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State and Path Analysis of RSSI in Indoor Environment

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Abstract. Received signal strength (RSS) ranging is not suitable in indoor environment due to complicated multipath signal propagation, leading to inaccurate distance estimation. This paper shows the experiments which collect RSSI signals in indoor environment for analysis. The objective of these experiments is to discover possible solution to reducing indoor lognormal shadowing effect. Two assumptions were made for the status of signal strength between two radio transceiver: the states of transmitter and receiver, and the path of signal propagation. Experimental results show that the state of transmitter or receiver at a location does not exist. Instead, signal strength and the level of attenuation are determined by individual combination of transmitter and receiver locations. More specifically, it is determined by the paths between transmitter and receiver's locations.

Keywords: Indoor Environment, Path Loss, Received Signal Strength

1. Introduction

Received signal strength indication (RSSI) provided in wireless communication standards such as IEEE 802.11 and IEEE 802.15.4 is widely used in many applications. These applications include indoor location tracking [1] of persons or objects, mobile handoff between hybrid network, robot movement and navigation, and etc. However, radio signal propagation in indoor environment suffers irregular attenuation regardless of time and space [2]. This leads to inaccurate distance estimation. From our studies, we classify the reasons of RSSI variation in indoor environment as shown in Fig. 1.

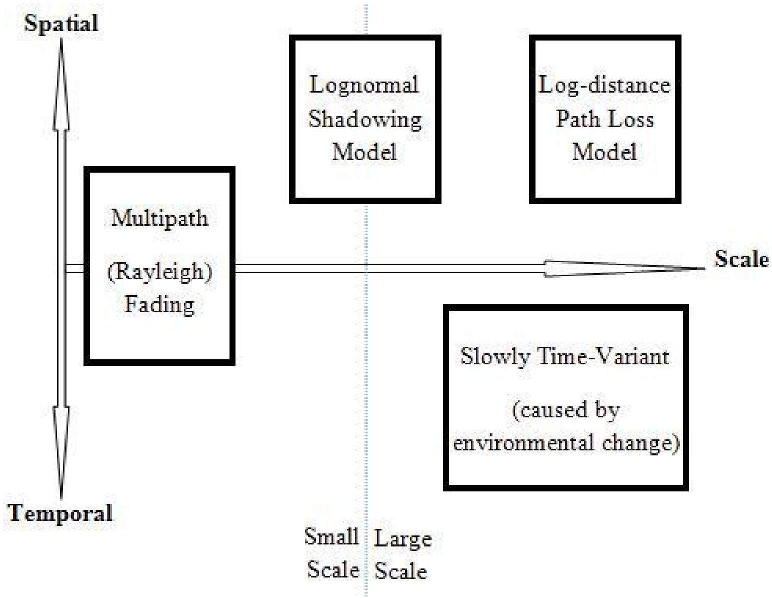

Fig. 1: Types of RSSI variation in indoor environment.

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The classification in Fig. 1 explains the reasons of RSSI variation in terms of both small/large scale and temporal/spatial characteristics. The variation of RSSI in small scale indicates that the fluctuation is a type of fast fading. Both small and large scale RSSI variation can also be either spatial or temporal. In temporal variation, we are able to reduce fluctuation by averaging the samples over time. Nevertheless, in spatial variation we may not get the same effect to obtain a stable signal by averaging over time. We may find good solution by averaging RSSI spatial variation over space if the movement speed is constant. However, the average solution is not practical if the receiver is random movement.

The major sources of the irregular attenuation to the signal strength are multipath fading (or Rayleigh fading) [3] and lognormal shadowing effects [4]. Rayleigh fading effect is a small scale variation over both time and space. Therefore, a simple moving average filter can eliminate the quick fluctuation problem. On the other hand, lognormal shadowing is a medium or large scale effect over space only. In this case, the local mean over time remains no change if no movement is made. The variation of RSSI signal in lognormal shadowing effect depends on the location of receiver itself.

2. State and Path Assumptions

From the above classification and analysis, it gives an idea about the location of receiver due to different RSSI local means obtained at different locations. In addition, the variation of RSSI local mean does not follow any rules but random process can be considered. This leads to the rise of the first assumption: there is a state exists at every location in indoor environment to affect the received level of radio signal strength. The state can be considered as the field strength of radio signal caused by the summation of all electromagnetic wave and noise regardless of frequency.

Since the state for receiver was assumed, it could be possible that the state of the location also affect the transmission level of a transmitter. If the level of state is high, the transmission power was assumed to have enhancement effect to the signal strength. Combining the two states or levels between transmitter and receiver, the potential difference of the states was assumed to cause fluctuation to the resulting received signal strength at different locations. If we are able to measure the potential difference of the states between transmitter and receiver and use it to offset the lognormal shadowing variation of RSSI over space, we might obtain a smooth and linear RSSI attenuation effect over space.

The second assumption was made to assume that states of transmitter and receiver do not exist. The variation of RSSI local mean depends purely on the combination of signal strengths of all paths. This could be a worse assumption because we are not able to control or to predict the paths taken by radio signal propagated in indoor environment. However, we are still able to reduce the lognormal shadowing effect by increasing the number of transmitter or antenna at the same location with the same transmission power. At receiver side, it receives the signals from the transmitters at the same location. Through comparison, we are able to reduce the fluctuation of RSSI local mean over space.

It is important to prove that whether the first or the second assumption is true, or both can be existed in the rule of indoor radio signal propagation. Thus we have to decide which solution can be adopted. For example, if the first assumption was true but we adopted the second solution, then we may not achieve RSSI signal improvement as expected. It is very clear that all transmitters at the same location would have the same level of transmission power because they were at the same location. On the other hand, if the second assumption was true but the first solution was adopted, the resultant RSSI improvement might also not achieved as expected. This is because all state measurements obtained from field strength of the location might be random too. Hence it is impossible to offset the variation of RSSI local mean using random measurement results.

3. Experimental Setup

To verify the two assumptions made about state and path of the RSSI signal, two experimental models were designed to be executed. The first experimental model is mainly used to evaluate the first assumption about the state of transmitter or receiver’s location. The second experimental is for the second assumption to verify the rule of radio propagation paths.

In the first experimental model, two radio communication transceivers are used to transmit signals to each other with the same transmission power. However, one radio transceiver **A** is located at a fixed location (stationary mode) while another radio transceiver **B** is moving by slowly increasing the distance between transceiver **A** and **B** as shown in Fig. 2.

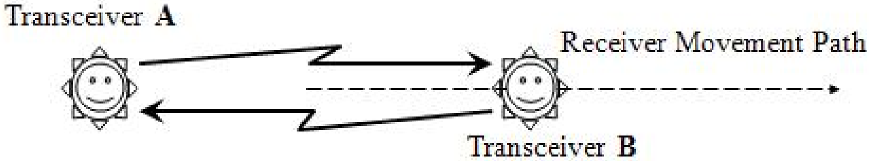
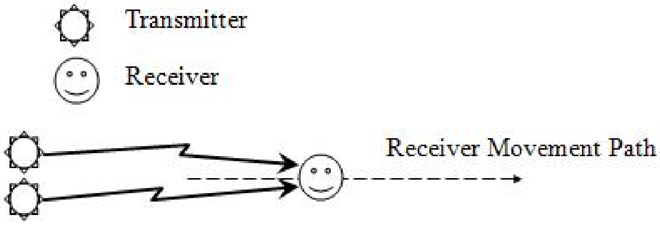
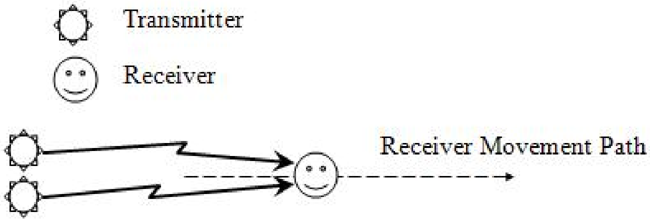


Fig. 2: First experimental model.

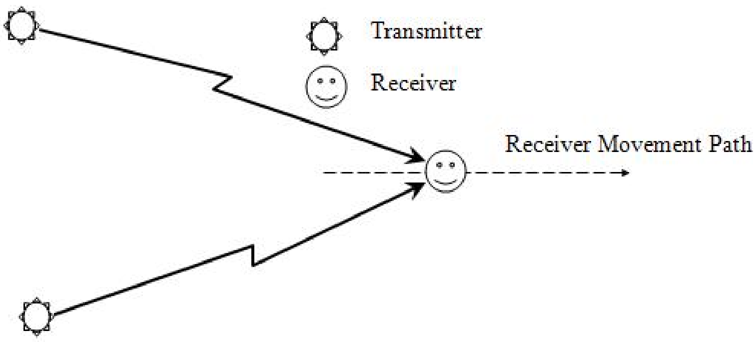
In the second experimental model, two transmitters are allocated at different locations but sending the similar data packets to a receiver. The receiver is in mobile mode to move from one side of the indoor area to another. Three combinations of location allocation between the two transmitters were designed as shown in Fig. 3.



(a) The two transmitter are near to each other



(b) One transmitter is near and another is far to receiver



(c) Both transmitters are far to each other and receiver

Fig. 3: Second experimental model.

4. Experimental Results and Discussion

After the experimental models setup was completed, RSSI signal was collected in an office building at a height about 2 meters. Fig. 4 illustrates the experimental results obtained from the first experimental model:

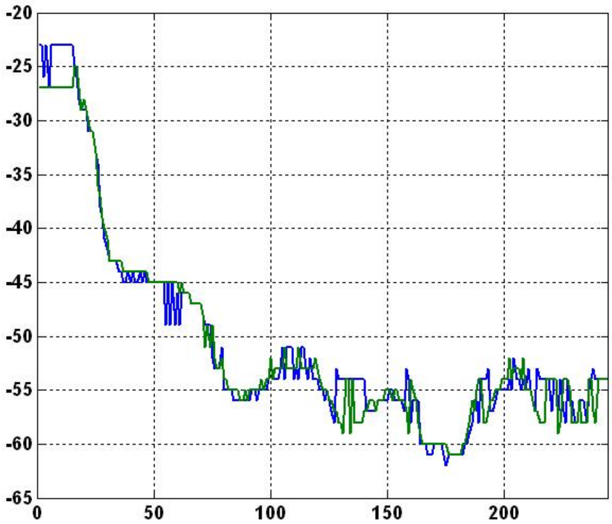
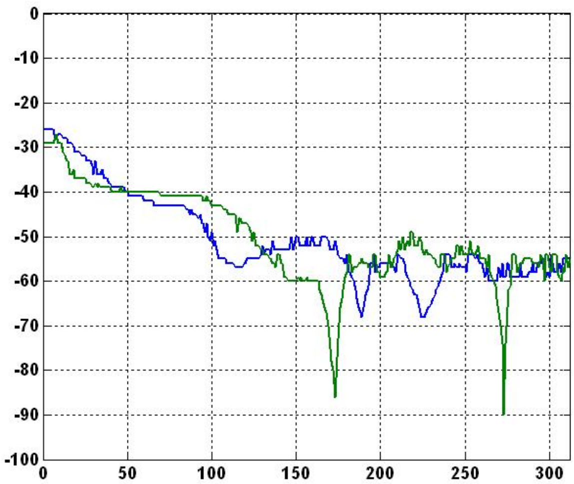


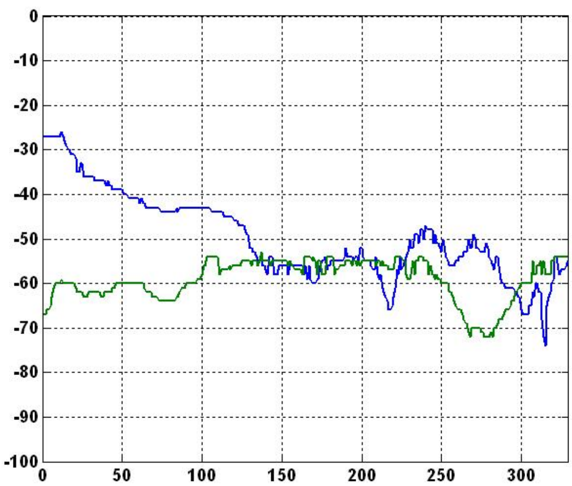
Fig. 4: First experimental model.

The result in Fig. 4 can be used to check whether a transceiver has higher state than another transceiver. If this happen, the RSSI signal measured from the two transceivers which receives signal from each other should be different in level of strength. However, Fig. 4 shows that both RSSI signals are identical. Hence it is proven that the states of transmitter and receiver do not exist.

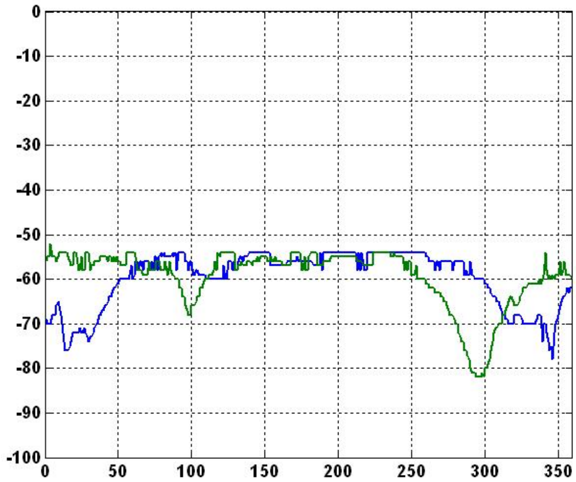
Although the first assumption does not exist, it does not mean the only the second assumption influence to the signal reception. It is interesting to know how it works and possibly, the paths of signals. This can be achieved by examining the results obtained from the second experimental model in Fig. 5.



(a) The two transmitter are near to each other



(b) One transmitter is near and another is far to receiver



(c) Both transmitters are far to each other and receiver

Fig. 5: Experimental results for the first model.

In Fig. 5(a), the two RSSI signals are similar to each other because the two transmitters are close to each other. In Fig. 5(b), the two RSSI signals are large in difference initially. When distance increases, the difference between the RSSI signals received from the two transmitters are converged and cannot differentiate between them. In Fig. 5(c), there is always similarity between the two RSSI signals from the two far transmitters. It can be concluded that RSSI signals are close to each other when transmitters are near to each other but they are not same due to the different paths are taken. At some locations, direct path or light of sight (LOS) may not be available. In this case the RSSI signal may reduce drastically. However, it is possible to detect and recover by comparing the RSSI signal from another transmitter which has the same transmission location as shown in Fig. 5(a).

5. Conclusions

In this paper, two assumptions were made so that the effect of lognormal shadowing could be reduced. Two experimental models were designed and executed. The experimental results show that the state due to field strength at a location does not influence to the transmission and reception of signal's strength. It is also shown that the RSSI signal may be reduced drastically at a location when LOS signal is not available. This can be detected and recovered by allocating two or more transmitters at the same location and compare the received signals from them.

6. References

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