An Advanced ARQ (A^2RQ) on Relay Link for 802.16j

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Purpose:

Propose an advanced ARQ (A^2RQ) protocol for 802.16j to improve capacity, delay and reliability performance on relay links.

An Advanced ARQ (A^2RQ) on Relay Link for 802.16j

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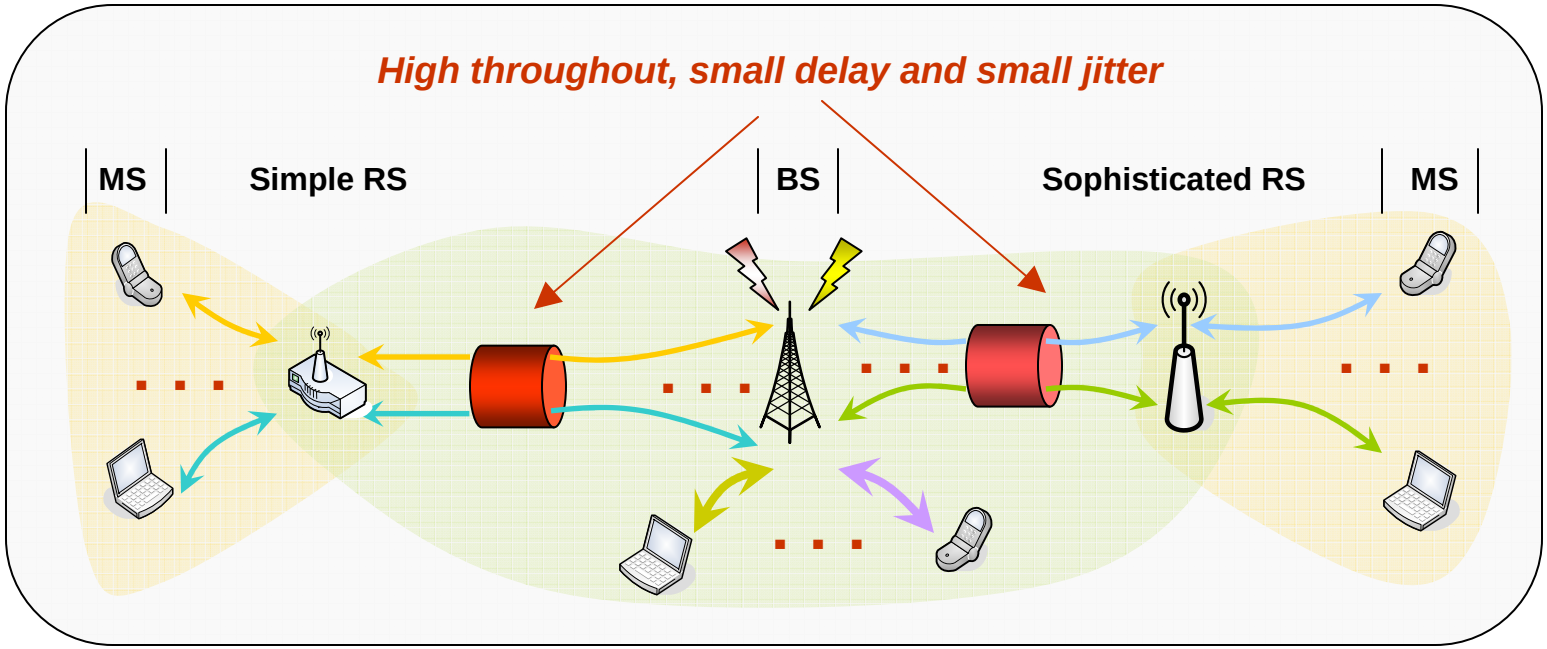
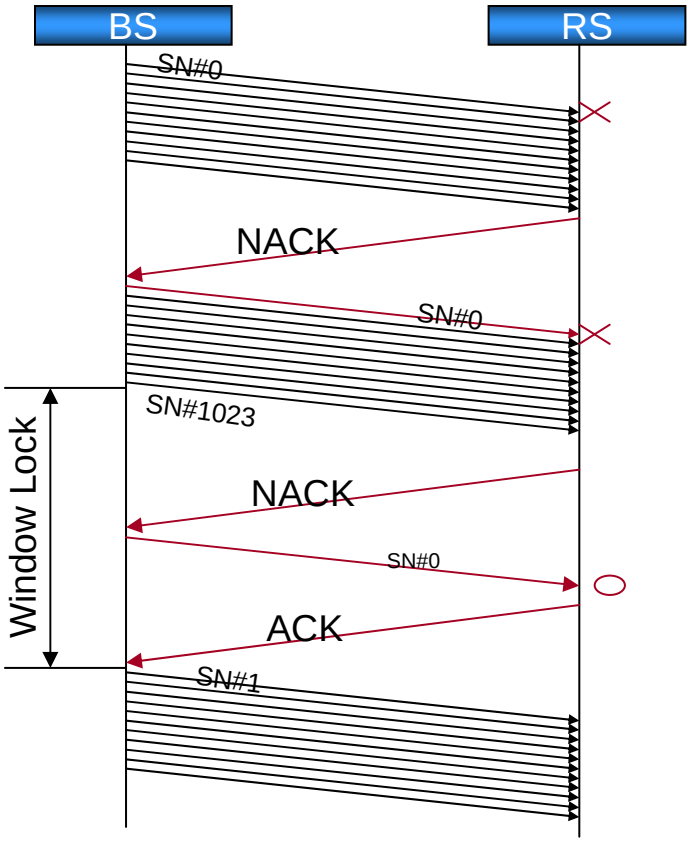
Concept of Advanced ARQ (A^2RQ)

- Relay stations have to share radio resources with mobile stations.
- Relay links have to carry traffic initiated from or terminated at all the MSs associated with it.
- To avoid becoming a bottleneck, it has to deliver *high throughput*, *low delay/jitter*, and *high reliability*.
- The concept of “advanced ARQ” is to provide reliable transmission, moderate to high throughput improvement while minimizing delay and delay jitter on relay links.



Problem of G-ARQ #1: *Window Lock*

- Window lock in G-ARQ:
  - In the presence of heavy traffic load, the transmitter will consume its ARQ window very quickly and has to wait an excessively long period of time for the acknowledgement before it can proceed with transmission/retransmission.

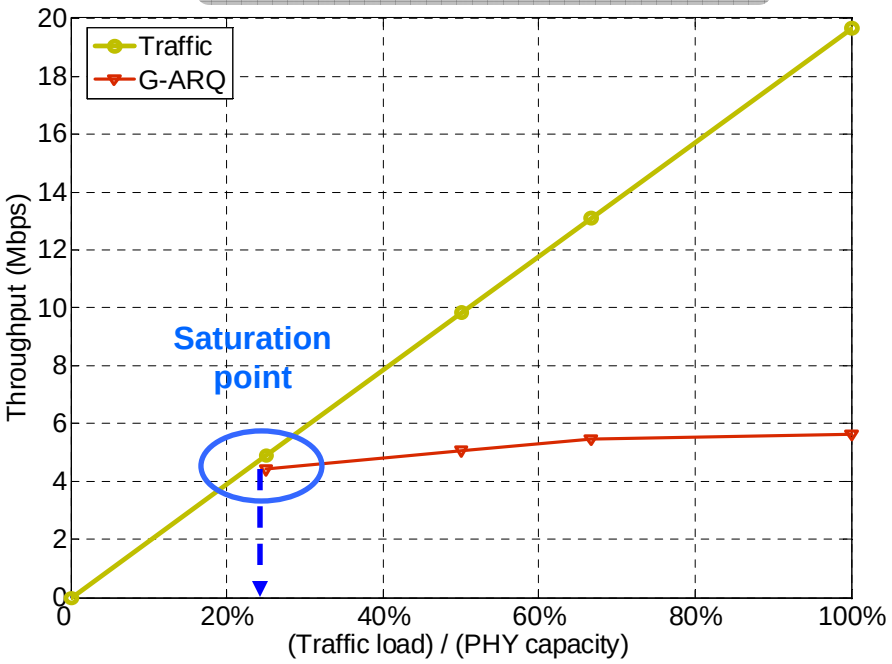


Problem of G-ARQ #1: *Window Lock*

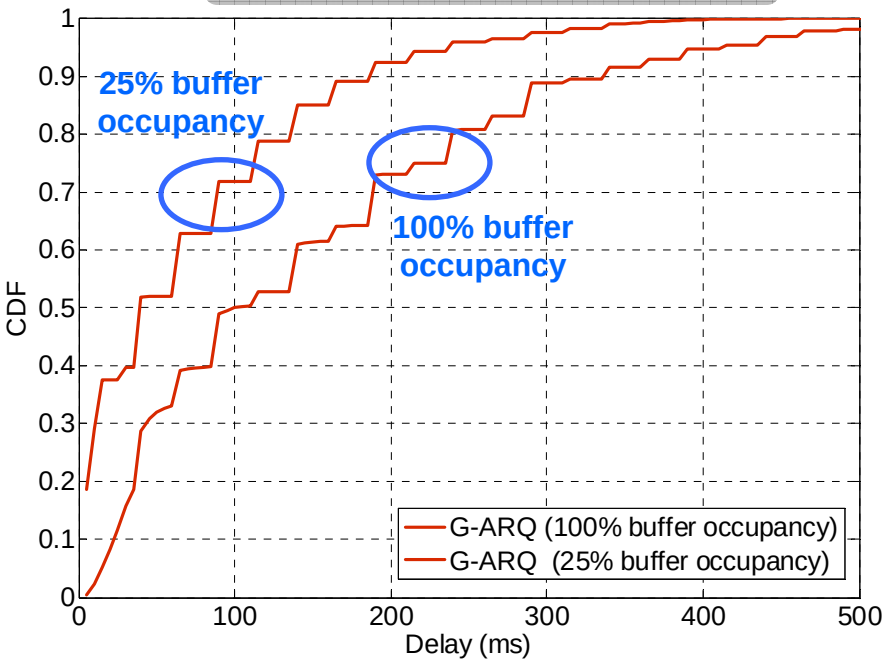
- The window lock causes the network to experience:
  - Suppressed throughput
  - Degraded delay distribution
  - Increased mean delay and jitter

Simulation condition	
Parameter	Value
ARQ Window Size	1024
ACK Period	10 Frames
ARQ Block Size	128 Bytes
Requested BER	10^{-3}

G-ARQ Throughput Performance



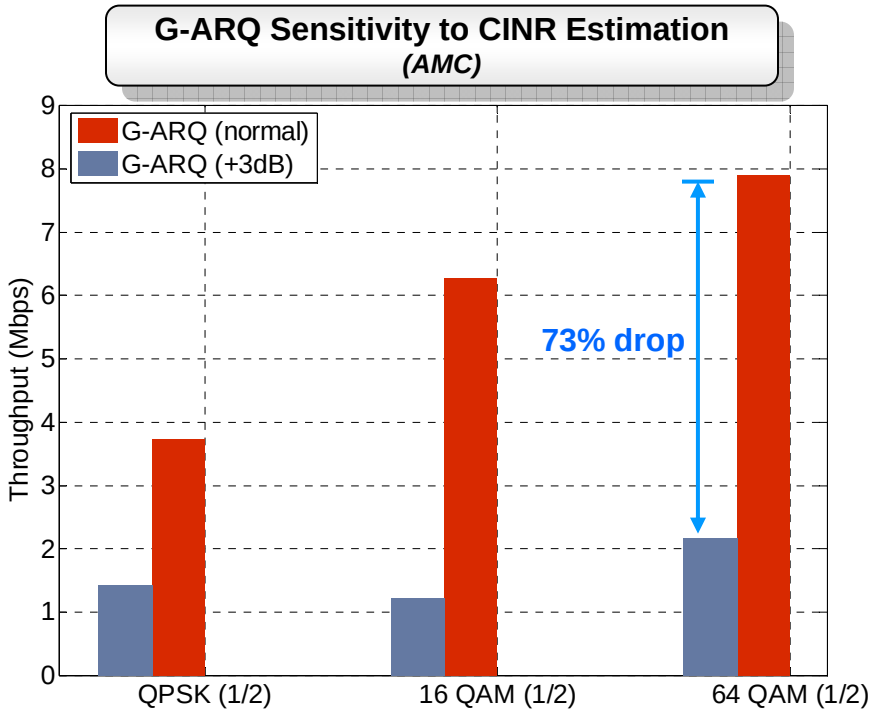
G-ARQ Delay Performance

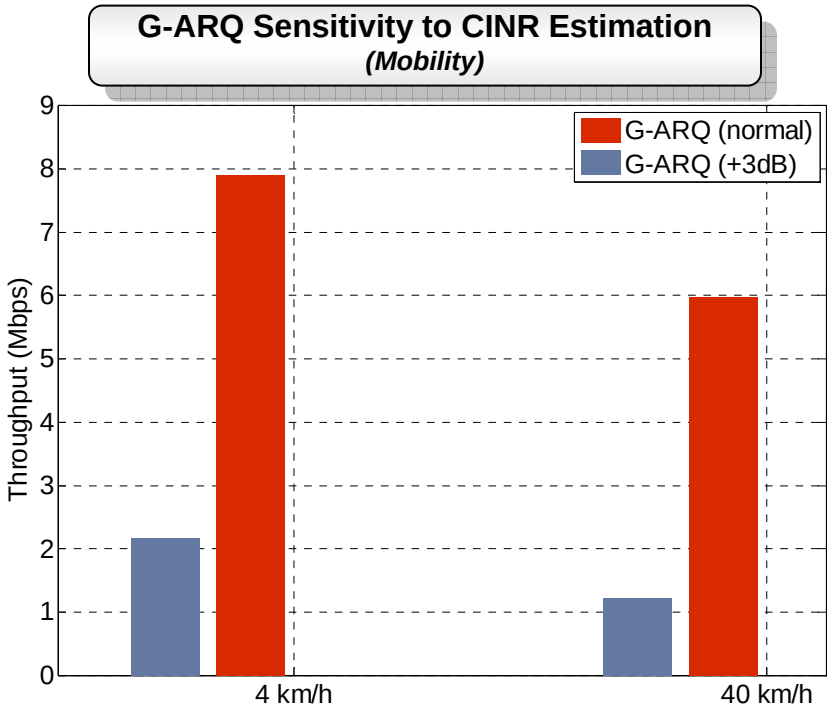


Problem of G-ARQ #2: *Sensitivity to CINR*

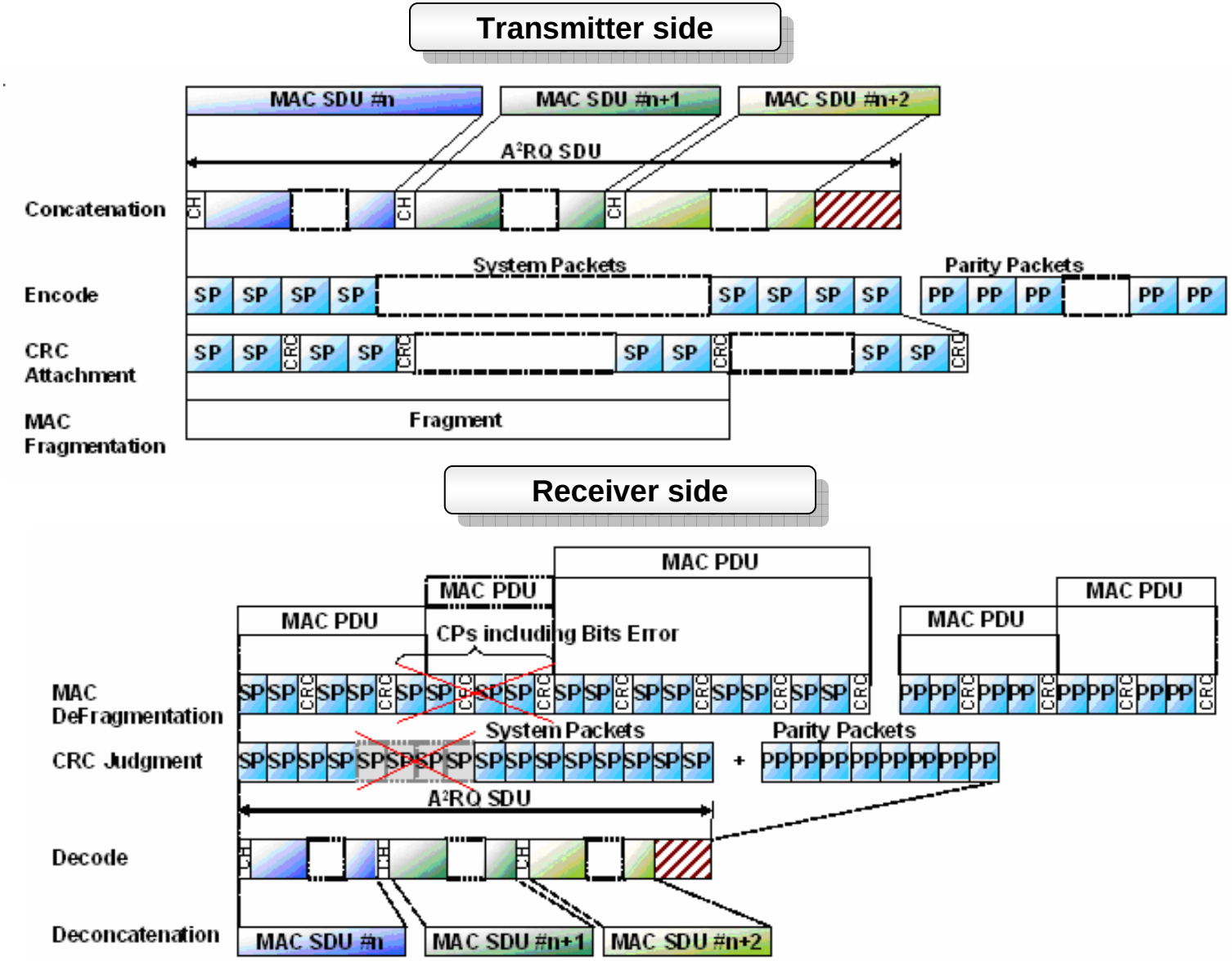
- The system performance is highly sensitive to the CINR estimation.
  - A slight shift of CINR estimation may cause *significant* throughput drop.

Simulation condition	
Parameter	Value
Velocity	0km/h, 4/km/h, 40km/h
Traffic model	Full buffer model
CINR	Normal, Normal+3dB



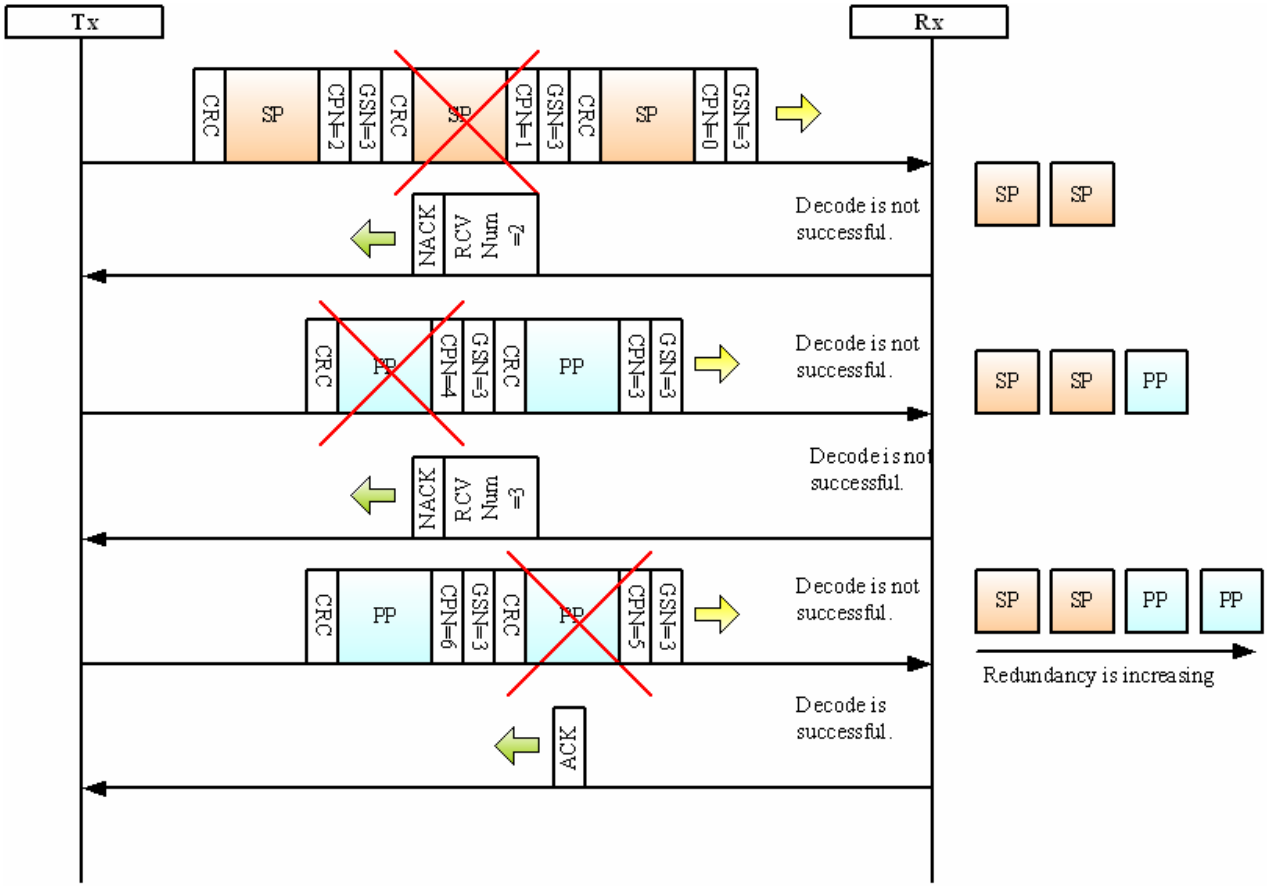


A²RQ: Basic Data Flow



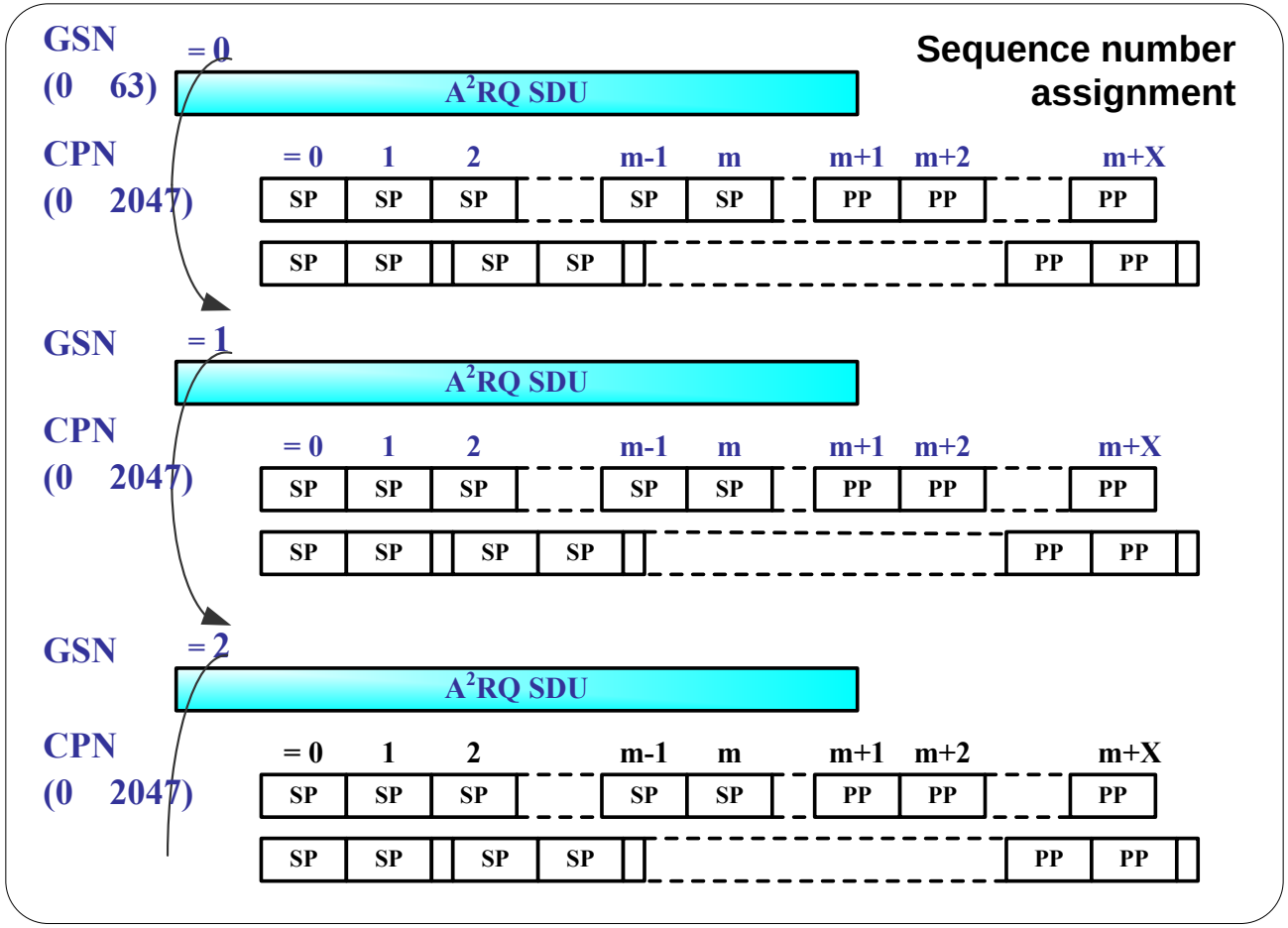
A²RQ: Sequence of Acknowledgement

- Sender transmits parity packets (PPs) in the case of receiving NACK.
- The redundancy is increasing in proportion to the number of received CPs.

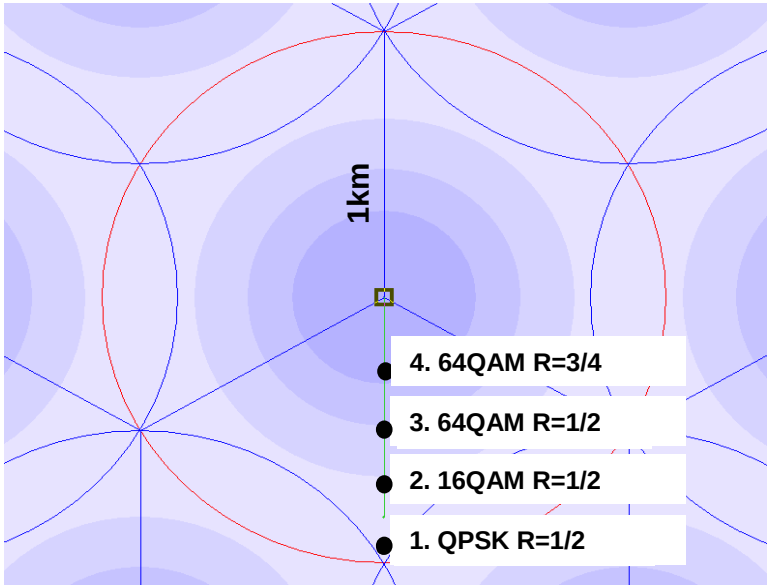


A²RQ: Large Sequence Number Space

- GSN (Group Sequence Number) for A²RQ: [0, 63].
- CPN (Coded Packet Number) for coded packets: [0, 2047].
- Total Window Size
  - A²RQ: GSN x CPN ($2^5 \times 2^{10} = 2^{15}$)
  - G-ARQ: 1024 ($=2^{10}$).



A²RQ: Simulation Conditions

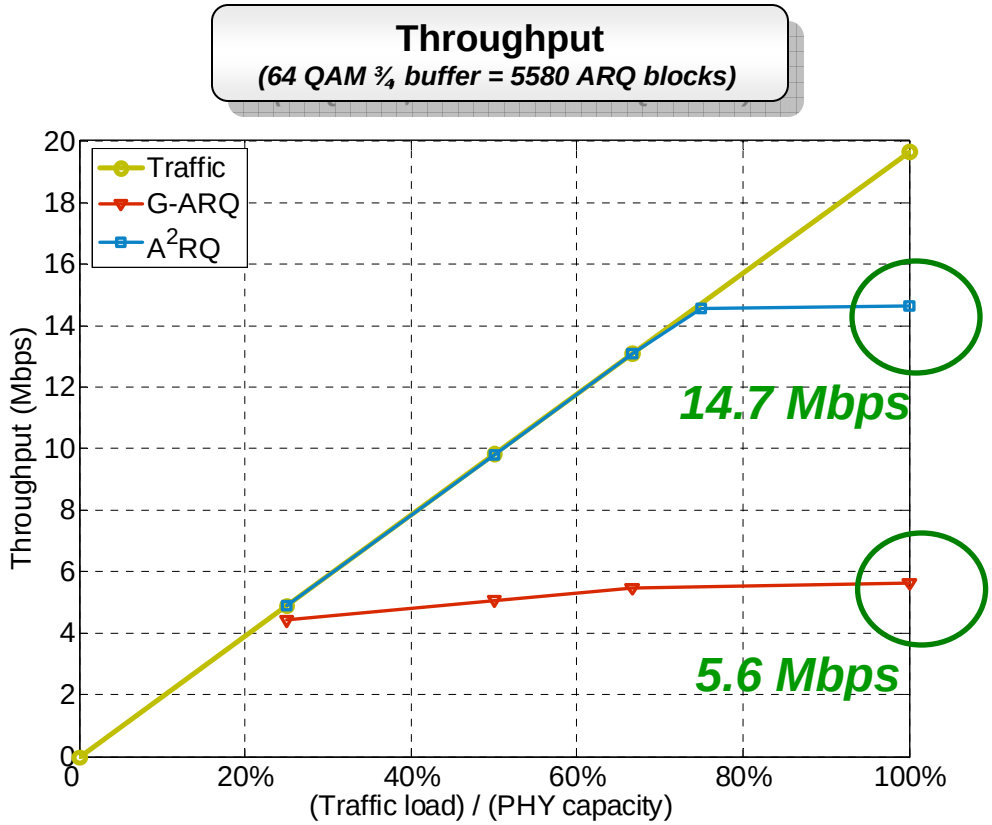


Simulation Condition		
Parameter	Value	
Channel Model	SUI	
Path loss Model	Cost 231	NLOS
Shadowing	Log normal Shadowing	
Cell Number	19 cells	
Number of user	1	Center cell
User Position	1. QPSK R=1/2 2. 16QAM R=1/2 3. 64QAM R=1/2 4. 64QAM R=3/4	Refer to the figure above.

Simulation Condition Cont'			
Center Frequency [GHz]		2.6	
Bandwidth [MHz]		10	
BS Tx Power [W]		10	
Mobility		Fixed Pedestrian Vehicular	0km/h 4km/h 40km/h
Required BER		10^{-3}	
Maximum MAC PDU Size		2047	
ACK Period [frame]		10	
G-ARQ	ARQ Window Size	1024	
	ARQ Block Size	128	
A-ARQ	Max CP Size [Byte]	128	
	Num of Initial PP	0	First transmission attempt
	Num of additional PP	9	Subsequent transmission contingent upon the failure of initial transmission
MAC Scheduler		PF	
Traffic Load Factor [%]		*100,66,50, 33,25*	
Simulation time		5100 frames	

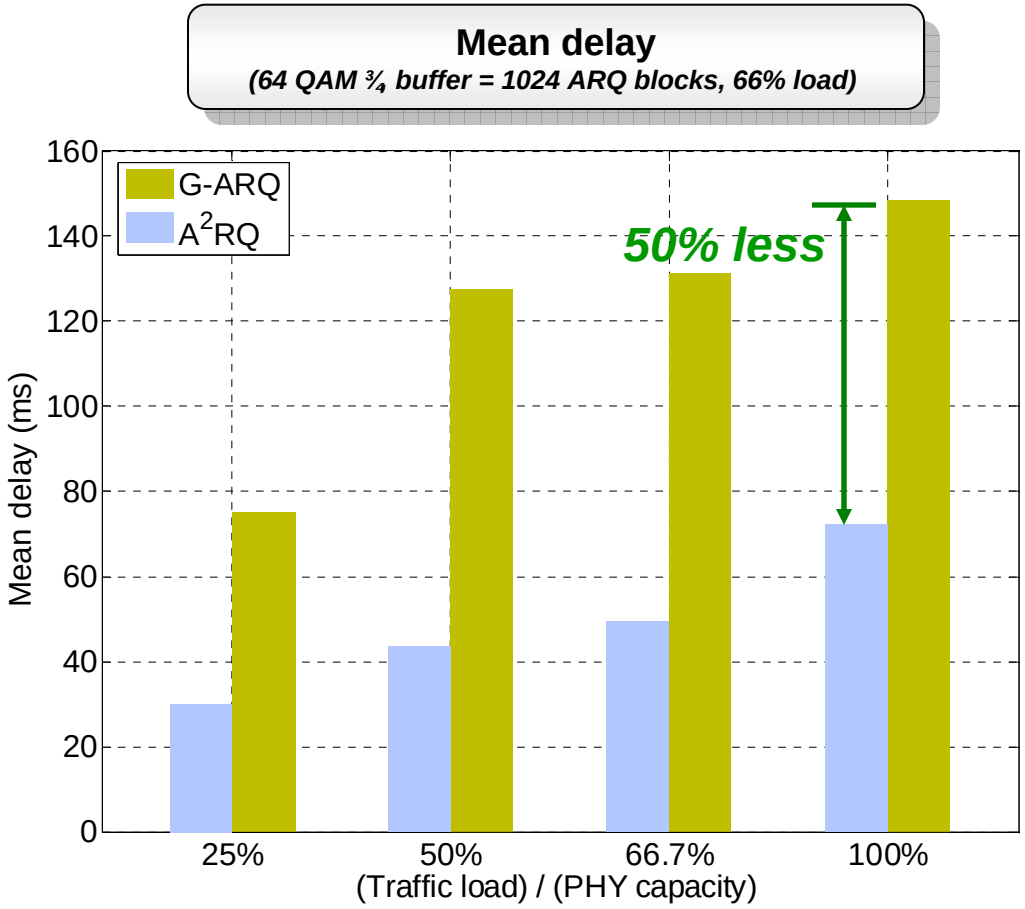
A²RQ: Throughput Performance

- **Major findings** (ACK period = 10 frames):
  - G-ARQ seriously suffers from the window lock effect, while A²RQ does not.
  - A²RQ significantly outperforms G-ARQ (*2.6* times higher)



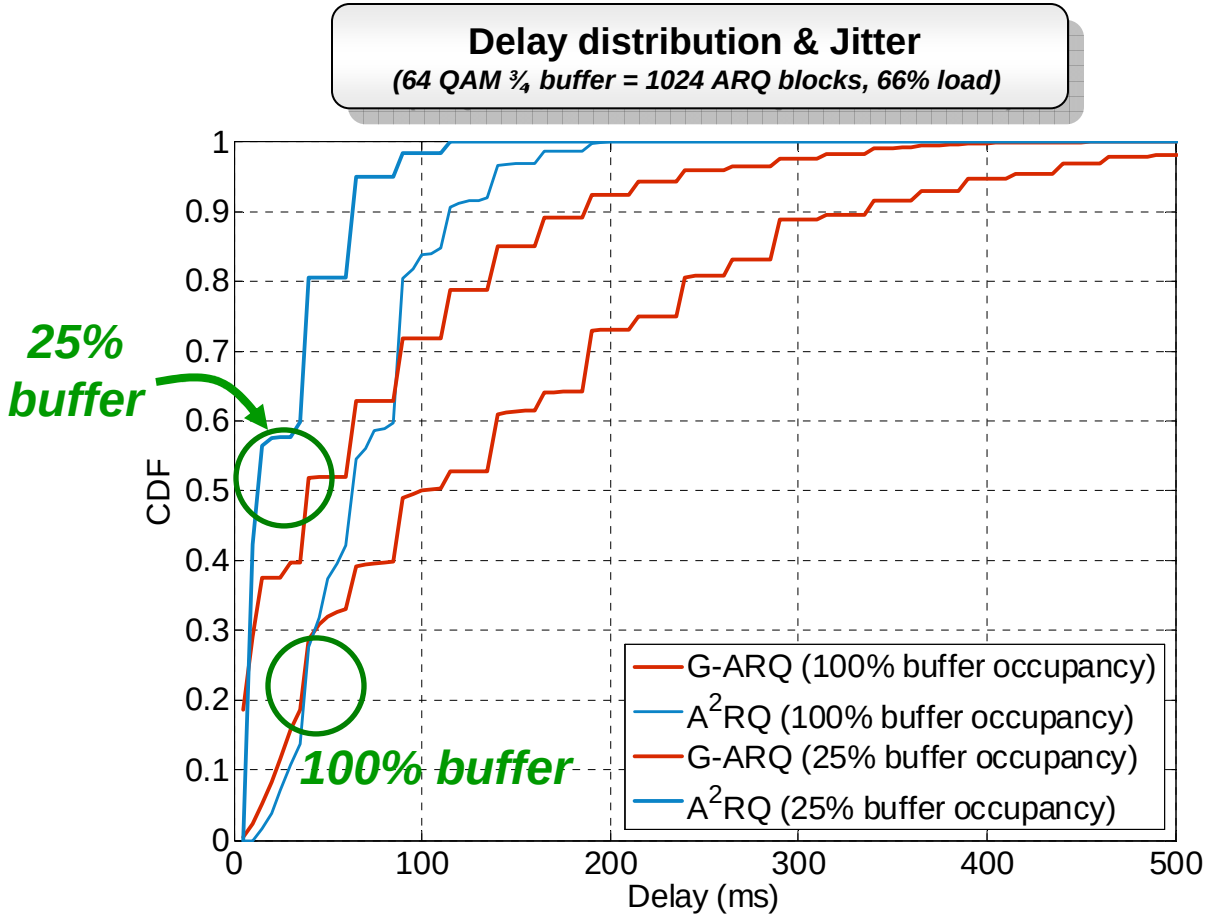
A²RQ: Delay Performance

- **Major findings** (ACK period = 10 frames):
  - A²RQ has much shorter average delay than G-ARQ.



A²RQ: Jitter Performance

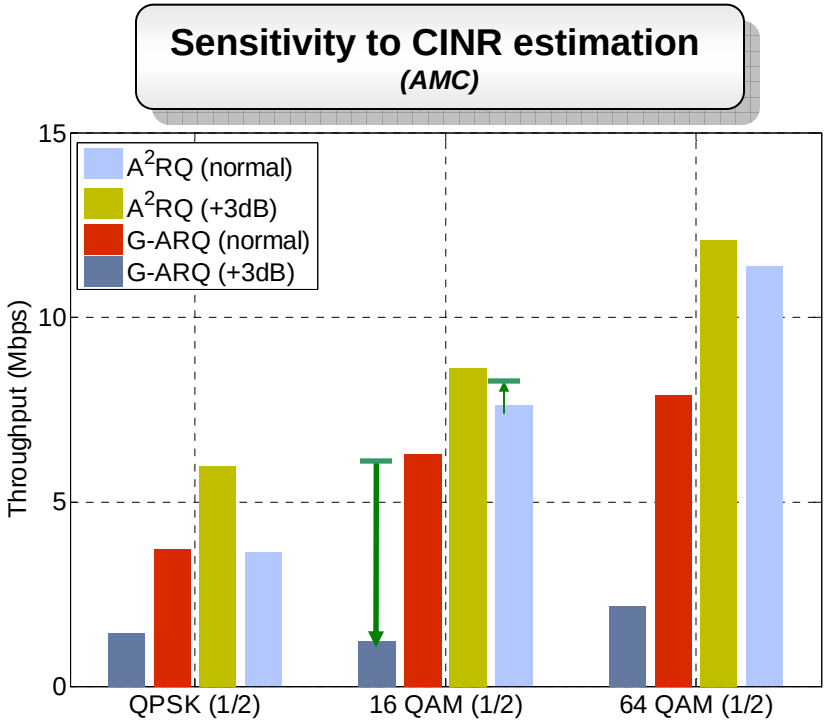
- **Major findings** (ACK period = 10 frames):
  - G-ARQ: maximum delay is 500 ms
  - A²RQ: maximum delay is 190 ms
  - A²RQ experiences much smaller jitter than G-ARQ.

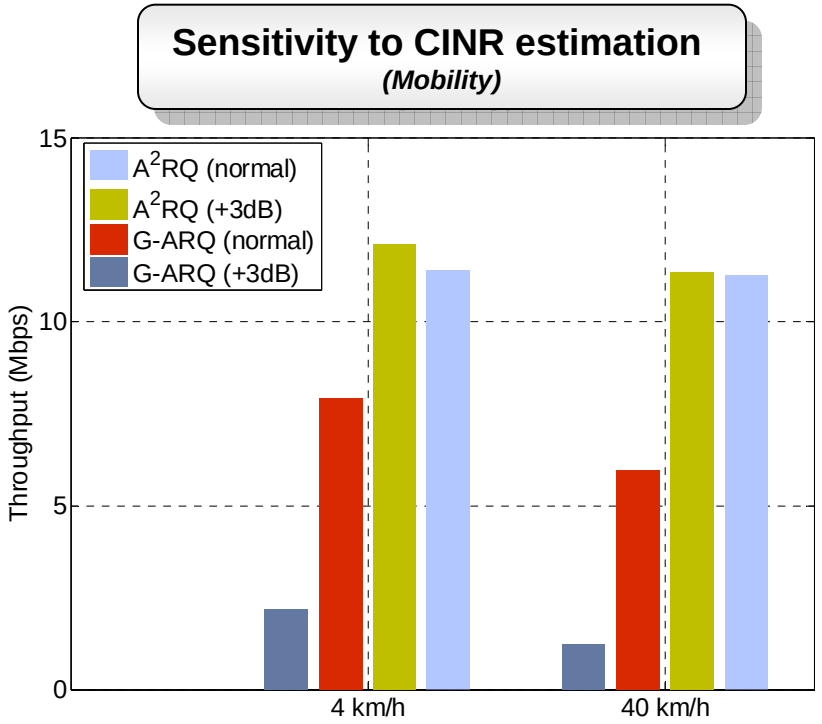


A²RQ: Sensitivity to CINR Estimation

- **Major findings** (ACK period = 10 frames):
  - A²RQ dampens the undesirable sensitivity to CINR estimation shift
  - When we have 3dB offset, throughput of G-ARQ decreases sharply, while A²RQ maintains a stable performance.

Simulation Condition	
Parameter	Value
Velocity	0km/h, 4/km/h, 40km/h
Traffic model	Full buffer model
CINR	Normal, Normal+3dB
ACK Period	10 Frames





Key Observations & Summary

- Several severe problems of G-ARQ have been observed, which lead to dismal performance degradation.
  - Window lock
  - Oversensitivity to CINR estimation

- As a result, when G-ARQ is directly applied on relay links, it cannot deliver the throughput, delay and jitter performance as demanded.

- An advanced ARQ (A^2RQ) addresses these issues, and consequently can achieve:
  - High throughput
  - Low delay
  - Small jitter
  - Improved reliability
  - With relatively low additional complexity

- To transport aggregated connections/traffic on relay links between BS and RS, A^2RQ provides a solution with superior performance.

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