Telecommunication Futures: A 360° View

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Setting the Stage

1. The ICT industry
2. Global trends
3. The role of technology
4. What will 5G & 6G look like?
5. The shape of the industry & the underlying infrastructure
6. Customers and institutions
7. Life for workers in telecommunications
8. Regulation and governance
9. Conclusion

Piscataway NJ – 5 Feb 2009 – 2
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Information & Communication Technology

- End-to-end ...
  - from the communications at the bottom of the stack
  - to media and applications at the top

- In the US, it’s 7% of GDP and still growing!
The ICT Industry

- Key ingredients

- Communications
- Storage
- Computing
- Software
- User interfaces

- Infrastructure
- Services
- Devices
- Media

- Data
- Information
- Knowledge
- Wisdom
- Decisions
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Global Trends: World View over 13 Years

- 153 countries, 1995 – 2007
  - Fixed telephone lines
  - Mobile subscribers per 100 population
  - Internet subscribers per 100 population
  - Broadband users per 100 population

Data source: ITU World Telecommunication Indicators 2008
Global Trends – Fixed Lines

Fixed Telephone Lines

Data source: ITU World Telecommunication Indicators 2008
Global Trends

Fixed Telephone lines per 100 pop. in 2007

Data source: ITU World Telecommunication Indicators 2008
Global Trends – Mobile Subscribers

Data source: ITU World Telecommunication Indicators 2008
Global Trends

Mobile Subscribers per 100 pop. in 2007

Data source: ITU World Telecommunication Indicators 2008
Global Trends – Internet Users

Data source: ITU World Telecommunication Indicators 2008
Global Trends

Internet Users per 100 pop. in 2007

Data source: ITU World Telecommunication Indicators 2008
Global Trends – Broadband Users

Broadband Users

Data source: ITU World Telecommunication Indicators 2008
Global Trends

Broadband Users per 100 pop. in 2007

Data source: ITU World Telecommunication Indicators 2008
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A “Livingston curve” showing the evolution of accelerator energy from 1930 until 2005. Energy of colliders is plotted in terms of the energy of particles colliding with a proton at rest to reach the same center of mass energy.
Role of Technology – Computing & Storage

Computing

- Grid Computing
- Autonomic Computing
- Blades
- Multicore

At constant cost!

IBM 360/370
1286/1386
Pentium
Pentium II
Pentium III
Pentium 4
Quad Core
Duo Core

Today

Storage

- Latent Semantic Indexing
- In-memory Databases

Areal Density (Mbits/in²)


Today
Role of Technology – Computing

Speed and Cost

MIPS


$M per MIP


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Role of Technology – Moore’s Law:
From single transistors to CMP
Role of Technology – Storage

Capacity and Cost

Role of Technology – Software

Programming Language Evolution

Software Quality by Industry

Model Driven Architectures
Policy Based Designs
Agents
Service Oriented Architectures

Languages, in decreasing order of verbosity

Lines of Code Per Function Point

Assembler
C
Java, C++
Perl

Range of Errors Per K lines of code

Auto
C&C
Military
Telecom
WWW

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Role of Technology – Software

Integration Level

- Single Functions
- Numerical Libraries
- Unix Software Tools
- Class Libraries
- Autonomous Software
- Web Services
- Agents

Year

Role of Technology – Software Complexity

Size of Linux Kernel across Releases

Source of data: www.Linux.org
Role of Technology – Networks & Interfaces

Networks
- Ad-hoc Networks
- OCDMA
- AutoRF

User Interfaces
- 6G Services
- Appliances

Performance vs. Time
- 1, 10, 100, 1000

Surface Area of Display
- CRT, Plasma
- Today

Access vs. Time
- 1940, 1960, 1980

Abstracted Image of Technology Evolution
Role of Technology – Content Delivery

Quantity and Cost (USA 1960 - 2009)

Cost of transmitting 1000 words (1972 dollars)

Trillion words transmitted per year

Radio

TV

CATV

Movies

Phone

Data Communication

FAX

Telegram

1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
0.001
0.0001

0.001¢
0.01¢
0.1¢
1¢
10¢
$1
$10
$100

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What will 5G & 6G look like?

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

Latency:  
- 2G: >200ms
- 3G: 100-200ms
- 4G: <100ms
- 5G & 6G: <20ms

Data rate:  
- 2G: 20 kb/s
- 3G: ~500 kb/s
- 4G: up to 7.2 Mb/s
- 5G & 6G: up to 50 Mb/s

Source: Deutsche Bank (March 2008)
What will 5G & 6G look like?
Another nG Roadmap

Source: mITF Roadmap, Wireless Week, 27-29.03.06 Yokosuka
What will 5G & 6G look like? – Research

3G and 4G Networks

• Mobility
• Ubiquity

Voice Wireless, News Text

Video on the Spot, Alerts

• Physical Sciences

Anticipation

• Speed
• Bandwidth

5G and 6G Service Networks

• Information Science

• Computer Science

• Physical Sciences

• Immediacy
• Relevance

Voice Fixed

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Shape of the industry & underlying infrastructure:
Network Layers

global

national

regional

metro

local
Shape of the industry & underlying infrastructure

Locations of cellular towers in the US
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Customers and Institutions

- Customers
  - Consumers
  - Small to mid enterprises
  - Corporate Enterprises
  - Government, state, local
  - Military
  - Education
  - Health care

- Service Providers
  - Supply chain of capabilities
- Original equipment manufacturers
  - Supply chain of components
- Media Industry
  - Creative talent
  - Advertising
- Support Infrastructure
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Life for workers in telecommunications

**People**
- Industry is global
- Change is a constant
- Roles, responsibilities, authority, culture

**Tools**
- Power applications
- Automation
- Devices
- Access
- Modes of interaction

**Processes**
- Open
- Visible
- Cross-connected
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Regulation and Governance

- Formal – regulatory
  - International
  - National
  - Local

- Standards
  - Codified
  - De facto
  - Consensus

- Markets
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Conclusion

ICT drives...
- Productivity
- Economic Activity
- New Social Structures
- Creation of Frameworks for Progress

It’s an Exciting World!
- Moving at an exponential pace
- Engineers are building the future

“\textit{You ain’t seen nothing yet!”}