Implementing Light Weight IoT Server Using MQTT 5 Protocol

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***Abstract*: In order to form the embedded devices with the power to exchange information with one another is important for the arrival of the web of Things (IoT). Several existing communication protocols are designed for little devices including the message queuing telemetry transport (MQTT) protocol or the constrained application protocol (CoAP). However, most of the prevailing implementations are convenient for computers or smart phones but they are doing not consider the strict constraints and limitations like error reporting, scalability, extensibility, portability, and support for little clients. During this proposed system, the IoT server has designed to figure on any quality of network and where the server, which should remain fairly small and straightforward, completes the most important part of the processing. The goal is to implement MQTT 5.0 publish/subscribe protocol in a simple, fast, elegant, and customizable way in order that it is often the answer for the IoT trend needs and to beat the prevailing protocol limitations. The IoT server runs on TCP by default but is often run on any ordered, lossless, bi-directional protocol.**

***Keywords*: IoT, MQTT, Publish/subscribe**

I. Introduction

Internet of things (IoT) is a field, which deals with connecting of real world physical devices like vehicles, industries, building, cities, and things to internet for sensing of the real-world parameters and transmitting those to remote locations for analysis, estimation and future prediction. With the improved technology in software and hardware, IoT devices are becoming more powerful. And with this speed of technological advancement, the future IoT devices will be programmable, will be able to host applications and even remote management of these applications will be possible. Remote management refers to remotely access the application programming interfaces of the device to install, update, delete and manipulate the initiation and termination of the applications in the device. Considering the heterogeneous nature of IoT devices, each kind of device may have its own proprietary communication protocol. Hence, for the possibility of remote management of every IoT devices, knowledge of all corresponding communication protocol is required. This way of communication makes it difficult to interact with all the IoT devices without having knowledge of proprietary systems.

In context with sensor, nodes deployed in wide area the networks to which they connect should be of wide range and building such many European countries to check the quality of water and air.

IoT deals with three things

- Sensing and local processing of data
- Transmission of data to the remote server
- Analysis of data done at server

The need for synchronizing devices in a network is rapidly growing in last few years. Starting from PC with internet to trending wireless technologies we are trying to reach out the point that everything around us should able to communicate with us and with each other. This kind of communication needs special standardized protocol. This caused the emergence of MQTT protocol in IoT.The environment of IoT is under surveillance hence the changes in the network should be in accordance with the environment, which is a great challenge. MQTT paved the way for many IoT based companies to overcome from that challenge. Many organizations has developed MQTT3.11 protocol, which in turn become trending in professional communities. Now MQTT 5.0 protocol is developed to remove the limitations of MQTT previous versions. The protocol which will be simple, accurate, efficient and most vital part is easy to customize as what the trend needs.

2. Related Works

Jorge E. Luzuriaga et.al **[1]** presented an experimental evaluation of both protocols in such scenarios, characterizing their behaviour in terms of message loss, latency, jitter and saturation boundary values. Based on the results obtained, we provide criteria of applicability of these protocols, and we assess their performance and viability. This evaluation is of interest for the upcoming applications of MOM, especially to systems related to the Internet of Things.

Sumit Pal et.al [5] has attempted to study one such Internet protocol which makes such a communication possible, the MQTT protocol. Using an Environmental monitoring system, we will determine the viability of such a protocol for transmission of sensor data and then use the same data to control electronic devices. We also compare the MQTT protocol with the traditional HTTP protocol and attempt to find out which protocol is the better one

Hua-Mei Xin and Kun Yang [4] studied the mechanisms of some existing routing protocols such as AODV, DSR and OLSR, which is widely used in Ad Hoc networks. And then their performance in IoT circumstances is exploited to find an

appropriate routing mechanism for the future IoT. The routing overhead, average end-to-end delay and throughput were also compared to find a suitable routing protocol scheme for the IoT. The result shows that DSR mechanism performs better in terms of routing overhead. The AODV mechanism can have better performances in terms of throughput.

Dinesh Thangavel [2] has presented and implement a common middleware that supports MQTT and CoAP and provides a common programming interface. Design the middleware to be extensible to support future protocols. Using the common middleware, we conducted experiments to study the performance of MQTT and CoAP in terms of end-to-end delay and bandwidth consumption. The experimental results reveal that MQTT messages have lower delay than CoAP messages at lower packet loss rates and higher delay than CoAP messages at higher loss rates. Moreover, when the message size is small and the loss rate is equal to or less than 25%, CoAP generates lower additional traffic than MQTT to ensure message reliability.

Hyun Cheon Hwang et.al,[3] have presented and implemented a reliable message transmission system using MQTT protocol to maintain ordering between messages for the work environment. This (system) consists of MQTT protocol, reliable message transmission server and client module. The reliable message transmission server module expands a message topic to a new message topic after combining the order flag and SEQ. The order flag is the value which determines whether to maintain ordering between the message or not. SEQ is the sequence number for each message and is managed by reliable message transmission system server module and is stored into a database in the server. The reliable message transmission system client module checks message's sequence before processing the messages and requests the previous message if there are missed messages to retain the messages ordering. For simulation, we implemented the reliable message transmission system with mosquitto MQTT message broker and the simulation showed that this proposed system could enhance the message transmission for IoT environment

Biswajeeban Mishra,and Attila Kertesz [6] has described the smart devices or things are present in Internet of Things (IoT) environments. the number of interconnected devices is continuously and rapidly growing. These devices communicate with each other and with other services using various communication protocols for the transportation of sensor or event data. These protocols enable applications to collect, store, process, describe, and analyze data to solve a variety of problems. IoT also aims to provide secure, bi-directional communication between interconnected devices, such as sensors,actuators, microcontrollers or smart appliances, and corresponding cloud services.

3. Proposed Methodology

The Proposed system of, MQTT v5.0 IoT server adds a significant number of new features to MQTT. The major functional objectives are providing the Enhanced Authentication between the client and server. Improved error reporting and handling mechanisms to provide the error free transactions. Performance improvements and support for small clients. The design of the packets in such a way to discard the malformed packets. An error that is detected after the packet has been parsed and found to contain data that is not allowed by the protocol or is inconsistent with the state of the Client or Server.

DISADVANTAGES OF HTTP PROTOCOL:

The widely existing application layer protocol is HTTP (Hyper Text Transfer Protocol) which when is used in context has certain advantages but its disadvantages overruled the advantages provided by it. Therefore, following are the disadvantages.

- **Request/Response paradigm**
  This paradigm used by HTTP protocol which is operated over the large number of devices it is going to flood the network and the congestion was created.so it cannot handle the burst throughput.
- **Large overhead**
  Http protocol was designed to transfer the text, images and other different types of formats it is very much needed to specify different things about the data in the header of the message so automatically the size of the header is increased. But in IoT it mostly deals with the transmission of the sensor data only so the size of the header is minimized.

All the above-mentioned challenges in IoT can be addressed by using a lightweight application layer protocol MQTT.

3.1 MQTT MESSAGE FORMAT:

MQTT messages contain a mandatory fixed-length header (2 bytes) and an optional message-specific variable length header and message payload. Optional fields usually complicate protocol processing. However, MQTT is optimized for bandwidth constrained and unreliable networks (typically wireless networks), so optional fields are used to reduce data transmissions as much as possible. MQTT uses network byte and bit ordering.

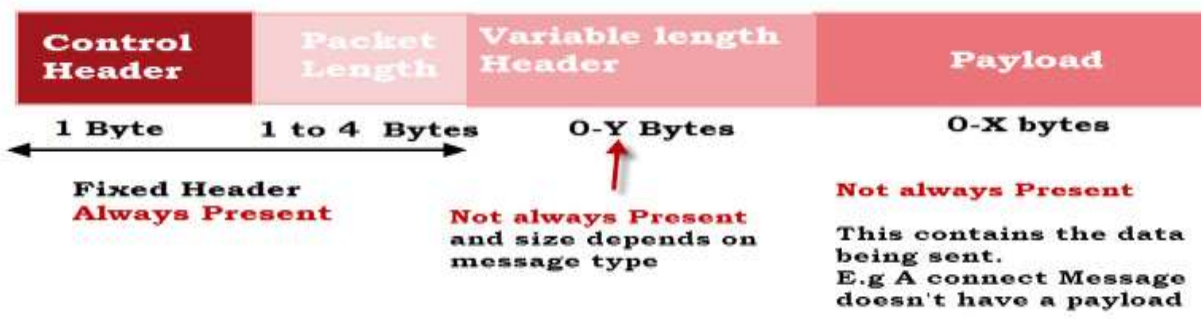
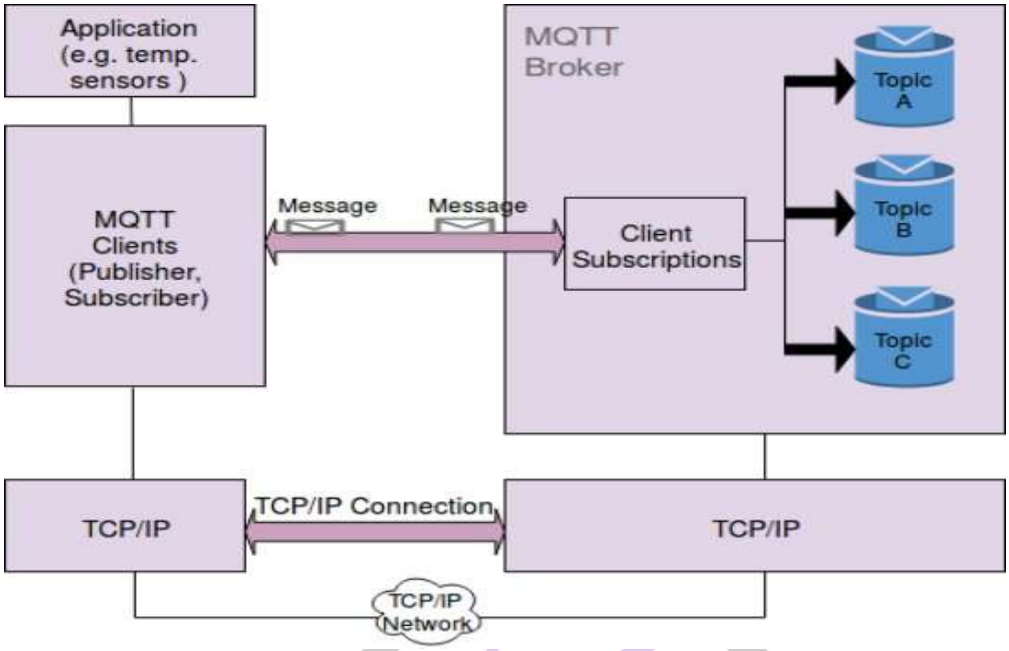


Figure 3.1 IoT Protocols Architecture

3.2 MQTT Architecture



3.2.1 PUBLISH/SUBSCRIBE

In MQTT protocol, publisher publishing messages and users subscribing to topics that are commonly considered as a Publish/Subscribe model. Subscriber subscribes to particular topics which are relate to them and by that receive every messages are published to those topics. On the other hand, clients can publish messages to topics, in such a way that allow all subscribers to access messages of those topics.

3.2.2 TOPICS AND SUBSCRIPTIONS

In MQTT, publisher publishes messages to topics that can be considered as message subject. Subscriber, thus, subscribe to topics to get specific messages. The Subscriptions of topics can be express, that restricts the data, which are collect to the particular topic. Topics contain two-wildcard level, to get data for a range of related topics.

3.2.3 MQTT BROKER AND CLIENT

MQTT is broker-based protocol. In this, end devices (i.e. clients) communicate via broker. The broker is a server, which can be installed on any machine in the cloud. The single client and broker can also communicate with each other. As MQTT runs above TCP/IP layer, it is also connection-oriented protocol. The client establishes connection with the broker (i.e. server) before the communication. MQTT is a publish-subscribe protocol. Here both client and server publish about any information (i.e. parameter such as temperature, humidity, event (ON/OFF) etc.) to each other using "PUBLISH" message. Any number of clients or end devices can subscribe for event with the broker. Due to this subscription, when there is a change in any event or parameter, broker will intimate to the subscribed clients about the change in event or parameter (i.e. temperature, humidity etc.).

3.3 WORKING PRINCIPLE

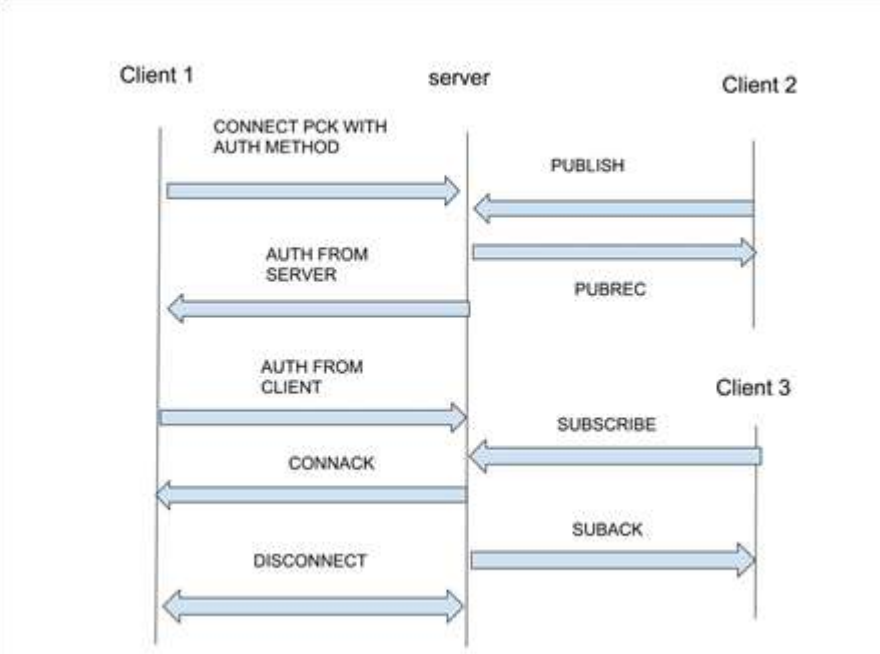


Fig 3.3 Working Principle of MQTT 5

Case1:

Broker wants to switch ON or OFF the light connected with remote client#1 Initially connection is established by client#1 with broker using CONNECT and CONNACKmessages. Next Broker communicate with Client#1 to switch ON or OFF the light interfaced with it. The messages such as PUBLISH and PUBREC are used for it. This use case is used to switch ON/OFF the street lights in zigbee or LoRaWAN network. The lights are usually connected with end nodes or end devices in these wireless networks. The single Zigbee or LoRaWAN gateway controls multiple end nodes. Multiple such gateways are needed to cover entire city.

Case2:

Client#2 or client#3 wants to update temperature/humidity status to the broker based on sensors Client#2 and Client#3 will intimate temperature or humidity update to the broker using PUBLISH message. This information is stored in the database and will be sent to all the subscribers who have subscribed for these topics (i.e. temperature, humidity). These informations is "pushed" to all the subscribed clients of the topics. client#1 has already subscribed for subscription to topics (i.e. temperature, humidity), it will get the information from broker using PUSH operation. This use case is used for obtaining different types of sensing information automatically whenever there is any updates. For this purpose, different types of sensors (such as humidity sensor, temperature sensor etc.) are interfaced with end nodes. These end nodes publish informations (of any event updates) to the broker. The broker intimates changes to all the subscribed clients.

Case 3:

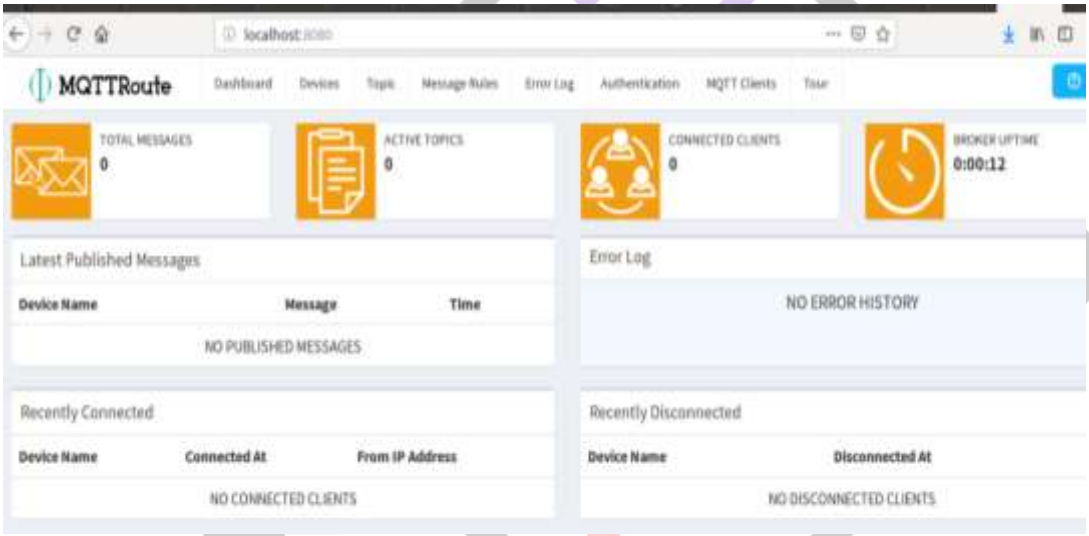
If The Initial Connect Packet Included An Authentication Method Property Then All Auth Packets, And Any Successful Connack Packet Must Include An Authentication Method Property With The Same Value As In The Connect Packet.The Implementation Of Enhanced Authentication Is Optional For Both Clients And Servers. If The Client Does Not Include An Authentication Method In The Connect, The Server Must Not Send An Auth Packet, And It Must Not Send An Authentication Method In The Connack Packet. If The Client Does Not Include An Authentication Method In The Connect, The Client Must Not Send An Auth Packet To The Server.If The Client Does Not Include An Authentication Method In The Connect Packet, The Server Should Authenticate Using Some Or All Of The Information In The Connect Packet, Tls Session, And Network connection.

4. Implementation Methodology

4.1 Run a MQTT Broker and IoT simulator

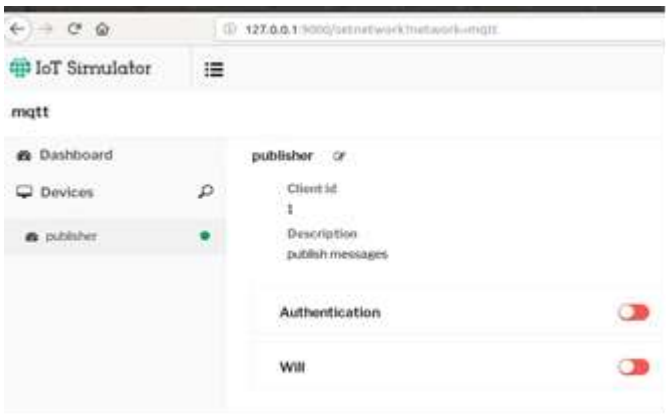
The above figure represents terminal to start the MQTT broker with help of the command **sh runbroker.sh** and to start the IoT simulator use the command **sh simulator.sh.** The Broker run under the port number 1883.The Simulator run under the port number 12345.The IoT simulator is a tool used to run the broker programs to provide the realistic imitation of MQTT.

MQTT Broker

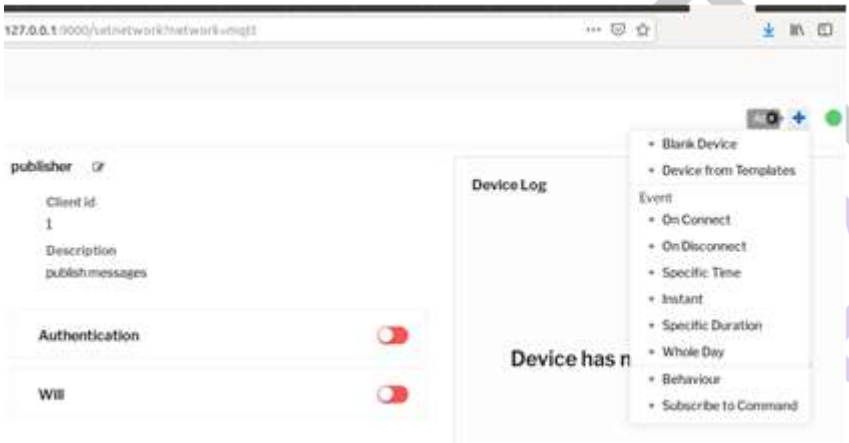


Create New Network

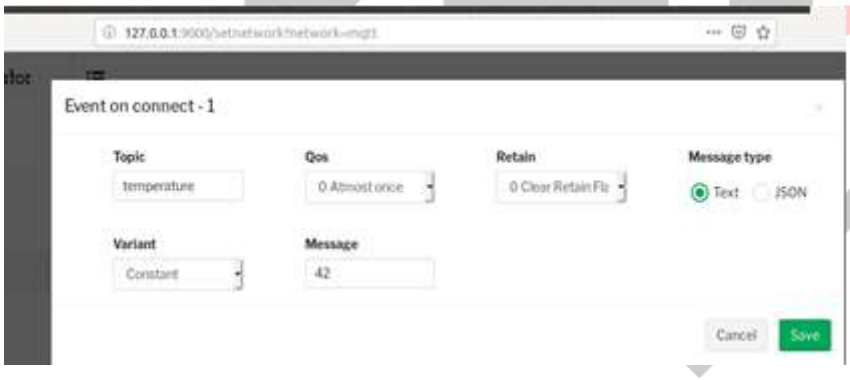
Adding Client



Connect Event



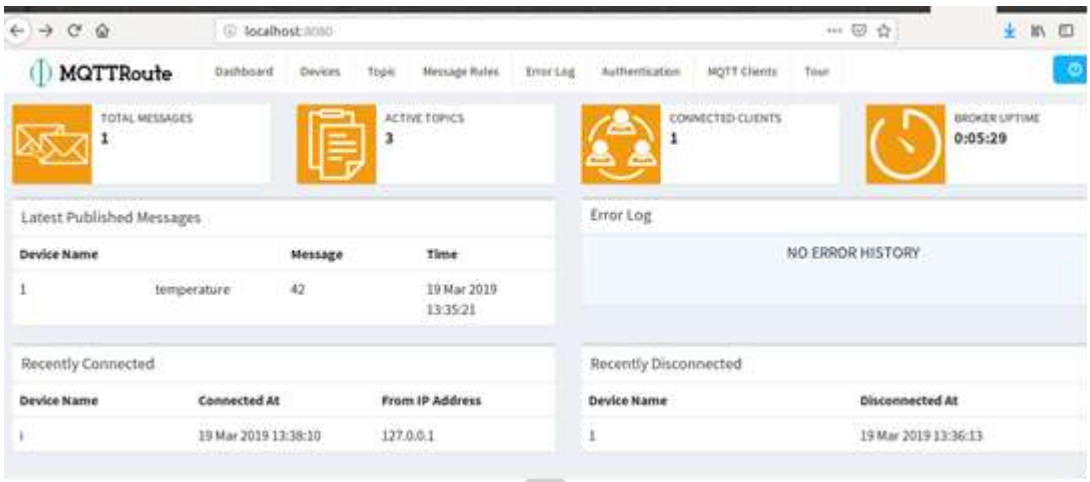
Publish a Message



QoS value	Bit 2	Bit 1	Description
0	0	0	At most once delivery
1	0	1	At least once delivery
2	1	0	Exactly once delivery
-	1	1	Reserved – must not be used

Table 4.1 - QoS definitions

Broker with Connected Client



5. Conclusion and Future work

The implementation of MQTT protocol on light weight IoT server, which means that both the clients and server implementing the protocol are low resourced work implemented this protocol on low resourced clients and servers. As here server is the main network element in the network, any failure in this leads to collapsing of total network of sensors, and it is pretty much possible for a low specs device to fail. So, this work can be extended by implementing effective fault tolerance and load balancing techniques by running more than one single board computers in parallel in the network. The ideology of MQTT can also be extended to be part of a large network of energy monitoring systems.

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