Flashback:
ICMP

ICMP: Error Messages

- SOURCE QUENCE
  - send by overworked routers to the sources of discarded datagrams.
- TIME EXCEEDED
  - send by router for packets whose TIME TO LIVE filed has expired.
- DESTINATION UNREACHABLE
  - send by routers who could not find forwarding address.
- REDIRECT
  - if a router thinks, not him, but some other router should have received the packet.
- FRAGMENTATION REQUIRED
  - if the fragment as required permission is not given to a router, it can request source to send fragmented datagrams


ICMP: Informational Messages

- ECHO/ REQUEST/REPLY
  - An echo request message can be sent to any ICMP host in a network. It sends replies.
  - Ping!
- ADDRESS MASK REQUEST/REPLY
  - A host, when boots can request for the correct address mask for the network. The router in the network send the correct 32 bit address mask.

ICMP Packets over IP

ICMP Hdr	ICMP Data Area
IP Header	IP Data Area
Frame Header	Frame Data
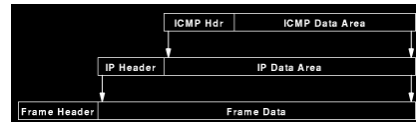
Some Example of ICMP Services

- Ping
  - send a datagram with ICMP echo request.
- Trace a Route
  - send IP packets with TIME TO LIVE set to 1, 2, 3, etc.
- Path MTU Discovery
  - set a FLAG bit in IP messages so that it cannot be fragmented by routers.
  - Send large messages and wait for FRAGMENT REQUIRED ICMP message to come back.
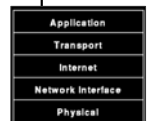 - Do experiment with various data sizes!

- IP- Internet Protocol
  - Addressing Scheme
  - Address Resolution
  - Datagram Forwarding
  - Encapsulation, Fragmentation & Reassembly
- TCP- Transmission Control Protocol
  - Connection startup & shutdown
 - Reliability: ordering, missing data handling

| Application |
| Transport |
| Internet |
| Network Interface |
| Physical |

Transport Layer Protocol

- Datagram service provided by IP is best effort and thus unreliable. For example, IP takes no responsibility if packets are lost, if there are duplicate packets, if a part of the router fails.

- But, many application programs want to assume that when a byte is send it will be delivered correctly at the other end.

- A Transport Protocol such as TCP, UDP, RTP protocol suits bridges this gap.

| Application |
| Transport |
| Internet |
| Network Interface |
| Physical |
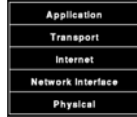
Flashback:
TCP

Why TCP?

- Datagram service provided by IP is best effort and thus unreliable. For example, IP takes no responsibility if packets are lost, if there are duplicate packets, if a part of the router fails.

- But, many application programs want to assume that when a byte is send it will be delivered correctly at the other end.

- TCP layer of TCP/IP protocol suits bridges this gap.
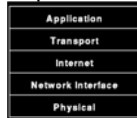
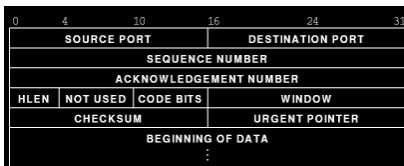| Application |
| Transport |
| Internet |
| Network Interface |
| Physical |

TCP Services

- Connection Orientation
  - application sets up virtual connections.
- Point-to-point Communication
  - each connection has exactly two endpoints.
- Complete Reliability
  - TCP guarantees all bytes will be delivered.
- Full Duplex Communication
  - Data can flow in both direction over connections.
- Stream Interface
  - Byte order is maintained but no records.
- Reliable Connection Startup
  - No interference from earlier connections.
- Graceful Connection Shutdown
  - All sent data will be delivered before shutdown.

TCP provides a completely reliable (no data duplication or loss), connection oriented, full duplex stream transport to applications.

TCP Segment Format

- TCP uses same format for DATA, ACK and 3-way handshake MESSAGES.

0	4	10	16	24	31
SOURCE PORT			DESTINATION PORT		
SEQUENCE NUMBER					
ACKNOWLEDGEMENT NUMBER					
HLEN	NOT USED	CODE BITS	WINDOW		
CHECKSUM			URGENT POINTER		
BEGINNING OF DATA					

TCP Segment Format
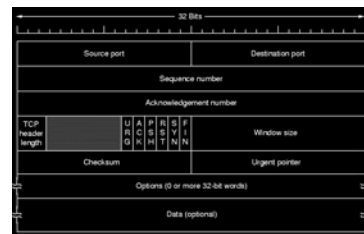
FIN=1 is used for closing a connection.

SYN=1, is used to request a connection

URG=1 if urgent point is in use Urgent pointer is used to request prompt delivery of data at the receiving end.
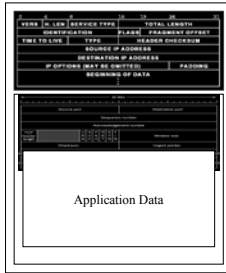
ACK=1 if ack field is valid

PSH=1 to indicate immediate send.

TCP & IP

- The message that travels..

Application Data

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Virtual Connection

- TCP provides a feeling to the applications that a completely reliable connection exists between two applications.
- TCP use IP to carry packets. Each TCP packet is encapsulated into an IP datagram. IP layers do not read inside the TCP packets.

- However, the IP or underlying hardware do not know about the connection.

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Relationship Between TCP and IP
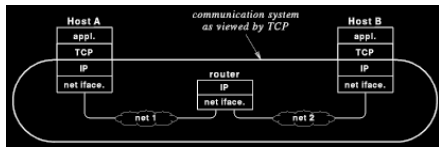
- TCP works at two endpoints.

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Time & Large Scale Network

- What should be a good time out time?

  - Local computers can respond within ms.
  - A satellite connected computer needs about .25min.
  - Use long delay for satellite connections and short for local connections.

What if the time over the same connection varies?

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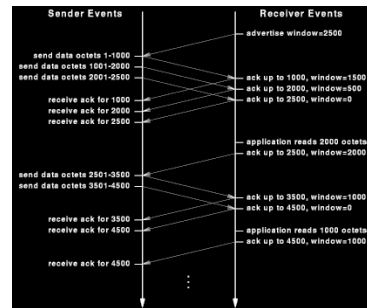
Adaptive Retransmission

- Previous Transport mechanisms used to use a fixed time delay. TCP uses an adaptive scheme.

- TCP monitors the round-trip-time for each communication.

- Measures average delay and variance.

- Sets the times as a weighted sum of average and variance.

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Buffer, Flow Control & Window

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Three Way Handshake

- TCP uses a three way acknowledgement scheme for making sure that connection can be created and gracefully terminated even when there is computer reboots.

Events at Host 1		Events at Host 2
send FIN + ACK	⋮	
		receive FIN + ACK
		send FIN + ACK
receive FIN + ACK		
send ACK		
		receive ACK
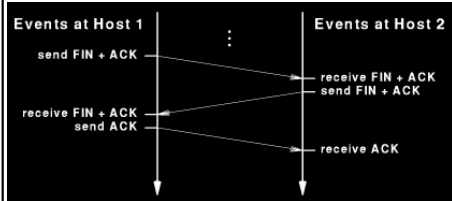
Congestion Control

- Congestion Collapse?
- When a message is lost, TCP assumes congestion!
- It sends one packet at a time even if the receiver advertised large buffer.
- If it receives acknowledgement, only then doubles the data per packet, and sends two additional packets.

- If these are acknowledged, then it sends four more packets..

Next Class:
IPV6
OSPF