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Ricevimento:
Martedi 9.30-11.00
Mercoledi 16.30-17.30

Iscrizione via web (consigliata!)

materiale del corso: sarà reso disponibile su web (pdf)

Testi consigliati:

William Stallings, *Wireless Communications & Networks*,
Prentice Hall, 2001, ISBN 0130408646

Jochen H. Schiller, *Mobile Communications*,
Addison Wesley, 2000, ISBN 0201398362

Yi B. Li, Imric Chlamtac, *Wireless and Mobile Network Architectures*,
John Wiley & Sons, 2000, ISBN 0471394920

Theodore S. Rappaport, *Wireless Communications: principles and practice*,
Prentice Hall, 2001, ISBN 0130422320

...altri testi e articoli saranno forniti in seguito.

Introduction to Wireless Networks: protocols and performance analysis

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Cumulative credits: some figures have been taken from slides found on the web, by the following authors (in alfabethical order):

J.J. Garcia Luna Aceves (ucsc), James F. Kurose & Keith W. Ross, Jochen Schiller (fub), Nitin Vaidya (uiuc)

Course Introduction

Introduction

General definitions

- **Communication network**:
  - **is a set of nodes connected by links and able to communicate with one another.**
- **Wireless network:**
  - **is a communication network based on wireless transmission**
- **users:**
  - **can be humans or processes.**
- **Network links:**
  - **point-to-point**
  - **multipoint**
  - **implemented with several transmission media.**

Wireless motivation and goals

- Computer networks started as a means for
  - Distributed processing
  - Communicating among people (e-mail, data exchange)
- The "web" and affordable hardware effect: Internet society
  - Internet-based enterprises
  - Internet-based home services
- Wireless effect: the network will be everywhere…Wireless Internet?
  - Computers used everywhere (new services, new applications...)
  - These computers need to be interconnected
  - new problems and standard to be studied
  - new system design and integration

This course motivation and goals

- Wireless/Wired integration
  - current protocol assumptions: born for wired connection
    - Bit error rate
    - Probability of channel failure
    - mobility
  - scarce resources in wireless domain: how to cope with this?
    - overhead reduction
    - energy management
- Wireless system analysis and design
  - new problems to be solved
  - new standard to be studied and defined
  - new system design and integration
  - new technologies

...need for System Modelling and Performance Analysis!

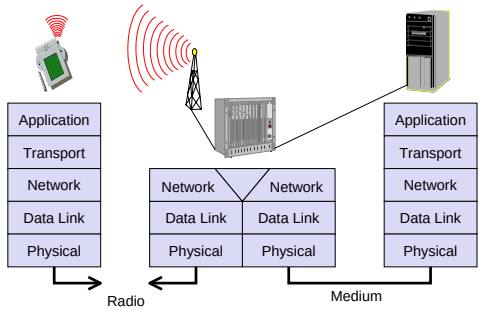
The OSI Architecture

- **Specifies the functions at each layer (implemented by different protocols)**

APPLICATION	End-user services (mail, file transfer)	Web access
PRESENTATION	Formatting, encryption, compression of data	
SESSION	Setup and management of end-to-end dialogue	
TRANSPORT	End-to-end delivery of messages to processes	TCP, UDP
NETWORK	End-to-end transmission of packets in net	IPv4, IPv6,
LINK	Transmission of packets over a link	PPP, HDLC, ATM CSMA/CD, TR, ETH.
PHYSICAL	Transmission of bit over physical media	FHSS, DSSS,CDMA

Simplified reference model used here

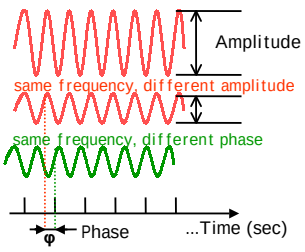
we will mainly concentrate on the Wireless part, dealing with the Wired inheritance about protocols (Standards)

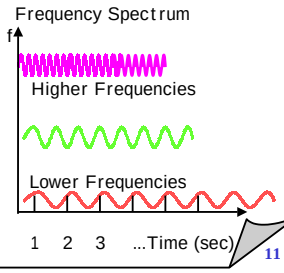


Background on wireless PHY layer

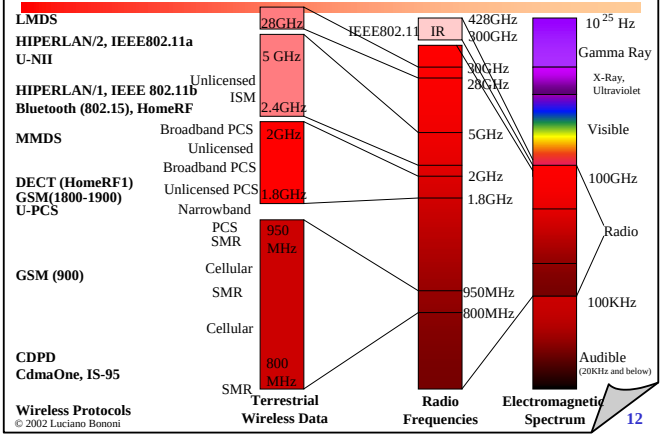
Wireless transmission: Electromagnetic waves

- **Different parameters of electromagnetic waves:**
  - amplitude **M** proportional to transmission energy (loudness)
  - frequency **f** (tone) measured in Hertz (Cycle/sec)
  - phase **φ** (peak shift with respect to reference signal) (rad)



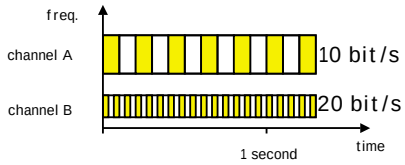


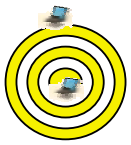
Wireless networks' spectrum



Wireless networks Bandwidth and Spectrum

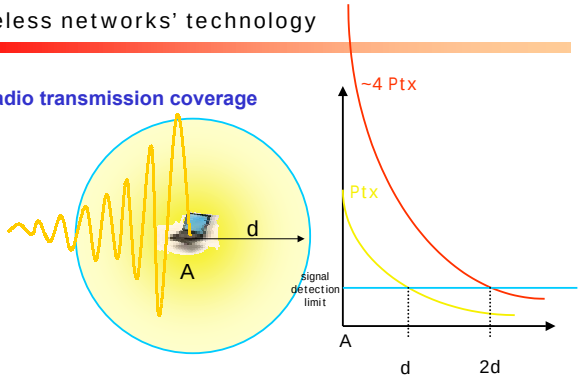
- **how can wireless channels have different bandwidth?**
  - bits run less or more faster? (NO)
    - Light speed: ~ <300.000 Km/s for every bit
  - the channel pipe (spectrum) is bigger (YES/NO)
  - the channel requires less time to accomodate (i.e. to code) one bit on the channel (YES)





Wireless networks' technology

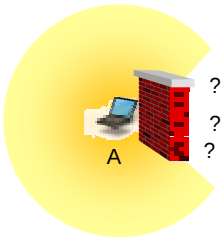
- **Radio transmission coverage**



The range is a function of power transmission (Ptx)
Signal strength reduces with d^2 (no obstacles)

Wireless networks' technology

- **Radio transmission coverage**



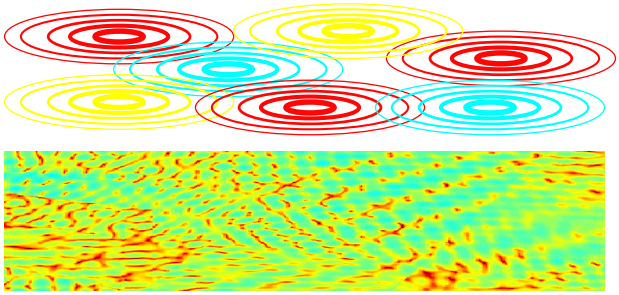
Rules of thumb:

- high frequencies are good for short distances and are affected by abstacles
- low frequencies are good for long distances and are less affected by abstacles

obstacles can reflect or absorbe waves depending on materials and wave frequencies

Wireless networks' technology

- **Radio transmission interference**



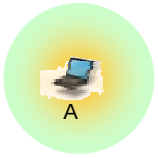
Wireless networks' technology

- **Narrowband radio system**
  - transmit/receive using a single radio frequency
- **Spread Spectrum technology**
  - bandwidth efficiency vs. reliability and security
  - Frequency Hopping Spread Spectrum
    - narrowband carrier hopping in a pattern sequence
  - Direct Sequence Spread Spectrum
    - bit coding and transmission spreading over the spectrum
- **Infrared technology**
  - line of sight or diffused, short range (in room)

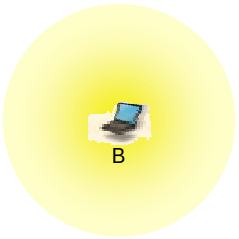
Wireless networks' technology

- **Radio transmission coverage**

host A (low Tx power)



host B (high Tx power)

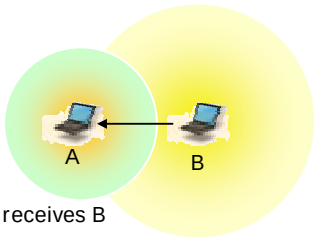


"...is there anybody outhere?"

both isolated

Wireless networks' technology

- **Radio transmission coverage**



A receives B

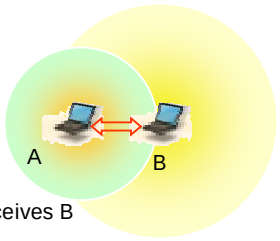
B cannot receive A

unidirectional(*) link

(*) sometimes improperly referred to as "asymmetric link"

Wireless networks' technology

- **Radio transmission coverage**



A receives B

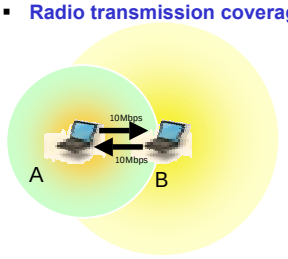
B receives A

bidirectional(*) link

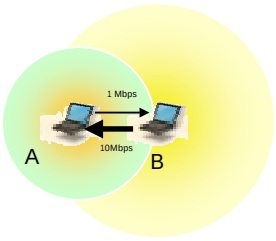
(*) sometimes improperly referred to as "symmetric link"

Wireless networks' technology

- **Radio transmission coverage**



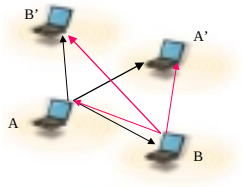
bidirectional symmetric link



bidirectional asymmetric link

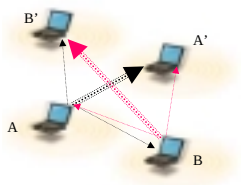
Wireless networks' technology

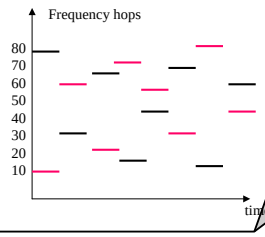
- **Narrowband radio system**
  - transmit/receive using a single, licensed, as narrow as possible radio frequency
  - undesired cross-talk between channels requires coordination and license for each site
  - low data-rates
  - e.g. ⟶ frequency X
  - e.g. ⟶ frequency Y



Wireless networks' technology

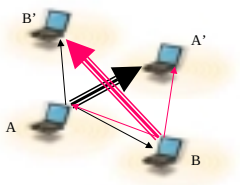
- **Frequency Hopping Spread Spectrum**
  - narrow band carrier changes frequency in a pattern known by both transmitter and receiver (single logical channel)
  - to unintended receiver FHSS appears as impulse noise

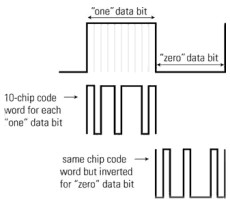




Wireless networks' technology

- **Direct Sequence Spread Spectrum**
  - redundant bit pattern (chipping code) spreaded over a large spectrum. Long chips increase probability of recovering the original bit (with no retransmission)
  - to unintended receiver DSSS appears as low power wideband noise





Wireless networks' technology

- **Infrared Technology (IR)**
  - frequencies just below the visible light
  - cannot penetrate opaque objects, and low diffusion
  - line-of-sight limitates mobility
  - short range technology (indoor, PAN, LAN nets)
  - High data-rate potential

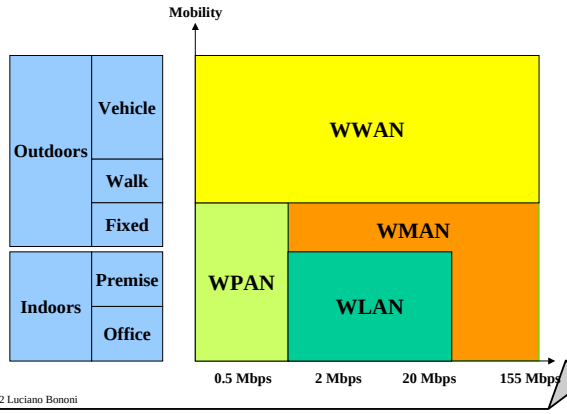
Transmission Technique Comparison

	PROS	CONS
Frequency Hopping Spread Spectrum (FHSS)	• Use less power than DSSS • Lower cost • Increased security due to frequency switching	• Lower throughput than DSSS
Direct Sequence Spread Spectrum (DSSS)	• High performance • Low interference • Increased security due to chip coding	• Expensive
Narrowband Microwave	• Long distance	• Line-of-sight with satellite dish • Requires FCC license • Not designed for WLAN use
Infrared	• High bandwidth	• Easily obstructed • Inexpensive

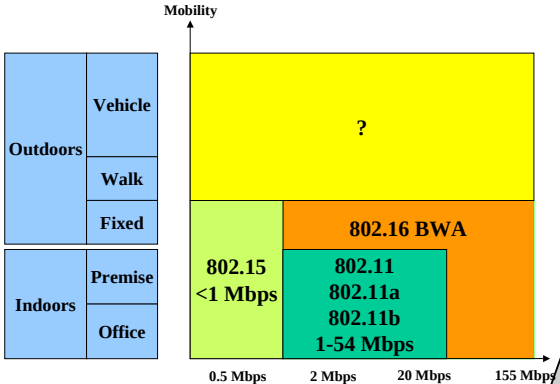
Wireless networks' coverage classification

- **Wireless Wide Area Network (WWAN)**
  - geographic coverage (e.g. satellite, cellular)
- **Wireless Metropolitan Area Net. (WMAN)**
  - Metropolitan coverage (e.g. town, large campus)
- **Wireless Local Area Network (WLAN)**
  - local area coverage (e.g. campus, building, home)
- **Wireless Personal Area Network (WPAN)**
  - reduced local area coverage (e.g. house, office)
- **Wireless Indoor Area Network (indoor)**
  - short range coverage (e.g. room, office)

Wireless network positioning

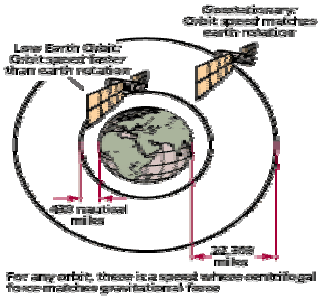


IEEE 802 Wireless standards



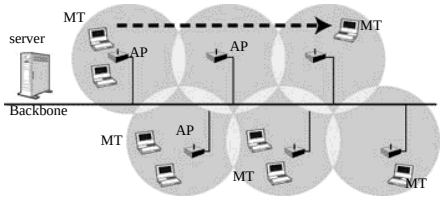
Wireless network structures

- **WWAN and WMAN**
  - Satellite (low orbit, geo-stationary)



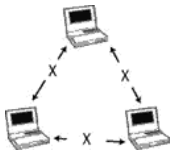
Wireless network structures

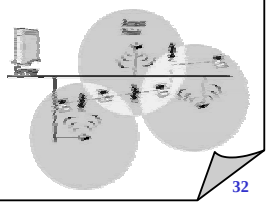
- **WWAN and WMAN**
  - Cellular or multi-Infrastructure WLAN
    - grid of Access Points (AP), managing local Mobiles terminals (MT), and connected to Backbones



Wireless network structures

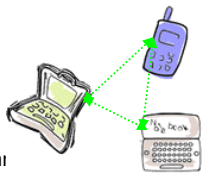
- **WLAN:**
  - Ad-Hoc:
    - peer-to-peer (P2P) "on the fly" communication
    - the network "is" the set of computers
    - no administration, no setup, no cost?
  - Infrastructure:
    - Centralized control unit (Access Point, local server)
    - Roaming between cells
    - resource sharing and backbone connection





Wireless network structures

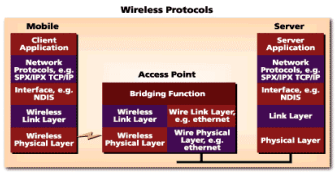
- **WPAN:**
  - cable connection alternative for in-home/office/workspace device connection
  - common technology and protocols required (e.g. HomeRF, Bluetooth)



- **Indoor:**
  - in room/workspace device conn

Wireless/Wired extension

- **Wireless protocols' design, integration, optimization**
  - layering, bridging functions
  - mobile IP
  - support and management for QoS
- **support for Wired-like applications**
  - Internet connectivity, DB access, e-mail
  - value added services



Wireless vs. Wired

Attribute	Wireless PAN/LAN	Wired LAN/PAN
Throughput	1-10 Mbps	10-100 Mbps
Integrity & Reliability	Subject to interference	Highly reliable
Simplicity/ Ease of Use	• No need to pull cable • Set up time is significantly lower • Moves, additions & changes much simpler	• Cable required • Set up time is significantly higher
Security	• Susceptible to interception • encryption	• Not as susceptible to interception

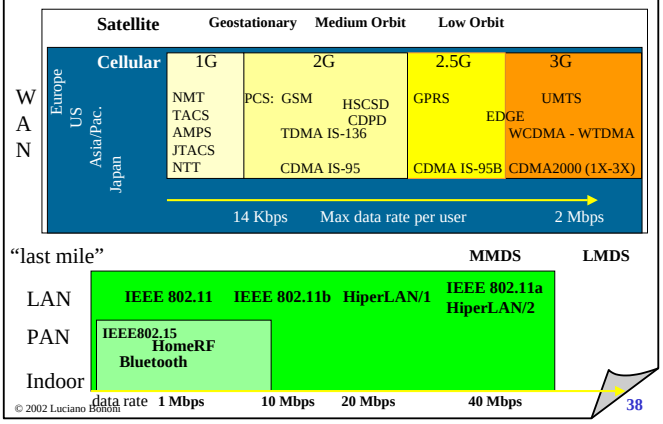
Wireless vs. Wired

Attribute	Wireless LAN/PAN	Wired LAN/PAN
Cost	• Initial investment in hardware costs more • Installation expenses and maintenance costs can be significantly lower	• Investment cost in hardware lower • Installation and maintenance costs can be significantly higher
Scalability	simple to complex networks	simple to complex networks
Safety	Very little exposure to radio frequency energy	No exposure to radio frequency energy
Mobility	Provides access to real-time information anywhere	Does not support mobility

Wireless networks' interoperability

- **...with the Wired Infrastructure:**
  - most WLANs support industry-standard like Ethernet (802.3) and Token-Ring (802.5)
  - newer solutions support ATM, FireWire, PPP...
- **…with other Wireless infrastructures:**
  - several types of interoperability are possible
  - the role of Standard definitions is to allow compliant products to interoperate
  - interference is possible in co-located solutions
  - security achieved through encryption

Wireless networks' taxonomy



Wireless World means...

- **New assumptions for the physical system...**
- **...willing to maintain needs for services and applications**
  - e.g. audio/video applications, interactive services
- **... dealing with limited resources (e.g. bandwidth, energy)**
- **... dealing with device limits (I/O, user interfaces)**
  - limited display, no keyboard, no mouse
- **... mobility of users and devices**
  - variable number of users in the system
- **... QoS problems, reliability, negotiation**

Wireless World integration

- **One possible solution for Integraton with wired world:**
  - to uncouple wired and wireless networks
  - protocol integration, maintaining services and protocols view from both sides
  - protocols and SW structures to adapt the contents transferred to etherogeneous devices
  - adaptive behavior of network protocols (from the wireless side)
    - the wired host does not know if the other host is wireless and dialogue with it in the standard wireless way (protocol transparency)
    - the wireless host know it is wireless and implements adaptive behavior

Wireless drawbacks

- **reduced Channel Capacity (1 or 2 order of magnitude)**
  - e.g. 11 Mbps vs. Gigabit Ethernet
- **Limited spectrum (etherogeneous frequency windows) available**
  - need for international frequency-allocation plans
  - need for frequency reuse
- **Limited energy (batteries): +20% every 5 years**
  - Moore law: SoC transistors double every year
- **Noise and Interference have great impact on performances and system design**
  - need for high power, bit error correction
- **Security: sensible information travels "on the air"**
  - need for protection based on cyphering, authentication, etc.

Wireless drawbacks

- **Mobility management**
  - **addressing and routing (eg. Mobile IP)**
- **Location Tracking**
  - **Broadcasting (paging) to find users/hosts**
  - **support for Location Based Services**
- **QoS Management**
  - **not a single layer management (application, transport, network, MAC)**
  - **depends on the system/user/application scenario**
  - **managed for the wireless cell only (no multi-hop)**
  - **advance reservation, admission control policies (centralized, distributed)**
  - **scheduling (centralized, distributed) for resources' allocation**
- **Best effort services**