WIMP IoT System

WIMP is an Internet of Things (IoT) system that connects a wearable fitness tracker, a mobile device, a cloud-based web application, and a mobile robot to monitor patients' physical activity and trigger context-specific physical interventions. The system consists of four main components: Fitbit watches worn by patients, a smartphone-based Mobile App, a Cloud App accessed via a web interface, and a Buddy Robot. Each component has a clearly defined role and they communicate through standardized, point-to-point links: Bluetooth between the Fitbit and the smartphone, and Internet connectivity between the smartphone, the Cloud App, and the Buddy Robot. The overall goal is to collect physiological and activity data continuously from the patient and use it to decide when the Buddy Robot should physically move and speak to deliver a message at a specific office.

Fitbit watches are the primary sensing devices in the WIMP system. They are worn by patients and continuously measure core physiological and activity signals, in particular heart rate and distance. Heart rate data is used to assess the current cardiovascular state of the patient, while distance acts as a proxy for physical activity, such as how far the patient has walked during a given period. For most healthy adults, a normal resting heart rate is between 60 and 100 beats per minute (bpm). A resting heart rate below 60 bpm is referred to as bradycardia, whereas a resting heart rate above 100 bpm is called tachycardia. These medically grounded thresholds are used by the system to interpret the values reported by the Fitbit. The application running on the Fitbit is implemented in JavaScript (Node.js) and is

responsible for collecting the raw sensor data and preparing it for transmission to the smartphone. The Fitbit device maintains a Bluetooth connection with the Mobile App and periodically sends batches of readings, including timestamps, current heart rate, and distance.

The Mobile App runs on an Android smartphone and acts as an intermediary between the wearable device and the Cloud App. On one side, it maintains a continuous Bluetooth connection with the Fitbit watch. On the other side, it connects to the Internet using the phone's available network interface (for example, Wi-Fi or cellular data). Whenever the Fitbit sends new sensor readings over Bluetooth, the Mobile App receives and buffers these data items, performs basic validation (for example, checking that values are within feasible ranges), and then forwards them to the Cloud App over the network. The communication with the Cloud App follows a simple request–response pattern in which the Mobile App sends patient data payloads and receives acknowledgements or status messages in return. The Mobile App does not implement any of the decision logic for interpreting the heart rate or distance values; instead, it focuses on reliable data transfer between the wearable and the cloud.

The Cloud App is a web-based application implemented in Node.js (JavaScript). It exposes a web interface through which the Mobile App sends patient data and through which system stakeholders can visualize and inspect the collected information. From a functional perspective, the Cloud App is the central decision-making component in WIMP. Whenever new data from a Fitbit watch arrives, the Cloud App processes it to determine whether any action is required. It parses the incoming heart rate and distance values and compares the heart rate against the normal resting range of 60–100 bpm. If the heart rate remains within this range, the Cloud App may log the reading and update any visual dashboards, but it does not trigger any physical intervention. If the heart rate is below 60 bpm, the Cloud App flags it as bradycardia; if the heart rate is above 100 bpm, it flags it as tachycardia. These abnormal conditions are candidates for an intervention involving the Buddy Robot. In such cases, based on the system configuration and the current patient context, the Cloud App decides which office the robot should visit and what verbal message it should deliver.

The Buddy Robot is a mobile robot that can move, rotate, and speak. Its embedded software is implemented in Android, which facilitates interoperability with the rest of the system and simplifies network communication. The Buddy Robot receives commands from the Cloud App via the network. These commands encode both a navigation target (the specific office where the robot must go and knock) and a speech payload (the message that the robot should deliver once it arrives). When the Cloud App decides that an abnormal heart rate requires a physical intervention, it sends a command to the Buddy Robot specifying the destination and the corresponding message. Upon receiving the command, the robot moves through its environment toward the target office, rotates as needed to orient itself, and knocks on the door according to its physical capabilities. Once at the office, the Buddy Robot uses its audio output to speak the specified message, which is directly derived from the decision made by the Cloud App.

The interactions among these four components form an end-to-end data and control flow. At the sensing end, the Fitbit watches continuously monitor the patient's heart rate and distance and stream these data to the Android Mobile App via Bluetooth. The Mobile App then forwards the data to the Cloud App over the Internet. The Cloud App receives, stores, and analyzes incoming measurements, applying simple thresholds to detect abnormal heart rate values such as tachycardia or bradycardia. When an abnormal event is identified and mapped to a required physical intervention, the Cloud App issues a command to the Buddy Robot. The Buddy Robot executes the command by moving to the designated office, knocking, and speaking the configured message. This closed loop—from sensing via the Fitbit to actuation via the Buddy Robot—is the core behavior of the WIMP system and is the basis for the experiments conducted with this IoT system.