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# Distance Measurement of ESP8266 for Control and Monitoring in Smart Home Application

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# Distance Measurement of ESP8266 for Control and Monitoring in Smart Home Application

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**Abstract.** Along with the growth of Internet of Things (IoT) projects, the development of smart home application was also incrementally raised. The research trends tended to implement the smart home application for monitoring the house hold devices through automation and also for metering the power usage independently. Therefore, the proposed research which was developed in this paper focused for building a smart home application which could control and monitor based on the power usage of the electronic household devices that serially connected to the sensor node. This paper also proposed a combination of MQTT as the messaging protocol for conserving the bandwidth usage. In term of the project's analysis, the main aspect was directed to investigate the feasibility of ESP8266 as the transmission module in our application. The developed system could successfully monitor the power usage (in Watt and Ampere) and perform the specified action from the client node. The research result also concluded that the ESP8266 was feasible for this kind of project.

## 1. Introduction

IoT has became one of the most discussed topic among researcher. The definition itself separates IoT into the two meanings which can be classified as the device that connects to the cloud or internet as the extension of it and the derivative device on local network that performs either transmission or receiving data [1]. In fundamental term, the IoT can be defined as any objects that directly connected to the internet identified by using Internet Protocol (IP) address. One of the IoT sector that prominently gains concern is smart home. The implementation of automatic system based on the connected object available on the recent house technology may bring this topic to next level. One of the beneficial purpose of deploying the smart home application is the utilization process for metering the power usage of the household electronic devices for preventing the unessential utilization of power [2]. Therefore the amount of household expense can be minimized.

This paper proposed to build an IoT based smart home application for monitoring the watt and current usage of household electronic devices as well as performing control mechanism by either replace or insert the electricity using the MQTT messaging protocol. In term of the research gap analysis, this research was directed to perform in-depth analysis regarding to the feasibility of using ESP8266 as the transmission module for supporting the smart home application.

## 2. Related Works

Previously there were several related papers that concerned their topic to investigate some areas in smart home project. Several papers focused their research for generating various type of smart home application, such as smart metering application [2], household monitoring application [3],[4],[9], automation of household devices [5], simulation of smart home application [6]. Some of the mentioned paper had already used the ESP8266 for their transmission module installed on each of the sensor node [2],[3],[4],[5],[8],[11].

In addition, There were also several papers that has investigated the implementation of MQTT protocol in IoT application [4],[7],[9],[10]. All of them analyzed the impact of deploying the MQTT regarding to its functionality upon developed in IoT project and the differentiation of packet sending and power consumption rate compared to the other messaging protocol in IoT (HTTP and CoAP). The most related paper [4], developed a monitoring application for household devices as well as could perform action related to the user defined action deployed using MQTT infrastructure. This paper did not perform a smart metering project which was related to the power management system of household application. Therefore, the proposed research was directed for extending both smart metering project [2] and the household monitoring system [4] to be able to monitor the energy consumption of each the available electronic household devices as well as perform the related action (disconnect/connect the electricity if the usage trend above/below the standard utilization). The proposed system also implemented the MQTT messaging protocol for conserving the bandwidth usage on each of the link on the IoT system.

In term of the feasibility experiment for testing the ESP8266 as the standard module for smart home application was not being performed on the mentioned paper above. Therefore, the main topic for the proposed research was deployed for calculating the distance of ESP8266 for control and monitoring in smart home application.

## 3. Proposed System

The configuration of the proposed system is described on the Figure 1. There exist 4 sensor module and 1 AC relay. The available sensors include the 5A Non Invasive Current sensor and Current Transformer sensor with a maximum current of 5 amperes, and the temperature and humidity sensor (DHT11). This current sensors produce an analog AC voltage generated from the current reading process. There were also an AC relay for either suspend or restore the electricity flow through the household electronic devices which reside on 220 Volts and 10 Ampere in maximum values.

The implementation topology deployed by using the MQTT messaging protocol. The main reason why the research deployed the MQTT because it provided publisher/subscriber mechanism which could significantly reduce the bandwidth utilization during the data transmission process for both link between publisher-broker or subscriber-broker. There were 3 nodes available including the sensor node performed as publisher/subscriber, the broker node, and the client node functioned as the publisher/subscriber. The diagram of the MQTT is described in Figure 2. The broker node was deployed using Raspberry pi 3+ and cloud MQTT server. The MQTT software installed in broker node was Mosquitto (for local network). Both sensor node and the client node behaved as publisher/subscriber. The sensor node published the data regarding to the sensor reading and subscribed the command from the client node to perform action (release/restore the electricity on relay module), while the client node subscribed the sensor's data and published the command action based on the available data metric from sensor node. Another notable advantage upon implementing the MQTT was the sensor node and the client node did not have to online at the same time since the broker node could have a capability to store the incoming sensor's data into its local database.

As far as the distance measurement of the proposed system was concerned there were two

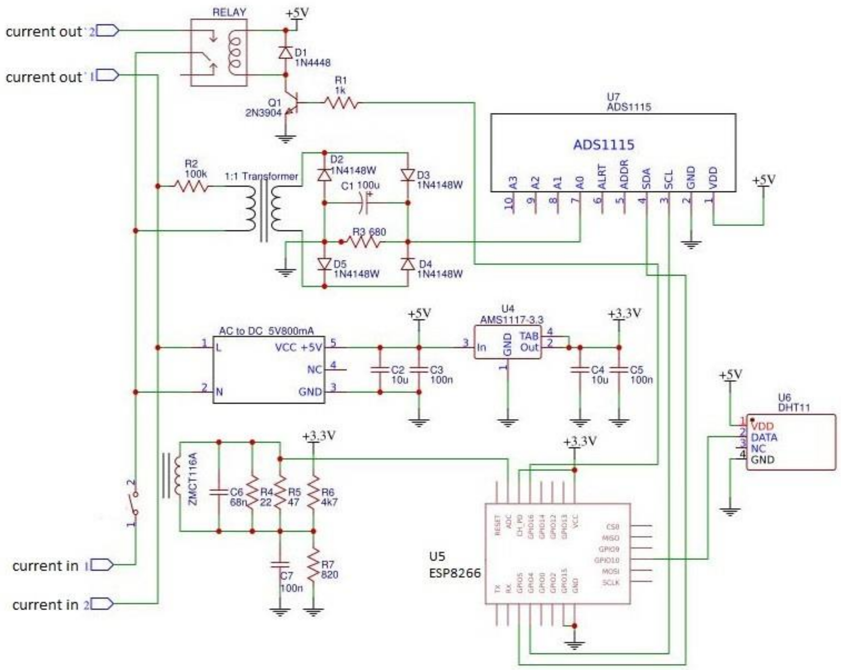


**Figure 1.** Block diagram of the sensor node

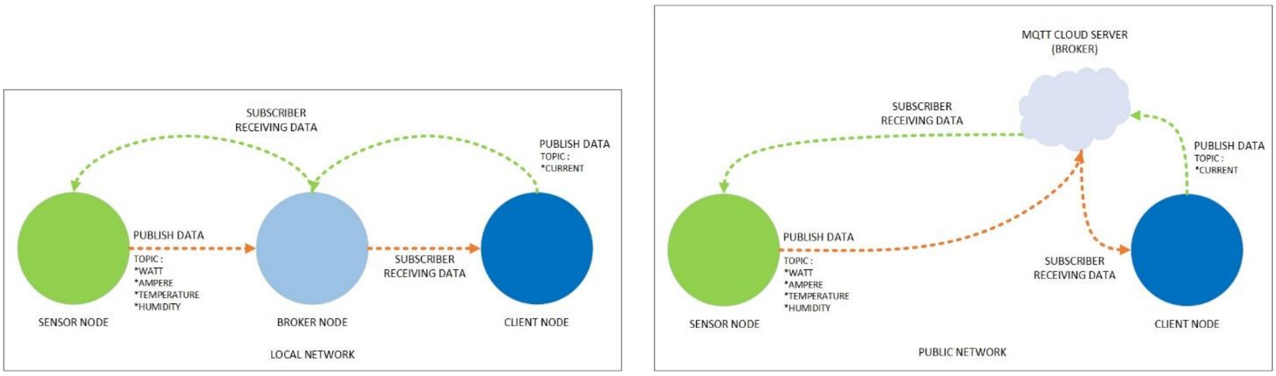


**Figure 2.** Topology of the smart home application

main experiment's scenario for evaluating the feasibility of ESP8266 including the No Line Of Sight (NLOS) and Line Of Sight (LOS). The map of the NLOS scheme and the possible location of physical interference are illustrated in Figure 3. There would be three different distance measurement in indoor side which varies in horizontal line. Each of the planned scenario in NLOS incremented the measurement distance within 2 metre interval which ultimately stopped on different final position scenario 1 after reaching 12 metre, scenario 2 after reaching 4 metre, and the scenario 3 after reaching 14 metre. The experiment only extracted the data from the link between sensor node and the broker node, since the link between the broker node and the client node was connected through the internet. In term, of the LOS scenario, the implementation of experiment was conducted by calculating the impact of increasing the distance measurement between sensor node and the broker node. The initial distance is 0 metre and the ultimate distance calculated after the packet loss hit 100%. The analysis was conducted by evaluating the Received Signal Strength Indicator (RSSI) in dBm and the packet loss percentage. In addition, this paper also investigated the comparison of power usage generated by the sensor node when implemented the MQTT and without implemented the MQTT.

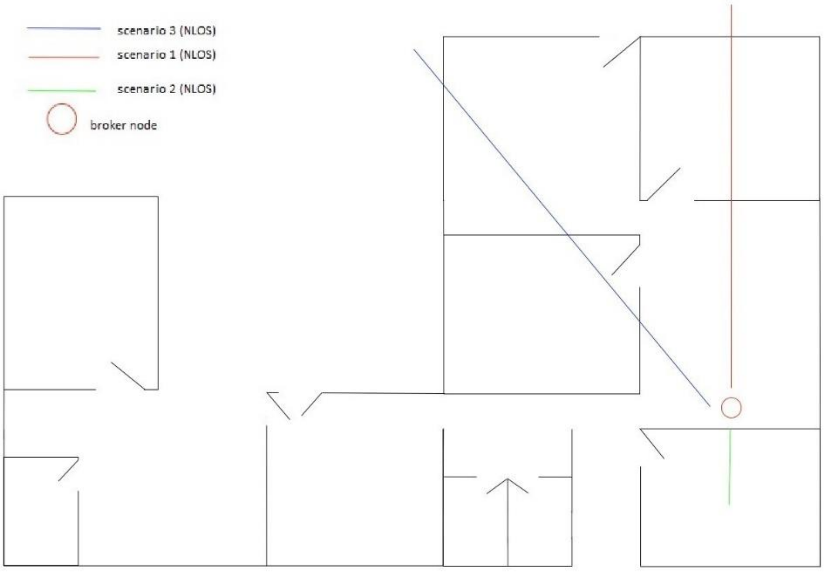


**Figure 3.** NLOS experiment scheme

## 4. Result and Analysis

In term of the research result and analysis, all of the proposed implementation scenario had been performed based on the given scenario. There were three implementation schemes including the the LOS approach, the NLOS approach, and the power consumption of sensor node in 10 hours period. Both in either LOS or NLOS, the experiment's variable that was used for analyzing the distance measurement of ESP8266 were packet loss ratio in percentage and the RSSI length in dBm. As can be seen form the Figure 4, 5, and 6, the measurement of packet loss variable through out the whole NLOS scenario still could produce healthy network environment by pointing almost 0 % in average even though there was an interval extension of the measurement distance. However on the first scenario, when the sensor node was shifted to 6 metre, there was a slight increase on the packet loss percentage, which could be caused by the similar signal interference during the experiment affecting some of the unreceived packet. Those trends in NLOS scenario indicated that ESP8266 could possibly become the alternative for either behave as the transceiver or receiver module. The implementation of MQTT transmission protocol during the experiment also did not causing the packet loss percentage to grow significantly which also demonstrated that MQTT was suitable for being deployed in IoT smart-home project. As far as the RSSI value is concerned, the Figure 7, 8, and 9, illustrates the received signal in dBm for the NLOS scenario. The graph shows that the RSSI value is increased along with the growth of the measurement distance. Under normal circumstances or the closest distance (0 metre) possible the normal value of RSSI was pointed at 48 dBm in average for all of the NLOS scenarios. There were no particular standard regarding to the RSSI value, therefore the authors could only assume that the vast decremented value of RSSI indicating that the signal strength was poor and it was not suitable for performing data transfer. Based on the experiment mapping stated on the section 3, the growth of distance which added by the physical interference (such as walls or house's furniture) has became the main aspect that brought the RSSI value to

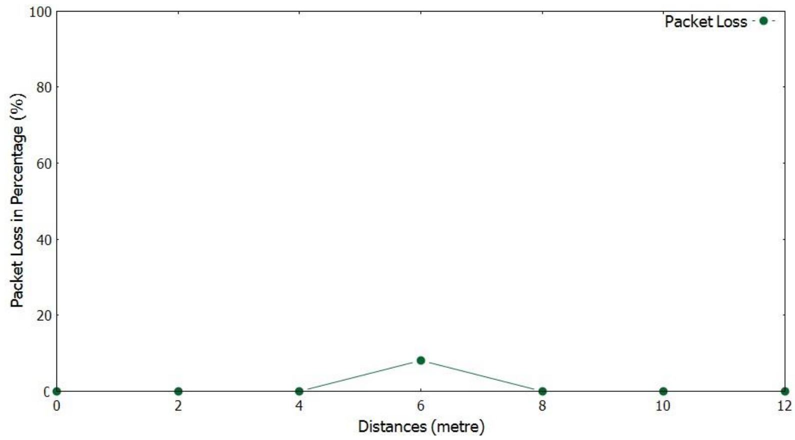


**Figure 4.** Packet loss ratio extracted from scenario 1

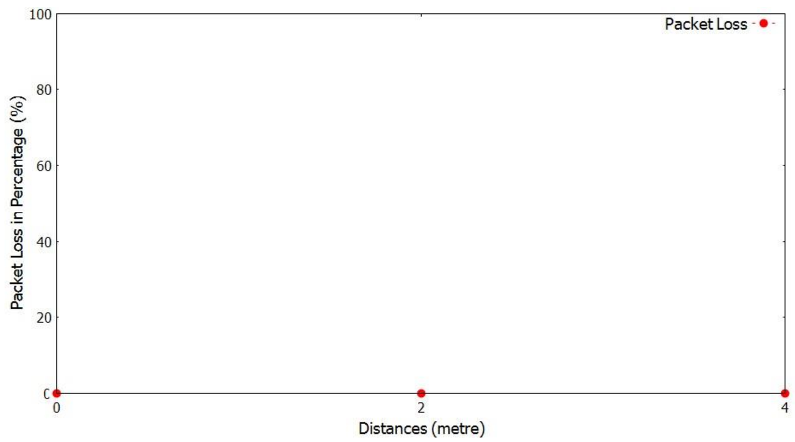


**Figure 5.** Packet loss ratio extracted from scenario 2

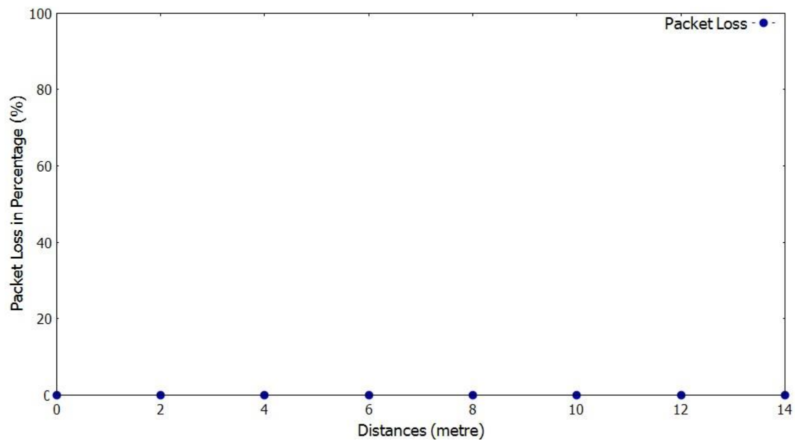


**Figure 6.** Packet loss ratio extracted from scenario 3

drop. Despite of the values of RSSI upon reaching 14 metre on NLOS's scenario 3, the packet loss variable still pointed in 0%, since the transmitted data was consisted of low bytes raw data generated by the publisher node. In term of the LOS scenario upon reaching more than 30 metre

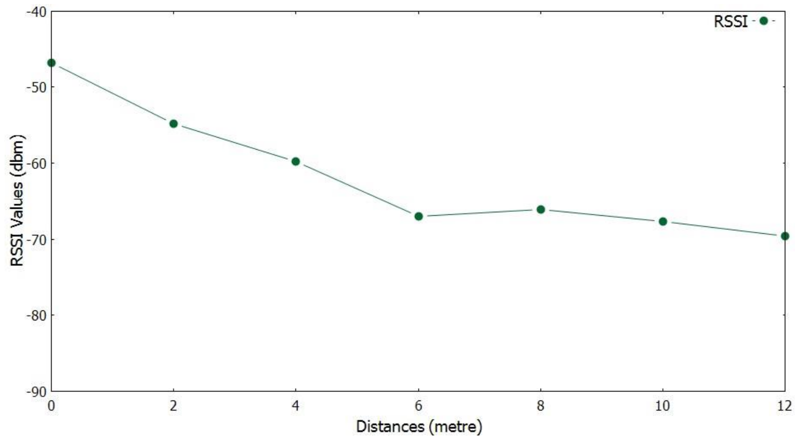


**Figure 7.** RSSI value extracted from scenario 1

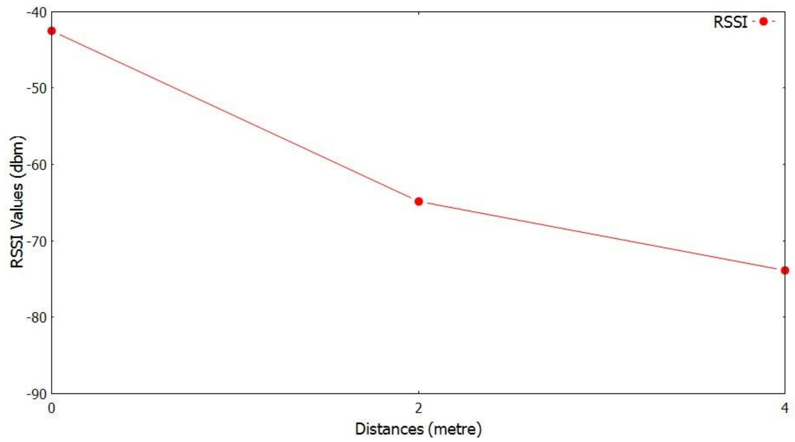


**Figure 8.** RSSI value extracted from scenario 2

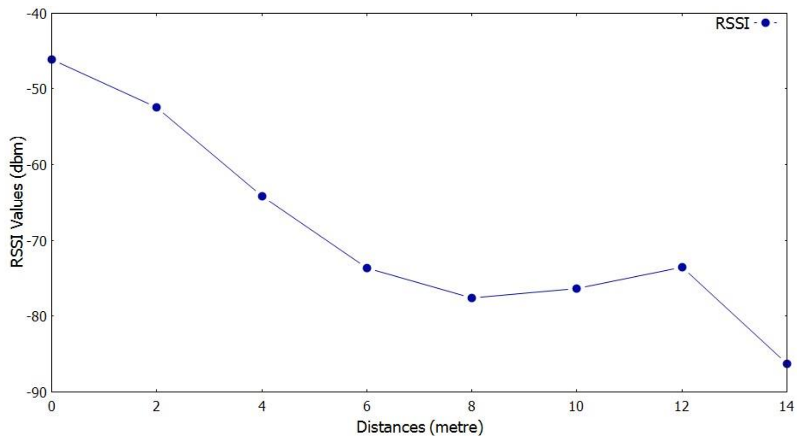


**Figure 9.** RSSI value extracted from scenario 3

distance, the value of packet loss percentage was increased. However, the packet loss percentage during 50 metre distance was monitored at 0%. This circumstance could be occurred due to the environmental aspects such as the wind that existed during the experiment illustrated in Figure

. The RSSI ratio also significantly rise along with growth of the distance. Since there were no physical interference, the RSSI value reached -95 at 75 metre. The distance measurement in LOS scenario were dependence several factors including the extension of distance measurement and natural phenomenon such as wind that could interfered the air which became the transmission media for ESP8266. The experiment's measured the transmission distance for ESP866 ranged within 190 metre. As far as the power consumption of sensor node is concerned, the Figure 12

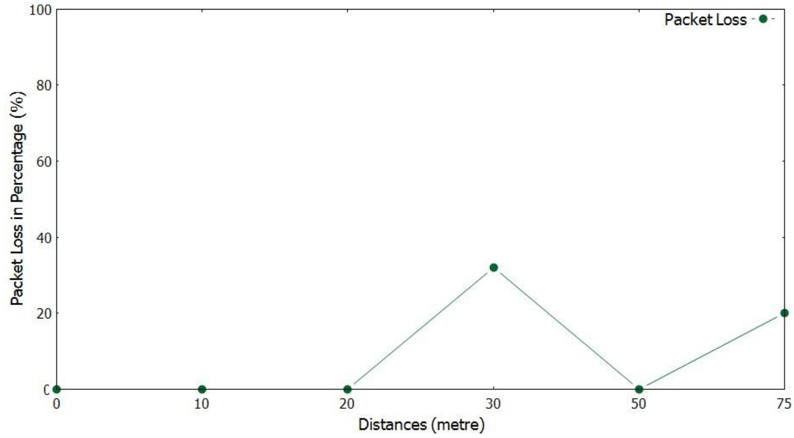


**Figure 10.** Packet loss value during LOS scenario

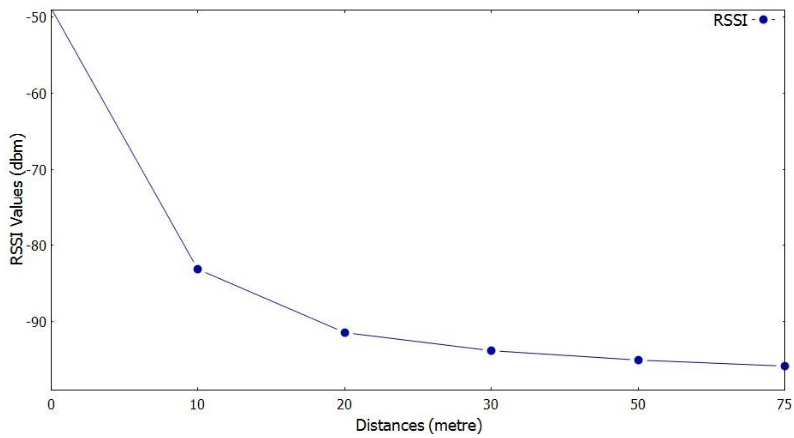


**Figure 11.** RSSI value extracted during LOS scenario

illustrated the power usage of sensor node while implements the MQTT and without implements it. The notable value for both schemes indicated that the implementation of MQTT did not consume more power even though there were a specific mechanism for encapsulating topic for each of the transmitted data.

## 5. Conclusion

In conclusion, ESP866 could become an alternative for being deployed as transmission module. However the developer should maintain the size of the transmitted data, therefore, the packet loss percentage can be minimized. The distance coverage based on the experiment reached up to 14 metre on indoor cases. The deployment of MQTT also did not interfere the transmission

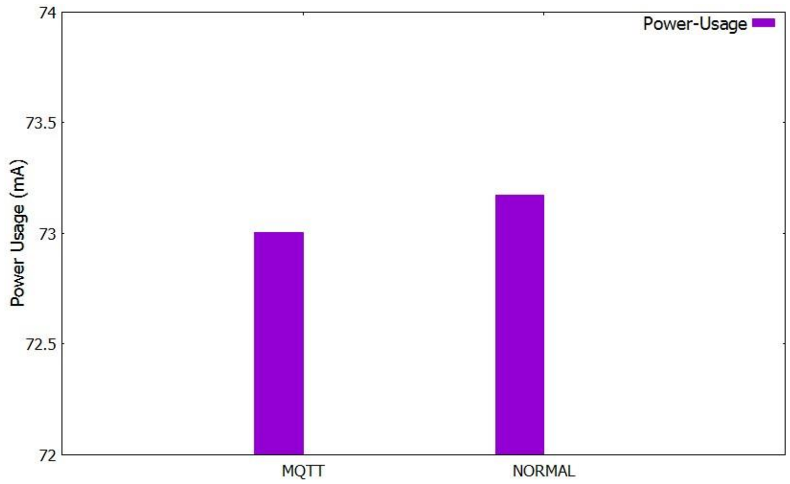


**Figure 12.** Power usage of sensor node within 10 hours period

process. The MQTT benefits the usage of the bandwidth during the data transmission since the subscriber only subscribes their concerned topic.

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