INTERNATIONAL UNIVERSITY OF EAST AFRICA

'Learning to Succeed'

FACULTY OF SCIENCE AND TECHNOLOGY

END OF SEMESTER EXAMINATIONS - DECEMBER 2025

PROGRAMME: BSSE

YEAR/SEM: YEAR 4/SEMESTER 1

COURSE CODE: SWE4111

NAME: SOFTWARE ARCHITECTURE

DATE:

TIME:

INSTRUCTIONS TO CANDIDATES:

SECTION A

Section A carries 40 marks and is compulsory. Draw clear well diagrams where needed

Question 1:

Case Study: A University Course Registration System

Scenario:

IUEA is building a new online course registration system called "EduReg". The system will replace the old paper-based registration process. Students will register for courses, view their schedules, and check prerequisites. Faculty will manage course offerings and view enrollment. Administrators will manage the overall system, generate reports and handle exceptions.

System Overview:

a. 15,000+ students will use the system during peak registration periods
b. Must integrate with existing Student Information System (SIS)
c. Must send email notifications
d. Should work on desktop and mobile devices

Requirements List

a. Students must be able to search for courses by faculty, course code or lecturer’s name.
b. The system must handle 5,000 concurrent users without performance degradation.
c. All pages must load within 2 seconds under normal network conditions.
d. Students must receive an email confirmation within 2 minutes of successful registration.
e. The system must be available 99.9% of the time during registration periods.
f. Students must not be allowed to register for courses without meeting admin prerequisites.

Business Process Flow (Student Course Registration Flow):

When a student attempts to register for a course, the following happens:

a. Student selects a course from the catalog
b. System checks if the student meets prerequisites
c. If prerequisites are not met, system shows error and stops
d. If prerequisites are met, system checks course capacity
e. If course is full, system offers wait list option
f. If space available, system checks for schedule conflicts
g. If no conflicts, registration is completed
h. System updates student's schedule
i. System sends confirmation email to student

System updates course enrollment count

You will need to present the EduReg system to different stakeholders.

Stakeholder Groups

Group 1: University Board of Trustees

This group is comprised of Non technical executives This group's main concern is the overall system purpose, external dependencies and costs (development, deployment and maintenance).

Group 2: Development Team Lead

This group is highly technical and their main concerns are; Internal structure, component responsibilities and software development team's work distribution.

Questions

a. **Categorize the given requirements as Functional or Non-Functional and explain your reasoning. Present this in a tabular format. (5marks)**

b. List three reasons why is it important to distinguish between functional and non-functional requirements? (3 marks)

c. Can you identify any 2 additional functional and non functional requirements for EduReg? (2 marks)

d. Draw and clearly mark a process flow diagram clearly documenting and presenting the University's suggested business process flow during student's registration. (10 marks)

e. Complete the table below: (10 marks)

Stakeholder	C4 Level	Key Information to Show	Why this Level?
University's Board of Trustees			
IT Director			
Developers on the Team			

f. For the IT Director, sketch a C4 Level 2 diagram showing Web Application, API Application, Database, Email Service, Integration with Student Information System (7marks)

g. Why does C4 use multiple levels instead of one comprehensive diagram? (1 mark)

h. What happens if you show too much detail to the wrong audience? (1 mark)

i. How would you maintain these diagrams as the system evolves? (1 mark)

Question 2:

BrightMart, a fast-growing online retail platform, wants to upgrade its system to support an

increasing number of daily users and store branches across the country. The new system must handle:

- Online ordering through a mobile app and web platform
- Automatic stock updates from different branches
- Notifications (SMS and email) to customers about order status
- A centralized admin dashboard that shows sales, stock levels, and customer activity
- Secure login for customers, branch managers, and system admins

To achieve this, BrightMart decides to redesign the system using:

- Middleware for handling authentication, logging, notifications, and communication between the app, website, and backend services
- A modular architecture where functions such as ordering, payments, notifications, and inventory operate independently
- REST APIs to enable communication between services
- A message queue to process large volumes of notifications and stock updates
- Role-Based Access Control so each user type accesses only what they are supposed to view
  During the initial tests, the system worked but experienced:
- Slow performance during peak hours
- Occasional failures in sending SMS notifications
- Security concerns due to exposed endpoints and weak password enforcement
- Difficulty integrating the mobile app and web platform with the notifications module

BrightMart now wants a full rollout and has asked you, the software architect, to evaluate and recommend improvements.

Questions

1. Identify the architectural style(s) that best fit the redesigned system.(2 marks)
2. Explain why these architectural styles are appropriate for an e-commerce platform that needs to scale and integrate multiple services. (8 marks)
3. Describe the role of middleware within the BrightMart system. (2 marks)
4. Identify and explain any three (3) middleware components required for smooth operation between the mobile app, website, and backend services. (7 marks)
5. Identify four potential security threats that an online retail system like BrightMart may face and for each threat give an appropriate mitigation strategy. (10 marks)
6. Explain two scalability or performance challenges highlighted in the case study. (4 marks)
7. Recommend architectural solutions to improve scalability for: (6 marks)

   i) The notification system

   ii) API traffic handling during peak hours

   iii) Integration of multiple branches sending frequent stock updates

SECTION B

Attempt any 3 questions. Each question carries a total of 20 marks. Draw clear well diagrams where needed

Question 1:

a. Define Software Architecture and explain its key elements. (4 marks)

b. Differentiate between Architecture, Design, and Coding. (3 marks)

c. Explain why software architecture is important in the Software Development Lifecycle (5 marks)

d. In a table, highlight the major differences between Monolithic Architecture and Microservices Architecture in terms of Structure,Deployment and Scalability. (5 marks)

e. Think about the apps you use daily (WhatsApp, Uber, e-banking, Jumia, AirBnB, Mobile Money, Your End Of Year Project, etc.)

   i. What architectural decisions can you identify? (1 mark)

   ii. Why might those decisions have been made? (1 mark)

   iii. Identify any two improvements in the architecture of the application identified that would greatly improve its performance. (1 mark)

Question 2:

a. What are design patterns? (1 mark)

b. List three categories of design patterns (3 marks).

c. You have been tasked to design a module for an e-commerce system. This module is responsible for creating different types of order objects and handling notifications when and order's status changes. Orders are categorized as Standard Order and Express Order (10marks)

   i. Draw a simple UML class diagram illustrating the Factory Method pattern for this scenario. Your diagram should include:

      a. An Order interface/abstract class with a method like calculateShipping().

      b. Concrete classes StandardOrder & ExpressOrder that implement the Order interface.

      c. An OrderFactory abstract class with the factory method createOrder()

      d. Concrete factories StandardOrderFactory and ExpressOrderFactory.

d. In a few sentences, explain why the Factory Method pattern is more suitable here than directly using the new keyword (e.g., new StandardOrder()) in the client code. (2 marks)

e. Write a pseudocode snippet showing how a client would use the ExpressOrderFactory to create an ExpressOrder and then call its calculateShipping() method. (4 marks)

Question 3:

a. What is the primary purpose of conducting a software architecture evaluation? (2 marks)

b. List 4 key benefits of performing this evaluation early in the development lifecycle(4

marks)

c. Briefly describe the focus of the following architecture evaluation methods:

    i. ATAM (Architecture Tradeoff Analysis Method) (2 marks)

    ii. SAAM (Software Architecture Analysis Method) (2 marks)

d. Why is it important to use structured scenarios when evaluating an architecture, as opposed to just informally discussing it? (2 marks)

e. What is the primary purpose of an architectural tactic? (1 mark)

Question 4:

You are part of a team evaluating the architecture of QuickShop, an online retail platform. The system has 500,000 registered users and is expected to scale to 2 million within 18 months. It experiences extreme peak traffic during flash sales and has a critical availability requirement of 99.9% uptime.

The current architecture is based on a microservices style with event-driven communication. Key services include: User Service, Product Catalog Service, Shopping Cart Service, Order Processing Service, Payment Service and Notification Service. All traffic is routed through an API Gateway. Each service uses its own MySQL database, and the system is deployed on premise using Kubernetes for orchestration.

The development team has provided the following quality attribute scenarios for review:

- Scenario 1 (Performance): During a flash sale, 5,000 concurrent users browse products and add items to their cart. The system must serve 99% of these requests in under 3 seconds without any failures.
- Scenario 2 (Availability): If the Payment Service crashes during normal operation, the system must preserve 100% of orders, queue them for later processing, and notify users of the delay.

a. "The QuickShop platform uses a Microservices architecture style." State two advantages and challenges of using this style for the design of the QuickShop.(4 marks)

b. Based on Scenario 1 (Performance), name and briefly explain two distinct architectural tactics that could be used to help the system achieve the 3-second response time goal. (4 Marks)

c. Based on Scenario 2 (Availability), name and briefly explain two distinct architectural tactics that could be used to ensure order preservation and graceful failure handling. (4 Marks)

d. The architecture includes an "API Gateway."

    i. What is the primary role of an API Gateway in a microservices architecture? (1 mark)

    ii. How does it contribute to achieving the system's quality attributes? (1 mark)

e. The decision to give each microservice its own MySQL database improves modifiability and loose coupling. Explain how this decision achieves this benefit and What is a potential trade-off or operational challenge introduced by this decision? (3 mark)

f. Consider the use of an event-driven communication pattern between services.

How does an event-driven approach specifically help in fulfilling Scenario 2 (Payment Service failure)? (2 marks)

ii. Despite its benefits, what is one risk or complexity introduced by using an event-driven architecture? (1 mark)

Question 5:

a. Explain in simple terms what these are: coupling, tight coupling, loose coupling, cohesion (4 marks)

b. List and briefly the four fundamental principles of Object-Oriented Programming. (8 marks)

c. What is the difference between a class and an object? (2 marks)

d. Based on the following class definition, create an object named student1 and call its introduce() method. (4 Marks)

```
public class Student {
String name;
int age;
public void introduce() {
System.out.println("Hello, my name is " + name);
}
}
```

Question 6:

a. What is the difference between a Functional Requirement and Non-Functional Requirement? And give one example of each (4 marks)

b. List and briefly describe the first three steps in the requirements analysis process (6 marks)

c. Which level of the C4 model is best suited for explaining the system's structure to non-technical stakeholders and what does it show? (3 marks)

d. Name two types of UML Behavioral Diagrams. (4 marks)

e. Why is it considered a best practice to use the C4 Model for high-level architecture documentation and UML for more detailed design modeling? (3 marks)

Question 7:

a. Differentiate between High-Level Design (HLD) and Low-Level Design (LLD) in terms of their purpose and typical audience. (4 marks)

b. List and briefly explain any four symptoms of a "rotting design" (8 marks)

c. What is the core purpose of Creational design patterns? (2 marks)

d. Name three different creational design patterns. (3 Marks)

e. The Singleton pattern ensures a class has only one instance.

i. What is a common use case (purpose) for this pattern? (1 mark)

ii. What is a potential drawback or consideration when using the Singleton pattern, especially in a multithreaded environment? (2 marks)

Question 8:

a. What does the acronym EMR stand for? (1 mark)

b. In the context of healthcare systems, what is meant by interoperability? (2 marks)

c. Describe the Brokered architectural style for connecting an LIS and an EMR. Explain one key advantage it has over a simple Point-to-Point connection. (3 marks)

d. A case study suggests using “asynchronous communication” as a tactic to achieve the quality goal of Performance.

    i. What would asynchronous communication mean in this context? (2 marks)

    ii. How does it improve performance compared to synchronous communication? (2 marks)

e. Name two security tactics that are critical for protecting patient data during exchange between LIS and EMR. (2 marks)

f. Explain why security is non-negotiable in this specific context. (2 marks)

g. List and briefly explain three common technical or operational challenges that can arise when trying to connect two independent systems like an LIS and an EMR. (6 marks)

Question 9:

a. Explain five types of software architectural patterns you are familiar with and mention examples of their applications (10 marks)

b. List and explain five quality attributes of software (10 marks)

Question 10:

The Agent Banking System comprises of SMS notification that sends a notification to both depositor and account owner, Account Balance Crediting service, Printing of Deposit receipts and Notification of account owner via SMS if the account owner has subscribed for such a service. The bank agent uses either an Android Point of Sale device.

a. Identify the software architecture that best fits this system and justify your choice. 2 marks)

b. Identify two areas where middleware is applied in the system. (3 marks)

c. Propose three security controls that should be implemented to enhance system protection.(3 marks)

d. Differentiate between frontend, backend, and full-stack frameworks, giving one example of each. (3 marks)

e. Discuss 3 benefits of using frameworks when developing software applications. (3 marks)

f. Describe four common functions of middleware and explain why they are important in distributed systems. (8 marks)

Question 11:

a. Explain any 4 common tactics for different quality attributes (8 marks)

b. Define and explain the software quality attributes of availability, performance, security,

maintainability and scalability(10 marks)

c. What is the primary focus while evaluating an architecture using the ATAM method? (2marks)

Question 12:

a. What is the difference between a Functional Requirement and Non-Functional Requirement? And give one example of each (4 marks)

b. List and briefly describe the first three steps in the requirements analysis process (6 marks)

c. Which level of the C4 model is best suited for explaining the system's structure to non-technical stakeholders and what does it show? (3 marks)

d. Name two types of UML Behavioral Diagrams. (4 marks)

e. Why is it considered a best practice to use the C4 Model for high-level architecture documentation and UML for more detailed design modeling? (3 marks)