



National Applied Research Laboratories

National Center for
High-performance Computing

TWAREN Network Infrastructure Update

Te-Lung Liu

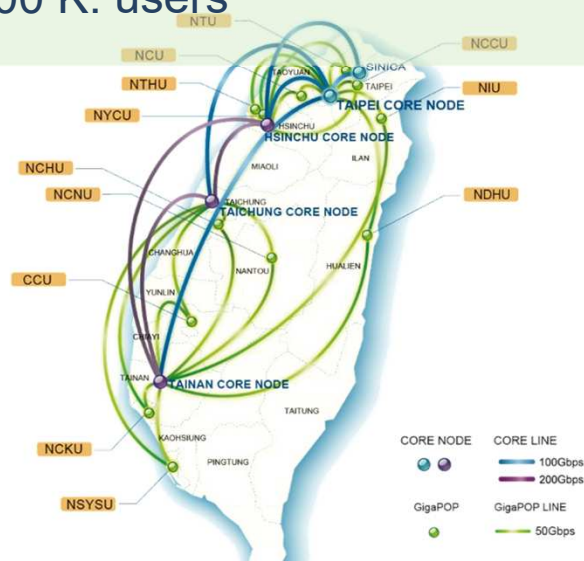
Commitment · Passion · Innovation

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TaiWan Advanced Research and Education Network

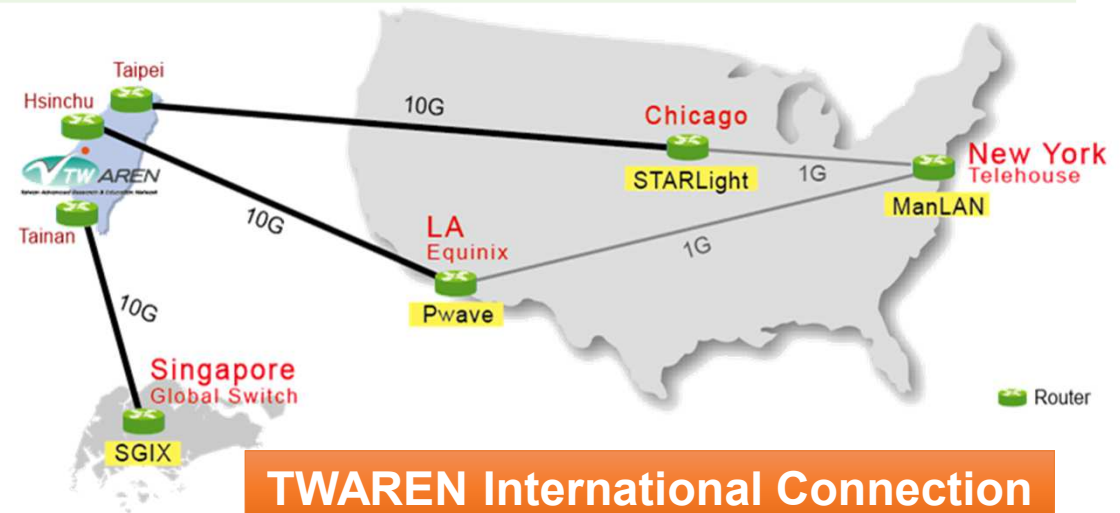
- **TWAREN** (Optical, dedicated bandwidth)

- ✓ 100G Bandwidth
- ✓ 12 GigaPOPs
- ✓ 94 universities & research institutes
- ✓ 500 K. users



TWAREN Domestic Backbone

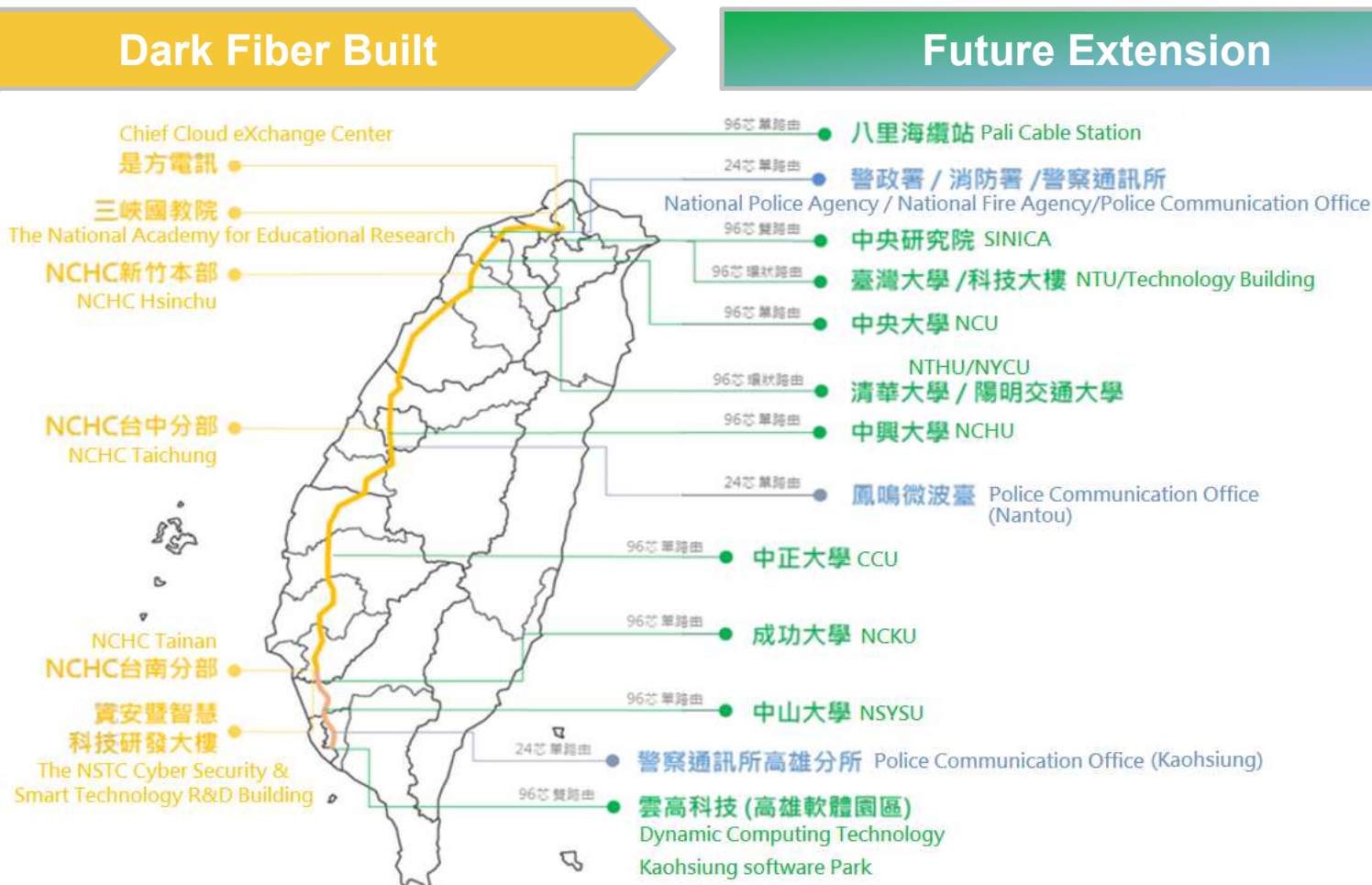
- ✓ Sharing underlying optical network with **TANet**
 - (4000 schools, 4.5 M. users)
- ✓ Network Availability: 99.99% ↑
- ✓ 30 Gbps international links to Los Angeles, Chicago, New York, and Singapore (and peers with other international research and education networks via these four exchange centers)



TWAREN International Connection

NCHC Dark Fiber Network Backbone

Resilience Enhancement of cyberinfrastructure of Taiwan



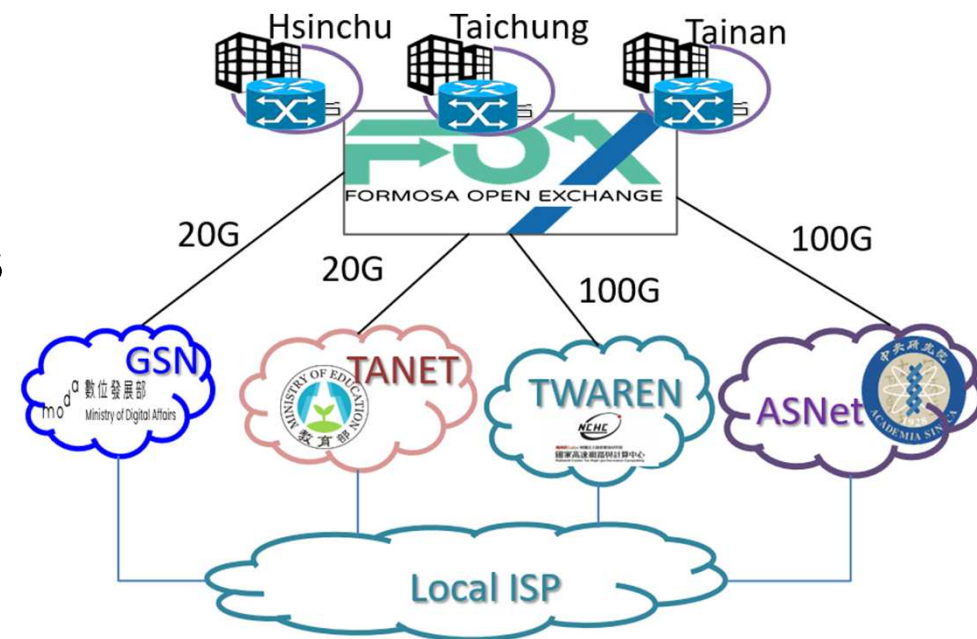
Formosa Open eXchange ; FOX

- Funded by DIGI+ Program (Digital Nation and Innovative Economic Development Program)
- Established in March 2022
- Started its operation and services in the beginning of 2023
- A neutral, non-for-profit network exchange center
- Mission
 - ✓ Enhancing the efficiency and resilience of public service network transmission



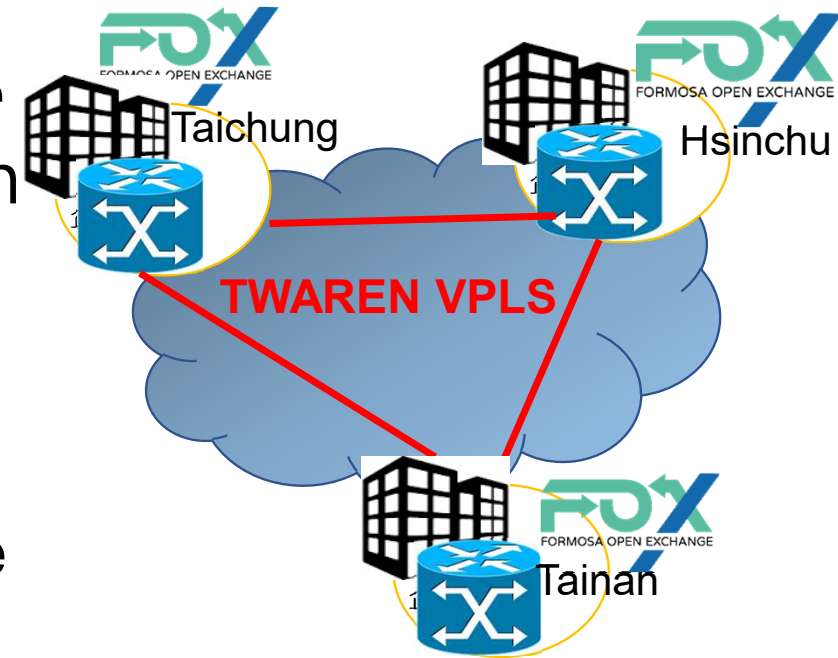
Public Service Network

- Integrating existing public networks and building a remote triple-center structure can enhance the efficiency and resilience of public service networks
 - ✓ Government networks (GSN)
 - ✓ Academic networks (TANet)
 - ✓ Research & Education networks (TWAREN, ASNet)
- Improve the cross-network transmission efficiency
 - ✓ Lower RTT
 - ✓ Higher available bandwidth



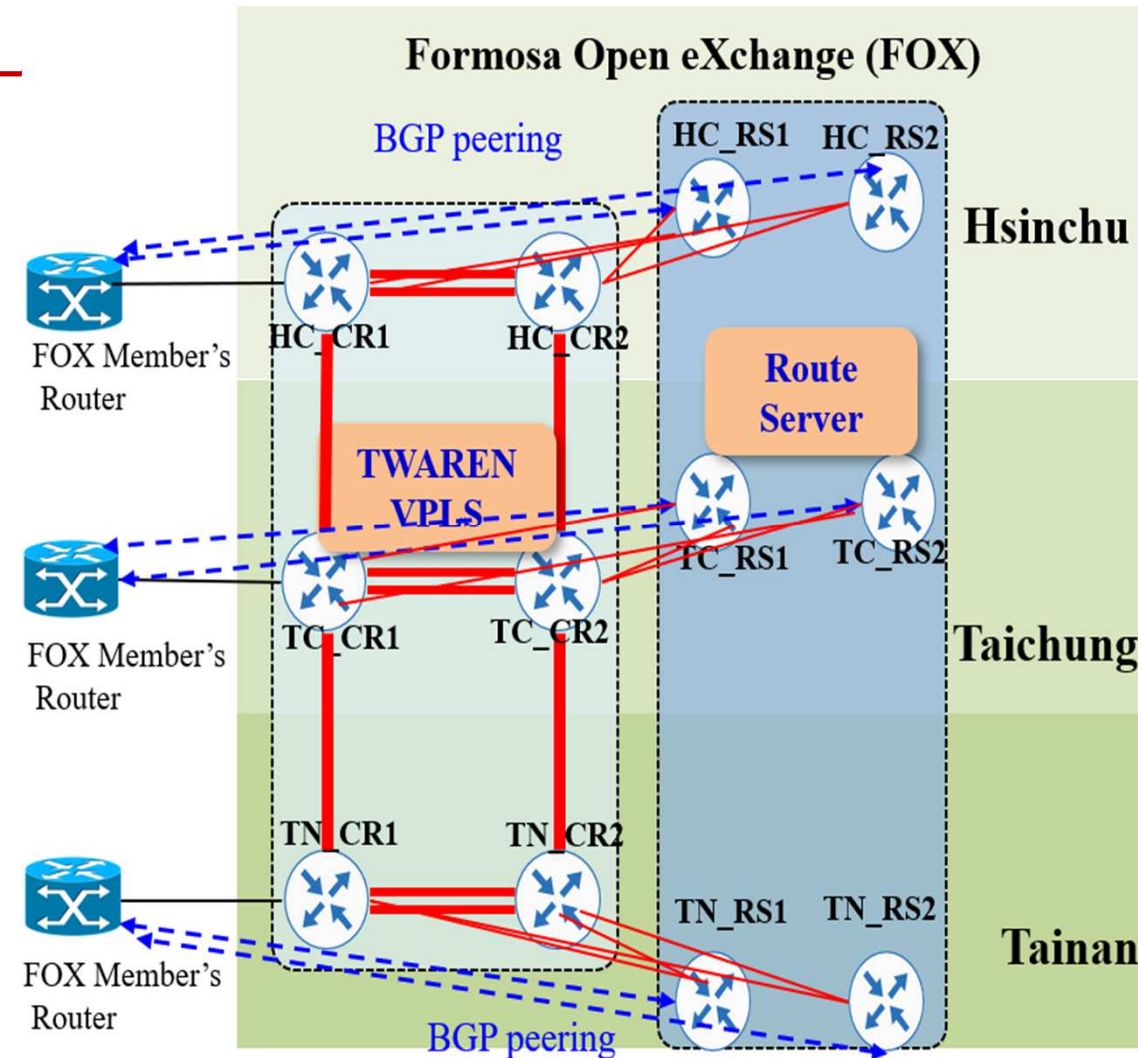
Resilient Architecture

- FOX is the main Layer 2 Internet eXchange Point (IXP) in Taiwan where various Autonomous Systems interconnect with one another and exchange traffic
- Connecting through TWAREN backbone with VPLS (Virtual Private LAN Service) using 100G bandwidth
 - ✓ Interconnecting the three FOX sites located in Hsinchu, Taichung, and Tainan
 - ✓ Resilient Network Architecture: Three sites serve as mutual backups for each other



Network Architecture

- FOX does not provide Internet connectivity
- FOX provides Route Server for simplified peering
- Routing information distribution controlled by IP network prefix access lists in the Route Server
- Implement RPKI (Resource Public Key Infrastructure) on Route Server to enhance routing security



Smart Network Maintenance and Operation

- 7X24 Network Operation Center(NOC)
- Introduced Artificial intelligence for IT operations (AIOPs) platform
 - create stories in chatops, providing evidence for the anomalies found
 - Event Correlation & Noise Reduction
 - Root cause analysis & automatic error detection

1:28 🔥 **Priority 1**

This is an overview of your story details.

Story title:
🔗 Log Anomaly found 4 logs containing errors for component: HC-IX-RR-02

Story:
2vnm-nsdu

Impacted applications (1):
🔗 NCHC_APP

Status:
Unassigned

Priority:
1

Owner:
Unassigned

User group:
Unassigned

Created:
March 4th 1:28 PM
by IBM Cloud Pak for Watson AIOPs

🔗 **Story resources**

We've created a topological view of the resources affected by this story.

🔗 **View timeline for story resource topology**

Created:
March 4th 1:28 PM

Updated:
Yesterday 10:39 AM

aiops_r

🔔 **Alerts**

We found 1 alerts associated with this story.

🔗 **View in Alert Viewer**

Critical alerts:
0

Minor alerts:
0

Information alerts:
0

Click "View alerts" to see all alerts.

🔗 **View alerts**

📌 **Recommended actions**

We've identified the associated with this story.

Click "Search past tickets" to find related tickets.

🔗 **Search past tickets**

Log Preview

Template: error_log

```
5613396 Base LAG-WARNING-tlagMemberStateEvent-2007 [LAG]: LAG 1 : return to Defaulted on member 1/1/c18/1 after currentWhileTimerExpired
5613398 Base LAG-WARNING-LagPortAddFailed-2003 [LAG]: Could not add port 1/1/c18/1 to LAG 1 because link-down
5613400 Base LAG-WARNING-LagPortAddFailureCleared-2005 [LAG]: Failure to add port 1/1/c18/1 to LAG 1 is resolved - link-down
5613415 Base LAG-WARNING-tlagMemberStateEvent-2007 [LAG]: LAG 1 : return to Defaulted on member 1/1/c18/1 after currentWhileTimerExpired
```

Cancel

🔗 **View alerts**

🔗 **Search past tickets**

🔗 **View alerts**

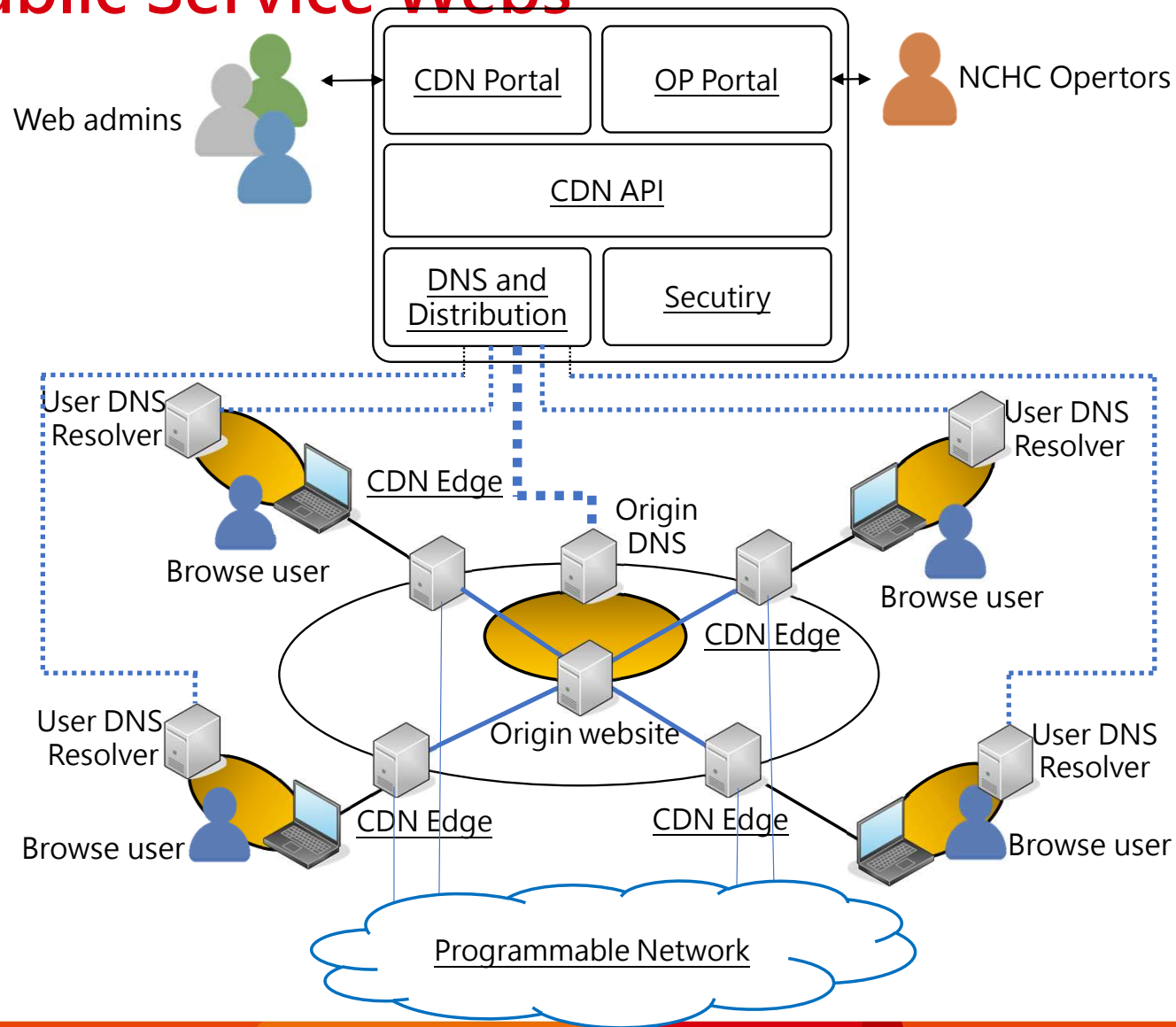
🔗 **Search past tickets**

🔗 **View alerts**

🔗 **Search past tickets**



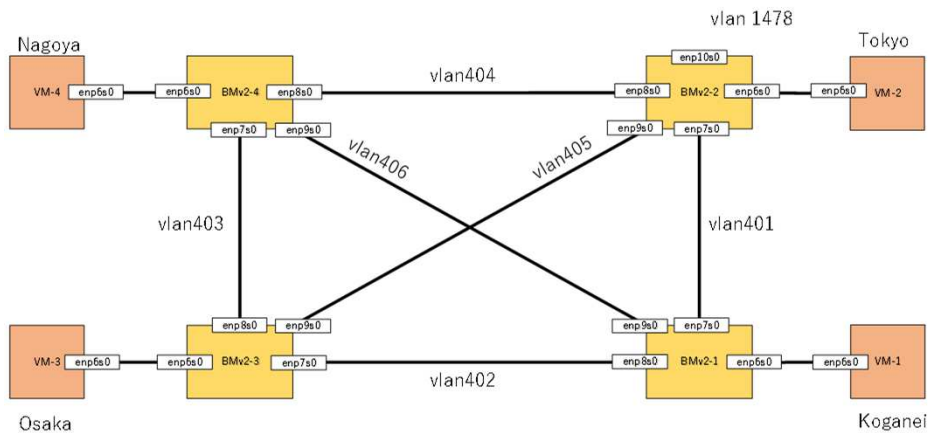
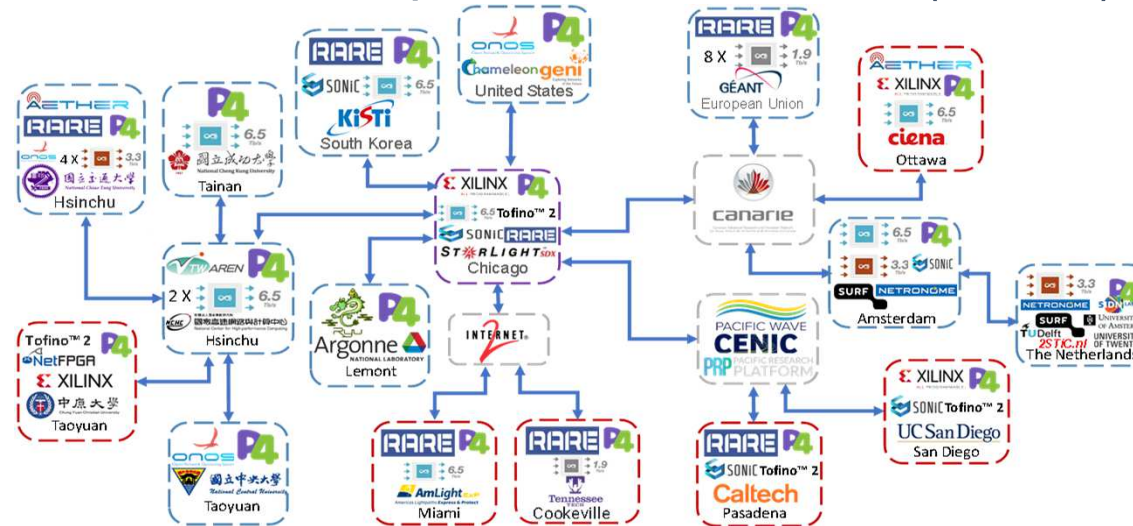
CDN for Public Service Webs



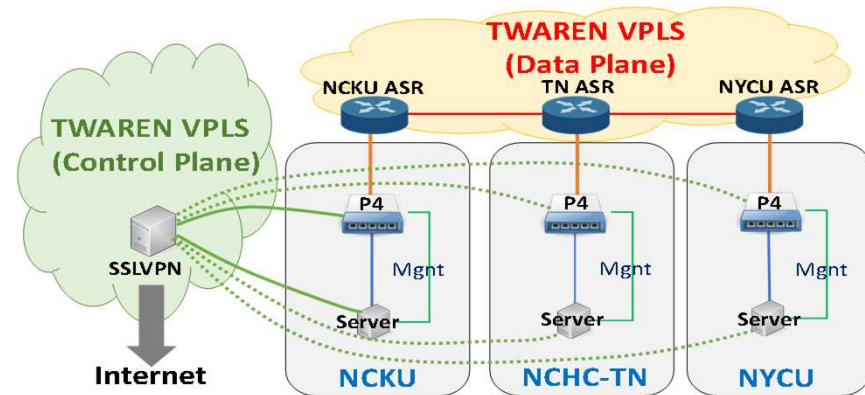
Programmable Switch and P4

- SDN separates Control Plane from Data Plane and enables Control Plane programmability.
- Lacking Data Plane programmability, SDN could not adapt to new protocols and frame formats
- **P4 (Programming Protocol-Independent Packet Processors)** is a programming language that could program/design data plane pipelines
- To test P4, we can choose software-based BMv2 for evaluation, or install hardware switches with Intel Tofino chips with full performance.
- Several P4 Testbeds are setup by research network entities.

International P4 Experimental Networks(iP4EN)



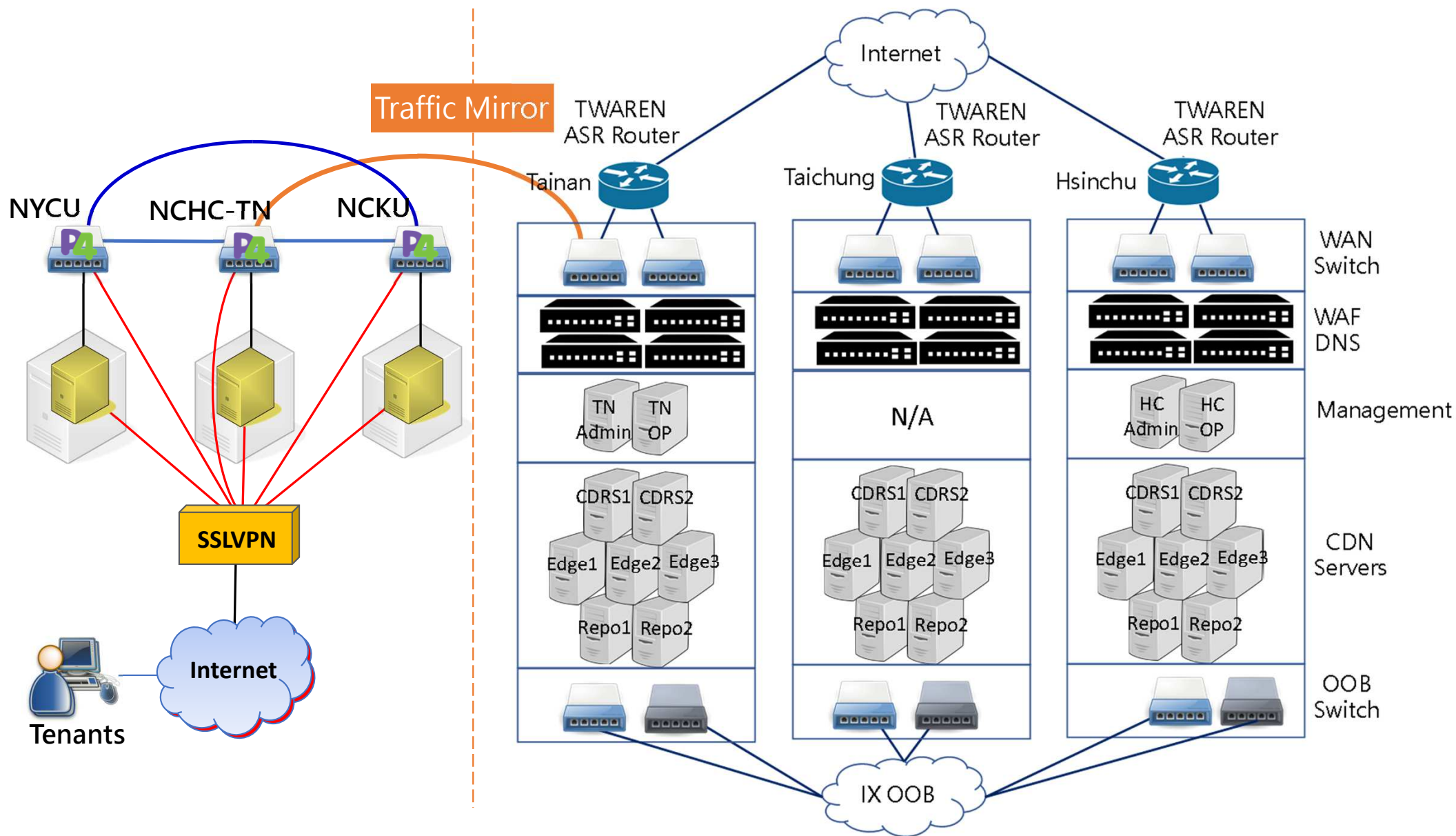
NICT P4 Experiment Environment



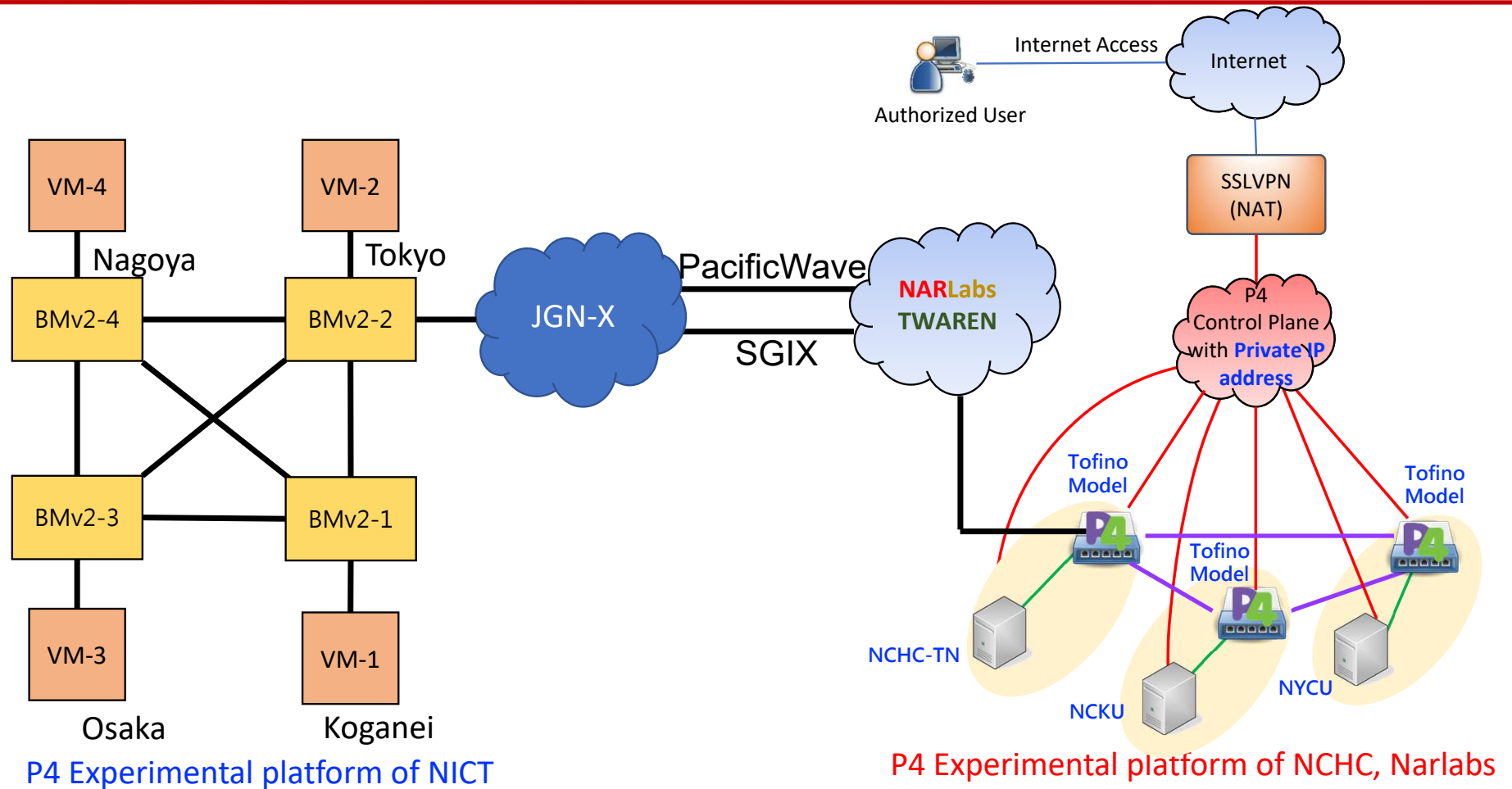
TWAREN P4 Testbed

TWAREN P4 Testbed

- Supported by [National Forward-Looking Infrastructure Project](#), we acquire P4 H/W switches for interconnecting CDN Edges for [flow analysis](#)
- We also extend the P4 networks to selected TWAREN GigaPOP to support research and education.
 - collaboration with [NYCU](#), [NCKU](#) and [Accton](#).
- Interconnection with [International Testbeds](#)
 - International P4 Experimental Networks ([iP4EN](#))
 - [NICT](#) P4 Experiment Environment

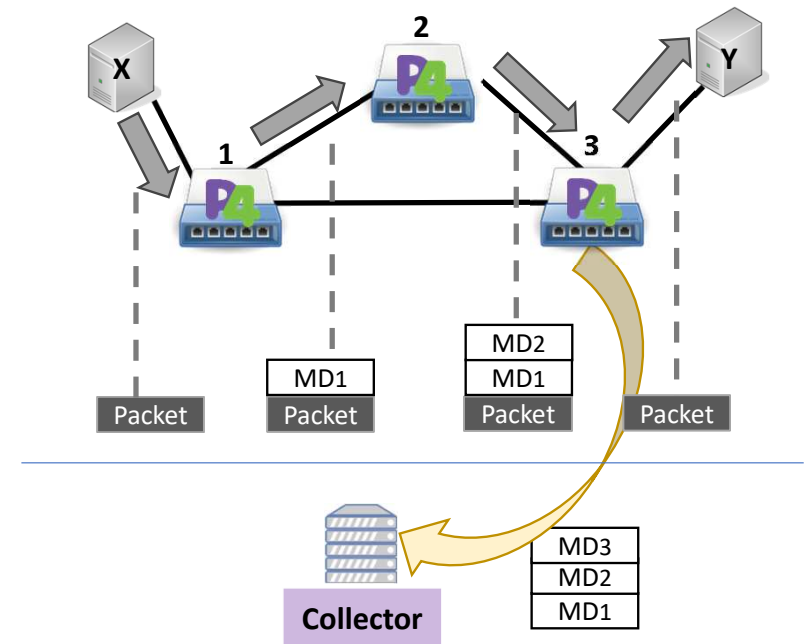


Interconnection with NICT



In-Band Telemetry (INT)

- A technique that **embeds network status as metadata into transmission packets**
- No additional management protocol required
- Monitors network **in real-time**
 - **microbursts could be detected**
- Could be **realized by P4** data plane programming
- Issues with INT
 - INT metadata may **exceed packet MTU**
 - lack of **Inter-domain integration** solution

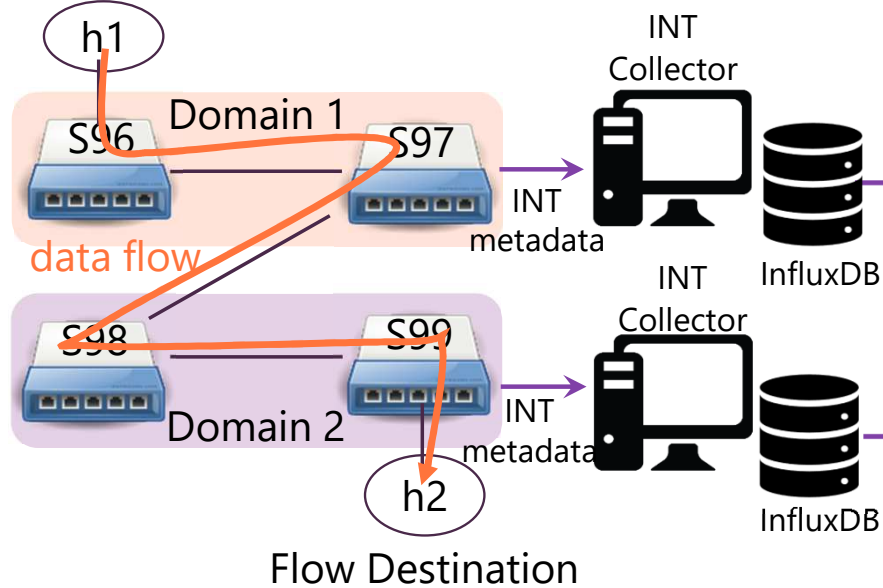


Cross-Site/Inter-Domain INT

- For monitoring traffic across network domains, we have implemented an **Inter-Domain INT Analyzer** that combine the information from collectors of each domain.
 - Demonstrated in SC with iCAIR
 - However, INT collectors only obtain info within its domain and **statistics between domains could not be collected**
- Therefore, we'll investigate a proper solution to monitor both **intra-site** and **inter-site** traffics with INT

Inter-Domain P4 In-Band Telemetry (INT) Analyzer

Flow Source



DB and Grafana configuration

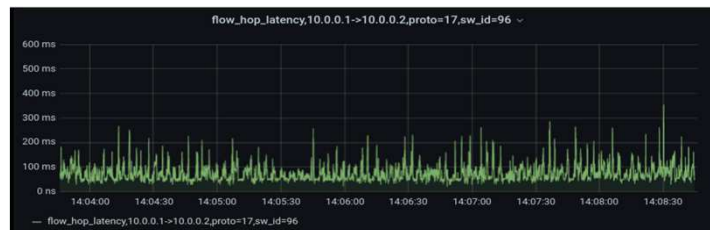
The screenshot shows the NAR Labs Grafana configuration interface. It includes fields for 'Database Site Number and DBType', 'Database 1' settings (Database IP, Port, Grafana IP, Grafana Port, Grafana DB Name), and 'Database 2' settings. There are also checkboxes for 'CreateDataSources', 'show Database information', 'query dashboard', and 'create or update dashboard'. A table at the bottom lists dashboard details.

Dashboard Id	uid	title	version	hyperlink
59	VKp3GNIVz	p4test_dashboard	1	link

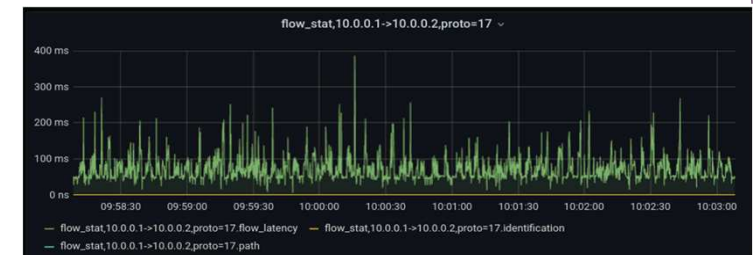
Grafana Visualization



Flow Path Visualization



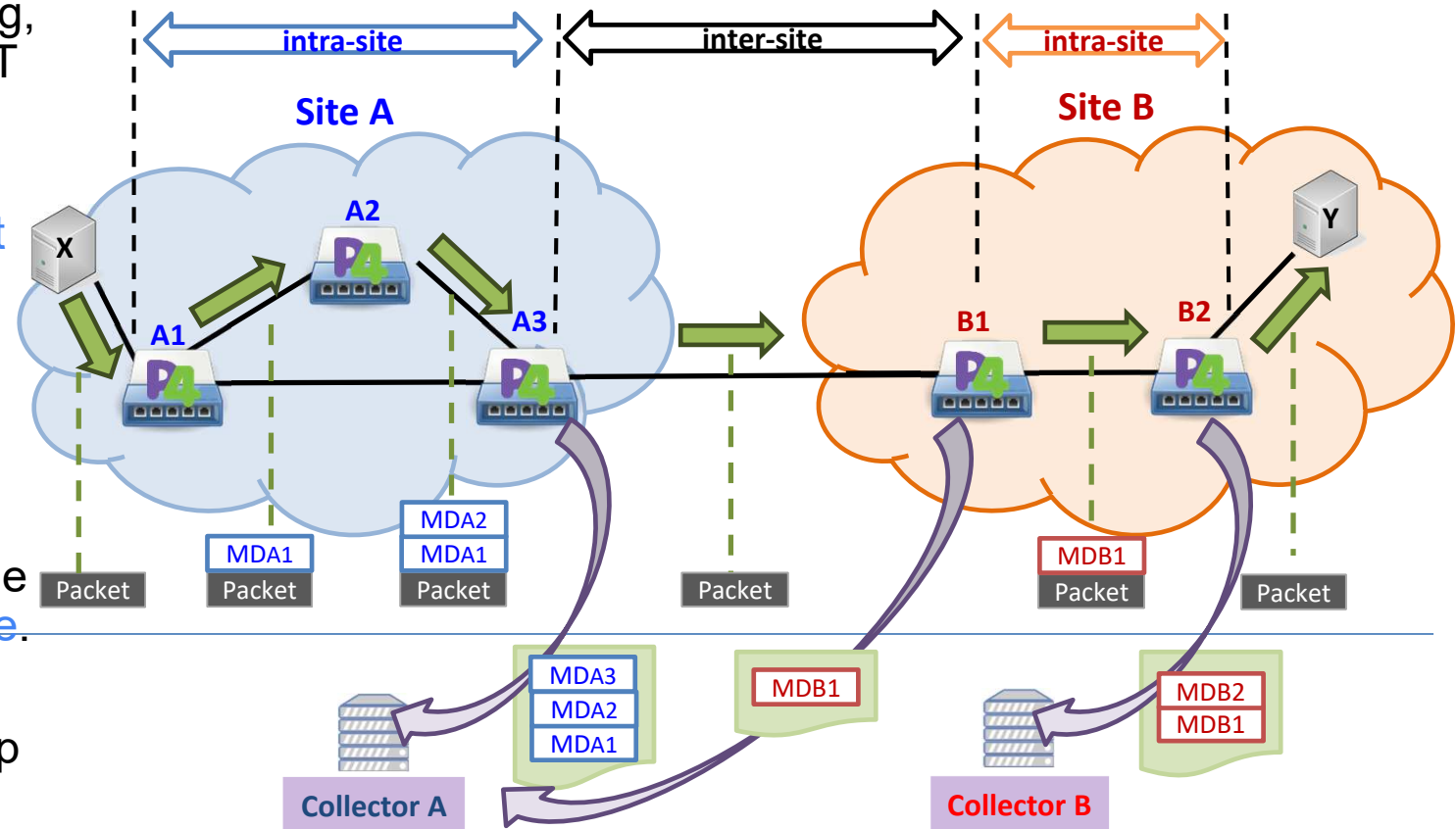
Flow Hop Latency



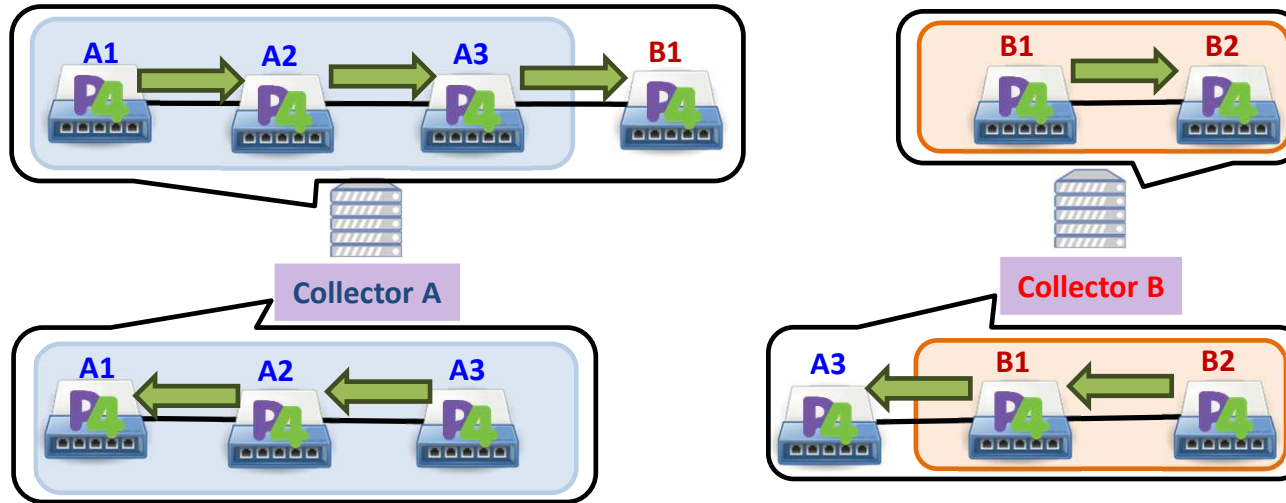
Flow Statistics

Cross-Site Network Telemetry based on Programmable Network Technology

- For inter-site network monitoring, we could analysis data from INT collectors of the sits that the packet traversed.
- However, **inter-site links are not monitored** by any INT collector
- We propose that site collector collects its **intra-site** and **outing inter-site links** INT status
- By integrating the data from all INT collectors, we can depict the **whole network status in realtime**.
- We will utilize our testbed with international partners to develop and evaluate the proposed solution.

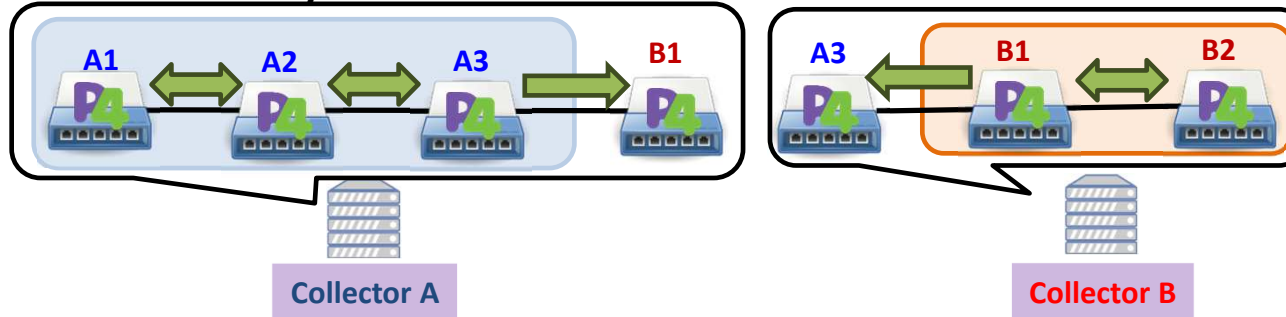


Collected telemetry information after packets traverse from X to Y



Collected telemetry information after packets traverse from Y to X

Collected telemetry information after bi-directional transmission between X to Y



Cross-Site/Inter-Domain INT

- If the network covers geographic areas, **single INT collector** may receive metadata from switches in distances, which causes time **synchronization** and **propagation delay** problems.
- In addition, too many metadata may cause packets to **exceed MTU**.
- We **divide network into sites**, each site collects its **intra-site** and **outing inter-site links** INT status
- By integrating the data from all INT collectors, we can depict the **whole network status in realtime**.
- We will utilize our testbed with international partners to develop and evaluate the proposed solution.

Thanks!

