  - Broadcast layer: HAPS – High Attitude (10-30km) Space Communications
  - Cellular Layer: Beyond 3G/4G mobile
  - Areas Layer: WxAN（including WLAN/WPAN/WHAN …)

Illustration of the FuTURE Concept

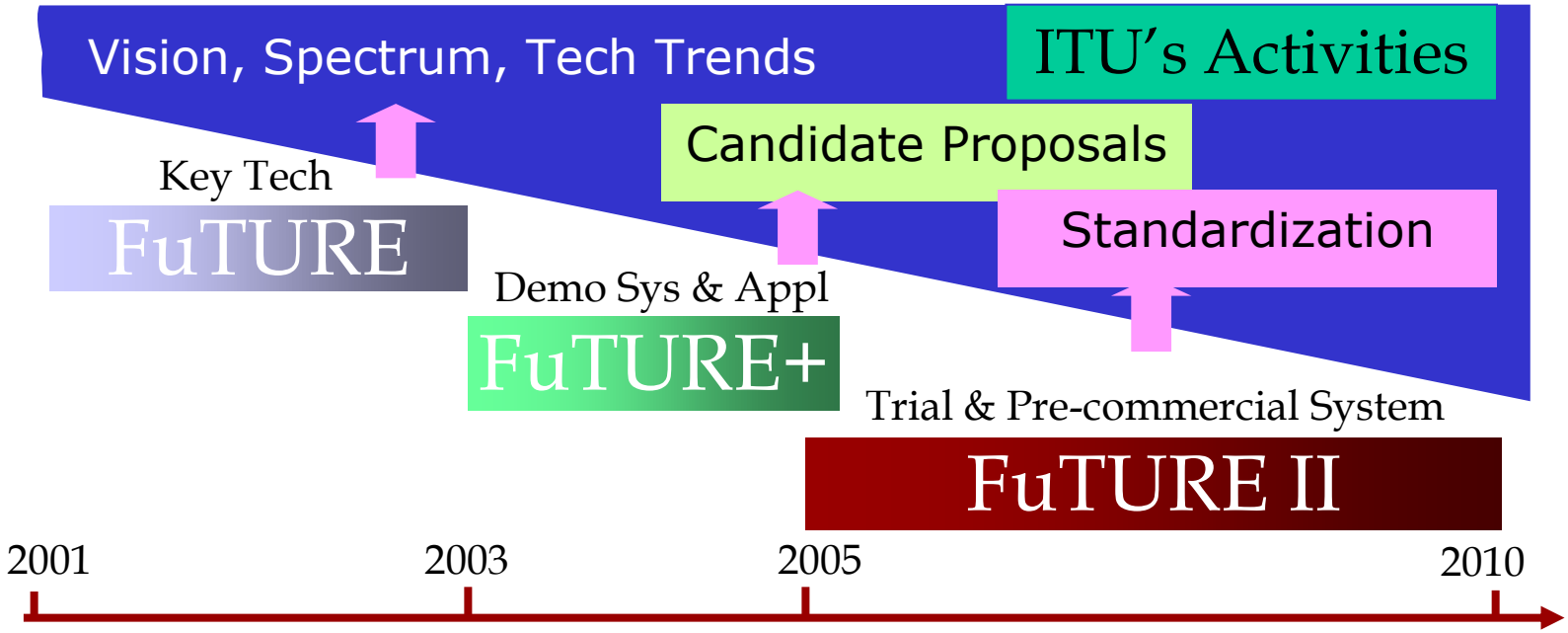


Roadmap of FuTURE

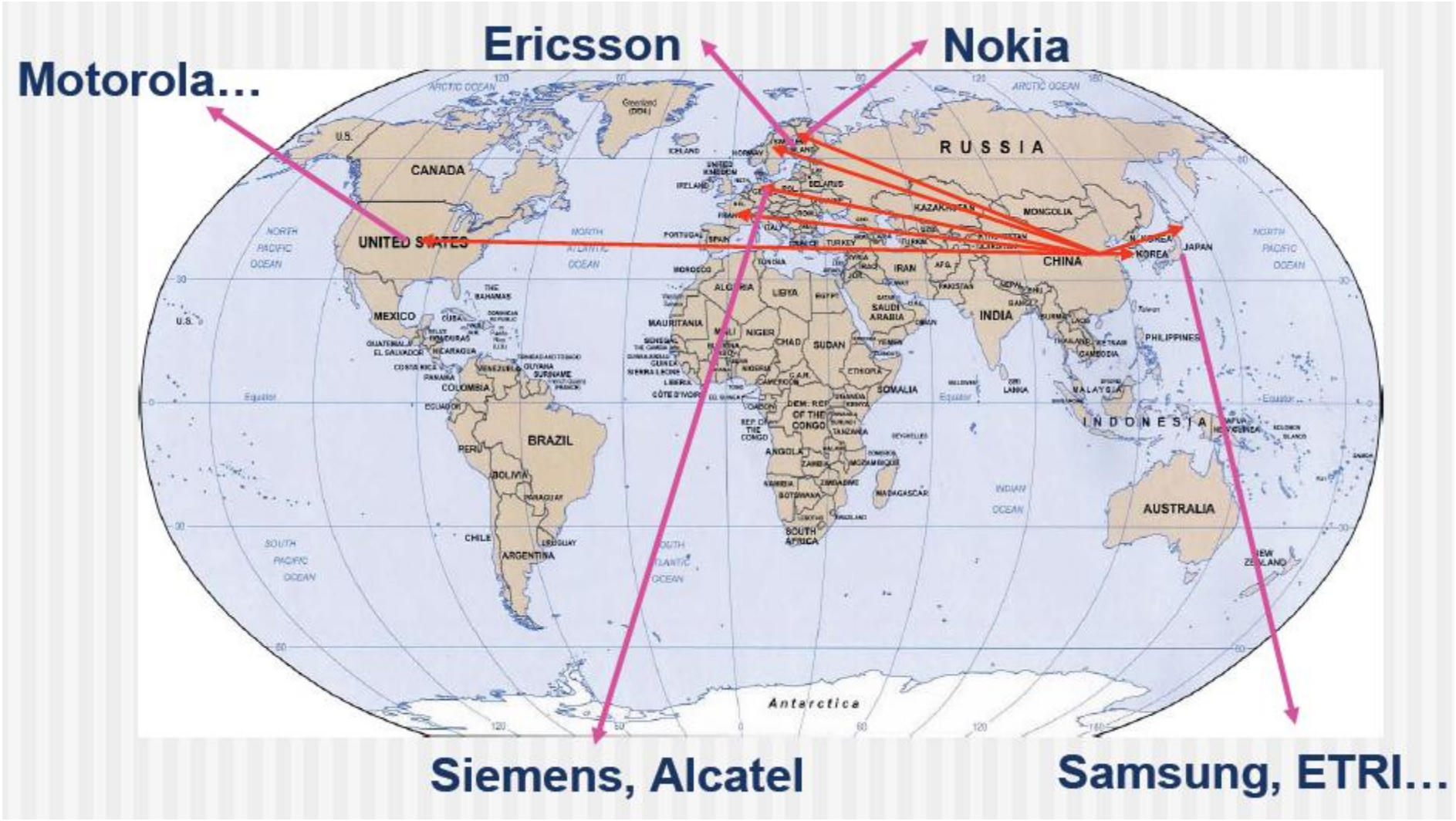
Phase 1: Six universities cooperating with six companies developed six transmission schemes for AMCS (4G) mobile.

Phase 2: Jointly develop AMCS(4G) experimental systems and networks supporting both FDD and TDD.

Phase 3: Trial & Pre-commercial System will be developed.



International Collaboration

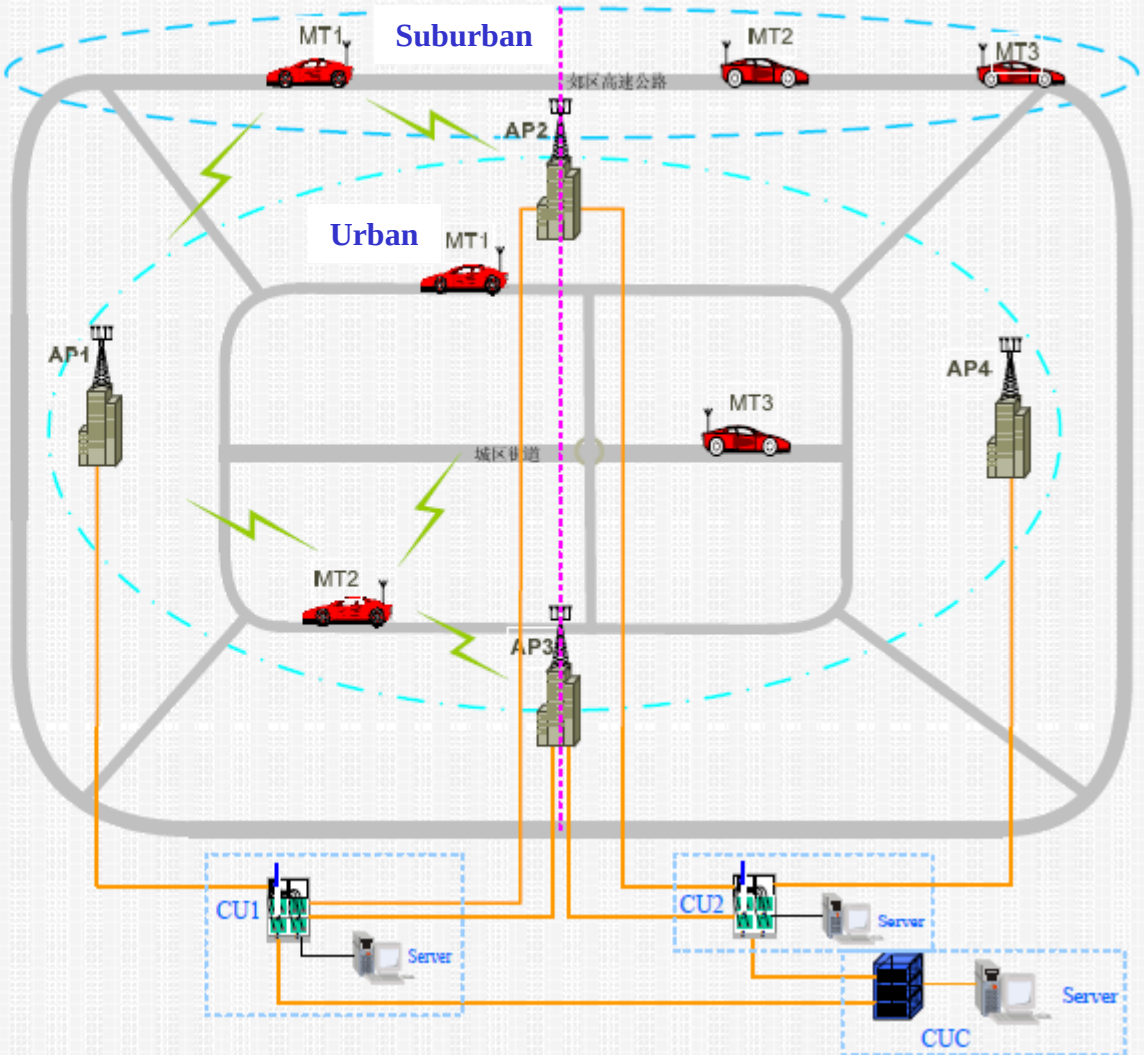


II. FuTURE FDD Demonstrator at SEU

FuTURE Demonstrator

Key features

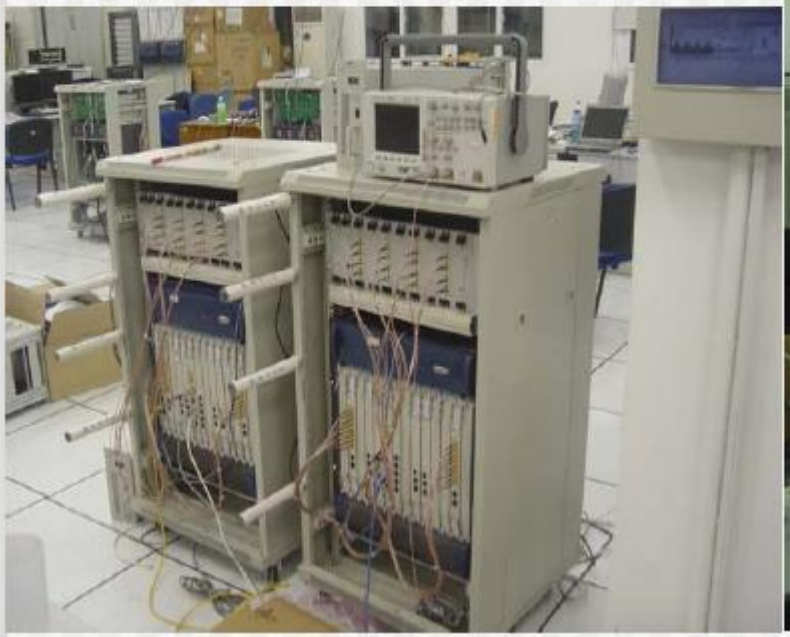
- combined FDD/TDD;
- distributed radio architecture based on RoF;
- MIMO GMC/OFDM links;
- environmental adaptation;
- 40-100Mbps full coverage for high mobility
- high speed local area hot-spot applications
- higher spectrum efficiency up to 2-10bps/Hz
- lower transmission power and better EMC performance



Photos of the Demonstrator

Base Station & Gateway

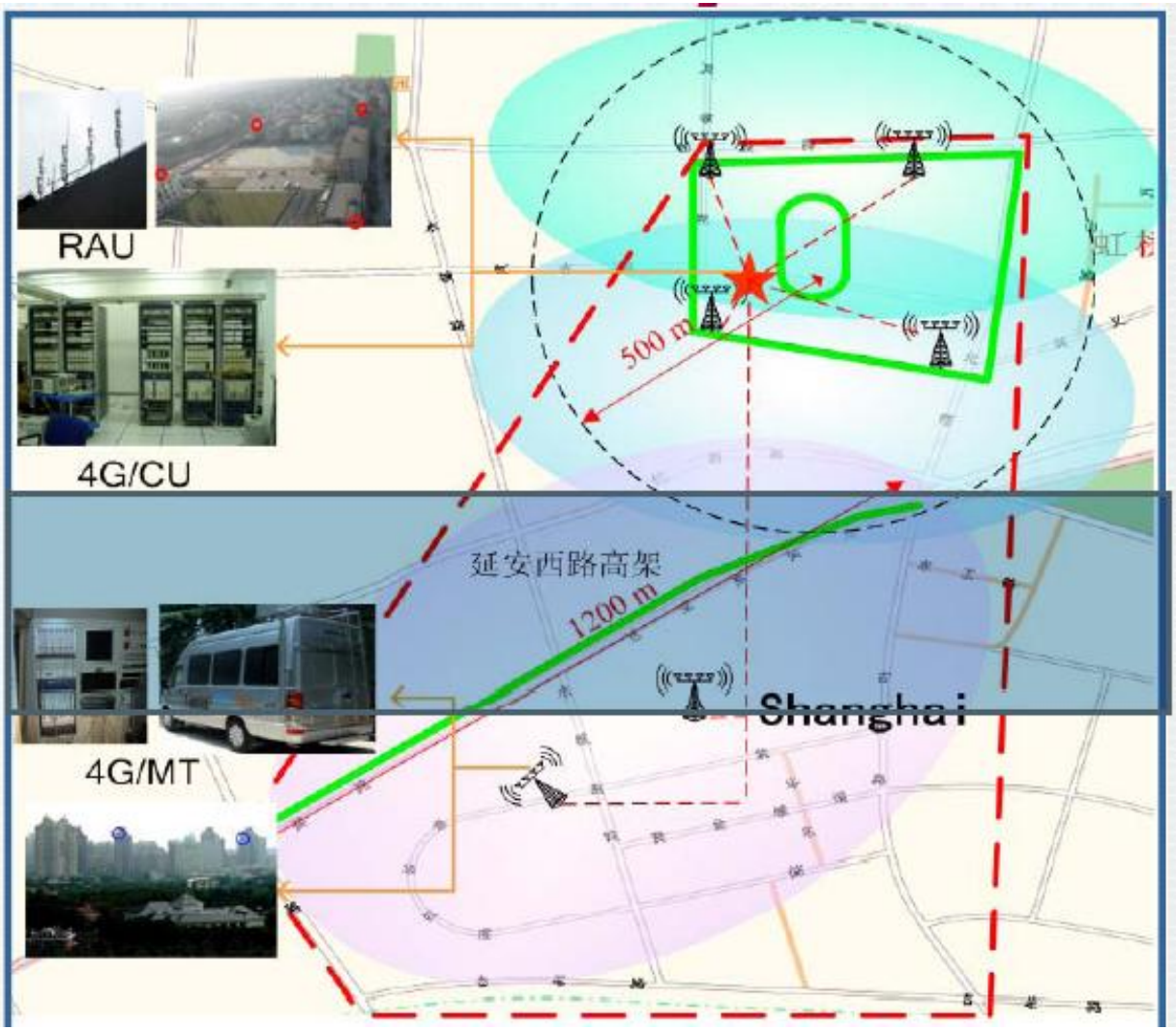
Mobile Terminals



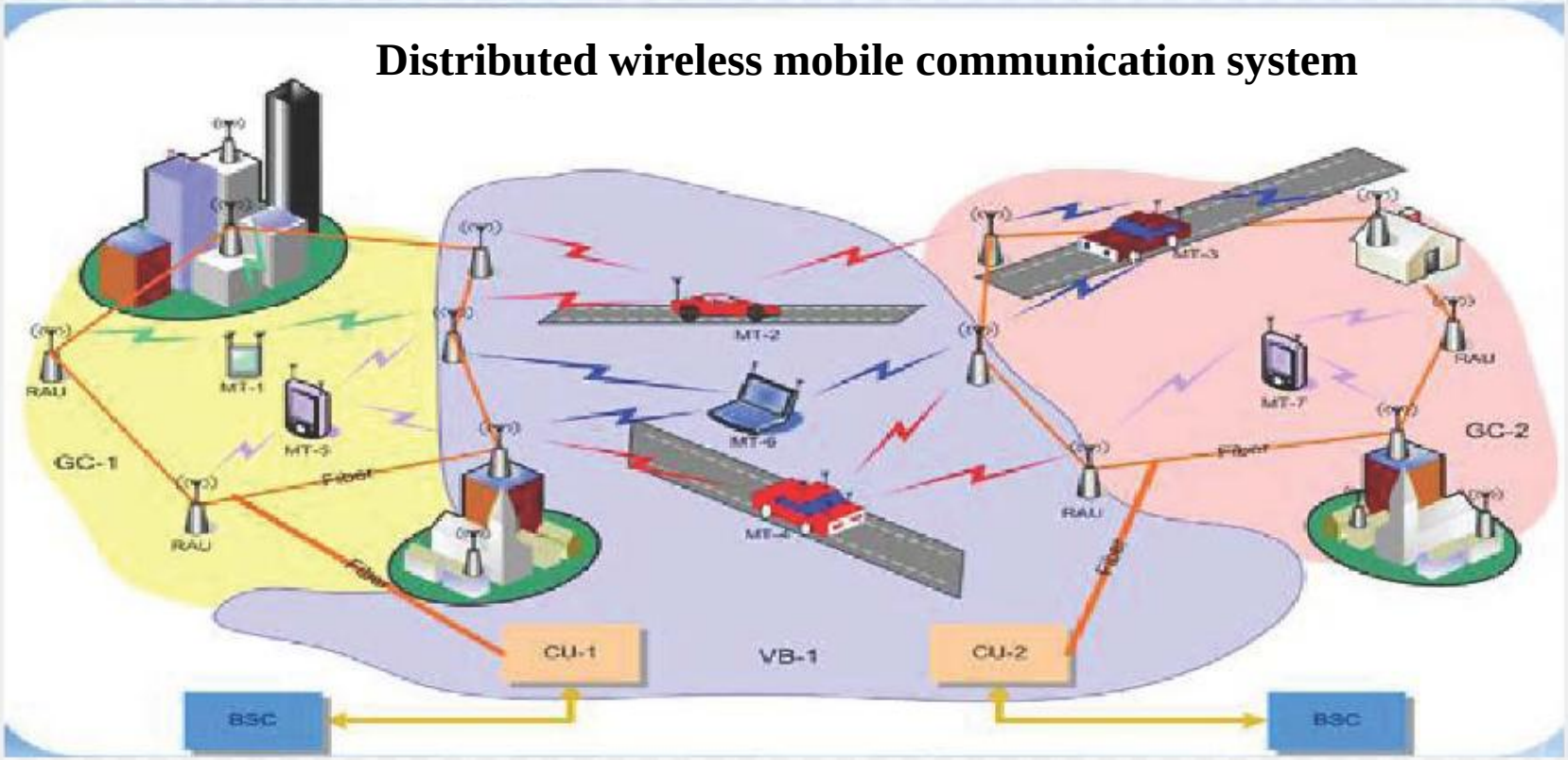
FuTURE Outfield Trial System (Shanghai)

FuTURE outfield deployment:

- Frequency Carrier: 3.5GHz
- Bandwidth: 20MHz
- RoF distributed antenna networks: 6 APs/3 cells
- 6 mobile stations
- GMC/OFDM modulation
- 8x4/4x4 MIMO
- >100Mbps data rate
- Antenna coverage: 0.5-1km
- Power for single antenna: 27dBm
- radio environment: from 0 to 120km



Key Tech. 1: Coopeative Distributed MIMO

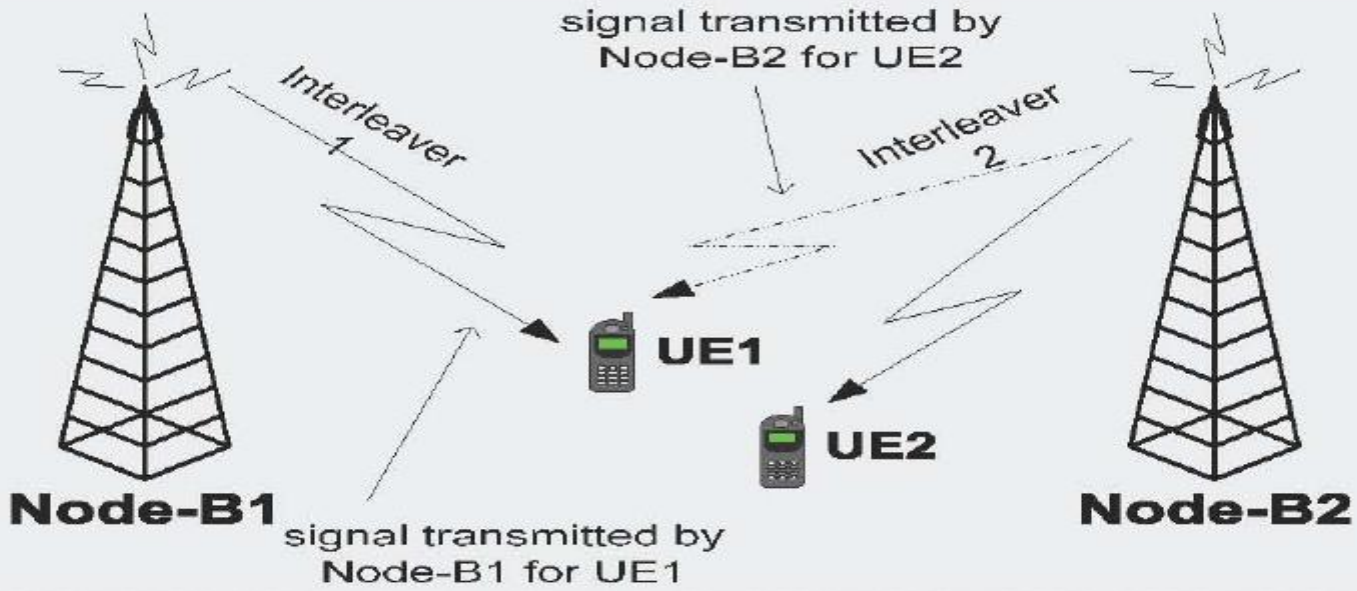


➔ Making the antennas as close as possible to the MTs to save the transmission power; while exploring the cooperative MIMO to improve the spectrum efficiency!

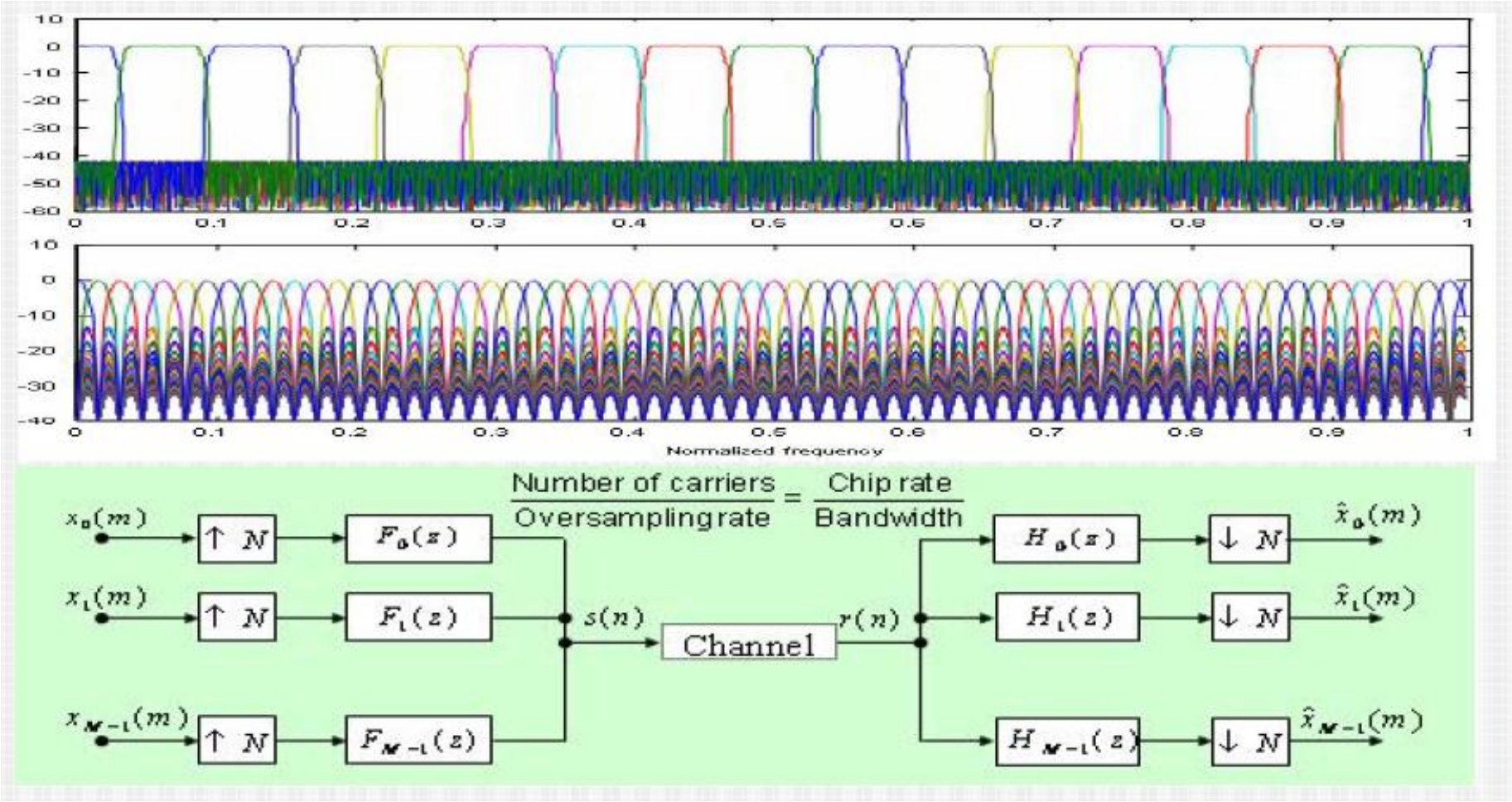
Key Tech. 2: Interleave-division Multiple Access (IDMA)

Multiple Cell Frequency Reuse Using IDMA

- Signals transmitted by different BS's are scrambled by different interleaving pattern and possible spreading;
- Multiple cell detection can be adopted for reducing the intercell interference.

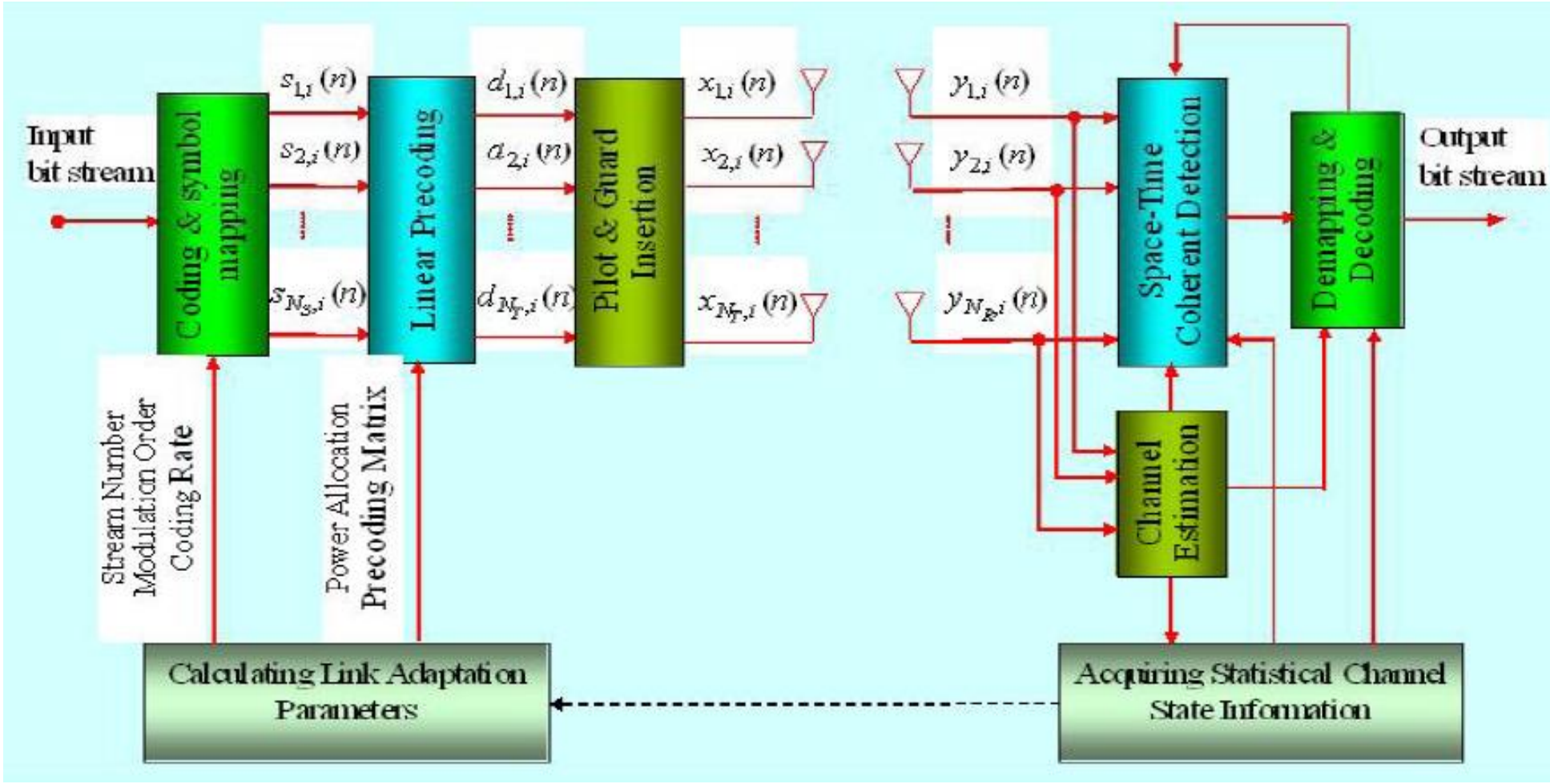


Key Tech. 3: GMC/OFDM Transmissions



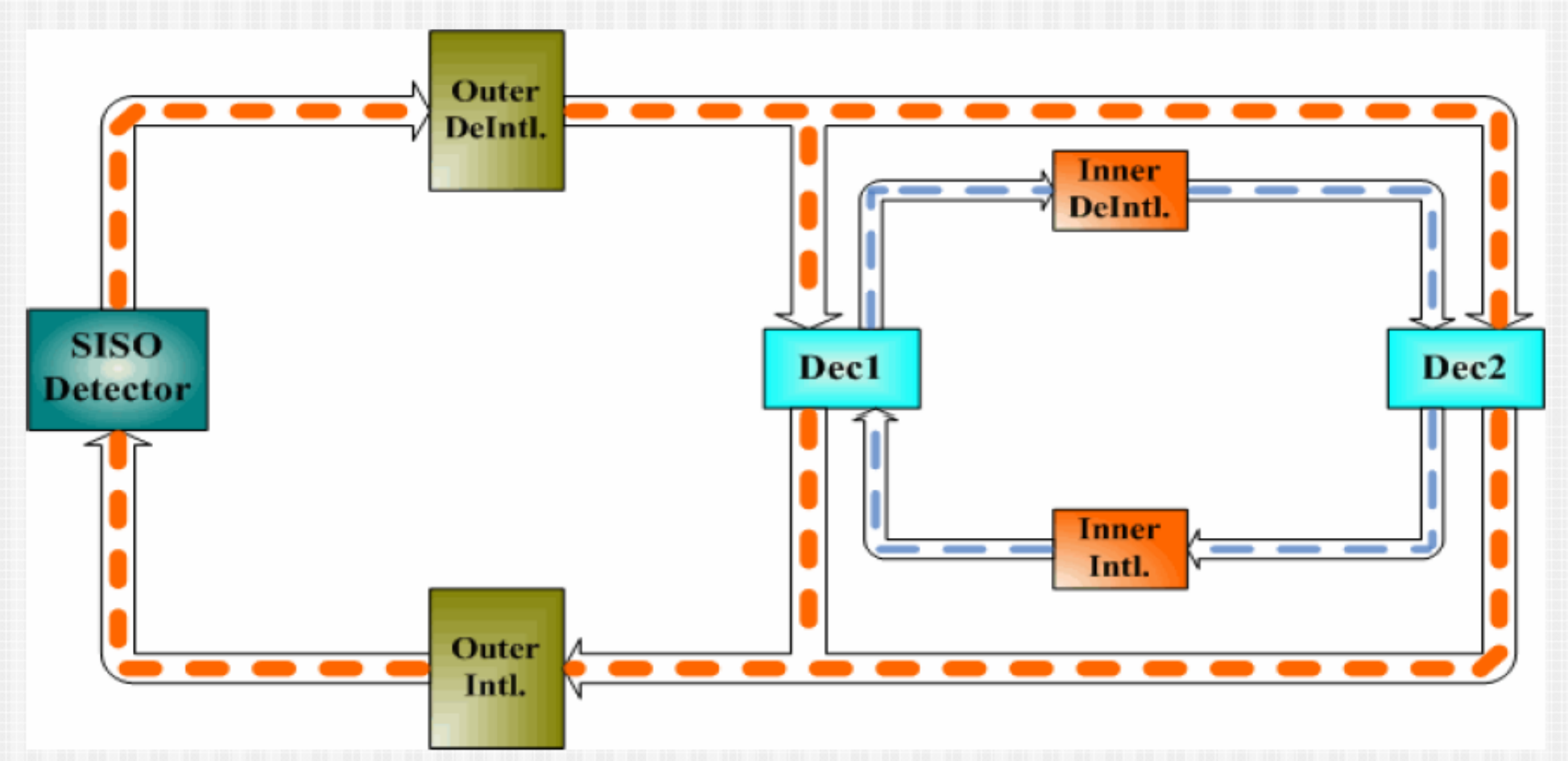
GMC: Generalized multicarrier -- X.Q. Gao & X.H. You et al, IEEE JSAC, vol.24, No.6, 2006

Key Tech. 4: Unifying MIMO Transmission



X.Q. Gao et al, IEEE Trans. on IT

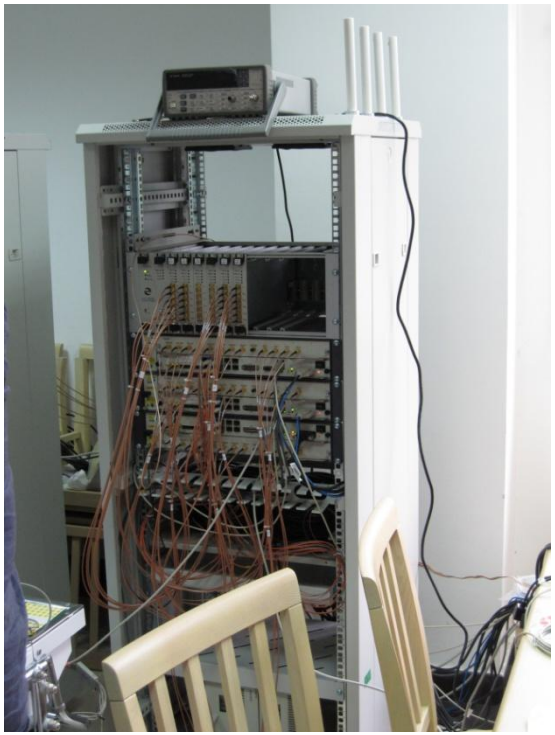
Key Tech. 5: Dual-Turbo Receiver



B. Jiang & X.Q. Gao et al., ICC'09 & IEEE Trans. on Wcom

Towards 4G (IMT-Advanced)

The Gbps transmission demo system at SEU



III. FuTURE TDD Demonstrator at BUPT

B3G **TDD** System Demonstrator—Key features

Baseband Parameter	Values
Duplex Mode	TDD
Carrier Frequency (Fc)	3.45 GHz
System Bandwidth (B)	20 MHz
Number of Sub-carrier	1024
Number of Effective Sub-carrier	884
Effective Bandwidth	17.2656 MHz
Sub-carrier Space (ΔF)	19.5 KHz
Cyclic Prefix (CP)	216（10.8 us）
Symbol Duration (Ts)	51.2+10.8=62.0 us
Modulation Scheme	16QAM
Turbo Code Rate (R)	0.5
MIMO Architecture	8（BS）×4（MT）

Indoor Demonstrator

Support following services simultaneously

- **Multiple VODs → media streams of high quality**
- **Wireless FTP download → high data rate transmission**
- **Internet, QQ → reliable internet access**
- **VoIP service → clear voice without time delay**

Wireless Environment

Performance of system

- *4T8R for uplink, peak data transmission rate reaches 100Mbps*
- *2T4R for downlink, peak data transmission rate reaches 50Mbps*
- *Block error rate is lower than 0.5%, bit error rate is lower than 1.0e-6*

Outdoor Demonstrator

RoF、Group Cell/Slide Handover、P-MIMO、FCGS、Distributed Antenna Array…

Outdoor Demonstrator (cont.)

- *Universal hardware platform*
- *Plug and play*
- *Modularization for system architecture*
- *Flexible system scale*
- *Full-scale distributed parallel process*
- *Completed SDR*

flexible single board structure

powerful shelf with 14 slots

Cooperative and distributed antenna architecture

Flexible MIMO schemes

Single frequency networking

Key Concepts and Technologies

- **All-IP Based Flat Architecture——Hi-Station**
  - Network Convergence, Flat architecture, Shorten Latency
- **Generalized Cellular Network——Group Cell and Slide Handover**
  - Breakthrough traditional cellular architecture
  - User always in cell center
- **Convergent Network Service——Mobile Ubiquitous Service Environment**
  - Providing Mobile Ubiquitous Services Supporting
- **Efficient Frequency Reuse Scheme——Soft Fractional Frequency Reuse**
  - Apply Extension/Fuzzy Set theory, Efficient Frequency Plan
- **Cell-edge user performance improving——Fast Cell Selection Scheme**
  - Proposal accepted by 3GPP LTE: *3GPP R1-050788*

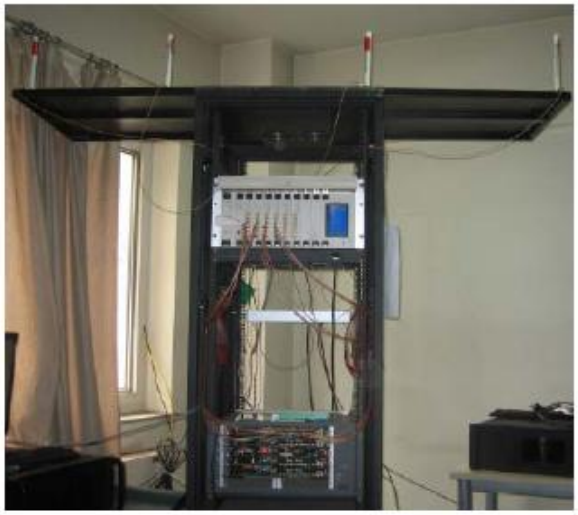
Towards 4G (IMT-Advanced)

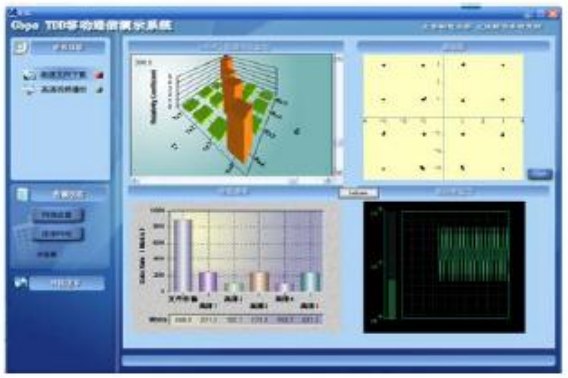
Gbps transmission demo system at BUPT

AP

- 4T X 6R，peak data rate 1Gbps

MT





IV. Summary

- FuTURE is the leading national programme in China in the area of B3G/4G R&D.
- Indoor and outdoor, TDD and FDD testbeds have been built to test and demonstrate the performance of various key B3G/4G technologies.
- SEU and BUPT are the two leading universities in the FuTURE project.
- SEU an BUPT have both moved on to focus on 4G/B4G technologies and have both built Gbps transmission demonstration systems.