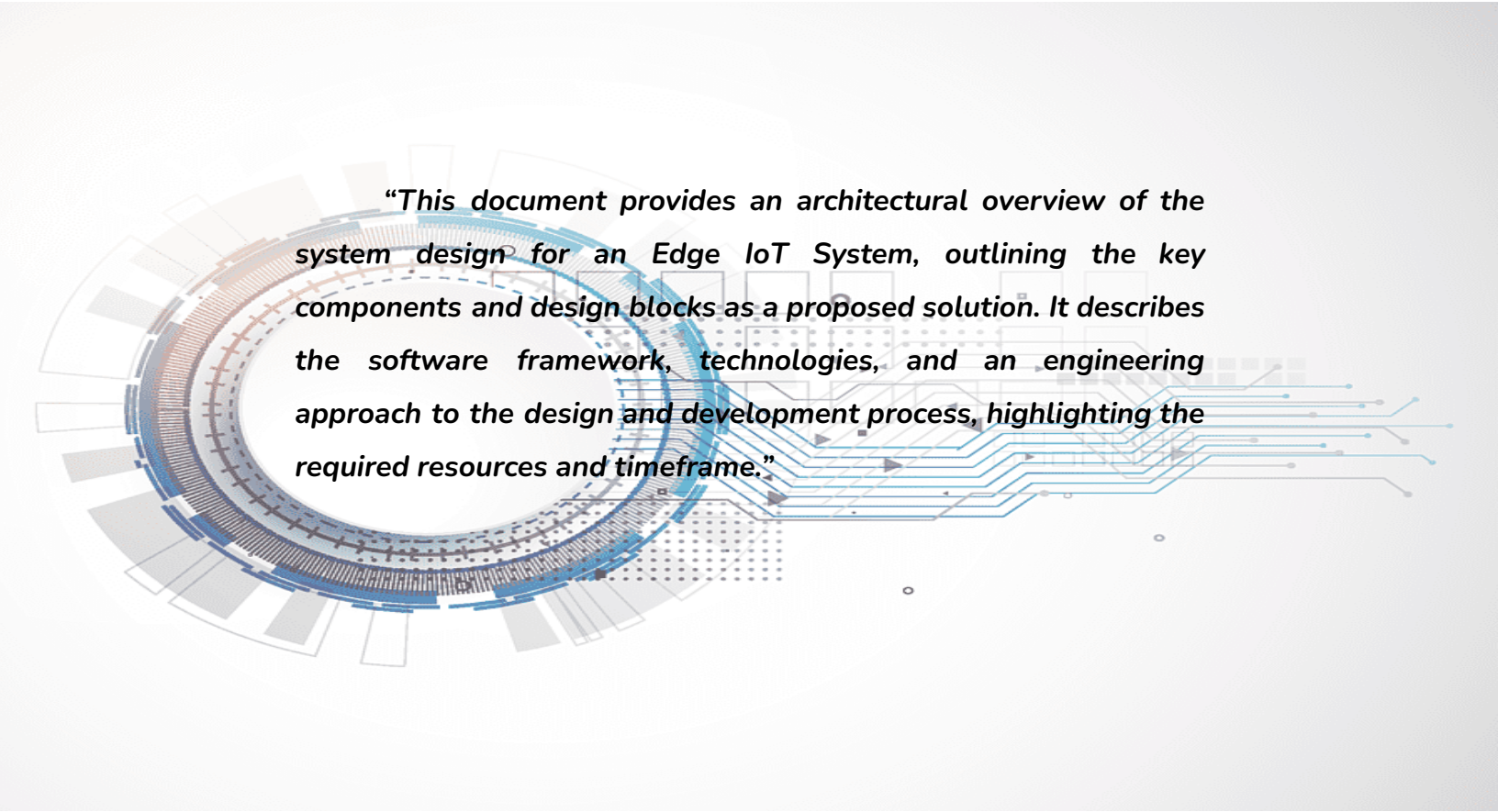
Edge IoT System

ARCHITECTURAL BLUEPRINT



“This document provides an architectural overview of the system design for an Edge IoT System, outlining the key components and design blocks as a proposed solution. It describes the software framework, technologies, and an engineering approach to the design and development process, highlighting the required resources and timeframe.”

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1. Project Overview

This document outlines development of an Edge IoT system focused on monitoring activities using a suite of sensors installed at the facility. Aimed at monitoring the activities of old age people, this system allows controlling household appliances remotely and monitoring status of multiple variables in real-time. Allowing users to access this data through mobile devices adds convenience to the monitoring and controlling practices. Artificial Intelligence aided processing further ensures the monitoring of usage patterns and allows an optimised control over the devices. Scalability and configurability are the key objectives that ensure a bespoke solution. To ensure user's privacy, the system aims to store and process data within a local host without transmission to any remote database or client with the exception of a secure link to mobile application.
The system aims to support various types of input patterns including monitoring of appliances, doors and to keep track of medicine schedules for elderly.

2. Challenges

The scalable nature of this project poses a significant challenge to the design. It's not only about adding new devices to the network. It includes modification at several layers in the design to accommodate those additions and changes. It covers the addition of software support for that device, adding its inputs to the compute layer to weigh in the data. Moreover, it requires adding blocks to the application layer in order to present that data to the user. Not all the sensors and control devices are the same as each may have data of a different category. The solution requires development of a generic software IO port that could offer compatibility with all types of supported input and output devices. The processing system needs to be able to recognize each device and weigh its data as per the demands.

3. Hardware

The initial prototype comprises off the shelf (COTS) hardware and modules for quicker PoC turnaround (C1 Hardware). After successful PoC, more improvements could be made to design customised hardware for sensor nodes and edge devices to ensure a more bespoke solution(C2 Hardware).

C1 Hardware

- Raspberry Pi 4, Raspberry Pi 5 is preferred
- Google Coral TPU (USB Accelerator for RPI4, M.2 PCIe Accelerator for RPI5)
- ESP32 Dev Kits / nRF52 Dev kits
- Sensor modules
- Controller modules (relays, FET switches etc)
- RPI GSM/ISM Cellular HATs

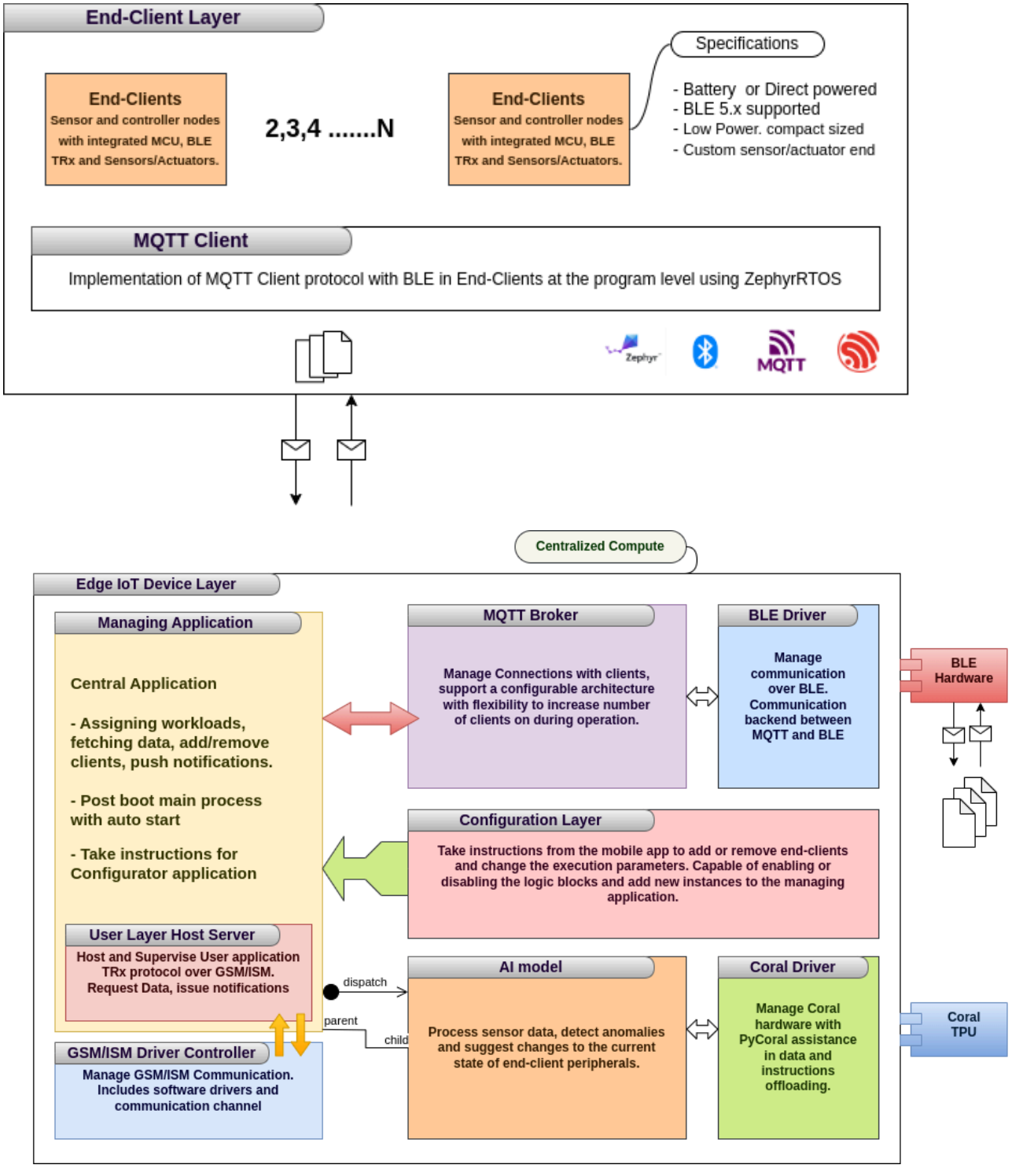
C2 Hardware

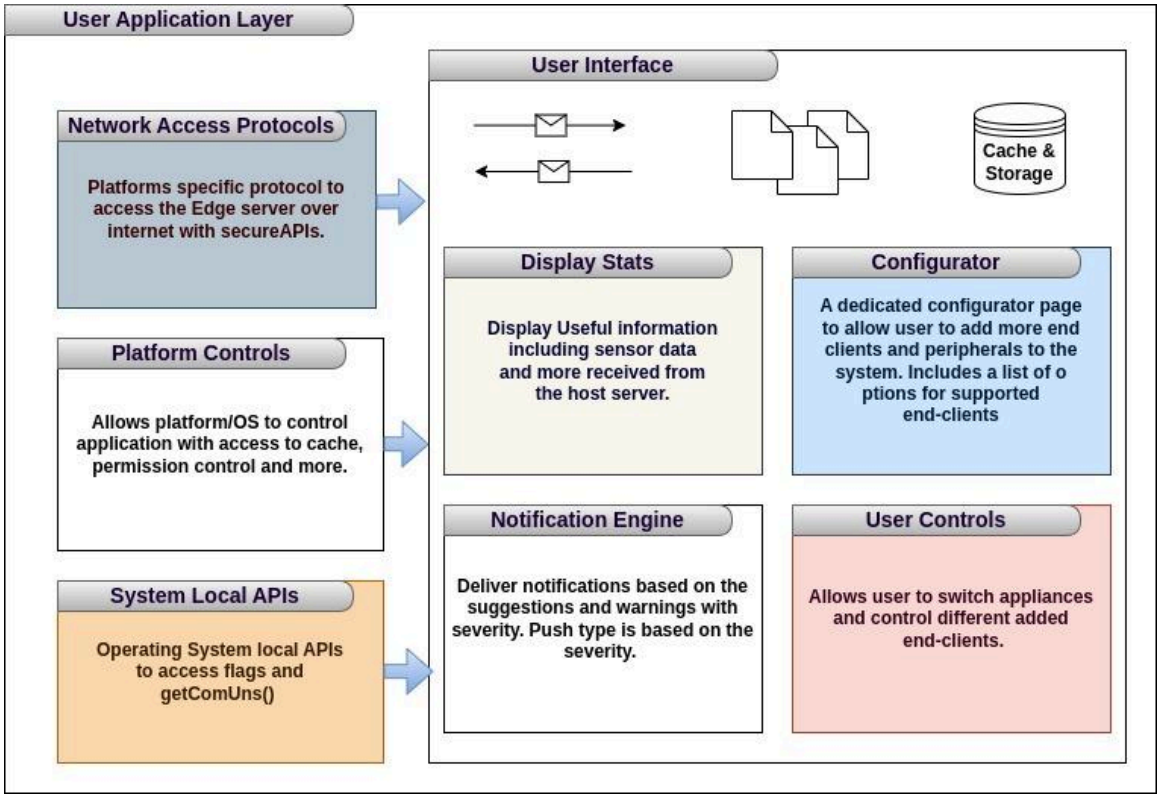
- RPI CM4 or RPI 5 SBC
- Custom designed carrier board
- USB Accelerator slot or M.2 Slot PCIe accelerator slot
- On Board Power Supply
- Custom Designed sensor nodes with integrated sensor + MCU
- Enclosure + Thermal relief system.

4. Software

- MQTT broker running on raspberry pi would allow integration of various modules and sensors with the core framework.
- MQTT Client running on MCU with RTOS enabled control.
- A configurator application (Flutter/React based) to allow taking commands from mobile app to add or remove devices and their respective data processing streams inside the main compute block.
- AI specific frameworks (Tensor/PyTorch etc)
- python3 based PyCoral compute offload to accelerator
- Zephyr RTOS for MCU

5. Systematic Block Design





6. Resources

Engineers and Developers:

1- AI Specialist

Requires experience with design and implementation of AI model to detect anomalies and provide suggestions based on the received sensor data. Understanding of optimization techniques for low power hardware are desired and experience with software integration is a plus.

2- Embedded Hardware Engineer

Requires experience with design of custom hardware with microcontrollers, wireless transceivers (BLE) and various types of sensors and actuators. Experience with manufacturing, board bring-up and troubleshooting is desired and understanding of firmware development is a plus.

Works closely with Embedded Software Engineer.

3- Embedded Software Engineer

Requires experience with creating custom applications in the linux environment. Experience with creating firmware for custom devices is desired and understanding of HAL (hardware abstraction layer) is a plus.

Works closely with Embedded Hardware Engineer and AI Specialist.

Note: May need more than x1 person for this role given the amount and scope of workload.

4- Mobile Application Developer

Requires experience with Android/IOS mobile apps including frontend and backend. Experience in creating a secure link with a custom host is required and understanding of secure communications is a plus.

Works closely with Embedded Software Engineer.

Equipment and Workspace:

- Access to C1 Hardware
- Workspace and workstations for team

7. Expected Timeframe

With the availability of engineers and developers, a C1 Hardware based solution could be prepared for demonstration in ~3 months. For added compatibility and support for a wider range of devices, the customised hardware solution and with maximum capabilities and complete testing could be completed in expected 7-8 months. These estimates are based on my past experience. It may vary depending on expertise of the team and working conditions.

About me

I am Aitesam, an engineering graduate with passion to work on embedded solutions.

I develop hardware and software solutions for commercial and industrial applications. Over the past 4 years, I undertaken several endeavours including my role as a freelance embedded solutions provider working with clients globally to develop electronics systems tailored to their requirements.

I also worked as a consultant helping my clients with expert review for their hardware designs before manufacturing, helping with troubleshooting and EMC compliance issues.

Over the last year, I have worked on development of FPGA based solutions including the development of RISC-V Vector extension for RV64 systems. It included design of architecture in compliance with RV-V Spec and the RTL implementation targeted for Xilinx Zynq-US+ FPGAs.

In regards to the IoT category, I have developed several systems for my clients. To name a few, I have developed multiple types of home automation equipment including DIN Rail mounted WiFi based controllers. To be more specific, I have developed a monitoring solution targeted for elderly care space. It included design of customised hardware to monitor the kitchen stoves to avoid the possibility of fire in case it is left open by mistake. Moreover, it involved monitoring the doors at home. The sensors were wirelessly connected to a raspberry pi powered hub running the MQTT broker. The hardware design featured highly efficient components enabling battery run-time of approx. 1.5 years.

I enjoy working on open source projects as a way to return back to the community. Which can be found on GitHub. For more information, check my LinkedIn profile.

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