CSIS Discussion Paper No.142

A Proposal for Lane Level Location Referencing

Satoru NAKAJO*, Ayako MIURA, Takeshi DOIHARA*, Ryosuke SHIBASAKI***

*Center for Spatial Information Science, The University of Tokyo

Cw503 4-6-1 Komaba Meguro-ku Tokyo Japan 153-8505

Tel: +81-3-5252-6412 snakajo@csis.u-tokyo.ac.jp

**Research Center for Advanced Science and Technology, The University of Tokyo

Abstract

The needs for precise location information exchange is increasing such as for autonomous 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, Autonomous Driving

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, 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. Constituents of Location Referencing Specification

2.1 Concept of Location Referencing Method

The basic concept of location referencing method the authors proposing is as described in bellow. First, the "standard" used when performing location referencing at the lane level is incorporated in a portion of the dynamic map. It does not necessarily have an independent layer for the location referencing Method. This means that sharing of this Method by both the information sender and information receiver makes it possible to reliably perform location referencing at a level that prevents lane errors at a location accuracy of about 25 cm.

Second, defining the method so as to enable location referencing at each of "straight segments" and "junctions/intersections". This means that when performing location referencing at the lane level, the location referencing method used at each road site is presumed to differ. The IDs and locations (profiles) of roadway links (straight segments) and common reference points (junctions/intersections) will be defined corresponding to each location referencing method. The aforementioned location referencing method is able to coordinate with geometry as well as topology at the lane level on a dynamic map.

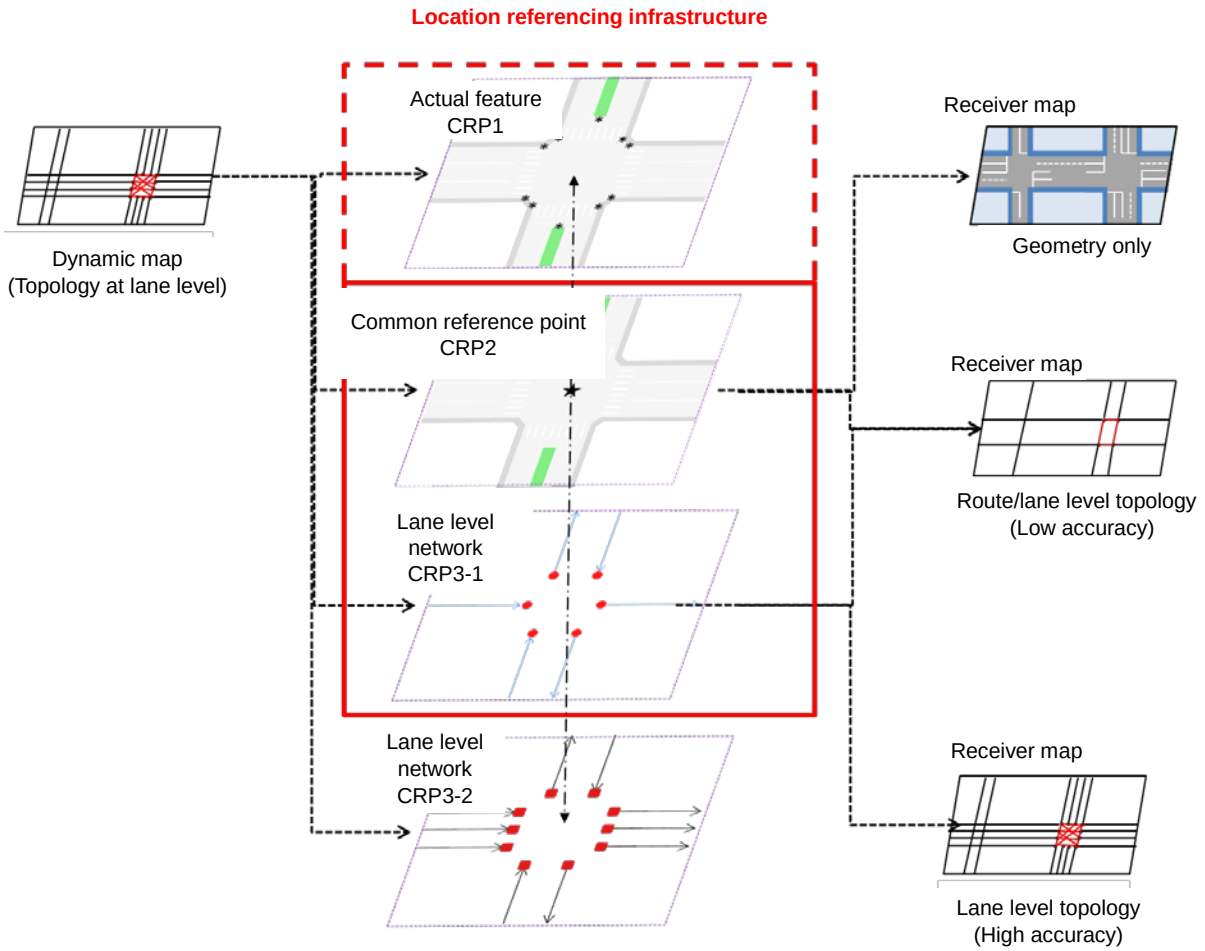


Figure 1 Exchange of Information Mediated by Location Reference Method (concept)

2.2 **Constituents of Location Referencing Specification**

The method needs the components of "links at the roadway level (ID + profile)" + "common reference points (CRP) of junctions/intersections (etc.)". The brief definitions of each component are as follows.

Links at roadway level (ID + profile) is that used to express location as "distance traveled from endpoint" + "lane information" on "straight segments"

CRP (ID + relationship with actual feature + (+ latitude and longitude)) is that used as common reference points of endpoints of "straight segments" and "junctions/intersections" (road sites where links at roadway level are not present). The CRP has multiple levels.

CRP present in the location referencing Method is composed of the three levels indicated below. As a result, together with affixing a point on a map, location information on geometry and topology (road section ID system level, roadway level, lane level) can be converted.

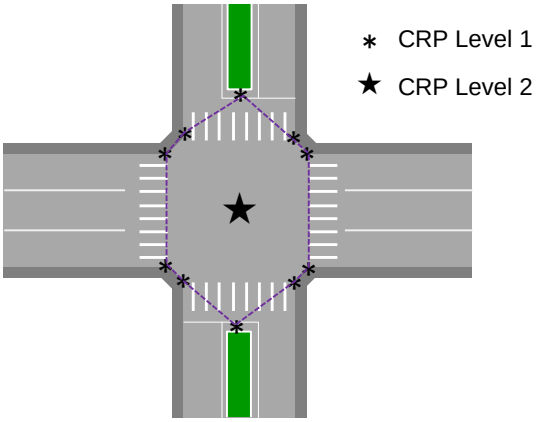
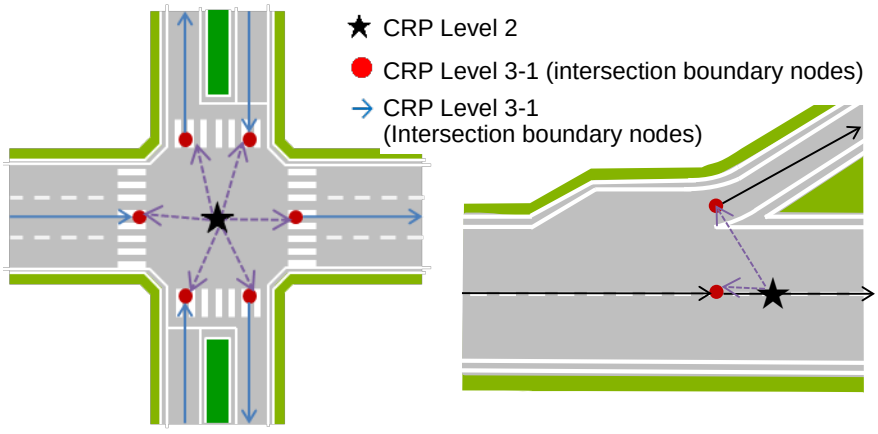
Table 1 Definition of CRP (Common Reference Point)

CRP Level	Purpose of Use	Definition
Common Reference Point (CRP) Level 1	Used to correlate between location referencing Method and geometry map	Points obtained from features having the following characteristics: ・Structures exhibiting little change ・Structures detectable from vehicles using lasers or cameras
Common Reference Point (CRP) Level 2	Points used as origins (common reference points) when representing locations at intersections and junctions. Points for correlating between road segment ID system, roadway link endpoints and lane link endpoints.	Points obtained virtually generated from points composing CRP level 1. Correlated with referencing point of road segment ID system.
Common Reference Point (CRP) Level 3-1	Points used as origins when representing locations on straight segments (intersection boundary nodes), and links for specifying applicable roadways (roadway links).	Network at roadway level composed of intersection boundary nodes and roadway links
Common Reference Point (CRP) Level 3-2	Points used as origins when representing locations on straight segments (intersection boundary nodes), and links for specifying applicable lanes (lane links). * Included in dynamic map but not used for location referencing Method	Network at lane level composed of intersection boundary nodes, profile line nodes and lane links.

2.3 **Relationship between CRP levels**

CRP are correlated in order from level 1 (actual feature) to level 2 (virtual point) to level 3-1 (virtual point (or actual feature)). The relationships between different CRP levels are defined as follows.

Table 2 Method Used to Correlate between CRP level 1 and CRP level 2

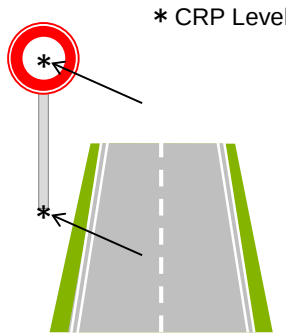
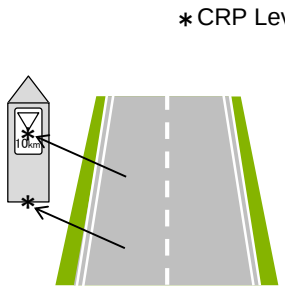
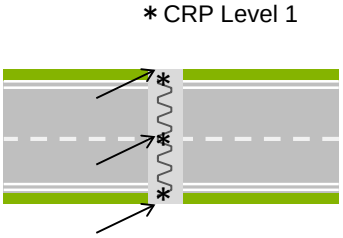
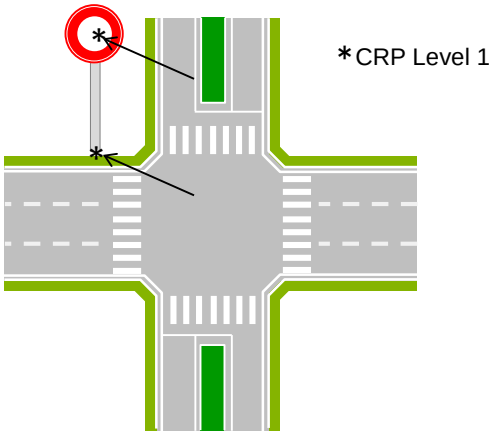
<table>
<tr><th colspan="3">Correlation Method</th></tr>
<tr><td>CRP
Level 1</td><td>CRP
Level 2</td><td>* A CRP level 2 point is generated virtually from points composing CRP level 1
 
</td></tr>
<tr><td>CRP
Level 2</td><td>CRP
Level 3-1</td><td>(Example 1) Designation of intersection boundary nodes of CRP level 3-1 using polar coordinates from CRP level 2
 

(Example 2) Generation of correspondence table between points of CRP level 2 and intersection boundary nodes of CRP level 3-1</td></tr>
</table>

2.4 **Definitions of CRPs**

A proposal for definitions of CRPs is as follows.

Table 3 Definitions of CRP Level 1

Constituent	Installed Location	Proposed Definition	
Common Reference Point (CRP) Level 1	Straight segments	Road sign 	・Location where road sign column contacts ground ・Location in center of road sign *Represented with positional coordinates (x,y,h)
		Distance marker (map point) 	・Location where distance marker contacts ground ・Location in center of distance marker *Represented with positional coordinates (x,y,h)
		Seams in road bed 	・Midpoint of seam center line ・Intersection between curb and seam center line *Intersection between curb and seam center line
	Intersections	Road signs 	・Location where road sign column contacts ground ・Location in center of road sign *Represented with positional coordinates (x,y,h)

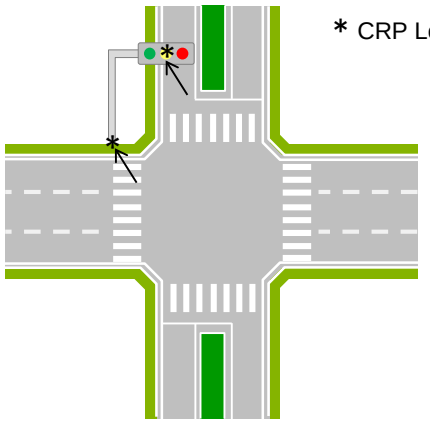
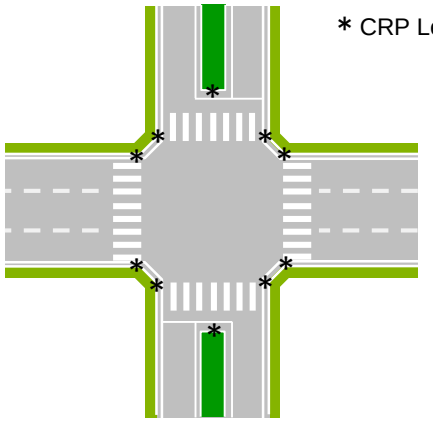
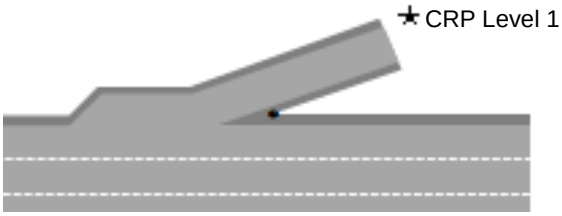
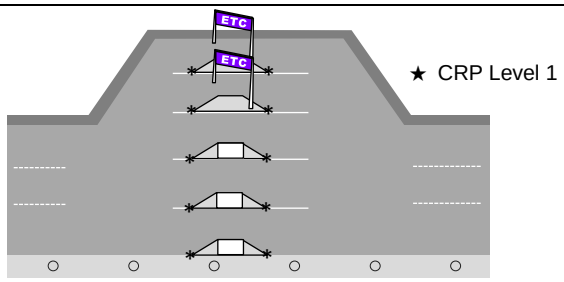
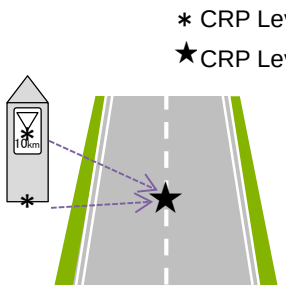
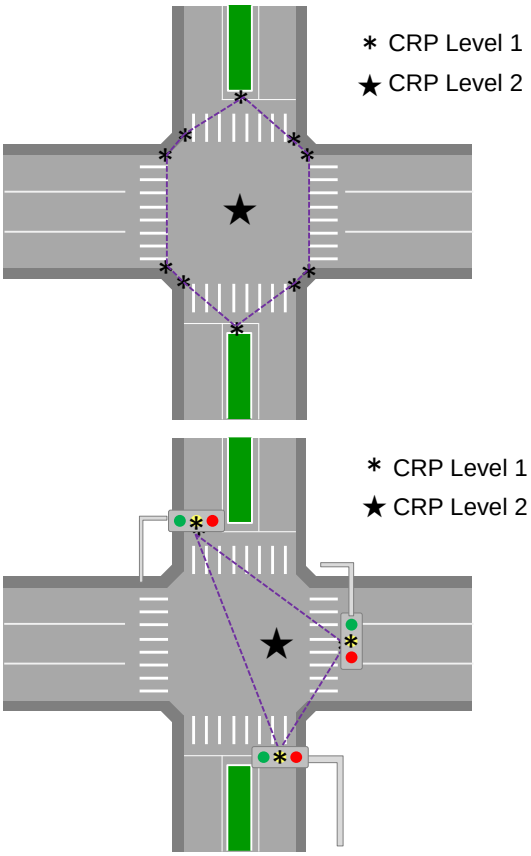
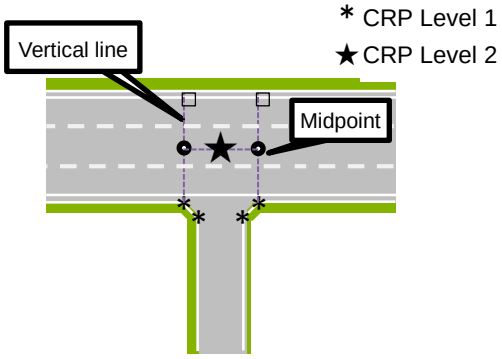
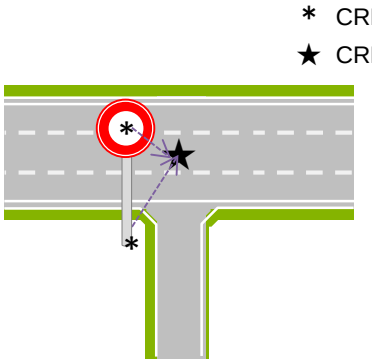
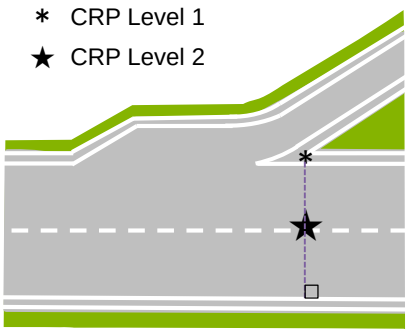
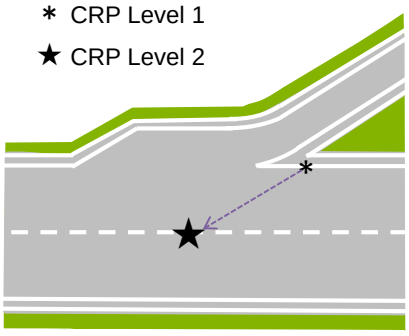
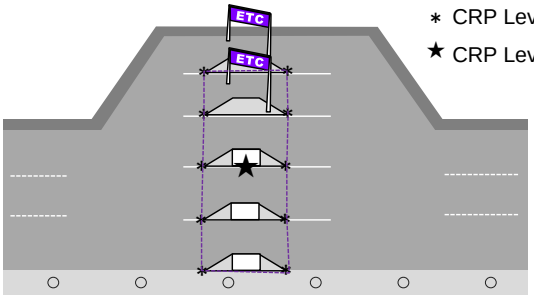
		Traffic signals  	・Location where light contacts ground ・Location in center of light *Represented with positional coordinates (x,y,h)
		Curb/Median strip  	・Apex of median strip ・Junctions of curb straight portion and curved portion *Represented with positional coordinates (x,y,h)
	Junctions/ branches	 	・Apex of concrete structure installed at back portion of striped traffic paint pattern of junctions and branches ・Impact absorbers (hard nose) *Represented with positional coordinates (x,y,h)
	Toll booths	 	・Apices of concrete structures on islands that compose toll booths

Table 4 Definitions of CRP Level 2

Constituent	Installed Location	Proposed Definition	
Common Reference Point (CRP) Level 2	Straight segments	Generated with polar coordinates from CRP level 1 	・Designation of polar coordinates from points composing CRP level 1 (distance marker) *Performed in conjunction with direct retention of positional coordinates of CRP level 2 on dynamic map
	Planar intersections	Generated as planar center of gravity 	・(Upper illustration) Planar center of gravity generated from points composing CRP level 1 (curb, median strip) ・(Lower illustration) Planar center of gravity generated from points composing CRP level 1 (locations of center lights of traffic signals)

	Linear intersections	Example 1) Generated as line midpoint 1)  Example 2) Generated with polar coordinates from CRP level 1 	・(Example 1) Midpoint of line connecting midpoints of vertical lines extending from points (curb) composing CRP level 1 ・(Example 2) Designation of polar coordinates from points compositing CRP level 1 (location where road sign column contacts ground or location in center of road sign surface)
	Junctions/ branches	Example 1) Generated as line midpoint  Example 2) Generated with polar coordinates from CRP level 1 	・(Example 1) Midpoint of vertical line extending from CRP level 1 (hard nose) ・(Example 2) Designation of polar coordinates from CRP level 1 (hard nose)

	Toll booths	Generated as planar center of gravity  	・Planar center of gravity generated from points composing CRP level 1

3. **Proposal for a location information distribution specification to be standardized**

A proposal for a location referencing information distribution specification is shown on bellow.

Use of contents distribution specifications capable of being represented by both latitude and longitude (geometry) and ID (topology). A location can be represented with either information alone if only one element is sent. In the case both elements are sent, the receivers use the information that is easier to use corresponding to the objective.

The use of ID is proposed for "straight segments" while the use of latitude and longitude is proposed for "junctions". It is desired to be able to determine whether or not latitude and longitude has been corrected (map matching) with the location referencing Method in the case of having decided to use latitude and longitude directly instead of using a method based on common reference points + polar coordinates (one of the methods stipulated in linear referencing of ISO19148) at junctions and branches (in consideration of the wide use of position representation according to latitude and longitude).

The method shall have an ability to represent points, lines and planes.

The description of definition of latitude and longitude WGS84 used in GPS will be used for the coordinate system and coordinates will be processed up to 10^{-7} significant digits. Although values will undergo location specification alone, it will be possible to determine whether or not values have been corrected (map matching) with the location referencing Method (dynamic map).

The description of definition of ID is as follows. Composed of lane link + distance traveled from end point + lane information (total number of lanes + number of oncoming lanes as viewed from left in the direction of travel). Lane link ID will be correlated with road section ID method (so as not to change frequently)

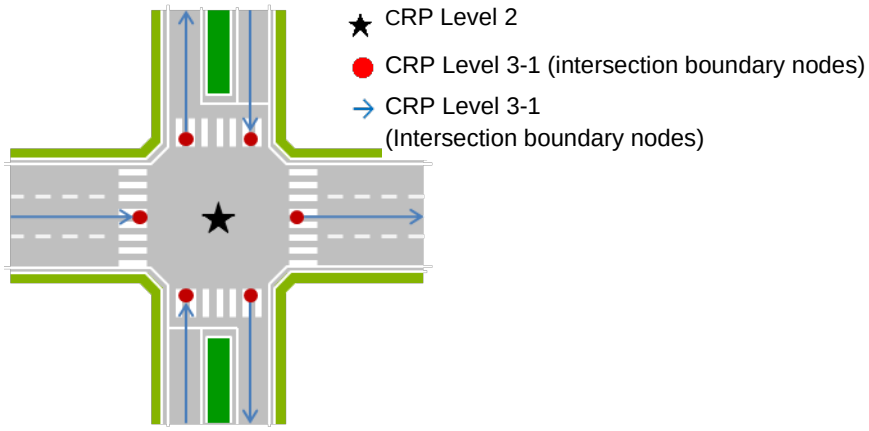


Figure 4 Concept of Location Referencing Method

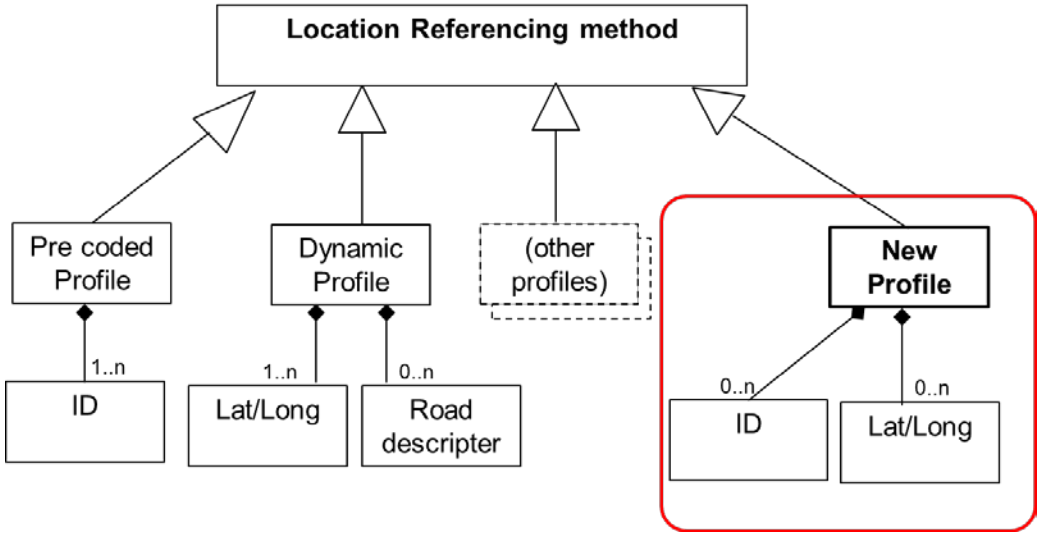


Figure 4 UML of the proposed location information distribution Specification

4. **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 shall be necessary to enhance the discussion between various kinds of experts related to location information and autonomous driving. It shall be needed to standardize this method officially internationally is also needed.

References

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