
Mobile Communications


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Overview of the Course

- **Part 1:** Introduction (1h)
 - **Part 2:** Wireless Transmission (3h)
 - propagation
 - digital modulation
 - medium access control
 - **Part 3:** Mobile Internet: Mobile IP (1h)
 - **Part 4:** Examples: Wifi, DVB-H/SH, LTE (4h)
 - **TD** (3h)
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Part 1: An Introduction to Mobile Communications


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- ## 1- Introduction
- Two different concepts:
 - *wireless transmissions*
 - *mobility*
 - One can be « mobile » while using wired technologies
 - nomadism: move between several offices
 - One can be fixed while using wireless technologies
 - e.g.: a fixed host using IEEE 802.11b
 - One can be physically mobile but fixed at the network layer
 - e.g.: move within the coverage area of a 802.11 base station
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History of wireless communication (1)

- 1895 Guglielmo Marconi (Nobel prize, 1909)
 - first demonstration of wireless telegraphy (1.5 km transmission)
- 1902 first message sent across Atlantic, by Marconi
- 1907 first commercial transatlantic connections
 - » huge base stations (30 100m high antennas)
- 1915 Wireless voice transmission New York - San Francisco
- 1920 Discovery of short waves by Marconi
 - reflection at the ionosphere
- 1928 many TV broadcast trials (across Atlantic)
- 1933 Frequency modulation (E. H. Armstrong)



History (2)

- 1982 Start of GSM-specification
 - goal: pan-European digital mobile phone system with roaming
 - 1983 Start of the American AMPS (Advanced Mobile Phone System, analog)
 - 1984 CT-1 standard (Europe) for cordless telephones
 - 1986 Introduction of Radiocom2000 in France
 - analog voice transmission
 - still in use today (700 subscribers in Nov.99!)
 - 1991 Specification of DECT
 - Digital European Cordless Telephone (today: Digital Enhanced Cordless Telecommunications)
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History (3)

- 1992 Start of *GSM*
 - roaming in Europe - now worldwide in more than 100 countries
 - services: data with 9.6kbit/s, FAX, voice, ...
 - huge success: 17 Millions of users in France (Nov.99)
- 1997 Wireless LAN - [IEEE802.11](#)
 - IEEE standard, 2.4 - 2.5GHz and infrared, 2Mbit/s
- 1998
 - Specification of *UMTS* (Universal Mobile Telecommunication System)
 - launch of *IRIDIUM* satellite system
 - » 66 satellites (+6 spare), 1.6 GHz, for mobile phones



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2- Mobile Communications

3 aspects:

1. Wireless Communication
2. Mobility
3. Portability



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2.1- Why are Wireless so different from Wired Comm.?

Low and variable throughput, with increased and variable delays

- Frequency band has to be **shared among all users**
 - » more users ⇒ less throughput per user
 - » just like non-switched Ethernet
- **Heterogeneous** network
 - » Change interfaces at media boundaries (e.g. switching from indoor Wifi to cellular coverage)
 - » Multiple simultaneous network connections possible
- The wireless waves are **very sensitive** to the environment
 - » Free Space attenuation
 - » Multipath effects
 - » Reflection, diffraction, scattering



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2.2- Mobility

Mobility has a big impact on Internet Protocols...

- Most Internet protocols have been designed at a time where all hosts were fixed...
- All layers are affected:
 - **applications**: need of resource discovery service
 - **transport layer**: must be adapted to quick changes of connection types and transmission features
 - **routing network**: because of host mobility
 - **link and physical layers**: obvious



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Mobility... (2)

Mobility requires new services

- Location-independent services
 - seamless access to services, wherever a mobile user is
- Location dependant services/information
 - where is the nearest resource?
- Authentication/Authorization/Accounting
- Privacy
 - to prevent the tracking of mobile users
- Security
 - mobile users know little about their wireless access network



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Mobility... (3)

- security is not only for fun... It's useful!



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2.3- Portability

- Risks to data
 - Physical damage, loss, theft, unauthorized access, etc.
- Small user interface
- Small memory and CPU
- Low power
 - Batteries must be used with caution:
 - » avoid intensive computing
 - » go into standby mode as soon as possible
 - » use low power transmissions (⇒ low bandwidth)

⇒ Applications must be adaptive
⇒ Content should be adapted to mobile users



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Power Management (1)

- Most power management optimizations focus on non-communicating components: screen/disk/CPU
 - Idea: *estimate when the device will not be used and suspend it for those intervals*
 - e.g., *turn off the display after inactivity, stop the disk, slow-down the CPU depending on load*
- **Communication devices are more difficult to optimize**
 - when a communication is suspended, the mobile is totally cut off from the world



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Power Management (2)

- the mobile can only guess about when other hosts may have data destined to it and wake up...
 - » can cause buffers to overflow both in the mobile and in the correspondent, resulting in packet losses
 - » leads to retransmissions, which means more power is used
- 2 approaches:
 - *MAC layer approach (e.g. TDMA)*
 - *application approach: the application or transport layers say when to suspend the device*



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Supporting Mobiles in Internet

- **Mobility-Aware Applications**
 - the **sender** can adapt its content to the capacities of its clients (end-to-end approach)
 - » not scalable: the server must support all formats
 - » not flexible: a new format implies to update all servers
 - the **receiver** can adapt the content to its capacities
 - » resource is wasted (BW + CPU)



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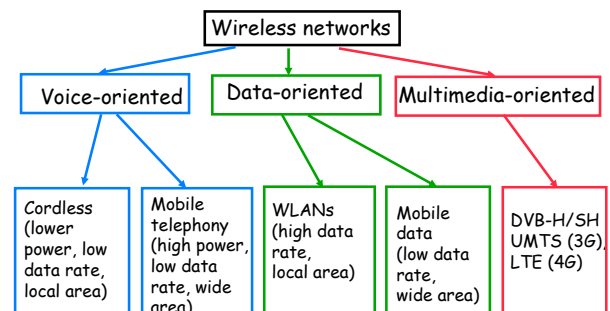
Supporting Mobiles... (2)

- **Network-Based Proxies**
 - the sender sends the same data to all clients, and **proxies** in the network adapt contents to the clients
 - more **scalable**: a proxy only has to know the formats used by its clients
 - more **flexible**: a new format implies to update the proxies only
 - another source of revenues to network operators



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3- Wireless Technologies



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Wireless Technologies

- We'll see rapidly:
 1. cordless telephony
 2. cellular mobile radio systems
 3. wireless LANs
 4. satellite-based transmissions
 5. future...



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3.1- Cordless Telephone

Low mobility, low power, two-way tetherless voice communication

- First generation is analog (70s), 2nd generation is digital
 - CT-2, DECT in Europe
- Assumptions
 - Few users per base unit (often one per base unit)
 - Few users per MHz
 - Short transmission range
- DECT and CT2 characteristics
 - 32 kbps ADPCM speech encoding
 - Average transmitter power ≤ 10 milliwatts



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3.2- Cellular Mobile Radio Systems (1)

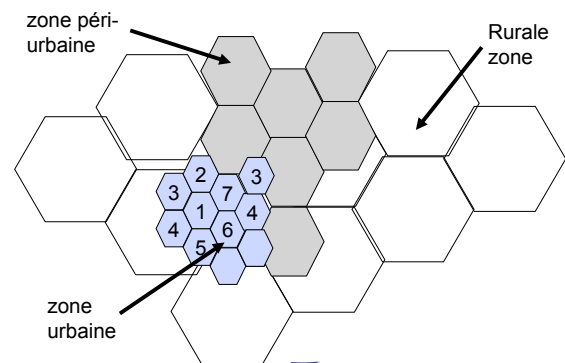
High mobility, wide-ranging, two-way tetherless voice com.

- Designed to provide voice services
- The key point is **frequency reuse**
 - An area is divided in geographical cells served by Base Stations (BS) using different frequencies
 - A radio channel can be used by several users in different cells
- Cells are grouped in **clusters** of seven cells
 - To prevent interference, frequencies are not reused in adjacent cells
- The size of the cells varies...



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Cellular Mobile Radio Systems (2)



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Cellular Mobile Radio Systems (3)

- Evolutions towards **smaller cells**
 - frequency reuse,
 - low power base stations,
 - less expensive base stations,
 - reduces battery drain on portable device
- First generation: 70-80, analog transmissions
 - US: AMPS
 - UK: TACS
- Motivations for 2nd generation:
 - higher capacity (users) for reduced cost
 - For Europe: pan-European standard, supporting roaming



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Cellular Mobile Radio Systems (4)

- 2nd generation: 90s
 - Based on TDMA (time) / FDMA (frequency)*
 - Europe: GSM
 - uses a European band around 900MHz
 - US: IS-54
 - uses the AMPS infrastructure, but requires high power transmissions
 - Japan: JDC
 - Based on CDMA (spread spectrum) / FDMA (frequency):*
 - US: IS-95



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Wide Area Wireless Data Systems

High mobility, low data rate, digital data communication to both vehicles and pedestrians

- Connectionless data packet delivery
- Deployed:
 - GPRS (bidirectional) (based on GSM).
- Evolutions
 - Higher channel bit rates
 - Smaller coverage areas (microcells)
- Examples:
 - UMTS (3rd generation)
 - LTE (4th generation)



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3.3- High Speed Wireless LANs (WLANs)

Low-mobility, high rate, data communications within a confined region

- Bandwidth ~ few Mbps
- Coverage ~ 50 m
- example:
 - IEEE 802.11 standard (Wifi)
 - in the unlicensed Industrial-Scientific-Medical (ISM) bands (915 MHz, 2.4 GHz). Most use spread-spectrum, low transmission power, and Ethernet-like protocol



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3.4- Satellite-Based Mobile Systems

- Wide area coverage
- Expensive infrastructure
- Low capacity if the goal is to transmit **individual** programs
 - » large coverage, so bandwidth is shared between many users
 - » e.g. satellite-based Internet access
- ...But high capacity if the goal is to **broadcast** the same content
 - » e.g. DVB-* systems
- Two types:
 - **Geostationary orbit systems (GEOs):**
 - » 3 satellites are sufficient, but lower capacity for a given spectrum
 - **Low-earth-orbit system (LEOS):**
 - » many satellites in lower orbit, lower latency, higher capacity, less expensive satellites



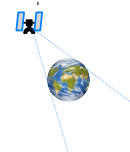
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Satellite-Based Systems... (2)



Low Earth Orbits

Height: 700-2000 km
Rotation Period: 90 min
Time in Line of Sight (LOS): 15 min
Earth/Sat./Earth latency < 0.1 sec



Geostationary Orbits

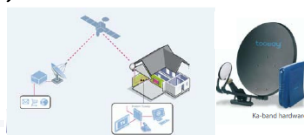
Height: 35,780 km
Rotation Period: 24 hours
Time in Line of Sight (LOS): 24 hours
Earth/Sat./Earth Latency 0.25 sec



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Satellite-Based Systems... (3)

- Constellation examples:
 - <http://www.spaceandtech.com/spacedata/constellations/>
 - Iridium (phone, 66 LEOS, Boeing)
 - GlobalStar (phone, 48 LEOS, Qualcomm Inc., Loral Corp.)
 - ICO (phone, 10 MEOS, Hughes)
 - SkyBridge (broadband, 80 LEOS, Alcatel)
 - Eutelsat (video/radio, 15 GEOs, Eutelsat)
- Example: Tooway high speed Internet access through satellites (Eutelsat, ViaSat)
 - <http://www.tooway.com/>



Ka-band feedbase