1 Integration of Biometric Sensors with Arduino NANO-BLE33 and ESP-01

1.1 Objective and Functionality

The user data collector is the part of the system responsible of collecting the users heart rate and galvanic skin resistance in order to later predict who is that user.

- Reading BPM and galvanic resistance data from the sensors on the Arduino NANO

- Getting the collected data from the Arduino to the ESP01 module through serial.

- Publishing the collected data to the corresponding MQTT topics (sensor3/heart and sensor3/galvanic)

1.2 Project Definition and Milestones

The development of the user data collector involved the following milestones:

1. Read data from BPM.

2. Read data from galvanic.

3. Get data from Arduino to ESP01.

4. Establishing connection with MQTT.

5. Publish the results on their corresponding topics.

1.3 Achieved milestones, execution order, priority, and dependencies

1. **Milestone 1: Read data from BPM and galvanic** - *Priority:* High. Fundamental for data collection. - *Dependencies:* Working hardware setup. - *Execution Order:* First, as it is the backbone of this system.

2. **Milestone 2: Establish connection with MQTT and publish data** - *Priority:* Medium. Important, the rest of the system needs this data. - *Dependencies:* Working WiFi setup. - *Execution Order:* Second, needed for debugging the data retrieval from Arduino to ESP01.

3. **Milestone 3: Getting data from Arduino to ESP01** - *Priority:* High. Essential for usage of real data. - *Dependencies:* Functional hardware setup and MQTT communication. - *Execution Order:* Third, focusing on data transmission.

1.4 Hardware setup

The biometric data collection system comprises the following hardware components:

- **Arduino NANO-BLE33:** Central to the collection and initial processing of biometric data, including heart rate and galvanic skin response (GSR).

- **ESP-01:** Functions as a WiFi module, enabling the Arduino NANO-BLE33 to connect to the internet and transmit data using MQTT.

- **MAX30105 Heart Rate Sensor:** Connected to the Arduino for monitoring the user's heart rate.

- **GSR Sensor:** Attached to the Arduino for measuring galvanic skin response.

1.5 Hardware Setup Diagram

The following diagram illustrates the physical connections between the Arduino NANO-BLE33, ESP-01, and the biometric sensors (Heart-rate and GSR sensors).
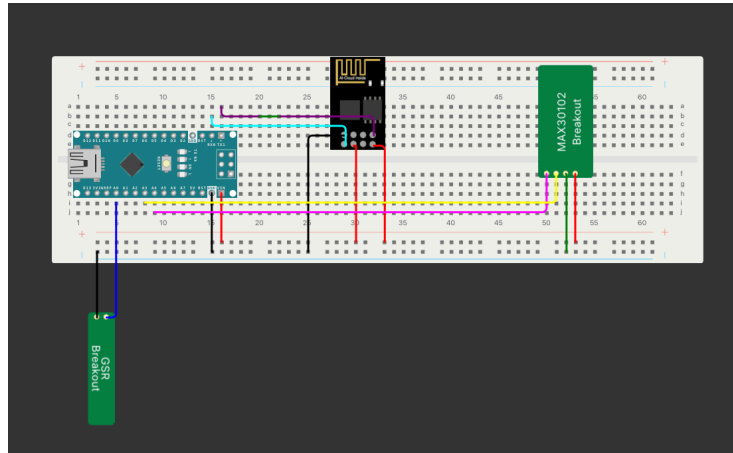
Figure 1: Hardware connection diagram of Arduino NANO-BLE33 with ESP-01 and biometric sensors.

1.6 Arduino NANO-BLE33 Software Implementation

The Arduino NANO-BLE33 is programmed to collect data from the heart rate and GSR sensors. Key aspects of the implementation include:

- Initializing the MAX30105 sensor and configuring it for heart rate detection.

- Reading the GSR sensor data from the analog pin (A0).

- Calculating the beats per minute (BPM) and preparing a JSON payload.

- Sending the JSON payload to the ESP-01 via Serial communication.

```
#include <Wire.h>
#include "MAX30105.h"
#include "heartRate.h"
// .. ...
 String jsonPayload = "{\"SensorValue\":";
 jsonPayload += sensorValue;
 jsonPayload += ", \"BPM\":";
 jsonPayload += beatsPerMinute;
 jsonPayload += "}";

  Serial.println(jsonPayload);
```

1.7   ESP-01 Software Implementation

The ESP-01 module is programmed to receive the biometric data from the Arduino NANO-BLE33 and publish it to an MQTT broker. The implementation covers:

- Establishing a WiFi connection.

- Setting up MQTT client and handling reconnections.

- Reading data from the Arduino via Serial communication.

- Publishing the received data to the MQTT broker under the topic "sensor3/data".

1.8   MQTT Communication Protocol

The system utilizes MQTT for data transmission, offering a lightweight and reliable method to send sensor data to the central server. The ESP-01 acts as the MQTT publisher, transmitting data to "sensor3/heart" and "sensor3/galvanic" topics.

1.9   Challenges and Solutions

During the integration of the biometric sensors with the Arduino and ESP-01, several challenges were encountered and subsequently addressed:

- **Serial Communication:** The initial challenge was to establish a stable and reliable serial communication between the Arduino NANO-BLE33 and the ESP-01. This was achieved by setting a consistent baud rate and implementing a protocol to ensure complete data packets were sent and received.

- **MQTT Connectivity:** Maintaining a stable MQTT connection, especially handling reconnections and network instability, was critical. This was addressed by implementing a reconnection strategy in the ESP-01's software.

1.10   Conclusion

The integration of the Arduino NANO-BLE33 with the ESP-01 for biometric data collection and transmission via MQTT represents a significant advancement in the biometric verification system. This setup not only provides real-time data monitoring but also enhances the system's capability to make a prediction on the user's identity.