LTE Futures

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Dinner Talk
Next Generation Mobile Networks - NGMN - Partner Forum
14 April 2010
Turin, Italy
Abstract

• Starting with the early 1990’s, almost from nothing, a set of global networks were created with stunning speed and equally stunning commitment of capital
  - These networks and servers reach over 3 Billion people on the planet
  - They account for well over half the business activity of service providers
  - Mobile services involve components touching many technologies, which are on exponential trajectories
  - We have seen an explosion of devices, services, and applications
  - Consumers and users of these services have often surprised us with what they will spend money on
  - The impact on people’s lives and institutions has been profound
Abstract (cont’d)

- We are about to embark on the next chapter of the mobile revolution where the global impact on the way we live and interact with each other will be even more dramatic
  - New unifying infrastructure build around LTE and IP
  - Extension to direct communication between devices
  - A driving force in economic growth around the world affecting all industries, governments, and individuals
  - Change in people’s life styles
  - Changes in who the players are for us in the industry
  - A global shift in where research and development will occur
# Broadband Ecosystem

## Portion of Broadband Network

<table>
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<tr>
<th>Function</th>
<th>Physical Network</th>
<th>Network Elements</th>
<th>Management Systems</th>
<th>Service Delivery Systems</th>
<th>Content Creation &amp; Delivery</th>
<th>End-User Equipment</th>
<th>End-to-End System</th>
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<tr>
<td>Interoperate</td>
<td>University R&amp;D</td>
<td>Commercial R&amp;D</td>
<td>Standards</td>
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<tr>
<td>Maintain &amp; Upgrade</td>
<td>Standards</td>
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</tbody>
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## Service Architecture

- University R&D
- Commercial R&D
- Venture Capital

## Function

- Automated
- Robustly
- Securely
- Scalably
- Adaptably
Agenda

- Trends and Projections
  - Adoption Curves (long term views)
  - Wireless Use Patterns - History & Future
  - Global Penetration
  - Infrastructure

- Technologies
  - User Equipment
  - ICT
  - Roadmaps

- Digitization - Beyond 4G
  - Stages and Evolution
  - The 5G and 6G World
  - IP as an Integration Enabler
  - Anticipation
  - Explosion of Services

- Questions & Answers
Agenda

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- **Questions & Answers**
Adoption: US Wireless Subscribers

Estimated Subscribers

Mid-Year 2009 Estimated Wireless Subscribers
Up 13.9 Million from June 2008

Source: CTIA
Adoption: Consumer Adoption Curves, US

Source: Technology Futures, Inc.

- Radio
- Pay Cable
- Online
- Television
- VCR
- Cell phone
- Color TV
- CD
- Broadband
Wireless Adoption Milestones

- 2007: Wireless-only households exceed wireline-only households in US
- 2008: ICT* is 7% of US GDP and still growing!
- 2009: Half the world uses cell phones

* Information-communication-technology producing industries (ICT): Consists of computer and electronic products; publishing industries (includes software); information and data processing services; and computer systems design and related services. (US BEA)
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Questions & Answers
Wireless-only Households in Canada and the US

Source: CRTC: Convergence Policy, Policy Development & Research, Feb 2010
Demographic Groups Most Likely to be Cellular Only

Source: Mediamark Research Inc. Survey of the American Consumer (Wave 56)
Percentage of US Households without Landline Telephones

Percentage of U.S. Households Without Landline Telephones

Source: National Health Interview Survey data
Projected North American Business Use of Landline and Cell Phones

MILLIONS OF USERS

Data: Gartner
Phone Behavior by Age in Single-Person Households

Source: Mediamark Research Inc. Survey of the American Consumer (Waves 56)
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- Questions & Answers
Global Trends: World View over 14 Years

- 153 countries, 1995 - 2008
  - Fixed Telephone Lines per 100 population
  - Mobile Subscriptions per 100 population
  - Internet Users per 100 population
  - Broadband Subscribers per 100 population

Data source: ITU World Telecommunication Indicators 2010
Global Trends – Fixed Telephone Lines

Fixed Telephone Lines

Data source: ITU World Telecommunication Indicators 2010
Global Trends

Fixed Telephone Lines per 100 pop. in 2008

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends

Fixed Telephone Lines per 100 pop. in 2008

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends – Mobile Subscriptions

Mobile Subscriptions

Data source: ITU World Telecommunication Indicators 2010
Global Trends

Mobile Subscribers per 100 pop. in 2008

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends

Mobile Subscribers per 100 pop. in 2008

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends – Internet Users

Data source: ITU World Telecommunication Indicators 2010
Global Trends

Internet Users per 100 pop. in 2008

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends

Internet Users per 100 pop. in 2008

Size shows population

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends – Broadband Subscribers

Broadband Subscribers

Data source: ITU World Telecommunication Indicators 2010
Global Trends

Broadband Subscribers per 100 pop. in 2008

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends

Broadband Subscribers per 100 pop. in 2008

Size shows population

Source: Telcordia. Data: ITU World Telecommunication Indicators 2010
Global Trends – Over 14 Years

Continuing...

Data source: ITU World Telecommunication Indicators 2010
Global Trends: Adoption by Developing Nations

Developing Nations and Profitable Data Revenue Models Keys to Driving Growth

Source: Wireless Communications - Q2 2006 Topical
Global Trends: Wired vs. Wireless Crossover

2002 was the turning point

Source: International Telecommunication Union

Fixed lines
Mobile

1.75 billion mobile
1.2 billion fixed

billion worldwide
ARPU -- Data as % of Total, by Country

Source: Chetan Sharma 2008
Wireless Data ARPU for Major Operators Worldwide

Source: Chetan Sharma 2008
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- **Questions & Answers**
US Mobile Antenna Sites – 1982 to 2010

Source: Telcordia Technologies. Data: FCC

Pre-cellular
US Mobile Antenna Sites – 1982 to 2010

1996
(red = new this year)
US Mobile Antenna Sites – 1982 to 2010

Source: Telcordia Technologies. Data: FCC
Cellular Sites in the US – 1985-2009

Reported Cell Sites in Service are Up 11.5% Year-to-Year

Source: CTIA
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Mobile Transformations
The 5 Year Cycles

- Carphones (mid-1980s)
- Handsets (early-1990s)
- Digital (mid-1990s)
- Content (2002-2007)
- Internet (2007-2010)

Source: IDC
Mobile Transformations – Looking Forward

- iPhone Launch: June 2007
- Android Announced: Jan. 2008
- LTE Becomes 4G Standard
- Apps Store 500M+: Dec. 2008

Source: IDC
Cellphone Milestones

- **First TV ad**
- **Motorola “brick”**
- **AMPS trial In Chicago**
- **Prototype Patent 1975**
- **Concept: 1946 1966**
- **250 billion text msgs in 2001**
- **First Smartphone -- touch screen, pager, calculator, calendar, fax, e-mail**
- **Polyphonic Ringtones**
- **Texting Vibrates, Flips open**
- **Sat-Phone**
- **StarTAC**
- **Treo**
- **iPhone**
- **BlackBerry**
- **Android**
- **LG**
- **Motorola**
- **Sony-Ericsson**
- **Nokia**
- **iDEN digital**
- **Sharp - first CameraPhone**
- **GPRS digital**
- **Bluetooth**
- **Wi-Fi**
- **E-911**
- **GPS**
- **Games**
- **Mp3 player**
- **Open Source OS**
- **App Store**
- **Number portability**
- **Wi-Fi-cellular handoff**
- **Wi-Fi-cellular hybrid**
- **1.9 trillion text msgs in 2007**
- **500 billion text msgs in 2004**
- **2002: More mobile subs than wired, worldwide**
- **2003: More mobile subs than wired, worldwide**
- **2006: More mobile subs than wired, worldwide**
- **2008: More mobile subs than wired, worldwide**
- **2009: More mobile subs than wired, worldwide**
- **2010: More mobile subs than wired, worldwide**

- **Prototype**
- **Concept: 1946 1966**
- **1973**
- **1983**
- **1984**
- **1985**
- **1986**
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Digitization – Energy Efficiency

COMPUTATIONS PER KILOWATT-HOUR

Vacuum-tube Era  Transistor Era  Microprocessor Era

CURRENT LAPTOPS  SICORTEX SC5832
DELL DIMENSION 2400
GATEWAY P3 (733 MHz)
DELL OPTIPLEX 6XI
IBM PS/2 E & SUN SS1000
INTEL 486/25 & 486/33
MACINTOSH 128K
IBM PC
IBM PC-AT
IBM PC-XT
CRAY 1
APPLE IIe
COMMODORE 64
COMPUTATIONS PER KILOWATT IF THEY FOLLOWED MOORE'S LAW, DOUBLING EVERY TWO YEARS
Shape of the Industry & Underlying Infrastructure: Network Layers

global

national

regional

metro

local
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Technology Roadmap
Cellular Technology Evolution: 2G, 3G, 4G...

2G
- IDEN
- WIDEN
- CDMA
- 9-05A
- 9-05B
- GSM
- GSM/GPRS
- PDC
- TDMA

3G
- EDGE
- WCDMA
- CDMA2000
- 1xEV-DO
- 1xEV-DOa
- 1xEV-DOb
- HSDPA
- HSUPA
- HSPA+
- TD-SCDMA
- 802.16d
- 802.16e
- 802.11n & Mesh
- 802.20 (CFDM)

4G
- LTE, UMB, 802.16n

Latency:
- >200ms
- 100-200ms
- <100ms
- <20ms

Data rate:
- 20 kb/s
- ~500 kb/s
- up to 7.2 Mb/s
- up to 50 Mb/s

Source: Deutsche Bank (March 2008)
Future Wireless Landscape

- Dominated by LTE with WiMAX playing a secondary role
- Two largest North American operators (Verizon and AT&T) will migrate towards LTE
Future Wireless Landscape

- Expect significant overlap and coexistence in migration path
  - LTE will coexist with Rev-A and with HSPA variants for some time
  - Multi-mode and backward compatible devices
- Expect deployment delays
  - Industry generally says “2010” timeframe
  - Major hurdle may be backhaul to serve more base stations with greater bandwidth
  - Patents, Patents, Patents.
Things to Expect by 2015

- Near nationwide deployment in US with all top metro areas covered by a 4G technology
- Backwards compatible terminals that can failover to 3G technologies
- All-IP core networks and greater move towards mobile VoIP
- More consumer electronics with embedded 3G/4G capabilities.
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## Stages of Wireless Evolution

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<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Whom can I reach, and how quickly?</td>
</tr>
</tbody>
</table>
| II    | When can I reach them?  
Time shifting - messaging, email & voicemail |
| III   | How much information can I exchange, and with what circle of recipients?  
Interoperable applications |
| IV    | Which applications make sense over which networks - LANs, WANs & broadband |
| V     | Can I combine all my handheld devices into one? |
Stages of Wireless Evolution

- **Stage VI** - How can I access data & information? Initial digitization of information & creation of browser functions
- **Stage VII** - How many applications can I use on my wireless handset?
- **Stage VIII** - How can I use the same applications on multiple devices? - Home, Office, PC, Smartphone...
- **Stage IX** - How can I get services that anticipate what I need?
- **Stage X** - How can I get anything, any place, any time?

- And always... How can I get more for less?
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- **Questions & Answers**
What Will 5G & 6G Look Like?

- Mobility
- Ubiquity
- Physical Sciences
- Speed
- Bandwidth
- Immediacy
- Relevance

3G and 4G Networks

Voice Wireless, News Text

Video on the Spot, Alerts

Anticipation

5G and 6G Service Networks

Voice Fixed

3D

Video On Demand, Movies

Computer Science

Information Science
5G and 6G Services

- **Immediacy**
  - Voice & Texting
  - Emergency Response
  - News
  - Financial Info
  - Gaming
  - Selected Entertainment Products
  - Streaming Audio / Video
  - ...

- **Anticipation**
  - Social networking
  - Location Based Services
  - Opportunity Driven Marketing
  - Scheduling / Alerts
  - Advanced Healthcare
  - Telematics
  - Financial Services
  - Diagnostics / Prognostics
  - ...
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- **Questions & Answers**
IP Leading to a Fully Packetized Future

- **Information / data / content / media - major drivers for applications**

1. First, everything must be indexed for searching (now underway)

2. Once digitized, indexed, objectified, everything will be made available on a wireless handset, through over-the-top applications (voice is just one service of many)

3. What’s now available to techies, the rest of the world wants

4. Google’s success: They’re the ones doing the mash ups for the masses
Convergence, Cooperation, Conflict?

- Telecom, broadcasting media, and Internet - all converging & competing in the same content delivery space
- Result is collision of world views, business models (e.g. ad-based vs. subscription-based)
- Operators, device vendors, IT and media firms, chipset vendors - all jostling for dominance
- User experience emerges as new battleground
- Leading players seek to acquire core assets they deem critical for success in converged space
- Seek to lead, and shape, necessary eco-system
- Colliding industries, “creative gales of destruction”, force players to experiment with new business models

Source: IDC
Traffic Impact of Introducing Packet-based Services
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  **Anticipation**
  - Explosion of Services

- Questions & Answers
Anticipation

- Transportation - Telematics
- Healthcare - Telemedicine
- Communications - Device-to-Device
Anticipation: Healthcare

- Healthcare - Telemedicine
  - Emergency response
  - Public health
  - Chronic disease management
  - Wellness
  - Remote patient-doctor interaction
Applications: Telemedicine

Emergency Response:

How to identify the emergency?
Gather relevant records?
Line up resources?
Get the patients to the right place?
Provide immediate intervention?

- Car accidents
- Falls
- Sports accidents
- Natural disasters
- Fire / explosion
- Medical conditions (heart attack, stroke, ...)

[Images of various emergency situations, including car accidents, falls, sports accidents, natural disasters, and medical emergencies.]

[Logo of Telcordia Technologies]
Applications: Telemedicine

Chronic disease management:

How to determine condition?
How to detect changes?
How to track patient actions?
How to respond?

- Patient monitoring
- Patient compliance
- Social network and support
- Diagnosis and case management
- Intervention
Anticipation: Transportation

- Transportation - Telematics
  - Safety
  - Convenience
  - Infotainment
  - Mobility
  - Sustainability
Applications: Telematics

Safety: How to avoid dangerous conditions?
How to prevent crashes?
How to mitigate accidents?

- Road condition notification
- Automatic response (braking for hazards)
- Side impact collision avoidance
- Accident notification and response
Applications: Telematics

**Mobility:** How to get from here to there?
How to do it faster?
How to do it greener?

- Multimode transportation
- Traffic routing
- Navigation
- Paratransit
- Emergency evacuation
Applications: Telematics

**Sustainability:** How to improve efficiency? How to interact with infrastructure? How to look after vehicles?

- Diagnostics and prognostics
- Load based signaling
- Road Maintenance (vehicle as sensor)
- Parking availability
- Mixed traffic management
- Incentive based systems
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  Explosion of Services

- Questions & Answers
5G and 6G World: Integration, Convergence

End-to-End Environment

Source: IDC
5G and 6G World: Market Driven by Applications

Applications unlike anything you’ve seen on a phone before.

Applications designed for iPhone are nothing short of amazing. That’s because they leverage the groundbreaking technology in iPhone — like the Multi-Touch interface, the accelerometer, GPS, real-time 3D graphics, and 3D positional audio. Just tap into the App Store and choose from thousands of applications ready to download now.

Browse the App Store in iTunes
5G and 6G World: Market Driven by Applications

Source: IDC

150,000 apps... And counting!
Digitization: 5G and 6G Services

- Services, Applications
  - Games
  - Bill pay
  - M-Commerce
  - Social networking
  - Store / restaurant finder
  - Turn-by-turn navigation
  - ... 

- Applications -- magnet for customers and revenue!
Digitization – IP as a Wireless Integration Enabler

- Over-the-Top Services
- App Stores
- Long-term, it’s all about services!

Source: IDC
Mobile Data Services Market: % Revenues by Segment Forecasts: India 2003-2012

Others include mobile commerce & mobile marketing / advertising

Source: Frost & Sullivan
Example: Telematics – Projected Growth in Navigation Devices (millions)

Source: Telematics Research Group 2007

OEM market share: 45% in 2005... 6% in 2012
Example: Telematics – Subscriber Base Growth

Source: Frost & Sullivan
Example: Telematics – Wireless Revenue Breakdown

Source: Frost & Sullivan
Operators Still Have (the) Key Assets!

- Network, backhaul
- Spectrum
- Customer relationships
- OSS / BSS
- Transaction-generated information
- Spatial coordinates, user location
- Most small developers still want ties with operators
- Service provider of last resort
- Brand and mind share
- Regulatory backing (after all is said, they build & operate critical social infrastructure)

Source: IDC
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- Questions & Answers
Discussion

It’s an Exciting World!

- Moving at an exponential pace
- Wireless is the future

“You ain’t seen nothing yet!”
Thank you!