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IoT Edge Data Retrieval System for Big Data Analytics in Smart Retail Stores

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***Abstract:** An IoT Edge system is to collect the sensor, set point and other device data with the help of micro controller and send those to IoT Hub via Edge Hub. The Building Management System (BMS) playing major role to control, communicate between various devices such as sensors, actuators with user interfaces, consumers and other technical devices. Commercial buildings like retail stores have two important systems called HVAC (Heating, Ventilating, and Air Conditioning) and refrigeration control. The proposed IoT Edge system collects the various device data via BAS and send it to IoT Hub.*

IoT Hub is a secure and two-way communication service system between the IoT Edge and the cloud platform where we can process telemetry data generated from sensor devices. IoT Edge helps to a computing near datasource. IoT Edge agent monitor and control all the modules running on it. With high speed internet connection users can access information and computational resources from anywhere in the world. Cloud platform can supply a range of Virtual machines with shared resources with big power and storage using inexpensive disks, which are much necessary for enterprise applications with Big Data. Disks.

***Key words:** sensors, cloud, IoT (Internet of things), Edge System, Smart Retail system.*

I. HVAC ANDREFRIGERATION SYSTEM

Heating, Ventilating, and Air Conditioning (HVAC) systems designed for retail system controlling the heating and cooling temperature thresholds. The HVAC system keeps the store area as s comfortable shopping zone by maintaining proper interior temperature, lighting and air circulation.

Retail stores are functioning with the help of container/cold storage. Significant electrical energy is used to maintain chilled and frozen food in both product display cases and walk-in storage coolers, which are called as refrigeration system.

II. EXISTING BMS SYSTEM:

BMS (Building Management system) is the three-layered system as explained below.

Field Layer: It consists of actuators (e.g. analogue values of temperature or pressure, digital Values of contacts), sensors (valves and switches) and their cabling to the corresponding Control system.

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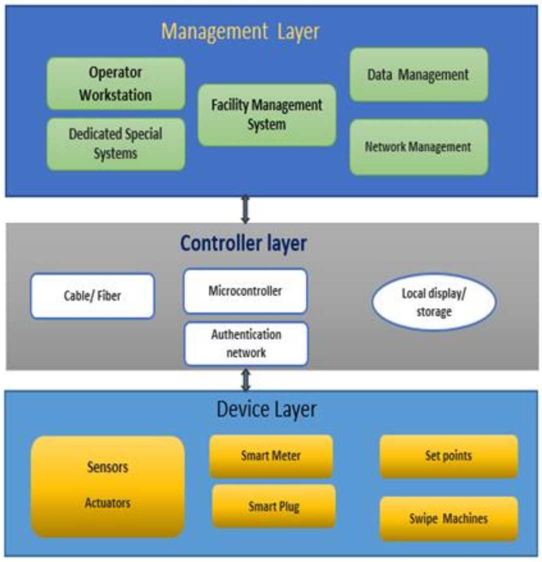

Figure1: Traditional layered architecture for BMS.

Control Layer: micro controller controls each sensor devices in the stores with various protocols. Controlling layer contains various electrical and IO modules.

Management Layer: This layer is responsible for storage management, data retrieval, data management and authentication. BACnet is one of the widely used BAS protocol to communicate with control level.

The existing BMS system can be viewed as local systems that perform local management tasks autonomously. Any remote systems to control or monitor those are communicating with the local management systems via IP connection. Limitations data from various remote buildings into common analytical platform such as an Azure IoT system and intercommunication between the various BMS systems via legacy protocols become challenging for Big Data analytics in IoT platform.

Common analytical platform which are built on top of telemetry data will work as a best IoT monitoring and controlling system. Ex:Demand savings applications.

III. PROPOSED SYSTEM:

Legacy BMS system is enhanced with proposed data retrieval system with the help of Azure IoT hub platform. IoT Data retrieval modules, which are collecting the sensor data or set point from the store executive controller.

Data retrieval system provide the base platform and keep extracting the data from the store round the clock.

Since the sensor and set point data are continuously extracted, those can be utilized in smart applications for energy savings. Utilizing the live device data,better handling of sensor or set point data will be helpful in energy savings at peak hours.

IV. OVERALL SYSTEM ARCHITECTURE:

Overall architecture of IoT Data Retrieval system is shown as below: it has two major components named 1. Initializer and2. Extractor modules. Initializer Module connect with Store controller to identify the number of racks, modules and their associated details. Extractor modulekeep polling the controller at interval of 10minutes and fetching the response data. Azure SDKs exposing the API to connect with edge hub and sending live data to it. Configurations are likeIP address, store details and other Edge parameters. Proposed system should be deployed as a Docker container which is recommended by Azure IoT Edge architecture.

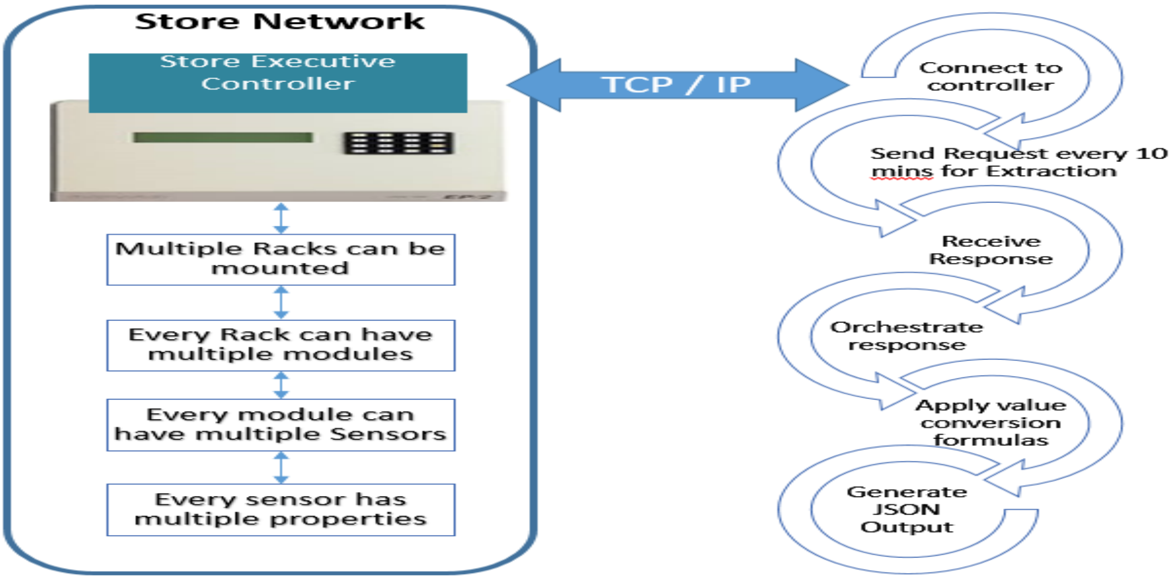

Figure 2: Proposed IoT Edge based system

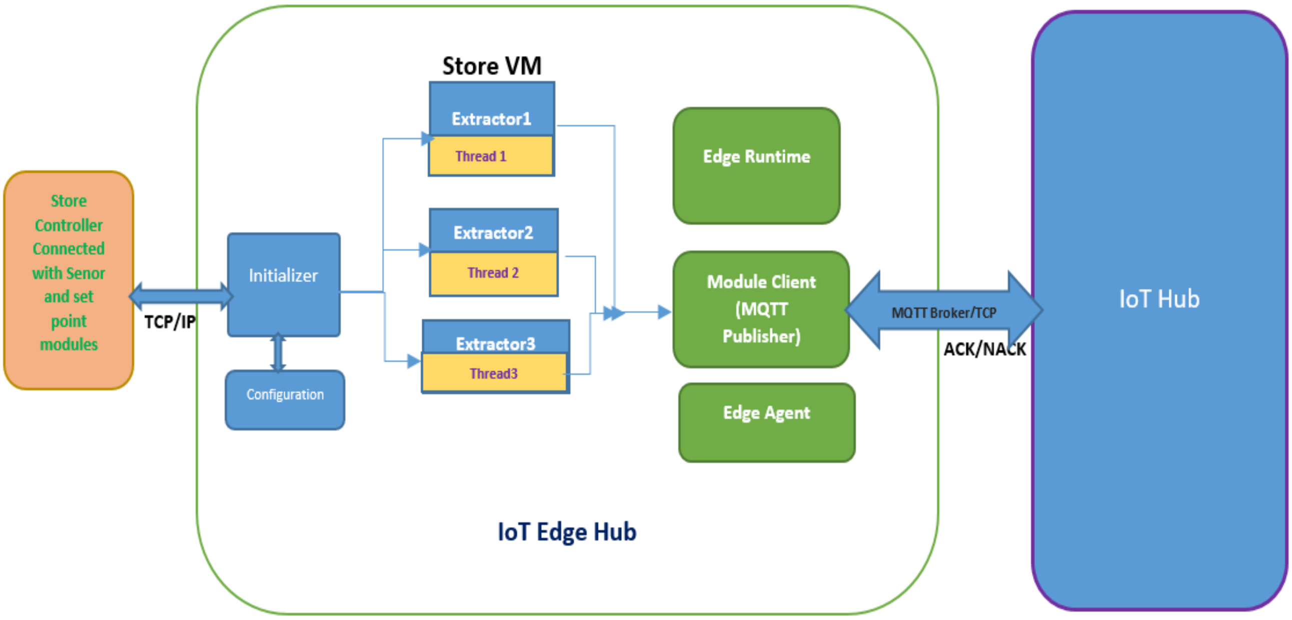

Figure 3: Over all architecture of IoT Data Retrieval system

V. DETAILED SYSTEM DESIGN:

Initializer Module:

Initializer is an entry point for IoT Data Retrieval system; it is starts from edge configuration where store details along with setup required for edge connectivity.

Once the process starts, it collects the rack counts to fetch the details about HVAC and refrigeration system, Racks can be of any types, it is either HVAC or Refrigeration.

EXTRACTION MODULE:

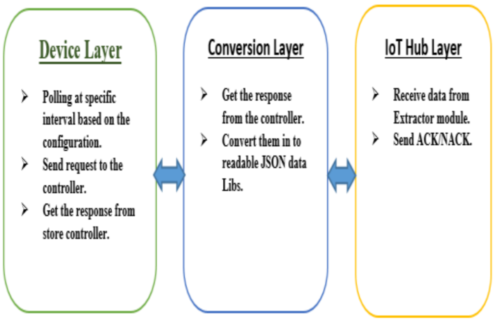

Figure 4: Logical flow of Data Retrieval system

Based number of racks present in the store, multiple threads are spawned to requests the controller for sensor data on each polling cycle.

Communication between controller and Data Retrieval System is happening via RESTful calls.

The output obtained from the controller are sent to JSON convertor to generate various readable JSON data.

JSON message generated from IoT Data Retrieval system is sent to IoT Hub further processing. IoT Edge willsend the successful or failure response for every messages sent to IoT Hub.

Sequence number or hash mapsent alongwith JSON message is to uniquely identify the eachJSON packet.

Mainly RESTful calls are invoked to the executive store controller to fetch live sensor values as response.

Various application configurations (Building or store number to uniquely identify it, IP address to connect fromVM, edge configurations (connection string for IoT Hub), Hub region, HVAC/Refrigeration rack names and numbers are present as part of configuration setup used to start the application.

VI. CYCLE HANDLER ALGORITHM

Step1:

Main () process initiate Initializerthread
If (Controller status! = COMMLOSS)
then Start Initializer,
Collect Racks details such as status, names, IP address,
Start an Extractor Module.
else report an error.

Step2:

At every one-hour
If (Module status =active)
Collect sensor names, Circuit details of refrigeration racks, Scale details.

Step3:

At every 10 mins,
Poll controller to get the sensor and set point values.

Step4:

Convert responses from the Controller in to readable JSON data.

Step5:

Get the connection string from Edge Hub Environment setup and publish data with telemetry topics.

Step6:

If (Data Received by IoT Hub)
IoT Hub will send ACK
Else
IoT Hub will send NACK with error.

Cycle handler algorithm is designed to define the polling logic for Data IoT Data Retrieval.

Errors due to network issues, resending the requests to controllers after time out issues are handled at transport layer level protocol itself. retry mechanism is limited to 3 times.

Module client is used tosend (publish) the telemetry datato Edge Hub with the helpof MQTT (Message Queuing Telemetry Transport). MQTT broker, which is part of the Publisher-Subscriber module, send the data to IoT hub using connection string. Here security mechanism named Security demon implemented by Azure is allowing only one process to send the data to IoT Hub.

Azure Agent is an in-built component of Edge Hub is the monitoring container for all the custom modules running in Edge hub, it restarts the any containers if any modules go down.

IoT Data Retrieval System is containerized using Docker commands and pushedinto Azure Container registry for mass deployment in any number of stores. Stores may have rich On-primes Edge environment or cloud VMs.

Advantages of doing Edge Analytics, it is quicker since its closer to the device where thedata is being generated instead of at the cold storage where data is saved to unlock the value buried on that. Edge analytics is used where communication cost is high and instant action is necessary.

VII. RESULTS AND DOCKER DEPLOYMENT:

IoT Data Retrieval system is deployed as a Docker container in IoT Edge and along with other custom module, and hosted in ACR (Azure container registry) for mass deployment, which can be deployed in any number of commercial retail stores.

Azure Agent is the monitoring container deployed by Microsoft to monitor the custom modules running in the same Edge Hub. Data will be sent IoT Hub from any custom modules with connection string fetched from the Edge setup.

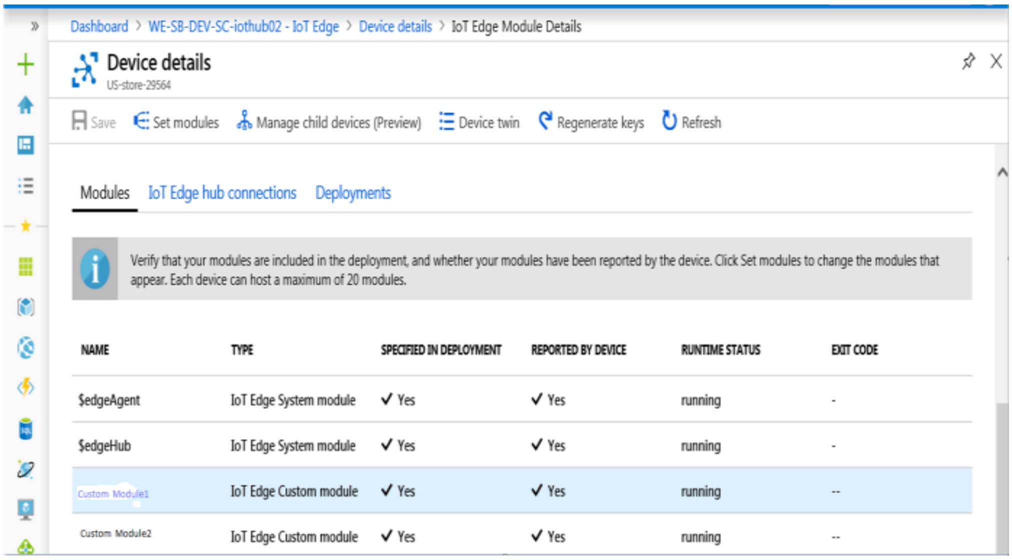

Figure 5: Edge Device details snapshot of Data Retrieval system

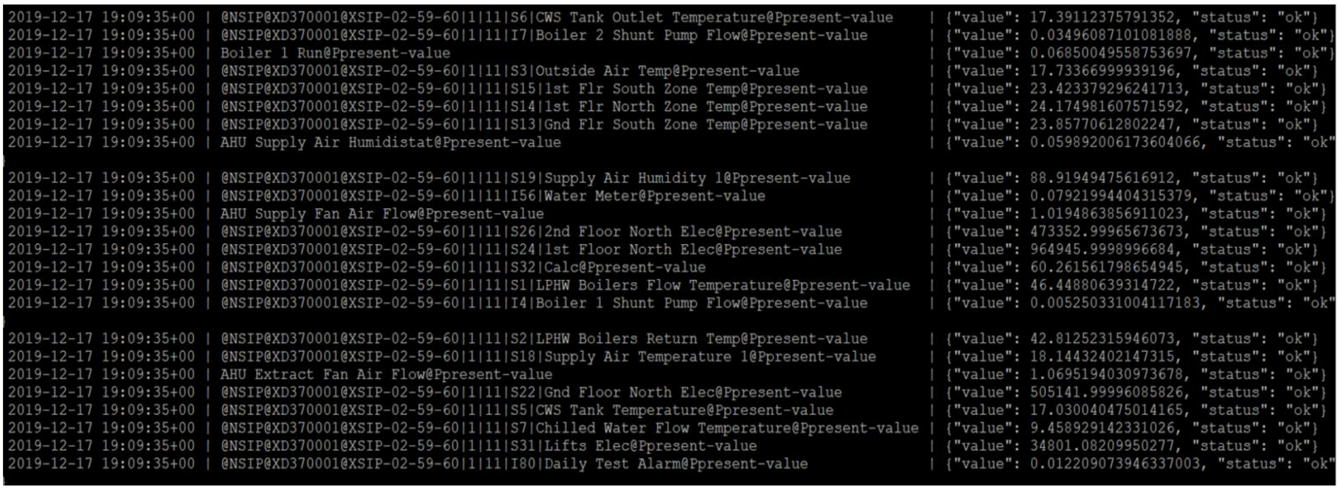

Figure 6: Sample Raw Sensor data (JSON Format) coming fromthe IoT Data Retrieval module.

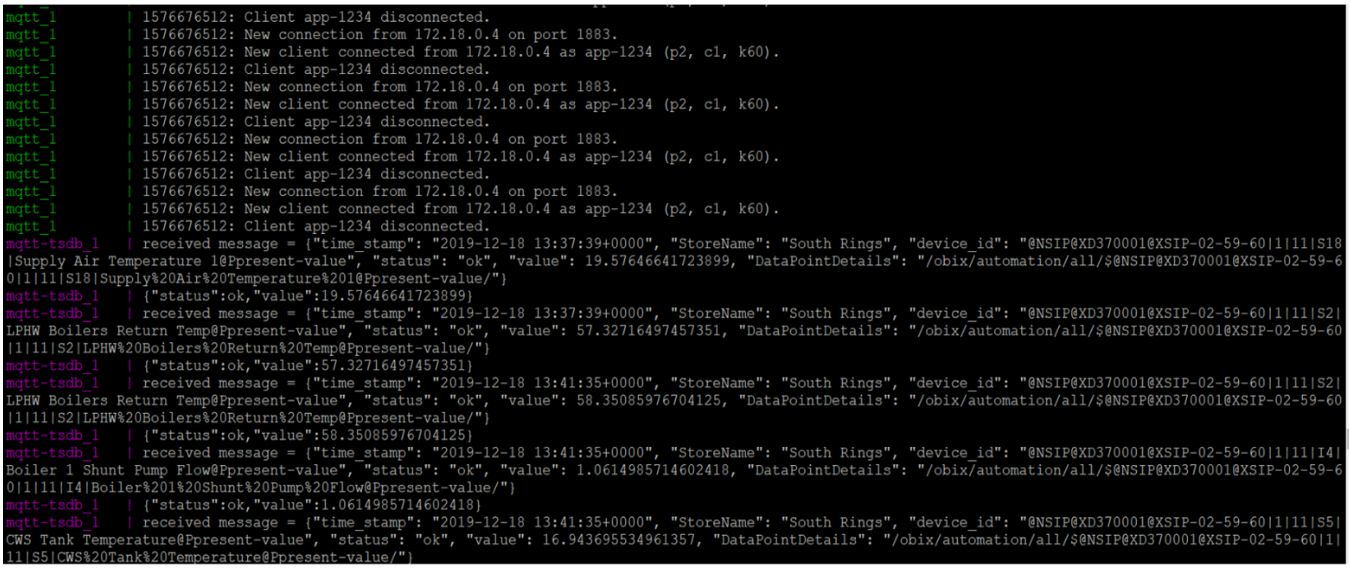

Figure 7: MQTT Subscriber receiving Telemetry data from Publisher

VIII. CONCLUSION AND FUTURE WORK:

This proposed system design with IoT Edge is best suited for Edge analytics, which will reduce the delay due to network traffic when compared to IoT Hub. Since the custom modules are controlled by Edge hub, any issue is monitored and will be restarted in case of any failure or after down time.

Apart from any real time quick decision, which are controlled by Edge Hub, Machine learning relatedanalytics canbe done in IoT Hub where the system has completedata, which are for long time.

Alerts will be sent to store manager or stakeholders like a technician to address any issue like phase lose in Hvac or refrigeration racks. If this system is not controlled by central system like Edge platform, more manualeffort needed tomonitor the retailstores at 24/7 , will result inunattended priority alerts due to human mistakes, finally causes the productlose on expensive food items.

This work can be extended for energy savings intelligent application on peak hours with high tariffs. Apart from the sensor data setpoint readings like cool setpoint and heat setpoint playing amajor role. The proposed system needs additional modules called watchdog to monitor the system against data lose and any other issues like communication lossor powerfailures andoverloaded situation in controller.

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