Analysis of eMBMS in LTE Networks

An ENSC 427 project on eMBMS in LTE Networks using OPNET

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Group 13

www.sfu.ca/~atian/ensc427.html

Tian, Angel Si 301122374 atian@sfu.ca

Wu, Yang 301119796 yolandaw@sfu.ca

Yang, Wen Lin (Eric) 301120640 wlyang@sfu.ca

Table of Acronyms

LTE: Long-Term Evolution

eMBMS: evolved Multimedia Broadcast Multicast Service

SFN: Single Frequency Network

SNR: Signal to Noise Ratio

MNO: Mobile Network Operator

4G: Fourth Generation

TB: Terabytes

MCH: Multicast Channel

MCE: Multicell/Multicast Coordination Entity

MME:Mobility Management Entity

e-BM-SC: evolved Broadcast Multicast Service Center

eNodeB: E-URAN Node B/ evolved Node B

E-UTRAN: evolved UMTS Terrestrial Radio Access Newtork

UE: User Equipments

EPC: Evolved Packet Core

S-GW: Serving Gateway

P-GW: PDN Gateway

e-MBMS GW: e-MBMS Gateway

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Abstract

The Long Term Evolution (LTE) is a more advanced telecommunication technology than 3G mobile network, it is commonly marketed as 4G LTE. It allows users to deliver data and multimedia using mobile phones and data terminals. In our project, we modeled the evolved Multimedia Broadcast and Multicast Service (MBMS) in LTE architecture in OPNET 16.0 Modeler. MBMS data transmission in LTE contains single-cell and multi-cell transmissions. We plan to focus on the simulation of single-cell transmission and then analyze the results.

Introduction

Motivation

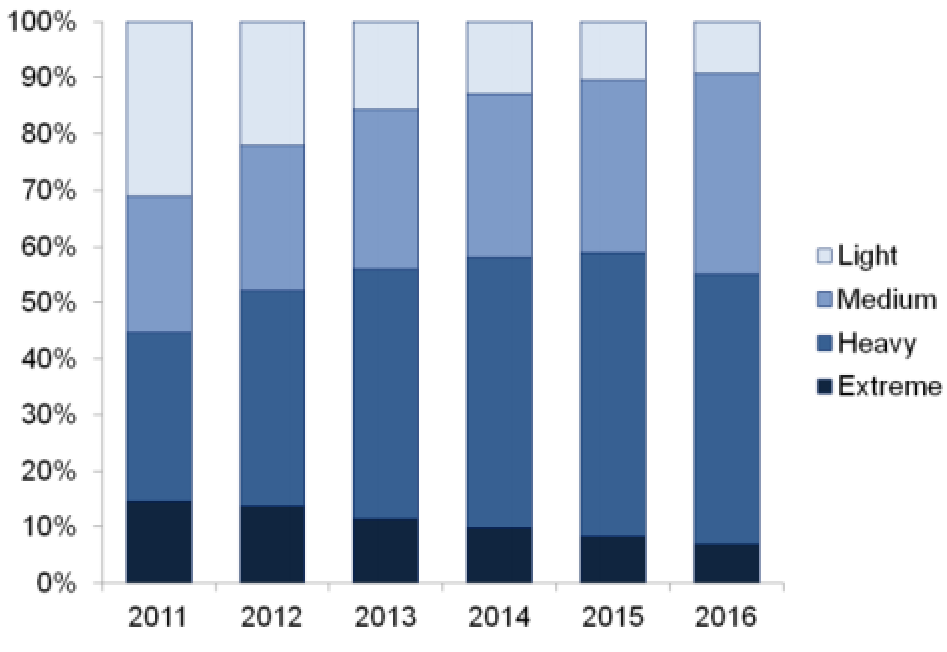

Figure 1: Mobile data usage[6]

In year 2011, mobile users consumed 432,000 terabytes (TB) of data per month and the telecommunication industry predicts a huge growth in the mobile data usage rate per month. It will increase by fifteen fold by year 2016, and that would be a 6.6 million TB usage per month [8]. In order to support the transition in the medium to heavy categories of usage, a broadcasting method is needed. The eMBMS architecture was designed for supporting broadcast/multicast services in LTE.

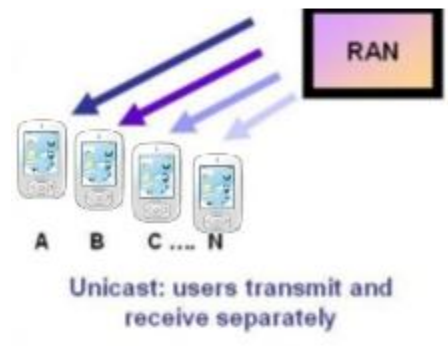

Figure 2 Unicast [9]

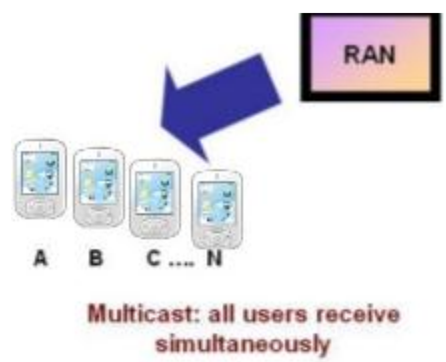

Figure 2: Multicast [9]

One of the benefits of the eMBMS design is that it uses a Single Frequency Network (SFN) that allows a group of eNodesBs to transmit in the same Multicast Channel (MCH). It will also enable the flexibility to the Mobile Network Operator (MNO) to dimension unicast and broadcast to suit the sub-scribers interest [9]. Unicast mean a one to one transmission that transmits information individually and the user receives it separately. Multicast or broadcast describes the one to many transmission methods that all users receive the information simultaneously. The LTE resources are allocated into targeting services areas. It can be as small as venue-specific broadcast to region-specific broadcast or as large as nation-wide broadcast.

The diagram below is an example of unicast and broadcast allocation based on the sub-scriber needs.

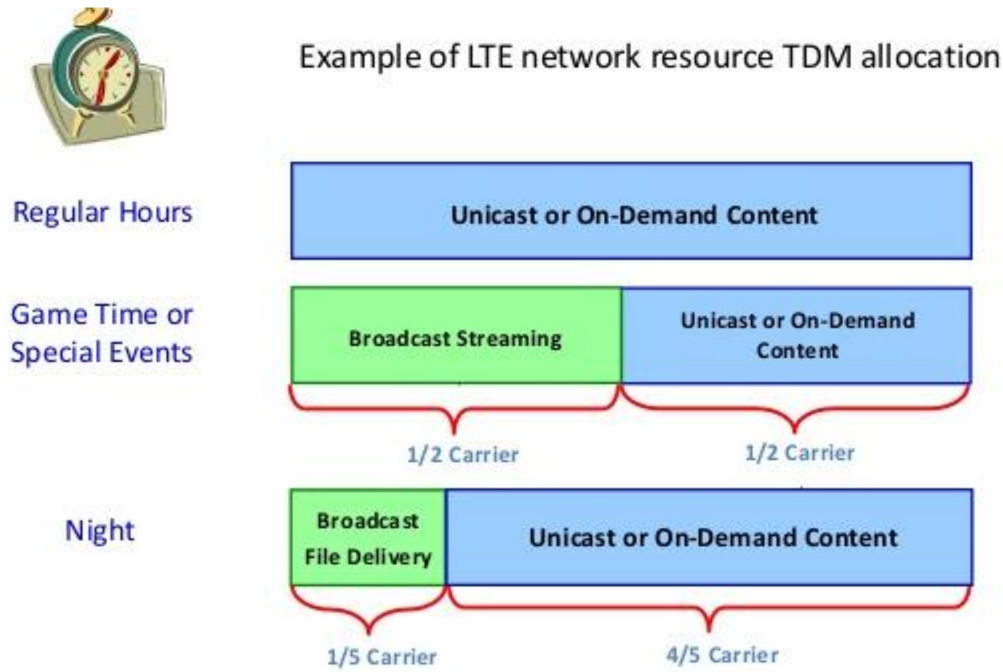

Figure 3: Example of LTE Network resources TDM allocation[9]

During regular hours, it is Unicast or On-Demand contents, then we have Game time or special event hours, where it is separated into broadcast streaming and unicast or on-demand content. During night time, a small portion is broadcasting files and rest of the carrier is used for unicast of On-Demand content.

Design Implementations

eMBMS Architecture

The evolved Multimedia Broadcast Multicast Service has the following architecture [7].

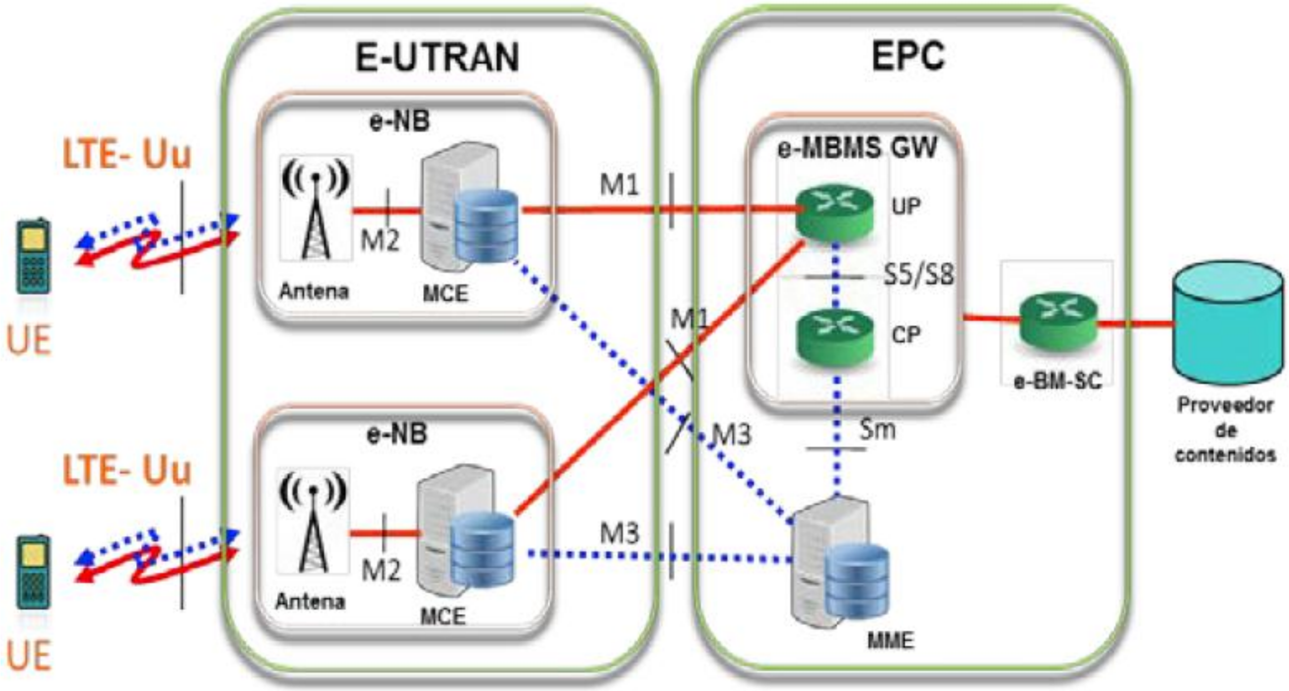

Figure 4: The eMBMS [7]

The multicast packets that are received at the EPC will be forwarded to the eNodeBs, and the packets will be carried by the Broadcast Bearer and transmitted to the UEs. There are three main domains in the e-MBMS architecture design, the User Equipment domain, the evolved UMTS Terrestrial Radio Access Network (e-UTRAN) and the Evolved packet core (EPC). The evolved Node Bs, the base stations collects information that will transmitted using air-interface to the users and the Multi-cell/multicast Coordination Entity are responsible for the transmission of synchronized signals from one cell to another by allocating the same radio resources. The users access the MBSFN services by the equipment employed in the UE domain.

There are five main component for the User Equipment are the Mobility Management Entity that is responsible for the Access Stratum signaling which provides secure signaling procedures for LTE gives authentication and authorization functions for both UE and interconnection for in between external packet data networks(PDNs). That also coordinates the User Equipment tracking, paging, polling and reachability procedures. It will also provide warning message transfer function and controls the roaming procedures. The Second part of the five component is the Serving Gateway. What it does is providing an anchor for the user plane and the mobility for the LTE and other 3GPP technologies. Next we have PDN Gateway that provides connectivity from the UE to external packet data networks. It performs policy enforcement, packet filtering, lawful interception and packet screening. Lastly we have the e-MBMS Gate way for forward the MBMS packets to each of the e-NB transmitting service.

In our simulation, since multicast gateway, MME and e-BMSC are already included in the EPC of the LTE modeller, we mainly constructed the E-UTRAN part. First, we created the cells with radius 1000m and placed one eNodeB in the center of each cell. We added UEs into each cell. We used a UE as a service provider that sends the packet to a network, and other UEs will join the network so that the service UE can multicast the video to the other LTE UEs.

Single cell configuration

In the single cell scenario, we use a topology that includes an EPC node, an eNodeB, and various numbers of UEs. We start with 2 UEs at first, and then we gradually increase the number of UEs in the network to see the effect of adding more UEs in the same cell. See the following figure.

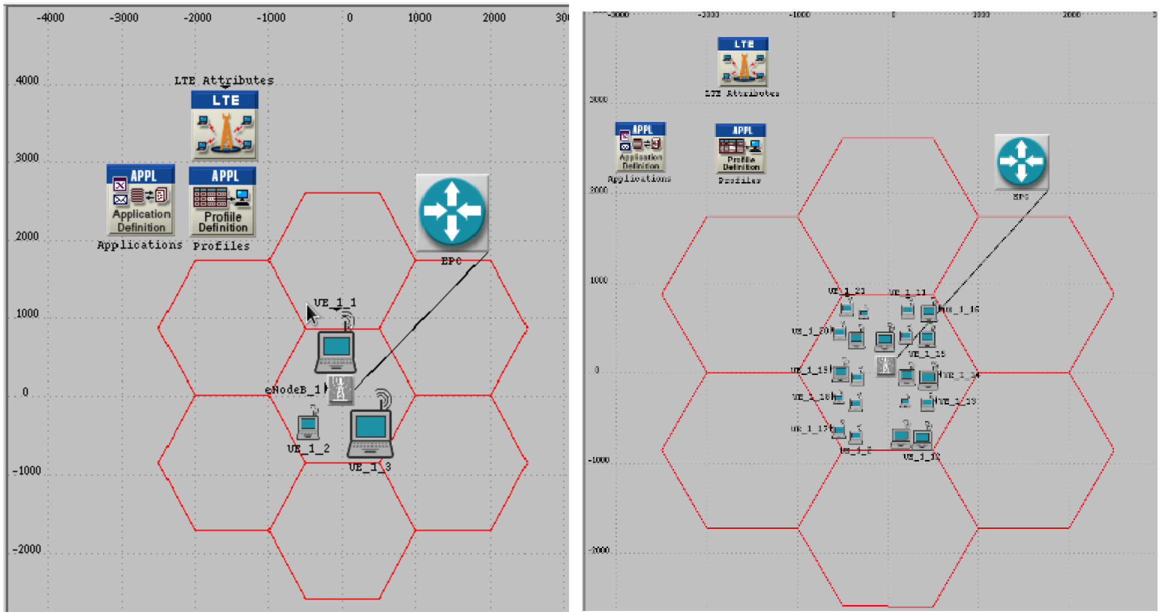

Figure 5: Single Cell Multicast Topology (2 and 20 UEs)

Multi-Cell configuration

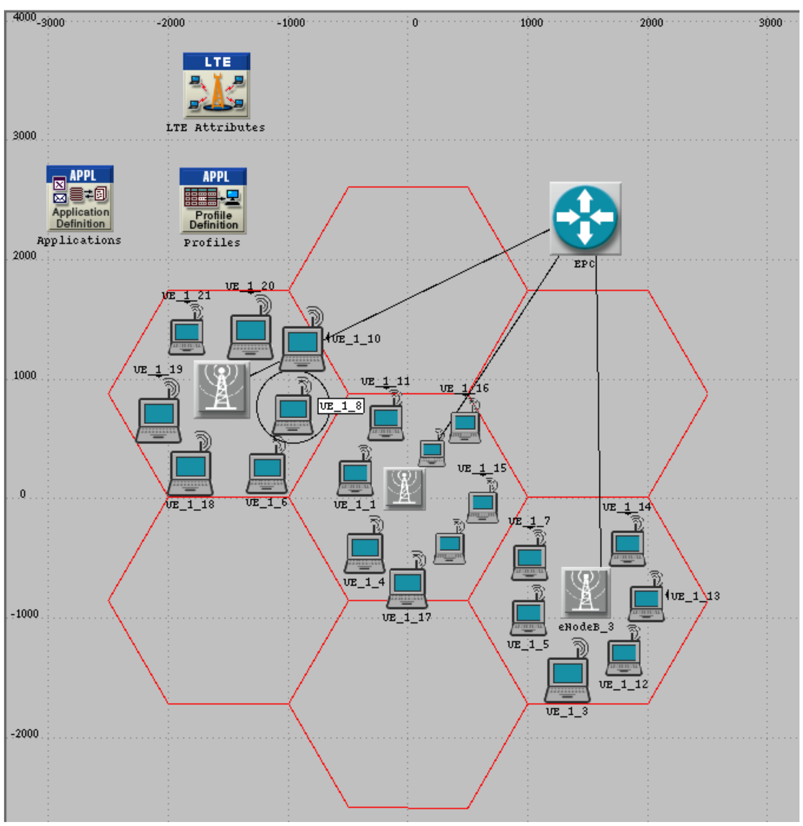

Figure 6: Multi-Cell Multicast Scenario (20 UEs)

In the multi-cell configuration, we use a topology that is the same as the single cell 20 UEs configuration, except that we split the 20 UEs into 3 different cells. We want to compare the 3-cell scenario results with the single cell scenario results to see the effect of splitting the UEs.

We create an application called video which will be used by the service UE to multicast to LTE UEs using IP Multicasting routing (PIM-SM) and the associated broadcast service in LTE. The incoming and outgoing stream interarrival time is set to None and 1s correspondingly, so that the service UE only sends the packets. And we set the outgoing stream frame size to 10 bytes. See the following figures.

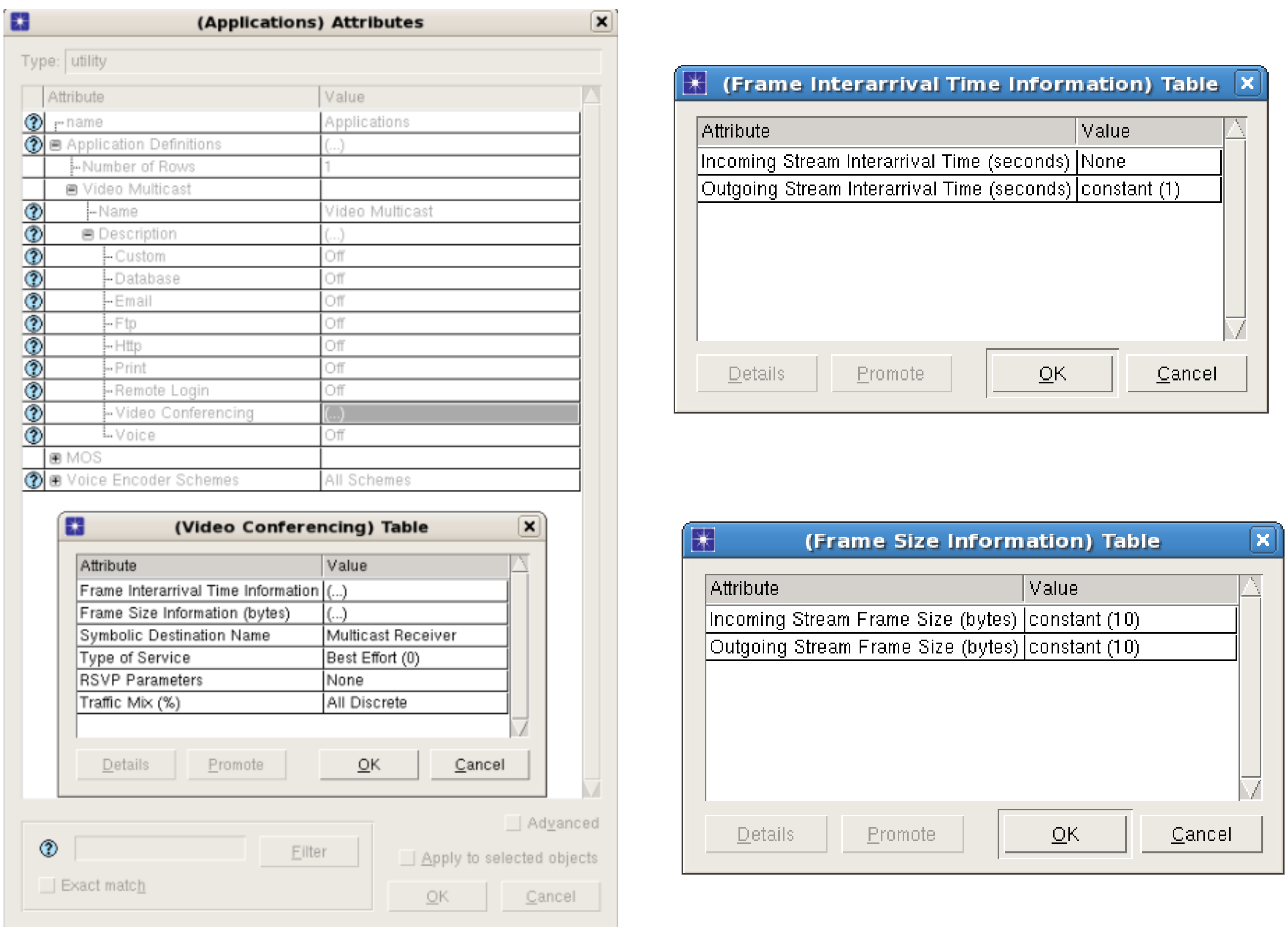

Figure 7: Video Application Specifications

The following figure is the profile definition attributes; we set the profile for the application video multicast, set the start time offset to uniform (5, 10), and set the start time to 110s.

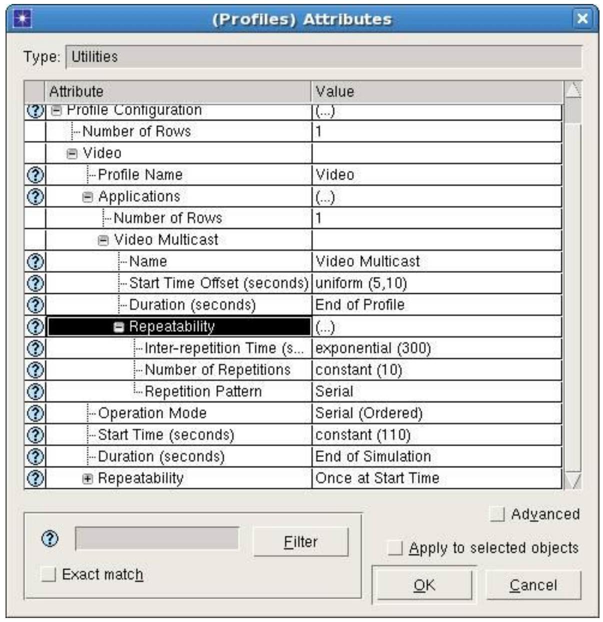

Figure 8: Profile Attributes

Then we set UE_1_1 as the services provider and it sends the packet to a network which has IP address of 224.0.6.1. See the following figure. The symbolic name is set to the one we created in the application definition attributes. Even though it says Multicast Receiver, it only means that it’s the one “receives” what we set in the application attributes.

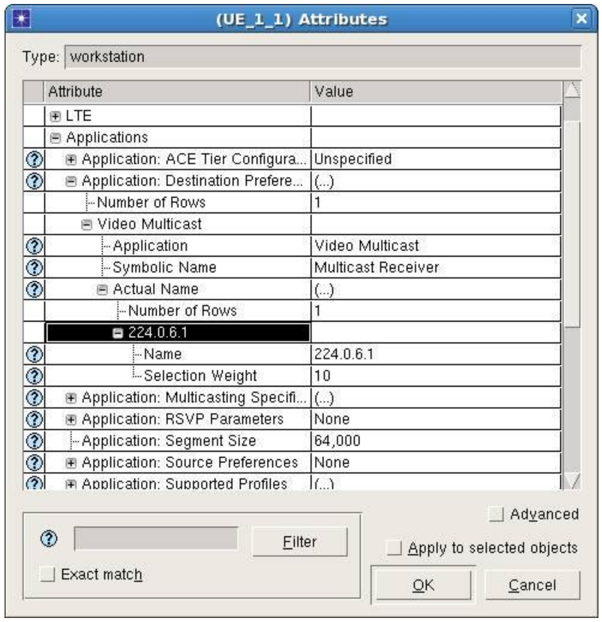

Figure 9: UE_1_1 as the service provider

Finally, we set the service UE and other receiving UEs as following. Use application of Video that we created. Under the Application Multicasting Specifications, we include all UEs in the network of 224.0.6.1. And all UEs join the network at 100s after the simulation starts.

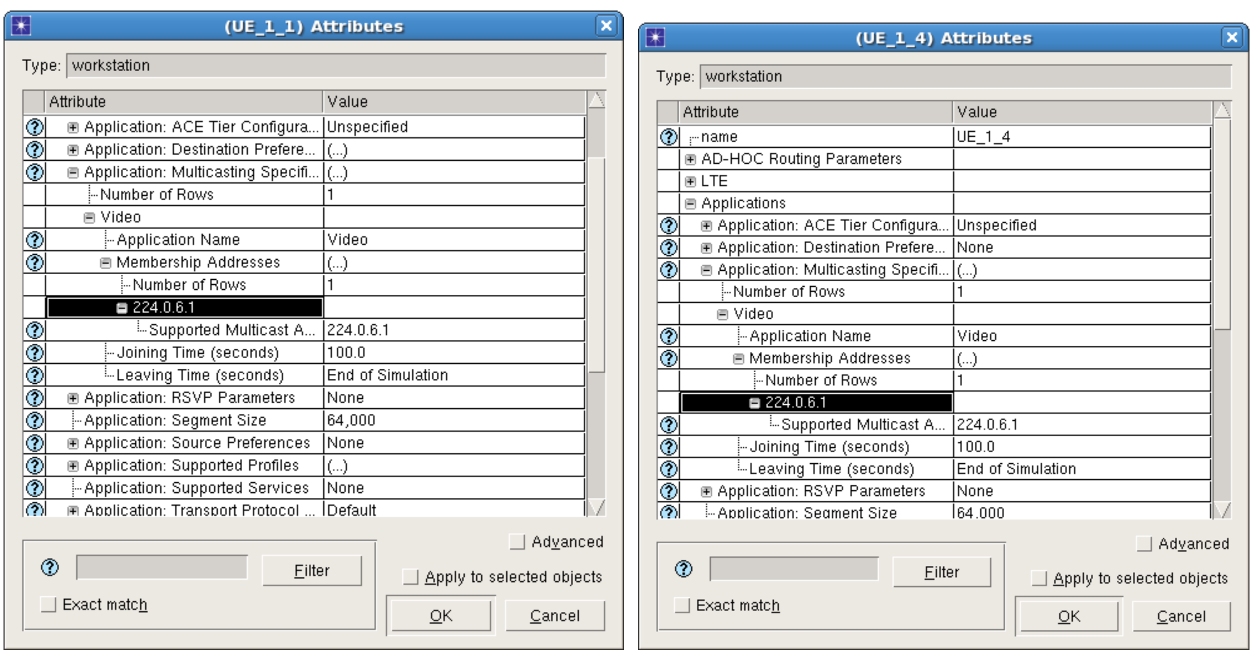

Figure 10: Multicasting Specifications for server and receivers

Simulation Results

Single Cell Configuration

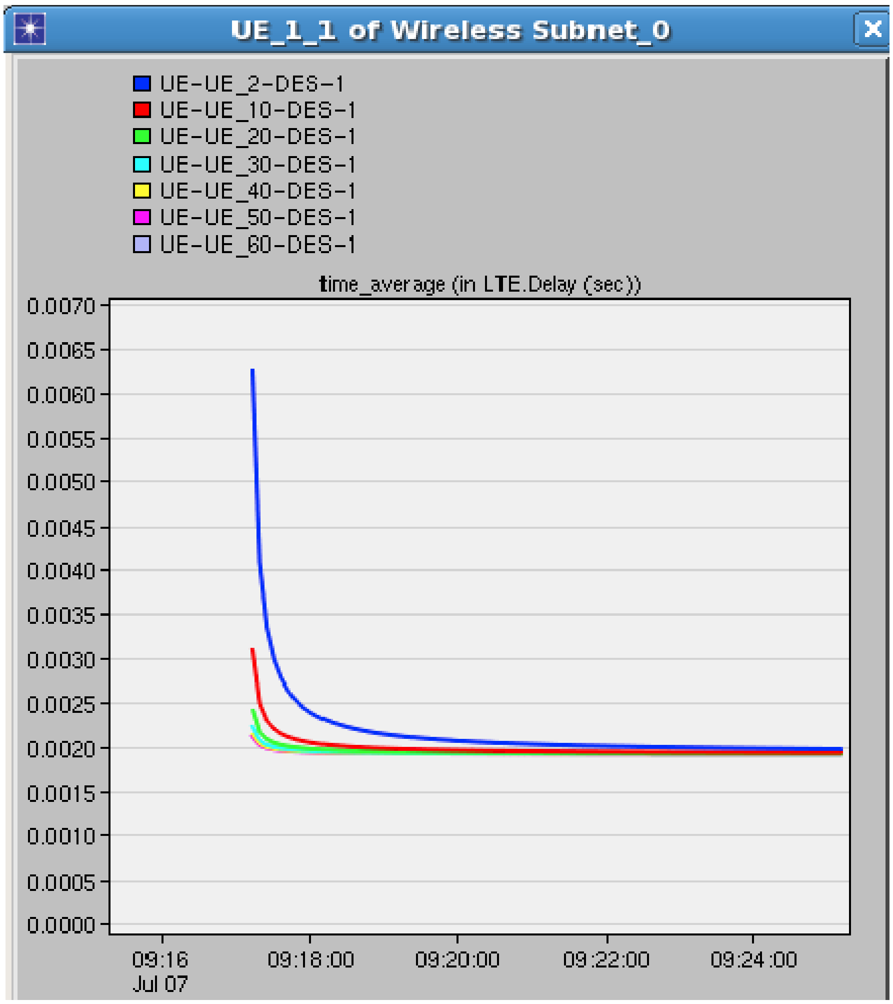

Figure 11: Delay for Single Cell Scenario

From the delay result figure, we can see that as the number of UE increases from 2 gradually to 60, the delay performance becomes better. When there are only 2 UEs, the initial delay is the about 0.0063s, and it decreases a lot in a short period. And it finally reaches at around 0.002s. All other scenarios have the similar results.

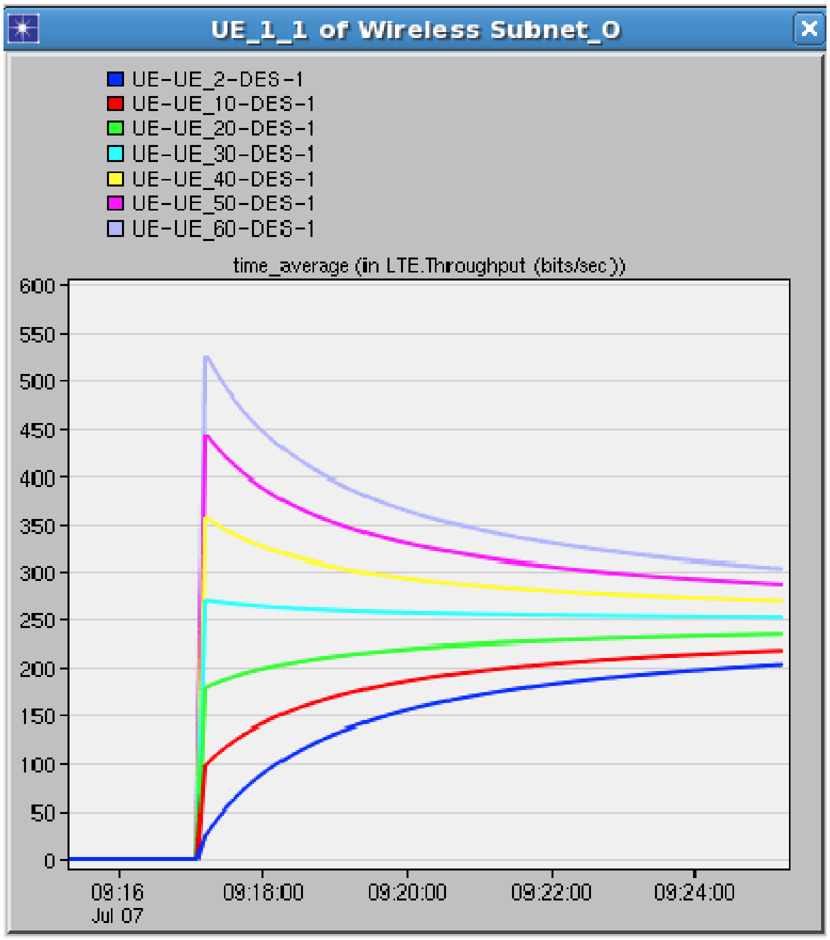

Figure 12: Throughput for Single Cell Scenario

From the throughput result figure, we can see that the throughput performance increases as the number of UEs increases. However, as the number of UEs reaches near 30, the throughput decreases as time goes on. The 2, 10, 20, 30, 40, 50, and 60 UEs scenarios starts with throughput of 10, 100, 180, 270, 360, 440, and 520 bits/sec correspondingly, and will reach steady levels of 200, 210, 230, 250, 270, 290, and 300 bits/sec correspondingly.

Multi Cell Configuration

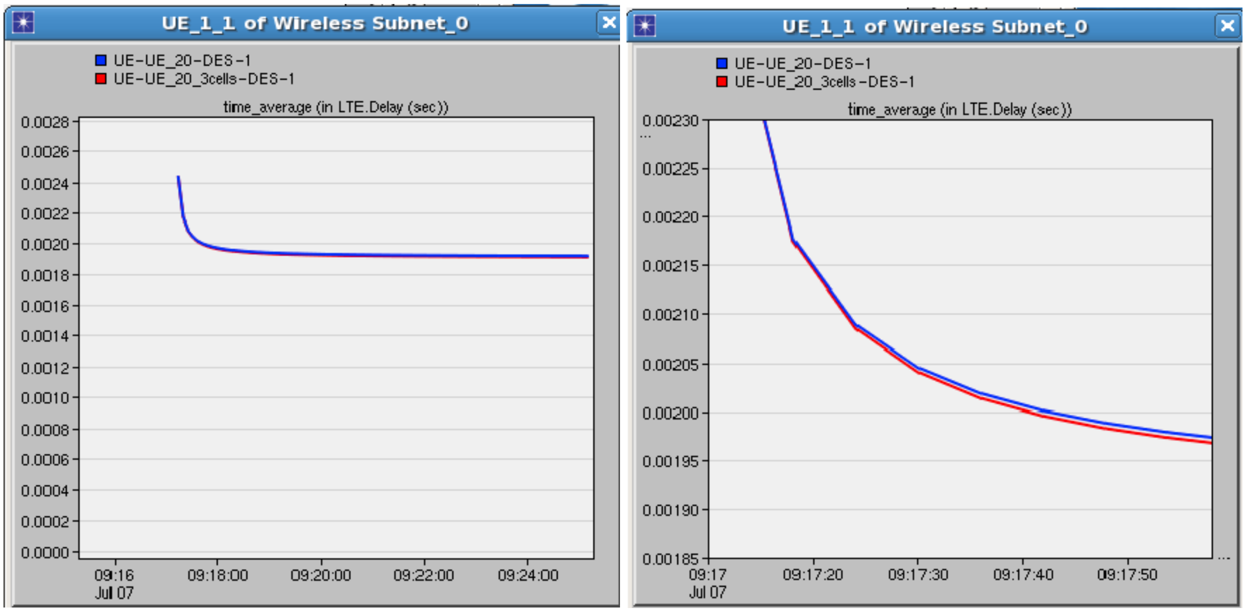

Figure 13: Delay Comparison between Single and Multi Cells

As we can see from the delay comparison from above, we can see that the 3 cell perfomace slightly better than the single cell. For both scenarios, the delays both decrease from 0.0025s, and they will reach a steady level of around 0.0195s, however, the delay for 3 cells scenario is better for about 0.00001s.

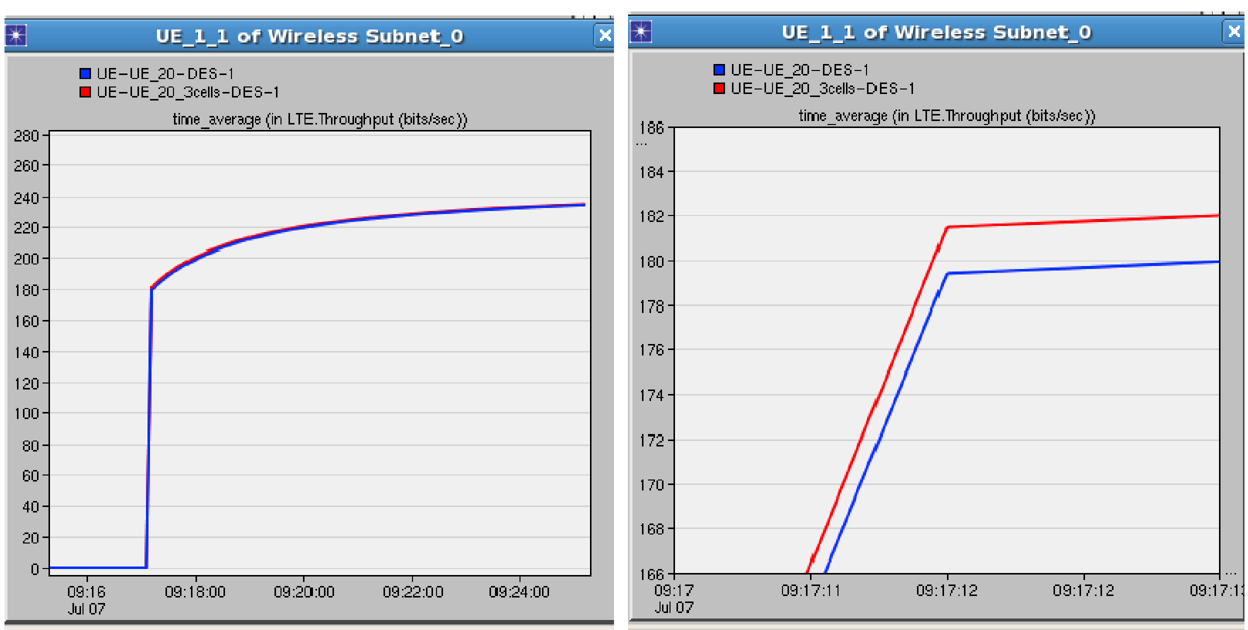

Figure 14: Throughput Comparison between Single and Multi Cells

Also, the throughput is slightly better for the 3 cells scenario than the single cell scenario. Both of them increase the throughput to the level of about 180 bits/sec almost instantaneously. However, the 3 cell scenario is better than the single scenario for about 2 bits/sec. Since we only set the frame size to 10 bytes, if the frame size increase, the effect will be significant.

Conclusion

As the number of UEs increases, the maximum throughput also increases. The MBMS feature requires high performance of networks. From our simulation results, the LTE eMBMS topology did not reached saturation when it has the maximum number of UEs (60) in the single cell scenario, it means that the LTE network has the ability to support eMBMS among 60 or more user devices per cell.

With the same number of UEs, compared the throughput of the single cell scenario with the three cells scenario, at the same time (for example 09:17:12), the three cells scenario allows more throughput than the single cell scenario. It means that multi-cell configuration enlarged the capacitance of network traffic. Therefore, multi-cells eMBMS networks have better performance than single cell eMBMS.

Future work

In the future, we plan to figure out the correct settings to enable the physical parameters for the LTE model study how the cell radius and the distance from UEs to eNodeB affects the throughput and SINR of the system. We assume that, as the distance from UEs to eNodeB increase, the performance of the network will decrease. In addition, we want to study the effects of different cell radius to the network performance and the parameter to study are SINR and throughput.

Since it is not possible for an eNodeB to serve infinity large number of UEs, We have an assumption that the LTE network will reach the throughput saturation at a certain number of UEs. After the saturation point, the global throughput will no longer increase no matter how many more UEs are added into the network. Unfortunately we have not found the number of UEs that saturate one single cell. From the current result, if the saturation point exist, it will be larger than 60. We plan to continue discovering the saturation point.

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