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Rename the completed Word document to *yourlastname\_Q6.docx* before emailing it to [tlupfer@sandiego.edu](mailto:tlupfer@sandiego.edu). In other words, my quiz would be named *lupfer\_Q6.docx*.

This is a closed-book, off-grid (no Internet searches) quiz. You have 20 minutes to complete it.

**Reminder**: USD Honor Code: [www.sandiego.edu/conduct/documents/HonorCode.pdf](http://www.sandiego.edu/conduct/documents/HonorCode.pdf)

**All questions are worth 5 points (20 x 5 = 100 points total)**

At the highest level, what are the two types of Bluetooth communication? Hint: you use one of them to listen to audio wirelessly.

1. **Answer**: BLE (Bluetooth Low Energy)
2. **Answer**: Bluetooth Classic (used as in audio example)

You are developing a BLE-based continuous health monitor to measure heartrate and respiration rate that will be attached to a patient’s chest. The health monitor communicates with a hub in their home to send acquired data to the cloud to be analyzed. In testing the system, you notice the health monitor does not seem to achieve the typical BLE range of 10 meters, depending on the patient’s position and physical orientation relative to the hub. Why is that?

1. **Answer**: Since the human body is made largely of water, and water absorbs 2.4GHz RF waves relatively easily, a human in between BLE devices can drastically reduce range as in this case.

If you determine that the connection between the health monitor and the hub gets broken and reestablished as the patient moves around their house, what is a possible solution? There are several, so give it some thought and propose at least one.

1. **Answer**: An easy consideration for the user would be to rethink placement of the hub, as an optimal location would be very central. Another potential solution would be to add multiple hubs.

The continuous health monitor is powered by a 3V CR2032 coin cell with a capacity of 200mAh. The peak battery current drawn by the health monitor is 10mA. If the health monitor were to continuously draw that much current from the battery, how long would the battery last?

1. **Answer**: 20 hours

You find that the battery actually powers the health monitor for much longer than the worst-case scenario you calculated above. Why is that?

1. **Answer**: The battery can power it for much longer thanks to low power operation made possible my intermittent (as opposed to constant) data transmission/communication, only operating when necessary.

What are the three main layers of the software architecture of a BLE device?

1. **Answer**: Application
2. **Answer**: Host
3. **Answer**: Controller

What is the name of the interface between the bottom two layers?

1. **Answer**: HCI (Host Controller Interface)

What is the name of the interface developed by ST Micro that is a superset of the above interface?

1. **Answer**: ACI (Application Control Interface)

Going back to the continuous health monitor and the hub, identify which is acting as a peripheral and which is acting as a central.

1. **Answer**: Health Monitor – Peripheral
2. **Answer**: Hub – Central

What does a peripheral do to indicate it is available to communicate with a central?

1. **Answer**: Broadcasts

What do we call a peripheral that only does the above BLE operation?

1. **Answer**: Beacon

What do we call a central that only expects the above behavior from a peripheral?

1. **Answer**: Host

Describe an application for a peripheral and central that are operating in the above restricted fashion? Hint: I described two potential applications.

1. **Answer**: Grocery store monitoring foot traffic via beacons pinging shoppers’ cell phones.

Questions 15-17 deal with unidirectional communication from the peripheral to the central. What is the name of the state that must be established for bidirectional communication between a peripheral and a central?

1. **Answer**: Connected

Which side allows the above state to be established (the peripheral or the central)?

1. **Answer**: Central

The B-L475E-IOT01A development board contains an SPBTLE-RF module which contains a BlueNRG-MS chip. What type of interface connects the STM32L475E MCU with the BlueNRG-MS chip?

1. **Answer**: SPI