Smart City- an IoT based Approach

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***Abstract*—Internet of thing is an emerging technology that creates a massive network of things communicating with one another. Data, humans, devices and communications are critical elements of an IoT ecosystem. For a developing country such as India, which has quite limited technology penetration at the national level, an efficient architecture for IoT needs to be based on present technology advances, capabilities that provide affordable and sustainable solution, and entrepreneurial and social value. Smart city is an important concept for the development of any nation. It should be equipped with different electronic devices on the basis of IoT, therefore becoming smarter than before. The smart street light proposed in the system is energy efficient and the dustbin proposed is eco-friendly. Pollution sensor is placed on the top of street light to measure the air pollution. The sensor data will be stored in the cloud for analysis and remote access.**

Keywords—Internet of things (IOT); Sensor; QoS; cloud;

I. INTRODUCTION

Due to the rapid growth of the population density in urban cities, infrastructure and services are required to provide the necessities of the city residents. On this basis, there is a significant increase for digital devices, e.g. sensors, actuators, and smart phones that drive to huge business potentials for the IoT, since all devices can interconnect and communicate with each other on the Internet. The IoT prototype is subject to smart and self-configuring objects that are connected to each other through a global network infrastructure. IoT is mostly considered as real objects, broadly scattered, with low storage capability and processing capacity, with the target of improving reliability, performance and security of the smart city and its infrastructures. With this knowledge, an IoT - based smart city system is proposed.

Smart cities have become smarter than before thanks to the recent developments of digital technologies. A smart city is equipped with different electronic elements employed by several applications, like street cameras for observation systems, sensors for transportation systems, etc. In addition, this can spread the usage of individual mobile devices. Therefore, by considering the heterogeneous environment, different terms, such as features of objects, contributors, motivations and security rules should be investigated.

In the IoT context, devices can be integrated based on the geographic location and evaluated by using an analyzing sys- tem. Sensor services for the collection of particular data can be used with several occurring systems concerning the monitoring of cyclists, vehicles, public parking lots, etc. There are many service domain applications that use an IoT infrastructure in order to facilitate operations in air and noise pollution, the mobility of vehicles and surveillance systems. The revolution of the Internet provides an infrastructure in which many people are able to interconnect to each other. The next revolution of the Internet will make it possible to provide suitable interconnections among the objects. In 2011, the number of objects that are interconnected together was much more than the number of people.

The objective of the proposed system is to design a city with automated street lights which will be energy efficient and with smart garbage bins. To measure the air pollution, upload all the parameters measured to the cloud and also to analyse the stored data in order to provide better services to the citizen.

II. RELATED WORKS

Various works have been carried out on smart city. As there is a rapid advancement in technologies, smart city project can be achieved using one of these different technologies. In [1], author has proposed an Architecture of an IoT based middle ware for smart city which will act as a communication layer between the heterogeneous systems in the city, giving the authorities control over the infrastructure and data. This architecture will help the authorities operate more efficiently in a vendor agnostic environment and will motivate them to implement innovative business models which will lead to autonomous self-driven cities. This IoT middle ware system consists of a messaging system, a queuing and a routing system which can route data to any analysis platform. One of the major advantages for going for a middle ware for all IoT systems in a smart city is that the hardware utilization for communication will be maximized and the capex & opex cost will be minimized, compared to multiple end-to-end systems. In [2], the author has proposed dynamic light control solutions that permits an energy saving of more than 500/0 compared to classical static, time-based street light. The pro- posed system makes use of weather and human activity sensors

for the implementation of the Dynamic street light system. In this paper they have relied on two categories of indicators which are deemed relevant to dynamic street light control.

The first category is a set of environmental indicators. Sensed with a weather station, the main environmental indicator is luminosity. The second category of indicators describes the activity on the street.

In [3], the author proposed an advanced smart lighting system framework which adjusts the intensity of the light according to needs or according to the time. The results of these proposals show that the consumption of electricity gets reduced to about 50% but the main drawback of his system was that it consumes some amount of electricity when the natural light's intensity value is not above a given value or when the street lights are stated to function according to the given time parameters even when there is no need of street lights. In [4], the author proposed a life cycle of urban data in Chinese smart cities. Life cycle consists of three phases namely data collection that is followed by data analysis. The analyzed data is then used for providing smart services to the citizens. There are various project challenges faced in smart cities project. Data is owned by government or the IT companies which is not made open to the citizen limiting the citizen participation in making smart solutions to the urban problems. Second issue faced is the top-down approach is adopted for smart cities. This approach makes services being delivered are deficient and hence preventing local innovation. In [5], the author addressed a dynamic street light control from a Hardware perspective. The work aimed at developing a low cost, low power micro-controller to dynamically adjust the light levels of LED street luminaries. Few sensors have been integrated to the micro-controller board in order to implement light control rules, based only on environmental factors. Arduino UNO Atmega 328P-PU has been selected as the controller in this system due to the low cost, compatibility, compact size and easy interfacing over several type of other controller including Field Programmable Gate Array (FPGA), Programmable Logic Controller (PLC) and Programmable Integrated Circuit (PIC) LCD and light intensity are the two outputs used in the proposed system and connected to the micro-controller. However, the system has been tested only in Indoor environments. In [6], the author described about use of M2M communication. M2M communication allows sensors as well as mobile devices, computers to communicate each other without human intervention. An M2M network uses the existing network ike cellular networks (instead of building a new network) to transfer the data's in any part of the world. Typically Machine Type Devices (MTD) transmits/receives small amount of data. Security plays a vital role in any communications environment, and it is more critical in M2M communications. Recent Research interest in M2M is increasing but there is a lack of research contributions in identifying the main issues in security on M2M environments. Since huge number of devices connected in the M2MAN, there is no standard protocols define for M2M communication.

III. PROPOSED SYSTEM

The proposed Smart City- an IoT based approach can be divided into mainly three section, namely Sensor Node, Internet/Cloud and User Node. The sensor values and appliances status is received and analyzed by the raspberry-pi and, sent to cloud storage and user via Internet.

The detailed block diagram of the system is shown in Fig. 1

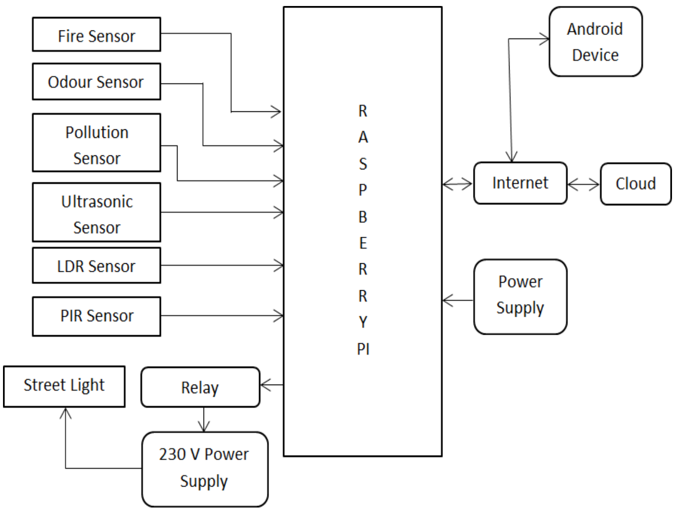

Fig. 1. Block Diagram of Overall System

A. System Description

The block diagram shown in Fig. 3 includes mainly the Sensor Node, Internet/Cloud and the User Node which are described below.

1) Sensor Node

It consists of sensors and appliances that are to be controlled. Sensors and appliances are connected to Raspberry Pi. Pi decides what sensor data are to be transferred to the cloud using the python platform.

Fire Sensor is a sensor designed to detect and respond to the presence of a flame or fire. It makes use of IR and comparator circuit to operate. Odour Sensor is used to detect foul smelling gases like N2O, CO, etc. Pollution Sensor is a device that detect and monitor the presence of air pollution in the surrounding area. Ultrasonic Sensor is a device that can measure the distance to an object by using sound waves. PIR Sensor is an electronic Sensor that measures IR light radiating from objects in its field of view. LDR Sensor is a device that has a variable resistance that changes with the light intensity that falls upon it. This allows them to be used in light sensing circuits.

2) Internet/Cloud Backend

For the implementation of proposed functionalities, cloud platform such as IBM Bluemix, Amazon Web Services, etc can be used. Further operation and filter can be done to the data using MySQL Workbench, which is one of the services provided in AWS. Cloud Services and receives the data sent by Pi through internet connection. It does two-way communication with Pi and User node.

3) User Node

This is a user support layer. It is a platform from where user can access the information about pollution in the surrounding area. User node can be an Android App in a phone or a Web App in a computer. User is able to receive data. For example, When the user is in certain location and the pollution in that region is high, he will get a notification either to leave area or take precaution.

1) System Features: The system is concerned with three major issues Safety, Power efficient Street Light and Litter free surrounding.

1) Safety Concern
The system is fitted with pollution sensor to measure the pollution of the surrounding area so that if the air pol- lution is high (beyond a threshold) an alert notification will be sent to the user, stating the condition of the area.
2) Power efficient Street Light
The System is fitted with PIR sensor to detect human activity and a LDR sensor to detect the light intensity. In the day time, street light will be off and in night when motion is detected only then street light will glow otherwise it will be in off state which helps in reducing power consumption.
3) Litter free surrounding

This system is fitted with Ultrasonic sensor to detect the garbage level in dustbin, Odour sensor to check if there is any foul smell coming out of dustbin or not and a Fire sensor to detect fire in dustbin. All this data is sent to the authorized department in order to provide better services to the residents.

IV. IMPLEMENTATION

The implementation of the entire system is categorized in terms of Hardware and Software. Once the hardware part is assembled ie. sensor nodes with Raspberry Pi, comes the software part. Implementation is done mainly three different domains - Python, Cloud and Android. IBM Bluemix is used for implementing cloud operations. Android App is developed using Android Studio. Raspberry Pi uses Raspbian as a Oper-ating System(OS) and Python IDE is used for writing Pyhon codes. In addition to these, Putty and Xming are also used for accessing Raspberry Pi terminal from a laptop without connecting Raspberry Pi to monitor and separate keyboard and mouse.

The communication mechanism between different nodes is based on mqtt protocol. MQTT is a machine-to-machine (M2M)/IoT connectivity protocol. It was designed as an ex- tremely lightweight publish/subscribe messaging transport. It is useful for connections with remote locations where a small code footprint is required and/or network bandwidth is limited. The System uses ”iot.eclipse.org:1883” as a mqtt broker where diffent topics are created for the user to publish or
subscribe.

After a MQTT client is connected to a broker, it can publish messages. MQTT has a topic-based filtering of the messages on the broker, so each message must contain a topic, which will be used by the broker to forward the message to interested clients. Each message typically has a payload which contains the actual data to transmit in byte format. MQTT is data- agnostic and it totally depends on the use case how the payload is structured. Its completely up to the sender if it wants to send binary data, textual data or even full-fledged XML or JSON.

V. WORK FLOW

Sensor node, Cloud and end User Device all comes into picture while realizing in a sequential manner. First of all, data captured by sensor node is sent to the cloud and also the end User. In cloud, obtained data is manipulated and different task is performed which are all explained in the form of flowchart.

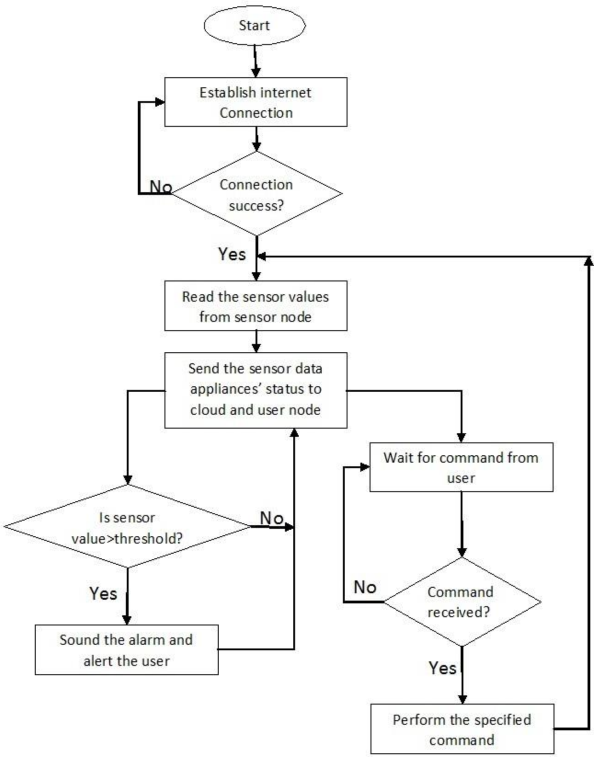

Fig. 2. Flowchart for the System using Raspberry-pi

Fig. 2 illustrates the sequence of activities in the ISC. When the internet connection is established it will start reading the parameters of different sensors. The threshold levels for the required sensors are set. The sensor data are sent to the cloud storage as well as the end user. The data can be analyzed anywhere any time. If the sensor parameters are greater than the threshold level then the respective alarm will be raised, and end user is notified with alert. The user is able to see values coming from sensor node, and also remotely control the home appliances.

The detailed opeartions happening in the cloud is shown in Fig. 3. First the data in cloud is separated according to the source they are sent from.

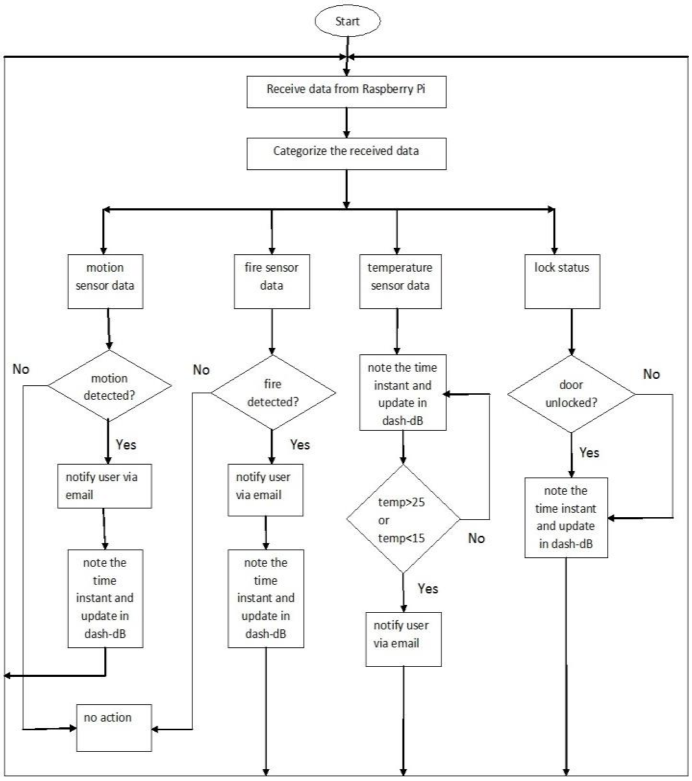

Fig. 3. Flowchart showing Detailed Cloud Operations

For eg: motion sensor data, fire sensor data and temperature sensor data are first separated, then each data is checked. If motion or fire is detected from the received data then user is notified via email and that exact instant of time is saved in a dash-dB table.

V. Result

The Quality of Service (QoS) level is an agreement between sender and receiver of a message regarding the guarantees of delivering a message. There are 3 QoS levels in MQTT:

1) At most once (0)
2) At least once (1)
3) Exactly once (2)

QoS is a major feature of MQTT, it makes communication in unreliable networks a lot easier because the protocol handles retransmission and guarantees the delivery of the message, regardless how unreliable the underlying transport is. Also it empowers a client to choose the QoS level depending on its network reliability and application logic.

A. At most once (0)

The minimal level is zero and it guarantees a best effort delivery. A message wont be acknowledged by the receiver or stored and redelivered by the sender. This is often called fire and forget and provides the same guarantee as the underlying TCP protocol.

B. At least once (1)

When using QoS level 1, it is guaranteed that a message will be delivered at least once to the receiver. But the message can also be delivered more than once.The sender will store the message until it gets an acknowl- edgement command message from the receiver.

C. Exactly once (1)

The highest QoS is 2, it guarantees that each message is received only once by the counterpart. It is the safest and also the slowest quality of service level. The guarantee is provided by two flows there and back between sender and receiver.

The Round-Trip Delay time (RTD) or Round-Trip Time (RTT) is the length of time it takes for a signal to be sent plus the length of time it takes for an acknowledgment of that signal to be received. This time delay therefore consists of the propagation times between the two points of a signal.

To calculate RTD, two python codes is run : one publisher and one subscriber for different QOS Publisher sends a time-stamp of the moment it is sent as the message and the subscriber prints the time-stamp of the sent as well as received message. The difference between the received and sent time-stamp gives the RTD. The RTD for different QOS are observed to be different. The RTD is maximum for QOS-2 and minimum for QOS-1.

	Different QOS		
	QOS-1	QOS-2	QOS-3
Round Trip Delay Time (RTD) In Seconds	0.300381	0.351937	0.987955
	0.276321	0.309702	1.11196
	0.298737	0.338293	0.913541
	0.307348	0.312028	0.906115
	0.299203	0.305806	0.925123
	0.309988	0.303237	0.922354
	0.303936	0.453029	0.980266
	0.295921	0.487394	0.930914
	0.291621	0.753097	0.866448
	0.322207	0.310773	0.913768
	0.35289	0.330946	1.000624
	0.294583	0.307151	0.873627
	0.269409	0.325329	0.962085
	0.30185	0.389047	1.168426
	0.314331	0.325641	0.91456
	0.291204	0.314614	0.929088
	0.277165	0.312098	0.896656
Average RTD	0.30041735	0.36647776	0.953147647

Table 1. Different QoS

Table 1 consists of various RTD obtained during the transmission of message with different QOS. It also shows the average RTD for each QOS. The table data is latter plotted to obtain the graph shown in Fig.4

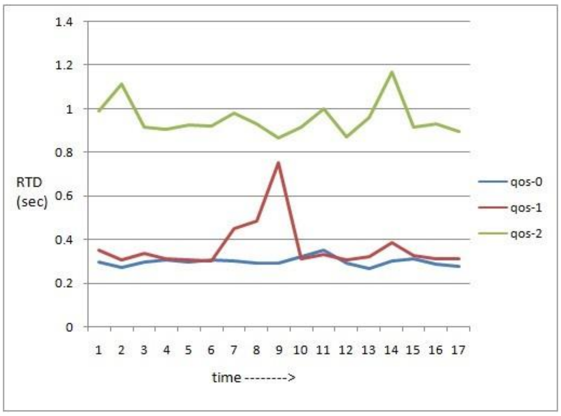

Fig. 4. RTD for different QOS

VI. CONCLUSION

A study is carried out on existing smart city automation system based on various technologies such as ZigBee, Bluetooth, etc., and proposed a more robust system for improving certain aspects of smart city with an IOT based approach. The proposed system system is able to send sensor data to the remote user and user can in turn closely control and monitor the data in order to keep the city clean and robust. The performance of the IOT system developed is realized for different QoS.

REFERENCES

[1] Tintu Joseph , Roopesh Jenu, Ajmal K Assis,Sajith Kumar V A, Sasi P M, Dr. Alexander G, "IoT Middleware for Smart City ", Centre for Development of Advanced Computing, Trivandrum, India, 2017.

[2] Nabil Ouerhani, Nuria Pazos, Marco Aeberli, Michael Muller, "IoT based Dynamic Street Light Control for Smart Cities ", International Symposium on Networks, Computers and Communications, pp. 171-175, Switzerland, 2016.

[3] Sanchit Bhasin, Tanupriya Choudhury, Subhash Chandra Gupta, Praveen Kumar, "Smart City Implementation Model Based on IoT ", 2017.

[4] Fehda Malik, Munam Ali Shah, "Smart City: A Roadmap Towards Implementation ", 23 rd international Conference on Automation and Computing, University of Huddersfield, pp.. 29-34, Huddersfield, UK, 2017.

[5] Rohaida Husin, Syed Abdul Mutalib Al Junid, Zulkifli Abd Majid, Zulk- ifli Othman, "Automatic Street Lighting System for Energy Efficiency based on Low Cost Microcontroller ", International Journal of Simulation: Systems, Science, and Technology, pp. 43-48, Vol. 13, Malaysia, 2012.

[6] Anto Merline M, Vimalathithan R, "Smart City: Issues and Reserch Challenges in Implementation ", IEEE International Conference on Smart Grid and Smart Cities, pp. 263-266, Coimbatore, India 2017.

[7] Gaurav Sarin "Developing Smart Cities using Internet of Things : An Emperical study", 3rd International Conference on Computing for Sustainable Global Development, pp. 40-43, Vol.4, NewDelhi, India, 2016.