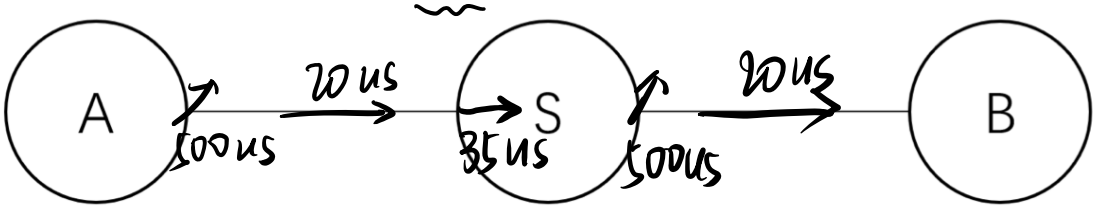
1. Suppose that the network is a circuit-switched network. The circuit setup time under circuit switch is ***s*** sec, the data rate is ***b*** bps, and the propagation delay is ***d*** sec for each hop. Please calculate the delay of sending a packet of ***x*** bits over a k-hop path.

total time = $S + \frac{x}{b} + dk$

↓ set up ↓ transmission time ↓ propagation time


2. Consider the network topology shown below, host A and host B are connected to switch S. Both links are electric cables at 10Mbps raw bandwidth with 20μs propagation delay. S starts to forward the received packet 35μs after receiving.




a) Calculate the delay of transmitting 10000 bits in one packet from host A to host B;

b) Calculate the delay if there are two packets sent one after the other, and each packet has a length of 5000 bits.

a) $t = \left(\frac{10^4 \text{ bits}}{10^7 \text{ bps}} \times 10^6 + 20\right) \times 2 + 35$

$= 2075 \text{ us}$


b) $t = \left(\frac{5000 \text{ bits}}{10^7 \text{ bps}}\right) \times 2 + 20 \text{ us} + 35 \text{ us}$

$+ 500 = 1575 \text{ us}$

3. List six access technologies. Classify each of them as home access, enterprise access, or wide-area mobile access.

1. digital subscriber line (DSL/ADSL): home access
2. cable to HFC : home access
3. cellular mobile access wide-area mobile access
4. wireless access network wide-area mobile access
5. Ethernet enterprise access
6. Dial-up modem: home access

4. List four transport services that an application requires.
   a) For each of the service classes, indicate whether UDP or TCP (or both) can provide such a service.
   b) For e-mail, interactive games, text messaging, present their requirement on the above services (data integrity, throughput, timing and security)

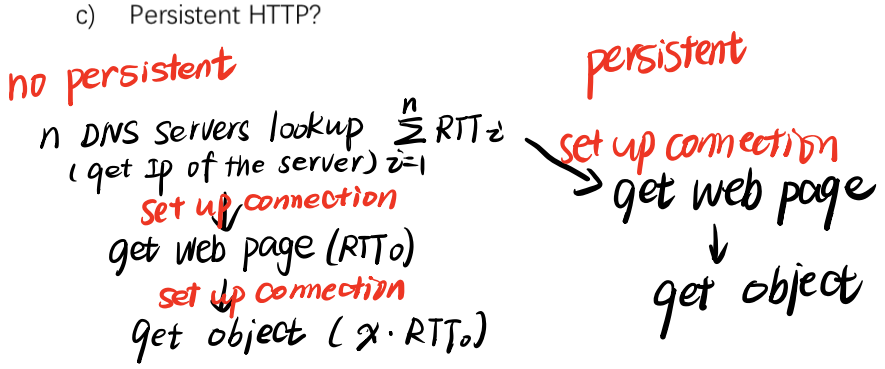
(a)

| | TCP | UDP |
|---|---|---|
| data integrity | ✓ | ✗ |
| timing | transfer file within certain time, but may not satisfy the requirements of the application. | |
| throughput | have a basic throughput guarantee, but may not satisfy the requirements of Application. | |
| security | ✗ | ✗ |

(b)

| | data integrity | throughput | timing | security |
|---|---|---|---|---|
| e-mail | required | elastic | elastic | required |
| interactive game | elastic | few kbps required | required | elastic |
| text messaging | required | elastic | elastic | required |

5. Suppose within your Web browser you click on a link to obtain a Web page. The IP address for the associated URL is not cached in your local host, so a DNS lookup is necessary to obtain the IP address. Suppose that n DNS servers are visited before your host receives the IP address from DNS; the successive visits incur an RTT of $RTT_1, \ldots, RTT_n$. Further suppose that the Web page associated with the link contains exactly ten objects on the same server. Let $RTT_0$ denote the RTT between the local host and the server containing those objects. Assuming zero transmission time of the object, how much time elapses from when the client clicks on the link until the client receives the objects?
   a) Non-persistent HTTP with no parallel TCP connections?
   b) Non-persistent HTTP with the browser configured for 4 parallel connections?
   c) Persistent HTTP?




a) $\sum_{i=1}^{n} RTT_i + (RTT_0 \times 2) \times (10+1) = \sum_{i=1}^{n} RTT_i + 22RTT_0$

b) $\sum_{i=1}^{n} RTT_i + (RTT_0 \times 2) \times (1+3) = \sum_{i=1}^{n} RTT_i + 8RTT_0$

c) $\sum_{i=1}^{n} RTT_i + RTT_0 \times (1+1+10) = \sum_{i=1}^{n} RTT_i + 12RTT_0$

6. For email application, give four entities involved in the email transmission. For every transmission between two neighboring entities, what protocols are used respectively?