

Exploring the Impact of COVID on Global Telecommunication Networks and ICT Solutions

**Sahar Ahmadzadeh¹, Sangita Pokhrel², Rahul Kumar Jha³,
Gayathri Karthick⁴, Rebecca Jeyavadhanam Balasundaram⁵,
Soonleh Ling⁶**

^{1,2,4,5,6}Department of Computer Science and Data Science, York St. John University, United Kingdom

³Department of Electrical Engineering, Tribhuvan University, Nepal

E-mail: ¹s.ahmadzadeh@yorks.ac.uk, ²s.pokhrel@yorks.ac.uk, ³rahul.752418@pasc.tu.edu.np, ⁴g.karthick@yorks.ac.uk, ⁵r.balasundaram@yorks.ac.uk, ⁶s.ling@yorks.ac.uk

Abstract

The emergence of COVID-19 and its spread all over the world caused a significant increase in network traffic. Therefore, for more secure and consistent communications, it is crucial to investigate the factors that affect network traffic. In this study, the review of COVID-19 consequences on global telecommunication networks with an emphasis on network traffic is presented. The impact of lockdown on digital telecommunication networks in various countries around the globe is investigated. The rapid expansion of the virus forced countries to set up lockdown measures, and this caused people to stay at home; therefore, network traffic increased significantly from March 2020 to the middle of April, and then it slightly changed to be more stabilized until the middle of May 2020. Such increased network traffic has affected many aspects, such as mobile networks, roaming factors, and economic situations. In this research, supporting programs to protect network connectivity are studied around the globe. In a situation where people are mostly working remotely, security is a challenging issue that should be taken into careful consideration. This study provides a broad understanding of how COVID-19 affected digital communications and how governments responded to unprecedented crises.

Keywords: Network Traffic, Internet Service Providers, COVID, Internet Speed, Information Communication Technologies (ICT)

1. Introduction

These days, the world is involved in a challenge that has never been faced before. COVID-19 caused massive impacts on various economical and industrial factors all over the world [1]. [2] provides statistics on total and active infections, recoveries, and deaths relevant to the COVID-19 pandemic. Increased network traffic is just one of the impacts of COVID-19 as a result of the lockdown. The fact of more people working remotely and students are conducting learning online, coupled with the substantially increased use of teleconferencing applications, has caused a significant increase in network traffic. After running lockdowns in countries around the globe, people have mostly stayed at home and preferred communicating remotely, which in turn leads to increased traffic in the communication network instead.

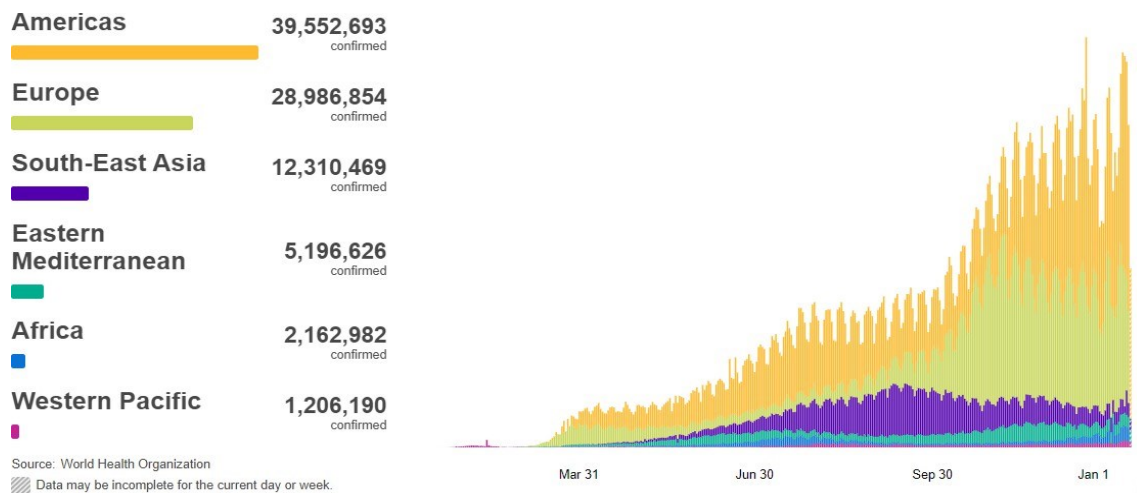


Figure 1. Worldwide Effect of Confirmed Cases of COVID19 [3]

As shown in Figure 1, the worldwide confirmed cases of COVID-19 from the first of February to the beginning of July 2020 are shown. The increased number of deaths and affected cases highlights the importance of paying serious attention to lockdown measures.

The global spread of COVID-19 necessitates a comprehensive study of its impact on network traffic to effectively manage unpredicted traffic in smart cities reliant on IoT technologies, thereby enhancing resilience. There is broad literature related to the effect of COVID on internet traffic. For instance, in [4], implications of COVID on internet traffic are discussed. This paper reports on a measurement study based on gathered and processed network data to assess the impact of the first wave of COVID from February to June 2020 on Internet traffic. The study analyses internet traffic during lockdown in Europe, focusing on ISPs, IXPs,

and academic networks. Results show a 15-20% increase in traffic initially, which continued over multiple months. The increase is mainly due to increased use of remote work applications, teleconferencing, and video on demand, which can increase up to 200%. Despite this, the internet reacted well. The paper aims to expand this research and analyse effective parameters affecting network traffic during global outbreaks.

In [5] the impact of lockdown on COVID propagation management through deep learning is investigated. As discussed in [6], there are some ICT tracking and localisation technologies investigated in Italy, and in this study, the research on these ICT technologies is investigated in detail further. Round Trip Time (RTT) is a factor that is

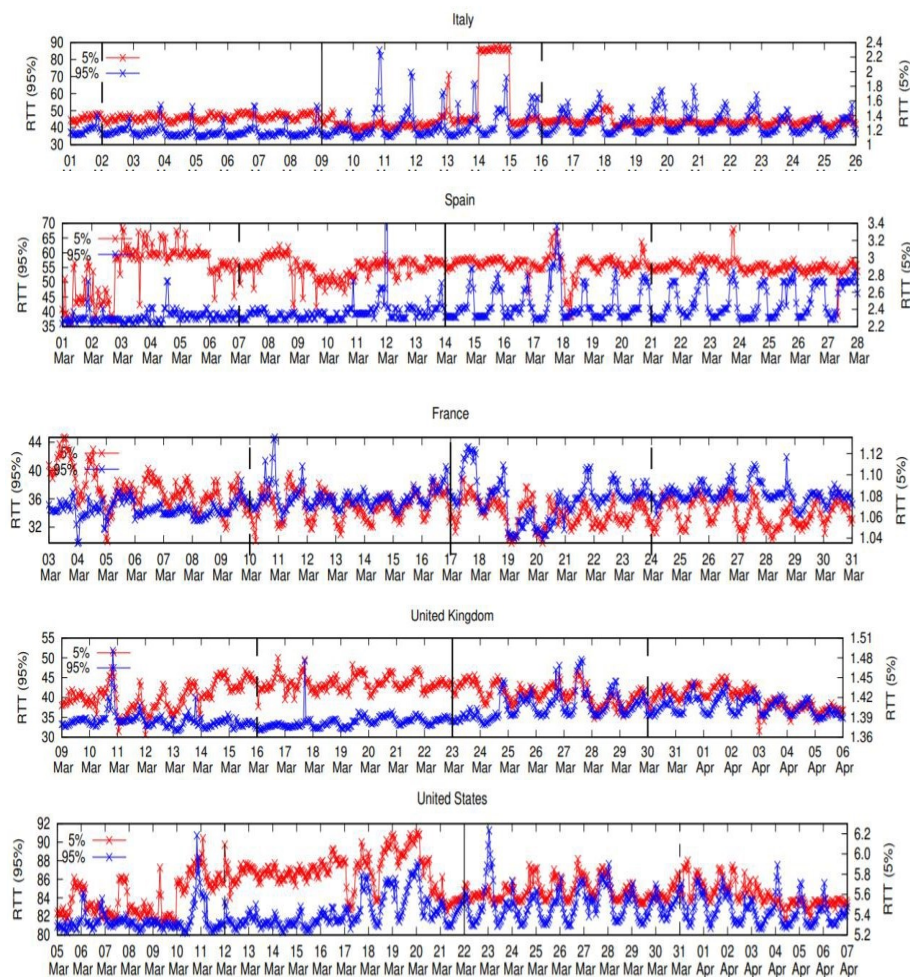


Figure 2. Evolution of the 5th and 95th percentile RTT Values Per Country [7]

taken into account when measuring internet traffic. It is defined as the sum of the times it takes for a data packet to be sent to a destination and the time it takes for the packet's acknowledgement to be received back at the origin.

In Figure 2, the evaluation of the 5th and 95th percentile Round-Trip Time (RTT) values per country is presented, as discussed in [7]. The average RTT values before and after the reported lockdown date are calculated, and the 5th and 95th percentiles are computed for each country based on hourly data. The paper reveals a significant increase in internet consumption for all countries after the onset of lockdowns. The varying ramps in the graph across different countries are attributed to factors explored in the article.

This research delves into the effect of COVID-19 on network traffic control and user applications, specifically in the economic, industry, healthcare, and education sectors, with a focus on smart cities where the IoT plays a crucial role. It also examines the effects of the pandemic on various Internet Service Providers (ISPs) worldwide, taking into account factors such as lockdown measures and global telecommunications. The overarching goal is to comprehend the effects of COVID-19 on global telecommunications and underscore the significance of international collaboration.

The study investigates the effects of the pandemic on the different ISPs in various countries. Figure 3 illustrates a block diagram depicting the impact of COVID-19 on global telecommunications across different aspects post-lockdown. The research concentrates on these factors and their implications in different countries globally. The paper's structure is outlined as follows:

Section I introduces the research, providing motivation and outlining contributions. Section II explores the worldwide effects of COVID-19 on traffic volumes. Section III discusses the effective factors on network traffic during lockdown, offering comparisons across various countries and presenting case studies on the use of different applications. Section IV addresses the management of the global effects of COVID-19. Section V highlights the challenges posed by COVID-19 on various network parameters. Section VI delves into Information and Communication Technology (ICT) solutions, reviewing effective network traffic parameters, objectives, and methodologies for enhancing network performance during the COVID crisis. Section VII concludes the paper, summarizing key findings and implications.

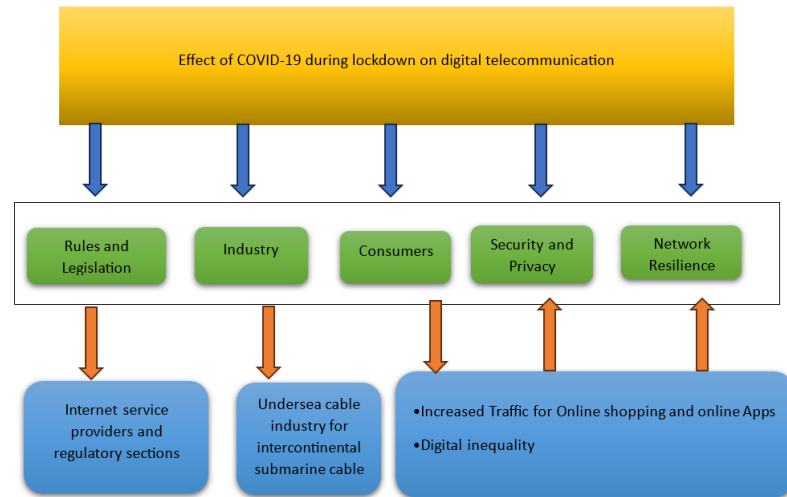


Figure 3. Block Diagram for the Effect of COVID on Different Aspects of Global Telecommunication

2. Worldwide Effects of COVID-19 on Traffic Volumes

In this section, the effect of increased internet traffic after lockdown is investigated globally. Table 1, provides a comparison of internet fixed speed and mobile speed change, from the period before the outbreak until the middle of Jun 2020 in different countries.

Table 1. Percent of Fixed and Mobile Speed Change for 20th July Compared to the Week of March 2, 2020 [8]

Country/ Internet speed variation	Fixed speed change	Mobile speed change
Global	+5%	+7%
USA	+10%	+4%
UK	+3%	-1%
Italy	+9%	+9%
Spain	+4%	-9%
Brazil	+18%	+14%
Japan	+29%	+1%
South Africa	+23%	-10%
Saudi Arabia	+10%	+24%
Emirates	+20%	+22%
France	+6%	+5%
India	+5%	+3%
Nigeria	-2%	-3%
Canada	+8%	-9%

In [8], the global effects of lockdown on internet speed and performance are studied and represented in Table 1 and Figure 4. As it appears in all these graphs, all of these countries experienced significant changes in internet fixed and mobile speeds due to unprecedented lockdown programs. According to the research provided by the Organizations for Economic Cooperation and Development (OECD), the impact of the COVID crisis was studied on internet exchange points (IXPs) which are physical infrastructures. It allows internet traffic to be shared between content delivery networks and ISPs, through which ISPs and content delivery networks exchange internet traffic between their networks.

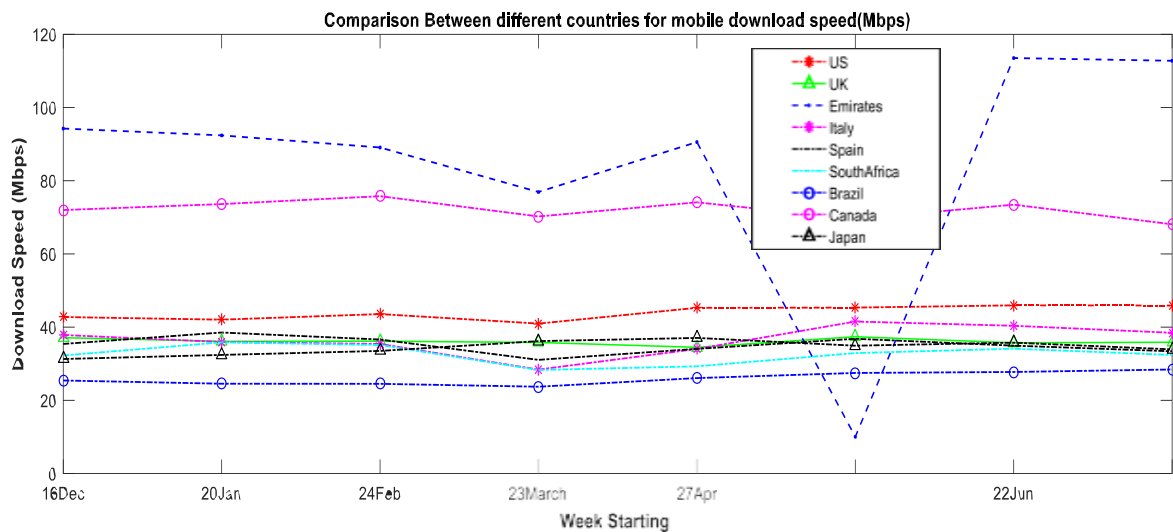


Figure 4. Investigation of the Mobile Download Speed in Different Countries

In [9], updated information for mobile and fixed broadband speeds around the world is provided. About increased online traffic after the outbreak, there are challenges, which will be discussed in the following section.

3. Effective Factors on Network Traffic During Lockdown

In this section, effective parameters that affect network traffic during the outbreak have been investigated. These parameters are explained as follows:

3.1 Online Applications

In [10], effect of COVID-19 on increasing online shopping during the lockdown is shown. Investigation into the apps that are used for different purposes reveals that the lockdown situations had an impact on using online applications in some countries, such as the UK. According to [11], as a result of COVID consequences, gaming, VPN, video, downloads, web,

and voice minutes of use have been significantly changed during the outbreak. Figure 5 shows the effect of the lockdown on in-home media consumption during the outbreak in March 2020. According to the report that was revealed by Vodafone, data usage rose by 30 percent in the UK even before the government ordered a lockdown and by 50 percent in some EU countries.

Table 2. Investigation of The Effect of Covid on Various Aspects of the Internet Network

Parameter	Objective	Methodology	Advantage or outcome	Paper
Internet security	To Tackle the cybersecurity impacts of the coronavirus outbreak, Investigation on the effect of cybersecurity attacks such as Distributed Denial of Service (DDoS) because of the surge in traffic during COVID-19, an examination of how the COVID situation affected the e-learning systems	Reviews cybersecurity effects of COVID on digital systems, Identifying Software Defined network approaches to tackle this issue, A strategy has been put out to create a cyber-threat detection model that takes into account the particulars of using e-learning systems during emergencies and distinguishes between abnormalities in the communication network and periods of heavy traffic.	To provide a more secure network against network traffic, Provide features that are useful for automated decision-making during new and unexpected events. A plan to develop a cyber-threat detection model that considers the unique characteristics of using e-learning platforms in emergency situations and makes a distinction between anomalies in the communication network and times of high traffic has been proposed.	[29], [30], [31]

Digital Inequality and social effect	Research on public communication and information over the internet during the COVID-19 pandemic	Quantitative research on general population internet usage during The web-based survey COVID is used to select from a sample that was gathered in the Netherlands.	Internet access is not evenly distributed among the general population.	[32]
Channel Bandwidth Utilization	Data Interleaving Technique in Mobile Communication (DITMC) technique for reducing this effect: simulation-based experimental research with particular focus on India	Data Interleaving Technique in Mobile Communication	60.52% enhancement in channel and bandwidth optimization is possible with low overhead, also this model is useful to enable telecom operators to manage an augmented number of mobile subscribers in limited bandwidth	[24]
Mobile Traffic	Investigation of the impact of the COVID pandemic on a UK Mobile Network Operator (MNO)	Quantifying the changes in users' mobility and investigating on its impacts on cellular network usage and performance.	To bring insights at different temporal granularity on the status of the cellular network	[25]
Virtual Private Networks (VPN)	To understand the effect of COVID crisis on VPN	Investigation on how VPN providers and IT companies used VPNs during pandemic	IT industry is built on strong foundations and it surely has all the required resilience to absorb the shocks of corona crisis.	[26]

Digital Infrastructure	To assist policymakers in determining what measures should be considered to control the effect of COVID crisis	Investigation on the policies to enhance the effect of telecommunication during a pandemic	Classification of countries by their resilience by examining the interaction of a range of factors such as availability of suitable broadband connectivity, computing resources, digital skills, and so on.	[33]
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However, after the lockdown, people were also downloading more apps for shopping, health and fitness, food delivery, managing their money, and video conferencing all of which all affected internet traffic.

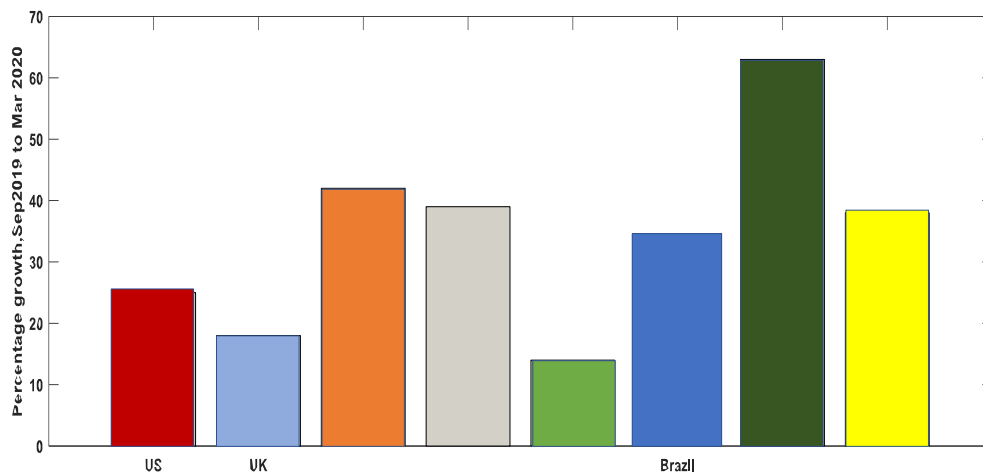


Figure 5. Worldwide Effect of COVID on Internet Bandwidth in IXPs

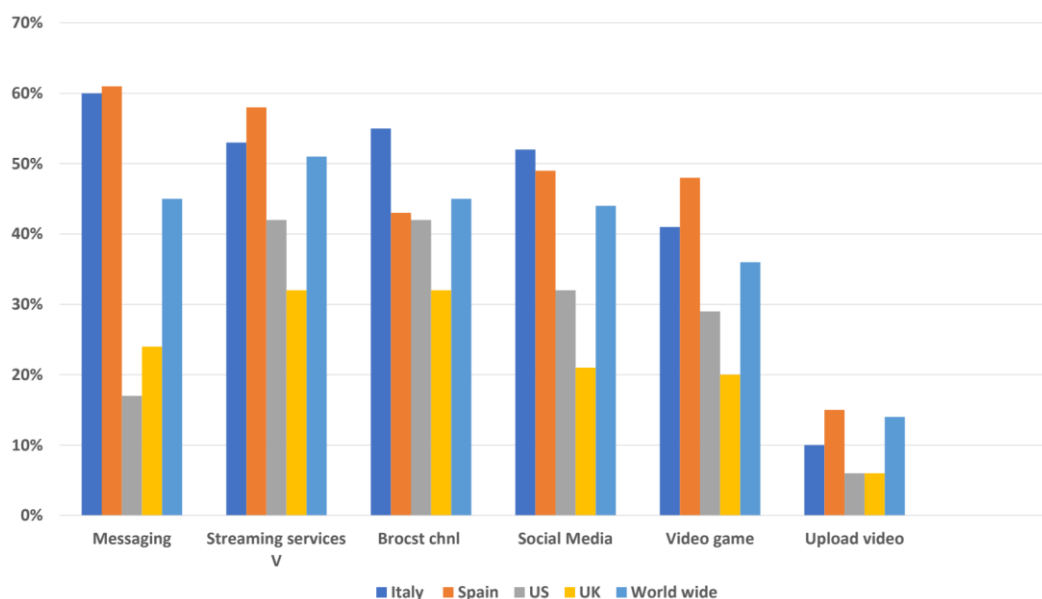


Figure 6. In-home Media Consumption due to the COVID outbreak as of March 2020 [13]

The study referenced in [12] investigates the effects of COVID-19 lockdowns on Internet Service Providers (ISPs) in the US and Europe. It examines changes in internet traffic during the spring and fall waves of the pandemic, particularly focusing on European ISPs' responses to increased demand. The measures taken by ISPs include sharing anonymized customer data with the public sector, offering free communication services in affected regions, and promoting solutions for remote work. Notably, in-home media consumption, such as gaming, VPN usage, video streaming, downloads, web browsing, and voice minutes, experienced significant shifts during the pandemic. Figure 6 illustrates how Vodafone reported a 30% increase in data usage in the UK before government-mandated lockdowns, escalating to 50% in certain EU countries. Post-lockdown, there was a notable increase in app downloads related to shopping, health, fitness, food delivery, financial management, and video conferencing, influencing internet traffic. In response, ISPs in the US and Europe adapted by introducing new service packages tailored to meet the demands of activities like home schooling and facilitating online events. Moreover, the significance of telemedicine in public health during the pandemic is underscored. Telemedicine apps play a crucial role in diagnosing health issues, providing solutions, and enabling virtual doctor visits without the necessity of physical presence in hospitals. The framework for applying telemedicine in public health monitoring is elaborated in [13], addressing challenges associated with its global implementation as part of the COVID-19 response.

3.2 Wi-Fi Upload/Download

An increase in Wi-Fi upload traffic due to the COVID-19 pandemic impact highlights the need for Wi-Fi infrastructure. VPNs, secure home networking, remote working/conferencing software, and other such solutions require extra resources in order to address the issue of increasing upload traffic following the outbreak. Moreover, the globe needs to ensure that the capacity of Wi-Fi networks can meet the global increase in demand for video, collaborative tools, and other data-heavy traffic applications. In that way, an additional spectrum, such as 6 Gigahertz, will be needed to fulfil the demands for high-speed and highly secure infrastructure.

3.3 Mobile Broadband

According to [14], mobile broadband is a communication technology which is widely used. As a result of COVID, three UK telecommunication company has published a report which explains the COVID-19 impact on national 4G and 5G-based networks. The report reveals that mobile broadband usage increased by 12% and calls grew by 8% to 2.5 billion in March 2020 [15].

4. Managing the Global Effect of COVID on Network Traffic

To manage the global effect of COVID, an IoT infrastructure and ICT solutions are needed, which are studied in the literature. For instance, in [16], application of the Cognitive Internet of Medical Things (COIMT) is studied. ISPs may also provide regulations to manage the traffic.

4.1 Network Resilience

To control the network traffic, various solutions are in practice. For instance, in Europe, Netflix has lowered the streaming quality by 25%. This approach helped to provide the required capacity for other uses. Amazon, Sony, and Google, have undertaken the same measures. Although the network is responding very well, it should be noted that frequent monitoring and checking of the network by technicians and engineers who have scarce resources is sometimes essential.

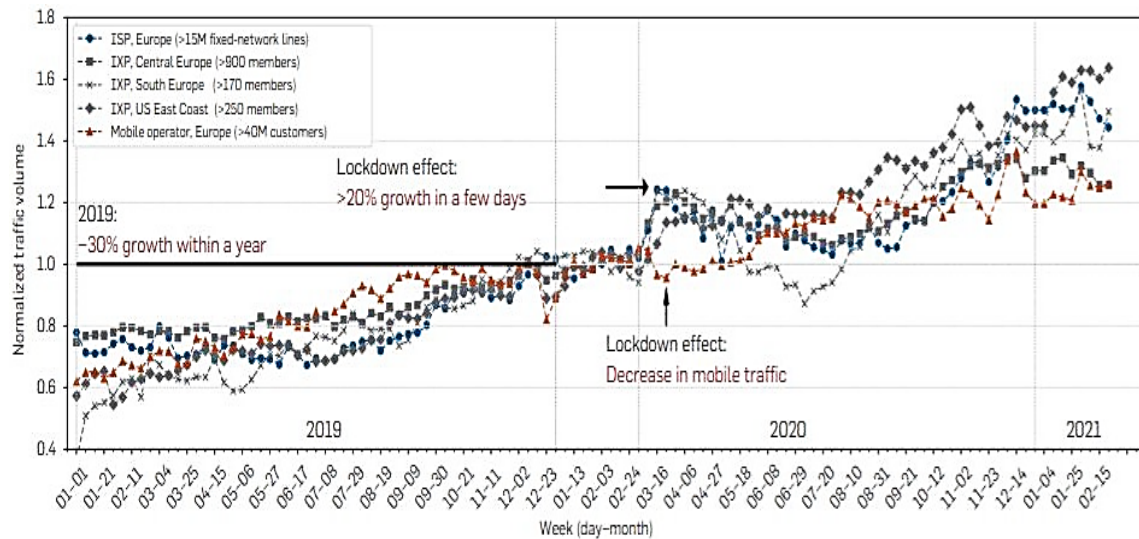


Figure 7. Worldwide Effect of COVID on Internet Traffic at IXPs [14]

Many attempts have already been undertaken worldwide to implement emergency protocols in order to guarantee the continuation of public safety service. To address capacity challenges, for example, the commission and the Body of European Regulators of Electronic Communications (BEREC) are debating the establishment of a unique mechanism to track the state of internet traffic in each region.

4.2 Telecom Infrastructure for Disaster Management

Among lessons learned from COVID, the most important is that the global telecommunication networks with their digital infrastructure must be better organized for difficult and unpredicted situations of all kinds. This is an important point that should be taken into consideration. It should be noted that the negative consequences of disasters can be reduced if robust resilience networks and disaster management techniques are provided appropriately. To achieve this goal, developing a national telecommunication plan is a policy that can be followed by governments to identify a specific department or agency to manage emergencies. Some other ways of practice consist of training programs, ICT recognition as critical infrastructure, providing contact points for ICT response, and developing methods in a way that experts can enter quickly, and speed up the decision-making through the mechanism's adoption in line with the telecom rules and regulations.

5. Challenges

With progress in telecommunication technologies such as 5G, the negative impacts of network traffic during lockdown were reduced [17]. There is literature that discusses the use case of 5G technology during COVID-19 to tackle the unpredicted effect of an increase in network traffic during COVID [18]. However, some challenges should be taken into consideration for appropriate network management during high peak hours, which will be described as follows:

5.1 Digital Inequality

Digital inequality is related to different factors, such as economic and regional situations. Such factors provide the opportunity for some people to get access to the internet and even benefit from high-speed services, while some other portion of society may not even have access to the internet. For those with limited digital literacy and low-income people who used to connect to public internet facilities, the effect of lockdown appeared in their lives more significantly. For example, students from low-income families may not be able to submit their assignments or attend online classes due to a lack of home internet access in lockdown situations. According to [19], the Oxford Internet survey revealed that nearly 70% of people in Britain use public Wi-Fi, and nearly 20% access the Internet in libraries.

To overcome the problem of the digital divide, there are some programs under practice, such as the Oxford Digital Inclusion Project, which is a research project focusing on the role of public libraries in decreasing the effect of the digital divide. In that way, consumers can request assistance from digital helpers who can do certain tasks to help users, such as setting up an email account or teaching how to use Skype.

According to [20], the majority of people are affected by the digital divide in the US, which puts their lives in danger. Some programs under the practice need to be extended to support those groups of people who do not have access to the Internet. It is also mentioned that between February and the middle of March 2020, there was about a 10% increase in the number of counties that saw their download speeds fall below the government standard. [21] addresses universal internet access as a global social problem.

5.2 Internet Security

As the world is more digitally connected and with increased traffic in the network, the importance of network security becomes more highlighted. There are various types of threats, including social engineering attacks, supply chain attacks, IoT and infrastructure attacks, identity and mobile authentication, and polymorphic attacks [22]. These attacks target information that corporations and employees are inadvertently posting on their social media sites, and corporations share this information with their vendors. The risk of some attacks, such as ransomware which is a type of malicious software designed to block access to a computer system until a sum of money is paid, is high in companies, cities, or even countries.

Mobile device authentication systems, including facial recognition and biometrics, are likely to be attacked as well. Concerning the importance of privacy considerations, some research, such as [23], discusses the privacy considerations of contact-tracing mobile apps. However, when the rate of traffic increases in the network, the risk of attacks also increases.

5.3 Bandwidth

There is streaming content, such as video gaming and other bandwidth-hungry applications. In contrast, online conferencing services, even video-calls, consume far less bandwidth. Therefore, the categorization of these applications based on bandwidth consumption is important to see how the outbreak affects bandwidth usage for different applications. Studying the portion of bandwidth that is allocated for different applications is an important issue that should be considered for resource allocation purposes. With increased traffic in the network, appropriate bandwidth allocation for demanded applications should be taken into consideration [24].

5.4 Mobile traffic

After the lockdown, mobile traffic suffered a significant increase and is now more widely distributed across the countries as people travel less frequently. Certain applications, such as mobile voice calls, affected mobile traffic and data usage as the lifestyle of people changed after lockdown. In [25] the effect of COVID on a UK mobile network operator is investigated. In this paper, the changes in users' mobility are quantified, and its impact on cellular network usage and performance is investigated.

5.5 Virtual Private Networks (VPN)

Since the outbreak started, the number of connections to organisations' VPNs and conferencing services has increased. Businesses need to use a VPN to get access remotely to their organization's private environment. The use of VPNs has increased significantly during the outbreak, which has significantly affected the network traffic [26]. COVID-19 not only affected coastal cellular networks but also the offshore section. According to [27], some of the impacts of COVID-19 on the underwater cable industry and the result of increased traffic load can be counted as manufacturing, deployment, and maintenance.

6. ICT Solutions

To overcome these challenges, some ongoing studies should be taken into consideration. For instance, [28] discusses the mitigation of the effect of increased traffic during the lockdown period on channel and bandwidth optimization in mobile communication in North Western India. In this work, data interleaving technique in mobile communication is used for channel utilization and overhead reduction. The simulation results show that a significant increase of 60.5% in channel and bandwidth optimization is achieved with an overhead of 0.2%. However, a global, adoptable solution for bandwidth utilization still needs to be further investigated. Table 2 provides a review of the available literature on the effect of COVID-19 on digital communication and addresses the solutions.

7. Conclusion

According to the investigation provided in this research, the main infrastructure of the internet is under pressure, and as a result, the symptoms were apparent in the early days of lockdown when isolation protocols were implemented across the world. In this situation, each country is reacting differently. Although the responses and solutions provided by different countries may not be perfect, it is allowing organizations across the globe to have some chance to react to unprecedented changes.

It should be noted that the internet infrastructure is responding and is still capable of handling the additional network traffic. However, providing the required network capacity to prevent possible catastrophic events as the result of suddenly increased traffic should be taken into consideration. This paper provides a comprehensive review of the effect of COVID-19 on

global telecommunication networks' different aspects, such as ISP's measurement programs, measurements provided, and regulations; the effect of increased traffic on internet security; and the effect of fixed and mobile Wi-Fi broadband in different countries around the globe. Also, the global effect of COVID-19 on network traffic, including ISP programs, network resilience, and telecom infrastructure for disaster management, is studied accordingly. As a plan, disaster management programs for the improvement of telecom infrastructure should be implemented. As increased traffic affects network security, network protective software should be provided. Also, governments should legislate rules and regulations to support consumers and ISPs, more specifically to reduce the effect of digital inequality and provide internet and telecommunication facilities for economically vulnerable users during pandemic situations.

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