Connecting The Unconnected

With Cisco Validated Solution

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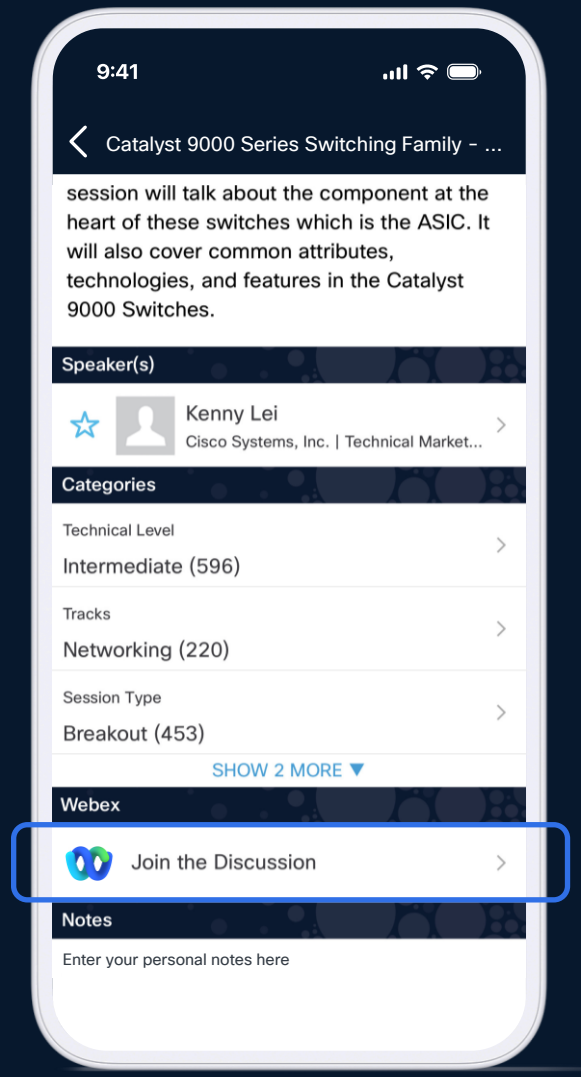


Agenda

01 Non-Terrestrial Connectivity

02 Building Resiliency with Satellite Connectivity

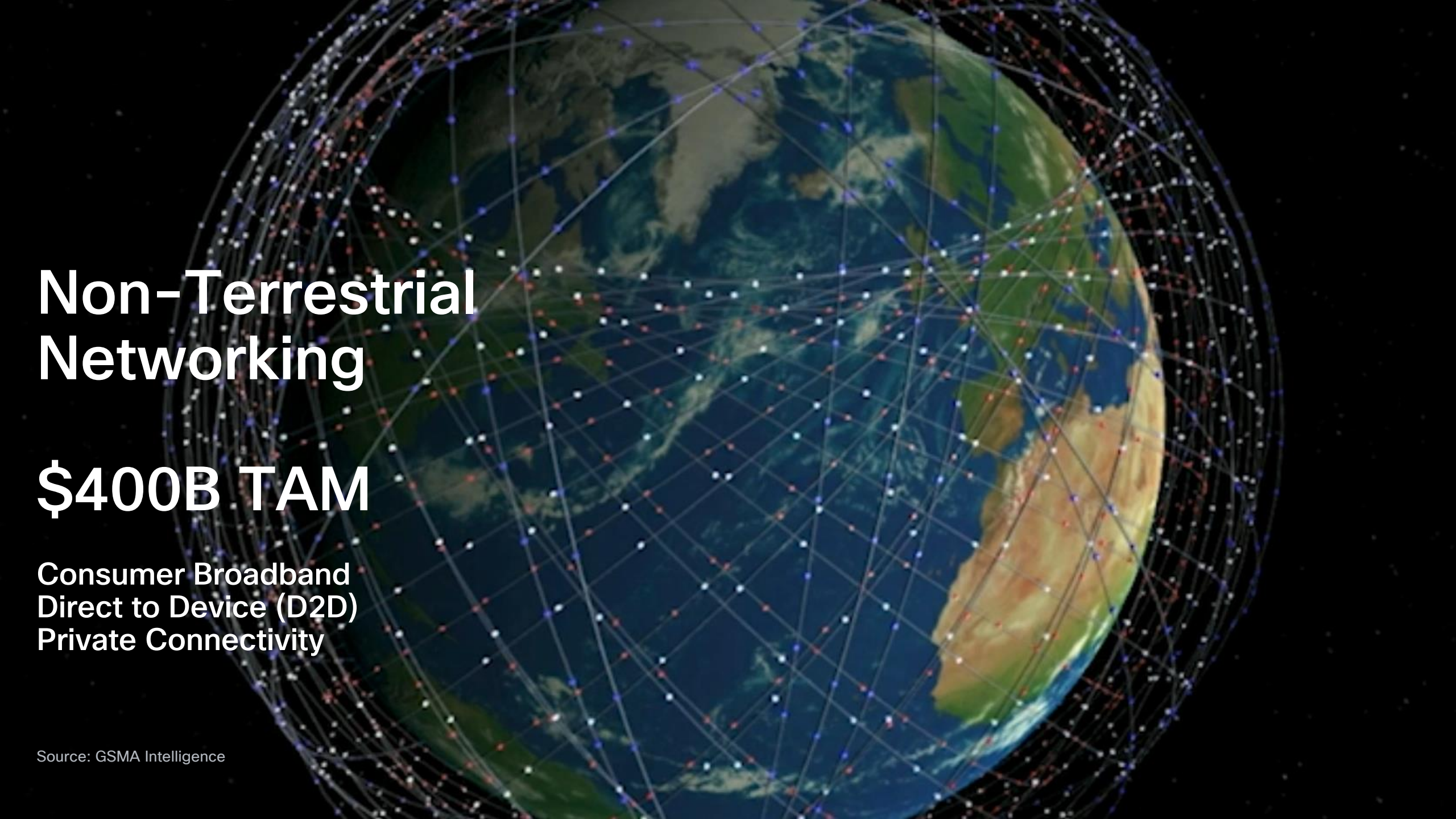
03 Cisco Validated Solution

04 Summary

Key Abbreviations

B2B	Business to Business
BBR	Bottleneck bandwidth and Routing-trip propagation Time
CPE	Customer Premises Equipment
CSR	Cell Site Router
D2D	Direct to Device
EVC	Ethernet Virtual Circuit
GEO	Geostationary Earth Orbit
IoT	Internet of Things
LEO	Low Earth Orbit
MEF	Metro Ethernet Forum
MEO	Medium Earth Orbit
MNO	Mobile Network Operator
MVNO	Mobile Virtual Network Operator
NR	New Radio (5G)
NTN	Non-Terrestrial Network
NWPI	Network Wide Path Insight
OMP	Overlay Management Protocol
O-ISL	Optical Inter-satellite Link
PCA	Provider Connectivity Assurance
PE	Provider Edge
POP	Point of Presence
RAN	Radio Access Network
SD-WAN	Software Defined Wide Area Network
SNO	Satellite Network Operator
TAM	Total Addressable Market
TLOC	Transport Locator
TN	Terrestrial Network
UMTS	Underlay Measurement and Tracing Service

Non-Terrestrial Connectivity



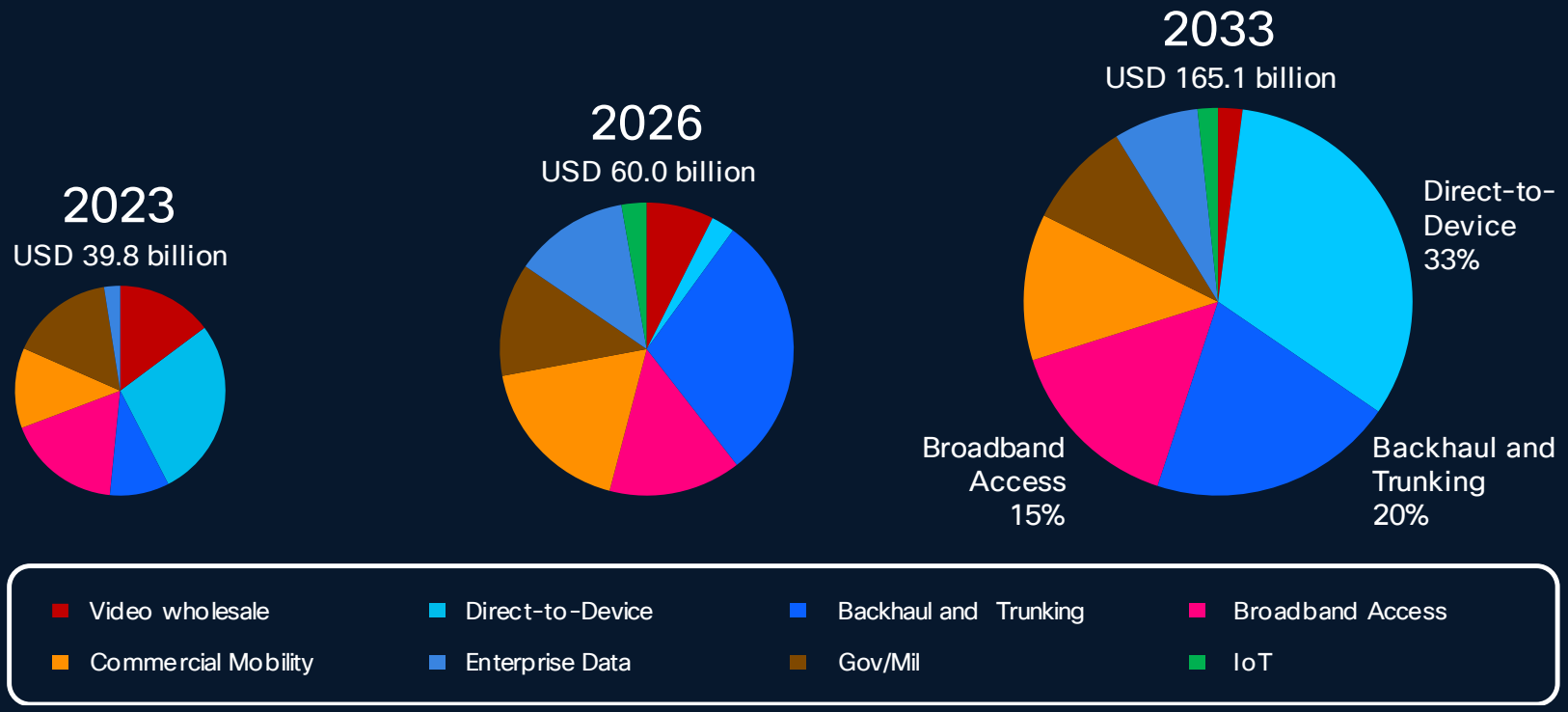
Non-Terrestrial Networking

$400B TAM

Consumer Broadband
Direct to Device (D2D)
Private Connectivity

Source: GSMA Intelligence

How big is the satellite opportunity for Telcos?



Source: Analysys Mason 2025

Developing a satellite strategy provides telcos with a unique edge over their competitors

- **Untapped markets for telcos**
  - Rural broadband
  - Satellite Mobility
  - Enterprise networks in remote locations
  - Government/Military
- **New service opportunities**
  - Enhanced quality of service
  - Global coverage
  - Network resiliency
  - Emergency services/Disaster recovery
  - Private networks/Data ownership at global level
- **Cost optimization of rural deployments**

Connecting the Unconnected

Use Cases

Consumer Connectivity

Consumer Broadband

Mobile Connectivity

Business Continuity

Business Broadband

Mobile Backhaul

Private VPN

SD-WAN VPNs

Industry Verticals

Aviation Maritime

Automotive

Industrial IoT

Utility

Smart Agriculture

Supply Chain

Emergency Services

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Competitive Outlook

Satellite Operator Constellation

Satellite Constellation	Satellites in Orbit	Planned Constellation	% Deployed
Starlink	7875	12000	66%
Lynk	5	5000	0.1%
Kuiper	27	3232	1%
Eutelsat OneWeb	655	673	97%
SES / Intelsat	142	142	100%
Iridium	66	66	100%
AST SpaceMobile	5	60	8%
Viasat / Inmarsat	23	41	56%
Globalstar	32	32	100%
Ecostar	10	10	100%
Space42 (Yashat + Bayanat)	6	8	75%

Source: GSMA Intelligence

Competitive Outlook

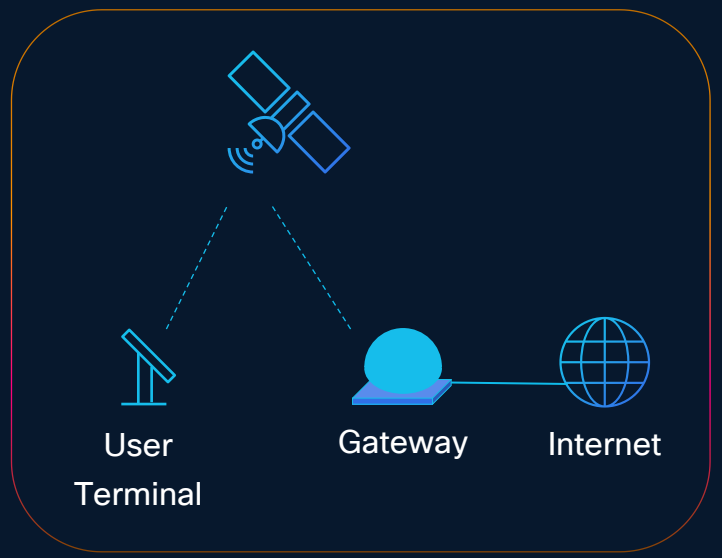
Satellite Operator Footprint

Satellite Operator	Live Partnership with Telecom Operator	Planned Telecom Operator Partnership	Solution: Direct to BTS	Solution: Direct to Device
AST Space	0	31	6%	94%
Lynk	3	23	4%	96%
Starlink	8	13	52%	48%
SES / Intelsat	8	12	95%	5%
Eutelsat / OneWeb	3	8	91%	9%
Others	11	38	47%	53%
Total / Average	**33**	**125**	**42%**	**58%**

Source: GSMA Intelligence

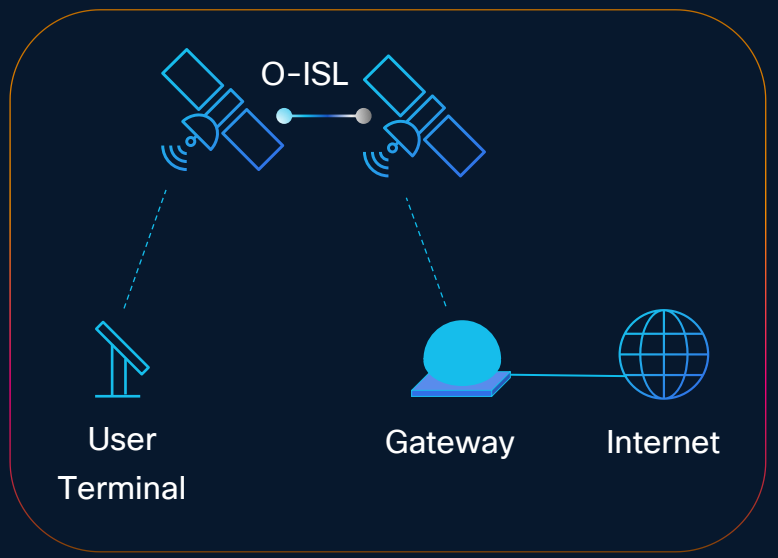
Evolving Satellite Architectures

LEO TYPE - 1



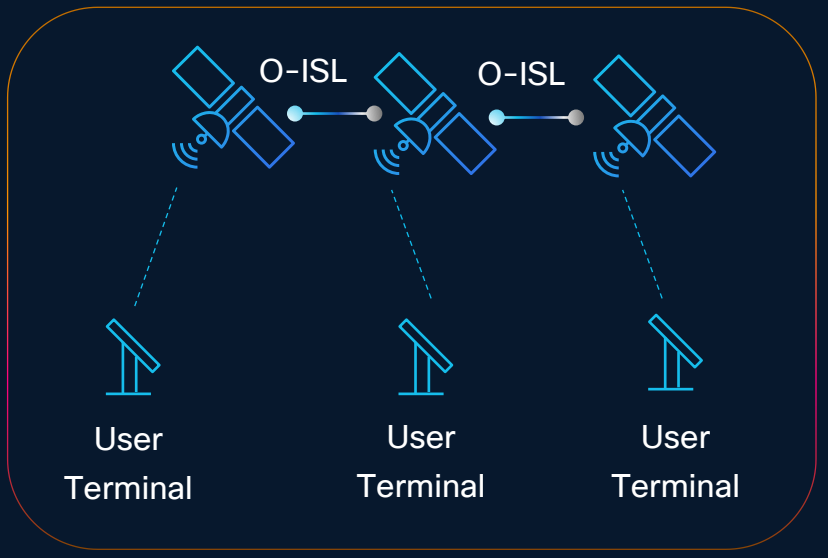
- Traffic is served by single Satellite
- Traffic is routed to nearest GW
- Coverage ~1000Km
- Use cases:
  - Fixed connectivity solutions
  - IoT solution

LEO TYPE - 2



- Traffic is routed to nearest GW
- Coverage multiple of 1000Km
- Use cases:
  - Broadband
  - Backhaul
  - Enterprise P2P
  - D2D solution

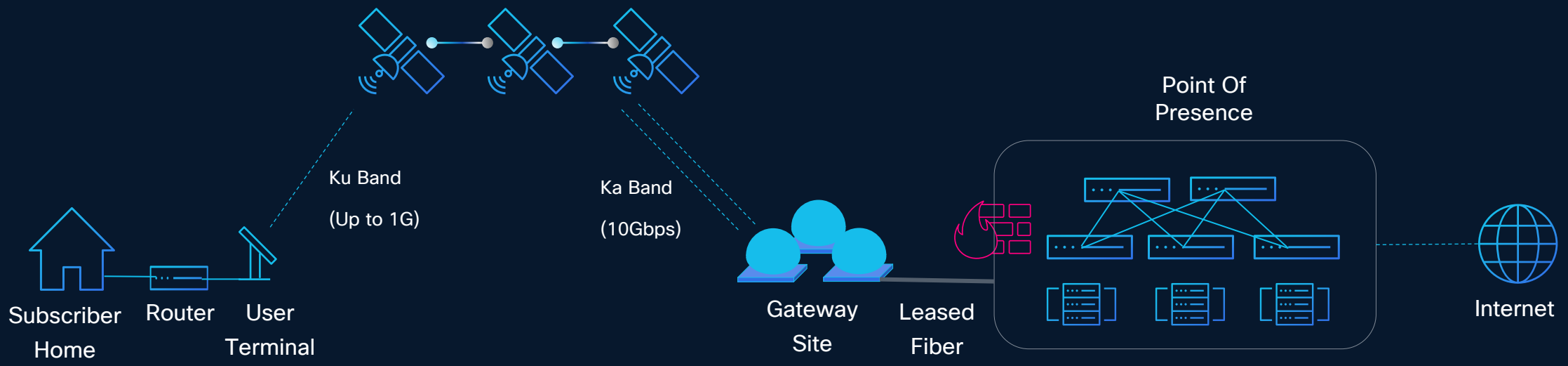
LEO TYPE - 3



- GW less architecture
- Flexible Routing
- Any to Any connectivity
- Lowest point-to-point latency for long distance communication
- Use cases:
  - Backhaul,
  - Enterprise P2P, P2MP solutions

Service Architecture

L3 Services : Home Subscriber

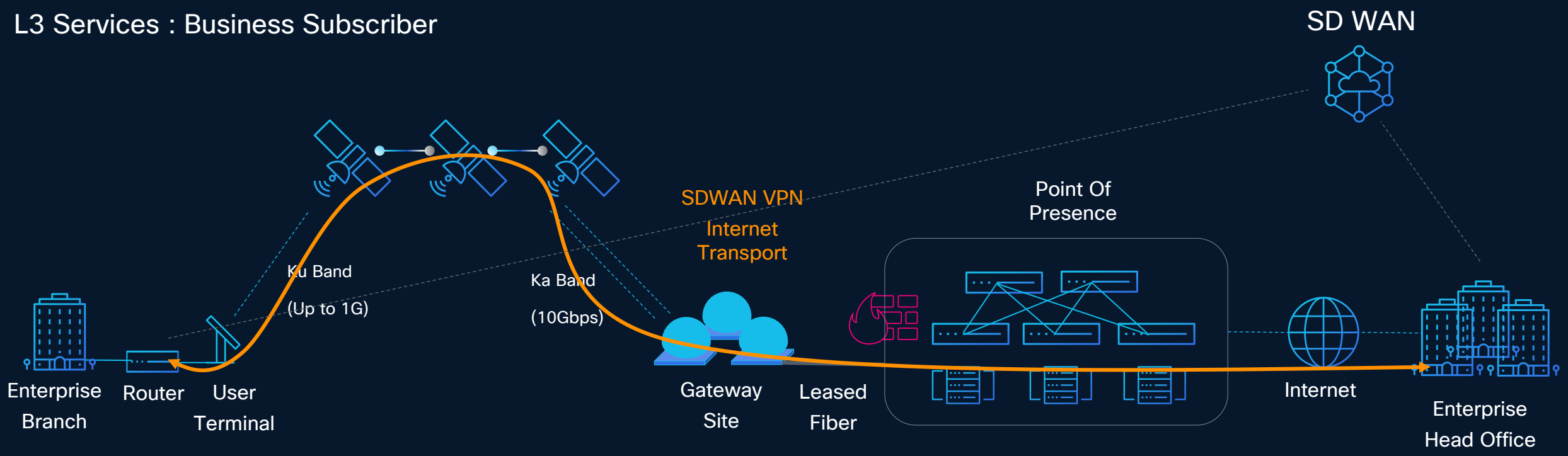


DHCP IP Address Assignment to Router interface 1

2 Subscriber connects to internet

Service Architecture

L3 Services : Business Subscriber



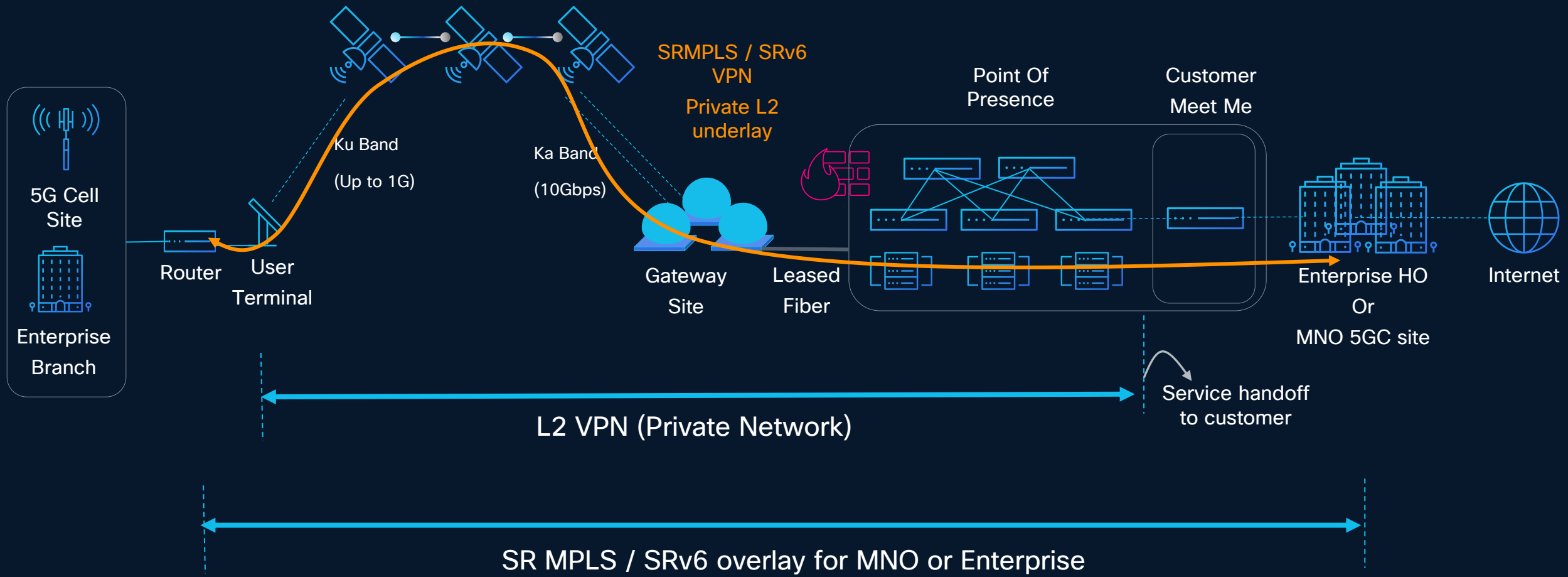
1 DHCP IP Address Assignment to Router interface

2 Router checks connectivity to internet

3 SDWAN VPN overlay is provisioned for Enterprise network

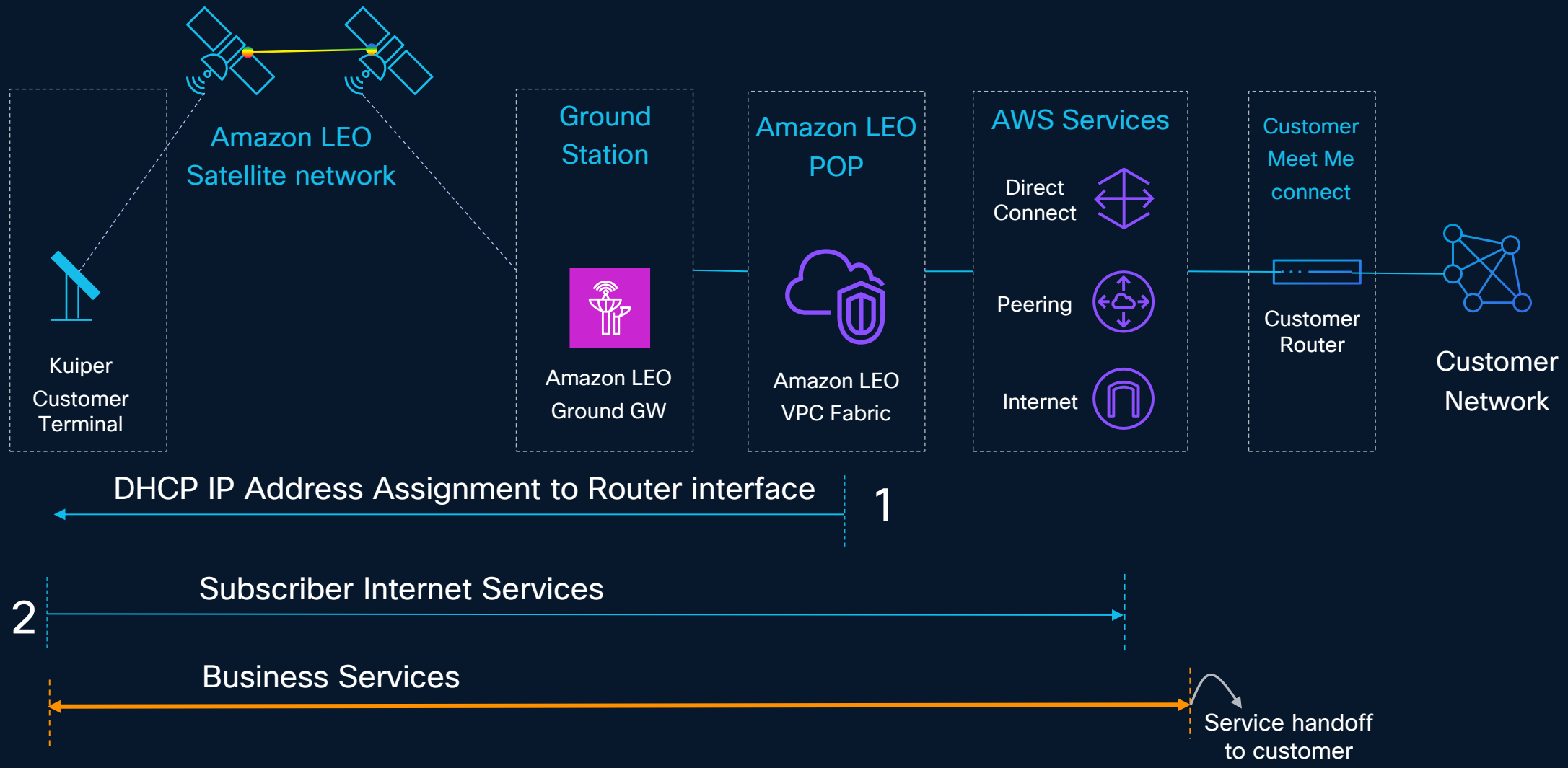
Services Architecture

L2 Services



Network Architecture

Example: Amazon LEO



Cisco Offerings

Cisco NTN Solution

Mobile backhaul
- Cell site router with dense 1/10GE interface support
- Policy-based routing
- Time synchronization

Meet-me Point / Peering services
- High scale and mature feature sets
- MEF 3.0 certified platform

Terrestrial infrastructure services
- Metro fabric architecture
- Cisco® 8000 Series or Nexus-based data center fabric
- Distributed Edge/ Inference solution

SD-WAN managed services
- Service on demand

Service assurance
- SLA measurement with PCA
- Improved user experience with PCA-UE
- Performance visibility across domains with ThousandEyes®

Security
- Post-quantum security
- Trusted routing products for defence and govt sector
  - Trust Anchor, Secure Boot, Secure OS
  - DDoS protection
  - MACSec / IPSec

Mobility roaming partnership
- Rich 3GPP feature set

Private 5G
- Remote site connectivity using NTN
- P5G Mobility Solution

Direct to device/NTN-IoT
- Full Stack Serivces with IoT Contact Center Solution

Cisco Offerings

Routing and switching

- Access routing: NCS 540, 8000 Series
- Ground stations/POP infrastructure: NCS 57xx, 8000 Series
- Routed Optical Networking with ZR/ZR+ Optics
- Cisco Virtual Routing Platforms – XRd and vXR 8000 emulator

Optical

- Ground station connectivity
- Coherent optics

Assurance

- Cisco® Provider Connectivity Assurance (PCA)
- PCA-UE AIOps (intelligent traffic identification and management)
- SRv6 Integrated Performance Measurement (SR-IPM) for SLA visibility at high rate

IoT/Direct to device

- Mobility Services Platform
- IoT Control Center
- Private 5G

SD-WAN and Security

- Enterprise site connectivity
- Security

CX Professional Services

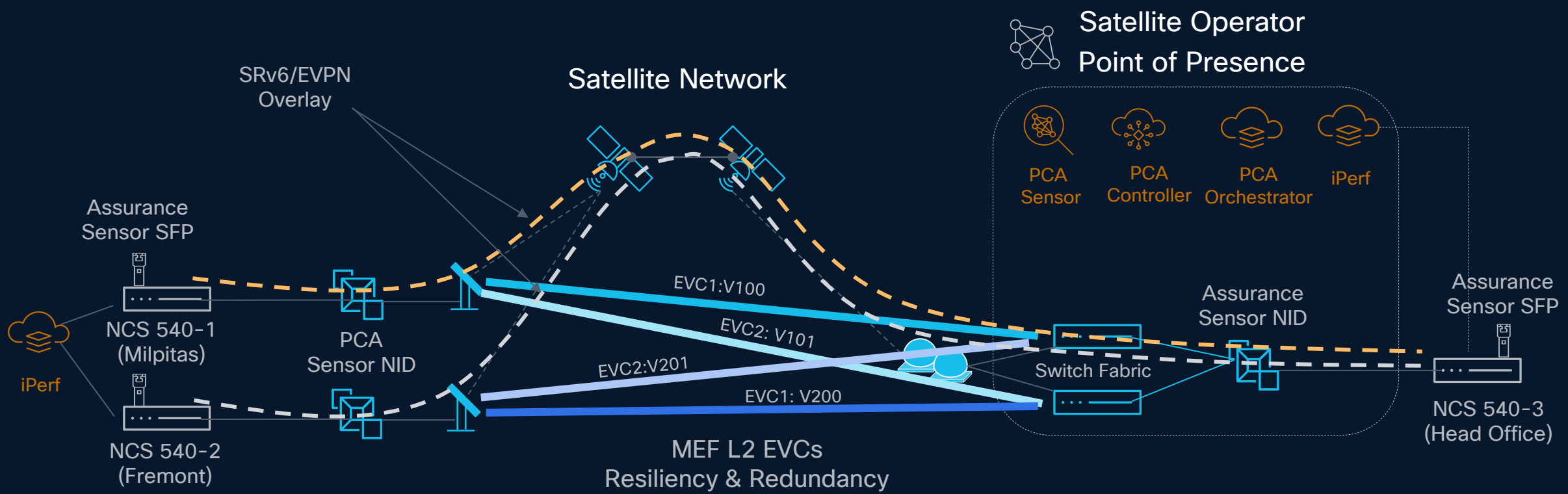
- Planning, deployment, and integration professional services for satellite ecosystem
- Consulting services

Cisco Validated Design

Mobile Backhaul and Enterprise Over Private L2 VPN

Cisco Lab Topology

L3 EVC based Private VPN Scenario



Features Validated

- SR/MPLS L2 / L3 VPN Overlay
- SRv6 L3 VPN Overlay
- SRv6 EVPN Overlay
- Segment Routing Performance Management (SR-PM) and Integrated Performance Management (IPM)
  - Latency Measurement
  - Liveness check
  - Packet loss measurements
- Satellite Terminal Performance Measurement
- Quality of Service (QoS) Measurement

Performance Results

Bandwidth Performance Single Terminal

Test Description	Single iPerf Flow		Multiple iPerf Flows	
TCP Baseline	Upload	Download	Upload	Download
	19.7 Mbps	200 Mbps	21.0 Mbps	180.2 Mbps
UDP Baseline	Upload	Download	Upload	Download
	21.9 Mbps	198 Mbps	27.8 Mbps	218 Mbps

- Avg Terminal Up-link performance is observed between 18-25Mbps
- Avg Terminal Down-link performance is observed between 100-190Mbps
- Avg latency is <20ms, packet loss is <1%

Performance Results

Bandwidth Performance with QoS

Test Description	Upload	Download	Jitter	Packet Loss
Low Latency Flow [QoS Marking: DSCP 48] 10Mbps UP / 100Mbps Down	9.98 Mbps	99.9 Mbps	1.65ms (Up) 0.29ms (Down)	0.20% (Up) 0.10% (Down)
Best Effort Flow [QoS Marking: DSCP 40] 10Mbps UP / 100Mbps Down	9.98 Mbps	99.9 Mbps	1.71ms (Up) 0.20ms (Down)	0.21% (Up) 0.10% (Down)
Low Latency Flow [QoS Marking: DSCP 48] 25Mbps UP / 150Mbps Down	24.8 Mbps	150 Mbps	0.75ms (Up) 0.13ms (Down)	0.82% (Up) 0.05% (Down)
Best Effort Flow [QoS Marking: DSCP 40] 25Mbps UP / 150Mbps Down	24.8 Mbps	149 Mbps	0.62ms (Up) 0.13ms (Down)	1.00% (Up) 0.88% (Down)
Low Latency Flow [QoS Marking: DSCP 48] 50Mbps UP / 250Mbps Down	38.0 Mbps	234 Mbps	0.60ms (Up) 0.08ms (Down)	23.00% (Up) 6.06% (Down)
Best Effort Flow [QoS Marking: DSCP 40] 50Mbps UP / 250Mbps Down	29.2 Mbps	246 Mbps	0.30ms (Up) 0.08ms (Down)	42.00% (Up) 1.6% (Down)

Low Latency Class maintained better KPI performance compared to Best Effort class.

Performance Results

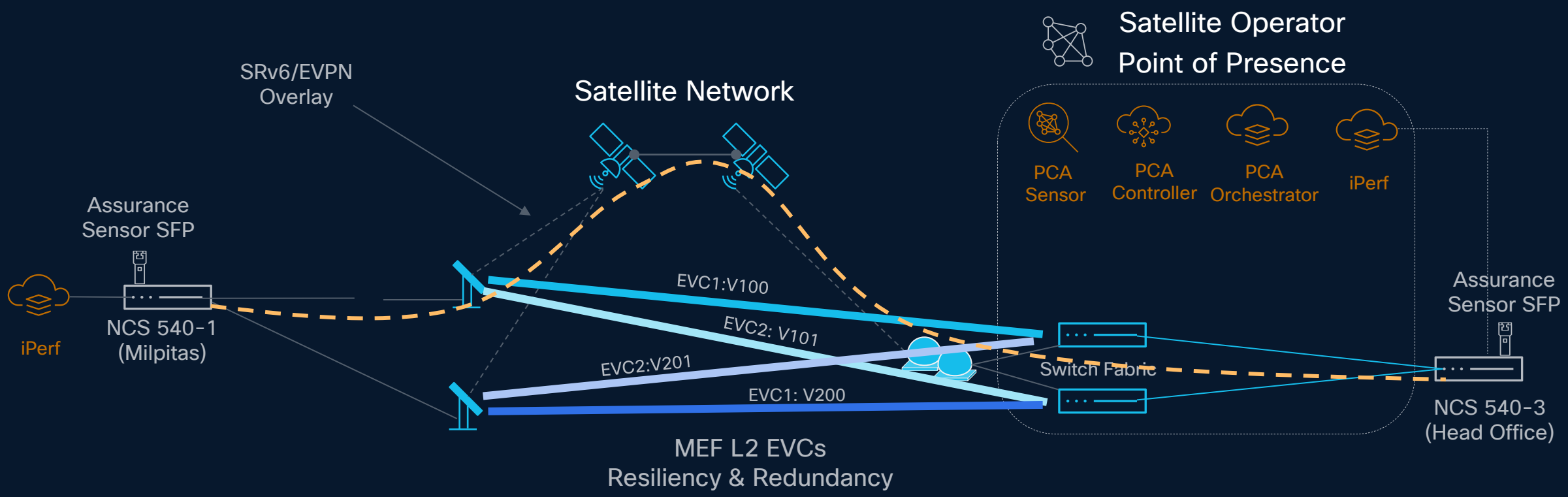
Bandwidth Performance with QoS

Test Description	Upload	Download	Jitter	Packet Loss
Mix QoS Flows (5Mbps Up / 25Mbps Down per flow)				
Flow 1: Low Latency	5 Mbps	25 Mbps	2.58ms (Up) 0.75ms (Down)	0.06% (Up) 0.08% (Down)
Flow 2: Best Effort	5 Mbps	25 Mbps	3.03ms (Up) 0.75ms (Down)	0.08% (Up) 0.10% (Down)
Mix QoS Flows (10Mbps Up / 50Mbps Down per flow)				
Flow 1: Low Latency	9.97 Mbps	49.9 Mbps	2.05ms (Up) 0.38ms (Down)	0.13% (Up) 0.20% (Down)
Flow 2: Best Effort	9.80 Mbps	49.9 Mbps	2.16ms (Up) 0.38ms (Down)	1.9% (Up) 0.19% (Down)
Mix QoS Flows (15Mbps Up / 75Mbps Down per flow)				
Flow 1: Low Latency	15.0 Mbps	74.9 Mbps	0.98ms (Up) 0.24ms (Down)	0.17% (Up) 0.13% (Down)
Flow 2: Best Effort	14.4 Mbps	74.9 Mbps	1.12ms (Up) 0.24ms (Down)	4.3% (Up) 0.14% (Down)

Low Latency Class maintained better KPI performance compared to Best Effort class.

Cisco Lab Topology

Multi-Terminal Scenario



Features Validated

- Satellite multi-terminal solution
- Traffic load-balancing across multiple terminals
- SRv6 Flex-algo for intelligent slicing and traffic path programmability based on service SLAs
- Local and remote failure scenarios

Performance Results

Bandwidth Performance with Multi-terminal

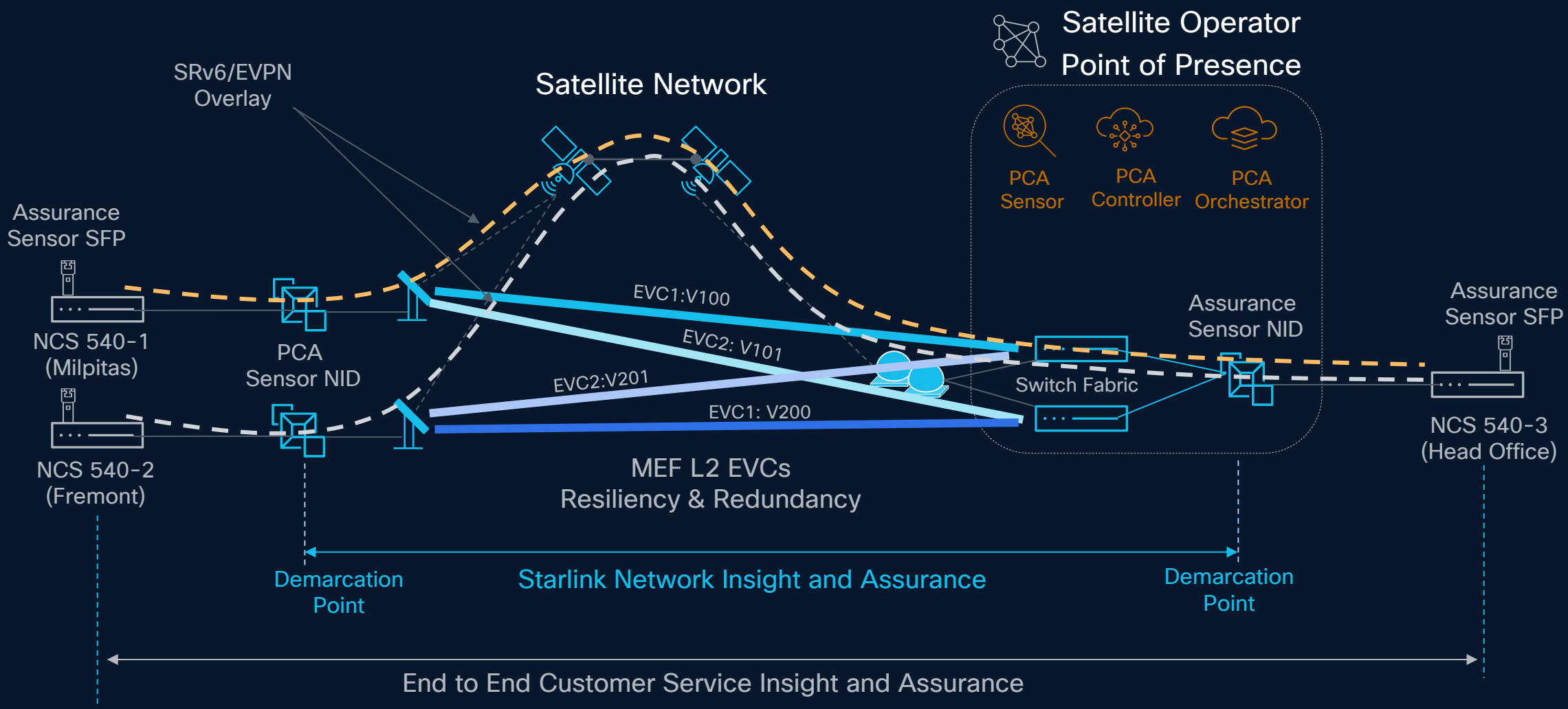
Traffic Load-balancing Across Multiple Terminals	Flows are load-balanced across Terminals	
TCP Baseline	Upload	Download
Two iperf flows are generated in Uplink (10Mbps) and Downlink (100Mbps each) direction	20.0 Mbps	293 Mbps
Two iperf flows are generated in Uplink (22Mbps) and Downlink (200Mbps)	38.4 Mbps	390 Mbps
UDP Baseline	Upload	Download
Two iperf flows are generated in Uplink (10Mbps) and Downlink (150Mbps)	20.0 Mbps	297 Mbps
Two iperf flows are generated in Uplink (22Mbps) and Downlink (200Mbps)	43.4 Mbps	393 Mbps

Failover Test with Multi-Terminal	Stable Condition		Failure Condition	
	Upload	Download	Upload	Download
Terminal Failure / Local Failure	43.4 Mbps	198 Mbps	32.5 Mbps	196.3 Mbps
Remote Failure	43.4 Mbps	198 Mbps	31.5 Mbps	195.8 Mbps

Note: Terminal bundling is not possible, as each terminal configures static unique EVCs

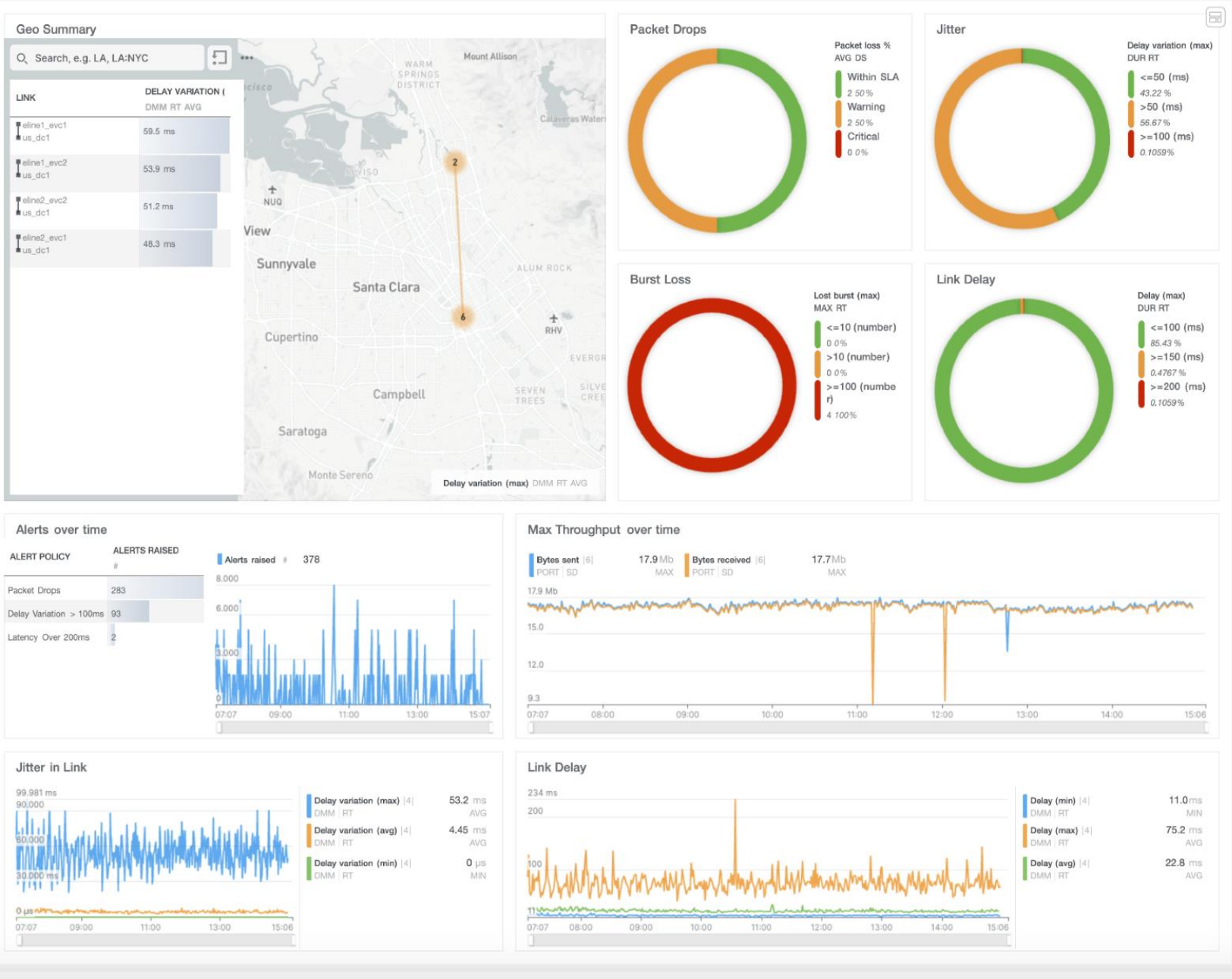
Cisco Lab topology

Service Assurance Scenario

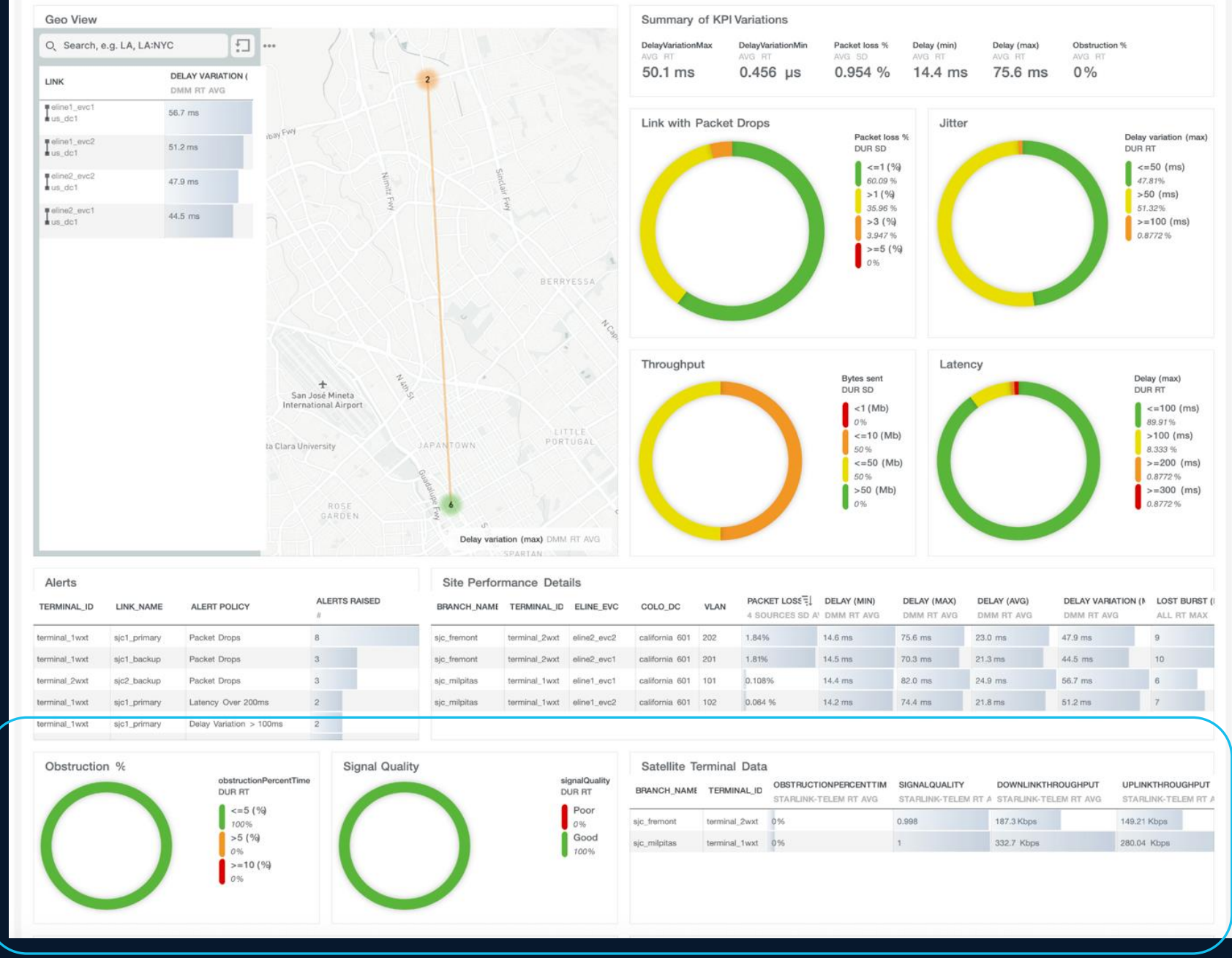


Cisco Lab Validation

Satellite Network Insight



End-to-End Service Insight



Correlation Analysis on Patterns, Trends, Location Data

Cisco 8000 Series

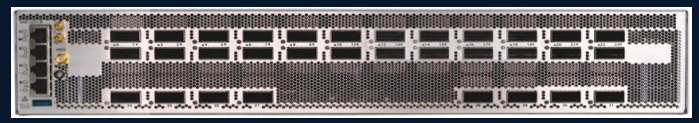
Satellite Operator Point-of-Presence Fabric and Meet-me-Switch

POP Fabric Types:

- Corporate IT
- NOC / SOC
- Services / Packet Core
- AI Inference

- Customer Meet Me
- Peering Fabric

8202-32FH-M



8212-48FH-M

8711-32FH-M

8711-48Z-M

8712-MOD-M

Scale & Features

- ✓ High Density Interfaces speed support:
  - 10G, 25G, 50G
  - 100G, 200G, 400G & 800G
- ✓ Reduced footprint
- ✓ Efficient Low Power consumption
- ✓ IP+Optical: 400G ZR/ZRP & 100G ZR support
- ✓ In-built Security Feature sets

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Cisco 8000 Series

Enterprise CPE and Backhaul Cell Site Router

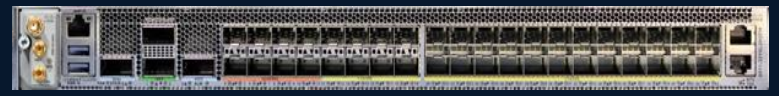
8011-12G12X4Y-A/D

12x1G + 12x1/10G + 4x1/10/25G

8011-4G24Y4H-I

4x1G Cu + 24x1/10/25G + 4x100G

8011-32Y8L2H2FH



32x1/10/25G + (8x10/25/50G OR 1x400G)
+ (1x400G OR 2x100G)

Flexible Deployment

- ✓ 1 RU I/C-temp devices offering 1/10/25/100/400G
- ✓ 1G auto-neg support
- ✓ Low forwarding latency

Best in-class experience

- ✓ Carrier Grade Feature and Scale support
- ✓ Class C, GNSS with PRTC-B for better performance
- ✓ Smart Fan Algo, Better power efficiency (40% lower power)
- ✓ MACSec on all ports, IPSec(upto 200G)

Simplification

- ✓ Unified architecture with SiOne SDK across Core, Edge, Access and DC
- ✓ Power Efficient Si-One, 80 Plus PSU cert

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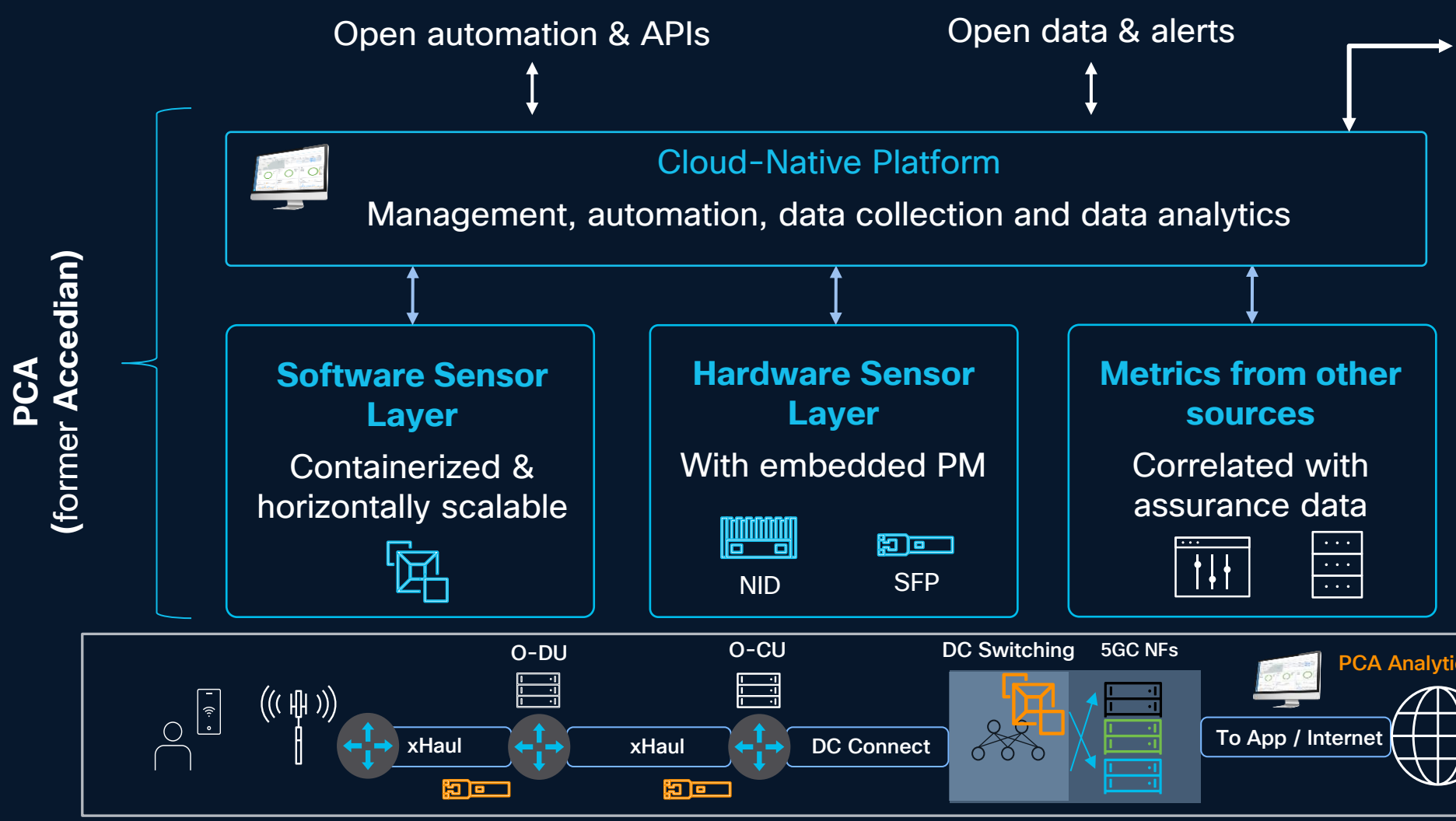
Cisco Provider Connectivity Assurance (PCA)



splunk> a cisco company

Simple integration with Splunk which Normalizes and correlates business, application, services and infrastructure data

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Solution Feature Highlights

Infrastructure Security

- Immutable Hardware Root of Trust
- Secured boot anchored in Hardware
- Session Key Service for Quantum-resistant Security
- Edge Protection: fastest attack detection & Mitigation
- Unique Operation Security features

Platform Advantages

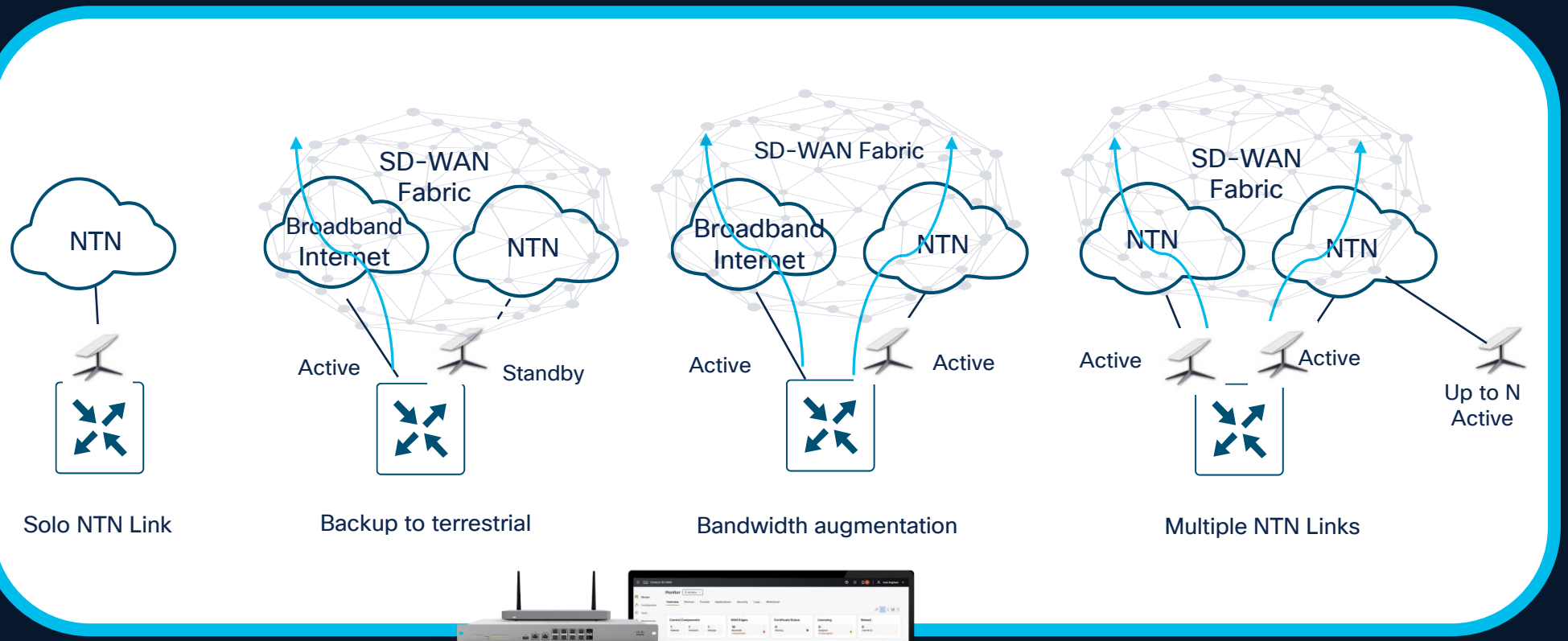
- MEF 3.0 Certified
- Varied connectivity options for terrestrial and non-terrestrial convergence: 1G/10G/25G/50G/100G/200G/400G
- Rich Carrier Grade Features including SRv6/EVPN and Timing Sync and Secure ZTP
- Carrier Grade Scale

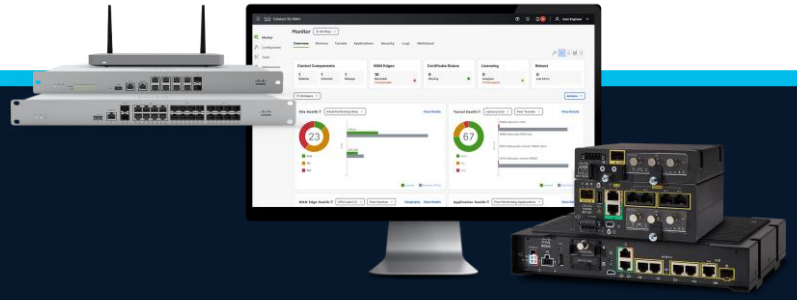
Integrated Insight

- SR-PM and SR-IPM
- Network End-point liveness monitoring
- Integrated Packet loss, latency and jitter measurement reduced number of monitoring protocols
- Intelligent Packet Routing and traffic load-balancing

SD-WAN

SD-WAN Test Scenarios





Improving Application Experience

Problem

1. LEO satellite networks can experience higher latency and packet loss than traditional networks due to factors like atmospheric interference, satellite handoffs, and network congestion

2. Satellite communication report average packet loss of 1-2%, with occasional spikes up to 4% or more

3. TCP's reliability mechanisms are designed to handle some degree of packet loss, but even 1% packet loss can significantly degrade application performance (70.7% decrease observed)

App-QoE Solutions

- Application-Aware routing can re-route traffic to terrestrial links (when available) in when packet loss over satellite exceeds a particular threshold of loss or latency
- TCP optimization policies that proxy local TCP connections and multiplex over optimized (BBR2) connections between WAN edge routers
- Packet Duplication policies that replicate traffic flows over multiple links to reduce the impact of loss on a single link
- Forward Error Correction policies that reconstruct lost packets
- Compression policies such as DRE/LZ which reduce the amount of traffic sent over the WAN

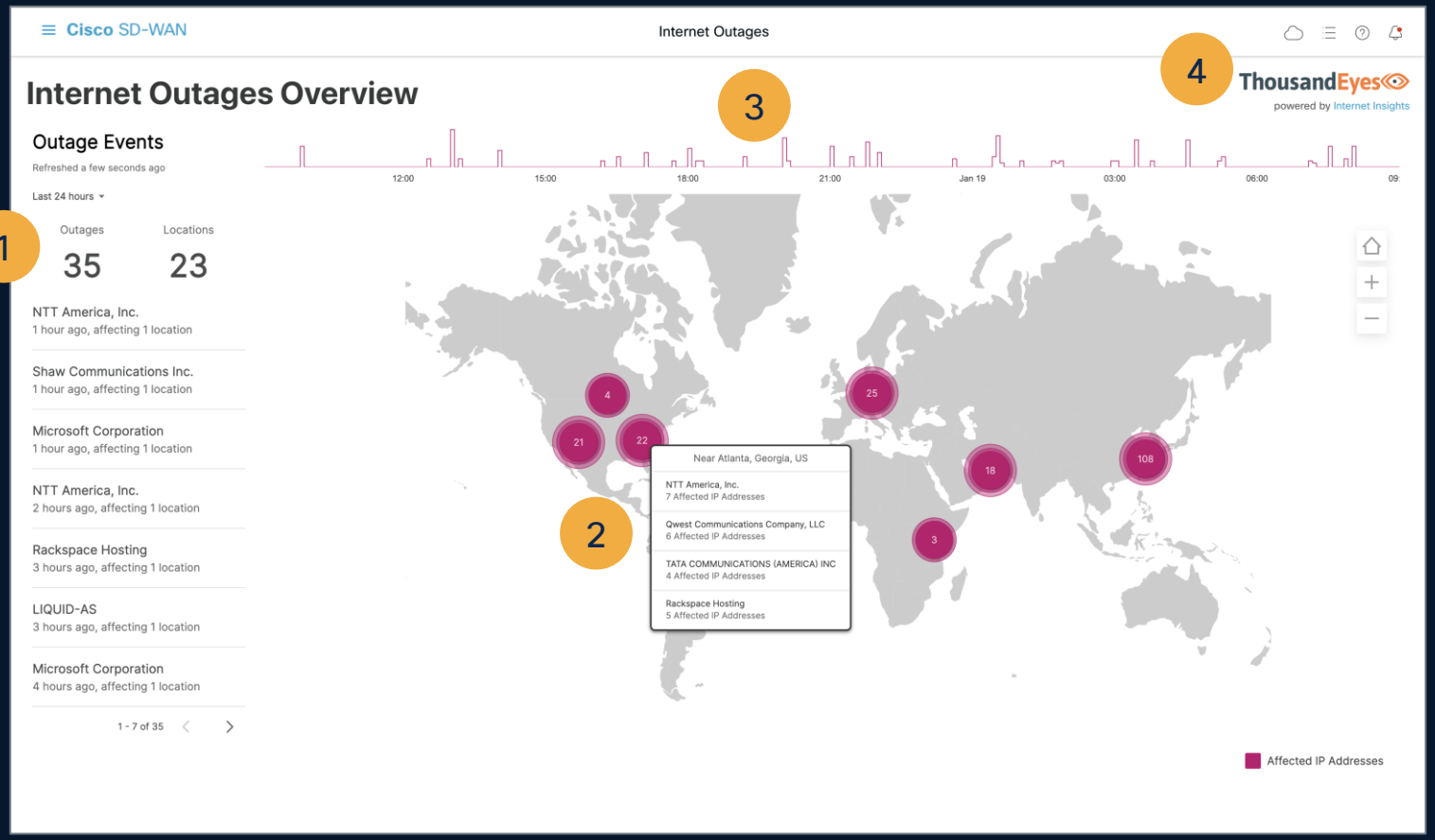
Performance Results

Test Name	Single iPerf Flow	Multiple iPerf Flow
TCP Baseline	30-50 Mb/s Download 5-7 Mb/s upload	50-57 Mb/s download 9-12 Mb/s upload
Forward Error Correction (FEC)	50-80 Mb/s Download 5-7 Mb/s upload	120-140 Mb/s Download 10-12 Mb/s upload
Packet Duplication	50-60 Mb/s Download 5-7 Mbps upload	60-80 Mb/s Download 9-11 Mb/s upload
TCP Optimization	150-200 Mb/s Download 5-7 Mb/s upload	220-255 Mb/s Download 15-18 Mb/s upload
FTP Baseline	4.33Gb file in 4min 10 Sec (8.5Mbps)	
FTP DRE/LZ + TCPopt	4.33Gb file in 1min 26 Sec (50Mbps)	

SD-WAN
Internet as Transport

Internet Outages Overview

Powered by ThousandEyes Internet Insight



Leverage insights on Internet outages to manage user's digital experience

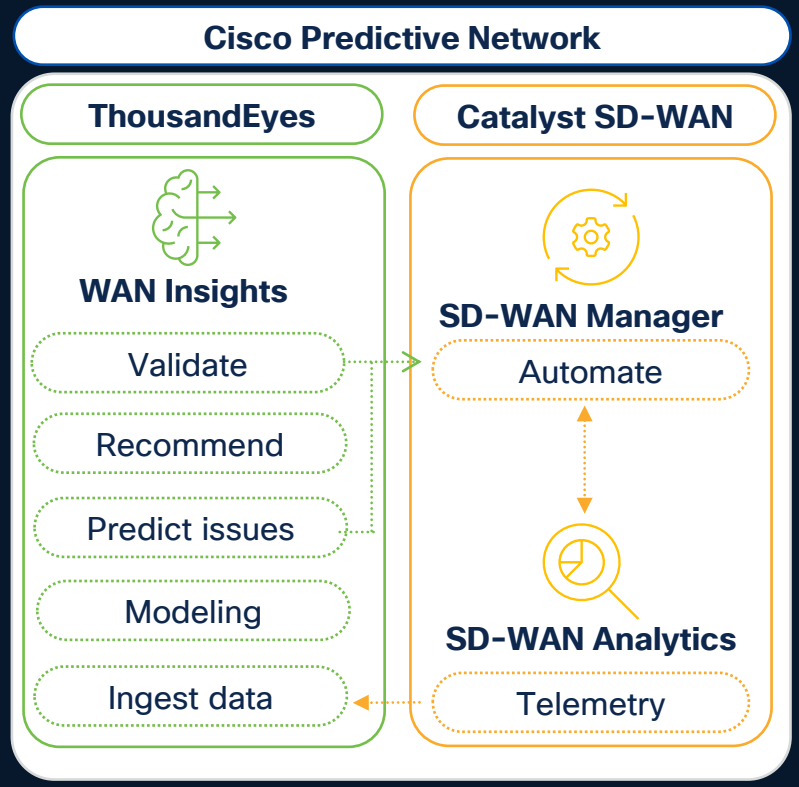
1. Detect ISP outages across the Internet
2. Discover the number of impacted locations and IP addresses
3. Gain insights into historical trends in Internet outages
4. Preliminary insights with SD-WAN Manager; ThousandEyes Internet Insights* for real-time insights into SaaS apps & networks

Predictive Path Recommendations

A Closed Loop Automation

- Predictive Path Recommendations (Powered by Thousand Eyes WAN Insights) generates predictive insights of recommended paths for application by leveraging telemetry from SD-WAN network.

- User can simply click on apply recommendation on SD-WAN Analytics and it triggers closed loop automation on SD-WAN Manager to update the centralized policy to use the recommended path for the specific application.



Underlay Measurement and Tracing Service (UMTS)

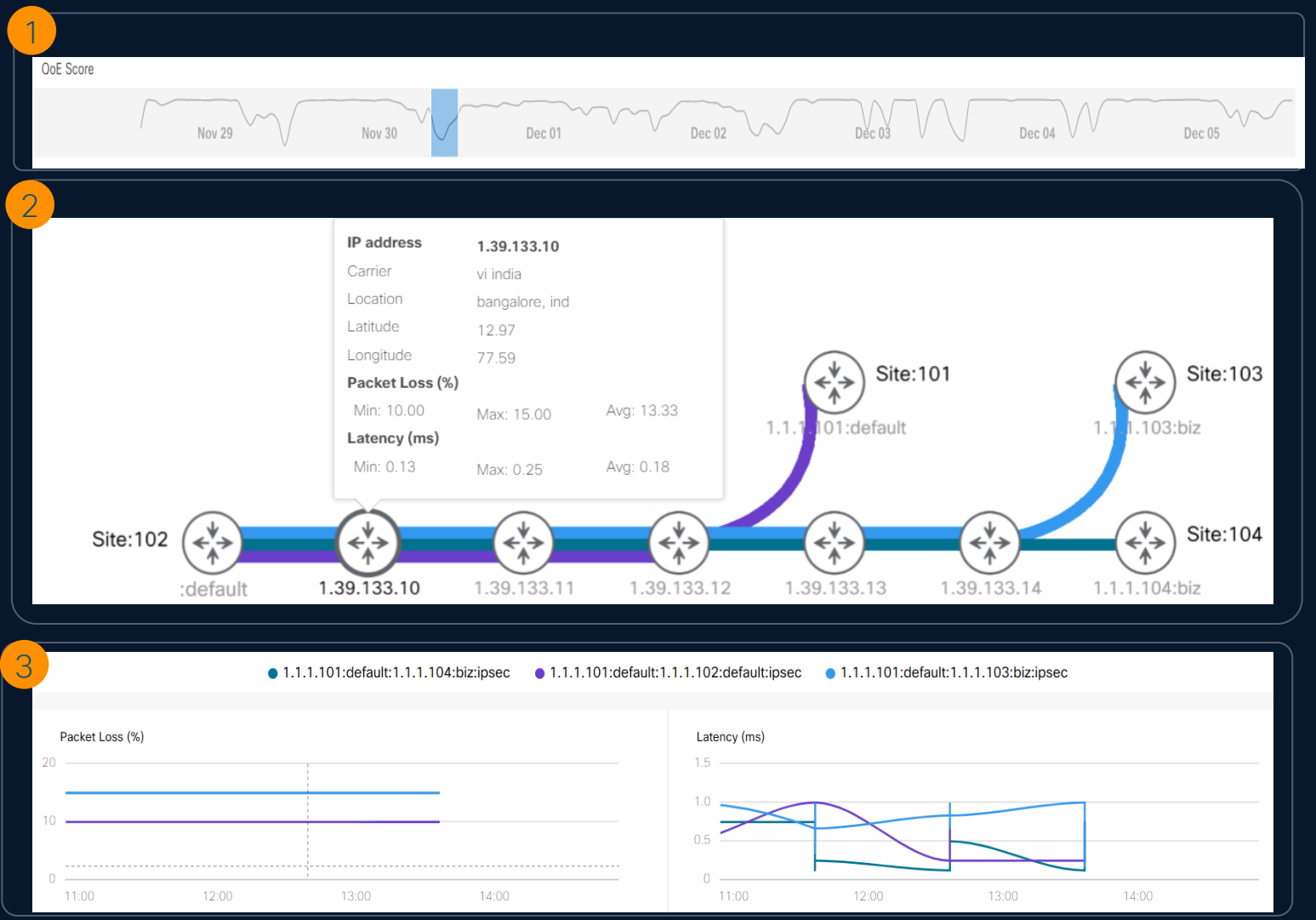
Benefits

Gain visibility into the exact underlay path against SD-WAN tunnel

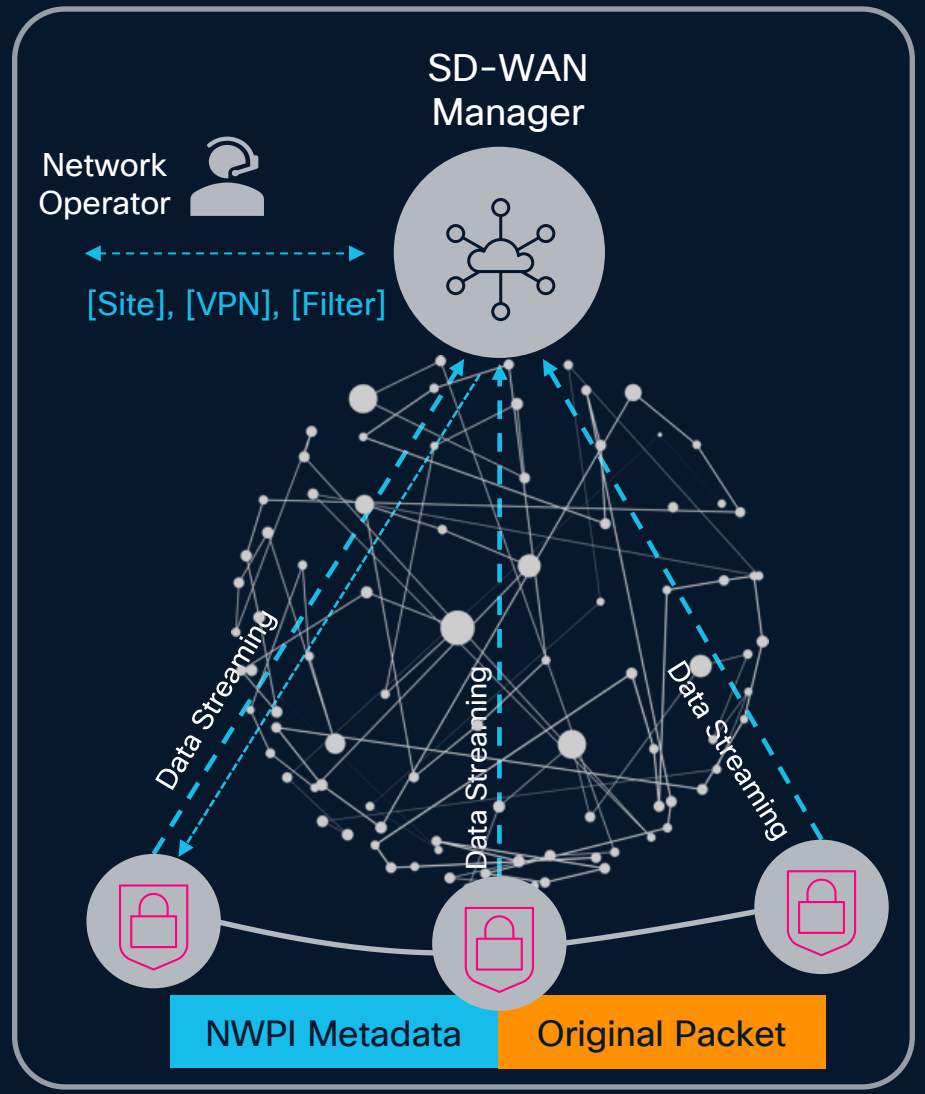
(including hop-by-hop metrics)

Highlights

1. Zoom into the specific time period showcasing drop in application health (QoE) trend line
2. View the hop-by-hop underlay path along with loss and latency metrics at every hop
3. View associated loss, latency besides underlay path



Network Wide Path Insight (NWPI)



NWPI provides network wide insights such as packet trace with network path info, path performance metrics and helps to validate policy design.

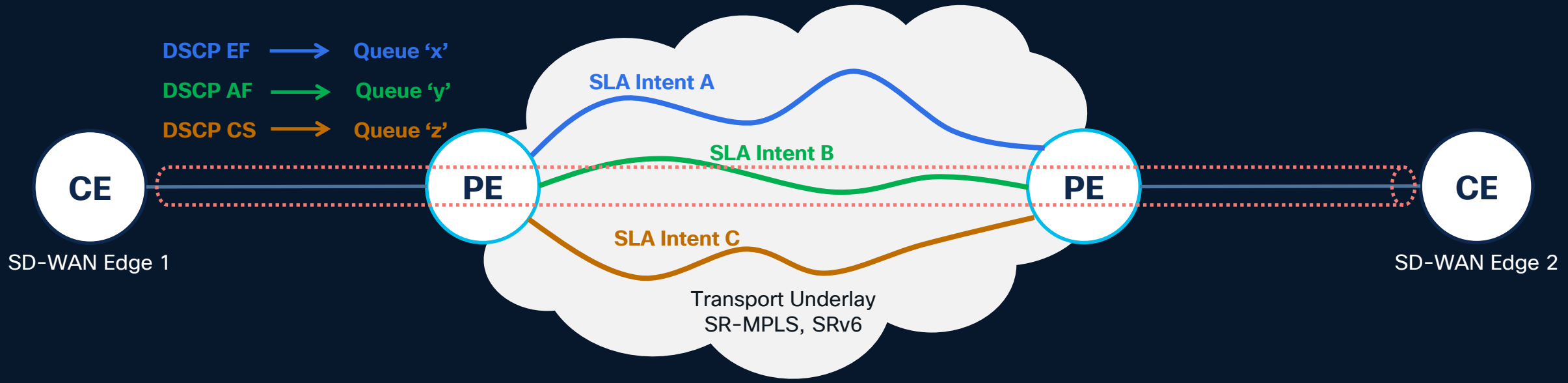
- Identifies application performance issues:
  - Flow Asymmetry
  - Bi-directional TLOC color Inconsistence
  - QoS congestion,
  - Local or WAN Interface drops
  - SLA violation
  - Path Change
  - Flow Reset
  - DPI packet classification status (First Packet Match failure etc.)

- Provides complete insight summary
  - Path insight - path selected and what features/policies have determined that routing decision.
  - Application Performance Insight – SLA violations
  - QoS Insight – congestion Alarms
  - Auto-on task can be configured to trigger the trace automatically.

SD-WAN
SR-MPLS / SRv6 as Transport

SD-WAN Overlay + SR-MPLS / SRv6 Underlay

Differentiated SLA Services with Underlay path Selection



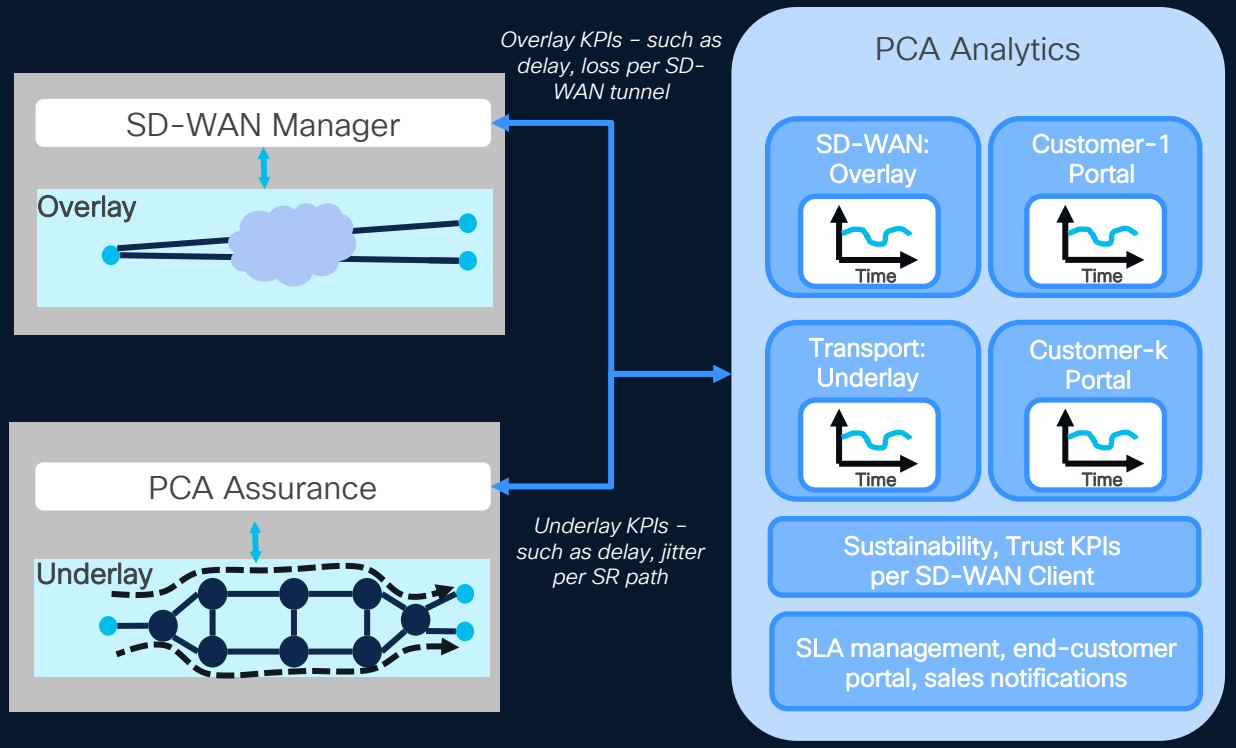
Unlock new SLAs – offer more underlay value

Guaranteed SLA Intent on Overlay and Underlay

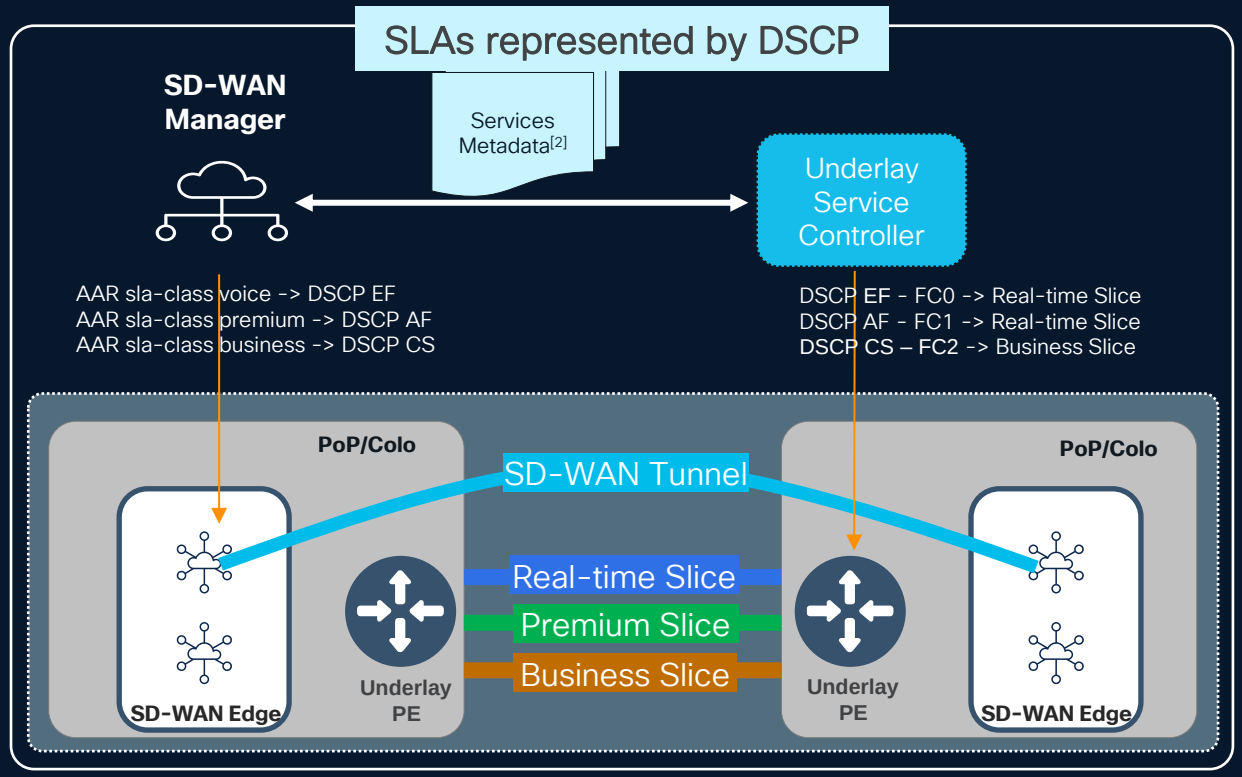
Overlay and Underlay Path Visibility

Policy and Visibility Integrations

Visualization and Assurance



SD-WAN/SR Policy Integration



Cisco 8000 Series Secure Router Portfolio

Small Branch	Medium Branch	Large Branch	Campus Site	Data Center
				
Cisco 8100	Cisco 8200	Cisco 8300	Cisco 8400	Cisco 8500

- Consistent Security Enforcement
- Amazing Throughput
- Secure Boot
- Security AI/ML
- Dying Gasp
- NIST Compliant PQC
- HA w/ RPS
- Line rate MACsec
- Physical Intrusion Detection
- 25GE WAN

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Cisco Mobility with NTN

Mobile Services Powered By Cisco Mobility Platform

Connected Intersection
Connected Field Service
Connected Utility
Connected Car
Asset Tracking
Connected Factory
Secure Branch
Secure Collaboration

APIs

Cisco Mobility Services Platform

SaaS

Provider Edge

Mobile Network Operators
Mobile Virtual Network Operators
5G

Enterprise Edge

5G
Private Mobile Network
Managed Service Partners

Mobile

Public Macro RAN

- National coverage
- 5G Spectrum efficiency
- 5G Low Latency

Private RAN

- Site coverage on private/shared spectrum
- Clean spectrum
- 5G Ultra Low Latency

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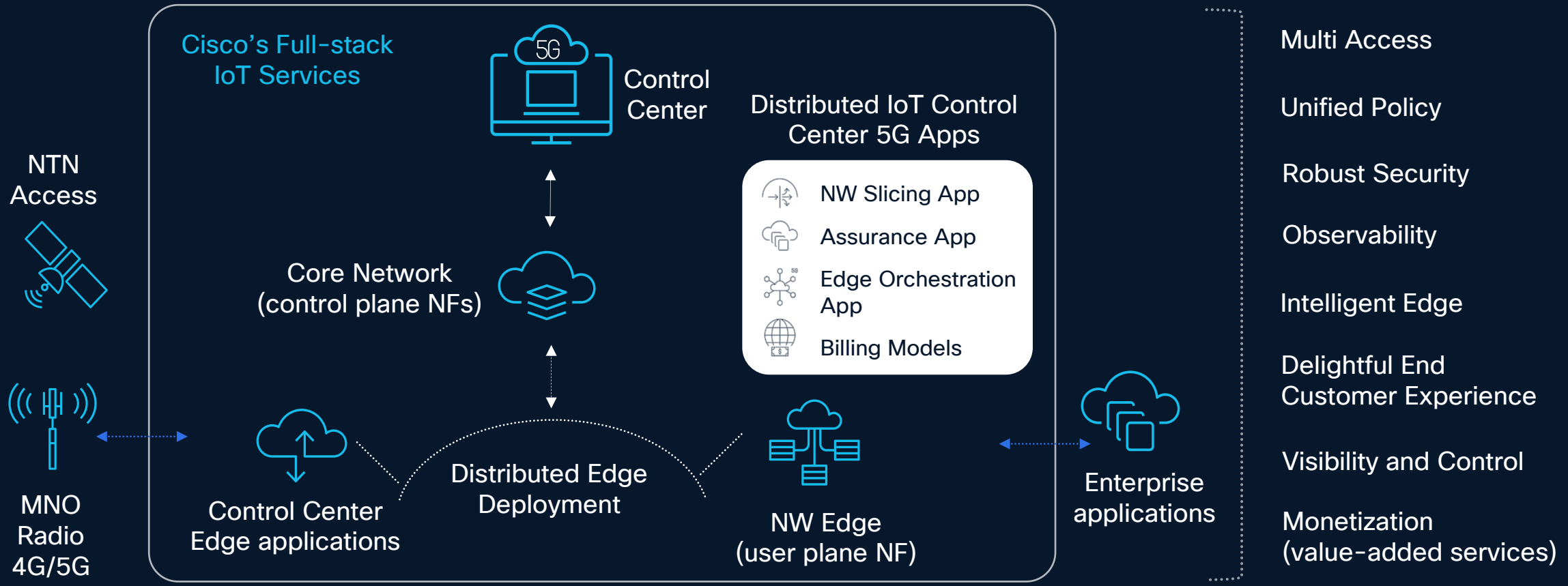
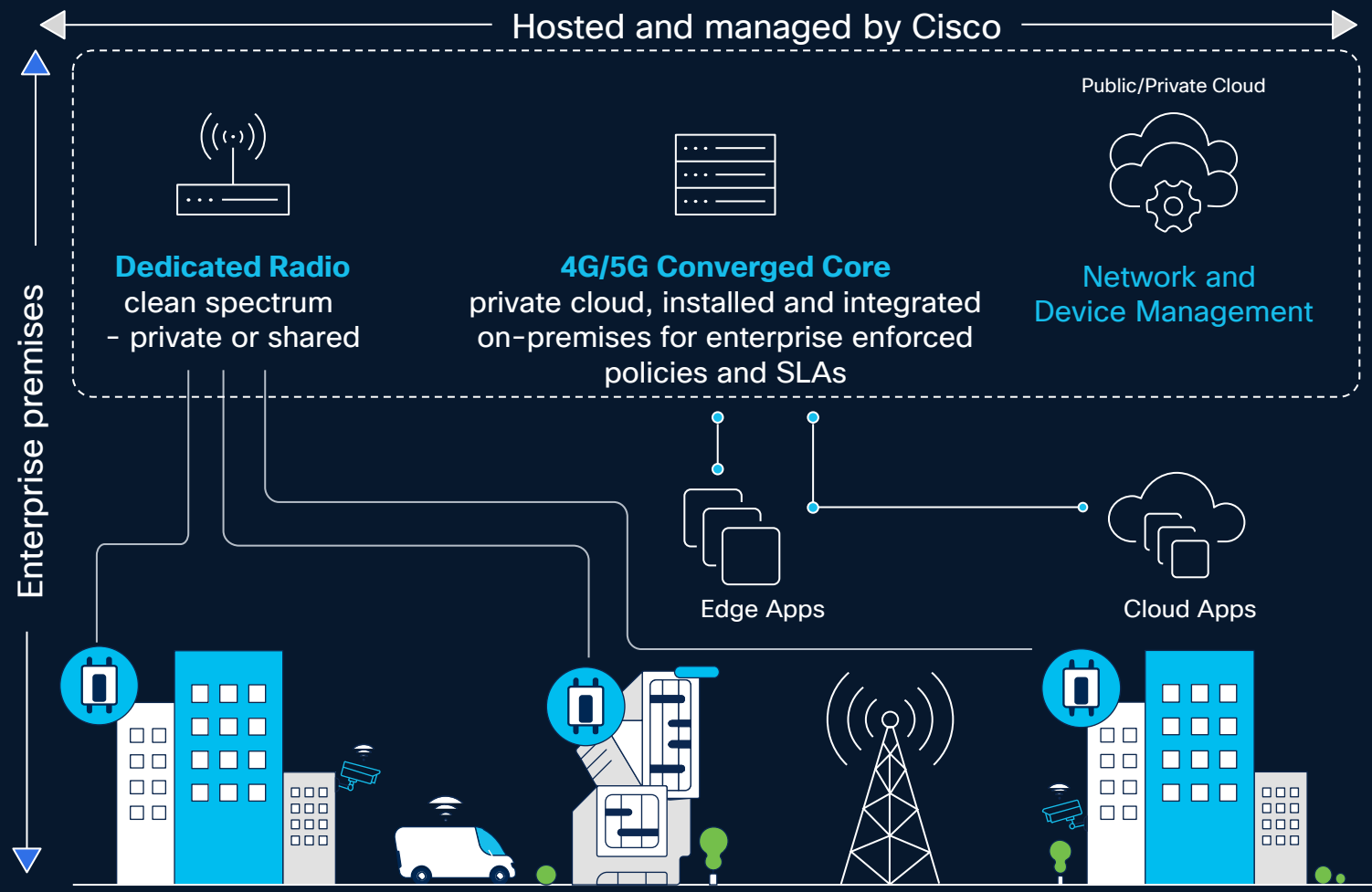
Cisco Full-Stack Service with IoT Contact Center

Enabling High Value, Multi-Access, Low-Latency Mission Critical Use Cases



Cisco Mobility 5G Architecture



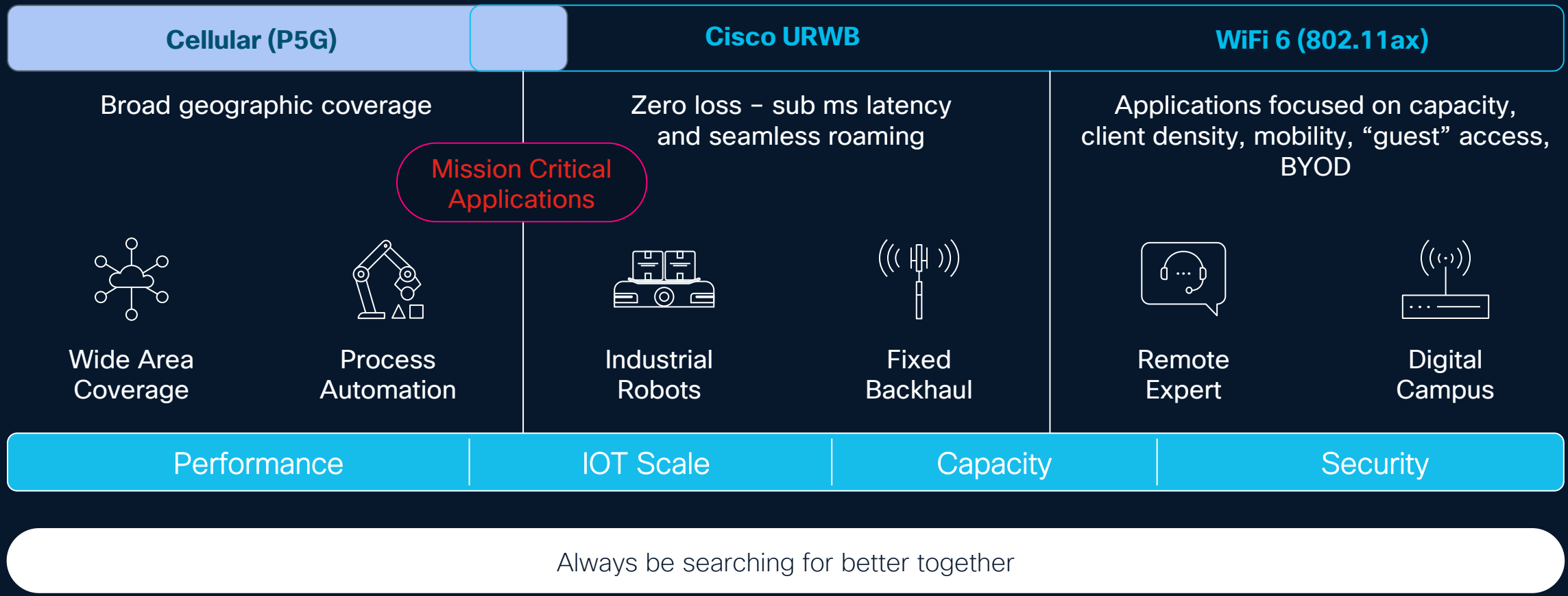
A dedicated mobile network connecting people, machines, and applications.

Automatic upgrades and enhancements.

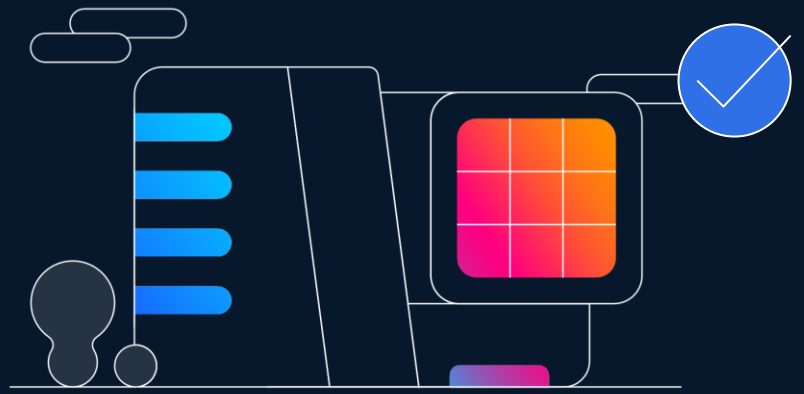
Intuitively simple operations and management Integrating with enterprise systems for common visibility and control.

Cisco Multi Wireless Access – Better Together!

Private Cellular, Cisco URWB and WiFi 6/7 are complementary Technologies



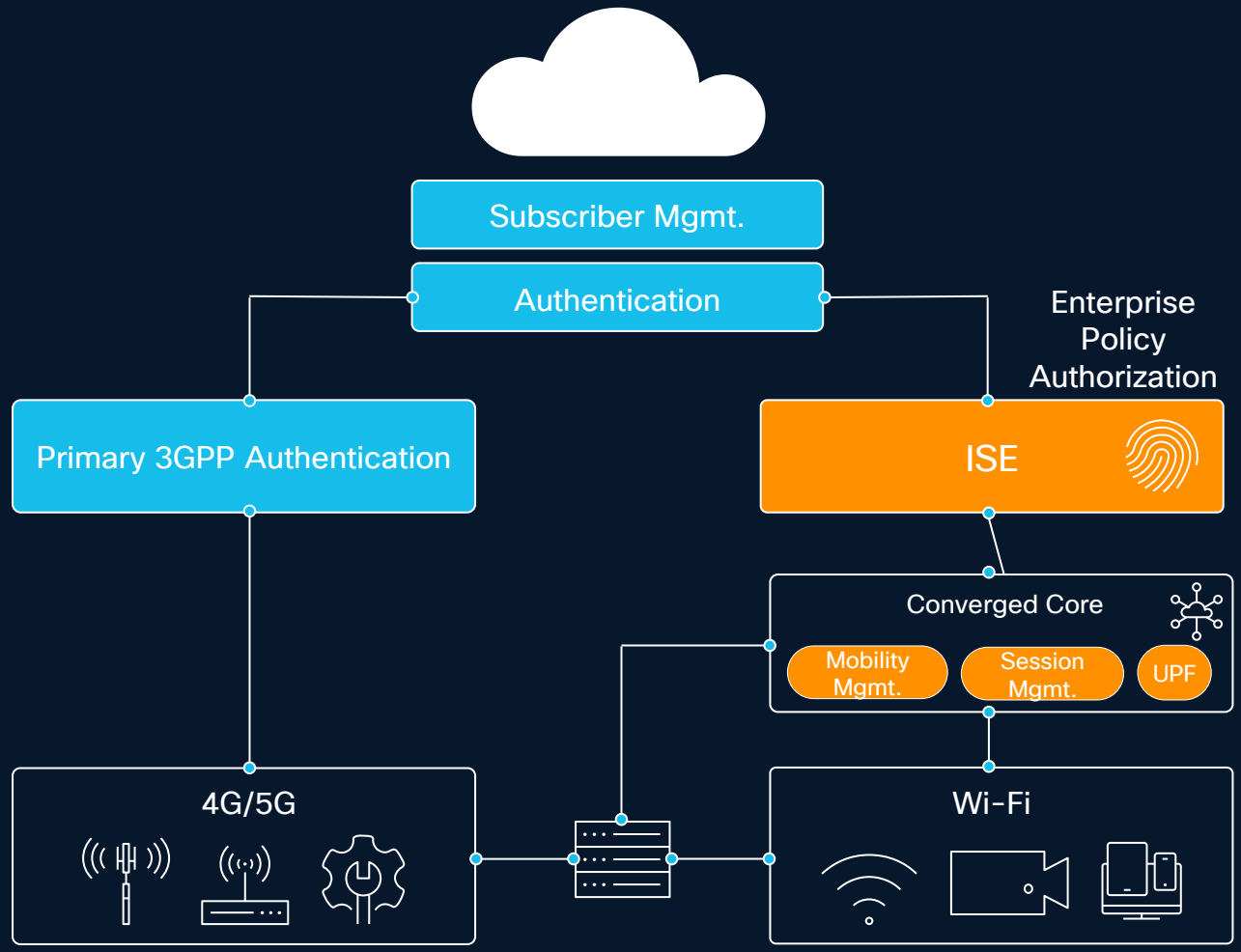
Seamless Identity and Policy Integration



Unified enterprise policy

Single point for identity-based enterprise policies

- For Private 5G, Wi-Fi, and Wired Networks.

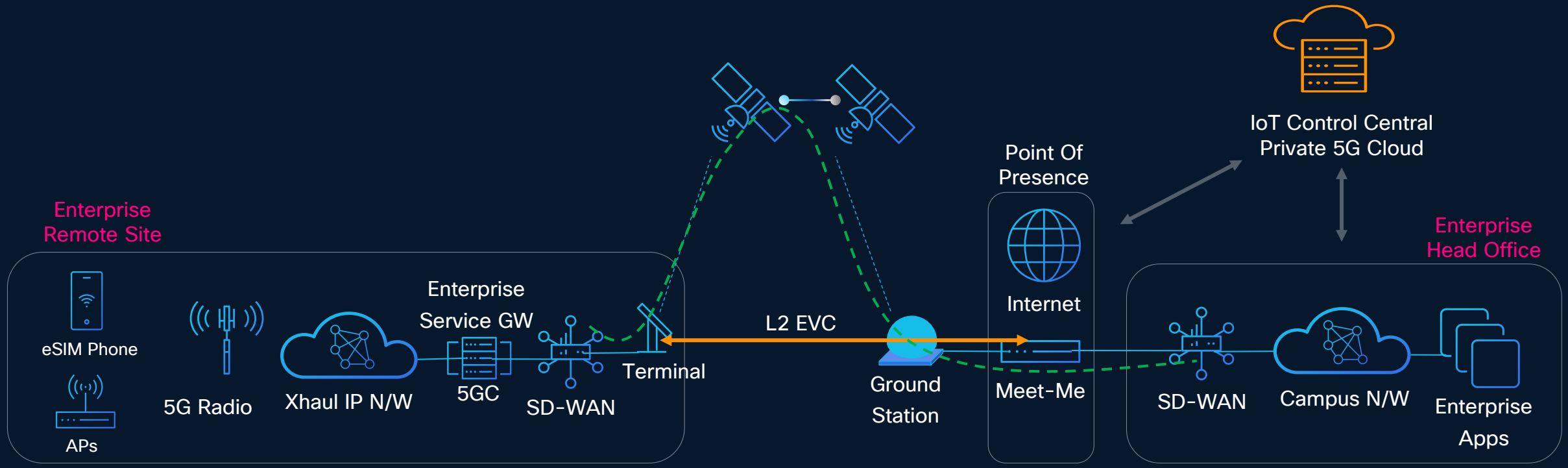


Private 5G with Non-Terrestrial Networking

Remote Autonomous Networking, Centralized OAM

- Enterprise *Remote* Private Wireless network
  - Often where Public / Infrastructure is non-existent
- Support Autonomous operation

- Multi-Site, single *Centralized* UX / OAM
- Access to Centralized Apps / Processes
- Deployed using SD-WAN over NTN MEF / E-line



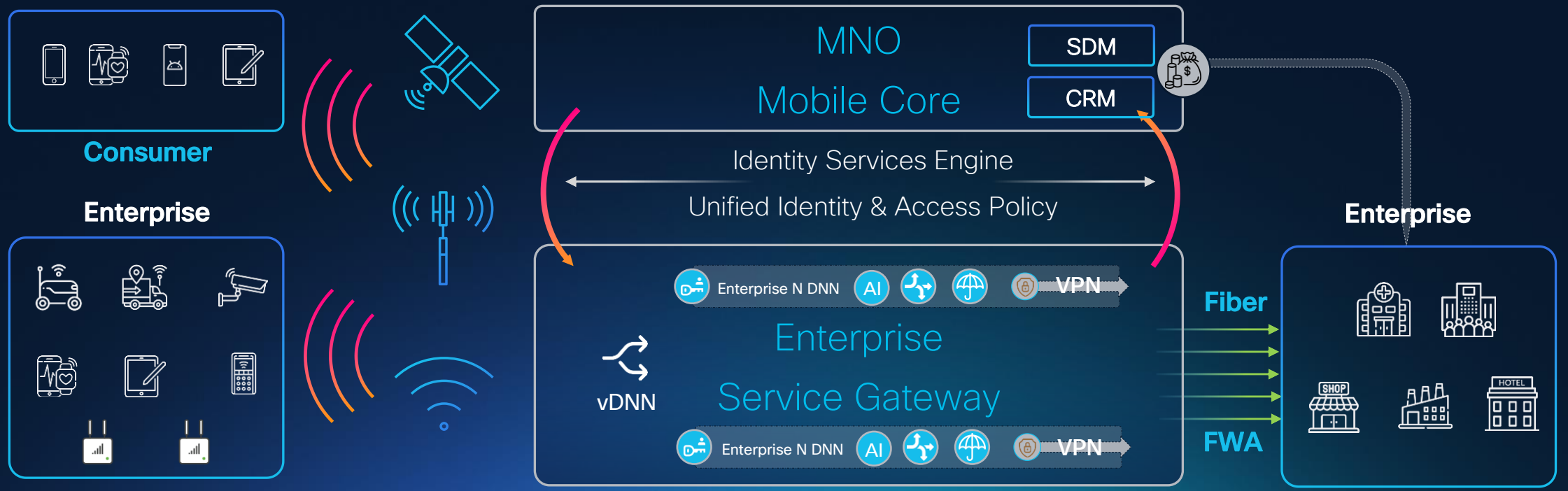
Unique B2B value which can expand into B2B2C premium market

Cisco Mobility Solution

Unified Service Policy

Multi-Radio Access

Expand to Enterprise



Summary

Cisco Non-Terrestrial Networking Solution

Connecting the Unconnected

Seamless convergence of terrestrial and non terrestrial networks

Visibility and Assurance | Automation | Security | Connectivity

Crosswork + Assurance

Peering / Cell Site Routers	Point of Presence Edge Fabric	Partner Interconnect	Automation & Assurance
Silicon One-based Platforms	Carrier Grade IOS-XR	Cisco Routed Optical Networking	Multi-agentic AI Platform
Capex and Opex efficiency	Rich Features and service support	Dramatic cost & power savings	Integrated with Cisco AI Assistant

Cisco Non-Terrestrial Networking Solution

Connecting the Unconnected

Seamless convergence of terrestrial and non terrestrial networks

Visibility and Assurance | Automation | Security | Connectivity

SD-WAN Routers

8000 Series Secure Routers

Secure WAN for Every Site

Mobility & IoT Control Center

Mobile Services Platform

Simplified deployment at Scale

ThousandEyes

Underlay Visibility

Assurance, Observability and Security

Internet and WAN insights

Cisco Validated Design Provides Ready to Deploy Solution

Improves User Experience and service throughput

Simplifies Deployment with network insights

Reduces Risk with enhanced security

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Thank you


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