Title: Advantages of a Coexistence Protocol for Relay Operation

Document Number: IEEE C802.16mmr-05/020r1
Date Submitted: 2005-11-15

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21a HaBarzel Street, Tel Aviv, Israel

Venue:
Meeting: IEEE 802.16 Session#40, Vancouver, Canada

Base Document:
Purpose: Present the advantages of using coexistence protocols in Relay/Cellular operation and propose text for PAR

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Advantages of a Coexistence Protocol for Relay operation

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Phases relay operation

- “Charge” phase
  - BS -> RS (Relay station)
- “Distribution phase”
  - RS (Relay station) -> SS/MSS
- “Collection” phase
  - SS/MSS -> Relay station
- “Discharge” phase
  - RS -> BS
- This presentation addresses mainly the collection/distribution phase
Reducing the interference

• May significantly increase the spectral efficiency
  – 36% throughput improvement with relays implementing “beam forming” – see IEEE C80216mmr-05_008r3
  • May be too expensive

• This contribution will investigate how a “coexistence protocol” can produce similar results
Assumptions for the following study

• The antennae on BS and RS are omnidirectional
• Same basic topology as in C80216mmr-05_008r3
• The operator uses 3 frequency channels
  – The rejection of the adjacent channel is 30dB
• The reference case: the BS and associated relays use the same frequency channel
• The improvement: due to assignment of different channels to interfering cells
Reference case

Interference victim
Which transmitters might produce interference at SS receiver?

- Those having the signal strong enough, in the LOS conditions
  - We group those transmitters in a “Coexistence Neighborhood”
  - Assume that all the transmitters (BS and RS) use the same transmit power
  - Short lines in the next figure involve high interference
Coexistence “neighborhood”
C/I Distribution for the reference case

<table>
<thead>
<tr>
<th>Min</th>
<th>to</th>
<th>dB</th>
<th>C/I+N distribution [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 dB</td>
<td>to</td>
<td>0</td>
<td>3.214</td>
</tr>
<tr>
<td>0 dB</td>
<td>to</td>
<td>3</td>
<td>10.756</td>
</tr>
<tr>
<td>3 dB</td>
<td>to</td>
<td>6</td>
<td>10.284</td>
</tr>
<tr>
<td>6 dB</td>
<td>to</td>
<td>9</td>
<td>10.151</td>
</tr>
<tr>
<td>9 dB</td>
<td>to</td>
<td>12</td>
<td>14.636</td>
</tr>
<tr>
<td>12 dB</td>
<td>to</td>
<td>15</td>
<td>14.057</td>
</tr>
<tr>
<td>15 dB</td>
<td>to</td>
<td>18</td>
<td>10.458</td>
</tr>
<tr>
<td>18 dB</td>
<td>to</td>
<td>21</td>
<td>7.377</td>
</tr>
<tr>
<td>21 dB</td>
<td>to</td>
<td>24</td>
<td>5.372</td>
</tr>
<tr>
<td>24 dB</td>
<td>to</td>
<td>Max</td>
<td>13.689</td>
</tr>
</tbody>
</table>

Bar chart showing the distribution of C/I+N in different intervals:

- >0
- 0 to 3
- 3 to 6
- 6 to 9
- 9 to 12
- 12 to 15
- 15 to 18
- 18 to 21
- 21 to 24
- 24<
How to reduce the interference?

- Every RS uses a different sub-channel
  - limited throughput
- Every RS uses a full channel and BS schedules the transmitted powers for all the Relays such that the interference will be lower when sending the info for the target SS/MSS
  - Very complicated exercise, may not work for all the links
  - Limited throughput
  - Requires use of low MCRs
    - Long transmission times -> high power consumption from the MSS
Changing the frequency patterns

• Use another frequency pattern in the distribution phase

• Advantage
  – Drastically reduce the interference (see figures)

• Disadvantage
  – Needs frequency assignment
Different frequency pattern
Characteristics of the new frequency pattern

- Same number of interferes in the “Coexistence neighborhood”
- No adjacent interfering relays
  - All the interferers are more distant
- The cumulated interference is lower
  - Higher MCRs can be used
    - Lower MSS required transmission time and power consumption
Performance of the new frequency pattern

<table>
<thead>
<tr>
<th>C/I+N distribution [%]</th>
<th>0.00%</th>
<th>5.00%</th>
<th>10.00%</th>
<th>15.00%</th>
<th>20.00%</th>
<th>25.00%</th>
<th>30.00%</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 dB to 3 dB</td>
<td>0 %</td>
<td>0 %</td>
<td>0 %</td>
<td>0.098 %</td>
<td>7.852 %</td>
<td>21.928 %</td>
<td>21.266 %</td>
</tr>
<tr>
<td>3 dB to 6 dB</td>
<td>14.088 %</td>
<td>10.373 %</td>
<td>27.392 %</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 dB to 9 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 dB to 12 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 dB to 15 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15 dB to 18 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 dB to 21 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 dB to 24 dB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 dB to Max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison of C/(I+N) distributions

![Comparison of C/(I+N) distributions](image)
How to obtain the frequency assignment?

- Using 802.16h approach:
  - Data base:
    - GPS position of the Relays and BSs
    - IP Address
    - BSIDs
  - Sending the Radio Signature by RSs/BSs
    - Every SS/MSS/RS/BS can evaluate the interference
    - The information is centralized by the BS
    - Through **BS-BS distributed communication** the systems in Community may learn the interference and the interferers
  - Frequency channel selection procedures
Extending the concept

• Every frequency may be thought as a bunch of sub-channels
  – OFDMA/OFDM modes

• Negotiating the allocation of sub-channels per “bunch”
  – Depending on traffic amount
  – Flexibility on assignments
    • Token-based protocol, developed in 16h, may apply
Distributed power control

• Protocol based coexistence in 802.16h:
  – every NETWORK will have the possibility to use max. power at pre-defined time intervals
  – High spectral efficiency
    • Links not creating interference may work in parallel

• Protocol-based coexistence for cellular deployment:
  – Systems using a given FREQUENCY CHANNEL will have the possibility to use max. power at predefined time intervals
    • Allows distributed power management
      – No need for BS Controller
      – Base Stations will be able to control the Relay powers
    • Allows high spectral efficiency
Interference-free operation in cellular networks

• Could be created by coexistence protocols
  – The MSS is able to transmit/receive at higher $C/(N+I)$
  • Same data is handled in much shorter time

Reduces the MSS power consumption!
Relay PAR Scope

• Opt. 1:
  – To include:
    • “higher layer mechanisms, as Coexistence Protocols”

• Opt. 2:
  – To create a new PAR (after 802.11h is done)
    • “extension of the protocol-based coexistence for Relay operation”
      – Keeps the 802.16h expertise center
Drafting an 802.16 Coexistence Protocol

• Already started for 802.16h
  – First application: License Exempt use
  – Other applications:
    • Relays
    • Light-licensed bands

• Should be formatted as a stand-alone chapter, application independent

• Every application may enhance it and should have a sub-chapter to detail its usage