COVID-19 and the Internet

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

Working From Home: How Coronavirus Could Affect the Workplace

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

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?
Lots of data, lots of data crunchers

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

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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.
Traffic changes from January 2019 to June 2020

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

During lockdown: Workdays look more like weekends
Changes in workday vs. weekend patterns at the ISP

- **Regular patterns**
  - Workday: Strong increase in evening hours
  - Weekend: More traffic during daytime

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VPN traffic at the 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.
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- 200% increase in VPN traffic in March during working hours
VPN traffic at the 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
People change \(\rightarrow\) 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

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- Difference between **workday and weekend** vanishes
- Applications for **remote work, education, VPN, and video conferencing** see significant increase in traffic

More in our *The Lockdown Effect* IMC 2020 paper

- Changes in transport ports
- Different traffic classes
- Educational network
- Hypergiant vs. non-hypergiant
  
  oliver.gasser@mpi-inf.mpg.de
  
  dl.acm.org/doi/10.1145/3419394.3423658
Backup
Changes in workday vs. weekend patterns at the ISP

- 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
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Changes in workday vs. weekend patterns: ISP vs. IXP

ISP

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

ISP

IXP

- At both vantage points workdays are mostly classified as weekends
Classify traffic by application class

- Classify based on transport ports and src/dst ASes
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- Email during working hours
- Video, gaming, and social media during evening hours
- Hardly any web conferencing
Classify traffic by application class

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Classify traffic by application class

- Classify based on transport ports and src/dst ASes

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- 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
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.
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March:

- Increase in web conf., VoD, and gaming
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April & June:

- Strong increase in web conf.
- Decrease in CDN and social media traffic
• Increase in incoming web and VPN traffic
• Decrease of outgoing QUIC traffic
• Increase in incoming web and VPN traffic
• Decrease of outgoing QUIC traffic
Analyzing the pandemic across time

- **base**: February before the lockdown
- **March**: During the lockdown
- **April**: First relaxation of restrictions
- **June**: Minimum restriction level

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Our analysis is based on **four weeks** representing the course of the pandemic from **February 2020** to **June 2020**.
Hypergiants vs. non-hypergiants

Normalized traffic volume

Weekend: 09:00-16:59
Weekend: 17:00-24:00
Workday: 09:00-16:59
Workday: 17:00-24:00
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**Table 1:** List of Hypergiant ASes as defined by Böttger et al.
Link-utilization before and after the lockdown at the IXP-CE

Port utilization (relative to physical capacity)

Fraction of IXP customer ports

February minimum link usage
February average link usage
February maximum link usage
March minimum link usage
March average link usage
March maximum link usage
Heatmap of traffic shift vs. residential traffic shift (Feb. vs. Mar.)

- Total traffic decrease
- Residential traffic decrease
- Total traffic increase
- Residential traffic increase
Traffic difference by top application ports at the ISP

![Graphs showing traffic differences between Feb. vs. Mar., Feb. vs. Apr., and Feb. vs. Jun.](image)

The graphs illustrate the change of normalized traffic volume for various ports over different hours of the day in February vs. March, February vs. April, and February vs. June. The ports include UDP/443, GRE, UDP/4500, TCP/8080, TCP/25461, TCP/8200, ESP, TCP/993, UDP/1194, and UDP/8801.
- Gaming: Large increase in number of active IP addresses and traffic volume
March:
- Large increase in web conf., coll. working, edu traffic
- Partial decrease in VoD and gaming

April:
- Growth in Email less pronounced
- Decrease in social media

June:
- Web conf. still growing, more focused on working hours
- Moderate growth in coll. working
- Decrease of VoD, gaming and social media
Traffic changes → networks change

- Traffic increase of **15-30%** within a few **days**
  - Networks usually provision for ≈**30%** increase per **year**
- Impact on peak traffic is limited, but **valleys get filled**
- The Central European IXP reports capacity increase of around **1,500 Gbps**
- Networks could **react quickly** to the additional need for capacity

Networks can accommodate sudden changes in demand if they are planned with spare capacity and quick reaction times.