Object Quality in the Context of the ETSI Collective Perception Service

Request for Quotation

CAR 2 CAR Communication Consortium

About the C2C-CC

Enhancing road safety and traffic efficiency by means of Cooperative Intelligent Transport Systems and Services (C-ITS) is the dedicated goal of the CAR 2 CAR Communication Consortium. The industrial driven, non-commercial association was founded in 2002 by vehicle manufacturers affiliated with the idea of cooperative road traffic based on Vehicle-to-Vehicle Communications (V2V) and supported by Vehicle-to-Infrastructure Communications (V2I). Today, the Consortium comprises 88 members, with 13 vehicle manufacturers, 33 equipment suppliers and 28 research organisations.

Over the years, the CAR 2 CAR Communication Consortium has evolved to be one of the key players in preparing the initial deployment of C-ITS in Europe and the subsequent innovation phases. CAR 2 CAR members focus on wireless V2V communication applications based on ITS-G5 and concentrate all efforts on creating standards to ensure the interoperability of cooperative systems, spanning all vehicle classes across borders and brands. As a key contributor, the CAR 2 CAR Communication Consortium works in close cooperation with the European and international standardisation organisations such as ETSI and CEN.

Disclaimer

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Outstanding Issues

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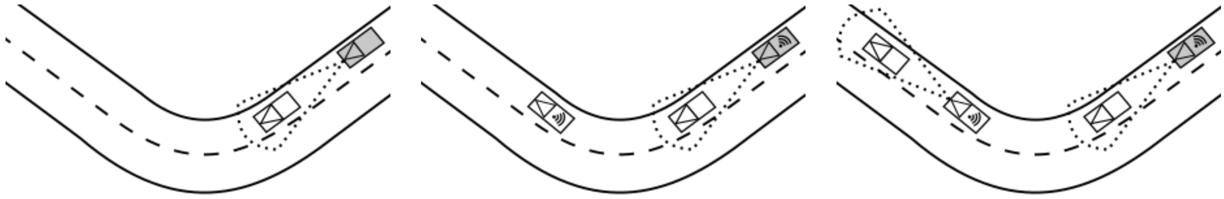
1 Introduction



(a)
Locally perceived objects for the gray vehicle

(b)
Locally perceived objects and received objects by V2X communications for the gray vehicle

(c)
Collectively perceived objects by the gray vehicle

Figure 1

The concept of Collective Perception by means of exchanging sensor information. (🛜 indicates a V2X enabled vehicle). White vehicles are known to the gray vehicle in the displayed configuration [RD-1]Fehler! Es wurde kein Textmarkenname vergeben.

As part of the ongoing standardization activities at the ETSI ITS Group, the CG 1 (Applications) is currently working on two work items related to what is known as the concept of Collective Perception.

In the context of V2X communications, Collective Perception aims at sharing information about detected objects by an ITS-S (e.g. by means of its own perception sensors) with other communication enabled traffic participants.

The currently defined message formats at ETSI merely focus on sharing information about the transmitting ITS-S itself: messages such as the CAM [AD-1] are designed to encapsulate the dynamic state and the properties of the disseminating ITS-S.

Data about the vicinity and the current driving environment of the transmitter, however, are not shared.

Although these ITS-Ss may be equipped with local perception sensors such as radar, lidar, camera systems and alike, information about other detected objects (e.g. vehicles, pedestrians, obstacles, debris, etc.) is not shared with other ITS-Ss within communication range.

Figure 1 details the concept of Collective Perception. In Figure 1 (a) the gray vehicle only perceives one object in front due to its on-board local perception sensor.

In Figure 1 (b), the gray vehicle is additionally aware of a second vehicle located outside of its current perception range due to V2X communications.

In case of the V2X vehicle being equipped with a local perception sensor itself, such as depicted in Figure 1 (c), the concept of Collective Perception enables this vehicle to share its detected object with other V2X-equipped vehicles as well.

The concept can be extended beyond vehicle-mounted sensors: infrastructure components can also actively share information about detected objects. Sensors mounted above an intersection provide the benefit of an extended field-of-view compared to vehicle-mounted sensors and an increased accuracy due to their well-known origin. Furthermore, infrastructure-mounted sensors provide the opportunity for specific adaptation of the sensor field-of-view to Vulnerable Road Users, e.g. by monitoring areas around pedestrian crossings.

The ETSI work items TR 103 562 [AD-2] and TS 103 324 [AD-3] provide reasoning and specification for the Collective Perception Service. The documents specify a novel message format that is used for the purpose of exchanging detected objects between ITS-Ss: the CPM. The message itself contains several containers that can be concatenated to convey information about the transmitting ITS-S, its sensory capabilities as well as its detected objects. Figure 2 depicts the basic structure of the CPM.

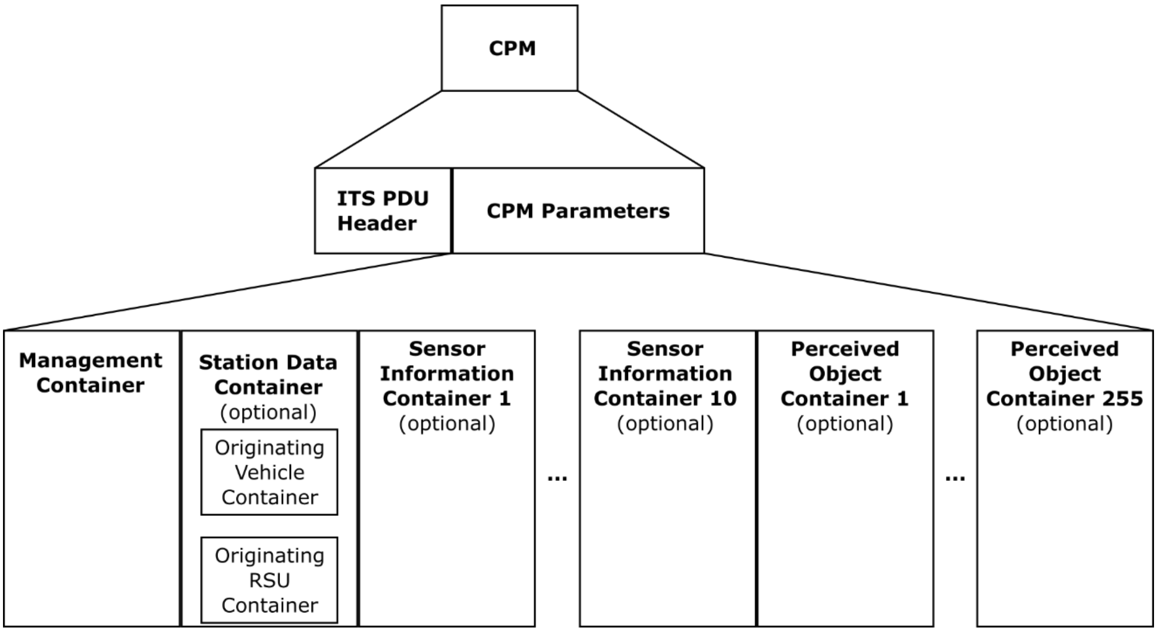


Figure 2
Basic Structure of the CPM [AD-2]

The *Management Container* thereby contains basic information about the transmitting ITS-S, such as the station type (e.g. vehicle, RSU, etc.) and the station's absolute position.

Further details such as the dynamic state or map-references of the disseminating ITS-S are provided as part of the *Station Data Container*.

Sensory capabilities of the disseminating ITS-S can be expressed by appending a *Sensor Information Container* which provides different methodologies for describing the range, aperture and position of the sensor.

Detailed information about the objects detected by the disseminating ITS-S are provided as part of the *Perceived Object Container*.

2 Data Quality in the Context of V2X Communications

A challenge associated to employing any sensor data, whether received from an on-board sensor or via V2X communications, is the quality associated to the received data.

Generally, data quality is a multi-dimensional concept [RD-2], [RD-4].

In the context of sensor data fusion systems and sharing of sensor data, this concept plays an even more important role as only data exhibiting a *high quality* can and will be used by the receiver's applications.

As such, the concept is also related to *trust*, as a receiver has to rely on the received data in case it cannot verify the integrity of the received information itself (e.g., by using its own on-board sensors).

In the context of V2X communications and standardized ETSI ITS-G5 message sets exchanged between ITS-Ss, data quality varies to a large extent for each received data element.

Data extracted from the CAM, for example, may be of very high accuracy in the case of being measured by an internal sensor, such as the disseminating ITS-S's speed, or in case it is a fixed property of the ITS-S, such as its length.

Even though these properties may be measured from an outside perspective, e.g. from a perception sensor attached to another ITS-S, inaccuracies will be associated to this measurement, thereby potentially degrading the application relying on information about other traffic participants.

Other information, however, may be more accurate when being measured from an external perspective.

An ITS-S's absolute position, for example, shared as part of the *Reference Position* data element of the CAM will be associated to some inaccuracy as a result of the GNSS.

Generally, applications utilizing the position information with respect to other traffic participants are less interested in the received global than in its relative position.

However, the latter can be computed by relating the receiving ITS-S's absolute position with the absolute position of the remote ITS-S [RD-3].

In the context of Collective Perception, in which data gathered about other traffic participants by a local perception sensor attached to a remote ITS-S but employed by a receiving ITS-S's applications, the concept of data accuracy and plausibility plays an even more prominent role.

It is thereby apparent that the better (i.e. more accurate) any ITS-S's positioning methodology and perception sensor capabilities, the less erroneous the resulting data on the receiver side.

Whilst positioning errors are usually expressed in the form of an error ellipse around the mean of a reported measurement, a common or even standardized measure for expressing the *data quality* of the measurement does not exist.

It is usually up to the sensor manufacturer and the sensor employer to agree on a measure for describing the quality of a reported metric.

When sharing information about detected objects between ITS-Ss of different manufacturers, it is therefore important to agree on a common methodology to describe data and object quality.

To both reduce the resulting message size (by including fewer objects) and increase information quality delivered by each received CPM, a data quality indicator can be used as a filtering mechanism on the transmitter-side.

Hence, only objects for which the computed quality metric is above a certain threshold will be included in the message.

Consequentially, the objective of this RFQ is to analyze existing approaches to harmonize interpretations for data quality in the context described above.

As a result, a suitable methodology should be identified and represented in a way that allows for a potential contribution of the findings to the ongoing standardization process.

3 Tasks

The following outlines potential tasks to be carried out.

3.1 Task 1: Analysis and Presentation of Existing Methodologies

- Introduction to the main concept of data quality in the context of sensor data fusion
- Literature review and comparison of different methodologies to express data / object quality and plausibility. Specifically, the review shall address the data elements and their requirements that are linked to expressing the quality aspect of a measurement.
- Assessment of the applicability of these methodologies to different sensor types as well as potential limitations (such as required computing power)
- Categorize methodologies in a suitable fashion
- Provide examples for existing core methodologies / metrics, if applicable
- Identification / Derivation of a suitable metric for data quality dimensions in the context of Collective Perception
- Assessment of applicability of existing data elements of the CPM for expressing data inaccuracies

3.2 Task 2: Computational Model / Proof of Concept

- Analysis of the current CPM format with respect to object quality dimensions
- Development of a computational model enabling simulations of the concept of Collective Perception for assessing the performance (e.g. resulting deviation of track from ground truth value) of the different identified / derived methodologies from Task 1. The number of methodologies to be analyzed has to be agreed upon with the contractee.
- Demonstration of the applicability of the developed concepts by utilizing different sensor data fusion methodologies
- Identification of applicable threshold-levels for the filtering mechanism outlined in Section 2.
- Assessment of the resulting information base on a receiving vehicle when filtering objects on the transmitter side based on the object quality indicator for different threshold levels
- Representation of the required changes to the existing CPM format to reflect the requirements of the developed concept (ASN.1 definition, report)

4 Provision of Commercial Offers

A proposal from an offering company/institute shall be submitted to the C2C-CC after 30 days from the publications of this RFQ and shall indicate:

- Short description of the offering company/institute demonstrating related expertise and/or preliminary involvement in similar investigation activities
- Description of how the identified tasks can be fulfilled (approaches, tools to be used, etc.)
- Work plan for completion including timeline for milestones achievement and deliverables provision
- Mode of work (e.g. bi-weekly progress / review meetings, options depending on the tasks, milestones, deliverables)
    - It has to be noted that the timeline of this RFQ has to comply with the timeline of the ETSI work items to this this work will contribute. The TR 103 562 [AD-2] has to be completed by end of October 2019. The work on the TS 103 324 [AD-3] will continue into early 2020.
    - It is therefore preferable to commence work from 06/2019. The work products shall be available by 12/2019.
- Project cost by detailing sub-costs associated to the execution of individual tasks

5 Appendix 1 – References

5.1 List of abbreviations

C2C-CC	Car 2 Car Communication Consortium
CAM	Cooperative Awareness Message
CG	C2C-CC Competence Group
CPM	Collective Perception Message
ETSI	European Telecommunications Standards Institute
GNSS	Global Navigation Satellite System
ITS	Intelligent Transportation System
ITS-S	ITS-Station
RSU	Road Side Unit
V2X	Vehicle 2 X Communication

5.2 Applicable documents

[AD-1] EN 302 637-2 V1.4.1 - Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service, Jan. 2019.

[AD-2] TR 103 562 - Intelligent Transport System (ITS); Vehicular Communications; Basic Set of Applications; Analysis of the Collective Perception Service (CPS), Sept. 2017.

[AD-3] TS 103 324 - Intelligent Transport System (ITS); Vehicular Communications; Basic Set of Applications; Specification of the Collective Perception Service (CPS), Jan. 2019.

5.3 Related documents

[RD-1] H.-J. Günther, O. Trauer, and L. Wolf. The Potential of Collective Perception in Vehicular Ad-hoc Networks. In 14th IEEE International Conference on ITS Telecommunications (ITST), 2015.

[RD-2] G. Cong, W. Fan, F. Geerts, X. Jia, and S. Ma. Improving data quality: Consistency and accuracy. In Proceedings of the 33rd international conference on Very large data bases, pages 315–326. VLDB Endowment, 2007.

[RD-3] C. F. F. Karney. Algorithms for geodesics. Journal of Geodesy, 87(1):43–55, Jan 2013.

[RD-4] J. E. Olson. Data quality: the accuracy dimension. Elsevier, 2003.

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