Implications of the First Wave of the COVID-19 Pandemic on the Internet Traffic

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Abstract

In this paper, we report on a measurement study by researchers from several institutions that collected and analyzed network data to assess the impact of the first wave of COVID-19 (February 2020 to June 2020) on the Internet traffic. The datasets from Internet Service Providers, Internet Exchange Points, and academic networks, primarily in Europe, provide a unique view on the changes of Internet traffic due to pandemic and the lockdown that forced hundreds of millions of citizens to stay and work from home. The analysis shows that the increase of Internet traffic was about 15-20% within a couple of weeks, an increase that is typically spread over multiple months under typical operation. However, traffic during peak hours does not increase by more than 5%. The increase was noticeably higher for specific applications, e.g., remote work applications, teleconferencing, video on demand; in some cases up to 200%. However, overall, the Internet reacted well to these unprecedented times.

As a result of the ongoing COVID-19 pandemic, the global population had to depend on residential Internet connectivity for work, education, social activities, and entertainment. This opens questions on how traffic characteristics changed during this period and if these changes challenged the operation of the Internet infrastructure. In this paper, we summarize a measurement study on Internet traffic shifts in the first wave of the COVID-19 pandemic, i.e., February 2020 to June 2020. Our study provides an empirical and multi-provider perspective on traffic shifts by using data from a diverse set of vantage points: one major Tier-1 Internet Service Provider (ISP), three Internet Exchange Points (IXPs) of which two are located in Europe and one in the US, one metropolitan area educational network, and a mobile operator.

The major observations are summarized as follows:

(1) The traffic volume changes follow demand changes, causing a "moderate" traffic surge of 15-20% during lockdown for the ISP/IXPs in our study, but decreases up to 55% at the education network. Even after the lockdown, an increase of about 20% at one IXP, but only 6% at the Tier- ISP, are still visible.

(2) Traffic increase takes place, typically, during non-traditional peak hours. Daily traffic patterns are moving to weekend-like patterns.

(3) Demand for online entertainment contributes the most to the surge of traffic originated by Hypergiants, including cloud and content providers.

(4) Traffic related to remote working applications, such as VPN connectivity applications and video-conferencing applications, surge by more than 200%.

(5) At the IXPs, we observe that port utilization increases. This phenomenon is mostly explained by a higher traffic demand from residential users.

(6) Traffic changes across networks differ. For example, in an educational network in our study, there was a significant drop (by up to 55%) in traffic volume on workdays after the lockdown. At the same time, remote working and lecturing cause a surge in incoming traffic, e.g., for email and VPN connections.

In **Figure 1** we show the changes in traffic at all the vantage points in our study from January 1, 2020 (01-01) to June 29, 2020 (06-29). We annotate the date when the COVID-19 outbreak started in Europe – around the date that the World Health Organization declared the novel coronavirus outbreak as a public health emergency of international concern. We also annotate the initial responses and first lockdown dates in Europe.

Figure 1 Traffic changes during 2020 at multiple vantage points – daily traffic averaged per week normalized by the median traffic volume of the first up to ten weeks.

We observe a significant increase of traffic at all vantage points (except the mobile operator) after the initial lockdowns. The opposite trend is visible after May, when the lockdown restrictions were relaxed and the economy gradually re-opened. Traffic demands for broadband connectivity, as observed at the ISP in Central Europe as well as at the IXP in Central Europe and the IXP in South Europe increased slowly at the beginning of the outbreak and then more rapidly (within days) by more than 20% after the lockdowns started. Recall, a 30% increase in traffic is expected to take place within a year, under typical network operation conditions. The traffic increase at the IXP in the US is a bit shifted as the lockdown in the US occurred several weeks later.

Apart from the observed similarities in the traffic changes at the ISP and IXP vantage points, the relative traffic increase at the IXPs seems to persist longer while traffic demand at the ISP decreases quickly towards May. This correlates well with the first partial re-opening of the economy, including shop re-openings in this region in mid-April and further relaxations including school openings in May. The decrease in mobile traffic can be explained by the fact, that people did not go out that frequently and would therefore use their home Wi-Fi more often instead of their phone's mobile data plan. However, after May, mobile traffic increased significantly. The decrease in mobile traffic can be explained by the fact, that people did not go out that frequently and would therefore use their home Wi-Fi more often instead of their phone's mobile data plan. However, after May, mobile traffic increased significantly.

Our analysis shows that indeed, the pandemic increased the demand for applications supporting remote teaching and working to guarantee social distancing as shown in our analysis across all vantage points. The Internet could handle this new load due to the flexibility and elasticity that cloud services offer, and the increasing connectivity of cloud providers. The results of our analysis confirm that most of the applications with the highest absolute and relative increases are cloud-based. Moreover, the adoption of best practices on designing, operating, and provisioning networks contributed to the smooth transition to the new normal. Due to the advances in network automation and deployment, e.g., automated configuration management and robots installing cross connects at IXPs with minimal human involvement, it was possible to cope with the increased demand. In summary, our study demonstrates that over-provisioning, network management, and automation are key to provide resilient networks that can sustain drastic and unexpected shifts in demand such as those experienced during the COVID-19 pandemic.

The COVID-19 pandemic drastically changed working and social habits for the global population. Yet, life continued thanks to the increased digitization and Internet as well as cloud investments that have taken place during the last decade. The Internet indeed played a critical support role for businesses, education, entertainment, and social interactions during these unprecedented times. In this paper, we analyzed network flow data from multiple vantage points, including some at the core, three IXPs located in Europe and the US, and a large academic network and a large ISP at the edge. Together, they allow us to gain a good understanding of the lockdown effect on Internet traffic in more developed countries. Overall, the observed Internet patterns were unique during the first wave of the pandemic, but the Internet reacted well to this challenge. For additional results and details on our methodology, we refer to the full report of our study [7].

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