**3GPP TSG RAN WG1 Meeting #105-e R1-** **21XXXXX**

e-Meeting, May 19th – 27th, 2021

**Agenda item: 8.1.4**

**Source: Nokia, Nokia Shanghai Bell**

**Title: On the alternative SCI solutions**

**Document for: Discussion and Decision**

# 1 Introduction

In this document we provide some simple examples to illustrate the differences between the alternatives 0, 1 and 2 proposed for the SCI reporting.

*Proposal 13: Study following alternatives for reporting the strongest coefficient indication (SCI) for Rel-17 port selection codebook in W2*

* *Alt 0: Reporting of the position, [il\*, fl\*], of the strongest coefficient of layer l using ceil(log2(K0)) bits, where K0=Beta\*K1\*Mv*
* *Alt 1: Reporting of the position, [il\*, fl\*], of the strongest coefficient of layer l, using ceil(log2(K1\*Mv)) or ceil(log2(K1))+ceil(log2(Mv)) bits*
	+ *FFS whether phase shifting the strongest coefficient to fl\* = 0 is needed*
* *Alt 2: phase shifting the strongest coefficient to fl\* = 0, and using ceil(log2(N)) bits to indicate the phase shift quantity for l-th layer. The strongest coefficient is indicated by il\*, using ceil (log2 (K1,l)) for l-th layer.*
* *Alt 3: SCI is not needed so that the SCI in R16 codebook is replaced with a strongest polarization indicator (1 bit)*

We consider a simple toy example with $K\_{1}=2$, $M\_{ν}=2$, $β=1$ and two cases for the window size: $N=3$ and $N=2$. We assume that, for $N=3$, $W\_{f}$ is reported with $\left⌈log\_{2}\left(\begin{matrix}N-1\\M\_{ν}-1\end{matrix}\right)\right⌉=1$ bit, whereas for $N=2$, $W\_{f}$ is not reported.

In the example we assume $K^{NZ}=K\_{0}=4$ and the NZC are: $W\_{2}=\left[\begin{matrix}a&c\\b&d\end{matrix}\right]$. The strongest coefficient is $c$ in position $\left[i\_{l}^{\*},f\_{l}^{\*}\right]=[0,1]$.

# 2 Example 1: $N=3,M\_{ν}=2$

Let’s assume $W\_{f}=\left[n\_{3,l}^{\left(0\right)},n\_{3,l}^{\left(1\right)}\right]=[1, 2]$.

* Alt 0.
	+ Shift on $W\_{f}$ (different from Rel16). The FD components are remapped with respect to $n\_{3,l}^{\left(0\right)}=1$, as $n\_{3,l}^{\left(f\right)}=\left(n\_{3,l}^{\left(f\right)}-n\_{3,l}^{\left(0\right)}\right)$, such that $n\_{3,l}^{\left(0\right)}=0$ after remapping. In the example, only the FD component $n\_{3,l}^{\left(1\right)}=1$ is reported.
	+ Shift on $W\_{2}$ (different from Rel16). None
	+ SCI. The SCI is calculated from the bitmap $B=\left[b\_{i,f}\right], b\_{i,f}\in \{0,1\}$ and $\left[i\_{l}^{\*},f\_{l}^{\*}\right]$ for example as follows:

$$SCI=\sum\_{f=0}^{f\_{l}^{\*}-1}\sum\_{i=0}^{K\_{1}}b\_{i,f}+\sum\_{i=0}^{i\_{l}^{\*}}b\_{i,f\_{l}^{\*}}-1$$

In the example, $SCI=2$, which is represented with $\left⌈log\_{2}(βK\_{1}M\_{ν})\right⌉=2$ bits.

* + UCI encoding (different from Rel16).
		- The SCI and bitmap need to be grouped together in G0 because the SCI depends on the bitmap.
		- If the FD component of the strongest coefficient is encoded first as in Rel16, because statistically more significant, the index $f$ needs to be remapped with respect to $f\_{l}^{\*}$ as $f=\left(f-f\_{l}^{\*}\right) mod M\_{ν} $, such that $W\_{2}$ is reported as $W\_{2}=\left[\begin{matrix}c&a\\d&b\end{matrix}\right]$, i.e., the columns of $W\_{2}$ are swapped
* Alt 1.
	+ Shift on $W\_{f}$(different from Rel16). The FD components are remapped with respect to $n\_{3,l}^{\left(0\right)}=1$, as $n\_{3,l}^{\left(f\right)}=\left(n\_{3,l}^{\left(f\right)}-n\_{3,l}^{\left(0\right)}\right)$, such that $n\_{3,l}^{\left(0\right)}=0$ after remapping. In the example, only the FD component $n\_{3,l}^{\left(1\right)}=1$ is reported.
	+ Shift on $W\_{2}$ (same as Rel16). The index $f$ is remapped with respect to $f\_{l}^{\*}$ as $f=\left(f-f\_{l}^{\*}\right) mod M\_{ν} $, such that $W\_{2}$ is reported as $W\_{2}=\left[\begin{matrix}c&a\\d&b\end{matrix}\right]$, i.e., the columns of $W\_{2}$ are swapped, and the FD component of the strongest coefficient is encoded first in the UCI as in Rel16
	+ SCI. The SCI is reported as $\left[i\_{l}^{\*},f\_{l}^{\*}\right]$ with $\left⌈log\_{2}(K\_{1})\right⌉+\left⌈log\_{2}(M\_{ν})\right⌉=2$ bits or calculated, for example, as follows:

$$SCI=K\_{1}f\_{l}^{\*}+i\_{l}^{\*}$$

which is represented with $\left⌈log\_{2}(K\_{1}M\_{ν})\right⌉=2$ bits.

* + UCI encoding (same as Rel16).
* Alt 2.
	+ Shift on $W\_{f}$(same as Rel16). The FD components are remapped with respect to $n\_{3,l}^{\left(f\_{l}^{\*}\right)}=2$, as $n\_{3,l}^{\left(f\right)}=\left(n\_{3,l}^{\left(f\right)}-n\_{3,l}^{\left(f\_{l}^{\*}\right)}\right)mod N\_{3}$, such that $n\_{3,l}^{\left(f\_{l}^{\*}\right)}=0$ after remapping. In the example, only the FD component $n\_{3,l}^{\left(0\right)}=N\_{3}-1$ is reported (in the same way as for Rel16 *IntS* mechanism, where $M\_{initial}=-n\_{3,l}^{\left(f\_{l}^{\*}\right)}$ and the window size is $N$ instead of $2M\_{ν}$).

$n\_{3,l}^{\left(f\_{l}^{\*}\right)}\in \{0,…,N-1\}$ also needs reporting with $\left⌈log\_{2}(N)\right⌉$ bits for each layer.

* + Shift on $W\_{2}$(same as Rel16). The index $f$ is remapped with respect to $f\_{l}^{\*}$ as $f=\left(f-f\_{l}^{\*}\right) mod M\_{ν} $, such that $W\_{2}$ is reported as $W\_{2}=\left[\begin{matrix}c&a\\d&b\end{matrix}\right]$ and the FD component of the strongest coefficient is encoded first in the UCI as in Rel16
	+ SCI. The SCI is reported as $\left[i\_{l}^{\*}\right]$ with $\left⌈log\_{2}(K\_{1})\right⌉$ bits
	+ UCI encoding (same as Rel16).

# 3 Example 2: $N=M\_{ν}=2$

In this case $W\_{f}=\left[n\_{3,l}^{\left(0\right)},n\_{3,l}^{\left(1\right)}\right]=[0, 1]$ and $W\_{f}$ is not reported. Alt 1 and Alt 2 become equivalent (with separate reporting of $i\_{l}^{\*}$ and $f\_{l}^{\*}$)

* Alt 0.
	+ Shift on $W\_{2}$. None
	+ SCI. Same as example 1
	+ UCI encoding.
		- The SCI and bitmap need to be grouped together in G0.
		- If the FD component of the strongest coefficient is encoded first as in Rel16 because statistically more significant, the index $f$ needs to be remapped with respect to $f\_{l}^{\*}$ as $f=\left(f-f\_{l}^{\*}\right) mod M\_{ν} $, such that $W\_{2}$ is reported as $W\_{2}=\left[\begin{matrix}c&a\\d&b\end{matrix}\right]$
* Alt 1.
	+ Shift on $W\_{2}$. Same as example 1
	+ SCI. Same as example
	+ UCI encoding (same as Rel16).
* Alt 2.
	+ Shift on $W\_{2}$. Same as example 1
	+ SCI (almost same as Rel16). The SCI is reported as $\left[i\_{l}^{\*}\right]$ with $\left⌈log\_{2}(K\_{1})\right⌉$ bits and the shift $n\_{3,l}^{\left(f\_{l}^{\*}\right)}=f\_{l}^{\*}\in \{0,…,M\_{ν}-1\}$ is also reported with $\left⌈log\_{2}(M\_{ν})\right⌉$ bits per layer. In this case the SCI is the same as Alt 1 when using $\left⌈log\_{2}(K\_{1})\right⌉+\left⌈log\_{2}(M\_{ν})\right⌉$ bits.
	+ UCI encoding (same as Rel16).