Media Access Control

- In telephone systems
  - Point-to-point connection
  - Allocation of network resources done entirely by the switch control
  - Users have no direct input to the decision process
  - Users have no direct access to the ‘transmission media’

Media Access Control

- MAC protocols give the users:
  - direct access to the media
  - control over resource allocation
  - typically broadcast (real or virtual)

Media Access Control

- Examples
  - Ethernet
  - Token Ring
  - Token Bus
  - FDDI (CDDI)
  - LATM

Media Access Control

- Advantages
  - High data rates (open new applications)
  - Low cost
  - Local organizational control
  - Enable sharing of resources
    - Disks
    - Printers

Media Access Control

- MAC protocols establish a set of rules that govern who gets to use the shared transmission media in an efficient manner.
- Obstacle to perfect channel utilization
  - Finite propagation delay means that each users' knowledge of the state of the system is imperfect and thus they can not perfectly schedule transmissions, i.e., some time will be wasted attempting to learn the state of the system and/or learning the fate of transmissions.

Alternative Media Access Control Strategies

- Static Allocation
  - FDM
  - TDM
- Problems
  - Management; not easy to add users
  - Wasteful in resources
- Example
  - A transmission media has a rate of 10 Mb/s and supports 50 users. The system uses static allocation. A user has a 1 Mbyte file to transmit. The file transfer time is:

$$\frac{1x10^{6}\, x8bit}{\dfrac{10^{7} bits / \sec}{50}} = 40 \sec$$

Alternative Media Access Control Strategies

- Suppose you *send a message* to all the other 49 users saying, '*I need the whole channel for about 1sec, do not use it, please'*

- As long as the overhead incurred in sending the message is less than 39 sec. the user will get better performance.

Alternative Media Access Control Strategies

- Dynamic allocation of resources
  - Deterministic
    - Polling
    - Token Ring
    - Token Bus
  - Advantage: the maximum time between users chances to transmit is bounded. (assuming a limit on the token holding time)
  - Disadvantage: Time is wasted polling other users if they have no data to send.
  - The technology does not scale

Alternative Media Access Control Strategies

- Random Access
- Each node sends date with *limited* coordination between users
  - Total chaos: Send data as soon as ready
  - Limited chaos: Listen before sending data, if the channel is busy do not send.
  - Further Limiting chaos: Listen before sending data, continue listening after sending and if collision with another transmission stop sending.

  [Carrier Sense Multiple Access with Collision Detection **CSMA/CD**]

Alternative Media Access Control Strategies

– Advantage: **Simple**

– Disadvantage:

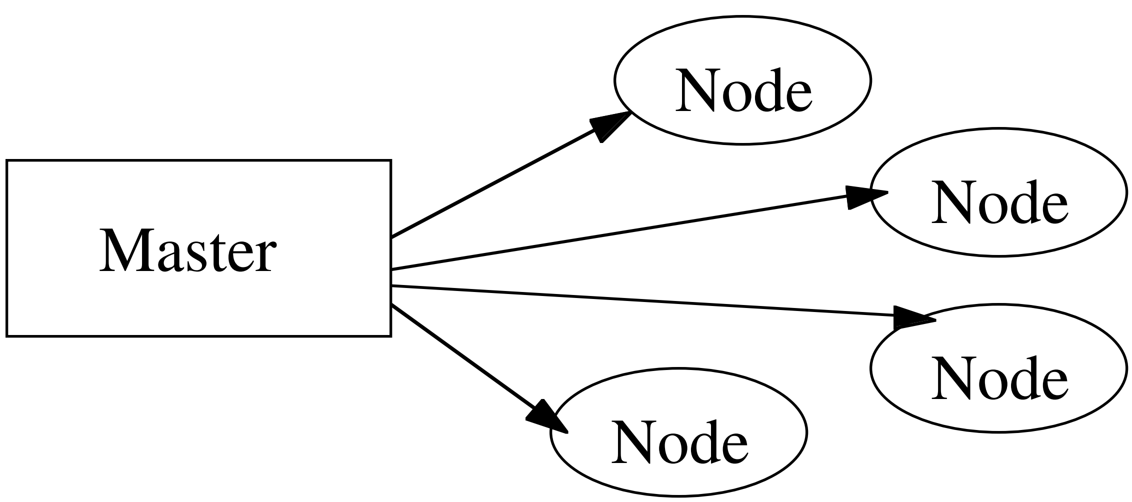
  - No guarantee that you will ever get to send.
  - The technology does not scale

Media Access Control

- Deterministic Protocols
- Random Access Protocols
  - Aloha
  - CSMA
  - CSMA/CD
  - Bitmap
- LAN Standards
  - IEEE 802.3 CSMA/CD
  - IEEE 802.4 Token Bus
  - IEEE 802.5 Token Ring
  - FDDI
  - IEEE 802.6 DQDB
  - LATM
- Issues in satellite and packet radio networks

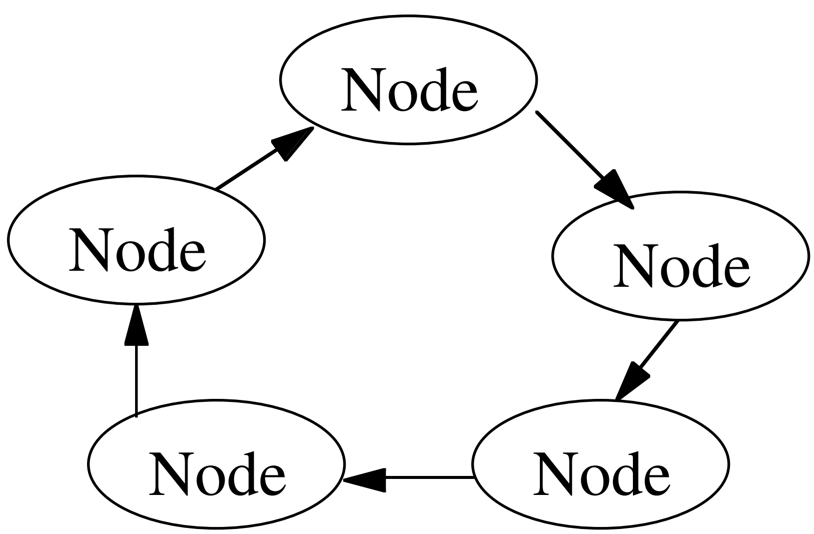
Deterministic Protocols

- Roll Call
  - Master/slave arrangement
  - Master pools each node: Do you have any data to send?
  - If polled node has data, then the data is sent, else the next node is polled



Deterministic Protocols

- Hub Polling
  - No Master station
  - Each node polls next node in turn



Random Access Protocols

- Assumption
  - Overlap in time and space of two or more transmissions causes a collision and the destruction of all packets involved.
  - [No capture effects]
  - One channel
  - For analysis no station buffering
  - Time
    - Synchronization between users (Slotted time)
    - No synchronization between users (unsloted time)
  - Knowledge of the channel state
    - Carrier sensing
    - Collision detection

Random Access Protocols Strategies

- Aloha
  - No coordination between users
  - Send a PDU, wait for acknowledgment,

    if no acknowledgment then **backoff** and retransmit
- Slotted Aloha
  - Same as Aloha only time is slotted

Random Access Protocols Strategies

- *p*-persistent CSMA
  - Listen to channel, on transistion from busy to idle transmit with probability *p*
  - After sending the PDU, wait for acknowledgment,

    if no acknowledgment then **backoff** and retransmit
    - Non-persistent, if channel busy then reschedule transmission
    - 1-persistent, Transmit as soon as idle
- CSMA/CD
  - 1-persistent but continue to sense the channel, if collision detected then stop transmission.

Limitations on Random Access Protocols

- Distance
- Speed

Random Access Protocols

Analysis of Aloha

- Description
  - Packet of length L (sec) arrives at station i
    - Station i transmits immediately
    - Station i starts an acknowledgment timer
  - If no other station transmits while i is transmitting then **success**
  - Else a collision occurred
  - Stations i learns that a collision occurred if the acknowledgment timer fires before the acknowledgment arrives

Random Access Protocols

Analysis of Aloha

- If collision detected then station i retransmitts at a later time, this time is pseudo-ramdom and is determined by a **backoff** algorithm

- Design Issue:
  - Determine the maximum normalized throughput for an Aloha system

Random Access Protocols

Analysis of Aloha

Assumptions

1. λ = Average number of new message arrivals to the system
2. Λ = Average number arrivals to the system, i.e., new arrivals + retransmissions
3. The total arrival process is Poisson

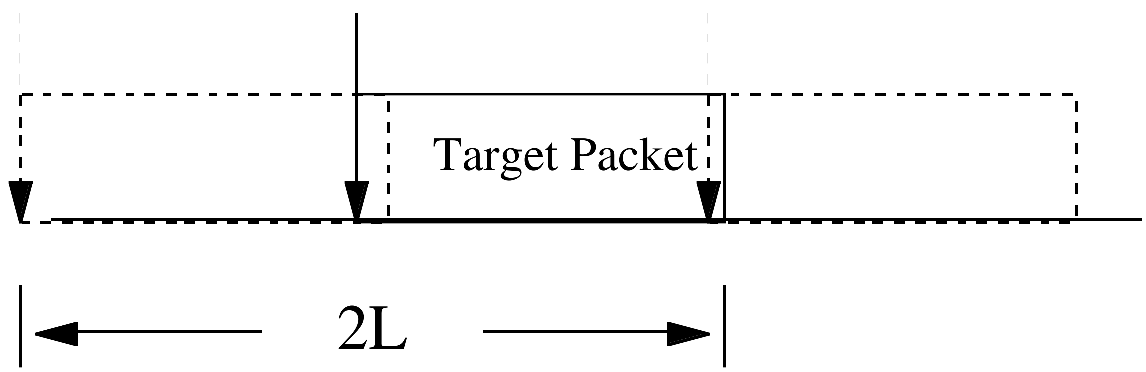
$$S = \lambda L \leq 1$$

$$S = \text{throughput}$$

Random Access Protocols

Analysis of Aloha

Collision Mechanism



Target packet is vulnerable to collision for 2L Sec.

Random Access Protocols
Analysis of Aloha

Probability of Collision $= 1 -$ Prob[no arrivals in 2L sec]

$$= 1 - e^{-2L\Lambda}$$

But

$\Lambda = \lambda + \Lambda(1 - e^{-2L\Lambda})$

Let

$G = \Lambda L =$ Offered load $(S = \lambda L)$

Then

$G = S + G(1 - e^{-2L\Lambda})$ or $S = Ge^{-2L\Lambda}$

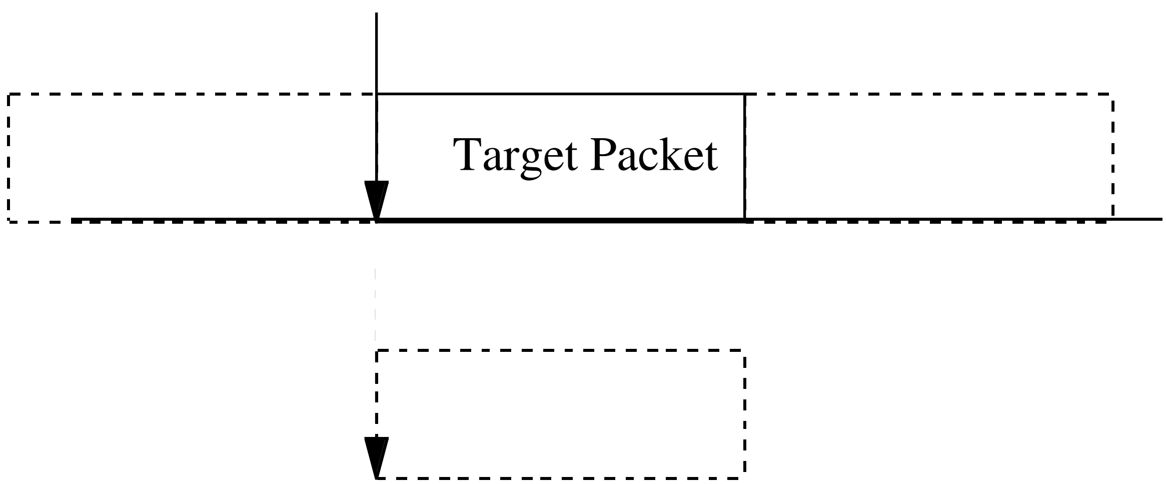
Find S_{max}

$\frac{dS}{dG} = 0$ when $G = \frac{1}{2}$ or $S_{max} = \frac{1}{2e} = 0.18$

The Maximum throughput for Aloha is 18%

Random Access Protocols

Analysis of Slotted Aloha



Synchronization reduces the vulnerable period from 2L to L so the maximum throughput is increases to 36%

Random Access Protocols

Delay Analysis of Aloha

Let

τ_{ack} = acknowledgment time

T_b = backoff time

N_r = Average number of retransmissions

T = Average delay

Assume $T_b \sim U[1, K_b]$

$$\frac{T}{L} = \frac{\tau_{ack}}{L} + 1 + N_r\left(\frac{\tau_{ack}}{L} + \frac{K_b + 1}{2}\right)$$

with

$$N_r = \frac{G}{S} - 1 = e^{2G} - 1$$

Random Access Protocols

CSMA Protocols

- Listen to the channel before transmitting to reduce the vulnerable period
- Let D = maximum distance between nodes
- Let R = the transmission rate (b/s)
- Let c = speed of light = 3×10^8 m/s
- The end-to-end propagation time = D/kc

  k is a constant for the physical media:

  k = .66 for fiber, k=.88 for coax

Random Access Protocols

CSMA Protocols

- Assume node A transmits at time t and node B at $t - x$, where x--> 0

  (That is, Node B transmits right before it hears A)

- If after 2D/kc sec. no collision occurred, then none will occur
- Let a= (D/kc)/L = normalized length of the bus
- Remember L = (Packet Length [bits])/R [b/s]
- As a --> 1, CSMA --> Aloha

Random Access Protocols
CSMA Protocols

- Limits on *a*
  - Want *a* small to keep vulnerable period short
    - Short bus
    - Lower speeds
    - Long packets
      - Minimum packet length to keep *a* large
      - Maximum packet length to be fair

Random Access Protocols
CSMA Protocols

- Example: Ethernet
  - Rate = 10 Mb/s
  - Minimum packet size = 512 bits
  - Maximum packet size = 12144 bits
  - D (max per segment) = 500 m
- Trends
  - Increase D performance degrades
  - Increase R performance degrades
  - a --> [0.001, 0.03]
- CSMA networks do not scale

Random Access Protocols

CSMA Protocols

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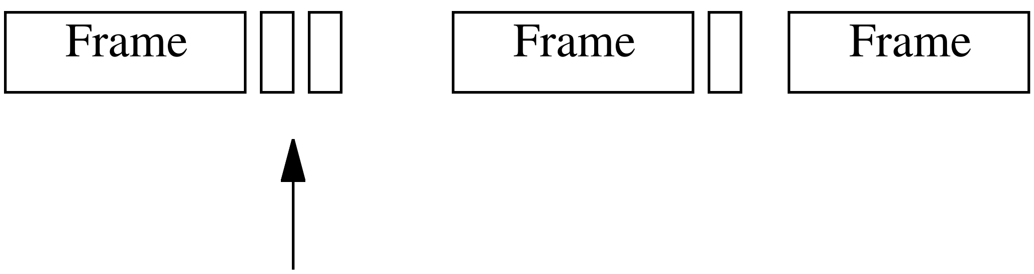

Contention slots

States of a Random Access Systems

- Idle
- Contention
- Successful Transmission