Relay Station Modes - design objectives of relaying frame structure

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Purpose:

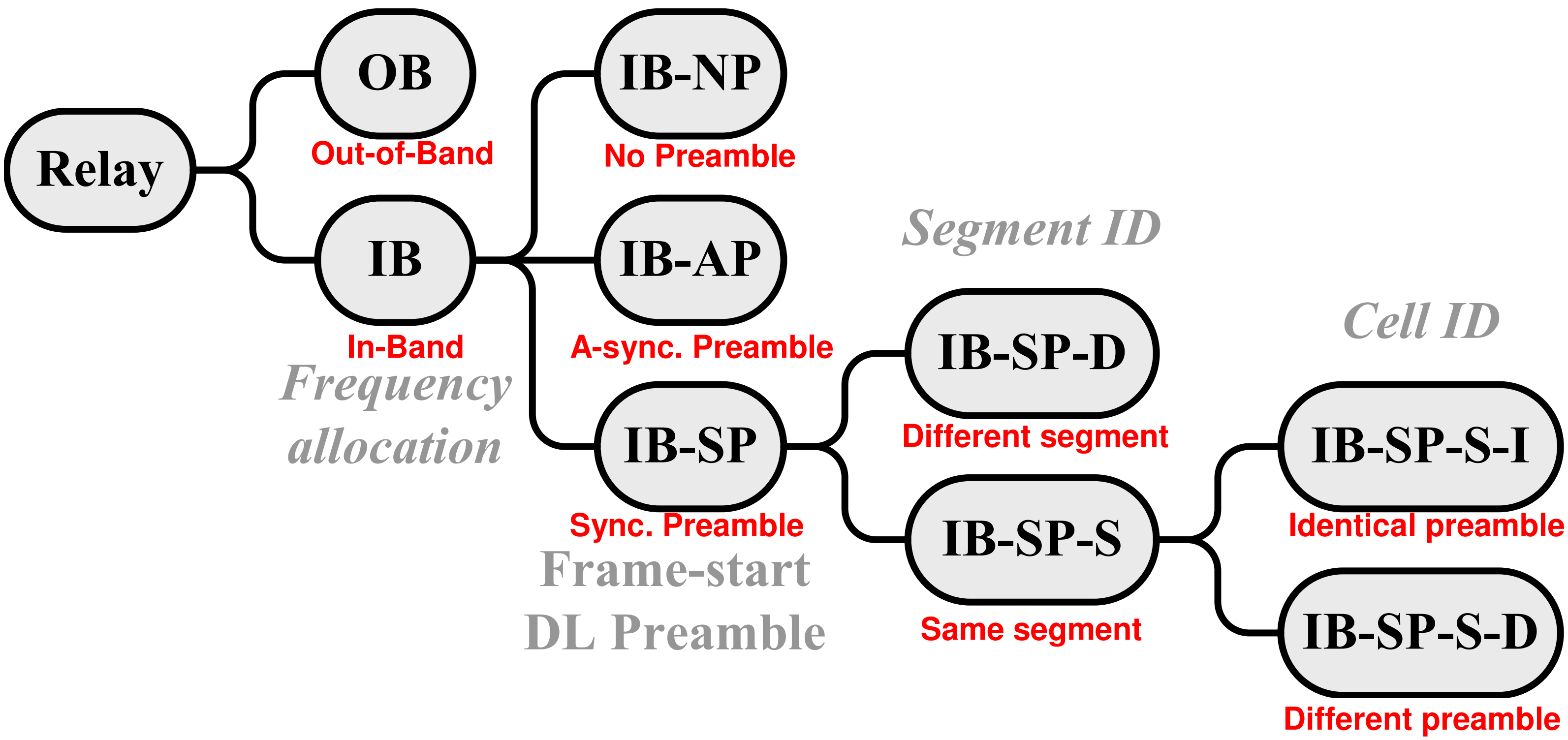
This contribution is to provide a analysis framework for designing relaying frame structure.

Why RS Modes?

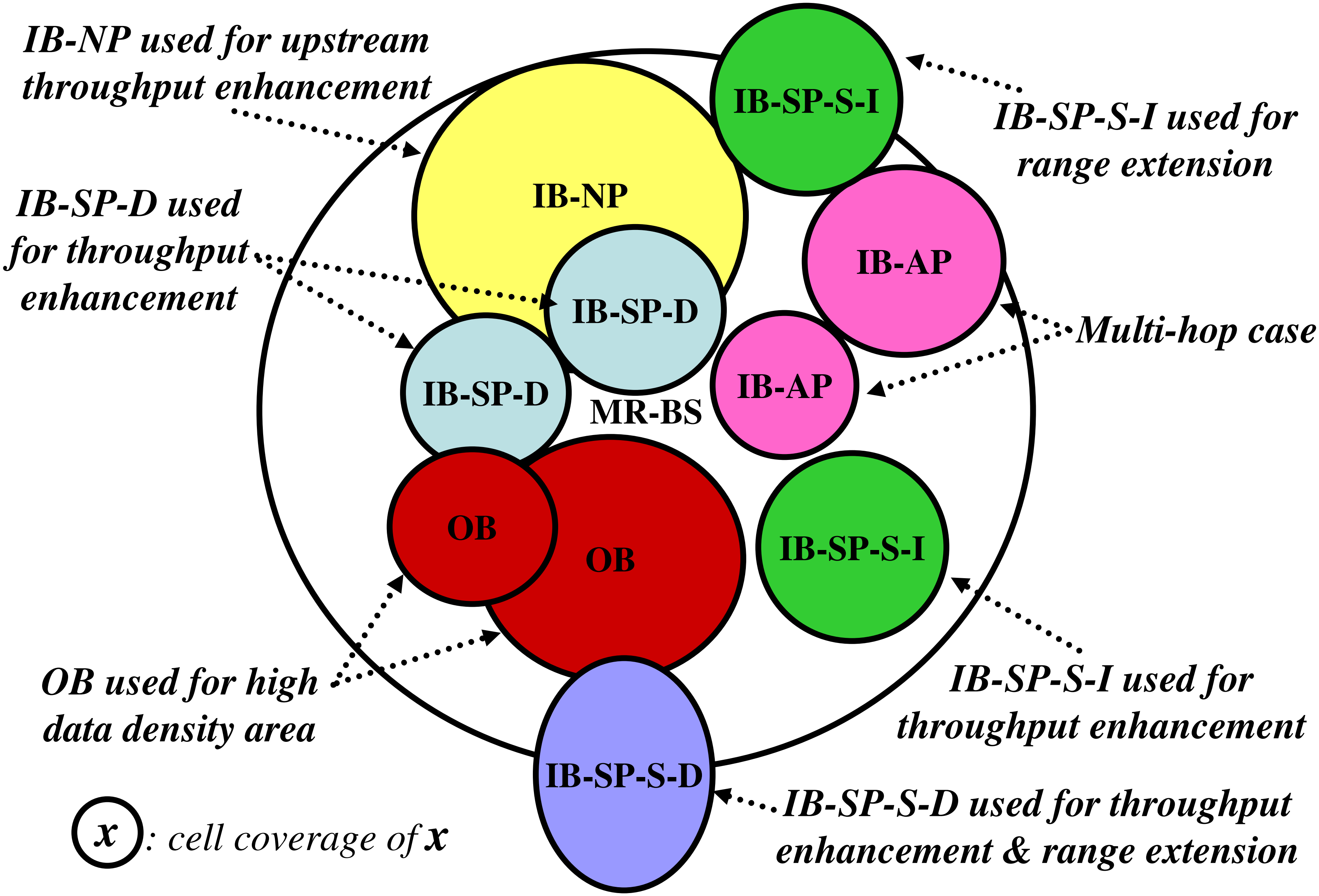
- In order to provide coverage extension and/or throughout enhancement in a Multihop Relay system under limited radio resources, the deployment of the MR-BS and RS should be flexible enough to accommodate several modes of RSs co-exist in a Multihop Relay system.
- An RS could adaptively change its mode depending on the operation environment especially in mobility.

Relay Station Modes

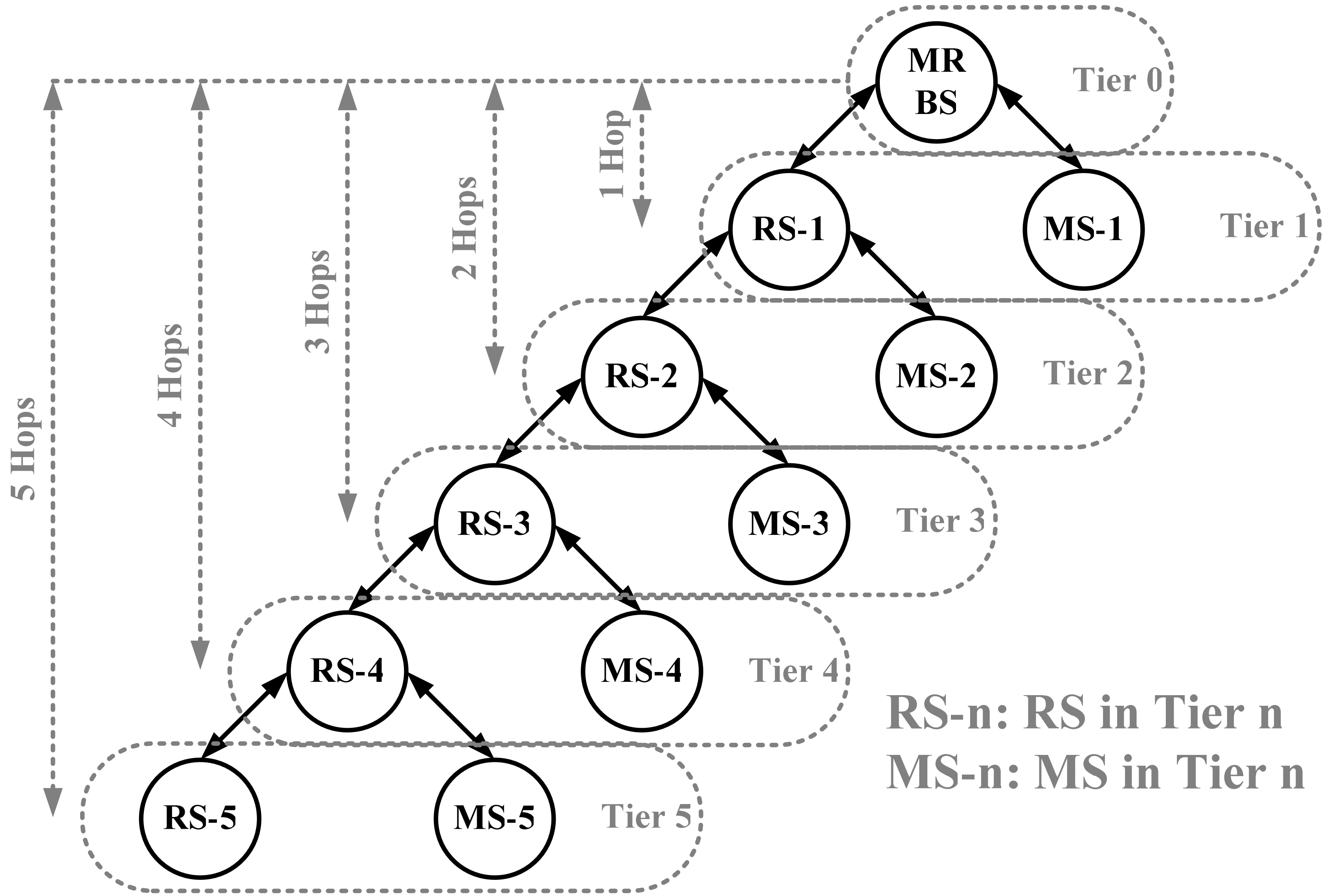
- RS Modes are categorized by the frequency allocation, frame-start DL preamble, segment ID, and cell ID
- Because segment ID and cell ID have to be derived from the frame-start DL preamble, each RS mode is mainly characterized based on the frequency and frame-start DL preamble.



Deployment Example of RS Modes



802.16j Network Topology
(Simple Scenario: each RS only in one tier)

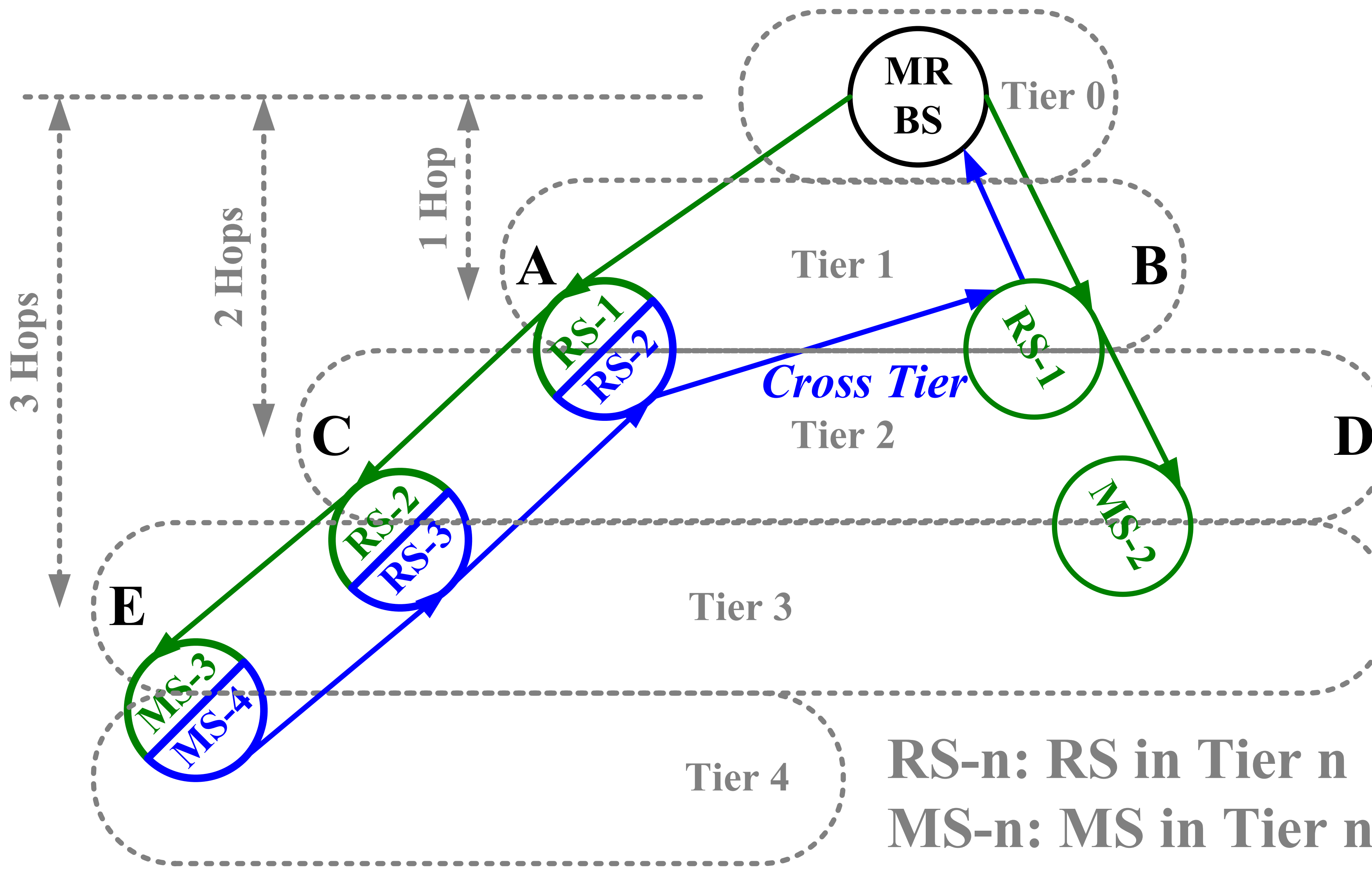


RS-n: RS in Tier n

MS-n: MS in Tier n

802.16j Network Topology

(Complex Scenario: one RS in more than one tiers)



Key Points

1. Various modes of RSs could co-exist in an Multihop Relay system.
2. Design objectives of relaying frame structure
   a) should accommodate different modes of RS
   b) should support Mobile RS
   c) should be flexible to support RS of more than 2-hop
   d) should support scenarios of complex topology
   e) should minimize transmission overheads and relaying path delay based on implementation considerations
   f) should maximize concurrent transmissions among MR-BS, RS and MS

Backup

Relay Station Modes (cont.)

- ***OB RS*** operating at different frequency from the serving MR-BS and shall transmit a frame-start DL preamble independently of the MR-BS.
- ***IB-NP RS*** does not transmit any frame-start DL preamble. It could be used when all MSs in the RS cell can successfully decode the FCH sent by the serving MR-BS (Ex: relaying the upstream traffic to MR-BS only)
- ***IB-AP RS*** transmits a frame-start DL preamble at separated OFDMA symbols from those used by the serving MR-BS. RS introduces extra overheads such as preamble, FCH, etc., in each hopping level and, hence, it requires a larger frame duration to accommodate the overheads, which could limit the MS and RS mobility.
- ***IB-SP-D RS*** transmits a frame-start DL preamble on same OFDMA symbols that are the same as those used by the serving MR-BS. The frame-start DL preambles sent by the RS and MR-BS are with different segment ID.

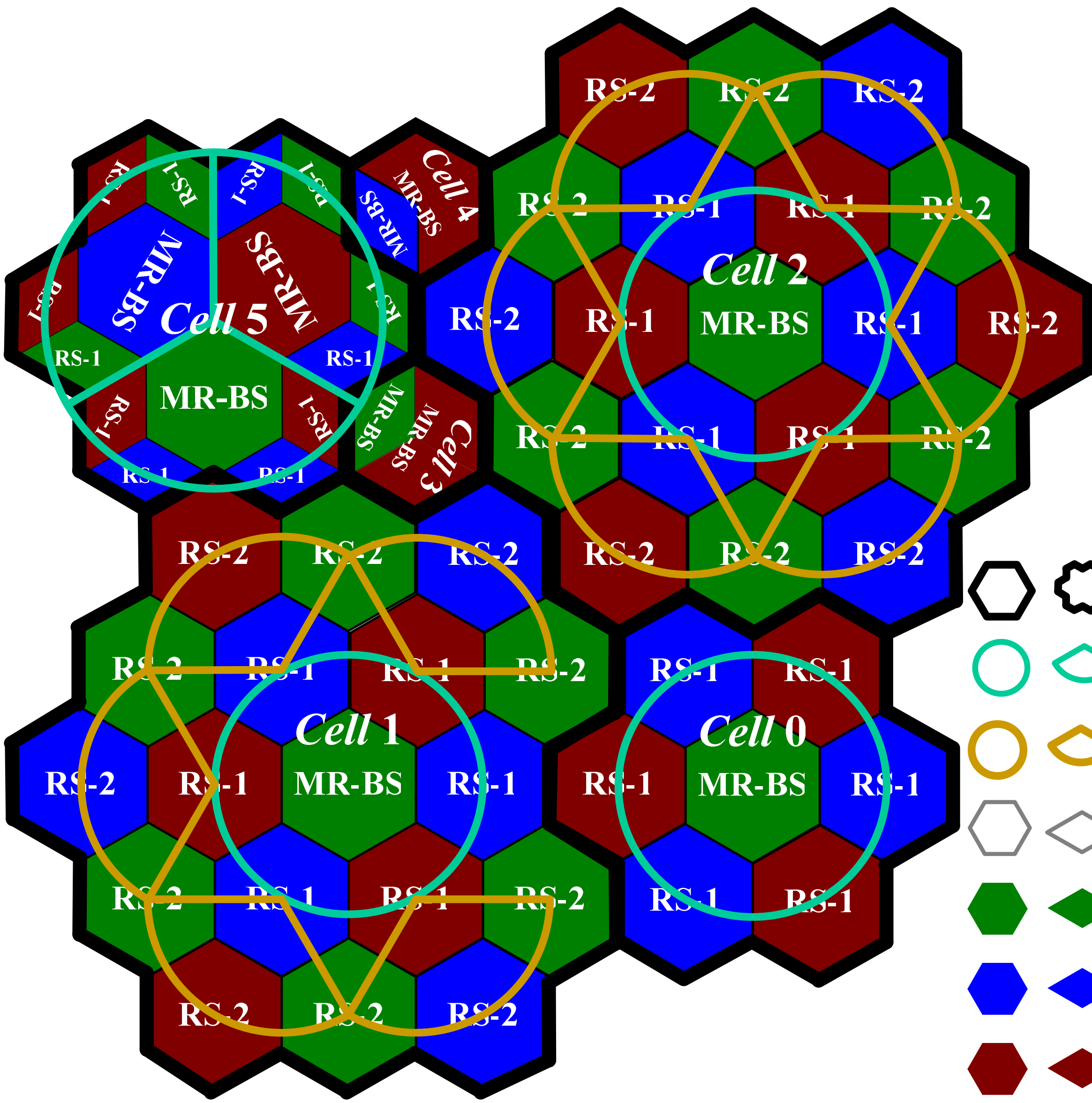
Relay Station Modes (cont.)

- ***IB-SP-S-I RS*** transmits a frame-start DL preamble using the same OFDMA symbols as the serving MR-BS. The frame-start DL preamble sent by RS is identical to the one sent by the serving MR-BS. In case that an MS receives signals from the serving MR-BS and RS simultaneously, the two frame-start DL preambles and FCHs are treated as multipath signals.
- ***IB-SP-S-D RS*** transmits a frame start DL preamble using the same OFDMA symbols as the serving MR-BS. The frame-start DL preamble sent by RS is different from the one sent by the serving MR-BS but the two preambles are with same segment ID. In case that an MS receives the frame-start DL preambles and FCHs from the serving MR-BS and RS simultaneously, it must be mitigated as co-channel interference.

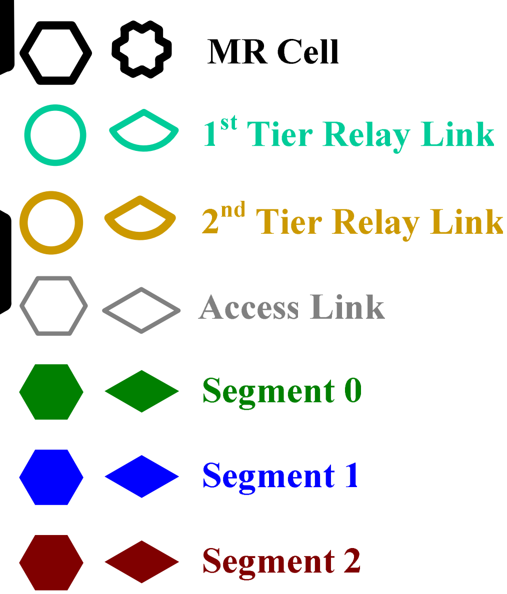
Relay Station Modes
(Comparison Table)

Mode	Tx Frame-start DL Preamble (Tx Timing relative to MR-BS)	Same Segment ID as MR-BS	Same Cell ID as MR-BS
OB	Yes (Don’t Care)	Possible	Possible
IB-NP	No (N/A)	N/A	N/A
IB-AP	Yes (Asynchronous)	Possible	Possible
IB-SP-D	Yes (Synchronous)	No	No
IB-SP-S-I	Yes (Synchronous)	Yes	Yes
IB-SP-S-D	Yes (Synchronous)	Yes	No

Deployment Example
Using Channel Segmentation for Multiple Tiers



different coverage area (i.e. different transmit power control) for relay-link and access-link shall be allowed



Different Coverage Area for Relay-link and Access-link

- By using distinct transmitting power (defined in IEEE 802.16e-2005) with receiving power control on access link and relay link, these two links can cover different area. Therefore, the frequency reuse scenarios for access-link and relay link could be differentiated.
- The co-channel interference for the access-link can be minimized by carefully plan the access-link coverage area with power control mechanism. Moreover, the performance of Multi-hop Relay system will not be sacrificed since the relay-link could allow to cover the its serving target by using power control mechanism.

Relay Usage Models

- **Pure Throughput Enhancement Usage Model**
  – MS inside an RS coverage can correctly decode the FCH sent from serving MR-BS

- **Pure Ranging Extension Usage Model**
  – MS inside an RS coverage cannot correctly decode the FCH sent from serving MR-BS

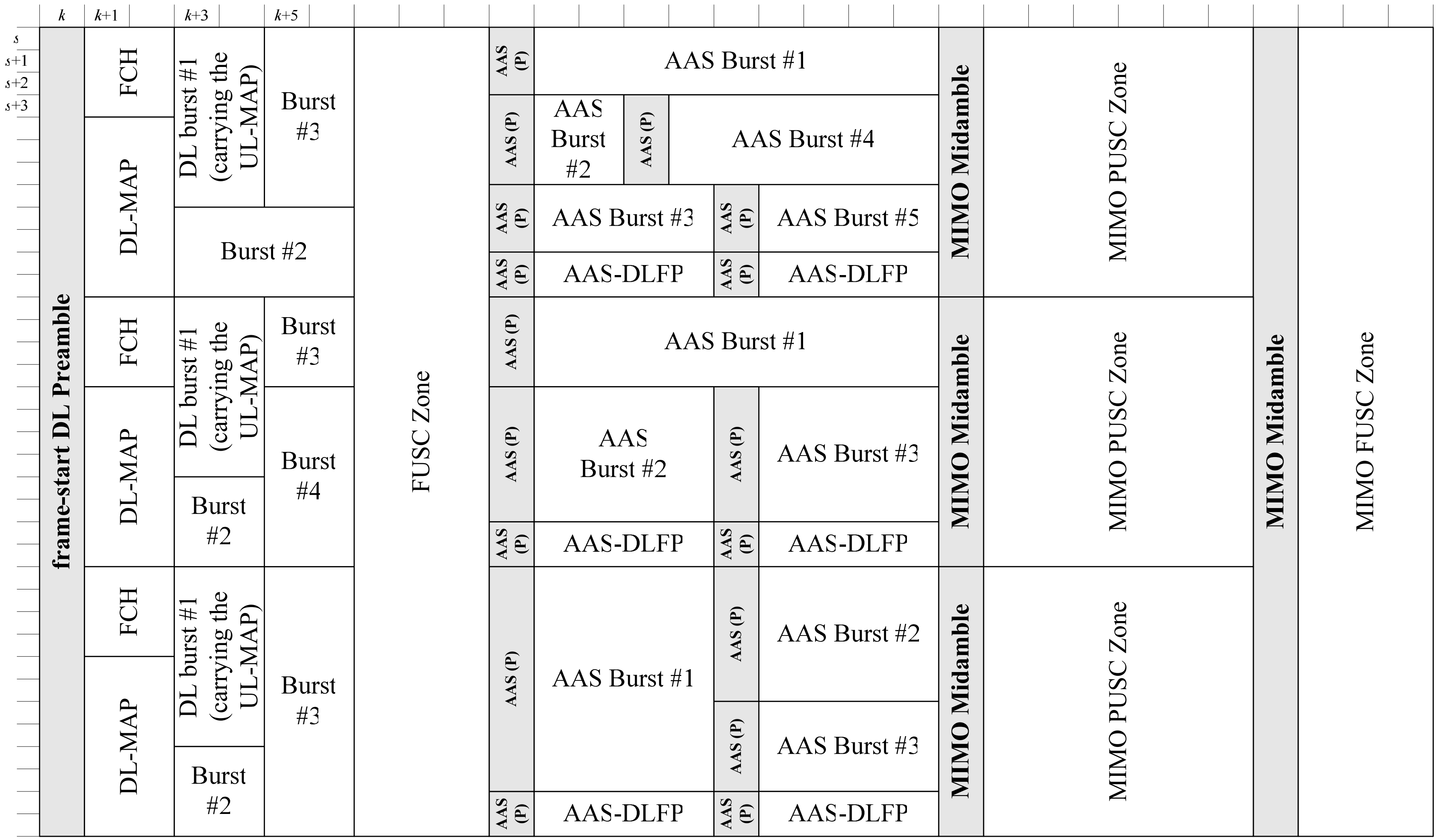
- **Mixed Operation Usage Model**
  – Some MSs inside an RS coverage can correctly decode FCH from serving MR-BS while others MSs cannot

Comparison of Different RS Modes

- ***OB***, ***IB-AP***, ***IB-SP-D***, ***IB-SP-S-I*** and ***IB-SP-S-D*** work in all usage models

- ***IB-NP*** works only when the MS inside the IB-NP RS coverage can correctly decode the FCH sent from serving MR-BS or another RS

Preamble Usage Definition



Frame-start DL Preamble is defined in page 552, 802.16-2004 and in page 513, 802.16e-2005
AAS Preamble is defined in 802.16e-2005 page 367
MIMO Midamble is defined in 802.16e-2005 page 599

MS Operational Effectiveness in Presence of RS

RS Category / Effectiveness to BS		IB-NP	IB-SP-S-I	IB-SP-S-D	OB/IB-AP /IB-SP-D
BS cell search & BS frame boundary detection @ MS		Same	Conditional*2	Conditional*3	Same
BS cell ID & BS segment identification @ MS		Same	Same	Same	Same
DL frequency/timing offset compensation @ MS		Same	Conditional*2	Conditional*3	Same
DL channel estimation @ MS	Only by pilots in its burst	Same	Same	Same	Same
	Also by preamble and/or pilots in other bursts	Possibly Negative*1	Possibly Negative*4	Possibly Negative*4	Same
Channel quality measurement @MS (CINR accuracy of BS preamble)		Same	Possibly Negative*2	Conditional*3	Same

Same: No change w.r.t. MS operational effectiveness
Conditional: Could be positive, same or negative depending on the operating environment, e.g., whether it is in range extension model or throughput enhancement model, whether the RS signal received by the MS is much stronger than the BS signal, whether the RNG-RSP (ranging response) message can be used effectively, etc
***1: depend on sources of bursts included in the channel estimation algorithm**
***2: MS may receive multi-path interference signals from BS & RS**
***3: MS may receive co-channel interference signals from BS & RS**
***4: due to channel estimation algorithm**

MS Operational Effectiveness in Presence of RS

Effectiveness to RS \ RS Category		IB-NP	IB-SP-S-I	IB-SP-S-D	OB/IB-AP /IB-SP-D
RS cell search & RS frame boundary detection @ MS		N/A	Conditional*2	Conditional*3	Same
RS cell ID & RS segment identification @ MS		N/A	N/A	Same	Same
DL frequency/timing offset compensation @ MS		Conditional*1	Conditional*2	Conditional*3	Same
DL channel estimation @ MS	Only by pilots in its burst	Same	Same	Same	Same
	Also by preamble and/or pilots in other bursts	Possibly Negative*4	Possibly Negative*4	Possibly Negative*4	Same
Channel quality measurement @MS (CINR accuracy of BS preamble)		N/A	Possibly Negative*2	Conditional*3	Same

Same: No change w.r.t. MS operational effectiveness
Conditional: Could be positive, same or negative depending on the operating environment, e.g., whether it is in range extension model or throughput enhancement model, whether the RS signal received by the MS is much stronger than the BS signal, whether the RNG-RSP (ranging response) message can be used effectively, etc
***1: time synchronization problem between BS & RS, Doppler shift**
***2: MS may receive multi-path interference signals from BS & RS**
***3: MS may receive co-channel interference signals from BS & RS**
***4: due to channel estimation algorithm**