Blink: Fast Connectivity Recovery Entirely in the Data Plane

Thomas Holterbach
ETH Zürich

NSDI
26th February 2019

https://blink.ethz.ch

Joint work with

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Maria Apostolaki	**ETH Zürich**
Stefano Vissicchio	**University College London**
Alberto Dainotti	**CAIDA, UC San Diego**
Laurent Vanbever	**ETH Zürich**

Fire at AT&T facility causes widespread outage in North Texas

TELECOM

Nationwide internet outage affects CenturyLink customers

Time Warner Cable comes back from nationwide Internet outage

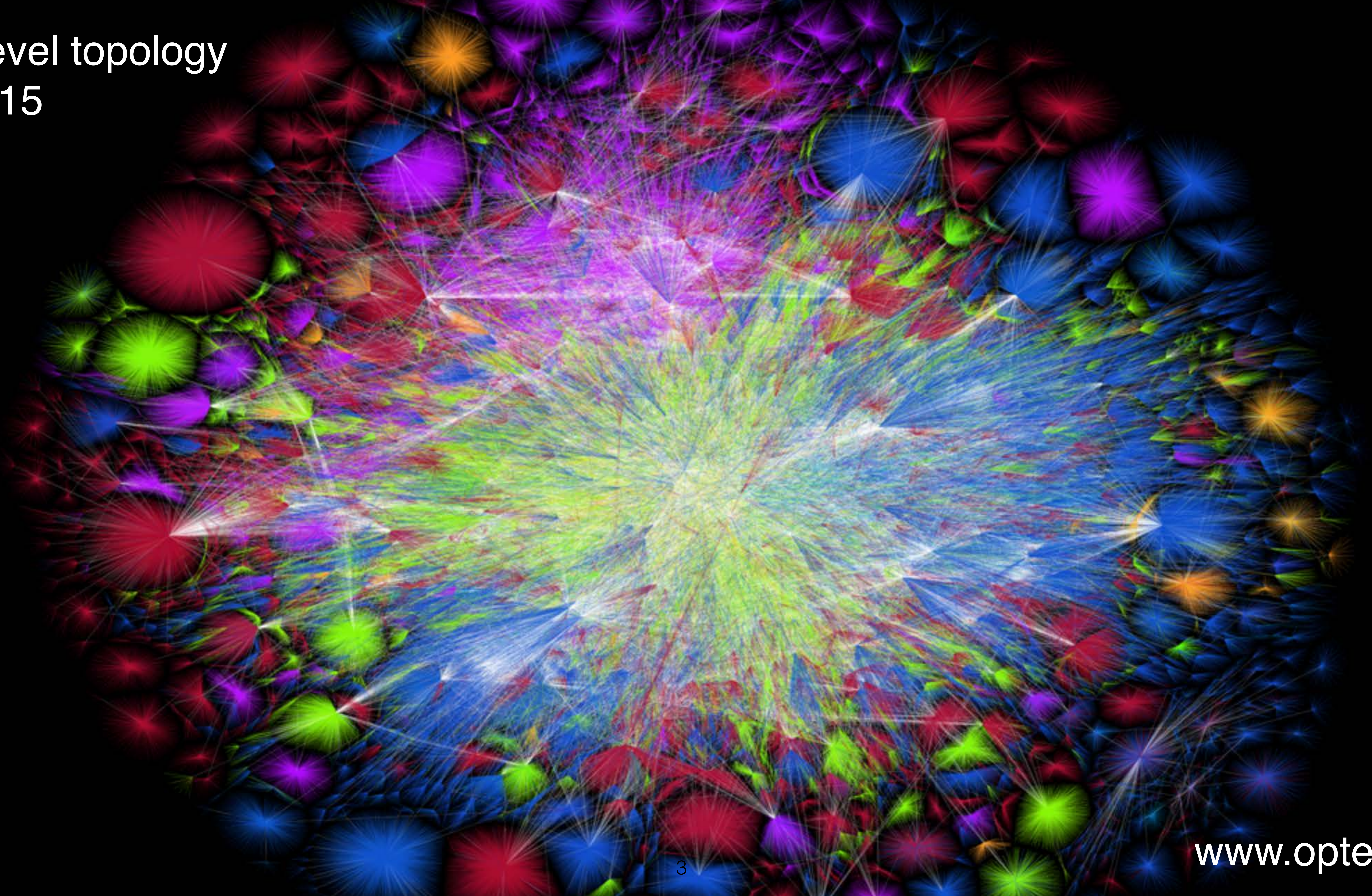
by Brian Stelter @brianstelter

August 27, 2014: 11:07 PM ET

Major internet outage hits the U.S. - Affecting customers of Comcast, Verizon, and AT&T

November 6, 2017 | Emerging Threats

AS level topology in 2015



www.opte.org

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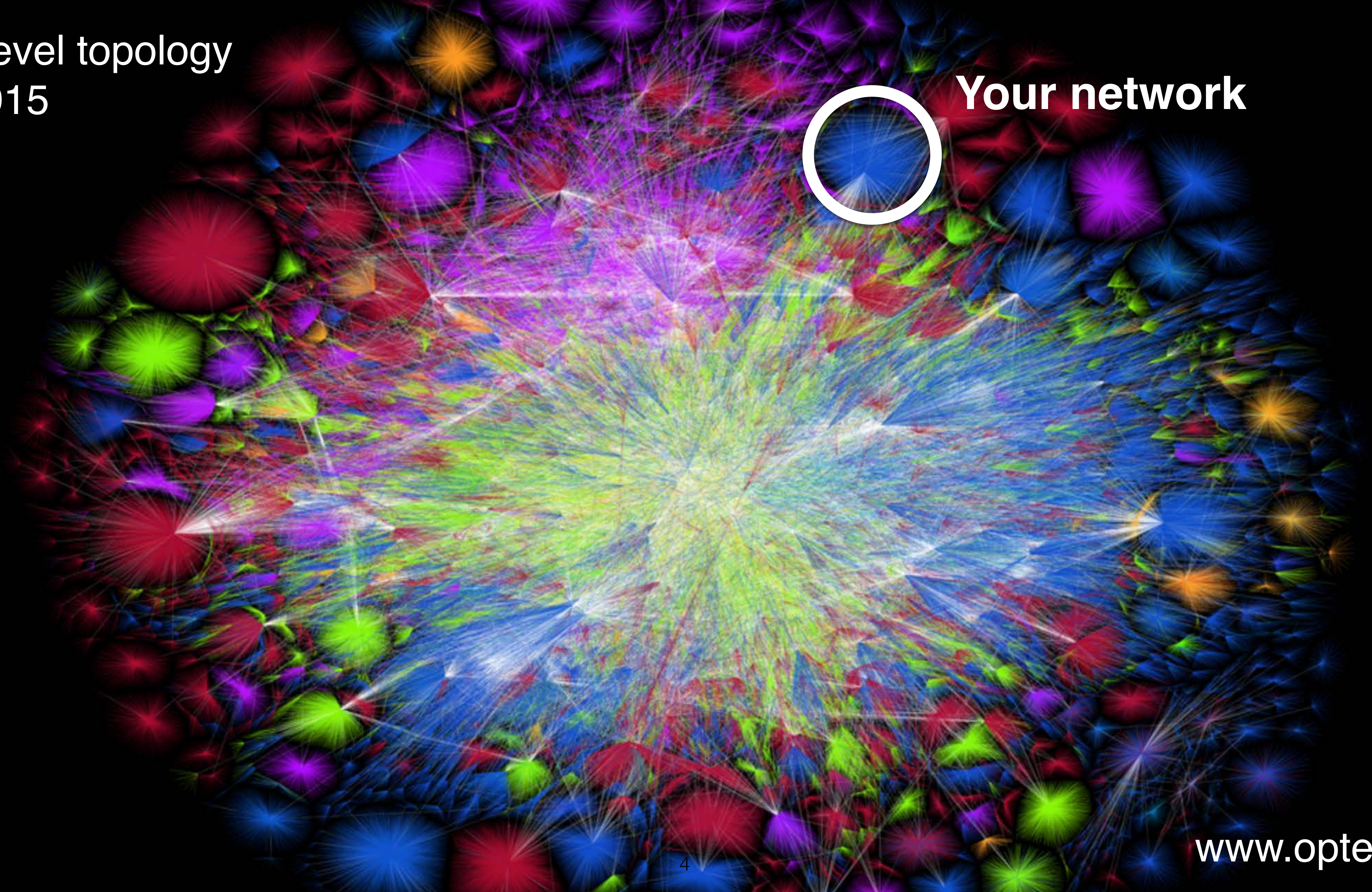

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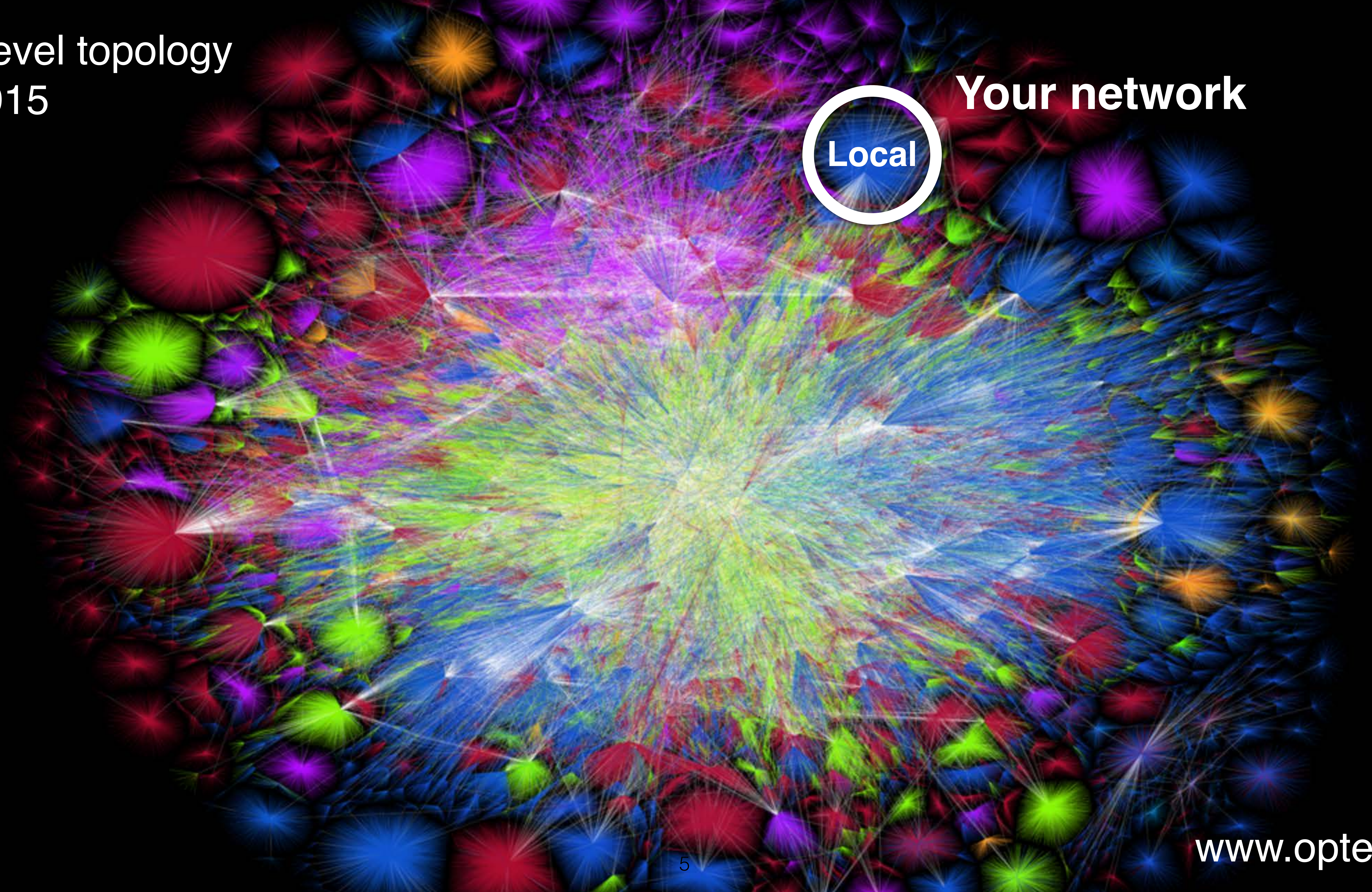

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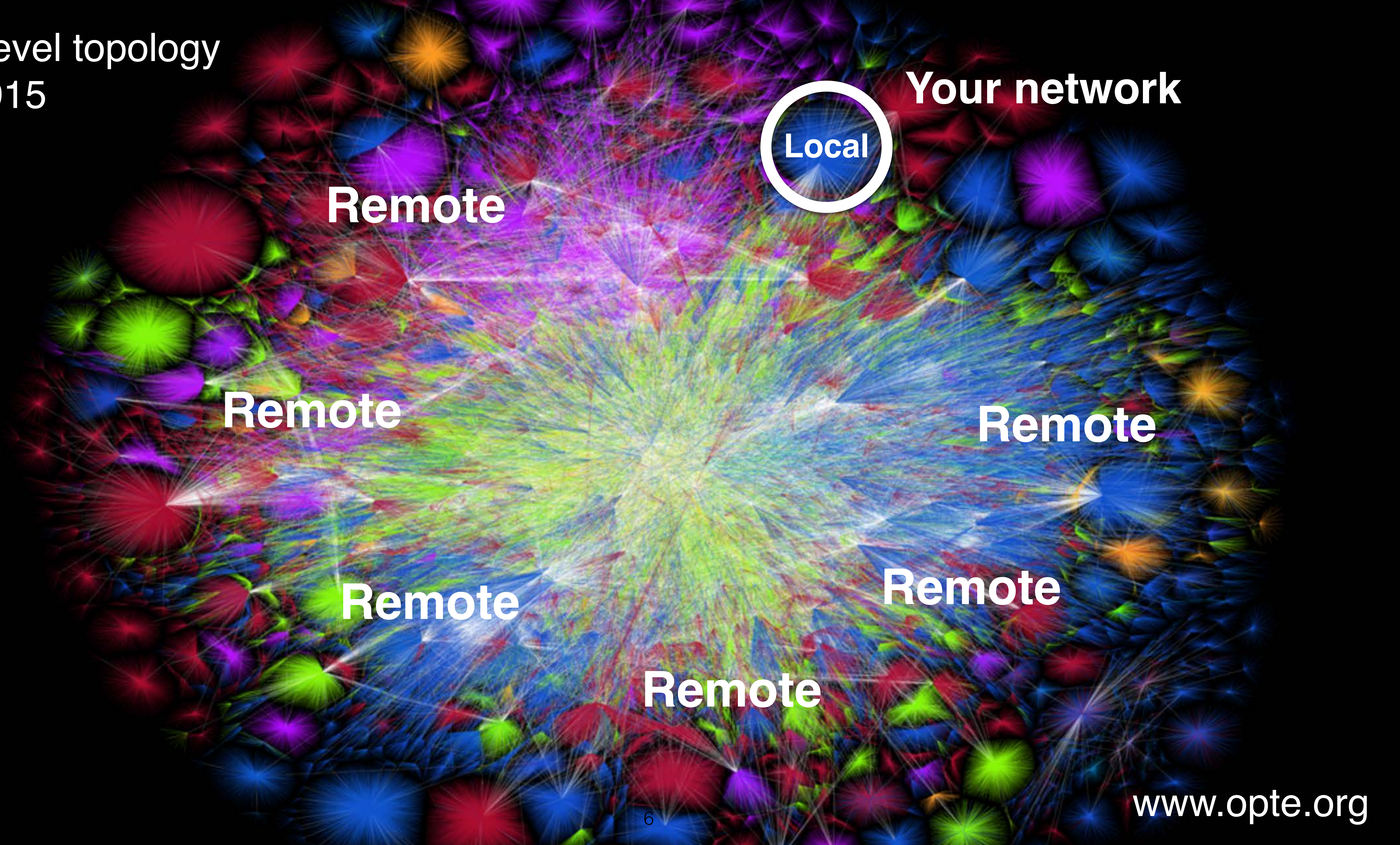

Upon local failures, connectivity can be quickly restored

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Fast failure detection
using *e.g.*, hardware-generated signals

Fast traffic rerouting
using *e.g.*, Prefix Independent Convergence
or MPLS Fast Reroute

Upon remote failures, the only way to restore connectivity is to wait for the Internet to converge

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… and the Internet converges *very* slowly*

*Holterbach et al. SWIFT: Predictive Fast Reroute ACM SIGCOMM, 2017

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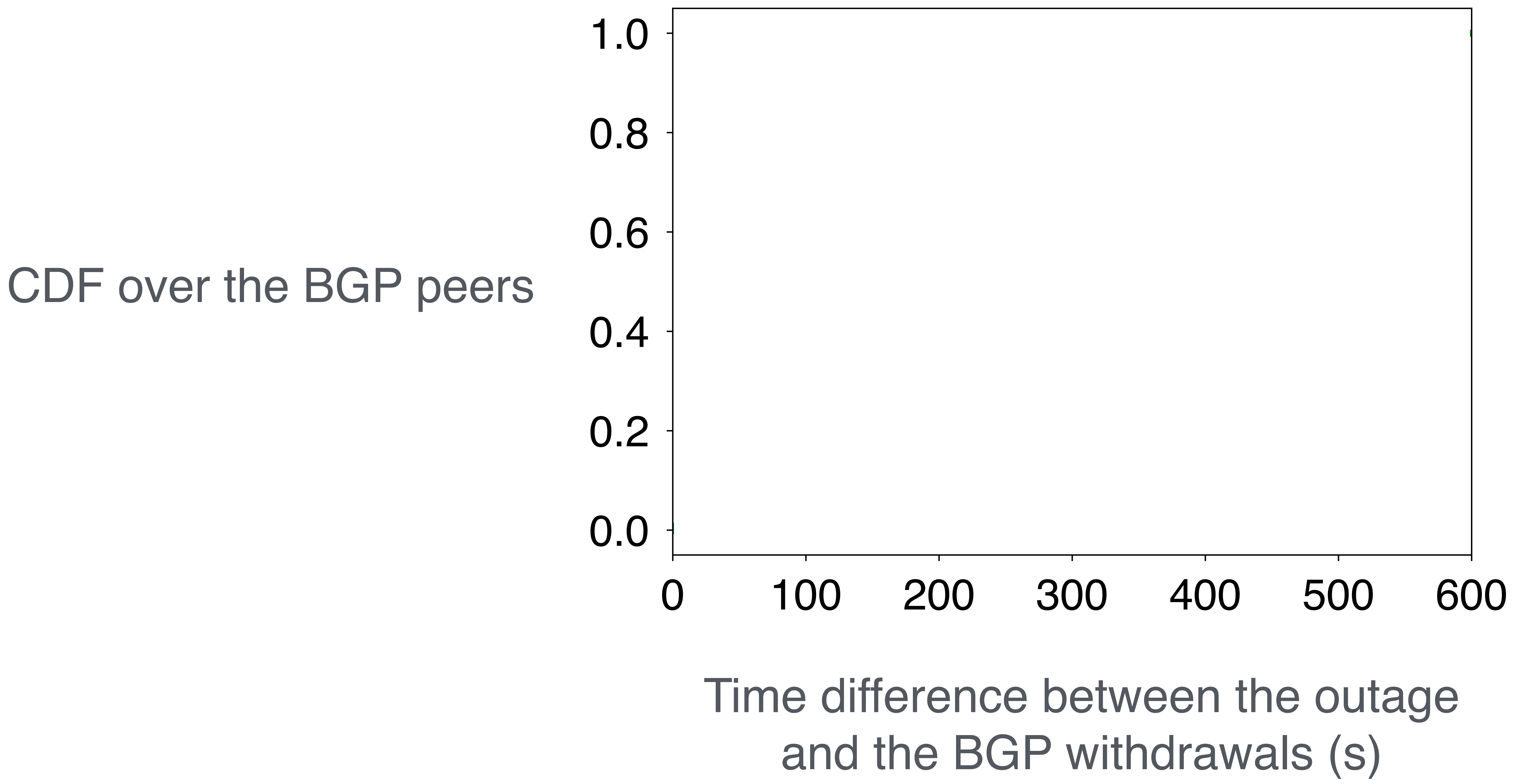

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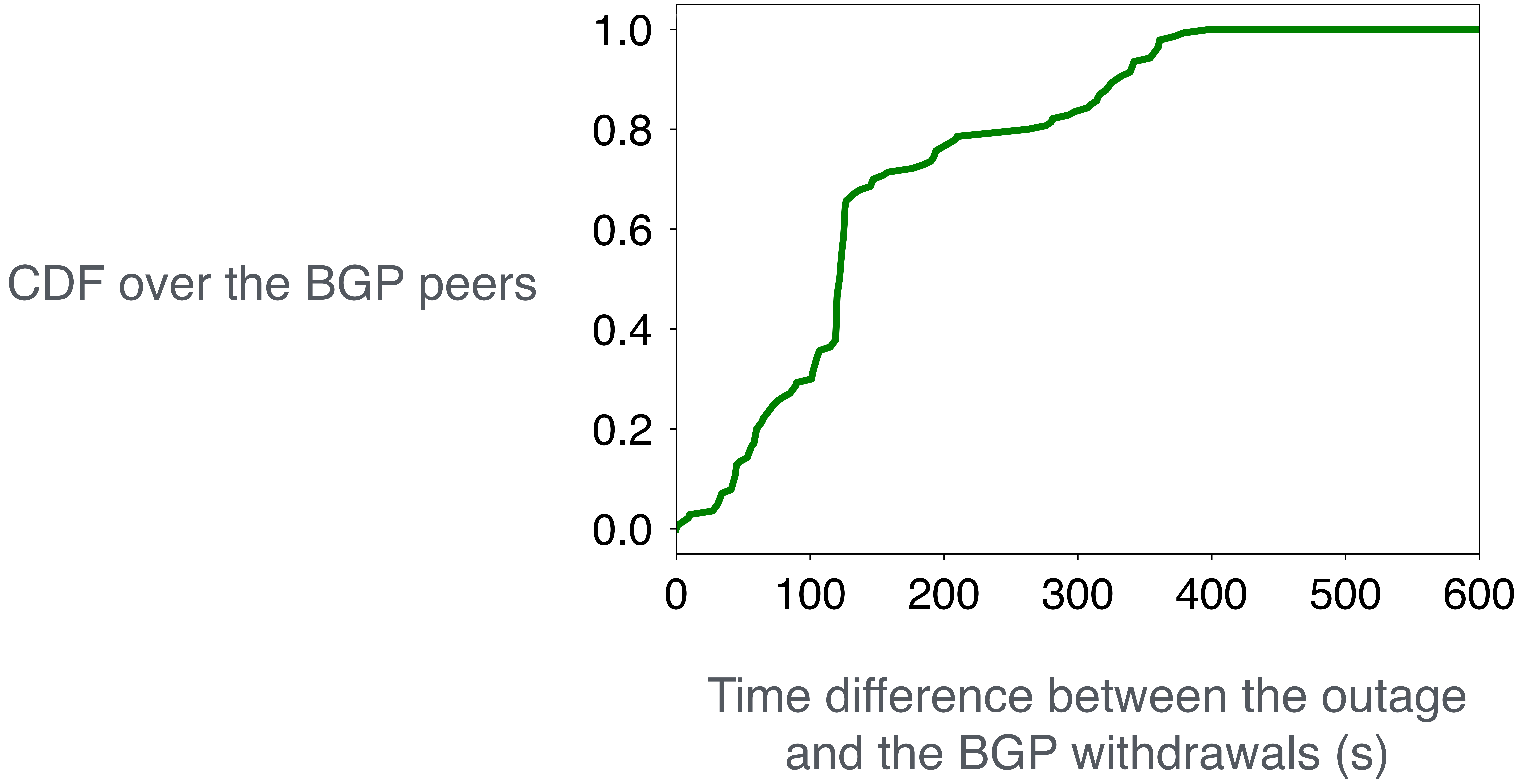

Control-plane (*e.g.*, BGP) based techniques typically converge slowly upon remote outages

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What about using data-plane signals for fast rerouting?

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Outline

1. Why and how to use data-plane signals for fast rerouting
2. ***Blink*** infers more than 80% of the failures, often within 1s
3. ***Blink*** quickly reroutes traffic to working backup paths
4. ***Blink*** works in practice, on existing devices

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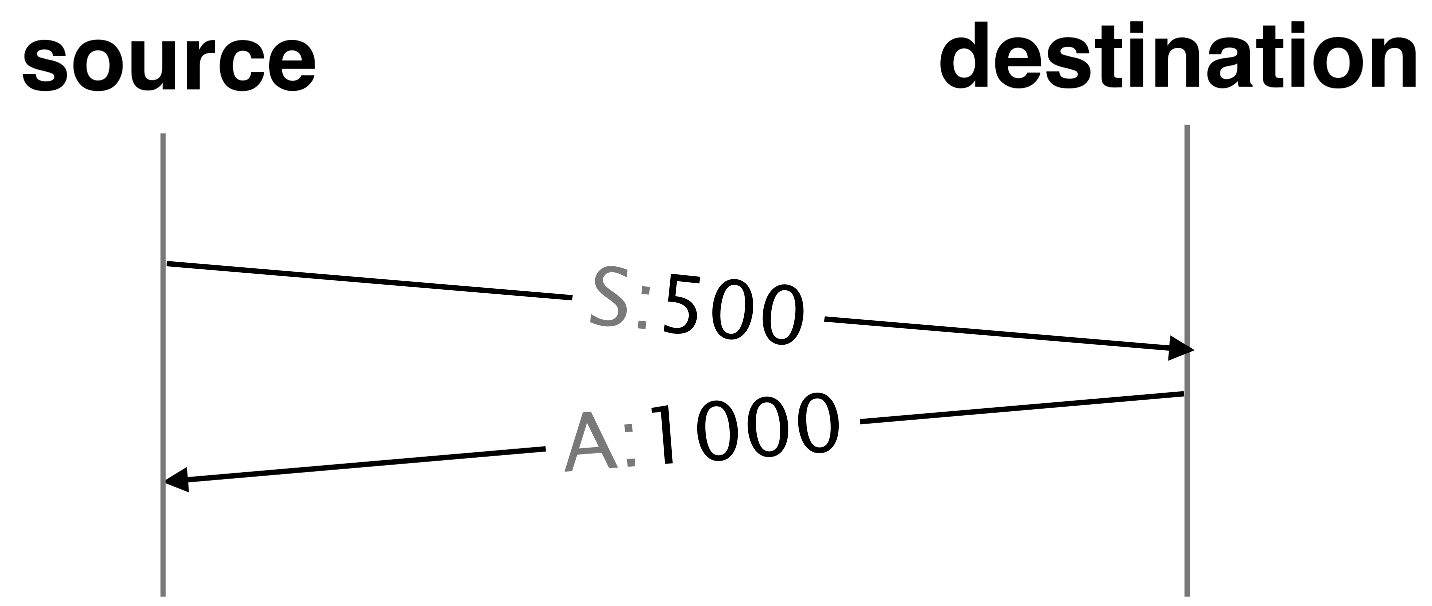

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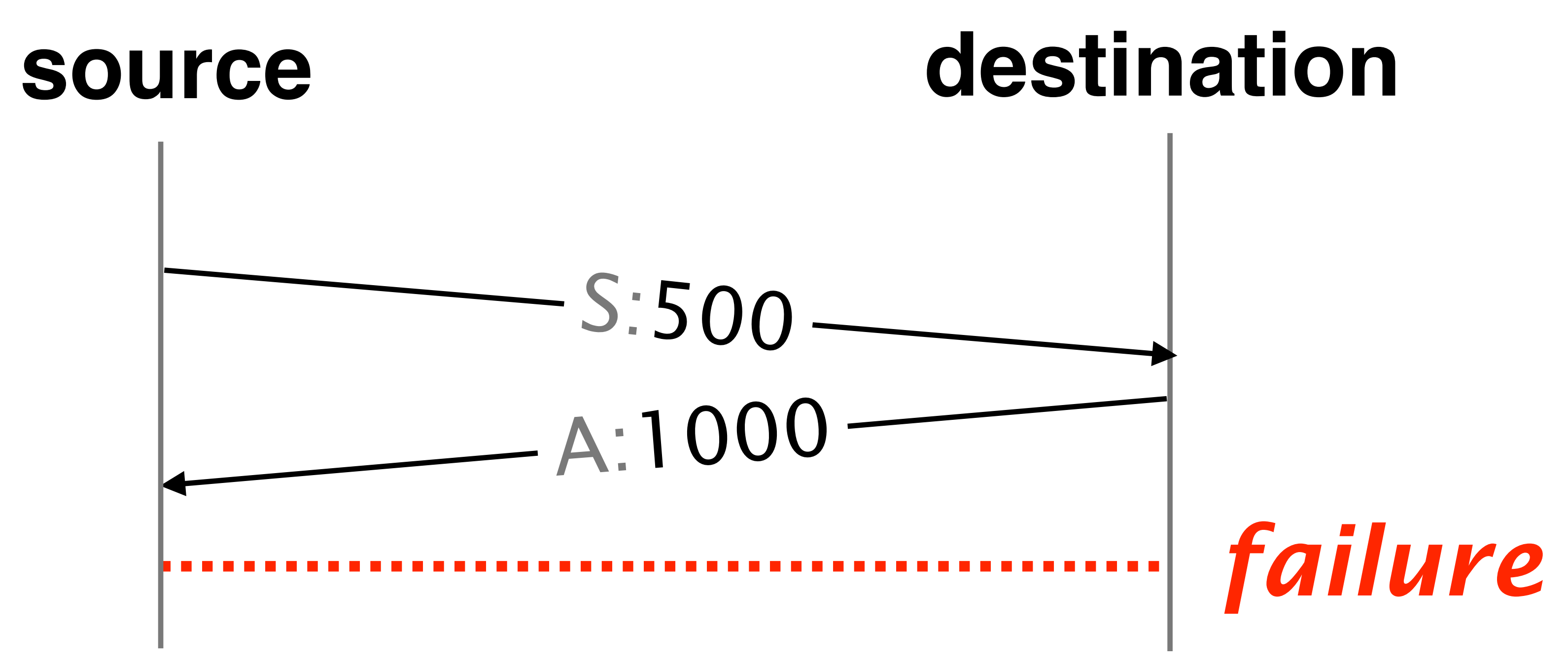

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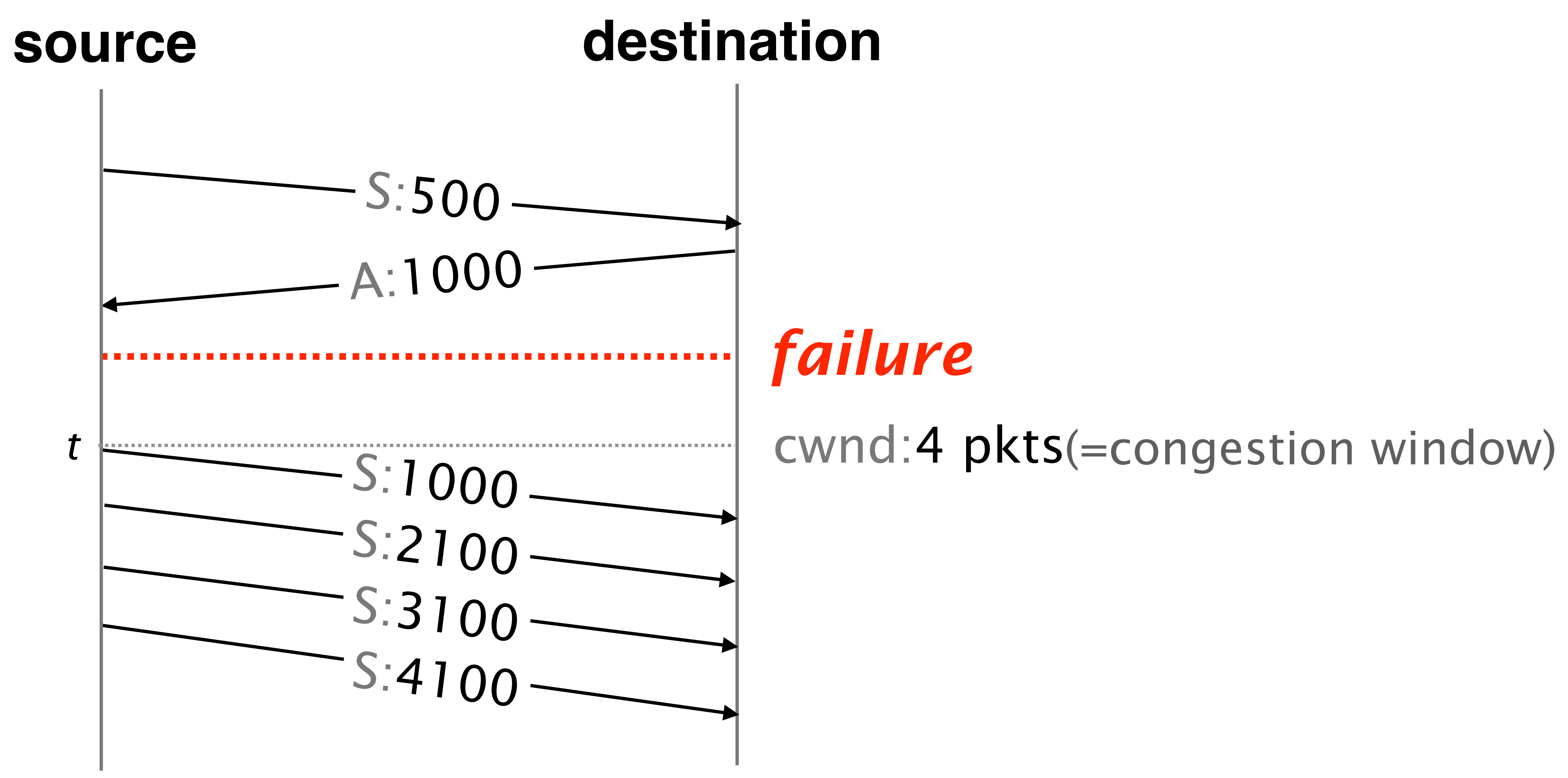

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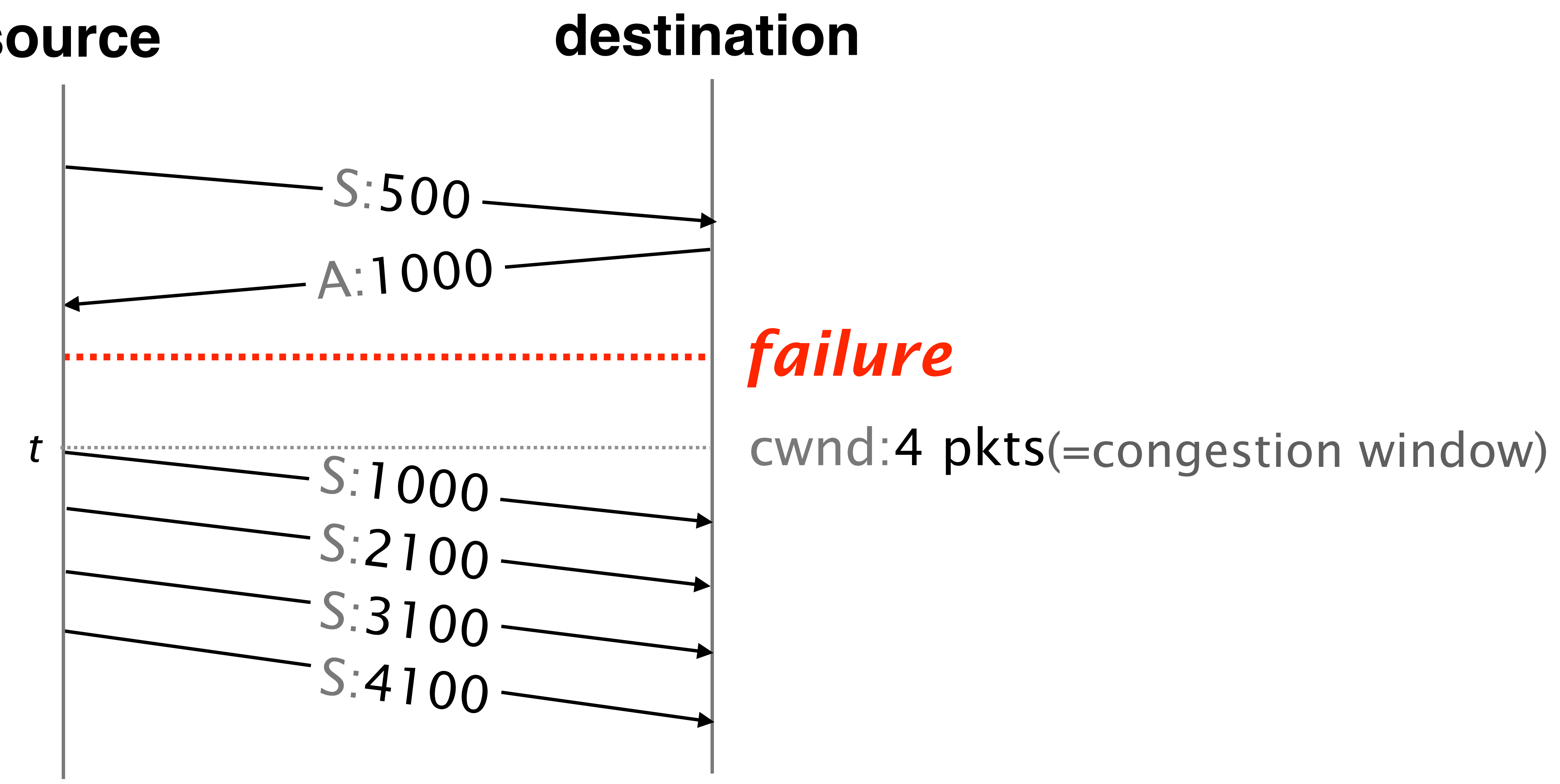

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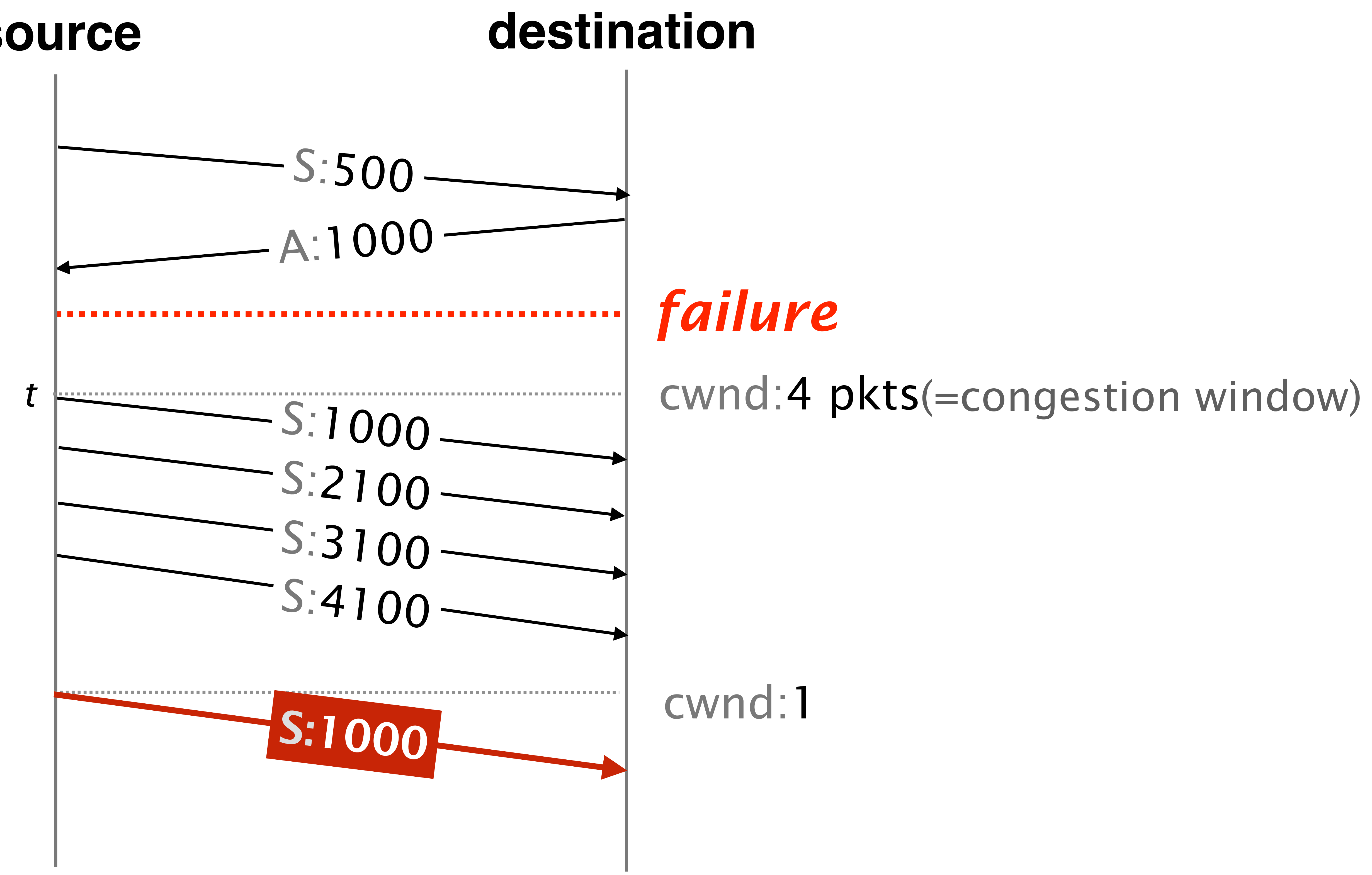

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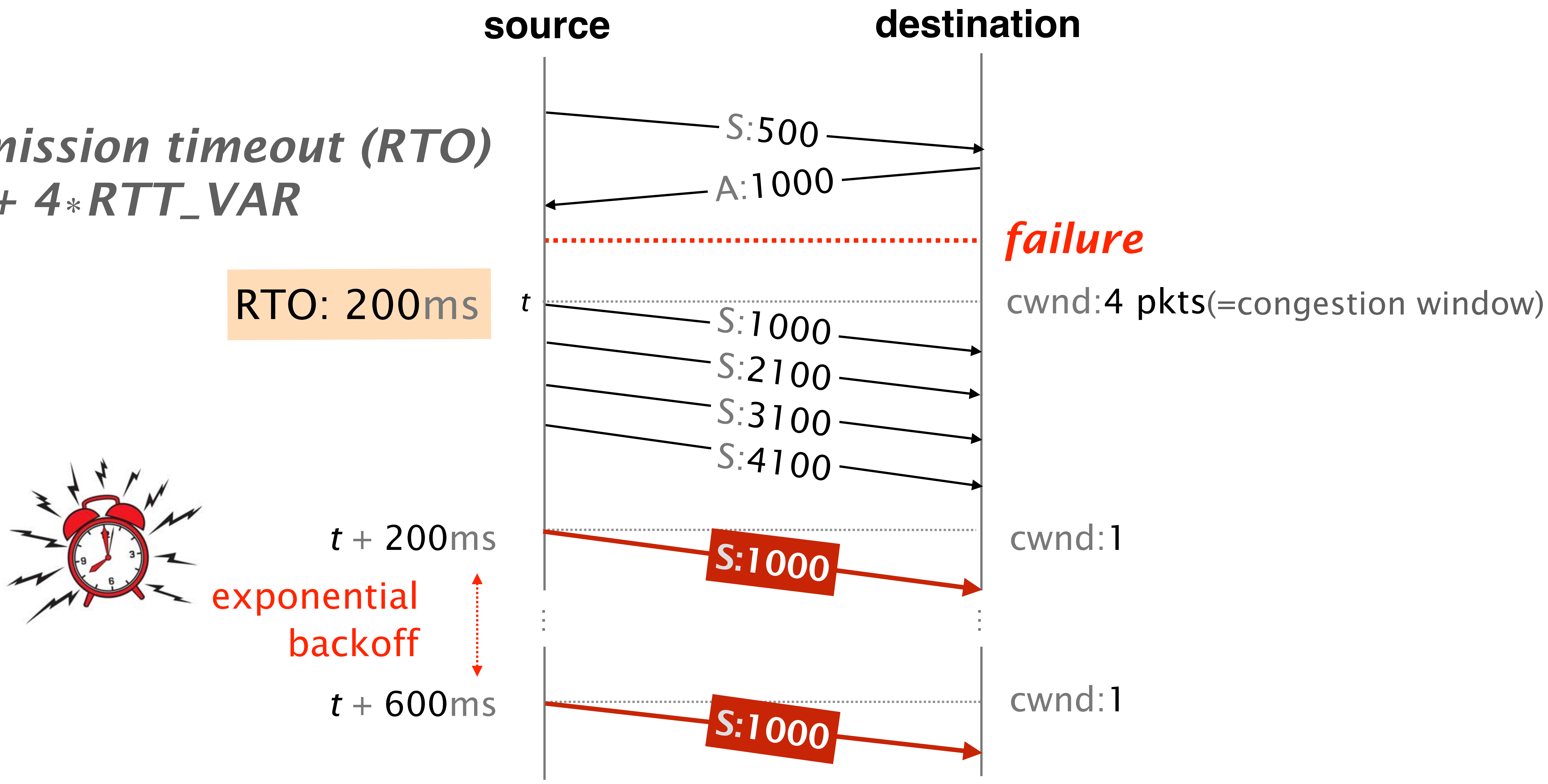

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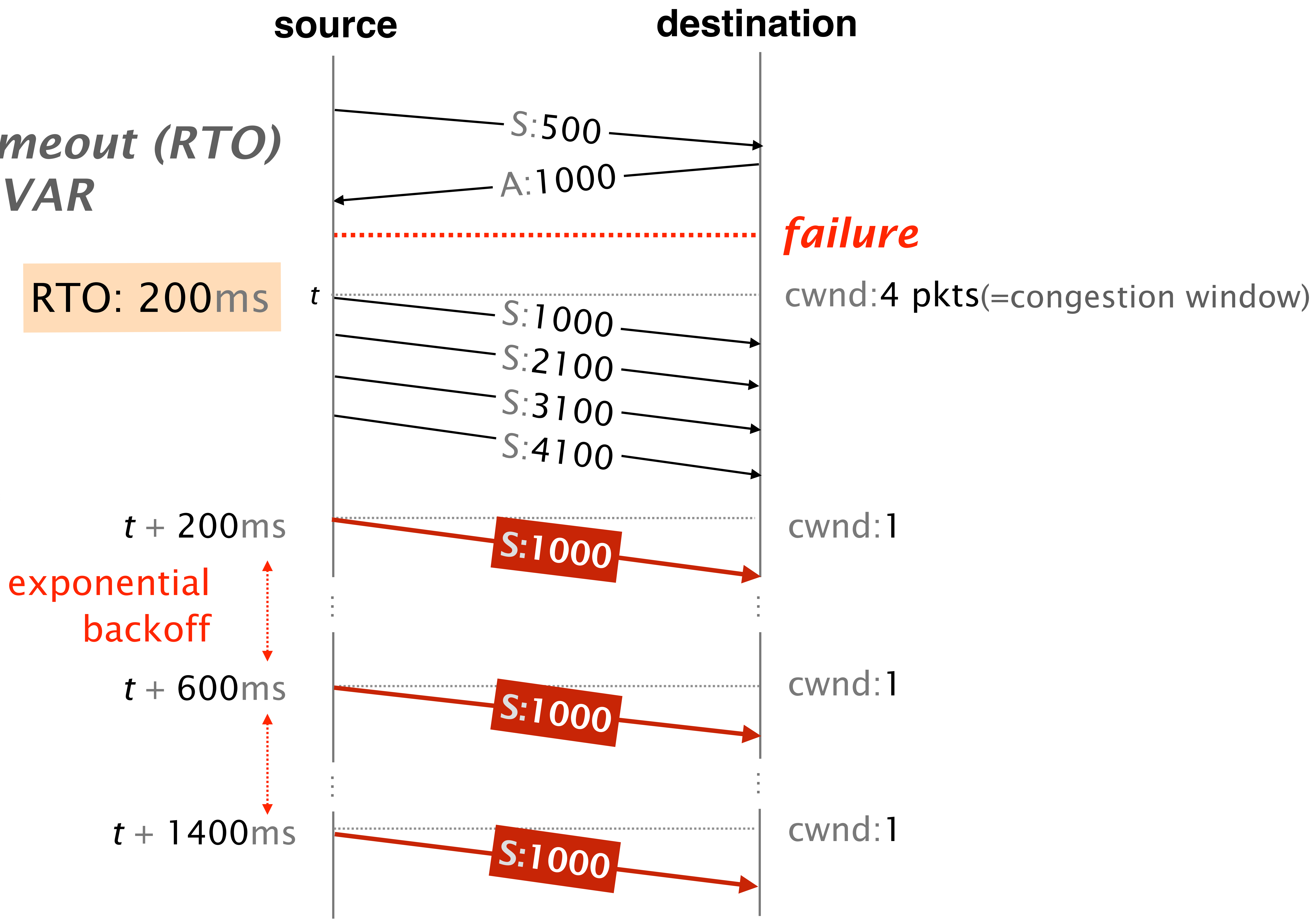

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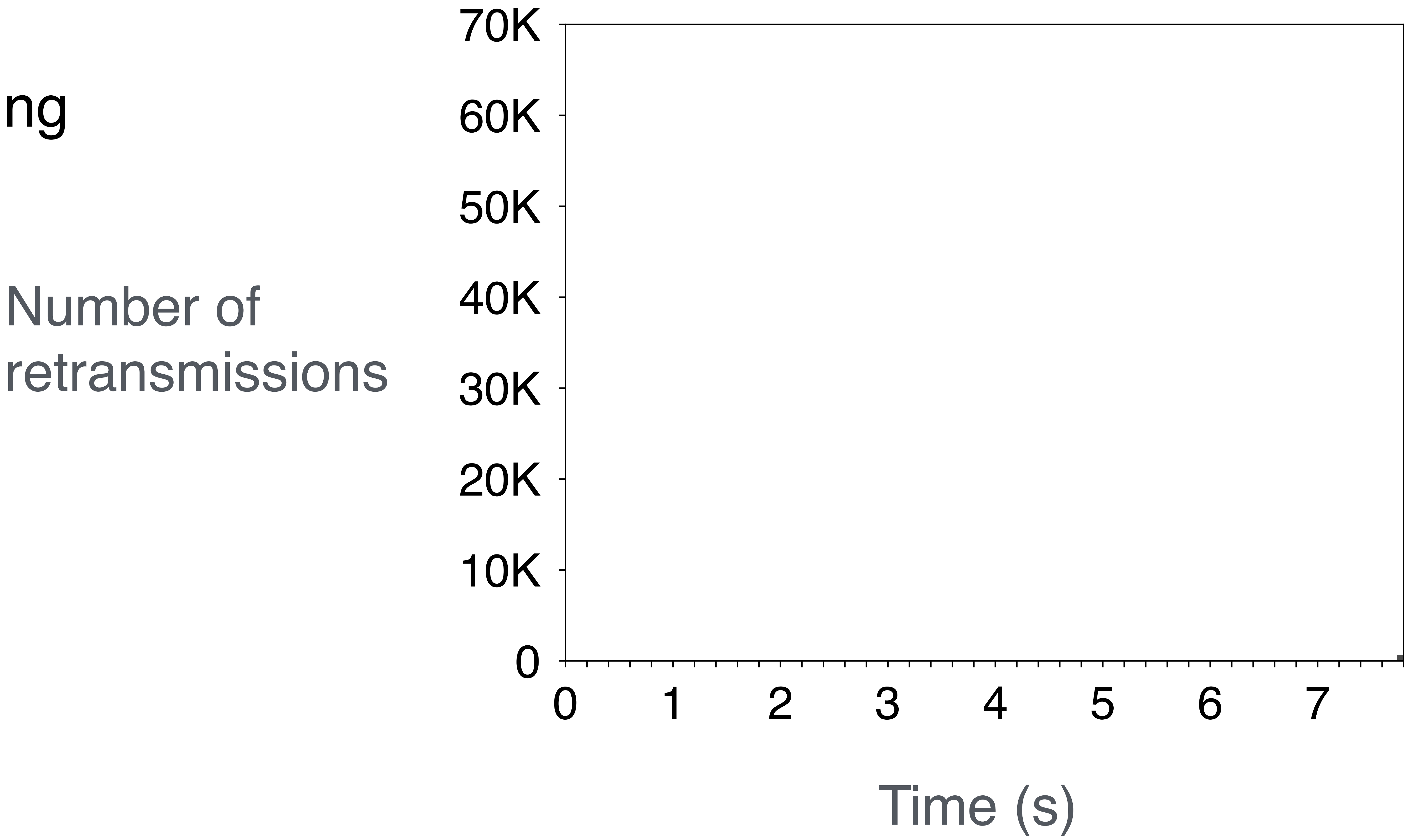

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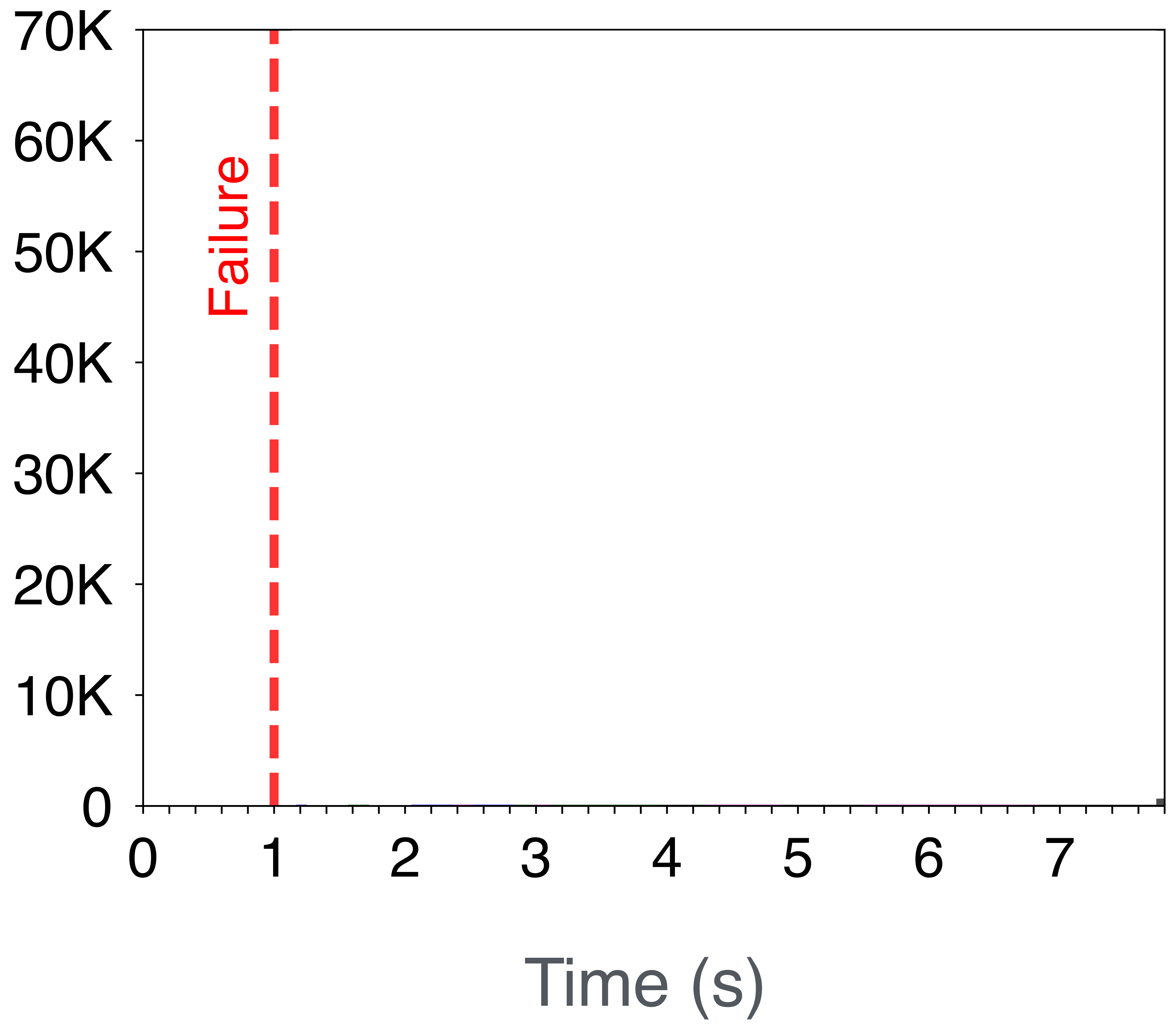

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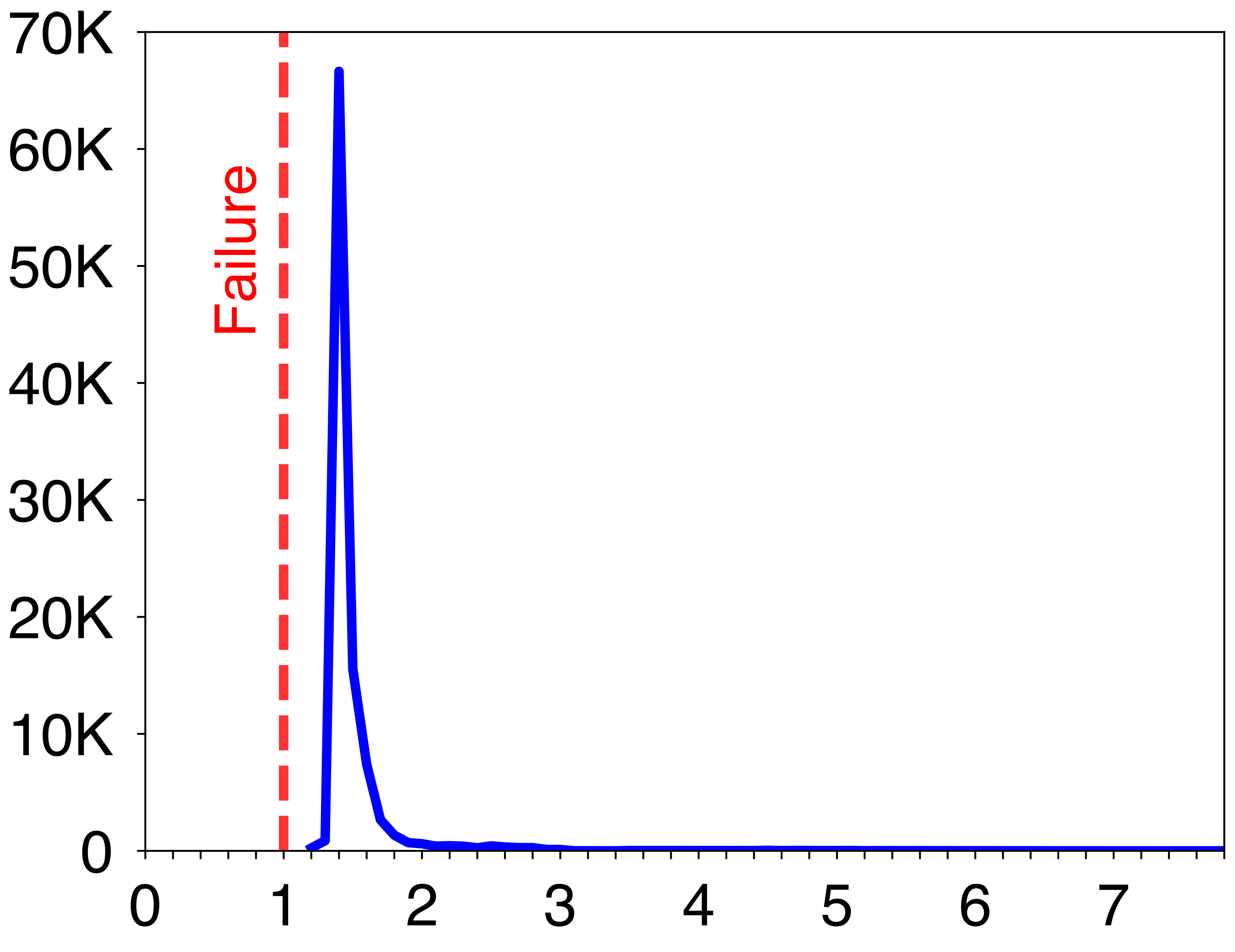

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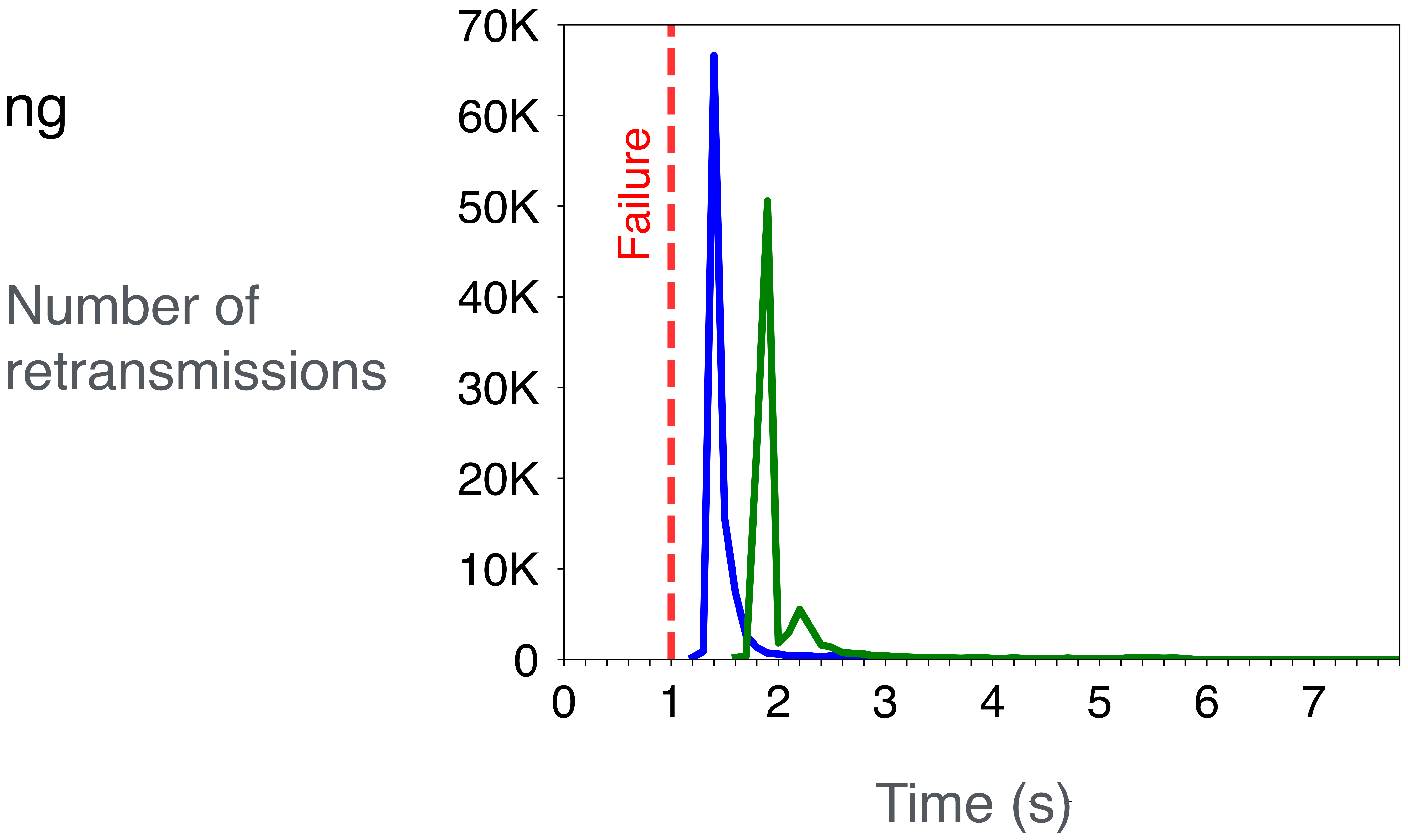

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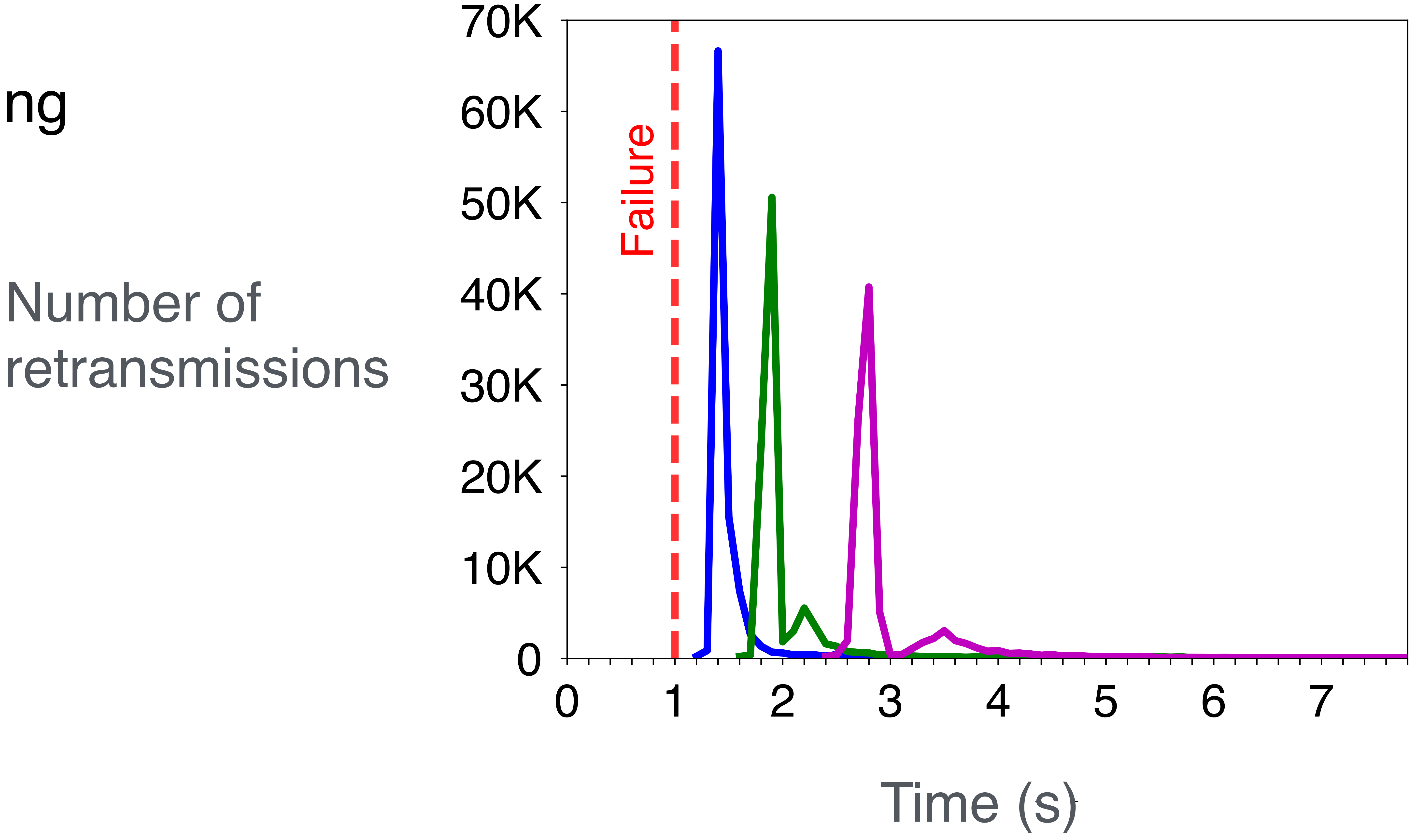

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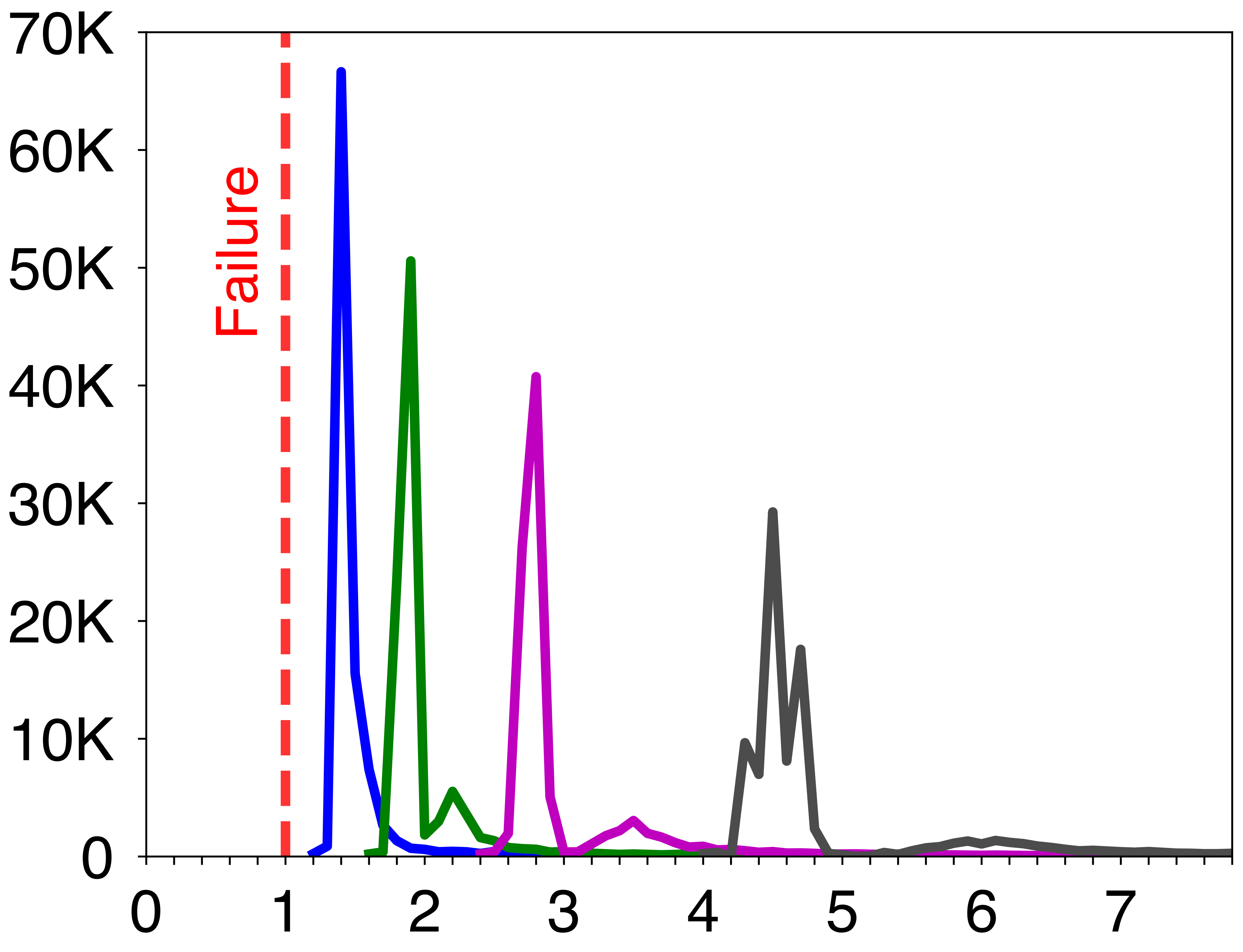

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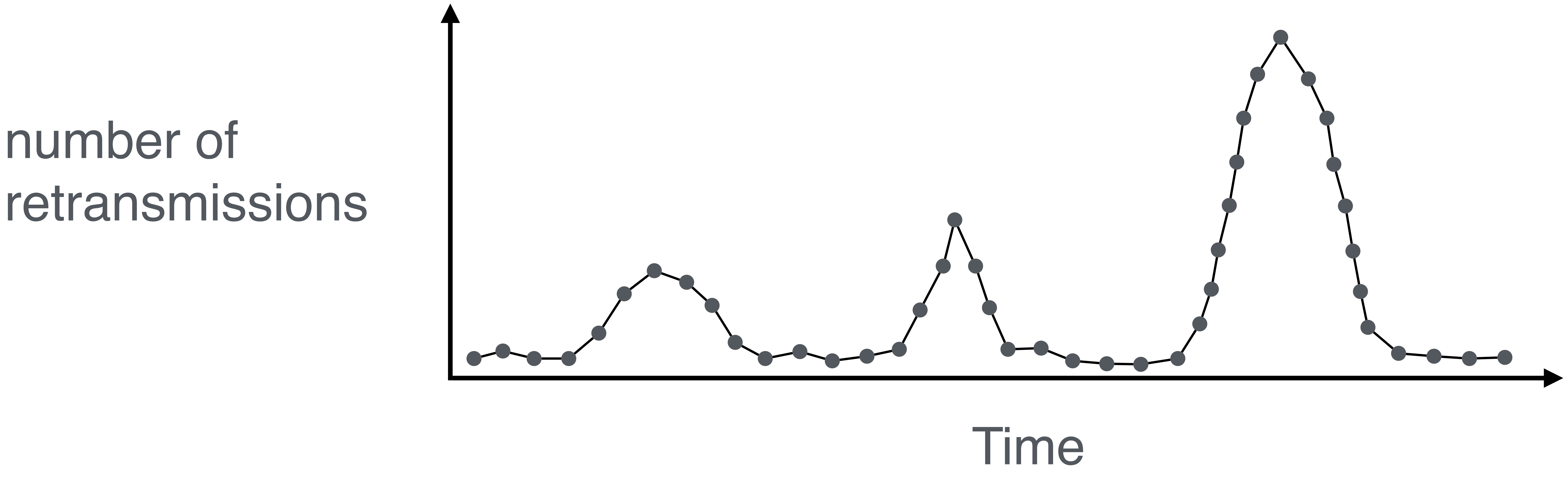

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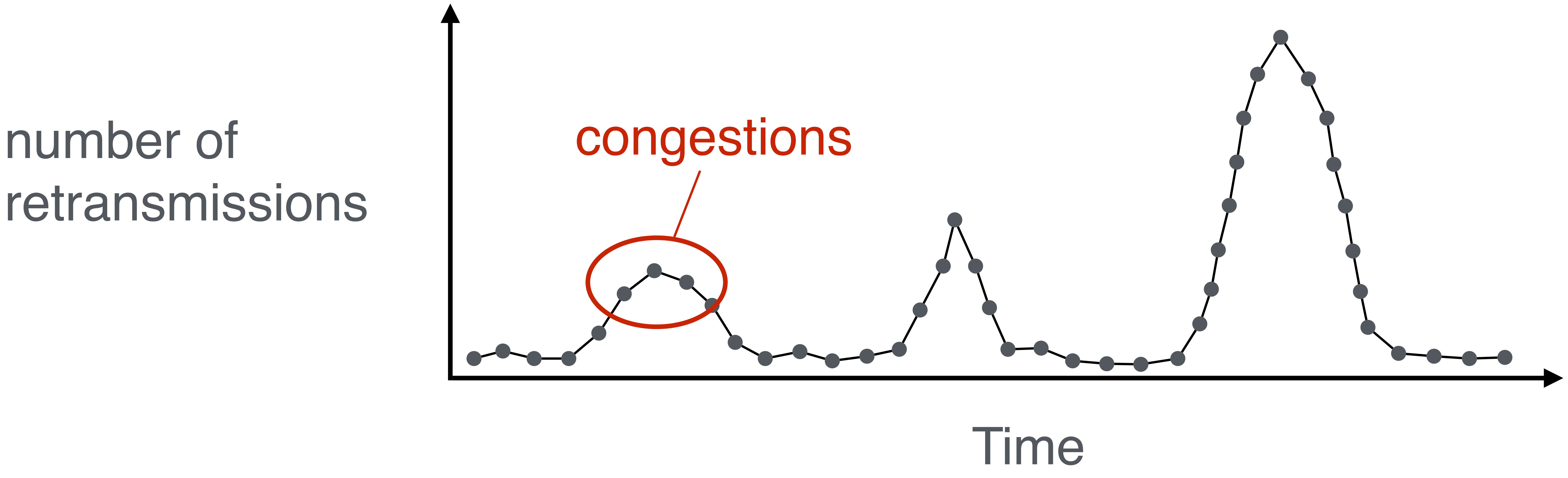

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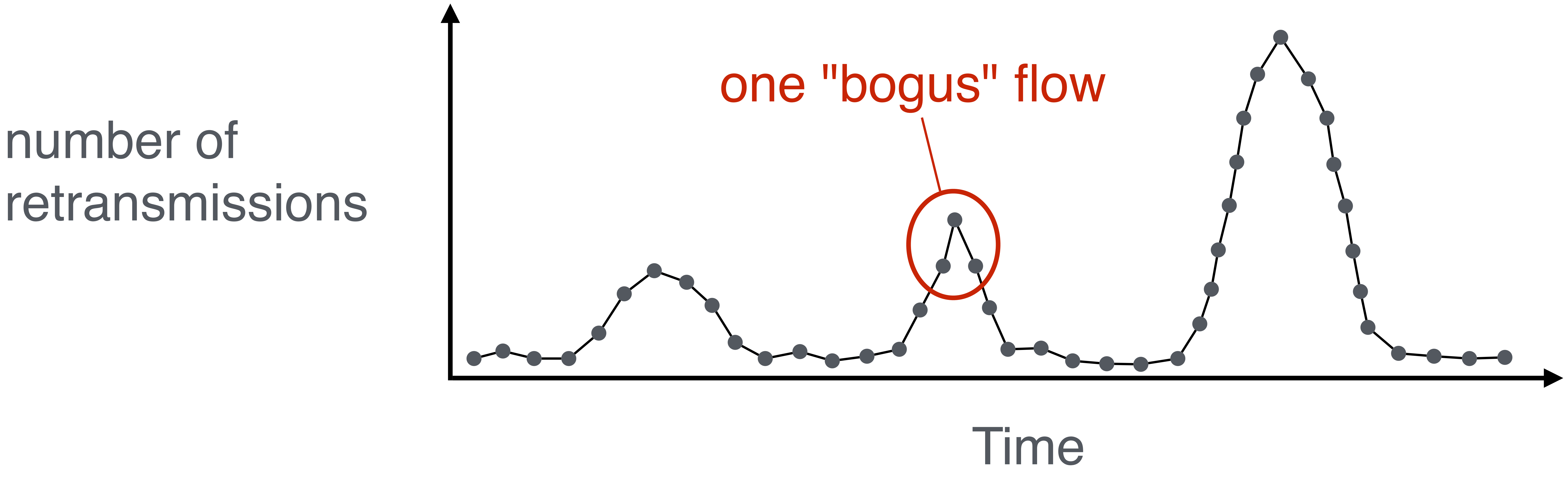

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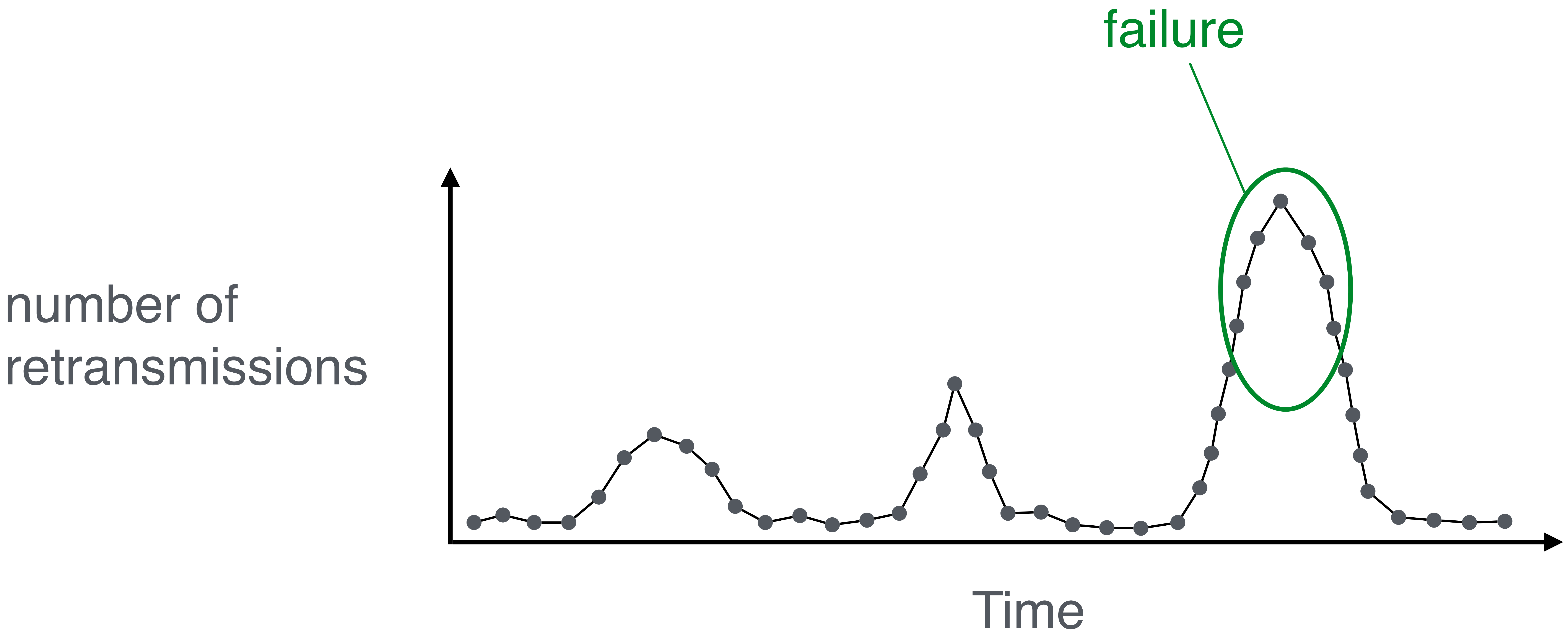

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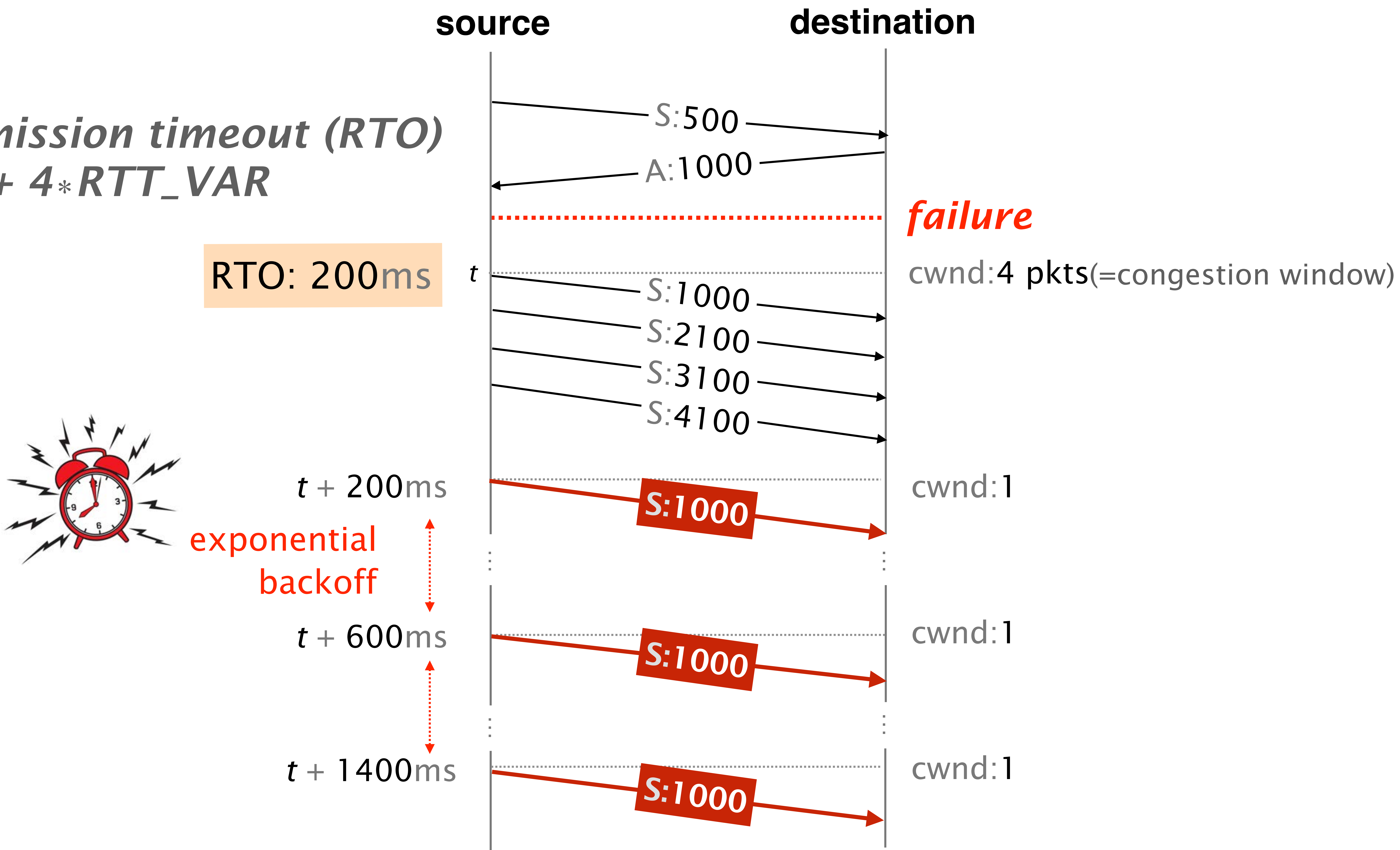

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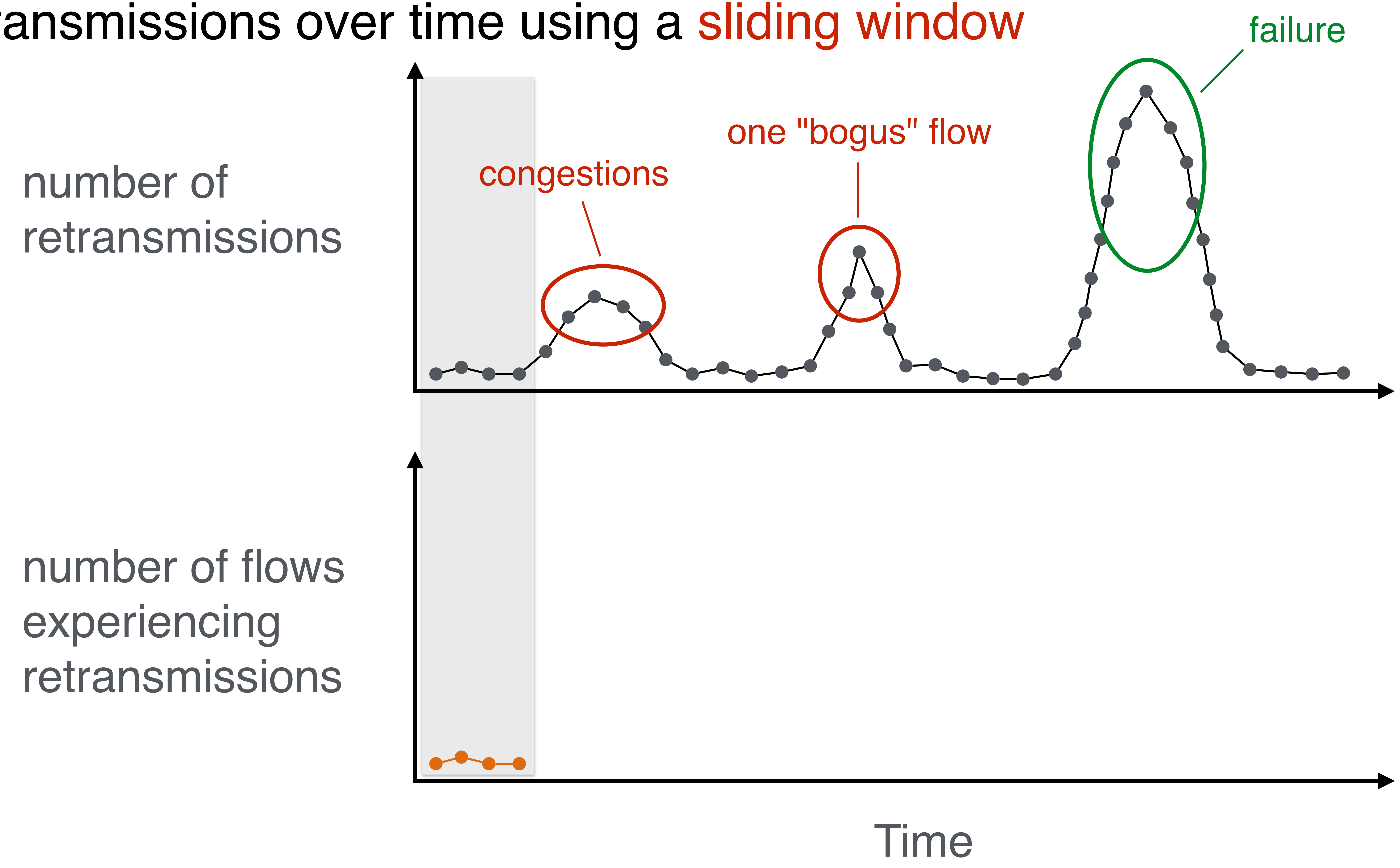

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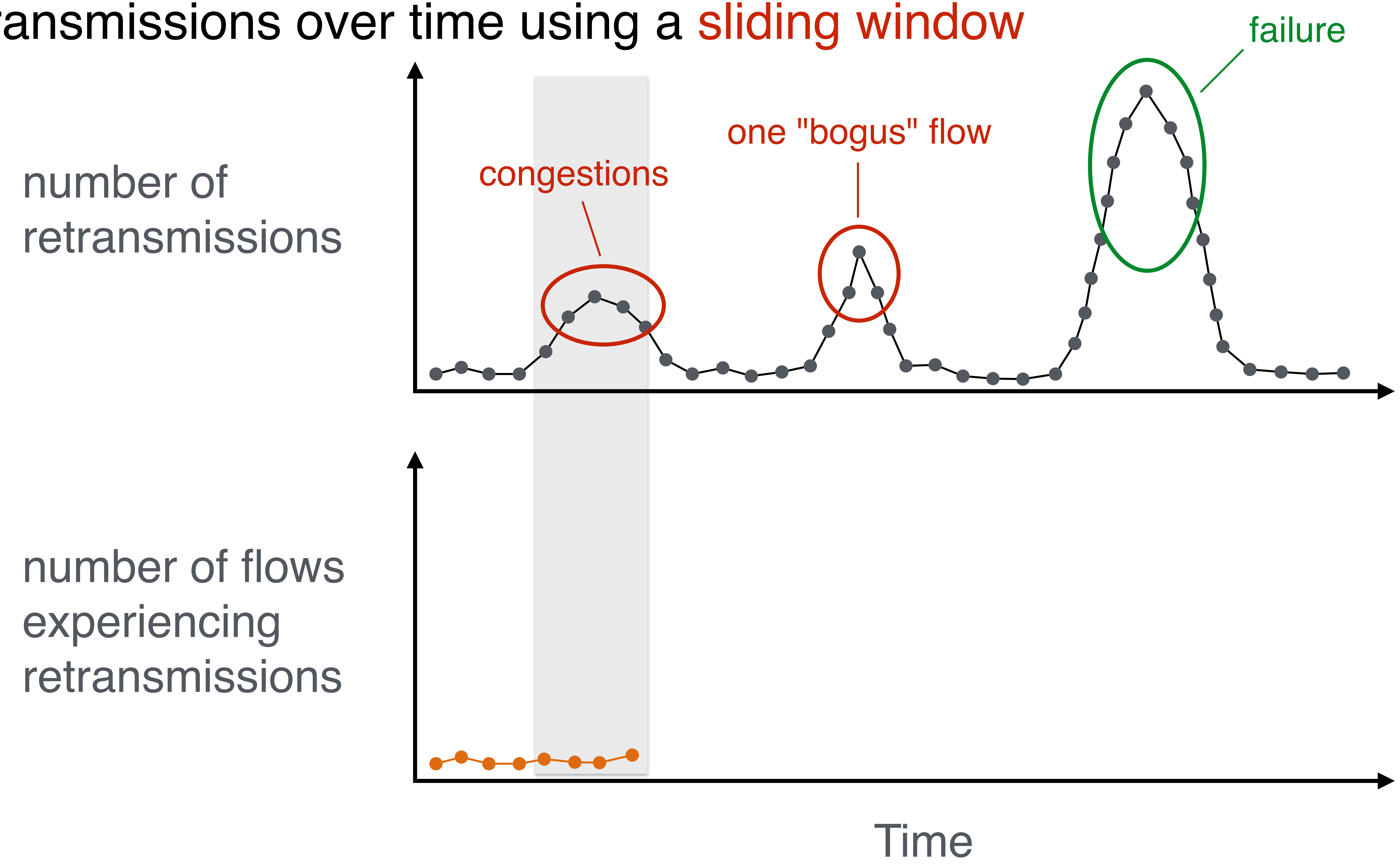

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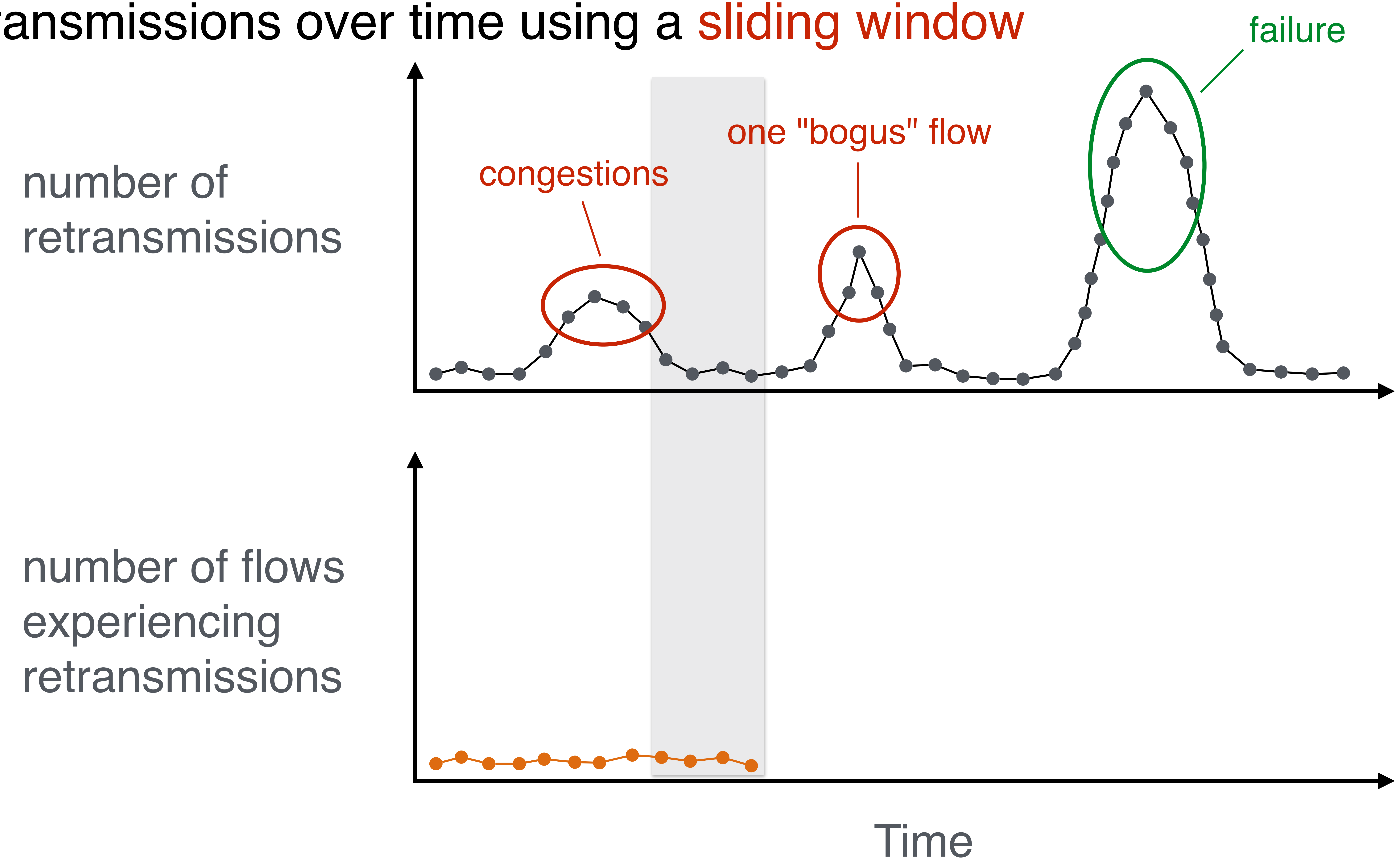

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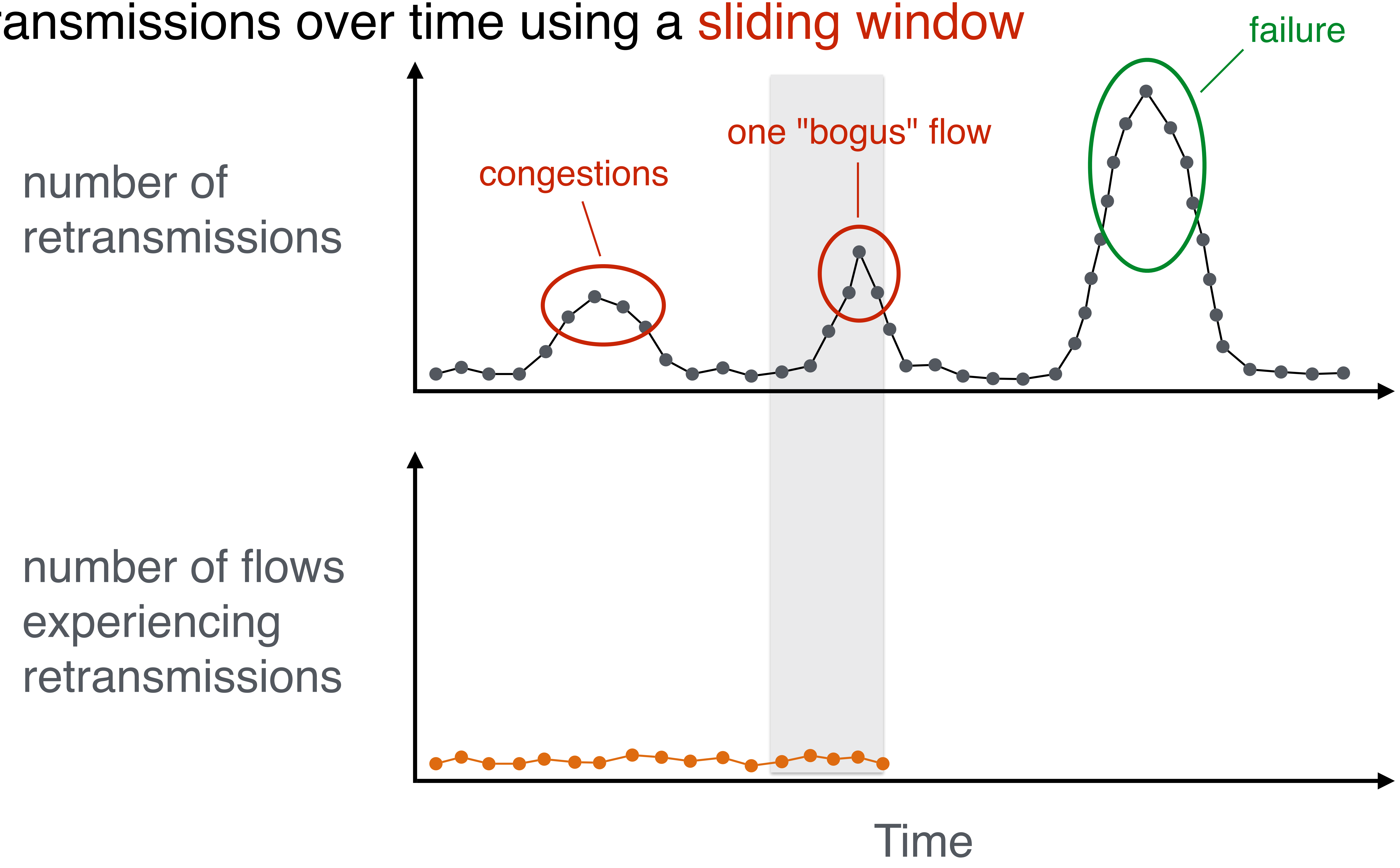

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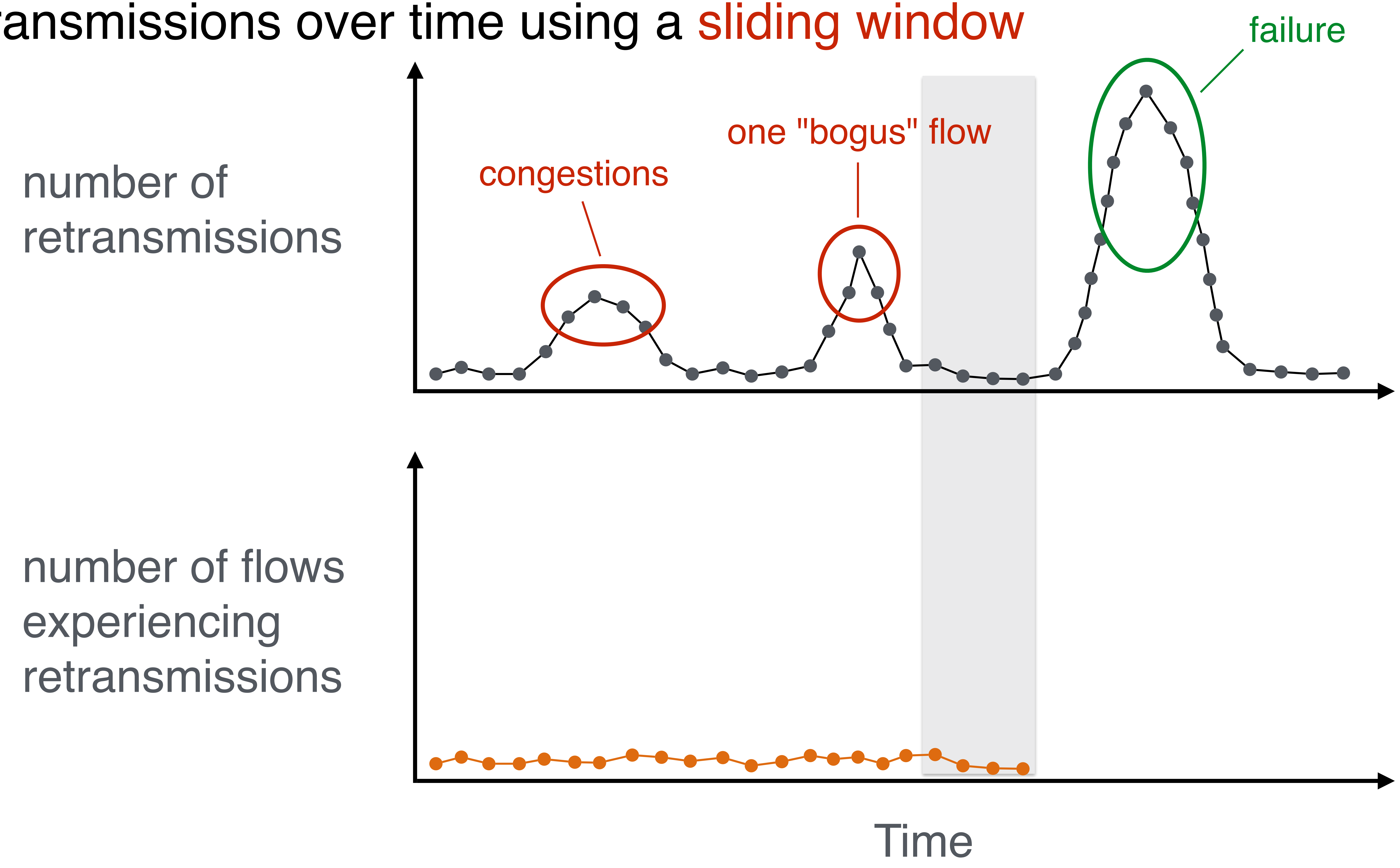

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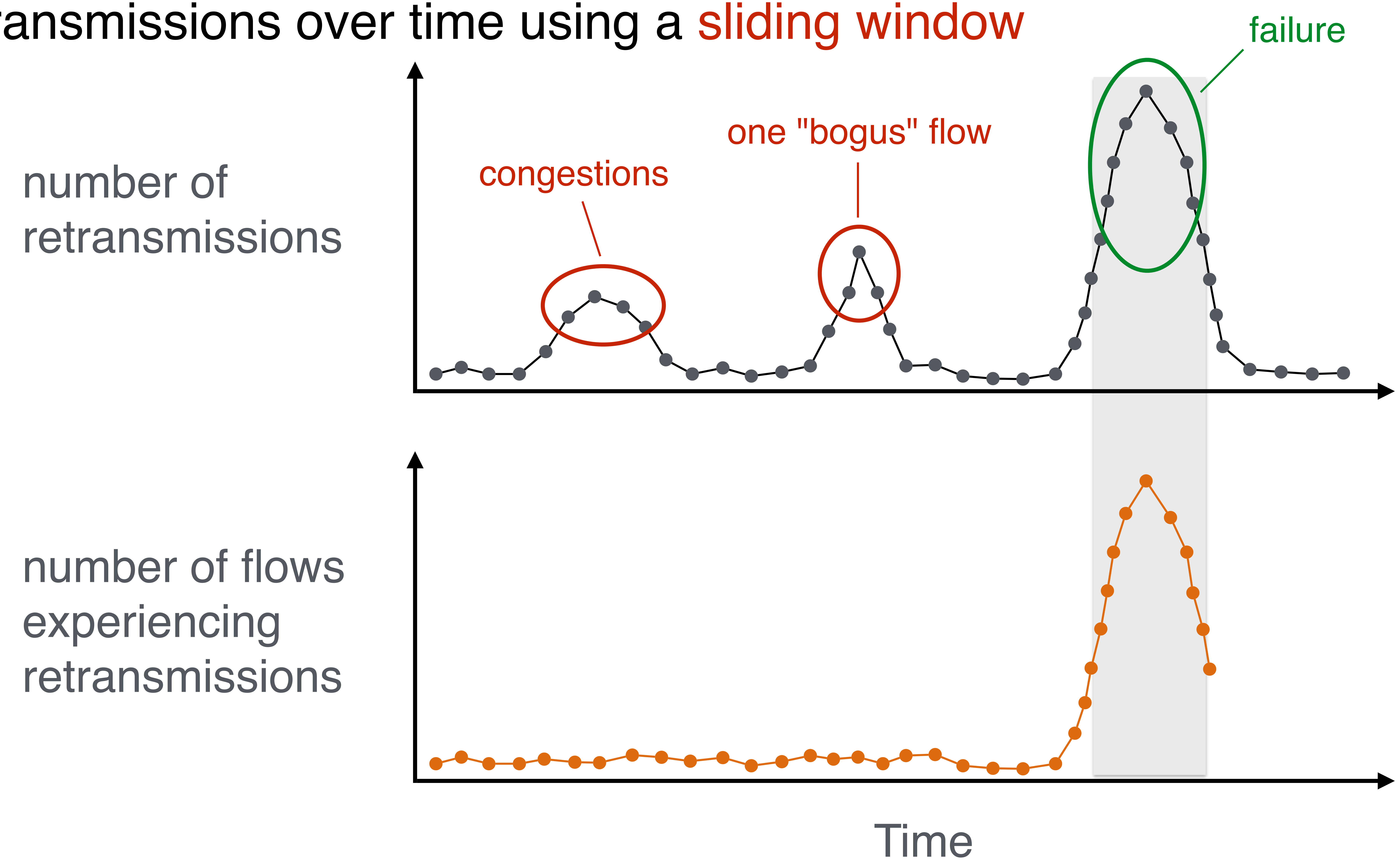

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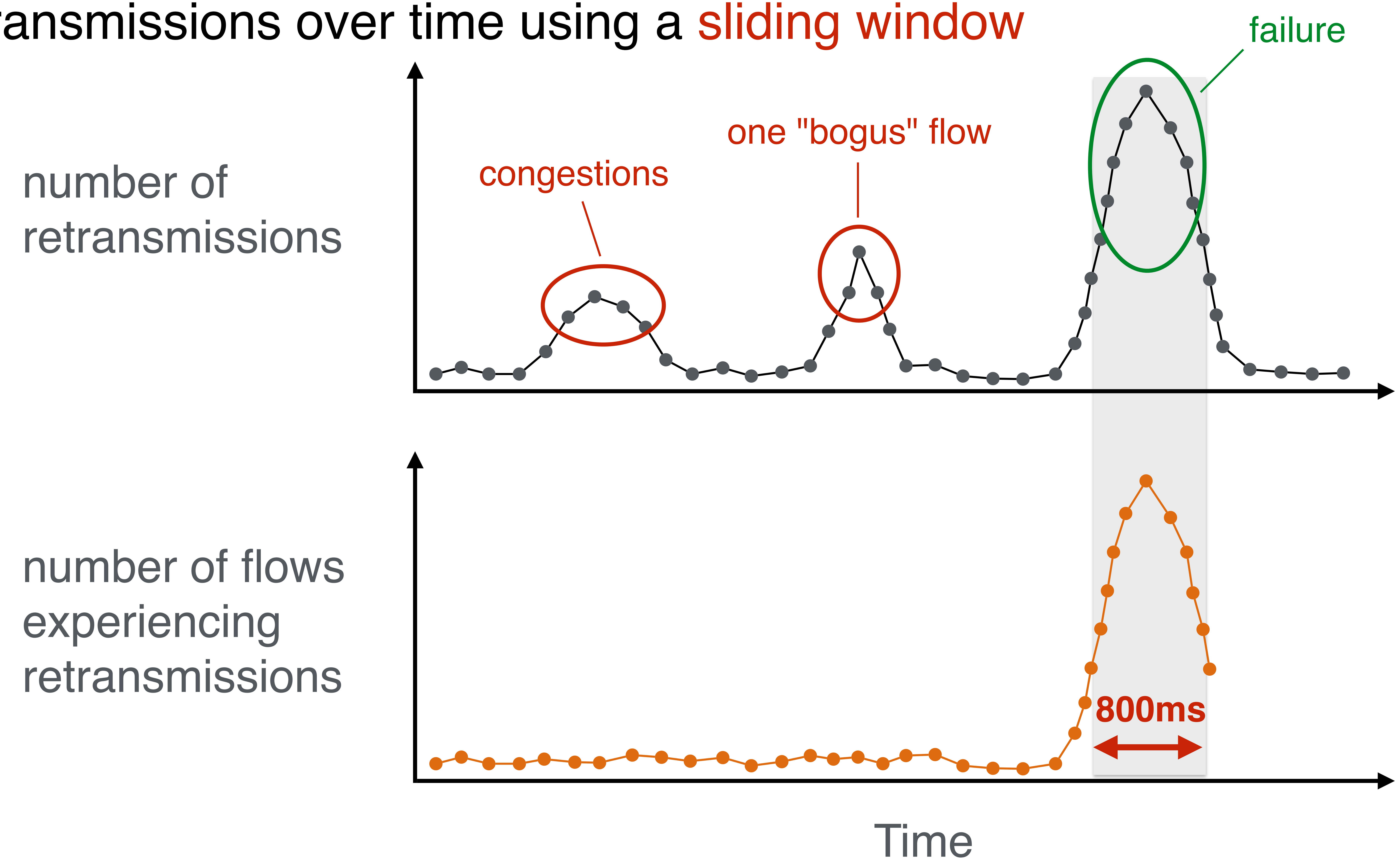

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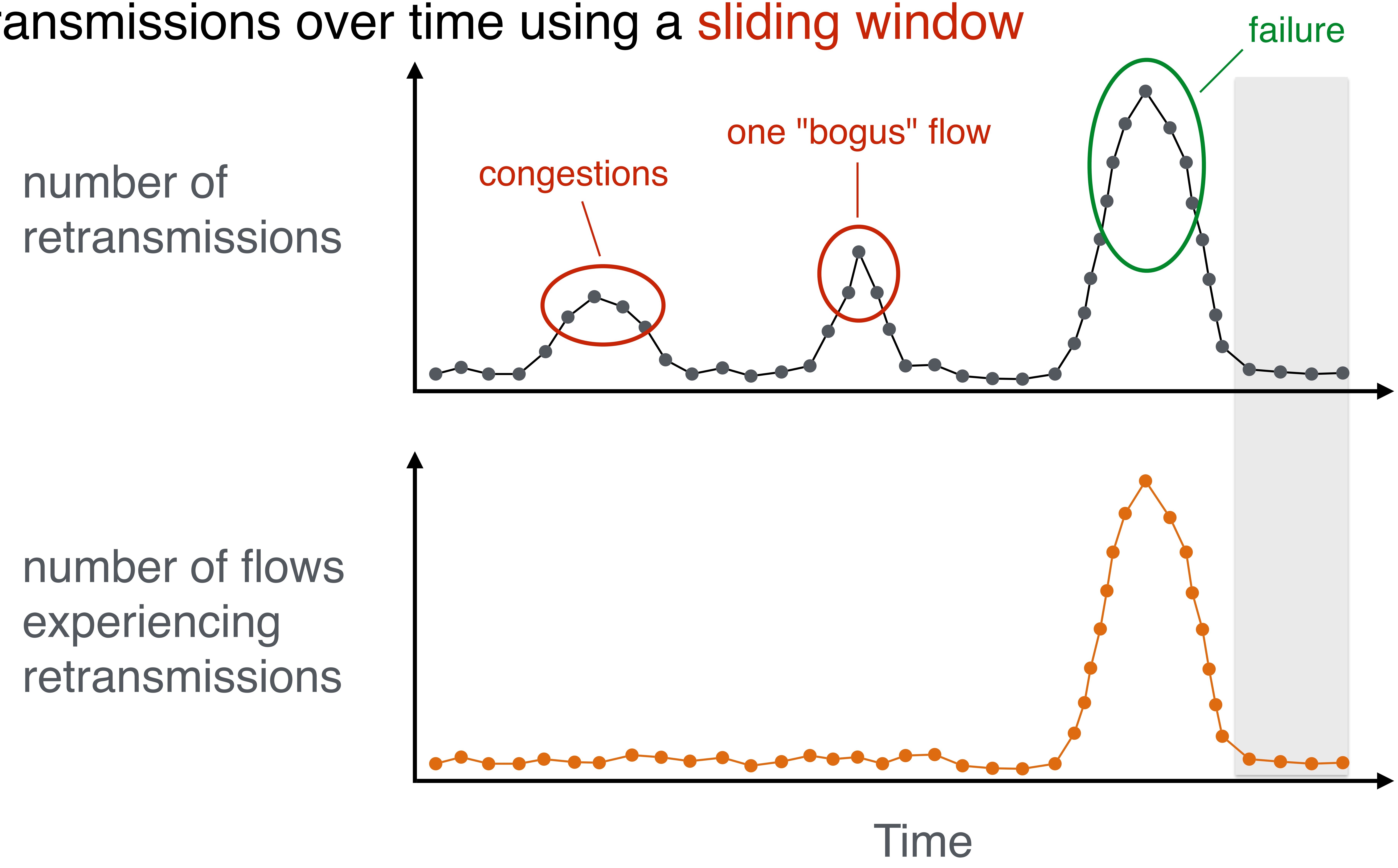

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Problem: those switches have very limited resources

Solution #1: ***Blink*** focuses on the popular prefixes, *i.e.*, the ones that attract data traffic

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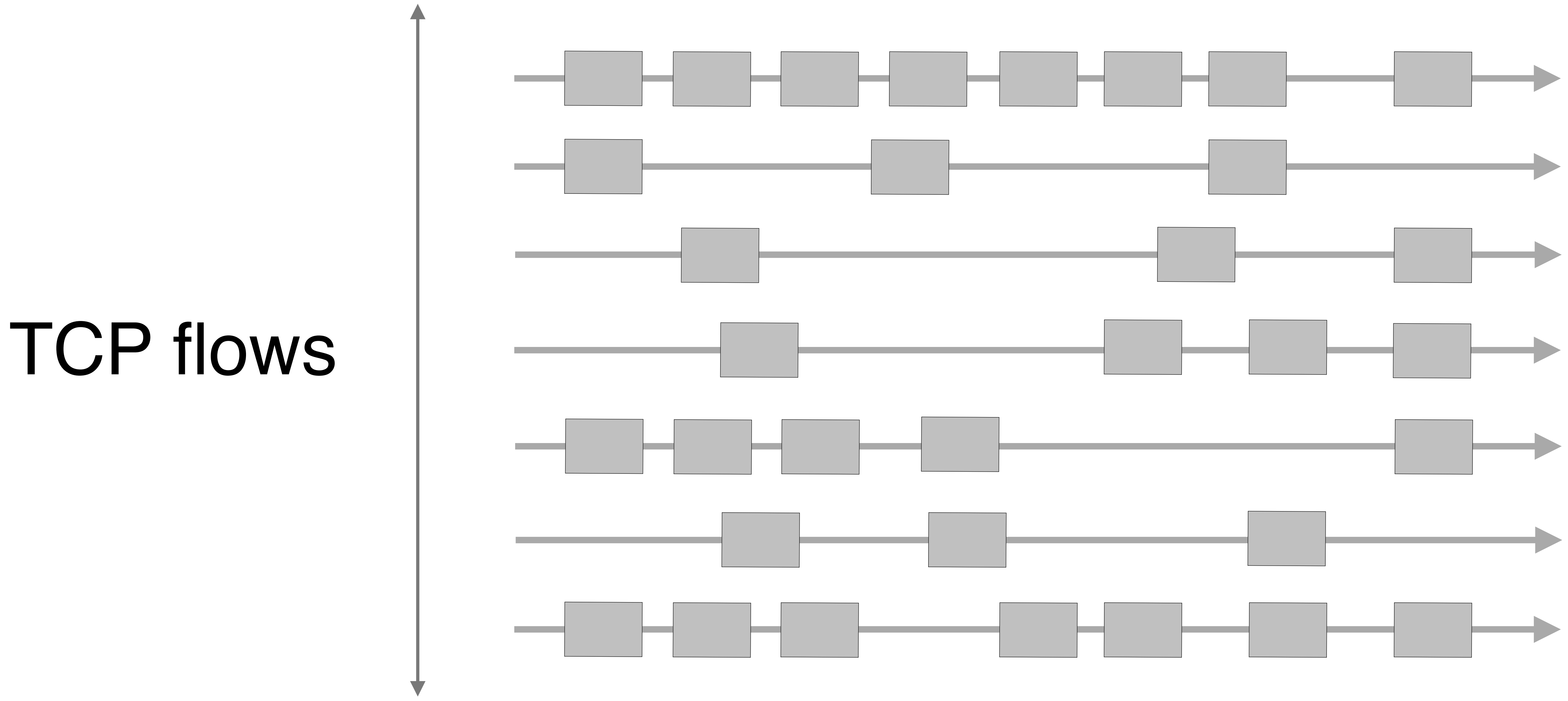
As Internet traffic follows a Zipf-like distribution* (1k pref. account for >50%), ***Blink*** covers the vast majority of the Internet traffic

*Sarra et al. Leveraging Zipf's Law for Traffic offloading ACM CCR, 2012

Solution #2: ***Blink*** monitors a sample of the flows for each monitored prefix



Traffic to a destination prefix

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and selects a new one in a *first-seen, first-selected* manner

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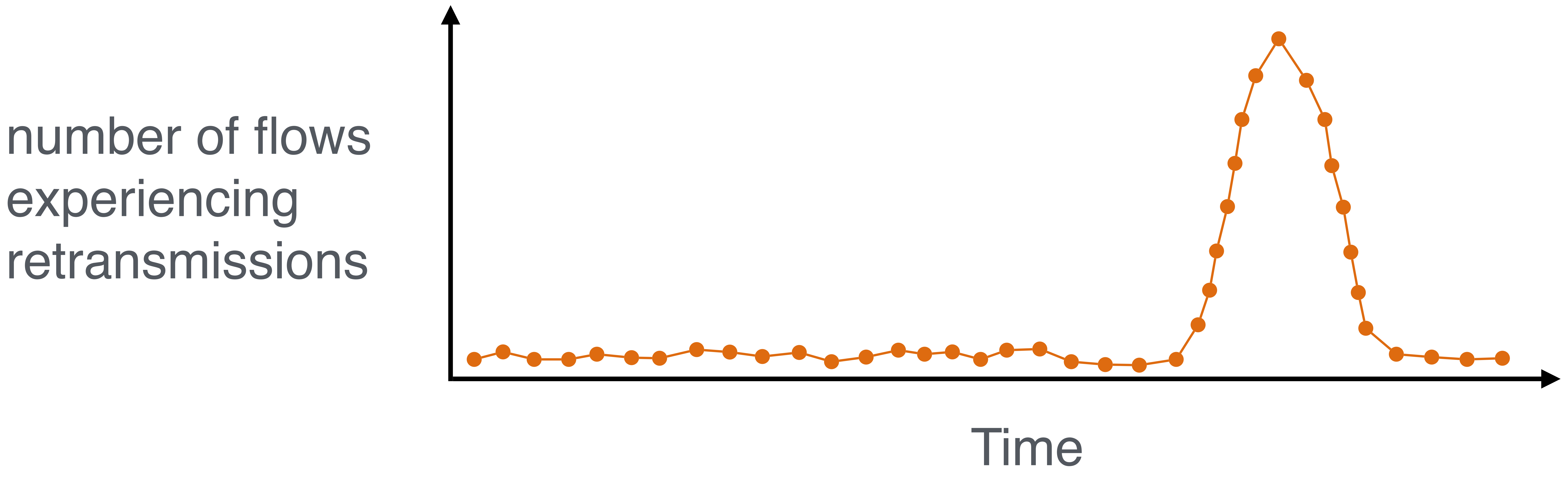

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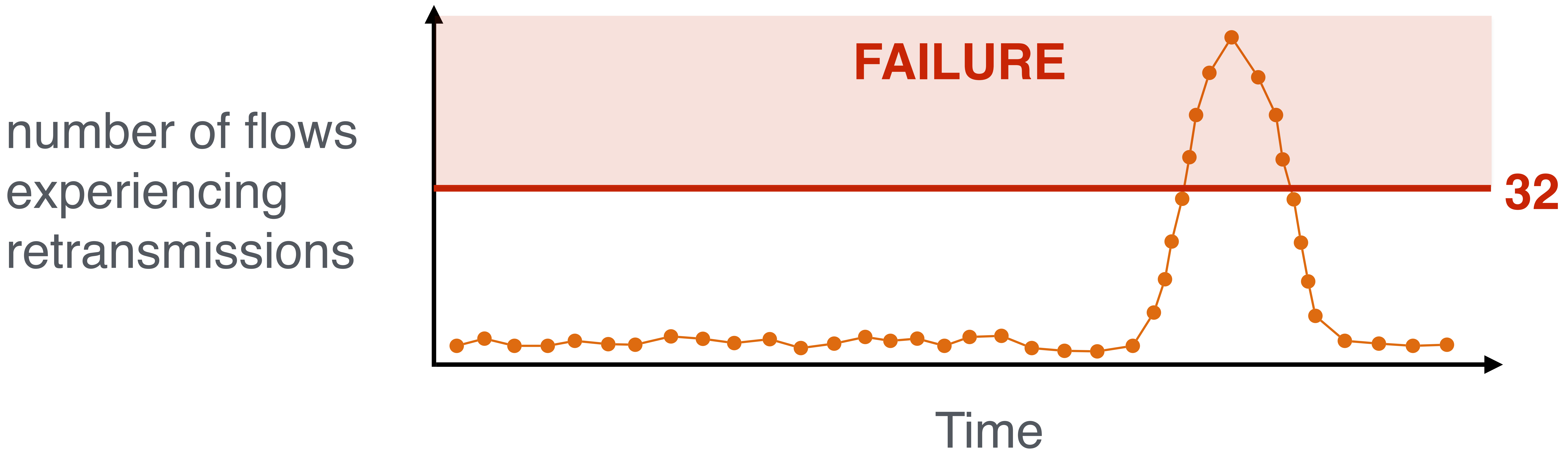

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13 from CAIDA, 2 from MAWI, covering a total of 15.8 hours

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We are interested in:

Accuracy: True Positive Rate vs False Positive Rate

Speed: How long does Blink take to infer failures

As we do not have ground truth, we generated synthetic traces following the traffic characteristics extracted from the real traces

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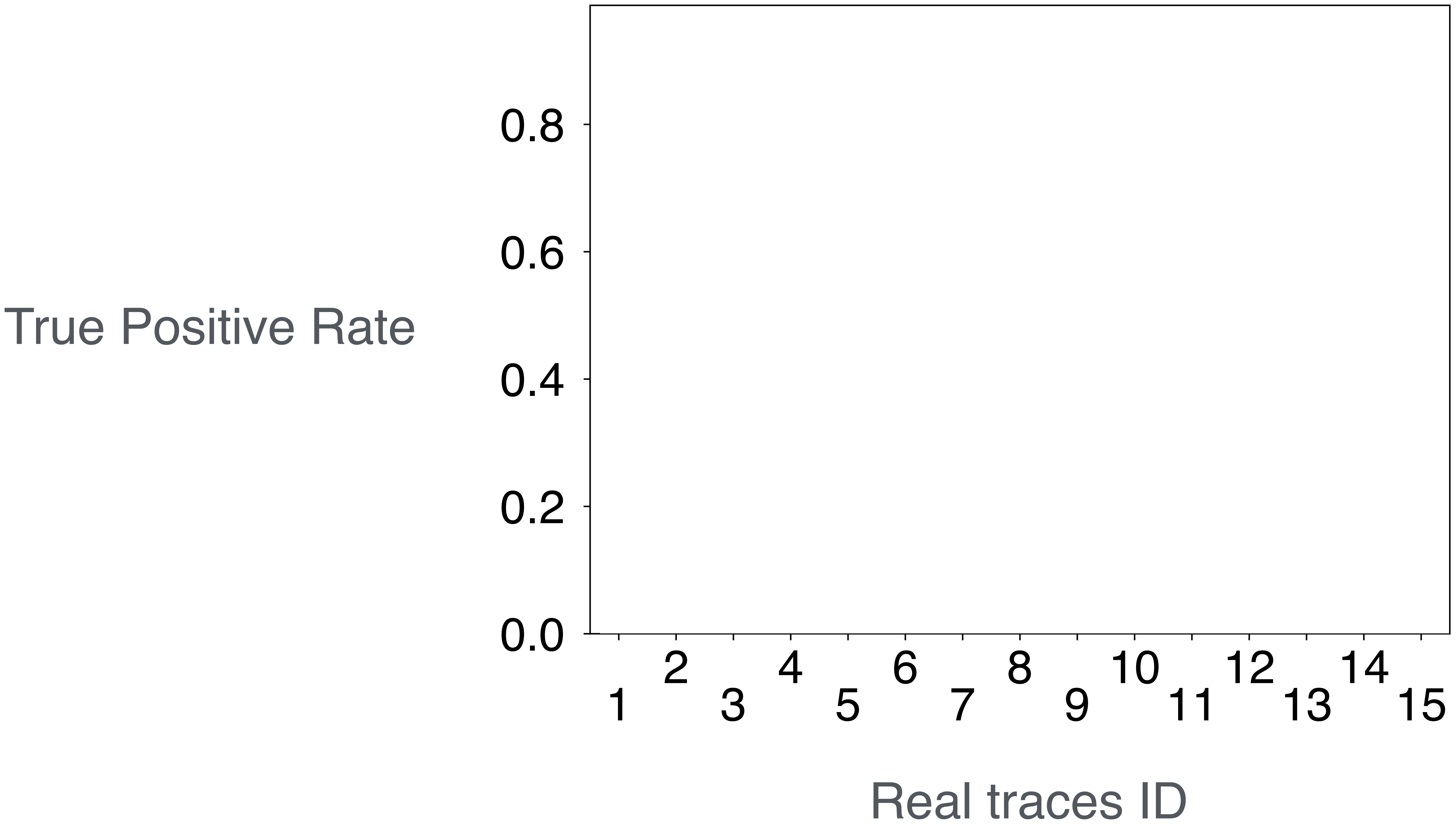
Step #1 - We extracted the RTT, Packet rate, Flow duration from the real traces

Step #2 - We used NS3 to replay these flows and simulate a failure

Step #3 - We ran a Python-based version of ***Blink*** on the resulting traces

Blink failure inference accuracy is above 80% for 13 real traces out of 15



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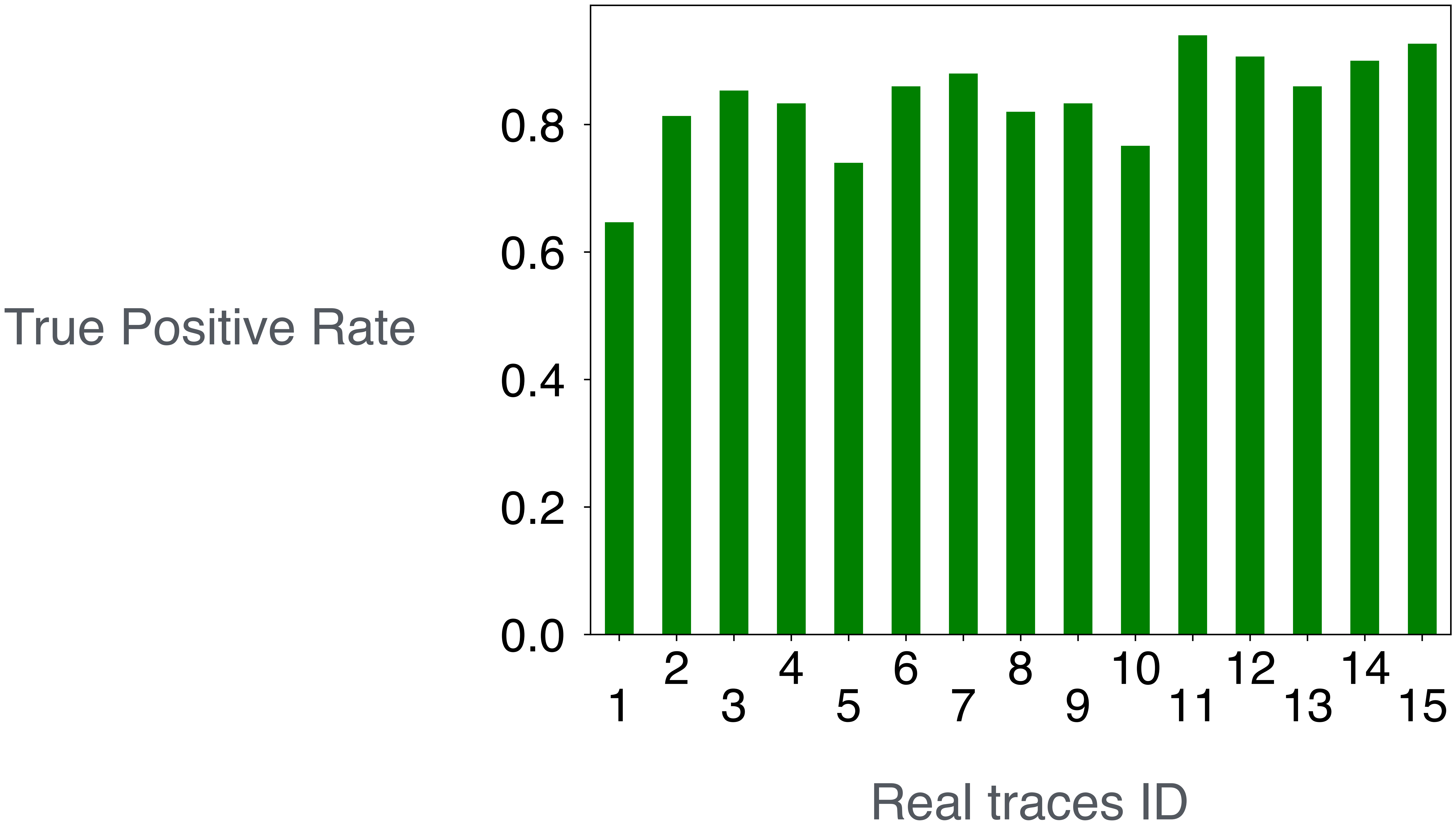

Blink avoids incorrectly inferring failures when packet loss is below 4%

packet loss %	1	2	3	4	5	…	8	9
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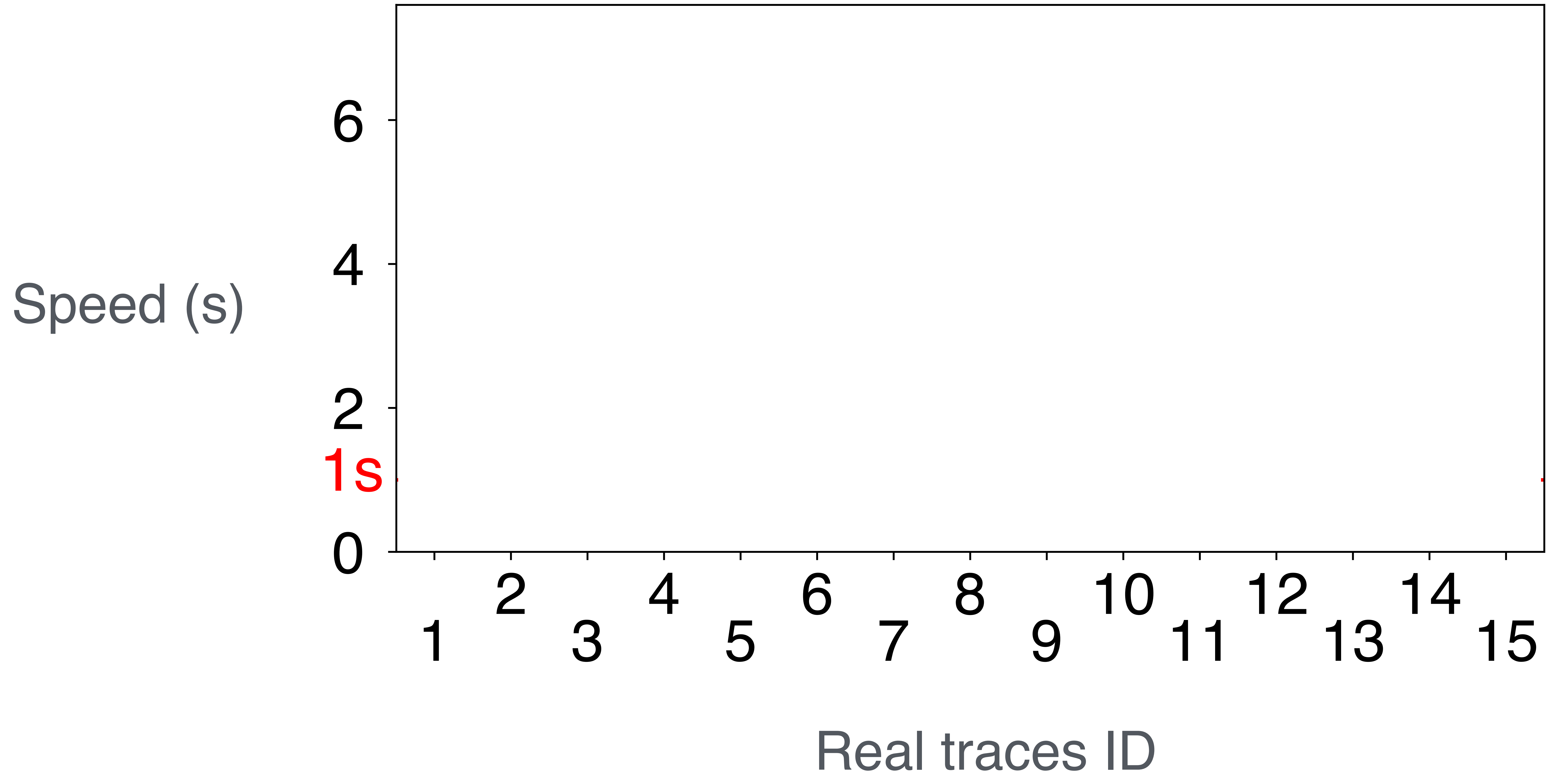
False Positive Rate	**0**	**0**	**0**	0.67	0.67	…	1.3	2.7

Blink infers a failure within 1s for the majority of the cases



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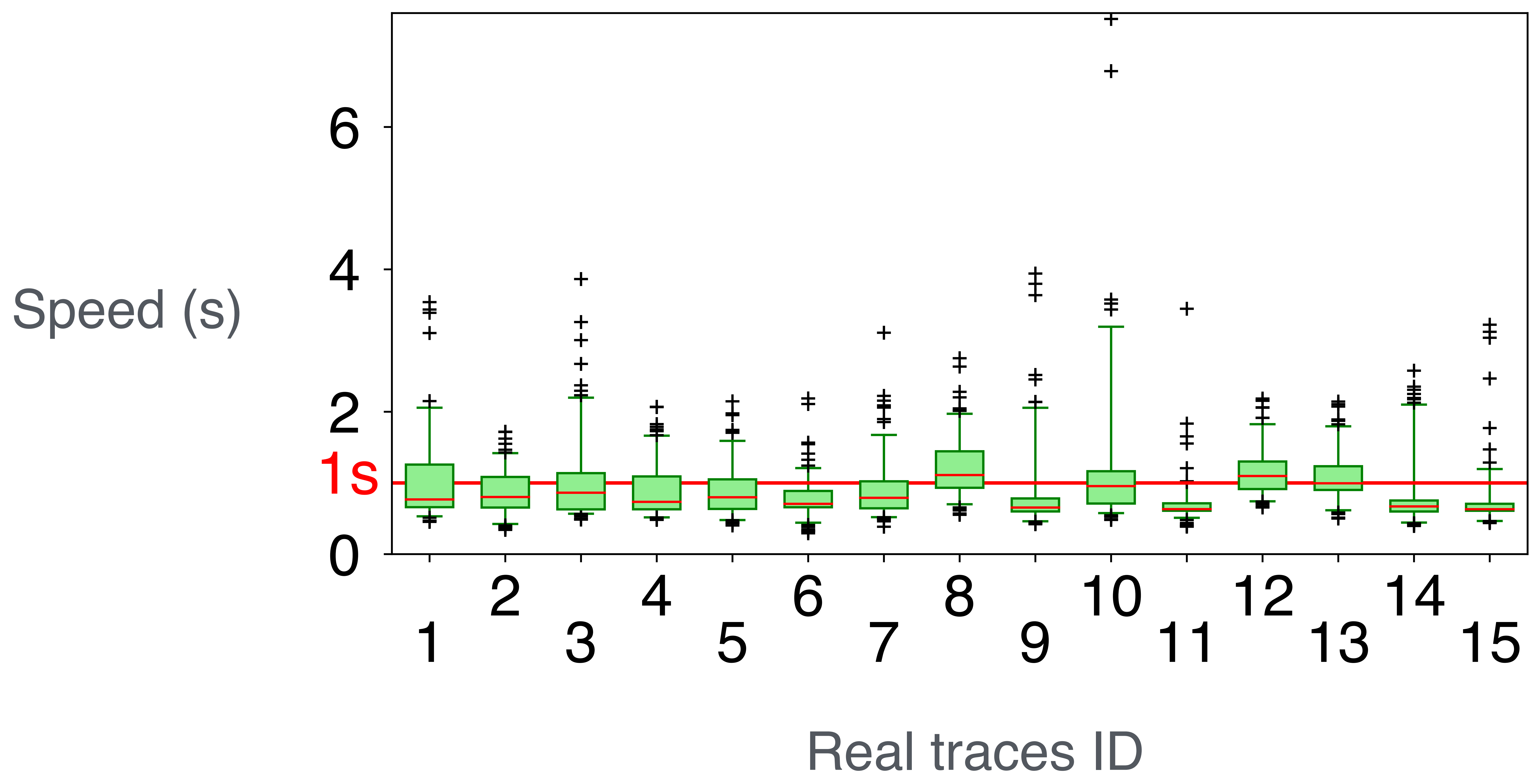

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4. ***Blink*** works in practice, on existing devices

Upon detection of a failure, ***Blink*** immediately activates backup paths pre-populated by the control-plane

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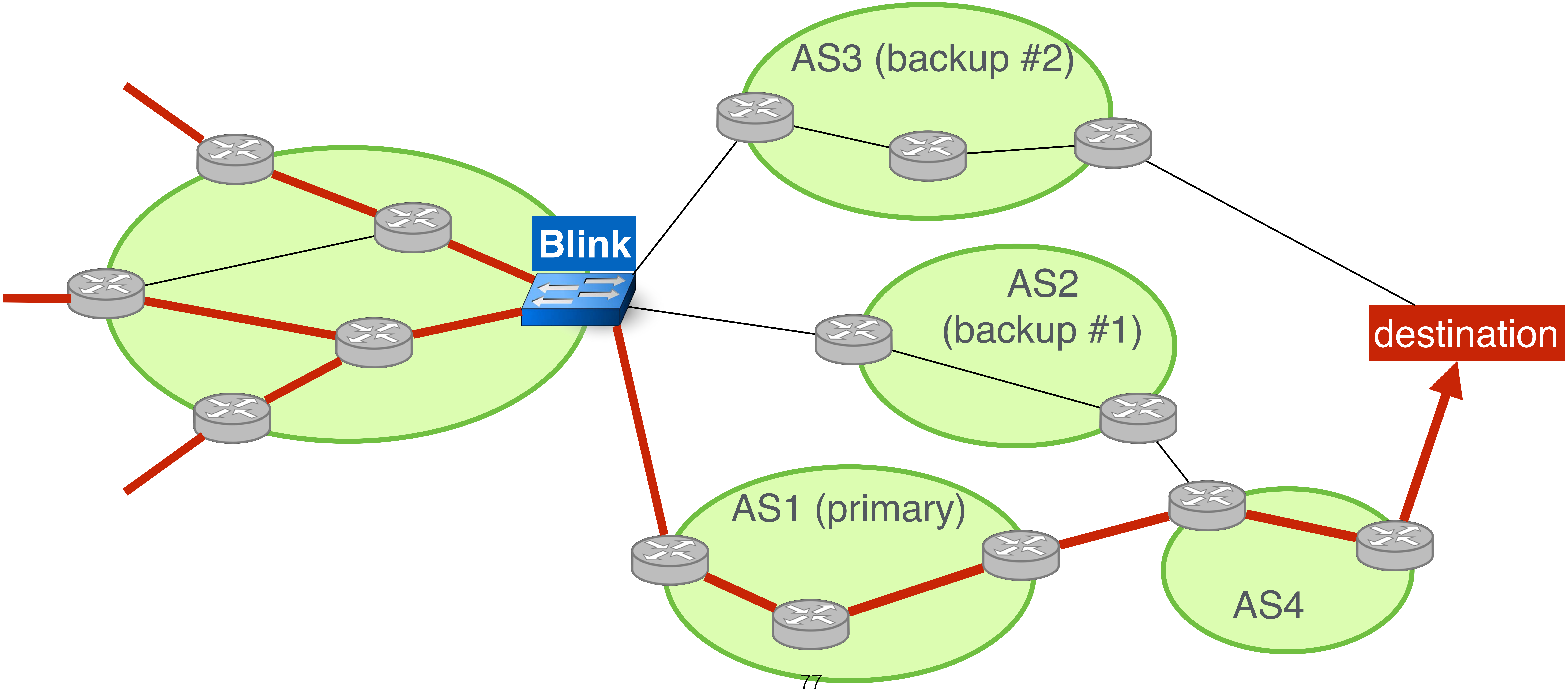

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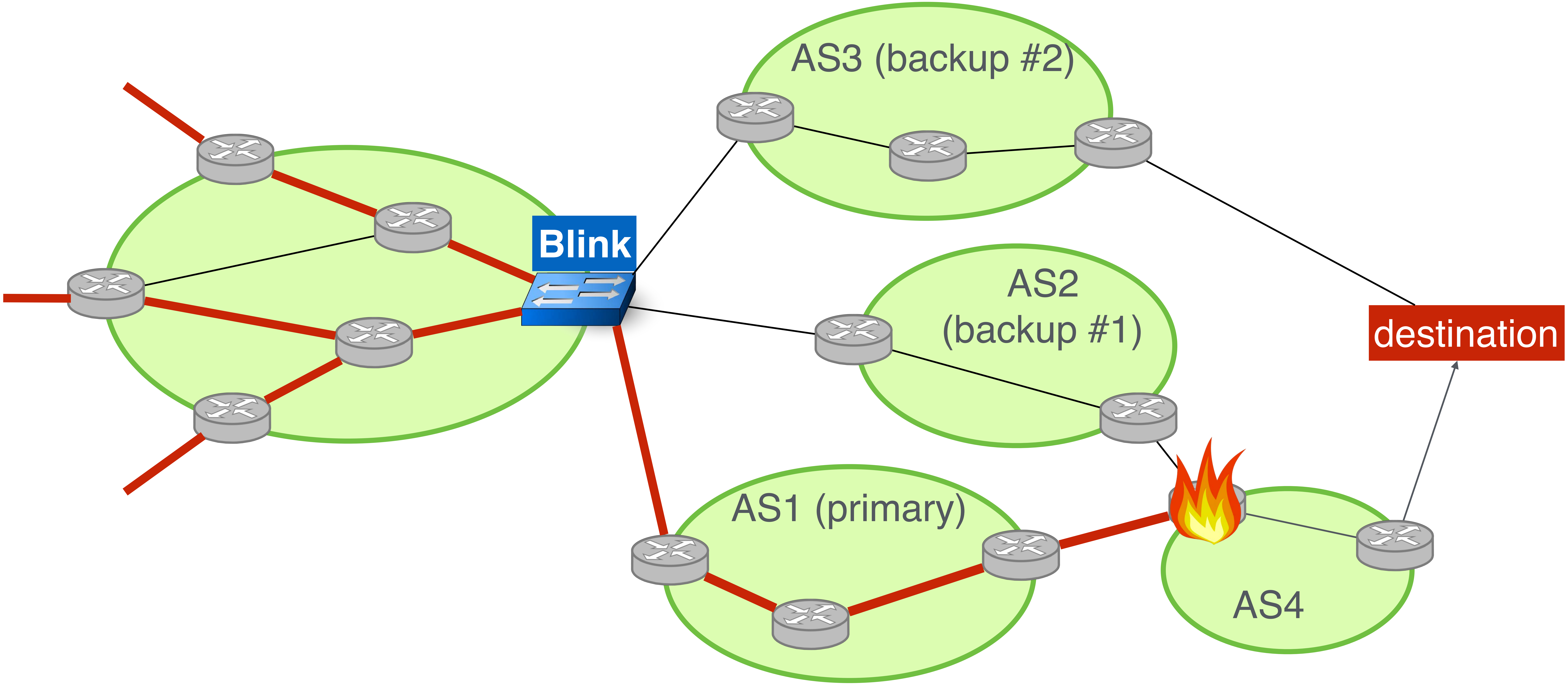

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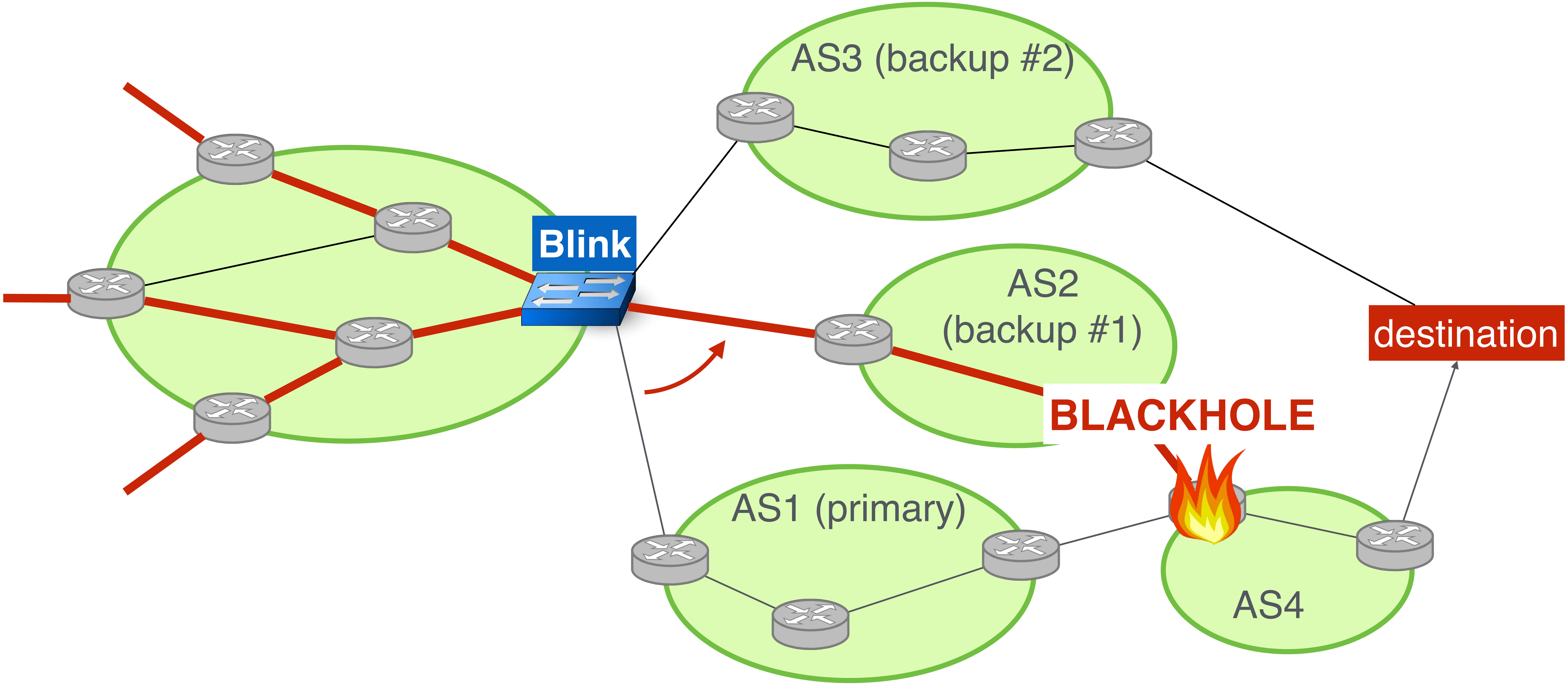

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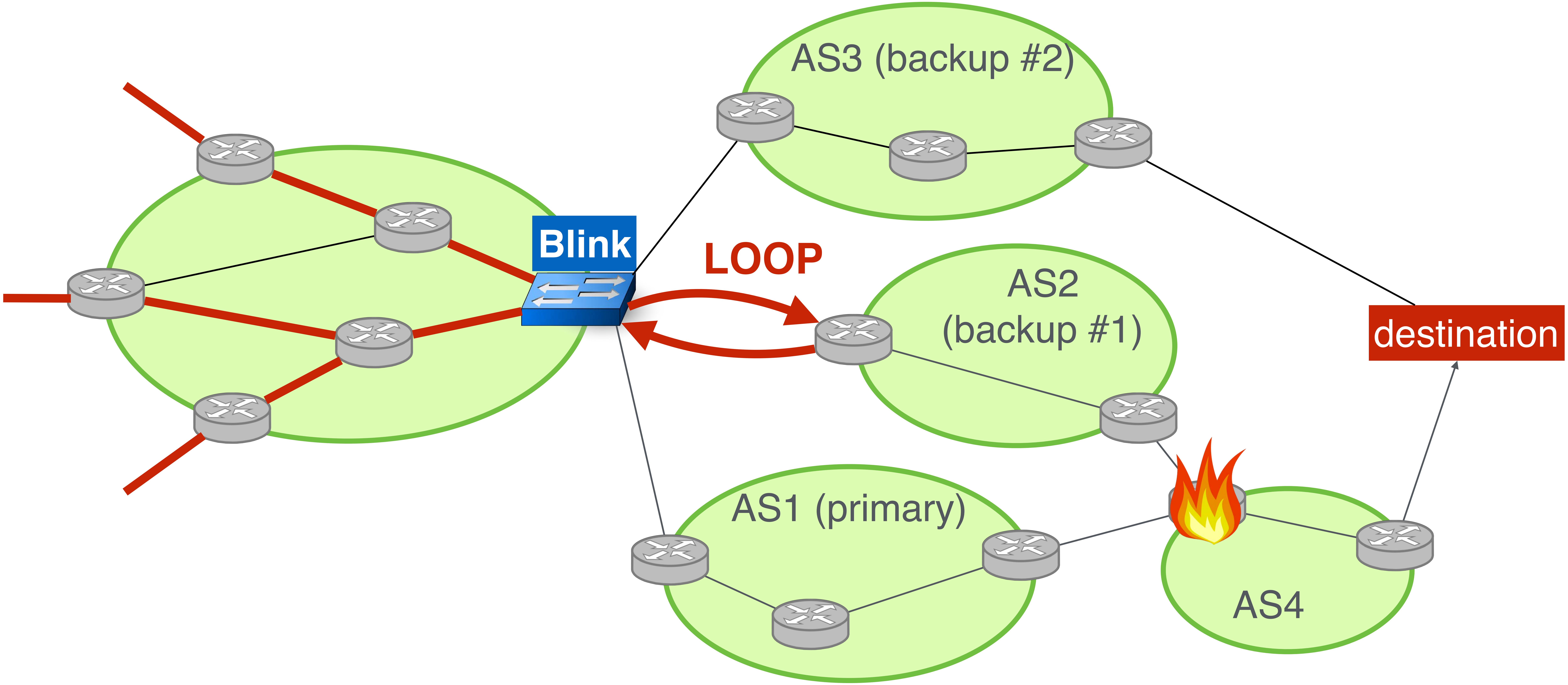

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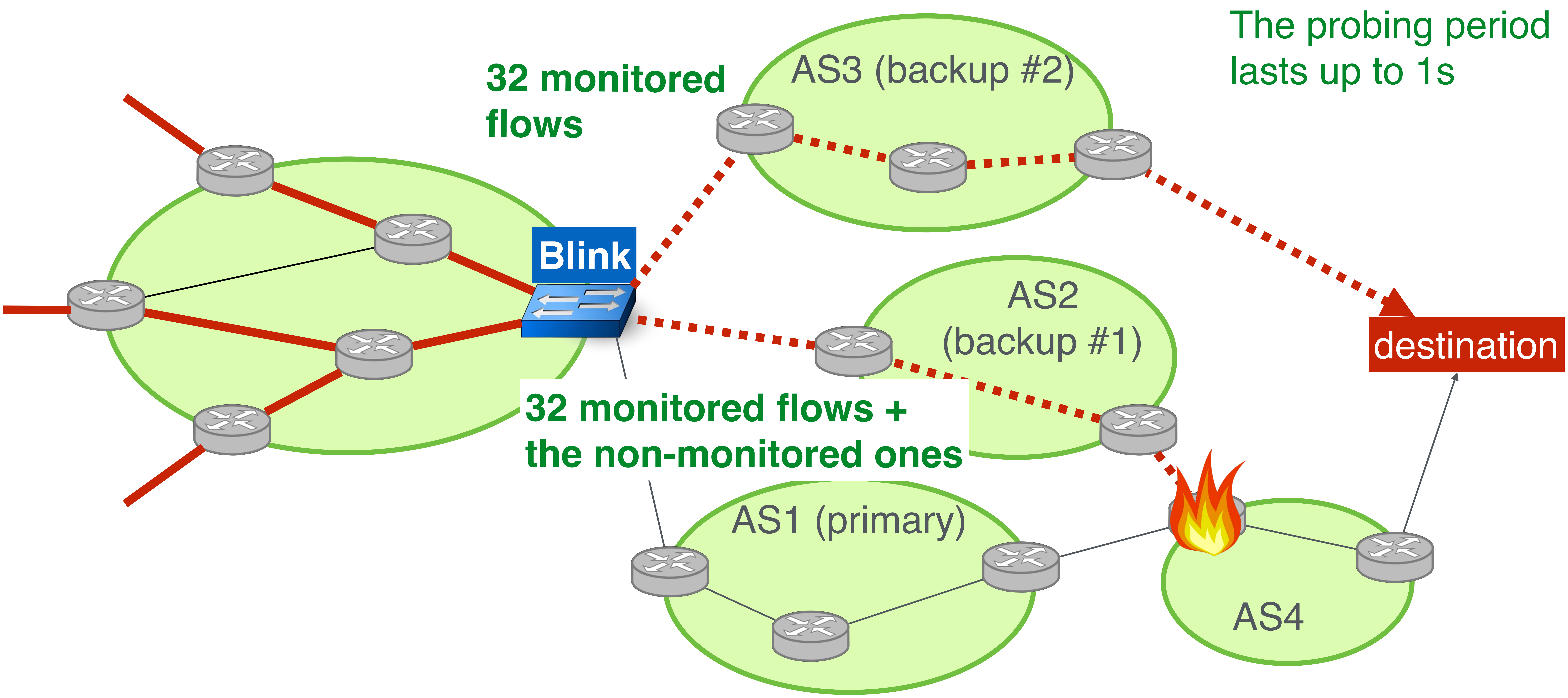

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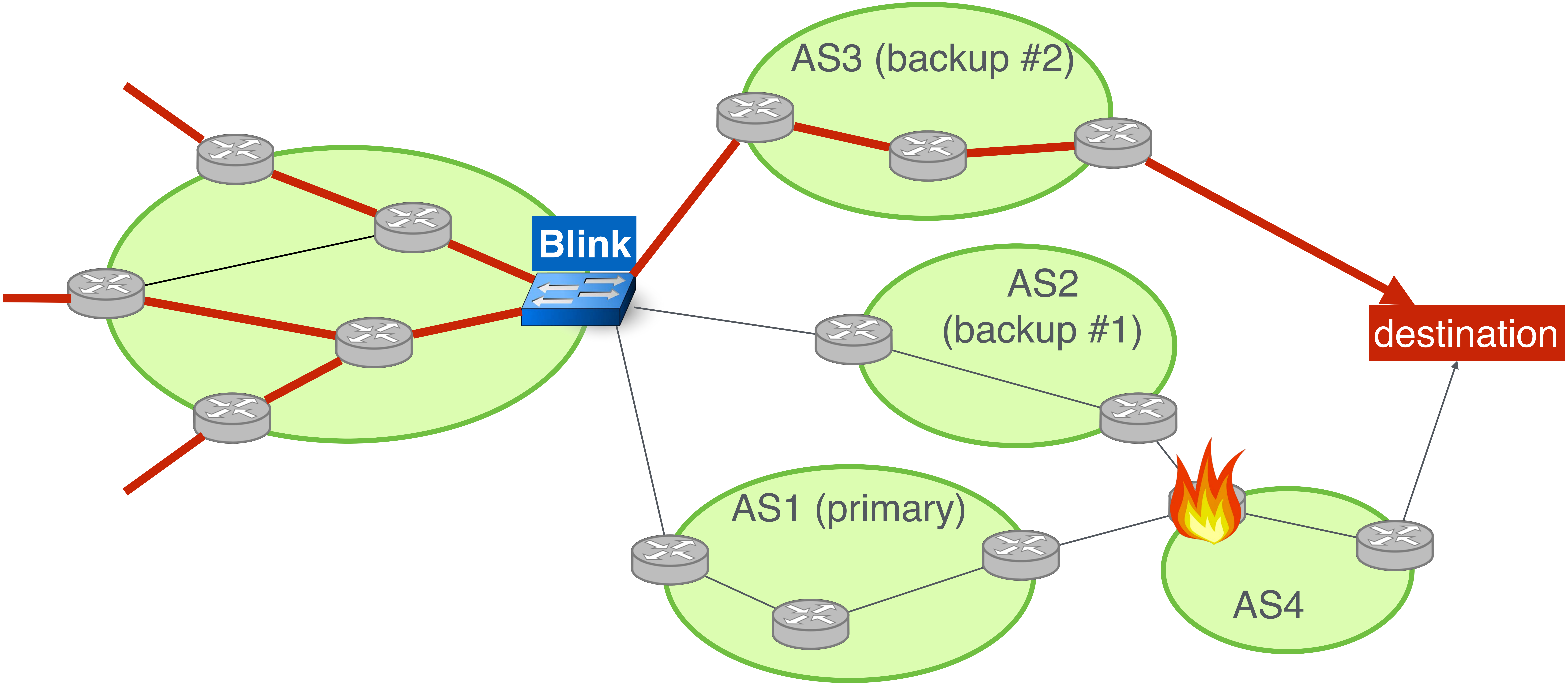

As for failures, ***Blink*** compares the sequence number of consecutive packets to detect blackholes or loops*

*See the paper for an evaluation of the rerouting

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and it detected 6 outages, each affecting *at least* 42% of *all* the flows

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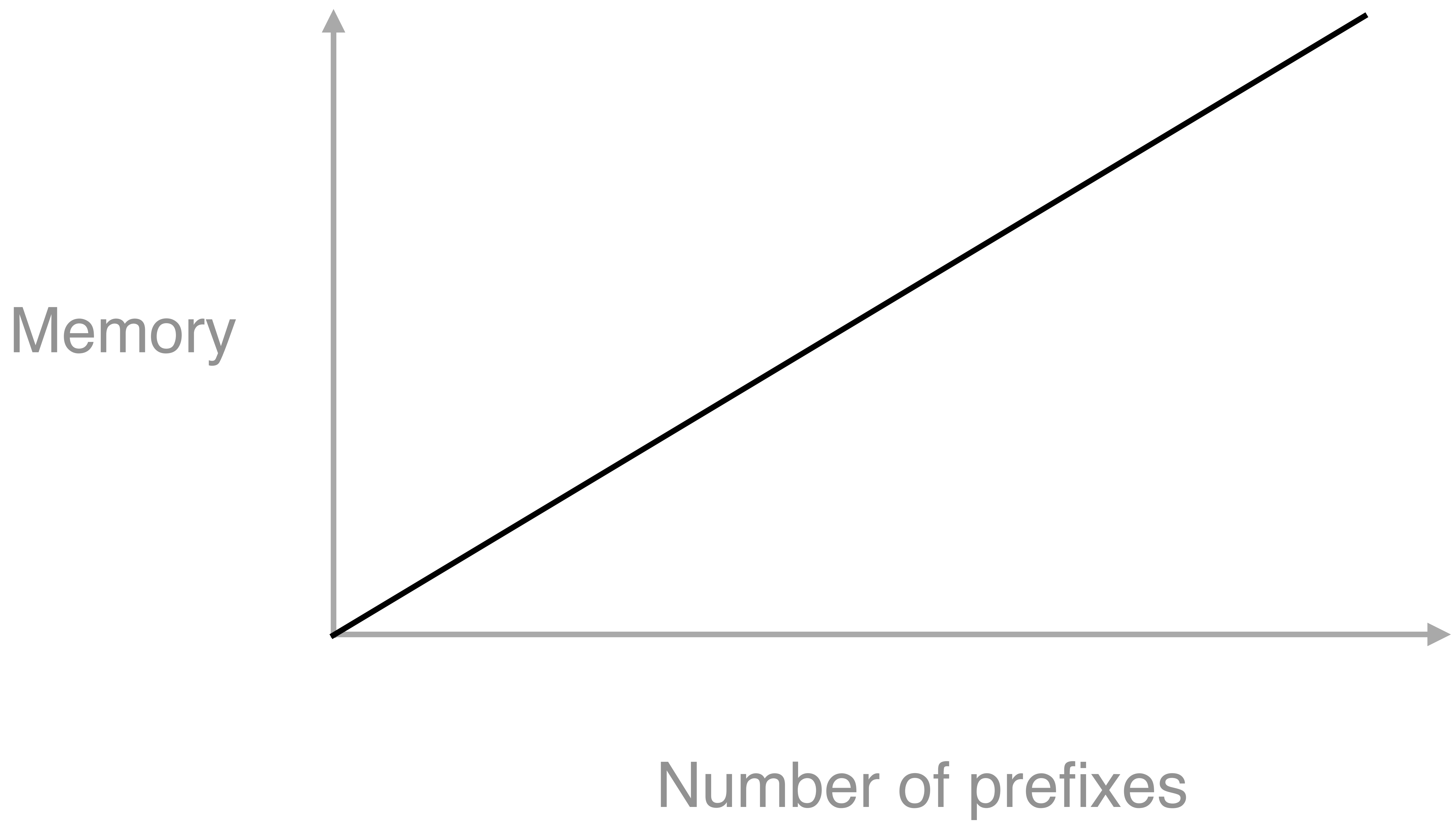

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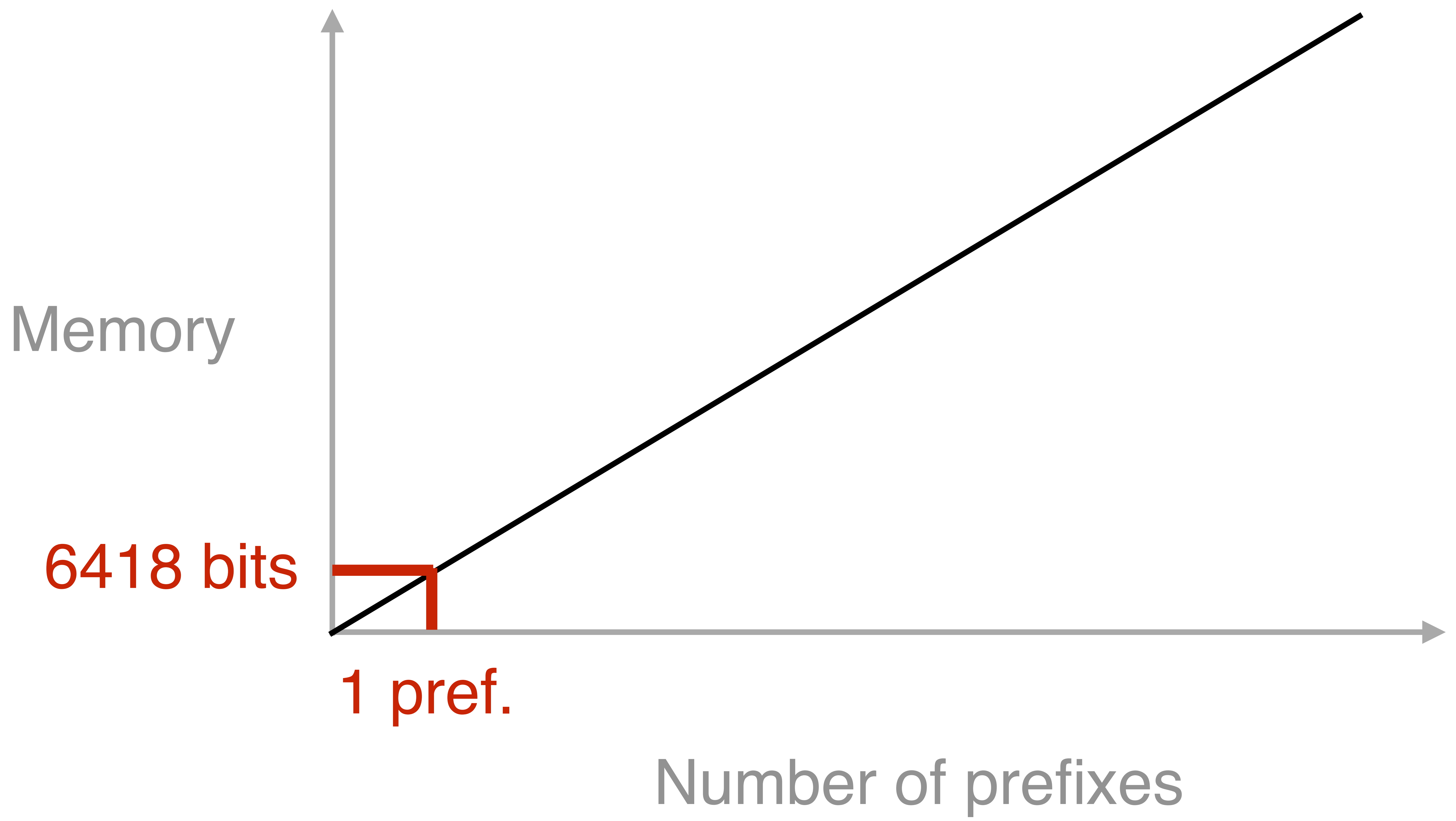

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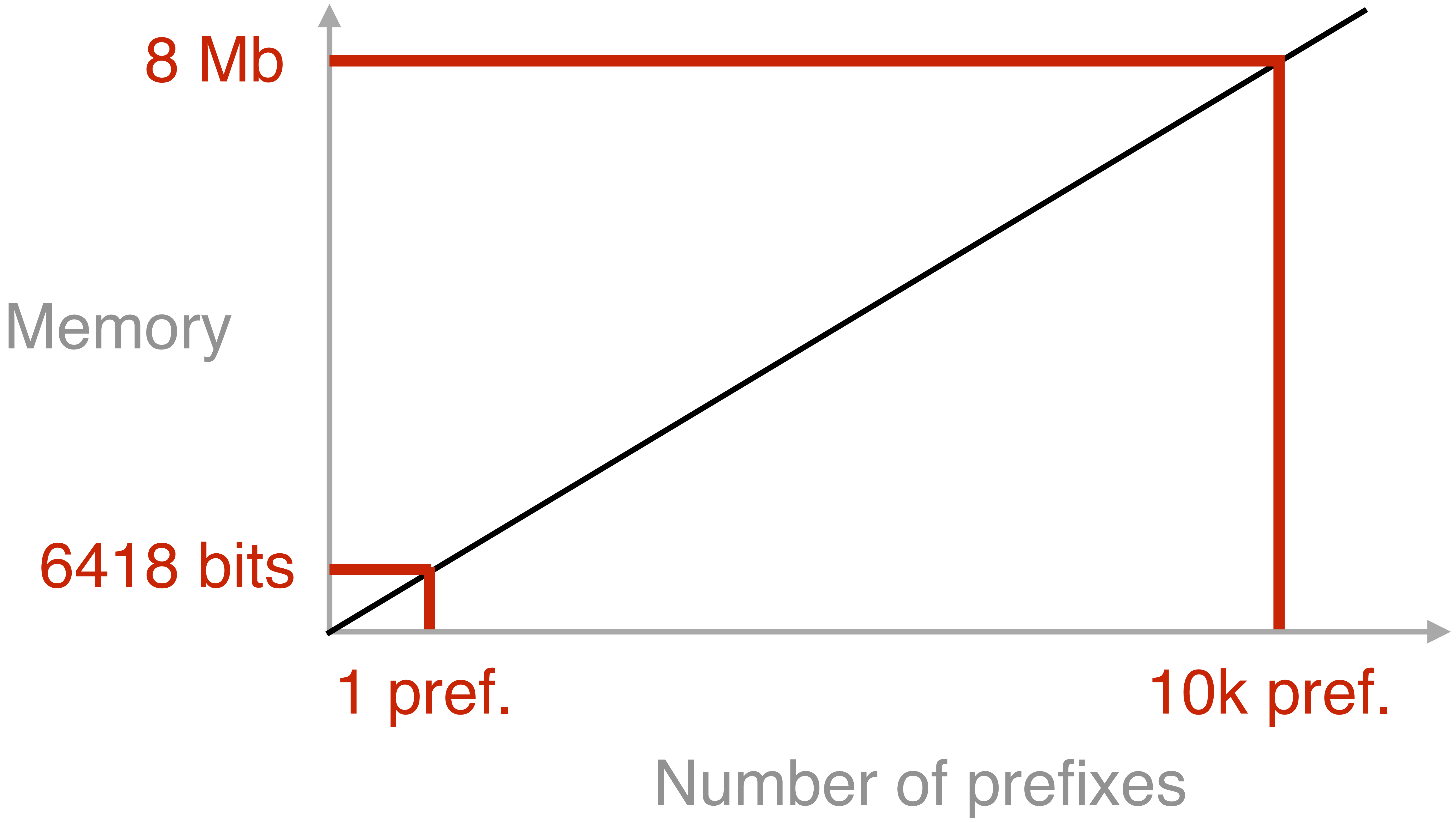
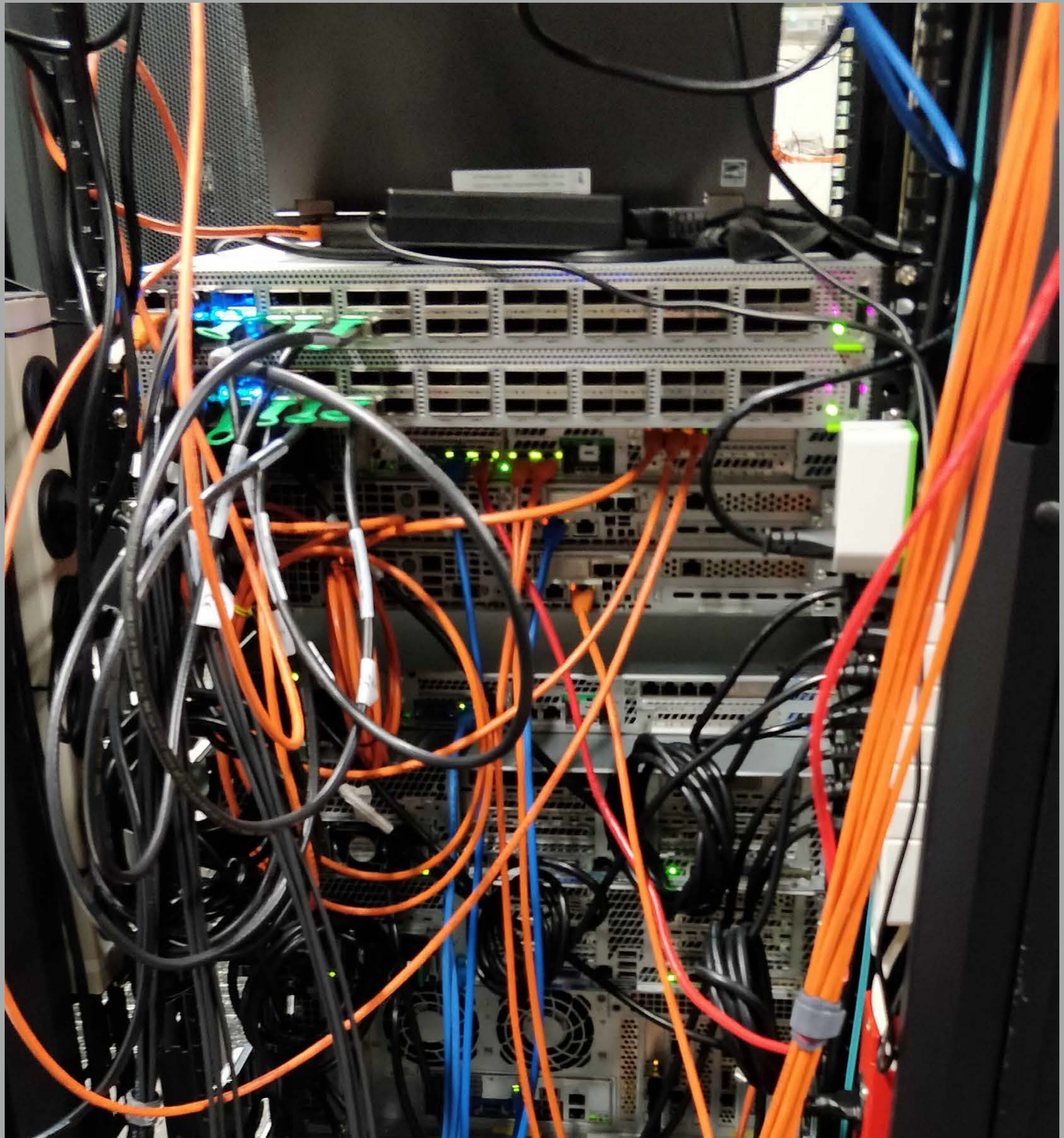


Blink works on a real Barefoot Tofino switch



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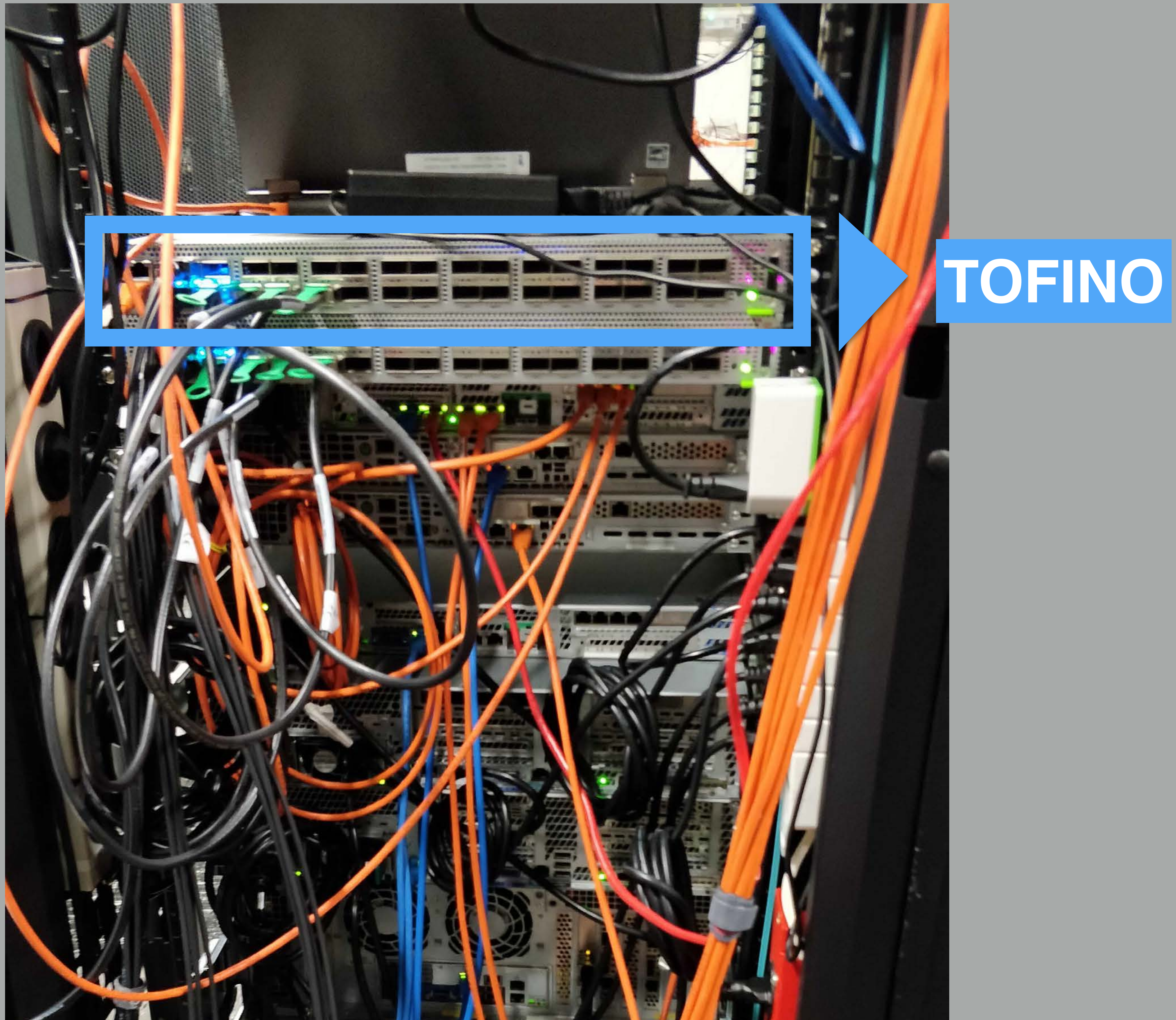

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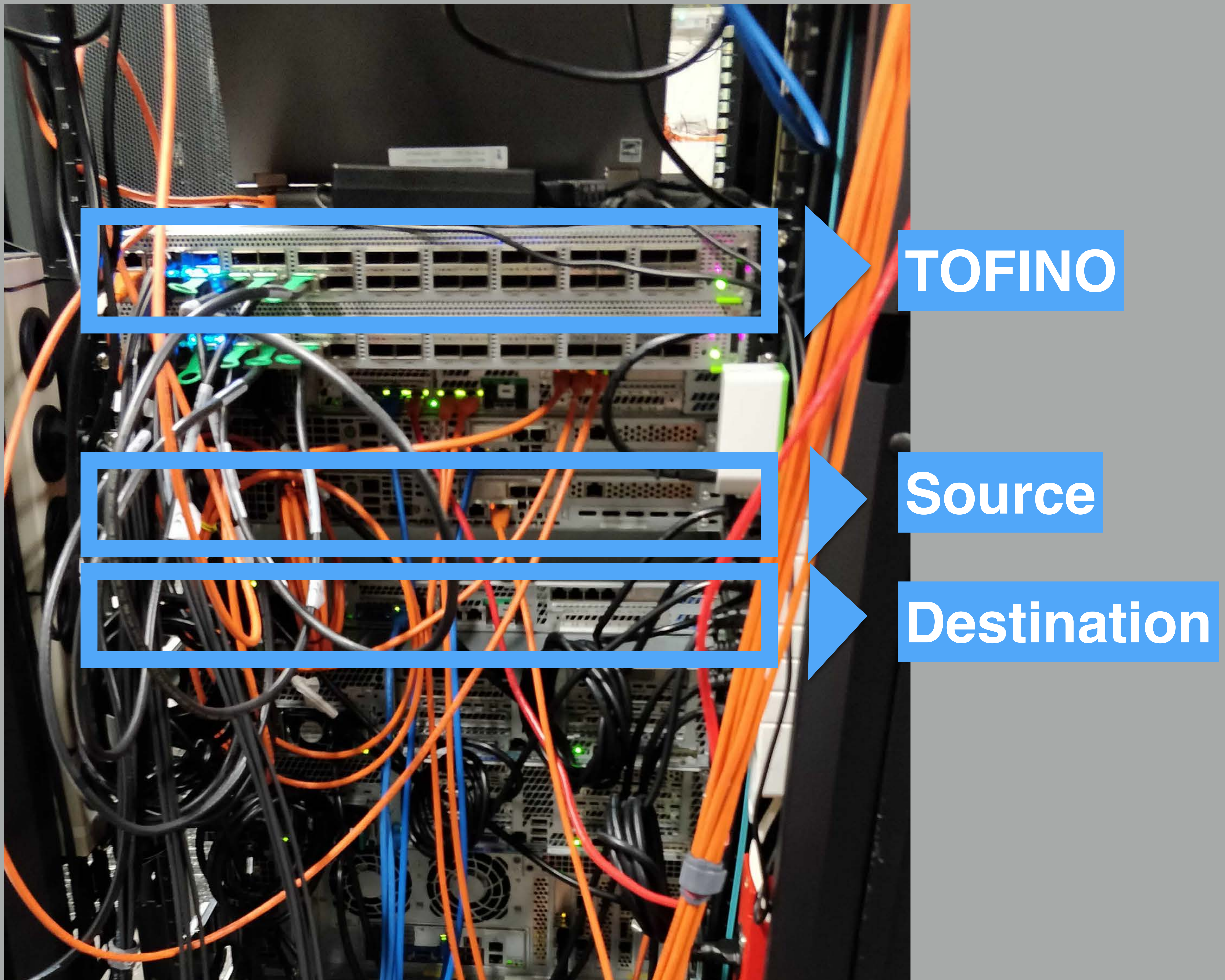
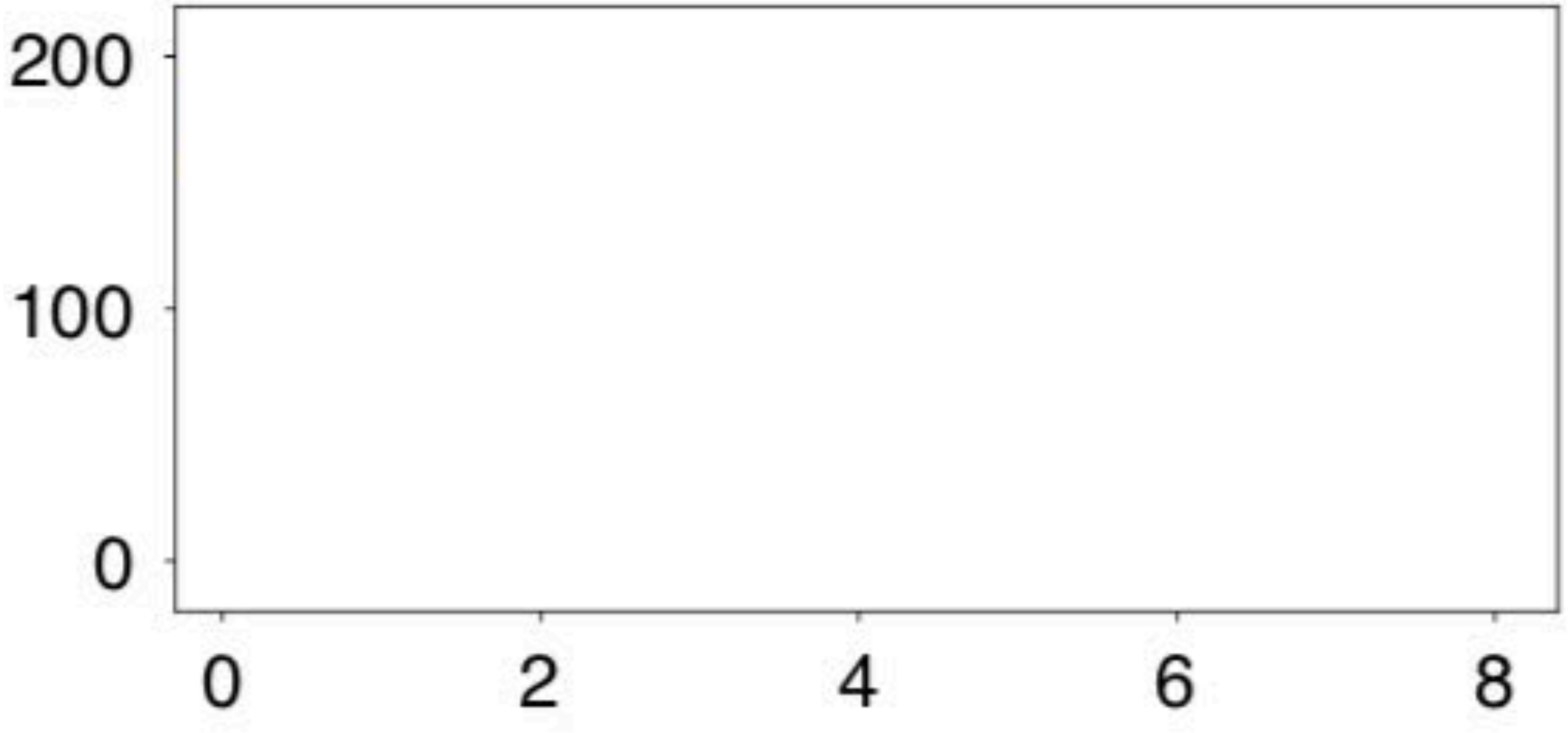


Blink works on a real Barefoot Tofino switch

RTTs in [10ms; 300ms]

Number of packets every 100ms

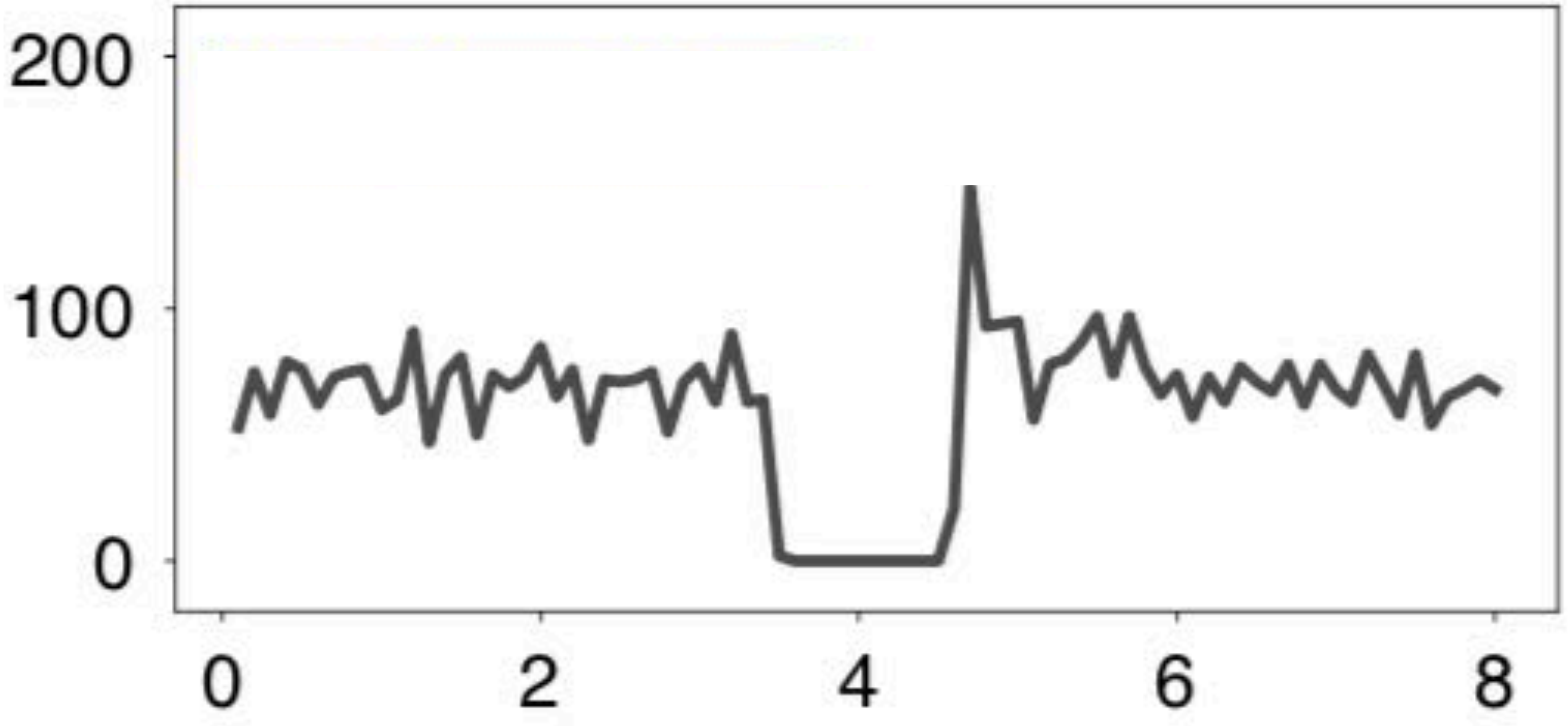


Time (s)

Blink works on a real Barefoot Tofino switch

RTTs in [10ms; 300ms]

Number of packets every 100ms

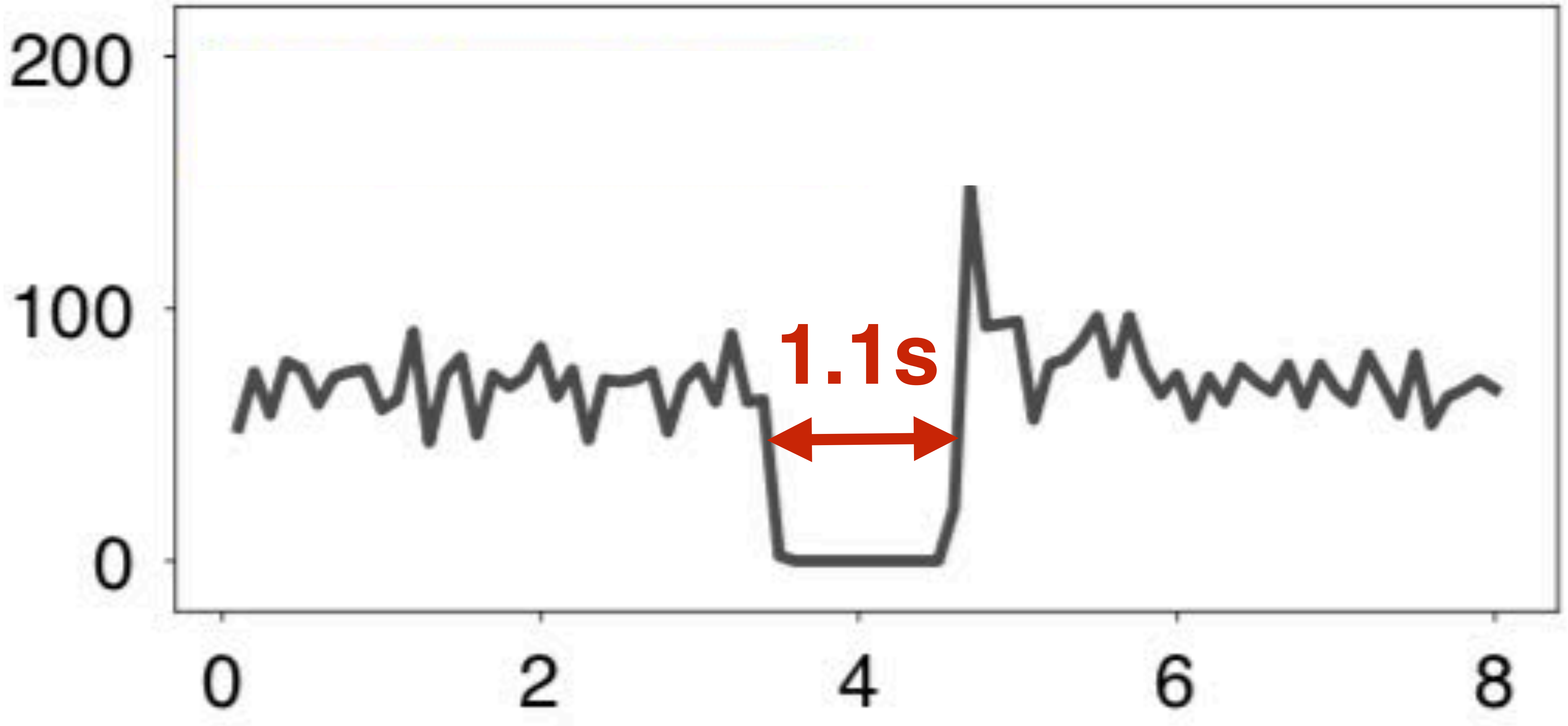


Time (s)

Blink works on a real Barefoot Tofino switch

RTTs in [10ms; 300ms]

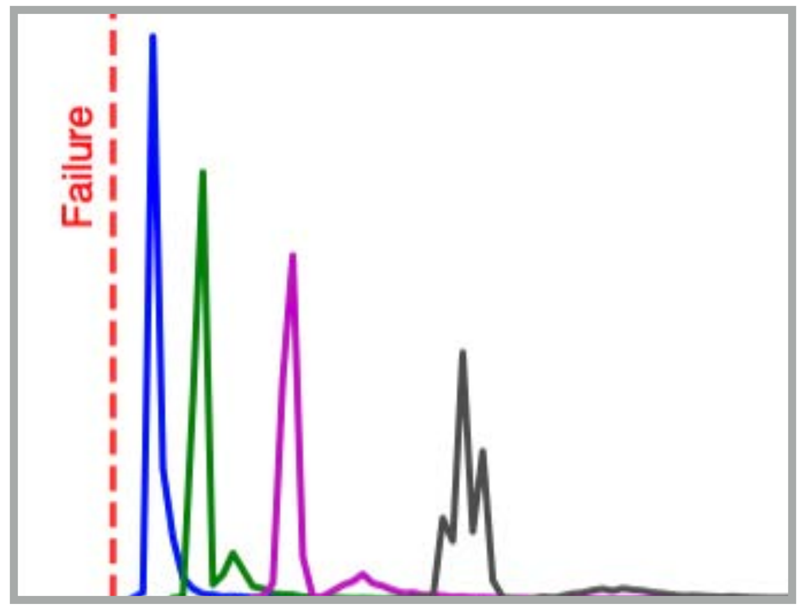
Number of packets every 100ms



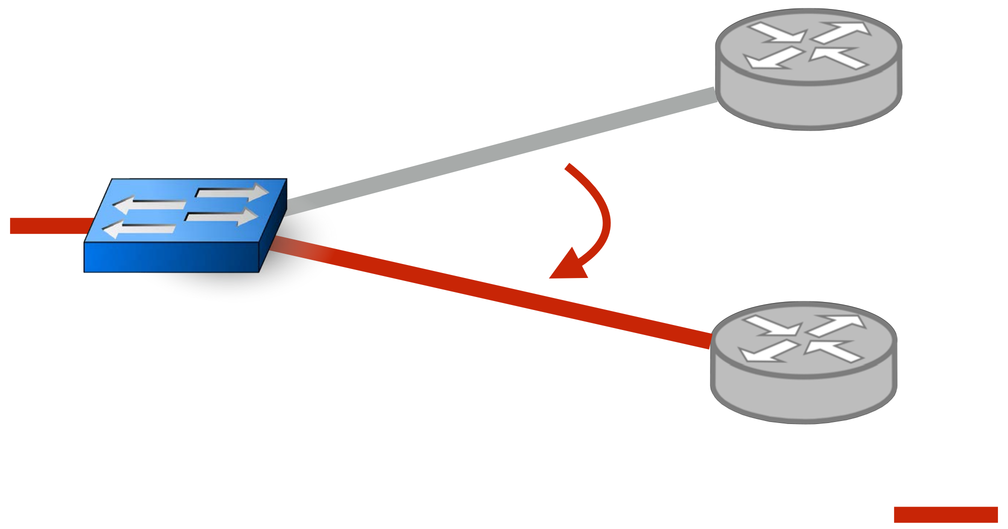
Time (s)

Blink: Fast Connectivity Recovery Entirely in the Data Plane

Infers failures from data-plane signals
with more than 80% accuracy, and often within 1s



Fast reroutes traffic at line rate
to working backup paths



Works on real traffic traces and on existing devices

https://blink.ethz.ch

Blink: Fast Connectivity Recovery Entirely in the Data Plane

Thomas Holterbach
ETH Zürich

NSDI
26th February 2019

Joint work with

Edgar Costa Molero ETH Zürich
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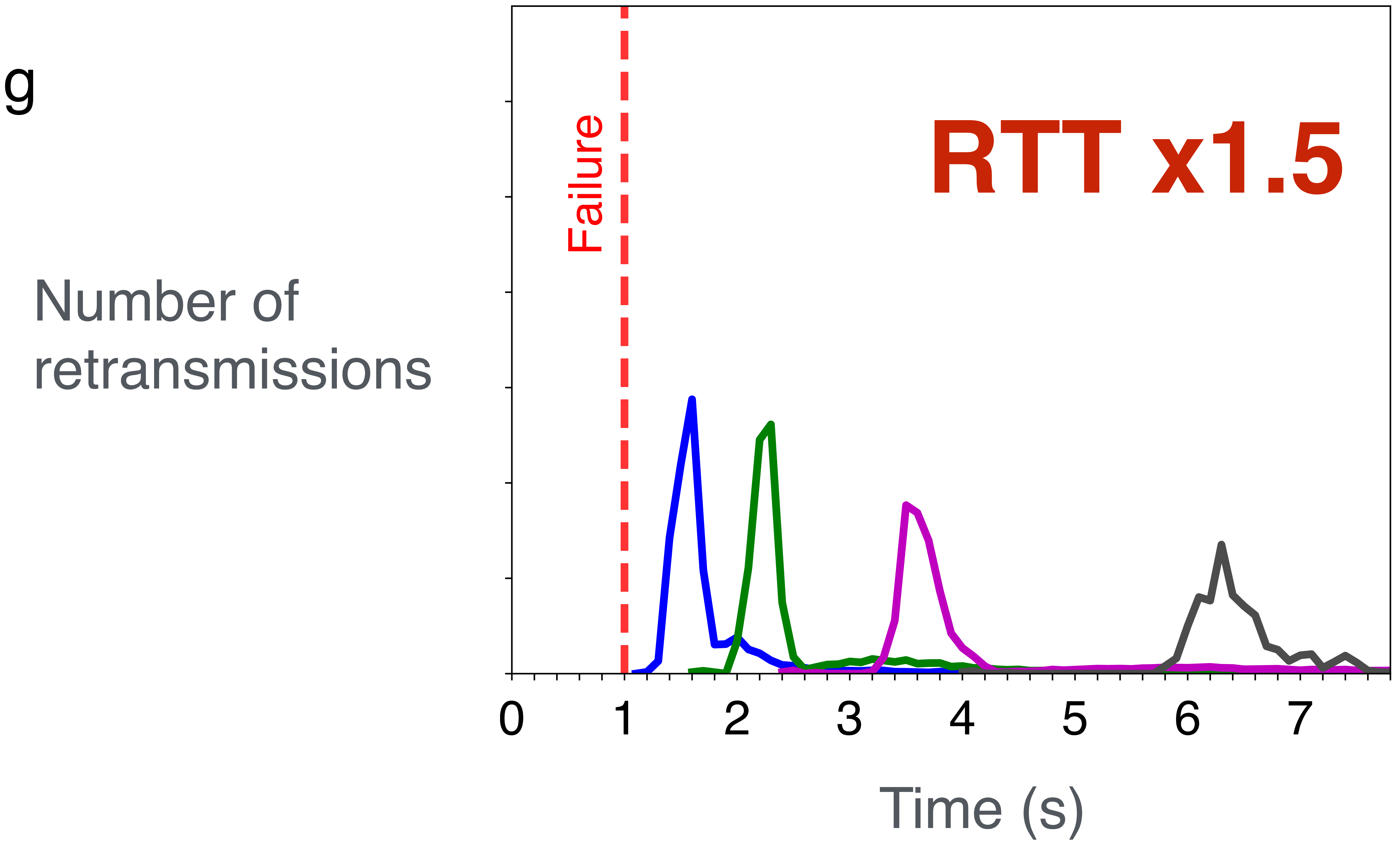
Stefano Vissicchio University College London
Alberto Dainotti CAIDA, UC San Diego
Laurent Vanbever ETH Zürich

When multiple flows experience the same failure

the signal is a wave of retransmissions

We simulated a failure affecting 100k flows with NS3

Same RTT distribution than in a real trace*



*CAIDA equinix-chicago direction A, 2015

When multiple flows experience the same failure
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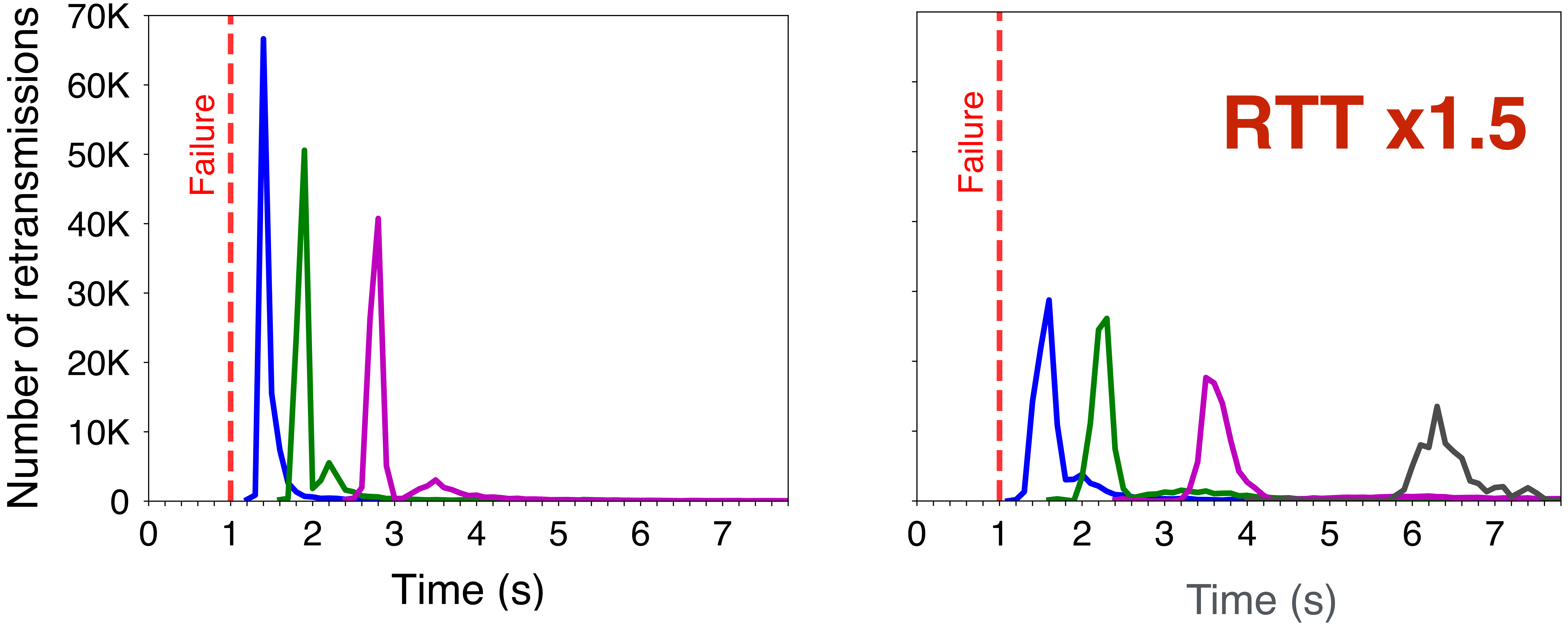
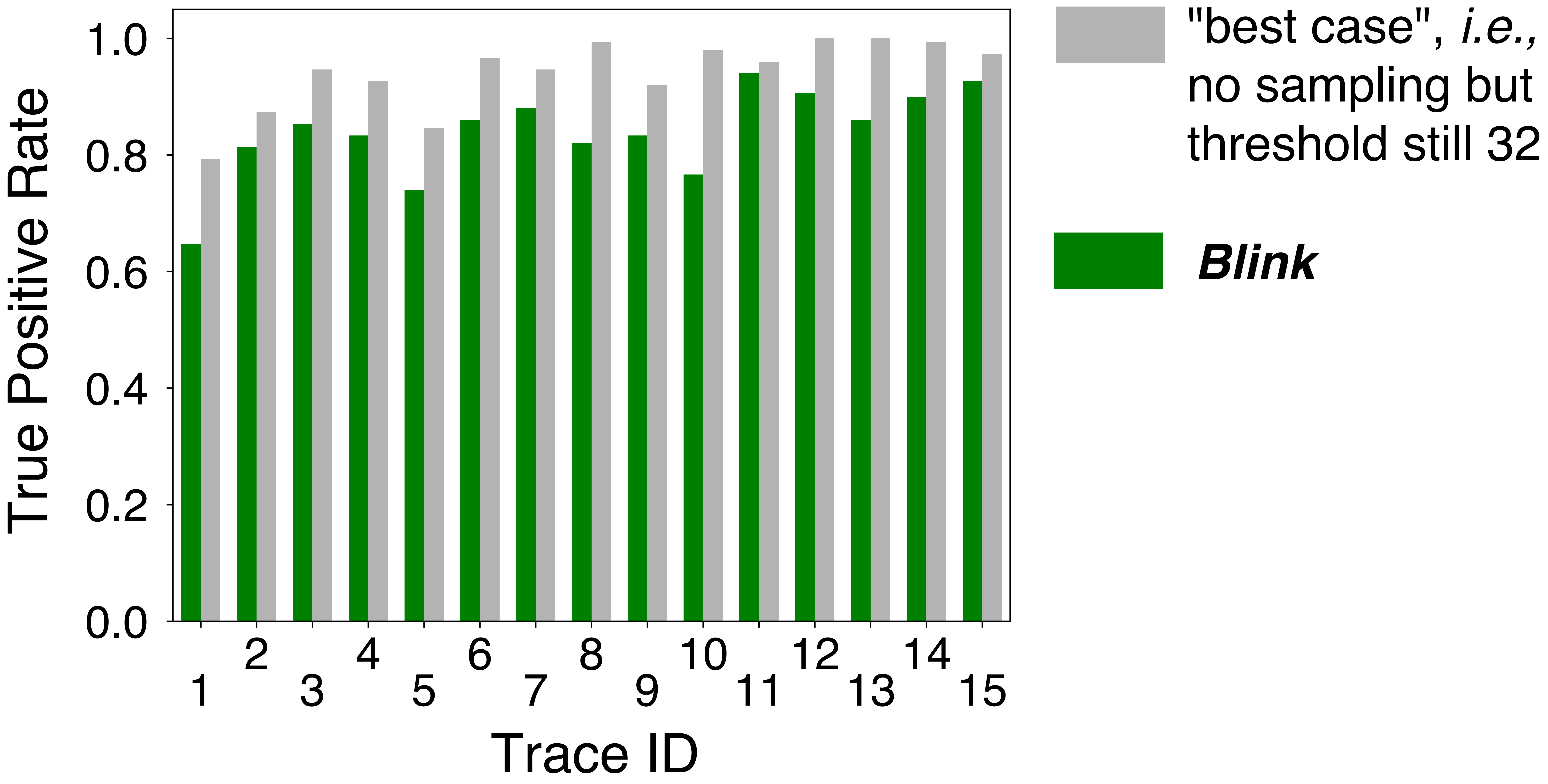
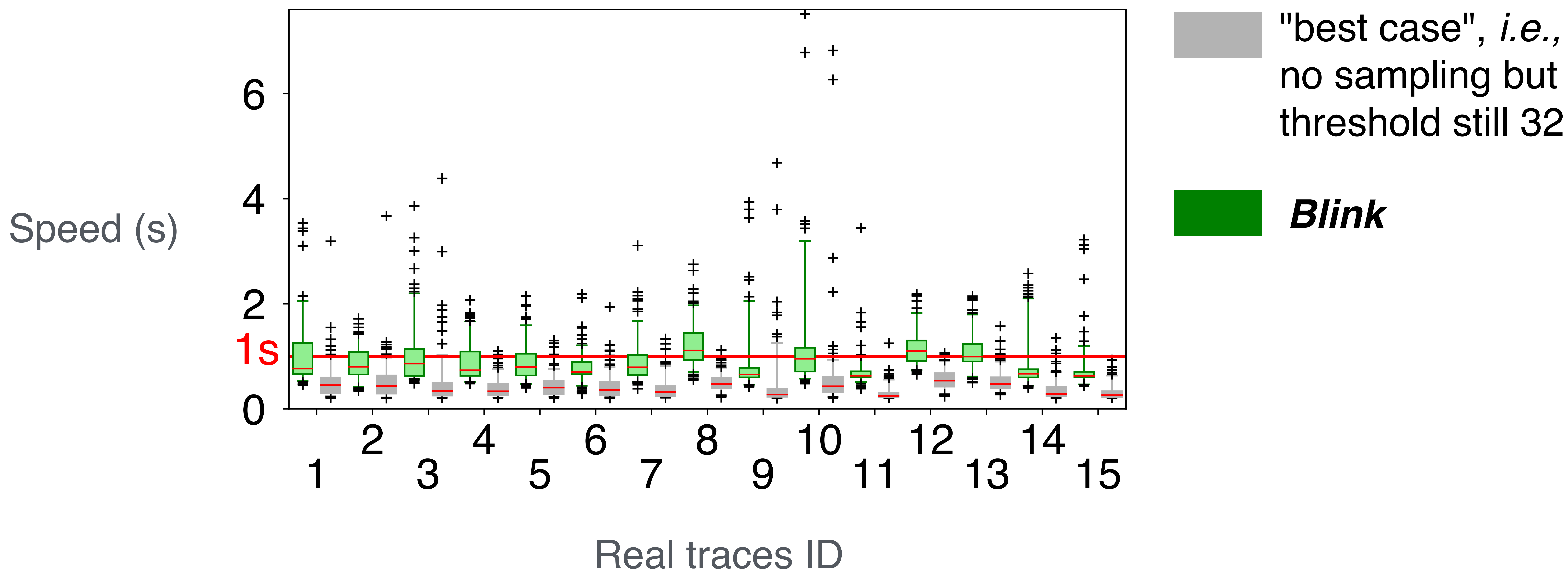


Blink failure inference accuracy is close to a best case scenario, and is above 80% for 13 real traces out of 15



Blink infers a failure within 1s for the majority of the cases



Blink avoids incorrectly inferring failures when packet loss is below 4%

packet loss %	1	2	3	4	5	···	8	9
	False Positive Rate							
Blink	0	0	0	0.67	0.67	···	1.3	2.7
no sampling but threshold still 32	59	85	93	94	95	···	97	98

Blink quickly infers and avoids forwarding loops

Number of packets every 100ms