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Future of IMT Systems: Wireless World Vision 2020

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&
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Outline

- Wireless World Research Forum (WWRF)
- Services in the next 10 years
- Network architectures
- Smartphones and tablets
- Security, privacy and trust
- Spectrum
- Cloud, computing, virtualization and analytics
- Conclusions and the way forward

The Wireless World

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WWRF's goal is to encourage research that will achieve unbounded communications to address key societal challenges for the future

We are using the term "Wireless World" in this broad sense to address

- *the support of innovation and business,*
- *social inclusion and*
- *infrastructural challenges*

This will be achieved by creating a range of new technological capabilities from wide-area networks to short-range communications, machine-to-machine communications, sensor networks, wireless broadband access technologies and optical networking, along with increasing intelligence and virtualization in networks

This will support a dependable future Internet of people, knowledge and things and the development of a service universe

Current Working Groups

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A User Needs & Requirements in a Secure Environment in different Socio-Economic settings

B Services, devices and service architectures

C Communication architectures and technologies

D Radio Communication Technologies

WWRF Vision in a nutshell

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7 trillion wireless devices
serving 7 billion people
by 2020

- All people will be served with wireless devices
- Affordable to purchase and operate
- Calm computing: technology invisible to users
- Machine to machine communications
  - Sensors and tags: e.g. in transport and weather systems, infrastructure, to provide ambient intelligence and context sensitivity
- All devices are part of the (mobile) internet

At a second glance

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- Wireless device(s) becomes our interface to the digital world
- An ambient life style where
  - … our mobile device becomes the key enabler to interact with smart environments and users
  - … our mobile guides and supports us against “digital threats”
- Has to be charged once a month only – green technology
- Untethered and connected user experience
- Ubiquitous service delivery with a consistent user experience
- In Other Words:

Wireless – The Way to Future

14 WWRF Fellows

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Dr Martin Cooper
USA

Dr João da Silva
Spain

Prof Ashok Jhunjhunwala
India

MrHåkan Eriksson
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Dr Young Kyun Kim
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Madame Li Mofeng
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Prof Mérouane Debbah
France

Prof. Hamid Aghvami
UK

Prof. Michael Walker
UK

Dr Kohei Satoh
Japan

Dr. Mikko Uusitalo
Finland

Prof Dr Sureswaran Ramadass
Malaysia

Dr Zhou Hong
China

Prof. Rahim Tafazolli
UK

Industry
Academia
Regulator

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Services and User Experiences In Next 10 Years….

Services
In Next 10 Years….

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Digital Society

By 2020….

From voice to data (including voice going IP)
5.5 billion MBB users, 1.5 billion FBB users

From pipe to content
all media will be on-line , 750 million connected TV users

From people to machines
50 billion connections (the Internet of Things)

From CT to ICT
70% of companies (especially SMEs) will be using Cloud-based services

User Interfaces

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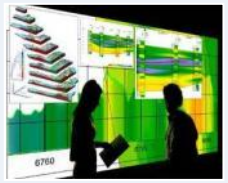
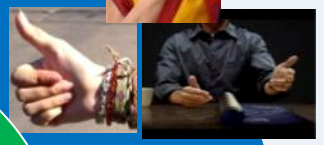


Living Room, Collaborative Data Walls

Touch

Input Interpretation



Limited Speech

Hand gestures

Experience design

Context

Physical environ

Fusion & Adaptation

Context Awareness

User(s)

Multiple inputs

Task

Mobile devices

Media PCs

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Network Architecture….

Communications become pervasive

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Pervasive Communication Systems consist of a very large number of ***computer-communication devices***, often of small size and/or embedded in the environment, which are able to interact with each other and with mobile users, ***dynamically form telecommunication networks*** and ***probe the environment*** in order to ***adapt and optimize,*** in a **context-aware** fashion, the networks performance and the user experience and QoS.

Network Architecture

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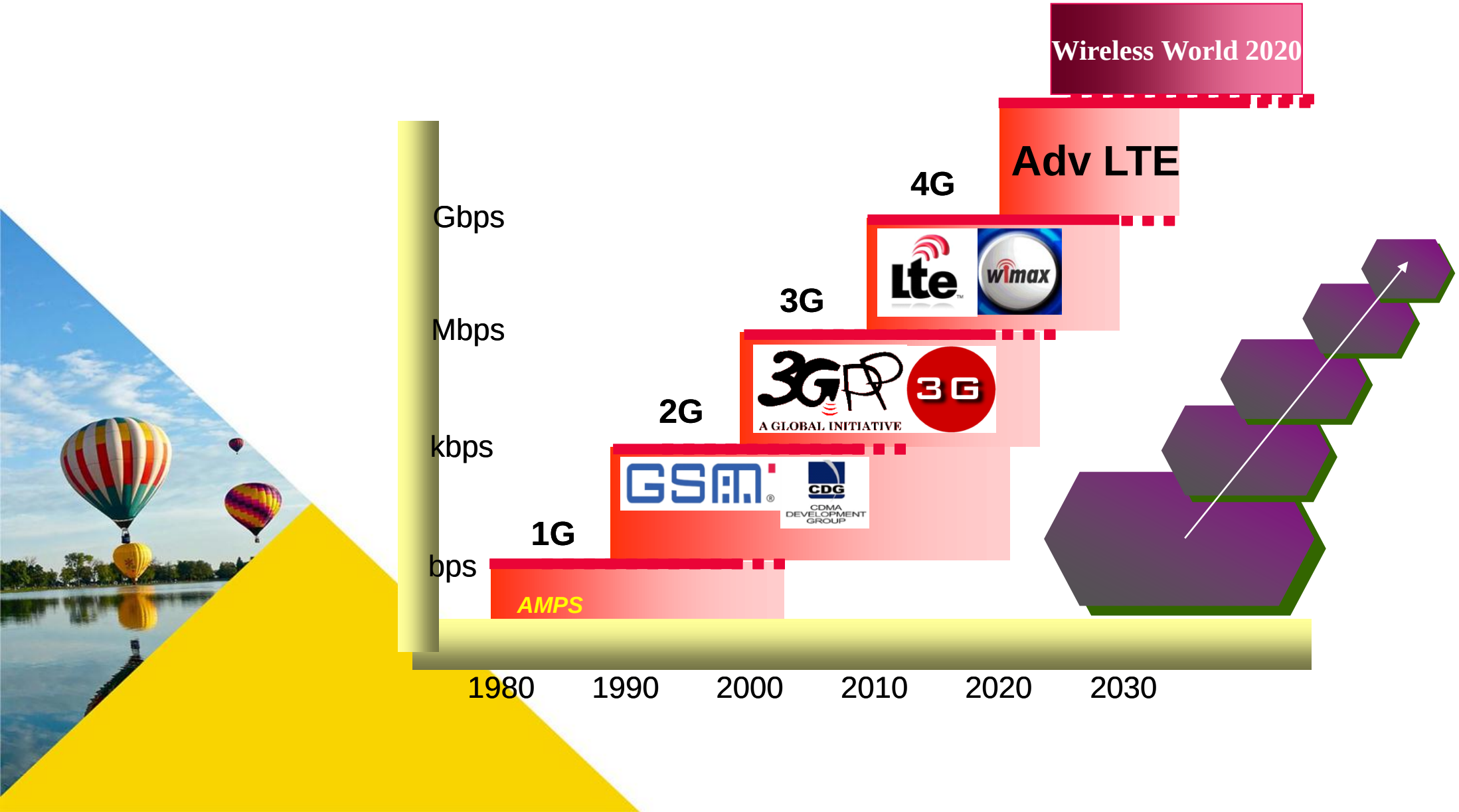

IMT-Advanced/4G

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- Comprehensive and secured all-IP mobile broadband
- Serve all types of client devices: laptop/tablet computers, wireless modems, smartphones, embedded wire less devices, etc.

Specific key requirements

- Based on an all-IP packet switched network
- Interoperate with existing wireless standards
- Nominal data rate of 100 Mb/s when mobile and 1 Gb/s when stationary
- Dynamic sharing of network resources to support more active users per cell
- Scalable channel bandwidth 5–20 MHz, optionally up to 40 MHz
- Peak link spectral efficiency of 15 bits/s/Hz in the downlink, and 6.75 bit/s/Hz in the uplink
- System spectral efficiency of up to 3 bit/s/Hz/cell in the downlink and 2.25 bit/s/Hz/cell for indoor usage
- Seamless connectivity and global roaming across multiple networks with smooth handovers
- Ability to offer high QoS for multimedia support

✓ **Wireless World beyond 2000: 5G (Beyond IMT-Advanced)!!**

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Communication Architectures -

Ideas about how to address this

- Adopting innovation oriented architectures and models
- More efficient use of spectrum, Cognitive radio/SDR
- Simple and transparent multimodal interfaces enabling new high value services
- ‘Green radio’ - power and spectrally efficient wireless ubiquity

User mobility trends

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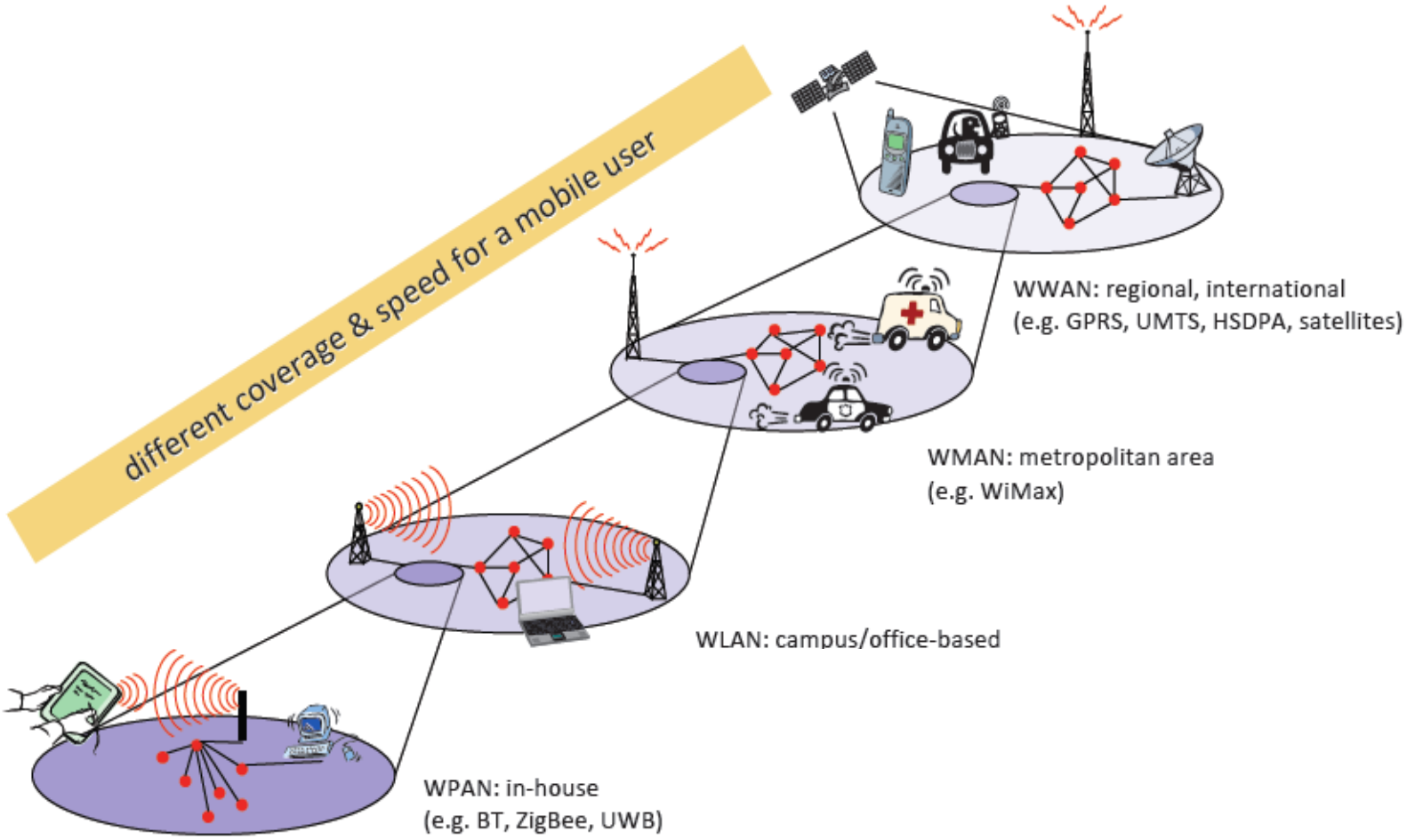
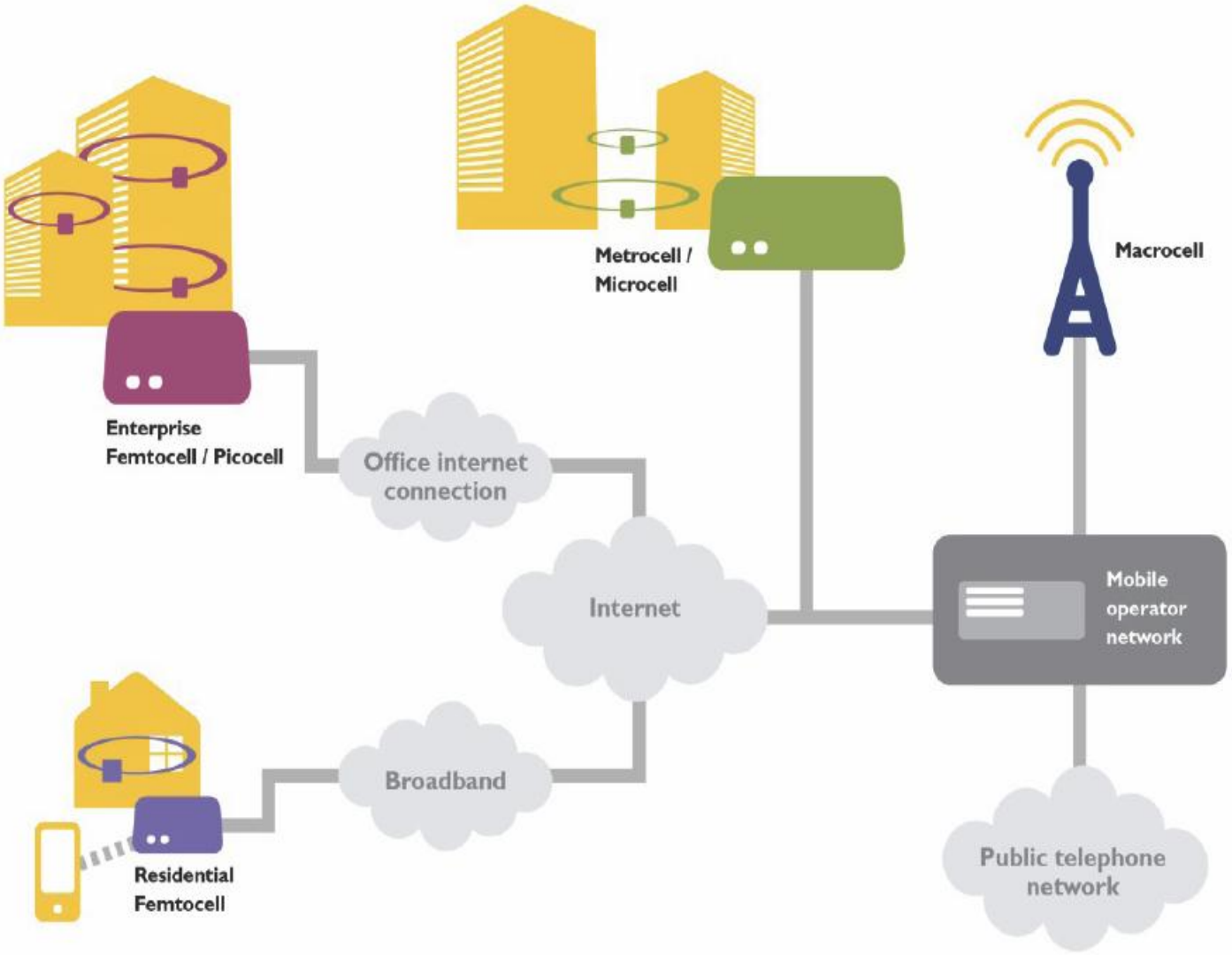
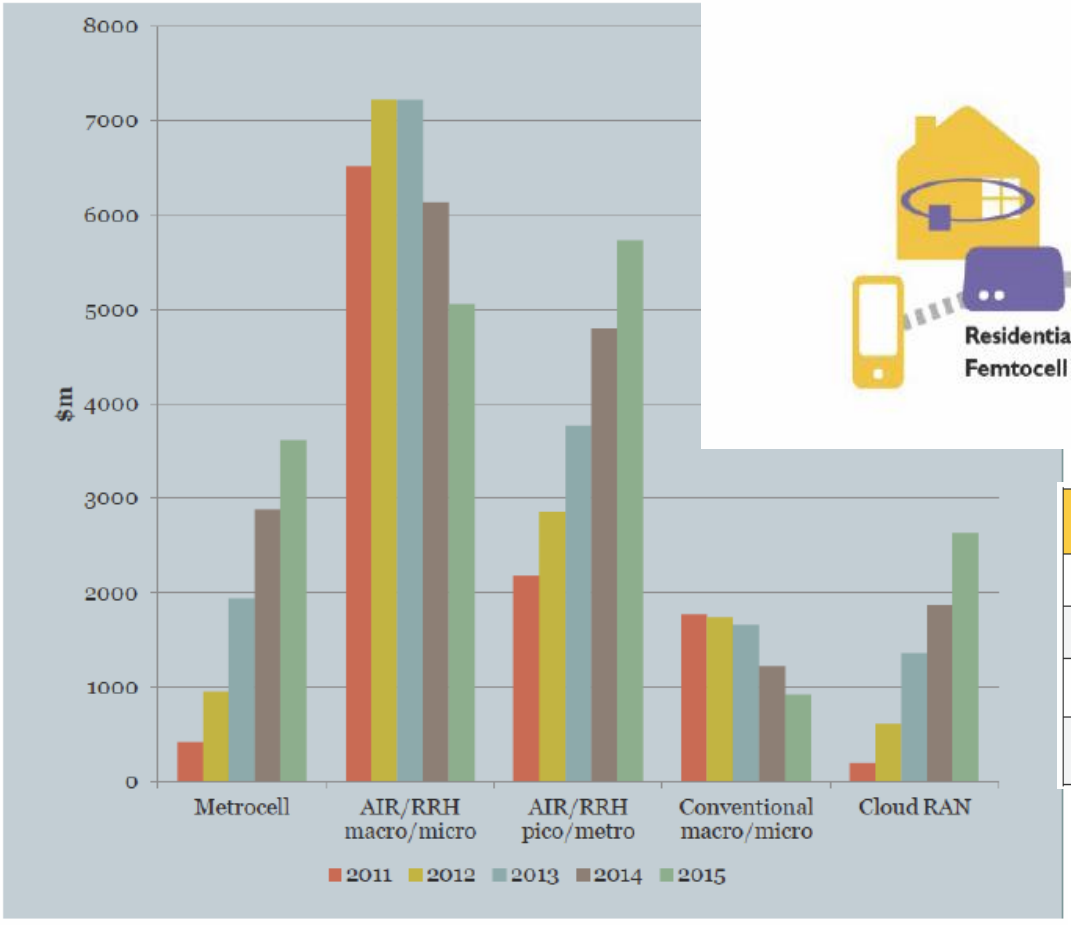


Small(er) cells





Technique	Capacity Gain
Frequency Division	5
Modulation techniques	5
Access to wider range of frequency spectrum	25
Frequency reuse through more cell sites	1600

Technology trend#1
Multiple Hierarchical Layers architecture or
the disappearing cell

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- Frequency reuse
- Discontinuous transmissions
- Handover

Single link single-user optimization

- CDMA
- Power control
- Turbo coding

Multiuser single-cell optimization

- OFDMA
- Advanced antenna technology (MIMO)
- **Relaying**
- **CoMP**

Multiuser multicell optimization

- **Multi- hierarchical CoMP &**
- **Multi- hierarchical Relaying**

GSM → UMTS → HSPA → LTE-(A)

System Concept Evolution

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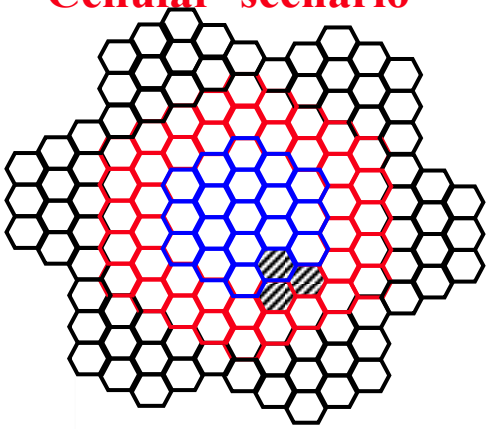
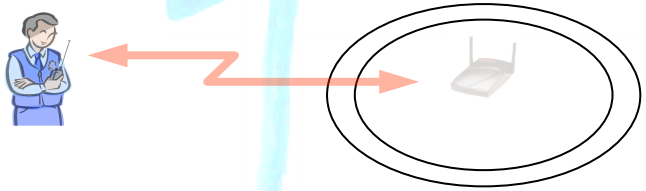
'Cellular' scenario

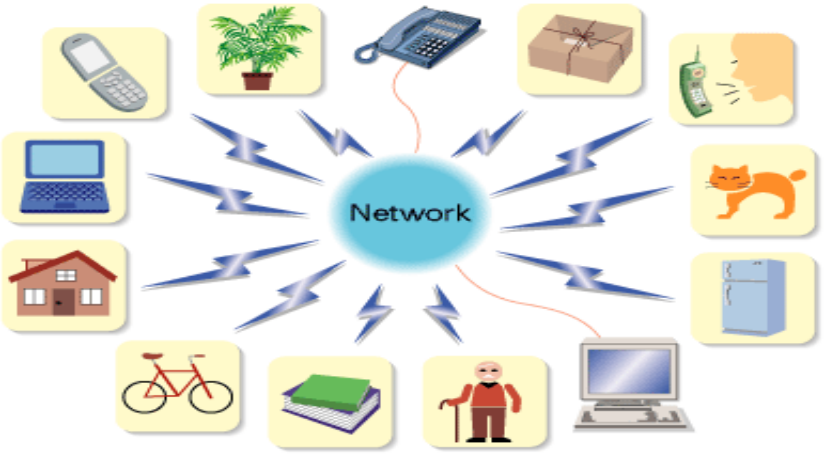


Single Link vs Single Cell vs Multicell optimization for peak / average / cell edge rate improvements

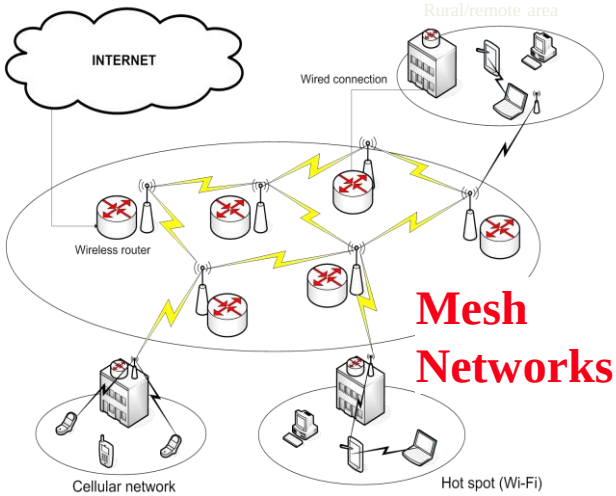
Open Access



Propagation constraints and lack of coordination create challenging coverage and interference scenarios



Cellular extended for M2M



Mesh Networks

Flexible deployment at the expense of coverage vs throughput vs delay tradeoff

Enabling Technologies

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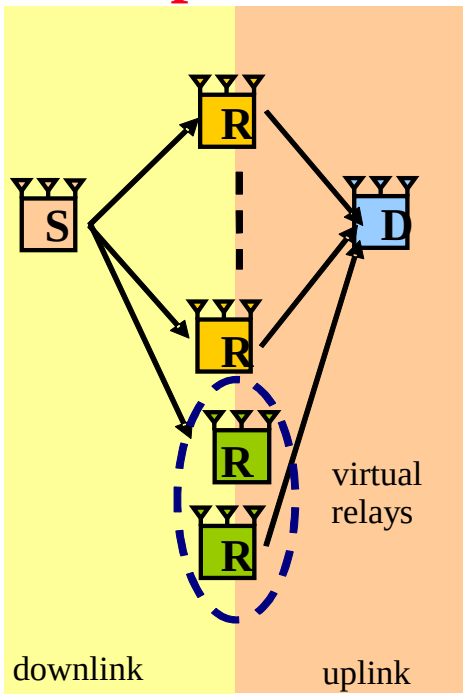
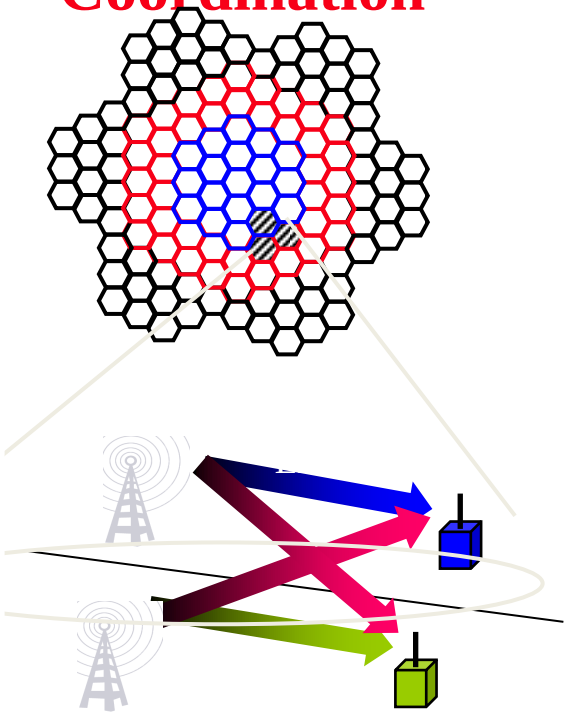
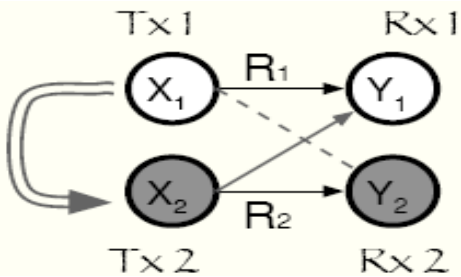
Cooperation



Coordination



Cognition



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Smartphones and Tablets….

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Growing Smartphone & Tablet

- Smartphones will outperform the overall market for mobile phones, growing at a compound annual growth rate (CAGR) of 24.9% for the period 2011-17 to reach 1.7 billion units, according to Ovum
- Worldwide media tablet sales to end users are forecast to total 118.9 million units in 2012, a 98 percent increase from 2011 sales of 60 million units, according to Gartner, Inc.

Demise of Cell Phone

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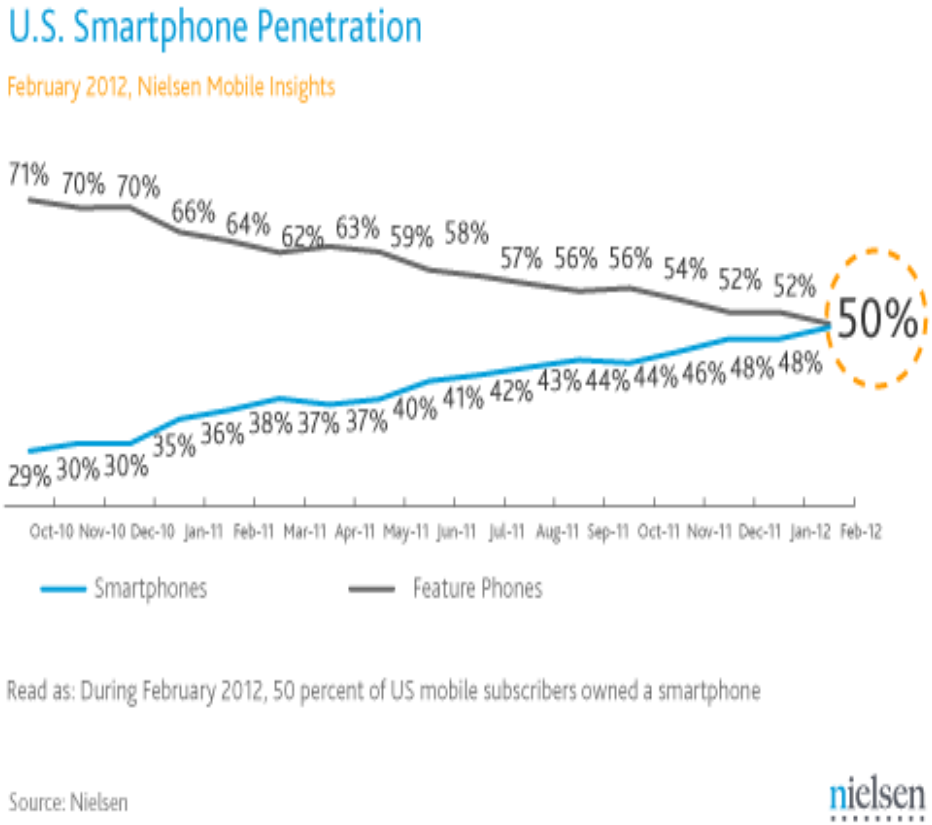
- Almost half (49.7%) of U.S. mobile subscribers now own smartphones, as of February 2012. According to Nielsen, this marks an increase of 38 percent over last year; in February 2011, only 36 percent of mobile subscribers owned smartphones.



Read as: During February 2012, 50 percent of US mobile subscribers owned a smartphone

Source: Nielsen

nielsen

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Security, Privacy and Trust….

Security & Privacy

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- Often when we discuss 2G, 3G, 4G …
  - We tend to forget security and privacy
  - WWRF has a group that addresses this
  - For the end user this is very important now as we begin to use wireless to exchange
    - Personal Info
    - Banking
    - Health Data

Security

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Canadian Anti-Fraud Centre

CAFC

Centre antifraude du Canada

FRAUD: RECOGNIZE IT. REPORT IT. STOP IT. LA FRAUDE: IDENTIFIEZ-LA. SIGNALEZ-LA. ENRAYEZ-LA.

Canada

Dates	April 2012	2011	2010
Fraud Dollar Loss	$24	$64	$58
ID Theft & Complaints – Dollar Loss	$5	$13	$9

- All $ in Millions

Privacy By Design

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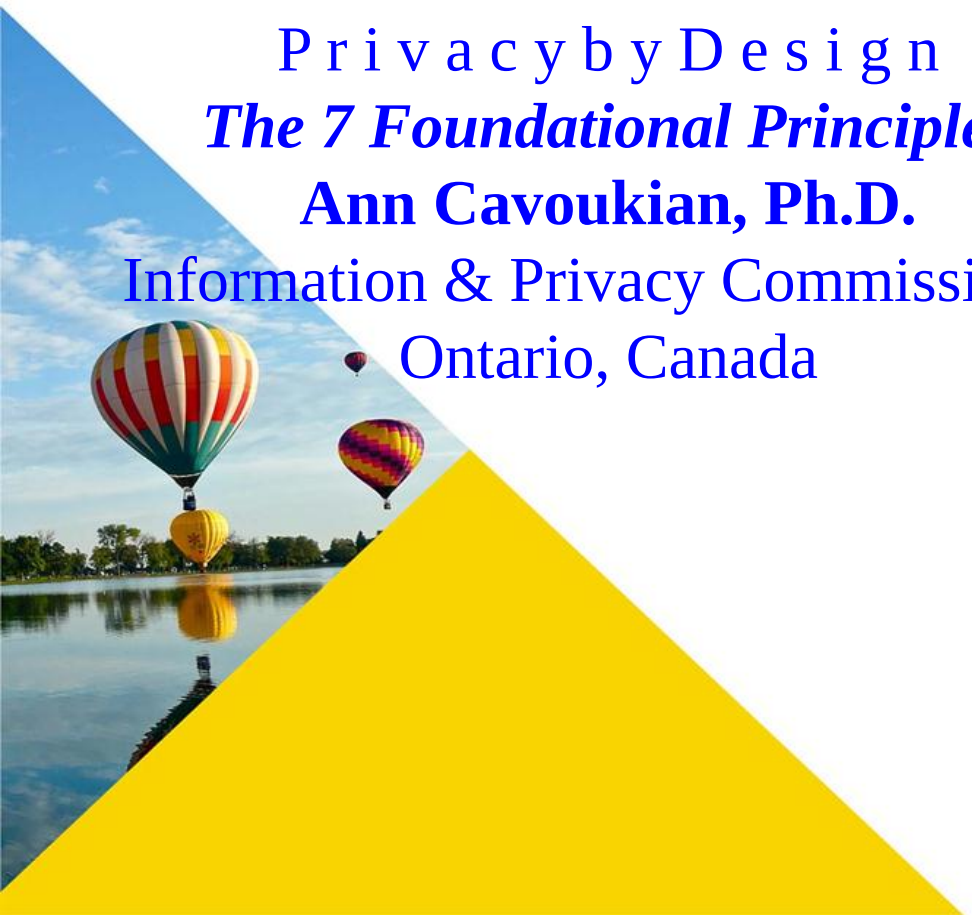
PbD
www.privacybydesign.ca

P r i v a c y b y D e s i g n

The 7 Foundational Principles

Ann Cavoukian, Ph.D.
Information & Privacy Commissioner
Ontario, Canada



- ***Proactive*** not Reactive; ***Preventative*** not Remedial
- Privacy as the ***Default Setting***
- Privacy ***Embedded*** into Design
- Full Functionality — ***Positive-Sum***, not Zero-Sum
- End-to-End Security — ***Full Lifecycle Protection***
- ***Visibility*** and ***Transparency —*** Keep it ***Open***
- ***Respect*** for User Privacy — Keep it ***User-Centric***

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Spectrum….

Spectrum Demand

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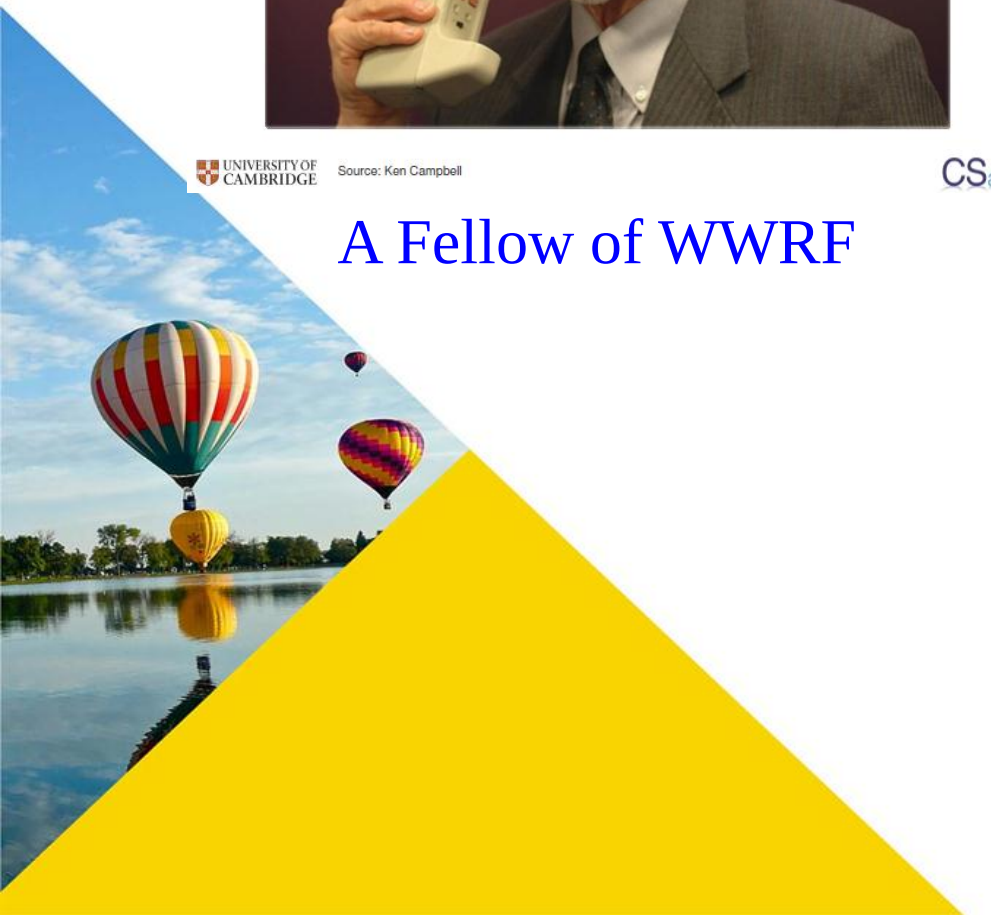
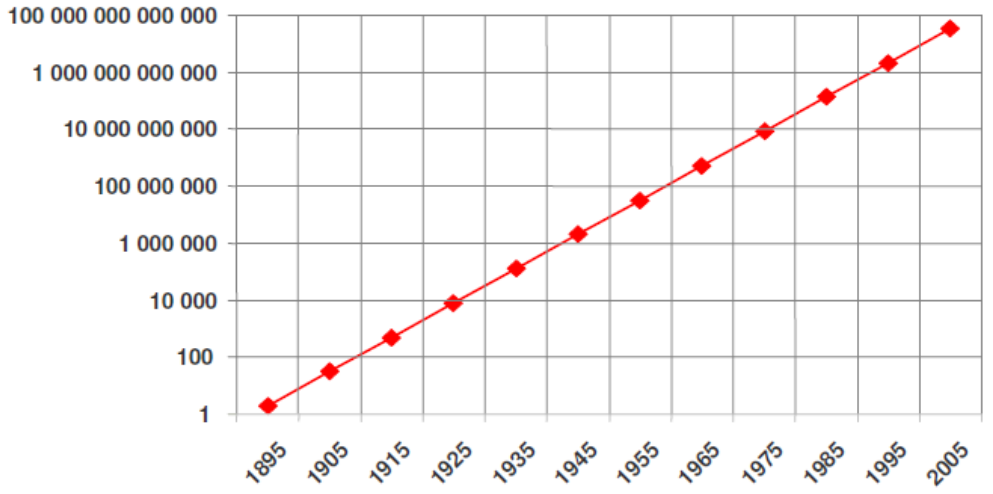
Marty Cooper

UNIVERSITY OF CAMBRIDGE Source: Ken Campbell CSaP



A Fellow of WWRF

Cooper's Law: Use of spectrum is doubling every 30 months



Source: ArrayComm, Martin Cooper

UNIVERSITY OF CAMBRIDGE CSaP

Global Spectrum Demand Forecast 2010 - 2020 (Australia)

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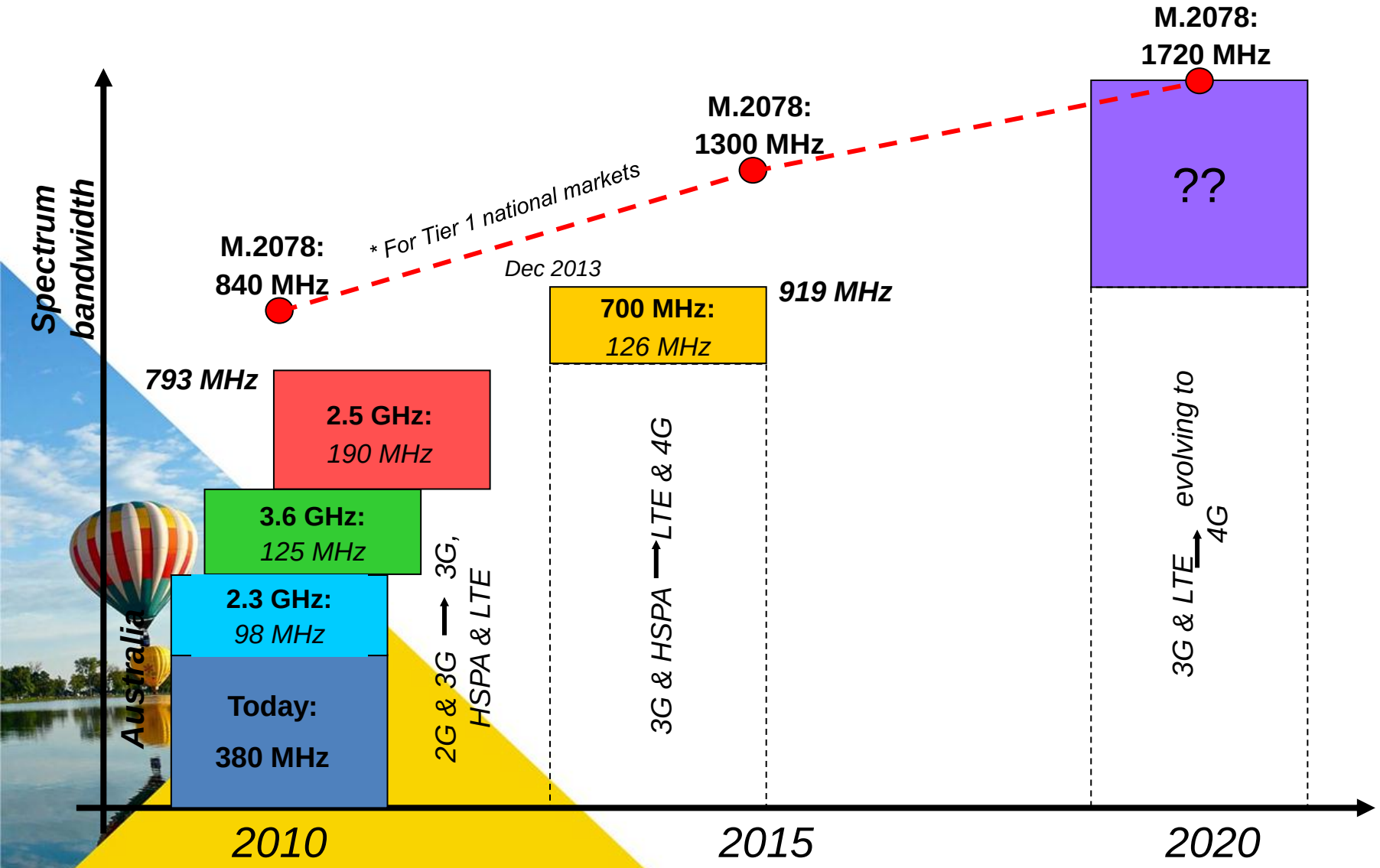

Source: ITU-R Report M.2078 (2007) Demand Forecast 2010-2020/ Austrlian mobile Telecommunications Association

Yesterday's Computers Filled Rooms..

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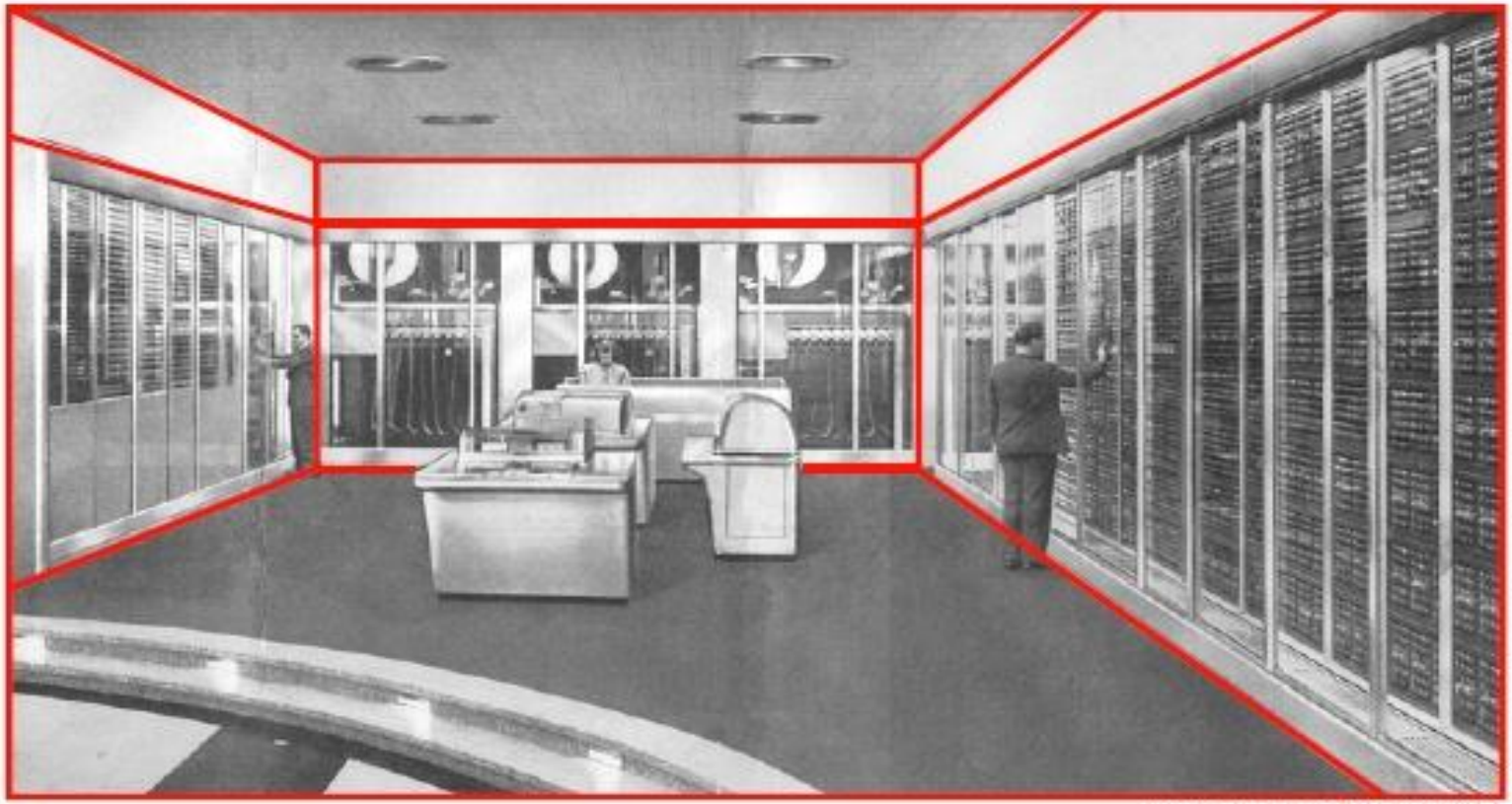

Source: Prof. F. Mattern, ETH Zürich

..So Will Tomorrow's

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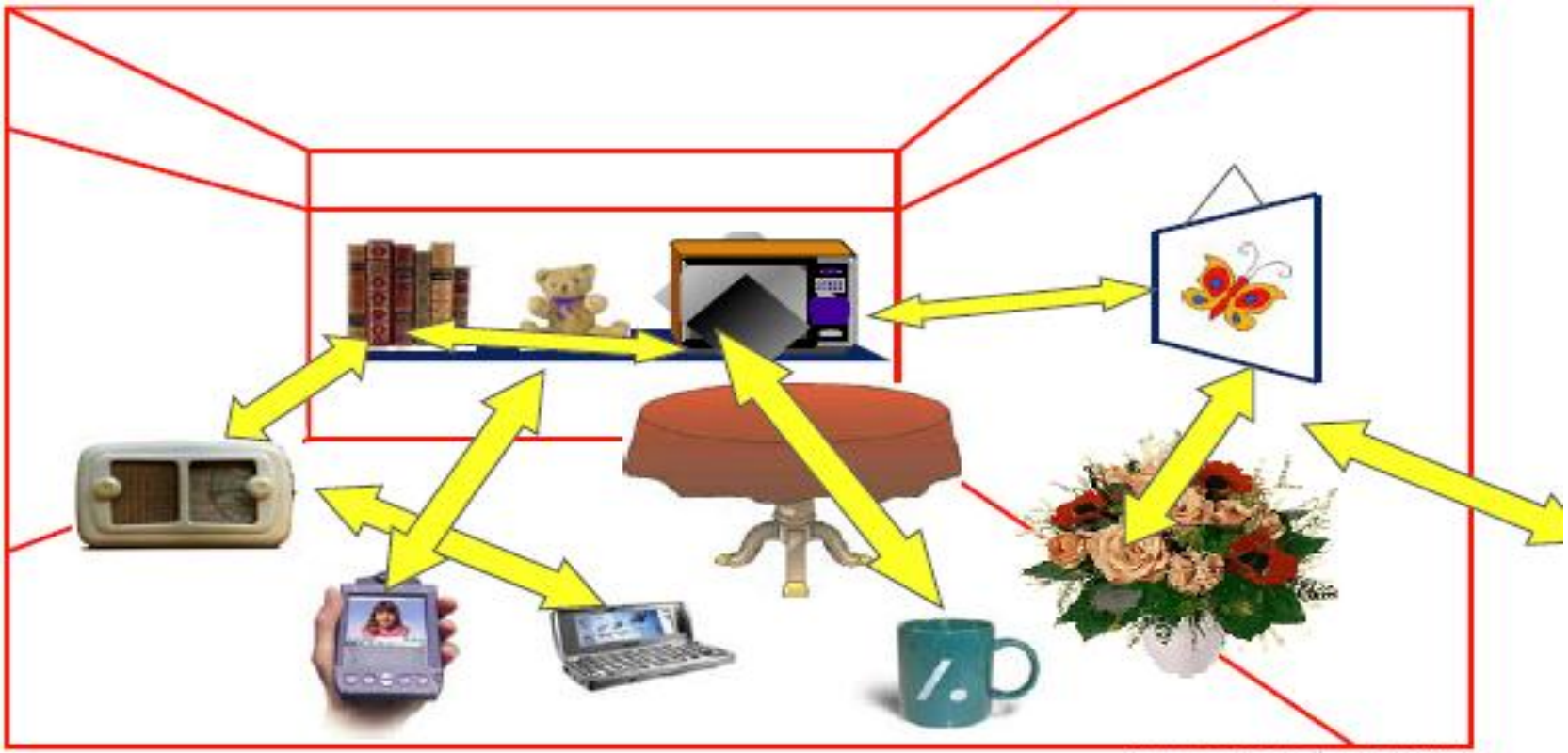

Source: Prof. F. Mattern, ETH Zürich

From Ubiquitous Computing and Pervasive Communications to the Internet of Things

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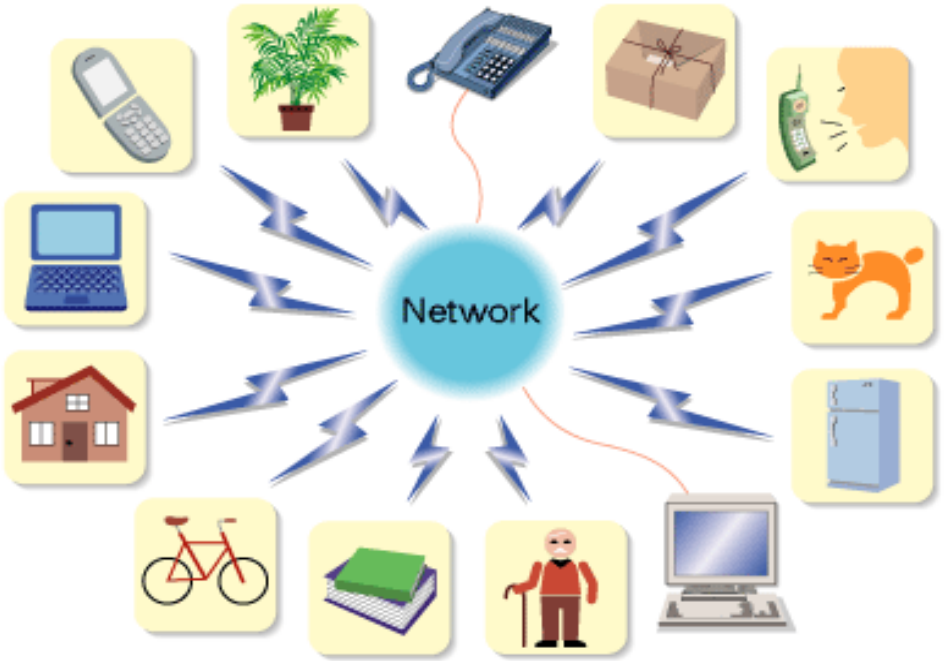
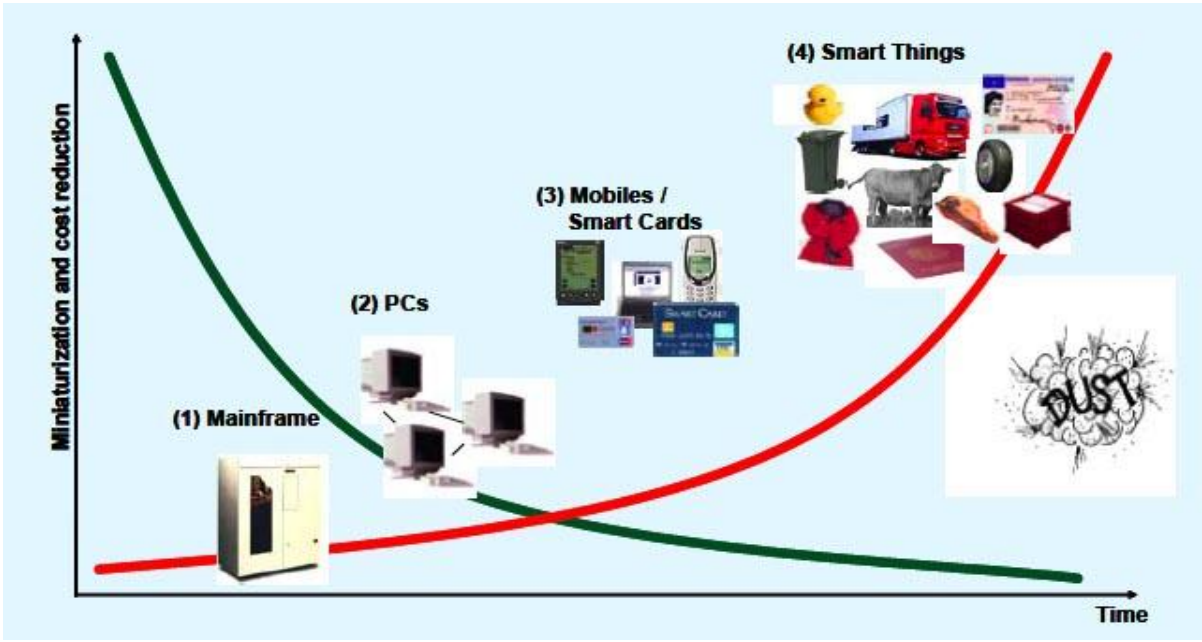


Ubiquitous computing will enable diverse wireless applications, including monitoring of pets and houseplants, operation of appliances, keeping track of books and bicycles, and much more.



"The Internet of Things is a description of a not-too-distant future time, where everyday objects, rooms and machines have sensors and can "communicate" about themselves and with each other."
(Prof. Elgar Fleisch)

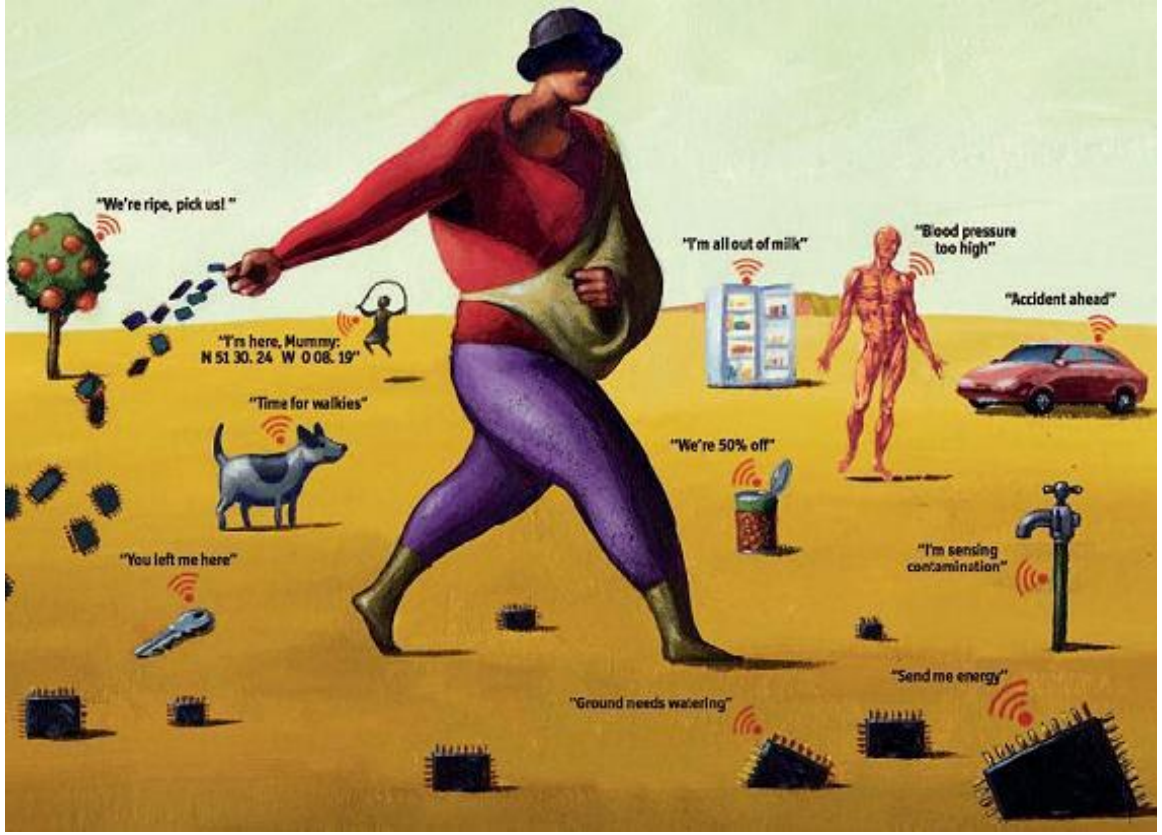
"*Things that think want to link*", Nicholas Negroponte(MIT)

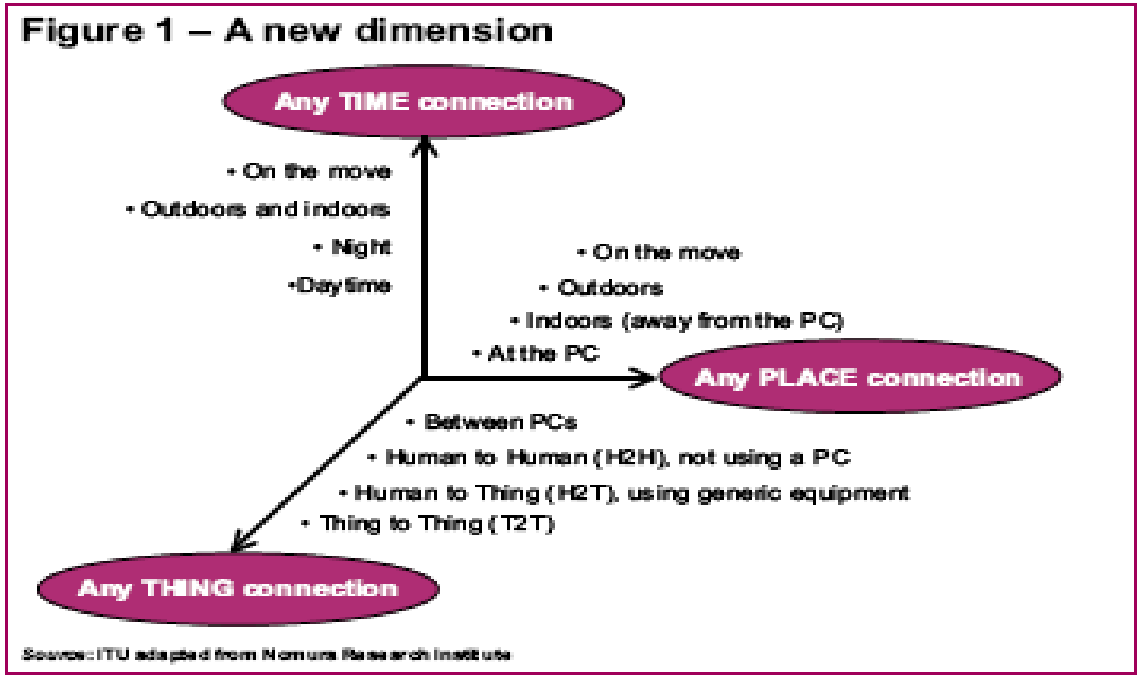
Technology trend#2
Internet of Things or
the disappearing technology

Wireless Sensor Networks interact with the physical world in the IoT

Potential applications include:

- Industrial/building automation
- Smart office
- Smart home
- eHealth
- Environmental monitoring
- Retail and logistics
- Biometrics for security
- …





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Cloud Computing, Virtualization and Analytics…

Cloud Computing

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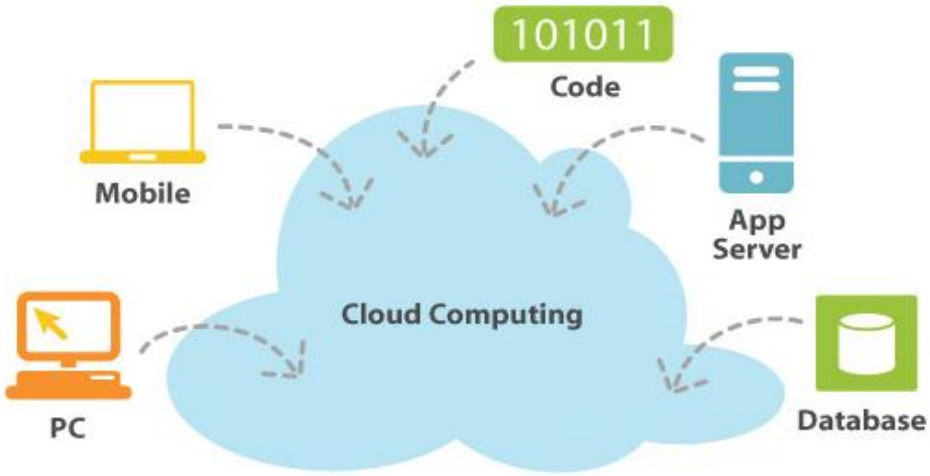

SaaS
Software as a Service

Email
CRM
Collaborative
ERP

CONSUME

PaaS
Platform as a Service

Application Development
Decision Support
Web
Streaming

BUILD ON IT

IaaS
Infrastructure as a Service

Caching
Legacy
File
Networking
Technical
Security
System Mgmt

MIGRATE TO IT

Distributed versus Centralized network architectures inspired by the Cloud (C-RAN)

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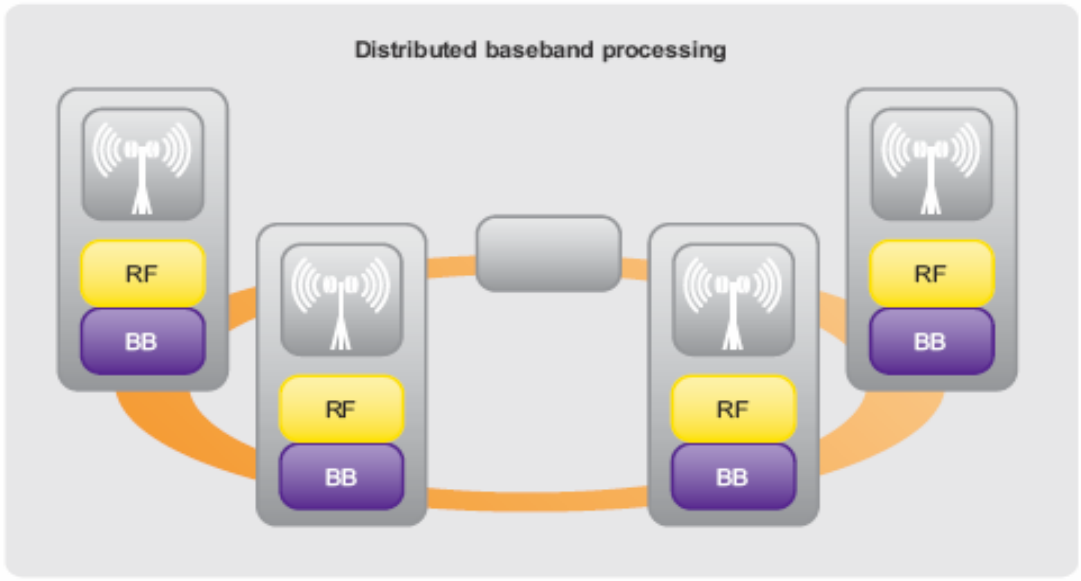

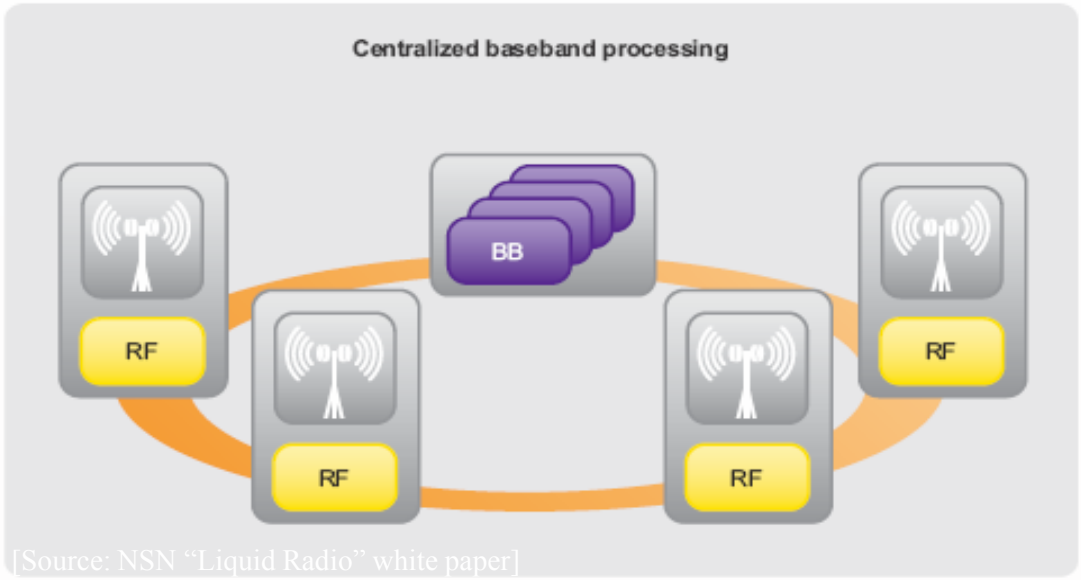

[Source: NSN "Liquid Radio" white paper]

Technology trend#3
Distributed versus centralized or *the rising Clouds*

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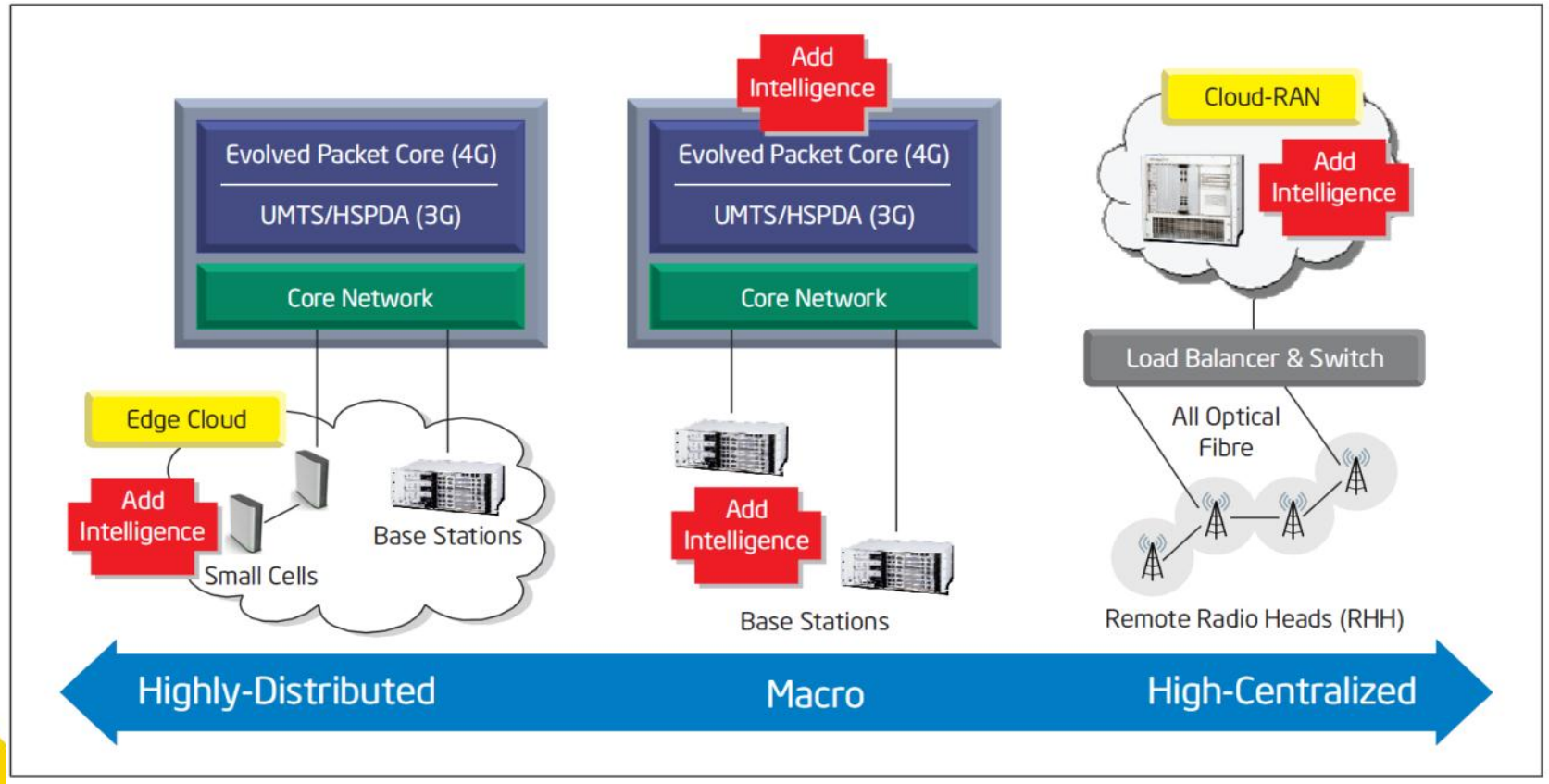

System concept..
..on the cloud

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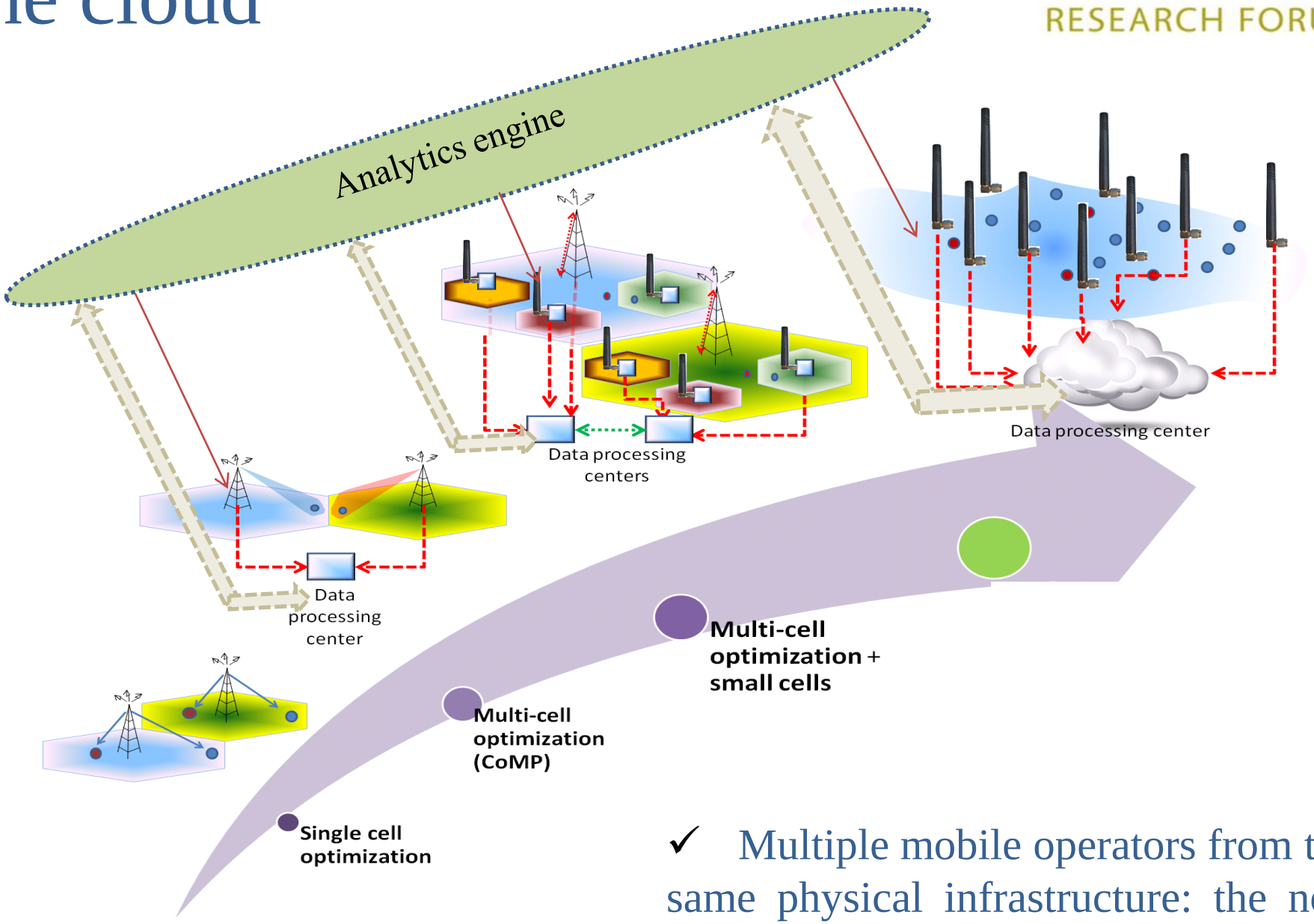

✓ Multiple mobile operators from the same physical infrastructure: the notion of virtualized cloud computing & SDN

Technology challenges

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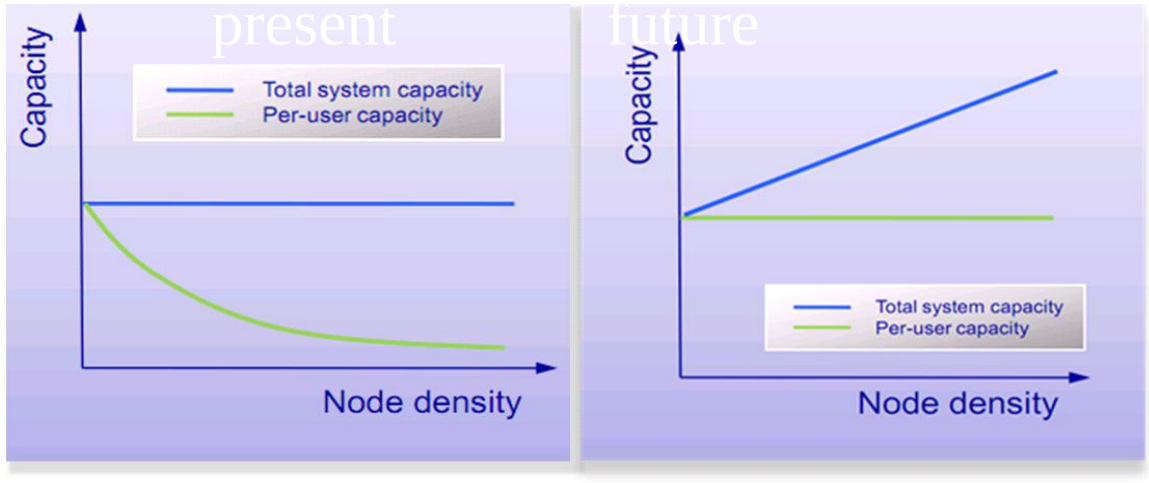
Cellular challenges:

- Manage huge number of nodes: *interference management*, *resources allocation*, *aggregation*
- Data rates may be rather low but delay sensitivity may vary
- Energy efficiency, often too stringent constraints
- Large dynamic range of delay constraints

M2M challenges:

- Large dynamic range of delay constraints
- Security
- Lack of unified standardization approach



Promising research directions and critical technology innovations

Advance resource management:

- Cross layer design
- Scheduled versus random or scheduled + random access?

Balancing centralized and distributed control:

- Centralized deployment concepts with Cloud-based architectures
- Augmentation of the wireless world intelligence with SON coordination, autonomics, cognitive networking

Efficient design and use of feedback signaling:

- Hierarchical feedback schemes
- Optimal exchange of contextual information among different layers

Conclusions and the way ahead

- Services, usability, and trillions of devices drive the wireless world beyond 2020
- Re-invent the network architecture towards a dense ‘user-centric’ network of low-complexity antenna units empowered by the cloud
- Jointly optimize the access and backhaul parts of the network, which may need to be seen as one merged architecture
- Multiple hierarchical layers functioning seamlessly across different radio access technologies, while minimizing interference and power consumption
- Diminish the need for system planning, configuration, and operation
- Highly efficient predictive system optimization methods

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Thank you!

For more information on WWRF and how to become a member
visit www.wwrf.ch