Advancing the Art of Internet Edge Outage Detection

ACM Internet Measurement Conference 2018

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Internet Edge Outages

Lightning Strike Sparks Fire At AT&T Facility, Outage Impacts Internet Service

...restore service after an electrical fire at one of its facilities impacted internet service for customers.

TECHNOLOGY NEWS NOVEMBER 28, 2016 / 6:45 AM / 2 YEARS AGO

German internet outage was failed botnet attempt: report

Eric Auchard

HURRICANE MICHAEL'S IMPACT —

Verizon fiber suffered "unprecedented" damage from Hurricane Michael

...ge to Verizon fiber delays restoration of...

...2018, 12:40 PM

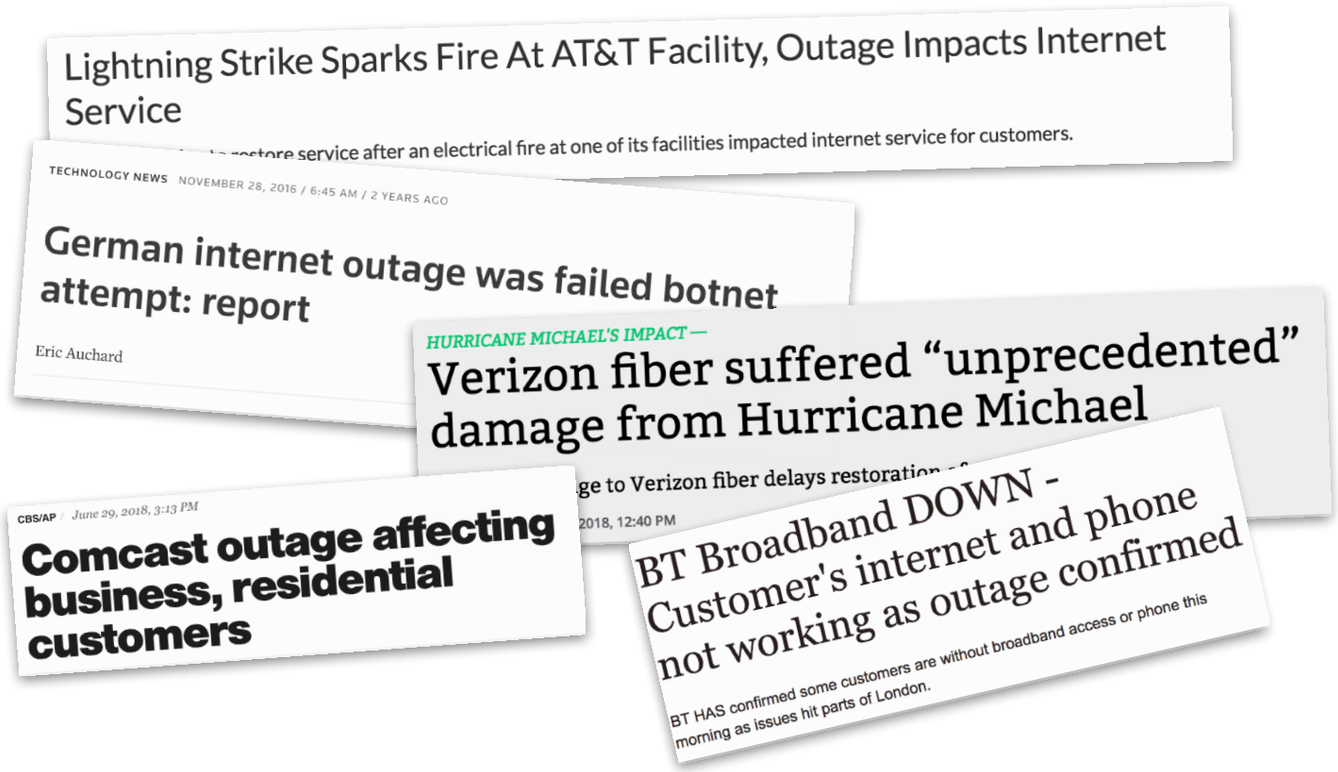
CBS/AP / June 29, 2018, 3:13 PM

Comcast outage affecting business, residential customers

BT Broadband DOWN - Customer's internet and phone not working as outage confirmed

BT HAS confirmed some customers are without broadband access or phone this morning as issues hit parts of London.

Internet Edge Outages

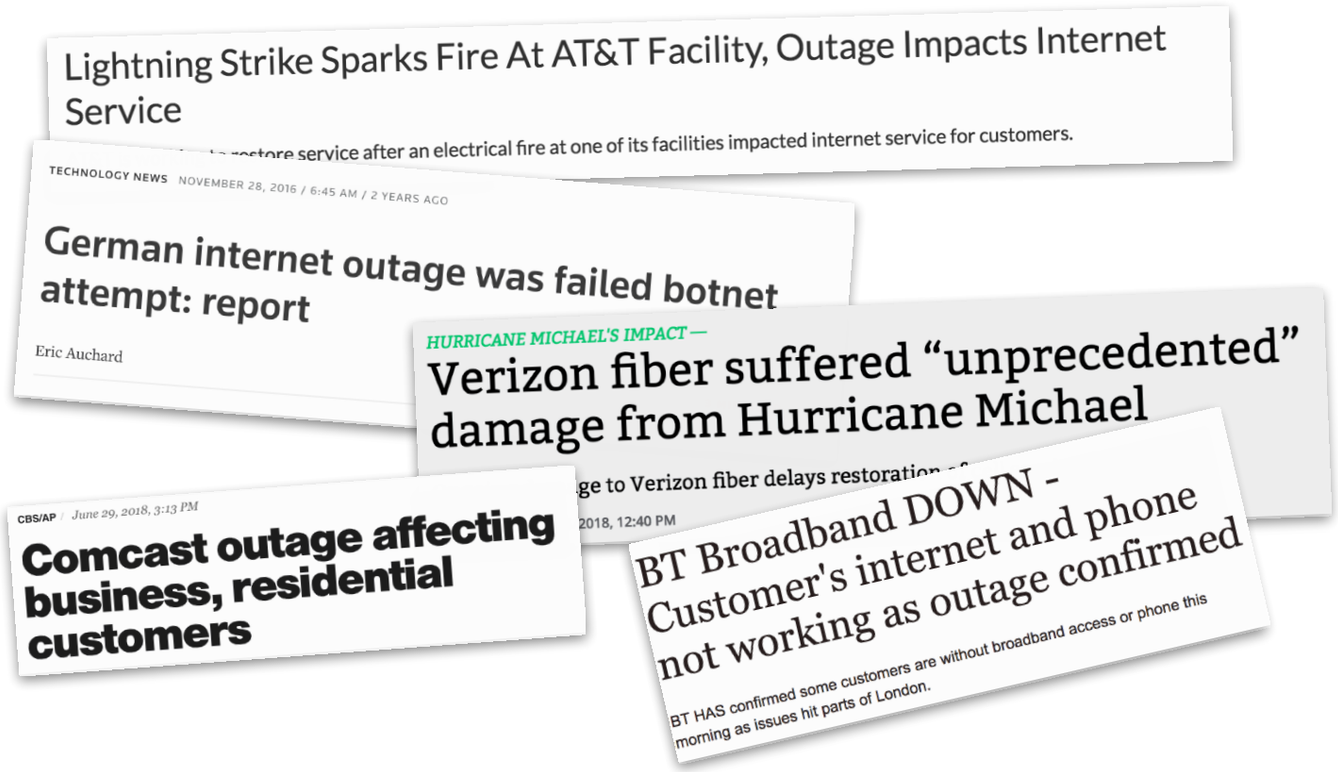


➡ **Uninterrupted Internet availability becomes increasingly critical**

➡ Growing interest in systems to detect Internet edge outages

➡ Regulatory Bodies, Governments, ISPs, Academic Research

Internet Edge Outages



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Goal: Track Internet edge outages on *(i)* a broad scale and *(ii)* a detailed level

Edge Outage Detection: Existing Approaches

- **Detecting outages in the control plane?**
  ➡ Edge outages often invisible in BGP

- **Deploying hardware in end user premises?**
  ➡ Potentially highly accurate, but does not scale

- **Actively probing addresses?**
  ➡ Challenging to scale, unresponsive addresses, difficult to interpret

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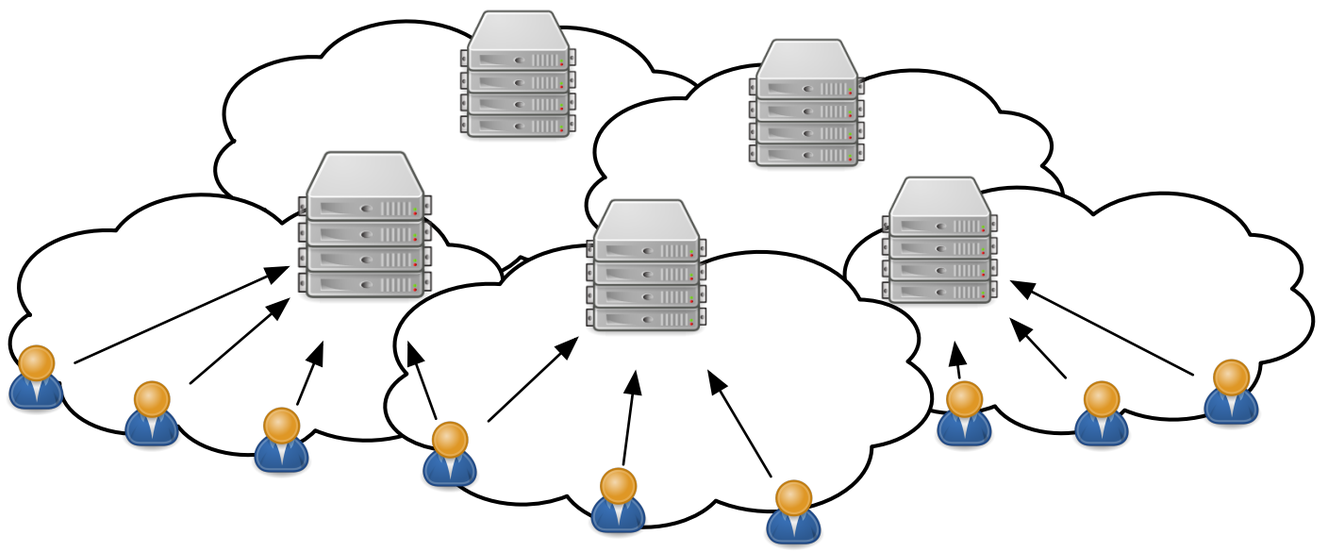
This work:
Passive edge outage detection based on CDN request patterns

Outline

- **Disruption Detection**
- Global View on Disruptions
- Device-Centric View on Disruptions
- U.S. Broadband Case Study

Disruption Detection using CDN Access Logs



200,000+ servers

1500+ ASes

120+ countries

> 3 trillion daily requests

Dataset: Hourly request counts per IPv4 /24 address block

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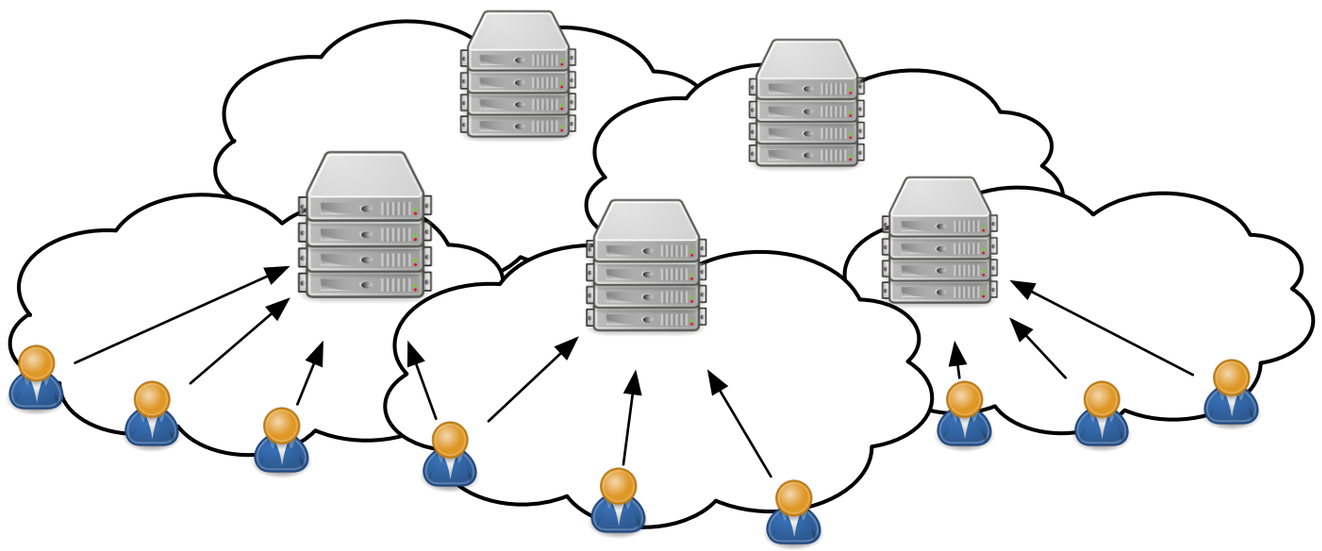

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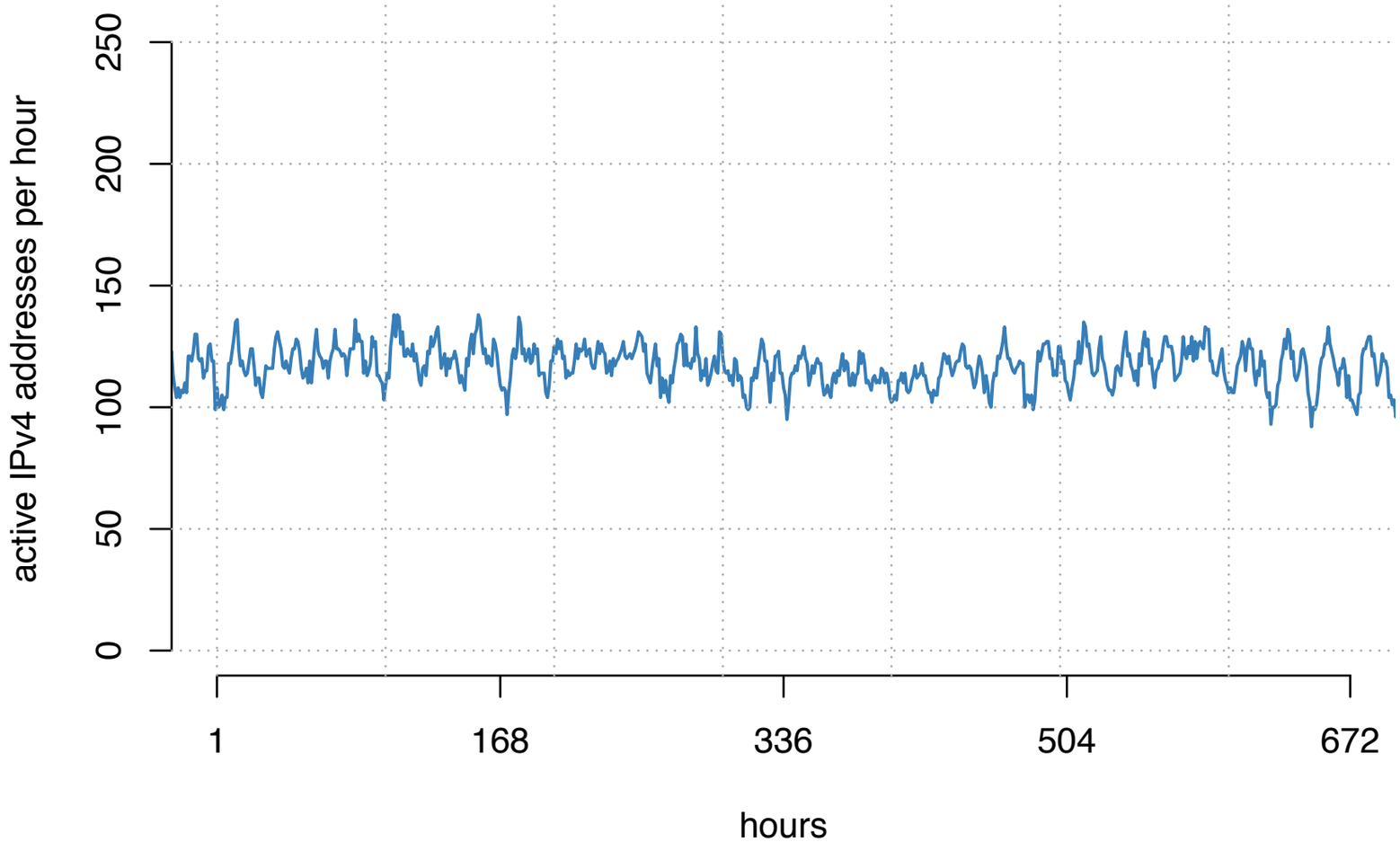
Dataset: Hourly request counts per IPv4 /24 address block

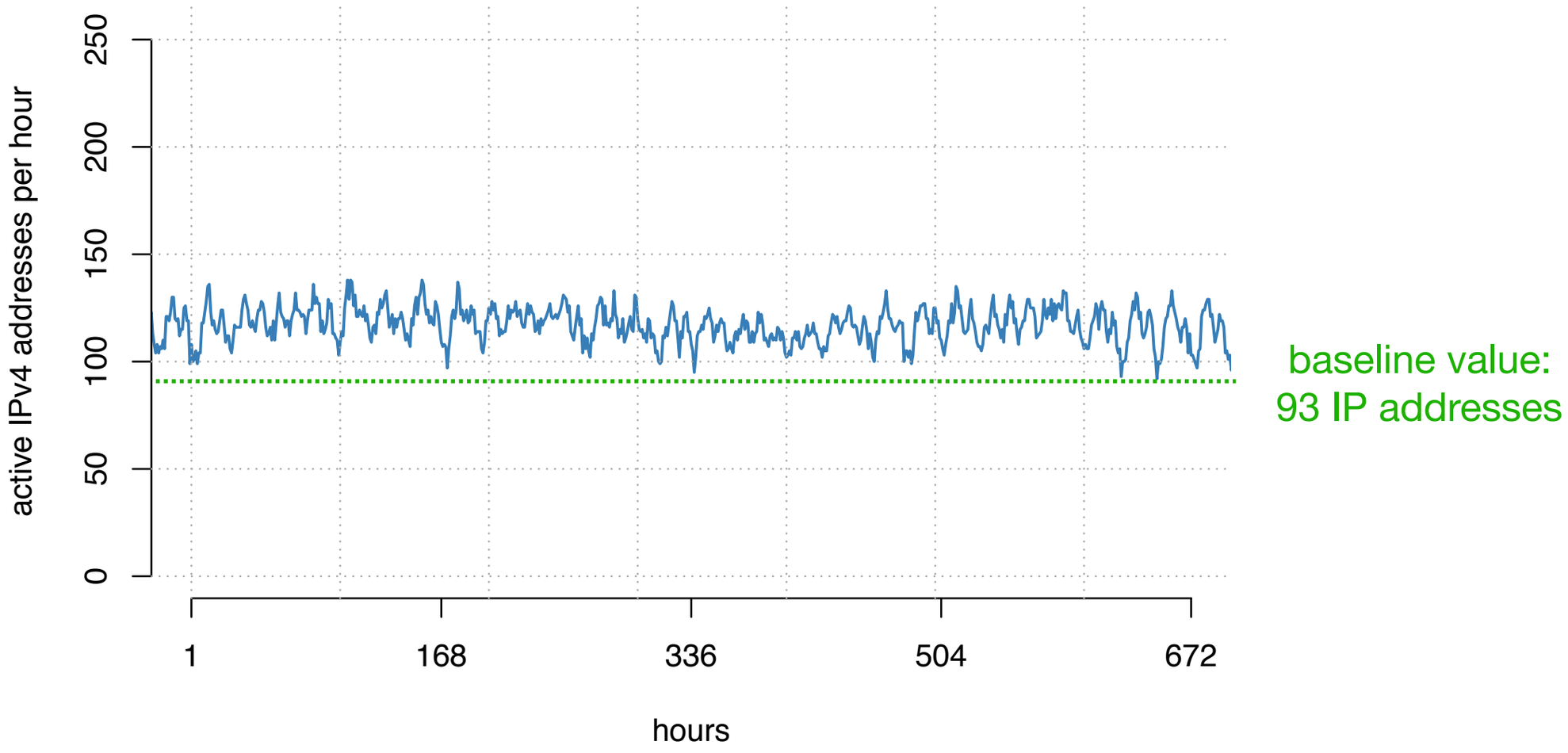
Assumption:
Edge outages will be reflected in absence/reduction of CDN requests.

Active IP Addresses per /24



typical residential /24 address block

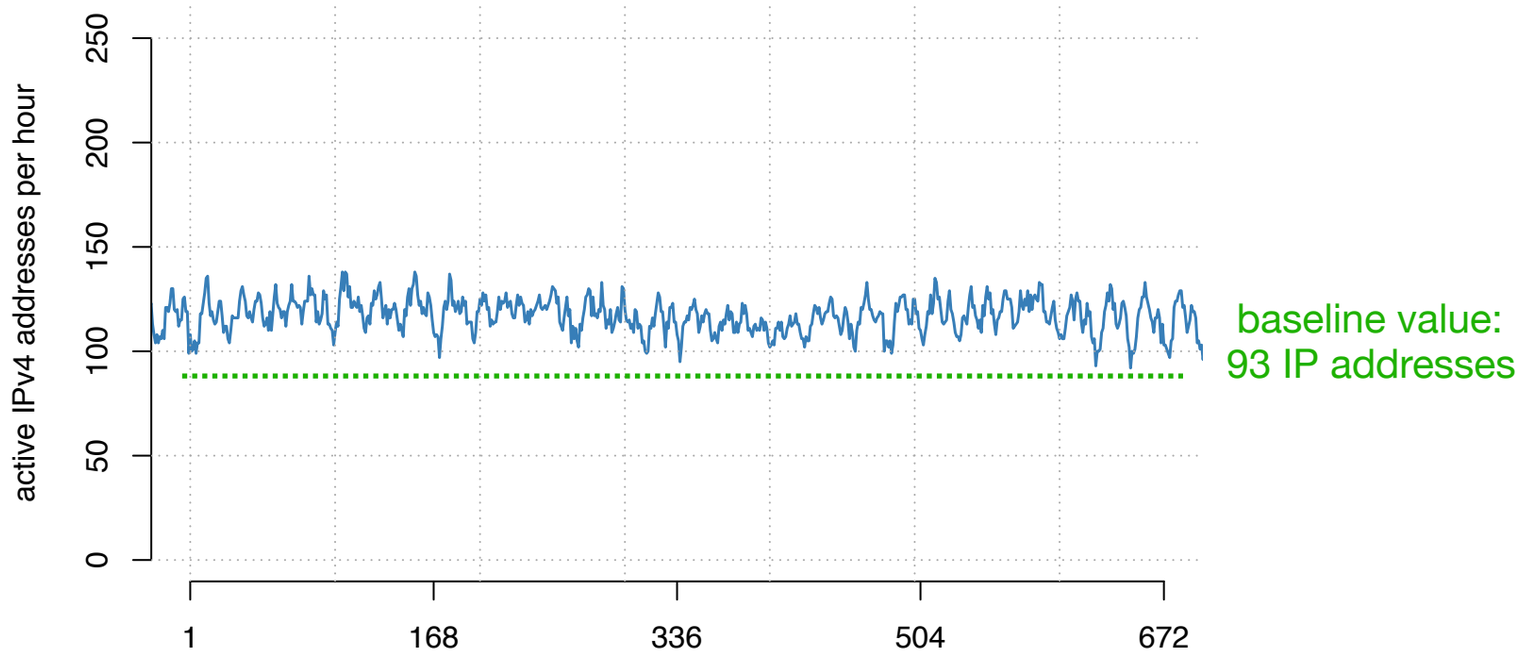
Active IP Addresses per /24: Baseline Activity



typical residential /24 address block

Number of addresses contacting the CDN every hour never drops below ‘baseline value’ value per block.

Active IP Addresses per /24: Baseline Activity



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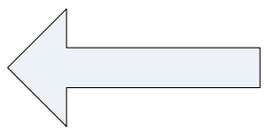
CDN

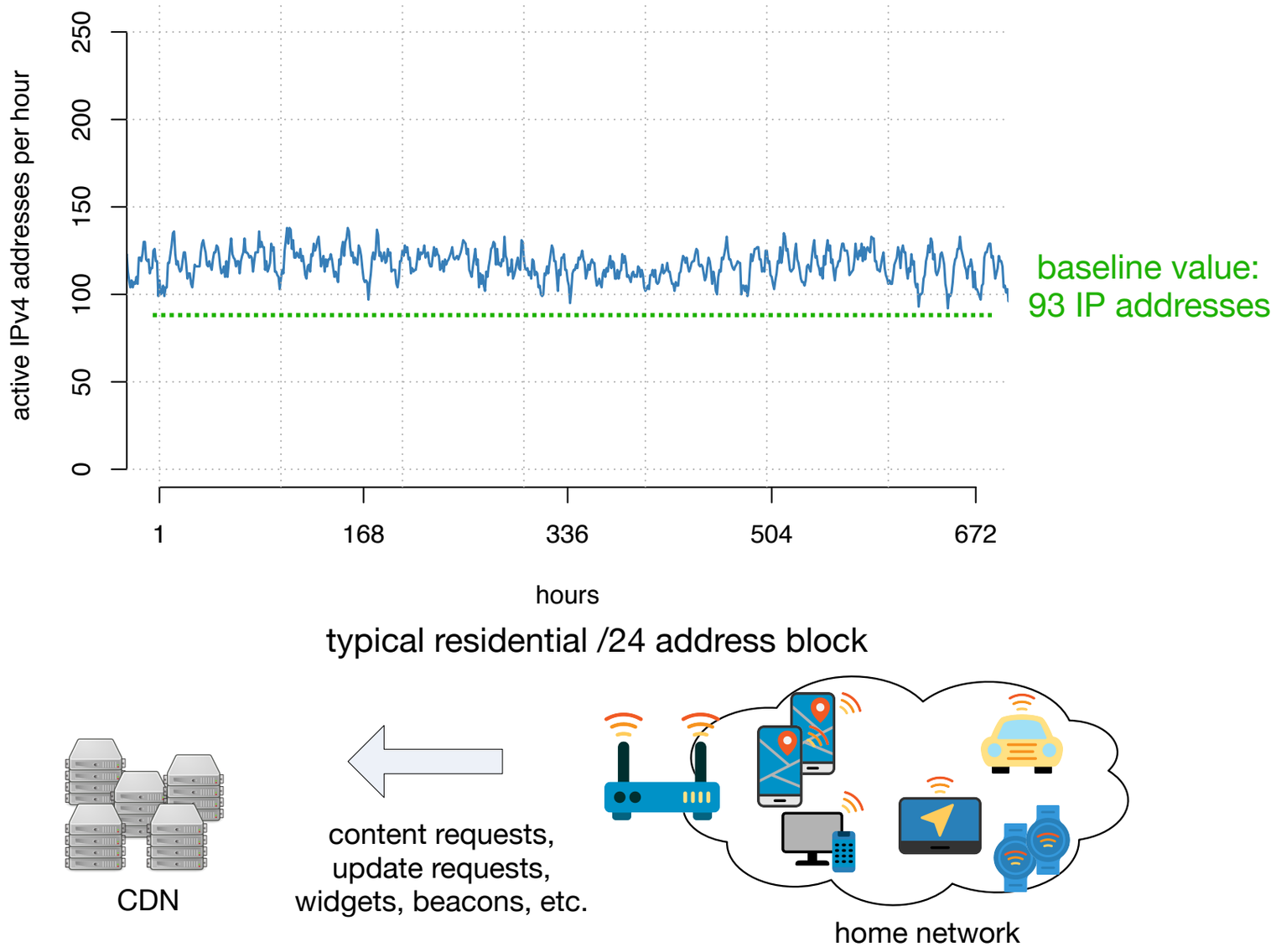


content requests,
update requests,
widgets, beacons, etc.

home network

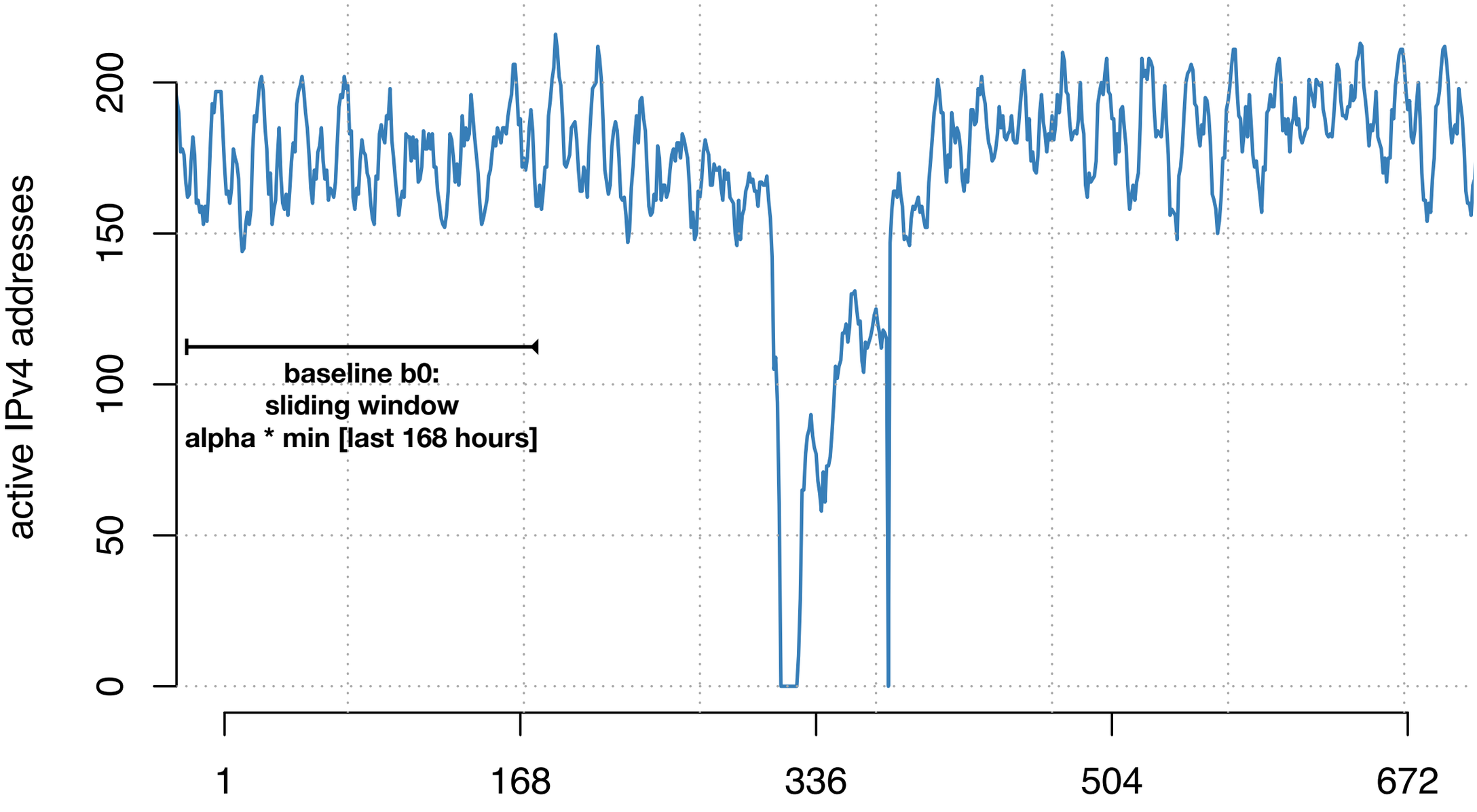
icons: mavadee / flaticon

Active IP Addresses per /24: Baseline Activity



- Some 2.3M /24 address blocks (83% of all client IPs) baseline > 40
- Robust signal, largely independent of user-triggered activity
- Dependent on a functioning network

Disruption Detection



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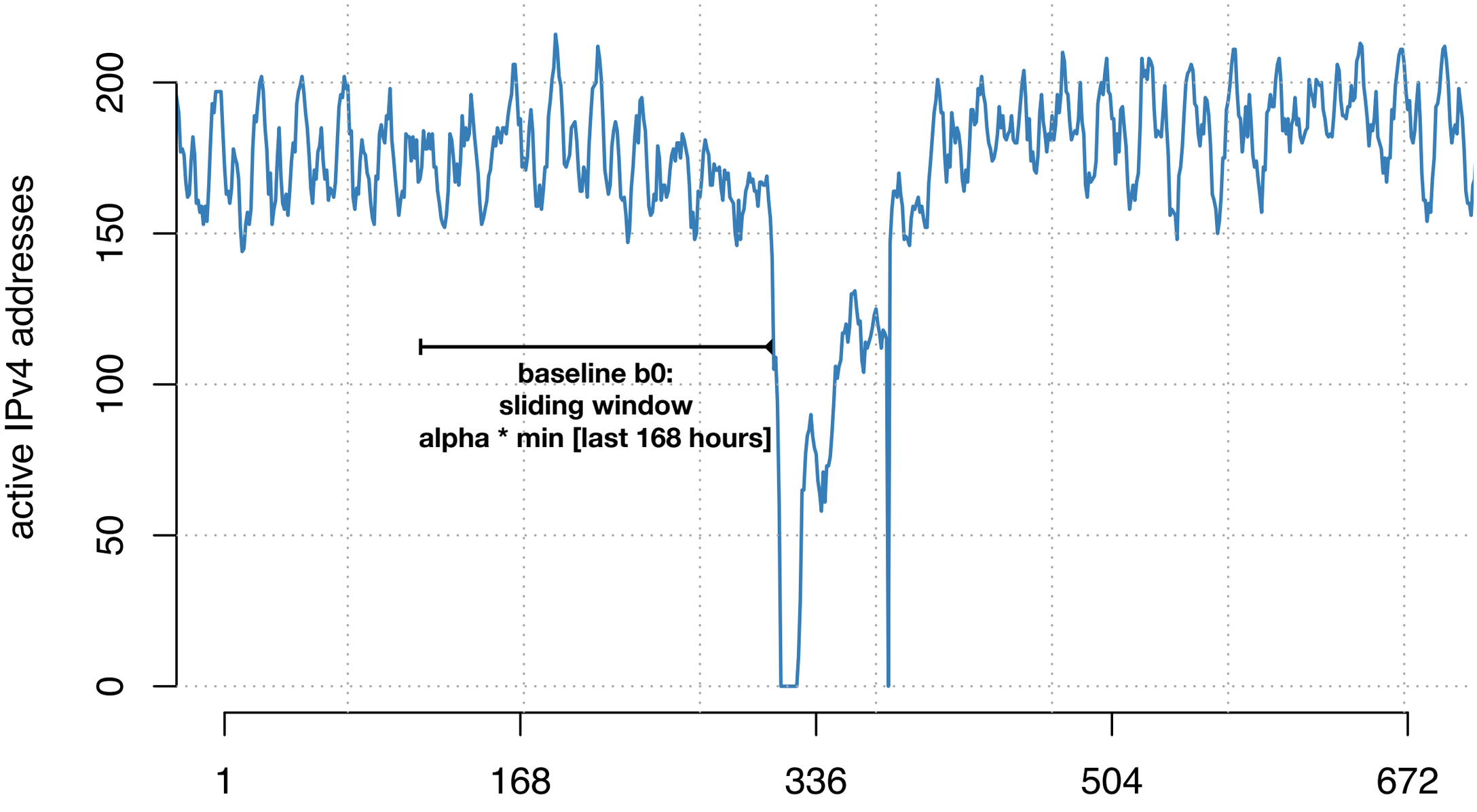

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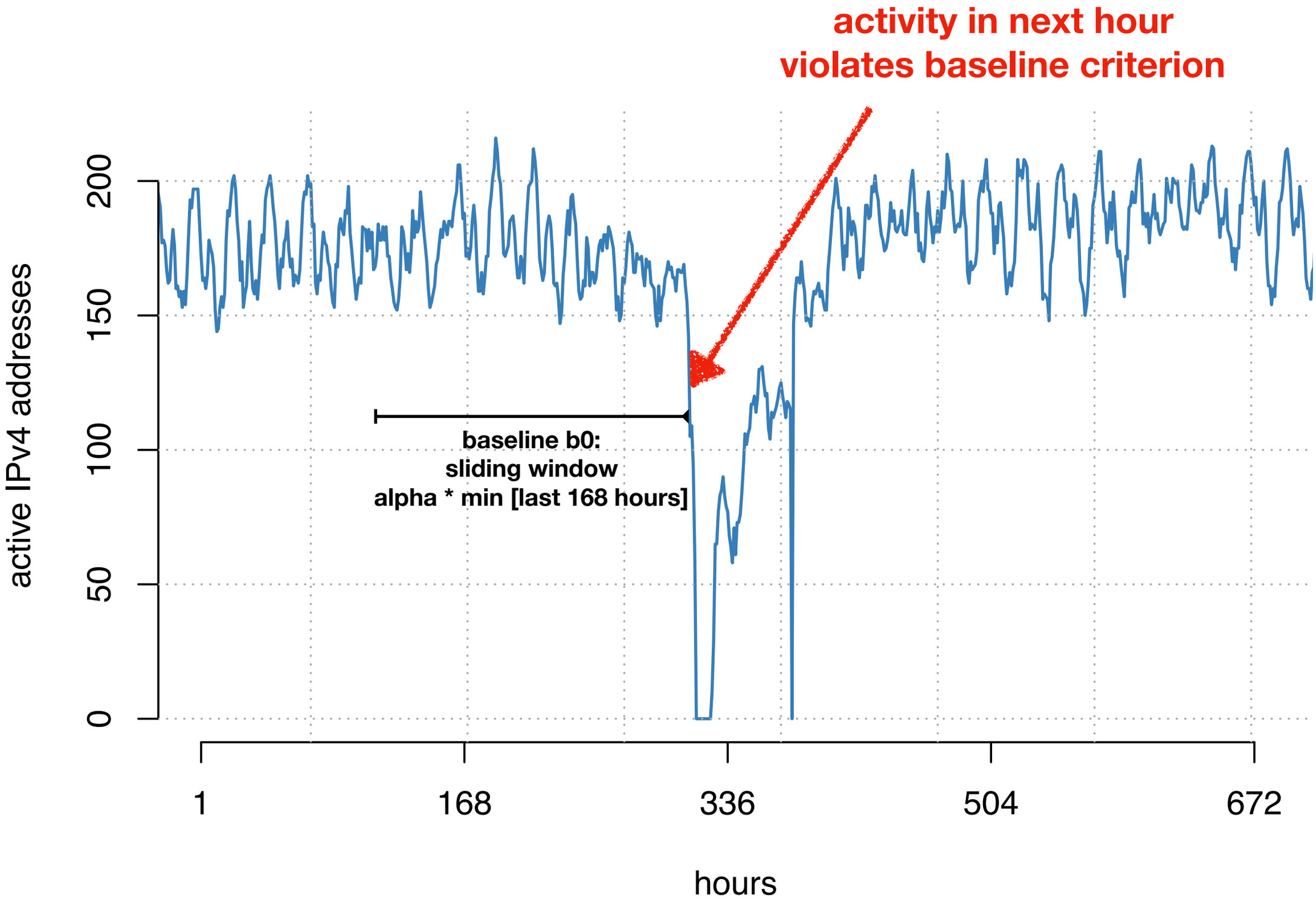

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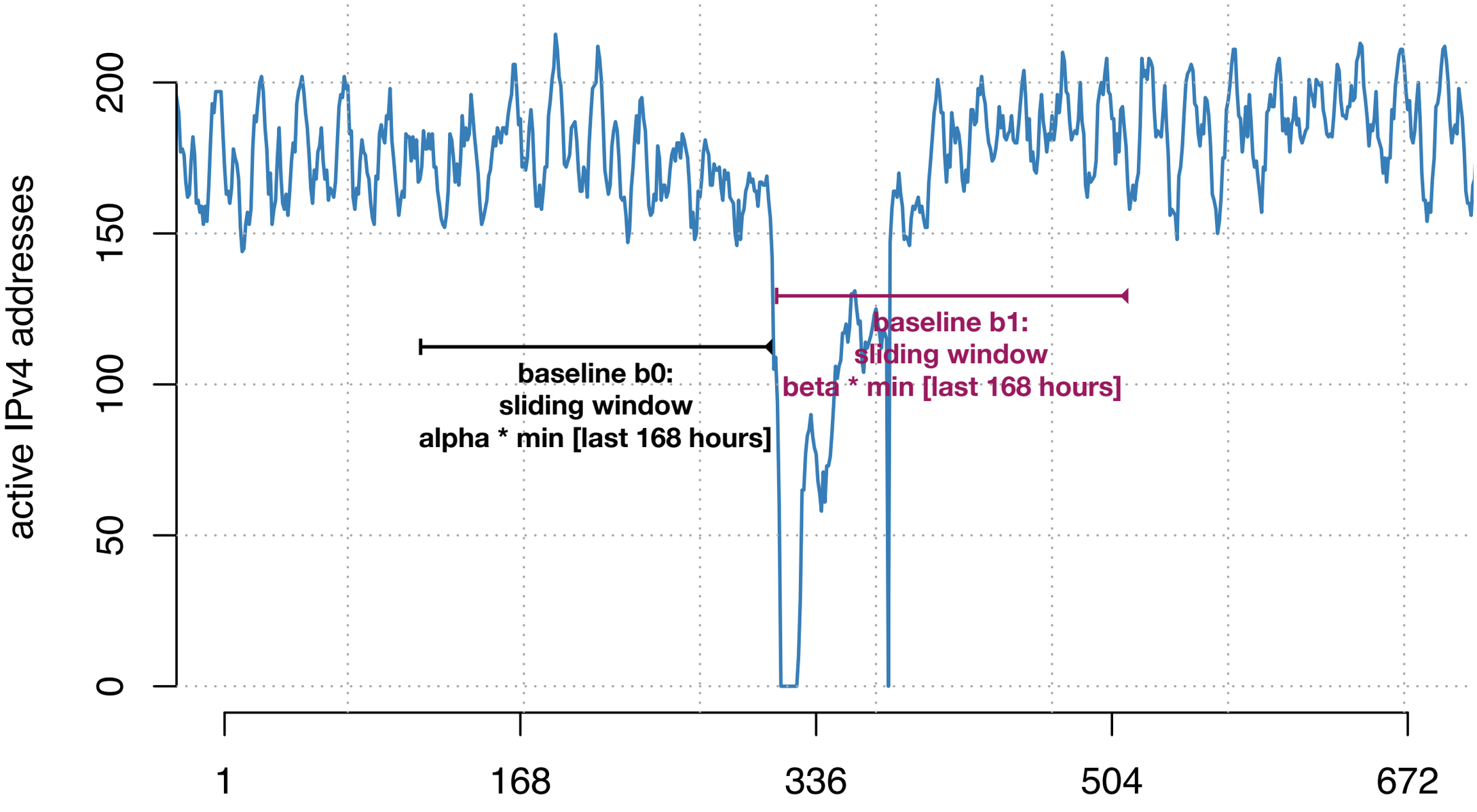

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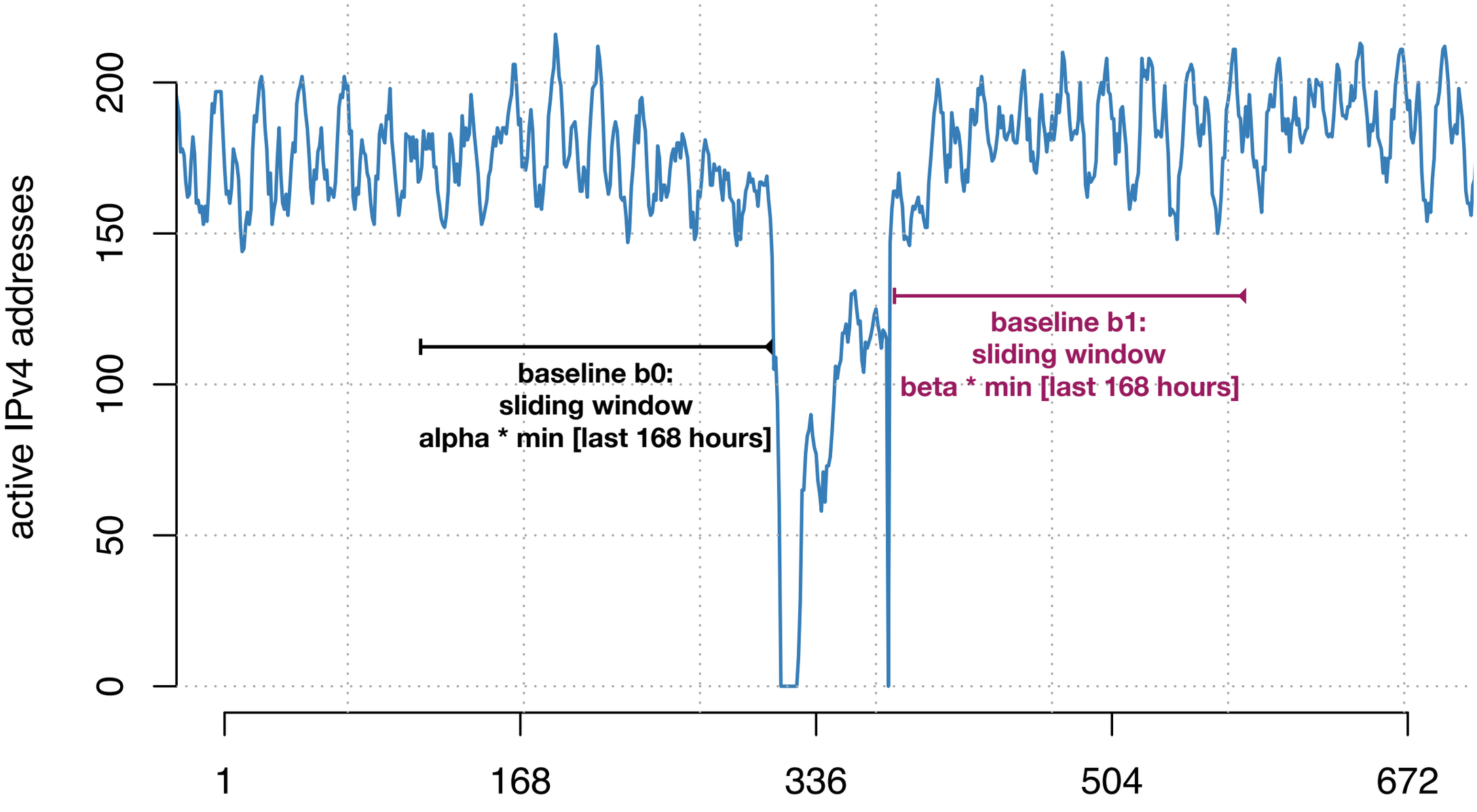

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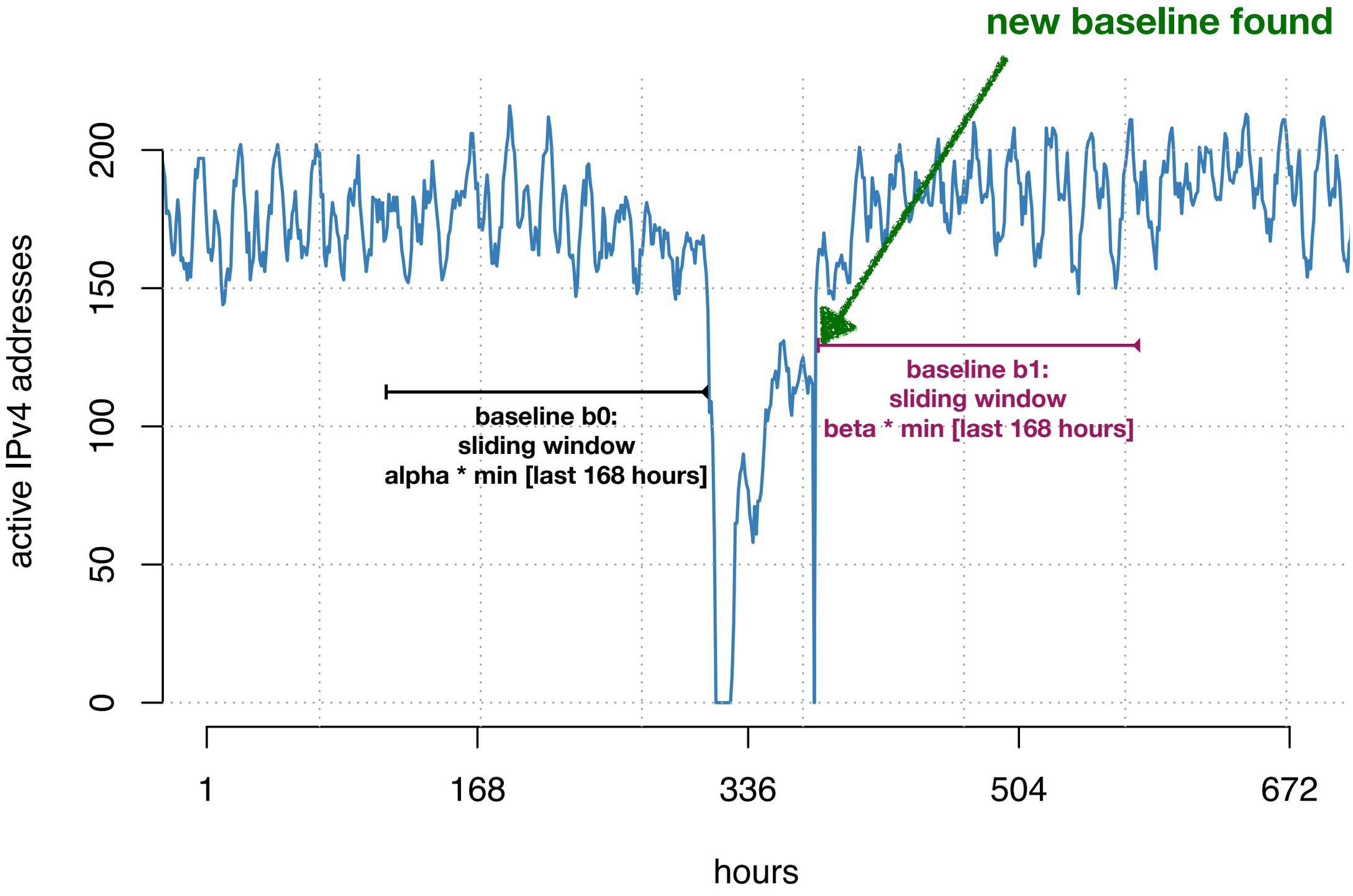

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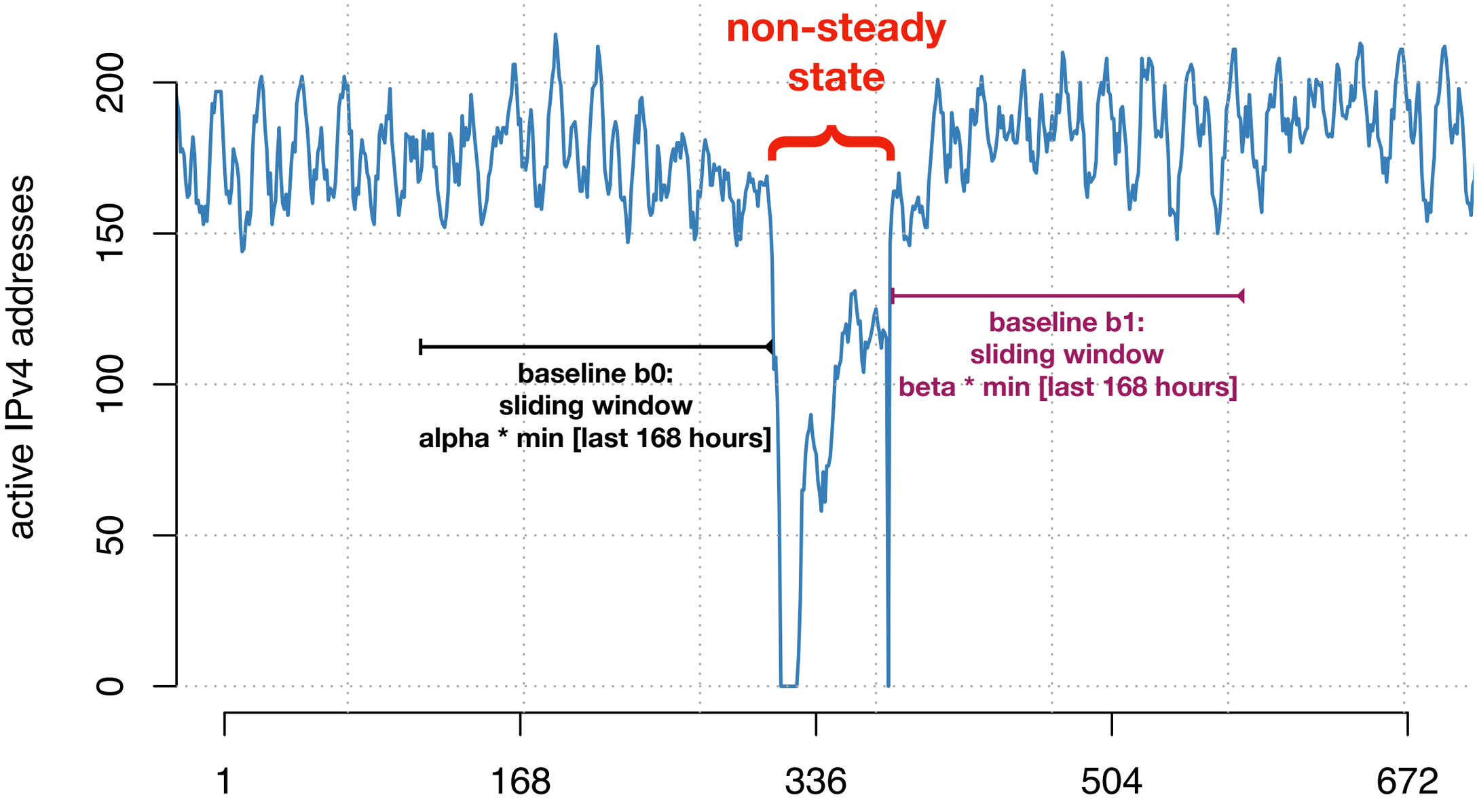

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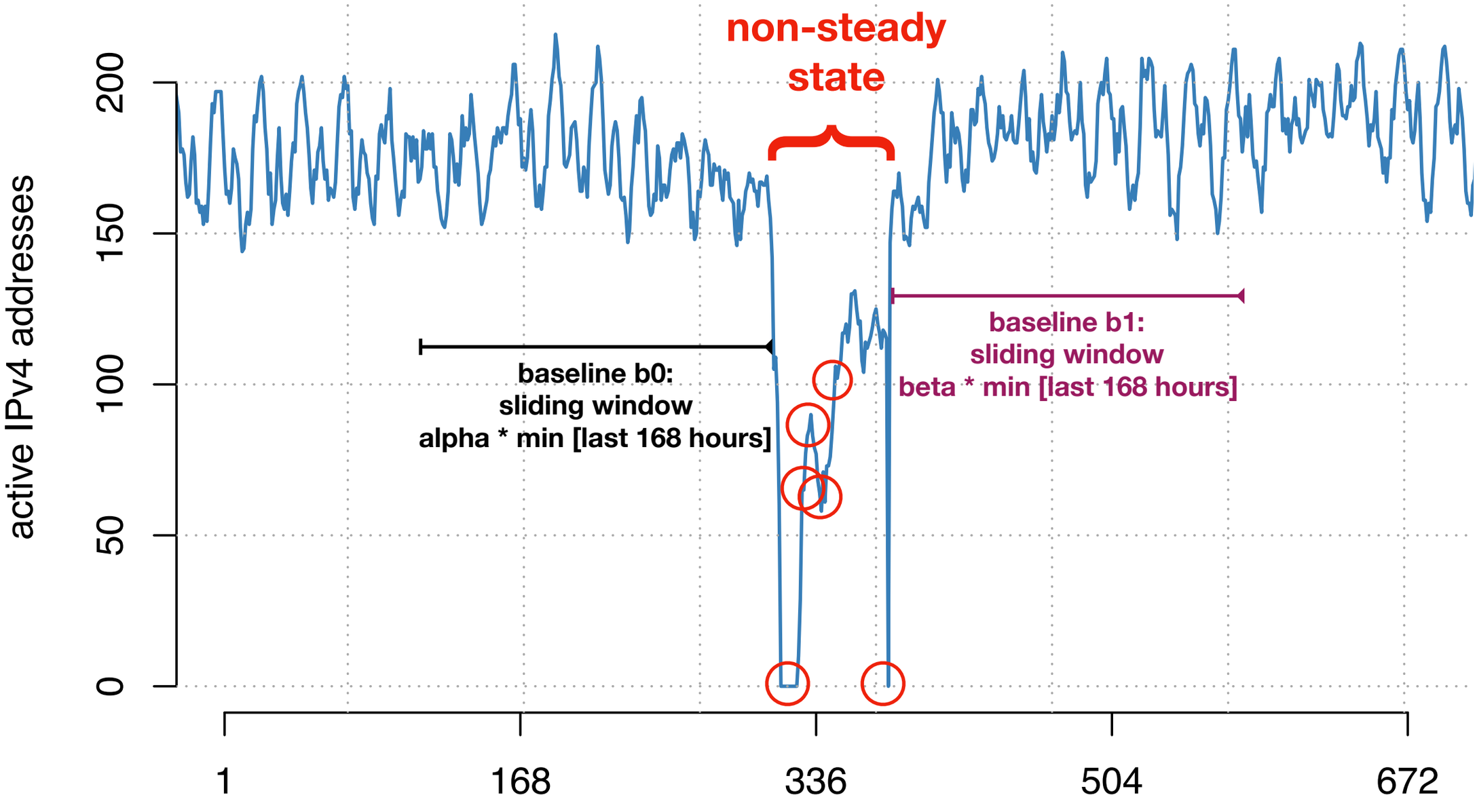
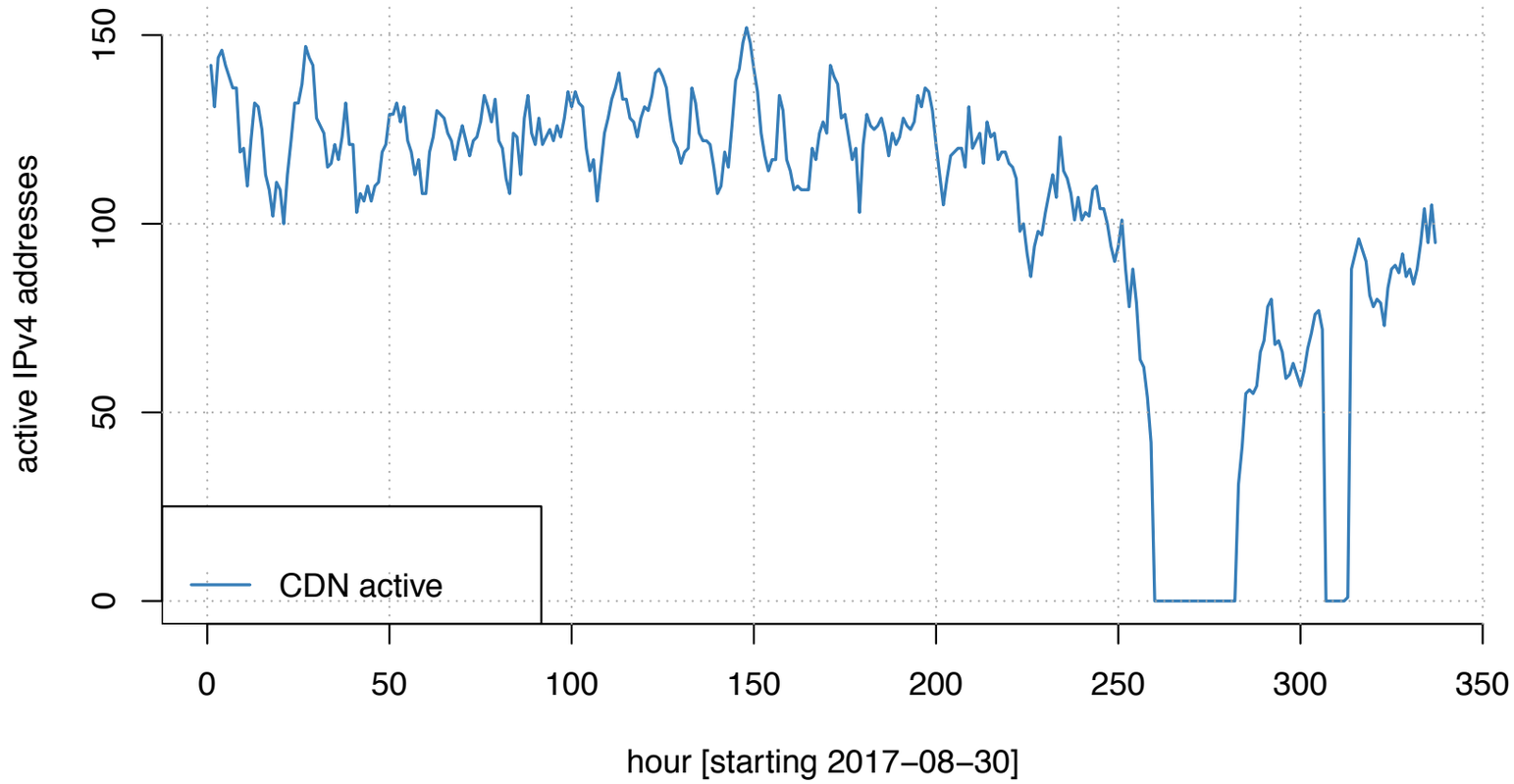


Did this Address Block really go offline?



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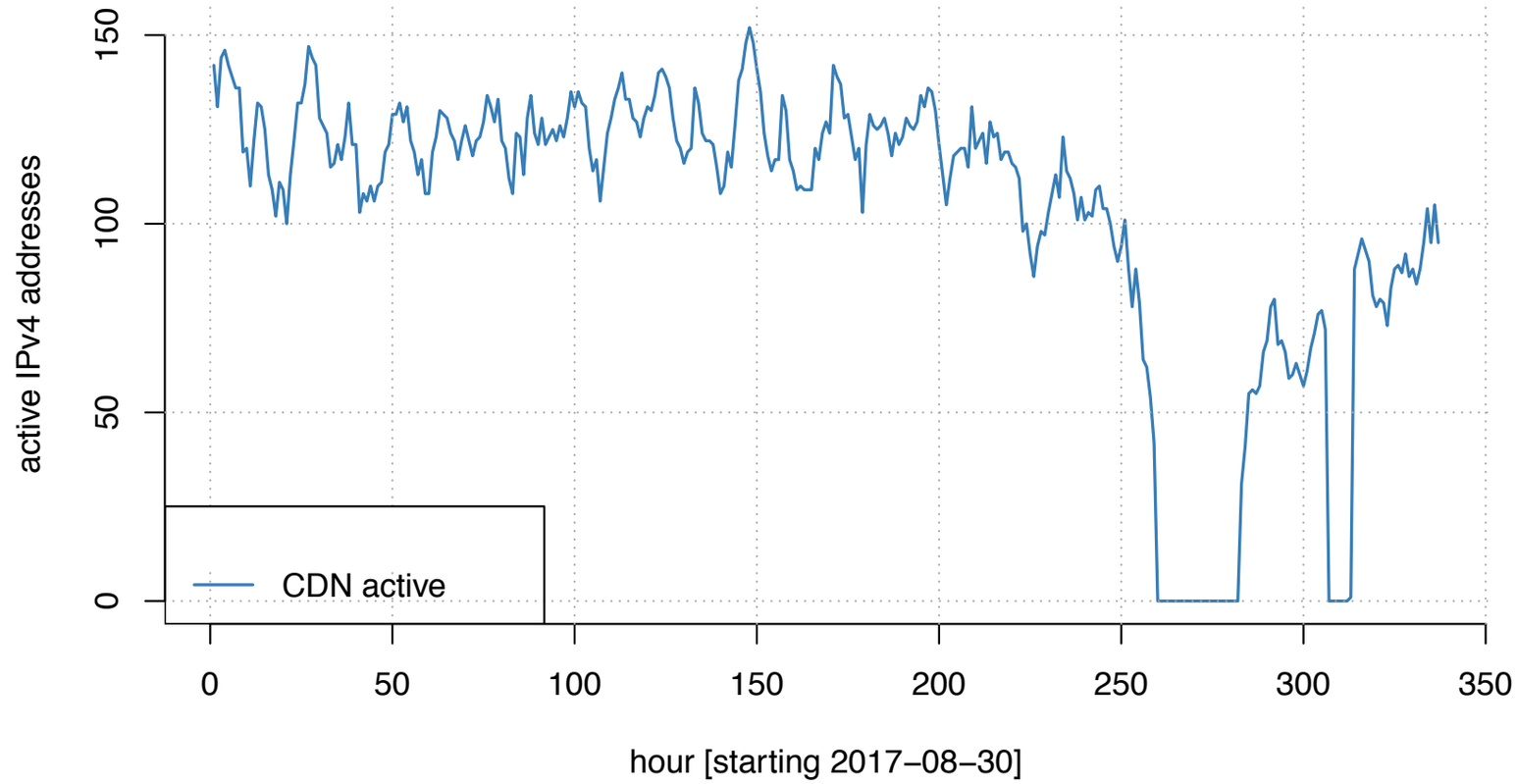

➡ **“Address Space Survey Data” (provided by ISI)**

- ➡ Ping *every* address in 1% of the allocated IPv4 /24s every 11 mins
- ➡ Some address blocks show a very steady number of responsive IPs

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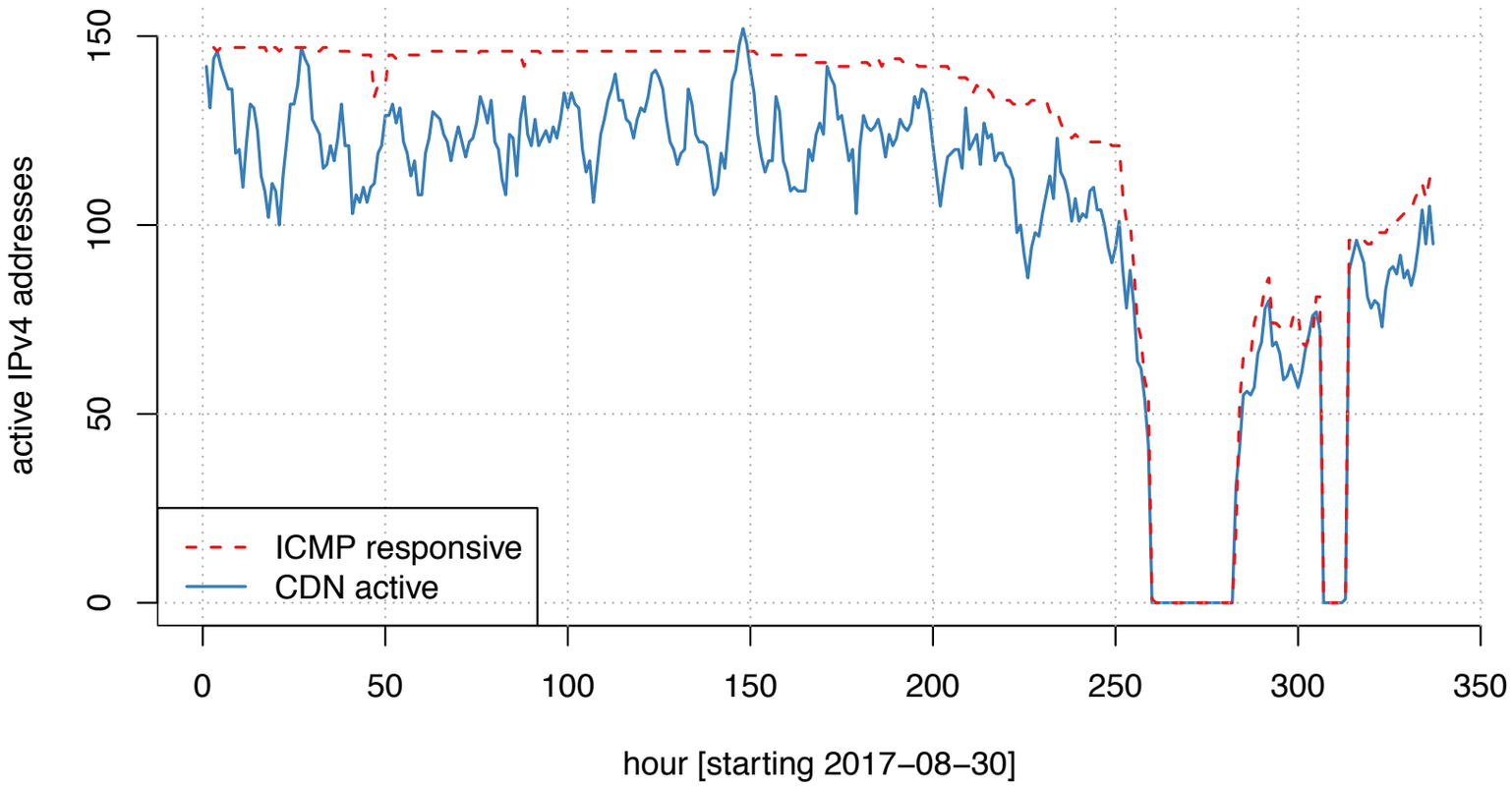

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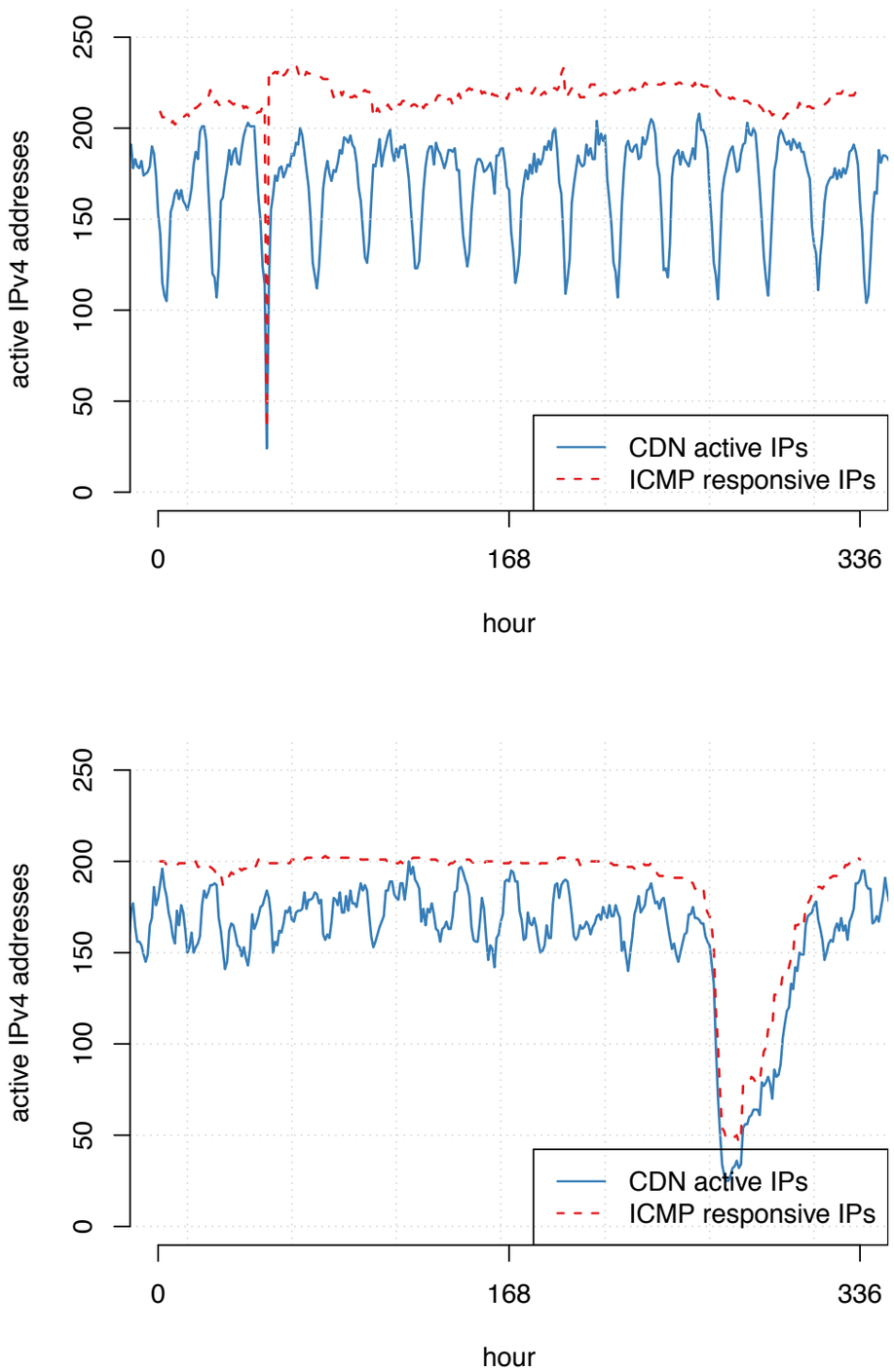
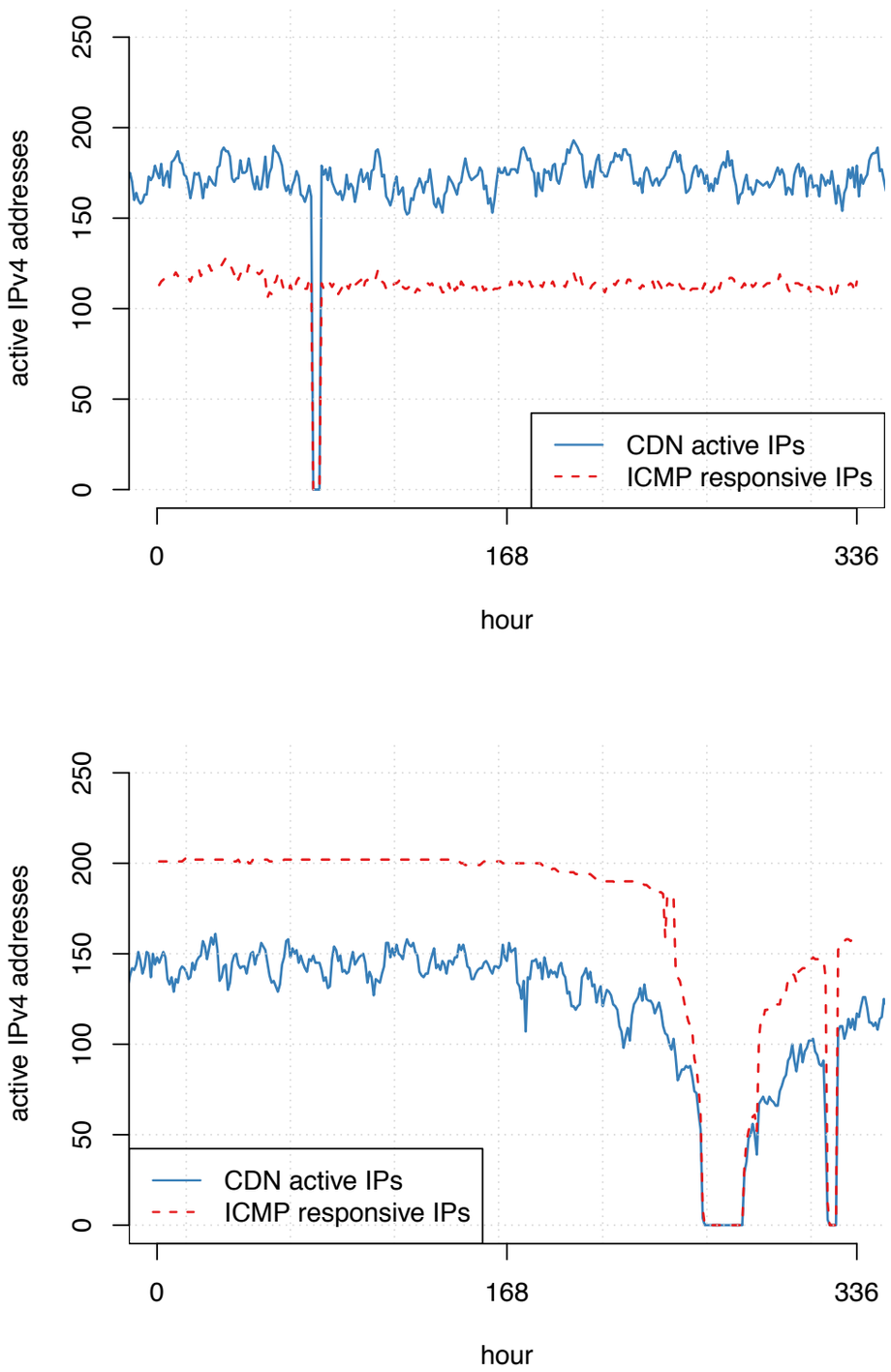
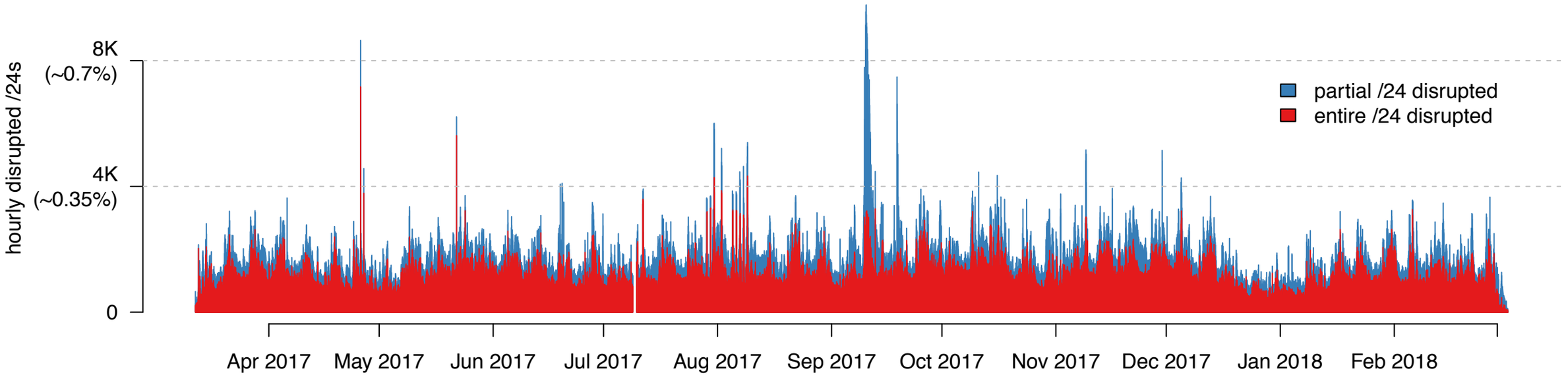
CDN Disruptions vs. ICMP



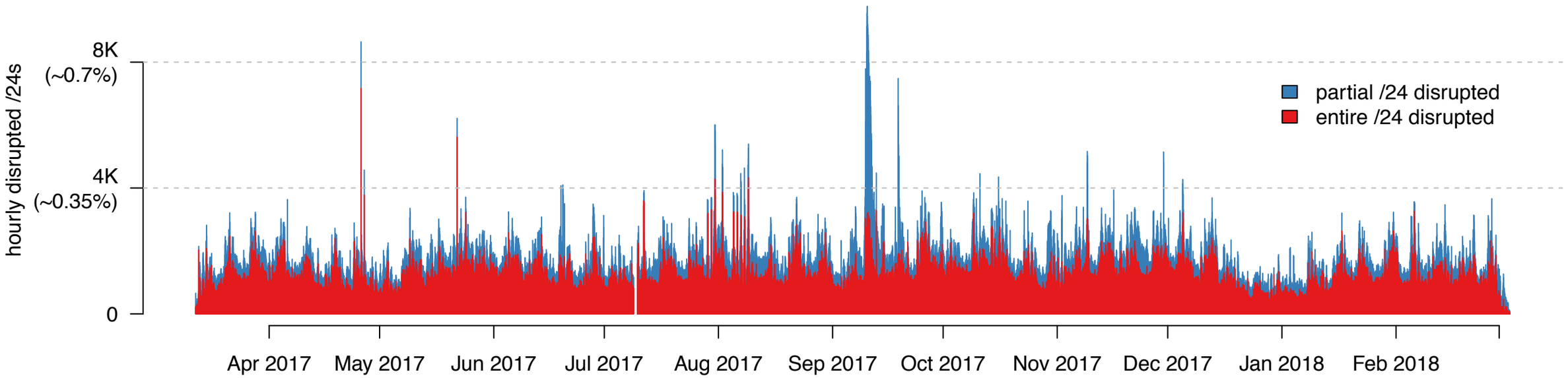


Global View on Disruptions



1.5M disruption events over the course of one year

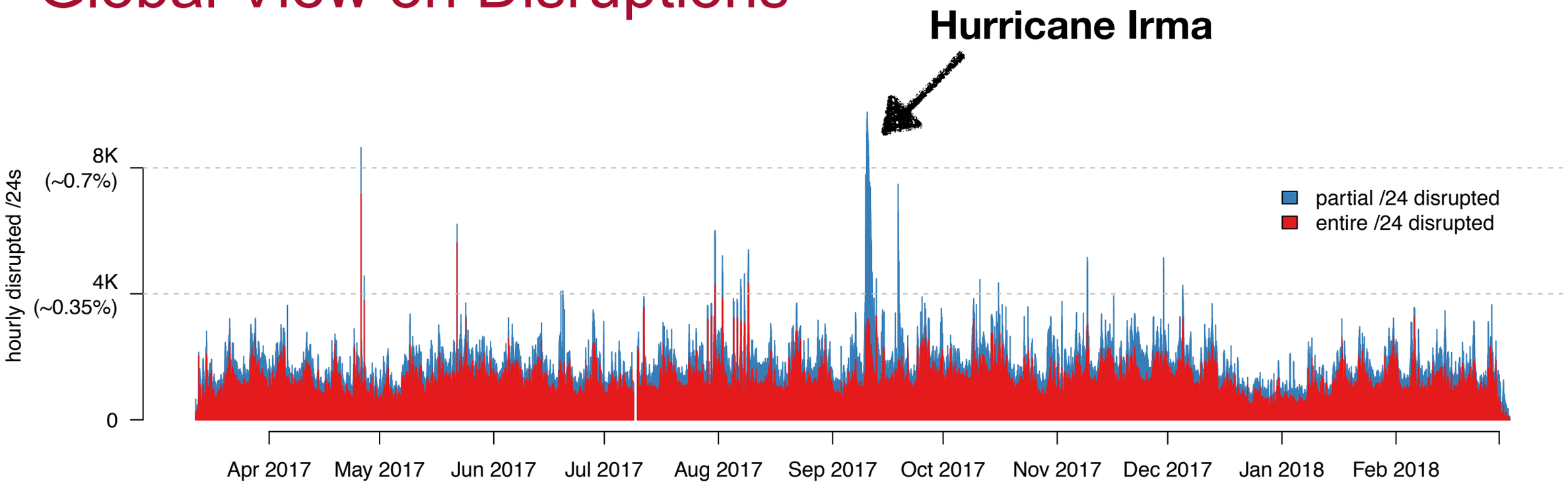
Global View on Disruptions



1.5M disruption events over the course of one year

- At least 0.2% of the monitored space faces a disruption
- Natural disasters, intended Internet shutdowns
- Weekly pattern, mostly absent during Christmas/NYE

Global View on Disruptions



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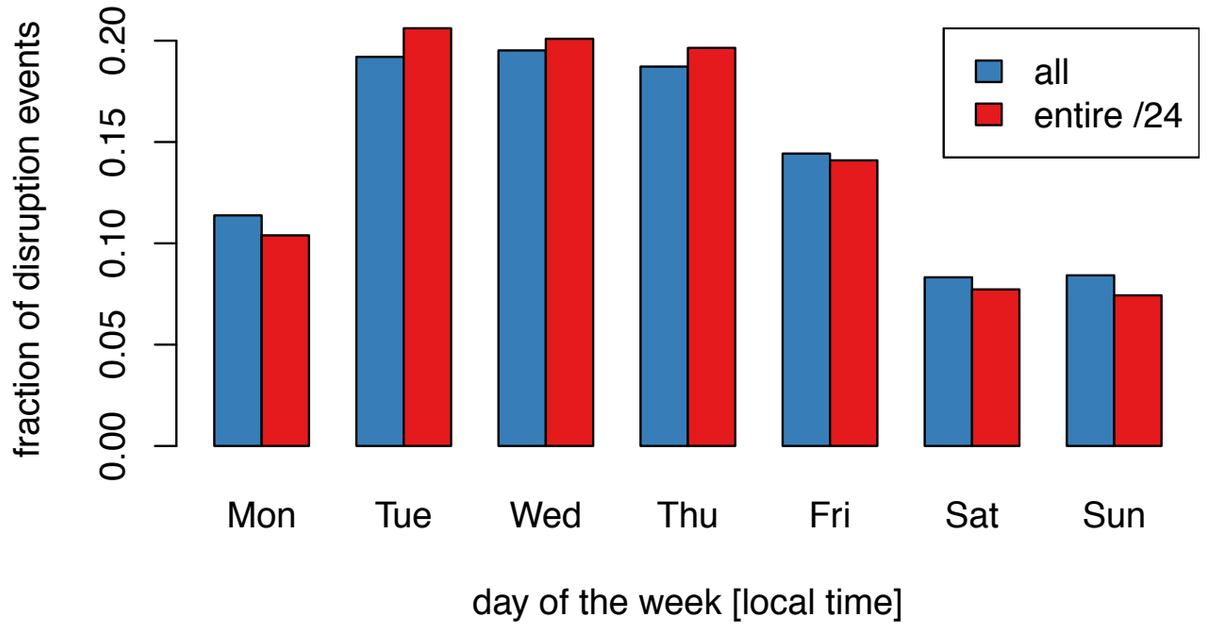
Weekly Pattern



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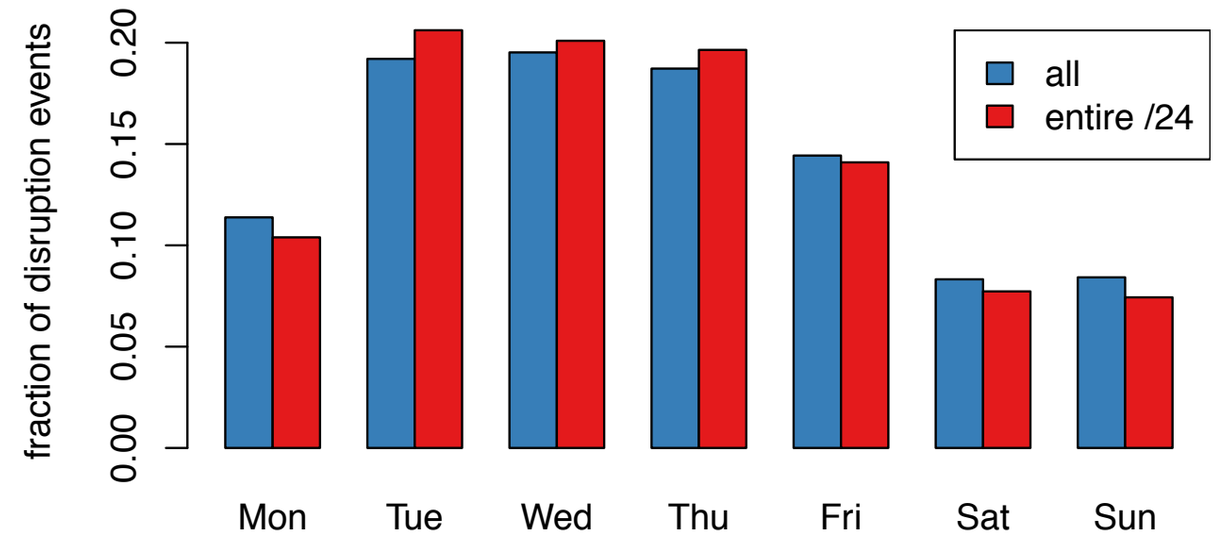
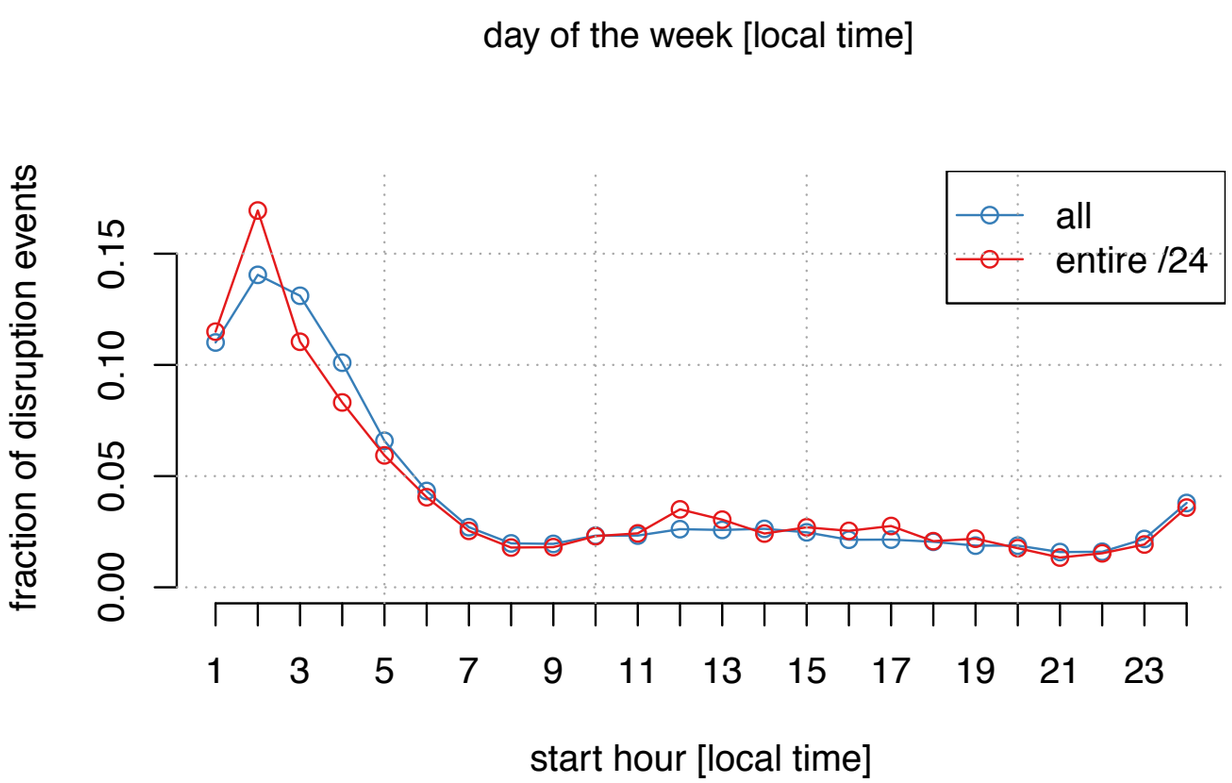
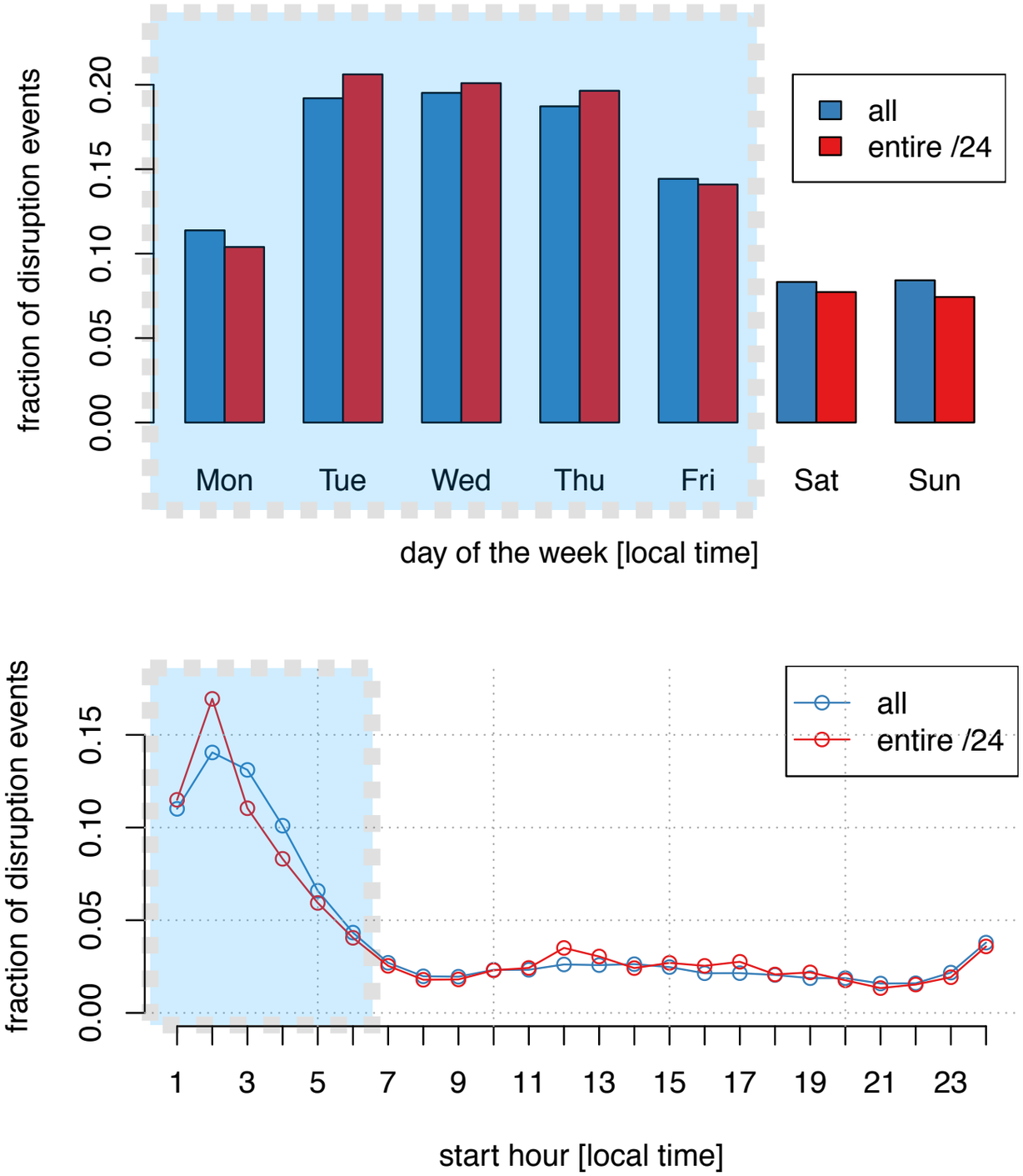




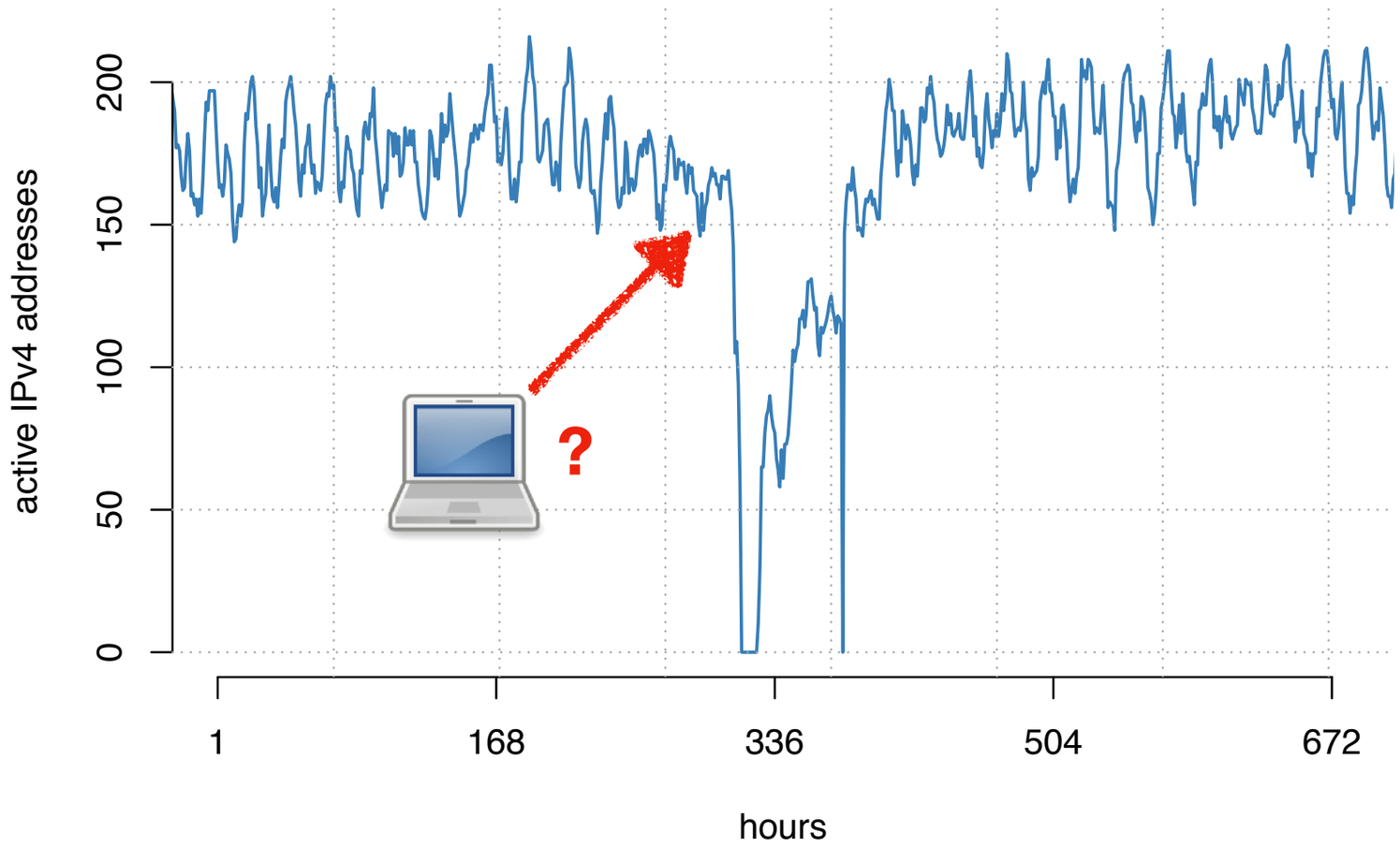
Weekly Pattern: Scheduled Maintenance Window



Outline

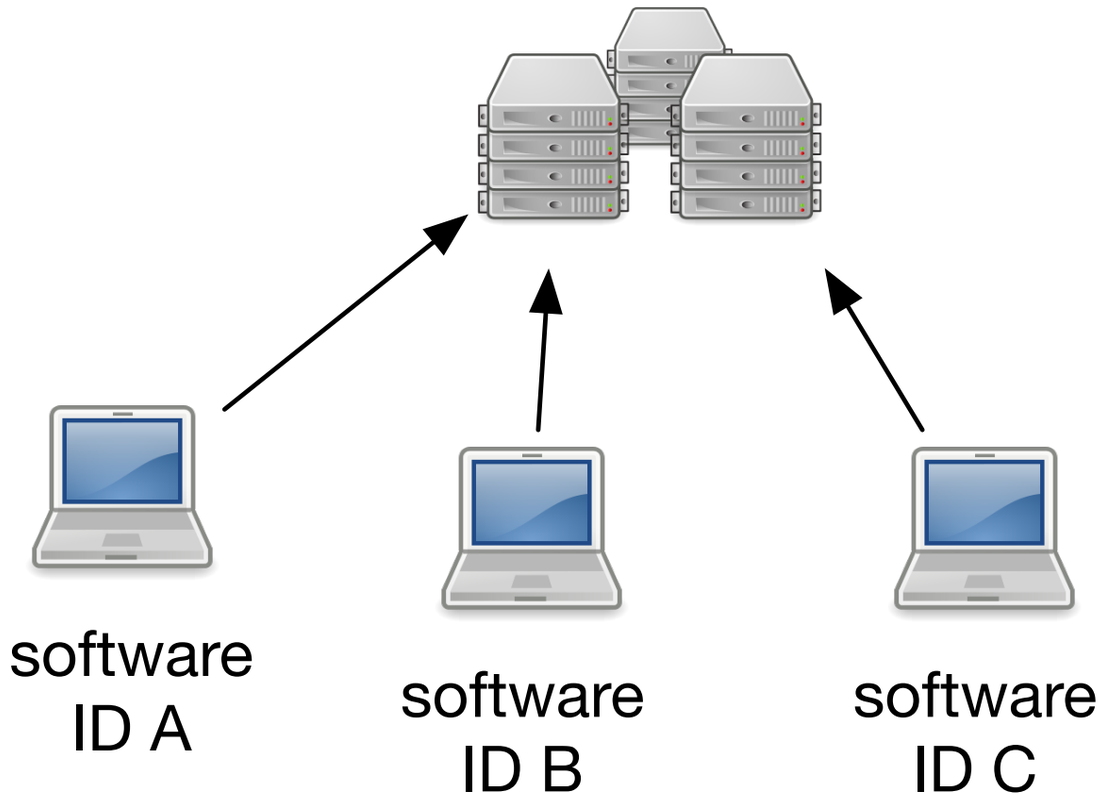
- Disruption Detection
- Global View on Disruptions
- **Device-Centric View on Disruptions**
- U.S. Broadband Case Study

Device Perspective on Disruptions



- ➡ Established that this *address block* lost connectivity
- ➡ Do *devices* really lose Internet connectivity?
- ➡ Or can they connect from somewhere else?

Device-Specific Dataset for Subset of Users



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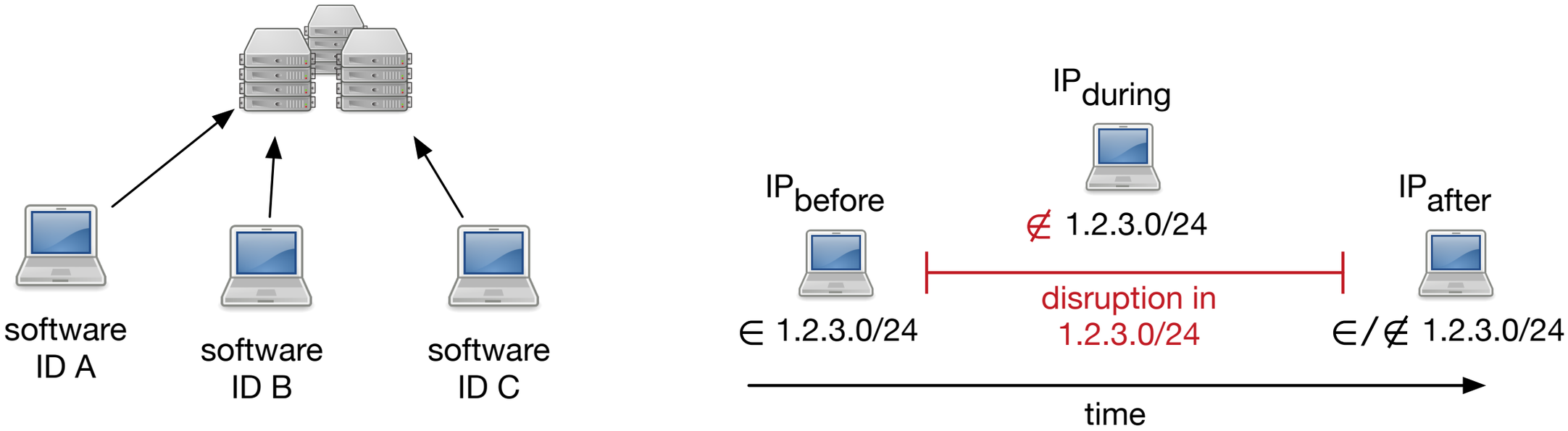
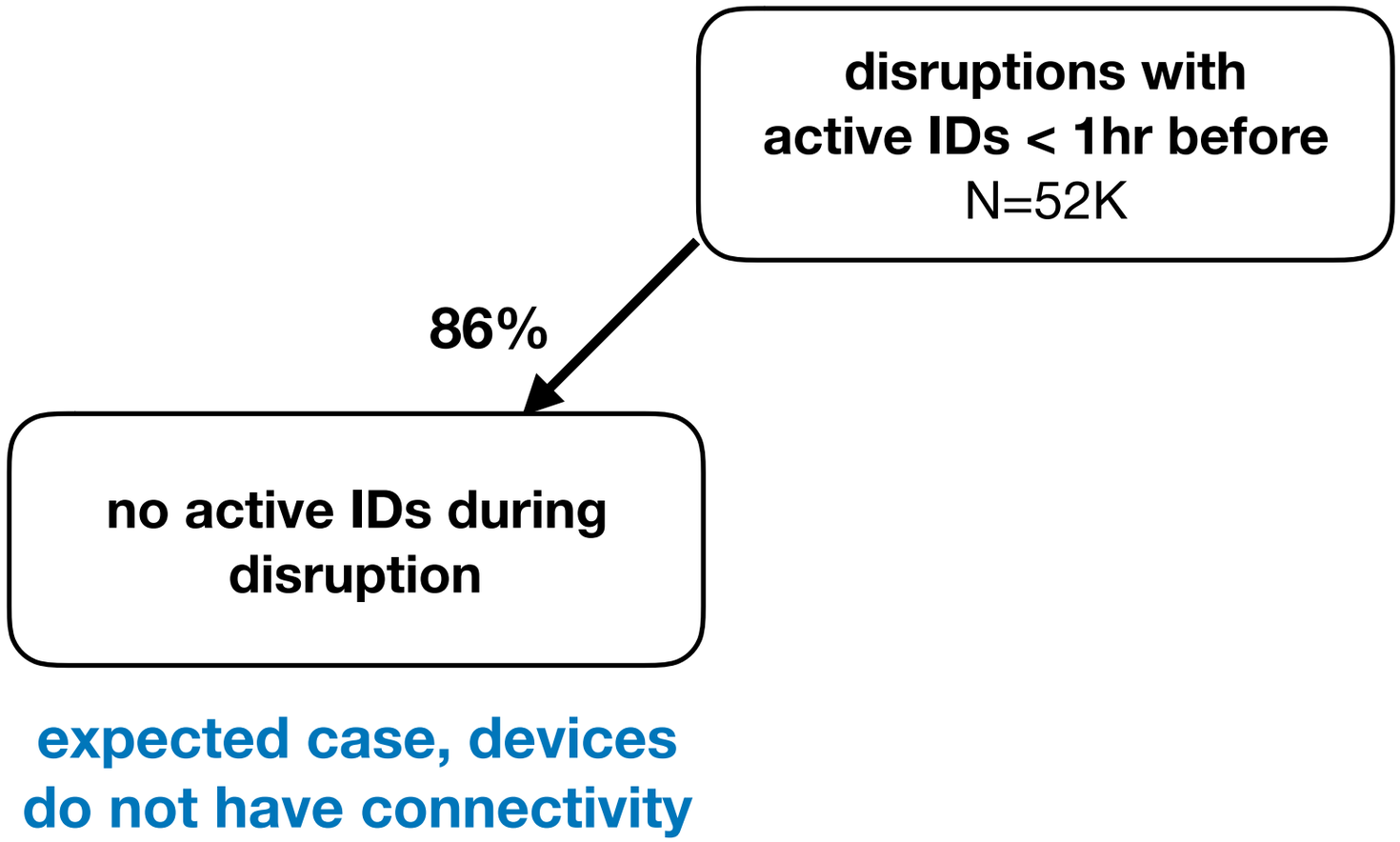


- ➡ Device-information for 52K “entire /24” disruption events
- ➡ Only consider disruptions which affected an entire /24
  (no activity during the disruption)

Device Perspective on Disruptions

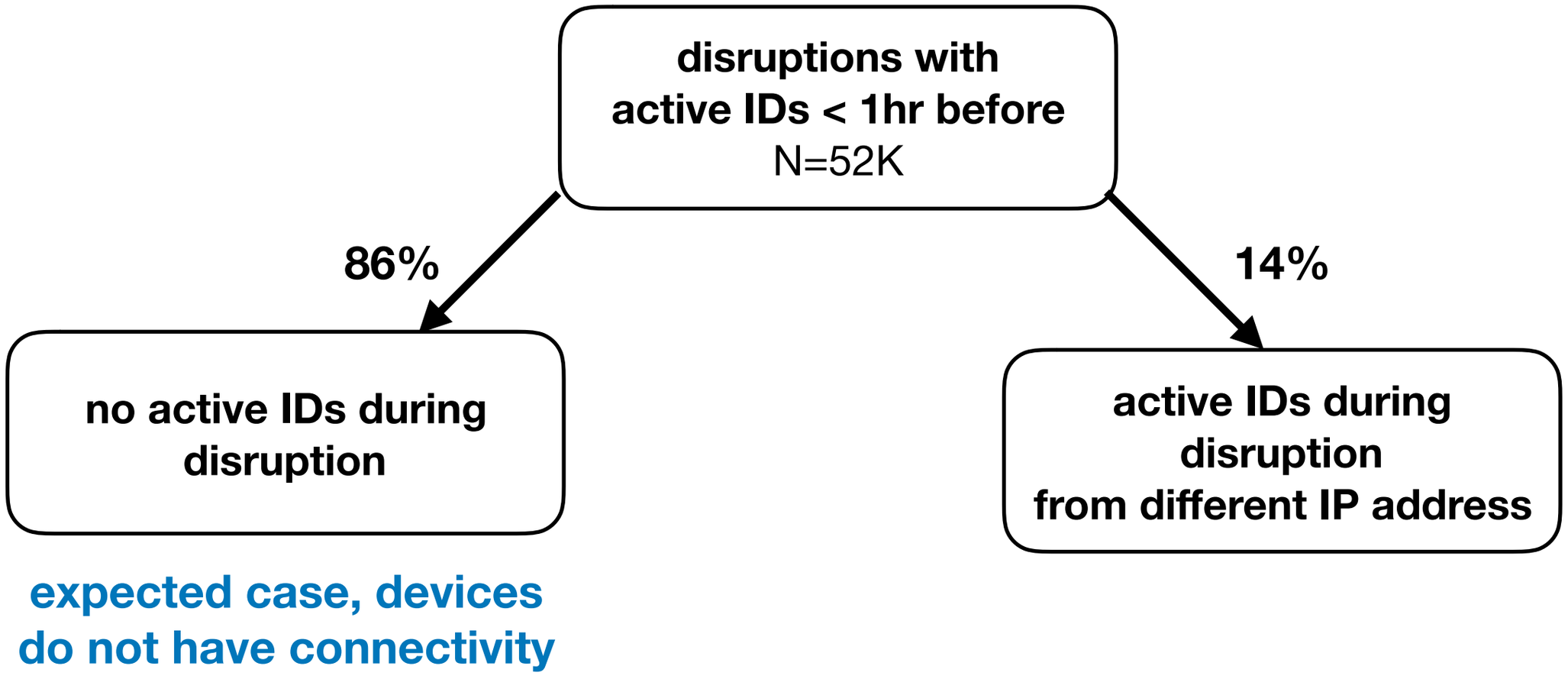
disruptions with
active IDs < 1hr before
N=52K

Device Perspective on Disruptions



expected case, devices do not have connectivity

Device Perspective on Disruptions



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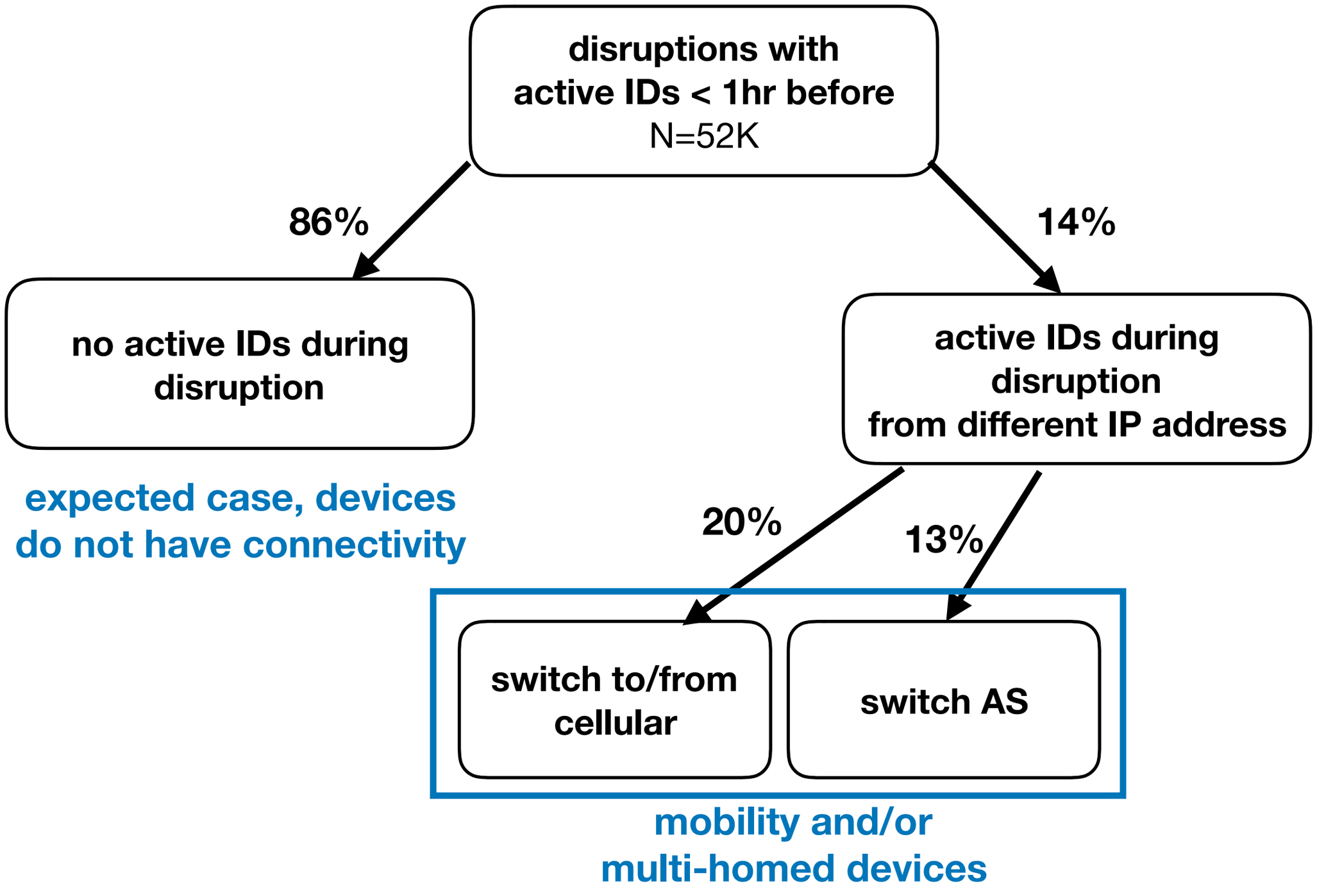
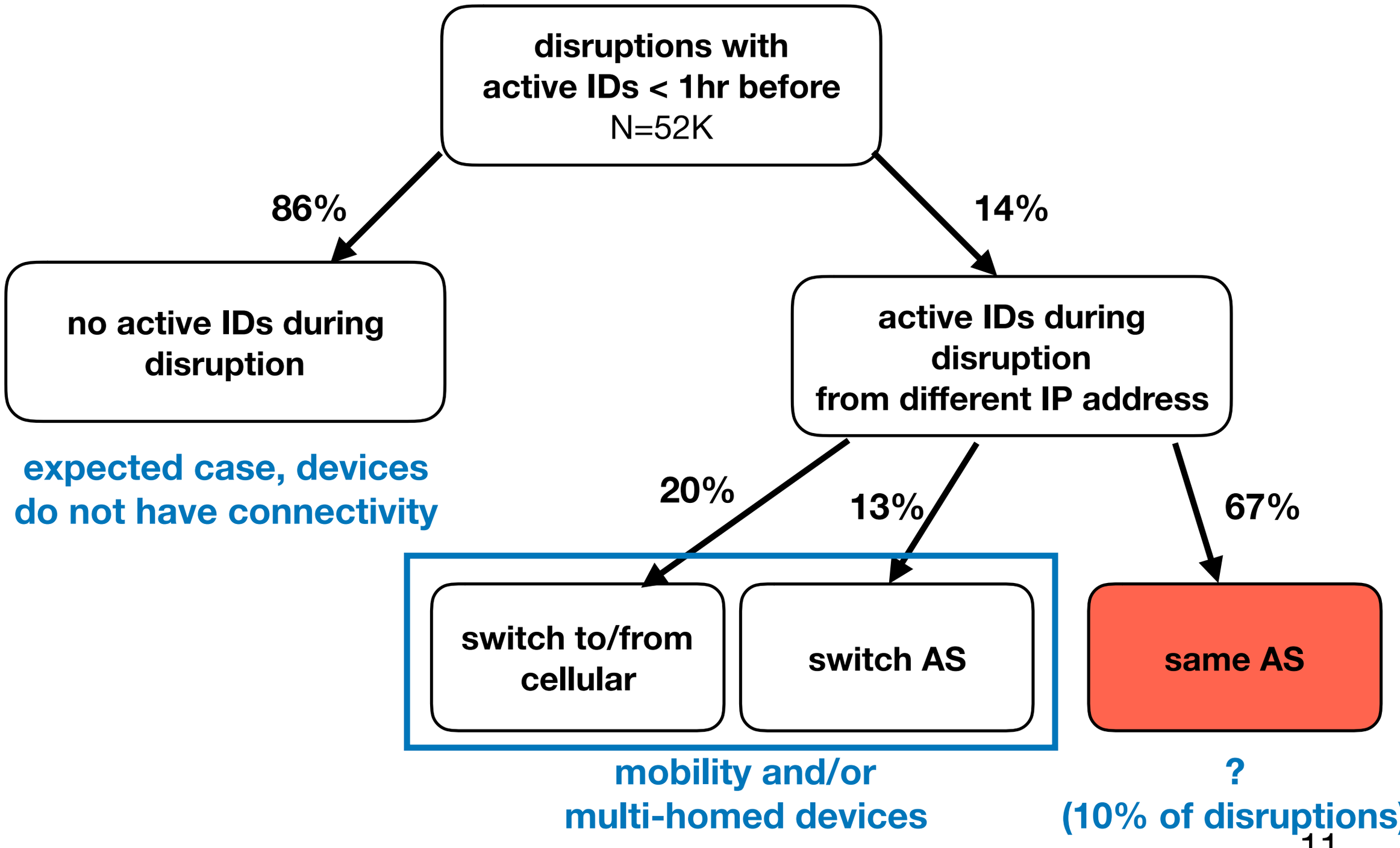


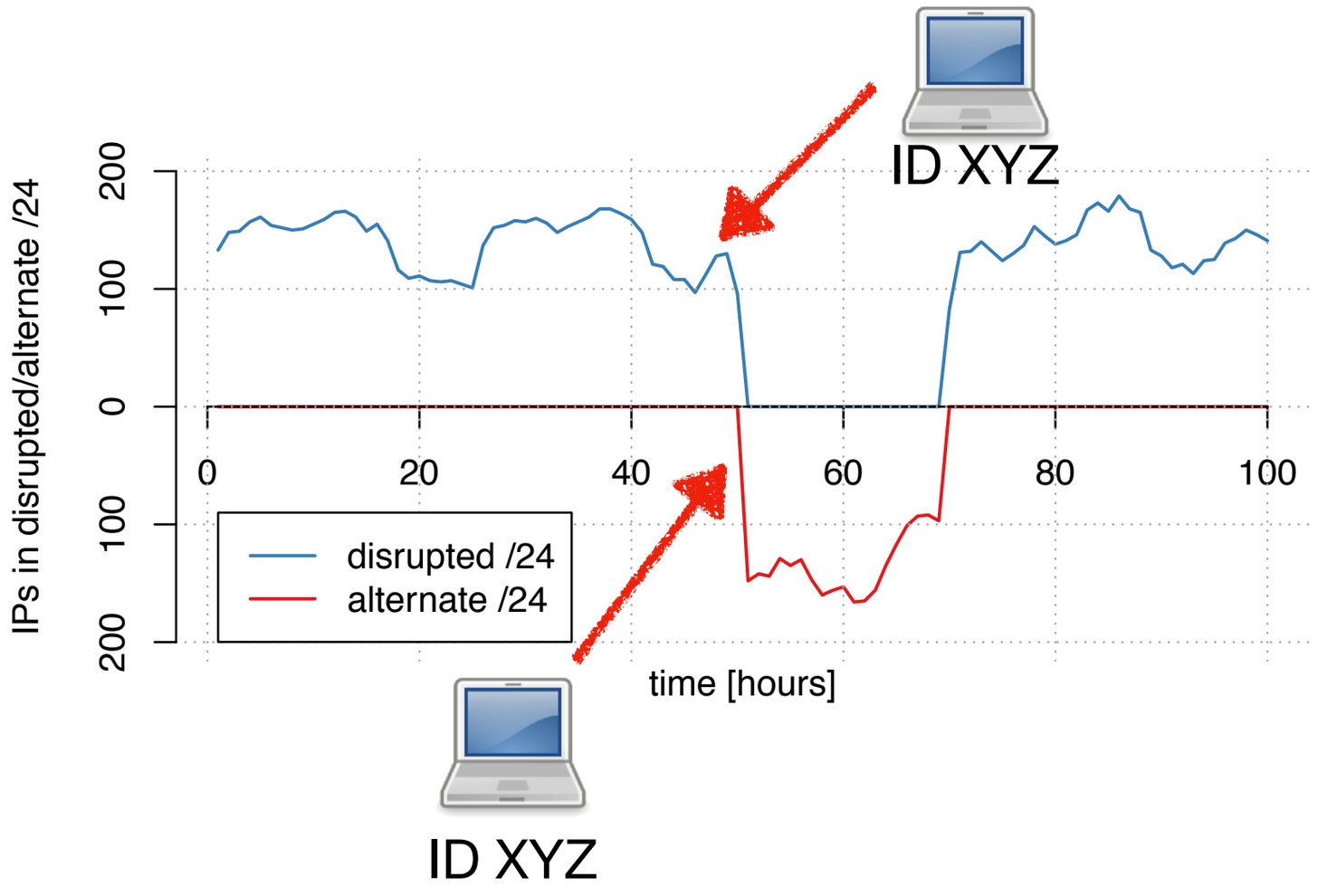
expected case, devices
do not have connectivity

mobility and/or
multi-homed devices

Device Perspective on Disruptions



Anti-Disruptions: Temporary Surges in Address Activity



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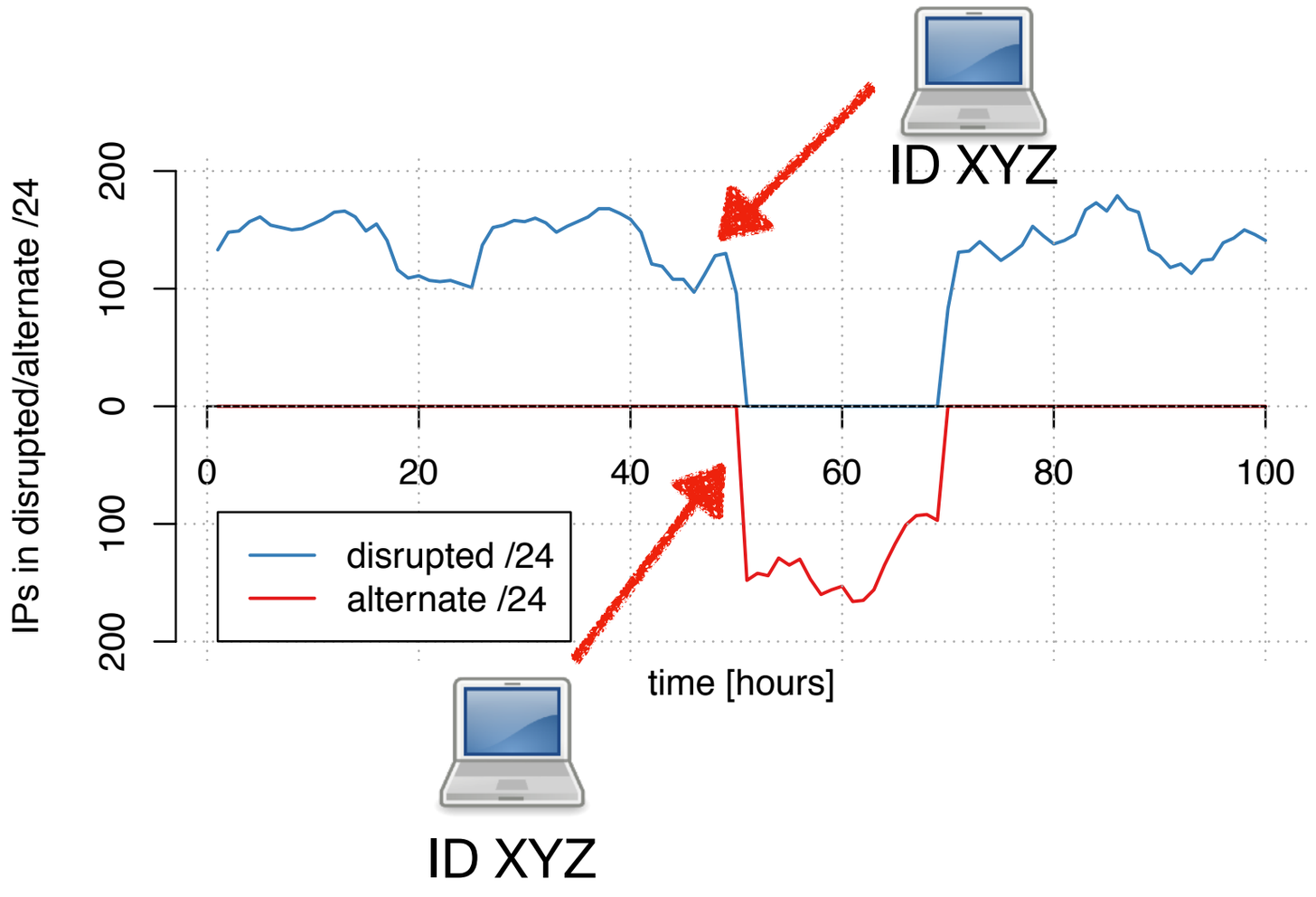
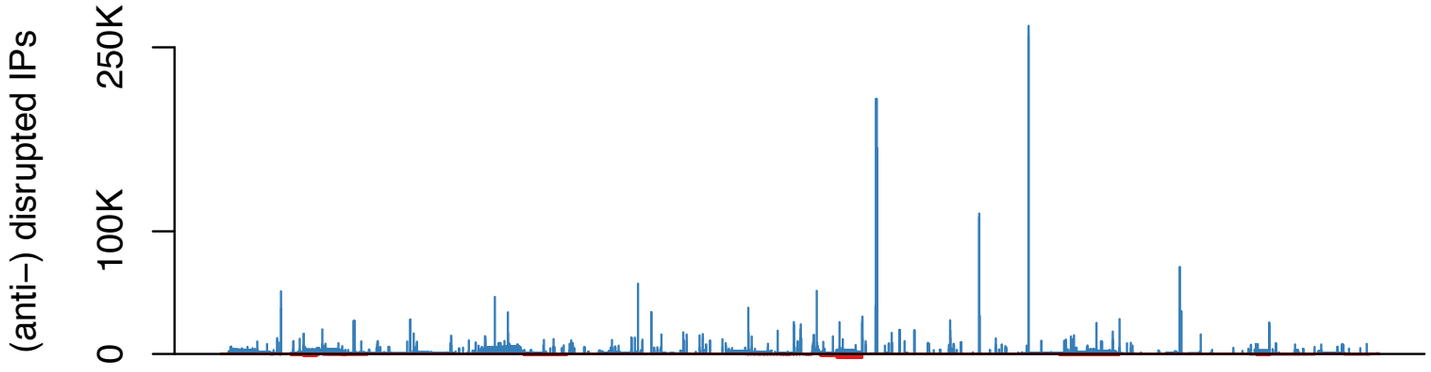


➡ **Some disruptions not service outages but address reassignment!**

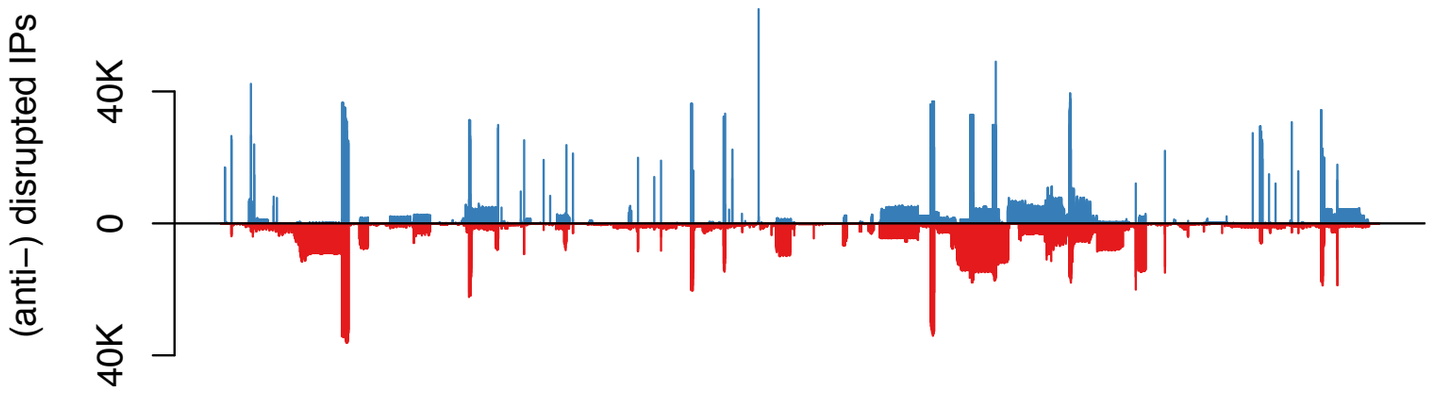
➡ Developed mechanism to detect anti-disruptions

➡ Rank ASes by correlation of disruptions with anti-disruptions

AS-Level Disruptions and Anti-Disruptions



major US cable ISP: No correlation between disruptions and anti-disruptions
(pearson r= 0.02)



Uruguayan ISP: Strong correlation between disruptions and anti-disruptions
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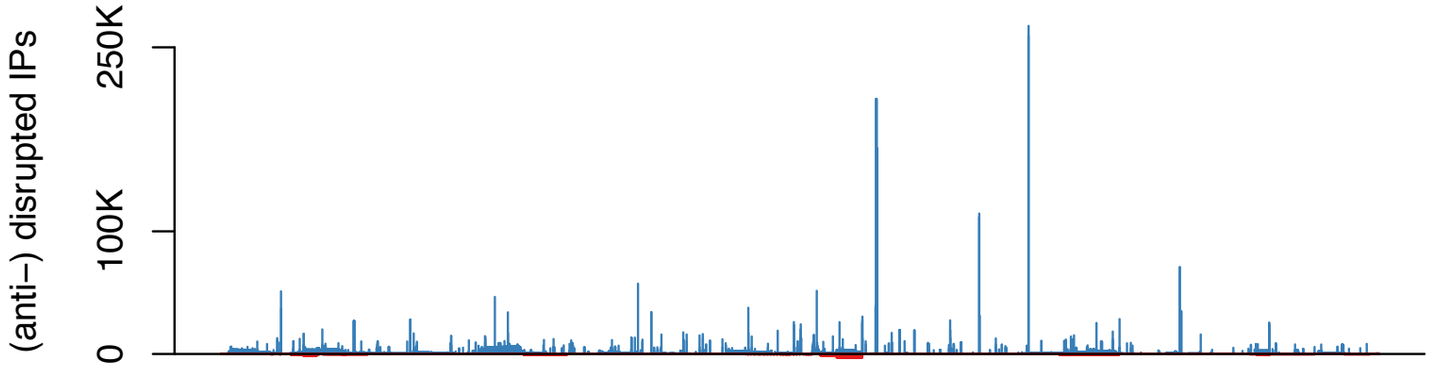

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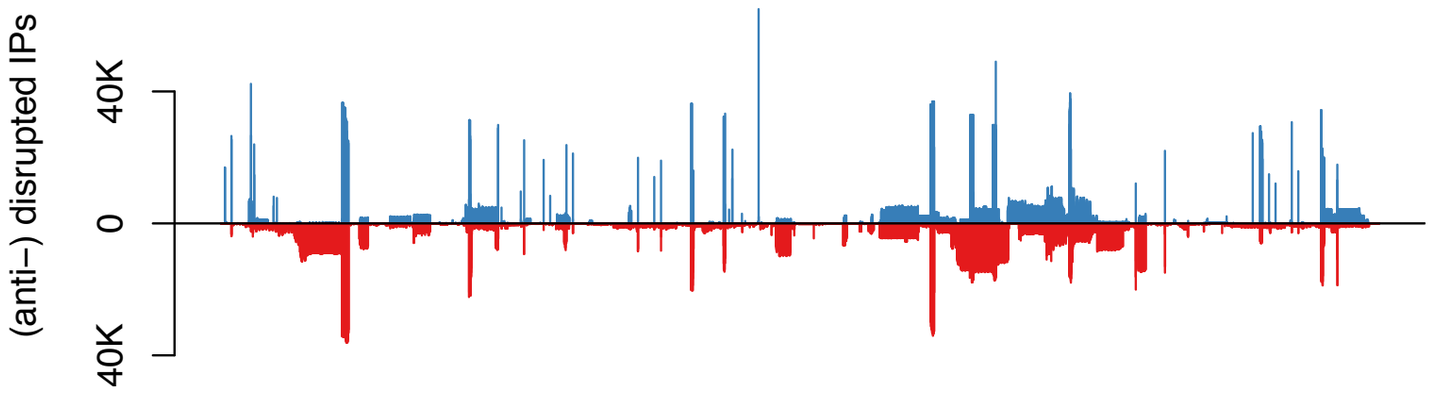

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Anti-Disruptions can heavily skew per-AS and per-country assessment of Internet reliability

Case Study: US Broadband ISPs

	ISP A Cable	ISP B Cable	ISP C Cable	ISP D DSL	ISP E DSL	ISP F DSL	ISP G DSL

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	ISP A Cable	ISP B Cable	ISP C Cable	ISP D DSL	ISP E DSL	ISP F DSL	ISP G DSL
anti-disruption correlation	0.22	0.03	-0.02	0.03	0.00	-0.04	0.05
% disruptions w/ intermittent activity	4%	1%	1%	0%	3%	6%	14%

Most major US broadband ISPs do not show strong signs of anti-disruptions.

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% disruptions w/ intermittent activity	4%	1%	1%	0%	3%	6%	14%
% /24s only disrupted maintenance window	67%	54%	75%	29%	60%	71%	62%

All (but one) ISP has majority of all disrupted /24s during scheduled maintenance window (Mo-Fr Midnight-6AM).

Case Study: US Broadband ISPs

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% /24s only disrupted maintenance window	67%	54%	75%	29%	60%	71%	62%
% /24s only disrupted during Hurricane Irma	11%	1%	2%	23%	1%	0%	3%

ISP A: Some 80% of all disruptions fall in the maintenance window, or are caused by force majeure (Hurricane Irma).

Relevant for SLAs, policies, and reliability assessment.

Implications

- **Outage Detection: Methodological Insights**
  - Baseline activity enables fine-granular detection of disruptions
  - Anti-disruptions due to reassignment
    - ➡ Can bias active and passive outage detection systems
- **Interpreting Service Outages**
  - Majority of outages (for many ISPs) during scheduled maintenance
    - ➡ Implications for SLAs, reporting requirements, regulations