University of Colombo, Sri Lanka

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UCSC *University of Colombo School of Computing*

BACHELOR OF SCIENCE IN COMPUTER SCIENCE
BACHELOR OF SCIENCE HONOURS IN COMPUTER SCIENCE
BACHELOR OF SCIENCE HONOURS IN SOFTWARE ENGINEERING
BACHELOR OF SCIENCE IN INFORMATION SYSTEMS
BACHELOR OF SCIENCE HONOURS IN INFORMATION SYSTEMS

Third Year Examination — Semester I— UCSC AY20 [held in October 2023]

SCS3203/IS3108 — Middleware Architecture

(Two (2) Hours)

Answer ALL questions

Number of Pages = 15 Number of Questions = 4

To be completed by the candidate								
Index Number								

Important Instructions to candidates:

- Students should answer in the medium of English language only using the space provided in this question paper.
- Note that questions appear on both sides of the paper. If a page is not printed, please inform the supervisor immediately.
- Write your index number CLEARLY on each and every page of this Question paper.
- The paper has **4** questions on **15** pages (including the Cover Page).
- Programmable Calculators and any electronic device capable of storing and retrieving text including electronic dictionaries, smartwatches and mobile phones are not allowed.
- Non-Programmable calculators are allowed.
- Do not tear off any part of this Question Paper. Under no circumstances may this paper, used or unused, be removed from the Examination Hall by a candidate.

To be completed by the examiners

1	
2	
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4	
Total	

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1. (a). In the context of enterprise platforms, how do the organization and communication of components become both similar and different between the 3-Tier Architecture and the Model-View-Controller (MVC) Architecture?

[6 marks]

(b). How does Service-Oriented Architecture (SOA) differ from Publish and Subscribe (Pub-Sub) Architecture in terms of handling real-time data updates and event-driven communication in modern web applications?

[6 marks]

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(c). In the context of distributed systems, what are the key distinctions between Remote Method Invocation (RMI) and Common Object Request Broker Architecture (CORBA) with respect to object-oriented communication and interoperability?

[6 marks]

(d). How do Session Beans and Entity Beans in Java Enterprise Edition (JEE) differ in their roles and functionality concerning state management, persistence, and business logic in enterprise applications?

[7 marks]

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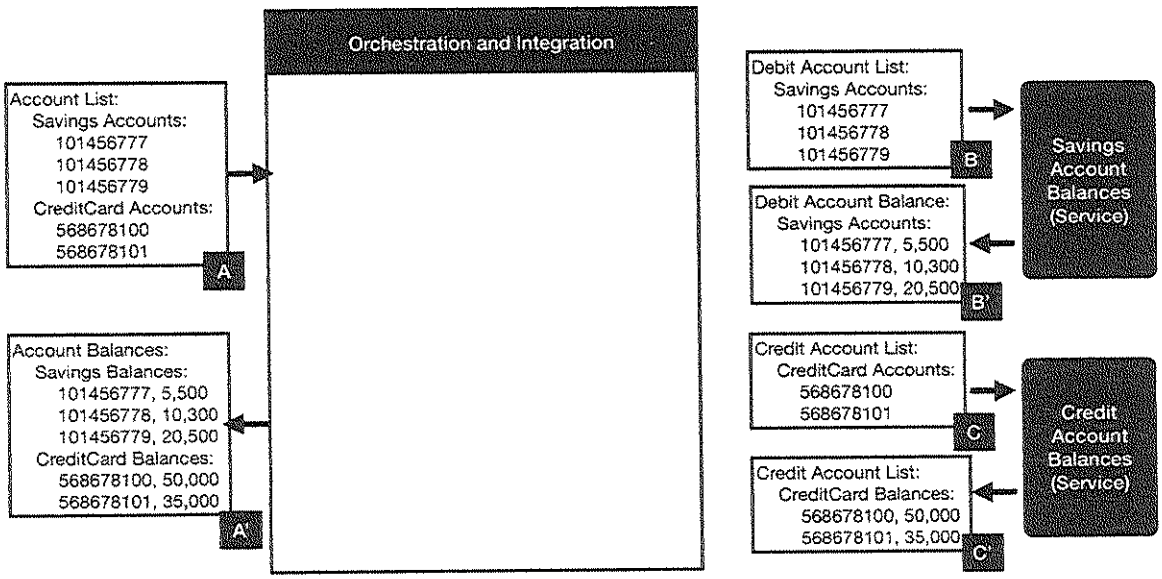
2. (a). The below diagram depicts a scenario in a banking platform where a client request needs to be serviced by orchestrating two internal services. The client request (A) contains a list of savings account numbers and credit account numbers, of which the account balances (debit and credit balances respectively) need to be extracted from existing services. However, the services for maintaining Savings and Credit are mutually exclusive. The architect has proposed to use an Enterprise Service Bus (ESB) to integrate and orchestrate with the Savings and Credit service endpoints. Propose the **integration patterns** that could be used to perform the orchestration of sending messages B and C to the internal services, using the original message A to formulate the final message A'.

(Note: The empty area in the rectangle labelled as Orchestration and Integration or the box below can be used to draw the integration patterns with clear connectivity/dependency among them.)



[10 marks]

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(b). Exchange of information within a distributed system could be done by marshalling/unmarshalling objects or by exchanging data using text formats such as POX, JSON or SOAP. Evaluate the use of these two mechanisms in the context of exchanging data among services in a high-throughput system. Discuss the advantages and disadvantages of using object-based and text-based messages in the evaluation.

[10 marks]

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(c). When using object-based communication protocols in distributed object systems such as RMI and CORBA, the conversion of objects is done through marshalling/un-marshalling and serialisation. Provide a comparison and contrast of the marshalling/un-marshalling method in contrast to the serialization method, specifically focusing on their processes and implications in distributed systems.

[5 marks]

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3. (a). **Service discovery** is an important aspect of the successful implementation of Microservices architecture. List down two (2) prominent methods of service discovery within Microservices architectures. Then, analyse and provide justification for selecting the more suitable method in the context of a large-scale Microservices platform characterized by a continuous increase and change in the number of services.

[10 marks]

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(b). There are several **client-service interaction styles** that are used in a Microservices implementation to enable the most suitable engagement based on the nature of the interaction. The table below summarises the different interaction styles based on the two dimensions: number of participants (one-to-one and one-to-many) and communication mode (synchronous and asynchronous).

	ONE-TO-ONE	ONE-TO-MANY
SYNCHRONOUS	Request/response	—
ASYNCHRONOUS	Notification	Publish/subscribe
	Request/async response	Publish/async responses

The table below summarises four client service interaction scenarios in an online e-commerce catalogue platform.

ID	Client	Service
01	Client request to login using mobile number	Service to validate the phone number and send the OTP to the user
02	Client request to login and capture user profile	Login validation and profile service. The profile is mandatory to continue with the remaining service steps.
03	Client request to add a product item to the shopping cart	Service for searching and finding the item from the inventory and allocating it to the requested user. Because the platform is concurrent and many users may be selecting the same item in the inventory, the search and allocation may take random time that is unpredictable.
04	Client request to deliver the items purchased to the registered postal address	Assume there are several delivery services registered with the e-commerce platform. The platform usually sends the delivery request to all active delivery services and selects the most suitable based on price and response time.

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Select the most suitable client service interaction style for each of the four (4) client and service interaction scenarios given in the above table. Justify your selection for each scenario.

[10 marks]

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(c). Most of the existing service implementations are based on the Service Oriented Architecture that is referred to as legacy/monolith platforms in comparison to the Microservices-based architectures.
Discuss three (3) strategies for refactoring existing legacy/monolith platforms into the Microservices architecture.

[5 marks]

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4. (a). Transaction management is an important aspect of commercial IT platforms. Usually, a transaction consists of a stable initial state and a stable end state. In between these two stable states, there can be several atomic operations that are temporary and unstable. Most transactions occur in concurrency and use shared objects; hence, ACID properties should be maintained in order for transactions to be accurate and trusted.
Listed below is a schedule of two concurrent transactions which has violated consistency and integrity related to ACID properties.

Schedule

Begin T_1

Savings_Balance = Savings_Balance – Amount

Begin T_2

Savings_Balance = (1 + Rate_1) * Savings_Balance

Current_Balance = (1 + Rate_2) * Current_Balance

Commit T_2

Current_Balance = Current_Balance + Amount

Commit T_1

Propose a new schedule compliant with ACID properties that is void of consistency violation.

[8 marks]

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(b). In order to enforce the serialisability of concurrent transactions, one needs a mechanism to delay the progress of transactions. Locking is the most frequently used technique to achieve transaction serialisability. Listed below is a schedule of a transaction that requires locks on two (2) objects to perform debit and credit to realise an account funds transfer.

Transaction T1

Begin $_{T1}$

lock_exclusive $_{T1}$ (Savings_Balance)

Savings_Balance = Savings_Balance – Amount

unlock $_{T1}$ (Savings_Balance)

lock_exclusive $_{T1}$ (Current_Balance)

Current_Balance = Current_Balance + Amount

unlock $_{T1}$ (Current_Balance)

Commit $_{T1}$

The above transaction seems to violate the 2-phase locking(2PL) rule related to concurrent transactions. Identify the issues in the above transaction and propose a new transaction routine that is compliant with 2PL.

[10 marks]

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(c). Fault tolerance is an important aspect of a high-available system. The use of redundancy is a popular approach to achieve fault tolerance and consequently, high availability. Explain the method of fault-masking using Triple Modular Redundancy to achieve high availability. Describe the application of Triple Modular Redundancy to a mission-critical system such as real-time aircraft navigation or nuclear plant automation (use only one application out of the two).

[7 marks]

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