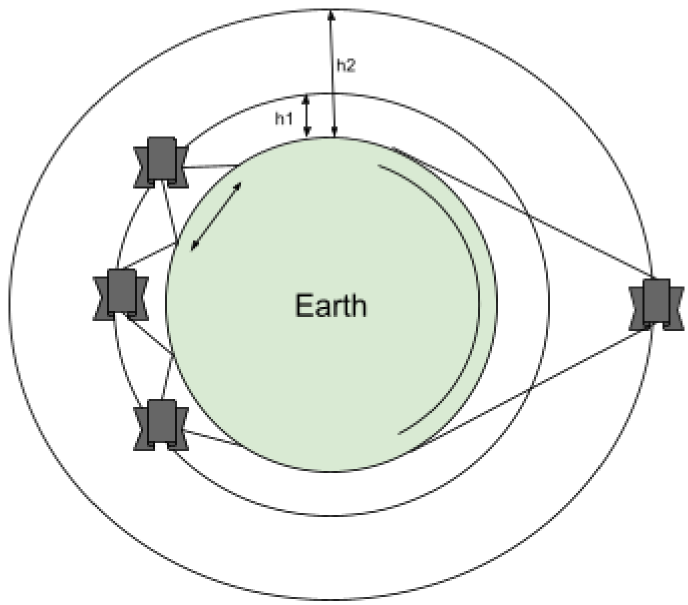
ECS 152A Spring 2022 Computer Networks

Quiz 1 Solution

Question 1: Describe in your own words and using a diagram the main challenge of setting up satellite internet connectivity.

Diagram:



Expected Points:

1. Satellites closer to Earth (let's say at height h1) has lower coverage as compared to Satellites that are installed a bit far (let's say h2)
2. Signals from Satellites closer to Earth have to travel smaller distances and hence lower latencies *or* high-speed internet connections.
3. If satellites are installed closer to earth, to connect the entire earth, a large number of satellites would be required. Hence, results in high installation cost.

Question 2: List two internet access technologies and compare their potential to provide better performance.

Listing any 2 internet access technologies correctly:
Dial-up, Hardwired Broadband, Wireless Broadband Access
DSL, Cable, FTTH/Fiber, Dial-Up, Satellite, Ethernet, WiFi, 3G, LTE, etc.

Listing any 2 valid performance benefits per access technology.

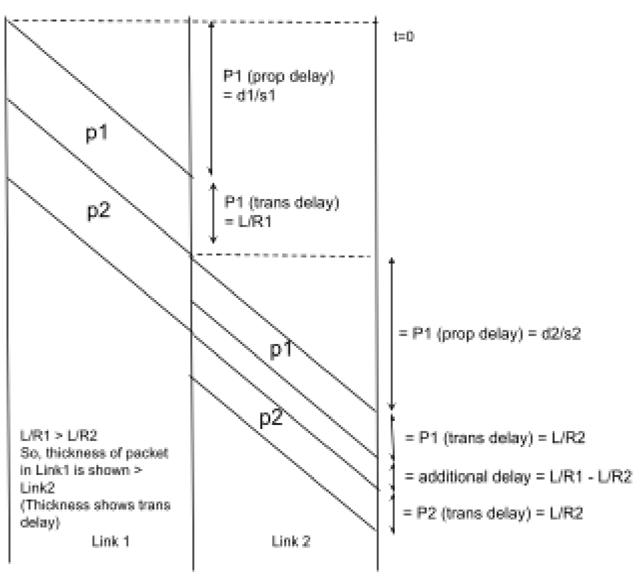
Quiz 2 Solution

1. **Suppose there is exactly one switch between a sending host and a receiving host. The transmission rates between the sending host and the switch and between the switch and the receiving host are R_1 and R_2, respectively. The link connecting the sending host to the switch and the link connecting the switch to the receiving host have lengths d_1 and d_2 respectively and propagation speeds as s_1 and s_2 respectively. Assuming that the switch uses store-and-forward packet switching, what is the total end-to-end delay to send *two* packets of length *L each* from sender to receiver completely? (Only consider transmission delay and propagation delay. Ignore queuing and processing delays.)**

   The transmission delay of Packet in first Link = L/R1 (for both packets)
   The transmission delay of Packet in second Link = L/R2 (for both packets)
   The Propagation delay of Packet in first Link = d1/s1 (for both packets)
   The Propagation delay of Packet in second Link = d2/s2 (for both packets)

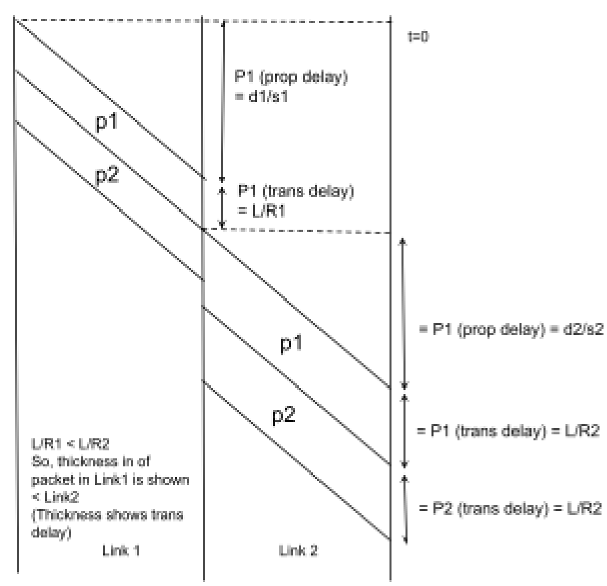
   Since packets are stored before transmitting and are sent one after the other, propagation delay of one link being less or more than the other link will not make a difference in contribution to the overall delay. The bottleneck will be if transmission delay of one link is less or more than the other. If you carefully note, in addition to the total time taken by packet 1, the total time to receive both the packets will just be affected by how much additional time is taken to transmit the second packet either at link 1 or at link 2. So, let's look at the following two cases (here horizontal direction represents transfer of packets and vertical direction shows progression of time):

Case 1: R1 < R2



Total delay = $\frac{2*L}{R1} + \frac{L}{R2} + \frac{d1}{s1} + \frac{d2}{s2}$

Case 2: R1 > R2



Total delay = $\frac{2*L}{R2} + \frac{L}{R1} + \frac{d1}{s1} + \frac{d2}{s2}$

2. **Consider two hosts, A and B, connected by a single link of rate R bps. Suppose that the two hosts are separated by m meters, and suppose the propagation speed along the link is s meters/sec. Host A wants to send a packet of size L bits to Host B. Suppose $s = 10^8$ meters/second, L = 12,000 bits, and R = 120 kbps (kilo-bits-per-second). Find the distance m such that d_{prop} (propagation delay) equals d_{trans} (transmission delay). Show your work.**

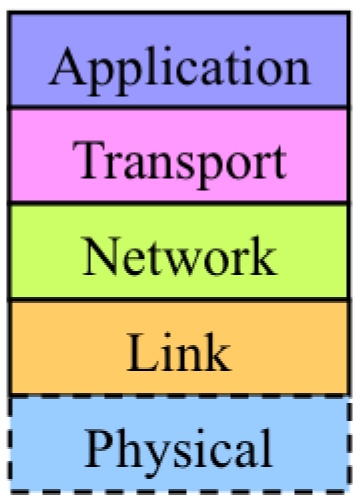
$d_{prop} = m / s$
$d_{trans} = L / R$

If $d_{prop} = d_{trans}$ then,
$(m / s) = (L / R) \Rightarrow m = (sL / R)$
$m = 10^7$ meters = 10,000 km

3. **Answer the following questions with respect to the Internet protocol stack.**

a. Draw the Internet protocol stack.
b. Name the highest layer of the Internet protocol stack implemented by a router. List any one protocol implemented at this layer.
c. Name the layer that deals with port numbers. List any one protocol implemented at this layer.

a) Showing the below diagram



b) Network layer - IP, ICMP, ARP, RIP
c) Transport layer - TCP, UDP, FCP, DCCP

Quiz 3 Solution

1. **Suppose there are 5 client-server pairs. Let R_s, R_c and R denote the capacity of server links, client links, and the shared network link respectively. Assume that all of the 5 client-server pairs (i.e., one client is connected to one server) are *simultaneously* communicating through the shared link labeled R.**

   What is the throughput for each client-server pair in the following scenarios?

   A) Given N as the number of connections of client-server pairs. Write a general throughput expression in terms of R_s , R_c and R
   B) What is the throughput when R_s = 4 Mbps and R_c = 6 Mbps and R = 15 Mbps
   C) What is the throughput when R_s = 6 Mbps and R_c = 8 Mbps and R = 45 Mbp

   A) $min\left(Rs, \frac{R}{N}, Rc\right)$ (1 point)
   B) $min\left(6, \frac{15}{5}, 4\right) = 3$ (1 point)
   C) $min\left(8, \frac{45}{5}, 6\right) = 6$

2. **If a TCP server were to support *n* simultaneous connections, each from a different client, how many sockets would the TCP server need in total? Why? Draw a diagram to justify your answer.**

   n+1 socket

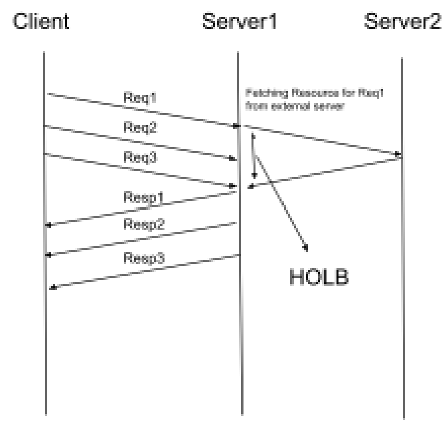
   TCP is connection oriented and requires first for the connection to be set-up between the client and the server. This it does by using a common "Connection/Welcoming Socket". Once 3-way handshake is completed, Server creates and allocates a new data socket specific to a given client for all the future communication.Thus, to support n simultaneous connections, the server would need n+1 socket.

   Diagram:
   Connection socket (n client point to n server socket)
   welcoming socket (n client point to 1 server welcoming socket)

Quiz 4 Solution

1. **Explain the head-of-line blocking problem in HTTP/1 using a diagram?**
    a. **How can the head-of-line blocking problem be mitigated in HTTP/1?**
    b. **How is the head-of-line blocking problem addressed in HTTP/2?**

Diagram



a) Pipelining: The whole batch of requests is submitted to the server for in-order processing.
b) Multiplexing: Issuing multiple new requests using seq. numbers over the same connection without having to wait for the previous ones to complete.

2. **Suppose you open Google.com in your web browser.**
The page load involves following steps:
1. Download the base HTML file from Google's web server.
2. Download the 8 small images referenced in the HTML file. The image files are hosted o the same web server.

Let RTT denote the round trip time between your host and Google's web server. With the assumption that the GET request is sent immediately with ACK such that there is no delay between the two.What is the total Page Load Time (PLT)?
a) without persistent HTTP?
b) with persistent HTTP?

a) For each request, there will be a TCP 3-way handshake (which will take 1 RTT) + Receiving of object (1 RTT).
Since, total there are 9 requests (1 base file + 8 images),
PLT = 9 * 2 = 18 RTT

b) In Persistent, only 1 TCP 3-way handshake is required (i.e., 1 RTT delay) and then for each additional request-response pair, an additional RTT delay.
So, PLT = RTT + 9*RTT = 10 RTT

Quiz 5 Solution

1. (a) Draw a diagram to explain how web caching helps improve web performance? (b) In browser caching, how can a web server inform the web browser if the server does not want the browser to cache a certain object or delete it after a certain period of time?

The Web cache checks to see if it has a copy of the object stored locally. If it does, the Web cache returns the object within an HTTP response message to the client browser. This saves a longer RTT from client to the server as the object is serve from the cache with much lower RTT.

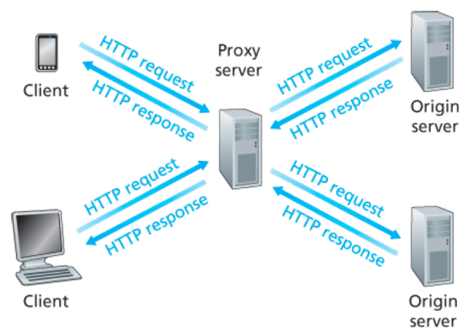


Figure 2.11 Clients requesting objects through a Web cache

The browser inspects the headers of the HTTP response generated by the web server. The header is cache-control. The server can set it to no-cache or expiry can be set to a certain time to force deletion.

2. Draw a diagram to illustrate how two data brokers (say databroker1.com and databroker2.com) circumvent the browser's same origin policy (SOP) to share data with each other on a website (say tmz.com)?

Step 1: Tmz.com will set GET request with to databroker1, which will contain the ID in the request's cookie header (1 point)

Step 2: databroker 1 send back 302 that contain location header that will redirect the browser to databroker2 that contain the id of databroker 1 in the URL as a query parameter. (1 point)

Step 3: Browser sends a get request to databroker2. The URL contains ID of databroker1 and the cookie header in this GET request contains ID of databroker2 (1 point)

SOP is circumvented because the request in step 3 contains databroker1's ID in request URL. URLs are exempt from that. SOP applies to cookie header and not the URL query parameters.

Quiz 6 Solution

1. **How is the Domain Name System (DNS) used for load balancing/distribution?**

   By including multiple IP addresses in the DNS response that are shuffled/rotated across users so different users pick different IP addresses.

2. **Why using a public DNS rather than your local DNS potentially hurt Internet performance? How can this performance issue be fixed in DNS?**

   The authoritative DNS server will return the IP address of the web server close to the DNS resolver/server used by the user. If a user uses a public DNS server that is not geographically close to the user, the DNS response from *authoritative DNS will point the user to the web server that is close to the public DNS server that is not close to the user*. This would result in higher RTT between user and web server, which would increase subsequent page load times.

   This can be mitigated using *EDNS* (aka DNS extension), where the DNS resolver/server used by the user *includes the IP address of the user* (or the IP prefix, i.e., first few bytes of the IP address) in the DNS request to the authoritative DNS server. This way the *authoritative DNS server responds back with the IP address of the web server that is actually close to the user, rather than the DNS resolver/server.*

3. **How is DNS CNAME abused by third-party advertisers or trackers for "cloaking"?**

   Ad tech firms are asking their clients (website publishers) to *delegate a subdomain for data collection and tracking and linking it to an external server using the CNAME DNS record.*

   The website's content and the tracking resources appear to originate from the same first party domain.

   In this way, CNAME Cloaking allows a third-party tracker to disguise itself as a first-party.

Quiz 7 Solution

1. Compare the severity of **timeout** and **duplicate acknowledgement** as congestion signals?

   Timeout signals congestion and results in a reset for congestion window size to initial value. Multiple duplicate ACK results in the congestion window being divided by 2 and stops the exponential increase in the congestion window.

2. Explain why having large buffers in the network can adversely impact the performance of TCP congestion control?

   Large buffer size can result in large queuing delays and added congestion and package drops.

3. Assuming **TCP Reno** is used, answer the following questions. Provide justification for your answers.
   a. Identify the intervals of time when TCP **slow start** and **congestion avoidance** are operating.
   b. After the 16th transmission round, is packet loss detected by a **duplicate ACK** or by a **timeout**?
   c. What is the value of **ssthresh** at the 1st transmission round?

   a. Slow start: [0-6] and [23-26] rounds
   Congestion Avoidance: [6-16] and [17-22] rounds

   b. After the 16th transmission round, packet loss is recognized by a triple duplicate ACK. If there was a timeout, the congestion window size would have dropped to 1.

   c. The ssthresh is initially 32, since it is at this window size that slow start stops and congestion avoidance begins.

Quiz 8 Solution

1. Explain why queueing can occur at a router's input port even though the router's switching fabric is capable of switching packets from multiple input ports at the same time.

   Multiple packets can be transferred in parallel as long as their output ports are different. However, if two packets at the front of two input queues are destined for the same output queued the one of the packets will be blocked and must wait at the input queue as the switching fabric can transfer only one packet to a given output port at a time.

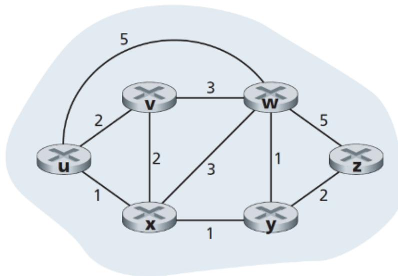
2. Consider the following forwarding table. What is the lookup result of the following packets? Briefly explain your answer. (3 points)

- **Packet 1:** *11001000 00010111 00011000 10101010*
- **Packet 2:** *11001000 00010111 00010110 10100001*
- **Packet 3:** *10001000 00010111 00010110 10100001*

Prefix	Link Interface
11001000 00010111 00010	0
11001000 00010111 00011000	1
11001000 00010111 00011	2
Otherwise	3

Packet 1: 1 Longest prefix matching between 1 and 0
Packet 2 : 0 Prefix matched
Packet 3 : 3 No prefix matched

Run Dijkstra's link-state routing algorithm on the network shown below for source node ***x*.**



Step	N'	D(u), p(u)	D(v), p(v)	D(w), p(w)	D(y), p(y)	D(z), p(z)
1	x	1, x	2, x	3, x	1, x	∞
2	xy	1,x	2, x	2, y		3, y
3	xyu		2, x	2, y		3, y
4	xyuv			2, y		3, y
5	xyuvw					3, y
6	xyuvwz					

OR

Step	N'	D(u), p(u)	D(v), p(v)	D(w), p(w)	D(y), p(y)	D(z), p(z)
1	x	1, x	2, x	3, x	1, x	∞
2	xu		2,x	3, x	1, x	∞
3	xuy		2, x	2, y		3,y
4	xuyv			2, y		3, y
5	xuyvw					3, y
6	xuyvwz					

Quiz 10 Solution

The Internet is a vast network of networks to support communication and exchange of information amongst different parts of the world. The Internet supports a variety of communication protocols implemented as a layered stack that helps sending or receiving messages in a reliable manner between end-to-end hosts.