Cooperative Relaying Mode Proposal for IEEE 802.16m

Document Number:
IEEE C80216m-08/1280
Date Submitted:
2008-10-31
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Venue:
TGm SDD: Relay IEEE 802.16m-08/040: Call for Comments and Contributions on Project 802.16m System Description Document (SDD)
Purpose:
For consideration and adoption by TGm group

Scope

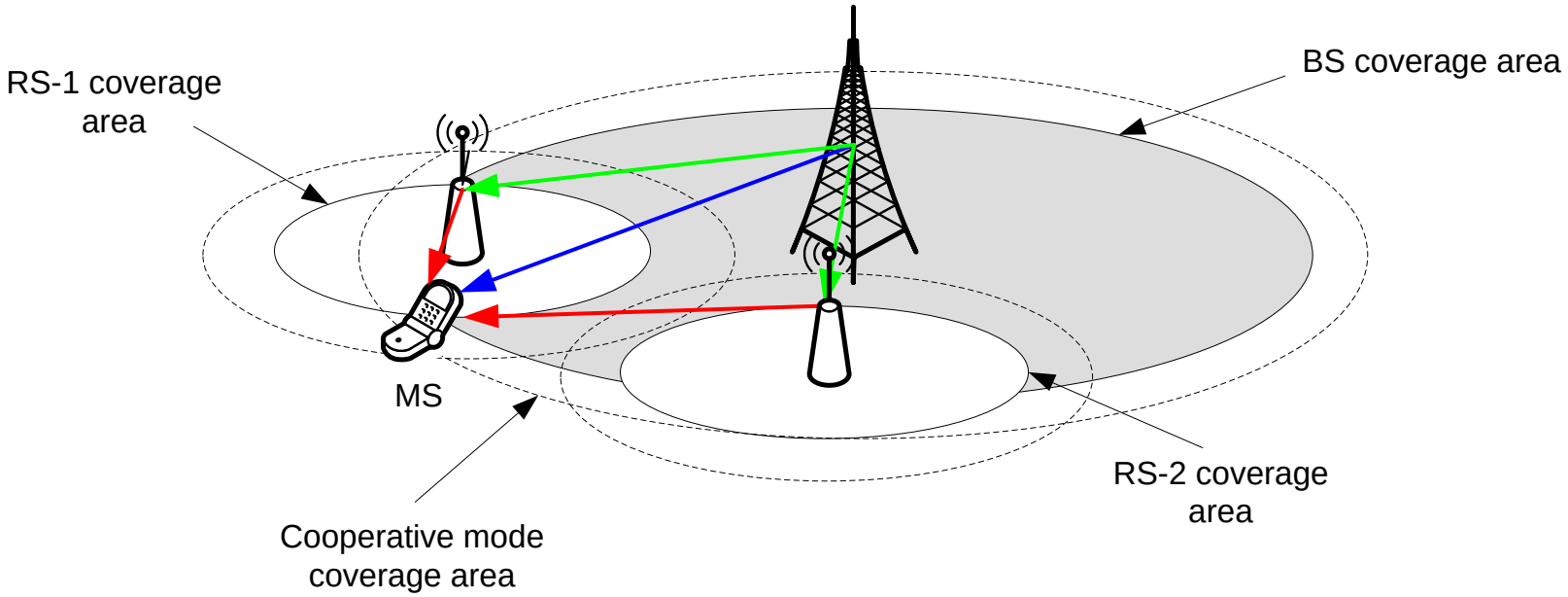
- Introduction
- Cooperative Relaying Mode Definition and Target Scenarios
- Overview of legacy cooperative diversity modes supported by IEEE 802.16j standard
- Cooperative relaying mode proposal for IEEE 802.16m standard
- Proposed text for System Description Document

Introduction

- In accordance to System Requirement Document IEEE 802.16m should provide mechanisms to enable multi-hop relays including those that may involve advanced antenna technique transmission
- IEEE 802.16m shall provide significantly improved coverage with respect to the Wireless OFDMA Reference System

Cell range	Performance target
Up to 5 km	Optimized Performance targets defined in Sections 7.1-7.3 should be met
5-30 km	Graceful degradation in system/edge spectral efficiency
30-100 km	System should be functional (thermal noise limited scenario)

Cooperative Relaying Mode Definition



Cooperative relaying is a mode when either an BS and one or more RSs or multiple RSs transmit data in a cooperative manner to one MS in the same time-frequency resource block

Cooperative Relaying Mode Target Scenarios

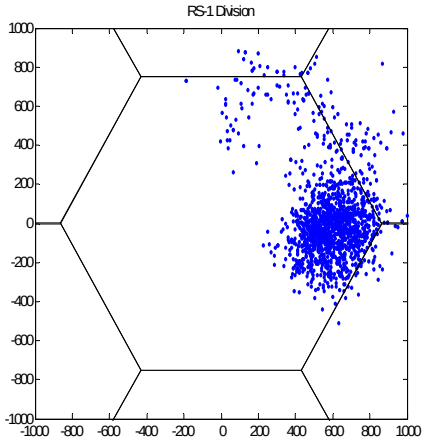
- Cooperative relaying mode can be used to increase the coverage area and to avoid coverage holes in the deployment areas by using advanced antenna technique transmission from multiple cooperative stations

- Cooperative relaying mode may be also considered as a simple solution for interference management suitable for the deployment cases where frequency reuse planning is not effective

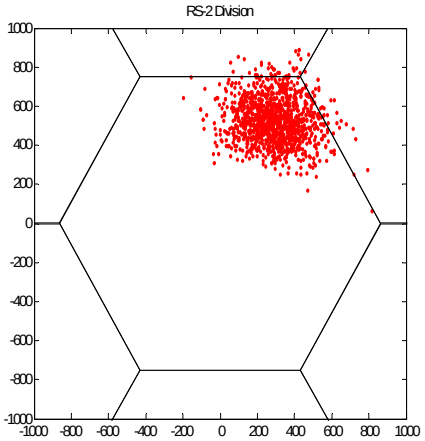
- Cooperative relaying gain is achieved without increasing the complexity of the MS by reusing the PHY functionality supported by baseline IEEE 802.16m system without relays

Regions with Preferred Relaying Modes

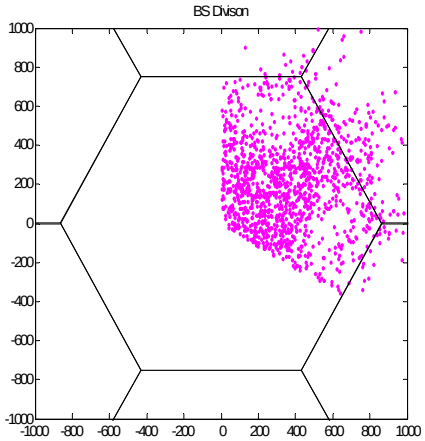
RS-1 Division



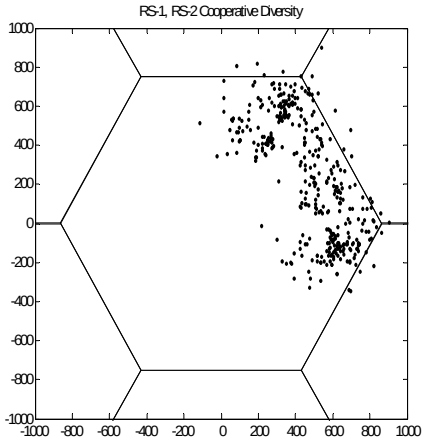
RS-2 Division



BS Division



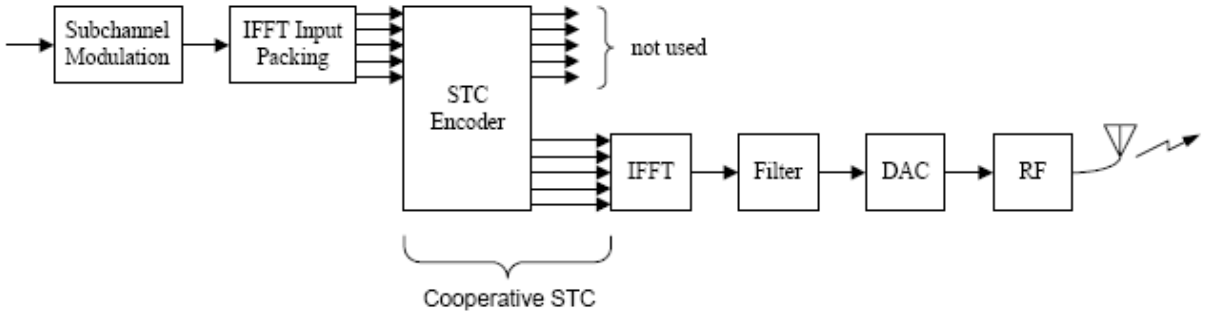
RS-1, RS-2 Cooperative



- System level simulation were performed for the two RS operating in ART scenario with parameters provided in Evaluation Methodology Document. For cooperative relaying mode only transmit diversity is considered
- The relaying mode that provides best spectral efficiency for the MS was selected as a preferred mode of operation. The regions where cooperative relaying was selected is clearly seen in the right figure.

Overview of Legacy IEEE 802.16j Cooperative Diversity

- Three types of cooperative relaying modes are defined in the IEEE 802.16j legacy system
  - Cooperative source diversity: transmitting antennas simultaneously transmit the same signal using the same time-frequency resource
  - Cooperative transmit diversity: STC-encoded signals are transmitted across the transmitting antennas using the same time-frequency resource
  - Cooperative hybrid diversity: is identical to cooperative transmit diversity except that at least one value for virtual antenna assignment is assigned to multiple physical antennas
- To enable cooperative transmit and hybrid diversity local STC encoding is performed



Open Loop Cooperative Transmit Diversity Proposal for IEEE 802.16m

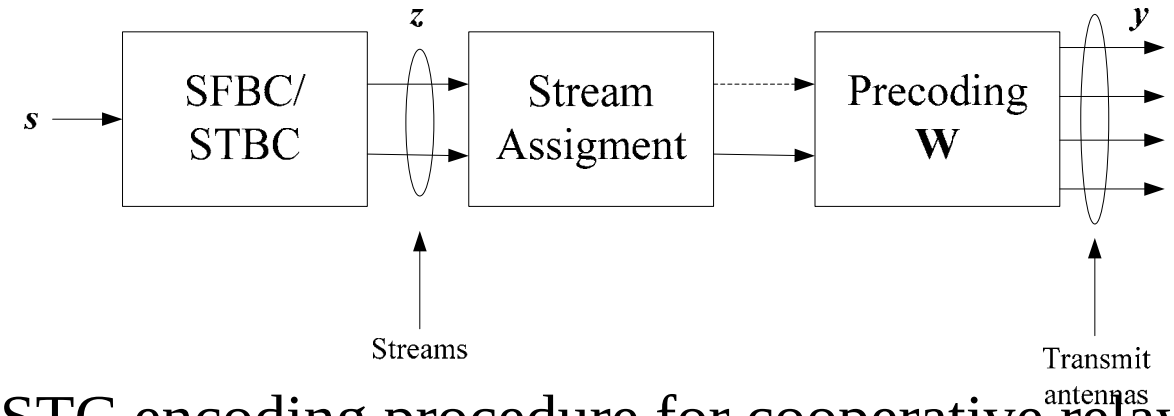
- Cooperative relaying for IEEE 802.16m system with relays should be optimized for the coverage extension scenario, so transmit diversity (rank-1 transmission) should be the main mode. Higher rank (spatial multiplexing) cooperative relaying mode transmissions are FFS
- To keep complexity at the MS transmit diversity SU-MIMO modes proposed for IEEE 802.16m should be reused for the local STC encoding in cooperative relaying
- Single-User Transmit Diversity is defined as $\mathbf{y} = \mathbf{z}$ or $\mathbf{y} = \mathbf{W} \times \mathbf{z}$ for more than two transmit antennas, where $\mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$ and $\mathbf{W}$ is random frequency dependent precoding matrices

Open Loop Cooperative Transmit Diversity Proposal for IEEE 802.16m (Cont'd)

- For cooperative transmit diversity BS assigns stream(s) to each cooperative station and precoding codebook **W** is selected based on the number of assigned streams and the number of transmit antennas at the cooperative station
- To enable channel estimation at the MS each cooperative station uses pilot pattern(s) corresponding to the stream assignment
- The stream(s) assignment is transmitted for each cooperative RS

Local STC Encoding for Cooperative Transmit Diversity

- Local STC Encoding block diagram



- Local STC encoding procedure for cooperative relaying

$$\mathbf{y} = \mathbf{W} \times \mathbf{P} \times \mathbf{z} \qquad \mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$$

where matrix $\mathbf{P}$ assigns stream(s) to specific RS operating in cooperative mode

System Recovery from Errors on Relay Link

- Some mechanisms may be used when cooperative station incorrectly receives cooperative burst
  - Cooperative RS that receive data in error does not transmit any data nor dedicated pilots (IEEE 802.16j)
  - BS does not allocate downlink resources for the MS operating in cooperative mode until correct decoding is acknowledged by all cooperative RS
  - Detailed description of protocols handling errors that might occur during relay link transmission are provided in contributions C80216m-08_1278 and C80216m-08_1279.

Closed Loop Cooperative Relaying

- Closed loop gain from multiple antenna transmission substantially increases with the number of transmitting antennas
- Multiple cooperative station apply precoding on antennas for further improvement of the efficiency of the cooperative relaying mode
- In this scenario MS estimates the channels and feedbacks PMI for each cooperative station to exploit closed loop cooperative gain
- Further coordination is required among cooperative stations to achieve this gain (e.g. mid-amble location, support of multiple CQI feedback channels, etc)
- Usage of closed loop cooperative relaying mode and coordination mechanism are FFS

Proposed Text to SDD

[Insert the following text into section 15 of the SDD:]

15.x.1 Open Loop cooperative relaying mode

Open loop cooperative transmit diversity scheme is the baseline open loop cooperative relaying mode. In cooperative transmit diversity mode, space-frequency (-time) encoded signals are transmitted across the transmitting antennas of cooperative stations using the same time-frequency resource. The cooperative transmit diversity mode uses downlink single-user MIMO modes. To achieve macro-diversity gain BS assigns different stream(s) to different cooperative stations. In this case each cooperative station performs local space-frequency (-time) coding. The modified single user transmit diversity encoding for cooperative mode is defined as

$$\mathbf{y} = \mathbf{W} \times \mathbf{P} \times \mathbf{z}, \quad \mathbf{z} = \begin{bmatrix} s_1 & -s_2^* \\ s_2 & s_1^* \end{bmatrix}$$

where **P** matrix that assigns stream(s) to specific cooperative station and may accept the following values $\mathbf{P}_1 = \begin{bmatrix} 1 & 0 \\ 0 & 0 \end{bmatrix}$, $\mathbf{P}_2 = \begin{bmatrix} 0 & 0 \\ 0 & 1 \end{bmatrix}$, $\mathbf{P}_3 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$

matrix **W** is precoding matrices that may be time-frequency dependent with dimensions defined from the number of transmit antennas and number of assigned streams.

Proposed Text to SDD (Cont'd)

The block diagram of local space-frequency (-time) coding is shown in Figure X.

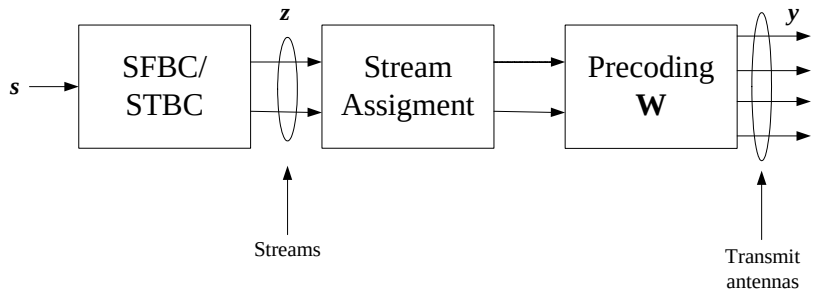


Figure X. Local transmit diversity encoding for cooperative mode

To enable channel estimation at the MS each cooperative station uses the pilot pattern(s) corresponding to the stream assignment.

Support of cooperative spatial multiplexing is FFS.

15.x.2 Closed loop cooperative relaying mode

For closed loop cooperative relaying mode MS achieves closed loop gain from all transmitting antennas of cooperative stations. In this case MS estimates the channels and transmits the PMI for each cooperative station. Support of closed loop cooperative mode and coordination mechanism are FFS.