Monitoring and Controlling of Internet of Things(IoT) devices using MQTT(Message Queuing Telemetry Transport) Protocol

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ABSTRACT

In smart homes, interconnected health monitoring wearables and smart farming monitoring and controlling of those system is challenging process due to lot of human asset requirement, incompatibility of frameworks due to lot of protocols and want of suitable technical solution. In this paper, an IoT based framework using lightweight MQTT protocol to monitor and control of IoT devices is proposed. The proposed work is to design a basic Orange Pi based circuit to persistently watch and peruse the values of sensors that are constantly changed and control the end devices based on the rules pre-configured, in order to get a full-fledged system which not only monitors values but takes action accordingly in real time. In this approach, an embedded framework is utilized to interface the sensors that gather the data of the surrounding environment. In view of the sensor data collected, a proactive prediction algorithm is advanced to implement a solution for any kind of problem. Gathered data is put away in an influx database, it can be queried based on the applicable data requirement. For communication between devices, MQTT protocol is used. This proposed approach would process the data and report it back to the end user by developing a web page. Along with report, it provides users with rule configure option to define control action to be taken based on the sensor data. The proposed solution is cost effective, flexible, scalable and dynamic nature, and thus can be effectively deployed and set-up in any region to monitor and control efficiently.

Keyword *MQTT, Orange Pi One board, sensors, IoT, influx database*

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1. INTRODUCTION

IoT is improving our lives by tackling real life problems ranging from pollution to global warming, traffic jam to natural disaster. Nowadays countries are becoming smarter by adopting IoT based system into disaster management, urban management and heath care. For example, cities are automating traffic management IoT systems effectively noting the flow of traffic based on changing condition and actions are taken by the traffic authorities accordingly. IoT applications such as parking application that guides autos to open spots, ability to foresee the onset of conditions that promote woods fires before their onset allows regulation team to respond rapidly and avoids disaster and saves our natural habitat. This same concept applies equally to seismic tremors and other natural disaster.

IoT defines the network of connected internet objects that can intercommunicate without any human mediation. It is formally characterized as a 'Framework of Information' in light of fact that IoT gives mass information from a wide range of mediums from conveyances, smart city, wearables, industrial internet, smart supply chain, smart grids, smart retail, connected health to traffic signal. All processing devices in this world are given with an IP address to make data transmission over a network by interfacing them with hardware such as sensor, networking gear and software.

IoT devices sense the data as well as also perform actions based on the sensor data. In most of the IoT applications like disaster management, health care and agriculture, data analytics play an important role in taking dynamic decisions for better performance of the applications. All devices such as sensors, smart-phones, and actuators are a part of this ecosystem and help in moving us towards this new generation of IoT, where devices are interconnected and speak to one another utilizing internet. Smart devices play a vital role in bringing IoT revolution [1]. Nearly 100 billion of devices will connect by 2020. Inexact economic growth rate is increasing every year by 30%.

The information to be monitored is sent through web to the end client (user) and for the real-time data acquisition, whichever protocol used play a vital role. In this paper MQTT protocol is used which is a lightweight protocol. All the existing platforms utilize proprietary application, protocol and follow different communication protocols and standards. Subsequently they cannot straightforwardly communicate with one another [2]. Customized service requirement is given to the end user through this interface.

To monitor and control the diverse parameters of the system effectively, it is required to implement a monitoring and controlling framework. For example, greenhouse parameters monitoring system where light, soil moisture, humidity, and temperature data are monitored continuously and controlled viably by actuating a slider or lights, humidity, heater, water pumps and fan according to condition of the environment.

2. RELATED WORK

The utilization of IoT in climate monitoring, agriculture monitoring, health care, smart city and home automation are increasing rapidly due to accessibility of new sensors, implantable wearables, and different environment condition sensing and wearable gadgets in current generation.

In a survey of IoT system, author in paper [3] has proposed a technology in which day-to-day communication with home appliances are remotely controlled using gadgets like tabs, smart-phones which has internet connectivity. House-hold interaction is disentangled by designing automation into IoT along with security to create a framework which enables anybody to monitor and control remotely from anywhere.

In [4], authors have proposed a framework to monitor CO_2 and noise levels in any particular area. The sensed parameters to cloud were sent through the framework. These information will be used for future analysis and shared by different users.

Authors in [5] have explored that MQTT protocol consumes low power than that of Hyper Text Transfer Protocol (HTTP) protocol. MQTT consumes time only while initializing the connection, but it takes much less power to maintain an open connection, to send and to receive messages.

In paper [6], survey results for different platform with gap analytics by assessing protocol shortcomings has been explored. From this paper, it can be seen that there is no true correspondence communication protocol suit and hence it makes interfacing heterogeneous devices more difficult and costly.

An architecture that provides real-time interaction between mobile clients and smart things is provided in [7]. An IoT based platform with five different segments namely virtual sensor, sensors, mobile applications, platform and web based health-care services and its management has been presented in [8].

Authors in [9] have proposed a block-chain technology for IoT framework. Key security prerequisites are highlighted and how block-chain can help to address these prerequisites are discussed. A design for data distribution in IoT system utilizing block-chain is presented to analyse that how existing security scheme can be made more dominant with the utilization of block-chain technology. Few issues including anonymity, integrity, versatility, and adaptability for data management in IoT framework has been highlighted.

3. METHODOLOGY

- Sensors are deployed in the fields with Orange pi one board, then sensed values are collected in the influx database.
- Influx database is lightweight and time stamped database is queried to get the collected sensor value
- End users are provided with web page which would analyse the queried sensor values and report it to users in dashboard and report format.

- Along with Report and dashboard option, rule configuration option is provided to define the rules which decide the control action to be taken.
- Different control action are set actuate, send alarm notification, send message and send email.
- Once set actuate control command is triggered, Control action command is sent to controlling part of circuit using MQTT protocol for communication.
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4. PROPOSED WORK

The functional model is shown in figure 1. The model contains two parts and are as mentioned below:

1. Sensors and actuators interfaced with Orange pi one
2. Web page at end user side

A. Sensors and actuators interfaced with Orange pi one:

Orange pi is used as an end client to which sensors, actuators are connected, to collect real time data. Orange pi acts as MQTT client to publish the sensor data to MQTT broker (server) and also to subscribe the actuator control data from MQTT broker.

B. Web page at end user side:

In monitoring and controlling system, analysis of sensor data is very important. Administrators, Customers and Operators are end users accessing the web page. End users acts as client to subscribe the sensor data from the MQTT broker and also publish the actuator control data to MQTT broker. All data of sensor and actuator to be published and subscribed are stored in influx database. Influx Database is extraordinarily situated to solve the challenges of billions of events flowing into IoT, which is required to be analyzed and filtered.

Django server is used to develop a web page, it takes the control data as input from end users and output the reports of analyzed data, notification and Dashboard back to end users. Django development server stores web page data in postgreSQL database. PostgreSQL is an endeavor class open source database management system.

Rule module in IoT Web Application allows user to define the action to be taken for a specific condition. Rules configured are saved in Kapacitor, it is a local data processing engine in the TICK stack. TICK stack is a accumulation of influx database and kapacitor technologies to deliver a platform for capturing, storing, visualizing and monitoring of data that is in time series. Kapacitor receives the data which is dumped into influx continuously either in a streamlined way or as batch entries periodically after a certain interval, it checks if any rule has been triggered. When a rule is triggered, the IoT Web Application continuously monitors the Influx for new alarms, as soon as a alarm is detected, the system takes the appropriate action as configured in the rule.

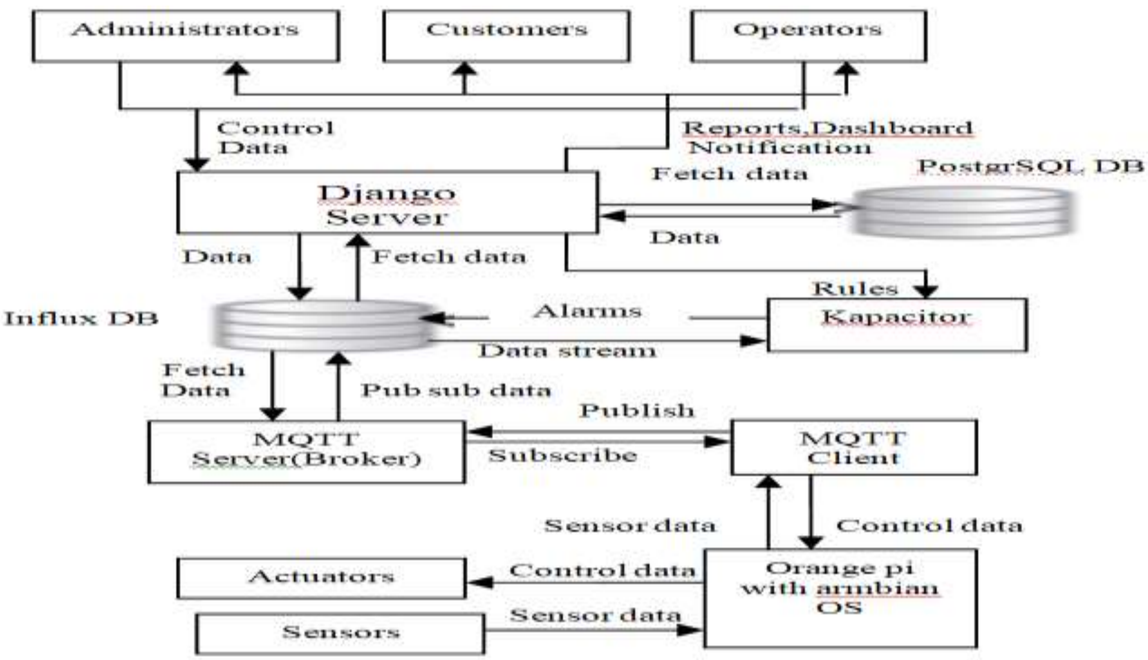

Fig 1 Functional model of the proposed work

Actions include notifying users about the anomaly via text or email, or controlling the end devices accordingly. Influx is a time series NoSQL (Non-Structured Query Language) database explicitly built for use cases based on IoT or sensor data. For the large volume and velocity of sensor data, NoSQL database are regularly preferred for storing such type of data.

C. IoT communication protocol:

In this paper, MQTT protocol is used for communication. MQTT protocol sends a message with minimized data packets and thus consumes lesser bandwidth. The size of the message should be between 0-255MB, but it is not preferred to send messages which are bigger in size. Generally, for IoT applications, the size of transmitted data is less, hence this protocol can be used for sending messaging over the network. MQTT's two command on a connection are 'publish' and 'subscribe' [10].

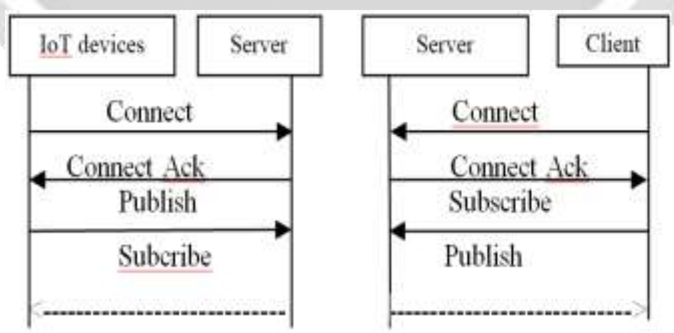

Fig 2 Working flow of MQTT protocol

Figure 2 shows the working flow of MQTT protocol. The communication between IoT devices and Server is established through CONNECT, PUBLISH, SUBSCRIBE, UNSUBSCRIBE and DISCONNECT message types.

5. EXPERIMENTAL RESULT AND ANALYSIS

The experimental setup leads to implementation of cost-effective, high speed, flexible monitoring and controlling system by using Orange pi one board, sensors and actuators.

Temperature Sensor: Temp = 28.00 C, Humidity = 50.00%

Gas Sensor : value =33, Density = 0.0

Temperature Sensor: Temp = 26.00 C, Humidity = 48.00%

Gas Sensor : value =32, Density = 0.0

Temperature Sensor: Temp = 27.00 C, Humidity = 49.00%

Gas Sensor : value =33, Density = 0.0

Temperature Sensor: Temp = 25.00 C, Humidity = 47.00%

Gas Sensor : value =31, Density = 0.0

Fig 3 Data collected from sensors

Temperature sensors measures temperature and humidity of the system, gas sensor will sense the gas level and density. Figure 3 shows the data collected from sensors frequently at interval of every five second.

time	compId	msgid	payload	topic	type	user
1548756062332559902	Temperature_Sensor	<<0,5,128,149,222,240,98,128,110,125,73,,99,72,0,1>>	{"temperature":39}	/hospital/shane-1/temperature	pub	root
1548756062077474671	Temperature_Sensor	<<0,5,128,149,222,236,118,181,110,125,73,0,99,69,0,1>>	{"temperature":37}	/hospital/vince-2/temperature	pub	root
1548756061248425982	Temperature_Sensor	<<0,5,128,149,222,223,215,190,110,125,73,0,99,62,0,1>>	{"Humidity":43%}	/hospital/vince-2/Humidity	Pub	root
1548756052276780477	SPO2_PulsioximeterSensor	<<0,5,128,149,222,86,242,104,110,125,73,0,98,246,0,1>>	{"oxygenpercent":95}	/hospital/shane-1/bloodoxygen	Pub	root

Figure 4 Sensor data stored in Influx data base

Figure 4 show the sensor data collected in the influx database. Payload column indicates the sensor data, time column indicates time in second, MsgID column indicates unique ID of each message. CompId column indicates topic that which MQTT client is publishing and subscribing.

Figure 5 Rule condition to define the condition in rules.

Figure 5 and Figure 6 shows the rule configuration option of the IoT system and the different control action that can be taken based on sensor data. Different control actions are send email, generate message, send alarm and set/actuate. In the above figure set/actuate control action is selected to turn on the actuator when the temperature of the system is higher than threshold value. Generate message action is selected when the system parameter value is out of good range.

Figure 6 Rule action in rule configuration to define the control action.

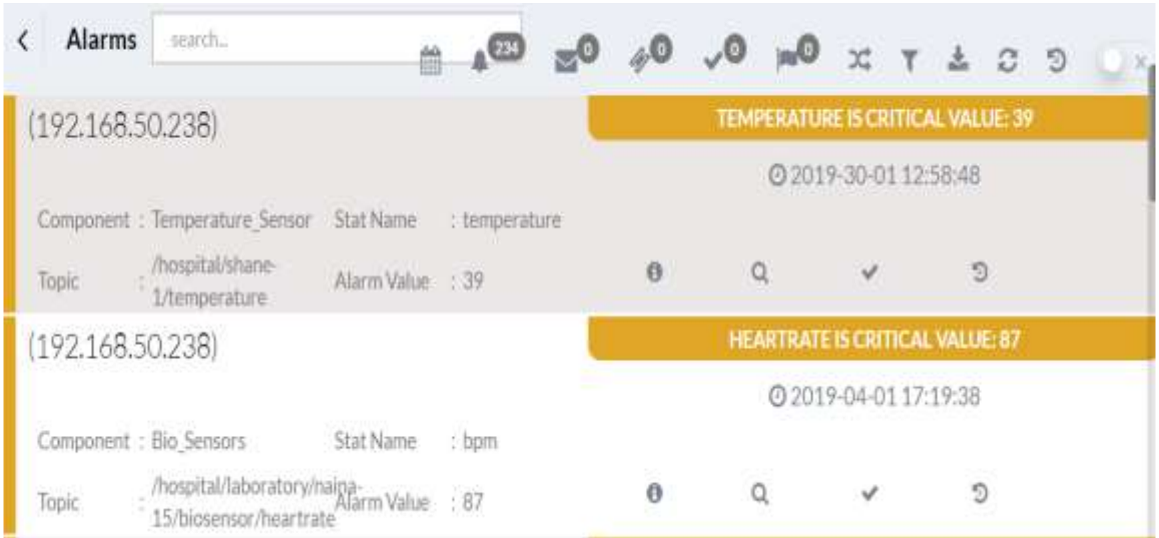

Figure 7 Alarm notification to end users

Figure 7 shows the Alarm notification to end user to inform them about the severity condition of the system. Component indicates sensor name, topic name indicates topic of the alarm message, statistics indicates parameters of the system and alarm value indicates parameter value which is out of good range.

Figure 8 Graph of Number of threads v/s elapsed time for average load predefined step size.

Figure 8 shows the normal load on the framework which is expanded by a predefined step measure. Performance estimation is taken for each dimension of load. As the number of active threads increases, elapsed time increasing linearly for an average load predefined step size

6. CONCLUSIONS

In this paper, an IoT based monitoring and controlling system is proposed which caters to the issues of full-fledged autonomous system which can be applied on health care, traffic control system, environmental degradation and pollution system. Sensors are connected to an Orange pi board, different parameters of the systems are observed and recorded frequently with the interval of five second. The analyzed sensor data is notified to end users and alert notification is sent in case of any issues. In web page, rule configuration option will make use of this analysed data to suggest the control action to counteract for any detected problem. It is scalable and cost-viability nature makes it convenient to set-up, install and use anywhere across domains.

7. FUTURE ENHANCEMENT

One of the real specialized difficulties of having millions and millions of devices deployed worldwide is the capacity to oversee them. Existing device management technologies depends on centralized, brokered communication models, also called as server or client paradigm which presents another technical limitation to oversee them globally.

To overcome the above challenges, future work is focused on integrating block-chain technology to IoT platform. Block-chain, a distributed ledger technology offers a method of recording transaction or original interaction in a manner that is intended to be transparent, secure, highly resistant to blackouts and efficient. Access control policies are defined in block-chain network which is distributed to avoid bottleneck when access control updates and queries are frequent.

5. ACKNOWLEDGEMENT

We wish to express our sincere gratitude to the Department of Computer Science and Engineering, Rashtreeya Vidyalaya College of Engineering, Bengaluru, Karnataka, India and EverestIMS technologies, Bengaluru, Karnataka, India, for providing the infrastructural support to carry out this work.

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