the evolution of portable ubiquitous networking and issues for spectrum management

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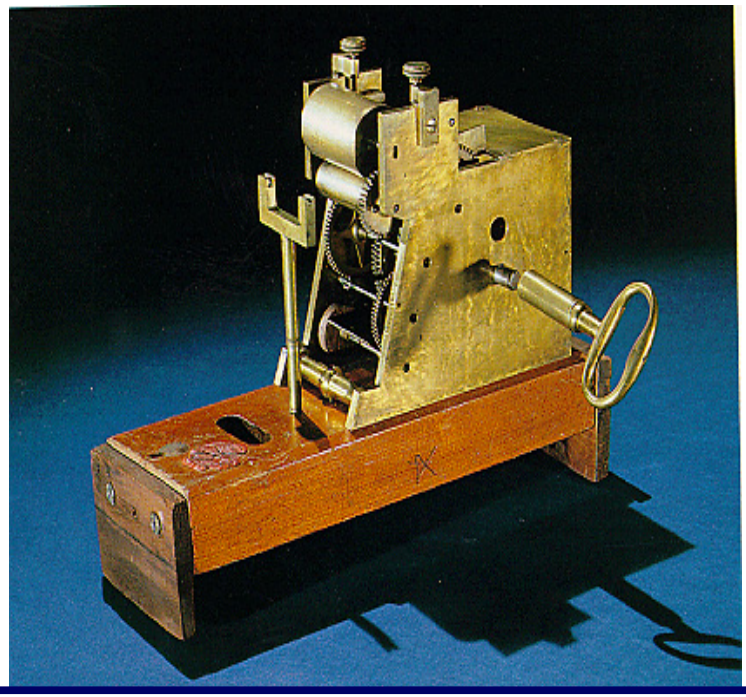
Lara Srivastava
Strategy and Policy Unit, ITU

International Telecommunication Union

Note: The views expressed in this presentation are those of the author and do not necessarily reflect the opinions of the ITU or its membership. Lara Srivastava can be contacted at lara.srivastava@itu.int

The dawn of information…

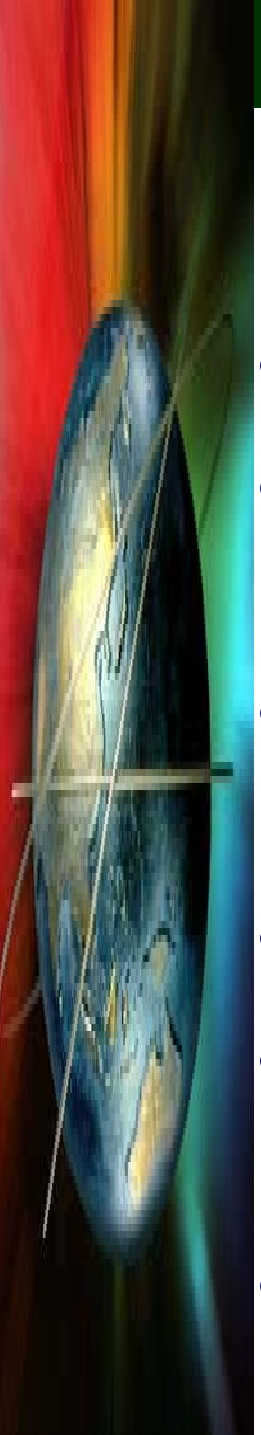


Telegraph Register Patent Model, patented May 1, 1849, patent number 6,420, by Samuel F. B.Morse (1791-1872

In 1844, the first interurban telegraphic communication from Washington to Baltimore, as Samuel morsed…

We have come a long day since then, …not to mention the old days of the clunky car phone

1910: Lars Magnus Ericsson and his wife Hilda



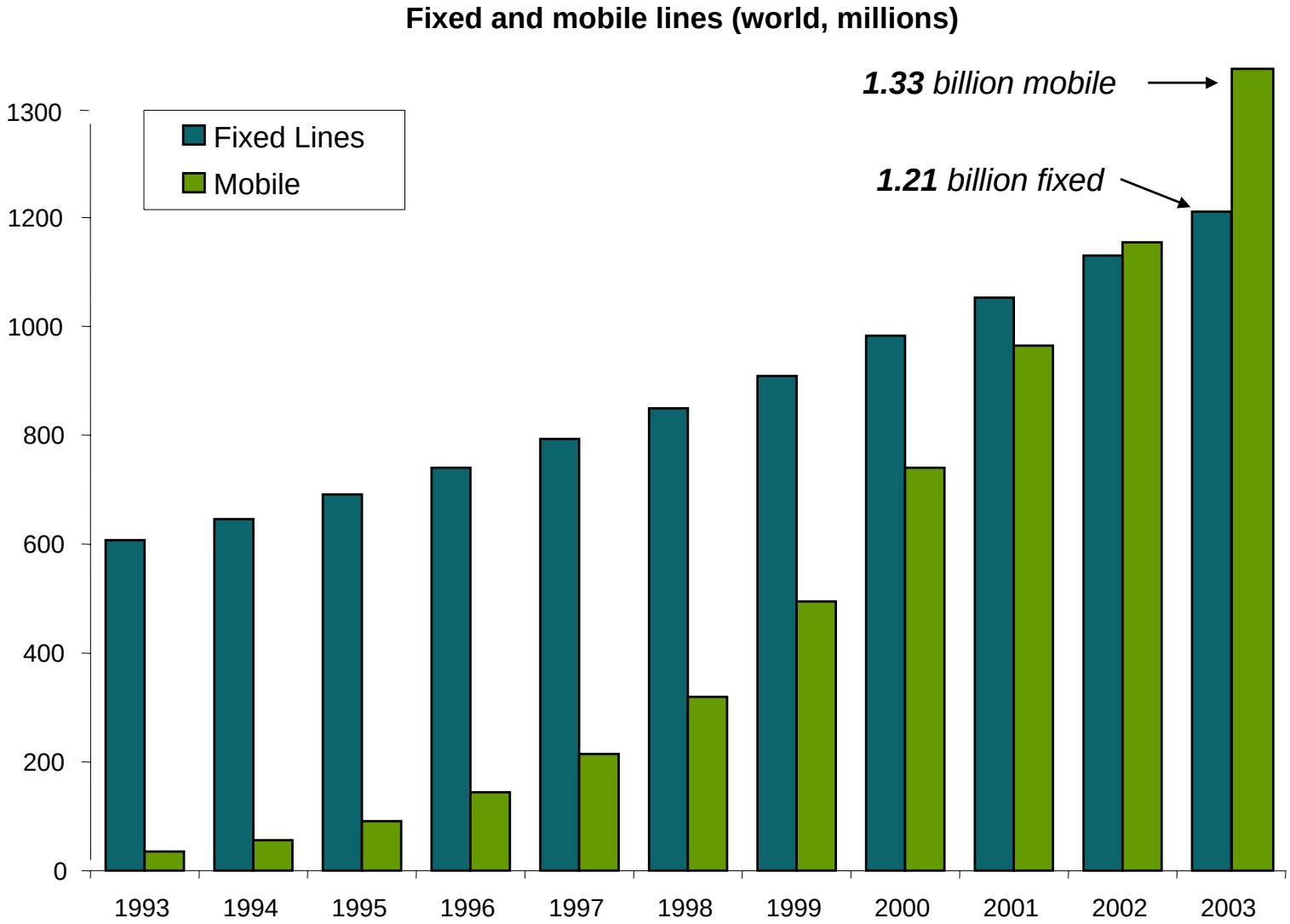
…to witness today's hi-tech world:

- the phenomenon of the World Wide Web
- the growth of high-speed broadband infrastructure, such as ADSL and FTTx
- the advent of wireless broadband, e.g. Wi-FI, Wi-Max
- the popularity of the mobile phone
- the emphasis on "always-on" communications and information access
- the advances in computing to render networks & tech even more "ubiquitous"

a world in which there are increasing demands on spectrum

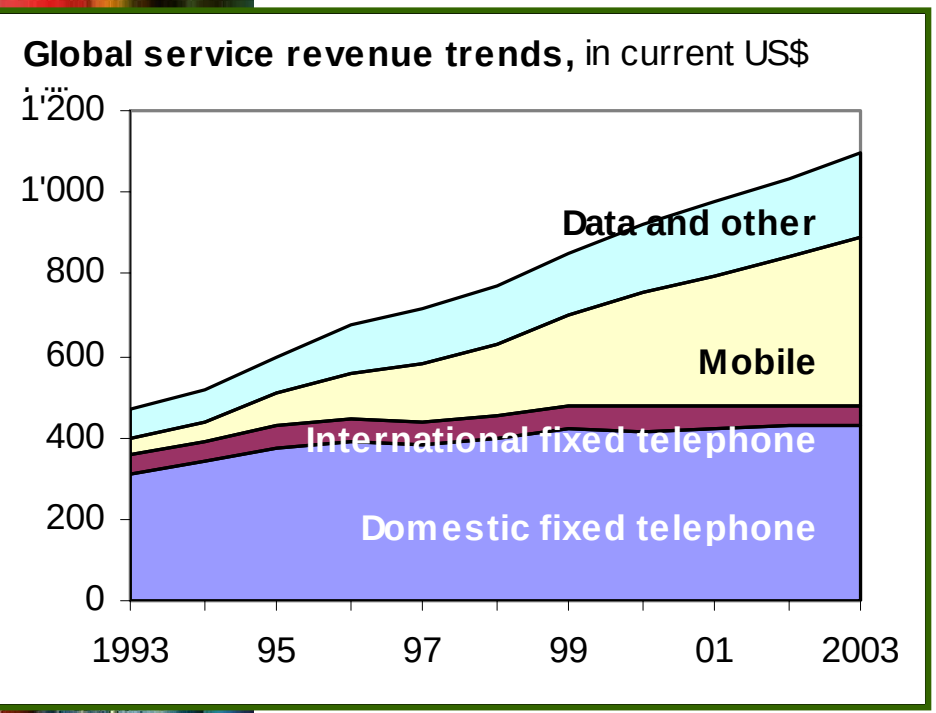
- ITU recording more and more frequency assignments over the last years
- recent efforts at liberalization further stimulating market
- potential of wireless in developing countries
- advent of new wireless applications
- growth of mobile phone already a telling example

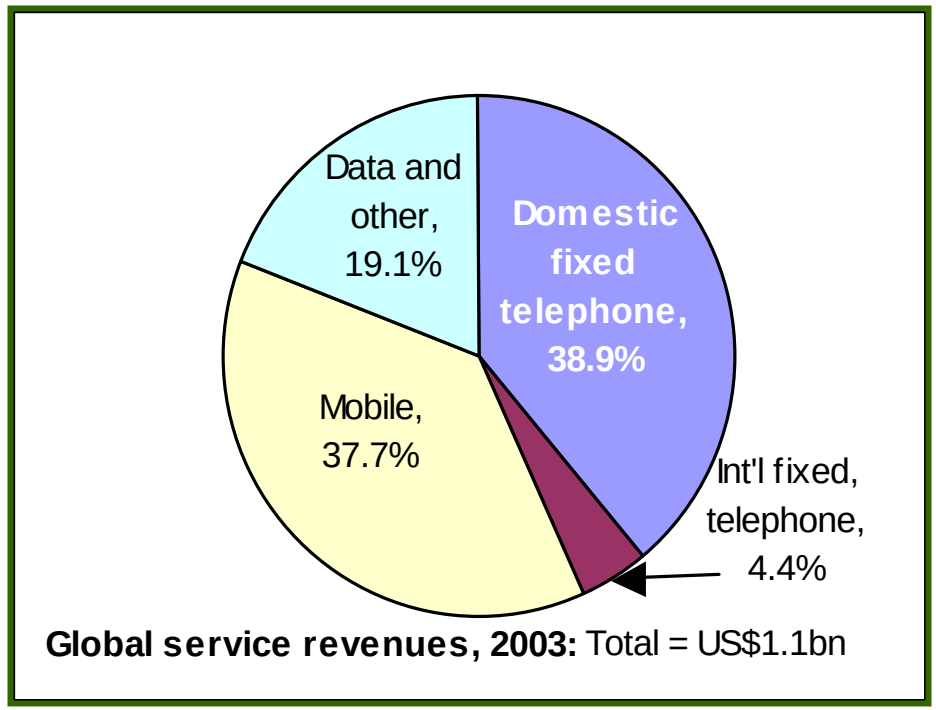
mobile mobile everywhere



Source: ITU

money money everywhere





3G or IMT-2000

- ITU-developed concept in mid-1980s
- Stands for “International Mobile Telecommunications”
  - Known as “3rd” generation systems (3G)
  - in Europe, often referred to as UMTS
- Unanimous approval resulting from collaboration of many entities, both inside and outside the ITU (ITU-R and ITU-T, and 3GPP, 3GPP2, UWCC, etc.)
- Promise of full interoperability and interworking of mobile systems on the basis of a single standard (without the fragmentation that had characterized the 2G mobile market)
- However, there were strong proponents of different approaches to 3G technology, resulting in ….

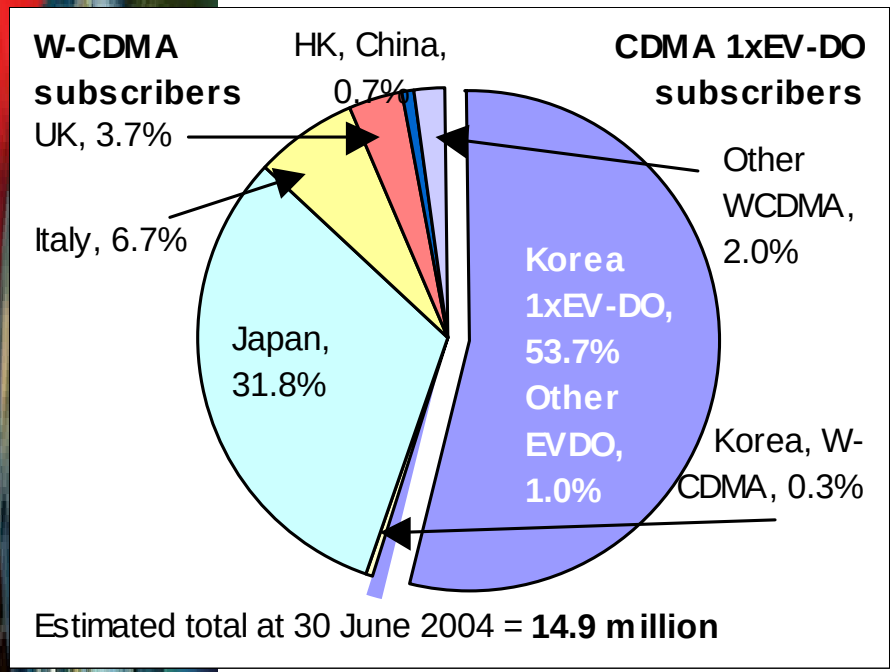
5 Terrestrial Radio Interfaces

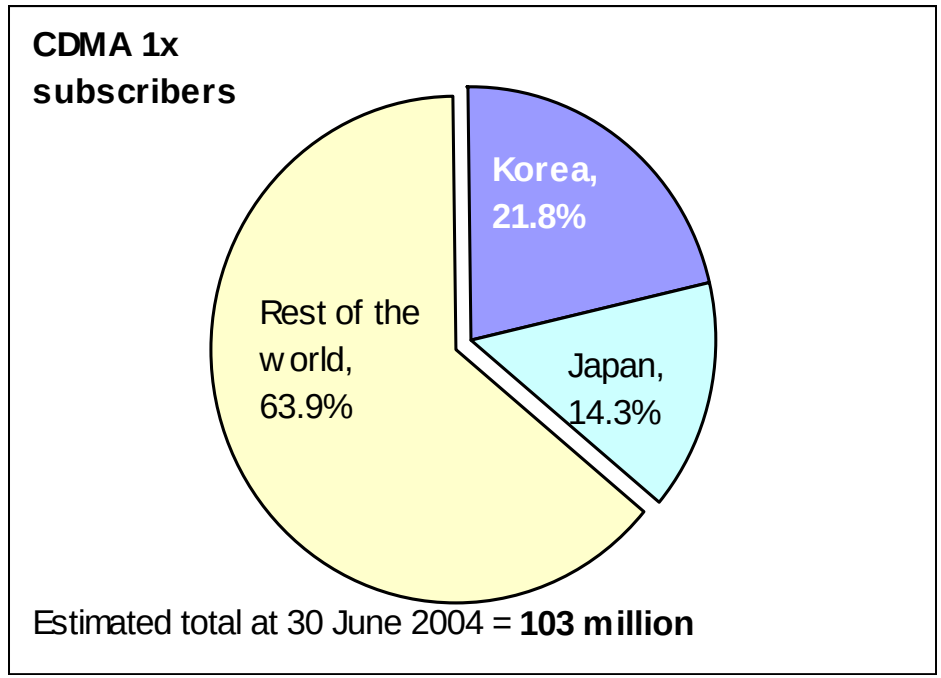
IMT-2000 CDMA Direct Spread	IMT-2000 CDMA Multi-Carrier	IMT-2000 CDMA TDD	IMT-2000 TDMA Single Carrier	IMT-2000 FDMA/ TDMA
W-CDMA (e.g UMTS)	CDMA2000	UTRA TDD & TD-SCDMA	UWC-136/ EDGE	DECT

3G CDMA

Although there are five terrestrial standards, most of the attention and energy in the industry has been toward the CDMA standards

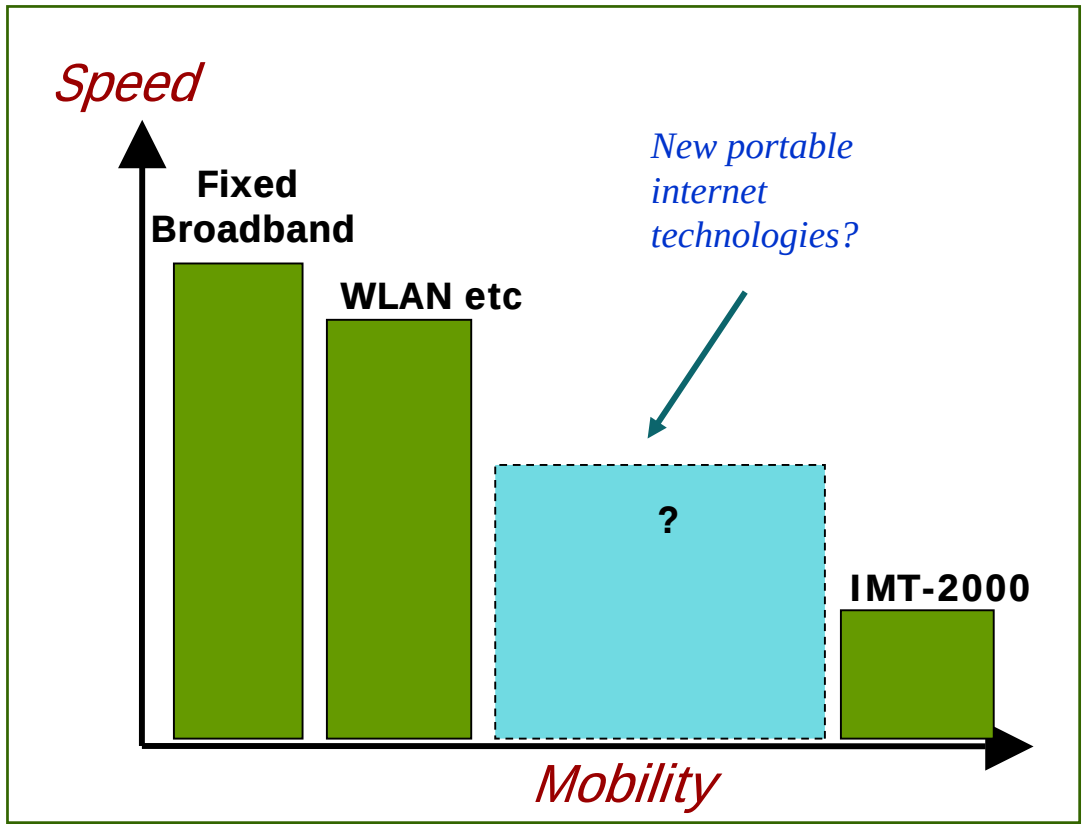
in 2004, there were over 117 m 3G (IMT-2000) users worldwide





what of other radio access systems for mobile data (and voice)?

- Alternative networking technologies for the transmission of mobile data exist, which may be mapped according to speed and mobility



a quick look at wireless LANs

- most popular is currently 802.11b (IEEE standard) or Wi-Fi (Wireless Fidelity)
  - Range is limited (100m) but speed is high (up to 11 Mbit/s). Mostly for stationary environments
  - Advantages: unlicensed spectrum, easy to deploy.
  - Disadvantages: no dedicated bandwidth, security concerns, high power consumption
  - 802.11a and 802.11g gaining in momentum
- others and some under development:802.11i, 802.11n, 802.11h and so on
- estimated (mid-2004): 115 million users worldwide

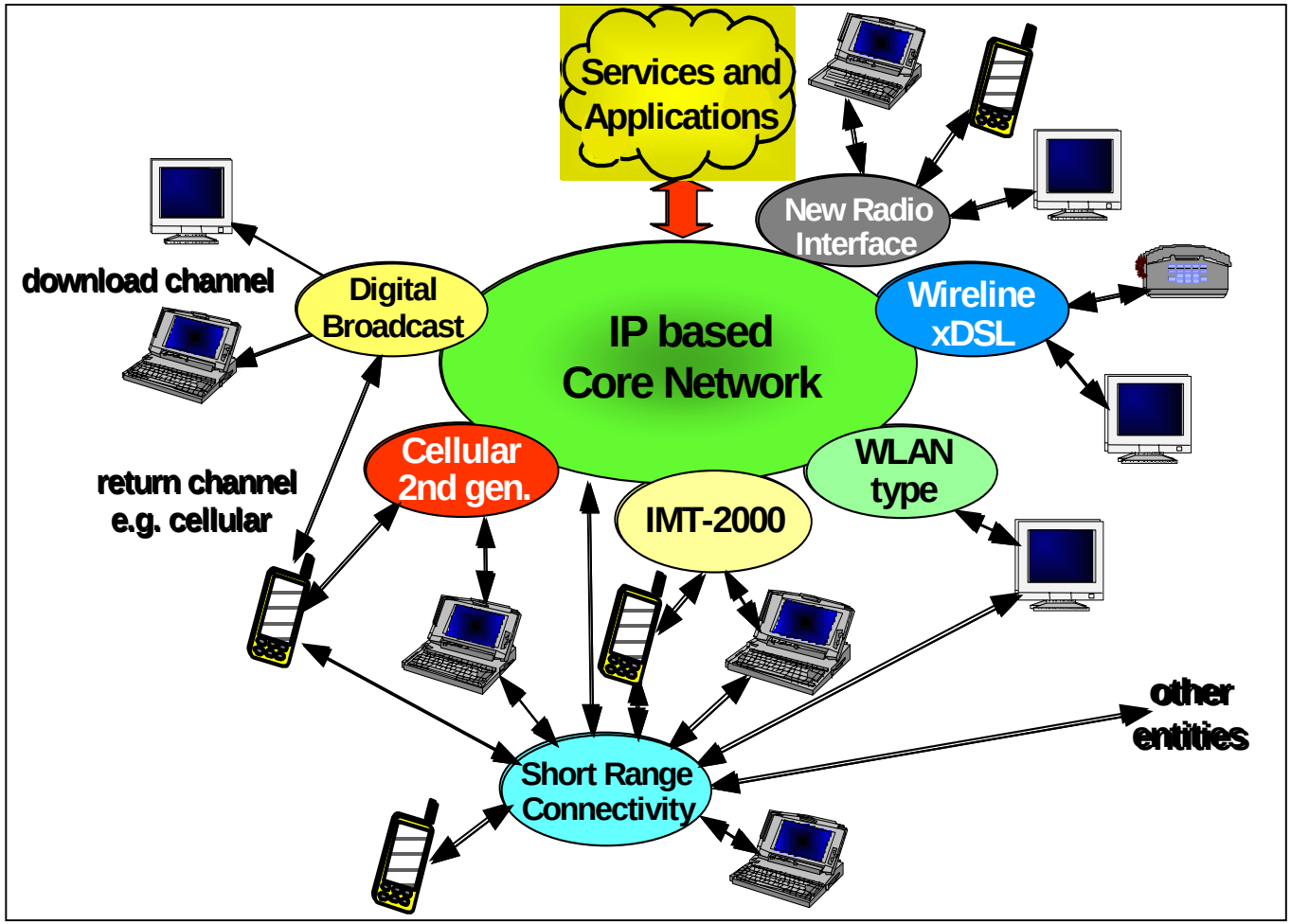
but what about longer-ranges for mobile data?

- 802.16 or WiMax
  - Worldwide Interoperability for Microwave access
  - Capacity: max 70 Mbit/s over 50 km
  - Type of WMAN (wireless metropolitan area network
- 802.20 also known as “Mobile-Fi”
  - Optimized for high-mobility environments
  - In terms of marketing, WiMax currently has a stronger push

and short-range technologies – also a burgeoning area

- Bluetooth
- Zigbee
- RFID (tomorrow's focus)
  - Enables the future "ubiquitous communication environment"
  - Takes the next step in "always-on" connections anywhere, anytime…
  - To anyone and "anything", I.e. RFID is at the heart of the aptly-named "Internet of Things", and ubiquitous networks

ITU vision: a complementary future



Source: ITU WP 8F

the radio spectrum scarcity issue

- originally (30 years ago), most of the occupied spectrum reserved for broadcasting, military and a few professional long-distance civilian links
- over the last decades, increasing pressures have led to scarcity in spectrum
- there is disagreement on whether this scarcity is actual or perceived

something wrong with traditional spectrum management?

- critics argue that the system is too slow not flexible enough
- “digitization” revolution placing additional pressures
- but today and in the past, the objectives of spectrum management remain the same:
  - harmonization
  - efficient use
  - right spectrum, right time, right application

approaches to spectrum mgmt

- traditional command and control
  - still exists for some areas , e.g. military, radio astronomy
- market-oriented mechanisms
  - licensing, depending on regulation, liberalization
- new methods of spectrum sharing and trading
- open access spectrum
  - Open to all users, either 1) co-existence for low-power transmissions, 2) spectrum use in bands allocated for license-exempt use, e.g. ISM)
- common spectrum/spectrum commons
  - Does not assign exclusive rights to individual users, but to group of users

focus: license-free open access

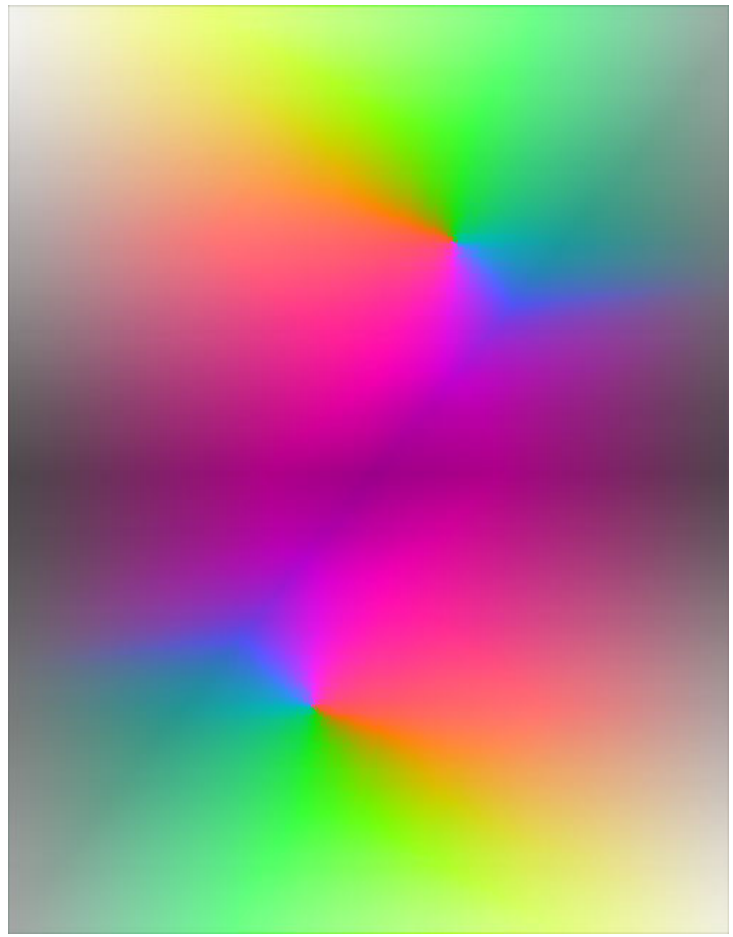
- for example, WLAN services
- eliminates requirement for administrative licensing
- lowers barriers to market entry and spurs competition
- significant concerns remain, however, as to long term viability:
  - over time, increasingly diverse and intense use of such bands might increase congestion affecting QoS

technical approaches to spectrum management on the road to ubiquitous networks

- "**open spectrum**" approaches are seen by many as one of the key solutions to (perceived) spectrum scarcity
- "open spectrum" is a collection of new radio technologies
- these technologies can serve to dynamically manage spectrum access and assist in spectrum sharing

classes of technologies for open spectrum

- spread spectrum
- cognitive, agile or software-defined radios
- mesh networks



Reminder: spectrum & interference

- our experience with radio mostly unchanged since the beginning of the last century
- when regulations were being set, radio access was still primitive. i.e. radio (later TV) only able to cope with one signal at at a time
- ‘confusion’ with near or adjacent channels = interference
- thus, problem is not interference between signals, but inability of receiver to differentiate between signals it needs (vs. other unrelated signals and noise)

spread spectrum

- a physical layer access method
  - note: many services already use spread spectrum e.g. 802.11b, but have limited amounts of spectrum allocated to them
- “wideband spread spectrum” spreads its signal over several continuous gigahertz of spectrum but uses only a tiny amount (*picowatts*) of power per Hertz
- this means that a UWB signal “looks” like background radiation (noise floor) to conventional narrowband radio receivers

software-defined radio (SDR)

- also known as cognitive or agile radio
- has embedded intelligence and RF technology allowing it to discern the kind of transmissions that are needed
- aware of rules of what spectrum is available for sharing, and can determine available chunks of spectrum
- SDR can transmit/receive customized RF modulation, which can be conventional, UWB or multi band
- can co-exist with legacy radio applications

mesh networks

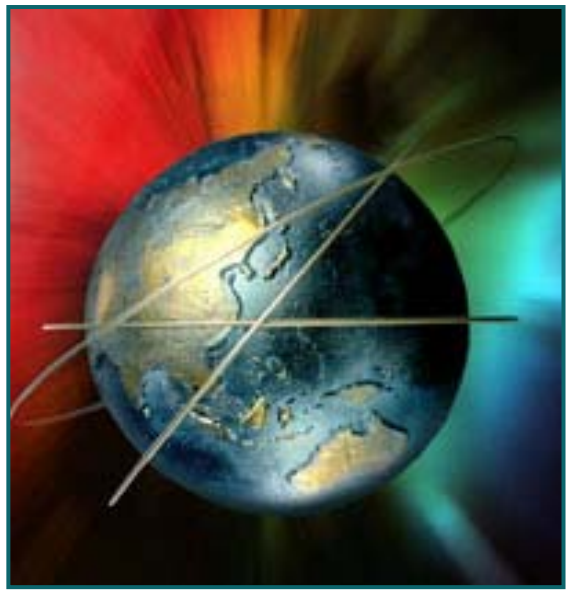
- mesh networks leverage intelligence and geographical spectrum re-use
- each open-spectrum device to be not only an end node in a network, but also a relay unit for any nearby neighbours forming a mesh network
- a mesh network means that as long as one or more nodes can access backbone gateway, any node that can connect to any other node of the mesh can access the backbone

concluding points

- spectrum management is a complex issue
- no single regime can address the rapid pace of technological innovation
- combination of approaches may be optimal , as might be a case-by-case analysis
- regulatory approaches AND technical approaches need to work in concert to allow maximum flexibility and efficiency in spectrum use

International Telecommunication Union

thanks–asante!



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