Homework 5 assignment for ECE671
Posted: 04/17/18
Due: 04/24/18

Note: In all written assignments, please show as much of your work as you can. Even if you get a wrong answer, you can get partial credit if you show your work. If you make a mistake, it will also help the grader show you where you made a mistake.

**Problem 1 (25 Points): CDN**

a. In class we have looked at a case study for Netflix. As we have seen, Netflix owns very little infrastructure. What other infrastructure and service providers does it make use of? What services are provided by these 3rd parties?

b. For this problem consider the network shown in Figure 1. Assume an average object size of .5Mbits, an average request rate of 30/sec, an average rate to browsers of 150Mbps, RTT from institutional router to any origin server of 2 sec, and an access link capacity of 15Mbps. What are the overall LAN and access link utilization? What is the total delay?

c. Now the access link capacity is increased to 100Mbps. What are the overall LAN and access link utilization? What is the total delay?

d. Now consider the network shown in Figure 2, where a cache is added to the institutional network. Suppose the cache hit rate is 30%. All other parameters for that network are similar to the ones given in b. What is the access link utilization? What is the total delay?

![Figure 1: Network without cache](image-url)
Solution:

a.
1. Amazon (3rd party) cloud services:
   - Netflix uploads studio master to Amazon cloud
   - Create multiple version of movie (different endodings) in cloud
   - Upload versions from cloud to CDNs
   - Cloud hosts Netflix web pages for user browsing
2. Three 3rd party CDNs host/stream Netflix content: Akamai, Limelight, Level-3

b. LAN: 15%, access link: 100%, total delay = Internet delay + access delay +
   LAN delay = 2 sec + minutes + usecs

c. LAN: 15%, access link: 15%, total delay = Internet delay + access delay +
   LAN delay = 2 sec + msecs + usecs

d. LAN: 15%, access link: 60%, total delay = 0.6 * (delay from origin servers) +
   0.4 * (delay when satisfied at cache) = 0.7 (2.01) + 0.3 (~msecs) = ~ 1.7 secs
   less than with 100 Mbps link (and cheaper too!)

Problem 2 (25 Points): NDN

In this problem we take a look at the Named Data Networking approach and
instantiation of the Information Centric Networking paradigm, which is one
potential future Internet architecture.

a. Describe the actions that are taken once an Interest packet arrives at a router.
   Described the alternatives for the case that (a) the requested content is
   currently stored on the cache or (b) it is currently NOT stored on the cache.

b. Assume a scenario in which two clients are connected to the same router.
   Client A requests contents content /com/netflix/video123 at time t_1 and client
   B requests the same content at time t_2 (t_2 > t_1). Show a snapshot of the
routers pending interest table (PIT) after the request from client B has arrived (assuming the content is neither cached nor has it arrived from an upstream router or custodian).

c. Now assume the content has arrived after Client A’s request but before the request from client B arrives. How will the router’s PIT look in this case?

d. Explain the function of the content store (CS). What happens if the content store is full (no additional storage space at the router) and a content arrives at the router?

e. Give an example for a forwarding information base (FIB) in NDN and explain the differences to a FIB in IPv4.

f. Consider a live streaming event like the Super Bowl. Explain the advantages of NDN over TCP/IP in this specific scenario.

Solution:

a. a) the content will be served directly from the router’s cache, b) upon arrival of the interest and entry in the PIT will be created and the interest will be forwarded based on the FIB.

b. Prefix          Face
/com/netflix/video123  1, 2

This assumes that both clients are connected to different faces of the router. If they are connected to the same face only one entry under faces exists.

c. There will be no entry in the PIT since client B’s request can be served from the CS.

d. The content store is basically a small cache on the router. Usually the content that has not been requested for the longest time will be removed from the cache to make space for new content.

e. The FIB in NDN specifies on which face or faces interests for a specific prefix should be forwarded. A FIB entry could look like

Prefix          Face
/com/netflix/     0
/edu/umass/       1

f. In TCP a single session has to be set up for each client request. This is not the case for NDN, since clients can be directly served from upstream routers. This greatly reduces the outgoing streams at the server (to 1 in the best case).

Problem 3 (20 Points): DASH

Answer the following questions assuming Dynamic Adaptive Streaming over HTTP is used for video streaming.

a. When using DASH for streaming, does this require a dedicated streaming server or can a regular HTTP server be used? Why or why not?

b. Give a brief explanation of the manifest file that’s stored on the server in addition to each video.

c. Explain the client behavior in the case where the highest possible quality of the stream is currently transmitted to the client and the buffer fill has fallen below the minimum threshold.
d. Assuming a 5-minute video should be offered in 5 different quality versions and the DASH segment length is 10 seconds. How many individual files will have to be stored on the server if AVC encoding is assumed?

Solution:

a. For DASH any regular HTTP server can be used. Each segment is requested by the client with an HTTP GET request and the HTTP server sends the segment in a regular HTTP reply.

b. The manifest file contains information on the quality level each segment is available at the server. The client uses this information to determine at which quality level the next segment should be requested. E.g., if a video file is chunked in 10 second segments at 5 different quality formats and the original video is 1 minute long, then for each quality format there would be 6 entries pointing to a specific portion of the video. In total, there would be 5*6=30 entries in that manifest file.

c. The client would request the next segment that is not in the buffer at the lowest available quality level to fill the buffer as fast as possible to avoid starvation and potential interruption of the video playout.

d. \(5\times 60/10\times 5 = 25 \times 6 = 150\)

Problem 4 (10 Points): Security

Suppose Alice wants to send an email to Bob. Bob has a public-private key pair \((K_B^+, K_B^-)\), and Alice has Bob’s certificate. But Alice does not have a public, private key pair. Alice and Bob (and the entire world) share the same hash function \(H(\cdot)\).

a. In this situation, is it possible to design a scheme so that Bob can verify that Alice created the message? If so, give an example for the communication between Alice and Bob with the aid of a block diagram that illustrates how the email is encrypted.

b. Is it possible to design a scheme that provides confidentiality for sending the message from Alice to Bob? If so, give an example for the communication between Alice and Bob with the aid of a block diagram that illustrates how the email is encrypted.

Solution:

a. No, without a public-private key pair or a pre-shared secret, Bob cannot verify that Alice created the message.

b. Yes, it’s possible as indicated by the image below
Problem 5 (20 Points): Buffer
Consider the figure below. A sender begins sending packetized audio periodically at $t=1$. The first packet arrives at $t=8$ at the receiver.

a) What are the delays (from sender to receiver, ignoring any playout delays) of packets 2 through 8? Note that each vertical and horizontal line segment in the figure has length of 1, 2, or 3 time units.

b) If audio playout begins as soon as the first packet arrives at the receiver at $t=8$, which of the first eight packets sent will not arrive in time for playout?

c) If audio playout begins at $t=9$, which of the first eight packets sent will not arrive in time for playout?

d) What is the minimum playout delay at the receiver that results in all of the first eight packets arriving in time for their playout?

Solution:
a. The delay of packet 2 is 7 slots. The delay of packet 3 is 9 slots. The delay of packet 4 is 8 slots. The delay of packet 5 is 7 slots. The delay of packet 6 is 9 slots. The delay of packet 7 is 8 slots. The delay of packet 8 is > 8 slots.

b. Packets 3, 4, 6, 7, and 8 will not be received in time for their playout if playout begins at t=8.

c. Packets 3 and 6 will not be received in time for their playout if playout begins at t=9.

d. No packets will arrive after their playout time if playout time begins at t=10.