Reverse Link Performance of Relay-based Cellular Systems in Manhattan-like Scenario

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Reverse Link Performance of Relay-based Cellular Systems in Manhattan-like Scenario

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Outline

- Relay Deployment Scenario
- Simulation Models
- Simulation Results
- Summary
Relay Deployment Scenario

- Consider an existing cellular network with well-planned coverage
  - Fixed Relay Stations (FRS) are deployed within the coverage of each cell
  - FRSs are deployed for throughput enhancement
- The same deployment scenario as C80216mmr-05_041

multi-cell environment
FRSs provide full coverage within each cell
Relay Deployment Scenario

- Interfering cells can be separated by increasing frequency reuse factor ($K$)
  - However, it takes $K$ times radio bandwidth throughout the system.

Frequency Reuse Factor = 1

Frequency Reuse Factor = 3

Frequency Reuse Factor = 4
Relay Deployment Scenario

Without relaying:
Non-Line-Of-Sight (NLOS) transmission in general
Longer distance from MS to BS
Higher transmit power for MS

With relaying:
Line-Of-Sight (LOS) transmission in general
Shorter distance from MS to FRS
Lower transmit power for MS
• Relay Deployment Scenario

• Simulation Models

• Simulation Results

• Summary
Simulation Models

**Mobile Station (MS)**
- Max. transmit power (0.5 Watts) for 1km cell radius
- **Power control** for reverse link transmission
  - Adaptive resource allocation (ARA) is an alternative solution
- If FUSC permutation is applied for each sector, MS and FRS in different sector can reuse the same sub-channel.
  - Additional intra-cell interference may be raised

**Fixed Relay Station (FRS)**
- 14 FRSs are deployed to provide full coverage within the cell
  - 4 directional antennas for each main street direction
  - 1 stand alone directional antenna is steering toward the BS’s direction
  - **Power control** for the reverse link transmission between FRS and BS
- Time domain relaying within the same radio bandwidth
Simulation Models

• Propagation models are the same as C80216mmr-05_041

\[ \text{Pathloss (dB)} = 38.4 + 35 \log_{10}(d) + 20 \log_{10}(f_c/5) \]

- \( f_c \) carrier frequency (GHz)
- \( d \) distance between Tx and Rx (meters)
- \( \sigma \) standard deviation of shadow fading (dB)
- \( P_{\text{LOS}} \) probability to have LOS condition

\[ P_{\text{LOS}}(d) = \begin{cases} 
1 & d \leq 15 \text{m} \\
1 - \left(1 - (1.56 - 0.48 \log_{10}(d))^{1/3}\right)^3 & d > 15 \text{m}
\end{cases} \]
Simulation Models

• Reference System: IEEE 802.16e OFDMA mode
  – Radio bandwidth for each cell: 6MHz
  – Total number of sub-carriers: 2048
  – Carrier frequency: 3.5GHz
  – Number of sub-channels in each sector: 96(FUSC), 32(PUSC)
  – Number of sub-carriers within each sub-channel: 18
  – Number of sectors: 3
  – Max. transmit power of each MS: 0.5W
  – Max. transmit power of each FRS: 5W
  – Antenna height of BS: Above rooftop (35m)
  – Antenna height of FRS: Above / below rooftop (to BS / MS)
  – MS speed: 30km/hr
  – Probability of changing direction at intersection: 50%
  – MS arrival: Poisson process
  – Handoff type: Hard handoff
• Relay Deployment Scenario

• Simulation Models

• Simulation Results

• Summary
Simulation Results

- CDF (Cumulative Distribution Function) of MS transmit power
  - ARA: Adaptive Resource Allocation
  - PUSC permutation
Simulation Results

- System capacity (Mbps/cell)
Simulation Results

- System capacity (Mbps/cell)
## Simulation Results

<table>
<thead>
<tr>
<th>K=1</th>
<th>MS Transmit Power</th>
<th>Cell Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Relay</td>
<td>Reference case (+0dB)</td>
<td>Reference case (+0%)</td>
</tr>
<tr>
<td>Relay, PUSC</td>
<td>-7.21dB</td>
<td>-44.53%</td>
</tr>
<tr>
<td>Relay, PUSC + adaptive resource allocation</td>
<td>-0.20dB</td>
<td>+40.95%</td>
</tr>
<tr>
<td>Relay, FUSC</td>
<td>-4.30dB</td>
<td>-35.44%</td>
</tr>
<tr>
<td>Relay, FUSC + adaptive resource allocation</td>
<td>+1.19dB</td>
<td>+41.66%</td>
</tr>
</tbody>
</table>
## Simulation Results

<table>
<thead>
<tr>
<th>K=3</th>
<th>MS Transmit Power</th>
<th>Cell Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Relay</td>
<td>-1.59dB</td>
<td>+5.97%</td>
</tr>
<tr>
<td>Relay, PUSC</td>
<td>-11.05dB</td>
<td>-40.99%</td>
</tr>
<tr>
<td>Relay, PUSC + adaptive resource allocation</td>
<td>-2.46dB</td>
<td>+69.29%</td>
</tr>
<tr>
<td>Relay, FUSC</td>
<td>-6.69dB</td>
<td>-7.67%</td>
</tr>
<tr>
<td>Relay, FUSC+ adaptive resource allocation</td>
<td>+0.90dB</td>
<td>+129.96%</td>
</tr>
</tbody>
</table>
## Simulation Results

<table>
<thead>
<tr>
<th>K=7</th>
<th>MS Transmit Power</th>
<th>Cell Throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Relay</td>
<td>-1.60dB</td>
<td>+13.01%</td>
</tr>
<tr>
<td>Relay, PUSC</td>
<td>-12.65dB</td>
<td>-40.35%</td>
</tr>
<tr>
<td>Relay, PUSC + adaptive resource allocation</td>
<td>-4.67dB</td>
<td>+75.08%</td>
</tr>
<tr>
<td>Relay, FUSC</td>
<td>-9.80dB</td>
<td>-2.68%</td>
</tr>
<tr>
<td>Relay, FUSC+ adaptive resource allocation</td>
<td>-0.29dB</td>
<td>+152.31%</td>
</tr>
</tbody>
</table>
• Relay Deployment Scenario
• Simulation Models
• Simulation Results
• Summary
Summary

• Relaying provides significant performances improvement on:
  – saving MS transmit power
    • Shorter distance between MS and FRS
    • Higher probability to have LOS transmission condition
      → Propagation loss reduction
  – increasing system capacity
    • Transform the conserved MS transmit power into cell throughput improvement through adaptive resource allocation
    • Overall cell throughput is outperformed to the case without relaying

• **Adaptive resource allocation/scheduling mechanism** should be an important function for relay-based systems
  – System capacity can be benefited by relaying through this function