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)

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

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)
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

2- Mobile Communications

3 aspects:
1. Wireless Communication
2. Mobility
3. Portability

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

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

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
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

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

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

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)

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

3- Wireless Technologies
Wireless Technologies

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

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

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...

Cellular Mobile Radio Systems (2)

- Evolutions towards smaller cells
  - frequency reuse,
  - low power base stations,
  - less expensive base stations,
  - reduced 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

Cellular Mobile Radio Systems (3)

- 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
**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)

**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

**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

**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

**Satellite-Based Systems... (3)**

- Constellation examples:
  - 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/