# ETSI TS 103 574 V1.1.1 (2018-11)


**Intelligent Transport Systems (ITS);**
**Congestion Control Mechanisms for the C-V2X PC5 interface;**
**Access layer part**

Reference
DTS/ITS-00445

Keywords
ITS, radio

*ETSI*

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
Sous-Préfecture de Grasse (06) N° 7803/88

## *Important notice*



## *Copyright Notification*

# Contents

# Intellectual Property Rights

## Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (https://ipr.etsi.org/).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

## Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

# Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Intelligent Transport Systems (ITS).

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# 1 Scope

The present document is the LTE-V2X intra-system congestion control specification. It describes the LTE-V2X PHY/MAC layer intra-system congestion control techniques as per Release 14 3GPP RAN specifications and includes interfaces to a congestion control management entity.

# 2 References

## 2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] ETSI TS 136 300 (V14.7.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2 (3GPP TS 36.300 version 14.7.0 Release 14)".

[2] ETSI TS 136 321 (V14.7.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification (3GPP TS 36.321 version 14.7.0 Release 14)".

[3] ETSI TS 136 331 (V14.6.2): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Resource Control (RRC); Protocol specification (3GPP TS 36.331 version 14.6.2 Release 14)".

[4] ETSI TS 136 214 (V14.4.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements (3GPP TS 36.214 version 14.4.0 Release 14)".

## 2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] ETSI TS 103 613 (V1.1.1): "Intelligent Transport Systems (ITS); Access layer specification for Intelligent Transport Systems using LTE Vehicle to everything communication in the 5,9 GHz frequency band".

[i.2] ETSI TS 136 101 (V14.7.0): "LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (3GPP TS 36.101 version 14.7.0 Release 14)".

# 3 Definition of terms and abbreviations

## 3.1 Terms

For the purposes of the present document, the following terms apply:

**channel occupancy ratio:** fraction of the total number of sub-channels *used* by the ITS-S for its transmissions out of the total number of *configured* (granted) sub-channels over a measurement period of 1 000 ms

NOTE: This is defined in ETSI TS 136 214 [4] and is valid for LTE-V2X only.

**channel busy ratio:** portion of sub-channels in the resource pool whose S-RSSI measured by the ITS-S exceed a (pre-) configured threshold sensed over last 100 ms

NOTE: This is defined in ETSI TS 136 214 [4] and is valid for LTE-V2X only.

**CRlimits:** limit on the maximum channel occupancy ratio for this ITS-S

NOTE: This is defined in ETSI TS 136 331 [3].

**resource pool:** set of resources that can be used for PSCCH and PSSCH

NOTE: Resource pool (for transmission and reception) is defined with the help of start RB, number of sub-channels, size of sub-channel, and available subframes.

**sub-channel:** set of contiguous physical resource blocks

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI TS 103 613 [i.1] and the following apply:

| | |
|---|---|
| CBR | Channel Busy Rate/Ratio |
| CR | Channel occupancy Ratio |
| LTE-V2X | Long Term Evolution - Vehicle to Everything |
| IE | Information Element |
| ITS-S | ITS Station |
| MCS | Modulation and Coding Scheme |
| PDB | Packet Delay Budget |
| PPPP | Prose Per Packet Priority |
| PSCCH | Physical Sidelink Control CHannel |
| PSSCH | Physical Sidelink Shared CHannel |
| RB | Resource Block |
| S-RSSI | Sidelink - Received Signal Strength Indication |
| UE | User Equipment |

# 4 Congestion Control Overview

## 4.1 Introduction

Congestion control is a mechanism employed by ITS-Stations (ITS-S) in order to deal fairly with situations where the channel becomes overloaded. Channel congestion is due to the number of neighbouring ITS-Stations increasing beyond the level that would allow V2X communications to operate as expected. The description focuses on the lower layers, with some limited interactions with the upper layers (network and transport, facilities) as described in clause 6.

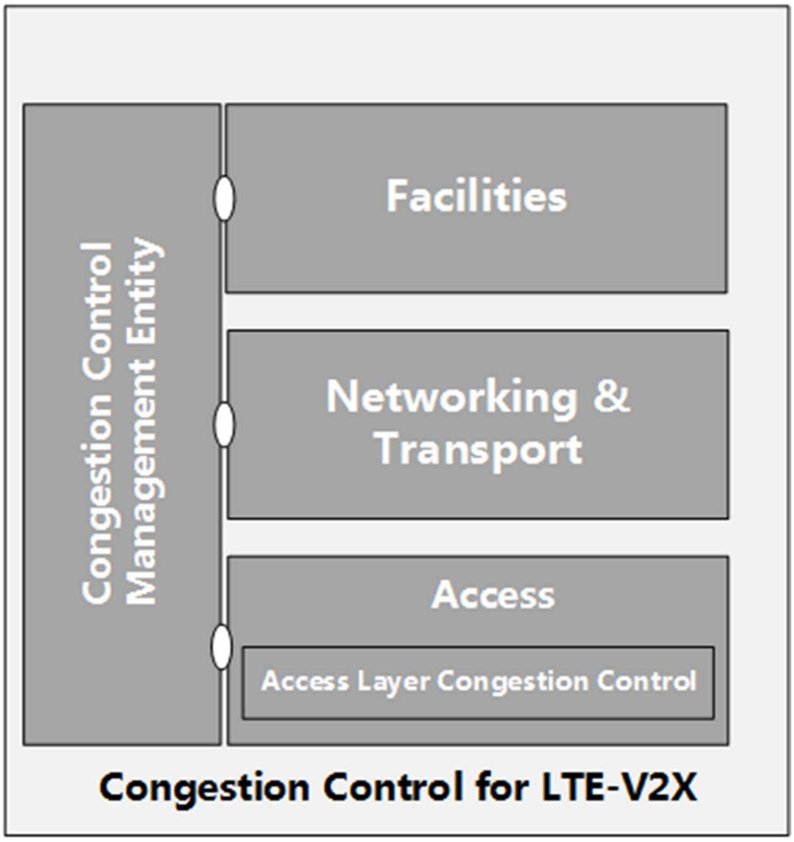
## 4.2 Operational requirements

Congestion control is a mandatory component of LTE-V2X access layer. It shall ensure throughput efficiency and fair resource allocation to ITS-Stations. Congestion control is done mainly at the PHY/MAC layer but involves components at several layers of the protocol stack to achieve the operational requirements:

- Sets the resource usage limit per ITS-S based on the channel load.
- When channel is lightly loaded, each ITS-S is allowed to use a larger portion of the channel resources.
- When channel is heavily loaded, each ITS-S is allowed to use a smaller portion of the channel resources.
- Service to the upper layers is allowed to degrade gracefully in the presence of increased congestion.
- Congestion control is specific to the transmission resource pool, as well as traffic priority class.

## 4.3 Congestion control architecture

The ITS-S architecture of the interfaces relevant to congestion control is shown in Figure 1.




NOTE: The congestion control Management Entity, that serves the role of message/parameter passing, may be viewed as part of the ITS-S Management layer. The interface between layers is a functional interface.

**Figure 1: Congestion control architecture for LTE-V2X in the ITS-S architecture**

## 4.4 Default parameters for mode 4

In LTE-V2X, radio transmission resources are grouped in "transmission pools". Each packet to be transmitted comes from the application layer down to the lower layers associated with a certain priority value (one of eight), called ProSe Per Packet Priority (PPPP) (see ETSI TS 136 300 [1]). The following parameters as described in ETSI TS 136 331 [1] shall be set per transmission pool and per PPPP:

- CBR.
- CR limit (max).

For the ASN.1 representation of the above see clause 6.3.8 of ETSI TS 136 331 [3].

ETSI TS 136 331 [3] defines the IE, so that Table 1 corresponding to CBR ranges is provided to the access layer. ITS-S shall measure CBR (parameter "CBRmeasured") and accordingly adjust the CR in order to comply with the CR limit values provided in Table 1.

**Table 1: CR limit values**

| CBR-based PSSCH transmission parameter configuration | PPPP1-PPPP2 | PPPP3-PPPP5 | PPPP6-PPPP8 |
|---|---|---|---|
| **CBR measured** | **CR limit** | **CR limit** | **CR limit** |
| 0 ≤ CBR measured ≤ 0,3 | No limit | No limit | No limit |
| 0,3 < CBR measured ≤ 0,65 | No limit | 0,03 | 0,02 |
| 0,65 < CBR measured ≤ 0,8 | 0,02 | 0,006 | 0,004 |
| 0,8 < CBR measured ≤ 1 | 0,02 | 0,003 | 0,002 |

# 5 Control mechanism

## 5.1 Calculation of CR

Prior to each transmission, the ITS-S shall ensure that its CR complies with CR limit by reducing used RBs.

The CR limit is satisfied for PPPP k, if the following condition is satisfied: the sum of the channel occupancy ratio for PPPP larger than or equal to *k* is less than or equal to the CRlimit for PPPP *k*:

$$\sum_{i \geq k} CR_i \leq CRlimit_k$$

*Example*: If an ITS-S is transmitting packets with priorities P1 and P2, where P1 is higher priority (P1<P2), then it shall ensure the following limits:

- $CR_{P2} \leq CRlimit_{P2}$
- $CR_{P1} + CR_{P2} \leq CRlimit_{P1}$

It is up to implementation to distribute resource usage amongst the packets with priority P1 and priority P2. For example, allocation of (P1 packets, P2 packets) to resources ($CRlimit_{P1}$ - $CRlimit_{P2}$, $CRlimit_{P2}$) or generally ($CRlimit_{P1}$ - *x*, *x*), where *x* <= $CRlimit_{P2}$, are all feasible.

## 5.2 Calculation of CBR

The value of the CBR shall be calculated as follows in LTE-V2X PHY/MAC layer (see ETSI TS 136 214 [4] and ETSI TS 136 321 [2]):

- For PSSCH, CBR is the fraction of sub-channels whose S-RSSI exceeds a threshold -94 dBm.
- For PSCCH with non-adjacent control and data resources (see below), CBR is the fraction of resource (2 PRB pair) whose S-RSSI exceed a threshold of -94 dBm.

NOTE 1: Sensitivity of LTE-V2X is -90,4 dBm (see ETSI TS 136 101 [i.2]), about 4 dB margin is allowed for the threshold.

The measurement window is subframes [*n*-100, *n*-1] for CBR measured at subframe *n*. See Figure 2.

NOTE 2: Physical subframe indexing, meaning n-100 is the subframe 100 subframes before the *n*th one, i.e. 100 ms before.

The CR shall be computed as the number of sub-channels used for transmissions in subframes in the interval [*n-a*, *n*-1] and granted in subframes [*n*, *n*+*b*], divided by the number of configured sub-channels in the transmission pool over subframes in the interval [*n-a, n*+*b*], where:

- $a$ is a positive integer and $b$ is a non-negative integer; $a+b+1 = 1\ 000$; $a \geq 500$ (subframe indexing again).
- *n*+*b* should not exceed the last transmission opportunity of the grant for the current transmission.

CBR shall be measured and CR shall be evaluated for each (re)transmission as follows:

- For a (re)transmission in subframe *n*+4, the CR is evaluated in subframe *n*.
- For a (re)transmission in subframe *n*+4, the CBR measured in subframe *n* is used.

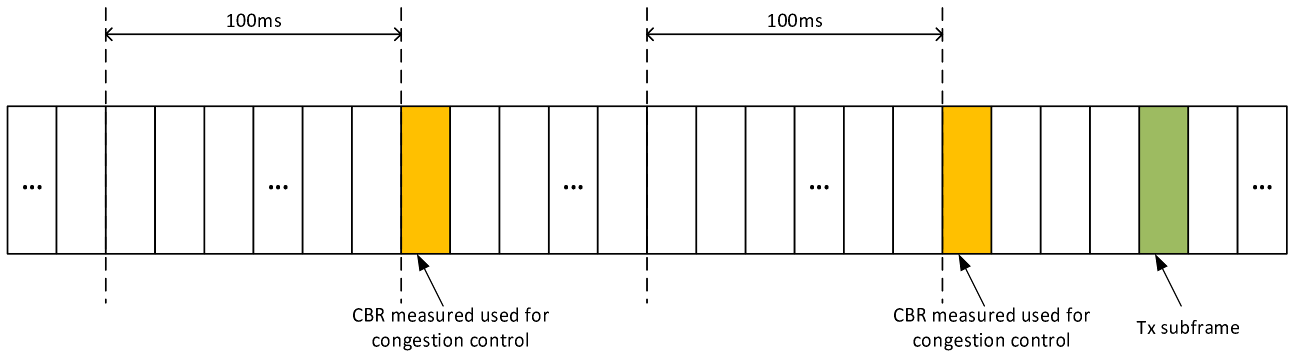


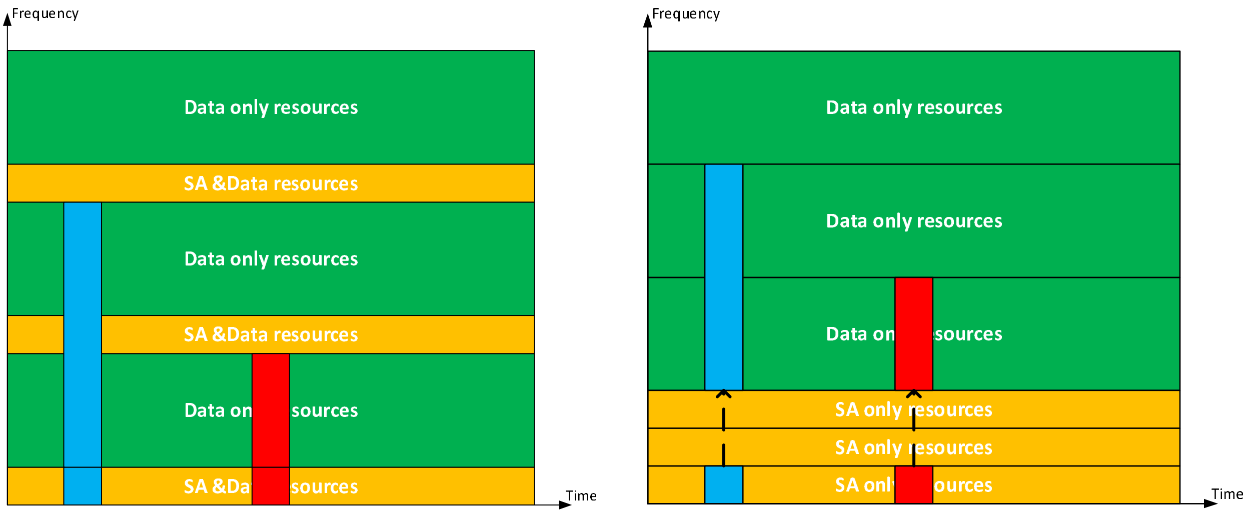

**Figure 2: Sliding window CBR measurement: CBR measured over [n-100, n - 1] relative to transmission on subframe**

## 5.3 Other considerations

For configurations where control and data resources are not adjacent in frequency, a separate CBR measurement is done for Control and Data pools, because CBR for the Control pool can be very different than CBR of the Data pool. Furthermore, the congestion control operation is also different. If Control pool is congested, the only way to reduce congestion is to drop packets to be transmitted. If the Data pool is congested, either radio resource parameters can be adapted (e.g. increase MCS, etc.) or transmissions can be dropped if the CR limit can still not be met.

From congestion control specification perspective, however, additional specification is not needed as implementations compliant with the calculations above and given configurations are expected to behave fairly. Note that only a subset of the radio layer parameters can be adapted (i.e. only transmit power) for the Control pool.

Separating congestion control behaviour for the Control pool and Data pool can be viewed as a separate resource pool case. The radio layer parameters involved in congestion control can be common for Control/Data pools, however, only a subset of parameters applies for Control pool (CR limit and transmit power).




**(a) Adjacent SA and Data resources** **(b) Non-adjacent SA and Data (optional)**

**Figure 3: Recourse Pool for LTE-V2X**

# 6 Congestion Control Process and data exchange

## 6.1 Introduction

Clause 6 describes the data exchanged between components of the ETSI ITS stack. For the purposes of the present document, the following description is informative.

## 6.2 Algorithm/flowchart (informative)

Example algorithm. For each transmission pool do:

- Step 1: Configuration parameters are in place.

NOTE: Parameters can be pre-configured or received via a network.

- Step 2: Receive upper layer packet with its associated PPPP.
- Step 3: Determine the PDB for this packet for this PPPP value, from configuration.
- Step 4: Compute the current CBR.
- Step 5: Compute CRlimit for this PPPP based on the CBR.
- Step 6: Select transmit resources for the packet such that can meet the CR limit.

## 6.3 Data exchange between access layer congestion control and Congestion Control Management Entity

This interface to the Management Entity carries the following parameters:

- TX packet statistics: how many packets transmitted, how many dropped.
- CBR for each TX pool and for each PPPP, computed as in clause 5.3.
- Maximum transmit rate at each PPPP level: this value is calculated based on the CR limit per priority, the maximum allowed MCS, the maximum allowed number of RBs, and any other device or network limitations.

The interface from the Management Entity carries the following parameter:

- PPPP for each packet to be transmitted.

## 6.4 Data exchanged between Congestion Control Management Entity and Facilities and Network/transport layers

This interface to the Network/transport layer carries the following parameters:

- CBR status for each TX pool, computed as in clause 5.3.
- Suggested transmission period.

NOTE: The interface from the network/transport layer may carry the CBR global parameter as a legacy parameter, but the Congestion Control Management Entity will ignore it, since the LTE Access stratum congestion control cannot make use of it.

The interface to the Facilities layer carries the following parameters:

- CBR status for each TX pool, computed as in clause 5.3.
- Suggested transmission period.
- TX packet statistics: how many packets transmitted, how many dropped.

The interface from the Facilities layer carries the following parameter:

- Traffic class for each packet to be transmitted.

# History

| Document history | | |
|---|---|---|
| V1.1.1 | November 2018 | Publication |
| | | |
| | | |
| | | |
| | | |