BS Coordinated Mesh Networking

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*<http://standards.ieee.org/faqs/affiliationFAQ.html>

Venue:

IEEE 802.16m-08/040"Call for Contributions on Project 802.16m System Description Document (SDD)", in response to the following topics: "Relaying Model", MAC related]

Base Contribution:

N/A

Purpose:

to be discussed and adopted by TGm for the 802.16m SDD

Notice:

Release:

Patent Policy:

BS Coordinated Mesh Networking

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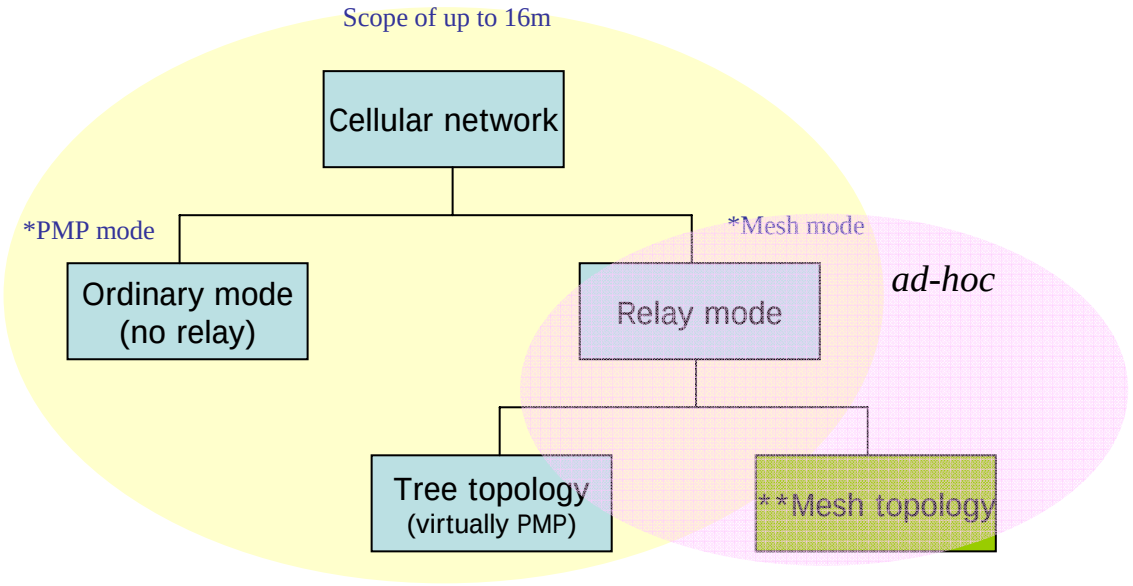
Update in Oct. 2008

Introduction (1/2)

- Tree v.s. Mesh



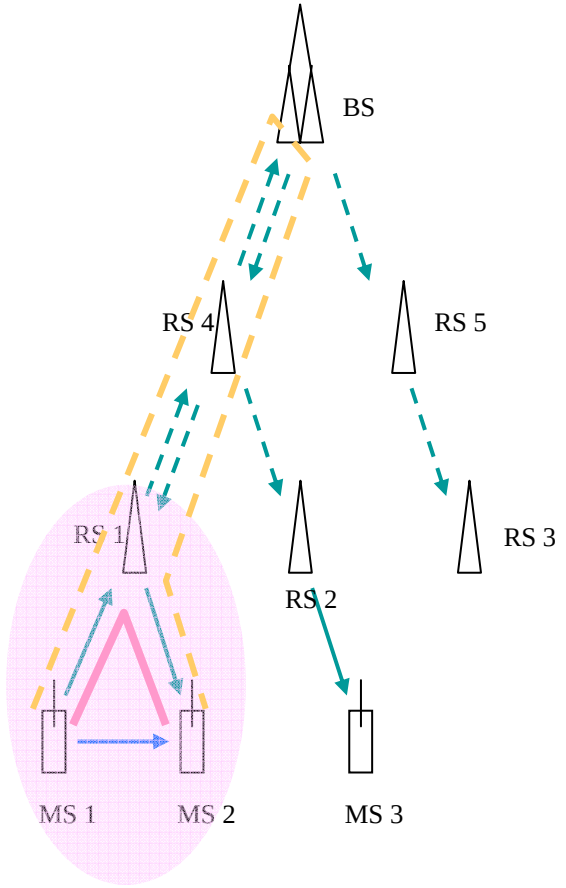
- Relay/node selection
- Handover
- Topology change from Mesh to PMP;
- Billing/charging
- Security

*: in .16e stage, “mesh mode” was referred to as “relay mode”
**: traffic may not go through BS nor RS

Introduction (2/2)

- Tree topology
  - Example: cellular network w/ single path relays
  - Pros: simple to handle (but not always)
  - Cons: not throughput-optimal; not always shortest path

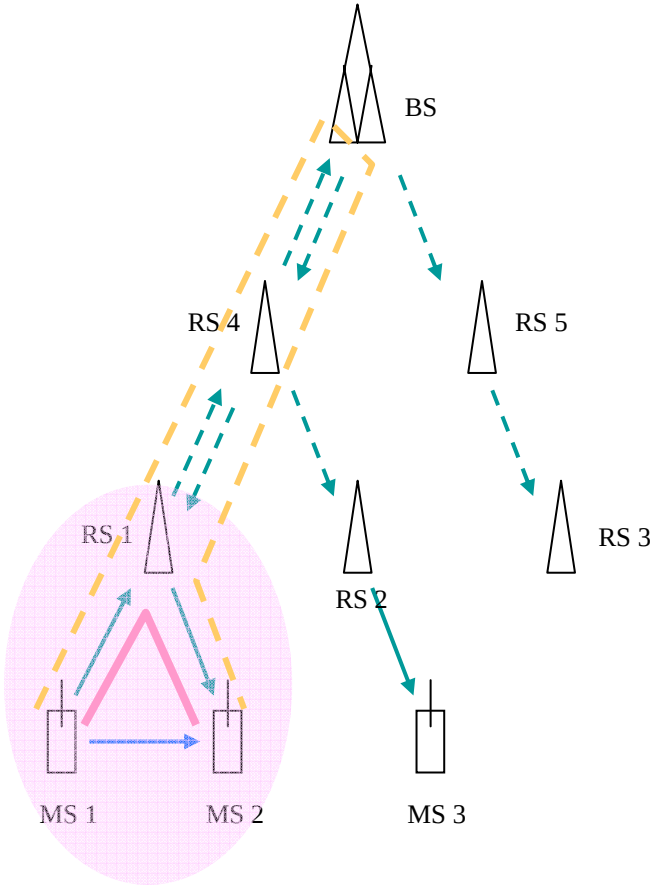
- Mesh topology
  - Example: *ad hoc* network
  - Pros: throughput-efficient (but not always)
  - Cons: hard to handle/control; hard to achieve or approach the know performance bound



Now, what is proposed…

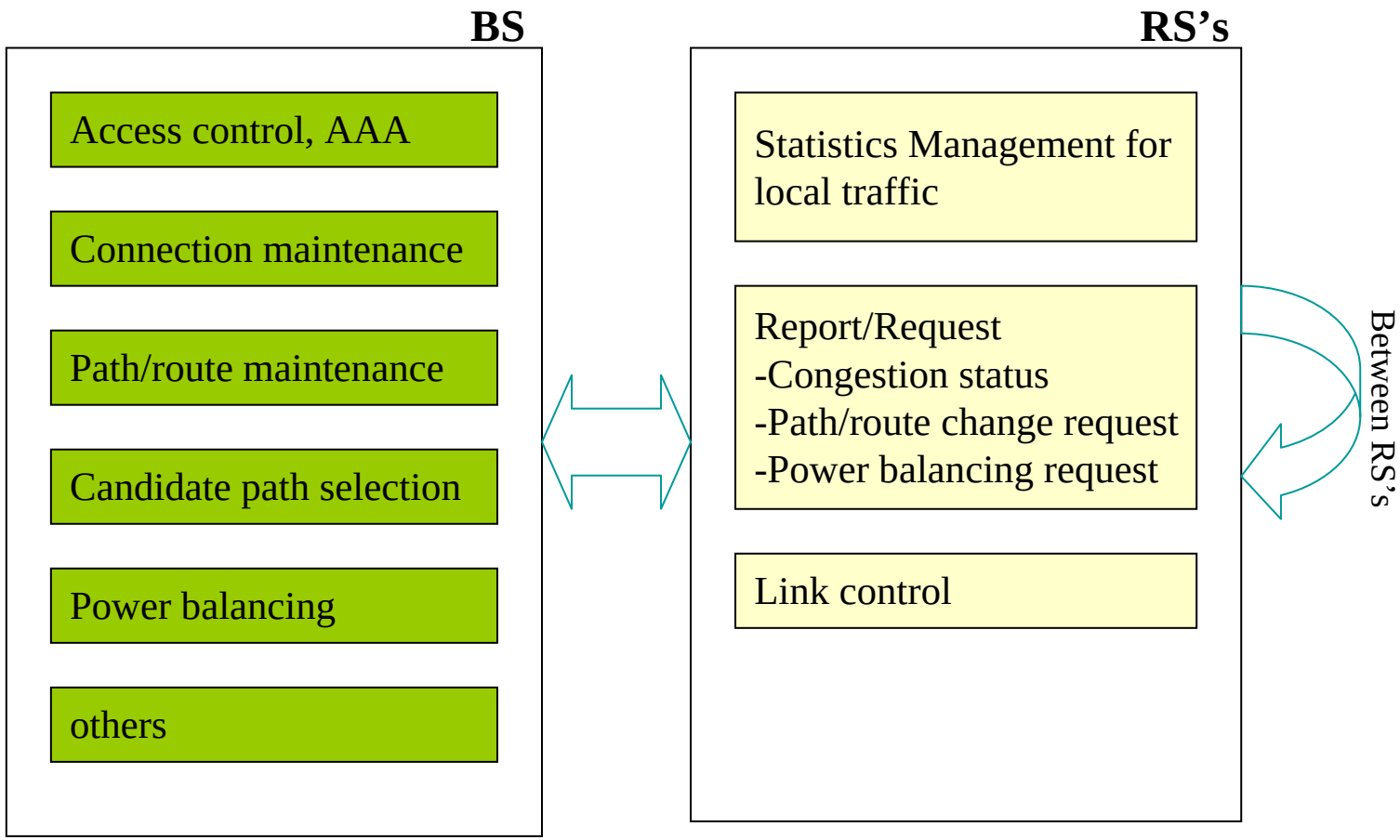
BS Coordinated Mesh Networking (1)

- Partitioning information
  - BS controlled (PMP networking)
    - Primary control information
      - Connection setup: AAA
      - Connection maintenance
  - BS non-controlled (Mesh networking)
    - Secondary control information
      - Link control
    - Traffic



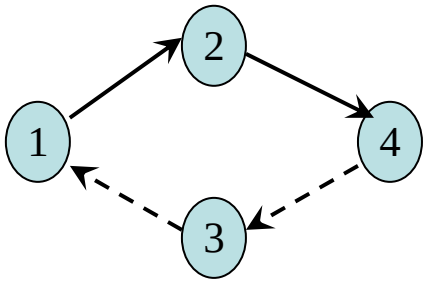
Functional Division and Collaboration

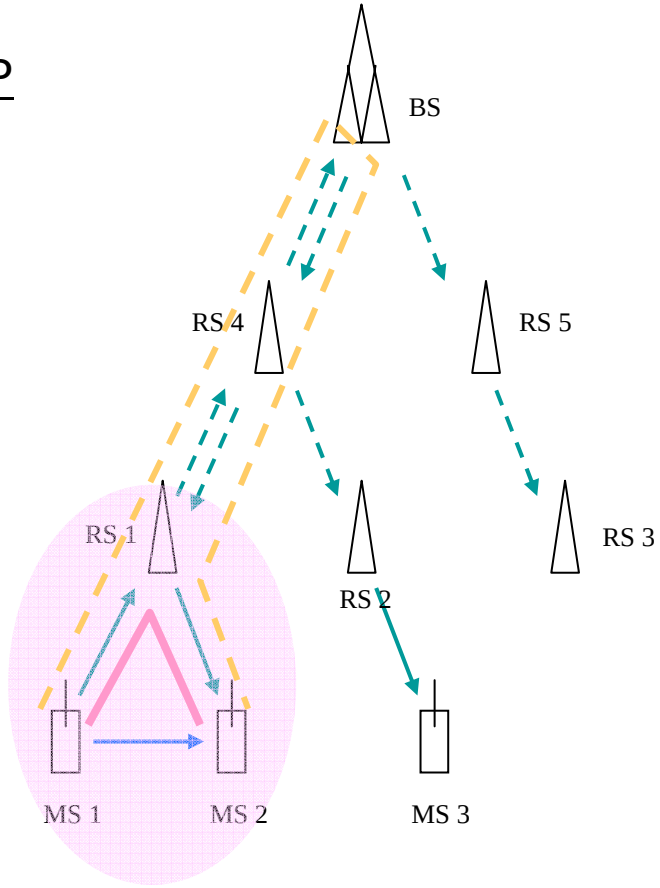
- Computing/Making Decision/Signaling for



Flow Division

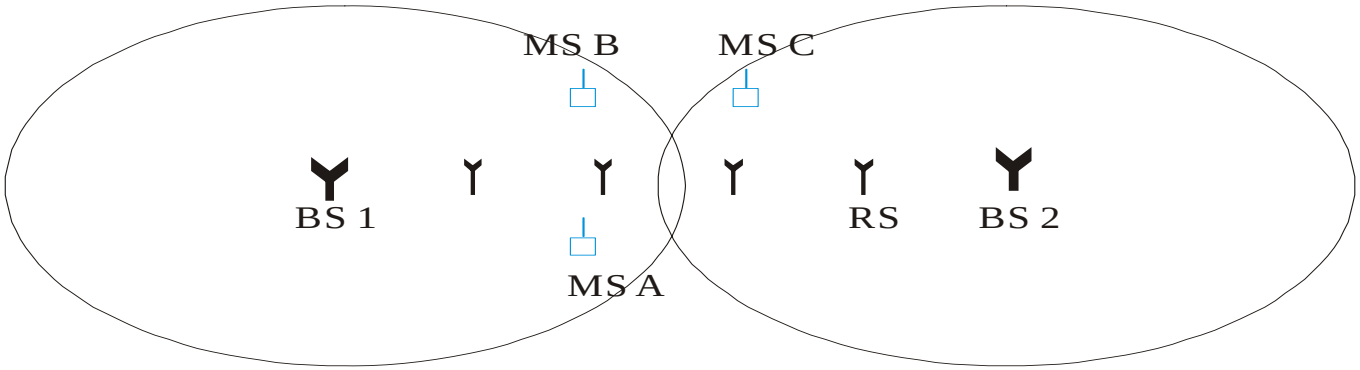
- Flow of Control Traffic
  - Primary (MS-RS, RS-RS, RS-BS) via PMP
  - Secondary (MS-RS, RS-RS)
- Flow of Data Traffic via Mesh
  - “Mesh” link formed
    - E2E Delay-wise shortest
    - Throughput-wise shortest
  - Forward path != backward path, wherever available





BS Coordinated Mesh Networking (2/5)

- Proposed Scope of CMN
  - Connection coverage
    - Within a cell (MS A and MS B)
    - Between adjacent cells (MS A and MS C; MS B and MS C)
  - One BS or multiple BS's make decision whether to open HMN connection or not
  - Routing map (or table) is handled by BS
    - BS handled routing map/table: a lookup table for the destination BS to check if the source RS and the destination RS are within CMN scope

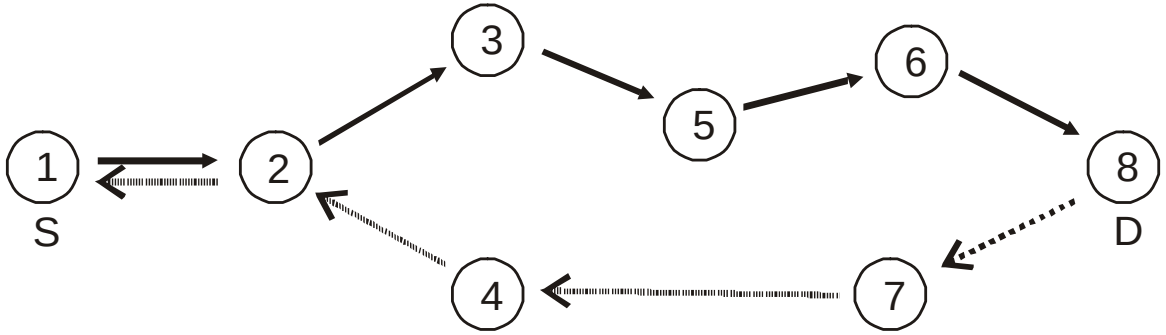


Procedure of BSCMN (1/3)

- (paging successfully done)
- Source MS → home RS → home BS → (backhaul) → destination MS
- Destination BS checks if the pair of MS's are eligible for CMN
  - And gives the result back to the home BS
- If CMN eligible,
  - Home BS ordered the home RS to do CMN
  - Destination BS ordered the destination RS to get ready for CMN

Procedure of BSCMN (2/3)

- If CMN eligible (cont.),
  - Home RS sends (using routing table/map)
    - BS-controlled information to BS (as PMP mode)
    - BS non-controlled information (incl. traffic) to the next RS or next node (as Mesh mode)
  - Destination RS can either copy the forward route from home RS or set up a different backward route using its own routing table/map
    - Depending on the traffic congestion on a certain node in the path(s)

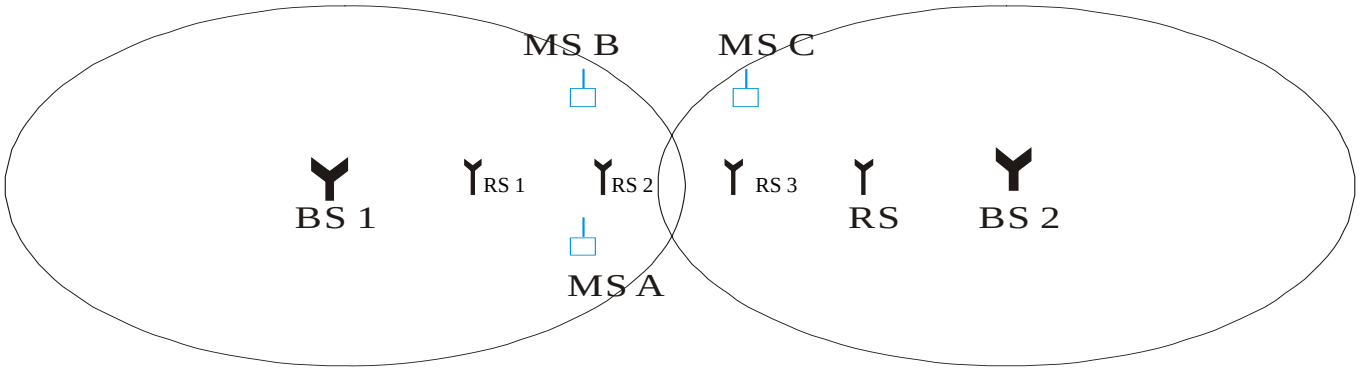


Procedure of BSCMN (3/3)

- If CMN eligible (cont.),
  - Radio Link Control: Each RS in the Mesh path can do its own link control
  - If MS location changes or if handover is needed,
    - The associated RS
      - (1) Reports to the BS and BS allocates a new RS to the MS
      - (2) Requests handover to the new RS

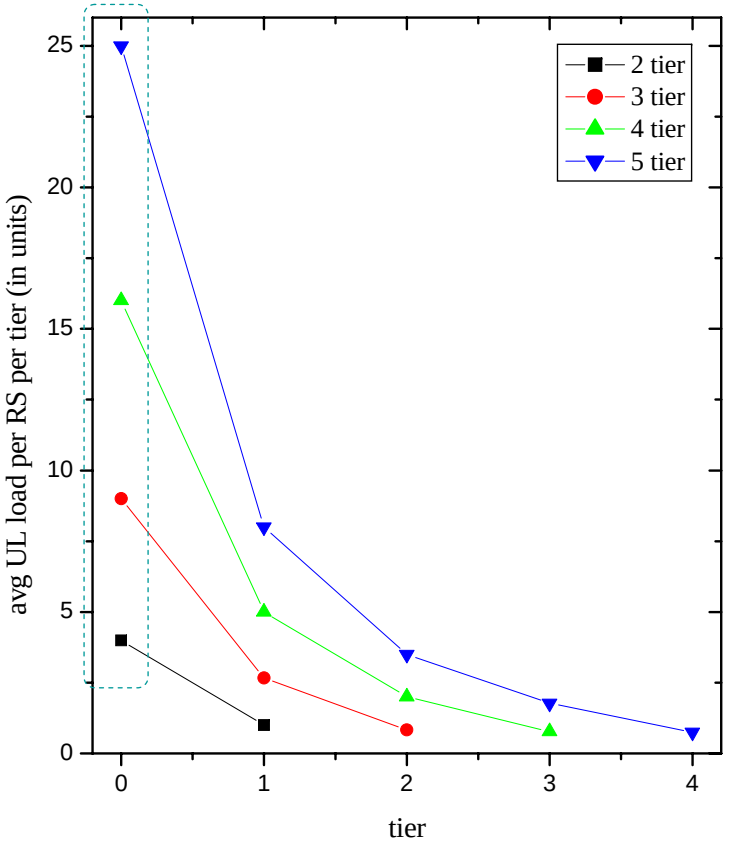
Handover in BSCMN with a Single RS

- Handover can be handled by RS with result report to RS (if no approval is needed in advance)
- Handover can be handled by BS with report from RS
- Within the same cell:
  - If MS A, which wants to talk to MS B, is connected to RS 2 and if RS moves to MS C point, then MS B (in a new location of MS C's) and MS A can be switched to RS 3, if needed and feasible
- Between two or more neighboring cells
  - If MS A, which wants to talk to MS B, is connected to RS 3, then RS 3 can be connected to RS 2, if feasible



Performance Review

- In multihop environments, the probability that an MS can use BSCMN is large; this prob increases as # hops increases
  - Since the area ratio of 0th tier relative to the whole cell is very small, it is very likely that a large number of MS's can experience the BSCMN
- E2E throughput increase: Since the throughput bottleneck usually happens in the 1st link from BS, if 10% of MS's uses BSCMN, it results in 10% potential increase in E2E throughput
  - In 16m FS, the 1st link can hardly be assigned more than two subframe
- E2E delay is reduced: by number of hops or by throughput increase in turn



Possible Improvements

- Reduction in control traffic due to reduction of avg # links/hops
- Alleviate the heavy load in the center tier(s)
- E2E throughput (resource utilization): possible reduction in number of hops
- E2E delay: result from reduced number of hops and from improved utilization and the alleviated burden on the 1st hop link (from BS)
- Handover dropping (connection level)
  - The same (under normal traffic load conditions)
  - Can be improved (under heavy traffic load conditions)
- Easy to control the mesh network in comparison to (full) mesh networking
- Easy to handle the UL/DL traffic asymmetry

$$\eta = \lim_{V_{relay}\to\infty} \frac{V_{receiveDown} + V_{relay}}{V_{receiveUp} + V_{relay}} = 1$$

$$\eta = \lim_{V_{relay}\to\infty} \frac{V_{receiveDown} + V_{relay} \cdot f_{selfish}}{V_{sendUp} + V_{relay} \cdot f_{selfish}} = \begin{cases} \frac{V_{receiveDown}}{V_{sendUp}} (>1), & f_{selfish} = 0 \\ 1, & f_{selfish} \neq 0 \end{cases}$$

Proposed Text

- Data traffic going up to BS and coming back through the same path in part should have a reduced path.
- [Note]
  - This mesh networking architecture does not violate the current scope of 16jm so far.