Document Title	Vehicle-2-X Remote Access Layer Protocol Specification
Document Owner	AUTOSAR
Document Responsibility	AUTOSAR
Document Identification No	1033

Document Status	published
Part of AUTOSAR Standard	Foundation
Part of Standard Release	R22-11

Document Change History			
Date	**Release**	**Changed by**	**Description**
2022-11-24	R22-11	AUTOSAR Release Management	• Initial release

Disclaimer

Contents

1 Introduction and overview

This protocol specification enables to exchange of format, message sequences and semantics of the AUTOSAR Protocol **V2XRemoteAccessLayer** (**V2xRAL**).

The protocol allows to exchange information between a node that runs the V2x stack with a node that runs the Remote Access Layer via a communication bus. This allows to separate the Access Layer for radio transmission from the V2x stack. As a result, lightweight devices with standardized interfaces for a smart antenna can be built that communicate with a more powerful node that runs the region-specific V2x stack.

1.1 Protocol purpose and objectives

The Access Layer is used to perform the radio transmission and reception according to the specification of the wireless communication network. The protocol specification supports the radio transmission technologies, LTE-PC5 (specified in [1]) and ITS-G5 ([2]). It defines the format of the messages that are exchanged between the V2x stack and the Remote Access Layer.

1.2 Applicability of the protocol

The V2xRAL protocol is explicitly designed to exchange the playoad and control data between the V2x stack and the Remote Access Layer within the car domain. The payload corresponds to the actual data sent or received over the radio network whereas the control data contains information collected during the reception or required for the transmission of messages. This protocol specification is applicable in the car domain in the context of V2X.

1.2.1 Constraints and assumptions

The protocol specification references system requirements from [3]. This is a temporary solution. Further, the system requirements will be tranferred to AUTOSAR Foundation level. This will be done in the next step to introduce V2x to the Adaptive Platform.

Within this protocol specification, it is assumed that the data communication between the V2x stack and the V2x Access Layer will happen over Ethernet, but any other communication technology can be used. The V2xRAL does not specify further details for communication over Ethernet such as VLAN, TCP or UDP, Ports, EtherType or other media dependent details. Security considerations for the communication channel are also not in the scope. It is assumed that any security protocol such as MACsec, IPsec or TLS could be used, since the V2xRAL is located on top of these layers.

The protocol does not prevent a duplication of V2x messages. Thus, if the V2XRemoteAccessLayer receives for any reason a V2x message twice from the radio network, it will also forward this frame twice on the network. Therefore, a sequence counter or transaction ID or any other means to identify a previously received or transmitted frame via this protocol is not observed or detected.

1.2.2 Limitations

The V2xRAL is specified for the car domain and is dedicated to be used with the V2xStack as specified in AUTOSAR. It might be that the usage of the V2xRAL does not provide sufficient parameters. But the protocol should be flexible enough to be extended even beyond this specification.

1.3 Dependencies

1.3.1 Dependencies to other protocol layers

The V2xRAL protocol is a lightweight protocol to provide a minimum set of control data besides the payload to perform radio network communication and does not depend on any other protocols. Due to the minimum set of data it can be exchanged within a raw Ethernet frame, but can also be placed on top of a protocol such as TCP/IP. Usage of TCP/IP may be required if protocols like IPsec or TLS need to be used for security reason.

1.3.2 Dependencies to other standards and norms

The V2x radio network transmission and reception is defined in standards such as SAE, IEEE and Chinese Telecommunication Industry Standard (YD/T). Details are specified by regional groups for the application in the V2x context, such as ETSI or Chinese GB/T. References to theses specifications can be found in section 3.1.

1.3.3 Dependencies to the Application Layer

The protocol has no dependency to the application. Meaning that there is no need and possibility to influence the protocol through the application.

2 Use Cases

This chapter describes the conditions where the protocol specification can be applied. It first introduces a typical communication setup with devices using the V2xRAL. Afterwards, the different use cases for the protocol will be described.

2.1 Communication setup

The V2xRAL is used to perform the communication between a node that runs the V2x stack, the V2x-stack node, and another node that runs the V2x Access Layer, the V2x Access Layer node. Typically, the communication channel between the two nodes is an ethernet channel, but different technologies like IPC can also be used.

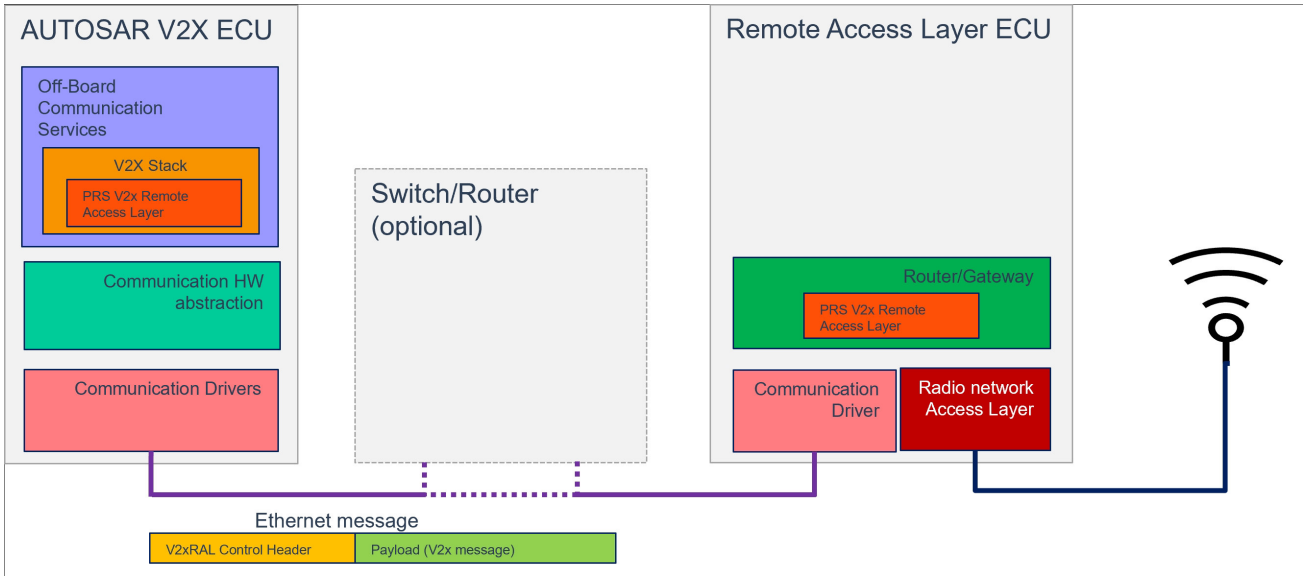

Figure 2.1: Possible application domain for a V2x stack and a V2xRAL

The V2x stack node generates the V2x messages such as CAM, DENM or BSM and wants to distribute them over a radio network. Since the V2x stack node does not have the capability to run the access layer on the same device, it sends the message as the payload to the V2x Access Layer node. Since the payload itself does not contain sufficient information for a radio transmission, additional control information need to be added. The specific data sent as control information depend on the radio technology (LTE-PC5 or ITS-G5) and its related specification. Thus, the V2x stack node will add the transmission control information required for the radio technology that is used and send the control information and the payload to the V2x Remote Access Layer node. This node retrieves the payload and the control information and starts sending the data over the radio network accoding to the relevant specification for this radio technology.

In the opposite direction, if the V2x Access Layer node receives a message from the radio network, it sends the received payload to the V2x stack. Further data that are

collected from the radio network device will be added to the control information, e.g. the average signal strength of the radio transmission.

2.2 Use case definition

ID	*Name*	*Description*
UC_0001	ITS-G5	Radio network is based on ITS-G5 (IEEE 802.11.p)
UC_0002	LTE-PC5	Radio network is based on LTE-PC5.

2.3 UC_0001 "Radio network based on ITS-G5"

The protocol is used if ITS stations are communicating according to the standard defined according to [4]. This specification is applied for ITS-stations in [5] and [6]. Especially the V2x stack for Europe is using this technology and AUTOSAR has specifications supporting ITS-G5 (see [7]), the application of this protocol is applicable. It supports an architecture where the access layer with the antenna can be separated from the actual processing of the V2x stack.

2.4 UC_0002 "Radio network based on LTE-PC5"

This protocol is applicable if a V2x stack and the access layer shall be separated, due to the vehicle architecture. It is applicable if radio network technology according to [1] is used, but the access layer and the V2x stack do not reside in the same device. AUTOSAR already has specifications applying this specification (see [8]), but others may follow in the future that use the same wireless transportation.

3 Related documentation

3.1 Input documents & related standards and norms

[1] YD/T 3707-2020: Technical requirements of network layer of LTE-based vehicular communication
http://www.ccsa.org.cn/

[2] EN 302 663 V1.2.1: Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems operating in the 5 GHz frequency band

[3] Requirements on Vehicle-2-X Communication
AUTOSAR_SRS_V2XCommunication

[4] IEEE Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification. Amendment 6: Wireless Access in Vehicular Environments (IEEE STD 802.11p-2010).

[5] SAE J2735_201603: Dedicated Short Range Communications (DSRC) Message Set Dictionary

[6] EN 302 571 V2.1.1: Intelligent Transport Systems (ITS); Radio communications equipment operating in the 5 855 MHz to 5 925 MHz frequency band; Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive

[7] Specification of Vehicle-2-X Geo Networking
AUTOSAR_SWS_V2XGeoNetworking

[8] Specification of Chinese Vehicle-2-X Network
AUTOSAR_SWS_ChineseV2XNetwork

[9] General Specification of Basic Software Modules
AUTOSAR_SWS_BSWGeneral

[10] EN 302 636-4-1 V1.3.1: Vehicular Communication; Geonetworking; Part 4 Geographical addressing and forwarding for point-to-point and point-to-multipoint communications; Sub-part 1: Media-Independent Functionality

[11] TS 102 724 V1.1.1: Intelligent Transport Systems (ITS); Harmonized Channel Specifications for Intelligent Transport Systems operating in the 5 GHz frequency band

3.2 Related specification

AUTOSAR provides a General Specification on Basic Software modules [9, SWS BSW General], which is also valid for the `V2XRemoteAccessLayer`.

Thus, the specification SWS BSW General shall be considered as additional and required specification for `V2xRAL`.

4 Protocol Requirements

4.1 Requirements Traceability

The following table references the system requirements specified in [3] and the mapping to the requirements of this protocol specification.

Requirement	Description	Satisfied by
[SRS_V2X_00232]	The V2X system shall cooperate with tolling zone stations in vicinity	[FO_PRS_V2xRAL_00007]
[SRS_V2X_00245]	The V2X system shall support per-packet transmission power control	[FO_PRS_V2xRAL_00008]
[SRS_V2X_00391]	The V2X system's access layer shall be ITS-G5 compliant	[FO_PRS_V2xRAL_00006]
[SRS_V2X_00451]	The V2X system's access layer shall be compliant to the ETSI Harmonized Channel Specifications	[FO_PRS_V2xRAL_00008]
[SRS_V2X_25001]	The V2X stack shall support a Remote Access Layer	[FO_PRS_V2xRAL_00002] [FO_PRS_V2xRAL_00003]
[SRS_V2X_25002]	The protocol between the Remote Access Layer and the V2X stack shall be backward compatible and support different technologies for radio networks.	[FO_PRS_V2xRAL_00004] [FO_PRS_V2xRAL_00005] [FO_PRS_V2xRAL_00010]
[SRS_V2X_25003]	The Remote Access Layer and the V2X stack shall exchange control and payload information to accomplish radio network communication.	[FO_PRS_V2xRAL_00001] [FO_PRS_V2xRAL_00009]

Table 4.1: RequirementsTracing

5 Definition of terms and acronyms

5.1 Acronyms and abbreviations

Abbreviation / Acronym:	Description:
3GPP	3GPP & The 3rd Generation Partnership Project provides environment to produce the Reports and Specifications that define 3GPP technologies.
5GAA	5GAA & The 5G Automotive Association is a global, cross-industry organisation to develop future mobility and transportation services.
C-V2X	Cellular V2X. Communication through a cellular modem.
BSM	Basic Safety Message.
CAM	Cooperative Awareness Message.
CBR	Channel Busy Ratio.
DCC	Decentralized Congestion Control.
DENM	Decentralized Environmental Notification Message.
L2ID	Layer 2 ID (equivalent to a "Message Authentication Code" for Ethernet).
MAC	Medium Access Control.
MDR	Maximum Data Rate.
PHY	Physical Layer.
PPPP	ProSe Per Packet Priority.
V2X	Either vehicle to vehicle (V2V), or vehicle to infrastructure (V2I) and/or infrastructure to vehicle (I2V). This terminology is used for Ad-Hoc networks, not for Vehicle-Backend communication.
V2xRAL	V2x Remote Access Layer
IPC	Inter Process Communication.
ITS-G5	Radio communication technology based on IEEE 802.11p
LTE-PC5	Sidelink communication through cellular modems (direct communication between cellular modems without intervention of a base station).
LTE-Uu	Cellular communication controlled by a base station.
TLV	Tag, Length and Value.

Table 5.1: Acronyms and abbreviations used in the scope of this Document

5.2 Definition of terms

Terms:	Description:
V2x Stack	The V2x stack implements the regional specific requirements for the communication between a vehicle and other road users such as cars, trucks, infrastructures (e.g. traffic light, speed limit), etc. Regions such as China, America or Europe have their own specification. Therefore, there exist several V2x stack implementations. Each one is region-specific.
V2x Message	A V2x message is a message received from another vehicle or Roadside Unit (RSU). The message follows the standard for V2X communication. It is typically encoded in ASN.1 PER coding format. A V2x message is also transmitted by the V2x stack from time to time.
V2x Remote Access Layer	The V2x Remote Access Layer (V2xRAL) is a logical unit that is able to communicate to Off-Board units through LTE-PC5 or ITS-G5. The Remote Access Layer includes the wireless PHY and MAC towards the antenna. This includes channel selection, modulation, congestion control, queuing, priority, QoS, etc. Necessary information to accomplish these tasks need to be provided from an upper layer or a remote-control unit, such as MAC addresses, Unicast, Broadcast, GeoNetwork addresses, Priority, Queue, DSMP control. These data are located in the Radio Transmission part of the control header. This data is required for a proper processing of the V2x-message according to the (regional) standard and its media communication. The payload is the data that contains the V2x-message as provided by the network layer. It typically does not contain control information for the media communication.

Table 5.2: Definition of terms in the scope of this Document

6 Protocol specification

6.1 Message format

The message format of the Remote Access Layer protocol is shown in Figure 6.1. The message does not rely on any data that has been sent previously with one exception: the value for the pseudonym has to be stored to detect a pseudonym change.

The protocol does not require any acknowledgement or segmentation.

Due to restrictions of the payload for V2x messages the V2xRAL message including the additional control header will fit into a single ethernet frame.

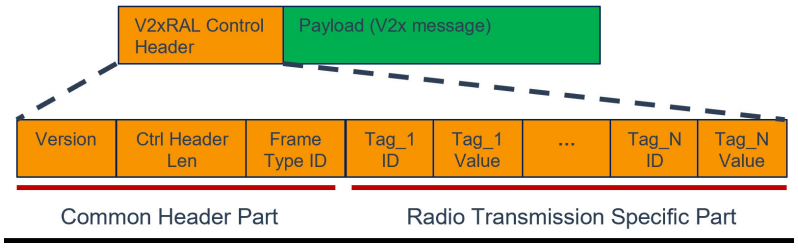

Figure 6.1: The general layout of the message that is sent and received by the V2xRAL

6.1.1 Control Header

[FO_PRS_V2xRAL_00001] ⌈The V2xRAL message is divided into two parts. The first part shall contain control data used by the wireless transport service. The second part shall contain the payload that is used for communication between ITS stations.⌋ *(SRS_V2X_25003)*

[FO_PRS_V2xRAL_00009] ⌈All data in the control header shall be sent in big endian format (high byte first).⌋ *(SRS_V2X_25003)*

6.1.1.1 Common part

[FO_PRS_V2xRAL_00010] ⌈The first byte of the V2xRAL message shall contain a one byte version information that specifies the version of this protocol specification. The first byte shall always contain the value 0x01. The values 0x00 and 0x02..0xFF are reserved for future use.⌋ *(SRS_V2X_25002)*

[FO_PRS_V2xRAL_00002] ⌈The second byte of the V2xRAL message shall contain the total **Control Header Length**. The length information includes the length byte and the version byte. This limits the control header length to 255 bytes. The minimum value of the length byte is 2, because the length and the version byte is mandatory and always present. The values 0 and 1 are reserved.⌋ *(SRS_V2X_25001)*

[FO_PRS_V2xRAL_00003] ⌈The byte that follows the Control Header Length shall be the **Frame Type Identifier** and specifies the radio communication network that the frame belongs to.⌋*(SRS_V2X_25001)*

[FO_PRS_V2xRAL_00004] ⌈After the Frame Type Identifier a number of data pairs follow. Each pair shall consist of a Tag Identifier and a Value. The Tag Identifier denotes the type of data and the Value represents the control information for this Tag Id. The Value for a specific Tag ID has fixed size that is specified in this protocol definition.⌋*(SRS_V2X_25002)*

Info: A length value is not provided (e.g. as TLV) to spare the space in the header.

[FO_PRS_V2xRAL_00005] ⌈The Tag IDs shall define a group of numbers that belong to a specific Frame Type. Tag IDs that are used for a specific Frame Type should not be used for another another Frame Type.⌋*(SRS_V2X_25002)*

Info: Making Tag-IDs unique to the Frame Type would reduce the risk that a Tag ID for one Frame Type is mis-used by another. But this is considered as a recommendation, not a binding requirement. Deviations are possible if in the future the limited number of Tag-IDs (up to 256) are exhausting.

Name	***Frame Type ID***	***Number of Bytes***	***Description***
ITS-G5	**0x01**	1 Byte	This V2xRAL message is dedicated for the use of ITS-G5 radio network.
LTE-PC5	**0x02**	1 Byte	This V2xRAL message is dedicated for the use of LTE-PC5 radio network.
—	**0x80..0x8F**	1 Byte	Customer specific.
—	**0x00, 0x03..0x7F, 0x90..0xFF**	1 Byte	Reserved.

Table 6.1: Definition of the Frame Type ID

6.1.1.2 Radio Transmission Part for ITS-G5

[FO_PRS_V2xRAL_00006] ⌈One of the radio communication protocols that need to be supported for the V2x stack in AUTOSAR is ITS-G5 for connection-less transport services in the ITS ad-hoc network as specified in [4]. This is currently the standard communication specified by the ETSI and used by [7]. Further protocols may follow, but the support of this technology is essential to support the aforementioned specification defined in AUTOSAR.⌋*(SRS_V2X_00391)*

[FO_PRS_V2xRAL_00007] ⌈The control header of the V2xRAL contains information about the tolling zone (see Tag-ID in Table 6.2).⌋*(SRS_V2X_00232)*

[FO_PRS_V2xRAL_00008] ⌈The control header of the V2xRAL contains information about DCC (see Tag-ID in table below) when sending a packet from the V2x stack to the

V2x Remote Access Layer and the CBR when sending a packet from the V2x Remote Access Layer to the V2x stack.⌋ *(SRS_V2X_00245, SRS_V2X_00451)*

Name	***TAG ID***	***No. of Bytes***	***Dir****	***Description***
Packet Interval	**0x10**	1 Byte	Tx	Packet interval for transmission interspace in milliseconds (well-known by the Access Layer for ITS-G5). One increment represents 10 ms. This allows a range of 0..2550 ms for the packet interval in steps of 10 ms.
Channel ID	**0x11**	1 Byte	Tx	Specifies the channel where the V2x message shall be sent to. Valid values are: **0** = ITS G5A CCH; **1** = ITS G5A SCH1; **2** = ITS G5A SCH2; **3** = ITS G5B SCH3; **4** = ITS G5B SCH4. Values 0x05..0xFF are reserved.
Tx Queue ID	**0x12**	1 Byte	Tx	Specifies which Tx queue shall be used. Range (0..5), 0x06..0xFF=reserved.
Tolling zone	**0x13**	1 Byte	Tx	Specifies if the vehicle is in the area of a tolling zone. **0** = Vehicle not in tolling zone, **1** = vehicle in tolling zone. Values 0x02..0xFF are reserved.
Src MAC	**0x14**	6 Byte	Tx	Specifies the source MAC address of the frame.
Dest MAC	**0x15**	6 Byte	Tx	Specifies the destination MAC address. Default value if the tag is omitted: FF.FF.FF.FF.FF.FF (indicates a broadcast).
CBR	**0x16**	1 Byte	Rx	Channel busy ratio in the range of 0(=0%) to 100(=100%). 101..255=reserved.
—	**0x00..0x0F, 0x17..0xFF**	—	—	Reserved.

Table 6.2: Definition of TAG IDs and values for ITS-G5

*Dir: Direction of the frame:

Tx stands for transmission by the ITS station and denotes the communication from the V2x stack to the Remote Access Layer.

Rx stands for reception by the ITS station and denotes the communication from the Remote Access Layer to the V2x stack.

Message Payload

The payload of the V2xRAL message contains the data that is generated by the V2x Geo Networking protocol. It consists of the lower layer header, including the MAC- and LLC-Header and the GeoNetworking Header with optional security, followed by the BTP packet, including the BTP header and the optional payload of the V2x message (see [10]).

More information on protocol items of the ITS-G5 protocol fields can be found here: [11].

6.1.1.3 Radio Transmission Part for LTE-PC5

Name	*TAG ID*	*No. of Bytes*	*Dir**	*Description*
MDR	**0x30**	3 Byte	Rx	Maximum data rate in bps (bits per seconds) (see [8]). Value is in the range of 0..1585200. 1585201..16777215: reserved.
CBR	**0x31**	1 Byte	Rx	Channel busy ratio in the range of 0(=0%) to 100(=100%). 101..255=reserved.
Traffic Period	**0x32**	1 Byte	Tx	Traffic period (see [8]). **0** = Traffic Period: 20ms; **1** = Traffic Period: 50ms; **2** = Traffic Period: 100ms; **3** = Traffic Period: 200ms; **4** = Traffic Period: 300ms; **5** = Traffic Period: 400ms; **6** = Traffic Period: 500ms; **7** = Traffic Period: 600ms; **8** = Traffic Period: 700ms; ▽

▽

△

				△ **9** = Traffic Period: 800ms; **10** = Traffic Period: 900ms; **11** = Traffic Period: 1000ms. Values 0x0c..0xFF are reserved.
PPPP	**0x33**	1 Byte	Rx/Tx	PPPP: ProSe per Packet Priority in the range of 1..8. 1=highest priority, 8=lowest priority. Values 0 and 9..255 are reserved.
Src L2ID	**0x34**	3 Byte	Rx/Tx	Specifies the source L2ID of the frame (equiv. to Src-MAC, see [8]).
Dest L2ID	**0x35**	3 Byte	Rx/Tx	Specifies the destination L2ID of the frame (equiv. to Dst-MAC, see [8]).
—	**0x00..0x2F, 0x36..0xFF**	—	—	Reserved.

Table 6.3: Definition of TAG IDs and values for LTE-PC5

*Dir: Direction of the frame:

Tx stands for transmission by the ITS station and denotes the communication from the V2x stack to the Remote Access Layer.

Rx stands for reception by the ITS station and denotes the communication from the Remote Access Layer to the V2x stack.

Message Payload

The payload of the Access Layer message for ITS-PC5 is the content that is used for the radio transportation. This is in general the input/output to/from the Network Layer (see [1]).

More information on protocol items of LTE-PC5 protocol fields can be found here: [1].

6.2 Message types

The V2xRAL protocol does not distinguish any message types. Typically, the Control Header comes along with the payload of the V2x message since the control header is pretty small (approx. 20-25 bytes). Combining both, the control and the payload information into the same frame ensures, that the remote access layer always has the adequate control data for the payload. This prevents that the wireless frame is sent with unwanted control data. Considering this, a V2xRAL message without control header is not usable in the context of this protocol. A control header can be sent without payload information but this is rarely applicable. A typical use case is the pseudonym change,

where the V2x stack can send a new pseudonym immediately to the V2x Remote Access Layer when commanded.

6.3 Services / Commands

There are no services defined for the V2XRemoteAccessLayer protocol. The main use case is the exchange of the payload of V2x messages and its control data between the network layer and the access layer.

One operational service is the change of the pseudonym. In this case, the V2x stack sends a command to the V2XRemoteAccessLayer to change the pseudonym. This information can be triggered by the V2x stack and can be transmitted with or without V2x message payload.

6.4 Sequences (lower layer)

The V2XRemoteAccessLayer protocol is stateless. Therefore, no sequences are specified within this protocol.

6.5 Error messages

The V2XRemoteAccessLayer does not use any error messages.

6.6 Backward compatibility

The layout of the control header supports backward compatibility. This is achieved by the control header length field at the very beginning of the control header. Thus, if the protocol layer parses the tag IDs it can process all known tag IDs. If a a new and unknown tag ID is found, all further tags cannot be processed since the length of the tag is unknown.

As a consequence, if the protocol will be extended by new tags and the new tag information is not essential for previous versions of the protocol, the new tags need to be added at the end of the tag fields (not in the middle or at the beginning). For any breaking change of the protocol it is recommended to change the frame type or even the protocol version.

7 Configuration parameters

There are no configuration items for the `V2XRemoteAccessLayer` protocol.

8 Protocol usage and guidelines

There are no additional guidelines available for this protocol.