Question 1

Please use the following answer as guidelines for grading. If the student responses are close to this, you can give them good marks.

REST API Design:

Endpoints: (2)

a. **POST /patientData:** This endpoint is used to upload new patient health metrics to the server. It accepts data like heart rate, blood pressure, and glucose levels in the JSON format.
b. **GET /patientData/{patientId}:** Retrieves the latest health metrics for a specific patient. This is crucial for doctors to access real-time data for decision-making.
c. **PUT /patientData/{patientId}:** Updates existing health records, useful for correcting or adding new data points.
d. **DELETE /patientData/{patientId}:** Removes a patient's data, ensuring compliance with data protection regulations.

Request and Response Structure: (1.5)

a. **Request: POST /patientData** with payload **{ "patientId": "12345", "heartRate": 80, "bloodPressure": "120/80", "glucoseLevels": 90}**
b. **Response: { "success": true, "message": "Data uploaded successfully", "dataId": "67890"}**

MQTT Design:

Topics: (1.5)

a. **healthmetrics/live/{patientId}:** Used for publishing live health metrics This allows subscribing services, like patient monitoring dashboards, to receive updates in real-time.
b. **alerts/highPriority/{patientId}:** For critical alerts that need immediate attention, such as abnormal heart rate readings.

2. **Publish-Subscribe Messages: (2)**
   a. **Structure:** Messages published to **healthmetrics/live/{patientId}** might include JSON formatted data like **{ "heartRate": 80, "bloodPressure": "120/80", "timestamp": "2023-09-01T12:00:00Z"}**.
   b. **Considerations for Topic Hierarchy:** This structure allows efficient data sorting and access control, ensuring that only authorized subscribers can access patient-specific data streams.

Comparison of REST vs. MQTT:

1. **Real-time Data Handling:** MQTT excels in real-time data updates due to its lightweight and publish-subscribe nature, making it ideal for continuous health monitoring. REST, while reliable, is less efficient for real-time updates due to the need for frequent polling.
2. **Network Efficiency:** MQTT is more network-efficient in scenarios requiring frequent message updates due to its lower overhead. REST typically consumes more bandwidth as each request includes headers and metadata.
3. **Scalability:** Both protocols are scalable, but MQTT may have the edge in scenarios involving thousands of devices due to its low bandwidth requirements and efficient message distribution model.
4. **Reliability:** MQTT provides inherent support for intermittent connections and can ensure message delivery even in unstable network conditions, which is crucial in remote healthcare monitoring. REST relies on stable HTTP connections, which may not always be practical in remote areas.
5. **Security:** Both protocols support strong security mechanisms. MQTT can use TLS/SSL for data encryption, and REST can secure connections using HTTPS. However, MQTT's broker-based model might require additional security considerations to manage subscriptions and access control effectively.

In conclusion, for a healthcare monitoring system, MQTT appears more suited for the continuous and real-time transmission of health metrics, while REST could be used effectively for less frequent, CRUD-style operations. The choice between MQTT and REST will largely depend on specific requirements such as data sensitivity, real-time needs, and infrastructure availability.

Question 2 The answers are available on course slides. Request TAs to check.

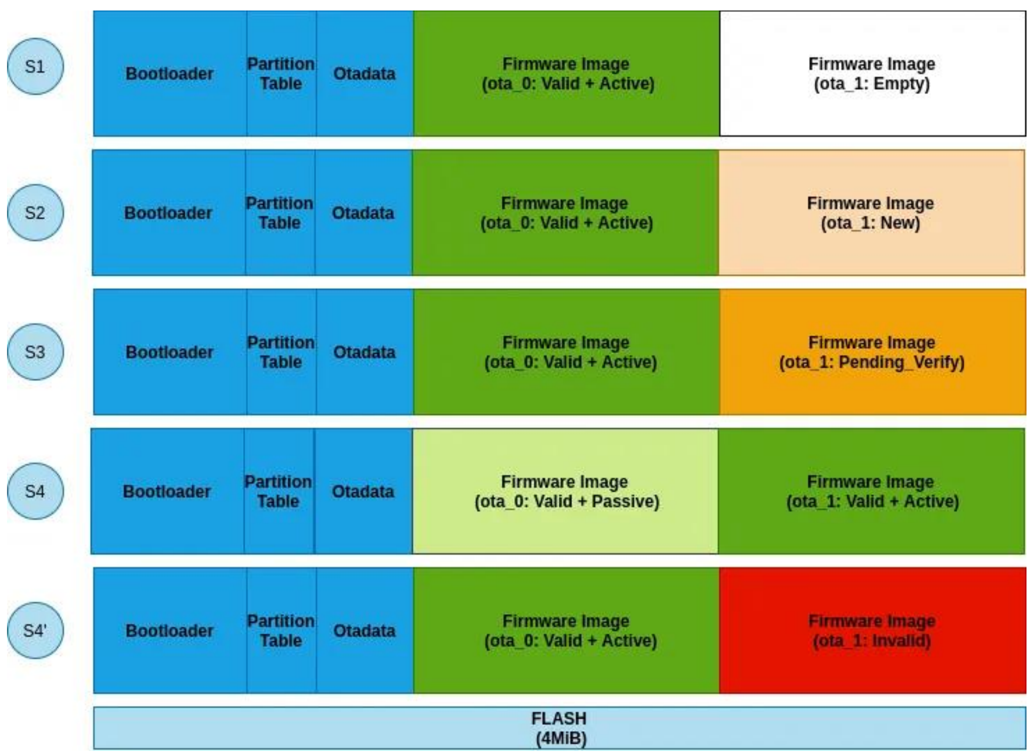
a) Advantages of OTA:
   i. Fix Bugs
   ii. Add New Features
   iii. System Updates
   iv. Driver Updates

   (or any other relevant advantage of OTA update over normal update)

b) Challenges implanting OTA updates:
   i. Connectivity and Bandwidth Limitation
   ii. Device Heterogeneity
   iii. OTA Update Reliability

iv. Power and Resource Constraints
v. Error Handling and Rollback
vi. Regulatory Compliance

c) The ESP32 platform addresses update failures through a dual-partition system that includes a recovery mechanism. This system consists of a bootloader and two firmware partitions (typically named OTA_0 and OTA_1). The device initially boots from the primary firmware partition (OTA_0). In the ESP32 OTA update process, a new firmware update is first loaded into the inactive ota_1 partition, allowing for a safe testing environment separate from the operational ota_0 partition. Upon a device reset, the bootloader shifts focus to ota_1 to verify the new firmware, tentatively running it to assess stability and functionality. If the firmware in ota_1 passes these essential operational checks, it becomes the new default firmware. Conversely, if it fails to meet the required performance criteria, the system automatically reverts to the stable firmware in ota_0, ensuring continuous reliable operation without disruption from potentially faulty updates. This approach minimizes risks associated with failed updates, maintaining device stability and user trust.



Marking Scheme:
Explain dual partition/basic OTA working: 0.5
Explain the process and failure handling: 1.5
Diagram: 1
If diagram and explanation are done together, clearly explaining the handling

Question 3

V2V: Vehicle-to-Vehicle

V2I: Vehicle-to-Infrastructure

V2P: Vehicle-to-Pedestrian

V2X: Vehicle-to-All (or Everything)

Question 4

0.5 marks for technology 0.5 for explanation.

1. Smart Agriculture.
    a. Zigbee and Z-Wave: Low power usage, can run on battery, with mesh networks capability the range can be extended.
    b. LoRaWAN: Long-range communication, up to 15 km in rural areas, low power consumption.
2. Wearable Health Monitors.
    a. Bluetooth and Bluetooth Low Energy (BLE):
    b. Wi-Fi: High bandwidth, allowing for the transfer of large amounts of data.
3. Connected Vehicles
    a. Cellular (LTE, 4G, 5G): Wide coverage, high data rates, supports mobile devices/
4. Wildlife Monitoring (like tracking tigers)
    a. NB-IoT: Very low power consumption, extending battery life significantly, excellent penetration and coverage, even indoors or underground.
5. Urban Air Quality Monitoring (city-scale)
    a. Cellular (LTE, 4G, 5G): Wide coverage, high data rates, supports mobile devices.
6. Smart Home Security System
    a. Wi-Fi: High bandwidth, allowing for the transfer of large amounts of data.
    b. Zigbee and Z-Wave: Low power can run on battery.

Question 5 -

Marking scheme: 3 marks for sensors mentioned and 4 marks for the outputs being appropriate to trigger the next module.

1. Filtration -
   a. Input: Raw water turbidity and pH levels
   b. Output: High turbidity or inappropriate pH levels triggering filtration before water is redirected.
   c. Sensors: Turbidity sensors, pH sensors
   d. Actuators: Valves, Pumps
2. Emergency water storage -
   a. Input: Water levels and quality parameters in the storage tank.
   b. Output: Low water levels or compromised water quality triggering refilling or purification processes
   c. Sensors: Water level sensors, Water quality sensors
   d. Actuators: Valves, pumps
3. Household purposes -
   a. Input: Flow rate and water pressure in household supply lines
   b. Output: Low flow or pressure drop triggering pumps to stabilize flow and pressure
   c. Sensors: Flow meters, Pressure sensors
   d. Actuators: Pressure regulators, Pumps
4. Drinking and agricultural purposes -
   a. Input: Water distribution metrics and soil moisture levels
   b. Output: Insufficient water distribution or soil dryness triggering increased water supply or irrigation
   c. Sensors: Flow meters, Moisture sensors (for agriculture)
   d. Actuators: Automated irrigation controllers (for agriculture), Pumps
5. Water recycling unit -
   a. Input: Conductivity and chemical contamination levels in the wastewater
   b. Output: High conductivity or contaminant levels triggering intensive recycling processes
   c. Sensors: Conductivity sensors, Chemical sensors
   d. Actuators: Pumps, Valves
6. Waste Treatment -
   a. Input: Organic and chemical content in the wastewater
   b. Output: High biological content or toxicity levels triggering specialized treatment processes
   c. Sensors: Biological oxygen demand (BOD) sensors, Toxicity sensors
   d. Actuators: Chlorinators, Sludge pumps

If the student is able to connect the input & output to make some logic, give marks.