



4G TDD MIMO OFDM Network

4G TDD 移动通信网

Prof. TAO Xiaofeng

Wireless Technology Innovation Institute (WTI)

Beijing University of Posts & Telecommunications (BUPT)

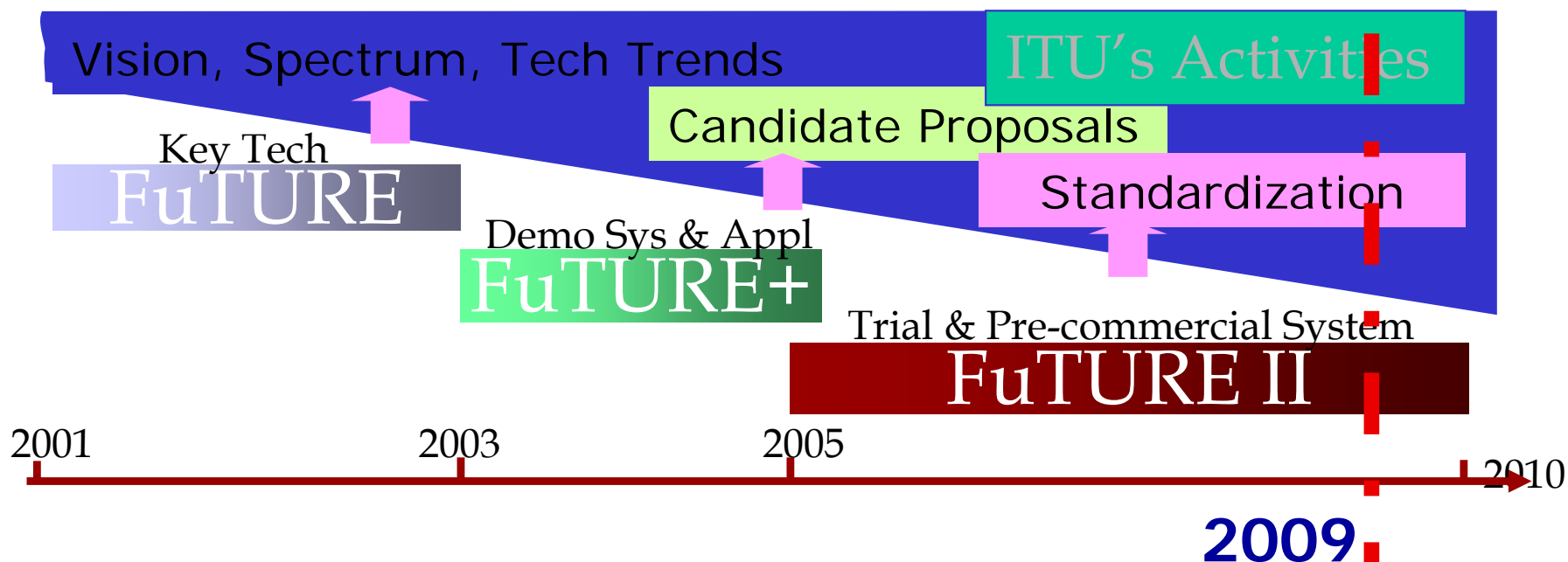
Beijing China

北京邮电大学无线新技术研究所 陶小峰



Background: FuTURE Project

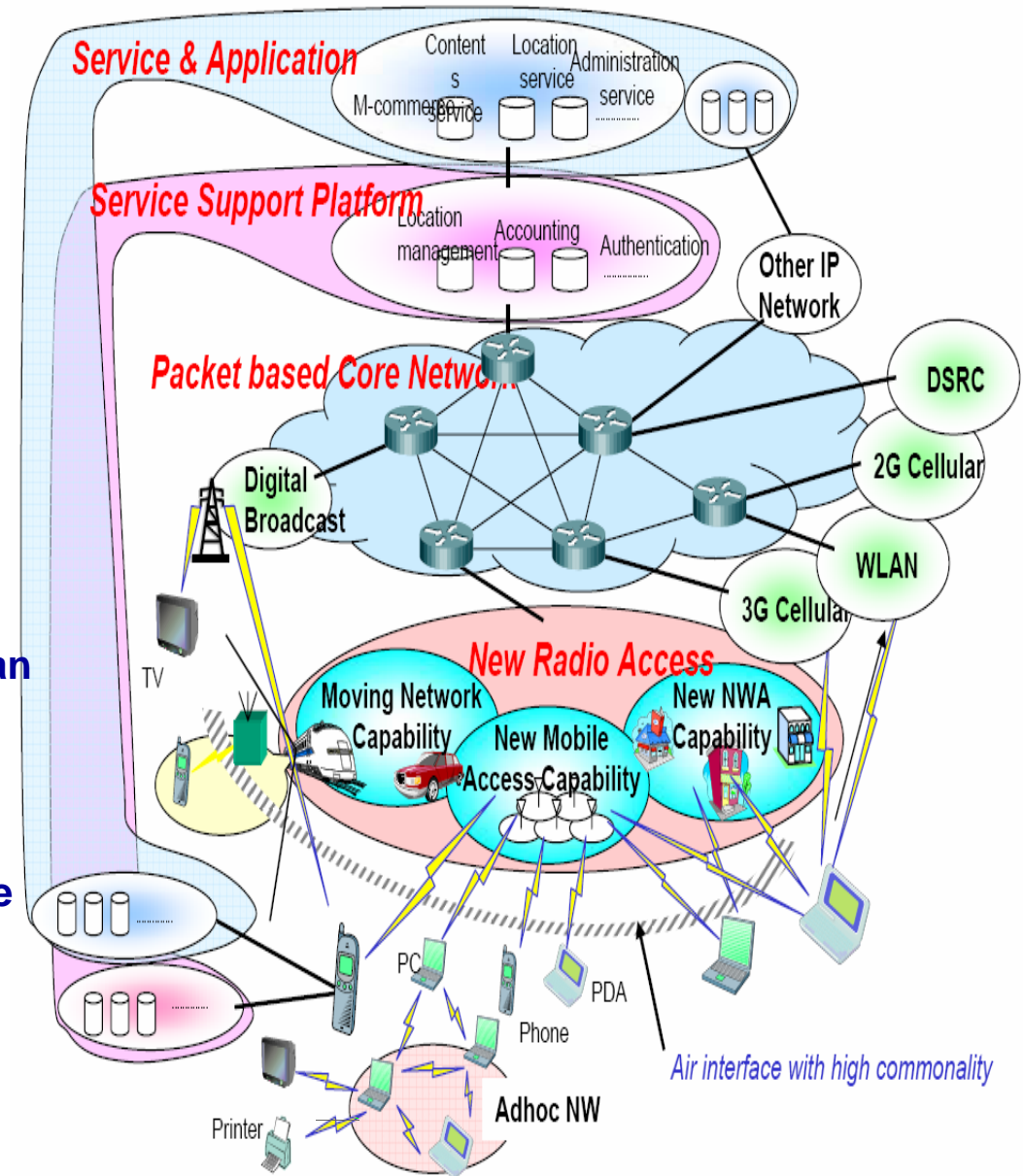
- **FuTURE – Future Technologies for Universal Radio Environment as a part of China High-Tech 863 program.**
- **Phase 1: Six universities cooperating with six companies developed six transmission schemes for 4G mobile.**
- **Phase 2: Jointly develop 4G experimental systems and networks supporting both FDD and TDD.**
- **Phase 3: Trial & Pre-commercial System will be developed.**





Vision of 4G Wireless Communication System(2002)

- Higher Data Rate (100M~1Gbps)
 - 3GPP TR 25.913 "Requirements for Evolved UTRA and Evolved UTRAN"
- Higher Mobile Mobility (250km/h)
 - ITU-R M.1645: "Framework and overall objectives of the future development of IMT-2000 and systems beyond IMT-2000"
- All-IP Architecture, Function Split of Control Plane and User Plane
 - ITU-T SG13 FGNGN
 - 3GPP TS 22.258 "Service requirements for an All-IP Network"
- Ubiquitous Services, Convergence of different Network Architecture
 - 3GPP TR 23.882 "3GPP system architecture evolution (SAE)"
- Versatile Multimedia Packet Service
 - WWRF (MUSE)



4G TDD Network Architecture (2001-2003)

□ Flat Radio Access Network

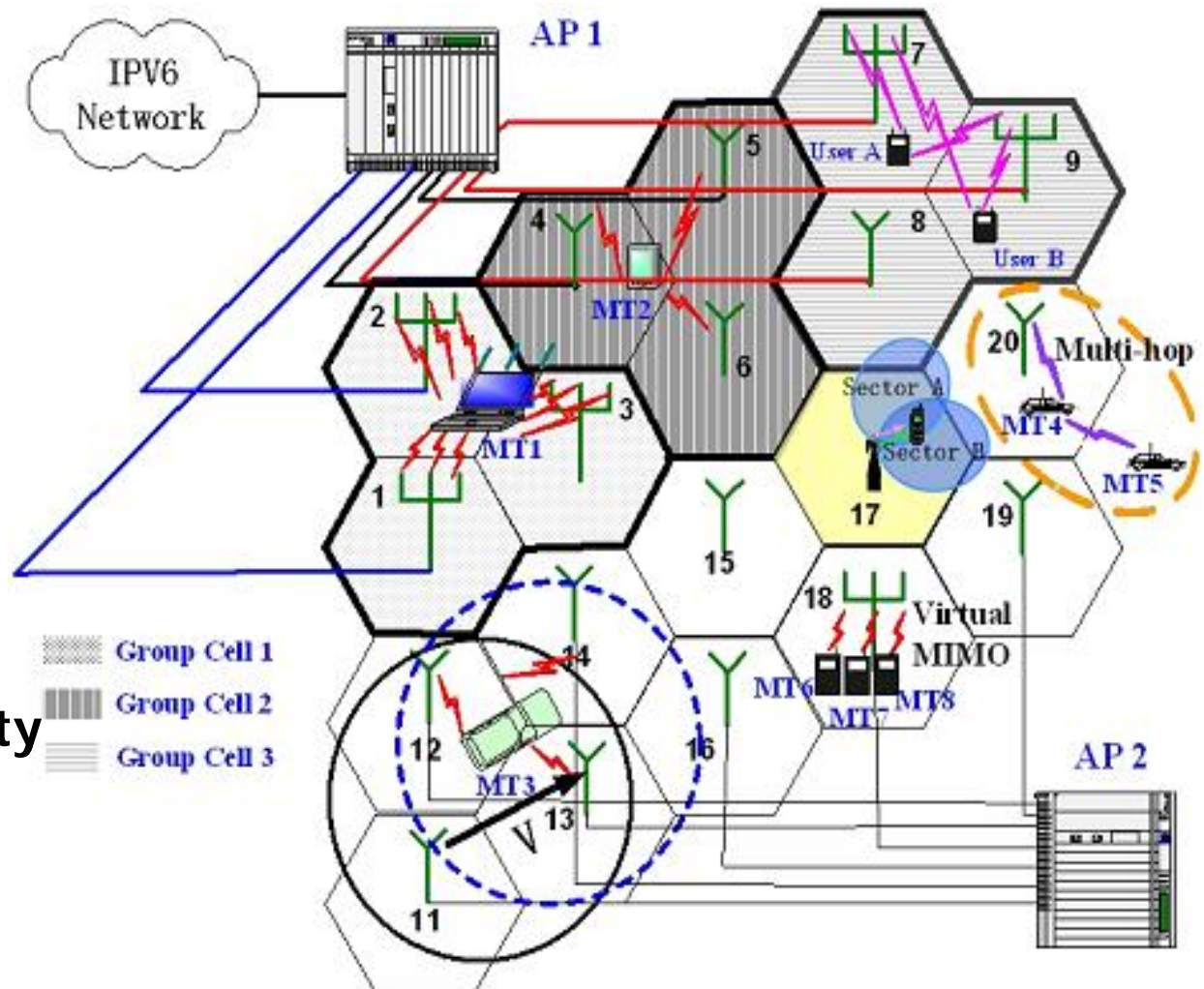
- All-IP based architecture
- Short latency

□ Novel Cellular Architecture

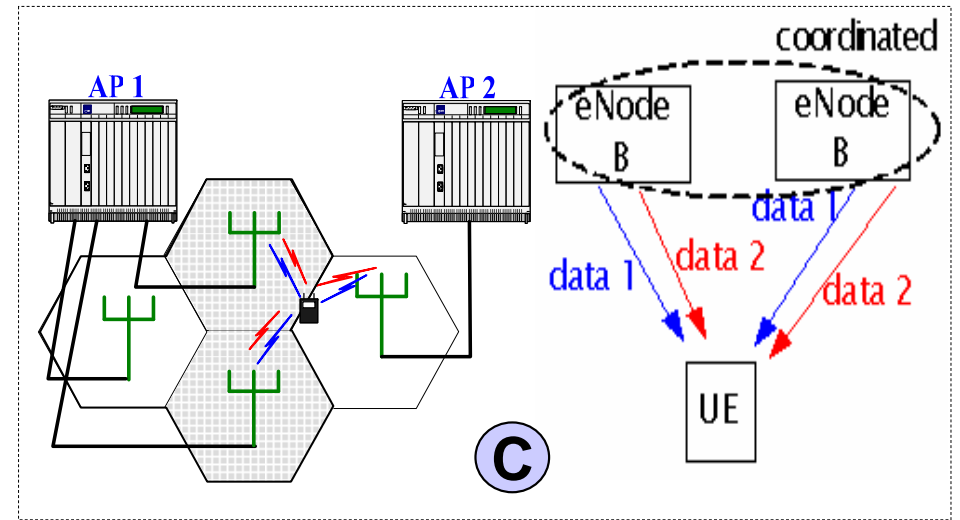
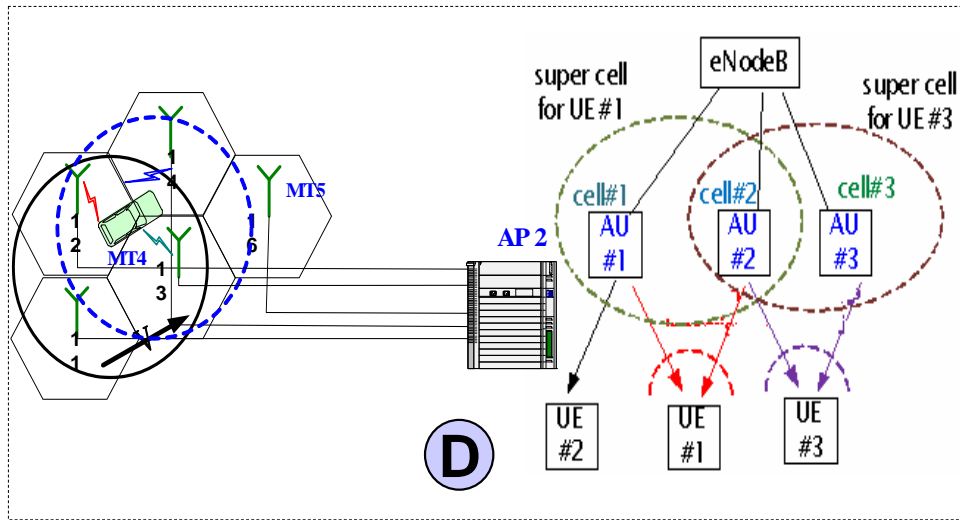
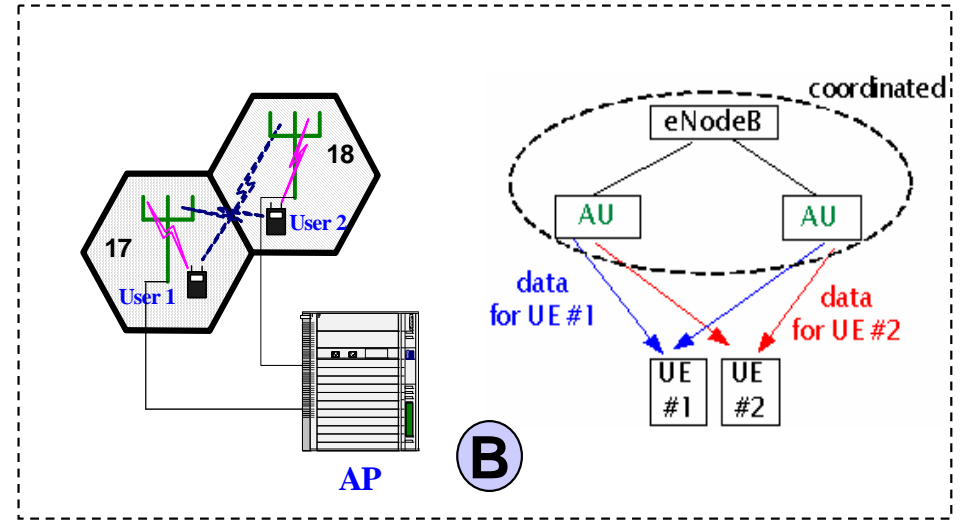
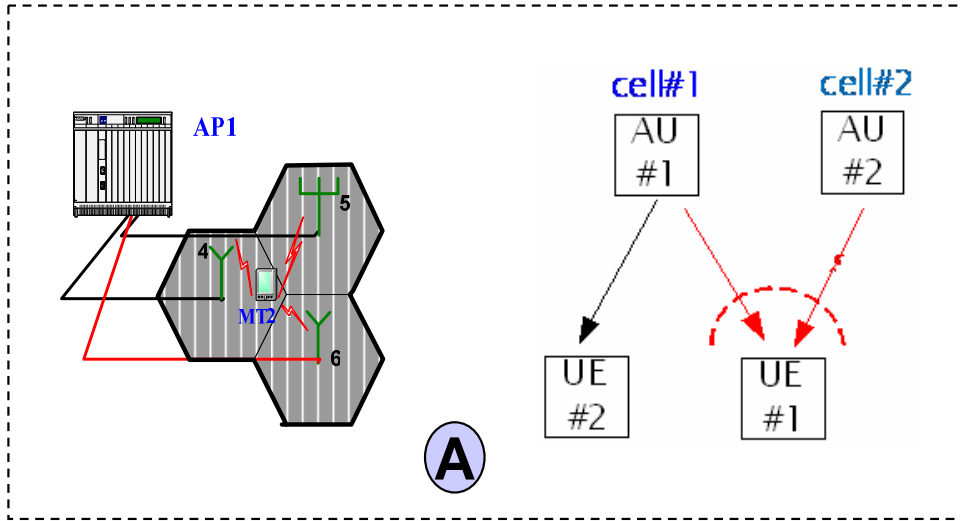
- Group Cell
- Slide Handover
- User always in cell center
- Solve “smaller cell” problem
- Avoid “cell edge” effect
- Avoid frequent handover
- Enlarge coverage area

□ Fully Explore Space Diversity

- Distributed Antenna Array
- Virtual MIMO
- Multi-hop, Relay



Group Cell (2001) vs 3GPP LTE-A CoMP (2008.9)



Efficient Frequency Reuse Scheme

Soft Fractional Frequency Reuse

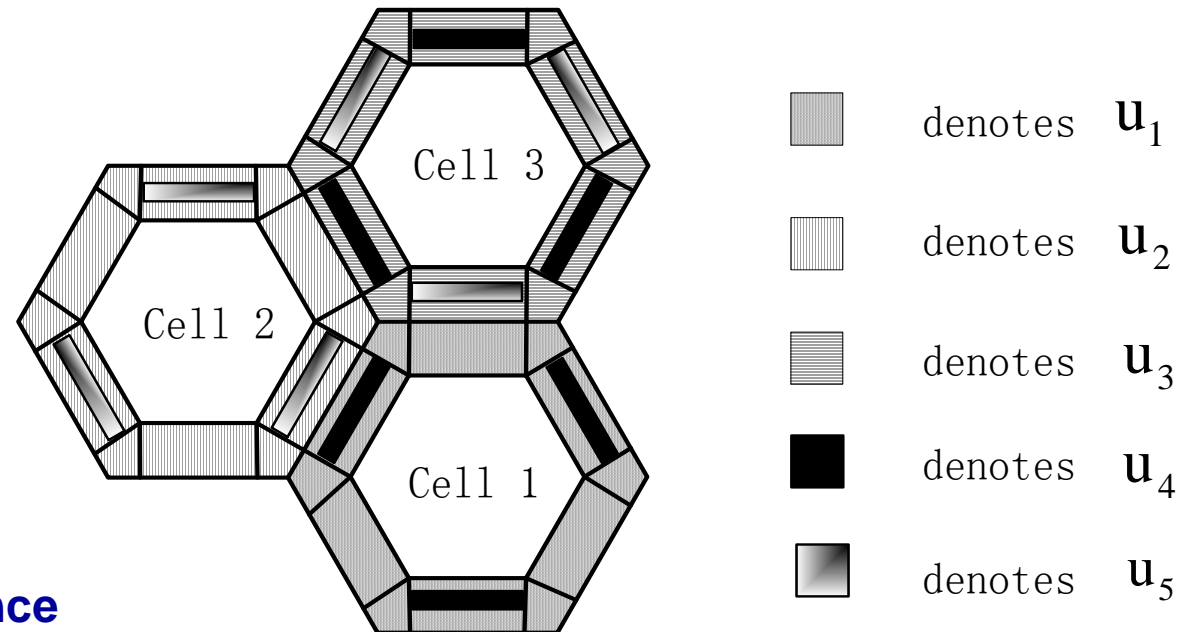
$$R_1 = [f_1, \textit{related field}, (C_1, C_2, \dots, C_9)],$$

$$R_2 = [f_2, \textit{related field}, (C_1, C_2, \dots, C_9)],$$

...

$$R_9 = [f_9, \textit{related field}, (C_1, C_2, \dots, C_9)].$$

- **Improve spectrum efficiency**
- **Mitigate inter-cell interference**
- **Improve cell-edge user performance**
- **Frequency plan for entire network**

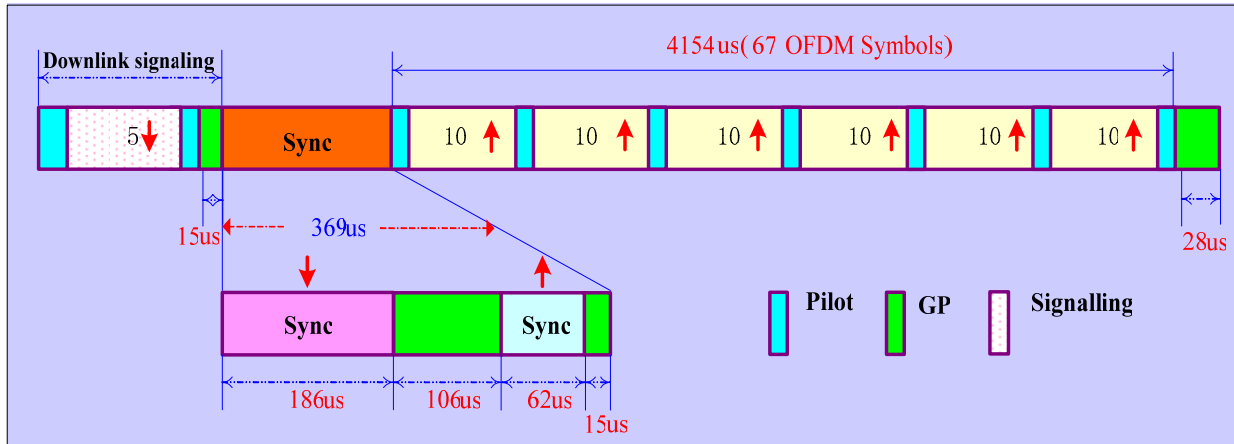


Extension/Fuzzy Set Theory

SFFR Proposals

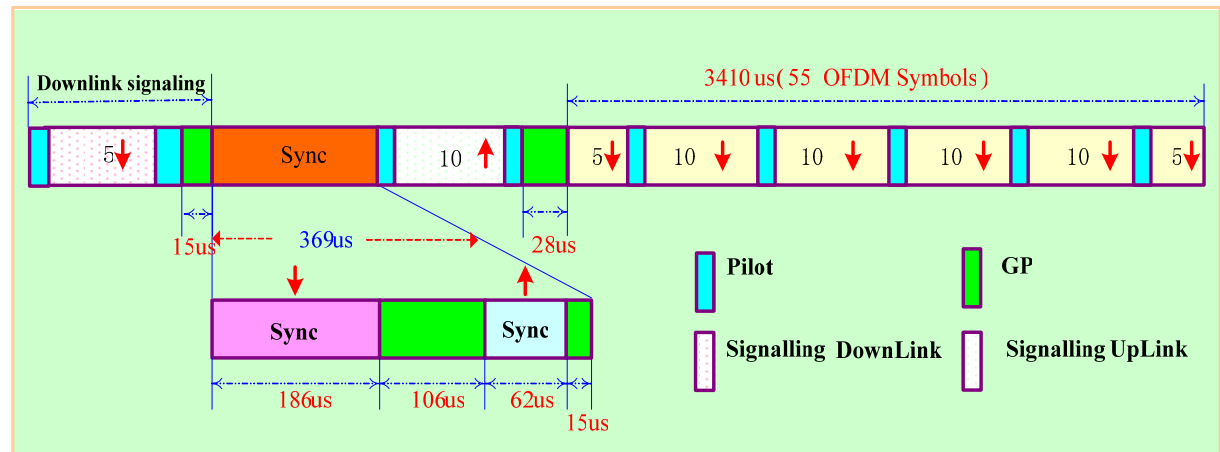
4G-TDD Key Tech I : Frame Structure Design

Uplink frame structure



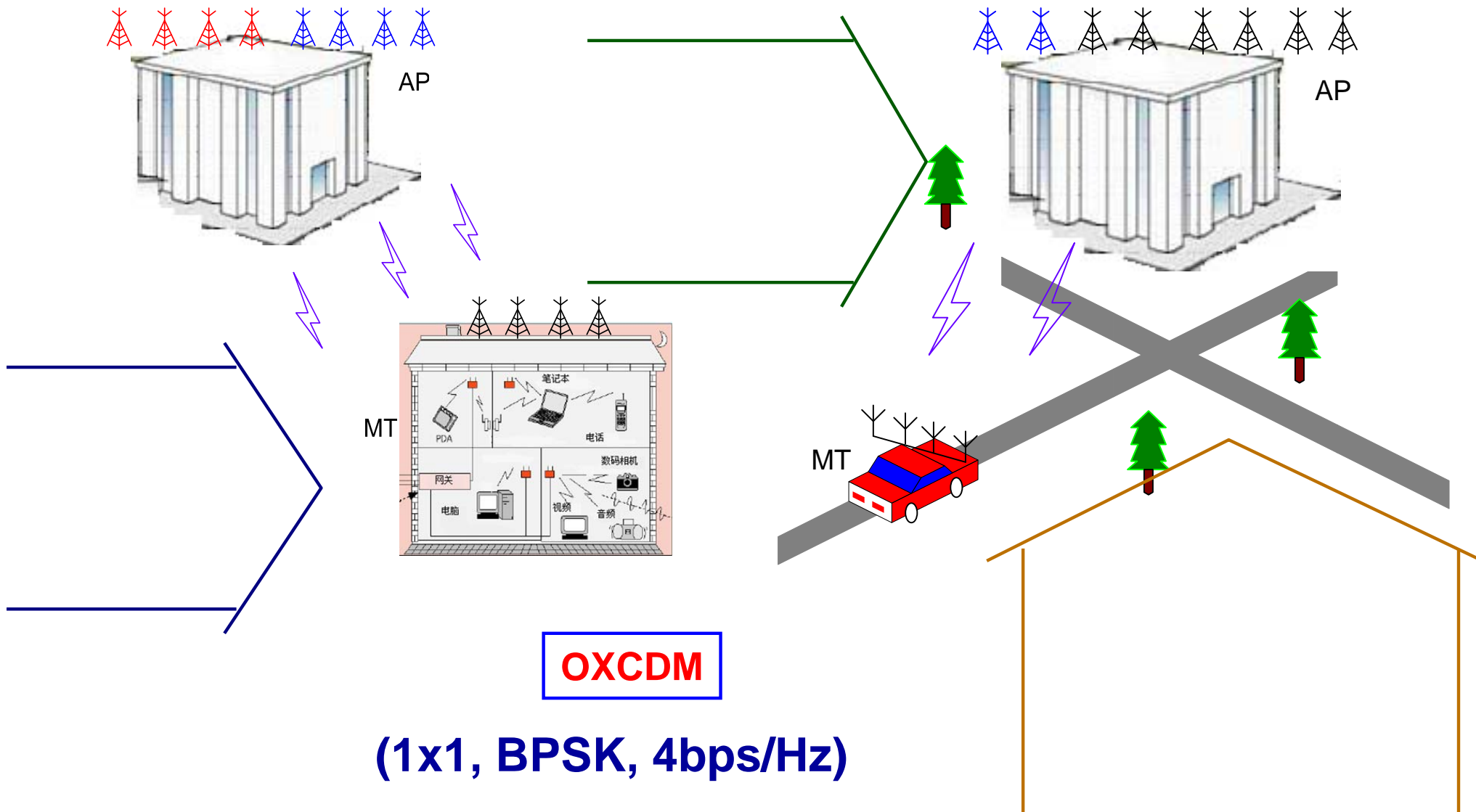
Downlink frame structure

- Compatible to TD-SCDMA system
- Convenient for resources allocation between uplink and downlink
- Combined with OFDM technique
- Support 15km coverage
- Peak data transmission rate up to 100Mbps





Adaptive MIMO (1x1~4x8, QAM, 7-10.5bps/Hz)



OXCDM

(1x1, BPSK, 4bps/Hz)



4G TDD System Design— Baseband Parameters

Baseband Parameter	Values
Duplex Mode	TDD
Carrier Frequency (F_c)	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 (T_s)	$51.2+10.8=62.0$ us
Modulation Scheme	16QAM
Turbo Code /LDPC Rate (R)	0.5/0.6
MIMO Architecture	8 (BS) \times 4 (MT)

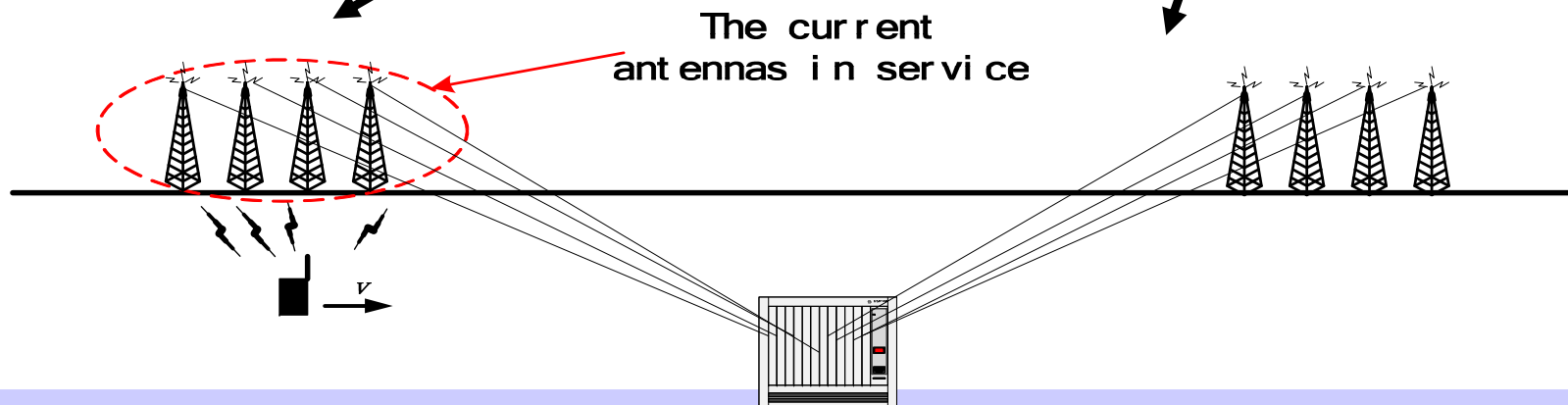


Scene for Outdoor Demonstration Group Cell (CoMP) 2006.4-10





Group Cell implementation scheme





IPv4/6 based Services



VOD and FTP on Mobile



Wireless Video phone on Open day

(round trip delay < 39ms)

With almost wired quality and save power



Exploring Internet on Mobile

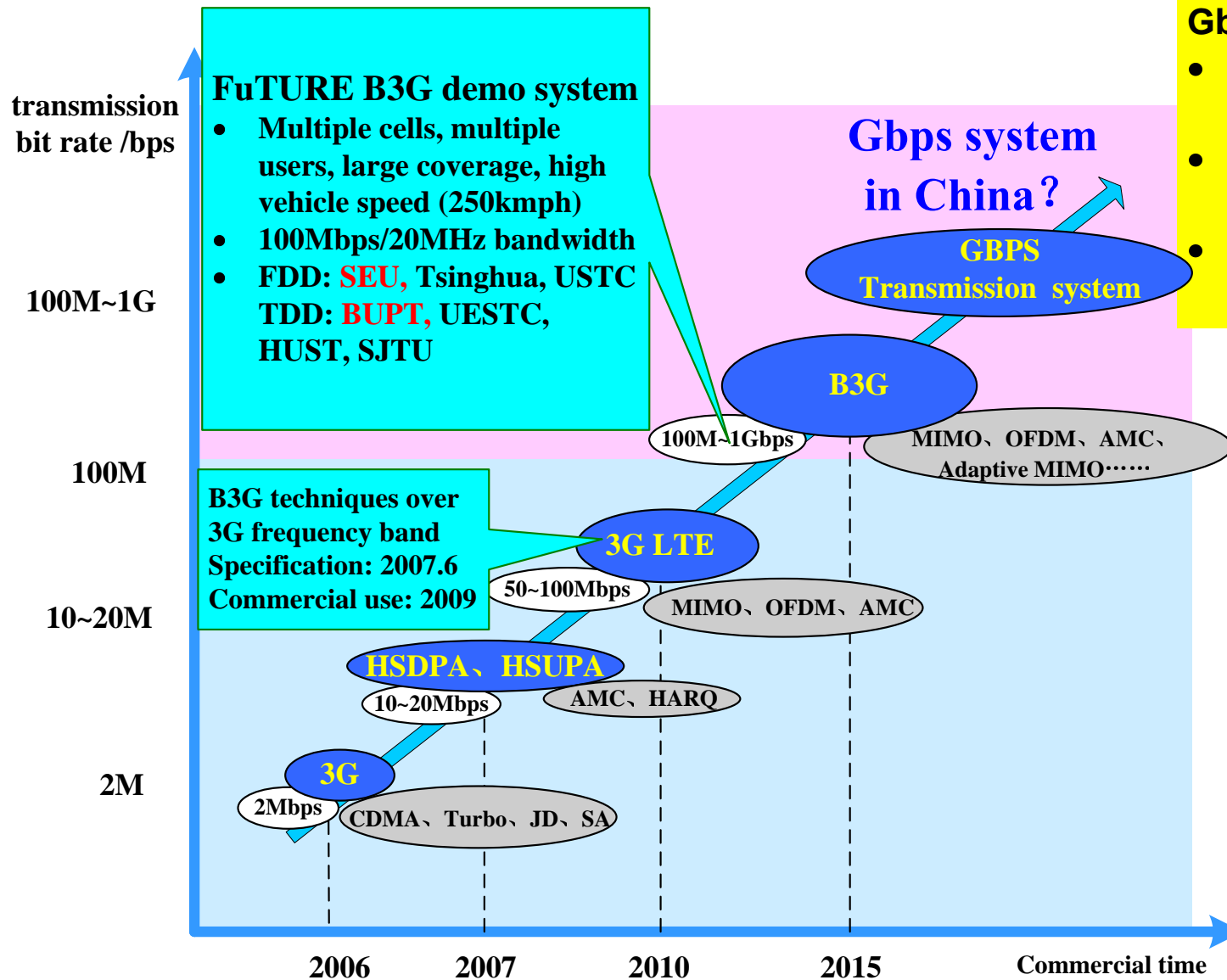


Wireless HDTV Transmission

BER < 10^{-8~-9}



Gbps background



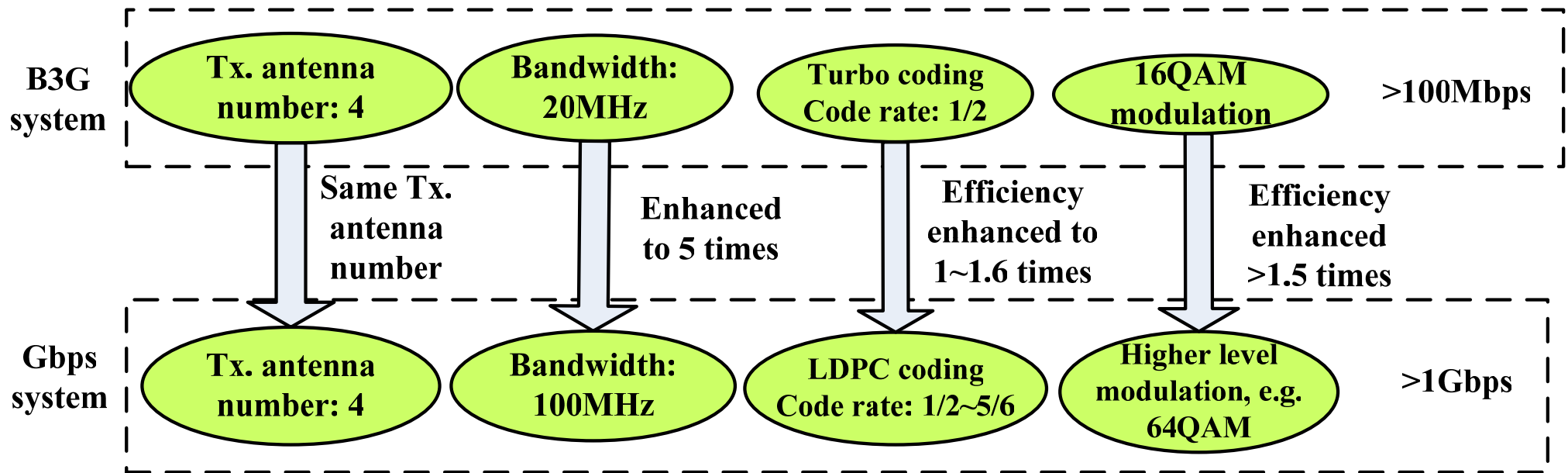
- Gbps system in the world:**
- Europe, 2004.11, 1G (Static)
 - Japan, 2006.2, 2.5G (low vehicle speed)
 - Korea, 2006.8, 100M (60kmph), 1G (static)





Gbps?

- 4G-TDD demo system already proven transmission technology with 7bps/Hz;
- Then, how to make Gbps possible?





AP



MT1

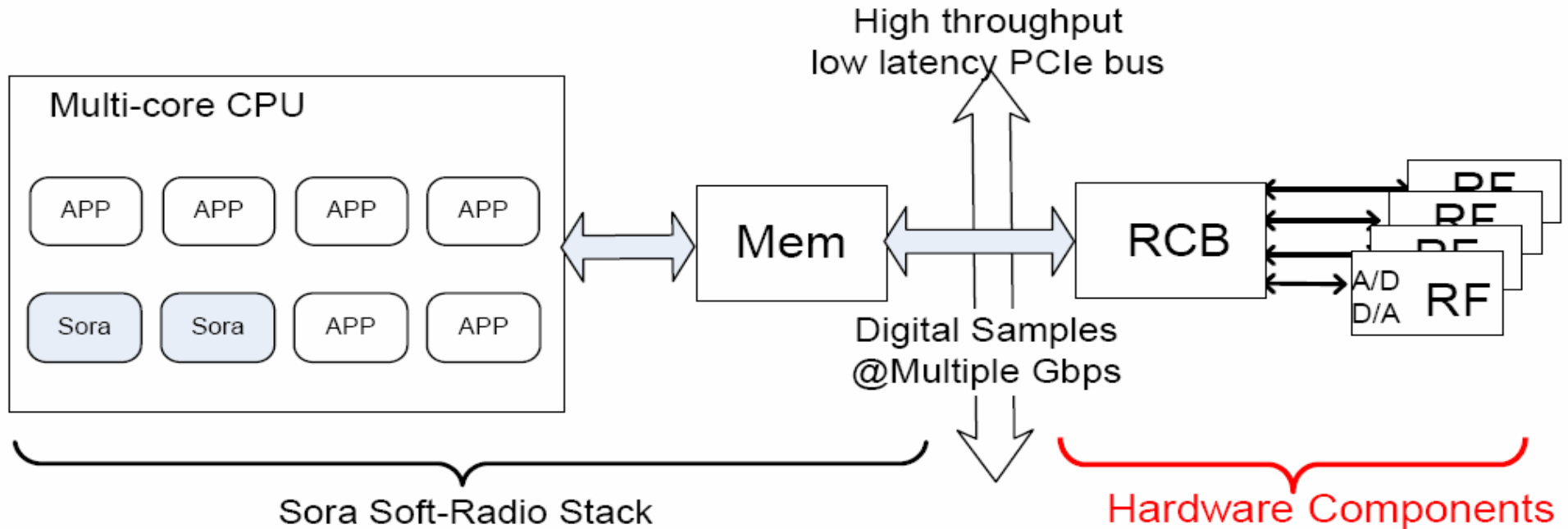
MT2

GBPS 4G TDD trial system
Peak data rate: 1.01Gbps
in BUPT



Key Concepts and Technologies of 4G TDD

- **All-IP Based Flat Architecture——Hi-Station**
 - Network Convergence, Flat architecture, Shorten Latency
 - Proposal accepted by 3GPP LTE Advanced: *3GPP RAN#41 CoMP*
- **Generalized Cellular Network——Group Cell and Slide Handover**
 - User always in cell center
 - Proposal accepted by 3GPP LTE Advanced: *3GPP RAN#41 CoMP*
- **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*



Hardware

- RF (A/D & D/A)
- RCB (radio control board)

Role of RCB

- transfer digital signals between RF and PC memory

- synchronization ⇔ asynchronization

PCIe bus

- latency < 1 μs



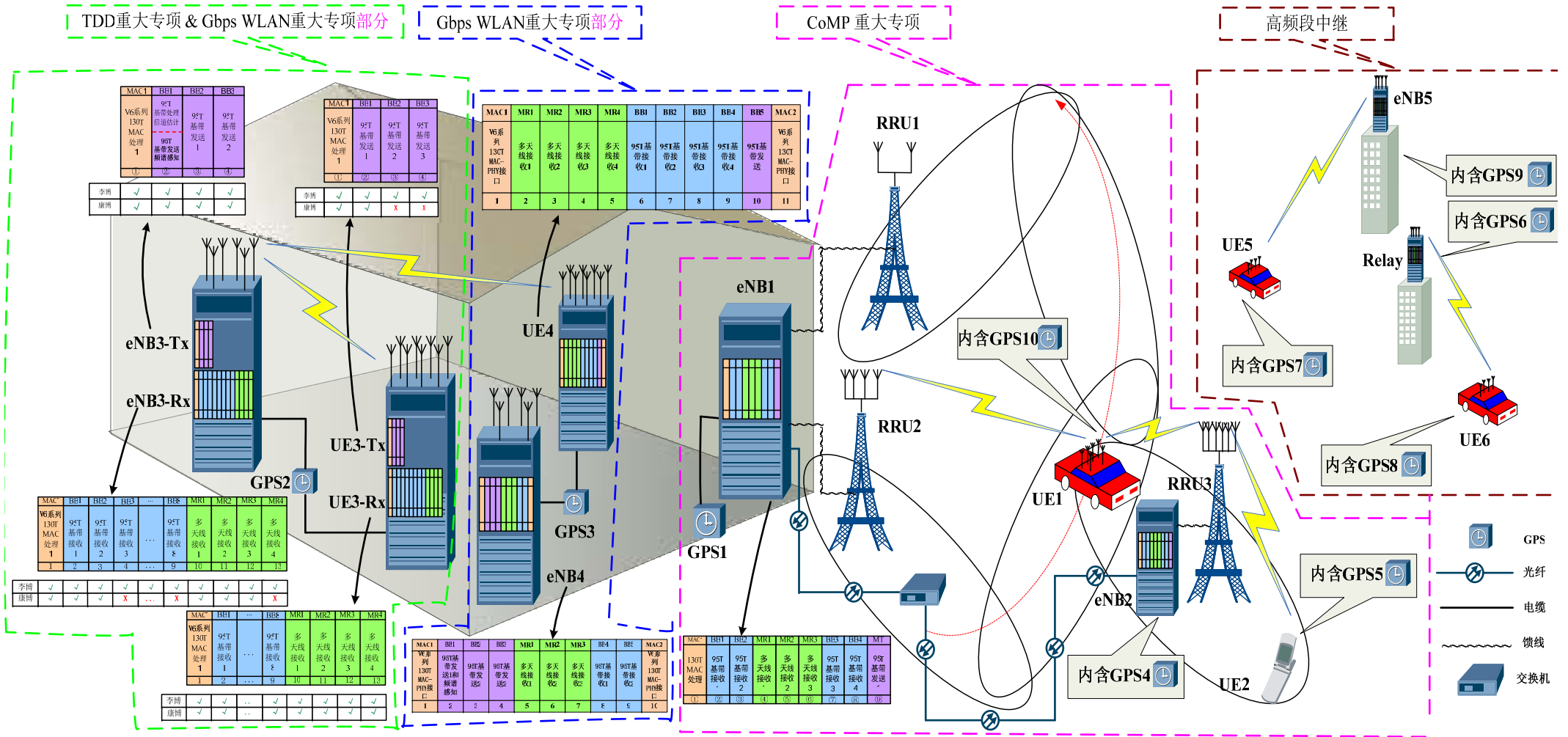


SoftLTE (PUSCH)

Parameter	Value in 20MHz BW
Transmission bandwidth	20MHz
Carrier Frequency	2300MHz
Subcarrier spacing	15kHz
Sampling frequency	30.72MHz
FFT size	2048 samples
CP size	160 (1st symbol) 144 (2~7th symbol)
Frame length	10ms
Subframe length	1ms
Slot length	0.5ms
Channel Coding Rate	3/4
Modulation	16QAM
Antennas	Tx = 1, Rx = 1 or Rx = 2
Peak data rate	42.816Mbps
Average data rate	25.6896Mbps



Next step....(from 2009)





Thanks!