Subject : Digital Communication
Code : UEC 607
Credit : 4

Dr. Amit Mishra

Courtesy: Digital Communication-Simon Haykin

What is multiple access?

Access to a given facility or a resource by multiple users

Facility: Transponder

Multiple users: Different channels under the satellite

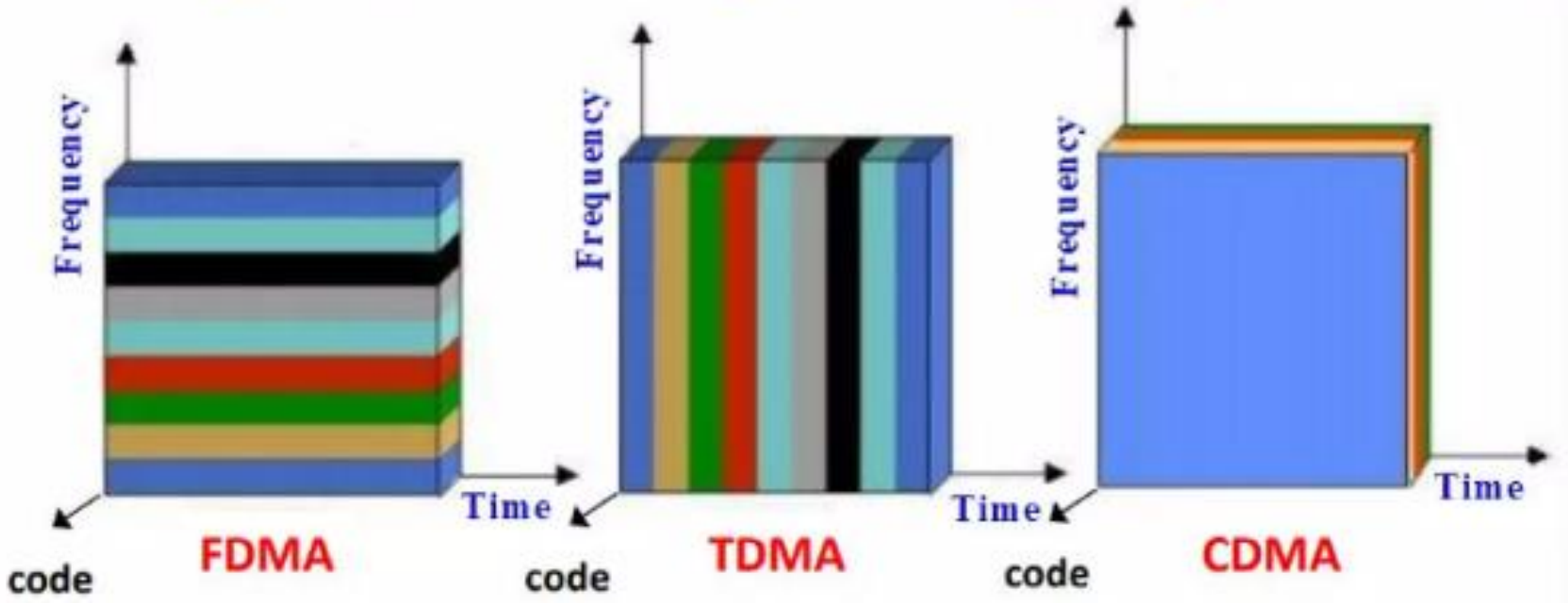
Classification of Multiple Access Technique

Frequency Division Multiple Access (FDMA)

Time Division Multiple Access (TDMA)

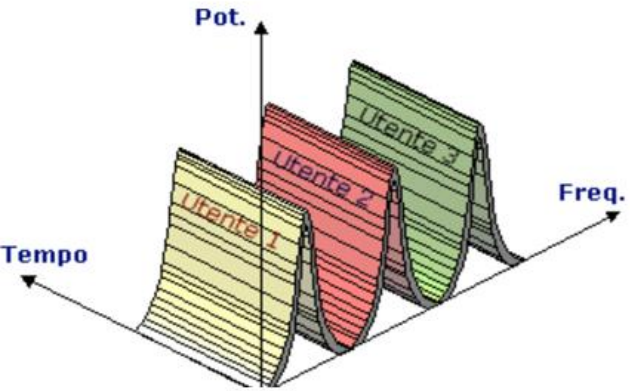
Code Division Multiple Access (CDMA)

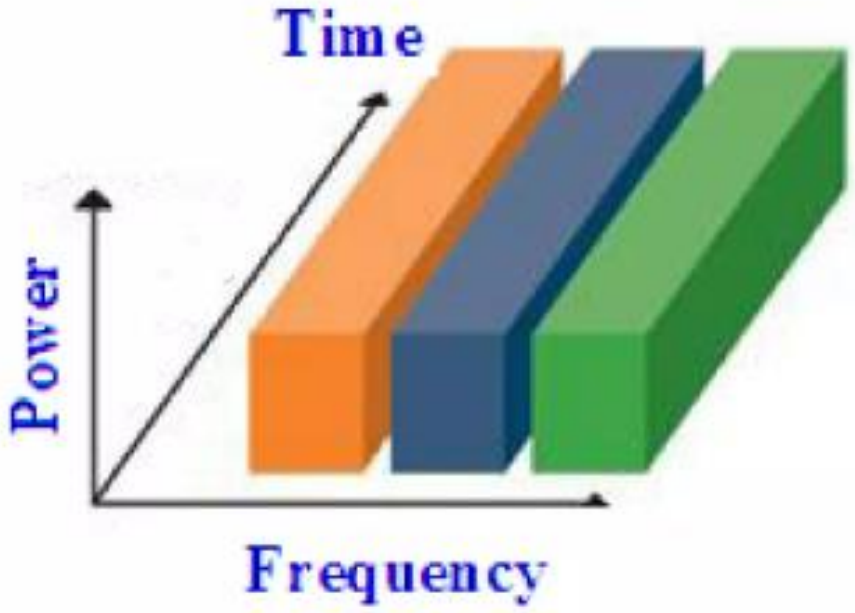
Space Division Multiple Access (SDMA)



FDMA

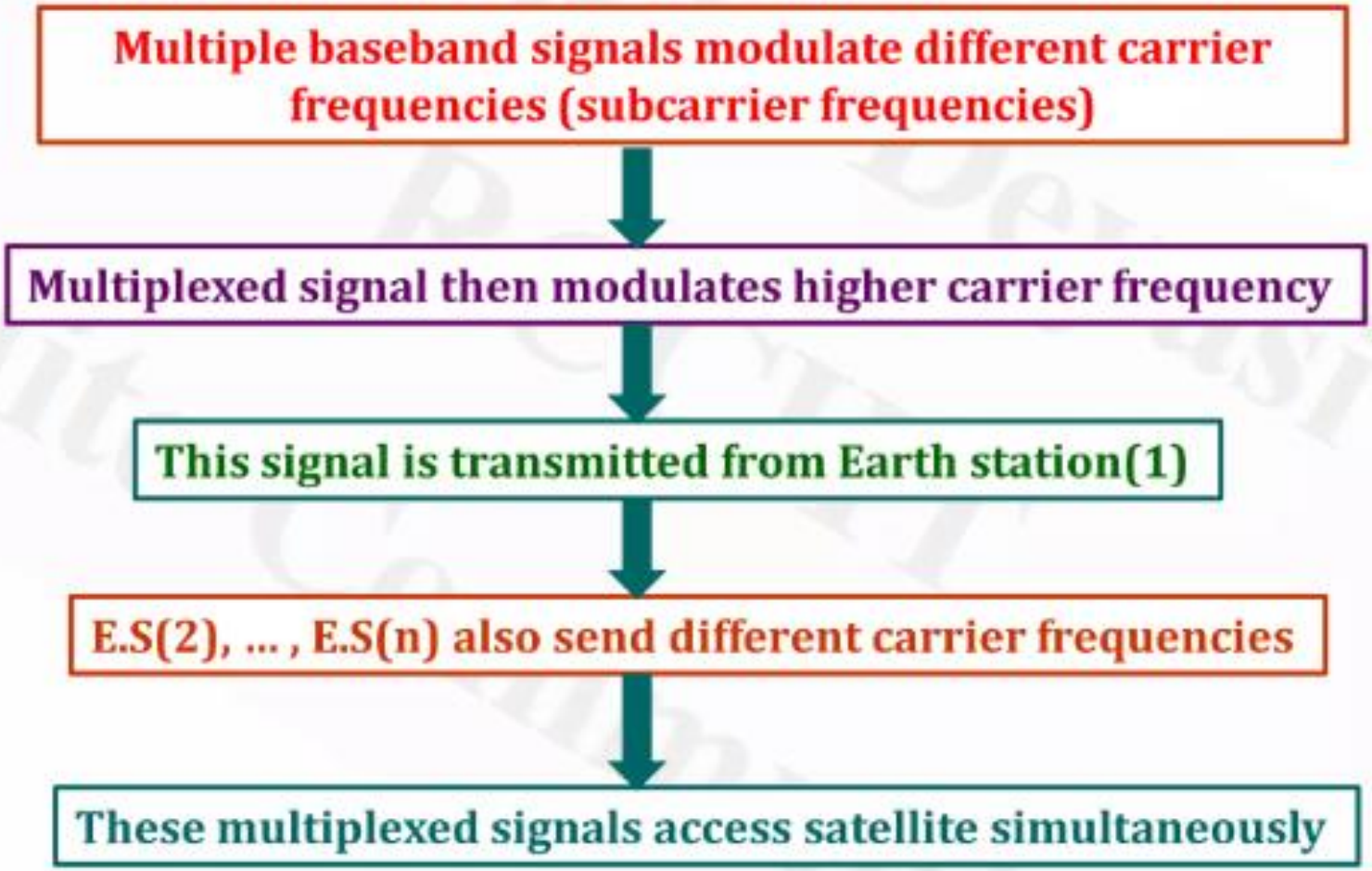
Different Earth stations are able to access the total available bandwidth in transponders due to their different carrier frequencies, therefore avoiding interference among multiple signals





- Each user transmits with no limitations in time, but using only a portion of the whole available frequency bandwidth.
- Different users are separated in the frequency domain.

FDMA


Multiple baseband signals modulate different carrier frequencies (subcarrier frequencies)
Multiplexed signal then modulates higher carrier frequency
This signal is transmitted from Earth station(1)
E.S(2), ... , E.S(n) also send different carrier frequencies
These multiplexed signals access satellite simultaneously

Are FDMA & FDM same?

No.

FDM is the process of grouping multiple baseband signals into a single signal for transmission through a single channel without multiple baseband signals

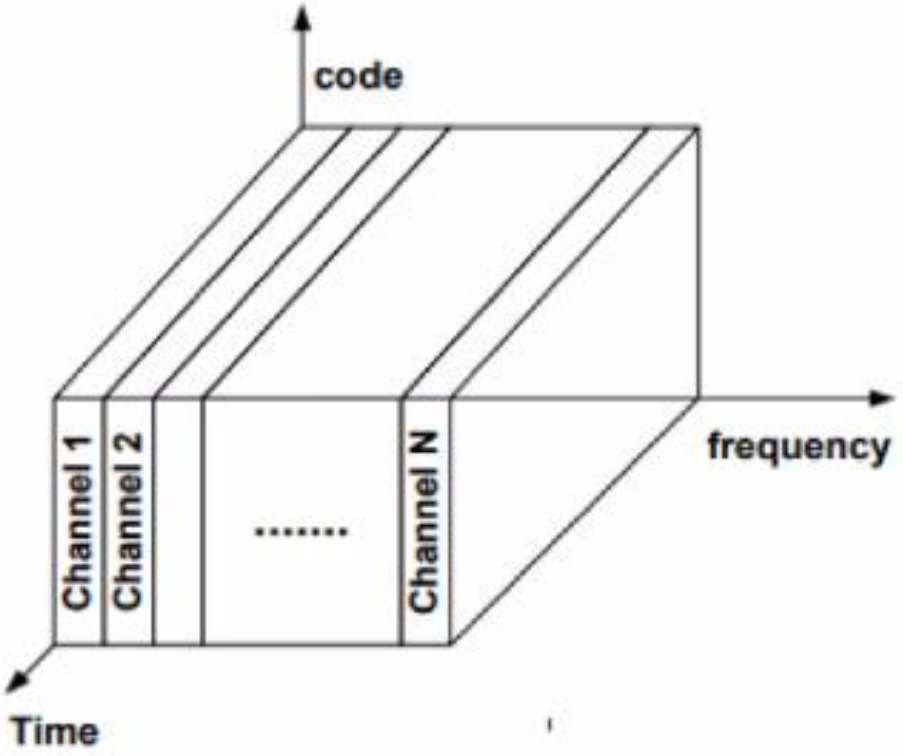
FDMA

Individual channels are assigned to individual users

Channels are assigned on demand to users who request service

Available frequency band is divided into number of non-overlapping channels

Continuous transmission



Number of channels in FDMA system

$$N = \frac{B_t - B_{guard}}{B_c}$$

B_t: total spectrum allocation

B_{guard}: guard band

B_c: channel bandwidth

FDMA: Advantages

One phone circuit at a time per carrier

Simple equipments required for earth station

Low Inter-Symbol Interference

No complex timing and synchronization technique required

No restriction regarding modulation technique used

Very efficient when traffic is uniformly constant

FDMA: Disadvantages

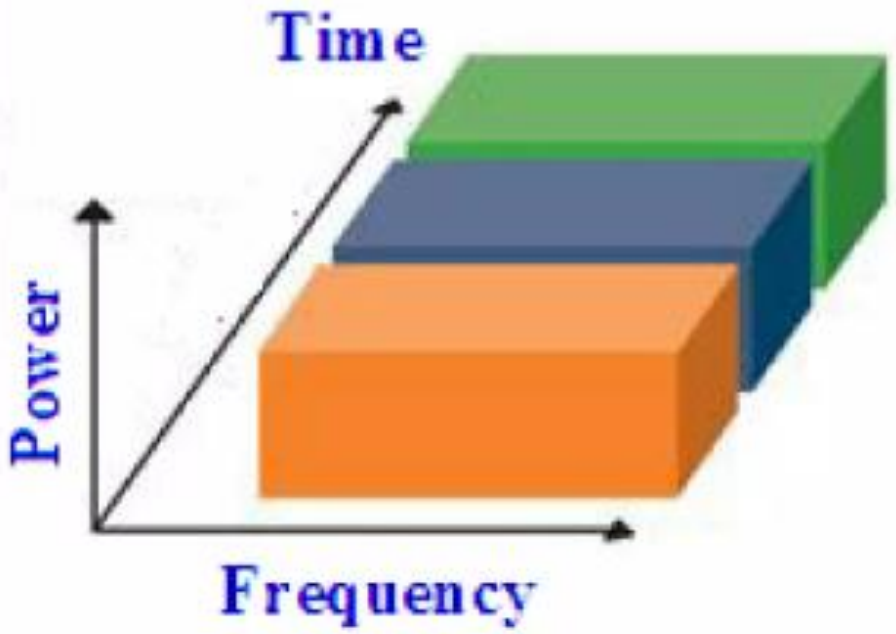
Intermodulation problem occurs which affects SNR

Adjacent channel interference

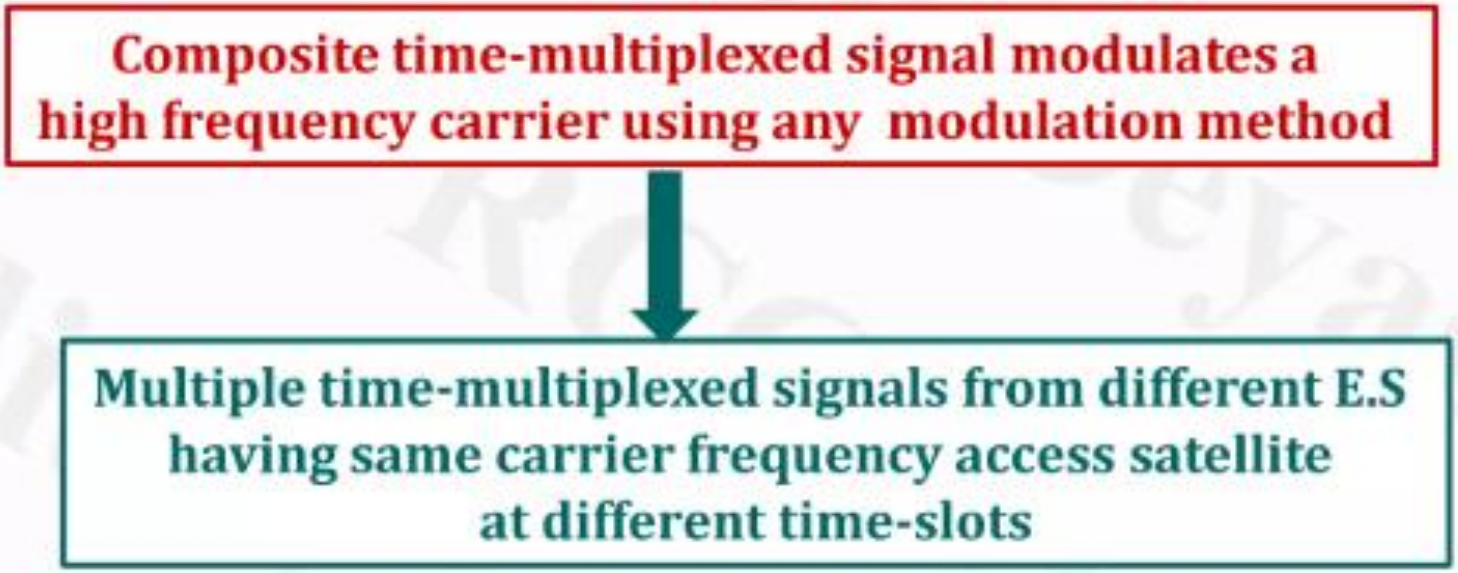
RF filter required which increases cost of the system

TDMA

Different Earth stations under one satellite make use of transponder through a single carrier on time sharing basis



TDMA


Composite time-multiplexed signal modulates a high frequency carrier using any modulation method
Multiple time-multiplexed signals from different E.S having same carrier frequency access satellite at different time-slots

Are TDMA & TDM same?

No.

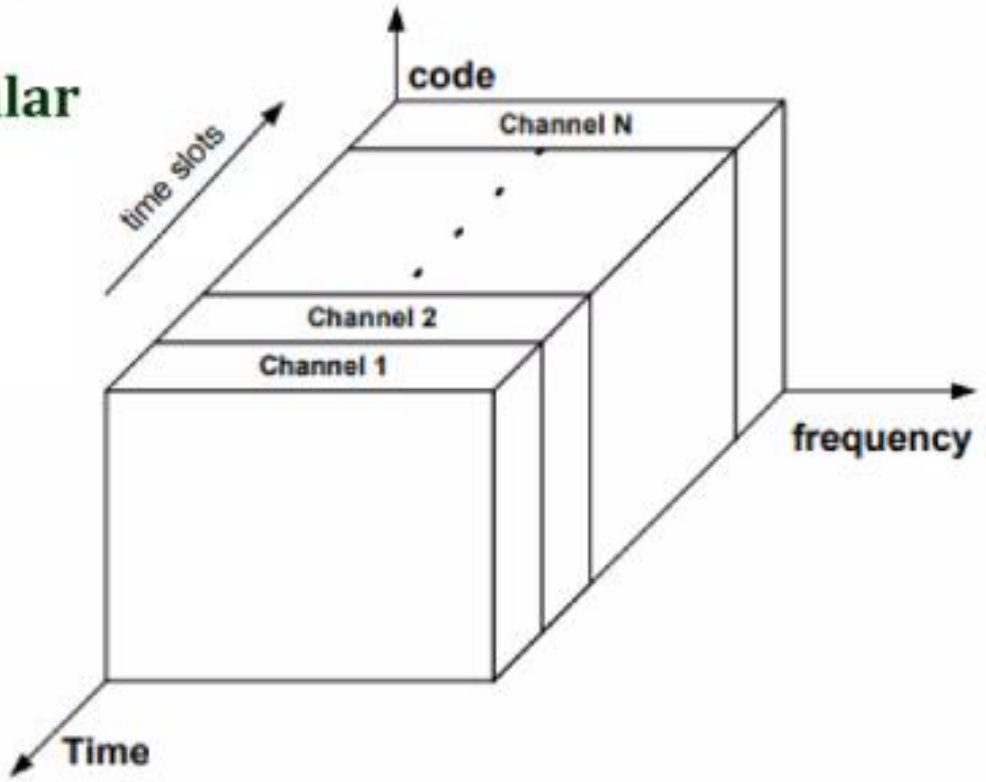
In TDM, multiple based band signals are simultaneously transmitted from a given earth station in digitized form through a single channel in different time

TDMA

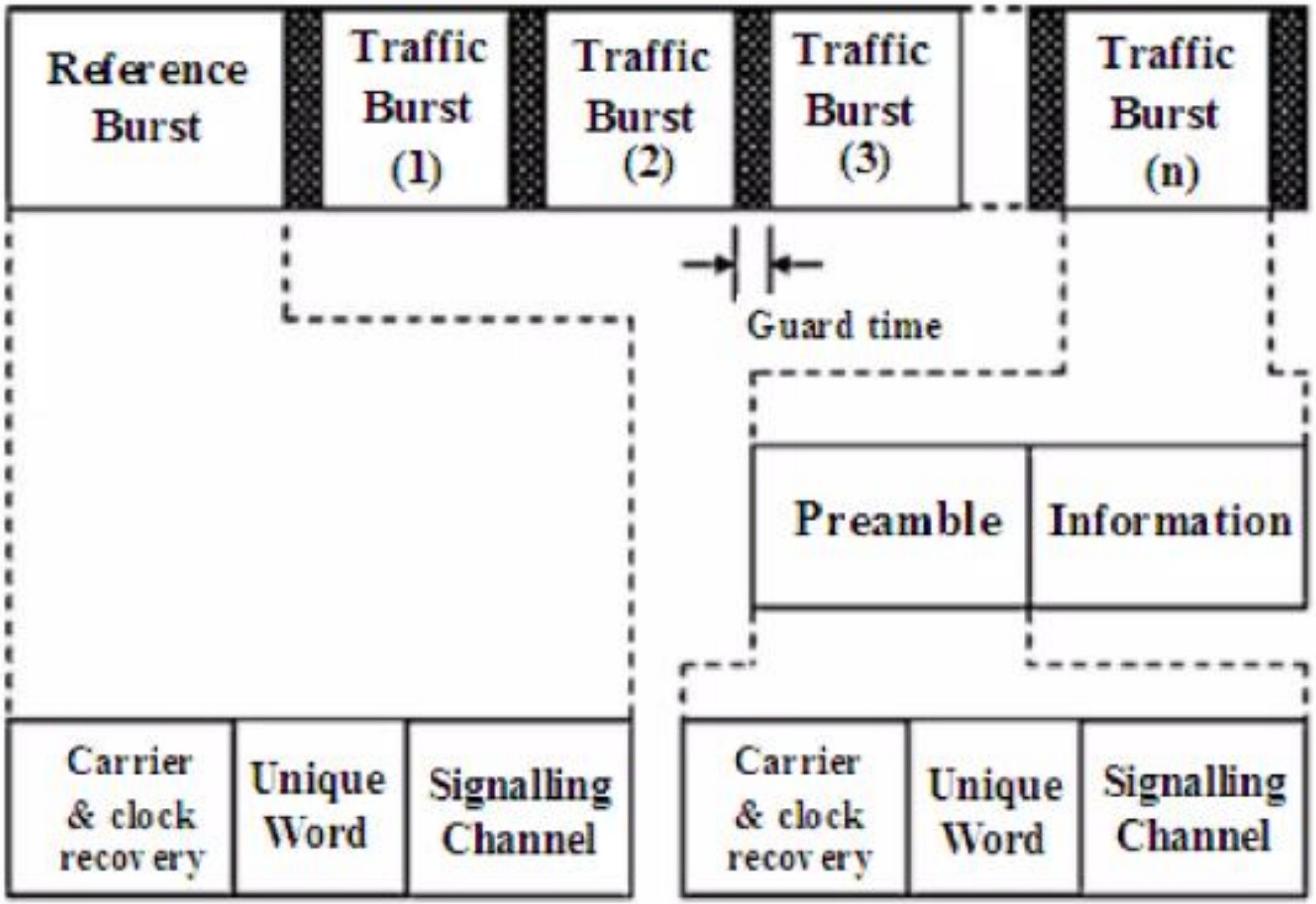
Carrier frequency is divided into 'N' timeslots, which is shared into 'N' terminals

Each user has a particular timeslot

Discontinuous transmission



TDMA Frame Structure



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TDMA: frame structure

Reference Burst

It is a combination of primary and secondary reference bursts

Primary is transmitted to primary reference station, secondary is transmitted to secondary reference station

If primary fails, it automatically switches to secondary

It doesn't carry any traffic information

It is used to provide timing references

Number of channels in TDMA system

$$N = \frac{m(B_t - 2B_{guard})}{B_c}$$

B_t: total spectrum allocation

B_{guard}: guard band

B_c: channel bandwidth

n: number of TDMA users per channel

TDMA: frame structure

Traffic Burst

These are positioned anywhere in the frame according to a burst time plan

Timing reference is taken from time of reference from primary reference burst

Guard Time

Separate different traffic bursts

It should be as low as possible

TDMA: Advantages

Flexible bit rate

No frequency guard band required

Narrowband filters not required

Cost-effective

Extended lifetime of source

TDMA: Disadvantages

Timing synchronization required

High peak power required for uplink

Difference between FDMA & TDMA

FDMA	TDMA
Synchronization is not required	Synchronization is required
Peak power is low	Peak power is large
Requires high carrier frequency	High carrier frequency is not necessary
Divide frequency band into disjoint subband	Divide time into non overlapping time-slot
Continuous transmission scheme	Discontinuous transmission scheme
Entire band of frequencies is divided into multiple RF channels/carriers, each carrier is allocated to different users	Its entire bandwidth is shared among different subscribers at fixed predetermined or dynamically assigned time intervals/slots

Difference between FDMA & TDMA

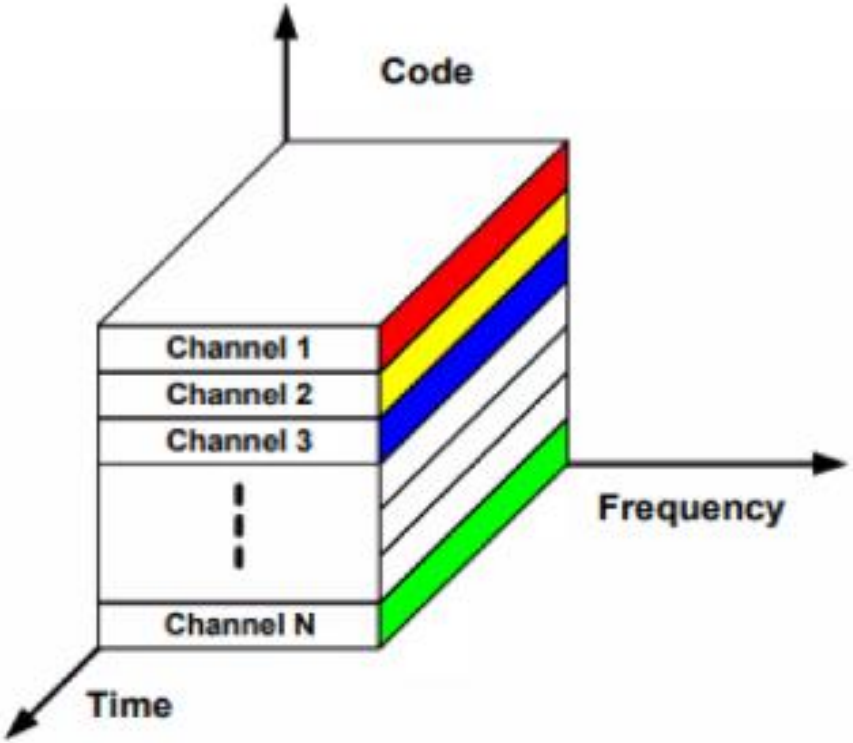
FDMA	TDMA
Duty cycle of earth station is higher	Duty cycle of Earth station is low
Lower data rate	Higher data rate
Less complex system	More complex system
Less immune to interference	More immune to interference
Used in GSM and PDC	Used in advanced mobile phone systems (AMPS)

- **Global System for Mobile communication (GSM)**
- **Personal Digital Cellular (PDC)**

CDMA

Total transponder bandwidth is simultaneously used by multiple Earth stations at all times

As each transmitter uses a unique code sequence, interference can be avoided



Receiving stations decoded the signals by matched decoder

CDMA: basic principles

- **In CDMA each user is assigned a unique code sequence (spreading code), which it uses to encode its data signal.**
- **The receiver, knowing the code sequence of the user, decodes the received signal and recovers the original data.**
- **The bandwidth of the coded data signal is chosen to be much larger than the bandwidth of the original data signal, that is, the encoding process enlarges (spreads) the spectrum of the data signal.**
- **CDMA is based on spread-spectrum modulation.**
- **If multiple users transmit a spread-spectrum signal at the same time, the receiver will still be able to distinguish between users, provided that each user has a unique code that has a sufficiently low cross correlation with the other codes.**

CDMA

It is a part of Spread Spectrum Multiple Access technique – more precisely *Direct Sequence Multiple Access*

Chip rate is always much higher than data rate

Consistently provides better capacity for voice and data communications, allowing more subscribers to connect at any given time

CDMA Schemes

Direct Sequence CDMA (DS-CDMA)

The original data signal is multiplied directly by the high chip rate spreading code

Frequency Hopping CDMA (FH-CDMA)

The carrier frequency at which the original data signal is transmitted is rapidly changed according to the spreading code

Time Hopping CDMA (TH-CDMA)

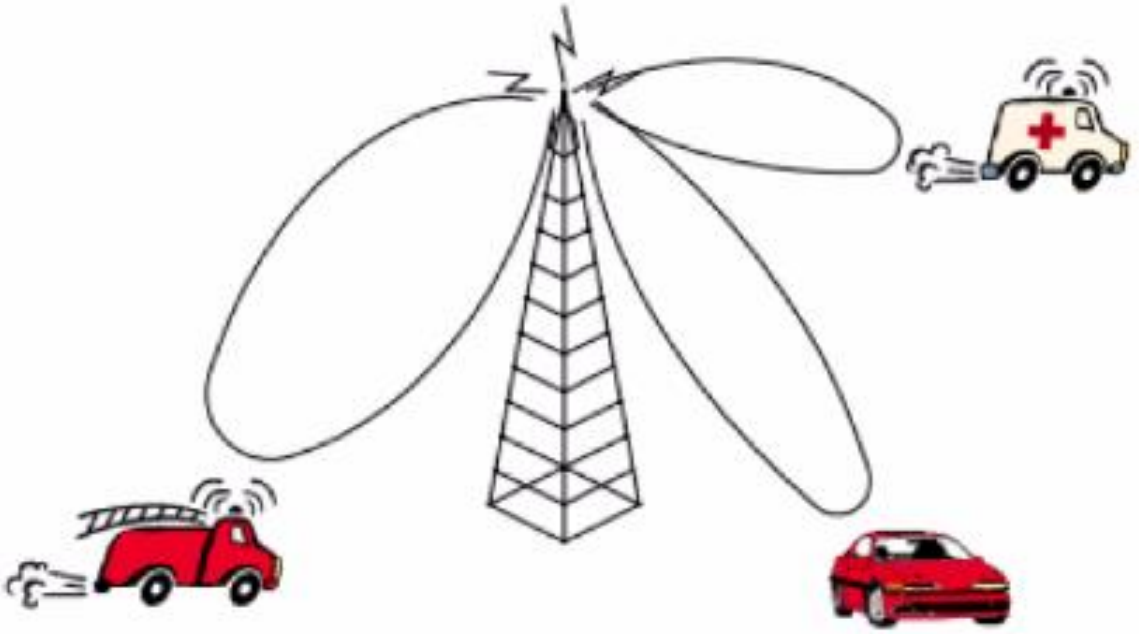
The original data signal is not transmitted continuously. Instead, the signal is transmitted in short bursts where the times of the bursts are decided by the spreading code

SDMA

It uses spatial separation between multiple transmissions

For this purpose, different antenna beam polarizations are used

Total Earth surface can be covered from a single satellite



SDMA

Base stations track user when moving inside cover area with same frequency

Optimizes the use of radio spectrum

IEEE 802.11

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

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

BSS: Basic service set
AP: Access point

Figure-1 *Basic service sets (BSSs)*

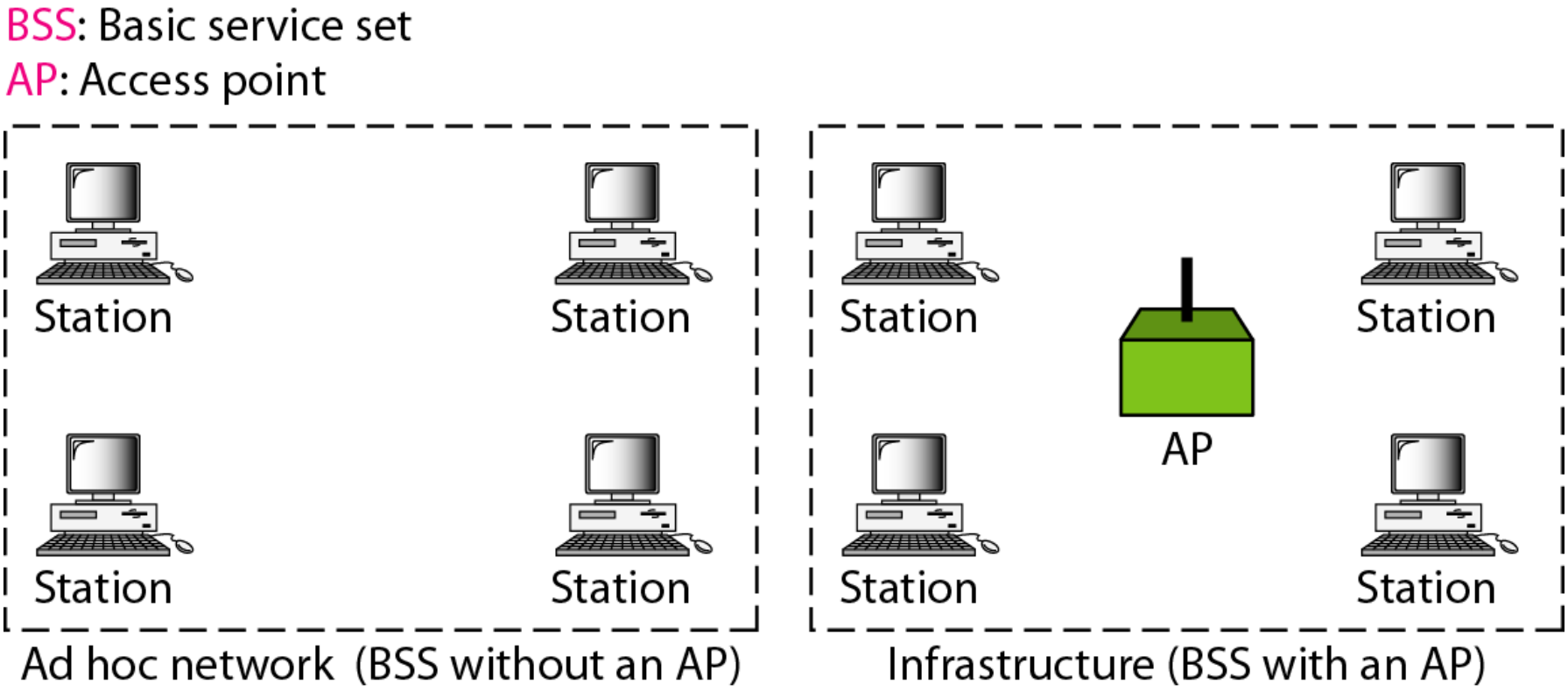
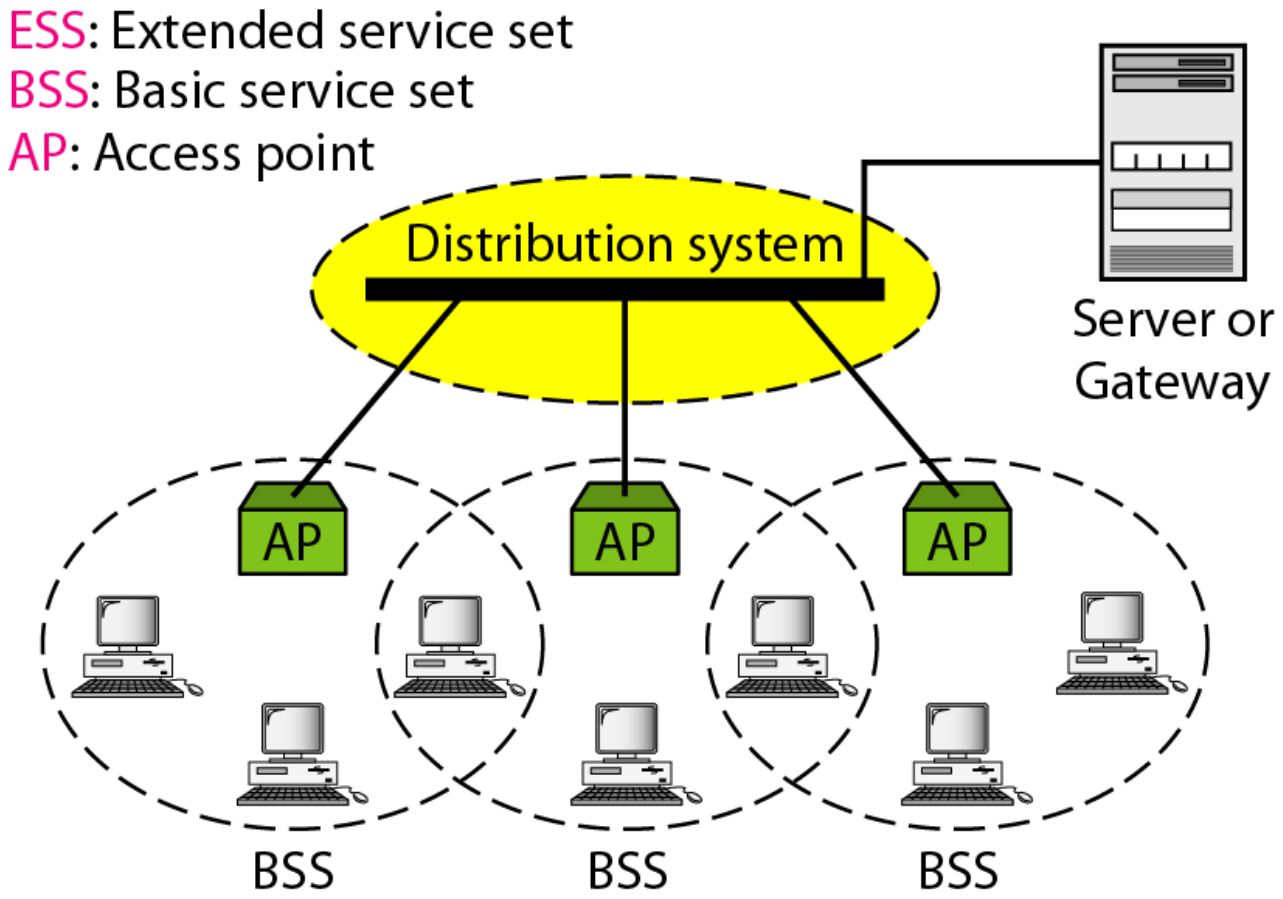


Figure-2 *Extended service sets (ESSs)*



IEEE 802.11 Overview

- Adopted in 1997.

Defines;

- MAC sublayer
- MAC management protocols and services
- Physical (PHY) layers
  - IR
  - FHSS
  - DSSS

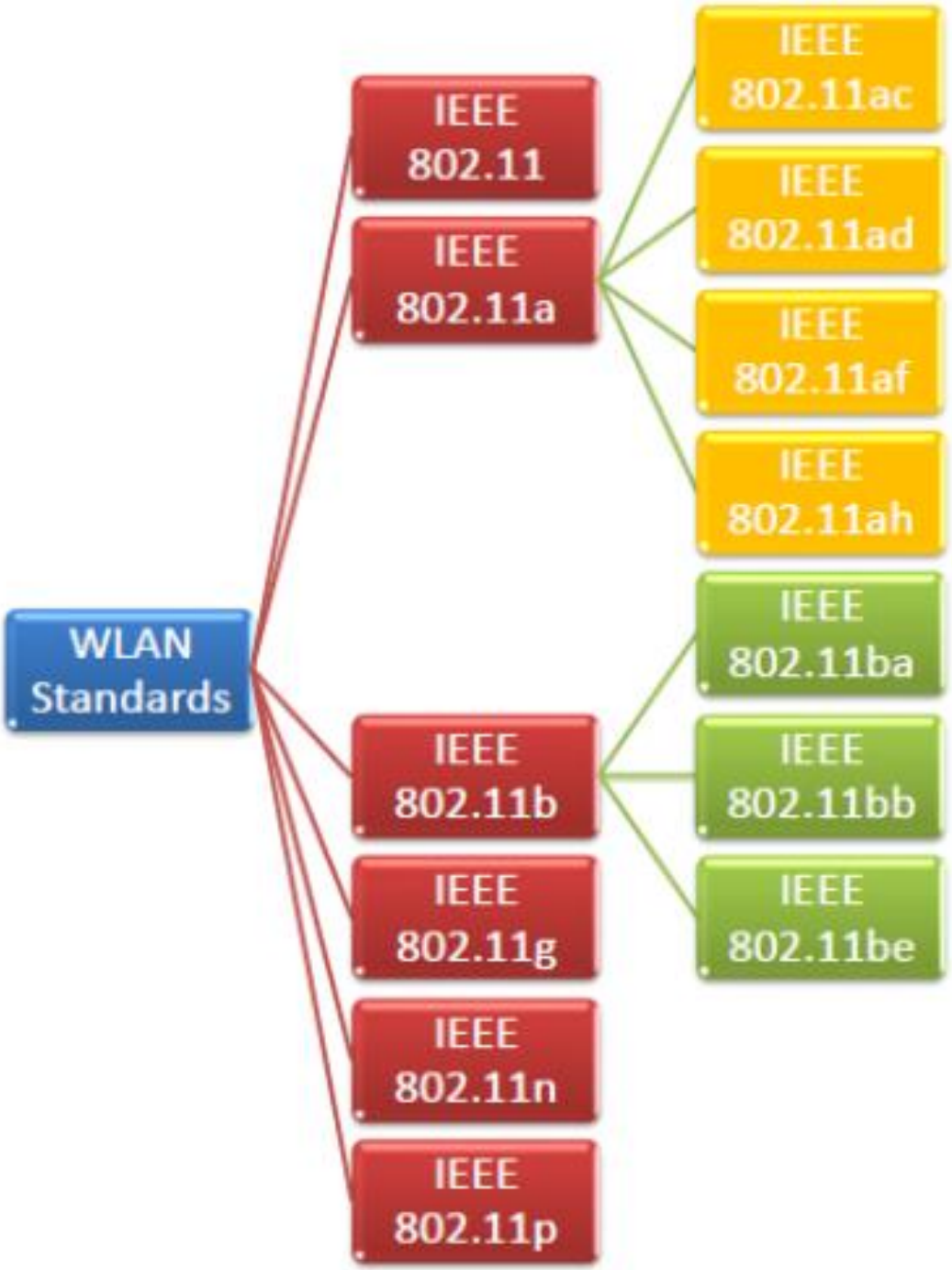
Goals
- To deliver services in wired networks
- To achieve high throughput
- To achieve highly reliable data delivery
- To achieve continuous network connection.

Classification

There are several standards of IEEE 802.11 WLANs.

The prominent among them are 802.11, 802.11a, 802.11b, 802.11g, 802.11n and 802.11p.

All the standards use carrier-sense multiple access with collision avoidance (CSMA/CA). Also, they have support for both centralised base station based as well as ad hoc networks.



IEEE 802.11

IEEE 802.11 was the original version released in 1997. It provided 1 Mbps or 2 Mbps data rate in the 2.4 GHz band and used either frequency-hopping spread spectrum (**FHSS**) or direct-sequence spread spectrum (**DSSS**). It is **obsolete** now.

IEEE 802.11a

802.11a was published in 1999 as a modification to 802.11, with orthogonal frequency division multiplexing (**OFDM**) based air interface in physical layer instead of FHSS or DSSS of 802.11. It provides a maximum data rate of 54 Mbps operating in the 5 GHz band. Besides it provides error correcting code. As 2.4 GHz band is crowded, relatively sparsely used 5 GHz imparts additional advantage to 802.11a.

IEEE 802.11b

802.11b is a direct extension of the original 802.11 standard that appeared in early 2000. It uses the same modulation technique as 802.11, i.e. DSSS and operates in the 2.4 GHz band. It has a **higher data rate** of 11 Mbps as compared to 2 Mbps of 802.11, due to which it was rapidly adopted in wireless LANs. However, since 2.4 GHz band is pretty crowded, 802.11b devices faces interference from other devices.

IEEE 802.11g

802.11g was indorsed in 2003. It operates in the 2.4 GHz band (as in 802.11b) and provides a average throughput of 22 Mbps. It uses **OFDM technique** (as in 802.11a). It is **fully backward compatible** with 802.11b. 802.11g devices also faces interference from other devices operating in 2.4 GHz band.

IEEE 802.11n

802.11n was approved and published in 2009 that operates on both the 2.4 GHz and the 5 GHz bands. It has **variable data rate** ranging from 54 Mbps to 600 Mbps. It provides a marked improvement over previous standards 802.11 by incorporating multiple-input multiple-output antennas (**MIMO antennas**).

IEEE 802.11p

802.11 is an amendment for including **wireless access in vehicular environments** (WAVE) to support **Intelligent Transportation Systems** (ITS). They include network communications between vehicles moving at high speed and the environment. They have a data rate of 27 Mbps and operate in 5.9 GHz band.

Thanks !