The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic

Oliver Gasser, Max Planck Institute for Informatics

RIPE81 Meeting | Virtual | 27-30 Oct 2020
COVID-19 and the Internet
COVID-19 and the Internet

Coronavirus: Half of humanity now on lockdown as 90 countries call for confinement

The New York Times

Working From Home: How Coronavirus Could Affect the Workplace

Will Shift to Remote Teaching Be Boon or Bane for Online Learning?

Reuters

Under lockdown, Italy's social and family life goes virtual
COVID-19 and the Internet

The Internet is essential in all these efforts, but how well does it cope?
Goals of this presentation

- Understand the **impact** of the COVID-19 pandemic on different types of networks
Goals of this presentation

- Understand the **impact** of the COVID-19 pandemic on different types of networks
- Present our results from **different networks** in the core and at the edge
Goals of this presentation

• Understand the **impact** of the COVID-19 pandemic on different types of networks

• Present our results from **different networks** in the core and at the edge

• Get to know your **experience** during COVID-19
Lots of data

- Edge network: Large European ISP
- Core networks: 3 IXPs in Central Europe, Southern Europe, and at US East Coast
- Academic network: REDIMadrid university network in Madrid
Lots of data, lots of data crunchers

- **Edge network:** Large European ISP
- **Core networks:** 3 IXPs in Central Europe, Southern Europe, and at US East Coast
- **Academic network:** REDIMadrid university network in Madrid

Anja Feldmann  
MPII

Oliver Gasser  
MPII

Franziska Lichtblau  
MPII

Enric Pujol  
BENOCS

Ingmar Poese  
BENOCS

Christoph Dietzel  
DE-CIX

Daniel Wagner  
DE-CIX

Matthias Wichtlhuber  
DE-CIX

Juan Tapiador  
Universidad Carlos III de Madrid

Narseo Vallina Rodriguez  
IMDEA, ICSI

Oliver Hohlfeld  
Brandenburg University of Technology

Georgios Smaragdakis  
TU Berlin, MPII
Traffic changes in different networks
Traffic changes from January 2019 to June 2020

- ISP, Europe (>15M fixed-network lines)
- COVID-19 outbreak in Europe
- Initial responses and lockdowns

The graph shows a significant increase in normalized traffic volume due to the COVID-19 outbreak in Europe, particularly in the initial responses and lockdowns period in 2020.
Once the lockdown started the ISP saw a +30% increase in traffic which normally spans over multiple months.
Traffic changes from January 2019 to June 2020

Similar behavior for the IXPs; for the IXP CE and IXP US the traffic levels remain elevated.
Once the lockdown started mobile traffic decreased measurably and increased again with the first relaxations in mid April.
Changes in workday vs. weekend patterns at the ISP

- Regular patterns
  - Workday: Strong increase in evening hours
  - Weekend: More traffic during daytime
- During lockdown: Workdays look more like weekends
Changes in workday vs. weekend patterns at the ISP

- **Regular patterns**
  - Workday: Strong increase in evening hours

During lockdown: Workdays look more like weekends
Regular patterns
- Workday: Strong increase in evening hours
- Weekend: More traffic during daytime
Changes in workday vs. weekend patterns at the ISP

- Regular patterns
  - Workday: Strong increase in evening hours
  - Weekend: More traffic during daytime
- During lockdown: Workdays look more like weekends
Classify days into workdays or weekends using traffic patterns.
Classify days into workdays or weekends using traffic patterns

- Pre-lockdown: Most days are classified correctly
- During lockdown: Workdays are classified as weekends; recovering after mid-May
Classify days into workdays or weekends using traffic patterns.

Pre-lockdown: Most days are classified correctly.

During lockdown: Workdays are classified as weekends.
Classify days into workdays or weekends using traffic patterns
Pre-lockdown: Most days are classified correctly
During lockdown: Workdays are classified as weekends; recovering after mid-May
Changes in workday vs. weekend patterns: ISP vs. IXP

ISP

Mon-Fri with workday-like pattern
Sat-Sun with weekend-like pattern

Date
Jan 1 Feb 1 Mar 1 Apr 1 May 1 Jun 1
Norm. traffic volume

Mon-Fri
Sat-Sun

IXP

Mon-Fri with workday-like pattern
Sat-Sun with weekend-like pattern

Date
Jan 1 Feb 1 Mar 1 Apr 1 May 1 Jun 1
Norm. traffic volume

Mon-Fri
Sat-Sun

At both vantage points workdays are mostly classified as weekends
Changes in workday vs. weekend patterns: ISP vs. IXP

- At both vantage points workdays are mostly classified as weekends
Poll

Q: Did the traffic in YOUR network change during the lockdown?

- Increase in traffic (more than 10%)
- No significant change (0–10%)
- Decrease in traffic
Application-level traffic changes
Classify traffic by application class

- Classify based on transport ports and src/dst ASes
Classify traffic by application class

- Classify based on transport ports and src/dst ASes

Email during working hours
- Video, gaming, and social media during evening hours
- Hardly any web conferencing
Classify traffic by application class

- Classify based on transport ports and src/dst ASes

- Email during working hours

- Video, gaming, and social media during evening hours

- Hardly any web conferencing
Classify traffic by application class

- Classify based on transport ports and src/dst ASes

<table>
<thead>
<tr>
<th>Day</th>
<th>CDN</th>
<th>Educational</th>
<th>Social media</th>
<th>Gaming</th>
<th>VoD</th>
<th>Email</th>
<th>Coll. working</th>
<th>Web conf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thu</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fri</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sun</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tue</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Email during working hours
- Video, gaming, and social media during evening hours
Classify traffic by application class

- Classify based on transport ports and src/dst ASes
- Email during working hours
- Video, gaming, and social media during evening hours
- Hardly any web conferencing
Changes in application classes: Central European IXP

March:
• Increase in web conf., VoD, and gaming
• Partial decrease in CDN and educational traffic

April:
• Strong increase in web conf.
• Decrease in CDN and social media traffic
March:

- Increase in web conf., VoD, and gaming
- Partial decrease in CDN and educational traffic
Changes in application classes: Central European IXP

March:
- Increase in web conf., VoD, and gaming
- Partial decrease in CDN and educational traffic

April:
- Strong increase in web conf.
- Decrease in CDN and social media traffic
Changes in application classes: Central European IXP

March:
- Increase in web conf., VoD, and gaming
- Partial decrease in CDN and educational traffic

April & June:
- Strong increase in web conf.
- Decrease in CDN and social media traffic
VPN traffic: Central European IXP

VPN identification

- Port-based: Well known port/proto combinations exclusively used by VPN services
- Domain-based: For TCP/443 traffic, IPs labeled "*vpn*", but not "www".

11
VPN traffic: Central European IXP

VPN identification

- Port-based: Well known port/proto combinations exclusively used by VPN services
- Domain-based: For TCP/443 traffic, IPs labeled *\texttt{vpn}*, but not *\texttt{www}*. 

![Graph showing VPN traffic comparison](image-url)
VPN traffic: Central European IXP

VPN identification

- Port-based: Well known port/PROTO combinations exclusively used by VPN services
- Domain-based: For TCP/443 traffic, IPs labeled *vpn*, but not www.

- 200% increase in VPN traffic in March during working hours
VPN traffic: Central European IXP

VPN identification

- Port-based: Well known port/proto combinations exclusively used by VPN services
- Domain-based: For TCP/443 traffic, IPs labeled *vpn*, but not www.

- 200% increase in VPN traffic in March during working hours
- Slight decrease in April
VPN traffic: Central European IXP

VPN identification

- Port-based: Well known port/proto combinations exclusively used by VPN services
- Domain-based: For TCP/443 traffic, IPs labeled *vpn*, but not www.

- 200% increase in VPN traffic in March during working hours
- Slight decrease in April & June
Poll

Q: Did certain parts of the traffic in YOUR network change during the lockdown?

- Increase for certain parts of the traffic
- Decrease for certain parts of the traffic
- Increase & decrease for certain parts of the traffic
- No change
How did edu traffic change?
Daily connections for different traffic classes at REDIMadrid

- Increase in incoming web and VPN traffic
- Decrease of outgoing QUIC traffic

<table>
<thead>
<tr>
<th>Feb 27</th>
<th>Mar 4</th>
<th>Mar 11</th>
<th>Mar 18</th>
<th>Mar 25</th>
<th>Apr 1</th>
<th>Apr 8</th>
<th>Apr 15</th>
</tr>
</thead>
<tbody>
<tr>
<td>VPN (In)</td>
<td>Web (In)</td>
<td>QUIC (Out)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Transition phase

Relative daily growth (Log)

Easter
Daily connections for different traffic classes at REDIMadrid

- Increase in incoming web and VPN traffic
- Decrease of outgoing QUIC traffic
What we found
People change → traffic changes

- Traffic increase of **15-30%** within a few **days**
People change → traffic changes

- Traffic increase of **15-30%** within a few **days**
- Difference between **workday** and **weekend** vanishes

The impact of the COVID-19 pandemic is directly reflected in changes to Internet traffic.
People change → traffic changes

- Traffic increase of **15-30%** within a few **days**
- Difference between **workday** and **weekend** vanishes
- Applications for **remote work, education, VPN, and video conferencing** see significant increase in traffic
People change → traffic changes

- Traffic increase of **15-30%** within a few **days**
- Difference between **workday** and **weekend** vanishes
- Applications for **remote work, education, VPN, and video conferencing** see significant increase in traffic
- **Absence of users** can lead to decrease in traffic
People change → traffic changes

- Traffic increase of **15-30%** within a few **days**
- Difference between **workday** and **weekend** vanishes
- Applications for **remote work, education, VPN, and video conferencing** see significant increase in traffic
- **Absence of users** can lead to decrease in traffic

The impact of the COVID-19 pandemic is directly reflected in changes to Internet traffic.
Poll

Q: Is YOUR network prepared for a second lockdown?

- Yes, better than for the first lockdown
- Yes, similarly as for the first lockdown
- No, we are just hoping for the best
How did the Internet do?

The Internet at our vantage points was able to cope with

- Major demand changes
- Major application changes
How did YOUR Internet do?

The Internet at our vantage points was able to cope with

- Major demand changes
- Major application changes

How was your experience?

- How well did your network cope?
- Did you see changes in traffic patterns?
- Did you experience outages, congestion, etc.?
- Did you have to provision additional capacity?
- ...
How did YOUR Internet do?

The Internet at our vantage points was able to cope with

- Major demand changes
- Major application changes

How was your experience?

- How well did your network cope?
- Did you see changes in traffic patterns?
- Did you experience outages, congestion, etc.?
- Did you have to provision additional capacity?
- ... 

Is this the new normal?
How did YOUR Internet do?

The Internet at our vantage points was able to cope with

- Major demand changes
- Major application changes

How was your experience?

- How well did your network cope?
- Did you see changes in traffic patterns?
- Did you experience outages, congestion, etc.?
- Did you have to provision additional capacity?
- ...

Is this the new normal?

oliver.gasser@mpi-inf.mpg.de