

Ublnet master – Multimedia Networking module

Final exam – 31th January 2025

Duration: 2 hours

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Birth Date:

Caution:

1. Only one A4 sheet with personal notes on ONE side for the exam plus one calculator are allowed.
2. Other course documents (slides, student notes) are NOT allowed.
3. Mobile phones, tablets and laptops must be turned off and put away.
4. Start to answer in the space provided at the end of the questions. Don't forget to indicate the question number you reply.

Exercise 1: Content Distribution – (12 points)

1. What is the rationale behind caching content close to users? Gives two reasons. (2 points)
2. From the CDN lab, we have seen that Akamai and YouTube employ different mechanisms to direct clients to a server depending on the client location. Which mechanism uses each one and how the mechanism works? (2 points)
3. In a TTL cache design problem, indicate the values of the optimal hit probability h_i of all the contents i belonging to a catalog of N elements, when B is the cache size in terms of the expected no. of files and w_i is the popularity of content i (w_i follows a Zipf-like law) for the cases below (4 points):
 - a. Identical utility [$U_i(h_i) = U(h_i)$] (1 point)
 - b. Linear utility [$U_i(h_i) = w_i h_i$] (1 point)
 - c. Weighted logarithmic utility [$U_i(h_i) = w_i \log h_i$] (1 point)
 - d. Which of the previous utilities is more suitable for a real operational cache? Why? (1 point)

NOTE: The next equations allow to compute the optimal hit probability h_i , but from theory you can guess the optimal solution.

$$U'_i(h_i) = \alpha$$

$$h_i = U'^{-1}_i(\alpha)$$

$$\sum_i h_i = \sum_i U'^{-1}_i(\alpha) = B$$

4. What is the typical CDN scenario motivating the usage of Overlay Routing? Describe it briefly (1 point)
5. Let be p the false positive probability a Bloom filter, n the number of already inserted (seen) elements, m the number of bits of the Hash table, and k the number of hash functions, and given
 - a. the expression of the false positive probability p of a Bloom filter

$$p = \left(1 - \left[1 - \frac{1}{m}\right]^{kn}\right)^k \sim (1 - e^{-kn/m})^k$$

- b. the expression of k which minimizes this false positive probability p

$$k^* = (m/n) \cdot \ln 2$$

dimension the Bloom filter for a typical example where a single server is likely to see $n = 40$ million objects and we are willing to tolerate a false positive probability of 0.1% (0.001).

- i. what is the value of m , when the optimal number of hash functions k^* is used? (1 point)
- ii. if you try to store the names of the 40 million objects as strings of 20 ASCII characters (1 object name = 20-character string, 1 ASCII character = 1 byte), which data structure will be bigger (in bits): the bloom filter or the string array? (1 point)
- iii. what is optimal value of k^* for this problem? (1 point)

Exercise 2: Video Streaming - (8 points)

- 1) You are a network protocol engineer responsible for implementing an application protocol for mobile stored non-interactive video streaming. (2 points)
 - a) As underlying transport protocol, you can use UDP or TCP. Make your choice and justify it. *NOTE: Both choices can be correct, the important thing is the rationale behind your choice.* (1 point)
 - b) Finally, you opt for a TCP-based like pseudo streaming approach not making use of bit rate adaptation. You must decide a streaming strategy. You hesitate among three options (i) "all-at-once:" to download the whole video at a high rate without stopping, (ii) "rate throttling:" to start downloading at a high rate (fast start) before throttling the rate to a value equal to 1.5 times the encoding rate, (iii) "on-off": to start downloading at a high rate (fast start) before alternating with active and inactive downloading periods. Which option will be more suitable for mobile video streaming. Justify your choice. (1 point)
- 2) What are the four most important Quality of Service (QoS) metrics impacting the Quality of Experience (QoE) for streaming of stored videos? Describe them briefly. *Note: they are not the classical QoS metrics as jitter, delay, throughput, packet loss.* (2 points)
- 3) Explain how rate-based HAS (HTTP Adaptive Streaming) policies and buffer-based HAS policies impact on the tradeoff between average video quality and total time that video is paused (re-buffering time plus startup delay). (2 points)
- 4) Explain the HAS workflow, that is, details the list of HTTP exchanges between a client sending a HAS request to a server? (2 points)