I. Context and Motivations

- Exponential growth of mobile Internet traffic volume
  - Emergence of 4G/5G coupled with Internet-capable mobile devices
  - New applications and services: M2M, online gaming, interactive mobile video and mobile TV, context-aware and 3D applications
- But, the revenues are not increasing with the traffic volume
  - Per-bit energy consumption cannot follow traffic growth
  - Overall operating BS cell power cannot follow BS growth
- Operators are seeking more cost-effective solutions to
  - Introduce new applications and services, and enhance user QoE
  - Increase system capacity, 1000 times of today’s throughput
  - Cope with the network traffic workload load demand and supply due to spatio-temporal traffic fluctuations
  - Reduce the total energy budget, and EMF emission
- Green radio key enablers
  - Small cell, HetNet, Relaying, Massive MIMO, and Cloud-RAN
  - Traffic management, offloading, content-optimized network
  - Virtualization, cloud computing, Software-defined network (SDN)
  - Network-wide coordination and orchestration

II. Fundamental Trade-offs on Green Radio

- Interplay between cost, latency, bandwidth, rate, and energy
- Trading for power
  - Expanding the bandwidth for a given rate requirement?
  - Reducing the transmission rate for a given bandwidth?
  - Delaying the service time without deviating a given QoS?
- BS cell size and energy efficiency
  - Reducing the cell size shorten distances between network and terminals → Lower the TX power up to 100B and same SINR
- Latency and energy efficiency
  - Minimizing protocol latency minimizes energy consumption in DSP, embedded system, and processor on both network and terminal
- BS availability and energy efficiency
  - Only 20% of BS sites carry 80% of traffic
  - Turn BS on and off for dynamic load balancing and traffic flow offloading → adjust the network workload demand and supply
- Content availability and energy efficiency
  - The majority of mobile data is content-based services (video, web)
  - Place and store popular content at the network edge (prefetching/caching) → reduce the E2E latency/energy
- Novel Radio transmission technologies and architectures
  - Radio network cloudfication and delivery as a service

III. Cloudification of Radio Network

- Centralized/virtualized base station pool
  - Migration from expensive specific hardware to GP platforms → lower the cost of equipment
  - Load balancing and traffic offloading to meet traffic fluctuation → energy saving by dynamically turning on and off the RAN
  - Rapid provisioning and new service adoption → meet new traffic demands
  - Efficient coordination and interference management across cells → increase the overall system capacity and radio collaboration

Scenarios
- MVNOaaS: value-added content and service bundle
- PMRaaS: dedicated and reliable content and service bundle

IV. Cloud-RAN Reduces 68% Power Consumption*

- Majority of power consumption is from BS
  - 50% by RAN
  - 50% by Air conditioning and other facility equipment

Scenario: China Mobile typical site model, total power consumption of traditional macro BS is 100%

- Traditional Macro Base Station: 48% of Energy
- Distributed Base Station: 24% of Energy
- C-RAN Architecture: 20.4% of Energy

*Source: China Mobile and ZTE