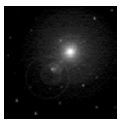
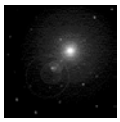
MEDIUM ACCESS PROTOCOLS

Static Channel Allocation

- Traditional Approach of sharing channel is to allot a separate
  - Time slot (TDM) or
  - Frequency (FDM)
- But such approach is not suitable for computer communication, because:
  - Large number of sender means large delay.
  - Time/Frequency wastage if everybody is not transmitting.
  - Difficult to manage dynamic addition and deletion of stations.



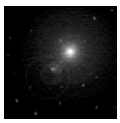
Dynamic Channel Allocation: Few Definitions



COMPUTER COMMUNICATION NETWORK

- Station Model
  - N independent stations. The probability of a frame generation in an time interval of length is $\lambda.\Delta t$. λ is the uniform frame arrival rate.
- Single Channel Assumption
  - All station transmits to only one medium.

Few More Concepts



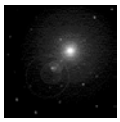
COMPUTER COMMUNICATION NETWORK

- Collision Assumption
  - all station can detect collisions. It requires retransmission.
- Continuous Time/Slotted Time
  - stations are allowed to transmit any time/ or at specific interval.
- Carrier Sense/No Carrier Sense
  - Stations can tell if anyone else is transmitting or not.

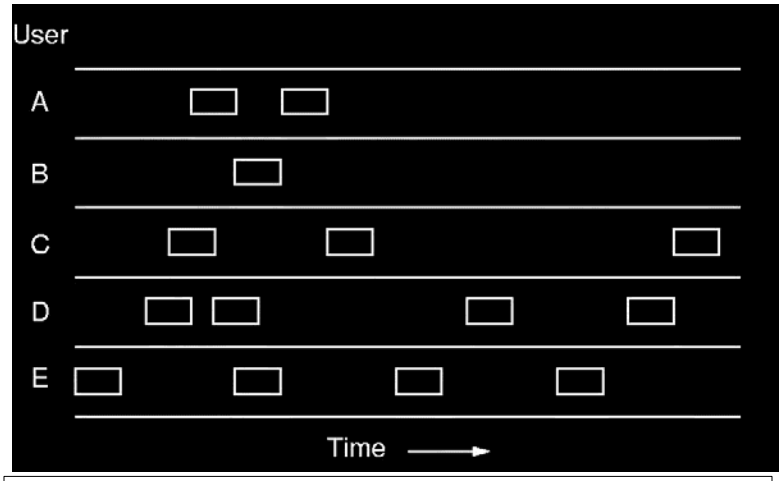
ALOHA Protocol

- In 1970, Normal Abramson and his colleagues at the University of Hawaii devised this method. The idea has since been extended and has found its way in almost all shared media protocols.
- The Basic Concept:
  - User is allowed to transmit whenever they have data to send.
  - There will be occasional collisions.
  - Due to feedback property of medium the transmitter will know.
  - It will retransmit just waiting after random amount of time.

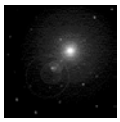
- It is Extremely simple, as no inter station co-ordination is required. All stations can act independently.



ALOHA Protocol

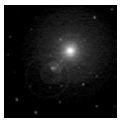


- Stations can transmit independently. Only occasionally there will be collision under light load.



Performance of ALOHA

- S= Frames generated per frame time.
  - If S>1 then user community is generating too much frames.
  - For reasonable throughput 0<S<1
- G=Average frames transmitted per frame time.
  - G>S
  - at low load G≈S
  - at high load there will be many collisions G>>S
- Relationship between S and G
  - Under all loads, the throughput S is just the transmitted load G times the probability that there was no collision P_0.
  - S=G. P_0



Performance of ALOHA

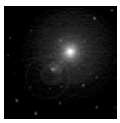
- With **rate of arrival** λ, the probability that k frames are generated during a given frame time is given by the Poisson's distribution:

$$pr[k] = \frac{\lambda^k e^{-\lambda}}{k!}$$

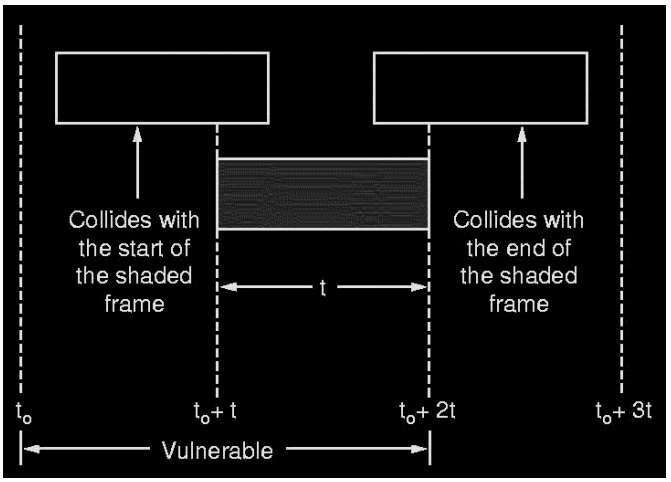
- What is the probability that 0 frames were generated during a given frame time?

$$p_0 = pr[0] = \frac{\lambda^0 e^{-\lambda}}{0!} = e^{-\lambda}$$

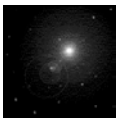
- What is the arrival rate and frame time slot for ALOHA?



Vulnerable Period of ALOHA



- The vulnerable period is two frame time long.



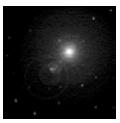
Efficiency of ALOHA

- The mean number of frames generated in an interval of two frame time long is 2G.
  - Probability of collision avoidance is:

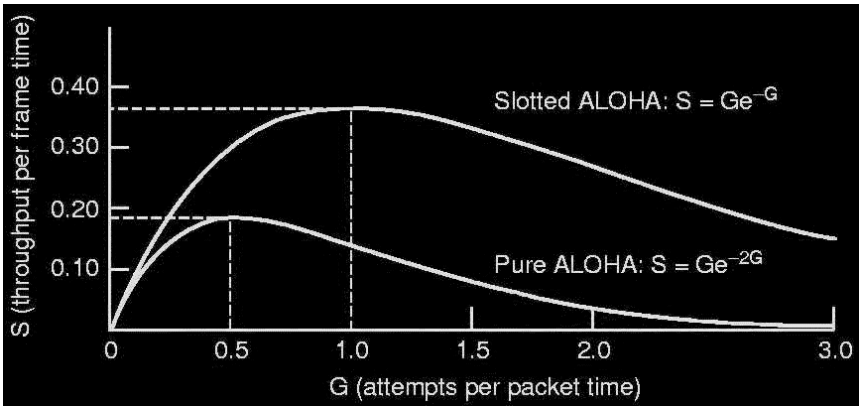
$$p_0 = e^{-\lambda} = e^{-2G}$$

- The throughput is

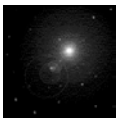
$$S = GP_0 = Ge^{-2G}$$



Throughput vs. Traffic for ALOHA

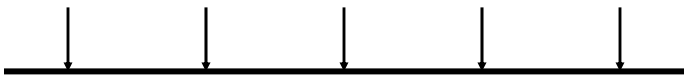


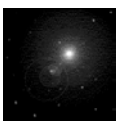
- The peak is at G=.05, with s=1/2e = 0.184
- That is the cost of independence!



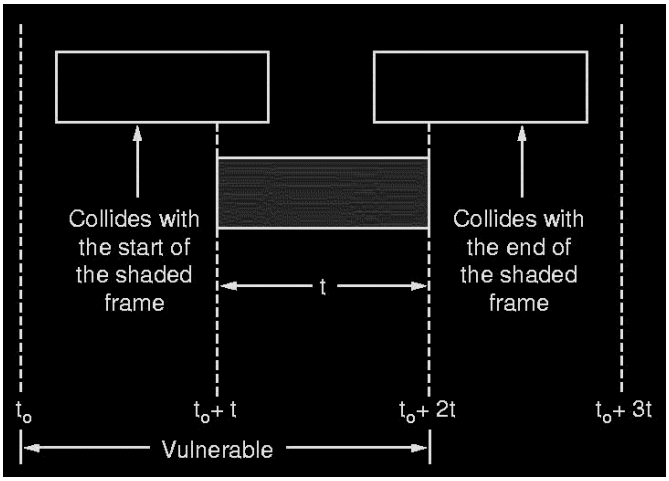
Slotted ALOHA

- In 1972, Robert's published a method for doubling the capacity of ALOHA system.
- Idea:
  - Divide the time in slots, each interval corresponds to one frame. (let one station emit a pip at the start of each interval).
  - A computer can transmit only at the beginning of a slot.

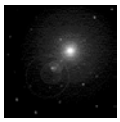




Vulnerable Period of Slotted ALOHA



- The vulnerable period is now one slot.



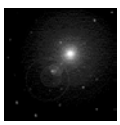
Efficiency of ALOHA

- The mean number of frames generated in an interval of two frame time long is G.
  - Probability of collision avoidance is:

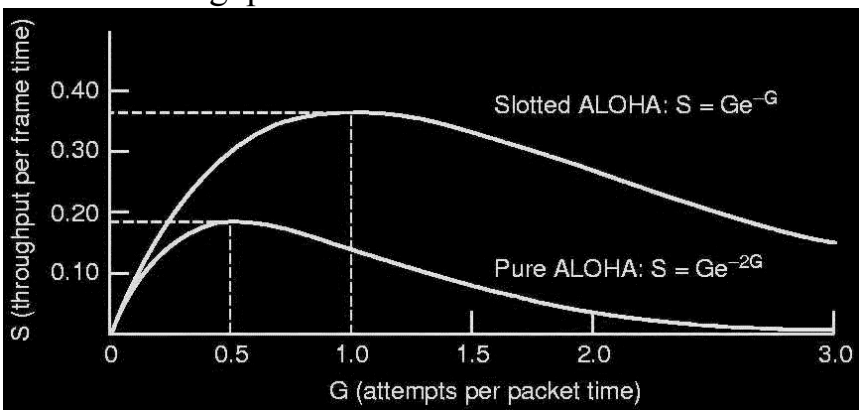
$$p_0 = e^{-\lambda} = e^{-G}$$

- The throughput is

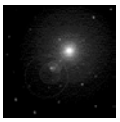
$$S = GP_0 = Ge^{-G}$$



Throughput vs. Traffic for Slotted ALOHA



- The peak is at G=1, with s=1/e = 0.368 compared to .184 of pure ALOHA



How many times a station have to try?

- The probability that a slotted ALOHA will avoid collision is

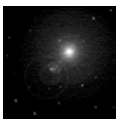
$$p_0 = e^{-\lambda} = e^{-G}$$

- The probability that exactly k-transmission will be required:

$$p_k = e^{-G}(1-e^{-G})^{k-1}$$

- The expected number of transmission is

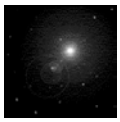
$$E = \sum_{k=1}^{\infty} k.p_k = e^{G}$$



Improvements: CSMA
Carrier Sense Multiple Access Protocols

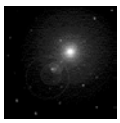
- In ALOHA, stations do not pay attention to what other stations are doing. In local area networks perhaps they can. Here are some ideas:

- 1-persistent CSMA.
  - Before transmission sense the carrier.
  - If no one else is transmitting only then transmit.
  - If others are transmitting, wait till the end
  - try transmission at the end of current transmission.



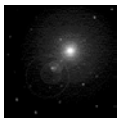
Non-persistent CSMA

- Idea:
  - try to be less greedy.
  - Before transmission sense the carrier.
  - If no one else is transmitting only then transmit.
  - If others are transmitting, wait do not keep on sensing the channel.
  - Wait a random amount of time and and repeat the process.



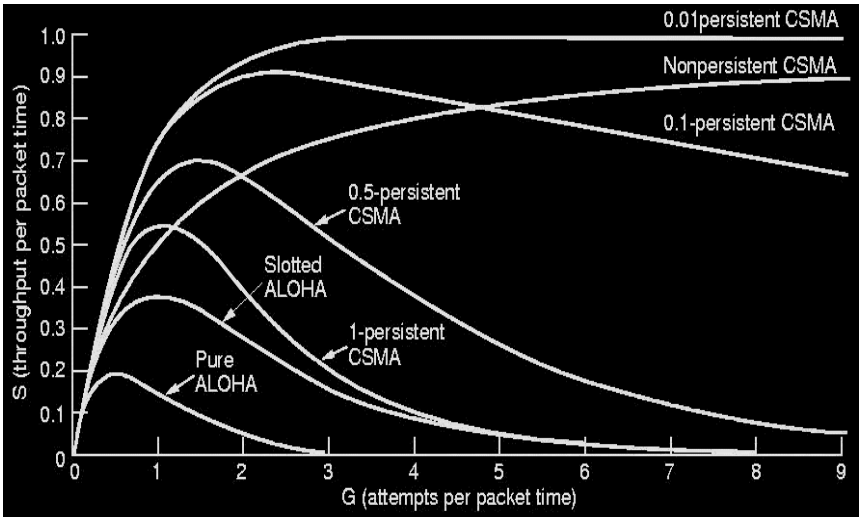
p-persistent CSMA

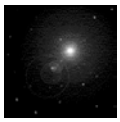
- Idea:
  - Try to be moderately greedy.
  - Before transmission sense the carrier.
  - If no one else is transmitting only then transmit.
  - If others are transmitting, flip a coin with probability p of head.
  - If head retransmit at the end of current transmission.
  - If tail, wait and flip the coin again at the end of the second transmission. If tail again.. Repeat..



COMPUTER COMMUNICATION NETWORK

Comparison of Channel Utilization

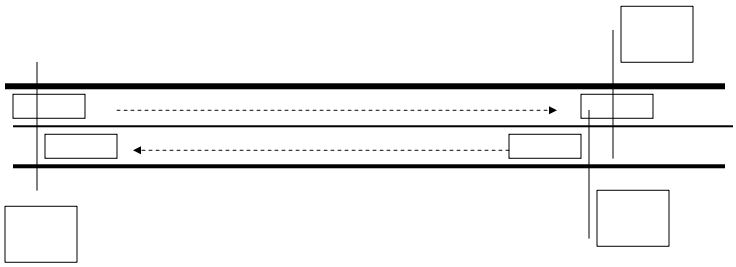


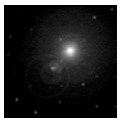


COMPUTER COMMUNICATION NETWORK

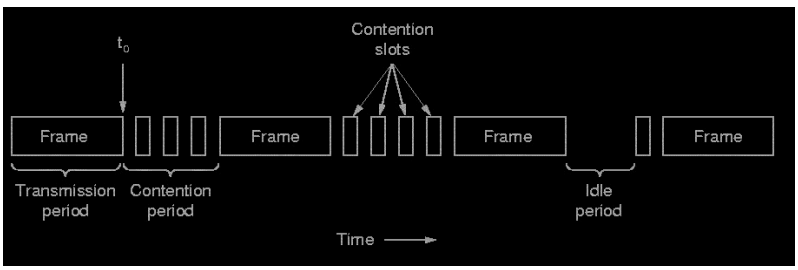
CSMA with Collision Detection

- Idea:
  - After transmission watch if it is going fine.
  - If there is a collision, why bother transmitting the whole frame.
  - How long a station have to wait to find out if there is a collision?

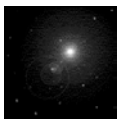




States of CSMA/CD

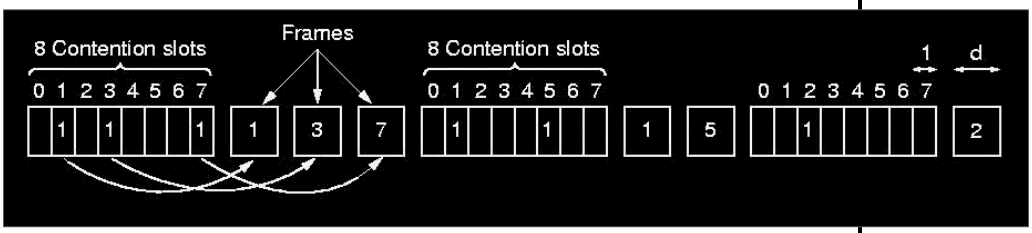


- CSMA/CD can be in three states (contention, transmission, or idle.
- This is the version which is used in Ethernet



Collision Free Protocols

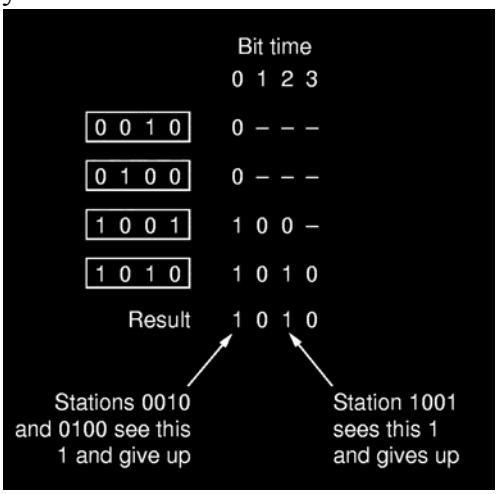
- Bit Map protocol



COMPUTER COMMUNICATION NETWORK

Collision Free Protocols

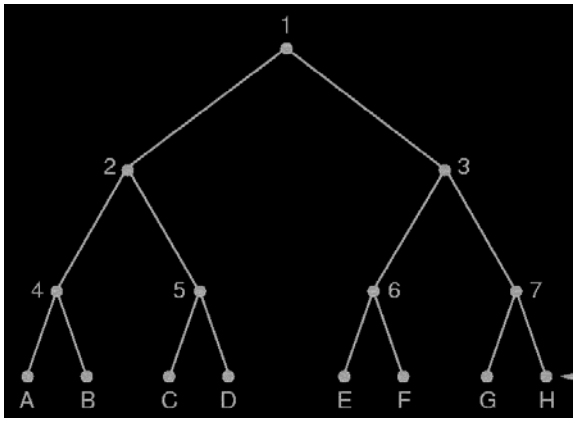
- Binary Countdown

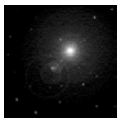


COMPUTER COMMUNICATION NETWORK

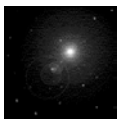
Collision Free Protocols

- The Adaptive Tree Walk

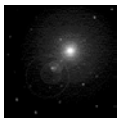




- NASA Fellowship
- Space Networking..



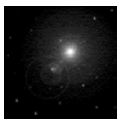
Example Real Protocol
Ethernet (IEEE 802.3)

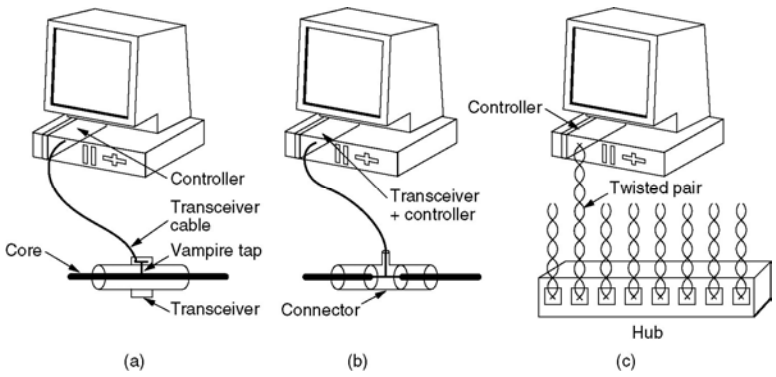


- Cabling:

Name	Cable	Max. segment	Nodes/seg.	Advantages
10Base5	Thick coax	500 m	100	Good for backbones
10Base2	Thin coax	200 m	30	Cheapest system
10Base-T	Twisted pair	100 m	1024	Easy maintenance
10Base-F	Fiber optics	2000 m	1024	Best between buildings

Various Cabling Modes





Ethernet (IEEE 802.3)

- Cable Topology

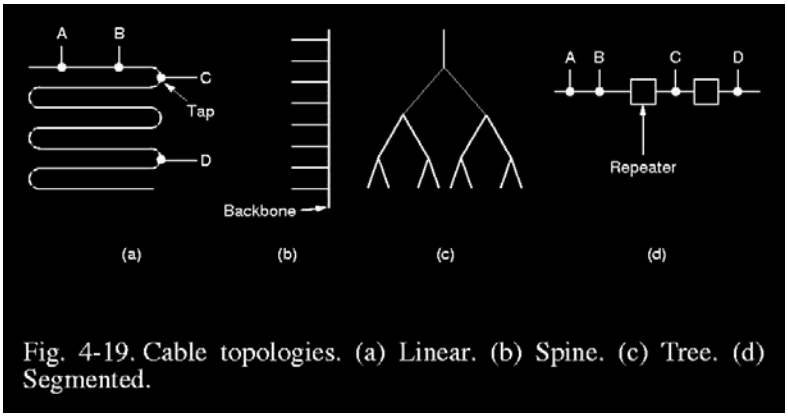
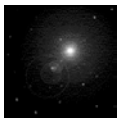
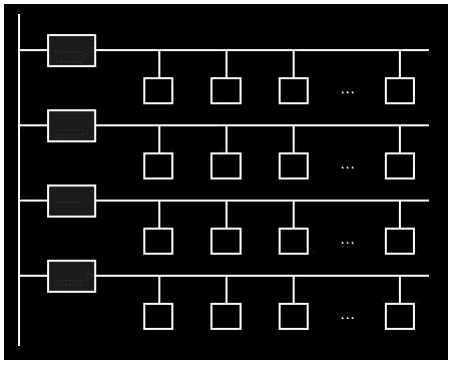


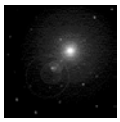
Fig. 4-19. Cable topologies. (a) Linear. (b) Spine. (c) Tree. (d) Segmented.



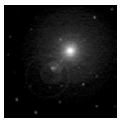
Extension

- Repeaters



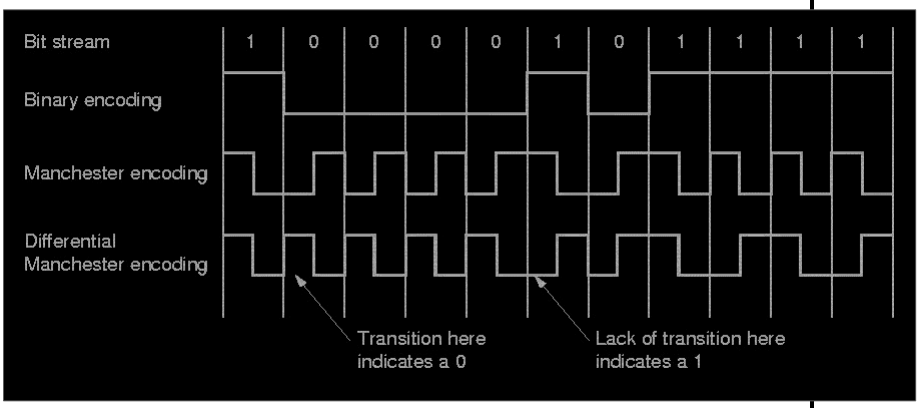


Encoding

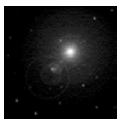


COMPUTER COMMUNICATION NETWORK

- Manchester Encoding

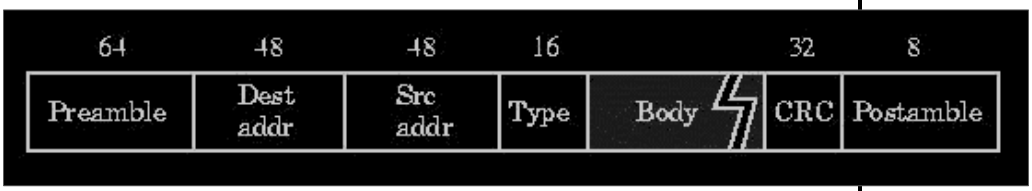


Frames

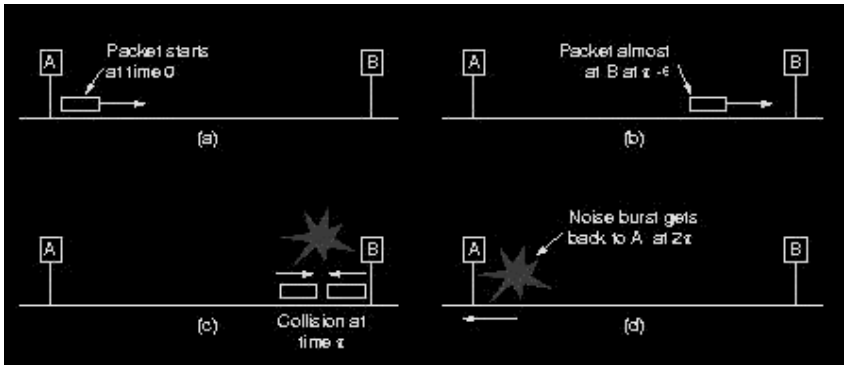


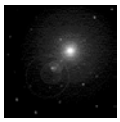
COMPUTER COMMUNICATION NETWORK

- 32-bit CRC is used for error checking



Collision Detection

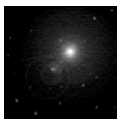




COMPUTER COMMUNICATION NETWORK

Binary Exponential Back-off

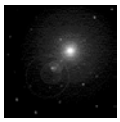
- Idea:
  - after each collision, each station waits either 0 or 1 timeslot before trying again.
  - If these is again collision, the stations picks 0,1,2 or 3, wand waits that many time slot before re transmitting.



COMPUTER COMMUNICATION NETWORK

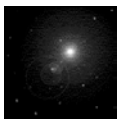
Channel Efficiency

- Probability of transmission for one station= p
- Probability of transmission in one slot =A
- Duration of a slot = 2 lambda
- Mean frame duration =P
- Frame length = F
- Network bandwidth= B
- Cable length=L



How many times a station have to try?

- Let p is the probability that one station acquires the channel. The probability that any one of the k stations acquires the channel in a slot is: $A = k.p.(1-p)^{k-1}$
- A is maximized when: $p_0 = 1/k, \quad A \to 1/e, \quad k \to \infty$
- The probability that it requires exactly j slots is: $A(1-A)^{j-1}$
- The average number of slots per contention is: $\sum_{j=0}^{\infty} j.A.(1-A)^{j-1} = 1/A$
- Channel Efficiency = $\eta = \frac{P}{P + \frac{2\lambda}{A}} = \frac{1}{1 + 2BLe/cF}$



Channel Efficiency of 802.3 10 Mbps with 512-bit slot time