TECHNOLOGICAL EFFECTS OF COVID-19 ON TELECOMMUNICATION SECTOR: GLOBAL ASPECT

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This Report in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Electronics and Telecommunication Engineering.

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APPROVAL

This Thesis titled "TECHNOLOGICAL EFFECTS OF COVID-19 ON TELECOMMUNICATION SECTOR: GLOBAL ASPECT", submitted by Dewan Arafath ID: 171-19-1959, Eleas Nobi Faisal ID: 171-19-1950, Samiha Rahaman ID: 171-19-1955 to the Department of Electronics and Telecommunication Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfilment of the requirements for the degree of B.Sc. in Electronics and Telecommunication Engineering (E.T.E) and approved as to its style and contents. The presentation has been held in January 2021.

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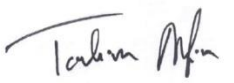

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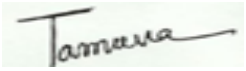

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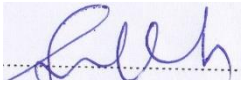

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We hereby declare that this thesis has been done by us under the supervision of **Professor Dr A K M Fazlul Haque**, **Professor**, Department of **E.T.E.** We also declare that neither this thesis nor any part of this thesis has been submitted elsewhere for the award of any degree or diploma.

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We would like to express our gratitude to him for his kind help to finish our project and also the other faculty members of Electronics and Telecommunications Engineering.

DEDICATION

We would like to dedicate this thesis to our parents because without their strict guidance it would not be possible to come this far. We would also like to dedicate this to all the teachers who have taught us even a word in our entire life.

ABSTRACT

“EFFECTS OF COVID-19 ON WIRELESS COMMUNICATION: GLOBAL ASPECT**”** in this thesis the outbreak of COVID-19 which has changed the whole scenario in the entire world including the communication systems has been discussed. Employing communications, wireless communication is also affected by this pandemic. The problems caused by the pandemic has been found out through a set of collected data and the possible solutions which can be imagined is being described in this thesis. It has been found out most of the common problems and how easily the problems can be solved so that the effects can be reduced or the problem is minimized. This study will help to get an overview of wireless communication which is being hampered due to the pandemic. Although there can be more problems and solutions, which could not be found out with the limited knowledge in this phase.

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CHAPTER 01: INTRODUCTION

1.1 Overview

The activities have been changed from the moment COVID-19 has appeared as a pandemic and it has caused a very much changed routine and new normal in the life both in social and economic life and people had to conduct their works in alternative ways available. It has already affected almost all of the sectors life such as education, transportation, health and many more. Works were being postponed and the workers of their corresponding working offices were incomplete isolated from the workstation and many companies were being shut due to the undoable working environment throughout the world. When the situation looked like this pandemic is going to last long and there is no remedy nearby then everybody understood that they have to resume work soon and cannot ignore the important works. So, doing work from home started and it was mainly through the internet. School, college, office works were done through applications like zoom, Google meets, Microsoft teams, Skype and so on. All sectors that are working remotely, are fully dependent on wired and wireless communication and this has been creating a huge pressure on both wired and wireless networks.

The home consumes of the internet has also increased due to this pandemic. As the work was from home and some students are at home, they are playing online games, watching movies through Netflix, Amazon Prime and also other OTT platforms. As a result, data traffic has been increased and calling the relatives increased more than often to know whether they are in good condition or not. They are talking to our officials to talk about works so the network is having a bit more traffic too than usual.

1.2 Aims and Objective

This thesis aims to find out

- The problems in the communications sector
- To know how the problem can be solved

- Impact of COVID-19 on various sectors
- Impact of COVID-19 on existing networks
- Future possible pandemic solutions

1.3 Motivation

This thesis has been motivated by the fact of some papers, journals and articles which describes the problems and impact caused by COVID-19 and the network sector how it is dealing with the new traffic. However, the solutions here are not in full use and they still can be optimized or can be replaced with better solutions.

1.4 Expected Outcome:

- This will enable the reader what the pandemic caused us and the network congestions
- The solutions will lead to a better and more effective solution for the fellow researchers
- The comparison will show how a new situation can change the whole scenario of network

1.5 Report Layout

Chapter 1: Introduction

In this chapter, the aims and objectives, motivation and expected outcome has been discussed.

Chapter 2: Background

In this chapter, the discussion is about the circumstances and details of related works and papers on this topic.

Chapter 3: Methodology

This chapter is all about the findings and solutions of the following topic of thesis what exactly is trying to be done.

Chapter 4: Data Analysis

This part analyzes the overall scenario and how the situation has changed during the pandemic and its effect on the network side mainly.

Chapter 5: Conclusion and Future Scope

This chapter describes the summary and the future scope will indicate where further investigation can be done and fellow researchers can take it to the next level.

CHAPTER 02: BACKGROUND

The knowledge has been gathered from the paper, article and journals. From the sources, the impacts of traffic and data will be known. The data which will be analyzed in the later part is taken from more than 500 of users all across the country.

2.1 Related works

Many events occurred which caused the internet and network to react forcefully. Events like New Year celebration and public holidays and occasion (religious/public) which includes major broadcast and the clustered crowd can cause unusual traffic. These are unpredictable traffics. Outages of the network, Denial of Service attack which can be managed by traffic engineering.

Though This COVID-19 pandemic is a recent phenomenon, the impacts on the internet or data and networks are now being discussed and written and this topic is trending in the meetings of the network and ISP operators how to face this increased traffic challenge. Although the Covid-19 pandemic is a recent event only, its impact on Internet infrastructure has already been widely been discussed through blog posts from individual companies as well as network operator meetings.

2.2 Impacts on Different sectors

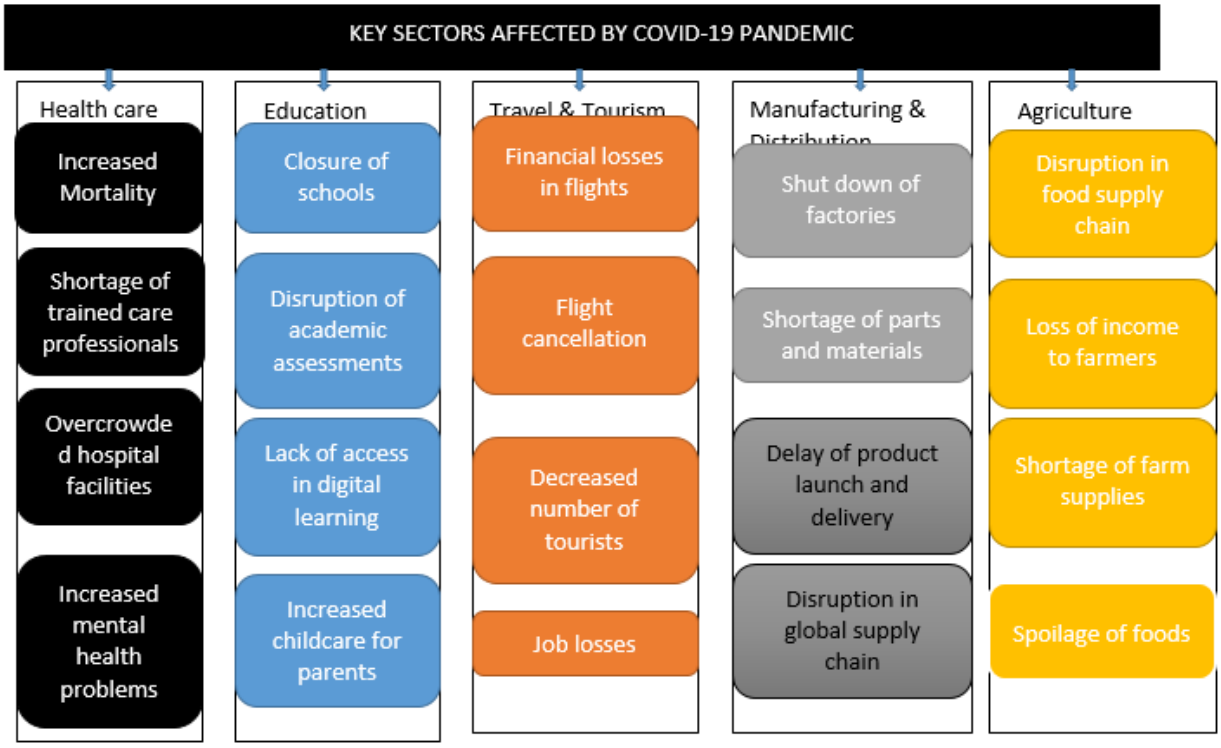

Figure 2.2: COVID-19 Affected Sectors

There is no sector available where COVID-19 did not have a bad impact [1]. The Table describes how deeply these sectors have been affected. It is been described shortly.

2.2.1 Health Sector

This sector has been affected the most. This disease has taken so many lives. The increased rate of mortality has made the shortage of professionally trained doctors and nurses as a result we are not getting proper treatments. Hospitals are very much crowded now due to pandemic and also the lack of on-duty doctors. As we are doing works from our home, homesickness is getting higher. We are having a boring time and mental health problems are rising.

2.2.2 Education Sector

The school is still on closure in many countries and so the assessment process is being altered and all the students do not have the internet facility which is causing them to get part from the flow of study. And now parents are busier with their children to monitor them and If they are finding everything suitable this difficult situation. New assessment technique can also be frustrating sometimes.

2.2.3 Travel and Tourism

This sector was the most affected of all the available sectors. As the social distancing and the lockdown was imposed people are unable to move from one place to another. Pre summer is being considered the peak time in South East Asia. So, it has made a very bad impact on every country's economy. Bus, Train and airlines sector counted a huge loss they probably hadn't have before. This also made a million people quit their job and they were income-less at that time.

2.2.4 Production and delivery

The products all over the world which were being exported or imported had a very bad time. The production associated with human interaction got stuck. So, which products were exported was being wasted and the products which were being imported could not be delivered as there was no freight or air delivery available. Shortage of essential products was seen and African countries suffered a lot. The people associated with production and delivery were jobless and their economic condition was at stake. Now in the modern era, having a digital platform that has enabled online shopping all over the world. Amazon, DHL, Ali-baba and much another product supplier who supply product all over the world could not ship anything. Their business faced a critical time.

2.2.5 Agriculture

Agriculture is the most important sector of any country. People live on food and if the food production is hampered that year that country has to starve without any confusion. The farmers who planted their crops couldn't collect them properly as there was not enough manpower to work

on. He had to work on this own and that has resulted as the riper crops or the climate has destroyed some of them. Also, they could not preserve it well because the collectors were not available and also every farmer does not have cold storage to store other than the government. And as the government works were also postponed due to the lack of preservation a large quantity of food is wasted which will cause short storage of food in the long run.

2.3 How communication is affected

This sector has a vital role to play. As there was a home office and classes from home all the surges were upon the internet, wired and wireless both. This pandemic is the most horrible global crisis the world has faced in many centuries so far! Very few phenomena had this kind of impact all over the world. The new normal to prevent this pandemic led to a different way to use or consume the telecommunication beneficiaries. How the change in traffic has occurred aggressively and the Quality of Experience (QoE) was perceived by the users are shown in the below data [2].

Table 2.3: Change in usage of services in COVID-19.

Type over usage	Week over week change	Change vs. pre COVID-19 typical daily
Gaming	4%	115%
VPN	-5%	49%
Video	0%	36%
Downloads	-1%	39%

Type over usage	Week over week change	Change vs. pre COVID-19 typical daily
Web	-2%	27 %
Serial	-8%	-12%
Voice minutes of use	-5%	25%

The chart shows that gaming varied 4% of increase normally but the COVID made it more than 100%, to be exact 114%! This means gaming, to be specific the online gaming has become the most trending pass time during this short period.

Using a VPN which was on decrease by 5% each week that hovered up 49% to ensure a secured connection as the working is being done on the internet. Video consuming was constant but it increased to 36% as the movie, series and other OTT platforms became very popular for entertainment. Downloads, web surfing and calling over voice is also being increased were the only decrease was in the social sites consuming.

CHAPTER 03: METHODOLOGY

3.1 Finding the problems

As the work is on the current phenomenon it is very hard to collect the data as the available data is very low in quantity, still, data was managed from the reviews, blog post, student journals and lastly the public review through Google Form. So, the findings are two inside. As this is communication systems, it can be both wired or wireless. Countries like Bangladesh have available wired connectivity via Wi-Fi in the city area, but in the rural region, it is still the mobile network that is used for using the internet. Both wired and wireless communication problems will be discussed gradually.

3.2 Problems faced on the current networks

The problems were faced in the current mobile networks and have found out some of those and they are described below

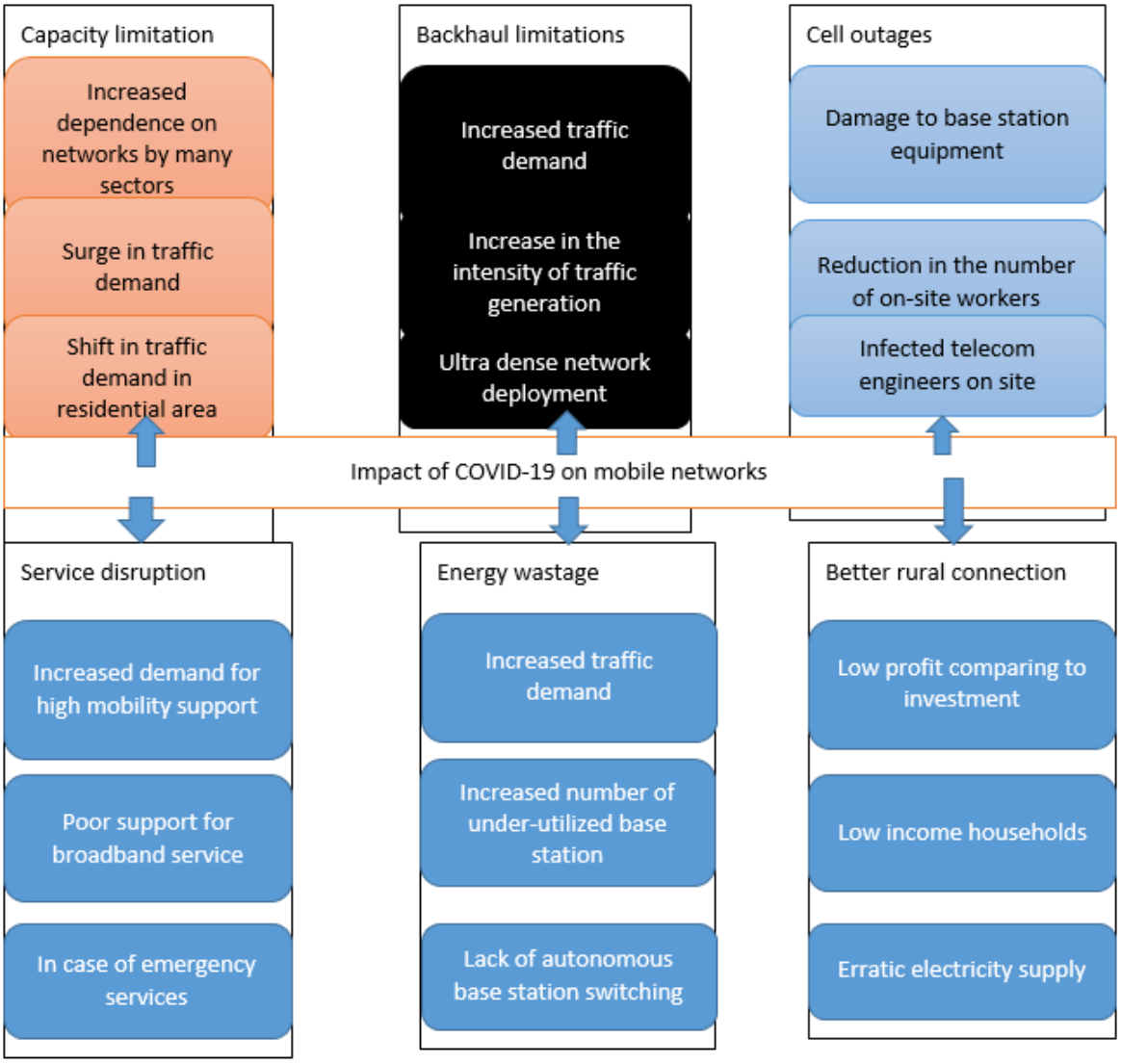

Figure 3.2**: Impact on Mobile Networks**

We have made six different major problems and sorted the problems under them.

3.3 Capacity Limitation

In this period various sectors have become dependent on the internet or more specifically on both wired and wireless networks. The service providers were unaware of this abrupt shift in the traffic from the city to the rural areas. As the lockdown was imposed everyone had to work from home and the residential area which had not that much traffic now due to the circumstances people had to access the network from that low traffic area. As a result, the traffic increased and the rural area network is not that much strong to handle this much surge of traffic. Which lead to very bad traffic congestion. Mainly networks are well developed where it is needed and most of them are city-centered as all the works and other economic activities are occurring within the city region. So, somehow the working from the remote places made an unprecedented surge in the traffic demand and the RANs in that areas were put under much more pressure than usual in the rural areas or where the demand was low to access the network. This problem may not be seen in the countries where there are good network infrastructure combining with broadband and mobile networks. But less developed countries do not have this much backup and as a result of the congestion in the network, high latency and relatively lower data rate this problem can be found and that can be a burden to execute the remote operations.

3.4 Limitation of Backhaul

Transmission of data can be in three ways.

- End devices are connected to the network which is known as an access network.
- Data routing among various sub-networks which is called core network
- Access to the core network or core to access networks is connected this is the backhaul network.

So, as the pandemic started the usual traffic surge which was used to happen at the city end now being spread all over the country. And which part had high population had to face high traffic too. As there was nothing to do, for entertainment purposes people played online games, watches movies, series over Netflix, Amazon Prime etc. OTT platforms, various video streams and online classes have put so much pressure on the limited capacity of the backhaul network at both cellular

and broadband network. The backhaul network was not that much optimized to face and overcome this surged traffic.

Likewise, can be said for mobile networks, Small Cells are deployed under a microcell coverage area and this is under UDN. So, this makes the scenario more complex. Because the chances to route the traffic to macro cells from small cells successfully is very low as the capacity may not be sufficient. This ended up in bad quality of service (QoS), high latency and congestion in the backhaul network.

3.5 Cell Outages

Outages of a cell reference to the fact that that cell is not in the state of working, to be specific this is mainly out of service. Out of service cells cannot work until the proper maintenance is done. When COVID-19 has spread all across the world the telecom workers who worked at the Base Stations, in the field level or the supporting role also had to work from home. As a result, when any kind of problem occurred immediately proper steps could not be taken as there were not enough technicians and also there were not enough people to work and solve the physical problems by attending to that particular location. Also, many of the working person got affected by this virus and got isolated and thus the working and solving procedure got very narrow. This made hard the situation and if any failure occurred only the digitized solution worked and if any kind of human interacted physical solution was needed that opportunity was very low though the workers who worked served with their life risk. Because most of the sectors were very much dependent on the network and if this also failed, we could have faced a tough situation. Which could be out of our control and result in us in a great disaster.

3.6 Interruption in Service

As there is now more mobile user, a high amount of traffic is created and this amount of traffic is not seen before. All across the country people now use the internet and network services and the high demand for service often leads to service degradation in both cases, wired and wireless.

Though mobile networks react better in this situation. So, due to the high demand for the service, any failure can happen which is very obvious and it can cause an interruption in service. Sometimes it is needed to talk emergency to the doctors or medical staffs but as the service is interrupted there is the possibility to miss out on the chances to consult with the doctors properly.

Moreover, the frequent disruption in the service can cause severe damage and it can cause the users many important things. In this hazardous situation where every moment is important. Lack of service quality can cause a life also if the communication does not take place at the right time.

3.7 Energy Wastage

The mobile network operators are facing the main problem of the wastage of energy which is consumed by the base station. The more energy consumption the more operating the network will cost. And the current pollution of air is also causing energy wastage. Now as the usage of the network is now decentralized and people from a remote area or the rural region are also now using the internet and other mobile network facilities, the centralized cluster of using the network is now being eliminated. People moved from their workplace and they are doing their meeting and works from home. So how the traffics were in the city and the energy consumed by Base Stations are now underused.

The city Base Stations are now having less traffic but the energy consumed by it is remaining constant. So the maximum energy is not utilizable and as a result, which energy-consuming was efficient has now become less efficient in some cases. If that energy could be used in other BSs that would have become efficient and traffic also can be controlled more efficiently by the underpowered base stations.

So, it can be seen that it is imposing loss of energy as well as financial to the network operators.

3.8 Limitation of Rural Connectivity

Due to this COVID-19 rural area connections are suffered the most. As the connectivity is limited here and the broadband connection is not always available or everywhere available the coverage area is very low and we know in our country it is a very poor connection or network coverage in the village parts. Also, in the global aspect, the connection in a rural area is not that much strong like the megacities. There are farmers in numbers and who are using smart solutions for crops are depending upon the internet. But as there are not enough manpower farmers are unable to cut their crops and they are getting economically handicapped. So, they will not be able to afford the internet for further solution and plans for their future crops this season.

In this regard, limited connectivity in rural areas harms the productivity of farmers who would have been able to leverage internet-based technologies, such as IoT (Internet of Things) networks to facilitate smart farming activities, such as irrigation, detection of diseases in plant leaves, and collection and analysis of relevant information from their farm.

3.9 Reaction of ISP

ISP stands for Internet Service Provider; they provide us with internet service. To be more precise this is a broadband service and many countries are dependent on it [4].

Table 3.9: How the traffic increased

COUNTRY	VIDEO TRAFFIC GROWTH	VIDEO ENGAGEMENT GROWTH
ITALY	30%	35%
FRANCE	20%	20%
SPAIN	30%	40%
CHINA	20%	15%
UNITED KINGDOM	18%	20%
UNITED STATES	20%	25%
INDIA	10%	60%
SOUTH AFRICA	3%	35%
ECUADOR	3%	10%
COLOMBIA	10%	43%
PERU	20%	40%
BRASIL	20%	25%

Here the video traffic growth is calculated and the video engagement growth throughout the world. Having a look at the users how they reacted can be judged by the Quality of experience. Here we have considered how video watch time was before 1 week of COVID-19 and after 1 week of COVID-19 has been changed and surged the traffic.

The same methodology for assessing video viewership growth is used here. Video engagement growth is the average of video watch time and video viewership growth. The calculation of video engagement growth for several countries that has been selected based on a mix of factors including Covid-19 exposure (high number of COVID cases), geographic diversity and size [5].

There are some more problems caused in this sector which is being added as a chart below.

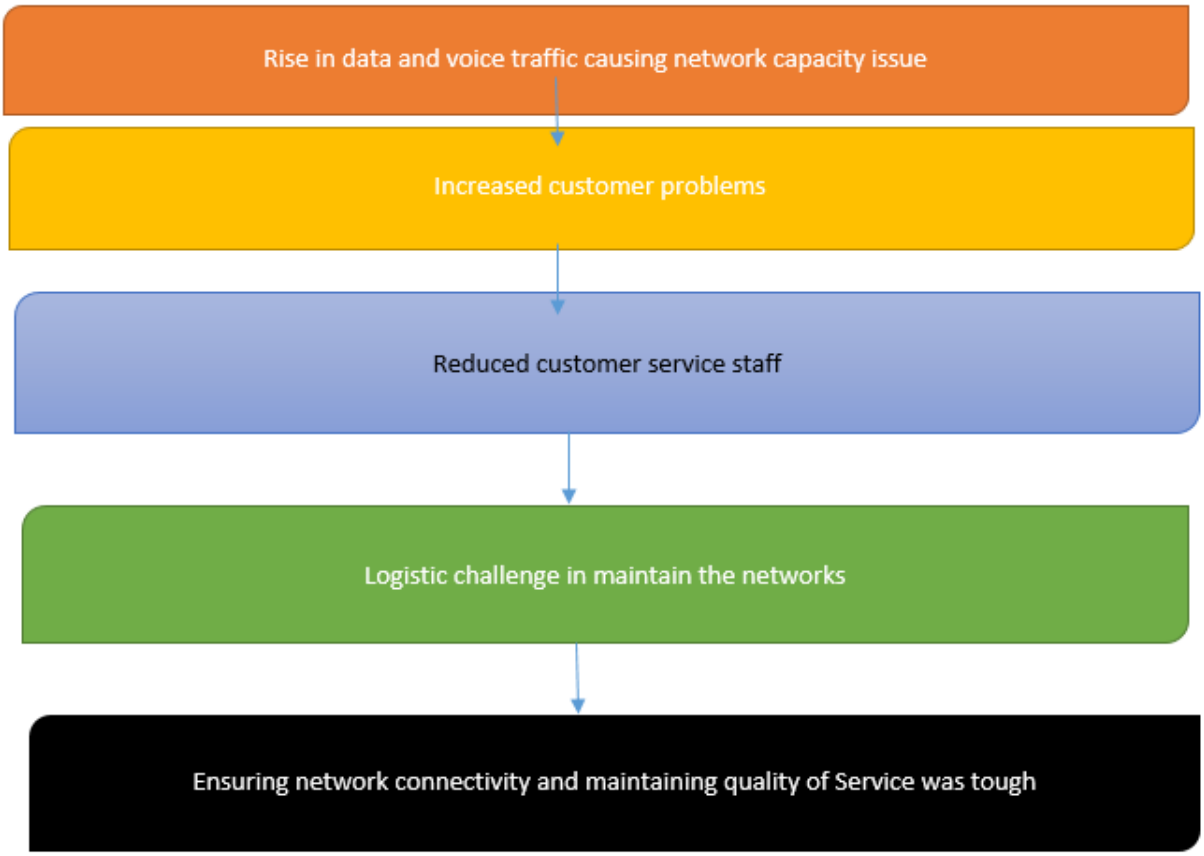

Figure 3.9: Some more Problems

CHAPTER 04: DATA COLLECTION

4.1 The Data Collection

In this thesis, the data considered can be divided into two major groups. One data has been collected through Google form and it will be called local data and the other set of data will be considered as global data which has been collected through Facebook's edge computing.

4.2 Local Data

Local data has been collected through Google form and the analysis is given below. There were 18 different questions to determine the problems.

4.2.1 Usage increase and area

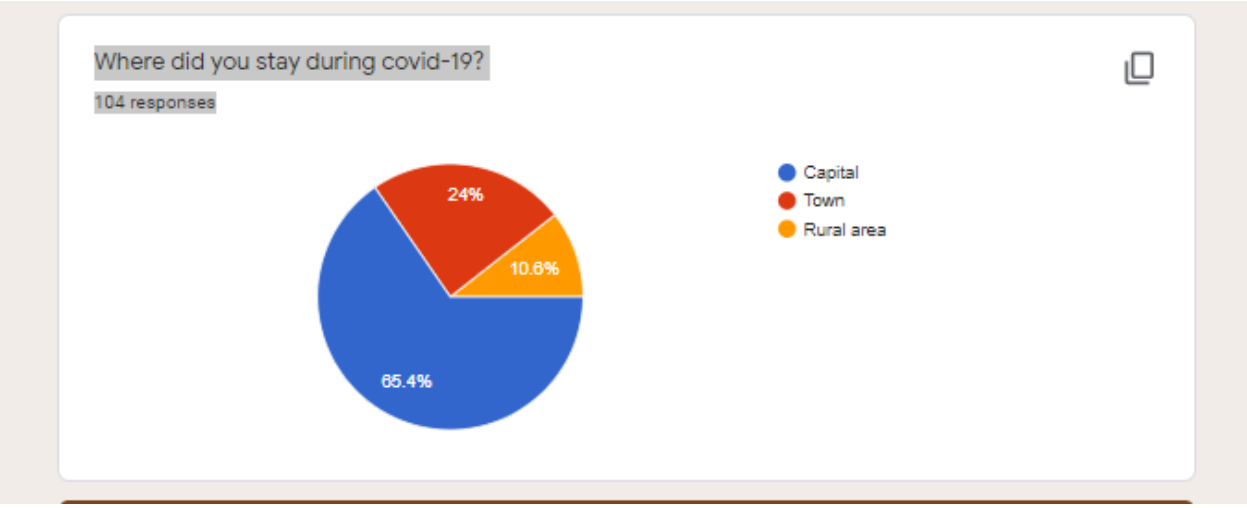

Figure 4.2.1: User area

From the pie chart it can be seen that about 66% people lived in the capitals while 24% were in town and 10% were in rural area. This shows the diversity seen after the lockdown was imposed. Moreover, 77% of the users said that they used internet more than before which indicated the user of internet and works done through internet has been increased.

4.2.2 Slowness of internet

The slowness or delay was seen and the question many misunderstood. They did not understand responsiveness means there was no delay in service, they took it as positive negative. That's why we assume 60% users had opinion which says there was delay in internet services usage. Which also indicates the internet faced issue with increased number of user and increased number of using time.

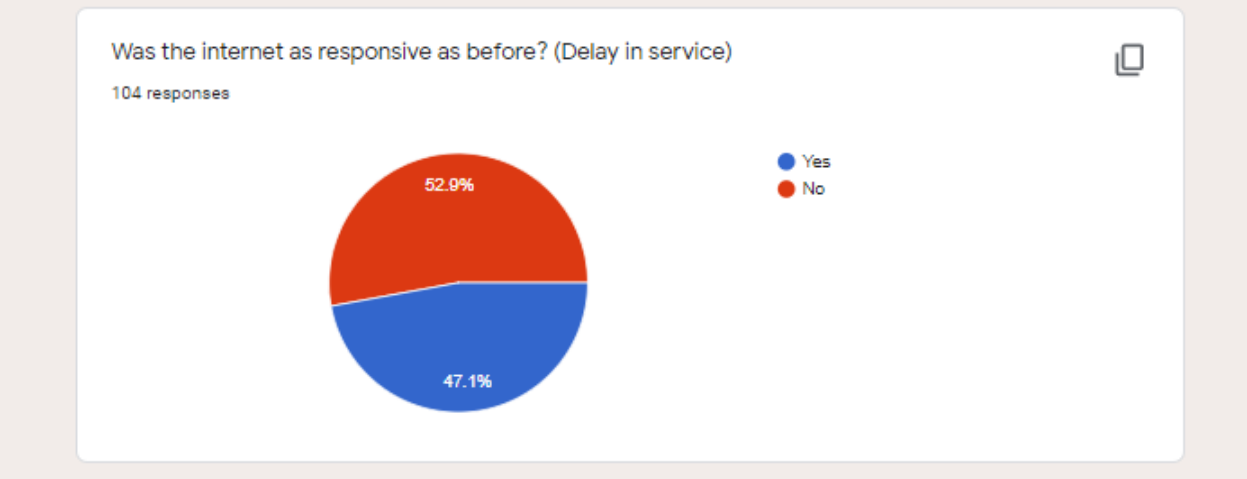

Figure 4.2.2: Responsiveness of internet

The pie chart indicates that 53% of the users stated that the internet was not as responsive as before. This means the associated things with internet or the services availed by using internet had issues which needed to be solved soon.

4.2.3 Services used

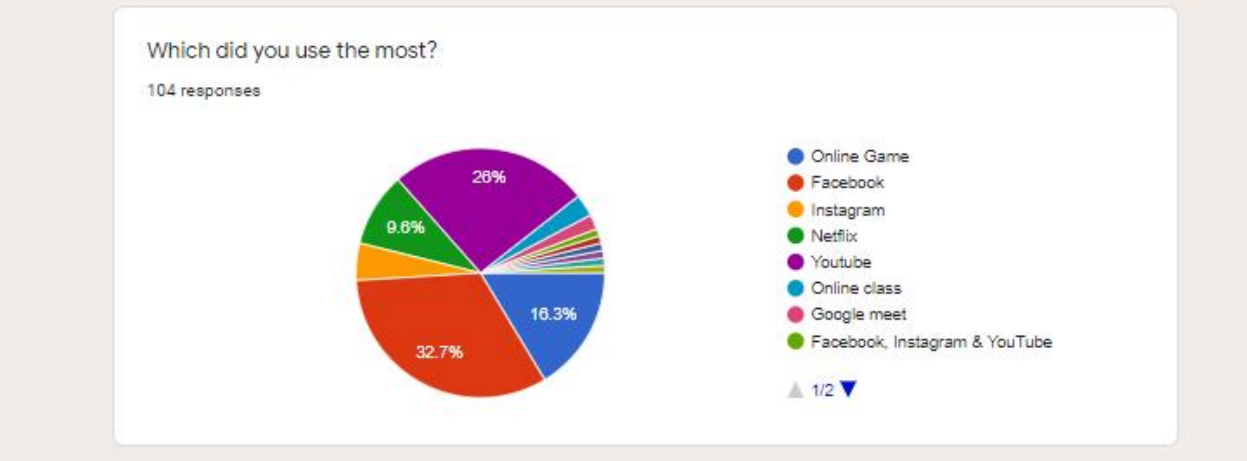

Figure 4.2.3: Services used the most

In this period of time they stated that 32.7% people used Facebook the most. The second most used application was YouTube. 16.3% people stated about the online gaming. The rest was among other apps, online classes etc. So, this signifies the number of users were most in the social sites which includes 9.6% Netflix users also.

4.2.4 Latency

Here the latency parameter has been taken as ping so that everyone can understand and accurate data can be collected.

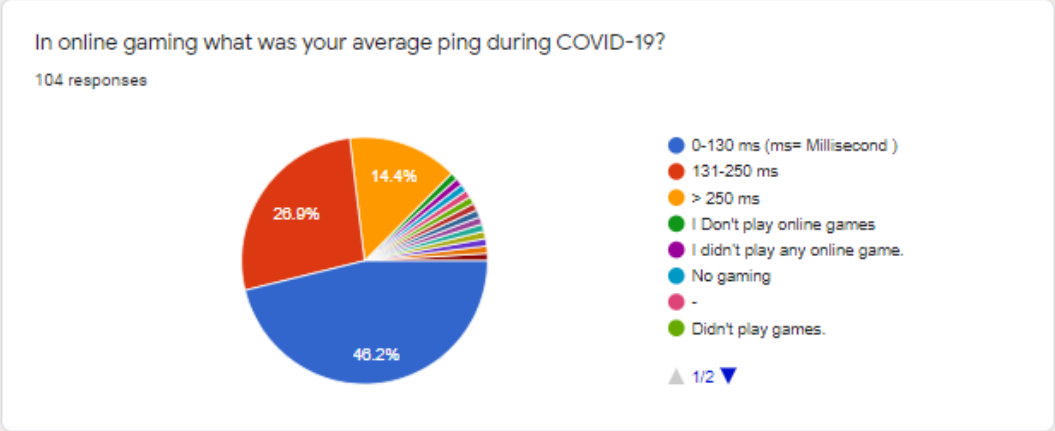

Figure 4.2.4: Latency experienced by users

As the data was taken and the ping time was asked. 46% users stated their ping was within 0-130 ms and total of 40% users said their ping was more than 130 ms, which is relatively high and clearly indicated online gaming users increased number resulted in higher ping.

4.2.5 Delay in usage of social sites

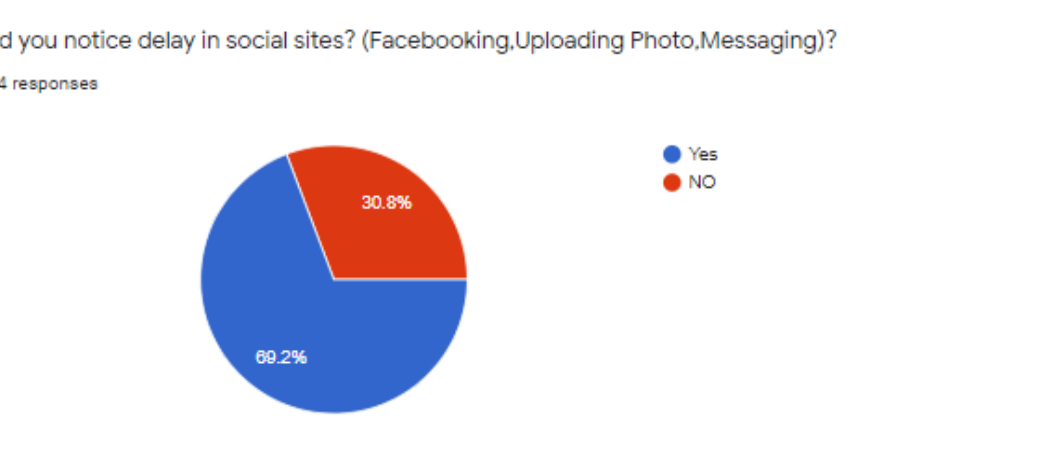

Figure 4.2.5: Delay experienced in social sites

In the above part the data collected indicates that Facebook, YouTube and Instagram these social sites were used in huge number. They also stated that they have seen delay in all the social sites. About 69% of the users said they faced using these sites which indicates the increased number of users also had an impact on the application.

4.2.6 User survey

Most of the users were in city and the data shows that most of the people used the broadband internet about 88.5% of the users to be specific & rest of the 11.5% used mobile data. This shows how much dependent the country is on broadband or ISPs.

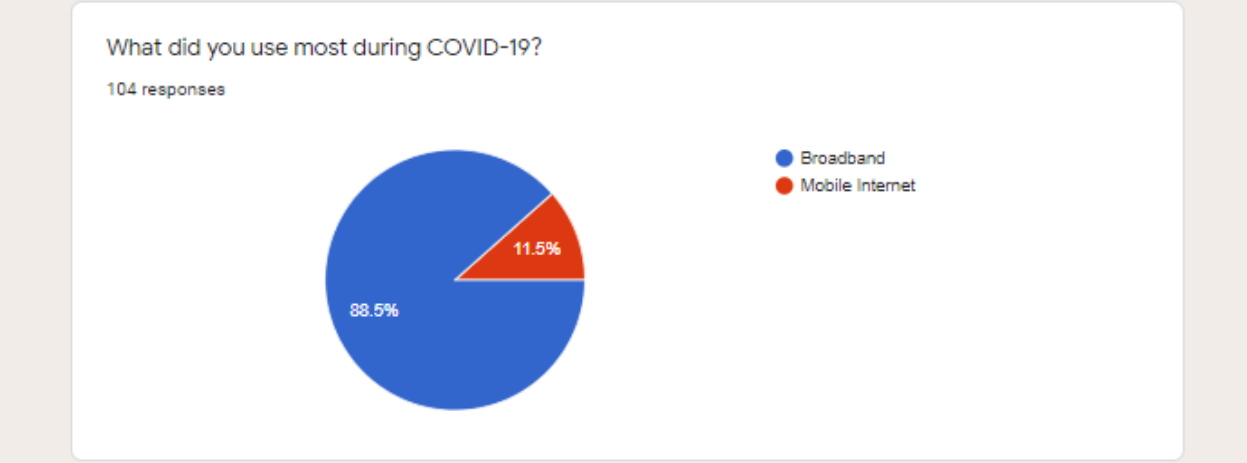

Figure 4.2.6: User ratio of mobile internet and broadband

This pie chart data indicates how much essential broadband is. To ensure better service, there is no alternate to up gradation of broadband services.

4.2.7 Mobile Networks

The data collected shows that the most used operator is Grameenphone and then Banglalink, Airtel, Robi and lastly Teletalk to use the internet. Data also shows the fact that 38.8% of the users stated that they made phone calls more than often in this pandemic period. So, this means consumer of mobile data and making phone calls were higher in this period. And they stated that the service was below average by 20% and 37% said it was just somehow satisfactory. Which means the service quality and the user experience both were downgraded at that time. Moreover, they noticed

service interruption like call drop or low voice quality and it has been experienced by about 64% of the users.

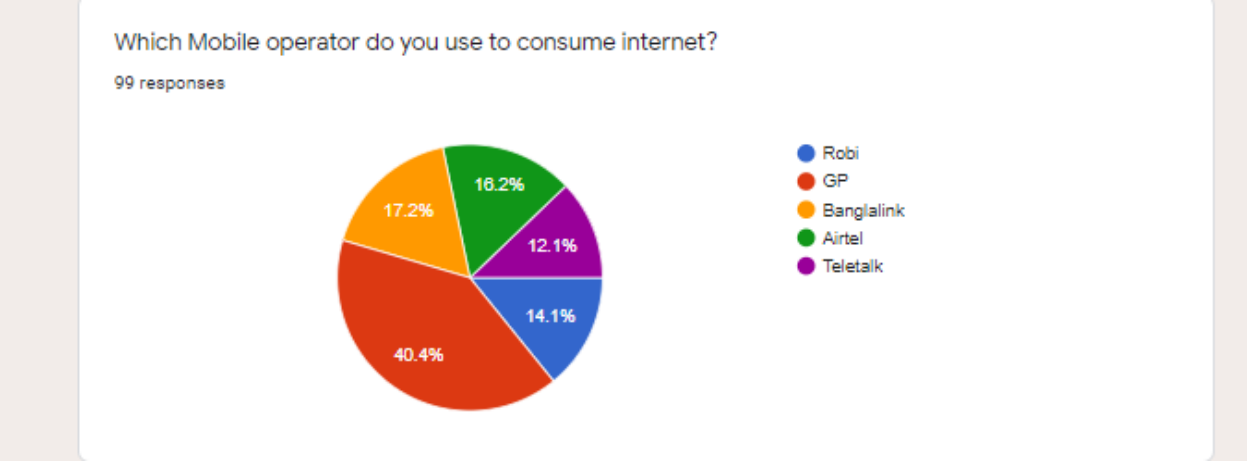

Figure 4.2.7(a): Mobile operator used to consume internet

Here among the 100 person most used operator is Grameenphone and then Banglalink, Robi, Airtel and Teletalk. GP is owned by 40% of the people, Banglalink by only 17%, Airtel by 16%, Robi 14% and Teletalk 12%. Huge subscriber is owned by GrameenPhone.

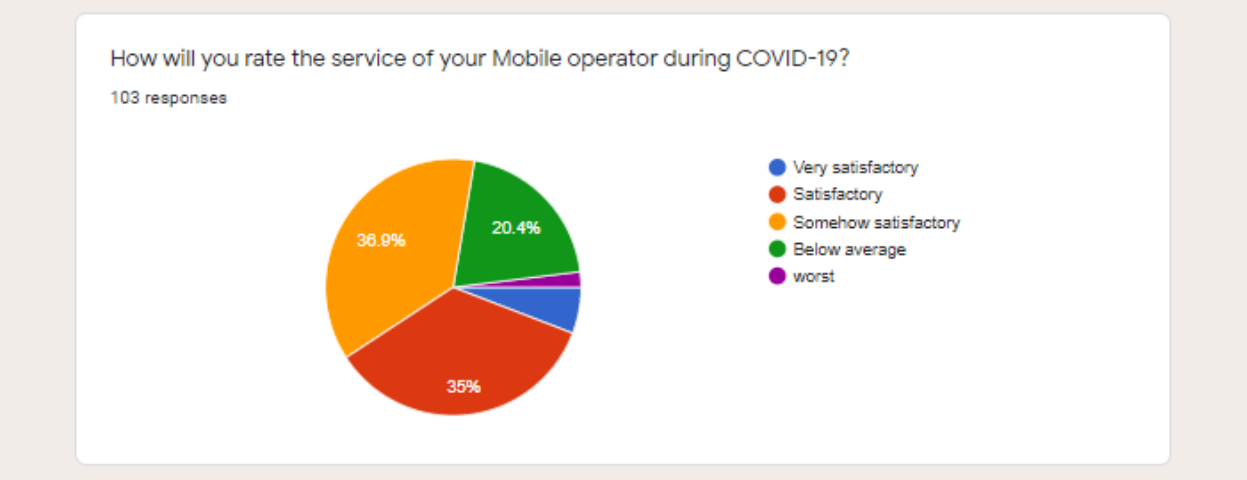

Figure 4.2.7(b): User experience of mobile network users

In this period of pandemic people expressed their service rating and it is below satisfactory said by 20.4% of subscribers and somehow satisfactory by 37%. This means they are not happy with the services they got. They got their services but not a level as they expected.

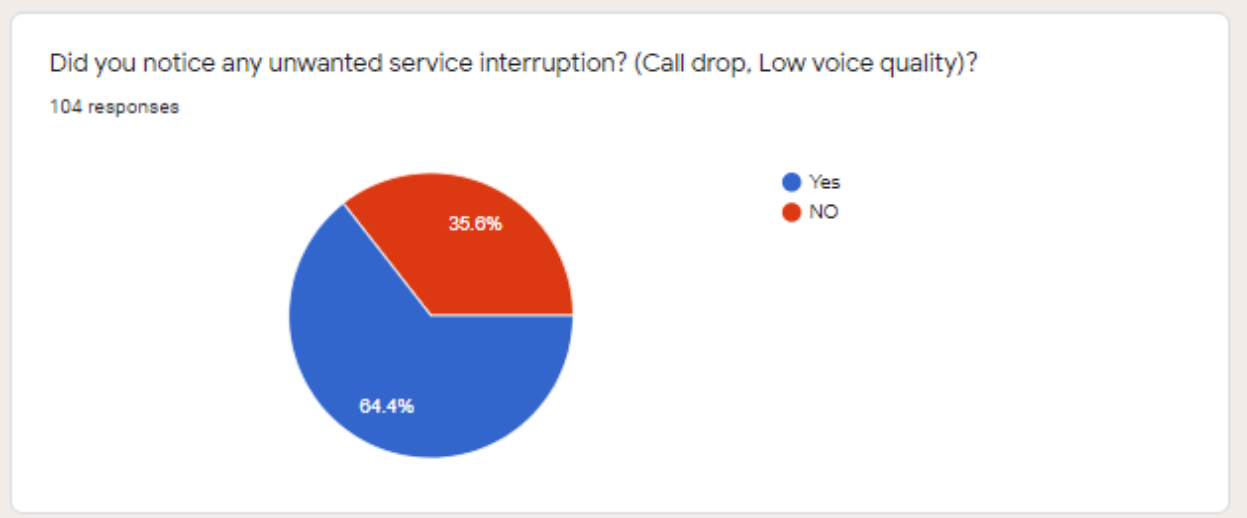

Figure 4.2.7(c): Unwanted interruption

About 64% of the users have experienced low voice quality or call drop which is a very un wanted service interruption. This needs to be fixed soon to gain the customer satisfaction and to attain the large number of subscribers owned by the mobile service operators.

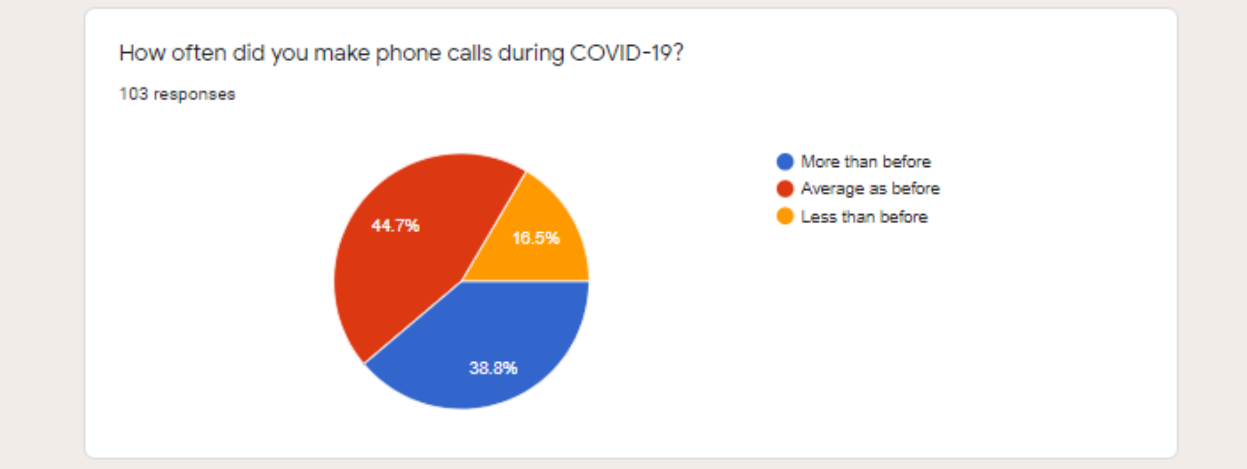

Figure 4.2.7(d): Continuity of making phone calls

From the survey it is known that about 39% of the users have increased their calling and this definitely adds extra pressure. Mobile operators has now more calls to handle.

4.2.8 ISP

Internet service provider or broadband internet is very demandable in this country where 88 out of 100 people use it to consume internet according to the survey.

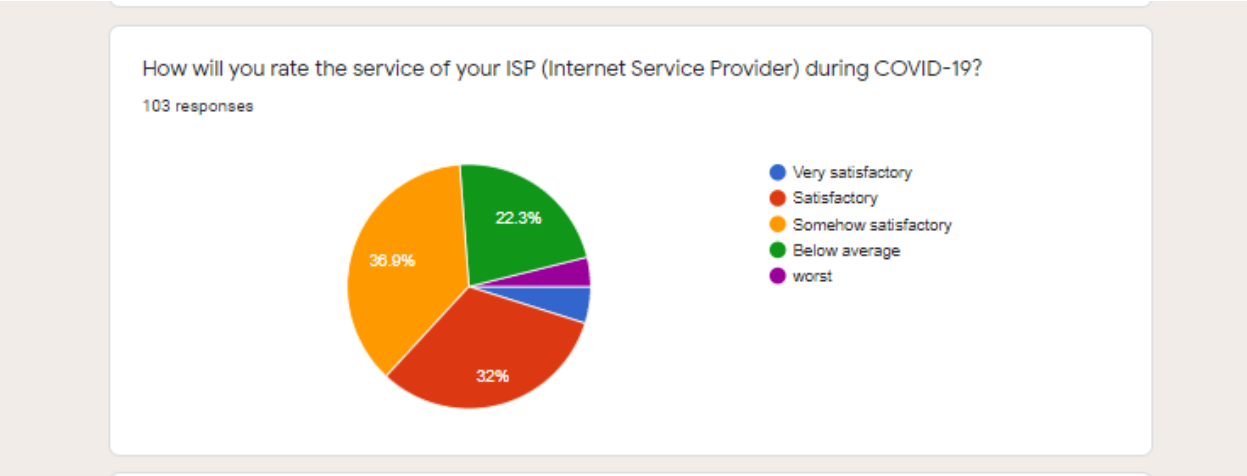

Figure 4.2.8(a): User experience of ISP internet users

The increased amount of user at a time made more congestion in the internet traffic. So, this caused service degradation and 22.3% said that it was below satisfactory and about 37% stated that it is somehow satisfactory. This refers to the fact that the service cannot meet or fulfil the requirements of the users.

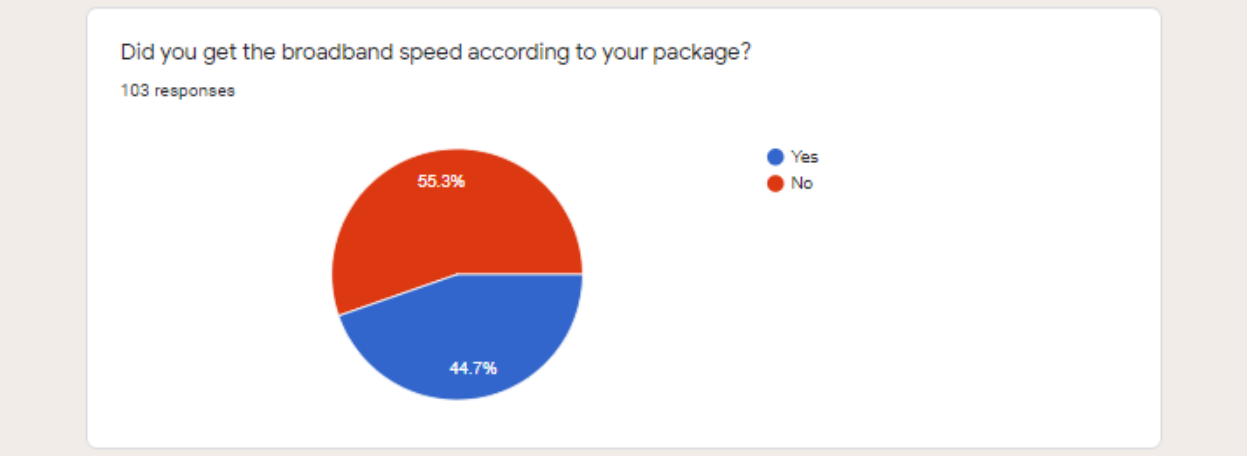

Figure 4.2.8(b): Down gradation of speed

In the data 55.3% of the users stated that they were not getting the expected speed that the package they are enrolled of. This indicates the increased users has an impact on the performance overall.

4.2.9 Bad session rate

Quality of Experience has a metric which is bad session rate and a BSR occurs when it takes more than 1 second to start, frequent buffering in less than 1 minute or if the video quality is poor in the user display.

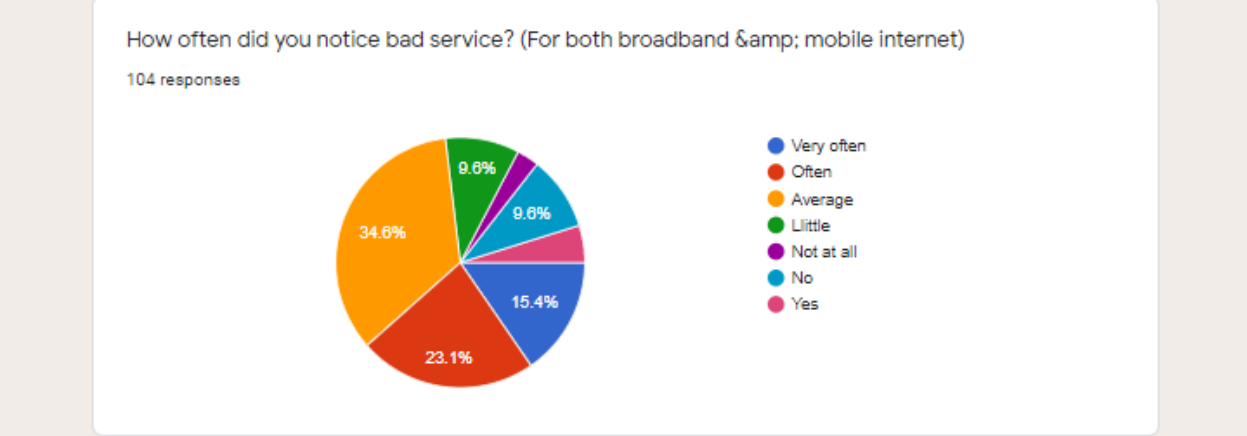

Figure 4.2.9: Bad session experienced

The pie chart shows that about 23% of the users said that they noticed bad service often and 15% stated that they faced more than often. This refers to the fact that bad session rate increased during the pandemic period.

4.2.10 Quality of Service (QoS)

Quality of service refers to the overall performance of the service used by the user. It has many metrics and some of them are discussed below.

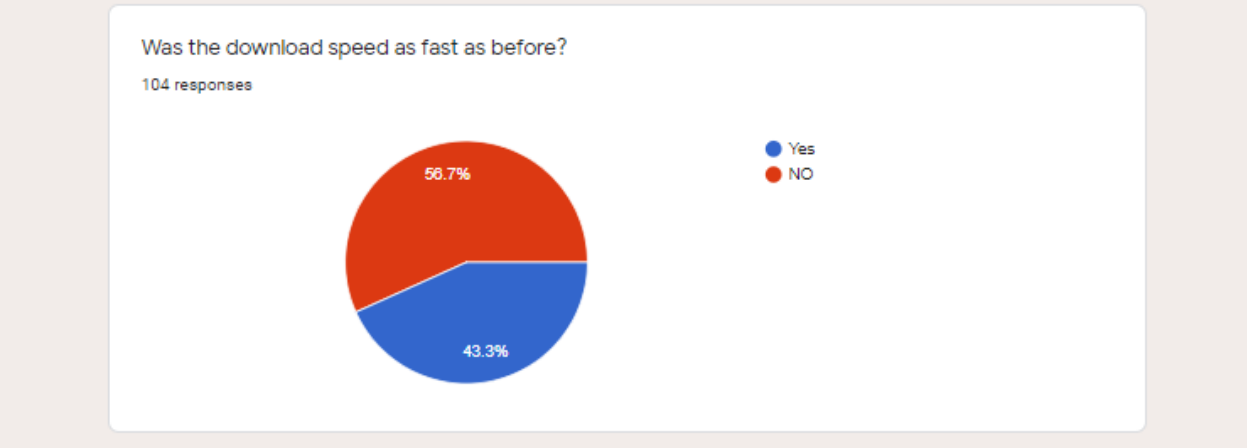

Figure 4.2.10(a): Speed variation while downloading

Firstly, the download speed, it has been decreased due to the user and the long using time 57% stated that they experienced reduced internet download speed.

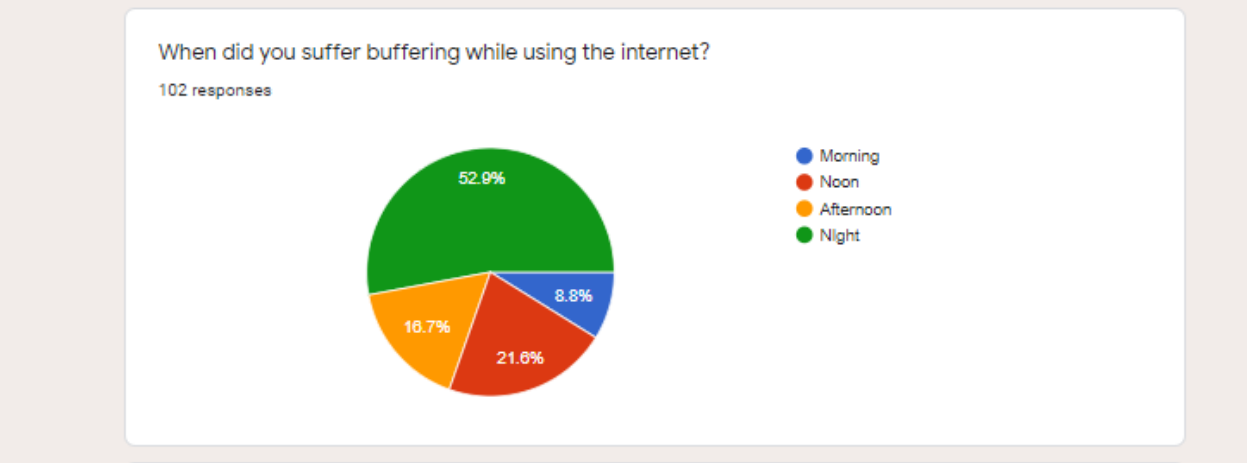

Figure 4.2.10(b): Buffering time session

Then, there is a definite time when the service faces most traffic. From the collected data the users stated that 53% of the users faced buffering at night. Then at noon 22% users faced traffic. So, the number of increased users made internet more congested and service become degraded.

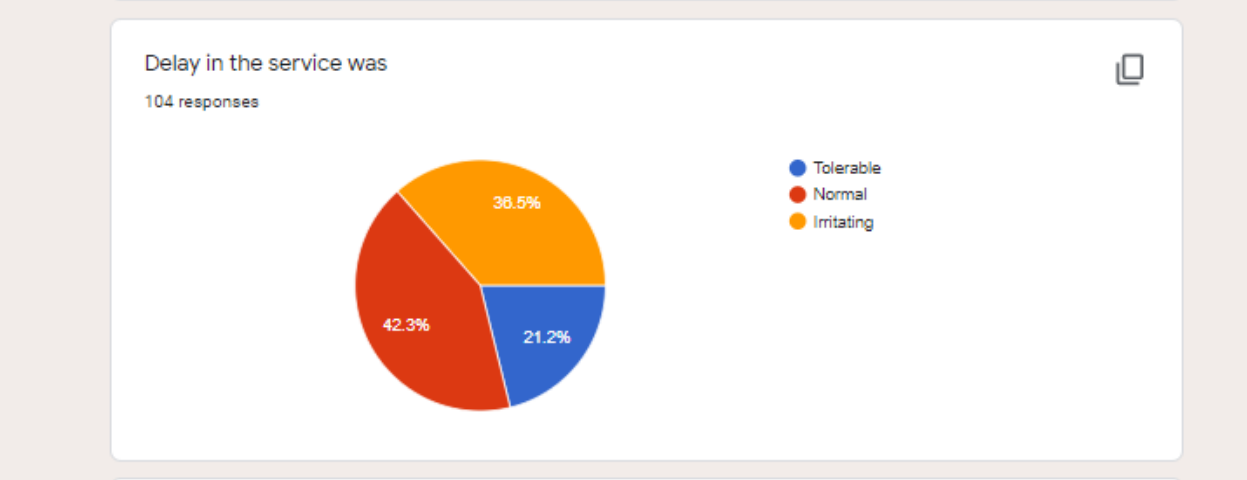

Figure 4.2.10(c): Quality of experience

Next, the service was irritating was approved by about 37% of the users. This ensures the fact that the Quality of Service has been worsen in this pandemic condition.

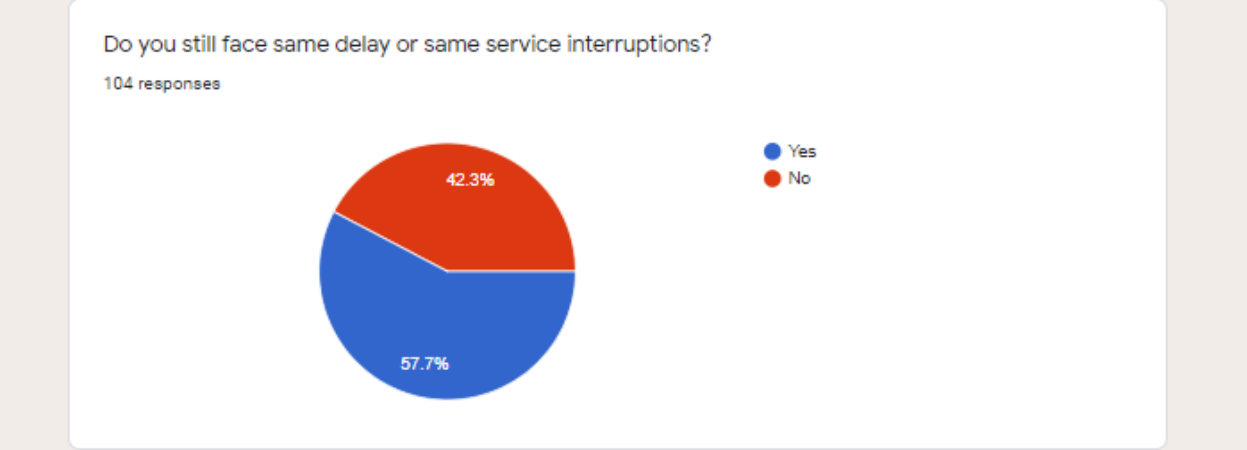

Figure 4.2.10(d): Service Interruption

And last also most importantly 58% of the users are still facing the same trouble with the services. This means the problem has not been solved yet and necessary steps should be taken to improve this condition.

4.3 Global data

Now, the global data will be considered and the global data has been collected from the Facebook's edge data.

4.3.1 Traffic Data

The figure that has been considered shows how the edge traffics were before the pandemic and after the pandemic, it rises directly at near about 40%. Which shows the impact on traffic is obvious.

4.3.2 Relative traffic growth over the continents

Here is shown the six continents in which Facebook is used and the blue vertical lines show the time when the lockdown was imposed. It shows the fact that after the lockdown is imposed the edge traffic has increased in most of the cases and shows in the graph as a sudden rise now it has been increased condition than before and becoming constant gradually.

4.3.3 Growth rate of services

The graph considered in this case shows the increase in services in the European region, India and the US. Live streaming service was being used over 300% at least. People started to message more about more than 50%, video consuming also increased by about 10-20% only photo was being uploaded and seen less at this time.

4.3.4 Content Delivery Network

From the data collected, interpreted graph states the condition of the content delivery network. It tells us if mobile networks and broadband has been experiencing more request for service.

The blue line shows globally the largest lockdown imposing countries and it shows that Mobile is having 1.25x CDN traffic than usual Broadband is having 1.4x CDN traffic than usual.

Till now it is on the increasing note.

4.3.5 Bad Session Rate (Global)

Here the graphs show how globally and country-wise bad session rate occurred. So, this graph states that not all the countries had a problem with BSR but South American few countries, India these countries suffered in this case.

The traffic growth was induced and that is the reason the bad session rate increased as we can see. This proves the fact that the growth of traffic after the imposed lockdown has created the traffic surge and hence it has resulted in Bad Session Rate.

4.3 6 Round Trip Times

Round trip refers to the time needed to send the signal and the acknowledgement that the signal is received. Also, in the overpopulated countries having a problem with that, otherwise, it is increased than previous but becoming more or less constant. Round trip time has also increased in this condition.

4.4 Possible Solution:

Here are some of the possible solutions

4.4.1 Continuous Monitoring and self-optimization

If we monitor our network very carefully we will have a clear knowledge of the current state of the network. If any kind of unusual problem happens or traffic piles up the support engineers can solve it and take actions according to that. And networks should be optimized. It will make the network more efficient and the connections will be more stable.

4.4.2 Backhaul optimization

Managing the backhaul network is the most important problem for us in the cellular network. We now have a very high demand for increased data rate and it will cause inflation drastically in the devices which are connected. Where there is the intensity of devices are high their bottleneck happens and it causes a performance drop. So, if we can optimize our backhaul, we can have a very stable connection.

4.4.3 Cell Outage Detection

Which cells are out of service that must be pointed out as early as possible because if the cell is out of service it will degrade the service quality? It will cause a problem and eventually increase the traffic of the network.

4.4.4 Prediction of mobility

In the conventional communication system, it is a lengthy process because it performs some signal interference plus noise ratio, received signal power and strength etc. So, if any kind of handover is required it is time-consuming and can cause service disruption. If we take the necessary steps to make predictive handover, when there will be high mobility we can easily predict and service will be much faster than we think.

4.4.5 Efficient network

What energy we are wasting if we can optimize it will also make the service better. Energy-efficient hardware tools, smart switching off to the component this kind of actions can save the energy and it will make the network more efficient.

4.4.6 Strengthen the rural connection

This thing is needed very much. We are city-centered and we often do not have good network service in the rural area. We barely notice them. In the perspective of our country though we are having 4G, actually in the rural area its mostly 3G service and the connection is poor. A broadband connection is not available there. We should make a good internet and network infrastructure to facilitate them.

4.4.7 Enabling 5G

5G can be a very good solution in this kind of situation. In the increased traffic, 5G has special features which will make the network better working and it has the feature to combine with AI [6]. So, this is a very good platform to establish 5G and roll it out.

5G has three special features eMBB,mMTC and uRLLC

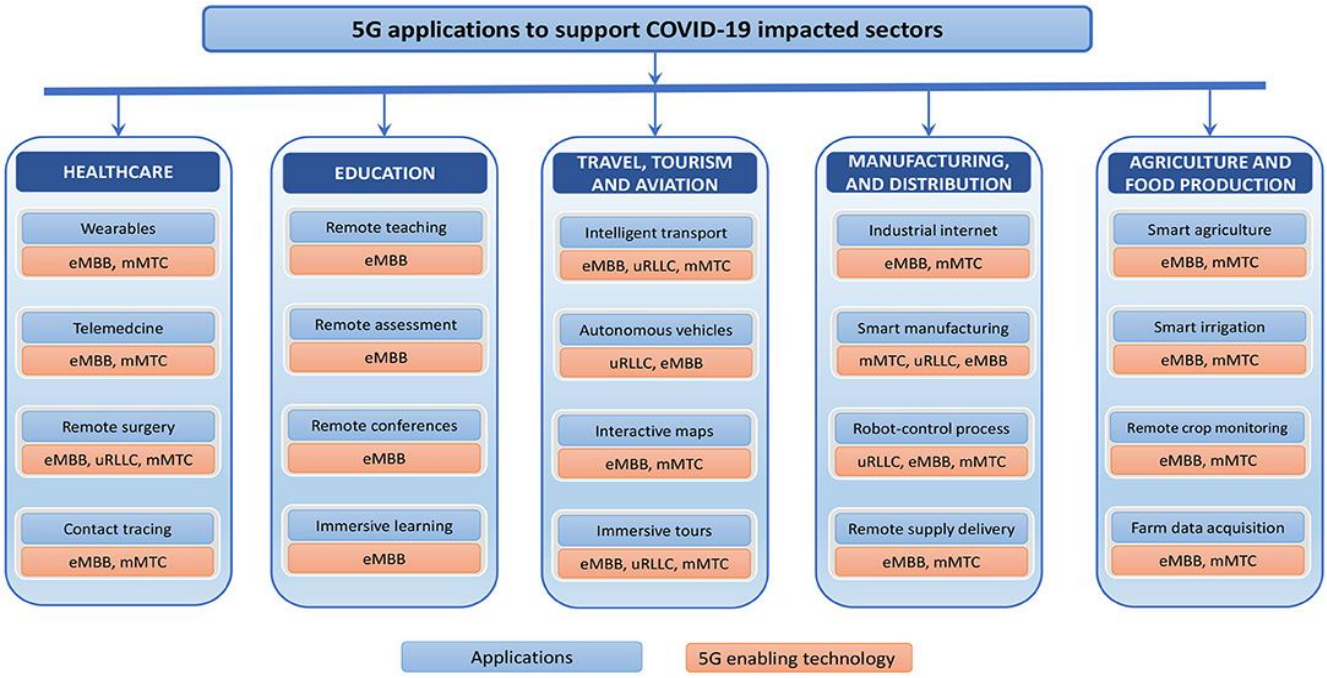

Figure 4.4.7: 5G applications to support

eMBB is Enhanced Mobile Broadband and it enables us to have a higher speed with a wider range [9].

mMTC is Massive Machine Type communication that can handle a very dense network and operate online services [10].

uRLLC is Ultra-Reliable Low Latency Communication which has very low latency and ping is so low due to it [11].

4.4.8 Ensuring better Quality of Service

If the quality of the service gets better the problems that have been risen can be minimized in a very effective way. In ISP services or for the broadband service when the service is down or any problems occur, one has to call to the customer care and therefore state his problem. If any problem occurs in massive range, the volume of calls increases. As a result, the customer care or support unit fails to receive all the calls and therefore taking note about the problems become more difficult. If a automated system had been used the service would be more fast, user friendly and definitely a better Quality of Service can be delivered which will result in a better Quality of

Experience for the user or customer.

Such a website has been made and it will help to keep all the logs and one can see about the status of his complained issue.

Firstly, there is a landing page by which customer or the users can submit their problem. The fields are Name of the complainant, his user id, email address and there is a checkbox of 5 problems from which he can choose multiple. Then he has to tell the problem briefly. After that in which type of device, he faced the problem and lastly how long he has been facing the issue, by completing these fields he will submit.

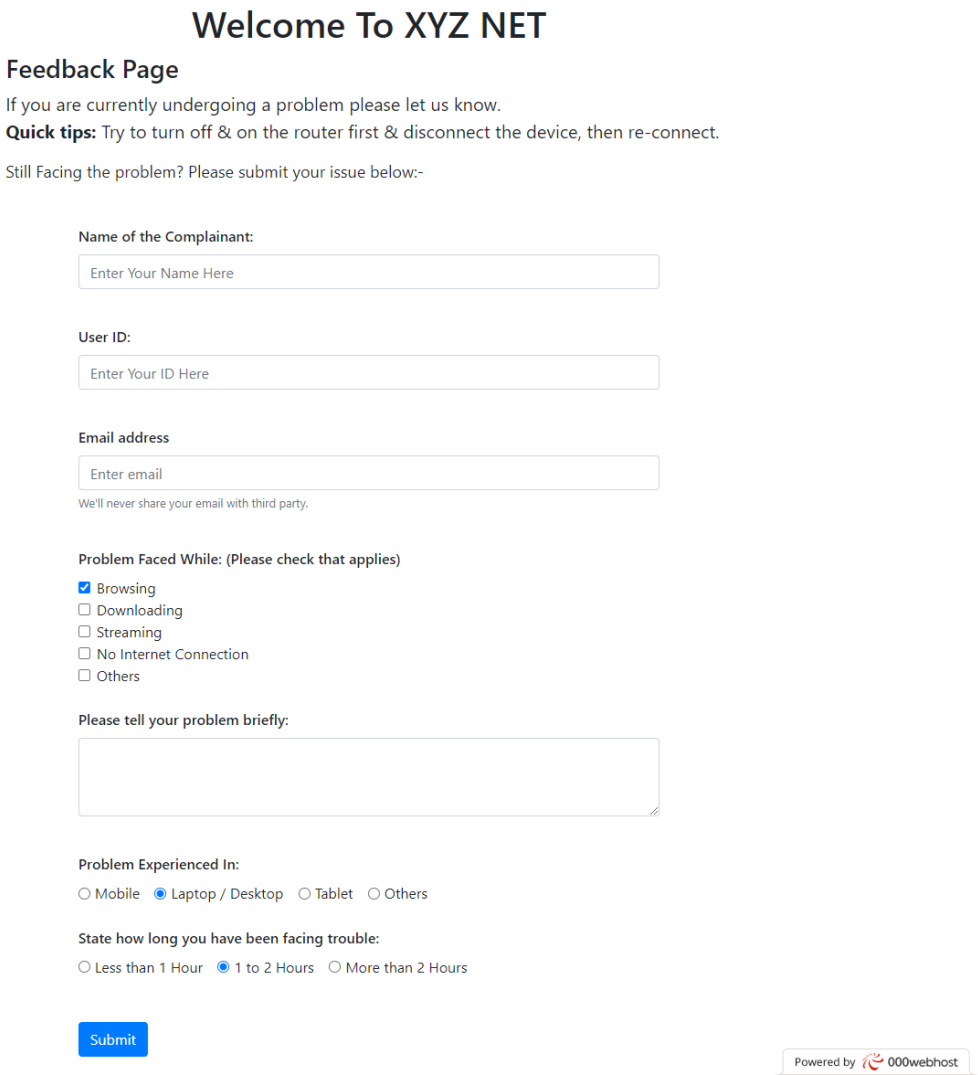

Figure 4.4.8(a): Client homepage

Then the data will be stored in a data base which will show all the submitted fields by the user. The filled database looks like this:

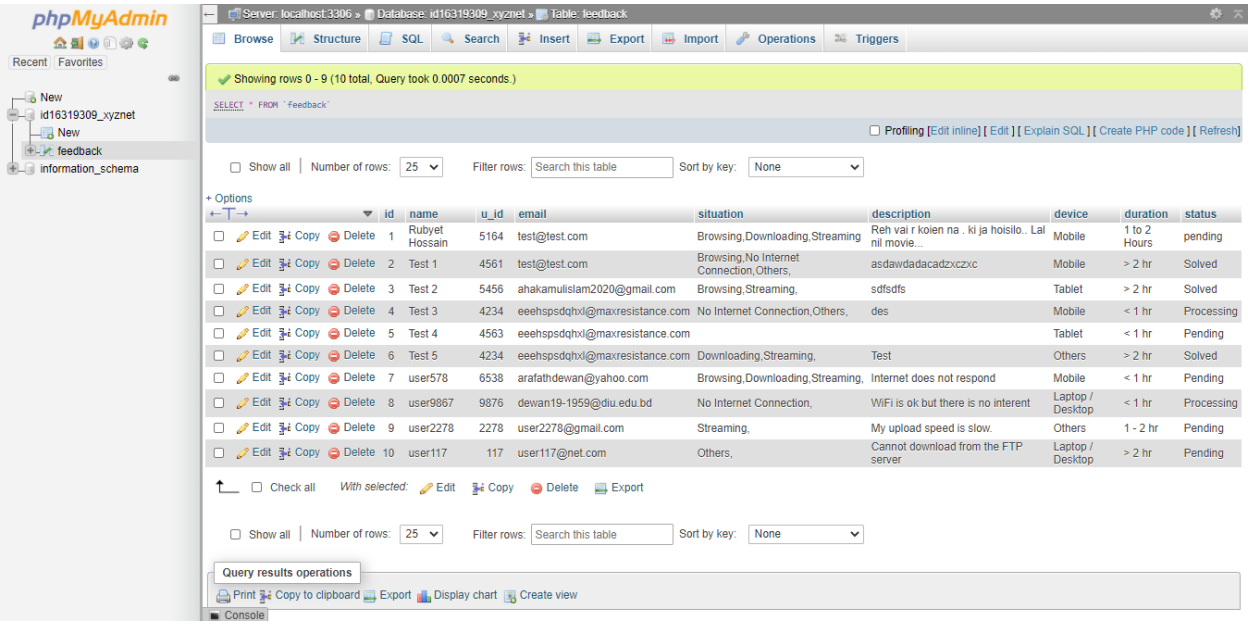

Figure 4.4.8(b): Database

Here is option which shows current condition of the complain of the customer. An automated mail will be sent to user filled email when he submits his form. There is another end which is client end which will show the detailed problem and there will be an action bar which will have two buttons for processing and solved.

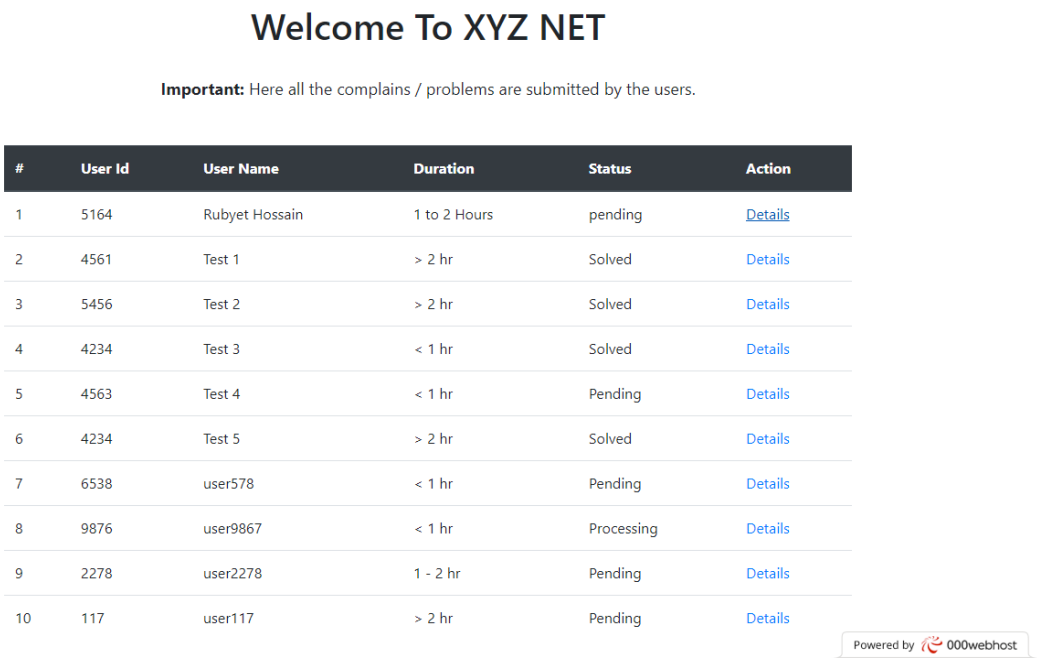

Figure 4.4.8 (c): Admin page

When the details button will be clicked, the whole form submitted by user will appear.

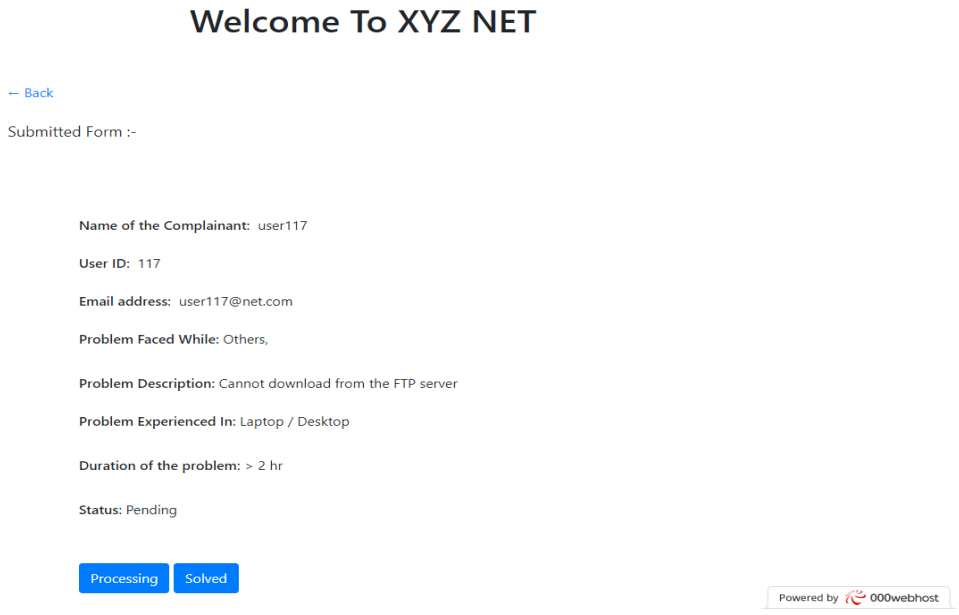

Figure 4.4.8 (d): Example 1

All the fields filled by the users will be seen as this when the details button will be clicked and ISP can take necessary steps according to the problem.

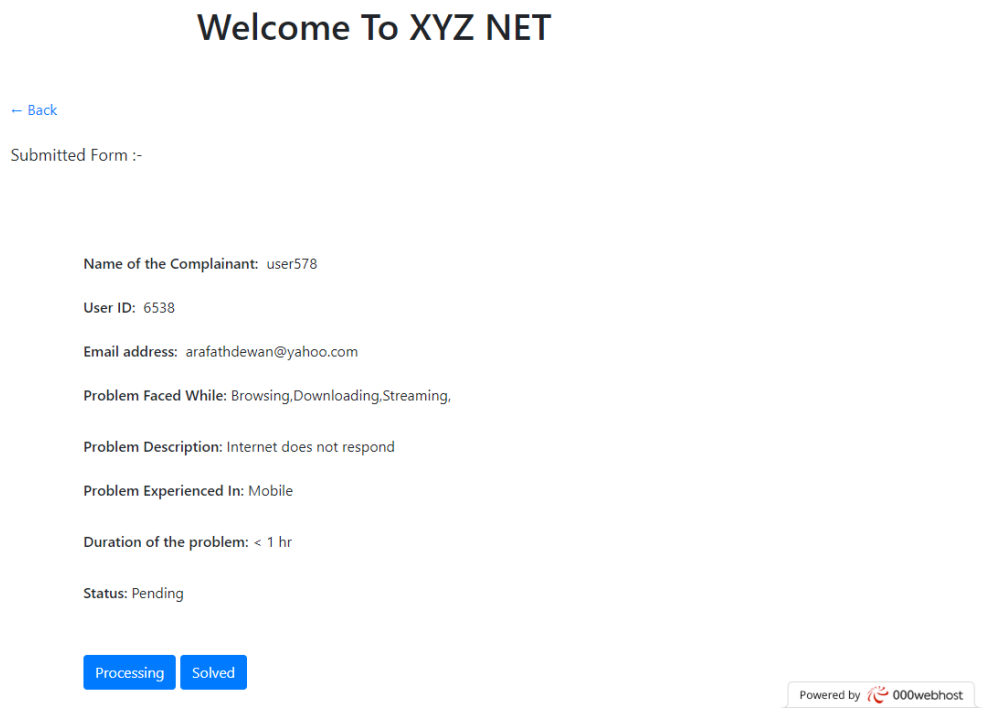

Figure 4.4.8 (e): Example 2

Here two examples have been given which shows that the complains filled by the customer side is working currently and they have received mails. Mails will be received thrice. When the complain is submitted, when the technical team is solving the issue which will be sent after the clicking of processing button and lastly when the problem will be solved, the ISP end will click solved, then another automated email will be sent. They are attached below.

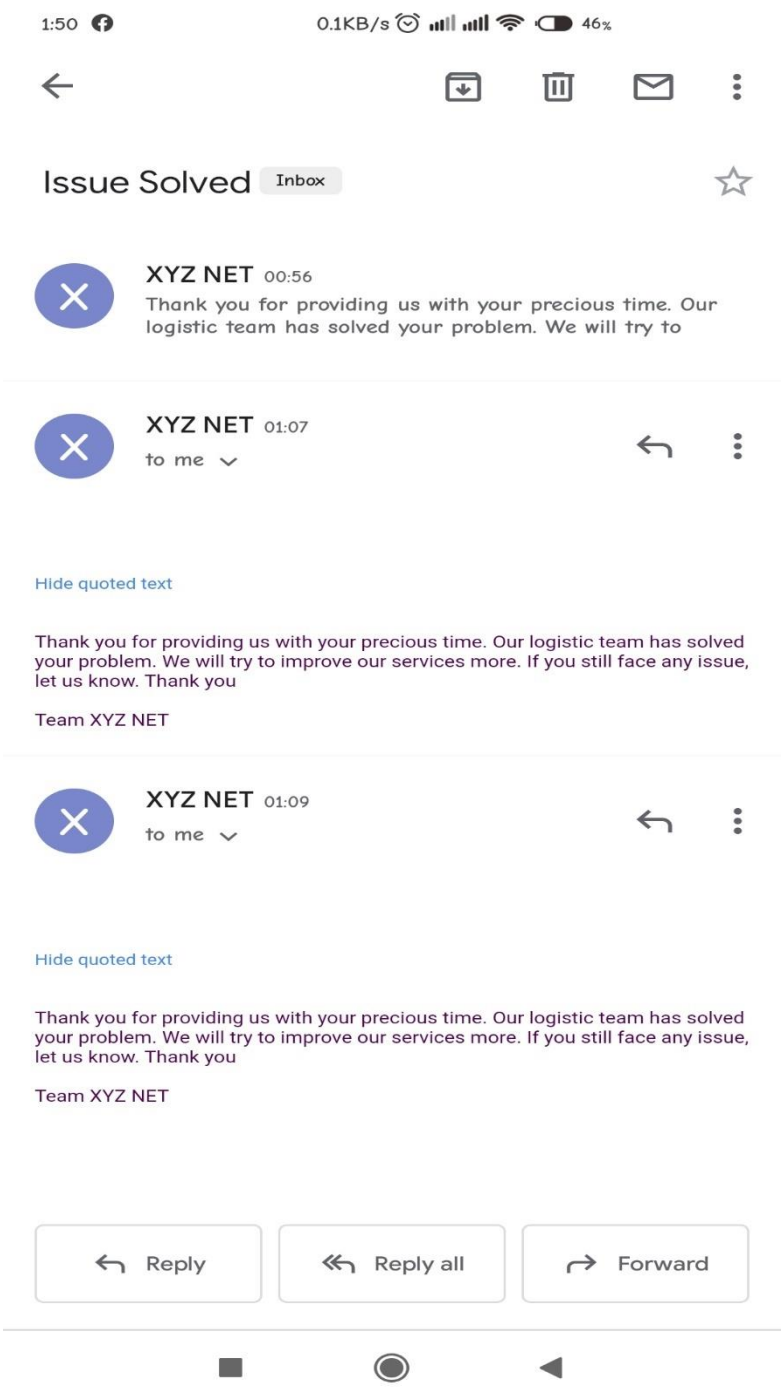

Figure 4.4.8 (f): Received mail automatically.

This makes the system more efficient. One does not have to call to customer care and also there is a record which problem is occurring in a continuous basis. This makes the Quality of Service better and also increases the Quality of Service.

Link for the land page of user end: https://xyznet103.000webhostapp.com/

There is also the server end which will be operated and it the website is hosted at a free host so any problem can occur which will be considered as technical fault.

CHAPTER 05: CONCLUSION

So how things stand now is in this pandemic people have experienced a lot of new things including unusual network traffics. The collected data is being analyzed and the possible solutions which can be imagined are described in the above sections. This implements that the service is being poorer than regular which has caused service degradation. So, it is time to make the networks more reliable and take the necessary steps so that it can cope up with any kind of situation. Probably this pandemic is not over. This can come back again as long as there is no reliable permanent solution. Moreover, there can be more dangerous pandemic than this in the future. Current situation says that the condition is again worsening and the any type of work is still not in full flow, people are having work from home again and this is still causing the surge in the internet uses and the education system is now totally online based. Also the other usage of the internet are also increasing at some points. It is time to maintain a constant standard Quality of Service. To sum up the covered area of this thesis contains the facts: an overview of the affected sectors in COVID-19, how the existing networks faced the problem, analysis of data, possible solutions, why 5G implementation is a good choice now, automation in feedback can assure better QoS. There are also some problems faced like: though the implementation of 5G has been suggested, barely in this country can assure the real services of 4G, some of the solutions can only be existent in theory only, and practical implementation is tough and costly. Also there is a chance for the future scopes which maybe - new evolutionary solutions to reduce the traffic in both wired and wireless network, bandwidth can be doubled when needed, in a certain period if this can be implemented it will be a very good find, the feedback can be taken through developing an application which will send the data to the server and after solution the complainant will receive notification via SMS, which will be a more professional way.

APPENDIX:

ACRONYMS

COVID-19	**:** Coronavirus Disease 2019
OTT	**:** Over The Top
QoE	**:** Quality of experience
RAN	**:** Radio Access Network
BS	**:** Base Station
IoT	**:** Internet of Things
ISP	**:** Internet Service Provider
CDN	**:** Content Delivery Network
BSR	**:** Bad Session Rate
eMBB	**:** Enhanced mobile Broadband
mMTC	**:** Massive Machine Type Communication
uRLLC	**:** Ultra Reliable Low Latency Communication
SMS	**:** Short Messaging Service

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