Proposal for IEEE 802.16m Support for Multi-hop Relay

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Re: IEEE 802.16m-08/040 – Call for Comments and Contributions on Project 802.16m System Description Document (SDD), on the topic TGm SDD: Relay

Purpose: Adopt the proposal into the IEEE 802.16m System Description Document

Introduction

- This contribution proposes the support of multi-hop relay as required in the TGm SRD.
- This contribution proposes the following aspects of multi-hop relay support:
  1. Relaying model
  2. Scheduling model
  3. Control and data plane functions

Relaying Models

- We consider that 16j usage models are quite thorough and useful as it is now. It is proposed that they need to be fully supported in 16m as summarized in the next chart.
- The following additional usage scenarios are proposed since the existing 16j models do not cover these scenarios which are useful for efficient communication, improved reliability, simplicity, and/or enhanced performance.
  - Local data forwarding for calls within a node and its subordinate nodes
  - Relay groups providing coverage to specific areas in cooperative manner
  - Relays connected to multiple super-ordinate BSs
  - Out-of-band relay, where relay links and access links may use different non-interfering carriers for transmission
  - Relays either transmitting or receiving from both super-ordinate and subordinate stations in the same time

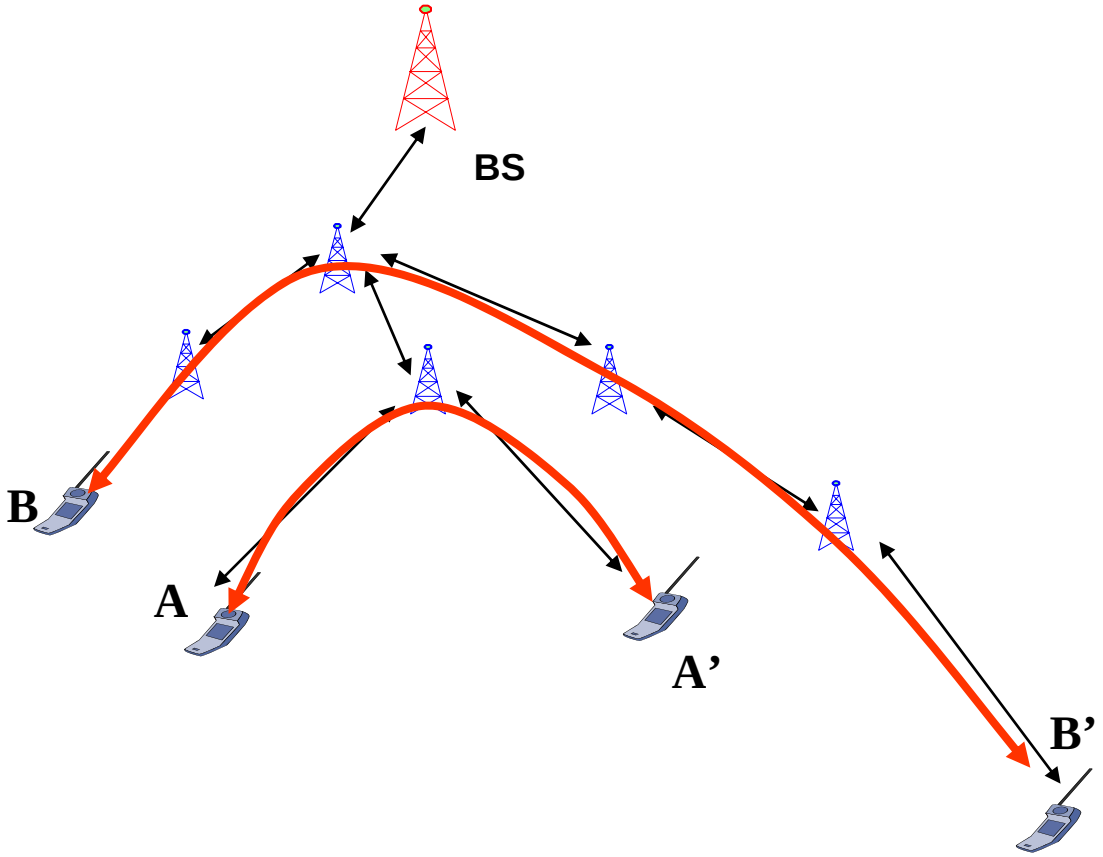
Local Forwarding

Two scenarios:

- An access RS node facilitates the communication between two MSs connected to it (e.g. AA')
- Any RS facilitates the communication among the MSs belong to any of the subordinate RSs in any of its branches

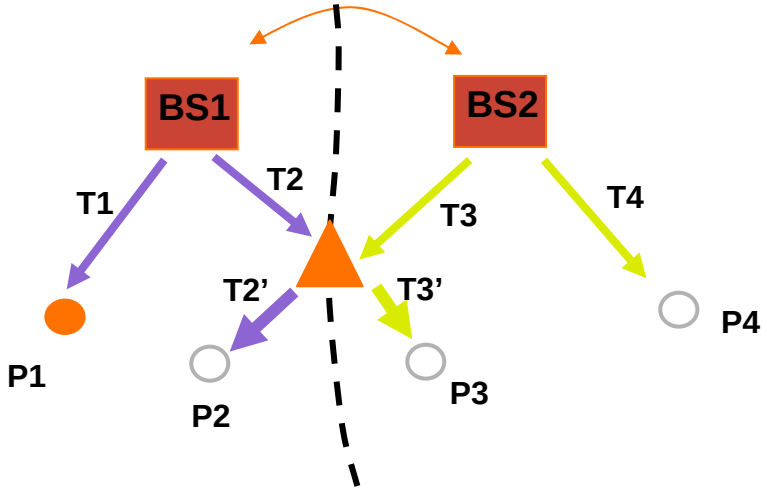
(data path connection without the involvement of the superordinate station or MR-BS).

- **Control messages and authentication can be done with the involvement of BS.**
- **In the case of a failure of the network or BS connection, RS may decide to facilitate local communication.**



Relay Connected to 2 Super-ordinate stations

- RS can forward data from (to) two base stations (i.e. shared RS) to (from) mobiles.
- Cell overlapping relays can be deployed so that the cell boundaries are effectively covered. Particularly simple solution for the inter-sector boundaries.
- In the case of one link fails, the other link can be active providing a highly reliable backhall for the RS.

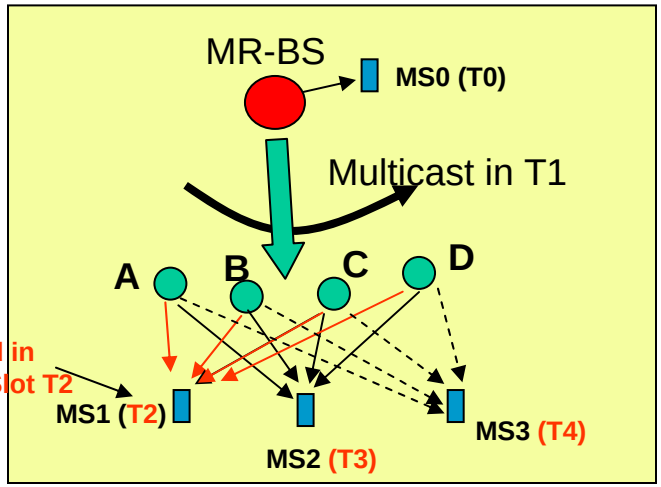


- Load balancing among BSs
- Effective cell edge coverage
- Higher reliability for relay link which is a necessity to have reliable multi-hop relay systems (since relay link is common to multiple MSs it needs to be reliable).

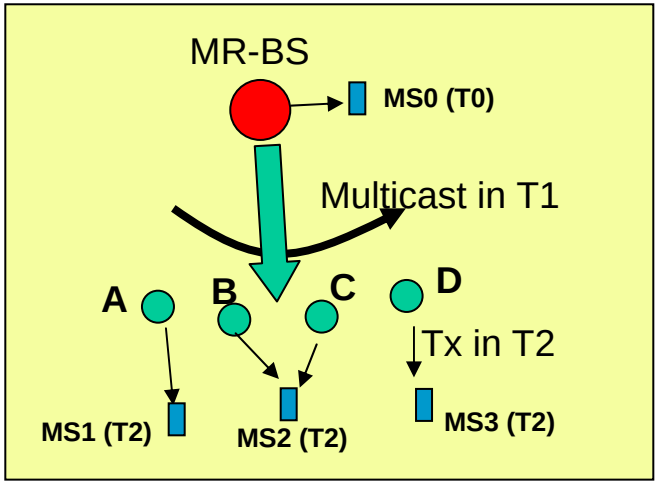
A Group of RSs to provide reliable coverage(1)

RSs cooperate to transmit to certain MSs which do not have sufficient signal quality. Two potential ways: Static and Dynamic

- **Static RS group:** All the RSs transmit same data to a given mobile (connected to the RS group), irrespective of wherever the mobile is located (i.e. All the RSs in the group cooperate all the time). This is the same for all the MSs, i.e. the relationship among RSs in the group is fixed)
- **Dynamic RS group:** The RSs cooperate dynamically on a per MS basis. MSs at overlapping areas may be served using multiple RSs in cooperation while MSs close to the RSs may be served exploiting spatial multiplexing providing extra capacity.



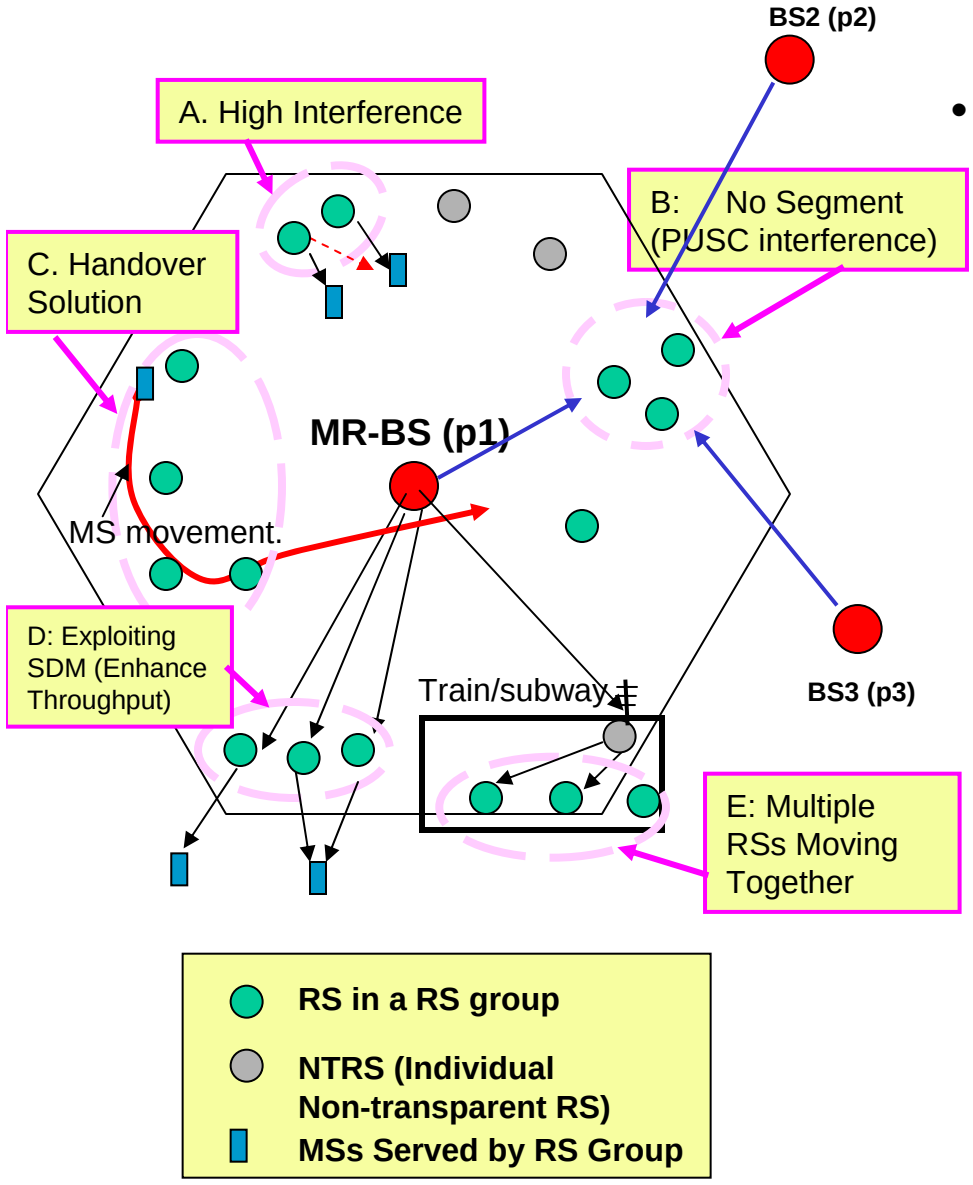
T0, T1, T2, T3 are the time/frequency unit the data is sent



STATIC RS GROUP: Limited application, provide only a few of the benefits mentioned previously. Very inefficient when RSs are located some what apart.

DYNAMIC RS GROUP: Depending on the mobile location/interference, flexibly exploit spatial multiplexing

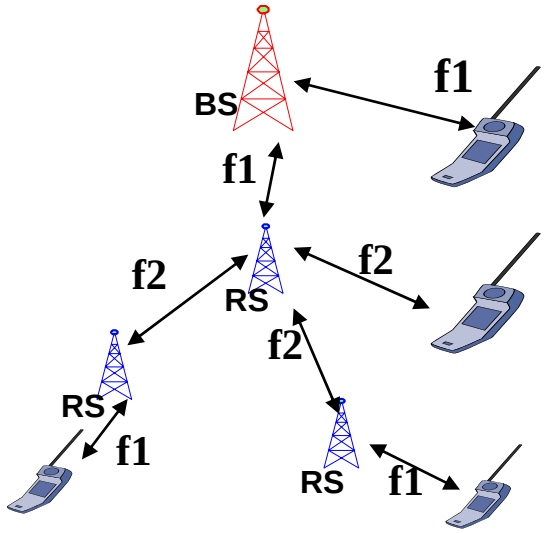
A Group of RSs to provide reliable coverage



- **RS group may be formed to obtain one or more of the following example benefits**
  - A. When there is high interference between RSs communications, e.g. closely located RSs under random deployment
  - B. When an RS is enabled at a location where segment allocation is not possible due to FCH/MAP interference
  - C. MS can move seamlessly across RS coverage areas while exploiting both macro-diversity and spatial diversity (Non-transparent RSs act as a BS to MS: # of handovers will be large)
  - D. To obtain cooperative diversity while keeping the capability of spatial diversity
  - E. Several RSs are moving together (e.g. in a train, one or more NTRSs can act as a parent while others form a group)

Out-of-band Relay

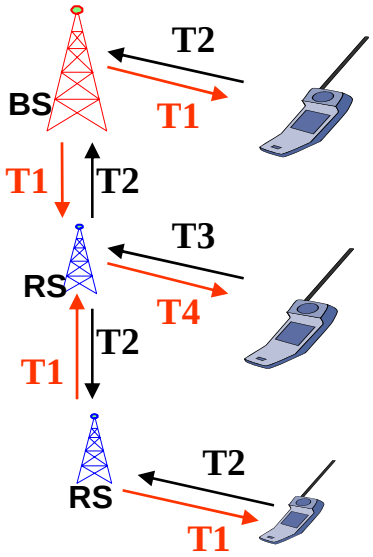
- **When multiple carriers are available, an RS has several options: Examples (1): use one carrier for the RS-BS or RS-RS communication and a different carrier for the RS to MS communication; (2) super-ordinate station links operate at one carrier and the communications to subordinate stations using a different carrier. This reduces the interference and increases scheduling freedom.**
- **Single or Dual Radio RSs may be used which may allow the efficient use of spectrum. Several methods of deployment.**



RSs using different carriers in relay and access links

RSs transmitting to super-ordinate station and subordinate station in the same time

- **An RS sends data to both super-ordinate station and the subordinate station (if RS) at the same time. A global zone may be defined in the frame structure.**
- **This removes the hard restriction of parent-to-child transmission in the DL portion of a radio frame and child-to-parent transmission in the UL portion of a radio frame as in 802.16j. Thus the overall hop-to-hop relaying latency can be reduced to within a radio frame. Also, the overall round-trip control latency can be reduced.**
- **In addition, simultaneous transmission/reception to/from parent node and child node allows for a more flexible, granular and efficient resource multiplexing between parent and child nodes.**
- **MS communications may be included if the zones are appropriately designed (i.e. not restricting to MS tranmitting in the UL subframe and MS receiving in the DL subframe in 802.16j).**
- **Flexible UL/DL load balancing**



RSs transmitting (receiving) to both superordinate station and subordinate station in the same time

Proposed Usage and Relaying Models

Model	Use Case Examples	Objectives
A. Fixed Infrastructure (16j)	**(1) Cell Edge,** **(2) Coverage Holes (shadowing from trees, buildings, valleys), and;** **(3) Outside cell area**	Fixed relays to enhance Coverage, Capacity, Range
B. In-building Coverage (16j)	Inside buildings, tunnels and underground premises	Fixed relays to enhance Coverage, Capacity
C. Temporary coverage (16j)	(1) Emergency/disaster situations (2) Special events	Nomadic relays to enhance coverage, capacity, range
D. Coverage in mobile vehicles (16j)	Inside buses/taxis inside trains, inside ferries	Mobile relays to increase coverage capacity and range
E. Local data forwarding	Self-explanatory from first column.	Improved efficiency for local calls and disaster/emergency situations
F. Group of RSs cooperate for communication	(1) RSs closely located; (2) RSs having inter-segment interference; (3) RSs moving together;	(4) cooperate diversity and SDM for enhanced coverage and capacity; (5) reduced handover
G. RSs serving two BSs	Cell edge coverage;	Increased coverage at cell edge; reliability for relay links
H. Out of band Relay	When multiple carriers are available	Efficient use of multiple carriers for multi-hop
I. RSs simultaneously tx/rx from/to its super-ordinate and subordinate stations	Explicitly described in the first column.	Load balancing, reduced hop-to-hop latency, simplicity and efficiency

Scheduling

- Access zone and relay zone allocation or frequency partitioning are centrally controlled by the MR-BS in a semi-static fashion.
- Dynamic distributed scheduling is supported for the case of non RS grouping
- For RS grouping, dynamic centralized scheduling is performed by the parent RS

Proposed SDD Text (1)

Insert the following text as indicated below.

15 Support for multi-hop relay

15.1 Relaying Models

15.1. 1 Relay Operation Models

The following relay operation models can be supported based on the RS capability:

- *Different hops can operate on different carriers or the same carrier*
- *Relays can receive from the super-ordinate station and transmit to the subordinate station (and vice versa) at the same time or the transmission/reception should be time separated*
- *FDD or TDD operation*
- *Unidirectional or bi-directional transmit/receive on the relay link*

Proposed SDD Text (2)

15.1.2 Relaying Operation Modes

15.1.2.2 Non-transparent Relay Mode

A relay that transmits its own SFH, BCH and USCCH

15.1.2 Transparent Relaying Mode

A relay that does not transmit a SCH, BCH and USCCH.

15.1.3 Non-Transparent RS group mode of operation

A relaying mechanism where a group of non-transparent relays appear as s single base station to an MS by transmitting the same SCH, BCH, USCCH and share the same BSID. These group of relays have a single parent station and may share the BSID of its parent.

15.1.4 A Transparent RS group mode of operation

. A relaying mechanism where a group of transparent relays work with a superordinate station (a non-transparent RS or MR-BS) to appear as s single base station to MSs by forwarding data and messages from the parent station to the MSs (and vice versa)..

15.2 Local Forwarding Mode

- *In local forwarding mode, MSs directly attached to one RS communicate with each other while the data is forwarded only by the RS. The BS supporting multi hop relay schedules the resource for the RS when centralized scheduling is adopted. While in distributed scheduling, the RS may schedule for local forwarding all by itself.*
- *The MAC addressing of the MAC PDU in local forwarding mode is FFS.*

Proposed SDD Text (3)

15.2 Scheduling modes

Access zone and relay zone allocation or frequency partitioning are centrally controlled by the MR-BS in a semi-static fashion. Dynamic distributed scheduling is supported for the case of non RS grouping. For RS grouping, dynamic centralized scheduling is performed by the parent RS.

Each RS performing the scheduling determines the resource allocation to its MS or sub-ordinate station and transmit the corresponding USCCH information.

Proposed Text Changes (3)

15.3 Control and Data Plane functions

15.3.1 CID Management

15.3.2 Connection and Service Flow Management

15.3.3 Data forwarding methods

15.3.4 R-amble/Preamble transmission and measurement schemes

15.3.5 Security Model