

ADVANCED NETWORKING (SENG 3308)

Chapter II ***The Link Layer and*** ***LANs***

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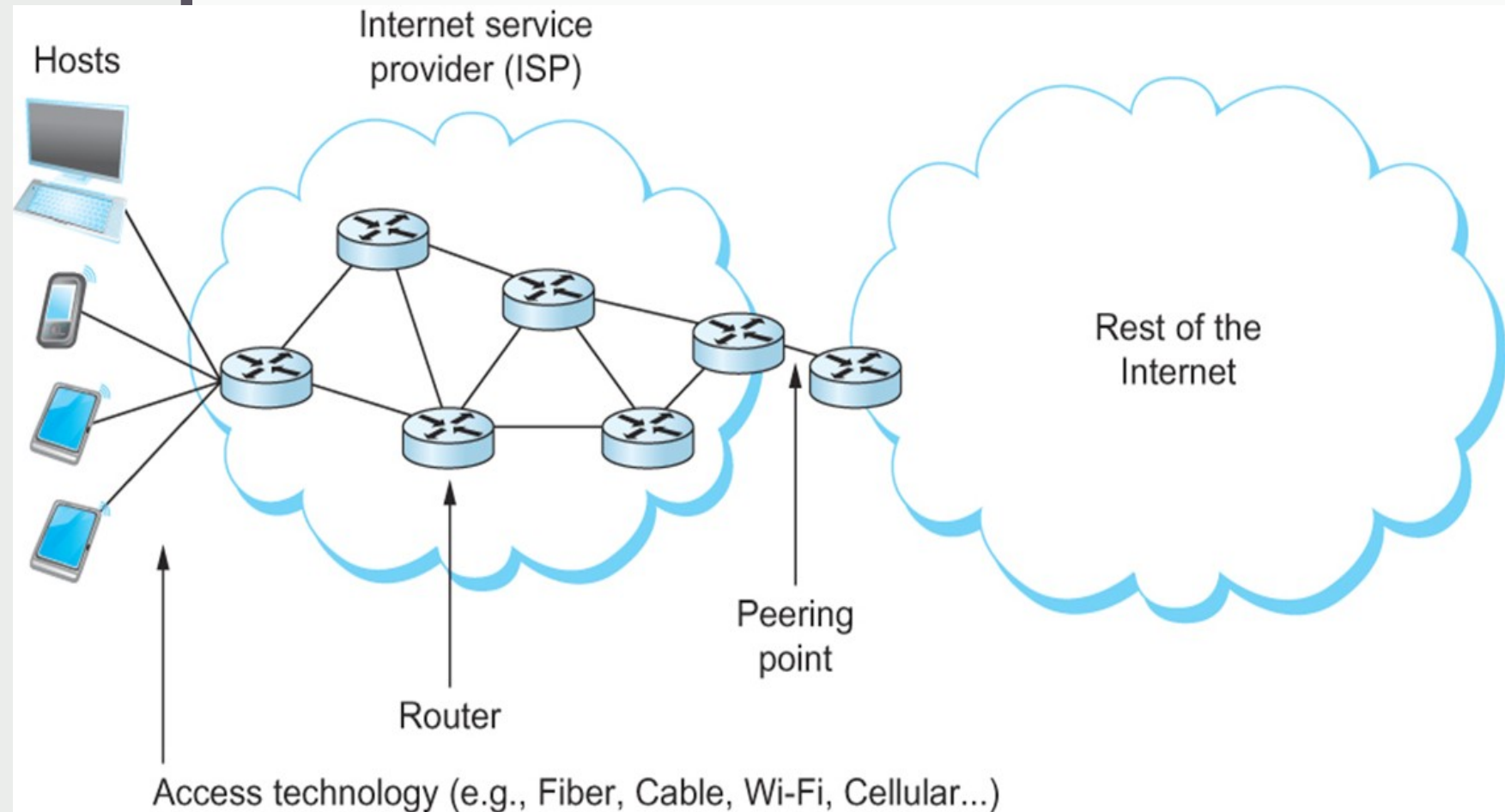
Introduction

- A LAN can be used as an isolated network to connect computers in an organization for the sole purpose of sharing resources, most LANs today are also linked to a WAN or the Internet.
- The LAN market has seen several technologies such as Ethernet, token ring, token bus, and Fibre Distributed Data Interface (FDDI).
- Ethernet has gone through a four-generation evolution during the last few decades, the main concept has remained the same. Ethernet has changed to meet the market needs and to make use of the new technologies.
- The IEEE has subdivided the data link layer into two sublayers: logical link control (LLC) and media access control³

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Introduction cont....



An end-user's view of the Internet

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Introduction

Links

- All practical links rely on some sort of electromagnetic radiation propagating through a medium or, in some cases, through free space

Ways to characterize the links are:

- By the medium they use
- Frequency
- Distance support
- Maximum bandwidth support

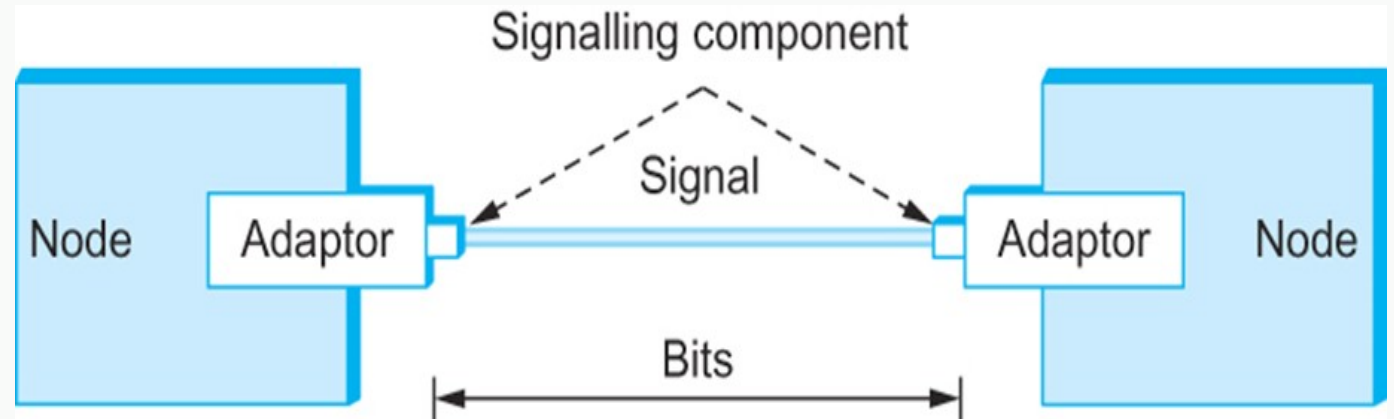
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Bit Encoding

- **Encoding** is the process of converting the data or a given sequence of characters, symbols, alphabets etc., into a specified format, for the secured transmission of data.
- **Decoding** is the reverse process of encoding which is to extract the information from the converted format.
- The data encoding technique is divided into the following types:
 - Analog data to Analog signals
 - Analog data to Digital signals
 - Digital data to Analog signals
 - Digital data to Digital signals

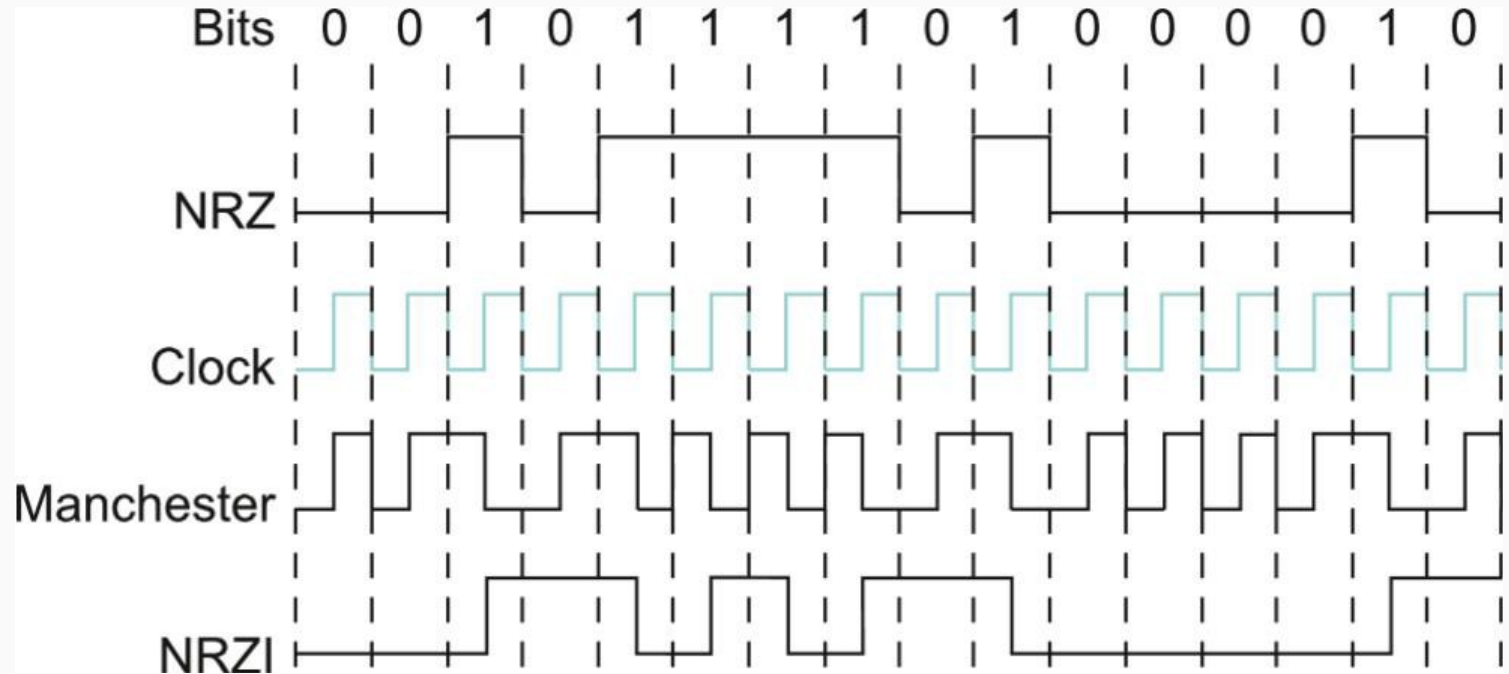
Bit Encoding



Signals travel between signaling components; bits flow between adaptors. The network adaptor contains a signalling component that actually encodes bits into signals at the sending node and decodes signals into bits at the receiving node.

Bit Encoding

Examples:



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Bit encoding

- **NRZ/non return to zero:** Codes has **1** for High voltage level and **0** for Low voltage level. The main behaviour of NRZ codes is that the voltage level remains constant during bit interval.
- The end or start of a bit will not be indicated and it will maintain the same voltage state, if the value of the previous bit and the value of the present bit are same.

Bi-phase Encoding

Introduction

- The signal level is checked twice for every bit time, both initially and in the middle.
- Hence, the clock rate is double the data transfer rate and thus the modulation rate is also doubled. The clock is taken from the signal itself. The bandwidth required for this coding is greater.
- There are two types of Bi-phase Encoding.
- Bi-phase Manchester

Block Coding

4B/5B Encoding

- In Manchester encoding, the clocks with double speed is required than NRZ coding. Here, 4 bits of code is mapped with 5 bits, with a minimum number of 1 bits in the group.
- The clock synchronization problem in NRZ-I encoding is avoided by assigning an equivalent word of 5 bits in the place of each block of 4 consecutive bits. These 5-bit words are predetermined in a dictionary.
- The basic idea of selecting a 5-bit code is that, it should have one leading 0 and it should have no more than two trailing 0s. Hence, these words¹¹are

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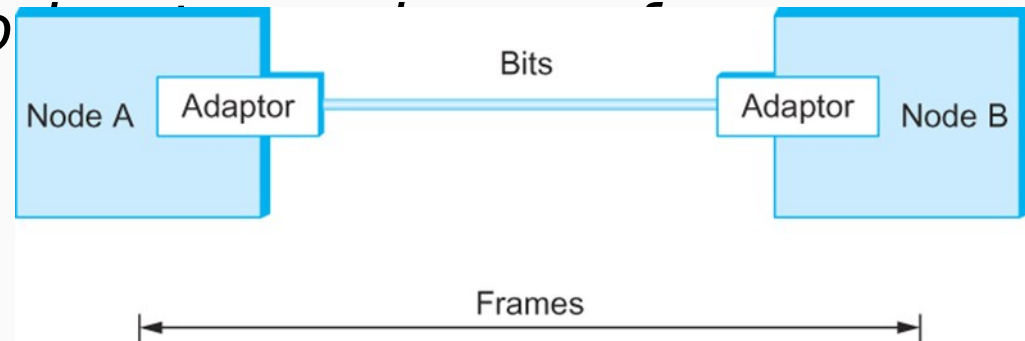
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Framing

- We are focusing on packet-switched networks, which means that blocks of data (called frames at this level), not bit streams, are exchanged between nodes.
- It is the network adaptor that enables the nodes to communicate.



Bits flow between adaptors, frames between hosts

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- When node A wishes to transmit a **Framing** frame to node B, it tells its adaptor to transmit a frame from the node's memory. This results in a sequence of bits being sent over the link.
- The adaptor on node B then collects together the sequence of bits arriving on the link and deposits the corresponding frame in B's memory.
- Recognizing exactly what set of bits constitute a frame—that is, determining where the frame begins and ends—is the central challenge faced by the

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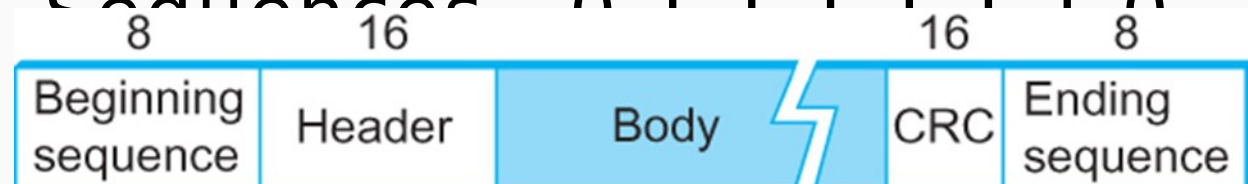
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Byte-oriented Protocols

- To view each frame as a collection of bytes (characters) rather than bits
- ✓ BISYNC (Binary Synchronous Communication) Protocol:
Developed by IBM (late 1960)
- ✓ DDCMP (Digital Data Communication Protocol): Used in DECnet

Bit-oriented Protocol

- HDLC : High Level Data Link Control Beginning and Ending Sequence



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Framing

- On the sending side, any time five consecutive 1's have been transmitted from the body of the message (i.e. excluding when the sender is trying to send the distinguished sequence) 01111110

- The sender inserts 0 before transmitting the next bit
- On the receiving side; 5 consecutive 1's
- Next bit 0 : Stuffed, so discard it
- Next bit 1 : Either End of the frame marker / Error
- Look at the next bit
 - If 0 (01111110) -- End of the frame marker
 - If 1 (01111111) -- Error,

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frames; because of electrical interference and thermal noises

- Error Detection and Correction
 - Two approaches when the recipient detects an error
 - ✓ Notify the sender that the message was corrupted, so the sender can send again. If the error is rare, then the retransmitted message will be error-free.
 - ✓ Using some error correct detection and correction algorithm, the receiver reconstructs the message
 - Common technique for detecting transmission error
 - ✓ CRC (Cyclic Redundancy Check): Used in HDLC, DDCMP, CSMA/CD, Token Ring

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frame that can be used to determine if errors have been introduced

- Transmitting two complete copies of data
- When the messages are Identical means No error otherwise Error happened.
- In general, we can provide strong error detection technique k redundant bits, n bits message, $k \ll n$
- For example in Ethernet, a frame carrying up to 12,000 bits of data requires only 32-bit CRC
- Extra bits are redundant
- ✓ They add no new information to the message

- Ethernet: the most successful local area networking technology of last 40+ years.
- Developed in the mid-1970s by researchers at the Xerox Palo Alto Research Centers (PARC).
- It uses CSMA/CD (Carrier Sense Multiple Access with Collision Detection) technology.
- A set of nodes send and receive frames over a shared link.
- Carrier sense means that all nodes can distinguish between an idle and a busy link.
- Collision detection means that a node listens as it transmits and can therefore detect when a frame it is transmitting has

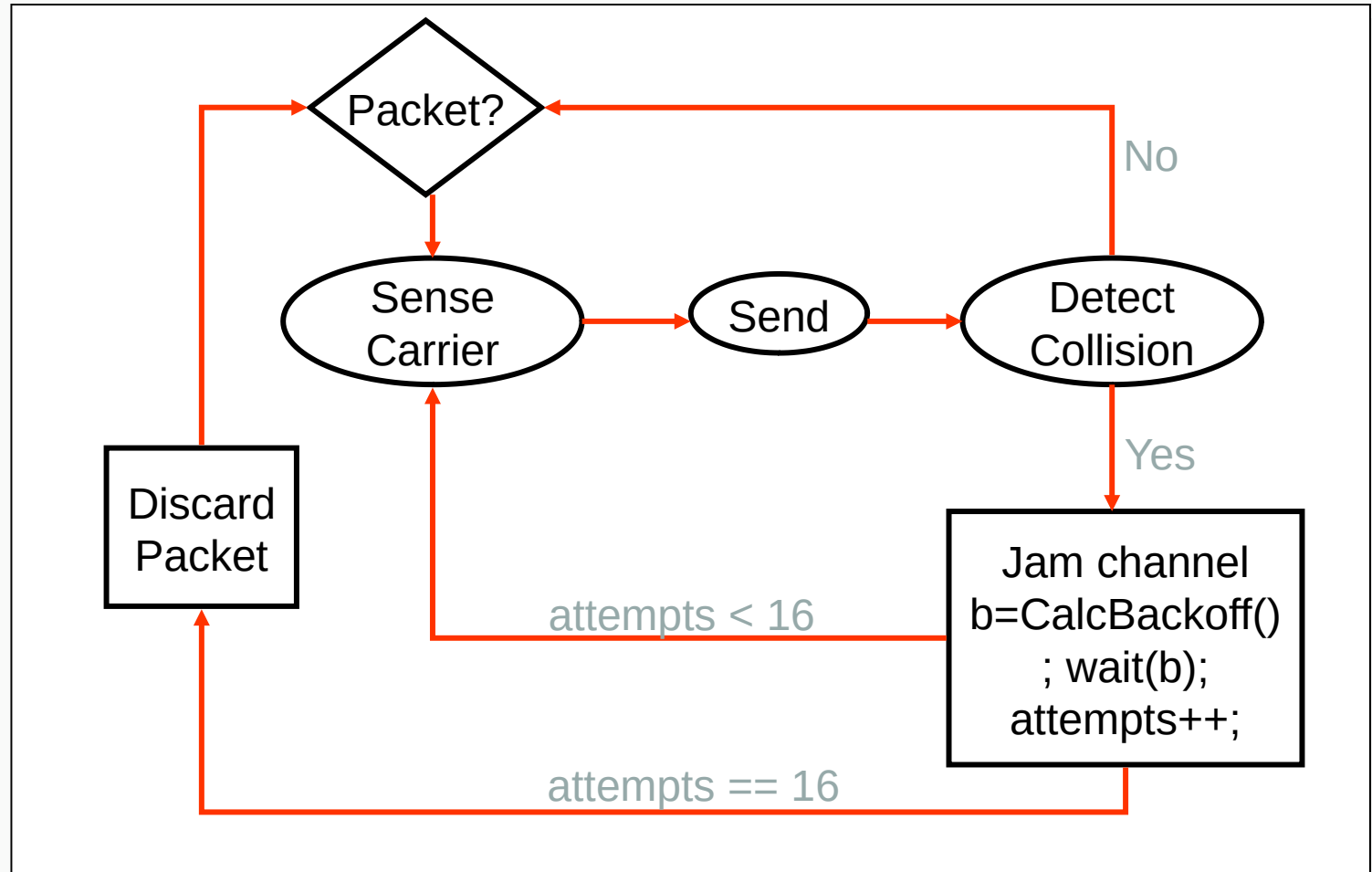
Ethernet

- STANDARD ETHERNET (10MbPS)
- FAST ETHERNET (100 MbPS)
- GIGABIT ETHERNET (1GbPS)
- 10-GIGABIT ETHERNET

Features

- Connectionless and unreliable
- Addressing (physical address): each hosts uses a unique 48 bits mac address.
- Frame length: minimum 64 Bytes and maximum 1518 Bytes including frame header information
- Auto-negotiation, different topology

Ethernet cont...



Carrier Sense Multiple
Access/Collision Detection

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- **Jam Signal:** make sure all other transmitters are aware of collision; 48 bits;

- **Exponential Backoff:** If deterministic delay after collision, collision will occur again in lockstep. If random delay with fixed mean

Few senders $\Rightarrow$ needless waiting

Too many senders $\Rightarrow$ too many collisions

Goal: adapt retransmission attempts to estimated current load

heavy load: random wait will be longer

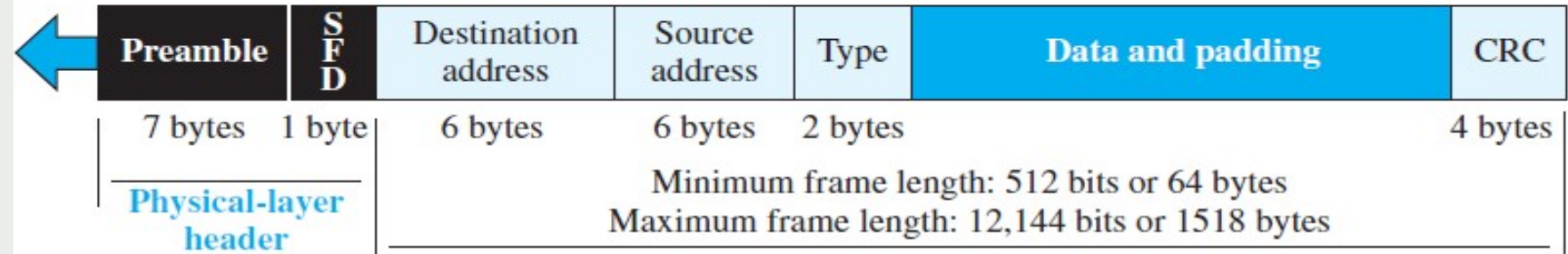
Ethernet cont....

Ethernet frame

Preamble: 56 bits of alternating 1s and 0s

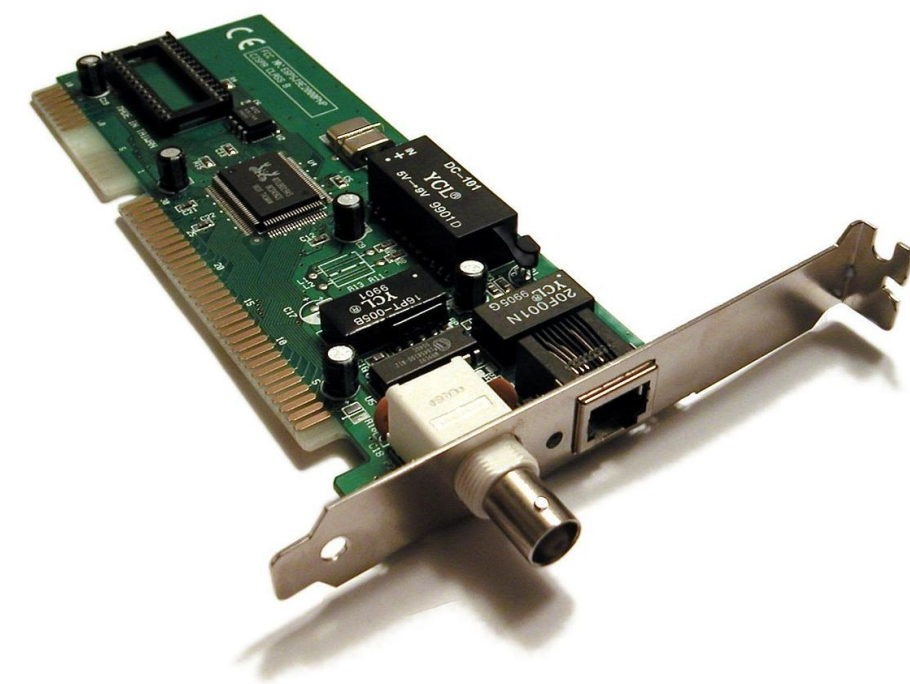
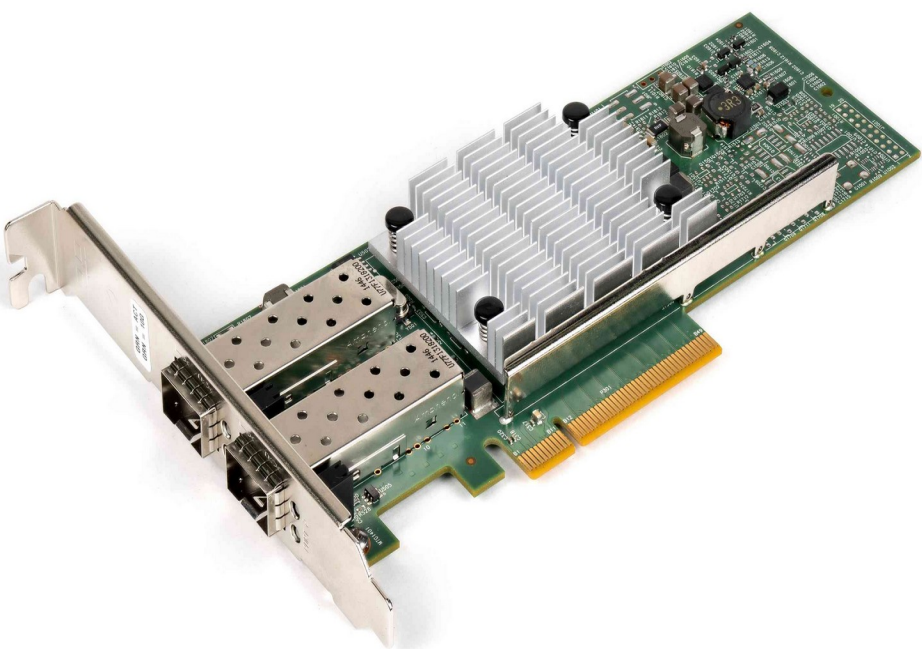
SFD: Start frame delimiter, flag (10101011)

Minimum payload length: 46 bytes
Maximum payload length: 1500 bytes



alert the receiving system to the coming frame and enable it to synchronize its clock if it's out of synchronization.

- Start frame delimiter (SFD): this field (1 byte: 10101011) signals the beginning of the frame. The SFD warns the station or stations that this is the last chance for synchronization. The last 2 bits are (11)₂ and alert the receiver that the next field is the destination address.



- The Network Interface card allows computers to communicate with each other through the network

- Each NIC has a 48-bit unique hexadecimal address called the *MAC address*
- A computer or device on a network can be reached by its MAC address through the NIC card
- An example of a MAC address: A1B2C3D4E5F6
- The first 6 hex digits in the MAC address is the OUI (organizationally unique identifier), assigned by the IEEE to each manufacturer (e.g. Cisco, Intel etc). The rest of the MAC address can be assigned in any way by the manufacturer to the individual

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- electromagnetic signals like;
Radio, microwave, infrared
- **Wireless Networks**
Wireless links all share the same "line"
 - The challenge is to share it efficiently without unduly interfering with each other
 - Most of this sharing is accomplished by dividing the "wire" along the dimensions of frequency and space
 - Exclusive use of a particular frequency in a particular geographic area may be allocated to an individual entity such as a corporation.
 - These allocations are determined by government agencies such as
FRA

- ~~Wireless Links~~ Wireless technologies differ in a variety of dimensions
 - ✓ How much bandwidth they provide
 - ✓ How far apart the communication nodes can be
- Four prominent wireless technologies
 - ✓ Bluetooth
 - ✓ Wi-Fi (more formally known as 802.11)
 - ✓ WiMAX (802.16)
 - ✓ 3G cellular wireless

- Wireless communication supports point-to-multipoint communication
- Communication between non-base (client) nodes is routed via the base station
- Three levels of mobility for clients
 - ✓ No mobility: the receiver must be in a fix location to receive a directional transmission from the base station (initial version of WiMAX)
 - ✓ Mobility is within the range of a base (Bluetooth)
 - ✓ Mobility between bases (Cell phones and Wi-Fi)

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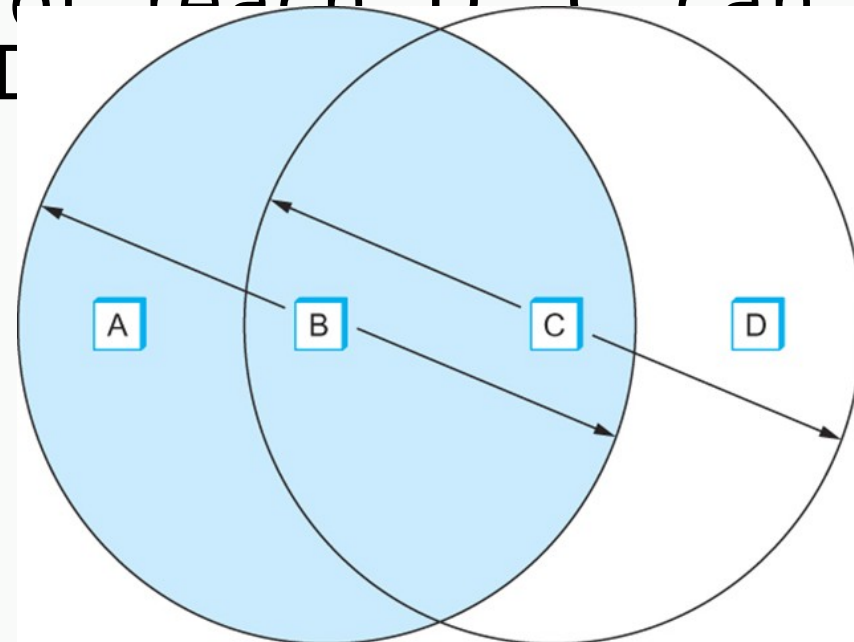
IEEE 802.11 (WI-FI)

- Wireless communication is one of the fastest-growing technologies.
- When hosts in a wireless LAN communicate with each other, they are sharing the same medium (multiple access).
- There are several characteristics of wireless LANs that either do not apply to wired LANs or the existence of which is negligible and can be ignored. These are:
 - ✓ Attenuation
 - ✓ Interference
 - ✓ Multipath propagation
 - ✓ Error

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- Consider the situation in the following figure where each of four nodes is able to send and receive signals that reach just the nodes to its immediate left and right
- For example, B can exchange frames with A and C, but it cannot reach D. C can reach B and D



IEEE 802.11 (WIFI)

- Suppose both A and C want to communicate with B and so they each send it a frame.

- A and C are unaware of each other since their signals do not carry that far. These two frames collide with each other at B.

- But unlike an Ethernet, neither A nor C is aware of this collision. A and C are said to hidden nodes with respect to each other

- Another problem called exposed node problem occurs

- Suppose B is sending to A. Node C is aware of this communication because it hears B's transmission.

- It would be a mistake for C²⁹ to

- 802.11 addresses these two problems with an algorithm called **IEEE 802.11 (Wi-Fi) Multiple Access with Collision Avoidance (MACA)**.
- Key Idea
 - ✓ Sender and receiver exchange control frames with each other before the sender actually transmits any data.
 - ✓ This exchange informs all nearby nodes that a transmission is about to begin
 - ✓ Sender transmits a Request to Send (RTS) frame to the receiver.
 - ✓ The RTS frame includes a field that indicates how long the sender wants to hold the medium

IEEE 802.11 (WI-FI)

- Any node that sees the CTS frame knows that
 - ✓ it is close to the receiver, therefore
 - ✓ cannot transmit for the period of time it takes to send a frame of the specified length
- Any node that sees the RTS frame but not the CTS frame
 - ✓ is not close enough to the receiver to interfere with it, and
 - ✓ so is free to transmit

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Frames: IEEE 802.11 (WI-FI)

- For each function, 802.11 specifies frame type at MAC sublayer
- Management frames involved in association and re-association
- Duration/Connection ID: indicates the time (in microseconds) the channel will be allocated for successful transmission of a MAC frame.
- Control frames related to medium access and data delivery (management, control and data)
- Addresses (Receiver Address (RA), Transmitter Address (TA), Basic Service Set Identifier (BSSID))



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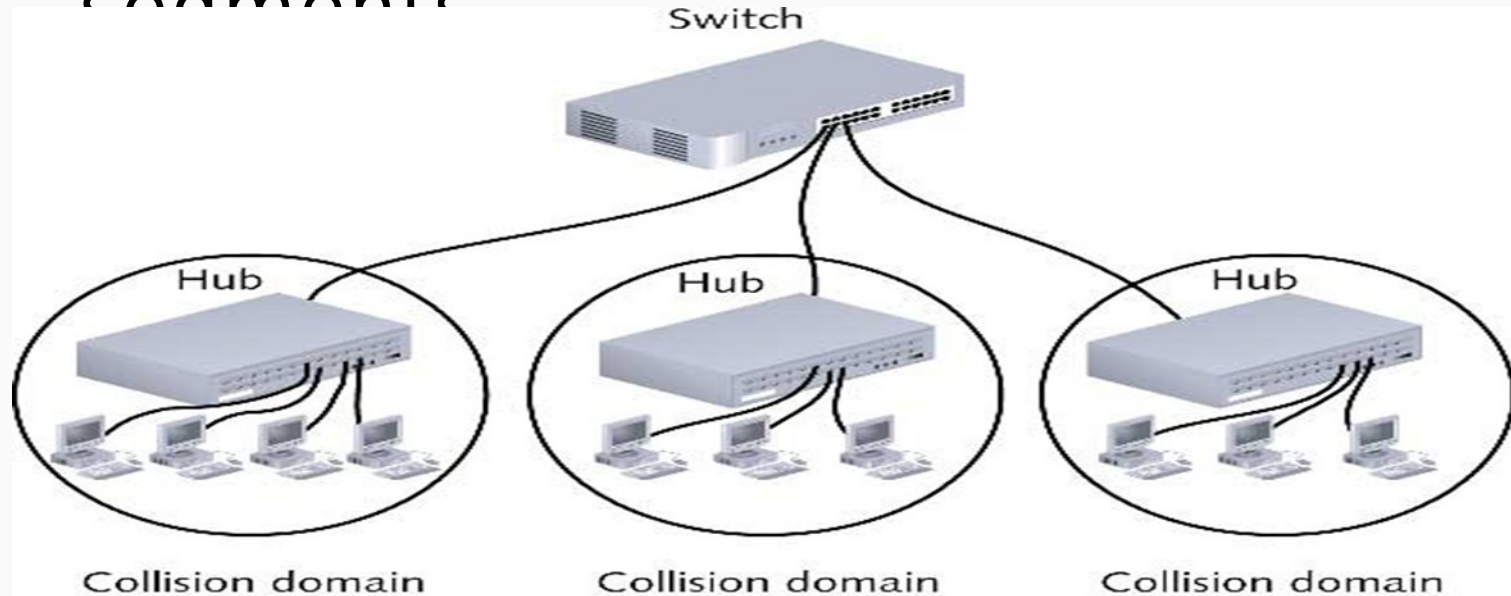
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IEEE 802.11 (WI-FI) Summary

Proto col	Frequ ency	Signa l	Year	Max. Data Rate
Legac y 802.11	2.4 GHz	FHSS / DSSS	1997	2 Mbps
802.11 a	5 GHz	OFDM	1999	54 Mbps
802.11 b	2.4 GHz	HR- DSSS	1999	11 Mbps
802.11 g	2.4 GHz	OFDM	2003	54 Mbps

- Shared Ethernet: fixed amount of bandwidth
- ✓ **Switched Local Area Networks**
 - ✓ Shared by all devices on a segment
 - ✓ All nodes on segment belong to same collision domain
- Switched Ethernet: enables multiple nodes to simultaneously transmit and receive data over different logical network segments



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Next Chapter III

Advanced Internetworking