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Investigation for LTE and WLAN Conjunction in NS3

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ABSTRACT: In recent days, operating Long Term Evolution(LTE) in unlicensed bands has become vital because of growth in mobile data traffic. We all use LTE, which is a fourth generation of data technology for cellular network. The data connection of our phone depends on specifically defined frequencies, which are licensed by the carrier. There are other frequencies which are the part of the radio frequency (RF) spectrum and these frequencies are called unlicensed and are opened for anyone to use. These unlicensed frequencies are used by remote control toys and walkie-talkies. LTE-U stands for Long Term Evolution of Unlicensed Spectrum where the carriers transmit data by using these unlicensed frequencies. On the other hand, even WLAN uses these unlicensed bands. If we place a LTE-U base station near a WLAN access point and set to the same channel, it leads to interference which affects the performance. But, we know that adding an LTE-U station is just like adding another wireless access point and when it is carefully designed and tuned highly, then the carrier would work closely to mitigate the negative effect. Mobile data congestion has become a major problem on cellular networks because of sky rocketing usage of mobile data. This problem is more in highly densed areas like Stadium, Cinema halls and Malls in large Metropolitan cities. To resolve this problem, Wifi offloading is a major goal with carriers which encourages the venues to provide high quality Wifi networks. This could be possible only in the fixed places like stadiums, but in case of events like temporary music festivals, it is highly impossible because of the same high density network congestion. LTE-U may solve this issue because it puts the financial and operational burden on the carriers which benefits all cellular users. Wifi works towards everyone benefit whereas in LTE-U, only certain customers gets benefits. Numerous scientists are working on the technologies which help LTE-U and WLAN to exist together. In this proposal, we will investigates how these two technologies, LTE and WLAN share the airwaves seamlessly and determine the effect of Throughput, Delay and Jitter when they coexist.

The name often used with WiFi is a WLAN – Wireless Local Area Network. WLAN is the wireless network of devices connected with radio signals based on IEEE 802.11. WiFi (Wi-Fi) is a term used for a family of products that work in WLAN networks.

KEYWORDS: Long Term Evolution; Wireless Local Area Network; Network Simulator; CSMA./CA; Throughput; Jitter; and Delay;

I. INTRODUCTION

Global mobile data traffic is rapidly growing and has reached 63 percent in the year 2016.The overall mobile data traffic may hit the run rate of 49EB per month by 2021 as per the report from [1]Cisco VNI Index as shown in the Fig 1.

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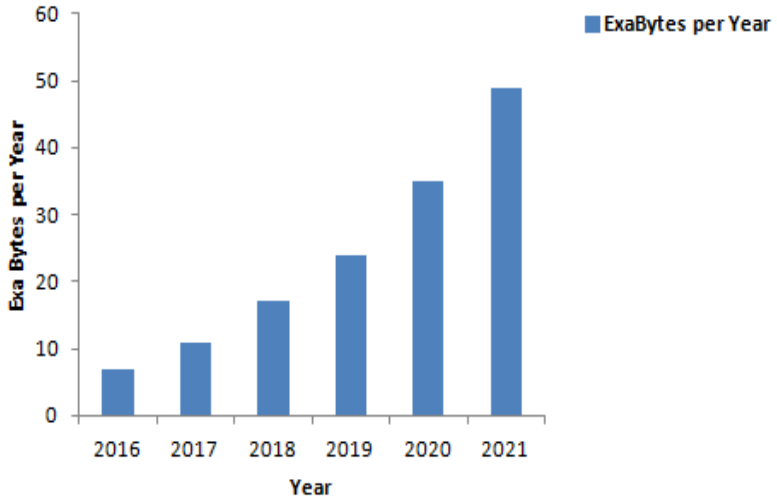

Fig. 1. Cisco VNI Index

Mobile data traffic is generated at user's home which is more. Those users who uses fixed broadband and Wi-Fi APs generates much traffic when compared with traffic generated by mobile. Offload pertains to traffic from dual-mode devices which supports both cellular and Wi-Fi connectivity, excluding laptops over Wi-Fi and small-cell networks. Offloading occurs at the user or device level when the user switches from a cellular connection to Wi-Fi or small-cell access.[2] The mobile offload projections comprises of the traffic from both public hotspots and residential Wi-Fi networks.

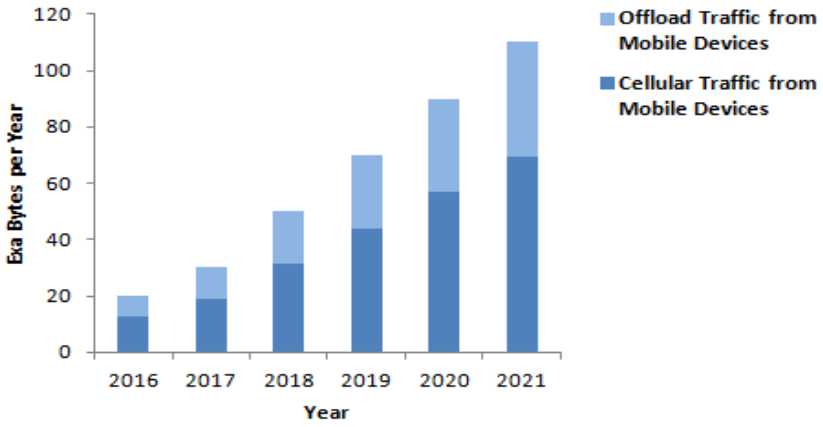

Fig. 2. Traffic from Mobile devices

From the above Fig 2, we can come to conclusion that percentage of total mobile traffic generated by mobile connected devices and mobile offload is increasing. [3]Offload capacity is confirmed by smartphone penetration, dual-mode share of handsets, home-based mobile Internet users, and dual-mode smartphone owners with Wi-Fi fixed Internet access at home. The above report proves that WiFi is widely used than LTE, even though it has more merits when compared to WiFi. [1] for growth in wireless standards.[2],[3] ,[4],[5],[6],[7] for coexistence technique between LTE and WLAN,[10] for modeling of WLAN nodes,[8][4] for various features for coexistence,[14] for resource allocation and throughput calculations[15 for Queueing theory.

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II. RELATED WORK

Long Term Evolution was termed by 3GPP Engineers as it is entitled as the next step (4G) in a evolution from 2G to 3G.The objective of LTE was to amplify the capacity and speed of wireless data networks using new DSP(digital signal processing) techniques and modulations that were urbanized around the twirl of the millennium. LTE features comprises an all-IP flat network architecture, end-to-end quality of service (Qos), higher download rates impending 300 mbps and upload rates of 75 mbps, increasing cell capacity to lodge 200 active users and sustaining fast moving mobiles WLAN or wireless LAN is a network that connects various devices wirelessly. The router of WLAN is employed as a Base Station, which allows wireless connections to the Wifi-activated devices ie., Laptops, tablets, smartphones and other wireless devices, such as smart appliances and smart home controllers inside the range of router's wireless sign[2].

LTE standarised cellular networks while Wifi is a standard for communication in free unlicensed spectrum.LTE requires a cellular operator who installs equipment like eNodeBs(base station), network core, fibers to the eNodeBs etc, which involves heavy capital expenditure to setup the network and substantial operating expenditure to maintain it. [4]The coverage and the performance of the service could be improved by installing femtocell routers in an area. To boost the coverage and capacity of the network, an user can install femtocell router at their homes. On the other hand, Wifi doesnot requires any cellular infrastructure. An user can just simply connect a Wifi router to access wireless internet. Wifi could be better than LTE femtocells for the following reasons: Femto cells shares bandwidth with each other and along with eNodeB. If the number of femtocells are more, consequently there will be decline in the connection speeds. In order to choose bandwith among femtocells, they need to communicate with eNodeBs which again slowdowns the data rate and dynamic performance. Wifi possess same issue with sharing Bandwidth but it works well in shared environment. Wifi 's data flow through wireline internet of the operator network which allows high data rates whereas LTE data flows is controlled by network core, which acts as a fat pipe through which all data flows to the internet and these network core should be upgraded regularly for better performance. Installation and maintenance of femtocell is expensive when compared to Wifi. The data rates are increasing rapidly along with the introduction of new standards like 802.11n and 802.11ac.802.11ac offers data rates close to 1Gbps.Wifi's coverage is small where more people can reuse the same frequencies whereas LTE covers upto 1km ,so frequency reuse is not possible and therefore large number of users are needed to share bandwidth.The Peak speed of LTE is around 50Mbps and of Wifi is around 1.3 Gbps and the peak of 802.11ac Wifi is 26 times faster than peak of LTE.The speed of Wifi depends on the ISP speed, number of people sharing the router and the separation distance from the router.The speed of LTE is provided by the network and the availability of LTE network.Radio interference and collision is a major drawback in Wifi.Wifi donot have good flowcontrol mechanism which causes real maximum speed to be one-fifth of the theoretical speed.LTE has proper flow control which allows maximum theoretical speed to be reached. There is no collision problem in LTE because the LTE has highly regularized band.[8]

LTE handles interferences better than Wifi and hence the combined efficiency and throughput is better than Wifi. But LTE is not a good neighbor in sharing the spectrum. The interference handling capability in WiFi is very bad, but is a good neighbor.LTE has carrier aggregation features which allows LTE to operate along with Wifi.LTE performance requires Spectrum which is very expensive whereas Wifi operates on Unlicensedspectrum,2.4/5GHz ISM bands,which provides the internet to those areas where Licensed spectrum is already in use. Even though these two technologies have their own advantages and disadvantages, we require these two technologies to work together in a single platform. Even their coexistence operation provide various applications like data offloading ,decongestion of LTE network in traffic hotspots and to increase the speed of internet.[8][4]

III. SYSTEM MODELLING

In order to investigate the conjunction behaviour of LTE and WLAN, we constructed a NS3 simulation scenario , which consist of 5 LTE nodes,3 WLAN nodes and a EnodeB using the parameters as summarized in Table I.

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Table I: Simulation Environment Parameters

Parameter	Value
SIFS(μs)	28
DIFS(μs)	128
Slot time δ(μs)	10
Transmission Rates(Kbps)	100
Simulation Time(s)	10

We consider two instances for simulation.

[1] 5 LTE nodes and 3 WLAN nodes simulated for simulation time:5s,10s,15s and 20s.

[2] 5 LTE nodes and 3,5,7,9 WLAN nodes simulated for the simulation time 10s.

In the first instance, we simulated for 5s,10s ,15s and 20s to obtain Throughput, Delay and Jitter. We then compared the throughput versus simulation time and Delay and Jitter versus simulation time which is discussed in detail in next section. In the second instance, number of WLAN nodes were incremented in steps of 2 that is 3,5,7 and 9 to obtain various throughput values. We then compared the throughput versus number of WLAN nodes in the next section. The NS3 Simulation uses LTE model,[10] WiFi model, Mobility model and Flow Monitor model in programming as NS3simulation supports 4G models.

IV. SIMULATION RESULTS AND DISCUSSIONS

In this section, we will investigate the behaviour of Throughput, Delay and Jitter on the conjunction of both LTE and WLAN. We simulated for 5s, 10s, 15s and 20s and the plot of Throughput versu Simulation Time is shown in the Fig 3.

A.Throughput vs Simulation Time

A log – log scale graph is plotted where Throughput and Simulation Time is plotted against Number of trials conducted. We know that Throughput is the rate of information that is transmitted according to various overheads. Throughput depends on several factors like data link rate, MAC efficiency, measured packet error rate, packet size, collision and number of users. We observed that throughput rises as the flow increases. The throughput plotted during 5s simulation time is the least among all .There is rise in throughput level as the simulation time increases. The throughput increases as the data flow increases throughout the simulation. The data rate increases and this causes the increase in throughput. LTE has efficient uplink scheduler, so the rise in the throughput is due to LTE. The throughput offers by WLAN is less when compared to the throughput offered by LTE, but the combination of both LTE and WLAN provides more throughput when compared with their respective individual throughputs. The Fig 3 shown below illustrates that rise in simulation time will therefore rises the throughput levels

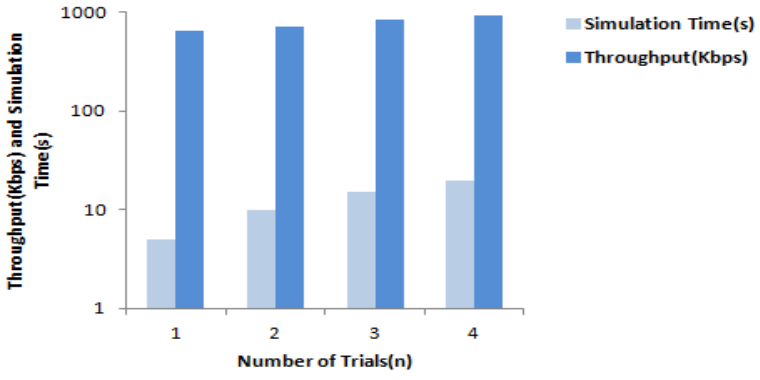

Fig.3. Throughput versus Simulation Time

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B.Delay and Jitter

WLAN uses a kind of contention based MAC mechanism known as CSMA/CA. In WLAN, the devices can use the channel only if it completes random access mechanism. If many devices uses the same channel at the same time, collision occurs which in turn leads in wasting the channel time and therefore, this causes long delay in accessing the channel. LTE uses MAC scheduler. In order to transmit, the device need to contact centralized scheduler, ask for uplink resources and have to get instructions from scheduler as to when and on what frequency it can transmit. This takes more time than accessing WLAN. But scheduler can balance resources across devices by setting priority classes for traffic. The traffic belonging to a high priority class need not have to wait for long time to access the network. Under no load condition, WLAN channels can be accessed more quickly because it is not scheduled. When the network is loaded then access delay is more in scheduled networks like LTE.

Jitter is the variation in the delay of the packets which moves from source to destination. If the connection speed is low, it causes high delay or latency. The rise in interference causes decrease in available bandwidth. If many users are using the connection at the same time and this causes interference which in turn causes increase in jitter.

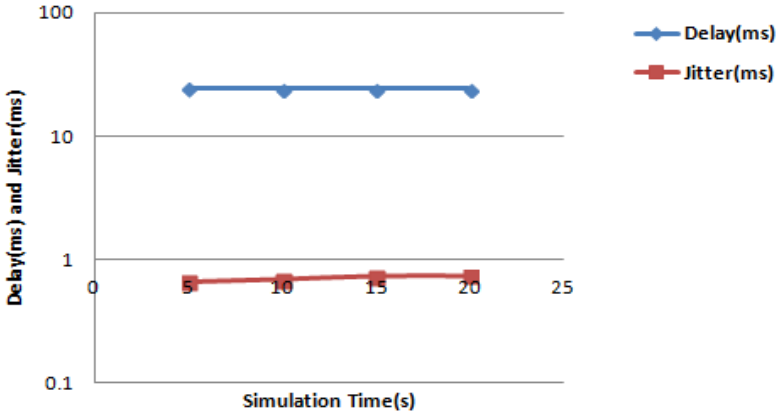

Fig 4. Plot for Delay and Jitter versus Simulation Time

We have plotted Jitter and Delay for various simulation time (5s,10s,15s and 20s) as shown in Fig 4. A log – log scale graph is plotted where Jitter and Delay is plotted against Simulation Time. We observe that jitter decreases as the load increase which means as the simulation time increases but delay increases as the simulation time increases. Delay depends on inter arrival time and simulation time. In case of huge traffic, almost all packets have to wait and this inter-arrival time do not contributes to sojourn time(amount of time a packet waits in a source before it heads to destination) and so in this condition, the delay depends on service time.

C.Throughput vs Number of WLAN Nodes

The Fig 5. shows the plot of Throughput versus Number of WLAN nodes. A log – log scale graph is plotted where Throughput is plotted against Number of WLAN Nodes as conducted. When simulation was carried for different number of WLAN nodes, we could see the decrease in throughput. This is because of increase in WLAN nodes. We know that WLAN is a good neighbor as it uses a kind of contention based MAC mechanism known as CSMA/CA, where it senses the channel before data transmission. In case, if it finds that the channel is busy ,then it waits for a random amount of time ie., back off counter will be started. If the number of WLAN nodes increases, then large amount of time gets wasted in sensing the channel instead of using it. Hence, this leads to the decrease in throughput.

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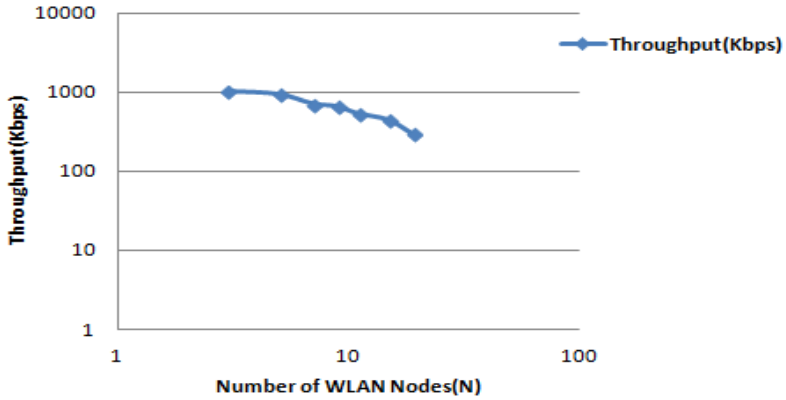

Fig 5. Plot for Throughput versus Number of WLAN Nodes

V. CONCLUSION AND FUTURE WORK

In this paper, we evaluate performance of LTE and WLAN when they exist together. We plotted various graphs for various Simulation Time and for various number of WLAN Nodes. From the simulation results, we can conclude that conjunction of both LTE and WLAN provides more throughput. The delay increases as Simulation Time increases whereas the Jitter decreases as the Simulation Time increases which implies that the conjunction of LTE and WLAN offers better Quality of Service, which is the major requirement in Cellular Industry. We infer that Throughput decreases as number of WLAN nodes increases. This is because LTE donot senses the channel before transmission whereas the WLAN, as a good neighbor, senses the channel. If it finds the channel is busy, it waits for sometimes. And then it make sure that the channel is free, only then WLAN participates in transmission. [8][3]

The study of coexistence of LTE and WLAN is being carried out in various countries like United States, Japan ,China and North Korea and they have implemented this concept in T-MOBILES. Even NS3 has come up with LBT Wi-Fi coexistence modules which works on the coexistence of LTE and WLAN. In future, the study of coexistence will be implemented in LBT Wi-Fi coexistence modules in NS-3 simulator..

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