Mobile Multi-hop Mesh/Relay Networking in IEEE 802.16

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Call for interest in the issue of mobile multi-hop mesh/relay networking in IEEE 802.16 systems

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Mobile Multi-hop Mesh/Relay Networking in IEEE 802.16

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Outline

• Background / Benefits
• Mesh Mode in Std 802.16-2004
• Scope / Backward compatibility
• Types of new Mesh/Relay mode
• Related works
• Tentative schedule
• Summary
• High frequency band such as 2-6 GHz has wide frequency bandwidth and enables to obtain higher throughput.

• The higher the frequency becomes, the more difficult non line-of-sight (NLOS) communication is.

• Simple Relay Station (RS) is expected to extend coverage to the NLOS area efficiently, compared to highly functional Base Station (BS).
Benefits

- Two benefits from introducing RS
  - Coverage extension:
    Expansion for coverage area of existing PMP mode
  - Throughput enhancement
    Higher throughput over multi-hop paths
Mesh Mode in Std 802.16-2004

- Current Mesh Mode has the following disadvantages
  - No compatibility with PMP mode
    - PHY: Different frame structure (not compatible to PMP mode), OFDM only (for both licensed and unlicensed bands)
    - MAC: Different Network Entry procedure (not compatible to PMP mode)
  - No support for TGe mobile station (MS)
    - Not support a fast route change for MS

❖ Need to develop **new Mesh/Relay mode** in IEEE 802.16
Scope

• Develop new Mesh/Relay mode compatible with PMP mode
  - PHY: Enhance normal frame structure
  - MAC: Add new protocols for Mesh/Relay networking

• Main differences from the Current Mesh Mode
  - Efficiently provide Mesh/Relay connection to MS
  - Support OFDMA as well as OFDM PHY mode
  - Backward compatible to PMP Mode
Backward Compatibility

• Definition
  - BS supporting the New Mesh/Relay mode is able to accommodate 3 types of SSs
    ▪ 802.16-2004 PMP mode SS
    ▪ TGe PMP mode MS
    ▪ New Mesh/Relay mode MS

• Such backward compatibility provides a smooth migration
  - TGe system can gradually support the new Mesh/Relay mode in the future
### Types of New Mesh/Relay Mode

- **Fixed Relay Station (FRS)**

<table>
<thead>
<tr>
<th>Type A</th>
<th>Type B</th>
</tr>
</thead>
</table>
| • FRS is located within BS coverage  
• FRS connecting with BS shares radio resource with other SSs | • FRS is located out of BS coverage  
• FRS connecting with BS uses a dedicated / shared resource |
Types of New Mesh/Relay Mode
(cont’d)

- Mobile Relay Station (MRS)

<table>
<thead>
<tr>
<th>Type C</th>
</tr>
</thead>
<tbody>
<tr>
<td>• MRS is located with in BS coverage</td>
</tr>
<tr>
<td>• TX power of MRS is the same as MS</td>
</tr>
<tr>
<td>• A fast route change</td>
</tr>
</tbody>
</table>
| (1) BS ~ MS-1  
  ⇒ BS ~ MRS-1 ~ MS-1 |
| (2) BS ~ MS-2  
  ⇒ BS ~ MRS-2 ~ MS-2 |
| * SSs can select the optimal route according to a situation. |
Related Works

- New Mesh/Relay schemes were proposed in 802.16 etc.

IEEE S802.16d-03/67
“Directed Mesh in 802.16”
by Radiant Network PLC

IEEE C802.16e-04/417
“Transparent Uplink Relaying for OFDMA” by Motorola
“Affordable Infrastructure for Deploying WiMAX Systems: Mesh v. Non Mesh” by Stevens Institute of Technology

C. Related Works (cont’d)

“Affordable Infrastructure for Deploying WiMAX Systems: Mesh v. Non Mesh”

Unrelated to the topic, the type of mesh network is not a new concept. Infrastructure mesh is a type of mesh where all nodes are connected. It is different from “point to point” or “thin” mesh. In IEEE 802.16, the WiMAX standard and Internet Protocol (IP) protocol, mesh networks are an important class of wireless network architectures, which are supported and utilized by WiMAX. A mesh network is a type of “mesh” network. This option is not widely discussed or supported (still an exception). Additional research and standardization work is needed to bring full benefits of mesh architecture to WiMAX. Infrastructure mesh has many advantages over the client mesh in its ability to manage, secure, and cost-effectively to manage, and does not suffer from initial scaling issues.

D. Different Technologies of Infrastructure Meshes

Infrastructure mesh is a new way of delivering broadband access for residential and WiMAX. There are different types of architectures by which many systems can be formed. WiMAX has an advantage of flexibility for delivering many different services at a lower cost and a smaller scale, which is possible only in WiMAX. We have considered different ways to design the infrastructure mesh and the size of the element in each way. The size of a cell that can form a mesh cluster is given by the formula: $n^2$, where $n$ is an integer. This gives 4, 9, 16, 25, 36, 49, 64, 81, 100. Since we need the main 8x8 formed by each 8x8 mesh, the size of the cluster is going to be the same as the 8x8 mesh. In our case, the 8x8 mesh would be 32, 52, 77, and 97. The size of the cluster should be a multiple of the 8x8 mesh, so we choose the 97 and our cluster is the “32 52 77 and 97.”

Since 80 is used, 32 is added. Considering the size of a cluster of 32, 52, 77, and 97, it is convenient to use the size of the 80x80 clusters we consider randomly to use for more, for redundancy. Mesh 80. For example, as shown in Figure 7, if we consider the size of 32 cells, there will be each main 8x8 mesh surrounded by six Mesh 8x8 options. In this architecture, the main 8x8 manages all the traffic from the main 8x8 network and then takes eight virtual packets in the 80x80. In the same way, we have provided different architectures, or infrastructure mesh, which is the basis for our analysis.

[Figure 1, Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7]
# Tentative Schedule

- **Starting new Study Group / Task Group**

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>802.16 session</th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>May</td>
<td>#37 Interim</td>
<td>Call for Interest</td>
</tr>
<tr>
<td></td>
<td>July</td>
<td>#38 Plenary</td>
<td>Propose to form SG – Approved</td>
</tr>
<tr>
<td></td>
<td>Sept.</td>
<td>#39 Interim</td>
<td>SG: the 1st meeting</td>
</tr>
<tr>
<td></td>
<td>Nov.</td>
<td>#40 Plenary</td>
<td>SG: the 2nd meeting</td>
</tr>
<tr>
<td></td>
<td>Jan.</td>
<td>#41 Interim</td>
<td>SG: the 3rd meeting – Complete a PAR</td>
</tr>
<tr>
<td></td>
<td>Mar.</td>
<td>#42 Plenary</td>
<td>802 EC endorses PAR approval</td>
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<tr>
<td></td>
<td>May</td>
<td>#43 Interim</td>
<td>TG: the 1st meeting</td>
</tr>
<tr>
<td>2006</td>
<td>July</td>
<td>#44 Plenary</td>
<td>TG: the 2nd meeting</td>
</tr>
<tr>
<td></td>
<td>Sept.</td>
<td>#45 Interim</td>
<td>TG: the 3rd meeting</td>
</tr>
<tr>
<td></td>
<td>Nov.</td>
<td>#46 Plenary</td>
<td>TG: the 4th meeting</td>
</tr>
</tbody>
</table>
Summary

• Highly functional BS vs. Simple RS
  - Coverage extension
  - Throughput enhancement

• The current IEEE802.16 has the following issues
  - Mesh option: No compatibility with PMP mode
  - PMP mode: No relay function

• Need to develop new Mesh/Relay mode which is compatible with IEEE Std 802.16-2004 and P802.16e

• Let’s start new Study Group together!!!
E-mail List

• Welcome anyone who has an interest in this issue!

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