3GPP TSG-RAN WG1 NR Ad Hoc Meeting #2 **R1-1711527**
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Source: **Cohere Technologies**
Title: **PRACH Preamble Format Design**
Agenda item: **5.1.1.4.1**
Document for: **Discussion/Decision**

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1. Introduction

In [1] the Root Hamming windowed repetition Zadoff-Chu sequence was presented, and was shown to greatly improve resilience to Doppler. In this submission, we demonstrate that the Doppler resilience of repetition M-sequences can also be improved through the application of a window.

2. Root Hamming Windowed M sequence

We propose a 3x repetition M-sequence with a Root-Hamming window. Let N denoted the length of the M-sequence in baseband. Then, $M = 3N$ is the length of the final sequence. Denote the sequence by p, then:

$$p[m] = w_r[m]\, s[mod(m, N)], \text{ for } m = 0,1, \dots, M-1$$

Where w_r denotes the Root-Hamming window, and s denotes a M-sequence. The Root-Hamming window is defined below:

$$w[m] = \sqrt{0.54 - 0.46\, cos(2\pi m/(M-1))} \quad \text{for } m = 0, 1, \dots, M-1$$

3. Simulation results/Discussion

The PRACH performance of a repetition M-sequence was compared with and without a Root-Hamming window. In the simulations, a unit power amplifier was used for all sequences, so effects of PAPR are included. The channel parameters are given in table 1. The sequence parameters are given in table 2.

Table 1: Simulation Parameters

Channel model	**CDL-C (100 ns scaling)**
MIMO order	**1 x 1 x 2**
UE speed	**250, 500 km/h**
Carrier frequency	**4 GHz**
Timing offset	**0-100 μs**
Frequency offset	**0.1 ppm at UE, 0.05 ppm at TRP**
PRACH bandwidth	**1.08 MHz**

Table 2: Sequence Parameters

Symbols in M sequence	**255**
Subcarrier spacing	**3.75 kHz**
Repetitions of M sequence	**3**
Total number of symbols	**765**

Figure 1 compares the missed detection rate of the two sequences at 500 km/h. Note that the application of the Root-Hamming window gives both an SNR gain and removes the error floor.

- **SNR Gain:** the blue line is shifted 0.5 – 1.0 dB to the left of the red line.
- **Error floor:** the red line asymptotes slightly below 10^{-3} missed detection rate, while the blue line achieves a missed detection rate below 10^{-4}.

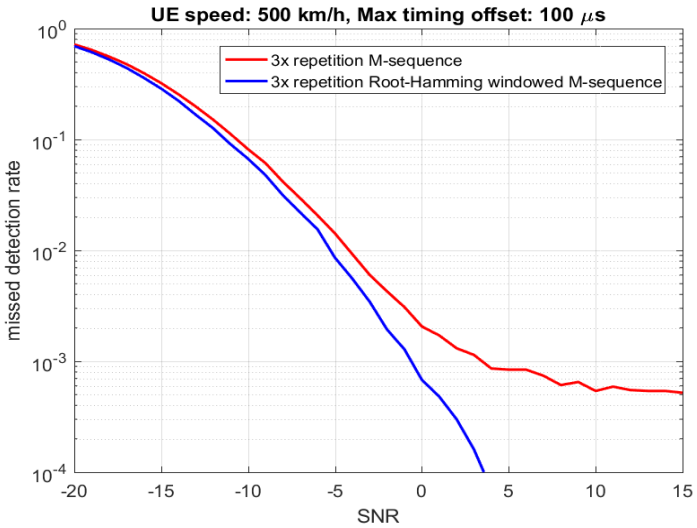

Figure 1: Miss detection probability; 500 km/h; maximum timing offset: 100 µs.

Figure 2 compares the missed detection rate of the two sequences at 250 km/h.

- **SNR Gain:** the blue line is shifted 0.5 – 6.0 dB to the left of the red line.

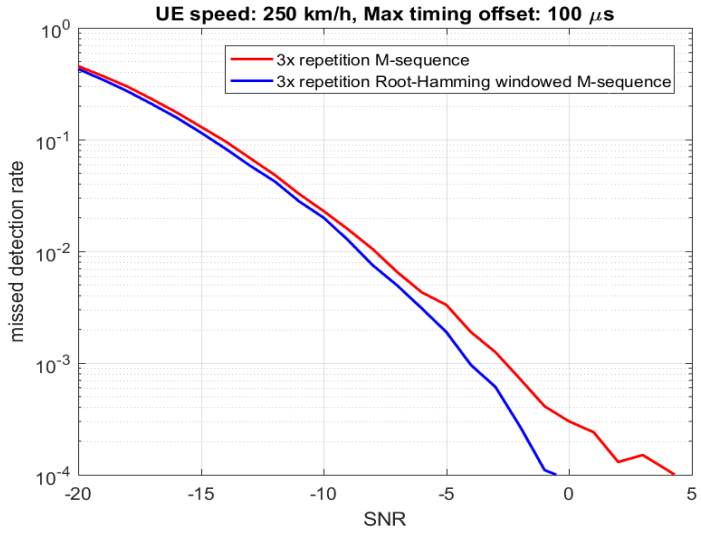

Figure 2: Miss detection probability; 250 km/h; maximum timing offset: 100 µs.

3.1 Discussion

Observation 1: The application of windowing to repetition PRACH sequences improves resilience to Doppler.

Observation 2: For 3x repetition sequences the Hamming window gives excellent performance.

Observation 3: For different repetitions, other windows will be optimal.

Proposal 1: For the high speed and large cell case, for repetition PRACH sequences the use of windowing should be further studied.

4. References

[1]. R1-1705458, “PRACH Design”, 3GPP RAN1 #88bis, Spokane, WA, USA, April 2017.