# Relay Combining Hybrid ARQ for 802.16j

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Purpose:

The proposal is to recommend an HARQ scheme for discussion and adoption in 802.16j.

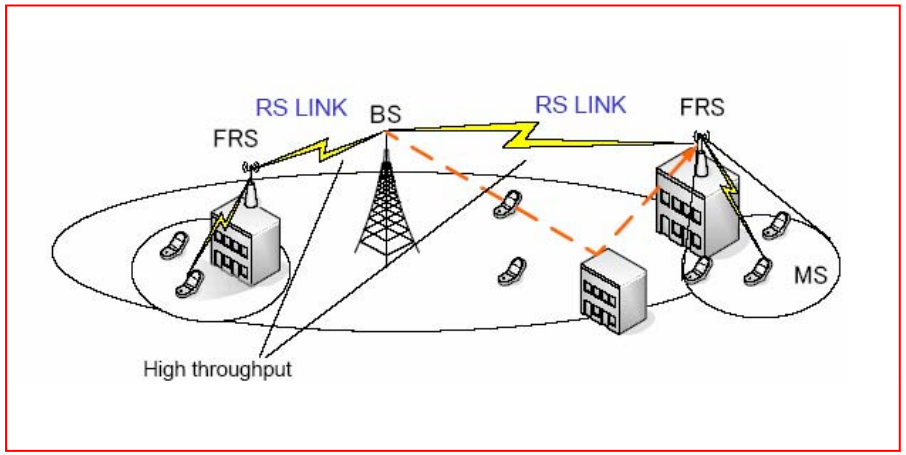
# Relay Combining Hybrid ARQ for 802.16j

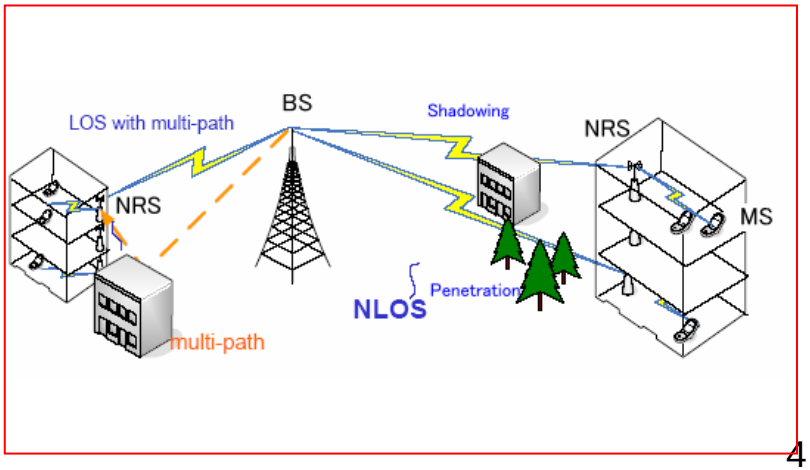
# Outline

- Usage scenarios.
- Frame structure.
- Retransmission policies.
- Principle of chase combining and incremental redundancy.
- Comparison of HARQ for 802.16e and 802.16j
- Proposed relay combining HARQ and implementation.
- Summary.

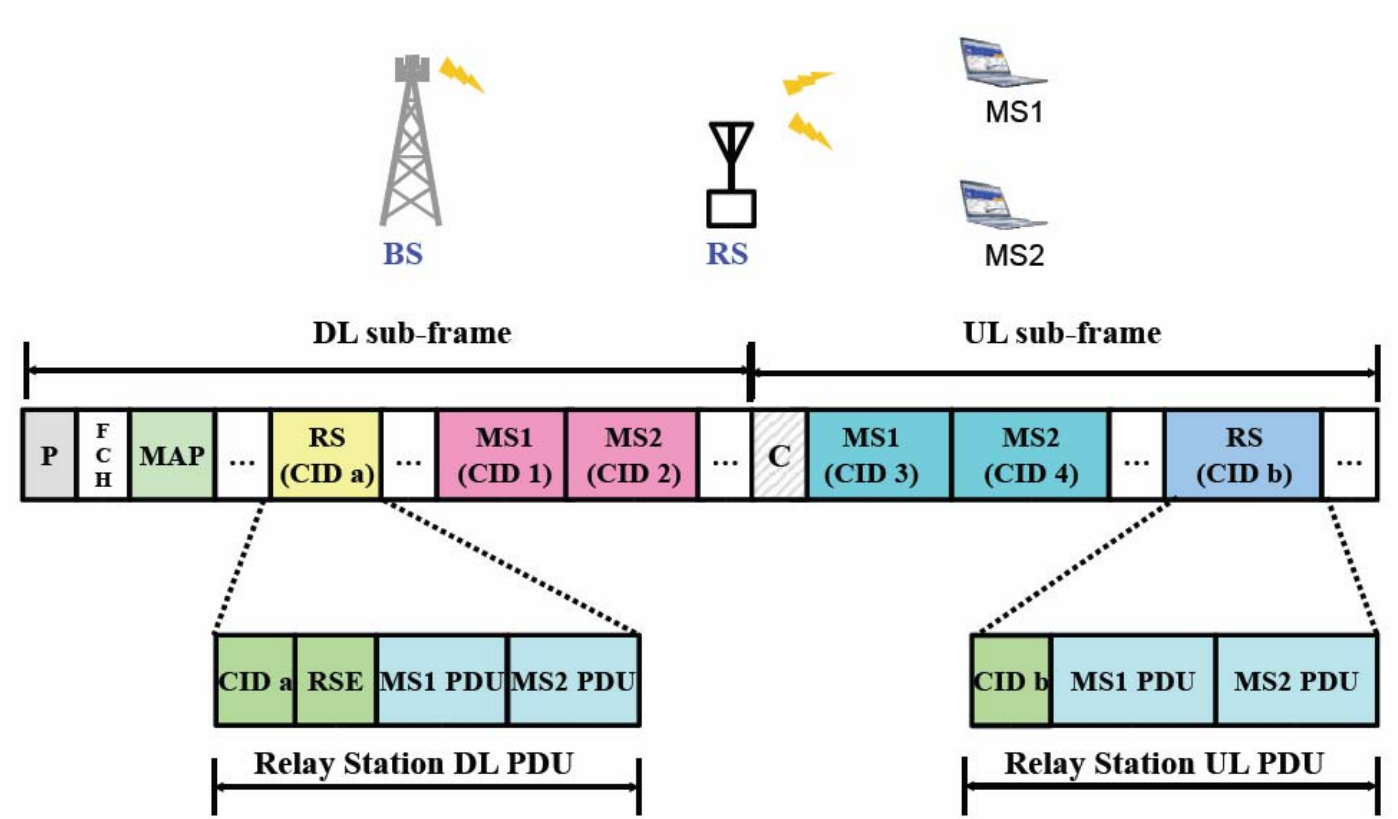
# Usage Scenarios

- Fixed RS-----coverage extension and reducing coverage hole.
- Nomadic RS-----coverage extension to building.
- BS can not directly communicate with MS.
- Ref[1-2]



# Frame Structure

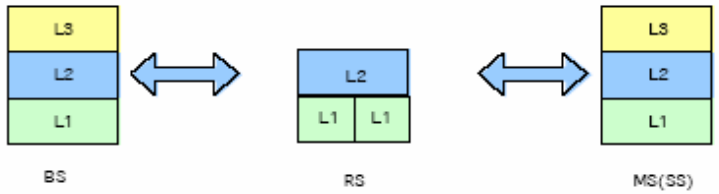



Note: our proposed HARQ scheme can be employed in any current frame structure, here we just give an example.

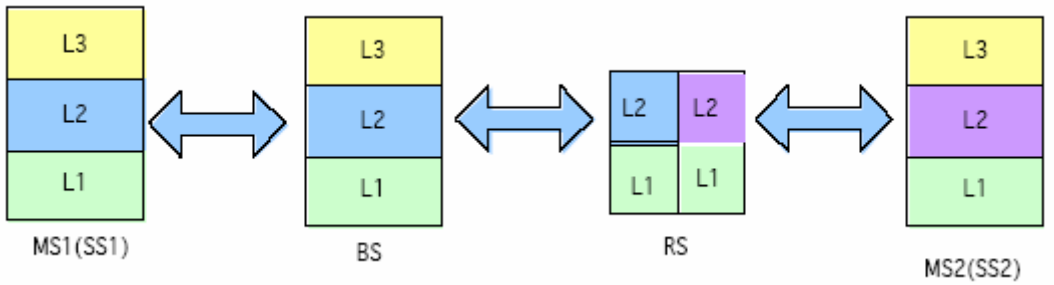
** Source: "A Recommendation on PMP Mode Compatible Frame Structure", CCL/ITRI, IEEE 802.16mmr-05/005r2*

# Retransmission policy

- BS controlled (ACK/NACK only from BS/MS)[3-4]
  - RS informs BS of retransmission need.
  - Multi-hop path involved and large delay.
  - The same block is used in multi-hop links.
  - The same block number sequence.
  - The same block size.

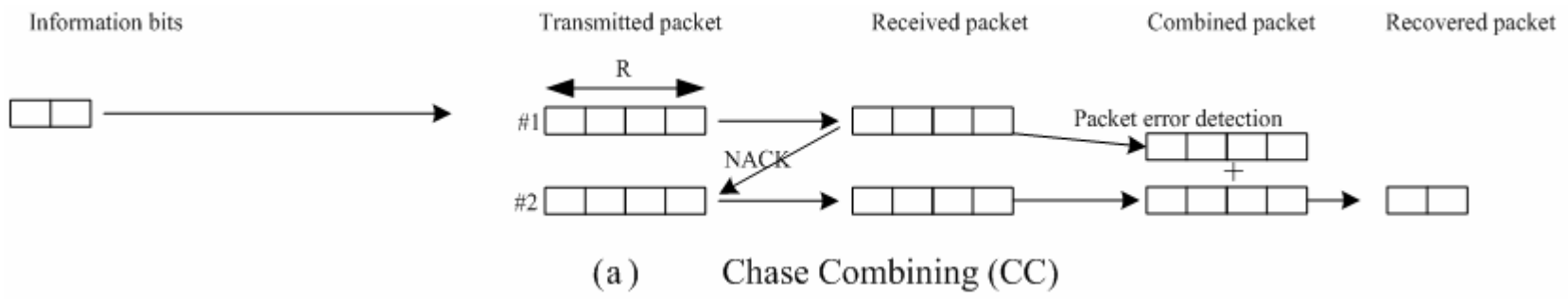



- BS, RS controlled (ACK/NACK from BS/MS and RS)[3-4]
  - BS handles retransmission direct to MS, RS.
  - RS handles retransmission for MS connected to it.
  - Require more complexity at RS (decode and forward, buffering).
  - Different blocks may be used for each ARQ.
  - Different block size.
  - Different sequence number.
- The BS controlled retransmission is more reliable and simple than BS,RS controlled retransmission. We prefer the former.



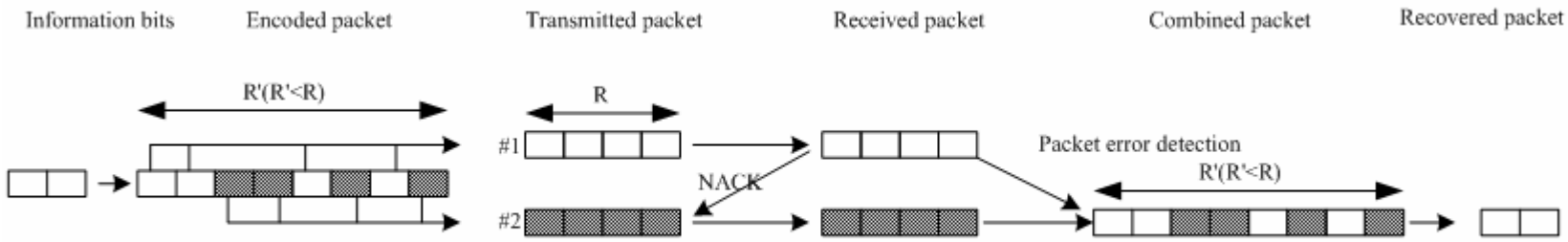
# Principle of Chase Combining and Incremental Redundancy

## Chase Combining (CC)—achieve time diversity gain




(a) Chase Combining (CC)

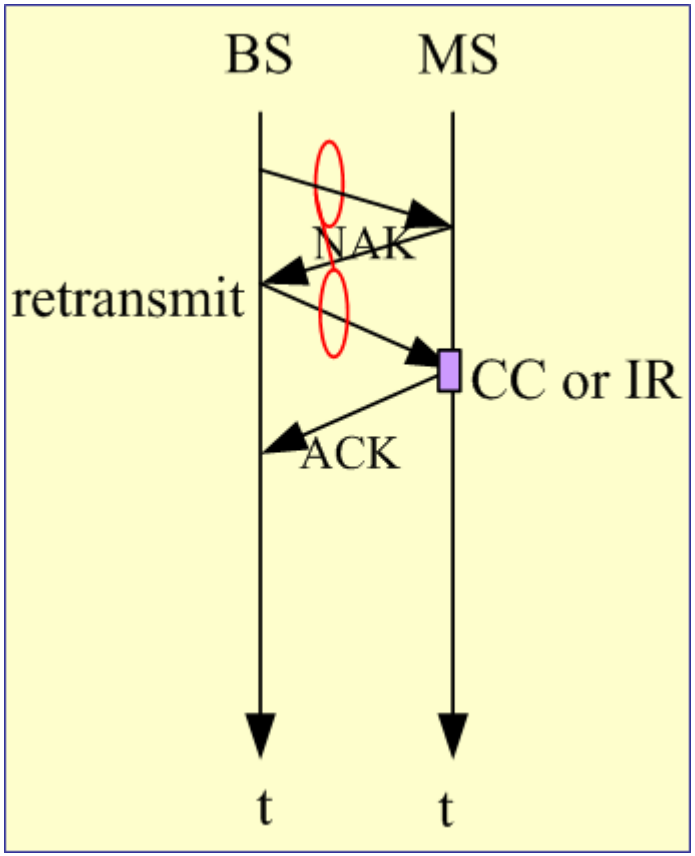
## Incremental Redundancy (IR)-achieve coding gain



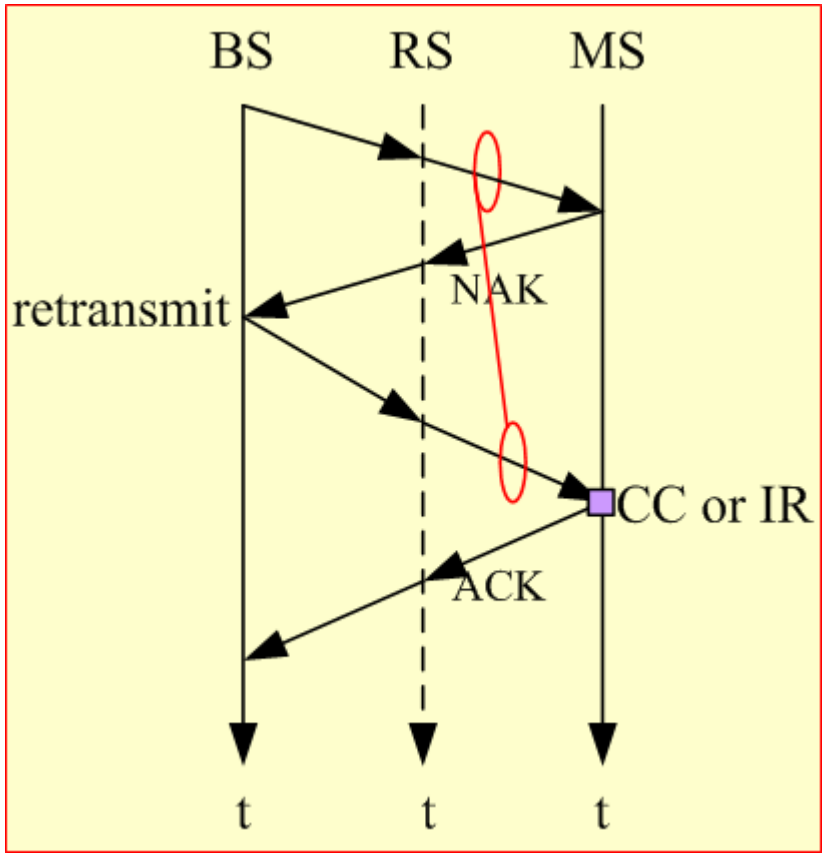

(b) Incremental Redundancy (IR)

# Comparison of HARQ for 802.16e and 802.16j

HARQ for 802.16e

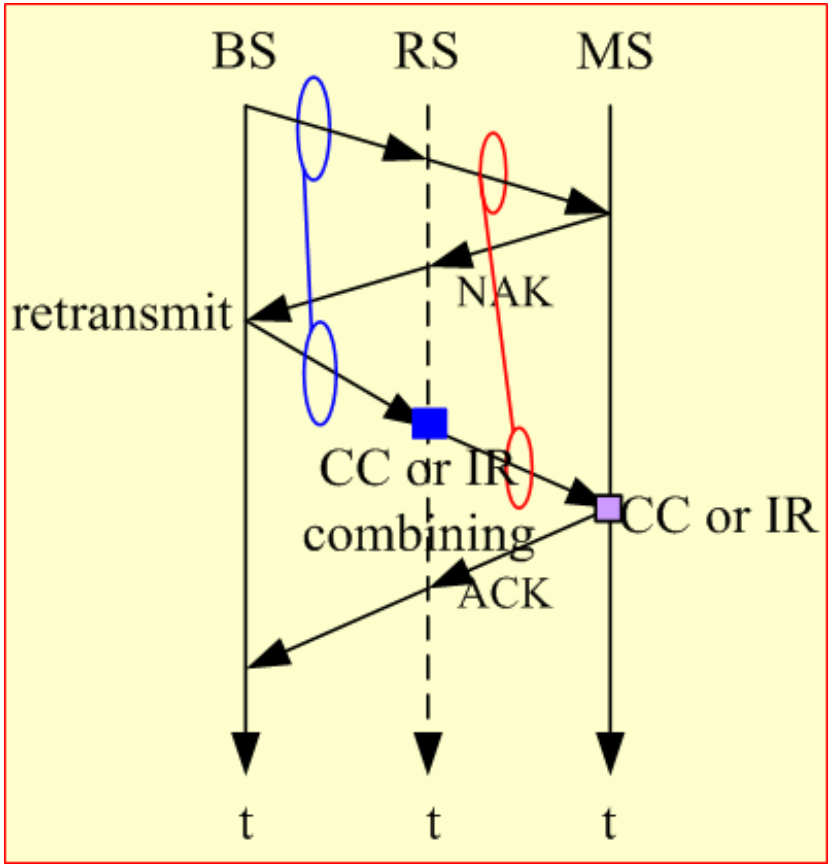



Conventional HARQ for 802.16j

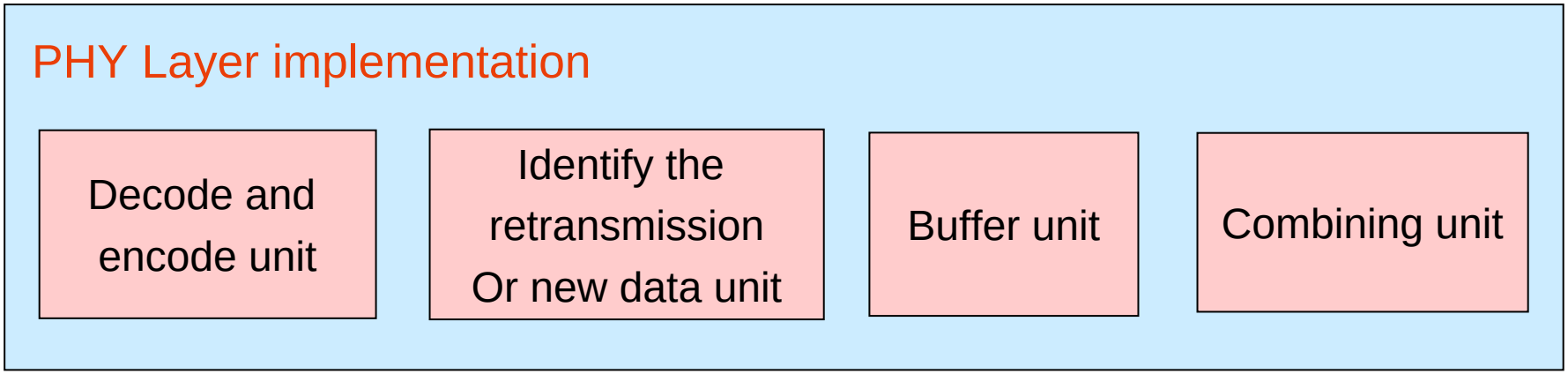


# Proposed relay-combining HARQ

- Based on BS controlled
  - ACK/NACK only from BS.
  - RS informs BS of retransmission need from MS.
  - RS combines the multiple received copies from BS and relay it to MS.
  - MS combines the multiple received copies from RS.
  - Chase combining and incremental Redundancy both are applied at RS.
  - The type of RS is decode and forward which is more flexible than amplify and forward.



# RS functions and implementation




- RS functions
  - Buffer the received data.
  - RS checks whether the received data is retransmission or not based on DL MAP of frame structure.
  - RS combines the received multiple copies.
  - RS estimates the channel information between BS and RS.

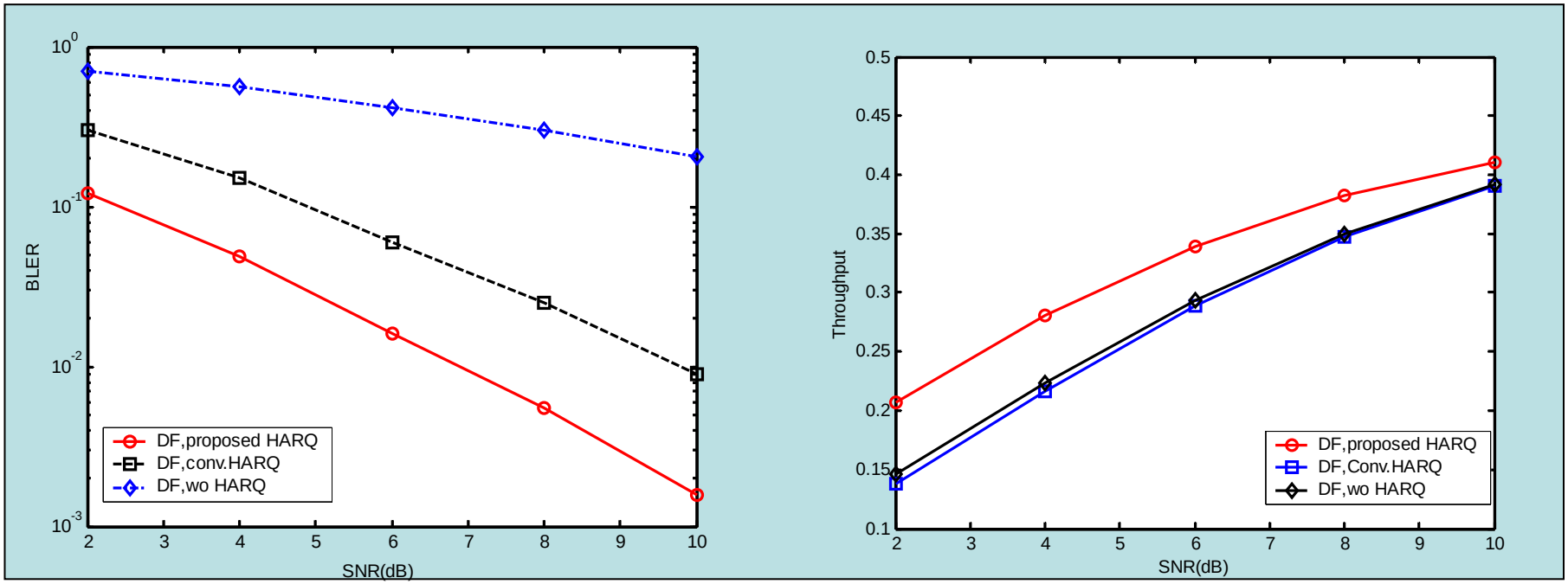
# Summary and Recommendation

- Relay combining HARQ scheme is proposed to improve throughput and provide high reliability.
- This scheme can be applied for any current frame structure.
- We recommend the RS supporting HARQ to be included in technical requirements for 802.16j.

Appendix1

# Simulation Parameters and Results

| | |
|---|---|
| Modulation | QPSK |
| Coding scheme | Convolutional code |
| Code rate | 1/2 |
| HARQ scheme | Chase Combining |
| Maximum allowed retransmission number | 3 |
| Antenna number at BS,RS and MS | 1 |
| Channel model | Rayleigh fading channel, Fd*T=0.01, 0.1 |



Appendix2

# References


- [1] C80216j-06_036 Proposed Technical Requirements for IEEE 802.16 TGj.
- [2]C80216j-06_049r1 Technical requirements for 802.16j.
- [3] C80216mmr-05_028 Open problems in Mobile Multi-hop Relay System.
- [4] C80216j-06_029 Usage scenario considerations for 802.16 relay.

Appendix3

# Main idea of references

- Ref.[1]
  - In this contribution, it proposes the technical requirements for IEEE 802.16j. In the requirements, it mentions that the ARQ/HARQ processing should be provided by relay station and FEC block is enabled by relay station.
- Ref.[2]
  - In this contribution, it describes four usage scenarios such as fixed RS, nomadic RS in building, nomadic RS in the field and mobile RS. Then gives the technical challenges and requirements. It suggests that the RS supports ARQ/HARQ of MS/SS
- Ref.[3]
  - In this contribution, it recommends that the function of RS related to ARQ should be defined and suggests two kinds of ARQ schemes, e.g. per hop ARQ, multi-hop ARQ.
  - It analyzes the advantages and disadvantages of per hop ARQ and multi-hop ARQ. For the former the different blocks may be used for each ARQ and for the latter the same blocks is used in multi-hop link.
- Ref.[4]
  - In this contribution, it suggests some usage scenarios such as access control, radio resource assignment, link type, handover and retransmission policy.
  - It suggests two types of retransmission policy. One is BS controlled which means ACK's only from BS; another is BS and RS controlled which means ACK's from BS and RS.

Appendix4

# Merits of the proposed scheme

- The same block is used in multi-hop links. The block size and sequence number are the same.
- Do not need to modify the normal ARQ protocol.
- The scheme can be implemented easily at relay station.
- The scheme can greatly improve throughput and provide high reliability.

Appendix5

# Example for Chase Combining

First transmission $y_1 = h_1 x + n_1$

First retransmission $y_2 = h_2 x + n_2$

Chase Combining result

$$h_1^* y_1 + h_2^* y_2 = (\|h_1\|^2 + \|h_2\|^2)x + h_1^* n_1 + h_2^* n_2$$

Appendix6

# Example of Incremental Redundancy

- We assume the transmission bits are [0 1 1 1]
- After encoding with coding rate 1/3, the transmission bits are [1 0 1 1 0 0 1 0 1 1 0 1 ].
- The puncturing matrix are [1 0 0; 0 0 1;1 1 0],[0 0 1;1 0 0; 0 0 0],[0 1 0; 0 1 0; 0 0 1] for the first, second and third transmission.
- The first transmission bits after puncturing by [1 0 0; 0 0 1;1 1 0] are [1 1 0 1 1 1]. At the receiver, the received bits are [1 1 0 1 1 0]. Then viterbi decoding is used to decode the received bits. If error is detected, the second puncturing matrix is used to transmit data. Then the second transmission bits are [0 1 1]. At the receiver, the received bits are inserted to the first received bits to construct a lower code rate codeword [1 0 1 0 0 0 1 0 1 1 0 1 ]. Then the codeword is decoded by viterbi decoding into [0 1 1 1 0]. Then it is correctly received. Otherwise the third transmission bits will be transmitted.

Appendix7

# Example of Implementation for downlink relay combining HARQ

- In the downlink transmission from BS to RS, RS synchronizes with BS from the downlink preamble and decode the received data from the DL MAP information.
- Based on the DL MAP, the RS encodes and forwards the relay data to MS at the downlink transmission from RS to MS.
- If error is detected at the MS, the NAK is fed back to RS, otherwise the ACK is fed back to RS at the uplink transmission based on UL MAP in frame structure.
- RS will relay the ACK or NAK to the BS in the uplink transmission from RS to BS.
- BS will transmit the new data or retransmit the data according to the ACK or NAK. If NAK is received, BS will retransmit the data, and the RS will combine it with the previous data based on the DL MAP which informs the combining scheme, new or retransmission, user ID and so on. Then the RS will encode and forward the combined signal to the MS at the downlink transmission from RS to MS. In addition, the MS will combine the received data with the previous data and then decode it.