Wireless 5G:
Challenges from Technical and Services Aspects

By

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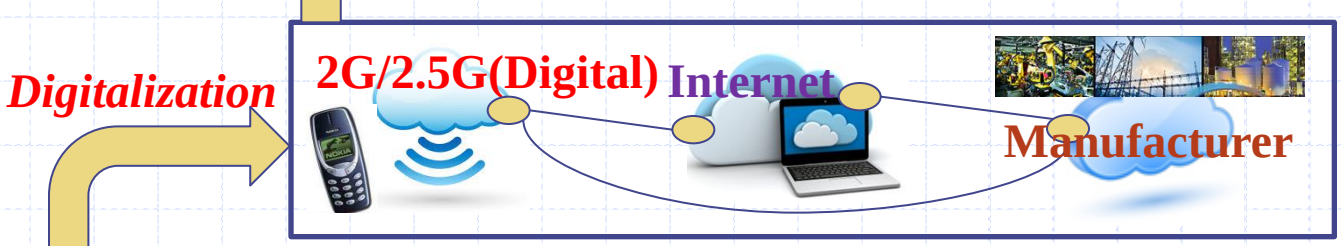
Wireless Evolution: Technologies, Services and Business Models



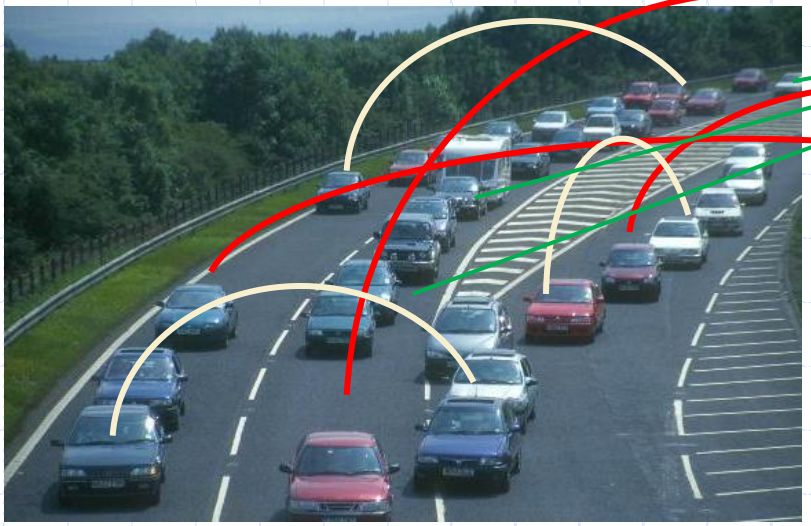
Source: Prof. Bo-Chao Cheng

Internet of Vehicles: Vehicular Telematics Applications (1/2)

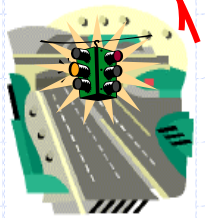
Safety/Auto Services

Navigation & Mobility

Infotainment & E-commerce



Telematics Enabled Vehicles



V2I Communication
V2V Communication
GPS

Connected Vehicle Services

- Safety/Auto services
  - Driver Safety and Security
  - Vehicle Maintenance
- Navigation & Mobility
  - Traffic, ETA, POI, Localized Searches
  - Tolls and Parking
- Infotainment & E-Commerce
  - Digital Content
  - Social Networking

Enabling Trends

- Smartphone Platforms
  - App Store Business Model
  - Tethering for OBU
- OBU and Passenger Entertainment Systems
  - Embedded wireless and sensors
  - Smartphone integration with improved HMI
- Infrastructure
  - Vehicle Infrastructure Integration (Future)
  - Cloud based delivery

Internet of Vehicles: High Speed Rail (HSR) (2/2)

- **Train Control System**
  - **Data transmission**
    - **Required high reliability and security**
- **Communication System**
  - **Voice communication**
    - **Train crews and operation center**
  - **Data transmission**
    - **Diagnostics, CCTV or etc.**
  - **Passenger service**
    - **Wi-Fi connecting to Internet**

Acela Express
(Amtrak, USA)

TGV
(SCNF, France)

Tokaido Shinkansen
(JRC, Japan)

Health ICT Significant Initiatives & Trend

- Major world economies are investing in Health ICT (Information and Communications Technology) to enable connected personalized healthcare to help reduce costs and improve quality through their national socio-economic development priority initiatives
  - US - Health-IT (2004-2013); EU - i2010 Initiative (2006-2010) & Seventh Framework Programme (FP7) (2007-2013); Japan: U-Japan (2006-2010), and China: “12-5” (2011-2015)

- Health ICT Trend
  - Go to Mobile (m-Health)
  - Go to Personalization
  - Go to Data Analysis and Behavior Coaching
  - Go to Cloud (Computing)

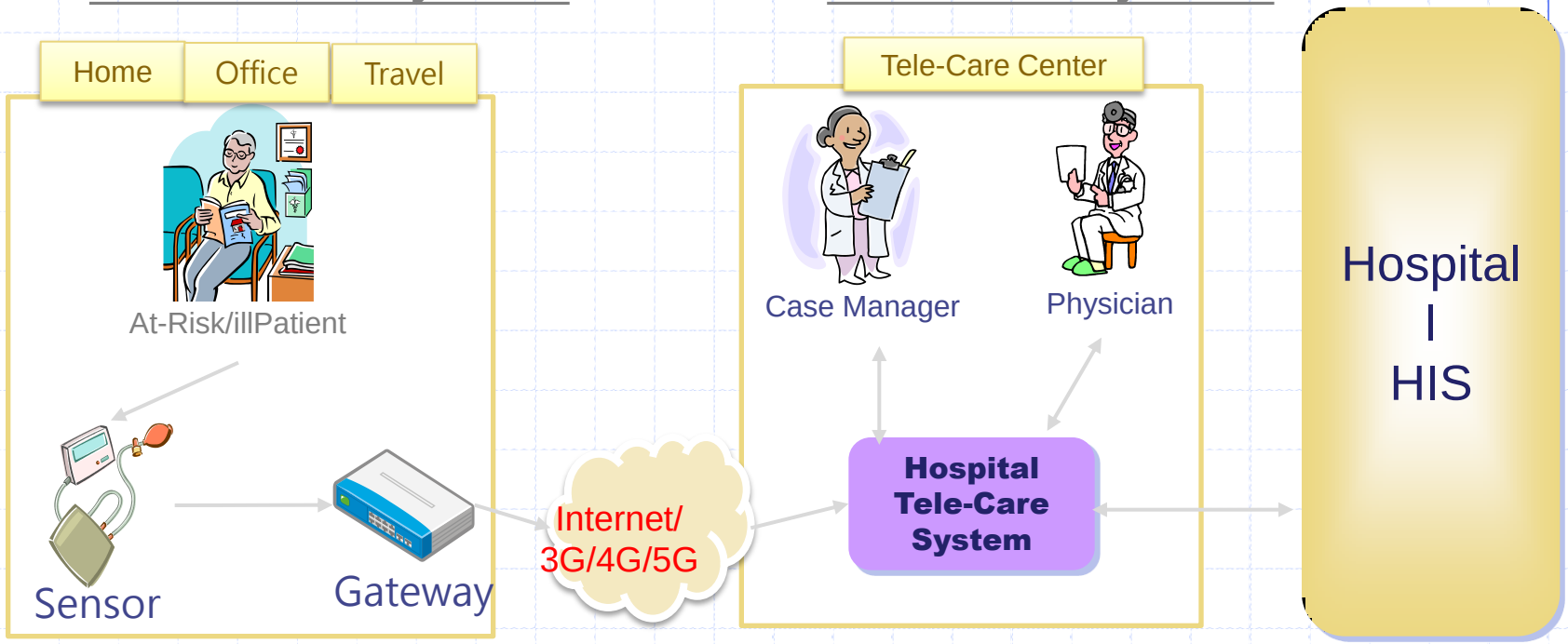
Healthcare Service Trend: Personalized eHealth

- Personalized eHealth is supported by worldwide major governments as a way to reduce costs and improve medical quality through their national socio-economic development initiatives
  - Personalized healthcare moves traditional treatment-centric disease management toward prevention through systematically life style changes
  - eHealth provides ubiquitous and reliable support and access of healthcare management at anywhere and anytime

General e-Healthcare System

Front-End System

Backend System



HIS: Health Information System

Source: Dr. Tsong-Ho Wu, ITRI Fellow

All of The Following Seven Key Technologies for ICT Applications & Services Have Being Constantly Improved:

- Communication
- Computing
- Storage
- Interface
- Sensor
- Actuator
- Software Algorithm

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Source: Dr. Adam Drobot

Wireless 5G: Why Now?

- Currently 3G/ 4G could deliver unprecedented:
  - Coverage
  - Bandwidth
  - Latency (not quite yet!)
  - Reliability

But 3G/4G could not fulfill many of the demanded emerging services and the new type of social media-enabled traffic pattern now

- After iPhone was introduced in 2007, Steve Jobs' Un-equilibrium Relationship occurs Immediately, i.e. Create a Market Gap of "Demands >> Supply"
- Traffic volumes will be increased at least 10~500 X from 2010 to 2020
- Energy required will be needed by at least 100X, Need Green Energy Comm.
- Need "Best Effort" QoS >> "Guaranteed" QoS Services for End-to-End Internet Networks, and Spectra Efficiency
- Need new Business Models and Spectra Efficiency

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Wireless 5G: How? (i.e. Anticipated Features)

- In the Near Future: Wireless 5G's anticipated features
  - Wireless 5G technologies should deliver explosive range & depth services:
    - Personalization,
    - Immediacy,
    - Anticipation,
    - Smart Data Pricing (SDP)
  - NFV/SDN-Based Mobility Management for Wireless 5G
  - Cognitive Radio Network (CRN)-Based Spectrum Sharing
  - Small Cell Networks (for huge data transactions applications)
  - New Business Models: NaaS, DaaS, KaaS

Examples:

Three Features and Killer Application Scenario for the Future Wireless 5G

- Feature 1: Small Cell Networks & Fog Networking
- Feature 2: Smart Data Pricing
- Feature 3: SDN-Based Mobility Management
- Feature 4: Ultra-Low Latency Delay for E2E Network
- Application Scenario: Internet of Vehicles Me

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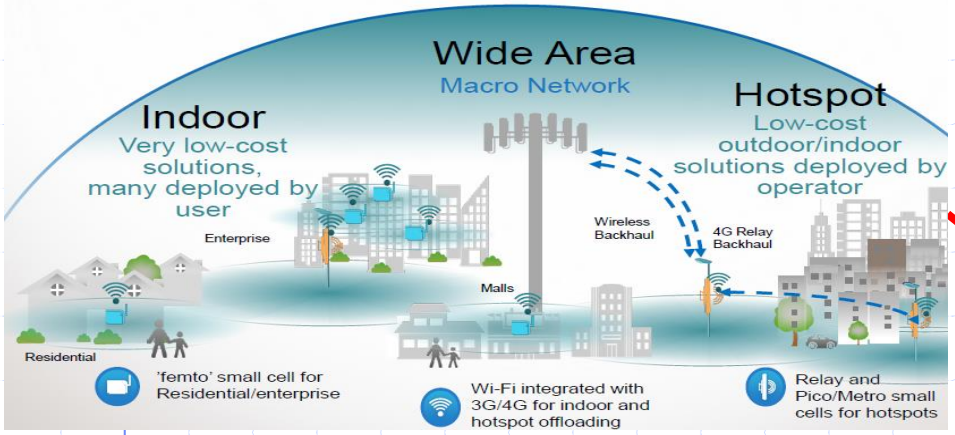
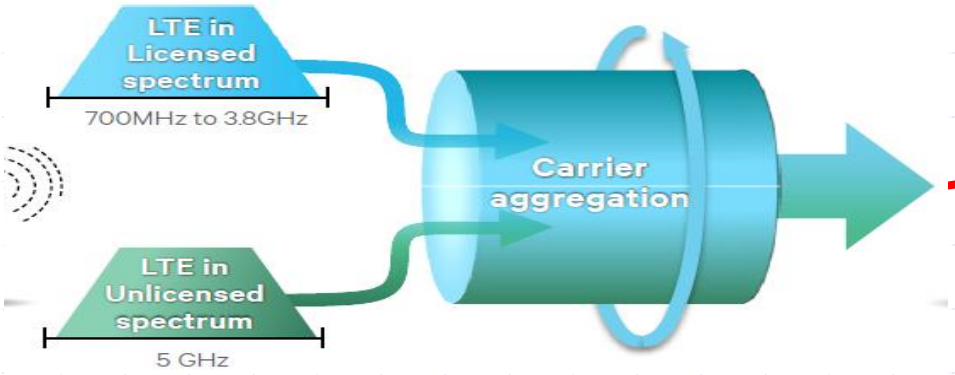
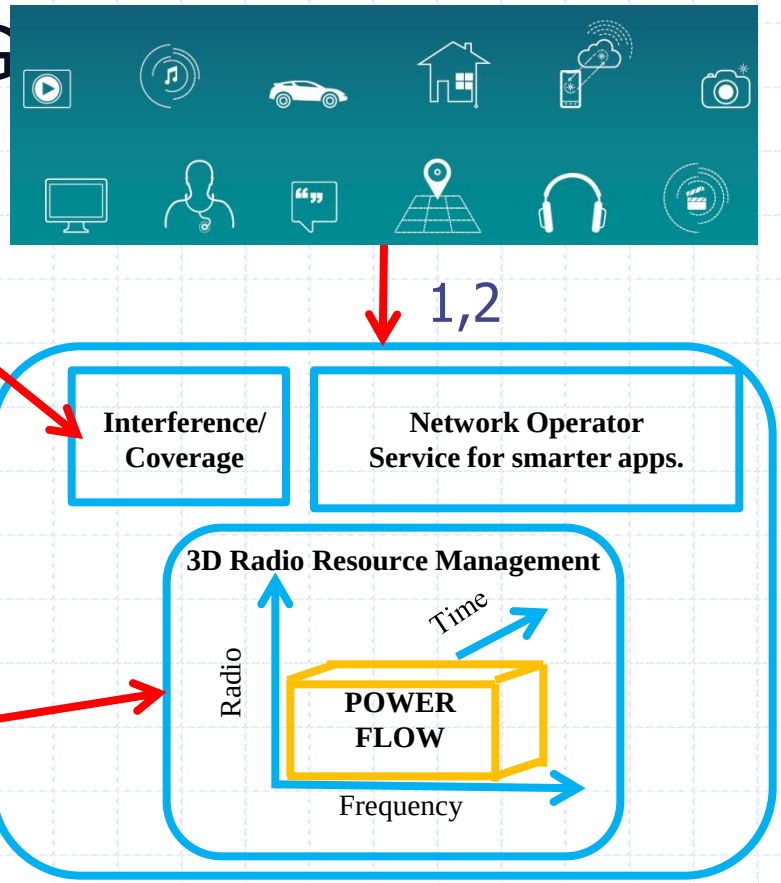
Small Cells for LTE-A/B, IoT, 5G







1. More efficient traffic aggregate for smarter apps and services
2. More efficient QoS management for revenue based model
3. More adaptive network management for deploying to multiple areas (Wide, Hotspt, Indoors) and business cases (Metro, Residential, Enterprise)
4. More efficient spectrum/radio resource management to squeeze more capacity and value out of spectrum

Source: Ming-Jye Sheng, EDGE Lab. Princeton University

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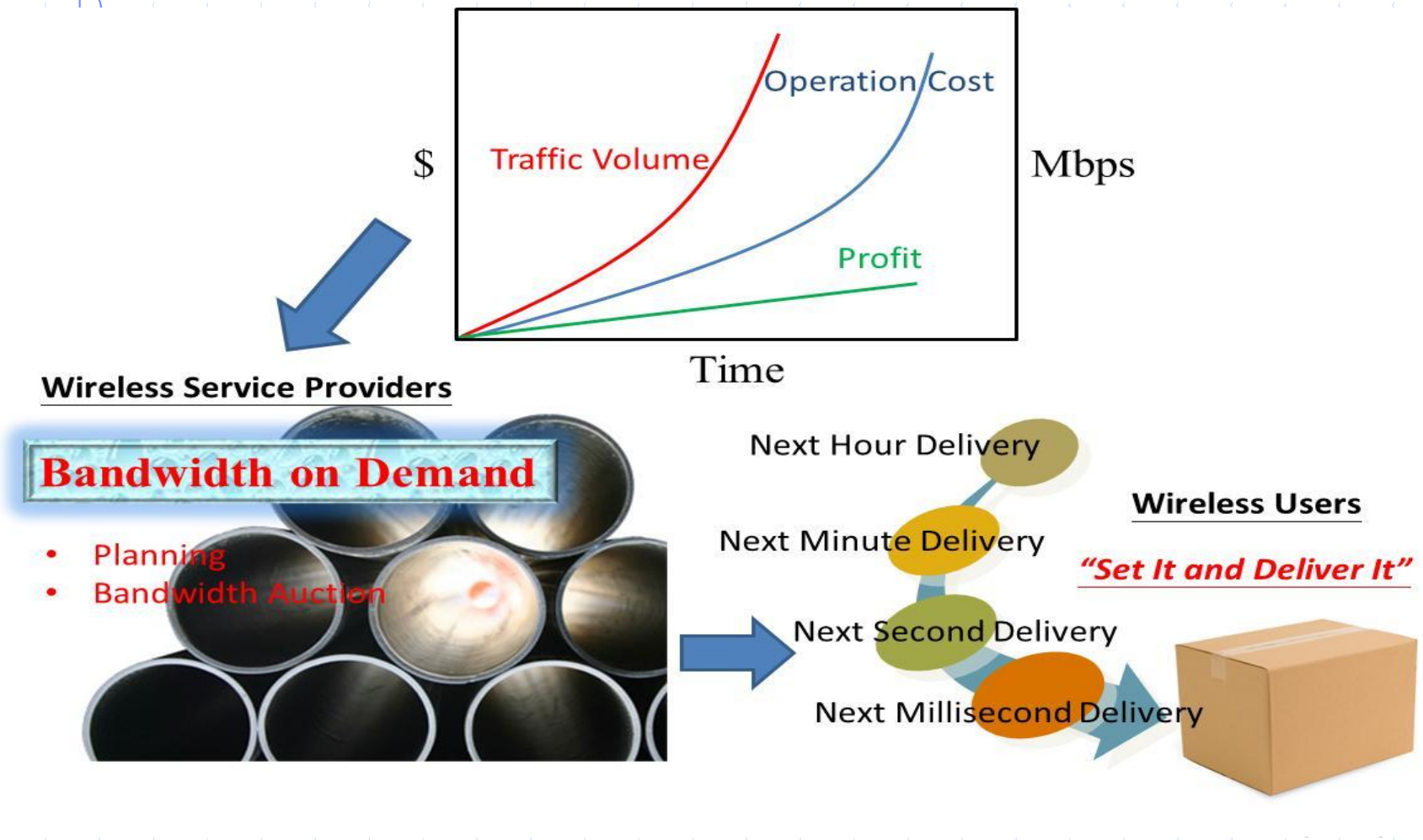
Why Smart Data Pricing? (1/3)

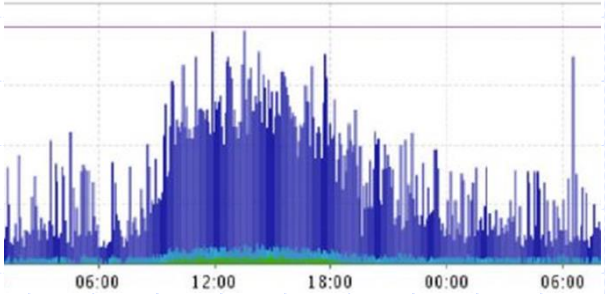


Why Smart Data Pricing? (2/3)

- Bandwidth-Hungry Devices
- Cloud Service
- M2M Applications
- Capacity-Hungry Application

Flat-Rate Pricing

Network Congestion
(Bursty Internet Traffic)



Source:
http://www.potaroo.net/studies/1slash8/1slash8.html

Hard Solution:
Network Deployment

Soft Solution:
Pricing Strategy

- Usage-Based since 2008
- Application-Based

Cons
1. What Time
2. Traffic Condition
3. Network Resource

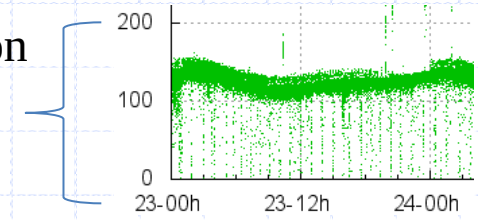
Applications for Smart Data Pricing (3/3)

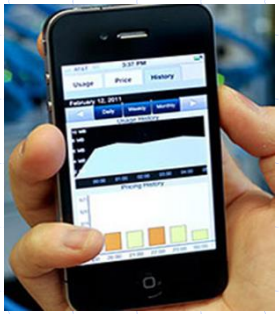
Time & Traffic Dependent Pricing:
- Peak Load Pricing
- Off-Peak Discounting

→ Change of User Incentives for Internet Access → Time- & Traffic-Shifting Data Demand

Pros:
- Ease Network Congestion
- Flatten Traffic Burst

Cons:
- Network Neutrality
- Hurt Demand ?





Example: TUBE Solution by Mung Chiang's LAB, PRINCETON https://www.princeton.edu/engineering/news/archive/?id=5103

- **TUBE by Chiang's lab**, a solution, allows smartphone users to pay for their network usage based on what time they download videos and other data.
- The UI on an iPhone provides users with **information on pricing** and usage history to encourage them to use their phone during **off-peak hours**.

What is SDN-Based Mobility Management*

- Incompatible wireless systems will still coexist in the future
- In SDN-based mobility management
  - Core network and radio network are reconfigurable
  - Both network and mobile node can choose their prefer mobility management protocols

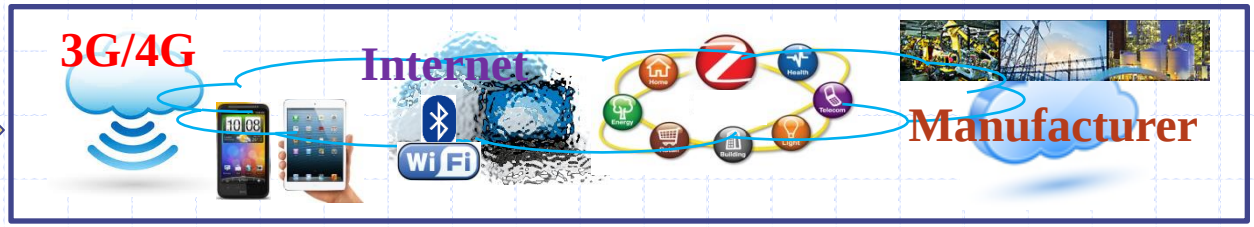
*Jyh-Cheng Chen, et. al, "Reconfigurable architecture and mobility management for next-generation wireless IP networks," IEEE Transactions on Wireless Communications, August 2007

*Jyh-Cheng Chen, et. al, "RAMP: reconfigurable architecture and mobility platform". IEEE GLOBECOM 2005

Why SDN-based Mobility Management

- The network can incorporate different mobility protocols with different features.
- Mobile node can change its mobility protocol at anytime when moving into different networks.
- Can incorporate new protocols easily
- Can integrate heterogeneous networks easily
- Provide guaranteed QoS for end-to-end Internet

Wireless Evolution: Technologies, Services and Business Models



Source: Prof. Bo-Chao Cheng

Wireless 5G: Enabling Technology to Realize IoT Applications & Services

Internet of Things (IoT) :

- many new emerging services (such as Vehicle-to-Vehicle (V2V) Services, Mobile e-Healthcare services) can be realized via D2D, M2M, and V2V

Wireless 5G: Few Key Features needed to deal with the following scenarios :

- Traffic volumes will be increased at least 10~500 X from 2010 to 2020
- Ultra low latency from end-to-end wireless network (target<10 ms)
- Energy required will be needed by at least 100X, Need Green Energy Comm., and Spectrum Efficency
- Need “Best Effort” QoS >> ”Guaranteed” QoS Services for End-to-End Internet Networks,

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Major Key Factors (By Dr. Shih-I Chen, III, 2014)

- Network Architecture
  - toward flat architecture
- System Procedures
- Smaller TTI

1. System Specs

2. Implementation
   Provisioning
   Deployment

- Processing Delay
- Resource Management
- Network load
- Channel Status

TTI + Frame Alignment

RAN Edge

1ms	1.5ms	1ms	1ms	0.5ms

faster processing

80% ? 80% ? 80% ? 80% ?

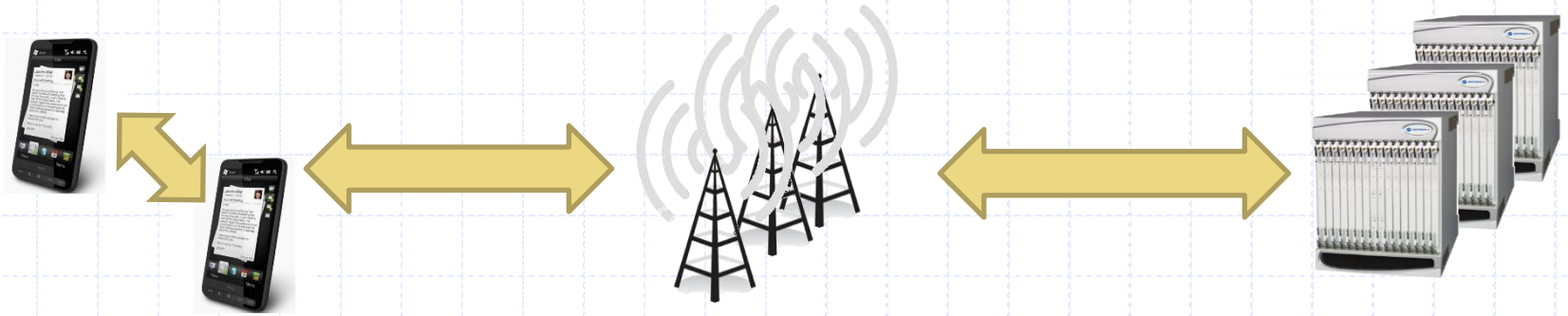
0.2ms	0.3ms	0.2ms	1ms	0.1ms

Reference: FP7 ICT LOLA

Emerging Network Topologies for Further Reduced End-to-End Latency (by Dr. Shih-I Chen, III)

Cloud-Radio-Access-Network (C-RAN)

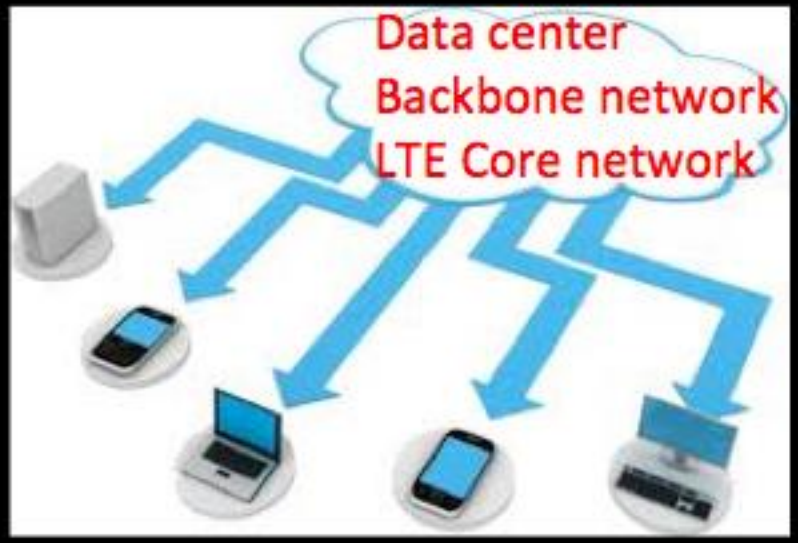
Centralized BB processing and load balance could facilitate RAN resource allocation and reduce radio access network processing delay



Device-to-Device (D2D) communications could significantly eliminate network processing delay

Software-Define Network (SDN) could reduce core network transport delay

Rise of the Clients



Source : Professor Mung Chiang, Princeton University

Many Types of Clients & Edge Devices

Source : Professor Mung Chiang, Princeton University

Why Now?

- Cognitive of end user application experience
  - End to end principle, again
  - How 5G may look like
- Each client/edge device in the past several years as become
  - Powerful (in sensing, storage, computing, control, comm.)
  - Limited (in battery, storage, computing, information)
  - Maybe mobile
- Crowds of clients/edge devices are
  - Dense
  - Distributed
  - Under-organized

Source : Professor Mung Chiang, Princeton University

Technology Trend: Cloud-based Networking >> Fog-based Networking (www.fognetwork.org)

- Pushing processing and storage into the “cloud” has been a key trend in networking and distributed systems in the past decade. In the next wave of technology advance, the cloud is now descending to be diffused among the client devices, often with mobility too: the cloud is becoming “fog.”

- Fog Networking combines the study of mobile communications, micro-clouds, distributed systems, and consumer big data into an exciting new area

Source: Prof. Mung Chiang, Princeton University

From Cloud to Fog

2000 – 2015

2015 – 2030 ?

Source : Professor Mung Chiang, Princeton University

Cloud Networks >> Fog Networks

- What It Is?
  - Compared with Cloud-based Radio Access Network (C-RAN), Fog Networking Radio Access Network (F-RAN) is P2P for the Applications & Services architectural solution. It will be able to provide new emerging services which require ultra-low latency delay with differentiated QoS for end-to-end wireless 5G Network
- Why Wireless 5G Needs It?
  - Deliver many new IoT services and applications (like real-time stream mining and security monitoring in big data centers, smart homes, V2V for car safety, distributed management for resources allocation, etc.) for end-users at the edge of network
- How to Implement It?
  - The interface between what stays on edge and what goes to cloud is the key
  - Both F-RAN and C-RAN should cooperate with each other, just like WiFi and LTE for different usage scenarios depending on business model and applications behavior

Wireless 5G for New Enabling Services Creation

-IoT Applications & New Emerging Services Creation

- Based on "**Fog/Cloud Computing**" **Platform** to develop Mobile Applications which are ubiquitous, scalable, reliable and cost effective
  - Internet of Vehicles (IoV), Healthcare Services, and IoM (Internet of Me)
  - Privacy-preserving secured communications
  - Green Communications for Future Mobile Wireless Technology and Services Provision
  - Smart Data Pricing Applications
  - ISP, Content provider, Consumer Win-Win-Win ecosystem
  - New Business Models: NaaS,, DaaS, and KaaS

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Gracias !

Dziekuje !

謝謝 !

Thank You !

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