[Smart Cities, NS-3, LTE-EPC]

[Sarah Hossam Abdelhameed Elmowafy]

[Mohamed Sayed AbdelWahab Hussien]

[Ahmed Shehata Mahmoud AboMooustafa]

[AbdelMageed Ahmed AbdelMageed Hassan]

Abstract

In this project, we simulate the LTE with EPC network using NS-3. The simulation is done through three different types of applications and the information that describe each flow like the Jitter sum or the number of lost packets, etc. all of them are plotted to see the differences between them through the applications.

Introduction

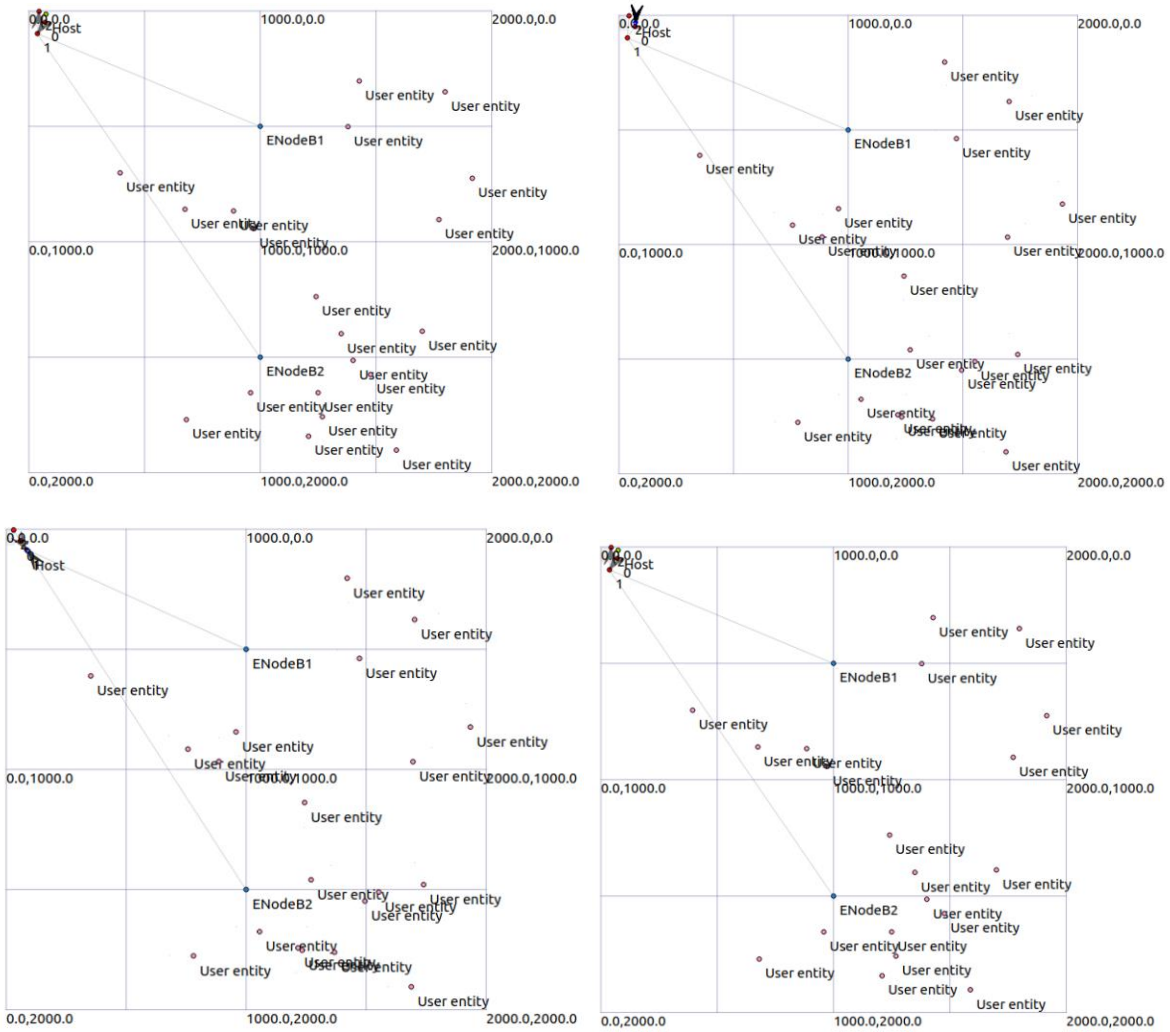
LTE (long Term Evolution) or 4G is the fourth generation of mobile network, The main target of LTE network is to connect the user to the external network so that the user entity can send and receive to and from the external network. Simply the control plane is used to exchange signaling messages between the nodes, to control user entity data session while user plane is used to exchange user data so that the user entity can send and receive user data to and from the external network. LTE network contains the access network (E-UTRAN) and it contains the eNBs while the core network is called Evolved Packet Core (EPC) and it contains the MME, SGW, PGW and HSS that connect between the user entity and the PDN or the host.

Here the network is composed of two parts, the LTE part that contains a number of user entities that maybe a car, laptop or even a phone, connected to one of the two eNBs, and the other part is the EPC part that connect the UEs to the host.

Mobility

The network covers an area of 2km x 2km, eNBs are fixed with 1 km. eNBs are stable and have constant position and it is located in the center of the area (1000, 500), (1000, 1500) while the entities which their initial positions are scattered over the whole area are mobile using *RandomWalk2dMobilityModel*,

In reality, each entity may have a completely different speed with different positions or directions of movements but for the sake of being visible we set the mobility for all the nodes to 200 meters each second. and the figures below depicts the change in their locations.



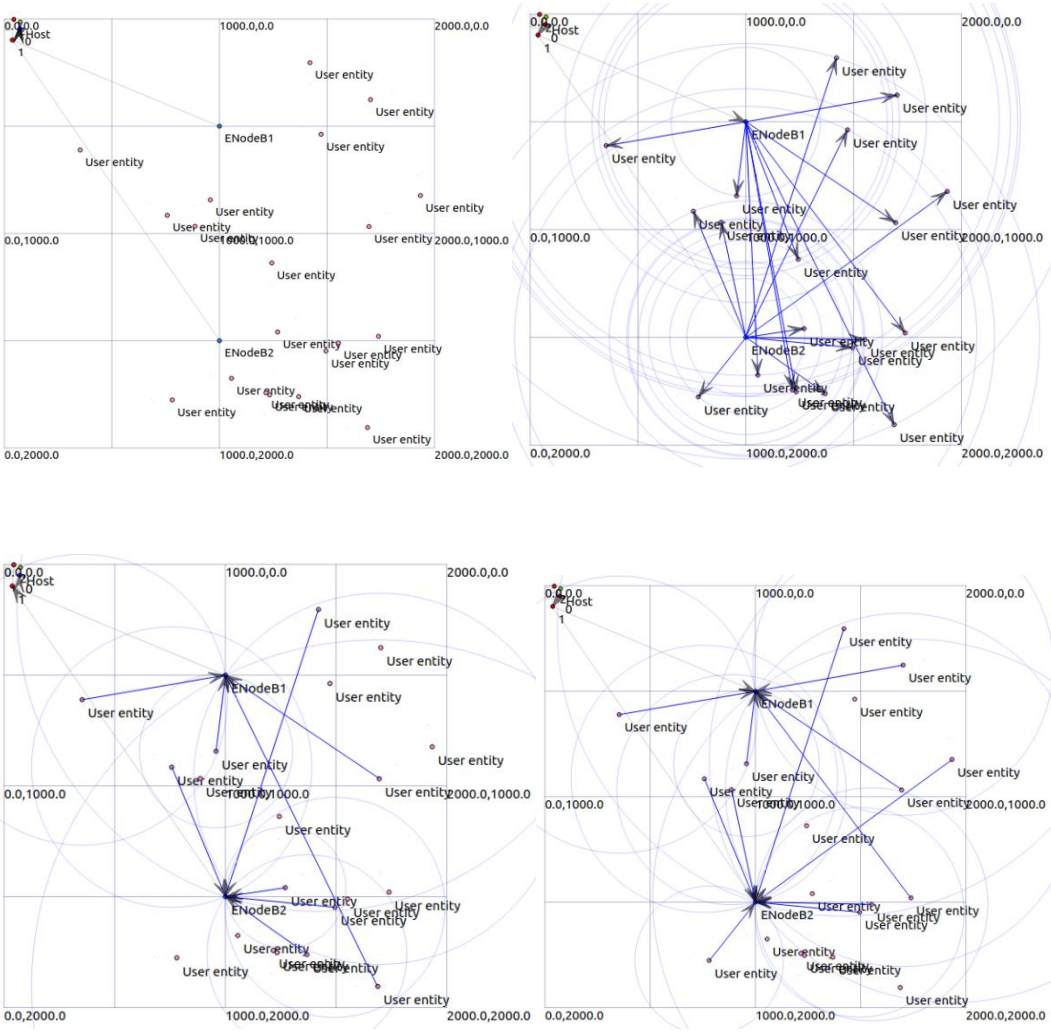
Applications

1. UDP Client Server
2. Bulk Send Applications
3. ON-Off Applications

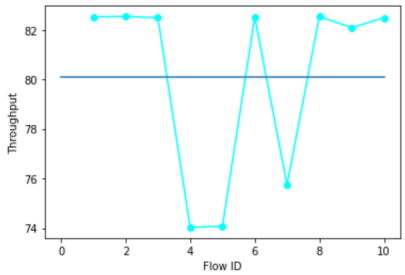
In the three applications, the server is the host while the clients are the user entities.

UDP Client Server Application

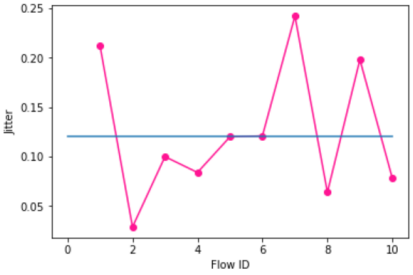
In UdpClientServer application, UDP is the transport layer protocol. In UDP, the client does not form a connection with the server like in TCP and instead just sends a datagram. Similarly, the server need not accept a connection and just waits for datagrams to arrive. Datagrams upon arrival contain the address of the sender which the server uses to send data to the correct client.



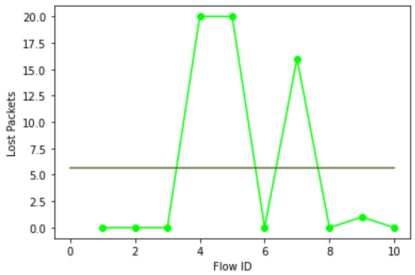
Flows Statistics



Throughput



Jitter



Lost Packts

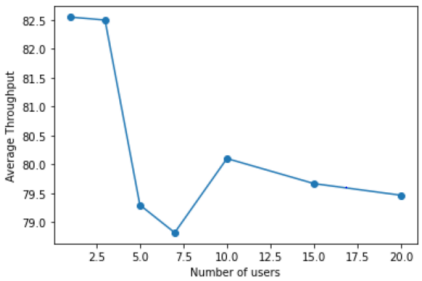
In these plots, the cyan plot is shows the variation in the throughput for each flow, the maximum throughput is more than 82 and the minimum is around 74 with average of 80.

In the pink plot, we can see that the jitter for the first plot is high as there's no periodicity in the data and then it decreases to less that 0.05 with the second flow and the average is 0.12.

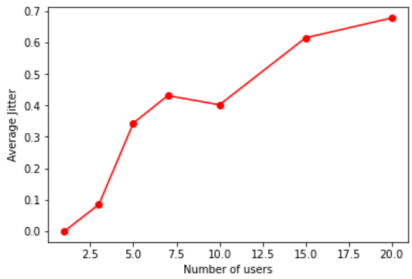
For the lime green plot, we have no loss packets in the first flows then the loss increases to 20 packets with average of around 6 packets for all flows.

There is a perfect negative relationship between the throuput and the number of lost packets, they are negatively correlated, when the throughput is high, the number of lost packets deacrease and vice versa.

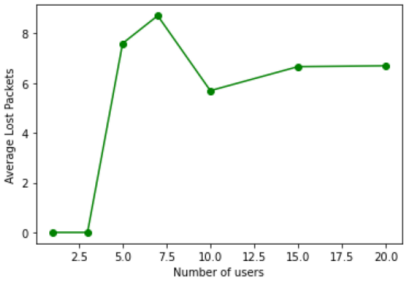
User Entities Comparison



Throughput



Jitter



Lost Packt

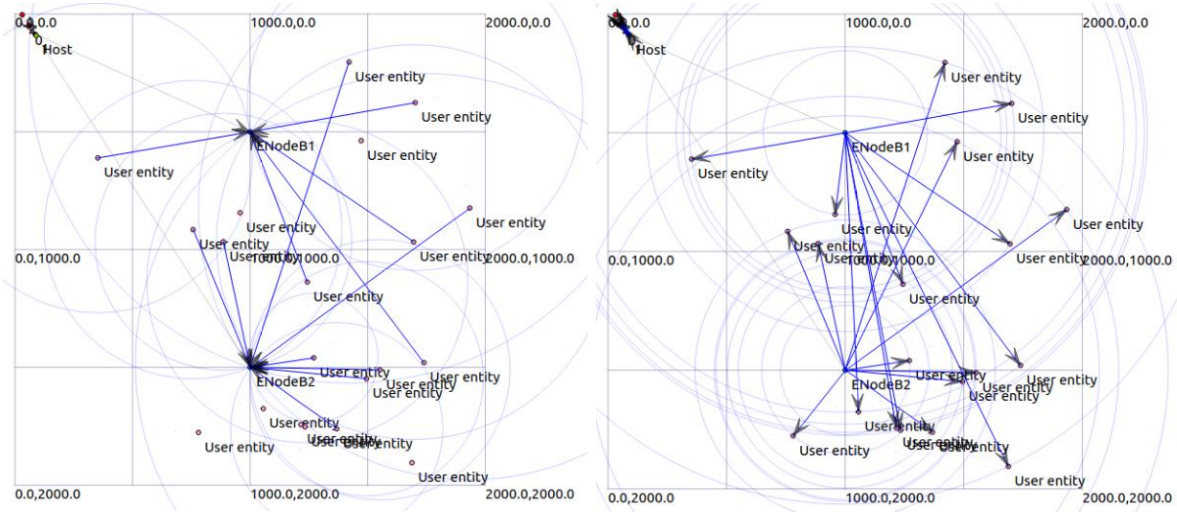
On the left, the blue plot shows the average throughput along with different number of users, for one user the throughput has the highest value as the bandwidth is dedicated for just one entity, when the number of users increase the average throughput decrease. The maximum number of packets is exceeded with increasing the number of user entities.

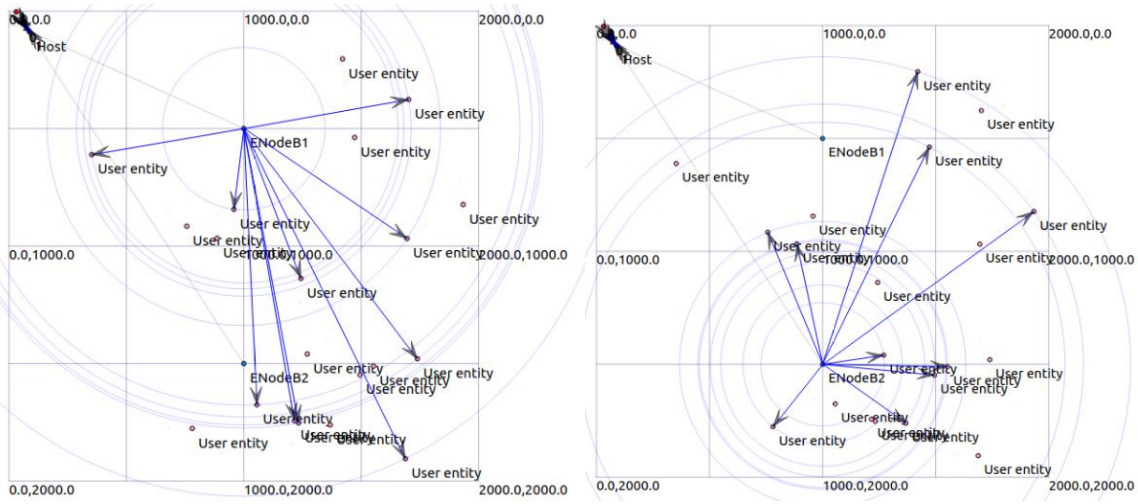
Jitter is the deviation from true periodicity of a presumably periodic signal. Here in the middle, the red plot show the variation of the jitter as it increases with the number of users, because of the increment in the number of packets that may lead to the deviation in the true periodicity.

On the right side, the plot shows increment in the number of packet loss while the user numbers increase.

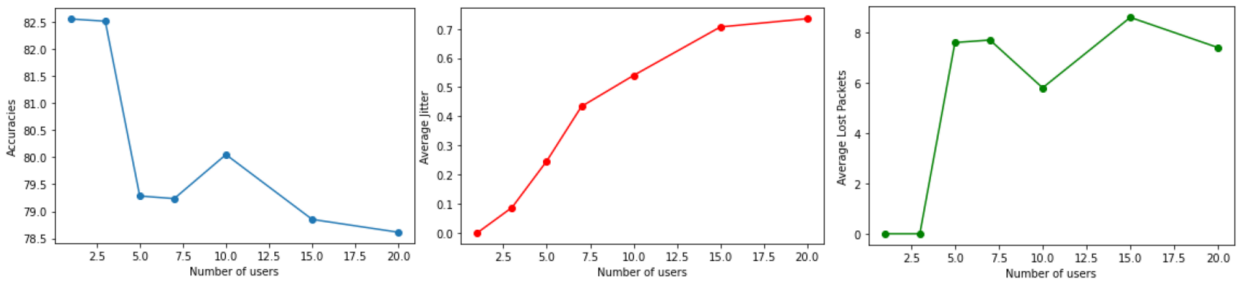
On Off Application

This traffic generator follows an On/Off pattern: after *Application::StartApplication* is called, "On" and "Off" states alternate. During the "Off" state, no traffic is generated. During the "On" state, cbr traffic is generated. This cbr traffic is characterized by the specified "data rate" and "packet size".





User Entities Comparison



Throughput Jitter Lost Packet

In the blue plot shows the average throughput along with different number of users, for one user the throughput has the highest value as the bandwidth is dedicated for just one entity, when the number of users increase the average throughput decrease.

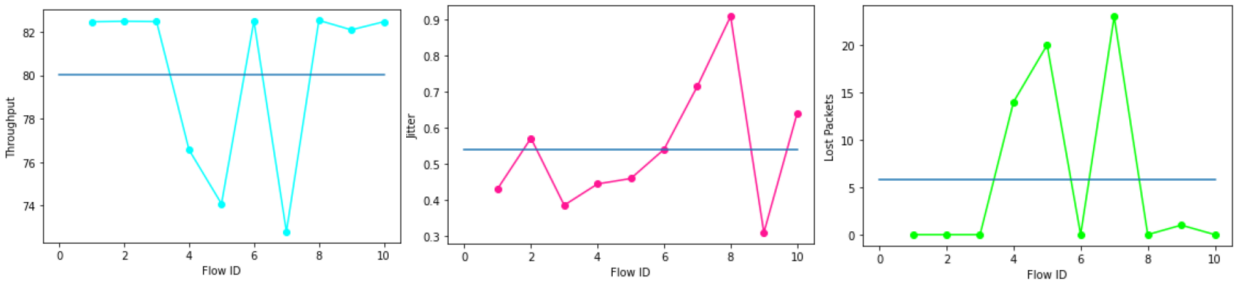
The maximum number of packets is exceeded with increasing the number of user entities.

In the middle, the red plot show the variation of the jitter as it increases with the number of users, because of the increment in the number of packets that may lead to the deviation in the true periodicity.

On the right side, the plot shows increment in the number of packet loss while the user numbers increase.

There's a perfect negative relationship between the throuput and the number of lost packets, they are negatively correlated, when the throughput is high, the number of lost packets deacrease and vice versa.

User Entities Comparison



Throughput Jitter Lost Packts

In the left plot shows the variation in the throughput for each flow, the maximum throughput is more than 82 and the minimum is around 74 with average of 80.

In the middle plot, we can see that the jitter values are variying between the flows and not stable for each connection.

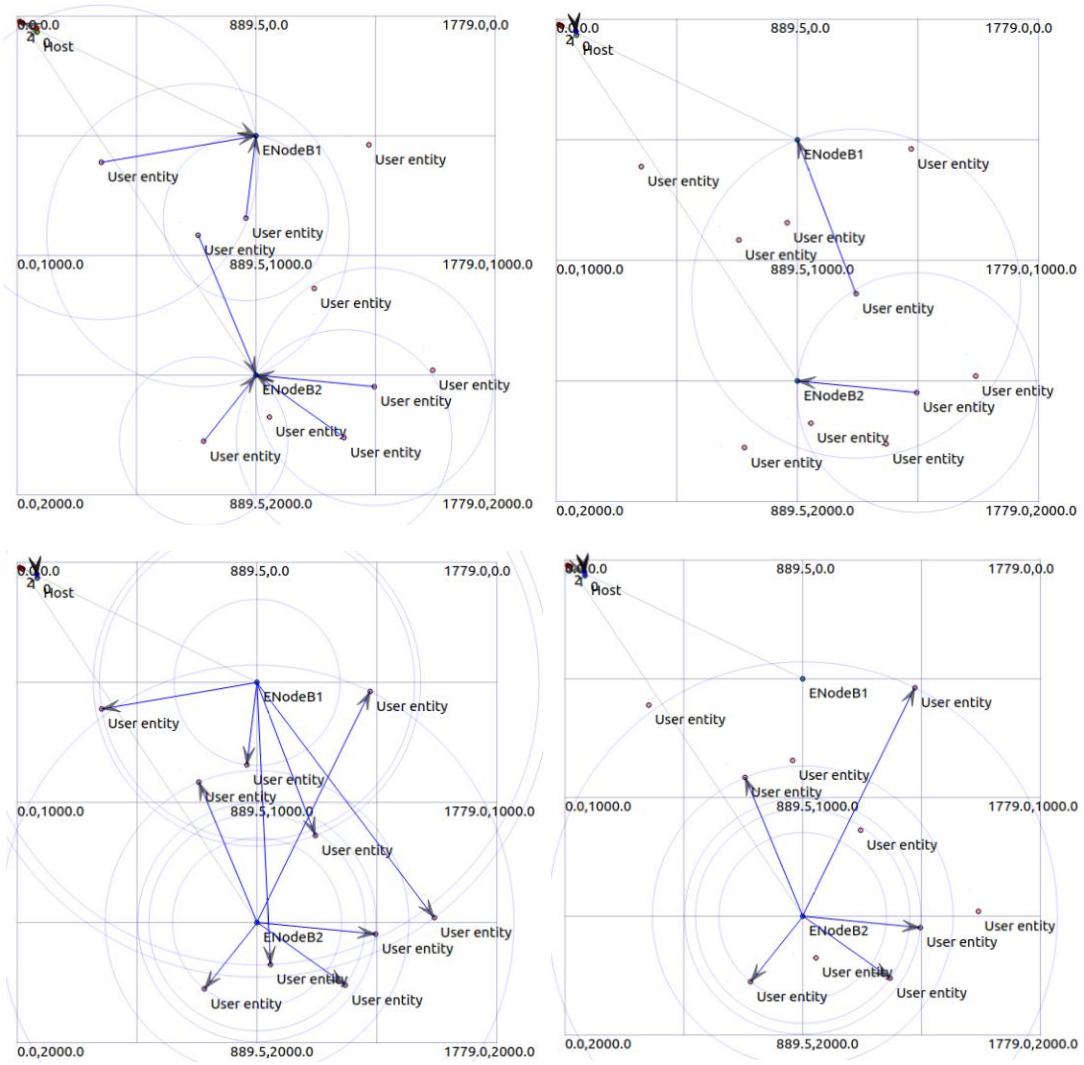
In the right plot, we have no loss packets in the first flows then the loss increases to more 20 packets with average of around 6 packets for all flows.

again, we see the perfect negative relationship between the throuput and the number of lost packets, they are negatively correlated, when the throughput is high, the number of lost packets deacrease and vice versa.

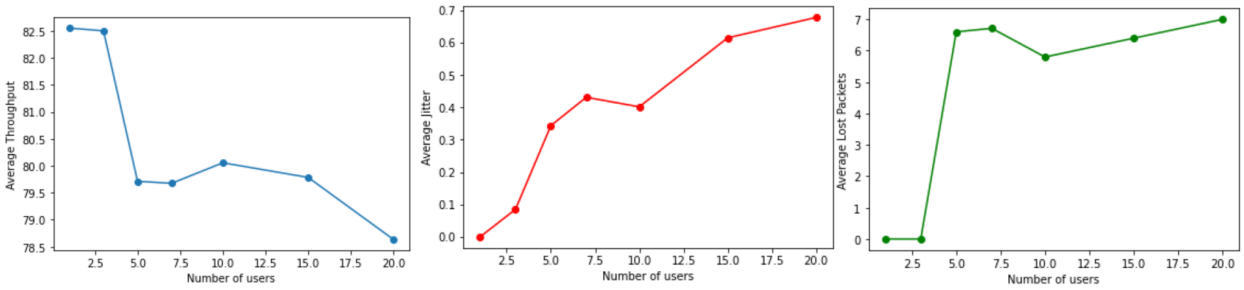
Bulk Send Server Application

Bulk send application sends constant flows of data packets as fast as possible from the host to User entities until the application is stopped or the send buffer is filled up.

When the buffer is filled up, the application waits until some space is freed up again in order to start sending more packets, causing a delay. It sends as much traffic as possible, filling the bandwidth.



User Entities Comparison



Throughput Jitter Lost Packet

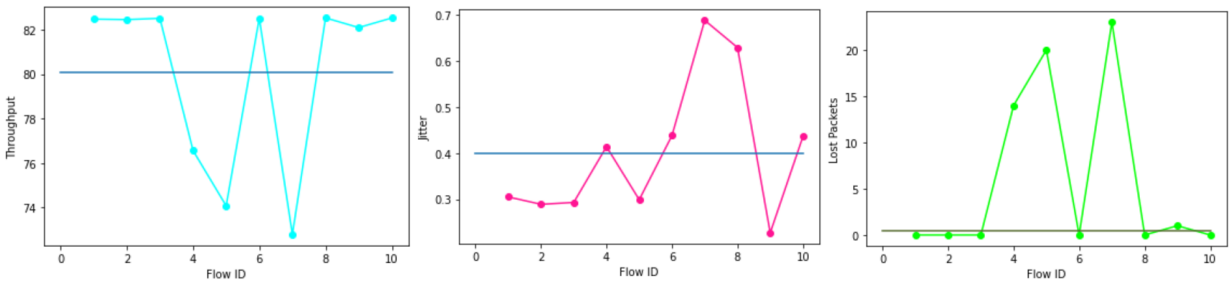
In the blue plot shows the average throughput along with different number of users, for one user the throughput has the highest value as the bandwidth is dedicated for just one entity, when the number of users increase the average throughput decrease.

The maximum number of packets is exceeded with increasing the number of user entities.

In the middle, the red plot show the variation of the jitter as it increases with the number of users, because of the increment in the number of packets that may lead to the deviation in the true periodicity.

On the right side, the plot shows increment in the number of packet loss while the user numbers increase.

There's a perfect negative relationship between the throuput and the number of lost packets, they are negatively correlated, when the throughput is high, the number of lost packets deacrease and vice versa.



Throughput Jitter Lost Packts

Again, the left plot shows the variation in the throughput for each flow, the maximum throughput is more than 82 and the minimum is around 70 with average of 80.

In the middle plot, we can see that the jitter values are variying between the flows and not stable for each connection.

In the right plot, we have no loss packets in the first flows then the loss increases to more 20 packets with average of around 6 packets for all flows.

The perfect negative relationship between the throuput and the number of lost packets, they are negatively correlated, when the throughput is high, the number of lost packets deacrease and vice versa.

Conclusion

ETL EPC network has been simulated for 20 seconds using three different applications on two base stations and dynamic number of users, the three applications have almost the same throughput. In UDP and On-Off applications, the packet loss is quite similar and higher than it is in Bulk send application. The lowest jitter is in UDP client server application with 0.12 seconds and the highest is in On-Off application with 0.54. There's a perfect negative relationship between the number of packet loss and the throughput, when the number of users increases, the throughput decreases, and the packet loss increases too. also, increasing the simulation time increases the average number of send and received packets and hence the lost packets and the jitter increases too.

References

https://www.nsnam.org/doxygen/classns3_1_1_on_off_application.html