Differential Feedback for 802.16m Beamforming

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Outline

- Overview of differential schemes
  - Rotation based
  - Codeword hopping based
- Simulation results
- Conclusion

Reference

[1] IEEE C802.16m-08/1182r3, "Codebook Design for IEEE 802.16m MIMO Schemes."

[2] IEEE C802.16m-08/1109, "DL SU-MIMO codebooks."

[3] IEEE C802.16m-08/1095r1, "Differential Precoding Codebook."

[4] IEEE C802.16m-08/1187, "Evaluation of CL SU and MU MIMO Codebooks."

[5] IEEE C802.16m-09/0024, "Simplified Differential Feedback Method for IEEE 802.16m CL SU/MU-MIMO."

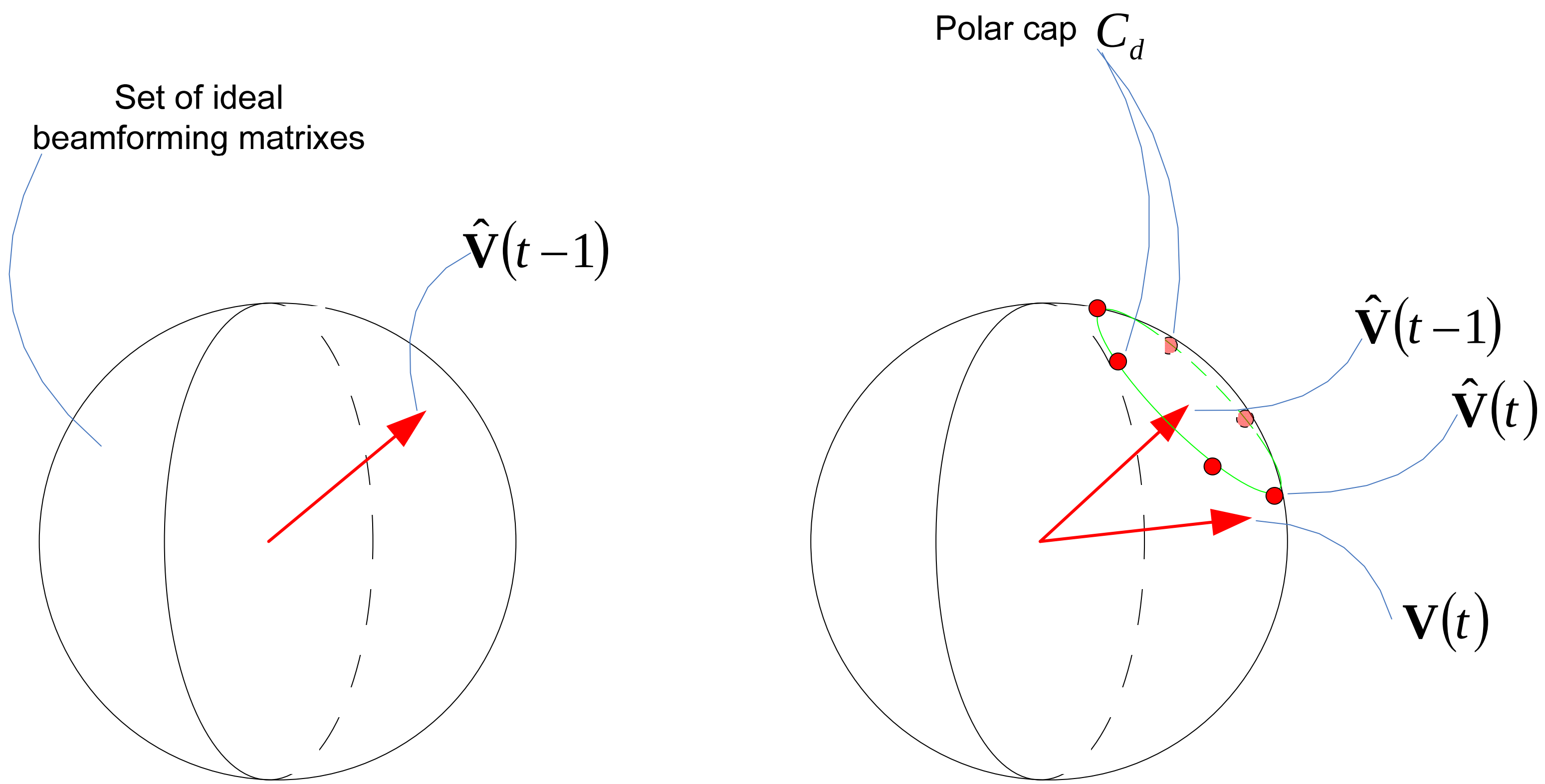
[6] IEEE C802.16m-08/1074r1, "Evaluation of Codebook and Differential Feedback for DL Closed-Loop SU-MIMO."

System Model

$$\mathbf{y} = \mathbf{H}\hat{\mathbf{V}}\mathbf{s} + \mathbf{n}$$

- $\mathbf{H}$ is channel matrix of dimension $N_r \times N_t$.
- $\hat{\mathbf{V}}$ is beamforming matrix of dimension $N_t \times N_s$.
- $\mathbf{s}$ is transmitted signal vector of dimension $N_s \times 1$.

Rotation Based Scheme



Rotation Scheme I

- Differentiation at SS: $$\mathbf{D} = \mathbf{Q}^H(t-1)\mathbf{V}(t)$$
- Quantization at SS: $$\hat{\mathbf{D}} = \arg\max_{\mathbf{D}_i \in C_d} \left\| \mathbf{D}^H \mathbf{D}_i \right\|_F$$
- Beamforming matrix reconstruction at BS:

$$\hat{\mathbf{V}}(t) = \mathbf{Q}(t-1)\hat{\mathbf{D}}$$

- Beamforming at BS: $$\mathbf{y} = \mathbf{H}\hat{\mathbf{V}}(t)\mathbf{s} + \mathbf{n}$$

[1],[2], and [3] use this scheme for differential feedback.

Rotation Scheme II

SS always feeds back for maximum number of streams.

- $\hat{\mathbf{V}}$ and $\mathbf{D}$ are square matrix of dimension $N_t \times N_t$.

[4] [5] use this scheme.

- Differentiation at SS: $\mathbf{D} = \mathbf{V}(t)\,\mathbf{Q}^H(t-1)$

- Quantization at SS: $\hat{\mathbf{D}} = \arg\max_{\mathbf{D}_i \in C_d} \left\| \mathbf{D}^H \mathbf{D}_i \right\|_F$

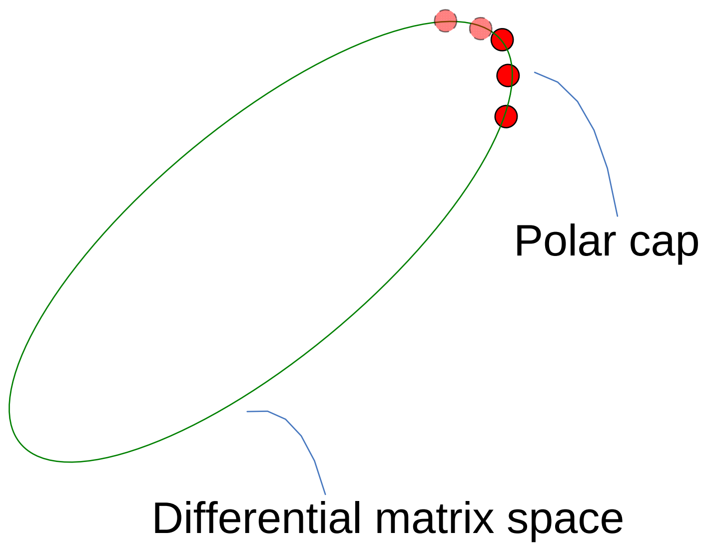
- Beamforming matrix reconstruction at BS:

$$\hat{\mathbf{V}}(t) = \hat{\mathbf{D}}\,\mathbf{Q}(t-1)$$

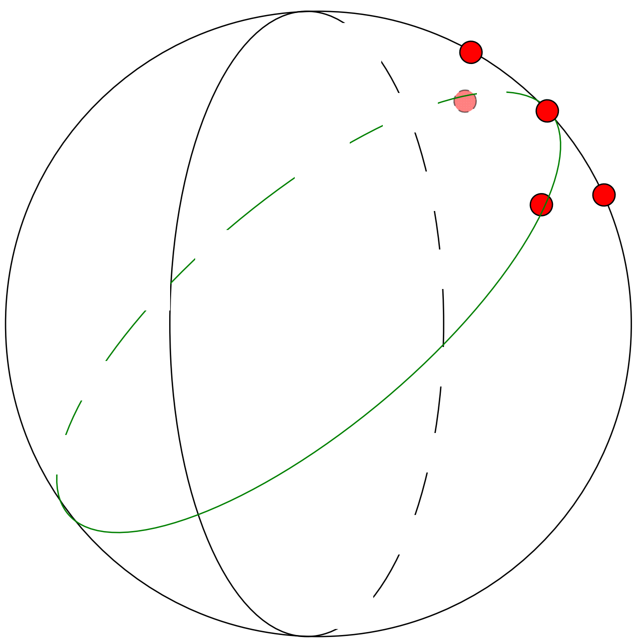
- Beamforming at BS: $\mathbf{y} = \mathbf{H}\,\hat{\mathbf{V}}(t)\mathbf{s} + \mathbf{n}$

Scheme I has a compacter codebook than scheme II because of reduced dimension.

Differential codebook of
scheme I

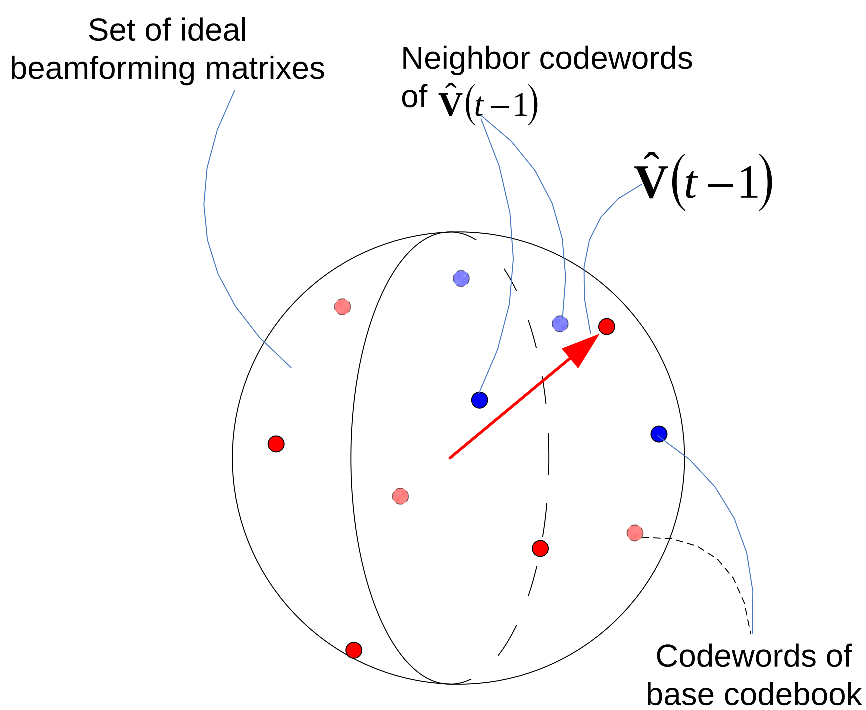


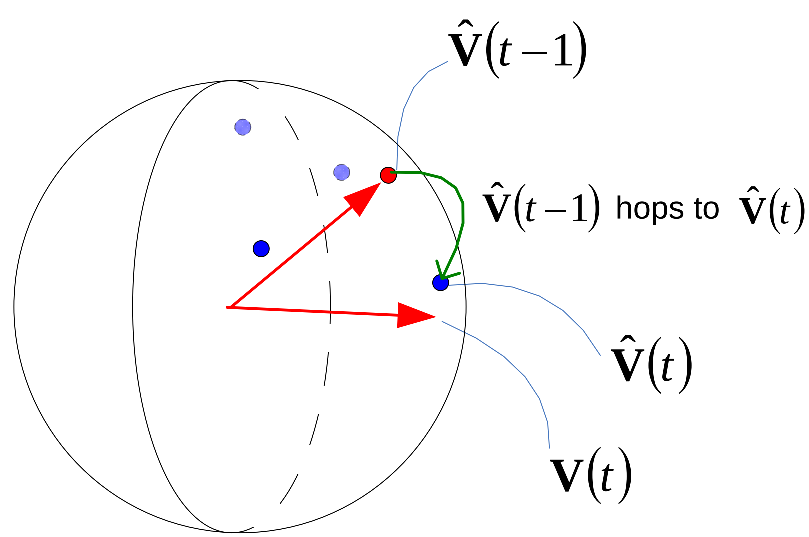
Differential codebook of
scheme II



Codeword Hopping [6]

- Each codeword has a list of 8 closest neighbors.
- Next beamforming matrix is selected from the 8 neighbors.
- Beamforming accuracy is worse than that the non-differential scheme using the whole codebook.





SLS Results for SU-MIMO

- Differential outperforms non-differential.
- Rotation scheme I is better than codeword hopping.

	Uncorrelated channels	Highly correlated channels
16e 6-bit codebook (b/s/Hz)	6.7217	7.2527
Rotation scheme I, 3-bit differential [1] (b/s/Hz)	6.7706	7.5414
Codeword hopping, 3-bit differential [6] (b/s/Hz)	< 6.7217	< 7.2527
SE gain of rotation scheme I [1] over codeword hopping [6]	**> 0.73%**	**> 3.98%**

Differential vs. non-differential

- Rotation scheme II outperforms non-differential.
- Improvement due to differential feedback decreases as correlation for rotation scheme II with DFT codebook.

	Uncorrelated channels	Weakly correlated channels	Highly correlated channels
DFT 4-bit codebook (b/s/Hz)	6.4855	6.8481	7.5046
Rotation scheme II, 4-bit differential [4] (b/s/Hz)	6.7177	7.0519	7.5060
SE gain of rotation II [4] over non-differential	**3.58%**	**2.98%**	**0.02%**

Rotation scheme I vs. rotation scheme II

- Rotation scheme I outperforms rotation scheme II in terms of throughput and overhead.
- Scheme I is tailored to stream number while Scheme II is not.

	Uncorrelated channels	Highly correlated channels
Rotation scheme I [1] (b/s/Hz)	6.7706	7.5414
Rotation scheme II [4] (b/s/Hz)	6.7177	7.5060
SE gain of scheme I [1] over scheme II [4]	**0.79%**	**0.47%**
Overhead comparison: [1] vs. [4]	**3.3 bits : 4 bits**	**3.3 bits : 4 bits**

SLS Results for MU-MIMO

- Differential outperforms non-differential.
- Rotation scheme I is better than codeword hopping.

	Uncorrelated channels	Weakly correlated channels	Highly correlated channels
16e 6-bit codebook (b/s/Hz)	6.3643	6.903	7.6895
Rotation scheme I, 3-bit differential [1] (b/s/Hz)	6.6172	7.5492	9.766
Codeword hopping, 3-bit differential [6] (b/s/Hz)	< 6.3643	< 6.903	< 7.6895
SE gain of rotation scheme I [1] over codeword hopping [6]	**> 3.97%**	**> 9.36%**	**> 27.0%**

Rotation scheme I vs. rotation scheme II

- Rotation scheme I outperforms rotation scheme II in terms of throughput and overhead.

	Uncorrelated channels	Weakly correlated channels	Highly correlated channels
Rotation scheme I [1] (b/s/Hz)	6.6993	8.0027	11.3129
Rotation scheme II [4] (b/s/Hz)	6.6766	7.7787	10.1239
SE gain of scheme I [1] over scheme II [4]	**0.34%**	**2.88%**	**11.74%**
Overhead comparison: [1] vs. [4]	**3.53 bits : 4 bits**	**3.53 bits : 4 bits**	**3.53 bits : 4 bits**

Conclusions

- Differential outperforms non-differential.
- Rotation schemes have higher throughput than codeword hopping.
- Rotation scheme I has smaller quantization errors than rotation scheme II because of compacter codebook.