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Title: A Precoding Scheme for Multi-BS MIMO Transmissions

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Abstract:
DL Multi-BS MIMO offers significant edge-cell throughput benefits at the expense of PHY (over the air) and backhaul signaling. In this contribution we propose a simple and robust signaling scheme that views Multi-BS MIMO as an extension of Single-BS MIMO precoding methods. The PHY signaling involves the transmission by the MS of the best precoding matrix vector to each of the BS part of the MIMO cluster. The backhaul signaling involves the exchange or forwarding of the signaled precoder vectors to the anchor-BS that implements the scheduling and weight vector estimation function.

Purpose: To include in the SDD, the precoded Multi-BS DL transmission shceme.

Standards Board Patent Committee (http://standards.ieee.org/board/pat).

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Multi-BS Transmission

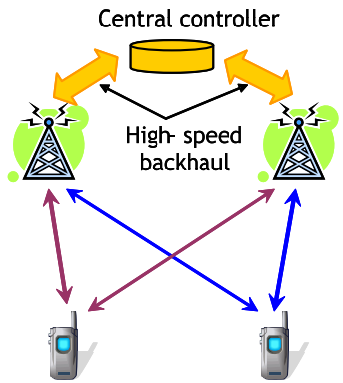

Figure: DL Network MIMO

- To achieve multiuser minimum-mean-squared-error (MMSE) beamforming across multiple base stations in a cellular network (known as Network MIMO), there is a need to feed back channel information from all interfering users to a multitude of base stations.
- This contribution proposes that the channel information can be signaled using what we call *nominal* precoding matrices. A side-effect of this type of feedback transmission is the smooth transition between network MIMO and non-network MIMO modes as the MS changes the entries of its MIMO active set (MAS).

Principle of Operation - I

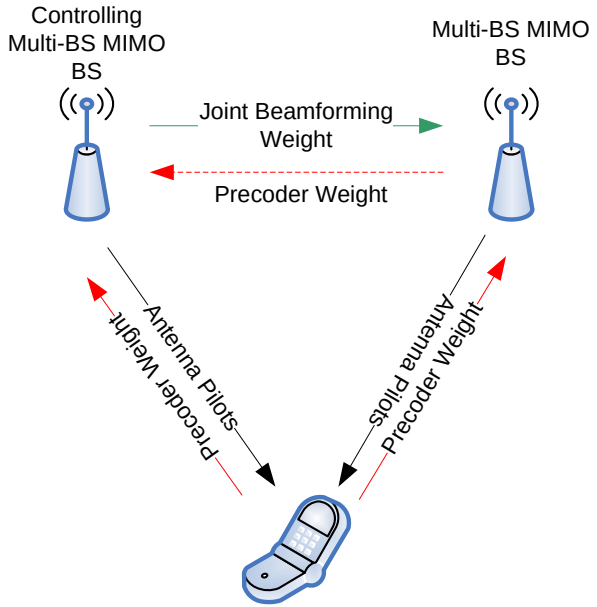

Figure: Precoder weight feedback for Multi-BS MIMO

- We define a precoder matrix that is called Nominal Precoder (NP) and this precoder is either a-priori assumed by the MS or it is signaled to the MS during its initial network entry phase or update of its MAS.

Principle of Operation - II

- Each MS that participates in the network MIMO mode measures the DL channel from each BS and sends back the NP weight (NPW) that optimizes a common agreed metric (e.g. maximizes the SINR) at the MS location.
- The NPW represents a quantized (compressed) version of the BS-MS channel and it is sent to the BS and from there to the MAS Controlling BS (MASC-BS). Note that physically the MASC-BS function with respect to weight determination can be distributed across the MAS. The NPWs from all participating BSs can then be used to form an estimate of the NxM channel matrix.

Detailed Description

- If we assume N user terminals each with r receive antennas and a MAS that consists of M Base stations each with t transmit antennas, the channel matrix of the n-th user is an $(r \times Mt)$ matrix,where each entry is a complex Gaussian representing the channel between the q-th BS transmit antenna and the p-th MS receive antenna. The received signal is then,$y_n = H_n x + \nu_n$, where y is the received r-dim vector and x is the vector that represents the superposition of N user signals at the Mt transmit antennas. Let us denote the $\hat{w}_{np}^m$ the feedback precoded weight by terminal n as determined by the MS precoder weight determination algorithm at its p-th MS receive antenna and as sent to the m-th base station.
- The BS upon reception of $\hat{w}_{np}$ by all the MAS users, it relays the weights to the designated MASC-BS. The MASC-BS performs a mapping function f that maps the received precoder vectors into transmit beamforming weights. The exact mapping function is outside of the scope of standardization.

Detailed Description

- The MASC-BS uses as channel estimates in populating the channel matrix H_n, the feedback precoded weights and then forms the zero-forcing (ZF) or MMSE solution in determining the DL beamforming weights of all users that participate in the Multi-BS MIMO scheme.
- In doing so, the transmission to the n-th user either will not interfere with other user transmissions (ZF) or if it will, the received SINR at all user locations is maximized subject to a noise enhancement margin (MMSE).
- It should be noted that the granularity of the precoder matrix is another design variable that is usually left outside of the specification. The higher the granularity the better the MASC-BS can jointly null interference.

Flexibility

- One significant implication of the suggested scheme based on precoder weights is when mobility and heterogeneity in the RAN (ASN) is considered.
  - The MS as it updates its MAS, can seamlessly switch between Multi-BS and Single-BS MIMO reception modes.
  - The MIMO active set (MAS) may be heterogeneous with respect to the antenna configurations of the individual BSs. The MS will be able to seamlessly transmit the precoder weights that are suitable for each antenna configuration. For example, it can transmit a beamforming weight for a 4x2 configuration that corresponds to the strongest BS-sector in its MAS while simultaneously transmit a 2x2 configuration that corresponds to the second strongest BS-sector in its MAS.
  - The scheme is generic enough to allow flexibility with respect to the UL PHY signaling waveform that supports the precoder weight transmission. Example of PHY waveforms include precoded CDMA or LS-OFDMA or any other PHY signaling waveform that can either help or completely eliminate the latency between BSs with respect to precoder weight.