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Our capstone client expressed frustration at the current data transfer system from our device. Currently, the device records motion data to an SD card, which our client manually removes to access. The client would prefer an easier way to remove the data from the device, as extracting the data off the device is clunky at best and could damage the device at worse. This is why I investigated enabling Bluetooth connection between a computer and the ESP32 microcontroller.

Bluetooth is a wireless communication standard that uses radio waves to establish connections between devices. The technology is based on short-range radio frequency communication, typically with a range of 10 meters (33 feet) [3]. Bluetooth functionality in an ESP32 microcontroller is achieved through the integrated Bluetooth module, which allows the microcontroller to communicate wirelessly with other Bluetooth-enabled devices. The Bluetooth module supports both Bluetooth Classic (BR/EDR) and Bluetooth Low Energy (BLE) protocols [2]. It features dual-mode Bluetooth, allowing it to connect to a wide range of devices, including traditional Bluetooth accessories and low-power IoT devices [1]. The ESP32 runs a Bluetooth protocol stack, which handles the lower-level Bluetooth communication protocols [2]. This stack is responsible for tasks such as pairing, encryption, and data transmission.

The ESP32 can establish secure connections with other Bluetooth devices through a pairing process. The ESP32 supports various pairing methods, including PIN-based pairing and Secure Simple Pairing (SSP), depending on the use case [4]. Once a connection is established, the ESP32 can send and receive data with the paired device using the Bluetooth protocol. The ESP32 can act as a server or a client, depending on the application. For example, it can collect sensor data and send it to a smartphone or receive commands to control connected peripherals.

Our ESP32 is being used as a sensor device, as it will be collecting movement data from an attached accelerometer, therefore the best Bluetooth protocol to use would be the BLE protocols. The host stack is the part of the protocol stack that supports the Bluetooth functionality from a software perspective. The ESP32 has two host stacks both capable of BLE; ESP-Bluedroid, which is capable of both classic Bluetooth and BLE, and ESP-NimBLE which is only capable of BLE [4]. For our purposes ESP-NimBLE is the best option because it demands less storage and flash from the microcontroller [1]. This is best as we want our device to operate as long as possible on one battery charge. Reducing the demand for storage and power will be essential.

Connecting a Bluetooth-enabled ESP32 to a laptop is simple from the user's perspective. It can connect to a Bluetooth enabled device like a laptop through the system settings feature just like any other Bluetooth device. Activating the Bluetooth functionalities we will need, like establishing a connection or sending a file will be more difficult but there is an overwhelming number of resources online for utilizing the Arduino Bluetooth library.

Our goal is to use Bluetooth on the ESP32 to make data transfer easier and safer. We want to create secure connections, encrypt data, and ensure that only authorized devices can exchange information with the ESP32. This will simplify and secure data transfers for our client. If we can implement this technology, we could remove the SD card in favor of a permanent, more secure data storage component. While our client may need to oversee data transfer at first, the ease of Bluetooth transfer could have the potential for the parents to upload the data from the device to a computer and send it to our client, so she does not need to travel to collect data.

References

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