

# Slides for Closed-loop Multi-user MIMO for Uplink Transmissions

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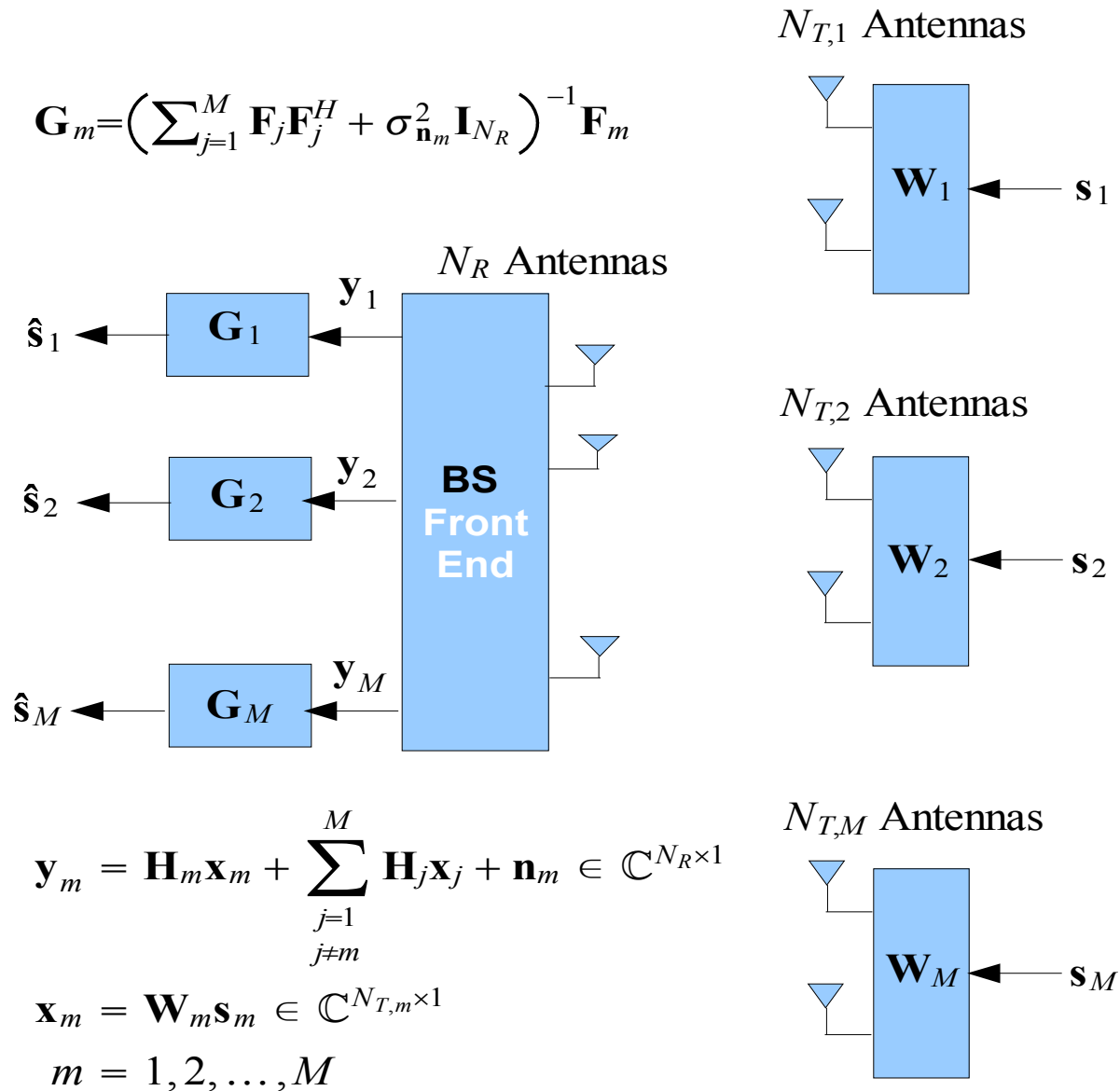
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# Received Base Station Signal Model



# Precoder and Decoder Designs

- The optimum precoding matrix for the  $m$ th MS is defined as

$$\mathbf{W}_m = \mathbf{V}_m \mathbf{P}_m \in \mathbb{C}^{N_{T,m} \times N_{S,m}}$$

- Matrix  $\mathbf{V}_m$  is the right singular matrix of the singular value decomposition  $\mathbf{H}_m = \mathbf{U}_m \mathbf{\Sigma}_m \mathbf{V}_m^H$  where  $\mathbf{U}_m \in \mathbb{C}^{N_R \times N_R}$  and  $\mathbf{V}_m \in \mathbb{C}^{N_{T,m} \times N_{T,m}}$  are unitary matrices and  $\mathbf{\Sigma}_m \in \mathbb{C}^{N_R \times N_{T,m}}$  a singular value matrix.

- Matrix  $\mathbf{P}_m \in \mathbb{R}^{N_{T,m} \times N_{S,m}}$  denotes the diagonal stream power loading matrix for the  $m$ th MS.

- The UL-MIMO receiver can be implemented as a bank of  $M$  Wiener decoders that each estimate an MS's spatial streams. This structure is illustrated in previous figure.

- A linear estimate of the transmitted vector is  $\hat{\mathbf{s}}_m = \mathbf{G}_m^H \mathbf{y}_m \in \mathbb{C}^{N_{S,m} \times 1}$  where the  $m$ th Wiener decoder  $\mathbf{G}_m$ ,  $m = 1, 2, \dots, M$ , is defined as

$$\begin{aligned} \mathbf{G}_m &= (\mathbf{F}_m \mathbf{F}_m^H + \mathbf{R}_{\mathbf{v}_m})^{-1} \mathbf{F}_m \\ &= \left( \sum_{j=1}^M \mathbf{F}_j \mathbf{F}_j^H + \sigma_{\mathbf{n}_m}^2 \mathbf{I}_{N_R} \right)^{-1} \mathbf{F}_m \\ \mathbf{F}_m &= \mathbf{H}_m \mathbf{W}_m = (\mathbf{U}_m \mathbf{\Sigma}_m \mathbf{V}_m^H) (\mathbf{V}_m \mathbf{P}_m) = \mathbf{U}_m \mathbf{\Sigma}_m \mathbf{P}_m \\ \mathbf{R}_{\mathbf{v}_m} &= \sum_{\substack{j=1 \\ j \neq m}}^M \mathbf{F}_j \mathbf{F}_j^H + \sigma_{\mathbf{n}_m}^2 \mathbf{I}_{N_R} \end{aligned}$$

# Codebook for Closed-loop Multi-user MIMO

- From the above equations we see that the above precoding technique requires that the effective channel matrices  $\mathbf{F}_m$ ,  $m = 1, 2, \dots, M$ , and  $\sigma_{\mathbf{n}_m}^2$  be available at the BS.
- This can be accomplished using a closed-loop approach. For the closed-loop approach it is simple to quantize MS-estimated effective channels  $\mathbf{F}_m$  and transmit codebook indices that encode the effective channels back to the BS.
- A large number  $M$  of active MSs results in an unacceptably high computational and feedback load. We therefore propose that the maximum number of active or concurrent MSs is  $M = 4$ .
- It must be emphasized that uplink MS receptions and downlink BS receptions are related as follows

$$\begin{array}{ccc} \mathbf{H}_m & & \mathbf{H}_m^T \\ \text{Channel observed at BS for uplink receptions} & = & \text{Channel observed at MS for downlink receptions} \end{array}$$

Hence to estimate  $\mathbf{H}_m^T$  an MS requires downlink pilots for each of the BS's  $N_R$  antennas. The same pilot signals can be shared by all  $M$  active MSs.

- An alternative is to use uplink pilots dedicated to each of the MS's transmit antennas and let the BS estimate  $\mathbf{H}_m$ . However, this would require more feedback overhead since there are  $M$  active MSs as opposed to one BS.

# Proposed Text

## **11.x.y. Closed-loop Uplink MU-MIMO**

Closed-loop MU-MIMO precoding techniques may be used to further increase the spectral efficiency of uplink transmissions. Using closed-loop MU-MIMO identical subframe time-frequency resources (Physical Resource Units) may be concurrently transmitted by two or more active MSs to a BS. The maximum number of active MSs that may be concurrently transmitting using the same uplink Physical Resource Units is four. MS-estimated effective MIMO channel matrices will be provided to a BS in the form of uplink codewords. The BS will use MS-estimated effective MIMO channel matrices to perform its decoding of concurrent uplink transmissions.

# References

See latest revision of IEEE C802.16m-08/687  
for details