



RIPE NCC

RIPE NETWORK COORDINATION CENTRE

The Resilience of the Ukrainian Segment of the Internet

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Assumption vs. Reality



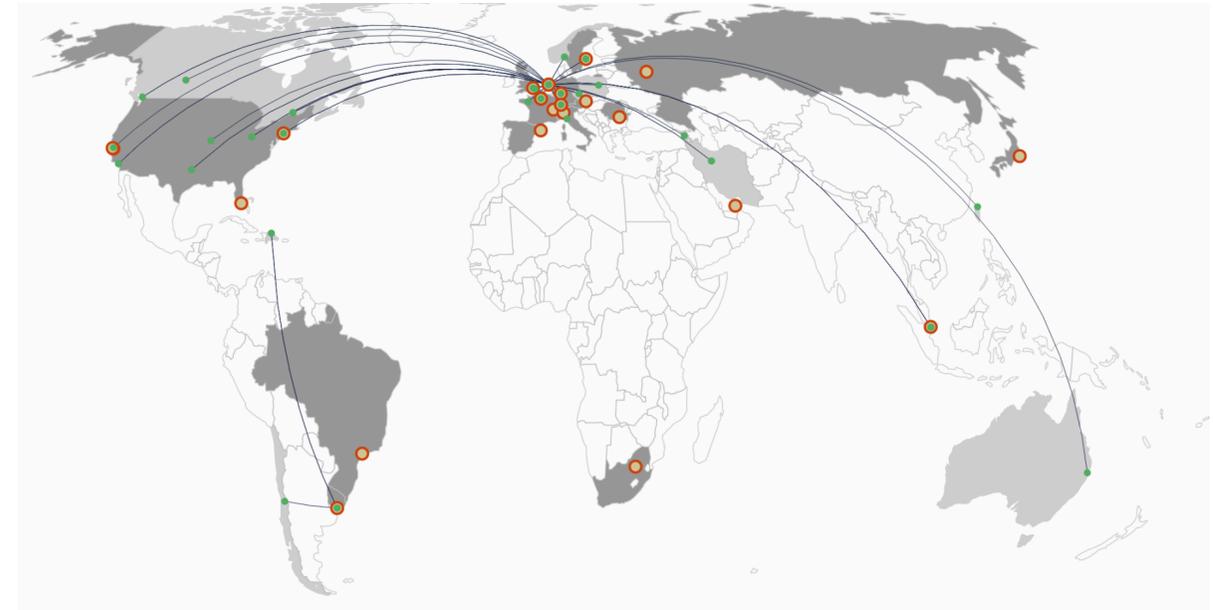
- Assumption:
 - Rapid destruction of Ukrainian Internet infrastructure

- Reality:
 - Remarkable resilience

Our Observation Systems



- RIS
 - Monitors inter-network routing system (BGP)
- RIPE Atlas
 - > 10,000 devices worldwide that monitor local Internet conditions (latency, loss)
- For community, by community



What Did We See?



- Three interesting observations:
 1. Slow - not rapid - decline in connectivity
 2. Power grid stability
 3. International connectivity changes with the outside world

1. Start of War: Slow Decline



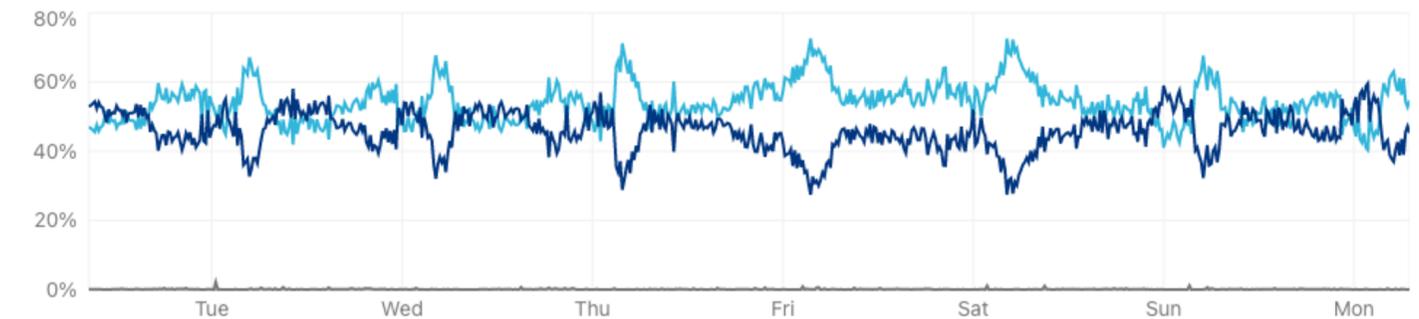
Connected RIPE Atlas probes

Customers started switching to mobile services

Mobile vs. Desktop — Ukraine (Excluding Bots / Last 7 days)



● Mobile 53% ● Desktop 46% ● Other 0%



Data shown from Feb 21, 2022 8:30 AM (UTC) to Feb 28, 2022 7:00 AM (UTC)
Source: <https://radar.cloudflare.com>

2. Electricity Grid Stability Effects



- Electricity grid under attack (October 2022 -)
- Power is key necessity for Internet infrastructure to function



Connected RIPE Atlas probes

3. How Did International Connectivity Change?



- Number of direct network connections between networks (01-01-2022 vs. 01-12-2022)
- Russia - Ukraine
 - 1,402 -> 462 (-78%)
- Russia - Rest of the world
 - 23,301 -> 21,756 (-6%)
- Ukraine - Rest of the world
 - 6,643 -> 6,905 (+4%)





Elements of Resilience

Ukrainian End-User Market Overview



- One of the least concentrated markets worldwide
 - Herfindahl-Hirschman index (HHI) based on users per ASN
 - Correlates with Huawei Cloud HHI calculation (2019)
- No dominant players in the market
 - If an individual network goes down, this has a relatively small effect on the whole network

Top 10 least concentrated markets for end-user per network (ASN)

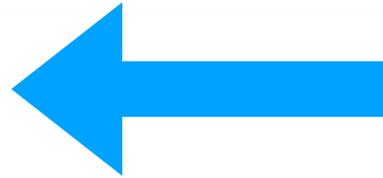
	Country	HHI
1	Brazil	0.018
2	Russia	0.047
3	United States	0.05
4	<u>Ukraine</u>	<u>0.052</u>
5	Lebanon	0.067
6	Singapore	0.069
7	Albania	0.072
8	Guadelope	0.081
9	South Africa	0.083
10	Japan	0.087

Ukrainian Internet Exchanges (IXPs)

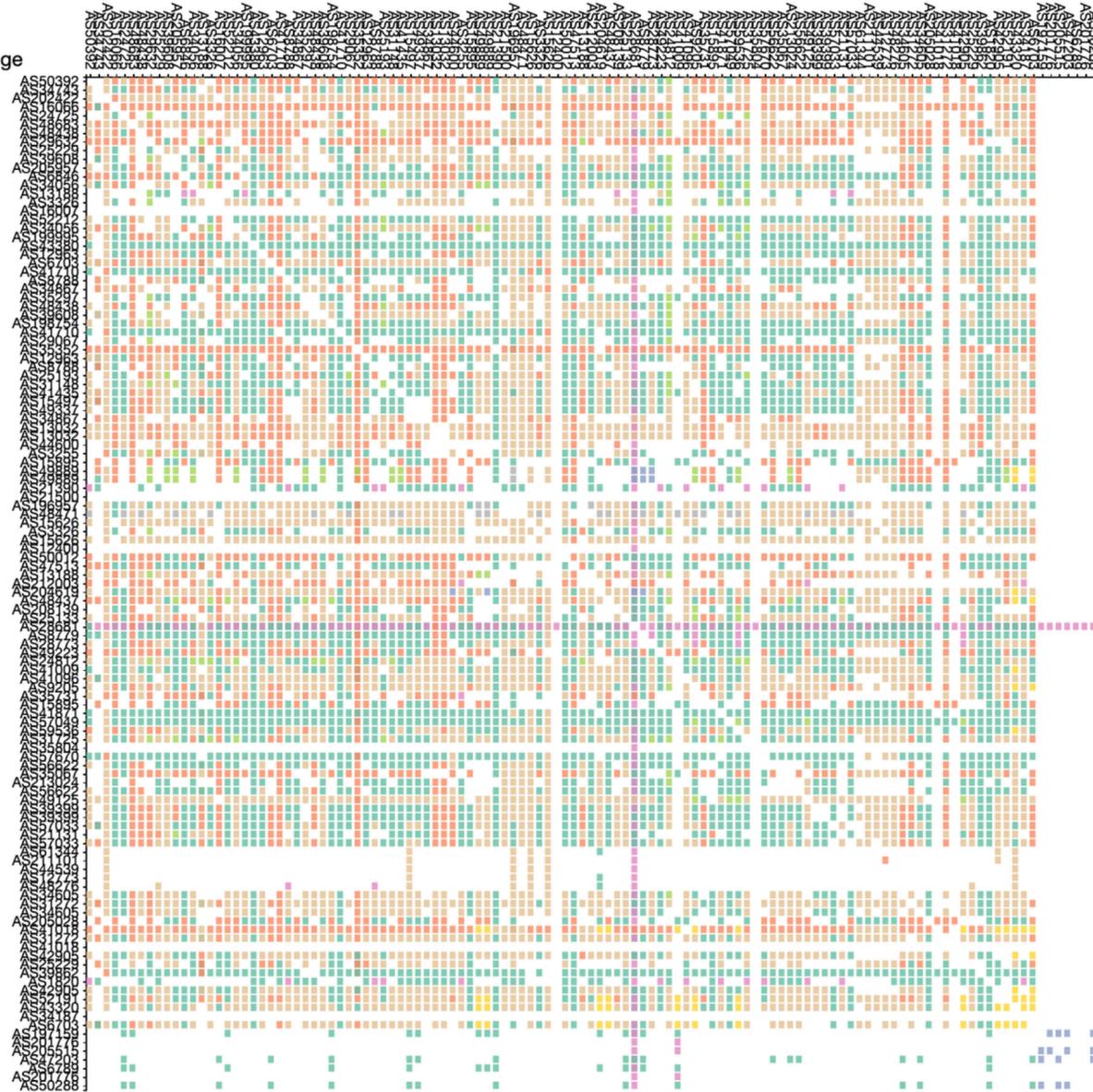


- kremen-IX
- UA-IX
- LVIV-IX-Main
- KM-IX-Main
- IF-IX-Ivano-frankivsk local exchange
- GigaNET Odessa-Odessa local exchange
- GigaNET Kyiv-Global exchange
- GigaNET Kharkov-Kharkov local exchange
- DTEL-IX-PUBLIC
- DN-IX
- Crimea-IX
- CLOUD-IX KIEV
- 1-IX Internet Exchange

Destination (North to South)



13/17 are active between the RIPE Atlas probes in the country



- Mesh between Atlas probes in Ukraine
 - What is between them?
- The majority of these paths are mediated by IXPs (the total of coloured cells)
- Many different IXPs are used, indicating **diversity** in IXPs



Human Factor

Free Internet Access in Bomb Shelters



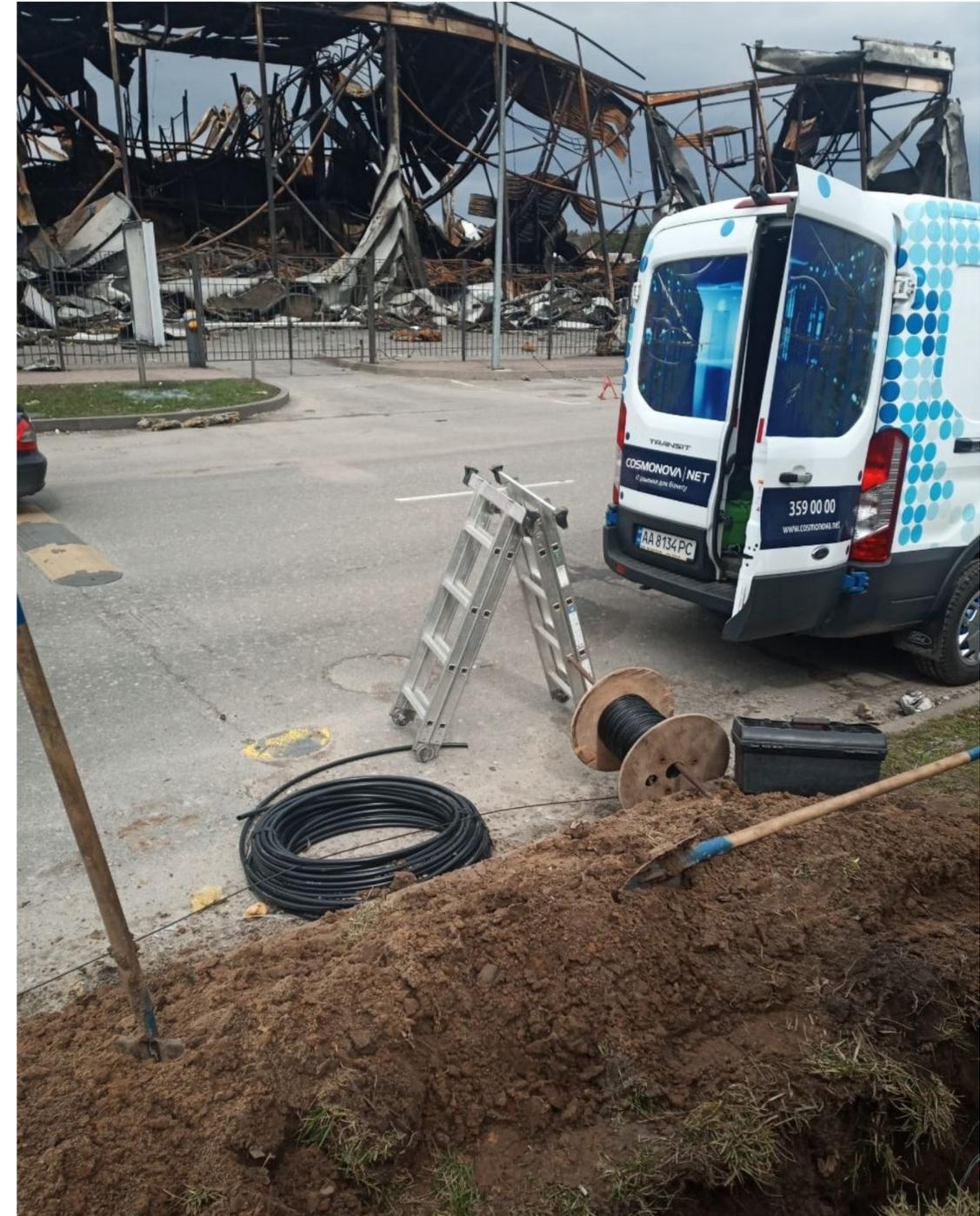
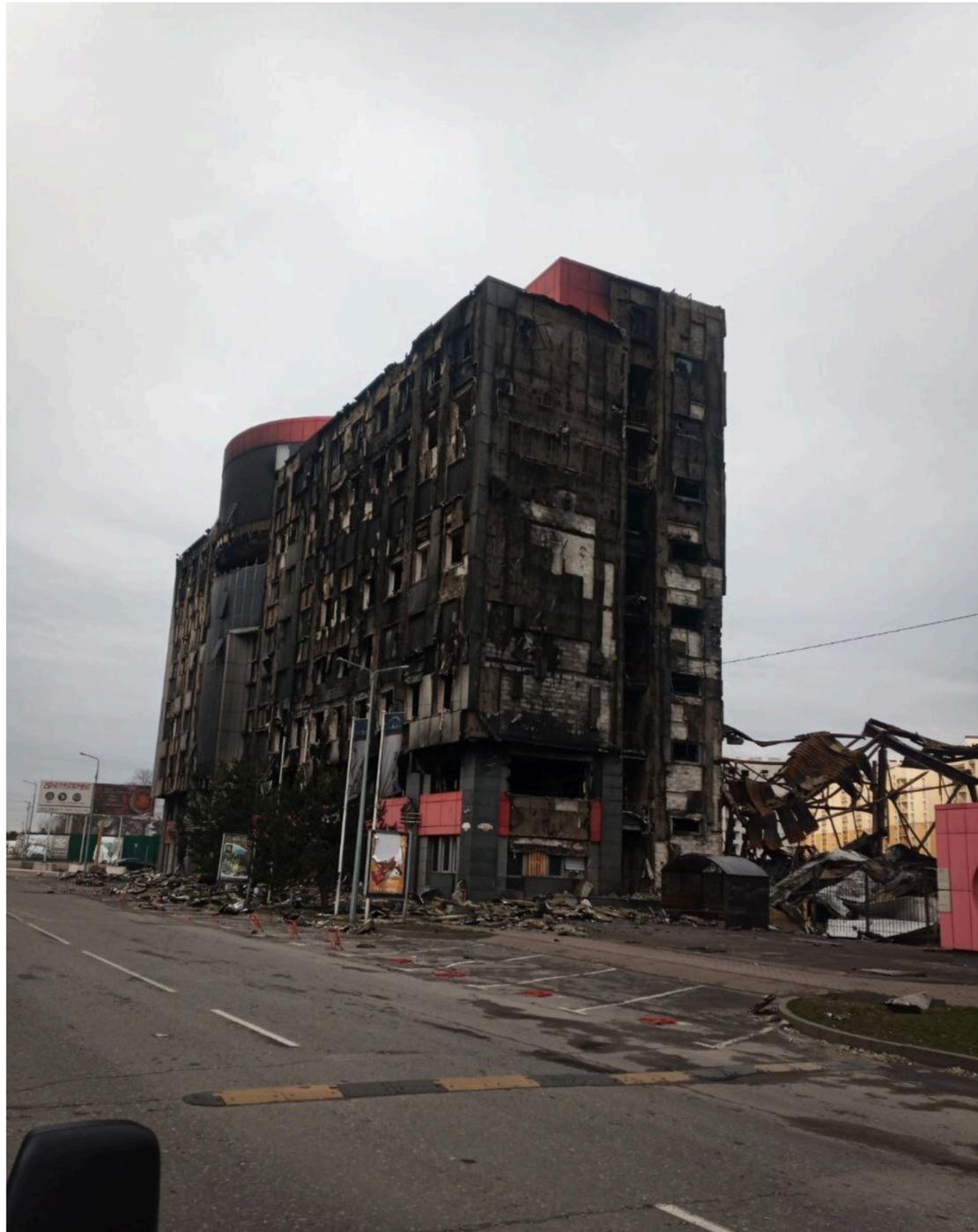
Despite the drop in revenue, operators have taken on additional social functions



People



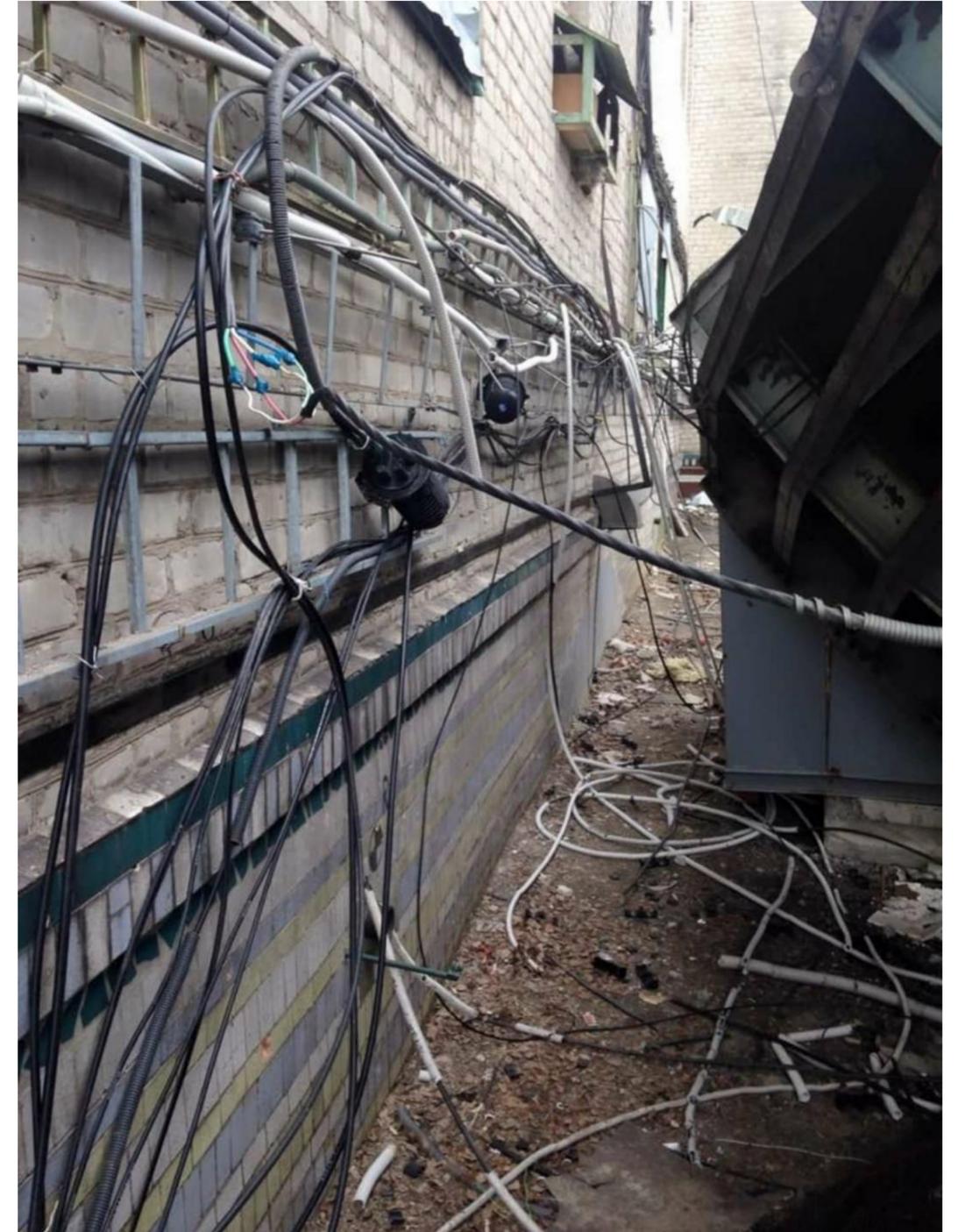
People



People



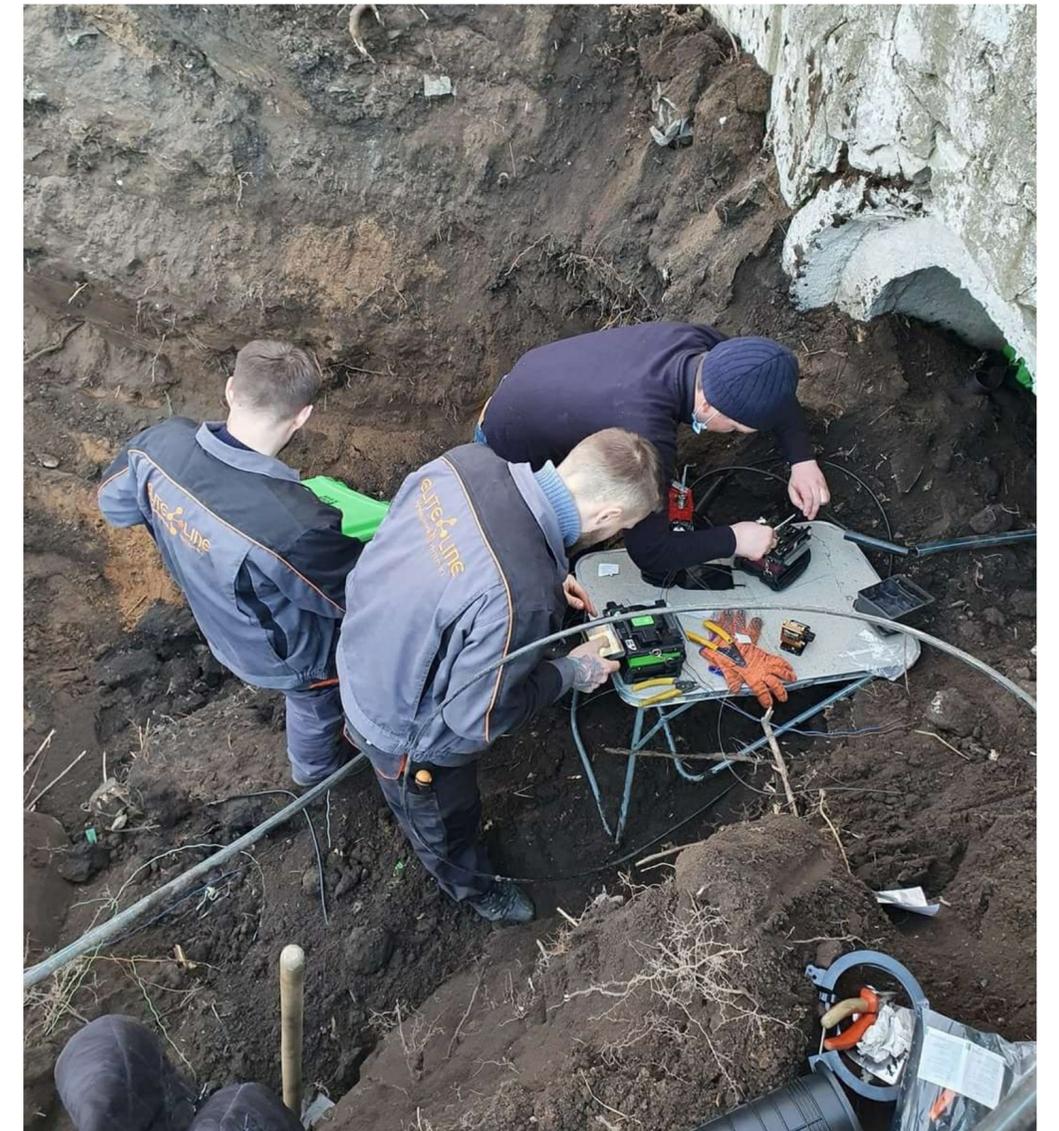
People



People



People



People



People





Summing Up

Conclusions



- Internet needs
 - Physical infrastructure (fibre, routers)
 - Electrical power
 - People to operate it
- Diversified infrastructure dramatically increases reliability/resilience
- There are still bottlenecks to Internet infrastructure - in particular, power provision
- The key factor remains the people who keep the systems running



Questions



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Ministry
of Digital Transformation
of Ukraine

Broadband during the war and blackouts: the experience of Ukraine

Andrii Nabok

Head of the fixed broadband at the Ministry of Digital Transformation of Ukraine



The Ministry of Digital Transformation of Ukraine has been building a digital state in Ukraine for 3 years

This would be impossible to achieve
without the Broadband availability
for almost every citizen of Ukraine

Until Russia's full-scale invasion, Ukraine reached the highest broadband coverage in Europe

90%

Rural households were covered by fiber broadband

Only in 2021

1M+

Ukrainians in 3,000 villages got the opportunity to use fiber broadband for the first time

7K+

Social facilities were connected

Among them more than

900 schools

545 kindergartens

1638 ambulatory care

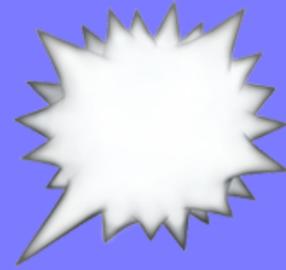
18 hospitals

55 fire departments

1927 houses of culture

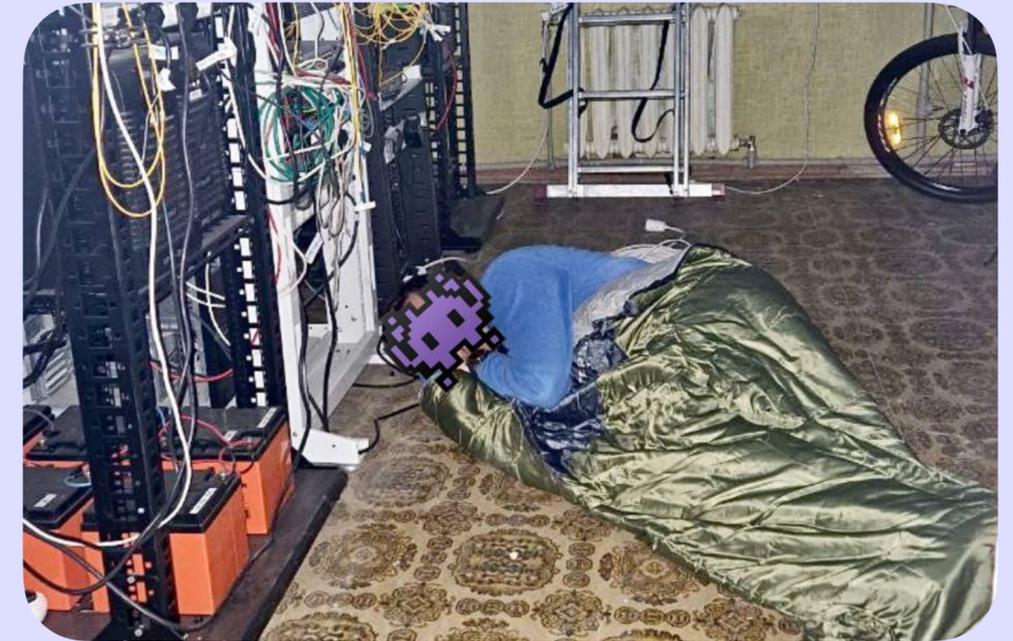
841 libraries

392 ASCs



Cutting Ukrainians off from energy and communication has been one of the main goals of the occupiers ever since

The daily routine of Ukrainian Telecom companies during the war looks like



The main challenges faced by ISPs



Power outage

This is damaged or destroyed energy infrastructure that provide electricity to ISPs.



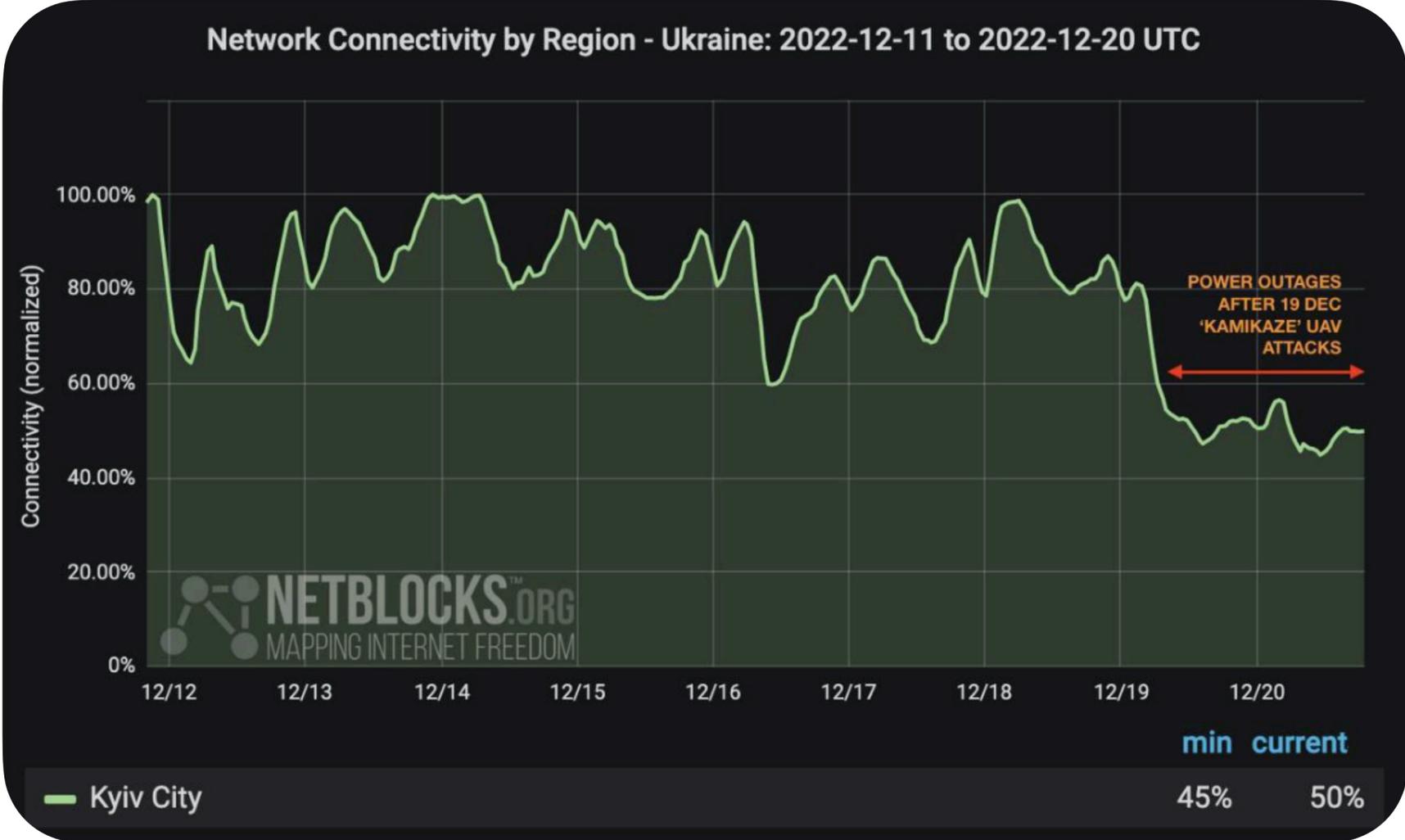
Destruction and infrastructure damage

These are kilometers of damaged optical cables, stolen or destroyed active operator equipment.

It will take weeks to restore damaged networks, months for base stations. Reconstruction can begin after liberation and demining of territories.

How does the lack of electricity affect the use of the Internet?

After one of the rocket attacks, 50% of Kyiv's fixed and mobile networks did not work



The only solution is to connect all subscribers, even in multi-apartment buildings, to PON technology

Technologies

6-10 hours per day

availability of light in most regions of the country

xDSL: 7% of subscribers

outdated technology, but relevant during power outages

Docsis, WiMax: 8% of subscribers

outdated technology, not relevant during power outages

PON: 29% of subscribers

the only relevant technology that can exist in Ukrainian realities

FTTB: 56% of subscribers

relatively modern technology, while not relevant during long-term power outages

What helps ISPs stand and restore communications?

 Starlink terminals

Backup source of traffic

 High-capacity batteries

Powerful batteries that allow ISPs to provide Internet, despite a power outage, from 12 hours up to several days

 Generators

They also help to maintain connection, or the uplink, despite a power outage



Support Ukraine

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Community Efforts to Support Ukraine

Community Support for Ukraine

- A special welcome to operators from Ukraine at RIPE Meeting
- Keep Ukraine Connected



- Community support for RIPE NCC initiatives

Ukraine and the RIPE NCC



- RIPE NCC received request from Ukrainian government to deregister IP addresses of Russian members
 - We expressed sympathy but declined the request
 - RIPE NCC remains neutral in political disputes to maintain a stable, open Internet
 - We support all our members
- Ukrainian (and Russian) members given extra time to pay invoices

https://labs.ripe.net/author/hans_petter_holen/an-open-internet-remains-the-goal/

Ukraine and the RIPE NCC



- Discussion in RIPE community about how to protect Ukrainian IP addresses from being transferred under coercion
- Temporary review of all transfer requests by Managing Director
- Support for new RIPE Policy
 - Ukrainian government agrees this is the best way forward
- Held online BGP security training for network operators



Discussion: The Way Forward