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ORGANISATION OF ISLAMIC COOPERATION (OIC)
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SEMESTER FINAL EXAMINATION
 DURATION: 3 HOURS

WINTER SEMESTER, 2022-2023
 FULL MARKS: 150

SWE 4537: Server Programming

Programmable calculators are not allowed. Do not write anything on the question paper.

Answer all 6 (six) questions. Figures in the right margin indicate full marks of questions whereas corresponding CO and PO are written within parentheses.

1. MagellanTV is a streaming service that specializes in documentary content. It offers a wide range of documentaries across various genres, including history, science, nature, and more. As a system architect, answer the following question:

- a) Each incoming request directed to MagellanTV's load balancer is associated with a unique request ID (R) that remains consistent for a specific user. Following this, the load balancer directs the request to a designated server identified by its server ID (S).

5 + 7
(CO2)
(PO2)

$$S = \text{hash}(R) \% N \quad (1)$$

Here, a uniform hash function is being used and N is the number of servers.

In addressing an unexpected surge in incoming requests, an extra server was introduced to the system. Surprisingly, even after that, a significant number of customers encountered an unanticipated delay in response time as a consequence.

- i. Employing essential diagrams, analyze this observation with proper explanation.
 - ii. Provide a better alternative solution to handle this situation.
- b) Bloom filter ensures that there will be no False Negative outcomes, however, there is a chance for False Positive results. Justify this statement with appropriate examples.
- c) Explain the following topics with appropriate examples:
- i. Checksum
 - ii. Quorum

6
(CO1)
(PO1)

3.5 ×
2
(CO1)
(PO1)

2. *Chirp*, a dynamic social networking site, boasts an extensive user base of 300 million monthly active users, with a noteworthy 50% engaging on a daily basis. Users share their thoughts through posts, limited to 240 characters, with an average of 2 tweets per day. Notably, 10% of these tweets incorporate media, either photos or videos, each restricted to a maximum duration of 1 minute. The platform ensures a responsive user experience, with a viewer-to-uploader ratio maintained at 3:1. Data retention spans five years, and posts from verified accounts are cached for an extended period of one year. To enhance system efficiency, the network is optimized for data retrieval, with a 1 MB sequential read from memory taking a mere 250 microseconds, while the same operation from the network requires 10 milliseconds. Despite a robust infrastructure, the system handles approximately 3500 queries per second, underscoring the platform's popularity and the need for seamless scalability.

- a) Using the information in the scenario, estimate the Storage, Cache, and Bandwidth requirements.
- b) Design *Chirp* as a microservice architecture with a proper diagram and explain the purpose of each service.

5 × 3
(CO2)
(PO2)

10
(CO3)
(PO3)

3. You want to develop a platform to connect avid travelers, offering a space where they can share their rich travel experiences and insights with like-minded individuals. Through blogging/vlogging, users will be able to post about their journeys, providing valuable advice and recommendations. The platform includes a location-based forum, allowing users to filter and search for posts related to specific destinations. Whether seeking inspiration or offering suggestions, users can engage in meaningful conversations centered around various locations. While anyone can view shared posts, the ability to contribute through blogs and vlogs is reserved for registered users. Users will be authenticated with their email and password. On the homepage, anyone will be able to see posts from other users. The following is only available if the user is logged in to the platform:

- There will be a section to create a new post on the homepage. Users can post photos and videos as well.
- For every post, users can like/comment on the post.
- Commenting on the post will take the user to a separate page where all the comments regarding that post will be shown and there'll be a section to post new comments.
- There'll be a profile page where information regarding the current user will be shown.

Express JS (Backend) and Mongoose (Database) will be used to develop this platform. The development process has already encompassed the creation of view files, the establishment of routes for these view files, and the configuration of related files. For the data model, just mention the keys of the model, i.e. *UserModel: name, email, password* etc.

- a) Design the necessary routes, middleware, and controller functions satisfy the following requirements: 7+11
(CO3)
(PO3)
- User authentication
 - The key features of the app
- b) You want to create an additional feature by facilitating group travel plans. Users can seamlessly create and join travel groups, where information such as itineraries, photos, transportation details, and expenses are collaboratively shared. Design the necessary routes, middleware, and controller functions to achieve this. 7
(CO3)
(PO3)
4. a) Explain the working mechanism of *Google File System* based on the master and the client. 7
(CO1)
(PO1)
- b) Below is a part of the description of an artist painting one of his masterpieces - 8+10
(CO2)
(PO2)
- “The artist painted in bold strokes. His bold strokes of vibrant colors adorned the canvas. Then the canvas absorbed the colors with grace. The artist continued to paint. The masterpiece of the artist came to life as the vibrant, bold strokes strokes on the canvas added depth and emotion to the painting.”
- Using it as input, answer the following questions.
- Apply the Map Reduce algorithm on the given input.
 - Consider each sentence as a *document*. For example:
 - Document 1: The artist painted in bold strokes.
 - Document 2: His bold strokes of vibrant colors adorned the canvas. and so on...
- Now, calculate the Relevance Factor for "artist strokes canvas".

5. a) Describe how the requests made by clients are routed to a partitioned database with the help of Table 1.

7
(CO1)
(PO1)

Table 1: Assignment of partitions to nodes for Question 5.a)

Key-range	Partition	Node	IP address
A-ak - Bayes	partition 0	node 0	10.20.30.100
Bayeu - Cean	partition 1	node 1	10.20.30.101
Ceara - Deluc	partition 2	node 2	10.20.30.102
Delusion - Frenssen	partition 3	node 0	10.20.30.100
Freon - Holderlin	partition 4	node 1	10.20.30.101
Holderness - Krasnoje	partition 5	node 2	10.20.30.102
Krasnok - Menadra	partition 6	node 0	10.20.30.100
Menagw - Ottawa	partition 7	node 1	10.20.30.101
Otter - Reth	partition 8	node 2	10.20.30.102
Reti - Solovets	partition 9	node 0	10.20.30.100
Solovyov - Truck	partition 10	node 1	10.20.30.101
Trud - Zywies	partition 11	node 2	10.20.30.102

- b) Encoding involves converting data from its in-memory representation (e.g., objects, structs, lists, arrays) into a byte sequence or some other format that can be easily stored or transmitted. Various methods exist for encoding data, and in the process, we have the opportunity to conserve space. Design three different binary encoding approaches to encode the JSON object given in the Code Snippet 1.

5 × 3
(CO5)
(PO3)

```
1 {  
2   "name": "John Doe",  
3   "age": 30,  
4   "salary": 25000.00,  
5   "tasks": [  
6     {  
7       "title": "Read a book",  
8       "isComplete": false  
9     },  
10    {  
11     "title": "Groceries",  
12     "isComplete": true  
13    }  
14  ],  
15 }
```

Code Snippet 1: A JSON object for Question 5.b)

- c) Evaluate the encoding methods employed in Question 5.b) and elucidate which technique demonstrated superior performance and the reasons behind its effectiveness.

3
(CO2)
(PO2)

- | | |
|---|-------------------------|
| 6. a) Identify the situational contexts in which leader-based (single or multi-leader) and leaderless replication are respectively deemed suitable. | 2
(CO1)
(PO1) |
| b) With appropriate examples and diagrams, explain the write and read operation of leaderless replication. | 10
(CO1)
(PO1) |
| c) Define rebalancing, mention the best strategy for rebalancing with appropriate justification. | 1 + 3
(CO1)
(PO1) |
| d) Explain the following topics with appropriate examples: | 3 × 3
(CO1)
(PO1) |
| i. Multi-level Indexing | |
| ii. Sparse indexing | |
| iii. Dense indexing | |