# R&D Collaboration Opportunities in Wireless Communications

International Center for Wireless Collaborative Research

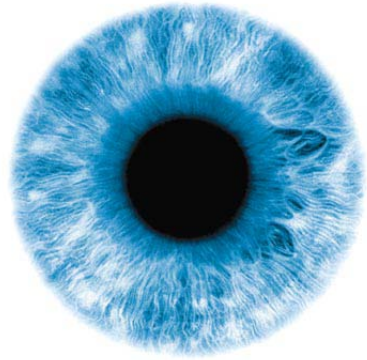
**Dr. Yang Yang**

**Shanghai Research Center for Wireless Communications**

**UC4G Project Progress Workshop, UCL, 8 July 2010**

# Outline

- **R&D Collaboration Opportunities (National Major Projects)**
- **SWAN: Shanghai Wireless Advanced Network**



# National Major Special Projects in Science and Technology

- Budget: ~ 600B RMB for 16 Projects
  - Large aircraft
  - New generation mobile wireless broadband communication networks (2008-2020, 70B RMB)
  - Manned space flight and lunar exploration program
  - High-resolution Earth observation systems
  - Large-scale advanced pressurized water reactor and high temperature gas cooled reactor nuclear power plant
  - High-end CNC machine tools and basic manufacturing equipment
  - A great-scale integrated circuit manufacturing equipment and complete sets of technology
  - The core electronic components, high-end general chips and basic software products

**These eight projects are managed by the MOST**

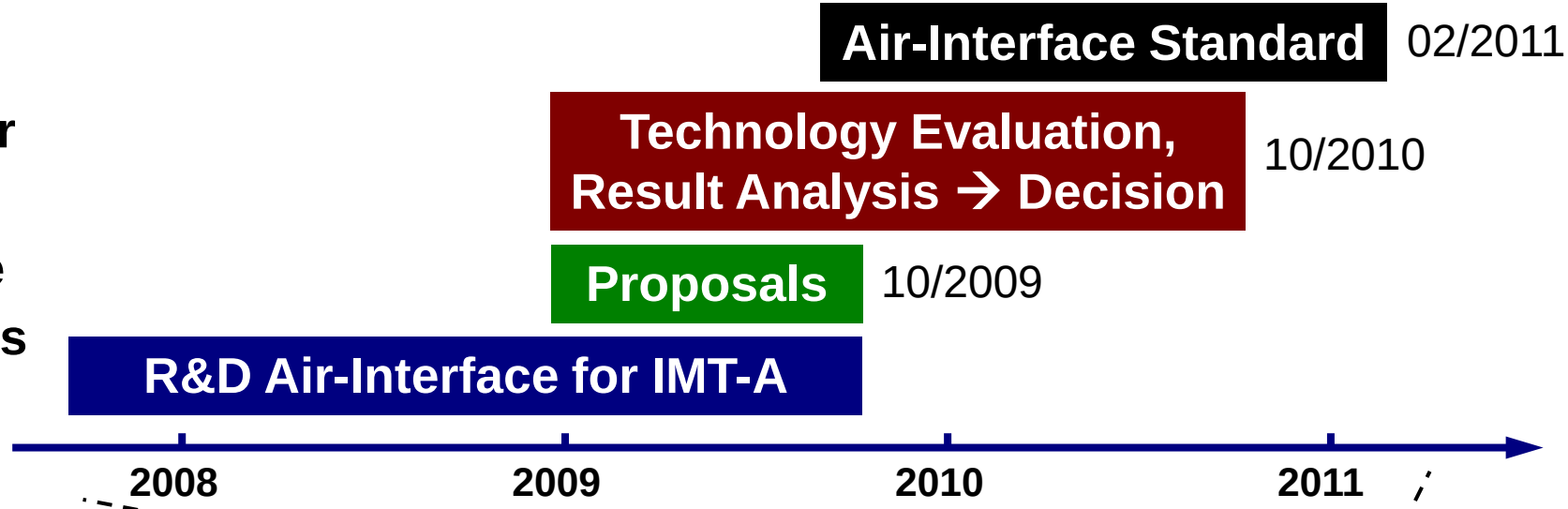
# National Major Special Projects in Science and Technology of China

## New Generation Mobile Wireless Broadband Communication Networks

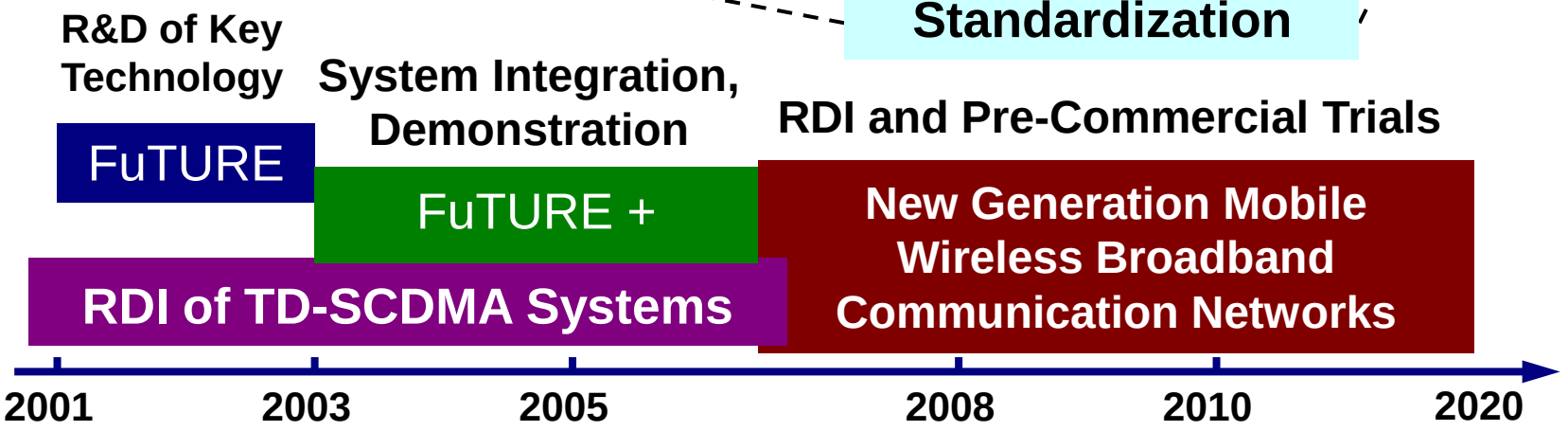
**Budget 70B RMB (~7B GBP), 2008-2020**

# International and National R&D Activities towards Future Mobile Wireless Broadband Communication Networks

**ITU-R time schedule for developing air-interface technologies for IMT-A**




**RDI of 3G and future mobile systems in China**



## 2009 Call for Proposals

- Research, Development and Industrialization (RDI) of Enhanced TD-SCDMA Systems (10+8 projects)
- RDI of LTE Systems (14 projects)
- RDI of IMT-Advanced Systems (11 projects)
- Mobile Networks, Services and Applications, and the R&D of Mobile Terminals (7 projects)
- RDI of Broadband Wireless Access Systems (3 projects)
- RDI of Short-Distance Wireless Interconnection and Wireless Sensor Networks (10 projects)
- RDI of Key General Technologies for Wireless Mobile Communications, Project Management Support (4 projects)

## 2010 Call for Proposals

- Research, Development and Industrialization (RDI) of Enhanced TD-SCDMA Systems (5 projects)
- RDI of LTE Systems (11 projects)
- RDI of IMT-Advanced Systems (4 projects)
- Mobile Networks, Services and Applications, and the R&D of Mobile Terminals (3 projects)
- RDI of Broadband Wireless Access Systems (4 projects)
- RDI of Short-Distance Wireless Interconnection and Wireless Sensor Networks (2 projects)
- RDI of Key General Technologies for Wireless Mobile Communications, Project Management Support (6 projects)

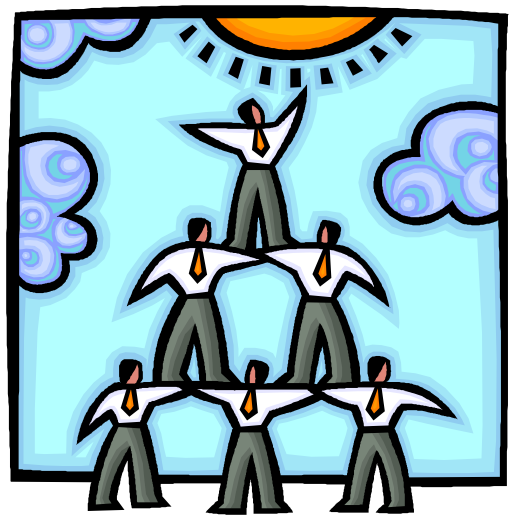
## 2011 Call for Proposals

- Research, Development and Industrialization (RDI) of LTE and LTE-Advanced Mobile Systems (6 projects)
- R&D of Mobile Internet, New Services and Applications (4 projects)
- Advanced Wireless Technologies (3 projects)
- RDI of Broadband Wireless Access Systems and Short-Distance Wireless Interconnection (2 projects)
- Internet of Things and Ubiquitous Networks (3 projects)

# Mobile Wireless Broadband Communication Networks

- **Shanghai Research Center for Wireless Communications (WiCO) has been involved in several successful research proposals (2009 and 2010)**
  - **R&D of Baseband Chips for TD-LTE Mobile Terminals (PI)**
  - **A Wireless Testing and Evaluation Platform for IMT-Advanced Key Technologies (PI)**
  - **R&D of Relay Technologies for IMT-Advanced Systems (PI)**
  - **Multi-Cell Multi-User Interference Avoidance and Cancellation Technologies for IMT-Advanced Systems (PI)**
  - **Co-I for other 17 collaborative research proposals**
- **Total funding exceeds RMB 70M.**

# WiCO and SWAN Wireless Testbed



# WiCO: Shanghai Research Center for Wireless Communications

- Science and Technology Commission of Shanghai Municipality
- Changning District Government, Shanghai
- Chinese Academy of Sciences (CAS), Shanghai Institute of Micro-system and Information Technology
- Southeast University

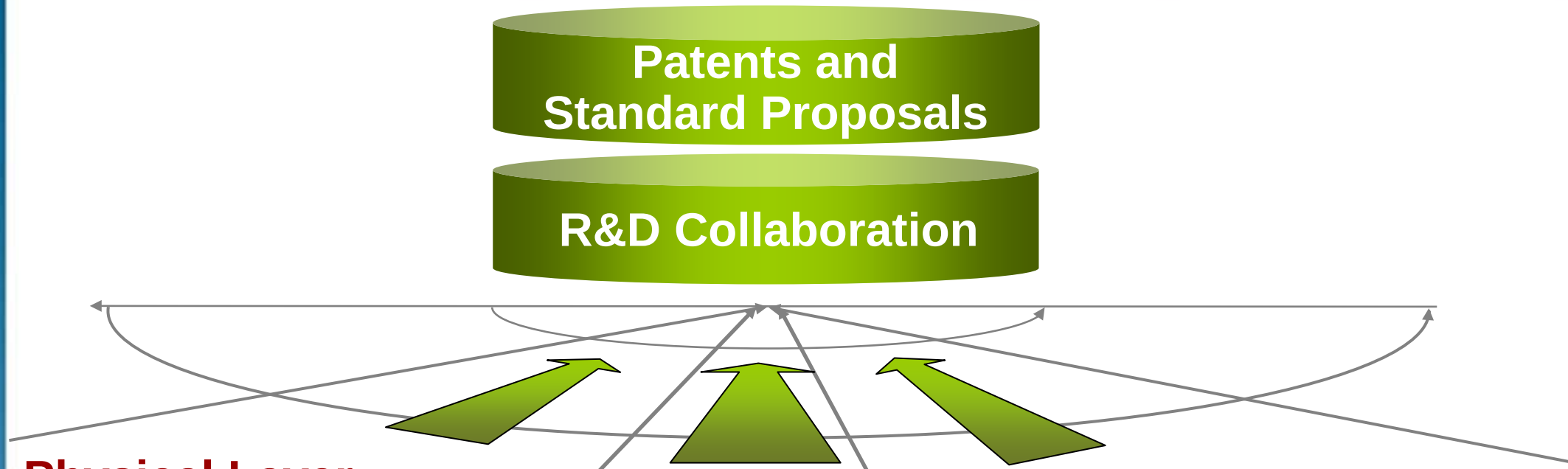
→ International Center for Wireless Collaborative Research

→ International Collaboration Base of Science & Technology

→ Research and Engineering Center for Broadband Wireless Communication Technologies, STCSM

→ Key Laboratory of Wireless Sensor Networks and Communications, CAS

# Research Areas




## Physical Layer

- Cognitive Radio and Dynamic Spectrum Access
- Interface management technologies

## Wireless Testbed

- Simulation platform
- Indoor testing platform
- Outdoor environment
- Application demo system

## Network Layer

- Relay technologies
- Self-organized Networks
- Networks convergence

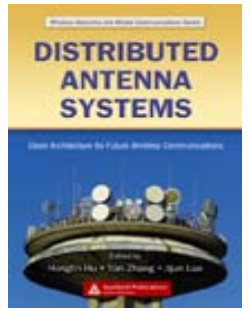
# Research Outcomes (2003-2009)

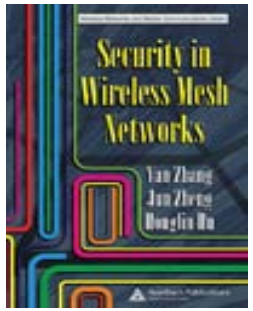
*140+* patents; *6* books; *140+* articles; *70+* standard proposals

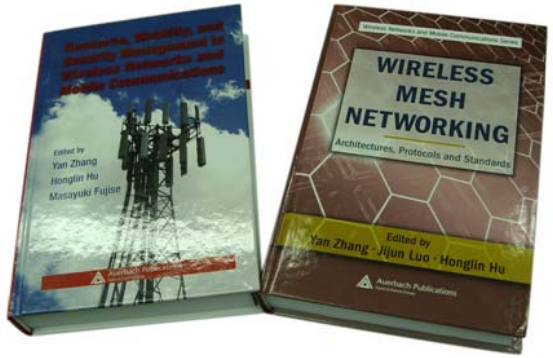
| 发明名称 | 申请号 |
|---|---|
| 一种分层软小区无线网络及其接入控制方法 | PCT/CN2004/000772 |
| 一种正交频分复用系统中的信号均衡方法 | 200410066488.4 |
| 一种多发射多接收天线正交频分复用发射/接收机 | 200410084227.5 |
| 一种基于速度和位置的无线通信系统的切换方法 | 200410089455.1 |
| 一种自适应滤波方法及装置 | 200410089454.7 |
| 一种多载波 | 一种基于多带滤波器组的正交复用多载波发射、接收装置及其方法 200510026962.5 |
| 正交频分复用 | 一种基于多带滤波器组的正交复用多载波传输降低峰均比的装置及其方法 200510026964.4 |
| 一种通信系统 | 基于多子带滤波器组的单载波频分多址发射、接收装置及其方法 200510029196.8 |

| Conference | Tdoc Number | Title |
|---|---|---|
| Athens, Greece, 9 – 13 May, 2005 | R1-050480 | Downlink Multiple Access Scheme for Evolved UTRA |
| | R1-050481 | Uplink Multiple Access Scheme for Evolved UTRA |
| Quebec, Canada, 30- 31 May 2005 | REV-05063 | An Introduction To MBFB Based VMC for Uplink of EUTRA |
| | REV-05064 | An Introduction To OFTDM Based VMC Scheme |
| Sophia Antipolis, France, 20–21 June, 2005 | R1-050609 | GMC Transmission Technique for E-UTRA systems |
| | R1-050610 | Adaptive dual cyclic timeslot structure for E-UTRA systems |
| | R1-050662 | GMC based interleaving FDMA for E-UTRA |
| | R1-050663 | OFTDM transmission scheme in GMC sub-band for E-UTRA |
| London, UK, 29 August – 2 September, 2005 | R1-050781 | GMC Transmission Scheme and Parameters for Evolved UTRA Uplink |
| | R1-050782 | Text Proposal: GMC Based Uplink Basic Transmission Scheme for TR 25.814 |
| | R1-050784 | Unifying MIMO for E-UTRA |
| | R1-050785 | Text Proposal: Pilot Structure Used in Single Carrier Transmission for E-UTRA Uplink |
| San Diego, USA,10–14 October, 2005 | R1-051132 | Further considerations and Simulations of Unifying MIMO for Evolved UTRA |
| | R1-051133 | DFT-S-GMC: GMC based SC-FDMA for 3GPP LTE uplink |
| | R1-051134 | On the implementation of DFT-S-GMC |
| | R1-051135 | Performance comparison between DFT-S-GMC and DFT-S-OFDM |
| Seoul, Korea, 7-11 Nov, 2005 | R1-051384 | Further description of DFT-S-GMC implementation |
| | R1-051385 | Further simulation results of DFT-S-GMC in comparison with DFT-S-OFDM |
| | R1-051386 | On the PAR/CM performance of DFT-S-GMC |
| | R1-051387 | Bandwidth Efficiency Aspects of DFT-S-GMC |

| 论文题目 | 会议名称 | 作者 |
|---|---|---|
| aptive Transmission Mode Selection Scheme for stributed Wireless Communication Systems | IEEE Communications Letters, | Honglin Hu, Martin Weckerle, and Jijun Luo |
| laptive Frequency-Domain Interference Cancellation and annel Equalizer for MIMO-CP-CDMA Systems | in Proc. IEEE WCNC 2006, pp.1573-1577, 2006 | Jing Xu, Haifeng Wang, Shixin Cheng, Ming Chen, Zhiyong Bu |
| timal Regions Planning for Adaptive Transmission Mode lection Scheme | in Proc. IEEE GLOBECOM 2006, . | Honglin Hu, Huiyue Yi, Mingqi Li, Xiaodong Zhang |
| educed CQI Feedback Signaling wnlink Multi-Stream MIMO Trans | DFT Spread Generalized Multi-Carrier Scheme for Broadband Mobile Communications | PIMRC 2006 |
| vel Bi-orthogonal Filter Des ter-Bank Based Transmission | 未来移动通信系统中的小区间干扰协调技术 | 电信科学 |
| vel SNR Analysis for Adaptive dulation and Coding in Generali rrier Systems | 基于 DFT 扩频的广义多载波频分多址上行链路传输方案——DFT-S-GMC | 电信科学 |
| nt channel estimation and c cking in the Evolved UTRA uplink | 基于 simulink 的分布式 mimo ofdm 无线通信仿真 | 系统仿真学报 |
| novel time domain channel estim chronization errors | Complexity-Reduced Multistage Detection for MIMO Systems Using Sphere Decoding | ICWMMN 2006 |
| 于单载波 OFDM 系统的有效信于 | Layer Extrinsic Information Transferring (LEXIT) Detection Algorithm for Diversity MIMO Systems | IET ICWMMN'06 |
| esource, Mobility and Security M tworks and Mobile Communicatio | Novel Complexity Reduced Sphere Decoder in MIMO systems | IGSSTA |
| reless Mesh Networking: Archit andards, | 移动无线城域网安全机制分析 | 中文期刊：信息安全与通信保密 |
| nt Design for LDPC Coded laptive Antenna | An Improved MIMO Single-Carrier MMSE Frequency-Domain Equalization for Space-Time Block Code | IST summit 06 |
| mulant-Based JAFE Algorithm in mporally Correlated Gaussian No | A Bidirectional Adaptive Detction for BLAST Systems Based on Deterministic Sampling | ICCCAS06 |
| | 多天线系统联合自适应调制编译检测算法 | 浙大学报工学版 |
| | A Bidirectional Adaptive Sequential Gaussian Approximation for MIMO Systems | VTC |
| | An Effecient Algorithm for MIMO Detection | ICWMMN2006 |
| | Multistage Sequential Gaussian Approximation for MIMO Systems | ICWMMN2006 |
| | The Multi-level Mapping Sequential Gaussian Approximation for MIMO Detection | Wicom2006 |
| | Ordered Group Interference Cancellation for Quasi-orthogonal Space Time Block Codes | Wicom2006 |
| | An Efficient Peak-to-Average Power Ratio Reduction Algorithm for WiMAX System | APCC 2006 |
| | FuTURE B3G 系统现场集成试验 | 移动通信 |
| | 基于业务模型的 B3G 系统FBB性能测试方法 | 计算机工程 |



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   Ming-Shun Lu  Chung-Liang Chang  Wei-Jen Lee  Li Wang
   Industry Applications, IEEE Transactions on
   Volume: 45 Issue: 6 Date: Nov.-dec. 2009 Page(s):2109 - 2115
   Digital Object Identifier : 10.1109/TIA.2009.2031937
   Abstract | Full Text: PDF (1219KB)

3. **Smart Grids - the future or fantasy?**
   Slootweg, H.
   Smart Metering - Making It Happen, 2009 IET
   Page(s):1 - 19
   Abstract | Full Text: PDF (57430KB)

- **This list covers all R&D areas in Electronics and Electrical Engineering**
- **36. Carrier aggregation for LTE-advanced mobile communication systems**
- **60. Self-configuration and self-optimization for LTE networks**
- **97. Relay technologies for WiMax and LTE-advanced mobile systems**

# Accepted Standard Proposals on SON at Chinese IMT-Advanced Promotion Group

| 序号 | 名称 | 提交单位 | 认领企业 |
|---|---|---|---|
| 1 | IMT-A_LTE+_09471 Issue on PRACH load congestion | 上海无线通信研究中心 | 中兴 |
| 2 | IMT-A_LTE+_09479 Consideration of Cell type in MRO | 上海无线通信研究中心 | 中兴 |
| 3 | IMT-A_LTE+_09480 Distinguish the cause of RLF | 上海无线通信研究中心 | 大唐 |
| 4 | IMT-A_LTE+_09546 HO Configuration Negotiation | 上海无线通信研究中心 | 中兴 |
| 5 | IMT-A_LTE+_10051 Consideration on Unnecessary HO | 上海无线通信研究中心 | 中兴 |
| 6 | IMT-A_LTE+_10142 Issues on Mobility Change Request Procedure | 上海无线通信研究中心 | 中兴 |
| 7 | IMT-A_LTE+_10242 The Negotiation of Cell Reselection Parameters in MLB | 上海无线通信研究中心 | 中兴 |
| 8 | IMT-A_LTE+_09290 避免与MRO功能冲突的MLB | 中国科学技术大学 | 大唐 |
| 9 | IMT-A_LTE+_09291 UE Specific Parameters in MRO | 中国科学技术大学 | 华为 |
| 10 | IMT-A_LTE+_09476 基于满意用户比的小区负载参数及测量方法 | 中国科学技术大学 | 大唐 |
| 11 | IMT-A_LTE+_09477 小区间HO参数交互对MLB性能的影响 | 中国科学技术大学 | 大唐 |
| 12 | IMT-A_LTE+_10139 SON小区PCI自适应规划 | 上海交通大学 | 普天 |
| 13 | IMT-A_LTE+_10144 避免to wrong cell问题的切换参数的优化 | 上海交通大学 | 大唐 |

53.8%

# Wireless Testbed: Motivation

**New Technologies**

- OFDM
- MIMO
- Smart Antenna
- Cognitive Radio
- Link Adaptation
- Wireless Relay
- Network Coding
- IPv6
- …

**New Requirements**

- Users
- Operators
- Manufacturers
- Standards
- …

**Testing and Evaluation**

- Indoor/Outdoor
- Open, Flexible
- Expendable,
- Professional,
- Multiple bands,
- …

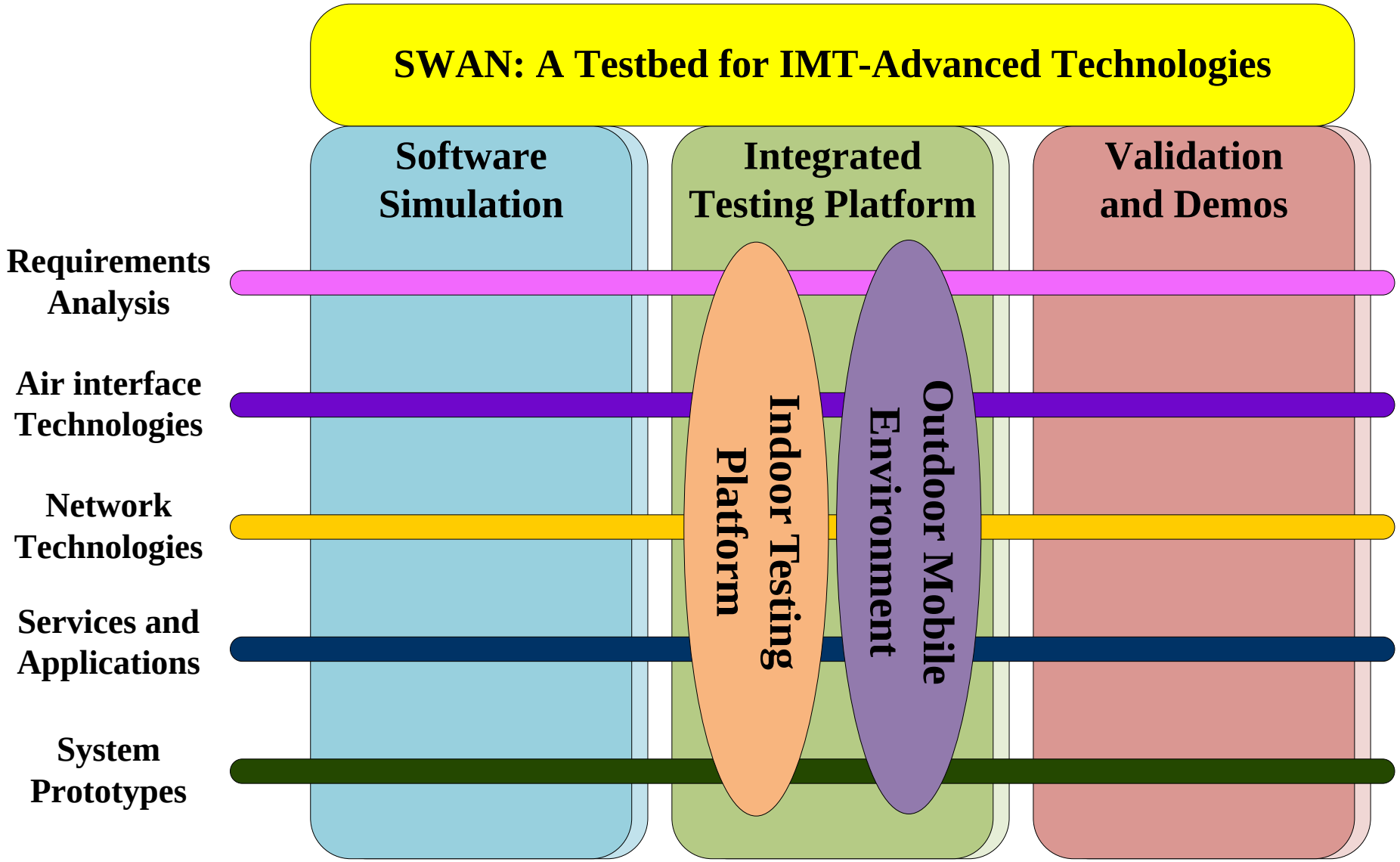
→ **New Standards**

→ **New Systems**

→ **New Business Models**

→ **New Services**

# SWAN: Shanghai Wireless Advanced Network



# SWAN: Funding and Partners

- **Funding: RMB 33M, Match Funding: RMB 49.5 M**
- **Duration: 2 years**
- **Industrial and Academic Partners:**
  - **China Telecom, Huawei, ZTE, Datang Mobile**
  - **Southeast University, Tsinghua University, Beijing University of Posts and Telecom (BUPT), Huazhong University of Science and Technology (HUST), Xian Jiaotong University (XJTU), University of Electronic Science and Technology of China (UESTC), and University of Science and Technology of China (USTC).**

# SWAN: Technical Objectives and Requirements

- **Wireless data rate: 1 Gbps (static) and 100 Mbps (mobile)**
- **Spectrum efficiency: 5-10 bps/Hz (D-link), 2.5-7 bps/Hz (U-link)**
- **Frequency bands: 450-470MHz, 698-790MHz, 2.3-2.4GHz, 3.4-3.6GHz**
- **Transmission bandwidth: 20/40/100 MHz**
- **MIMO support: 6x4 MIMO**
- **Wireless channel models: Rice, Rayleigh, Nakagami, GSM, DCS, IS-54, IS-95, 3GPP/3GPP2 SCM, SUI, WINNER, etc.**
- **Application protocols: HTTP, SSL, FTP, Telnet, POP3, SMTP, RTSP, RTP, etc.**

# Software Simulation Platform

- 3GPP LTE R8 uplink and downlink channels implementation
- Parallel computing facility at Shanghai Supercomputer Center (25K cores)
- Multi-cell multi-user scenarios (system-level simulations)

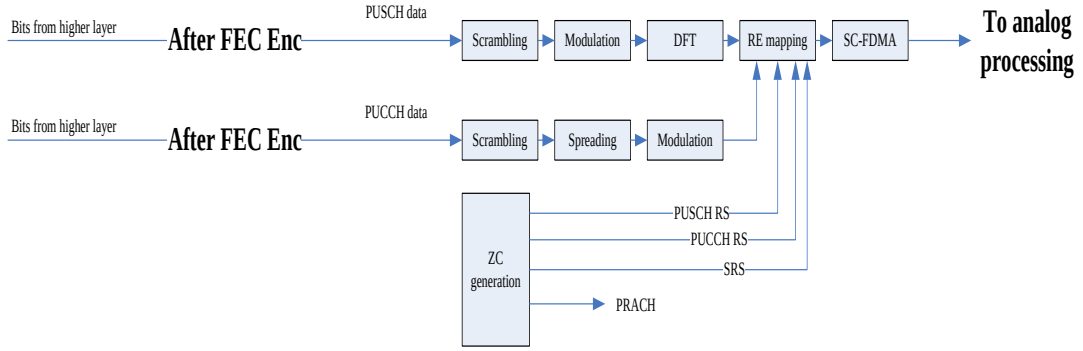



图1 UL 传输链示图

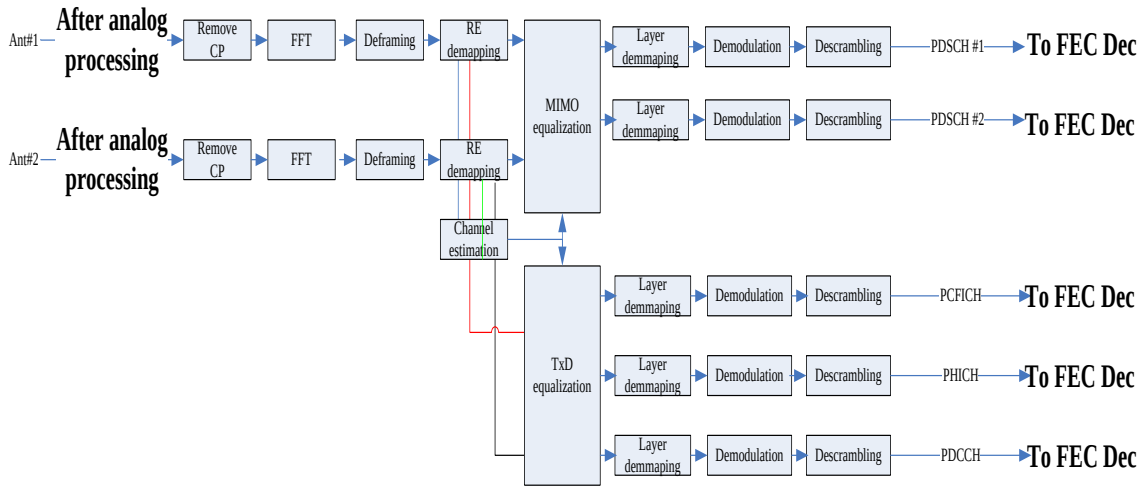
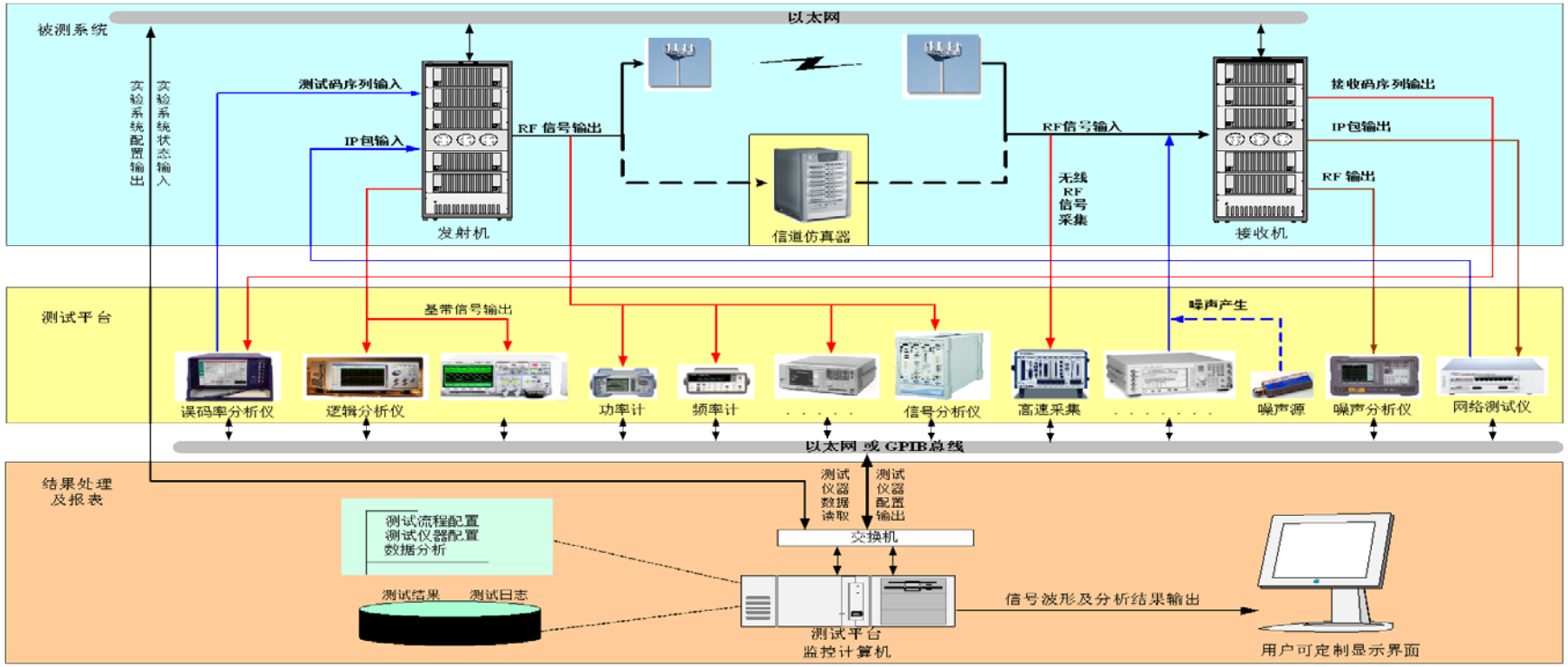



图2 DL 传输链示图

# Indoor Testing Platform-1

- A VISA-based open, shared and flexible testing environment
- It covers wireless channel measurement and modeling, wireless transmission performance (RF and baseband), wireless networking protocols, wireless services and QoS




**System Under Test (SUT)**

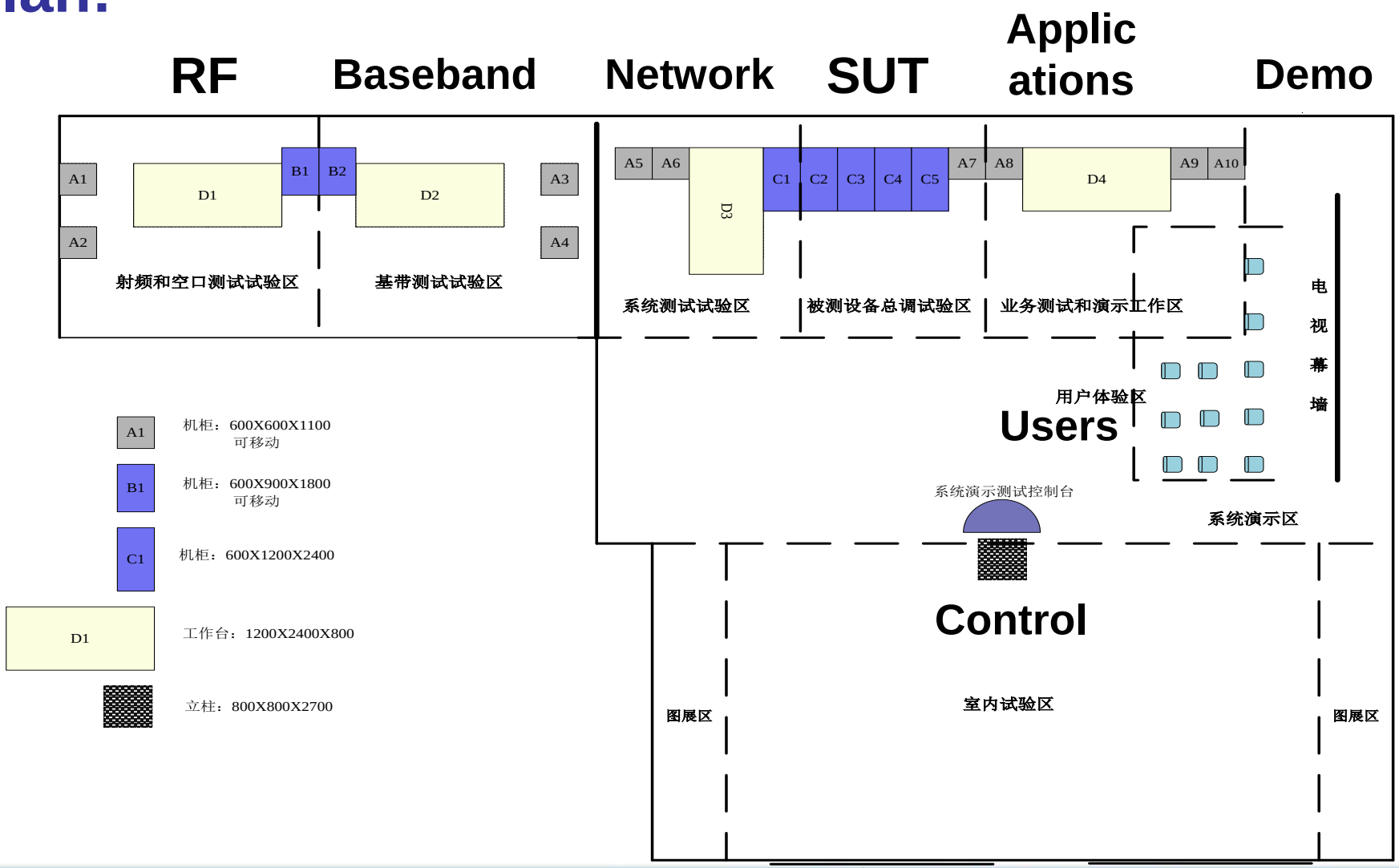
**Software & Hardware Equipments**

**Control & Demo Platform**

# Indoor Testing Platform-2

## Floor plan:

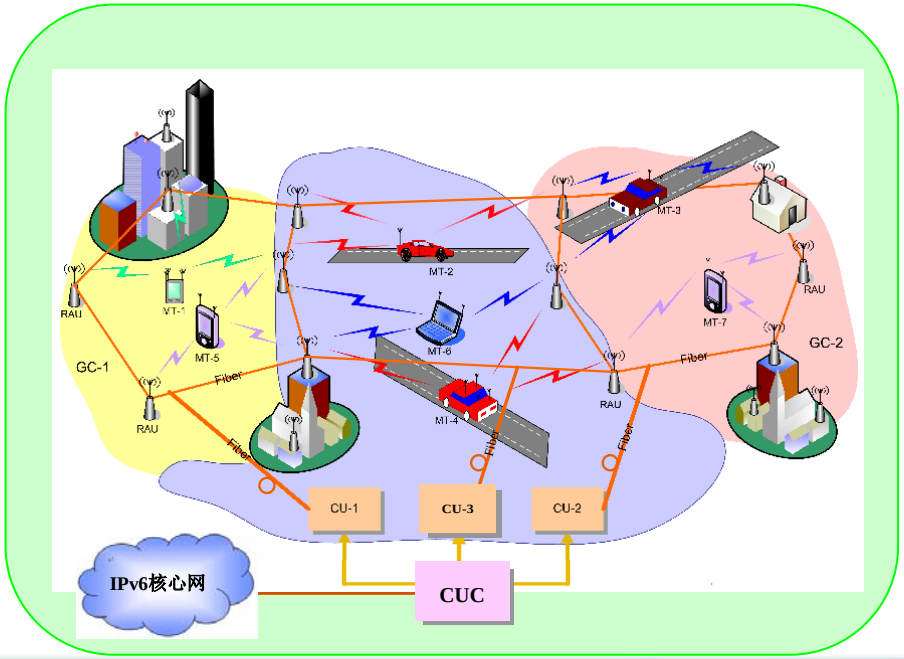
## 200m²

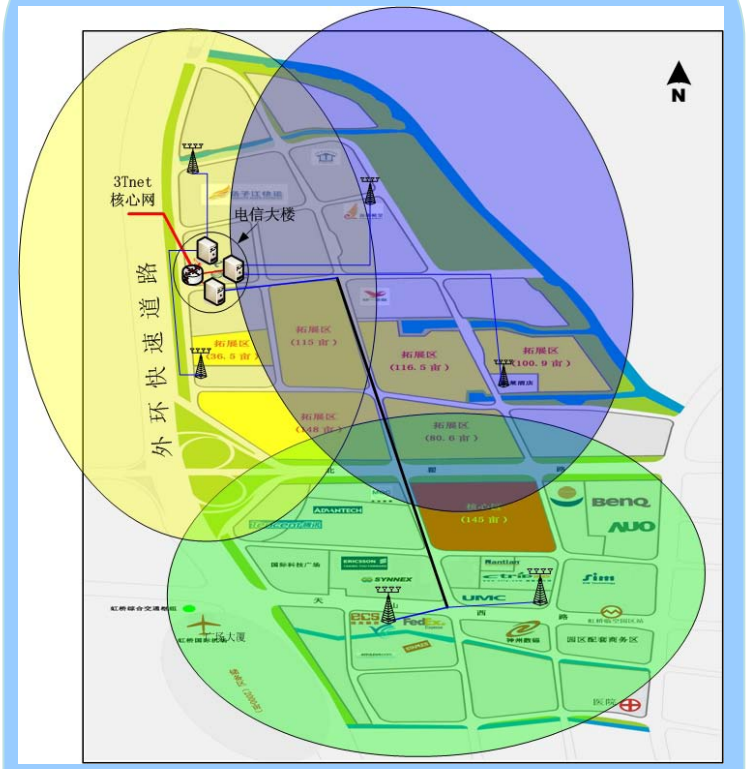


# Outdoor Mobile Environment-1

- Distributed MIMO wireless testing system
- 3 cells, 6 base stations
- Support both TDD and FDD systems
- Support urban, suburban, rural, and highway communication scenarios





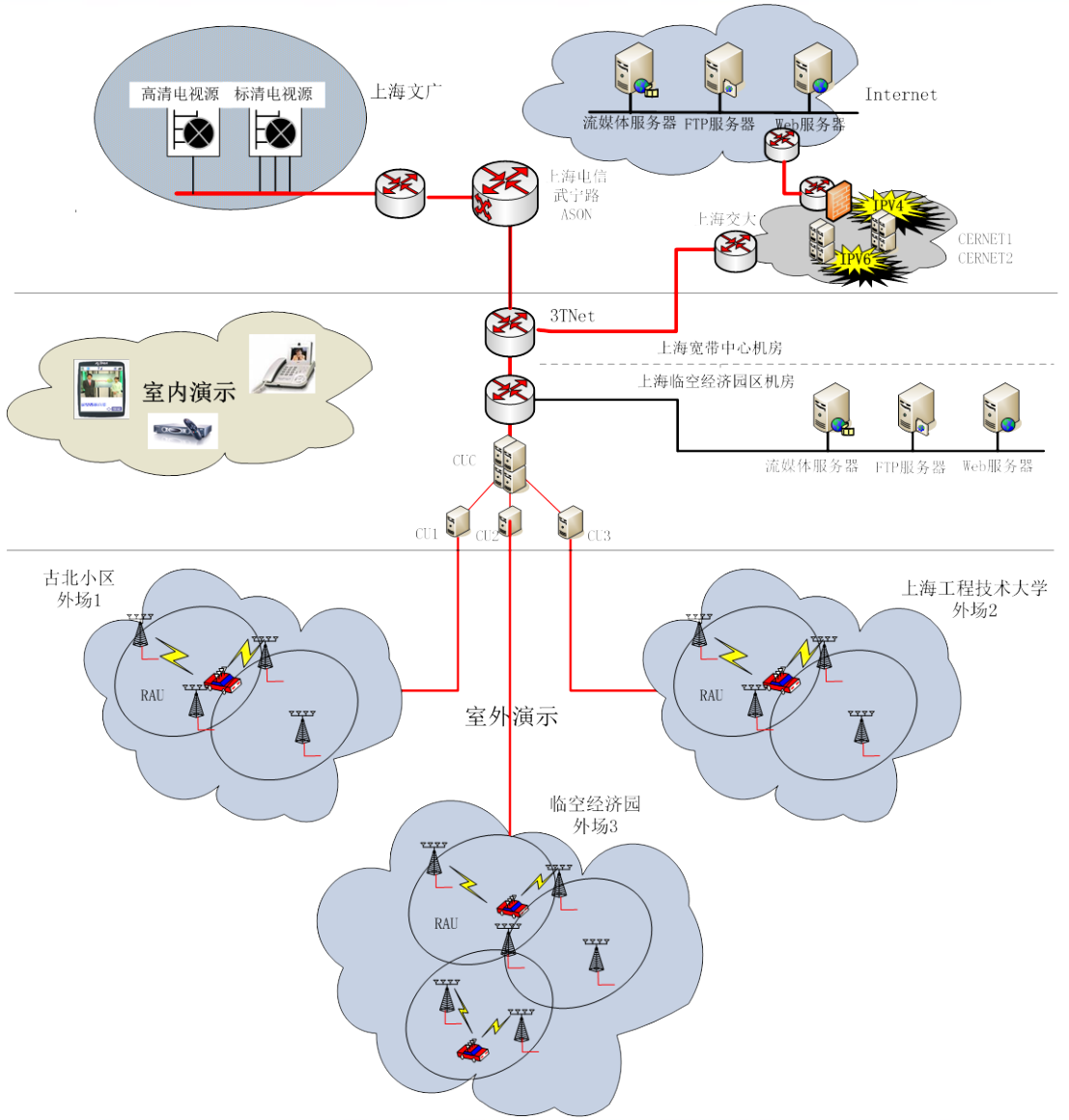




# Outdoor Mobile Environment-2

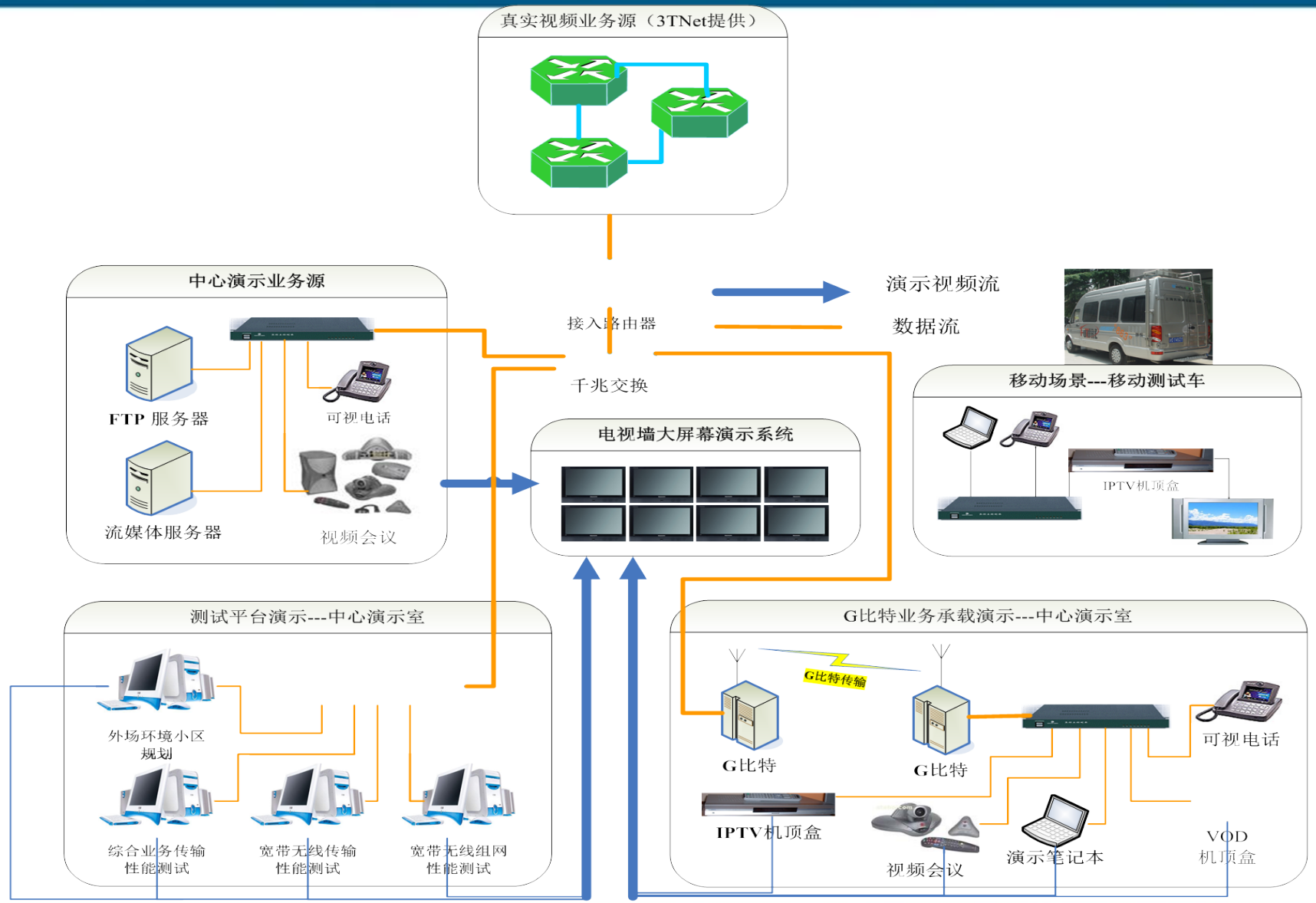
- Support multiple frequency bands
- Support multiple transmission bandwidths
- Support urban, suburban, rural, and highway communication scenarios
- Support relay technologies
- Support distributed radio networks

# Applications Demonstration Platform-1

- Multimedia traffic from the Internet, digital TV programs, and telecommunication networks
- High data-rate and very bursty traffic to demonstrate the capabilities of IMT-Advanced technologies

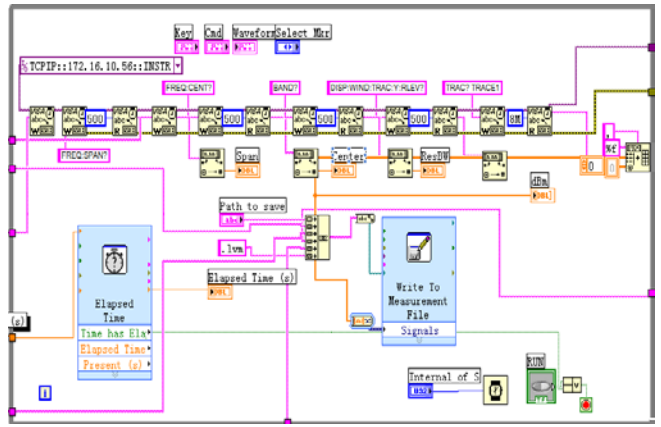


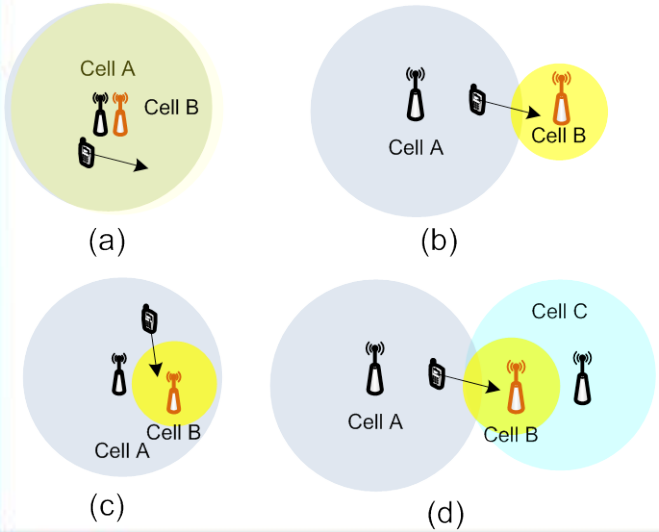
# Applications Demonstration Platform-2

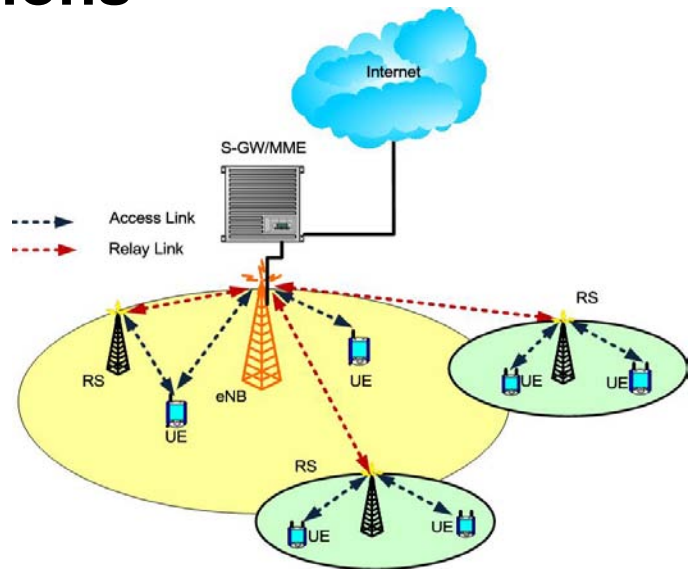


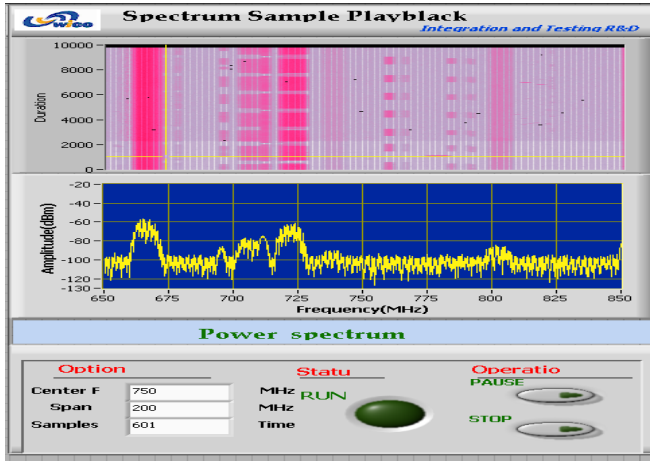
# Other Research Focuses at WiCO

- Cognitive radio and dynamic spectrum access
- Self-organized network (SON)
- Relay technologies (with Nokia)
- Interference management (TD-LTE)
- Networks convergence (WiFi, WSN, 3G)
- Green communications





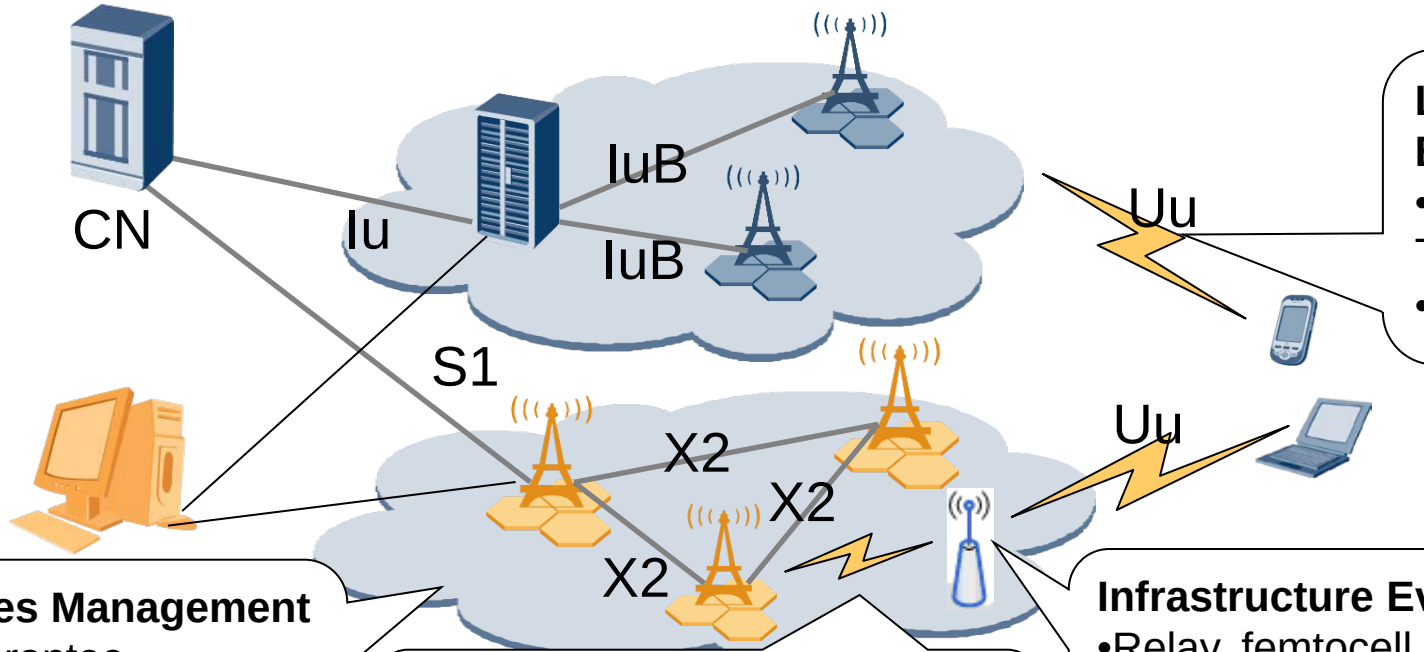



# Green Communications

- **Energy efficient wireless network infrastructure design and implementation**
- **Measuring and evaluation methodology of carbon emission for ICT technologies**

  ➔ **Green STAR network, ITU Green-ICT standards, GeSI, GreenTouch, …**
- **Low-energy base stations: power amplifier, front-end filter**


**Link Performance Enhancement**
- Energy efficient TX/RX technologies
- MIMO techniques

**Resources Management**
- QoS guarantee
- Low energy consumption
- Energy efficiency models

**Self-Organized Network**
- Dynamic energy management
- Interference management

**Infrastructure Evolution**
- Relay, femtocell
- Cooperative communications
- Networks convergence

# International Collaborations




WiCO-Nokia P1, 2004

WiCO-Ericsson, 2004

WiCO-Siemens, 2005

WiCO-CEA-LETI, 2005

WiCO-France Telecom, 2005

WiCO-Mobile VCE, 2005

WiCO-Prompt, 2006

WiCO-Nokia P2, 2007

WiCO-CSIRO, 2009

WiCO-Nokia P3, 2010

...

## WiCO-Mobile VCE 2005

# International Joint Research Labs

## Remote Research Collaboration Facility (RRCF)

### China-Quebec Academic-Industry Alliance

- China-Quebec academic-industry R&D on bottleneck technologies
- A platform to accelerate patents to be transferred to market with lower cost and high profits

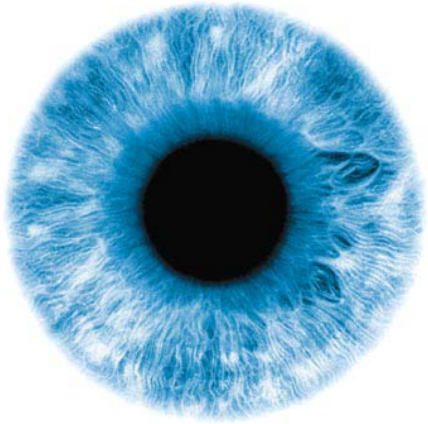
## WiCO-Nokia Joint Research Laboratory

### Technology Alliance

- Research on 4G key technologies
- More patents for international standards
- Specialist committees; visiting professors

# Conclusions

- WiCO has strong research interests and expertise in 3G/4G mobile communication networks.
- WiCO has undertaken many R&D projects from the MOST, CAS, STCSM, and Telecom Industries.
- WiCO is keen to promote international R&D collaborations for knowledge creation, technology transfer and standardization.
- WiCO is a professional and fair player in generating and sharing IPRs.




**Dr. Yang Yang, Yang.Yang@shrcwc.org**

**Shanghai Research Center for Wireless Communications (WiCO)**

Add: 6/F Information Building, 280 Linhong Road, Shanghai 200335, China

Tel: +86(21) 6128 0608

Fax: +86(21) 6128 0638

http://www.shrcwc.org