3GPP TSG RAN WG1 email discussion [5G-ACIA] R1-20xxx

E-mail discussion, October 12 - 16, 2020

Source: Ericsson

Title: Simulation Assumptions and URLLC Features for 5G-ACIA Performance Evaluation

Document for: Discussion

1 Introduction

TSG RAN discussed the possibility of providing performance evaluations to 5G-ACIA for their LS on 3GPP NR Rel-16 URLLC and IIoT performance evaluation [1] and has agreed to facilitate such an activity [3][4]. The target date for the completion of this activity is TSG RAN Meeting #91e in March 2021.

In the following, Ericsson view is provided for the simulation assumptions and design features to use in this evaluation.

2 Simulation Parameters

In TR 38.824, detailed simulation parameters were provided for system level an link-level simulation assumptions. Most parameters can be reused from TR 38.824, and we only discuss those that may need to be revised according to 5G-ACIA LS.

## 2.1 Performance Metric

From 5G-ACIA LS, three performance metrics are provided:

1) CSA: single CDF of CSA distribution of all UEs in factory hall

2) Latency: single CDF of latency distribution of all UEs in factory hall

3) Percentage of UEs satisfying re-quirements and

4) resource utilization

It was also pointed out that Metric 3) and 4) are of low priority. In our view, it is sufficient to report 1) CSA and 2) Latency.

5G-ACIA LS selected use case 2 from TS 22.104 for evaluation (see Appendix 1). For use case 2, the parameters are:

* transfer interval TI = 1 ms
* survival time duration Ts = 1 ms

Thus, a packet is allowed up to 2 attempts. Given the CSA requirement of 99.9999%, this translates to BLER requirement of BLER<=1e-3.

Ericsson preference is summarized below:

|  |  |
| --- | --- |
| Performance metric | 1) CSA: single CDF of CSA distribution of all UEs in factory hall 2) Latency: single CDF of latency distribution of all UEs in factory hall |
| Performance requirement | CSA = 99.9999%Or, equivalently: BLER <=1e-3 |

## 2.1 Inter-BS/TRP distance, BS antenna height and channel model

In [1], it is suggested to consider a factory hall of 120m x 50m x 10m, which is then fully covered by 12 service areas of 50m x 10m. BS antenna height is recommended to be 1.5 m for InF-SL and InF-DL, 8m for InF-SH and InF-DH. The number of BS/TRPs is not given. Moreover, there is a suggestion from 5G-ACIA on selection of dense or sparse clutter models based on number of UEs.

For the simulation study, the number of BS (hence inter-BS/TRP distance) should be selected according to the deployment scenario (e.g., carrier frequency, antenna configuration, number of UEs). It is reasonable to reuse the base station layout for the factory automation use case (see Figure 1 below), considering that the factory hall size in 5G-ACIA LS is the same as that in TR 38.824. On the other hand, the simulation study in TR 38.824 didn’t consider that the hall is divided into 12 service areas of 50m x 10m. Thus, we are also fine to discuss further the BS layout.

For the channel model and BS antenna height, our preference is InF-DH and 8m. In summary, Ericsson preference is provided in the table below.

|  |  |
| --- | --- |
| Inter-BS/TRP distance | We are fine to reuse the base station layout from TR 38.824 (reproduced in Figure 1 below) for the factory automation use case. We are also open to discuss further if the BS layout should be revised considering the 12 services areas. |
| BS antenna height | 8m |
| Channel model | InF-DH |

Figure . Base station layout for factory automation use case in TR 38.824.

## 2.2 Traffic model

### 2.2.1 Traffic arrival in downlink

The LS from 5G-ACIA says *“For DL messages for all the UEs in one service area within one transmission interval <…> To cover different typical situations, we have identified the following three options for DL traffic arrival time assumption:*

* ***Option-1****: all UEs’ DL messages arriving at NG-RAN node in the first transfer interval are uniformly random distributed within the TI time window.*
* ***Option-2:*** *all UEs’ DL messages arriving at NG-RAN node in the first transfer interval are in one burst.*
* ***Option-3:*** *All UEs in one service area can be divided into several groups, DL messages of UEs in the same group will arrive at NG-RAN node in one burst with the following assumptions.*
	+ - *Number of groups within a service area: 2*
		- *Number of UEs in a group: all groups have equal number of UEs*
			* + *3GPP can determine to use either a pre-defined value or a random value for the burst arrival time differences between different groups. ”*

To align simulation assumption, companies are encouraged to provide a view on what option is preferable for simulations. Ericsson preference is:

|  |  |
| --- | --- |
| DL traffic model | Either Option 1 (the best case for the system) or Option 2 (the worst case) as in LS from 5G-ACIA. |

### 2.2.2 Traffic arrival in uplink

The LS from 5G-ACIA says: *“For DL-UL traffic arrival time relationship, two options can be considered as follows.*

* ***Option-1:*** *DL and UL traffic arrival time instants are independent*
* ***Option-2:*** *UL traffic arrives at some pre-defined x time duration, where x can be, e.g., half of transfer interval, after the respective DL traffic arrival time.”*

To align simulation assumption, companies are encouraged to provide a view on what option is preferable for simulations. Ericsson preference is:

|  |  |
| --- | --- |
| UL traffic model | Option 1 as in LS from 5G-ACIA. |

## 2.2 Number of UEs per Cell

In the 5G-ACIA scenario, the UEs randomly distributed within the respective service area, with up to 50 UEs per service area. Considering that there are a total of 12 service areas, the total number of UEs is up to 12x50=600 UEs.

Since the service areas are laid out evenly in 50m x 10m rectangles, it is reasonable to assume that the UEs are randomly distributed in each cell, regardless of the BS layout. Assuming the BS layout in TR 38.824 with 12 BS is applied, the number of UEs per cell can be {10, 20, 40, 50}, as suggested in 5G-ACIA LS.

|  |  |
| --- | --- |
| Number of UEs per Cell | {10, 20, 40, 50}The UEs are randomly distributed in each cell. |

## 2.3 Other assumptions for FR1

For FR1, it has been pointed out there is no FDD bands at 4 GHz. However, due to the smaller SCS available in FR1, it is very challenging to satisfy the latency requirement of 1ms if using TDD. Thus our preference is to continue to use FDD for FR1, as in TR 38.824. There are numerous FDD bands for FR1 as defined by RAN4 (see Appendix 2). We suggest to use band n7 as described in TS 38.104.

Specifically, Ericsson preference is summarized below for FR1:

|  |  |
| --- | --- |
| Duplex | FDD |
| Carrier frequency | 2.6 GHz |
| Simulation bandwidth | 50 MHz for DL and 50 MHz for UL |
| SCS | 30 kHz |

## 2.4 Other assumptions for FR2

For FR2, only TDD is available. The same parameters are assumed in 5G-ACIA LS and TR 38.824, and summarized below.

|  |  |
| --- | --- |
| Duplex | TDD |
| Carrier frequency | 30 GHz |
| Simulation bandwidth | 160 MHz  |
| SCS | 120 kHz |

3 URLLC/IIoT Features

## 3.1 Features for FR1

To satisfy the reliability and latency requirements of use case 2, Rel-15 features appear to be sufficient. We do not see that Rel-16 features are absolutely necessary. On the other hand, it may be interesting to study Rel-16 features such as monitoring span for PDCCH monitoring, and sub-slot based HARQ-ACK.

Due to the nature of periodic deterministic traffic pattern, DL SPS and UL CG are perfect for the use case. There is no need to use dynamic scheduling for UL nor DL, thus saving the overhead of PDCCH.

More specifically, we suggest the following in the simulation study for FR1:

* UL CG with one configuration is assumed to achieve 1 ms latency in UL.
* DL SPS with one configuration is assumed to achieve 1 ms latency in DL.
* UE Capability: Capability #2
* (Optional) PDCCH performance of monitoring span (7,3) for FDD.
	+ If TDD has to be used for FR1, PDCCH performance of monitoring span (2,2).

## 3.2 Features for FR2

For FR2, SCS of 120 kHz is assumed. This makes it easier to achieve the 1ms latency requirement, even though only TDD is possible for FR2. Due to the limitation of TDD only for FR2, it is even more important to rely on DL SPS and UL CG to support the traffic pattern, thus eliminating the latency caused by PDCCH. Similar to FR1, Rel-15 features appear to be sufficient. We do not see the need to invoke Rel-16 features.

Thus we suggest the following in the simulation study for FR2:

* UL CG with one configuration is assumed to achieve 1 ms latency in UL.
* DL SPS with one configuration is assumed to achieve 1 ms latency in DL.

3 References

1. RP‑201279, “LS on 3GPP NR Rel-16 URLLC and IIoT performance evaluation (5G-ACIA-LS-2020-WI042; to: RAN, RAN1; cc: SA1, RAN2; contact: Bosch”, 5GCIA
2. R1-2007186, “RAN1 LS to RAN plenary”
3. RP-202069, “Way forward and RAN work for 5G ACIA requested simulations”, Ericsson
4. RP-202097, “on 3GPP NR Rel-16 URLLC and IIoT performance evaluation” (to: 5G-ACIA; cc: RAN1, RAN2, SA1; contact: Ericsson)
5. TR 38.824.

Appendix 1. Performance requirements in TS 22.104

The services requirements of motion control are copied below from TS 22.104 V17.4.0.

TS 22.104 V17.4.0, Table 5.2-1: Periodic deterministic communication service performance requirements

| Characteristic parameter | Influence quantity |  |
| --- | --- | --- |
| Communica­tion service availability: target value (note 1) | Communication service reliability: mean time between failures | End-to-end latency: maximum (note 2) (note 12a) | Service bit rate: user experienced data rate (note 12a) | Message size [byte] (note 12a) | Transfer interval: target value (note 12a) | Survival time (note 12a) | UE speed (note 13) | # of UEs | Service area (note 3) | Remarks |
| 99.999 % to 99.999 99 % | ~ 10 years | < transfer interval value | – | 50 | 500 μs  | 500 μs | ≤ 75 km/h | ≤ 20 | 50 m x 10 m x 10 m | Motion control (A.2.2.1) |
| 99.999 9 % to 99.999 999 % | ~ 10 years | < transfer interval value | – | 40 | 1 ms  | 1 ms | ≤ 75 km/h | ≤ 50 | 50 m x 10 m x 10 m | Motion control (A.2.2.1) |
| 99.999 9 % to 99.999 999 % | ~ 10 years | < transfer interval value | – | 20 | 2 ms  | 2 ms | ≤ 75 km/h | ≤ 100 | 50 m x 10 m x 10 m | Motion control (A.2.2.1) |
| NOTE 1: One or more retransmissions of network layer packets may take place in order to satisfy the communication service availability requirement.NOTE 2: Unless otherwise specified, all communication includes 1 wireless link (UE to network node or network node to UE) rather than two wireless links (UE to UE).NOTE 3: Length x width (x height).NOTE 12a: It applies to both UL and DL unless stated otherwise.NOTE 13: It applies to both linear movement and rotation unless stated otherwise.  |

Appendix 2. NR operating bands for FR1

TS 38.104 V16.4.0 (2020-06), Table 5.2-1: NR *operating bands* in FR1

|  |  |  |  |
| --- | --- | --- | --- |
| **NR *operating band*** | **Uplink (UL) *operating band*BS receive / UE transmit****FUL,low   –  FUL,high** | **Downlink (DL) *operating band*BS transmit / UE receive****FDL,low   –  FDL,high** | **Duplex mode** |
| n1 | 1920 MHz – 1980 MHz | 2110 MHz – 2170 MHz | FDD |
| n2 | 1850 MHz – 1910 MHz | 1930 MHz – 1990 MHz | FDD |
| n3 | 1710 MHz – 1785 MHz | 1805 MHz – 1880 MHz | FDD |
| n5 | 824 MHz – 849 MHz | 869 MHz – 894 MHz | FDD |
| n7 | 2500 MHz – 2570 MHz | 2620 MHz – 2690 MHz | FDD |
| n8 | 880 MHz – 915 MHz | 925 MHz – 960 MHz | FDD |
| n12 | 699 MHz – 716 MHz | 729 MHz – 746 MHz | FDD |
| n14 | 788 MHz – 798 MHz | 758 MHz – 768 MHz | FDD |
| n18 | 815 MHz – 830 MHz | 860 MHz – 875 MHz | FDD |
| n20 | 832 MHz – 862 MHz | 791 MHz – 821 MHz | FDD |
| n25 | 1850 MHz – 1915 MHz | 1930 MHz – 1995 MHz | FDD |
| n26 | 814 MHz – 849 MHz | 859 MHz – 894 MHz | FDD |
| n28 | 703 MHz – 748 MHz | 758 MHz – 803 MHz | FDD |
| n29 | N/A | 717 MHz – 728 MHz | SDL |
| n30 | 2305 MHz – 2315 MHz | 2350 MHz – 2360 MHz | FDD |
| n34 | 2010 MHz – 2025 MHz | 2010 MHz – 2025 MHz | TDD |
| n38 | 2570 MHz – 2620 MHz | 2570 MHz – 2620 MHz | TDD |
| n39 | 1880 MHz – 1920 MHz | 1880 MHz – 1920 MHz | TDD |
| n40 | 2300 MHz – 2400 MHz | 2300 MHz – 2400 MHz | TDD |
| n41 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD |
| n48 | 3550 MHz – 3700 MHz | 3550 MHz – 3700 MHz | TDD |
| n50 | 1432 MHz – 1517 MHz | 1432 MHz – 1517 MHz | TDD |
| n51 | 1427 MHz – 1432 MHz | 1427 MHz – 1432 MHz | TDD |
| n53 | 2483.5 MHz – 2495 MHz | 2483.5 MHz – 2495 MHz | TDD |
| n65 | 1920 MHz – 2010 MHz | 2110 MHz – 2200 MHz | FDD |
| n66 | 1710 MHz – 1780 MHz | 2110 MHz – 2200 MHz | FDD |
| n70 | 1695 MHz – 1710 MHz | 1995 MHz – 2020 MHz | FDD |
| n71 | 663 MHz – 698 MHz | 617 MHz – 652 MHz | FDD |
| n74 | 1427 MHz – 1470 MHz | 1475 MHz – 1518 MHz | FDD |
| n75 | N/A | 1432 MHz – 1517 MHz | SDL |
| n76 | N/A | 1427 MHz – 1432 MHz | SDL |
| n77 | 3300 MHz – 4200 MHz | 3300 MHz – 4200 MHz | TDD |
| n78 | 3300 MHz – 3800 MHz | 3300 MHz – 3800 MHz | TDD |
| n79 | 4400 MHz – 5000 MHz | 4400 MHz – 5000 MHz | TDD |
| n80 | 1710 MHz – 1785 MHz | N/A | SUL |
| n81 | 880 MHz – 915 MHz | N/A | SUL |
| n82 | 832 MHz – 862 MHz | N/A | SUL |
| n83 | 703 MHz – 748 MHz | N/A | SUL |
| n84 | 1920 MHz – 1980 MHz | N/A | SUL |
| n86 | 1710 MHz – 1780 MHz | N/A | SUL |
| n89 | 824 MHz – 849 MHz | N/A | SUL |
| n90 | 2496 MHz – 2690 MHz | 2496 MHz – 2690 MHz | TDD |
| n91 | 832 MHz – 862 MHz | 1427 MHz – 1432 MHz | FDD2 |
| n92 | 832 MHz – 862 MHz | 1432 MHz – 1517 MHz | FDD2 |
| n93 | 880 MHz – 915 MHz | 1427 MHz – 1432 MHz | FDD2 |
| n94 | 880 MHz – 915 MHz | 1432 MHz – 1517 MHz | FDD2 |
| n951 | 2010 MHz – 2025 MHz | N/A | SUL |
| NOTE 1:   This band is applicable in China only.NOTE 2:   Variable duplex operation does not enable dynamic variable duplex configuration by the network, and is used such that DL and UL frequency ranges are supported independently in any valid frequency range for the band. |

**TS 38.104 V16.4.0 (2020-06), Table 5.3.5-1: *BS channel bandwidths* and SCS per *operating band* in FR1**

|  |
| --- |
| **NR band / SCS / *BS channel bandwidth*** |
| **NR Band** | **SCS****kHz** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **25 MHz** | **30 MHz** | **40 MHz** | **50 MHz** | **60 MHz** | **70 MHz** | **80 MHz** | **90 MHz** | **100 MHz** |
| n1 | 15 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| n2 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| n3 | 15 | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |  |
| n5 | 15 | Yes | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes |  |  |  |  |  |  |  |  |  |
| 60 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| n7 | 15 | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| 30 |  | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |
| 60 |  | Yes | Yes | Yes | Yes | Yes | Yes | Yes |  |  |  |  |  |

Appendix 3. Activity plan

As it was agreed in [3]:

* *Discussions are on the RAN1\_NR reflector*
	+ *Email activity only during short periods (< week) distributed across the time allocated to the activity*
	+ *No email activity in weeks before/during/after RAN1 meetings or RAN defined inactive periods*

Based on statements above, the following activity plan has been proposed:

1. 12-16 October 2020
	* Discussion on which URLLC features to include in the evaluations and simulation assumptions
2. 14-18 December 2020
	* First round of simulation results
3. 22-26 February 2021
	* Second round of simulation results
4. 8-12 March 2021
	* Finalization of the report to RAN#91