MIMO Broadcast for 16m E-MBS

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Venue:

802.16m-08/016r1: Call for SDD Comments and Contributions – Downlink MIMO Schemes

Base Contribution:

IEEE C802.16m-08/370

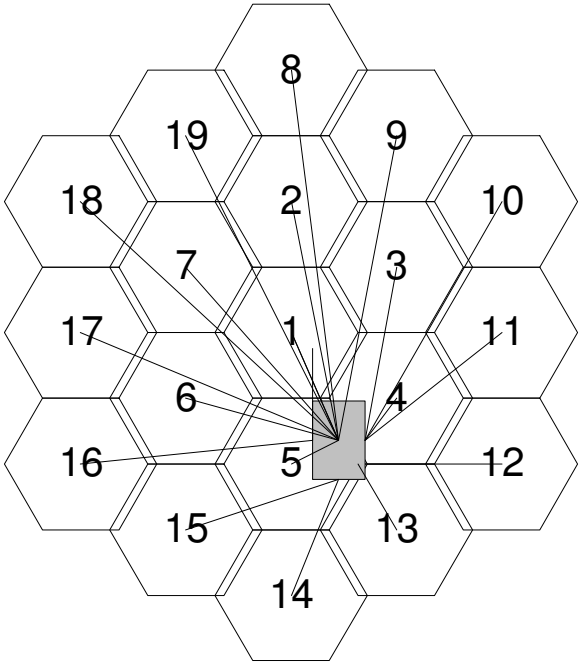
Purpose:

To be discussed and adopted by TGm for the 802.16m SDD.

Background

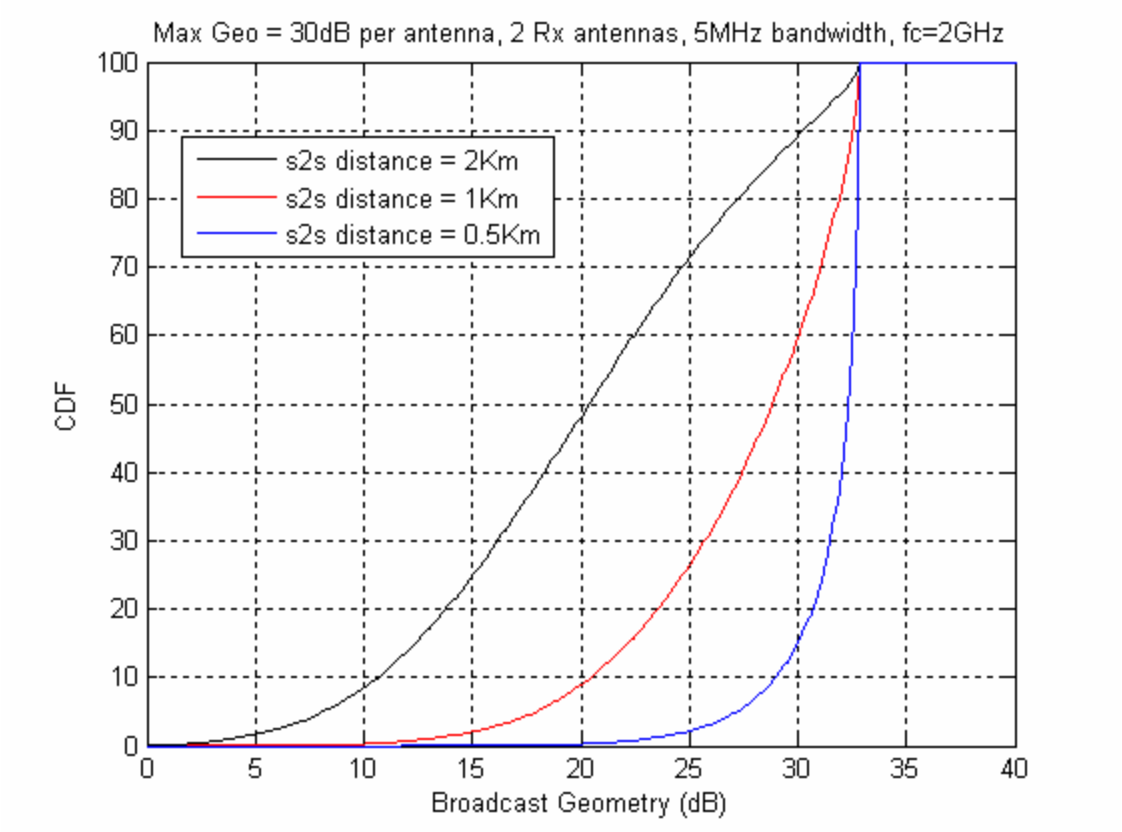
- In conventional multicast/broadcast (MB) over cellular systems, transmission from a single antenna is assumed.
- Multiple transmit antenna techniques are used for unicast in the LTE and WiMAX systems.
- Multiple transmit antennas can be used to improve multicast/broadcast as well.
- A key difference between unicast and broadcast is that only open-loop MIMO techniques can be utilized for multicast/broadcast.
  - Open-loop Spatial multiplexing

Single-Frequency Network (SFN)



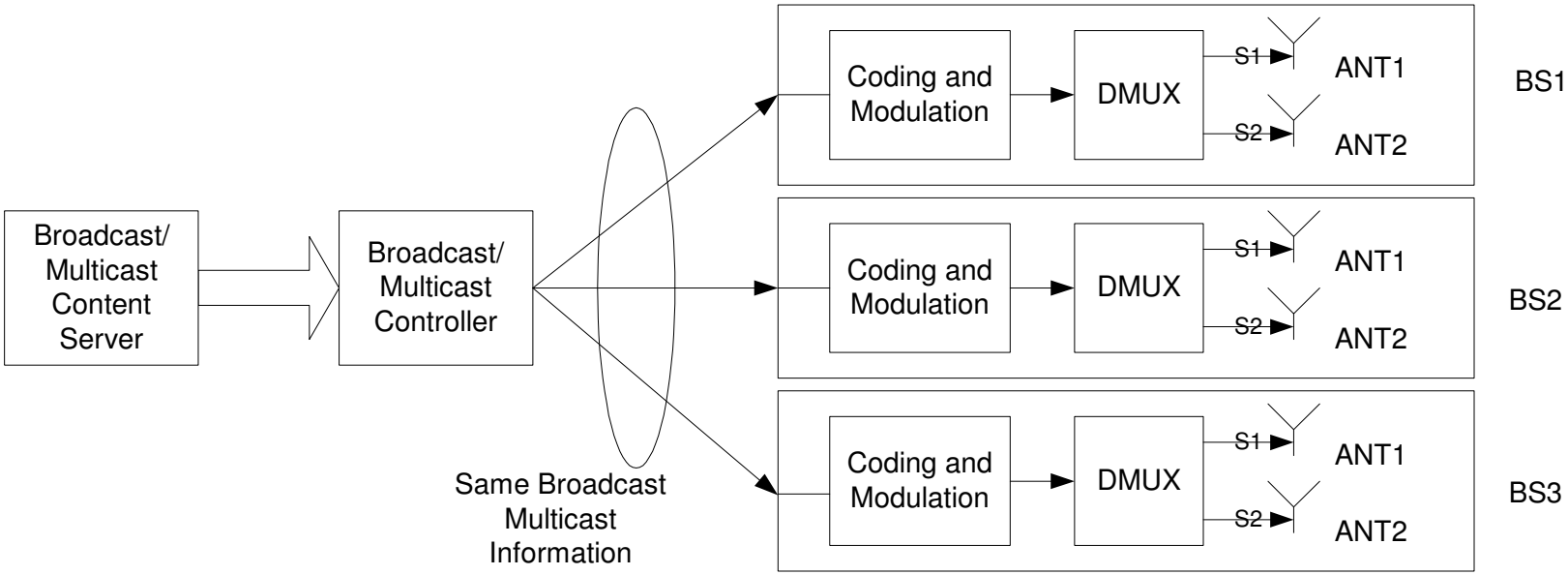
- An SFN operation is realized by transmitting the same information in the same OFDM time-frequency resource from multiple synchronized cells:
  - Cell synchronization within the OFDM symbol cyclic prefix required

SINR in SFN



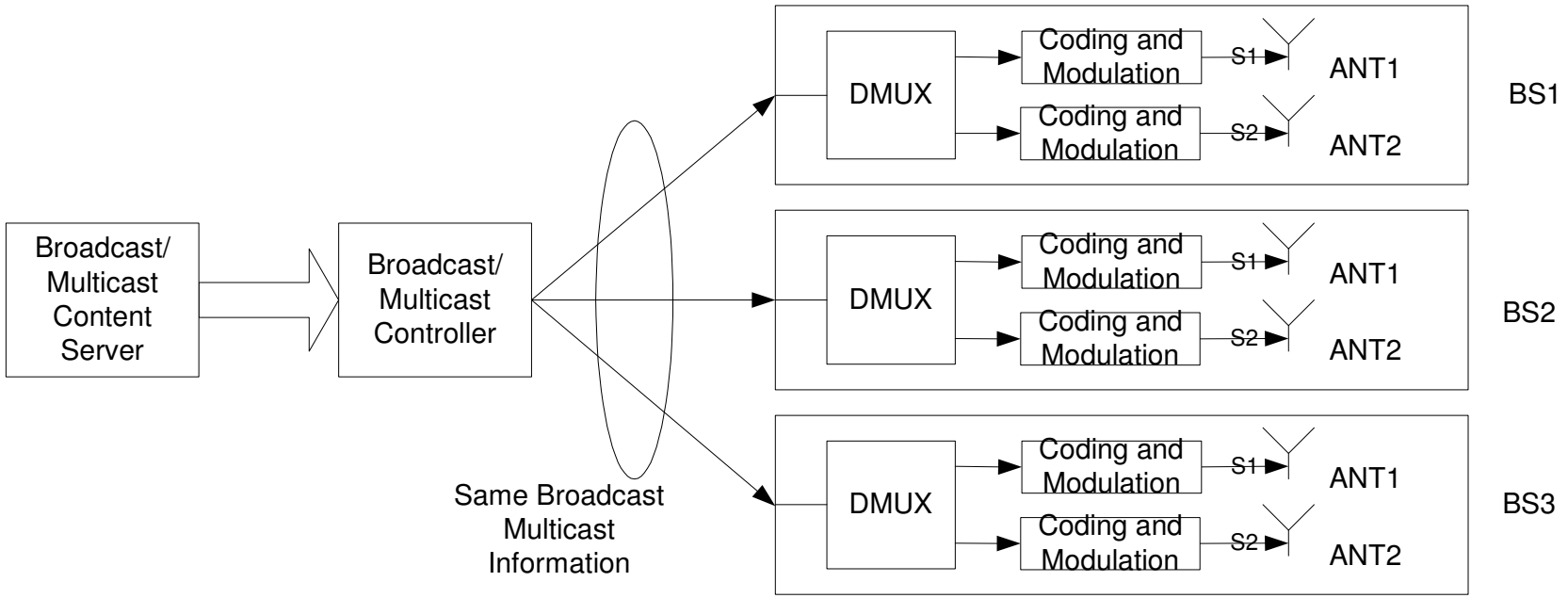
- 10% Geometry point (90% broadcast coverage) is approximately 11dB, 21dB and 29 dB for site to site distance of 2.0, 1.0 and 0.5Kms.
  - Very large SINRs provide potential for spatial multiplexing for broadcast

MB Spatial Multiplexing (1/4)



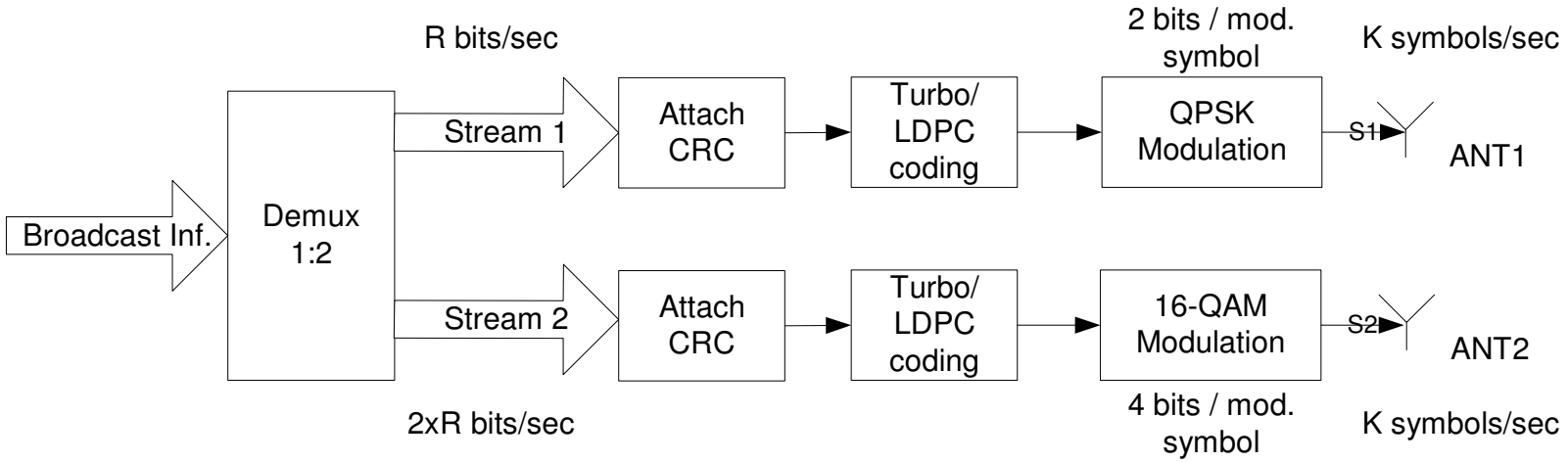
- SCW: Potential transmission of 2 spatial-multiplexed E-MBS streams in a 2X2 MIMO
  - No dynamic rate control due to broadcast nature of the transmission

MB Spatial Multiplexing (2/4)



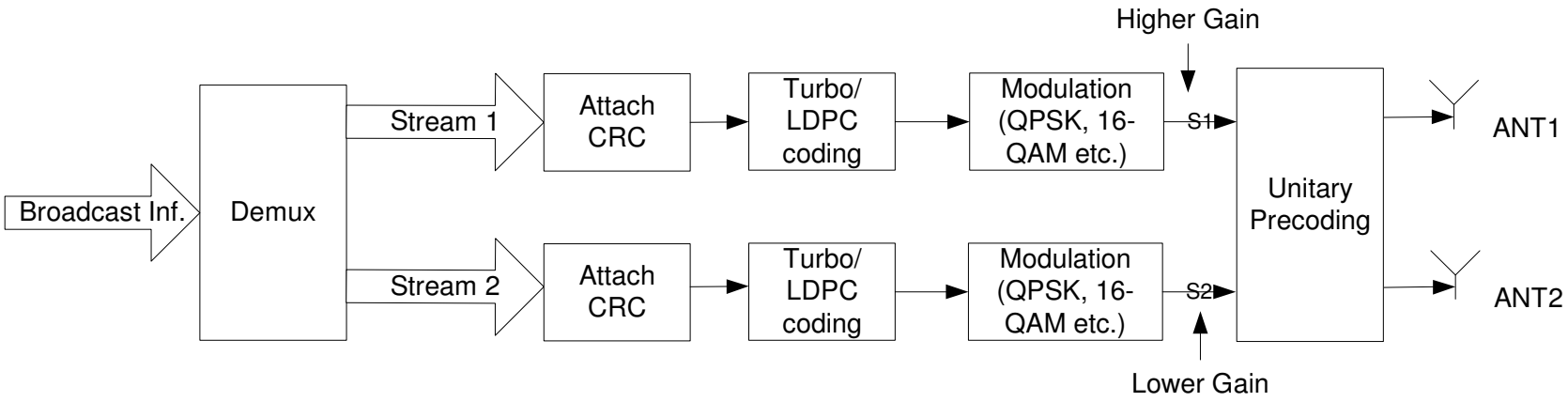
- MCW: Streams on different antennas or beams can still be independently coded for efficient interference cancellation at the receiver.

MB Spatial Multiplexing (3/4)



- Streams on different antennas or beams can be independently coded and modulated e.g. with static AMC:
  - Potential to provide greater reliability to the stream cancelled first at the receiver.
  - Enables efficient interference cancellation at the receiver

BM Spatial Multiplexing (4/4)

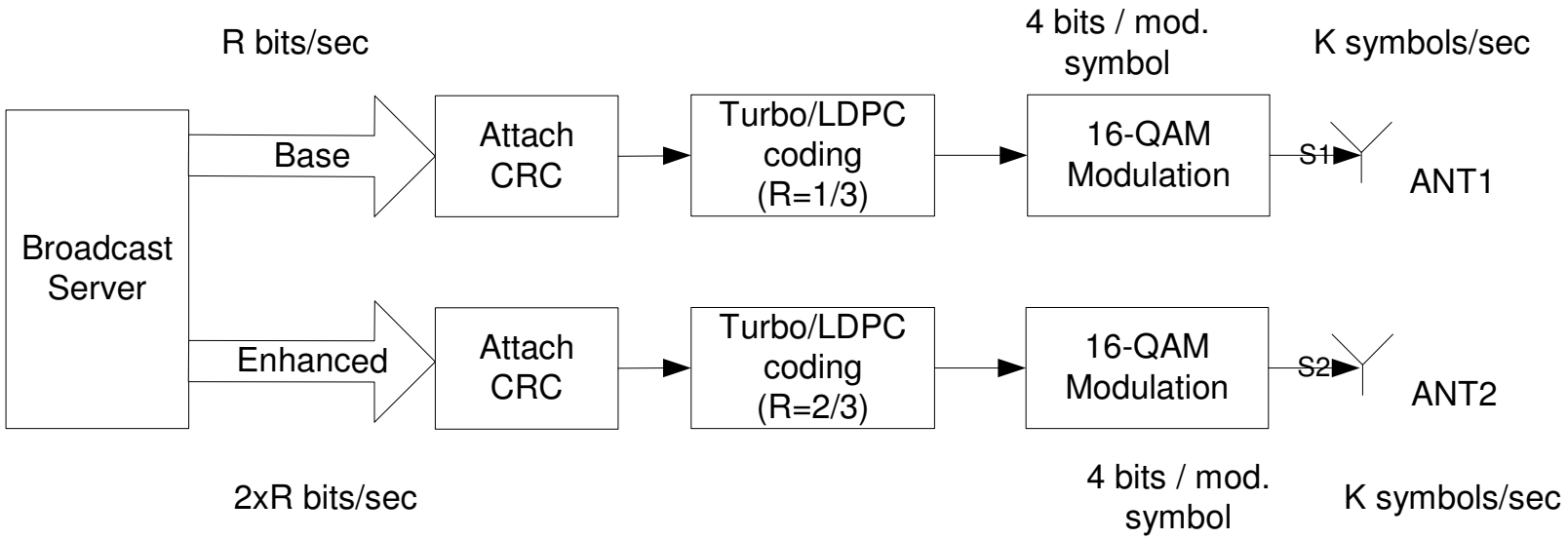


- Power control: Stream 1 that is detected first at the receiver is made more robust via higher power gain for stream 1 than stream 2.

Base and Enhanced Layer

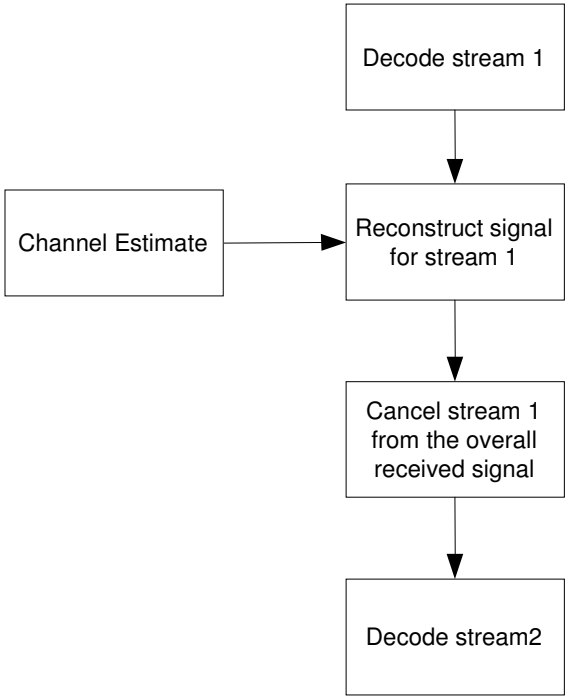
- The base layer and enhanced layer carry the same broadcast program such as a video streaming application.
- In the case of “video streaming application”, for example, base layer carries a lower quality audio and/or a lower quality picture resolution.
  - The enhanced layer can carry additional information to enhance the audio and video quality of the video streaming application.
  - In general, base layer is decoded by all the users receiving the broadcast content.
  - The enhanced layer is only decoded by users experiencing good channel quality such as users close to a base station.
  - The users experiencing good channel quality can then experience a higher quality video streaming by decoding the enhanced layer.

Base and Enhanced Layer SDM



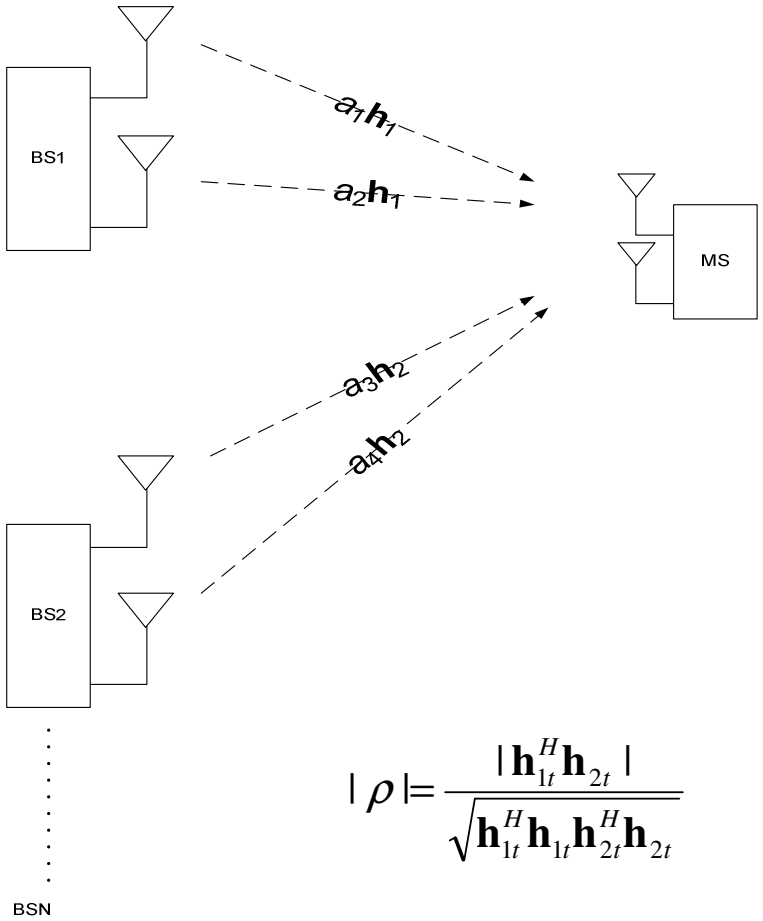
- Base layer is carried with more robustness (better coding, modulation and/or higher power).
- Users with good channel can decode the enhanced layer by canceling the base layer signal.

Interference cancellation



- More robust stream can “always” be first decoded.
- The dynamic changes in stream quality should be relatively low:
  - This is due to “extensive” frequency diversity (converted from spatial diversity) present in the SFN.
  - The difference in effective SINR between different antennas (stream) is expected to be small.
- For users closer to the cell (these users may only see one base station), the frequency diversity may be smaller.
  - However, these users have “very large” SINR and are likely to be able to decode both the base layer and the enhanced layer (given some decorrelation among streams).

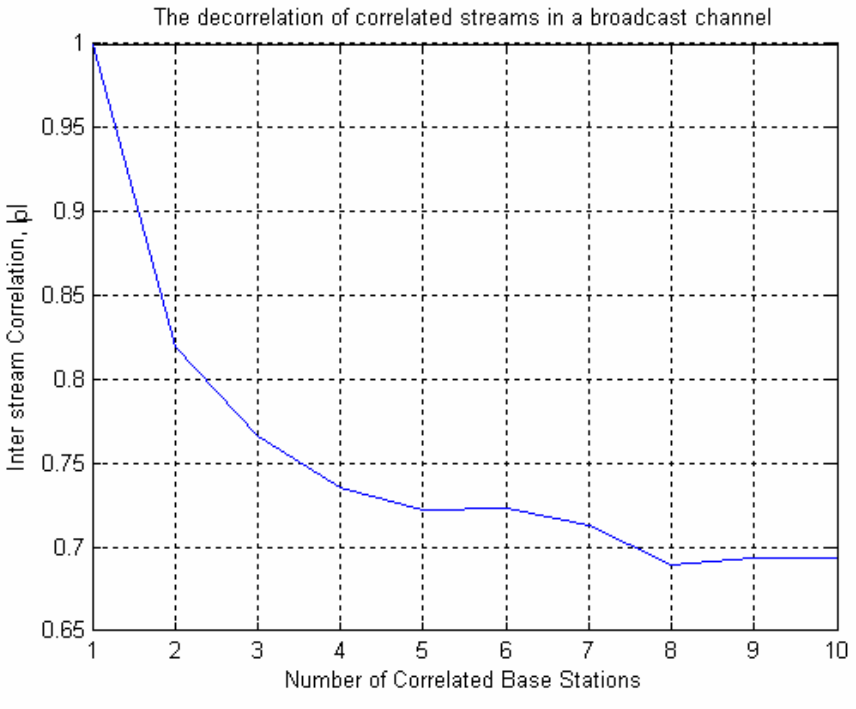
Spatial correlations in E-MBS

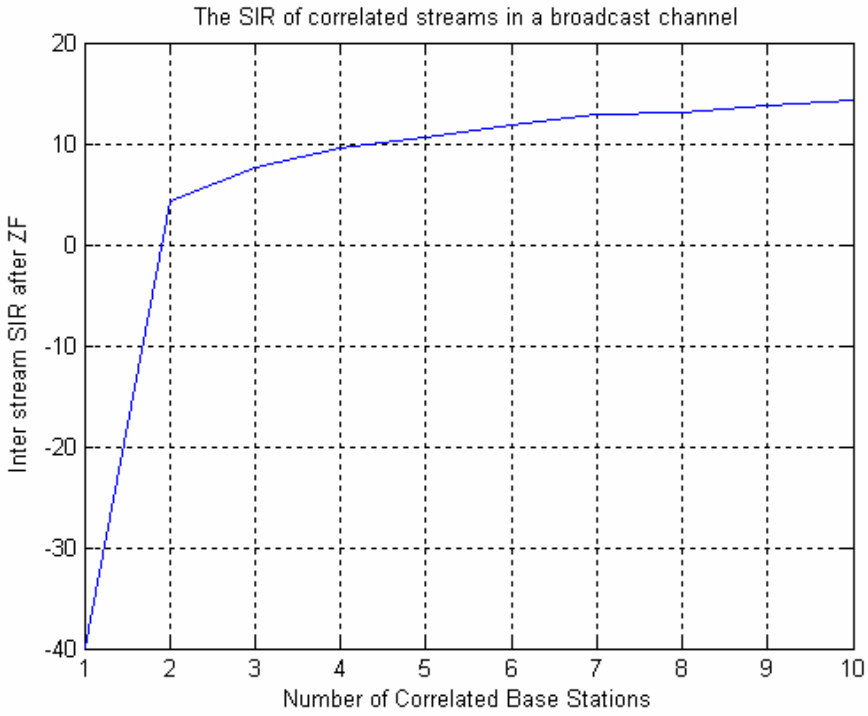


$$|\rho| = \frac{|\mathbf{h}_{1t}^{H}\mathbf{h}_{2t}|}{\sqrt{\mathbf{h}_{1t}^{H}\mathbf{h}_{1t}\mathbf{h}_{2t}^{H}\mathbf{h}_{2t}}}$$

- In SCM
  - Each BS Tx Antennas are correlated ($\mathbf{h}_1$,$\mathbf{h}_2$)
  - Each MS Rx Antennas are un-correlated
  - Each Tx Antenna is scaled by some arbitrary scalar relative to every other Tx Antenna (a_i)
- Effective Broadcast channel
  - Is sum of all channels from 1st antenna from each BS
  - $\mathbf{h}1t = a1\mathbf{h}1 + a3\mathbf{h}2$
  - $\mathbf{h}2t = a2\mathbf{h}1 + a4\mathbf{h}2$
  - The effective Inter Stream Correlation is the correlation between effective channel1 and effective channel 2

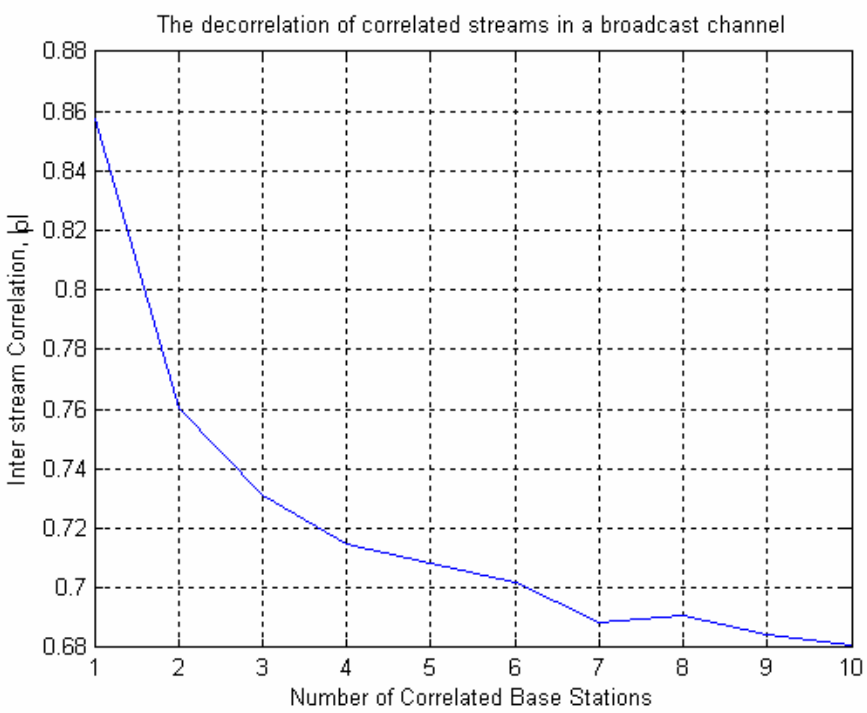
Perfect Antenna Correlation

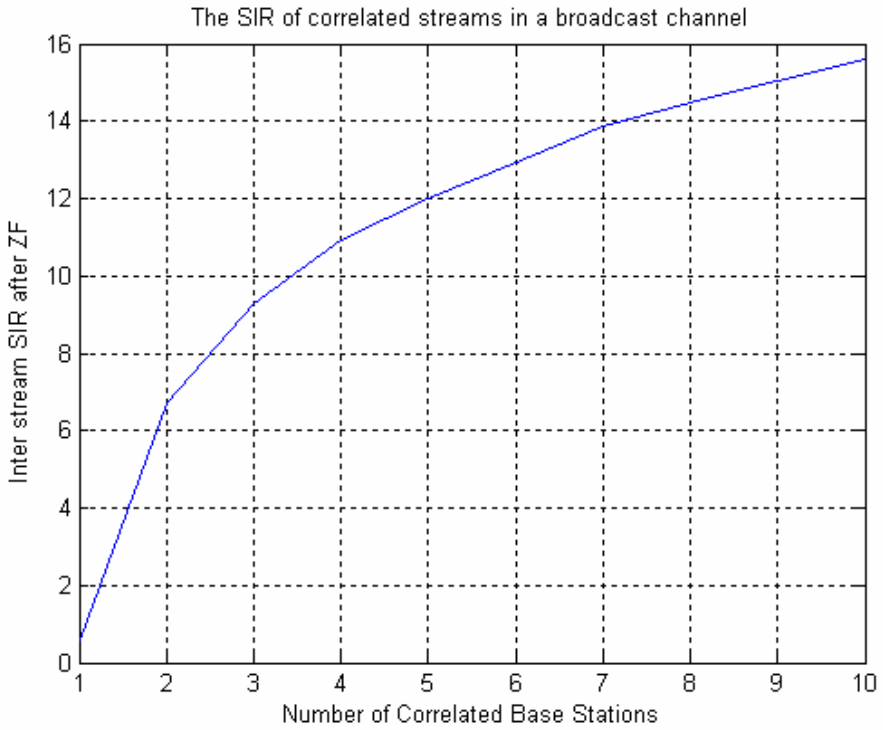




- Perfect Antenna Correlation represents the Worst Case correlations:
  - Indicates that Broadcast/Multicast environment is better suited for spatial multiplexing

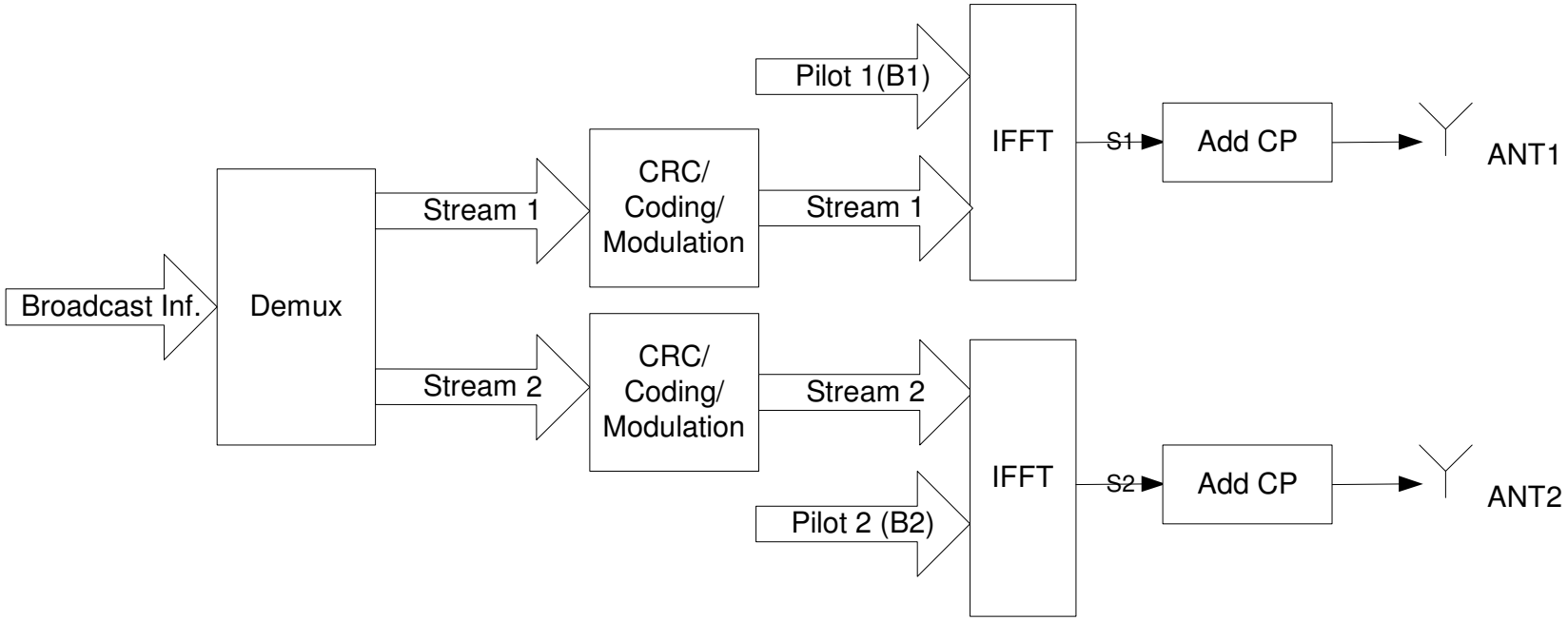
SCM Channel Model





- Correlations based on SCM channel model also indicates the same trend that E-MBS environment is better suited for spatial multiplexing
- The streams or less correlated as the user moves away from the base station:
  - Potentially more base stations are received
  - SINR probably goes down
- The loss in SINR as the user moves away from the BS can potentially be compensated by increased de-correlations of the streams

MIMO Broadcast Pilots



- Orthogonal pilot signals are transmitted for each of the antennas or beams or streams from a given base station.
- The pilot signals for a given antenna from multiple base stations in the broadcast zone then use the same time-frequency resource:
  - Allow for composite MIMO channel estimation

Summary

- Summary
  - An SFN operation enables very high SINR for broadcast
  - These high SINRs can potentially be exploited by using SDM for broadcast.
  - “Differentiated QoS” can be provided to MB users via SDM of a base layer and an enhanced layer of broadcast content.
  - Only 2-3 BS’s will de-correlate perfectly correlated Tx antennas
  - It is possible to do spatial multiplexing in a correlated broadcast channel where it won’t be possible in a similar unicast channel

- Proposed Text for 16m SDD (802.16m-08/003r1): Incorporate the following text in Chapter 15: Support for Enhanced Multicast Broadcast Service of the SDD:
  - ***To provide enhanced multicast and broadcast spectral efficiency in 16m, spatial multiplexing should be a transmission mode for E-MBS.***