

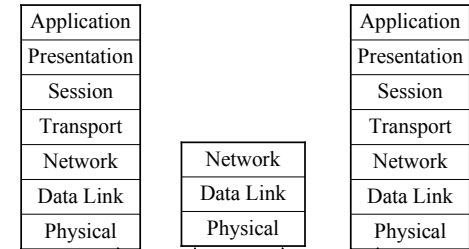
COMP476
Networked Computer Systems

Transport Layer

Transport Layer

- The first, or lowest, end to end layer.
- The transport layer delivers packets to the appropriate application on the host.
- Some transport layer protocols correct transmission errors.
- There are several popular transport layer protocols including TCP and UDP.

Intermediate Nodes



Internet Port Numbers

- Applications are identified by a 16 bit integer number known as a port number.
- Internet ports do **NOT** refer to plugs in the back of the machine.
- The full address of an application is
`InternetName:port`
- Applications bind to a port number to receive data sent to that port.

Well Known Ports

- Port numbers under 2K are reserved for specific “well known” application servers
 - 21 ftp
 - 23 telnet
 - 79 finger
 - 80 HTTP web servers
 - 443 HTTPS secure web servers
 - 17 Quote of the Day

Lesser Known Ports

- Well Known Ports are only used by servers.
- Servers for non-standard applications use higher numbered ports.
- Applications accessing a server use a higher numbered port.
- When a program connects to a remote system, it is automatically assigned a port.

Ports in a URL

- Some web servers, particularly test systems, use a port other than 80.
- The port number follows a colon after the IP name

`http://www.acme.com:4321/file.html`

Multiple Protocols

- There are two major transport layer protocols in the Internet Protocol suite
 - Transmission Control Protocol (TCP)
 - User Datagram Protocol (UDP)
- The different protocols provide different services.

TCP and UDP

TCP	UDP
Connection Oriented	Connectionless
Complete reliability corrects lost, corrupted and out-of-order packets	best effort delivery
Full Duplex communication	Full Duplex communication
Point to Point communication	Point to Point, 1 to many, many to 1, many to many
Stream Interface	Message Oriented
Reliable connection startup	no connection

Popular TCP Applications

- HTTP - web protocol
- telnet - terminal protocol
- ftp - file transfer protocol
- any program that has lengthy transfers that require reliability.

Popular UDP Applications

- DNS requests
- WINS requests
- Streaming Audio
- Any application that needs to send a short amount of data that can be resent if necessary (*idempotent or at-least-once*).
- Time critical applications

Connection Oriented

- A program using TCP must connect to the remote host before sending any data.
- Connection verifies ability to communicate with the destination.
- To establish a connection, TCP sends:
 - message to the server requesting a connection.
 - Response from server accepting connection.
 - Message to the server specifying parameters.

Error Correction

- TCP corrects lost, corrupted, delayed and out-of-order packets.
- Applications do not have to worry about the transmission reliability.
- Data is delivered exactly as it was sent.
- UDP does not correct any errors. Higher level software must recover from problems.
- UDP is far more efficient than TCP.

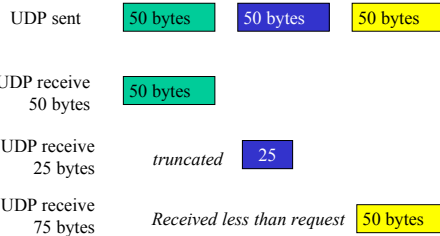
Point to Point Communications

- TCP connects one sender to one receiver.
- All data sent over a TCP connection goes to the same receiving application.
- TCP connections do not support broadcasts.
- Connections are full duplex allowing communication in both directions.

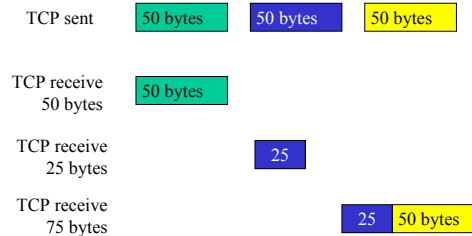
Arbitrary Communications

- UDP does not require a connection.
- A program using UDP can send or receive messages to and from any other system.
- A program can broadcast messages using the IP address 255.255.255.255
- UDP programs can receive broadcasts.

Packet Interface



Stream Interface



TCP Header

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

UDP Header

Source Port	Destination Port
Message Length	Checksum
Data	

The checksum is optional. It can be set to zero to omit error checking.