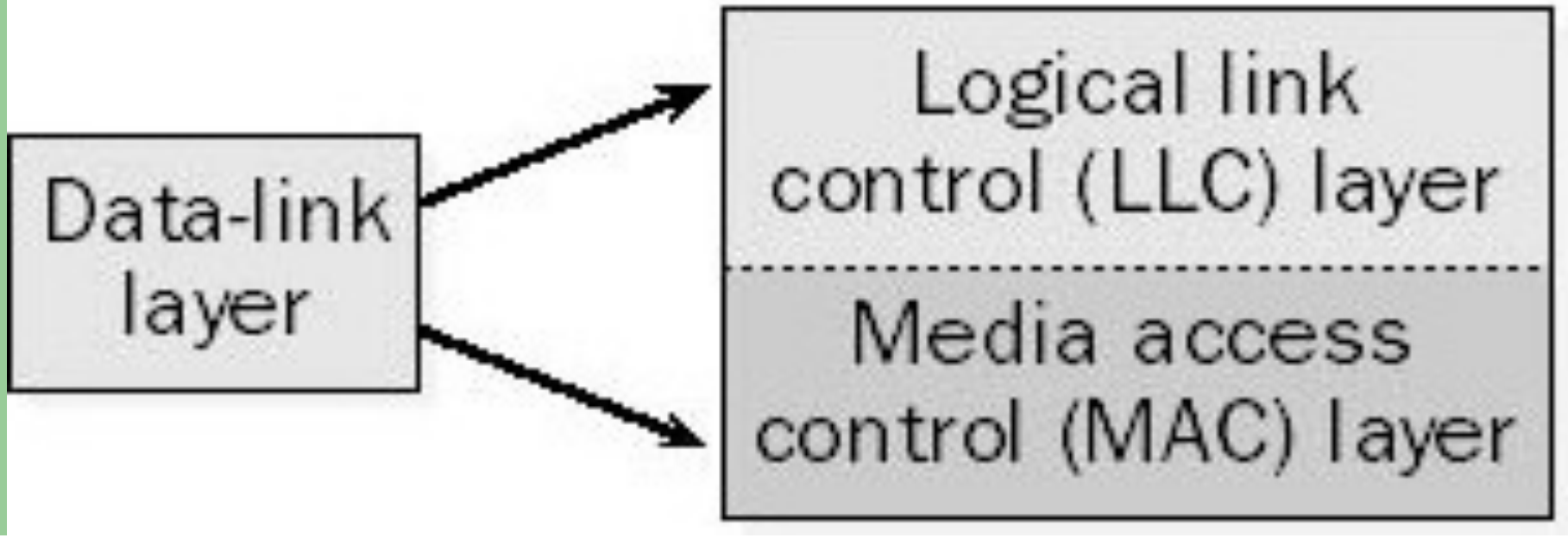
Computer Networks

Data Link Layer

- The physical layer provides only a raw bit-stream service.
- Data link layer attempts to make the physical link reliable while providing the means to activate, maintain, and deactivate the link .
- Sends and Receives packet to and from the network layer.

Data Link Layer

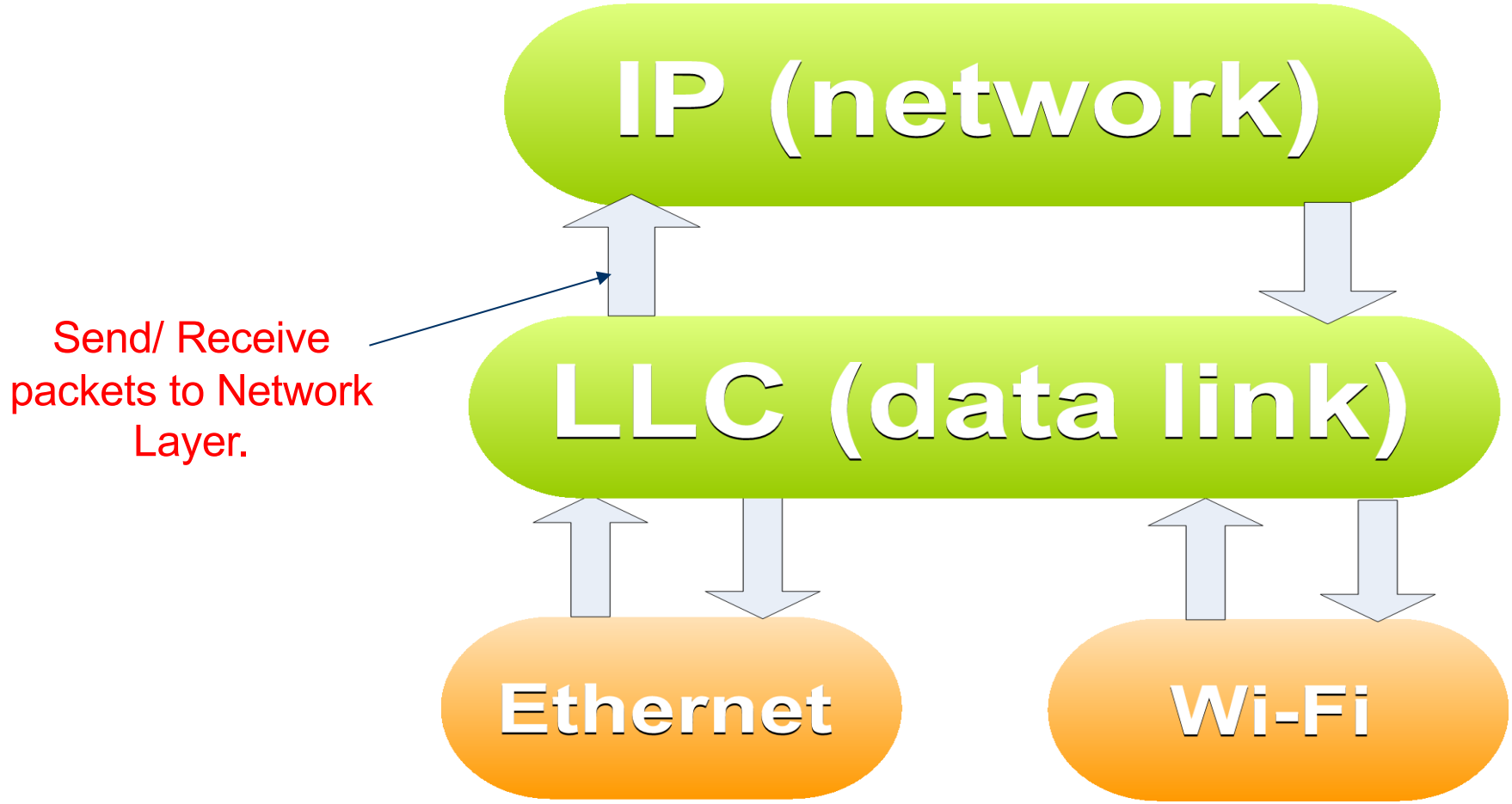
- **For LANs, the Project 802 standards of the Institute of Electrical and Electronics Engineers (IEEE) separate the data-link layer into two sub layers.**



Data Link Layer

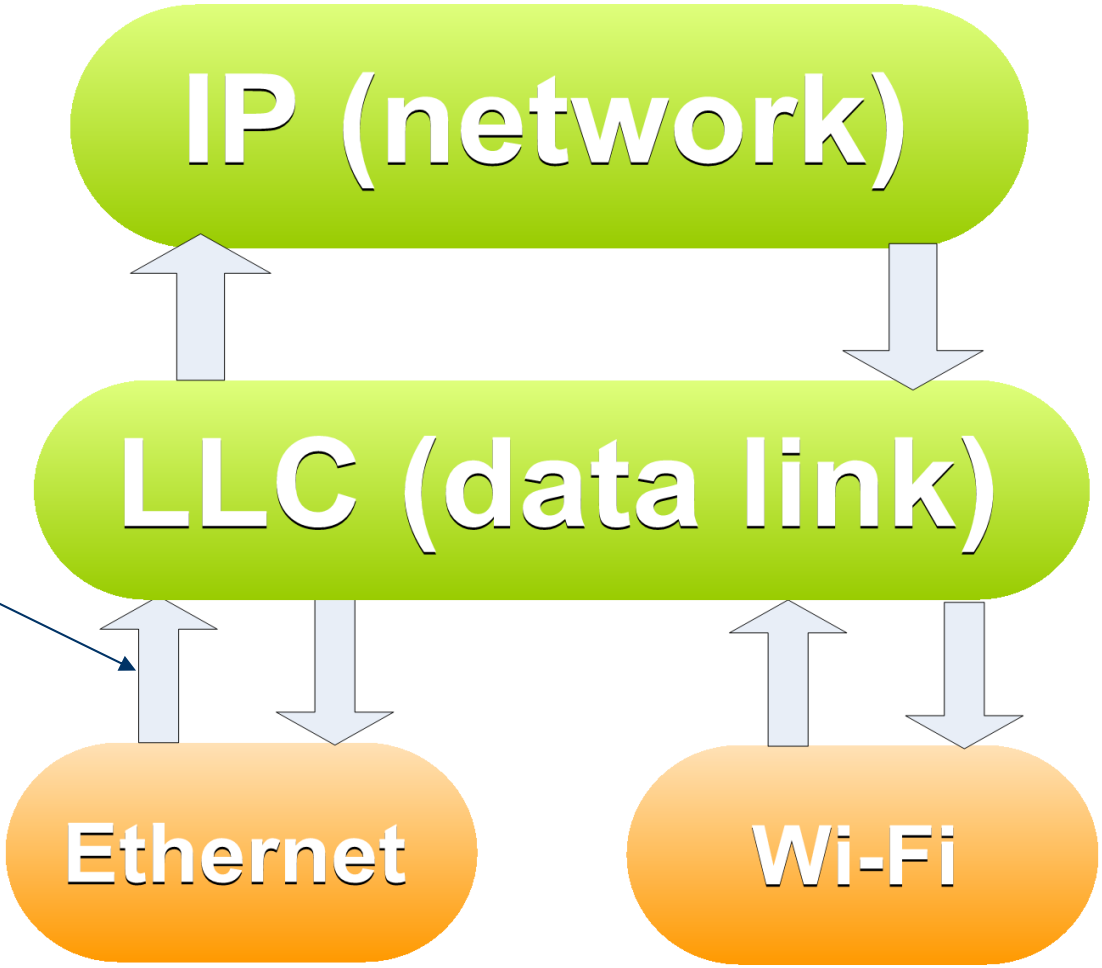
- **Logical link control(LLC) layer is the upper part of the two layers.**
- **Responsible for flow control, error correction, and re sequencing functions for connection-oriented and connectionless communication which is been already discussed.**
- ***MAC layer is responsible to provide a method for stations to gain access to the medium*.**

Media Access Control(MAC)

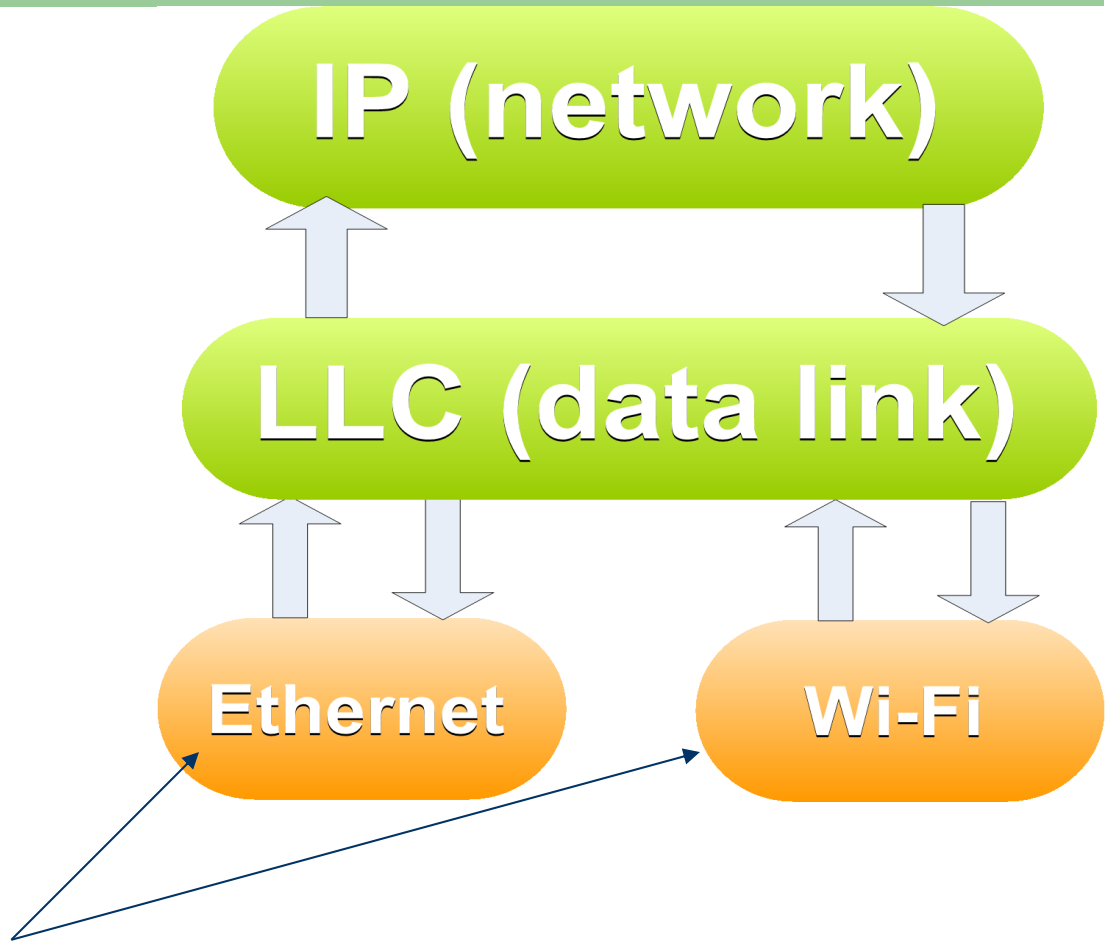


Media Access Control(MAC)

Physical Layer provides binary send/receive to Data-Link Layer

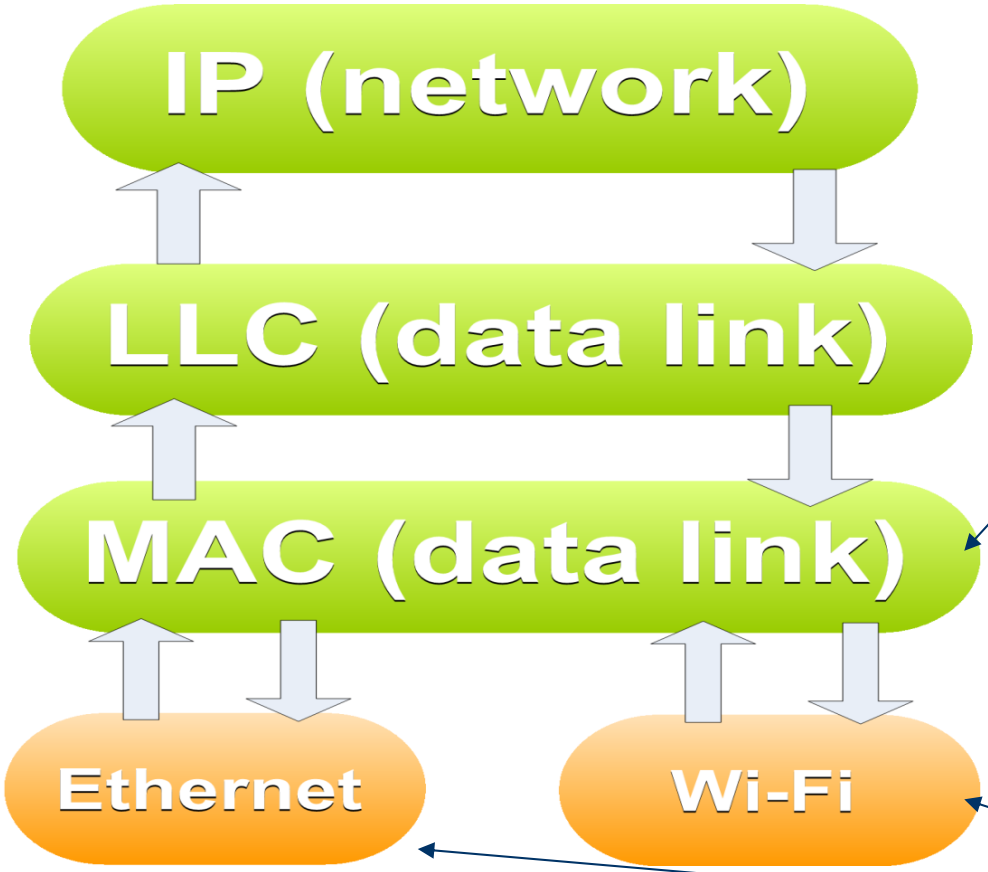


Media Access Control(MAC)



But, different media have different constraints about multiple nodes accessing the medium.

Media Access Control(MAC)



MAC layer provides medium-access service to the Data-Link layer

A separate **protocol** is needed to implement the **service** for each different transmission medium

Media Access Control(MAC)

- Network links in broader expect is classified to

1. Point to Point Link.
2. Broadcast Link.

- Broadcast Link or Channel are referred as multi access channel or random access channel.

Media Access Control(MAC)

- MAC sub layer are more focused on Local Area Network(LAN) and wireless LAN.
- Medium Access Control is a sub layer whose protocol determines use of multi-access channel.
- Channel cannot carry two signals in the same frequency range at the same time.

Media Access Control(MAC)

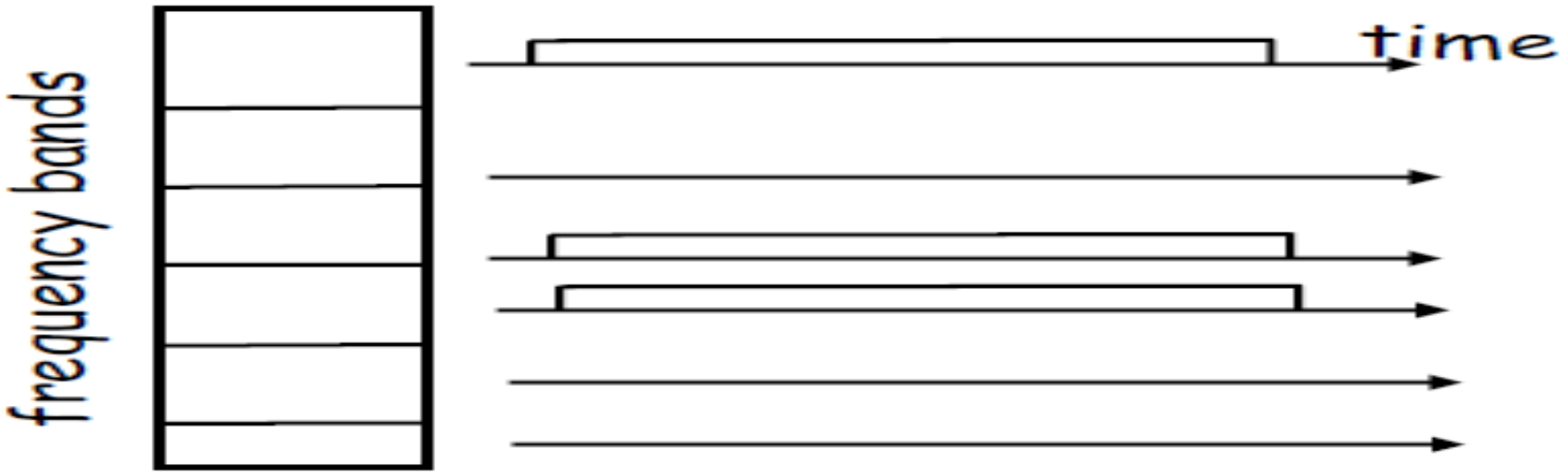
- To overcome this situation Single broadcast channel can be allocated among multiple user by

1. Statically.
2. Dynamically.

Static Channel Allocation

- **Traditional way of allocating channel is Frequency Division Multiplexing.**

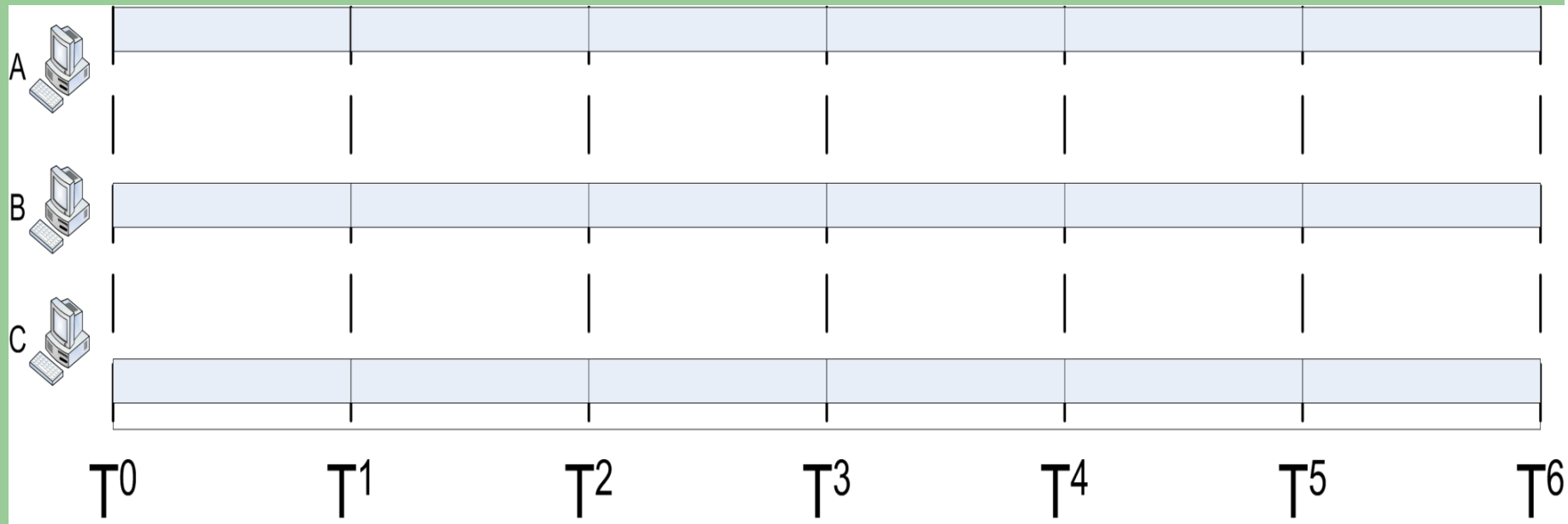
  eg:- Telephony.



Static Channel Allocation

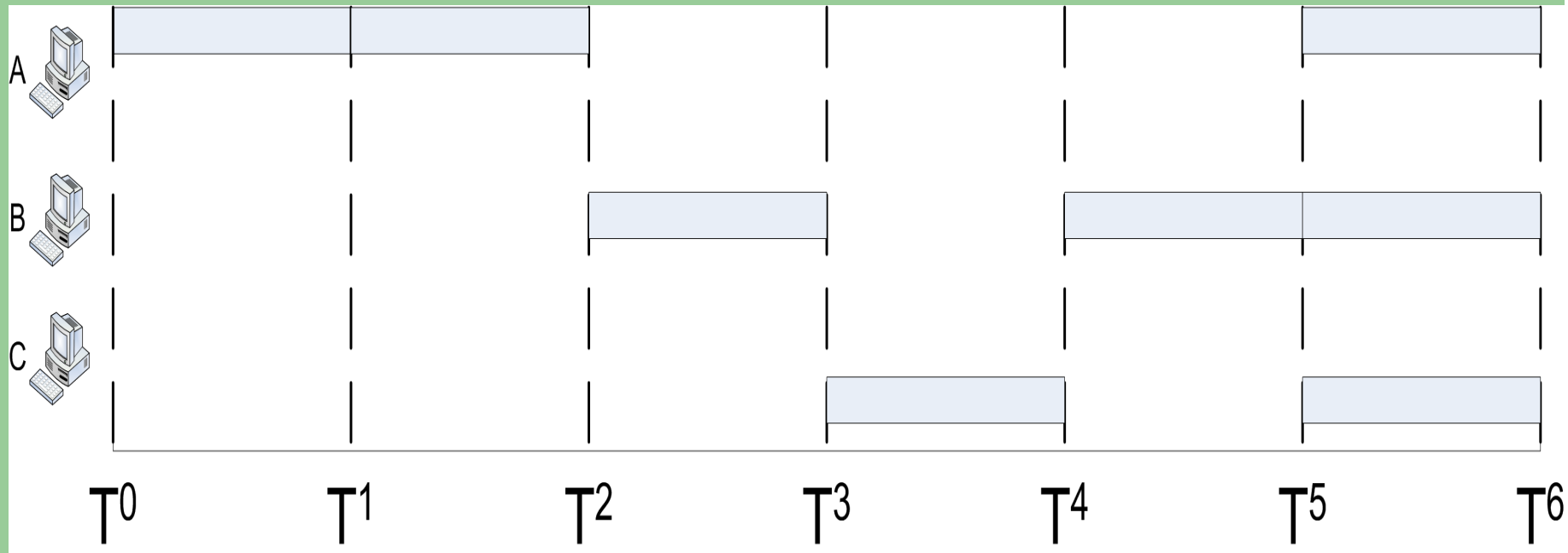
- Channel spectrum divided into frequency bands.
- Each station assigned fixed frequency band.
- Unused transmission time in frequency bands go idle.

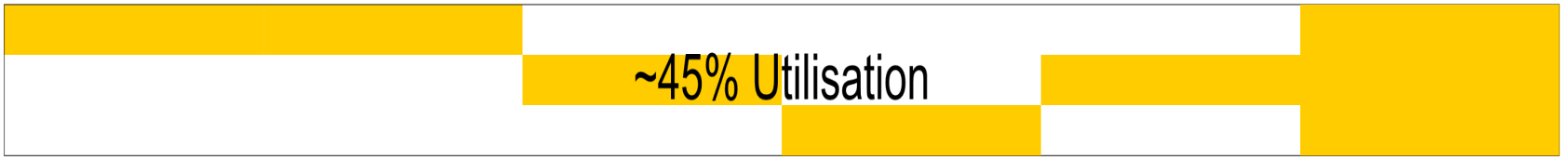
Static Channel Allocation



100% Utilisation

Static Channel Allocation





Static Channel Allocation

- In Time Division Multiplexing(TDM) each station gets fixed length slot.

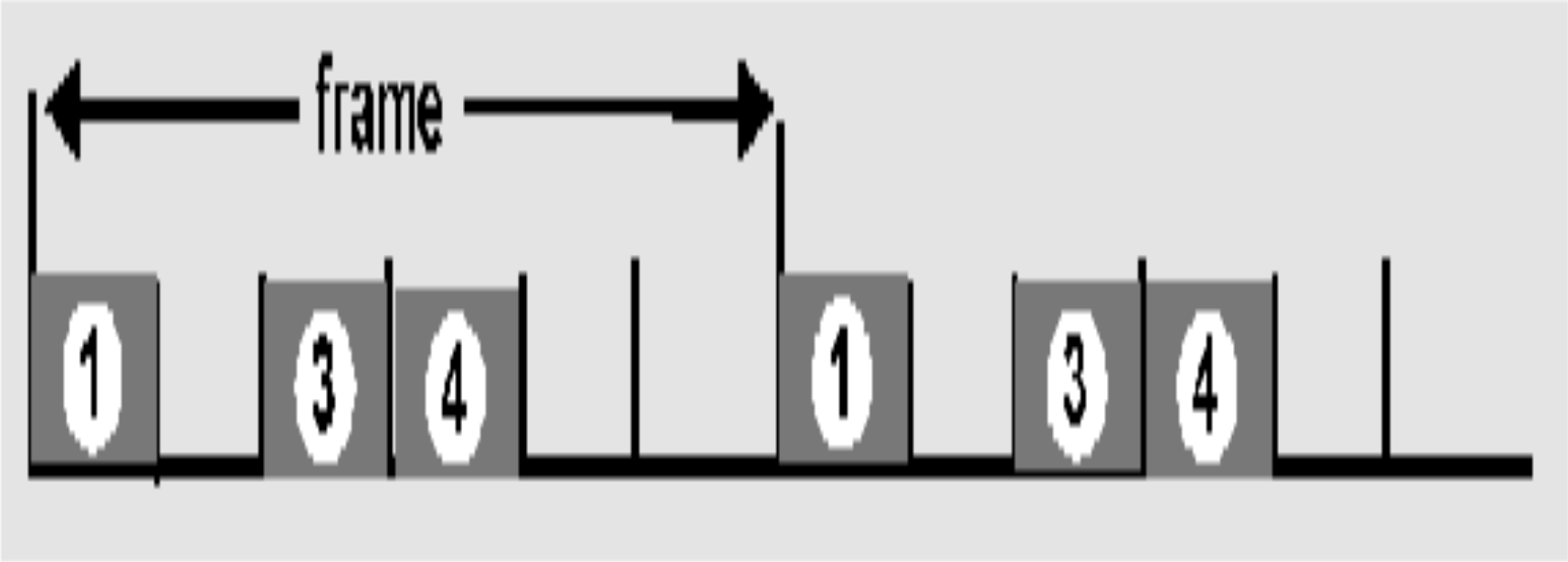
  (length =packet transmission time) in each round.

- Unused slots go idle.

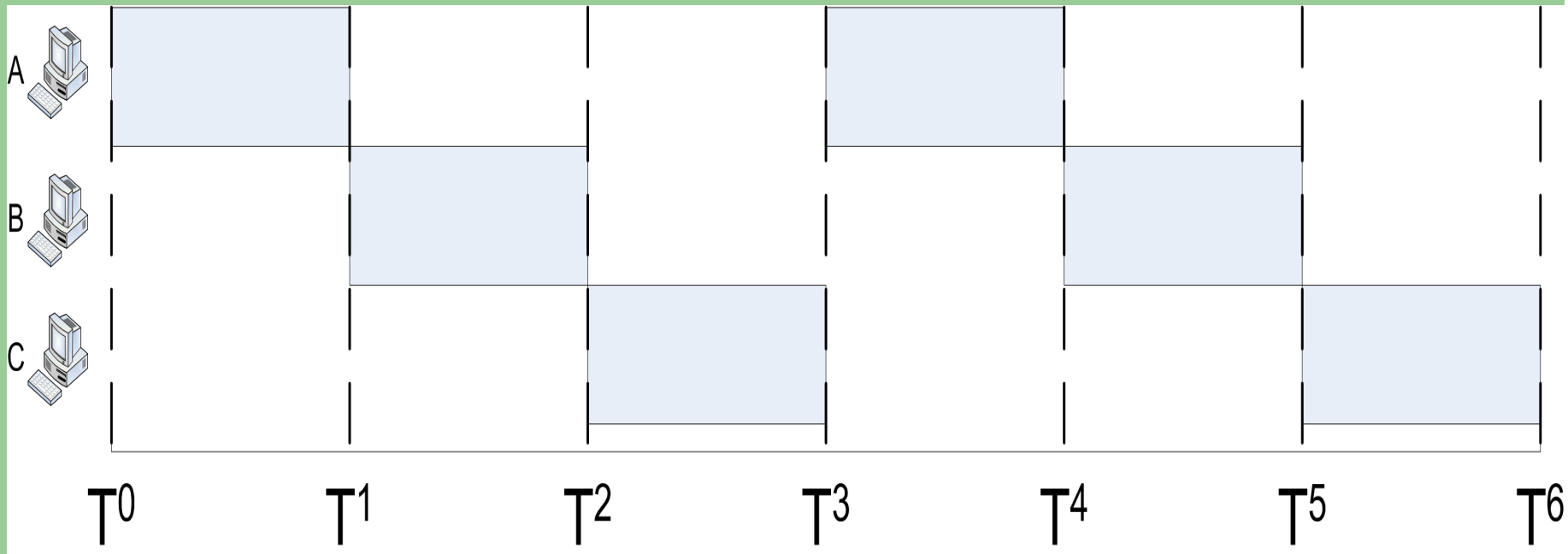
- example: 6-station LAN, 1,3,4 have packet.

- slots 2,5,6 idle.

Static Channel Allocation

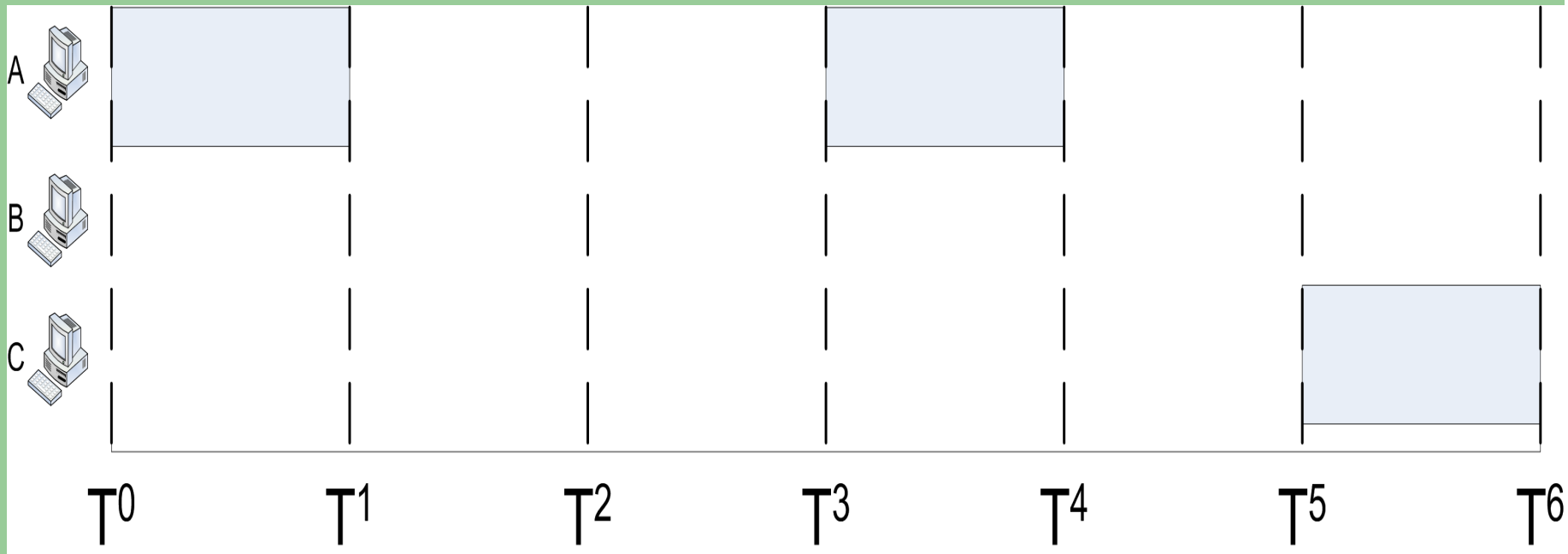


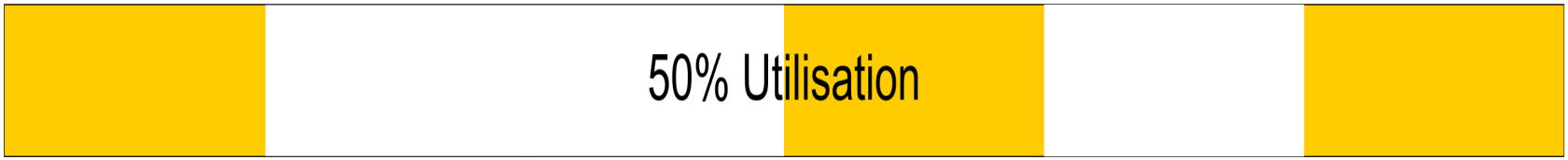
Static Channel Allocation



100% Utilisation

Static Channel Allocation





Static Channel Allocation

- **Both static channel allocation technique:**

  1. Time Division Multiplexing.

  2. Frequency Division Multiplexing.

- **Both allocation technique works well for constant traffic and poor for bursty traffic and is idle most of the time.**

- **Very poor in Bandwidth utilization.**

Dynamic Channel Allocation

- To Overcome the limitation with bursty, heterogeneous traffic we must find a dynamic way to allocate a node access to the channel.
- When a node has no traffic to send it does not waste bandwidth.
- When a node has traffic to send it can obtain all capacity of the channel, not just a slice.

Dynamic Channel Allocation

- Dynamic channel allocation is based in five assumption.

- Independent Traffic.
- Single Channel.
- Observable Collision.
- Continuous or Slotted Time.
- Carrier Sense or No Carrier Sense.

Dynamic Channel Allocation

- **Independent Traffic:-**

  Independent number of station generates frame for transmission.

  No of Frame=λΔt

  λ= Constant,Δt= time interval.

- **Once frame is generated station is blocked until the frame is not successfully transmitted.**

Dynamic Channel Allocation

- **Single Channel:-**
- **All station are provided with single shared channel.**
- **All station can transmit and receive on the basis of priorities.**

Dynamic Channel Allocation

- **Observable Collision:-**
- **Collision occurs if two frames are transmitted simultaneously.**
- **All station can detect the collision.**
- **A mixed or collided frame has to be resend again.**

Dynamic Channel Allocation

- **Continuous or Slotted Time:-**
- **Frame transmission for continuous time can begin at any instant.**
- **Slotted time or divided into discrete interval and the frame transmission must begin at the start of the slot.**

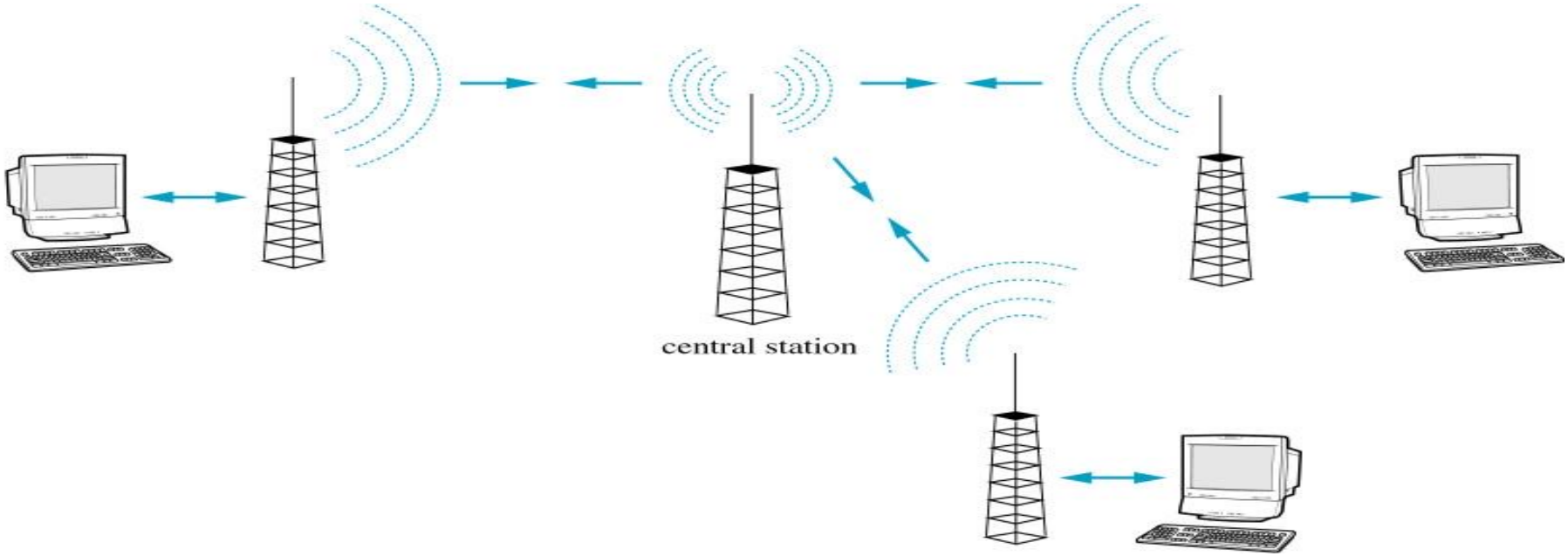
Dynamic Channel Allocation

- **Carrier Sense or No Carrier Sense:-**
- **With carrier sense assumption station can perceive if the channel is in use. Waits until it is free.**
- **With no carrier sense assumption station cannot sense the channel if it is free or in use.**

Multiple Access Protocols ALOHA

- System in which multiple users share a common channel.
- Also known as contention protocol developed at University of Hawaii in early 1970's by Norman Abramson and his colleague.
- Abramson used short range radios(ground based radio broadcasting) to connect the users of remote island to the main computer in Honolulu.

Multiple Access Protocols
ALOHA



- **The ALOHA system has two version.**
- **Pure ALOHA and Slotted ALOHA.**

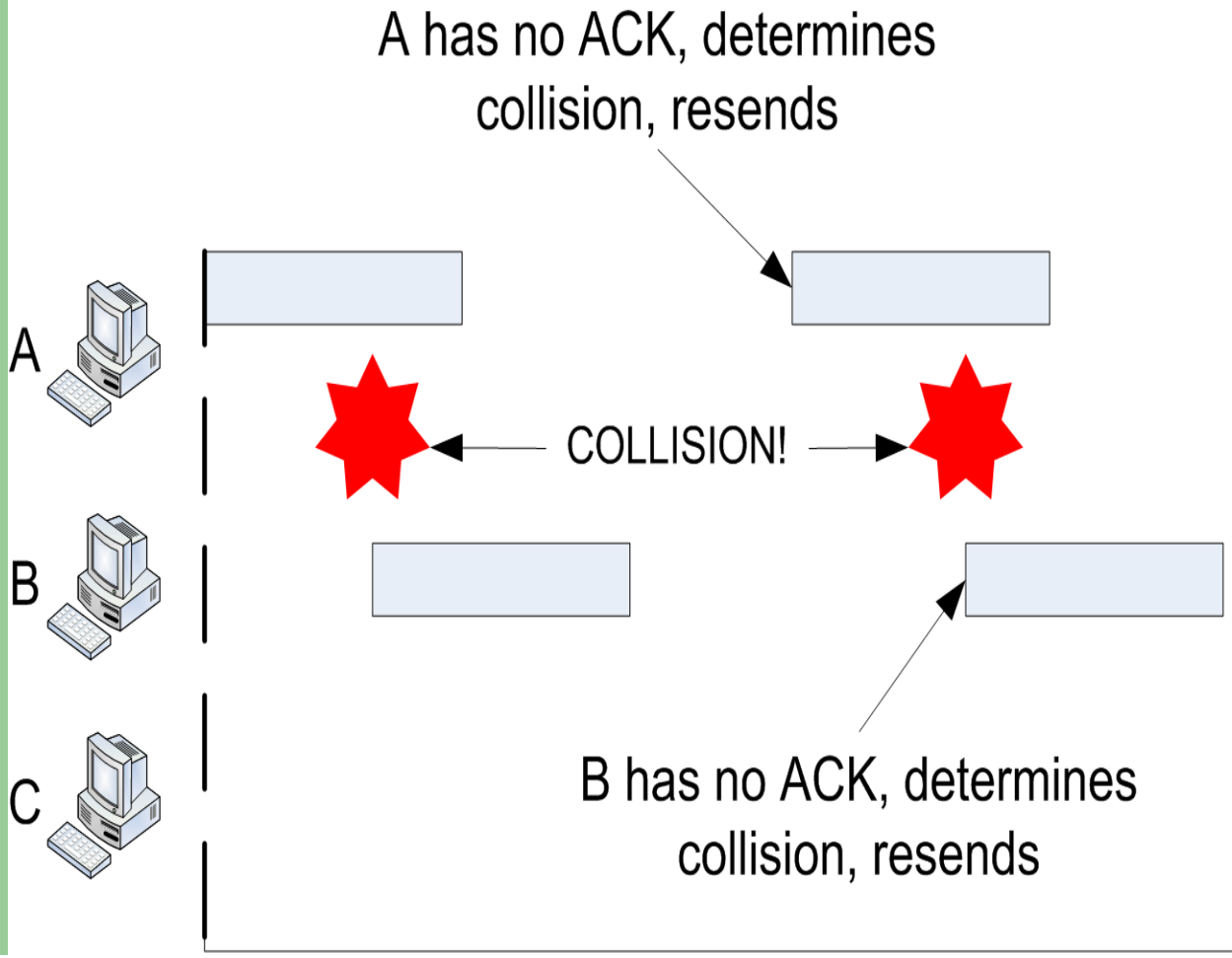
Multiple Access Protocols
Pure ALOHA

- Based on very simple principle.
- It allows any station to broadcast anytime.
- If collision occurs station waits for random time and tries again.
- If the first bit of a new frame overlaps with just the last bit of a frame almost finished.

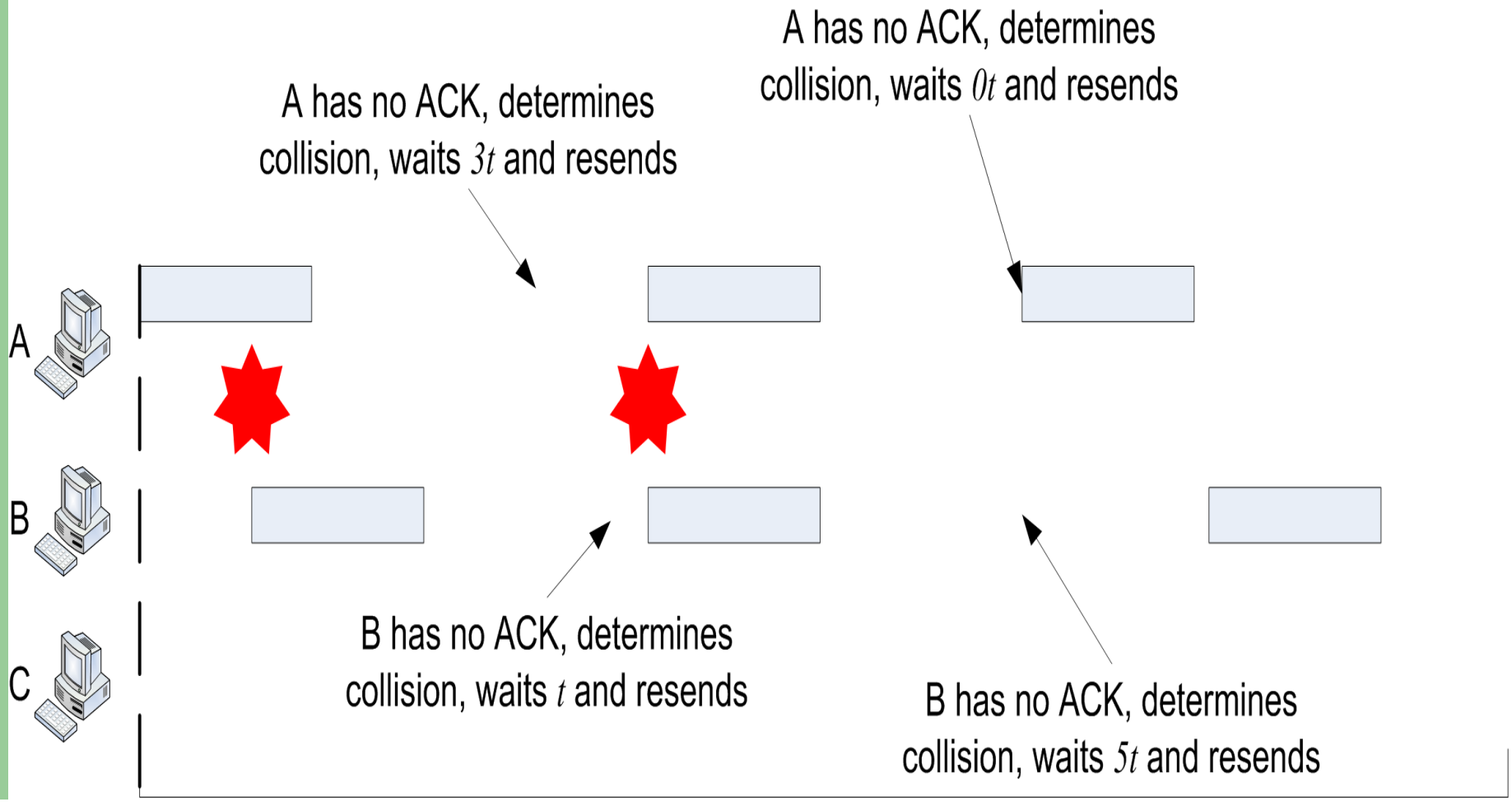
Multiple Access Protocols
Pure ALOHA

- Both frames will be totally destroyed and both will have to be retransmitted later.
- Sending station can listen to the broadcast to know if frame was rightly delivered.
- In wired LAN the sender will be able to listen for collision while transmitting.
- If all the frames are of same length the throughput of ALOHA system is maximized.

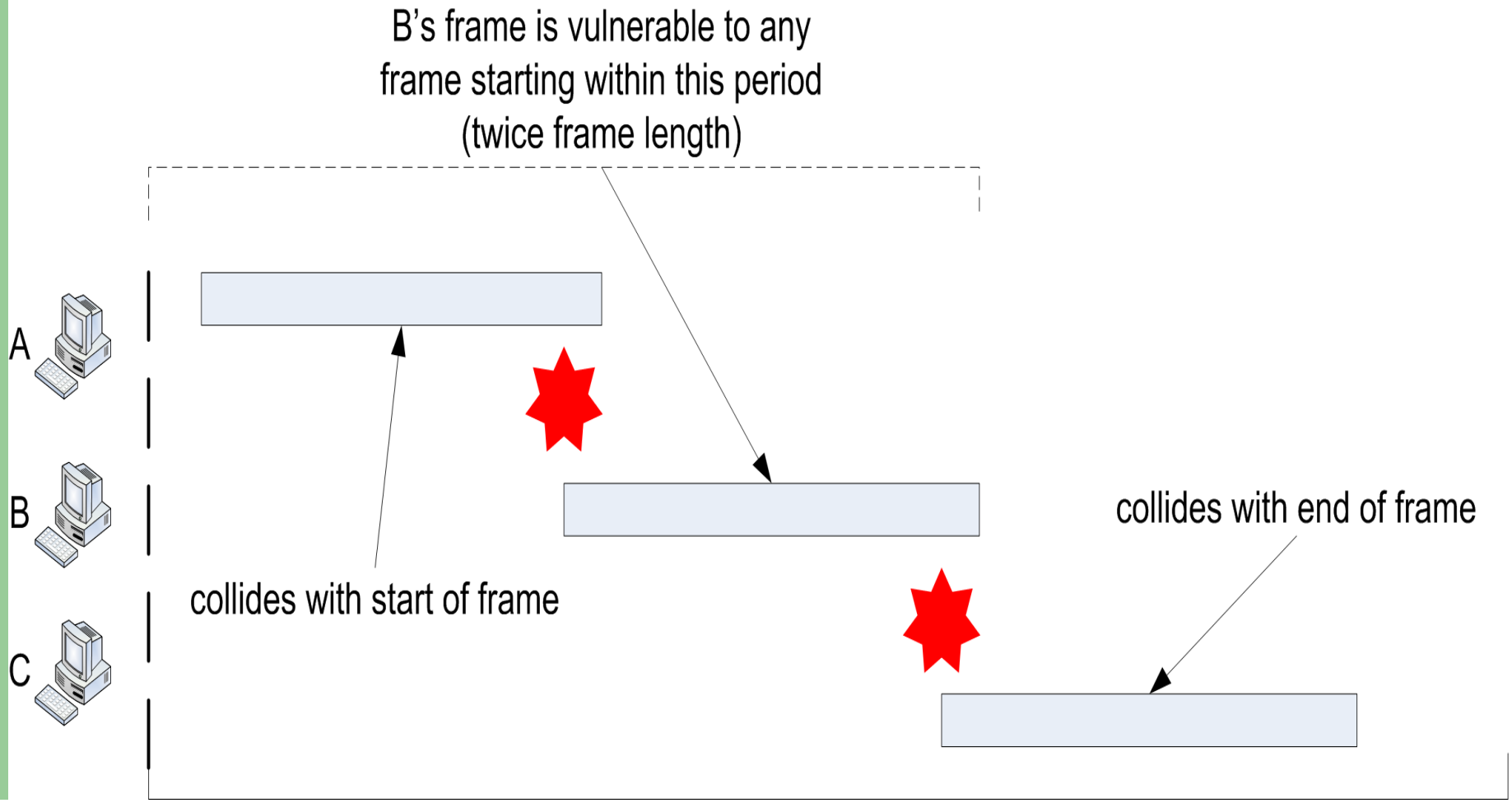
Multiple Access Protocols
Pure ALOHA



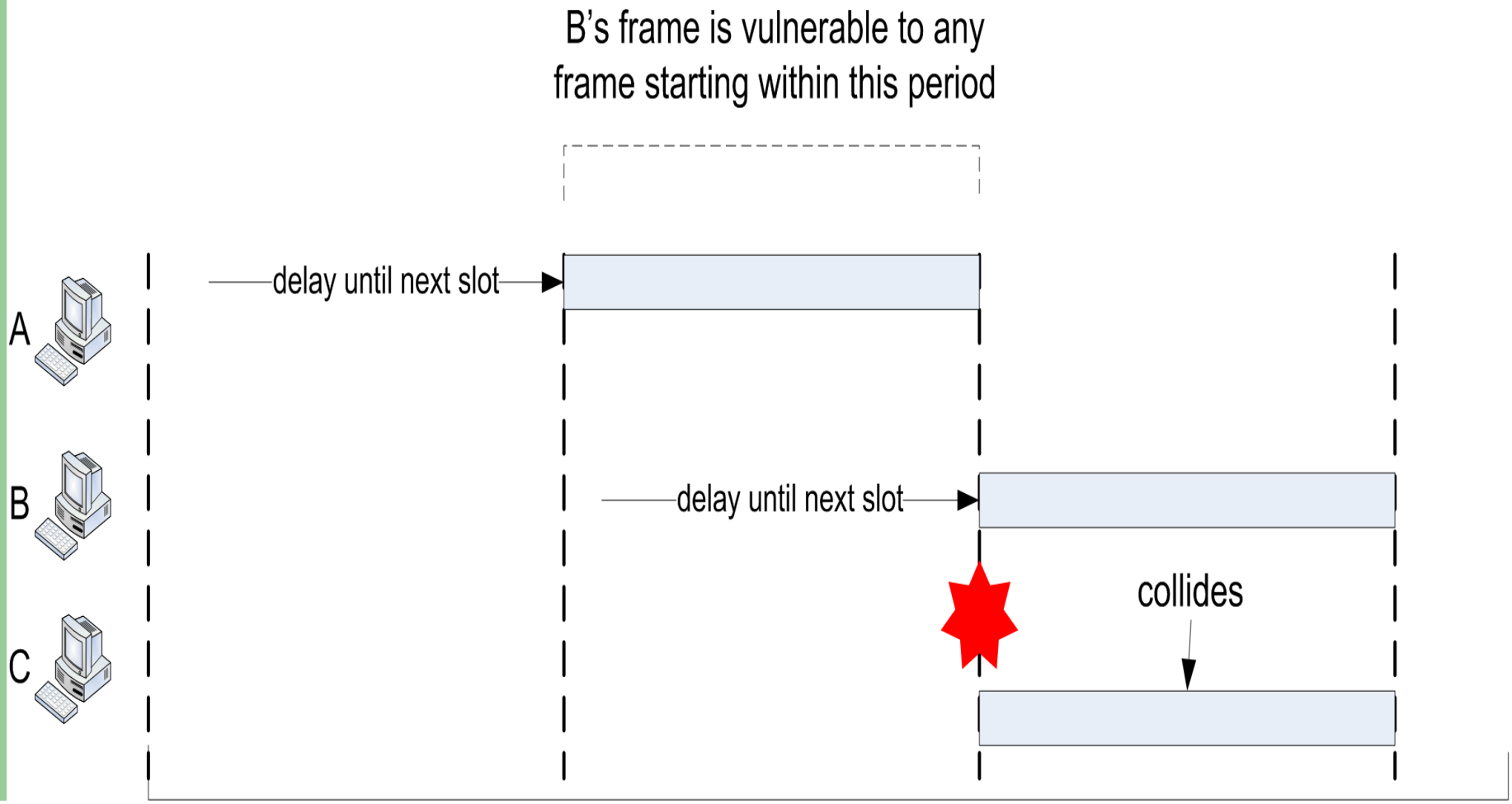
Multiple Access Protocols
Pure ALOHA



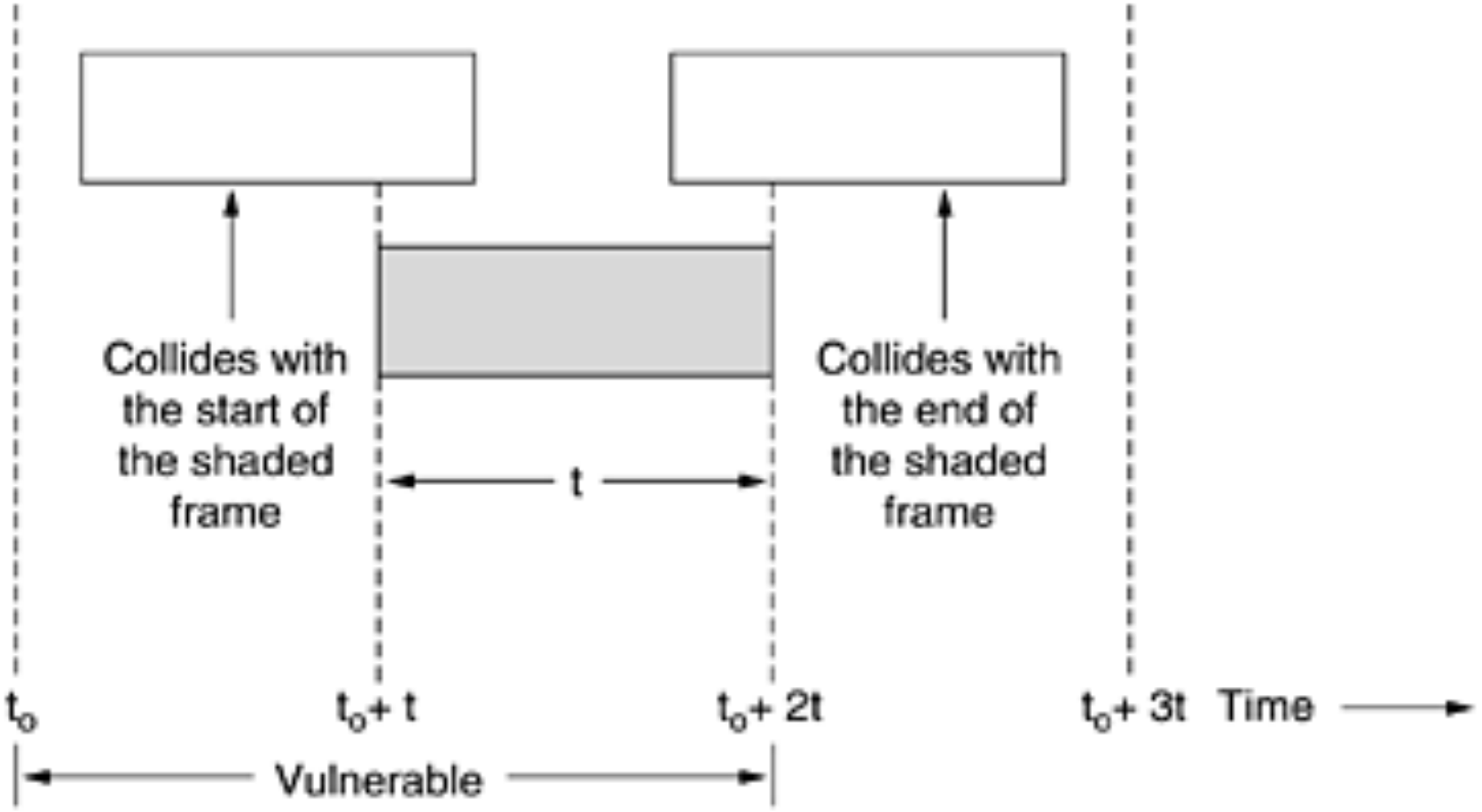
Multiple Access Protocols
Pure ALOHA



Multiple Access Protocols
Pure ALOHA



Multiple Access Protocols
Pure ALOHA



Multiple Access Protocols
Slotted ALOHA

- **Overcomes the limitations of Pure ALOHA.**
- **Robert published method for doubling the capacity of traffic on the channel and also known as Robert Method.**
- **Slotted ALOHA divides time into discrete interval where each interval corresponds to one frame.**

Multiple Access Protocols
Slotted ALOHA

- Each station transmits the data at the beginning of the slot.
- Users can't send the data as his/her wish.
- Stations should wait for the beginning of the next slot to send the data which will reduce the collision.
- Vulnerable period is reduce to half of that of Pure ALOHA.

Multiple Access Protocols
Pure / Slotted ALOHA

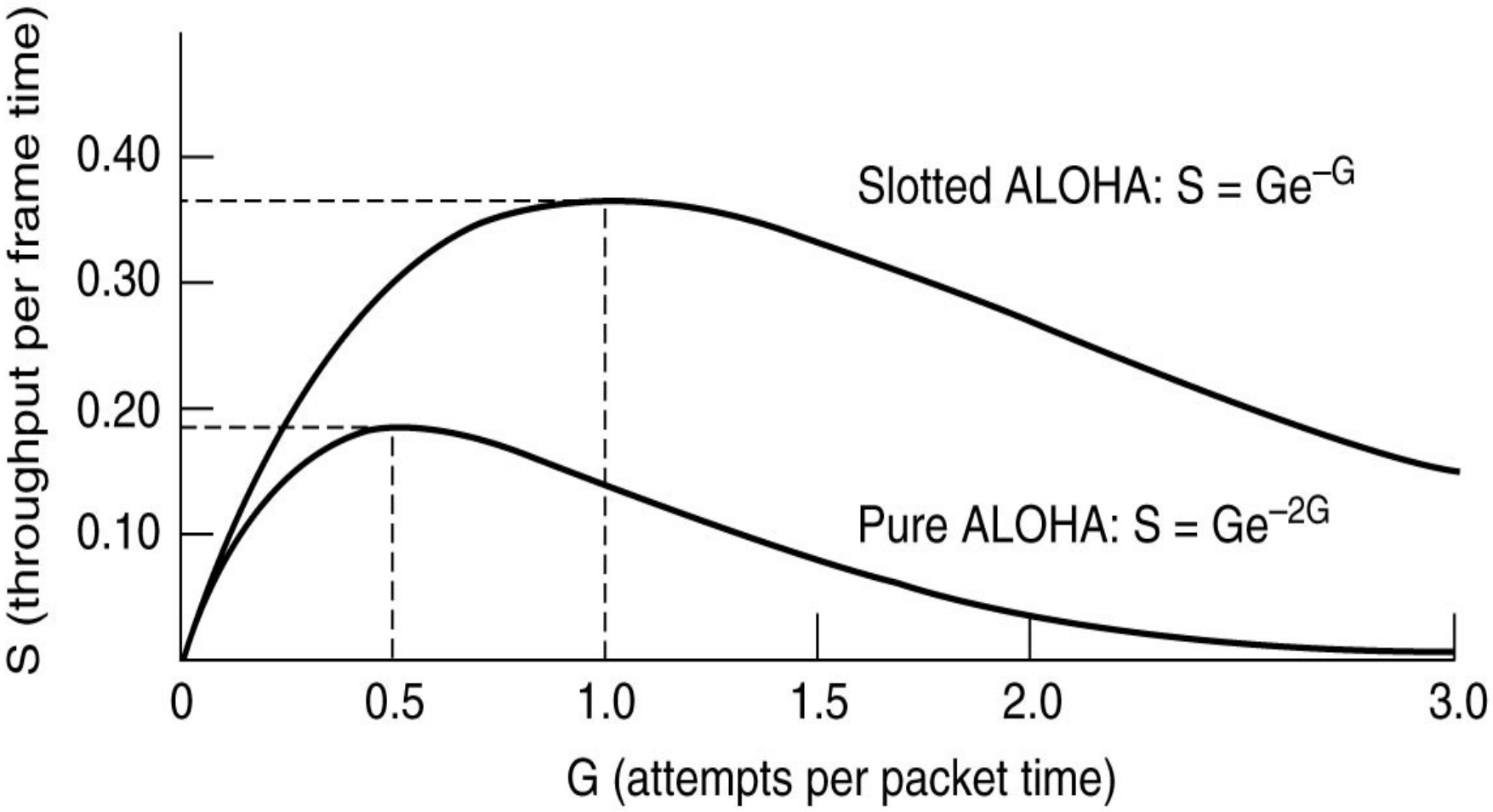
- **Reducing collisions increases throughput.**

- **Throughput *S* = Number of frames successfully received for a given unit time. Generally:**
  - ***G* = *offered* load (total frames generated)**
  - ***P(s)* = probability of success for a single frame**
  - ***S* = *G* × *P(s)***

Multiple Access Protocols
Pure / Slotted ALOHA

- We can also increase *S* by increasing *G*.
- But *P(s)* is a function of *G*
  - For Pure ALOHA: $P(s) = e^{-2G}$, $S = Ge^{-2G}$.
  - For Slotted ALOHA: $P(s) = e^{-G}$, $S = Ge^{-G}$.

Multiple Access Protocols
Pure / Slotted ALOHA



Carrier Sense Multiple Access Protocols

- Carrier Sense Multiple Access(CSMA) protocol operates on the principle of carrier sensing.
- In this protocol Station listens the presence of carrier on the medium and is then decided to act accordingly.
- It is classified as:-

Carrier Sense Multiple Access Protocols(Persistent / Nonpersistent)

1. **Non-Persistent CSMA:- To transmit a frame it checks the medium. It waits if the medium is busy for fixed interval of time and checks again. If it finds free, it proceeds to transfer the frames. Algorithm leads to better channel utilization but longer delays than 1-persistent CSMA.**
2. **1- Persistent CSMA:- Station monitors the medium continuously until it is idle and will transmit immediately. Collision occurs if two stations transmits at the same time.**

Carrier Sense Multiple Access Protocols(Persistent/Nonpersistent)

3. P- Persistent CSMA:-

Possibility of collision and re-transmission is reduced in the P-Persistent CSMA. All station are not permitted to transmit at a time when the medium is idle.

Carrier Sense Multiple Access Protocols(Persistent / Nonpersistent)

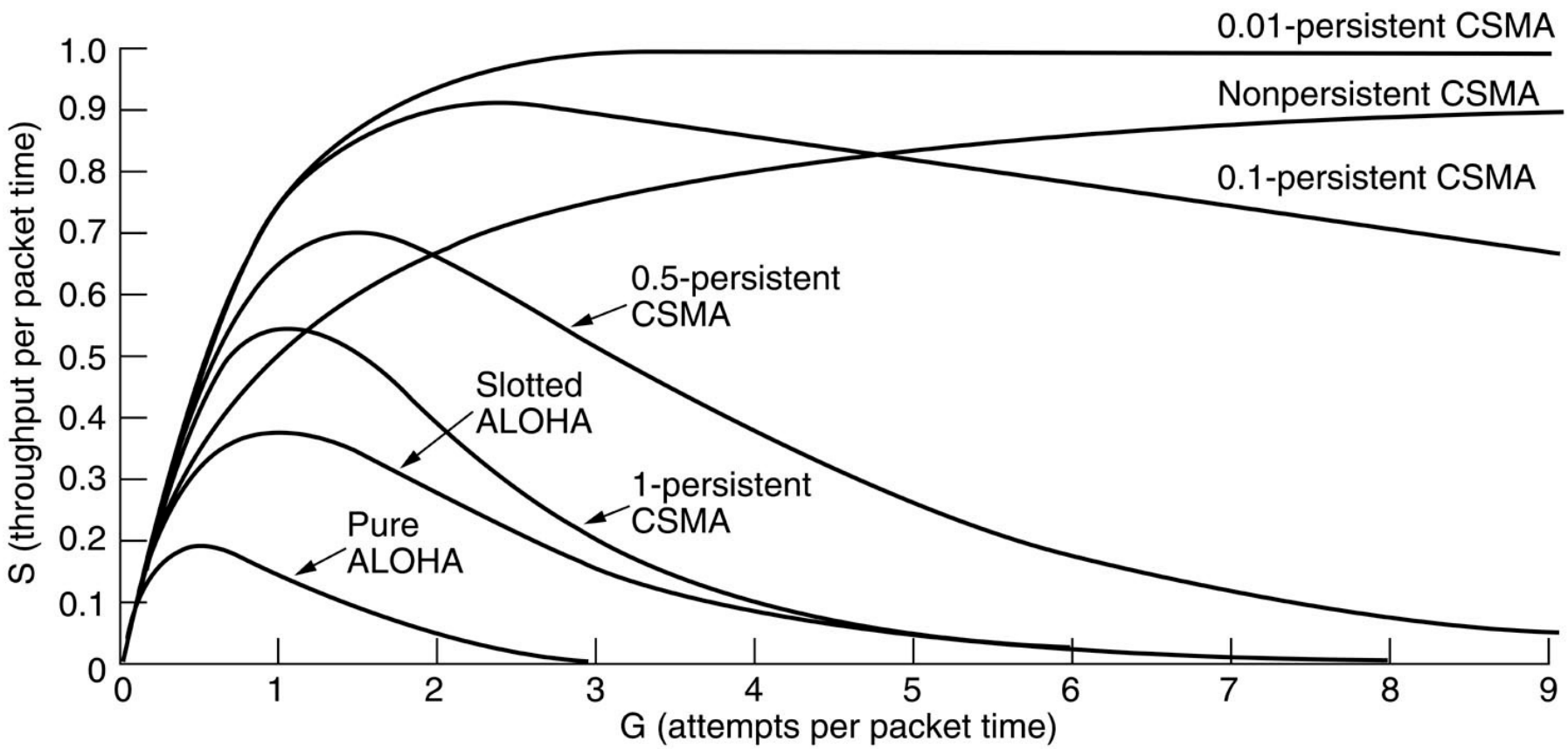


Fig:- CSMA Performance

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

- Persistent and Non persistent CSMA protocols are clearly an improvement over ALOHA because they ensure that no station begins to transmit when it senses the busy channel.
- Improvement of CSMA-CD is that the stations abort their transmissions as soon as they detect a collision.
- This strategy saves time and bandwidth.

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

- To reduce the impact of collisions on the network performance, Ethernet uses an algorithm called CSMA with Collision Detection (CSMA / CD.
- CSMA/CD is a protocol in which the station senses the carrier or channel before transmitting frame just as in persistent and non-persistent CSMA.
- If the channel is busy, the station waits.

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

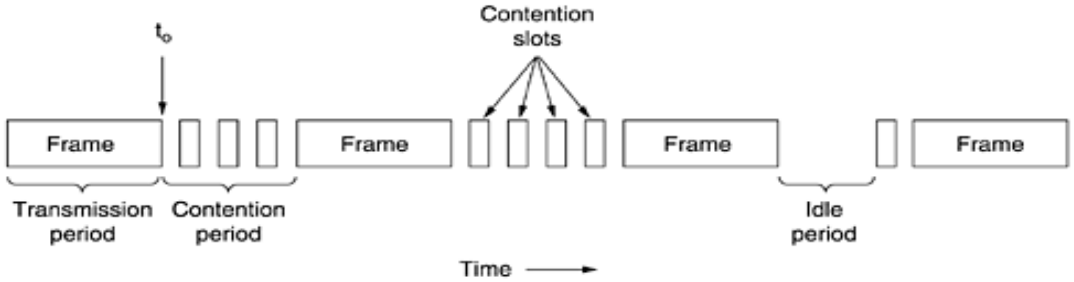
- It listens at the same time on communication media to ensure that there is no collision with a packet sent by another station.
- In a collision, the issuer immediately cancel the sending of the package.
- This allows to limit the duration of collisions: we do not waste time to send a packet complete if it detects a collision.

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

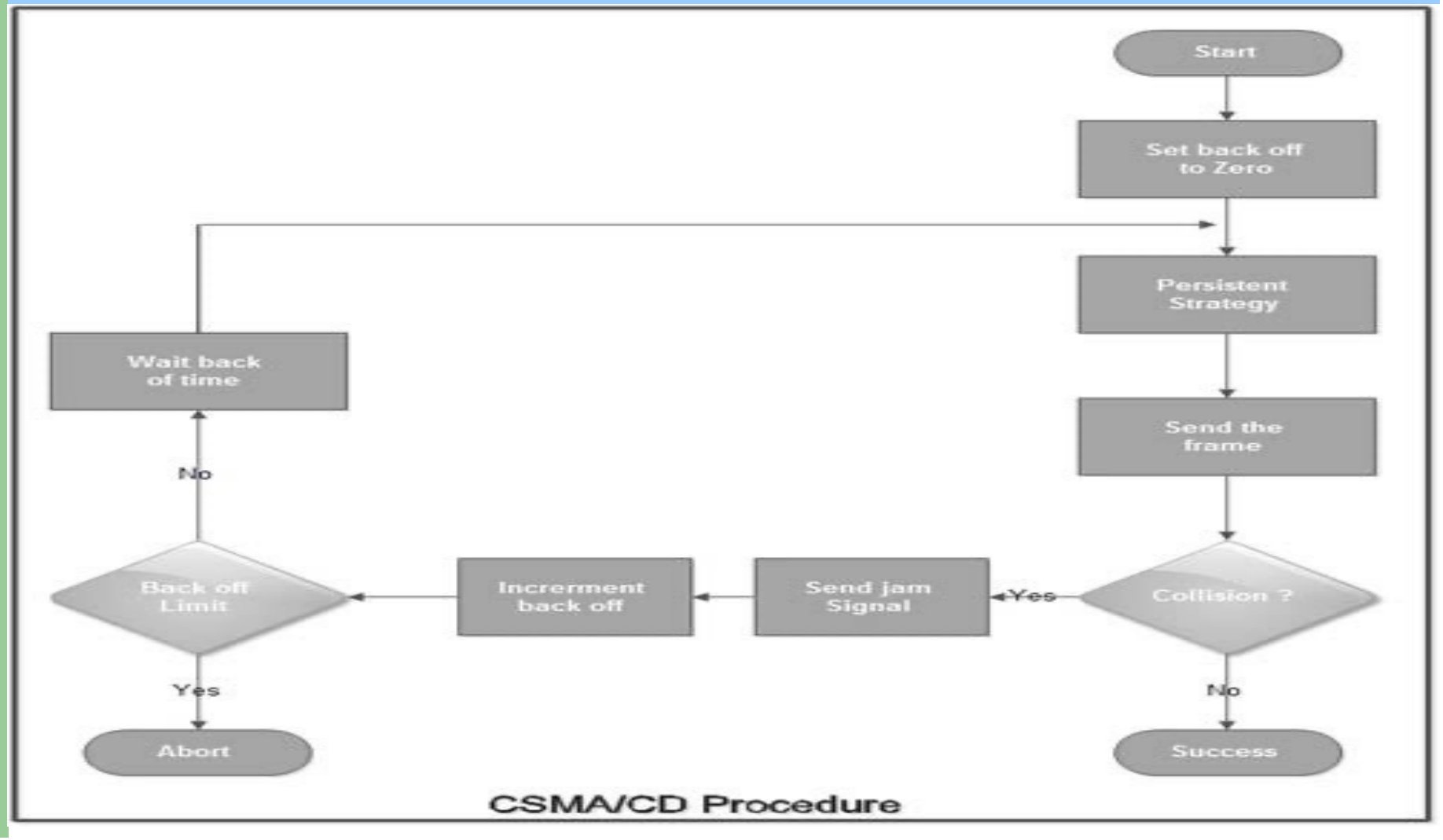
- After a collision, the transmitter waits again silence, and again, he continued his hold for a random number; but this time the random number is nearly double the previous one: it is this called back-off (that is to say, the "decline") exponential.
- In fact, the window collision is simply doubled (unless it has already reached a maximum).
- From a packet is transmitted successfully, the window will return to its original size.

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

- ***CSMA/CD*** **is used for the traditional Ethernet.**
- ***CSMA/CD*** **is an important protocol. IEEE 802.3 (Ethernet) is an example of *CSMACD.* It is an international standard.**
- **The MAC sublayer protocol does not guarantee reliable delivery. Even in absence of collision, the receiver may not have copied the frame correctly.**



Carrier Sense Multiple Access with Collision Detection(CSMA-CD)



CSMA/CD Procedure

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

- The station that has a ready frame sets the backoff parameter to zero.
- Then it senses the line using one of the persistent strategies.
- It then sends the frame. If there is no collision for a period corresponding to one complete frame, then the transmission is successful.
- Otherwise the station sends the jamming signal to inform the other stations about the collision.

Carrier Sense Multiple Access with Collision Detection(CSMA-CD)

- The station then increments the backoff time and waits for a random backoff time and sends the frame again.
- If the backoff has reached its limit then the station aborts the transmission.

Carrier Sense Multiple Access with Collision Avoidance(CSMA-CA)

- Channel is reserved using special frames.
- Data frames will never collide.
- Used in Wireless LAN 802.11 protocol family.

Carrier Sense Multiple Access with Collision Avoidance(CSMA-CA)

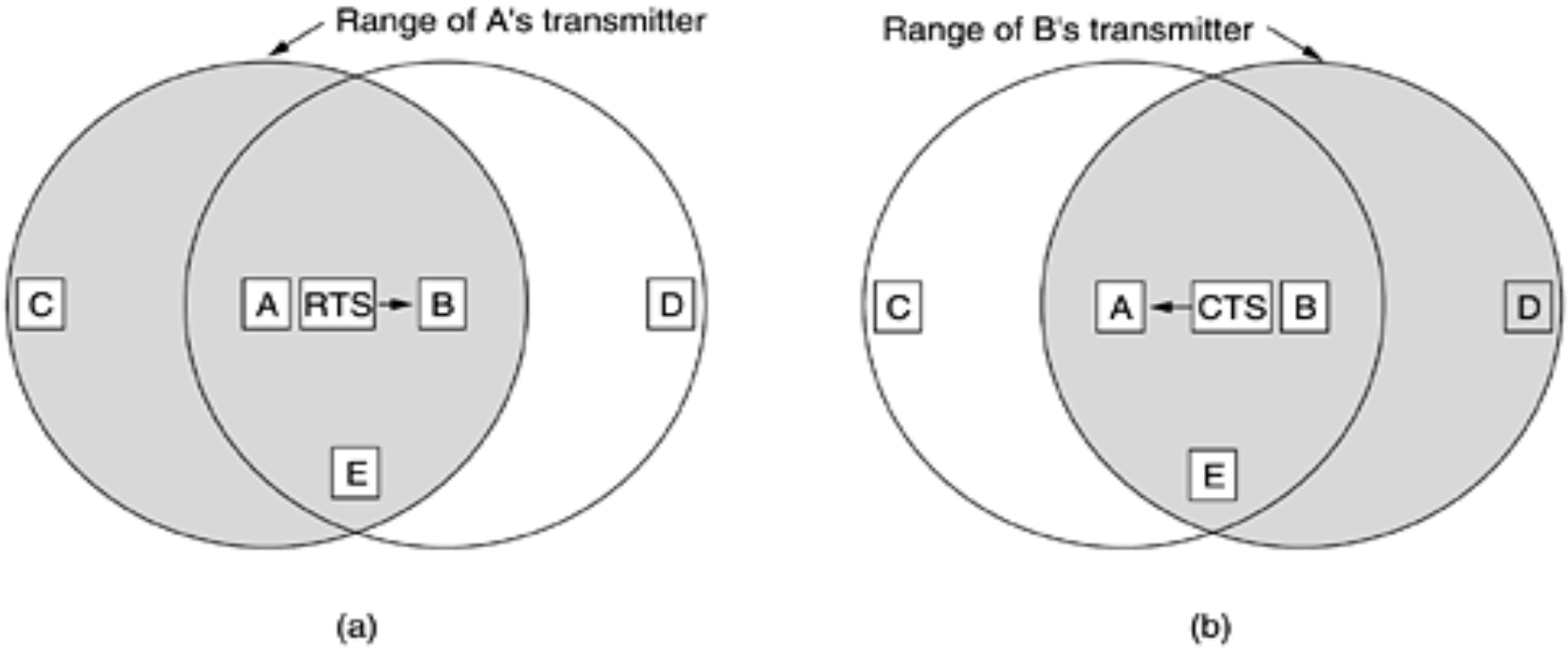
- **Wireless LAN Protocol.**

Wireless LAN Protocols

- LAN which uses radio for physical link is called a wireless LAN and is broadcast Channel.
- Wireless LAN uses CSMA but there can be interference at the receiver side.
- Problem like Hidden Terminal and exposed terminal problem may occur.

Wireless LAN Protocols

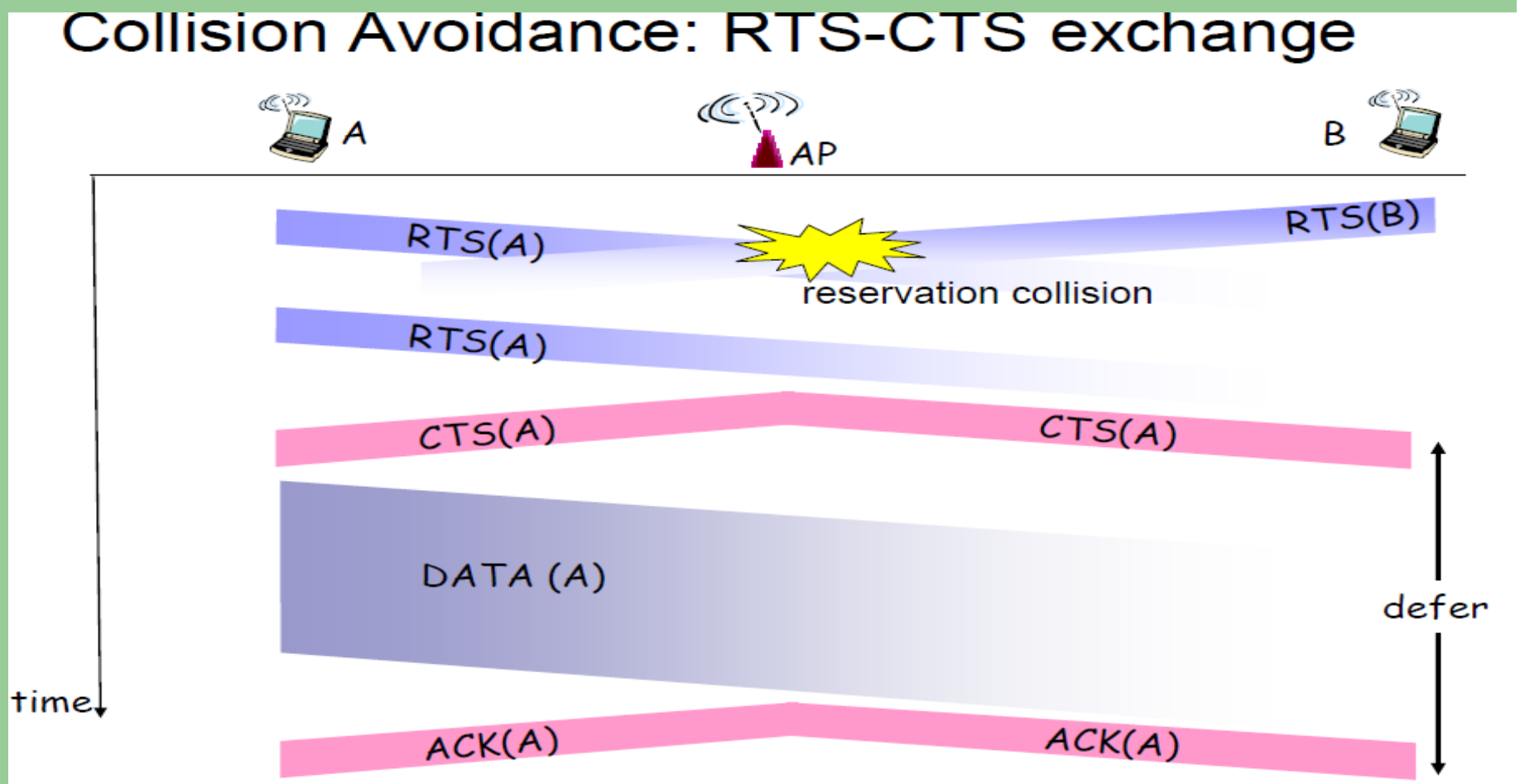
- **Multiple Access with collision Avoidance protocol can tackle these problem.**



Wireless LAN Protocols

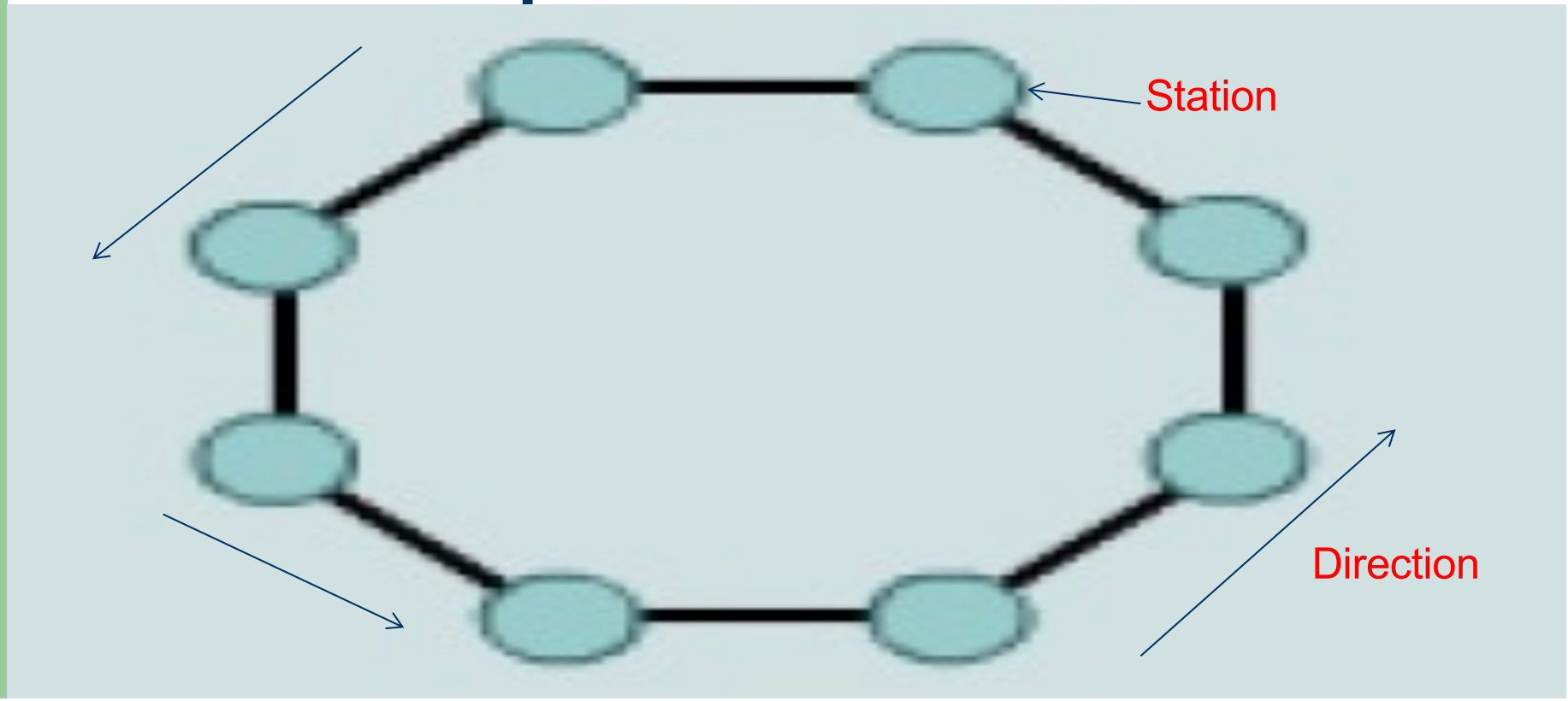
- A starts sending Request To Send (RTS) frame to B.
- RTS frame contains the request and the length of data frame that will flow.
- B than replies with Clear To Send(CTS) frame.
- A after getting CTS frame, begins transmission of data.

Wireless LAN Protocols



Token Ring

- **It is also known as Token Passing and is collision free protocols.**



Token Passing

- Implemented protocol is called Token Bus.
- Small message so named token are send from one station to another in pre-defined manner.
- Token represents permission to send.
- Transmission of frame follows after the token and reaches to pre-defined destination.

Ethernet

- **Ethernet is also named as MAC Sublayer Protocol.**

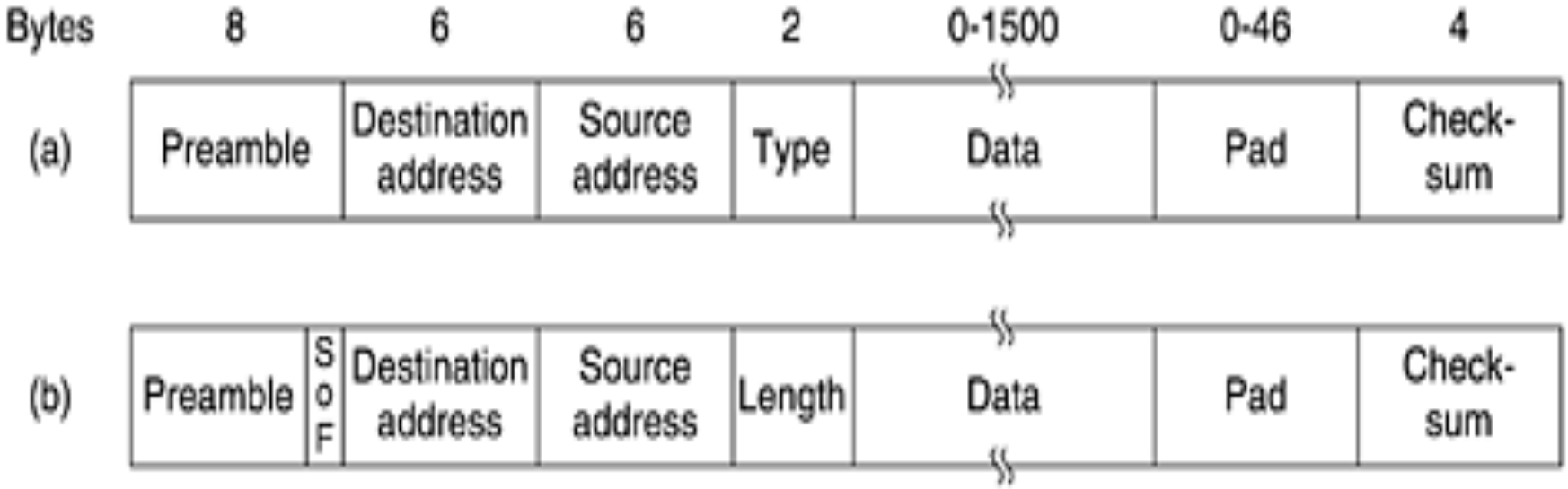


Fig:-Frame formats. (a) DIX Ethernet. (b) IEEE 802.3.

Ethernet

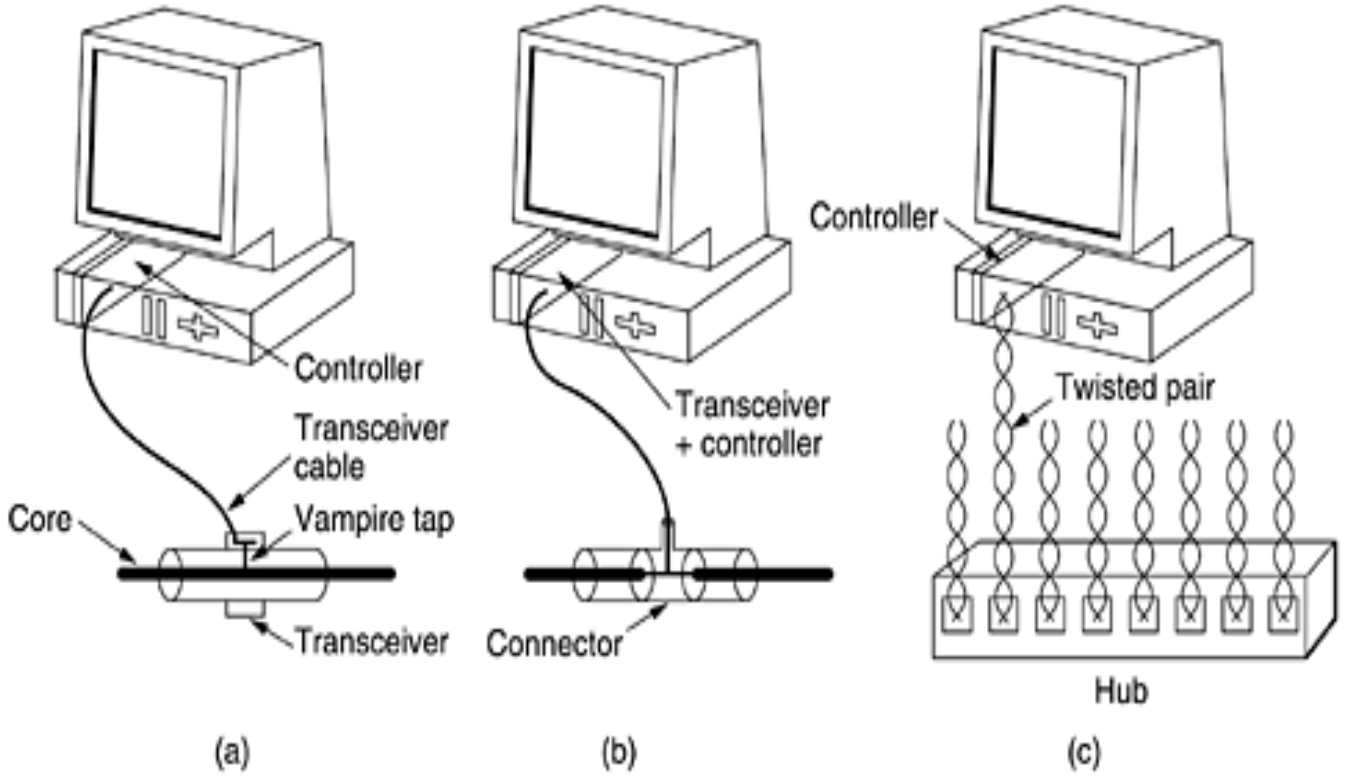
- Ethernet are also classified as Classic Ethernet and Switched Ethernet.
- Classic Ethernet provides with the speed of 3 to 10 Mbps.
- Switched Ethernet runs at 100,1000,10000 Mbps named with Fast Ethernet, Gigabit Ethernet and 10 Gigabit Ethernet.
- Only switched Ethernet is used nowadays.

Ethernet

Name	Cable	Max. seg.	Nodes/seg.	Advantages
10Base5	Thick coax	500 m	100	Original cable; now obsolete
10Base2	Thin coax	185 m	30	No hub needed
10Base-T	Twisted pair	100 m	1024	Cheapest system
10Base-F	Fiber optics	2000 m	1024	Best between buildings

Ethernet

Three kinds of Ethernet cabling. (a) 10Base5. (b) 10Base2. (c) 10Base-T.



End of Lecture 6