PROJECT

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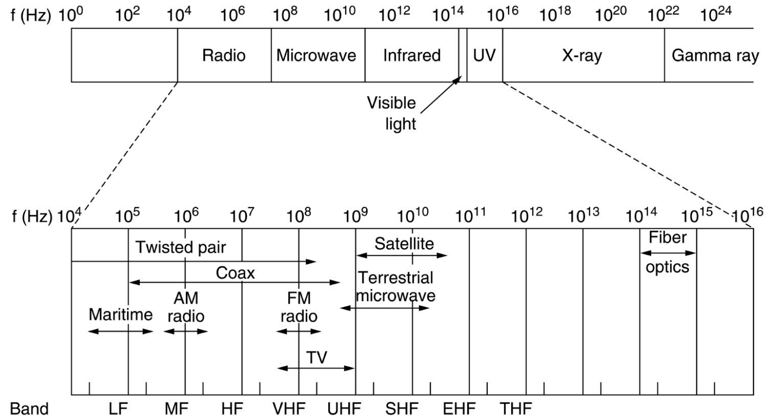
MATERI 9. MULTIPLE ACCESS

Frequency Spectrum



Introduction

- Most communication systems require the sharing of channels
- Shared media is common in cable television, telephone systems, and data communications
- Two types of combining signals are:
  - **Multiplexing** - combining signals from the same sources
  - **Multiple Access** - combining signals from multiple sources

- **Multiplexing** is sending multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end.

- **Compression** means transmitting/storing the same amount of information using less amount of resources

Both Compression and Multiplexing are attempts to make better use of resources: the Communication Channel.

- A communications medium can be shared equally by dividing either quantity among users
- The frequency spectrum can be divided by using:
  - **FDM (Frequency Division Multiplexing)**
  - **TDM (Time Division Multiplexing)**
  - **CDMA (Code Division Multiple Access)**

Frequency-Division Multiplexing and Multiple Access (FDM/FDMA)

- FDM divides the transmission frequency range (Bandwidth) into narrower bands called (subchannels).
- The subchannels are smaller frequency bands and each band is capable of carrying a separate voice or data signals!
- Guard bands are used to prevent interference on the receiving end of the signal (Accommodate the
- delay of the near-far-problem)
- Disadvantage (FDMA): Full utilization of the available frequency band is not possible!!
- Advantage: Multiple callers can share the frequency spectrum.

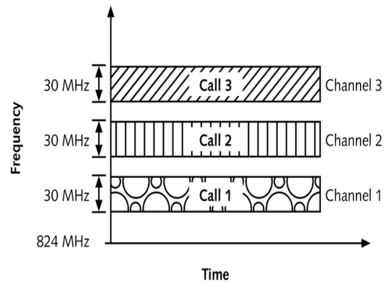


Figure 9-13 FDMA

- Single channel per carrier
- All first generation systems use FDMA

Time-Division Multiplexing and Multiple Access (TDM/TDMA)

- TDM is used mainly for digital communication
- In TDM the entire bandwidth of the radio channel is used but is divided into time slots that are periodically allocated to each station for the duration of the call

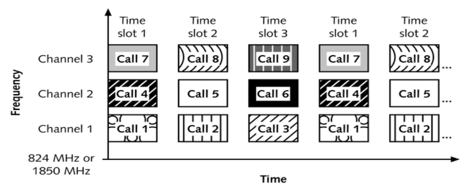
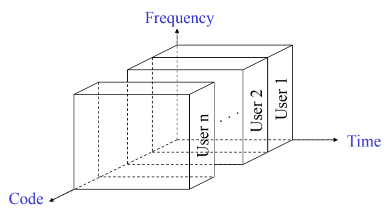


Figure 9-14 TDMA

- Multiple channels per carrier
- Most of second generation systems use TDMA

Code Division Multiple Access (CDMA)



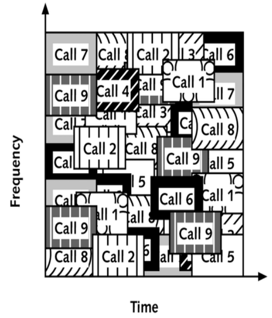
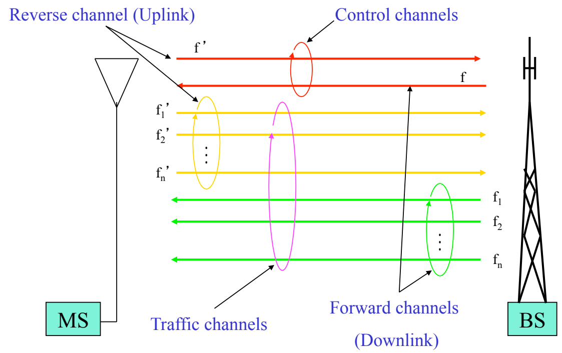


Figure 9-15 CDMA

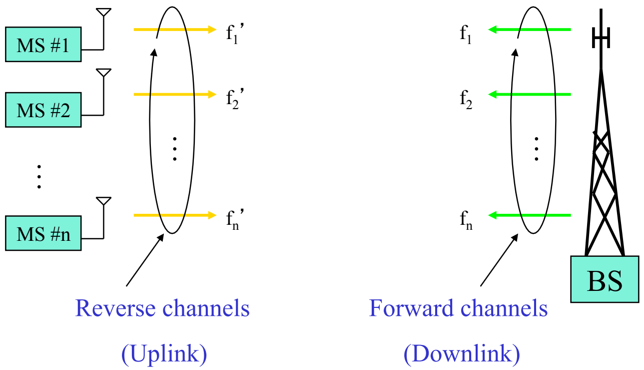
- Users share bandwidth by using code sequences that are orthogonal to each other
- Some second generation systems use CDMA
- Most of third generation systems use CDMA

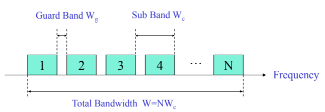
Types of Channels

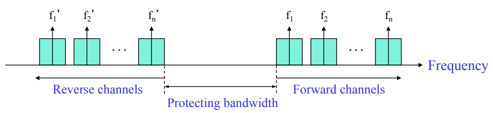
- Control channel
  - Forward (Downlink) control channel
  - Reverse (Uplink) control channel
- Traffic channel
  - Forward traffic (traffic or information) channel
  - Reverse traffic (traffic or information) channel



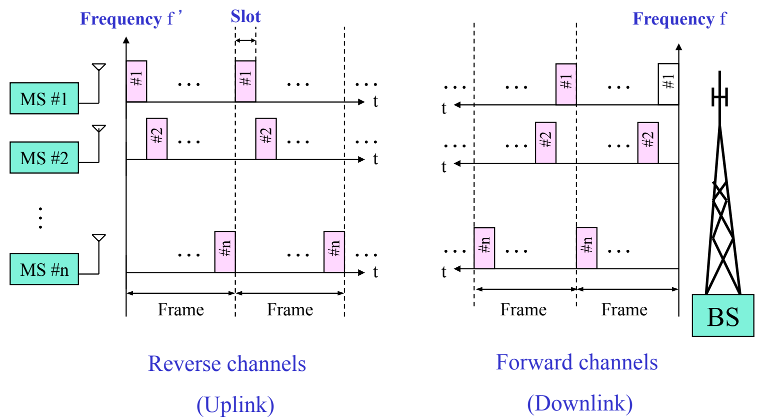
FDMA

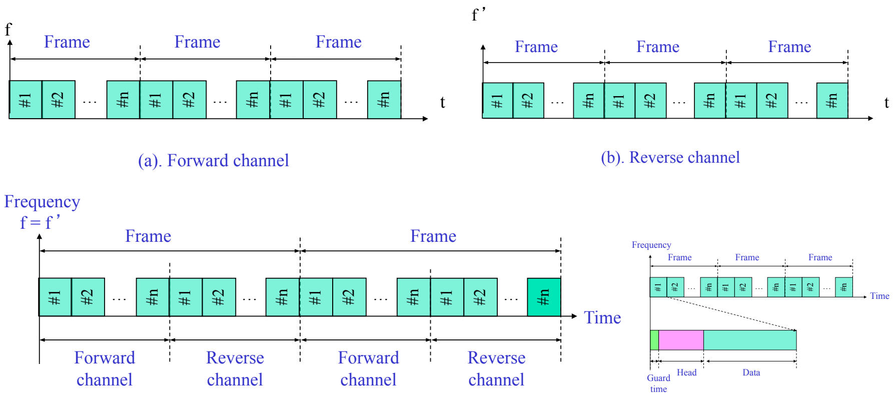




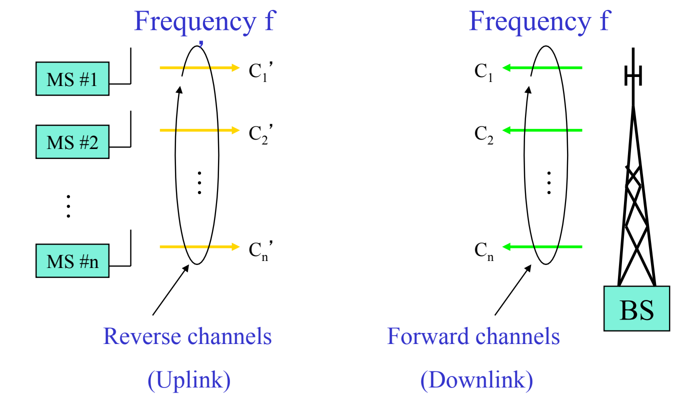


TDMA





(c). Channels in Simplex Mode

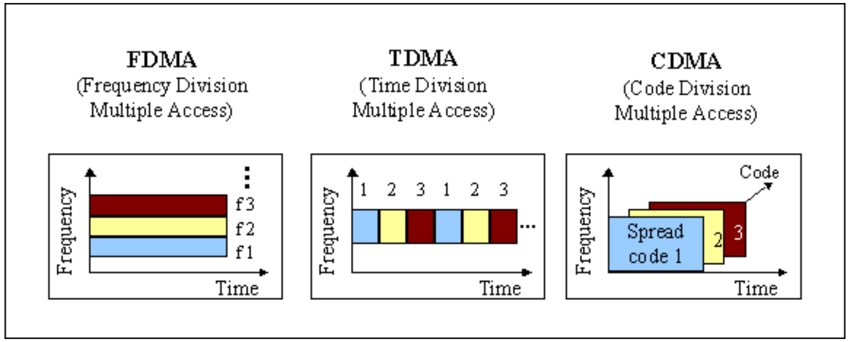


Note: $C_i' \times C_j' = 0$, i.e., C_i' and C_j' are orthogonal codes,
$C_i \times C_j = 0$, i.e., C_i and C_j are orthogonal codes

Comparison of FDMA, TDMA, and CDMA

Operation	FDMA	TDMA	CDMA
Allocated Bandwidth	12.5 MHz	12.5 MHz	12.5 MHz
Frequency reuse	7	7	1
Required channel BW	0.03 MHz	0.03 MHz	1.25 MHz
No. of RF channels	12.5/0.03=416	12.5/0.03=416	12.5/1.25=10
Channels/cell	416/7=59	416/7=59	12.5/1.25=10
Control channels/cell	2	2	2
Usable channels/cell	57	57	8
Calls per RF channel	1	4*	40**
Voice channels/cell	57x1=57	57x4=228	8x40=320
Sectors/cell	3	3	3
Voice calls/sector	57/3=19	228/3=76	320
Capacity vs FDMA	1	4	16.8
Delay	?	?	?

* Depends on the number of slots ** Depends on the number of codes

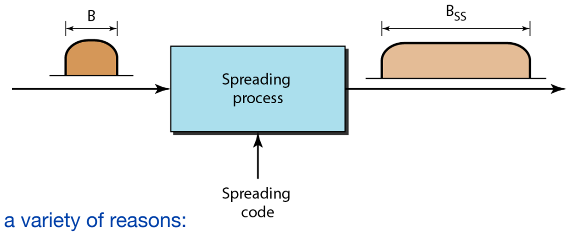


Operator	Produk	Jaringan
Bakrie Telecom	Esia	CDMA 800MHz
Hutchison	3	GSM
Indosat	IM3, Indosat Matrix, Indosat Mentari	GSM
	StarOne	CDMA 800MHz
Mobile-8	Fren, Mobi dan Hepi	CDMA 800MHz
Natrindo	Axis	GSM
Sampoerna Telekom	Ceria[34]	CDMA 450MHz
Smart Telecom	Smart	CDMA 1.900MHz
Telkom	Flexi	CDMA 800MHz
Telkomsel	Kartu AS, Kartu HALO dan Simpati	GSM
XL Axiata	XL	GSM

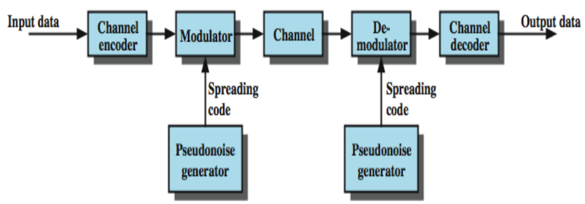
Spread Spectrum Techniques for Wireless Communication

Spread Spectrum Communication

- Methods by which a signal generated with a particular bandwidth is deliberately spread in the frequency domain, resulting in a signal with a wider bandwidth.



- These techniques are used for a variety of reasons:
  - Establishment of secure communications
  - Increasing resistance to natural interference, noise and jamming
  - Prevent detection
  - Limit power flux density



Types of Spread Spectrum Systems

- There are two important types of spread-spectrum systems:
  - **Frequency-hopping** ➔ Splits the band into subchannels – signal then hops to transmit
  - **Direct-sequence** ➔ Transmission signal is spread over an allowed band

Spread Spectrum modulation techniques present two major advantages for Wireless Local Area Networks (WLAN)

WLAN IEEE 802.11

TABLE 1: IEEE 802.11 PHY STANDARDS

Release date	Standard	Band (GHz)	Bandwidth (MHz)	Modulation	Advanced antenna technologies	Maximum data rate
1997	802.11	2.4	20	DSSS, FHSS	N/A	2 Mbits/s
1999	802.11b	2.4	20	DSSS	N/A	11 Mbits/s
1999	802.11a	5	20	OFDM	N/A	54 Mbits/s
2003	802.11g	2.4	20	DSSS, OFDM	N/A	54 Mbits/s
2009	802.11n	2.4, 5	20, 40	OFDM	MIMO, up to four spatial streams	600 Mbits/s
2012 (expected)	802.11ad	60	2160	SC, OFDM	Beamforming	6.76 Gbits/s
2013 (expected)	802.11ac	5	40, 80, 160	OFDM	MIMO, MU-MIMO, up to eight spatial streams	6.93 Gbits/s

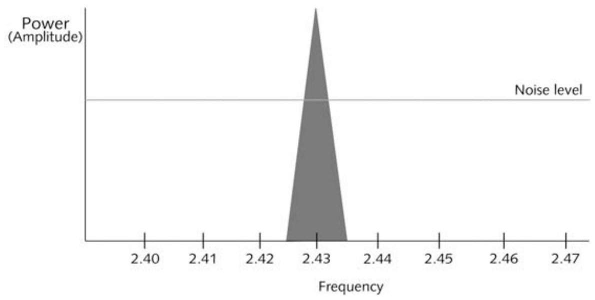
Wireless Modulation Schemes

- Four primary wireless modulation schemes:
  - Narrowband transmission
  - Frequency hopping spread spectrum
  - Direct sequence spread spectrum
  - Orthogonal Frequency Division Multiplexing
- Narrowband transmission used primarily by radio stations
- Other three used in IEEE 802.11 WLANs

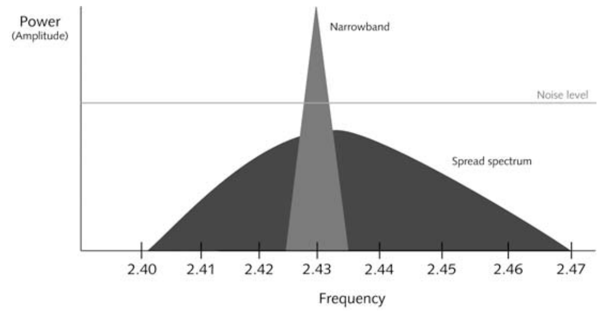
Narrowband Transmission

- Radio signals by nature transmit on only one radio frequency or a narrow portion of frequencies
- Require more power for the signal to be transmitted
- Signal must exceed noise level
- Total amount of outside interference
- Vulnerable to interference from another radio signal at or near same frequency
- IEEE 802.11 standards do not use narrowband transmissions

Narrowband Transmission



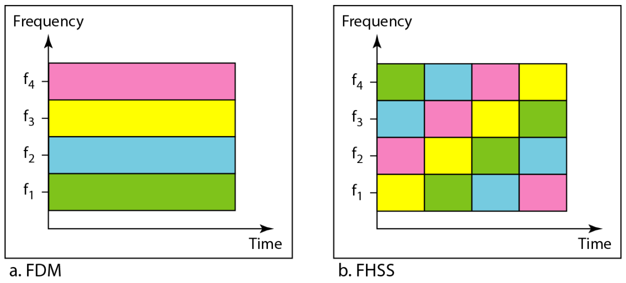
Spread Spectrum Transmission



- Advantages over narrowband:
  - Resistance to narrowband interference
  - Resistance to spread spectrum interference
  - Lower power requirements
  - Less interference on other systems
  - More information transmitted
  - Increased security
  - Resistance to multipath distortion

Frequency Hoping Spread Spectrum (FHSS)

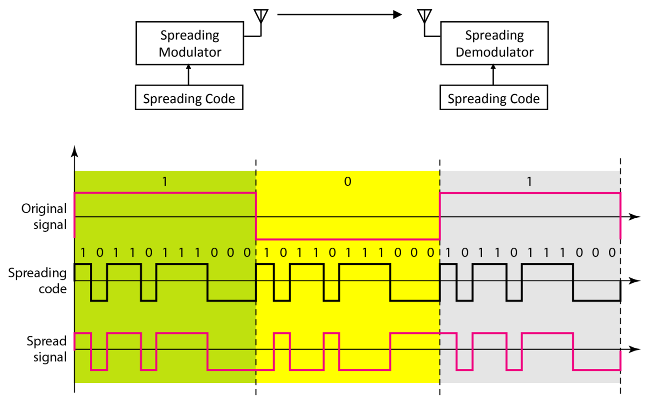
- FHSS uses frequency-shift keying (FSK) technology, meaning that the signal jumps from frequency to frequency within the ISM band to avoid interference.
- Devices using FHSS send a short burst of data, shift frequencies (hop) and then send another short burst of data.
- This implementation used by Apple, Lucent, Farallon



Direct Sequence Spread Spectrum

- DSSS communicate within a fixed frequency band, but split each byte of data into several parts.
- Each part is encoded to create encrypted "pseudo-noise," and multiple copies of the signal (usually 10 or more) are sent concurrently at offset frequencies. Only one signal needs to arrive intact in order for the original message to be decrypted. This makes DSSS very redundant and nearly immune to complete data loss.

DSSS Example



FHSS vs DSSS

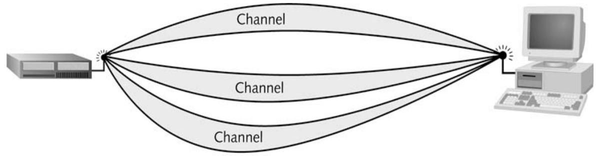
- DSSS has some immediate advantages over FHSS.
  - DSSS has better modulation, and greater range,
  - Another advantage to DSSS is efficiency. DSSS is able to give better performance with fewer access points than FHSS,

- DSSS can use a higher number of access points to get an overall higher aggregated bandwidth than FHSS.

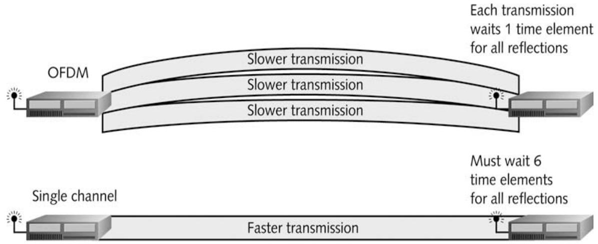
Orthogonal Frequency Division Multiplexing (OFDM)

- With multipath distortion, receiving device must wait until all reflections received before transmitting
- Puts ceiling limit on overall speed of WLAN
- OFDM: Send multiple signals at same time
- Split high-speed digital signal into several slower signals running in parallel
- OFDM increases throughput by sending data more slowly
- Avoids problems caused by multipath distortion
- Used in 802.11a networks

Multiple Channels



Orthogonal frequency division multiplexing (OFDM) vs. single-channel transmissions



- OFDM systems, such as IEEE 802.11a and 802.11g, use different modulation techniques depending on the data rate. Modulations include DBPSK, DQPSK, 16-QAM, and 64-QAM.

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OFDM Modulation Schemes and Data Rates

Modulation Scheme	Data Rate (Mbps)
DBPSK	6
DBPSK	9
DQPSK	12
DQPSK	18
16-QAM	24
16-QAM	36
64-QAM	48
64-QAM	54