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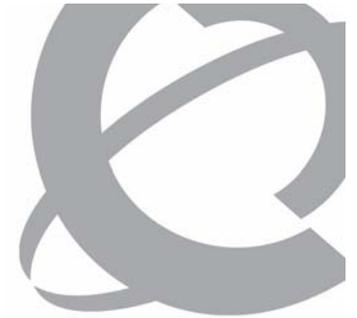
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Adaptive MIMO modes for LTE

Nortel

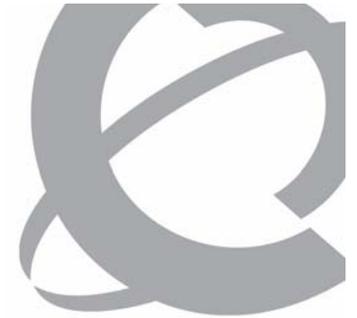
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Introduction and Background

- > Several MIMO proposals are presented at LTE
 - For the 2-transmit and 2-receive MIMO case, there is no single MIMO transmission format that can fulfill all the MIMO channel environment
 - Each modes has its advantages at certain channel conditions
 - Spatial multiplexing (SM) performs well in the higher SINR region
 - STTD performs well in the lower SINR region
 - SM performs well in the scattered channel environment and especially in the balanced eigenvalue MIMO channel, however fails to work e.g. in the LOS channel
 - STTD, on other hand, works well for all the channel conditions, however with lower bit rate
- > We propose adaptive MIMO modes based on a simple mode feedback mechanism
 - UE computes the metric to determine the best mode
 - The mode switching criteria are proposed and discussed



Two Basic MIMO Modes for 2-Transmit MIMO

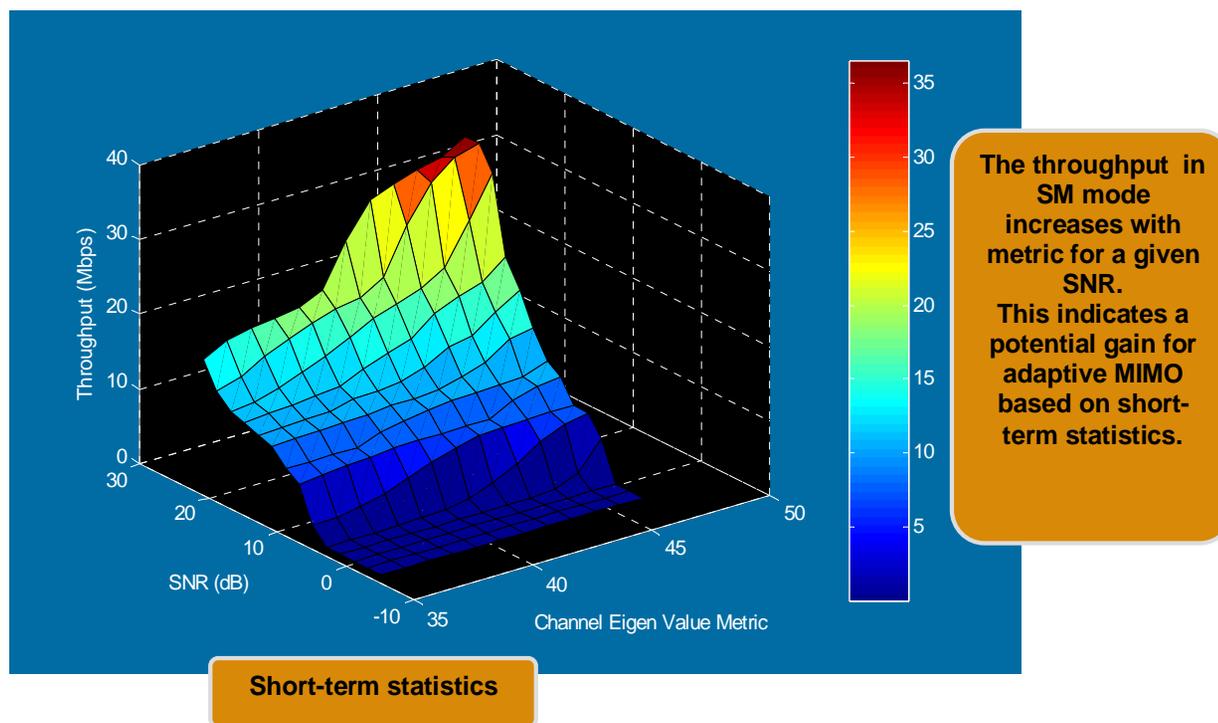
- > For the two branch transmit case, we have two distinct MIMO modes operation
 - STTD
 - Provides reliability to link performance
 - Independent of channel matrix illness
 - Spatial multiplexing
 - Provides higher user bit rate
 - Sensitive to channel matrix illness
 - One mode can not perform best in the presence of the real-world channel conditions
 - Dynamic adaptation of the MIMO modes is proposed
- > UE feedback back SINR alone is not necessary enough for the Node-B to select the best mode
 - Additional MIMO Channel information should be incorporated

Select mode that best utilizes the current channel condition

The effect of eigenvalue spreading in spatial multiplexing



- > The MIMO mode select is also primarily determined by the MIMO channel eigen-value spread



SM provides significant throughput gain if the eigenvalue spread of the MIMO channel matrix is small.

The Proposed MIMO Modes Switching Procedure (DL Case)



- > Node-B sends the MIMO pilot
- > UE measures
 - Receiver output Channel Quality (CQI)
- > UE transmits back to Node-B the
 - CQI to indicate the coding modulation
 - MIMO Mode indicator (MMI)
- > Based on the CQI and MMI reported by the UEs, the Node B selects the UEs to transmit to along with
 - Coding modulation
 - MIMO transmission modes
- > Node-B indicates the transmission format to UEs



CQI for [2Tx, 2Rx] STTD

> Post-processing SNR for STTD is given by

$$\mathcal{V}_{STTD} = \frac{\sum_i \sum_j |h_{ij}|^2}{\sigma_n^2}$$

> \mathcal{V}_{STTD} is the CQI associated with STTD.



CQI for [2Tx, 2Rx] Spatial multiplexing

- > Post-processing SNR for SM is given by (MMSE decoder is assumed)

$$\gamma_{SM,i} = \vec{h}_i' (\vec{h}_j \vec{h}_j' + \sigma_n^2 I)^{-1} \vec{h}_i, \quad i, j = 2, \quad i \neq j$$

- > The average SNR can be estimated as

$$\bar{\gamma}_{SM} = 2^{\frac{\sum_{i=1}^M \log_2(1 + \gamma_{SM,i})}{M}} - 1$$

- > $\bar{\gamma}_{SM}$ is the CQI associated with SM.



The MIMO Mode Switching Criterion

- > The MIMO mode switching is based on the capacity provided by STTD and SM:
 - UE compute two metrics

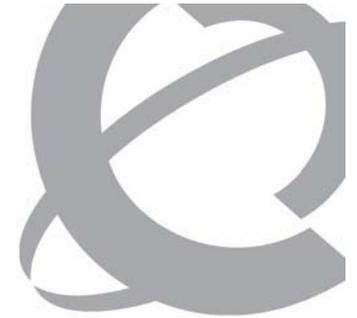
$$C_{STTD} = \log_2(1 + \gamma_{STTD})$$

$$C_{SM} = M \log_2(1 + \bar{\gamma}_{SM})$$

- > The switching criterion $C_{SM} > C_{STTD}$

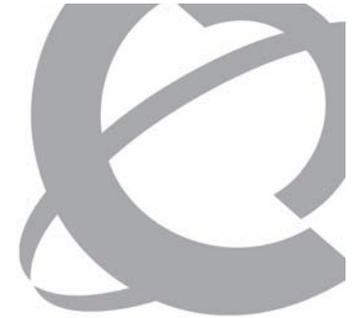
or equivalently

$$(1 + \bar{\gamma}_{SM})^M > (1 + \gamma_{STTD})$$



Feedback information required

- > MIMO mode indicator (MMI) — a one-bit indicator to indicate the Node-B of the preferred MIMO mode.
- > CQI — the post-processing SNR associated with that specific MIMO mode indicator, which is used for MCS selection.



Summary

- > Use adaptive MIMO mode to exploit the most of the current channel condition.
- > Only an additional one-bit indicator is needed for this mode feedback.
- > The fed-back CQI is associated with each specific mode, which is used by the Node-B for MCS selection.
- > Is applicable to both localized and distributed transmission
- > The concept can be easily extended to other variations of MIMO modes, such as antenna selection, antenna grouping, and double-STTD.