**3GPP TSG RAN WG1 #110bis-e R1-221xxxx**

**e-Meeting, October 10th – 19th, 2022**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

**Title:** Summary of TDCP Alternatives for Comparison

**Document for:** Discussion and Decision

[110bis-e] **Agreement**

For the Rel-18 TRS-based TDCP reporting, down select one of the following alternatives by RAN1#110bis-e:

* AltA. Based on Doppler profile
	+ E.g., Doppler spread derived from the 2nd moment of Doppler power spectrum, average Doppler shifts, Doppler shift per resource, maximum Doppler shift, relative Doppler shift, etc
* AltB. Based on *quantized amplitude of* time-domain correlation profile
	+ E.g. Correlation within one TRS resource, correlation across multiple TRS resources
	+ Note: The correlation over one or more lags of TRS resource may be considered.  The lags may be within one TRS burst or different TRS bursts

Note: Different alternatives may or may not apply to different use cases

FFS: The need for a measure of confidence level in the TDCP report, and/or UE behaviour when the quality of TDCP measurement is not sufficiently high

FFS: TDCP parameter(s) signalled with respect to each alternative

For the purpose of performance comparison and down-selection in RAN1#111, the alternatives for TDCP are summarized below:

**Table 1**

|  |  |  |  |
| --- | --- | --- | --- |
| **TDCP report** | **What to report (spec impact)** | **How to calculate: examples, possible implementation (companies are to state their calculation method)** | **Support (per RAN1#110bis-e)** |
| A1. Doppler spread | One Doppler spread value | * Difference between lowest- and highest-value Doppler shifts in Doppler power spectrum (\*).
* Curve fitting between a known correlation profile as a function of Doppler spread (e.g. $X\left(δ\right)=J\_{0}\left(2πDδ\right)$) with calculated time-domain correlation profile (\*\*)
 | vivo, Google, LG, OPPO, Huawei/HiSi, Xiaomi, Mavenir, Apple (1st pref), CATT, IDC, Spreadtrum, NEC (2nd pref), Nokia/NSB  |
| A2. Relative Doppler shift per resource | With N TRS resources: (1) Doppler shift for a reference TRS resource + (N-1) differential Doppler shifts; (2) CRI of the reference TRS resource | * [A2 proponents]
 | ZTE, .. |
| A3. Relative Doppler shift per CIR peak | With M identified peaks in measured CIR: (1) Doppler shift for a reference CIR peak + (M-1) differential Doppler shifts;(2) M values of delay shift in CIR | * [A3 proponents]
 | ?? |
| B. Time-domain correlation profile  | Non-zero quantized amplitude for each delay value (quantized amplitude vs delay) | * Auto-correlation of a time series measured from a TRS resource.
* Multiple profiles can be calculated from different lags of the same resource or different resources
* [Normalized vs un-normalized] [equation]
* Indication of delay in terms of a lag value corresponding to a given quantized amplitude, e.g., for a given correlation amplitude, report symbol/TRS occasion index with respect to a given correlation amplitude [no equation]

[B proponents] | Samsung, Ericsson, MediaTek, vivo, Qualcomm, DOCOMO, OPPO, Sharp, Lenovo (highlighted bullet), Apple (2nd pref), IDC, NEC (1st pref), CEWiT, Fraunhofer IIS/HHI, |

(\*) Doppler power spectrum is derived from time-domain correlation profile (see B)

(\*\*) Time-domain correlation profile is defined in B.

**Table 2 Additional inputs**

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Share your inputs, if any, on each cell of Table 1** |
| Ericsson | **Alternative B column 2 in Table 1:**We propose the following changes/additions:Non-zero quantized amplitude for ~~each~~ a number of delay values $τ$ (quantized amplitude vs delay):$$A\left(t,τ\right)=\left|\frac{c\left(t,τ\right)}{c\left(t,0\right)}\right|$$where$$c\left(t,τ\right)=\sum\_{n=0}^{N-1}h\_{n}\left(t+τ\right)∙h\_{n}^{\*}\left(t\right)$$and $h\_{n}$ is the channel for subcarrier n.**Alternative B column 3 in Table 1:**Comment 1. We propose to correct the following typo:* Multiple ~~profiles~~ Auto-correlation values can be calculated from different lags of the same resource or different resources

2. We have seen no one propose to report the un-normalized Auto-correlation. The overall rx power c(0) carries no useful information and the normalization saves a lot of overhead by making the Autocorrelation strictly smaller than one and removing the need to report the Auto-correlation for zero lag. We therefore propose to remove the bullet on Normalized versus un-normalized equation and instead include Normalization in the first bullet. Thus we propose the following changes:* Normalized Auto-correlation of a time series measured from a TRS resource.
* Multiple ~~profiles~~ Auto-correlation values can be calculated from different lags of the same resource or different resources
* ~~[Normalized vs un-normalized] [equation]~~

Comment 3. We also propose to include the following text giving two examples for how to perform estimation of the auto-correlation:How to perform the estimation should be up to UE implementation but for the purpose of evaluations we give two examples. The autocorrelation can be estimated by replacing the channel $h\_{n}$ for subcarrier *n* in the defining formula in column 2, with the matched filter subcarrier components $X\_{n}=R\_{n}∙S\_{n}^{\*}$  of the received signal $R\_{n}$ where $S\_{n}^{\*}$ is the complex conjugate of the known transmitted TRS signal. For $c\left(t,0\right)$ one can use the arithmetic average over the two TRS symbols separated by the time $τ$ , i.e.$$A\left(t,τ\right)≈\frac{\left|\sum\_{n=0}^{N-1}X\_{n}\left(t+τ\right)∙X\_{n}^{\*}\left(t\right)\right|}{\frac{1}{2}∙\sum\_{n=0}^{N-1}\left(X\_{n}\left(t\right)∙X\_{n}^{\*}\left(t\right)+X\_{n}\left(t+τ\right)∙X\_{n}^{\*}\left(t+τ\right)\right)}$$or one may use the geometric average for $c\left(t,0\right)$, i.e. $$A\left(t,τ\right)≈\frac{\left|\sum\_{n=0}^{N-1}X\_{n}\left(t+τ\right)∙X\_{n}^{\*}\left(t\right)\right|}{\sqrt{\sum\_{n}^{}\left|X\_{n}\left(t+τ\right)\right|^{2}}\sqrt{\sum\_{n}^{}\left|X\_{n}\left(t\right)\right|^{2}}}$$Which example is used in evaluation can be stated by company along with their evaluation results. Further methods to remove noise bias and to suppress noise would typically be used. |
| Lenovo | **Re Alt-A:**We still would like to have better understanding from Alt-A proponents on how the Doppler shift can be differentiated from CFO, since they both cause a frequency shift with the same order of values. Even if this will be handled in a spec-transparent manner based on UE implementation, it is important that the proponents explain how this can be done so we can assess the feasibility and efficiency of Alt-A before supporting it**Re Alt-B:**We have added one bullet point (highlighted) that can help as a workaround regarding specifying the autocorrelation function. Instead of reporting the quantized correlation amplitude for a fixed lag, alternatively the lag is reported (in terms of a symbol index or TRS occasion index) with respect to a fixed correlation amplitude. The fixed correlation amplitudes can be configured from a small set of values, e.g., two values corresponding to strong, weak correlation, so that the process is less dependent on the underlying autocorrelation function as much as possible |
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