Multi-Hop ARQ

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2006/8/24

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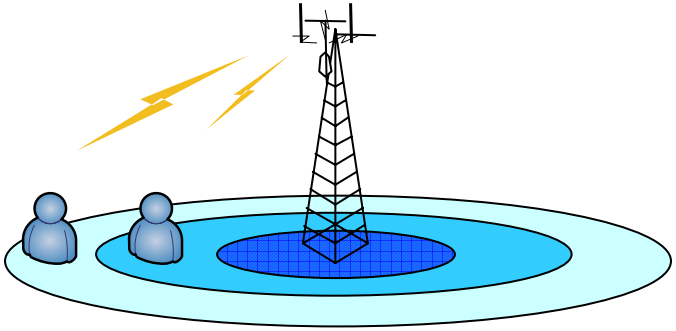
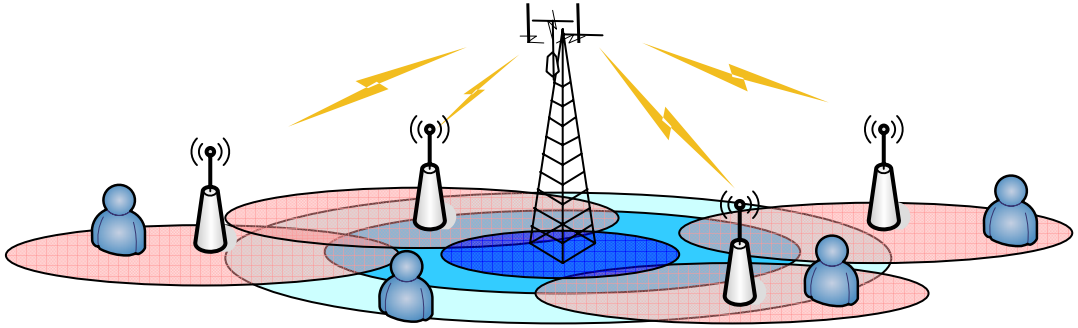
Introduction



Single Hop

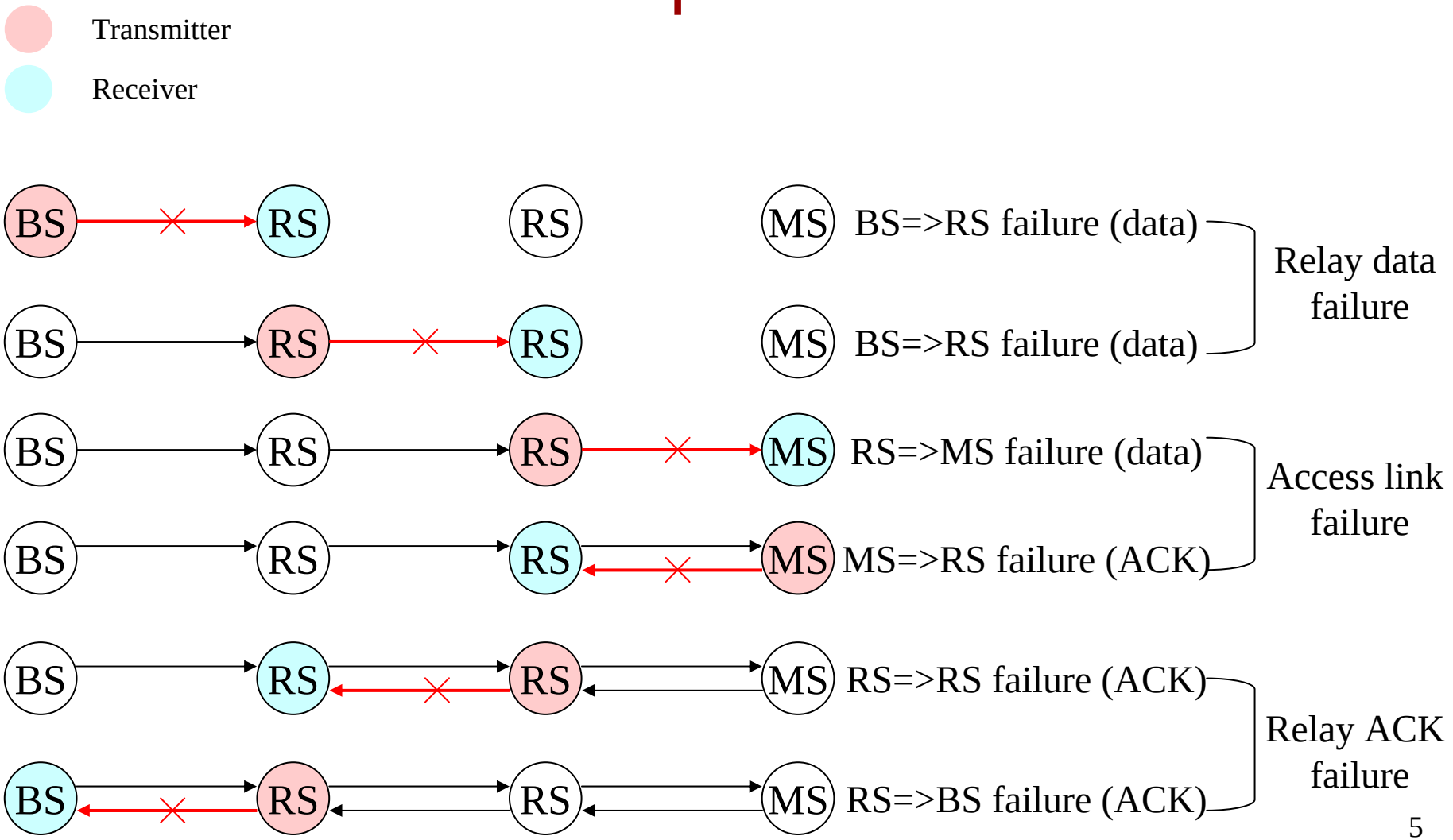


Multi Hop

Introduction

- Mobile radio system beyond 3G will comprises single-hop (SH) and multi-hop (MH) communication [WWRF]
  - But most current researches target on SH connections
- Reliability issue is more crucial in MH network
  - MH links face more interference and fading effect than SH links
- The traditional approaches cannot solve the problem effectively
  - Retransmission introduces longer delay and waste radio resource
  - Local retransmission causes other impacts
- New ARQ mechanism is needed for MH network to ensure reliability

Multi-Hop Scenario

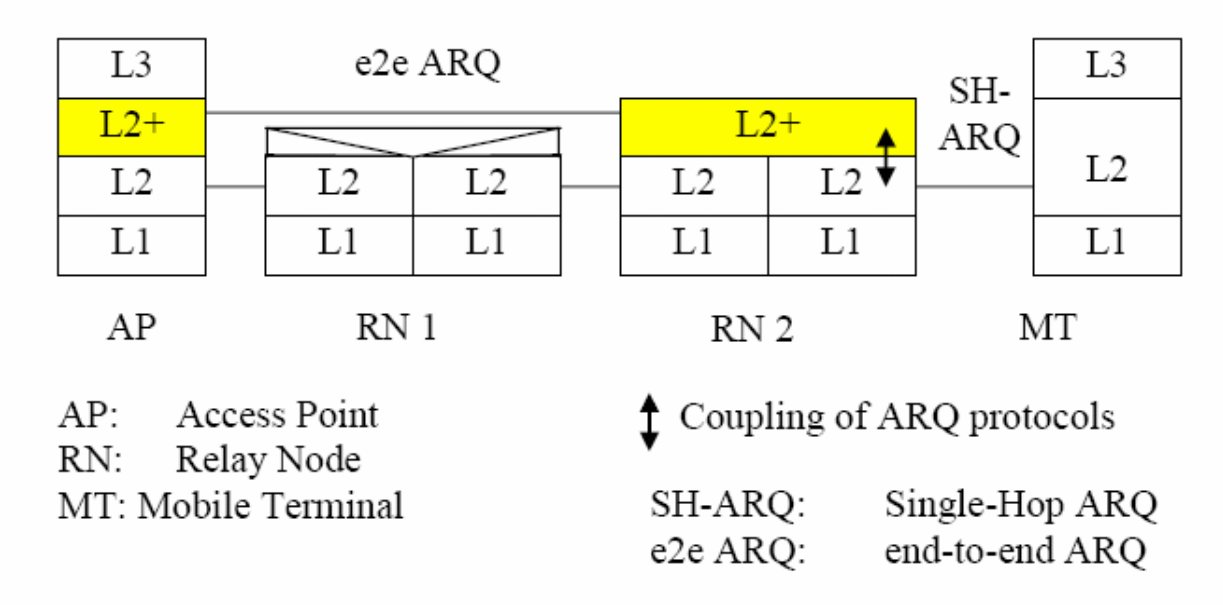


Multi-Hop ARQ Issues

- Relay data failure
  - Error propagation
  - Transmitting error packets wastes radio resource if RS do not detect it
  - Retransmission increases transmission delay
- Relay ACK failure
  - ACK failure cause retransmission
  - Congestion occurs due to local retransmission

Multi-Hop ARQ [1]

- Multi-Hop ARQ is a coupled ARQ protocol
  - e2e ARQ protocol
    - Run between AP/BS and last RN
  - SH-ARQ protocol
    - A conventional ARQ protocol

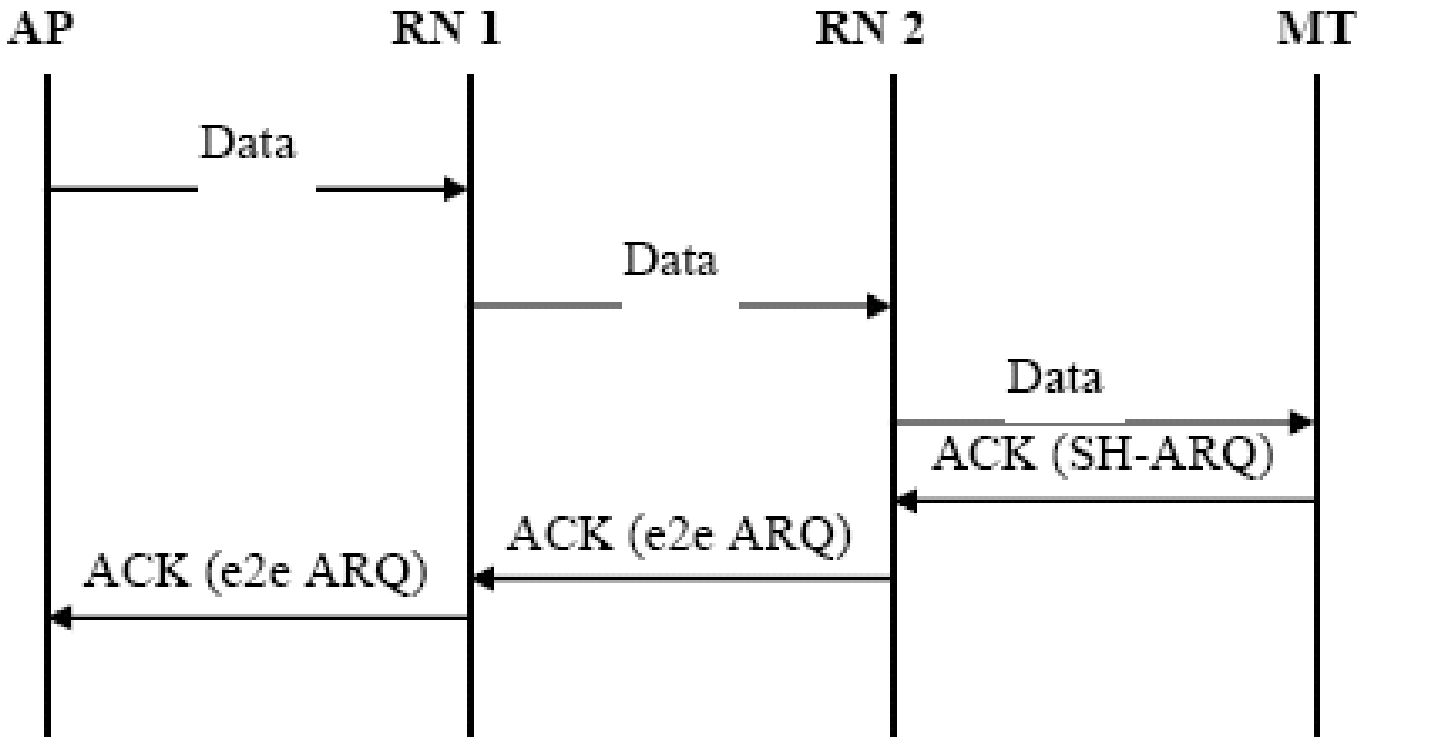


Multi-Hop ARQ [1]

- On the UL
  - All correctly received and ACKed packets between MT and RN2 are stored in the layer L2+
  - The e2e ARQ protocol only takes care of correct delivery to AP/BS
- On the DL
  - Only correctly delivered packets on the last hop will be ACK by the RN towards the AP/BS and will be released
  - The RN and AP will in turn release packets from their queues

Multi-Hop ARQ [1]

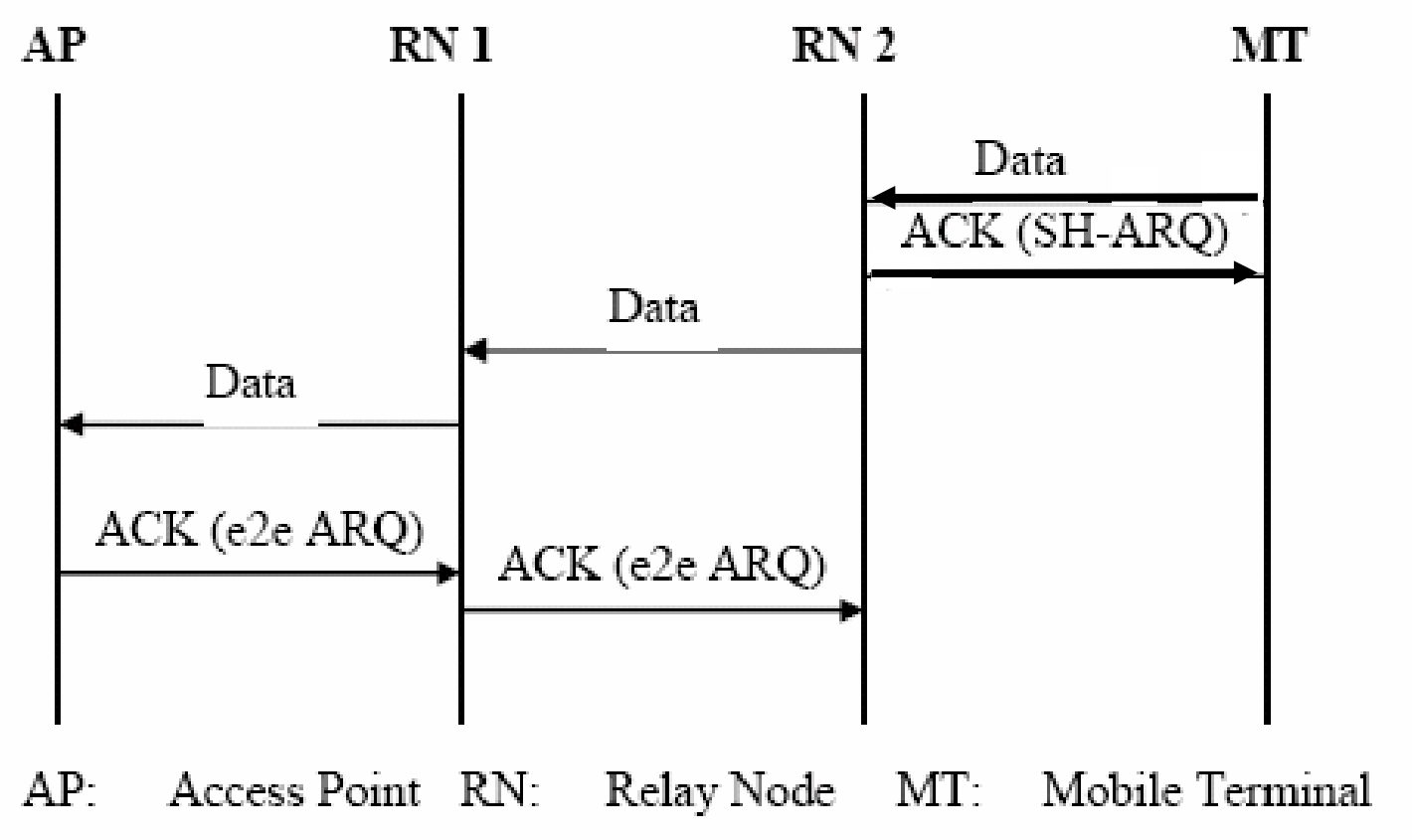
MSC of downlink



AP: Access Point RN: Relay Node MT: Mobile Terminal

Multi-Hop ARQ [1]

MSC of uplink

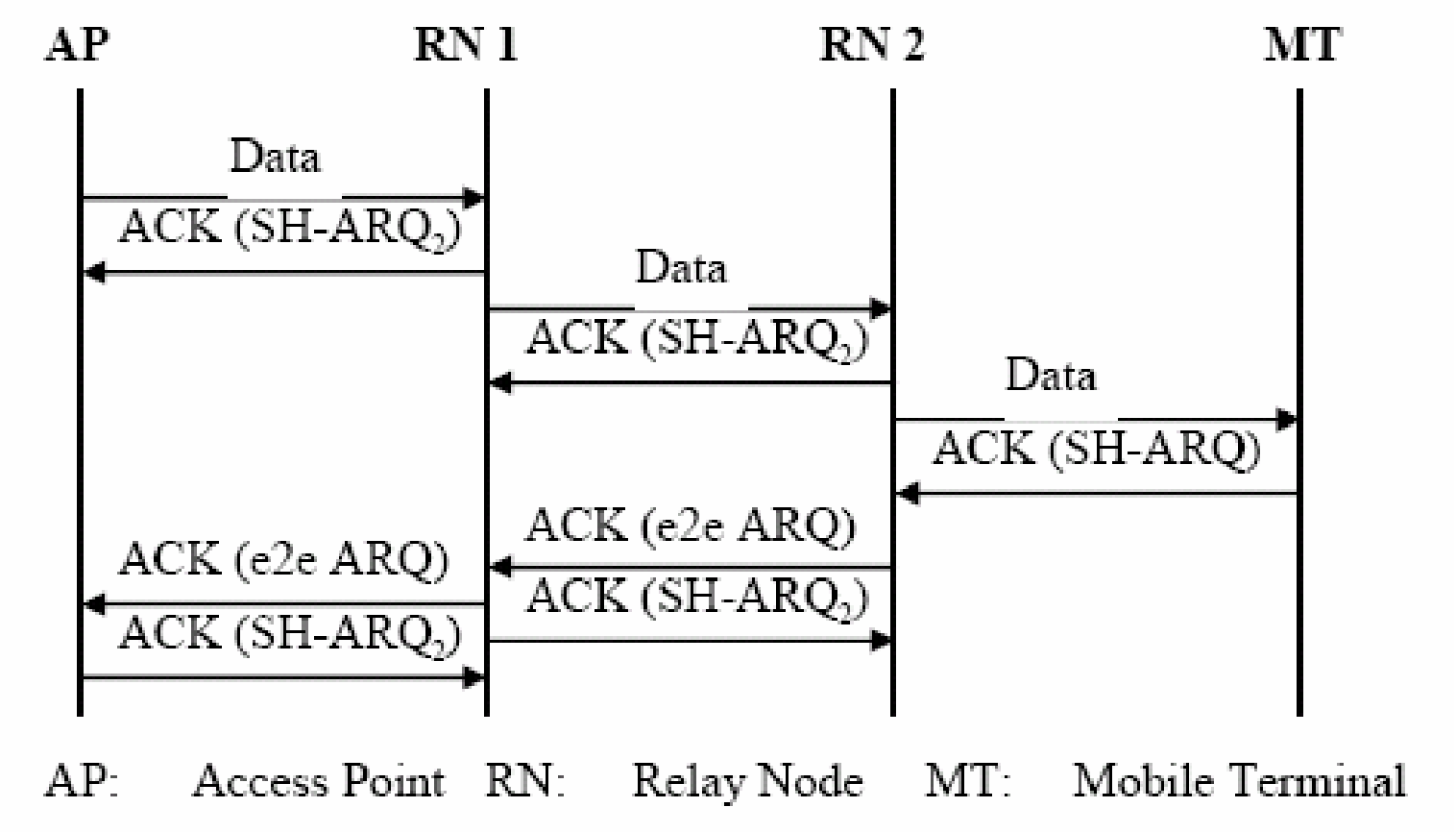


Multi-Hop ARQ [1]

- Advantage
  - Transparency for MT
    - MT do not need recognize the differences of connection between RN or AP
  - Support for QoS
    - Reliability of relay link is guaranteed
    - Latency issues are not solved
  - Low complexity, low cost MT
    - Buffers and processing for ARQ protocols are located at AP/BS and RN, not MT
    - MH ARQ protocol requires larger buffers than SH protocols due to the longer RTT
  - Flexible integration of legacy MT / different ARQ protocols
    - Existing and new ARQ protocols can be integrated easily
  - Independent optimization of e2e ARQ and SH-ARQ protocol
    - Optional feature can be exploited (next page)

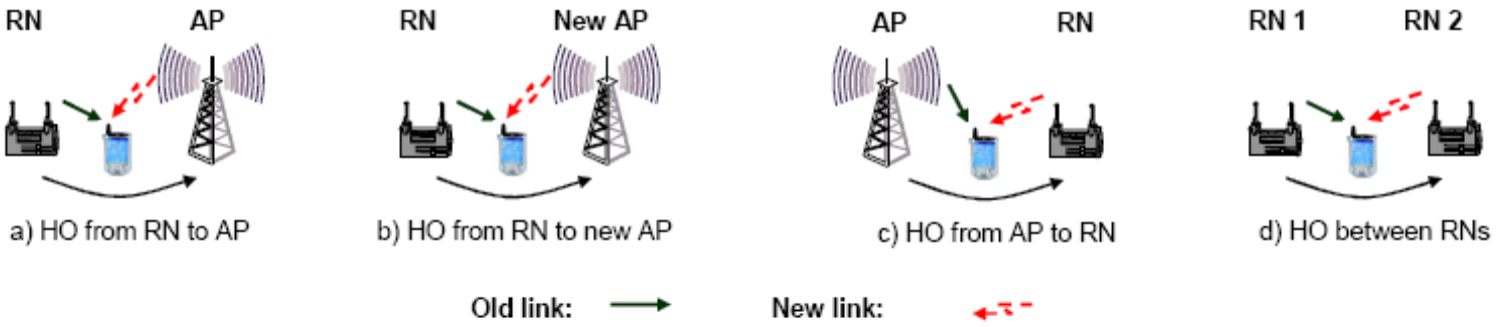
Multi-Hop ARQ [1]

MSC of downlink (with second SH-ARQ)



Multi-Hop ARQ [1]

- Mobility support
  - HO from RN to AP
    - AP transmits packets that has not been stored in RN
    - RN keeps transmitting packets until the packets are ACKed by AP
  - HO from RN to new AP
    - Similar to upper case
    - Un-ACKed downlink packets will be forwarded to new AP after handover
  - HO from AP to RN
    - Un-ACKed packets will be forwarded and stored in RN after handover
    - MT will retransmit uplink packets to new RN if the AP do not ACKed
  - HO between RNs
    - The same with the case of handover from AP to the RN



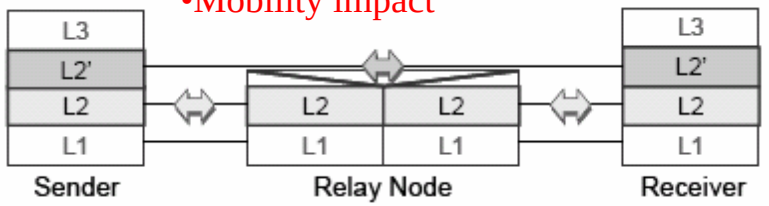
Relay ARQ [2]

- Not a layered concept
  - All nodes are involved un the link layer MH transmission and understand the same ARQ protocol
  - Using the same SQN
  - All underlying PHY can support the same data unit size
  - Same protocol state for all hops

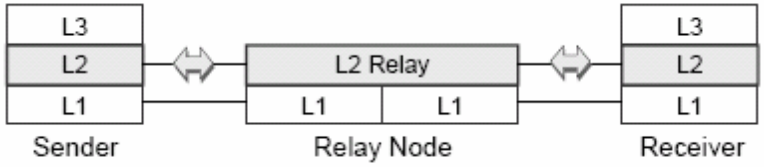
•Competing retransmission

•Complex protocol stack

•Mobility impact



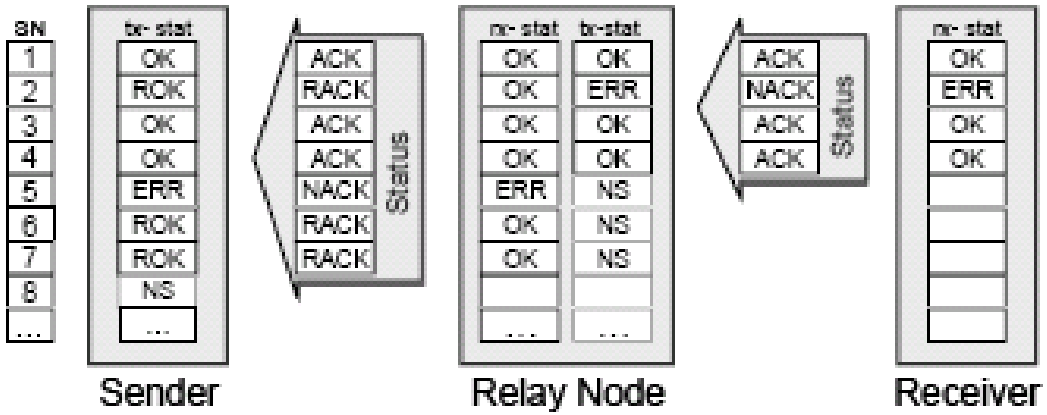
Layered ARQ approach



Relay ARQ concept with two hop

Relay ARQ [2]

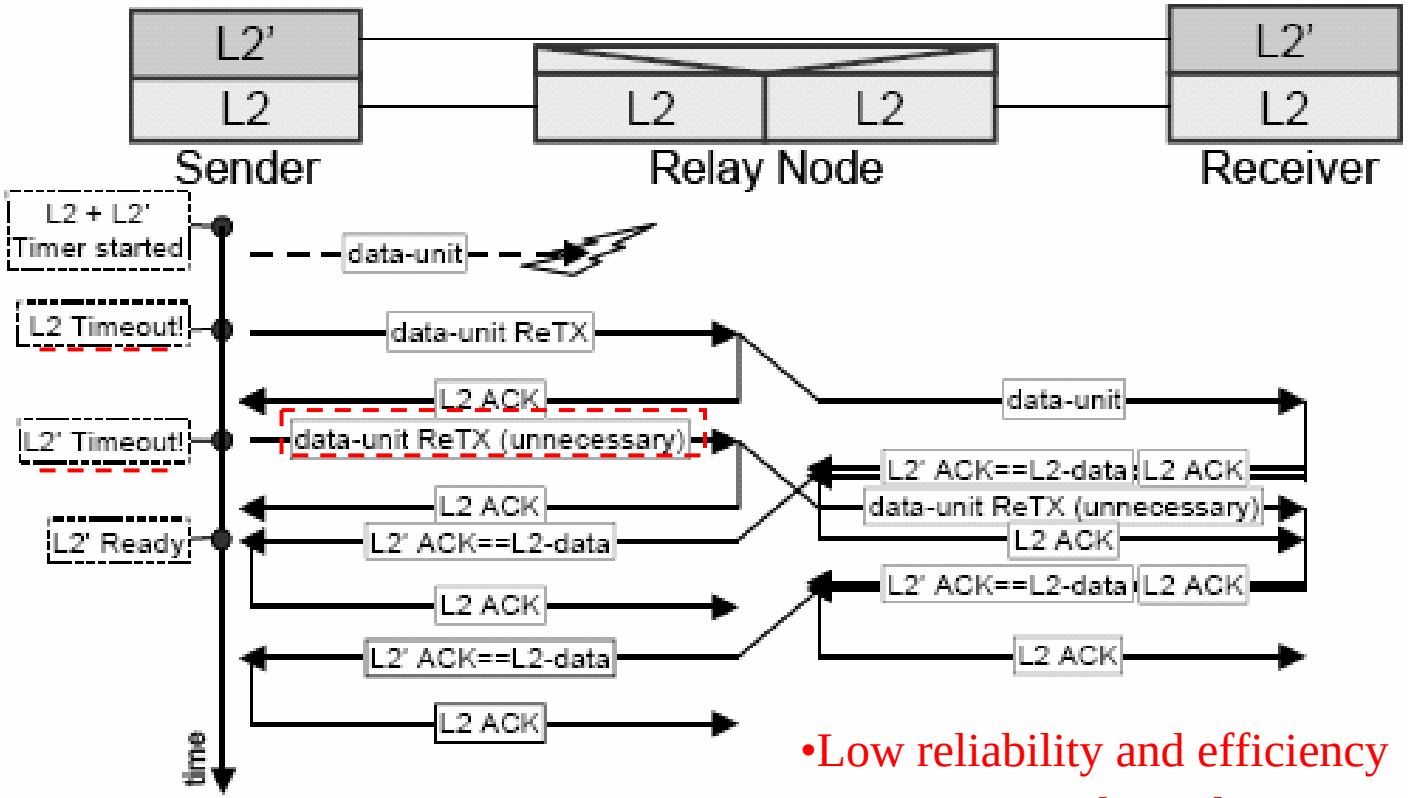
- Operations
  - Each node uses the same sliding window, and maintains Tx and Rx state
    - OK/ROK/NS/ERR
  - The sender keeps the packets in its send window
    - Take back the transmission responsibility in case transmission failure
  - RS perform local retransmission when receiving NACK
  - Sender discard packets as soon as it receives a final ACK



Data and Status Exchange for Relay ARQ

Relay ARQ [2]

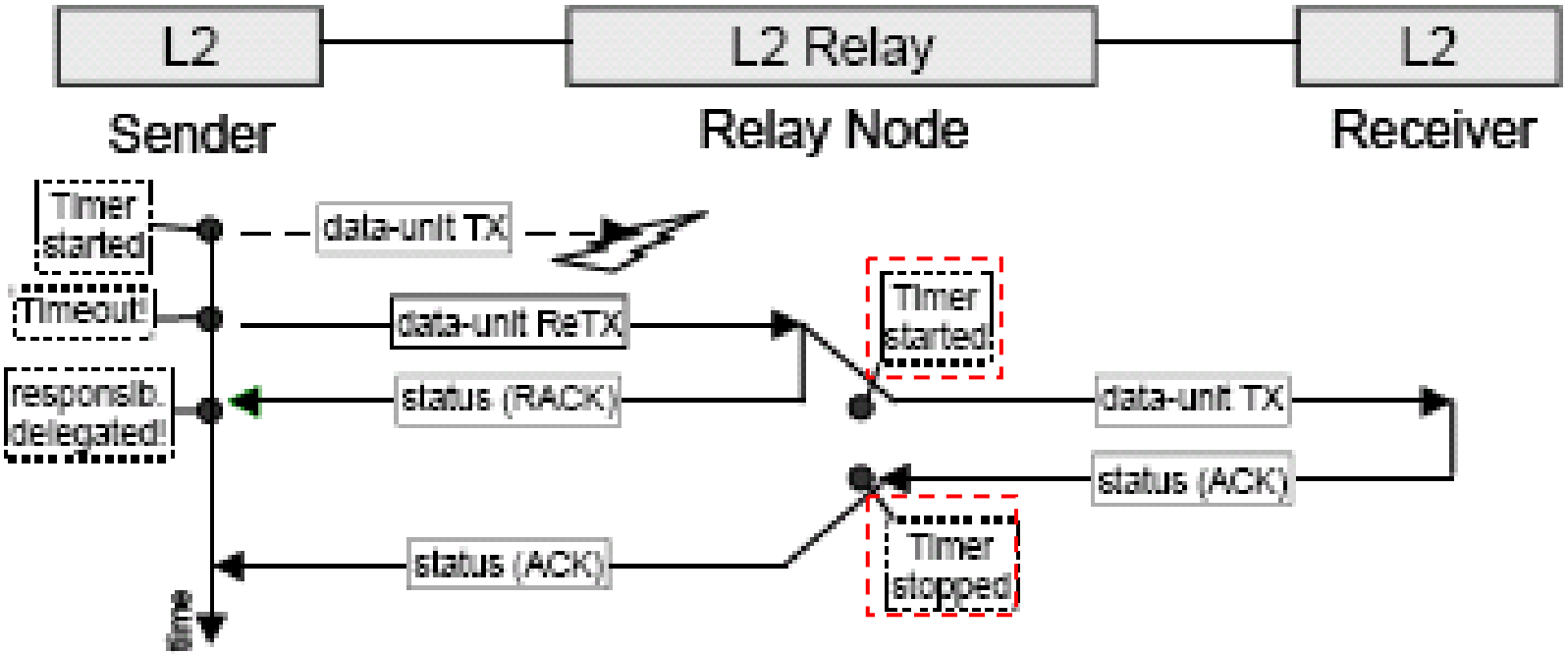
MSC for Layered ARQ



- Low reliability and efficiency
- Timer setting depend on RTT of underlying links

Relay ARQ [2]

MSC for Relay ARQ



- Soft state ARQ is efficient to support changes of network topology

Relay ARQ [2]

Relay ARQ forward packets out of order

Diverging data rate weaken the benefit of Relay ARQ

		objSize=500kbyte			objSize=100kbyte		
		RelayARQ	IPRelay	Gain	RelayARQ	IPRelay	Gain
blep=0.1		rttFirstHop=40 rttSecondHop=40					
dataRateFirstHop=640	dataRateSecondHop=640	477.3	457.1	4%	356.2	303.9	17%
dataRateFirstHop=1280	dataRateSecondHop=640	474.8	471.3	1%	363.9	333.7	9%
dataRateFirstHop=640	dataRateSecondHop=1280	484.0	470.5	3%	361.7	313.0	16%
dataRateFirstHop=1280	dataRateSecondHop=1280	840.9	770.7	9%	448.9	385.7	16%
blep=0.1		rttFirstHop=60 rttSecondHop=30					
dataRateFirstHop=640	dataRateSecondHop=640	453.7	435.1	4%	324.8	277.1	17%
dataRateFirstHop=1280	dataRateSecondHop=640	455.0	449.7	1%	336.4	293.8	14%
dataRateFirstHop=640	dataRateSecondHop=1280	473.9	460.2	3%	336.5	289.7	16%
dataRateFirstHop=1280	dataRateSecondHop=1280	774.5	702.6	10%	404.8	333.7	21%

Data rate increases the benefit of Relay ARQ

		objSize=500kbyte			objSize=100kbyte		
		RelayARQ	IPRelay	Gain	RelayARQ	IPRelay	Gain
blep=0.1		rttFirstHop=80 rttSecondHop=80					
dataRateFirstHop=640	dataRateSecondHop=640	433.4	407.6	6%	263.5	211.8	24%
dataRateFirstHop=1280	dataRateSecondHop=640	436.1	417.9	4%	263.1	222.8	18%
dataRateFirstHop=640	dataRateSecondHop=1280	440.6	417.0	6%	257.3	228.8	12%
dataRateFirstHop=1280	dataRateSecondHop=1280	645.3	540.9	19%	288.4	243.4	18%
blep=0.1		rttFirstHop=30 rttSecondHop=60					
dataRateFirstHop=640	dataRateSecondHop=640	452.6	442.1	2%	318.1	277.0	15%
dataRateFirstHop=1280	dataRateSecondHop=640	463.8	460.1	1%	329.9	296.7	11%
dataRateFirstHop=640	dataRateSecondHop=1280	447.5	449.6	0%	317.3	294.2	8%
dataRateFirstHop=1280	dataRateSecondHop=1280	759.3	716.0	6%	405.0	341.8	18%

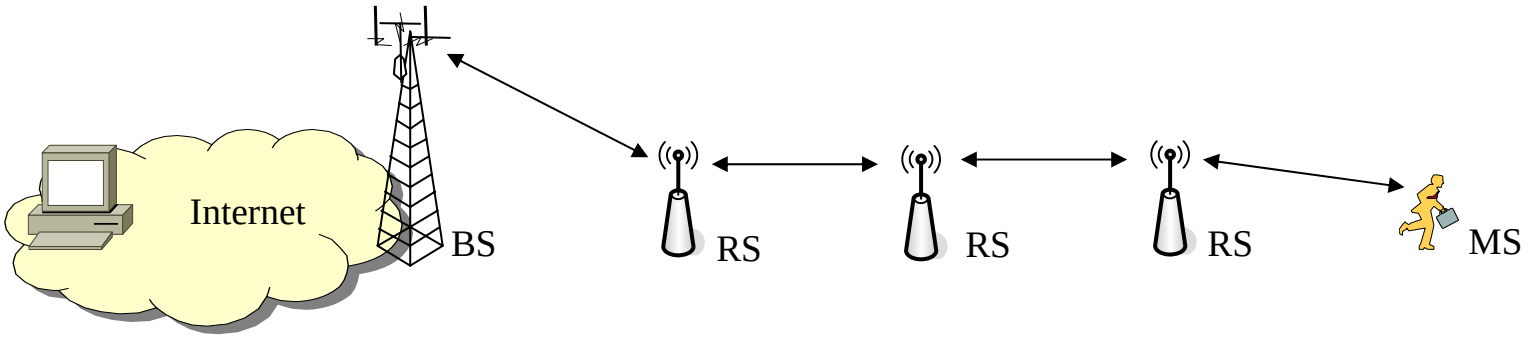
Up to 20% better than IP Relay

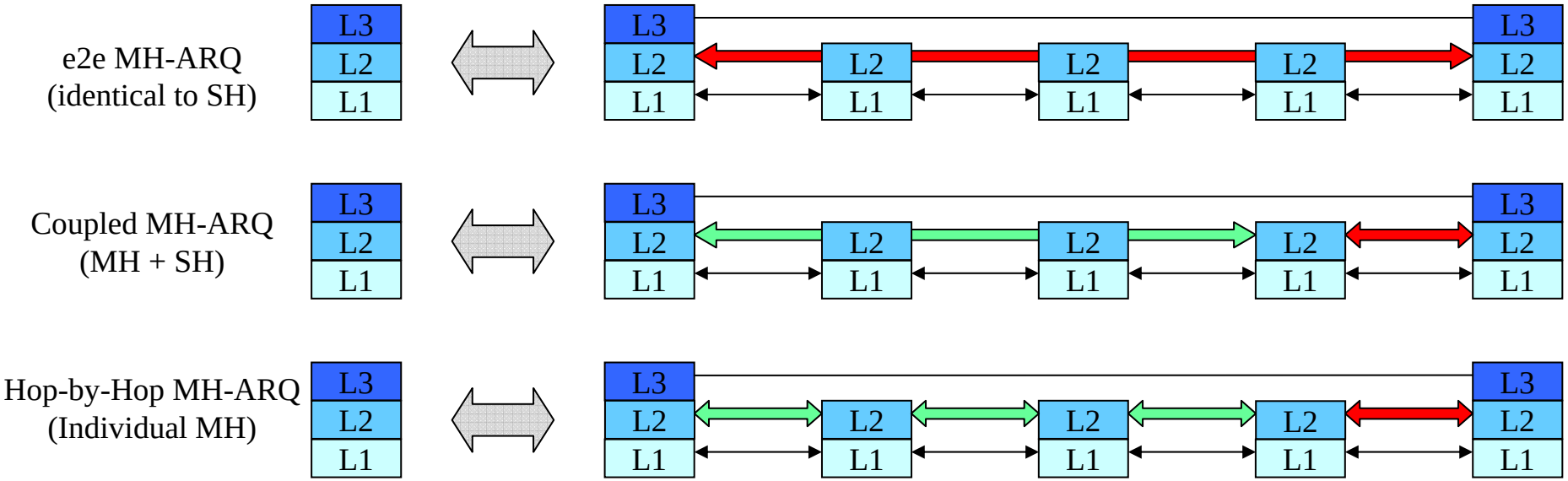
Simulation Result

Summary

- Multi-Hop ARQ
  - Transparency, low cost, and low complexity for MT
    - But put the burden to RN due to longer RTT
  - Increase reliability and solve partial QoS problem
    - Latency issues are not solved
  - Flexible integration and optimization of different protocol
- Relay ARQ
  - Solve competing retransmission
  - Higher reliability and efficiency
  - Less complex protocol stack
  - Adaptive to network dynamics
  - Limited improvement over layered ARQ
  - Introduce congestion problem

Multi-Hop ARQ Classification





Research Topics

- How to maintain ARQ
  - E2e ARQ
    - End nodes takes the responsibility
  - Hop-by-hop ARQ
    - Each nodes takes the responsibility
  - Hybrid scheme
    - Choose some nodes to take responsibility for ARQ in a relay path
- Retransmission reduction
- Tradeoff between signaling overhead and latency
- Congestion prevention

References

- [1] Wiemann, H.; Meyer, M.; Ludwig, R.; Chang Pae O; "A Novel Multi-Hop ARQ Concept," in proceeding of Vehicular Technology Conference – VTC 2005 spring, Vol. 5, pp. 3097-3101, in June 2005.

- [2] Lott, M.; "ARQ for Multi-Hop Networks," in proceeding of Vehicular Technology Conference – VTC 2005 fall, Vol. 3, pp. 1708-1712, in Sep. 2005. (Winner)

Thank You