.ITS USE CASE	
Use Case Title:	Priority Request for the ITS-G5 context
Project Name:	Standaardisatie Tafel (NL)
Source:	Compass4D, ISO-19091, ETSI-TS103301, SAE-J2735
Date:	2015-11-25
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Abstract:	Use case description, functional and technical requirements and profiling of message sets for priority request.
Agenda Item:	None
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Document(s) Impacted:	Dutch Profile
Intended purpose of document:	☐ Decision ☒ Discussion ☐ Information ☐ Other <specify>
Decision requested or recommendation:	

Disclaimer

1.1 Use Case Priority Request

1.1.1 Introduction Use-Case

1.1.1.1 Use case ID

PR

1.1.1.2 Background

Priority Request addresses the generation and transmission of signal requests message and signal request status messages. Priority Request supports prioritization of public transport and public safety vehicles (ambulance, fire brigade, etc.) to traverse a signalized road infrastructure (e.g. intersection) as fast as possible or using a higher priority than ordinary traffic participants. The corresponding signal request messages are sent by an V-ITS-S to the traffic infrastructure environment (e.g. R-ITS-S, C-ITS-S) in a signalized environment (e.g. intersection) for requesting traffic light signal priority (typically for public transport) or signal preemption (typically for public safety vehicles). The Priority Request may not only be requested for the approaching signalized environment but also for a sequence of e.g. intersections along a defined path covering several intersections. In response to the request the infrastructure (single traffic controller R-ITS-S or traffic control centre C-ITS-S) will acknowledge with a status information if the request has been granted, cancelled or changed in priority due to a more relevant signal request (e.g. ambulance).

The following messages are used in this use case description:

- Cooperative Awareness Message (CAM)
- Signal Phase and Timing message (SPAT)
- Intersection topology message (MAP)
- Signal Request Message (SRM)
- Signal Status Message (SSM)

1.1.1.3 Objective

To improve safety, environment, traffic flow or for other reasons it can be advantageous to give priority to specific classes of vehicles.

1.1.1.4 Source

ETSI TC ITS, KennisPlatform Verkeer en Vervoer (KAV), DITCM architecture V1.0, ISO-19091, ETSI-TS103301, SAE-J2735, ETSI-CDD.

1.1.2 Description Use-Case

For emergency, safety, environmental, traffic flow efficiency and Business reasons it is advantageous to give priority to specific classes of road users (at the moment no other than road users are considered but waterway crossings with roads may be considered at some time). The level of priority will depend on the type of user. At this moment an initial prioritization is recognized resulting in the following:

- Emergency vehicles and motorcycles

- Public transport vehicles
- Special transportation such as heavy goods vehicles
- Other vehicles.

The priority in each of the classes is further defined depending on the class. For instance emergency vehicles do have active emergency and passive emergency states while public transfer may have more states, active duty or not and on time or not (possibly with a severity indicator). As for this class difference states for the other classes are also defined.

In this use case, all types of vehicles can request priority for an intersection or road section, and the traffic (light) controller determines in what way it can and will honour the request. Optionally, the requesting vehicle is informed about the action taken by the traffic light based on the request. This reply can be used to assist emergency vehicles in passing an intersection, but would also allow for heavy goods vehicles to calculate their fuel consumption reduction.

1.1.3 Target System (as applicable)

- R-ITS-S (linked to Traffic Light)
- C-ITS-S (linked to Traffic Control Centre)
- V-ITS-S (Priority requesting vehicle)

1.1.4 Implementation environment (as applicable)

Typically signalized intersections. Potentially also applied for restricted access bollards and barriers, special lane access or possibly even water bridges.

1.1.5 Actors (as applicable)

Traffic light controller (TLC) to process the priority request and to provide the necessary signal status data to the R-ITS-S.

Driver of priority requesting vehicle, for example: emergency vehicle, public transport vehicle, heavy goods vehicle.

Road operator, fleet operator, asset operator (e.g. restricted area or bridge).

1.1.6 Pre-conditions (if any)

- TLC is connected to R-ITS-S and can provide information on current and next phase, and signal status (i.e. priority) information.
- TLC is programmed with a variety of priority control schemes (e.g. early green, phase rotation, phase skipping, etc.), and with an intelligent algorithm for providing priority signal timing for priority requests.
- R-ITS-S is able to send information on the static topology of the signalised intersection. Optionally this static information is provided to V-ITS-S by other methods.
- V-ITS-S supports V2I services and can send information on priority request.
- R-ITS-S supports I2V services and can send information on signal phase and timing, and signal (priority) status.
- R-ITS-S supports validation and prioritization of requests from V-ITS-S's.

- V-ITS-S supports I2V services and can receive information on signal phase and timing.
- V-ITS-S supports transmission of priority request.
- The road operator has established a policy for priority control.

1.1.7 Triggers conditions (if any)

Current prioritizing techniques require a trigger point (x, y location). This is for example done within KAR for Public Transport and Emergency Vehicles priority requests to determine from what location a message is to be broadcasted. Depending on the choice of communication protocol (CAM or SRM) a location can be determined based on the included geolocation (CAM) or id number of the intersection the message is directed at. An predefined geolocation (fictional loop) is not needed.

1.1.8 Use-Case Diagram (if any)

This use case can be used via ETSI ITS-G5 and/or mobile internet (i.e. 3G/4G). For emergency vehicles the use case is safety related and therefore it is recommended to use ETSI ITS-G5 to ensure a fast and accurate message handling. For public transport the use case is more comfort orientated. Therefore message handling via mobile internet can suffice, though ETSI ITS-G5 could be advantageous. This profile focusses on Priority Request using ETSI ITS-G5).

1.1.9 Normal Flow (as applicable)

This profile defines two approaches for prioritization: legacy protocol migration (based on CAM and SPAT and new style protocol (based on SRM and SSM).

The former supports smooth migration from legacy prioritization systems (e.g. KAR) to cooperative systems. This allows to include old data messages, transported by CAM which includes the "publicTransport" container that allows the inclusion of legacy prioritization request data to be sent to the traffic light controller. For the prioritization status response the traffic light controller uses a "SPAT" data extension. The latter offers a more sophisticated procedure for signal request defined by the messages SRM and SSM which allows prioritization and pre-emption along one or more intersections.

In both approaches the V-ITS-S transmits relevant data such as the status of the vehicle, punctuality, line number and a reference to a signal group to a R-ITS-S. The R-ITS-S connected to the TCL receives this information and the TLC can decide the alter the signal phase timing in order to accommodate the request. To acknowledge the priority request the R-ITS-S will transmit a response including information that the request is granted or not.

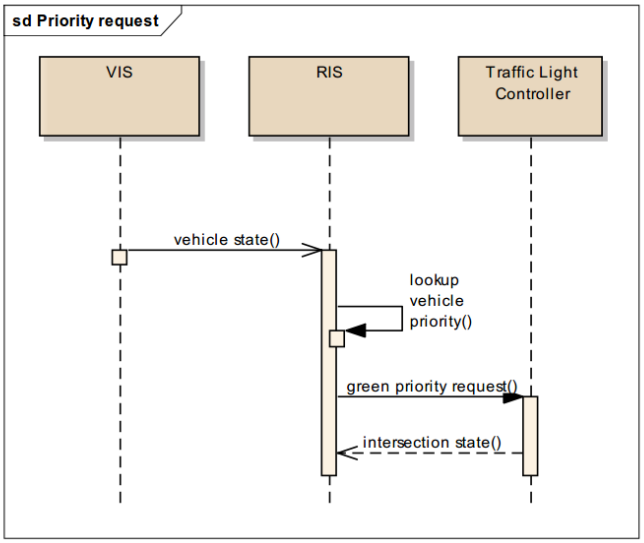

Figure 1: Sequence diagram Priority Request via cooperative communication.

1.1.9.1 Alternative flow (if any)

As an alternative to cooperative communication priority request information and signal phase and timing information can be transmitted via connected communication.

1.1.10 Post-conditions (if any)

Under the best conditions the priority requesting vehicle can traverse the signalized intersection without any interruption. As a means to cancel or close a priority request the V-ITS-S transmits information that allows the R-ITS-S connected to the TLC to determine that the vehicle has passed the intersection and can resume its normal operations.

At that moment the TLC initiates recovery operations to restore normal timing operation which might include appropriate coordination. Some recovery may include split time compensation to clear queues which might have formed on the phases that were adversely affected by the priority request. Notably, both the handling of priority requests and the recovery operations affect the accuracy of signal phase and timing information.

1.1.11 Termination conditions (if any)

There are a few termination conditions to be defined;

1. An Emergency Vehicle has changed its priority status when it no longer needs to use the light bar and siren and thus the made request isn't needed anymore.
2. A granted request for a Public Transport of Heavy Goods Vehicle is conflicted by a request with a higher priority (for example, from an Emergency Vehicle).
3. The TLC has a technical failure resulting in a reset or shutdown of the TLC while a granted priority request is pending from an Emergency Vehicle. It is foreseen that an "Approaching Emergency Vehicle" message shall warn approaching vehicles as a backup.

1.1.12 Use-Case Illustration (as applicable)

Most information in this section is taken from SAE J2735 [REF]. Due to publication restrictions of SAE-J2735 only a general description of SRM is provided. For a detailed description see the documents ISO-19091, ETSI-EN302637-2, ETSI-TS103301, SAE-J2735 and ETSI-CDD.

Priority request by CAM

For the request of signal prioritisation the CAM message contains the "publicTransportContainer" with the "ptActivation" data frame [REF]. This data frame is intended to include legacy prioritization protocols like the R09.16 used in Germany, Austria and Switzerland. As this data frame is defined as a "blob", other countries may include regional legacy protocols for public transport prioritization (e.g. KAR). In addition to the ptActivation data frame the CAM message also includes its ordinary data elements such as the position of the approaching vehicle, and its identity ("stationID").

* KAR (Korte Afstand Radio) – Current system usage in the Netherlands for priority requests for Public Transport and emergency vehicles. A short study comparing KAR and message sets mentioned here should indicate what aspects of KAR are already allocated within C-ITS which are not. On the basis of this study further action should be taken to achieve this use-case.

Priority response by SPAT

In existing legacy public transport prioritization systems, based on analogue radio communication, the only way for a response to the driver is the traffic light signal. For bidirectional information exchange the data frame "PrioritizationResponse" has been included to the European content of the regional extension.

The "PrioritizationResponse" contains a list of prioritisation responses which includes the information if the request is successfully assigned. The response contains the "stationID" of the requestor, the status of the traffic light prioritisation ("priorState") and the corresponding "signalGroupID" identifier, which relates to driving permission for the related manoeuvre.

Priority request by SRM

The Signal Request Message is a message sent by a V-ITS-S to the R-ITS-S at a signalized intersection. It is used for either a priority signal request or a pre-emption signal request depending on the way each request is set. Each request defines a path through the intersection which is desired in terms of lanes and approaches to be used. Each request can also contain the time of arrival and the expected duration of the service. Multiple requests to multiple intersections are supported. The requestor identifies itself in various ways (using methods supported by the RequestorDescription data frame), and its current speed, heading and location can be placed in this structure as well. The specific request for service is typically based on previously decoding and examining the list of lanes and approaches for that intersection (sent in MAP messages). The outcome of all of the pending requests to a signal can be found in the Signal Status Message (SSM), and may be reflected in the SPAT message contents if successful. The main data frames and data elements of the SRM message are shown in the figure below.

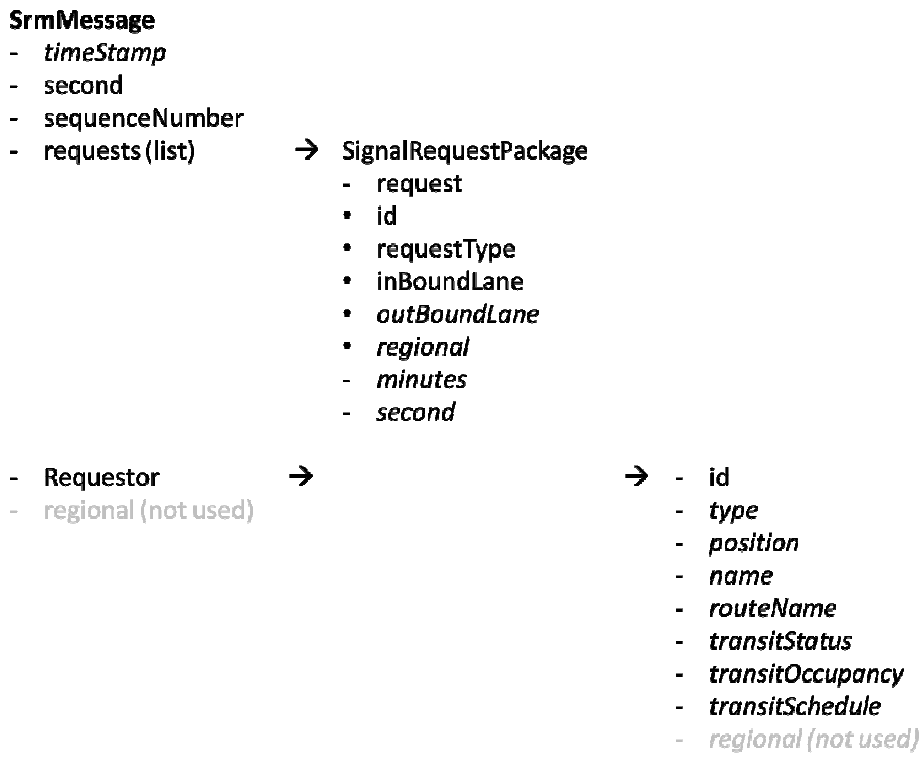

Figure 2: main DF and DE SRM message

Priority response by SSM

The Signal Status Message is a message sent by an R-ITS-S at a signalized intersection. It is used to relate the current status of the signal and the collection of pending or active pre-emption or priority requests acknowledged by the controller. It is also used to send information about pre-emption or priority requests which were denied. This in turn allows a dialog acknowledgment mechanism between any requester and the signal controller. The data contained in this message allows other users to determine their "ranking" for any request they have made as well as to see the currently active events. When there have been no recently received requests for service messages, this message may not be sent. While the outcome of all pending requests to a signal can be found in the Signal Status Message, the current active event (if any) will be reflected in the SPAT message contents. The main data frames and data elements of the SRM message are shown in the figure below.

SsmMessage
- *timeStamp*
- *second*
- *sequenceNumber*
- status (list) → SignalStatus
- regional (not used)

SignalStatus
- sequenceNumber
- id
- sigStatus (list) → SignalStatusPackage
- *regional (not used)*

SignalStatusPackage
- *Requestor* → id
- inBoundOn → request
- *outBoundOn* → sequenceNumber
- *minutes* → *role*
- *second* → *typeData*
- *duration*
- status
- *regional (not used)*

Figure 3: main DF and DE SSM message

Illustration

The following use case illustration is derived from ISO TS 19091.

1. V-ITS-S equipped vehicle enters R-ITS-S range.
2. V-ITS-S transmits CAM or CAM and SRM.
3. R-ITS-S verifies that V-ITS-S messages are acceptable (authentic, valid, etc.).
4. R-ITS-S receives and monitors the vehicle position using CAM.
5. R-ITS-S manages and prioritizes requests (either CAM or SRM).
6. TLC determines the best signal timing plan to accommodate the active priority requests and executes plan (if it can be accommodated).
7. R-ITS-S broadcasts MAP and SPAT information or/and SSM.
8. V-ITS-S receives the SPAT or SSM and determines if and when the request will become active at the intersection.
9. V-ITS-S determines that the priority requesting vehicle has cleared the intersection and sends a new SRM to cancel the priority request.
    a. *OR*: R-ITS-S determines that the time to live for the request has expired and terminates the priority action.
    b. *OR*: R-ITS-S determines that the vehicle has cleared the intersection based on receipt of the CAM and terminates the priority action.
10. R-ITS-S receives the cancel SRM (or timeout) and terminates the priority action
11. R-ITS-S initiates the configured recovery procedures to normal signal timing operation.

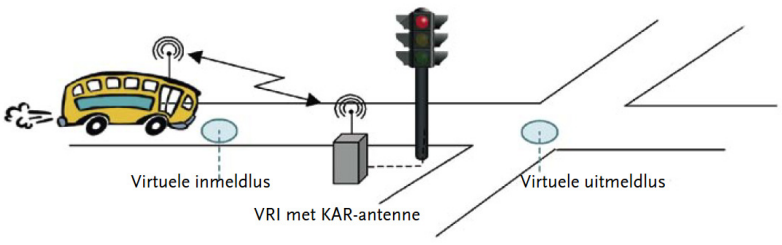

Figure 4: illustration priority request based on KAR

Infrastructure services

In scope of the Priority Request use case, ETSI TS 103 301 [REF] specifies the application support facilities provided by the facility layer that construct, manage and process messages distributed from infrastructure to end-users or vice-versa based on payload received from the application. Within the scope ETSI TS 103 301, the term message refers to the facilities layer; the term payload refers to the applications layer. The payload is generated by the application and provided to the corresponding service of the Facilities layer. The Facilities service merges the "ItsPduHeader" (ETSI TS 102 894-2 **Fout! Verwijzingsbron niet gevonden.**) with the SPAT, MAP, SRM or SSM payload (as specified in ISO TS 19091 [REF], in order to construct a message. These message are then referred to as "SpatMessage" or Intersection Status Service (ISS), "MapMessage" or Road Topology Service (RTP), "SrmMessage" or Intersection Signal Control Service (ISC) and " SsmMessage" or Intersection Signal Status Service (ISS) respectively (ETSI TS 103 301 [REF]).

1.1.13 Potential requirements (as applicable)

- R-ITS-S shall support I2V services and can send SPAT, MAP and SSM.
- V-ITS-S shall support I2V services and can send CAM and SRM.
- The static topology of the signalised intersection, including road segments, lanes and traffic light layout shall be available for the V-ITS-S.
- Reliable information on current and expected signal phase and timing shall be available from the TLC.
- V-ITS-S shall receive the signal phase and timing information timely.
- For ITS-G5:
    - R-ITS-S at the traffic light controller shall broadcast the Signal Phase and Timing (SPAT) message at 1 Hz. to indicate the current (and future) signal state information and priority response.
    - R-ITS-S at the traffic light controller shall broadcast at 0.5 Hz. information that describes the geometrics of the intersection in MAP format. Changes to the base geometry are flagged, to allow a vehicle receiving the MAP information message to only process the changes if the version for the base geometric is different from what is currently stored in the vehicle.
    - V-ITS-S shall broadcast CAM message at X Hz. to indicate vehicle identify, status and priority activation.

1.1.14 Linked use cases (as applicable)

- Green Light Optimal Speed Advisory
- Approaching Emergency Vehicle
- Priority Request (for emergency, public transport and freight vehicles)
- Red Light Violation Warning
- Dilemma Zone Protection
- Green Wave
- Continuous Speed Advice (Corridor Speed Guidance)
- GLOSA / Green Wave for Cyclists
- Idling Stop Support

- Start Delay Prevention