Case Study of Application of a Wireless Measurement System to a Moving Vehicle

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ABSTRACT

Wireless measurement systems are useful in outdoors measurements. They save the time required to lay cables and eliminate the need to carry cables to the measurement site. Furthermore, they enable easy measurement of moving objects. Wireless measurement systems therefore have a lot of advantages. On the other hand, maintaining a stable connection between wireless sensors and the control unit is a concern, especially when the measurement object is moving.

This paper reports a case study to examine whether wireless connection was made successfully for moving vehicles.

1. INTRODUCTION

In a previous report, the development and application of a new wireless measurement system was covered[1]. In that system, the position of the wireless sensor was fixed. For the current report, we applied the system to a moving vehicle such as an automobile. Conducting a wireless measurement of a moving vehicle requires a measurement system that covers a longer distance. To realize such a measurement system, we used wireless access points. These access points extend the distance between wireless sensor and control unit. When using access points, the wireless path will change frequently. But even in this situation, the wireless transfer speed has to be kept stable. We examined whether the transfer speed was kept stable even when the wireless connection path changed due to the use of access points.

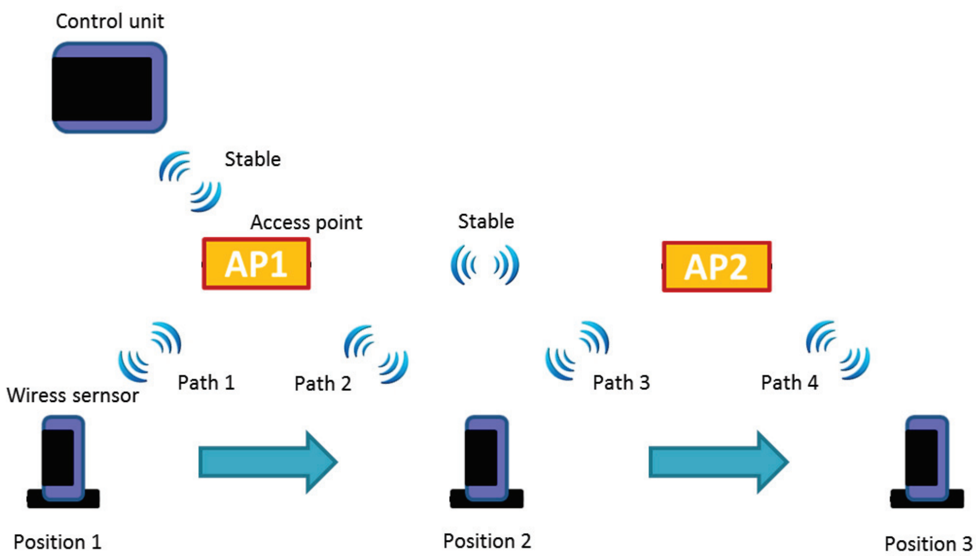

Figure 1 - Basic configuration of wireless system

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Figure 1 shows the block diagram of a wireless measurement system using access points. It consists of a control unit, two wireless access points, and a wireless sensor which moves from Position 1 to Position 4. The control unit and the moving wireless sensor are connected by the access point AP1. The access point AP2 is also connected to the control unit via the AP1.

At first, when the wireless sensor is on Position 1, it is connected to the control unit via Path 1. Then, when the wireless sensor moves to Position 2, the access point connected to the sensor changes from AP1 to AP2. In other words, the wireless connection path changes from Path 2 to Path 3. As the path changes, the wireless sensor is connected to the control unit via AP2 and AP1. This path is kept when the wireless sensor reaches Position 4.

When using Path 1 and Path 2 to connect to the control unit, only AP1 is used. However when Path 3 and Path 4 are used, the wireless sensor is connected to the control unit by using two wireless access points, AP1 and AP2. In this case, it is a concern how much transfer speed decreases due to the use of two access points. Therefore we examined the influence of using two access points for a moving vehicle in this case study.

2. Measurement System and Measurement

The configuration of the measurement system is shown in Figure 2. In this experiment, we used RIONOTE (RION) as a control unit, three SA-A1WD (RION) as wireless sensors, and two SX-AP-4800AN (SILEX) as access points. In this report, the wireless sensors are described as WD1, WD2, and WD3, and the access points are described as AP1 and AP2. WD3 is mounted on an automobile which moves 60 m from the 0 m position to the 60 m position. The wireless transfer speed and electrical field strength are measured at Position A, Position B, and Position C. WD1 and WD 2 are positioned on either side of the road as shown in Figure 2.

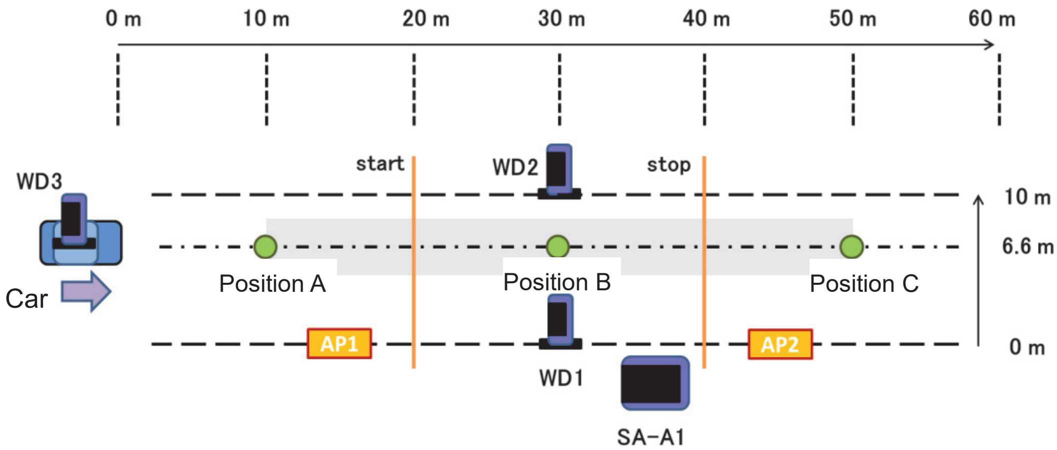

Figure 2 - The configuration of the measurement system

The control unit governs the wireless sensors via the access points. When the wireless sensors receive the measurement start command from the control unit, the sensors start measurement and begin to send monitor data to the control unit. The measurement data are stored in the internal memory of the wireless sensors. When the measurement is stopped, these measurement data are transferred from the wireless sensors to the control unit. Required transfer speed for real time monitoring in four channels is shown in Table 1.

Table 1 - Required transmission speed for each analysis

Analysis Method	Transmission Speed
Octave Analysis	0.3 Mbps
One-third Octave Analysis	1.0 Mbps
Waveform	4.6 Mbps

3. Measurement Results and Discussion

The car with WD3 was moved from the 0 m position to the 60 m position at 10 km/h and 20 km/h.

The measurement was taken twice for each speed. Electrical field strength and car speed were measured at each position for each time, and the measurement data were averaged. The averaged data are shown in Table 2. The table also shows which access point WD3 was connected to.

Table 2 - Electrical field strength between devices

Position	Electrical field strength (dBm)					WD3 connected to
	[1] Control unit – AP2	[2] AP1-AP2	[3] WD1-AP1	[4] WD2-AP1	[5] WD3	
Position A	-56	-65	-67	-68	-55	AP1
Position B	-57	-65	-68	-70	-61	AP1
Position C	-56	-65	-69	-71	-54	AP2

The positions of the control unit, AP1, AP2, WD1, and WD2 were fixed, so the electrical field strength was steady. The electrical field strength of the WD1-AP1 [3] and the WD2-AP1 [4] connection was lower than that of the AP1-AP2 [1] connection in spite of the longer distance. This might be caused by the fact that WD1 and WD2 were placed directly on the ground.

WD3 was connected to AP1 at Position A, and also at Position B, but the electrical field strength was lower by 7 dB than at Position A. The WD3 connection subsequently changed from AP1 to AP2 at Position C. At this point, the electrical field strength recovered from -61 dBm to -54 dBm.

Table 3 - Transfer speed of each wireless sensor at each position

Position	Transfer speed (Mbits/sec) WD1	WD2	WD3	WD3 connects to
Position A	3.62	2.61	3.47	AP1
Position B	3.78	2.23	3.41	AP1
Position C	3.60	2.13	10.6	AP2

Table 3 shows the transfer speed of each wireless sensor at each position. As the positions of WD1 and the WD2 were fixed, the transfer speed was steady. The transfer speed of WD1 is faster than that of WD2, because WD1 was closer to the AP1 than WD2. This confirms the result that the electrical field strength of [3] is stronger than that of [4] in Table 2.

Although the electrical field strength of WD3 at Position A and Position B is different, the transfer speed is identical. It is thought that the transfer path from WD3 to the Control unit goes through 5 → 2 → 1 at Position A and Position B. In this case, the bottleneck of the transfer speed is path [2] where the electrical field strength is weakest. The electrical field strength of path [2] determined the transfer speed regardless of the electrical field strength of path [5]. On the other hand, at Position C, WD3 was connected to AP2 directly without path [2]. The transfer path therefore was shortened to [5] → [1]. A transfer speed of more than 10 Mbps can be achieved in spite of the fact that the electrical field strength is the same as at Position A, because the bottleneck path [2] is removed.

The lowest transfer speed is the 2.13 Mbps of WD2 at Position C in Table 3. The minimum required transfer speed for one-third octave analysis is 1.0 Mbps according to Table 1. So in this case, the system fulfills the transfer speed requirement for one-third octave analysis data. However, as the required transfer speed for waveform data is 4.6 Mbps according to Table 1, the system does not fulfill the transfer speed requirement for waveform data.

4. Conclusion

We examined the feasibility of extending the application range of a wireless measurement system by using access points. The system was applied to a moving vehicle, and the effectiveness of the system was confirmed. In the present examination, a transfer speed suitable for handling one third octave band analysis data was obtained. On the other hand, the transfer speed required for handling waveform data was not obtained. However, as in this system data are saved in the internal memory of the wireless sensors, interruption of data acquisition can be avoided.

In the current examination, we used only two access points and the distance between devices was not very large. It is necessary to further examine the application possibilities of the system. For example, the number of access points as well as the distance between devices could be increased. We also intend to gather more data regarding the applicability of the system to other situations.

Reference

1. Yonemoto Y, Kurosawa Y, Nakajima Y, Ohya M. Measurement Examples of a New Wireless Measuring System　Proc INTER-NOISE 2014; 16-19 November 2014; Melbourne, Australia 2014. p.503-9