Redefining Ethernet Performance With OT Software-Defined Networking

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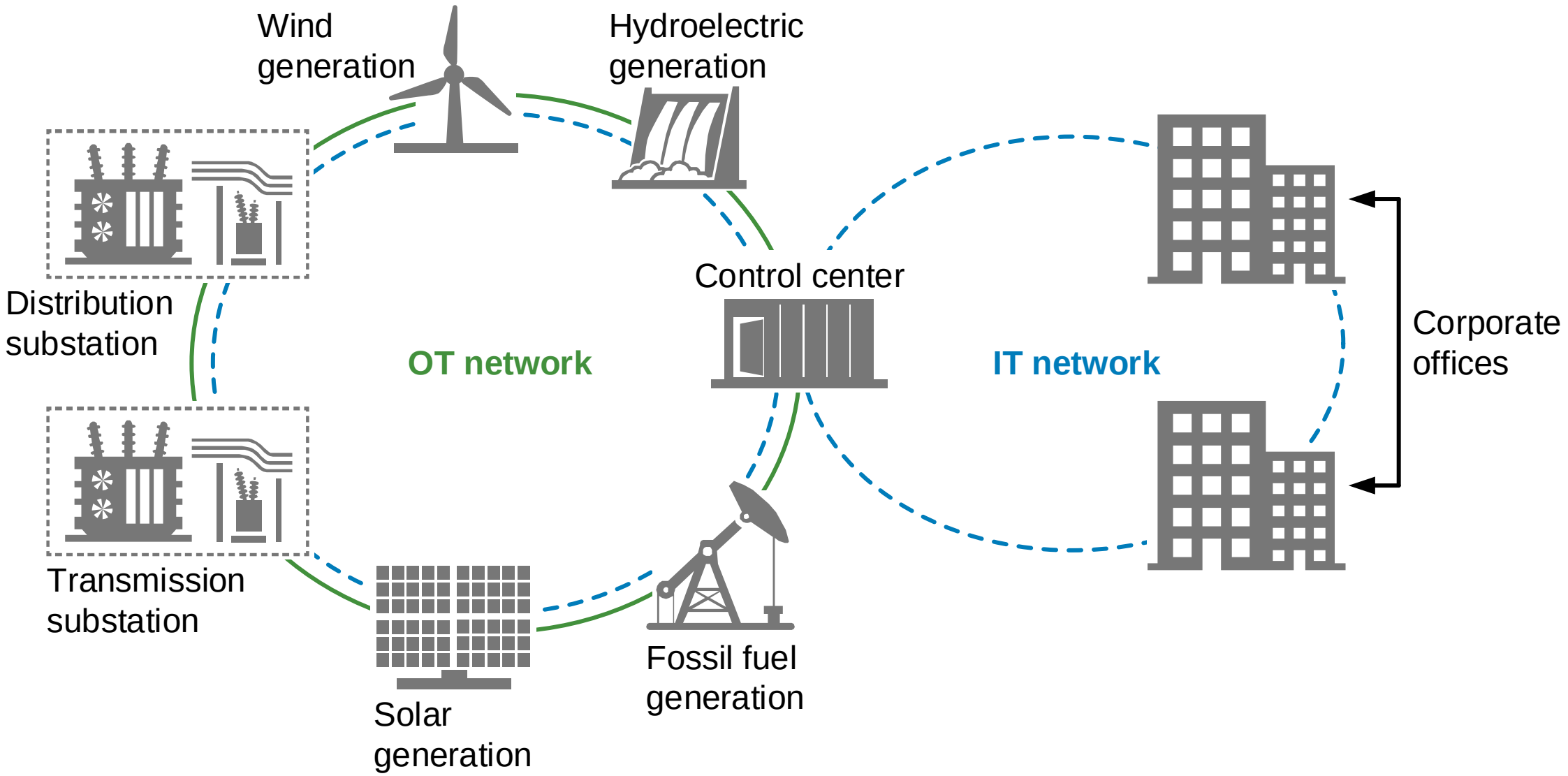
IT versus OT networks



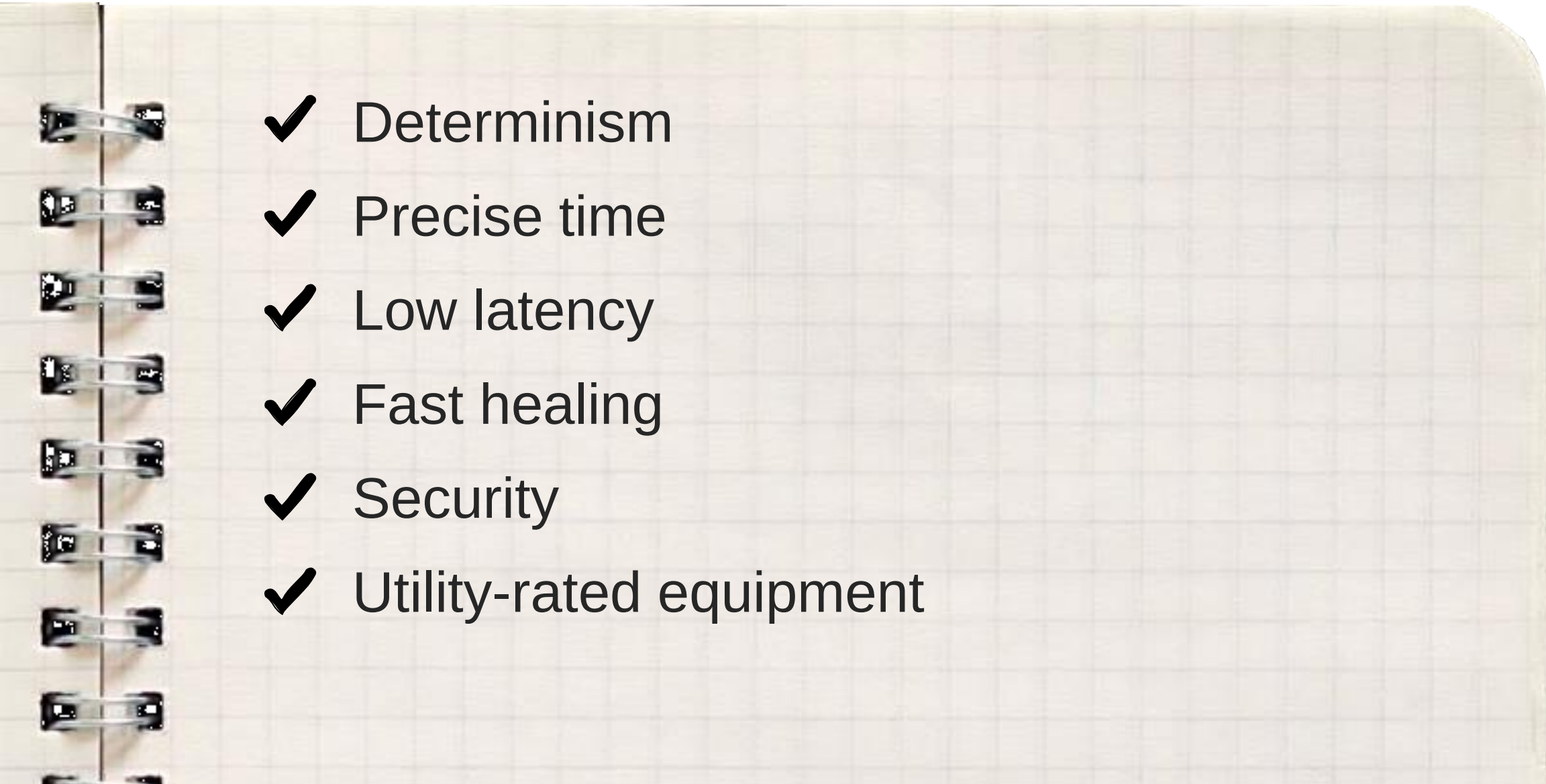
Challenges of IT designed for convenience

- Designed for plug-and-play
- “Conveniently” does things we don’t want
- Uses reactive failover
- Lacks cybersecurity profile
- Provides topology-dependent performance
- Is difficult to test
- Leads to blocked ports and reduced network efficiency

Communications Networking

BACK TO BASICS

Dependable communications design goals

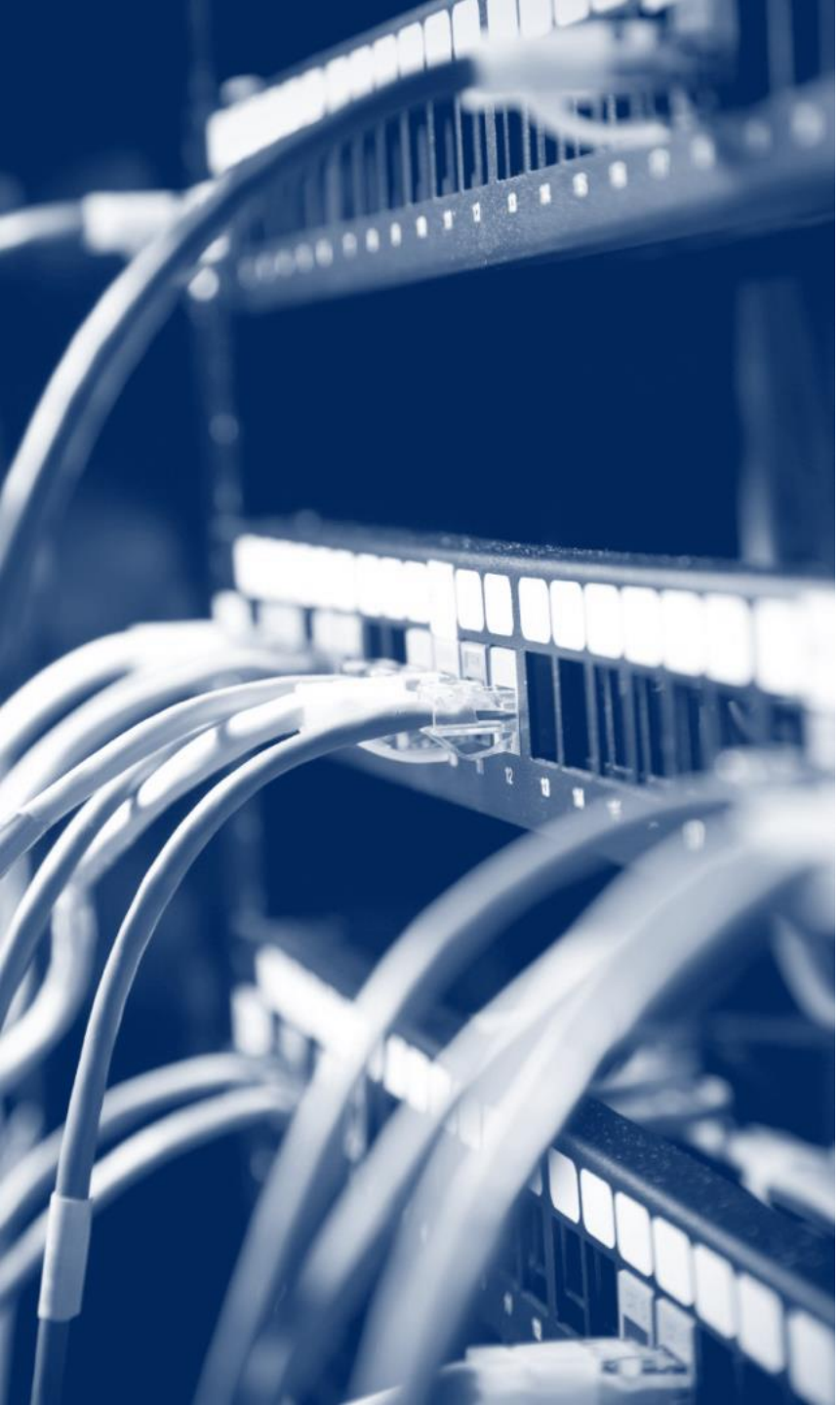


- ✔ Determinism
- ✔ Precise time
- ✔ Low latency
- ✔ Fast healing
- ✔ Security
- ✔ Utility-rated equipment

Traffic-engineered networking

Proactively designing and planning source-to-destination transport of each data frame

Predetermining reaction of communications infrastructure to network events

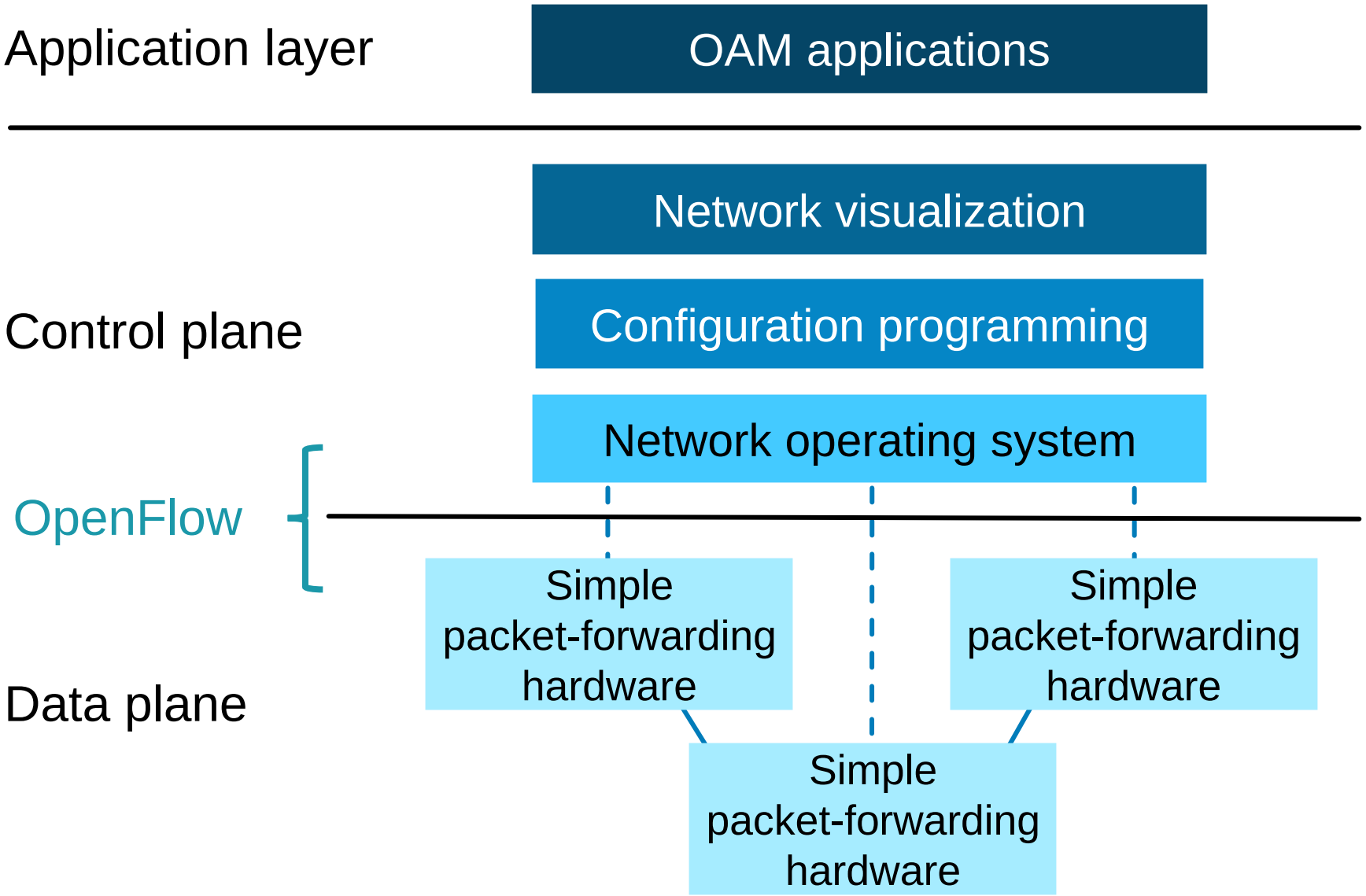


Bringing traffic engineering to Ethernet LANs

Innovating substation Ethernet

- Applying SDN to enable engineering of best network
- Enhancing performance, configuration, and management of proactive OT and dynamic IT networks

Implementing SDN with OpenFlow



SEL SDN solution

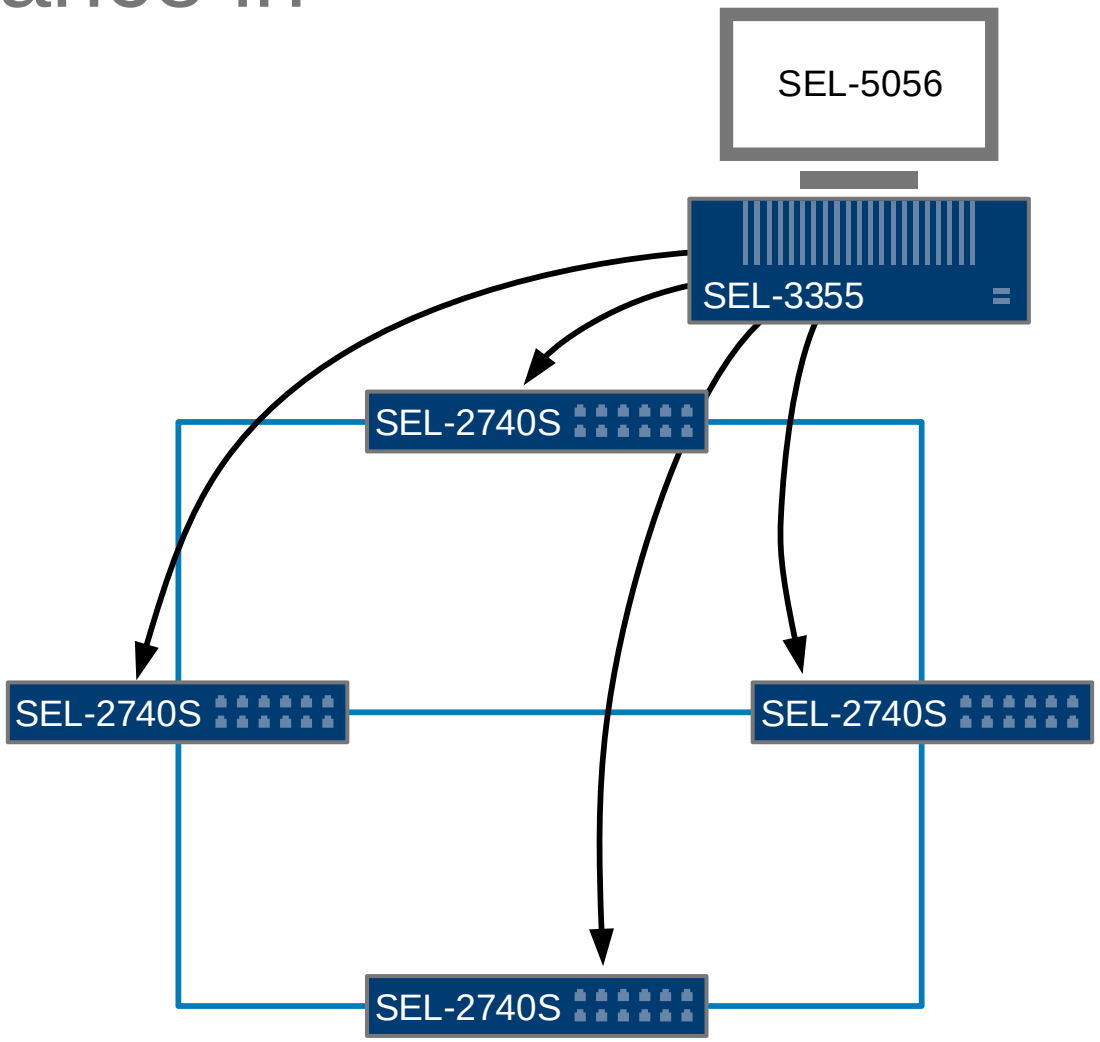
Improving Ethernet performance in mission-critical applications

SEL-2740S

Software-Defined Network Switch

SEL-5056

Software-Defined Network Flow Controller



Getting to know SDN terminology

Flow

Single communications session that matches ingress rule and has a set of forwarding instructions

OpenFlow

Open-source standard that defines how flow controller and switches interoperate

Flow controller

Central controller that programs switch flow tables

How SDN works

Control plane inspects each Ethernet packet and performs the following functions

Match fields

Match rule based on portion of Ethernet packet

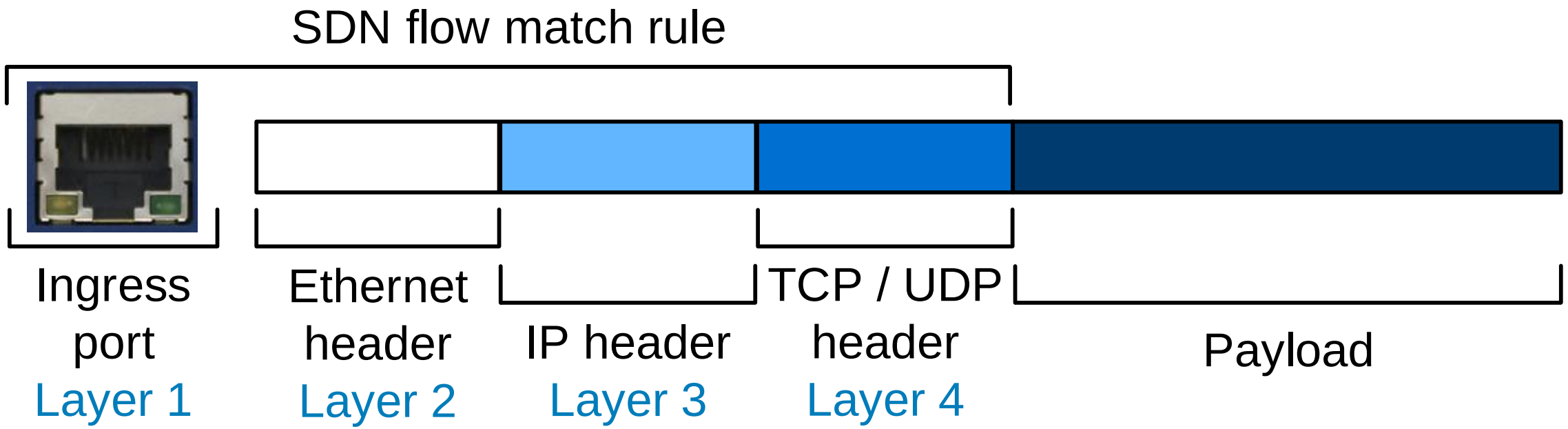
Instructions

Perform one or more programmed actions

Counters

Increment counters and send counter data to centralized point

Multilayer matching rules forward approved packets



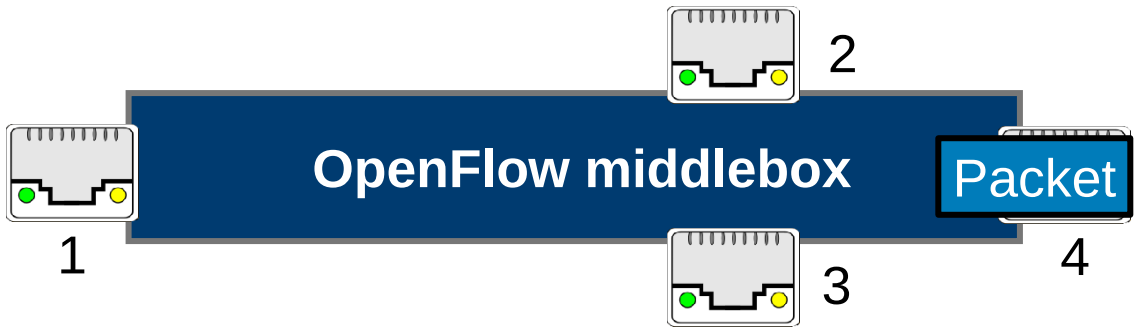
OpenFlow match / action example

L2 unmanaged switch

Physical Port ID	Src MAC	Dst MAC	Ether Type	VLAN ID	IPv4 Src	IPv4 Dst	TCP/UDP Src	TCP/UDP Dst
*	*		*	*	*	*	*	*

00:30:A7:06:11:97

Action
Output forward Port 4



OpenFlow match / action example

L3 forwarding

Physical Port ID	Src MAC	Dst MAC	Ether Type	VLAN ID	IPv4 Src	IPv4 Dst	TCP/UDP Src	TCP/UDP Dst
*	*		*	*	1.1.1.2	2.2.2.2	*	*

Action
Output forward Port 3

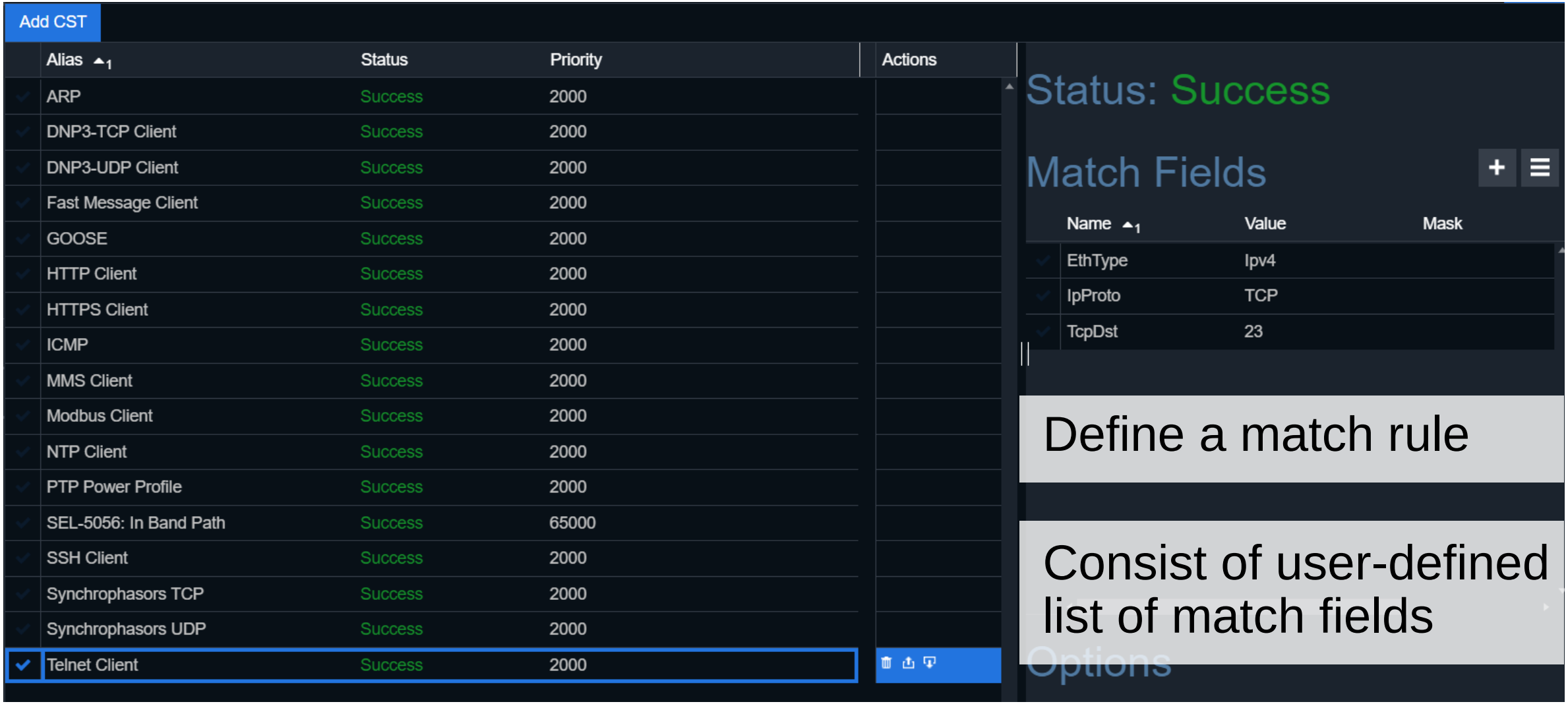
OpenFlow match / action example

Application-specific forwarding

Physical Port ID	Src MAC	Dst MAC	Ether Type	VLAN ID	IPv4 Src	IPv4 Dst	TCP/UDP Src	TCP/UDP Dst
*	*		*	*	1.1.1.2	2.2.2.2	*	TCP 20000

Action
Output forward Port 4

Connection service types



Creating a logical connection with CST

1 Select physical device

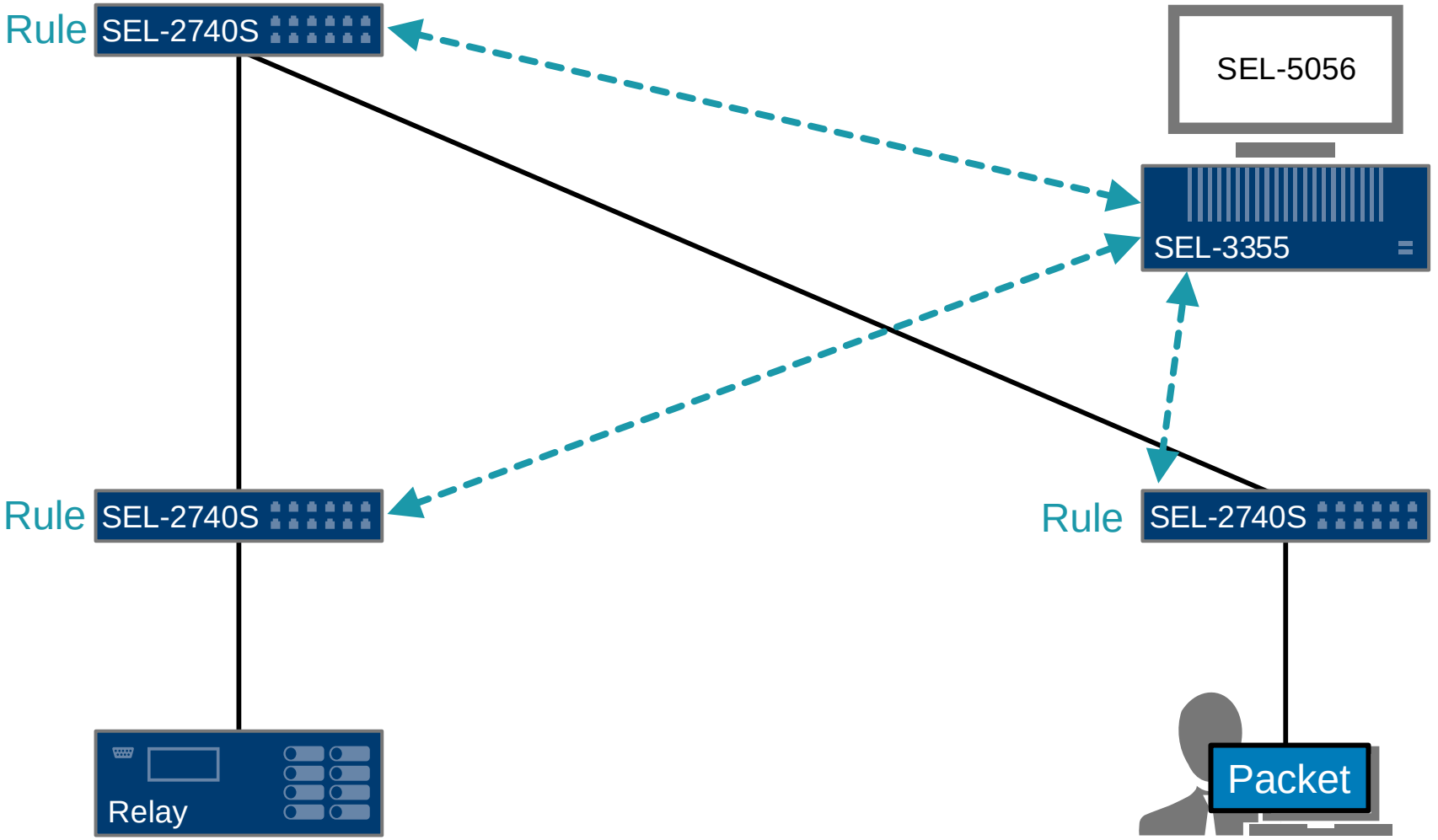
2 Select **CST**

3 Select **End Point**

4 Click **Create**

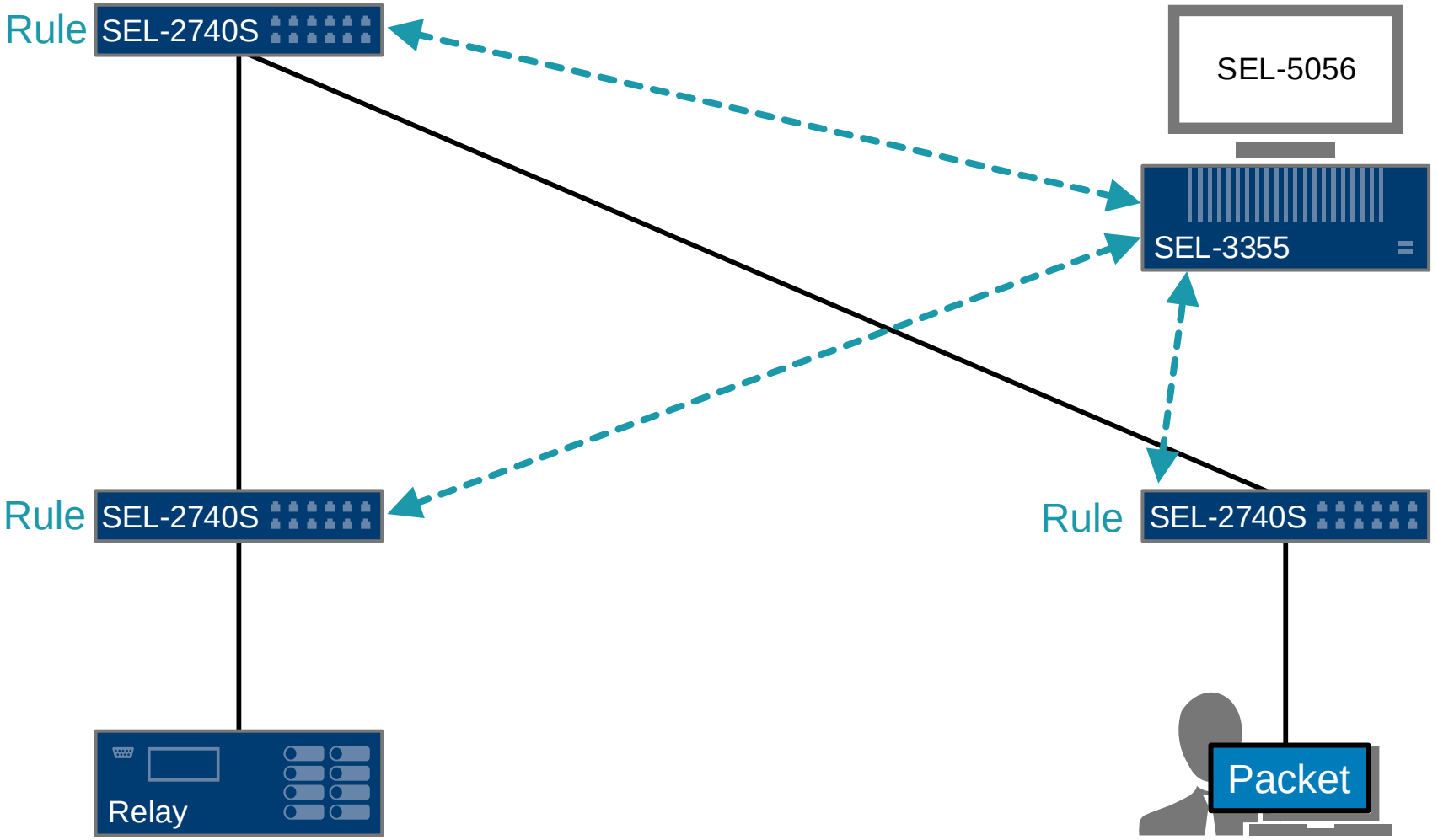
Reactive SDN in operation

Typical IT SDN

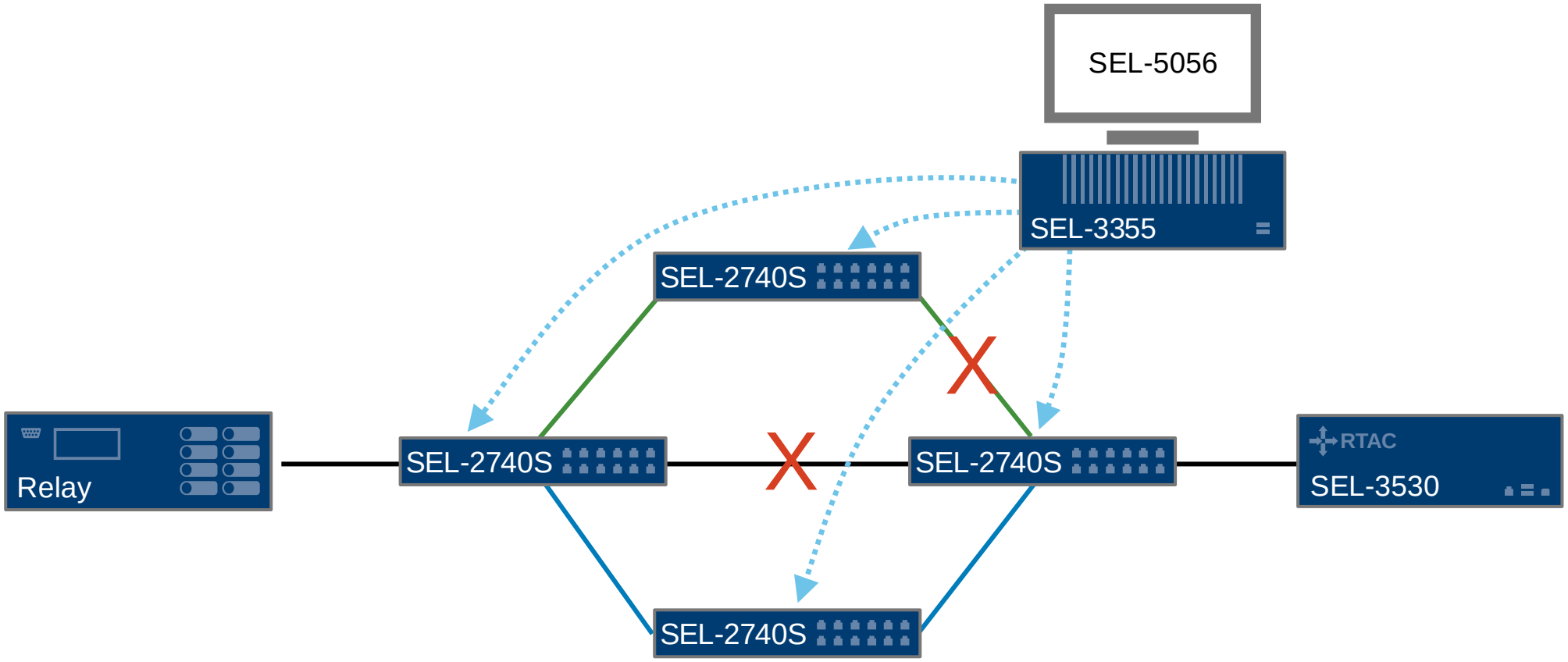


Proactive SDN in operation

SEL OT SDN



Proactively engineer traffic for reliability



Primary path

Backup path

Secondary path

SDN fast failover is awesome!

Product	Topology	Healing method	Failure point	Healing time
Manufacturer Device 1	10-node ring	STA (rapid PVST)	L4	**97 ms**
Manufacturer Device 2	4-node ring	STA (RSTP)	L1 or L2	**60 ms**
SEL-2730M	10-node ring	STA (RSTP)	L4	**10 ms**
SEL-2740S	10-node ring	SEL SDN fast failover	L4	**<100 µs**

Engineering benefits

- ☑ Centralized traffic engineering
- ☑ Faster healing
- ☑ Predetermined failover
- ☑ Greater situational awareness
- ☑ Path- and packet-level control

Performance benefits

Integrate seamlessly with existing infrastructure

OpenFlow 1.3 support

Ensure mission-critical application performance

<100 µs failover

Avoid performance delays

No blocked ports

Cybersecurity benefits

Move to enhanced security model

Employ deny-by-default architecture

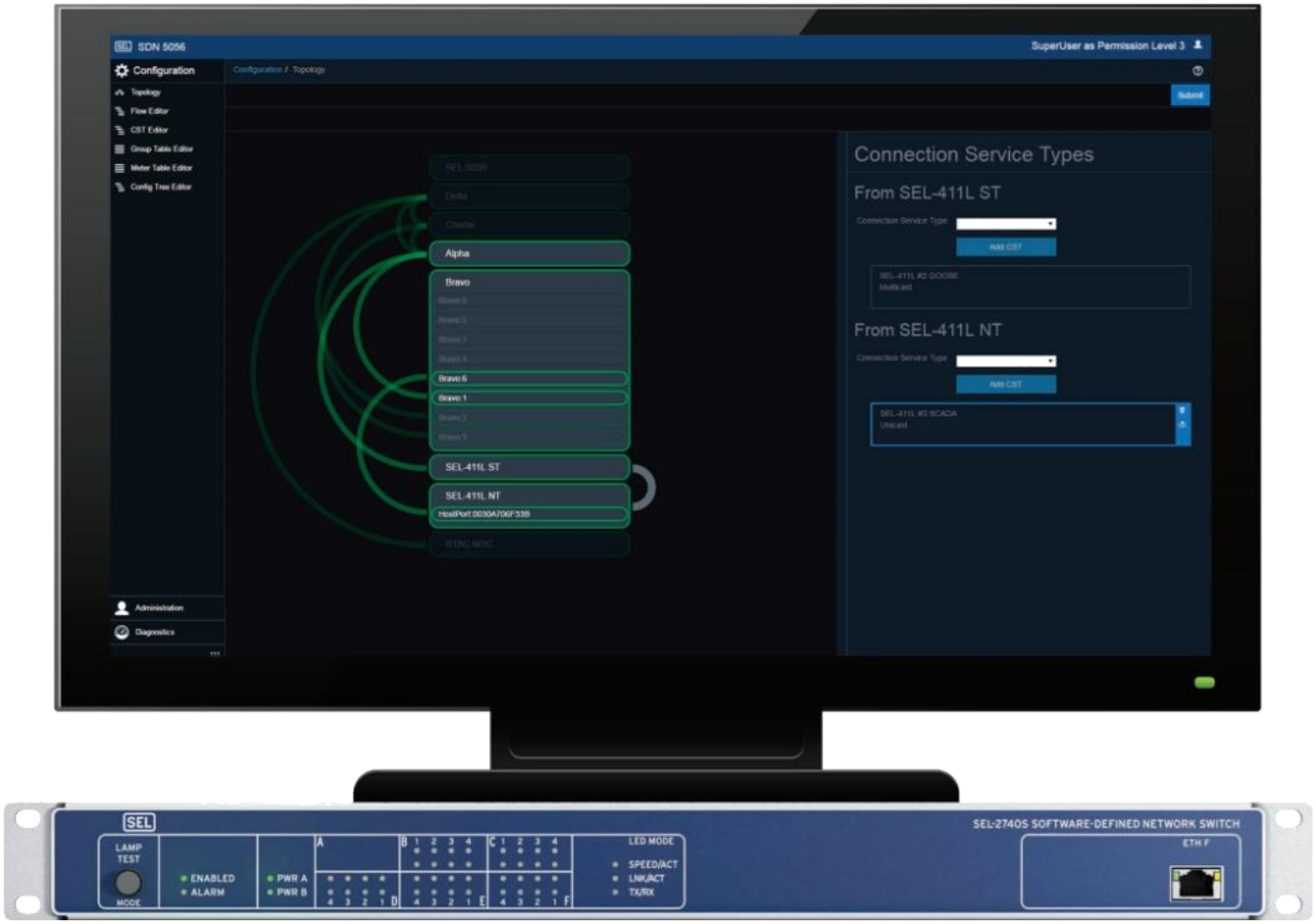
Secure control plane

Eliminate MAC table and BPDU spoofing

Improve situational awareness (packet and byte)

Know which flows are on your network and where they are all the time

SEL-5056 Flow Controller simplifies network design and testing



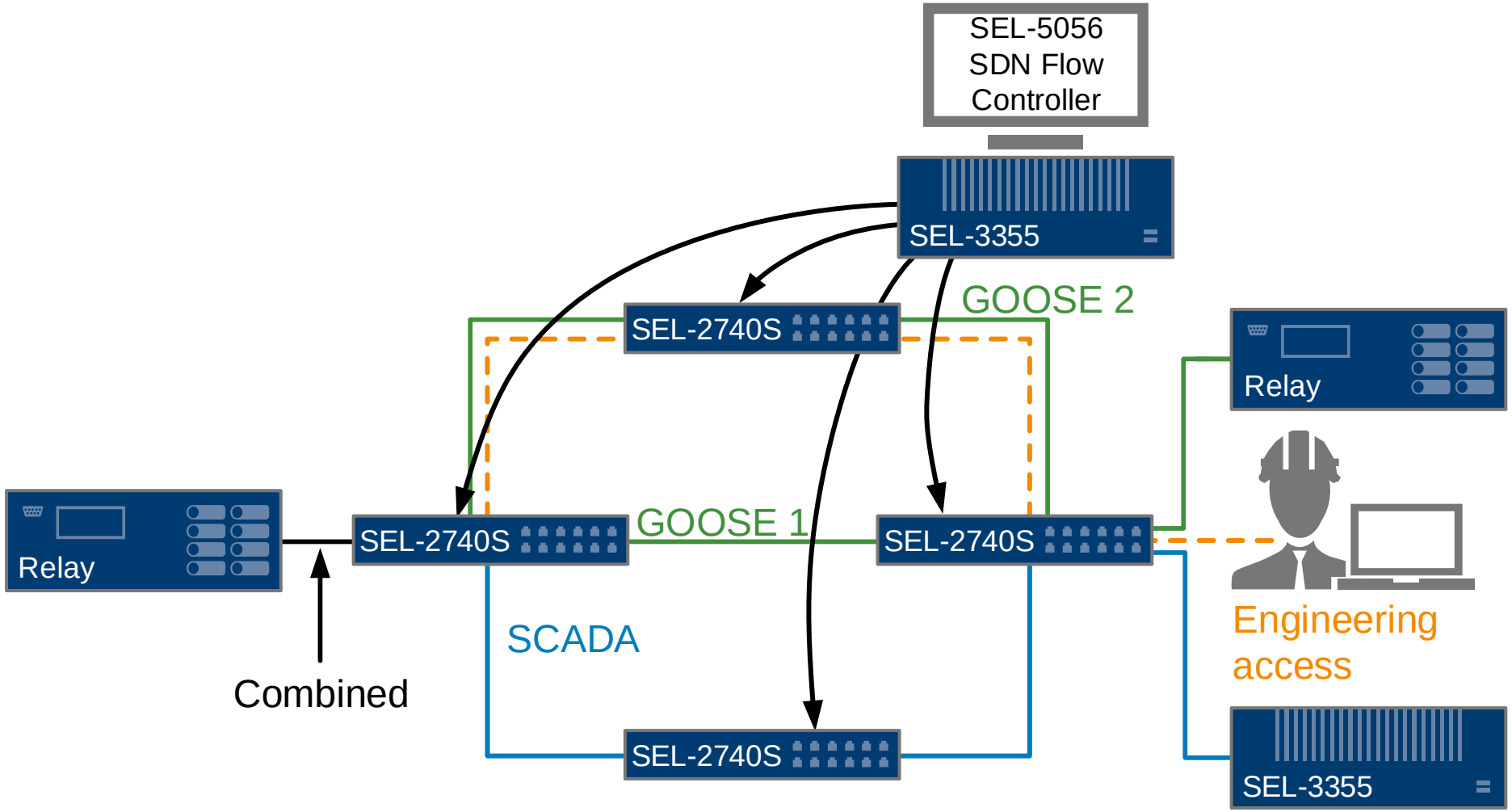
- ☑ Centralized network management
- ☑ Programmatic network testing
- ☑ Greater situational awareness

Network visibility

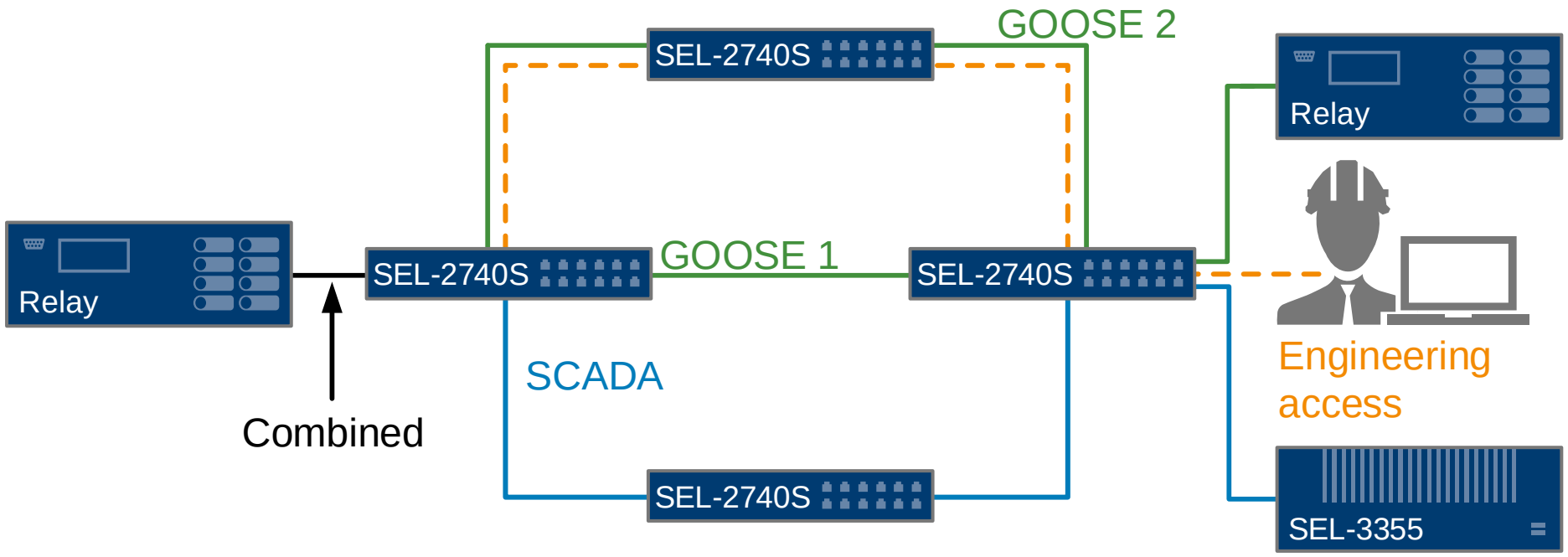
Physical connections

Logical connections

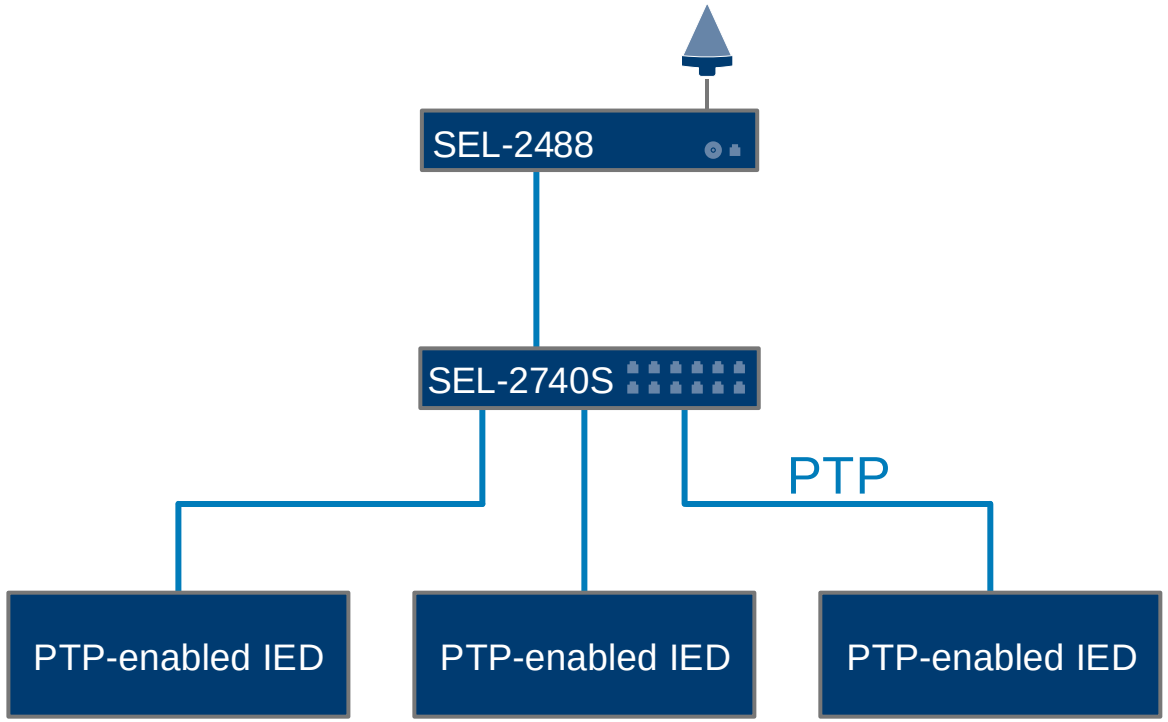
Control packet forwarding by application



Flow controller is not required for network operation



PTP time synchronization through SEL-2740S SDN switch



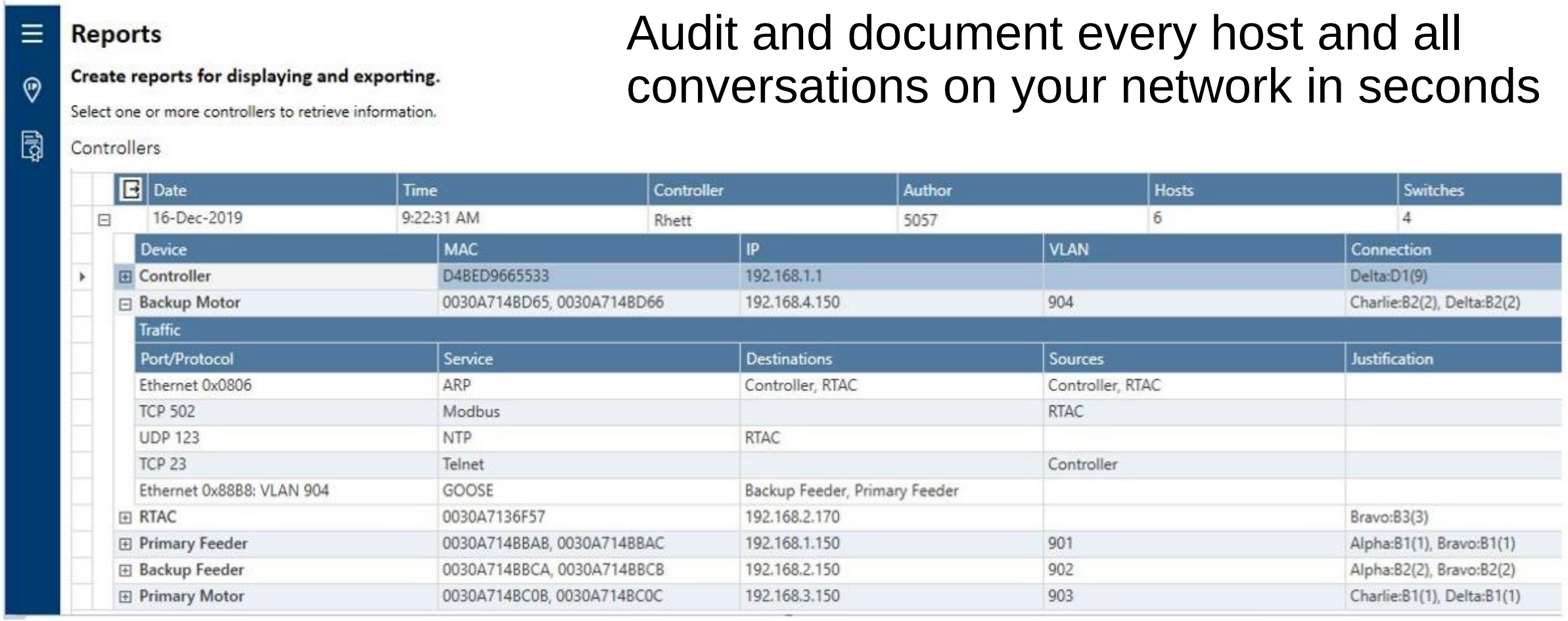
SEL-2740S supports IEEE 1588 PTP transparent clock with IEEE C37.238 power system profile

SEL-2740S adds residence time (time for packet to pass through switch) plus cable delay into PTP packet correction field

SEL OT SDN vs. non-SEL IT SDN

Key attributes	OT SDN with SEL flow controller	IT SDN with non-SEL flow controller
Network operation	Static	Dynamic
Network control	Proactive	Reactive
Flow controller	Power protection applications	Network load balancing
Security	Drop packet	Flood packet
Latency	Fast-fail group timing	Flow setup timing
Network management	Fault reactive	Traffic reactive

SEL-5057 Flow Auditor



Reports

Create reports for displaying and exporting.

Select one or more controllers to retrieve information.

Controllers

Date	Time	Controller	Author	Hosts	Switches
16-Dec-2019	9:22:31 AM	Rhett	5057	6	4

Device	MAC	IP	VLAN	Connection
Controller	D4BED9665533	192.168.1.1		Delta:D1(9)
Backup Motor	0030A714BD65, 0030A714BD66	192.168.4.150	904	Charlie:B2(2), Delta:B2(2)

Traffic

Port/Protocol	Service	Destinations	Sources	Justification
Ethernet 0x0806	ARP	Controller, RTAC	Controller, RTAC	
TCP 502	Modbus		RTAC	
UDP 123	NTP	RTAC		
TCP 23	Telnet		Controller	
Ethernet 0x88B8: VLAN 904	GOOSE	Backup Feeder, Primary Feeder		

RTAC	0030A7136F57	192.168.2.170		Bravo:B3(3)
Primary Feeder	0030A714BBAB, 0030A714BBAC	192.168.1.150	901	Alpha:B1(1), Bravo:B1(1)
Backup Feeder	0030A714BBCA, 0030A714BBCB	192.168.2.150	902	Alpha:B2(2), Bravo:B2(2)
Primary Motor	0030A714BC0B, 0030A714BC0C	192.168.3.150	903	Charlie:B1(1), Delta:B1(1)

Audit and document every host and all conversations on your network in seconds

Simplify NERC CIP Compliance Efforts

- CIP-007-6 R1.1 – Ports and Services
- CIP-010-2 R1.1.4 – Baseline Configuration for Open Ports
- CIP-005-5 R1.1–3 – Electronic Security Perimeter
- *NEW* - CIP-015-1 R1-3 – Internal Network Security Monitoring (INSM)

Questions?