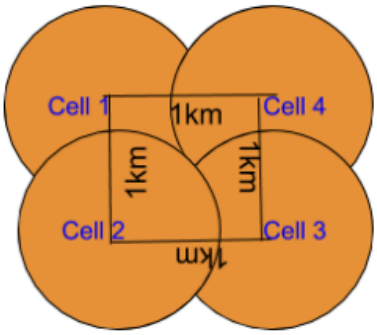
Group size: 2

The objective of this assignment is to understand and change code of LTE Schedulers algorithms in NS-3 for necessary stats collection. Further, you need to evaluate and compare performance of different Scheduler algorithms.

Create a topology as shown in below figure. Add P-GW and Remote Host to this topology and connect them with point-to-point link of 1 Gbps



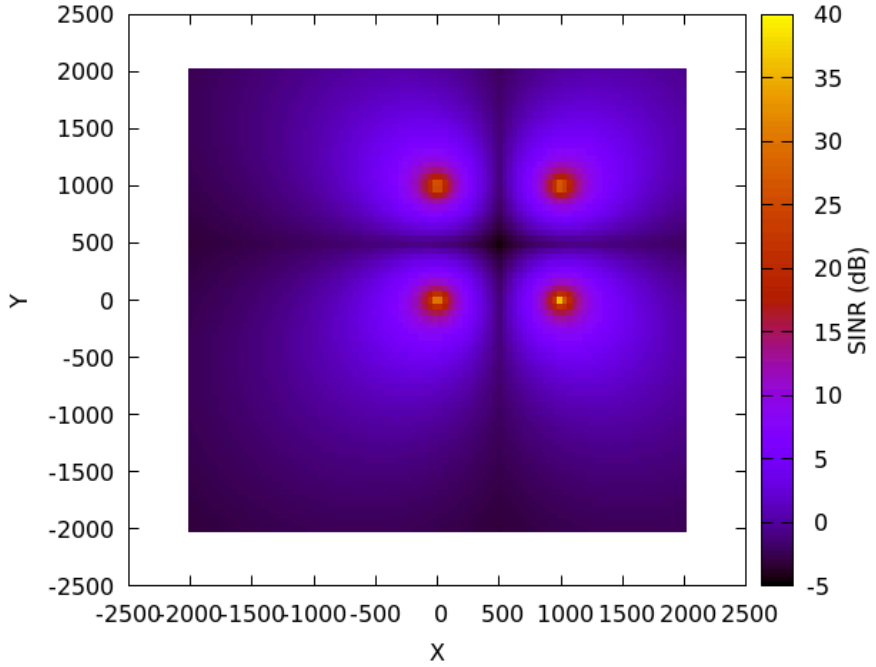
Simulation Parameter	**Value**
Number of UEs	5 per eNB; 1 Downlink UDP Flow per UE from the Remote Host
Number of eNBs	4
Inter distance between eNBs	1 KM
eNB Tx Power	30 dBm (1W)
Application Type	UDP
Full buffer case (UDP Traffic)	1500 bytes per every **1ms** by UDP; Each UE is configured with 1 DL UDP flow of 12 Mbps
Non Full buffer case (UDP Traffic)	1500 bytes per every **10ms** by UDP; Each UE is configured with 1 DL UDP flow of 1.2 Mbps
UE mobility speeds	0, 5 m/s; where in a given expt all UEs are configured with one of these two speeds
UE mobility model	RandomWalk2d Mobility
UEs placement in a Cell	Random disc placement within 500m radius of eNB
# of RBs	50 in DL and 50 in UL (LTE FDD)
UE attachment to eNB	Automatic to one of eNBs based on received signal strength, so handovers may take place during mobility
Total simulation time	10 seconds
Number of seeds per experiment	5; RngRun1 = "Last TWO DIGITS of one of your ROLL NUMBERS" RngRun5 = RngRun1+4

Considering the Topology and given simulation parameter:

1. 5 UE are placed near each enB
2. Distance between enB is taken 1km and UE does Random Walk with speed either 0m/s or 5m/s.
3. UEs are placed in radius of 500m by taking enB as Center

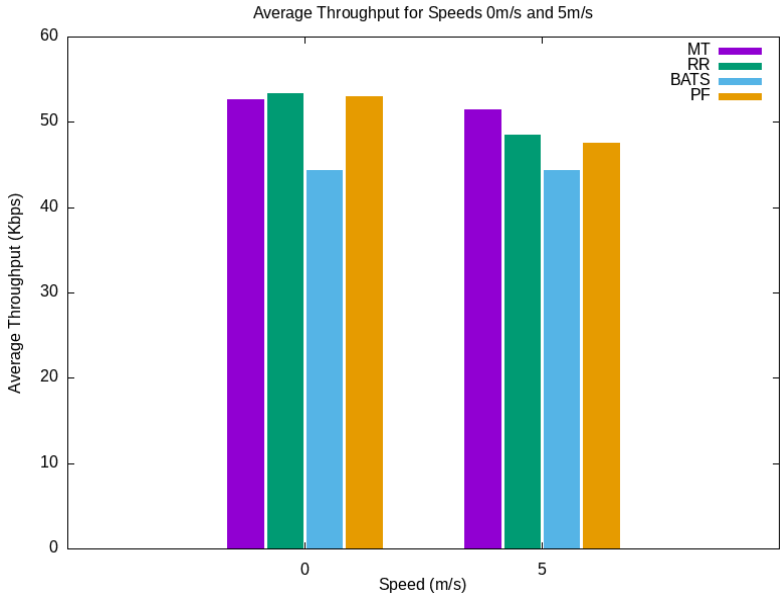
4. Power of each enB is 30dBm and UE are let to attach to any enB from which it gets good signal strength. UE automatically selects enB which is closer to it.
5. Remote Host to UE routing is made. UE has apps which only has downlink data coming from Remote host using UDP.
6. enB allocates 50 RB for DL and 50RB for UL by using LTE FDD.
7. Two cases are created for Full Buffer case and Non Full Buffer case, having different speeds for downlink and uplink.
8. The code is run 5 times using a loop. In each loop seed value for RngRun is changed. Because of this change random displacement of UE and Random walk of UE are changed in each iteration.
9. Main script takes scheduler type, speed, RngRun and fullBufferFlag as input from user.

Graph 1: SINR Radio Environment Map (REM) of 4-cell topology given above.



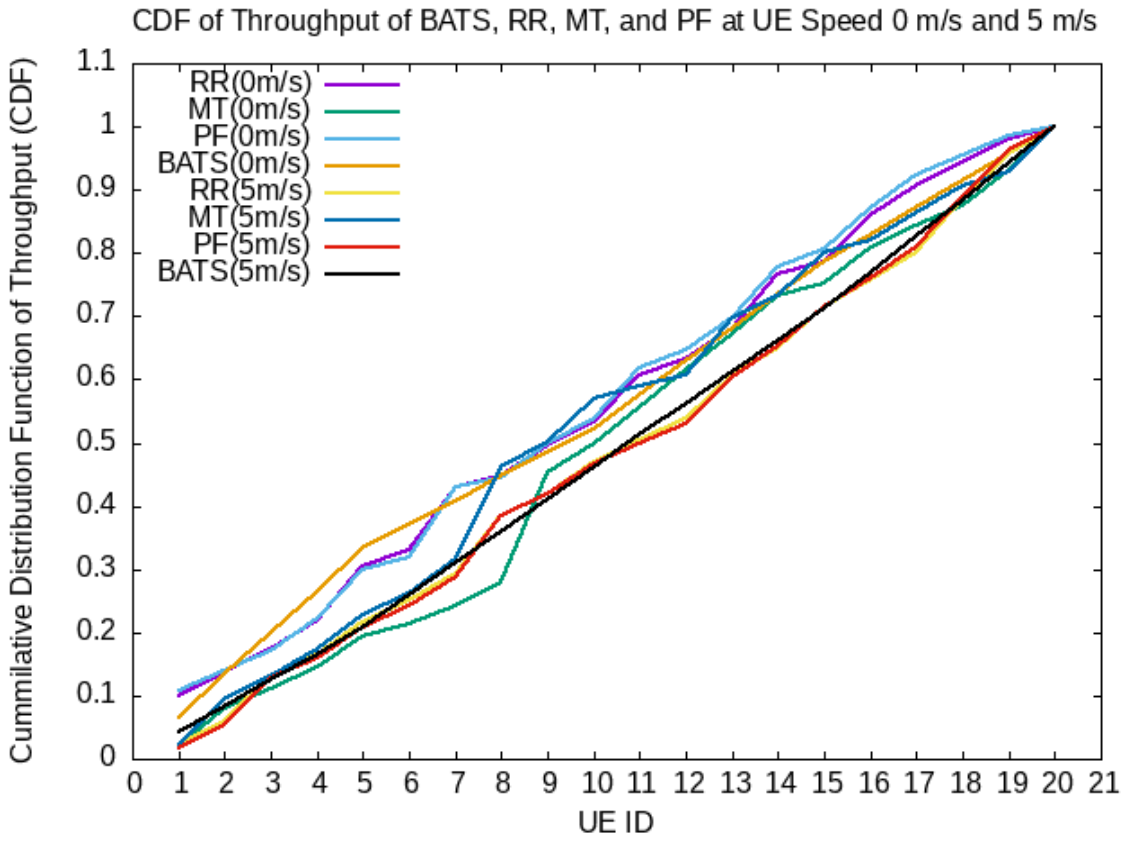
This graph shows SINR Radio Environment Map.
It can been seen from the graph that at coordinates (0,0), (1000,0), (1000,1000), (0,1000) where enB is located, SINR of 30db is seen.

Graph 2: X-axis: Speed (0, 5) m/s; Y-axis: (Average Aggregate System throughput) with bars for four scheduler algorithms for full buffer scenario. Get sum of throughputs of all 4 cells (i.e., all 20 UEs flows) in different runs by varying seed values and then get the average of that for plotting.



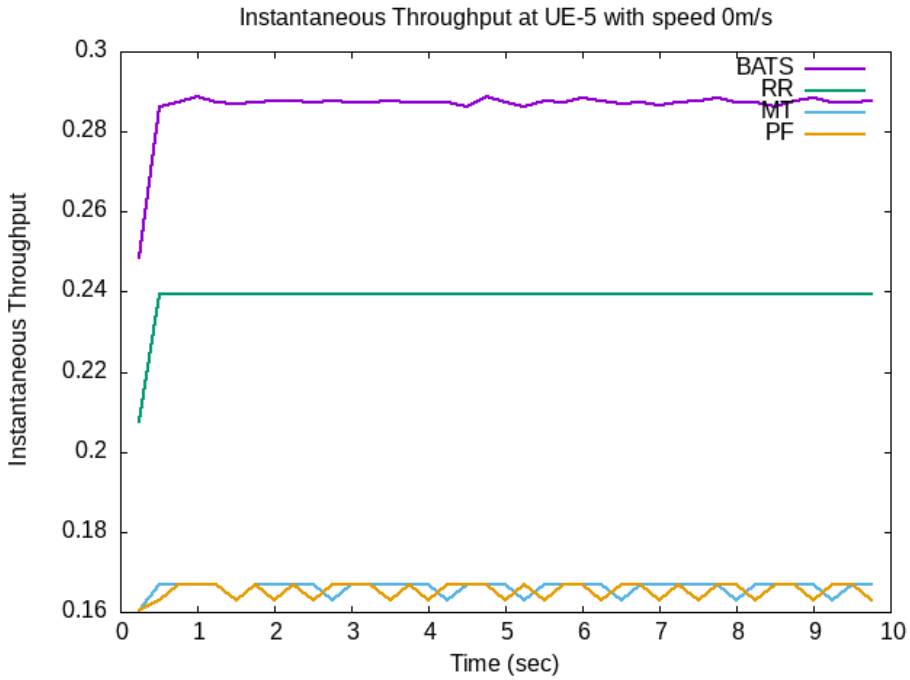
For this graph sum of received bytes by each UE within a span of 10sec is taken to calculate the throughput. Average of throughput is calculated by changing the seed value 5 times.
It can be seen from the graph that throughput of RR, BATS, and PF are decreased when UE is moving at a speed of 5m/s. Throughput by using MT as a scheduler remains constant when UE is moving or not.

Graph 3: Throughput CDF plot for different schedulers at Speed (0,5) m/s for full buffer scenario; One curve each for 0 m/s and 5 m/s. But here you need not to do any averaging. Have list of per UE throughputs across all cells in all different runs by varying seed value and use that for plotting CDF.

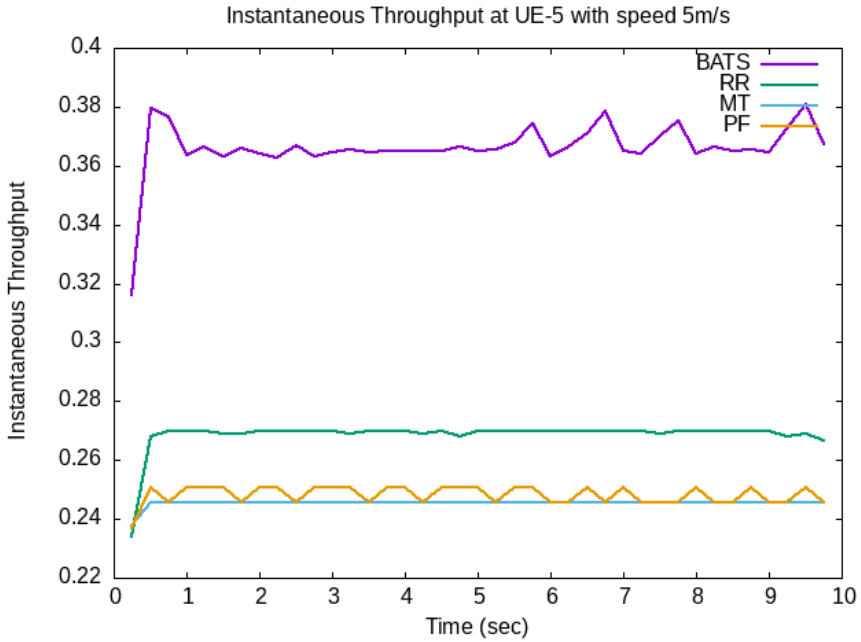


To create this graph all schedulers are executed on both speeds 0m/s and 5m/s. The list of UE throughputs across all the cells is taken, and the CDF of their throughputs is taken.
From the graph, it can be seen that all the lines of CDF are linearly increasing, which means every UE has approximately the same throughputs. The CDF of UE throughput at a speed of 5m/s is more constant that is, lines of CDF having UE speed 5m/s is more linear than lines of CDF having UE speed 0m/s. BATS scheduler at UE speed of 5m/s is nearly straight line, which indicates that BATS allocates resources evenly so that each UE has same throughput.

Graph 4: SINR/Instantaneous throughput values for UE 0 in the simulation for one seed (RngRun1). X-axis: Time in msec, Y-axis: SINR and Instantaneous throughputs of UE0 for Speed of 0 m/s for all four schedulers for full buffer scenario. Refer Help section at the end of this document to know how to measure Instantaneous throughputs.

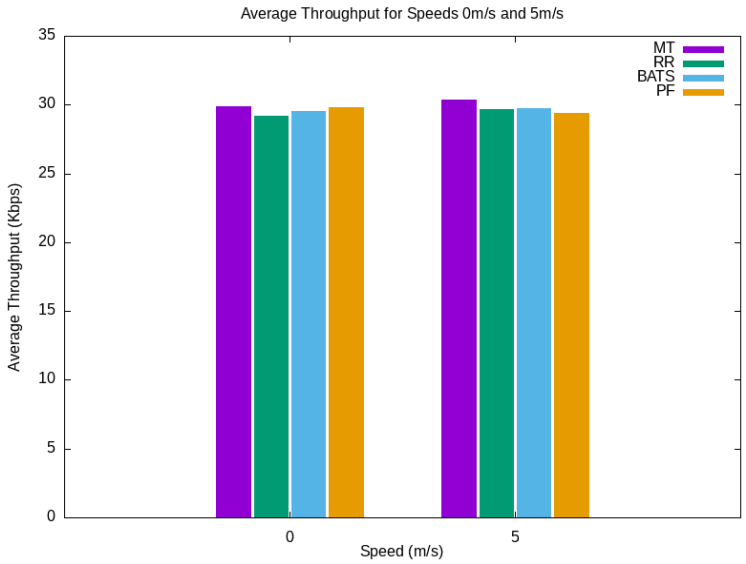


Graph 5: SINR/Instantaneous throughput values for UE 0 in the simulation for one seed (RngRun1). X-axis: Time in msec, Y-axis: SINR and Instantaneous throughputs of UE0 for Speed of 5 m/s for all four schedulers for full buffer scenario

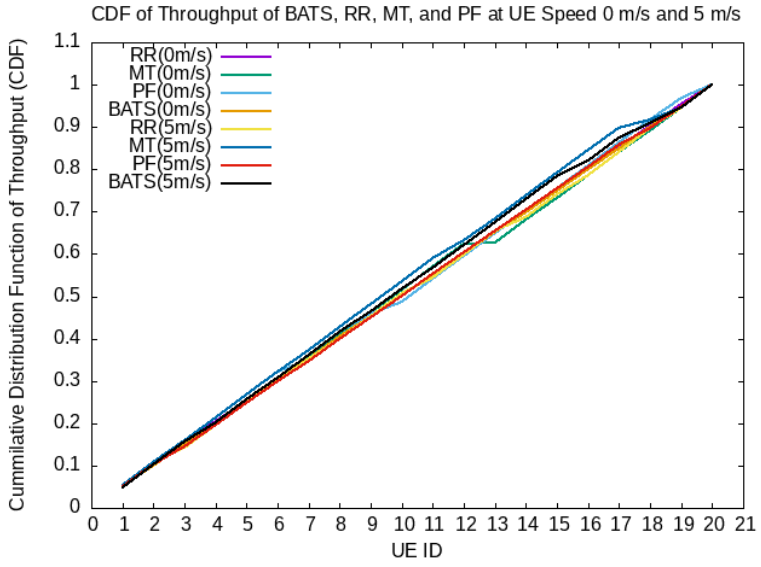


For both Graph 4 and 5, Instantaneous Throughput is calculated by considering the received Bytes at UE 5 in the time frame of 0.25sec. In Graph 4 where speed of UE is 0m/s there is less fluctuation in instantaneous throughput than in Graph 5. In both graph 4 and 5 instantaneous throughput of BATS is greater than all other schedulers.
As seen in Graph 2 BATS has less average throughput but BATS allocates resources in such a way that every UE gets equal throughput. So only in few instances other schedulers like RR, PF and MT provides very high throughput than BATS, because of that average throughput of these schedulers are more. But at more instances BATS provide more throughput per UE than these schedulers. So instantaneous throughput of BATS is more than these schedulers.

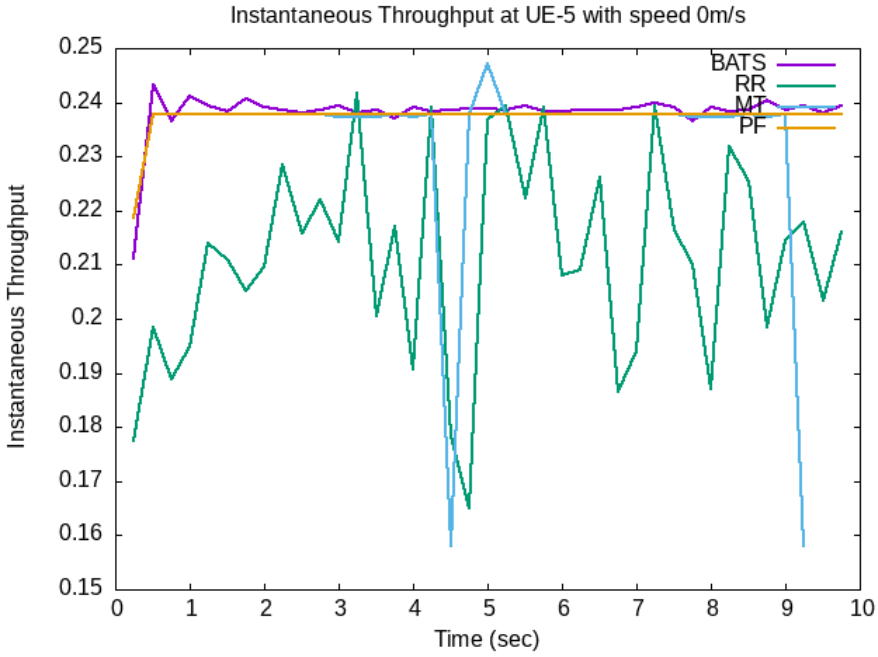
Graphs for Non Full Buffer mode are as follows :
Graph 6: Repeat now for non full buffer scenario and report your observations. X-axis: Speed (0) m/s;Y-axis: (Average Aggregate System throughput) with bars for four scheduler algorithms



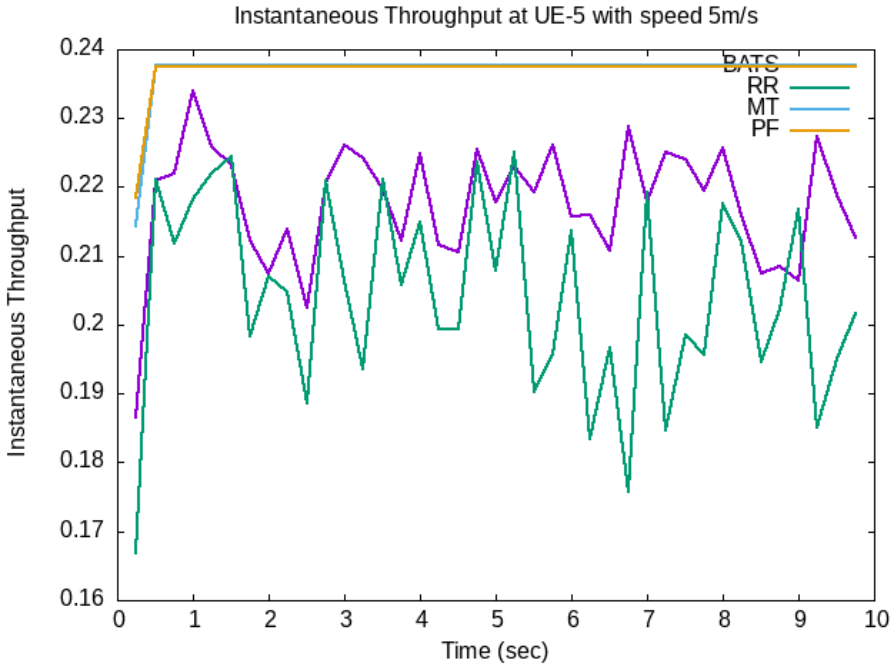
Graph 7: This graph is same as graph3 but taking non full buffer case



Graph 8: This graph is same as graph4 but taking non full buffer case



Graph 9: This graph is same as graph5 but taking non full buffer case



Observation:

By looking at graphs of Non Full Buffer, Throughput values are less, as the downlink speed is less than full buffer case. Since downlink speed is less, so every scheduler assigns resources optimally to achieve optimal throughput. In graph 6 there is less difference between throughputs

of each scheduler and also in graph 7 lines of throughput CDF of all UEs of different schedulers are linear which indicates equal throughput for all UEs