CSE 3300/5299 Homework 1 (Due on 02/19/2024 Midnight)

Submission: specify your name and course number here(CSE3300 or CSE5299)

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Course Number: CSE5299

Question 1 (5 pts)

A student at UConn is working on a collaborative project with a team in Washington State University (WSU). He has 100 Gigabyte of data, and his professor asked him to send the data to WSU as fast as possible. The student has two options, either to send it with a friend who will be traveling to WSU in one week (7 days), or use 1 Mbps dedicated link to transfer the data, which way would be faster (ignore propagation delay)? Explain why.

Answer: Sending 100 Gigabyte of data via his **friend** would be must faster (1 week / 7 days).
Explanation: Assuming propagation delay as zero.
We have 100GB data with 1Mbps dedicated link speed.
Note: 1GB = 1024MB, 1 Byte = 8 bits
100GB = 102400 MB = 819200 Mb(bits)
If the speed is 1 Mbps, we can only send 1 Megabit per second.
So, it would take 819200 Seconds = 13653.3333 minutes = 227.555555 Hours = 9.48 days.

Friend traveling to WSU in one week = 7 days = 24 * 7 = 168 hours

Therefore, sending 100 GB of data via the friend is faster (168 hours) than sending through 1Mbps dedicated link (227.5 hours).

Question 2 (20 points)

Suppose there is a 2 Mbps link shared by multiple users. Each user requires 200 kbps when transmitting, but each user transmits only 20 percent of the time.

a. How many users can be supported when circuit switching is used, show your steps? (5 points)
   Answer: While using circuit switching, each user has a dedicated fixed link. So, whether the user is online/offline, the link is reserved for them.

   If 1 user uses 200kbps, then for 2Mbps = 2000kbps = 2000/200 which would be 10 users at most.

   Note: Even if the user is 20% of the time, in circuit switching, the link is available to them only and cannot be reassigned to another user.

b. Assume packet switching is used. Suppose there are 30 users. Find the probability that at any given time, exactly 10 users are transmitting simultaneously. (Hint: Use the binomial distribution. No need to calculate the final number, just show the formula) (5 points)
   Answer: Given,

   Transmission rate (p) = 20% = 0.20,

No. of users (n) = 30,
Simultaneous users (k) = 10

Binomial Distribution Formula:

Binomial Distribution Formula!

$$p(x=k) = C_k^n \times p^K \times (1-p)^{n-k}$$

$$\therefore p(x=10) = C_{30}^{10} \times 0.20^{10} \times (1-0.20)^{30-10}$$

$$= C_{10}^{30} \times 0.20^{10} \times 0.80^{20}$$

c. This is a follow-up question of b. Find the probability that there are at least *k* users transmitting simultaneously (just list the formula with the parameter *k* (*k* can be any integer between 0 and 30)). (10 points)

Answer:

For at least k-users transmitting simultaneously, we can use the same formula.
Let ‘**i**’ be the integer.

$$p(x \geq k) = \sum_{i=k}^{n} \left(C_i^{30} \right) \times 0.20^{i} \times (1-0.20)^{30-i}$$

Question 3 (5 points): True or False

a. A user requests a Web page that consists of a base file and three images. For this page, the client will send one request message and receive four response messages (Consider nonpersistent connections).
Answer: False

b. With nonpersistent connections between browser and origin server, it is possible for a single TCP segment to carry two distinct HTTP request messages.
Answer: False

Question 4 (5pts)

Why is it impractical to eliminate the mail server and instead allow your User Agent to send an email message directly to a recipient?
Answer: Without a mail server, the sender and receiver must always stay online to exchange mail communications. If either of them is offline, mail delivery fails at the origin since the sender is unaware of the receiver's status.

A mail server acts as a bridge between the sender and the receiver, ensuring that the mail is delivered to the receiver's end. It stores all the incoming mail sent by the senders and sends them once the receivers are online and ready to receive emails. This eliminates the need for both sender and receiver to be online simultaneously. The server can handle various tasks related to email sending, receiving and storage.

Question 5 (20 points) DNS name resolution

This problem focuses on using DNS to resolve the address of *www.amazon.com* (Fig.1). Answer the following questions.

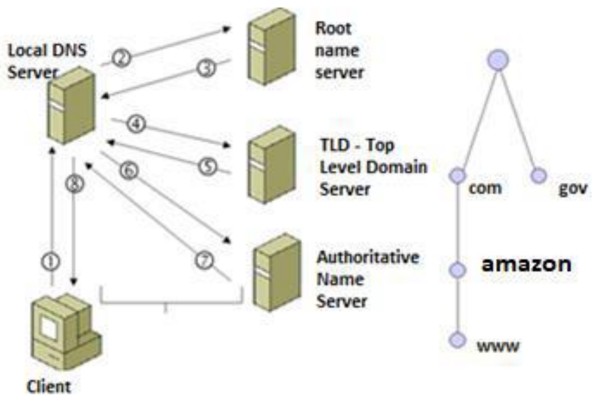

Fig.1 DNS name resolution

a. Why might a local DNS server be able to skip sending a query to the Root DNS server? (5 pts)
Answer: When the Client requests a URL, the Local DNS Server initially checks with the Root name server and saves the address of the URL in its **cache**. If the same request comes from the client for amazon.com, the Local DNS server first checks the Authoritative Name Server since the address information is available in its **cache** thus avoiding re-query the Root Name Server.

b. What type of response is being issued in Step 5, referral or final answer? How do you know? (5 pts)
Answer: In Step 5, the TLD server sends the location of amazon.com address to the Local DNS server. **It is referral.** Initially, the root DNS server locates the TLD Server address since it contains **`.com`** information and returns the information to Local DNS and then the local DNS server communicates with `TLD` server for fetching information about `amazon.com`. The TLD provides information about the IP location of amazon.com to the Local DNS server.

c. What TLD server is responsible for Amazon? (3 pts)
Answer: The Top-Level Domain (TLD) server is responsible for having information of **`.com`** servers connected over the internet. Its main purpose is to resolve the IP address of **`amazon.com`** server.

d. What type of response is being issued in Step 8? How do you know? (5 pts)
Answer: In step 8, **HTTP** response is being used. After the local DNS server inquires the information of `amazon.com` IP address from the Root Server -> TLD Server -> Authoritative Name server, it returns the original IP address of `amazon.com` to the client.

e. What is being returned in Step 8? (2pts)
Answer: In step 8, the local DNS server **returns the final IP address** of the URL `amazon.com` after its inquiry at Root Server, TLD server and Authoritative Name server.

Question 6 (25 points) Delay to load web pages.

Suppose within your web browser you click on a link to obtain a web page. The IP address for the URL is not cached in your client, so a DNS lookup is required. Four DNS servers are visited before your host receives the IP address from DNS: the first DNS server visited is the local DNS cache, with an RTT delay RTT_0=5 msecs; the second, third and fourth DNS servers contacted have RTTs of 40, 24, and 50 msecs, respectively. The RTT between the Client and a CNN Web server is RTT_{HTTP} =70 msecs.

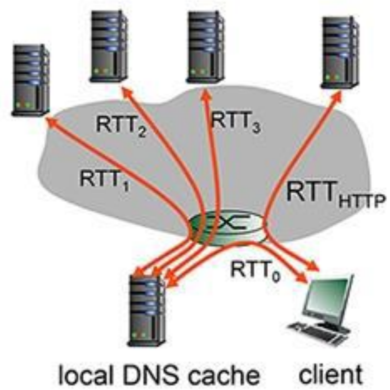

Fig.2 The load of web pages

a. Why do you think the RTT to the local name server is smaller than the other RTTs? (5 pts)
Answer: The Client initially connects to the local DNS server, since it's a direct link, the RTT0 is much faster in comparison to the other servers. If the local DNS cache already has information regarding the final RTT HTTP server, it can redirect the client to the final server. So, the RTT to local name server is much smaller compared to the other RTTs.

b. How long does it take for the name *www.cnn.com* to be resolved (assume nothing is cached)? You must show all your work! (5 pts)
Answer: For resolving the domain `www.cnn.com`, it takes a total of **119ms.**
Explanation:

1. Firstly, the Client system connected to local DNS Cache – 5ms
2. Since nothing is cached, the local DNS server checks with all the other DNS servers which have RTTs of 40ms, 24ms, 50ms each.
3. Once the final **CNN** server is found, the RTT_{HTTP} of 70ms is added.
4. Totally, 189ms is taken for resolving the domain `www.cnn.com`.

$RTT_0 + RTT_1 + RTT_2 + RTT_3 = 5+40+24+50+70 = 119ms.$

c. After the IP address is returned to the client, what 2 steps must be taken before the base HTML web page can be displayed on the browser? (5 pts)
Answer: TCP and HTTP

- After the IP address is returned to the client, the client initiates a TCP connection to the server. This involves a three-way handshake, to ensure a reliable connection is set up. This process takes one round trip time (RTT).
- Once the TCP connection is established, the client makes a HTTP request to the server for the base HTML web page. The server then responds with the HTML content which processes an another RTT.

d. What is the total delay between clicking on the link and displaying the base web page (include full DNS query in b. and steps in c.)? You must show your work. (10 pts)
Answer: Total delay b/w clicking on link and displaying the base web page is **259ms.**

1. Initially, DNS query needs to be made for finding the CNN domain which takes 119ms for resolving the domain.
   i.e., $RTT_0 + RTT_1 + RTT_2 + RTT_3 = 5+40+24+50= 119ms$
2. Once the final domain server is found, the Client will be connected to the CNN server where the RTT_{HTTP} is 70ms.
3. We need to make two requests – TCP and HTTP for returning the base web page which takes 70ms each.
4. Totally, we add DNS query(119ms), TCP request(70ms), HTTP request(70ms) = 289ms.

$140(RTT_{HTTP} + RTT_{HTTP}) + 119(RTT_0 + RTT_1 + RTT_2 + RTT_3) = 259ms$

Question 7 (10 points)

Consider distributing a file of F = 15 Gbits to N 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. For N = 10, 100, and 1,000 and u = 300 Kbps, 700 Kbps, and 2 Mbps, prepare a chart giving the minimum distribution time for each of the combinations of N and u for both client-server distribution and P2P distribution.

Answer:

File F = 15 Gbits = 15 * 1000 Mbits = 15000 Mbits

Server upload rate(u_s) = 30 Mbps
Peer Download Rate(d_i) = 2 Mbps
Peer upload rate (u) = 300Kbps, 700Kbps, 2 Mbps.

Client – Server:
We need to calculate the minimum distribution for client and server using the formula,

$D_{c\text{-}s} = max\{NF/u_s, F/d_{min}\}$

N = 10, $D_{c\text{-}s}$ = max{10 * 15000/30, 15000/2} = max {5000, 7500} = 7500s	N = 100, $D_{c\text{-}s}$ = max{100 * 15000/30, 15000/2} = max {50000, 7500} = 50000s	N = 1000, $D_{c\text{-}s}$ = max{1000 * 15000/30, 15000/2} = max { 500000, 7500} = 500000s

Note, in Client-Server distribution, we don't have to take upload rate(client) into consideration.

		N		
		10	100	1000
U	300kbps	7500	50000	500000
	700kbps	7500	50000	500000
	2 Mbps	7500	50000	500000

Peer-to-Peer(P2P):
To distribute File F to N Clients using P2P approach, we use the following formula,

$D_{P2P} = max\{F/u_s, F/d_{min}, NF/(u_s + \sum_{i=1}^{N} u_i)\}$

For u=300kbps = 0.3Mbps

N = 10 D_{P2P} = max {15000/30, 15000/2, 10*15000/(30 + $\sum_{i=1}^{10}$ 0.3)} = max {500, 7500,4545} = 7500s	N = 100 $D_{c\text{-}s}$ = max{15000/30, 15000/2, 100*15000/(30 + $\sum_{i=1}^{100}$ 0.3)} = max {500, 7500, 25000} = 25000s	N = 1000, $D_{c\text{-}s}$ = max{15000/30, 15000/2, 1000*15000/(30 + $\sum_{i=1}^{1000}$ 0.3)} = max { 500, 7500, 45454} = 45454s

Repeating the same process for u = 700kbps, 2Mbps, we get

		N		
		10	100	1000
U	300kbps	7500	25000	45454
	700kbps	7500	15000	20548
	2 Mbps	7500	7500	7500

CSE3300: Question 8 (10 points)

Compare the two application architectures: client-server and peer-to-peer, show their advantages and limitations respectively.

CSE5299: Question 8 (10 points)
Read the paper Chord (http://nms.lcs.mit.edu/papers/chord.pdf) and understand its design. For its example shown in Figure 5, we get finger tables and key locations after node 6 joins. If node **3** now leaves (so we have node **0,1,6 left**), please show their finger tables and key locations.

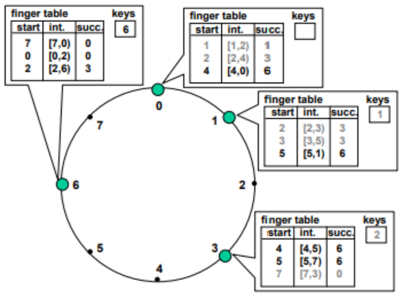

Figure 5: Finger tables and key locations after node 6 joins

Answer:

After Node 3 leaves, the finger tables and key locations of the chord network will be updated, and the keys redistributed among the remaining nodes.

To do that, we need to follow the below steps:

i. Remove Node 3: We remove the node 3 and all its keys must be redistributed to its next node in the ring.
ii. Update Finger Tables: Now, we need to update the finger tables for nodes 0,1, and 6
iii. Redistribute the keys: The keys that were managed by node 3 will now be taken over by the next node in the ring according to the chord rules.

Original Finger Table (with Node3):

- Node 0: Starts at 1, 2, 4 (Successors are 1, 3, 6)
- Node 1: Starts at 2, 3, 5 (Successors are 3, 6, 6)
- Node 6: Starts at 7, 0, 2 (Successors are 0, 0, 3)

Original Keys:

- Node 0: Holds keys 7, 0
- Node 1: Holds key 1
- Node 3: Holds keys 2, 3
- Node 6: Holds keys 4, 5, 6

After the node 3 leaves, node 6 is the immediate successor of node 3. So, it will take over the keys that are previously managed by Node 3.

Update Finger Tables:

- Node 0: Starts at 1, 2, 4 (Successors are now 1, 6, 6)
- Node 1: Starts at 2,3,5 (Successors are now 6, 0,0)
- Node 7: Starts at 7,0,2 (Successors are now 0,1,0)

Updated Key Locations:

- Node 0: Holds keys 0 and 7
- Node 1: Holds key 1
- Node 6: Takes over keys 2 and 3 from the removed node 3, and retains its original keys 4, 5, and 6