WAVE 핸드오버상에서 수신 신호 세기의 이용

조 웅[*]

Usage of RSSI in WAVE Handover

Woong Cho[*]

요 약

수신 신호 세기 (RSSI: Received signal strength indicator)는 아날로그-디지털 변환기 입력단에서 수신신호의 세기를 나타낸다. 통신시스템에서 수신 신호 세기는 수신단에서 채널의 상태를 결정하는데 사용된다. 본 논문에서는 핸드오버상에서 실측값을 바탕으로 한 수신 신호 세기의 이용에 대해 알아본다. 먼저 WAVE (Wireless Access in Vehicular Environments)라 일컫어지는 차량통신을 위한 5.9GHz 주파수대에서 RSSI값을 측정한다. 측정된 데이터를 바탕으로 하여 빠른 핸드오버 방식 적용을 위한 수신 신호 세기의 이용에 대해 논의하고, 실제 고속도로 환경에서 RSSI를 이용하여 핸드오버를 적용한다.

ABSTRACT

Received signal strength indicator (RSSI) represents the strength of the received signal at the front end of analog-to-digital convertor (ADC) input. RSSI value can be used for deciding the status of channel at the receiver. In this paper, the usage of RSSI in handover is studied using the practical measurement data. We first measure RSSI in 5.9GHz frequency band which is commonly used in wireless access in vehicular environments (WAVE) system. i.e., vehicular communications. Then, to implement a fast handover, the usability of RSSI data is analyzed based on the measured data. We also apply handover in practical highway environments.

키워드

RSSI, Handover, Vehicular Communications, WAVE, ITS
수신 신호 세기, 핸드오버, 차량통신, 도로전용 무선통신, 지능형 교통시스템

Ⅰ. Introduction

Vehicular communications provide various services, i.e., anti-collision warning, emergency warning, traffic information broadcasting, multimedia downloading, and etc., by combining information and communications technology (ICT) with vehicles especially focusing on safety related applications. To support communication links in intelligent transport systems (ITS) areas, wireless access in vehicular environments (WAVE) standard is widely adopted in many countries, where WAVE defines the specification of the PHY/MAC layer and upper layers for vehicular communications in IEEE 802.11p [1] and IEEE 1609 families, respectively. In the PHY layer, IEEE 802.11p adopts an orthogonal frequency

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* 중원대학교 컴퓨터시스템공학과(wcho@jwu.ac.kr)

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division multiplexing (OFDM) scheme with the 5.9GHz frequency band. To investigate the 5.9GHz channel characteristics in vehicular environments, practical measurements of channel and the performance using these channels are introduced in [2,3,4], and antenna technology for vehicular communications are studied in [5,6]. Several handover methods in vehicular environments were suggested in [7,8,9,10]. However, they mostly focus on reducing handover delay [7,8], and their analyses are based on simulations [9,10]. Whereas, handover applications which are based on practical environments are not thoroughly investigated. In this paper, we study application of RSSI in handover of IEEE 802.11p based systems using measured RSSI values in real communication environments. We first measure the RSSI value of 5.9GHz signal in vehicular environments. Then, the usage of measured data is studied to design a fast handover scheme. The proposed method is tested in practical highway environments.

The rest of the paper is organized as follows. In Section II, we introduce the RSSI measurement. The usage of RSSI is discussed in Section III. The result of practical handover implementation is presented in Section IV, and conclusions are given in Section V.

Ⅱ. RSSI measurements

In this section, we present the measurement results of RSSI with and without moving a vehicle. We use 5.850GHz center frequency and 10MHz bandwidth with an OFDM signal. Both transmitter and receiver use an omni-directional antenna with 8dBi gain. The detailed antenna specification is shown in table 1.

Each road side equipment (RSE) can transmit signal with 8 levels of power, where the power level 1 to 8 corresponds to 4 to 23dBm in effective isotropically radiated power (EIRP) approximately with 2 to 2.5dBm power difference for each level. While the RSE is transmitting signal, an on board unit (OBU) records RSSI for a given scenario. The heights of the RSE and OBU antennas are approximately 3.5m and 2m, respectively.

Table 1. Antenna specification

Item	Value
Frequency range	5.83~5.89GHz
Gain	8dBi (±1)
V.S.W.R	≤1.5
-3dB beam width	15° ± 2°
Polarization	Vertical
Normal impedance	50Ω
Max power	1 Watt

2.1 Measurement setup

For measuring RSSI, 2 RSEs and 1 OBU are used. When a vehicle is not moving, we first locate the OBU 0m away from the RSE, and then we move the OBU to 5m unit from the RSE and record the RSSI. When a vehicle is moving, we use 2 RSEs where the RSEs are separated from each other with 1km distance, and the RSSI is measured for each RSE.

2.2 Measurement results

2.2.1 Without moving

In this measurement, we send 100 packets and record the maximum, minimum, and average value of the RSSI at a given location. We transmit signal with power level 6, i.e., approximately 16~17dBm EIRP. Fig. 1 represents the measured RSSI values. The figure shows that the RSSI decreases when the distance between the RSE and OBU increases, which is normal phenomena in wireless channels. When the OBU's antenna is located below that of the RSE, i.e., 0-20m, the RSSI value is very low

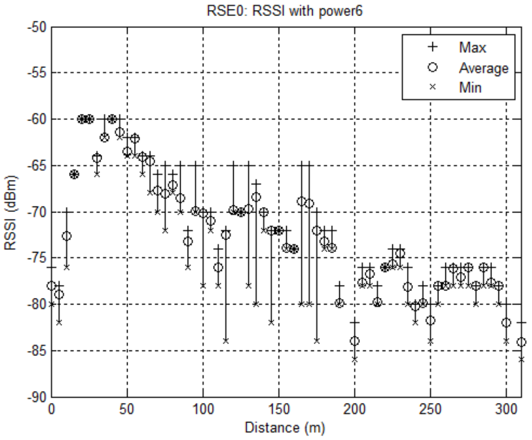

Fig. 1 RSSI value when a vehicle is not moving

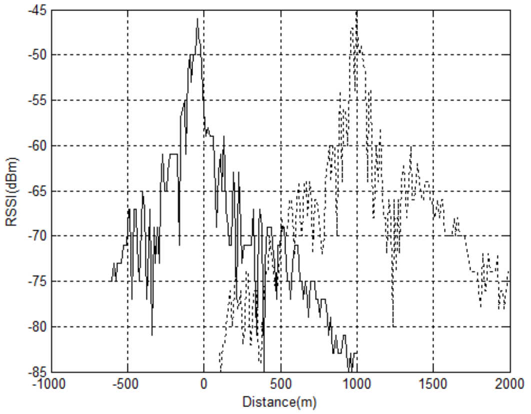

Fig. 2 RSSI value when vehicles are moving

due to the antenna beam mismatch. Since there is a tradeoff between the antenna gain and beamwidth, it is important to determine a proper antenna property especially in vehicular communications. Notice that the RSSI fluctuation is severe even though a vehicle is not moving. Fig. 1 shows that the largest RSSI variation is 15dBm at one location, which makes it difficult to determine an appropriate handover point when RSSI is used for handover. It is also worth mentioning that there is a point where the transmitted signal is not receiving, i.e., null point. The null points are 195m and 305m in Fig. 2. It is measured that these points are changing depending on the height of antenna and transmit power. In general, the null points appear at approximately 200m and 300m distance. These points also affect the calculation of the handover point.

2.2.2 With moving

Fig. 2 depicts RSSI of the received signal when vehicles are moving. We transmit signal with power level 7, i.e., approximately 20dBm EIRP. The line curve and the dotted curve represent the RSSI of RSE1 and RSE2, respectively. Although we plot one figure, it is observed that the RSSI value depending on the distance is almost the same regardless of vehicle speed. Fig. 2 is measured when a vehicle is moving at 60km/h. The figure shows that the trend of RSSI is similar, and there exist many crossing points at the overlapped areas of RSE1 and RSE2. Therefore, it may have lots of ping-pong phenomena if the RSSI is directly used for handover. By considering the measured data of RSSI for both moving and non moving cases, we will develope a fast handover using RSSI in the next section.

Ⅲ. Handover implementation of RSSI

As we mentioned in the previous section, the raw data of RSSI may not be used directly for handover since the signal fluctuation is severe in the 5.9GHz band, which causes frequent handover in the vehicle. To capture the signal changes, we plot the RSSI at the overlapped area of RSE1 and RSE2 in Fig. 3. We also depict the corresponding number of handover occurrence if only the instantaneous RSSI is used for handover. Fig. 3 indicates that there are many cross points, which result in frequent handover. However, if the average RSSI is applied, we may reduce the number of handover occurrence. To minimize the ping-pong effect we consider two methods to evaluate the average RSSI. The first one is using the following equation.

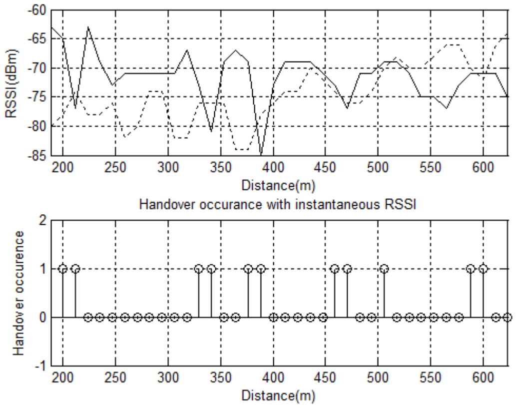

Fig. 3 RSSI value and the number of handover occurrence with instantaneous RSSI

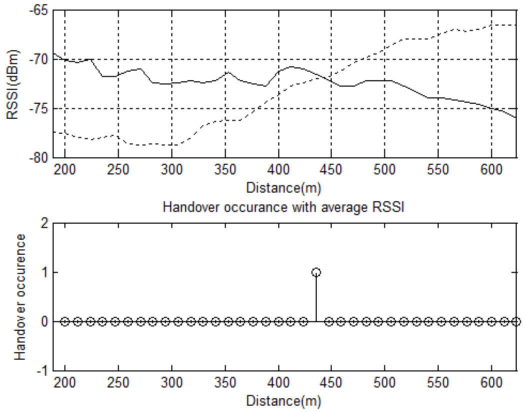

Fig. 4 RSSI value and the number of handover occurrence with the AvgRSSIA

$$AvgRSSIA = WinSize \times [priority \times previousRSSI + (1 - priority) \times currentRSSI],$$

where the previousRSSI and currentRSSI are instantaneous RSSI values, WinSize represents the window size of sampled RSSI signals. Using “priority”, we can emphasize either the previousRSSI or the currentRSSI. The second method is to use two WinSizes for calculating the average RSSI, which can be expressed in the following equation, The only difference is using different window sizes for the previousRSSI and currentRSSI. Using the second method, we can adjust the average RSSI value with more flexibility. In Fig. 4, we depict the average RSSI and the number of handover occurrence with AvgRSSIA. We use the priority of 0.3 and window size of 10, i.e., 10 samples of instantaneous RSSI signals. As we depicted in Fig. 4, only 1 handover occurs. By adjusting the priority and window size, we can optimize the number of handover occurrence. Although we omit the result of handover using the AvgRSSIB, we can obtain similar performance compared with the AvgRSSIA method. Notice that it is also critical to apply these methods in practical scenarios besides numerical optimization. In the next section, we consider practical handover implementation using the aforementioned method.

$$AvgRSSIB = WinSizeA \times [priority \times peviousRSSI] + WinSizeB \times [(1 - priority) \times currentRSSI]$$

Ⅳ. Practical handover implementation

In this section, we present the result of practical handover implementation. We use two RSEs and one OBU by applying the AvgRSSIA method in highway environments. A vehicle is moving with 60km/h, and then we check the RSSI. Fig. 5 depicts the RSSI values when we apply handover application. The figure indicates that handover occurs at approximately 60sec point. However, there are two points where the RSE1 signal is appearing, i.e., ping-pong effect, after the OBU handover from RSE1 to RSE2. Although the numerical and simulation results do not show the ping-pong effect, the proposed method may not be perfectly applicable in practical environments.

There are several reasons of the ping-pong effect. The most important factor is the fluctuation of RSSI signals. As we described earlier, the RSSI value varies severly even though a vehicle is not moving. In practical environments, a vehicle is moving and the surrounding obstacles such as adjacent vehicles,

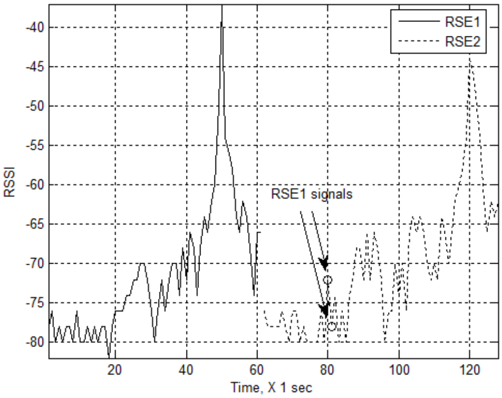

Fig. 5 Handover implementation in practical highway environments

big trucks, and constructions on the road may cause many reflected signals, which also affect the signal fluctuations. In addition, the null point makes it difficult to decide the exact handover point. Therefore, to establish reliable handover in practical vehicular environments, we may consider other factors besides the RSSI value. First, the location information; Since the roads have a unique pattern compared with cellular communications. Secondly, the null point, i.e., which signal has to be assigned at the null point. The last thing is how to transfer data when a handover occurs. We may need some buffers to pass over the data from the previous RSE to the current or next RSE.

V. Conclusions

In this paper, we studied the RSSI based handover using measured data. We analyzed the RSSI properties in the 5.9GHz frequency band. Then, we tuned the RSSI using the priority and window size to apply handover. It is revealed that we can apply the average RSSI for fast handover by choosing the optimum priority value and window size. Based on the results of this paper, we can simply realize handover scheme in vehicular environments. However, to implement handover in practical environments with high reliability, we may need to consider other factors such as location, null points, and data transfer method.

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저자 소개

조 웅(Woong Cho)

1997년 울산대학교 전자공학과 졸업(공학사)

1999년 한양대학교 대학원 전자통신공학과학과 졸업(공학석사)

2003년 Univ. of Southern California 대학원 전기전자공학과 졸업(공학석사)

2007년 Univ. of Florida 대학원 전기컴퓨터공학과 졸업(공학박사)

2008년 2월~2011년 2월 한국전자통신연구원

2012년 3월~현재 중원대학교 컴퓨터시스템공학과 교수

※ 관심분야 : 무선통신, 협력통신, ITS