Green Evolution of Mobile Communications
(CMCC Perspective)

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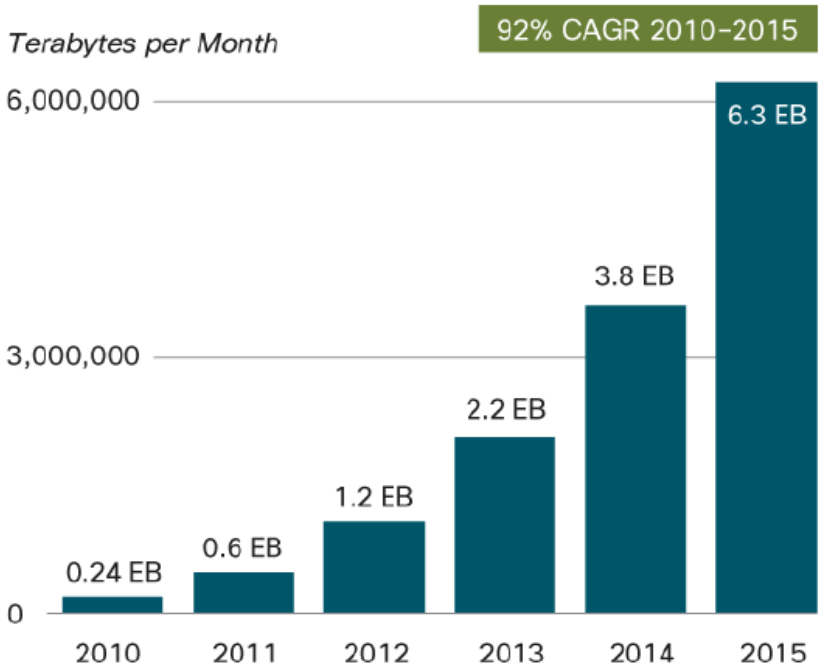
GreenTouch 2012

Content

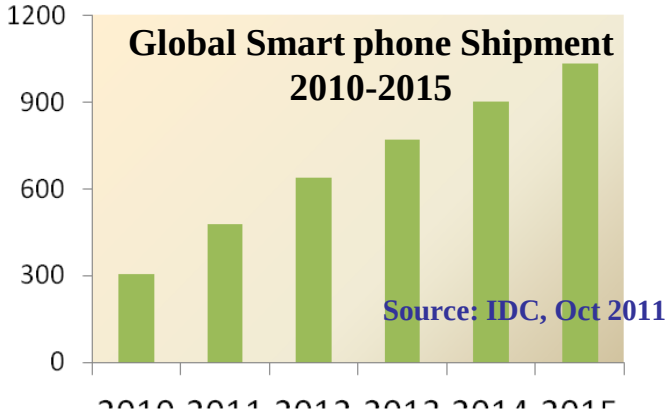
Explosion of Mobile Broadband

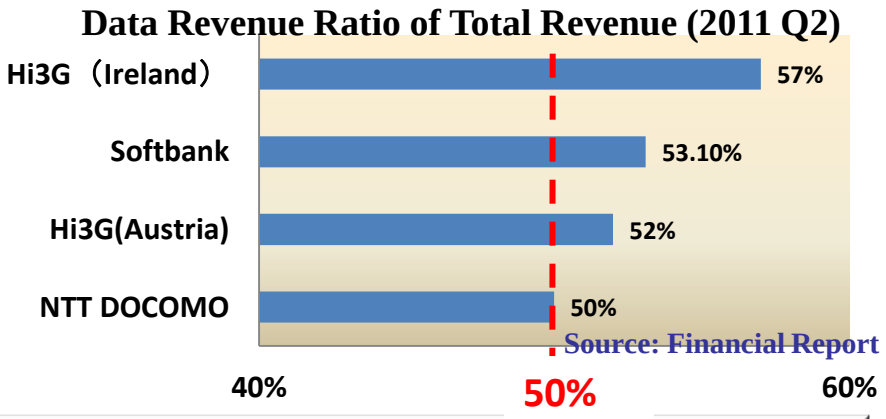
- Overall mobile data traffic is expected to grow to 6.3 exabytes per month by 2015, a 26-fold increase over 2010.
- Mobile data traffic will grow at a CAGR of 92 percent from 2010 to 2015.



Source: Cisco VNI Mobile, 2011

Smart phone shipment in 2011 increases 60% from 2010, and will reach 1 billion by 2015

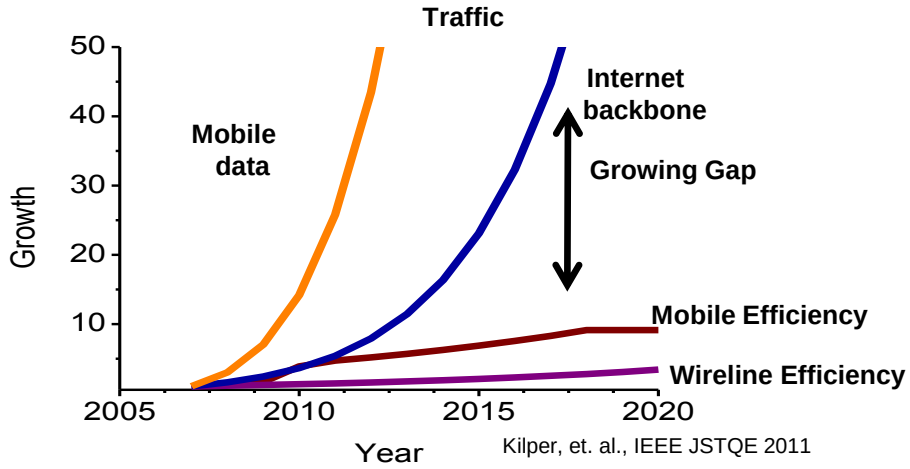




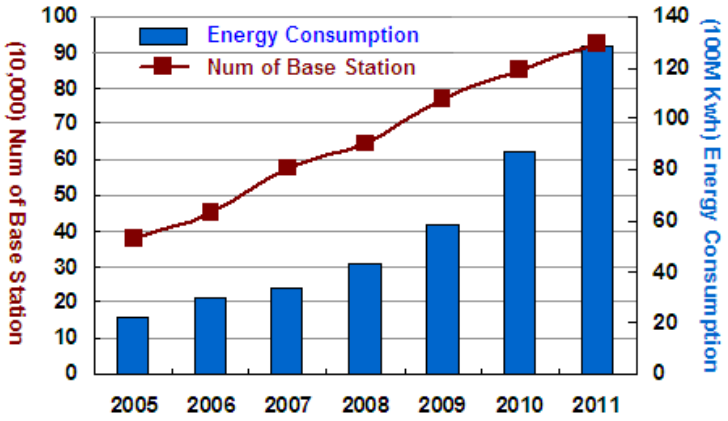
Operators' data revenue starts to exceed voice

Facing Green Challenges

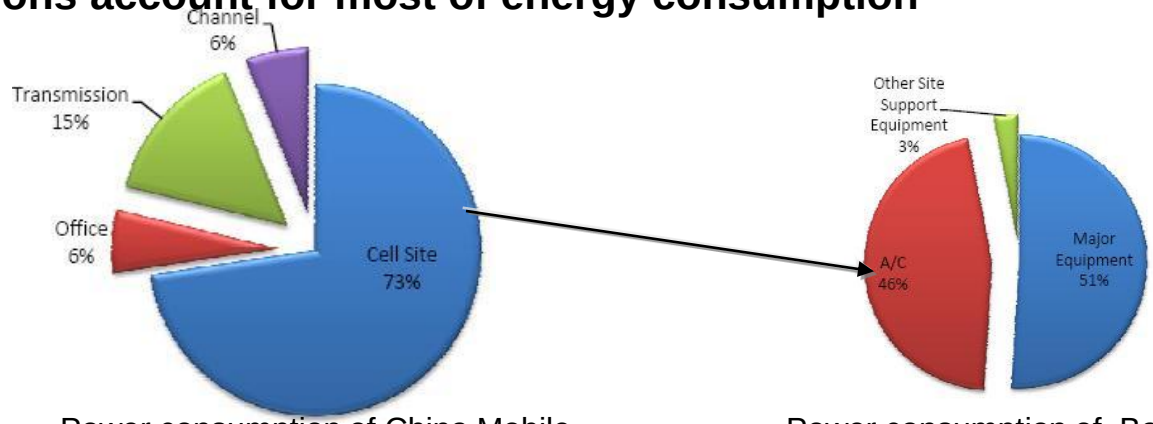
- A large gap between the growth rate of traffic and the improvement of network energy efficiency
- Power consumption increased rapidly with the network expansion
- Over 13 Billion KWH power consumption in 2011



Kilper, et. al., IEEE JSTQE 2011



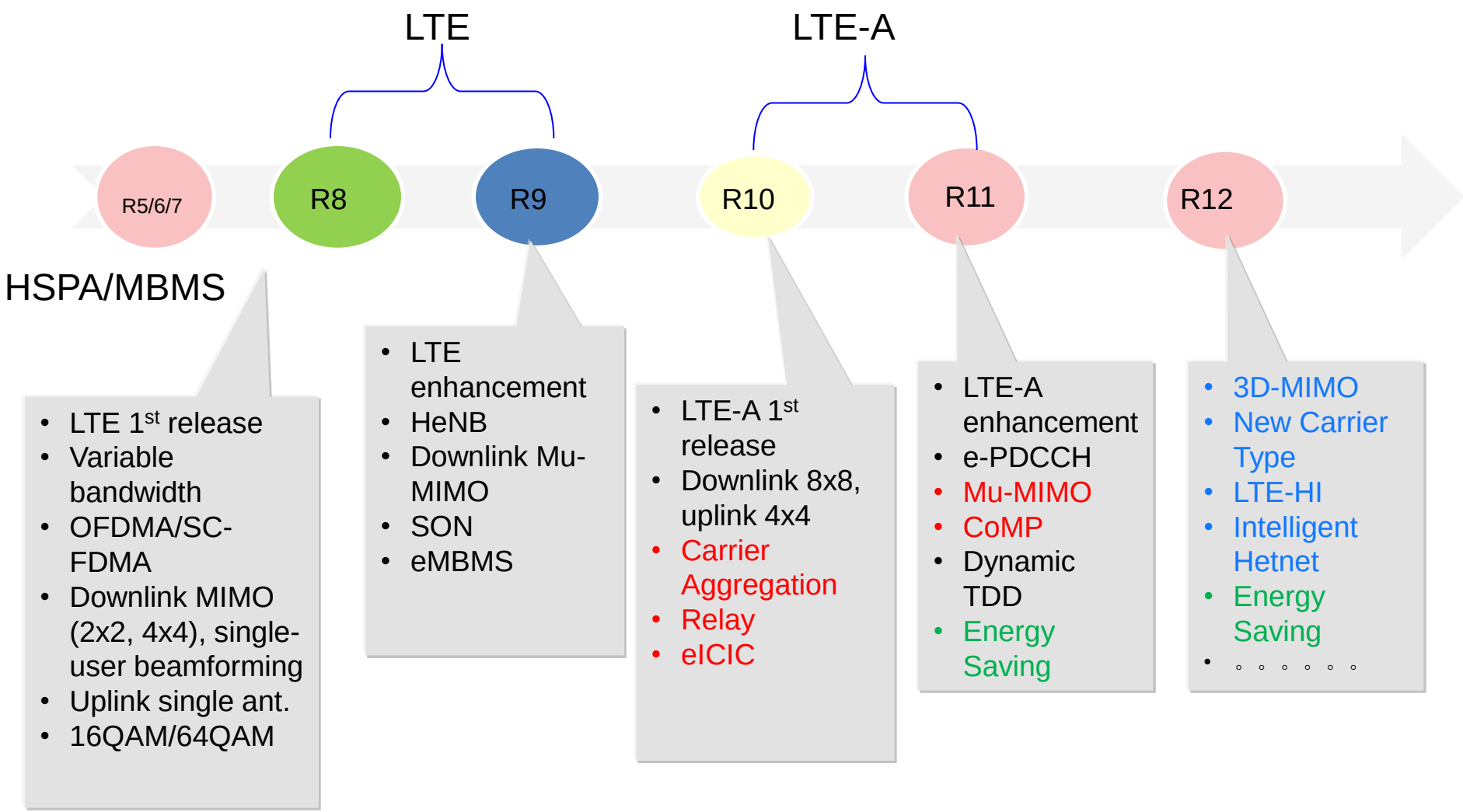
- Base stations account for most of energy consumption



Power consumption of China Mobile

Power consumption of Base station

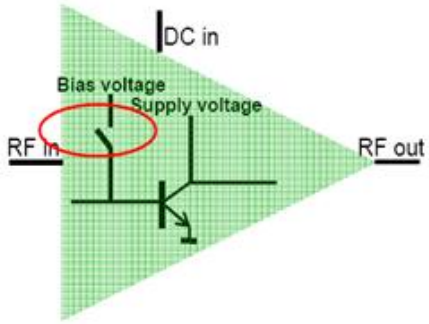
LTE Standardization Progress

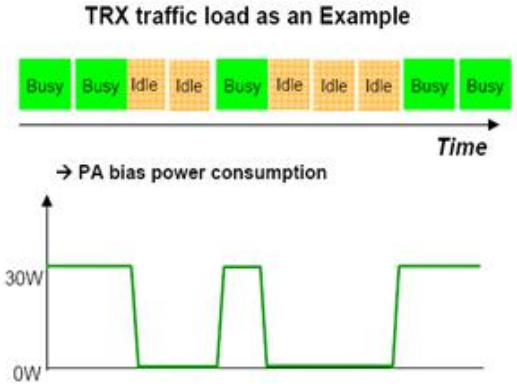


Content

CMCC'S Green Action Plan

- **Applying power saving technology in GSM and TD-SCDMA network**
  - PA bias on/off based on time slot
  - 10%~20% power saved every year
  - 6.72 million TRX deployed





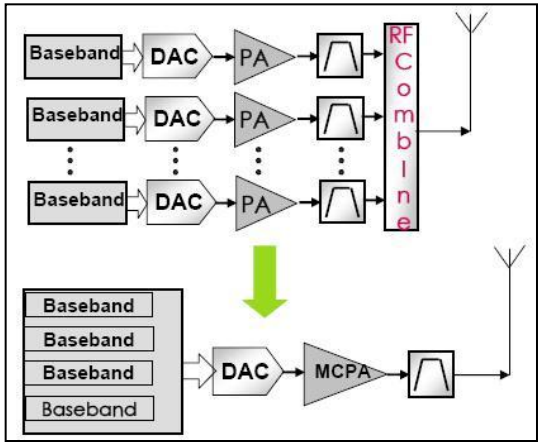
2008

2009

2010

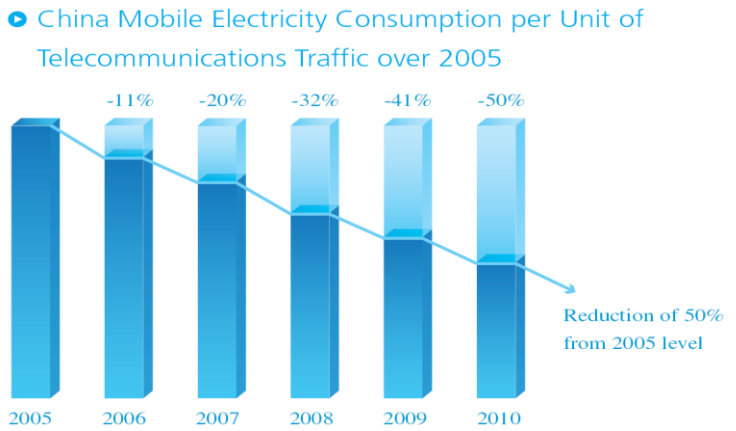
2011

- **Introducing new BTS with lower power**
  - More than 2 million MCPA(Multi-Carrier Power Amplifier) TRX deployed in GSM network since 2009 and over 15% power efficiency improved
  - Distributed base station(BBU+RRU) widely deployed in TD-SCDMA
  - High power efficiency PA technology used in TD-SCDMA RRU，i.e. DPD, Doherty
  - BTS energy efficiency improved from 10% to 25%



CMCC'S Green Action Plan

In 2011, the electricity consumption per unit telecom traffic decreased by 11% compared to 2010



At the end of 2011, more than 9,000 wind and solar power base stations had been deployed

79,000 sets of free cooling equipment installed with energy saving from 20% to 80%

Renewable Energy SITE

Environment and Thermal

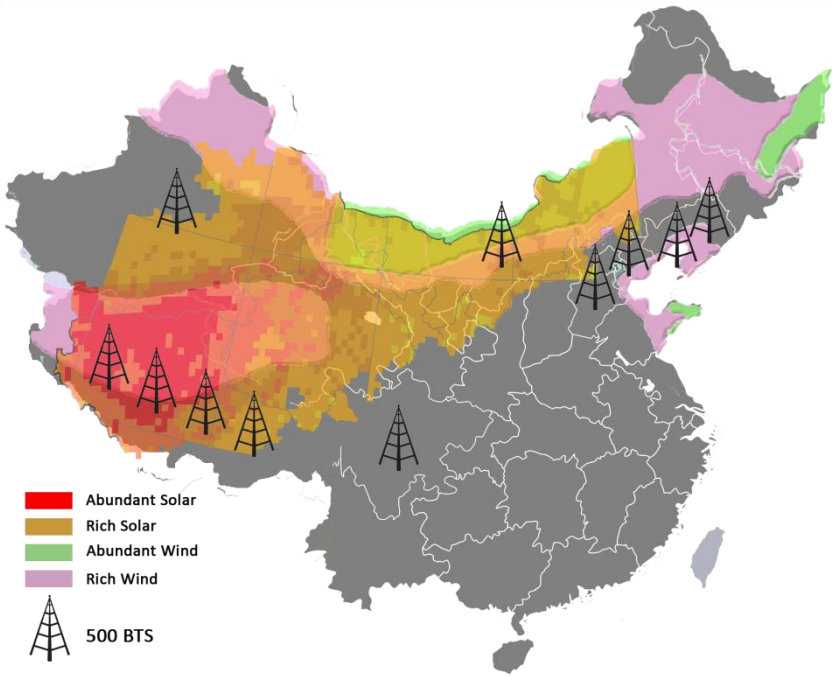
Batteries

Green Packaging

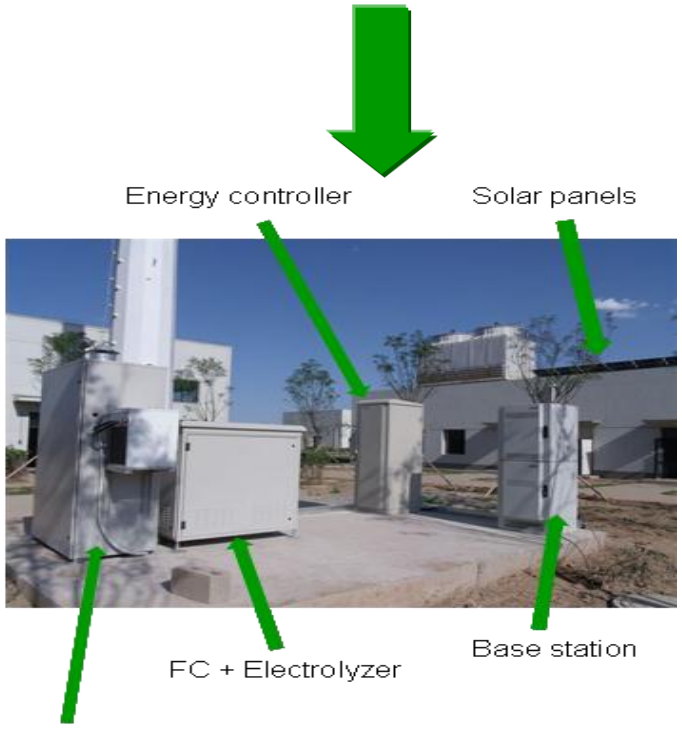
Over 7000 units battery cooler deployed, 3.5Million KWh power saved. Large scale of new battery trials around country

Over 50% wireless equipments used green packaging which saved approximately 15,000 cubic meters of timber

BTS Powered by Sun, Wind, and Water



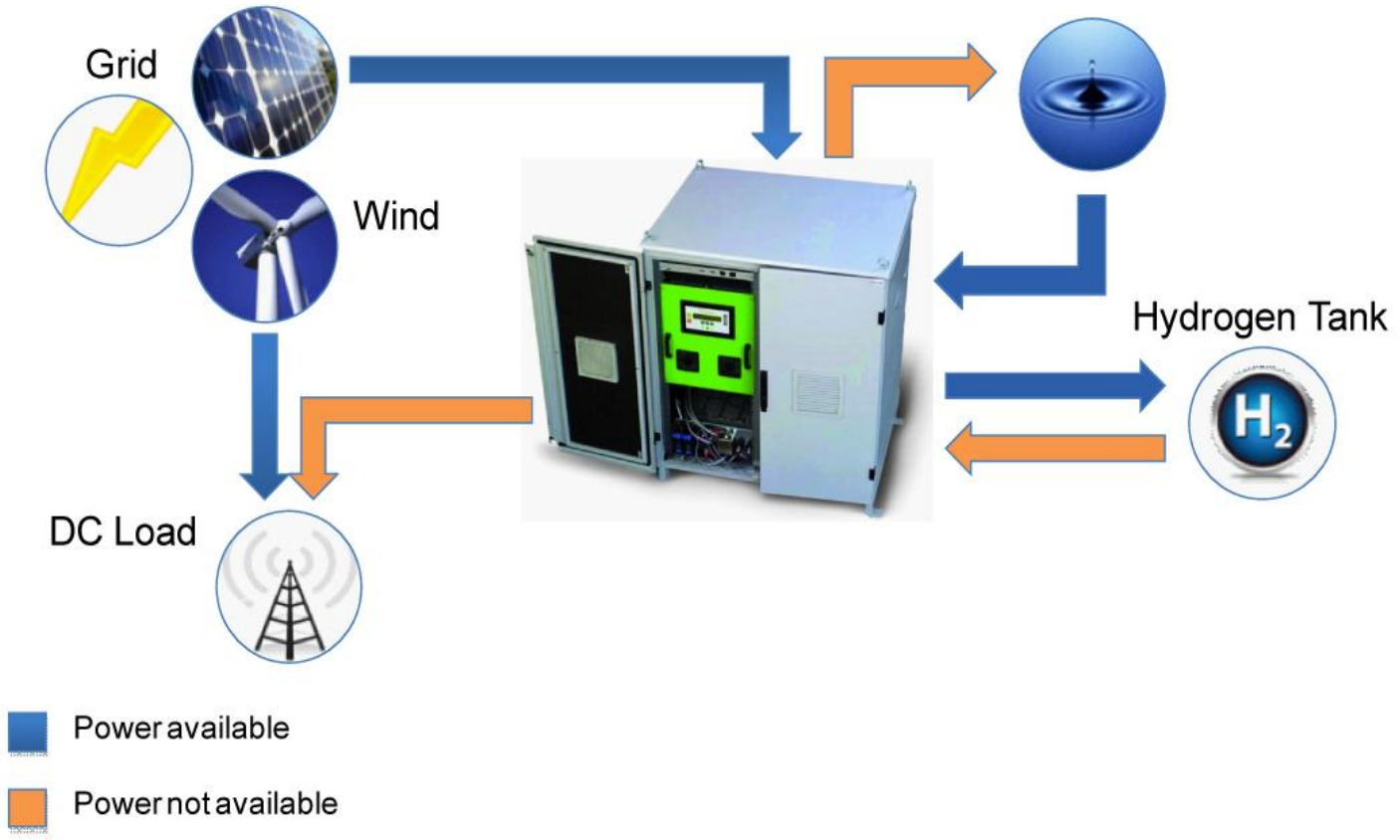
In 2011	BTS
Solar	7057
Wind	435
Solar + Wind	1316
Fuel cells	162
Alternative energy base stations	8970



BTS Powered by Sun, Wind, and Water

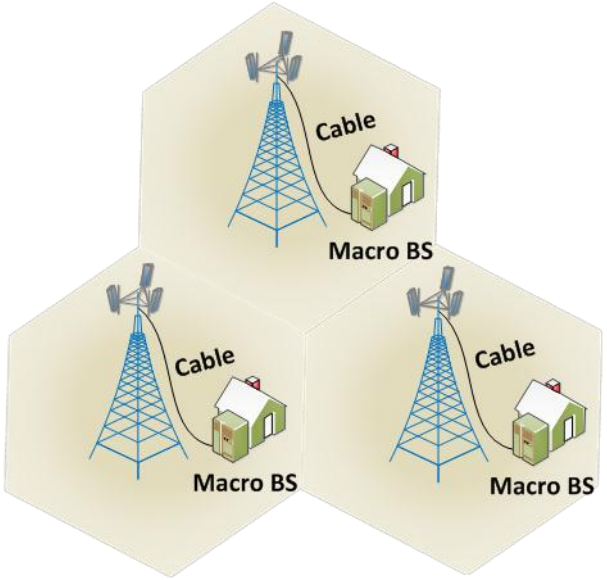
100% automatic cycle system with Zero Carbon emission, combined solar wind and hydrogen fuel cell

Demo site: 30 miles south of Beijing



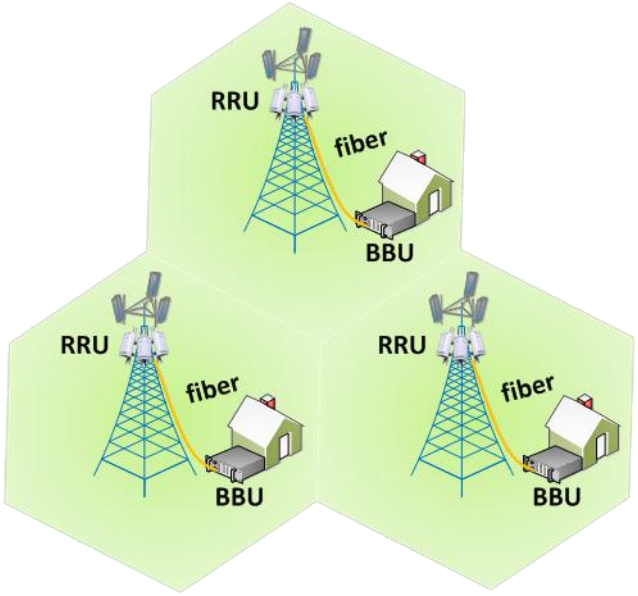
The Evolution of RAN Architecture

Traditional BTS



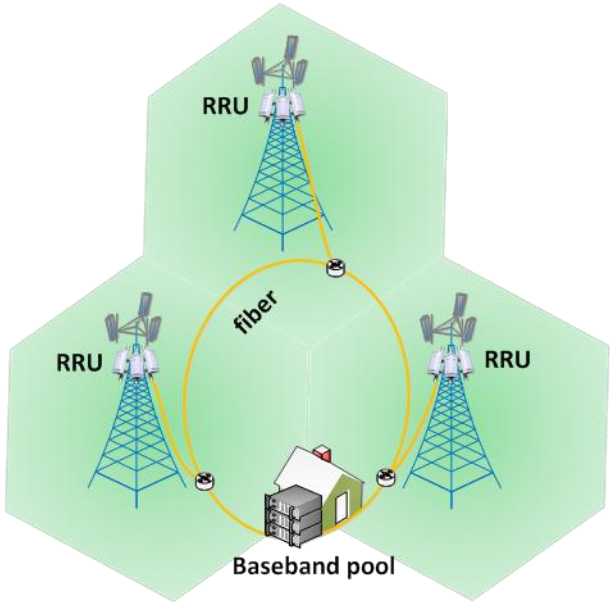
- Traditional BTS system
  - (Huge) integrated system
  - BTS & supporting facility require indoor protection
  - Long RF cable to antenna

Distributed BTS



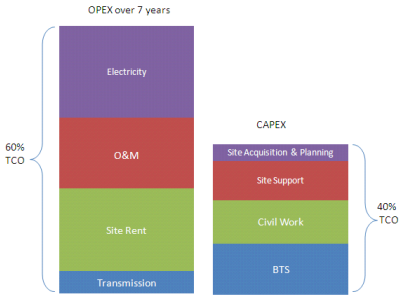
- Distributed BTS
  - Outdoor RU, Indoor BBU
  - DU to multi-RU
  - DU-RU connected via point-to-point dark fiber

C-RAN



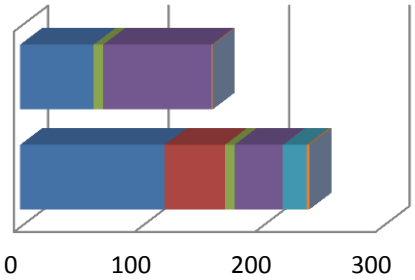
- C-RAN
  - Centralized processing
  - Collaborative Radio
  - Open platform towards Cloud computing

Advantages and Challenges of C-RAN



Lower CAPEX and OPEX

Save up to **15%** CAPEX and **50%** OPEX with simplified remote radio site, power bill *



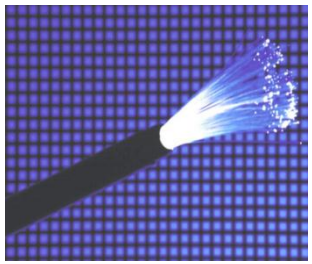
Faster system roll out

due to simple remote radio site requirement

Save up to **1/3** the time*

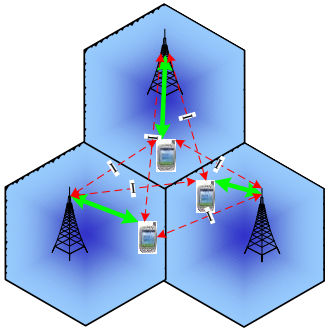
Lower energy consumption

Save up to **71%** of power compared to traditional RAN system*



Fiber Hungary

Not only WiFi, broadband access network, but also C-RAN demands a lot of fiber resources



Collaborative Radio

Great potential but still facing quite some challenges

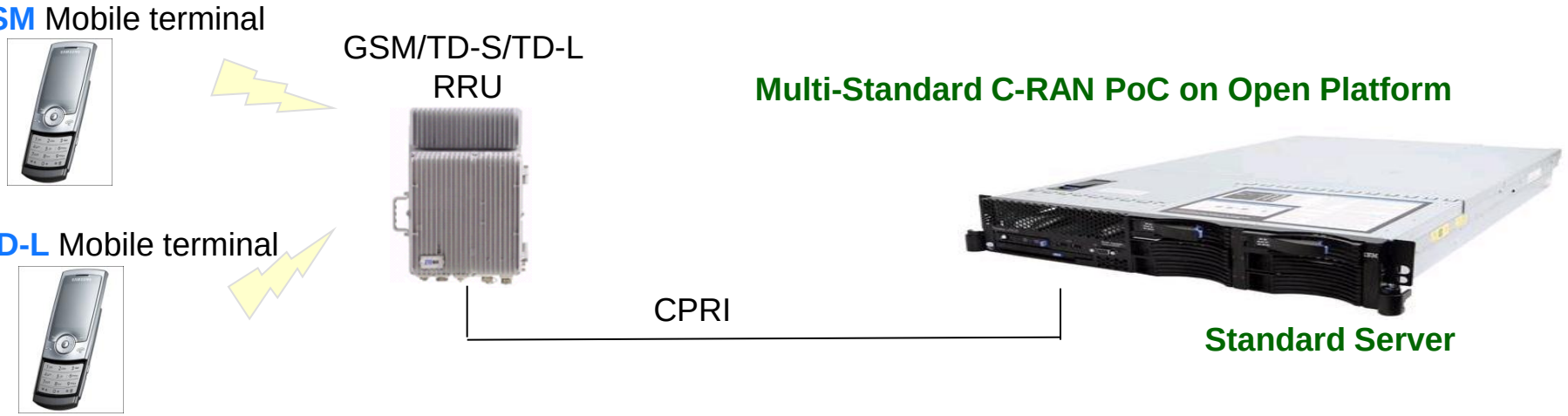
TDD channel reciprocity

Real-time Cloud

How to build large scale BBU pool, how to manage real-time resources for radio processing in Cloud

*Base on China Mobile research on commercial network

Open IT Platform based BBU



Current Status

•Have built two independent C-RAN prototype system, realized TD-LTE PHY processing in real time on GPP.

•GSM/TD-SCDMA/TD-LTE can be supported efficiently on the same platform

•OTA test under going, Single BS demo-ed in 2011 ITU Telecom World, Geneva

•TIA2012 Green ICT Pavilion: multiple BS demo

Challenges & Future Work

•GPP can't achieve comparable power/performance for L1 like SoC.

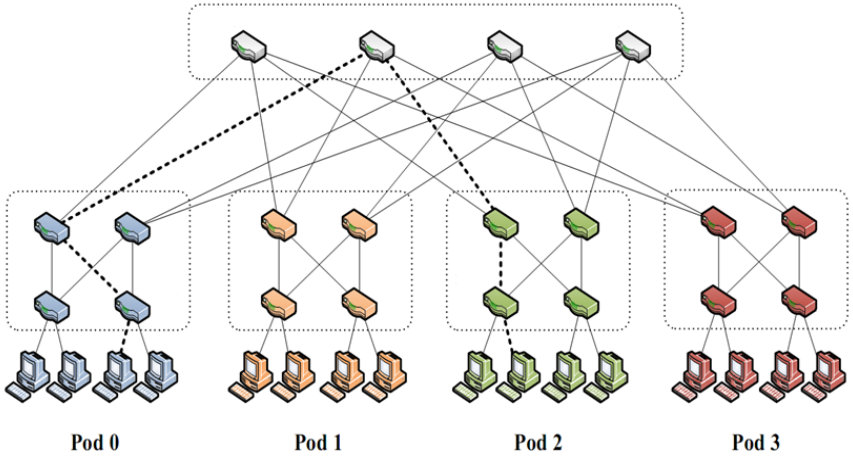
- Including CPU/MCH/ICH etc. chips, so the power consumption is considerable.

•Accelerator to assist GPP

- Analyzing the GPU/FPGA/ASIC as Acc.

•Definition of the interface between the Accelerator and CPU(API). Open Platform.

Real-Time Cloud Platform for BTS



Fat-Tree Topology

Future: Large Scale, Real Time BBU Pool

Challenges and Future Work

- Scalable system that can support 10~1000DU without interrupt of service
- Effective low power interconnect
- Very low latency data routing
- Real-time OS and scheduling scheme

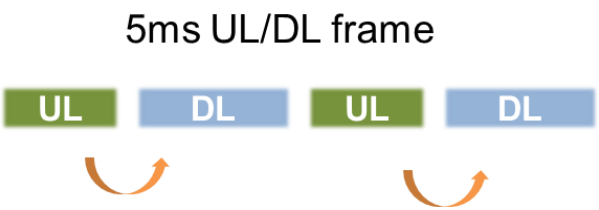
- Build telecom grade reliable (99.999%) real-time Cloud with lower grade building blocks (e.g. general processor)
- Scalable, Reliable, and Cost Effective system

The Challenges We are Facing…

Power Efficiency

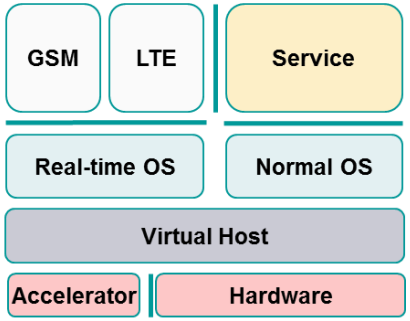
Design high power efficiency GPP

Target: **1000** LTE carrier in one 19” rack, **5W** per carrier within total power of **5000W**



Real-Time Virtualization

Develop virtual environment that can achieve **sub-1ms** real time requirement of wireless communication processing

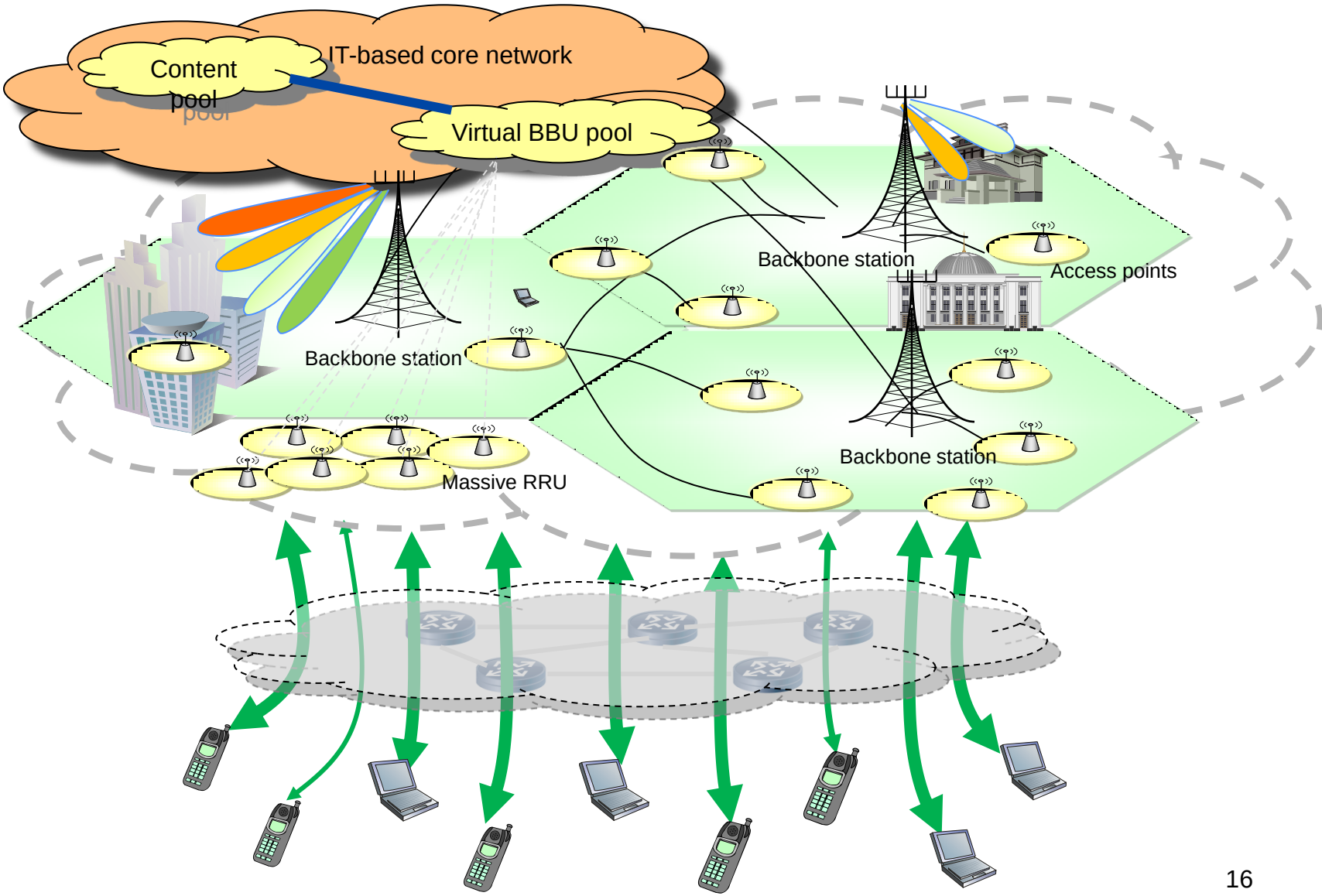


Standardization

Work with global vendors and other operators to standardize the IT-based C-RAN solution

PHY accelerator, real-time OS, service API, etc.

Future Vision of Mobile Network(1/2)



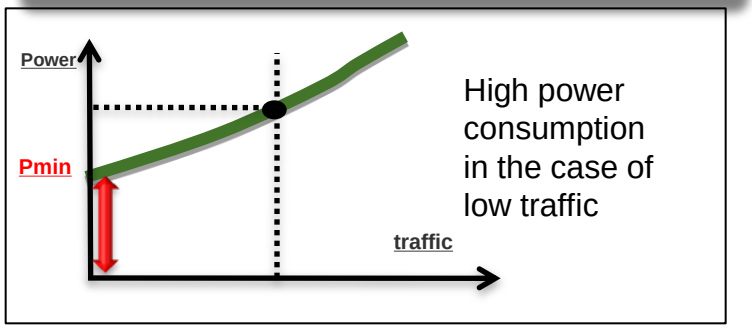
Future Vision of Mobile Network(2/2)

- **Key technologies**
  - Flexible cell coverage
    - Cell shrinking and expanding with on-off access point
    - Plug-and-play access points of lower cost and small size (single antenna)
  - Flexible carrier frequency and bandwidth
    - Carrier aggregation (e.g. lower frequency and higher frequency)
    - multiple spectrum access with on-off carriers
  - Flexible traffic delay
    - Decoding delay tolerant
    - scheduling (retransmission) delay tolerant with on-off slots
    - Handover and Content distribution delay tolerant
  - Network MIMO
    - Large-scale antenna system (maybe hybrid)
    - Cloud cell access （good bye physical cells）
  - Network virtualization
    - Optical fiber for computation resource delivery, like water pipes
    - Backbone stations and some access points may be virtualized (faucet).
- **Challenges**
  - Tradeoff between communication and computation
  - Network energy consumption balance

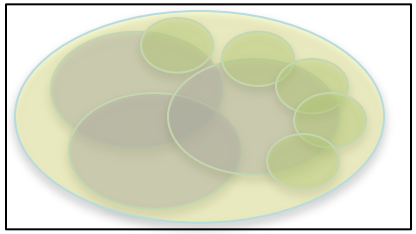
Energy-aware Heterogeneous and Hierarchical Wireless Network

中国移动通信 CHINA MOBILE
移 动 信 息 专 家

Power consumption of BS and traffic



Heterogeneous and hierarchical wireless network deployment

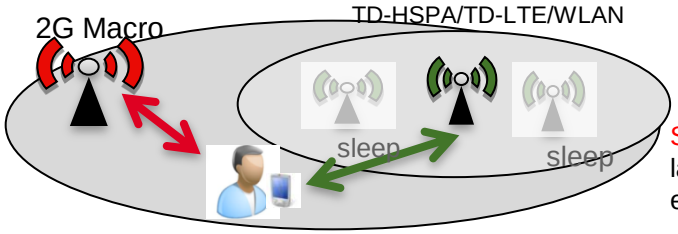


- GSM, TD-SCDMA, TD-LTE, WLAN
- Macro, Micro, Pico
- More small cells with overlapped coverage

To introduce sleep mode of BS

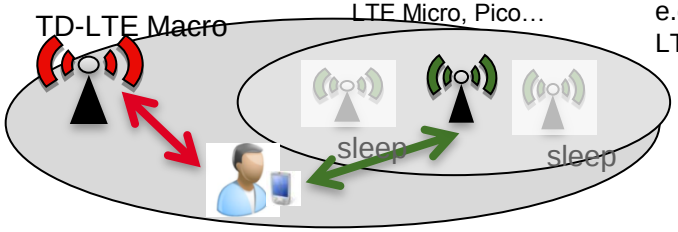
To introduce cooperation between them

Phase 1: TD-LTE/WLAN Hotspot



Signaling BSs: Always-on large cells, low data rate e.g. 2G/LTE Macro

Phase 2: TD-LTE continuous coverage



Data BSs: On-demand small cells, high data rate e.g. TD-HSPA/TD-LTE/WLAN

Key issues to be addressed:

- **How to avoid coverage hole?**
  - Extended coverage by neighbouring cells (e.g. cell zooming in/out)
- **How to activate the suitable cells timely?**
  - Inter-RAT or intra RAT signalling/OAM control
  - Accurate positioning of user movement and UE radio channel judgement , e.g. Dormant cells with beacon for measurement
  - Prediction of user movement

Summary

- Significantly improving the energy efficiency of current networks
  - Green Action Plan
  - Renewable Energy BTS
  - C-RAN
  - Energy Aware Heterogeneous Network
- Making future mobile communication green
  - Rethinking Shannon
  - Beyond Cellular
  - 5G?