**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 |
| Ericsson2 | @Lenovo: Regarding what you have added in Alt B, it is one possibility. Just to make it clear, in either case, for what you have in mind also, the UE will be measuring normalized autocorrelation. And, the examples we showed for A(t,tau) above are also up to UE implementation and does not need those specific formulas to be specified in specs.Regarding your two level reporting idea, this is more related to how the measured correlation should be quantized (i.e., the small set of values). What type of quantization is needed can be determined later based on evaluations. |
| ZTE | Re A2, regarding component of report format (considering report overhead or not), in our views, the proposal from the FL is a good example, but may not be needed in this so-detailed level. Similarly, in B, we do not discuss the list of ‘non-zero quantized amplitude for each delay value’ (differential or absolute). To make it general, we have the following suggestion for second column. Then the sub-bullet(s) can be removed or captured in the third column, if needed.With N ≥ 1 TRS resources, Doppler shift per resource (e.g., differential or absolute value) For calculating the Doppler shift, I guess that we may not need to further clarify it. All are senior delegates/experts. ^\_^ If needed, we have the following example * Doppler shift fd is derived based on the following equation: fd = angle(r)/(2\*pi\*t)
	+ where r is the channel correlation measured from different TRS symbols and t is the time domain interval for the channel correlation.
* For differential manner, the differential value (e.g., relative Doppler shift) is: fd - fd\_reference
 |
| Qualcomm | Re Alt-BFor the formula of auto-correlation, our understanding is what Ericsson mentioned as “geometric average.”Actually, if the signal $X\left(t\right)$ and $X(t+τ)$ are already the normalized version themselves, i.e. $\sum\_{n=0}^{N-1}X\_{n}\left(t\right)∙X\_{n}^{\*}\left(t\right)=\sum\_{n=0}^{N-1}X\_{n}\left(t+τ\right)∙X\_{n}^{\*}\left(t+τ\right)$, the two formulas (arithmetic and geometric average) are equivalent.Regarding profiles with longer lag than 2 slots, we can understand its motivation for lower-speed scenario, and we can also support (but should not require receiving phase continuity of course, which is satisfied by the formulation with $\left|\right|$ operation in the numerator). Yet, however, maybe a 2nd-level thing to discuss is overhead. For example, for a 5msec lag, 2 TRS bursts with total 8 symbols seem redundant – actually 2 single-port CSI-RS symbols with 5msec time spacing would work. Therefore, we think longer lag does not need to be tied with existing TRS definition, and a single-port CSI-RS resource set with newly defined time spacing is enough – this can also leverage some work anyway need to be done for Type-II-Doppler CSI topic. |
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