NUS-ISS

MASTER OF TECHNOLOGY IN SOFTWARE ENGINEERING

Graduate Certificate Examination

Sample Examination Questions

Subject: *Architecting Scalable Systems*

SECTION A

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Question 1 *(Total: 25 Marks)*

Refer to the case study in **Appendix A** and answer the following questions:

a. One of the measures of success of a platform is how it grows its ecosystem by growing its reach with new types of interactions and numbers of users.

i. Two **seeds** that the current platform has are 'Arrival Time' and 'Passenger Load'.
It is required that the platform should to be scalable to support 10,000 updates of arrival times and passenger loads per minute in Phase 1 and the expected response time for updating the users is less than 3 seconds for 90% of the requests.

ii. Amongst many others, some **interactions** are 'View Arrival Times and Passenger Loads at Favourite Location' and 'View Arrival Times and Passenger Loads at Adhoc Location'.
The volume of users currently, in Phase 1 is 100,000 public users and 10,000 registered users; the numbers are projected to grow in future. For the computation of arrival times and passenger loads, updates are expected to be synchronized every 30 seconds (which is the average time for buses to travel between two bus stops).

With respect to the seed and the interactions described above, given the projected growth as described above, explain **two** aspects of the architecture that are crucial to the success of the platform.

(2 Marks)

b. With reference to the domain model found in Section 7 of the case study, analyze the following issues. For **each** issue, identify the **most likely cause**, propose an effective **countermeasure** (by revising the domain model) and suggest the major **drawback(s)** of the countermeasure, if any.

i. The ArrivalTimeComputer service is in charge of computing the latest arrival times for a bus trip based on its position and speed. As the Lead Solution Architect, you are of the opinion that the current domain design is suboptimal in the speedy computation of arrival times.

(5 Marks)

ii. The BusNetworkManager service is in charge of managing the bus stops and bus trips of various bus routes. As the Lead Solution Architect, you are of the opinion that the current domain design is suboptimal in the use of runtime memory. In fact, you are wary of the potentially high memory usage of the instances of the BusNetworkManager service.

(4 Marks)

c. Platforms enable creation of business ecosystems and one such enabler is the services exposed to partners and other participant applications/services of the ecosystem.
Hint: APIs are best identified in an 'outside-in' fashion, catering to the specific needs of the clients.

During the first phase, development of the following APIs to be triggered by the vehicle onboard units were selected and your team designed the following APIs using the RESTful approach: (i) Receive Current Position & Speed and (ii) Receive Passenger Entrance/Exit.

The following interfaces illustrate the current design of the two APIs based on the RESTful approach (c.f. Richardson Level 2 Maturity Model).

URI	Service	Inputs	Outputs	Explanation	HTTP Action
/arrivaltime	ArrivalTimeComputer	Bus Trip, Bus Route, Position, Speed	Processed or not processed.	Update the platform with the position and speed of a bus	PUT
/passengerload	PassengerLoadComputer	Bus Trip, Bus Route, Passenger Event	Processed or not processed.	Update the platform with one passenger event (entrance/exit) of a bus	PUT

After the initial deployment of the APIs on the staging environment, a functionality cum load testing was carried out. An update latency of around 20 to 30 seconds was observed whenever there are large batches of concurrent updates from multiple vehicle onboard units. This is suboptimal as it results in inaccurate users' view on the arrival times and passenger loads at the observed locations.

As a solution architect, explain the **likely reasons** for the update latency. How would you refactor the APIs to address the issue? Illustrate your **new design** using a concrete example.

(6 Marks)

d. Based on the requirements for Phase 1, identify the **two** most important **quality attributes** for the storage/database technology to be used for the platform. These factors would be documented as part of the architectural guiding principles of the platform. **Justify** why these two quality attributes are more important than the others.

(2 Marks)

e. Based on the two quality attributes identified in Q1(d), propose **two** cloud-based storage/database services to be used for the platform. **Justify** your choices by elaborating on how the services help the solution architecture in fulfilling the two quality attributes.

(4 Marks)

f. After the platform services are implemented, they would be deployed into production environment. Assuming that the services identified in the domain model found in Section 7 of the case study are to be deployed using containers. Due to the licensing constraint of the container platform, there is a need to run two or more of the above services in the same container instance. Propose which are the most suitable **services** to be collocated in the same container. **Justify** your choices by elaborating on the benefits gained by their collocation.

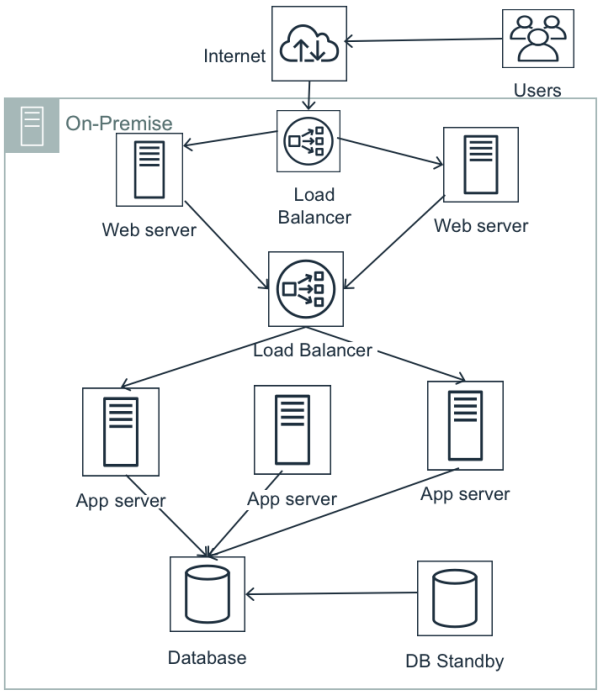
(2 Marks)

Question 2 *(Total: 13 Marks)*

The new pilot mobile application for the bus commuters (code named ***BusInfo4Me***) would be hosted on the MLTTP platform. It provides information for the bus commuters via interactive maps, dashboards, etc. A bus commuter can browse for information regarding real-time bus arrival times and passenger loads of various bus trips. This can help them plan for smoother journey. The app also supports commuter journey mapping with multi-segment routes (a segment is between two bus stops) and allows the bus commuters to personalize their favourite locations. Answer the following questions.

a. The following diagram illustrates a reference architecture for on-premises deployment of a traditional web application. The key components include hardware load balancers, web servers, application servers and database. As a solution architect, **redraw** the architecture so that it is a cloud native architecture that is suitable for MLTTP bearing in mind the key functionalities including commuter journey mapping with multi-segment routes, real time arrival times and passenger loads. Identify and label the architectural components that need to be added, removed or changed. For the backend, will you **prefer** having only microservices or a hybrid architecture? Justify yourpreference by elaborating on its benefits in the context of your revised architecture.

(7 Marks)



b. Based on the scaling requirements specified in section 4 'Performance and Scalability of the Platform' of the case study and the functionality described above, would you prefer to leverage on virtual machines or containers for hosting? Briefly explain your design decisions regarding the scaling of the above factors.

(3 Marks)

c. Consider the prediction of arrival times using machine learning, the technical stack involves using cloud vendor's *(you can choose any vendor)* fully managed services to deliver highly accurate forecasts. The prediction model combines time series data with additional variables to build forecasts. Draw an architecture diagram for the Update Arrival Times at Observed Location use case. Label the appropriate cloud products/managed services that you recommend. Comment on the alternative choices that can be considered for every mandatory component proposed in your architecture.

(3 Marks)

Question 3 *(Total: 12 Marks)*

Refer to the Phase 2 requirements specified in Section 2, the initial architecture specified in Section 6 and the logical architecture for Phase 2 in Section 8 of the case study in **Appendix A** and answer the following questions:

a. With reference to the **incomplete** logical architecture diagram in Figure 6 in Section 8, as the Lead Solution Architect, evaluate the logical architecture and identify **one undesirable architectural decision** and propose the **corrective action**. Justify your answer by explaining how the undesirable architectural decision leads to the proposed corrective action. Also complete the diagram by suggesting the **packaging of the functional elements** (that are yet to be packaged) into subsystems.
Hint: You may draw just the necessary parts of the diagram to illustrate your answers.

(6 Marks)

b. For the prediction functions of Phase 1, the stakeholders expect the accuracy of the predicted values to improve gradually over time. As part of analysis of historical data in Phase 2, propose **one** metric that can be used to measure and track the accuracy of the prediction with consideration of the following design decisions:

- If the proposed metric can be directly captured/reported, propose the **component(s)** that should be responsible to capture and report the metric, the **frequency** of metric captured/reported, the **duration** to keep the data, and the **location** where the data should be stored.
- If the proposed metric has to be calculated based on other data/metrics, explain how the proposed metric is calculated, the **component(s)** that should be responsible to perform the calculation, the **frequency** of metric calculation, the **duration** to keep the data, and the **location** to store the data. Provide similar elaboration for up to two metrics that the proposed metric depends on.

(6 Marks)