Uganda:
Data on internet blocks and nationwide internet outage amid 2021 general election

Last week, amid its 2021 general election, Uganda was disconnected from the internet entirely. The country experienced a widespread internet blackout that lasted 4 days, starting on the eve of the election (13th January 2021) and ending in the morning of 18th January 2021. In the days leading up to the election, access to major social media platforms and circumvention tools was blocked -- *even when the OTT (Over the Top) tax (commonly referred to as the "Social Media Tax") was paid*.

In this report, we share OONI network measurement data on the blocking of social media and circumvention platforms leading up to Uganda's elections, as well as IODA data (and other public data sources) on the internet blackout that occurred amid and following the election. We also share findings from experiments run in Uganda (before and after the internet blackout) through the use of the `miniooni` research client.

Background

Uganda has had the same President (Mr. Yoweri Museveni) since 1986. Multiparty elections have been held in the country since 2006, but President Museveni (and his National Resistance Movement party) has won every election over the last 35 years (even though past elections have been marred by allegations of rigging).

During Uganda’s 2016 general election, access to major social media platforms was blocked both amid the election (in February 2016) and leading up to President Museveni’s (fifth) inauguration (in May 2016). At the time, authorities justified the blocking of social media on the grounds of security, though this reportedly harmed the political opposition which relied on social media platforms to organize protests.

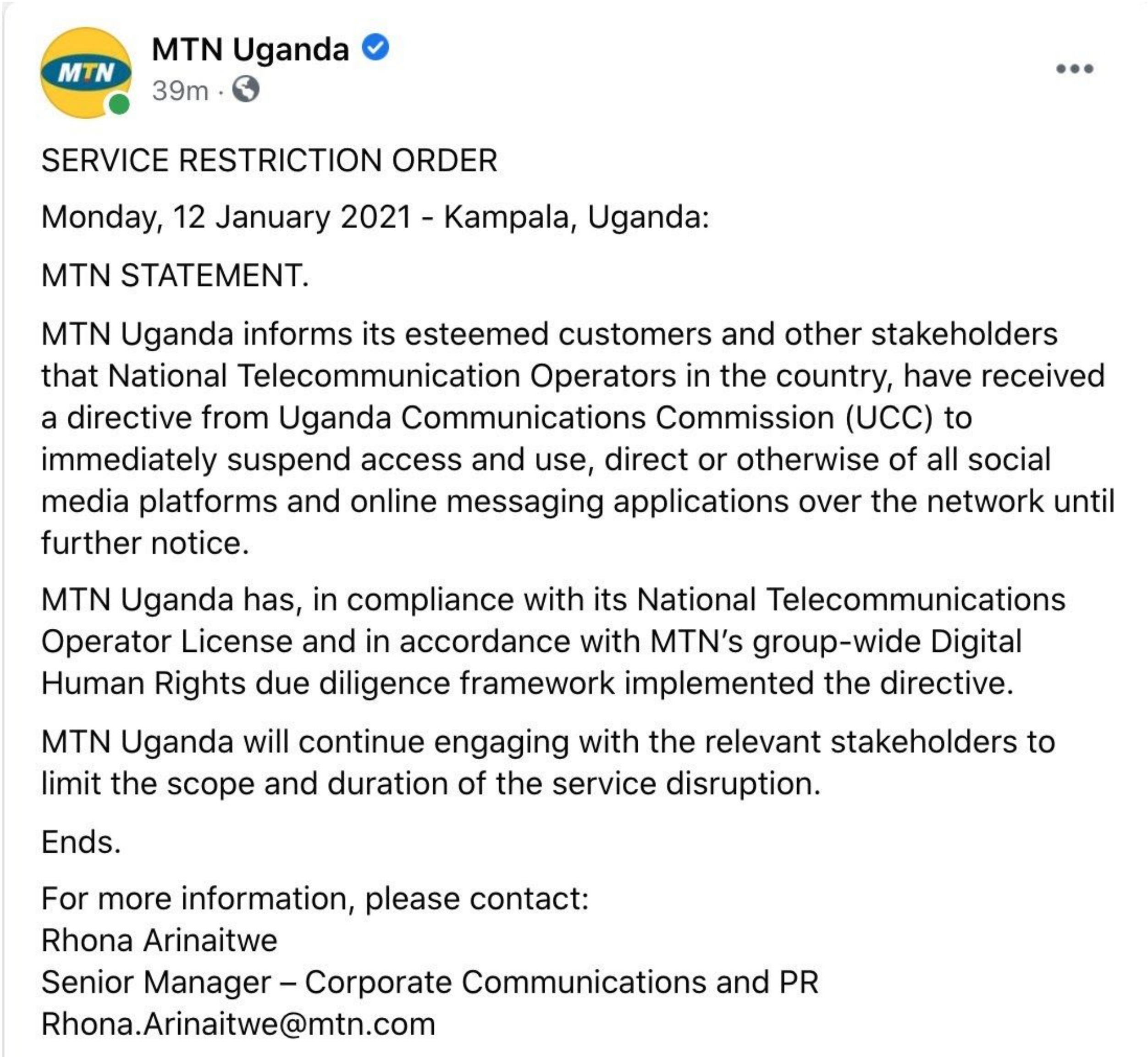
Two years later (in July 2018), Uganda introduced the Over the Top (OTT) tax -- commonly referred to as the “Social Media Tax” -- which requires internet users in Uganda to pay taxes to the government in order to access a wide range of online social media platforms (such as WhatsApp, Facebook, Twitter, Viber, Google Hangouts, Snapchat, Skype, and Instagram, among many others). To access such platforms, users of Ugandan Internet Service Providers (ISPs) are required to pay UGX 200 (USD 0.05) per day, which has reportedly led to millions of people in Uganda abandoning online social media due to affordability constraints.

According to President Museveni, this social media tax is meant to reduce capital flight and improve Uganda’s tax to GDP ratio. However, previous studies in the region have shown that restricting internet access (through internet disruptions) and increasing the cost of internet access have the potential to impact Uganda’s economic growth.

To limit untaxed access to social media, Ugandan ISPs have also blocked access to a number of circumvention tools as well. In 2018, we published a research report which documented the blocking of online social media and censorship circumvention platforms in Uganda (when the OTT tax was not paid) through the analysis of OONI network measurement data.

Over the last 2.5 years, people in Uganda had access to major social media platforms if they paid the OTT tax. But this changed in the week leading up to Uganda’s latest (2021) general election (held on 14th January 2021), when Ugandans reported that they were unable to download apps from the Google Play Store. In the days that followed, locals also reported that they were unable to access major social media platforms (such as Facebook) -- even once they had paid the OTT tax.

On 12th January 2021, Ugandan ISPs confirmed the blocking of online social media platforms and online messaging applications in compliance with a directive from the UCC.



SERVICE RESTRICTION ORDER

Monday, 12 January 2021 - Kampala, Uganda:

MTN STATEMENT.

MTN Uganda informs its esteemed customers and other stakeholders that National Telecommunication Operators in the country, have received a directive from Uganda Communications Commission (UCC) to immediately suspend access and use, direct or otherwise of all social media platforms and online messaging applications over the network until further notice.

MTN Uganda has, in compliance with its National Telecommunications Operator License and in accordance with MTN's group-wide Digital Human Rights due diligence framework implemented the directive.

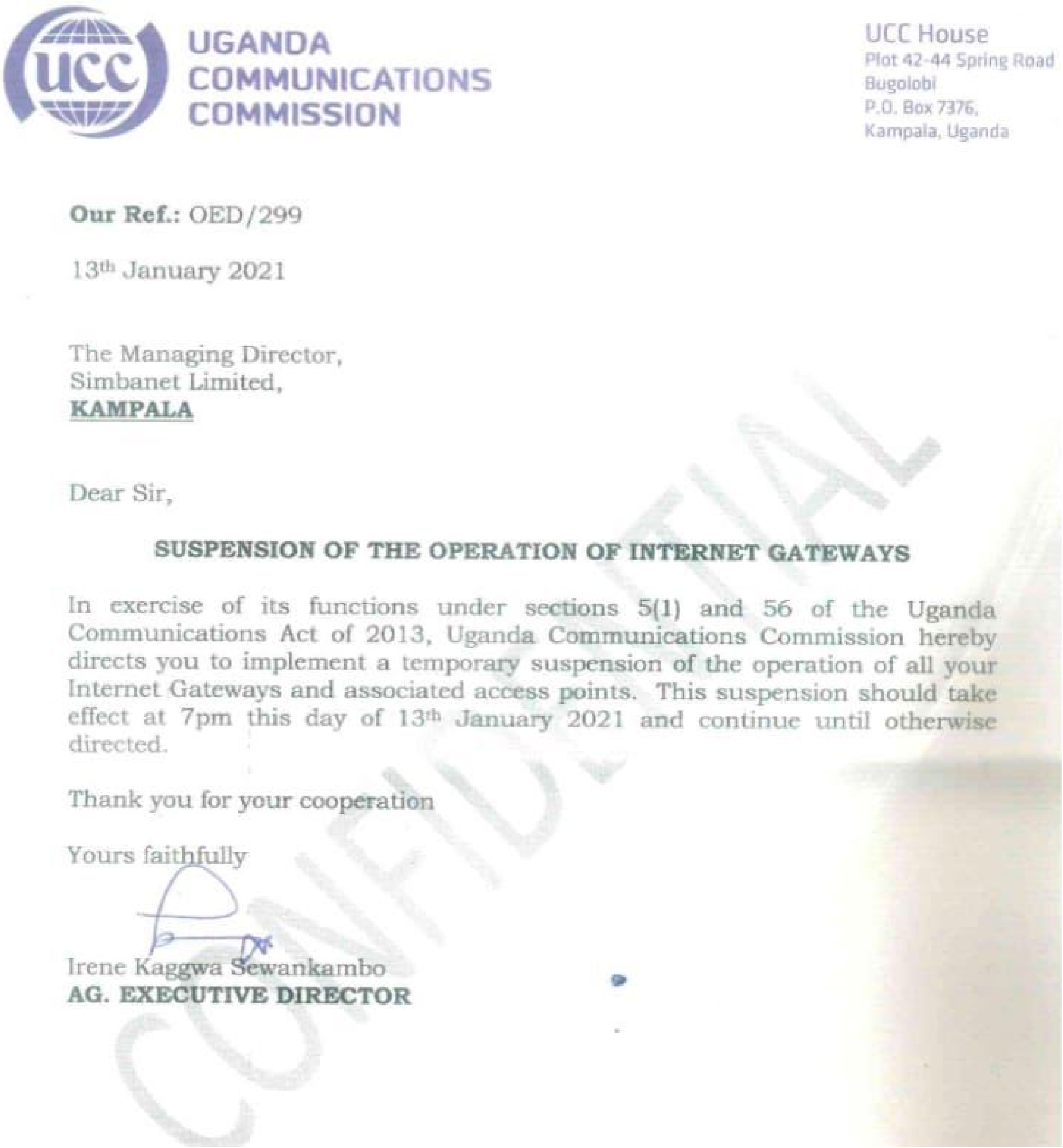
MTN Uganda will continue engaging with the relevant stakeholders to limit the scope and duration of the service disruption.

Ends.

For more information, please contact:
Rhona Arinaitwe
Senior Manager – Corporate Communications and PR
Rhona.Arinaitwe@mtn.com

The recent blocking of social media reportedly followed Facebook's closure of "fake" accounts which it said were linked to Uganda's government and used to boost the popularity of posts. This move was seen as a form of retaliation as (on 12th January 2021) President Museveni accused Facebook of "arrogance" for determining which accounts are fake and interfering with the election; he stated that he had therefore instructed the blocking of Facebook and other social media platforms. To limit censorship circumvention, the Uganda Communications Commission (UCC) reportedly ordered the blocking of more than 100 VPNs.

On the eve of Uganda's 2021 general election, the UCC ordered the suspension of the operation of all internet gateways and associated access points in Uganda. The order specified that this suspension should take effect at 7pm on 13th January 2021, as illustrated below.



UGANDA
COMMUNICATIONS
COMMISSION

UCC House
Plot 42-44 Spring Road
Bugolobi
P.O. Box 7376,
Kampala, Uganda

Our Ref.: OED/299

13th January 2021

The Managing Director,
Simbanet Limited,
KAMPALA

Dear Sir,

SUSPENSION OF THE OPERATION OF INTERNET GATEWAYS

In exercise of its functions under sections 5(1) and 56 of the Uganda Communications Act of 2013, Uganda Communications Commission hereby directs you to implement a temporary suspension of the operation of all your Internet Gateways and associated access points. This suspension should take effect at 7pm this day of 13th January 2021 and continue until otherwise directed.

Thank you for your cooperation

Yours faithfully

Irene Kaggwa Sewankambo
AG. EXECUTIVE DIRECTOR

Overall, the run-up to Uganda's 2021 general election was marred by violence, as authorities reportedly cracked down on opposition rallies, while opposition candidates and their supporters experienced threats and intimidation over the last months. President Museveni's re-election was primarily challenged by Bobi Wine (one of 10 candidates challenging President Museveni in the 2021 general election), a 38-year-old pop star who emerged as a prominent member of Uganda's political opposition in 2017 and ran for Uganda's presidency in the latest election. However, Mr. Museveni was re-elected, winning almost 59% of the vote and a sixth presidential term (despite accusations of vote fraud by the opposition).

Methods

To investigate the blocking of online platforms, we analyzed OONI measurements collected from Uganda (similarly to our 2018 study examining the blocking of social media and circumvention tools with the introduction of the OTT tax). OONI measurements are regularly collected and contributed by users of the OONI Probe app, which is free and open source, designed to measure various forms of internet censorship and network interference.

More specifically, we limited our analysis to OONI measurements collected from Uganda between **9th January 2021 to 19th January 2021**, as network disruptions were first reported on 9th January 2021, while internet connectivity was restored in the country by 18th January 2021. We further limited our analysis to OONI measurements pertaining to the testing of social media websites and apps, as well as to the testing of circumvention tool websites and apps.

While a wide range of social media and circumvention tool websites can be tested through OONI's Web Connectivity test (designed to measure the TCP/IP, DNS, and HTTP blocking of websites), the OONI Probe app currently only includes tests for the following social media apps: WhatsApp, Facebook Messenger, and Telegram. Quite similarly, the OONI Probe app currently only includes tests for the following circumvention tools: Tor and Psiphon. Our analysis was therefore limited to the testing of these specific apps.

Our findings are also limited by the type and volume of measurements contributed by volunteer OONI Probe users in Uganda (i.e. if a blocked service was not tested in Uganda in the analysis period, relevant measurement findings will not be available). Prior to 12th January 2021, there was a divergence of measurements from probes run by users who had and had not paid the OTT tax. After 12th January 2021, we observed the disappearance of that divergence as users who had paid OTT tax experienced the blocks previously instituted on ones who had not paid the tax, as well as new blockages imposed on all users.

To investigate the blocking of circumvention tools further, we also ran a series of experiments (with the help of volunteers in Uganda) through the `miniooni` research client. We ran these experiments to characterize TLS blocking patterns. As test cases, we selected the Play Store's website, ProtonVPN's website, and Facebook's website. We checked whether their blocking depended on DNS, TCP, or TLS blocking. In the case of TLS blocking, we further investigated whether it depended on the value of the SNI extension.

To explore Uganda's internet blackout (when access to the internet was disrupted entirely), we referred to the following public data sources: Internet Outage Detection and Analysis (IODA), Google traffic data, Oracle's Internet Intelligence Map, and Cloudflare Radar data. Our goal was to check whether the signals and timing of Uganda's internet blackout can be verified and corroborated by all four separate public data sources, and how they can compare to the UCC order (which instructed the suspension of internet gateways and associated access points at 7pm on 13th January 2021).

Blocks in the election run-up

App Stores

On 9th January 2021, people in Uganda started reporting that they experienced difficulties downloading apps from the Google Play Store. This appears to be corroborated by OONI measurements, which show that the testing of `google.play.com` presented signs of blocking on several networks almost every time that it was tested between 10th January 2021 to 18th January 2021 (the relevant URL was not tested in Uganda on 9th January 2021).

While we also heard reports of potential Apple App Store blocking too, we cannot confirm this based on OONI measurements, which show that `apps.apple.com` was accessible on several networks in Uganda every time it was tested between 11th January 2021 to 18th January 2021. It is possible though that it may have been blocked on different networks (in comparison to those tested), or that access may have been interfered with in ways beyond those measured.

Social media

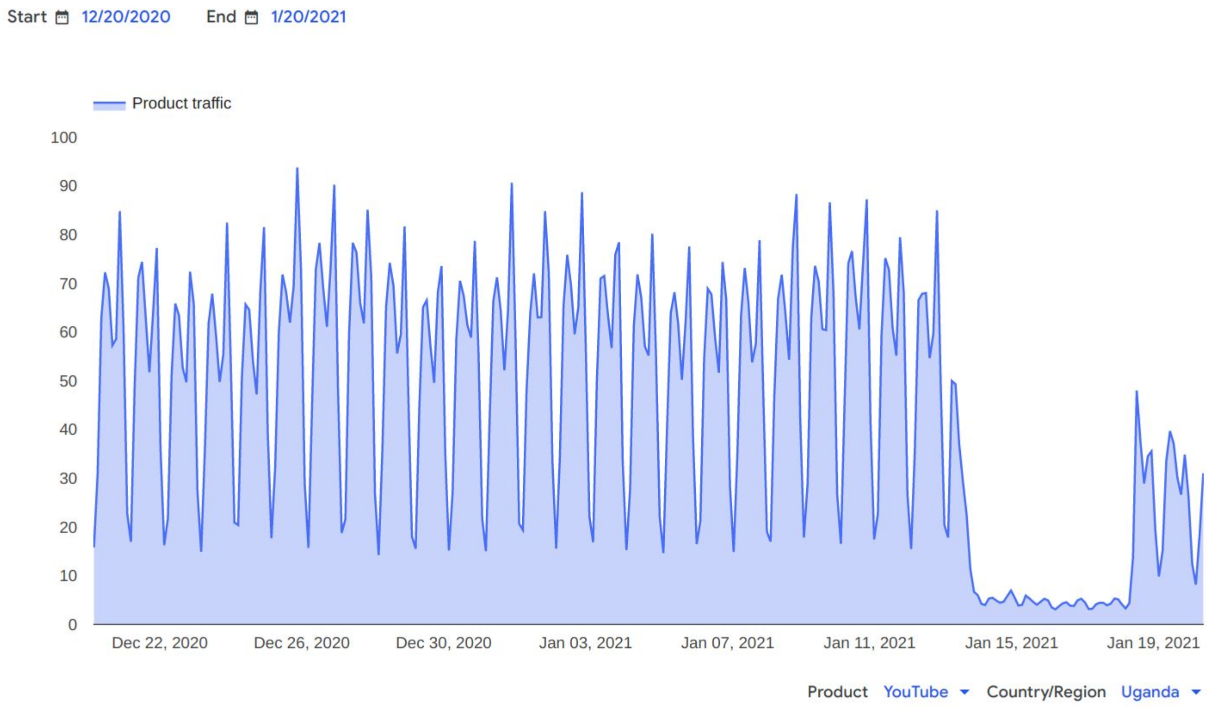
Websites

In the days leading up to Uganda's 2021 general election, OONI measurements show that a number of social media websites presented signs of blocking. These include `www.facebook.com`, the blocking of which appears to have started on 12th January 2021 (following President Museveni's instruction to restrict Facebook access in response to Facebook's closure of "fake" accounts, and on the same day that Ugandan ISPs notified their customers of such blocking) and which appears to be ongoing. Most OONI measurements collected between 12th January 2021 to 19th January 2021 suggest the blocking of `www.facebook.com` on several networks in Uganda.

Similarly, OONI measurements collected from Uganda on the testing of `www.instagram.com` between 12th January 2021 to 19th January 2021 suggest the ongoing blocking of this social media website (though a relatively limited volume of measurements -- in comparison to the testing of `www.facebook.com` -- has been collected during this period). While the testing of `www.whatsapp.com` first presented signs of blocking on 9th January 2021, we more consistently observed signs of blocking between 12th January 2021 to 19th January 2021.

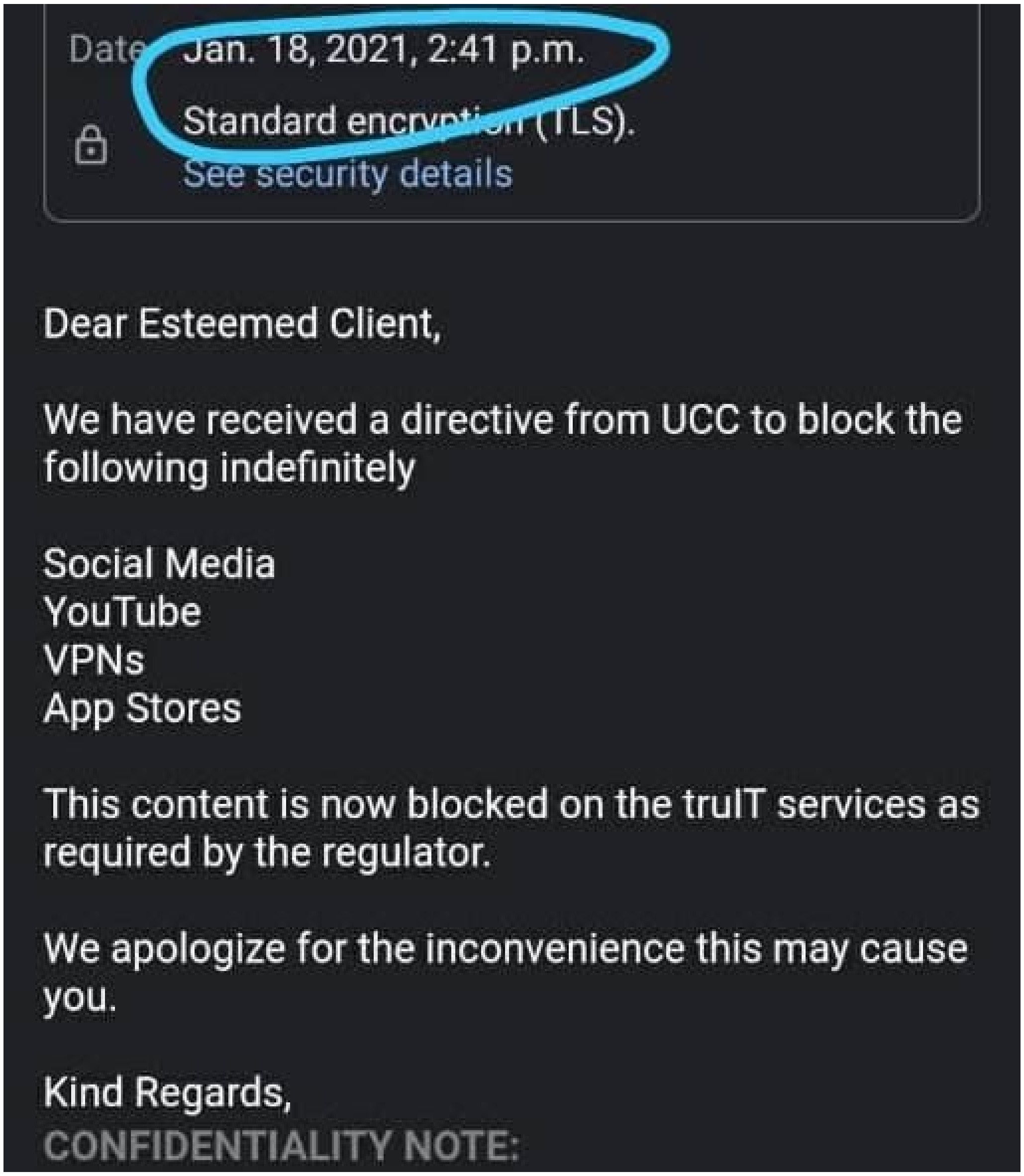
All OONI measurements collected between 12th January 2021 to 19th January 2021 consistently show that access to `twitter.com` appears to have been blocked on several networks in Uganda. Similarly, all OONI measurements collected during this time frame on the testing of `www.viber.com` show that access to this website was blocked in Uganda as well. During this period, we also observed signs of blocking for many other social media websites, such as skype.com, snapchat.com, wechat.com, tumblr.com, linkedin.com, as well as the blocking of dating sites (such as grindr.com).

Interestingly, `www.youtube.com` (which is not included amongst the OTT taxed platforms) only started presenting signs of blocking from 18th January 2021 onwards, once internet connectivity in Uganda was restored (following the 4-day internet blackout). This is not only shown through relevant OONI measurements collected from multiple networks in Uganda, but YouTube disruption is also suggested through Google traffic data which shows that the levels of YouTube traffic originating from Uganda are significantly decreased in comparison to the pre-internet blackout levels, as illustrated below.



Source: Google Transparency Reports, Traffic and disruptions to Google: YouTube, Uganda, https://transparencyreport.google.com/traffic/overview?fraction_traffic=start:1608422400000;product:21;region:UG&lu=fraction_traffic

This is further corroborated by a notification that Ugandan internet users received from their ISPs on 18th January 2021, which explicitly lists YouTube among the blocked internet services (in compliance with a UCC directive).



Date Jan. 18, 2021, 2:41 p.m.

Standard encryption (TLS).
See security details

Dear Esteemed Client,

We have received a directive from UCC to block the following indefinitely

Social Media
YouTube
VPNs
App Stores

This content is now blocked on the truIT services as required by the regulator.

We apologize for the inconvenience this may cause you.

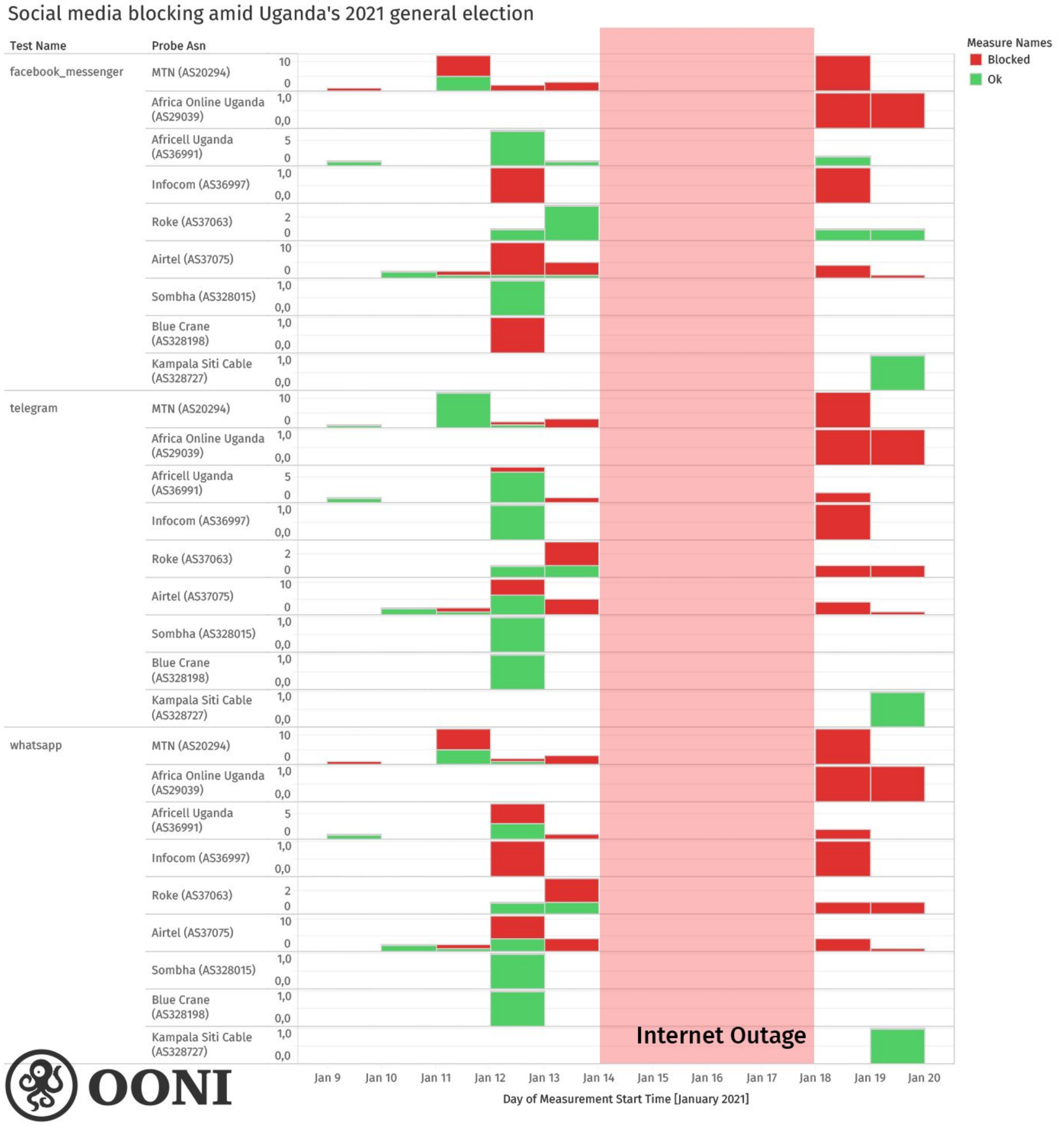
Kind Regards,
CONFIDENTIALITY NOTE:

It is possible that this move may be in response to government orders to censor specific YouTube channels affiliated with the political opposition. Following deadly riots in November 2019 over the arrest of opposition presidential candidate (Bobi Wine), it was reported in December 2019 that the UCC wrote to Google requesting that over 14 YouTube channels be shut down for allegedly mobiling the riots. The UCC claimed that these YouTube channels spread misinformation, fueled riots, and undermined public interest. Possibly as a result of non-compliance on Google's end, the Ugandan government may have resorted to blocking YouTube itself. Given that YouTube is hosted on encrypted HTTPS, ISPs cannot limit the blocking to specific channels, but rather need to block the whole of `www.youtube.com`.

It’s worth noting that in all the above social media cases, we observe the same HTTP failures and `connection reset` errors in OONI measurements, increasing our confidence with respect to their blocking because ISPs often block websites through the use of the same techniques. This is also consistent with our measurement findings in our 2018 study in Uganda. The following sections (“Characterizing website blocking”) dive into this deeper, as we investigated some of the blocked websites through the use of more advanced techniques (which we haven’t integrated into the OONI Probe apps yet).

Apps

To examine the blocking of social media apps, we analyzed OONI data collected from Uganda on the testing of WhatsApp, Facebook Messenger, and Telegram. Starting from 12th January 2021, all three apps presented signs of blocking on several networks, as illustrated through the chart below.



Source: OONI measurements collected from Uganda between 9th January 2021 to 19th January 2021, https://explorer.ooni.org/search?until=2021-01-20&since=2021-01-09&probe_cc=UG

Through the above chart, it is evident that:

- All three apps (WhatsApp, Facebook Messenger, Telegram) presented signs of blocking on several Ugandan networks (including major providers, such as MTN) on 12th and 13th January 2021;
- These apps did *not* present signs of blocking on all networks, as some tests suggested that the apps worked on some networks (between 12th and 13th January 2021);
- No OONI measurements were collected from Uganda between 14th January 2021 to 17th January 2021, suggesting the presence of an internet outage (since OONI Probe requires internet connectivity to perform tests, and the absence of measurements is consistent across all networks in Uganda during this time frame);

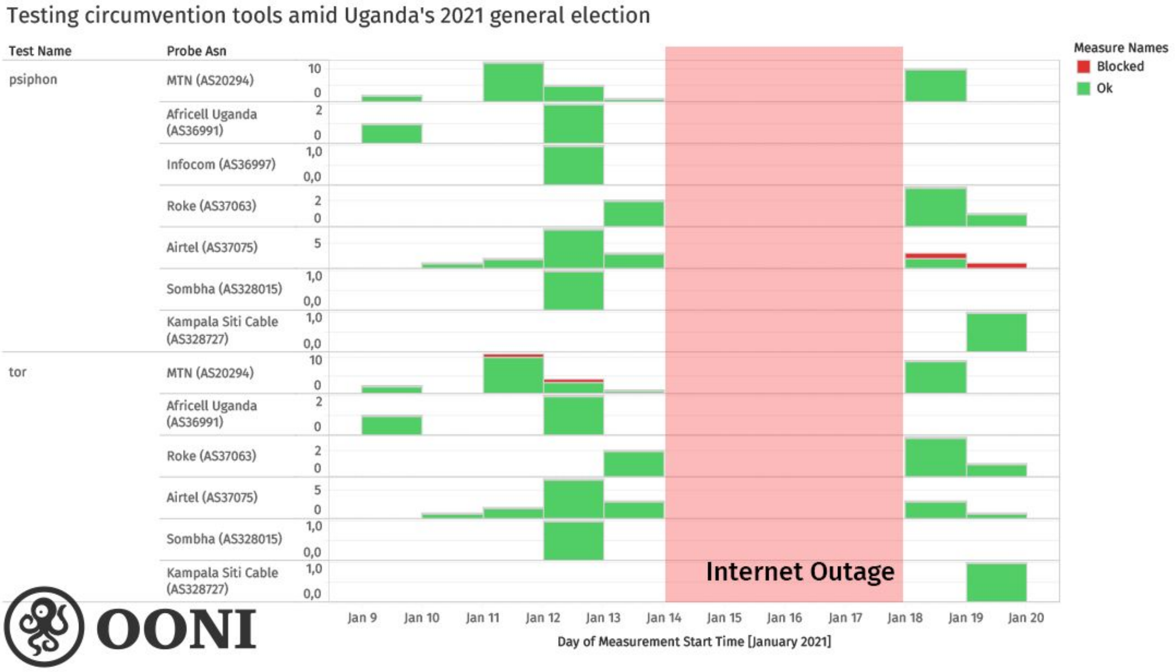
- OONI Probe testing (across networks) in Uganda resumes at around the same time on 18th January 2021, further suggesting the presence of an internet outage during the previous days;
- Social media apps remain blocked (the blocking of which is suggested by a larger volume of measurements in comparison to previous days) from 18th January 2021 onwards on most networks.

More specifically, WhatsApp appears to be blocked because attempted connections to WhatsApp's registration service and web interface (`web.whatsapp.com`) consistently fail. While DNS lookups consistently resolve to IP addresses associated with Facebook, Facebook Messenger appears to be blocked because attempted TCP connections to Facebook's endpoints failed. In many Telegram measurements, we see that TCP connections to *some* Telegram endpoints succeed, while others fail, and that HTTP(S) GET requests to `web.telegram.org` do not send back a consistent response to OONI servers. As these patterns (for WhatsApp, Facebook Messenger, and Telegram) are quite consistent across many measurements and networks throughout the same time periods, they provide strong signals of potential blocking.

Circumvention tools

To limit censorship circumvention, the Uganda Communications Commission (UCC) reportedly ordered the blocking of more than 100 VPNs in the days leading up to the country's 2021 general election.

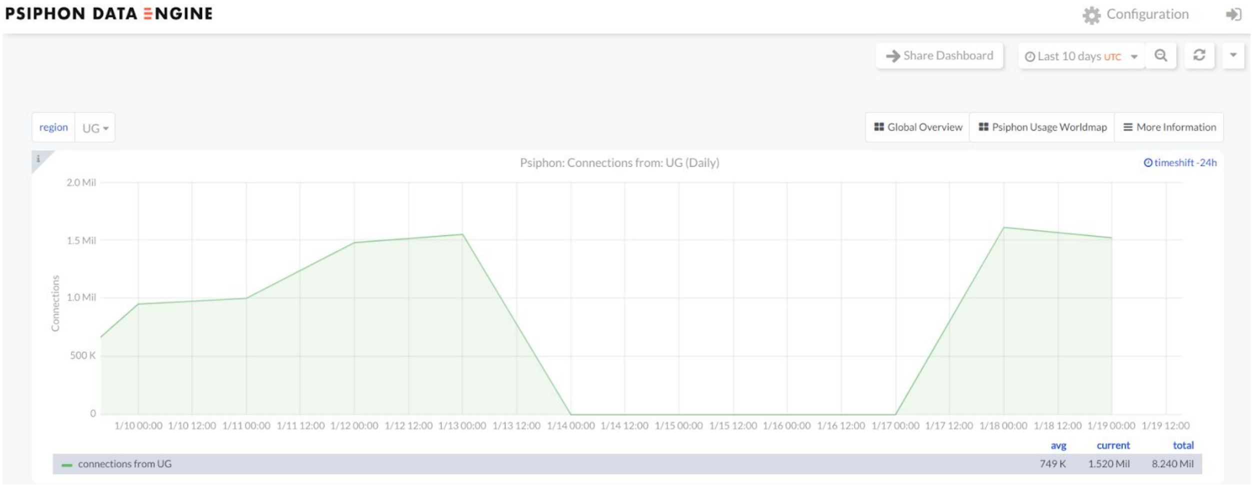
As the OONI Probe app currently only includes 2 circumvention tool tests, we can only share relevant measurements for those 2 tools: Tor and Psiphon. In both cases, we did *not* observe any significant signs of blocking, as most measurements (collected from multiple networks in Uganda) showed that the tools worked as expected. This is illustrated through the following chart, which shares OONI measurement coverage per test across networks (showing that almost all test results indicated that Tor and Psiphon worked).



Source: OONI measurements collected from Uganda between 9th January 2021 to 19th January 2021, https://explorer.ooni.org/search?until=2021-01-20&since=2021-01-09&probe_cc=UG

As is evident through the above chart, Psiphon appeared to work on multiple networks in Uganda between 9th January 2021 to 19th January 2021 (excluding the days between 14th to 17th January 2021, when there appears to have been an internet outage). Throughout this period, the OONI Probe Psiphon test was able to successfully bootstrap and create the Psiphon tunnel, and use it to fetch a webpage from the internet (suggesting that this circumvention tool worked in the tested networks).

Psiphon accessibility in Uganda is further suggested by the Psiphon Data Engine, which shows the number of Psiphon connections originating from Uganda.



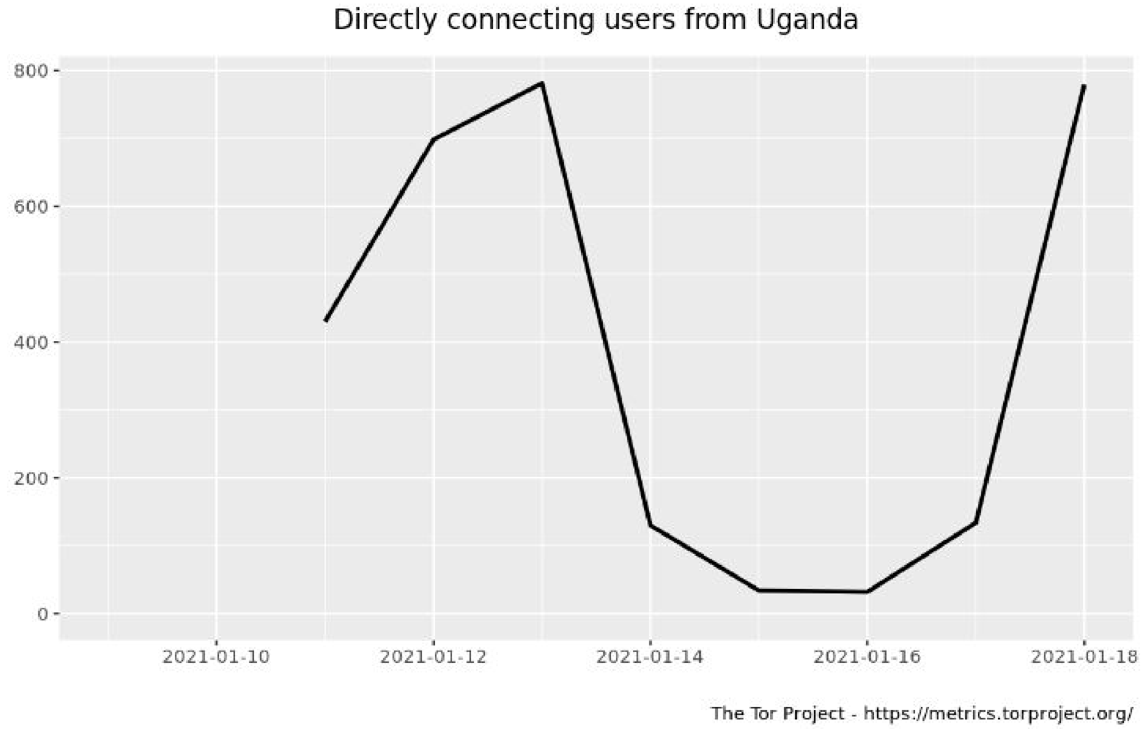
Source: Psiphon Data Engine, Connections from Uganda (January 2021), https://psix.ca/d/nyi8gE6Zk/regional-overview?orgId=2&var-region=UG

The above graph (taken from the Psiphon Data Engine) shows an increase in connecting Psiphon users between 11th to 13th January 2021 (which is when Ugandan ISPs were instructed to start blocking social media platforms, regardless of OTT tax payment), possibly in an attempt to circumvent social media censorship. Starting from the evening of 13th January 2021 (which is when the UCC instructed the suspension of all internet gateways), we observe a complete drop in Psiphon users (lasting for several days), and we see that Psiphon users resume connections by 18th January 2021 (which coincides with the dates of the reported internet blackout).

However, starting from 18th January 2021, the OONI Probe Psiphon test started to present signs of potential Psiphon blocking on Airtel (AS37075); while the test was able to bootstrap Psiphon, it was unable to fetch a webpage from the internet. These findings though are not conclusive, since very few Psiphon measurements have been collected from Airtel (AS37075) since 18th January 2021. We therefore encourage further Psiphon testing on this network.

Similarly to Psiphon, Tor appeared to work on multiple networks in Uganda between 9th January 2021 to 19th January 2021 (excluding the days between 14th to 17th January 2021, when there appears to have been an internet outage). As part of OONI Probe Tor testing throughout this period, most reachability measurements of selected Tor directory authorities and bridges were successful. Even in the cases where OONI measurements presented a few anomalies, Tor still appeared to be functional given that some Tor directory authorities were reachable.

Tor accessibility in Uganda is further suggested by Tor Metrics, which shows the estimated number of directly connecting Tor users from Uganda.



Source: Tor Metrics, Directly connecting users from Uganda (January 2021), https://metrics.torproject.org/userstats-relay-country.html?start=2021-01-09&end=2021-01-20&country=ug&events=off

The above graph (taken from Tor Metrics) shows that there was a spike in Tor usage on 12th January 2021 (which is when Ugandan ISPs were instructed to start blocking social media platforms, regardless of OTT tax payment), possibly in an attempt to circumvent social media censorship. Starting from the evening of 13th January 2021 (which is when the UCC instructed the suspension of all internet gateways), we observe an almost complete drop in Tor users, which coincides with the dates of the reported internet blackout. As internet connectivity resumed in Uganda, so did the number of Tor users in Uganda.

Apart from the testing of tools, OONI measurements also suggest the potential blocking of several circumvention tool websites which presented the same type of anomalies (with `connection_reset` errors) during the analysis period. These include protonvpn.com, safervpn.com, hotspotshield.com, nordvpn.com, torproject.org, and ultrasurf.us. However, the blocking of such websites does not necessarily mean that their apps are blocked as well (this, for example, does not appear to be the case with Tor, which seems to work in Uganda).

Characterizing website blocking

We ran custom experiments with `miniooni` to determine the extent of the blocking. This client allows us to test experimental measurement methodologies that have not been integrated into the regular OONI tests yet.

We ran tests with and without TLSv1.3, changing the SNI or the target endpoint and using QUIC/HTTP3 instead of HTTP. In the following sections, we only discuss tests measuring the Play Store's website, ProtonVPN's website, and Facebook's website.

Play Store's website

We tested `https://play.google.com` eight times on MTN on 19th and 20th January 2021 (once internet connectivity had been restored in Uganda). All domain name resolutions succeeded. They all returned IP addresses belonging to Google's autonomous system (AS15169). We therefore excluded the possibility of DNS interference.

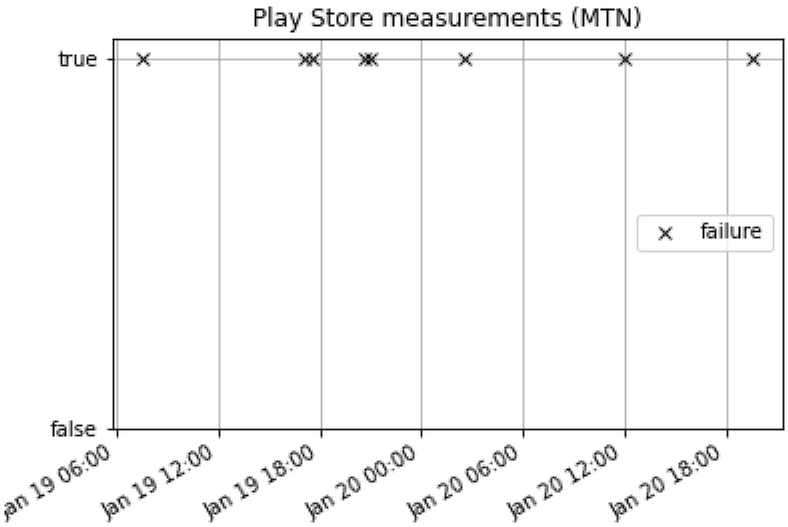


*Figure*: Play Store measurements from MTN

All TLS handshakes using TLSv1.3 and `play.google.com` as the SNI failed. In seven cases (#1, #2, #3, #4, #5, #6, #7), the error was connection reset (`ECONNRESET`). This error forces the operating system kernel to close a TCP connection immediately. In the remaining case, the error was "network down" (`ENETDOWN`). This error indicates that a router could not forward our traffic through a dead network.

If we inspect the `ENETDOWN` measurement, we see the error happening right after sending the TLS ClientHello message. (The failure is the seventh event in the `network_events` key inside the `test_keys` key.) The time elapsed between sending the ClientHello and receiving the

`ENETDOWN` error is comparable to the round trip time (100 ms). (We estimate the round trip time by observing the time required for the connect system call to complete.)

One of the measurements that failed with `ECONNRESET` was from a SIM card where the OTT tax hadn't been paid. All other failures were from SIM cards with the OTT tax paid.

After every measurement, we ran another measurement using `example.com` as the SNI. Eight times out of eight, we received the ServerHello (see, e.g., #1, #2, and #3). This result strongly indicates SNI based blocking of the Play Store's website.

ProtonVPN's website

We tested `https://protonvpn.com` fourteen times from MTN and fourteen times from Airtel. We ran these measurements between 13th to 20th January 2021.

In both networks, we saw no DNS errors. The domain name resolutions always returned IP addresses belonging to the Proton VPN autonomous system (AS209103). We therefore excluded the possibility of DNS interference.

MTN

Measurements always failed when using the `protonvpn.com` SNI on MTI and TLSv1.3. The failure was `ECONNRESET` nine times (see, for example, #1, #2, and #3). We observed three `ENETDOWN` errors (#1, #2, and #3). In two cases, the experiment failed because of an error in our measurement script.

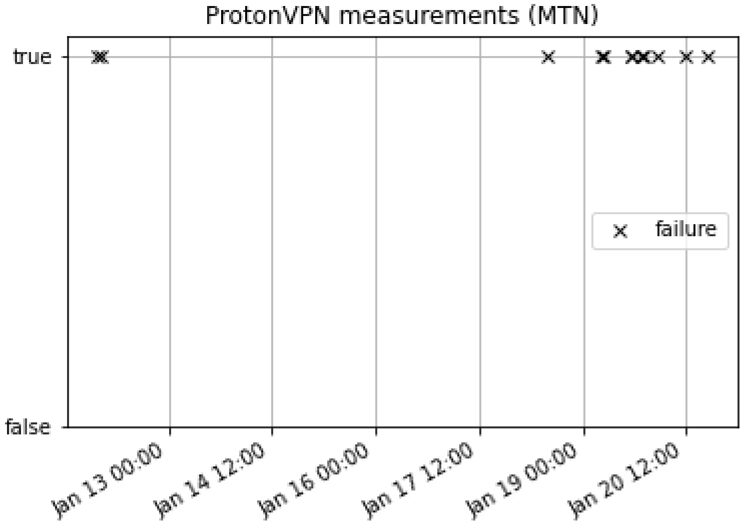


*Figure*: ProtonVPN measurements from MTN

One of the `ECONNRESET` failures was from a SIM without the OTT tax paid. All these failures occurred while the TLS handshake was in progress.

The `ENETDOWN` errors occurred roughly 50 ms after sending the ClientHello. In all these cases, the connect time was at least 200 ms.

After every measurement, we ran another one with `example.com` as the SNI and TLSv1.3. In all fourteen cases, we successfully received the ServerHello (see, e.g., #1, #2). This result strongly suggests SNI based blocking.

Airtel

All nine measurements run before 20th January 2021 succeeded. After that date, we observed three `ENETDOWN` errors (#1, #2, #3) and two timeout errors (#1, #2). All these errors occurred when connecting.

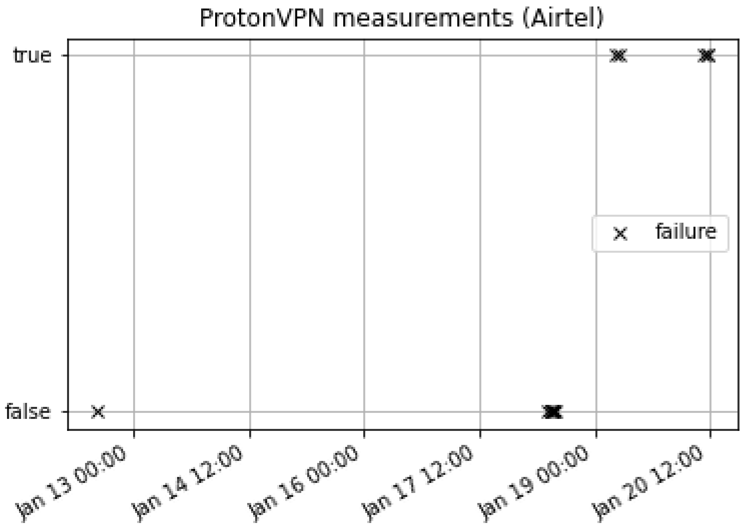


***Figure***: *ProtonVPN measurements from Airtel*

We also tried connecting to `https://example.com` using TLSv.13 and `protonvpn.com` as the SNI after each regular measurement. Fourteen times out of fourteen, we received the ServerHello (see, for example, #1, #2).

This result indicates that there was no SNI based blocking. Consistent failures after 20th January 2021 suggest that there was TCP blocking.

Facebook’s website

We tested `https://facebook.com` and `https://www.facebook.com` between 18th and 20th January 2021 from MTN and Airtel. All domain name resolutions returned IP addresses belonging to Facebooks’ autonomous system (AS32934). We therefore excluded the possibility of DNS interference with the measurements.

We measured `https://facebook.com` and `https://www.facebook.com` nineteen times from MTN and fourteen times from Airtel.

MTN

We always failed to connect to both domains. The error was “connection refused” nine times for each domain (e.g., #1, #2) and `ENETDOWN` once for each domain (e.g., #1, #2).

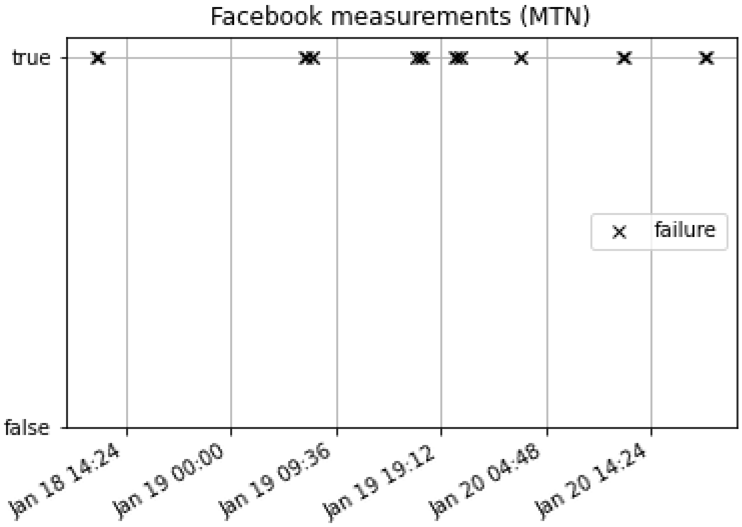


***Figure***: *Facebook measurements from MTN*

To search for SNI blocking evidence, we repeated each measurement after a short time interval using TLSv1.3 and the same SNIs with `https://example.com`. We observed failures connecting (three times out of nine for each SNI; see, for example, #1) and during the TLS handshake (six times; e.g., #1). We conclude that there was evidence of SNI based blocking for both `facebook.com` and `www.facebook.com`. We also note that `https://example.com` has not always been reliably reachable during the testing period.

Interestingly, we could not access Facebook's website using the QUIC protocol (`h3-29`). The QUIC handshake always timed out (see, e.g., #1, #2, #3). By inspecting the `network_events` key of these measurements, we notice that the code calls `sendto` several times (`sendto` is called `write_to` in `network_events`). Each time, it writes the initial message containing the

ClientHello. Because there is no reply, the message is transmitted several times. Eventually, the client times out.

We repeated each experiment using `example.com` as the SNI (see, e.g., #1 and #2). The behavior of the QUIC client is the same as before. It calls `sendto` several times, and then eventually it times out. We conclude that these Facebook QUIC endpoints are likely blocked.

Airtel

We recorded nine failures and four successes. The successes all occurred around the morning of 19th January 2021. In all cases, we failed when connecting (see, e.g., #1, #2, #3). This result indicates that there is blocking of the relevant TCP endpoints.

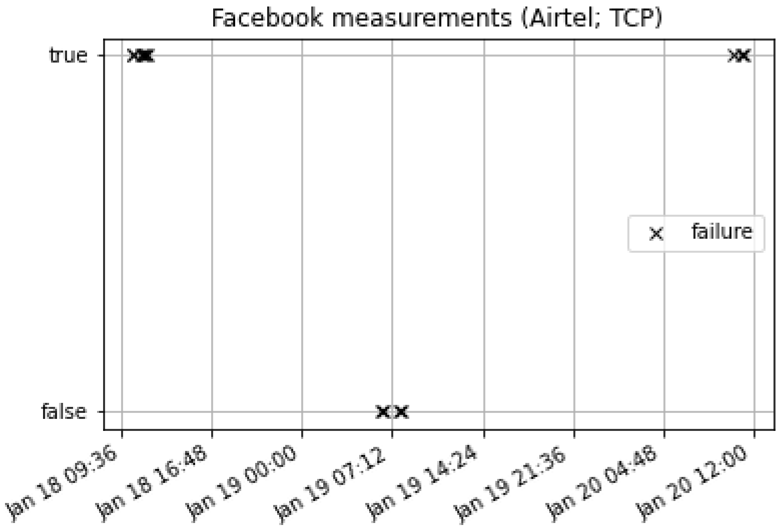


***Figure***: *Facebook measurements from Airtel (using TCP)*

We nearly immediately repeated the experiment using TSLv1.3 and the same SNIs with `https://example.com`. All these experiments failed in the TLS handshake. In five out of thirteen cases, the error was `ENETDOWN` (see, e.g., #1). In all other cases, the error was `ECONNRESET` (see, e.g., #1). This result indicates that there is SNI based blocking, in addition to TCP blocking.

As for MTN, Facebook's QUIC endpoints failed (#1, #2, #3, #4, #5, #6, #7, #8, #9). All these measurements failed after the QUIC handshake completed. The client and the server exchange some extra data after the handshake, then the client times out reading or writing. When it times out writing, it retransmits several times before giving up. When it times out reading, it just blocks until there is no network activity for several seconds.

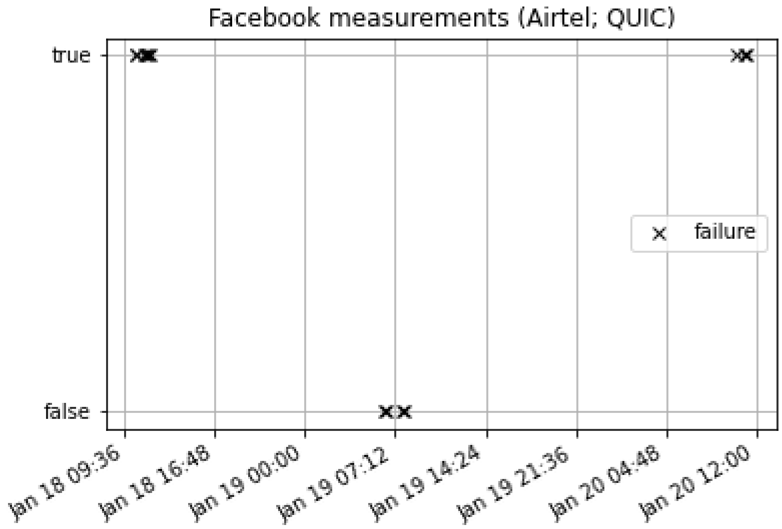


*Figure*: Facebook measurements from Airtel (using QUIC)

We retried using `example.com` as the SNI. The QUIC handshake, of course, completed successfully (see, e.g., #1, #2, #3). There was no reason to expect otherwise. The QUIC handshake succeeded for `facebook.com` and `www.facebook.com` as well. We cannot say whether the failures were in some way related to using Facebook SNIs in the QUIC handshake.

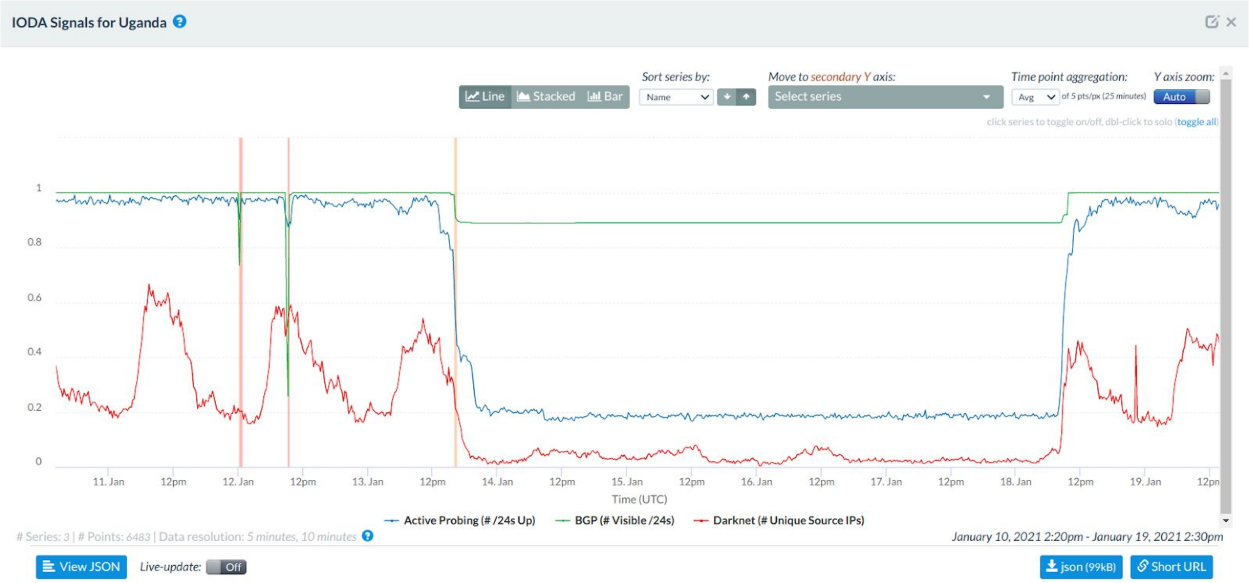
It remains nonetheless curious that we had observed QUIC failures when using Facebook QUIC endpoints at the same time when the TCP endpoints were failing.

Internet outage amid 2021 general election

On the eve of Uganda's 2021 general election (in the evening of 13th January 2021), the country was disconnected from the internet entirely. Uganda remained disconnected from the internet on election day (14th January 2021), and the nationwide internet outage lasted for almost 5 days (as internet connectivity was restored in the morning of 18th January 2021). This internet outage is visible through several public data sources: Internet Outage Detection and Analysis (IODA), Oracle's Internet Intelligence Map, Cloudflare Radar, and Google traffic data.

The Internet Outage Detection and Analysis (IODA) project of the Center for Applied Internet Data Analysis (CAIDA) measures Internet blackouts worldwide in near real-time. To track and identify internet outages, IODA uses three complementary measurement and inference methods: Routing (BGP) announcements, Active Probing, and Internet Background Radiation (IBR) traffic. Access to IODA measurements is openly available through their Dashboard, which enables users to explore internet outages with county, region, and AS level of granularity.

IODA data from the following chart (taken from the IODA dashboard) clearly shows that Uganda experienced a widespread internet outage, starting at around 16:00 UTC on 13th January 2021 (which is 19:00 in Uganda, the same time that the UCC instructed the suspension of all internet gateways), and lasting up until around 09:30 UTC on 18th January 2021.


IODA Signals for Uganda

Sort series by: Name

Move to secondary Y axis: Select series

Time point aggregation: Avg of 5 pts/px (25 minutes)

Y axis zoom: Auto

Series: 3 | # Points: 6483 | Data resolution: 5 minutes, 10 minutes

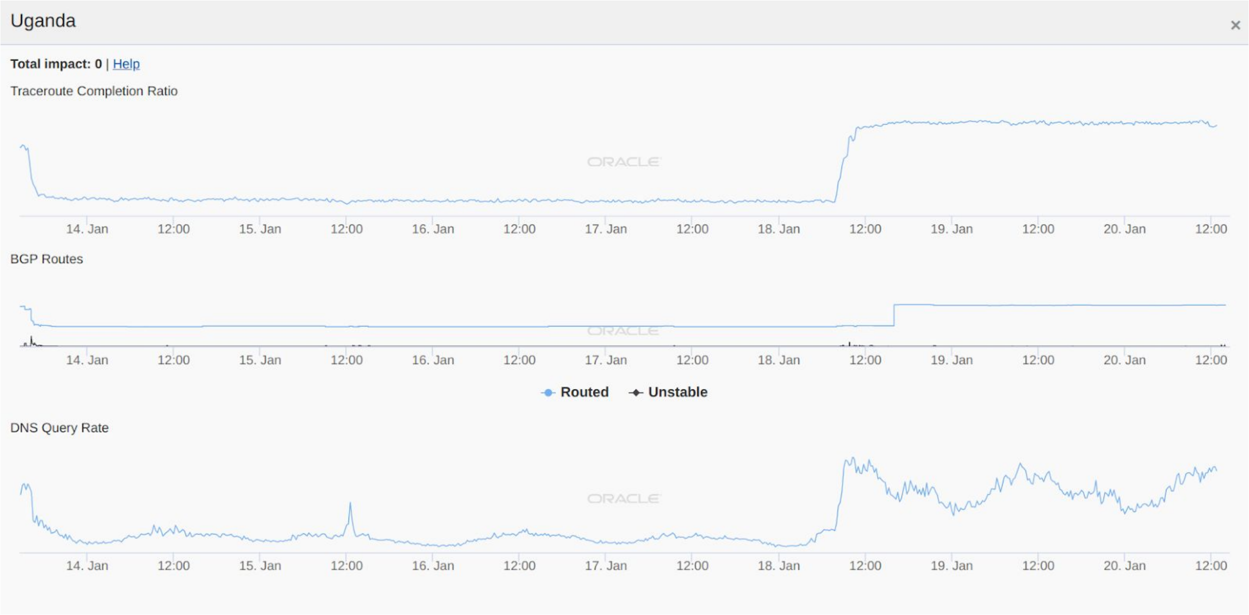
January 10, 2021 2:20pm - January 19, 2021 2:30pm

Live-update: Off

Source: Internet Outage Detection and Analysis (IODA), IODA Signals for Uganda, https://ioda.caida.org/ioda/dashboard#view=inspect&entity=country/UG&lastView=overview&from=1610280000&until=1611057600

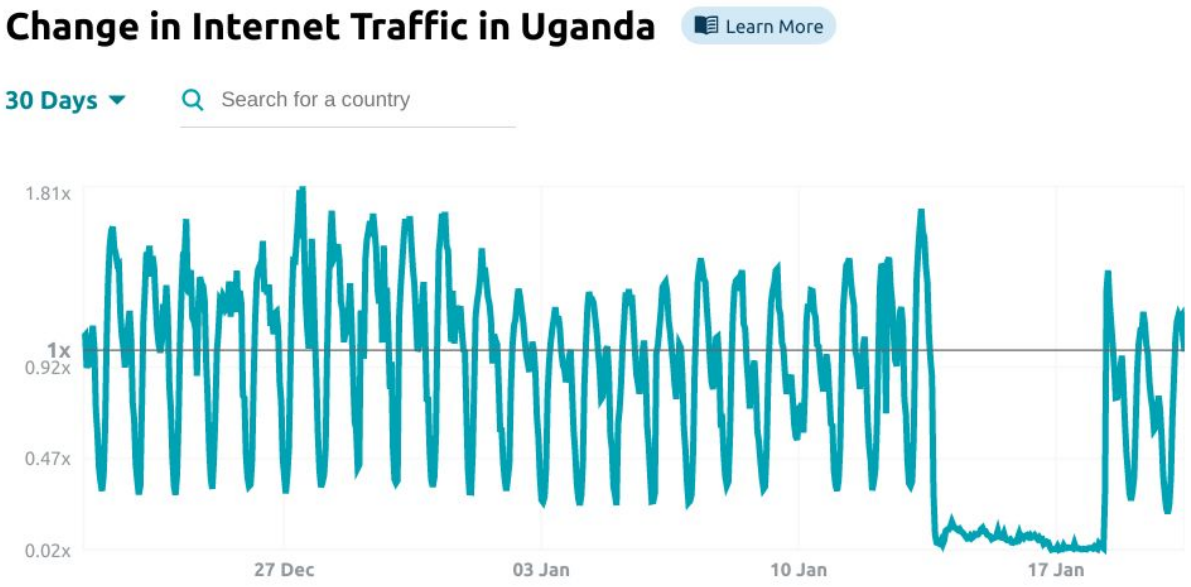
Within this time period, we observe a major drop in both active probing and IBR signals, and also a drop in the BGP signal correlating in time with the drop in the other signals, strongly suggesting that Uganda experienced a widespread internet outage. This is further indicated by the fact that we see these signals resume to their previous levels on 18th January 2021.

Quite similarly, Oracle’s Internet Intelligence Map tracks internet disruptions worldwide based on three signals: Traceroute completion ratio, BGP routes, and DNS query rate. Between 13th to 18th January 2021, Oracle’s Internet Intelligence Map records the same internet outage in Uganda as IODA data (with almost identical timings in the drop of signals).



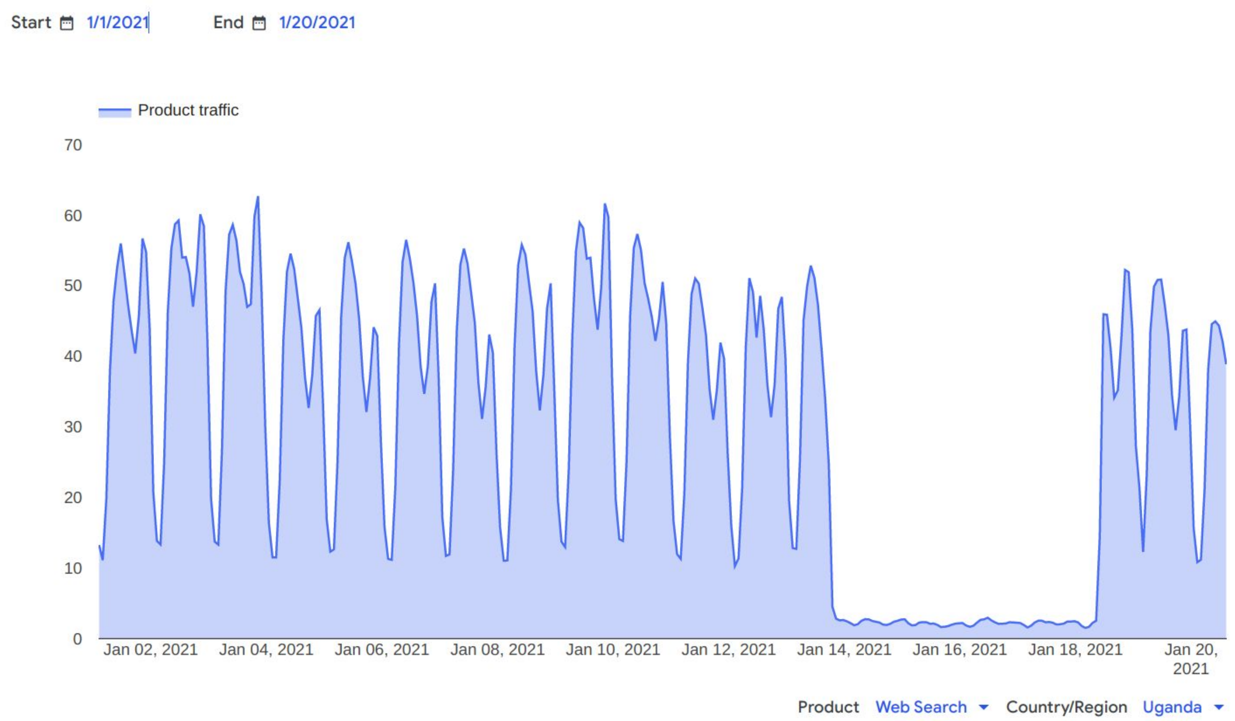
Source: Oracle Internet Intelligence Map, Uganda (January 2021), https://map.internetintel.oracle.com/?root=national&country=UG

This internet outage is further corroborated by Cloudflare Radar data, which tracks internet traffic disruptions worldwide. The following graph clearly shows that almost no internet traffic originated from Uganda between (the evening of) 13th January 2021 to (the morning of) 18th January 2021 -- similarly to both IODA and Oracle Internet Intelligence data.



Source: Cloudflare Radar, Change in Internet Traffic in Uganda (January 2021), https://radar.cloudflare.com/ug?date_filter=last_30_days

Uganda’s internet outage is further corroborated by Google traffic data, which very visibly shows that almost no Google traffic originated from Uganda during the same time period. It also shows that Google traffic resumed on 18th January 2021, similarly to what is shown by IODA, Oracle Internet Intelligence, and Cloudflare Radar data.


Start 1/1/2021 End 1/20/2021

Product Web Search Country/Region Uganda

Source: Google Transparency Report, Traffic and disruptions to Google: Uganda (January 2021), https://transparencyreport.google.com/traffic/overview?hl=en&fraction_traffic=start:1609459200000;end:1611187199999;product:19;region:UG&lu=fraction_traffic

As the same internet outage (involving the same dates and times) is shown through four separate data sources, we are confident that Uganda experienced a severe internet outage amid its 2021 general election. This is further suggested by the absence of OONI measurements from Uganda during this time period (since OONI Probe requires internet connectivity to perform tests), as well as by the drastic drop in Tor users and Psiphon users during this period.

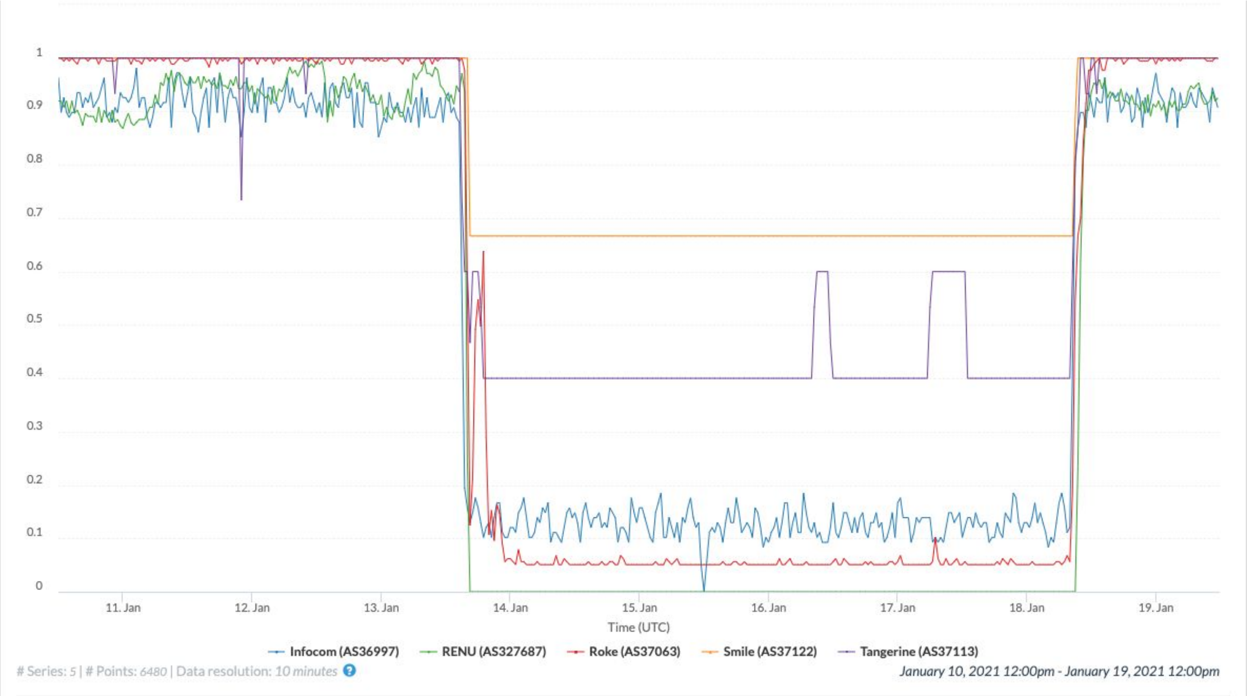
When asked about this internet outage, Mark Kiggundu, Technology Program Manager of DefendDefenders, said:

“The internet as a vast network of people, information and knowledge enable individuals to enjoy diverse human rights including the right to freedom of opinion and expression. It is also a source of livelihood for many and a major contributor to development in any given state. Therefore, interference with its access or availability not only infringes on fundamental human rights, but is also a threat to life and livelihood.”

Network-level analysis

IODA provides data at the network-level granularity, allowing us to drill-in deeper and examine which networks were affected by the internet outage in Uganda. Analyzing network-level data also allows us to examine if there were differences in the times at which the outage began and ended across various networks.

Unlike previous large-scale government-mandated blackouts (such as the Iranian nation-wide blackout in 2019) where there were significant differences in outage times across networks, many networks in Uganda appear to have experienced outages that began and ended at the same time.

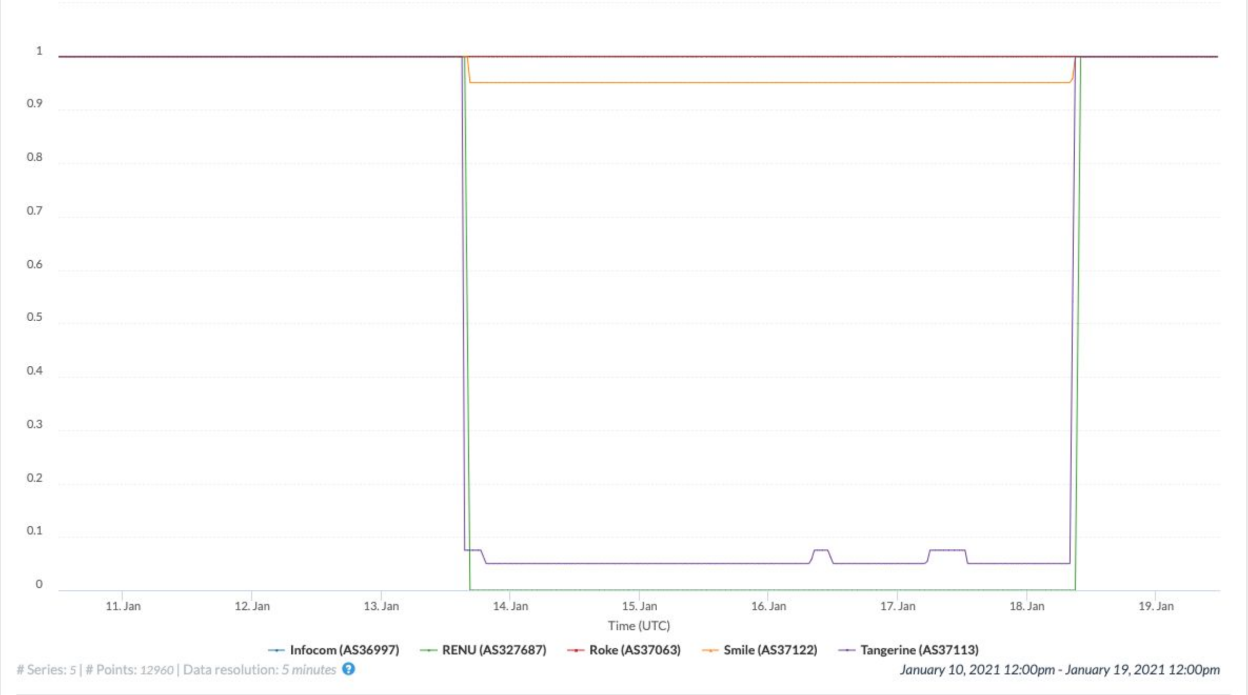


Source: Internet Outage Detection and Analysis (IODA), Active probing signals for networks whose outages began and ended at the same time.
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/36997&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/327687&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37063&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37122&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37113&lastView=overview&from=1610280000&until=1611057600

The above graph shows IODA's active probing signal for five major networks in Uganda; we see that the outage began at around 16:00 UTC on 13th January 2021 and ended at around 09:30

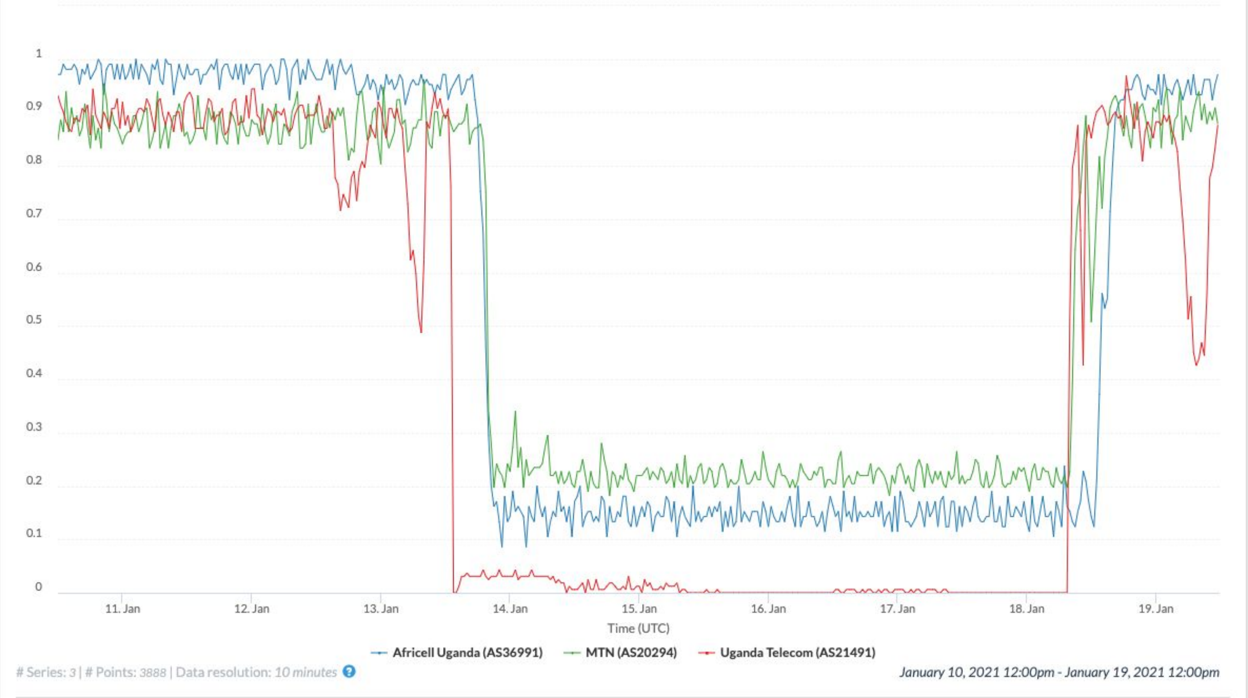
UTC on 18th January 2021 for all these networks. This level of coordination in timings suggests that network operators were able to anticipate and execute the enforcement and the relaxation of the shutdown according to pre-planned schedules.

Although the timing patterns of the outages are identical across the networks below, the way these outages manifest in IODA's signals varies.



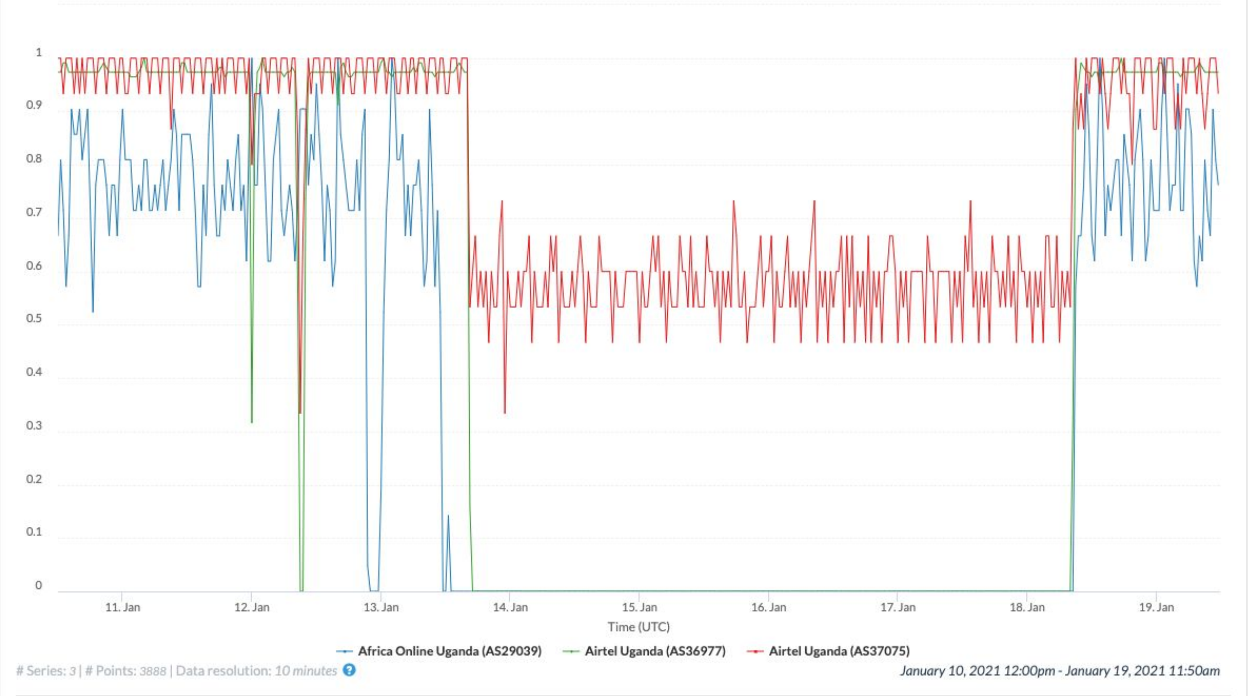
Source: Internet Outage Detection and Analysis (IODA), BGP signals for networks whose outages began and ended at the same time. Only some of these networks' outages are visible in BGP.
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/36997&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/327687&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37063&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37122&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37113&lastView=overview&from=1610280000&until=1611057600

The graph above shows IODA's BGP signals for the five networks from the previous graph that had similar outage timing patterns. We see that only some of these networks' outages are visible in the BGP signal although each had a noticeable drop in the active probing signal. There is a large drop in BGP-visible /24 blocks for RENU (AS327687) and Tangerine (AS37113) and a smaller but discernible drop for Smile (AS37122). However, Infocom (AS36997) and Roke (AS37063) do not see any drop in BGP-visible /24 blocks during this period. These dissimilarities in the outage's signature in IODA's signals may reflect the use of different approaches by these networks' operators for disconnecting their networks.



Source: Internet Outage Detection and Analysis (IODA), Active probing signals for networks whose outages began before/after 16:00 UTC on 13th January 2021 (the time at which most other networks' outages began).
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/36991&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/20294&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/21491&lastView=overview&from=1610280000&until=1611057600

Not all networks experienced the outage at the same time, however. The outage affecting Africell Uganda (AS36991) began several hours earlier, at around 13:00 UTC on 13th January 2021. On the other hand, the outage affecting MTN (AS20294) and Uganda Telecom (AS21491) began a few hours later, at around 19:00 UTC. Like the dissimilarities in outage signatures across networks, these differences in timing patterns also suggest that the implementation of the shutdown was left to the network operators.



Source: Internet Outage Detection and Analysis (IODA), Active probing signals for networks that experienced short but significant outages before 13th January 2021.
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/29039&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/36977&lastView=overview&from=1610280000&until=1611057600
https://ioda.caida.org/ioda/dashboard#view=inspect&entity=asn/37075&lastView=overview&from=1610280000&until=1611057600

Some networks appeared to experience brief but major outages even before the multi-day outage that began on 13th January 2021. Two ASNs operated by Airtel Uganda (AS36977 and AS37075) experienced a brief outage on 12th January 2021 at around 00:30 AM UTC and another short outage on 12th January 2021 at around 09:00 AM UTC. Africa Online Uganda (AS29039) experienced an outage on 12th January 2021 at around 22:00. These outages could perhaps be due to potential tests that network operators may have performed in anticipation of the government order to suspend internet connectivity.

Conclusion

During Uganda's last general election (in 2016), access to major social media platforms was blocked. Now, amid its 2021 general election, Uganda not only experienced social media blocking (regardless of OTT tax payment), but also a 4-day internet outage.

In the days leading up to Uganda's 2021 general election, ISPs appear to have blocked access to the Google Play Store (hampering people's ability to download apps), as well as to a number of social media apps (including WhatsApp, Facebook Messenger, and Telegram) and websites (such as facebook.com) -- regardless of OTT tax payment. Access to certain circumvention tool websites (such as protonvpn.com) appears to have been blocked as well, though both Tor and Psiphon appear to have worked throughout the election period.

Starting from the eve of Uganda's 2021 general election (in the evening of 13th January 2021), Uganda was disconnected from the internet entirely. The country experienced a 4-day internet outage (which included election day), as shown through several public data sources: Internet Outage Detection and Analysis (IODA), Oracle's Internet Intelligence Map, Cloudflare Radar, and Google traffic data. This is further corroborated by the absence of OONI measurements from Uganda during this time period (since OONI Probe requires internet connectivity to perform tests), as well as by the drastic drop in Tor users and Psiphon users during this period.

Even though internet connectivity in Uganda was restored on 18th January 2021, access to social media and circumvention platforms remained blocked. Notably, Ugandan ISPs only appear to have started blocking access to YouTube on 18th January 2021, even though the platform is *not* included on the OTT list of taxed platforms.

While Ugandan ISPs (such as MTN) have been transparent to their customers about these internet restrictions, the necessity and proportionality of these restrictions remain quite unclear, particularly since they coincided with the electoral process when access to information and communications platforms is crucial.

Acknowledgements

We thank OONI Probe users in Uganda who contributed measurements, making this study possible.