1. [30 pt] Consider the network provided in Fig. 2.12 of the textbook. For simplicity, let’s assume that the LAN delay is 0 and the Internet delay is 2 seconds. Assume that the average object size is 80Kb and there are 20 requests per second from the institution’s browsers to the origin servers.
2. Calculate the traffic intensity on the access link.
3. Find the total response time. The total response time/delay is the sum of LAN delay, access delay and Internet delay. Here, the average access delay can be calculated as x/(1-y) where y is the traffic intensity you calculated above and x is the average time required to send one object over the access link.
4. Now suppose a cache is installed in the institutional LAN with a hit rate of 0.5. Find the total response time.

Diagram

Description automatically generated

1. **traffic intensity = (20 requests/sec) \* (80 Kb/request)/(15 Mbps) = 0.1067**
2. **LAN delay = 0 sec**

**access delay = x/(1-y) = (80 Kb/15 Mbps) / (1-0.1067) = 0.00597 sec**

**Internet delay = 2 sec**

**total response time = LAN delay + access delay + Internet delay = 2.00597 sec**

1. **total response time = 0.5 \* 0.00597 sec + 0.5 \* 2.00597 sec = 1.00597 sec**
2. [10 pt] What is the use of mail access protocols? Why can’t we use SMTP to deliver the emails all the way to receiving user agent’s computer?

**Internet Mail Access Protocol (IMAP) provides retrieval, deletion, folders of stored messages on server. We can’t use SMTP directly deliver the emails to user agent’s computer because “typically the sender’s user agent does not dialogue directly with the recipient’s mail server.” We need to use SMTP to deliver emails to the source mail server, then the source mail server will know where is the destination mail server.**

1. [20 pt] Suppose Client A initiates an FTP session with Server S. At about the same time, Client B also initiates an FTP session with Server S. What are the possible source and destination port numbers for the following? (note that popular services such as FTP have preassigned port numbers <https://en.wikipedia.org/wiki/List_of_TCP_and_UDP_port_numbers>)
2. The segments sent from A to S
3. The segments sent from B to S
4. The segments sent from S to A
5. The segments sent from S to B
6. If A and B are different hosts, is it possible that the source port number in the segments from A to S is the same as that from B to S?
7. What if A and B are the same host, same question (e).

**Port number for FTP is 21.**

1. **The segments sent from A to S**

**Source port number: 5432**

**Destination port number: 21**

1. **The segments sent from B to S**

**Source port number: 2345**

**Destination port number: 21**

1. **The segments sent from S to A**

**Source port number: 21**

**Destination port number: 5432**

1. **The segments sent from S to B**

**Source port number: 21**

**Destination port number: 2345**

1. **Yes, if both A and B are using the same application.**
2. **No, otherwise the server cannot identify the process.**
3. [20 pt] For the Internet checksum that we discussed in class (used in UDP and TCP), consider two bytes 01011100 and 01100101.
4. Calculate the Internet checksum of the two bytes
5. Show that the checksum captures all 1-bit errors (1 bit changed in either of the two bytes) using an example.
6. Show that the checksum might not capture all 2-bit errors (1 bit changed in each of the two bytes) using an example.
7. **01011100**

**01100101**

**-----------------------------------**

**sum 11000001**

**checksum 00111110**

1. **01011101**

**01100101**

**-----------------------------------**

**sum 11000010**

**checksum 00111101**

1. **01001100**

**01110101**

**-----------------------------------**

**sum 11000001**

**checksum 00111110**