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Wireless Sensor Integration into System's Network for Real-time Data Streaming: Lessons Learned

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Introduction

This integration project is part of a larger research project that is developing a prototype system called REaCH – Real Time Emergency Communication System for HAZMAT Incidents. First responders put their own lives at risk to help individuals, families, and communities. They experience tragic frontline issues, such as accidents, deaths, chronic illnesses, such as cancer and heart disease, and behavioral health issues that may end in suicide, etc.

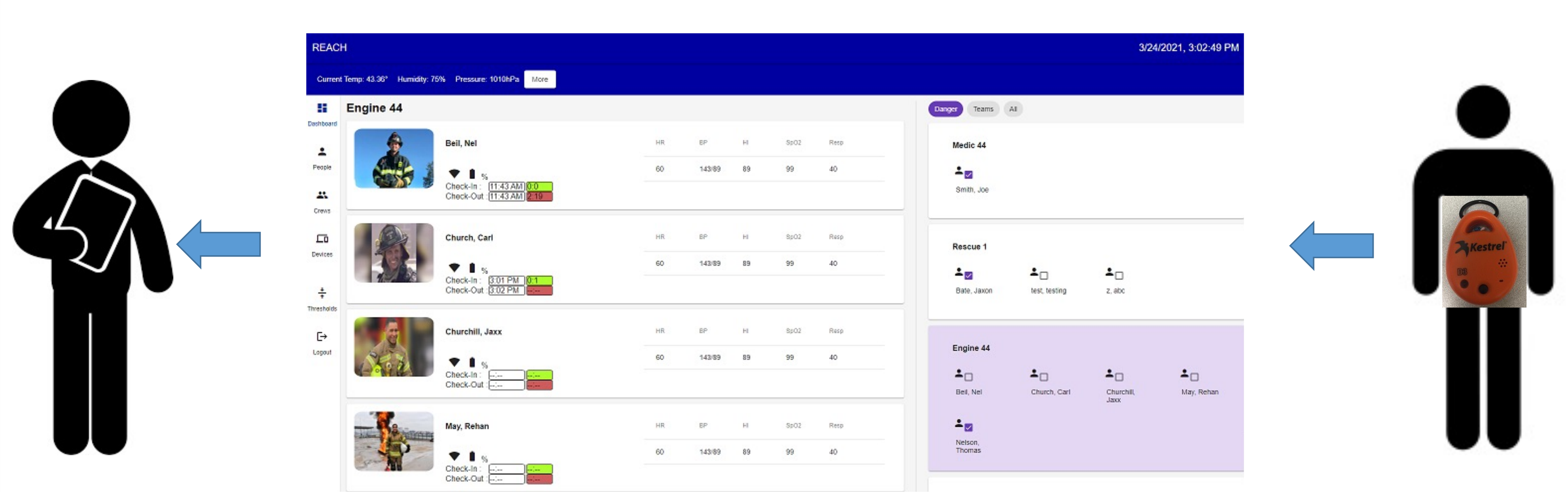
Given the increase in the number of deaths of first responders due to frequent exposure to hazardous materials (HAZMAT) and the increased fatalities caused by physical stress and overexertion as revealed by the National Fire Protection Association (NFPA), the REaCH prototype aims to minimize the impact of HAZMAT exposure to first responders' health through real-time health monitoring of first responders utilizing Internet of Things sensors and technology. This project embodies the first implementation of integrating a wireless sensor device into the REaCH system prototype to stream real-time data to the dashboard for live monitoring.

In this research, we integrated the Kestrel DROP wireless sensor to collect environmental data from the sensor placed inside the First Responder's PPE suit to monitor the Ambient Heat Index. The sensor implements a Bluetooth Low Energy communication protocol which is a low-power wireless communication technology. The tablet- or smartphone-based REaCH system must be able to establish connectivity and reliably stream live, accurate data from the sensor smoothly to achieve the goal of the research.

Research Question

How should Kestrel wireless sensor be integrated into the REaCH system's network to reliably stream live, accurate data?

Research Goal



Challenges

Real-time data acquisition from the Kestrel sensor poses several challenges:

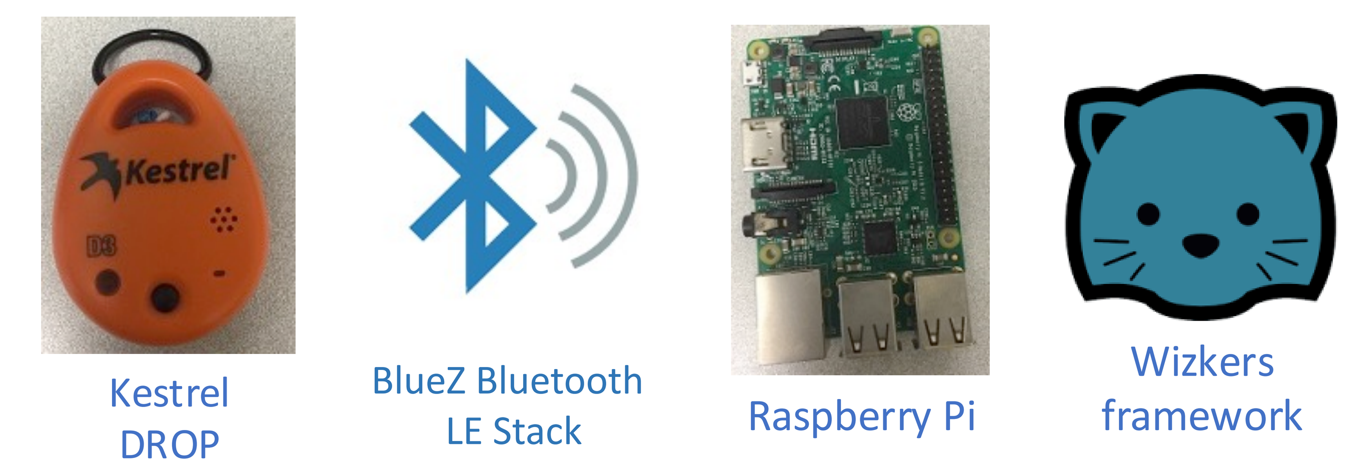
Connectivity issues: Unable to establish a stable connection with the device initially. Various troubleshooting approaches had to be undertaken to determine the root cause.

Complexity of data streaming process: The sensor generates a series of timestamped data points that need to be converted into human-readable values. At the same time, the data has to be reliably and accurately streamed to the system.

Wizkers open-source framework issues: Issues encountered while incorporating wizkers into the REaCH system:

- Had to ensure that Raspberry Pi's environment was up-to-date and compatible with the framework.
- Need to be able to interact with the framework's REST API for readings to be forwarded to the REaCH's system.

Key IoT Streaming Components



REaCH Communication Architecture

Below is an overview of the communication architecture from both hardware and software perspectives for smooth and reliable real-time data streaming from the sensor:

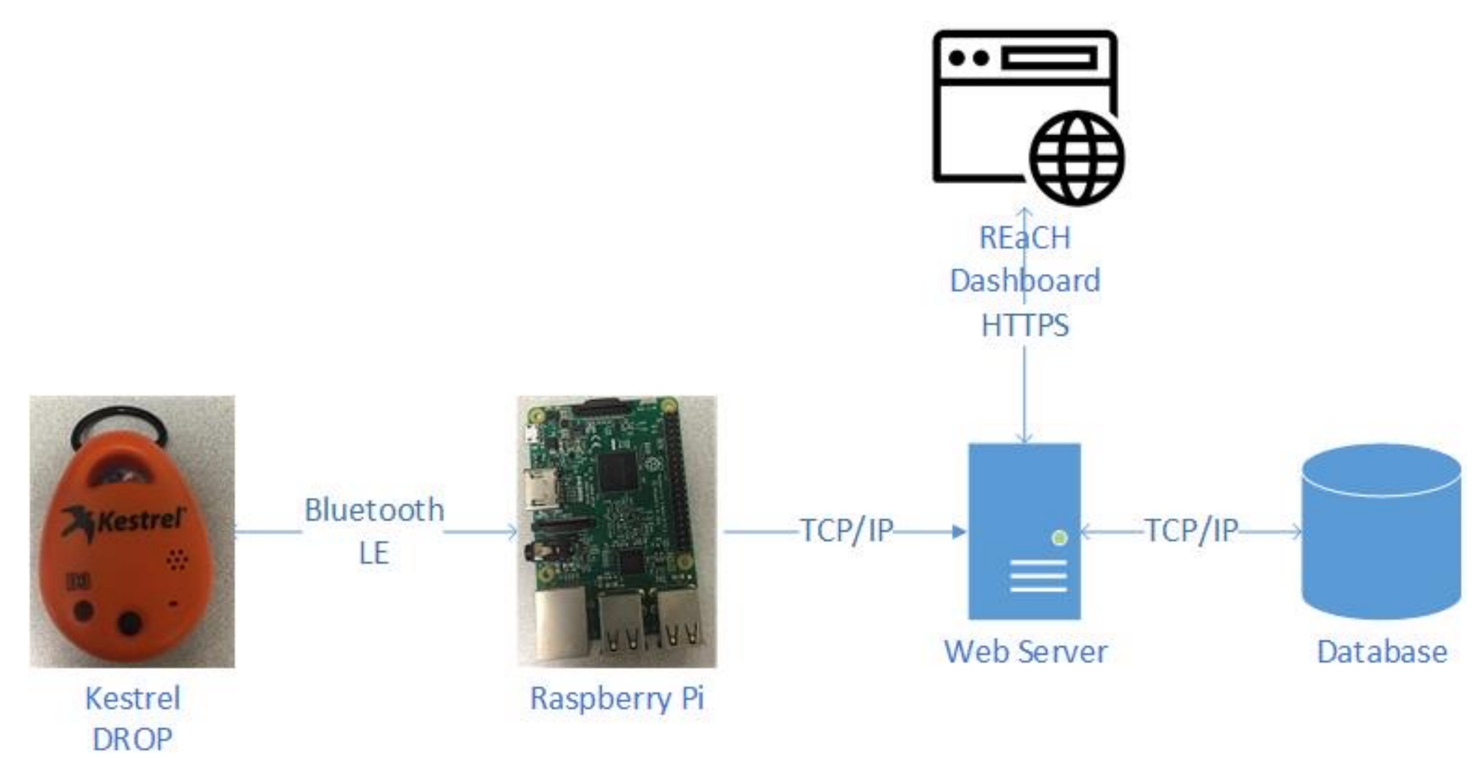


Figure 1: Hardware Communication Architecture

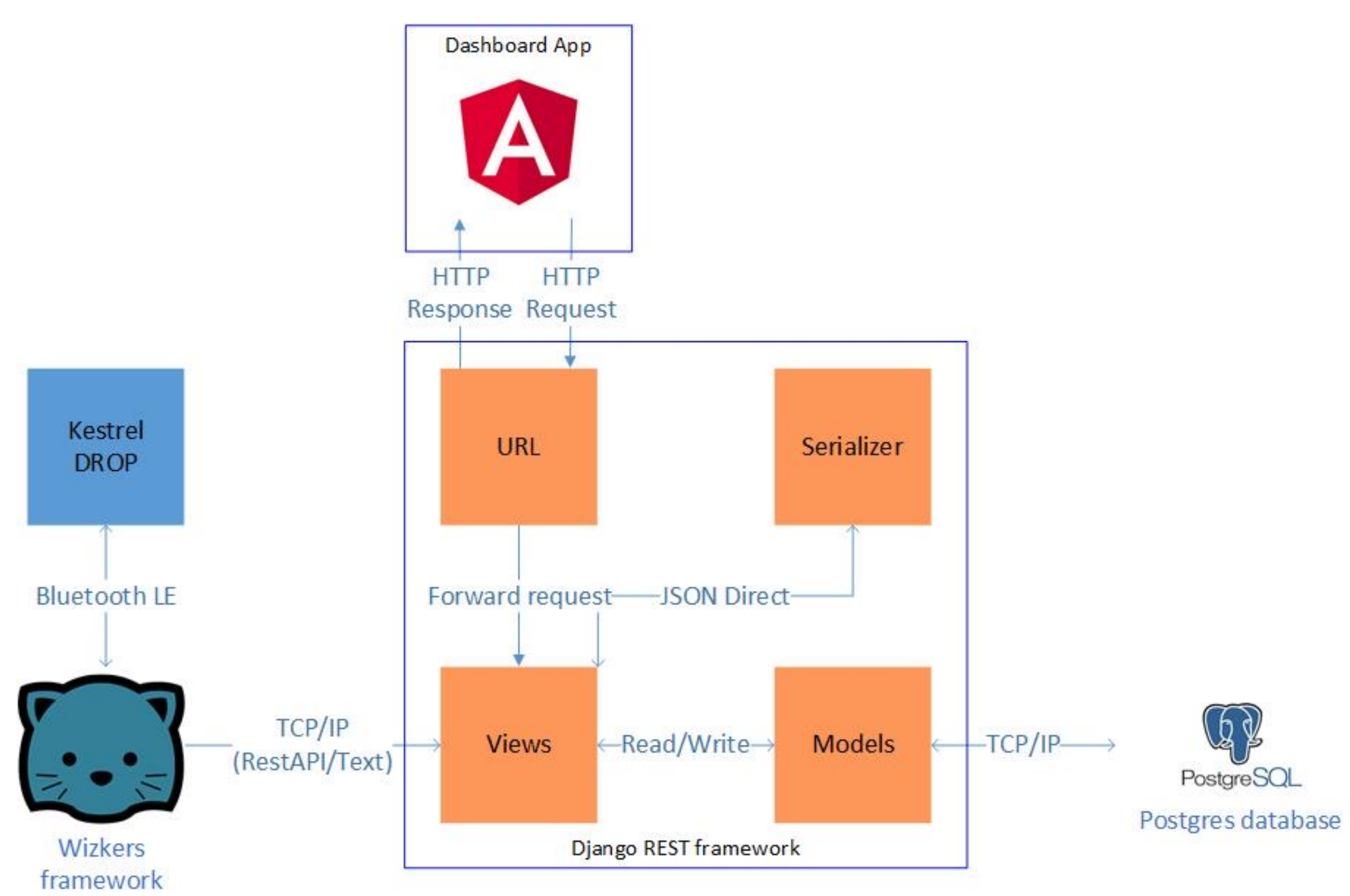


Figure 2: System Communication Architecture

Lessons Learned

While designing the communication architecture for wireless sensor integration into the REaCH system's network and deriving solutions for challenges faced in this project, here are the several takeaways:

Stable connectivity relies on the ease of setup, ease of use and support community of a platform's Bluetooth LE stack: Raspberry Pi implements BlueZ stack, which is an easy-to-use and a stable Bluetooth LE stack. Additionally, the Wizkers framework was developed on the Raspberry Pi platform.

Troubleshooting approach: It is imperative to eliminate possible causes from multiple perspectives, namely, hardware, operating systems, and libraries compatibilities. Server output logs and debuggers are helpful tools.

Design decision consideration: Since the overarching goal of the larger project is to develop a smart dashboard prototype that could incorporate deep learning capabilities, sensor data points should be collected and stored. Therefore, the architecture will be streaming the data points directly to the database to be stored.

Leverage open-source framework deployed by the sensor: Leveraging and exploring the sensor's implemented open-source framework facilitates progress as we avoided from reinventing the wheel. Plug-ins could also be developed in the future to modify existing configuration of the open-source framework to suit our needs.

IoT application development differs from other kinds of software development: IoT devices are diverse and their programming environment varies. As developers, we had to learn through trial-and-error with different combinations of hardware and software as well as approaches to meet project requirements.

Future Work

As this project embodies the first implementation of integrating a wireless sensor device into the REaCH system prototype, it paves way for future work as follows:

•Integrate multiple Kestrel sensors on Wizkers server for readings to be forwarded to Django REST framework and map readings to respective sensors in the database.

•Integrate sensors from different manufacturers and process heterogeneous data.

•Establish secure transmission when Protected Health Information is being collected.

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