Progress Report on Next-generation Infrared Beacon in Japan

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SUMMARY

As one of the road-vehicle communication media, the infrared beacon (IR beacon) has played a significant role in Japanese VICS (Vehicle Information and Communication Systems) since 1996. It is used for providing or receiving traffic information between RSU (Road-Side Unit) and OBU (On-Board Unit).

Requirements regarding lane-by-lane communications especially for downlink are recently increasing from TICS (Transport Information and Control Systems) applications, so that UTMS (Universal Traffic Management Society of Japan) has started the research work for developing next-generation IR beacon and finished creating the draft specifications.

INTRODUCTION

The current IR beacon adopts the most suitable hardware and communication protocol to be used for disseminating traffic information to OBU. For example, RSU is installed above the center of each lane, so the communication area for uplink is limited to such narrow width as no more than one vehicle can enter into the area at the same time. Thus, an uplink can be received by a RSU without any complicated negotiation. On the other hand, a downlink is transmitted from more than one RSU above each lane, but as the downlink is synchronized each other, even a vehicle moving across two adjacent lanes can receive the downlink without any interference. Fig.2-1 shows the communication between RSU and OBU.

Recently, new needs of the lane-by-lane communication such as removal of non-public transport from bus exclusive lane or lane by lane dissemination of information for intersection's or sharp curve section's dead angle.

Also, the international standardization activity has taken place since 1992 at the ISO/TC204/WG15, where the communications between RSU and OBU (DSRC) being discussed, so that results studied by the working group should be taken into account for the next-generation IR beacon specifications.

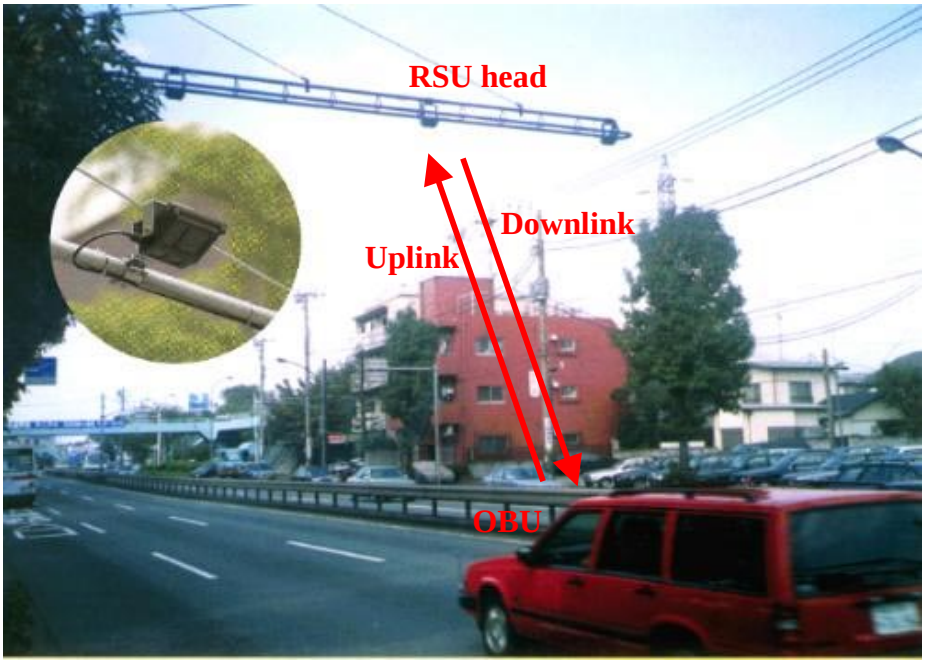

Fig.2-1 The communication between RSU and OBU (using current IR beacon)

BASIC TARGET

Based upon these requirements come up to UTMS from the typical TICS applications, with consideration to ISO activities, we have defined the basic target as shown below in determining next-generation IR beacon specifications.

>Viewpoints from application requirements.

- Lane-by-lane communications (Point-to-point communication).
- Volume of downlink: 10KB (when a vehicle is moving at 70km/h or less).

>Viewpoints from the communication protocol (with considerations to ISO activities).

- Communication specifications based upon OSI model.
- Simplified negotiation procedure to establish communications.

>Moderate price of hardware.

OUTLINE OF NEW SPECIFICATIONS

Communication Structure

Taken the initial scope of ISO/TC204/WG15 into account, (following to OSI 7-layer model, the communication structure is simplified as Layer 7: Application Layer (L7) / Layer 2: Logical Link Control Sub-layer (L2-LLC) & Medium Access Control Sub-layer (L2-MAC) / Layer 1: Physical Layer (L1).

L7 and L2-LLC are being discussed at the ISO/TC204/WG15, the communication structure determined by the working group will be introduced to our new specifications.

Thus, L2-MAC and L1 have been specified in our specifications.

Layer 2 : Medium Access Control

An example of data handling procedure (simple negotiation) as follows (cf. Fig.4-1).

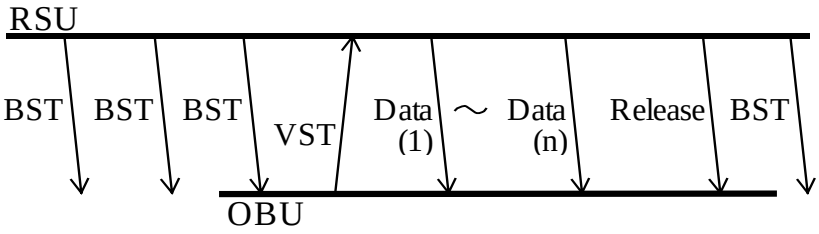

Fig.4-1 An example of data handling procedure

- RSU constantly transmits the Beacon Service Table (BST).
- OBU transmits the Vehicle Service Table (VST) to RSU after receiving the BST at a communication area. At that time, the random number is used for its own link address.
- RSU transmits the BST attached data frames to the link address after received VST.
- OBU receives the data attached on its own link address.
- RSU transmits 'release' to OBU after finished the data frame transmission.
- OBU knows the end of communications after received the 'release'.
- RSU returns to the status of constantly transmitting BST after transmitted the 'release'.

Communications between RSU and OBU are established only in a communication area. OBU is usually at a stand-by status and RSU is at a constant transmission status. So, the road-vehicle communications start for the first time when an OBU that has received BST transmits VST. Since such a simplified negotiation procedure is adopted, the two-way communications are realized within such a short communication time as 257ms for a vehicle moving at 70 km/h.

Because the communication protocol is capable of sending the same synchronized downlink from more than one beacon-head, this protocol can be applied to the existing system.

Layer 1 : Physical Layer (Hardware)

A major feature of next-generation IR beacon is that width of the communication area is limited to 2.5m to avoid interference of downlink signals between adjacent lanes. As most of the lane width is 3.0m to 3.5m in Japan, such a narrow width as 2.5m has been applied. It will be enough width to isolate both uplink and downlink from adjacent lane interference.

Fig.4-2 shows communication areas for the current IR beacon and the next generation

type. Table 4-1 shows the typical hardware specifications.

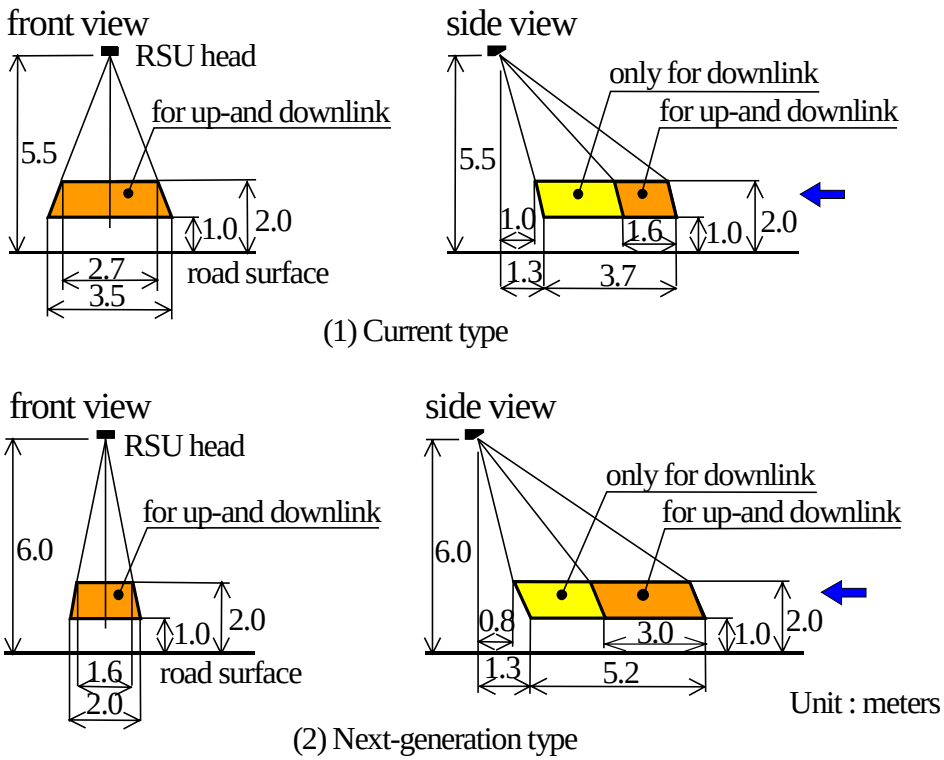

Fig.4-2 Commnication area (current type vs next-generation type)

Table4-1 Hardware Specifications (extracted)

	Communication Speed	Minimum irradiance	Receiver sensitivity
Downlink	1024kbps	36mW/m^2	9mW/m^2
Uplink	64kbps	16mW/m^2	4mW/m^2

APPLICATIONS OF THE NEXT-GENERATION INFRARED BEACON

Using lane-by-lane communications, the next-generation IR beacon would be applied for following applications except for the conventional traffic information dissemination.

- Dissemination of each direction's traffic information at nearer location to an intersection or interchange.
- Lane-by-lane traffic signal control for bus and emergency vehicle priority passage.
- Removal of non-public transport from the bus priority or exclusive lane.
- Removal of non-emergency vehicles from the lane an emergency vehicle is move.

- Lane-by lane dissemination of information for intersection’s dead angle or sharp curve section’s dead angle.
- In-flow traffic control for the restricted area.

FUTURE ACTIVITIES

The draft specifications were completed in February 1999. The standardization works will be lasted until the end of 1999, with gathering verification data through field experiments. Results of those works are planned to come up with the ISO working group to be discussed.

In addition, studies on applicable systems using the next-generation IR beacon will be promoted simultaneously.