Networked Wireless Systems - CS5070

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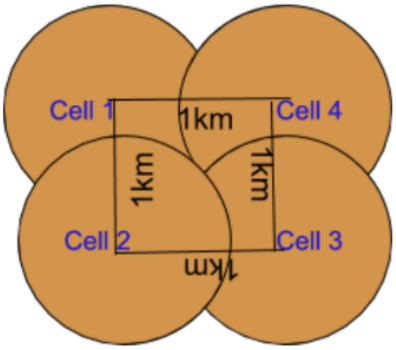
The objective of this assignment is to understand and change code of LTE Schedulers algorithms in NS-3 for necessary stats collection. Further, you need to evaluate and compare performance of different Scheduler algorithms.

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.



4 eNode-B Topology

Configure eNBs and their UEs with the parameters as given in below Table:

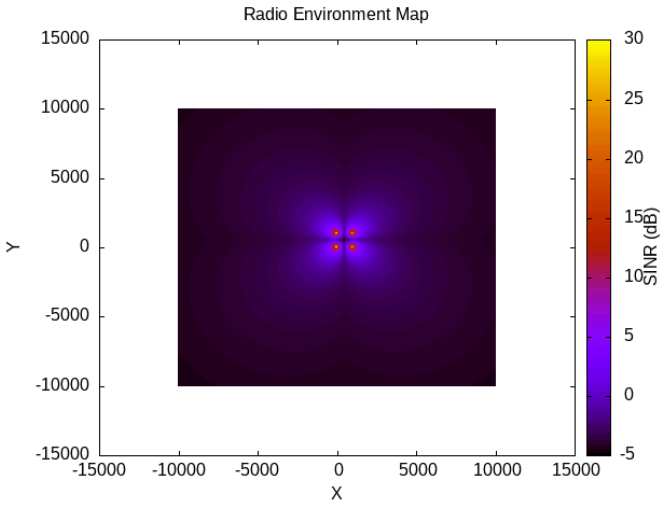
Simulation Parameter	**Value**
Number of UEs	5 per eNB; 1 Downlink UDP Flow per UE from the Remote Host
Number of eNBs	4
Inter distance between eNBs	1 KM
eNB Tx Power	30 dBm (1W)
Application Type	UDP
Full buffer case (UDP Traffic)	1500 bytes per every **1ms** by UDP; Each UE is configured with 1 DL UDP 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" - 15 RngRun5 = RngRun1+4

Compare Proportional Fair (PF), Round Robin (RR), Max Throughput (MT) and (BETS) available in NS-3 LENA LTE module by creating a 4-cell LTE network as shown above with the simulation parameters given in the table.

Output Graphs:

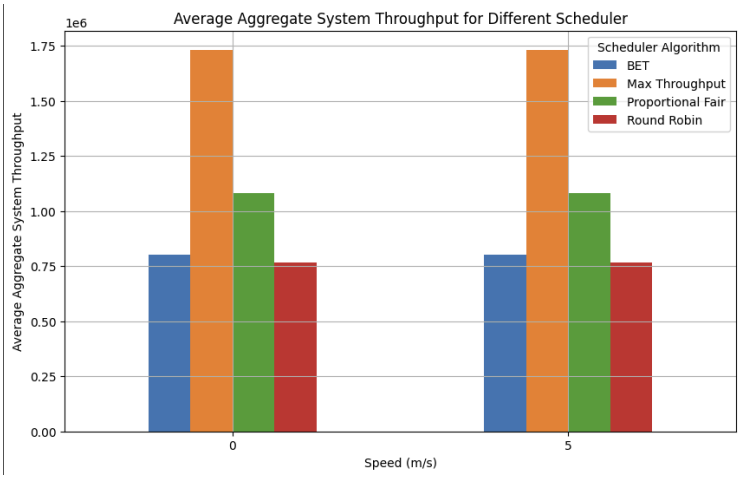
Graph 1: SINR Radio Environment Map (REM) of 4-cell topology given above.



REM Plot - Graph-1 (4 eNodeB)

<u>Observation:</u> We can see that the radio frequency is fading after 1000m from the eNode-Bs and at 10000m we can see there are no signs of radio propagation/emissions from either of the BS's. Also, see that the frequency coverage of the 4 e-NodeBs are overlapping. Different color gradings on the map represent various SINR levels.Particularly the bright spots indicate high SINR levels.

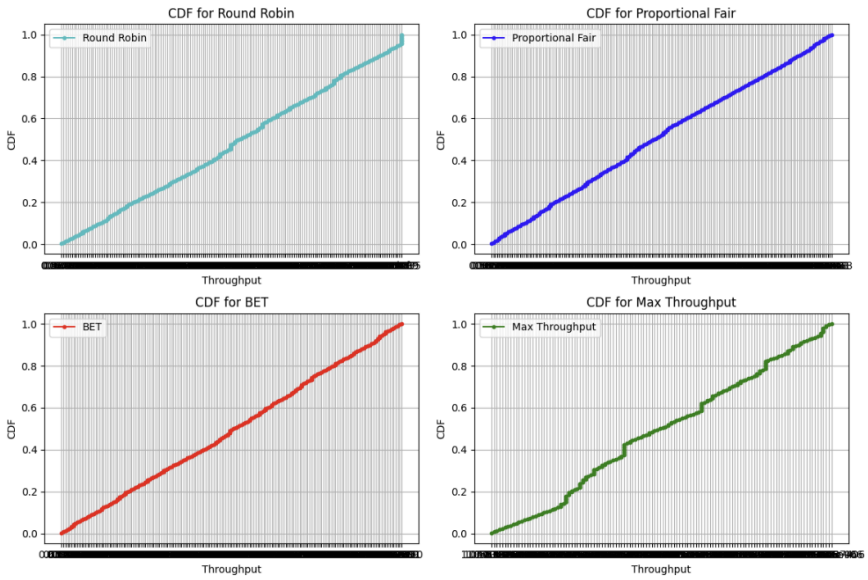
Graph 2: X-axis: Speed (0, 5) m/s; Y-axis: (Average Aggregate System throughput) with bars for four scheduler algorithms for full buffer scenario. Get sum of throughputs of all 4 cells (i.e., all 20 UEs flows) in different runs by varying seed values and then get the average of that for plotting.



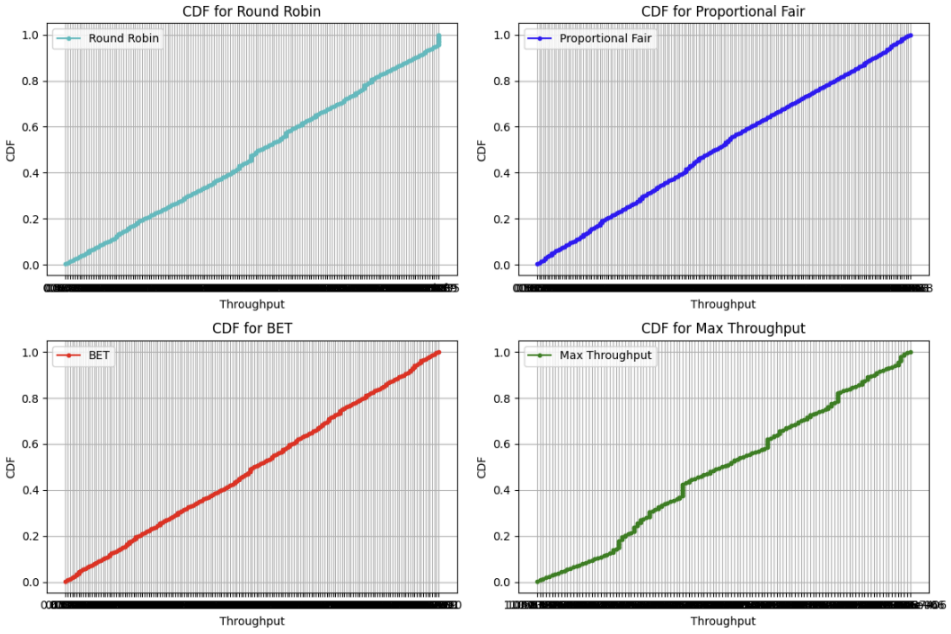
Plot for Average Aggregate System Throughput for different schedulers

<u>Observation:</u> We can see that in our setup, Maximum throughput is given by Max Throughput scheduler in both the cases ie. when UE's speed is 0 or 5 m/s. This algorithm is likely more efficient in maximizing network capacity and providing better user experiences.

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.



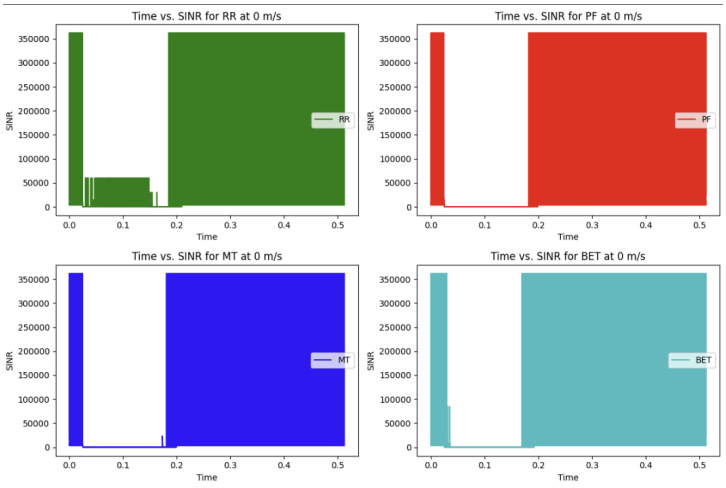
CDF plot for different schedulers at Speed 0 m/s for full buffer scenario



CDF plot for different schedulers at Speed 5 m/s for full buffer scenario

<u>Observation:</u> We can see that the throughput is equally distributed among all the UE's i.e around 1 in all the scheduling cases, irrespective of the speed of the UE's.

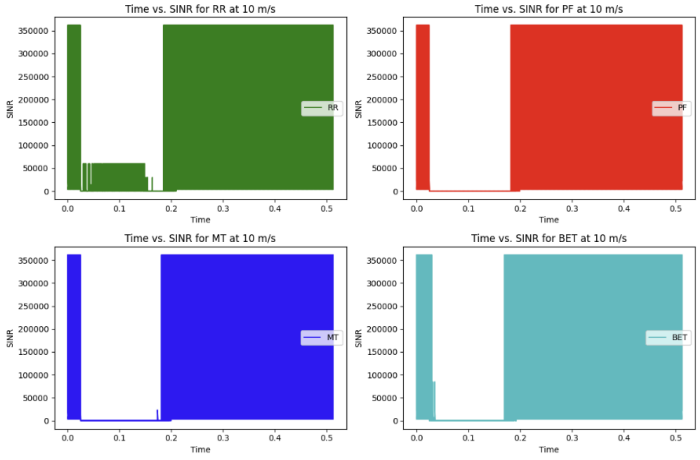
Graph 4: SINR/Instantaneous throughput values for UE 0 in the simulation for one seed (RngRun1). X-axis: Time in msec, Y-axis: SINR and Instantaneous throughputs of UE0 for Speed of 0 m/s for all four schedulers for full buffer scenario. Refer Help section at the end of this document to know how to measure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



SINR/Instantaneous Throughput for UE 0 in the simulation for one seed (RngRun1) - 0 m/s

<u>Observation:</u> We can see the the SINR values remain same throughout the time

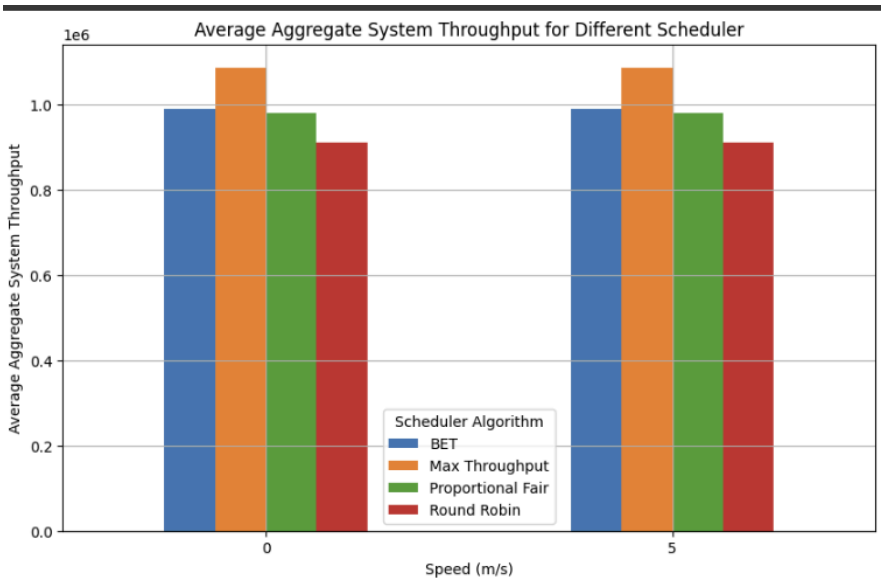
Graph 5: SINR/Instantaneous throughput values for UE 0 in the simulation for one seed (RngRun1). X-axis: Time in msec, Y-axis: SINR and Instantaneous throughputs of UE0 for Speed of 5 m/s for all four schedulers for full buffer scenario



SINR/Instantaneous throughput values for UE 0 in the simulation for one seed (RngRun1) - 5 m/s

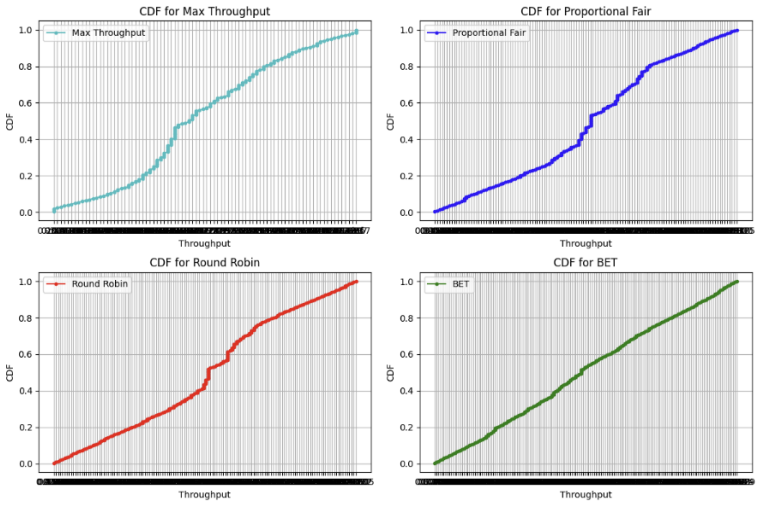
<u>Observation:</u> We can see the the SINR values remain the same throughout the time.

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

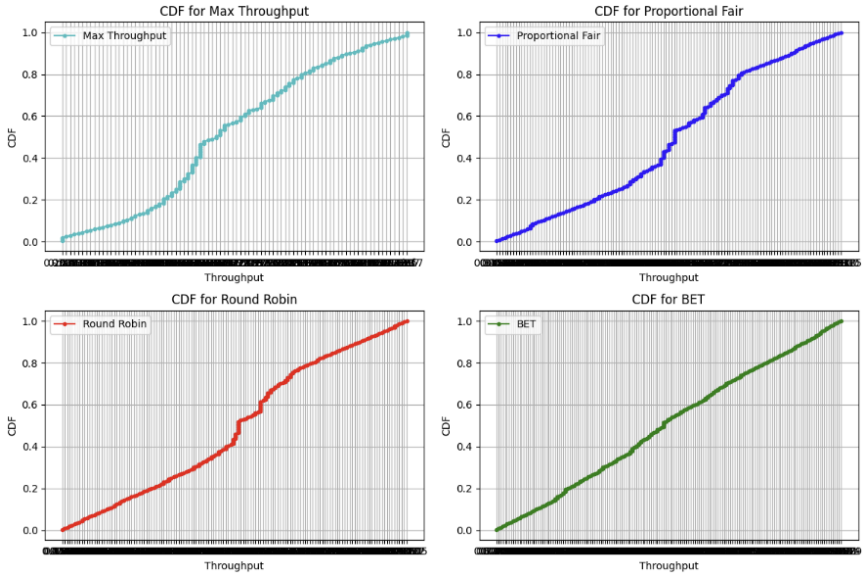


Plot for Average Aggregate System Throughput for different schedulers in non-full buffer scenario

<u>Observation:</u> We can see that in our setup, Maximum throughput is given by Max Throughput scheduler in both the cases ie. when UE's speed is 0 or 5 m/s. This algorithm is likely more efficient in maximizing network capacity and providing better user experiences.



CDF plot for different schedulers at Speed 0 m/s for non-full buffer scenario



CDF plot for different schedulers at Speed 5 m/s for non-full buffer scenario

<u>Observation:</u> We can see that the throughput is equally distributed among all the UE's i.e around 1 in all the scheduling cases, irrespective of the speed of the UE's.

References:

1. https://www.nsnam.org/docs/models/html/lte-design.html#mac
2. https://www.nsnam.org/docs/models/html/lte-user.html#radio-environment-maps
3. https://www.nsnam.org/docs/models/html/lte-user.html
4. https://www.nsnam.org/docs/models/html/lte-design.html#round-robin-rr-scheduler
5. http://code.nsnam.org/ns-3-dev/file/028452e3b558/src/lte/examples/lena-rem.cc
6. http://code.nsnam.org/ns-3-dev/file/028452e3b558/src/lte/examples/lena-intercell-interference.cc