1) The four sources of packet delay and the key factor(s) that affect each. (Section 1.4.1)

dnodal = dproc + dqueue + dtrans + dprop

processing delay, queuing delay, transmission delay, propagation delay

Processing delay: determine output link, check for bit errors

Key factors: time required to examine packet’s header and determine where to direct the packet (time required to determine output link), time required to check for bit errors

Queuing delay: waiting at output link for transmission

Key factors: number of earlier arriving packets that are queued and waiting for transmission onto the link (congestion level of router)

Transmission delay: push (transmit) all of the packet’s bits onto the link

Key factors: length of packet, transmission rate of link, L/R

(packet length(bits)) / (Link bandwidth(bps))

Propagation delay: propagate from beginning of link to receiving router

Key factors: length of physical link, propagation speed, d/s

Propagation speed: 2 x 10^8 m/s, about the speed of light

(length of physical link) / (speed (2x10^8 ))

2) The name and function of each layer in the IP stack. (Section 1.5.1)

Application layer: Network applications and their application layer protocols

Function: allows applications in one end system to exchange packets of information (messages) with applications in another end system -FTP, SMTP, HTTP

Transport layer: process to process data transfer

Function: transports application layer messages between application endpoints

TCP, UDP

Transport layer packet: segment

Network layer: routing of network layer packets (datagrams) from source to destination

Function: move datagrams from one host to another -Transport layer segment and destination address passed to network layer

IP protocol: defines fields in the datagram and how end systems and routers act on these fields

Routing protocols: determine the routes that datagrams take between sources and destinations

Only one IP protocol, but many routing protocols

Link layer: data transfer between neighboring network elements

Function: move a packet from one node (host or router) to the next node in the route

Ethernet, 802.11 (WiFi), PPP (Point to Point Protocol)

Link layer packet: frame

Physical layer: bits “on the wire”

Function: move individual bits within the frame from one node to the next

Different protocols for twisted pair, coaxial cable, fiber optics (bits moved across link in different ways)

3) Define IP address, socket, and protocol, and describe their role in process communications. (Sections 1.1.3, 1.5.2, 2.1.2)

-IP address: A quantity that uniquely identifies a host

Role: uniquely identifies a host

Socket: A software interface that a process uses to send messages into, and receive messages from, the network

Role: Identifies a process on a host (using a port number), as many processes can be running on same host

Process sends/receives messages to/from its socket

Protocol: defines the format and order of messages exchanged between communicating entities, as well as the actions taken on the transmission and/or receipt of a message or other event

Role: Governs all activity in the Internet involving communication between remote entities

Different protocols are used to accomplish different communication tasks

4) The three primary protocols used for email. (Section 2.3)

SMTP (simple mail transfer protocol): has a user agent(mail reader like outlook) and a mail servers which has a mailbox which contains incoming message, message queue of outgoing (to be sent) mail messages, and SMTP

protocol client: sending mail server: receiving mail server

SMTP uses persistent connections and has multiple objects sent in multipart message

SMTP: push

IMAP (Internet Mail Access Protocol): more features, including manipulation of stored messages on server

Keeps all messages in one place: at server and allows user to organize messages in folders while keeping user state cross session

Stateful and can be used as a mail access protocol retrieve mail from servers

POP (Post Office Protocol): authorization, download is stateless and can be used as a mail access protocol retrieve mail from servers

5) Dedicated and shared access networks as discussed. (Section 1.2.1)

6) FDM and TDM. (Section 1.3.2)

Circuit switching: dedicated resources (FDM and TDM), guaranteed performance, circuit segment idle if not used, used in traditional telephone networks

FDM (Frequency Division Multiplexing): frequency divided among users, users get a little bit of the bandwidth all the time

TDM (Time Division Multiplexing): time divided among users, users get all the bandwidth a little bit of the time

Packet switching: allows more users on network, great for bursty data, no call setup, shared resources

7) Throughput vs. bandwidth. (Section 1.4.4)

Throughput: rate at which bits transferred between sender and receiver

Bandwidth: the width of a frequency band that a link dedicates for a connection

8) HTTP (non-persistent and persistent). (Section 2.2.2)

HTTP (Hypertext Transfer Protocol)

Non persistent: one object sent over TCP connection, connection is then closed, downloading multiple objects require multiple connections

Persistent: multiple objects can be sent over single TCP connection between client and server

HTTP is stateless, server maintains no information about past client requests

Cookie file kept on user’s host, managed by browser, identifies users

9) Web caching and its benefits. (Section 2.2.5)

Web cache (proxy server): between client and origin server, satisfies HTTP requests on origin server’s behalf, keeps copies of recently requested objects in storage.

If client requests object that is cached, web cache returns object instead of origin server

Both a server and a client, used by ISP

Reduce response time for client request

Reduce traffic on an institution’s access link