Implementation of mobile sensor communication system on multicell networks

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Abstract. A monitoring technology for large area with low-cost and high efficiency is highly demanded. Wireless Sensor Network (WSN) is the solution for a monitoring technology. However, not all monitoring must be continuous, there are some monitoring that can be carried out periodically. Therefore, it is possible to invent a mobile sensor communication system on multicell networks. This research aims to implement a WSN system by collecting data from mobile sensors on multicell networks. The focus of research is on the design of mobile sensor communication with low-cost device as transceivers, namely NodeMCU. The design is implemented using 4 NodeMCU units, 3 of them are functioned as access points, while 1 unit is employed as a client connected to the sensor. The experimentation was conducted by varying transmission distances of sensors with and without barriers. Moreover, handover and blankspot areas are also included accordingly. The result of experimentation shows that the usage of low-cost devices has still a possibility to build monitoring mechanism on multicell networks even though the transmission power was significantly influenced by the availability of barriers.

1. Introduction

Recently, wireless technology and its application, particularly for communication system have been growing up rapidly. Some kind implementation of wireless technology can be found in Wireless Sensor Network (WSN) which commonly consists of a collection of sensor nodes scattered in a certain area [1,2]. Basically, WSN is similar to wireless ad-hoc networks which depend on wireless connectivity of networks so that data or information can be wirelessly transmitted. In WSN, the data or information monitored from the sensor nodes is then sent to the base-station to be further processed. The WSN technology has been developed and widely applied in various fields including agriculture [3,4], slope monitoring [5,6], environment and housing [7,8], and health [9,10].

In fact, not all monitored information is required to be continuous, but it can be obtained only periodically. In some cases, the aspect like the temperature of the environment, condition of objects, and others are not necessary to be monitored continuously. Moreover, since the monitoring area should be extensively inspected, hence the mobile sensor can be one of the technological solutions to be applied. This technological solution will provide efficiency especially in the use of sensor number. Research
related to the use of mobile sensor has been intensively investigated [4-12], although the investigation was focused more on protocol engineering and its utilization on mobile WSN. It is noticeable that the established mobile WSN system could help in the transferring process of monitoring data using a mobile node equipped with data error checking functions [3].

Furthermore, WSN did not only provide location mapping information but it also could proceed mobile and silent data [13]. Here, the medical information system in a hospital is discussed for both mobile and silent data. The system also monitors the condition of medical devices or patients who move from one place to another. One of the challenges to implementing the mobile sensor system is by maintaining the coverage of Wi-Fi signals utilizing low-cost devices. Due to the monitoring area is relatively wide, it is necessary to have some transceivers at several observation points to get the data or information. Thus, in order to have an impact on cost efficiency for implementing mobile sensor communication on multicell networks, in this paper, the transceiver devices with relatively cheap are required to be used as sensor nodes. For this reason, it is necessary to collect the information of the feasibility of low-cost transceiver devices. One of them is NodeMCU which is an open source internet of things (IoT) platform.

2. Brief overview of system
The design of the mobile sensor communication system on multicell networks to implement a WSN system is mainly configured by the use of low-cost devices of NodeMCU functioned as transceivers. Other devices are also involved in the configuration including DHT11 humidity and temperature sensor and PCs provided with Arduino and GUI-based applications. It should be noted that each device is equipped with a power supply in order to work properly. Figure 1 shows the block diagram of the system developed for implementing a WSN system. It shows the proposed system is designed by using 3 NodeMCU units as access points of the transceiver, and 1 NodeMCU unit is used as a client connected to the sensor and served as a mobile node.

![Figure 1. Block diagram of the developed system.](image)

The proposed system is experimented based on the scenario of mobile sensor route illustrated in Figure 2. Three access points as transceivers are positioned in such a way to represent the blank spot and handover areas. In order the configuration is isolated from other hotspots, the connection mechanism has been set with a static IP address. When the mobile sensor moves and comes into one cell, it will be directly connected to the static IP address that was previously set up.

The experimentation scenario applies 2 routes which take across the handover area and the blank spot area for Route I and Route II, respectively. On Route I, the mobile sensor firstly moves through the handover area. If the mobile sensor comes into the area of cell 2, it will get an IP address with a signal from Access Point 2. Handover process occurs when the mobile sensor moves from the area of cell 2
into the area of cell 3 while it gets a new IP address from Access Point 3. Here, the handover mechanism is simple where the mobile sensor will be stay connected to the first cell until it is disconnected to obtain a signal from the first cell. If the mobile sensor has not received yet a signal from the previous cell, then it will be switched to the next cell which provides a signal. Meanwhile, on Route II, the mobile sensor takes across the path and passes through the blank spot area between two cells.

![Figure 2. Experimentation scenario of mobile sensor route on multicell networks.](image)

3. Experimentation and results discussion

3.1. Transmission distance

The experimentation of mobile sensor communication system on multicell networks is conducted in the floor plan with and without barriers as visualized in Figure 3. At first, the experimentation is performed for varied transmission distance between the mobile sensor and the access point in which this is to determine the range of signal received by the mobile sensor from some access point. This experimentation is carried out in the area with and without barriers as overviewed in Figures 4 and 5, respectively.

![Figure 3. Floor plan of system experimentation.](image)
In the experimentation, the mobile sensor moves toward the access point and it is then connected automatically. The results of transmission distance experimentation with and without barrier are summarized in Table 1. It shows that the further the mobile sensor from the access point, the smaller signal strength becomes. In the unhindered area, the mobile sensor can be detected up to a distance of 60 meters. Whilst in the area with barriers, the mobile sensor can be detected up to a distance of 45 meters.

| Without Barriers | With Barriers |
|------------------|---------------|
| **Distance (m)** | **Distance (m)** | **RSSI (dBm)** | **RSSI (dBm)** |
| 15               | 15            | -14           | -14           |
| 30               | 30            | -60           | -41           |
| 45               | 45            | -86           | -56           |
| 60               | 60            | -93           | lost          |
| 68               | 65            | Lost          | lost          |

**3.2. Communication between access point and client**

Next attempt is the experimentation of communication between the access point and the client. This attempt aims to specify the incoming data from DHT11 humidity and temperature sensor when the mobile sensor moves from a certain place to other places. The experimentation results of communication between the access point and the client in the area with and without barriers are tabulated in tables 2 and 3, respectively.

| Access point to client | Data from DHT11 sensor |
|------------------------|------------------------|
| **Distance (m)** | **RSSI (dBm)** | **Connection status** | **Temp. (°C)** | **Temp. (°F)** | **Humidity (%)** |
| 15                    | -27               | connected             | 26             | 78.8           | 90             |
| 30                    | -43               | connected             | 26             | 78.8           | 90             |
| 45                    | -56               | connected             | 27             | 80.6           | 89             |
| 60                    | lost              | disconnected          | –              | –              | –              |
| 68                    | lost              | disconnected          | –              | –              | –              |
Table 3. Communication between access point and client in area without barriers.

| Access point to client | Data from DHT11 sensor |
|------------------------|------------------------|
| Distance (m) | RSSI (dBm) | Connection status | Temp. (°C) | Temp. (°F) | Humidity (%) |
| 15          | -40        | connected         | 27         | 80.5       | 83          |
| 30          | -69        | connected         | 38         | 100.4      | 51          |
| 45          | -88        | connected         | 32         | 89.6       | 66          |
| 60          | -93        | connected         | 31         | 87.8       | 67          |
| 68          | lost       | disconnected      | –          | –          | –           |

The results in table 2 show that the maximum distance between the mobile sensor and the access point to be still connectable in the area with barriers is as far as 45 meters with a signal strength of -56 dBm. When the distance has raised up to be 55 and 60 meters, the mobile sensor could not acquire an IP address yielding the communication with the access point to be lost so that no data is transmitted to the access point. The recorded temperature data only indicates that the process of sending data from the DHT11 humidity and temperature sensor was run well.

Furthermore, based on the results in Table 3, data from the sensor transmitted by the access point is well received by the client. The sensor connected to the client has sent the recorded data to the computer for being displayed using the Arduino command. It is found that the access point is still connectable with the client in the area without barriers when the distance is less than 60 meters and to be disconnected when the distance is around 68 meters. There are some different data of temperature and humidity shown in Table 2 and Table 3 due to the difference in measurement time.

4. Conclusion

The implementation of mobile sensor communication system on multicell networks has been demonstrated. The proposed system which was designed by using NodeMCU units has been realized and experimented in the area with and without barriers. The experimentation results have shown that the mobile sensor system with a reasonable range could still run well by using low-cost devices. The important thing to consider in the design process is the placement of access point which functions as a transceiver. The location of the access point in the blocked area will affect the performance of the system.

Acknowledgment

The authors would like to thank Dr. Wahyudin Darmalaksana, the Head of Research and Publishing Center, the State Islamic University (UIN) Sunan Gunung Djati, Bandung, Indonesia, for financially supporting the publication of the paper.

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