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A comprehensive study on MQTT as a low power protocol for internet of things application

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Abstract. Power consumption has always been a problem in the Internet of Things community, especially for small wireless devices. The devices need something to power them up in the long run. To achieve a sustainable and power-efficient device, there needs to be some kind of protocol which can conserve power, works well on unreliable networks, and does not compromise security. The study was done to compare the power usage of MQTT (Message Queueing Telemetry Transport) protocol with other several lightweight Internet of Things protocols, which are CoAP (Constrained Application Protocol) and HTTP (Hypertext Transfer Protocol). The comparison was done by measuring the current consumption in each protocols each time the ESP8266 board sends a message to the corresponding server of the protocol in an interval. To conclude, we studied the comparison of power usage in the ESP8266 board with the MQTT protocol and compared it with other protocols.

1. Introduction

Low power consumption in Internet of Things devices is mandatory in order to provide sustainability and green energy. There are many ways (achieve low power consumption in IoT devices such as low-power protocols, sleep mode features, etc. [1]. Some issues including security also need to be developed [2].

The object being compared in most comparative researches on MQTT (Message Queueing Telemetry Transport) with other protocols are the speed of transmission [3], packet loss rate [4], and mean response time [5]. In this paper, the compared object is power consumption. More specifically, current consumption.

The study was done to prove MQTT's capabilities as a low power protocol. In this case, the power consumption in three different session layer protocols was compared. These protocols are MQTT, HTTP (Hypertext Transfer Protocol), and CoAP (Constrained Application Protocol) as shown in Fig 1 [6].

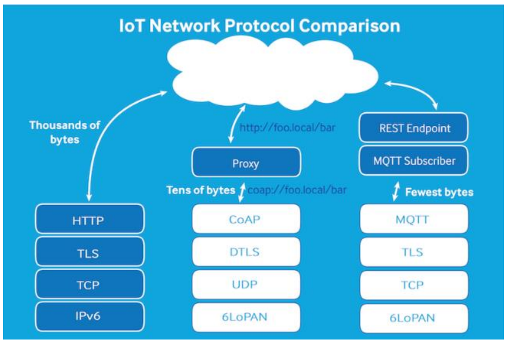

Figure 1. The Internet of Things Network Protocol layer structure (source; https://www.artik.io/blog/2015/09/iot-101-networks/)

2. Protocols

Three Internet of Things layer session protocols were compared to each other in terms of power usage. The protocols are as follows.

2.1. MQTT

Message Queuing Telemetry Transport (MQTT) is a publish/subscribe based messaging protocol, which is designed for constrained devices and low-bandwidth, high-latency, and unreliable networks. The protocol's design principles are to minimize network bandwidths and device resource requirements whilst also attempting to ensure reliability and some degree of assurance of delivery. These principles make the protocol ideal for M2M (Machine to Machine) communications on Internet of Things devices, and also for mobile applications where bandwidth and battery power are at a premium [7].

MQTT works over the TCP/IP protocol. It uses port 1883 which is assigned by the Internet Assigned Numbers Authority (IANA). For using MQTT over SSL, port 8883 is used.

Some of local brokers for MQTT are Mosquitto, Mosca, HiveMQ, etc. The public brokers are iot.eclipse.org, test.mosquitto.org, broker.hivemq.com, www.cloudmqtt.com, mqtt.dioty.co, etc.

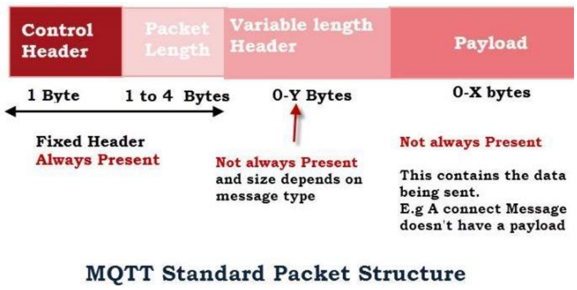

Figure 2. MQTT standard packet structure (source; http://www.steves-internet-guide.com/mqtt-protocol-messages-overview/).

2.2. RESTful HTTP

Although mainly used for web applications, some also use HTTP (Hypertext Transfer Protocol) for Internet of things applications. IoT applications which use HTTP usually take advantage of REST, which is an architectural style that defines a set of constraints and properties based on HTTP. Web Services that conform to the REST architectural style, or RESTful web services, provide interoperability between computer systems on the internet [8].

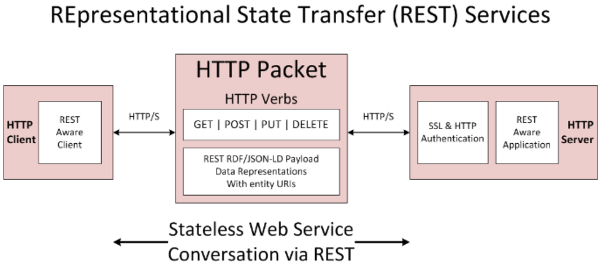

Figure 3. RESTful HTTP standard packet structure (source; http://nutrients.readthedocs.io/en/latest/02_dir/$_02-core-12-rest-prov.html)

2.3. *CoAP*
The Constrained Application Protocol (CoAP) is another session layer protocol designed by IETF Constrained RESTful Environment (Core) working group to provide lightweight RESTful (HTTP) interface. Representational State Transfer (REST) is the standard interface between HTTP client and servers. However, for lightweight applications such as IoT, REST could result in significant overhead and power consumption. CoAP is designed to enable low-power sensors to use RESTful services while meeting their power constrains [9].

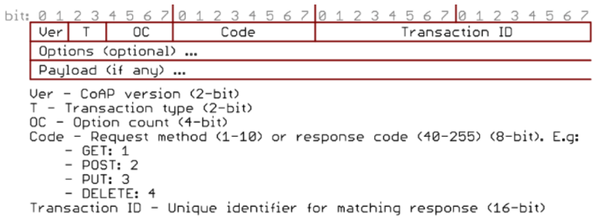

Figure 4. CoAP Standard Packet Structure (source: https://www.sparkfun.com/news/1705)

3. Limitations of measurement
The following are the limitations on the measurement of power usage.

3.1. *Topology*
The topology used is point-to-point, as it is the simplest communication topology between two devices.

3.2. *Device*
The device which is used for applying the session layer protocol is NodeMCU ESP-12E board. The board uses different libraries for each communication protocol.

3.3. *Network*
Local networks were used for transferring data in each protocol. In this case, the receiving side which is the broker/server is a HP 14-af118au laptop which uses Mosquitto, Copper, and Json-server for MQTT, CoAP, and HTTP respectively. For the transmitting side, PubSubClient, ESP-CoAP, and ESP8266HTTPClient libraries were used for MQTT, CoAP, and HTTP respectively.

3.4. *Transmitted message*
The message “Hey, I’m Paul!” is sent once at a time to the receiving side in a 5 second interval.

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3.5. Point and period of measurement
The point of measurement is in the transmitting side, which is the NodeMCU ESP-12E board. The period when the message transmitting occurs is the one which is going to be measured. 10 samples are taken in each protocol.

4. Method of measurement
The measurement uses shunt resistor technique. This technique is a substitute of current reading with ammeter which enables current measurement through voltage reading.

The following is the ohm's law:

$$V = I.\ R \quad (1)$$

where:
I = current
V = voltage
R = resistance

If a 1-ohm resistor is used as the resistance, we get the following value:

$$V = I.\ 1 \quad (2)$$

thus,

$$V = I \quad (3)$$

Therefore, the current can be measured by reading the voltage in a voltmeter parallel with the shunt resistor to substitute the Ammeter as shown on Fig 5.

The shunt resistor must be placed as close to the ground as possible in order to avoid the common-mode voltage as shown at schematic on Fig 6 [10].

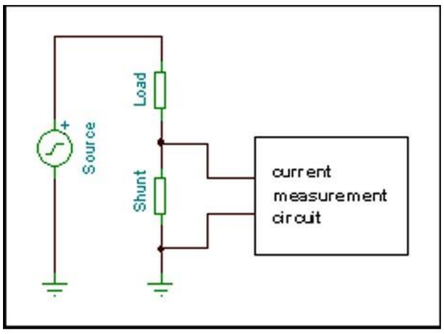

Figure 5. Shunt resistor as ammeter substitute.

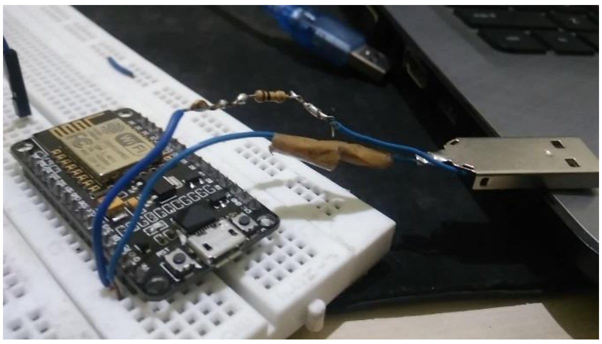

Figure 6. Shunt resistor measurement circuit with 1-ohm resistor as shunt, USB as source, and NodeMCU as load.

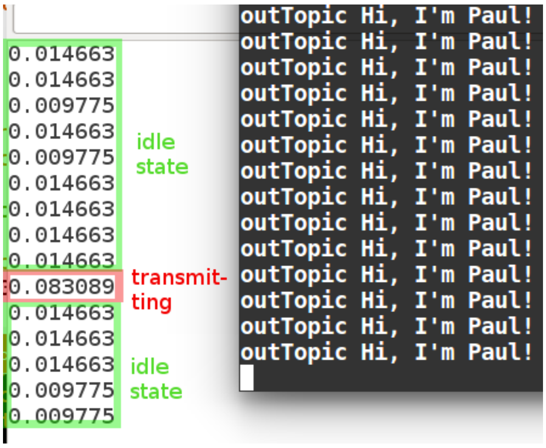

Figure 7. Current usage display.

To implement the current measurement data must be sent and enveloped by the protocol with idle and transmit mode for power analysis as in Fig.7.

5. Measurement results

Below are the results of achieved current measurements.

5.1. HTTP

Table 1. Current measurement results on RESTful HTTP.

No.	Current (mA)
1	63.539
2	63.539
3	64.5161
4	58.651
5	63.539
6	68.426
7	53.763
8	58.651
9	58.651
10	73.314
AVERAGE	62.65891

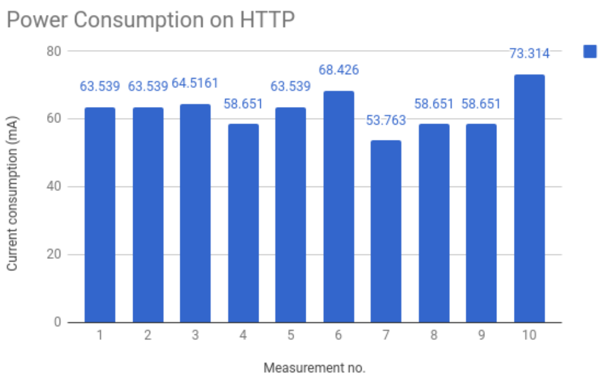

Figure 8. Current measurement results on RESTful HTTP.

5.2. CoAP

Table 2. Current measurement results on CoAP.

No.	Current (mA)
1	58.651
2	68.426
3	63.539
4	58.651
5	58.651
6	58.651
7	63.539
8	63.539
9	63.539
10	58.651
AVERAGE	61.5837

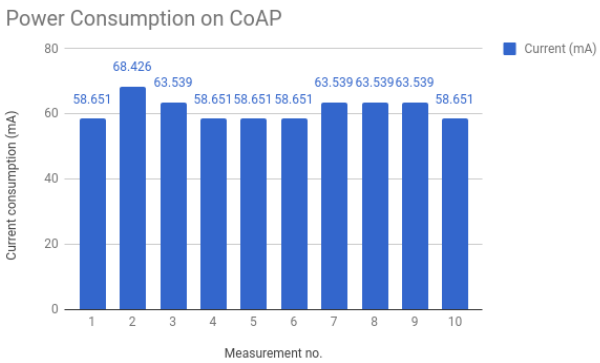

Figure 9. Current measurement results on CoAP.

5.3. MQTT

Table 3. Current measurement results on MQTT.

No.	Current (mA)
1	83.089
2	68.426
3	63.539
4	68.426
5	73.314
6	73.314
7	68.426
8	68.426
9	68.426
10	73.314
AVERAGE	70.87

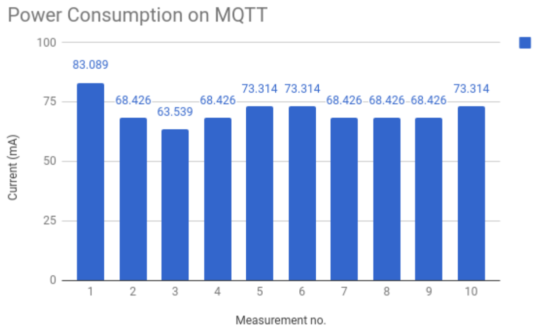

Figure 10. Current measurement results on MQTT.

6. Conclusion

The test results show that CoAP has the lowest power consumption, and in contrast, MQTT has the highest power consumption. This shows that MQTT is not the protocol which consumes the least power.

Acknowledgement

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