Architecture and Technical Specification

Project Details

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1 Introduction

1.1 Purpose and Scope

The main goal of the Fitolo project is to introduce, validate and promote a novel approach to data acquisition in Gyms, which emphasizes a timely and intelligent approach to the acquisition of valuable exercise metrics. The project will reflect its approach to an architectural concept, which will serve as a basis for implementing an ecosystem of devices in a Gym environment. Based on this architectural concept, the project will also develop concrete security services, mobile and web applications as well as a gym management system (an ERP).

In this context, the purpose of the present document is to introduce the Fitolo Device architecture. Moreover, this document is accompanied by another document named “Detailed Component Specifications”, which is destined to provide the detailed specification of each one of the modules that comprise the architecture, along with its role in the implementation of the project’s use cases.

Note that the Fitolo Device architecture will serve as a reference for implementers of all devices present in the Fitolo Ecosystem, and may be subjected to regular upgrades. Two future versions of the said upgraded architecture have also been formulated by the authors for future implementation.

1.2 Methodology

Our methodology for specifying the Fitolo architecture includes the following activities and steps:
Step 1: Analyze

- Review of Relevant Projects and Initiatives
- Analysis of Reference Architectures for IoT/IIoT, IoT Security and relating them to our project
- Analysis of Fitolo Device Requirements

Step 2: Architect

- Introduction of Modules that address requirements
- Structuring principles and interfaces between modules
- Technical specifications of each module

Step 3: Implement

- Instantiation of the Fitolo Architecture based on the needs of the use cases
- Validation of security functionalities against security requirements of the use cases
- Validation of nonfunctional properties of the architecture

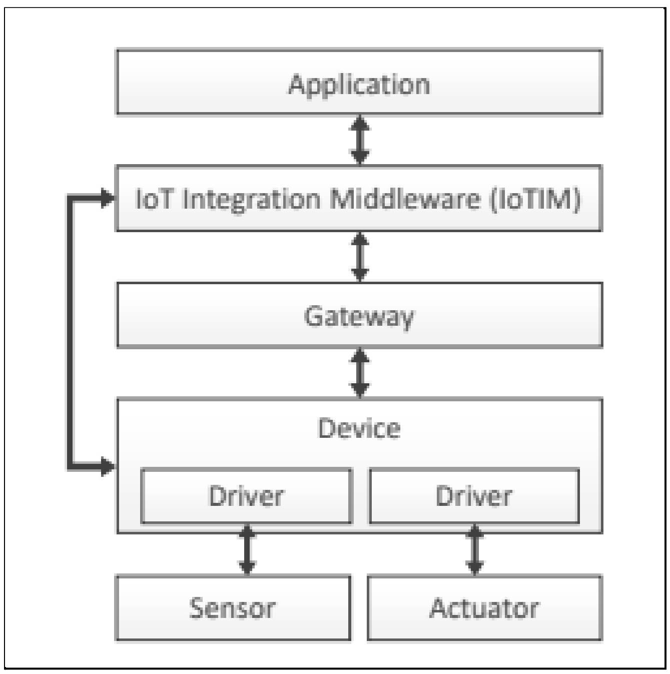
2 Architecture

2.1 Reference Layered Architecture Used

This section presents an IoT reference architecture which

- offers a unified terminology and
- maps to existing architecture descriptions.

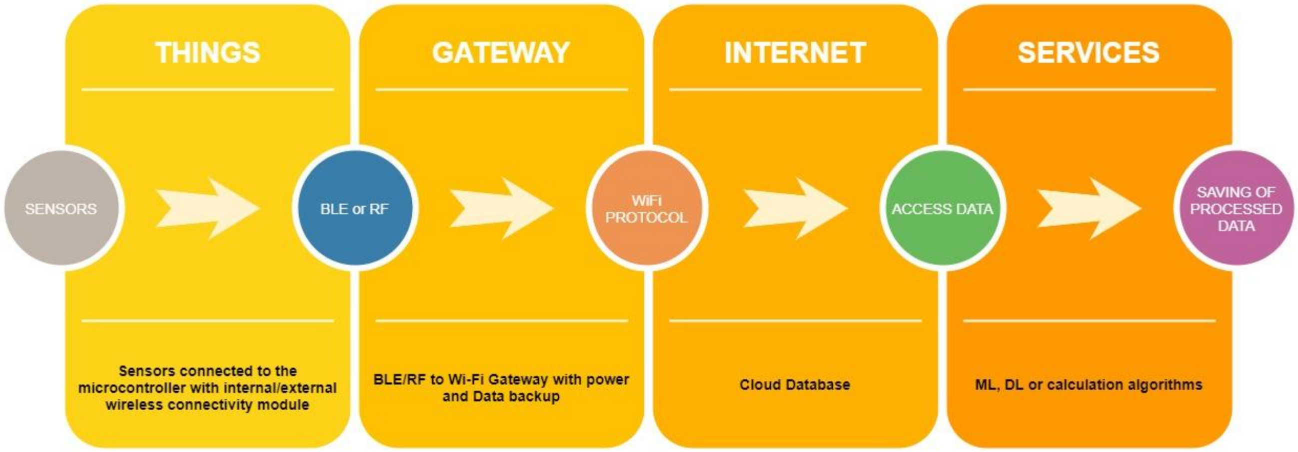
This is primarily a cloud-centric IoT architecture, where almost all of the IoT data processing is done on the cloud or a remote server.



Note: For the sake of simplicity, the components are depicted without cardinalities. Furthermore, components can also be omitted. The reference architecture is to serve as a uniform, abstract terminology, which eases the comparison of different platforms.

Reference: Guth, J., Breitenbücher, U., Falkenthal, M., Leymann, F., Reinfurt, L.: Comparison of IoT Platform Architectures: A Field Study based on a Reference Architecture. In: Proceedings of the International Conference on Cloudification of the Internet of Things (CIoT). IEEE (2016)

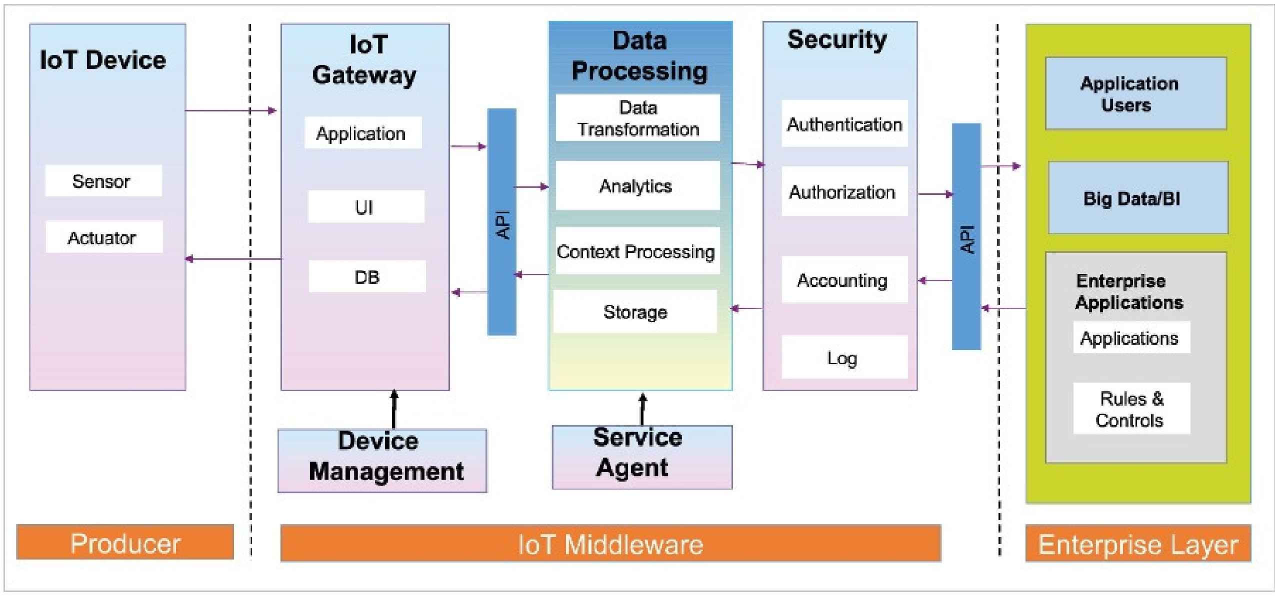
2.2 Structure and Technologies



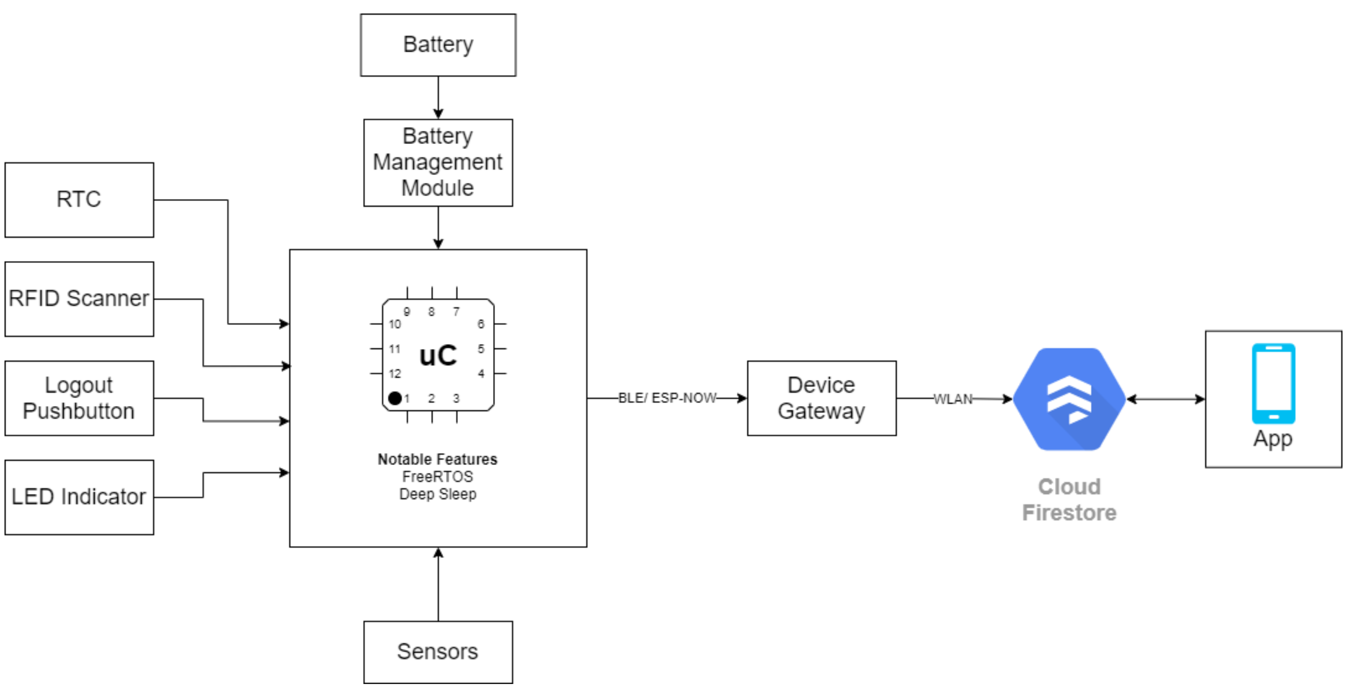
In the first layer, we are using wireless connectivity-enabled microcontrollers to collect, structure and send data to a gateway (can be a BLE to Wi-Fi or RF to Wi-Fi). The Devices use a single dual-core microcontroller and are battery-powered. They are put into deep sleep in between sessions with other power-saving strategies to increase the device life. The device employs a Real-time Operating System to parallelize all the tasks In the second layer, the gateway receives the data and routes it internally according to the availability and the quality of Wi-Fi and strength of internet connectivity at that instant.

The gateway has an internal power backup and a data backup which ensures no data loss due to internet unavailability of power unavailability. The gateway sends the data to an access point using Wi-Fi protocol which is then saved to Google Cloud Firestore database. Cloud has access to services such as ML, DL and other calculation algorithms which access the data, processes it and stores it in different branches of the database.

2.3 High-Level Logical View for Reference



2.4 End to End Infrastructure of our devices



3 Technology Stack Selection

3.1 Protocol Survey

Bluetooth Classic - Relatively short operating range and low power. It consumes much less power than WiFi, and a lot less than cellular technologies, but still significantly more than technologies such as Bluetooth Low-Energy or Zigbee.

Wi-Fi-Direct - WiFi-Direct uses the same basic technology as traditional WiFi. It uses the same frequency and offers similar bandwidth and speed. But, it doesn’t require an access point, allowing two devices to have a direct connection similar to Bluetooth. WiFi Direct is over a hundred times faster than Bluetooth. It has a very high power consumption.

Bluetooth Low Energy - With consuming very low power, it can support a data transfer speed of up to 1Mbps (classic Bluetooth can do up to 2-3 Mbps). BLE supports mesh networking, it allows mesh networks with up to 32,767 devices.

Zigbee - It is a short-range networking technology similar to Bluetooth LE with similar applications. It uses the same 2.4 GHz carrier frequency, consumes very little power, operates over a similar range, and offers mesh networking. A Zigbee mesh network can include up to 65,000 devices which is twice as many as Bluetooth LE can support

Z-Wave - Uses a sub-1GHz band. This increases range and reduces interference. Lower frequency radio waves propagate further.

6LOWPAN - The 6 refers to Internet Protocol (IP) version 6 and the LoWPAN refers to Low-power Wireless Personal Area Network. Another protocol similar to Zigbee, but is IP network based like Wi-Fi.

GSM/GPRS - Outdated protocol using cellular network data.

LTE - Uses Cellular network to transfer data and mobile data to send data to the cloud. Uses a high amount of power and can send very small amounts of data.

LoRa - LoRa (short for Long-Range) enables very long-range communication of more than 6 miles in some areas, while consuming little power.

NB-IoT - Unlike LoRa/LoRaWAN, NB-IOT is a cellular technology. This means it is more complex, more expensive to implement, and consumes more power. But, it offers higher quality cellular connections and direct access to the internet. NB-IOT is only intended for transmitting very small amounts of data.

3.2 Component Selection

Refer to the document: “Detailed Component Specifications”