CS321: Computer Networks

Wired LAN Protocol: Ethernet
Wireless LAN Protocol: IEEE 802.11

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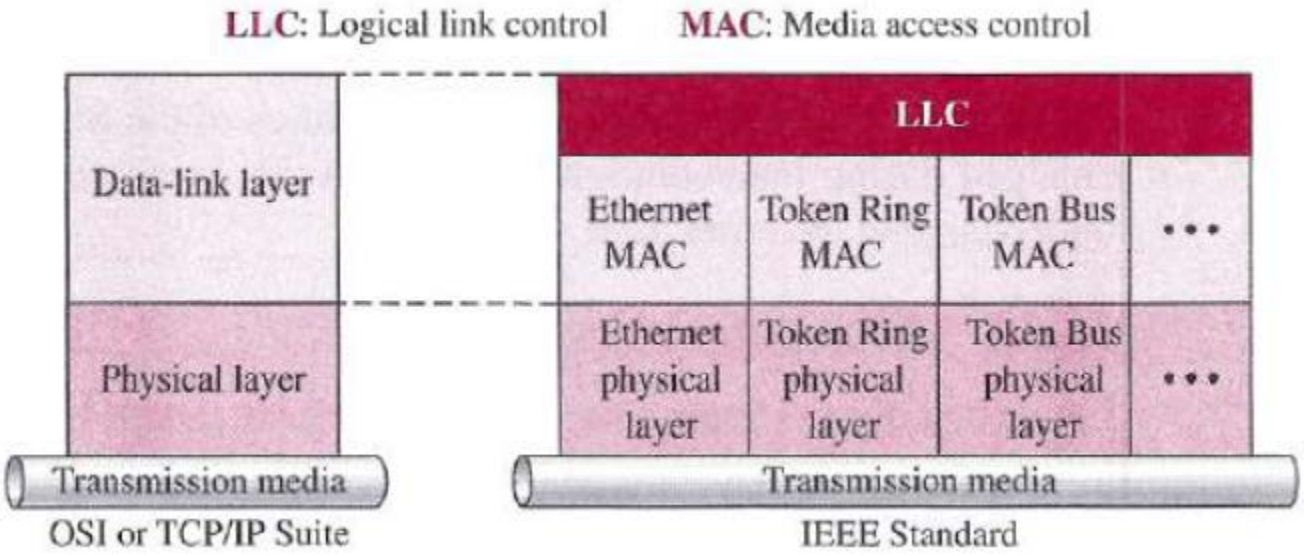
Wired LAN Protocols

- Following CSMA/CD approach
  - Ethernet
- Following token-passing approach
  - Token Ring
  - Token Bus
  - FDDI (Fiber Distribution Data Interface)



Ethernet

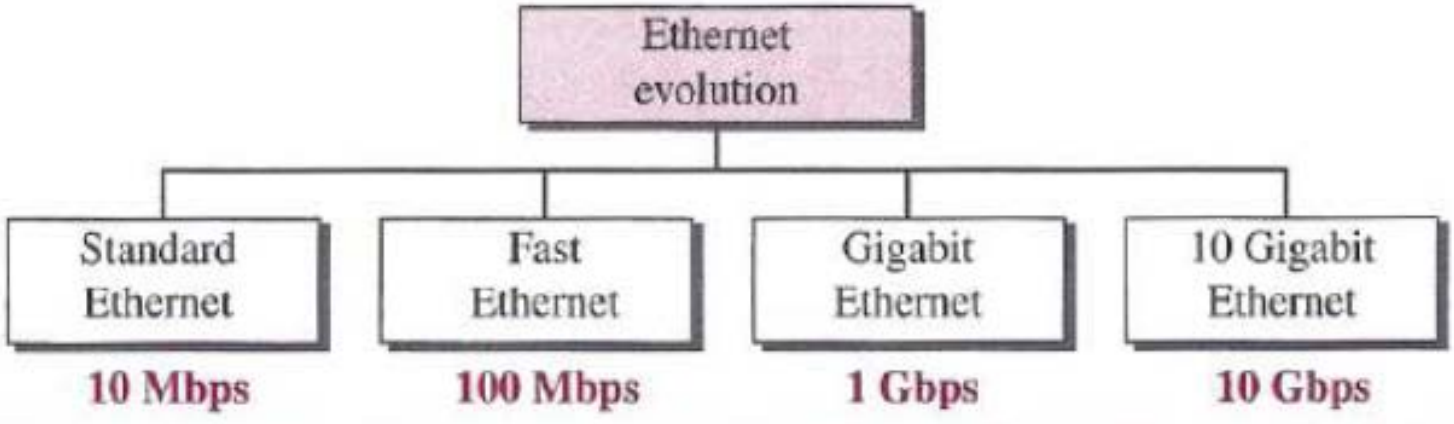


Table 13.1 *Summary of Standard Ethernet implementations*

Implementation	*Medium*	*Medium Length*	*Encoding*
10Base5	Thick coax	500 m	Manchester
10Base2	Thin coax	185 m	Manchester
10Base-T	2 UTP	100 m	Manchester
10Base-F	2 Fiber	2000 m	Manchester

Table 13.2 *Summary of Fast Ethernet implementations*

Implementation	*Medium*	*Medium Length*	*Wires*	*Encoding*
100Base-TX	UTP or STP	100 m	2	4B5B + MLT-3
100Base-FX	Fiber	185 m	2	4B5B + NRZ-I
100Base-T4	UTP	100 m	4	Two 8B/6T

Ethernet

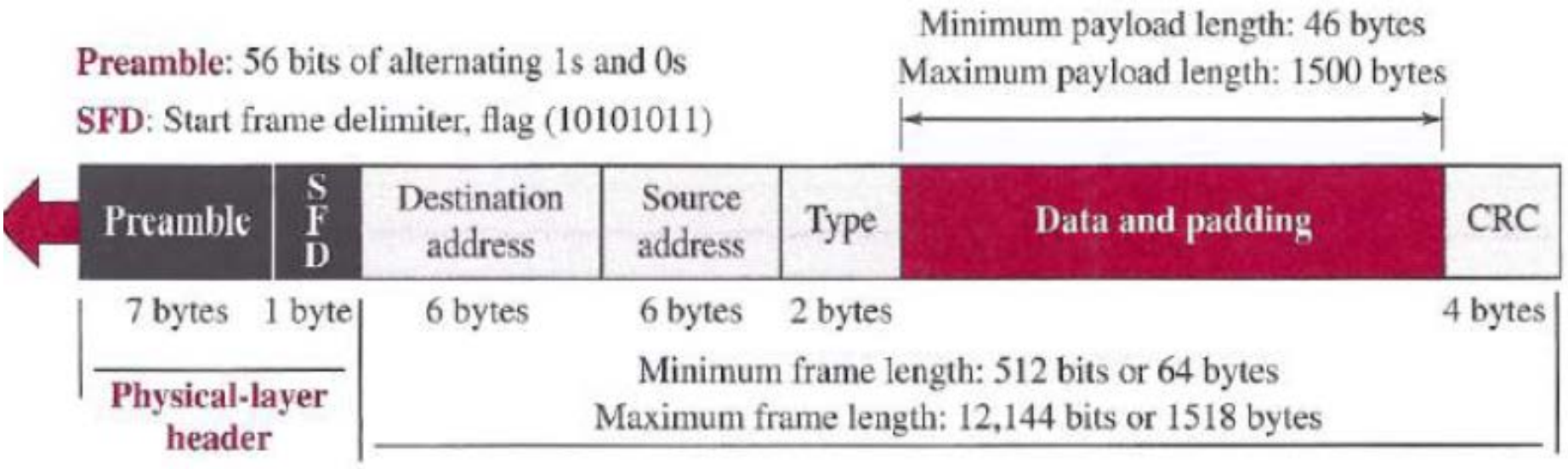
Table 13.3 *Summary of Gigabit Ethernet implementations*

Implementation	*Medium*	*Medium Length*	*Wires*	*Encoding*
1000Base-SX	Fiber S-W	550 m	2	8B/10B + NRZ
1000Base-LX	Fiber L-W	5000 m	2	8B/10B + NRZ
1000Base-CX	STP	25 m	2	8B/10B + NRZ
1000Base-T4	UTP	100 m	4	4D-PAM5

Table 13.4 *Summary of 10 Gigabit Ethernet implementations*

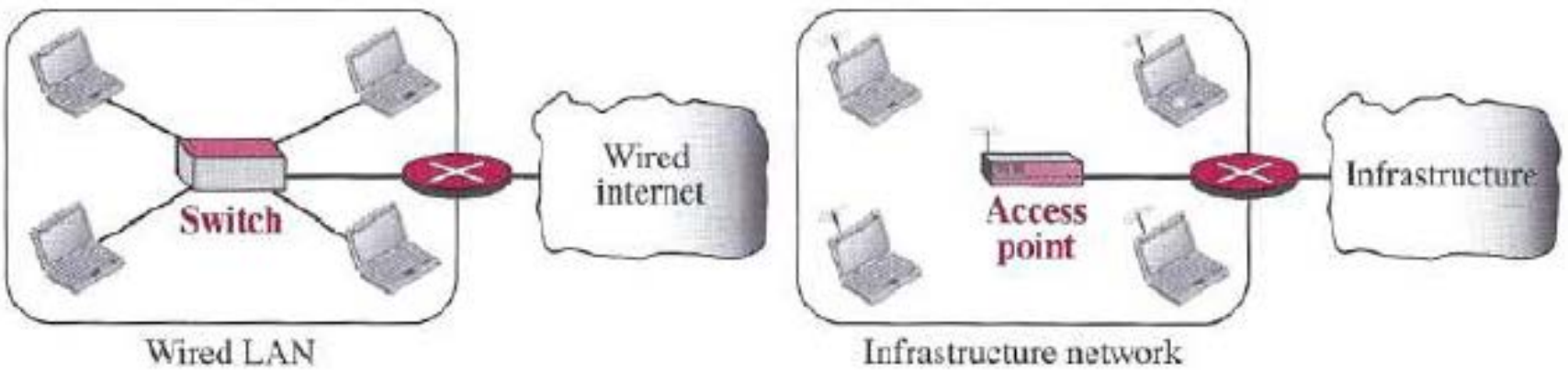
Implementation	*Medium*	*Medium Length*	*Number of wires*	*Encoding*
10GBase-SR	Fiber 850 nm	300 m	2	64B66B
10GBase-LR	Fiber 1310 nm	10 Km	2	64B66B
10GBase-EW	Fiber 1350 nm	40 Km	2	SONET
10GBase-X4	Fiber 1310 nm	300 m to 10 Km	2	8B10B

Frame Format



- Type: defines the upper-layer protocol whose packet is encapsulated

Wireless LAN

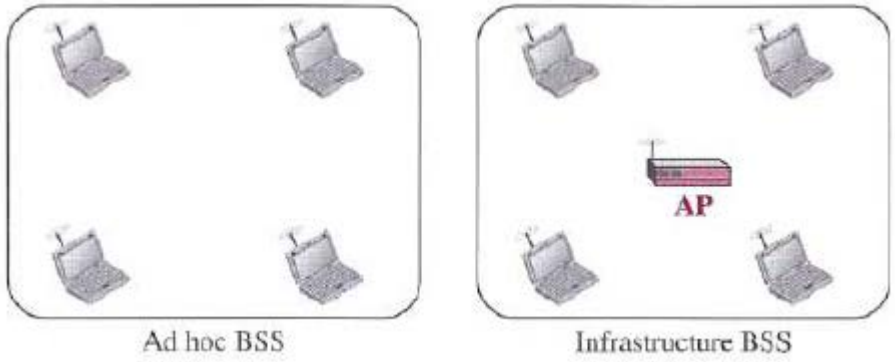


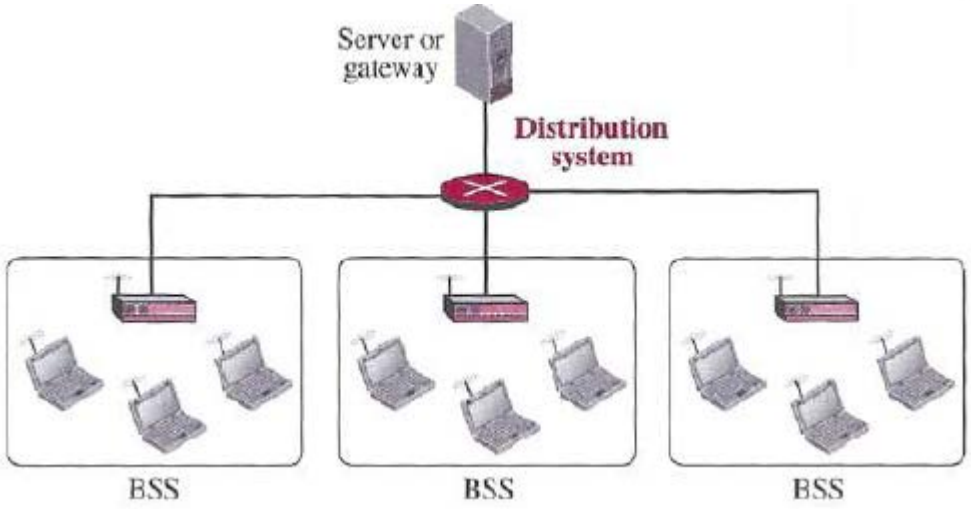
- Influential Characteristics
  - Attenuation
  - Error
  - Interference
  - Multipath Propagation

IEEE 802.11 PROJECT

- Institute of Electrical and Electronics Engineers (IEEE) defines standard for Wireless LANs (802.11)

- Architecture:
  - BSS (Basic Service Set)
  - ESS (Extended Service Set)





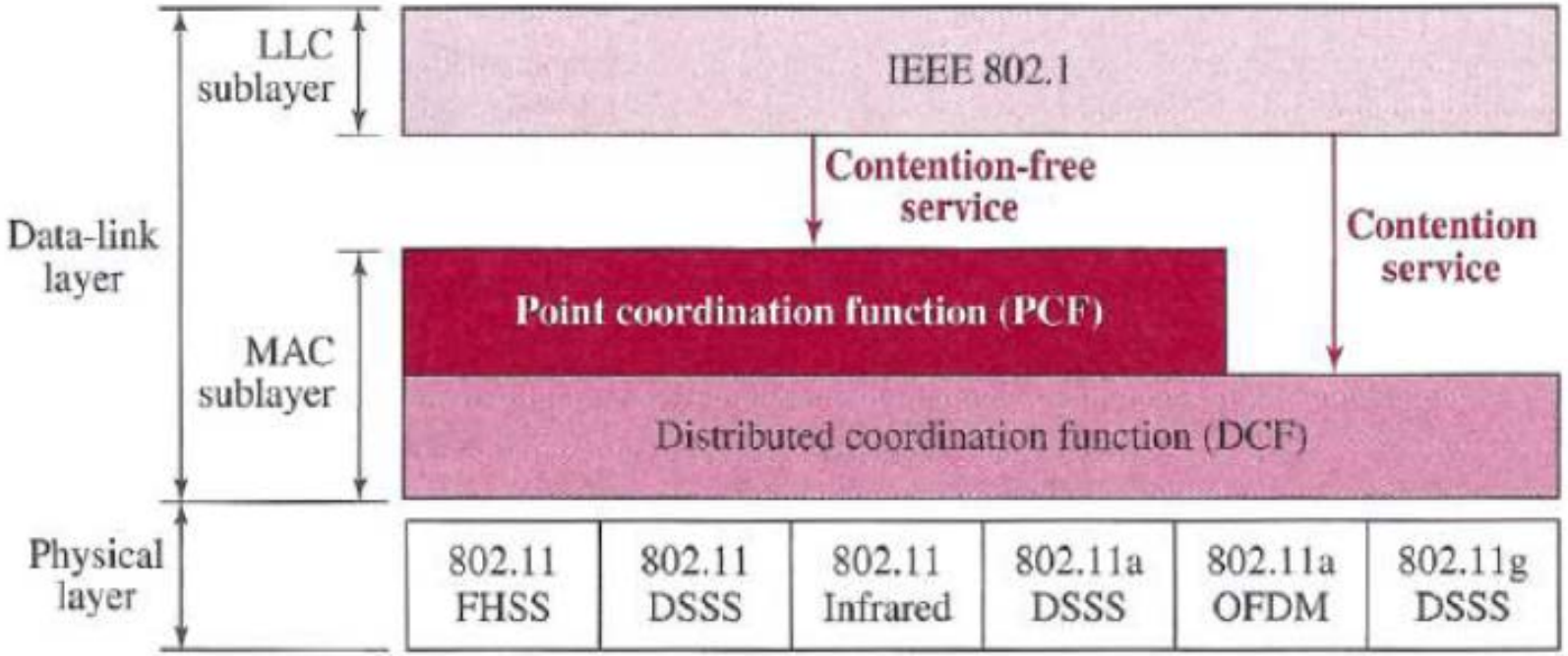
Pathway to present WiFi

- IEEE 802.11-1997: The WLAN standard was originally 1 Mbit/s and 2 Mbit/s, 2.4 GHz RF and infrared (IR) standard (1997)
- IEEE 802.11b: Enhancements to 802.11 to support 5.5 Mbit/s and 11 Mbit/s (1999)
- IEEE 802.11e: Enhancements: QoS, including packet bursting (2005)
- IEEE 802.11g: 54 Mbit/s, 2.4 GHz standard (backwards compatible with b) (2003)

- IEEE 802.11-2007: A new release of the standard that includes amendments a, b, d, e, g, h, i, and j. (July 2007)
- IEEE 802.11n: Higher-throughput improvements using MIMO (multiple-input, multiple-output antennas) (September 2009)

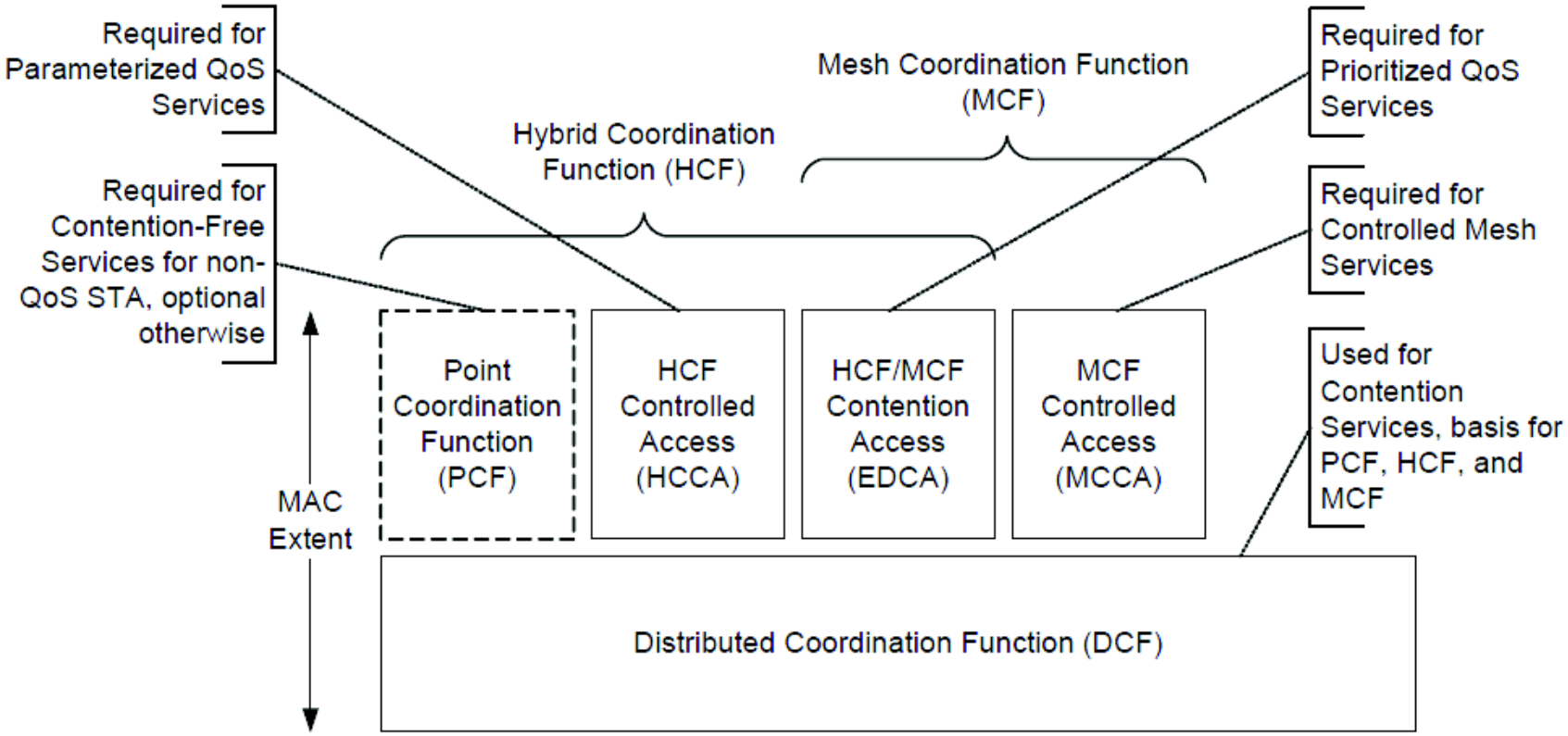
- IEEE 802.11-2012: A new release of the standard that includes amendments k, n, p, r, s, u, v, w, y, and z (March 2012)
- IEEE 802.11ac: Very High Throughput < 6 GHz; potential improvements over 802.11n: better modulation scheme (expected ~10% throughput increase), wider channels (estimate in future time 80 to 160 MHz), multiuser MIMO;(December 2013)
- IEEE 802.11ad: Very High Throughput 60 GHz (December 2012) — see WiGig

MAC Layer in IEEE 802.11



- MAC protocols
  - DCF (Distributed Coordination Function)
  - PCF (Point Coordination Function)

MAC Protocols



Cont…

- Distributed Coordination Function (DCF)
  - Symmetric, all stations (including APs) behave the same way
  - Follow CSMA/CA
  - Stations contend for access to medium

- Point Coordination Function (PCF)
  - Built on DCF
  - Allows periods of contention-free operation interleaved with periods of contention
  - One station (typically AP) polls others to control who transmits
  - Permits more efficient operation under heavy loads

Cont…

- Slot time: basic unit of MAC algorithm

  = Time required for station to sense end of frame, start transmitting, and beginning of frame to propagate to others
- SIFS (Short Inter-Frame Space)

  = Time required for station to sense end of frame and start transmitting

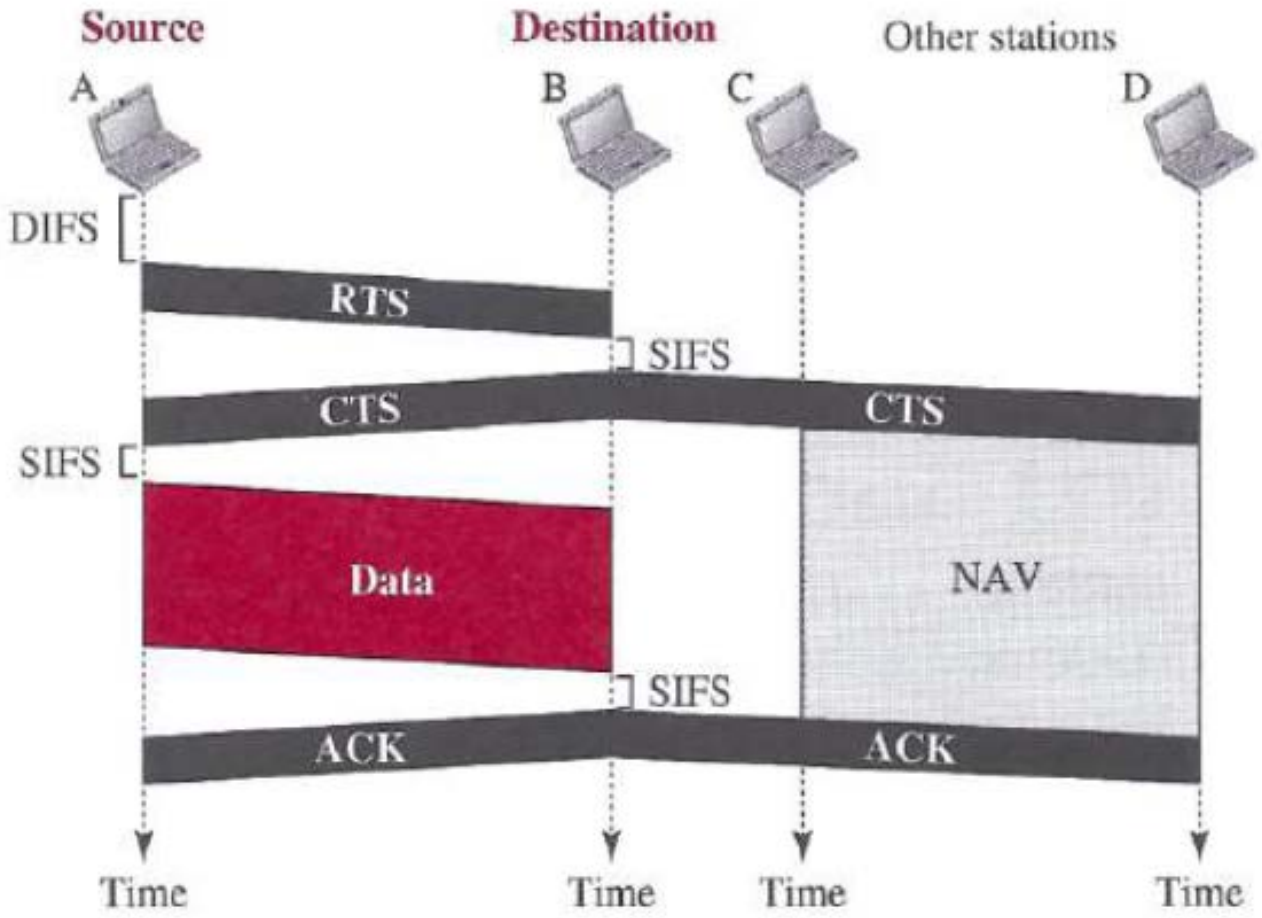
  = By that time the transmitting station will be able to switch back to receive mode and be capable of decoding the incoming packet
- DIFS (DCF Inter-Frame Space)

  = SIFS + 2 *Slot time
- PIFS (PCF Inter-Frame Space)

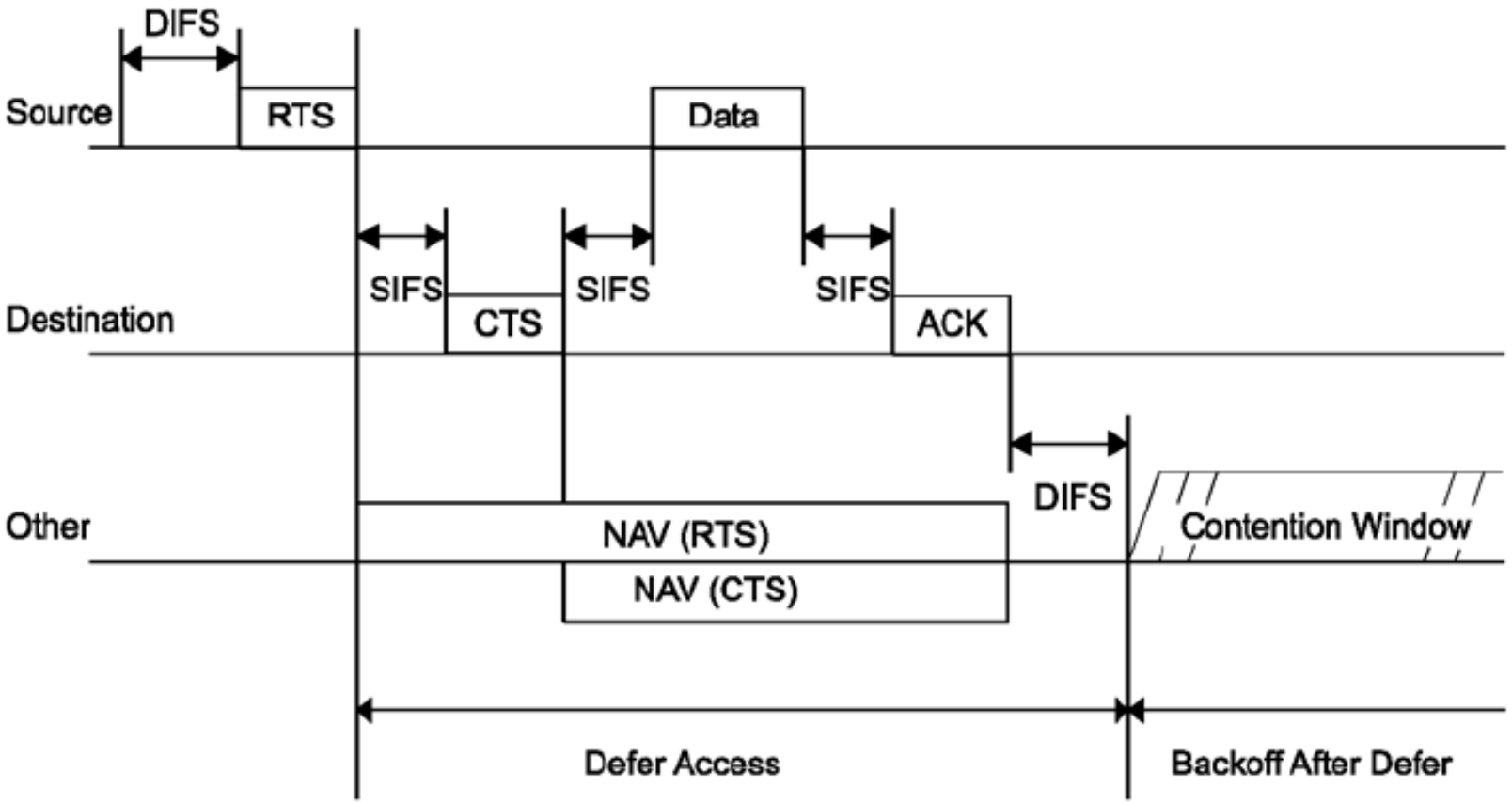
  = SIFS + Slot time
- AIFS (Arbitration Inter-Frame Space)

DCF

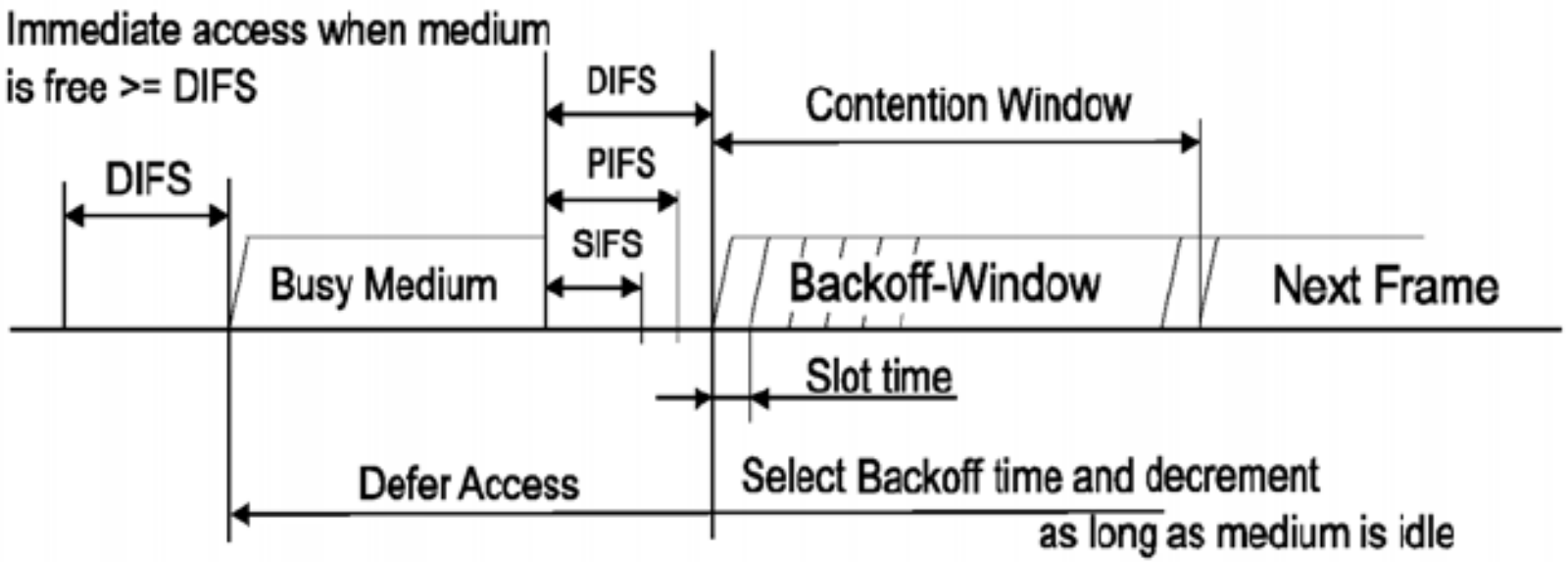
- DCF follows CSMA/CA protocol

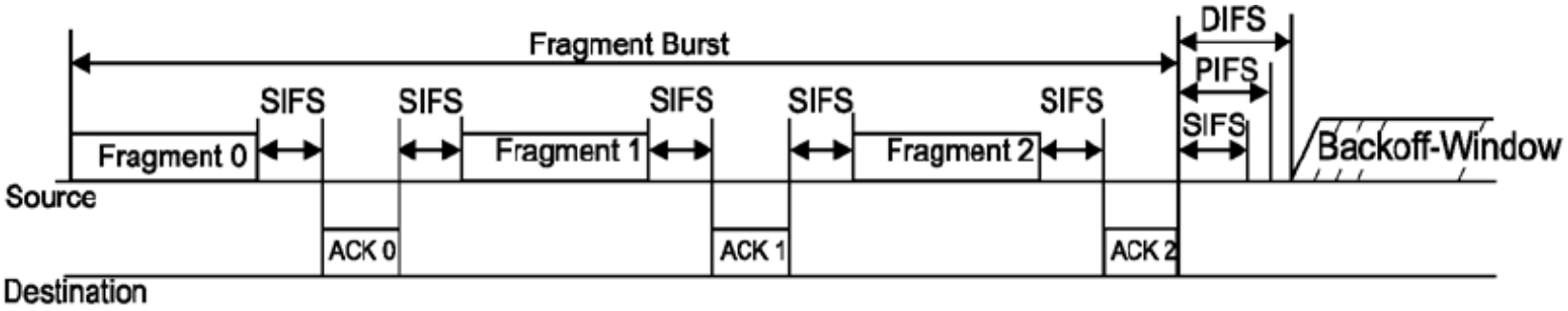


RTS-CTS Access Method

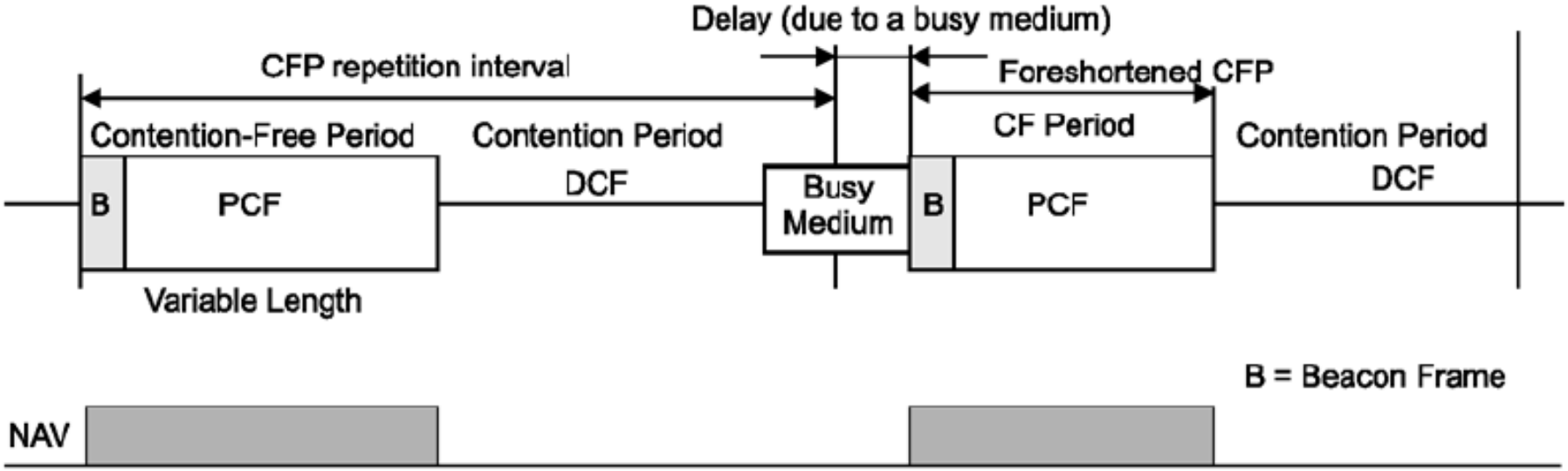


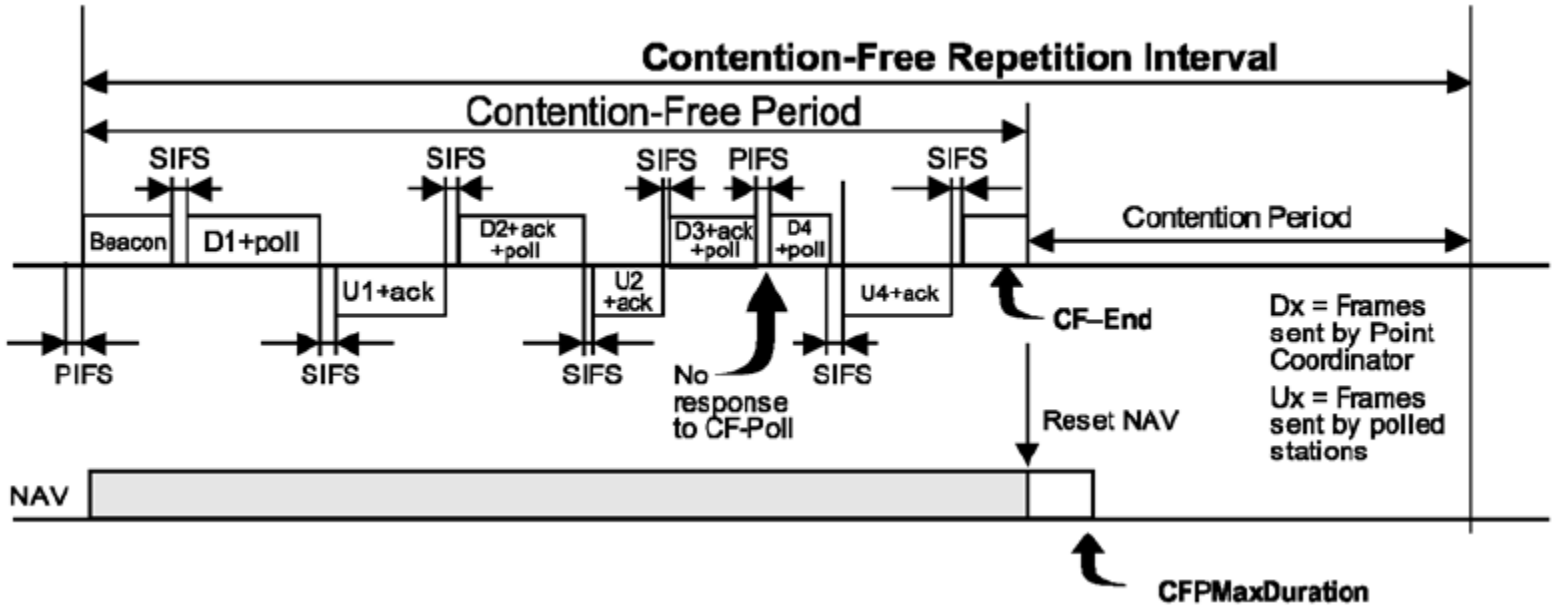
Basic Access Method



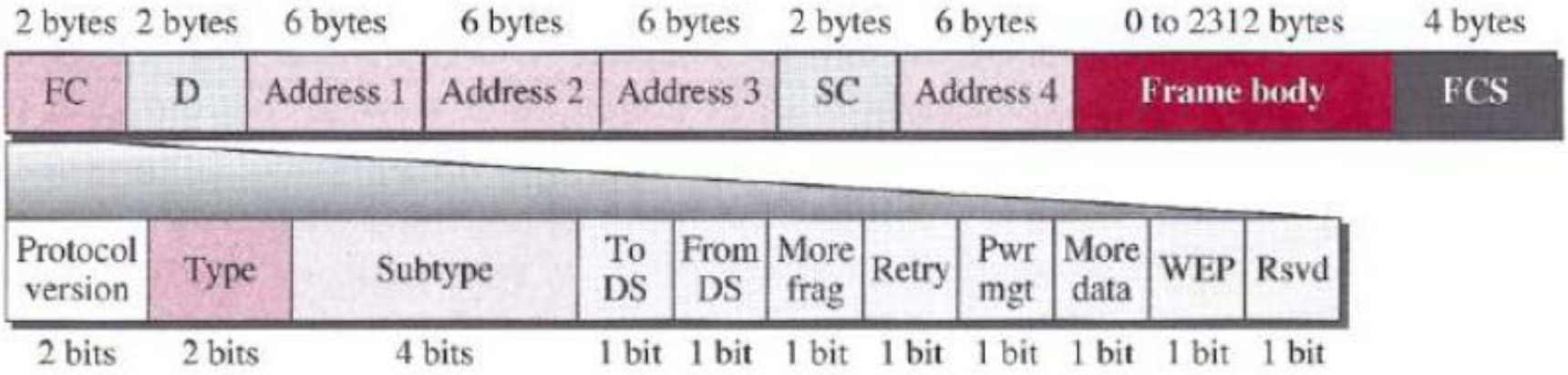


CFP/CP

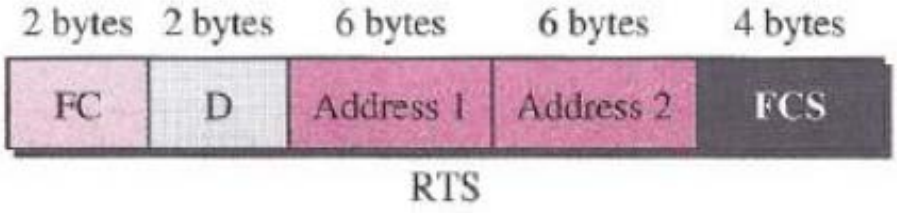

Delay (due to a busy medium)
CFP repetition interval
Foreshortened CFP
Contention-Free Period
Contention Period
CF Period
Contention Period
DCF
B
PCF
DCF
Busy Medium
B
PCF
Variable Length
B = Beacon Frame
NAV

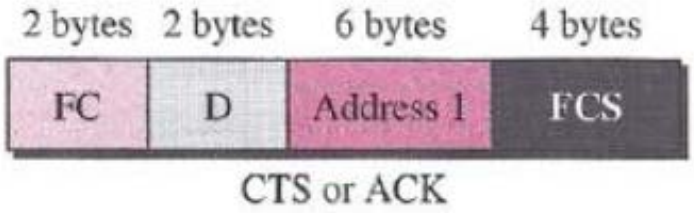

Contention-Free Repetition Interval
Contention-Free Period
SIFS
SIFS
SIFS
PIFS
SIFS
Beacon
D1+poll
D2+ack +poll
D3+ack +poll
D4 +poll
Contention Period
U1+ack
U2 +ack
U4+ack
CF–End
PIFS
SIFS
SIFS
No response to CF-Poll
SIFS
Dx = Frames sent by Point Coordinator
Ux = Frames sent by polled stations
Reset NAV
NAV
CFPMaxDuration

Frame Format



- FC: Frame Control
- D: Duration / ID
- SC: Fragment number & Sequence counter
- FCS: Frame Check Sequence (CRC-32)





Frame Control (FC)

Field	*Explanation*
Version	Current version is 0
Type	Type of information: management (00), control (01), or data (10)
Subtype	Subtype of each type (see Table 15.2)
To DS	Defined later
From DS	Defined later
More frag	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

Subtype	*Meaning*
1011	Request to send (RTS)
1100	Clear to send (CTS)
1101	Acknowledgment (ACK)

Cont…

To DS	*From DS*	*Address 1*	*Address 2*	*Address 3*	*Address 4*
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

Few Other Wireless Networks

- Bluetooth
  - It is a Wireless LAN designed to connect heterogeneous devices
- WiMAX
  - Where wired access to Internet is difficult
- Cellular Network
  - 1G, 2G, 3G, 4G, 5G
- Satellite Network
  - GEO, MEO, LEO Satellites

Thanks!