
Dr. Sudhir Dixit
WWRF Vision Committee Chairman &
Vice Chair Asia Pacific

Director, Hewlett-Packard Laboratories
Bangalore, India
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
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

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
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

• 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

Dr Martin Cooper  USA
Dr João da Silva  Spain
Prof Ashok Jhunjhunwala  India
Mr Håkan Eriksson  Sweden
Dr Young Kyun Kim  Korea

Madame Li Mofeng  China
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
Services and User Experiences
In Next 10 Years....
Services
In Next 10 Years…. 

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

- **Input**
  - Limited Speech
  - Touch

- **Interpretation**
  - Hand gestures
  - Physical environ

- **Context**
  - Multiple inputs
  - Task
  - User(s)

- **Fusion & Adaptation**

- **Experience design**

- **Living Room, Collaborative Data Walls**

- **Mobile devices**

- **Media PCs**
Network Architecture....
Communications become pervasive

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.
IMT-Advanced/4G

- Comprehensive and secured all-IP mobile broadband
- Serve all types of client devices: laptop/tablet computers, wireless modems, smartphones, embedded wireless 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)!!
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

- **WWAN**: regional, international (e.g., GPRS, UMTS, HSDPA, satellites)
- **WMAN**: metropolitan area (e.g., WiMax)
- **WLAN**: campus/office-based
- **WPAN**: in-house (e.g., BT, ZigBee, UWB)

Different coverage & speed for a mobile user.
Small(er) cells

Operator expenditure on small cell infrastructure

<table>
<thead>
<tr>
<th>Technique</th>
<th>Capacity Gain</th>
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<tbody>
<tr>
<td>Frequency Division</td>
<td>5</td>
</tr>
<tr>
<td>Modulation techniques</td>
<td>5</td>
</tr>
<tr>
<td>Access to wider range of frequency spectrum</td>
<td>25</td>
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<tr>
<td>Frequency reuse through more cell sites</td>
<td>1600</td>
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</tbody>
</table>
Technology trend #1
Multiple Hierarchical Layers architecture or
the disappearing cell

- Frequency reuse
- Discontinuous transmissions
- Handover

- CDMA
- Power control
- Turbo coding

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

- Multi-tier hierarchical Relaying

- GSM
- UMTS
- HSPA
- LTE-(A)
System Concept Evolution

Open Access

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

‘Cellular’ scenario

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

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

Cellular extended for M2M
Enabling Technologies

Cooperation

Coordination

Cognition
Smartphones and Tablets....
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

- 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.

U.S. Smartphone Penetration
February 2012, Nielsen Mobile Insights

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

Source: Nielsen
Security, Privacy and Trust....
• 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
<table>
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<tr>
<th>Dates</th>
<th>April 2012</th>
<th>2011</th>
<th>2010</th>
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<tr>
<td>Fraud Dollar Loss</td>
<td>$24</td>
<td>$64</td>
<td>$58</td>
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<tr>
<td>ID Theft &amp; Complaints – Dollar Loss</td>
<td>$5</td>
<td>$13</td>
<td>$9</td>
</tr>
</tbody>
</table>

• All $ in Millions
Privacy By Design

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**
Spectrum....
Spectrum Demand

Marty Cooper

A Fellow of WWRF

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

Source: ArrayComm, Martin Cooper
Global Spectrum Demand Forecast 2010 - 2020 (Australia)

Today:
- 380 MHz
- 3.6 GHz: 125 MHz
- 2.5 GHz: 190 MHz
- 700 MHz: 126 MHz

M.2078:
- 840 MHz
- 793 MHz
- 1300 MHz
- 1720 MHz

2010
- 2G & 3G
- HSPA & LTE

2015
- 3G & HSPA
- LTE & 4G
- 700 MHz: 126 MHz
- 919 MHz

2020
- M.2078:
  - 1720 MHz

Yesterday's Computers
Filled Rooms..
So Will Tomorrow's
From Ubiquitous Computing and Pervasive Communications to the Internet of Things

“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
- ...
Cloud Computing, Virtualization and Analytics...
Cloud Computing is needed to address the dynamic, exponentially growing demands for real-time, reliable data processing in the Internet of Things.
Distributed versus Centralized network architectures inspired by the Cloud (C-RAN)

[Source: NSN “Liquid Radio” white paper]
Technology trend#3
Distributed versus centralized or the rising Clouds
System concept..  
..on the cloud

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

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, autonemics, 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
Thank you!

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