EUROPEAN UNION AGENCY
FOR CYBERSECURITY

Telecom Security During A Pandemic

Telecom security good practices and lessons learned from the COVID-19 outbreak

NOVEMBER 2020

ABOUT ENISA

The European Union Agency for Cybersecurity (ENISA) is the Union's agency dedicated to achieving a high common level of cybersecurity across Europe. Established in 2004 and strengthened by the EU Cybersecurity Act, the European Union Agency for Cybersecurity contributes to EU cyber policy, enhances the trustworthiness of ICT products, services and processes with cybersecurity certification schemes, cooperates with Member States and EU bodies and helps Europe prepare for the cyber challenges of tomorrow. Through knowledge sharing, capacity building and awareness raising, the Agency works together with its key stakeholders to strengthen trust in the connected economy, to boost resilience of the Union's infrastructure, and, ultimately, to keep Europe's society and citizens digitally secure. For more information, visit www.enisa.europa.eu.

CONTACT

To contact the authors please email resilience@enisa.europa.eu.
For media enquiries about this paper, please email press@enisa.europa.eu.

AUTHORS

Georgia Bafoutsou (ENISA) and Marnix Dekker (ENISA).

ACKNOWLEDGEMENTS

To support the stocktaking and the analysis, ENISA contracted Mojca Volk, Ph.D., University of Ljubljana via the ENISA call for expressions of interest framework. We are grateful for the useful early input on this project from Oscar Koeroo, Paul Slootmaker (KPN), Alejandro Becerra and Edi Fernando (Telefónica). This ENISA paper has been reviewed by the Article 13a group and the document contains input from this group.

LEGAL NOTICE

COPYRIGHT NOTICE

ISBN: 978-92-9204-406-0 and DOI: 10.2824/239478

CONTENTS

EXECUTIVE SUMMARY

The COVID-19 pandemic triggered major changes in the use of electronic communication networks and services in the EU: employees working from home instead of in the office, children receiving home-schooling, citizens using streaming services for entertainment instead of going out, people meeting up over a video link instead of in person, etc. The security and resilience of electronic communication networks and services became even more important for the EU's society and economy.

In this paper, we look at the role telecom providers played in ensuring the security and resilience of the services and networks during the pandemic.

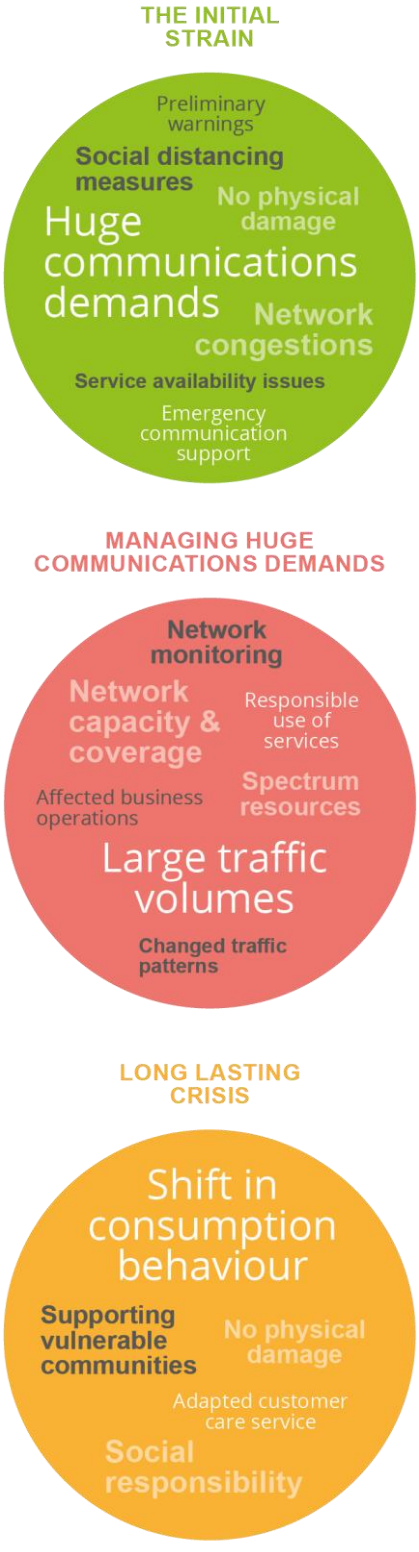
This paper focuses on the telecom networks and services themselves, not the endpoints. So COVID-related cyberattacks like COVID phishing emails and scam domain names are out of scope here. Also we don't discuss the arson attacks on base stations inspired by the conspiracy theories about the pandemic.

Throughout this paper we give examples of good practices and we conclude with lessons learned. We look at the following three aspects.

- **Early response phase:** in this phase, providers activated their business continuity plans and supported emergency communications and public warnings. We give examples of such activities in the EU and across the globe.
- **From initial strain to the new normal:** providers had to deal with major surges and shifts in usage and traffic patterns from the start of the pandemic. This gradually stabilised to what is now considered the new normal. We look in detail at the changes in usage and traffic patterns and the network performance monitoring during the pandemic, and examine how providers managed the increased network loads.
- **Response by the national authorities and collaboration with the sector:** we give a brief country-by-country summary of the pandemic response by the national telecom security authorities in the EU and we give examples of collaboration initiatives and information sharing between providers and authorities as well as in the private sector.

The general take away from the pandemic so far is that the services and the networks have been resilient during the crisis, despite major changes in usage and traffic.

The pandemic also had a lasting effect on the perception of consumers about telecoms: Electronic communication networks are now considered as a lifeline for citizens and they are crucial to keep the economy and society going.



From discussions with experts in the sector and the national authorities, we can also draw the following first lessons and ideas for improvements:

1. There is a need for intense cooperation and policy alignment between the various stakeholders in the public sector (competent authorities/ministries) but also between the public and the private sector, among the industry and with the citizens.
2. There is a need to build trust between the public sector and critical infrastructure operators. Information relevant to the handling of the crisis has to be disseminated in a timely way to key stakeholders, so that they can successfully adjust and apply their business continuity plans.
3. It is a crucial in this period to provide enhanced support to digitalisation, focusing on:

    - enhancing network capacity and coverage in rural areas;
    - encouraging investments and innovation (broadband/fibre vouchers, teleworking, e-government).

4. The internal operations of the providers have to be flexible, able to adapt to emerging situations and aligned with the company's business continuity plan. Remote and unmanned monitoring and surveillance of the infrastructure and diagnostic, as well as remote access to networking equipment should be promoted.
5. Telecom customers should be supported with advanced customer care services.

1. INTRODUCTION

The COVID-19 pandemic required an immediate response from the EU's telecom sector. In this paper, we look at the role of telecom providers in ensuring the security and resilience of the telecom networks during the pandemic.

We focus on the networks and services, the telecommunication infrastructure. Out of scope are COVID related attacks on endpoints like COVID phishing emails and COVID scam domain names. The ENISA Threat Landscape 2020 gives an overview of such attacks.

The paper focuses on the following three aspects:

- **Early response phase:** this section summarises the steps taken by providers in the early response phase, in activating business continuity plans and supporting emergency services and communications.
- **From initial strain to the new normal:** this section looks in detail at the network traffic changes. It gives examples of how providers are coping with the load and the need to manage the network traffic.
- **Response by the authorities and collaboration with the industry:** this section summarises the response of national authorities in the EU, country-by-country. It contains some examples of collaboration between the authorities and the industry and within the industry.

Note that throughout the paper, we highlight a few examples from the real world, using information from public sources, for the sake of illustration (not to single out a single provider for criticism or praise).

This paper does not intend to give a full and complete overview of how EU providers reacted to overcome the crisis, but it gives a number of interesting examples from providers in the EU and in the rest of the world.

1.1 TARGET AUDIENCE

The paper targets security and resilience experts in the telecom sector, cybersecurity experts and experts at national authorities and ministries.

1.2 SCOPE

The scope of this report is the impact of the pandemic on electronic communication networks and services. The goal is to give an overview of the different activities telecom providers undertook to safeguard the security and resilience of their networks and services during the pandemic.

1.3 METHODOLOGY

The methodology for this paper was a stock-taking desktop research to collect a wide range of examples, statistics, and good practices, followed by targeted interviews with sector experts.

At the start of this work, the Article 13a Expert Group provided direction and provided information about the reaction to the pandemic by the EU telecom security telecom authorities (see Chapter 4 of this report). The group also reviewed a final draft of the paper.

2. EARLY RESPONSE PHASE

In this section, we look at the role of telecom providers in the early response to the pandemic. We examine at two key activities:

- providers activating their business continuity plans;
- providers supporting emergency services and emergency communications.

2.1 ACTIVATION OF BUSINESS CONTINUITY PLANS

Following the outbreak of the pandemic, telecommunications networks and services were given the status of critical infrastructure across the globe. Telecom providers quickly adapted and activated their business continuity plans.

Providers implemented changes to the workplace, including protection measures such as contact limitation, turns/shifts, remote working and decentralizing key engineering staff, to avoid that one infection would affect an entire engineering or security function.

Most providers, from the onset, reduced physical meetings, events and business travel, gradually moving to a complete halt of all (non-essential) travel. Note that the approach of individual operators was different depending on the rules and the government strategy in each country.

Remote work was a global recommendation adopted by most organisations and institutions, including the World Health Organization (WHO). Most telecommunication operators followed suit and advised employees to work from home whenever possible.

Telstra in Australia, for example, ordered 20 000 of their staff to work from home despite not having detected a COVID-19 case within their organisation. Telefónica in Europe, Orange Global and Liquid Telecom in Africa are just some of the organisations that took similar measures. Verizon reported 100 000 of their employees working from home. In addition to office jobs, people that worked in distributed call centres, helpdesks and even network operations centres resorted to teleworking. VEON, for example, closed their offices in Amsterdam, London and Luxembourg and provided work from home arrangements for call centre services. Orange reported on the capacity to transfer and distribute its operational customer support activities to one of its five major service centres around the world. Airtel India activated remote network operations centres with only 2 % of its staff required on site.

2.2 SUPPORTING EMERGENCY SERVICES AND COMMUNICATIONS

At the start of the COVID-19 outbreak, many countries started using emergency communications and public warning systems to inform the public about the pandemic, movement restrictions, social distancing measures, contact information (about how to get medical support) and accurate health information. Often this involved telecom providers, for example, by broadcasting text messages (SMS) to citizens.

In the Netherlands, Greece, Romania, the United Arab Emirates, Azerbaijan and New Zealand, for example, cell broadcast messages were used to alert the public on the specific measures taken to fight the outbreak. Wireless emergency alerts were used to send city-wide and state-wide messages regarding social distancing and shelter-in-place measures in the United States, while the Canadian provinces used their Common Alert Protocol (CAP) - based

broadcast immediate mobile alert system. France, Pakistan, the United Kingdom, Portugal, Slovenia, Denmark, Iraq, Saudi Arabia and Sudan sent nation-wide SMS messages to the entire population. In Czechia, O2 disseminated SMS messages to roaming visitors in agreement with the national health authorities. Nepal Telecom, Etisalat and Du in the United Arab Emirates and Zain in Sudan and Iraq used ringtone messages to alert the public. Zain in Sudan used automated message calls. Vodacom Democratic Republic of the Congo used an SMS broadcast to notify the population. Ncell Nepal used outbound dialling, SMS messaging and call tone messages to distribute government announcements.

Additionally, the COVID-19 pandemic meant that emergency call centres came under unprecedented strain. In some countries congestions of emergency call centres occurred.

In Italy, for example, the number of calls to 112 doubled within a day when the first positive COVID-19 case was confirmed. In Croatia, the number of calls to 112 increased by approximately 50 % in the first 3 weeks, as did the average call duration. Other helplines experienced similar increases. The helpline of the Ministry of Health in Portugal, for example, reached a historic record shortly after confirmation of the first two cases of COVID-19 in Portugal. The non-emergency online service 111 in the United Kingdom saw a record number of enquiries reaching as high as 210 000 in a single day. More than 15 000 calls to the 1135 line were reported within 24 hours in Greece following the outbreak, with the trend increasing to reach 20 000 calls per day by the end of the first week. In the United States, the authorities reported a temporary rise in the number of 911 calls in regions where shelter-in-place orders were issued, as well as in COVID-19 hotspot areas, such as New York City, where the number of reported 911 calls surpassed those recorded during the terrorist attack on the World Trade Center on 11 September 2001. (source: European Emergency Number Association –EENA)

The measures taken by telecommunications operators to ensure sufficient communications capacities and coverage for emergency response were critical from the very beginning. Telecommunications providers around the world took proactive measures in offering support plans for other front-line professionals involved in the COVID-19 response activities, whose effective and efficient operations depended on communications services.

Vodafone UK doubled the calling capacity for the NHS 111 telephone advice service to reach a capacity of 2 400 simultaneous calls, after the volume of calls has surged by as much as 400 % compared to the pre-pandemic peak.

In Sri Lanka, Dialog Axiata partnered with Wavenet International and MyDoctor to launch a free trilingual hotline offering information and advice and providing online access to doctors. Operators in numerous other countries worldwide provided various forms of discounted or free hotline services, portals and short codes, including Vodacom Mozambique and Lesotho, O2, O2 Family, T-Mobile and Vodafone in Czechia , Liquid Telecom in Zimbabwe, Cosmote in Greece, operators in Greenland and the United Kingdom's Tesco and O2. Providers set up zero-rated short code numbers for call centres in Azerbaijan. In the Dominican Republic, the Dominican Telecommunications Institute and the Emergency Operations Center launched a call centre dedicated to the pandemic.

In Brazil, the national telecommunications agency, Anatel, provided a dedicated access code, 111, for emergency assistance related to the pandemic in cooperation with the telecommunications operators.

FirstNet, operated by AT&T, a provider of professional communications services for response authorities in the United States, deployed Cell on Wheels and distributed devices to provide additional capacity and communications capabilities to emergency medical personnel in North Carolina. They deployed a portable base station at a COVID-19 test facility in the Northeast where the situation was particularly devastating. CenturyLink equipped the US Naval hospital ship Mercy with 1 gigabyte ethernet connectivity free of charge within 48 hours of its arrival in Los Angeles.

Liquid Telecom in Africa installed free Wi-Fi at COVID-19 quarantine centres. Hellas Sat, in partnership with Africom, provided free unlimited broadband connectivity to 127 public clinics and hospitals across Zimbabwe.

Telekom Malaysia deployed 5G base stations at two quarantine centres (Malaysia Agro Exposition Park Serdang and Institut Latihan Kementerian Kesihatan Malaysia), operating on 700 MHz and 3.5 GHz bands on Stand Alone (SA) architecture to deliver free Wi-Fi to patients and medical staff and provided 5G fixed wireless access terminals. Telekom Malaysia partnered with Huawei and the setup was completed in 3 days. In Thailand, the Ministry of Digital Economy, in cooperation with Huawei Technology, provided an artificial intelligence assistant solution with 5G technology to a hospital, to help increase the capacity of its examination and care. Satellite service provider SES cooperated with the Luxembourg government's SATMED project to connect the e-health SATMED platform in remote healthcare institutions in Bangladesh and Niger to communicate with national and international doctors. Cambodia's Cellcard deployed 5G services conjoined with Ezecom's fibre optics in the Khmer Soviet Friendship Hospital and The Chak Angre Health Center to help fight the pandemic.

3. FROM INITIAL STRAIN TO THE NEW NORMAL

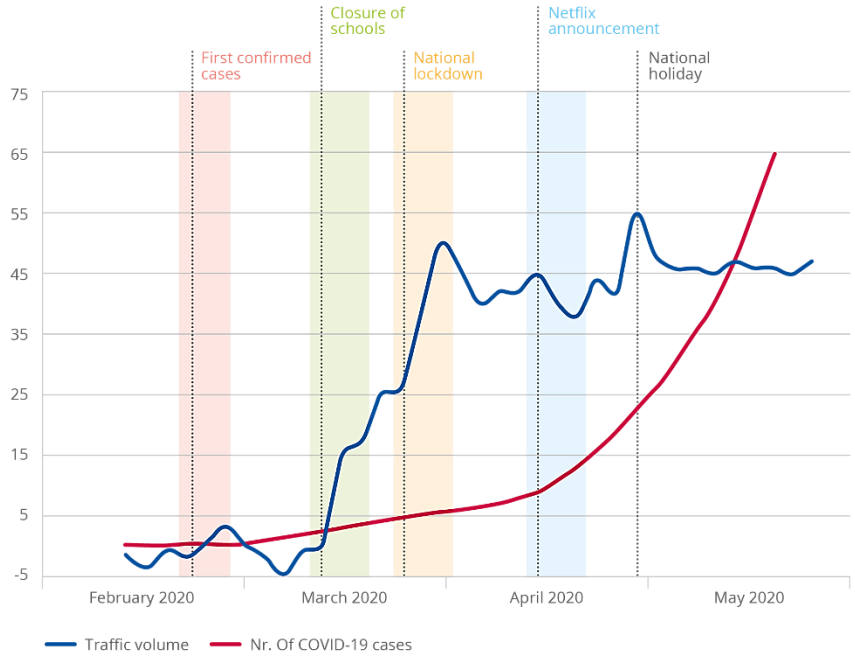
From the start of the pandemic, the normal service usage and network traffic changed drastically. Telecom providers reported several changes in the usage of telecom services and in traffic patterns.

INITIAL CHANGES IN USAGE AND TRAFFIC PATTERNS

- An initial spike in traffic volumes as users attempted to be informed and connected with family and friends.
- Increased consumption of voice services along with a significant drop in the volume of mobile handoffs.
- Increased and persistent upstream traffic volumes as a result of increased use of online collaboration tools for remote work and schooling.
- Usage hotspots in business and commute areas relocated to residential and rural areas.
- A persistent and long-lasting burden on the network, measured in weeks and months.

Figure 1 shows the number of COVID-19 infections and the network traffic on a single timeline. This is an example of one EU country, but this timeline is representative of the traffic changes experienced by other operators in Europe and the United States.

Figure 1: A schema of the volume of traffic on the telecommunications networks as the pandemic evolved (*Source*: Fastly)



The figure shows that at the start of the pandemic, the networks experienced an initial strain, primarily due to people connecting with families and friends, and trying to access information about the pandemic. A number of consecutive spikes in traffic took place following major announcements and new measures. The biggest spikes were seen following the declaration of a nationwide lockdown, and following the closure of businesses and schools.

Following this initial period of changes and peaks, the volume of traffic continued to grow, marking the new normal, where changed consumption habits are consolidating. In comparison to other crises, during the current pandemic the traffic changes lasted for a long time and it is expected that the pandemic will leave a permanent mark on network traffic patterns and the consumption habits of citizens.

The rest of this section will focus on these three phases: the initial strain, the increased demand under lockdown and the new normal.

3.1 THE INITIAL STRAIN

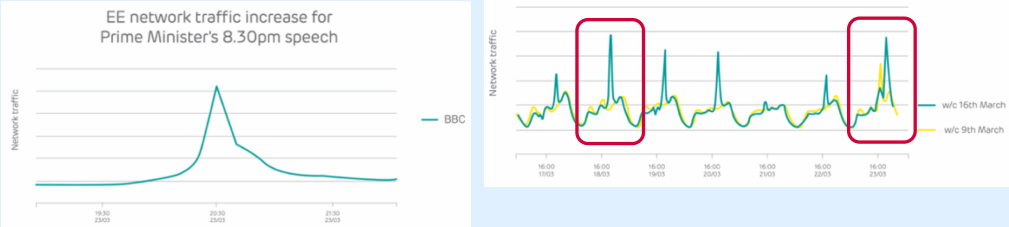
At the start of the pandemic there was a sudden and large increase in the overall communications demands. Several providers experienced overloads and brief congestions.

For example, in some areas in Europe and the United States, the increase in mobile traffic volume was similar to Christmas and New Year peak times, except they lasted longer. According to Nokia, networks saw an increase of 20–40 % in the regions impacted by the pandemic. In Europe, the biggest spikes were measured in Italy and Spain. A 70 % increase in traffic was reported by Italian operators. Mobile networks in Italy experienced increases in peak throughput by as much as 90 % and average mobile data usage by 50 %. Vodafone Italy reported peak traffic throughputs reaching and even exceeding 90 %, while average throughput increased by 80 %. According to Telecom Italia, the internet traffic on their fixed network rose by 70 % following a lockdown, a large portion of which was attributed to gaming. During the first week of quarantine, Spanish mobile networks experienced a 35 % increase in throughput and fixed networks a 50 % increase. Telefónica's Movistar, Orange, Vodafone, Másmóvil and Euskaltel reported a 40 % increase in traffic on IP networks within just the first few days and a 50 % increase in the use of mobile voice and 25 % in mobile data when quarantine was enforced in certain regions of Spain. WhatsApp usage in Spain was said to have increased fivefold in a matter of days.

Large strain and network disruptions were reported in several other European countries as well, including, for example, Lithuania, Switzerland and the United Kingdom. For instance, several operators in the United Kingdom, including Vodafone, O2, Three, Virgin, Tesco, GiffGaff and EE, experienced issues on 17 March 2020 around 9 a.m., when social distancing measures were enforced and millions of users were forced to work remotely. Voice services on 2G, 3G and 4G networks were affected the most with anywhere between 3 % and 9 % of calls not getting through, whereas mobile data, Wi-Fi and messaging services were not affected.

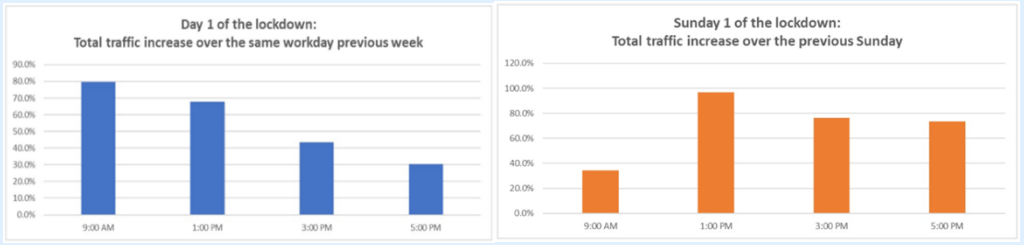
In the United Kingdom, government announcements and the enforcement of social distancing measures resulted in spikes and traffic pattern changes. Looking closer at reports from EE and Virgin, two UK broadband providers, there were spikes in mobile data traffic following the Prime Minister's daily 5 p.m. briefings. Additionally, when quarantine measures were announced at 8.30 p.m. on Monday 23 March 2020, data traffic on EE's mobile network increased by more than five times compared to just 1 hour before.

Figure 2: EE's network traffic volumes displaying volume spikes as a result of large number of subscribers watching the 5 p.m. briefings (left), and a significant spike in network traffic on 18 March after social distancing measures were announced and when lockdown was announced on 23 March (right) (*Souce*: EE)



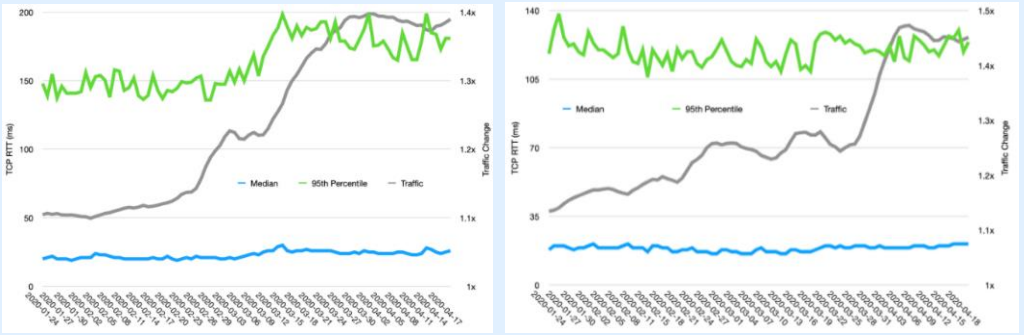
Nokia's statistics from the week of 9 March when several European countries declared a state of emergency and implemented lockdown measures showed an increase in the overall traffic on day 1 of the lockdown reaching anywhere between 30 % (5 p.m.) and 80 % (9 a.m.), with boosts between 50 % and 70 % for most of the day. On the first Sunday of lockdown, traffic rose even further, reaching increases of anywhere between 34 % and 97 % during the day. Further analysis of Nokia's traffic volumes per type of communications service on the first day and the first Sunday of lockdown revealed spikes in the use of messaging, social media services and streamed video (see Figure 3).

Figure 3: Total network traffic statistics from several western European networks for the first day of lockdown (left) and the first Sunday following the declared lockdown (right) (*Source:* Nokia)



The difference in network resilience across different countries was observed in Cloudflare's data in a comparison between the United Kingdom and Italy. The graphs show significant increases in the TCP round trip time along with increased traffic volumes in Italy, whereas in the United Kingdom despite the spikes in the traffic volume the TCP round trip time was not affected as drastically (see Figure 4).

Figure 4: Increased internet traffic volumes (grey) did not have impact on the TCP round trip timed (green) in the United Kingdom (left), whereas in Italy (right) both median and 95 percentile TCP round trip time increased along with the traffic volumes. This confirms that networks in Italy were under more strain (*Source:* Cloudfare)



3.2 CHANGED DEMANDS UNDER LOCKDOWN

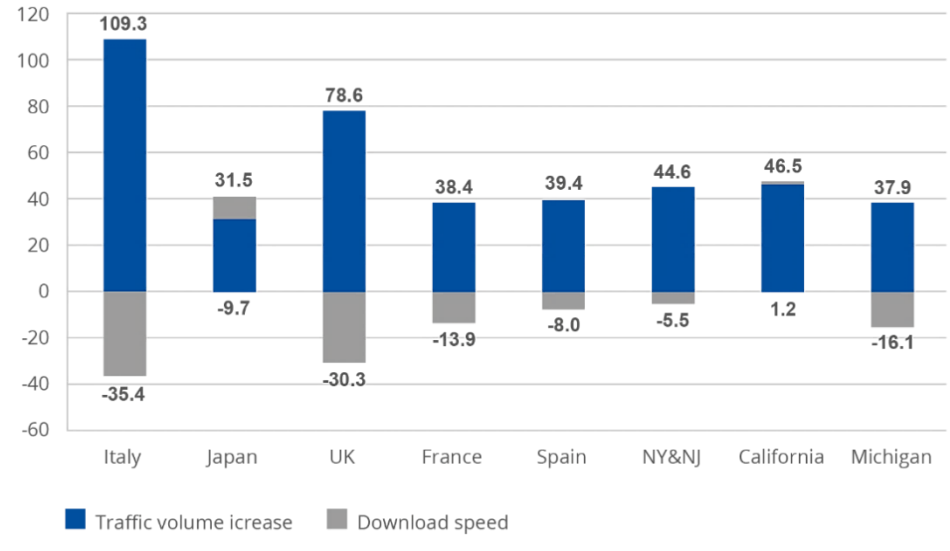
During the lockdown, the demand for communication services continued to grow and the usage patterns changed. There were the three following major changes.

- **Shift of peak hours**. According to Cloudflare, for instance, in addition to the normal evening peak hour, two additional peak times occurred, one in the morning and another in the afternoon. The same patterns were observed by Sandvine. According to BT in the United Kingdom and AT&T in the United States, for example, daytime traffic rose by 30 % to 50 %.
- **Changes in upload traffic volumes**. Changes in service consumption and, in particular, increased use of videoconferencing and online collaboration tools, led to a considerable increase in upload traffic volumes.
- **Shift of hotspot locations**. There was a visible shift of service consumption hotspots, causing unexpected strains, in particular in residential broadband access networks. The volume of traffic dropped significantly in city centres, business districts and industrial centres (including, for example, airports, major metro stations and tourist attractions).

Sandvine saw an almost 40 % growth of internet traffic across different types of consumer networks between February and mid April. Sandvine reported increased demands on both the fixed and wireless networks, whereas the biggest volume increase was seen on Tier 1 fixed broadband networks (cable, DSL, FTTx).

According to data provided by **Fastly**, over the roughly 1-month period from the end of February to the end of March, traffic increased in Italy by 109.3 % (more than doubling). The increase was 78.6 % in the United States, 39.4 % in Spain, 38.4 % in France and 31.5 % in Japan Kingdom**.** These increases in traffic volume coincided with decreases in download speeds (35.4 % in Italy, 30.3 % in the United Kingdom, 13.9 % in France and 8 % in Spain). In Japan and California on the other hand, average download speeds actually increased, by 9.7 % and 1.2 %, respectively.

Figure 5: Increased internet traffic volumes in selected European countries and US states that were significantly hit by the pandemic, and the corresponding download speed deteriorations (Source: Fastly)



A statistical analysis of average download speed data for individual countries was prepared by the Phoenix Center, based on data provided by Ookla for fixed and mobile connections covering 116 countries between 16 December 2019 and 11 May 11 2020. It showed that for fixed connections, 54 out of 108 countries experienced speed degradations, and 33 % of these were statistically significant with levels of 10 % or higher. The average speed reduction was estimated at 9.2 %, while the average speed increase was estimated at 6.6 %, indicating considerable differences between countries. Most of the countries that experienced degradations of 5 % or more have relatively low per-capita gross domestic product, but there were exceptions, for example, France, Italy and Japan. For mobile broadband, 77 countries experienced degradations, with 66 of those experiencing statistically significant drops. In general, data showed that mobile networks suffered more than fixed networks, with an average speed reduction of 9.9 % and an average speed increase of 8.9 %, which points at a more symmetrical difference.

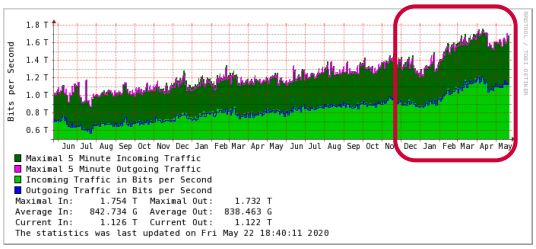
According to the Europe, Middle East and Africa Satellite Operators Association, since the start of the pandemic satellite operators providing broadband connectivity directly to consumers have experienced a 15–70 % increase in data traffic across Europe and America (depending on the country) and an increase in subscriptions in Brazil, Mexico and the United States Satellite networks primarily served broadband consumers, while remote enterprise connectivity was mostly idle due to the pandemic. Application proportions in the total volume of traffic were similar to those seen on fixed broadband networks, with two exceptions, a huge portion of WhatsApp traffic accounting for 12.78 % of the entire volume and much lower percentages of gaming traffic compared to typical fixed broadband lines.

3.2.1 Impact on the internet backbone

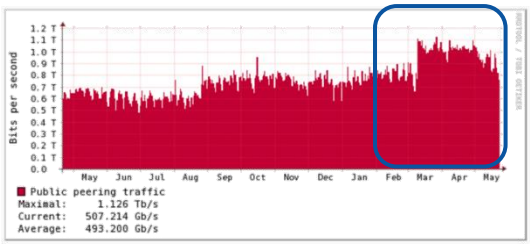
Network backbones and the internet core demonstrated sufficient capacities to cope with the impacts a pandemic causes with respect to increased service usage, spikes in traffic volumes and changes in traffic patterns. Internet exchanges saw huge increases in the volume of traffic passing through their networks. In general, a change in volume took place in all world regions, spanning anywhere between 10 % and 40 % depending on the situation and the state of government action.

The Deutsche Commercial Internet Exchange (DE-CIX) in Frankfurt, Germany, reported a world record of 9.1 Terabits/s data throughput in March 2020 following an increase of 12 % since December 2019. The reported volume corresponds to as much as two million simultaneous HD video transmissions. A similar spike in internet traffic was also reported by the Amsterdam Internet Exchange, who hit the 8 Tbps barrier on 30 March 2020 and reported a 17 % growth of overall daily traffic volume. Record volumes were also reported by NAPAfrica with evening peaks at its Johannesburg, Durban and Cape Town exchanges exceeding 1.1 Tbps on 25 March 2020 (see Figure 6).

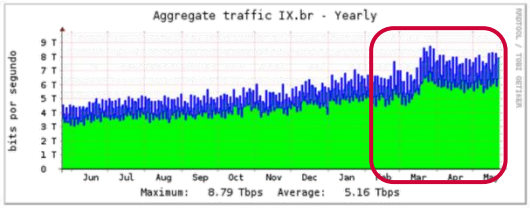
Figure 6: Increased traffic volumes were observed at internet exchanges around the world



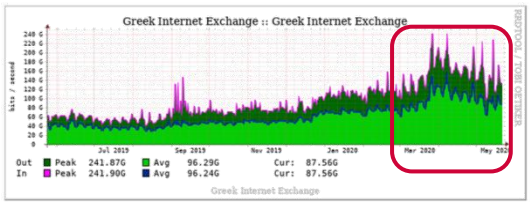
Hong Kong's Internet Exchange (*Source:* HK IX)



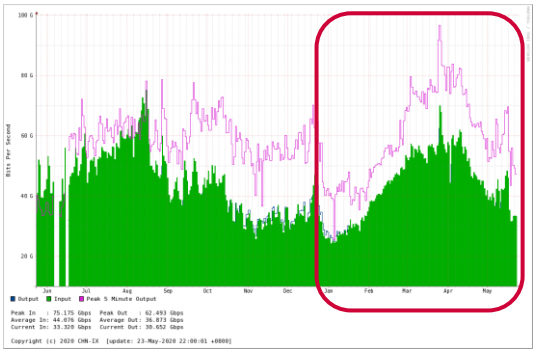
Milan IX (*Source:* MIX)



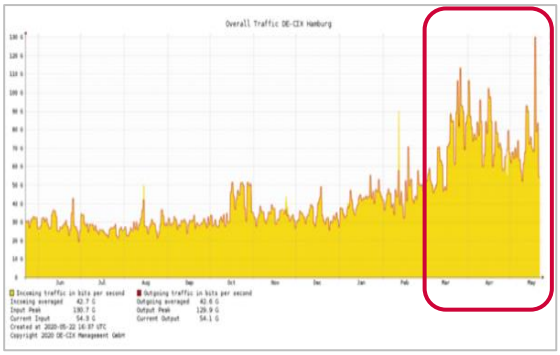
Aggregated Brazilian internet exchanges (*Source:* IX Brazil)



Greek IXP (*Source:* GR IX)



China IX (*Source:* CHN IX)



DE-CIX Hamburg, Germany (*Source:* DE CIX)

3.2.2 Increased usage of mobile and fixed voice services

Along with an increase in internet traffic, the use of more traditional communication services like voice telephony also increased.

In France, for example, Orange reported a 100 % increase in voice calls. According to Vodafone, voice traffic in some countries rose by 40–50 % and even up to 100 %. Vodafone UK, for example, experienced a 25 % increase in fixed telephony traffic and a 42 % mobile voice traffic increase. In Spain, the demands for voice services rose by 25 % within the first weeks of confinement according to Telefónica.

Increased use of voice services was also reported in the United States, in particular with Wi-Fi calling, which in some areas saw an increase of 100 %. Operators AT&T, Verizon and Sprint all experienced spikes in voice calls when restrictions were initially imposed at the end of March 2020. According to AT&T, voice calls on Sunday 22 March increased by 44 % compared with a typical Sunday, while Wi-Fi calling increased by 88 %. Verizon reported a

25 % increase overall and a 10 % wireless increase in calls between 12 March and 19 March 2020, with their duration 15 % higher and the biggest portion of the increase attributed to conference calls. Similarly, Sprint reported a 20 % increase in calls and a 25 % increase in messaging. Mobile handoffs, on the other hand, dropped by as much as 29 % nationwide with users staying home under quarantine. Even sharper decreases were observed in commuter hotspot areas, such as the New York Metro (– 53 %) and Upstate New York (– 49 %).

A surge in the use of voice calls was also reported in India, with estimates reaching as high as a 15–20 % increase in calls made through mobile phones in the initial days following the implementation of the quarantine. Later on, the frequency of calls decreased due to large commuter populations staying at home, but the average call duration times increased, by as much as 30 % ([1]).

3.2.3 Impact on broadband traffic

Fixed consumer broadband networks experienced the biggest increases in traffic during the pandemic (see for example the report by Sandvine). This was caused by traffic shifting from enterprise, education and public Wi-Fi networks to residential fixed broadband networks. In addition, Nokia reported that aggregation networks and service edge routers experienced the biggest strain. According to Ookla, the largest performance degradation was detected in dense residential areas where the networks are not built for such large volumes of traffic and the network performance is optimised for evening peak hours. As a result, the available capacities and network coverage did not suffice during specific periods of the pandemic, in particular when quarantine measures took effect and people worked and attended school from home.

In Europe, Vodafone UK experienced broadband traffic growth of 15 % within the first 2 weeks of quarantine alone, and reported a 30 % increase in internet traffic across its fixed and mobile networks. On fixed broadband networks, the United Kingdom's BT reported a 100 % increase in daytime traffic, while volumes on the mobile part of the network decreased slightly compared to pre-pandemic levels as a result of people staying at home and resorting to Wi-Fi instead.

Fixed broadband use in Italy and Spain increased by more than 50 %. In Spain, Vodafone reported an increase in bandwidth demand of almost 40 % and in mobile data traffic growth of 50 %. They detected an increase in mobile broadband demand of almost 20 % and in fixed broadband of 35 % during peak evening hours in Italy and Spain. Telefónica saw a 35 % overall data increase across its networks in Spain, with 26 % increases in the fixed network and 48 % in the mobile network. Considerable increases in the volume were also reported by Telia operating in Denmark, Estonia, Finland, Latvia, Lithuania, Norway and Sweden with a more than 50 % overall traffic increase, mostly visible during off-peak hours and with major regional differences, whereas peak traffic levels were up by approximately 35 % as of 29 March 2020.

In the United States, operators reported a rise in network usage of 20–35 % for fixed networks and of 10–20 % for mobile networks in the first weeks following the declared state of emergency. The demands increased in particular in suburban, exurban and residential areas as a result of remote work and schooling. Similar trends were observed on the American cable networks as reported by NCTA's Altice, CableOne, Charter, Comcast, Cox, GCI, Mediacom, Midco and Sjoberg's, reporting a 14 % increase in national downstream peak growth and a 32 % increase in national upstream peak growth since 1 March 2020.

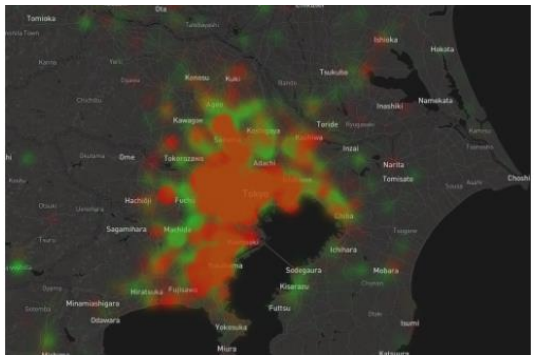
([1]) Nepali Telecom, on the other hand, reported a decline in voice business of approximately 25 % due to most business coming to a halt and most people using social media to communicate. Mobile voice usage with China Telecom also saw a decrease of almost 19 % in Q1 2020 compared to Q4 2019, with wireline voice usage decreasing by 25 %.

In South-East Asia, peak traffic increases reached 38 % by the end of March and average throughput increased by 12 %. Nepali Telekom, for example, saw a 40 % increase in data usage compared to the pre-lockdown period, mainly accounted to YouTube, social media and online learning apps. Due to limited resources, data caps were not removed and the internet usage experience deteriorated due to high spikes in communication demands. Zain reported a 20–50 % increase in high-speed broadband data traffic across various markets since March 2020. Similarly, an increase of 25 % in data traffic volumes was reported in India between early February and late March. In Malaysia, Telecom Malaysia reported a 30 % increase in usage trending, and of this, the increase of international link traffic was 5 %. China Telecom saw a 37.4 % increase in mobile handset data traffic on 3G, 4G and 5G networks in Q1 2020 compared to the same period last year and reported continued and rapid growth. They reported an increase in average daily network traffic in April 2020 on 4G of 17.78 % and on broadband network of 22.61 %, with video and image processing the two primary driving forces.

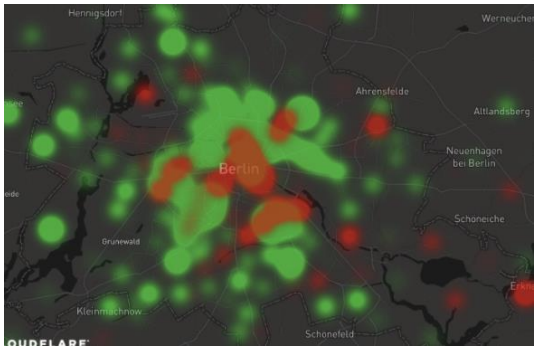
The situation was similar in Africa. Vodafone, for instance, reported traffic increases in some African countries similar to those in Europe, with increases ranging between 25 % and 50 %. South America saw an average growth of traffic volume of 25–30 %. Vodacom Group for instance reported a 40 % increase in data traffic during the lockdown period. The data increase was said to have been driven by paid traffic for businesses resorting to remote work and an increase in the use of streaming services. An increase in free traffic for education, government and health portals was also reported. South Africa's Seacom, operating major undersea fibre cables, also saw a 15 % increase in internet traffic across its network.

Figure 7: A visualisation of the differences in the traffic volumes before (early January 2020) and after (late March 2020) the outbreak, with red representing areas where internet usage decreased and green where it increased (*Source:* Cloudflare)

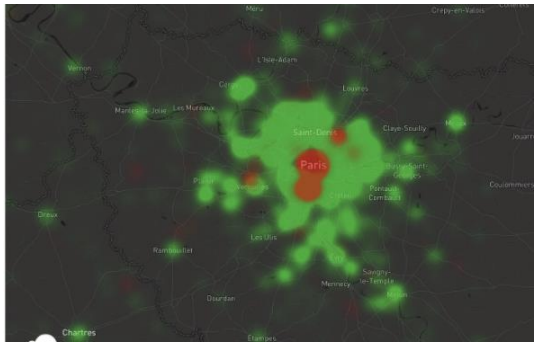
New York City (United States)



Tokyo (Japan)



Berlin (Germany) red areas: Tegel airport (north-west)



Paris (France) red areas: Le Bourget airport and industrial zone (north-east), the Palace of Versailles (west)

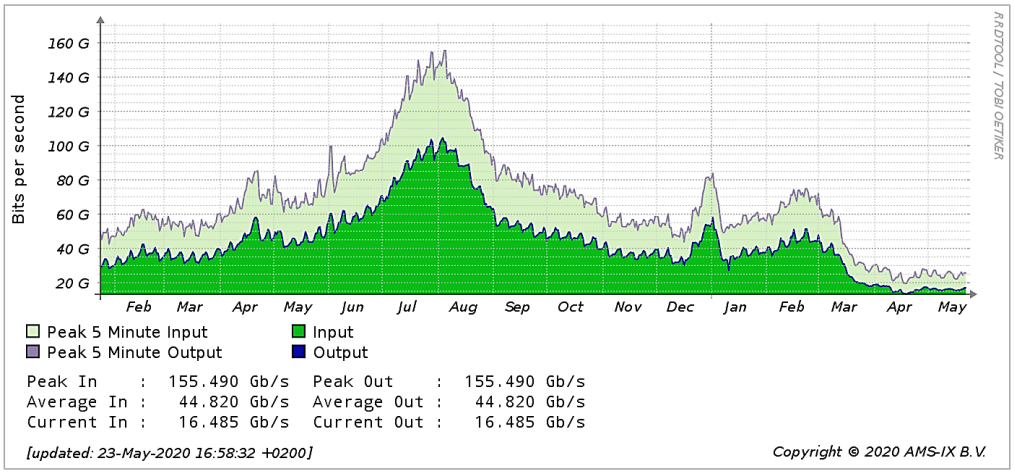
3.2.4 Impact on mobile handoffs

The stay-at-home orders were also reflected in the volume of handoffs.

AT&T, for example, reported a 27 % drop in mobile handoffs in March versus a typical week. In New York City, T-Mobile saw an 86 % increase in subscribers with limited mobility, meaning they connect to cell sites in their primary location only, and similar volumes in the San Francisco Bay Area with a 77 % increase in limited subscriber mobility.

Another effect of people staying at home and all travel being banned was a significant drop in the volume of traffic seen on GPRS roaming exchange (GRX) networks (see Figure 8).

Figure 8: Decreased traffic volumes on the Amsterdam GRX from March 2020 (*Source*: AMS IXP)



This is also confirmed by reports from roaming operators, such as Vivo Brazil and Syniverse, who experienced significant drops in traffic as a result of global travel restrictions.

Nepali Telecom also reported a considerable decline in international long distance traffic, by as much as 20 %, which was attributed to the impeding recession and people experiencing a shortage of available resources to be spent on communications services. A similar phenomenon was reported by China Telecom. However, according to i3Forum, while there was a 30 % drop in international traffic overall, international voice traffic increased by 20 % year-on-year in March 2020, and the duration of calls increased by 30 % in March 2020 and by more than 60 % in April 2020 compared to 2019.

Network backbones and the internet core demonstrated sufficient capacities to cope with the consequences of the pandemic with respect to increased service usage, spikes in traffic volumes and changes in traffic patterns. Internet exchanges saw huge increases in the volume of traffic passing through their networks. In general, changes in volume took place in all world regions, spanning anywhere between 10 % and 40 % depending on the situation and the state of government action.

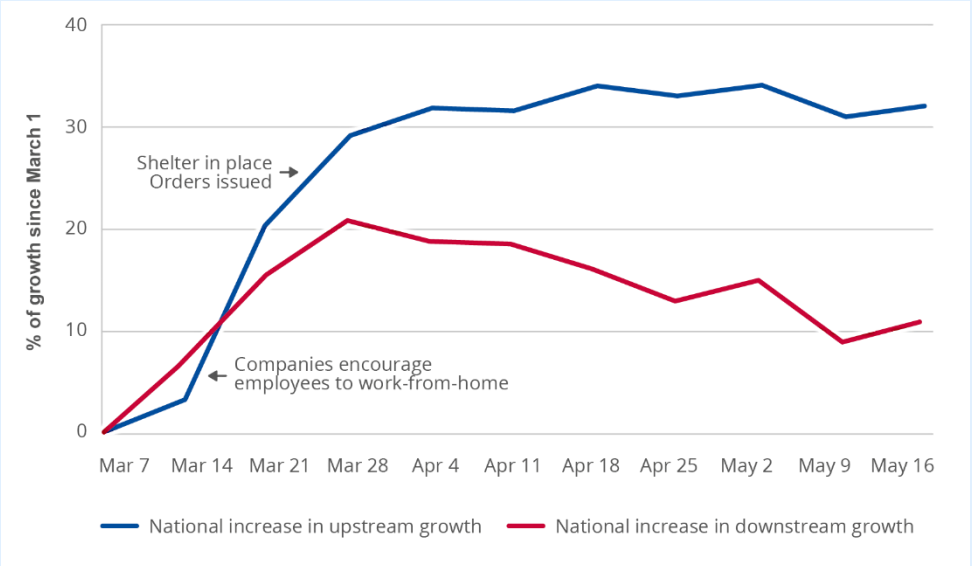
3.3 NEW NORMAL

The strain on the networks started to decrease once the pandemic situation stabilised and countries around the world progressed with relaxing the social distancing measures. Providers have indicated that even after lockdown restrictions were lifted, a number of traffic pattern changes have remained.

Since the implementation of Phase 0 of deconfinement in Spain, for example, Telefónica reported a 13 % drop in fixed data traffic in certain timeslots as people over 14 years of age are allowed to leave home in the mornings and in the evenings. There was also a drop in mobile data traffic, although to a lesser extent, with a 6 % decline compared to a week earlier at the highest daily peak in the evenings. In addition, there was a 9 % decrease in the evening peak time of voice traffic usage compared to a week earlier.

In the United States, Comcast data also showed that the traffic volumes eventually plateaued. The new volumes and patterns persisted, however, driven primarily by remote work. VoIP and video conferencing continued to dominate weekday usage at 210–285 %, and VPN traffic was up by 30–40 %. Since 1 March the upload traffic increased by 32 % and downstream by 11 %, and downstream peak hours shifted from 9 p.m. to between 7 p.m. and 8 p.m., while upload peak traffic times shifted from 9 p.m. to daytime hours between 8 a.m. and 6 p.m. On wireless, a 17 % decline in LTE data usage was reported and a 36 % increase in mobile data usage over Wi-Fi. Weekend usage was driven by entertainment, streaming and gaming services with peak hours continuing in the evenings. Gaming downloads were up by anywhere between 20 % and 80 %, depending on new releases. The stabilisation of the increased volume trends was also reported by US Telecom. A 10.4 % mean traffic increase was reported in the second week of June 2020 compared to the record peak increase of 27 % reported earlier on 16 April 2020. (see Figure 9).

Figure 9: Comcast traffic volume growth trends between March and May 2020



3.4 NETWORK MANAGEMENT AND MAINTENANCE DURING A PANDEMIC

In response to changed usage behaviour and increased traffic, telecommunications operators took different measures. In addition to monitoring their networks 24/7, many network management interventions took place to cope with the increased loads, such as:

- changing network configurations;
- deploying new technologies;
- securing additional spectrum, where needed, or sharing spectrum with peers;
- engaging emergency deployments, including using new technologies, such as 5G.

3.4.1 Management of network capacity and performance

To deal with the increased traffic peaks and pattern changes, telecom providers responded in a variety of different ways, depending on the situation. Measures included increasing capacity, implementing call gaping, codec reconfigurations to reduce voice quality, time limits, direct retry, dynamic quality and data consumption balancing, and configuration of traffic prioritisation, in particular to support emergency communications and essential services.

In Europe, Ekinops in the Paris area in France, for example, increased the bandwidth of its single fibre network to assist a local telecom provider CM'IN, in keeping the city of Chartres online. Orange France reported having reconfigured network parameters in response to mobile voice traffic doubling in volume. Telecom Italia reported on conducting a series of network improvements, which led to an increase in bandwidth of up to 37 % on selected routes compared to the pre-pandemic situation. It activated 5 000 new cabinets to offer high-capacity broadband connectivity for the so-called white areas, which are not subject to public tenders for broadband infrastructure, and set up a dedicated control room for monitoring network traffic. Telenor increased the capacities of 300 base stations. Comcast reported that they performed more than 700 000 diagnostic speed tests each day.

Operators in Iran took measures to expand the capacity and data rates of their networks, including increasing the speed of fixed internet services, capacity enhancements of country-wide backbone network and gateways as well as the expansion of capacity of high-speed links to fixed and mobile network operators.

In China, 5G was deployed specifically for fixed wireless applications to deliver connectivity. The Chinese telecommunications industry reportedly installed more than 63 000 new 4G and 5G base stations between late January and the end of March 2020. Subisu Cablenet in Nepal increased local cache for YouTube and Facebook to manage internet bandwidth shortage. In India, a Tier 1 operator implemented a mechanism to feed the core network back with radio congestion indicators in order to monitor congestions and implement real-time balancing of video traffic quality and data consumption in an attempt to deliver a consistent Quality of Experience (QoE) for subscribers without impacting essential services on the frontline of the pandemic.

Liquid Telecom, operating in Africa, enhanced connectivity capacities across its east Africa backbone by deploying Multiprotocol Label Switching (MPLS) across a closed wide area network to enable video conferencing services and the use of digital tools for the members of the parliament and East African Community ministries and businesses resorting to remote work. It upgraded major fibre network links in Kenya for improved bandwidth performances available to their enterprise and wholesale customers. Vodacome South Africa was said to have increased its network capacity with an investment worth USD 26.7 million. Australian NBN opened up network capacity free of charge to allow for up to 40 % more bandwidth

across all technologies, including fixed wireless and satellite services, to improve network performance.

Some national authorities and European bodies issued guidance to providers about traffic management, i.e. about what measures operators are allowed to take to deal with network traffic changes and to avoid congestion. Following are two examples:

- The Body of European Regulators for Electronic Communications (BEREC) issued, together with the Commission, a joint statement on coping with the increased demand for network connectivity due to the COVID-19 pandemic.
- The German Federal Network Agency, issued guidance for operators on acceptable traffic management measures in the event of network overload during the COVID-19 pandemic.

3.4.2 Management of spectrum resources

In addition to technical reconfigurations within the network, increasing spectrum resources to overcome network capacity and coverage issues was another strategy used during the COVID-19 pandemic. This included applying for licenses for unallocated spectrum bands as well as for shared spectrum use in agreement with license owners, securing licenses for the deployment of new technologies, such as 5G, to support ad hoc augmentation, and applying for access to backhaul spectrum where needed. Actions included cooperation with the national regulatory authorities (NRAs) and other operators to gain regulatory approvals, followed by spectrum relocation, reconfiguration of existing and placement of additional network equipment, including COW/COLT, RDUs, permanent large-radio-zone BTS, VSAT, high-performance antennas, etc.

During COVID-19, fast and flexible changes to regulations proved essential. Formal procedures were expedited to enable fast awarding of licenses and management of license fees under emergency conditions.

Cooperation and regulatory initiatives are further analysed in Section 4.

3.4.3 Network maintenance

At the start of the crisis, providers delayed all non-essential investments and non-essential maintenance operations. Over the course of the next weeks and months, however, maintenance operations restarted. In order to help operators maintain the essential communications services operational, the telecommunications services were declared as essential so that operators could be granted travel and access permissions during lockdown.

In many countries, network maintenance operations had to be adapted to limit the exposure of essential workers. For example, providers used remote and unmanned monitoring, remote surveillance of the infrastructure and online diagnostics, remote (online) access to networking equipment and even drones. Redundant teams of essential technicians and non-overlapping work shifts were organised to limit risk exposure. Contacts with suppliers and subcontractors were limited. Following are some specific examples.

Deutsche Telekom reported that regular network maintenance and upgrades continued. Within 2 weeks of April alone, they reported to have carried out around 9 000 interference elimination in the fixed network and connected 20 000 households to Fiber to the Home (FTTH). In addition, they provided 100 000 households with vectoring or super vectoring delivering speeds of up to 250 Mbps. 1 700 technical field interventions were reported servicing or troubleshooting mobile rad+io systems. Within a week, they also reported to

have integrated 180 new LTE stations into the network. The state of pandemic had not considerably negatively impacted maintenance of and investments in their network, and in some cases even worked in their interest, for example the closure of schools in Germany allowed them to proceed with installing fiber optics in schools.

As part of its business continuity plan, Orange defined a list of priority activities, including network supervision, essential maintenance operations, technical support and commercial assistance. They reported 130 additional customer operations per day managed by their field teams to increase the speed of their internet connections or at their data centres.

From late January 2020 until 25 March 2020, the telecommunications industry in China mobilised a total number of dispatches for 375 000 communications support personnel and 174 000 communications support vehicles.

Another considerable challenge was the mitigation of delays in shipping essential supplies. A plan is typically available with operators as part of capacity planning to make sure essential equipment is on stock. Whereas transportation itself was not such an issue as with other types of emergencies that cause extensive physical damage and trouble with accessing the affected sites (e.g., a hurricane or a destructive earthquake catastrophe), logistics delays took place during the COVID-19 pandemic as a result of measures taken to limit or even fully stop movements of people and goods across borders in an attempt to limit the spread. Increased border controls and border crossings, ports and airports closing down were paralysing to logistics and transportation, and the countries and operators that depend on imports from other countries were affected more.

According to information provided by Nepal Telecom, for example, increases in internet bandwidth were not possible because of Nepal's dependence on capacities supplied from India, where there was also a shortage, as well as due to expected delays in shipping of the required equipment.

Equipment manufacturing factories closing down, in particular in China, was an additional factor in delays with availability of essential equipment.

South Korean vendor LG Electronics, for example, reported on the effects of the pandemic that caused disruption to its supply chain, which was cited as a factor in the 34 % annual decline in revenue from its mobile business. The smartphone industry sustained an unprecedented decline as a result of the production and supply issues resulting from COVID-19, with worldwide smartphone shipments dropping by 11.7 % year over year in just Q1 of 2020. China sustained the largest regional impact, which caused worldwide implications because of global dependency on China's smartphone supply chain. The 5G industry was also impacted, with 5G deployments in Europe and the Middle East expected to experience delays in 2020 because of supply chain constraints, particularly if involving the Chinese vendors Huawei and ZTE.

Overall, it seems that despite the pandemic, most of the network maintenance and updates continued without much delay. A report from RIPE Labs, based on an analysis of BGP data, which analyses reconfiguration activities (IP prefix announcements, withdrawals, changes in origin), found no visible decreases in the volume of changes on networks in March 2020 compared to earlier months.

3.4.4 Network investments and 5G

Triggered by the pandemic, governments around the world took steps to encourage investments in the telecommunications networks and services, in particular in 5G.

The Chinese government, for instance, urged mobile operators to ramp up 5G investment. The Chilean regulator updated antenna regulations to drive 5G infrastructure deployment by reducing permit approval times. The motivation was in several cases clear also with telecommunications operators themselves. In the United States for example, the interest to invest in 5G fixed-wireless access solutions increased in response to increased demands because of work and schooling from home. The operators Verizon, T-Mobile US and US Cellular confirmed to continue with their 5G deployment plans, whereas AT&T, Verizon and T-Mobile were clearly said to have interests in expanding their business in to 5G FWA. However, with the length and depth of the recession yet to be seen and understood, the long-term network investment outlook has remained uncertain.

3.4.5 Adapting customer care services

Numerous operators around the world responded in support of their subscribers' increased communications demands by releasing data caps and offering discounted or even free allowances, which further stimulated increases in the overall use of communications services.

Taking a closer look at the ways operators supported their subscribers, numerous initiatives and calls for action were issued on the international and the national levels. Operators around the world proceeded with measures such as increasing or removing data caps, offering free unlimited internet service and access to entertainment and educational contents, flexible payment options and the temporary suspension of long-distance and international roaming fees for their subscribers.

In the United States, the Federal Communications Commission (FCC) launched a Keep Americans Connected initiative in response to the need to protect the most vulnerable consumers, which was pledged by more than 700 companies and associations, including AT&T, T-Mobile, Comcast, Verizon and CenturyLink. In Europe, a similar initiative was launched by Telecommunications Industry Ireland, with BT Ireland, EIR, Pure Telecom, Sky Ireland, Tesco Mobile Ireland, Three Ireland, Virgin Media Ireland and Vodafone, and by the British regulator Ofcom in the United Kingdom with O2 UK, Vodafone UK, 3UK, BT/EE, Openreach, Virgin Media, Sky, TalkTalk, Hyperoptic, Gigaclear and KCOM. Another such initiative was launched by the Comisión Nacional de Telecomunicaciones and telecommunications operators in Honduras. Operators in other countries followed suit, for example Vodafone Hungary, Spanish Telefónica, Post Luxembourg, Belgian Proximus, Orange in France, Ukranian Intertelecom, Beeline in Armenia, Kygyzstan and Georgia, Unite and Moldtelecom networks in Moldova. Zain Kuwait, Zain Saudi Arabia, VNPT Group, Viettel and MobiFone in Vietnam, Nepal Telecom, Airtel in India, Guatemalan Tigo, Cuban Telecommunications Enterprise, Chilean Claro, Entel, GTD, Movistar and VTR, and Liquid Telecom and Orange Mali in Africa.

Support measures were also launched by backbone and satellite providers; TOMIA, for instance, an inter-carrier connectivity provider in the United States, offered a number of free roaming services to their existing customers, and NBN in Australia provided a temporary boost to data allowances for Sky Muster satellite customers to support those in remote areas.

Services to reach government and healthcare websites and hotlines were zero-rated, including for example with Tesco, O2, EE and Vodafone in the United Kingdom, and with

Airtel Nigeria in Africa. Consular services were free with many operators as well, for example Megafon, Beeline and Tele2 provided free calls for roaming hotline numbers to help Russian citizens abroad through teleconsultations, and A1 Belarus provided their subscribers with free calls to the 'hotlines' of Belarusian diplomatic missions.

The way customer care services were organised also needed to be adapted, in an attempt to limit personal contacts to prevent the disease from spreading further and to ensure the safety of both the employees and the customers, as well as to cope with the increased volumes of customer care inquiries as a result of increased usage demands.

3.4.6 In-store services move online

Following the implementation of social distancing measures, physical shops adapted in various ways, including shorter working hours, specific protocols within stores of how customers were served and segregating vulnerable customer groups (e.g. the elderly, pregnant women), and in numerous countries even the complete closure of stores for the period when the pandemic was at its worst. These limitations led operators to encourage or set up new customer care services through other channels, in particular in the form of online portals, virtual assistants, virtual rooms, etc.

Most operators in Europe closed their shops following the outbreak of COVID-19. French Orange encouraged customers to make use of customer assistance, subscription management services and purchases through their websites, mobile apps and chat services. They scaled up customer relations resources accordingly, including contact numbers, voice guides, chatbots, call centres and multichannel messaging services. Their customer operations were managing an additional 130 inquires per day in response to increased demands for upgrading internet connection speeds and data centre support. Nearly 3 500 additional business services employees were mobilised to manage critical customer care activities. They also reported on their capacity to transfer and distribute their operational customer support activities to one of their five major service centres around the world if required.

In Sweden, Telenor offered its customers the possibility to book a digital meeting remotely to get help from the store in place of an in-person visit. Deutsche Telekom closed approximately 500 stores in mid March in Germany as well as all stores in the Netherlands and 80 % of shops in the United States. They integrated a voice bot into the voice portal to automatically answer selected inquiries using artificial intelligence. Belgian Proximus encouraged its subscribers to make an appointment in their physical stores or use video chat instead. Vodafone UK, after closing their stores, encouraged its customers to use their mobile application, website resources, helpline and self-help guides instead, as well as a newly set up chatbot. O2 in the United Kingdom used a virtual queue system to manage in-person visits to their stores.

In the United States, Sprint closed 71 % of its stores nationwide and AT&T 40 %, and both operators adopted reduced operating hours for those that remained open. Shaw in Canada closed all its stores and encouraged the use of other service platforms instead, such as the MyShaw App, online chat, Facebook Messenger, Twitter or phone. In New Zealand, Vodafone New Zealand, Spark and 2degrees closed their stores for foot traffic while turning them into no-contact distribution sites aimed at providing essential connectivity gear for their customers, in particular handsets, modems and replacement SIMs. Vodafone Australia closed part of its stores in Sydney, redeployed employees to customer care lines and encouraged its customers to use self-service channels in an attempt to manage increased call volumes and reduced availability of its employees in

Mumbai following measures implemented in India. Telekom Malaysia closed all retail outlets.

In some countries, however, in particular in underserved world regions, the closure of physical shops significantly affected both the operators and the customers. In India, for example, where 90 % of the population uses prepaid accounts, the operators recorded a 35 % decline in balance top-ups due to customers being unable to visit retail stores. To manage this situation, some operators, including Vodafone Idea and Bharti Airtel, extended the validity period and offered additional allowances after India's regulator issued a request to prevent people from visiting the stores. In addition, the three major operators offered customer incentives to recharge the accounts of other subscribers online who might not be proficient with such services (Vodafone's 'Recharge for Good' scheme, Airtel's 'Earn from Home' program, Reliance Jio's JIOPos Lite App). Airtel launched a programme to incentivise micro entrepreneurs with large fleets of workers, such as delivery services and transport companies (e.g. Uber), to provide recharging services for citizens in return for a 4 % margin, thus providing income for such companies as well.

3.4.7 In-house visits

To ensure the safety of personnel and customers, customer care services requiring house visits or visits at the operator's premises were also adapted. Operators took steps to limit physical contact between their employees and customers by replacing house visits with remote diagnostics and encouraging self-install/repair by the users themselves with online/remote support where possible in the form of online instructions and manuals, video guides and live support via voice or video service. For essential house visits that could be preplaced with other forms of support, safety protocols were established. This included, for example, qualifying customer contacts, e.g. by checking if any infected people were on the premises by calling prior to the appointment and again immediately upon arrival, and providing personal protective equipment for technicians and customers (gloves, face masks, hand sanitisers, washing protocols, physical distancing instructions, protective gear and eyewear, etc.).

In the United Kingdom, the Department for Digital, Culture, Media amd Sport issued COVID-19 guidance for telecommunications infrastructure deployment in England, which included guidance for works that have to take place at other people's homes. Norwegian Telenor and the United Kingdom's Virgin Media, Openreach and CommunityFibre, developed protocols for in-house visits of its personnel and subcontractors. These included contacting the customer in advance to agree on the visit protocol, contacting them again a few days before and on the day of the visit to clarify if there were any conditions related to quarantine or isolation that would require postponing the visit. The customer was also required to inform the operator in case an infection was detected with them in the days following the visit. In Belgium, Proximus also adapted their in-house visits accordingly to limit the chance of exposure and respect social distancing when on site.

4. RESPONSE BY AUTHORITIES AND INDUSTRY INITIATIVES

4.1 RESPONSE BY THE NATIONAL TELECOM AUTHORITIES

Across the EU, national telecom security authorities and other national competent authorities cooperated closely with the operators and with crisis centres. Reporting mechanisms were set up from the beginning of the pandemic. Operators and national internet exchanges exchanged information on the evolution of network traffic as the pandemic evolved and on the response of the networks and services to the increased communication needs.

In Austria, the Authority for telecom security (https://www.rtr.at/en) remained in close contact with the operators, with weekly exchanges of information.

In Belgium, the authority for post and telecoms (https://www.bipt.be/operators) set up a daily reporting mechanism on network traffic with the largest operators. Over the following months the frequency was reduced to successively thrice, twice and once a week. Reporting was suspended at the beginning of June. They also coordinated contact between operators and the crisis centre to allow lockdown exceptions, like the opening of telecom shops. Conference calls with the operators proved to be useful.

In Bulgaria, the telecommunications authority (https://crc.bg/en) acted as a coordination centre, supporting the measures of the government and the national crisis centre. They urged the public to use fixed telephony rather than mobile telephony in an effort to reduce mobile traffic, which was severely increased.

In Croatia, the national competent authority for telecoms (https://www.hakom.hr/) provided the relevant state institutions with daily/weekly reports about the status of their networks and the internet traffic situation. Planned upgrades were accelerated (e.g. expansions on intercity capacities; internet upstream interconnection capacity; increase of cell capacity by adding all available spectrum for LTE).The ISPs were well prepared for an increase in data traffic, maximum capacities were not reached and the networks have the capacity to absorb an even bigger increase in traffic.

In Cyprus, the authority for electronic communications (http://www.ocecpr.org.cy/) ensured the frequent exchange of information between the NRA and the operators. The public was informed about teleworking and the basic security measures to be more prepared against phishing emails during the COVID-19 crisis.

In Czechia, the Czech Telecommunication Office (https://www.ctu.eu/) collected monitoring reports of the telecom and the postal services operators. The initial increase in data due to the use of videoconferencing tools was analysed from these reports and there were no problems in public communication nets.

In Denmark, the competent authority (https://www.cybersecurityintelligence.com/centre-for-cyber-security-cfcs-3071.html) handled the situation with a more or less closed down society in close collaboration with the 10–15 most essential providers. They reported on a regular basis in accordance with the guidelines the authority had set out, i.e. about operating status on net and services, special challenges and problems, risks related especially to COVID-19 and any

unusual cyber related activities and incidents. Emergency legislation was put in place, so that the police could carry out DNS-blocking to prevent access to unauthorised homepages.

In France, the competent authority (https://www.ssi.gouv.fr/agence/cybersecurite/ssi-en-france/) took measures to enable them to take down abusive websites more quickly (related to COVID-19 misinformation and scams).

In Germany, according to the NRA (https://www.bundesnetzagentur.de/EN/Home/home_node.html), from week 14 to week 22, the pandemic affected the electronic communications networks to a very small extent only. Despite considerable increases in voice and data traffic in some cases, the networks remained stable.

In Greece, the NRA (www.eett.gr) monitored the situation and regularly collected data from network operators. They reported weekly on the status of internet capacity, regulatory and other measures. Teleconferencing proved to be effective way to establish trust between the NRA and the operators when dealing with crises like the recent pandemic.

The Greek communications security authority (www.adae.gr) disseminated a two-pillar questionnaire to the operators. Providers were asked about potential alterations that occurred in their BCP or in their systems' RTOs, in the contracts with third parties or with their suppliers. They were also asked to audit their internal critical departments and the most critical business processes, and to identify potential alterations. The second pillar of the questionnaire contained technical questions about specific parts of their networks and specific systems that were mostly overloaded either in the core, aggregation or the access part of the network. Finally, the authority performed audits on the new SMS platform that managed all the SMS messages sent during lockdown by Greek citizens to declare their will and reason for leaving their house as well as the authorisation answers sent by the server.

In Hungary, the NRA (http://english.nmhh.hu/) issued a statement that residential users should save internet capacity by using lower resolution video downloads and limiting their internet usage to the minimum necessary. Regardless of these measures the networks were in a very good condition.

In Ireland, ComReg (https://www.comreg.ie/) released additional radio spectrum on a temporary basis to MNOs to mitigate this extra traffic demand (https://www.comreg.ie/industry/radio-spectrum/spectrum-awards/covid-19-temporary-spectrum-management-measures/). Clarifications were made as to who is considered essential worker. ComReg also provided weekly updates to the Department of Communications Climate Action and Environment based on the information provided by operators on their network traffic and capacity for voice and data; weekly industry preparedness team meetings were hosted and attended by all operators, in order to discuss and deal with urgent issues.

In Luxembourg the NRA (https://web.ilr.lu/FR/ILR) received updates from the national internet exchange. There were no congestions. Some problems arose with customer installation and fault management, due to the refusal of customers to let operator field personnel inside their homes.

In Malta, there were two distinct streams of activities carried out by the government and the competent authority (https://www.mca.org.mt/). Before the restrictive period and eventual partial lockdown was in place, the government, through the relevant ministry, requested that providers of ECS provide detailed business continuity plans covering plans to tackle growth in traffic, situations where there could be power losses and/or shortages of fuel supply as well as situations where staff are impaired to travel or quarantined. The authority requested that providers monitor and report on traffic evolution, initially three times a week, down to once

every 2 weeks as the traffic situation quickly become stable. Providers were also requested to alert the NRA of any arising situations that might alter the risk of a security or integrity incident.

In the Netherlands, the radio communications agency (https://www.agentschaptelecom.nl/) was in daily contact with the providers to share information.

In Norway, in the early stages of the pandemic, the competent authority (https://www.nkom.no/) ensured that providers reviewed their contingency plans. Status reports from providers on ongoing incidents, capacity status, availability of critical personnel and equipment were collected. Information on regulatory decisions relevant to the sector was coordinated.

In Poland, the NRA (https://uke.gov.pl/en/) received reports from the 16 largest operators on voice and data load on networks and other phenomena that threatened the security and continuity of services. On the basis of this information, a message was published on the authority's website and Facebook/Twitter profiles that the situation related to quality and continuity of telecommunications services was under control. Individual operators published similar information.

In Romania, ANCOM(https://www.ancom.ro/en/) sent a questionnaire to the most important electronic communication providers regarding traffic evolution and the security measures implemented in the context of COVID-19. Providers had to answer the questionnaire every 2 weeks and significant changes as soon as possible. Based on this information, ANCOM reported to ENISA and BEREC. ANCOM also asked electronic communication providers not to suspend or disconnect their subscribers in case of non-payment of invoices during the state of emergency. ANCOM also had a dialogue with the Ministry of Internal Affairs, highlighting the importance of cooperation between the electronic communication providers and the national crisis cell.

In Serbia, RATEL (https://www.ratel.rs/en/) provided information, advice and recommendations on relevant topics on its official website. The first instructions were released immediately and they concerned the procedure for obtaining lockdown exemption permits for operators' employees in order to be able to carry out essential repairs and maintenance during lockdown. A number of suggestions to users and recommendations for optimal network configuration and connections made from home have also been provided in the media as well as on social media platforms (Facebook and LinkedIn). Responsible use of the internet and warnings about possible misuse were also promoted. The largest EC operators and ISPs updated RATEL daily on their networks and services status, network load, usage, congestion and demands for additional capacity.

In Slovenia, (https://www.akos-rs.si/), the government started the national plan for protection of rescue in the event of a pandemic. Most of bigger telecom providers in the country had pandemic contingency plans in place. Higher demand was solved with additional links and by setting additional base stations and network elements.

In Slovakia, the NRA (https://www.teleoff.gov.sk) established a special pandemic commission, which met regularly in order to promptly solve operational issues related to the pandemic. In accordance with ENISA requirements, a questionnaire was sent to the main telco operators. The NRA also provided recommendations for operators on how to manage their networks during the COVID-19 crisis, in accordance with recommendations from the International Telecommunication Union (ITU) and the European Telecommunications Standards Institute.

In Sweden, PTS (https://www.pts.se/en/) activated its crisis management organisation at an early stage to be able to monitor the situation closely and to be prepared to act if necessary. Telcos made use of their respective pandemic plans (produced during the 'bird-flu' H5N1 in 2009) and updated them. The government clarified which sectors in society should be

prioritised when it came to testing for COVID-19 and childcare (legislation was implemented), so society could still function. PTS analysed and indicated which functions within electronic communications and postal services should be prioritised.

The National Telecommunications Coordination Group (a voluntary forum for cooperation between different telecommunications providers and PTS, with the aim to restore national infrastructure for electronic communications during severe strains or difficulties in society), started to meet in February and have had regular meetings since then. Members of the group have tried to foresee what could happen to electronic communications given different scenarios related to COVID-19 to be able to prepare for different situations and reduce the impact on society.

In Switzerland, the COVID-19 crisis triggered the declaration of the highest national state of emergency. The crisis committee, of which BAKOM (https://www.bakom.admin.ch/) is a member, was called up and met weekly. The state of emergency was relaxed to the second level on 19 June. The overload of telephony at the beginning of the lockdown was quickly solved by increasing the capacity of the affected interconnection links. A mechanism was activated, whereby essential staff of the operators could be exempted from civil protection duty. An emergency decree was prepared intended to limit telecom traffic, e.g. in the event of a severe overload. It was not necessary to enact the decree.

4.2 INDUSTRY INITIATIVES

Numerous cooperative initiatives and joint actions were launched around the world in order to support the industry in its response and to facilitate cooperation and exchange of practices.

Twenty eight trade associations from around the world joined the Information Technology Industry Council's (ITI) call for governments at all levels worldwide to adopt clear and uniform guidance regarding essential ICT workers for the purpose of their business continuity and maintenance operations. The call came when increasing numbers of jurisdictions issued orders restricting individuals' freedom of movement in reaction to COVID-19. ITI specifically addressed the authorities in the United States, Brazil, India and Malaysia where such issues were identified. In Colombia, the Comision de Regulacion de Communicaciones facilitated work with territorial entities to guarantee digital attention and the movement of technical crews so that communication networks could continue to operate during curfews and other measures associated with the pandemic.

However, the implementation of such measures of national levels was not always trivial. In India for example, despite telecommunications networks having been recognised as critical infrastructure, the Cellular Operators Association of India had to intervene with state authorities after operators experienced issues with their technicians being denied access to telecom sites located in COVID-19 hotspots by local authorities, posing a significant threat to the uninterrupted operation of services. German 1&1 Drillisch announced delays in its 5G network build due to issues with permissions to access sites during the ongoing lockdown in the country.

4.2.1 Exchanging good practices

Several platforms were set up to support the monitoring of the COVID-19 situation with networks and internet traffic and to share best practices and measures taken to keep the communications services running.

The WHO published a WHO COVID-19 SMS message library and together with ITU they called on all telecommunications companies worldwide to support the delivery of these messages in communication with the general public via SMS and voice messages.

During COVID-19, the European Emergency Number Association data and strategies per country on emergency calls and public warning during COVID-19 outbreak was tracking the use of Public Warning Systems (PWS) in Europe and comprehensive reports per country were provided.

ITU launched the Global Network Resiliency Platform (#REG4COVID), where regulators, policymakers and other interested stakeholders were able to share information, view what initiatives and measures have been introduced around the world, and discuss and exchange experiences, ongoing initiatives and innovative policy and regulatory measures designed in response to COVID-19.

The Broadband Commission for Sustainable Development, the UN's high-level public–private partnership, released the Agenda for Action, with the intention to bring together intergovernmental, regional, national, industry, civil society and technical and academic communities to shape strategies around three main pillars of resilient connectivity, affordable access and safe use of online services for informed and educated societies, in order to mitigate the impact of the COVID-19 pandemic, ease its immediate adverse impacts and contribute to long-term development for better preparedness and resilience.

As part of the RIPE hackathon on the health of the internet during the COVID-19 crisis, an experimental interface was developed from the RIPE Atlas database, the RIPE Atlas dashboard: Network delays during national lockdowns on the health of the internet to monitor and study congestion that could occur at large eyeball networks during mass quarantines.

ITU released new guidelines for countries to develop national emergency telecommunications plans to keep networks online during national emergencies. Contingency planning also includes specific elements relevant to COVID-19.

NCTA members in the United States and other providers joined to report key metrics during the pandemic in an online dashboard: COVID-19: How cable's internet networks are performing.

In the Caribbean, a COVID-19 taskforce was launched, consisting of telecom operators and industry experts, to engage governments and regulators and share best practices during the pandemic.

The Digital development joint action plan and call for action, initiated by the World Bank, ITU, GSMA and the World Economic Forum, provided a set of guidelines for regulators and decision-makers on a number of ICT-enabled pandemic response objectives.

In 2018, the Broadband Commission published a report on epidemic preparedness: Preventing the spread of epidemics using ICT, extensively elaborating on the use of ICT and mobile networks in particular for pandemic response. This report provides numerous examples from past incidents, such as the Ebola and Zika outbreaks, as well as useful resources on the use of text messaging services for epidemic information and infection management, for example SMS messages sent to at-risk travellers, and the use of mobile data for pandemic tracking and prediction. It also provided guidelines and examples on the use of various mobile technologies for sharing vital information with the public, such as IVR, SMS and USSD, as well as, for example, suggested messaging content, user journeys and messaging frequency.

Ookla set up interactive dashboards with per-country insights into their data to monitor the impact of COVID-19 on the performance and quality of global mobile and broadband internet networks.

The European Commission and BEREC, with the support of NRAs, set up a reporting mechanism to monitor internet traffic in the EU Member States.

4.2.2 Adaptation of streaming quality and scheduling of popular releases

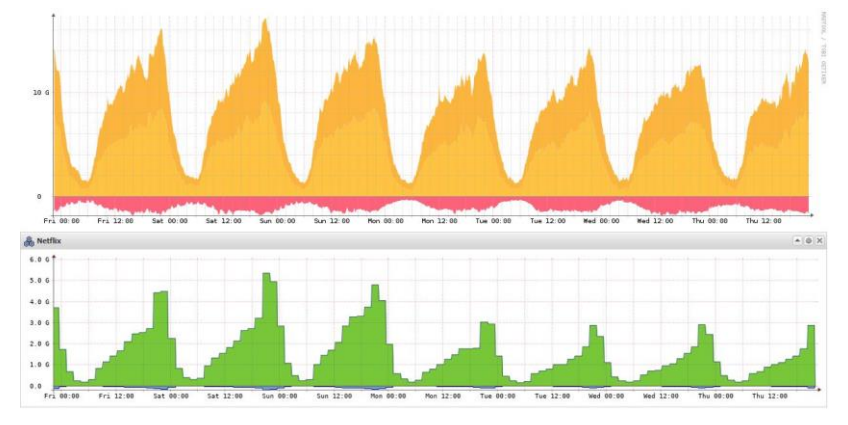
To manage the increased demand in communications, cooperation within the industry as well as with the end users was essential, and at the same time a cost-efficient measure, in particular to promote responsibility with regards to how the content was served during the pandemic.

The telecommunications industry reached out to content providers with agreements on reducing the bitrates for specific types of content to preserve the operation of vital communications services, and to agree on careful scheduling of downloads of popular new content, such as gaming updates.

In March 2020, the European Broadcasting Union prepared a strategy for adapting streaming quality during the crisis. Among other provisions, the strategy provided guidance on the adaptation of streaming services in respect of network congestion issues through streaming bitrate reduction, in particular during office hours, and arranging adaptive streaming manifests for premium quality to fixed large screen devices over mobile devices. Some reports speculate that without the OTT video streaming service providers shifting to standard definition, networks in many regions of the world would have seen the percentage of the overall traffic volume reach as high as 70 % and the quality of service would have been severely affected on many networks, especially during evening peak hours.

In Europe, the strain on communications networks was considerably relieved following a call by the EU's Commissioner for Internal Market, Thierry Breton, to major streaming content providers, including Netflix, YouTube, Amazon and Disney, to take action in reducing the bitrates and switching to standard definition in response to increased connectivity demands resulting from social distancing measures. Netflix for example, reduced their bitrates across all streams in Europe, thus reducing its traffic on European networks by 25 %. They did not restrict higher resolutions; instead, they readjusted and changed encoding for the existing qualities.

Figure 10: The effect of Netflix reducing their bitrates on the volume of traffic observed in the Netherlands (*Source:* SKV)



Following Europe, similar measures were also implemented in other world regions and with other content providers. Akami, for example, cooperated with Microsoft and Sony to agree on dynamic rescheduling for downloads of new gaming updates to off-peak times. Sony, Ubisoft and Xbox limited their internet footprints. In Colombia, the ICT ministry requested that internet platforms offer services in standard definition as opposed to more data intensive higher definitions that could overload already stressed networks.

4.2.3 Promoting responsible use of network resources

Once networks experienced spikes in the volume of traffic and congestions, numerous telecommunications operators and regulators also reached out to their customers asking them to use the resources responsibly. From past emergency experience, this is one of the most cost-effective measures to be taken in managing network overloads during high consumption demands.

The United Kingdom's Ofcom, in cooperation with the biggest telcos including BT, Sky, O2, Vodafone and Virgin Media, launched a Stay Connected campaign and provided guidelines to its subscribers on how to adapt their usage to help keep the network operational. Telefónica's Movistar, Orange, Vodafone, Masmovil and Euskaltel in Spain, as well as regulators such as the United States' FCC took similar measures in an attempt to raise awareness with the end users. In Italy, a joint letter was issued by the country's fixed and mobile operators in March 2020 urging consumers to take a number of measures to keep network bandwidth available for critical services and teleworking. The operators suggested delaying video streaming and gaming to outside of peak working hours, using landlines rather than mobile services for voice calls, avoiding video in work collaboration tools and avoiding massive emails with sizeable attachments.

In Nepal, ISPAN, NTA and Nepali Telecom issued a request to people to use the internet responsibly and avoid binge watching and gaming, and also to not change their internet settings because of limited possibilities to provide assistance through at-home visits. Similar guidelines were provided by numerous other operators and organisations around the world, including the Secretariat of the Inter-American Telecommunication Commission, the Communications Regulatory Authority of the Republic of Lithuania , the Mexican Ministry of Communications and Transportation in coordination with other federal government institutions, the Communications Regulatory Agency of Bosnia and Herzegovina, CenturyLink, OGERO in Lebanon, French ARCEP and Greece's Ministry of Digital Governance. The importance of governments promoting smart and responsible use of network resources by the general public during times of crisis was also emphasised by numerous other national and international organisations, including for example the World Economic Forum, NCTA and Cablelabs.

4.2.4 Management of spectrum resources

The NRAs worldwide handled demand for additional spectrum resources.

In addition to providing access to additional spectrum capacities, regulators in numerous countries, including Malaysia, Argentina, Canada, Romania, Kenya, Yemen and Mauritius, have delayed or even partially waived payments of spectrum fees, thus supporting additional investments into providing sufficient connectivity capacities. In April 2020, for example, the Ministry of Internal Affairs and Communications of Japan deferred the collection of payments for spectrum user fees in areas where emergency measures were to be taken due to the spread of the COVID-19 pandemic.

Demands for additional spectrum resources were particularly high in the United States, where the FCC granted special temporary authority to multiple wireless carriers in coverage (600–700 MHz) and capacity (1.7–2.2 GHz) bands, including to operators AT&T, Sprint, T-Mobile, US Cellular, Verizon, and several service providers in rural communities. This constituted granting special temporary authorities either on a secondary non-interference basis for operating in spectrum licensed to other operators, or for spectrum bands that are not licensed. For example, on 17 March 2020 the FCC approved a move by US Cellular to access AWS-3 spectrum held by Advantage Spectrum for a period of 60 days to boost capacity in parts of California, Oregon, Washington and Wisconsin, and on 16 March 2020 cleared T-Mobile US to use the additional 600 MHz of spectrum licensed to several broadcast companies, including Dish Network, Comcast, NewLevel, LB License Co, Channel 51, Omega, Bluewater and TStar License Holdings, to allow the operator to respond to increased usage demands. AT&T secured new access to AWS-4 and 700 MHz spectrum, including in Puerto Rico and the US Virgin Islands. Bluegrass Cellular was granted access to AWS-1 spectrum in Kentucky and Union Wireless in Wyoming. On 27 March 2020 temporary spectrum access was granted to 33 wireless internet service providers serving 330 counties in 29 states to help support rural communities facing an increase in broadband needs during the pandemic and for telework, remote learning and telehealth in particular.

In Europe, similar demands were reported in Ireland, where the regulator ComReg released additional spectrum capacities in the 700 MHz and 2.6 GHz spectrum bands available for temporary licensing at low costs, with changed conditions for 2.1 GHz to ensure it can be used for 4G connectivity. Regulators and operators in the United Kingdom, France and Italy, on the other hand, reported that the available spectrum was sufficient and no requests for additional capacities were made.

In the Middle East, Jordan released available spectrum on a short-term basis to MNOs in capacity bands, sub-1 GHz and fixed wireless access, followed by similar measures in Saudi Arabia for capacity bands and sub-1 GHz (an additional 40 MHz in the 700 MHz and 800 MHz bands). Oman's regulator TRA has temporarily allocated additional spectrum in the 1.8 GHz and 2.1 GHz bands for free, proceeded with allowing licensees to activate wireless broadband service through WFBB-LTE-FDD using the 4G frequencies, and encouraged operation of the national roaming facility. In the United Arab Emirates, the national regulator extended the validity of all wireless permits to hospitals and medical centres as well as provided a package of wireless frequency as backup to support the Health sector's wireless communication systems.

In South America, Panama's NRA announced granting of temporary spectrum licenses to MNOs upon request and similar actions have also been announced in Brazil. The Secretariat of the Inter-American Telecommunication Commission, took a number of actions to encourage the expansion of internet coverage and other telecommunications services, especially in areas that do not have access, including agile granting of permits for temporary use of spectrum and for the deployment of infrastructure in order to expand network coverage. National Authority of Public Services in Panama authorised free access for 90 days to an additional 30 MHz band of the AWS band to all mobile operators, thus making available in total an additional 120 MHz of spectrum.

In Africa, the African Telecommunications Union issued a set of guidelines to governments in order to make the necessary spectrum available for different types of services as well as availability of different combinations of spectrum bands free of charge for emergency communications to support rapid deployment of terrestrial and satellite systems with limited interference. In Ghana, Vodafone and MTN were granted free access to additional spectrum bands for capacity augmentation. Tunisia made all IMT spectrum tech-neutral on a short-term basis while South Africa's regulator ICASA granted temporary access to spectrum bands in the 700 MHz, 800 MHz, 2.3 GHz, 2.6 GHz and 3.5 GHz bands. Additional spectrum was made

available to mobile operators by the Communications Authority of Kenya. In Sudan, NRAs have granted additional radio frequency spectrum free of charge to Zain on a temporary basis. Kenya fast-tracked approval of Alphabet's Loon project to expedite the commercial deployment of internet-enabled balloons in partnership with Telkom Kenya, delivering 4G coverage to remote, previously unserved communities. Agência Reguladora Multissetorial da Economía of the African Cape Verde proceeded with allocating additional spectrum to mobile operators and also implemented technological neutrality of the 900 MHz band for the operators to reinforce 2G, 3G and 4G networks.

In Malaysia, the regulator granted Telekom Malaysia early access to 700 MHz and 3.5 GHz on a trial basis to support 5G operation in COVID-19 quarantine hotspots, followed by awarding operators Telekom Malaysia, Celcom Axiata, and units from Maxis and DiGi.Com access to the 700 MHz band of 5G network on 15 May 2020.

New Zealand completed direct allocation of spectrum in the 3.5 GHz band for an interim period until November 2022, with Spark and 2degrees gaining rights to 60 MHz and Dense Air 40 MHz. The move followed postponement of the 5G spectrum auction in an attempt to boost 5G rollout throughout 2020 in response to the pandemic.

5. CONCLUSIONS AND LESSONS LEARNED

The experiences collected so far have shown that the emergency caused by the pandemic lasted for a much longer period of time compared to any other crisis. The operators were forced to address many security and resilience challenges through established business continuity management practices as well as a good measure of flexibility and creativity.

The exact situation and lessons learned were unique with practically each country and operator. Larger negative effects appeared more often in fragile and conflict-affected countries and regions, although there were exceptions in more stable and higher-income countries as well.

The most interesting lessons learned as described in Sections 2, 3 and 4 are gathered as follows.

5.1 LESSONS LEARNED FOR OPERATORS

1. Telecommunications operators should support emergency services.
   There should be support plans established for frontline professionals involved in the crisis response activities, and measures to ensure sufficient communications capacities and coverage to support emergency response services in staying connected and being able to communicate smoothly. The measures could include coverage in hotspot zones and in locations where critical response infrastructures are located permanently (e.g. hospitals) or deployed temporarily.

2. Cooperative initiatives to support the monitoring of the situation and the sharing of best practices are necessary. Continuous cooperation within the industry is essential in addressing the challenges as they emerge.

3. The crisis plans of the operators and the related decision-making processes should stay flexible and adapt dynamically through time as the crisis evolves. It is important to set up committees and boards with sufficient know-how to guide the decision-making process.

4. There is need for subscriber support during all stages of a crisis.
   - Alleviating measures could include increasing or removing data caps, offering free unlimited internet service and access to entertainment and educational contents, flexible payment options and temporary suspension of long-distance and international roaming.
   - Setting up new customer care services, mostly in the form of online portals, virtual assistants and virtual rooms is essential for enhanced customer support during crisis. House visits should be replaced, where possible, with remote diagnostics and encouraging self-install/repair by the users themselves with online/remote support where possible in the form of online instructions and manuals, video guides as well as live support via voice or video service. For essential house visits, safety protocols should be established.

5. The management of exceptionally high demands as a result of the pandemic calls for reconfigurations of existing network equipment and placement of additional network equipment, securing of additional spectrum resources, resource sharing between

operators, applying for access to backhaul spectrum, as well as emergency deployments, including using new technologies.
Interesting practices include capacity increases, implementation of call gaping, codec reconfigurations resulting in voice quality reduction, time limits, direct retry, dynamic quality and data consumption balancing, configuration of traffic prioritisation to support emergency communications and essential services.

6. Using remote and unmanned monitoring, surveillance of the infrastructure and diagnostics, e.g. remote access to networking equipment and even drones, limits the exposure of essential personnel of the operators. Redundant teams of essential technicians and non-overlapping work shifts should be organised to limit risk exposure, and contacts with suppliers and subcontractors limited.

5.2 LESSONS LEARNED FOR AUTHORITIES

1. Responsible use of telecommunications resources with regards to how the content is served and consumed during the emergency should be promoted through awareness-raising initiatives.
   Guidelines can include both general things users can do to keep spikes in traffic load smaller as well as measures they can take themselves in case they experience interruptions or degraded service quality. Some examples include:
   - ✓ using fixed or Wi-Fi telephony, or over-the-top apps, instead of mobile voice services if interruptions start to occur;
   - ✓ prioritising traffic for important use, such as access to information, remote work and education, and rescheduling consumption of non-essential services such as streamed video entertainment and online games to off-peak hours;
   - ✓ applying settings that reduce data consumption, including the use of Wi-Fi or lower resolution for content, avoiding sending large files, such as videos and presentations, and using e.g. cloud sharing services instead or compressing the contents;
   - ✓ choosing online collaborative work tools instead of video conference calls.

2. Agreements should be reached for reducing the bitrates for specific types of content to preserve the operation of vital communications services and for careful scheduling of downloads of popular new content, such as gaming updates.

3. Cooperation with the competent authorities and supervising ministries, policy alignment and fast and flexible responses of the regulatory initiatives are essential. There is a need for fast awarding of licenses and management of license fees under emergency conditions. Temporary release of additional radio spectrum and increase of interconnection voice circuits among operators are some interesting initiatives on behalf of the states.

4. Information to do with the handling of crisis has to be disseminated in a timely way to key stakeholders, so that they can successfully adjust and apply their business continuity plans.

5. Declaring the telecommunications services as an essential service is necessary for granting the operators travel and access permissions during potential lockdowns, or for keeping the telecommunication stores open.

6. Reporting mechanisms should be set up for the competent authorities to gather information on the evolution of network traffic and on the response of the networks and services in the increased communication needs.

7. Underserved communities become even more vulnerable in crises times. Therefore, network capacity and coverage should be enhanced in rural areas, and investments and innovation should be encouraged.

5.3 CONCLUSIONS

Overall we can draw the following conclusions:

- The general take away from the pandemic so far is that the services and the networks have been resilient during the crisis, despite major changes in usage and traffic.
- Overall the business continuity plans of operators worked well. Business continuity has always been an important point of focus for the sector.
- There has been good collaboration between providers and national authorities, not only at the beginning of the pandemic but also in the later stages.
- The perception of consumers has changed: Electronic communications are now considered a lifeline for citizens and key enablers for the economy and society.

TP-02-20-882-EN-N

ABOUT ENISA

The European Union Agency for Cybersecurity (ENISA) is the Union's agency dedicated to achieving a high common level of cybersecurity across Europe. Established in 2004 and strengthened by the EU Cybersecurity Act, the European Union Agency for Cybersecurity contributes to EU cyber policy, enhances the trustworthiness of ICT products, services and processes with cybersecurity certification schemes, cooperates with Member States and EU bodies, and helps Europe prepare for the cyber challenges of tomorrow. Through knowledge sharing, capacity building and awareness raising, the Agency works together with its key stakeholders to strengthen trust in the connected economy, to boost resilience of the Union's infrastructure, and, ultimately, to keep Europe's society and citizens digitally secure. For more information, visit www.enisa.europa.eu

ENISA
European Union Agency for Cybersecurity

Athens Office
1 Vasilissis Sofias Str
151 24 Marousi, Attiki, Greece

Heraklion office
95 Nikolaou Plastira
700 13 Vassilika Vouton, Heraklion, Greece

enisa.europa.eu

ISBN: 978-92-9204-406-0

DOI: 10.2824/239478