Moving Cell Array Prediction for LORAWAN-Handover Based On Received Signal Strength Indicator (RSSI) Algorithm

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Abstract. This paper discusses the prediction of movement from the vehicles with Long Range Wide Area Network (LoRaWAN) handover communication, based on Received Signal Strength Indicator (RSSI) algorithm. The experiment consists of observation on three different environment area which is rural, sub-urban and urban at road in Kedah and Perlis state in Malaysia. This three-environment area measured based on the past studies. Handover session with a moving vehicle, predicted the movement based on direction of Global Positioning System (GPS) latitude and longitude. The communication session transferring from previous cell area network that pass by the vehicle to a new targeting cell area network with the base station connection. From this experiment and study, it is shown that the predictable or movement from one cell to another cell based on RSSI algorithm with base station connectivity can be achieved.

1. Introduction

Nowadays, Intelligent Transportation System (ITS), rapidly grows and shared any kind of information, communication and technologies that applied to the transport infrastructure in automotive areas. ITS been using widely for real-time information and data observation to improve safety and security to the transportation based on mobile device sensor using the internet of things (IoT) concept and development. A significant research has developing many technologies devices, that can predict or calculate any information based on specific algorithm or method. Long-range-wide-area-network or LoRaWAN is one of the technology devices (non-cellular) using a star network topology to communicate between each node directly with another gateway for wide range of signal [1]. LoRaWAN improves capability of high communication link with low cost and power consumption by using the modulation technique. Chirp spread modulation is the technique used by LoRaWAN to encoded the data.

Besides that, the distance range of communication can be up to (10 kilometer) [2] which can be developed into handover network system for LoRaWAN to predicted the data more accurate and precisely. But the main question is, how the predictable process can be sure whether there is a way of enabling this whole new set of devices with precise location path information by utilizing the fact that these devices are continuously connected to the network. The purposes of this study is to developed handover system LoraWAN using RSSI based algorithm to predicts which base station to transfer communication from previous base station to new base station. The system is achieved by utilizing the
mobile speed and direction information from Global Positioning System (GPS) of the latitude and longitude points. Figure 1, show the hexagonal cell area where inside located the base station (BS) of the communication. This base station used for the predictable movement of vehicles from one cell to another cell for the continuous communication of the LoRaWAN.

![Hexagonal cell diagram](image)

**Figure 1. Hexagonal cell system**

2. Existing Studies
The study by Radhwan Mohamed Abdullah et al [3] show the improvised vertical handover decision algorithm by integrating multi-criteria within a wireless network. The concept and idea are to propose an enhanced algorithm for vertical handover decision based on multiple criteria, thus enabling the devices make decision for the correct and accurate handover decision. The outcomes from the simulation performed exhibited that the proposed algorithm enhanced the probabilities of handovers, when compared to the conventional algorithm for network decision. Next, study by Wixted et al [4], discusses the performance and reliability of LoRa wireless and LoRaWAN in a typical environment. This was planned as a practical exercise to develop the familiarity of both system at Glasgow.

Besides that, study by Sarra Naoui et al [5] propose solution to enhance the LoRaWAN security protocols, where the established node at the end and the network server is chosen by trustworthy nodes as proxies that can avoid the attack from malicious nodes. This showed that the use of LoRaWAN are in secured connection whether from to server or to the connection to the base station. The others study is using radio raging technique such as RSSI is very popular due to lower cost and its simplicity compared to other method of radio raging technique, although there are many models viable to analyzes the path loss model, not many of them could use in certain unique environments [6].

3. Experiment Setup and Environment Area
The communication node hardware in this study was developed with two devices of Arduino Uno, two modules of LoRa, where one is for transmitting the data and another is for receiving the data. This process connected with the network switcher for the process transferring the communication session from one cell to another. The placement or the height base for sender node is set to 1.5m from ground and the receiving node taken far from the sender node to establish the communication. The environment area for this experiment is tested in three different area in Perlis (Arau-Changlun Road, Kangar Road) and Kedah (Bukit Kayu Hitam-Changlun Road) state in Malaysia as shown in Figure 3. This is to show the signal propagations communication from the LoRa devices with base station from three different area. The settings of LoRa is set that to sending and receiving the RSSI method based on the speed
direction of the vehicle and the latitude and longitude from GPS for the prediction movement. Figure 2 show the setup for the experiment.

![Experiment setup for the LoRa prediction](image)

**Figure 2.** Experiment setup for the LoRa prediction

(a) Rural area (Arau-Changlun Road)  
(b) Sub-urban area (Bukit Kayu Hitam-Changlun Road)  
(c) Urban area (Kangar Road)

**Figure 3.** Environment area in Perlis, Malaysia
4. Handover Prediction
The prediction of the vehicle movement from one cell to another cell is based on the previous study of LoRaWAN with RSSI value. The tabulated graph in Figure 4, shown the data measured on RSSI with the distance from 1000 meter to 5000 meters. The RSSI values over the distance for the rural area (black colour) is between -60dBm to -90dBm. When the distance movement of the vehicle increased and the RSSI value is -100dBm to -120dBm, the prediction of the vehicle movement is onto the sub-urban area (blue colour) and from -120dBm to -140dBm is in the urban area (red colour). Next, Figure 5 displays the prediction process flow with hexagon cell, which the (base station 13) green colour is the active base station and the others is the possible vehicle movement to neighbour base station. The optimal RSSI on each end of the wireless link is between -48 dBm and -160 dBm to achieve the highest possible data rates.

For the movement of the vehicle from the active base station are based in the direction methods on the right of the hexagonal cell. The direction is fixed with six possible movement based on direction (in degree value) from the GPS. The process started when the vehicle moves from the active base station (base station 13) to the target base station in red (base station 8). When the GPS detected the direction are 0°, then the prediction movement of the vehicle is towards to the direction 1. The flow process of the prediction movement based on the latitude and longitude from GPS is shown in Figure 6. The prediction is using to know exactly where the movement of the vehicle towards to the base station. For examples if the GPS is detected on 180 degree movement then the vehicle is move to the direction 4 as shown in figure 5. Therefore, we can predict that the movement from (BS13) of the vehicle are moves to the base station 17.
Figure 5. The prediction of vehicle movement from active base station to target base station
5. Result and Discussion

Aside from the process of handover propagation issues in the mobile communication, handover delay will happen when the communication node is moving between two or more cell network that cover by base station. Communication handover is a process when the base station cell network transferring ongoing communication link form current cell network area into a new cell network area that pass by the vehicle like in the Figure 7. During this handover process, the ongoing communication link will also have a delay in data transferring sequence. Figure 8 shown the result of the handover delay occurred when the process of the movement happened by measured the process between two base station is occurs. As from the experimental and measurement based on data from the previous study shown that, the higher RSSI value towards into another cell, the better handover process.

![Diagram of handover process](image_url)
6. Conclusion
This study explored full potential of the handover LoRaWAN system for the connection and predictable movement of the vehicle by using RSSI value and GPS connection with base station. The studies show that RSSI value is important in this study to exactly predictable the movement of the vehicles from active base station to the targeting base station. In the meanwhile, 5G technology will be introduced in next few years. With this implementation of communication technology, the amount of base station is expected to increase too. With huge amount cell network base station, the performance of handover process will become significantly important. From this study, it can be concluded that the prediction of the vehicle movement from one cell to another targeting cell with handover LoRaWAN device using RSSI algorithm and GPS to get the direction from base station can be predicted and developed.
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