1 INTRODUCTION

The Russian invasion of Ukraine, starting in February 2022, caused thousands of casualties [6] and millions of refugees [11]. One of the many implications of this conflict is the impact on the Internet performance, both in Ukraine and in Russia.

In this paper we analyze the Internet performance on both sides of the Ukrainian-Russian border, showing the clear asymmetry around the Ukrainian-Russian border, with a clear performance degradation in Ukraine and a performance improvement in Russia. Clearly the connectivity in Ukraine was affected by infrastructure aspects such as power outages or damaged communication lines and equipment, causing routing changes and congestion along bottlenecks, and in some cases resulting in user performance degradation. In Russia, on the other hand, major content providers such as Netflix [12] discontinued their service to Russian customers, and the Russian government block access to Facebook and Twitter [9], resulting in content degradation.

Some preliminary insights into the impact of the war on the Internet performance in Ukraine has been discussed in [1, 2]. The strong correlation between the Ukrainian refugee crisis and the Internet performance was introduced in [5]. The current work introduces a detailed comparison between the performance trend in Ukraine and in Russia during the first two months of the war based on publicly available Internet measurement data from various source, such as RIPE Atlas [7], Google [4], Cloudflare [3] and Speedtest [10].

A note from the authors. Our hearts are with the families of the casualties and with the refugees. We hope that our work will help in accentuating the injustice of this unnecessary conflict, and we hope that the conflict will reach a quick resolution soon.
We analyzed the traffic rate trends based on measurement data from Cloudflare [3] and Google [4].

A comparison of the web search traffic rate is shown in Figures 2a and 2d. These figures illustrate the normalized daily peak rate of web search requests in each of the two countries. Similarly, Figures 2b and 2e depict the normalized peak rates of Youtube traffic. Finally, Figures 2c and 2f show the normalized peak traffic rate measured by Cloudflare.

Shortly after the beginning of the conflict there is a clear traffic rate reduction in Ukraine, shown in the three top graphs of Figure 2. Comparing the first two weeks of the war to the two weeks beforehand, we found that the Google search rate in Ukraine decreased by over 30%, and the Cloudflare rate decreased by over 20%. Over the same period of time the Google search rate in Russia increased by 5%, and the Cloudflare traffic rate increased by almost 25%. This steep increase in Russia is aligned with the following explanation from Cloudflare’s CEO, Matthew Prince: “As the conflict has continued, we’ve seen a dramatic increase in requests from Russian networks to worldwide media, reflecting a desire by ordinary Russian citizens to see world news beyond that provided within Russia”.

The Youtube traffic rate in Ukraine showed a similar trend to the web search and the Cloudflare measurements, showing a steep decrease at the beginning of the conflict. The rate of Youtube access in Russia was reduced by over 10% at the beginning of March, which is aligned with the Russian government’s announcement about blocking Facebook and

2.2 Traffic Rate

These results clearly illustrate the performance degradation in Ukraine, which may be explained by infrastructure damage and outages, while the performance improvement in Russia is in line with the reduction in some of the content consumption. Note that the high latency jitter in Ukraine indicates higher network load and congestion than in previous periods.

These results clearly illustrate the performance degradation in Ukraine, which may be explained by infrastructure damage and outages, while the performance improvement in Russia is in line with the reduction in some of the content consumption. Note that the high latency jitter in Ukraine indicates higher network load and congestion than in previous periods.

Figure 2: Ukraine (green) vs. Russia (red) daily peak traffic rates
Twitter [9], thus reducing the exposure to many of the Youtube links that were conventionally accessed from these social networks prior to the blocking decision.

2.3 RTT and Loss

One of the metrics that significantly degraded as of the beginning of the war was the median latency, as previously shown in Figure 1. We now show that a similar latency trend can be seen in the RIPE Atlas Round-Trip Time (RTT) measurements we analyzed, shown in Figure 3a. We analyzed RTT measurements of about 200 probes in Ukraine and about 600 probes in Russia over a period of more than 3 months, using the built-in periodic Ping measurements to the K-Root DNS servers, summing up to over 20 million RTT measurements. The number of connected probes was analyzed on a per-day basis. Data was extracted from RIPE Atlas using the Magellan tool [8].

The median RTT is illustrated in Figure 3a. The figure illustrates an increased RTT in Ukraine starting on the first week of the war, while the RTT in Russia has very slight fluctuations over the observed period. The measured packet loss rate over these measurements is illustrated in Figure 3b, showing a large loss rate increase in Ukraine, while the loss rate in Russia had very slight variability over most of the observed period.

![Figure 3: RIPE Atlas RTT measurements from Ukraine probes to K-Root servers](image)

We further investigated the RTT changes in Ukraine by following the RIPE Atlas Traceroute tests to the K-Root servers. We compared the traces in 21 February to the traces in 21 March, and found that for many of the RIPE Atlas probes the path to the K-Root servers have changed during this month. Specifically, many of the probes which used a routed through Germany in February switched to a different path through the Netherlands in March. This routing change was a common change in many of the traces during this period, and can be explained by routing constraints caused by infrastructural aspects.

The RTT and loss rate measurements from the RIPE Atlas platform confirm the general trend of the performance degradation in Ukraine, as opposed to the performance in Russia. This trend is shown to be visible not only in local traffic, as shown in Section 2.1, but also over a large distance, as shown in the RIPE Atlas measurement analysis.

3 CONCLUSION

We presented a measurement study of the Internet performance in Ukraine and in Russia during the first two months after the beginning of the conflict on February 2022. This analysis presents an asymmetric picture: Internet performance in Ukraine significantly degraded, while the performance in Russia improved. Ukraine suffered from various infrastructure issues and from the refugee crisis, resulting in reduced download and upload speeds, increased latencies, and high loss rate. Russian users, on the other hand, experienced improved download and upload speeds, likely due to reduced streaming consumption from leading services such as Netflix and Youtube.

REFERENCES

[1] E. Aben. The Resilience of the Internet in Ukraine. Ripe labs, 10 March 2022, https://labs.ripe.net/author/emileaben/the-resilience-of-the-internet-in-ukraine/, 2022.
[2] E. Aben. The Ukrainian Internet. Ripe labs, 28 February 2022, https://labs.ripe.net/author/emileaben/the-ukrainian-internet/, 2022.
[3] Cloudflare. Cloudflare Radar. https://radar.cloudflare.com/, 2022.
[4] Google. Google Transparency Report. https://transparencyreport.google.com/traffic/overview, 2022.
[5] T. Mizrahi and J. Yallouz. Using Internet Measurements to Map the 2022 Ukrainian Refugee Crisis. Arxiv, 2022.
[6] Reuters, Jerusalem Post Staff. Russia-Ukraine war: 21,000 civilians killed, mayor of Mariupol estimates. 13 April 2022, https://www.jpost.com/international/article-703925, 2022.
[7] RIPE NCC. RIPE Atlas. https://atlas.ripe.net/, 2022.
[8] RIPE NCC. RIPE Atlas Tools (Magellan). https://ripe-atlas-tools.readthedocs.io/en/latest/, 2022.
[9] N. Sganga. Russia blocks Facebook and Twitter access. 4 March 2022, https://www.cbsnews.com/news/russia-blocks-facebook-twitter/, 2022.
[10] Speedtest. Speedtest global index. https://www.speedtest.net/global-index, April, 2022.
[11] UNHCR. Ukraine refugee situation. https://data2.unhcr.org/en/situations/ukraine, April, 2022.
[12] A. Young. Netflix Disconnects from Russia. 7 March 2022, https://www.yahoo.com/entertainment/netflix-disconnects-russia-021949757.html, 2022.