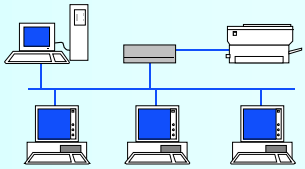


Distributed Systems
600.437
Basic Communication Protocols

Department of Computer Science
The Johns Hopkins University

Information Slide

- Code material is available on the CS undergrad lab machines (hops, barley, ugrad1..n) in the directory ~cs437/tutorials/
- A new web page of reference material and programming documentation is available at http://www.cnds.jhu.edu/courses/cs437/ref.html
- Lecture slides can be obtained at the course web page http://www.cnds.jhu.edu/courses/cs437 or at http://www.cs.jhu.edu/~yairamir
- Next Monday we will talk about material that is available at ~cs437/tutorials/week2 on hops, and hand out the first programming exercise.

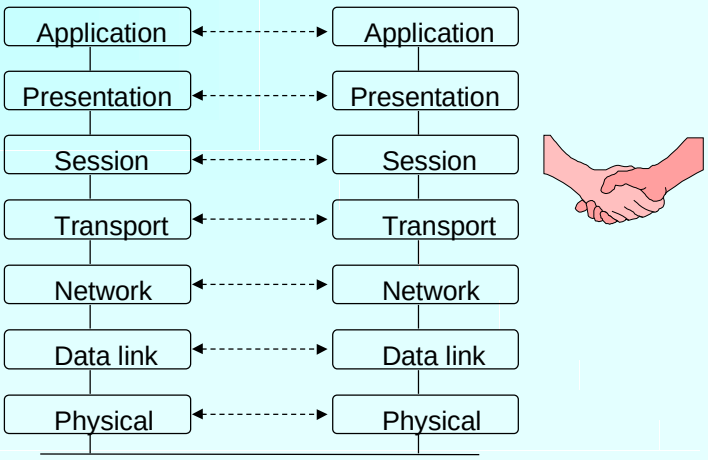
Basic Communication Protocols

Lecture 2

Further reading: Data Networks (2nd edition),
D. Bertsekas and R. Gallager,
Prentice-Hall.

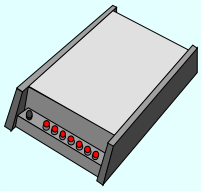
Internetworking with TCP/IP
Volume I, 3rd edition
D. E. Comer

Open Systems Interconnection Model (OSI)



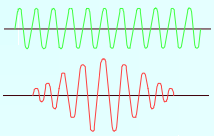
The Physical Layer

Provides: Unreliable bit pipe.



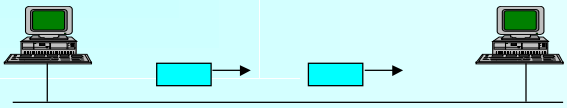
Timing:

- Synchronous.
- Intermittent synchronous.
- Asynchronous.



The Data-Link Layer

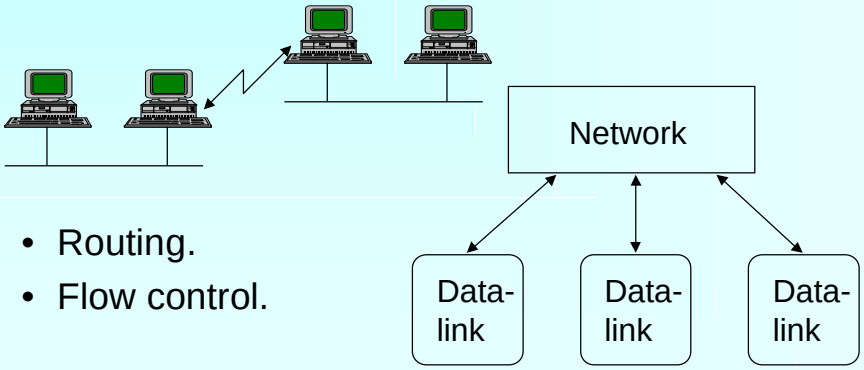
Provides: Direct link for reliable packets.



- Packet boundaries.
- Error detection and correction in packets
- Data-link control (omission free)
- Media access control

The Network Layer

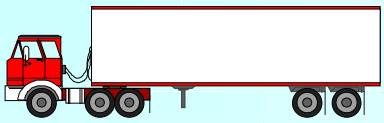
Provides: End-to-end link for reliable packets.



- Routing.
- Flow control.

The Transport Layer

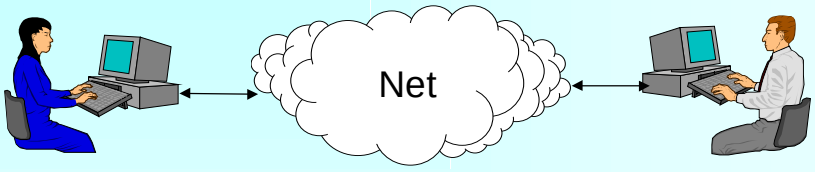
Provides: End-to-end link for messages.



- Break and reassemble packets-messages.
- Flow control.
- Internetworking (gateways).

The Session Layer

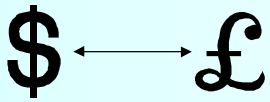
Provides: Virtual session.



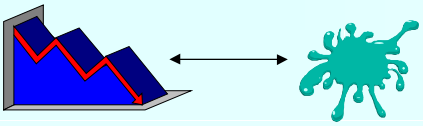
- Name service, directory.
- From the processor to the process.
- Access rights.
- Billing.

The Presentation Layer

Provides: Virtual network service.



- Conversion (ASCII-EBCDIC, floats, endian issues, etc.)
- Compression.
- Encryption.



Automatic Repeat reQuest (ARQ) Protocols.

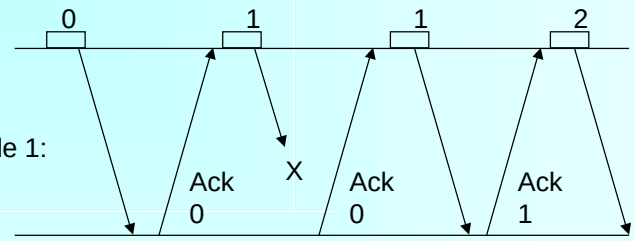
Causes for message omission:

- Buffer spill.
- Error detection in a packet.

ARQ protocols:

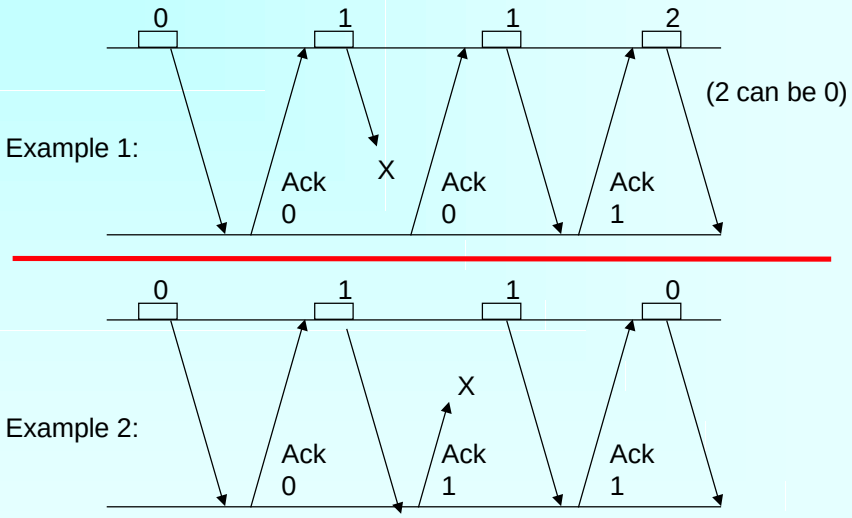
- Send & Wait.
- Arpanet.
- Go back *n*.
- Selective Repeat.

Send & Wait ARQ

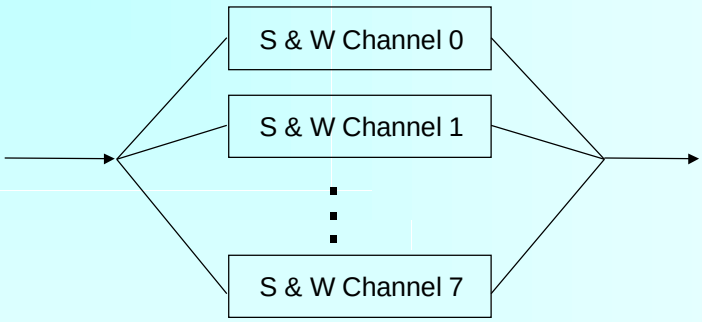


(2 can be 0)

Send & Wait ARQ (cont.)



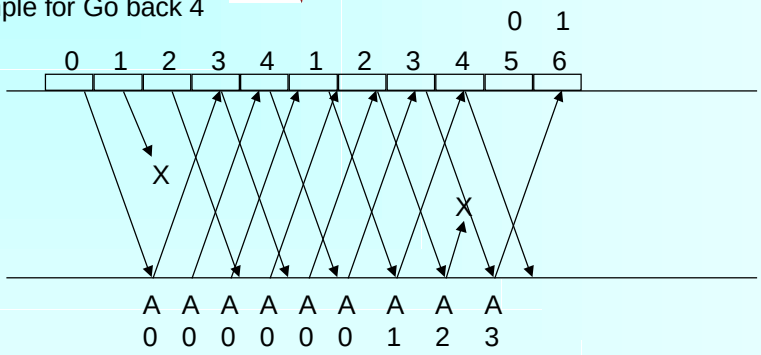
Arpanet ARQ



- Better line utilization than S & W.
- Unlimited memory required in theory.

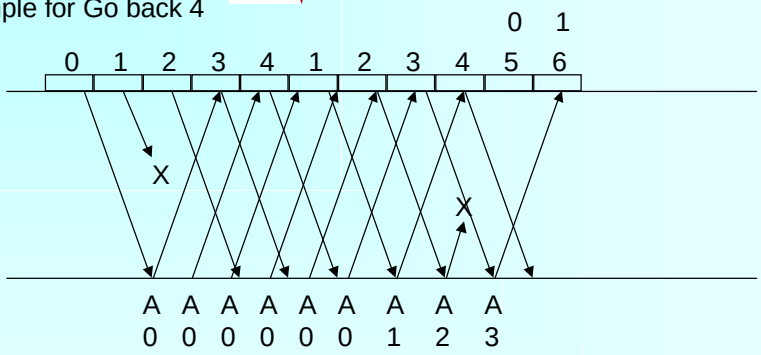
Go back *n* ARQ

Example for Go back 4



Go back *n* ARQ (cont.)

Example for Go back 4

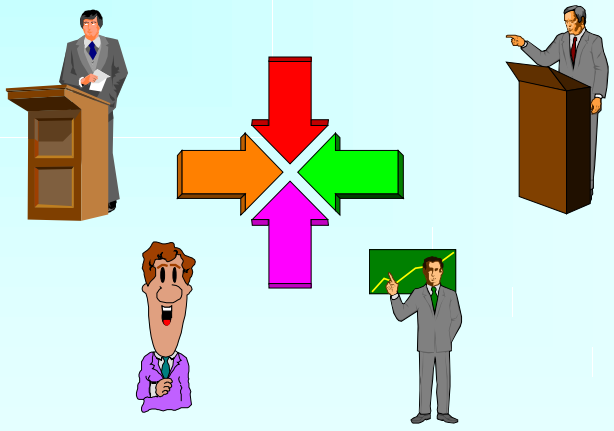


- Good utilization
- limited memory required (one packet only).
- Full window is retransmitted in case of (one) error.

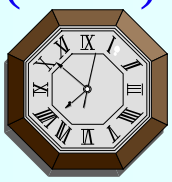
Selective Repeat ARQ

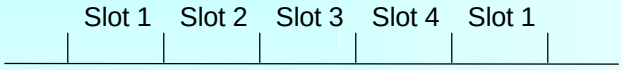
- Combines acks and nacks.
- Sliding window technique (as Go back *n*).
- Specifically indicating which packet is missing.
- Limited memory required (a full window).

Medium Access Control for Multi-access Communication.



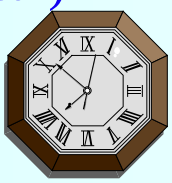
Time Division Multiplexing (TDM)





- The best utilization if everyone always has something to send.
- Wastes time if this is not the case.
- Slots can be unevenly assigned.

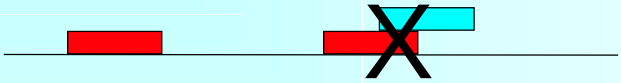
Slotted Aloha (Theoretical)



- Send at the next slot.
- If collision occurs - pick a random waiting time and send again at the next slot.

- Breaks.
- Maximal utilization is 0.36 (but much less for a desired behavior).

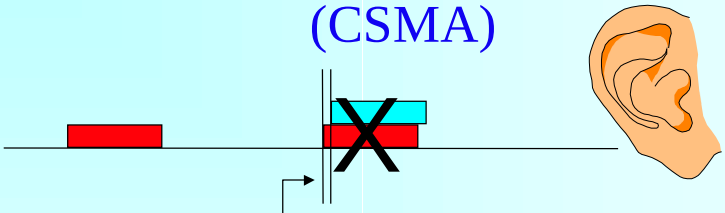
Aloha



- Send immediately.
- If collision occurs - pick a random waiting time and send again at that time.

- Breaks.
- Maximal utilization is 0.18 (but much less for a desired behavior).

Carrier Sense Multiple Access (CSMA)



- Listen to the line. Send if line is free.
- If collision occurs - pick a random waiting time and **try** again at that time.

CSMA/CD

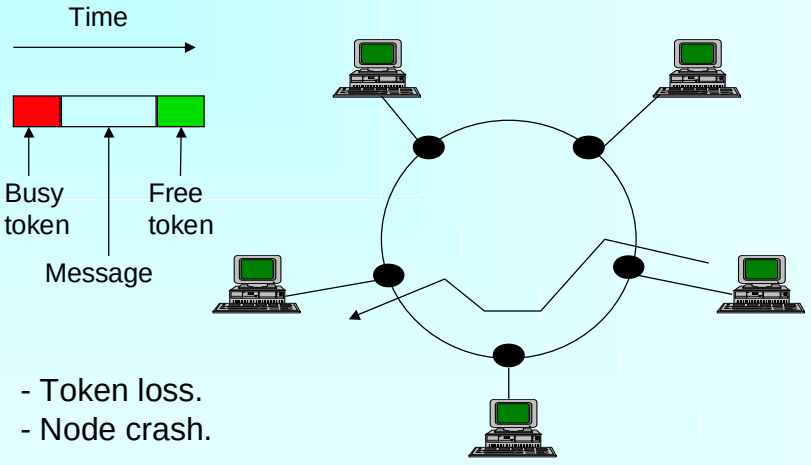
Carrier Sense, Multiple Access with Collision Detection.

Points to clarify:

- Propagation delay.
- X persistent CSMA
- Splitting algorithm for collisions

Ethernet = Persistent CSMA/CD with binary exponential backoff.

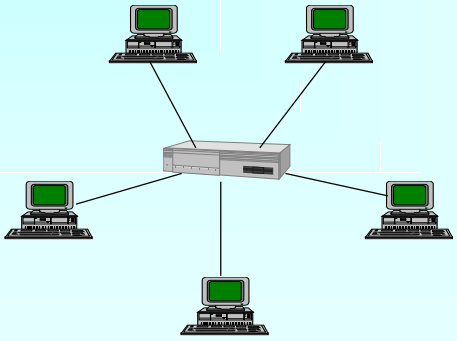
Token Ring



- Token loss.
- Node crash.

A Star Configuration

Can be used to mimic a bus configuration.
e.g. for Ethernet, Fast Ethernet, 1Gig Ethernet
or Token Ring.



Distance Vector Routing

- Each router knows the id of every other router in the network.
- Each router maintains a vector with an entry for every destination that contains:
  - The cost to reach the destination from this router.
  - The direct link that is on that least cost path.
- Each router, periodically sends its vector to his direct neighbors.
- Upon receiving a vector a router updates the local vector based on the direct link's cost and the received vector.

Link State Routing

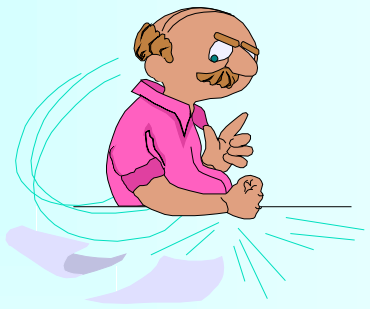
- Each router knows the id of every other router in the network.
- Each router maintains a topology map of the whole network.
- Each router, periodically floods its link state updates (with its direct connectivity information).
- Upon receiving a vector, a router updates the local topology map and re-calculates shortest paths.

Internet Routing

- Routing Information Protocol:
  - **Distance vector protocol.**
  - **Hop count metric**
  - **Exchange is done every 30 seconds, fault detection every 180 seconds.**
  - **Cheap and easy to implement, unstable in the presence of faults.**
- Open Shortest Path First:
  - **Link state protocol.**
  - **Internal hierarchy for better scaling.**
  - **Optimization for broadcast LANs with routers on them. (A designated router represents the whole LAN) - Saves control messages and size.**

Internet Routing (cont).

- A hierarchical routing protocol that connects networks, each of which runs an internal routing protocol.
- RIP or OSPF are common internal protocols.
- BGP - Border Gateway Protocol -
  - **A path vector protocol with additional policy information for each path. Path vector protocols have the complete path in each entry and not only the next direct member.**
  - **Generally used as the hierarchical routing protocol.**

Important Issues

- Flow Control.
- Stability.
- Management.
- (Security).