CS5070: LTE Scheduling Algorithms

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Summary of LTE Scheduling Algorithms

The following LTE scheduling algorithms have been assessed in this simulation.

Proportional Fair (PF)

PF is a scheduling algorithm that aims to maximize the total throughput of a cell while allotting a minimal level of service to all the UEs in that cell. It is popularly used in wireless systems since it ensures fairness to all UEs by assigning resources based on channel quality and past resource allocation history of a UE.

Round Robin (RR)

RR is a scheduling algorithm in which each UE is assigned a resource in cyclic order for use. It is easy to implement and starvation-free, since each UE will get a chance to use the critical resource.

Maximum Throughput (MT)

MT is a scheduling algorithm that aims to maximize the throughput of the cell. It achieves this by allocating maximum resources to UEs which are experiencing better channel conditions and SINR. This leads to starvation of UEs at the cell edge.

Blind Average Throughput (BAT)

BAT is a scheduling algorithm that allocates resources based solely on the average throughput of UEs, irrespective of the channel conditions. It aims to service all UEs equally on average.

SINR Radio Environment Map (REM)

The generated REM of the 4-cell topology is shown in Fig 1. The “red spots” on the REM are regions with higher SINR, and we can infer the exact positions of the eNBs of each cell from it. We also observe that the SINR is poor in the region between eNBs, especially at the origin (0 m, 0 m). This may be due to inter-cell interference or due to the fact that the origin is out of the coverage area of any of the cells.

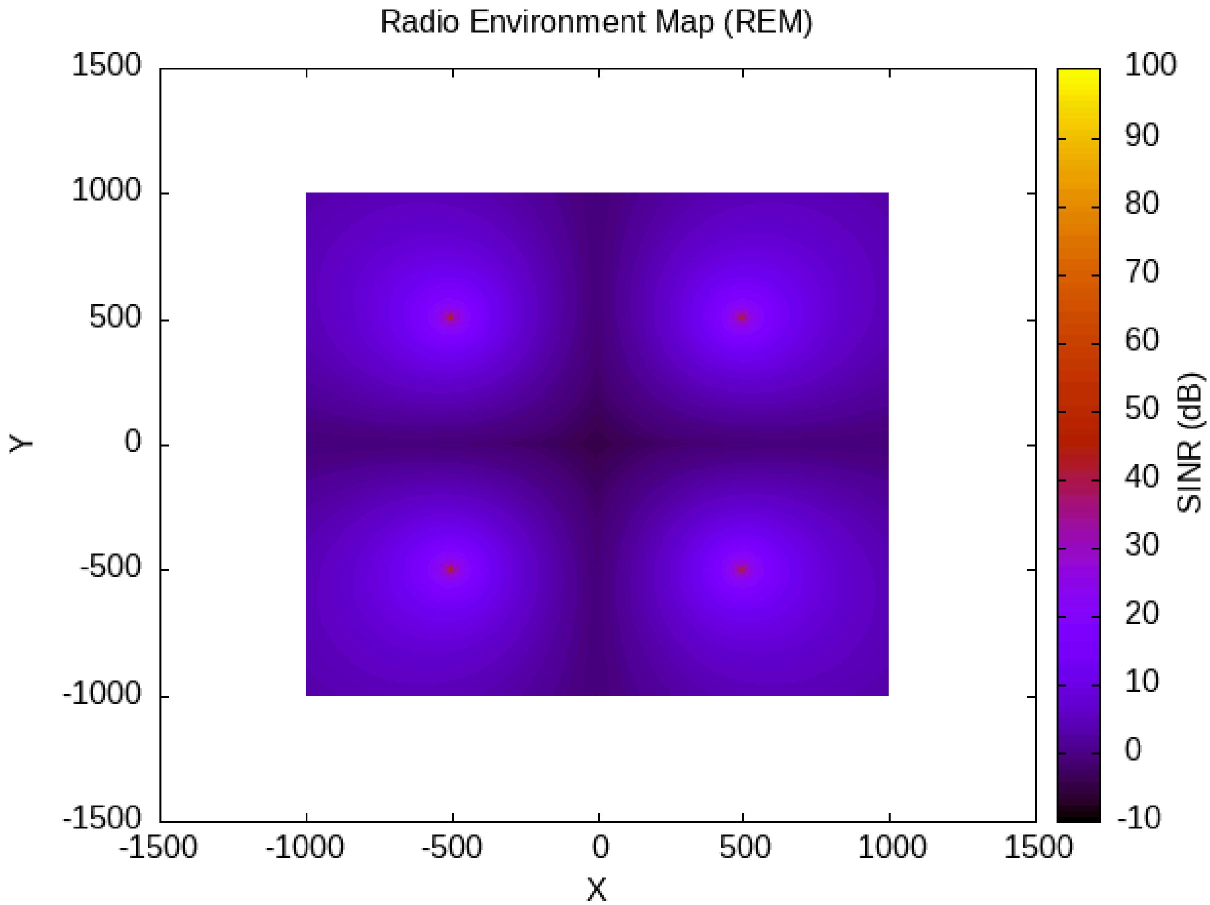

Fig 1. SINR REM of the 4-cell topology.

Average Aggregate System Throughput

Fig 2 shows the average aggregate system throughput for the full buffer scenario. The following observations can be made.

1. The average aggregate throughput in both cases obeys PF > RR >> BAT > MT. We can infer that PF is the best scheduler to maximize average aggregate throughput. MT is the worst algorithm for this metric since it services nearby UEs and not those at the cell edge.
2. RR scheduler may also be used to improve average aggregate throughput since it is much easier to implement than PF scheduler, incurring a very small loss in average throughput.
3. On introducing mobility, the average aggregate throughput of the UEs goes down for all schedulers. This is because of possible handovers or movement of UEs to the cell edge.

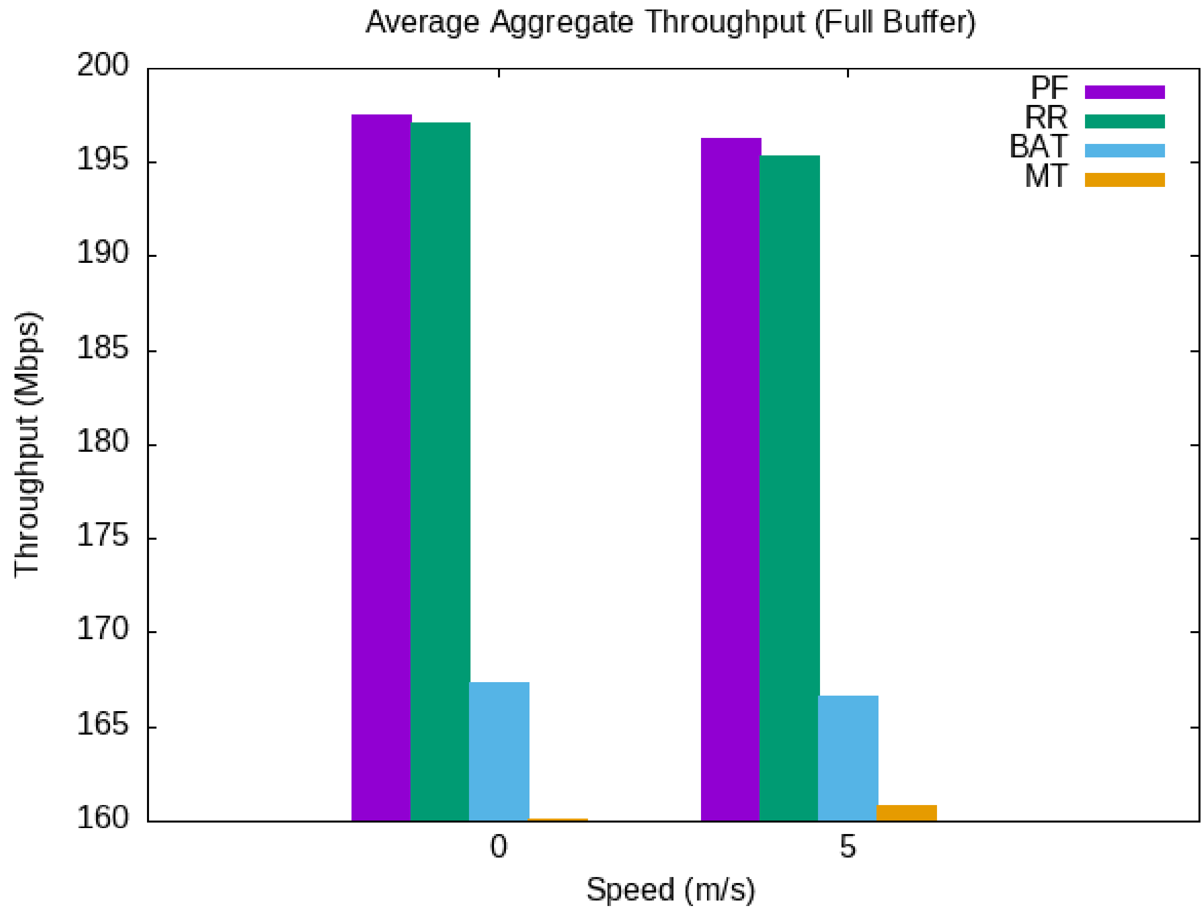

Fig 2. Average aggregate throughput of UEs in full buffer scenario.

Throughput CDF

Fig 3 shows the throughput CDF for different schedulers in the full buffer scenario. In all cases, throughputs of UEs are rearranged in descending order. That is, UE 1 has maximum average throughput, and UE 20 has the least. The following observations can be made.

1. MT scheduler starves 5-6 UEs, since it reaches the entire throughput with 14-15 UEs.
2. BAT scheduler performs the best in achieving equal throughput for all UEs, since it has the most linear CDF out of all curves.
3. PF and RR schedulers are closely matched in their CDFs as well. UEs closer to the eNBs experience more throughput and those at the cell edge experience lesser throughput.

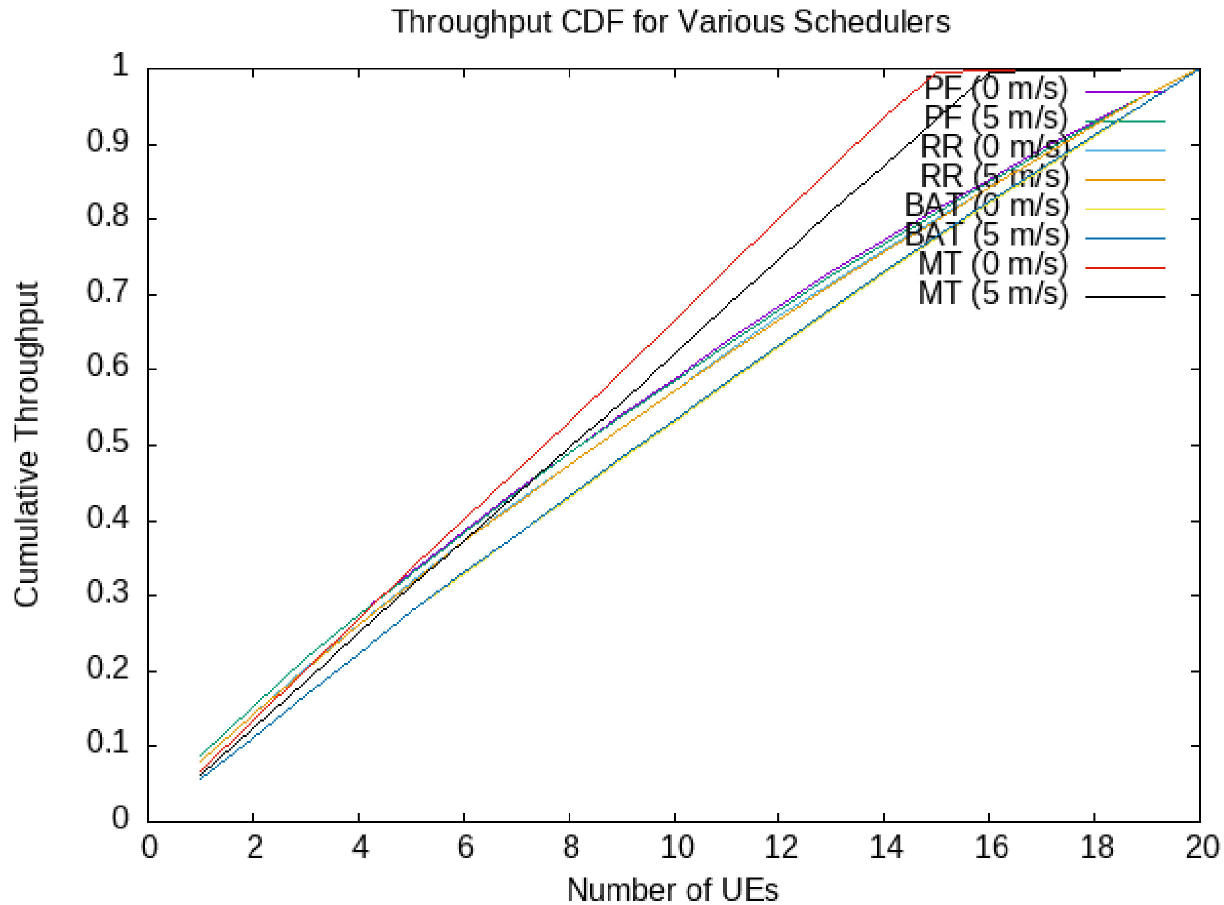

Fig 3. Throughput CDF of various schedulers in full buffer scenario.

SINR/Instantaneous Throughput for UE 1

Figs 4 and 5 depict the variation of instantaneous throughput (in Mbps on left y-axis) for UE 1 and its SINR (in dBm on right y-axis) for the full buffer scenario without and with mobility.
The following observations can be made for the case where UEs are not mobile.

1. The instantaneous throughput trend is RR > PF > BAT >> MT = 0. We infer that UE 1 was not the closest UE to the eNB in this simulation run, thus it was starved by the MT scheduler.
2. The jitter in the instantaneous throughput of the UE is RR > BAT > PF. In this topology, RR scheduler is the best for real-time applications like gaming, video conferencing, etc.

The following observations can be made for the case where UEs are mobile.

1. The instantaneous throughput trend is still RR > PF > BAT >> MT = 0. However, the first three schemes are now more closely matched in their throughput.
2. The jitter in the instantaneous throughput of the UE is PF > RR > BAT. In this topology and accounting for mobility, PF scheduler is the best for real-time applications like gaming, video conferencing, etc.

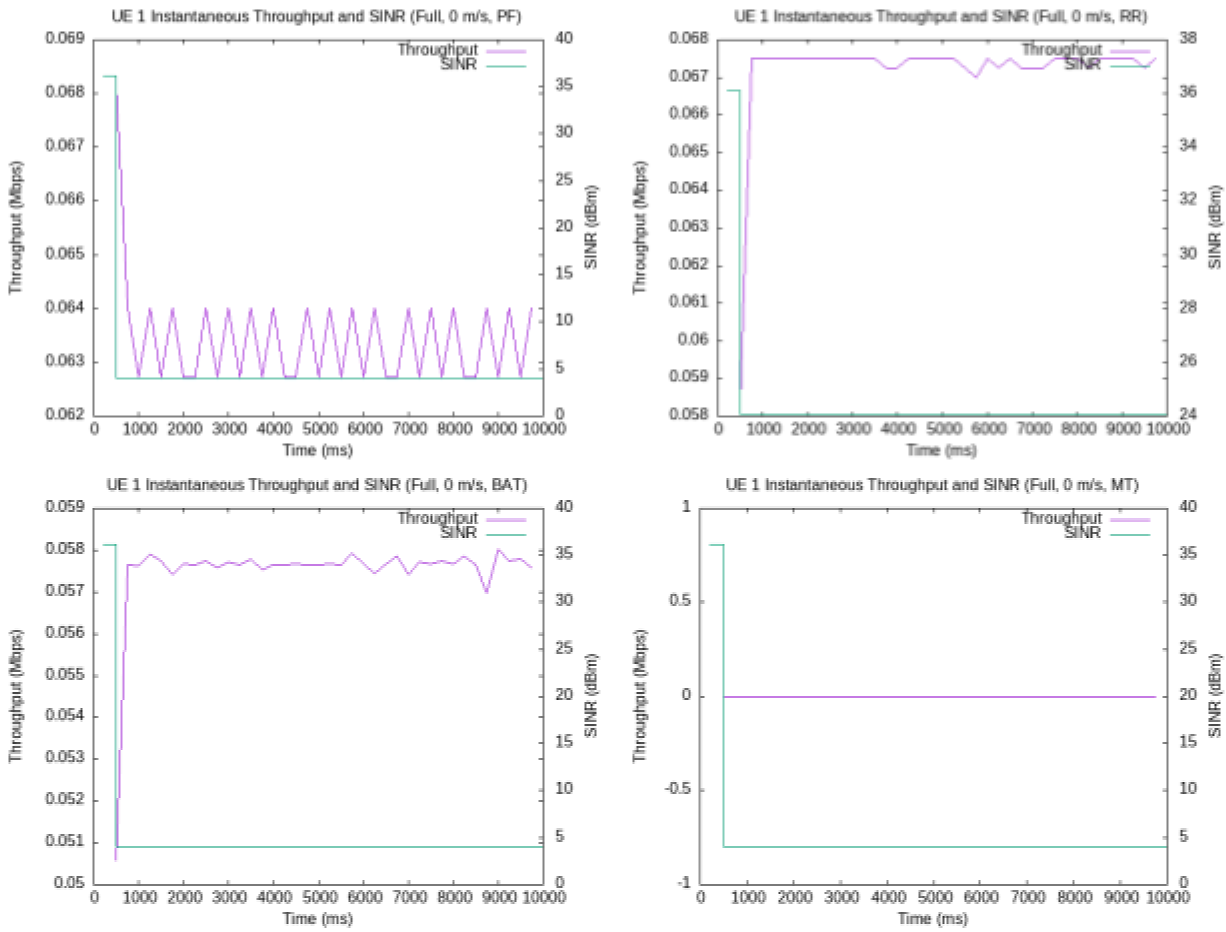

Fig 4. Instantaneous throughput and SINR of UE 1 for various schedulers in the full buffer scenario without mobility.

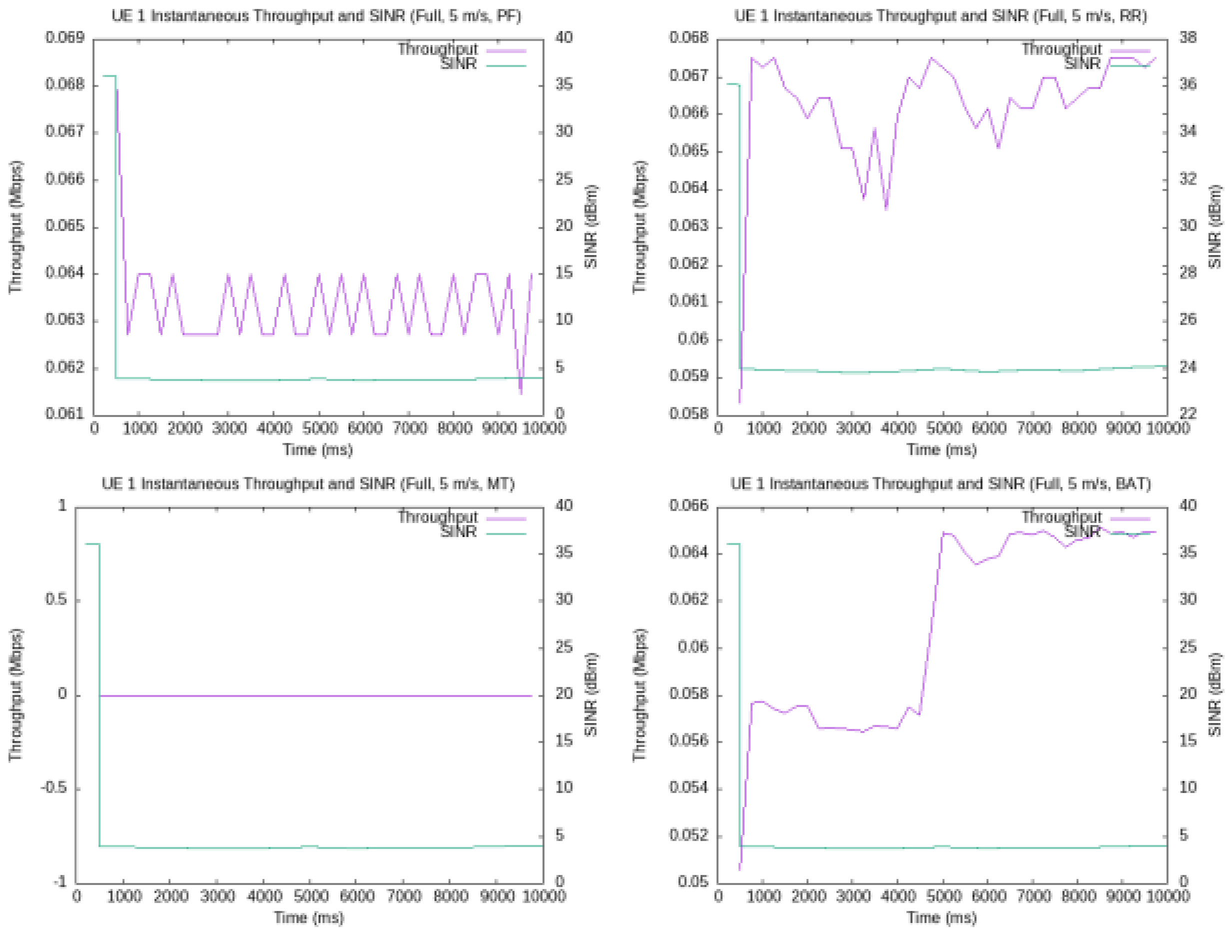

Fig 5. Instantaneous throughput and SINR of UE 1 for various schedulers in the full buffer scenario with mobility.

Non-full Buffer Scenario

We now consider a non-full buffer scenario with slower UDP flows and more inter-packet arrival delay from the LTE core network. The average aggregate throughput is shown in Fig 6. The following observations can be made.

1. The order of average aggregate throughput is PF > MT > RR > BAT. Even in this scenario, PF is the best with respect to this metric. However, there is a relative improvement in throughput for MT scheduler, since it can schedule all the packets for the UEs closest to the eNB due to the higher inter-packet delay.
2. RR performs better on average aggregated throughput when the UEs are mobile rather than stationary. The movement of UEs enables them to experience better channel conditions, as compared to when they are stationary, thus resulting in a higher throughput when they are allocated the resource.

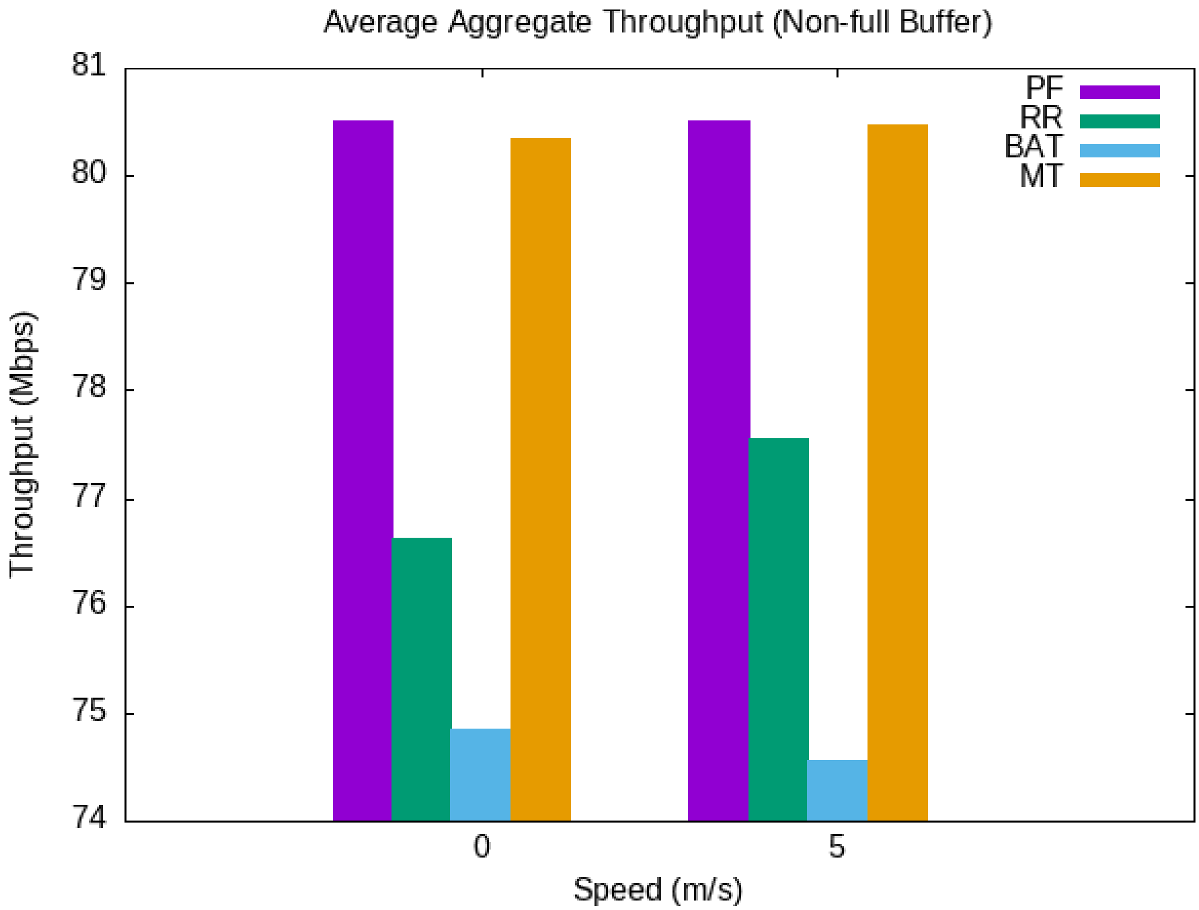

Fig 6. Average aggregate throughput for various schedulers in a non-full buffer scenario.