UNIVERSITI TEKNOLOGI PETRONAS

FINAL EXAMINATION
JANUARY 2025 SEMESTER

COURSE	:	**EDB4713 - UBIQUITOUS COMPUTING**
DATE	:	**10 APRIL 2025 (THURSDAY)**
TIME	:	**2.30 PM - 5.30 PM (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **SEVEN (7)** pages in this Question Booklet including the cover page .

ii. **DOUBLE-SIDED** Question Booklet.

1. A modern campus is evolving into a smart digital environment where classrooms, laboratories, public spaces, and administrative offices are equipped with a variety of smart devices. These include sensors, smart displays, wearable devices, and mobile gadgets that continuously interact with both the physical and virtual worlds.

a. **Instructions:**

Fill in each blank (1 and 2) below using the correct terms from the provided options (A–E). Each option can be used once, more than once, or not at all.

Question:

In ubiquitous computing, (1) focuses on interactions between humans and devices (e.g., smartphones, tablets), while (2) deals with interactions between devices and the physical environment (e.g., sensors measuring temperature or motion).

Options (A-E):

A. Human–ICT Device Interaction (HCI)

B. ICT Device to Physical World Interaction (CPI)

C. Interaction Across Environments

D. Inter-Device Context (IDC)

E. Human–Physical Collaboration (HPC)

[2 marks]

b. The questions below explore key concepts in ubiquitous computing, particularly focusing on Weiser's classification of smart devices and their extended forms.

i. Briefly describe what a "Tab" and a "Board" are, according to Weiser's forms of ubiquitous computing.

[2 marks]

ii. Explain the following extended forms in ubiquitous computing by providing a short definition or example for each:

Dust:

Skin:

Clay:

[6 marks]

iii. Identify **ONE (1)** incorrect statement from the following list and justify your answer:

- Tabs are small digital devices for quick personal tasks.
- Pads are medium-sized devices for general computing purposes.
- Boards are small wearable sensors used for real-time activity tracking.
- Clay refers to devices capable of reshaping themselves based on usage.

[2 marks]

c. As a systems architect, you're tasked with designing a distributed architecture integrating diverse smart devices to support campus-wide services like context-awareness, resource management, and dynamic human–system interactions.

- Clearly describe the major components of your proposed system and briefly explain how they interact to ensure smooth data sharing and coordinated services across the campus.
- Discuss key implementation challenges, specifically addressing scalability, security, and real-time data processing. Provide relevant examples for a smart campus scenario.
- Finally, propose a fault-tolerance mechanism that could handle situations like a sudden failure of a building's sensor network. Justify your proposed solution's effectiveness in maintaining reliability using diagrams or sketches to illustrate your ideas clearly.

[12 marks]

2. Modern digital environments are increasingly characterized by interconnected devices and systems. Imagine a smart urban campus where a distributed system coordinates resources across multiple buildings such as classrooms, libraries, and offices. In this campus, sensors, smart displays, mobile devices, and servers work together to manage tasks like environmental control, resource scheduling, and user interactions.

a. Define middleware in your own words and briefly explain its primary role in distributed systems.

[2 marks]

b. In a smart campus, middleware acts as the backbone for communication and integration across various devices and applications.

i. Identify and describe three key characteristics or services that middleware provides in the context of a smart campus environment.

[6 marks]

ii. For each characteristic/service you listed, give a specific example of how it might improve resource scheduling or environmental control in a campus setting

[4 marks]

c. Design a middleware solution tailored specifically for a smart urban campus to ensure effective communication, scalability, and reliability. Your answer should clearly present a high-level architecture diagram (simple sketch recommended) identifying main middleware components (such as communication bridges, abstraction layers, and service managers). Explain how these components facilitate seamless communication among diverse systems (e.g., sensors, smart displays, mobile devices, servers) and address scalability and reliability. Additionally, critically evaluate one potential challenge you might encounter implementing this middleware and propose a clear strategy to overcome or mitigate it.

[12 marks]

3. Middleware integrates diverse systems through design patterns and layered architectures, enabling scalable, maintainable, high-performance distributed applications in modern dynamic environments.

a. Briefly explain one key benefit that middleware design patterns offer when integrating diverse systems in distributed environments. Illustrate your explanation with a relevant practical example.

[3 marks]

b. Middleware design patterns and layered architectures promote effective system structure, modularity, and scalability.

i. Identify and describe two middleware design patterns (different from patterns previously discussed) that enhance reusability and efficient integration. Provide a practical example for each pattern.

[4 marks]

ii. Draw a simple diagram illustrating a layered middleware architecture designed for modularity and scalability. Clearly label at least three layers in your diagram and briefly explain the role of one selected layer.

[6 marks]

c. Communication mechanisms and performance considerations are crucial to successfully deploying middleware in real-world distributed environments.

i. Compare and contrast asynchronous and synchronous communication methods in middleware, providing one practical example of each approach.

[4 marks]

ii. Clearly discuss how middleware design can improve scalability and performance in distributed systems, especially in resource-constrained environments such as IoT, and illustrate your answer with an appropriate example.

[9 marks]

4. Low-power wireless communication is essential for connecting devices in resource-constrained environments. **FIGURE Q4** shows a comparative overview of various short-range, low-power, and cellular IoT wireless technologies, illustrating how they differ in range (x-axis), data rate (y-axis), and approximate cost/power consumption.

FIGURE Q4

a. Identify and briefly explain two key trade-offs in low-power wireless communication systems.

[3 marks]

b. Consider the practical implications of different low-power wireless technologies by analyzing their performance characteristics shown in **FIGURE Q4**:

i. Compare BLE and LoRa regarding communication range, data rate, and power consumption.

[4 marks]

ii. Explain how energy consumption is balanced against communication distance, highlighting factors clearly shown in **FIGURE Q4**.

[6 marks]

c. Building on your analysis of technology characteristics, explore the practical importance of selecting suitable technologies and frequencies for specific low-power wireless application scenarios.

i. Clearly describe one practical application scenario where long-range, low-power wireless communication is essential, and justify your selection based on the technology's specific characteristics.

[3 marks]

ii. Discuss clearly how frequency selection (e.g., 2.4 GHz vs. sub-GHz) influences both communication range and interference in low-power wireless systems, providing relevant examples.

[10 marks]

-END OF PAPER-