DATA TRAFFIC MANAGEMENT CHALLENGES DURING COVID-19

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Abstract

The extensive rapid growth of the mobile data traffic in the last decade is expected to continue in the future in similar or higher rates. As a result, the mobile network operators have been facing the challenges of serving to the high demand by upgrading their current network architectures.

On top of that an extraordinary situation occurred during COVID-19 situation. The data traffic enormously increased in few weeks, the traffic pattern drastically changes imposing some immediate measures and actions from all stakeholders, telecom network operators, content providers, regulators policymakers etc.

In this article, we will present the impact of COVID -19 globally and focused in Albanian case as well as on some of the solutions on traffic successful data traffic handling such as WiFI off-loading and LTE-U implementation or expansion of spectrum allocation.

A comparison within the several methods is presented, with regard to their deployment requirements, performance and feasibility.

Key words: *traffic management, mobile data, WiFi offload, LTE-U, spectrum*

1. INTRODUCTION

The extensive growth of mobile data traffic has been the scope of many recent studies, which predict its continuity in higher unimaginable levels. This situation is defined by CISCO and many mobile network operators as a "Mobile Data Apocalypse", or "Mobile Data Explosion". According to their forecasts [1], in 2020 monthly global mobile data traffic was forecasted to be 30.6 exabytes, while its Compound Annual Growth Rate (CAGR) between 2015 and 2020 has been estimated to be as 54%. Furthermore, on 2020 it was expected that average mobile network connection speed will be 6.5 megabits per second, compared to 2 megabits per second in 2015. The later CISCO reports [2] forecast that globally, mobile data traffic will grow 7-fold from 2017 to 2022, a compound annual growth rate of 46%. This exponential growth of traffic is motivated by many factors, from which the most important is definitely technological development of mobile networks.

In parallel to this, mobile applications have had an extensive deployment to many domains of our daily life. We do not use mobiles nowadays just for the traditional communication of voice calls or short messages, but also for education, business, banking, health or entertainment purposes. In addition, one of the most trending projects on mobile operators' focus are nowadays M2M communications. In a near future, our home appliances, cars and many other devices will be connected in the so-called Internet of Things (Internet of Everything), which will bring additional data traffic to mobile networks.

Considering this evaluation of the current situation, which also indicates the future of our networks, mobile operators are faced with the challenge of increasing their capacities through novel architectures, which will be more and more required to handle the voluminous data traffic. Data traffic management in mobile networks is one of the most important activities in order to cope with high demand of this new trend in communications. It is not in the interest of operators to transfer large files through their network because these files cause longer occupancy of resources and heavier traffic. Thus, it might be considered a possible balance of the data traffic between operators' current licensed spectrum in which the network traditionally operates with the open unlicensed spectrum. This idea would consist on using the current cellular network for transmitting only the user requests for specific type of data content (i.e., large files as AVI videos) and some delay tolerant techniques for making the

delivery of this content to the end user. This strategy would bring many benefits to mobile operators because there would be less data traffic on their networks and there might also be provided a better quality and less latency on data delivery.

Nevertheless the mobile data forecasts in CISCO reports do not consider the COVID-19 situation and dramatically changes in traffic due to pandemic situation in different levels and category of users. A great number of countries were lockdown due to COVID-19. At this crucial time, telecom network operators are facing a drastic increase demand for data communication due to a number of changes in daily life of citizens, doing business online, emergency health services, government and regulatory decisions etc. They are addressing how to strengthen digital infrastructure to enable and facilitate business continuity.

In this article, we will present the impact of COVID -19 globally and focused in Albanian case as well as on some of the solutions on traffic successful data traffic handling such as WiFi off-loading and LTE-U implementation or expansion of spectrum allocation. The reactions from different stakeholders and regulatory measures on data traffic management during COVID-19 are also part of this article.

2. DATA TRAFFIC - THE IMPACT OF COVID-19

At the beginning of March 2020, different countries in Europe imposed lockdowns to contain the pandemic. During this period, Internet access proved to be vital for modern society and critical for connectivity when physical movement was limited. Internet communications also became more important when business meetings and business travelling were replaced with virtual meetings to maintain economic activities [3].

According to AKEP [4], during March in some countries such as in UK, France Italy people stuck in their homes are using the internet much more. Visits to web sites increased up to 60%. A similar pattern is in United States. Internet traffic increased 40% after a national emergency declared due to COVID-19. In UK due to network congestion on 17th of March 2020 the networks of five mobile operators were blocked for about five hours leaving their subscribers without telephone and internet access.

Referring to “Coronavirus impact on Internet use” [5], Internet speeds to Amazon and Facebook have fallen by over 50% only few days after lockdown due to COVID-19. In Germany internet speed has decreased by 26% on March 2020. There has been a 5.3% decrease in internet speed in Europe. The situation was improved later once providers took measures to boost speeds. The daily Google searches reached an unprecedented growth between 11th of March to 18th of March 2020 with almost 100 times more searches.

Internet traffic grew 36% in Spain after lockdown. In Albania the Internet speed decreased by 18% while the total traffic in Internet is increased fast, 47.3% more during first quarter of 2020. The mobile data traffic during first quarter of 2020 was 20 million Gbyte. The 47% more compared to the end of 2019. The biggest operator in the market Vodafone Albania declared 90% growth of traffic after lockdown due to COVID-19.

3. USER BEHAVIOR DURING COVID-19

The user behavior changed during COVID-19. From normal daily activity to a new way of working from home, virtual meetings, spending more time on Netflix, games etc. In addition the online daily activity was distributed during all the day.

The time of usage of Internet access devices such as smartphone/mobile phones, laptops, PC/desktops also increased during COVID-19. Results of survey of GlobalWebIndex done during 16-20 March 2020 [6] with 2234 baby Boomers, 6124 Gen X, 3681 Millennial and 806 Gen Z, notices that the time spent with mobile phones increased from 43% to 82% as it is given in the figure below. The usage of other access devices such as laptops and PC/desktop also increased.

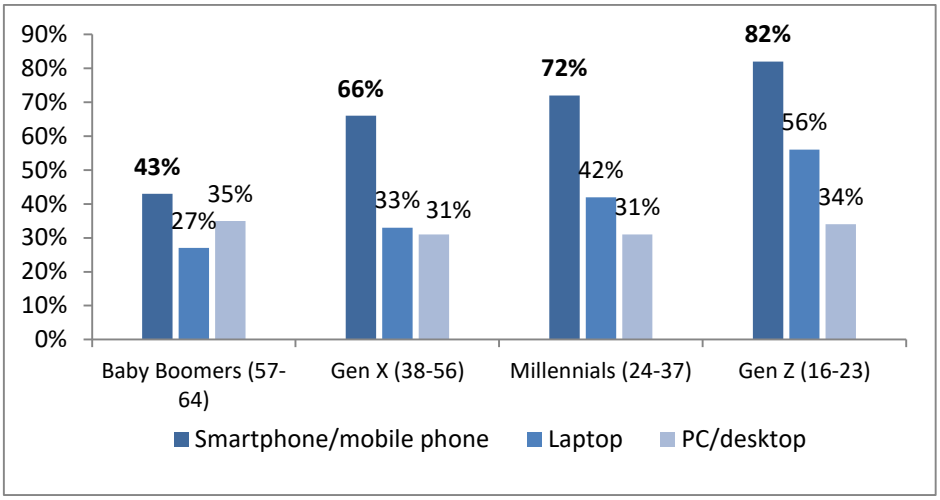

Figure 1. The increase of usage of access devices

Source: Author, based on survey of GlobalWebIndex 16-20 March 2020

This user behavior and high demand for connectivity changes the traffic shape. The time of day for normal users, or the working day for the employees during the lockdown is different. The normal hours of peak traffic are now distributed during all the day. According to [6] Vodafone peak mobile usage in the UK used to be 6 p.m. to 8 p.m., now it's noon till 9 p.m. Also in the U.K., BT saw its broadband daytime data traffic go up by 60%, although that's still only half the average evening peak usage. In the Joint Action Plan as response to COVID-19 crisis, published by the World Bank [7], notices that our high dependency on digital infrastructure and increased reliance on secure online services have never been greater.

4. INTERNET USAGE AND MOBILE DATA TRAFFIC, THE CASE OF ALBANIA

In Albania, the telecommunication market has been fully open for competition since 2008. There is a great number of Internet Service Providers (ISPs) in the market offering broadband connections based on fixed networks. Triple/quarter play services voice, Internet, TV have been provided for many years. The Internet users and fixed broadband subscriptions in Albania are increasing in average by 10-15% yearly. By the end of 2019, the total number of fixed broadband subscriptions was 436000, which is an increase of 20% compared to the previous year. Albania has experienced rapid increase of broadband penetration from fixed networks during last years. The 2019 data show an increase on both indicators, the household coverage/penetration rate which is about 60% and the population coverage/penetration rate per individual which is at 15.2%. Although the number of broadband subscribers is steadily increasing, penetration rates are lower than in EU and countries in the region. The digital divide between urban and rural areas for fixed network is present. The majority of Internet users are based on mobile networks.

There are three mobile operators in the market. Mobile broadband is provided widely, based on Long-Term Evolution (LTE) /3G-4G. Total number of mobile network users who have used broadband Internet access at least once during 2019 was about 2.4 million. Mobile broadband penetration is 62% by the end of 2019. The growth of broadband access based on UMTS/LTE especially after 2015, associated with the great number of mobile applications and the increased penetration of smart devices is closely linked with mobile data traffic growth. The figures published yearly from Albanian regulatory body (AKEP), for electronic communication market gives that the average use of data in a month per user was increased over 20 times during last decade. By the end of 2019 the monthly consumption of user reached 3.4GBs/month which is comparable with some European countries. The situation with voice communication is not the same. In average the outgoing calls in minutes is more

or less the same during last years. The figure below gives the evolution of monthly data traffic per user in mobile networks compared with outgoing calls in minutes.

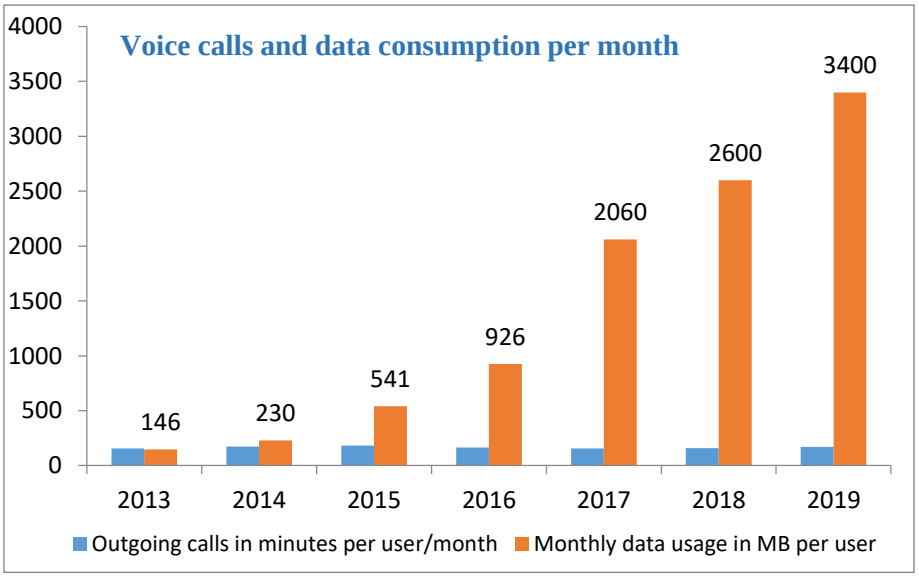

Figure 2. Voice calls and data monthly use in mobile in Albania

Source: Author based on AKEP annual reports

Besides this trend of fast growth of mobile data traffic which is in line with global and regional developments, during COVID-19, the Internet traffic and mobile data traffic was increased faster. Albania was lockdown due to COVID-19, on 9th of March 2020. The public schools were closed, a great number of business, public institutions continue the work from home for more than one month. The online learning was applied in all levels of schools. The usage of online platforms increased fast. Furthermore a great number of e-services provided especially to address the necessities during COVID-19. The graph below gives the increase of internet traffic after the lockdown on 9th of March 2020.

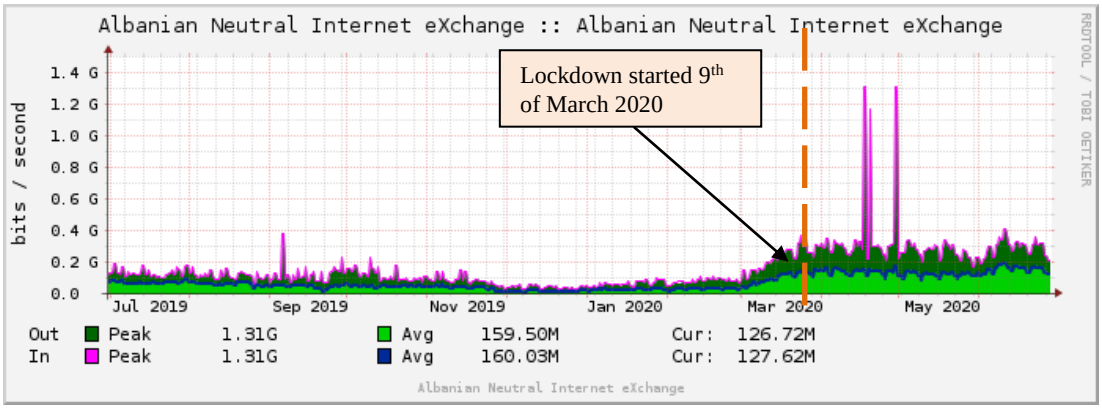

Figure 3. Internet traffic based on Albanian Neutral Internet eXchange

Based on AKEP data, during COVID-19, the Internet traffic and mobile data traffic was increased in similar way with other countries in Europe. The total traffic in Internet is increased fast 47.3% more during first quarter of 2020. The mobile data traffic during first quarter of 2020 was 20 million

Gbytes. The 47% more compared with end of 2019. The biggest operator in the market Vodafone Albania declared 90% growth of traffic after lockdown.

Furthermore, a survey during March-April 2020 [8] regarding to the ICT usage from SMEs during Covid-19 gives the following results:

- 75% of enterprises declare that have use online services during COVID-19
- 81% of them declare that they will continue to use online services in the future. This trend is for all economic activities.

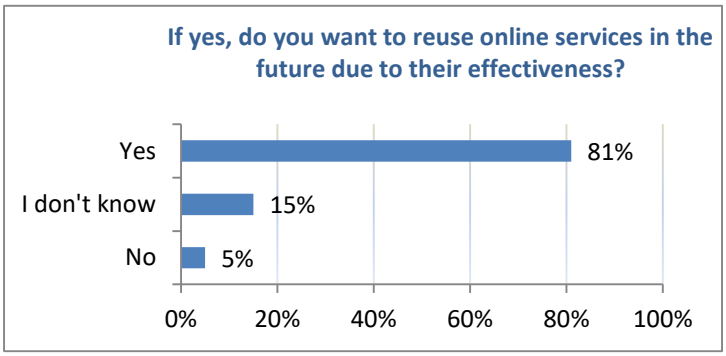

Figure 4. The usage of ICT from SMEs, Source: Survey findings [8]

Furthermore 38% of enterprisers will change their investment plans towards online services, particularly those acting in services provision. Regarding the investments, 51% of the enterprisers declare that they will invest in new technology and risk management. This is an indicator that besides the changes during the COVID-19 the SME are considering to use more

This overload of traffic impacted the speed of Internet. Tech4i2 data [5], illustrated that the internet slowed down by 5%-7% across Europe due to overload from the lockdown in most countries. Albania was one of the cases with the worst performance where the internet speed was reduces by 18% as it is given in the figure below.

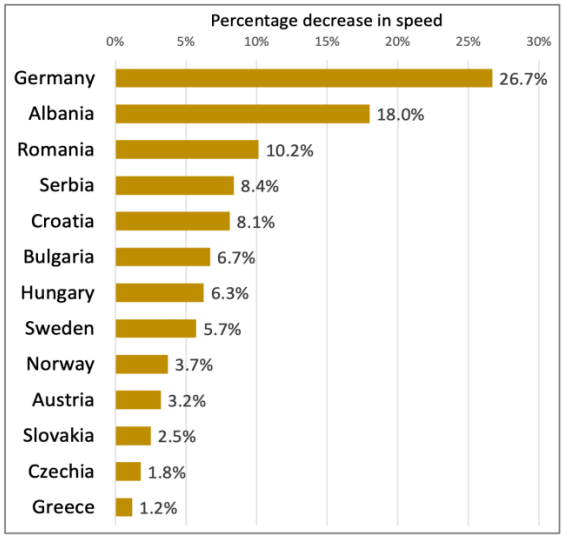

Figure 5. Percentage of Internet speed decrease

Source: "Coronavirus impact on Internet use" [5]

Normally, the explosive growth of data communication asks for more investments in CAPEX in infrastructure and other aspects related [9], in addition of other measures appropriate data traffic management might be one of the solutions in critical situations.

5. THE IMPORTANCE OF DATA TRAFFIC MANAGEMENT

Challenges of the mobile data traffic and traffic management have been considered in a number of studies during the years. Referring to [9], a summary of different techniques used from operators to manage traffic (ITU, 2013) are summarized below:

- Best efforts: No traffic management by provider, no changing for tiered QoS;
- Traffic management only applied during periods of high congestion;
- Priority always given to most vulnerable types of services e.g. voice, video, streaming, games;
- Throttling/degrading of some types of traffic e.g. P2P;
- Priority given to some service providers content or applications over other;
- Blocking rival‘s content or applications e.g rival IPTV service;

Impact of COVID-19 in telecom networks shows for high congestion, lower QoS and reduction of Internet speed, and sometimes blocked the networks as it was mentioned above. In this situation appropriate traffic management solution need to be applied. In the sections below the article will present different solutions considered to cope with high data traffic in mobile networks.

6. GENERAL SOLUTIONS FOR OFFLOADING

In this section, some general offloading solutions implemented by operators are presented. These solutions are based on femtocells for indoor offloading and Wi-Fi and for outdoor. During COVID-19, because people are at home, more mobile devices are connecting over Wi-Fi, so the Wi-Fi indoor offloading is important, while Wi-Fi outdoor offloading remain important in special locations such as near hospitals.

Wi-Fi for indoor Offloading - Femtocells are small cells, deployed by access points placed indoor, which operate in low power and are designed for residential or business environments. This strategy of deploying smaller cells was firstly presented for achieving an improvement on voice and data services in indoor areas. Since some users will switch from macro-cells to femtocells, the total traffic on main Base Stations will be reduced and lower interference level is introduced. The main advantage of this strategy consists on the fact that femtocells do not require any specific hardware implementation because they operate on the same traditional licensed spectrum. On the other hand, short range base stations need to be installed.

Wi-Fi for Outdoor Offloading - Wi-Fi is a ubiquitous technology in urban areas, deployed by operators or users in small residential areas. Wi-Fi networks operate in the unlicensed spectrum and this way they cause no interference to 3G/LTE cellular networks. This is a main advantage of using Wi-Fi technology for offloading purposes. MADnet architecture proposes a metropolitan Wi-Fi network used for offloading. Due to in COVID-19 situation the main users are lockdown the article is not consider further the Wi-Fi for outdoor offloading.

LTE-U: Extending LTE Advanced to Unlicensed Spectrum

In this section an overview of LTE-U is presented, the benefits it brings to the LTE cellular networks in handling data traffic. LTE-U is a radio access technology, proposed for providing carrier-grade wireless service in the 5 GHz unlicensed band [11]. It is based on carrier aggregation as LTE Advanced, but the aggregation in LTE-U is made between a carrier in the licensed spectrum and another one in the unlicensed spectrum. The system will work as a unified system of both bands: core network will remain the same. What operators tend to implement today for handling always-growing

data traffic is mainly based on two main ideas: increasing the number of small indoor cells and making an efficient usage of traditional spectrum as well exceeding its limits seeking for more capacity.

LTE-U takes into consideration both this ideas as it also takes advantage from the large number of small cells planned to be deployed by operators. LTE-U may be considered a simple idea with great benefits, as its main benefits consist on offering a better link performance, providing mobility management and an excellent coverage. However, speaking about unlicensed spectrum, it is the traditional spectrum for implementing legacy wireless technologies like Wi-Fi. This way, a deep evaluation of interference scenarios between LTE-U and Wi-Fi should be considered before deployment of this new strategy.

This section continues with the benefits of LTE-U in a user's and operators' perspective, and with an evaluation of interference in different settings of co-existence mechanisms used.

LTE-U Benefits - The most important benefit of LTE-U from operator's perspective is the fact that LTE-U systems work as unified systems. Operator will have to manage the same Core Network and small cells for both spectrums. Moreover, the same authentication mechanisms are implemented and the same operating systems are used. Unified network will enable operators to manage their system through a cost-effective and simple process. To deploy LTE-U systems, operators may choose between two main deployment options. First option, called Supplemental Downlink (SDL), uses unlicensed spectrum only for downlink purposes. A carrier from unlicensed band is aggregated with another form the licensed band, creating an "aggregated fatter data pipe" [11], as shown in Figure 6. Uplink remains the same. Considering the fact that usually largest mobile data traffic is caused in download requests, this strategy provides an improvement of performance in heavy downlink traffic scenarios. In the second option, both downlink and uplink take advantage from unlicensed spectrum. The system would profit from the flexibility of choosing resources for uplink/downlink by adjusting channel assignment when needed.

Users will experience an enhanced performance when LTE-U is implemented. First, the wider data pipe created after aggregation provides higher capacities. Furthermore, performance reached by this system is stable and reliable. This reliability comes from the fact that LTE-U has an "anchor" in the licensed (traditional) band. Unlicensed carriers are used only for data traffic (downlink or both downlink/uplink), while signaling is always done in licensed spectrum. This means that QoS, in terms of data rate the user experiences, is ensured and the fundamental information contained in signaling is always transmitted, being independent from the conditions of channels in unlicensed bands. It is also very important that users experience a "seamless" mobility between both spectrums without noticing a switch from licensed to unlicensed. The unified system that LTE-U provides, enables this seamless mobility. Both spectrums are managed with the same technology which enables an easy internetworking between licensed and unlicensed parts of the system.

7. ADVANTAGES/DISADVANTAGES OF WI-FI AND LTE-U

This section presents a comparison between both strategies explained previously. It focuses on the advantages of Wi-Fi firstly, and then continues with the enhancements that LTE-U provides compared to Wi-Fi features. In the end, a few drawbacks of LTE-U are also discussed.

Wi-Fi offloading advantages/disadvantages

Using Wi-Fi systems for offloading purposes may be considered as a simple strategy to handle growing data traffic. The Wi-Fi system considered in this report is deployed in parallel to HSPA and femtocells and with this environment Wi-Fi is evaluated to be a low cost solution in [12]. Since Wi-Fi access points are deployed extensively in urban areas, operator managed APs may be used by cellular networks to offload their data traffic. Moreover, the main advantage of using Wi-Fi for this type of implementation consists in the fact that Wi-Fi operates in the unlicensed band (2.4 and 5 GHz), different from frequency bands assigned to traditional cellular networks. Because of this, no interference is caused between Wi-Fi and 3G/LTE networks. Speaking about technical implementation of this system, a simple architecture is needed to be implemented for Wi-Fi offloading. It will use

commonly accessible techniques which are easily prototyped and developed because they take advantage from existing hardware equipment. No novel hardware is required to implement a system that combines traditional cellular network with Wi-Fi hotspots.

On the other hand, deploying a city-wide Wi-Fi system which is intended to be used only for offloading purposes by cellular network operators may result in an expensive solution. If operators would deploy their own Wi-Fi APs, it would require a lot of investment for a service that their current cellular network is aimed to offer. This way, a better option would be a collaboration between cellular network operators, Wi-Fi service providers and end users. Furthermore, since Wi-Fi and cellular networks operate on different spectrums they require different technologies to be managed. This results in a more complex internetworking between usage of licensed and unlicensed band.

Wi-Fi vs LTE-U Advantages

Comparing Wi-Fi systems used for offloading with LTE-U networks, it may be admitted that LTE-U brings more benefits than Wi-Fi in terms of stability and capacity. LTE-U offers a better performance than Wi-Fi for the same transmit power of the APs. LTE-U network's architecture is more coordinated and synchronized, offering a better use of resources by managing interference issues at the same time. Since LTE-U has an anchor in licensed spectrum, signaling is always done in the traditional cellular network. This ensures an always efficient signaling, transmitting all the fundamental information properly. This anchor in licensed spectrum also provides the seamless mobility to LTE-U users, which is one of the main features of this system based on user's experience. Moreover, total overhead information in LTE-U is reduced because the same signaling is used for both licensed and unlicensed spectrums.

Figure 6 shows the results of initial studies by Qualcomm [13] that compare performance of LTE-U and Wi-Fi. The qualitative results indicate a two-fold increase in performance: twice the capacity for the same number of LTE Advanced nodes using unlicensed spectrum compared to Wi-Fi is achieved. Also, the same capacity is reached in LTE-U for fewer nodes than in Wi-Fi. Figure 6 shows the results for a specific deployment in which small cells are deployed indoor but also serve for outdoor traffic.

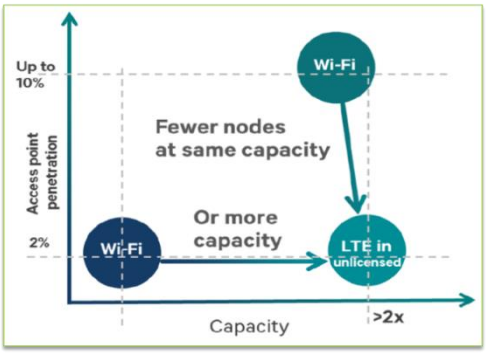

Figure 6. LTE-U offers better coverage or more capacity, [14]

8. LTE-U DRAWBACKS AND DISCUSSIONS

The main problem regarding LTE-U as discussed previously is related to its possible interference with Wi-Fi, especially in high density networks in which co-existence mechanisms should be implemented by operators. However, there are also other issues that may be discussed. Speaking about commercialization, extending LTE Advanced to unlicensed band may be brought to market early in countries such as U.S.A, China and South Korea because their existing standards support co-existence mechanisms for LTE-U in 5 GHz band. However, other countries should modify their standards to support LBT features [13]. Moreover, not all mobile equipment support LTE technology, even those supporting LTE not necessarily also support Carrier Aggregation. Since LTE-U is planned to operate in unlicensed spectrum, also other frequency bands may be considered beside 5 GHz. An example of

these bands may be ISM (industrial, scientific and medical) band of 2.4 GHz. 5 GHz has the advantage of offering a large number of non-overlapping channels and also causes higher propagation losses as a result of inherent features of transmission in high frequencies. These two elements enable 5 GHz band to provide a good throughput performance to Wi-Fi users when LTE-U is deployed in the same environment. This makes 5 GHz a better option to be used and enables Wi-Fi and LTE-U to be "good neighbors" to each other.

9. REACTIONS DUE TO DRASTIC CHANGE IN DATA TRAFFIC AND REGULATORY MEASURES

The increased of Internet traffic, high demand for network capacity during COVID-19, lead to immediate reaction, measures and actions from different stakeholders, telecom network operators, content providers, regulators policymaking etc.

Referring to a number of articles, and notices published from ITU, World Bank, EC, BEREC, GSMA, World Economic Forum, different regulatory bodies, network operators and content providers it was noticed that all responsible institutions in European countries were alerted and closely monitoring the situation in order to react fast, but even to be proactive, when possible. In various countries, the relevant Ministry, the Regulatory Authority as well as National Cyber Security Centre have been dealing with that [14]. They were communicating quite often with the stakeholders, reviewing plans, creating awareness on the situation.

In many European countries, they asked operators to review and enrich the Business Continuity plans and to reconsider the plans for major upgrades in their networks. Some immediate and prompt actions to be identified and listed in case of sudden traffic increase. The guidelines how to work remotely in a safe way were provided. The guidelines for a rational usage of Internet were delivered to all potential users. Sometimes, it was clearly requested to use fixed networks rather than mobile ones.

The providers of video-streaming were asked to reduce the quality of their videos in order to spare valuable capacity. Some main market players like Netflix, Amazon, Google/YouTube and Facebook were voluntarily applying that.

Access providers were let free to reduce the max data speed or even to cancel some free-of-charge data plans. But it was stressed that in case of traffic optimization measures, the throttling to be equally applied for the services of the same category (i.e. streaming). Restrictions that affect only single content or application providers are considered as illegal

In France, the postpone of launching "Disney+" VOD service was requested. Meanwhile, in Spain, Disney requested to accelerate the launch in that country, trying to grasp the business opportunity of augmented audience in that period.

In some cases, it was requested to the mobile operators not to stop or slow down the rollout plans, but instead, when possible to accelerate. The aim, of course, is to gain valuable capacities for the data traffic.

Last, but not least, in some cases legal initiatives were taken, proposing necessary changes in the legislation related to the sector, in order to face the situation. In global level, "…*the industry association GSMA, which represents the interests of mobile network operators worldwide, called for a relaxation of spectrum licensing and management rules in view of the sudden and significant increase in traffic demand. The European Telecommunications Network Operator's Association (ETNO) has also issued FAQs on COVID-19, telecoms and network data*… [14]".

In Albania regulatory body issued a guideline for a rational use of Internet. The telecom operators took measures to guarantee the continuity of business, facilitate the service provisions during COVID-19 and invested for network capacity to improve the situation. Long term plans for emergency situations are needed.

World Bank, ITU, GSMA, World Economic Forum initiated a joint action plan [7], as a Crisis response in digital infrastructure, digital economy.

CONCLUSIONS

COVID -19 and lockdown decisions in a number of countries increased drastically the Internet traffic. The mobile data communications is increased faster, the users behavior changed. The quality of service declined. The network operators challenged with high demand and the necessity to address the network capacity requirements. A number of different stakeholders react immediately to take measures to guarantee the continuity of digital connectivity and provision of online services.

It was noticed that, in general, the situation with the traffic increase was successfully faced. Sure, the measures of the government, institutions, market players, user etc. helped a lot, but it was another factor that diminished the risks. As a main principle, the mobile service providers are designing their network based on the peak hour of the day. In some cases, even the special events of the year which create unusual traffic increase are taken into account. In the countries/operators where those rules were properly followed, the problems were minor. Since the beginning of the pandemics, in addition to the traffic increase the traffic pattern changed. Anyway, this change helped somehow the situation, especially thanks to the dimensioning rule based on the peak hour/peak day. The peak hour was replicated several times during the day. So, the extra amount of the traffic was almost evenly distributed all over the day.

The appropriate traffic management solutions need to be applied in combination with other measures and additional investments. To summarize, from technical point of view choosing the best offloading opportunity is a complex process, which is highly depended by specific network's features. These features are related to network user's density, geographical/demographical characteristics, technical and commercial decisions of operators, etc. High density network typically experience higher data traffic loads and they require more effective offloading strategies than networks with lower densities. Furthermore, geographical condition of a specific environment should be taken into consideration as it may facilitate or worsen changes of the network. Last, commercial domain of operators is also another key factor which affects novel architectures they deploy. When the operators opt for a new strategy or business model implementation, they strongly consider the financial aspects such as TCO (total cost of ownership) and return of investment factor.

A long term plans for investment in digital infrastructure and other related digital components and regulatory measures are needed.

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