

Tutorial 1 Solutions (Week 5)

Section I - Multiple Choice, Fill-in Questions

1. List the four different types of delays encountered in packet switched networks:
 - a. processing delay
 - b. queuing delay
 - c. transmission delay
 - d. propagation delay
2. Consider the operation of downloading a Web page consisting of an index page that references 3 JPEG objects located on the same server. Ignoring latency involved in transferring the objects themselves, fill in the blanks below with the correct values:
 - a. Utilizing HTTP/1.0 with no parallel connection capability, the number of RTTs required to download the page is **8RTT**.
 - b. Utilizing HTTP/1.1 with pipelining, **3** RTTs are required to download the page.
3. DNS responses have a TTL field. Why is this necessary?
 - a. The TTL field is decremented at each DNS server that the response passes through on its way to the client, and servers drop responses with a TTL of 0, so the TTL field prevents responses from looping indefinitely.
 - b. The TTL field allows DNS servers to prevent cache poisoning.
 - c. The TTL field is necessary for tracking the number of DNS servers involved in resolving the query.
 - d. **The TTL field causes DNS servers to delete entries after some time, so that if the host moves and the underlying address changes, the server will eventually get the correct address.**
4. Transport layer may be able to provide reliability by using its own mechanisms, despite working over an unreliable network layer.
 - a. **True.**
 - b. False.
5. UDP has which of the following characteristics:
 - a. Three-way hand shake for connection establishment.
 - b. Connection state at the server.
 - c. Regulated send rate.
 - d. **None of the above.**

Section II – Problem Solving

1. Calculate the *end-to-end delay*, $d_{end-end}$, between the source host and the destination host in a network with 4 routers between source and destination? Assume that the network is NOT congested (i.e. d_{queue} is insignificant), and that:
 - a. all packets are 10,000 bits in length,
 - b. each link is 5 kilometers long,
 - c. the processing time is 10msec at the source host and at each router,
 - d. the transmission rate of each link is 1Mbps,
 - e. the propagation speed of each link is 2.5×10^8 meters/second.

CALCULATIONS:

The delay along one hop = $d_{proc} + d_{prop} + d_{trans} = 10\text{msec} + 5 \times 10^3 / 2.5 \times 10^8 + 10,000 / 1 \times 10^6 = 10 \text{ msec} + 0.02\text{msec} + 10\text{msec} = 20.02 \text{ msec}$

The packet will be transmitted along 5 hops (first hop is from the source, and once at each router).

Thus, the end-to-end delay = $5 \times 20.02 = 100.1 \text{ msec}$

2. UDP and TCP use 1s complement for their checksums. Suppose you have the following three 8-bit bytes: 01010101, 01110000, 01001100. What is the 1's complement of the sum of these 8-bit bytes? (Note although TCP and UDP use 16-bit words in computing the checksum, for this problem we will only consider 8-bit summands). Show all work. Is it possible that a 1-bit error will go undetected by the checksum? How about a two-bit error?

Answer:

$$\begin{array}{r} 01010101 \\ + \quad 01110000 \\ \hline 11000101 \\ + \quad 01001100 \\ \hline 00010010 \end{array}$$

The last addition has an overflow so we add it to the above sum resulting in a final result of 00010010. One's complement of this is 11101101 which is the final checksum value.

All one-bit errors will be detected by checksum, but two-bit errors can be undetected (e.g. if the last digit of the first word is converted to a zero and the last digit of the second word is converted to a 1).

3. Answer these questions in a concise manner. A few sentences (2-3) should suffice.

(a) List one advantage and one disadvantage of using a text-based header (as in HTTP) instead of a binary format (as in IP and TCP).

Advantages: A text-based header is easier for human beings to read and debug. Text-based headers are also extensible.

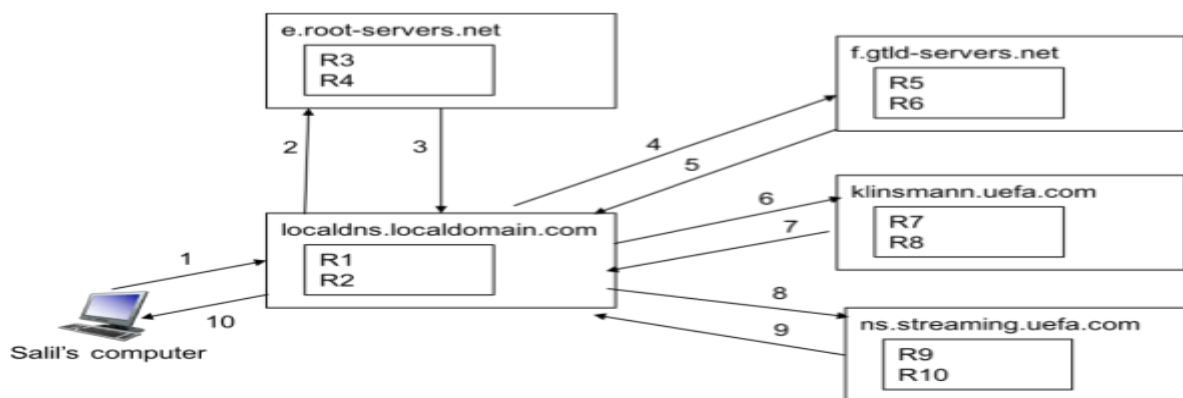
Disadvantages: However, they are verbose (i.e., waste bandwidth) and harder to parse. IP use a binary format to limit the bandwidth consumed by the header, and to simplify parsing at the router, which must process packets very quickly (e.g., within a few nanoseconds on high-speed links). In fact, big-header size needs to be compressed for many low-bandwidth/low-power communication.

(b) Web caches and content distribution networks (CDNs) both reduce the time for a client to download Web pages by moving content closer to the users. Give two reasons why CDNs have been more widely deployed (and successful) than Web caching?

Answer: The content providers can contract with CDNs to deliver their content, which improves performance, reduces cost, and makes their site robust to unexpected surges in demand. In contrast, the content provider cannot require millions of sites throughout the world to deploy proxy servers.

Also, proxies cannot cache all content. Some content is un-cacheable because it is dynamically generated. CDNs can run the server software that generates the dynamic content.

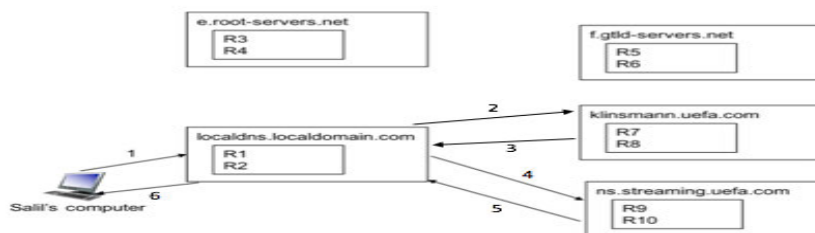
4(a)



| Seq | Type | Data |
|-----|------|-----------------------------|
| 1 | Q | vid1.streaming.uefa.org (A) |
| 2 | Q | vid1.streaming.uefa.org (A) |
| 3 | R | R3 (NS), R4 (A) |
| 4 | Q | vid1.streaming.uefa.org (A) |
| 5 | R | R5 (NS), R6 (A) |
| 6 | Q | vid1.streaming.uefa.org (A) |
| 7 | R | R7 (NS), R8 (A) |
| 8 | Q | vid1.streaming.uefa.org (A) |
| 9 | R | R9 (CNAME) + R10 (A) |
| 10 | R | R9 (CNAME) + R10 (A) |

4(b)

After 2 minutes, all records other than R7, R8, R9 and R10 would be cached at the local DNS server. This is because R7, R8, R9 and R10 have a TTL of 10 seconds. Hence, the sequence of queries would be as follows:



| Seq | Type | Data |
|-----|------|-----------------------------|
| 1 | Q | vid1.streaming.uefa.org (A) |
| 2 | Q | vid1.streaming.uefa.org (A) |
| 3 | R | R7 (NS) + R8 (A) |
| 4 | Q | vid1.streaming.uefa.org (A) |
| 5 | R | R9 (CNAME) + R10 (A) |
| 6 | R | R9 (CNAME) + R10 (A) |

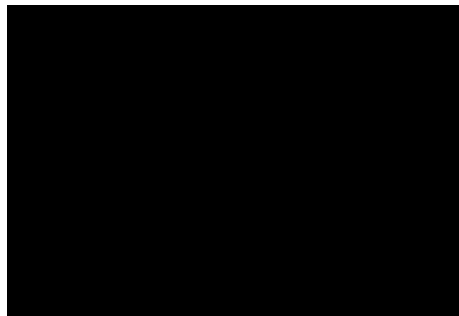
5. Two hosts located at two ends of a continent are trying to transfer data using a window based reliable transport protocol (for pipelining). Suppose that the one-way propagation delay between the hosts is 15 milliseconds. If the hosts are using packets of length 1500 bytes over a 1 Gbps transmission link, how big the window size must be for the channel utilization to be greater than 98%?

$$0.98 = X (L/R) / (RTT + L/R)$$

$$0.98 = X ((1500 * 8) / 10^9) / (30 * 10^{-3} + (1500 * 8) / 10^9)$$

$$= 2450 \text{ packets}$$

[REDACTED]



[REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

7. Consider a TCP connection between sender A and receiver B. Sender A sends a 900 byte TCP segment (including 20 bytes of TCP header) with sequence number 3100. What acknowledgement number will receiver B reply with to inform sender A that it has received this segment correctly and in order? (Ignore the possibility of a cumulative ack for this question.)

Answer:

Data contained in the Segment is $900 - 20 = 880$ Bytes. Sequence Number = 3100 (pointing towards first byte of data). Ack = $3100 + 880 = 3980$.

8. Given that the previously calculated values for Estimated RTT and RTT Deviation are as shown below, and that the new sample RTT shown has just been measured, what Timeout interval will TCP use for the next transmitted segment?

- i. EstimatedRTT (k) = 4 ms
- ii. DevRTT (k) = 2 ms
- iii. New SampleRTT = 8 ms
- iv. $\alpha = .125$
- v. $\beta = .25$

Answer:

$\text{DevRTT} = (1 - \beta) (\text{DevRTT}) + \beta | \text{New SampleRTT} - \text{Estimated RTT} | = (1 - 0.25)(2) + 0.25(8 - 4) = 2.5$ ms

$\text{Estimated RTT} = (1 - \alpha) \text{EstimatedRTT} + \alpha (\text{New SampleRTT}) = (1 - 0.125)(4) + 0.125(8) = 4.5$ ms

$\text{Timeout} = 4.5 + 4(2.5) = 14.5$ ms

9. A host A establishes a TCP connection with host B. Host A transfer 200 Bytes of data to host B in a single TCP segment that is successfully received and acknowledged by B. Host B then transfers 1000 Bytes of data to host A in a single segment that A acknowledges. Host B then closes the connection by

issuing a FIN that is acknowledged by host A. Host A now issues a FIN segment that is acknowledged by B. Assume that the Initial Sequence Numbers (ISN) used by host A and B are 33000 and 55000, what are the sequence numbers used by A and B in their final ACK send in response to the FIN segment from the other side? How many total segments are sent out by A and B in this interaction?

| Segment No | Type | Sender | Receiver | SeqNo | AckNo |
|------------|---------|--------|----------|-------|-------|
| 1 | SYN | A | B | 33000 | NA |
| 2 | SYN/ACK | B | A | 55000 | 33001 |
| 3 | ACK | A | B | 33001 | 55001 |
| 4 | DATA | A | B | 33001 | 55001 |
| 5 | ACK | B | A | 55001 | 33201 |
| 6 | DATA | B | A | 55001 | 33201 |
| 7 | ACK | A | B | 33201 | 56001 |
| 8 | FIN | B | A | 56001 | 33201 |
| 9 | ACK | A | B | 33201 | 56002 |
| 10 | FIN | A | B | 33201 | 56002 |
| 11 | ACK | B | A | 56002 | 33202 |