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Software defined radio networking: Opportunities and challenges

Putting more IT/SW to the network

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EURECOM, Mobile Communication Department

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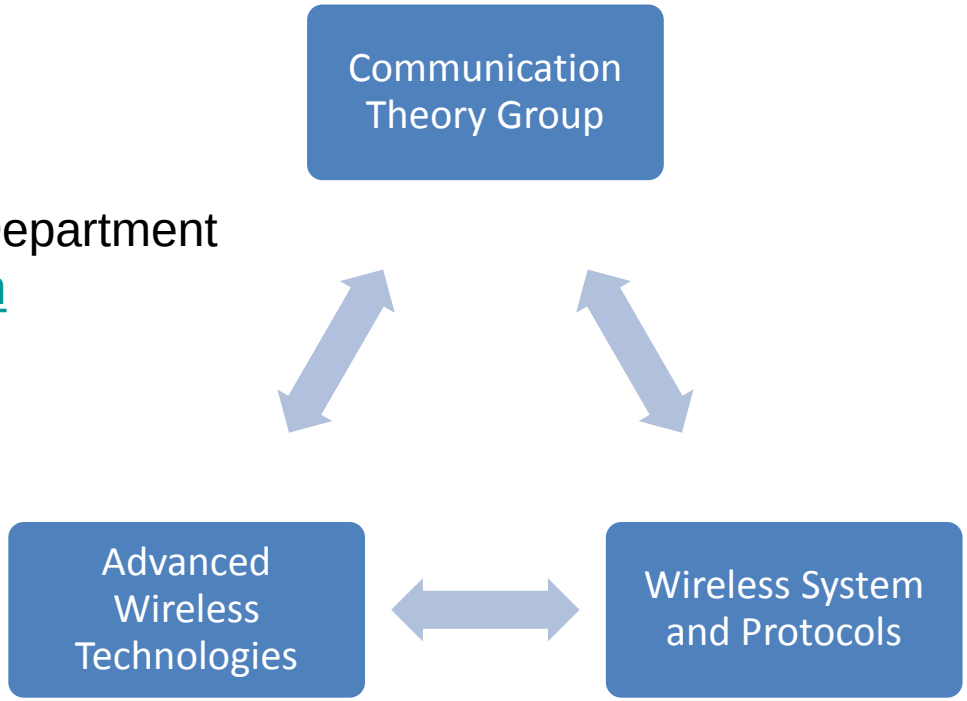
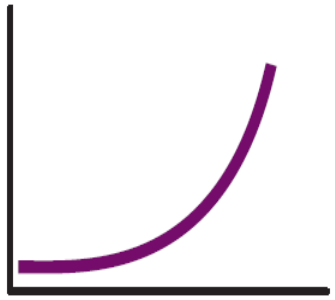


Trends and use cases

Drivers

User Requirements, Cost, Energy, and Sustainability

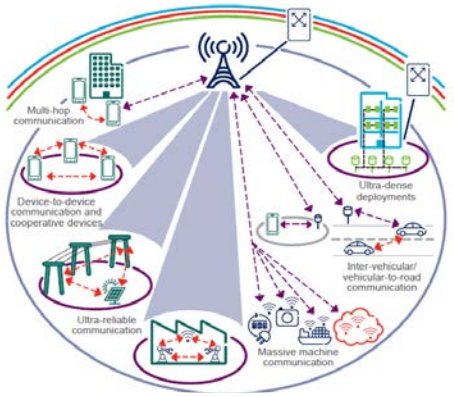


Global energy budget ?

Massive Traffic Growth

Global network architecture ?

Number of connected devices



Global network cost ?

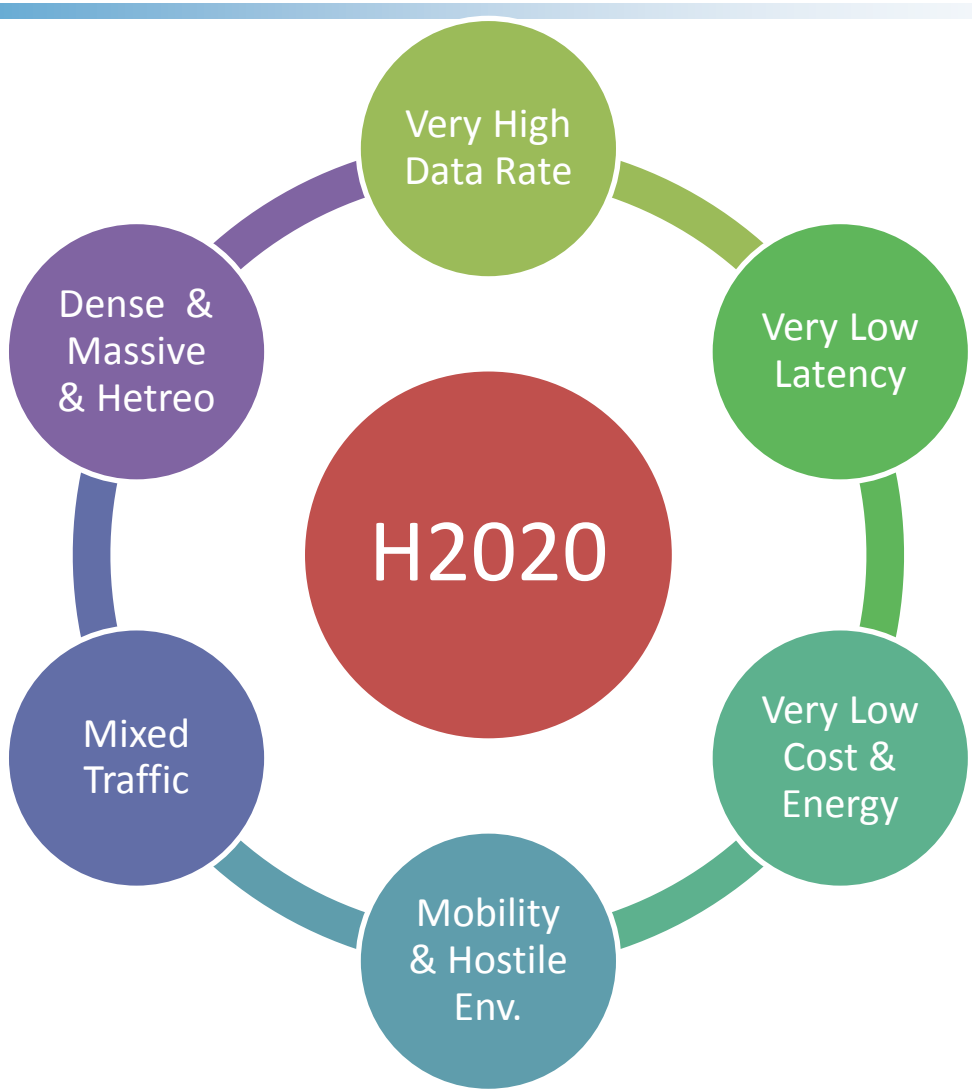
Divers use-cases

Enablers

Ubiquity, Mobility, and Wireless

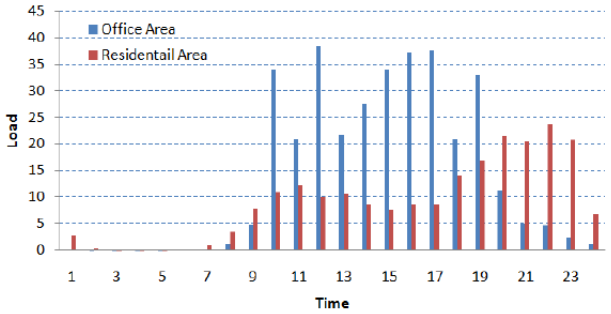
Fundamental Challenges

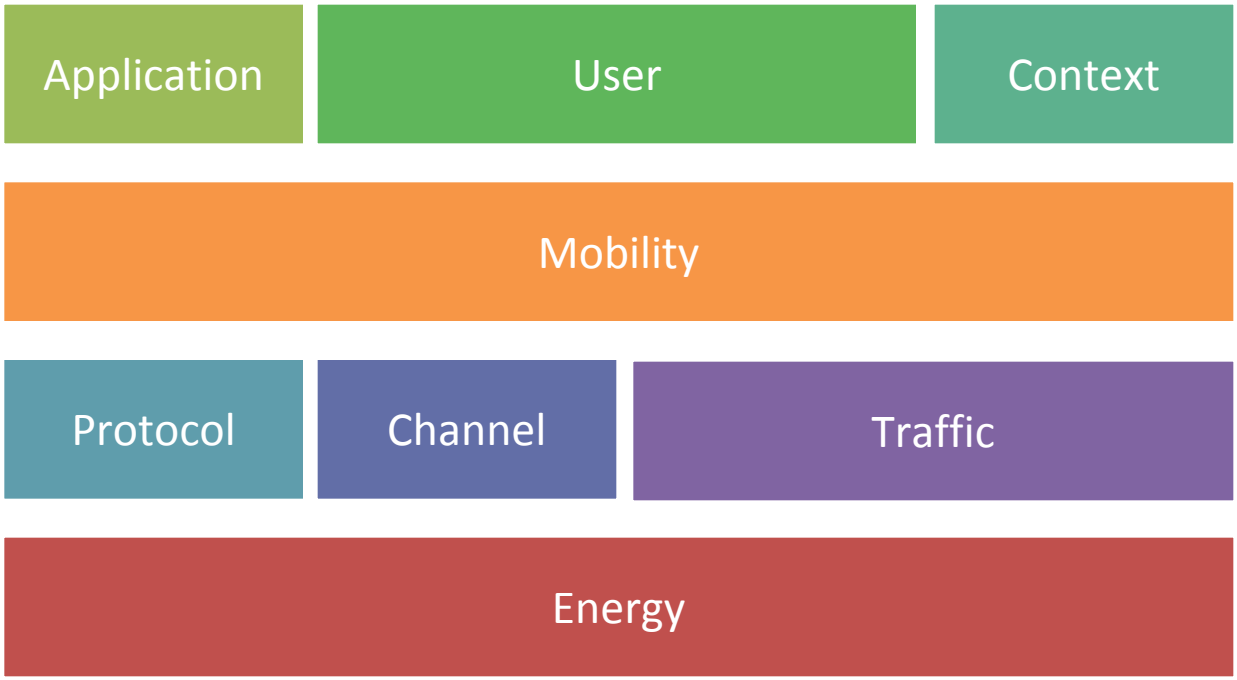
★ ***Deep Impact of the network architecture***



Mobility and Energy

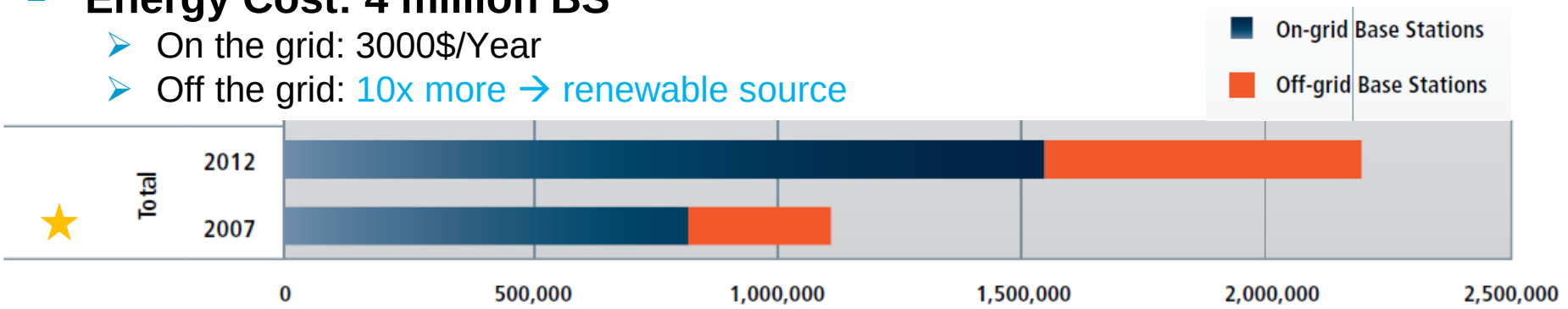
- **Mobility creates network dynamics**
- **Time-varying energy consumption**

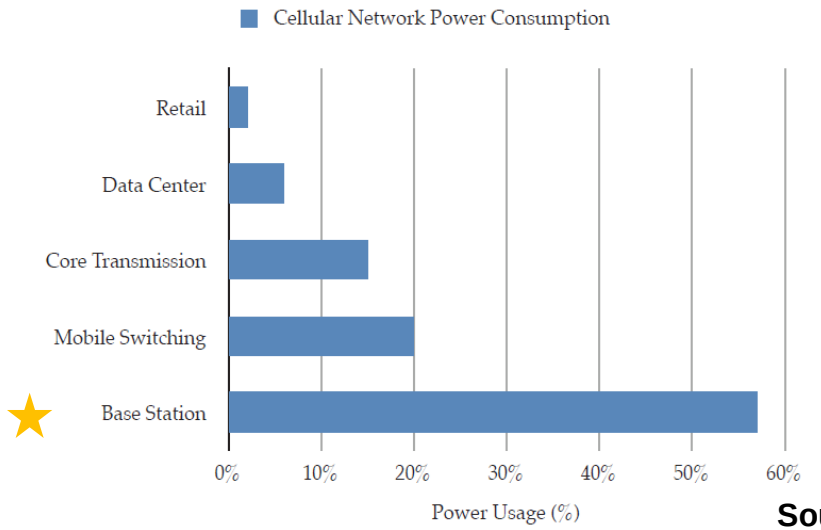


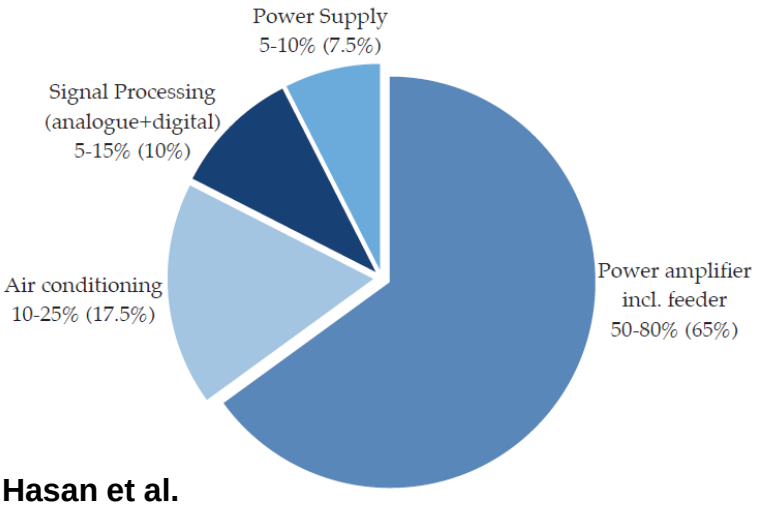


Energy
Environmental and Cost Aspect

- **Worldwide energy consumed by ICT, currently, is 3%**
  - 2% of total carbon emission, **of which 0.2% represents wireless ↑**
- **Energy Cost: 4 million BS**
  - On the grid: 3000$/Year
  - Off the grid: 10x more → renewable source



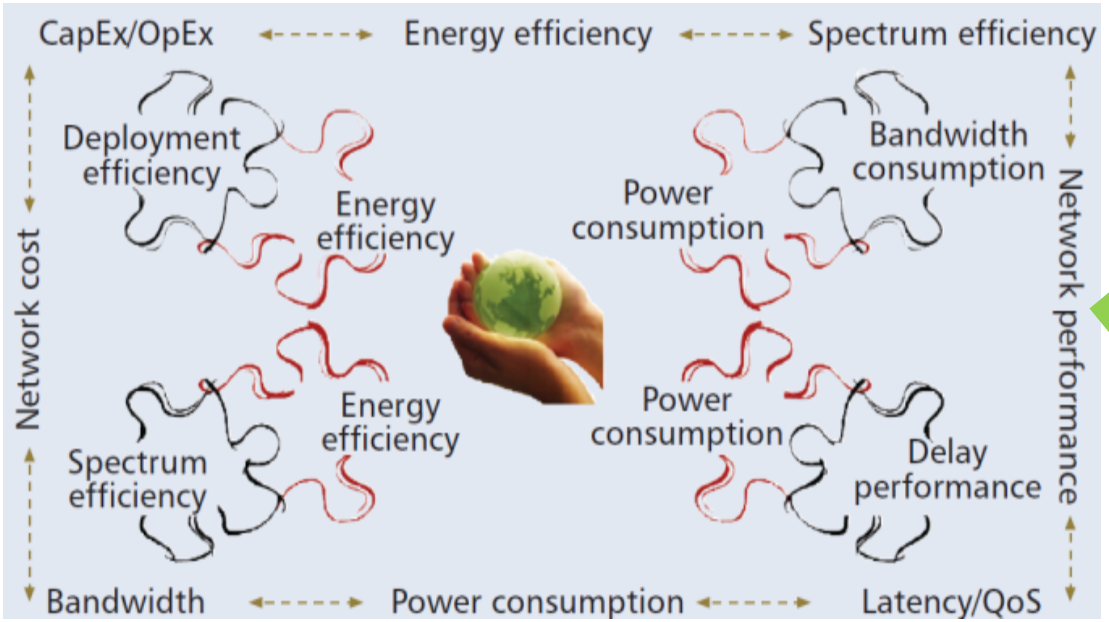




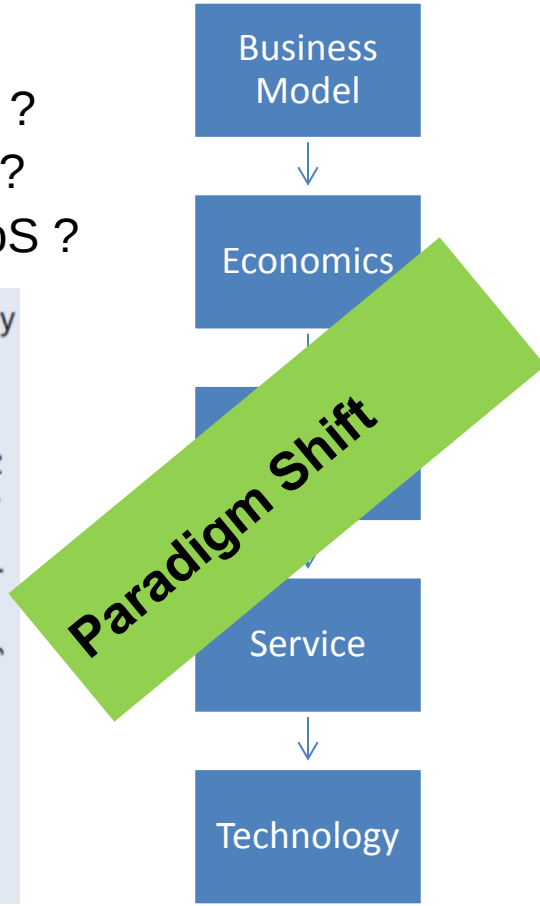
Source: Z. Hasan et al.

Fundamental Trade-offs

- **Interplay between energy and cost / bandwidth / rate / delay**
- **Trading for Energy**
  - Increasing network cost for a given performance?
  - 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 ?



Source: C. Yan



Paradigm Shift to Maintain Profitability

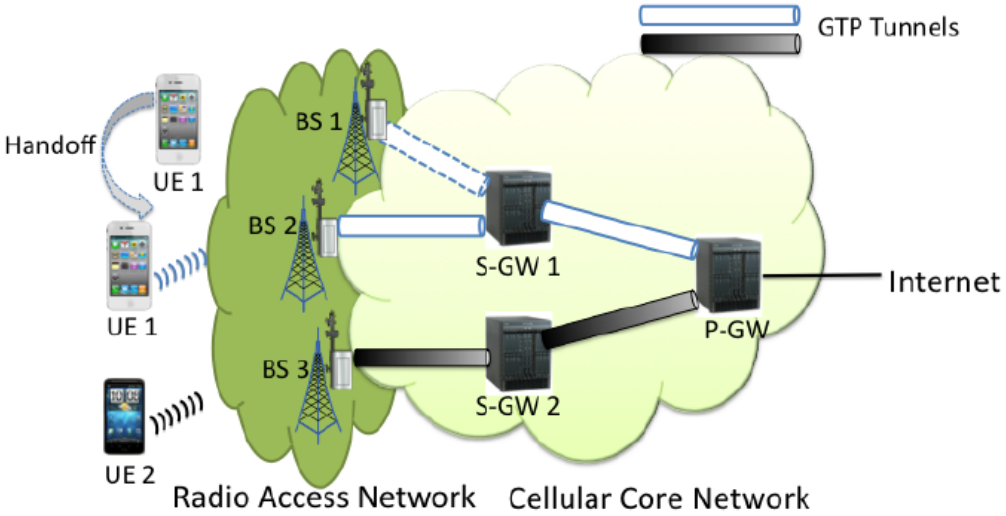
Current Network	Challenges
▪ Fixed power ▪ Full coverage ▪ Full load ▪ Max. spectral efficiency ▪ HTC traffic ▪ …	▪ Power Proportional ▪ Coverage scaling ▪ Load-aware ▪ Energy-aware ▪ Mixed HTC and MTC ➢ Cyber-physical systems ★ ▪ …

Paradigm Shift to Maintain Profitability

Current Network	Emerging Technologies
▪ Seen as different transport pipes ▪ Not flexible ▪ Not scalable ▪ Costly ▪ Homogeneous ▪ …	▪ SDN: Cost ↓ ▪ SON: <40% ▪ XaaS/NFV: Cost ↓ ▪ SDR : Cost & Energy ↓ ▪ Spectrum Sharing: <50% ▪ Heterogeneous: <60% ▪ Cooperation, …

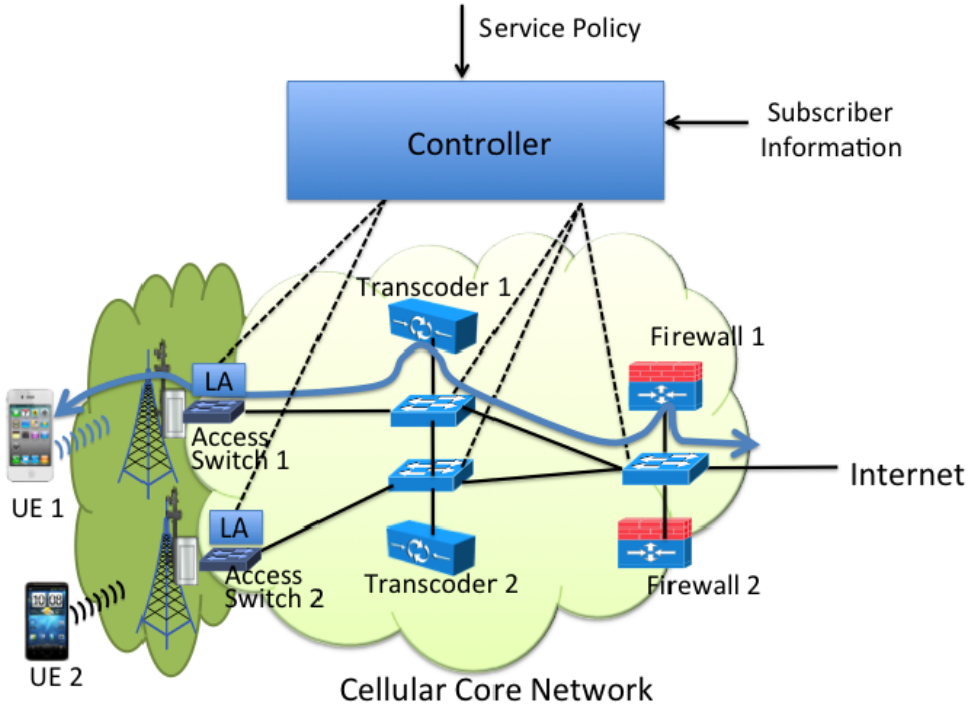
SDN

iJoin and CellSDN projects



- **Switches can easily handle the state and bandwidth**
- **Improves the scalability and flexibility**

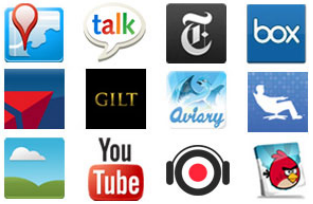
Prio	Predicates	Service Actions
1	provider = B	Firewall
2	provider != A	Drop
3	app = video ∧ plan = Silver	[Firewall, Transcoder]
4	app = VoIP	[Firewall, Echo-Cancel]
5	device type=M2M fleet	[HighPriority, Firewall]

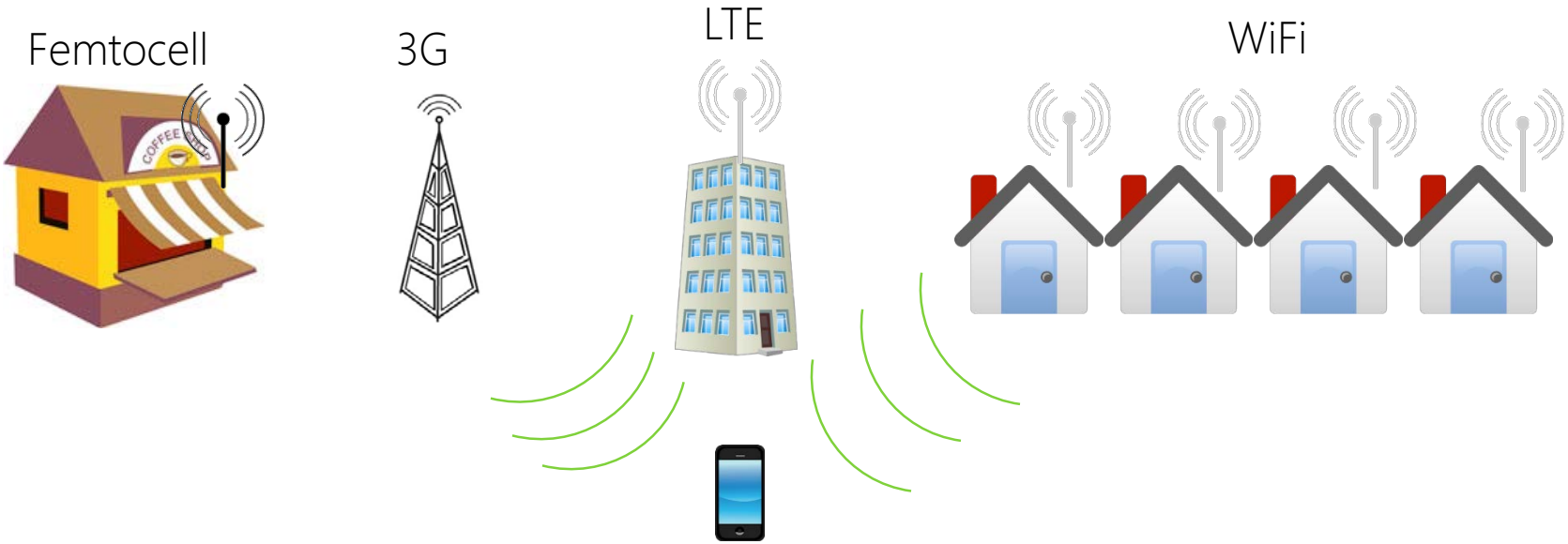


SDN

★ OpenRadio: *Why aren't network and apps/user/device a partner?*

- **Open the wireless infrastructure to provide users, applications, and carriers control over their state across all layers in an end to end manner?**

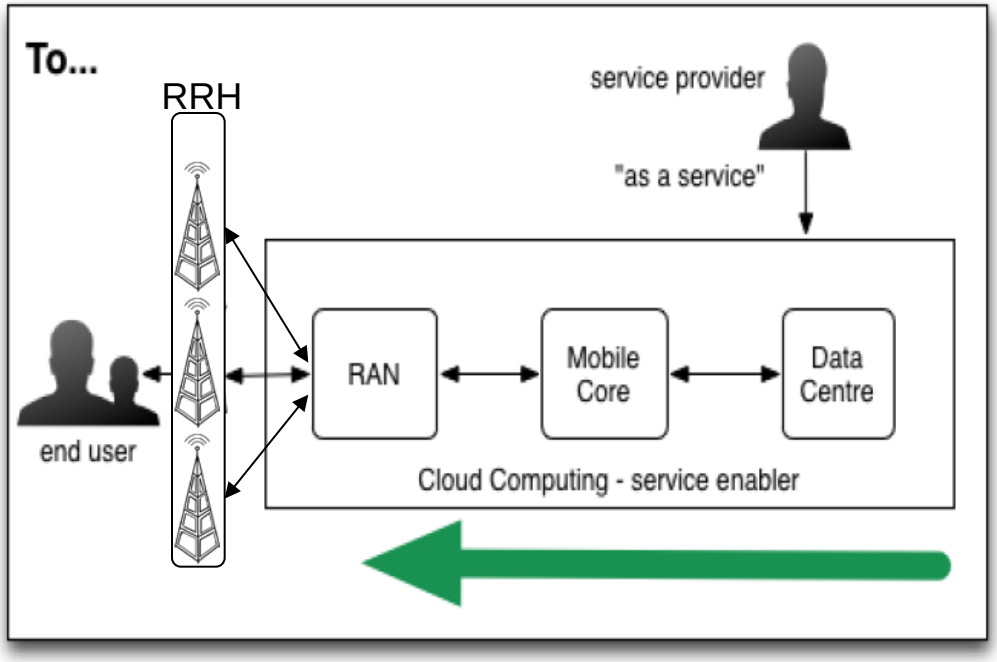


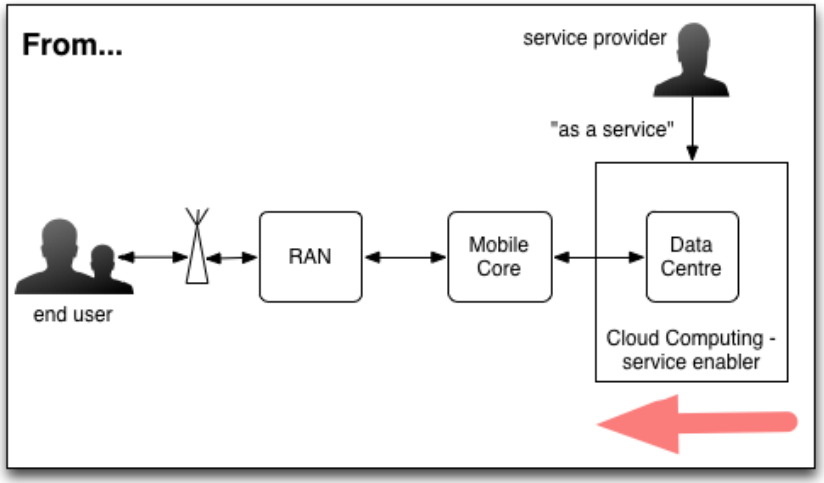


Cloudification of Radio Network

MCN project

- **On-Demand, Self-Service, Elasticity, Pay-as-you-Go, Remote Access**
- **Infrastructure- Platform- Software-as-a-Service (IaaS/PaaS/SaaS)**
- **CAPEX : # of equipment↓**
- **OPEX: centralization and energy saving**





SDR

★ *Full GPP BBU is not a myth: Local or in the Cloud*

eNB RX

OFDM_demod time
:202.992302 us (100 trials)

ULSCH demodulation time
:347.516264 us (100 trials)

ULSCH Decoding time (39.23 Mbit/s, avg iter 2.000000)
:1271.786873 us (100 trials)

eNB Tx

OFDM_mod time
:176.144838 us (100 trials)

DLSCH modulation time
:55.319101 us (100 trials)

DLSCH scrambling time
:22.194255 us (100 trials)

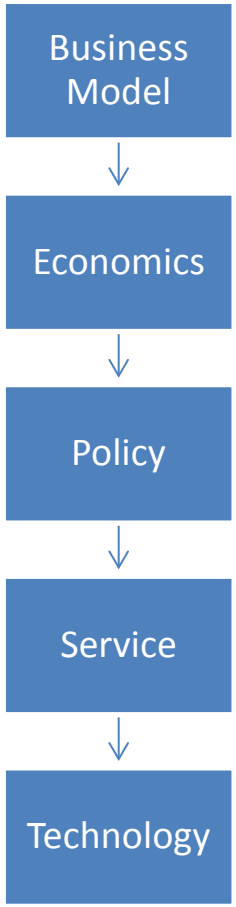
DLSCH encoding time
:79.016000 us (100 trials)

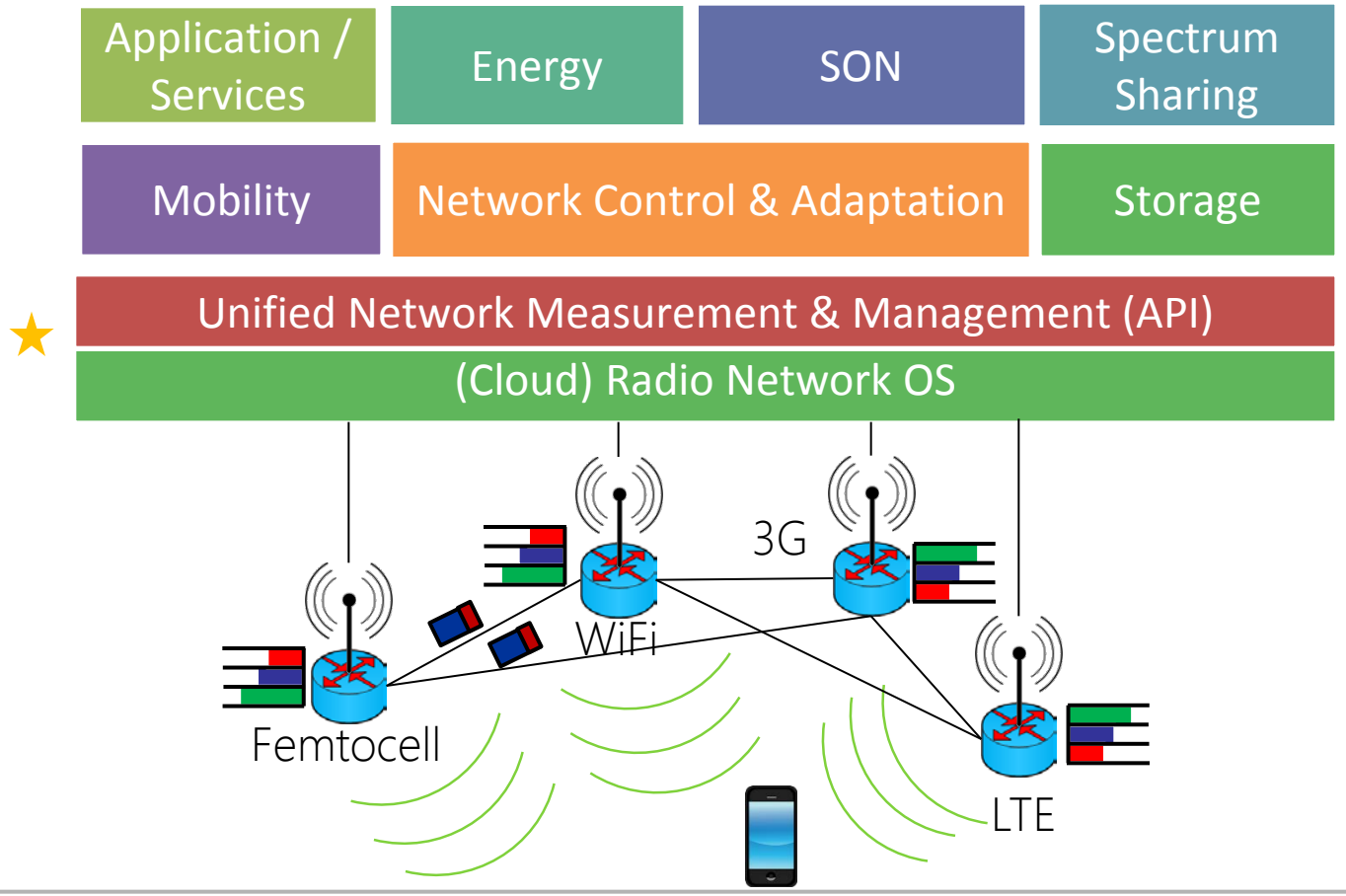
- **Summary (processing for 1ms subframe)**
  - **RX : 1820 ms (< 2 cores)**
  - **TX : 330 ms (1/3 core)**
- **On 3 GHz machine, < 2 cores for 20 MHz eNB**
- **On future AVX2 (256-bit SIMD), turbo decoding and FFT processing will be exactly twice as fast**
  - **1 core per eNB**

Unified Software Interface

★*Build a Complex Service as a software*

- **Fine-grain control on how application, user, device, and/or operator are served ?**





Conclusion

- **Requirement for next generation mobile network are defined**
- **Need for a paradigm shift is there**
  - Most of possible enabling technology ingredients are available
- **Towards smarter wireless networks: Unified cross technology wireless network OS and APIs**
  - Fine-grained network-wide measurement and control
  - End-to-end realtime network adaptation and optimization
- **Network function virtualization (NFV)**
  - Complex network function/service as software apps
- **Radio networking architecture depends on the deployment and scenario**
  - D-RAN vs C-RAN
  - Heterogeneity: Marco, micro, pico, femto
  - mW vs mmW
  - Licenses vs unlicensed bands
  - …

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