front-end and optical pulse sensors can capture cardiac signals in a wearable form factoriieta.org. Implementations often rely on threshold detection or lightweight signal processing on boards like Arduino or ESP32. The Arduino IoT Cloud and similar platforms are used to store and visualize patient data remotelyiieta.orgiieta.org. These surveys highlight the potential of combining simple biomedical algorithms with IoT frameworks to achieve robust remote health monitoringiieta.orgirjet.net.

Overall, the literature indicates that merging IoT connectivity with wearable biosensors can enable continuous health surveillance and emergency alerts. However, many systems focus either solely on health monitoring or only on safety (e.g. fall alerts). HeartSOS aims to integrate both aspects: it leverages established wearable ECG/heart-rate sensing and couples it with alert mechanisms inspired by IoT-based panic-button designs.

System Architecture

Figure: System architecture of HeartSOS, showing wearable sensors, microcontroller, cloud platform, and user interfaces. The wearable sensor node houses two key biomedical sensors: an AD8232 ECG module (to measure electrical heart activity) and a pulse-rate sensor (photoplethysmography) for heart-rate detectioniieta.org. These sensors feed data into an **ESP32 microcontroller**, which has a dual-core CPU and built-in Wi-Fi for wireless communicationiieta.org. The ESP32 samples and processes the analog signals, converting them into digital values.

Processed data are sent over the Internet to a cloud server or IoT platform (e.g. Arduino IoT Cloud or ThingSpeak)iieta.orgiieta.org. This IoT cloud provides a centralized database where patient vitals (ECG waveforms, heart rate) are stored and visualized. Authorized users (caregivers or doctors) can access this data via a smartphone app or web dashboard. In routine operation, the system continually updates the cloud with the wearer's latest vital signs.

Crucially, the architecture includes an **alert mechanism** for emergencies. A low-power communication module (Wi-Fi or NB-IoT/GSM) can send instant alerts when triggered. In case of a detected emergency (e.g. cardiac anomaly or fall), the device obtains the user's GPS location and transmits it along with the alert message to designated contactsmdpi.com. This allows responders to quickly reach the patient. In effect, HeartSOS extends typical IoT health architectures by adding an emergency notification layer: continuous monitoring in the cloud plus on-demand push alerts for immediate action.

Implementation

- **Sensors:** The core sensors are an ECG sensor (AD8232) and an optical heart-pulse sensor. The AD8232 measures the heart's electrical signals via electrodes on the chest, while the pulse sensor measures blood volume changes to compute beats per minuteiieta.org. These are attached to the body in a comfortable wearable form (e.g. chest strap or wristband).

- **Microcontroller:** An ESP32 development board serves as the central processor. It reads analog inputs from the ECG and pulse sensors and runs the signal-processing firmware. The ESP32 is chosen for its cost-effectiveness, dual-core processor, sufficient memory, and integrated 2.4 GHz Wi-Fi radioiieta.org.

- **Communication Module:** In addition to Wi-Fi, the design may include an NB-IoT or GSM module for cellular backup. The ESP32 can post data to the Arduino IoT Cloud (or similar) via Wi-Fi; alternatively, when Wi-Fi is unavailable, the cellular link can push essential alerts. This hybrid connectivity ensures data reaches the cloud and alerts are delivered reliablymdpi.com.

- **Power Supply:** The wearable is powered by a rechargeable Li-ion battery (with a TP4056 charging board). This battery powers the sensors and ESP32. Efficient power management and low-power modes are used to extend battery life.

- **Software & Cloud:** The ESP32 is programmed (using Arduino IDE or similar) to perform analog-to-digital conversion, filtering, and alert logic. It is configured to connect to the Arduino IoT Cloud platform, which logs sensor data in real time. A smartphone app (provided by the IoT platform) allows users to monitor ECG and heart-rate graphs remotelyiieta.org.