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Joint and Partial Carrier Components Assignment Techniques Based on User Profile in LTE Systems

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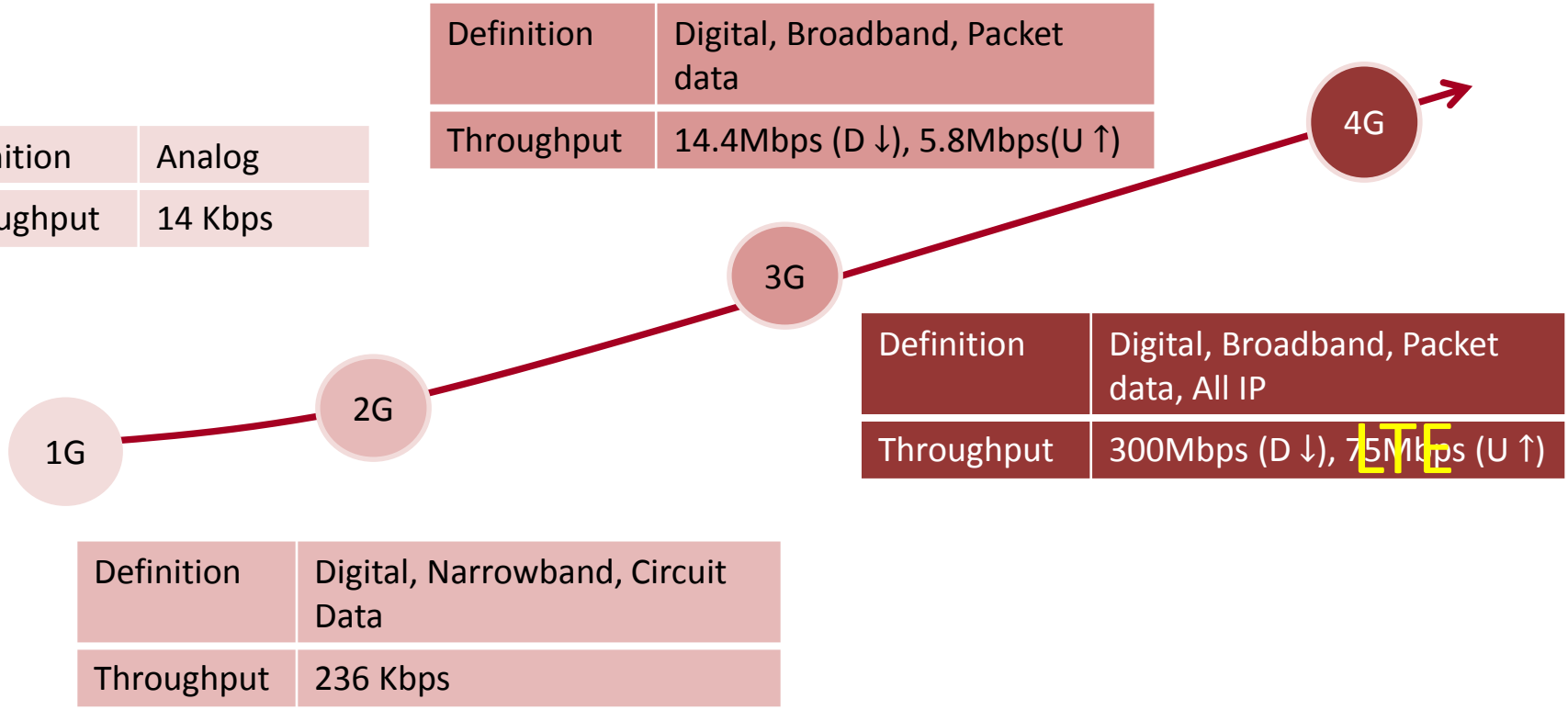
Outlines

- Introduction
- User Profile
- Analysis
  - Joint and Partial
  - Disjoint Buffer
- Results
- Conclusion

Communication Speed Over Generation



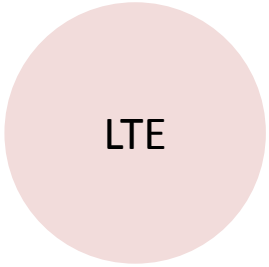
Definition	Analog
Throughput	14 Kbps

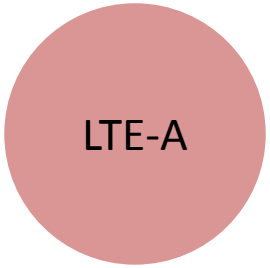
Definition	Digital, Narrowband, Circuit Data
Throughput	236 Kbps

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

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

LTE and LTE-A

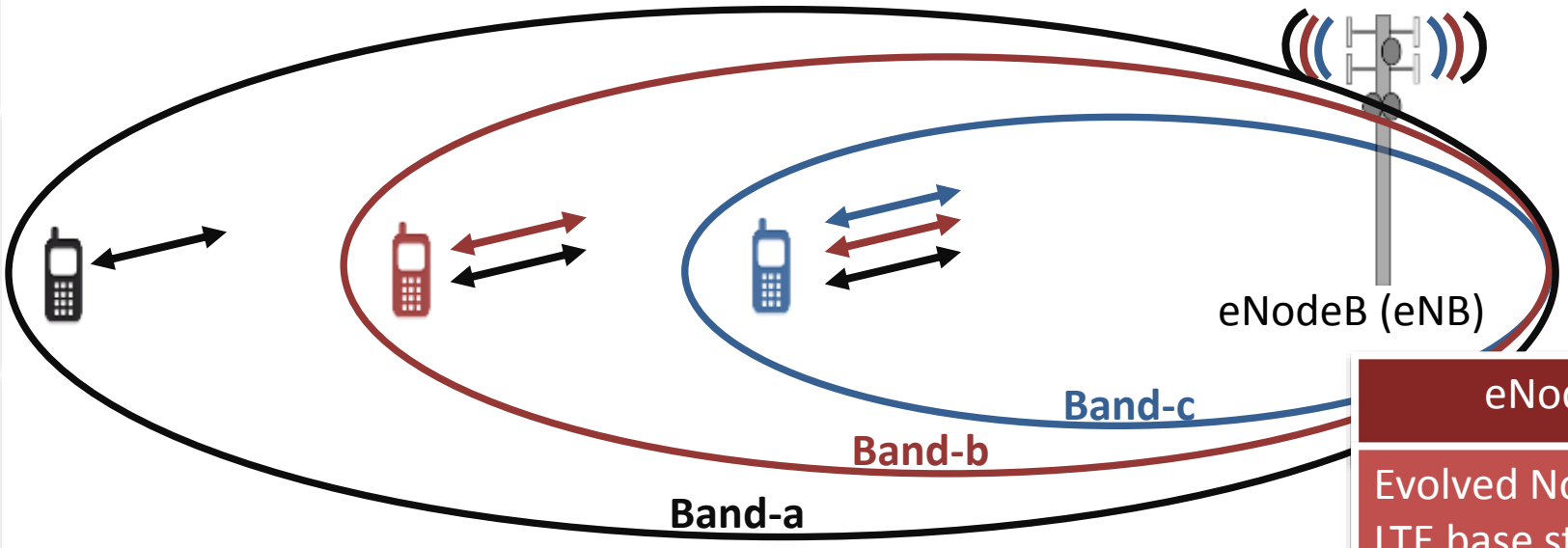




Theoretical Throughput	300Mbps (D ↓) - 75Mbps (U ↑)	3Gbps (D ↓) - 1.5Gbps (U ↑)
Experienced Throughput	13Mbps (D ↓) crowded area	
Technology	OFDMA (D ↓), SC-FDMA (U ↑)	OFDMA, CA, RN

CA

Carrier Aggregation (CA)



eNodeB

Evolved Node B:
LTE base station

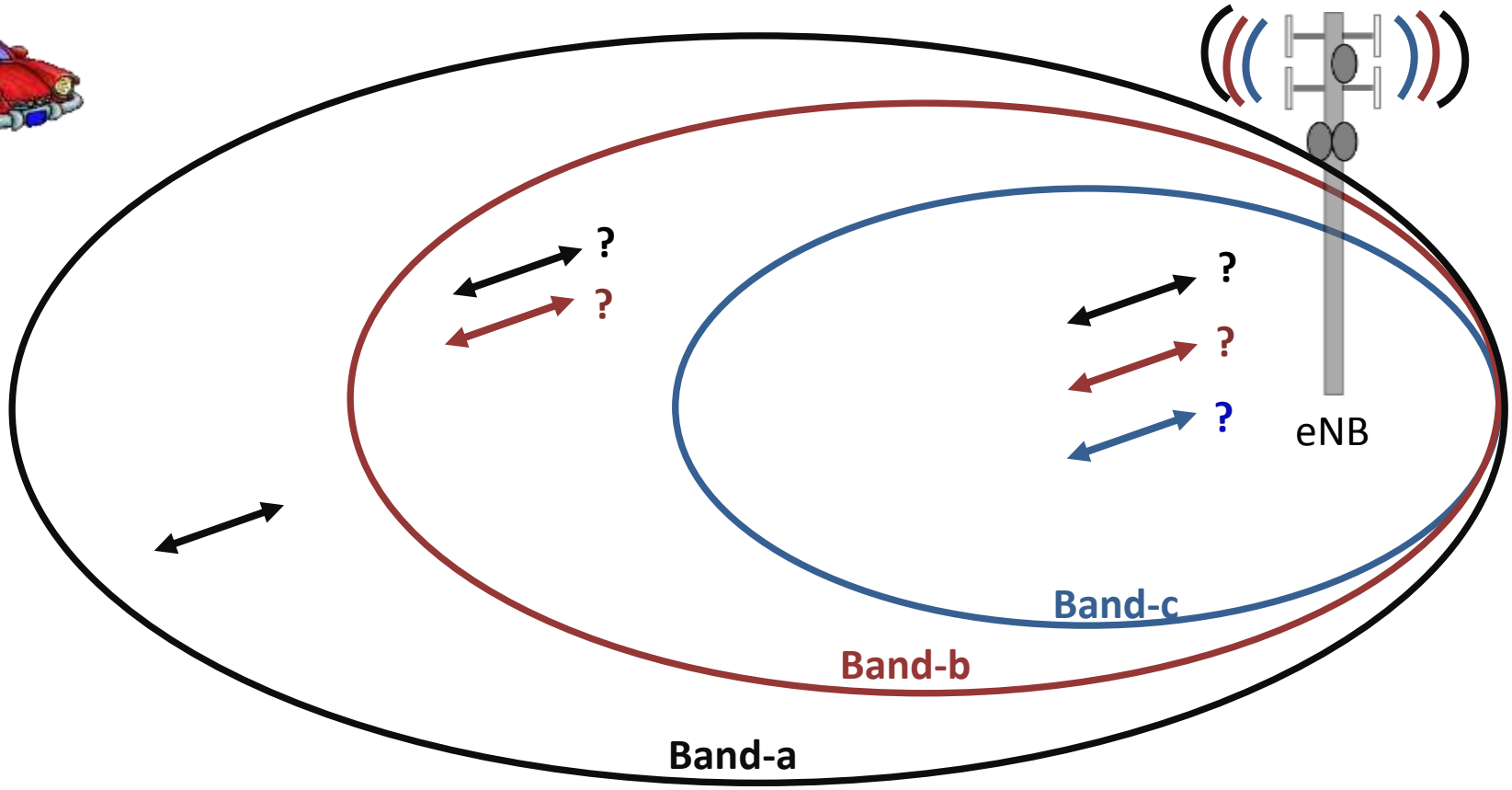
Secondary Carrier Components

Primary Carrier Component

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

First Problem

Which bands should eNB assign to each user?



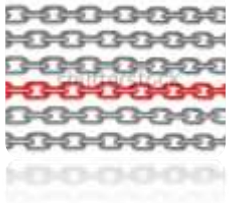
Second Problem

How many CCs should be assigned to each user?

Objective

Improve LTE systems (LTE and LTE-A) performance by proposing a novel Carrier Components assignment method.

Current Solutions



- Carrier Assignments
  - Randomly select band for each user (R)
    - Not utilize and balance bands in short term and no QoS
  - Methods based on Load Balancing
    - For example: Selecting Least Loaded band for each user (LL)
  - Methods based on Channel Quality Indicator (CQI)
    - Assigning channel based on its quality
    - Providing QoS.

Current Solutions (Cont.)

- Number of Required CCs
  - How many CCs is required?

  - All of CCs can be used but increasing energy consumption of devices and interference
  - Gradually increasing number of CCs but delay if more CCs needed

User Profile Examples

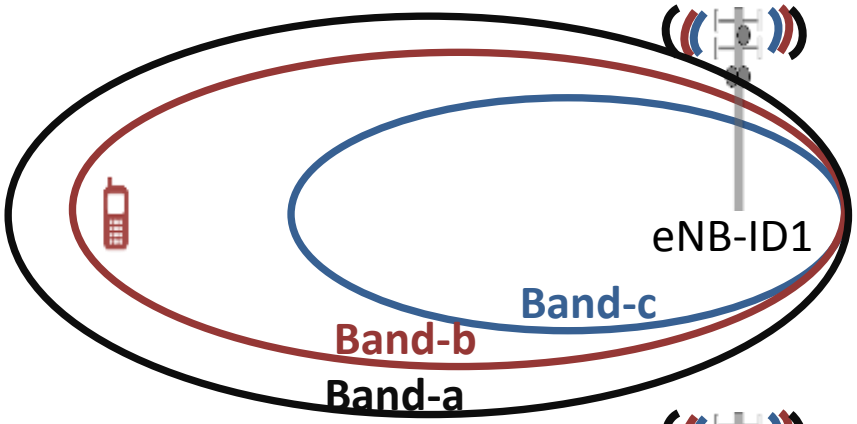
			User Profile				
			Teenager	**House wife**	**Businessman**	**Graduate Student**	**Grand Parent**
Traffic Types	**RT**	**Video**	Very High	Middle	Low	Medium	Low
		Online game	Very High	Low	Low	Medium	Low
		Movie	Very High	Very High	Low	Medium	Low
		Talk	Low	Medium	High	Medium	Very High
	NRT	**Web**	High	Low	Very High	Medium	Low
		Mail	High	Low	Very High	Medium	Low
		SMS	Very High	Medium	Low	Medium	Low
		Mobility	Low	Medium	Very High	Low	Low
		Location	Low	Medium	High	Medium	Low

Why: Carrier Assignment Based on User Profile

- User profile of each user for each eNB
  - Application type
    - What type of applications are used by users? (such as game, mail, video, talking..)
  - Data consumption
    - How much data do users use? (such as 100MB non-real time, 1GB real time)
  - Time
    - When do users mostly consume data during the day? (such as 10:00 am – 11:00 am)
  - Location
    - Where do users spend the most time during the day? (such as school, work, road …)
  - Users' device type
    - LTE (Only 1 CC), LTE-A (Up to 5 CCs)

User Profile Detection

	Band-a/Band-b/Band-c			RT Services		NRT Services	
eNB-ID	Times	Connection Time	Idle Time	Video	Game	Web	Mail
ID1	f1	c1	t1	v1	g1	w1	m1
ID2	f2	c2	t2	v2	g2	w2	m2
ID3	f3	c3	t3	v3	g3	w3	m3
ID4	f4	c4	t4	v4	g4	w4	m4



Statistical examples:

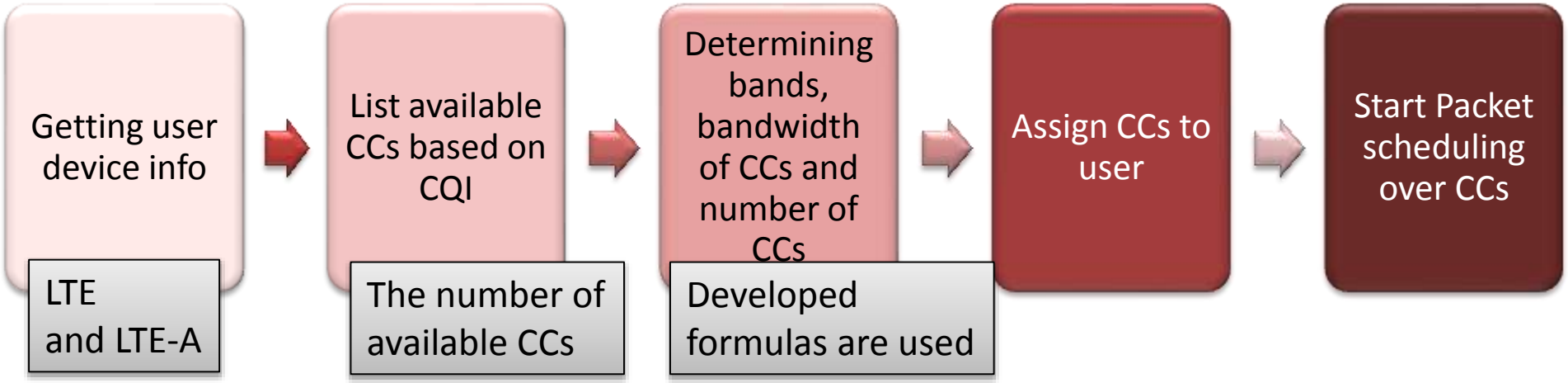
$$\Delta T_j^i = 100\ x\ \frac{f_1}{\sum_{s=1}^{k} f_s}$$

$$\Delta C_j^i = 100\ x\ \frac{c_1}{\sum_{s=1}^{k} c_s}$$

Examples

- Case1: Higher ΔC and lower ΔT
- Case2: Lower ΔC and higher ΔT

Carrier Assignment Based on User Profile

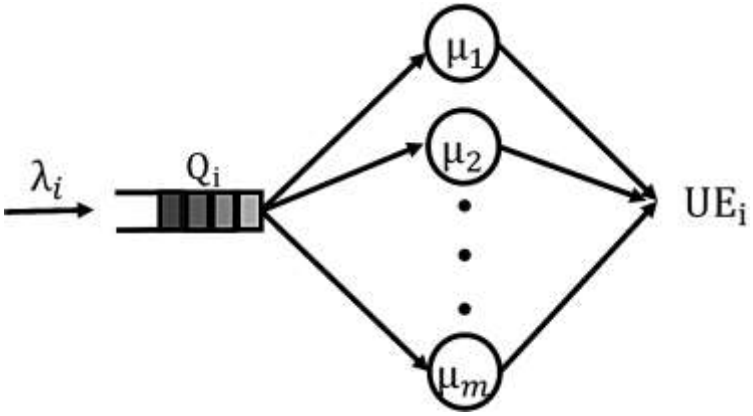


Band is determined by using active number of users and their data usage

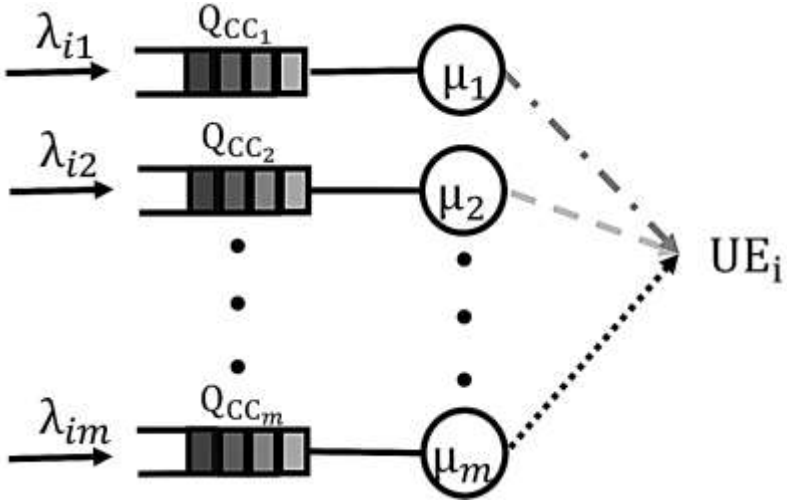
$$MAX\ \{\alpha = \frac{maximum\ user\ capacity\ in\ a\ band}{Active\ users\ in\ a\ band} * \text{Con. Time}\}$$

$$CC = a\ user\ data\ usage / \frac{maximum\ packet\ capacity\ in\ a\ band}{Sum\ of\ all\ of\ packet\ arrival\ rates\ in\ a\ band}$$

Disjoint Buffers



Joint Buffer System

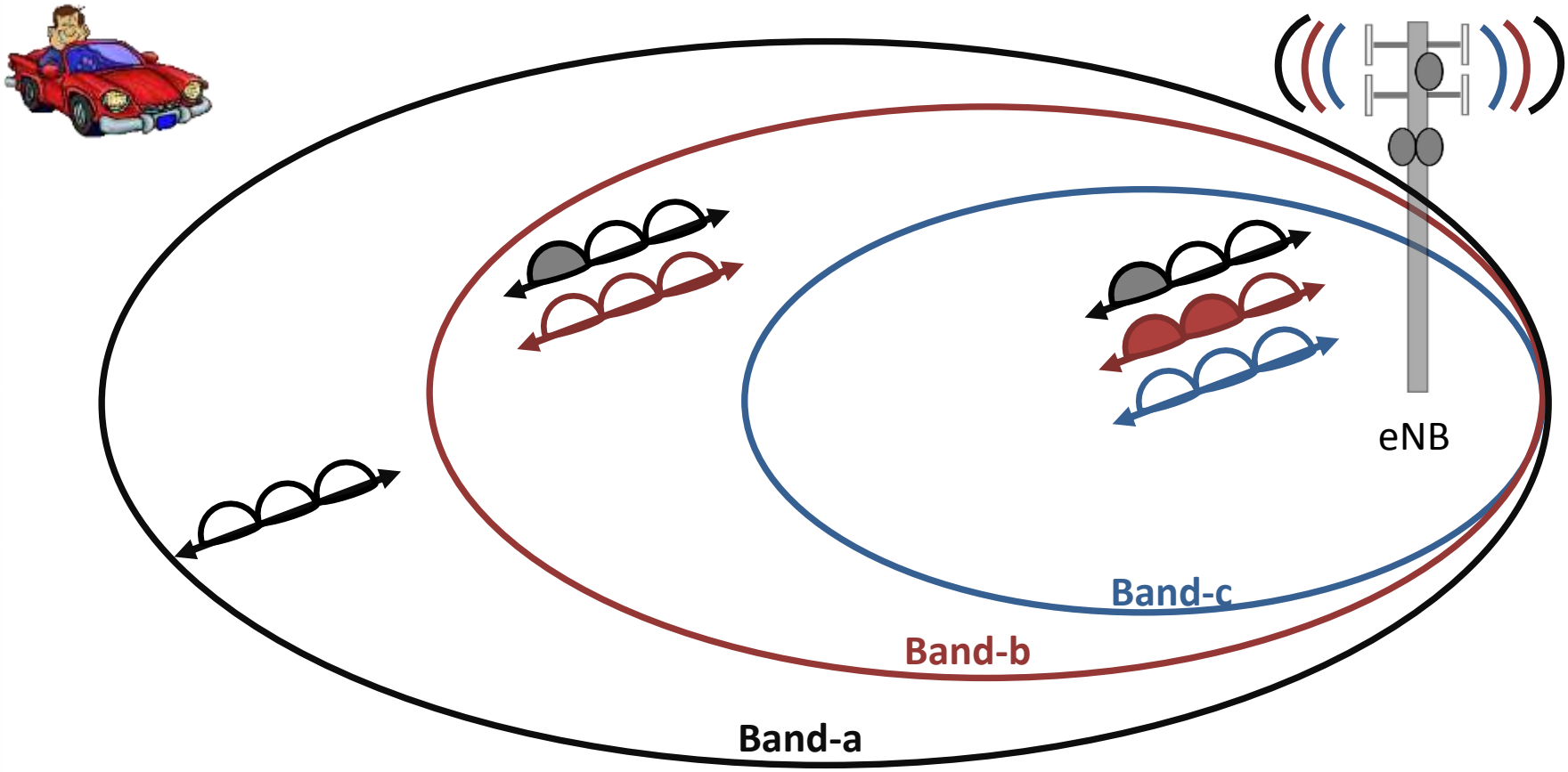


Disjoint Buffer System

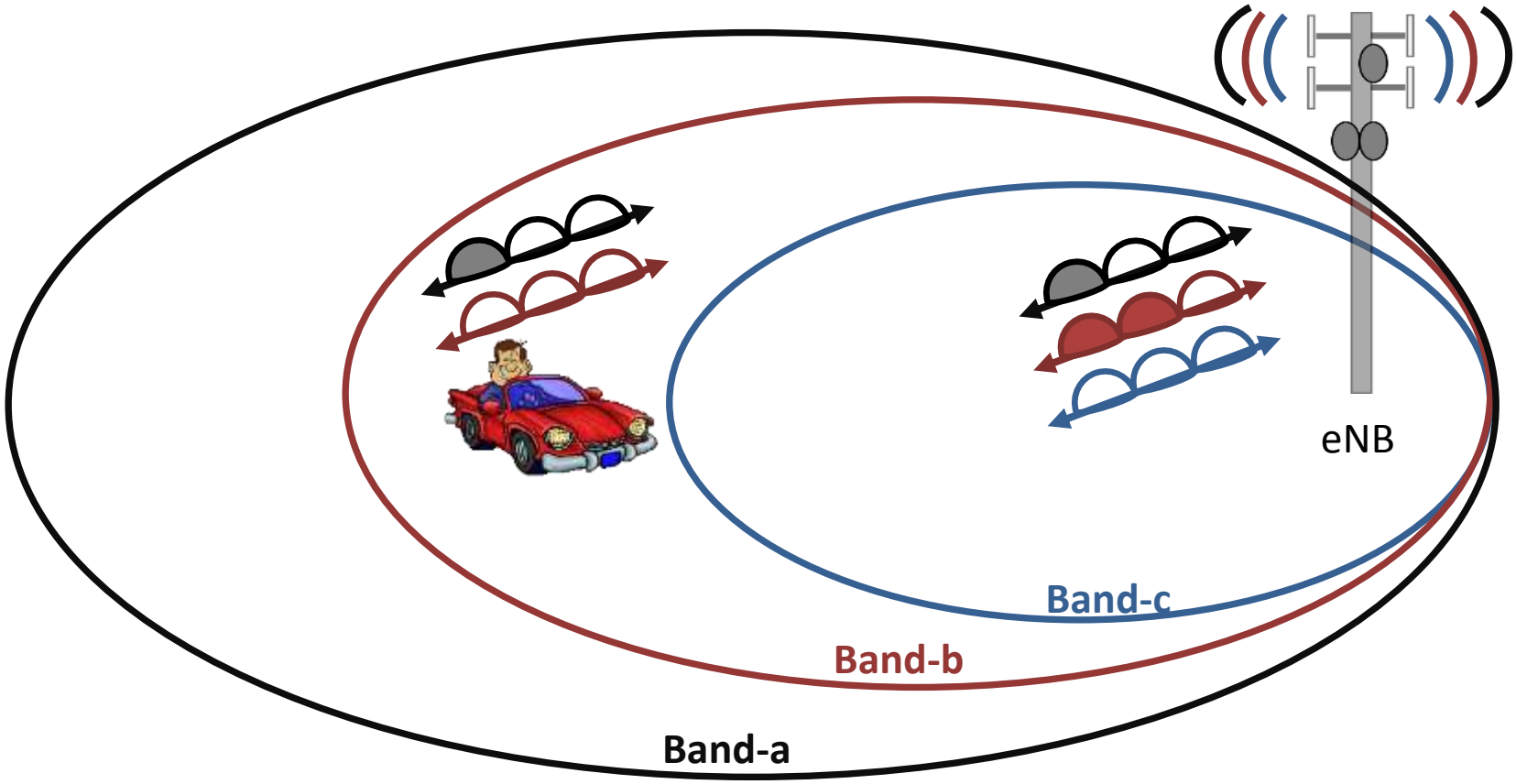
Application of User Profile to Two Techniques

- Joint Technique
  - Assign all SCCs at the same time for a user
- Partial Technique
  - Assign some SCCs at the same time for a user

Joint Technique



Partial Technique



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 all Q_{CC}	≙	50 packets
Bandwidth size of CCs	≙	10MHz
Modulations	≙	QPSK, 16QAM, and 64QAM
CQI Index	≙	3, 5, 7, and 11
Transmission Time Interval	≙	1ms
Time for CCA	≙	20ms
CQI Index threshold	≙	5

- Two type users
  - LTE (1 CC), LTE-A (5 CCs)
  - 1/2 of users are LTE-A.
  - Users are freely move around of eNB.

Results

- Discrete event simulation for downlink process with proposed carrier assignment.
- 200 realizations for different number of users with increasing data traffic.
- We compare
  - LL (Least Loaded (Modified based on CQI) with full CCs assignment),
  - UPLL (Least Loaded dynamic number of CCs assignment based on perfect user profile estimation),
  - $UPLL^{10}$ (Least Loaded dynamic number of CCs assignment based on 10% error user profile estimation)
  - $UPLL^{25}$ (Least Loaded dynamic number of CCs assignment based on 25% error user profile estimation)

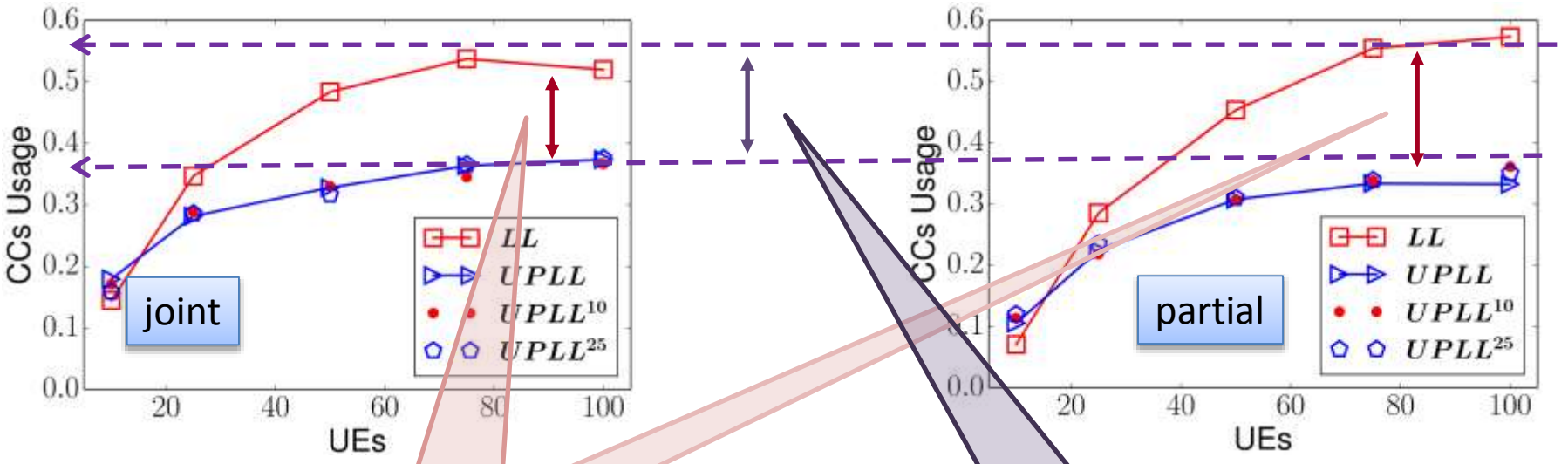
LL is least load with 4 CCs.

LL vs UPLLs

UPLLs is proposed assignment with errors and at most 4 CCs.

Objective

Observing effects of number of users on CCs usage for Joint and Partial.



LL is higher than UPLLs

LL is better in joint and UPLLs is better in partial

Overall CCs usages of UPLLs are similar and better than LL.

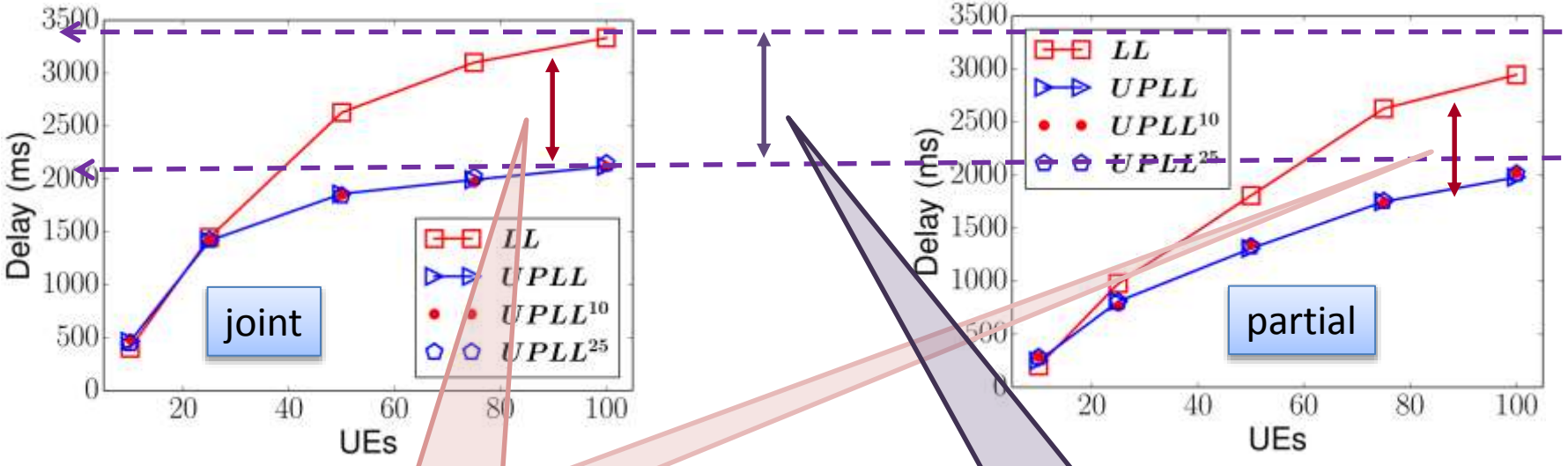
LL is least load with 4 CCs.

LL vs UPLLs

UPLLs is proposed assignment with errors and at most 4 CCs.

Objective

Observing effects of number of users on delay for Joint and Partial.



LL is higher than UPLLs

LL and UPLLs are better in partial.

Overall delay of UPLLs are similar and better than LL.

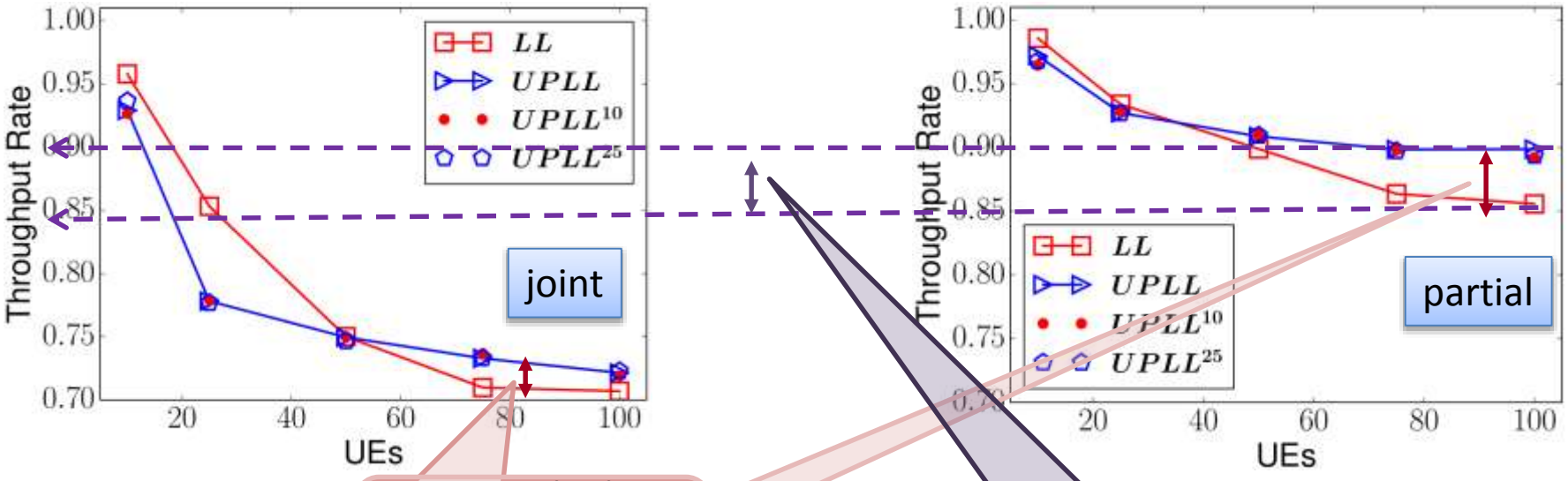
LL is least load with 4 CCs.

LL vs UPLLs

UPLLs is proposed assignment with errors and at most 4 CCs.

Objective

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

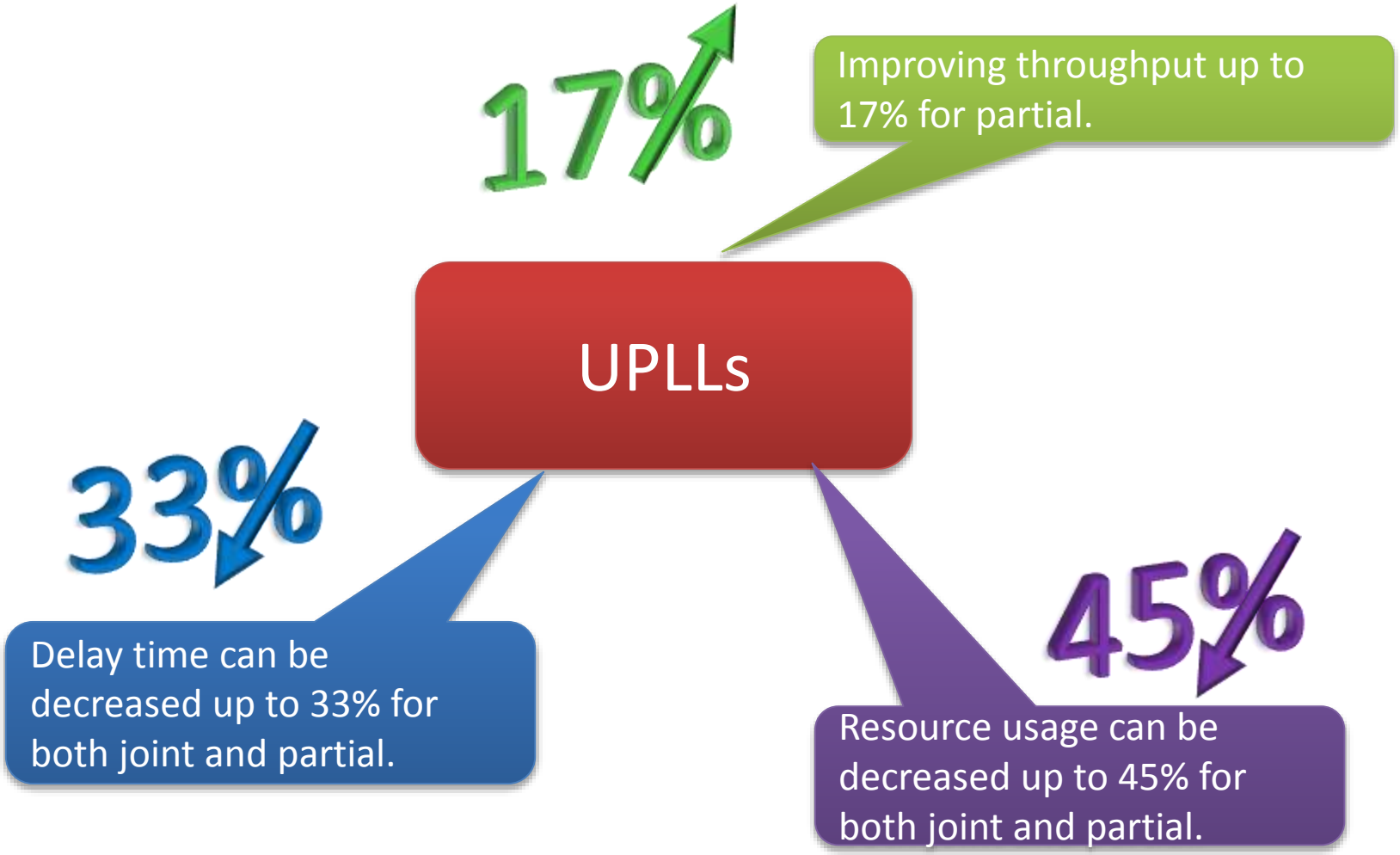


UPLLS is higher than LL for high traffic.

LL and UPLLs are better in partial.

Overall throughput of UPLLs are similar and better than LL. (Only high traffic in joint).

Summary of Results



Conclusion

Thank You

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