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HW 2

1. Answer:
   1. Application layer protocols: DNS and HTTP   
      Transport layer protocols: UDP for DNS; TCP for HTTP
2. Answer: **NOTE:** k = n; o = x from the original problem statement
   1. The total amount of time to get the IP Address is  
      **RTT1 + RTT2 + … + RTTk**  
      Once the IP address is known, RTTx elapses to set up the TCP connection and another RTTx elapses to request and receive the small object. The total response time is:  
      **2 RTTx + RTT1 + RTT2 + … + RTTk**
3. Answer:
   1. **RTT1 + … + RTTk + 2RTTx + 5 ⋅ 2RTTx   
      = 12RTTx + RTT1 + … + RTTk**
   2. **RTT1 + … + RTTk + 2RTTx + 2 ⋅ 2RTTx   
      = 6RTTx + RTT1 + … + RTTk**
   3. **RTT1 + … + RTTk + 2RTTx + RTTx   
      = 3RTTx + RTT1 + … + RTTk**
4. Answer:
   1. Note that each downloaded object can be completely put into one data packet. Let Tp denote the one-way propagation delay between the client and the server.   
        
      First consider parallel downloads via non-persistent connections. Parallel download would allow 5 connections share the 450 bits/sec bandwidth, thus each gets 90 bits/sec. Thus, the total time needed to receive all objects is given by:   
        
      (320/450 + Tp + 320/450 + Tp + 320/450 + Tp + 240,000/450 + Tp)   
      + (320/(450/5) + Tp + 320/(450/5) + Tp + 320/(450/5) + Tp + 240,000/(450/5) + Tp ) = **3308 + 8\*Tp (seconds)**

Then consider persistent HTTP connection. The total time needed is give by:  
  
(320/60+Tp + 320/450 +Tp + 320/450+Tp + 240,000/450+ Tp ) + 5\*(320/450+Tp + 240,000/450+ Tp ) = **3209 + 14\*Tp (seconds)**   
  
Assume the speed of light is 300\*106 m/sec, then **Tp=80/(300\*106 )= 0.266666667 microsec.** Tp is negligible compared with transmission delay.   
  
Thus, we see that the persistent HTTP does not have significant gain over the non-persistent case with parallel download.

1. Answer:
   1. Yes, because Bob has more connections, he can get a larger share of the link bandwidth.
   2. Yes, Bob still needs to perform parallel downloads; otherwise he will get less bandwidth than the other three users.
2. Answer:
   1. The time to transmit an object of size L over a link of rate R is L/R. The average time is the average size of the object divided by the transmission rate of the link, R:   
        
      X = (625,000 bits)/(15,000,000 bits/sec) = 41.6666667 milliseconds or 0.041 seconds  
        
      The traffic intensity on the link is = AB = (20 requests/sec)(0.041 sec/request) = 0.8333334. Thus, the average access ­­­­­­­­delay is (0.041)/(1 - 0.8333334) = 0.2460000984 seconds. The total average response time is therefore 0.246 sec + 2 sec = 2.246 seconds.
   2. The traffic intensity on the access link is reduced by 33% since the 33% of the requests are satisfied within the institutional network. Thus, the arrival rate of the objects to the link also changes since only 66% of the objects need to be fetched from the origin servers (the rest are obtained from the cache). As a result, B=20 x 0.041 = 0.833 requests/sec.   
        
      Thus the average access delay is (.041 sec)/[1 – (.041)(.833)] = 0.0424 seconds. The response time is approximately zero if the request is satisfied by the cache (which happens with probability .33); the average response time is 0.0424 sec + 2 sec = 2.0424 sec for cache misses (which happens 66% of the time). So the average response time is (.33)(0 sec) + (.66)(2.0424 sec) = 1.347984 seconds. Thus the average response time is **reduced from 2.246 sec to 1.348 sec.**