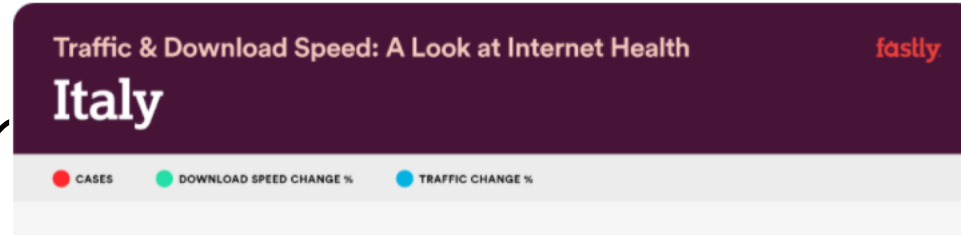


COVID-19: the Ther



Mobile Network Traffic Grew 50% Between Q3 2019 and Q3 2020

As in Q2 2020, the year-on-year traffic growth returned to a normal level, around 50%, compared to the same period in 2019 and the first part of 2019.

The quarter-on-quarter growth for mobile network traffic was also reflected in people's communication patterns, such as lockdowns and social distancing measures to be reflected in people's communication patterns.

Ericsson | December 1, 2020

COVID-19 Sees Hungarian Mobile Network Traffic Grew 50%

During the summer, Telenor saw that mobile network traffic and voice calls were 15% longer. Year-on-year growth in internet usage trends: data traffic for Telenor users. Total used GBs for Telenor users.

Budapest Business Journal | November 15, 2020

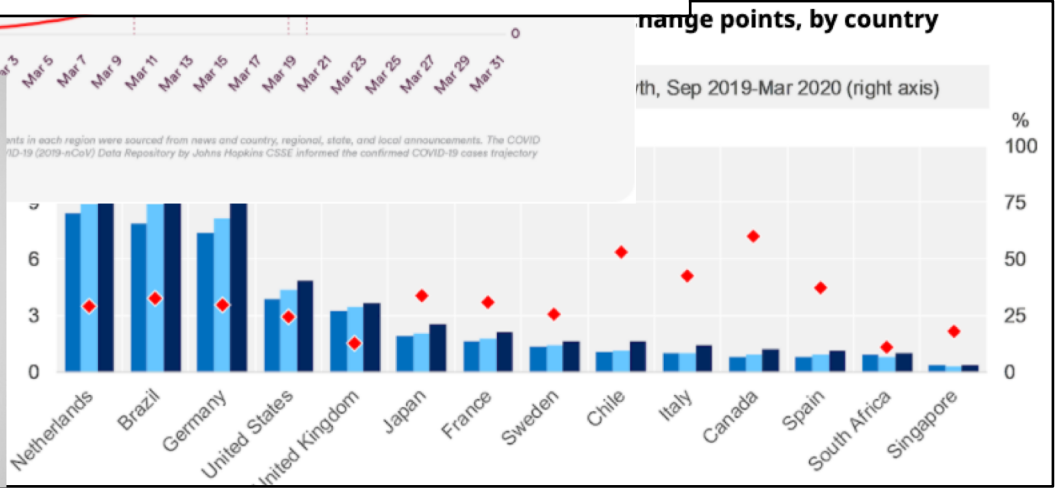
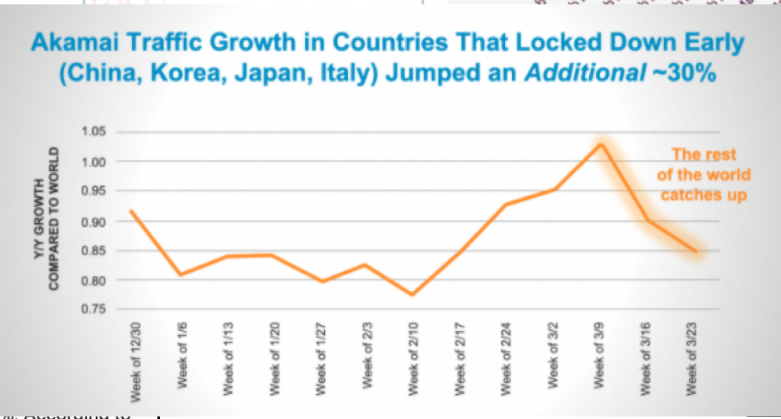
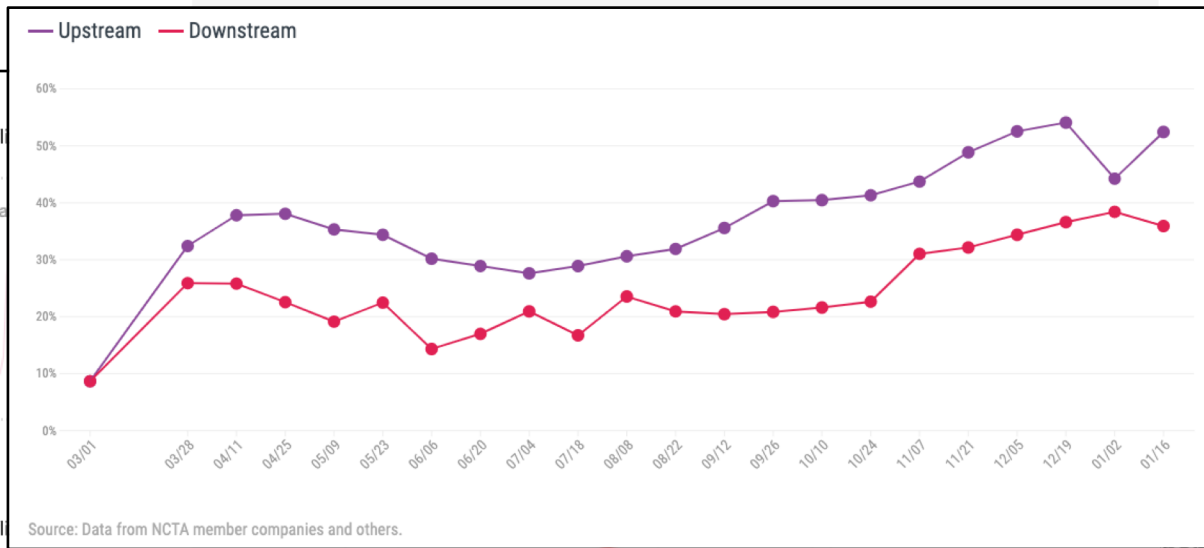
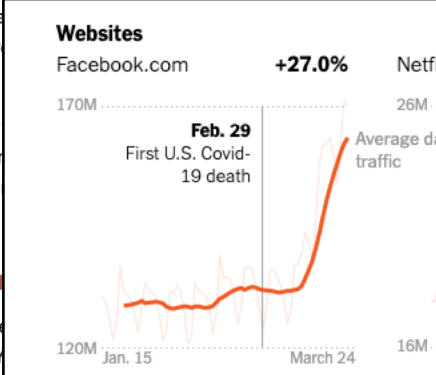
How the Internet reacted to COVID-19: perspective from Facebook

"While a surge in the popularity of video products was accompanied by significant traffic growth, the largest traffic impact resulted from video products. Moreover, we found that the impact was mainly on broadband networks."

Facebook | October 1, 2020

Ghana's Data Traffic Growth Accelerates, Vodafone Says

Chief Executive Officer of Vodafone Ghana revealed the outbreak of COVID-19 in Ghana has seen a surge in data traffic and an increased demand for network and infrastructure in Ghana.



COVID-19: the Theme of 2020

The Lockdown Effect:

Implications of the COVID-19 Pandemic on Internet Traffic

Anja Feldmann Max Planck Institute for Informatics	Oliver Gasser Max Planck Institute for Informatics	Franziska Lichtblau Max Planck Institute for Informatics
Enric Pujol BENOCS	Ingmar Poesse BENOCS	Christoph Dietzel DE-CIX Max Planck Institute for Informatics
Daniel Wagner DE-CIX	Matthias Wichtlhuber DE-CIX	Juan Tapiador Universidad Carlos III de Madrid
Narseo Vallina-Rodriguez IMDEA Networks ICSI	Oliver Hohlfeld Brandenburg University of Technology	Georgios Smaragdakis TU Berlin Max Planck Institute for Informatics

Turning Up the Dial: the Evolution of a Cybercrime Market Through SET-UP, STABLE, and COVID-19 Eras

Anh V. Vu, Jack Hughes, Ildiko Pete, Ben Collier, Yi Ting Chua, Ilia Shumailov, Alice Hutchings
firstname.lastname@cl.cam.ac.uk
Cambridge Cybercrime Centre, Department of Computer Science & Technology
University of Cambridge, Cambridge, CB3 0FD, UK

How the Internet reacted to Covid-19 – A perspective from Facebook’s Edge Network

Timm Böttger, Ghida Ibrahim and Ben Vallis
Facebook

A Characterization of the COVID-19 Pandemic Impact on a Mobile Network Operator Traffic

Andra Lutu Telefonica Research	Diego Perino Telefonica Research	Marcelo Bagnulo Universidad Carlos III de Madrid
Enrique Frias-Martinez Telefonica Research	Javad Khangosstar Telefonica UK	

- How well has the current network infra responded to the COVID stress test?
- How should the network infra evolve in the post-pandemic era?

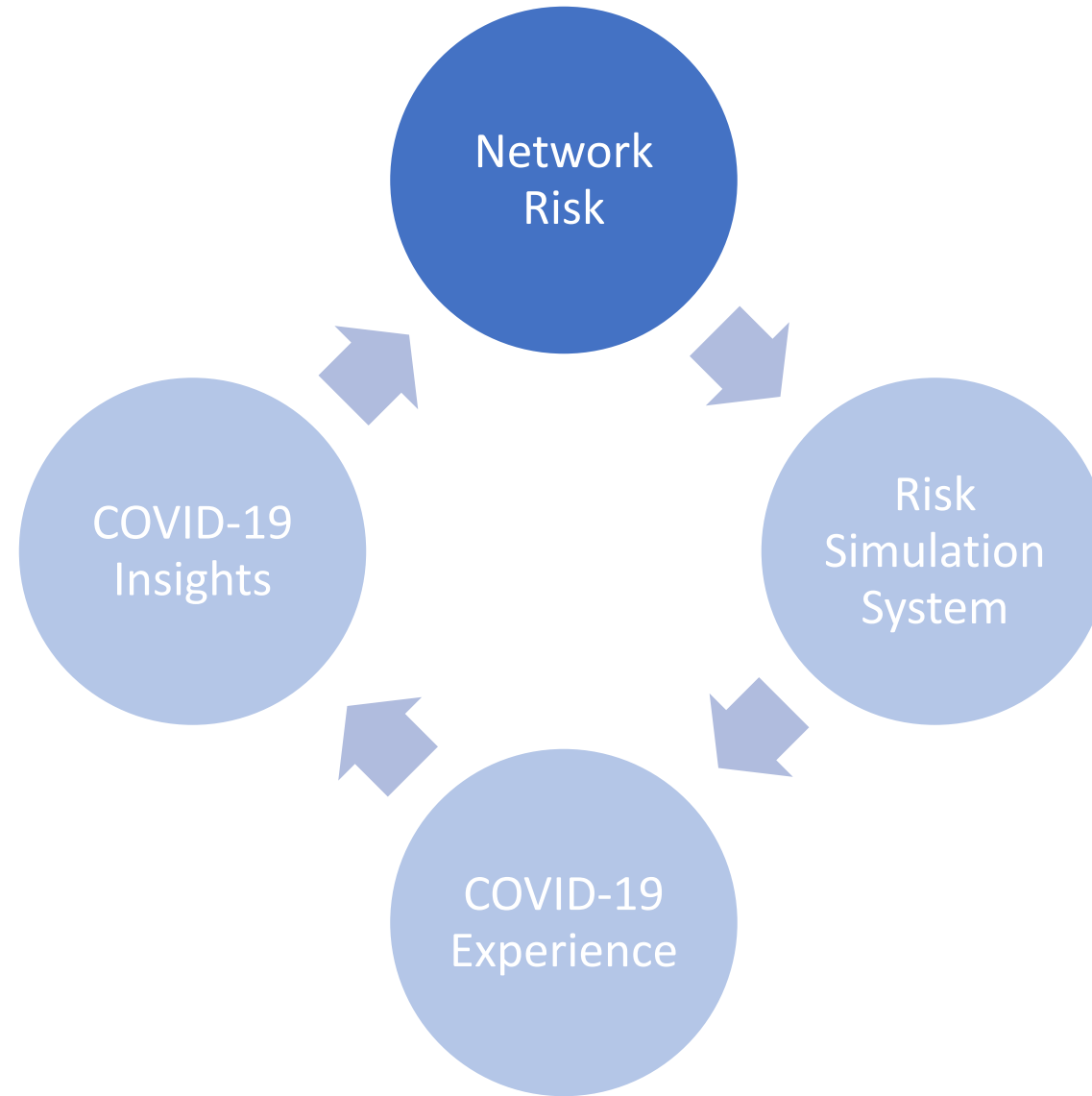
COVID-19: the Theme of 2020

The Lockdown Effect: Implications of the COVID-19 Pandemic on Internet Traffic		
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How the Internet reacted to Covid-19 – A perspective from Facebook’s Edge Network
Timm Böttger, Ghida Ibrahim and Ben Vallis Facebook

- Use *network risk* as an indicator for robustness of the network

- How well has the current network infra responded to the COVID stress test?
- How should the network infra evolve in the post-pandemic era?



Backbone Network

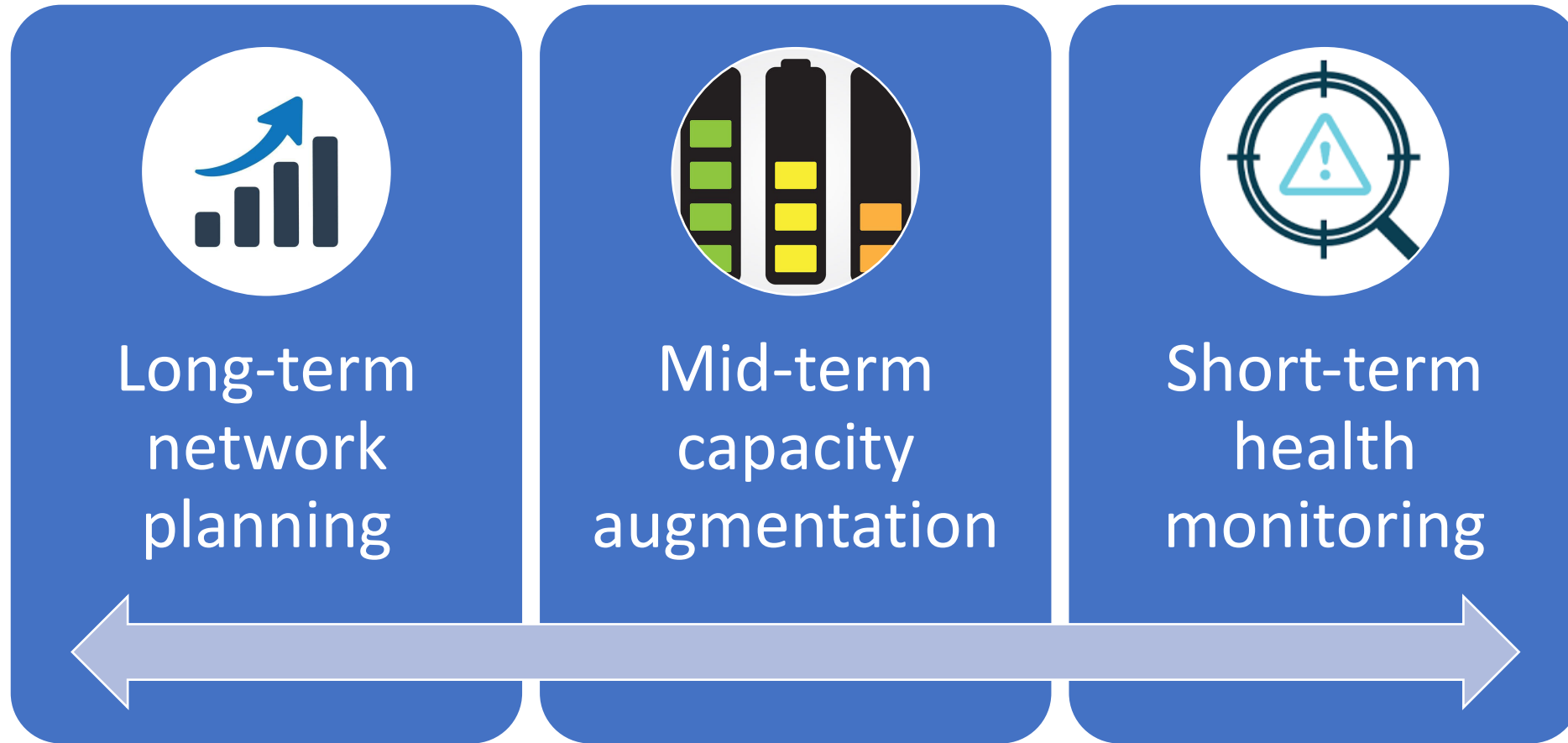


- Interconnects Point-of-Presence (PoP) and Data Center (DC) nodes
- Large scale
 - Hundreds of PoPs
 - Tens of DC regions (hundreds of DCs)
- Quality of Service (QoS)
 - 4 QoS classes for different services

Network Risk

- Failures are frequent
 - Fiber cuts, power outages, misconfigurations, etc.
 - Device thefts, hurricanes, fires, etc.
- Severe impact
 - Congestion, packet loss, long latency, availability drop, etc.
- Risk
 - Potential failures in the network
 - Anticipate the consequence before bad things happen

Network Risk



Network management lifecycle

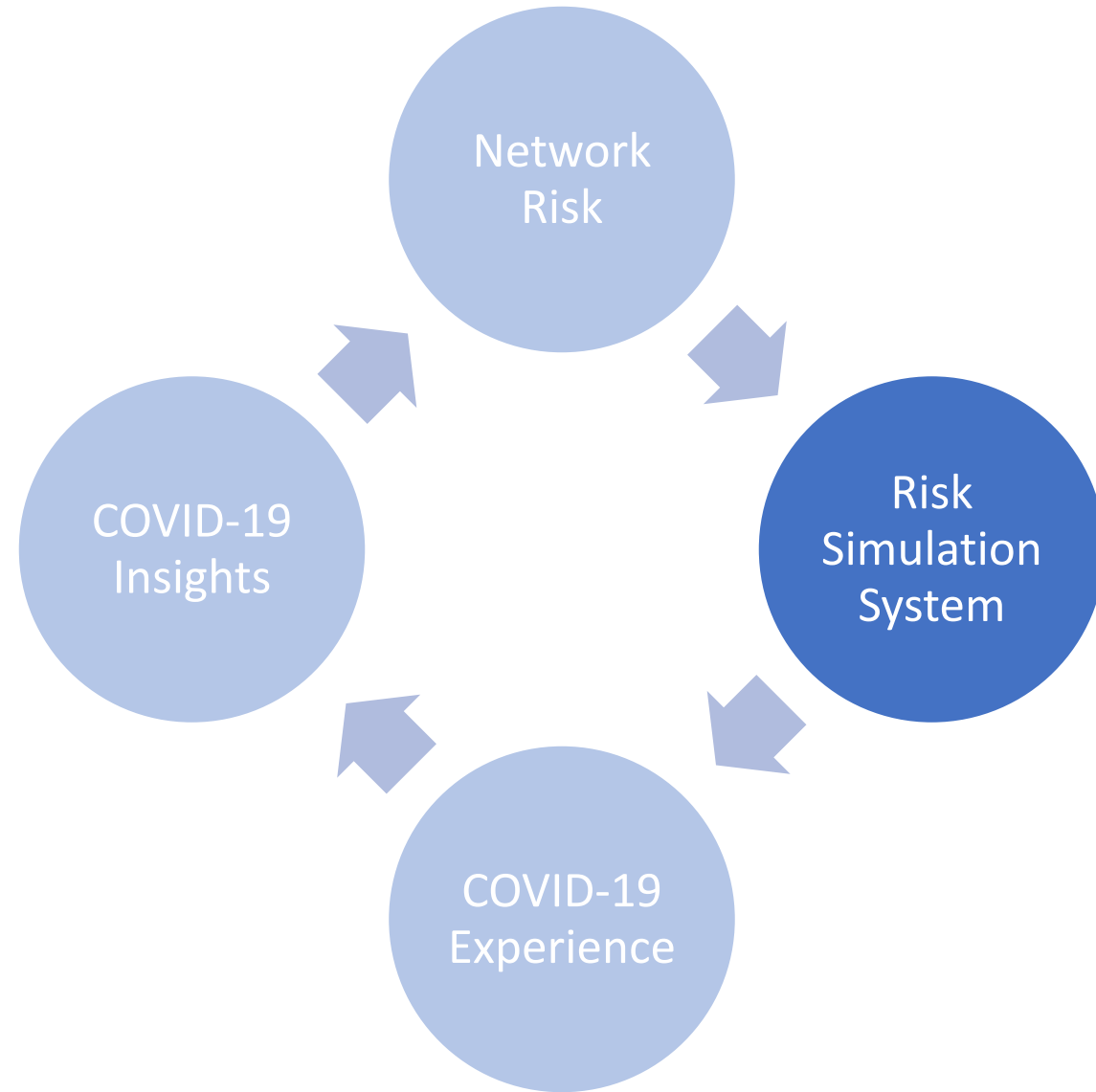
Risk Metrics

Unified metrics
across teams

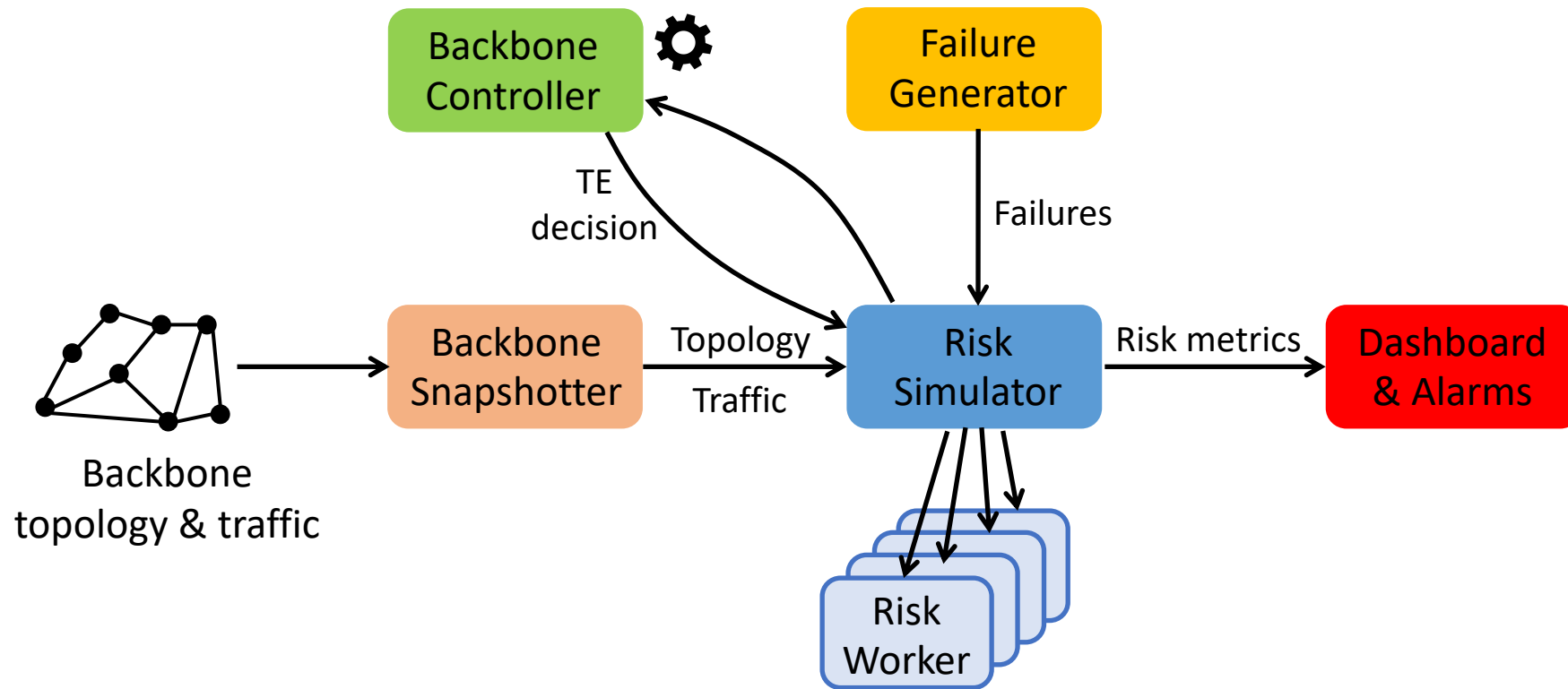
Different aspects
of failures

SLOs of QoS
classes

- Demand loss
 - Total loss of all the flows in a QoS class
 - Maximum loss across all failure scenarios
- Availability
 - Percentage of time a flow is 100% admitted
 - Lowest availability among all the flows in a QoS group
- Latency stretch
 - Path dilation of a flow against the shortest path weighted by failure probability
 - A set of the latency stretches of all the flows in a QoS group



Risk Simulation System (RSS)



RSS Operation Modes

- 18k lines of C++ code
- Several years in prod
- System optimizations

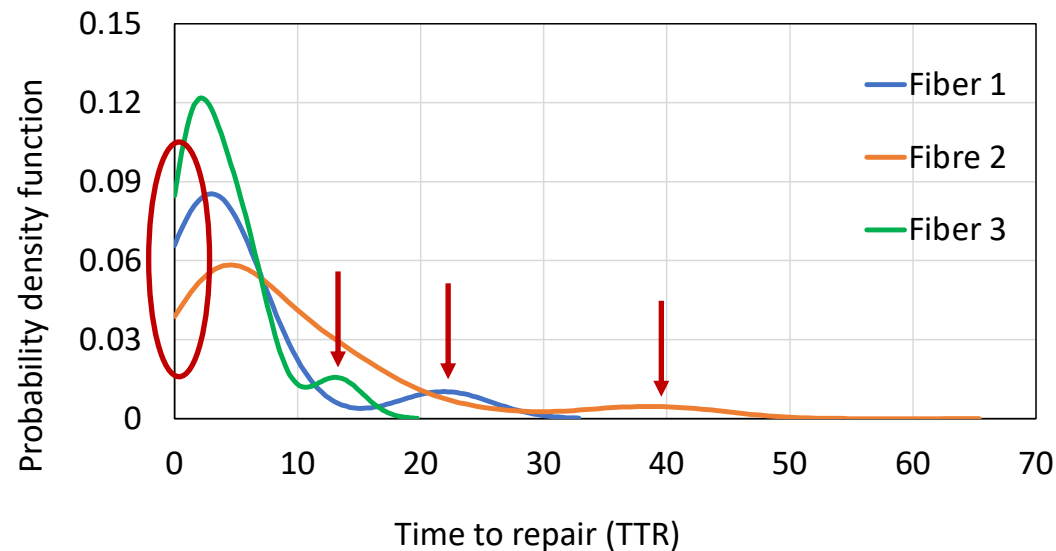
- Customized failures
 - Decommission workflow
 - Natural disasters
- QoS protection policies
 - Protected failures per QoS class
- Potential failures
 - Failure count with cutoff

Fine-grained risk simulation
Thousands of failure scenarios
~ 250s per case

Coarse-grained risk simulation
Millions of failure scenarios
~ 0.1s per case

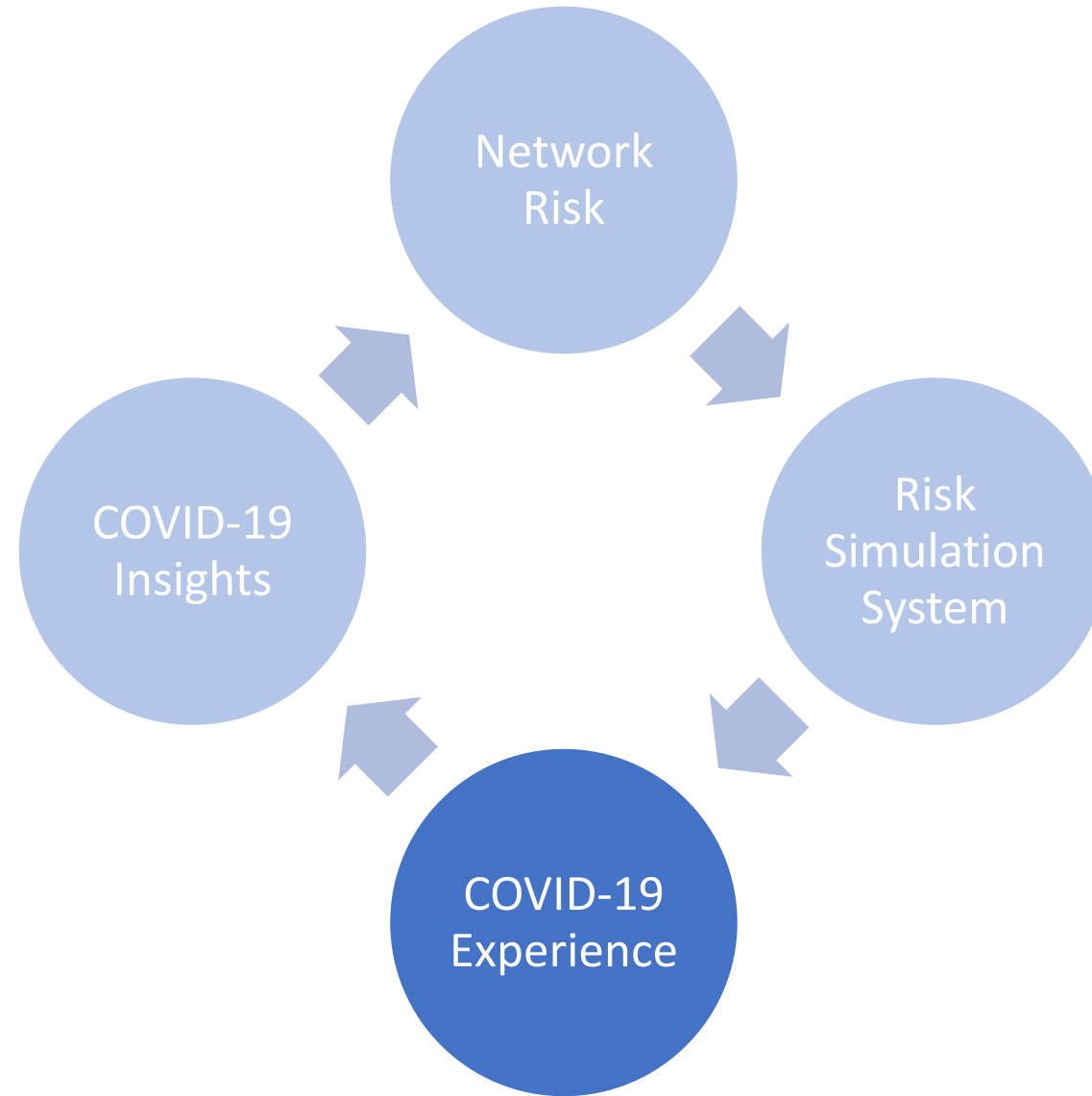
Failure Modeling Challenge

- Time To Repair (TTR) of subsea fibers follow arbitrary distributions

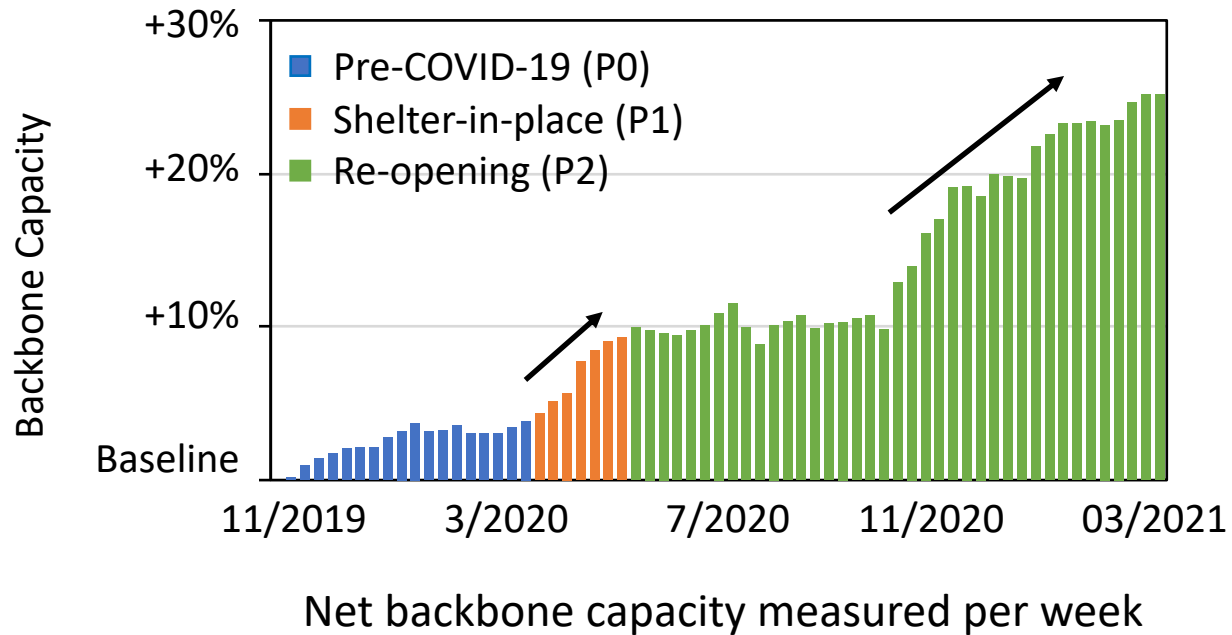


TTR distribution of three subsea fibers

- Lower bound of TTR
 - Physical time constraints for repair
 - Secure permits to enter water
 - Sailing time to failure site
- Multi-modal
 - Distinct parts
 - Different failure profiles
 - Dependent on depth under water



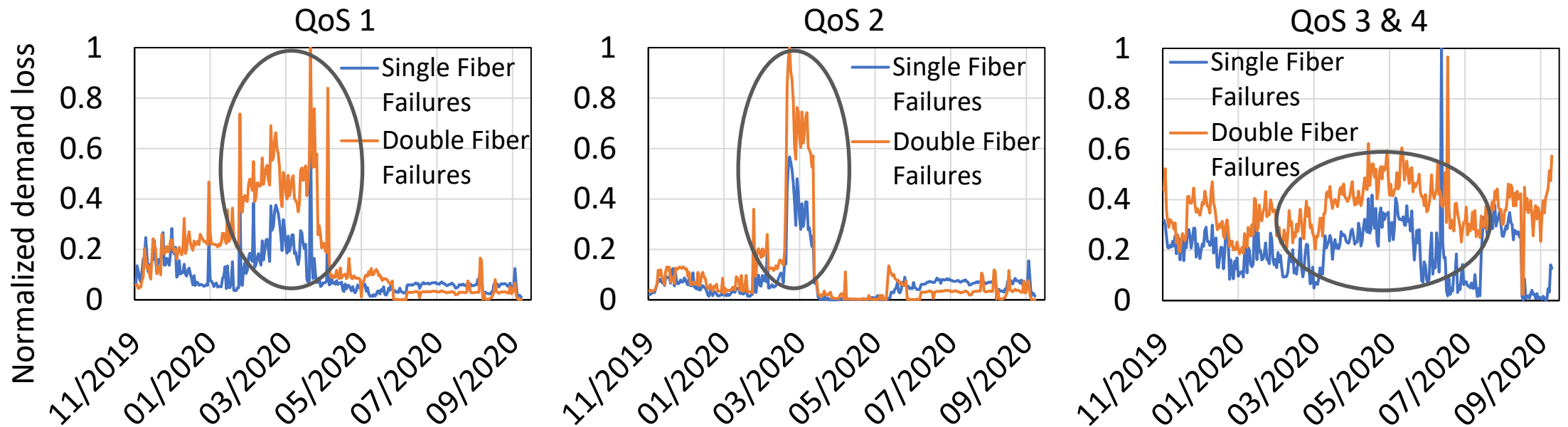
Capacity Enhancement



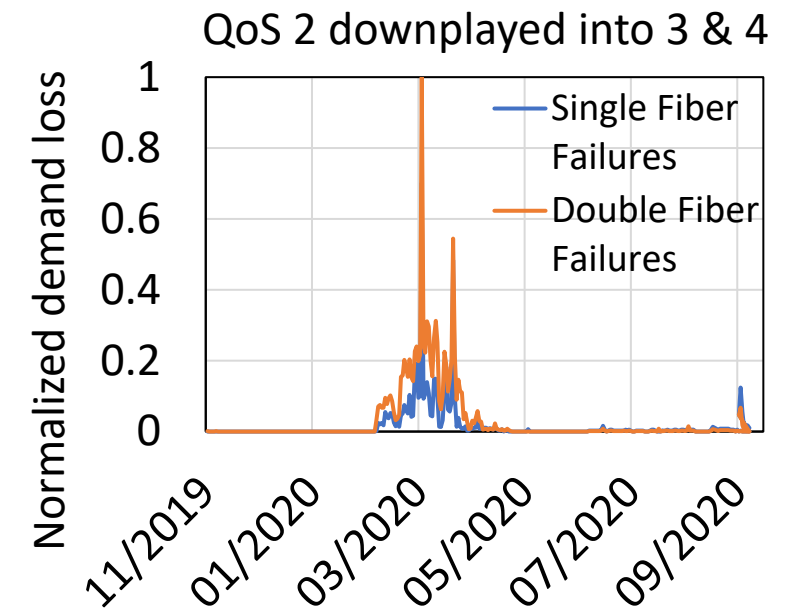
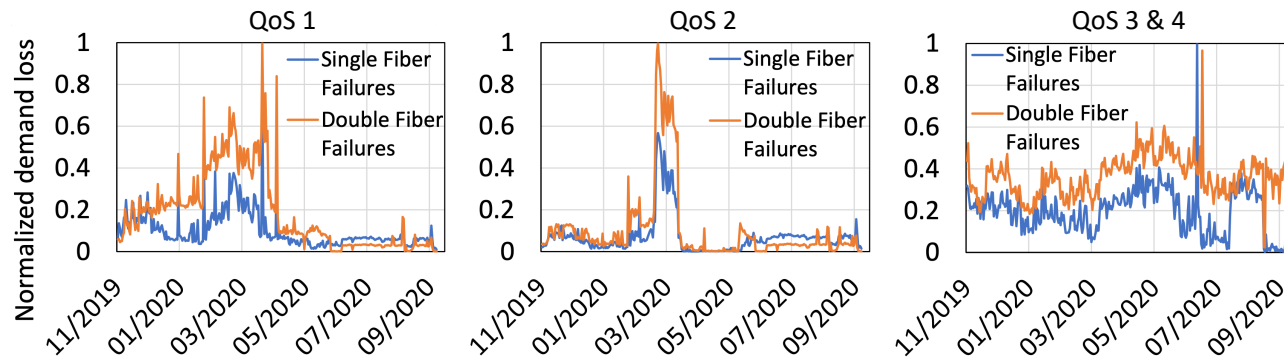
- Capacity up and down
 - Network growth
 - Migrate wavelengths
- More capacity added
 - Turn up dark fibers
 - Provision new wavelengths

QoS Downgrade

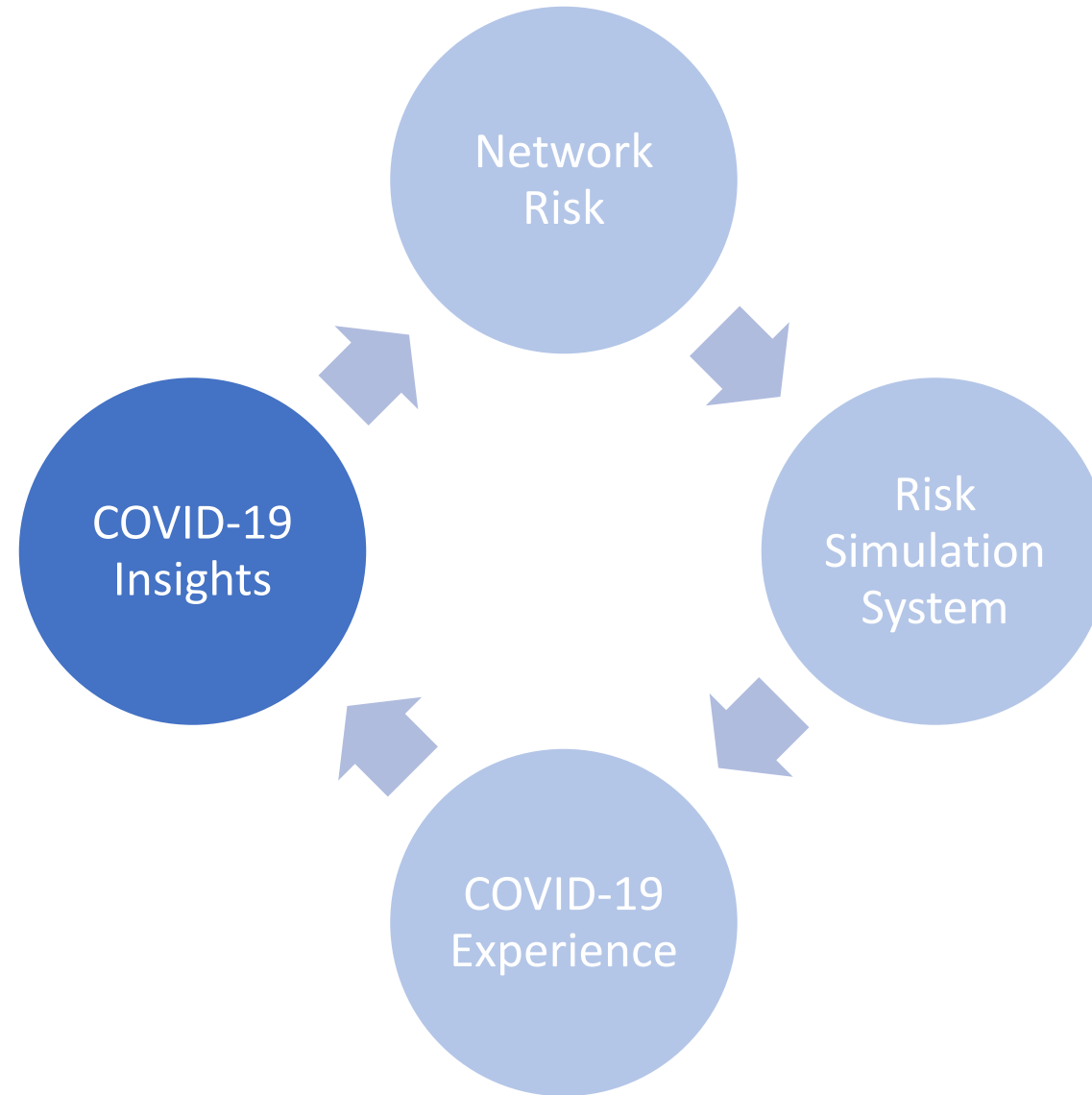
- Higher risk in QoS 1 (control messages) and QoS 2 (user traffic)
- No significant change in QoS 3 and 4 → non-user traffic
- Hypothetical demand loss related to traffic increase



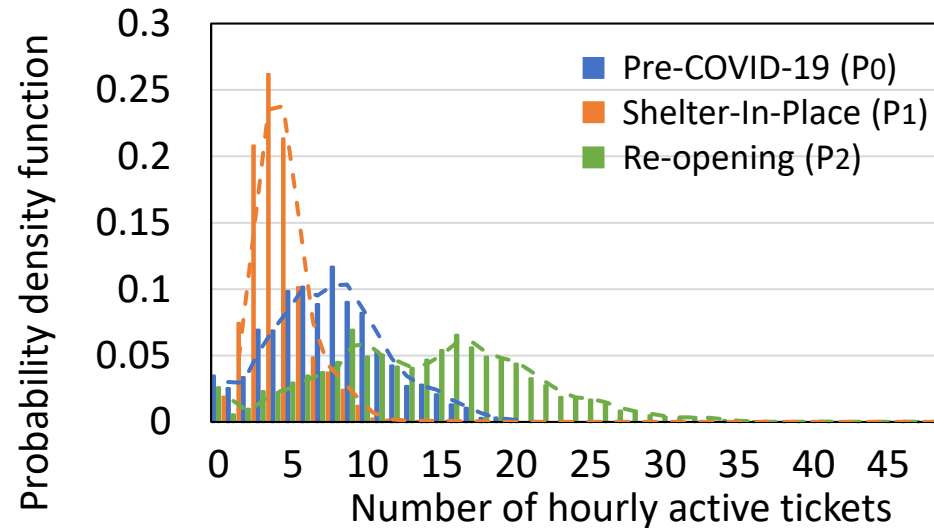
QoS Downgrade



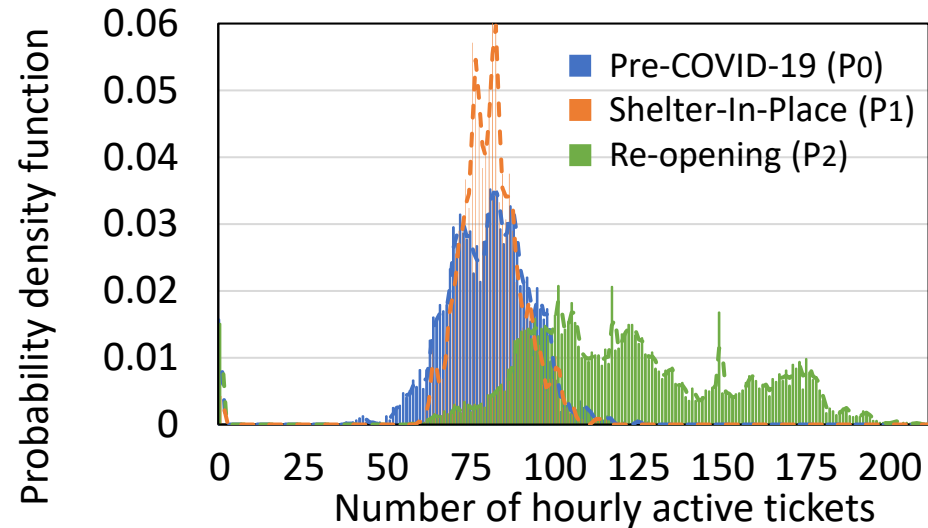
- QoS classes assigned by service
- Opportunities for optimization
 - User traffic vs. machine traffic
 - A service downgrading QoS classes if possible



Failure Statistics Change



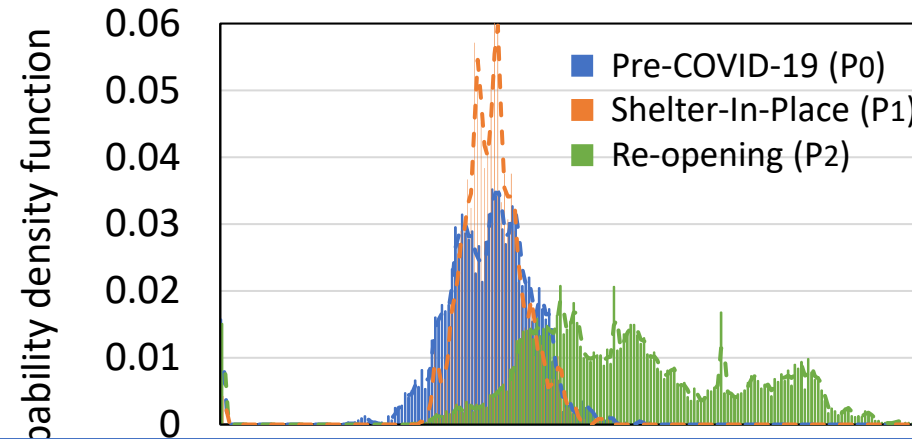
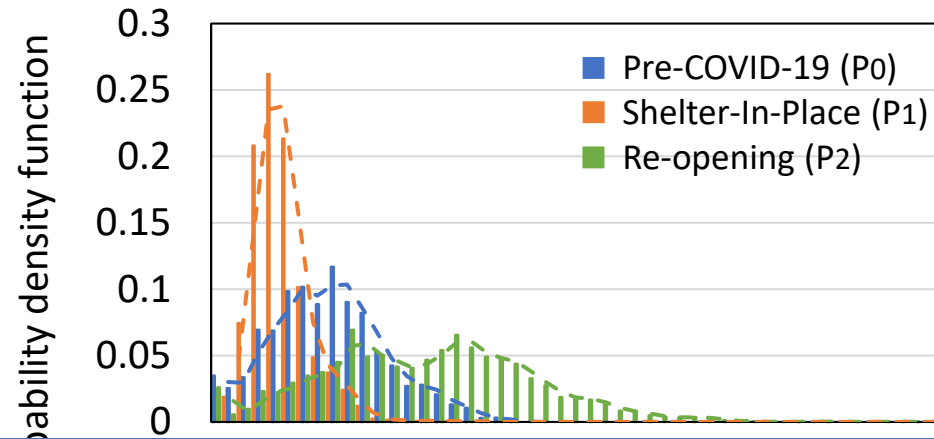
Optical failures



IP failures

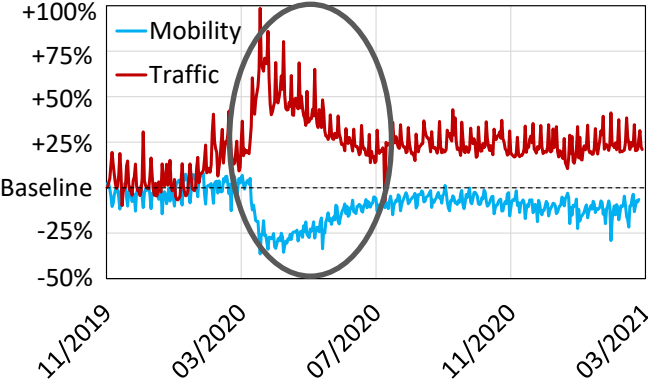
- Fewer optical failures during lockdown
 - Reduced human activity
- More optical failures after re-opening
 - More maintenance work
- IP failures remain the same during lockdown
 - Less impacted by human activity
- More IP failures after re-opening
 - More maintenance work

Failure Statistics Change

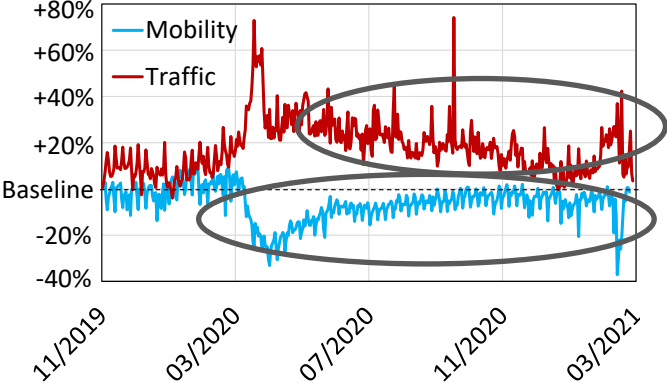


- Automate network operations → reduce human activity
- Short-term failure statistics → tradeoff between model stability and agility
- Fewer optical failures during lockdown
 - Reduced human activity
- More optical failures after re-opening
 - More maintenance work
- IP failures remain the same during lockdown
 - Less impacted by human activity
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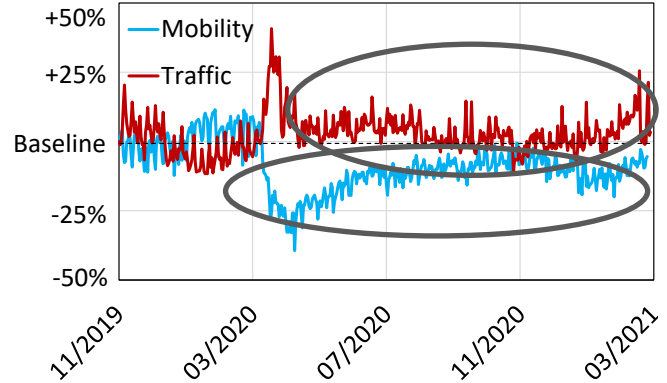
Mobility Correlated with Traffic



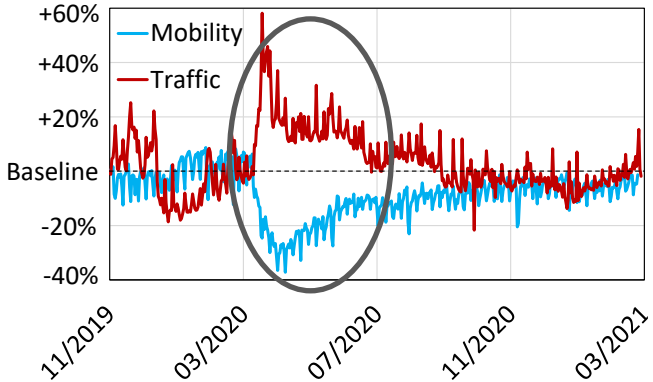
Chicago



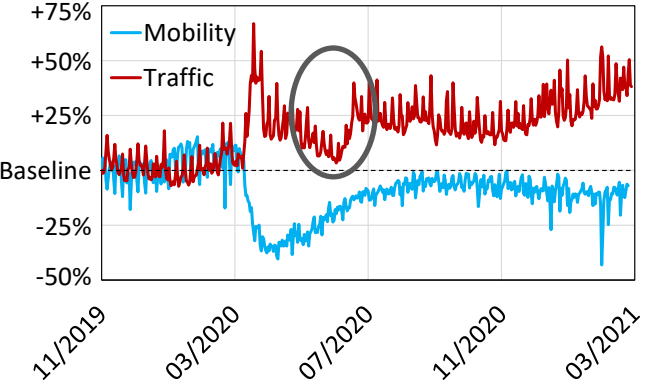
Dallas



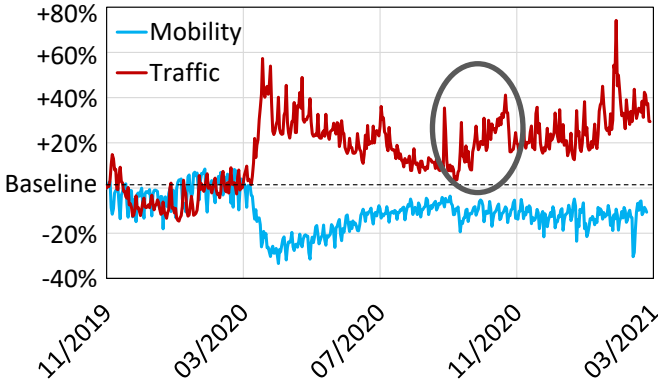
Los Angeles



Miami

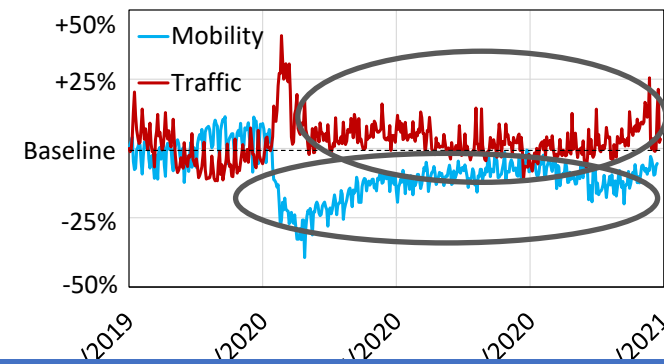
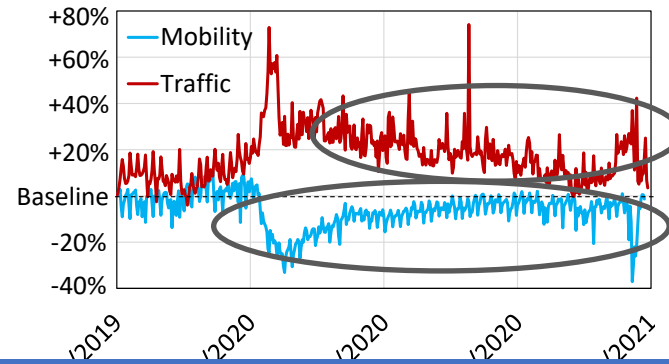
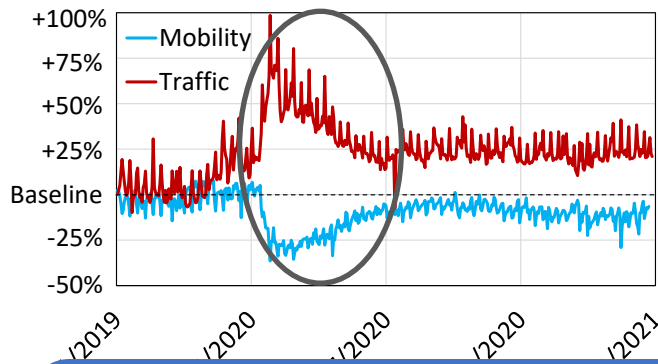


New York City

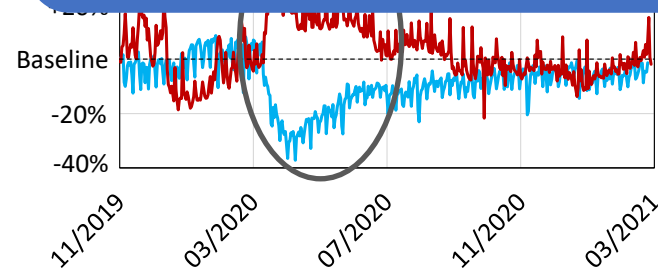


Seattle

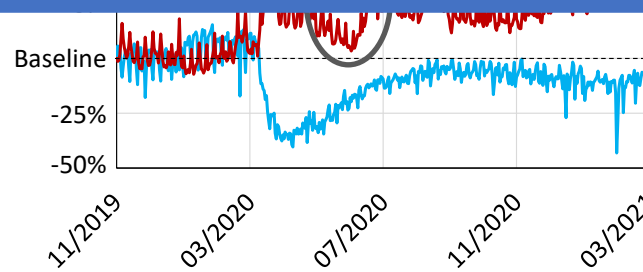
Mobility Correlated with Traffic



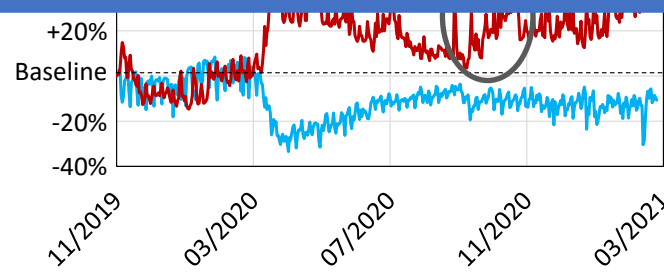
- Use offline signals for traffic prediction
- Challenging: complicated interplay of different factors, and case by case



Miami



New York City



Seattle