POS1-56

# Pedestrian-to-vehicle Communication Access Method and Field Test Results


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## 1. Introduction

The standard of 700MHz band intelligent transport systems (ITS) including Vehicle–to-Vehicle (V2V) communication and Infrastructure-to-Vehicle (I2V) communication has been published in Japan [1]. In response to this situation, Pedestrian-to-Vehicle (P2V) communication which can coexist with I2V and V2V communication on the same frequency is required for pedestrian's safety.

This paper proposes three access methods which are suitable for this system. They are evaluated by static simulation in which a roadside Unit (RSU), many on-board units (OBEs) and many pedestrian portable terminals (PPTs) are distributed throughout a large intersection. Moreover these methods are tested using radio equipment in real field.

## 2. Scenarios and Communication Requirements of 700MHz Band ITS

Figure1 shows an intersection model for this simulation. Figure 2 designates a scenario that assumes a collision between a pedestrian on crossroad and a vehicle which is going to turn right. Table 1 shows scenarios which indicate I2V, V2V and P2V communication, and defines communication requirement and evaluation criteria for each scenario.

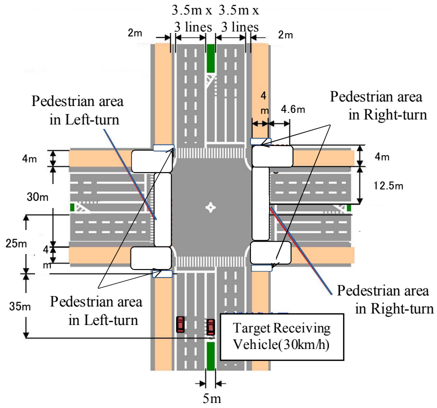



Figure 1: Intersection Model

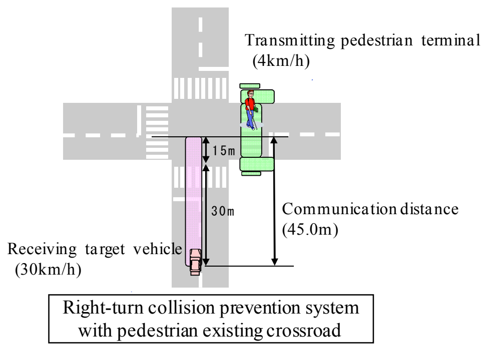



Figure 2: Example of Scenario

Table 1: Definition of Scenarios and Communication Requirement (Intersection model)

| Scenario | | | Communication Requirement | Cumulative Distance [m] | Cumulative Number [times] | Evaluation Criteria: Cumulative Packet Arrival Rate |
|---|---|---|---|---|---|---|
| Transmitter | Receiver | Appli -cation type | | | | |
| RSU | OBE | *1 | Communication dist. 0-60m, to receive more than or equal to 1 packet while vehicle is moving 10m | 10 | 5.1 | ≥ 99% |
| OBE | OBE | *2 | Communication dist. 0-124.7m, to receive more than or equal to 1 packet while vehicle is moving 10m | 10 | 3.6 | ≥95% |
| PPT | OBE | *3 | Communication dist. 0-45m, to receive more than or equal to 1 packet while vehicle is moving 10m | 10 | 12.0 | ≥ 95% |
| RSU | PPT | *4 | Communication dist. 0-42.4m, to receive more than or equal to | 1 | 9.0 | ≥99% |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | 1 packet while pedestrian is moving 1m (0.9sec.) | | | |
| OBE | PPT | *5 | Communication dist. 0-45m, to receive more than or equal to 1 packet while pedestrian is moving 1m (0.9sec.) | 1 | 9.0 | ≥ 95% |

*1 Right-turn collision prevention system with pedestrian existing crossroad
*2 Right-turn collision prevention system with vehicle going straight
*3 Right-turn or left-turn collision prevention system with pedestrian existing crossroad
*4 Support for pedestrian existing crossroad
*5 Support for pedestrian to avoid vehicle going to right-turn or left-turn

## 3. Proposal of Access Method for the P2V communication

Table 2 shows three proposals of access method for P2V communication which can coexist with I2V and V2V communication on the 700MHz band. Figure 3 shows how each access method operates.

Table 2: Proposal of Access Method

| | |
|---|---|
| Proposal 1 | -RSU , OBE and PPT transmit their signals in their own reserved periods.<br>-PPT uses one of RSU reserved periods. It's predefined as a PPT reserved period.<br>-RSU broadcasts both RSU reserved periods and a PPT reserved period. |
| Proposal 2 | -RSU , OBE and PPT transmit their signals in their own reserved period.<br>-PPT uses the following periods as PPT reserved periods.<br>(1) PPT uses RSU reserved periods in which none of the RSUs are using.<br>(2) PPT uses a part of a RSU reserved period in which RSU isn't transmitting..<br>-RSU broadcast both RSU reserved periods and PPT reserved periods. |
| Proposal 3 | -OBE and PPT transmit by CSMA/CA except for used RSU reserved period.<br>-RSU broadcasts only used RSU reserved periods. |

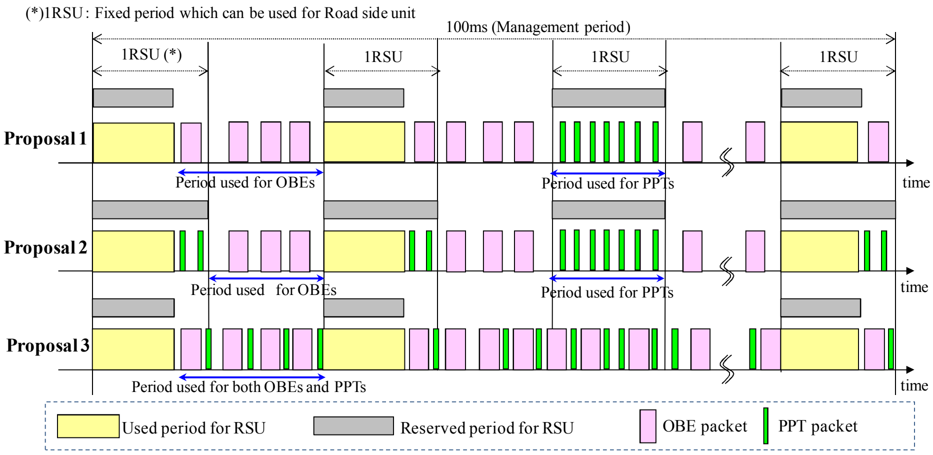


Figure 3: Explanation of Access Method for Pedestrian Portable Terminal

## 4. Simulation Parameters and Procedures

Table 3 shows the parameters of radio equipment. The following procedures are applied for each access method proposed in Table2. Packet arrival rate and cumulative packet arrival rate for each scenario in Table 1 are calculated. These rates are calculated by signal-to-interference and noise power ratio (SINR) by using radio propagation model. FUPM (Fast Urban Propagation Module) [2] is adopted as the radio propagation model because of shortening of simulation time. All radio equipment in this simulation stay at the same place. Table 4 defines other parameters. If all scenarios in Table1 satisfy the communication requirements, the access method is defined that it can coexist with present system.

How to calculate the cumulative packet arrival rate is described below. Cumulative number for each scenario is defined in Table 1.

$$\text{Cumulative packet arrival rate [\%]} = (1 - (1 - P)^N) \times 100$$

P: Packet arrival rate from transmitter to receiver

N: Cumulative number: average number of packets which transmitter sends while the distance between transmitter and receiver changes d [m] defined in each scenario as shown in Table1.

Table 3: Parameters of Radio Equipment

| | Transmission interval [msec] | Transmitted power [mW/MHz] | Transmitted data length [byte] | Modulation, coding rate | Number of radio equipments [unit] |
|---|---|---|---|---|---|
| RSU | 100 | 10 | 2000 | 16QAM, 1/2 | 10 |
| OBE | 100 | 10 | 100 | QPSK, 1/2 | 252 |
| PPT | 100 | 10 | 20 | 16QAM, 1/2 | 512 |

Table 4: Other Parameters

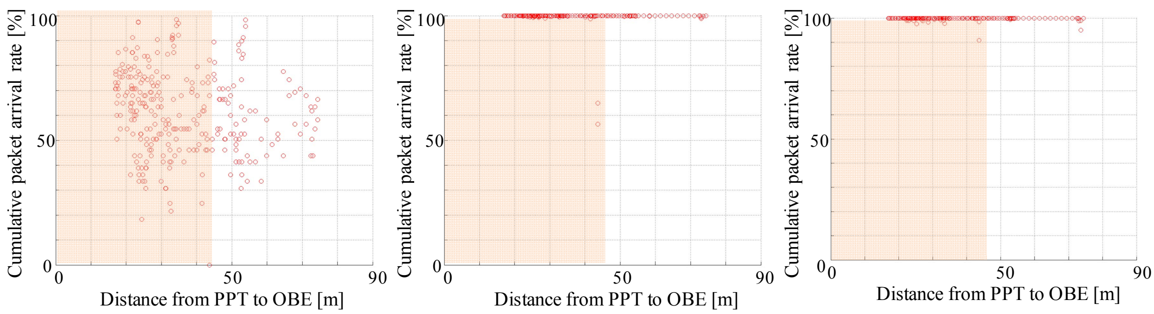
| | |
|---|---|
| PHY and MAC layer parameter | Based on ARIB STD-T109 |
| Antenna height | RSU 5.0m / OBE1.8m / PPT 1.5m |
| Antenna gain | RSU Omni antenna: Gain 1.8dBi<br>OBE Directional antenna: Gain -1.4 to 0.8dBi<br>PPT Directional antenna: Gain -11.7 to -4.1dBi |
| Carrier sense level | Preamble portion -85dBm / Non-preamble portion -65dBm |
| Propagation loss | Shadowing loss caused by other vehicle 0 to 38dB<br>Shadowing loss caused by buildings 0 to 40dB |
| Propagation model | FUPM |

# 5. Simulation Results

Table 5 shows simulation results. Figure 4 reveals representative graphs of distance versus cumulative packet arrival rate from PPT to OBE. According to Table 5, Proposal 2 and 3 satisfy all requirements. The result suggests that PPT can coexist with present system if using proposal 2 or 3.

Table 5: Simulation Results

| Evaluated scenario | | | Result | | |
|---|---|---|---|---|---|
| Transmitter | Receiver | Application Type | Proposal 1 | Proposal 2 | Proposal 3 |
| RSU | OBE | *1 | OK | OK | OK |
| OBE | OBE | *2 | OK | OK | OK |
| PPT | OBE | *3 right-turn | NG | OK | OK |
| | | *3 left-turn | NG | OK | OK |
| RSU | PPT | *4 | OK | OK | OK |
| OBE | PPT | *5 right-turn | OK | OK | OK |
| | | *5 left-turn | OK | OK | OK |




(a) Proposal 1 (b) Proposal 2 (c) Proposal 3

Figure 4: Representative Result (PPT to OBE)

# 6. Field Test Procedures

In field test, only proposal 2 and 3 are tested. As Figure 5 shows, not only evaluated OBEs and PPTs but also interfering OBEs and PPTs are allocated in the test course. Transmission interval of interfering OBEs and PPTs is shorter than that of evaluated OBEs and PPTs described in Table 6. Field test parameters are the same as simulation parameters defined in Chapter 4.

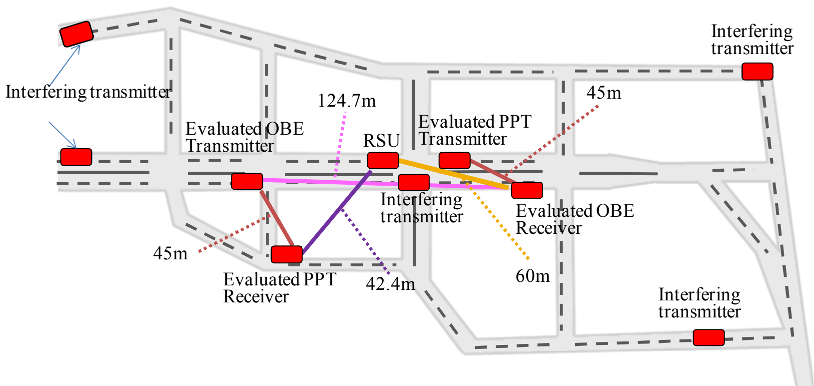



Figure 5: Allocation of Radio Equipments in Field Test Course

Table 6: Transmission Interval

| | | | |
|---|---|---|---|
| OBE | Packet transmission interval | Evaluated transmitter | 100 msec |
| | | Interfering transmitter | 2msec (correspond to 250 units) |
| PPT | | Evaluated transmitter | 100 msec |
| | | Interfering transmitter | 1msec (correspond to 500 units) |
| RSU | RSU transmission interval | | 2,000byte (1.616msec) x 10 (correspond to 10 RSUs) |

## 7. Field Test Results

Table 7 shows field test results. Proposal 2 satisfies all requirements. The result suggests that PPT can coexist with present system if using proposal 2.

Table 7: Field Test Results

| Scenario | | | Result | |
|---|---|---|---|---|
| Transmitter | Receiver | Application Type | Proposal 2 | Proposal 3 |
| RSU | OBE | *1 | OK | OK |
| OBE | OBE | *2 | OK | NG |
| PPT | OBE | *3 right-turn | OK | OK |
| | | *3 left-turn | OK | OK |
| RSU | PPT | *4 | OK | OK |
| OBE | PPT | *5 right-turn | OK | OK |
| | | *5 left-turn | OK | OK |

## 8. Conclusion

Simulation results show PPT can coexist with present system if using proposal 2or 3 and field test shows proposal 2 is more suitable for the present system. If the number of PPTs is much fewer than 500, proposal 1 will be possible to coexist with it.

On the next step, we should adopt the evaluation conditions such as radio propagation model which is more suitable for P2V communication system and rise up the accuracy of our evaluation.

## Acknowledgments

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## References

[1] Association of Radio Industries and Businesses of Japan, “ARIB STD-T109”, http://www.arib.or.jp/tyosa kenkyu/kikaku_tushin/tsushin_std-t109.html (Japanese)
[2] Peter D. Holm, “A New Heuristic UTD Diffraction Coefficient for Nonperfectly Conducting Wedges,” IEEE Transactions on Antennas and Propagation, Vol. AP-48, No.8, pp.1211-1219, Aug. 2000.