Chapter 3.1

Acknowledgment: This material is based on the slides formatted by Dr Sunilkumar S. manvi and Dr Mahabaleshwar S. Kakkasageri, the authors of the textbook: Wireless and Mobile Networks, concepts and protocols. Most of the slides are used without any change. Some additional slides are taken and/or inspired by material from various paper and / or electronic resources. Some comments and/or additive information are directly enclosed in the original slides. Such comments are usually written with a different color. I apologize for any involuntary omission to other references if any.

Chapter 3

Wireless Local Area Networks

These slides are based on the slides formatted by Dr Sunilkumar S. manvi and Dr Mahabaleshwar S. Kakkasageri, the authors of the textbook: Wireless and Mobile Networks, concepts and protocols. See slide number one.

Learning objectives

- To understand wireless local area networks (WLANs)
- To study the requirements of WLANs
- To understand the architecture of WLANs
- To know the modulation and access technologies used in WLANs
- To study the protocols of different layers of WLANs
- To illustrate the applications of WLANs

Network components

- WLAN adapters
- Access points
- Outdoor WLAN bridges
- WLAN routers

WLAN adapters

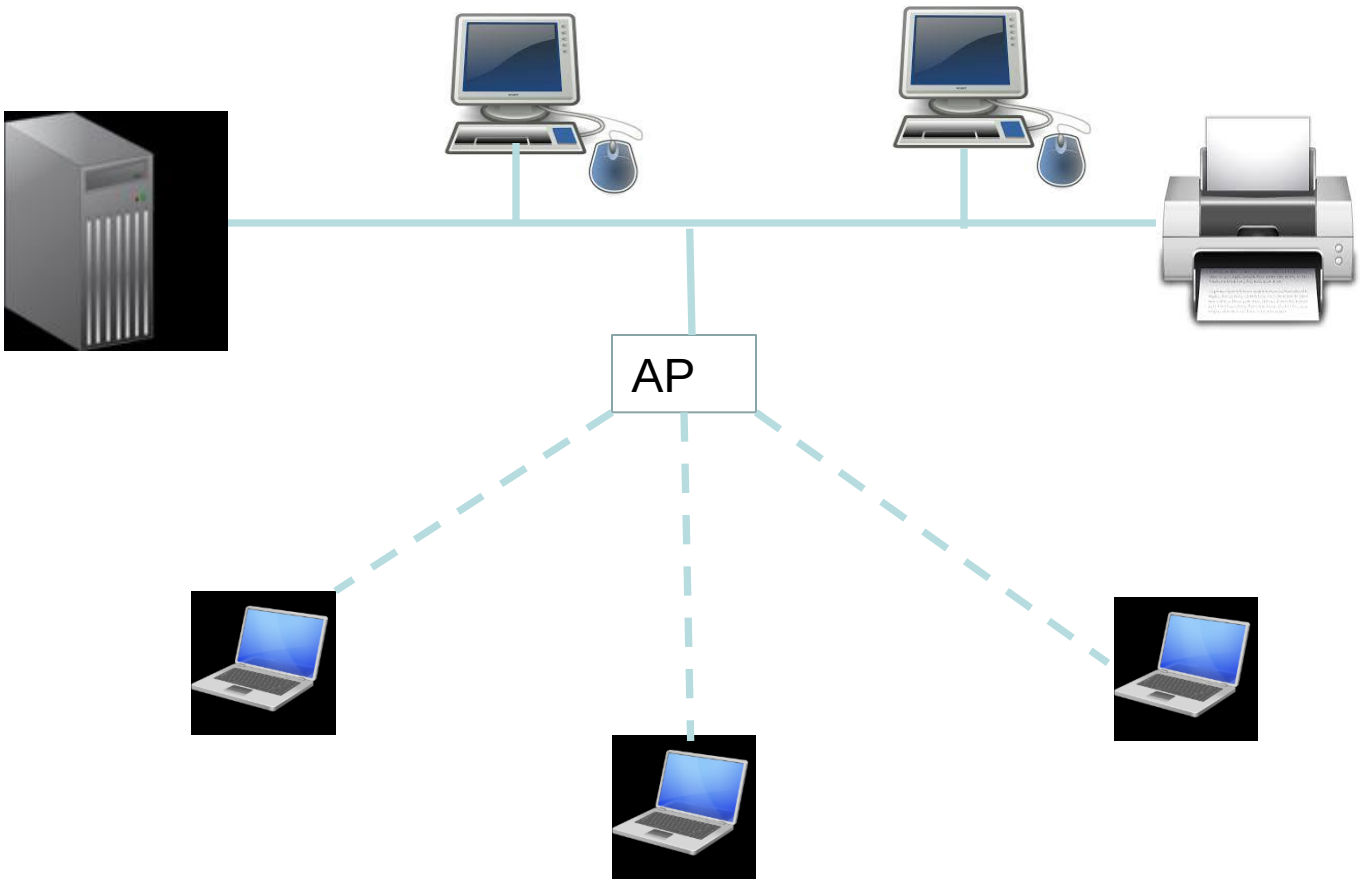
- Wireless adapters are made in the same basic form factors as their wired counterparts.
- It usually contains the functionalities of physical and data link layer (includes LLC and MAC operations).
- They enable end-users to access the network. In a WLAN, adapters create a transparent connection to the network (Cf. next slide).

WLAN adapters (cont..)

Access points

- The Access Point (AP) is the wireless equivalent of a wired LAN hub. (Cf. next slide)
- It receives, buffers and transmits data between the WLAN and the wired network, supporting a group of wireless user devices.
- An AP is typically connected with the wired backbone through a standard Ethernet cable, and communicates with wireless devices by means of an antenna.
- AP covers range of 20-500 m, and a single AP can support between 15 and 250 users, depending upon the technology, configuration and use.

Example single-cell wireless LAN configuration



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Characteristics of access points

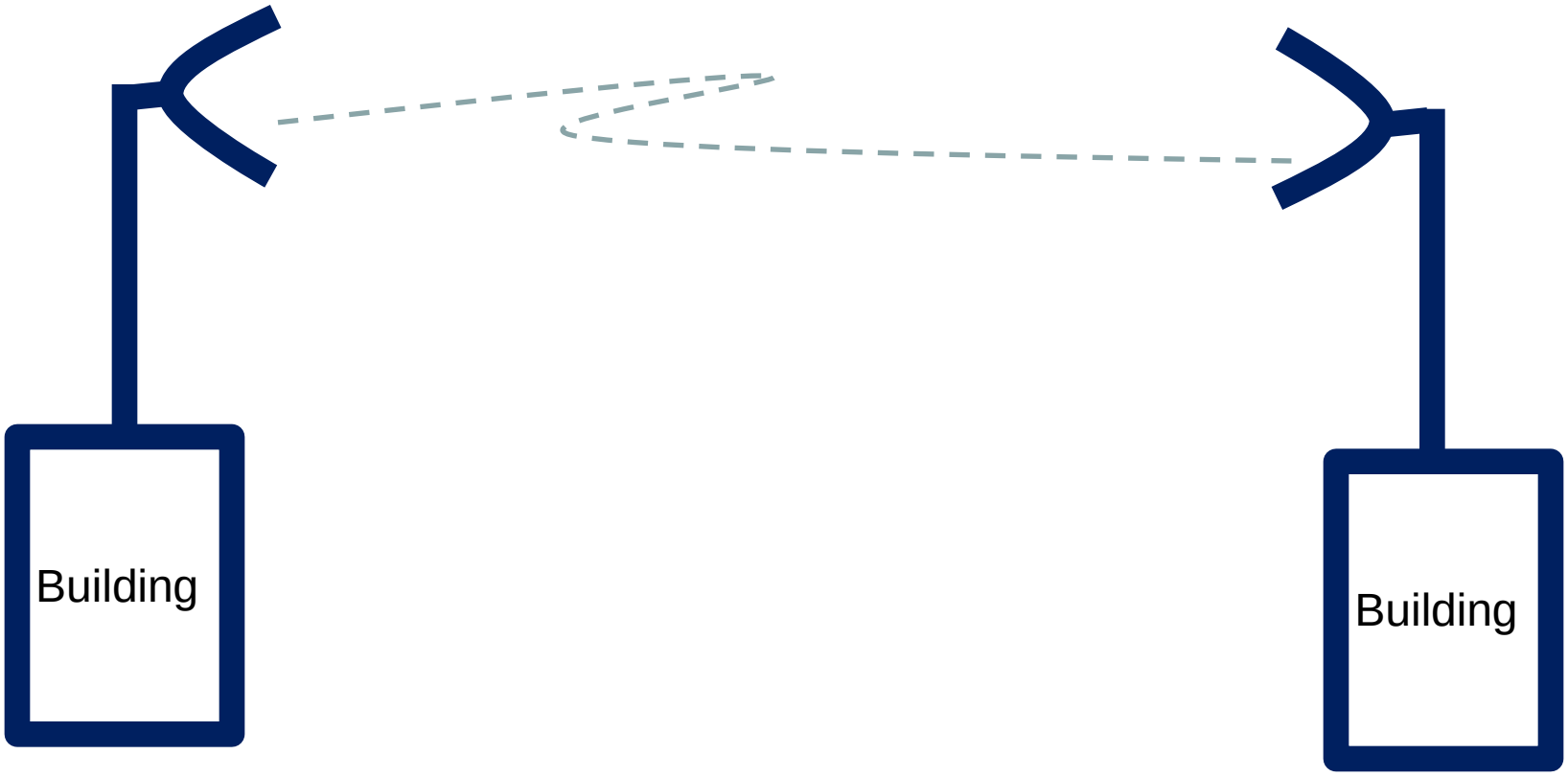
- Access points should be on the same subnet.

- Access points do not perform load balancing.
- Client determines if it should switch between access points based on retry level.
- Load balancing is performed by client so as to balance the load among the access points.

Outdoor WLAN bridges

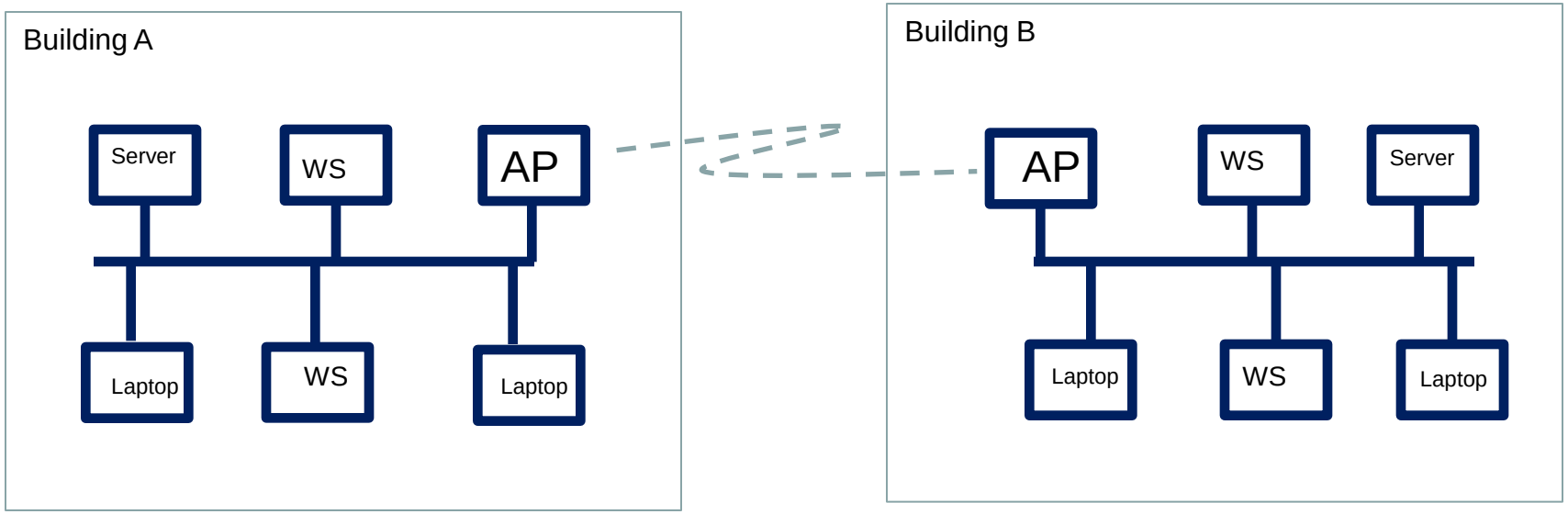
- These are used to connect wired LANs in different buildings (to create one large LAN).
- WLAN bridge supports fairly high data rates and covers ranges of several miles with the use of line-of-sight directional antennas.

Outdoor WLAN bridges (Contd..)

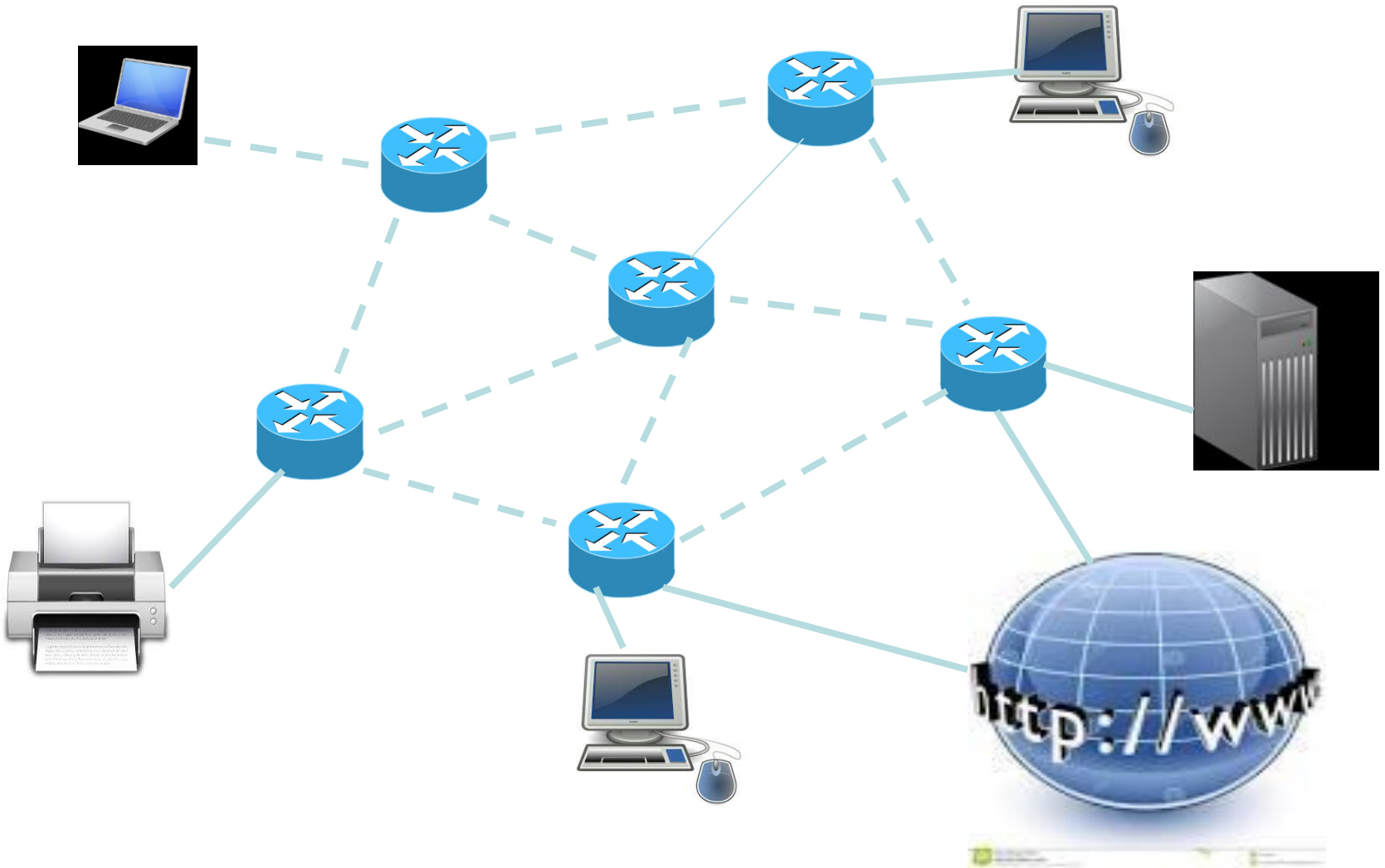


Outdoor WLAN bridges (Contd..)

- Some access points can also be used as a "bridge" between buildings of relatively close proximity.



Wireless routers



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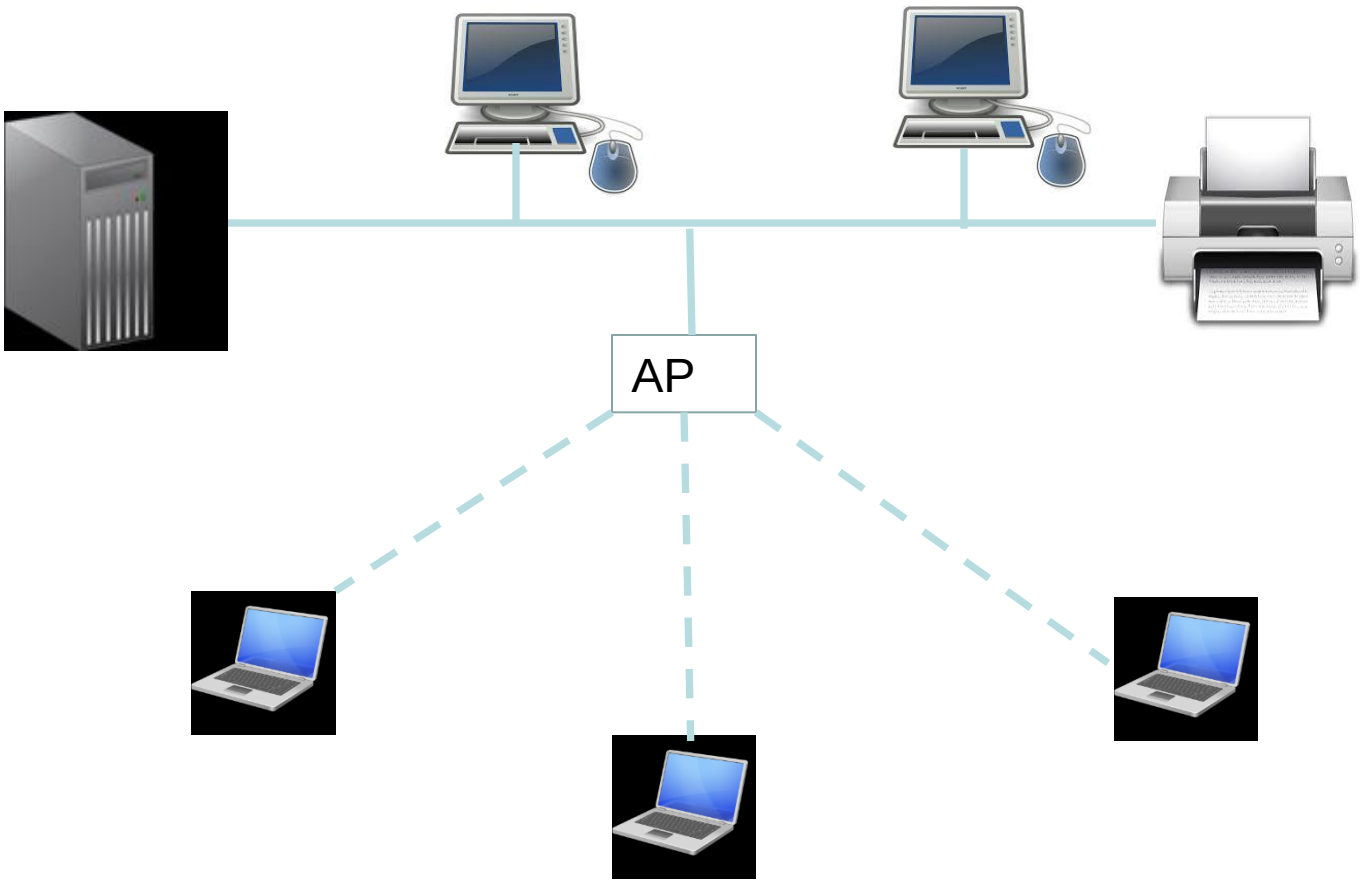
WLAN routers

- Basic function of the router is to transfer the packets between the networks.
- The difference between WLAN routers and AP is that AP allow wireless clients access to a single network, while WLAN routers allow clients to browse a number of different networks (Cf. Next two slides).
- The router always takes the IP address into account to make decisions on how to forward (i.e., route) the packet; whereas, AP generally ignore the IP address and forward all packets.

AP: one single network



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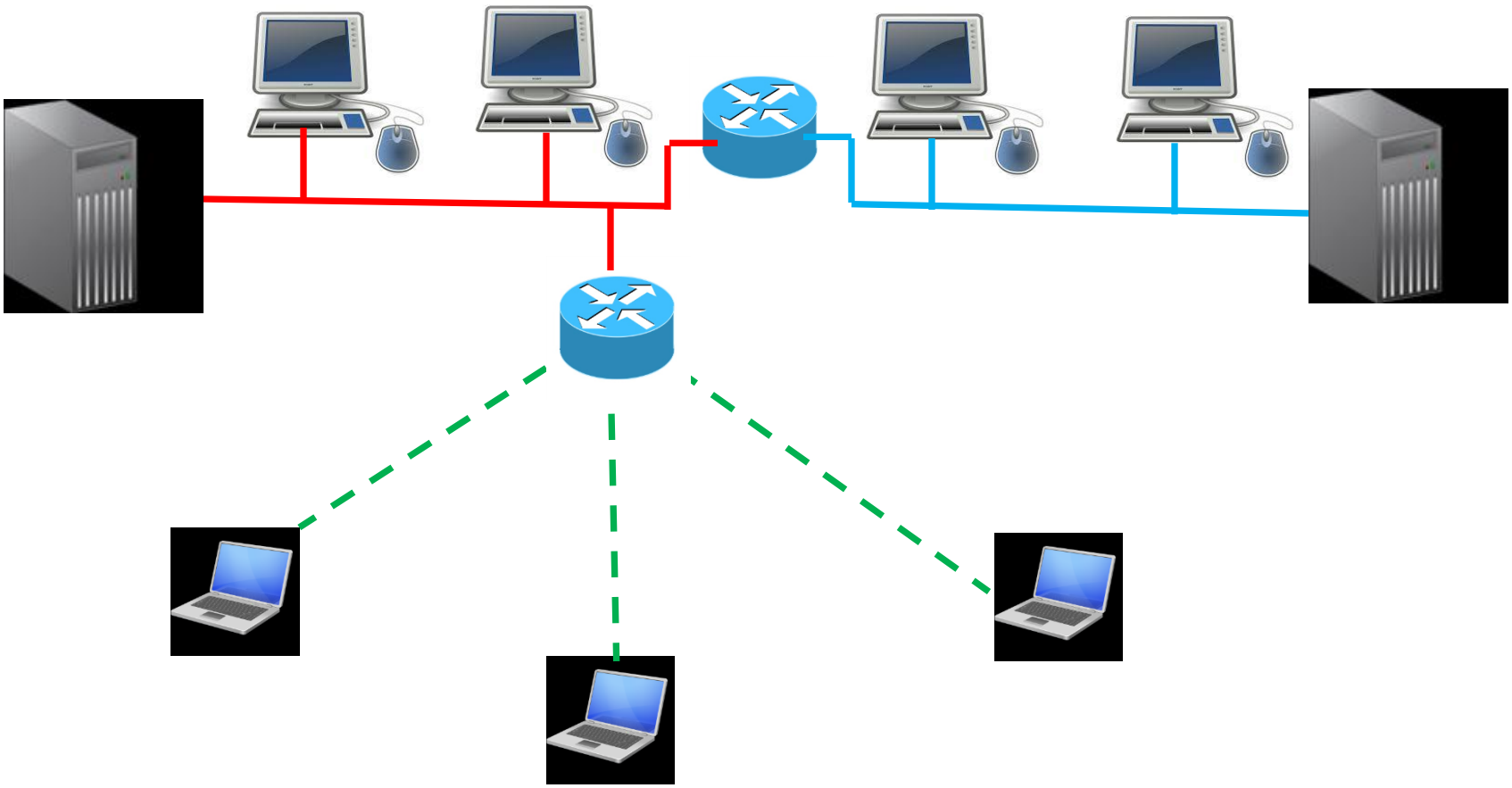
Routers: different networks



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Advantages of WLAN routers

- WLAN routers share IP address in the home and small office networks.
- WLAN routers are ideal for wireless networks in public areas, especially if there are multiple networks that are accessible.
- WLAN routers improve the network management.
- Routers only send packets to specific, directed addresses. They do not forward the often numerous broadcast packets that are sent out by other devices.
- This results in an increase in the network performance.

Design requirements of WLAN

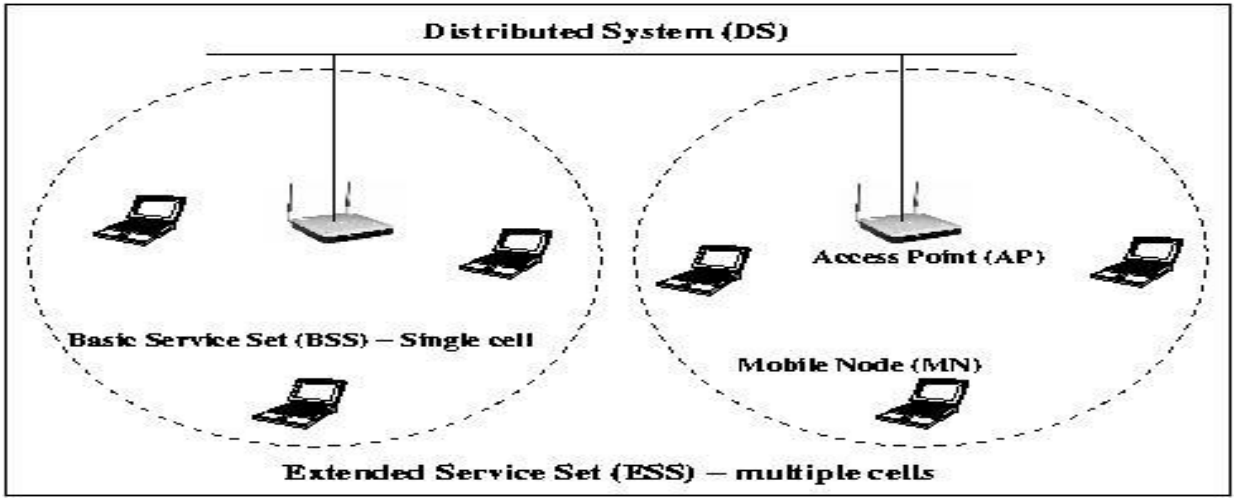
- Range and Coverage
- Throughput
- Integrity and Reliability
- Compatibility
- Interoperability
- Licensing Issues
- Security
- Cost
- Scalability
- Battery Life and
- Safety

Network architecture

- Two modes of WLANs:
  - Infrastructure based and
  - Infrastructure-less WLAN.

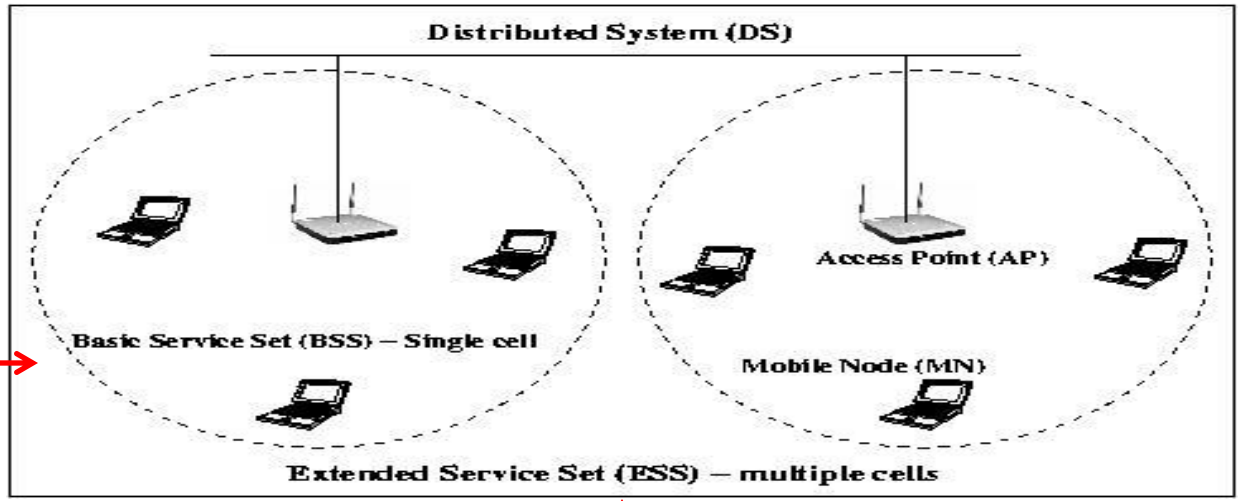
Infrastructure based WLAN

- A typical infrastructure based WLAN defines two pieces of equipment, a wireless station, which is usually a PC equipped with a wireless network interface card (NIC), and an AP, which acts as a "bridge" between the wireless and wired networks.



Infrastructure based WLAN (Contd..BSS and ESS)

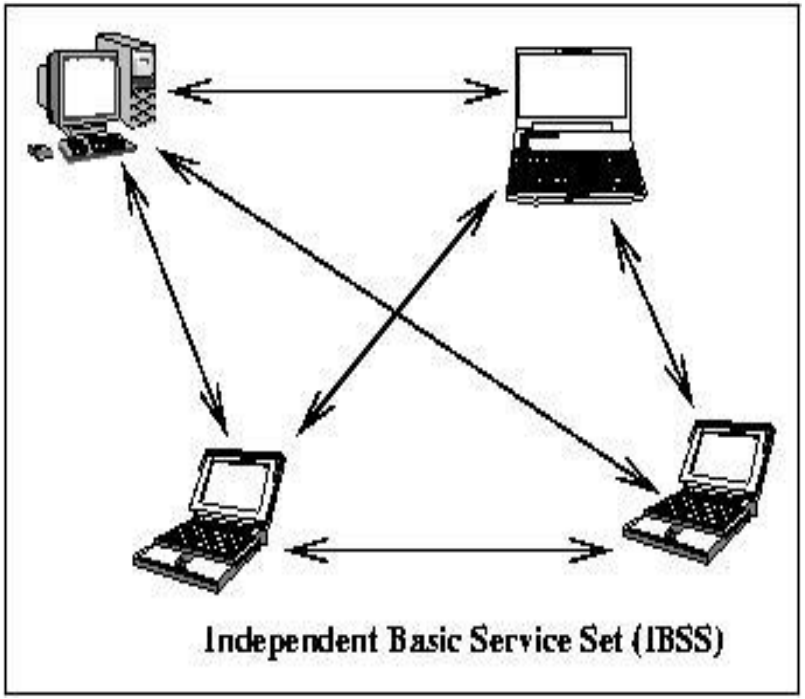
- A Basic Service Set (BSS) is a set that consists of one access point (connected to the wired network infrastructure) and a set of wireless end stations.
- An Extended Service Set (ESS) is a set of two or more BSSs.
- Since most corporate WLANs require access to the wired LAN for services (servers, printers, Internet links), they will operate in infrastructure mode.



Infrastructure-less WLAN

- These are sometimes referred as ad-hoc networks since they are temporary networks established as and when required.
- There are two kinds of ad-hoc networks: peer-to-peer (Cf. next slide) and multihop.
- peer-to-peer mode (also called Independent Basic Service Set, or IBSS) is simply a set of wireless stations that communicate directly with one another without using an AP or any connection to a wired network.
- This mode is useful for quickly and easily setting up a wireless network.

Infrastructure-less WLAN (cont..)



WLAN standards

- IEEE 802.11
  - IEEE 802.11a
  - IEEE 802.11b
  - IEEE 802.11c
  - IEEE 802.11d
  - IEEE 802.11e
  - IEEE 802.11f
  - IEEE 802.11g
  - IEEE 802.11h
  - IEEE 802.11i
  - IEEE 802.11j
  - IEEE 802.11k
  - IEEE 802.11m
  - IEEE 802.11n

IEEE 802.11

- The 802.11 network architecture is composed of several components and services that interact to let station mobility be transparent to the higher layers of the network stack (wireless nodes and access points are examples of such components).
- It supports topologies like infrastructure Basic Service Set (BSS), Extended Basic Service Set (EBSS), and Independent Basic Service Set (IBSS).
- IEEE 802.11 was the first standard in WLANs (1997).
- All of the 802.11 implementations support data rates of 1 Mbps and, optionally, 2 Mbps.

IEEE 802.11(Contd..)

- Physical layer implementations: three different ways:
  1. Direct Sequence Spread Spectrum (DSSS) in the 2.4 GHz band,
  2. Frequency Hopping Spread Spectrum (FHSS) in the 2.4 GHz band, and
  3. Infrared light (IR).
- The fundamental access method of 802.11 is Carrier Sense Multiple Access with Collision Avoidance or CSMA/CA.
- Addressing either for peer-to-peer configuration or for integration with an existing wired LAN.
- Operation within possibly overlapping wireless LANs (with the mobility of a device between multiple wireless LANs).
- Privacy and security of user data being transferred over the wireless media.

IEEE 802.11a

- It is an extension of 802.11
- As other extensions, the goal is to span other multiple physical encoding types, frequencies and applications.
- Operates in the 5-GHz band.
- 802.11a supports data rates of up to a maximum of 54 Mbps.
- Uses OFDM which increases data rate.
- Each channel in 802.11a is 20 MHz and is divided into 52 sub-channels, each about 300 KHz wide.
- The distance (range) of a node about 150 feet indoors and 300 feet outdoors.

IEEE 802.11b

- 802.11b is often referred to as Wi-Fi.
- 802.11b operates in the 2.4 GHz band
- Uses Direct Sequence Spread Spectrum (DSSS) modulation.
- Data rates up to 11 Mbps.
- The distance (range) of a node is about 200 feet indoors and 600 feet outdoors.

802.11e

- Modifies MAC layer to support QoS for multimedia applications.
- Expectations for handling voice traffic (with a target of 20 ms or less delay), MPEG (Moving Picture Expert Group) video at up to 3 Mbps, and data streams at up to 10 Mbps.
- The group “e” is considering ways to introduce load balancing between APs.

802.11g

- Provides a high rate extension to 802.11b allowing for data rates up to 54 Mbps (from 11 Mbps).
- Just as 802.11 b, 802.11 g operates in the 2.4 GHz
- Opens the possibility for using 802.11 networks in more demanding applications, such as wireless multimedia video transmission and broadcast MPEG.
- 802.11 g uses OFDM (just as 802.11a)

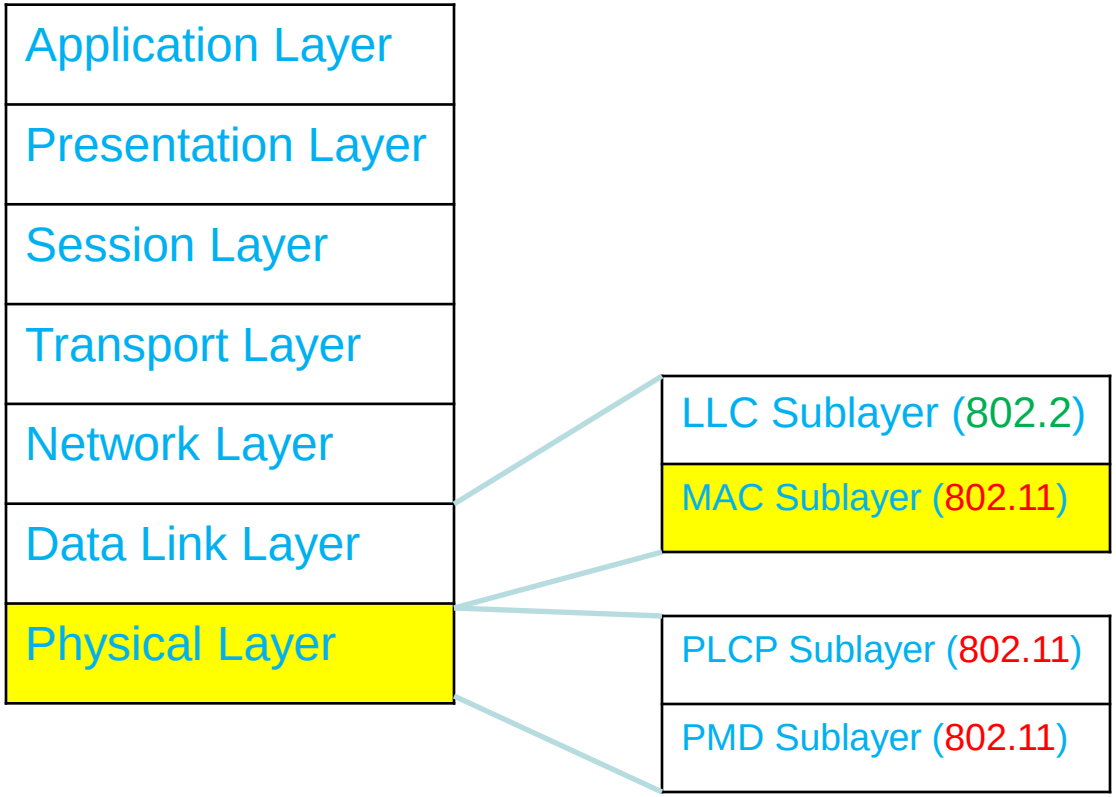
802.11n

- In 2004, IEEE announced the creation of a new group “n”
- Frequency bands: 5 GHz, 2.4 GHz
- 802.11 n uses OFDM (just as 802.11a).
- Speed up to 150 Mbps (at least 100 Mbps)
- Better operating distances

Other IEEE 802.11x

- Most of the other standards are under development.

The IEEE 802.11 protocols



PLCP: Physical Layer Convergence Procedure

PMD: Physical Medium Dependent

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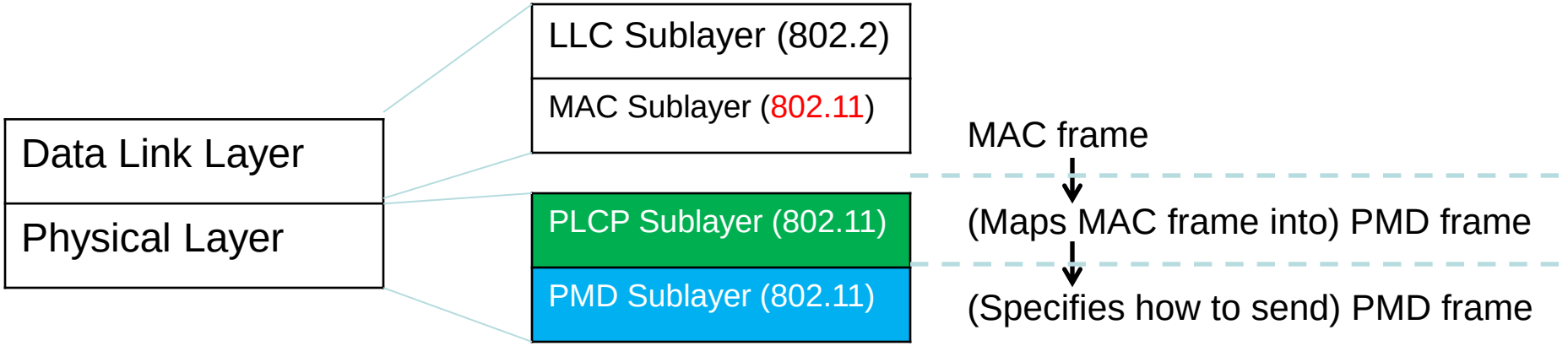
Functionality of PHY layer

- The PMD makes up standards for characteristics of wireless medium (such as DSSS or FHSS) and specifies how to send and receive data over such a medium
- The PLCP
  - Maps the MAC frames into frame formats that PMD layer can transmit.
  - Provides a carrier sense indication back to the MAC layer to verify activity on the media and determines when data can be sent.



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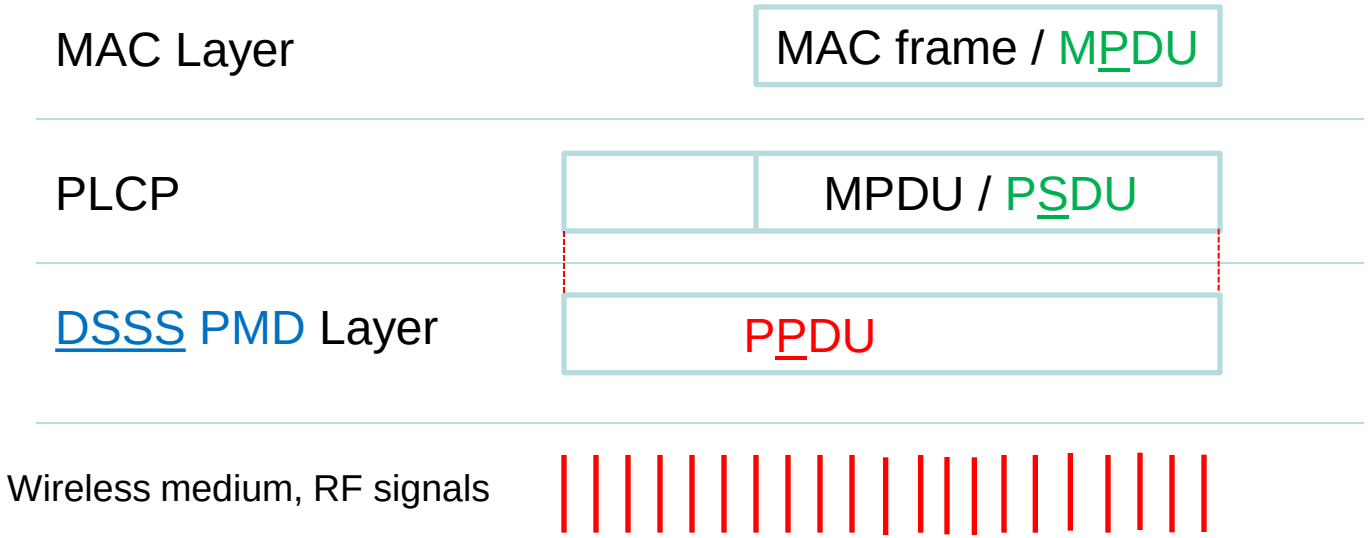
Physical layer implementations

- DSSS PHY (Direct Sequence Spread Spectrum)
- FHSS PHY (Frequency Hopping Spread Spectrum)
- Infrared (IR) PHY

DSSS PHY

- The DSSS PHY uses the 2.4 GHz frequency band.
- Data transmission over the media is controlled by the DSSS PMD sublayer.
- The DSSS PMD takes the PLCP Protocol Data Unit (PPDU) and transforms the bits into RF signals for the wireless medium by using carrier modulation and DSSS techniques.

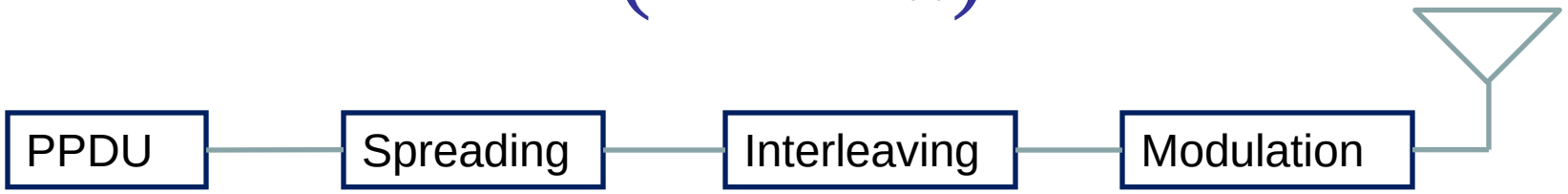


Remark: the MPDU (MAC Protocol Data Unit) is seen a PSDU (PLCP Service Data Unit) by the PLCP

DSSS PMD transmitter and receiver

- DSSS Modulation (encoding using Barker Spreading Method)
- Interleaving
- Modulation

DSSS PMD transmitter and receiver (Contd..)

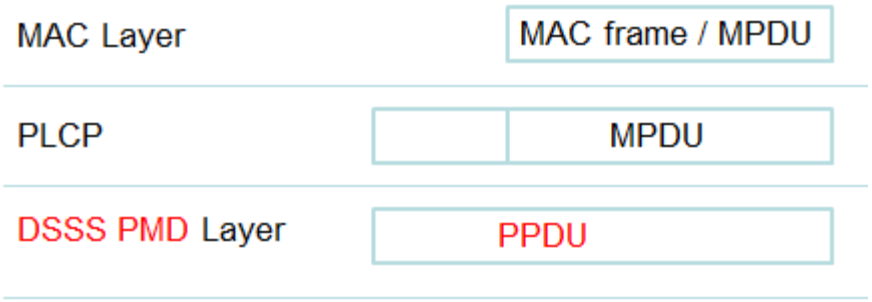


Spreading: a 1 or a 0 is XOR-ed with so-called Barker spreading sequence: *10110111000*

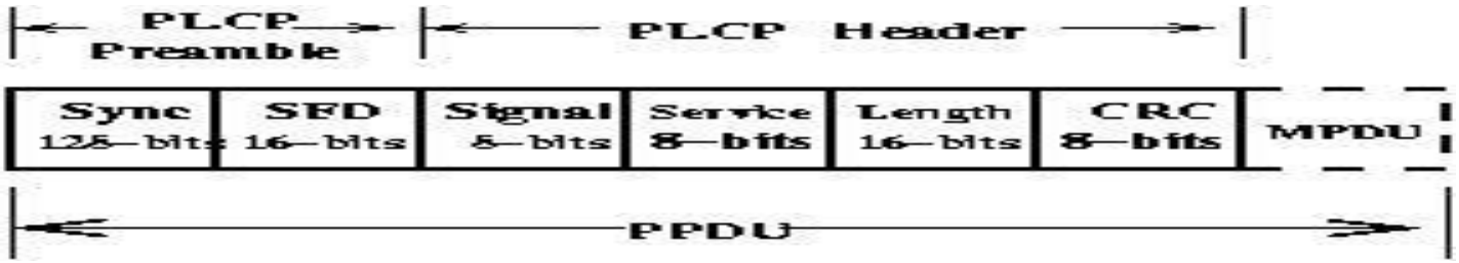
Interleaving: replacing sequences with longer sequences for instance:
0 is replaced by 00000
1 is replaced by 11111

Modulation: DBPSK, DQPSK
DBPSK: Differential Binary Shift Keying
DQPSK: Differential Quadrature Shift Keying

DSSS PHY PPDU format



- The PPDU (the PLCP PDU) consists of a PLCP preamble, PLCP header, and MPDU (the MAC PDU / MAC frame).
- The PLCP preamble and PLCP header are always transmitted at 1 Mbps, and the MPDU can be sent at 1 Mbps or 2 Mbps.



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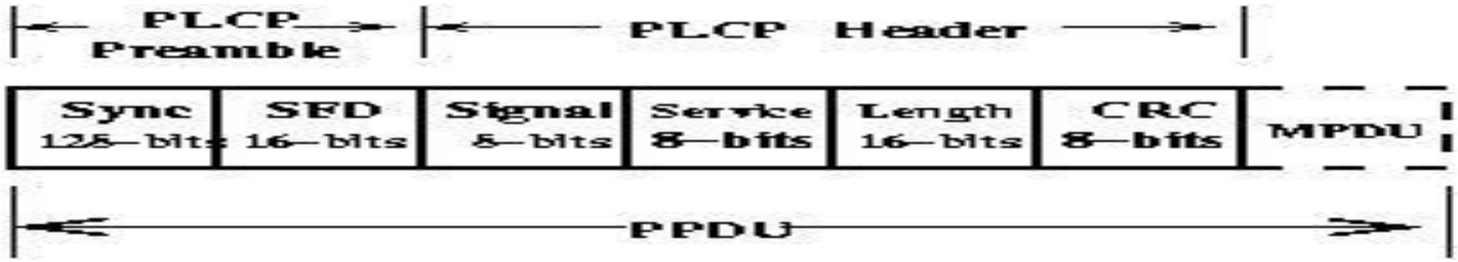
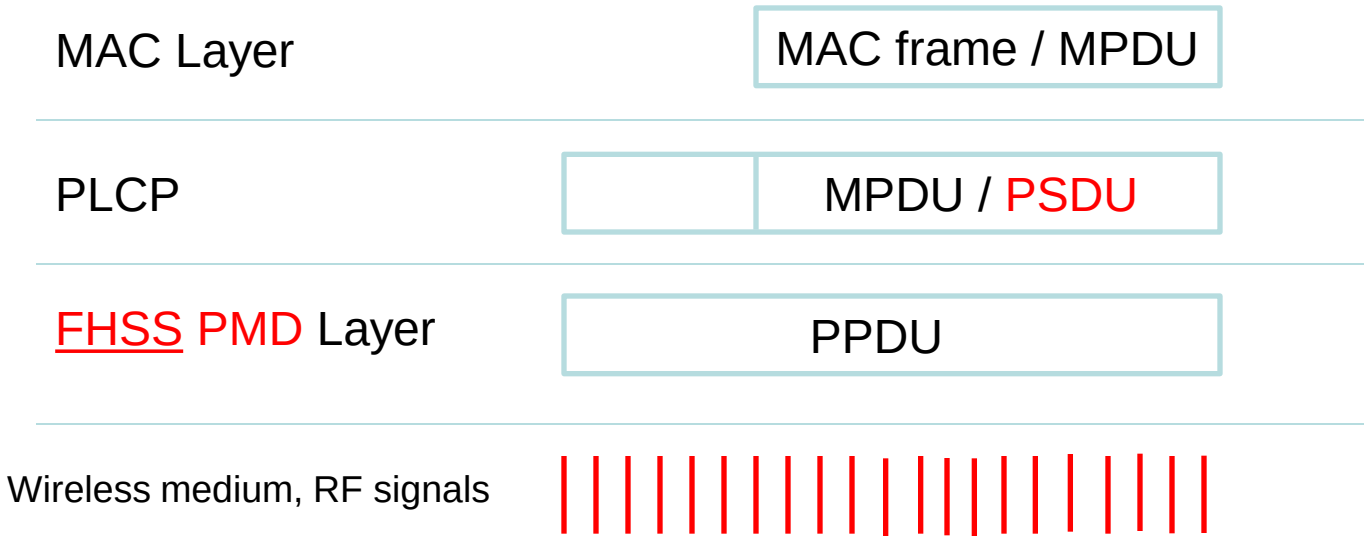
DSSS PHY PPDU format (Contd..)



- SYNC: 128 bits in length, contains a string of 1s which are scrambled prior to transmission (use of PN code) . Used to synchronize the receiver with the transmitter. Receiver correlates to PN code.
- Start of frame delimiter (SFD): used to marking the start of a PPDU frame.
- Signal: Defines which type of modulation (and the rate) that must be used to receive the incoming MPDU.
- Service: The service field is reserved for future use and the default value is 00h.
- Length: The length field is an unsigned 16-bit integer that indicates the number of microseconds necessary to transmit the MPDU.
- CRC: The CRC field contains the results of a calculated frame check sequence from the sending station.

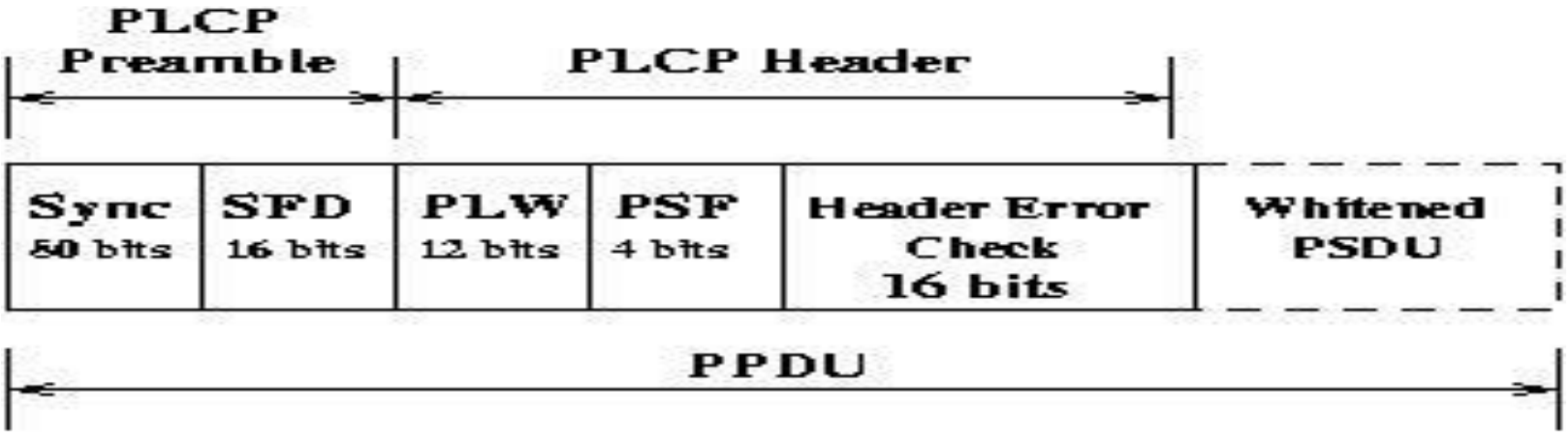
FHSS PHY

- The structure of the FHSS PHY is the same as the DSSS PHY.
- The FHSS uses the 2.4 GHz frequency band.
- Data transmission over the media is controlled by the FHSS PMD sublayer.
- The FHSS PMD transmits the binary bits from the (whitened) Protocol Service Data Unit (PSDU) by using carrier modulation and FHSS techniques.

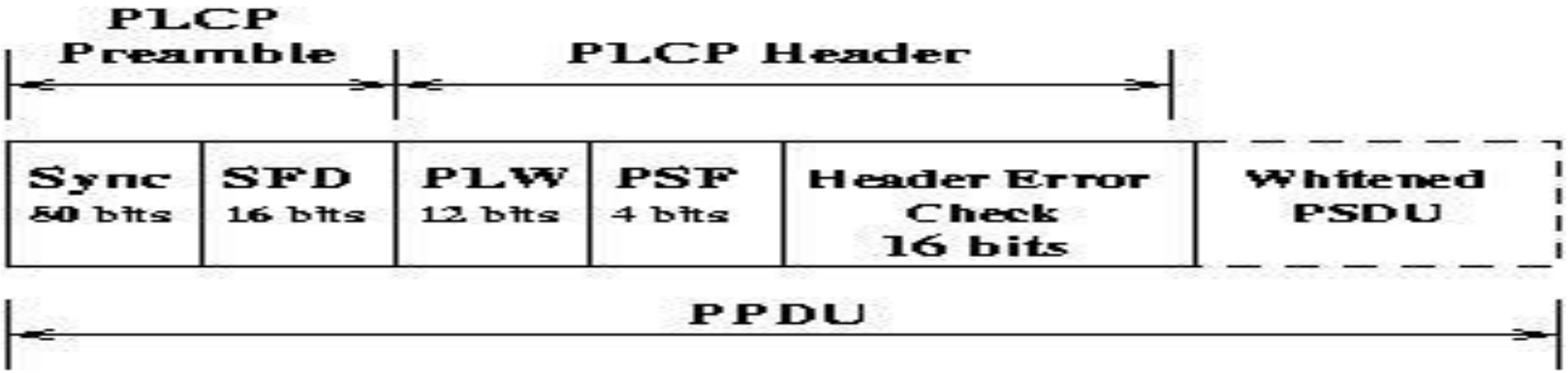


FHSS PHY PPDU format

- The PLCP sublayer in the FHSS PHY performs the same functions as the PLCP in the DSSS PHY.



FHSS PHY PPDU format (Contd..)



- SYNC
- SFD
- PLW (PSDU Length Word) : used to detect the end of the PPDU (Length in DSSS)
- PSF (PLCP Signaling Field) : identifies the data rate of the PSDU (from 1 to 4.5 Mbps). The PLCP Header and Preamble are transmitted at 1 Mbps (Signal in DSSS)
- Header Check Error

END of Chapter 3.1

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