CSIS Discussion Paper No.148

Use cases and basic concept proposal for Lane Level Location Referencing

Satoru NAKAJO*

*Center for Spatial Information Science, the University of Tokyo, Japan
Cw503 4-6-1 Komaba Meguro-ku Tokyo Japan 153-8505
Tel: +81-3-5252-6412 snakajo@csis.u-tokyo.ac.jp

Abstract

The needs for precise location information exchange is increasing such as for automated driving and for safety application in ITS. Location information exchange in lane level is required broadly. In this paper, basic concept of a lane level location referencing method is briefly explained. The main concept explained on this paper is come mainly from the result of discussion between the authors. The purpose of this paper is to make a reference for further research and creating a standard within the global level.

KEYWORDS:

Location Referencing, Spatial Information Distribution/Exchange, Automated Driving, Dynamic Map

1. Introduction

The needs for location referencing method which can use in lane level is increasing because of the rapid technological progress in autonomous driving and cooperative systems in ITS. On the other hand, there are no widely used standard which can execute location referencing within lane level. Based on the situation above, the authors have decided to create a location referencing method which can use for autonomous driving and cooperative systems within lane level.

In this paper, Use cases in service level and function level and constituents of Location Referencing Method are briefly described. The authors noticed that some of the ideas described in this paper may need further research for realizing an actual use.

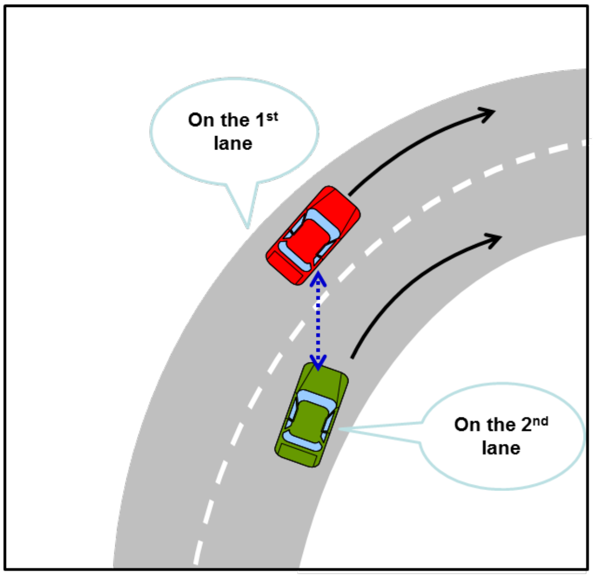
2. Use cases

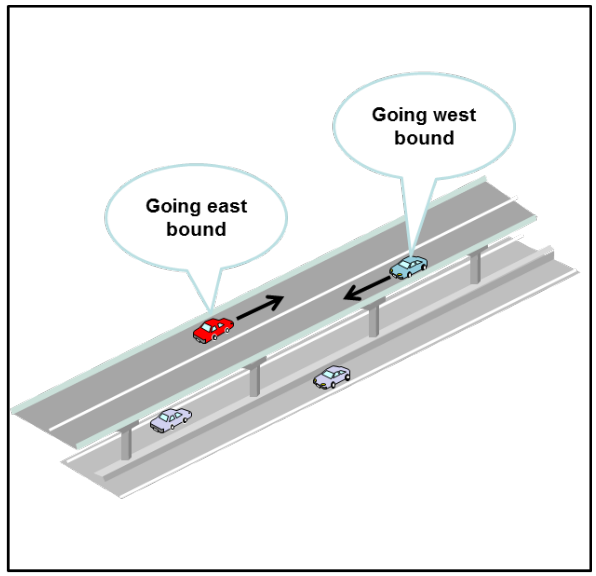
2.1 Service level

We defined several use cases for service levels as follows based on several discussion with related professionals in Japan and overseas. We noticed that there two types of services. One is the use cases to deliver the location as “which lane” and the other is as “where in a lane”. We defined use cases for both types.

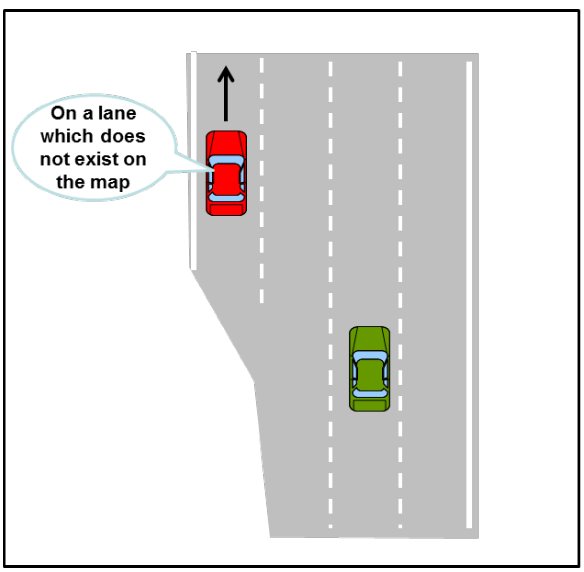
<Use cases for “which lane” information delivering>

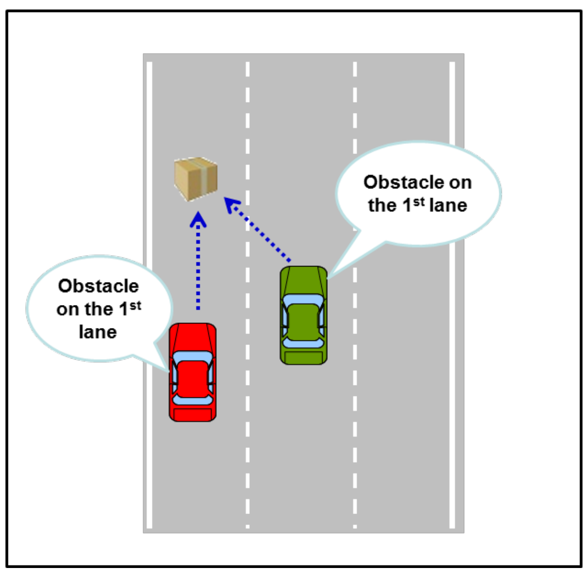
1) Exchange the lane information of the vehicle



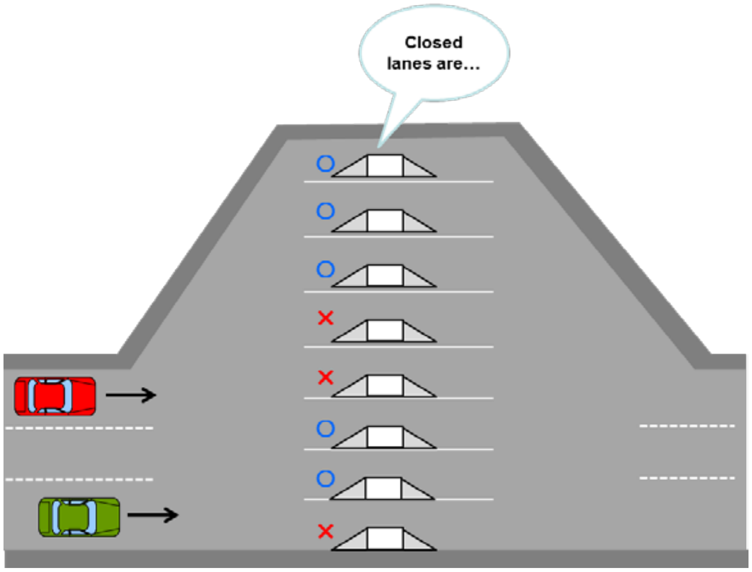


2) Delivering road changes or obstacles

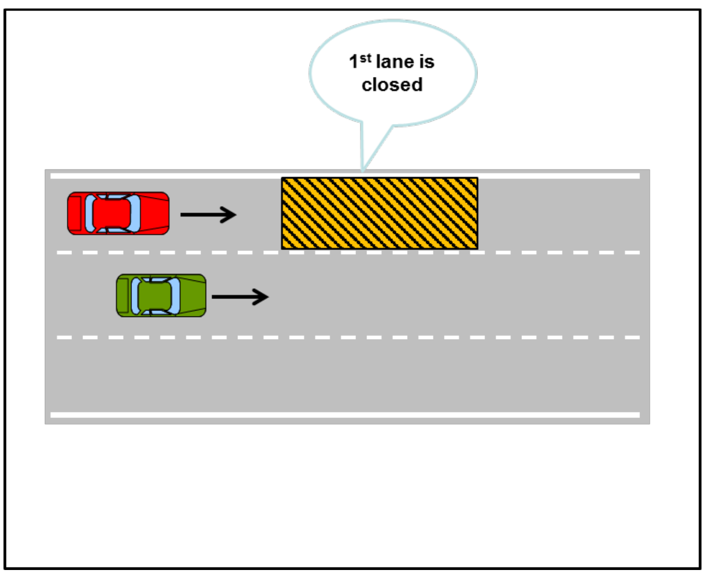




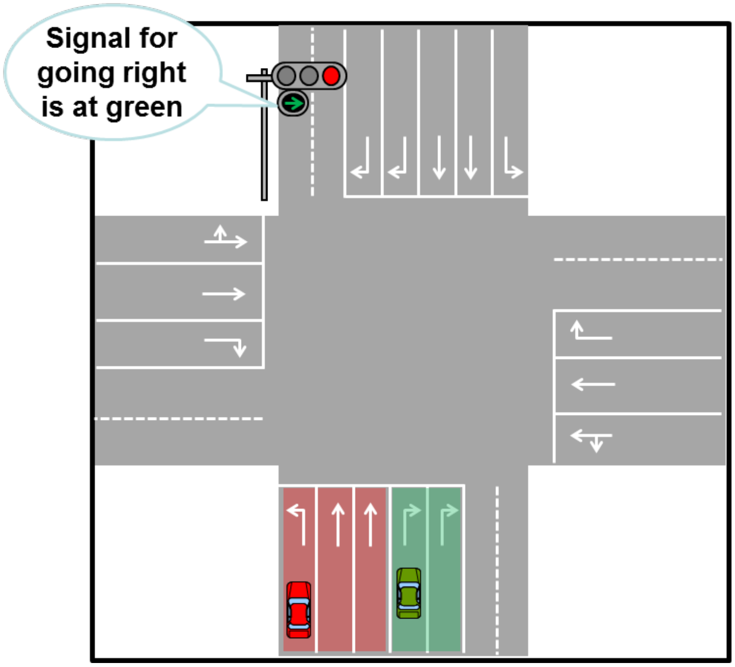
3) Delivering lane closure at toll gates



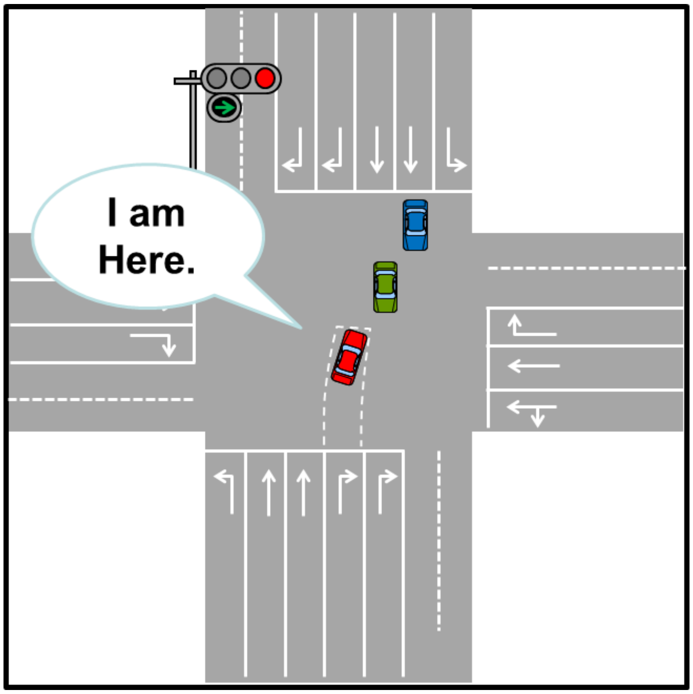
4) Delivering lane closure at road sections



5) Delivering signal timing information



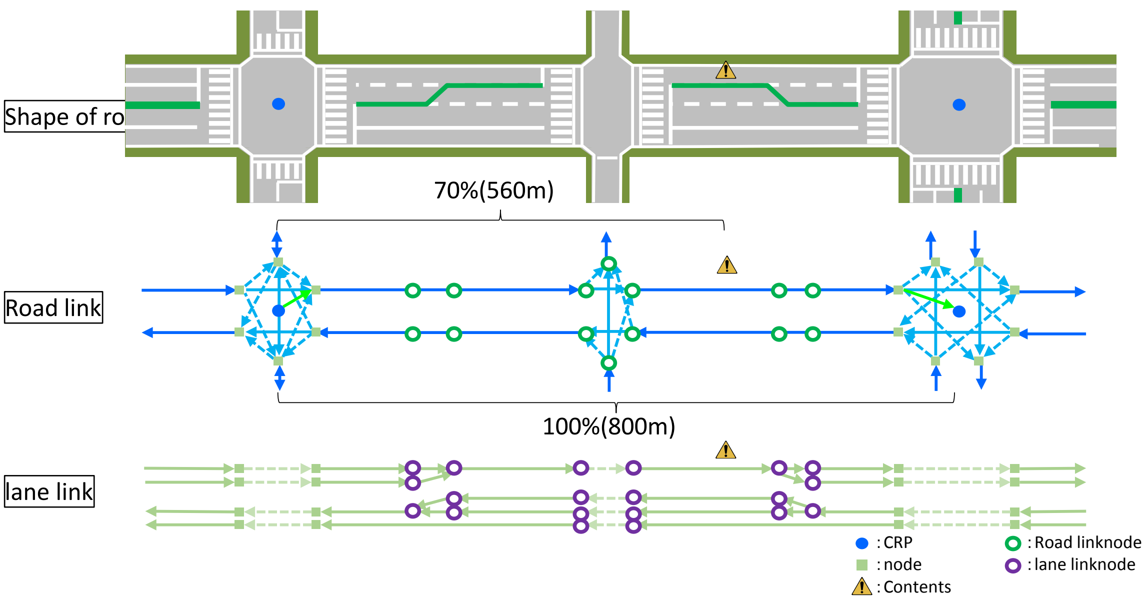
<Use case for “where in a lane” information delivering>

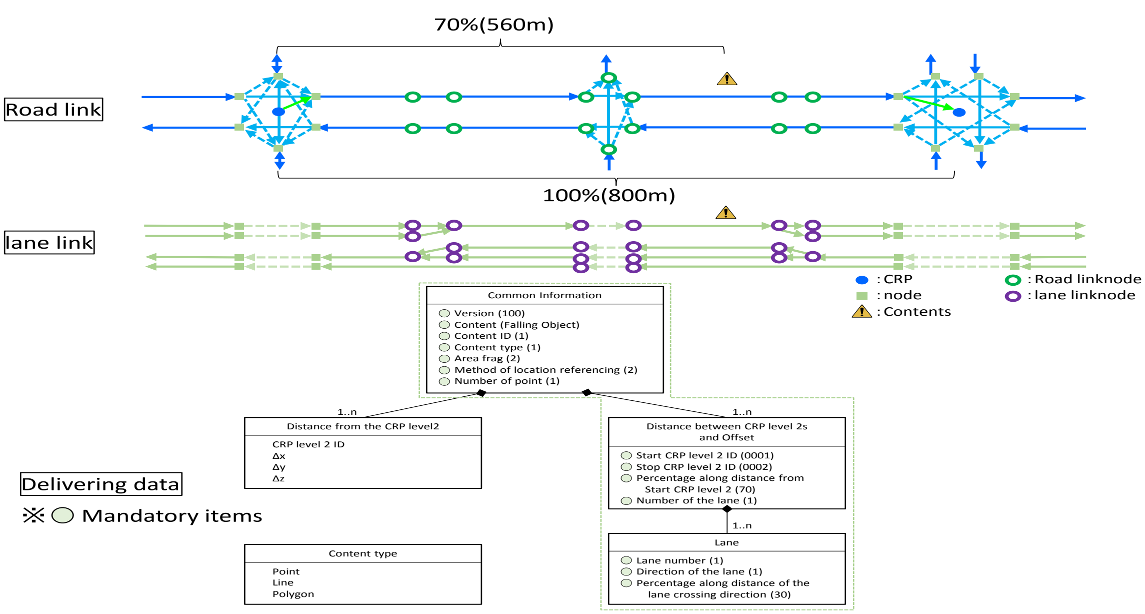


2.2 Function level

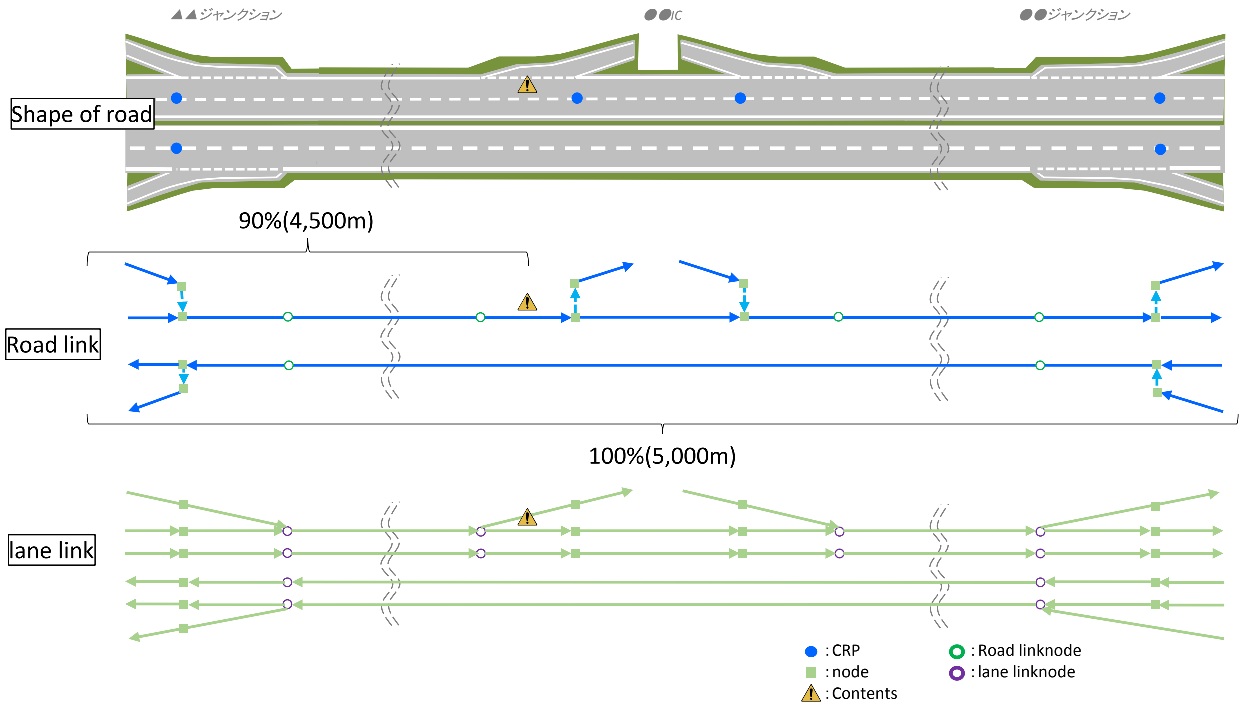
We defined several use cases for function level as follows. In function level, we defined type of road and defined the shape of road, road link, lane link and needed delivering messages. We defined the road link and lane link just for a reference for discussing the necessary location information. We do not intend to standardize the road link or lane link model in this paper.

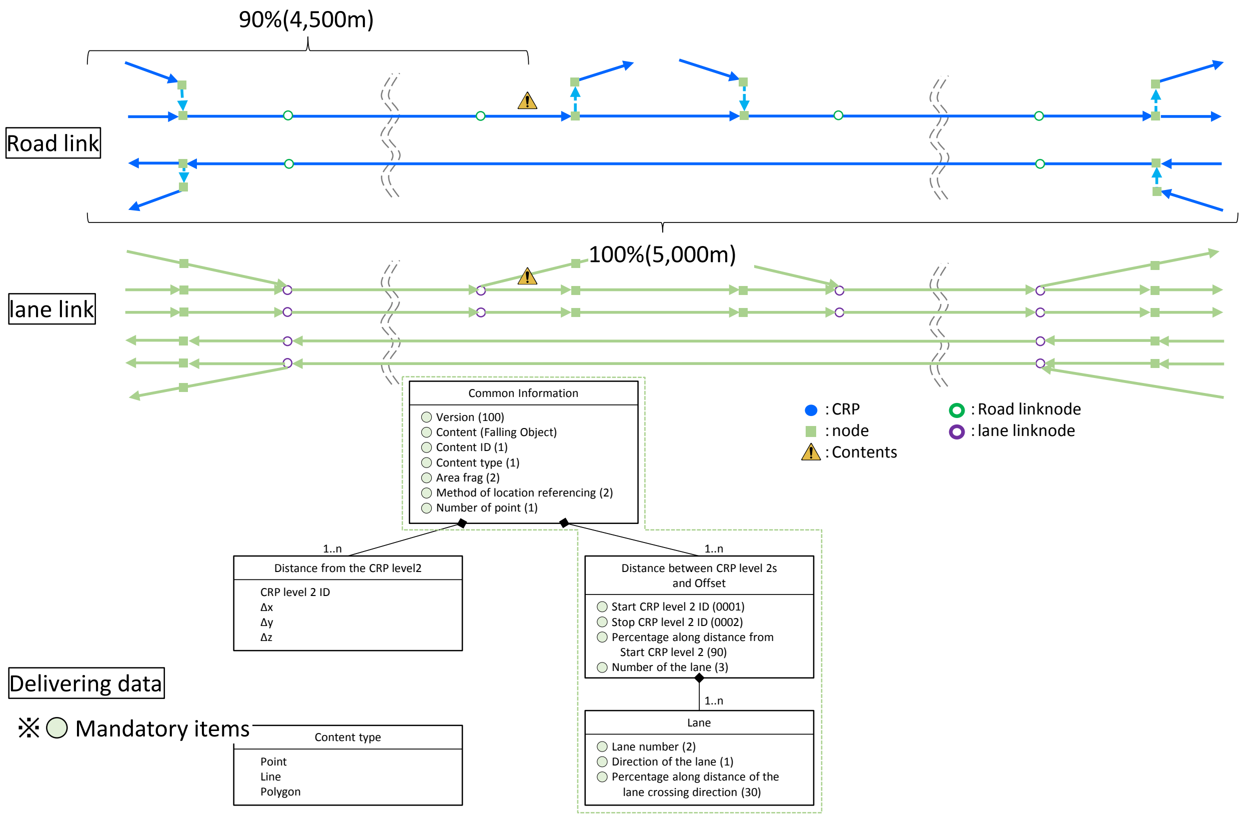
Type1) Ordinary road



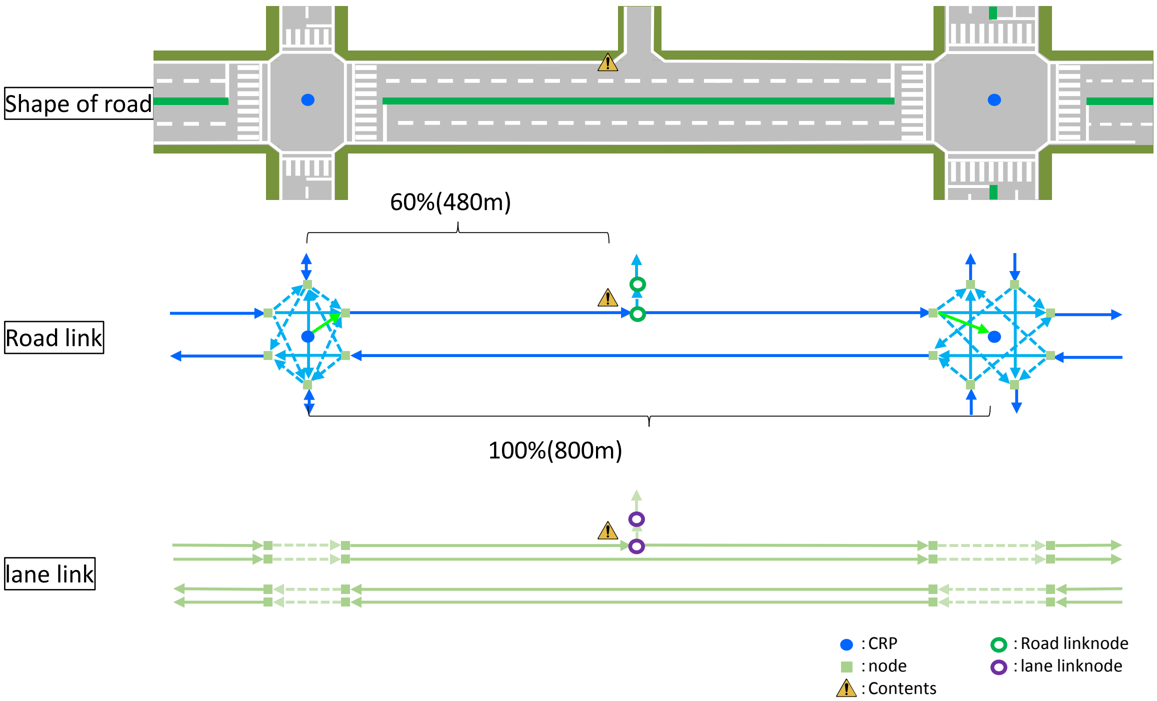


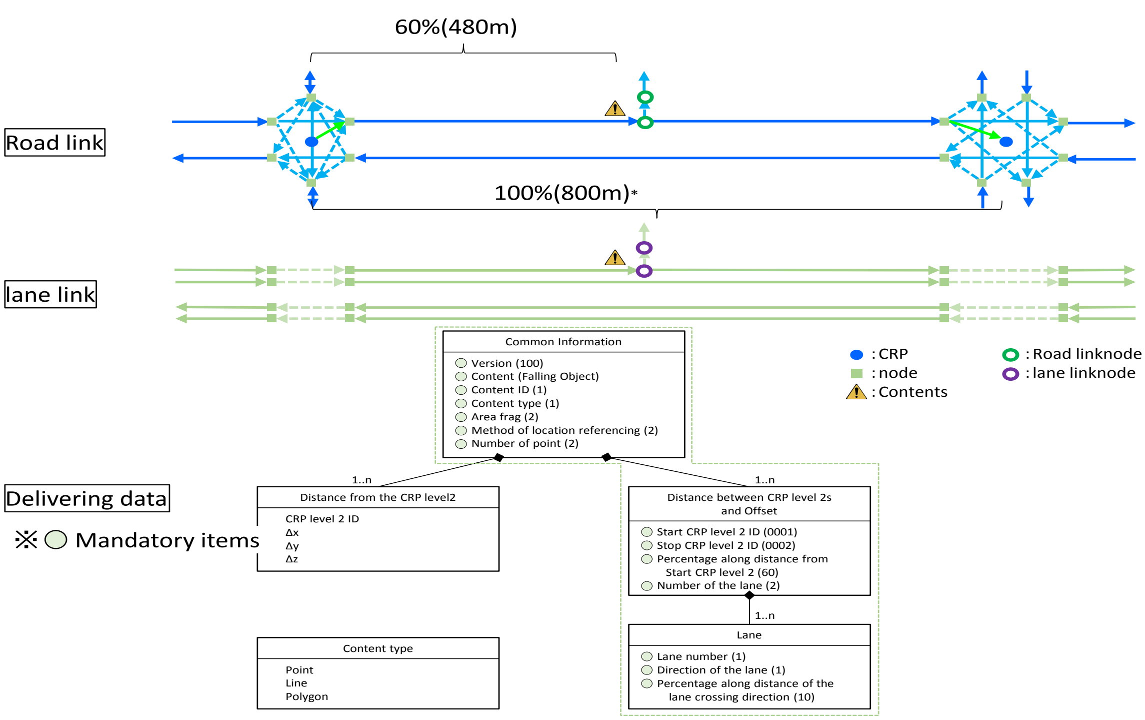
Type 2) Junctions



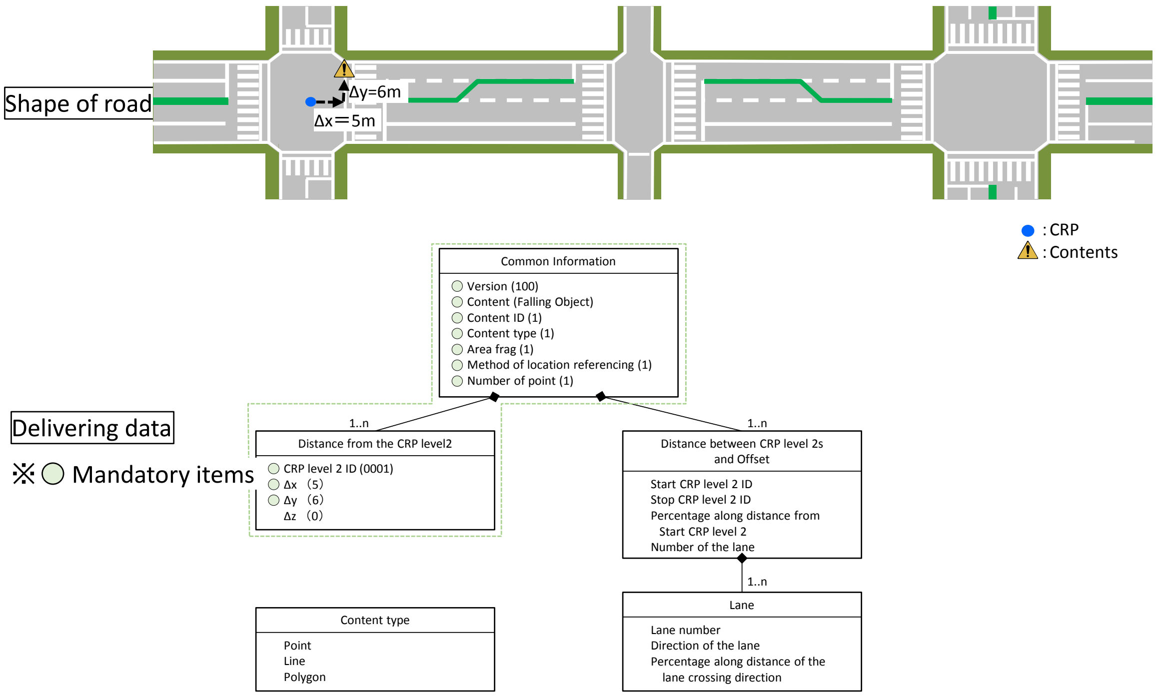


Type 3) Small intersections

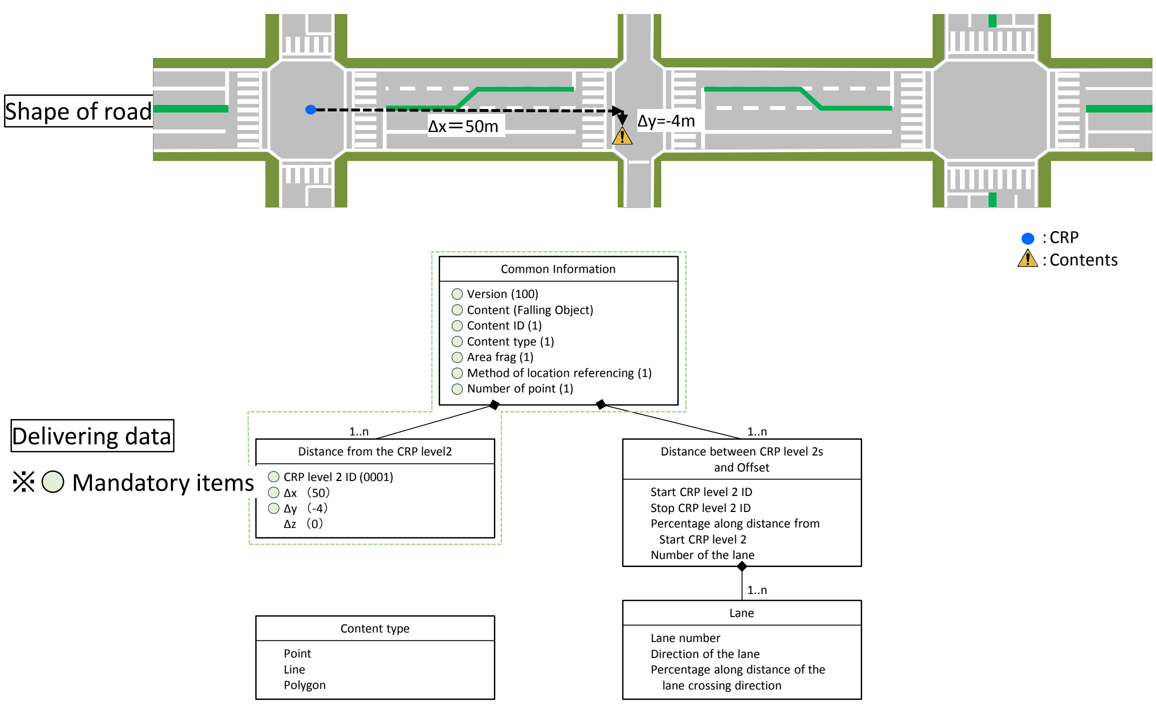




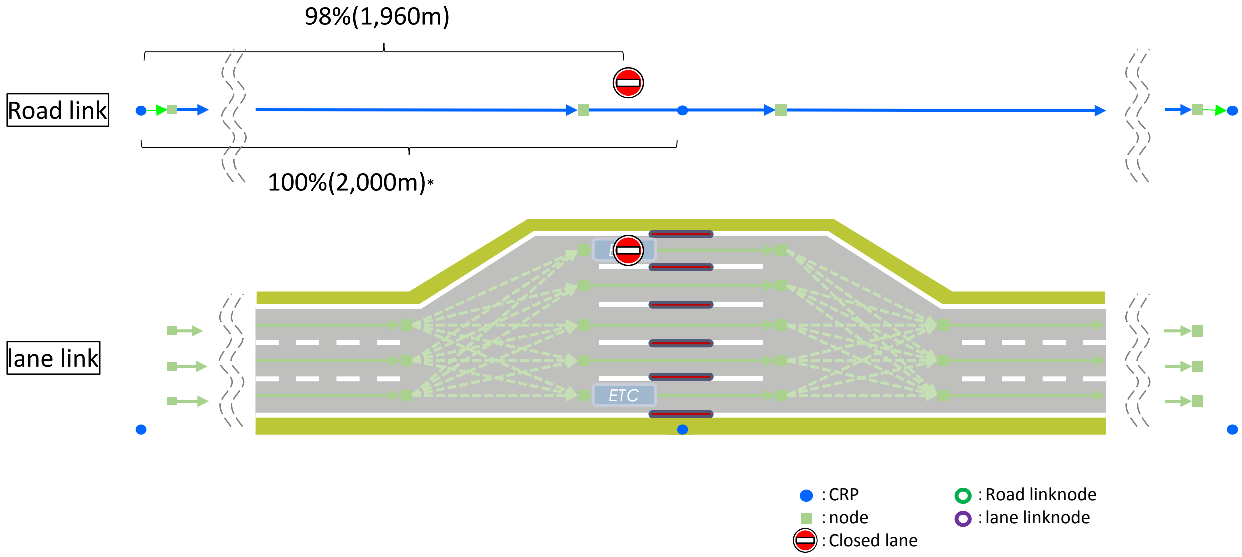
Type 4) Inside in a lane

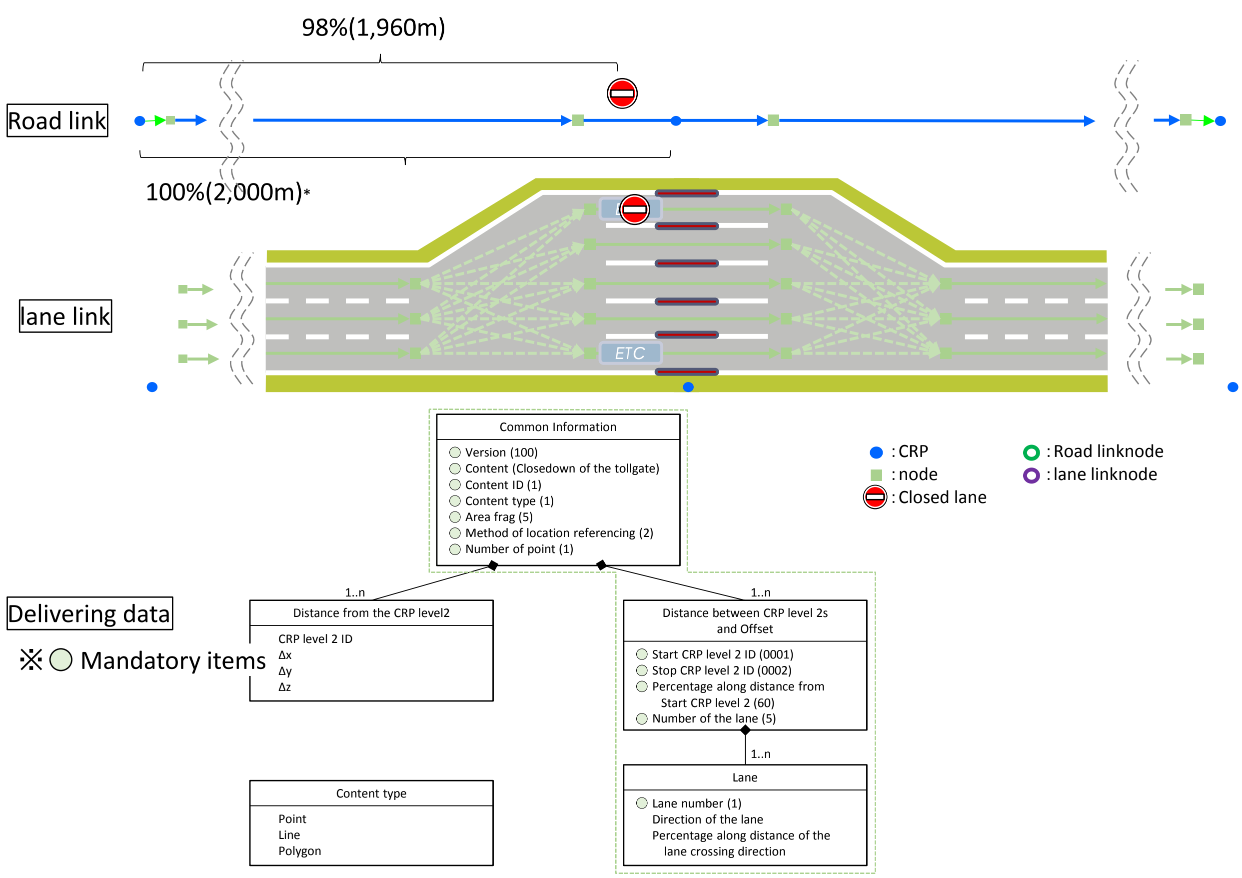


Type 5) In an intersection

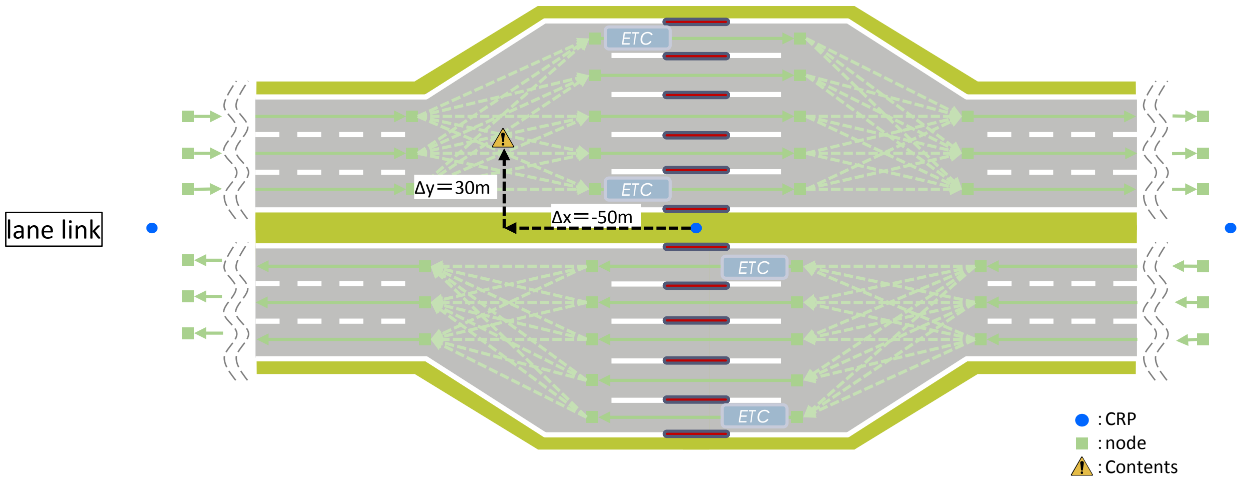


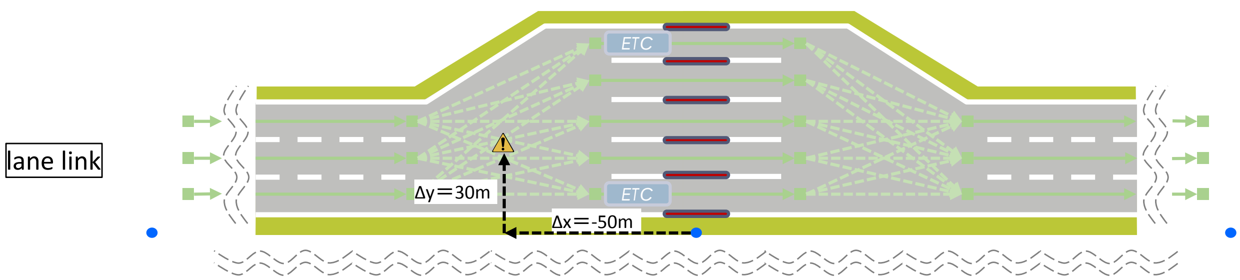
Type 6) Toll gate

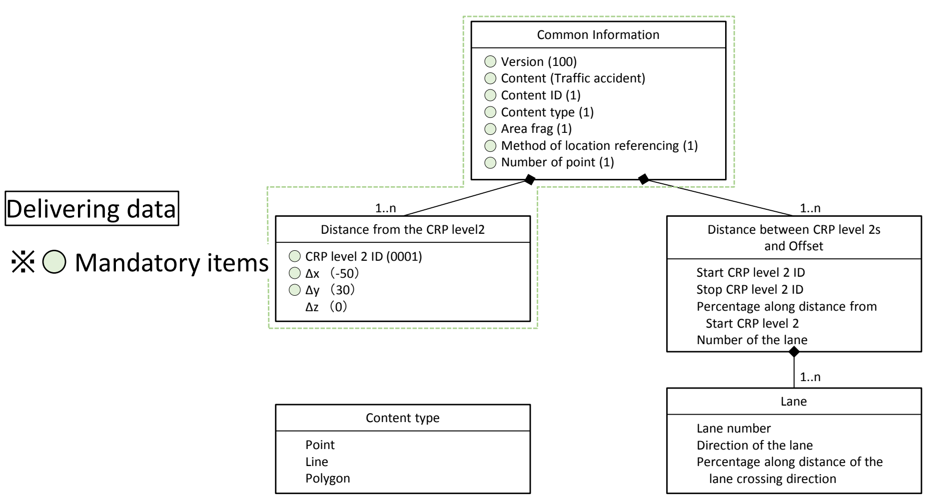




Type 7) Accident around a tall gate







3. Requirements for a lane-level location referencing system

General requirements for a location referencing had already defined in ISO17572 Part1. On this paper, the authors had tried to define additional requirements for a lane-level location referencing system. There are four additional requirements are defined.

R-1. A Lane-level location reference will have an accuracy with location measurement errors of $\sigma<25$cm. It is likely that maps will be used in conjunction with in-vehicle sensor information. That being the case, the map and the in-vehicle sensor must have equivalent locational accuracy. For instance, if the vehicle needs to detect an object of 1 meter in width, the effective detection distance will be 200 meters with current in-vehicle sensor technology and the required relative accuracy at the distance of 200 meters will be ±1m. Depending on the map, accuracies with location measurement errors of $\sigma<25$cm will be required for the in-vehicle sensor to be accurate as the map. This is because 4σ falls within a measurement error of roughly 1 meter. .

R-2. A Lane-level location reference will take into account the situation that some of the senders/ receivers may not have lane information. When the sender and the receiver are different entities, they may use different provider maps. In such a case, because the accuracy of the maps may differ, it will become necessary to determine a common location referencing rule.

R-3. A lane-level location reference will express location reference under 3-dimensional circumstances taking into account traverse banking. Location referencing on the map will be possible even when banking exist.

R-4. A lane-level location reference will take into account that coordinate values may be off-point due to change over the years. For instance, it has a(n) (Earth's) crustal movement of 20 cm/year in some point in Japan, so there may be discrepancies between the true location determined in real-time with a high-accuracy GPS and the location on a map created in the past.

4. General Concept of the system

This method is being adopted for lane-level location references, a level that allows for location referencing within lanes. Location referencing via this method will assume the use of CRP (Common Reference Point). A CRP is a virtual point that is able to be referenced by the relative locations with regard to real-world geographic objects. CRP contains locational information and ID. When using this method for location referencing, the following condition will apply: The locational information and ID of the CRP will be shared by the sender and receiver of the locational information in advance.

When locational information would like to be sent for an event, the sender will send the receiver the nearby CRP ID and the relative locational information from the CRP. By doing so, the sender and receiver will be able to reference the event location on their mutual maps even if they have different maps. (See Figure 1)

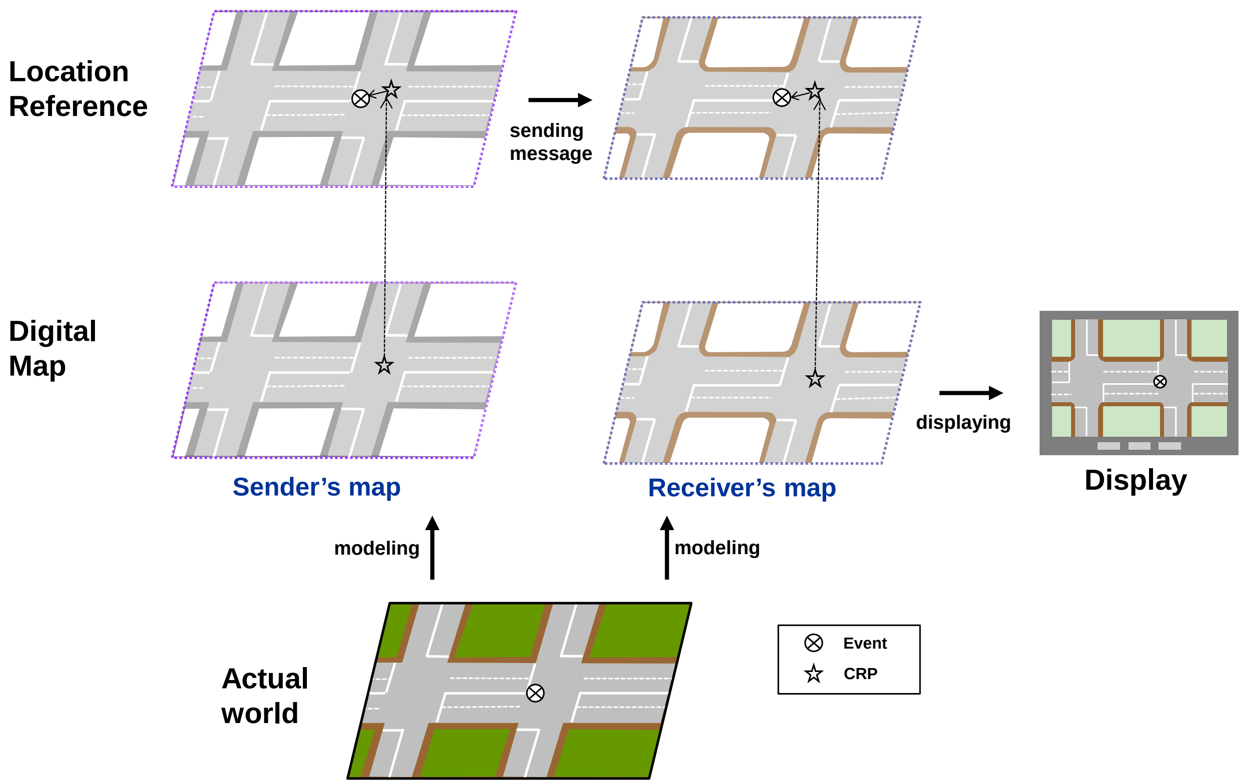


Figure 1 Concept of location referencing using CRP

There are two (2) ways to reference location that use this method (method 1 and 2 described below). Method 1 will be used in locations that require accuracies with location measurement errors of σ<25cm, while method 2 will be used for all other locations.

(Method 1) Delta from the CRP

(Method 2) Distance between CRPs and Offset

(Method 1) Delta from the CRP

The location will be referenced by using the incremental distance from CRP (Δx, Δy, Δh). In order to achieve an accuracy with location measurement errors of σ<25cm when using this method, the following condition will apply:

The location will be referenced by using the incremental distance from CRP (Δx, Δy, Δh).

(Method 2) Distance between CRPs and Offset

The location will be referenced by using distance between CRPs (the distance from the starting

CRP within the distance between the CRPs) and offset.

As a general rule, the distance between CRPs will be measured along the centre line of the route. Furthermore, the travel distance representation will not be uniquely defined.

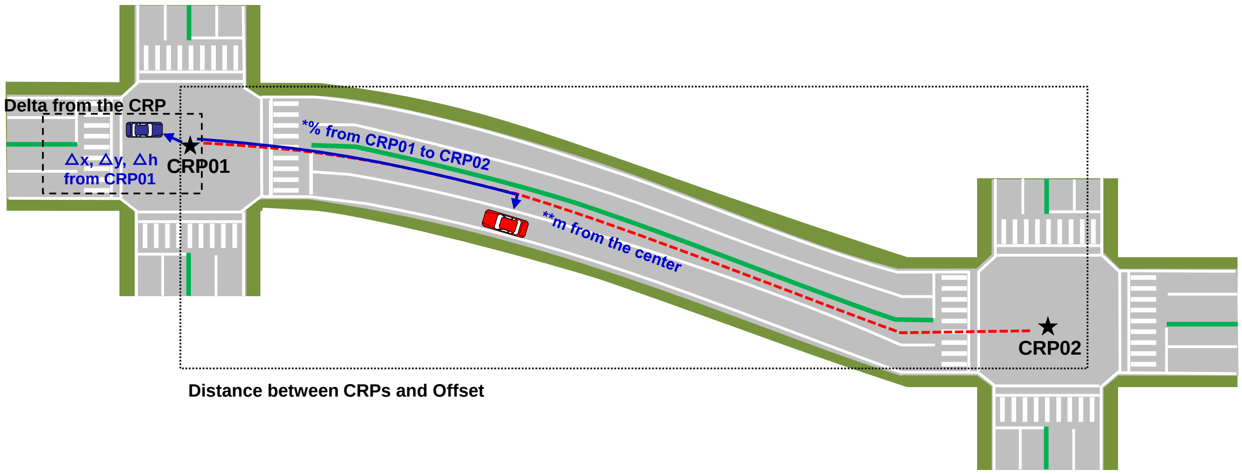


Figure 2 Explanation of lane level location referencing

5. Definition proposal of CRP

CRP is defined to be a virtual point that is referenced using the relative distances from real geographic objects. It contains locational information and ID. AP(Anchorage Point) is a geographic point that represents the geographic objects which exists on the road that is defined on both the sender and receiver's maps. The geographic objects to which they belong have the following characteristics:

- Actual objects/features that rarely change.
- Objects/features that are detectable from vehicles using sensors (lasers, cameras, etc.) under ideal circumstances.

(An) AP(s) is/are used to construct CRP(s) on maps which will become the basis for referencing locational information. CRP will be the basis for referencing the locational information of events in which determining high accuracy location is desirable. CRP will be shown by the relative distance(s) from AP(s). Furthermore, it is desirable to have the CRP constructed from at least two (2) APs given the possibility of situations such as the following:

- A geographic object that is to be an AP is destroyed by phenomena such as accidents.
- The AP may not be able to be detected from the vehicle from certain directions.

Figure 3 indicates the relationship between AP and CRP and the elements they contain. Furthermore, the latitude, longitude, and height of the CRP is a definite location and will be used as reference values in determining most locations on a map.

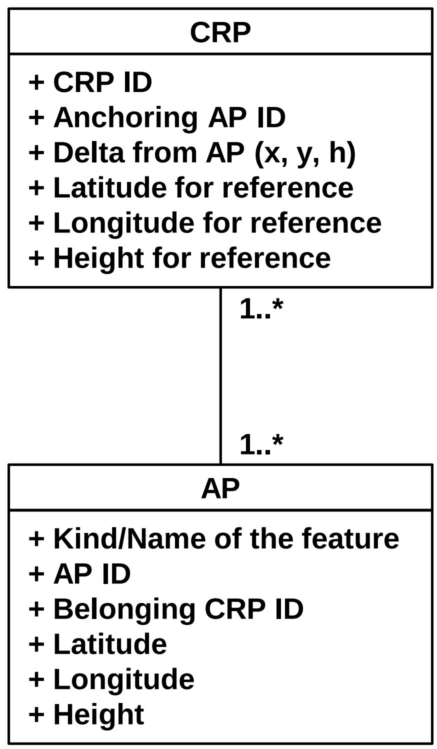


Figure 3 Data structure proposal of CRP

5 Specification proposal for contents delivering message

The data structure of lane-level location references is shown in Figure 4. There are two (2) ways to reference location that use this method (method 1 and 2 described below). Method 1 will be used for locations that require accuracies with location measurement errors of $\sigma<25$cm, while method 2 will be used for all other locations. Both location referencing methods contain point, linear, and polygon information.

(Method 1) Delta from the CRP

The sender of the locational information will send the CRP ID(s) necessary for location referencing and the incremental distance from the appropriate CRP(s).
In defining the incremental distance, the CRP will be defined as the origin, the positive Y-axis will extend

northward from the CRP, the positive X-axis will extend perpendicular to the Y-axis to form the coordinate plane, and Δx and Δy will be measured from the origin. Positive Δh will be defined as the direction opposite that of gravity with the road surface as the origin. All incremental distances will be measured in meters. The receiver of the location information will determine the location of the event from the incremental distance from the appropriate CRP(s) on its own map by referencing the CRP ID(s) received.

(Method 2) Distance between CRPs and Offset

The sender of the locational information will send the Start CRP ID, Stop CRP ID, Percentage along distance from start CRP, Offset direction, and Offset distance meter, and Direction of the road. Furthermore, the transfer of Position on the road and Number of the lane will be optional. This is because a standardized definition of these elements is difficult to establish due to differences in each country's road structure.

The determination of Start CRP and Stop CRP will use Direction of the road. The two (2) points nearest in the forward and backward direction of Direction of the road from the location referencing point will be Start CRP and Stop CRP. Of the two (2) CRPs, the point closer to the location referencing point will be Start CRP.

Furthermore, the forward and backward direction of Direction of the road will not be dependent on the directions used in highway operation.

The receiver will determine the location of the event sent from the information received, Start CRP ID, Stop CRP ID, Percentage along distance from start CRP, Offset direction, and Offset distance in meter. In cases that involve multi-lane roads, Number of the lane is used to determine in which lane the event is located.

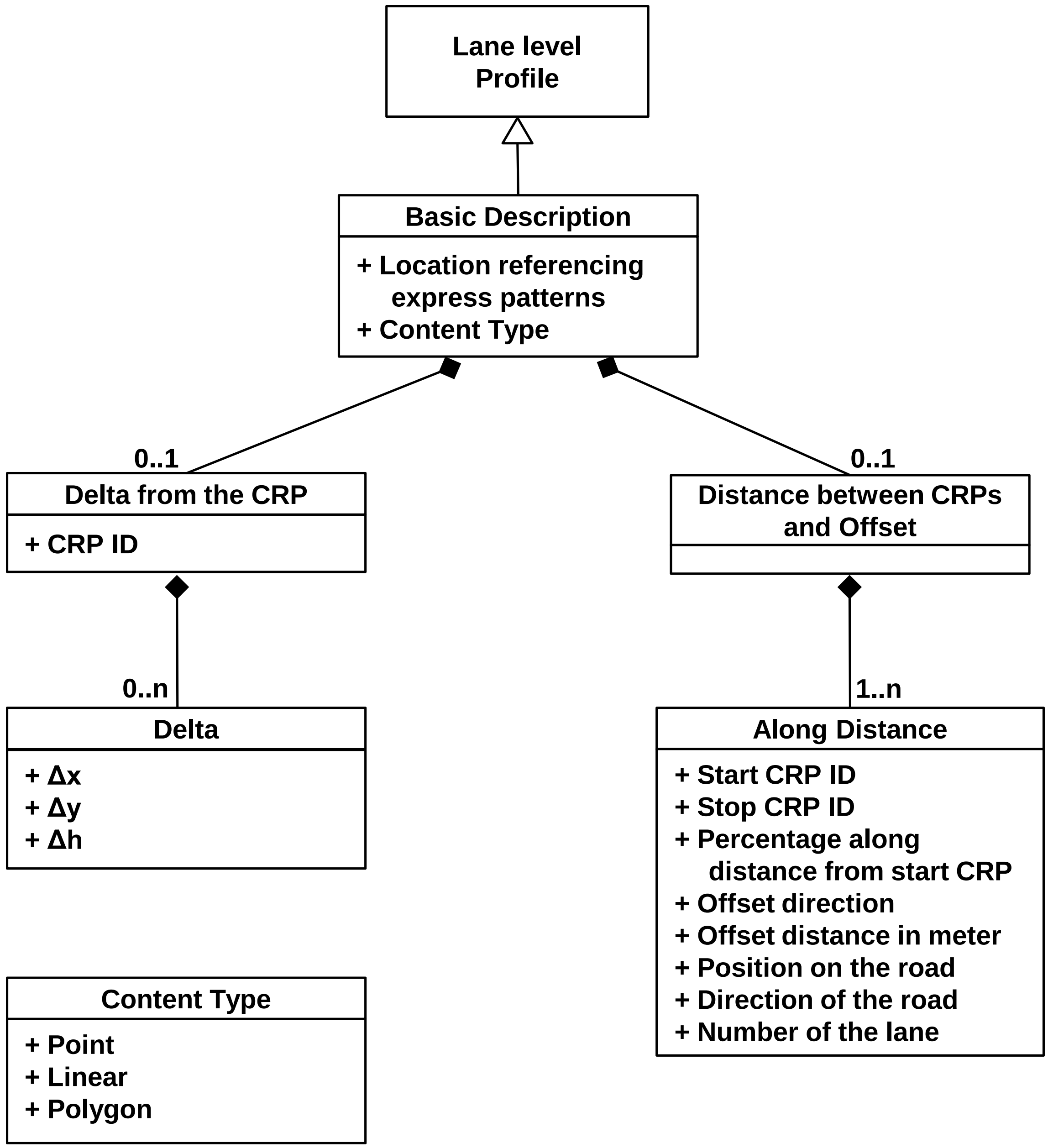


Figure 5 Contents delivering message data structure proposal

6. Conclusion

In this paper, the authors briefly discuss the basic concept of lane level location referencing method. To realize and to be widely used in the world, it will be necessary to enhance the discussion between various kinds of experts related to location information and autonomous driving. It will be needed to standardize this method officially internationally is also needed.

To make this method useful, at least two challenges of the following should be conquered.

First is the definition for distinguish the lanes. At this moment, the proposed data structure contains the element of lanes but the details are not defined yet. This part should be clearly defined.

Second is the definition for deploying for CRPs and APs. In this paper, the concepts of CRP and AP are described but how to deploy to the real world is sitill remaining as a challenge. A rule should be defined under real world field test.

References

1) ISO 17572-1:2015, *Intelligent transport systems (ITS)* -- *Location referencing for geographic databases* -- *Part 1: General requirements and conceptual model,* 2015

2) ISO 17572-2:2015 *Intelligent transport systems (ITS)* -- *Location referencing for geographic databases* -- *Part 2: Pre-coded location references,* 2015

3) ISO17572-3:2015 *Intelligent transport systems (ITS)* -- *Location referencing for geographic databases* -- *Part 3: Dynamic location references,* 2015

4) ISO 19148:2012 *Geographic information* -- *Linear referencing,* 2012

5) Satoru NAKAJO, -*Personal Perspective*- *Location Referencing for lane level information*, ISO/TC204/WG3 meeting, 13 October 2015 (Personal Access)

6) Satoru NAKAJO, Ryosuke SHIBASAKI, *Realizing for Lane Level Location Referencing*, 13th ITS Symposium in Japan, 3 December 2015 (Japanese)

7) Ryuichi IMAI, Satoru NAKAJO, Mitsuaki MATSUYAMA, Koichi SHIGETAKA, Minoru ISHIDA and Takahiko HAMADA, *Location Referencing Method for Distribution for Various Road Related Data*, April. 2012, Journal of Japan Society of Civil Engineers. (Japanese)

8) Kees WEVERS, *Transport Network ITS Spatial Data Deployment Platform Purpose, status and prospects*, Joint UNECE-Belgium Workshop on ITS, 18 November 2014