**IoT System Design**

The diagram above is a design for an end-to-end IoT based room occupancy detection system. Accurate occupancy estimates include various benefits like – minimizing energy consumption, tracking human movements, maintaining adequate air quality, improving building security, tracking and rescuing survivors in emergencies such as fires etc.

The IoT device comprises of 5 sensors for measuring light, sound, temperature, CO2 & PIR which are connected to Arduino Uno micro-controller. The table below lists the sensors used for detection of the various parameters in a room. The Arduino Uno micro controller is responsible for collection, calibration, and transmission of the sensed data. It is based on “ATmega 328P 8-bit” micro-controller.

**Table 1. Details of Sensors Used**

|  |  |  |
| --- | --- | --- |
| **Parameter** | **Unit** | **Sensor** |
| Temperature | C | DHT22 |
| CO2 | ppm | MQ135 |
| Light | lux | Grove - Light Sensor v1.2 |
| Sound | decibels | Grove – Sound Sensor |
| PIR (Passive Infrared) | Persons (count) | Sharp GP2Y0A02YK0F Infrared Proximity Sensor |

**Edge processing**

The IoT device with the sensor nodes transmits the sensed data to the smart edge. The IoT device communicates with the edge device, which is a Raspberry Pi 3 Model B. The Raspberry Pi 3 Model B features a quad-core 64-bit ARM Cortex-A53 CPU running at 1.2GHz, along with 1GB of RAM. It also includes onboard Wi-Fi and Bluetooth connectivity, as well as a variety of ports including HDMI, Ethernet, USB, and GPIO.

**Connectivity**

The IoT device transmits data to edge first instead of uploading directly to the cloud. This happens via “WiFi” facilitated by a WiFi module built in the IoT device. The estimation models run on the RPi edge and output stored in its RAM before being uploaded to the cloud via HTTPS messaging protocol.

**Data storage, processing & visualization**

Amazon Web Services (AWS) cloud platform is leveraged for the IoT data storge and further processing. The edge node uploads the sensed data to the AWS cloud. In addition, the data transmission from the edge to the cloud is in bursts (as opposed to continuous) after aggregation, processing and application of estimation algorithms takes place. Amazon Timestream database is used for storing the data from the edge as it is a fully managed time series database that can handle large volumes of time-stamped data generated by IoT devices. It is designed to make it easy to store, query, and visualize time series data, and can be integrated with other AWS services such as IoT Core, Kinesis Data Streams, and Lambda.

The reasons for going with an Edge computing architecture is for scalability and performance. This architecture helps with collecting sensed data efficiently and quickly from multiple devices in a location for example a building with multiple rooms. In addition, the edge computing architecture helps with better “Throughput” and low latency as these are highly desirable for this kind of application.

The data stored in the cloud are leveraged to train the Machine Learning model on a regular basis to generate insights, predictions etc. A dashboard based off Tableau is created for the end users to visualize the insights so they can monitor and take decisions accordingly.