Reliable Multicasting with Selective Acknowledgement for IEEE802.16j

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Purpose:

For discussion and approval of inclusion of the proposed text into the P802.16j baseline document.

Introduction

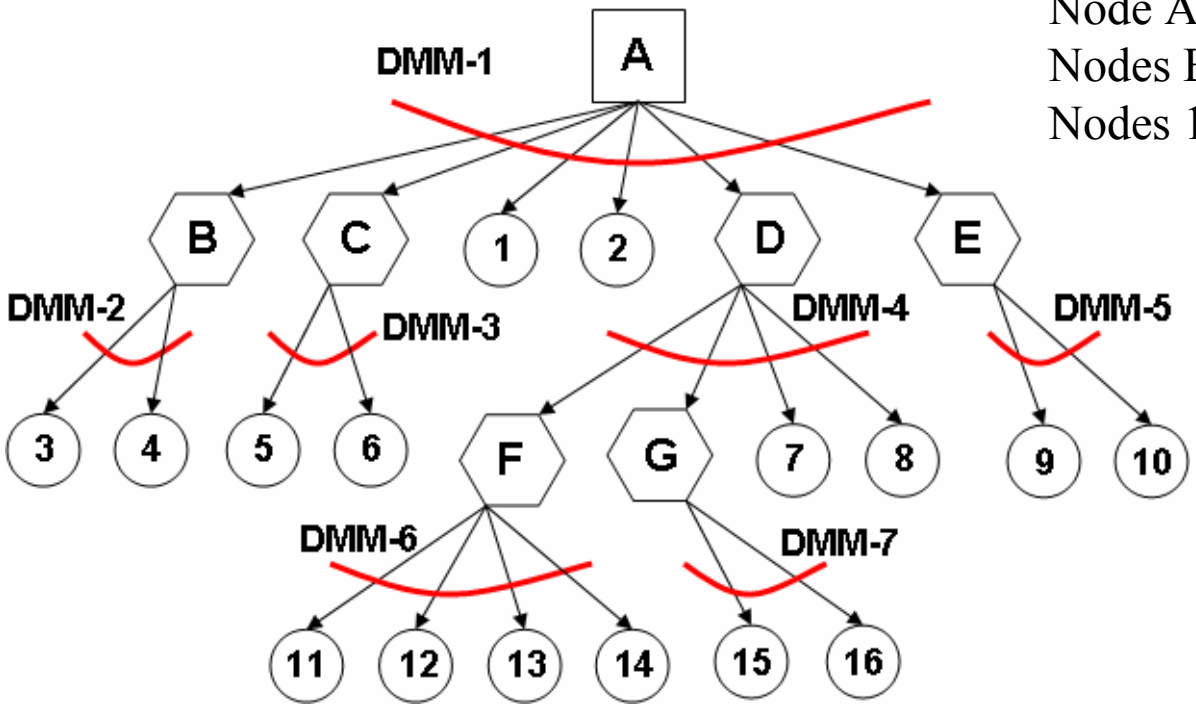
- ARQ is not applicable to multicast/broadcast connections in IEEE 802.16-2004 and IEEE 802.16e standards
- The relay-based IEEE 802.16j network topology has some unique aspects in which, by allowing ARQ for a subset of relay stations (RSs) may considerably improve the reliability of multicast transmissions
- The proposed contribution provides a reliable layer-2 multicasting for a subset of intended receivers in a selective fashion.

Purpose

- To improve the reliability of the information transmitted to the critical RSs by allowing ACK/NACK messages in the link layer multicasting in a selective fashion.
- To specify the required ARQ mechanism for implementing reliable multicasting.
- To provide an example mechanism for the selection of critical RSs for implementing reliable multicasting (implementation dependent).

Default Multicast Mode (DMM)

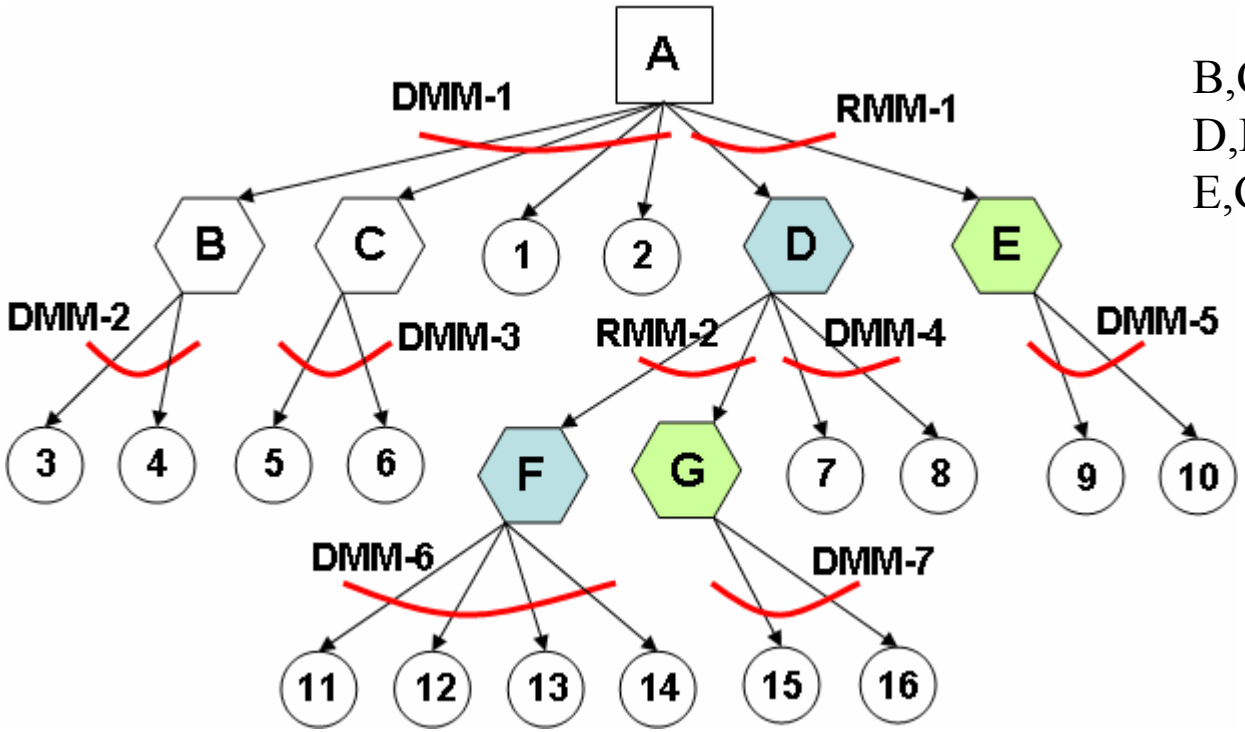
- No ACK/NACK messages are allowed
- Hence multicast transmissions are unreliable at the link layer level
- Unreliable transmission to critical RSs (e.g., RS D) may impact large number of SSs



Node A: MMR-BS
Nodes B,C,D,E,F,G: RSs
Nodes 1-16: MSs and SSs

Reliable Multicast Mode (RMM)

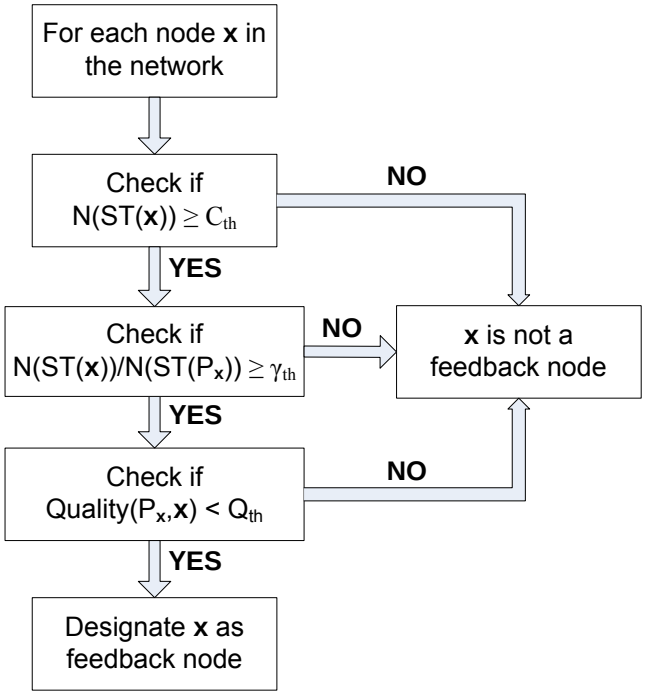
- ACK/NACK messages are allowed only for critical RSs (CRSs)
- A non-critical RS (NCSR) may also operate in RMM mode if it has support of RMM mode; but it sends no ACK/NACK messages



B,C: DMM-RS
D,F: RMM-CRS
E,G: RMM-NCRS

An Example Mechanism for the Selection of CRSs

- The critical RS(s) may be determined by the serving MMR-BS and how they are selected is implementation dependent.
- Service capacities, channel qualities, and the overall network topology may be used to determine if a RS is critical or not



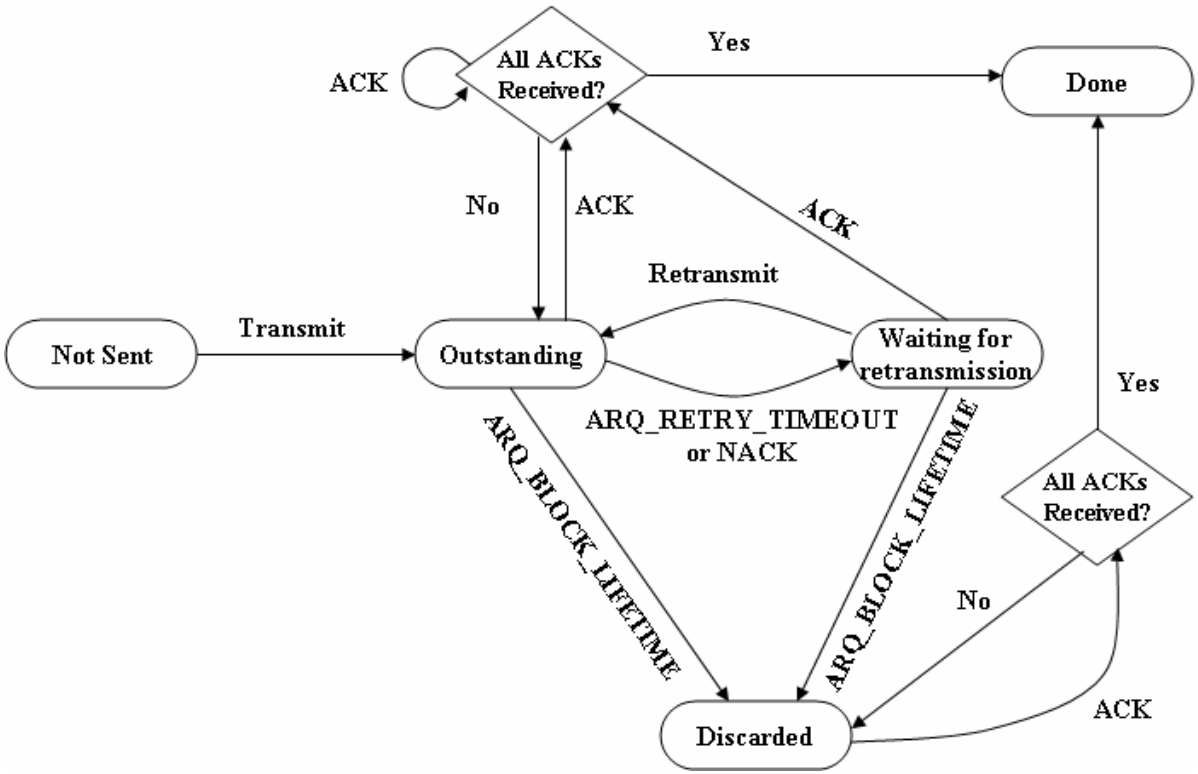
$N(ST(\mathbf{x}))$: number of client nodes under the sub-tree with root node **x**
$ST(\mathbf{x})$: sub-tree defined by the root node **x**
$P_{\mathbf{x}}$: parent node of node **x**
$Quality(y,x)$: channel quality from node y to node **x**
C_{th}: service capacity (i.e., number of clients that are served) threshold
Q_{th}: channel quality threshold

RMM-ARQ mechanism

- The RMM-ARQ can utilize the ARQ feedback IE and ARQ parameters introduced in Section 6.3.4
- However, there needs to be some changes in ARQ operation and transmitter/receiver state machines for proper functioning of RMM-ARQ.

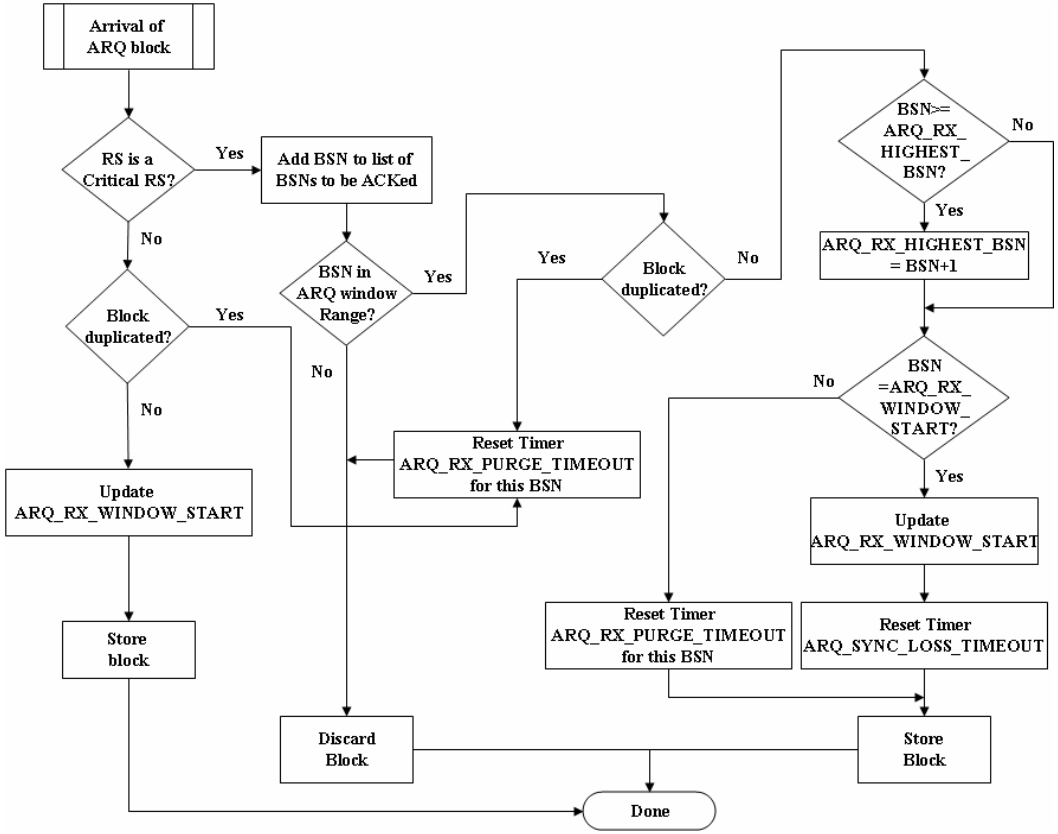
Changes in the Transmitter State Machine

• A packet in the transmitter can not go to "Done" state unless ACKs from all the CRSs are received



Changes in the Receiver State Machine

- An RMM-CRS operates as in DMM receiver state machine
- An RMM-NCRS does not send ACK/NACK; but performs duplicate packet detection and keeps track of ARQ_RX_WINDOW_START



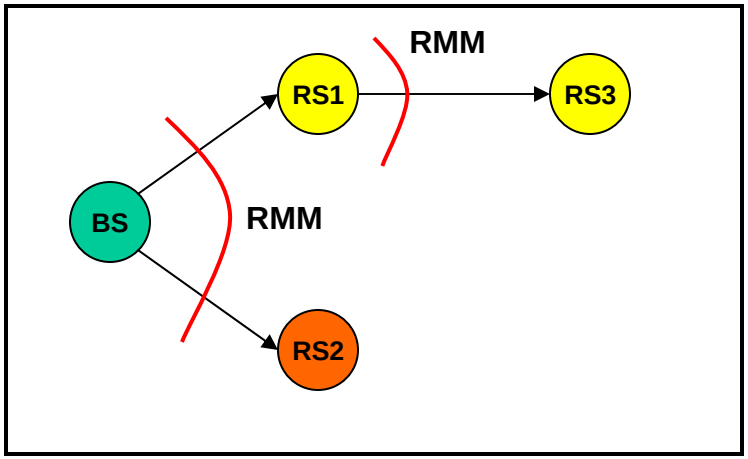
Other Changes

- The TLVs for ARQ Support (11.7.8.1) and ARQ Enable (11.13.18.1) are updated to incorporate RMM related information within REG-REQ/REG-RSP and DSA-REQ/DSA-RSP types of messages
- The RMM is specified in a separate section from DMM and no changes in the available ARQ and multicast sections are done (i.e., it is completely orthogonal with the current multicast mode operation in the standard)

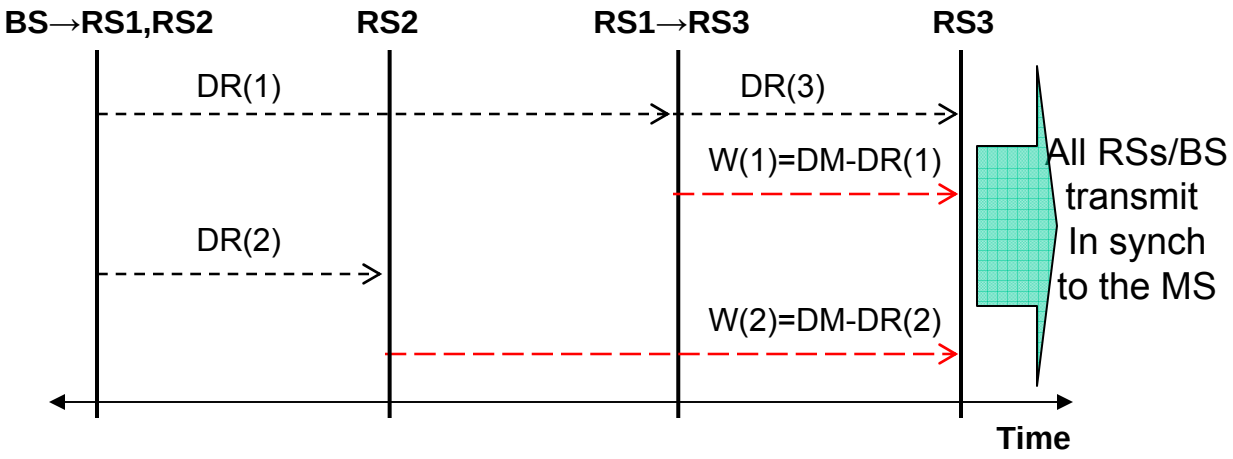
Possible Use of RMM in the MBS (1)

- One scenario where RMM can be quite useful happens in the context of MBS specified in Section 6.3.23.
- In MBS, relays and BS must synchronize their transmissions to the SSs and a packet must be pre-transmitted from BS to the RSs for such a synchronization.
- RMM then becomes an ideal transmission mode for pre-transmission since it is more reliable than the default multicasting and more bandwidth efficient than the unicasting

Possible Use of RMM in the MBS (2)

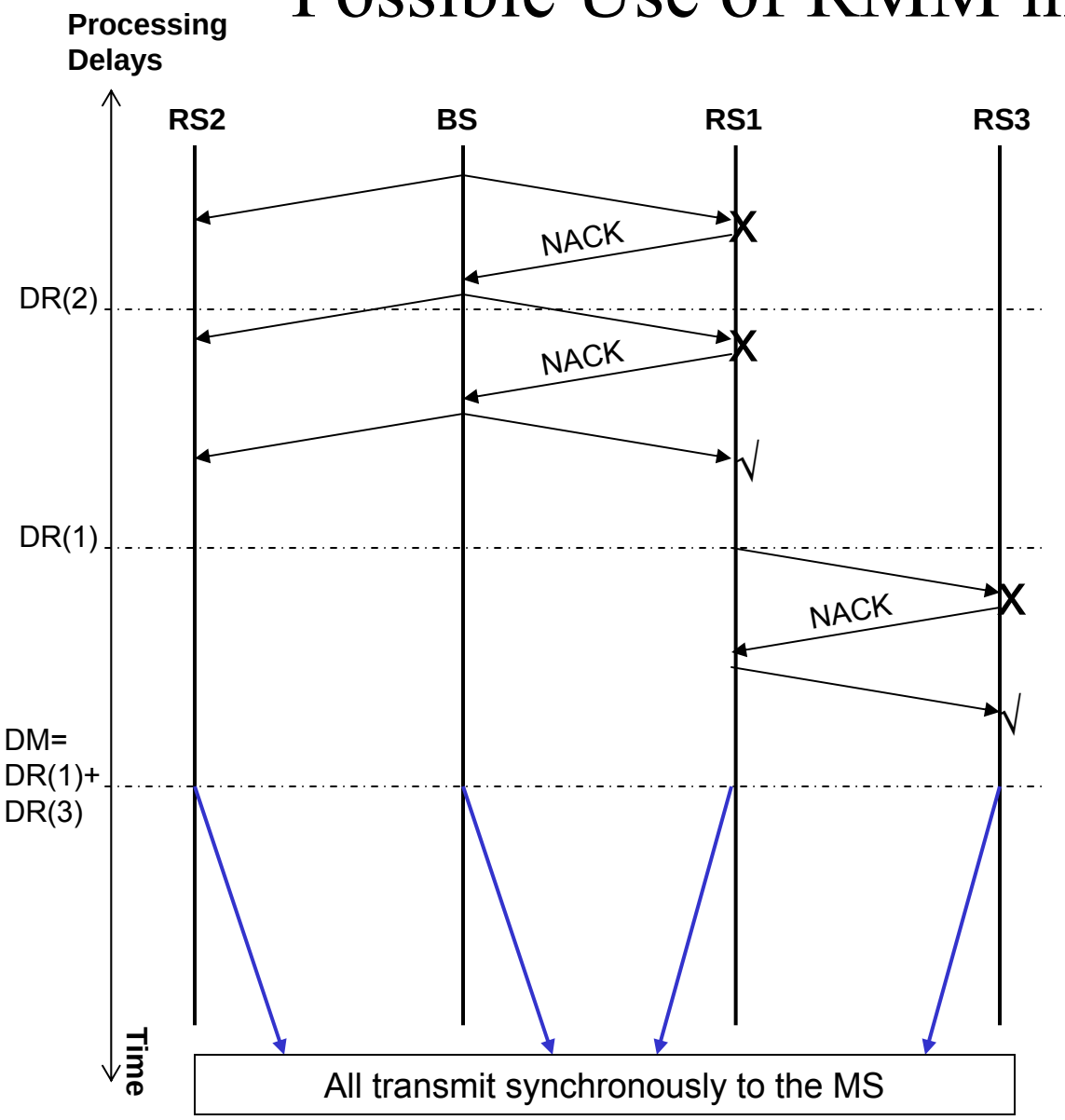


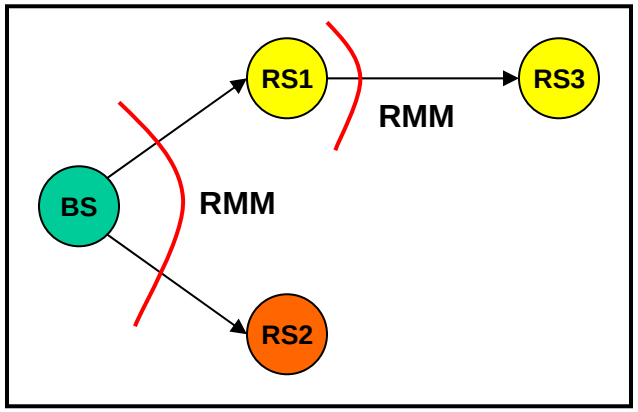
• Consider a simple scenario where RS1 and RS3 are critical RSs and RS2 is a non-critical RS (there may be other non-critical RSs and MSs which are not shown for simplicity)
• The processing delay at RS-i is given by DR(i)
• DM = DR(1)+DR(3) is the transmission delay where the BS waits before transmitting the MBS packets to the MS
• Each RS also has to wait an amount of W(i) before transmission
• We consider that the DR(i) are set so as to accommodate the retransmission delays



• Initially, the BS pre-transmits to RS1 and RS2 using RMM-ARQ (can be larger number of RSs in practice)
• RS2 will not have any re-transmissions and hence wait for an amount of W(2) before transmitting to MS
• Any re-transmissions for RS1 should finish within DR(1). RS1 then pre-transmits to RS3 (and any other RSsthat may be connected to RS1) using RMM-ARQ.
• Any re-transmissions for RS3 should finish within DR(3)
• After all the RSs receive the packets, they transmit synchronously to the MSs

Possible Use of RMM in the MBS (3)





- In this example, DR(1) and DR(3) are set so that RS1 can accommodate a maximum of two re-transmissions while RS3 can accommodate only one re-transmission
- These come at the expense of increased latency, but may significantly improve the reliability
- Especially over multiple hops in 16j systems, it may become highly likely that the packets are lost and RMM-ARQ can be used as a solution to this

Possible Use of RMM in the MBS - Summary (4)

- Using ARQ for retransmissions in MBS will introduce latency. However, it is possible to have synchronous transmissions with RMM for reliability.
- We basically consider RMM for pre-transmissions to different RSs in MBS. MBS requires to obtain delay requirements at each relay and sets a maximum cumulative delay DM. RMM can then be used by setting the ARQ timeout periods (determined by ARQ_RETRY_TIMEOUT) so that they fulfill the processing delays DR(i) for each RS.
- How the timeout periods are set corresponding to each CRS is implementation dependent.
- Similar concepts apply to any unicast pre-transmissions with ARQ to RSs for enabling MBS.
- Bottomline: In 16e systems, ARQ was not used in MBS, but due to multiple hops, it will be good to allow ARQ at the expense of increased latency in 16j systems.

Summary

- RMM is an optional mode which can be used to enhance the reliability of multicast/broadcast transmissions for RSs that support RMM
- It is especially helpful if there are large number of MSs/SSs under a few RSs
- It may be used for pre-transmission in MBS
- Critical RSs may be determined by MR-BS and how to select them is implementation dependent