Cooperative Diversity Schemes for Multi-Hop Relay System

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Purpose:
Propose to support cooperative diversity schemes in IEEE82.16j specification.

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Cooperative Diversity Schemes for Multi-hop Relay System

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Types of Transmission Protocols: Example

- Simple Relay vs. Cooperative Diversity
  - Simple Relay (SR)
    - First Time Slot
      ![Diagram of Simple Relay (SR) First Time Slot]
    - Second Time Slot
      ![Diagram of Simple Relay (SR) Second Time Slot]
  - Simple Receive Diversity (SRD)
    - First Time Slot
      ![Diagram of Simple Receive Diversity (SRD) First Time Slot]
    - Second Time Slot
      ![Diagram of Simple Receive Diversity (SRD) Second Time Slot]

(Reference-IEEE: S802_16mmr-05_012r1)
System Level Simulation (1)

• Simulation Scenario
  - Layout

- Simulation Set-up

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell layout</td>
<td>19 cell, wraparound</td>
</tr>
<tr>
<td>RS configuration</td>
<td>6 FRS per cell, 2/3 position from BS</td>
</tr>
<tr>
<td>BS Power</td>
<td>20W</td>
</tr>
<tr>
<td>RS Power</td>
<td>10W</td>
</tr>
<tr>
<td>BS-RS Link</td>
<td>LOS pathloss model (shadow fading, 3.4dB)</td>
</tr>
<tr>
<td>BS-MS, RS-MS Link</td>
<td>NLOS pathloss model (shadow fading, 8dB)</td>
</tr>
<tr>
<td>Mobile speed</td>
<td>3km/h</td>
</tr>
<tr>
<td>Scheduling</td>
<td>Round robin</td>
</tr>
<tr>
<td>Traffic model</td>
<td>Ethernet (~100Kbps)</td>
</tr>
</tbody>
</table>
System Level Simulation (2)

• Frame Structure & Resource Allocation: Downlink

- Orthogonal allocation

1. BS link MS1
2. RS link MS2
3. RS link MS3
4. BS link MS4

- Overlap allocation

1. BS link MS1
2. RS link MS2
3. RS link MS3
4. BS link MS4
System Level Simulation (3)

• C/I Measurement

<table>
<thead>
<tr>
<th>Allocation</th>
<th>Carrier Power</th>
<th>Interference Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple Relay (SR)</td>
<td>$C_{Total} = P_{best}$</td>
<td>$I_{Total} = \sum_{j=1}^{18} \left( \frac{1}{7} (BS_j + \sum_{r=1}^{6} RS_r') \right)$</td>
</tr>
<tr>
<td>Orthogonal Allocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overlapped Allocation</td>
<td>$C_{Total} = P_{best}$</td>
<td>$I_{Total} = \sum_{j\neq i}^{19} \left( BS_j + \sum_{r=1}^{6} RS_r' \right)$ $+ \sum_{j=i}^{19} \left( BS_j + \sum_{r=1}^{6} RS_r' \right) - P_{best}$</td>
</tr>
<tr>
<td>Simple Receive Diversity (SRD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Orthogonal Allocation</td>
<td>$C_{Total} = P_{best} + P_{\text{second best}}$</td>
<td>$I_{Total} = \sum_{j=1}^{18} \left( \frac{1}{7} (BS_j + \sum_{r=1}^{6} RS_r') \right)$ $+ \sum_{j=1}^{19} \left( BS_j + \sum_{r=1}^{6} RS_r' \right)$ $- P_{\text{best}} - P_{\text{second best}}$</td>
</tr>
<tr>
<td>Overlapped Allocation</td>
<td>$C_{Total} = P_{best} + P_{\text{second best}}$</td>
<td></td>
</tr>
</tbody>
</table>

System Level Simulation (3)
System Level Simulation (4)

- Performance Comparison: SR vs. SRD

- Orthogonal Allocation

- Overlapped Allocation
Types of Transmission Protocols: Diversity

- Simple Relay (SR)
- Receive Diversity (RD)
- Transmit Diversity (TD)
- Tx-Rx Joint Diversity (JD)

Notes: →: first time slot, ⋯⋯⋯⋯→: second time slot
Types of Transmission Protocols: Multiplexing (1)

- **Spatial Multiplexing with Receive Diversity: Type A (SMRD-A)**
  - First time slot
    
  - Second time slot

- **Extended SMRD-A**
  - First time slot
  
  - Second time slot

(Images of the diagrams are shown in the document.)
Types of Transmission Protocols: Multiplexing (2)

- Spatial Multiplexing with Receiver Diversity Type-B (SMRD-B)

- First Time Slot

- Second Time Slot

- Third Time Slot

- Fourth Time Slot
Simulation Model: SMRD

• Channel Model

\[ h_{S,R1}, h_{S,R2}, h_{S,D}, h_{R1,D}, h_{R2,D} \]

- Rayleigh fading
- AWGN

• Assumptions
  - A single antenna for all terminals and two antennas for destination
  - No interference among symbols over the different links
  - Binary DPSK modulation
Simulation Result: SMRD

- Extended SMRD-A vs. SMRD-B ( \( \bar{\gamma}_{S,R1} = \bar{\gamma}_{S,R2} = \bar{\gamma}_{S,D} = \bar{\gamma} \) )

- Extended SMRD-A

- SMRD-B
Summary

- Cooperative diversity will be a useful means for enhancing throughput and outage performance in Mobile WMAN.

- A generic frame structure must be designed so as to accommodate various types of cooperative diversity schemes without any revision in the future.

- A great care must be taken as a cooperative diversity scheme is employed in a cellular environment (e.g., resource vs. interference).

- A new evaluation methodology might be required to assess the advantage of cooperative diversity schemes.