Selective Periodic Component Carrier Assignment Technique in LTE and LTE-A Systems

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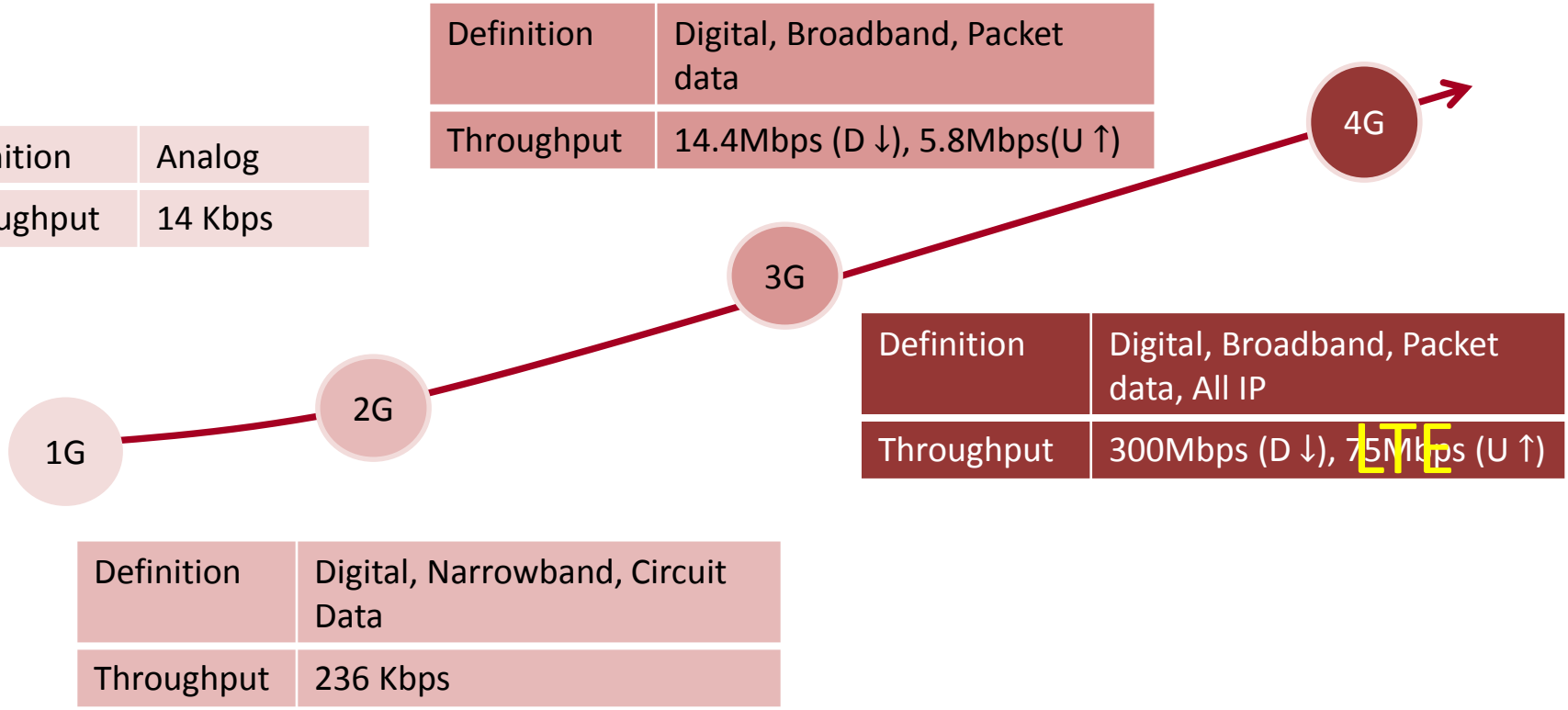
Outlines

- Introduction
- Periodic Carrier Assignment Techniques
- Analysis
- Results
- Conclusion

Communication Speed Over Generation



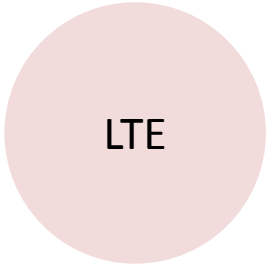
Definition	Analog
Throughput	14 Kbps

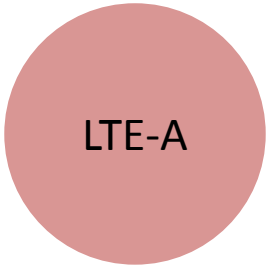
Definition	Digital, Broadband, Packet data
Throughput	14.4Mbps (D ↓), 5.8Mbps(U ↑)

Definition	Digital, Broadband, Packet data, All IP
Throughput	300Mbps (D ↓), 75Mbps (U ↑)

Definition	Digital, Narrowband, Circuit Data
Throughput	236 Kbps

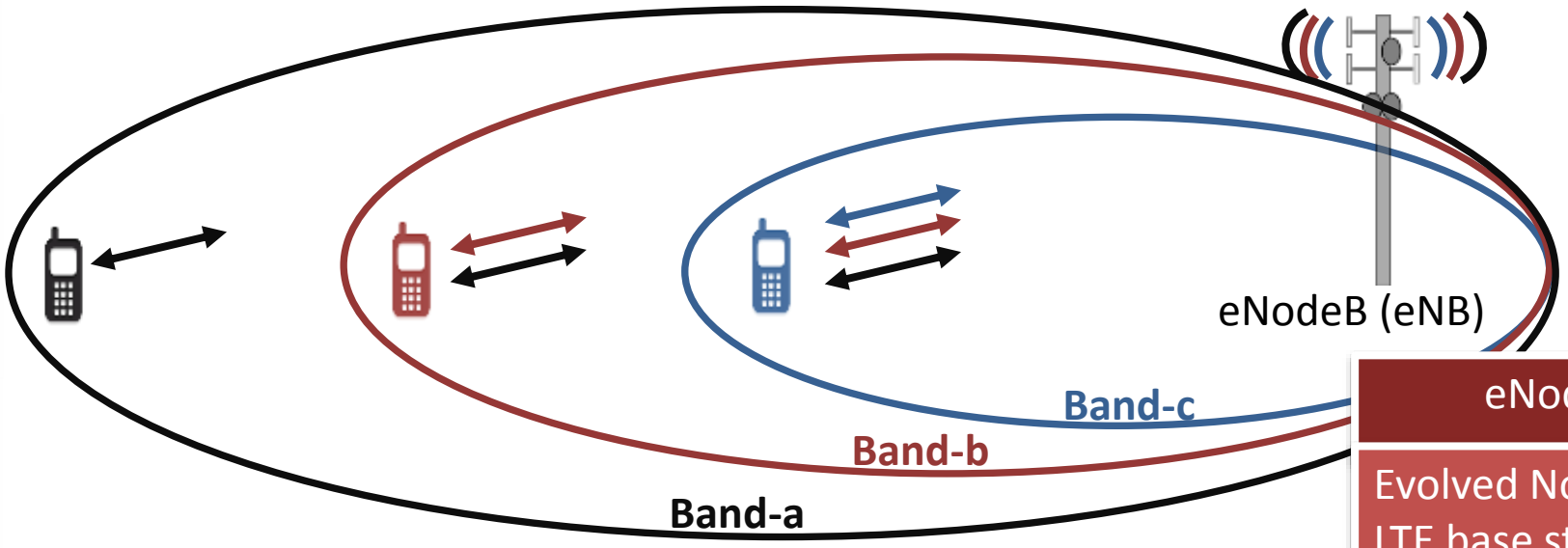
LTE and LTE-A





Theoretical Throughput	300Mbps (D ↓) - 75Mbps (U ↑)	3Gbps (D ↓) - 1.5Gbps (U ↑)
Experienced Throughput	13Mbps (D ↓) crowded area	
Technology	OFDMA (D ↓), SC-FDMA (U ↑)	OFDMA, CA, RN, MIMO

Carrier Aggregation (CA)



eNodeB

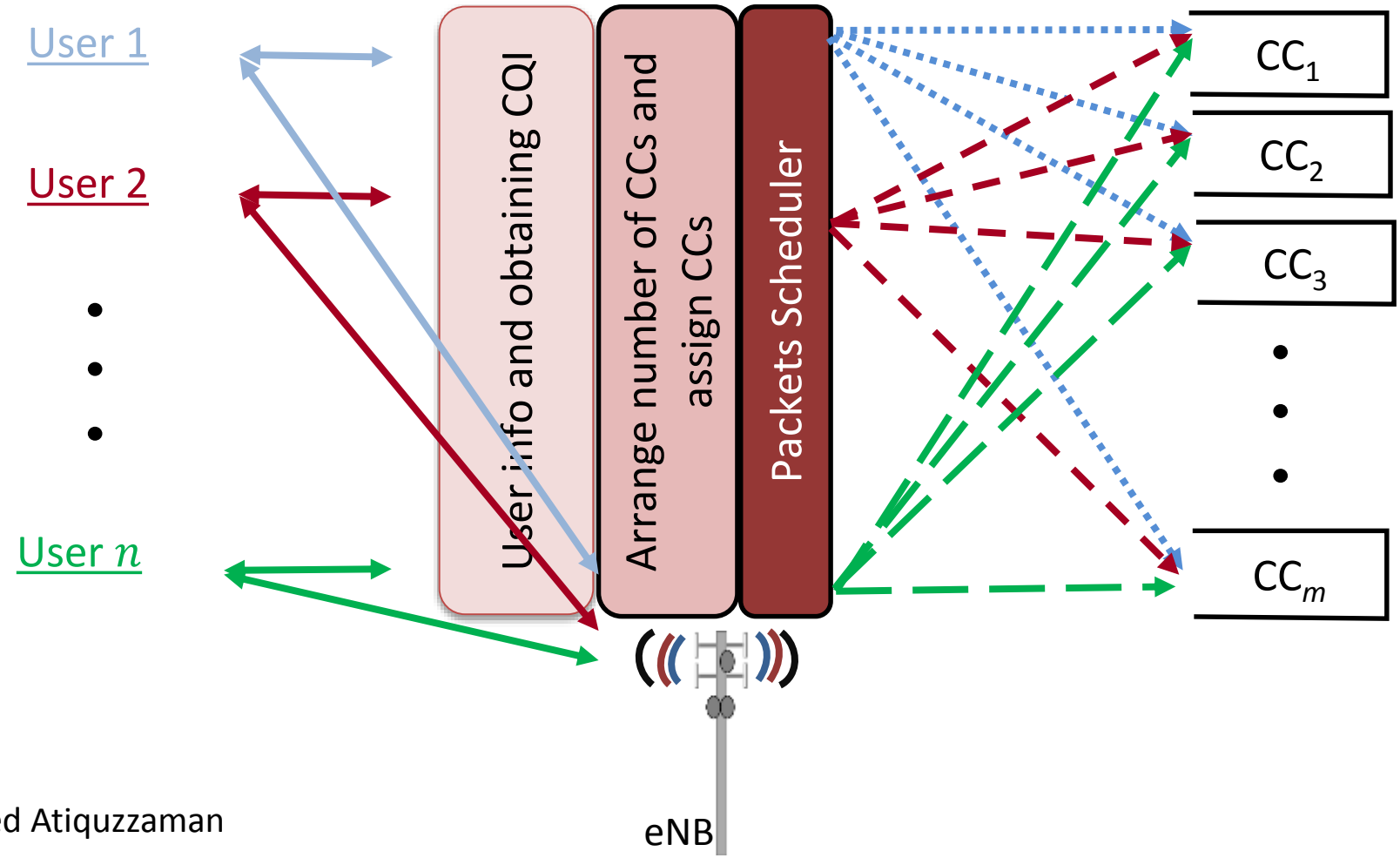
Evolved Node B:
LTE base station

Secondary Component Carriers

Primary Component Carrier

Up to 5 Carrier Components (CC) for downlink and uplink

Carrier Assignment with Packet Scheduling



Periodic Carrier Assignment

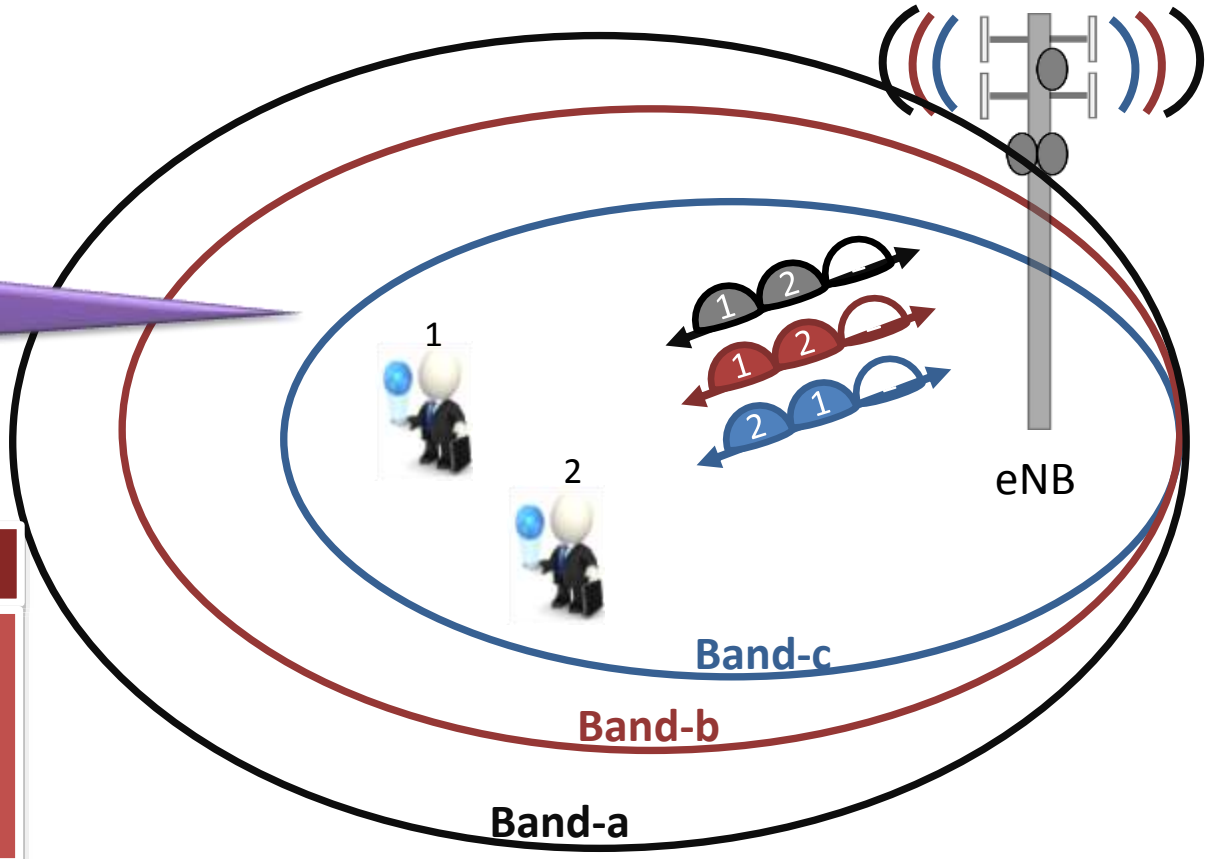
Can performance of Periodic Reassignment of components carriers be improved?

$t = 21$

Disadvantage:
All component carriers are jointly assigned at the same time.

Definition

Therefore, such assignment is called as Joint Periodic Component Carrier Assignment.



Objective

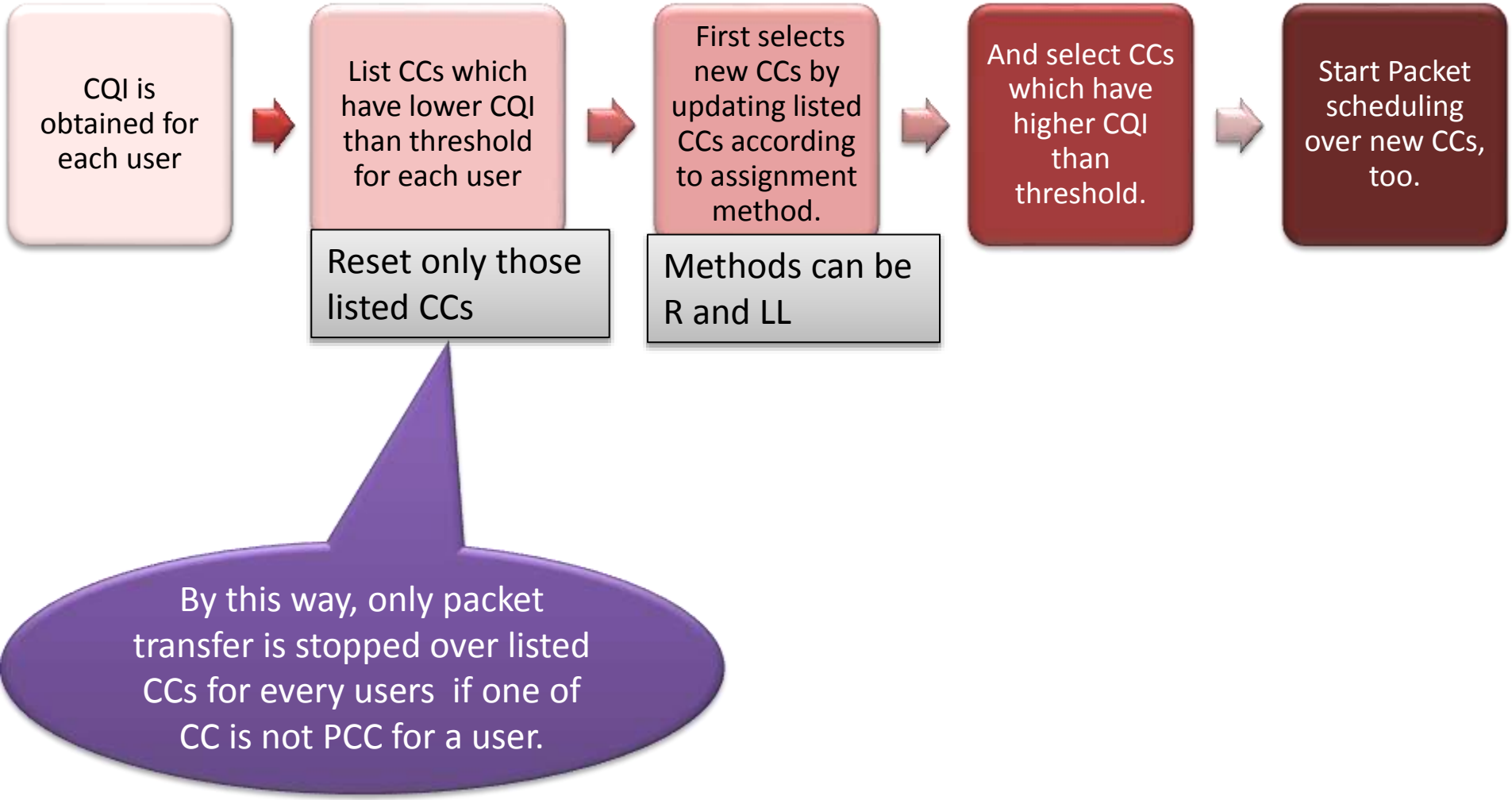
Proposing **selective** *periodic component carrier* assignment technique (s-pCCA) to increase the performance of *periodic component carrier* assignment method (which can also be called as *Joint Periodic Component Carrier Assignment*) for LTE and LTE-A systems

Periodic Carrier Assignment Cases (For both Joint and Selective)

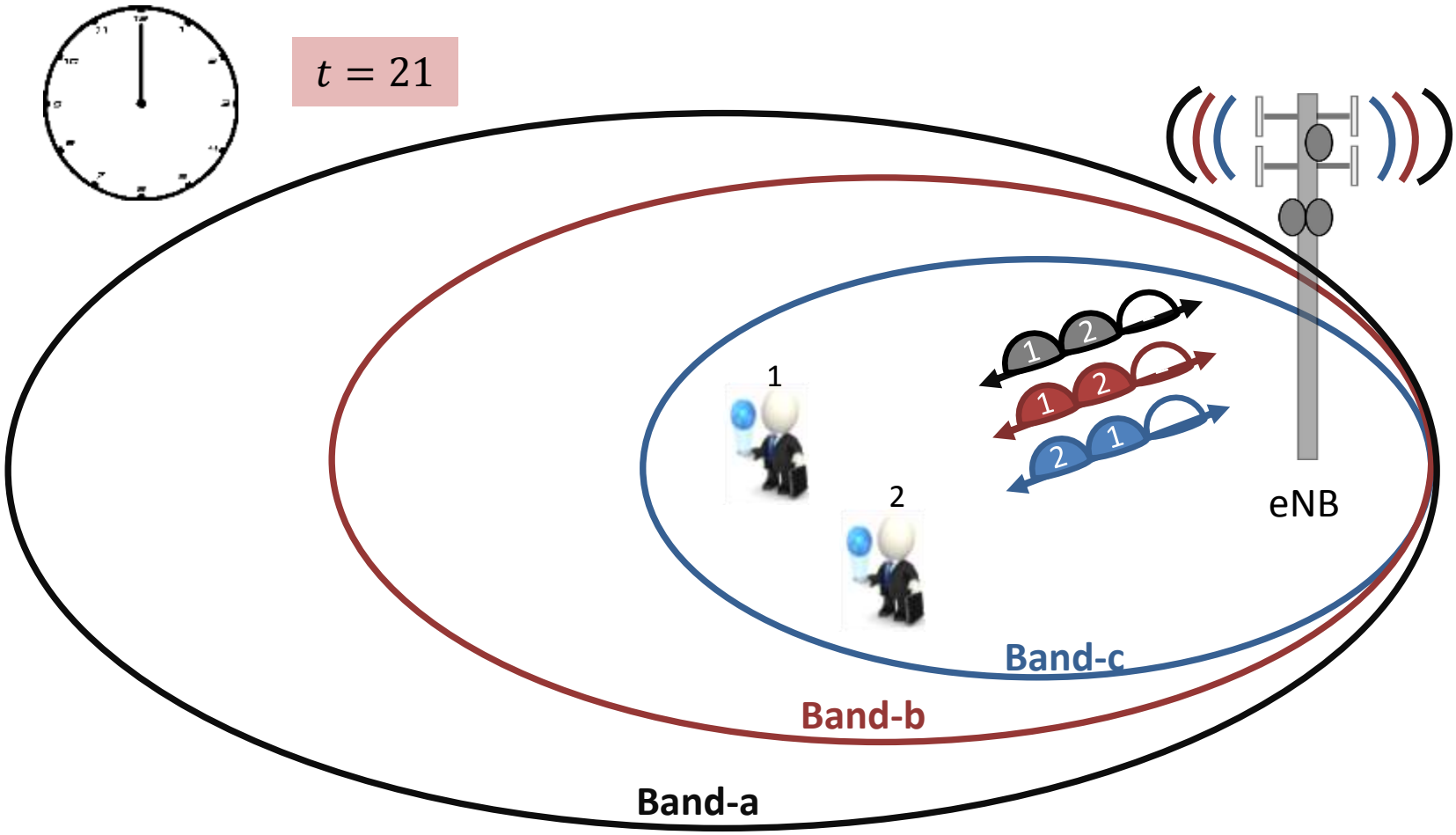
- Case 1: PCC is required to be updated, therefore SCCs are required to be updated (This case also includes when all carriers are required to be updated).
- Case 2: *SCCs are required to be updated but PCC is not required to be updated.*

The performance metrics of joint and selective techniques are same for Case 1 because all carrier should be reassigned for both joint and selective.

Selective Periodic Carrier Assignment Process

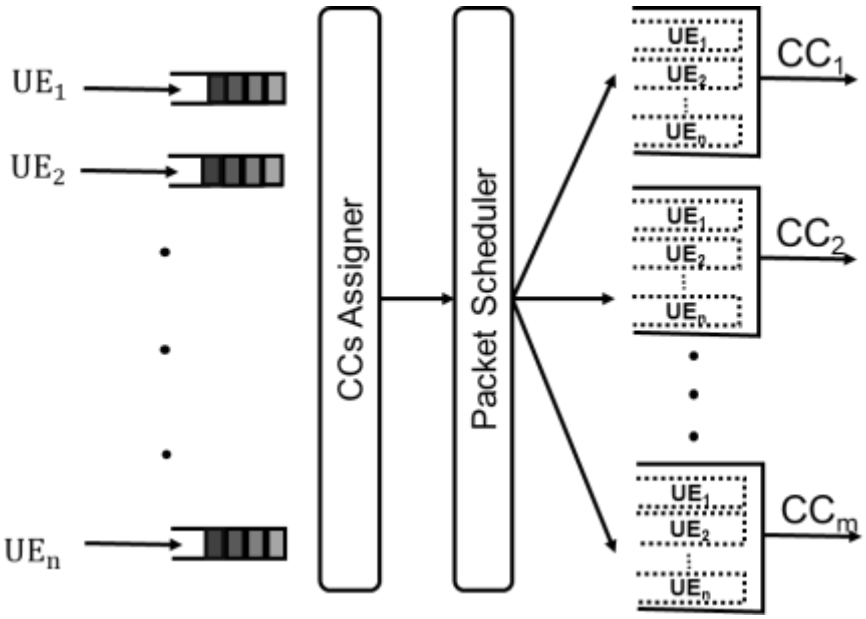


Selective Periodic Carrier Assignment Animation

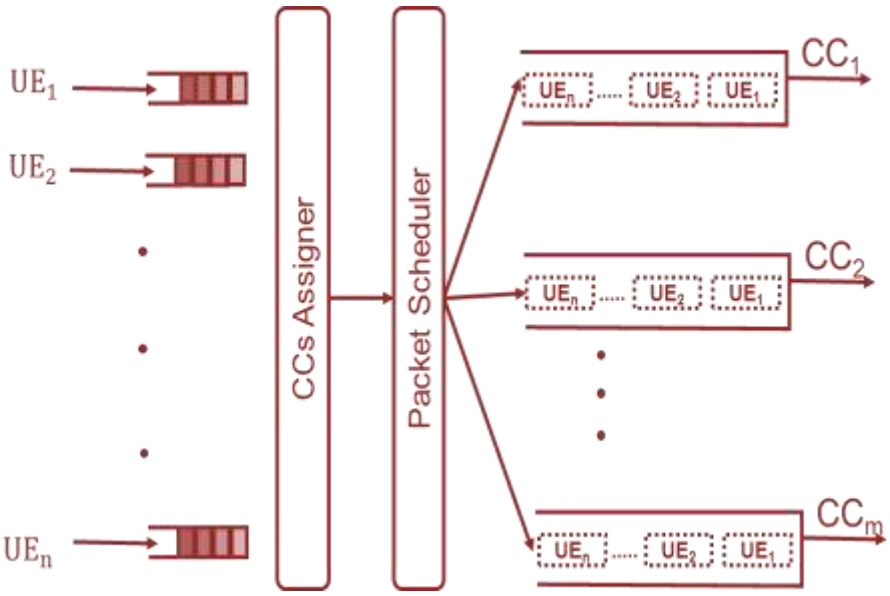


Queuing Analysis

Disjoint Queue Model



Joint Queue Model

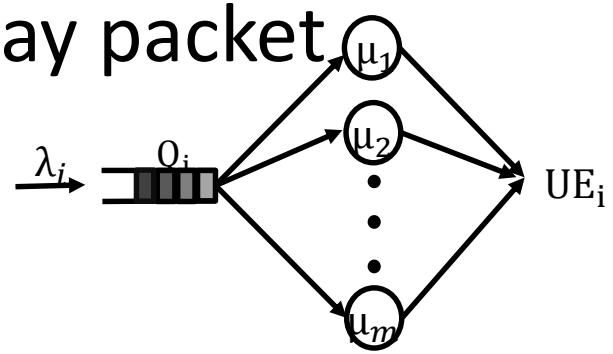


Joint queue model used in this paper

Queuing Analysis for Selective Periodic Carrier Assignment

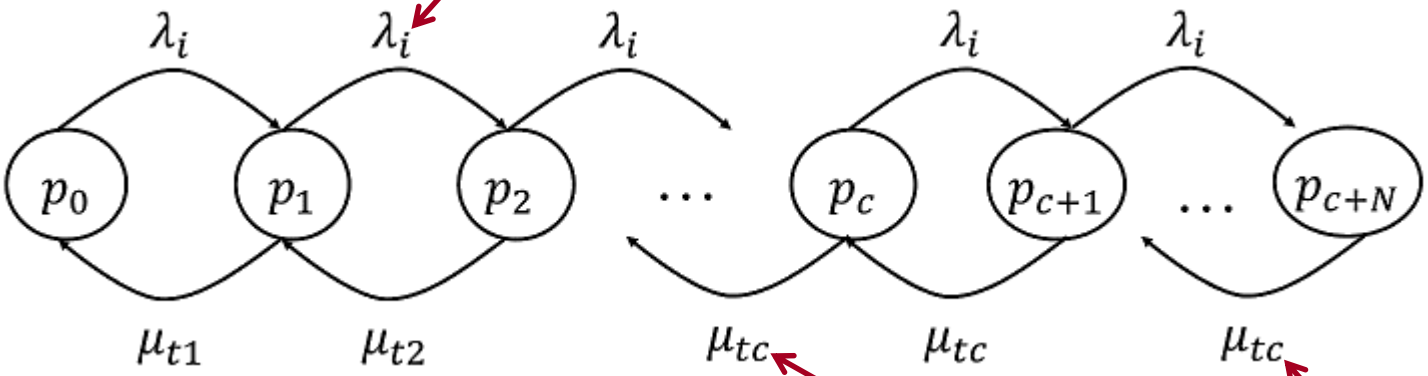
Case 2: *SCCs are required to be updated but PCC is not required to be updated.*

- Assume, one user with min-delay packet scheduling.



During carrier assignment process

λ_i: Arrival rate of user i



$$\mu_{ti} = \sum_{j=1}^{i} \mu_j$$

$$1 \le c \le m$$

Queuing Analysis for Selective Periodic Carrier Assignment

- Drop Probability : $D = p_0 \frac{\mu_{tc}^c \rho^{c+N}}{\prod_{v=1}^{c} \mu_{tv}}$

Drop probability

Rate of dropped packets from the system buffer.

$$\rho = \frac{\lambda_i}{\mu_{tc}}$$

- Occupancy: $n = \begin{cases} p_0 \frac{\mu_{tc}^c}{\prod_{v=1}^{c} \mu_{tv}} \rho^{c+1} \left(\frac{1-(N+1)\rho^N + N\rho^{N+1}}{(1-\rho)^2} \right) & \rho \neq 1 \\ p_0 \frac{\mu_{tc}^c}{\prod_{v=1}^{c} \mu_{tv}} \left(\frac{N(N+1)}{2} \right) & \rho = 1 \end{cases}$

Occupancy

Number of packets in the system buffer.

- Delay: $\delta = \frac{n}{1 - D}$

Delay

Average waiting time of a packet in the system buffer.

Queuing Analysis for Joint Periodic Carrier Assignment

- Drop Probability : $D \approx 1$

Because there is no service rate.

- Occupancy: $n \approx \infty$
- Delay: $\delta = \tau$

If we assume periodic carrier assignment takes τ time.

Simulation parameters

Num. of eNB	1
Used Bands	800MHz, 1.8GHz, 2.6GHz
Num. of CCs in Each Band	4
Total Num. of CCs	12
Queue Length of Each Queue	50 packets
Bandwidth of CCs	10MHz
Modulations	QPSK, 16QAM, and 64QAM
CQI	3, 5, 7, and 11
Transmission Time Interval	10ms
Time for CCA	20ms
CQI Threshold	5

- LTE (1 CC), LTE-A (4 CCs)
- 1/2 of users are LTE-A.
- Users are freely move around of eNB.
- Min-delay packet scheduling.
- Packet arrival follow Poisson dis. and with 250 packet arrival rate per second for each user

Results

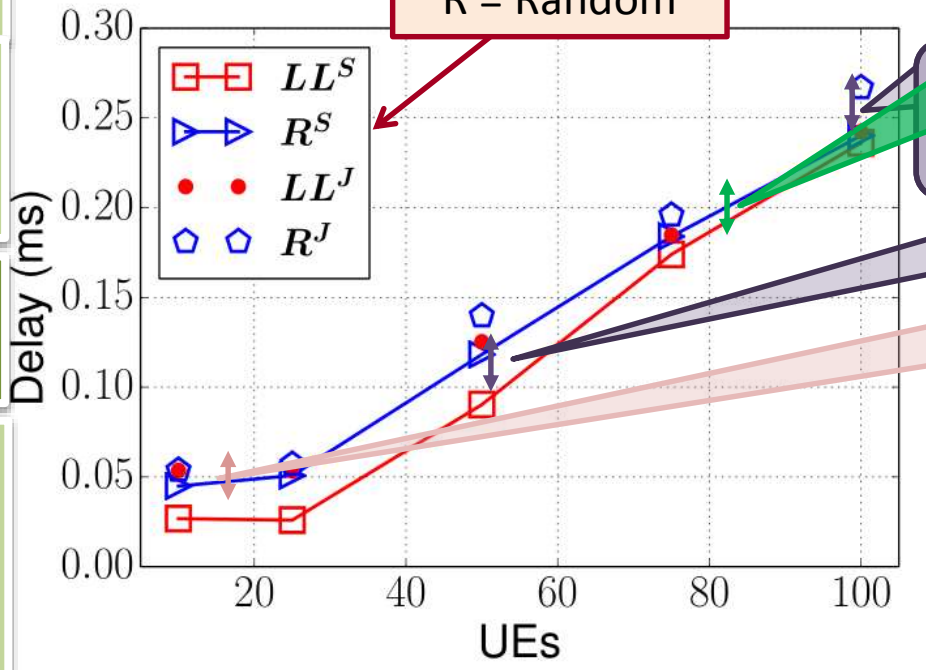
- Discrete event simulation for downlink process with periodic carrier assignment methods.
- We compare
  - LL (Least Loaded) with 4 CCs assignment to LTE-A type users and 1 CC assignment to LTE type users) for Joint and Selective techniques.
    - LL^J represents Least load carrier assignment with joint technique.
    - LL^S represents Least load carrier assignment with selective technique.
  - R (Random) with 4 CCs assignment to LTE-A type users and 1 CC assignment to LTE type users) for Joint and Selective techniques.
    - R^J represents Random carrier assignment with joint technique.
    - R^S represents Random carrier assignment with selective technique.

Joint vs Selective

Objective

Observing effects of number of users on overall delay for Joint and Selective.

S = Selective
J = Joint
LL = Least Load
R = Random



Delay gap between Joint and Selective decreases in LL when number of user increases.

Delay between Joint and Selective is significant in R when the number of user is high.

Not much delay differences between Joint and Selective when the number of user is low in R method but difference is high in LL.

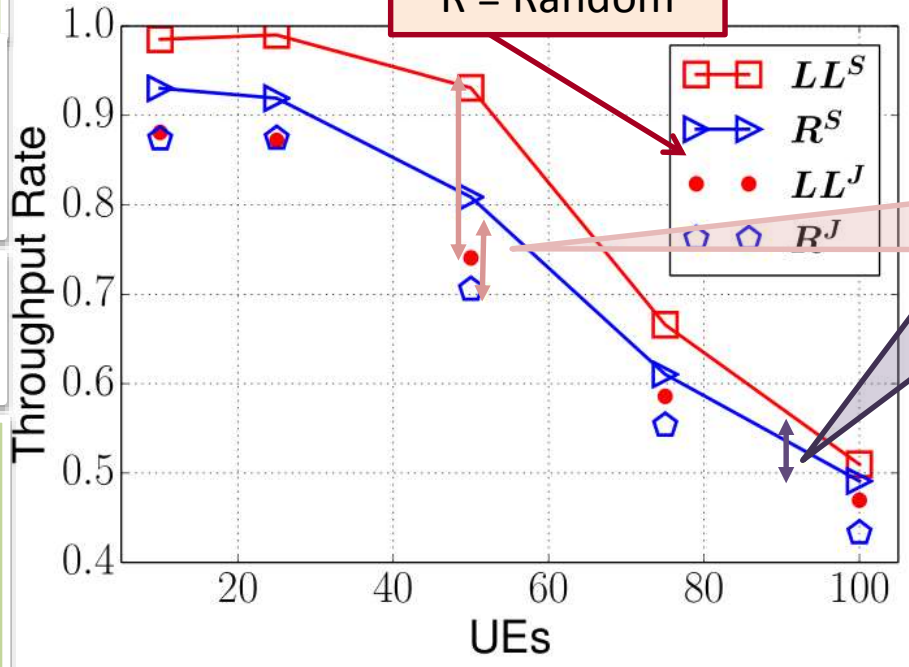
Selective technique is better than Joint technique in terms of overall delay for both R and LL.

Joint vs Selective

Objective

Observing effects of number of users on throughput for Joint and Selective.

S = Selective
J = Joint
LL = Least Load
R = Random



Throughput gap between Selective and Joint is decreasing while the number of user is increasing.

Throughput of Selective is much higher than Throughout of Joint for both LL and R.

Selective technique is better than Joint technique in terms of throughput for both R and LL.

Joint vs Selective

Objective

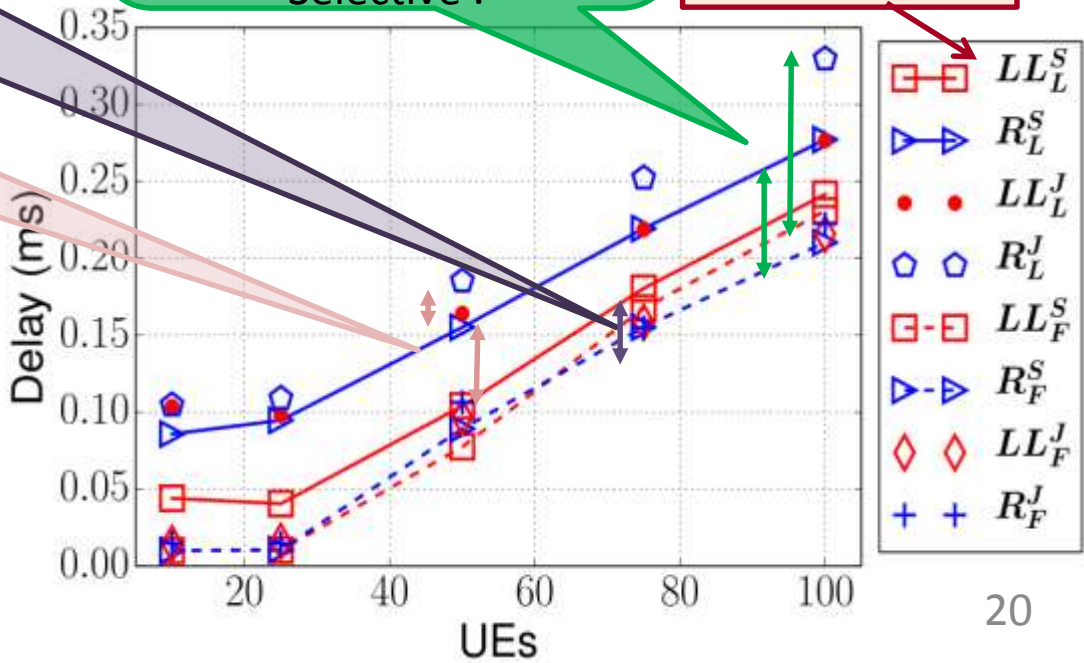
Observing effects of number of users on device base delay for Joint and Selective.

Delay of Selective is slightly lower than delay of Joint for LTE-A type device in both LL and R.

Delay gap between LTE and LTE-A type devices of Joint is much higher than delay gap between LTE and LTE-A type devices of Selective .

S = Selective
J = Joint
LL = Least Load
R = Random
L = LTE
F = LTE-A

Delay of Selective is lower than delay of Joint for LTE type device in both LL and R.



Selective technique is better than Joint technique in terms of device base delay for both LTE and LTE-A type devices in R and LL.

Joint vs Selective

Objective

Observing effects of number of users on device base throughput for Joint and Selective.

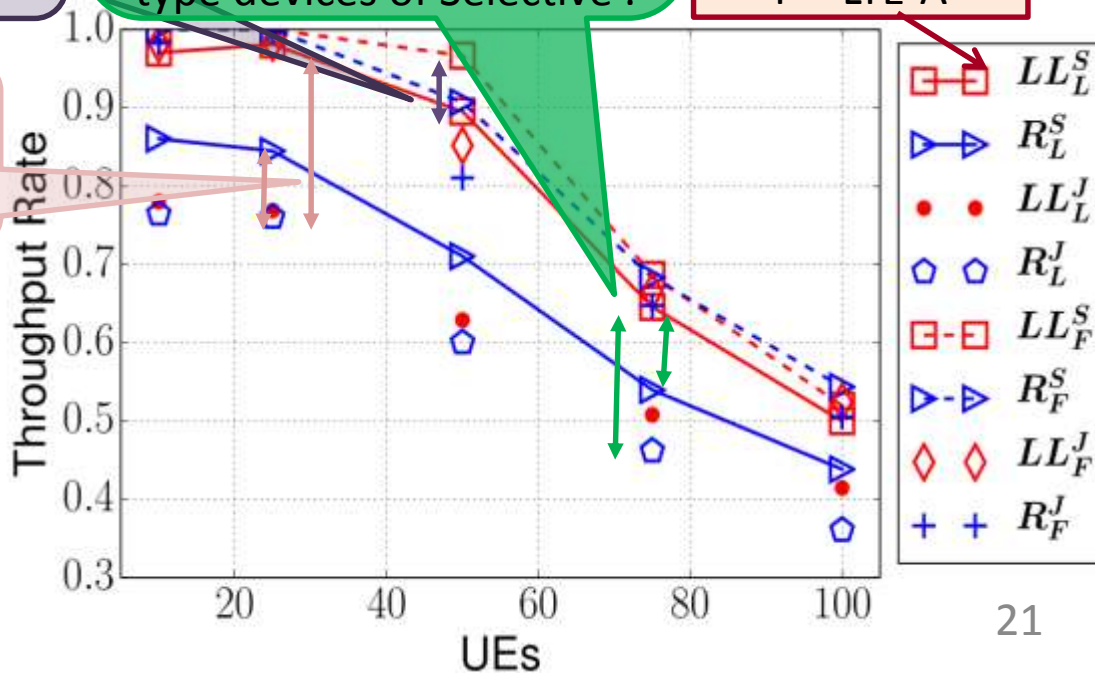
Throughput of Selective is slightly higher than throughput of Joint for LTE-A type device in both LL and R.

Throughput of Selective is higher than throughput of Joint for LTE type device in both LL and R.

Selective technique is better than Joint technique in terms of device base throughput for both LTE and LTE-A type devices in R and LL.

Throughput gap between LTE and LTE-A type devices of Joint is much higher than throughput gap between LTE and LTE-A type devices of Selective .

S = Selective
J = Joint
LL = Least Load
R = Random
L = LTE
F = LTE-A



Summary of Results

Throughput is higher up to 25% in Selective compared to Joint.

Selective vs Joint

Delay time can be decreased up to 35% for both R and LL in Selective compared to Joint.

Conclusion

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