

# Monitoring & Analytics on FABRIC

Nishanth Shyamkumar, Hyunsuk Bang, Bjoern Sagstad,  
Prajwal Venkateshmurthy, Sean Cummings, Nik Sultana

May 7, 2026  
Midwest RCD

ILLINOIS  
TECH

CNS-2346499

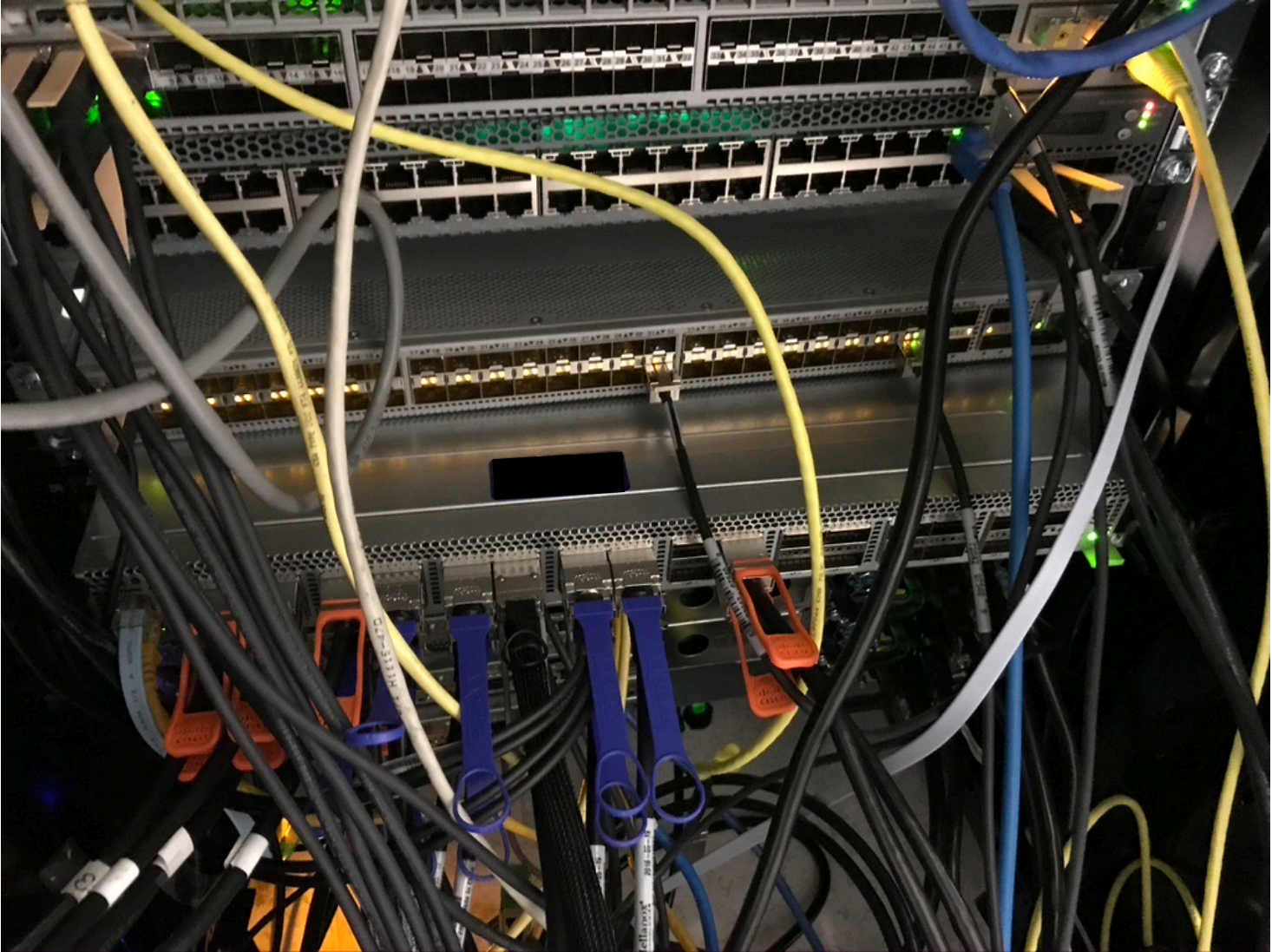
# What's a “network profile”?

- Informally: **what's on the network?**

# What's a “network profile”?

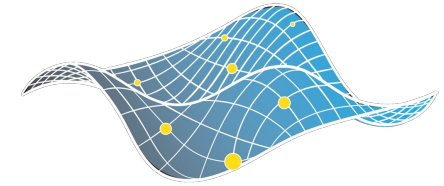
- Informally: **what's on the network?**
- Traffic composition over time:
  - **Header types:** What protocols are being used.
  - **Encapsulation patterns:** How is the network being used.
  - **Flows**
    - Number of packets
    - Packet sizes
    - Inter-packet delays
    - Other details – e.g., some/all TCP flows contain frequent RSTs.
  - **Relative utilization:** should some types of traffic be prioritized?
  - Indicators of misconfiguration and compromise.

# Testbeds



# *Federated* Testbeds

- Examples: PlanetLab, GENI, Chameleon, FABRIC.
- Large scale, many resources, flexibility for experiments.
- Testbeds *are* experiments!
- **My research interests:**
  - Understanding how testbeds work and how they're used.
  - How they can be evolved by their users.  
In particular: user-contributed testbed services.



# Related Work

- **Network profiling of different types of networks.**  
Internet and telecom backbones, domestic Internet access, datacenters, ...
- Differences: topology, workloads, traffic rates, traffic patterns.  
For example, stability wrt workloads and traffic patterns.
- Similar motivation but...  
**substantial differences in tooling, transparency, and observations.**
- In all cases: how do these observations change over time?

# Goals of the Patchwork Project

## 1) **Providing a network profiler for FABRIC.**

Developing user-provided service for (shared) federated testbeds.

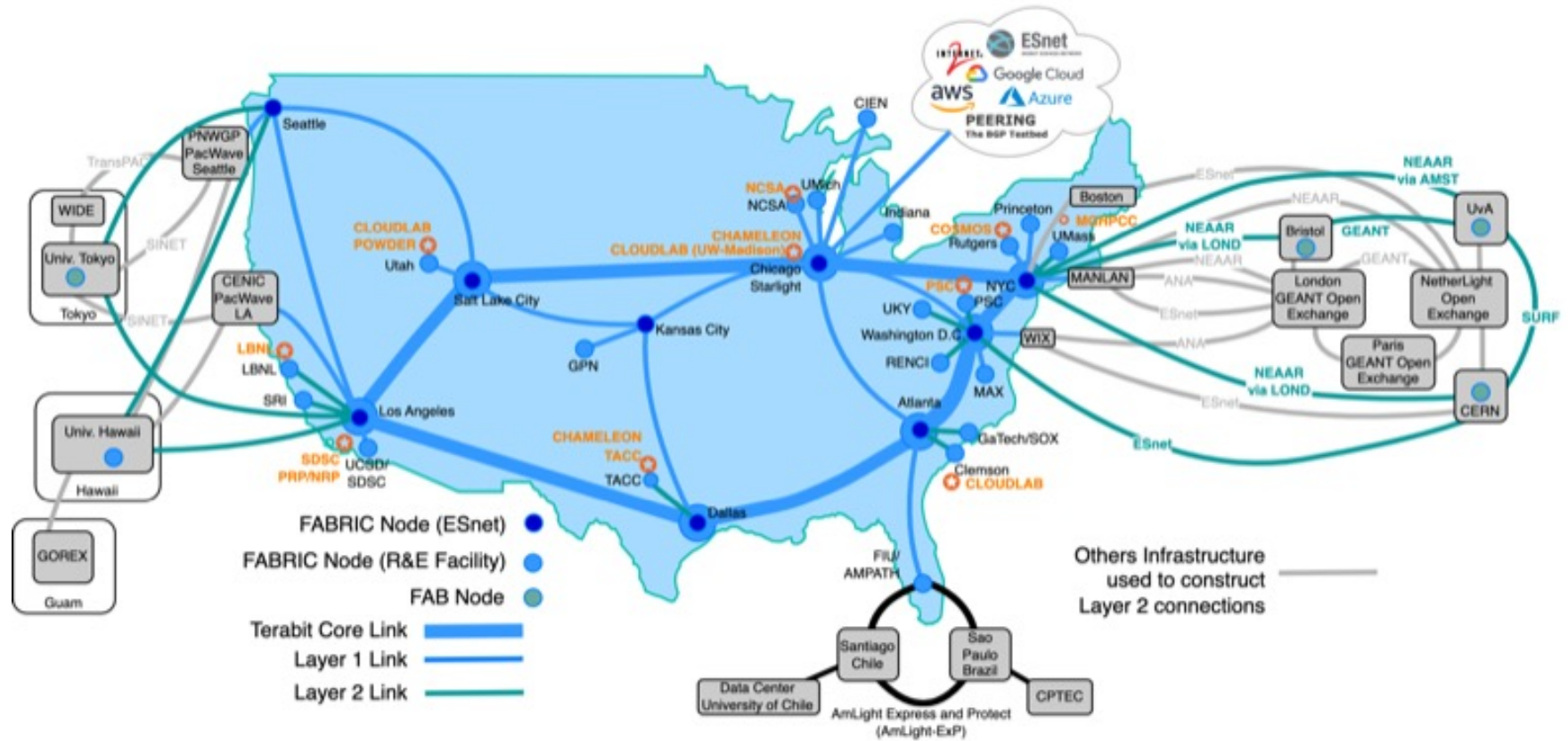
Two usage modes:

1. Individual experiment profiling. (“Experimenter mode”)
2. Testbed-wide profiling. (“Operator mode”)

## 2) **Developing a profile of the entire FABRIC network.**

And doing this periodically.

# FABRIC Background



# FABRIC Site

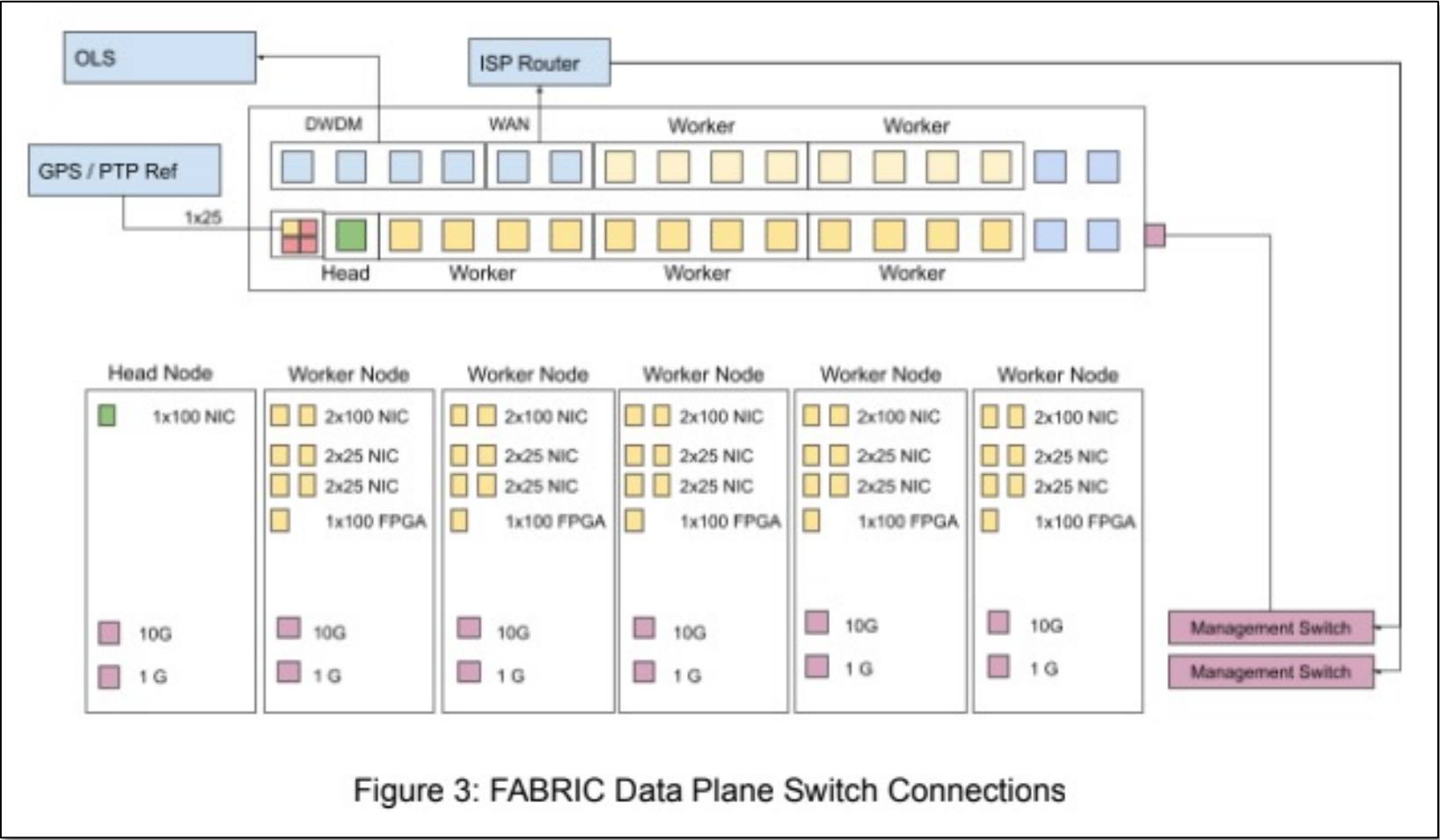
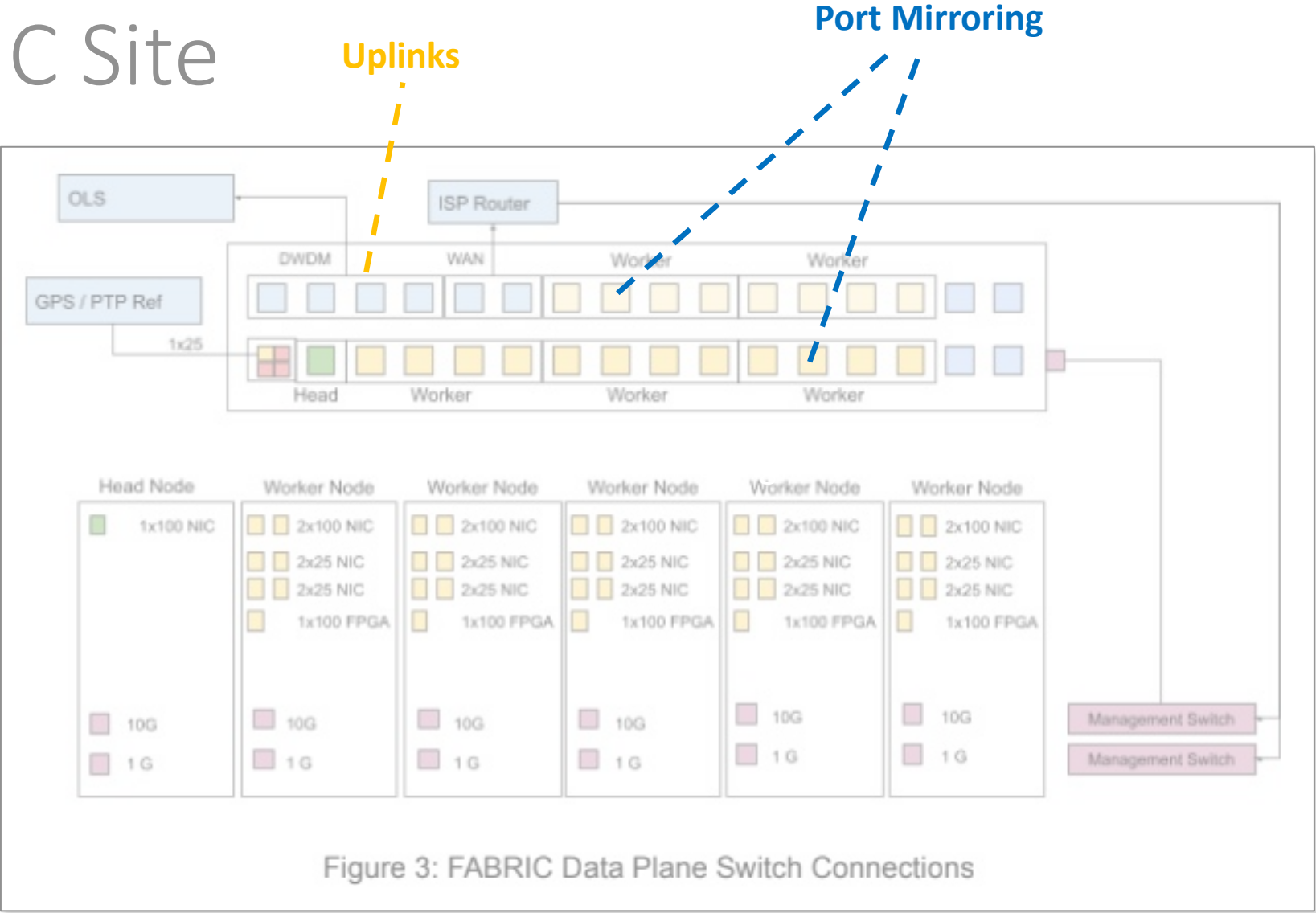


Figure 3: FABRIC Data Plane Switch Connections

Credit: FABRIC Node Design v1.2 <https://drive.google.com/file/d/1EgbNT9nu8LTgADxY9ehZNnEChZYRIeZR/view><sup>1</sup>

# FABRIC Site

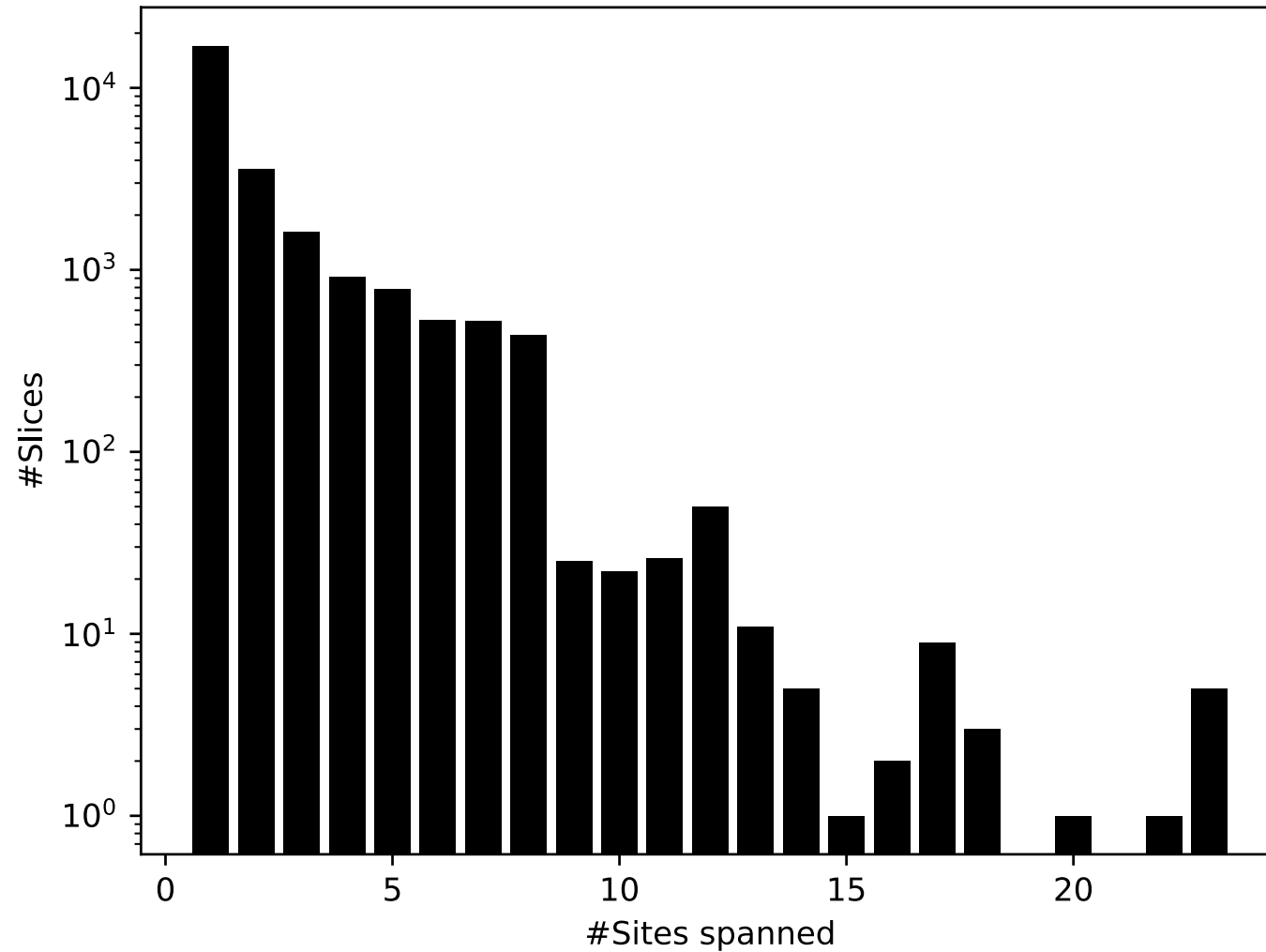


Credit: FABRIC Node Design v1.2 <https://drive.google.com/file/d/1EgbNT9nu8LTgADxY9ehZNnEChZYRIeZR/view><sup>12</sup>

# Resource and Infrastructure Study

- **Which ports should we focus on?**  
Uplinks? Mostly uplinks? Both uplinks and downlinks?  
How do we choose?
- **When** should we sample?  
How are “busy testbed” and “busy network” related?
- **How long** should we sample for?
- **Which sites** should we sample?
- **What data rates** should we support?

# Distribution of slices across FABRIC sites

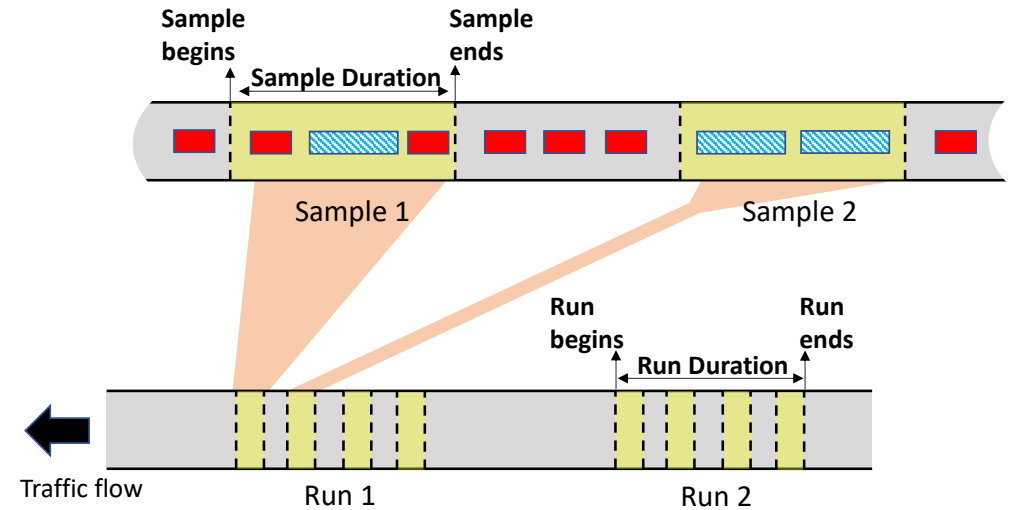


# Resource and Infrastructure Study

- **Which ports should we focus on?**  
Both uplinks and downlinks.
- **When** should we sample?  
Any time will yield data from various slices,  
and can recognize network-intensive periods from a “ramp-up”.
- **How long** should we sample for?  
12-24 hour intervals
- **Which sites** should we sample?  
Any/all – and we can find the busiest sites from MFlib.
- **What data rates** should we support?  
100Gbps

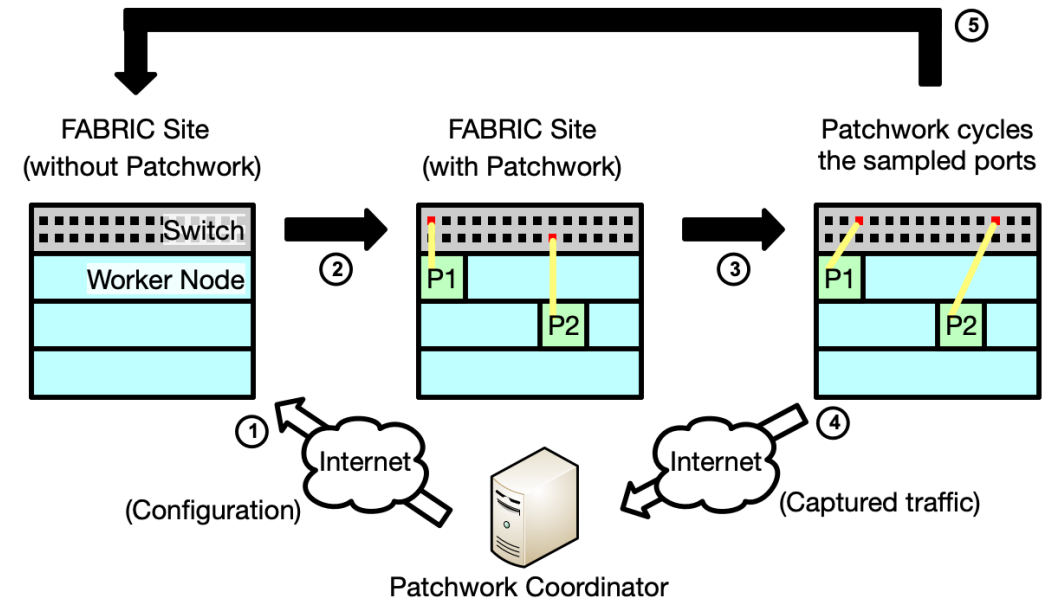
# Patchwork

- Runs as any experiment on FABRIC!  
It's a user-provided extension to the testbed.
- Loss detection:  $Tx+Rx \geq (\text{Mirror})Rx$
- Configurable (parameters) and customizable (filters, analysis).



# Patchwork

- Runs as any experiment on FABRIC!  
It's a user-provided extension to the testbed.
- Loss detection:  $Tx+Rx \geq (Mirror)Rx$
- Configurable (parameters) and customizable (filters, analysis).
- Cycling ports to get more coverage.
  - Mitigates disparity between switch ports and mirrors.
  - Ranking ports by activity.
- Offloading to Alveo FPGA NICs.
  - Filter, Truncation, Editing+Anonymisation.  
+ custom **DPDK** application for capture serialisation.
  - tcpdump (tuned) can capture up to ~8.5Gbps.
- (Re)usability – and not only by our group!



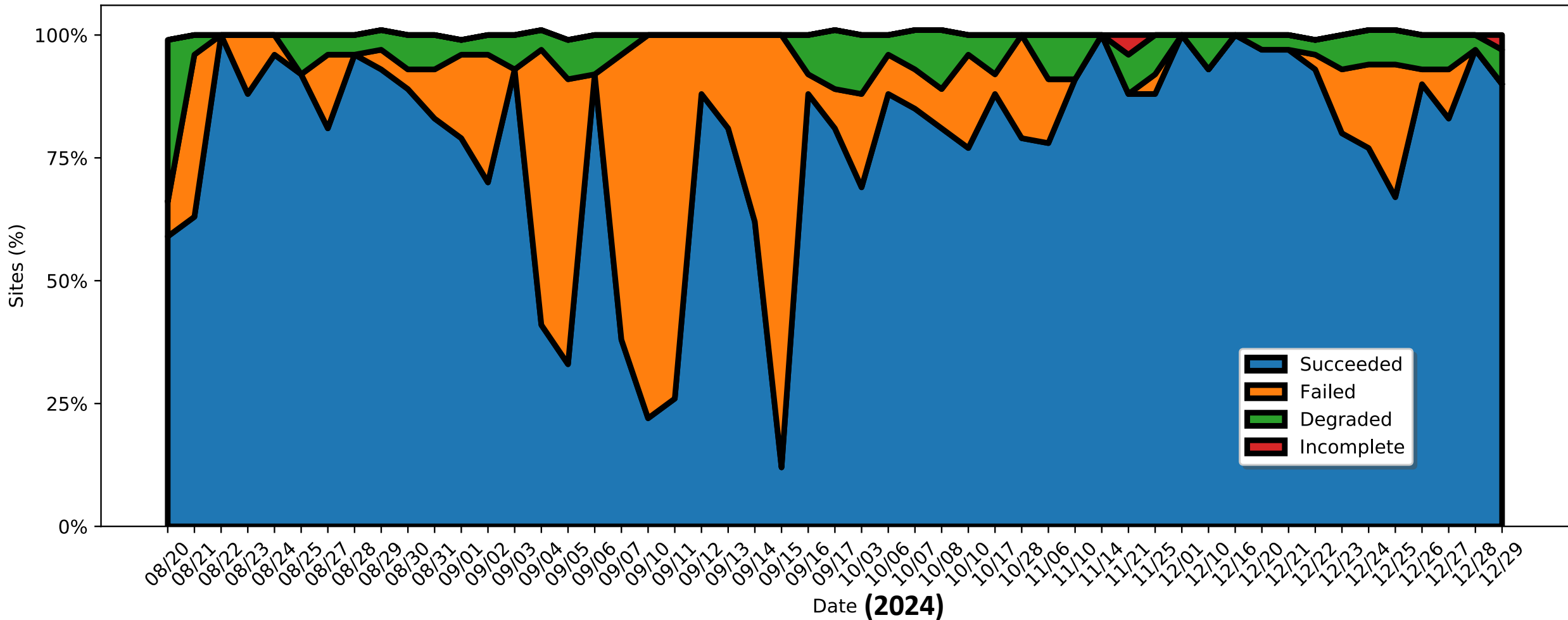
# Findings: User-developed Testbed Extension

- 1. Easy for other users to try!**  
Outside of the developers, ~20 other people used Patchwork.
- 2. Federation naturally decomposes the extension.**  
A separate Patchwork instance is run at each site.
- 3. Infrastructure frugality:**
  - a) bounding resource usage (testbed might be busy!)
  - b) back-off in request quantity (testbed might be busy!)
  - c) port cycling (mitigate disparity between switch and NIC ports)
- 4. Opportunism and minimal services:**
  - a) port mirroring (basic primitive – but only one mirror dest. port)
  - b) port stats for loss detection (provides welcome visibility)
  - c) offloading to FPGA NICs (for performance and free-ing up CPUs)
- 5. Storage bottleneck.**

# Findings: FABRIC's Profile

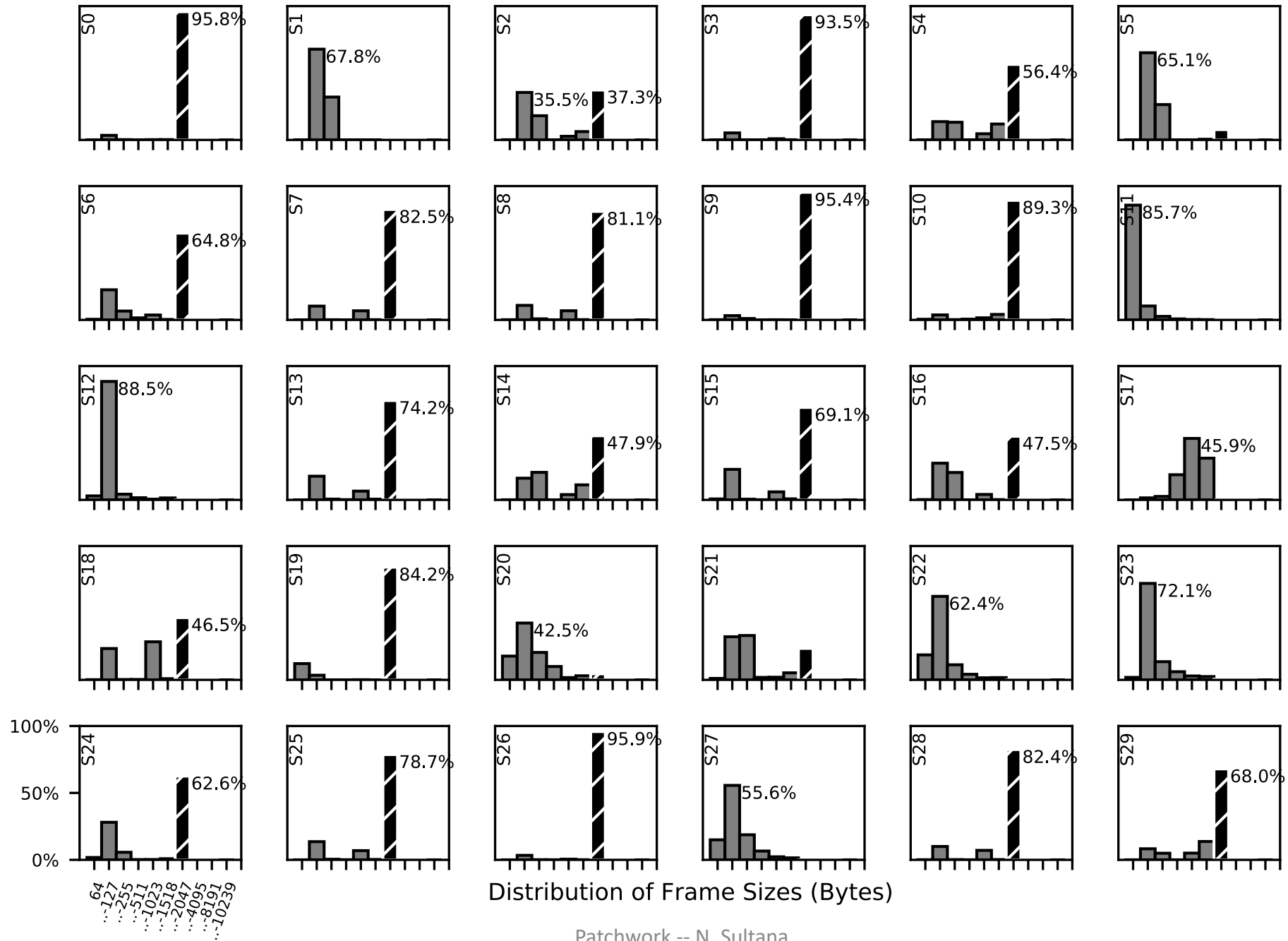
- 1. FABRIC sites have diverse network characteristics.**  
Different but persistent workloads.  
Most FABRIC sites exhibit a low variety of protocol headers.
- 2. FABRIC link utilization is often low, but it sometimes spikes to capacity.**  
Health headroom. Background network activity is highly variable.
- 3. Performance reproducibility is challenging.** For high-performance network experiments, QoS or resource scheduling policy is needed.
- 4. Jumbo frames are prevalent in FABRIC's network.**
- 5. IPv4 is the dominant network protocol used on FABRIC.**  
IPv6 traffic makes up less than 2% of FABRIC traffic we sampled.

# How well does Patchwork+FABRIC work?

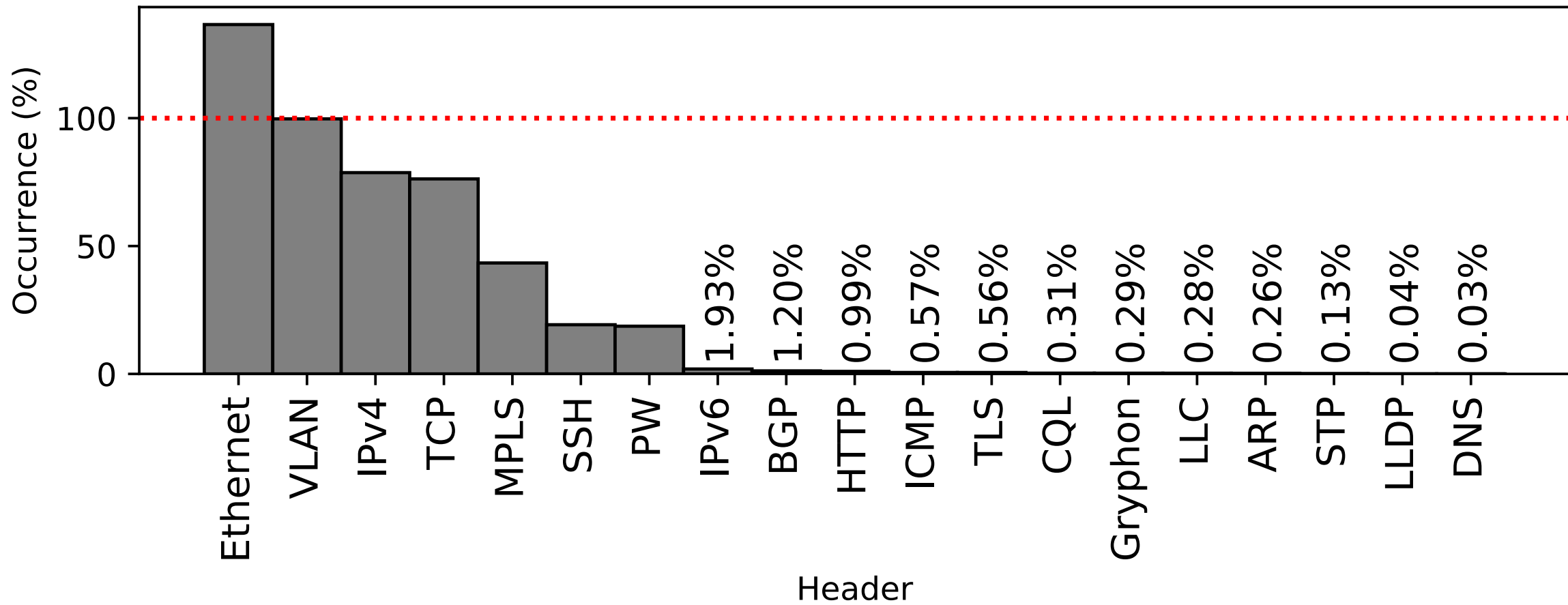


# FABRIC's Network Profile

- Granularity
  - Space: Global vs Site-level
  - Time: hour of day (other options: day of week, month)
- Headers/protocols
- Header diversity
- Frame sizes
- # sampled flows
- Size (in bytes) of sampled flows
- Frame size distribution in sampled flows
- Encapsulation depth and patterns





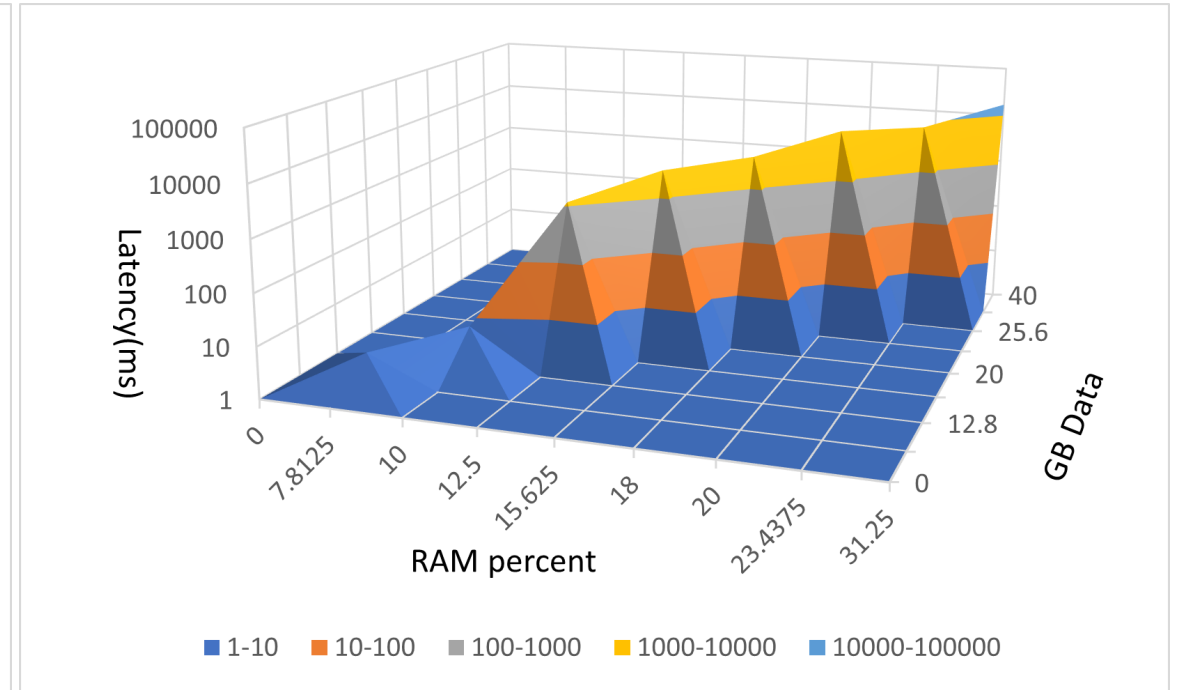
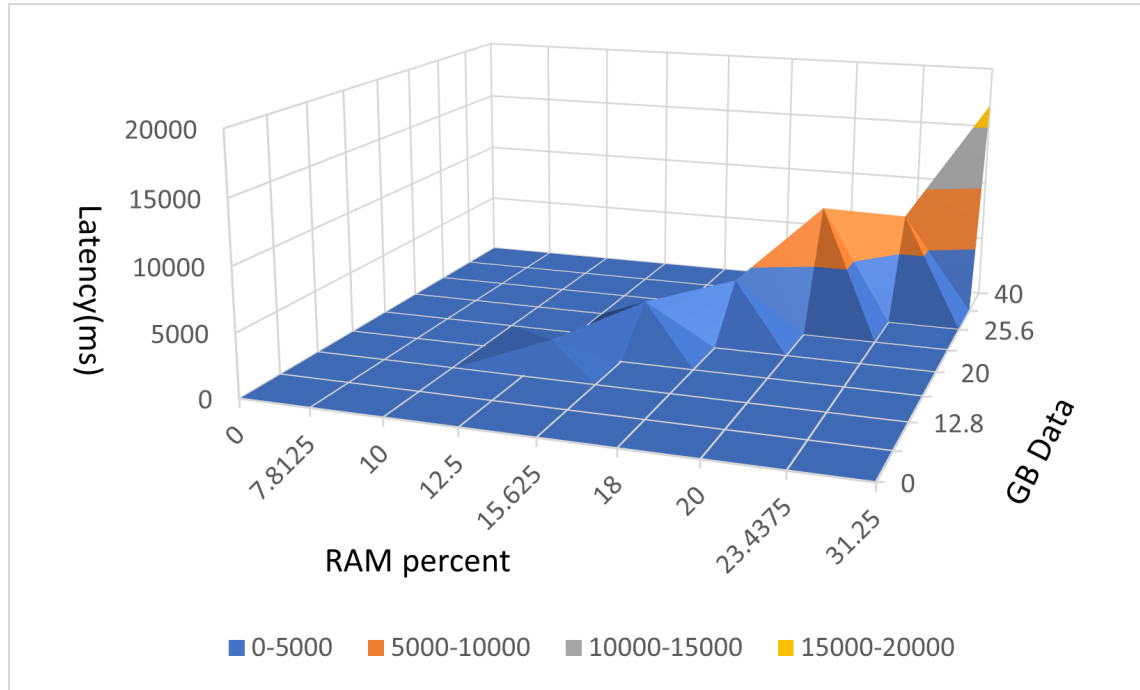


# Encapsulation examples

1. Ethernet
2. VLAN
3. MPLS
4. MPLS
5. "PW Ethernet Control Word"
6. Ethernet
7. IPv4
8. TCP
9. TLS

1. Ethernet
2. VLAN
3. MPLS
4. "PW Ethernet Control Word"
5. Ethernet
6. IPv6
7. SSH


# Patchwork: Performance vs Overhead



# Patchwork Dashboard



<https://packetfilters.cs.iit.edu/patchwork/dashboard/>



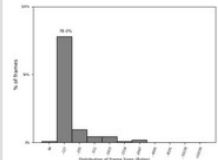
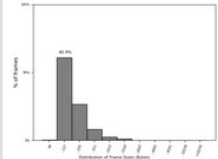
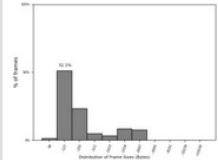
## Loom with a View (Beta)

This is an experimental, auto-generated dashboard that shows the network profile of the [FABRIC testbed](#). Data and graphs for this dashboard are generated using [Patchwork](#) which is invoked every few days across the whole of FABRIC to gather a snapshot of its network activity.

See our [paper on Patchwork](#) if you'd like to find out how the whole process works.

Subscribe to this dashboard's [RSS feed](#).

Click on a date to find out more information about the contents of FABRIC's dataplane that day:

<u>Date</u>	<u>Sites</u>	<u>Outcomes</u>	<u>Size</u>	<u>Distribution</u>
<a href="#">04 Oct 2025</a>	24	succeeded=87.50%, failed=4.17%, degraded=8.33%, inprogress=0.00%	7.9G	
<a href="#">01 Oct 2025</a>	24	succeeded=66.67%, failed=33.33%, degraded=0.00%, inprogress=0.00%	42M	
<a href="#">29 Sep 2025</a>	30	succeeded=80.00%, failed=3.33%, degraded=0.00%, inprogress=16.67%	8.3G	

# Best Community Paper Award

## Patchwork: A Traffic Capture and Analysis Platform for Network Experiments on a Federated Testbed

Nishanth Shyamkumar (Illinois Institute of Technology), Hyunsuk Bang (Illinois Institute of Technology), Bjoern Sagstad (Illinois Institute of Technology), Prajwal Somendyapanahalli Venkateshmurthy (Illinois Institute of Technology), Sean Cummings (Illinois Institute of Technology), Nik Sultana (Illinois Institute of Technology)



# Thank you

- Vaneshi Ramdhony and Alexander Wolosewicz at Illinois Tech
- OTS at Illinois Tech (Jim Tufts, Adrian Bucurica, Ibukun Oyewole, and Sejal Vaishnav)
- Tom Lehman at FABRIC and Xi Yang at ESnet
- Komal Thareja, Mert Cevik and Paul Ruth at RENCi
- Charles Carpenter and Yongwook Song at UKY
- Jonathan Sewter, Stacey Sheldon, Peter Bengough, and Yatish Kumar at ESnet
- Ilya Baldin at JLAB, Anita Nikolich at UIUC and Jim Griffioen at UKY
- Chris Neely at Xilinx/AMD
- Cees de Laat at UAmsterdam
- Joe Mambretti at StarLight/ICAIR/Northwestern

Find out more:

<https://packetfilters.cs.iit.edu/patchwork/>

Recent: Advanced Tutorial at KNIT11

KNIT = FABRIC's workshop

