50.012 Networks (2020 Term 6)

Homework 2

Hand-out: 8 Oct

Due: 20 Oct 23:59

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1. (Adapted from last year's midterm exam question) Consider a browser that wants to retrieve a Web document at a given URL. The IP address of the web server is initially unknown. Name the two application layer protocols used in this scenario and the corresponding underlying transport protocol that each application protocol typically uses. Explain briefly for each application layer protocol, why the specific underlying transport protocol is used.

HTTP and DNS are the two application layer protocol used.

HTTP uses TCP, DNS uses UDP.

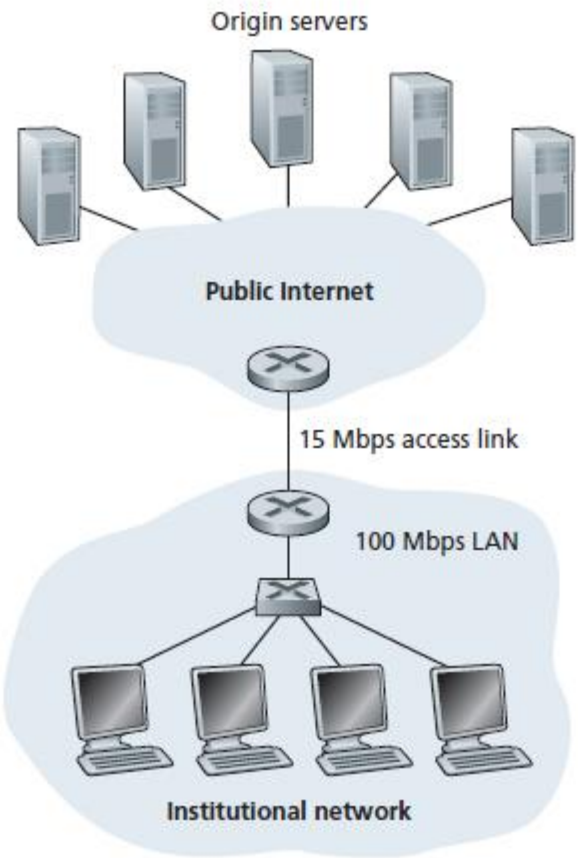
HTTP uses TCP because it needs the guarantees that TCP provides, the three-way handshakes and re-transmissions of lost packets

DNS uses UDP because its fast and requests are usually small. Also, they don't keep connections, hence the load on the servers are less, which is very important.

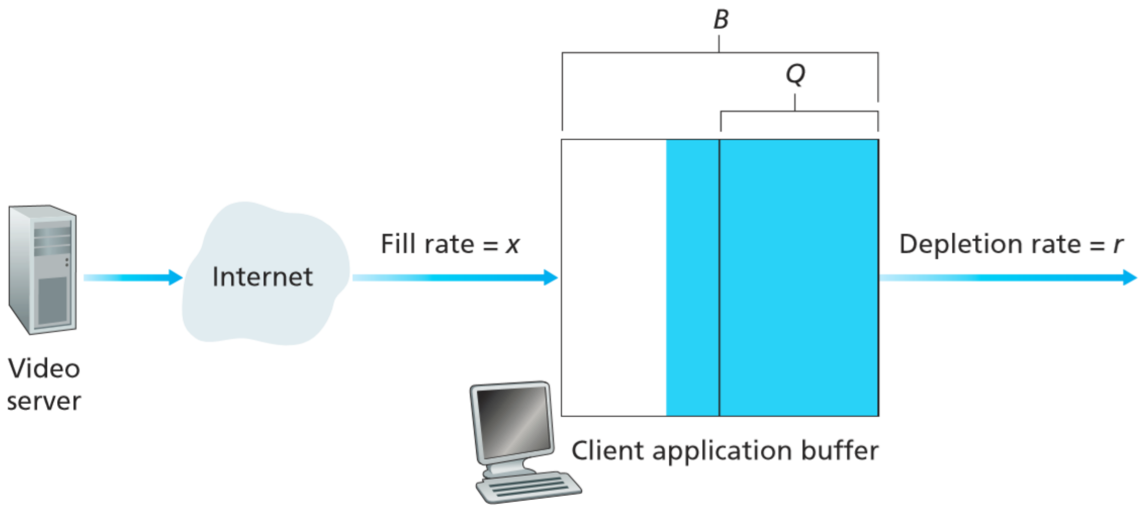
2. (textbook problem chapter 2, problem 9) Consider the Figure below, for which there is an institutional network connected to the Internet. Suppose that the average object size is 850,000 bits and that the average request rate from the institution's browsers to the origin servers is 16 requests per second. Also suppose that the amount of time it takes from when the router on the Internet side of the access link forwards an HTTP request until it receives the response is three seconds on average. Model the total average response time as the sum of the average access delay (that is, the delay from Internet router to institution router) and the average Internet delay. For the average access delay, use $\Delta/(1 - \Delta\beta)$, where Δ is the average time required to send an object over the access link and β is the arrival rate of objects to the access link.

2.1 Find the total average response time. **3.6 seconds**

2.2 Now suppose a cache is installed in the institutional LAN. Suppose the miss rate is 0.4. Find the total average response time under this case (assuming the response time is zero if the request is satisfied by the cache, which happens with probability 0.6). **1.24 seconds**



3. Recall the simple model for HTTP streaming shown in the Figure below. Let B denote the size of the client's application buffer, and let Q denote the number of bits that must be buffered before the client application begins playout. Also, let r denote the video consumption rate. Assume that the server sends bits at a constant rate x whenever the client buffer is not full.



3.1 Suppose that x < r. In this case playout will alternate between periods of continuous playout and periods of freezing. Determine the length of each continuous playout and freezing period as a function of Q, r, and x.

Playout = Q/(r-x) seconds **Freezing = Q/x seconds**

3.2 Now suppose that x > r. At what time does the client application buffer become full?

Q/x + [(B-Q)/(x-r)] seconds

4. (last year's midterm exam question) Consider distributing a file of $F = 6 \times 10^9$ bits to N=100 peers. The server has an upload rate of u_s = 30 Mbps, and each peer has a download rate of d_i = 2 Mbps and an upload rate of u_i=1 Mbps. Assume 1M = 10^6. Calculate the minimum distribution time (i.e., to let every peer have a copy of the file) for:

4.1 the client-server distribution mode, and

4.2 the P2P distribution mode.

F = 6 x 10^9
N = 100
server u = 30 x 10^6
peer d = 2 x 10^6
peer u = 1 x 10^6

4.1: max{20000, 3000}
20000 seconds

4.2: max{200, 3000, 4615.38}
4615 seconds

5. (last year's midterm exam question) Consider data communication over a link of RTT 100ms and transmission bandwidth 1Gbit/s. Assume $1G=10^9$. Consider a pipelined transport protocol that uses ACKs to decide if packets were received successfully. Answer the following three questions:

5.1 After the protocol has sent a packet, what is the minimum amount of time needed for the protocol to infer that the packet was lost? **100ms**

5.2 If the protocol uses a window size of 6 packets (each of size 1000 bytes), what is the maximum achievable data throughput? **60kB/s**

5.3 To fully use the transmission bandwidth, estimate the minimum window size (in bytes) needed.

6. (optional, will not be graded) (textbook problem chapter 2, problem 24) Consider distributing a file of F bits to N peers using a P2P architecture. Assume a fluid model (i.e., a peer can immediately upload a bit it just download, without any delay). For simplicity assume that d_{min} is very large, so that peer download bandwidth is never a bottleneck.

6.1 Suppose that $u_s \leqslant (u_s + u_1 + ... + u_N)/N$. Specify a distribution scheme that has a distribution time of F/u_s. [Hint 1: consider breaking the file into N parts, according to the uploading capability of each peer. Hint 2: define $u = u_1 + u_2 + ... + u_N$ can help simplify your reasoning. Hint 3: you need to ensure each node (server and every peer) transmits according to their uplink rate, and each peer node receives the whole file after F/u_s]

6.2 Suppose that $u_s \geqslant (u_s + u_1 + ... + u_N)/N$. Specify a distribution scheme that has a distribution time of $NF/(u_s + u_1 + ... + u_N)$. [Hint 1: built upon your answer for the sub-question 6.1, and consider breaking the file into N+1 parts, where the more powerful server under this assumption handles the last part. Hint 2 & 3 are the same as above]

6.3 Conclude that the minimum distribution time is in general given by $\max\{F/u_s, NF/(u_s + u_1 + ... + u_N)\}$.