UNIVERSITY OF TARTU
Institute of Computer Science

Distributed Systems (Spring 2020)

Task 1: system architectures and performance modelling

Practical information:
Due date: Friday, March 13, midnight
Each hour late after midnight is 10% less points
– After 6 hours, value of the task is zero points
– This task can be done in a team of max 3 persons ONLY.
Submit your solution to mohan.liyanage@ut.ee, (CC) huber.flores@ut.ee

Instructions: Please respond the following questions. Be clear and concise in your answers. Provide enough explanation to support your arguments. Ambiguous answers to fill up space are considered wrong and no points are granted.

1. Consider the following general architecture (Figure 1) of a search engine at application layer level. Compare a super-thin and super-fat client layering configuration for it. (8 points)

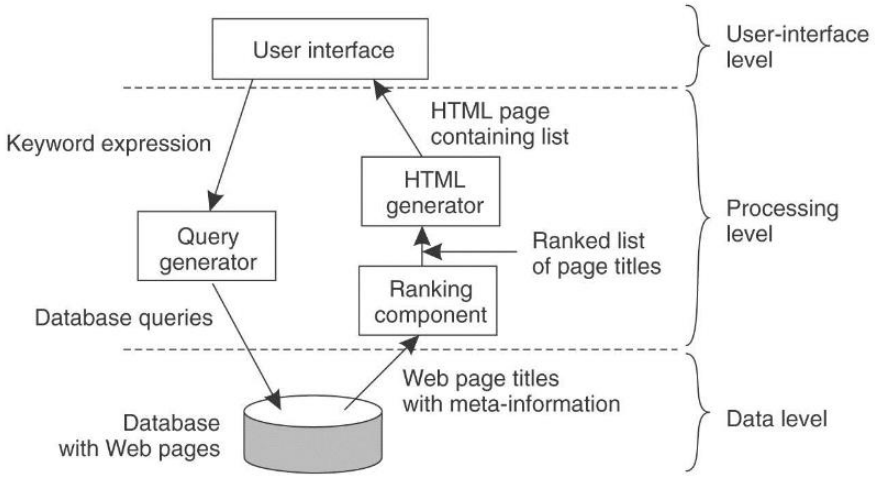

Figure 1: Search engine

2. A 128 Kbps communication link is used to transmit 2000-byte long packets. What is the service demand of a packet on that link? Does the service demand of the packet change with the traffic on the link? What would happen if the transmission increases x3 (6000-byte long packets)? (10 points)

3. A 6-CPU machine used to run a CPU-intensive benchmark that consists of several programs running concurrently. The programs in the benchmark are equivalent with respect to their use of CPU. Describe the QN model that is most appropriate to model this situation? More precisely, specify the number of classes, their type (open or closed), the queues, and their resource types. Justify your answer with diagrams and enough explanation. (10 points)

4. Explain the key differences between resource-centered (aka data-centered) and object-based architecture styles? Is the main difference perceived by clients or servers? Justify your answers. (8 points)

5. An online trading system recoded the periods of time during which the service was down during the last two days and obtained the results shown in Table 1. What was the availability of the site during the two days? (8 points)

Day	Start of Down Time	Duration of Down Time (min)
1	1:25 AM	12
1	7:01 AM	1
1	8:31 PM	5
2	2:15 AM	10
2	9:12 PM	6

Table 1: Online Trading Site Down Periods

6. Consider the same online traiding site of the previous exercise and consider the down times for days 3 and 4 shown in Table 2. Compute the availability and compare your results with those of the previous exercise. How would you compare the two cases? (8 points)

Day	Start of Down Time	Duration of Down Time (min)
3	9:35 AM	15
3	1:13 PM	2
4	10:31AM	3
4	2:15 PM	8
4	3:12 PM	6

Table 2: Online Trading Site Down Periods

7. A database server has two identical disks. The service demands of database transactions on these disks are 100 msec and 150 msec, respectively. Show how these service demands would change under the following scenarios: (10 points)

   - Disk 1 is replaced by a disk that is 40% faster.
   - Enough main memory is installed so that the hit rate of the database server's cache is 30%
   - The log option of the database management system is enabled (tip: batched report job). A log record is generated on disk 2 for each update transaction. Updates account for 30% of the transactions and recoding a log takes 15 msec

8. The workload of a database server is decomposed into four types of transactions: trivial (TT), medium (MT), complex (CT), and update transactions (UT). Table 3 shows the arrival rates and service demands for each class. (10 points)

	Class			
	TT	MT	CT	UT
Arrival rate (tps)	0.20	0.30	0.20	0.10
Service demand (sec)				
CPU	0.15	0.30	0.45	0.70
Disk 1	0.20	0.35	0.55	0.30
Disk 2	0.10	0.30	0.60	0.20

1. What is the effect on response time of TT transactions if their arrival rate increases by 50%?
2. What is the effect on response time of UT transactions if their arrival rate is increased by 25%?
3. What is the effect on the response time of TT transactions if UT transactions are run on a different machine?

From this list of questions, it is clear that the model does not need to consider classes MT and CT separately. How would you aggregate these two classes into a single class? In other words, what is the arrival rate and what are the service demands of the new aggregated class?

9. Explain the concepts of flooding vs random walk. Provide a simple example to justify your answers (8 points)

10. Consider the following CHORD system in the Figure 2. Assume the following considerations. (20 points)
    - Each node p maintains a finger table $FT_p[]$ with at most m entries: $FT_p[i]=succ(p+2^{i-1})$ Note: $FT_p[i]$ points to the first node succeeding p by at least 2^{i-1}.
    - To look up a key k, node p forwards the request to node with index j satisfying $q = FT_p[j] \leq k \leq FT_p[j+1]$
    - If $p < k < FT_p[1]$, the request is also forwarded to $FT_p[1]$

Describe the look ups for the following situations.

1. Key 15, starting at 4
2. Key 22, starting at 4
3. Key 18, starting at 20

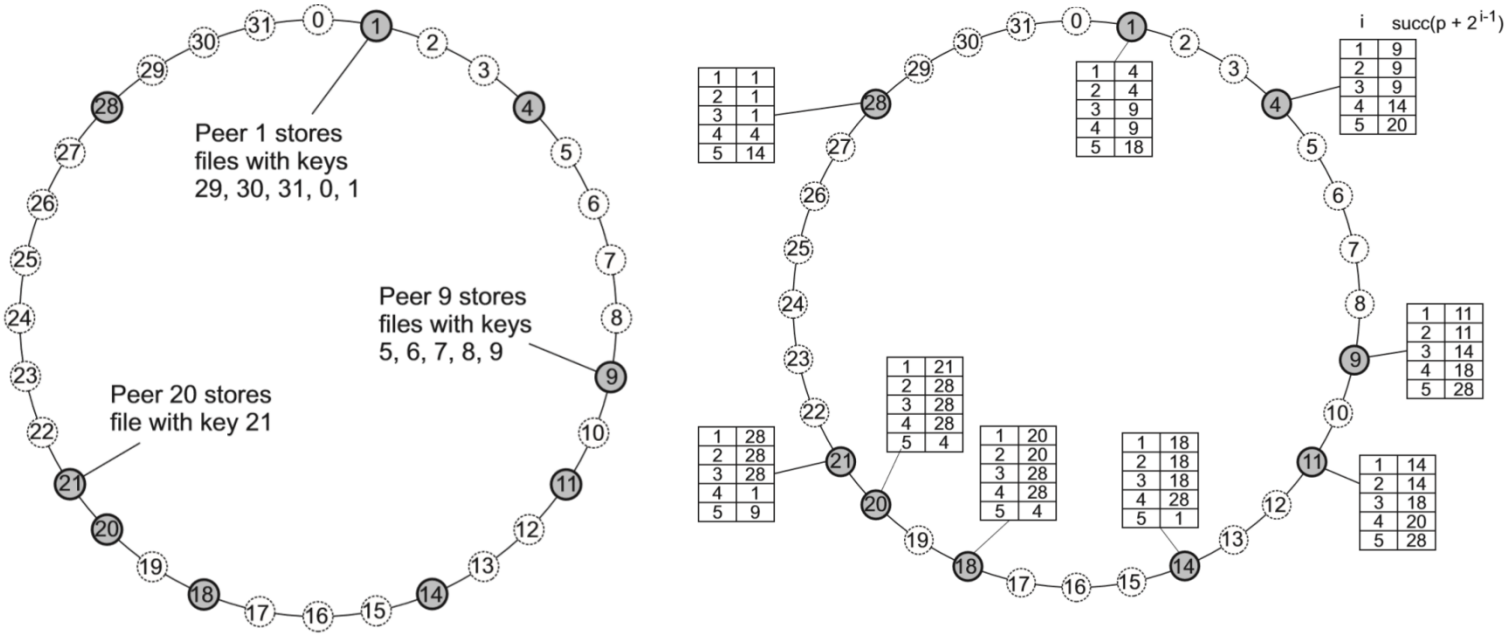

Figure 2: CHORD system