Implementing and Testing of IoT Technology in Agriculture

J. Maha Kavya Sri, Narendra VG, VidyaPai

Abstract— ***Agriculture involves various physical quantities that need to be monitored and controlled. IoT have several capabilities which are suitable for implementing Precise Agriculture. IoT architecture involves sensors, nodes and computing which can be edge, fog and cloud computing. In IoT there has been a need of communication between nodes, nodes and gateway and gateways to cloud. Different protocols are used at different layers of IoT architecture for communication. Those must be analysed for selecting appropriate protocol for an application. As IoT uses low power devices resources must be utilized properly. There has been a need of low bandwidth, low power communication protocols both in application and network layers to support heavy traffic in power constrained devices. In this paper detailed comparison is made between application layer protocols used in IoT namely MQTT and HTTP for their suitability in IoT applications.***

Keywords—IOT, HTTP, MQTT

1. INTRODUCTION

Real world quantities like temperature are existent everywhere. It is not possible to measure a quantity at one place and approximate it to all places. There is definite need of large number of sensing devices to represent the quantities for each and every bounded location. To satisfy this purpose things are created. Things are uniquely identifiable embedded computing devices which can sense, process real world quantities and communicate with other things. By bringing these things into the existing internet network will bring us a technology named as Internet of Things(IoT). To communicate with things and things to cloud, vice versa we use various protocols.

The communication can be done through wired or wireless. In wireless communication there are many communication technologies which are useful for specific applications. Mainly IoT architecture deals with three layers in which the first layer collects data from different devices like sensors and the second layer is responsible for transferring of data and the third layer is used for storing collected data. Data processing can be done at different layers depending on the application.

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2. LITERATURE REVIEW

[1] Among them MQTT (Message Queuing Telemetry Transport) and HTTP are application layer protocols. Wi-fi, Bluetooth, ZigBee etc. are Network layer protocols. Nodes are devices which are connected to sensors which form the basis of things in IoT. These nodes will communicate with each other and to gateway nodes. Computing can be edge, fog or cloud computing depending on the layer which it is done. Edge and Fog nodes are used to process the data before transmitting to the cloud for reducing burden on cloud. Fog computing can be done at the gateway nodes which receives data from different edge nodes. Architecture using distributed computing along with different communication protocols was proposed. [2] The comparison was made between wired and wireless technology in IoT. As part of wireless technology RFID system was used and remote monitoring of data was proposed. [3] Digital agriculture focused on production, transportation and security of products. [4] Presented research on various technologies used in internet of things for data collection, communication, and data fusion. Carried detailed discussion on wired and wireless communication so that one choose technology as per requirement. [5] Three layers of architecture were discussed. Used different sensors in perception layer to get data and also wireless sensor technology for data transmission from sensors. Data from base station are transferred by using GPRS. [6] Smart Agriculture was providing a better way for selecting sensors and using wireless sensor technology for communication. Integration of cloud computing with IoT provided better way for handling many problems related to storage and availability of data and there by reduced the cost for resources. [7] Comparison of different protocols and elements were made and produced results on emerging technologies and applications. [8] Used different types of sensors like temperature and humidity sensor for air, soil moisture, light sensor, soil temperature etc. to collect information once every 10 minutes. The processing of collected data was done in order to take appropriate action with the environmental factors. Communication was carried out through SMS with the administrator. [9] From the advent of this idea it created a lot of interesting applications in various areas. Precision Agriculture is one among them. It is a farm management concept based on measuring, and responding to various parameters of the soil and crop. The main idea was to develop a decision support system for farm

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management with the aim of reducing returns on inputs by preserving resources. Using cloud based architecture in Precision Agriculture provided communication between front-end and back-end nodes. Raspberry pi 2 was used as a node in the front-end layer which forwards data to the cloud storage and also connected to actuators for sending back data from cloud. [10] Not only in analysing the soil IoT is also applied for security of agricultural products from insects. Identification of crops with threats by wireless sensor networks was implemented. [11] Better analysis was made between M2M protocols. Analysis was mainly focused on light weight protocols MQTT and CoAP which are implemented using Thingspeak server. [12] MQTT protocol was implemented by using Eclipse server. Wire shark was used to measure packets transferred between the client and storage. Comparison between HTTP and MQTT for size of packets, latency, and power consumption was made after connecting to AWS server. [13] By using various techniques implementation of IoT cloud was analyzed. Various application which are using IoT are compared. Discussed about the services provided by IoT cloud. [14] Data repository for storing IoT data was discussed. Distributed storage along with parallel processing was helpful for handling IoT data. Integration of RFID and sensor technologies was proposed. [15] Research was carried on architecture of internet of things with using Bluetooth and 4G in the network layer. Bluetooth was used to send data from nodes to mobile station from where using 4G data sent to database and server so that action has been taken accordingly from the data acquired to control crop diseases. [16] To control the agricultural production accordingly with the environmental changes this methodology was implemented where wireless sensor technology was used. As part of implementation Android application was developed to receive alerts. [17] Soil Analyser was analysing contents of the soil by using different sensors in which the data is helping for the growth of a plant. It was using Bluetooth technology for connection of nodes. Data from microcontroller which is acting as a node are sent to the mobile application thereby sent to the server by connecting to internet. [18] Implementation of HTTP for communication was proposed. Arduino used as aggregator node for collecting data from sensors and raspberry pi was a host device for sending data to Thingspeak server. [19] An evaluation was made on transmission of data through UDP and HTTP by Wi-Fi communication and Bluetooth. Different parameters like time, power consumption, scalability, and infrastructure were calculated in three techniques of transmission. [20] Implementation of fog node by using MQTT protocol was proposed and checked the performance with traditional architecture. This architecture was tested to deliver data from clients to fog node in time as computation at fog node requires all client's data. [21] For increasing the productivity of crops an IoT framework was proposed which includes three layer architecture. Data from architecture sent to cloud and control system so that required action has been taken for greenhouse when required. [22] Agro-tech mainly focused on integration of internet of things with agriculture to save water resources. Temperature, humidity, soil moisture, etc. sensors were used in data perception and used this data to take action with the help of control logic. So the sprinklers and pumps acts accordingly. [23] Different messaging protocols was compared for quality of service, reliability, message size, header size, methods, transport protocol and security. [24] A Low Power IoT Network based on power and cost analysis of different sensor nodes was proposed. [25] Implemented MQTT protocol and discussed three different QoS of MQTT protocol. [26] Implementation of MQTT protocol was made by using ATMEGA 328 microcontroller which was connected to gateway through Ethernet collects data from different sensors and GPRS module was used for wireless connectivity. [27] Power consumption is main factor for internet of things it proposed system based on LoRaWAN. This protocol was used for transmission of data between nodes and cloud storage. Data was presented with web application.

3. OBJECTIVE

1. Implementing of MQTT client in gateway layer and MQTT server in backend layer
2. Checking the accuracy by using HTTP protocol.

4. METHODOLOGY

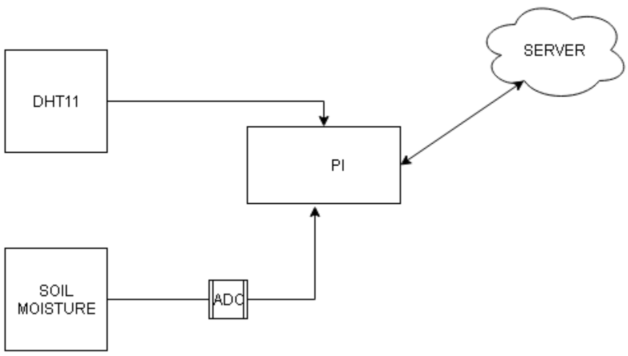

Fig1: Overview of methodology

A. Data Aquisition

Front end layer consists of two objects soil moisture sensor and temperature sensor. DHT11 is a 4 pin temperature and humidity sensor which gives 40 bit data composed of 16 bit humidity data, 16 bit temperature data and 8 bit checksum which are displayed as decimal data. Pins of sensors are connected accordingly to the Raspberry pi where second pin is signal pin and third pin is not used. Raspberry pi is a microprocessor running Raspbian operating system acting as a Gateway node. Figure 1 shows overall methodology where sensors are connected to Raspberry PI from where data are transferred to server through internet. Figure 2 shows overall setup. DHT11 sensor connected to Raspberry PI with the help of breadboard. Using Ethernet cable Raspberry PI is connected to laptop. Figure 3 shows readings from sensors taken by the PI. Soil moisture sensor gives the analog signals which the Raspberry pi can take only digital signals. For this purpose ADC is used to convert analog signals into digital signals. The method used for taking readings from DHT11 sensor tries up to fifteen times for every two seconds until it gets readings.

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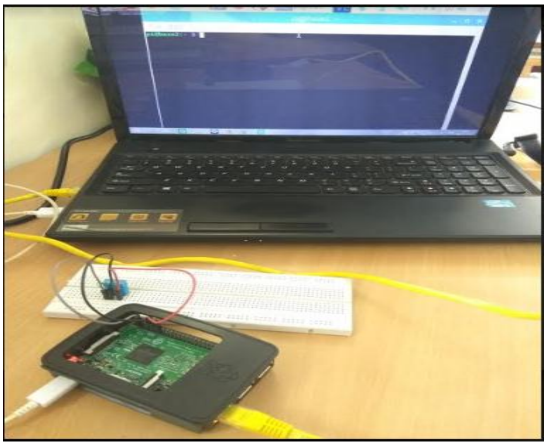

Fig2: DHT11 sensor connected to Raspberry PI

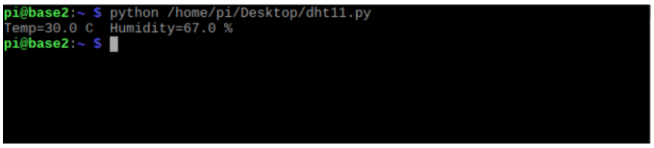

Fig3: Data from DHT11 sensor

B. Data Transmission

In the gateway layer Raspberry pi is connected to the wi-fi. From the gateway the data is transmitted to the Thingspeak storage using different application layer protocols. Thingspeak is an IoT platform which is used to collect and store sensor information. It also provides data in the three different formats namely json, xml, and csv to use in any applications. Data sent to the server can be visualized as charts and further can be analysed by using MATH works without any need of other software. HTTP is popularly used application layer protocol for data transfer. HTTP works through request-response messages. Data acquired from sensors to the gateway is send to the Thingspeak storage by using HTTP POST method in request message. Figure 4 and figure 5 shows data stored at server sent by HTTP protocol. Before sending the data, connection has to be established between client and server by using host and port. After sending data to storage the connection between client and server has to be closed. Time before sending data that is after connection establishment and time after acknowledgement has been calculated for every readings. The difference between two timestamps gives the time taken for transmission of data. Figure 6 shows communication by HTTP protocol and time for transmission. Gateway sends data to server for every 15 seconds gathered from sensors.

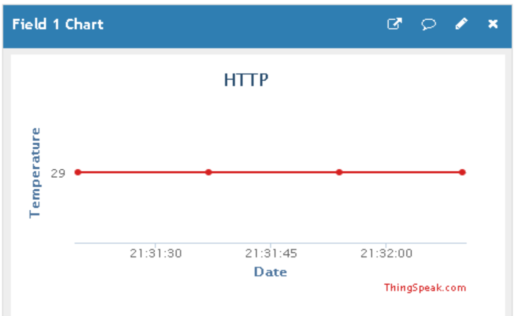

Fig4: Temperature readings stored at server transferred by using HTTP protocol. X-axis: Time, Y-axis: Temperature

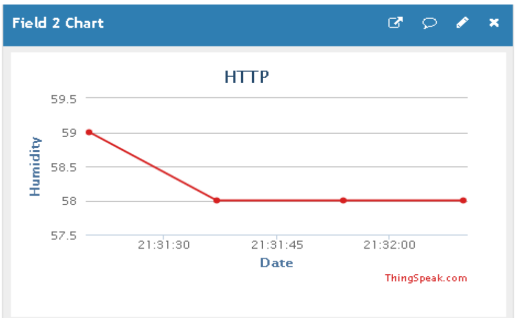

Fig5: Humidity readings stored at server transferred by using HTTP protocol. X-axis: Time, Y-axis: Humidity

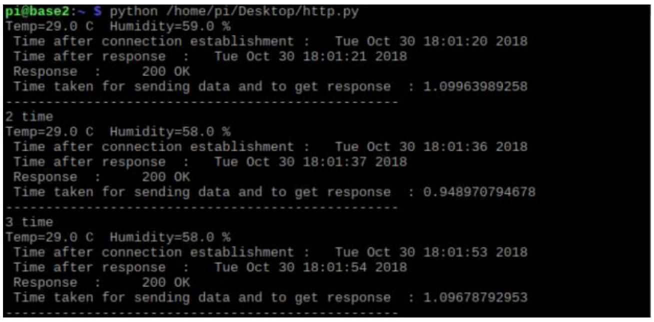

Fig6: Communication by HTTP protocol

MQTT is a machine-to-machine protocol which works as publish-subscribe message pattern. Publishers are the clients who are sending data to the broker which is a server. Broker sends data to clients who are registered for same topic called subscribers. Topic is used by the broker to maintain connection between the publisher and subscriber. MQTT works under three levels of quality of service. Once connection has been established to the server it keeps the connection open until the time expires. This time is mentioned during the time of connection establishment. This feature reduces the connection overhead compared to HTTP. MQTT uses port 1883 as default port for communication. Data is send to server by using apikey and channel id of the respected channel of the server. Figure 7 and figure 8 shows temperature and humidity data stored at server sent by MQTT protocol respectively. Timestamp after connection establishment is calculated for only first readings because it keeps the connection open and time after publishing of data to broker is calculated for every readings. The difference between two timestamps gives time taken for data transmission. Figure 9 shows communication by MQTT protocol between device (Raspberry PI) and server. Same as previous protocol Gateway is acting as a publisher sends data to the broker for every 15 seconds.

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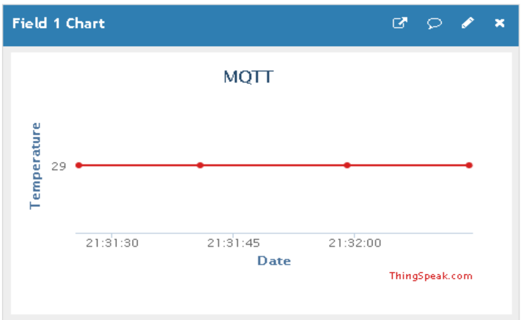

Fig7: Temperature readings stored at server transferred by using MQTT protocol. X-axis: Time, Y-axis: Temperature

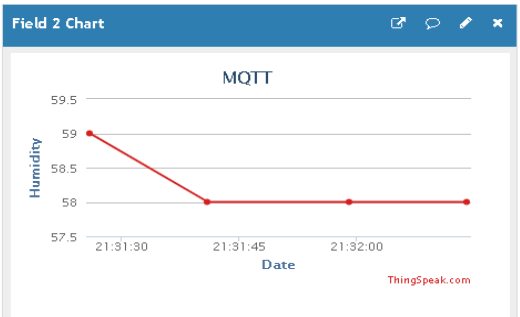

Fig8: Humidity readings stored at server transferred by using MQTT protocol. X-axis: Time, Y-axis: Humidity

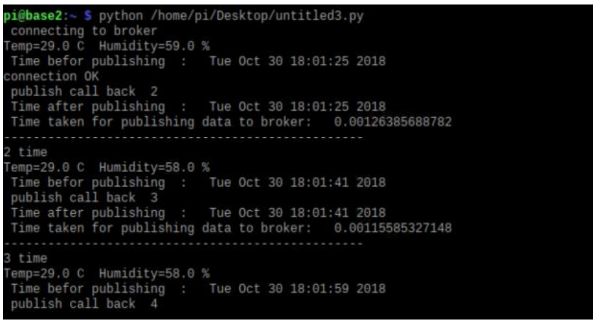

Fig9: Communication by MQTT protocol

We know that network traffic is not uniform and highly unreliable. There is no guarantee that the traffic on which the protocols tested is same. So, to ensure uniformness, both the protocols are tested at the same time to ensure maximum uniformness in network traffic. So, the time taken in transmission of packets and connection handshakes can be compared accurately. Table 1 shows time calculated for transmission of packets by HTTP and MQTT protocol. It is clearly showing the variation in time where communication by HTTP takes 1 second in first and third transmission of readings but communication by MQTT takes only a few nanoseconds in all transmission of three readings. To measure the time, time before sending data and time after acknowledgement is to be measured. The difference between two timestamps gives the time taken for communication between client and server for data sending. The power consumed in the transmission of packets is also calculated, as the power consumption is one of the major factors in application of IoT devices.

5. RESULTS

TABLE 1. Comparison of transmission time between device and server with HTTP and MQTT protocols

	HTTP	MQTT
1.	1s	1263856ns
2.	948970794ns	1155853ns
3.	1s	1147985ns

C. Cloud Storage

Data is stored in the cloud which is then forwarded after required processing. Thingspeak stores data in three different formats which can be used for any other applications. It stores data along with the timestamp which is used for analysing data. The processed data can be send back to the nodes at the gateway layer. Now to receive packets gateway layer must be in listening mode. Power consumption in receiving the packets is also calculated under both protocols. Along with this the time taken in receiving the packets from the cloud is also calculated.

6. CONCLUSION

As HTTP protocol requires connection to be established for every time it increases connection overhead which is not required for MQTT protocol. Data sent by using HTTP protocol is reliable because it is synchronous but MQTT is not reliable in all situations. MQTT is an asynchronous protocol. Time taken to send data by using MQTT protocol is fast as compared to HTTP protocol which is useful to low power IoT devices.

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