Wireless LAN and Personal Area Network Protocols

Lesson 01

Wireless LANs

Local area network (LAN)

- A set of computers, computational systems, units, and devices, for example, mobile phones, printers, laptops, smart sensors, and smart labels, networked using a standard suite of protocols
- Local refers to some defined area or a set of nearby or distant stations

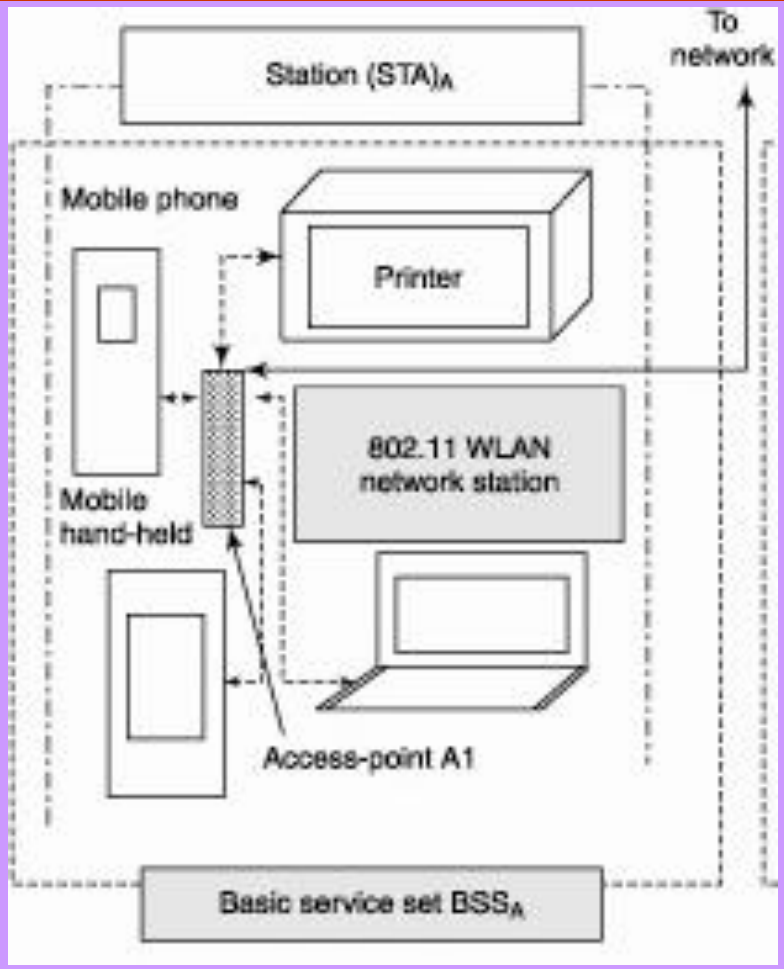
Wireless LAN (WLAN)

- IEEE 802.11a, 802.11b, … 802.11g standards recommended for WLAN in mobile communication and for establishing communication between mobile devices and Internet or other networks

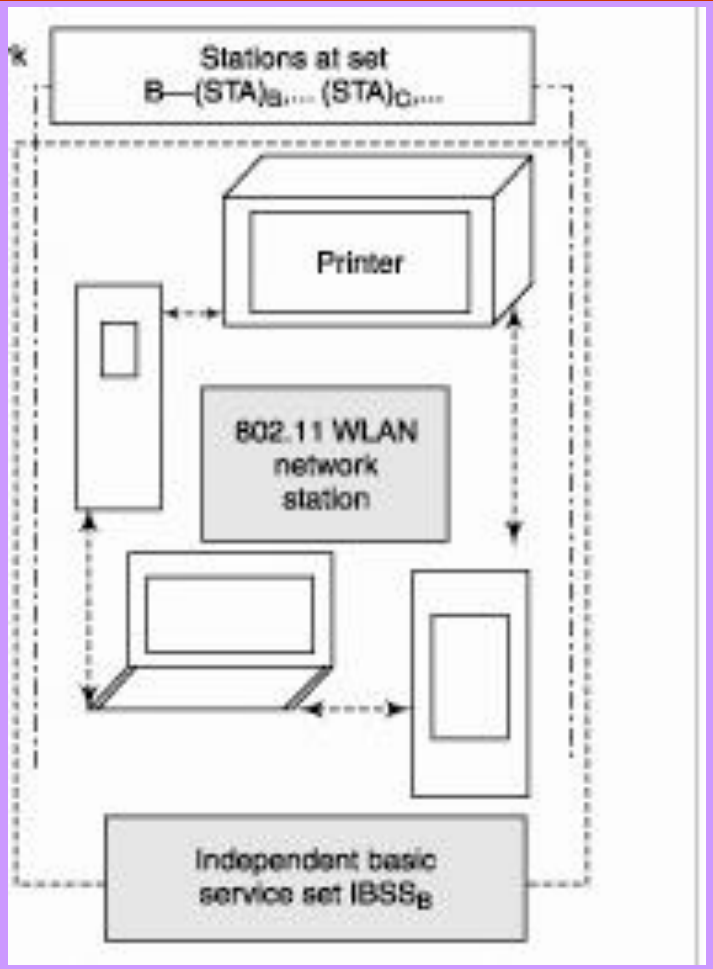
Two service sets in the WLAN architecture

- Basic Service set (BSS)– Set *A* has nodes which connect to an access-point
- Independent basic service set (IBSS)– Set *B* do not connect to any access-point
- IBSSs do not connect among themselves

BSS, which also has an access point for connectivity



IBSS, which has no access point to other IBSS or Network



Basic Service set (BSS) *A*

- BSS devices in each set interconnect to the access-point using 802.11
- Form a single station STA_A of WLAN using same frequencies for radio
- The BSS station interconnects to other stations through access-points

IBSS Set *B*

- Set *B* has several stations STA_B, STA_C, ….

Standard basic feature of 802.11

- Supports both access-point-based fixed infrastructure and WLAN network using BSSs
- Ad-hoc peer-to-peer data routing network using IBSS stations

Node in WLAN

- Each node of a station uses the same frequency band if it is at a distance from another station
- Uses a distinct frequency band if it is not distant enough from another station

Node in WLAN

- Node at a station can communicate directly to an access-point (in BSS)
- To another node at another station through the access-point
- Communicate among themselves after forming an ad-hoc or any other type of network (for example, Bluetooth) using same frequency band for each node

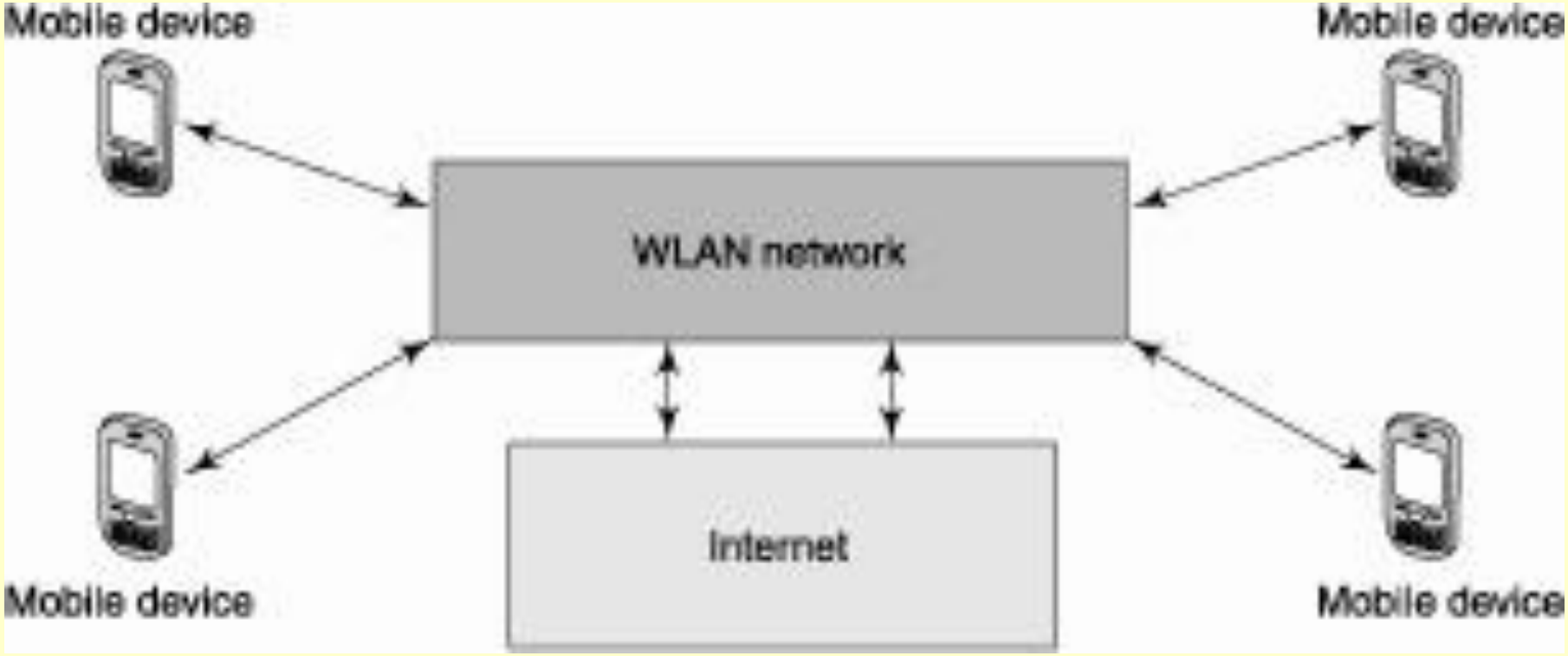
802.11 PROTOCOLS SUITE

- Does not specify the protocols for the nodes for data routing, exchanging, or supporting exchange of network topology information
- Thus, Bluetooth object exchanges can occur between the nodes
- The nodes can use ZigBee protocol for exchanges

WLAN and Internet Access

- IEEE 802.11a, 802.11b, and 802.11g standards
- WiFi (Wireless Fidelity) connectivity also uses WLAN standards IEEE 802.11x

Mobile communication using an 802.11 WLAN standard



IEEE 802.11 based standards for WLANs

- 802.11a– MAC layer operations such that multiple physical layers in 5 GHz (infrared, two 2.4 GHz physical layers)
- Infrastructure based architecture as well as Mobile ad hoc network (MANET) based architecture

802.11a

- OFDM at data rates of 6 Mbps, 9 Mbps,…
- Data rates supported are from 54 kbps to a few Mbps

802.11b

- 54 Mbps and at 2.4 GHz.
- Modulation DSSS /FHSS
- Supports short-distance wireless networks using Bluetooth (IEEE 802.15.1) based applications and the HIPERLAN2 (HIPERformance LAN 2)

802.11b

- OFDMA physical layer
- Provides protected Wi-Fi access
- The data rates are 1 Mbps (Bluetooth), 2 Mbps, 5.5 Mbps, 11 Mbps, and 54 Mbps (HIPERLAN 2)

802.11g

- Operates at 54 Mbps and at 2.4 GHz
- Used for many new Bluetooth applications
- Compatible to 802.11b
- Uses DSSS in place of OFDMA

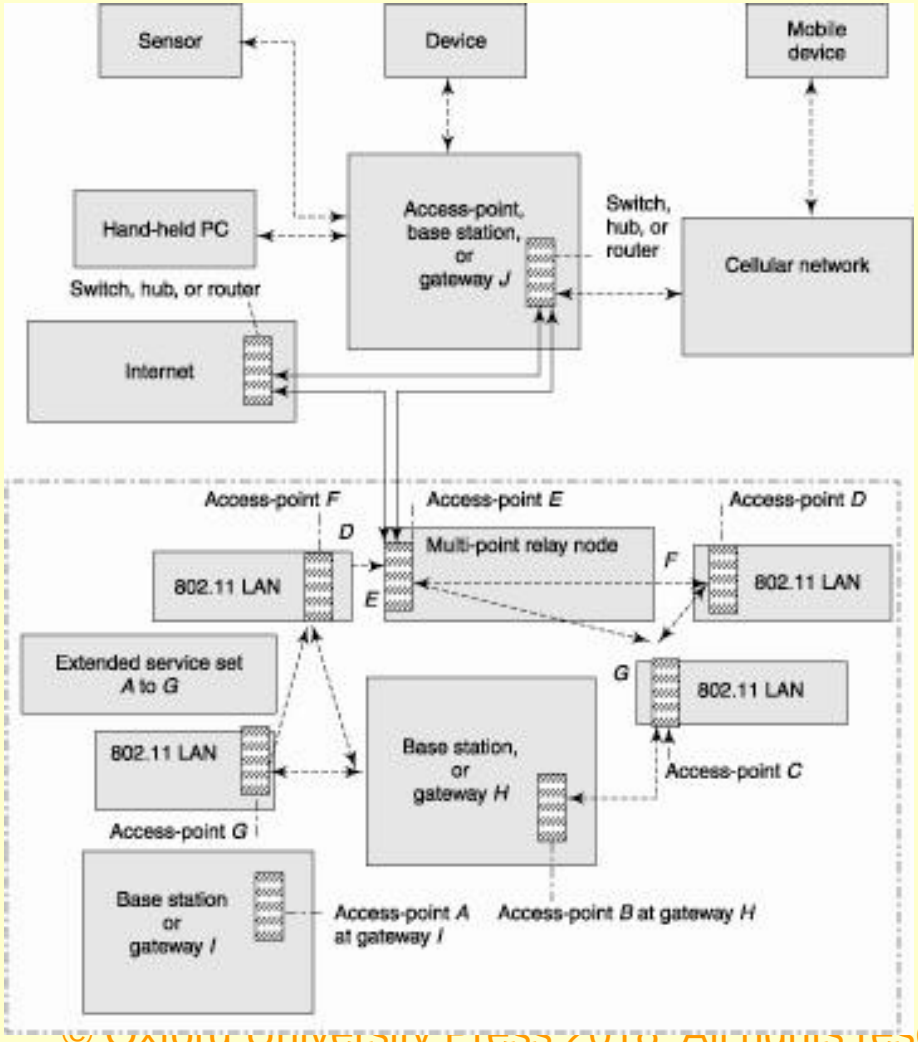
Extended Service Set (ESS)

- Functions as a distribution system possessing an ID, called ESSID
- The 802.11 provides the definition for ESSID, but the distribution system network protocols are not defined within 802.11
- Internet can be deployed by WLAN distribution system

Example

- **Access points, A, B, C, D, E, F, and G form the ESS**
- Access-points exist at base stations or gateways *J and H*
- An access-point also present at a multi-point relay node, *E*

802.11 station access-points *A* to *G* networked together forming an ESS



Stations in a given IBSS

- A mobile phone, TV with a set-up box, security system, and computer at home
- Form a WLAN station and can use the same frequency band for radio

Stations in a given IBSS

- Since it does not have an access-point to a distribution system or ESS, the station is a part of an IBSS
- These devices can also have Bluetooth OBEX exchange between mobile phone and computer

Example

- Consider the mobile phones, computers, and printers at a company office having independent workspace for each set of a mobile phone, a computer, and a printer
- Each set forms a WLAN station

Example

- Each station uses same frequency band for radio if the frequencies do not interfere and distinct frequency band if the frequencies are too close to each other
- All stations together form an IBSS, which is distinct from the IBSS at home

Protocols

- Depend on how the BSSs interoperate in a service provider servicing set up
- These protocols may or may not be TCP/IP or IPv6
- Also a node can be mobile and can move from one BSS to another such that its service access-point becomes different on moving (roaming

Standard basic feature of 802.11

- Supports BSSs and Ad-hoc peer-to-peer data routing network using IBSSs

WLAN network having stations at the BSSs in an ESS

- The mobile phones, computers, and printers at the company office having independent workspace for each set of a mobile phone, a computer, and a printer

WLAN network having stations at the BSSs in an ESS

- Each workspace has a wireless access-point for connecting to Internet in each office
- The frequency- band used by each device at the office for connecting to the access point is same

WLAN network having stations at the BSSs in an ESS

- The mobile phones, computers and printers form a WLAN station
- The station is a part of the BSSs of the company offices at the distant locations

WLAN network having stations at the BSSs in an ESS

- Each BSS of the company connects through a distinct access point in an ESS of the company
- All BSSs of the ESS form a WLAN network
- Each BSS uses an ESSID to communicate with the other BSS and may or may not use Internet as a distribution system

Roaming in a WLAN network

- Assume that there are the BSSs of the mobile phones, computers, and printers at the company offices and homes of the employees

Roaming in a WLAN network

- A mobile phone can roam between home and company offices
- It forms an ad-hoc network when it moves from one BSS station to another and gets connectivity to the WLAN network through the access-points

IEEE 802.x set of protocols defined for networking

- **802.1** [x =1] gives specifications for bridging of sublayers LLC (logic link control) and MAC (medium access control)
- For management of layers 1 and 2

IEEE 802.x set of protocols defined for networking

- *x* = 2 gives specifications for LLC sub-layer at layer 2
- *x* = 1 and 2 specifications common to all standards in 802.x for *x* = 3 and above
- *x* = 3 gives the specifications for MAC sub-layer of layer 2 and physical layer for wired LAN, called Ethernet

IEEE 802.x and 802.xy set of protocols

- Upper layers common in protocols 802.x
- *x* = 10 gives the security specifications for layers 2 and above and is common in protocols 802.1y
- *x=1; y* = 1 means 802.11
- *x=1; y*= 5 means 802.15
- *x=1; y*= 6 means 802.16

802.11 standard– a suite of WLAN protocols

- For the MAC sub-layer of layer 2 and physical layer (layer 1), which includes security 802.10 specifications

Physical layer

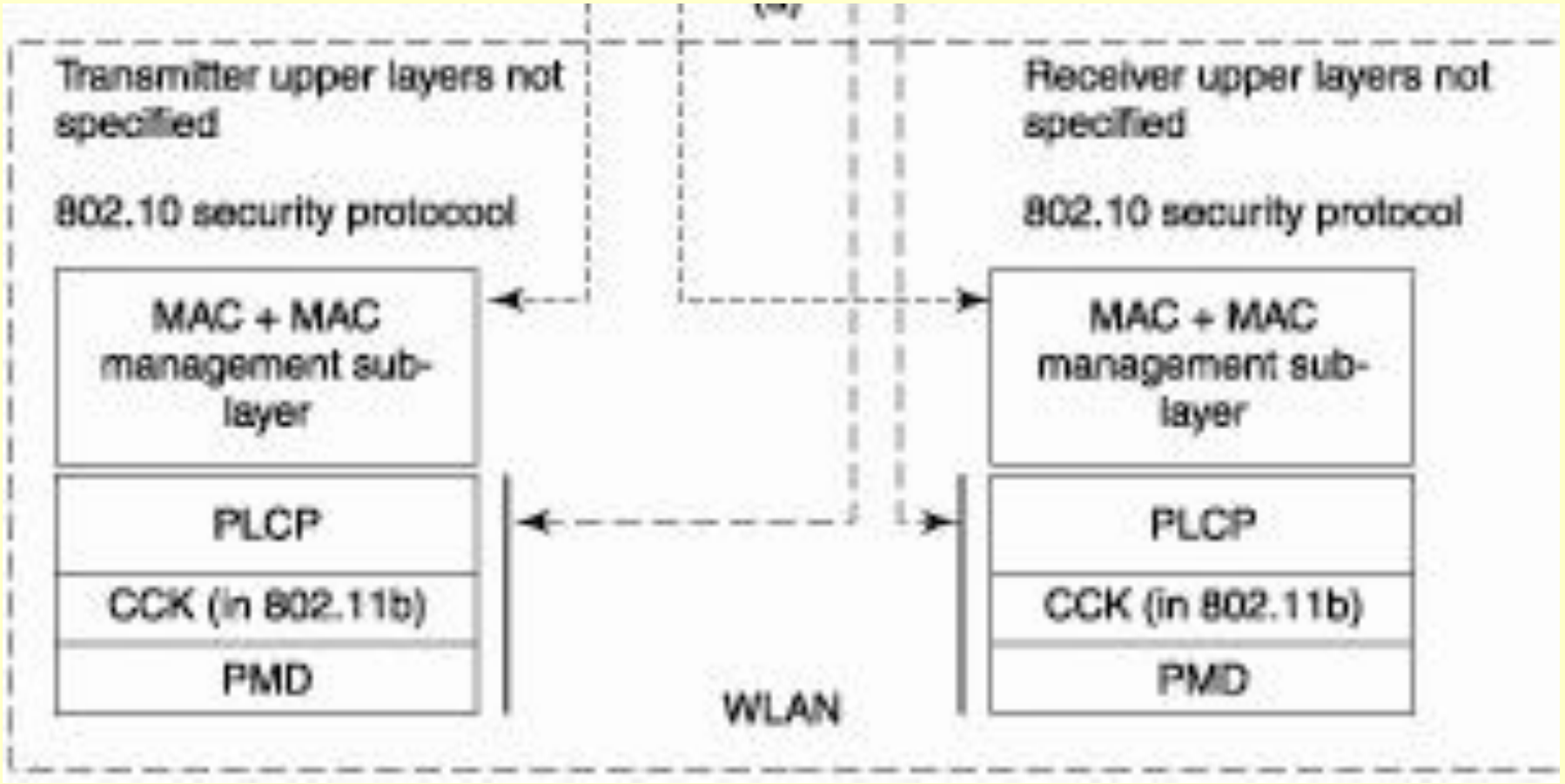
Physical layer (PMD)

- Three options: FHSS/DSSS/Diffused IR
- 802.11a OFDM 5 GHz (infrared, two 2.4 GHz physical layers), 6 Mbps to 54 Mbps
- 802.11b 2.4 GHz DSSS, supports 5.5 Mbps and 11 Mbps using CCK, 54 Mbps HyperLAN2
- Supports 802.15.4 ZigBee, 802.15.1 Bluetooth FHSS

MAC sub-layer of layer 2 (data link layer)

MAC
CSMA/CD, asynchroncus data transceiver, point coordination support for time-bound applications, acknowledged RTS/CTS (request to send/clear to send) mechanism before data transmission, power management, multiple physical layers, and roaming support

Basic protocols layers in IEEE 802.11



Physical layer two sub-layers

- PMD (physical medium dependent) sub-layer
- PLCP (physical layer convergence protocol) sub-layer
- There is an additional sub-layer in 802.11b—CCK (complementary code keying) for data rates of 5.5 Mbps by QPSK to map 4 bits and 11 Mbps 8-PSK to map 8 bits simultaneously

CCK

- Refer Sections 1.5 and 5.1
- QPSK to map 4 bits means four phase angles, each corresponding to distinct symbol
- 8-PSK to map 8 bits means eight phase angles, each corresponding to distinct symbol

PMD PROTOCOL

- **Specifications of the modulation and coding methods**
- Service access-point with 1 Mbps or 2 Mbps data rate to MAC layer

1. FHSS—radiated at 10 mW, 100 mW, and 1 W as per country-specific restrictions; Modulation 1 Mbps Gaussian BPSK or 2 Mbps Gaussian QPSK

PMD

2. DSSS—using 11-bit Barker code radiated at 10 mW, 100 mW, and 1 W as per country-specific restrictions and 1 Mbps or 2 Mbps data rates (symbol rates)

PMD PROTOCOL

- DSSS transmission characteristics—negligible interference and multi-path delay spread
- Modulation— DQPSK, 11-bit code—11 Mchip/s, Scrambling done by a polynomial $G_Q = z^7 + z^4 + 1$

PMD PROTOCOL

3. PPM (Pulse Position Modulation)—a modulation method. 16-PPM is used for 1 Mbps and 4-PPM for 2 Mbps data rate
- 16-PPM means that a code is transmitted for each quad of 4 bits and is positioned in one of the 16 slots (a slot is a 16-bit long sequence of bits, each slot-bit separated by 250 ns)

PMD PROTOCOL

- PPM method involves 250 ns pulses of diffused infrared (IR) for 10 m range within a room
- IR does not pass through walls and thus provides isolation from neighbouring room nodes

Examples of PPM of a quad of 4 bits

- Assume positioned in a 16 bit long slot with each slot-bit separated by 250 ns

(i) Consider a quad of 4 bits as 0000b = 0d. It means that at 0th position (counting positions from 0, 1, 2, …), there will be 1

- Hence the 16 bit sequence will have 0th slot-bit or lsb as 1. The transmitted bits after PPM will therefore be 0000 0000 0000 0001

Examples of PPM of a quad of 4 bits

(ii) Consider a quad of 4 bits as 0100b = 4d

- It means that at 4th position (counting positions from 0, 1, 2, …), there will be 1
- Hence the 16 bit sequence will have the 4th slot-bit as 1
- The transmitted bits after PPM will therefore be 0000 0000 0001 0000

Examples of PPM of a quad of 4 bits

(iii) Consider a quad of 4 bits as 1111b = 15d

- The transmitted bits after PPM in this case will be 1000 0000 0000 0000

PLCP Sub-layer

- Specifies sensing of the carrier at the receiver and packet formation at the transmitter
- The different transmission and reception protocols (FHSS, DSSS, and diffused IR) specified for the PMD
- Thus a convergence protocol sub-layer required in between the PMD and MAC sub-layers

PLCP Sub-layer

- PLCP sub-layer protocol prescribes the standard procedure for convergence of PMD to MAC at receiver and from MAC to PMD at transmitter
- Refer details in Section **10.1.10** PP.366 and 367

MAC and MAC Management Sublayers

- MAC sub-layer specifies CSMA/CD (CSMA/CollissionDetect), RTS/CTS, and PCF mechanisms
- Sub-layer specifies MAC management

MAC layer for medium access control features

- CSMA/CD
- Point coordination support for time-bound applications
- Acknowledged RTS/CTS (request to send/clear to send) mechanism before the data transmission
- MAC Frame Format– Refer Section **10.1.7**

Functions of MAC management sub-layer

1. Roaming management

- The access-point registers or deregisters the devices after the scanning
- Provisions for New device registration for device association at new access-point when it roams into the new area from another area covered by access-point

Functions of MAC management sub-layer

2. Internal receiver clocks are synchronized, which is necessary
- Generation of beacon signals is also part of management functions.
- A BSS periodically sends beacon signals, which contain—(i) time stamp for synchronizing node clock and (ii) power management and roaming data

Functions of MAC management sub-layer

3. Transmitter switches to power-save mode after each successful data transmission for power management periodically activating the sleep mode
- Buffering by a receiver and starting processing after enough data received in buffer also saves power

Summary

- Basic Service set (BSS) has nodes which connect to an access-point
- The mobile phones, computers and printers form a WLAN station
- The station is a part of the BSSs of the company offices at the distant locations
- ESS consisting of interconnected BSSs using Internet or any service provider network

…

...Summary

- Independent basic service set (IBSS)—Set *B* do not connect to any access-point
- IBSSs do not connect themselves
- A mobile phone, TV with a set-up box, security system, and computer at home
- Form a WLAN station and can use the same frequency band for radio

Summary

- WLAN 802.11.x specifications a suite of protocols for the MAC sub-layer of layer 2 and physical layer (layer 1)
- Includes security 802.10 specifications
- Physical layer— PMD (physical medium dependent) sub-layer
- Physical layer— PLCP (physical layer convergence protocol) sub-layer

...

...Summary

- Data link layer — MAC sublayer
- Data link layer — MAC management sublayer

End of Lesson 01

Wireless LANs