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Agenda Item:

Source: InterDigital Comm. Corp.

Title: Cross-correlation Matrices for Random Access Preamble Detection

Document for:

Summary:

This contribution identifies the cross-correlation matrices for random access preamble signatures for differential Phase Shift Keying (DPSK), coherent PSK, and a segmented cross-correlation for coherent PSK. These matrices were generated without additive noise or distortion of the signal.

Introduction:

In Tdoc R1-99138 it was shown that the use of differentially encoded RACH preamble signatures provide a performance advantage over the current FDD baseline for cases with high Doppler. Motorola has suggested that the differentially encoded approach be compared to a modified coherent approach using a segmented correlation of 4 segments of 4 symbols each. As part of this comparison the following correlation matrices have been generated. These matrices will be useful in understanding the performance differences of differential and segmented approaches. This performance data is provided in Tdoc R1-99140.

For the coherent PSK case, the cross correlation was computed for the original preamble signature matrix with itself:

Cross Correlation matrix for original preamble signatures

32	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	32	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	32	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	32	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	32	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	32	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	32	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	32	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	32	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	32	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	32	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	32	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	32	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	32	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	32	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32

For the DPSK case, the original preamble signature matrix was modified, by multiplying the appropriate rows by –1 so that each symbol in the first column of the matrix is +A. Next this modified matrix was differentially encoded. The following illustrates the cross-correlation for the DPSK-encoded signatures:

Cross Correlation matrix for DPSK-encoded modified preamble signatures

32	0	4	4	0	0	4	0	0	8	4	4	4	12	8	4
0	32	12	4	0	0	4	8	8	0	4	4	4	4	0	4
4	12	32	8	4	4	0	4	4	4	0	0	0	0	4	8
4	4	8	32	4	4	0	4	12	4	0	8	0	0	4	0
0	0	4	4	32	0	12	0	0	8	4	4	4	4	8	4
0	0	4	4	0	32	4	8	8	0	4	12	4	4	0	4

```
 4   4   0   0  12   4  32   4   4   4   8   0   8   0   4   0
 0   8   4   4   0   8   4  32   0   0   4   4   4   4   0  12
 0   8   4  12   0   8   4   0  32   0   4   4   4   4   0   4
 8   0   4   4   8   0   4   0   0  32   4   4  12   4   0   4
 4   4   0   0   4   4   8   4   4   4  32   0   0   8  12   0
 4   4   0   8   4  12   0   4   4   4   0  32   0   0   4   8
 4   4   0   0   4   4   8   4   4  12   0   0  32   8   4   0
12   4   0   0   4   4   0   4   4   4   8   0   8  32   4   0
 8   0   4   4   8   0   4   0   0   0  12   4   4   4  32   4
 4   4   8   0   4   4   0  12   4   4   0   8   0   0   4  32
```

The DPSK-encoded signature matrix was then decoded, and the cross-correlation computed for that decoded matrix with the original modified signature matrix (i.e., the original preamble signatures, multiplied by –1, as appropriate). Note that this is the ideal diagonal:

Cross Correlation matrix for DPSK-encoded/decoded modified preamble signatures

```
16   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0  16   0   0   0   0   0   0   0   0   0   0   0   0   0   0
 0   0  16   0   0   0   0   0   0   0   0   0   0   0   0   0
 0   0   0  16   0   0   0   0   0   0   0   0   0   0   0   0
 0   0   0   0  16   0   0   0   0   0   0   0   0   0   0   0
 0   0   0   0   0  16   0   0   0   0   0   0   0   0   0   0
 0   0   0   0   0   0  16   0   0   0   0   0   0   0   0   0
 0   0   0   0   0   0   0  16   0   0   0   0   0   0   0   0
 0   0   0   0   0   0   0   0  16   0   0   0   0   0   0   0
 0   0   0   0   0   0   0   0   0  16   0   0   0   0   0   0
 0   0   0   0   0   0   0   0   0   0  16   0   0   0   0   0
 0   0   0   0   0   0   0   0   0   0   0  16   0   0   0   0
 0   0   0   0   0   0   0   0   0   0   0   0  16   0   0   0
 0   0   0   0   0   0   0   0   0   0   0   0   0  16   0   0
 0   0   0   0   0   0   0   0   0   0   0   0   0   0  16   0
 0   0   0   0   0   0   0   0   0   0   0   0   0   0   0  16
```

A segmented cross-correlation was computed for the original signatures by breaking each signature into 4 segments of 4 symbols each, computing the cross-correlation for each segment, and summing the magnitude of those values. This segmented approach was then repeated for the sum of the squares of the magnitude of each segment.

Segmented Cross Correlation matrix for original preamble signatures (sum of magnitudes)

```
32   8   8   8   8  16   8   8   8  16  16   8   8  16  16   8
 8  32  16  16  16   8   8  16  16   8   8   8   8   8   8   8
 8  16  32  16   8   8  16   8  16   8   8   8   8   8   8  16
 8  16  16  32   8   8   8   8  16   8   8  16  16   8   8   8
 8  16   8   8  32   8  16   8   8  16   8   8  16   8  16   8
16   8   8   8   8  32   8  16  16   8   8  16   8   8   8  16
 8   8  16   8  16   8  32   8   8  16  16   8  16   8   8   8
 8  16   8   8   8  16   8  32   8   8   8  16   8   8  16  16
 8  16  16  16   8  16   8   8  32  16   8   8   8   8   8   8
16   8   8   8  16   8  16   8  16  32   8   8  16   8   8   8
16   8   8   8   8   8  16   8   8   8  32   8   8  16  16  16
 8   8   8  16   8  16   8  16   8   8   8  32   8  16   8  16
 8   8   8  16  16   8  16   8   8  16   8   8  32  16   8   8
16   8   8   8   8   8   8   8   8   8  16  16  16  32  16   8
16   8   8   8  16   8   8  16   8   8  16   8   8  16  32   8
 8   8  16   8   8  16   8  16   8   8  16  16   8   8   8  32
```

Segmented Cross Correlation matrix for original preamble signatures (sum of squares of magnitudes)

```
256   32   32   32   32   96   32   32   32   96   64   32   32  128   64   32
 32  256  128   64   96   32   32   96   64   32   32   32   32   32   32   32
 32  128  256   64   32   32   96   32   64   32   32   32   32   32   32   96
 32   64   64  256   32   32   32   32  128   32   32   96   96   32   32   32
 32   96   32   32  256   32  128   32   32   64   32   32   64   32   96   32
 96   32   32   32   32  256   32   64   96   32   32  128   32   32   32   64
```

32	32	96	32	128	32	256	32	32	64	96	32	64	32	32	32
32	96	32	32	32	64	32	256	32	32	32	64	32	32	96	128
32	64	64	128	32	96	32	32	256	96	32	32	32	32	32	32
96	32	32	32	64	32	64	32	96	256	32	32	128	32	32	32
64	32	32	32	32	32	96	32	32	32	256	32	32	64	128	96
32	32	32	96	32	128	32	64	32	32	32	256	32	96	32	64
32	32	32	96	64	32	64	32	32	128	32	32	256	96	32	32
128	32	32	32	32	32	32	32	32	32	64	96	96	256	64	32
64	32	32	32	96	32	32	96	32	32	128	32	32	64	256	32
32	32	96	32	32	64	32	128	32	32	96	64	32	32	32	256