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Analysis of High-volume Video Traffic Transmission in Mmwave Cellular Network (5G) and Comparing to LTE using Ns3

Md Nazmus Saadat

Universiti KualaLumpur MIIT
1016, Jalan Sultan Ismail, Kuala Lumpur, Malaysia

Shazrul Faiz Bin Mohamad

Computer & Networking Section Universiti Kuala Lumpur MIIT
Kuala Lumpur, Malaysia
shazfa96@gmail.com,mdnazmus@unikl.edu.my

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Abstract:
This project is focused on the high-volume video traffic in mmwave cellular network. This work targets for how the high-volume video traffic will affect the LTE and 5g network because of the massive used of video streaming in this modern day. Several simulations are carried out to study the performance of 5G and LTE network and system related to evaluate it. The simulation uses ns3 mmWave module which is a powerful opensource tool available to communication and networking researchers. This study aims to observe ns3 tool and its internal usage for the simulation of the network. Only the results that are achieved using ns3 mmWave module are published in this article. So, the work to be done to verify if the technology can perform the heavy traffic of the current and future video users and producers.

Keywords: *High Volume Video Traffic, LTE, 5G, MmWave Cellular Network, Ns3 MmWave Module.*

I. INTRODUCTION

A. Project Background

In Long Term Evolution (LTE) and 5th generation (5G) cellular wireless network systems, MilimeterWave (mmWave) communications are becoming as a better simulation tools because of its ability to produce many network protocols, features and their potential to gain the passive outputs that future networks needed. A comprehensive tutorial on the opensourcemmWave simulation tool for LTE networks and 5G mmWave have been deigned. It can be used to evaluate high-volume video traffic transmission. The next generation of multimedia technologies would allow telecommunications networks to accommodate a very good internet than the previous internet technology. This new technology will provide the consumers with the best quality performances of video content. Mobile devices is a common device nowadays that users use to access video content, leading cellular network of the next generation which is 5g network to provide a very high-data speeds. So, this project is to develop the simulation that able to know how the video data traffic will affect the LTE and 5G network. the researcher also will analyses the performance between LTE and 5G network using ns-3 mmWave.

B. Objectives

The objectives of this project are to develop a system that will be able to

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- To develop the simulation that able to know how the video data traffic will affect the LTE and 5g network
- To analyse the performance between LTE and 5G network using ns-3 mmWave module
- To study about the ns-3 and its internal usage for simulation of the network

C. Problem Statements

Massive used of video streaming will cause a huge data load. Nonetheless, communication at mmWave frequencies poses many problems at such high frequencies, environmental challenges, etc. So, the work to be done to verify if the technology can perform the heavy traffic of the current and future video users and producers.

D. Project Scope

- Prepare all hardware and software needed
  - Laptop, Debian MX Linux/Lubuntu Desktop, ns-3 MilimeterWave module.
- Setup and install Debian MX Linux/Lubuntu Desktop
  - Install the ns-3 MilimeterWave module in the Debian MX Linux/Lubuntu Desktop.
- Setup and configure ns-3 MilimeterWave module
  - Ns-3 MilimeterWave module will be set up and configured by following the purpose of the project.
- Test the completed system
  - Testing the simulation system by following the objectives.
- Documentation
  - All collected data and result will be documented.
- Update journal paper from day 1 to include every change and new experiments/results anytime.
- Submission of journal paper in IEEE + JTEC format (on JTEC website).

II. LITERATURE REVIEW

A. Background

This chapter consists of a discussion regarding several topics that have related to this project. The review begins with an explanation about the ns-3 Millimeter-Wave module. Then, continue with the literature review which consists of the work from the previous researchers that relate to the area of study. The next section will describe the overall review and background of the ns-3 Millimeter-Wave module. The explanation focused only on the related requirement for this project.

B. Ns3 MmWave Module

The ns3 is a great communication and networking tool that has been created that has networking features to develop new protocols and analyze manifold systems. Ns3 is the replacement of ns2. Ns2 has been tested and used by researchers around the world. Ns3 is an open source and is available for download from the website. An active industry and academic community of researchers has come out with several modules of this simulator tool. Hence, these ns3 tools can simulate a bigger area of networks.

There is a multiple folder that has been included in the ns3 tools. The SRC directory includes a set of C++ classes. In these C++ classes, there are some network protocol and simulation models. The various modules can be combined to construct various virtual network scenarios, making ns3 particularly good for analysis. In addition to the core module which provides the simulator's basic design, there are networking protocol modules also included. All modules are arranged in the library of models.

C. Review Paper

In [1], researchers proposed a study using the idea of network slicing. The researchers want to solve the

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issue of isolating the slices to increase the performance. So, they can reduce latency for high-priority applications. They use the ns3 network simulator to run the network simulation. Their approach is to use the ns3 simulator to model a network of slices. The open flow switch module supported by ns3 mmwave networks and focused on using IoT devices will be implemented for future work.

The authors in [2] proposed a modern heterogeneous multi-band hierarchical network radio access (HetNet). They want to arrange the operation by using the splitting scheme for 2C / U planes. The benefits of their plan aregreatly surpassed by the traditional one that incorporates the mmwavenetworks by using C/U splitting.

Wideband Millimeter-Wave propagation measurements and channel models were suggested by researchers in [3] for the future design of wireless communication systems. This article presents experimental measurements and models for the 28, 38, 60 and 73 GHz mmWave frequencies. For both transmitter and receiver, the researchers used a wideband sliding correlator sounder with steerable directional horn antennas.

The authors in [4] ask whether the transport protocol (TCP) will work in a 5G system. This paper offers an analysis of TCP taking-into account different factors. The factors are the congestion control algorithm which included TCP BBR, TCP packet length, edge vs remote servers, multi-connectivity and 3GPP stack parameters. The researchers want to encourage further study of this subject for future research.

In [5], the authors proposed a survey about the 5G mobile technology. This paper provides a comprehensive and inclusive analysis of recent development efforts towards 5G. The authors want to study the future scenarios of 5G.

In [6], the authors introduce a system architecture for 5G cellular networks with a TDMA-based MAC structure. The author also proposed the effective sharing of resources by allowing the simultaneous operation of non-interfering D2D links. As for the future work, the researcher will reviewneighborhood-discovery in 5Gfor regular handover with directional antennas.

Mobile communications for 5G cellular were proposed by authors in [7]. This study shows that when using steerable directional antennas at base stations and mobile devices, frequencies between 28 and 38 GHz can be used. The authors say that increasing mobile data growth poses a challenge for wireless service providers to prevail over the bandwidth's shortage. The authors provide a Millimetre-Wave solution for carrying higher frequency spectrum.

In [8], the authors proposed a simulation of the 5G mmWave in end-to-end network. This project offers an instructor on a full-stack mmWave (5G) module incorporated in the commonly used ns3 simulator. The author provides many examples of custom mmWave stack performance and tailored congestion control algorithms. The researchers consider that the ns3 module can be interfaced with the ns-3 LTE module's higher-layer protocols and core network models to allow end-to-end communication simulations in full-stack.

The researchers in [9] proposed a 5G mmWave mobile network multi-connectivity. This paper produces a new measuring system based on measurements of directional uplink, stream variance capture and enhanced control signaling. For future work, the authors intend to examine in more depth the possible control system implementations for which the reporting technique is acceptable. The researchers also want to research the implementation of architectures that are analog, hybrid or entirely digital.

Authors in [10] suggested a stable mmwave video streaming architecture based on multiple connections and network programs. The researchers want to test the quality of video streaming using a new combination of 3 things which is the Kodo network

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code library, ns3 mmWave, and real traces. They find that video streaming is reliable over the cellular mmwave links.Their future network is to research how additional performance improvements can be made with network coding and to expand the simulation model to decipher the spatial enhancement layer as well as to better define the PSNR of the video received.

In [11], the authors present a performance analysis of hybrid 5G cellular networks. This project was carried out at suburban areas. The aim of this paper is to study the performance of hybrid mobile networks. This network is operating in mmWave and 6GHz in suburban environments. The authors evaluate the SINR and SNR's complementary cumulative distribution (CCDF) function for stand-alone UHF and mmWave networks.

The researchers in [12] suggested system-level performance analysis for the 5 G mmWave cellular network. The researchers demonstrate in this paper that the network output increased automatically by overlaying mmWave small cells. It is because of the removing cross-tier interference. The researchers found that increasing the number of small cells per macrocell above the acceptable threshold of cell density contributes to the degradation of output.

The authors in [13] proposed the microwave photonics approaches for 5G standard. This paper is to study the different RF mmwave signal generation systems by using microwave photonic techniques. In this paper, the authors present diverse systems for the generation of microwave signals through the utilization of microwave photonic techniques to be employed in the new standard 5G. The authors had utilized a VPI photonics simulation platform software for this project. For future research, the authors want to study the performance of the system when employing different modulation formats. The authors did not complete in this paper due to the problems obtained when trying N-QAM data transmitting.

In [14], the authors present a multi-band millimetre-wave for 5G communication. The researchers show a simulated model of a 1X6 array of millimetre-wave square patch antenna on silicon and Roger RO4003 substrates for prominent multiple bands. This antenna can serve cellular networks (5G). it also can provide a device-to-device advance network, a special attribution of the 5G system. In this venture, silicon is used to increase bandwidth. The size of the feeding network also can be decrease.

Initial access in 5G networks were proposed by authors in [15]. The authors say that initial access can be significantly delayed because the base station and the user need to find the right alignment for directional transmission and reception. The findings for this project are there is a trade-off between IA lag and the likelihood of misdetection for this project. The researchers would like to review the cost of obtaining CI and the quality consequences of CI inaccuracy for future research.

In [16], an analysis about reflection of coverage in mmWave networks was proposed by the authors. This project is to study a user's likelihood of coverage in ammwave system depending on the availability of line-of-sight tracks or reflected tracks from any base station. The author believes that reflectors can be properly designed and installed to boost network performance.

The researchers in [17] proposed ultra-low latency in mobile 5G networks. This paper examines the challenges that might occur and provide the solutions to deliver end-to-end, reliable, ultra-low latency services in mmWave cellular systems concerning the MAC layer. The researchers focused on the architecture of the low latency core network, elastic MAC layer, and congestion management.

In [18], the authors proposed TCP and MP-TCP that can be use in the mmwave cellular network. This paper discusses how user experience in mobile mmWave networks can be influenced by a suboptimal relationship between the commonly used

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transport protocol, TCP and mmWave connections. The authors used multipath TCP in mmWave network for this project.

Next is the project that has been proposed by authors in [19]. In this paper, a case is made for using mmwave for a (5G) wireless system for ultra-dense networks. The authors provide an overview of enhanced local area (ELA) technology at mmwave. In this project, they focus on 5G specifications. By using more advanced spectral efficiency techniques, the authors wanted to further improve spectrally efficient systems such as 4G LTE in bands below 6GHz.

In [20], the authors proposed a performance assessment of 5G mmwave cellular access networks. They use a network deployment tool which will be measure based on capacity. This project will examine thebeamforming techniques in different architectures. For this task, the author used the capability-based network deployment tool. The authors conclude that the network requires more base stations than the power to give the user more beamforming capacity compared to 4G. The authors further expanded the research to include multiple antennas for future work.

Related Article Comparison

Serial	Year	Title	Authors' names	Significance of the study	Highlights	Parameters observed	Published at
1	2019	Performance Enhancement in 5G Cellular Networks Using Priorities in Network Slicing	Mohammad Shurman, Eyad Taqieddin and Omar Oudat	Using end-to-end network slicing which is includes slicing in the core network	Design a network of slices over 5G mmwave module using NS-3 simulator	End-to-end network slicing in 5g mobile network	IEEE
2	2018	LTE/Wi-Fi/mmWave RAN-Level Interworking Using 2C/U Plane Splitting for Future 5G Networks	Ahmed S. Mubarak, Hamada Esmaiel and Ehab Mahmoud Mohamed	Fifth generation (5G) mobile cellular networks have been envisioned to face the bottleneck of the current cellular networks in supporting the future high wireless data rates	Wi-Fi medium coverage band is used as an intermediate level between the large coverage LTE band and the small coverage mmWave band	2C/U plane splitting scheme	IEEE
3	2015	Wideband Millimeter-Wave Propagation Measurements and Channel Models for Future Wireless Communication System Design	T. S. Rappaport, George Maccartney, Mathew Samimi and Shu Sun	Presents experimental measurements and empirically-based propagation channel models for the 28, 38, 60, and 73 GHz mmWave bands	This paper presents the first combined contribution of wideband mmWave outdoor propagation measurements and channel models at 28, 38, 60, and 73 GHz for base station-to-mobile (access)	Wideband mmwave measurement at 28, 38, 60 and 73 GHz	IEEE
4	2019	Will TCP work in mmWave 5G Cellular Networks?	Menglei Zhang, Michele Polese, Marco Mezzavilla, Jing Zhu and Sundeep Rangan	To assess how TCP will perform in mmWave cellular network	This project is to identify if the TCP will work in mmWave cellular systems because TCP is the most widely used transport protocol	Performance of TCP on mmWave	IEEE
5	2015	5G mobile technology: A survey	Rupendra Nath Mitra and Dharma P. Agrawal	Several approaches for the envisaged 5G technology: high throughput, low-latency and high reliability	To study the future scenarios of 5G	Describing the improved substitute for OFDMA to energy efficient D2D communication	ScienceDirect
6	2015	Enabling Device-to-Device Communications in Millimeter-Wave 5G Cellular Networks	Jian Qiao, Xuemin (Sherman) Shen, Jon W. Mark, Qinghua Shen, Yejun He and Lei Lei	In this project, it introduced an mmWave+4G system architecture with TDMA-based MAC structure	Mmwave propagation characteristics and the corresponding challenges to enable D2D communication	Mmwave D2D communication	IEEE
7	2013	Millimeter Wave Mobile Communications for 5G Cellular: It Will Work!	Theodore S. Rappaport, Shu Sun, Rimma Mayzus	The increase of mobile data growth making a challenge for the wireless service providers to overcome bandwidth shortage	Today's cellular provide a high quality, low latency video and multimedia application for wireless devices	A milimeter wave solution for carrying higher frequency spectrum	IEEE
8	2018	End-to-End Simulation of 5G mmWave Networks	Marco Mezzavilla, Menglei Zhang, Michele Polese	Requirement of the future network can be achieved by having mmWave	To study the mmWave technology due to todays' network keep evolving and having a potential for multi-gigabit and low-latency wireless	Full-stack mmWave module integrated into the ns-3 simulator	IEEE
9	2016	Multi-Connectivity in 5G mmWave Cellular Networks	Marco Giordani, Marco Mezzavilla, Sundeep Rangan and Michele Zorzi	Multiple connection in mmWave can conduct into robust connectivity	The project proposed the measurement system such as UE transmitting sounding signals in directions that sweep the angular space	Directional uplink measurements, capturing channel variance and enhanced control signaling	IEEE
10	2018	Reliable Video Streaming over mmWave with Multi Connectivity and Network Coding	Matteo Drago, Tommy Azzino, Michele Polese, Cedomir Stefanovic and Michele Zorzi	The telecommunication network needed to support a higher bitrate in order to provide ultra-high video quality to the users	Video and multimedia streaming will be an essential application of the next generation of wireless networks (5G)	This project present a reliable video streaming architecture for mmWave networks, based on multi connectivity and network coding	IEEE
14	2016	Multiband Millimeter Wave Antenna Array for 5G Communication	Prithu Roy, R.K. Vishwakarma, Akshay Jain and Rashmi Singh	This paper presents a simulated design of millimeter wave square patch antenna 1X6 array on silicon and Roger RO4003 substrate for prominent multiple bands	Designed antenna can serve 5G cellular network as well as advance device-to-device (D2D) network which is special feature of 5G communication system	Silicon is used under feeding network to enhance the bandwidth and reduce the size of feeding network	IEEE
15	2016	Initial Access in 5G mm-Wave Cellular Networks	Marco Giordani, Marco Mezzavilla and Michele Zorzi	To overcome the high isotropic pathloss experienced at these frequencies, high directionality will be required at both the base station and the mobile user	This work provides a survey of recent directional IA techniques for mm-Wave cellular systems	A coverage and delay analysis is performed to compare various techniques including exhaustive and iterative search, and Context Information based algorithms	IEEE
16	2017	Coverage Analysis in Millimeter Wave Cellular Networks with Reflections	Aroon Narayanan, Sreejith T. V and Radha Krishna Ganti	The coverage probability of a user in a mmwave system depends on the availability of line-of-sight paths or reflected paths from any base station	Radio signals can propagate around an object, and it supports radio communication when a mobile device is blocked	This project is to analyse the impact of reflectors using stochastic geometry	IEEE

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17	2017	Achieving Ultra-Low Latency in 5G Millimeter Wave Cellular Networks	Russell Ford, Menglei Zhang and Marco Mezzavilla	This papers surveys some of the challenges and possible solutions for delivering end-to-end, reliable, ultra-low latency services in mmWave cellular systems in terms of the Medium Access Control (MAC) layer	Delivering high data rates on end-to-end service while maintaining reliability and ultra-low latency will require adjustment of all layer protocol stack	This project focused on low-latency core network architecture, flexible MAC layer and congestion control	IEEE
18	2017	TCP and MP-TCP in 5G mmWave Networks	Michele Polese, Rittwik Jana and Michele Zorzi	This article explains how the end-to-end user experience in mobile mmWave networks could be affected by a suboptimal interaction between the most widely used transport protocol, TCP, and	Provides insights on the throughput-latency tradeoff when Multipath TCP (MP-TCP) is used judiciously across various links	Multipath TCP in mmwave network	IEEE
19	2014	Millimeter-Wave Enhanced Local Area Systems: A High-Data-Rate Approach for Future Wireless Networks	Amita Ghosh, Timothy A. Thomas and Mark C. Cudak	To further improve spectrally efficient systems such as 4G LTE in bands below 6 GHz by using more advanced spectral efficiency techniques	The mmwave option enables the use of simple air interfaces and large bandwidths can be exploited to achieve high data rates	Using mmWave for a fifth generation (5G) wireless system for ultradense networks by presenting an overview of enhanced local area	IEEE
20	2017	Performance Evaluation of 5G Millimeter-Wave Cellular Access Networks Using a Capacity-Based Network Deployment Tool	Michele Matalatala and Margot Deruyck	Investigate the use of beamforming techniques through various architectures and evaluate the performance of 5G wireless access networks	5G network require almost 15% more base stations and 4 times less power to provide more capacity to the user with beamforming, comparing to 4G	Capacity-Based Network Deployment Tool	IEEE
21	2019	Analysis of high volume video traffic transmission in mmwave cellular network (5G) and comparing to LTE using Ns3	Shazrul Faiz Bin Mohamad	This project is to develop the simulation that able to know how the video data traffic will affect the LTE and 5G network	High volume video traffic and performance comparison between LTE and 5G network	This paper used Ns3 mmwave module to run the simulation	

III. METHODOLOGY

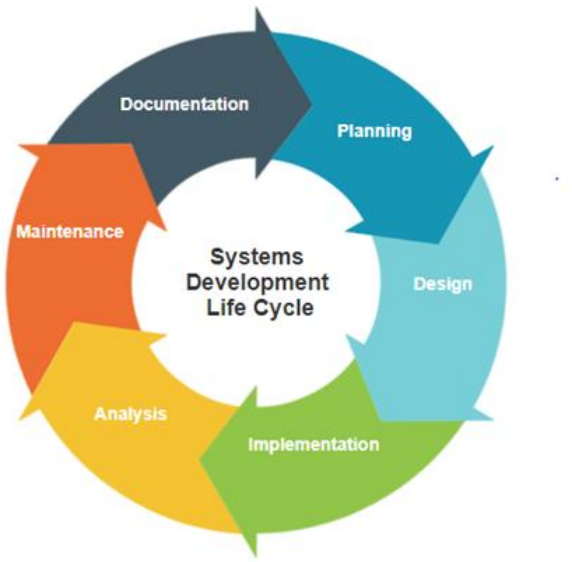

Figure 1

The methodology that is used for the flow of the project System Development Life Cycle (SDLC) as shown in Figure 1 as we focus on the system performance which need to improvise for better result. This project contains 6 phases which is planning, design, implementation, analysis, maintenance and documentation. Planning are the phase where all data high volume video traffic performance involved using ns3 mmWave module, ns3 command and source code. This phase also involving the defining the problem statement, objective and project title. This planning phase also where all the possibility been measure as for the estimate time for the task to be completed as shown in Work Breakdown Structure (WBS) and Gantt Chart. The hardware and software also include in this phase as well as the budget for this project. Design phase is where the drafting of the project flow to know how this project work. The installation ns3 mmWave module, running the simulation in ns3 and graph of result will be included. Implementation phase the project proceed by start running and testing the command and source code in the ns3 simulator and analyse the performance between LTE and 5G network. also implement the flow of the system as shown in the flowchart. Analyse phase is the phase where the simulation performance to be improving and collect as much data about how the high-volume video traffic transmission will affect the 5G mmWave cellular network. If there is any problem occurred and not fulfil the expectation result will proceed to the maintenance phase. Maintenance phase the system will be checked and analyse for the problem and will be improve the data that has been collected. The process will proceed to planning phase execute again. Documentation phase where the preparation for documentation of all result, record and correction to be submitted as a final report.

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A. Flowchart

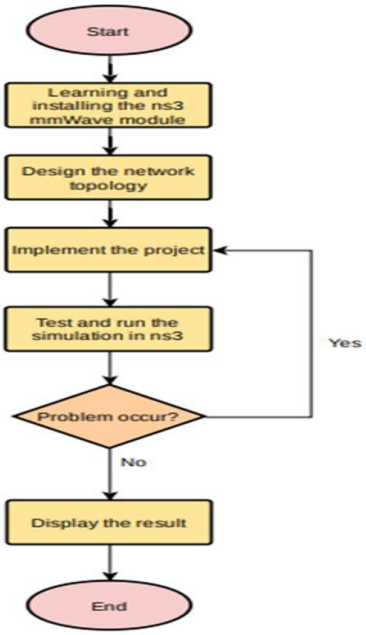

Figure 2 shows the project flowchart of high-volume video traffic transmission using Ns3 compared to LTE and 5G network. This project will start on the installation of the Ns3 mmWave module in the Linux Based System (Lubuntu). After the installation success, we will proceed to design the network topology. The project will be carried out in the simulator ns3. Then, we can run the simulation of the project according to the objectives of the project. All the data will be collected and the result from the simulation will be displayed.

IV. RESULT AND DISCUSSION

A. Introduction

As we know, millimeter wave communication has attracted many of the network researcher to use this platform. The ns3 is designed to simulate high-volume video transmission. By using this network simulator, we also can analyse the performance between LTE and 5G network. The ns3 simulator is an opensource and can be download at http://nsnam.org. Ns3 is needed to be installed in the Linux Based operating system. For window's user, it is require to install a virtual machine and then installed ns3 simulator in it. Users can test and check all the simulation in the ns3 mmwave module to see how mmwave cellular network (5G) works.

B. NS3 Mmwave Module

Figure 3

In this Ns3 mmwave module, it comes with SRC module that includes all the LTE file. As an example, some commands in the ns3 that has been executed as shown in the Figure 4 below.

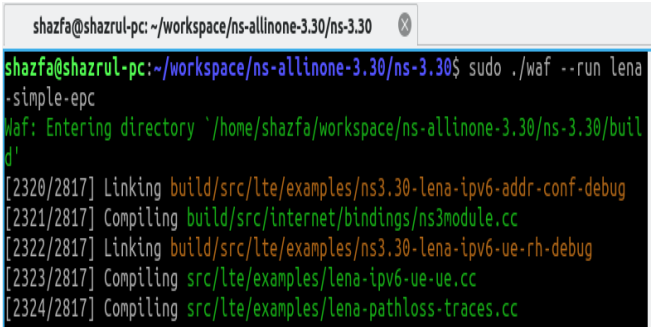

Figure 4

We can see the result in the Figure 5 that has been proposed by author in [19]. These are the layout of the Aps scenario. As we can see, from this idea of example result from [19], we planned to propose the same scenario but in terms of high-volume video traffic. We want to simulate a result that can show the 5g network performance and LTE network throughput like the author in [8] proposed in Figure 6.

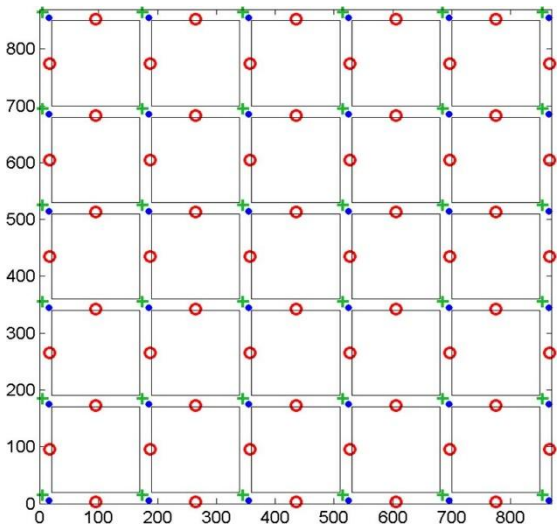

Figure 5

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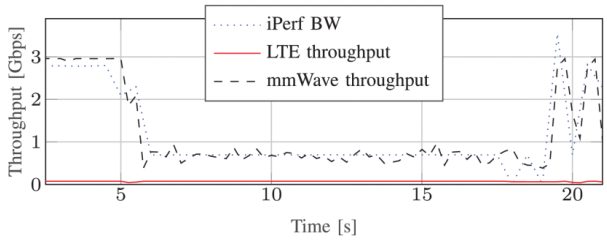

Figure 6

C. Discussion

A mobile network with mobile nodes in LTE/4G, 5G or a similar network environment can be created using the ns3 network simulator. The mmwave system incorporates the following 5G network functionality, which is 5G network simulation with multiple nodes and base station and multi-level LTE coverage as the author in [21] mentioned. The following instructions are executed in Figure 6 to work with the mmwave module in the ns3 network simulator with LTE support:

```
$ sudo apt install git build-essential (Activation of the Repository and the Packages)
$ git clone https://github.com/nsnam/ns-3-dev-git ns-3-dev (Cloning and Fetching the Library of ns-3)
$ cd ns-3-dev/src (Moving to the SRC Directory in ns-3)
$ git clone https://github.com/nyuwireless-unipd/mmwave mmwave (Activation, Cloning and Fetching the mmWave with ns3)
$ cp mmwave/ns-3-patches/patch-for-lte.diff lte (Initialization of LTE)
$ cd lte
$ patch -p1 -N -E -i patch-for-lte.diff
$ rm patch-for-lte.diff
```

To run the simulation, ./waf command is executed. Various variables and parameters can be modeled in the scenarios.

V. CONCLUSION

As a conclusion, this paper investigates high volume video traffic transmission in 5G mmwave cellular network. Communication at mmwave frequency may provide the high data rates required to support high-volume video traffic. The proposed solution was evaluated using simulation on ns3 mmwave module. This simulation also to analyse the performance between LTE and 5G network.For future recommendations, there are few aspects of the research that can be improved. One of the recommendations is investigating the high-quality video streaming over 5g mmwave cellular network. To offer ultra-high video quality, the next generation of multimedia would require a high data rate.

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