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TECHNICAL SPECIFICATION

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

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Contents

Intellectual Property Rights	4
Foreword.....	4
Modal verbs terminology.....	4
1 Scope	5
2 References	5
2.1 Normative references	5
2.2 Informative references.....	5
3 Definition of terms and abbreviations	6
3.1 Terms.....	6
3.2 Abbreviations	6
4 Congestion Control Overview.....	6
4.1 Introduction	6
4.2 Operational requirements	7
4.3 Congestion control architecture.....	7
4.4 Default parameters for mode 4.....	8
5 Control mechanism	8
5.1 Calculation of CR.....	8
5.2 Calculation of CBR	9
5.3 Other considerations.....	9
6 Congestion Control Process and data exchange.....	10
6.1 Introduction	10
6.2 Algorithm/flowchart (informative).....	10
6.3 Data exchange between access layer congestion control and Congestion Control Management Entity	10
6.4 Data exchanged between Congestion Control Management Entity and Facilities and Network/transport layers	11
History	12

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Foreword

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

Modal verbs terminology

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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.

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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.

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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.

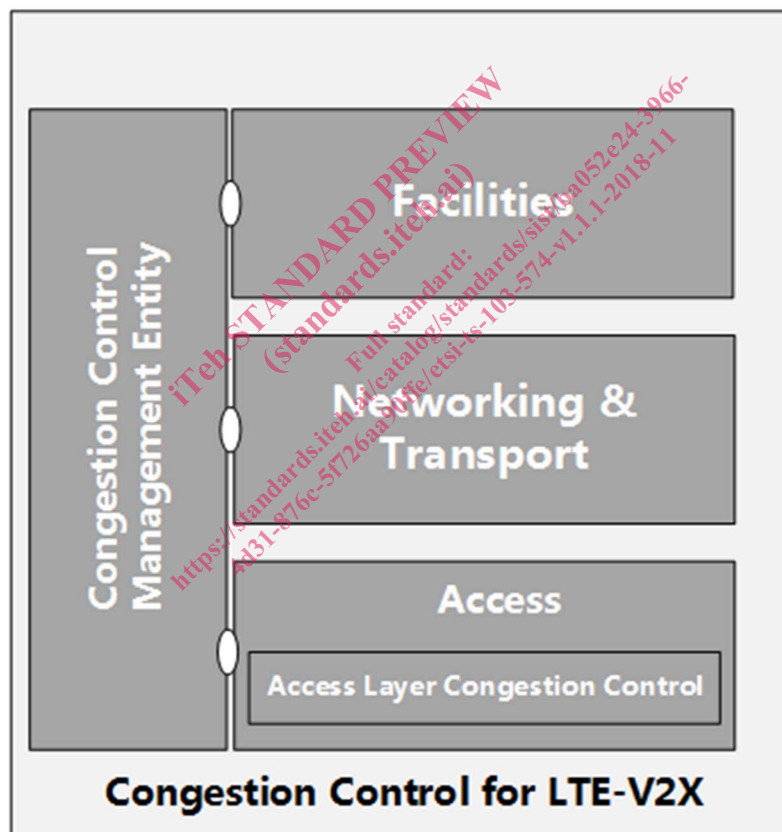
4.2 Operational requirements

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
$0 \leq \text{CBR measured} \leq 0,3$	No limit	No limit	No limit
$0,3 < \text{CBR measured} \leq 0,65$	No limit	0,03	0,02
$0,65 < \text{CBR measured} \leq 0,8$	0,02	0,006	0,004
$0,8 < \text{CBR measured} \leq 1$	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 $x \leq CRlimit_{P2}$, 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.

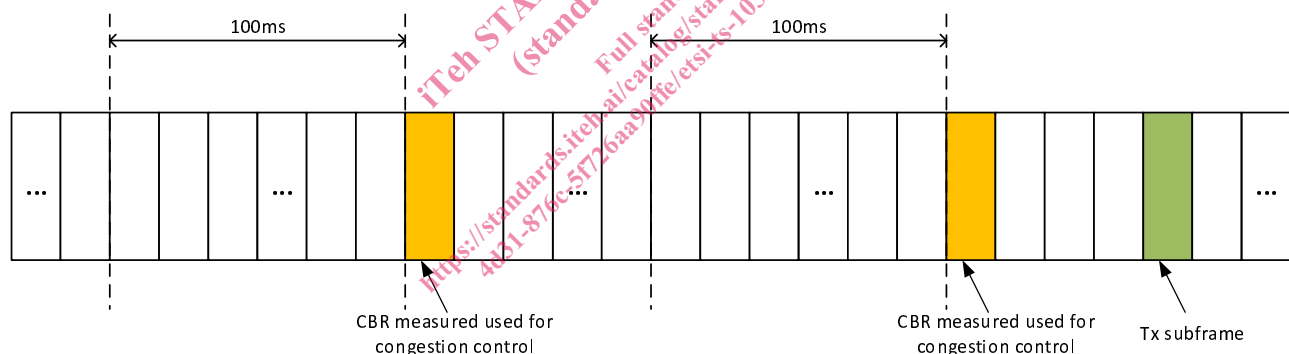


Figure 2: Sliding window CBR measurement: CBR measured over $[n-100, n-1]$ relative to transmission on subframe

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).