Future of radio systems - evolution or revolution

Dr. Kari Pehkonen

Head of Systems Research

Nokia Technology Platforms

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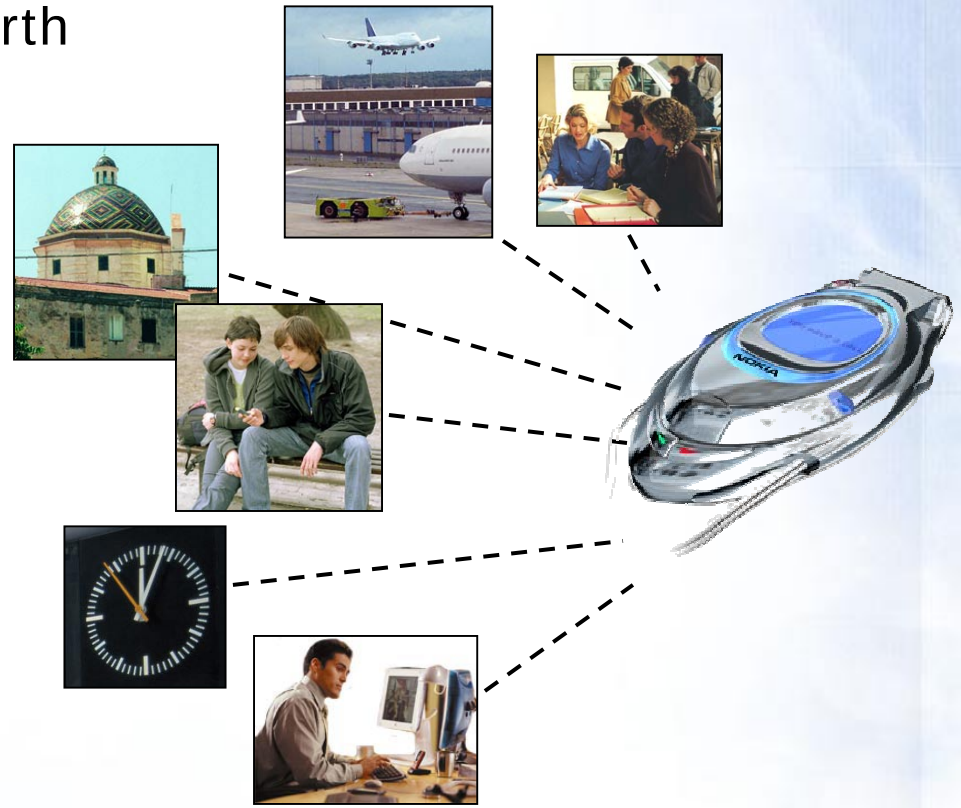
Outline

- Trends and drivers
- Cellular evolution towards 3.XG
- 4G – a challenger
- Role of complementary access technologies
- Conclusions

Computing and internet become ubiquitous

- Moore's law continues to rule - processing power today at insect brain level, mouse brain in 2010, human brain in 2020
- IPv6 can address every sand grain on Earth
- The personal terminal will become aware about its context:
  - People
  - Places
  - Networks
  - Services
  - Other devices
  - ...



Sources: R. Kurtzweil: The Age of Spiritual Machines; Dataquest; Prosessori

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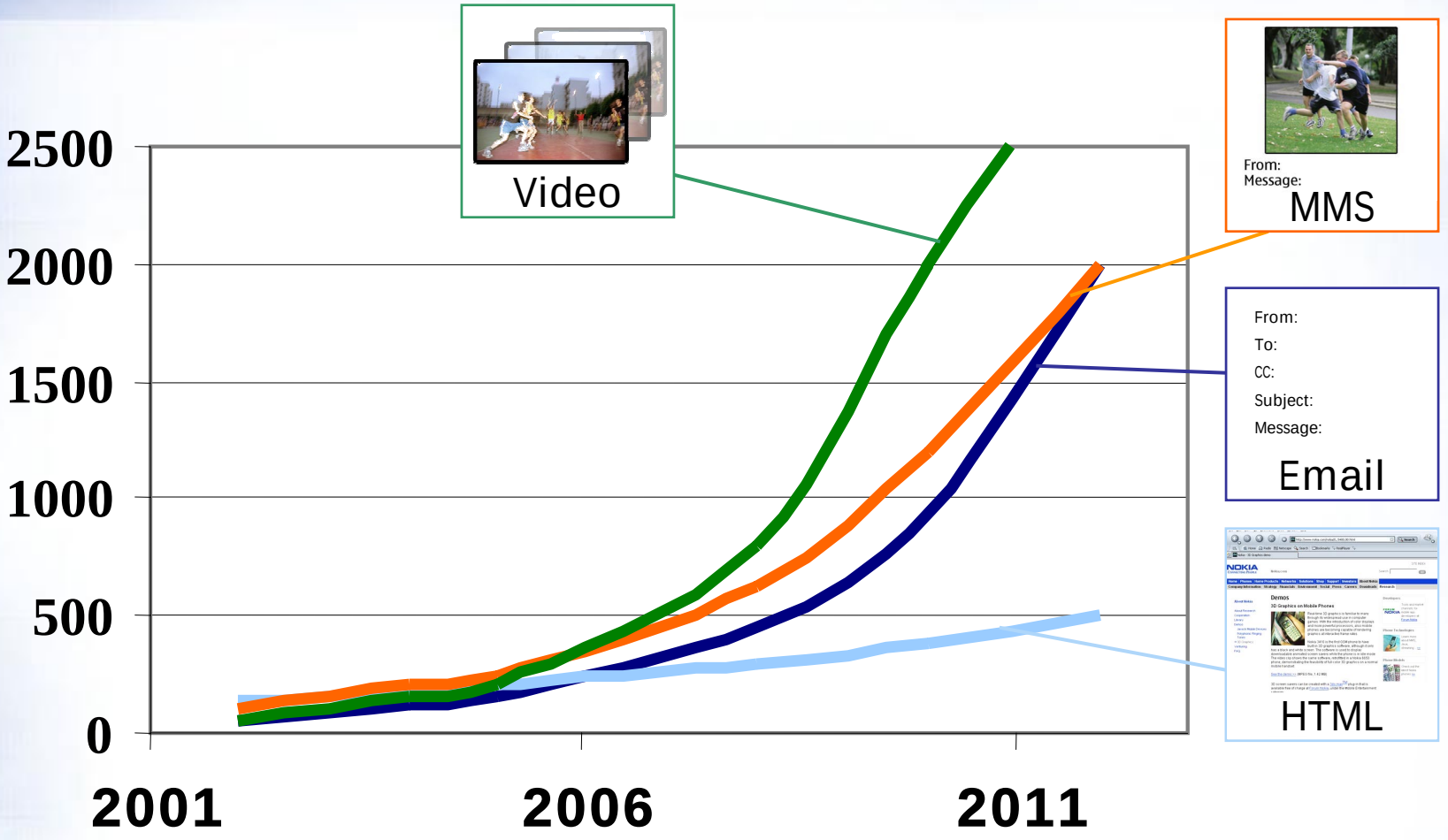
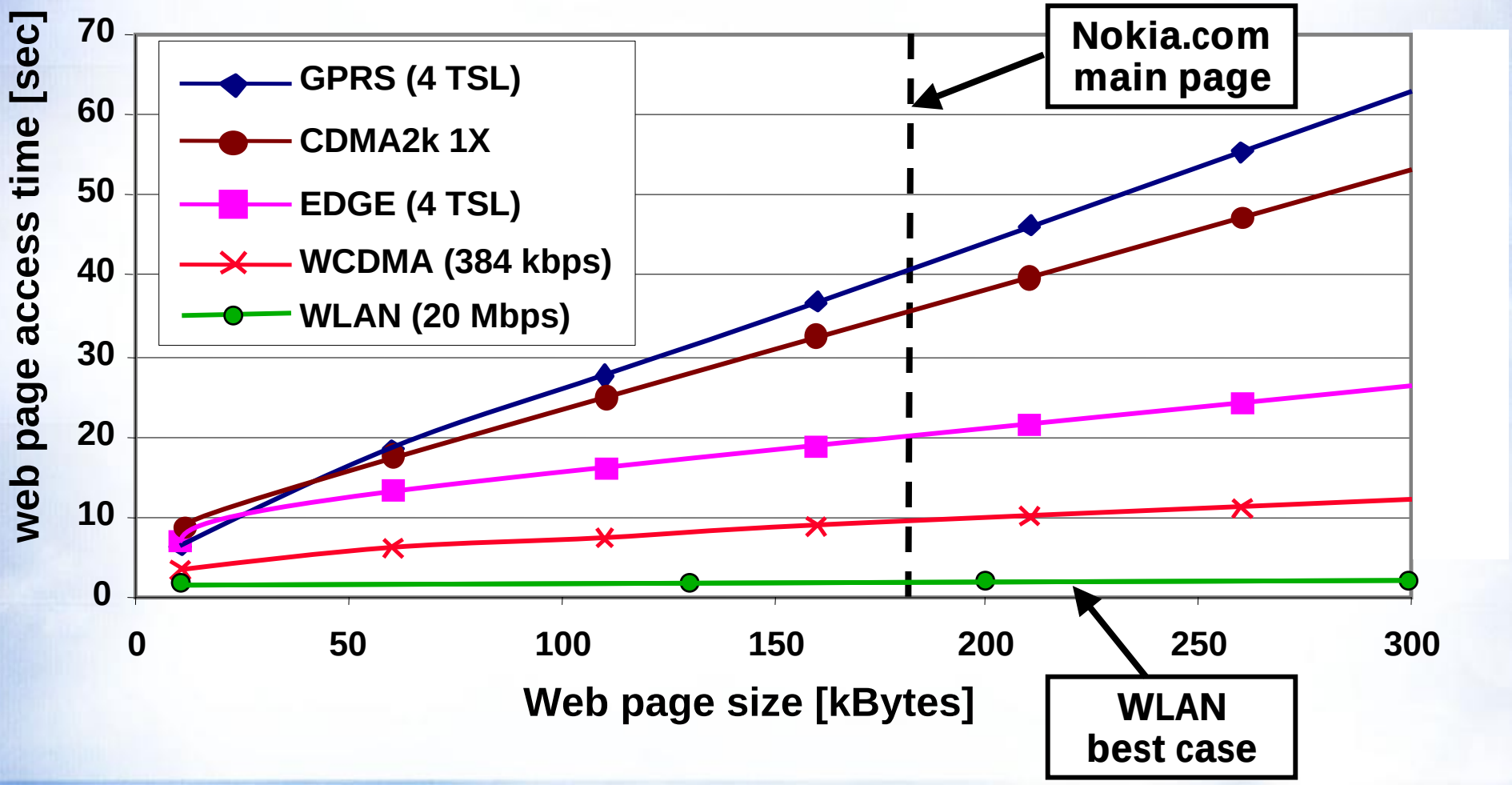
End user needs will cause content explosion



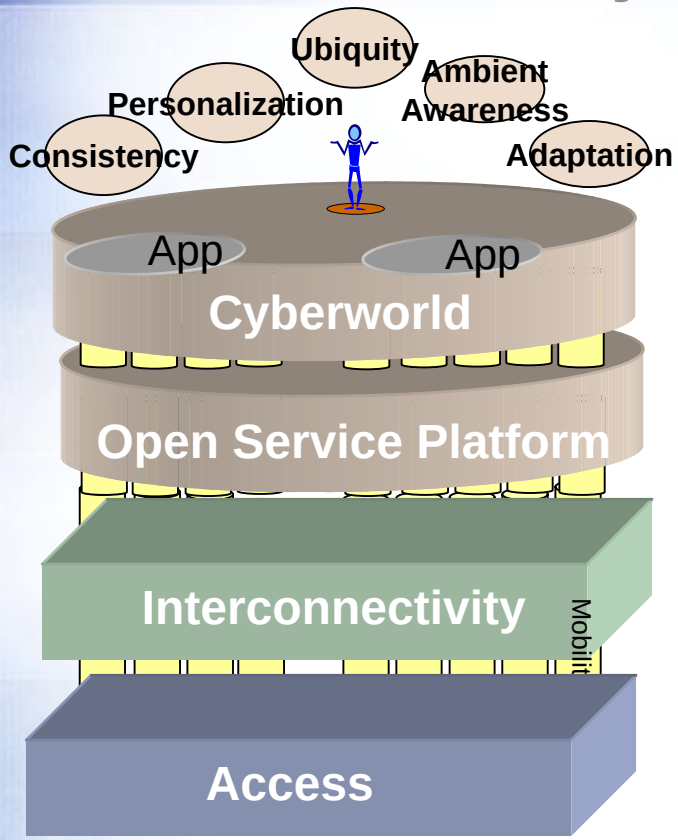
Better technical quality, larger content entities (e.g. longer video clips), and totally new content types will lead into content size explosion.

Bit rate does matter

Technology comparison on web performance



Cycles of innovation



Short cycles – up to ~ a year
Dynamic evolution of services
Regular updates of targets required
Servic

Medium cycles – several years
Evolution of network technologies and architectures
Network

Long cycles – up to ~ a decade
Investigation and test of new radio technology
Regulation and allocation of spectrum
Development of radio products
Radio

Systems B3G in operation

Applications and technologies have different innovation cycles

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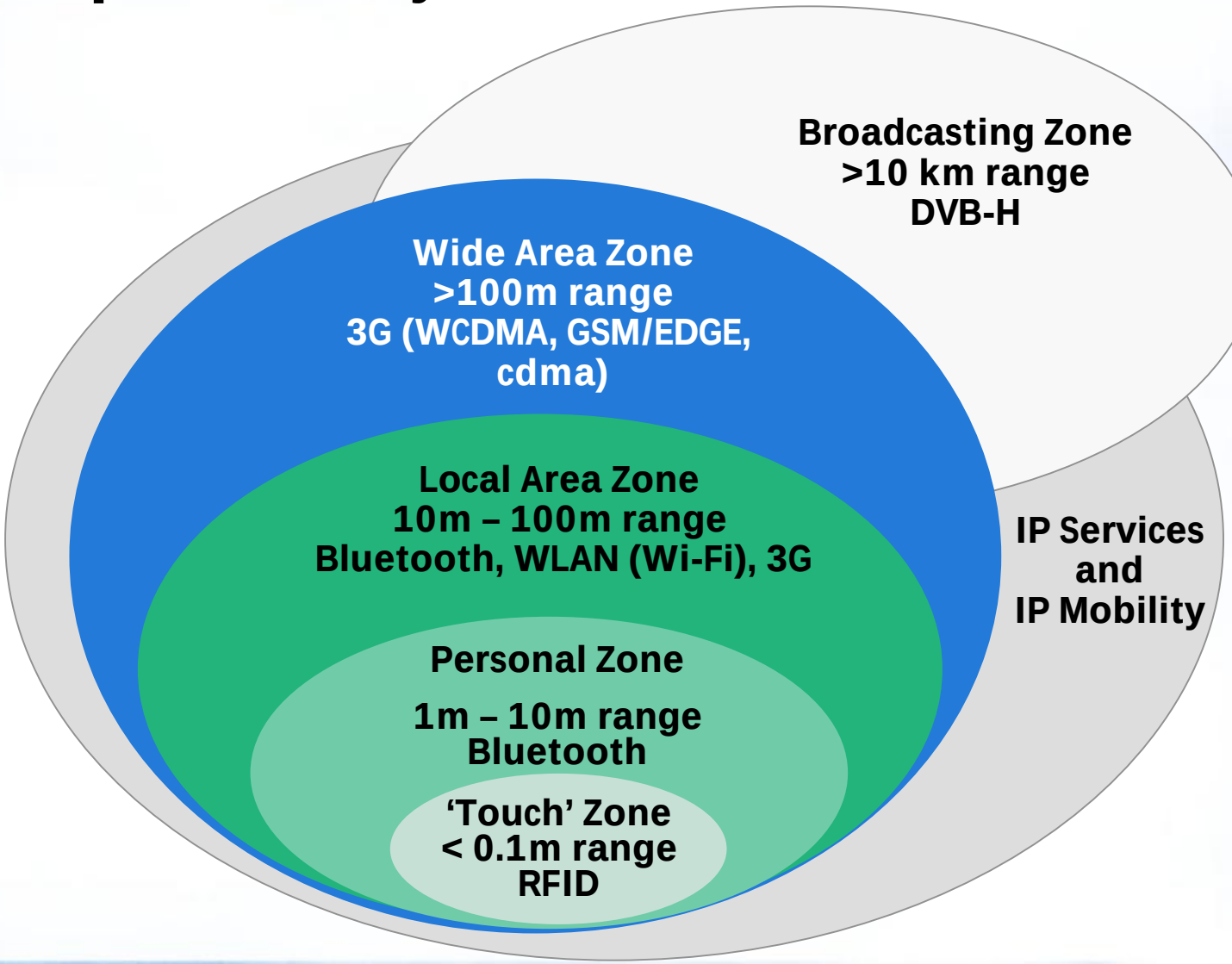
3G evolution will be inter-play between wide-area and complementary local area access technologies



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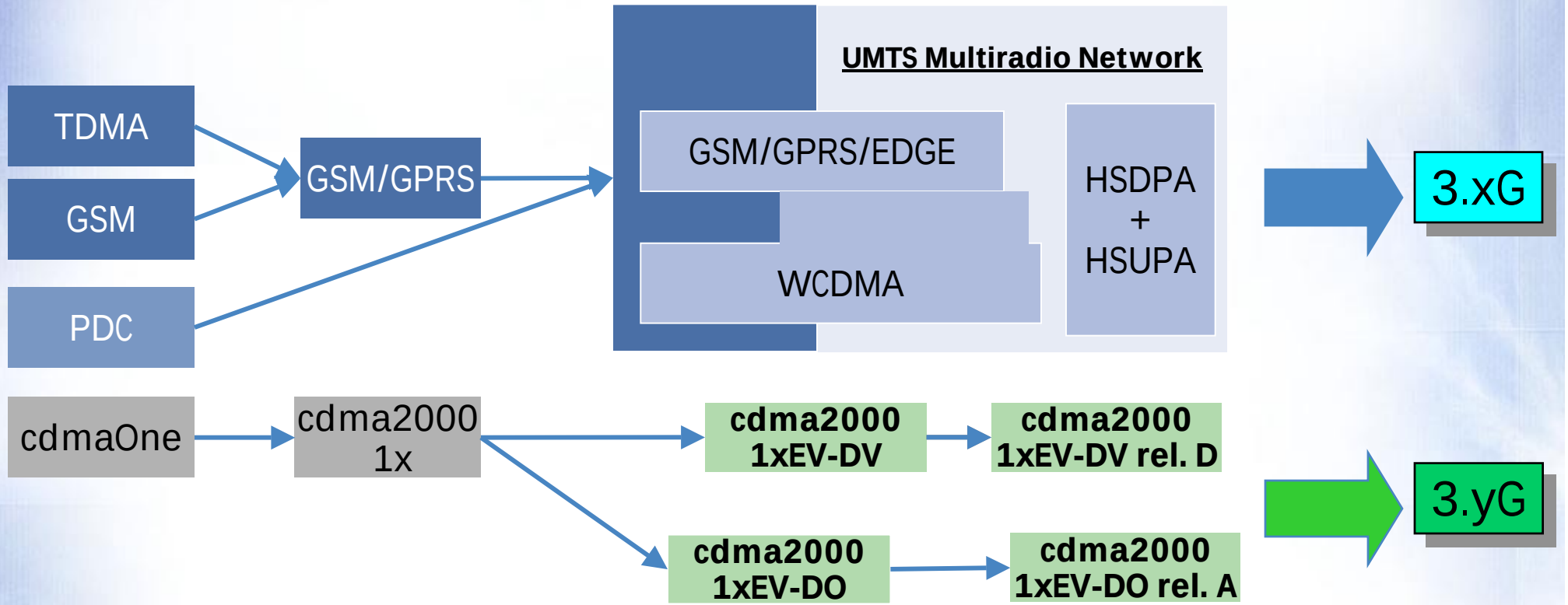
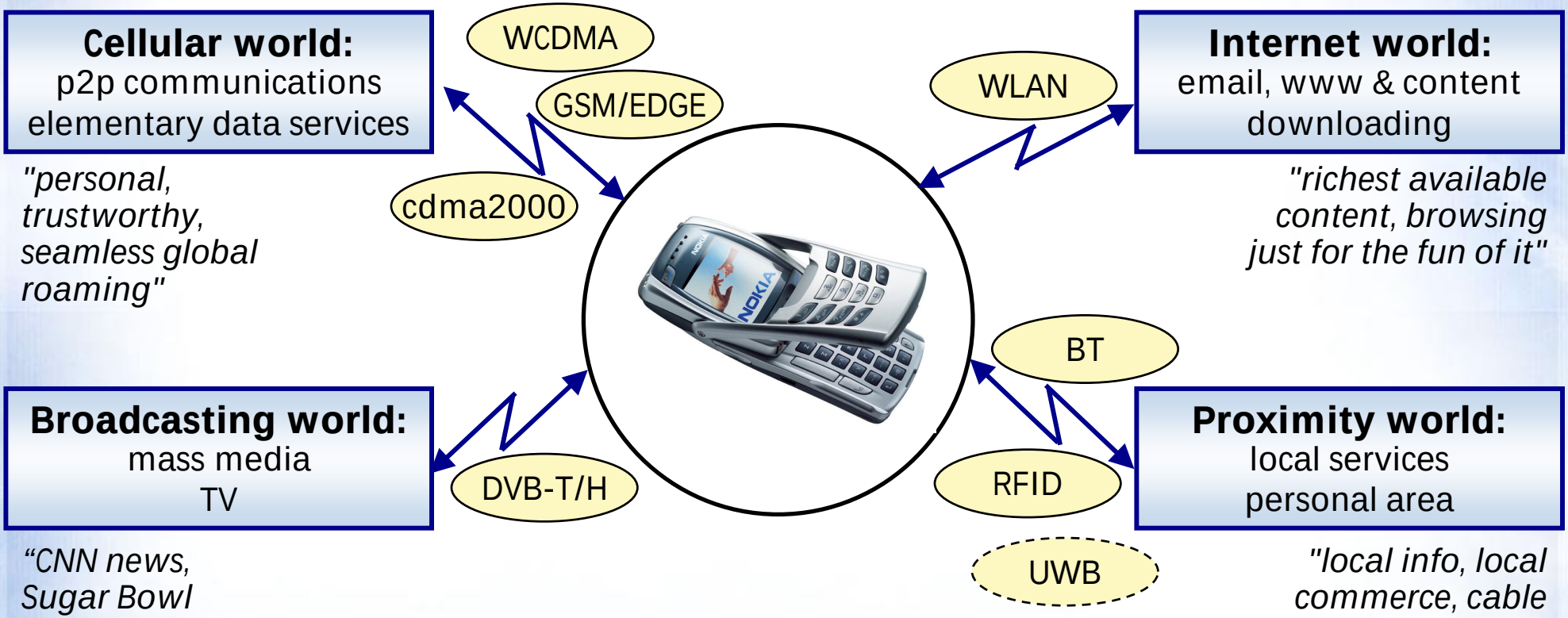
Global cellular evolution



Multiradio unites several worlds to a mobile terminal

- Multiradio: cellular + any complementing radios
- "One radio fits all" will not happen because of maximum e2e performance needs, maximum data rate needs, and pricing



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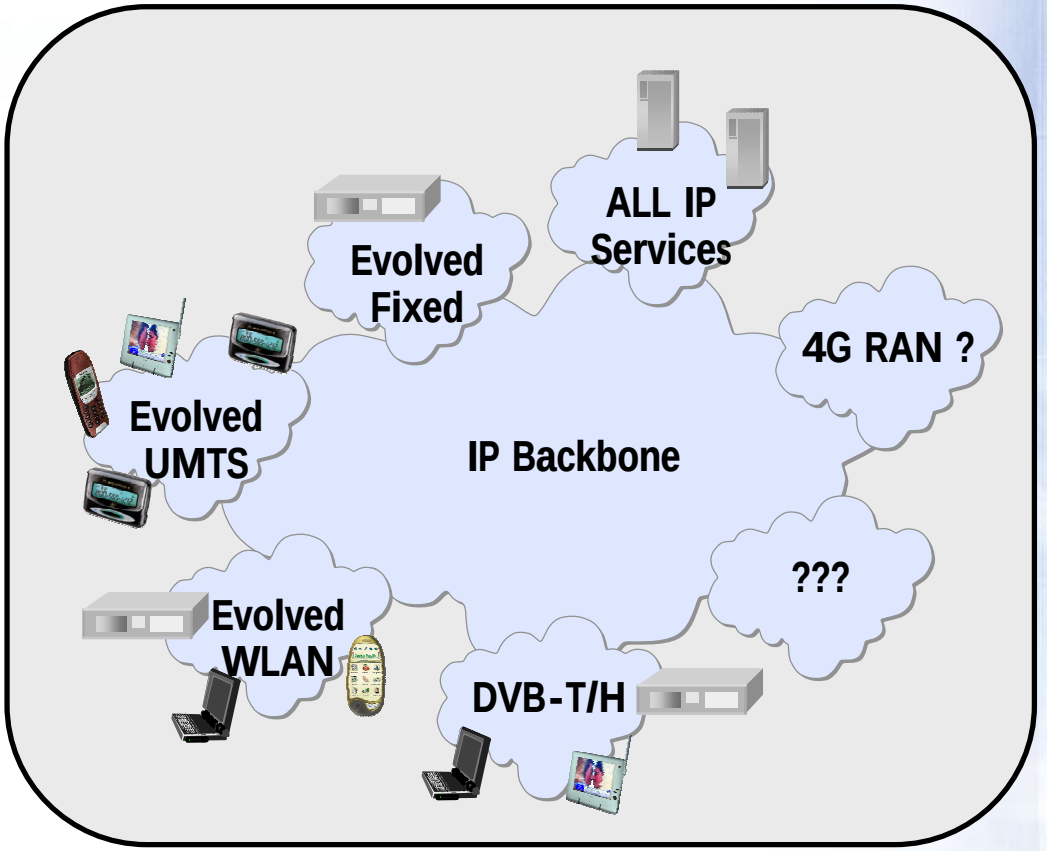
3G Evolution sets the benchmark for 4G

- Significant reduction of cost per byte
- Radio Access is multiradio capable
- N-mode terminals technically feasible
- Multiantenna Tx/Rx technologies
- Peak downlink data rates up to 30-60/100 Mbps (cellular/hot spot)



What is 4G?

- Many definitions for the term 4G exist. Nokia's view:
  - 3G evolution is based on the combination of existing/evolving technologies like cellular for wide-area and Wireless LAN for hot-spot usage
  - **4G is a research topic for new air interfaces and systems to be considered after 2010**
- Radio performance and higher throughput/lower delays identified as major drivers for 4G -> **revolution in radio**
- 3G evolution already requires high-throughput IP-based networks; 4G should utilize those -> **evolution in networks**

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Revolution requires challenging targets

- Research targets
  - Up to 100 Mbps/1 Gbps carrier bit rates in wide/local area deployments
  - Order of magnitude improvements in cellular efficiency
    - Single (isolated) cell up to 5-10 bits/s/Hz
    - Multicell >> 1 bits/s/Hz
- Adaptability to different radio environments
  - Parametrized solution yielding optimal or close to optimal performance in different radio conditions (wide area, local area)
- Start from scratch – no 2G/3G legacy in radio

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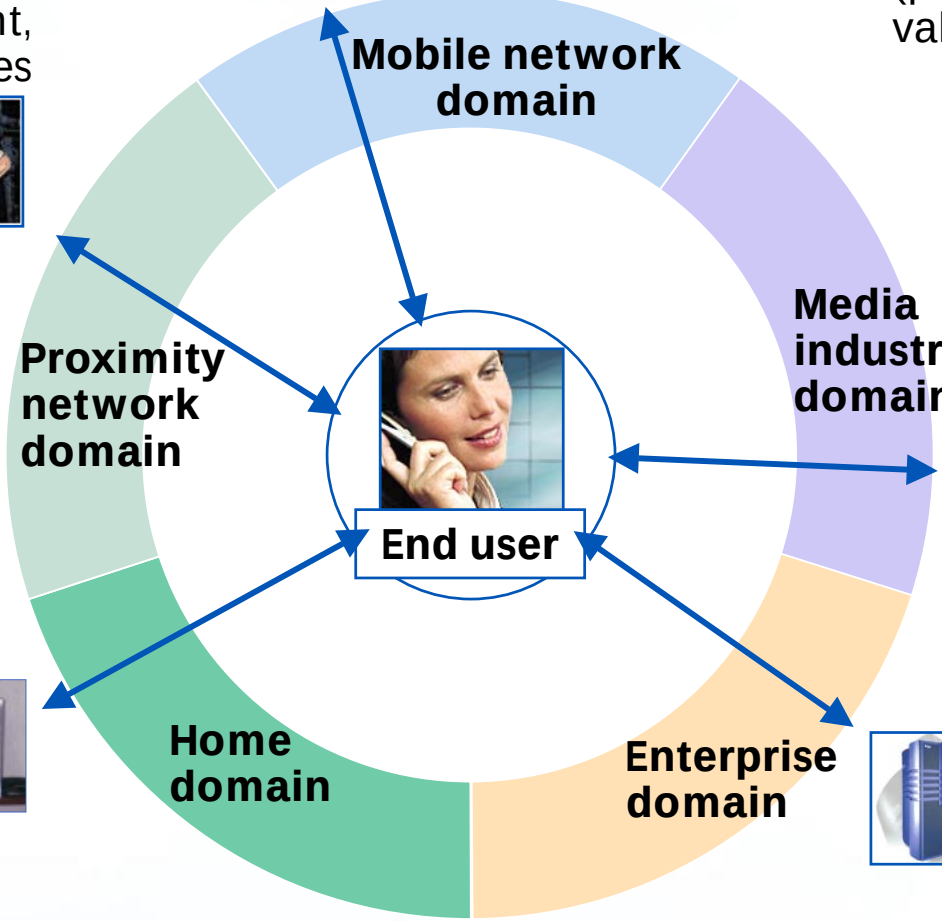
4G development needs to address different domains

Multi-player virtual reality games

Domains
Business ecosystems (products, services/content, value networks)

Share content, play games



Download 3D-movies and entertainment

Share Pictures

Send large documents, virtual reality meetings

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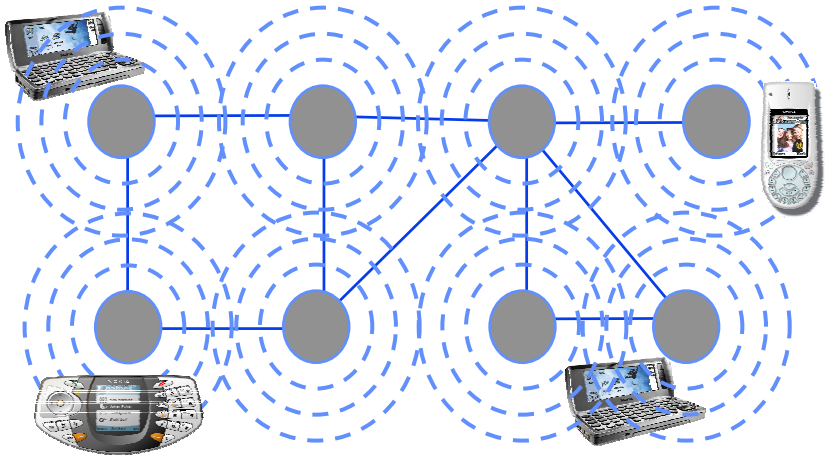
Building mobile 100 Mbps coverage is the biggest technology step and challenge for 4G

- Major new innovation in radio access network including basic radio technologies as well as network topology



- 4G requirements set major challenges for
  - Terminal power consumption
  - Network cost

4G is for the next decade and beyond

1. New solutions must be developed
   - Advanced antenna and multi-carrier concepts
   - Hardware challenges (e.g. power consumption and wide bandwidth)
   - Novel low-cost ways of building mobile broadband coverage
2. Standardisation
   - 4G requires agreement on completely new physical layer and networking solutions - a long process
3. New spectrum
   - The current mobile allocations are insufficient for 4G goals, a lot of new spectrum is needed (likely in the 3 – 5 GHz range)
   - Identification should happen in WRC 2007

⇨ **Wide-scale adoption in 2015, at the earliest**

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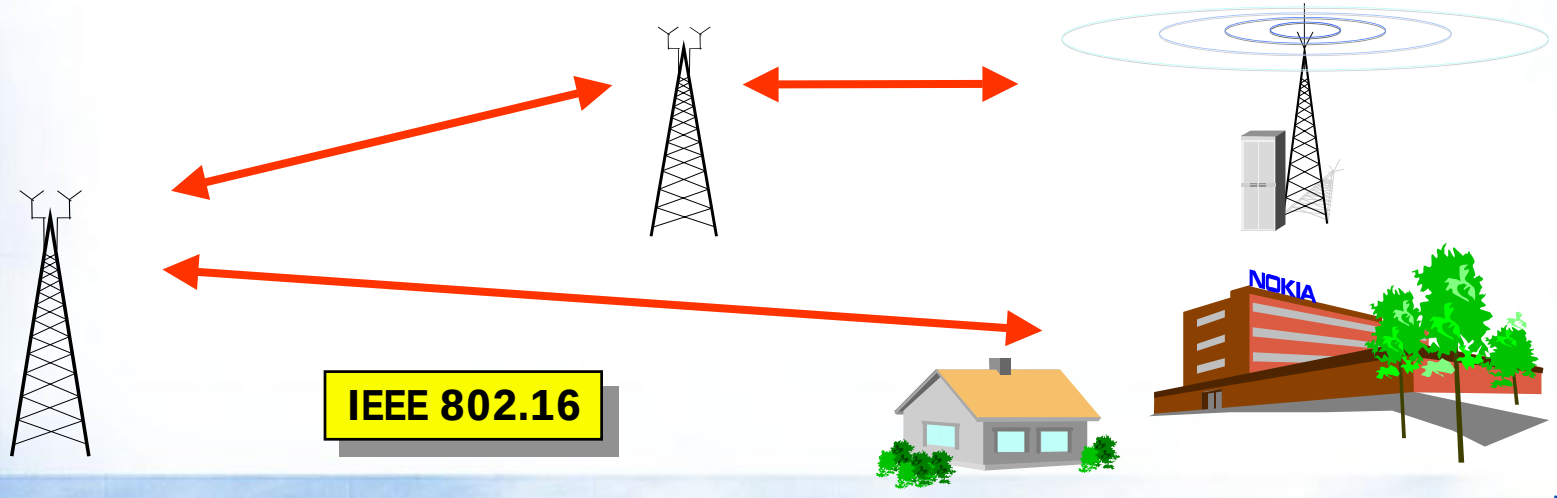
Complementary Access technologies (1/2)

- WLAN is an important tehnology in the overall radio technology picture
  - Key WLAN standards on unlicensed & shared bands
    - 11Mbps at 2.4GHz and 54Mbps at 5GHz
  - 'Uncoordinated deployment'
  - 3GPP and 3GPP2 are specifying the 3G/WLAN interworking
- Bluetooth offers high data rates in near environment
  - Specification radio channel data rate: 1 Mbps, throughput maximum: 700 kbps
- DVB-T/H
  - Digital content delivery to mass audience
  - One to many, at a set time, defined content
  - Speed 6-10 gigabytes/hour/multiplex

Complementary Access technologies (2/2)

- Ultra Wide Band (UWB)
  - High bit rates over short distance (“Wireless USB”)
    - Range: ~11m @ 110 Mbit/s , ~2.6m @ 480 Mbit/s for indoor channel
  - Above 3.1 GHz in USA
- Broadband Wireless Access (BWA)
  - 802.16/WiMAX
  - 802.20
- Many proprietary solutions
  - Navini, Broadstorm, Arraycomm, etc.



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Winning radio technology will address end-user needs

End-users are not interested in radio technologies directly, but through

Service end-to-end performance

"Wow, this is fast!"

Service price

"The transmission is so cheap that I don't have to think about it at all..."

Battery life

"I loaded my battery last week & still going strong..."

Ease of use

"Thank God the settings were preinstalled..."

"Yes, I hear you, loud & clear..."

Quality of service

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Conclusions

- Different layers of the system have different innovation cycles
  - Development of radio interfaces, network solutions, and service machineries should not be artificially tied together
- 3G networks will evolve gradually as IP-based to
  - Optimize service delivery
  - Integrate different access technologies, like those in hot spots (e.g., 802.11)
- 4G is a research topic for new air interfaces and systems
  - Challenging target setting
  - Wide scale adoption in 2015 at earliest (subject to outcome of WRC-07)
- Complementary technologies will enhance the access of services

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So will there be evolution or revolution ?

Evolution - definitely

Revolution – maybe

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CONNECTING PEOPLE

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