

# 802

# Wireless Access Techniques

## Overview

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# Wireless Access Techniques

**WLAN**, Wireless Local Area Network

- IEEE 802.11: WiFi

**WPAN**, Wireless Personal Area Network

- IEEE 802.15: Bluetooth, RF ID

**BWA**, Broadband Wireless Access

**WMAN**, Wireless Metropolitan Area Network

- IEEE 802.16: WiMAX

# Common Characteristics

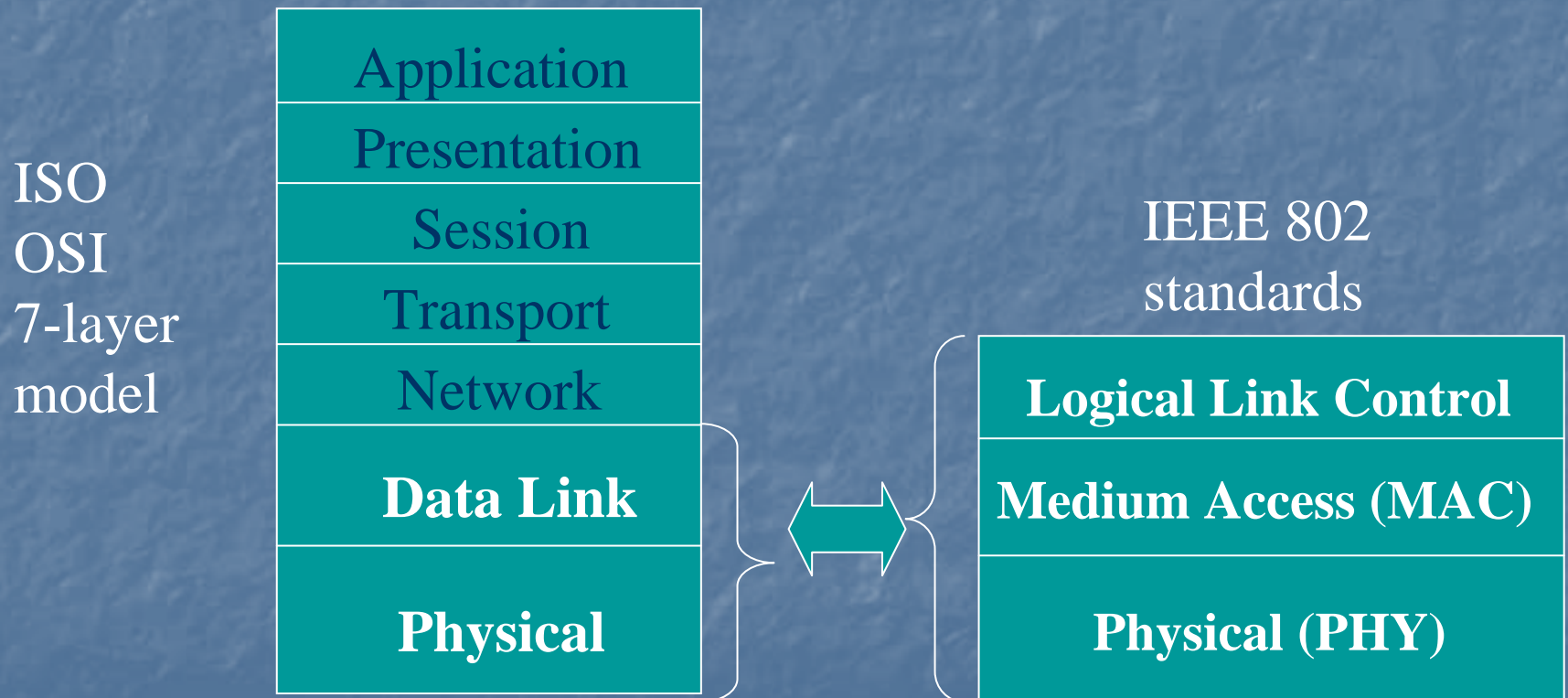
- **High data rate** (except for RFID) > 1 Mb/s
- **Packet transmission**
- **Low mobility**: stationary or pedestrian
- **Local coverage**
  - Access techniques for the Internet, or
  - Local services
- Physical & MAC layers and security mechanisms specified by wireless standards, higher layers based on common **Internet protocols**
- **Unlicensed** Industrial, Scientific, and Medical (ISM) bands mostly used

# Indoor Channel Models

- Average attenuation of some building materials at 2.4 GHz
  - Window 3 dB
  - Floor/ceiling 12-15 dB
  - Wall (wood) 10 dB
  - Wall (metal and concrete) 15-20 dB
- Typical rms delay spread in some environments
  - Home 50 ns
  - Office 100-150 ns
  - Large indoor spaces 250 ns
- Pedestrian speed (5 mph) leads to 37 Hz maximum Doppler at 5 GHz, i.e., coherence time in the order of 25 ms
- 10-15 dB fades observed when people are walking around the wireless station.
- Rich scattering environment => Antenna diversity (e.g., MIMO) help to improve capacity

# Scope of 802.11/15/16/... Standards

- Medium Access Control (MAC)
- Physical Layer (PHY)



# WLAN Characteristics

- 1... 54 Mb/s data rates (currently)
- Intended for short distances, one base-station covering, e.g.,
  - A few rooms/1 corridor in office building
  - A small house
  - A few hundred meters distances in open air, somewhat longer with directive antennas
- Power consumption not always very critical
  - Except when included in a mobile terminal, which is becoming more and more popular these days.

# WLAN Applications

- Cable-free access to internet in
  - Office environments
  - Homes (e.g., ADSL modem acting as the access point)
  - Hot-spots, like airports, conference centers, hotels, etc.
- Also used as high-speed Internet-access method for homes and small offices in urban areas, instead of ADSL or cable modems.

# WLAN Elements

- Extends Ethernet over wireless
- Two modes:
  - **Infrastructure WLAN**: Terminals communicate with Radio Access Point ('base-stations'), which acts as a bridge to the fixed Internet
  - **Ad-Hoc Network**: Terminals communicate with each other, without centralized control
- Each wireless station and access point has a wireless LAN card; Integrated solutions currently, e.g., in Laptops, ADSL Modems, PDAs/Communicators/mobile phones, game consols, etc.



# WLAN Application Aspects

- Designed for data communications
  - Problems with latency and Quality of Service in case of real-time audiovisual services
  - Limitations in data security mechanisms in WEP
- Recent enhancements (802.11e, 802.11i/WAP) of the standards are solving the problems encountered in early implementations.

# WLAN Standards

- Regulatory bodies specify the frequency bands and transmission power levels for different signal formats
  - FCC in USA
  - CEPT/ETSI in Europe
  - ARIB in Japan
- System standards by
  - IEEE (802.11) => ISO/IEC
- Interfaces between GSM/UMTS and WLAN developing under 3GPP.

# Transmission Power Levels

- 2400-2483.5 MHz (most commonly used band)
  - USA 1 W
  - Europe 100 mW EIRP or 10 mW/MHz (some variations in different countries)
- 5150-5350 MHz
  - Europe 200 mW EIRP, only indoor use
- 5470-5725 MHz
  - Europe 1 W EIRP, indoor and outdoor use

Certain mechanisms (dynamic frequency selection, DFS, transmit power control, TPC) are imposed to limit interferences to other services.

*EIRP: Effective radiated power level relative to isotropic*

# 802.11 Standards

- 802.11 Basic standard for Physical layer & MAC (1997)
- 802.11a OFDM-based physical layer for 5 GHz, 6-54 Mb/s (1999)
- 802.11b DSSS-based physical layer for 2.4 GHz, 5.5 and 11 Mb/s (1999,2001)
- 802.11c Supplement to support MAC bridge operation (1998)
- 802.11d Specification for operation in different regulatory domains (2001)
- 802.11e MAC enhancements for QoS (2005)
- 802.11F Interaccess point protocol (2003, withdrawn 2006)
- 802.11g OFDM-based (also other optional modes) physical layer for 2.4 GHz, ...54 Mb/s (2003)
- 802.11h Spectrum and power management enhancements to 802.11a (2003)
- 802.11i MAC security enhancements (WPA2) (2004)
- 802.11j Enhancement of 802.11a for 4.9-5.0 GHz in Japan (2004)
- 802.11k Radio resource management (active, 2007/10?)
- 802.11ma Technical corrections and clarifications (active, 2007/3?)
- 802.11n High-throughput enhancements (active, 2008/4?)

# 802.11 Standards

- 802.11p Wireless Access for the Vehicular Environment (active, 2008/7?)
- 802.11r Fast Roaming (active, 2008/10?)
- 802.11s ESS Mesh Networking (active, 2008/7?)
- 802.11T Wireless Performance Prediction (active, 2009/4?)
- 802.11u InterWorking with External Networks (active, 2008/10?)
- 802.11v Wireless Network Management (active, 2009/1?)
- 802.11w Protected Management Frames (active, 2009/1?)
- 802.11y 3650-3700 MHz Operation in USA (active, 2008/4?)

Note: Future dates with "?" indicate predicted times of issuing the standards.

# 802.11 Physical Layer

- 802.11 - FHSS, DSSS
  - 1 or 2 Mb/s, 2.4 GHz
- 802.11b - Complementary Code Keying (CCK) modulation
  - 11 Mb/s, 2.4 GHz
- 802.11a - OFDM
  - up to 54 Mb/s, 5 GHz
  - 802.11h adds Dynamic Frequency Selection (DFS) and Transmitter Power Control (TPC)
- 802.11g - OFDM and DSSS
  - up to 54 Mb/s, 2.4 GHz
- **Most implementations support many or all of these Phy's**
- 802.11n – MIMO OFDM
  - under development, >100 Mb/s, utilizes advanced multiantenna concepts

# WPAN, Wireless Personal Area Network

- Cable replacement
- Short distances, up to 10 m
- Bluetooth: 0.7-2 Mb/s data rates
  - Wireless earphones, hands-free sets
  - Mobile phone – laptop/PC synchronization
  - Low power, low cost
- High-rate WPAN, UWB systems
  - Digital image/video down-load/exchange
- Low-rate WPAN, RF-ID
  - Sensors, meter-reading, smart tags/badges, home automation
  - Ultra low power and cost need; short range

# 802.15 WPAN

- 802.15.1 WPAN based on Bluetooth
- 802.15.2 Coexistence of WPAN with other systems at 2.4 GHz
- 802.15.3 High-rate WPAN
- 802.15.3a High-rate alternative physical layer
- 802.15.3b MAC improvement
- 802.15.4 Low-rate WPAN (RFID, etc.)



# WMAN, Wireless Personal Area Network

## BWA, Fixed Broadband Wireless Access Systems

- Broadband Internet connections to homes and small offices
- Competes with ADSL and cable modems, but is able to offer higher data rates
- Original idea: Fixed terminals, possibly with directive antennas
- Recent developments: Applicable also to mobile users
  - Partly competing with high-data-rate cellular system developments, like HSDPA/HSUPA/3G-LTE

# 802.16 BWA = WiMAX

- 802.16 Fixed BWA systems between 10 and 66 MHz
- 802.16a Amendment for operation between 2 and 11 GHz
- 802.16c Enhancements including system profiles, 10-66 GHz
- 802.16.2 Coexistence between 2 and 11 GHz
- 802.16/Conf Test and conformance specifications
- 802.16d System profiles
- 802.16e Mobile WiMAX
- etc.
- 802.20 New standard development with full mobility, based on WiMAX