Mobile Multi-hop Mesh/Relay Networking in IEEE 802.16

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Purpose:

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

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May 2, 2005

Outline

- Background / Benefits
- Mesh Mode in Std 802.16-2004
- Scope / Backward compatibility
- Types of new Mesh/Relay mode
- Related works
- Tentative schedule
- Summary

Background

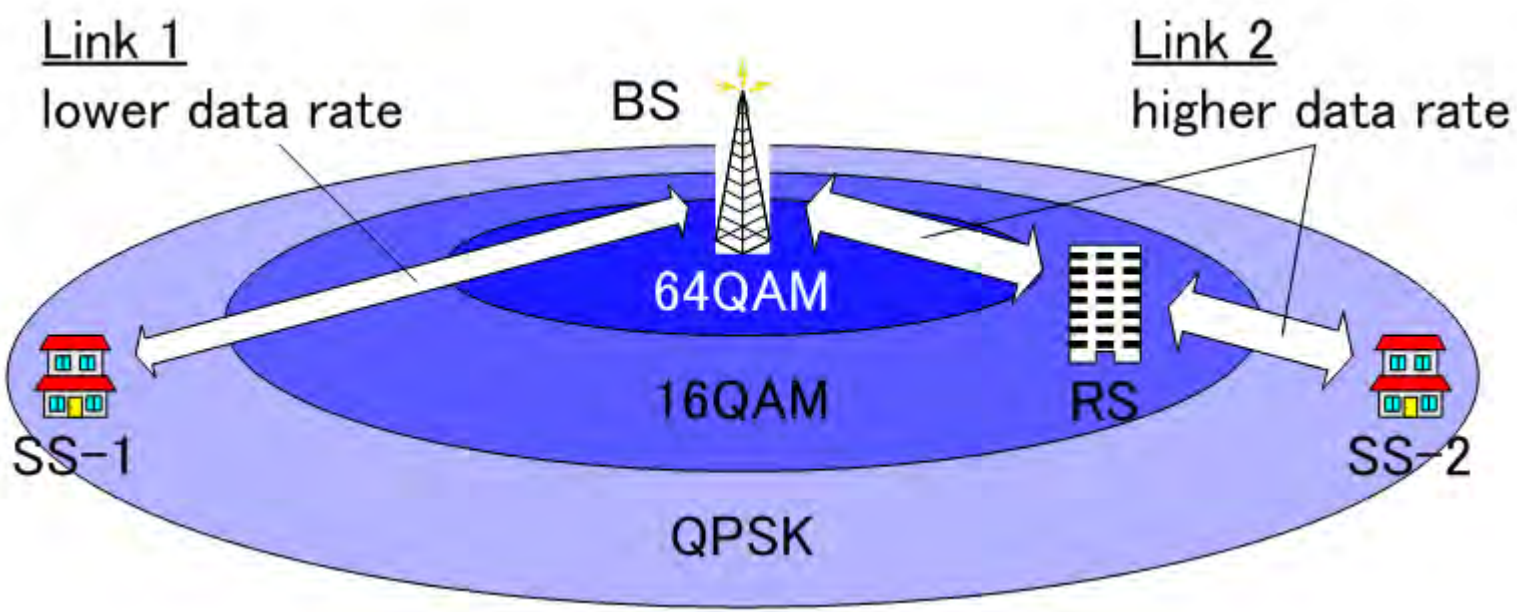
- High frequency band such as 2-6 GHz has wide frequency bandwidth and enables to obtain higher throughput.
- The higher the frequency becomes, the more difficult non line-of-sight (NLOS) communication is.
- Simple Relay Station (RS) is expected to extend coverage to the NLOS area efficiently, compared 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

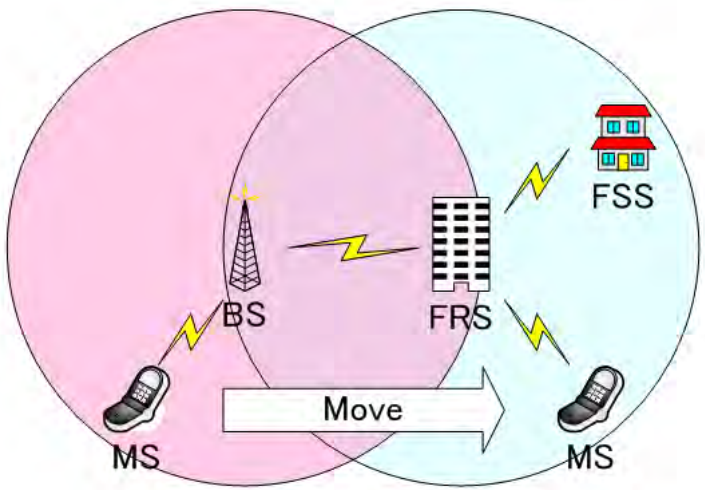
Backward Compatibility

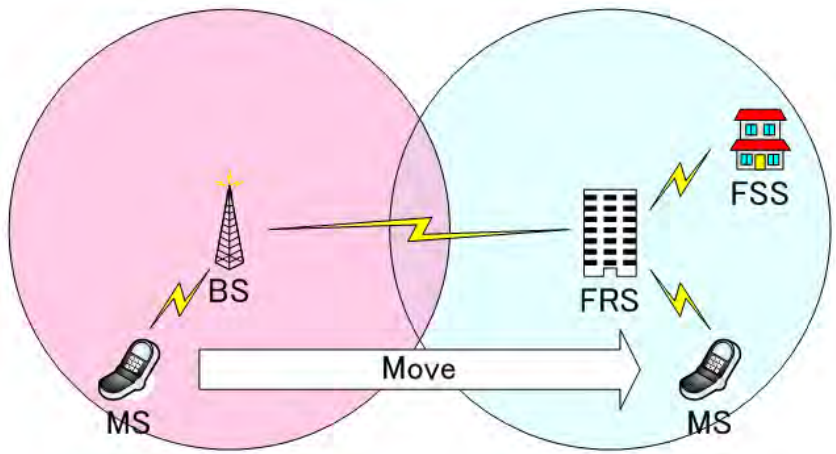
- Definition
  - BS supporting the New Mesh/Relay mode is able to accommodate 3 types of SSs
    - 802.16-2004 PMP mode SS
    - TGe PMP mode MS
    - New Mesh/Relay mode MS
- Such backward compatibility provides a smooth migration
  - TGe system can gradually support the new Mesh/Relay mode in the future

Types of New Mesh/Relay Mode

- Fixed Relay Station (FRS)

Type A	Type B
• 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)

Type C

- MRS is located with in BS coverage
- TX power of MRS is the same as MS
- A fast route change

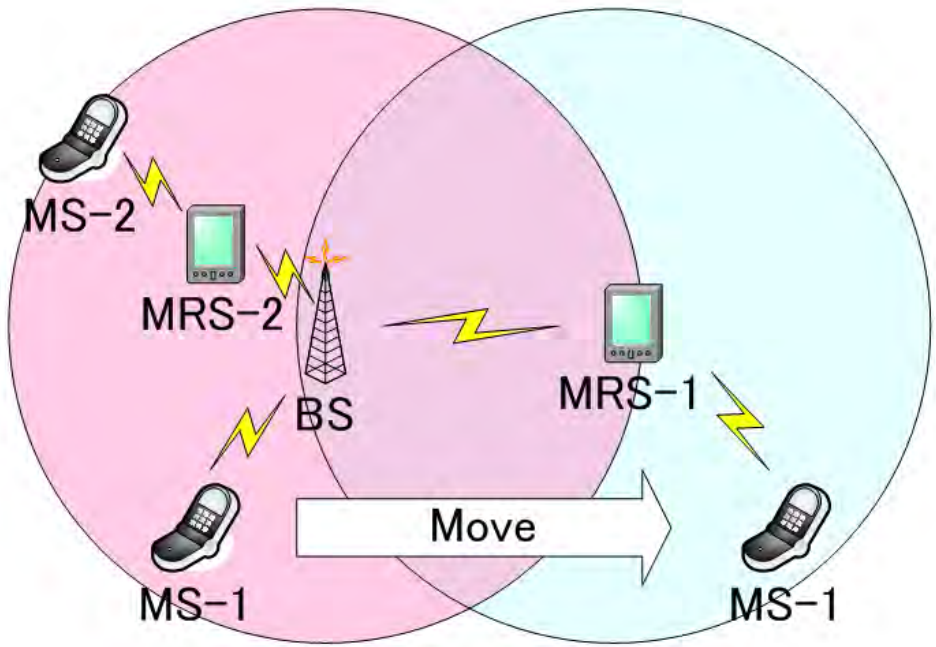
  (1) BS ~ MS-1

  ⇨ BS ~ MRS-1 ~ MS-1

  (2) BS ~ MS-2

  ⇨ BS ~ MRS-2 ~ MS-2

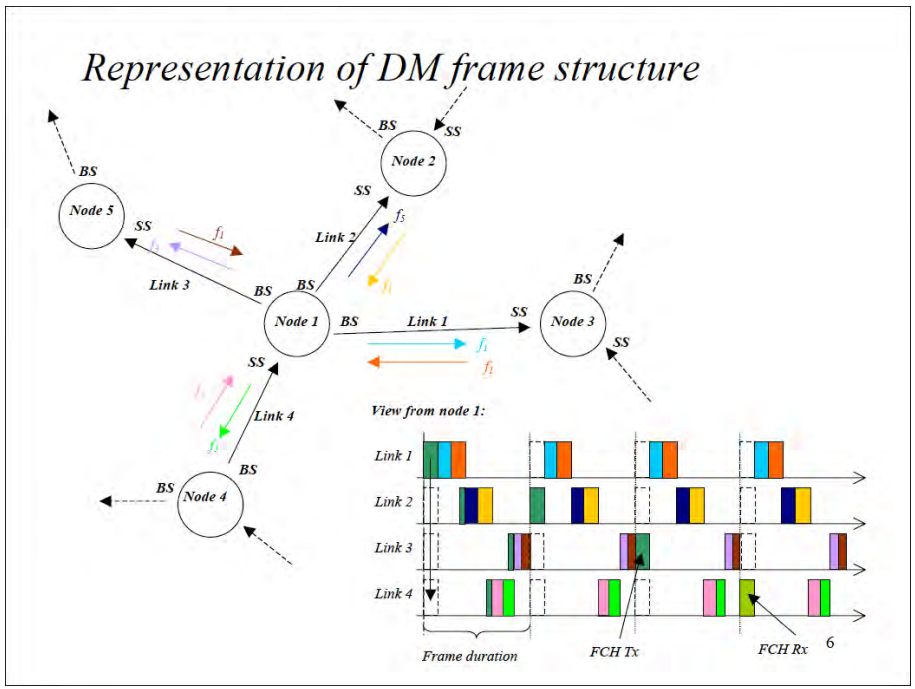
  * SSs can select the optimal route according to a situation.



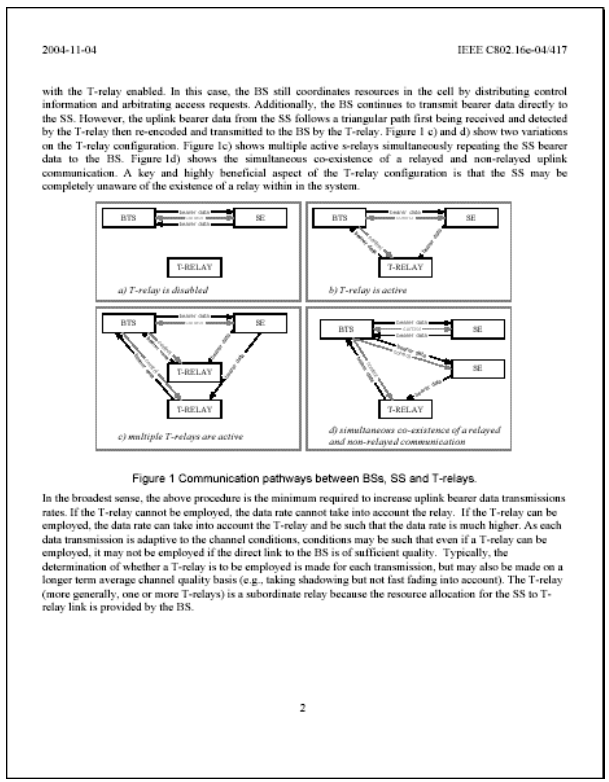
Related Works

- 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



Related Works
(cont'd)

"Affordable Infrastructure for Deploying WiMAX Systems : Mesh v. Non Mesh" by Stevens Institute of Technology

acquisition cost much lower than would any other broadband technologies. So the other alternative broadband service model would be with both Wi-Fi and WiMAX where Wi-Fi can be used to reach the end user and at the same time can take advantage of WiMAX to minimize backhaul cost, reduce the time for service provisioning and reduce customer acquisition cost [7].

C. Mesh Networks vs. Non Mesh

Unlike other mesh networks, the type of mesh network we are dealing is slightly different. Infrastructure Mesh is a type of mesh where subscriber nodes do not forward packets. It is contrasted with "ad-hoc" or "client" Mesh. Options in IEEE 802.16 are PMP MAC option and Mesh MAC option[1]. PMP MAC Option (Point-to-multipoint mode) is the default architecture, which is supported and enhanced by the WiMAX Forum. Mesh MAC Option is a type of "client mesh". This option is not actively discussed or supported (still on research). Additional research and standardization work is needed to bring full benefits of mesh architecture or infrastructure mesh to 802.16/WiMAX. Infrastructure mesh has many advantages over the client mesh as it is more secure, more predictable, easier to manage, and does not suffer from initial seeding issue.

D. Different Topologies of Infrastructure Mesh

Infrastructure mesh is a new way of delivering broadband access for residential and SOHO's. There are different types of architectures by which mesh systems can be formed. Weighing the advantages and disadvantages of each different systems and more careful analysis is required before WiMAX deployment. We have considered different topologies from one hop to three hops for our analysis. We have chosen hexagonal cell and the size of the clusters in such way it tessellates the plane. The number of cells that can form a regular cluster pattern is given by the formula $m^2 + n^2 + mn$ where m, n are integers. This gives 3, 4, 7, 9, 12, 13, 16, 19, 21.etc. So it has a N-sized cluster with one main base and (N-1) mesh BS. Since we need one main BS surrounded by mesh BS, the size of the clusters of mesh BS (Base Station) with one Main BS chosen would be: 7, 13, 19, 27, and 37. As seen in the figures below we have taken very limited hops: 1 (no forwarding) to max 3 with symmetrical pattern to form a regular pattern with main BS in the center.(1:6, 1:12, 1:18, 1:26, 1:36).

Main BS with wired backhaul at the center of a cluster of Mesh Base Stations is connected wirelessly to one (or more, for redundancy) Main BS. For example as shown in Figure 1, if we consider a cluster size of 7 cells, there will be one Main base station surrounded by six Mesh base stations. In this architecture the Main BS aggregates all the traffic from the Mesh base stations and then takes them via wired backhaul to the POP. In the same way we have considered different topologies of maximum up to three hops for our analysis.

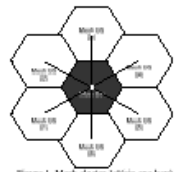


Figure 1. Mesh cluster 1:6(six one hop)

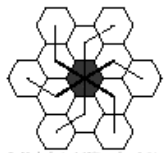


Figure 2. Mesh cluster 1:12(6 one hop & 6 two hop)

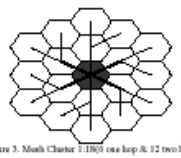


Figure 3. Mesh Cluster 1:18(0 one hop & 12 two hop)

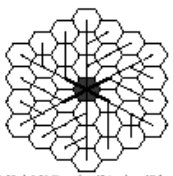


Figure 4. Mesh 1:36 (6 one hop,12 two hop ,18 three hop)

Considering the 1:6 case with the coverage area of 900 square miles of 1 mile cell radius there are 297 mesh BS and 50 main BS. So there will be a total of only 50 wired backhaul facility needed to serve all the users in 297 mesh BS coverage apart from its own users in the main BS coverage area. As seen in Fig 5 the number of main BS decreases as the mesh becomes

Tentative Schedule

- Starting new Study Group / Task Group

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

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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