ACIEM

Asociación Colombiana de Ingenieros

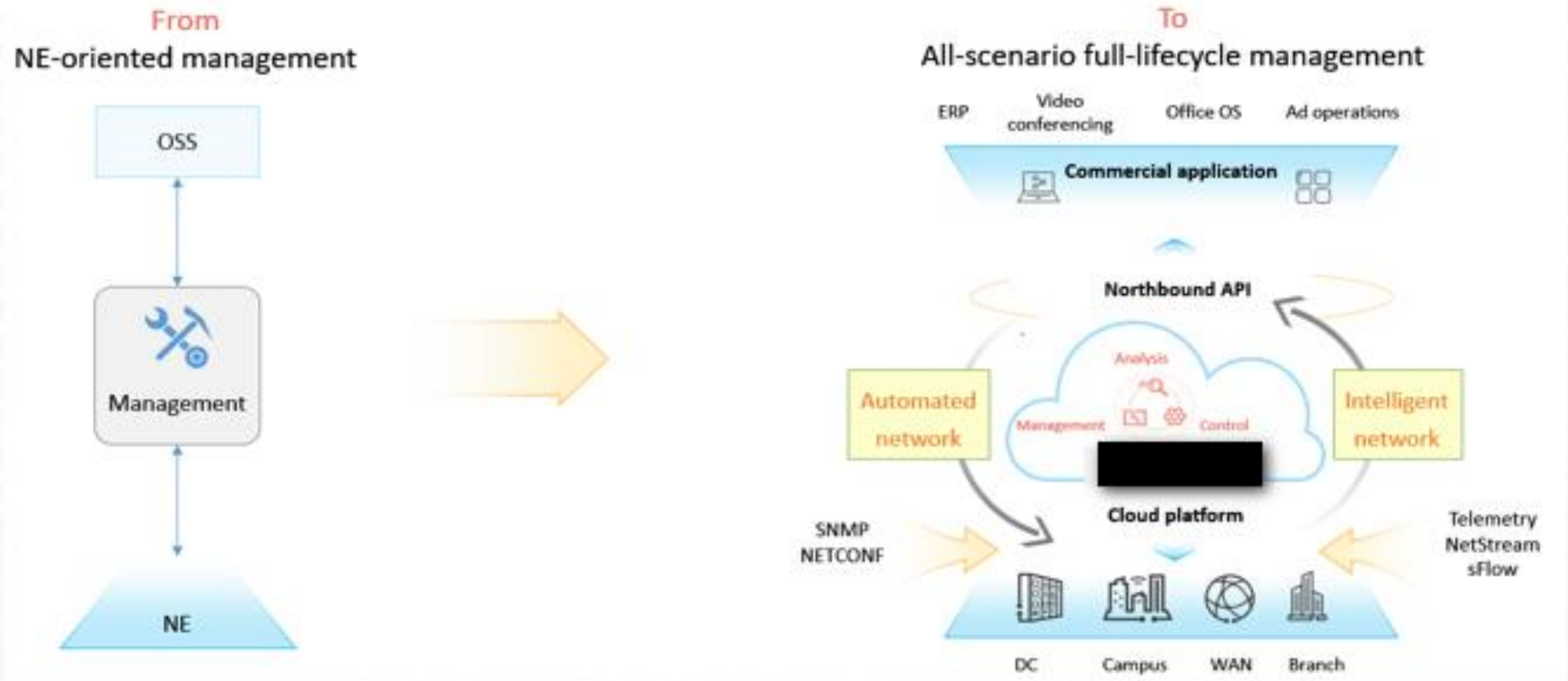
Tendencias Tecnológicas en Telecomunicaciones: Retos y Oportunidades

09-08-2023

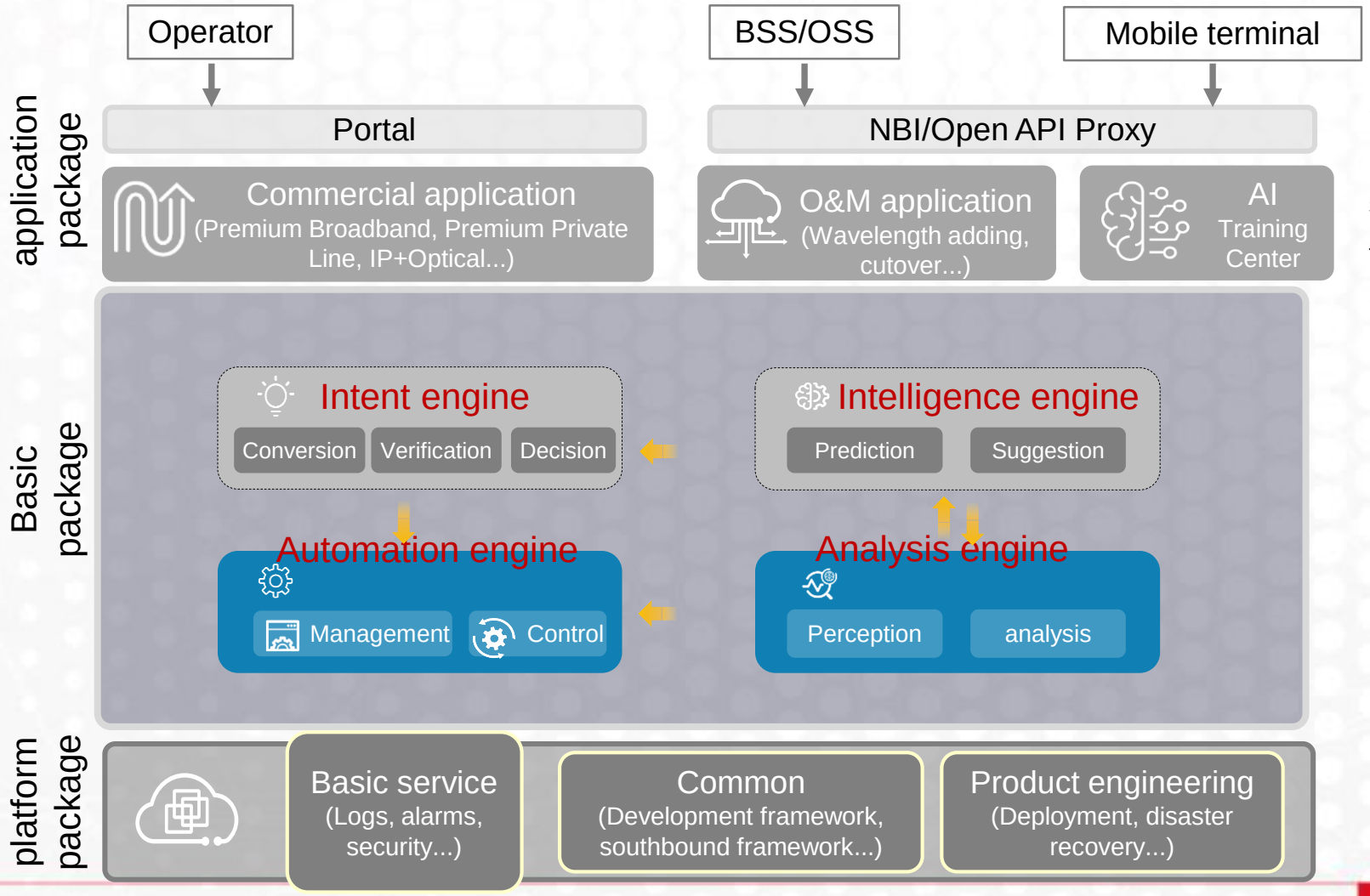
I. Automatización de Redes de Datos por SDN

Software Defined Networking (SDN) is basically the separation of the control plane and the data plane. The control plane function is removed from each device and is performed by a centralized controller.

Typical Application Scenarios of Network Management



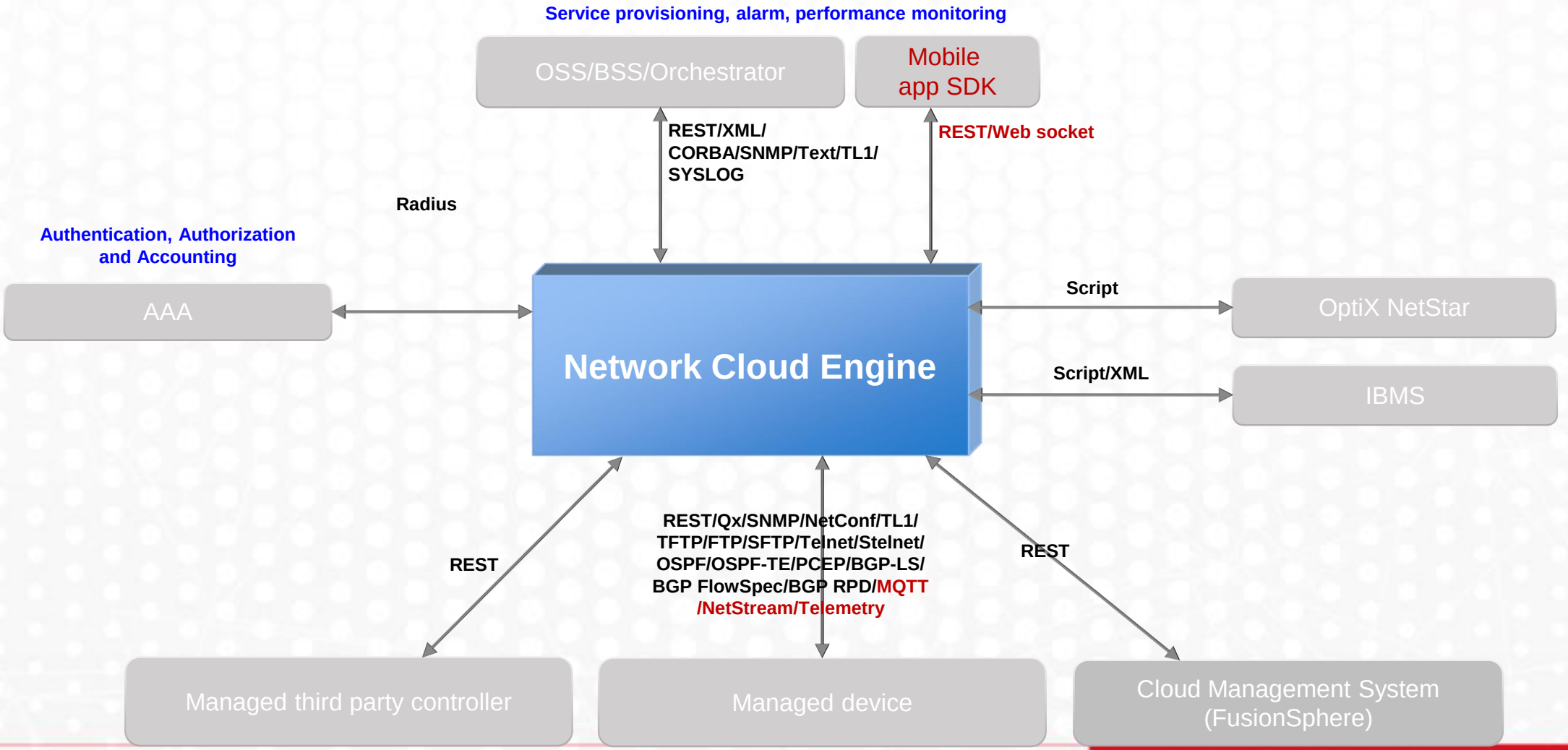
SDN Positioning



Se tiene como objetivo construir una red impulsada por intención (IDN) que primeramente sea automatizada, luego autoadaptable y finalmente autónoma.

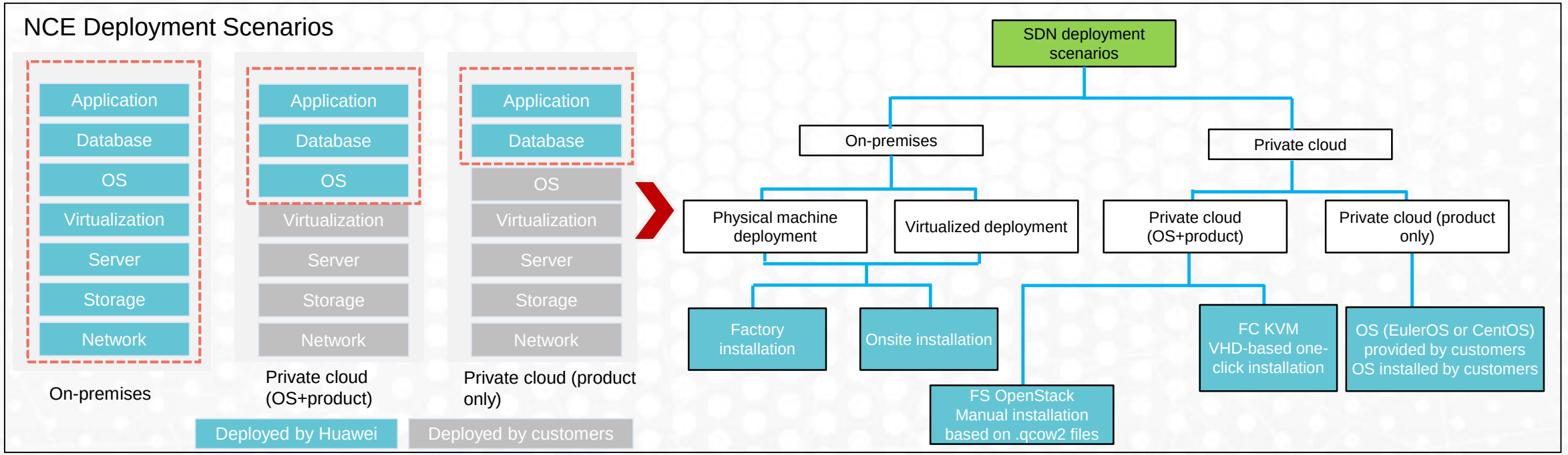
- **Automation:** Network deployment and maintenance are automated throughout the network lifecycle.
- **Self-adaptation:** Service policies are automatically generated based on big data using the real-time analyzer to implement proactive maintenance and closed-loop optimization.
- **Autonomy:** Artificial intelligence and machine learning are used to build an intelligent network that can automatically generate dynamic policies.

Interfaces Between SDN and Other Systems



Deployment Scenarios

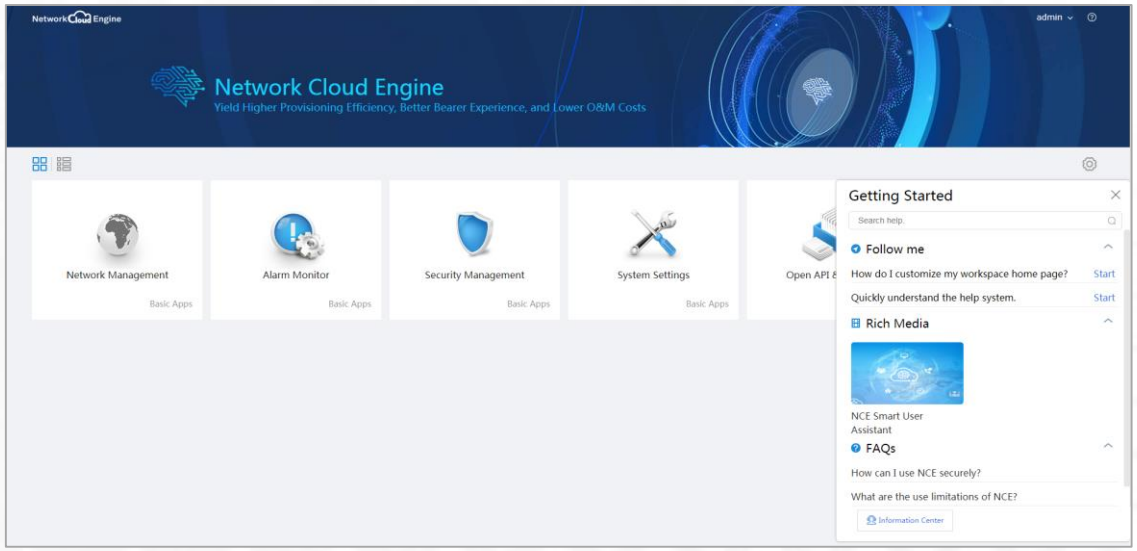
- Based on whether Huawei provides E2E support for software and hardware, SDN can be deployed in two modes: on-premises and private cloud.
- On-premises deployment refers to software and hardware integration. The Vendor provides the required hardware and software and completes the E2E configuration of the software and hardware.



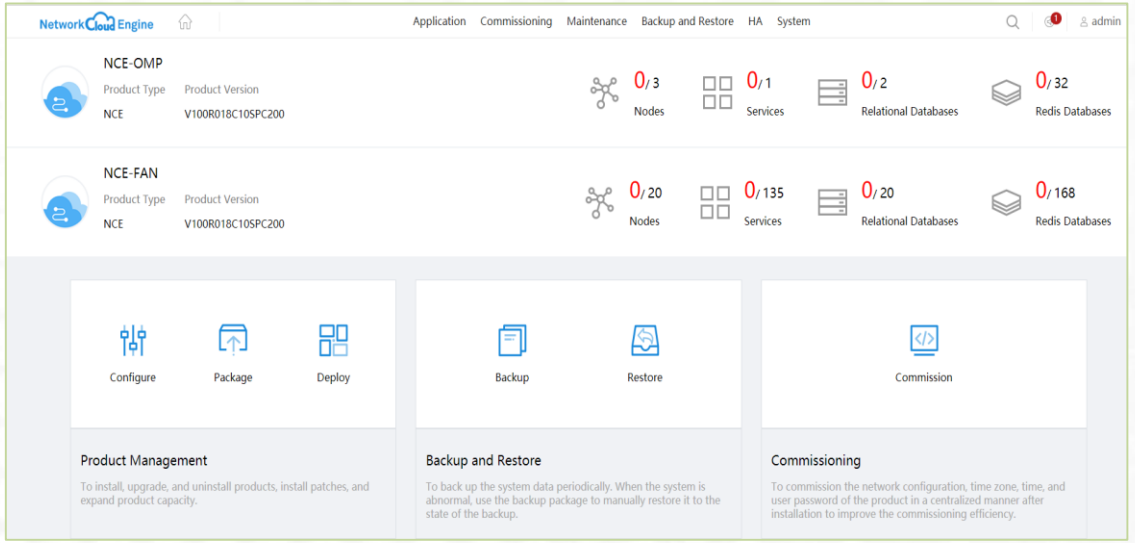
SDN Page: Unified User Portal

SDN proporciona dos interfaces de trabajo independientes en planos diferentes: plano de gestión y plano de O&M. Puede iniciar sesión en cada plano a través de una dirección IP y un número de puerto específicos. Esto le ayuda a concentrarse en sus propios escenarios de tareas para garantizar una gestión eficiente del sistema y la operación y mantenimiento de la red.

O&M plane: https://IP address of the O&M plane: 31943



Management plane: https://IP address of the management plane: 31945

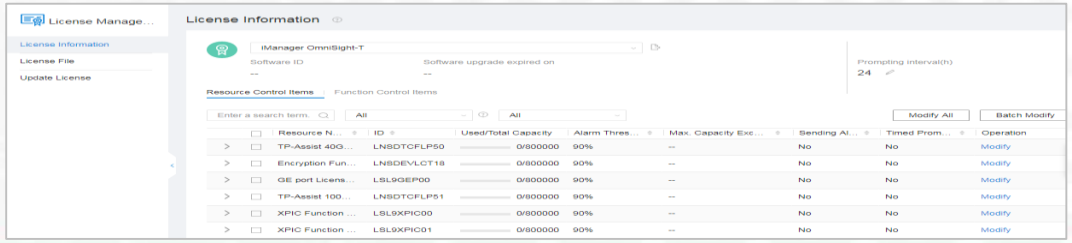


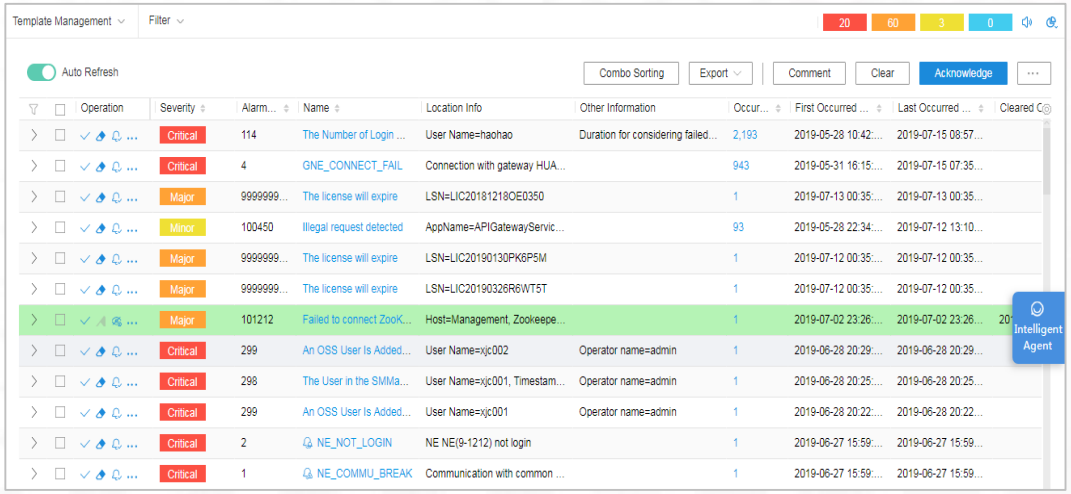
- Planificación e implementación de redes
- Diseño, aprovisionamiento y análisis de servicios
- Monitoreo, análisis, ajuste, mantenimiento y resolución de problemas de la red
- Configuración del sistema (gestión de licencias e interconexión del sistema en dirección sur)
- Gestión de red, gestión de seguridad y gestión de alarmas
- Todo tipo de casos de uso (aplicaciones)

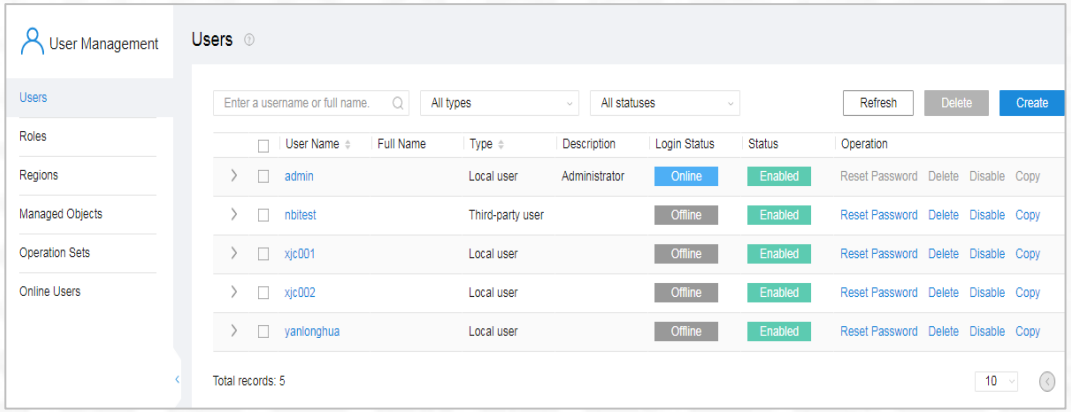
Gestiona de forma centralizada los recursos, las aplicaciones y las bases de datos para implementar funciones como la instalación y la implementación, la supervisión del sistema, el mantenimiento del sistema (gestión de usuarios y contraseñas, copia de seguridad y restauración de datos, y gestión de claves y certificados) y resolución de problemas del sistema (comprobación del estado del sistema, recopilación de datos de fallas, demarcación y localización de fallas y recuperación de desastres).

Common Apps Including Security Management, Alarm Monitor, and System Settings

App Name	Description
Alarm Monitor	● Configurar, monitorear, visualizar y manejar alarmas. ● El personal de O&M puede monitorear colectivamente las alarmas o eventos reportados por los objetos administrados o el sistema mismo y localizar y manejar rápidamente fallas de la red, asegurando el tiempo de actividad de los servicios.
Security Management	● **Gestión de usuarios:** incluida la gestión de permisos de usuario y políticas de seguridad del sistema. La gestión de seguridad evita que usuarios no autorizados accedan al sistema y garantiza la seguridad de los datos del sistema. ● **Gestión de registros**: permite que el sistema registre automáticamente los registros de seguridad, los registros del sistema y los registros de operaciones generados durante la ejecución del sistema. Esta función también admite consultas de registros, exportación de registros y volcado de registros.
System Settings(Ajustes del sistema)	Configuración de reenvío de registros, administración del ciclo de vida, administración de licencias, administración de acceso, notificaciones y configuraciones personales.







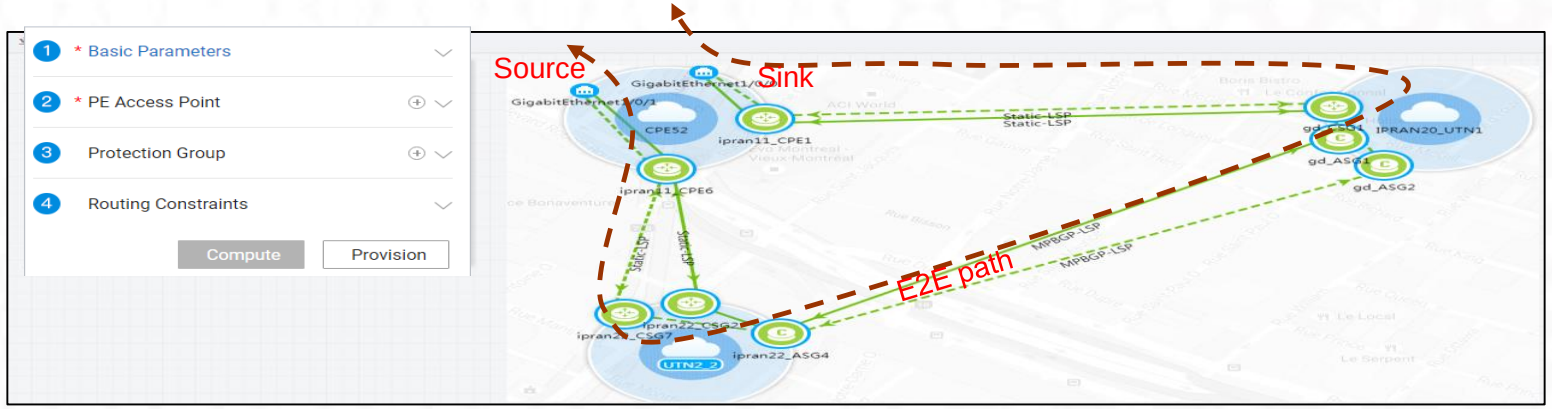
B2B Private Line: Quick Service Provisioning

Fast order provisioning and automatic process

Step 1: OSS work orders drive IntendAPI: (Paso 1: las órdenes de trabajo de OSS impulsan IntendAPI:)

- ✓ Source, Sink
- ✓ Service template
- ✓ Bandwidth and SLA...

Step 2: E2E path is automatically computed.



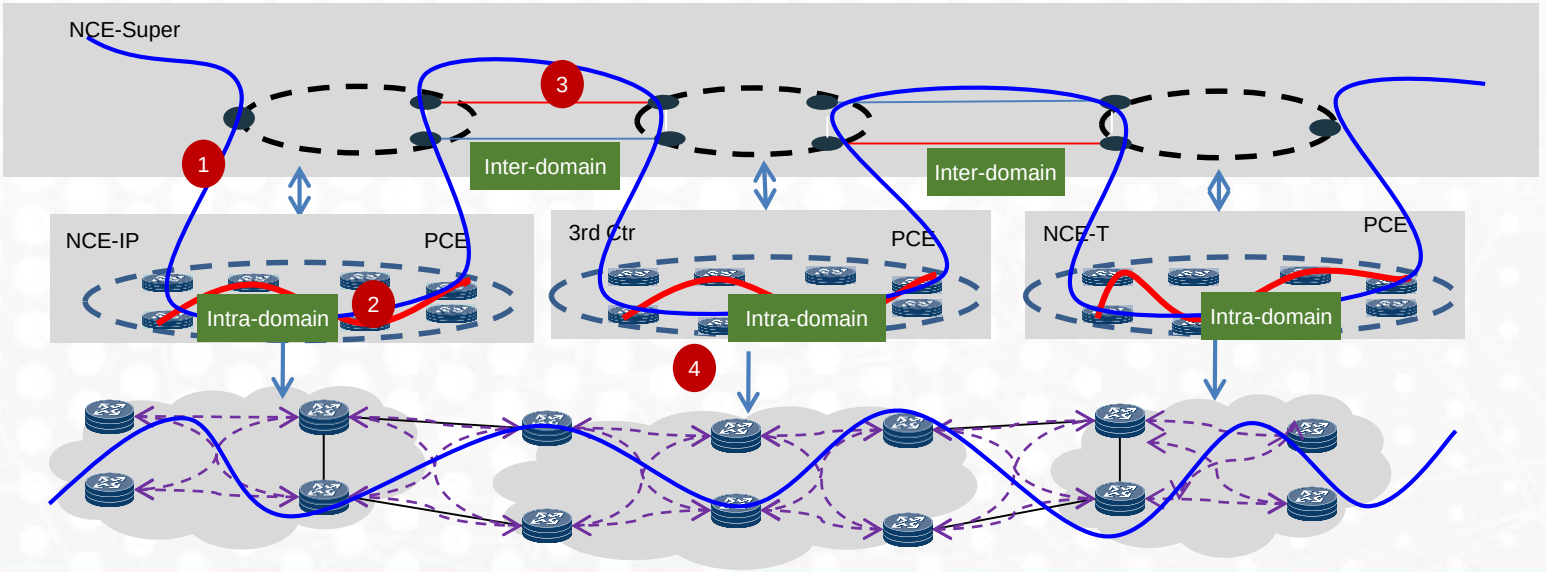
Multi-domain path computation

Step 1: Users specify path constraints.(Las usuarios especifican restricciones de ruta.)

1. Explicit or excluded NEs, links, and domains
2. Path computation based on the shortest path (minimum number of hops) in IP and optical domains
3. One of the shortest path, minimum delay, and bandwidth balance in the SPTN domain
4. Preconfigurations of delay and bandwidth for inter-domain links and border NEs
5. Domain control data related to delay and bandwidth for inter-domain links and NEs

Step 2: The SC computes the boundary and sends the possible single-domain paths and constraints to the DC.
Step 3: The DC computes paths in the domain and reports the paths that meet the requirements.
Step 4: The SC determines the E2E path based on the feedback from each DC.
Step 5: The SC delivers constraints to the DC and creates multi-domain paths.

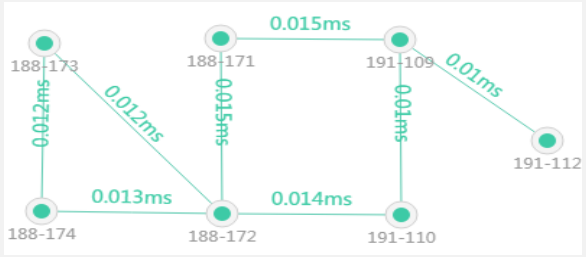
Multi-domain interactive algorithm for computing service paths of different SLAs



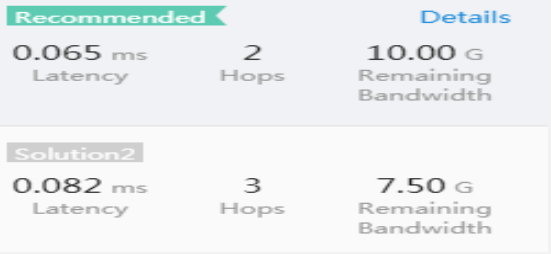
Optical Service Provisioning: Visualized and Guaranteed Latency

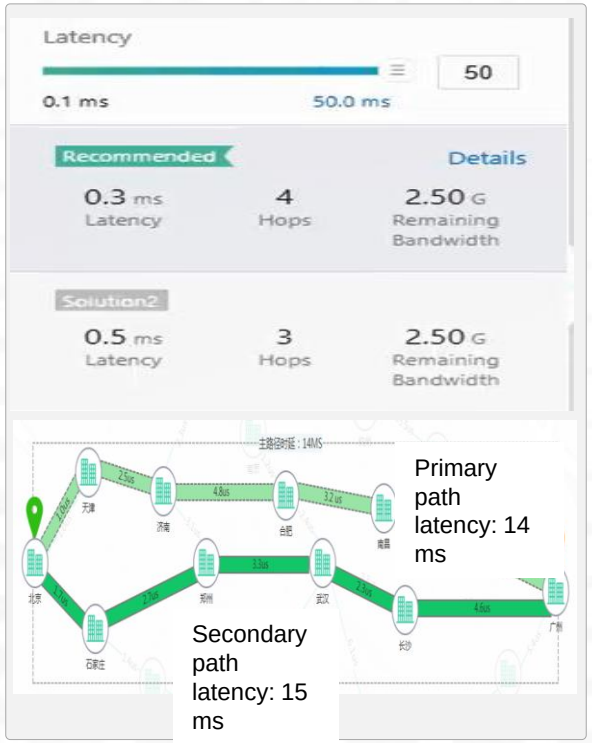
Real-time visualization of network latency → Assurable latency for service provisioning → Real-time service latency monitoring → Optimizable service latency

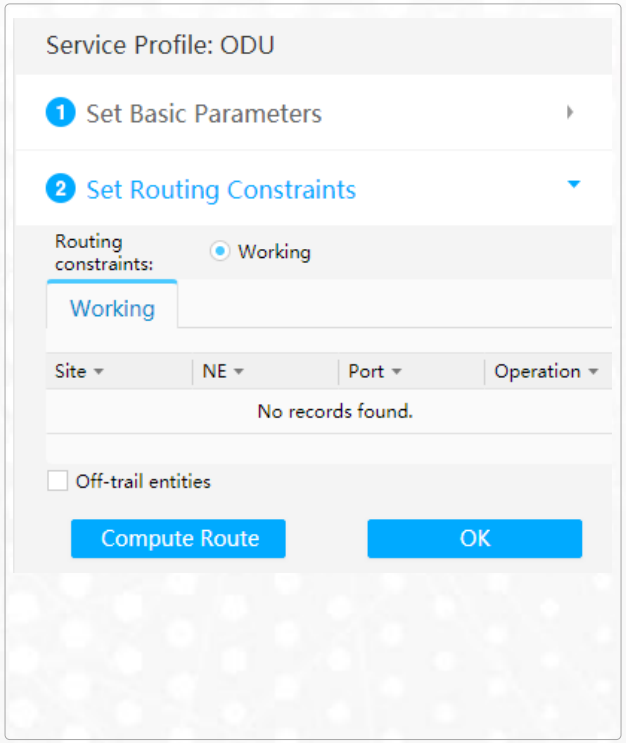
Latency map: indica la latencia mínima de enlace de capa eléctrica entre dos nodos cualesquiera.



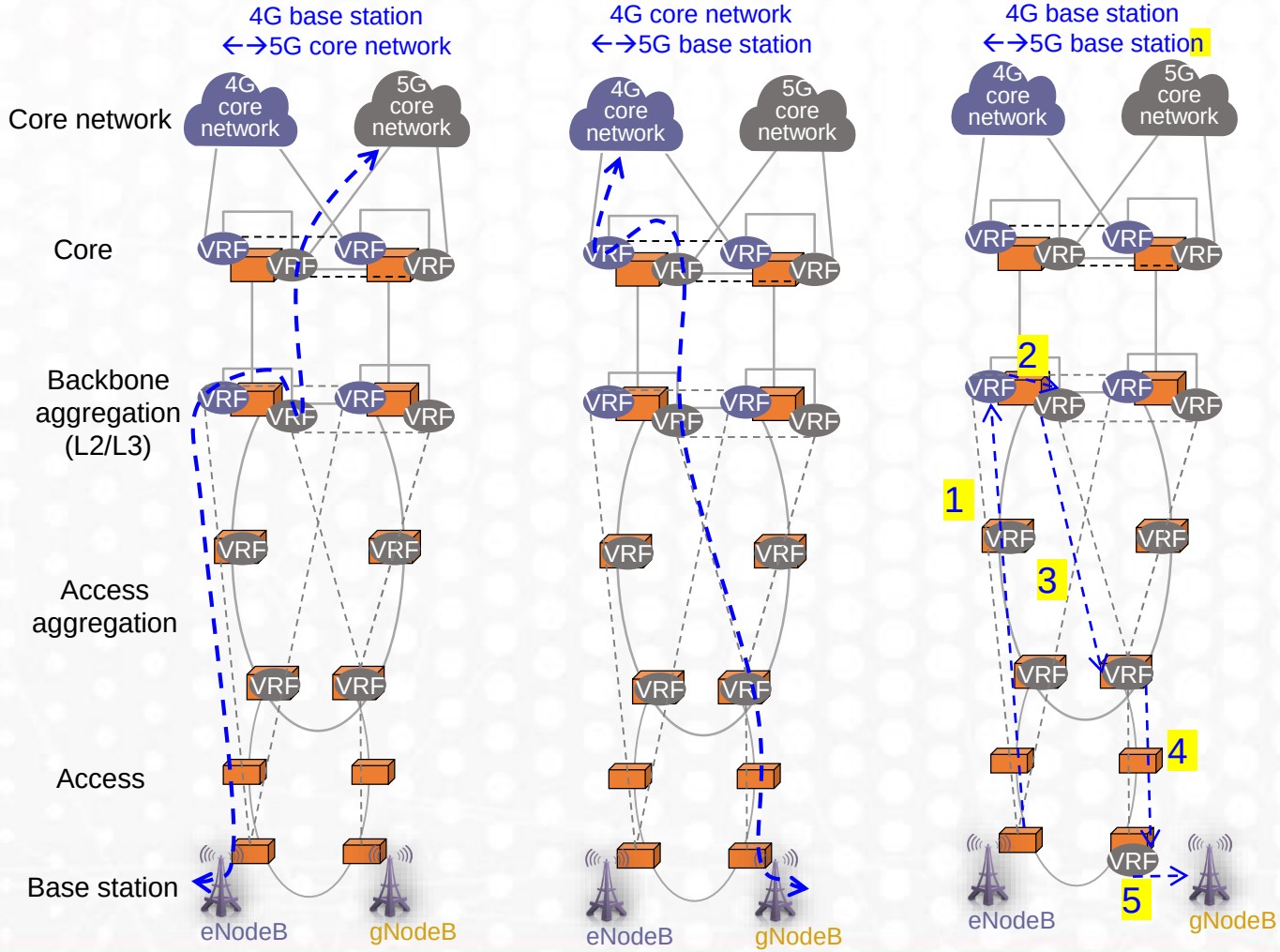
Latency estimation: admite estimación de latencia de nivel de servicio entre dos nodos cualesquiera.







4G L3VPN and 5G L3VPN Device Interoperability



VRF 4G VRF VRF 5G VRF

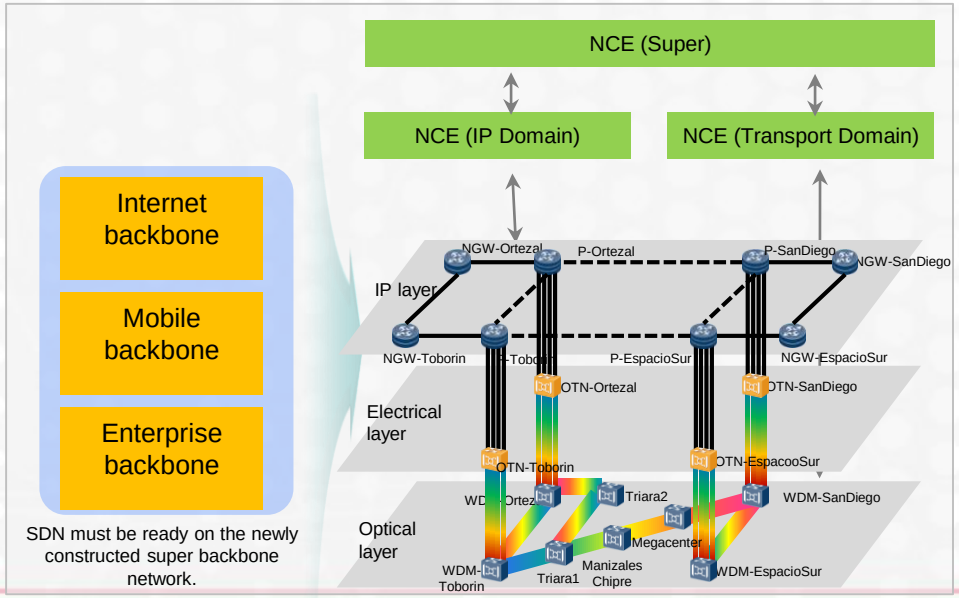
Interoperability analysis: 4G base station←→5G base station

1. Un nodo de acceso recibe un paquete de un eNodeB y transmite el paquete a un VRF 4G a través de L2VPN, L2VE (Ethernet virtual) y L3VE.
2. El 4G VRF tiene una ruta de segmento de red cruzada de VPN al gNodeB de destino y transmite el paquete al 5G VRF en el dispositivo local.
3. El VRF 5G tiene rutas específicas o rutas de segmento de red a gNodeB de toda la red. Después de encontrar el nodo de agregación del siguiente salto, el VRF 5G reenvía el paquete a ese nodo.
4. El VRF 5G en el nodo de agregación tiene una ruta específica al gNodeB de destino. Después de encontrar el nodo de acceso del siguiente salto, el 5G VRF reenvía el paquete a ese nodo.
5. El nodo de acceso transmite el paquete al gNodoB de destino a través de una ruta directa o estática.

IP + Optical: Overall Solution

Network planning | Network construction | Network transportation

Planning/ simulation	Multi-layer network discovery	Multi-Layer service deployment	Mand monitoringulti-layer visualization	Multi-layer protection and optimization	Multi-layer what-if analysis
Planet planning (collaborative) Network design (independent) BOQ quotation (independent) Installation and hardware commissioning (independent)	Network inventory discovery Cross link management Multi-layer topology discovery Geographical site management	Multi-layer link management Multi-layer link activation SRLG-based path disjoint Optically-aware IP routing (SRLG/delay)	Multi-layer topology Multi-layer visualization Traffic view Fault view	Multi-layer protection management Multi-layer capacity expansion Multi-layer reoptimization	Simulation of multi-layer link activation Simulation of multi-layer link deactivation Simulation of multi-layer capacity expansion (For details, see the what-if analysis description slide.)



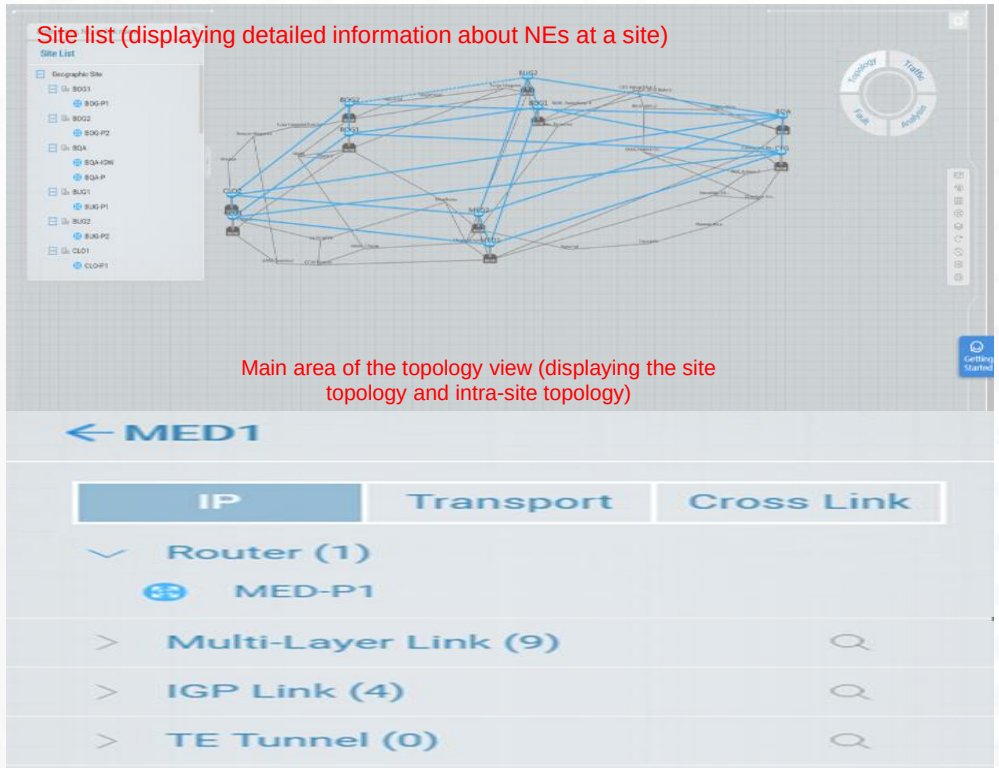
SDN must be ready on the newly constructed super backbone network.

Feature	Description	Value
Multi-layer discovery and deployment	1. Descubre enlaces IP multicapa desplegados durante la construcción inicial de la red. 2. Importa todos los datos de planificación de varias capas. 3. Activa enlaces IP multicapa en lotes y proporciona enrutamiento IP con reconocimiento óptico.	**The backbone network can be reconstructed and simplified** to improve IP+optical resource utilization.
Multi-layer visualization and monitoring	1. Amplía o reduce una topología 3D de dos capas, muestra información de varias capas (como enlace IP, capa eléctrica, capa óptica e información de pigtail) y proporciona mapeo de información de varias capas (como mapeo entre enlaces IP y túneles). 2. Proporciona una vista del tráfico para facilitar la expansión de la capacidad al cruzar el umbral de tráfico. 3. Proporciona una vista de fallas para mostrar enlaces multicapa defectuosos y sus alarmas.	Multi-Layer services and networks are visible in real time, achieving efficient O&M.
Multi-layer protection and optimization	1. Provides MLR-P/MLR-N protection. 2. Provides multi-layer BOD. 3. Provides multi-layer reoptimization.	1. La capacidad de los enlaces multicapa multicapa supervisada.

IP + Optical: Multi-Layer Visualization

- Multi-Layer topology visualization

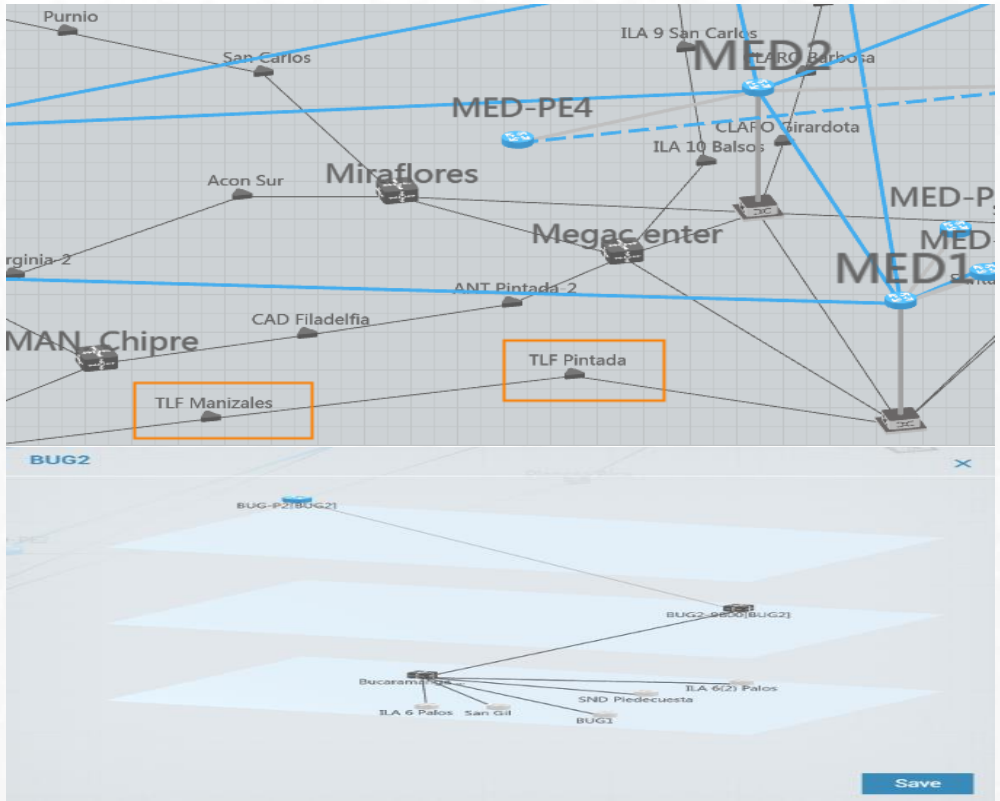
Las rutas eléctricas y ópticas de los servicios, los túneles TE y los enlaces multicapa se muestran de manera unificada. Solo se muestran enlaces y nodos abstractos entre dominios y entre capas. Cuando ve la ruta de un túnel específico, el sistema muestra la información de ruta óptica de los LSP primarios y de respaldo, incluida la información de ruta de fibra. Se resalta la ruta superpuesta. También se muestran la distancia de la fibra y el estado del enlace y del nodo.



Site information (including multi-layer links, IGP links, and TE tunnels related to sites)

Multi-layer topology view

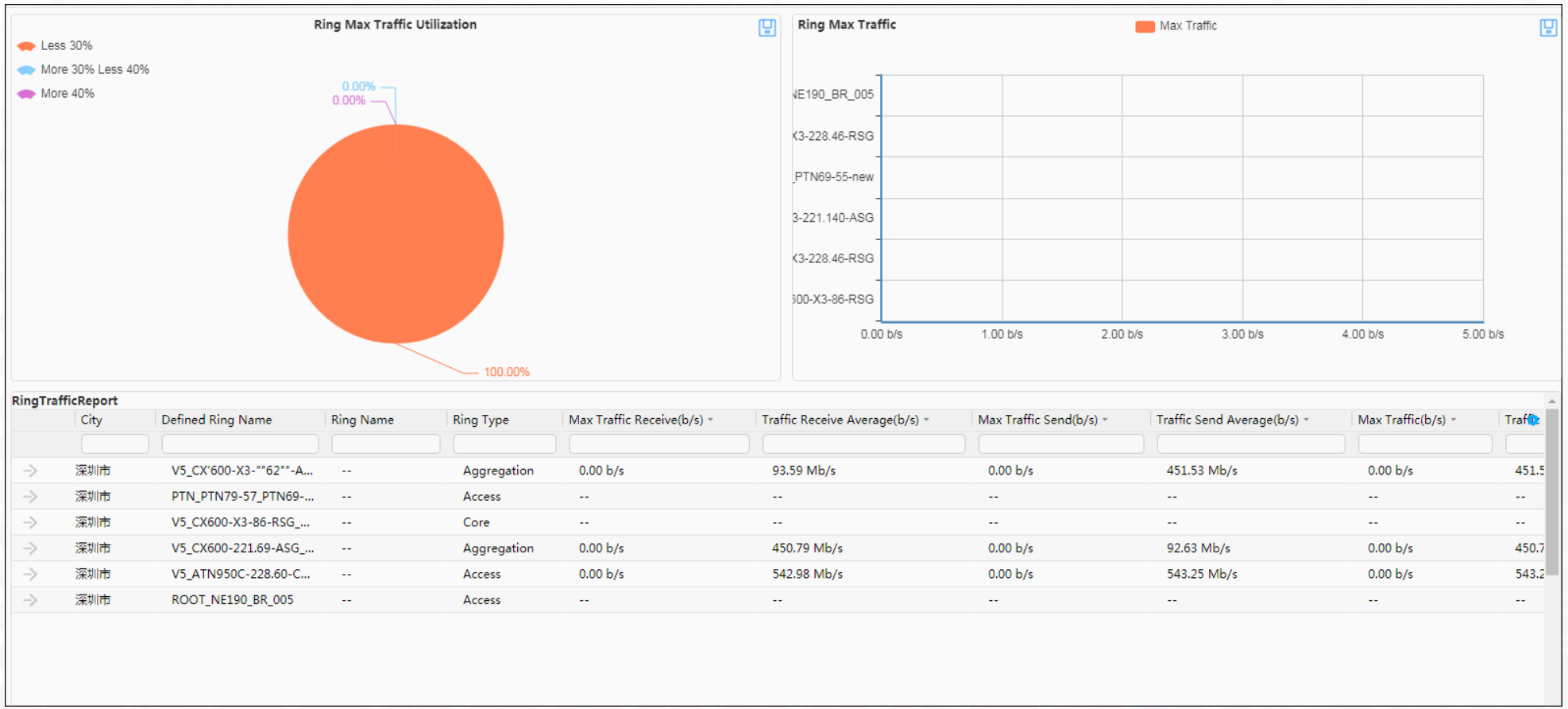
3D topology (adjustable through rotation, dragging, and zooming)



You can double-click a site to view its topology. (The topology of a site contains three layers of NEs: IP NEs, electrical NEs, and optical NEs.)

Performance Report

SDN Network Analysis and Optimization application provides various reports to help you know the status of the network and perform network O&M, capacity expansion and optimization.



RingTrafficReport

City	Defined Ring Name	Ring Name	Ring Type	Max Traffic Receive(b/s)	Traffic Receive Average(b/s)	Max Traffic Send(b/s)	Traffic Send Average(b/s)	Max Traffic(b/s)	Traffic
深圳市	V5_CX'600-X3-""62""-A...	--	Aggregation	0.00 b/s	93.59 Mb/s	0.00 b/s	451.53 Mb/s	0.00 b/s	451.5
深圳市	PTN_PTN79-57_PTN69-...	--	Access	--	--	--	--	--	--
深圳市	V5_CX600-X3-86-RSG_...	--	Core	--	--	--	--	--	--
深圳市	V5_CX600-221.69-ASG_...	--	Aggregation	0.00 b/s	450.79 Mb/s	0.00 b/s	92.63 Mb/s	0.00 b/s	450.7
深圳市	V5_ATN950C-228.60-C...	--	Access	0.00 b/s	542.98 Mb/s	0.00 b/s	543.25 Mb/s	0.00 b/s	543.2
深圳市	ROOT_NE190_BR_005	--	Access	--	--	--	--	--	--

New Capabilities Added to SDN (IP Domain) OpenAPI (RESTful)

Sub-solution	API Function Category	NBI Capabilities
Inventory	Physical inventory query	Queries information about PTN/NE/CX/ATN/BARS series NEs, including batch query and query of a single NE based on **res-id** (NE ID).
		Queries information about multiple boards based on NEs or a single board based on **res-id**.
		Queries information about multiple ports based on NEs or a single port based on **res-id**.
Service provisioning	MBGP L3VPN service provisioning	Includes the operation interfaces for L3VPN services, service nodes, service access points, and QoS.
	Static L3VPN service provisioning	Supports static L3VPN service provisioning for 5G services, including adding, deleting, modifying, and querying services, bound tunnels, and user-side static routes.
	Route flooding	Adds, deletes, modifies, and queries route flooding modes, route flooding domains, flooding nodes, primary/backup relationship of routes, and enables or disables route flooding.
	Routing policy template	Queries the routing policy list, including the routing policy template ID, template name, and routing policy name.
	Service QoS profile	Queries basic information about QoS packages of EVPN and dynamic L3VPN services, and supports query by page and sorting by specified field.
	Tunnel management	Adds, deletes, and modifies RSVP-TE, SR-TE, and SR-TP tunnels. Supports only VRPv8-based IP devices.
Optimization	MPLS optimization	Queries the PCE server address, configures optimization parameters, triggers global optimization, queries LSPs, and queries path computation status.
	IP network optimization	Adds, deletes, modifies, and queries traffic policies in batches or one by one, and queries northbound data statistics.
	Sending intelligent path computation requests	Initiates an intelligent path computation request. Supports the creation of multiple tunnels at a time, and supports concurrent requests. The system processes the requests one by one.
	L3TOPO	Queries, configures, and deletes the TE path computation attributes of an IGP topology.
Maintenance	MAC address ping detection management	Creates, starts, queries, and deletes MAC address ping detection tasks.
	Alarm management	Provides a unified alarm interface.

Key requirements and features

Overview:

RESTful NBIs in NCE (IP Domain) are optimized and enhanced.

1. Consulta de inventario físico

Proporciona RESTful OpenAPI para consultar datos de inventario físico. El OSS puede sincronizar los datos de recursos físicos (NE, placa y datos de inventario de puertos) desde NCE (dominio IP).

2. Provisión de servicios

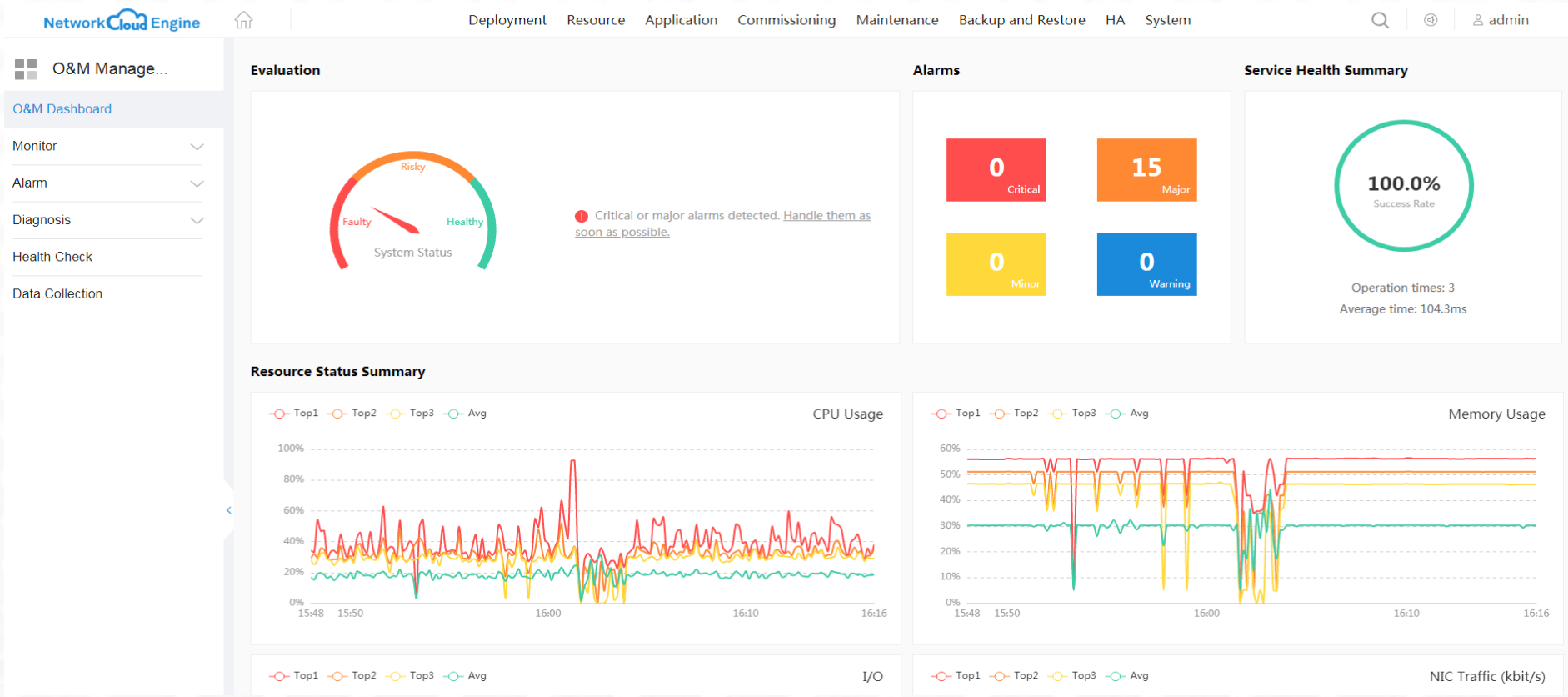
Proporciona la API RESTful de nivel de servicio para simplificar el aprovisionamiento y la integración del servicio OSS.

3. Capacidad de optimización

Proporciona la capacidad de optimización RESTful API para que OSS integre la capacidad de optimización de NCE (dominio IP).

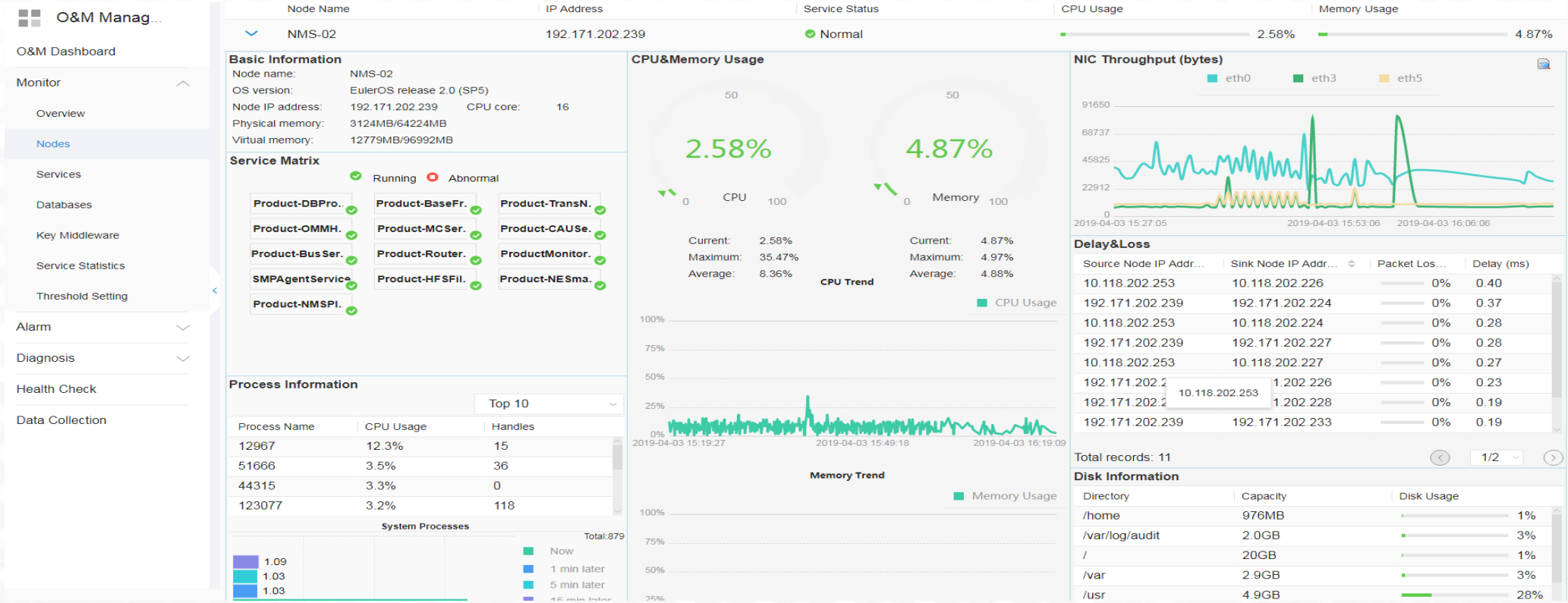
O&M Dashboard

With the O&M Dashboard, SDN provides visibility into current and historical execution states to detect failures and risks early.



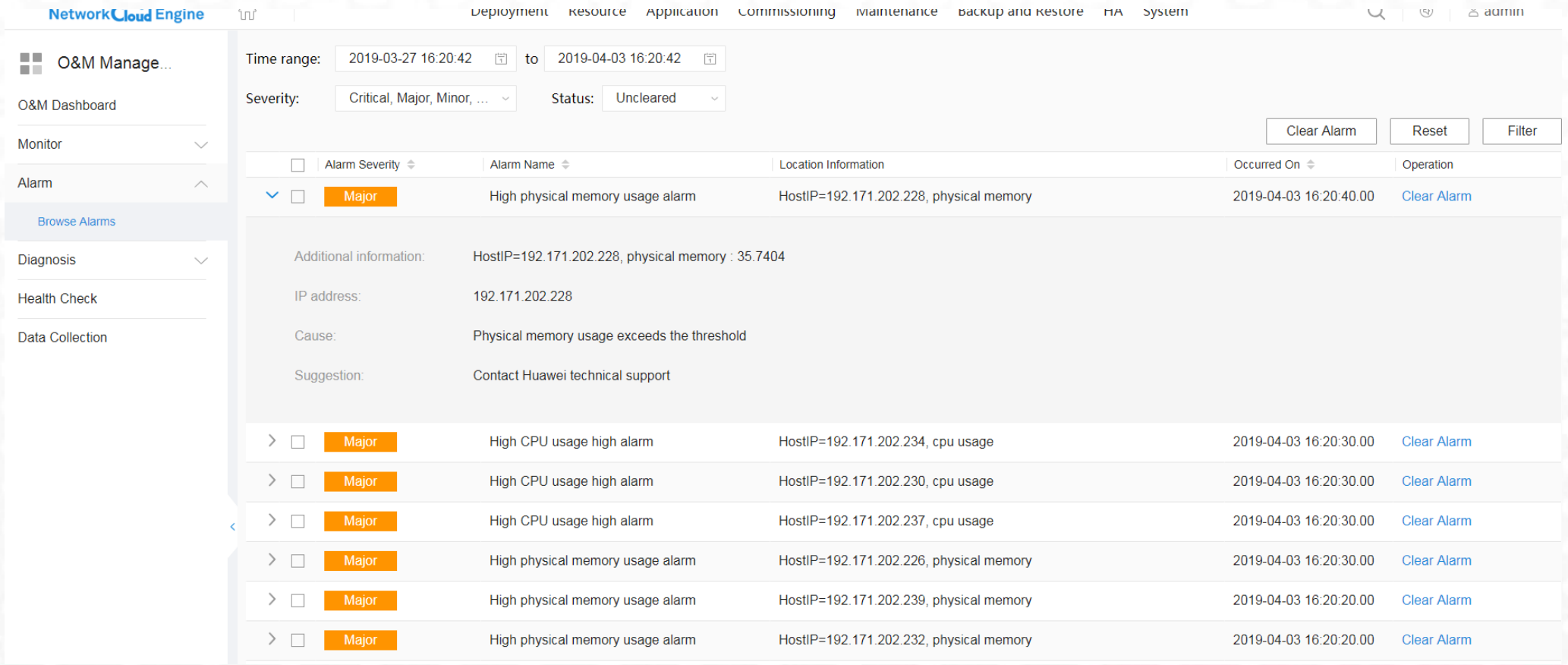
Unified Monitoring

With the O&M dashboard, SDN provides visibility into current and historical execution states to detect failures and risks early.



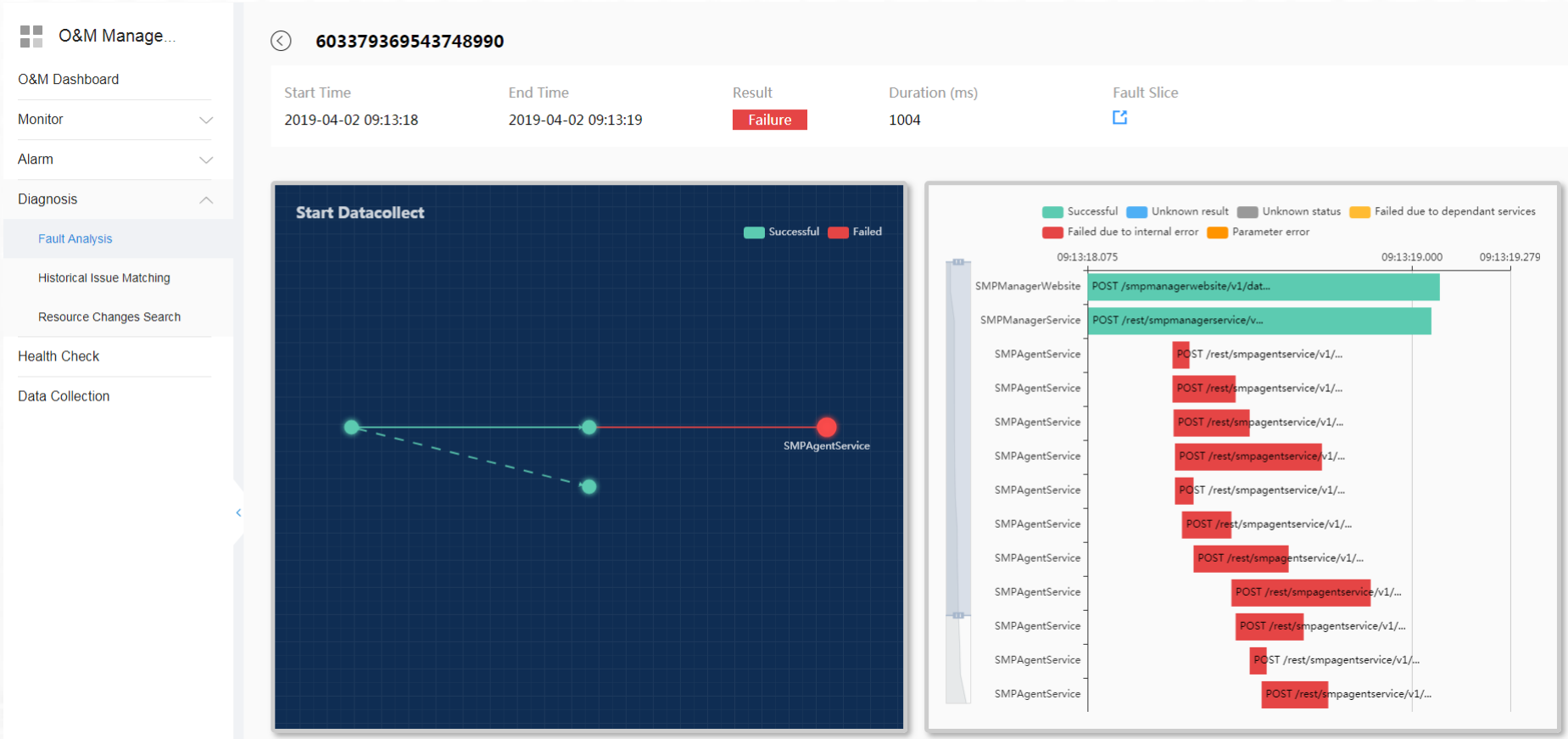
Alarms

With alarms, system exceptions are displayed via alarm indicators and popup messages.



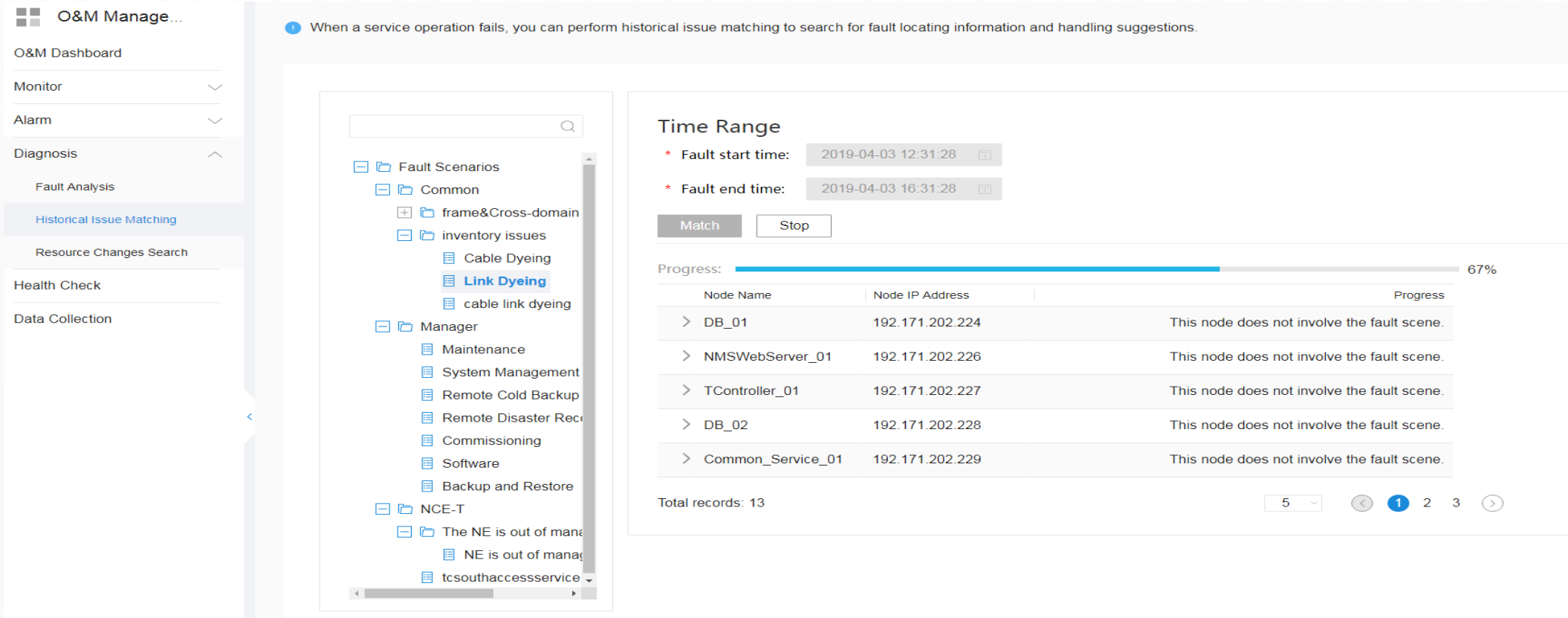
Fault Analysis

SDN quickly demarcates and locates faults based on the call chain analysis



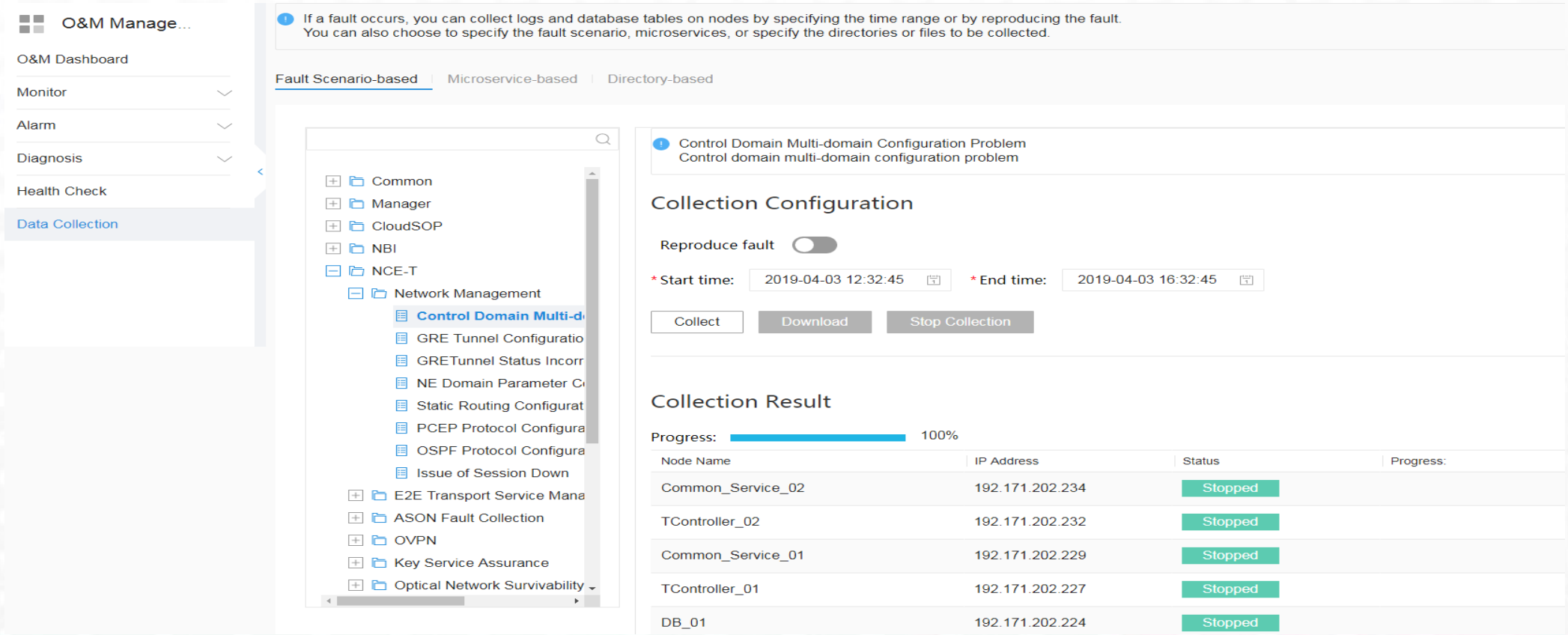
Replicated Fault Identification

With replicated fault identification, SDN detects a known problem by comparing the fault against historical issues and issues



Data Collection

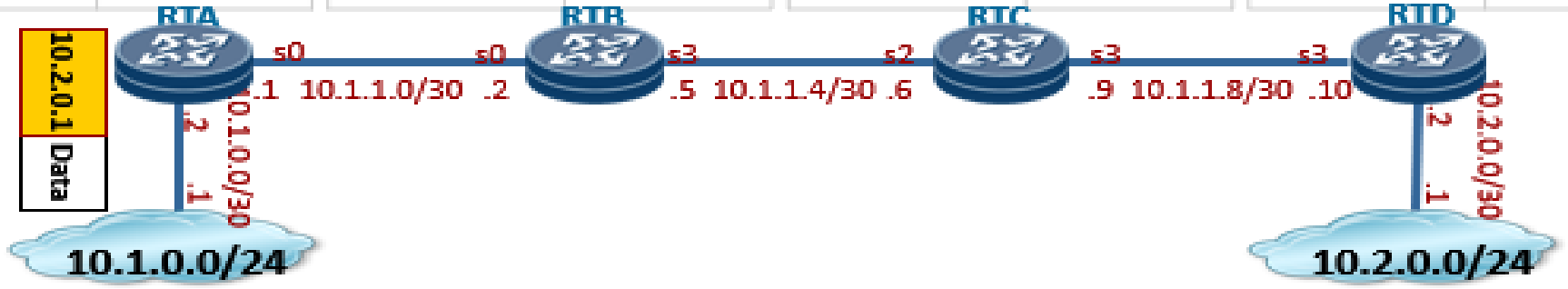
With data collection, scenario-based one-click information collection is provided if there is no online analysis and matching result available and more information needs to be collected.



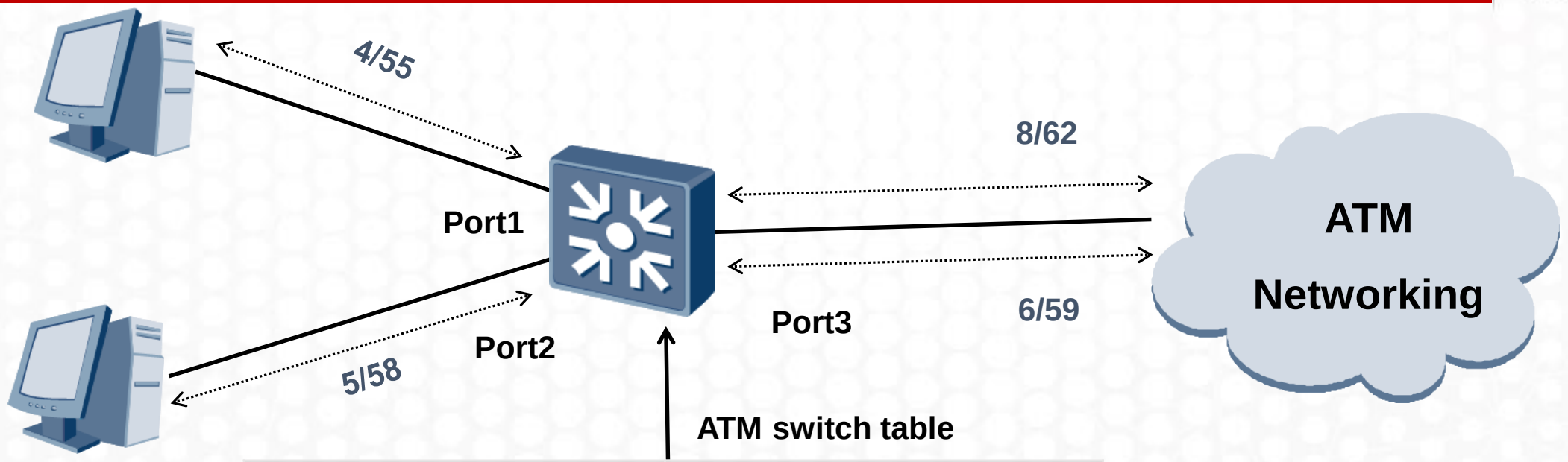
II. Transporte de Datos en Redes MPLS a SR

Traditional IP Forwarding

Network	Nexthop	Network	Nexthop	Network	Nexthop	Network	Nexthop
10.1.0.0/24	10.1.0.2	10.1.0.0/24	10.1.1.1	10.1.0.0/24	10.1.1.5	10.1.0.0/24	10.1.1.9
10.1.0.1/32	10.1.0.1	10.1.1.0/30	10.1.1.2	10.1.1.0/30	10.1.1.5	10.1.1.0/30	10.1.1.9
10.1.1.0/30	10.1.1.1	10.1.1.1/32	10.1.1.1	10.1.1.4/30	10.1.1.6	10.1.1.4/30	10.1.1.9
10.1.1.2/32	10.1.1.2	10.1.1.4/30	10.1.1.5	10.1.1.5/32	10.1.1.5	10.1.1.8/30	10.1.1.10
10.1.1.4/30	10.1.1.2	10.1.1.6/32	10.1.1.6	10.1.1.8/30	10.1.1.9	10.1.1.9/32	10.1.1.9
10.1.1.8/30	10.1.1.2	10.1.1.8/30	10.1.1.6	10.1.1.10/32	10.1.1.10	**10.2.0.0/24**	**10.2.0.2**
10.2.0.0/24	**10.1.1.2**	**10.2.0.0/24**	**10.1.1.6**	**10.2.0.0/24**	**10.1.1.10**	10.2.0.1/32	10.2.0.1

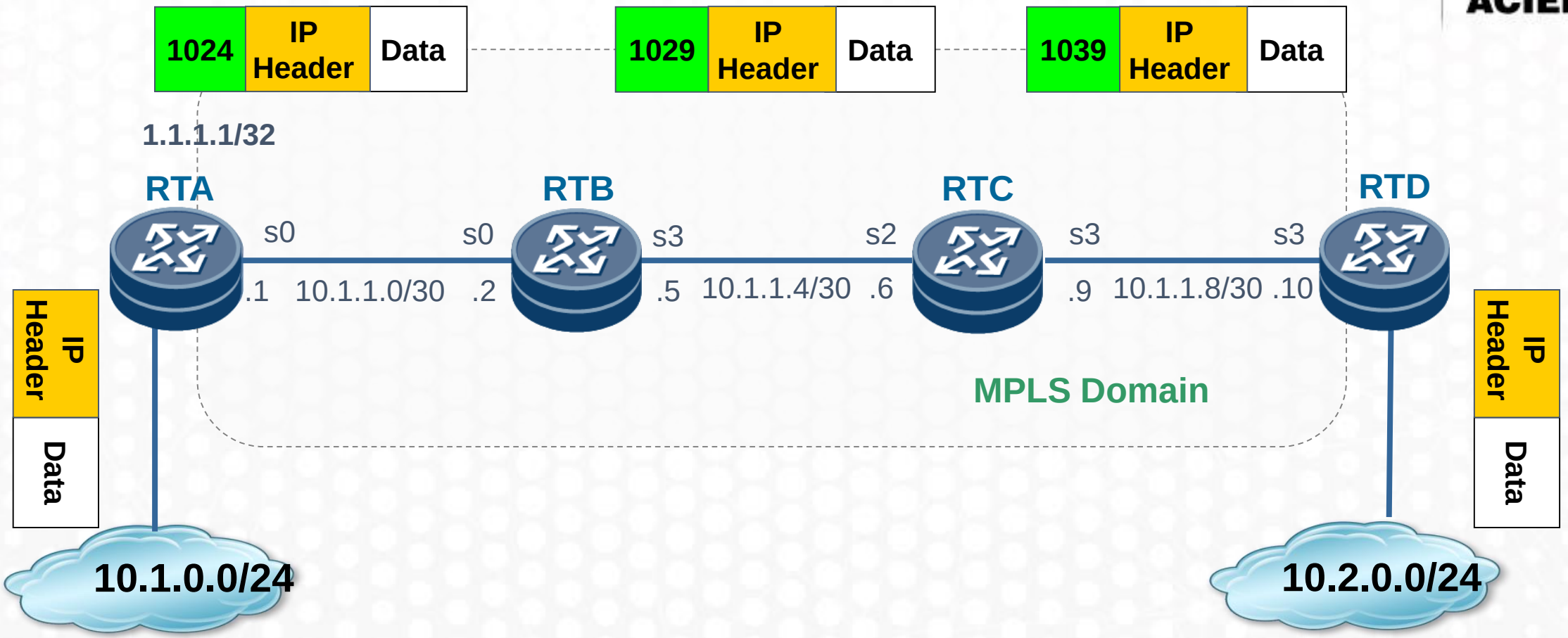


Forwarding of ATM cells

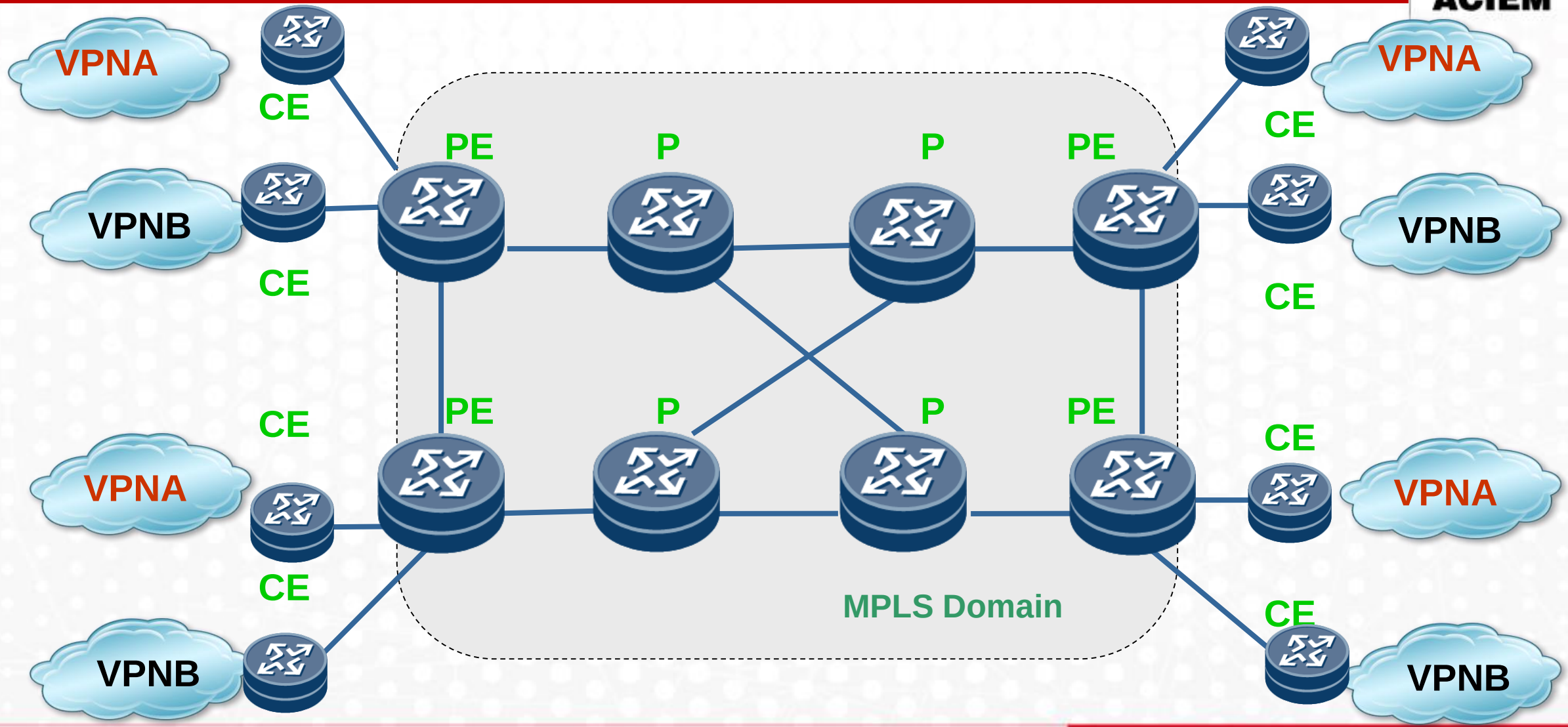


In		Out	
port	VPI/VCI	port	VPI/VCI
1	4/55	3	8/62
2	5/58	3	6/59
3	8/62	1	4/55
3	6/59	2	5/58

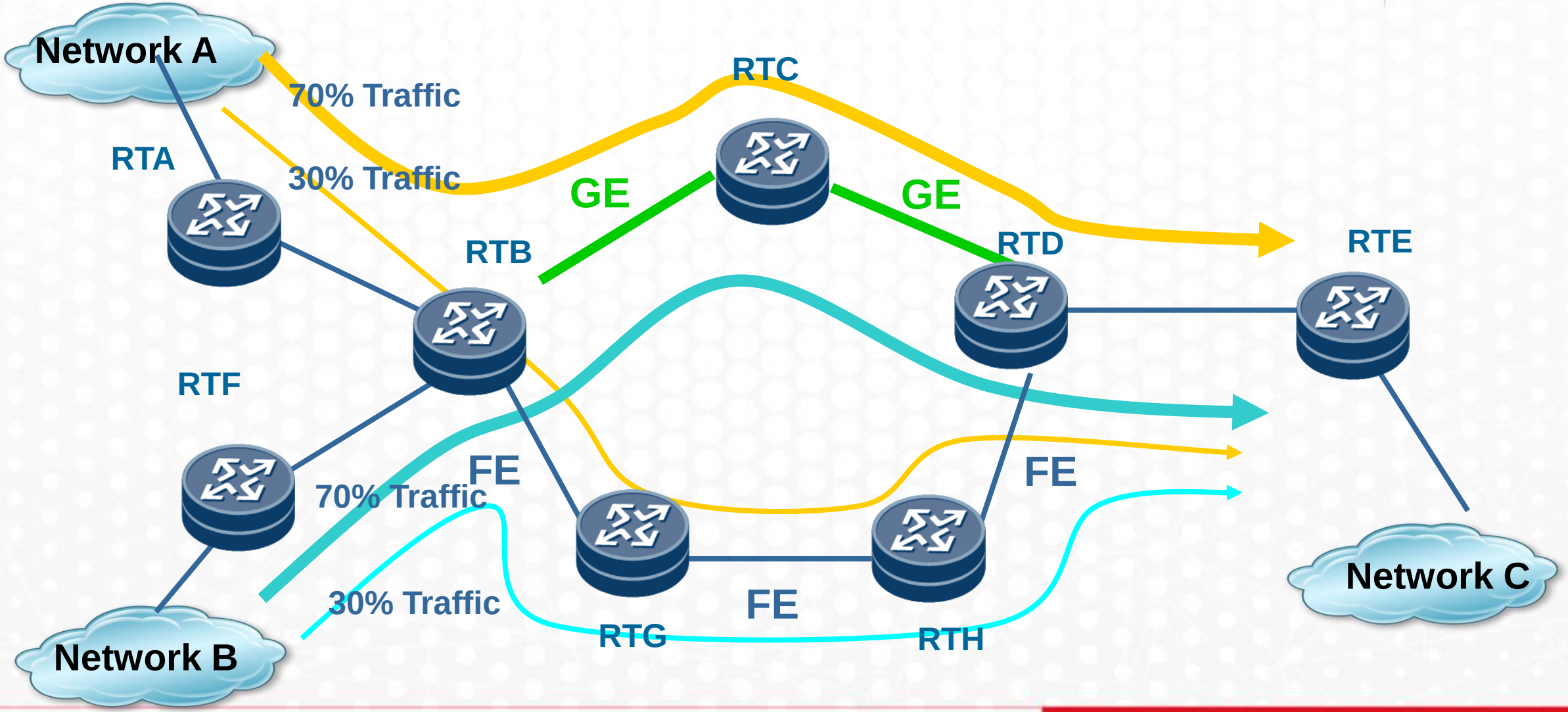
MPLS Label Forwarding



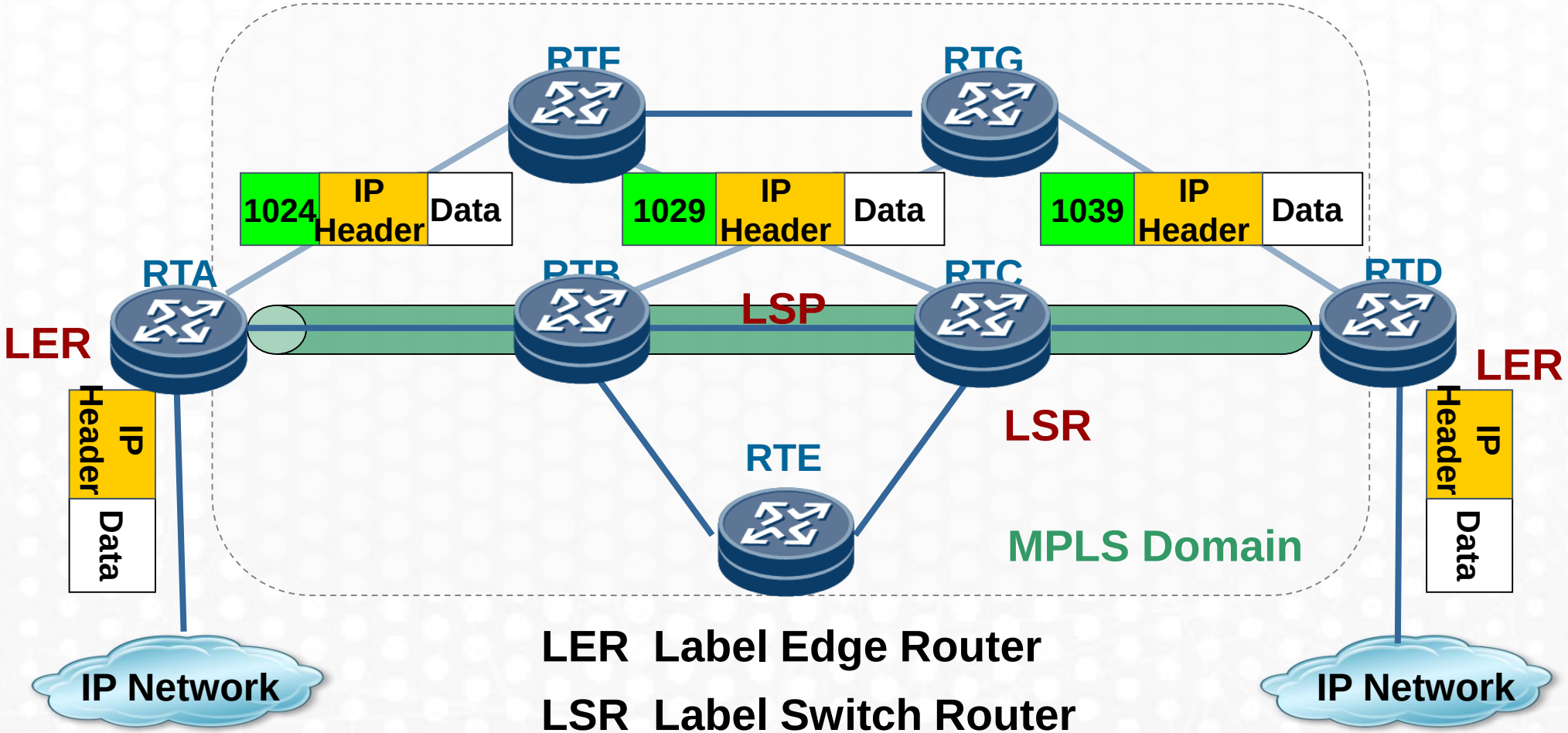
MPLS VPN Application



MPLS TE Application



MPLS Network Model

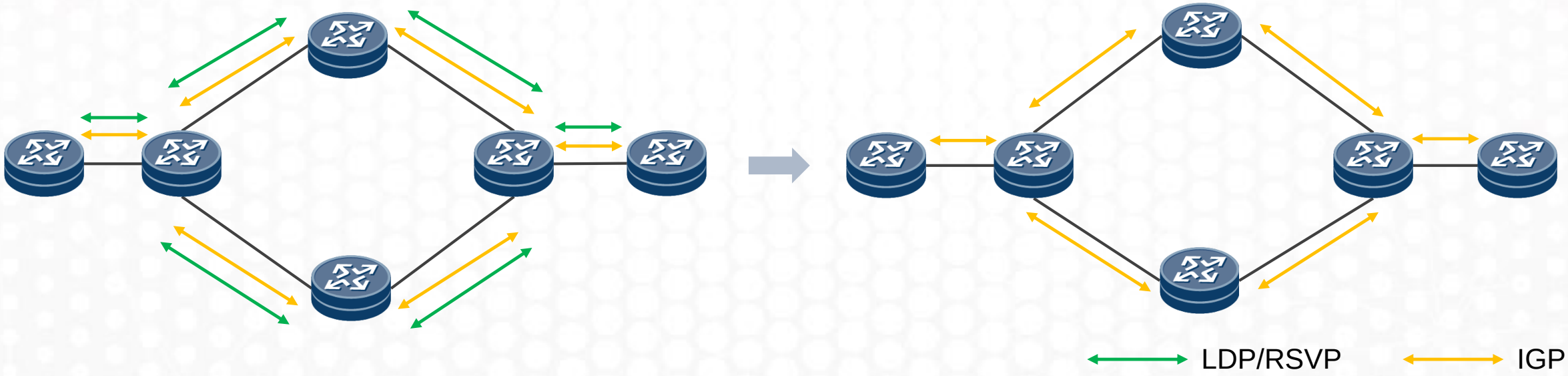


LER Label Edge Router

LSR Label Switch Router

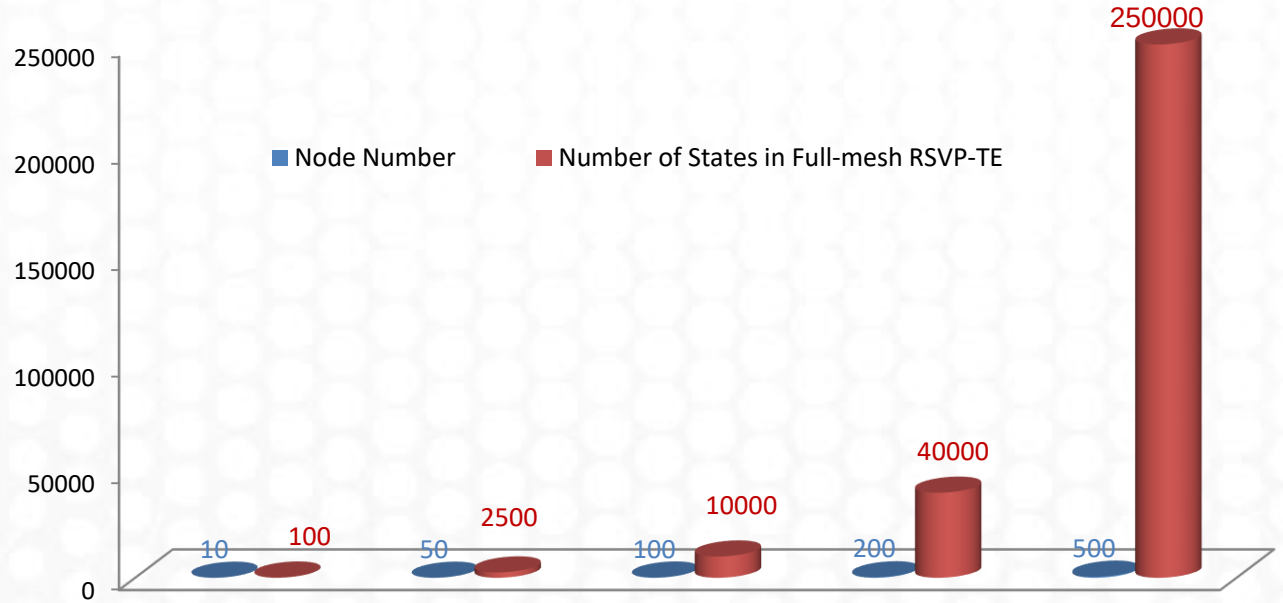
LSP Label Switch Path

Segment Routing Advantages



Attribute	Traditional MPLS	Segment Routing
Control protocol	IGP/LDP/RSVP-TE	IGP
Label distribution	The number of labels increases with the number of tunnels, consuming numerous resources.	Each adjacency or node is assigned a label regardless of the tunnel quantity, ramping down resource consumption.
Path adjustment and control	The configuration needs to be delivered node by node.	Path recalculation is performed only on the ingress node.

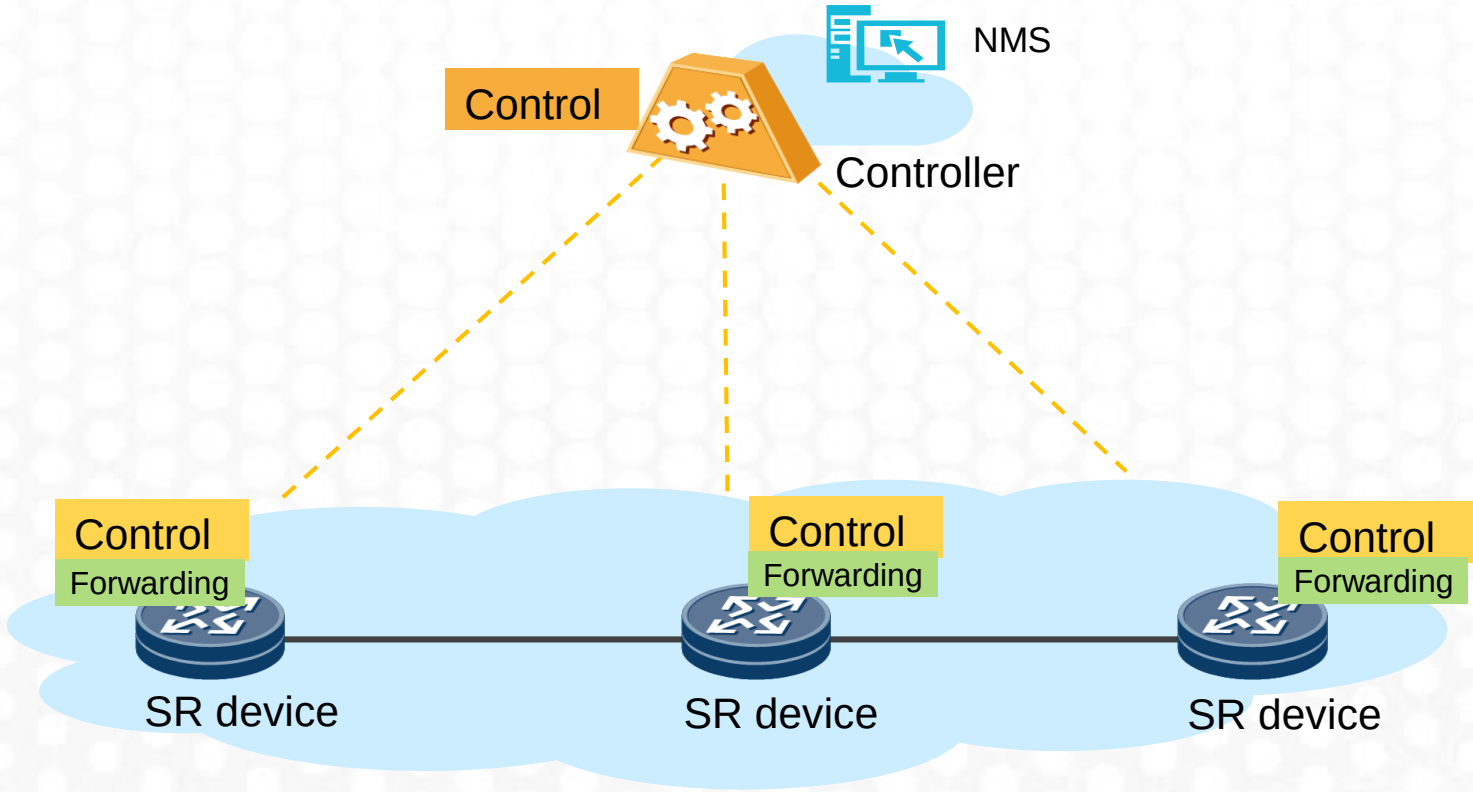
Segment Routing Advantages



Note: N indicates the number of nodes on the network and A indicates the number of links on the network.

Attribute	Traditional MPLS	Segment Routing
Number of label forwarding entries	N x A	N + A
Number of states to be maintained	N^2	N + A
Control plane	Connection-oriented. To maintain the connection status, a large number of update packets have to be sent and processed between nodes, which tends to overload the control plane.	SR changes the label stack of packets on the ingress node to control any service path. Transit nodes do not need to maintain path information, therefore lowering the burden on the control plane.

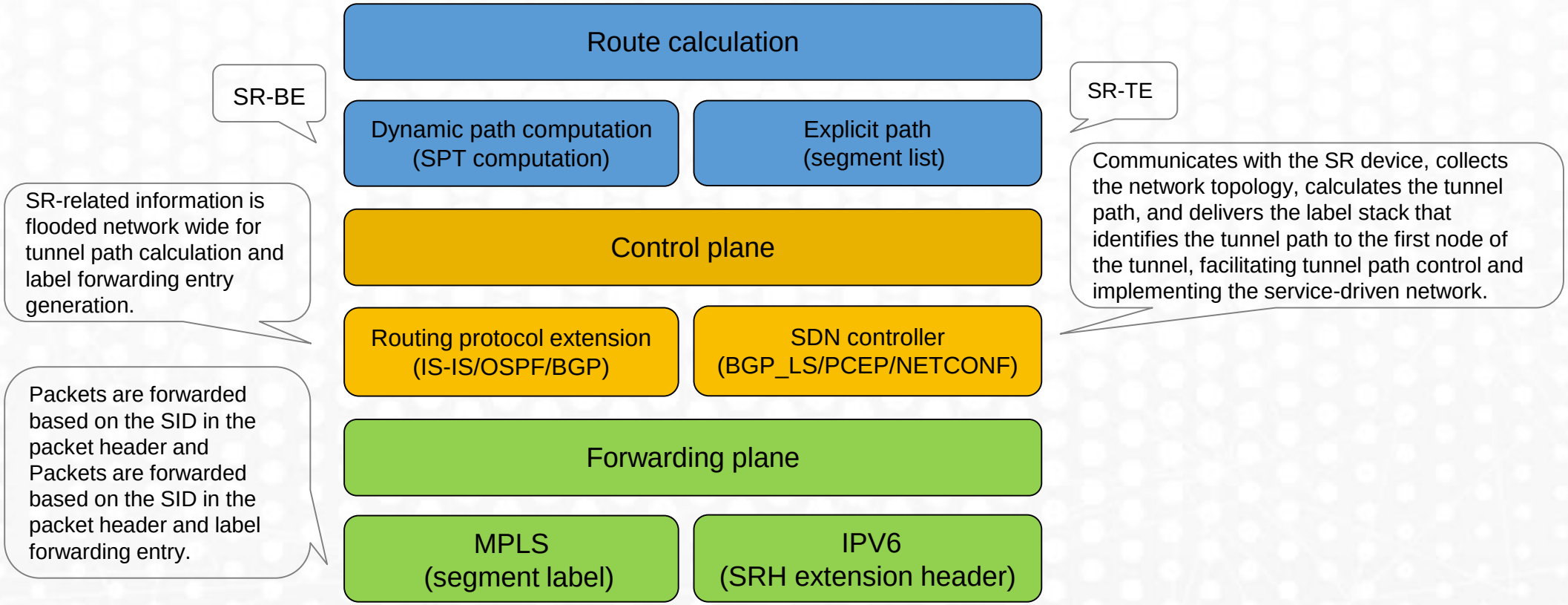
Segment Routing Advantages



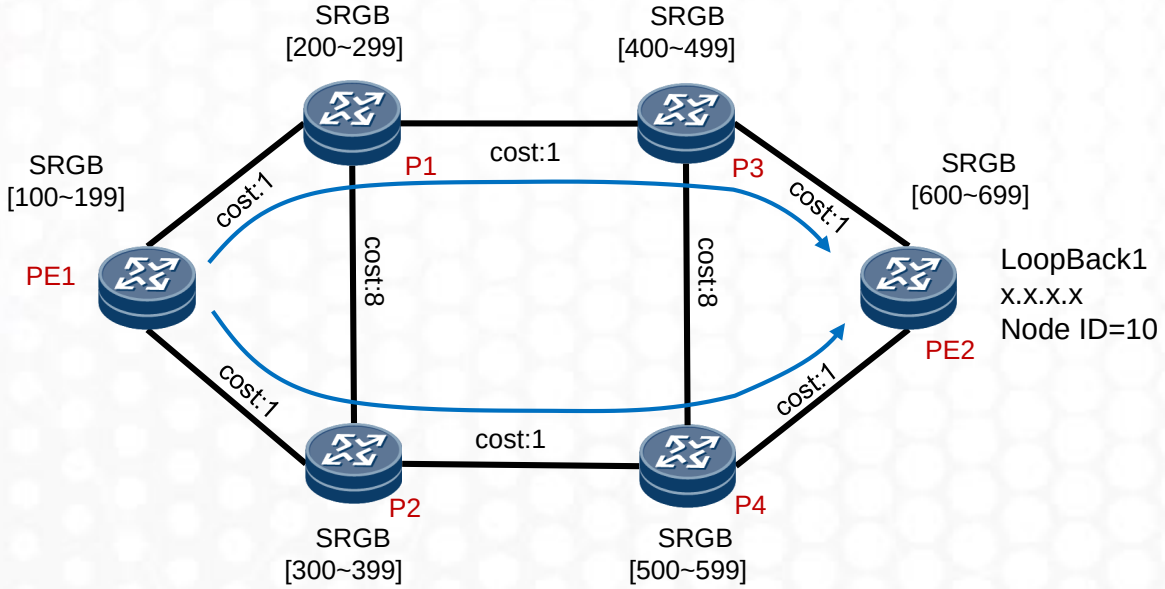
- By extending the existing protocols, the network can be smoothly evolved instead of being subverted.
- The source routing technology is adopted to control the ingress node and adjust service paths so that the network can quickly respond to the requirements of upper-layer applications.
- Distributed control and centralized control are balanced to prevent the controller from becoming a service bottleneck.

Overall Architecture

A series of ordered SIDs are added to packets on the source node (with the explicit path configured) to guide packet forwarding.



SR Implementation (IS-IS SR-BE)



2. All the nodes receive the node SID from PE2 and generate label forwarding entries for the node SID.

- Incoming label: local SRGB start value + advertised offset value
- Outgoing label: next hop SRGB start value + advertised offset value
- Next hop of the outbound interface: next hop of the outbound interface of the shortest path calculated by an IGP

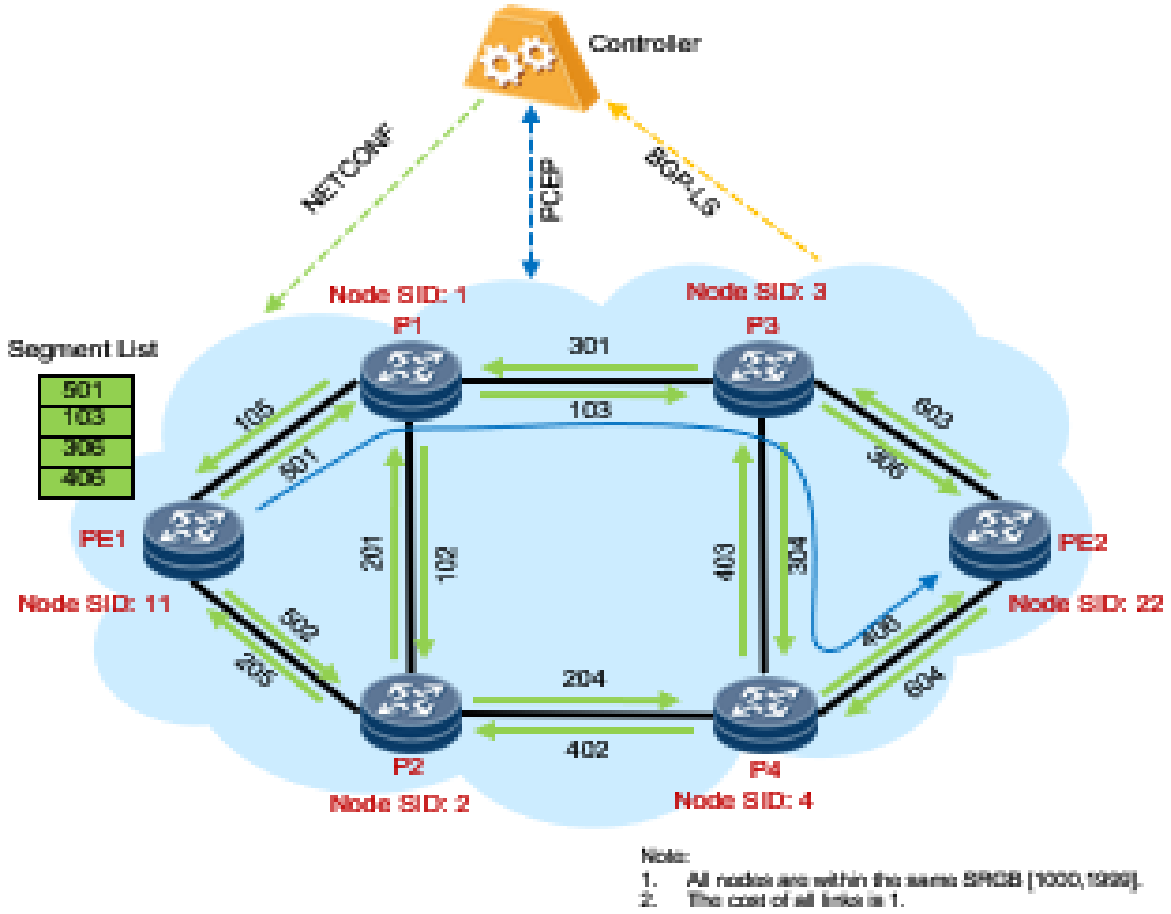
Label forwarding entry generated by each node along the PE1 -> P1 -> P3 -> PE2 path for node SID 10

Node	InLabel	Outlabel	Interface
PE1	110	**210**	PE1 -> P1
P1	210	410	P1 -> P3
P3	410	610	P3 -> PE2
PE2	610	N/A	N/A

Label forwarding entry generated by each node along the PE1 -> P2 -> P4 -> PE2 path for node SID 10

Node	InLabel	Outlabel	Interface
PE1	110	310	PE1 -> P2
P2	310	510	P2 -> P4
P4	510	610	P4 -> PE2
PE2	610	N/A	N/A

SR Implementation (SR-TE)



Workflow:

2. Report of labels and topology information

Each node on the network runs BGP Link-State (BGP-LS) to report topology information with the adjacency SIDs to the controller.

3. Path calculation

The controller runs the Path Computation Element Communication Protocol (PCEP) to calculate LSPs.

4. Path delivery

The controller runs PCEP to deliver LSP information (including the segment list and stitching labels) and NETCONF to deliver tunnel attributes to the ingress. The ingress runs PCEP to report the LSP status to the controller.

5. Tunnel creation

The ingress uses the label stack delivered by the controller to establish an SR-TE tunnel.

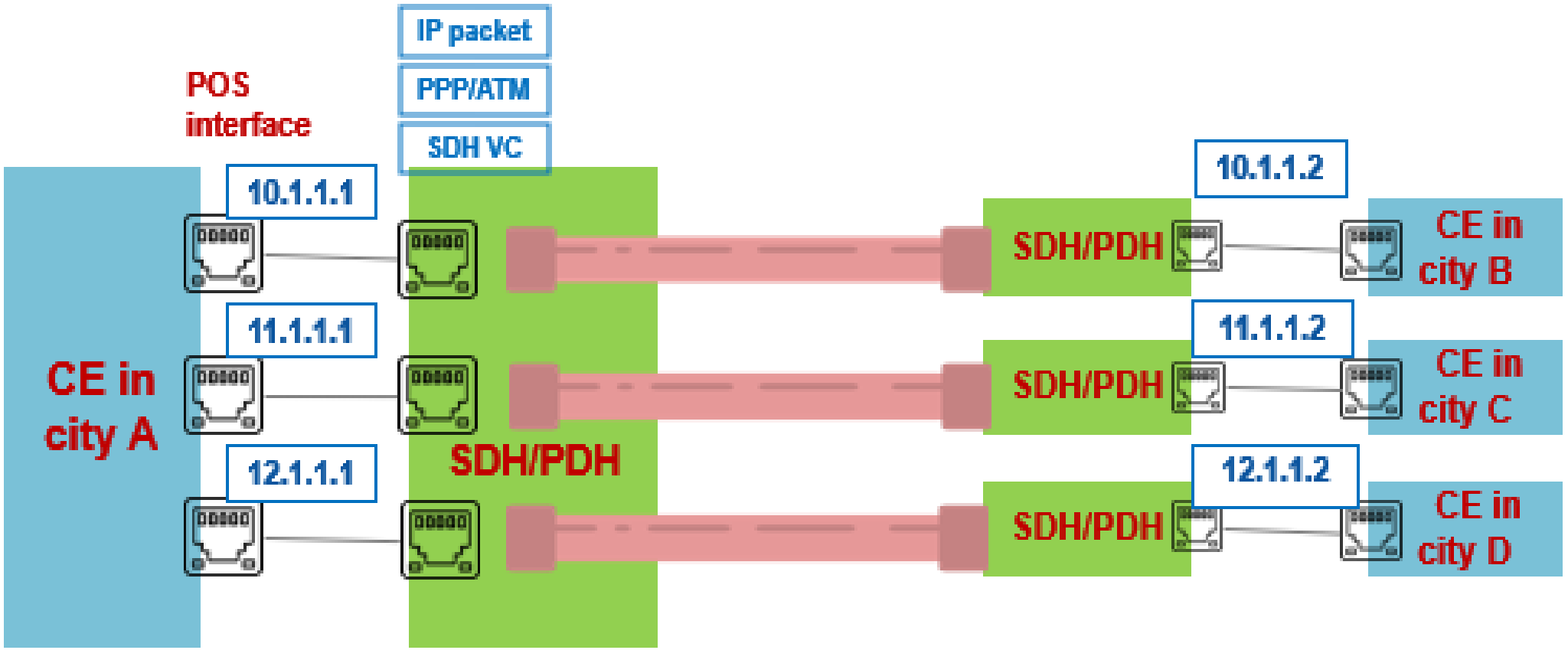
6. Packet forwarding

The ingress encapsulates the tunnel label stack into service packets. Each node through which the tunnel passes performs MPLS label switching and forwarding until the packets reach the egress.

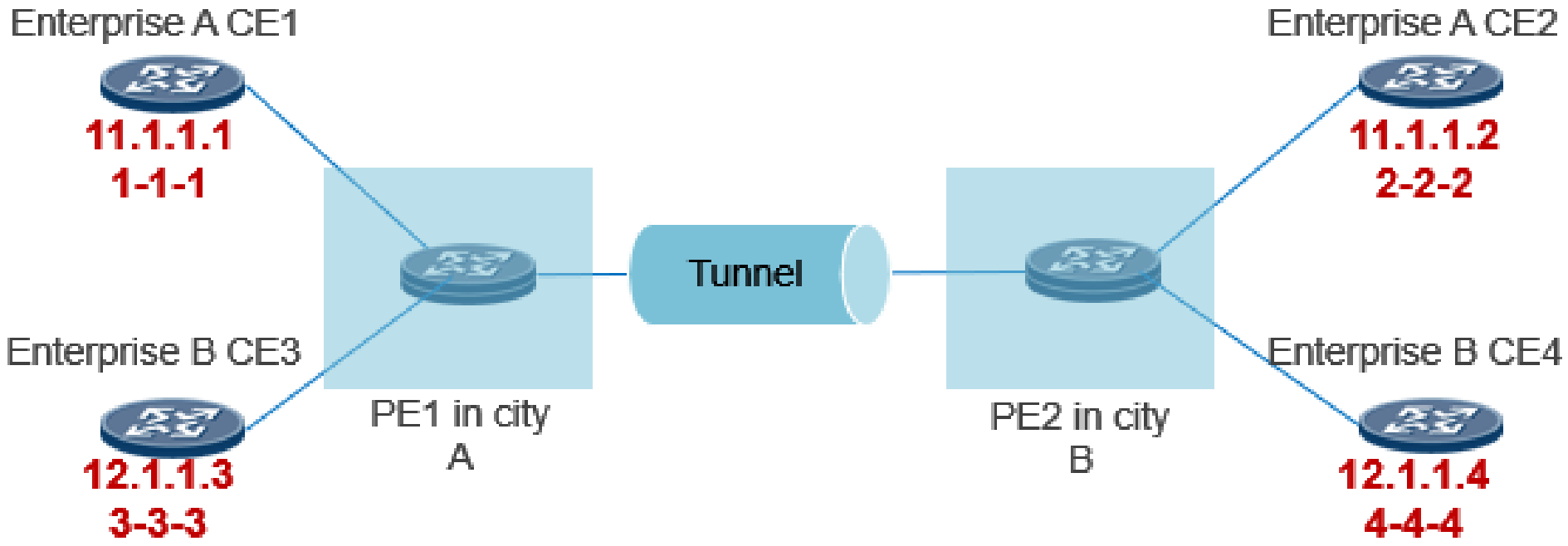
III. Evolución de Servicios de VPNs - EVPN

- EVPN (Ethernet Virtual Private Network) is a VPN technology used for Layer 2 network interconnection. EVPN uses the BGP/MPLS IP VPN mechanism to extend BGP and use extended reachability information so that MAC address learning and advertisement between Layer 2 networks of different sites can be transferred from the data plane to the control plane.

Leased Line Services in the TDM Era

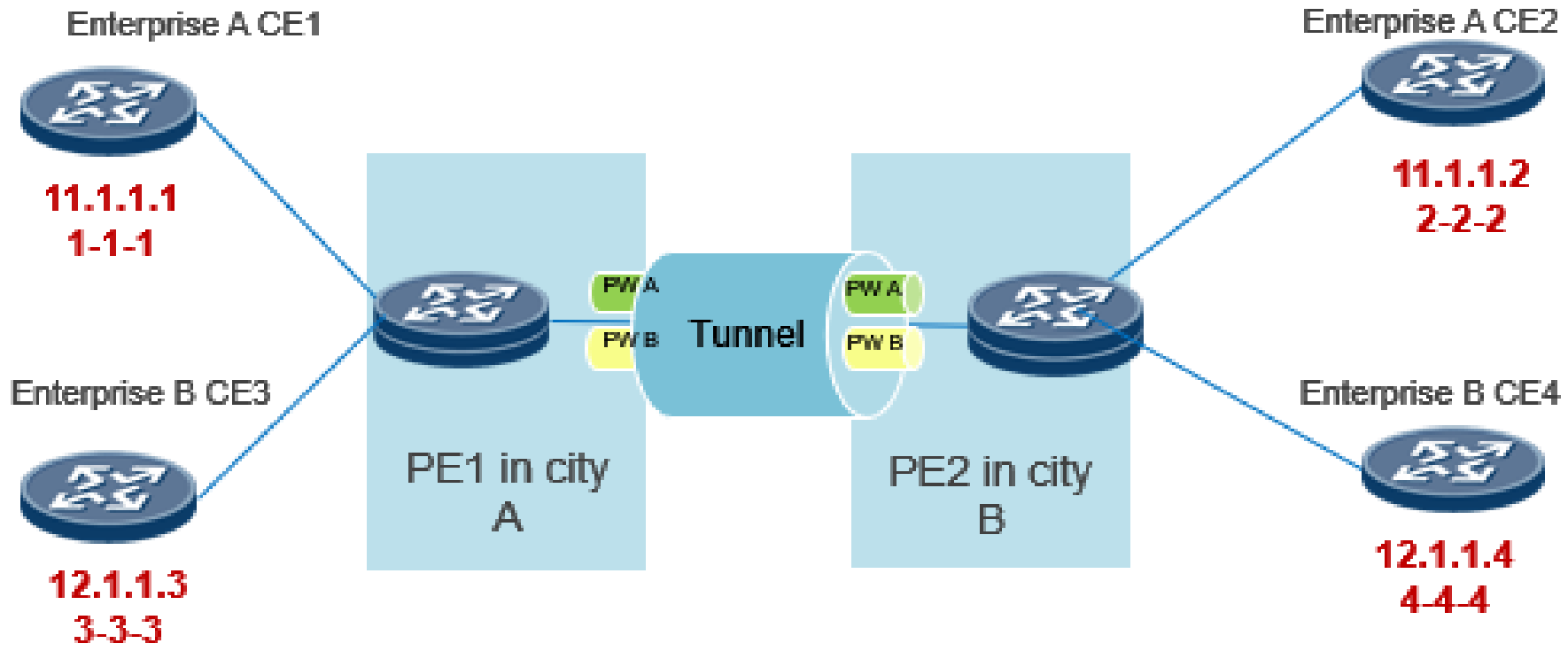


Understanding VPLS (1/4)



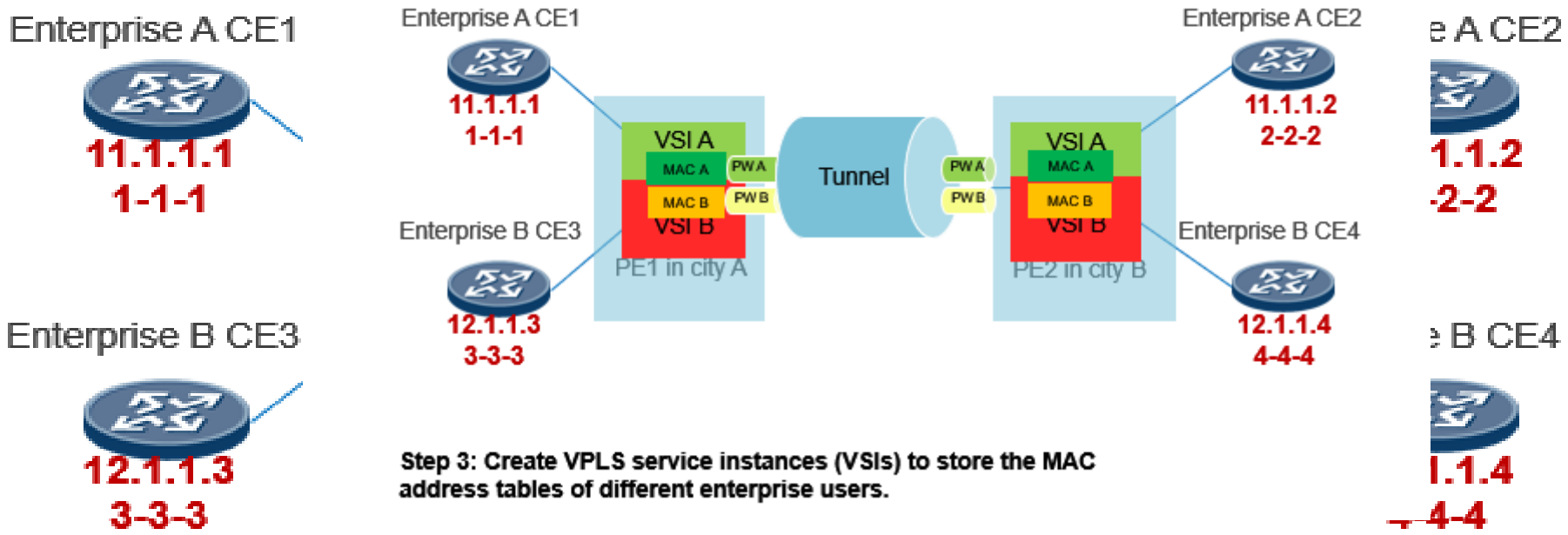
Step 1: Create a bearer tunnel (such as LDP and RSVP) between PE1 and PE2.

Understanding VPLS (2/4)



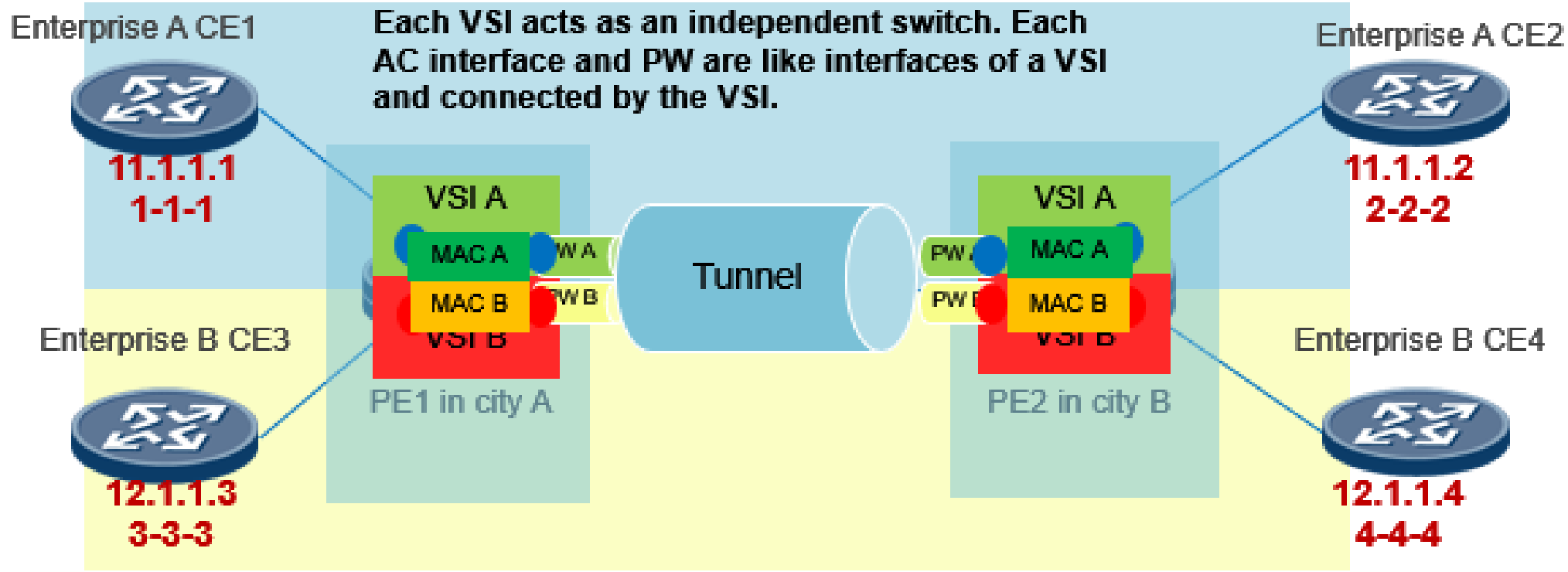
Step 2: Create PWs to carry services of different enterprises.

Understanding VPLS (3/4)



Step 3: Create VPLS service instances (VSIs) to store the MAC address tables of different enterprise users.

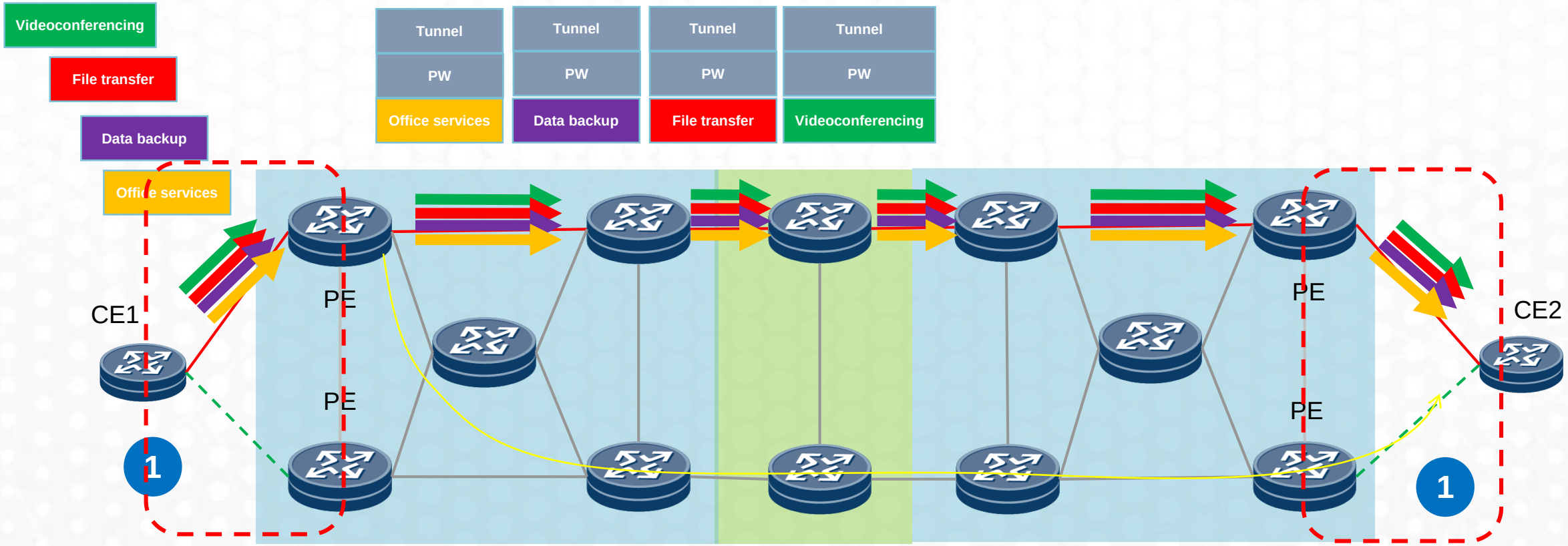
Understanding VPLS (4/4)



Step 4: Associate a PW with an AC interface in each VSI.

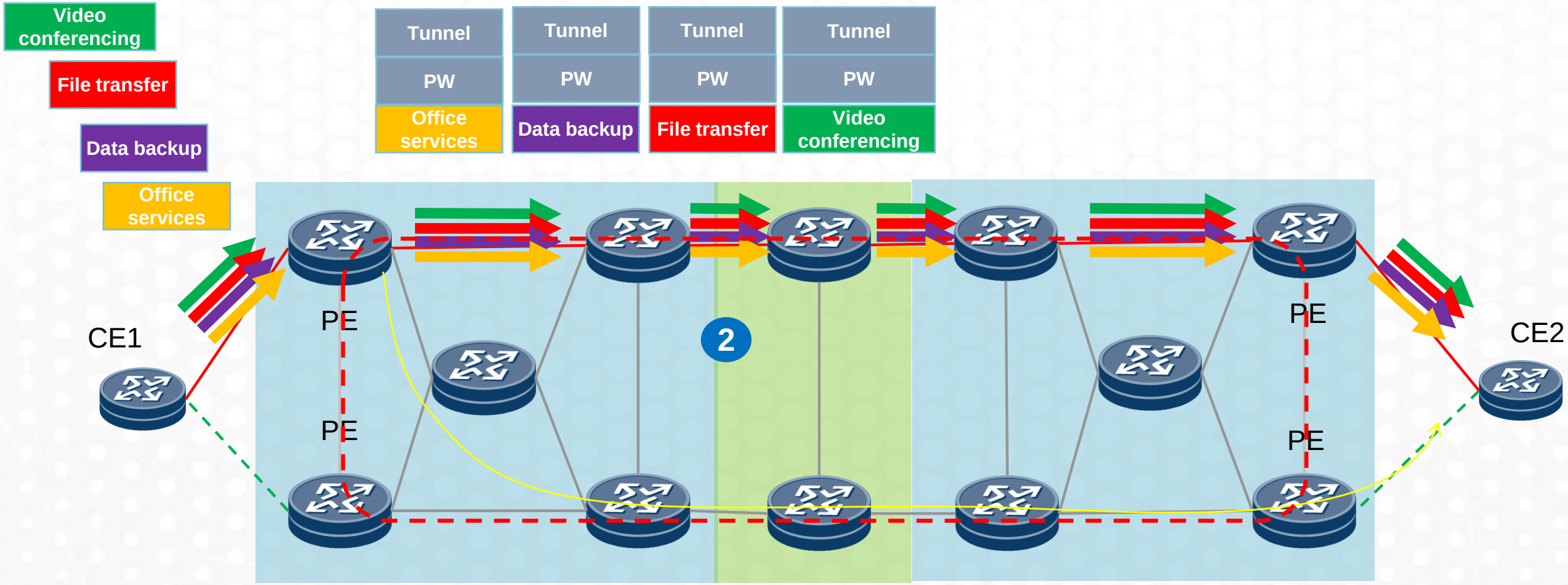
AC: A PE interface connected to a CE is an AC interface, which is used for user access.

Challenge 1: VPLS Single-Active Mode Causes Uneven Traffic Distribution (1/2)



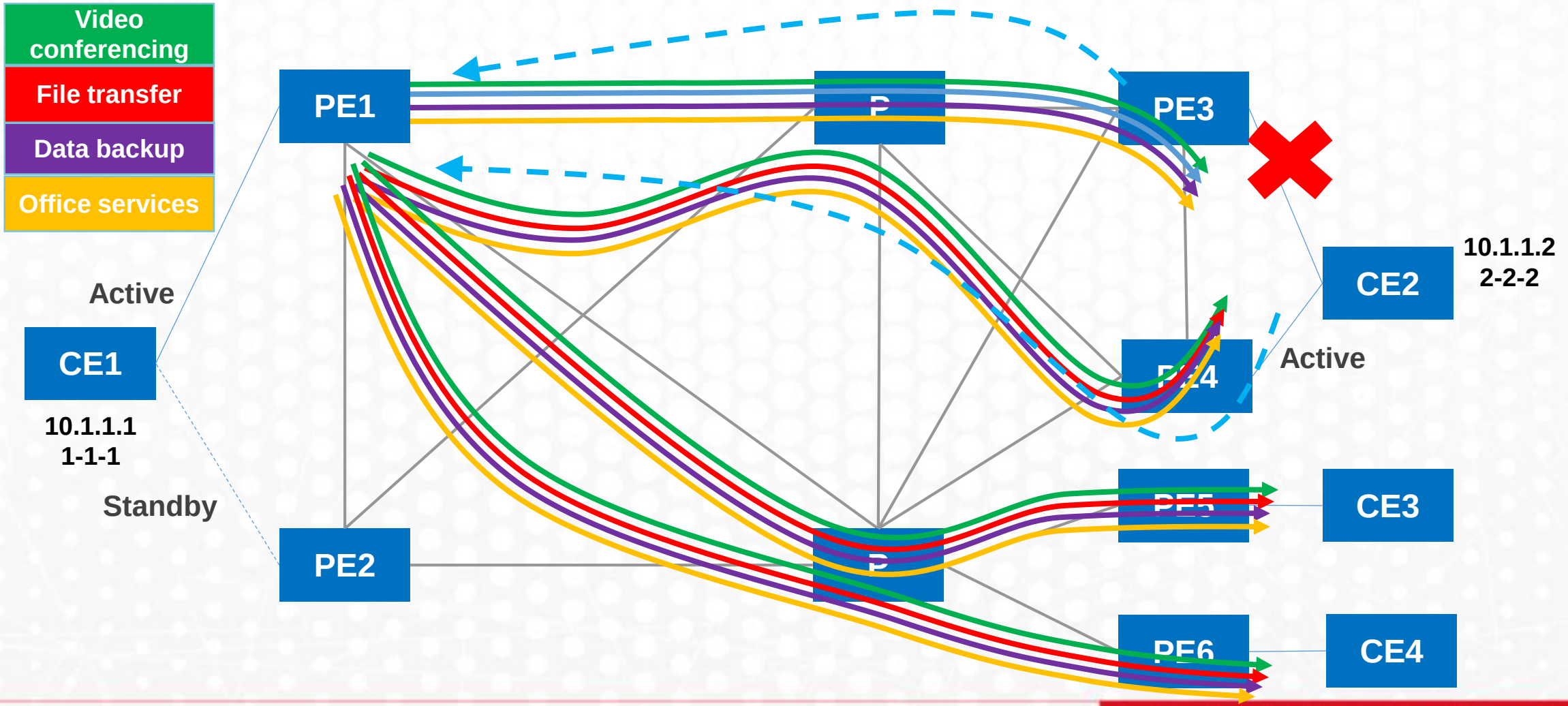
1 The links between CE1 and PEs work in active and standby mode, which wastes a link.

Challenge 1: VPLS Single-Active Mode Causes Uneven Traffic Distribution (2/2)

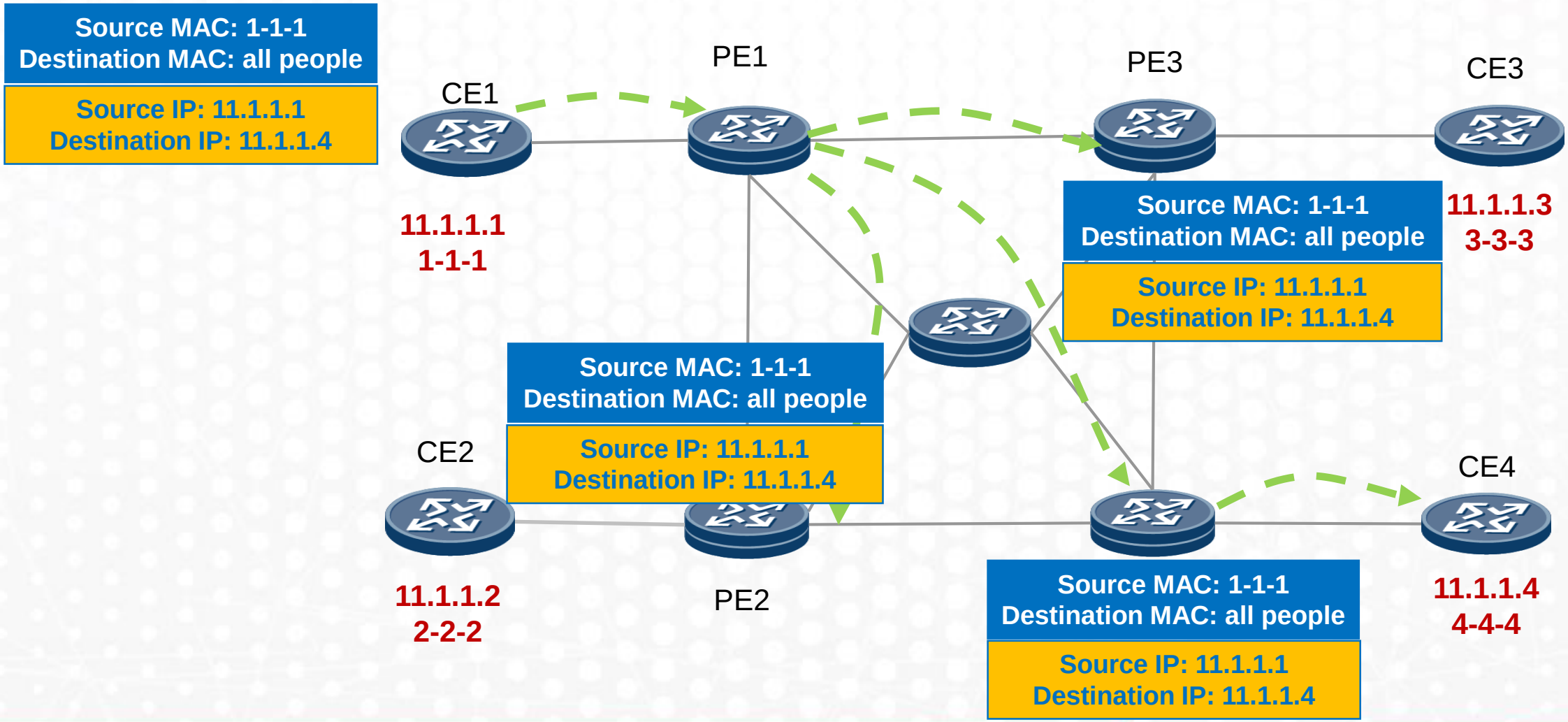


2 **Multiple paths cannot form on the network side, which may cause the active link to be congested.**

Challenge 2: VPLS Convergence Is Slow If a Fault Occurs

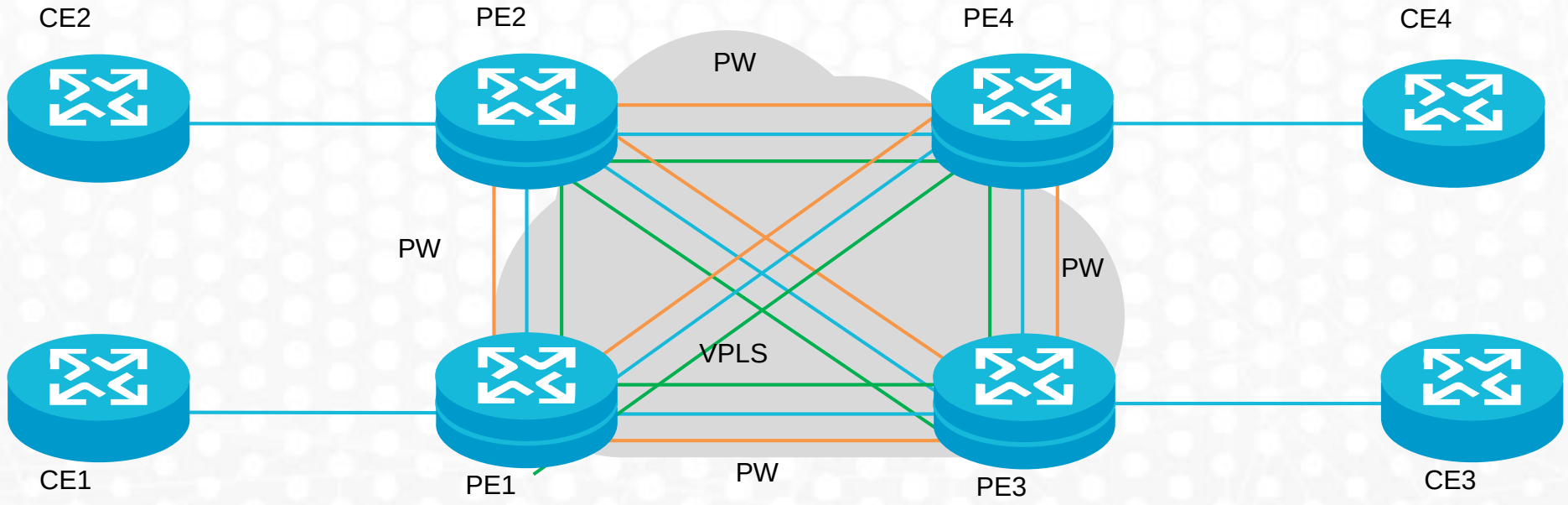


Challenge 3: ARP Request Flooding in Traditional VPLS Services

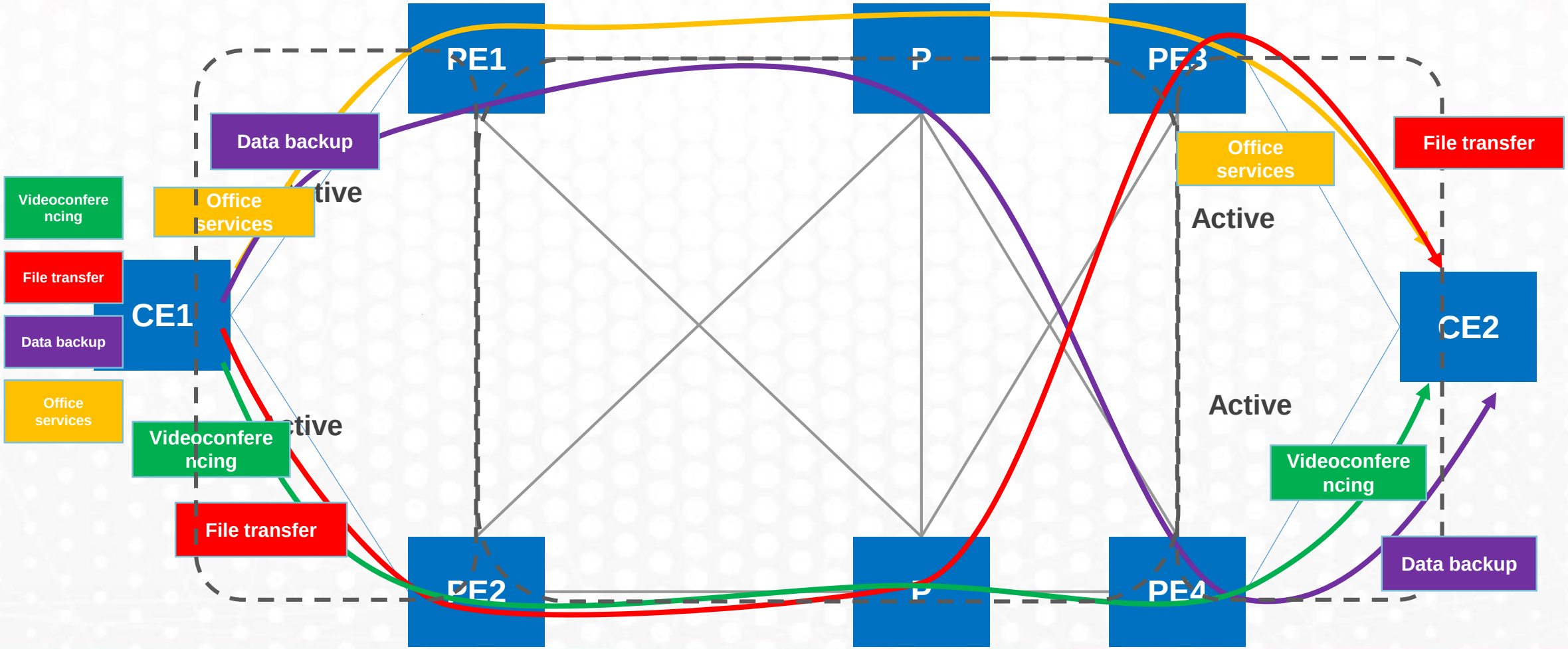


Challenge 4: VPLS Full-mesh Connection

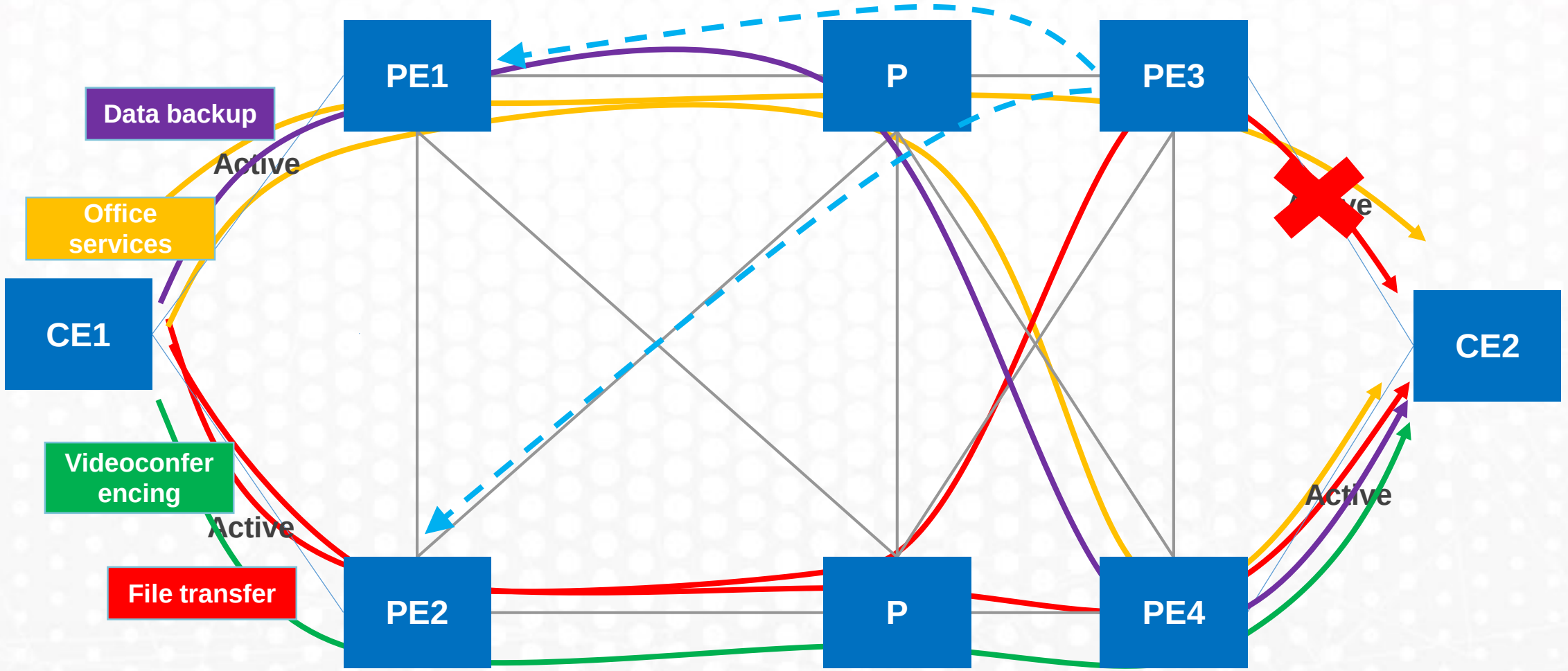
- On a VPLS network, multiple virtual switch instances (VSIs) that carry different services require dedicated PW connections between PEs, and all PEs must be fully meshed.



Value 1: EVPN Uses Active-Active Mode to Achieve Multiple Paths and Balance Traffic

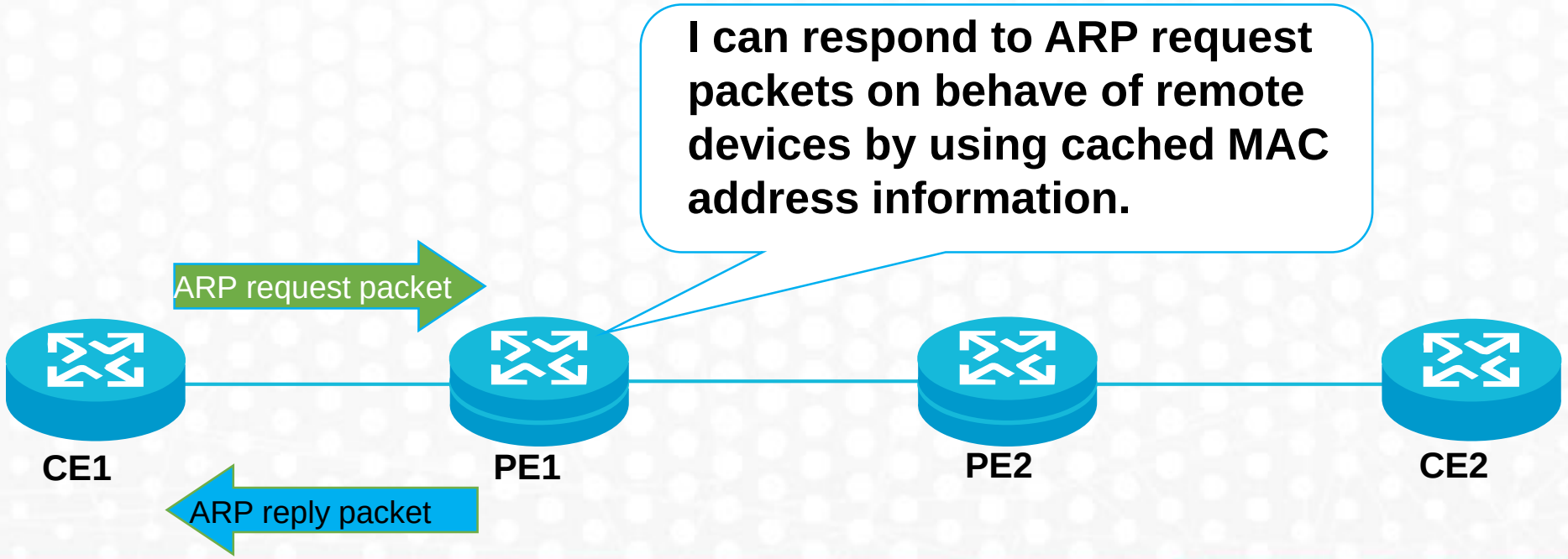


Value 2: EVPN's Fast Convergence Mechanism Makes Path Switching Easy

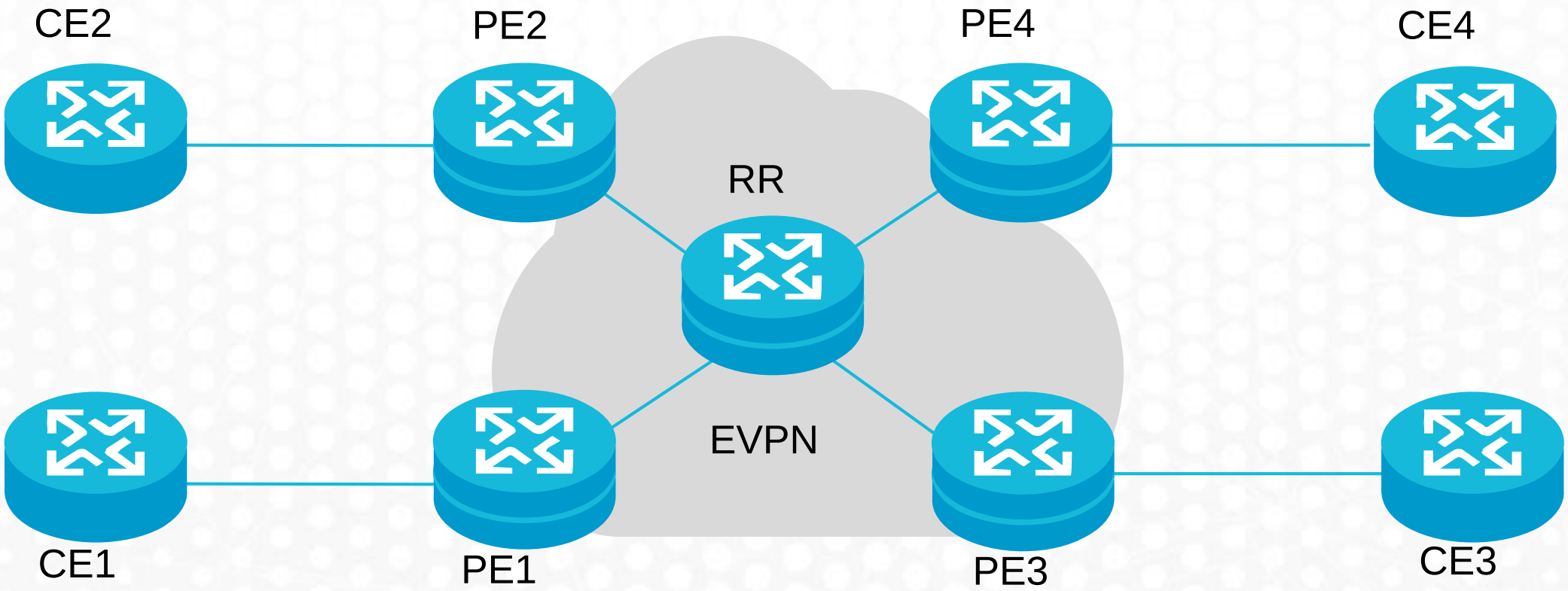


Value 3: Reduce Flooding Traffic

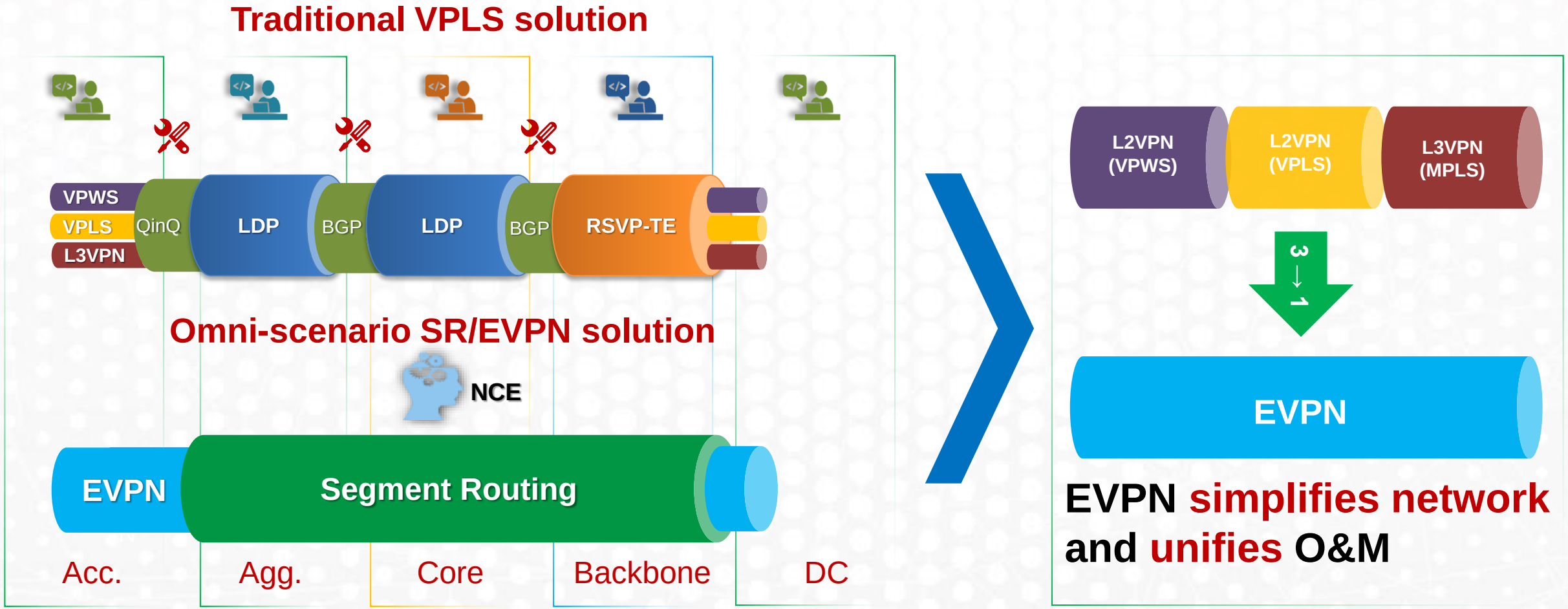
- EVPN enables PEs to use locally stored MAC addresses to respond to ARP request packets from connected sites, minimizing the number of broadcast ARP request packets.



Value 4: Use Reflectors to Reduce Connections



Value 5: L2/L3 Unified Bearer, Simplifying the Network



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