**3GPP TSG RAN WG1 #112bis-e R1-23xxxxx**

**e-Meeting, April 17th – 26th, 2023**

**Agenda Item: 9.5**

**Source: Moderator (InterDigital, Inc.)**

**Title: Rapporteur summary on LS reply for error source distributions (R1-2302282)**

**Document for: Discussion**

# Introduction

## RAN1 Task

In RAN2#121, the following agreement was made.

Agreements:

RAN2 anticipate that the error sources are overbounded by a Gaussian distribution.

LS to RAN1 to check this view and ask about the parameters for the overbound distributions.

Based on the agreement, the LS (R1-2302282) was sent to RAN1. The following question and task were asked and requested, respectively, by RAN2 in the LS. The LS is also shown in Appendix in this document.

* RAN2 would like to confirm with RAN1 on the above agreement regarding the distribution of error sources
* RAN1 to provide the parameters (e.g. mean and standard deviation) for the overbound Gaussian distribution.

In section 5, proposals are made based on the views presented by companies. The draft LS reply will be written based on the agreed proposals.

## Contact information

To facilitate discussions, please provide your contact information below.

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| --- | --- | --- |
| **Company** | **Point of contact** | **Email address** |
| InterDigital Inc. | Fumihiro Hasegawa | Fumihiro.hasegawa@InterDigital.com |
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# Background information

The following table was captured in TR 38.859 as the result of the study where the table captures error sources and identified candidate(s) for the distribution of each error source.

Table “Table 6.1.1-2: Identified candidates for distributions to model the errors due to different error sources” from TR 38.859

| Error source | Candidate(s) for distribution for error source |
| --- | --- |
| Timing measurement errors (NOTE 1, 2, 3) | Gaussian distribution |
| Inter-TRP synchronization errors | - Uniform distribution (NOTE 4)- Gaussian distribution |
| TRP location error (e.g., ***NR-TRP-LocationInfo*** in [16]) | - Uniform distribution (NOTE 5)- Gaussian distribution |
| TRP location error (e.g., Geographical coordinates in [17]) | - Uniform distribution- Gaussian distribution |
| ARP location error (e.g., ***ARPLocationInformation*** in [17]) | - Uniform distribution- Gaussian distribution |
| NOTE 1: Timing measurement errors are applicable to RSTD, RTOA and UE/gNB Rx-Tx time difference measurements.NOTE 2: It is assumed that the timing measurement error is associated with the first path.NOTE 3: It is assumed that the timing measurement error contains TEG related TX/RX timing error if the TEG related information is providedNOTE 4: This may already be consistent with the uncertainty related to ***NR-RTD-Info*** in [16].NOTE 5: This may already be consistent with the uncertainty related to ***NR-TRP-LocationInfo*** in [16]. |

# Checkpoints for email discussion

Tentative checkpoints regarding the assigned email discussion can be found below.

[112bis-e-R18-Pos-08] Email discussion on RAN2 LS on error source distributions in R1-2302282 by April 26 – Fumihiro (InterDigital)

* Tentative target for the agreement : Apr. 21
* Tentative target for the agreement of the draft LS : Apr. 25

## Deadline for the 1st round

* Deadline for the comments for the 1st round: Apr. 18 17:00 UTC

# Suggested proposals for approval and discussion

The agreed proposals will be used as baseline for the LS reply.

TBD

# Issues for discussion

## Confirmation of RAN2 agreement

**Details of proposals**

As described in the background section, RAN1 identified uniform and Gaussian distribution as candidate distributions for TRP location error, ARP location error and inter-TRP synchronization error.

For the timing measurement errors, RAN1 agreed that the distribution follows Gaussian distribution.

Gaussian distribution based overbounding enables integrity calculations. The discussion topic here is to agree whether it is possible to overbound the distribution of the identified error source by a Gaussian distribution. The following views are presented regarding the distribution for error sources and Gaussian distribution based overbounding.

* RAN2 agreement can be confirmed since Gaussian distribution was identified as one of the candidate distributions for the error sources identified during the study item [1].
* Parameterize the Gaussian bound [2].
* Inter-TRP synchronization error and TRP location error can be modeled as Gaussian distribution. In addition, timing measurement error can be model as Gaussian distribution according to the outcome of the study item [3].
* RAN2 agreement on the use of the Gaussian distribution for overbounding can be confirmed [4].
* Candidate distribution (uniform or Gaussian) for the error sources can be bounded by a Gaussian distribution. Thus, the RAN2’s assumption is correct. Depending on the distribution, the bound may be loose depending on the true distribution of the error source. RAN2 need to check whether the bound will be tight enough to be usable [5].
* Over-conservative variance may be needed for overbounding the distribution of the error source by using a Gaussian distribution. If an error source follows the Uniform distribution, it is possible to lose information of the uniform distribution by overbounding with a Gaussian distribution. A proposal is made to use both distributions (Gaussian and Uniform) instead of using a single one to overbound both [6].
* The error sources whose distributions have been identified in TR 38.859 can be assumed to have Gaussian distribution [7].
* RAN2 agreement on the use of the Gaussian distribution for overbounding can be confirmed [8].

### Issue #1 : Confirmation of RAN2 agreement

Below is a summary of companies’ inputs.

* Whether to confirm the RAN2 agreement, “RAN2 anticipate that the error sources are overbounded by a Gaussian distribution”
	+ Yes : [1,2,3,4,5,7,8]
	+ Concern : [6]

Considering two companies have questioned about tightness of the bound. Thus, the following proposal is made, capturing the LS texts in [5] about the tightness of the bound.

#### **Rapporteur proposal #1**

* Confirm the RAN2 agreement “the error sources are overbounded by a Gaussian distribution” for the error sources listed in Table 6.1.1-2 in TR 38.859 Tightness of the bound should be considered so that it is useful in the integrity framework..

#### Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
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## Parameters for the overbound Gaussian distribution

**Details of proposals**

The following views are presented in the contributions regarding the parameters for the overbound Gaussian distribution.

* The parameters for the Gaussian distribution can be mean and standard deviation. Zero-mean error can be assumed since any bias in the mean can be removed mostly by UE/gNB/LMF implementation. It is shown in the tables in 2.3.2 in [1] that quality information presented in TS 37.355 and TS 38.455 (e.g., nr-TimingQuality, nr-PathQuality, rtd-Quality, Timing Measurement Quality) can be used to present the standard deviation [1].
* The parameters for the Gaussian distribution can be mean and standard deviation [2]. Mean and standard deviations for each error source are listed in [2].
* The range of standard deviation for the timing measurement error can be derived from NR-TimingQuality in TS 37.355 [3]. rtd-RefQualit can be used to derive the range for the standard deviation for Inter\_TRP synchronization error [3]. locationUNC can be used to derive the value range for TRP location error. Finally, angle measurement quality can be used to derive the value range for the angle measurement error [3].
* Use existing fields to derive the range value for the standard deviation of the bound. The mean can be zero or non-zero, based on implementation [4].
* The value range for the standard deviation of the identified error source can be derived based on rtd-Quality-r16, NR-TimingQuality-r16 and LocationUncertainty-r16 [5].
* There is no need to report the mean. For the standard deviation for the overbound Gaussian distribution, it is proposed to introduce a new field [6].
* The standard deviation value can be derived based on uncertainty parameters (e.g., nr-TimingQuality, locationUNC) and TS 23.032 can be used as a reference [7].
* The parameters for the Gaussian distribution can be mean and standard deviation. It is up to RAN2 to decide the details of the parameters for the overbound Gaussian distribution [8].

Based on the above views, the following proposals are made.

### Issue #2 : Identification of parameters for an overbound Gaussian distribution

Based on the inputs from all companies, it can be agreed that parameters for the distribution of error sources can be mean and standard deviation.

#### **Rapporteur proposal #2**

* Parameters for the overbound Gaussian distribution can be mean and standard deviation

#### Companies views

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** |  | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
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### Issue #3 : Mean value for the overbound Gaussian distribution

Based on the majority view, except [4], it seems agreeable that the zero-mean can be assumed for the overbound Gaussian distribution.

#### **Rapporteur proposal #3**

* From RAN1’s perspective, Zero-mean can be assumed for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859

#### Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
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### Issue #4 : Standard deviation for the overbound Gaussian distribution

Whether to use the existing quality information and uncertainty information to derive the value range for the standard deviation for the overbound is discussed in companies’ contributions. The following views are presented.

* + Yes, existing quality information and uncertainty information can be used as a reference to derive the value range for the standard deviation for the overbound : [1,3,4,5,7]
	+ Introduce a new field for the standard deviation or range depending on the distribution of the error source : [6]

Based on the companies’ views, the moderator makes the following proposal. Whether to introduce a new field for reporting additional information related to the overbound can be discussed in RAN2.

#### **Rapporteur proposal #4**

* Existing fields corresponding to quality information (e.g., nr-TimingQuality, rtd-Quality-r16) and uncertainty information (e.g., LocationUncertainty-r16) can be used as a reference to derive the value range for the parameters (e.g., standard deviation) for the overbound Gaussian distribution for the error sources listed in Table 6.1.1-2 in TR 38.859.

#### Companies views

|  |  |  |
| --- | --- | --- |
| **Company** | **Support/Disagree** | **Reasons (Please provide an alternate proposal if there’s a concern about the proposal)** |
|  |  |  |
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# References

Discussion

[1] R1-2302642, “Discussion of RAN2 LS on error source distributions,” CATT, RAN1#121bis-e, Apr. 2023.

[2] R1-2302772, “Discussion on LS on error source distributions, ” OPPO, RAN1#121bis-e, Apr. 2023.

[3] R1-2303272, “Discussion on error source distributions for integrity, ” ZTE, RAN1#121bis-e, Apr. 2023.

[4] R1-2303442, “Discussion on LS reply regarding error source distributions, ” InterDigital, RAN1#121bis-e, Apr. 2023.

[5] R1-2303544, “discussion on draft reply LS on error source distributions, ” Ericsson, RAN1#121bis-e, Apr. 2023.

[6] R1-2303859, “Discussion on error source distributions, ” Huawei, HiSilicon, RAN1#121bis-e, Apr. 2023.

Draft LS reply

[7] R1-2302448, “[Draft] Reply LS on error source distributions, ” vivo, RAN1#121bis-e, Apr. 2023.

[8] R1-2303096, “Draft reply LS on error source distributions, ” Samsung, RAN1#121bis-e, Apr. 2023.

[9] R1-2303271, “Draft Reply LS on error source distributions, ” ZTE, RAN1#121bis-e, Apr. 2023.

[10] R1-2302643, “[Draft] Reply LS on error source distributions, ” CATT, RAN1#121bis-e, Apr. 2023.

[11] R1-2303441, “Draft Reply LS to RAN2 on error source distributions, ” InterDigital, RAN1#121bis-e, Apr. 2023.

# Appendix : R1-2302282, “LS on error source distributions”

**“1. Overall Description:**

During the discussion on RAT-dependent positioning integrity, RAN2 has reached the following agreement regarding the distribution of error sources:

Agreements:

RAN2 anticipate that the error sources are overbounded by a Gaussian distribution.

RAN2 would like to confirm with RAN1 on the above agreement regarding the distribution of error sources and respectfully ask RAN1 to provide the parameters (e.g. mean and standard deviation) for the overbound Gaussian distribution.

**2. Actions**

**To RAN1 groups**

**ACTION:** RAN2 respectfully asks RAN1 to confirm above agreement and provide the parameters (e.g. mean and standard deviation) for the overbound Gaussian distribution.”

# Summary of proposals, observations and LS reply from contributions for RAN1#112b-e

## [1, CATT]

Observation 1: The error sources may be cross-correlated and time-correlated. The parameterization of the Gaussian distribution for error sources is contingent upon whether the cross correlation and time correlation of the error sources are taken into account.

Proposal 1: Confirms RAN2’s agreement: “the error sources are overbounded by a Gaussian distribution”.

Proposal 2: In Rel-18, all identified error sources can be treated as independent Gaussian distribution variables. Time correlation of the error sources will not be considered.

Proposal 3: Each identified error source can be considered as a variable following a zero-mean Gaussian distribution.

Proposal 4: Inform RAN2 that the standard deviation of Gaussian distribution of the error sources can be presented by the quality parameters defined in TS 37.355 and TS 38.455 as shown in the following table.

-Note: Whether to use existing parameters or introduce new parameters to represent the standard deviation of Gaussian distribution of the error sources can be determined by RAN2 or RAN3.

|  |  |  |
| --- | --- | --- |
| **Error source** | **Standard deviation** | **Description** |
| RSTD error | *nr-TimingQuality (TS 37.355)**nr-PathQuality (TS 37.355)* | *nr-TimingQuality* specifies the target device′s best estimate of the quality of the RSTD measurement.*nr-PathQuality* specifies the target device′s best estimate of the quality of the detected timing of the additional path*.* |
| UE Rx-Tx time difference measurement error | *nr-TimingQuality (TS 37.355)**nr-PathQuality (TS 37.355)* | *nr-TimingQuality* specifies the target device′s best estimate of the quality of the UE Rx-Tx time measurement.*nr-PathQuality* specifies the target device′s best estimate of the quality of the detected timing of the additional path*.* |
| Inter-TRP synchronization | *rtd-RefQuality (TS 37.355)**rtd-Quality (TS 37.355)* | *rtd-RefQuality* specifies the quality of the timing of reference TRP.*rtd-Quality* specifies the quality of the RTD. |
| TRP/ARP location error | *locationUNC (TS 37.355)* | *locationUNC* specifies the uncertainty of the location coordinates and comprises the following sub-fields:- *horizontalUncertainty* indicates the horizontal uncertainty of the ARP latitude/longitude.- *verticalUncertainty* indicates the vertical uncertainty of the ARP altitude. |
| RTOA measurement error | *Timing Measurement Quality (TS 38.455)* | specifies the quality of the RTOA measurement. |
| AOA measurement error | *Angle Measurement Quality (TS 38.455)* | specifies the quality of the AoA measurement |

## [2, OPPO]

Proposal 1: The parameters for overbound Gaussian distribution for each identified error source are:

-TRP location error: the mean TRP location offset, and the std of TRP location offset

-Inter-TRP synchronization error: the mean inter-TRP synchronization offset and the std of inter-TRP synchronization offset

-ARP location error: the mean ARP location offset and the std of ARP location offset

-Angle of arrival measurement error: the mean AoA measurement error, the std of AoA measurement error, the mean ZoA measurement error, the std of ZoA measurement error.

-DL-PRS RSRPP measurement error: the mean RSRPP measurement error and the std of RSRPP measurement error

-RSTD measurement error: the mean RSTD measurement error and the std of RSTD measurement error

-RTOA measurement error: the mean RTOA measurement error and the std of RTOA measurement error

-UE Rx-Tx time difference measurement error: the mean UE Rx-Tx time difference measurement error and the std of UE Rx-Tx time difference measurement error

-gNB Rx-Tx time difference measurement error: the mean gNB Rx-Tx time difference measurement error and the std of gNB Rx-Tx time difference measurement error

## [3, ZTE]

***Proposal 1:*** *For distributions of timing measurement error sources which have been agreed as Normal distribution, the range of std can be based on the maximum value of the existing parameter NR-TimingQuality-r16:*

* *Std value :{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{31}{n})$ *, and n= 3*
* *Resolution: {mdot1, mdot5, m1, m5, m10, m20, m30}*

***Proposal 2:*** *Inter-TRP synchronization error is normal distribution.*

* *Std value:{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{31}{n})$ *, and n= 3*
* *Resolution: {mdot1, mdot5, m1, m5, m10, m20, m30}*

***Proposal 3:*** *TRP/ARP location error distribution is modeled as normal distribution. The std can be calculated based on the existing parameter LocationUncertainty including uncertainty value and confidence value.*

* *The std value* $δ$ *should make* *, and* , *where P is the confidence value, a is the Uncertainty value, and*  *is the inverse error function, and* *.*

* *The extra signaling is not needed.*

***Proposal 4:*** *For angle related error sources, the range of the std can be based on the maximum value of the existing parameter of Angle Measurement Quality.*

* *Std value:{0,1,2,... stdmax}, where* $std\_{max}=round (\frac{255}{n})$*, and n = 3*
* *Resolution: {0.1deg,...}*

## [4, InterDigital]

Observation 1: Mean for timing measurement error can be zero nor non-zero

Observation 2: Mean for TRP location error, inter-TRP synchronization error or ARP location error can be zero or non-zero.

Proposal 1: For the discussion related to LS reply for R2-2302271, limit the scope of the discussion to the error sources listed in Table 6.1.1-2 in TR 38.859.

Proposal 2: RAN1 can confirm that error sources with options for distributions listed in Table 6.1.1-2 in TR 38.859 can be overbounded by a Gaussian distribution.

Proposal 3: Mean for the error sources shown in Table 6.1.1-2 in TR 38.859 can be zero or non-zero depending on implementations at the UE or network.

Proposal 4: References for derivation of the value range for the standard deviation for error sources shown in Table 6.1.1-2 in TR 38.859 can be uncertainty or quality indicator in specification, e.g., nr-TimingQuality for timing measurement error, locationUNC for TRP/ARP location error and NR-RTD-Info for inter-TRP synchronization error.

## [5, Ericsson]

Proposal 1 The RAN2 assumption to always overbound errors with a Gaussian distribution is valid from the RAN1 perspective.

Proposal 2 The parameters for the gaussian distribution (mean and variances) can use the uncertainty parameters for the respective error measurement as a starting point.

## [6, Huawei, HiSilicon]

Observation 1: Having an overbounding Gaussian distribution for an error source with Gaussian distribution may result in an over-conservative reporting of the variance.

Observation 2: If RAN2 intention is to use overbounding Gaussian distribution for an error source with uniform distribution, it may lose the information of the uniform distribution, and the variance of the overbounding Gaussian distribution can be arbitrarily set.

Proposal 1: RAN1 clarifies that it is preferred to use the both distributions (Gaussian and Uniform) instead of using a single one to overbound both. RAN1 sees the problem of overbounding the uniform distribution with a Gaussian distribution.

Proposal 2: To describe any Gaussian distribution for an error source, there is no need to report the mean, and a new field for the std can be introduced.

Proposal 3: To describe any uniform distribution for an error source, there is no need to report the mean, and a new field for the range can be introduced.

Proposal 4: Endorse the reply in the Appendix.

## [7, vivo]

RAN1 would like to provide the following response for the value range of mean and standard deviation for the agreed error source as the following table, where the deviation is determined according to uncertainty parameter(e.g., nr-TimingQuality, locationUNC)

| Error source | Candidate(s) for distribution for error source | Value range of mean and deviation |
| --- | --- | --- |
| Timing measurement errors (NOTE 1, 2, 3) | * Gaussian distribution
 | Mean: 0Deviation: INTEGER (0..31)Resolution:ENUMERATED (0.1m, 1m, 10m, 30m, …) |
| Inter-TRP synchronization errors | * Gaussian distribution
 | Mean: 0Deviation: INTEGER (0..31)Resolution:ENUMERATED (0.1m, 1m, 10m, 30m, …) |
| TRP location error (e.g., ***NR-TRP-LocationInfo*** in [16]) | * Gaussian distribution
 | Mean of horizontal: 0 Deviation of horizontal: INTEGER (0..255) Mean of vertical 0Deviation of vertical: INTEGER (0..255) (and the Deviation value can be mapped to the uncertainty value in TS 23.032) |
| ARP location error (e.g., ***ARPLocationInformation*** in [17]) | * Gaussian distribution
 | Mean of horizontal:0Deviation of horizontal: INTEGER (0..255) Mean of vertical 0Deviation of vertical: INTEGER (0..255) (and the Deviation value can be mapped to the uncertainty value in TS 23.032) |
| NOTE 1: Timing measurement errors are applicable to RSTD, RTOA and UE/gNB Rx-Tx time difference measurements.NOTE 2: It is assumed that the timing measurement error is associated with the first path.NOTE 3: It is assumed that the timing measurement error contains TEG related TX/RX timing error if the TEG related information is provided |

## [8, Samsung]

RAN1 reply: RAN1 confirms the RAN2 agreement but it is up to RAN2 for deciding the parameters (e.g., mean and standard deviation) for the overbound Gaussian distribution.