Q1. Consider a mobile app that offers navigation recommendations to the users based on the current position and the given destination in an indoor environment. Give a suitable solution for developing the location system (based on the existing approached discussed in the class) for this app. Answer the following questions.

a. How do you estimate the user's current position by utilizing the wireless channel properties?

b. Give a step-by-step procedure to find out the best route from current position A to destination B for this app? State all the assumptions clearly. What is the cost function for your proposed path selection method?

c. Discuss a suitable method to make this app privacy-safe (i.e. no location traces for the user to be shared with external entities)?

Q2. Suppose you are tasked with designing an IoT-based wildlife tracking and environmental sensing system to be deployed in remote forest areas to study animal movement patterns, monitor temperature and humidity, and detect poaching events (e.g., gunshots or human movement). The nodes are solar-powered and expected to run for months with minimal human intervention. The system should relay data to a central server in a nearby research station located ~10 km away.

a. Choose the most appropriate wireless communication protocol for this deployment (e.g., Zigbee, LoRaWAN, NB-IoT, Wi-Fi, BLE). Justify your choice considering range, power, and data rate requirements.

b. How would you design the power management strategy for the sensor nodes to maximize their operational life? Discuss duty cycling, sleep modes, and energy harvesting.

c. To detect and classify wildlife movement, suggest a sensor fusion strategy using at least two different types of sensors. Describe how the combined signal improves reliability over single-sensor detection.

d. If the nodes are unable to communicate directly with the base station due to terrain, propose a suitable network topology or routing protocol that ensures reliable data delivery.

e. What data privacy or ethical issues might arise from such a system in regions inhabited by indigenous communities? How would you address them in your design?

Q3. Imagine an IoT-based urban air quality monitoring system deployed across a smart city. The system consists of stationary sensors installed on streetlights, mobile sensors embedded in public buses and taxis, and personal wearable air quality monitors used by citizens. The objective is to create a real-time, fine-grained pollution heatmap of the city, allow personalized exposure alerts, and help municipal authorities respond with micro-level traffic regulations and public health advisories.

The system supports edge-based anomaly detection for sudden spikes (e.g., gas leaks or fire), cloud-based analytics for temporal-spatial pollution patterns, and a citizen-facing mobile app for exposure history, suggestions, and route planning.

a. Identify and justify the most suitable IoT architecture model for this system. Mention which layers would handle what functionalities.

b. What set of sensors and communication technologies would you recommend for:

i. Fixed air quality stations
ii. Mobile vehicle-mounted nodes
iii. Personal wearable monitors

Justify your sensor choices with respect to power, cost, range, and reliability.

c. If the system needs to alert authorities within 3 seconds of detecting hazardous levels of pollutants in any street corner, what kind of data processing and communication protocol stack should be implemented? Justify with attention to latency and reliability requirements.

d. Suppose multiple sensors report slightly inconsistent values for the same location due to calibration errors or environment interference. Propose a strategy for data fusion or validation to ensure trustworthy data is used for analytics and alerts.

e. If the mobile app includes a feature for asthma patients to plan the "least polluted walking route", what additional context-aware data should the system integrate beyond air quality levels?

f. List and explain at least three major challenges (technical or ethical) in the long-term deployment of this system across a large city. Also, suggest mitigation strategies.