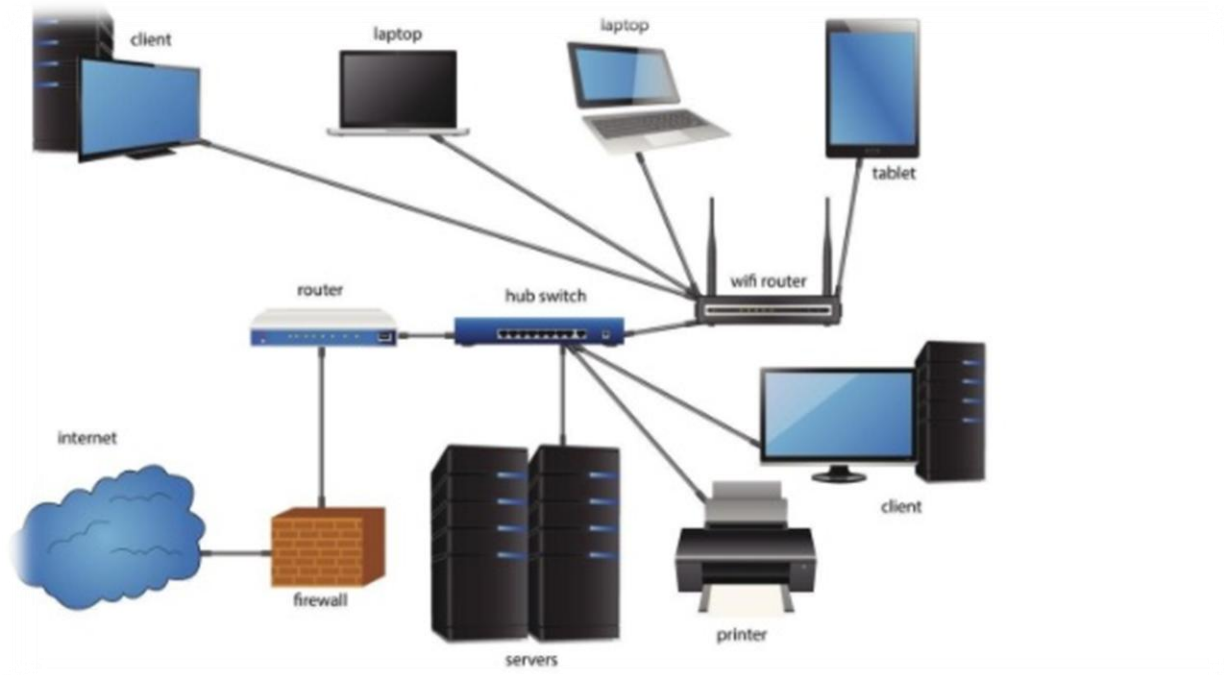


# COMPUTER NETWORKS



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**Department of Electronics and Communication Engineering**

# UNIT-3 Syllabus

- Channel Allocation Problems, Multiple Access Protocols
- IEEE standards for Local Area Networks
- IEEE standards for WLAN, Bluetooth

## Chapter 3

# Wireless LAN, Bluetooth

# IEEE 802.11

In 1990, the IEEE 802 Committee formed a new working group, IEEE 802.11, specifically devoted to wireless LANs, with a charter to develop a MAC protocol and physical medium specification.

Since that time, the demand for WLANs, at different frequencies and data rates, has exploded.

Keeping pace with this demand, the IEEE 802.11 working group has issued an ever-expanding list of standards.

IEEE has defined the specifications for a wireless LAN, called IEEE 802.11, which covers the physical and data link layers.

# IEEE 802.11 Terminology

Access point (AP)	Any entity that has station functionality and provides access to the distribution system via the wireless medium for associated stations
Basic service set (BSS)	A set of stations controlled by a single coordination function
Coordination function	The logical function that determines when a station operating within a BSS is permitted to transmit and may be able to receive PDUs
Distribution system (DS)	A system used to interconnect a set of BSSs and integrated LANs to create an ESS
Extended service set (ESS)	A set of one or more interconnected BSSs and integrated LANs that appear as a single BSS to the LLC layer at any station associated with one of these BSSs
MAC protocol data unit (MPDU)	The unit of data exchanged between two peer MAC entities using the services of the physical layer
MAC service data unit (MSDU)	Information that is delivered as a unit between MAC users
Station	Any device that contains an IEEE 802.11 conformant MAC and physical layer

# IEEE 802.11 Standards

**TABLE 1: IEEE 802.11 COMMON WIFI STANDARDS BREAKDOWN**

Standard	Frequency Band	Bandwidth	Modulation Scheme	Channel Arch.	Maximum Data Rate	Range	Max Transmit Power
802.11	2.4 GHz	20 MHz	BPSK to 256-QAM	DSSS, FHSS	2 Mbps	20 m	100 mW
b	2.4 GHz	21 MHz	BPSK to 256-QAM	CCK, DSSS	11 Mbps	35 m	100 mW
a	5 GHz	22 MHz	BPSK to 256-QAM	OFDM	54 Mbps	35 m	100 mW
g	2.4 GHz	23 MHz	BPSK to 256-QAM	DSSS, OFDM	54 Mbps	70 m	100 mW
n	2.4 GHz, 5 GHz	24 MHz and 40 MHz	BPSK to 256-QAM	OFDM	600 Mbps	70 m	100 mW
ac	5 GHz	20, 40, 80, 80+80=160 MHz	BPSK to 256-QAM	OFDM	6.93 Gbps	35 m	160 mW
ad	60 GHz	2.16 GHz	BPSK to 64-QAM	SC, OFDM	6.76 Gbps	10 m	10 mW
af	54-790 MHz	6, 7, and 8 MHz	BPSK to 256-QAM	SC, OFDM	26.7 Mbps	>1km ?	100 mW
ah	900 MHz	1, 2, 4, 8, and 16 MHz	BPSK to 256-QAM	SC, OFDM	40 Mbps	1 km	100 mW

**Topics discussed in this section:**

- **Architecture**
- **MAC Sublayer**
- **Physical Layer**

# 1. ARCHITECTURE

The standard defines two kinds of services:

- i. Basic Service Set (BSS)
- ii. Extended Service Set (ESS)



## i). Basic Service Set (BSS)

IEEE 802.11 defines the BSS as the building block of a wireless LAN.

A BSS is made of stationary or mobile wireless stations and an optional central base station, known as the access point (AP).

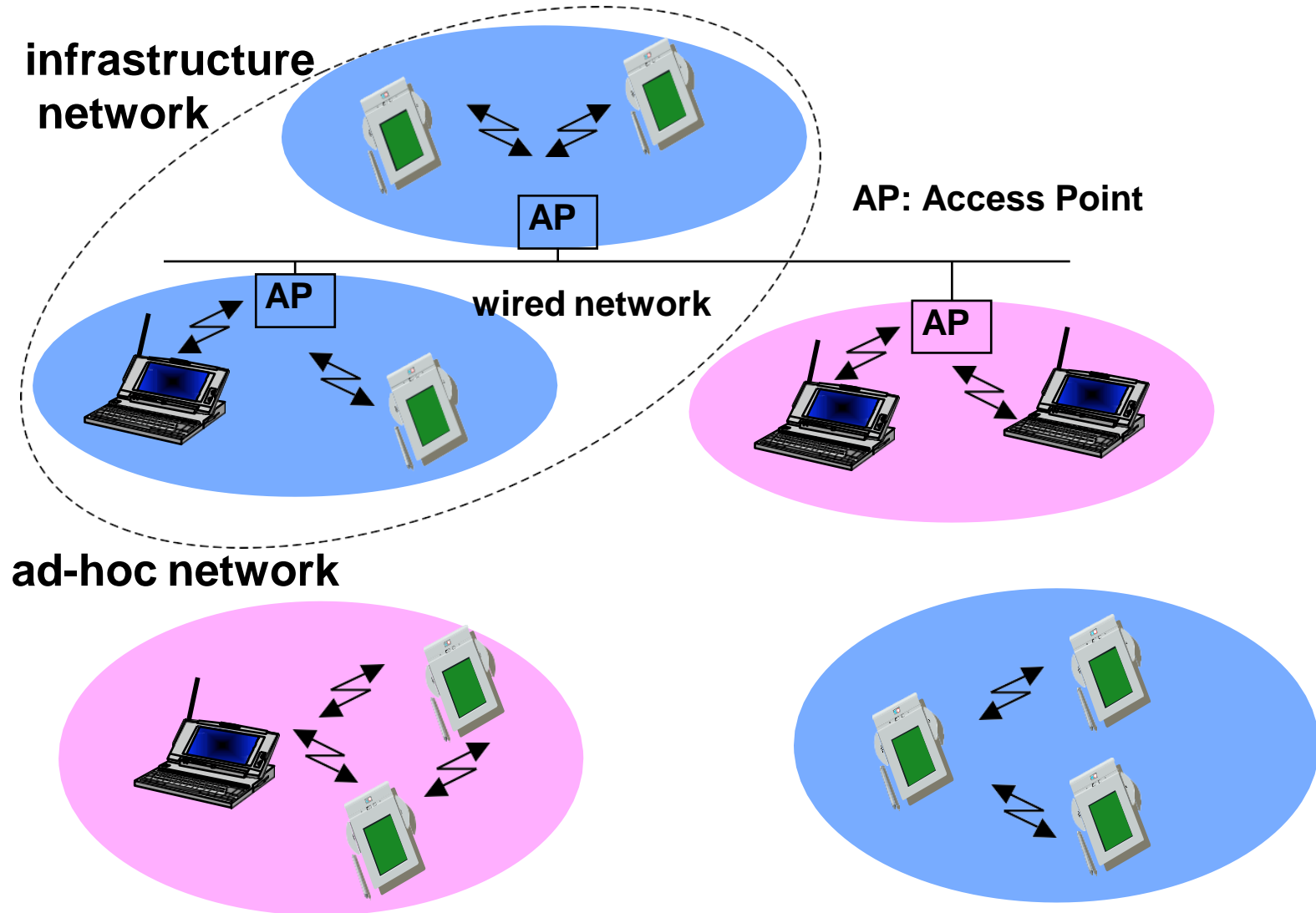
BSS network categories

- Ad-hoc network
- Infrastructure network

*Note*

**A BSS without an AP is called an ad **hoc** network;  
a BSS with an AP is called an **infrastructure** network.**

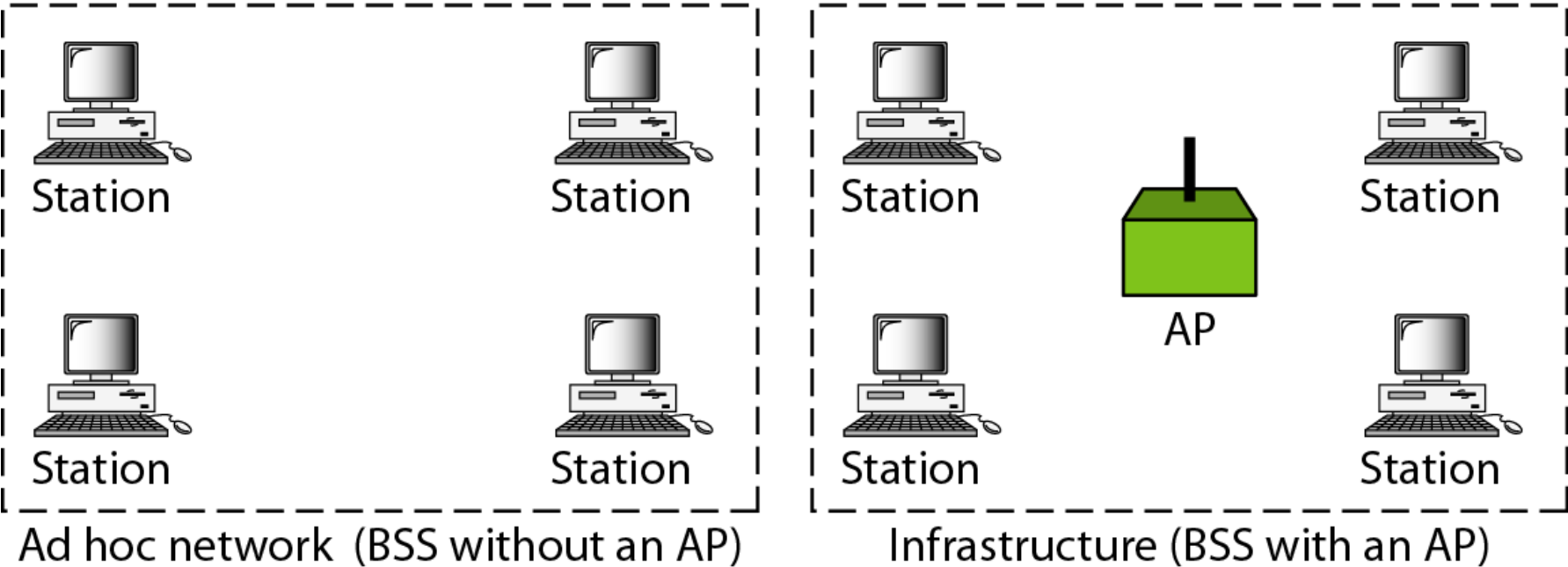
**Figure: Basic Service Sets (BSSs)**



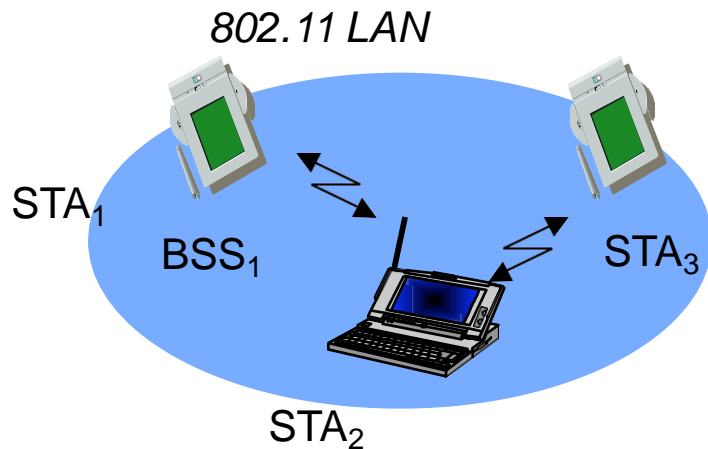
**Figure: Basic Service Sets (BSSs)**

**BSS:** Basic service set

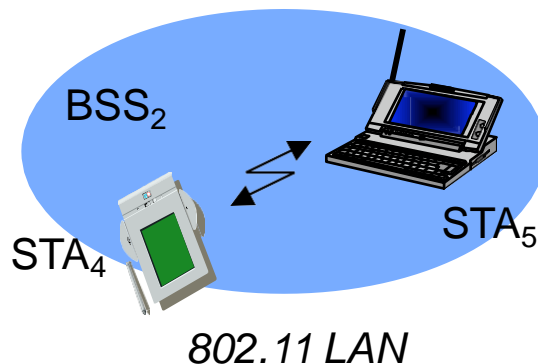
**AP:** Access point



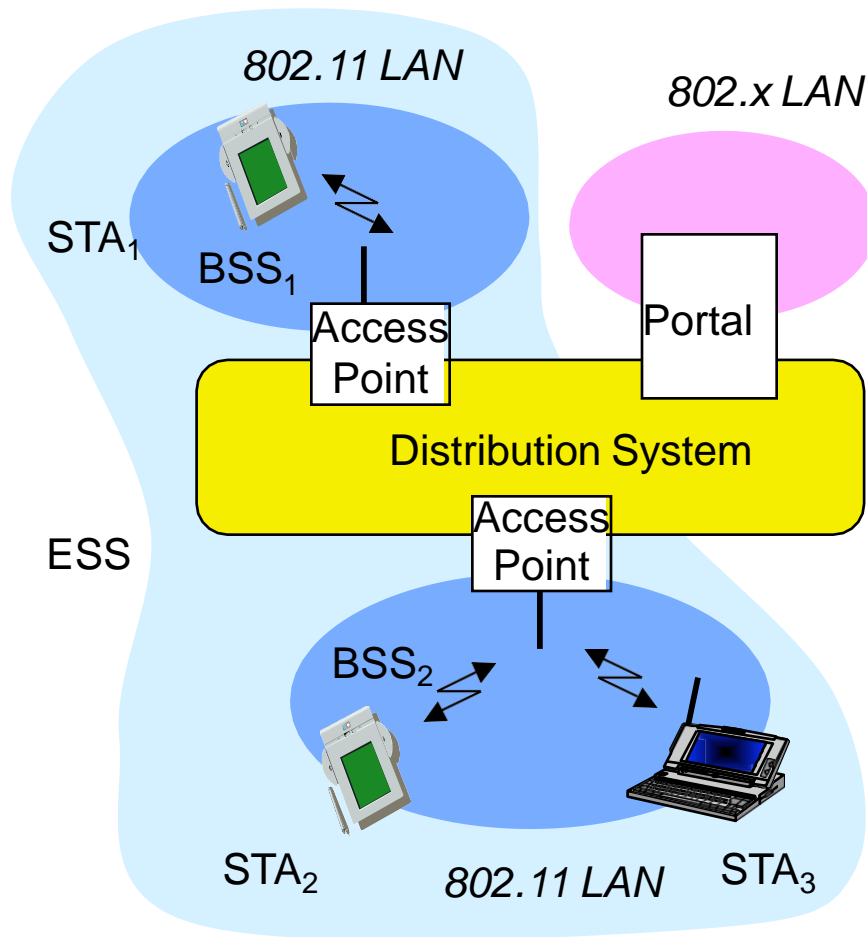
# 802.11: ad-hoc mode



- ❑ Direct communication within a limited range
  - o Station (STA): terminal with access mechanisms to the wireless medium
  - o Basic Service Set (BSS): group of stations in range and using the same radio frequency



# 802.11: infrastructure mode



- ❑ Station (STA)
  - o terminal with access mechanisms to the wireless medium and radio contact to the access point
- ❑ Basic Service Set (BSS)
  - o group of stations using the same radio frequency
- ❑ Access Point
  - o station integrated into the wireless LAN and the distribution system
- ❑ Portal
  - o bridge to other (wired) networks
- ❑ Distribution System
  - o interconnection network to form one logical network (EES: Extended Service Set) based on several BSS

## ii). Extended Service Set (ESS)

An ESS is made up of two or more BSSs with APs.

In this case, the BSSs are connected through a distribution system, which is usually a wired LAN. The distribution system connects the APs in the BSSs.

IEEE 802.11 does not restrict the distribution system; it can be any IEEE LAN such as an Ethernet.

The extended service set uses two types of stations:  
mobile and stationary.

The mobile stations are normal stations inside a BSS.

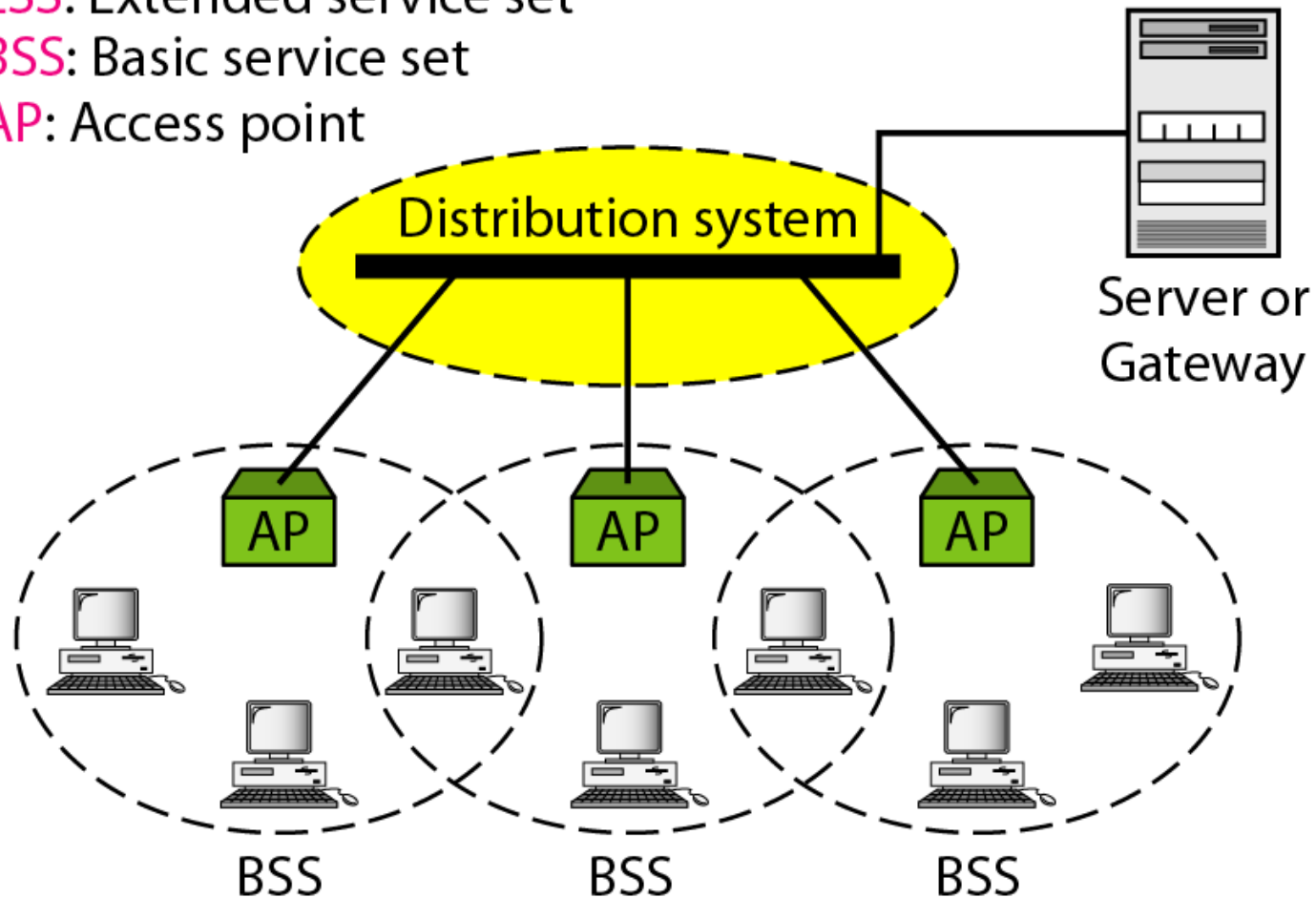
The stationary stations are AP stations that are part of a wired LAN.

## Figure: Extended Service Set (ESS)

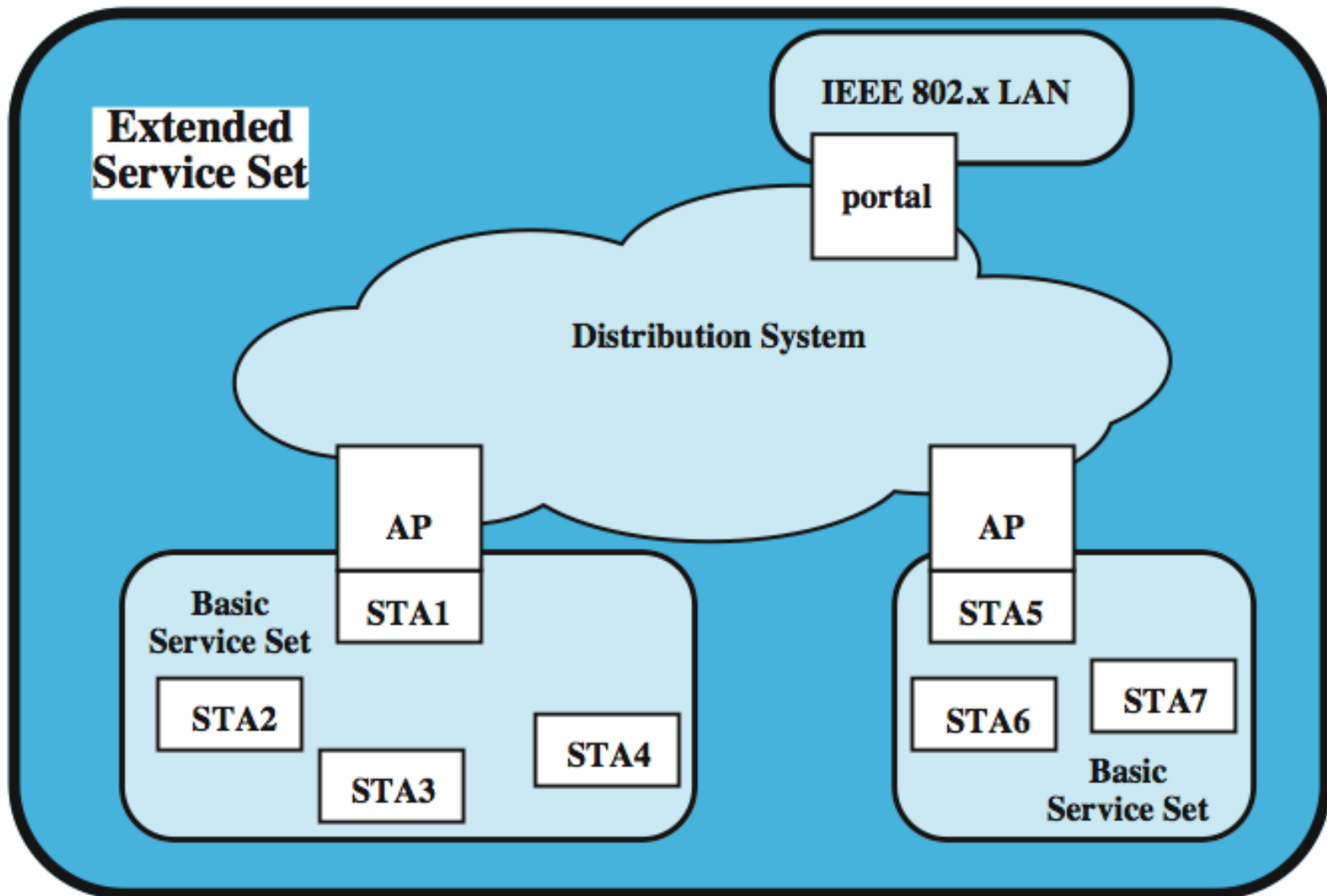
ESS: Extended service set

BSS: Basic service set

AP: Access point

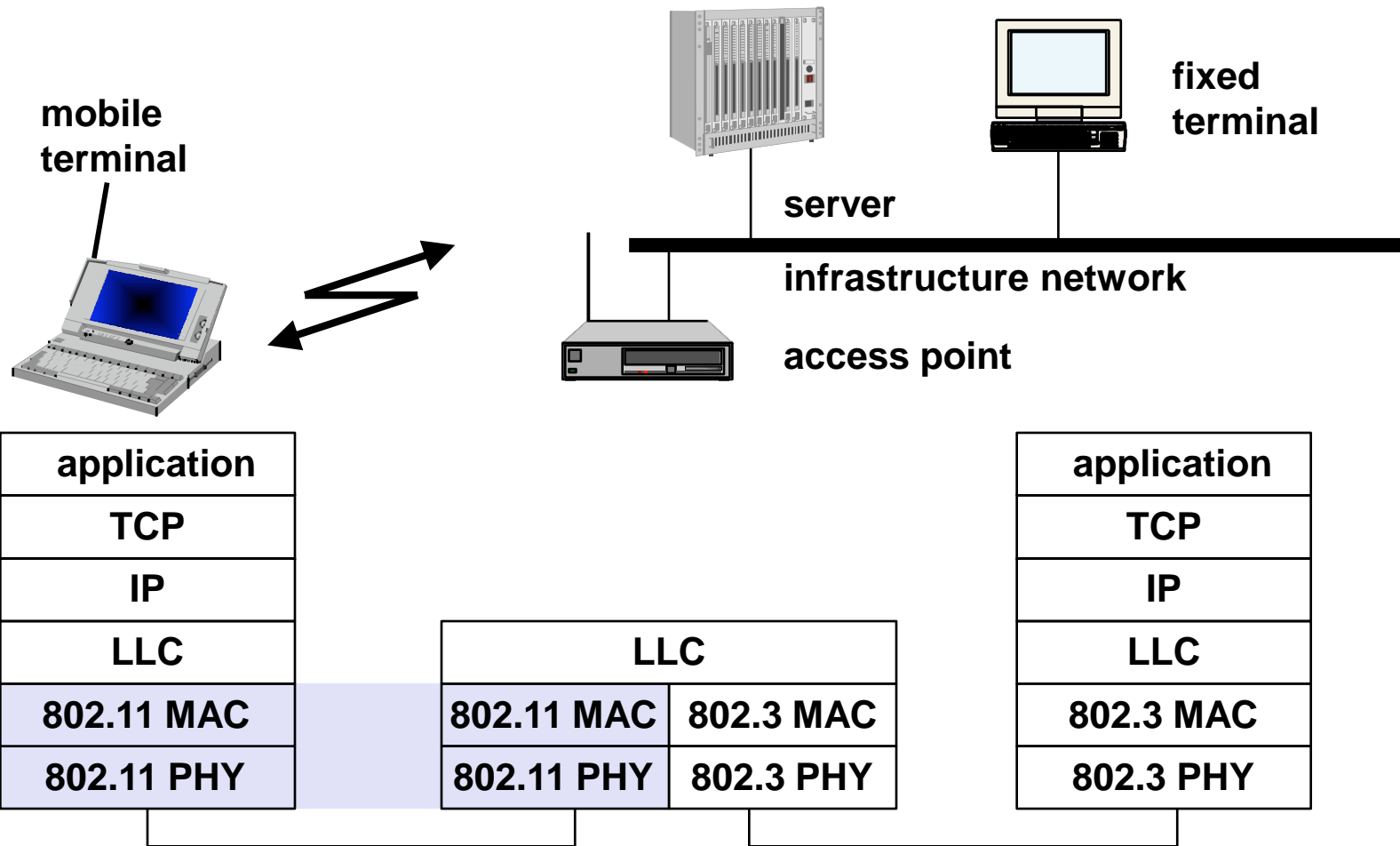




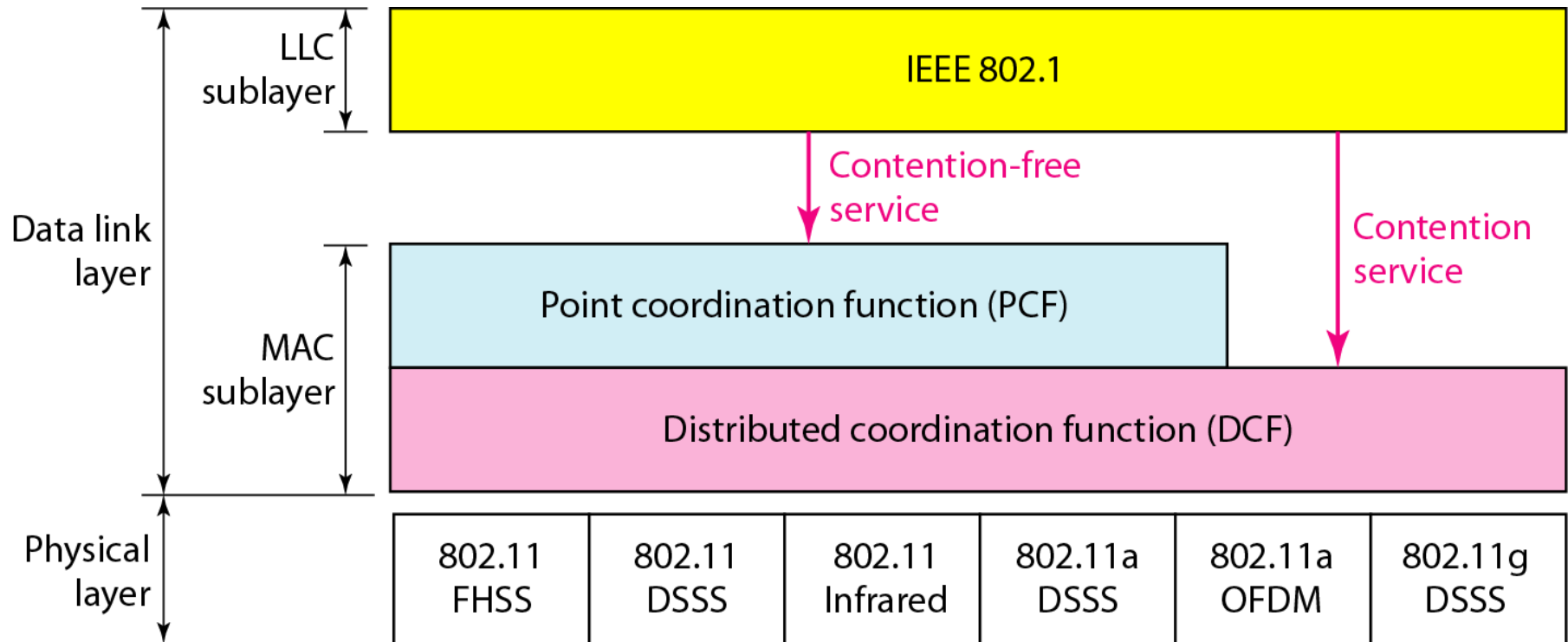


STA = station  
AP = access point

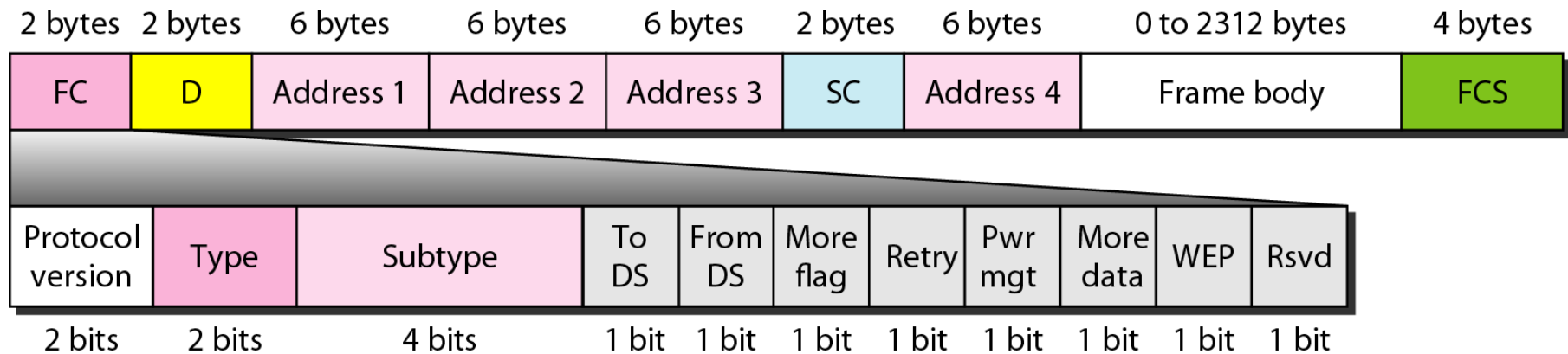
# IEEE standard 802.11



# 2. MAC Sublayer



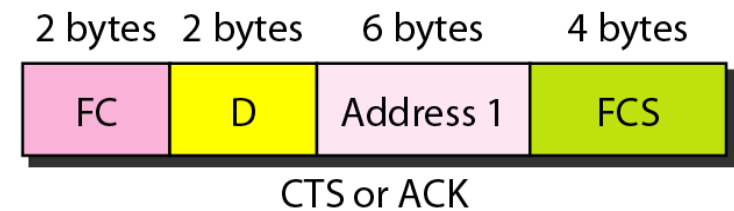
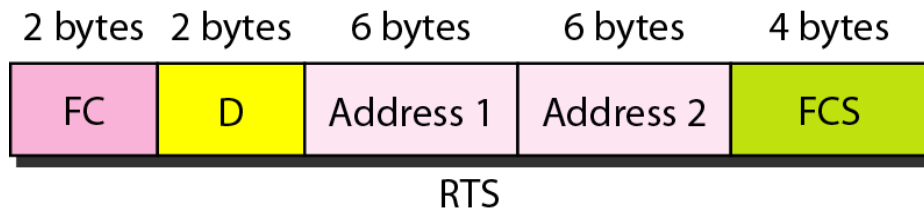
## Figure: Frame format



## ***Table:*** Subfields in FC field

<i>Field</i>	<i>Explanation</i>
Version	Current version is 0
Type	Type of information: management (00), control (01), or data (10)
Subtype	Subtype of each type (see Table 14.2)
To DS	Defined later
From DS	Defined later
More flag	When set to 1, means more fragments
Retry	When set to 1, means retransmitted frame
Pwr mgt	When set to 1, means station is in power management mode
More data	When set to 1, means station has more data to send
WEP	Wired equivalent privacy (encryption implemented)
Rsvd	Reserved

## *Figure:* Control frames



***Table:*** Values of subfields in control frames

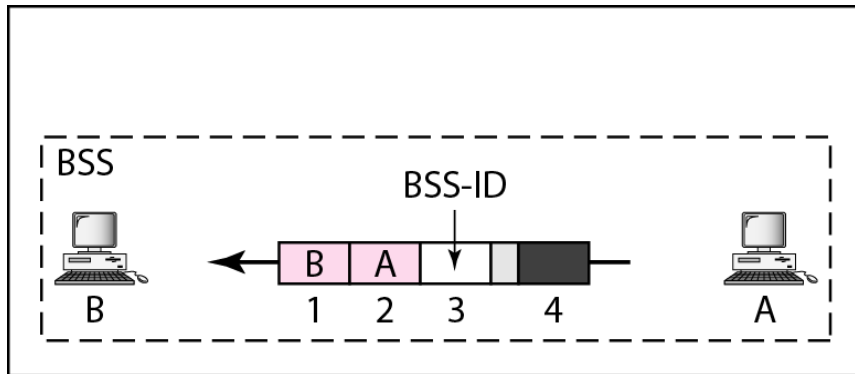
<i>Subtype</i>	<i>Meaning</i>
1011	Request to send (RTS)
1100	Clear to send (CTS)
1101	Acknowledgment (ACK)

## *Table:* Addresses

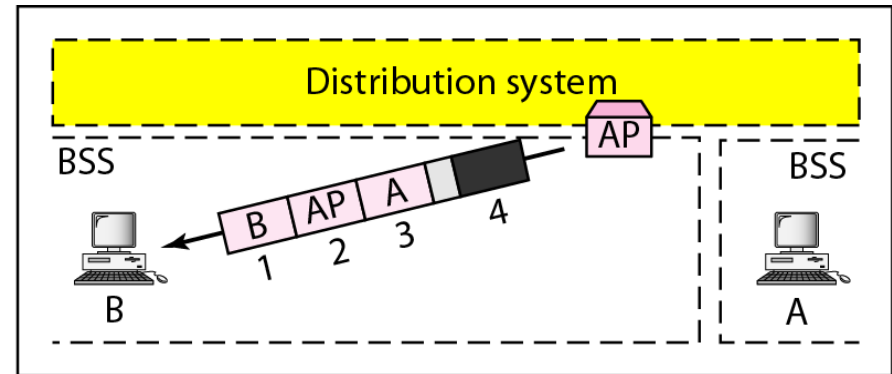
<i>To DS</i>	<i>From DS</i>	<i>Address 1</i>	<i>Address 2</i>	<i>Address 3</i>	<i>Address 4</i>
0	0	Destination	Source	BSS ID	N/A
0	1	Destination	Sending AP	Source	N/A
1	0	Receiving AP	Source	Destination	N/A
1	1	Receiving AP	Sending AP	Destination	Source



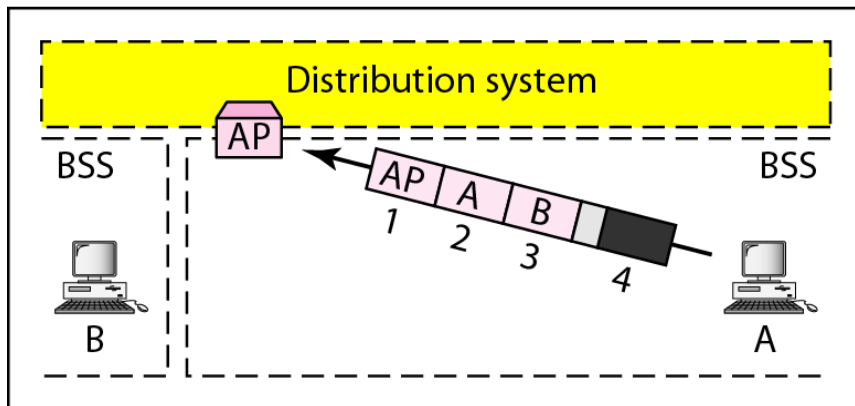
## Figure: Addressing mechanisms



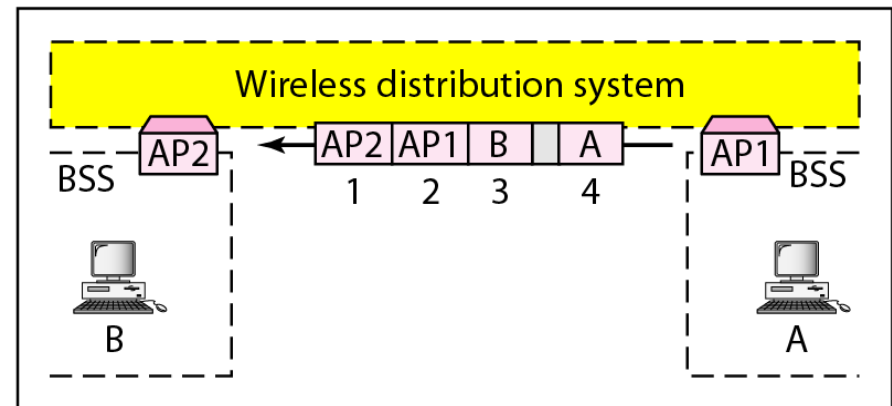
a. Case 1



b. Case 2

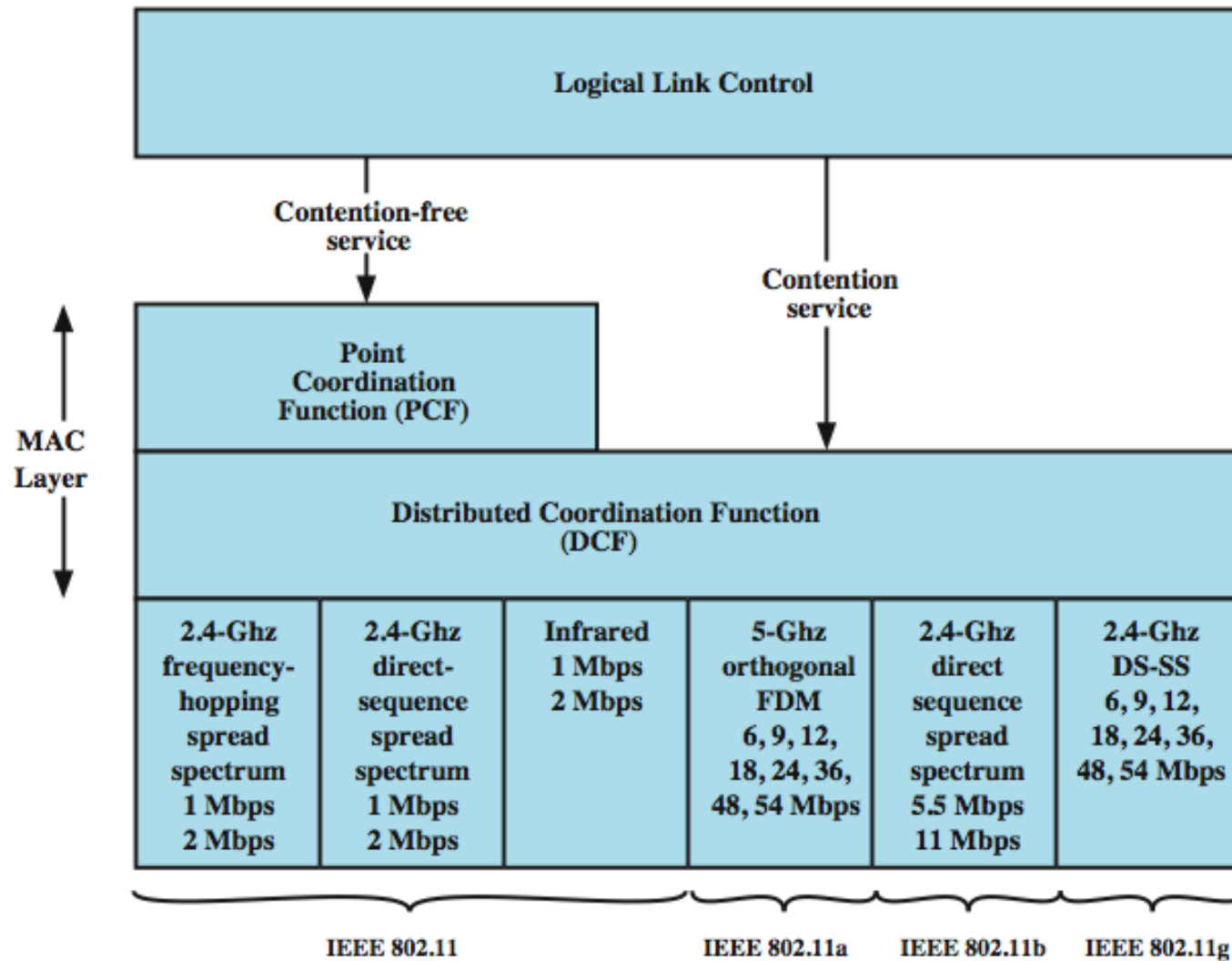


c. Case 3

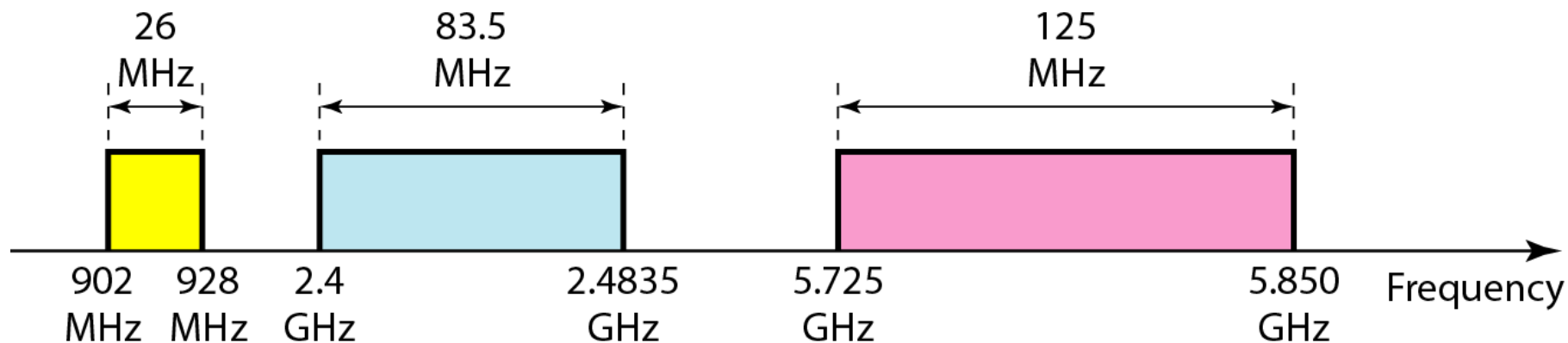


d. Case 4

**Figure: MAC layers in IEEE 802.11 standard**



## *Figure:* Industrial, scientific, and medical (ISM) band



# 3. Physical Layer

- 2 radio ranges (2.4 GHz and 5 GHz), 1 IR
  - data rates ranging from 1 Mbps to 54 Mbps

## ❑ IEEE 802.11

- 2.4 GHz band frequency hopping spread spectrum (FHSS)
- 2.4 GHz band direct sequence spread spectrum (DSSS)
- Baseband infrared

## ❑ IEEE 802.11a

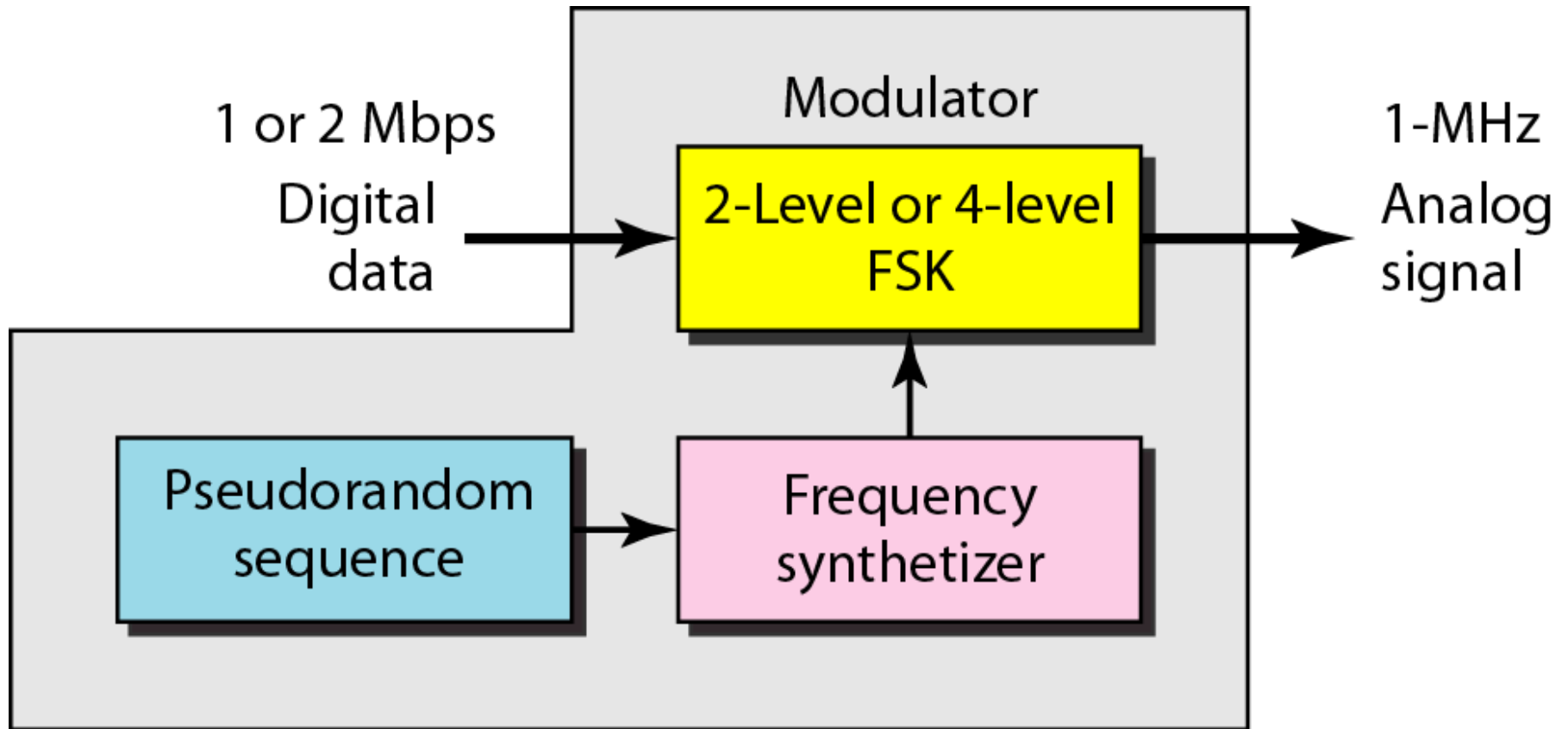
## ❑ IEEE 802.11b

## ❑ IEEE 802.11g

## i). 2.4GHz band FHSS

- Frequency changed within a specified band in a pseudo-random fashion, known only to transmitters and receivers
- Uses a pseudorandom number generator to produce the sequence of frequencies hopped to
- min. 2.5 frequency hops/s (USA), two-level GFSK modulation
- Uses 79 channels, each 1 MHz wide, starting at the low end of the 2.4 GHz band
- If all stations use same seed to the generator and stay synchronized in time => they will hop to same frequencies simultaneously
- The time interval spent at each frequency: dwell time
  - Adjustable parameter, but  $< 400$  ms
- Intruder not knowing the hopping sequence & dwell time cannot eavesdrop on transmissions

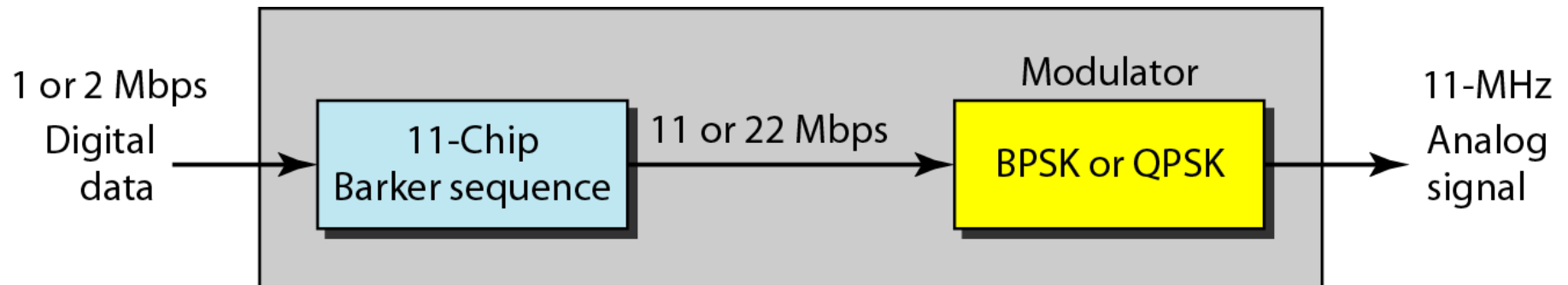
**Figure:** Physical layer of IEEE 802.11 FHSS



## ii). 2.4GHz band DSSS

- A spreading code is used to spread and despread the transferred data
- Each wireless station has its own spreading code
- DBPSK or DQPSK modulation (Differential Binary Phase Shift Keying or Differential Quadrature PSK)
- Chipping sequence: +1, -1, +1, +1, -1, +1, +1, +1, -1, -1, -1 (Barker code)

## *Figure:* Physical layer of IEEE 802.11 DSSS

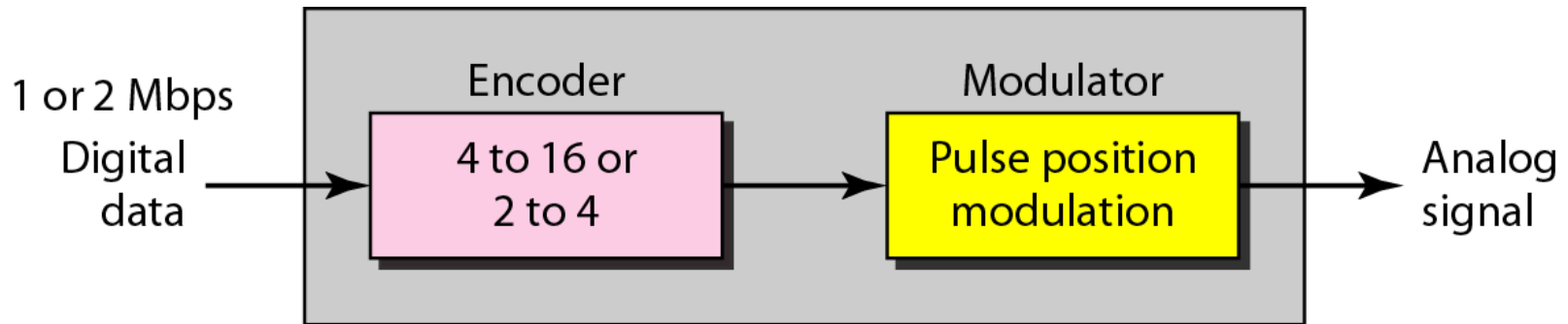




### **iii). Baseband Infrared**

- Infrared technique (for remote controls of TV sets)
- 850-950 nm, diffuse light, typically 10 m range
- Data rates 1-2 Mbps
- Infrared signals cannot penetrate walls, so cells in different rooms are well isolated from each other

## *Figure:* Physical layer of IEEE 802.11 infrared



## iv). IEEE 802.11 a, b, g

### ❑ IEEE 802.11a

- o Makes use of 5-GHz band
- o Provides rates of 6, 9 , 12, 18, 24, 36, 48, 54 Mbps
- o Uses orthogonal frequency division multiplexing (OFDM)
- o Sub-carrier modulated using BPSK, QPSK, 16-QAM or 64QAM

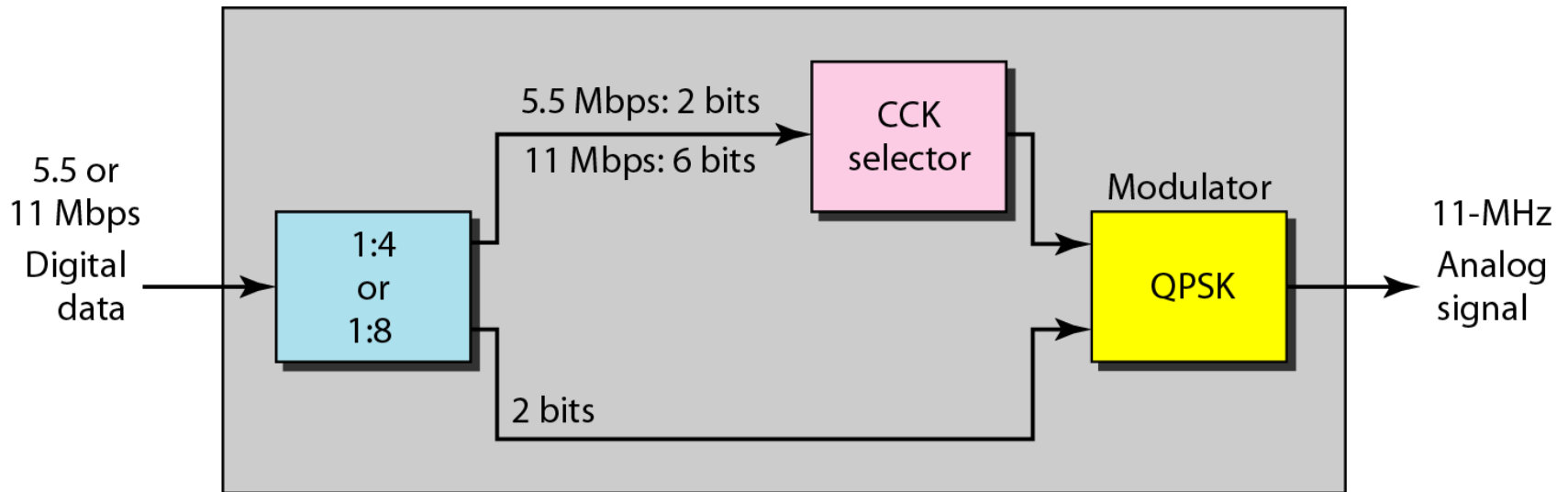
### ❑ IEEE 802.11b

- o Provides data rates of 5.5 and 11 Mbps
- o DSSS and complementary code keying (CCK) modulation

### ❑ IEEE 802.11g

- o Extends data rates to up to 54 Mbps
- o Uses OFDM, in the 2.4 GHz band

**Figure: Physical layer of IEEE 802.11b**



***Table:* Physical layers**

<i>IEEE</i>	<i>Technique</i>	<i>Band</i>	<i>Modulation</i>	<i>Rate (Mbps)</i>
802.11	FHSS	2.4 GHz	FSK	1 and 2
	DSSS	2.4 GHz	PSK	1 and 2
		Infrared	PPM	1 and 2
802.11a	OFDM	5.725 GHz	PSK or QAM	6 to 54
802.11b	DSSS	2.4 GHz	PSK	5.5 and 11
802.11g	OFDM	2.4 GHz	Different	22 and 54

# BLUETOOTH

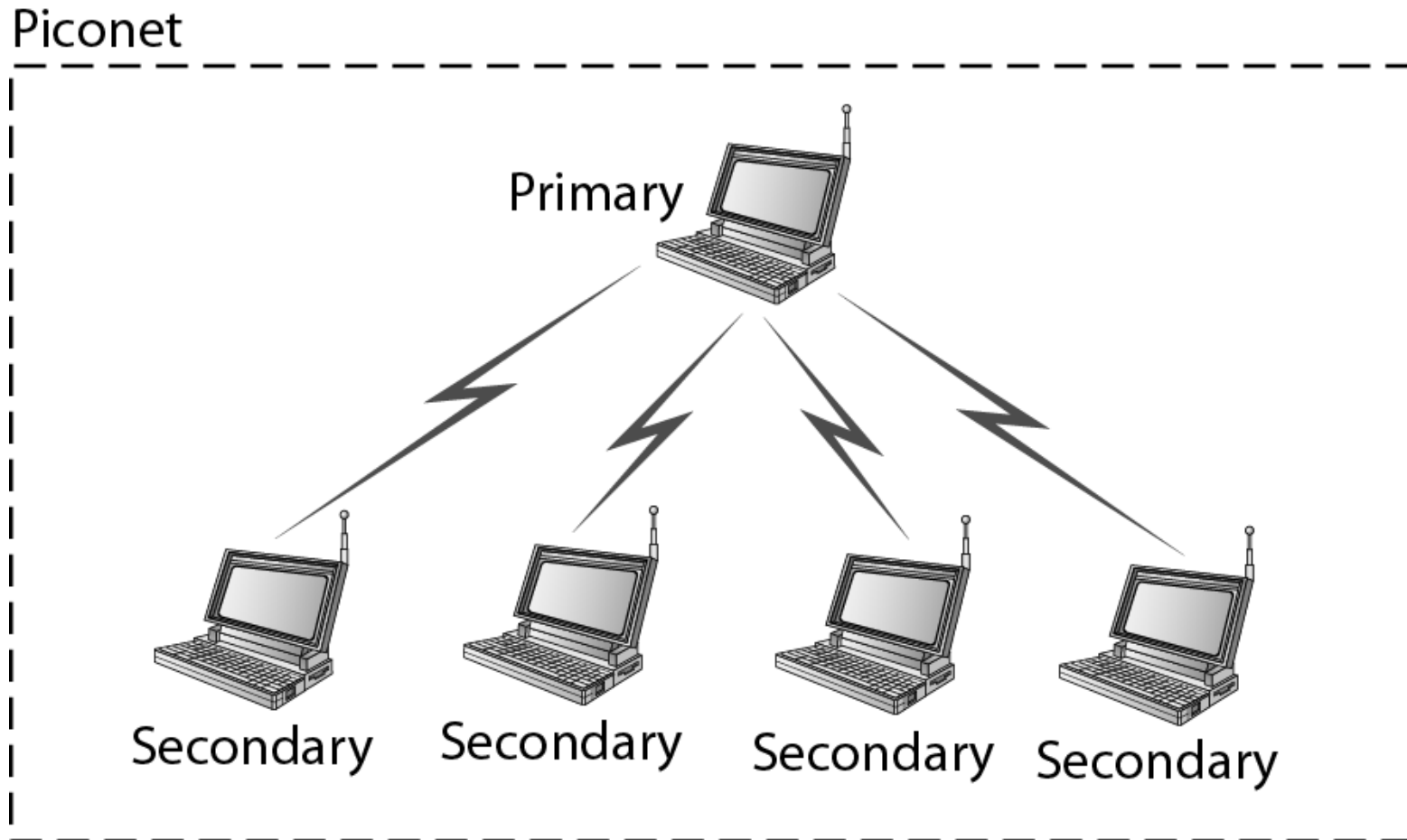
Bluetooth is a wireless LAN technology designed to connect devices of different functions such as telephones, notebooks, computers, cameras, printers, coffee makers, and so on.

A Bluetooth LAN is an ad hoc network, which means that the network is formed spontaneously.

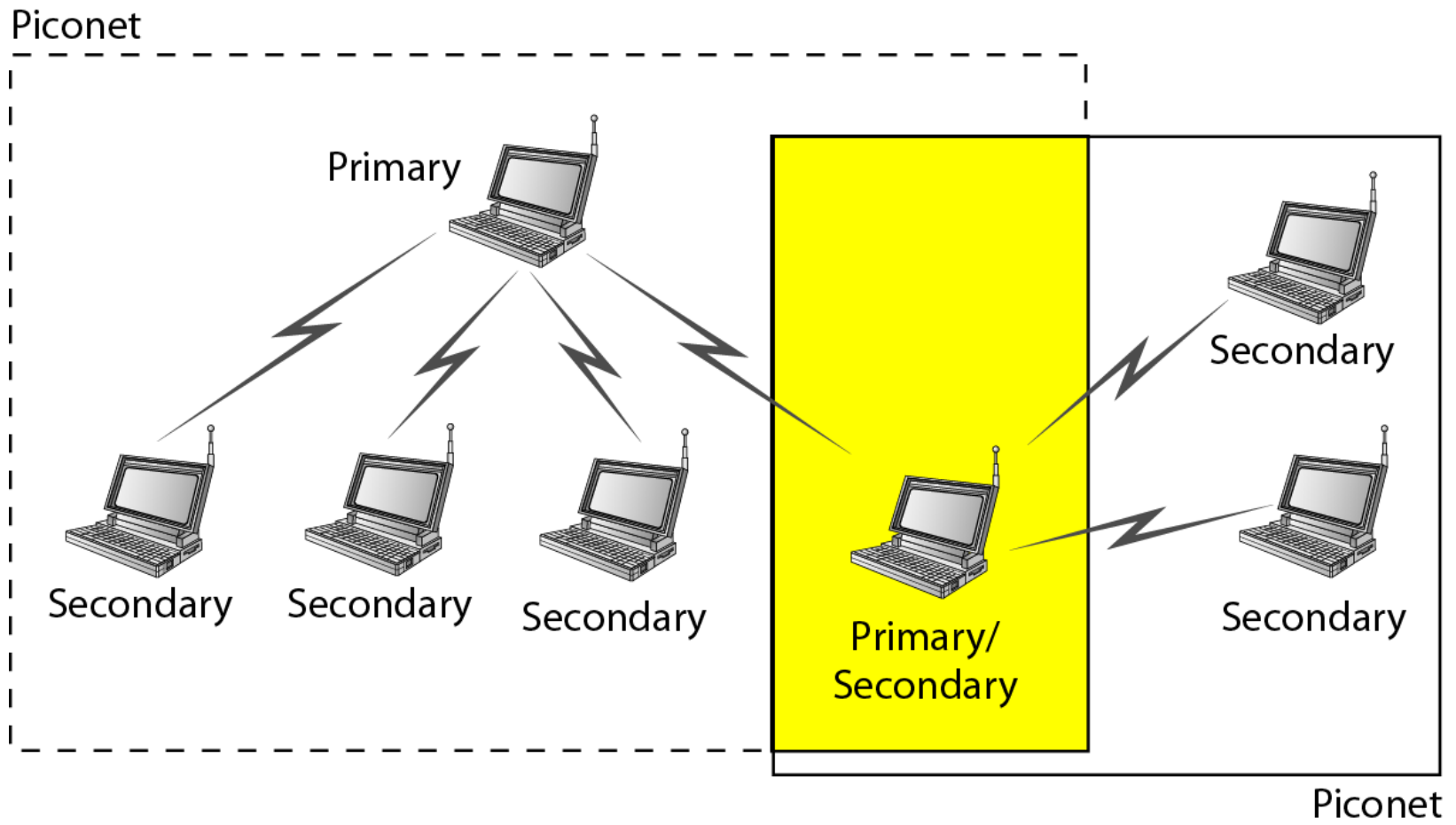
## *Topics discussed in this section:*

- **Architecture**
- **Bluetooth Layers**
- **Base band Layer**
- **L2CAP**

*Figure:* Piconet

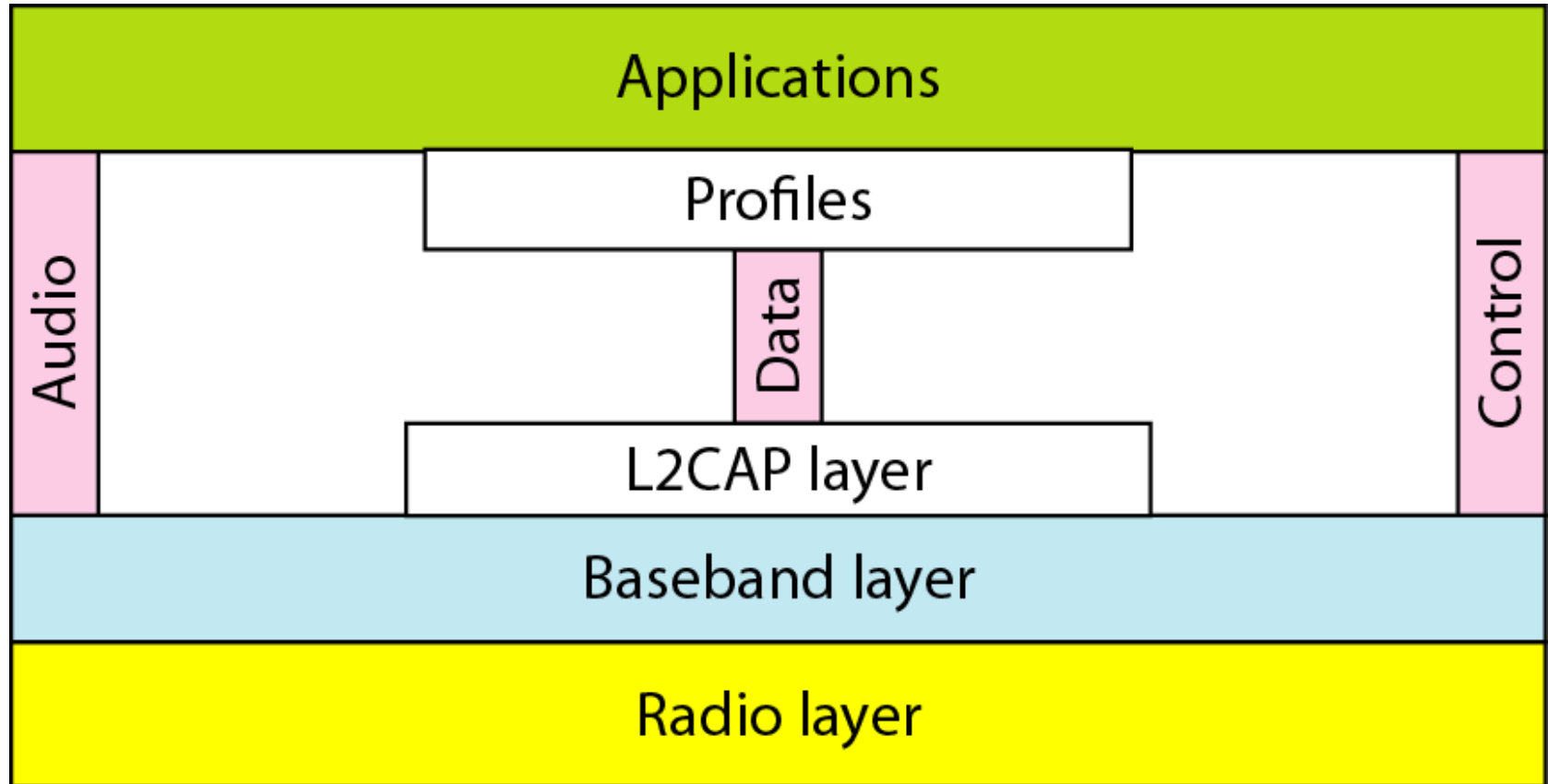


**Figure: Scatternet**

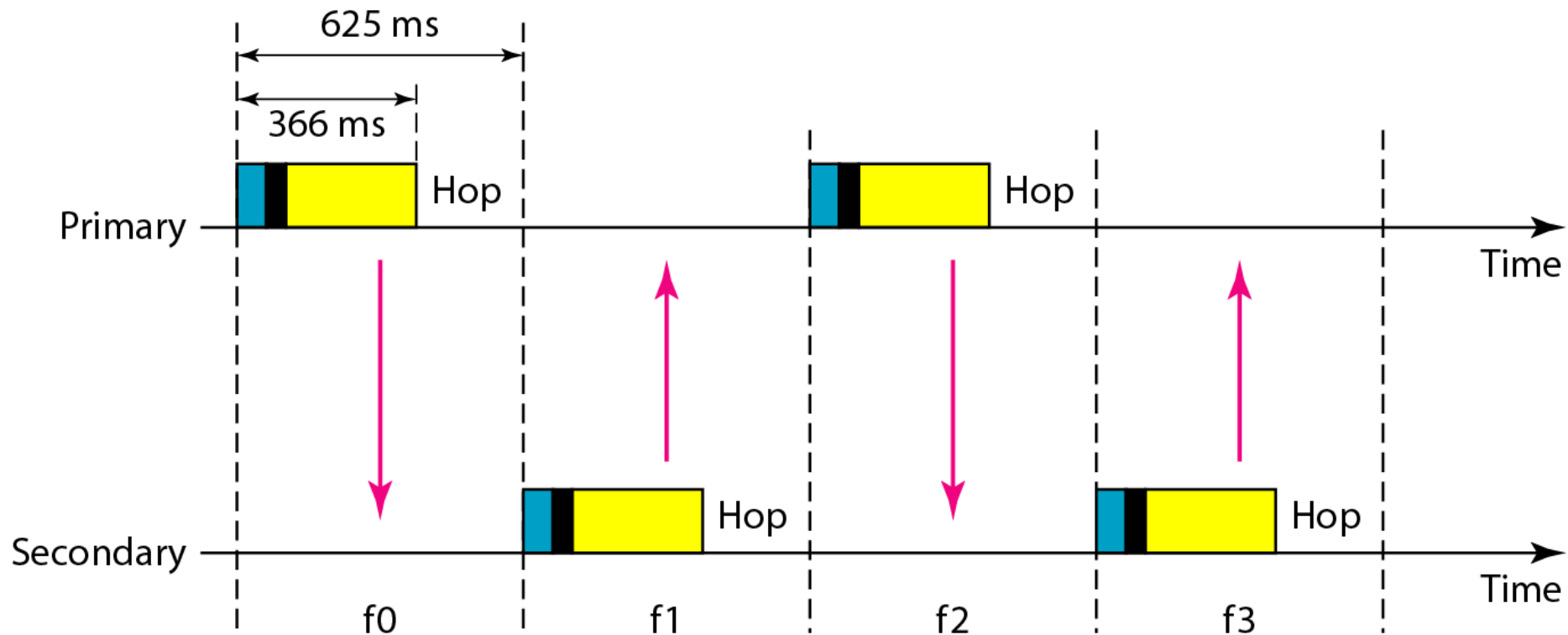




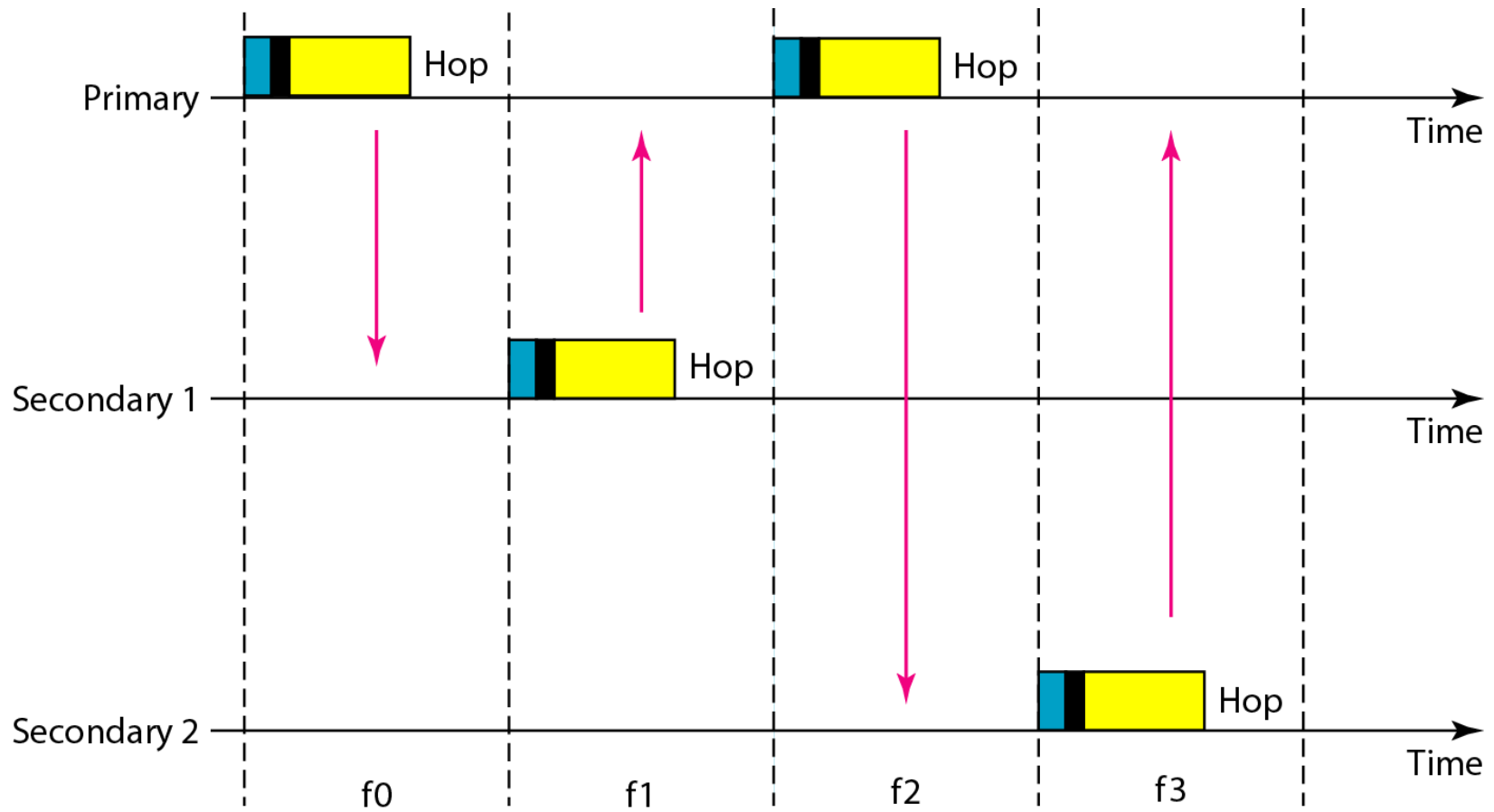
**Figure: Bluetooth layers**



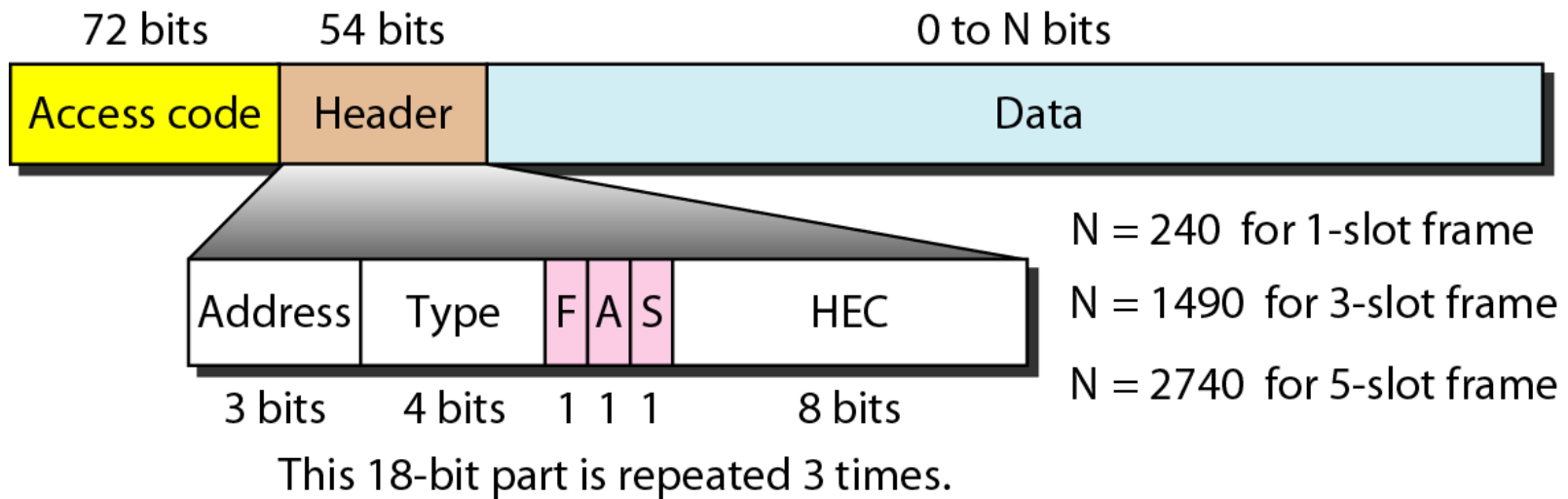
**Figure: Single-secondary communication**



**Figure: Multiple-secondary communication**



## *Figure:* Frame format types



## *Figure:* L2CAP data packet format



# Questions?