5G Non-Terrestrial Networking

Using Cisco Converged SDN Transport

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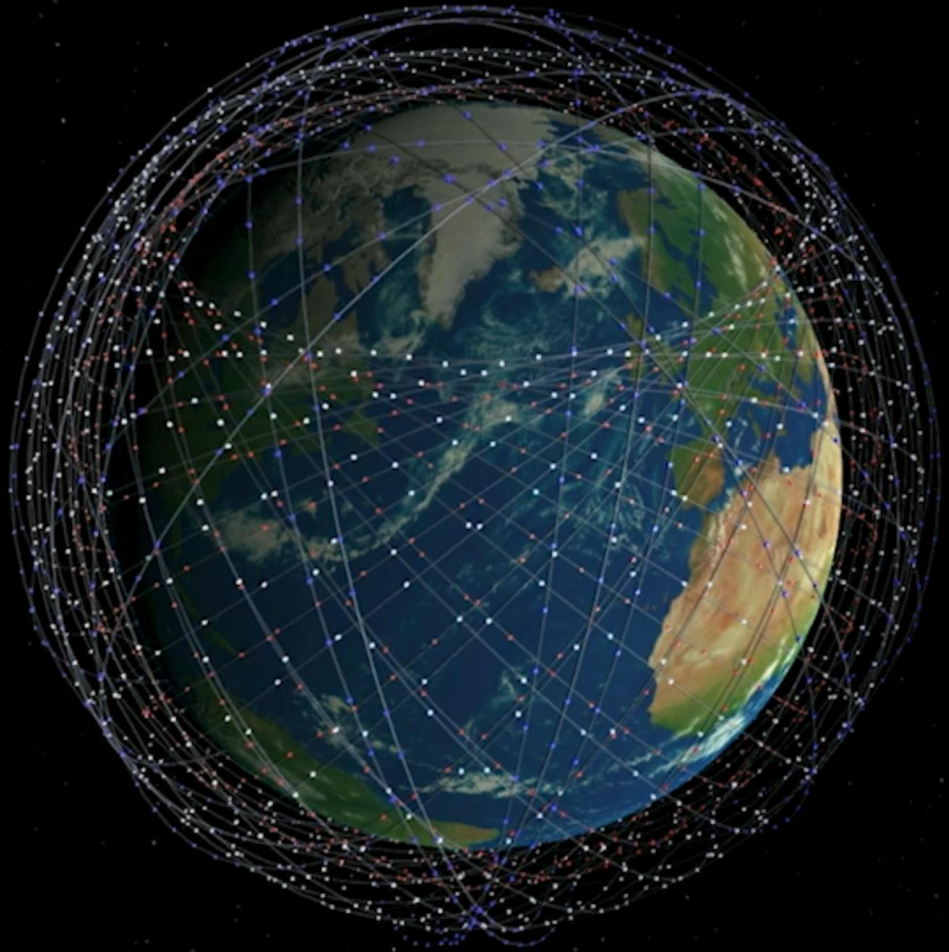
Agenda

- Market Outlook
- Non-Terrestrial Network (NTN)
- Cisco NTN Approach
- Summary

Key Abbreviations

3GPP	3rd Generation Partnership Project
B2B	Business to Business
BBR	Bottleneck bandwidth and Routing-trip propagation Time
CPE	Customer Premise Equipment
CSR	Cell Site Router
D2D	Direct to Device
GEO	5th Generation Network
gNB	5G Node B / Base Station
HAPS	High Altitude Platform System
IoT	Internet of Things
ITU-T	International Telecommunication Union
LEO	4th Generation Network
MEF	Metro Ethernet Forum
MEO	6th Generation Network
MNO	Mobile Network Operator
NR	New Radio (5G)
NTN	Non-Terrestrial Network
NWPI	Network Wide Path Insight
ORAN	Open RAN Alliance
OMP	Overlay Management Protocol
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
TN	Terrestrial Network
UAS	Unmanaged Arial Vehicle System
UMTS	Underlay Measurement and Tracing Service

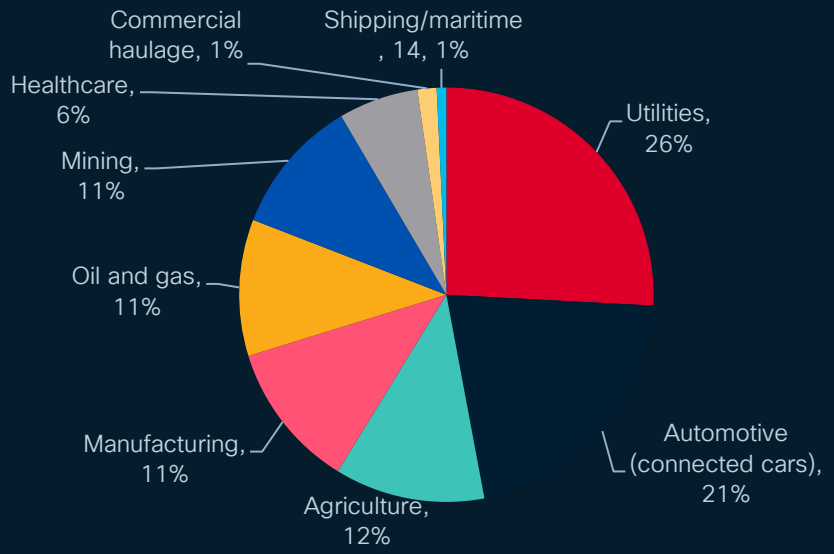


Non-Terrestrial Networking is Evolving to Address $400B TAM

- Direct to Device (D2D)
- Consumer Broadband
- Connectivity Services

Direct to Device over Satellite

1.9 billion devices (8% of the IoT market) are addressable by 2035



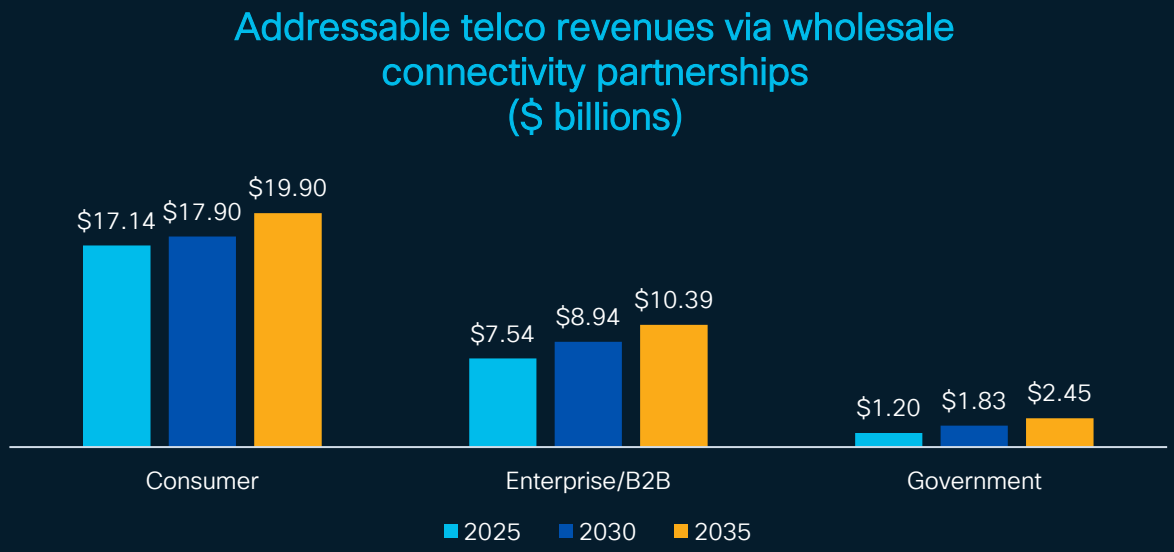
Figures are number of IoT connections addressable to satellite and the sector share of the total
Source: GSMA Intelligence

Revenue sell in = $10bn/yr by 2035
(25% of existing IoT connectivity revenues)

- 5G NTN Advantages
  - No need for dish or receiving equipment at consumer end – Cost Saving
  - Ease of integration with existing mobile network
  - Time to market
  - More accessible for consumers and businesses
  - Conduit to new revenue streams
- Target Segment
  - Consumer
    - Out of coverage
    - Patchy coverage
    - Roaming
  - B2B
  - Government

Revenue uplift with SNO + MNO Partnership

Opportunity: $35B by 2035



Source: GSMA Intelligence

There is realistic sell-in to B2B, Government and Defense sector beyond consumer connectivity.

- Consumer = 60%
- B2B verticals = 30-35%
- Government = 5-10%

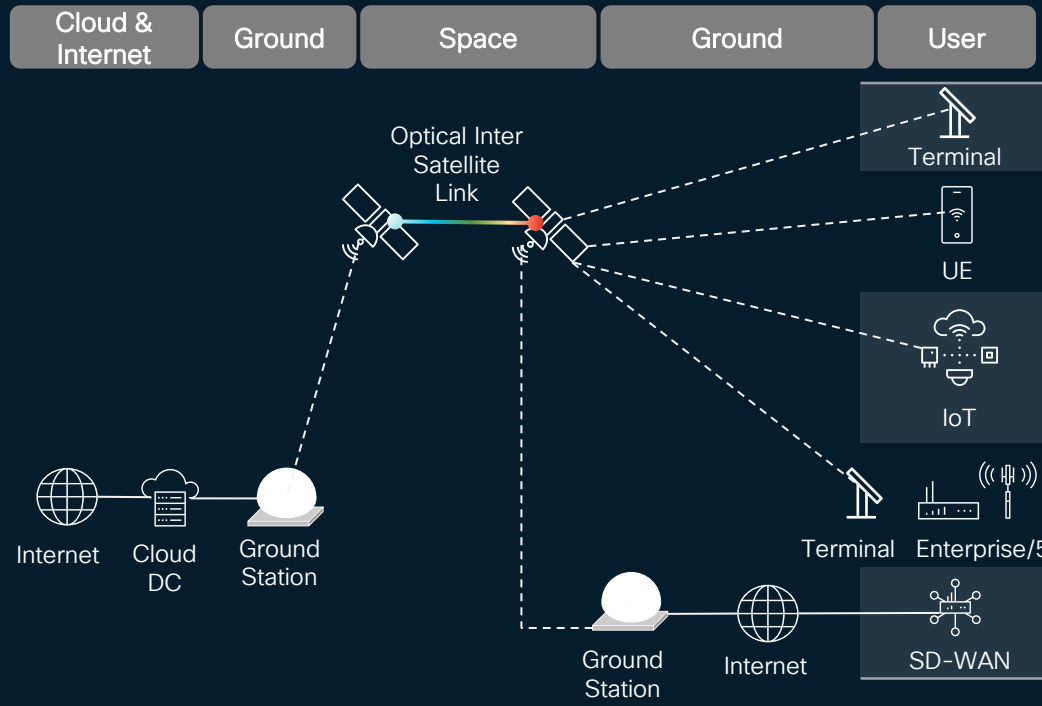
Why SNO+MNO Partnership?

- Easy to offer services as whole-sale provider
- CSPs owns terrestrial market
  - Customer relationships

Satellite Network Operators (SNO)

Non-Terrestrial Network (NTN)

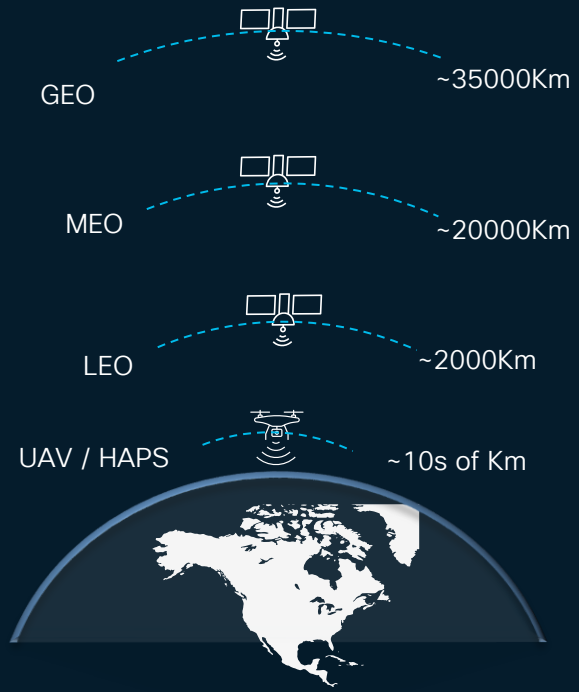
Access technology across multiple existing market; and gaining adoption in next couple of years (2025-2026)



	Markets	Submarkets
A	Direct to Home	• Consumer Broadband
B	Direct to Phone / IT equipment	• Voice / Text / Video • Emergency Services
C	Direct to IOT	• Smart home / Smart city • Smart Vehicles / Automotive • Vertical use cases: Healthcare, Utilities, Oil and Gas, Defense
D	Wholesale Connectivity	• Metro Ethernet Services: E-Line, E-tree, E-LAN, L2/L3 VPNs
E	Campus / Branch	• SD-WAN

Non-Terrestrial Network (NTN)

Non-Terrestrial Networking



Platforms	Altitude range	Round Trip Time	Typical beam footprint size
Geostationary Earth Orbit (GEO) satellite	35,786 km	~ 700ms	200 – 3500 km
Medium-Earth Orbit (MEO) satellite	7000 – 25000 km	~ 100ms	100 – 1000 km
Low-Earth Orbit (LEO) satellite	300 – 1500 km	~ 30ms	100 – 1000 km
UAV platform (including HAPS)	8 – 50 km (20 km for HAPS)	<10ms	5 - 200 km

UAV: Unmanaged Aerial Vehicle, HAPS: High Altitude platform Station

Satellite Service Evolution

Connectivity Solution
(Satellite Terminal Based)

- GEO Satellite Based
- DL throughput ~10Mbps
- Latency ~550ms (RTT)
- Parabolic Antenna Cost
  - ~ $100
- Service cost
  - ~$100/Month

Evolved

- LEO Satellite Based
- DL throughput ~100Mbps
- Latency ~50ms (RTT)
- Beamforming Antenna Cost
  - ~$400 - $1000
- Service cost:
  - ~$250/Month

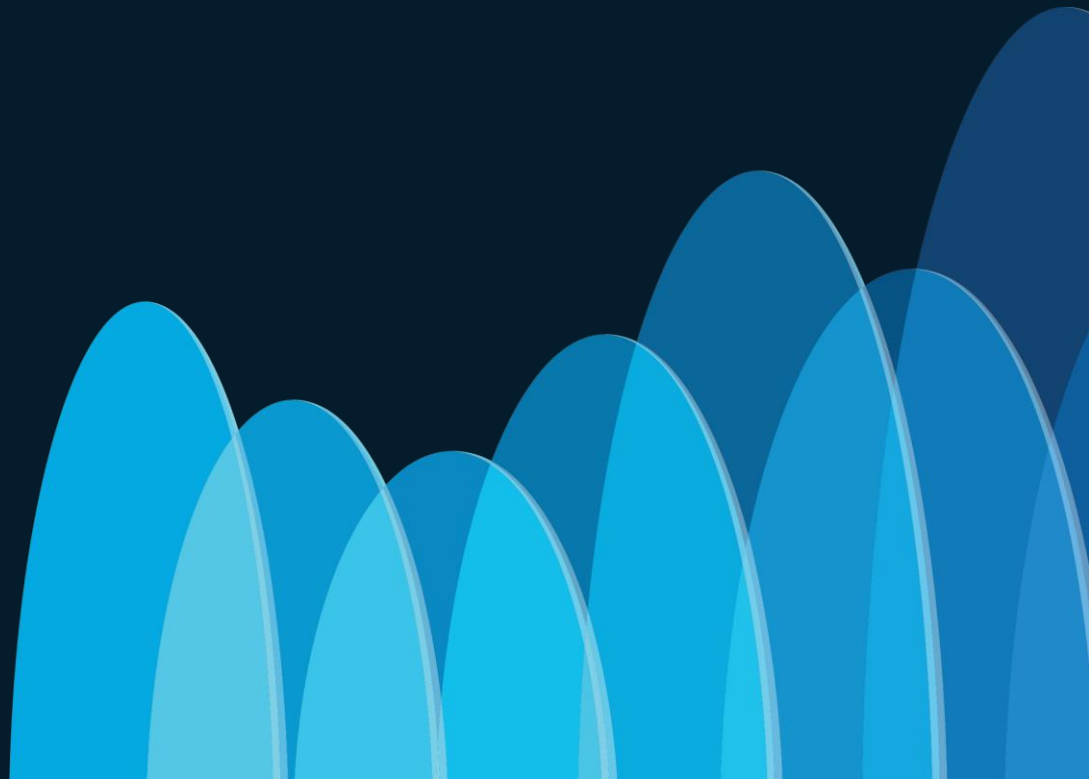
Mobility Solution
(Handheld Device Based)

- Special handheld devices designed to operate in one network
- DL throughput ~100Kbps
- Handheld device Cost
  - ~ $1000
- Service cost
  - ~$100/Month

Evolved

- Standard Smartphones
- DL throughput ~10Mbps
- Service cost:
  - ~$10/Month

Connectivity Solution



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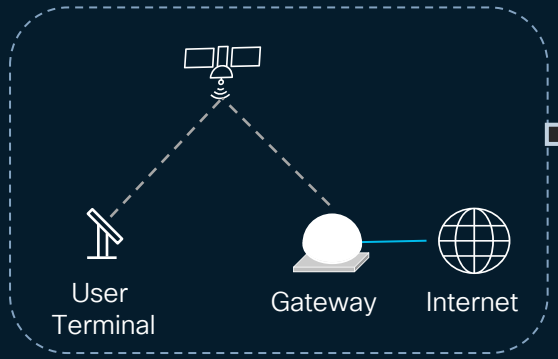
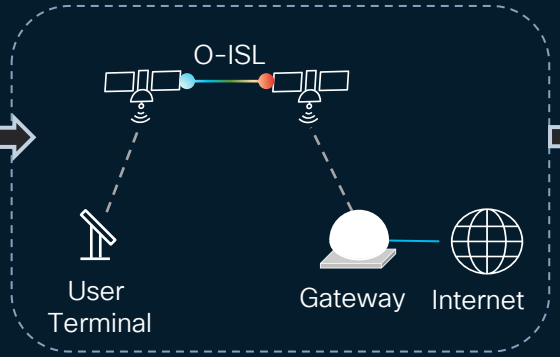
LEO Satellite Communication Architecture

LEO TYPE - 1



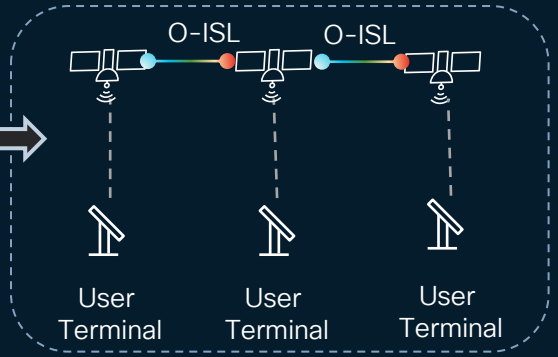
- Traffic is served by single Satellite
- Traffic is routed to nearest GW
- Coverage ~1000Km

LEO TYPE - 2



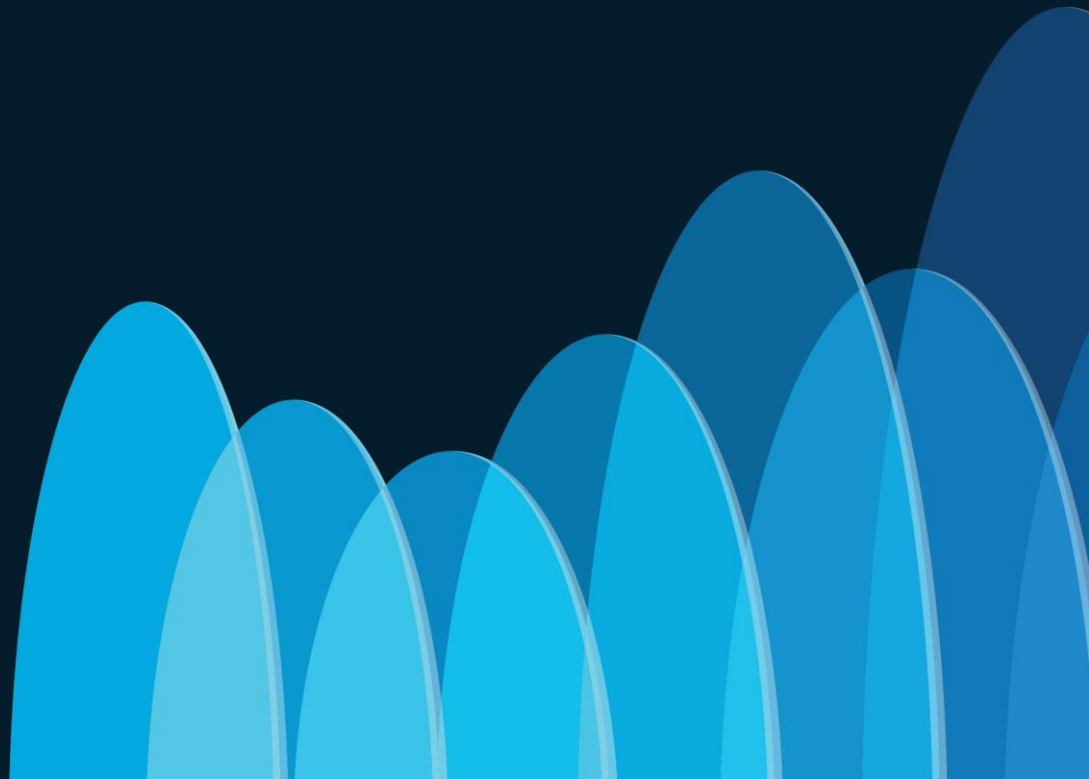
- Traffic is routed to nearest GW
- Coverage multiple of 1000Km

LEO TYPE - 3



- GW less architecture
- Flexible Routing
- Any to Any connectivity
- Lowest point-to-point latency for long distance communication

Mobility Solution



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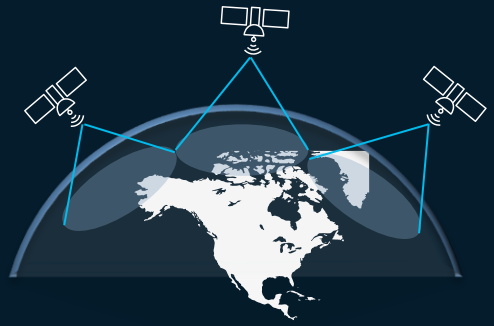
5G NTN in 3GPP



Direct to handset | Automotive | Home Broadband | Enterprise Connectivity | Mobile Backhaul

5G NTN-NR

Complimenting Terrestrial Networks in Underserved Areas

Rel-17+ covers GEO/MEO/LEO Satellites

Emergency Alerts | Smart City Smart Building | Tracking | Point of Presence

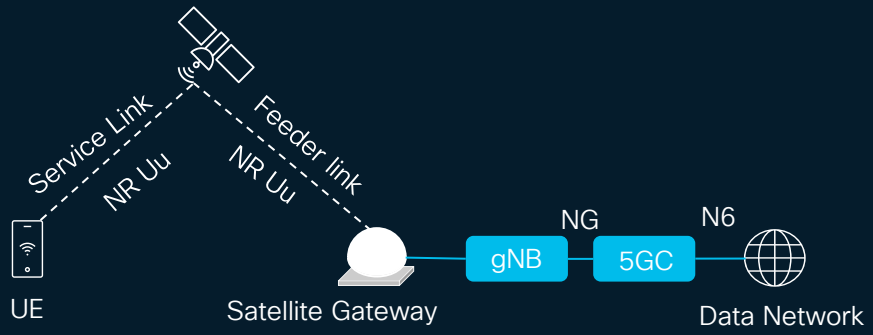
5G NTN-IOT

Addressing 5G Massive IoT Market

Rel-17+ covers GEO/MEO/LEO Satellites

Transparent and Regenerative Satellites

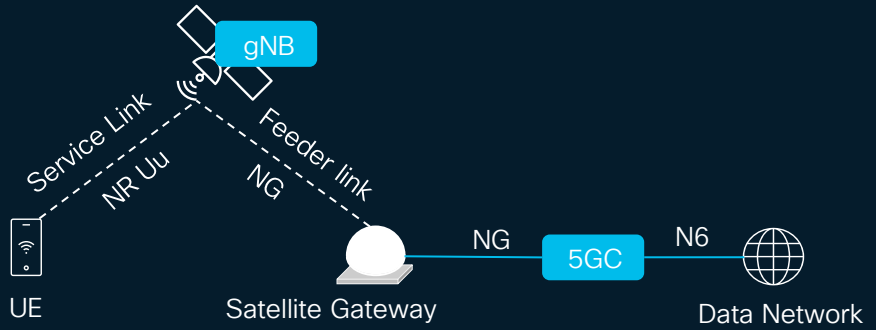
Transparent NTN payload
(bent-pipe) satellites



Rapid service deployment through existing satellites
- Long RTT (~26ms for LEO at 600Km and low elevation angle)

Broad platform support
- GEO/GSO, MEO and LEO satellites,
- HAPS, and UAV

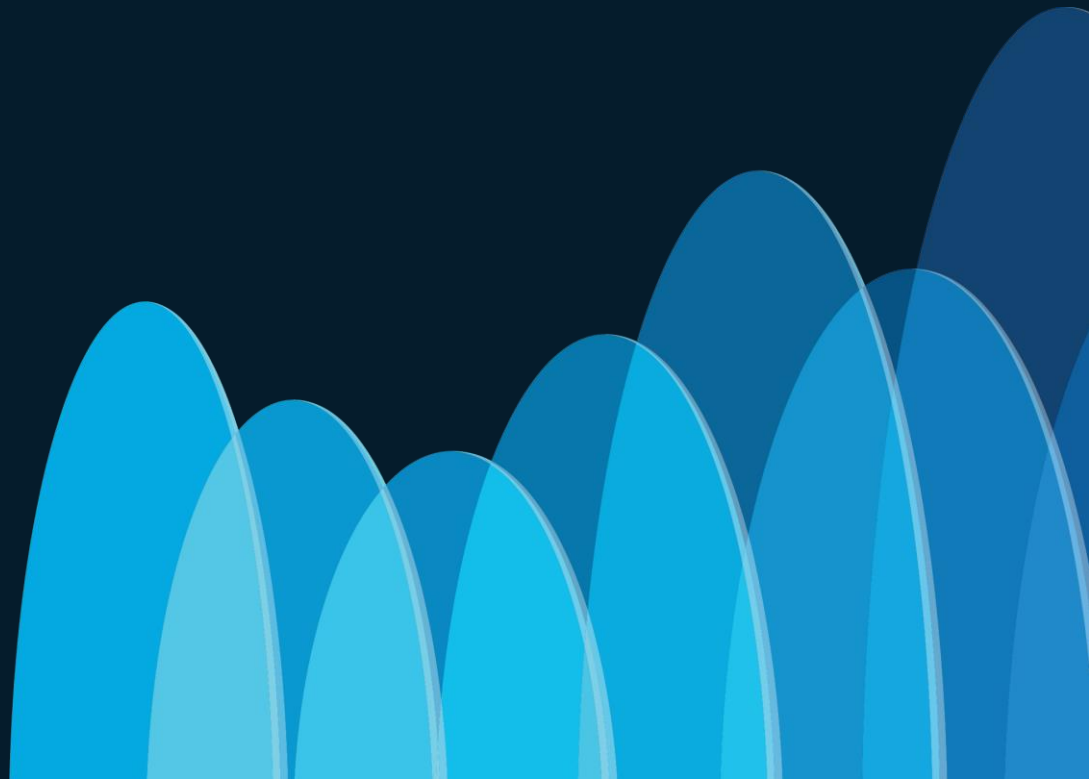
Regenerative NTN payload
(on board processing) satellites



gNB or DU function on the satellite
- Short RTT (~13ms for LEO at 600Km and low elevation angle)

LEO, HAPS and UAV focused.

Convergence of Networks



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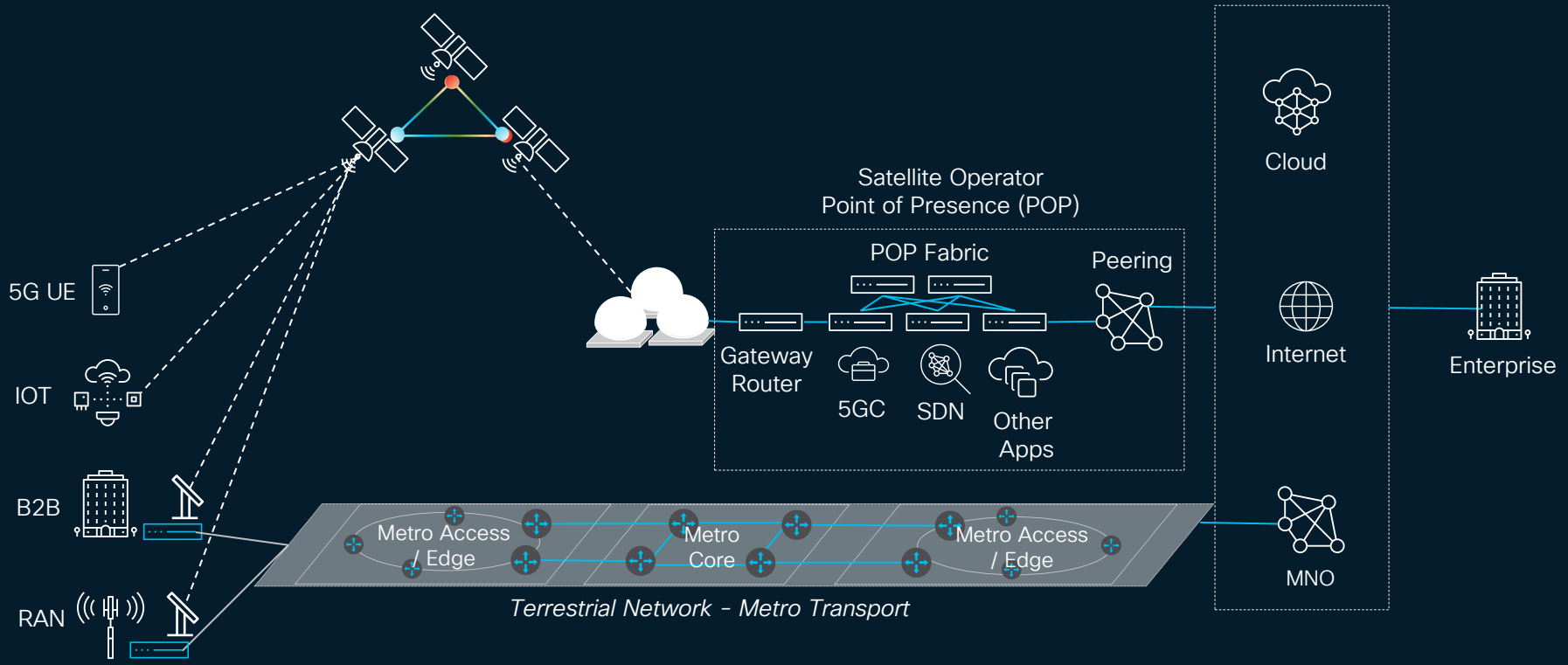
Convergence of Networks

Terrestrial and Non-Terrestrial



Key areas of focus

- Converged Services
  - Non-Terrestrial and Terrestrial service convergence
- Service Monitoring & Assurance
  - Standardization of Service demarcation, Key Performance Indicators (KPIs) for service level agreement (SLA) parameters
  - Service handover and provisioning
- Modem / virtualized Modem
  - Integrated solutions
- Terminal Systems and Design
- Architecture Standardization: 3GPP, ITU-T, O-RAN and MEF
  - Carrier Ethernet over NTN
  - Regenerative Satellites

Non-Terrestrial Networks (NTN)

Summary

$400B TAM with three key markets

- D2D
- Internet Broadband
- Connectivity Solution

Two Service offerings

- Mobility Solution
- Connectivity Solution

Business Focus areas

- Solution Simplification
- NTN and TN convergence
- 5G /6G adoption in NTN

Cisco NTN Approach

Cisco In Space Routing

STRV-1

1996

Satellite got an IP

NASA JPL (Jet propulsion laboratory) designs TCP/IP stack for DERA (Defense Evaluation and Research Agency) STRV-1b (Space Technology Research Vehical 1b) and configure it with an IP

2001

IP Leadership

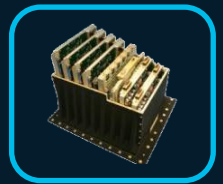
Cisco emerged as the leader in IP based architectures

CLEO Router

2003

First Space Router

27 Sept 2003, Cisco Internet Router was launched into LEO orbit for UK-DMC (Disaster Monitoring Satellite) built by SSTL (Surrey Satellite Technology Limited), Guildford, UK



Cisco 18400

2009

Space Routing in commercial Market

First space router on commercial GEO satellite was launched via IRIS IS-4 satellite on 23rd Nov 2009

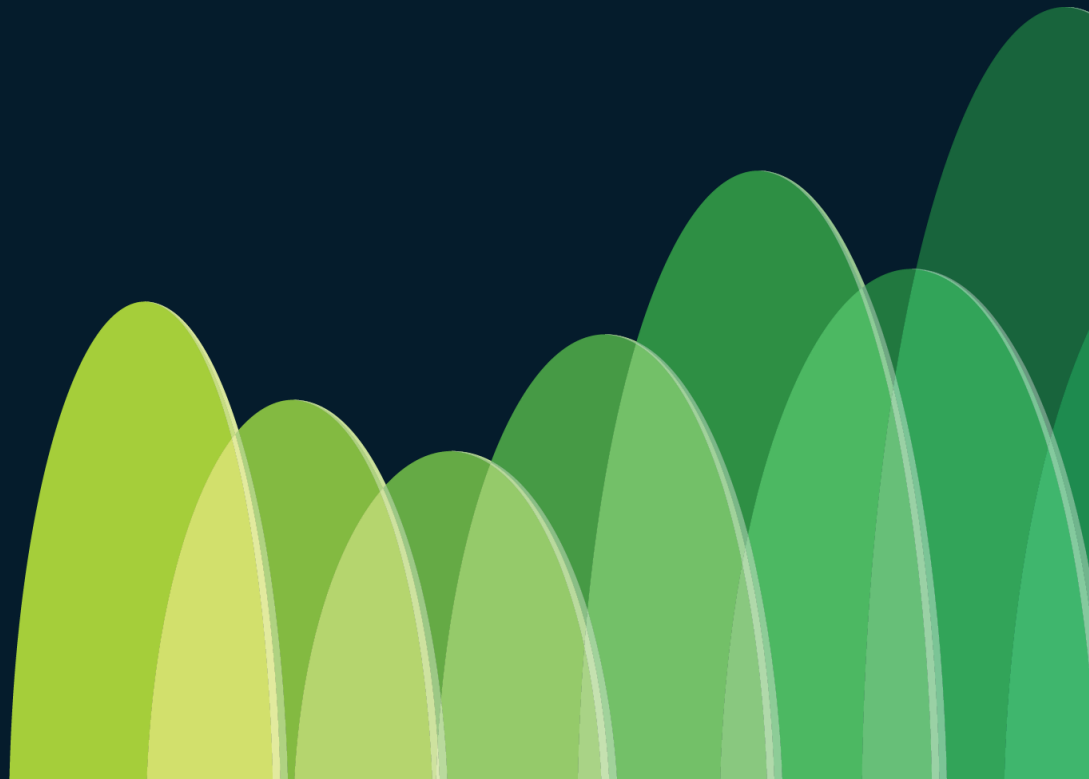
NM-1VSAT-GILAT

2009+

VSAT IDU

Cisco Introduced VSAT IDU module cards on ISR 2800 and 3800 series routers

Converged SDN Transport



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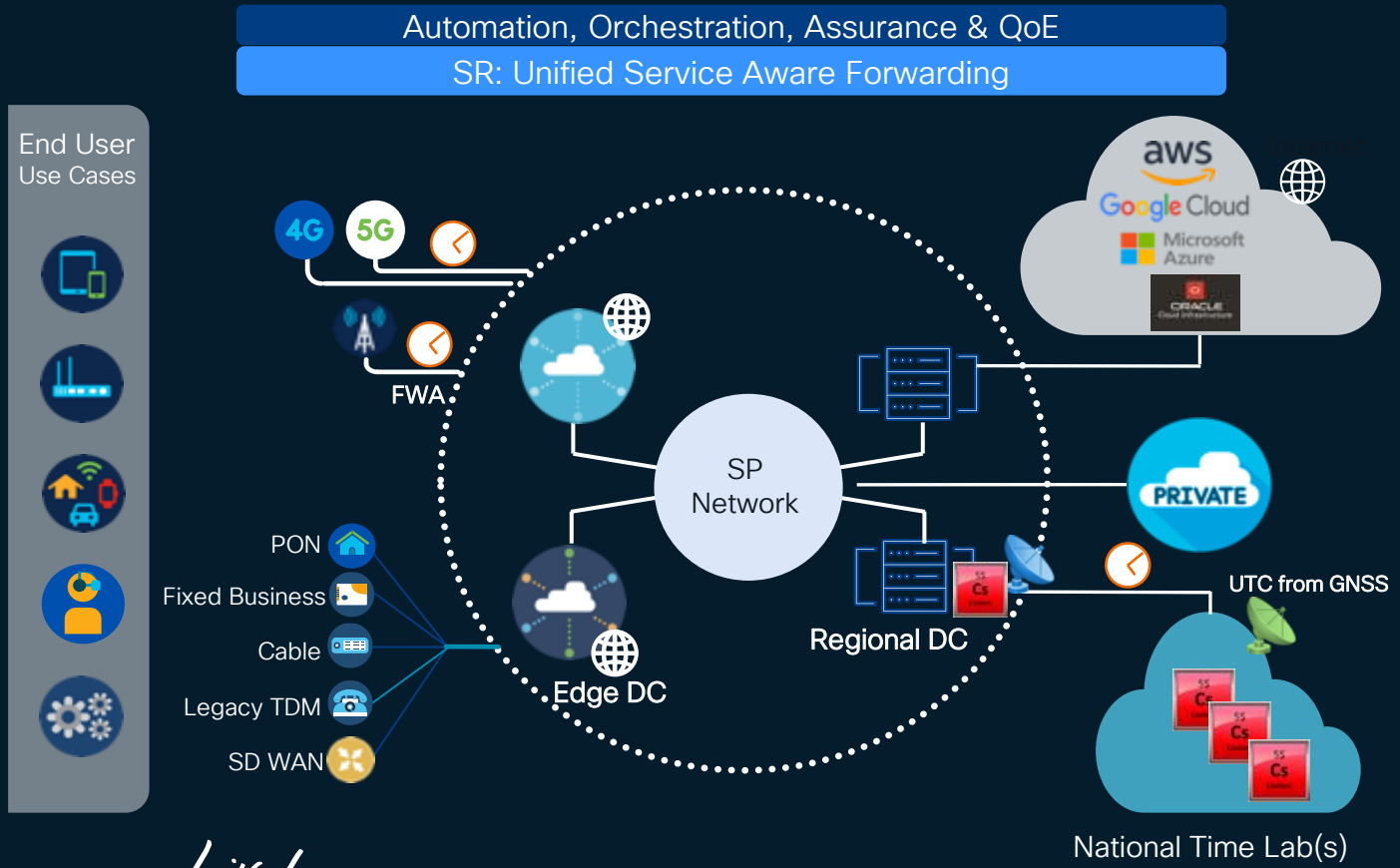
Cloud-Ready Converged SDN Transport



Converged Infrastructure
Wireline & Wireless

Programmable Transport & Network Slicing Services
SR: Unified Service Aware Forwarding

Cloud-Ready
On-Premises/Private Cloud/ Co-location/Public cloud

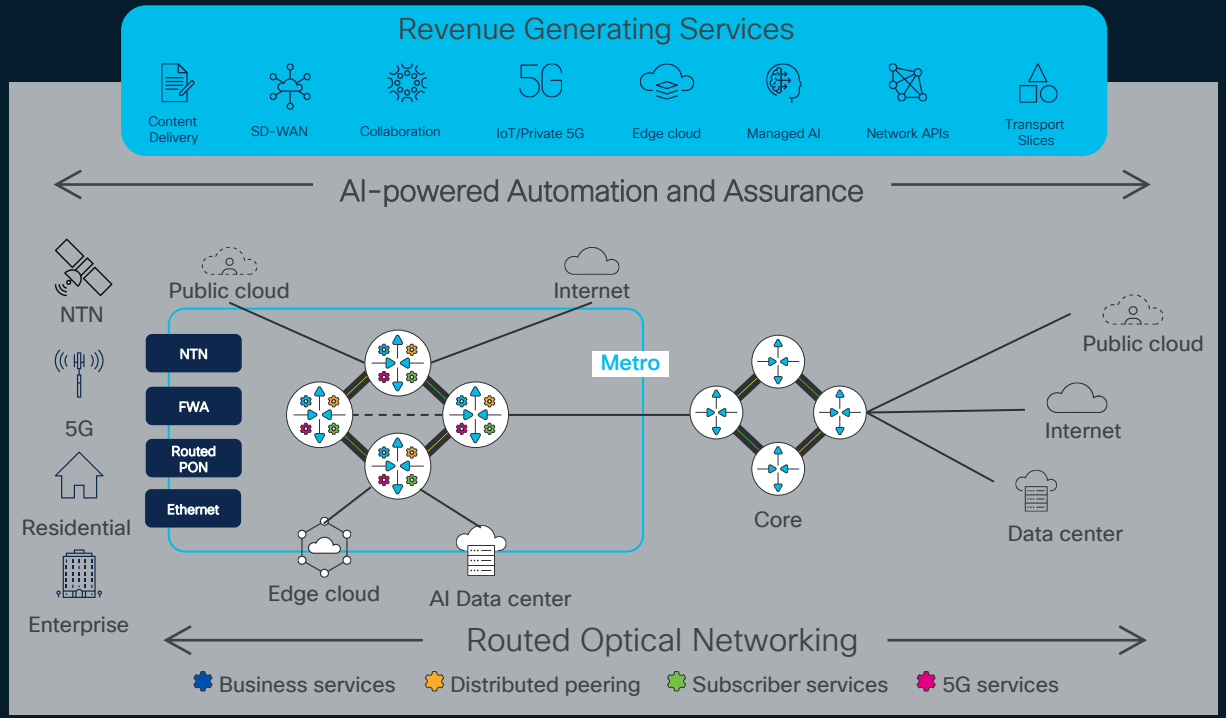
Simplified Operational Model with AIOps

Introducing Cisco Agile Services Networking

A network architecture that enables service providers to monetize the delivery of assured services and networking.

Use cases

- Agile Metro
- Agile DC Connectivity
- Agile Mobile Transport
- Agile Core



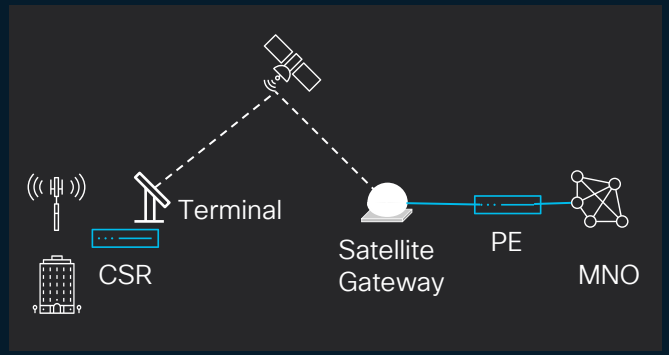
NTN Connectivity Use Cases

Access Network
- 5G Backhaul Connectivity
- Enterprise VPN
  - E-Line
  - E-LAN
  - E-Tree

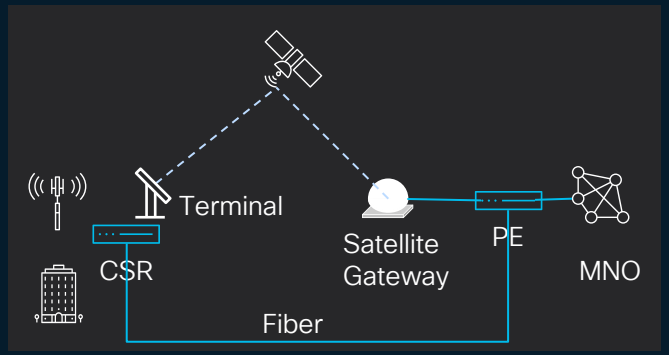
Secure Connectivity
- IPSec
- MACsec

Network Resiliency and Redundancy

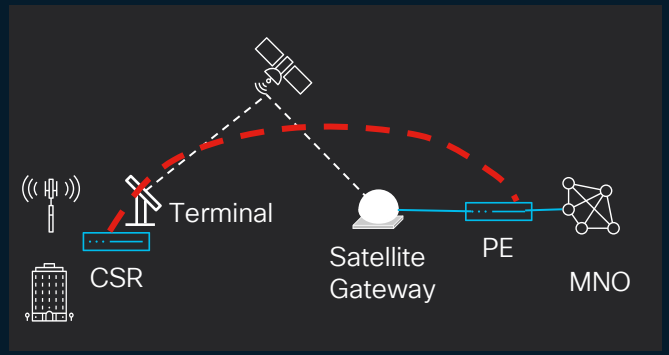
Service Continuity & Assurance



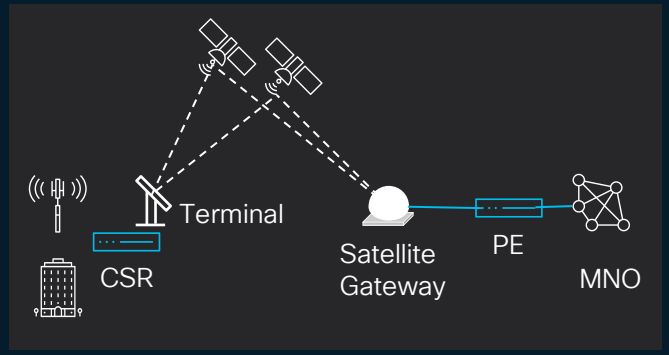
a) Last Mile Connectivity



b) Back-up to Terrestrial Connectivity



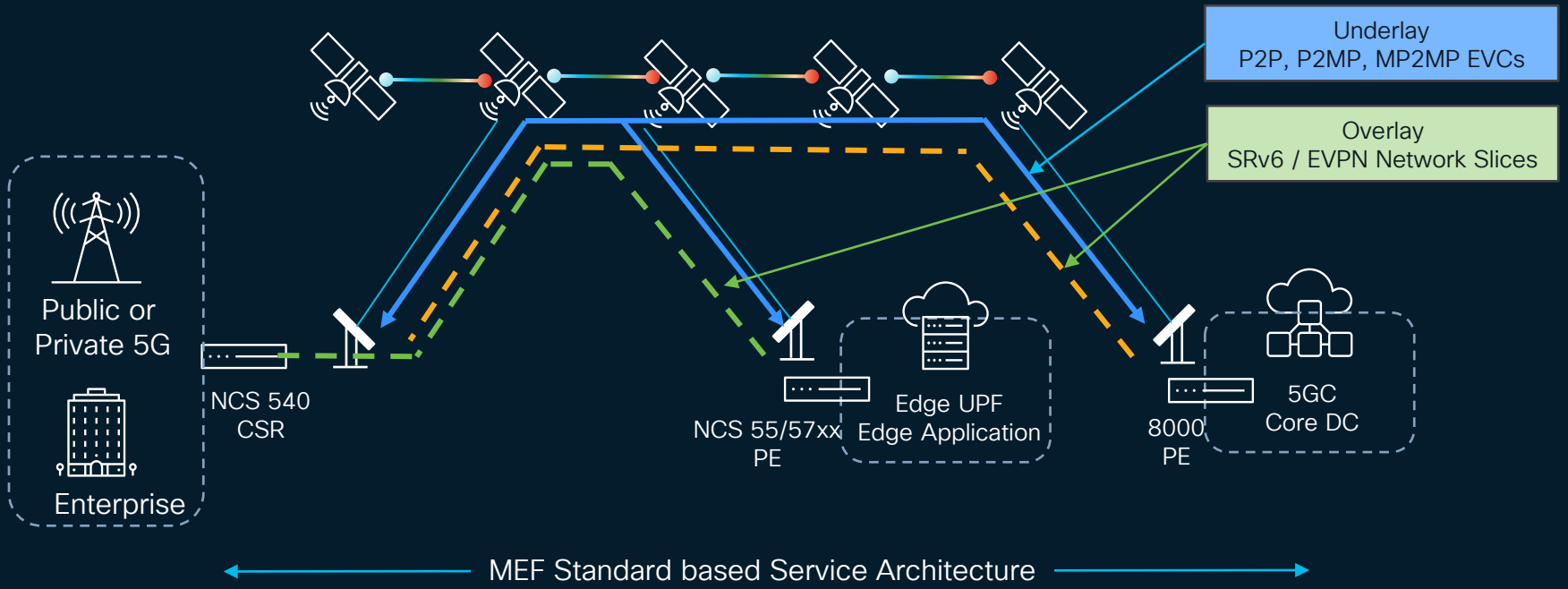
c) Secure Satellite links



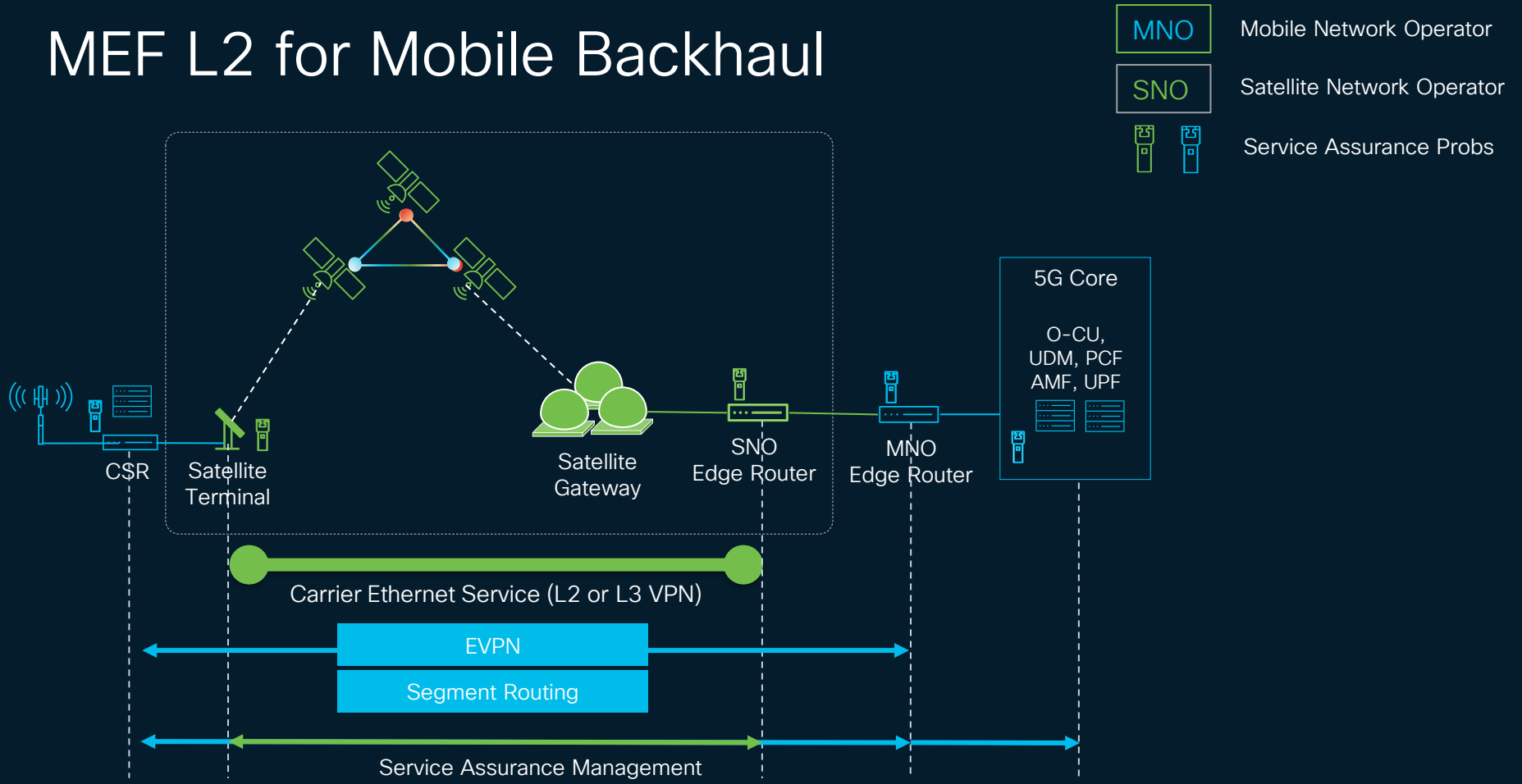
d) BW increase or redundancy

MEF Based Connectivity Services

Example: LEO Type-3 Gateway-less Architecture



MEF L2 for Mobile Backhaul

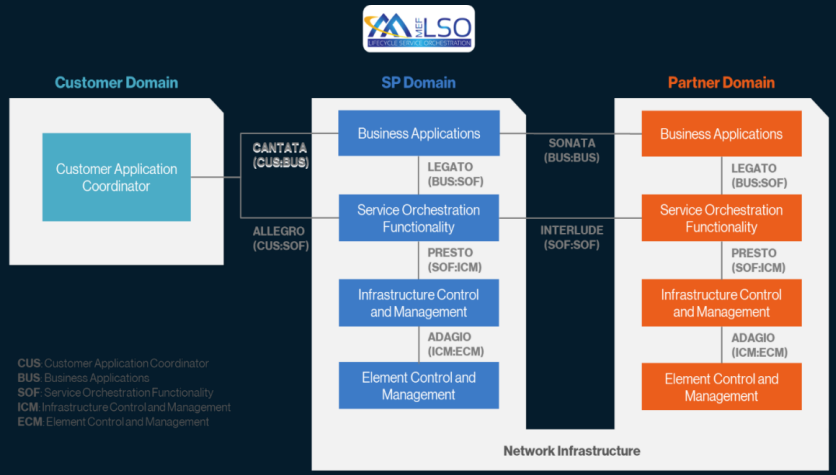


MEF Standardization

LSO APIs for NTN and TN convergence

Contributions to define new KPIs for LEO connectivity in MEF 23.2

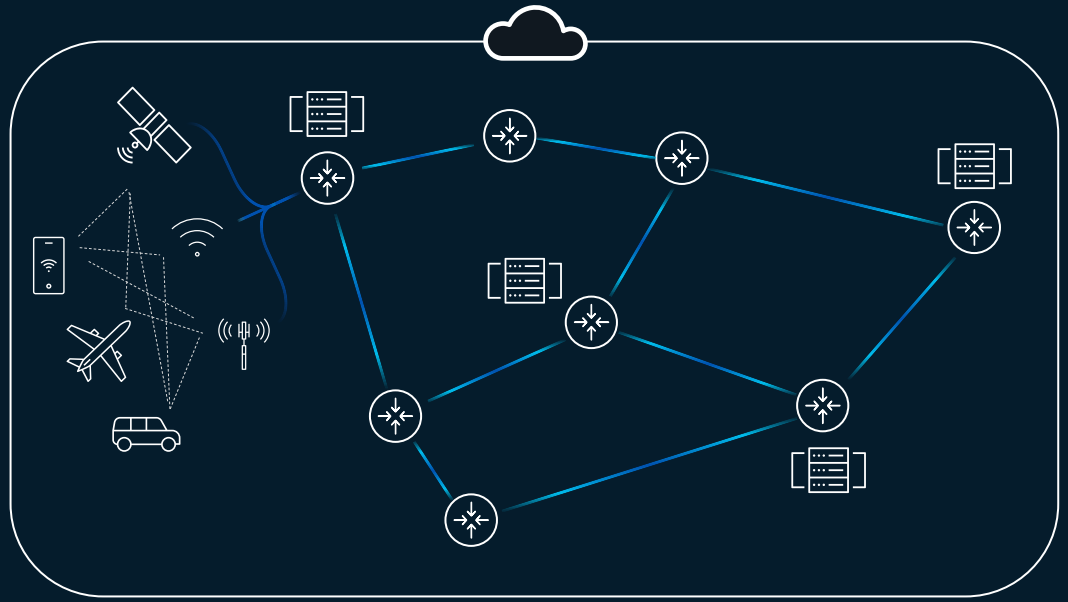
- Amendment required in MEF 23.2.1 (Token Sharing BWPs) and MEF 23.2.2 GEO Satellite
  - Specification for Performance Tier suitable for ultra-low latency and high reliability applications
  - Specification for Performance Tier suitable for LEO satellite



LSO reference Architecture
(MEF 55.1)

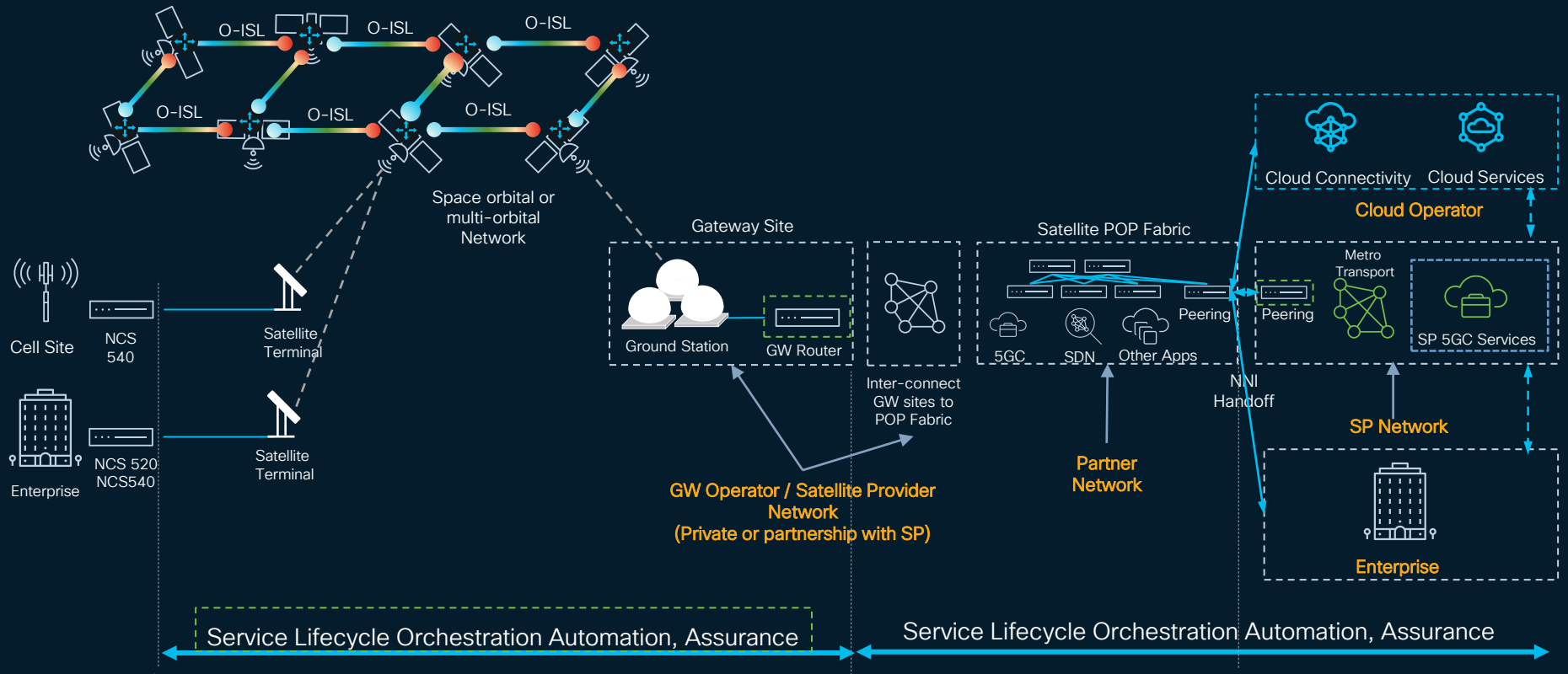
Customer Expectations have Evolved

In the era of Cloud velocity and Increasing Complexity



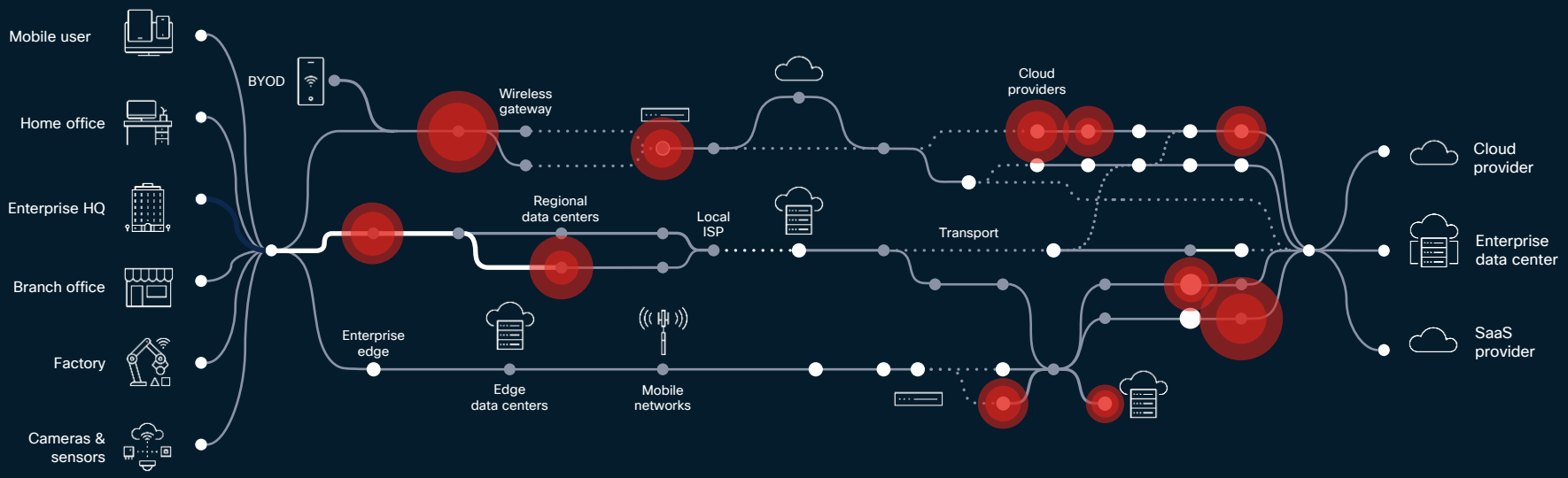
Multiple Silos of Network and Service Data: Layers | Vendors | Domains

Bird-Eye View of End-to-End Network

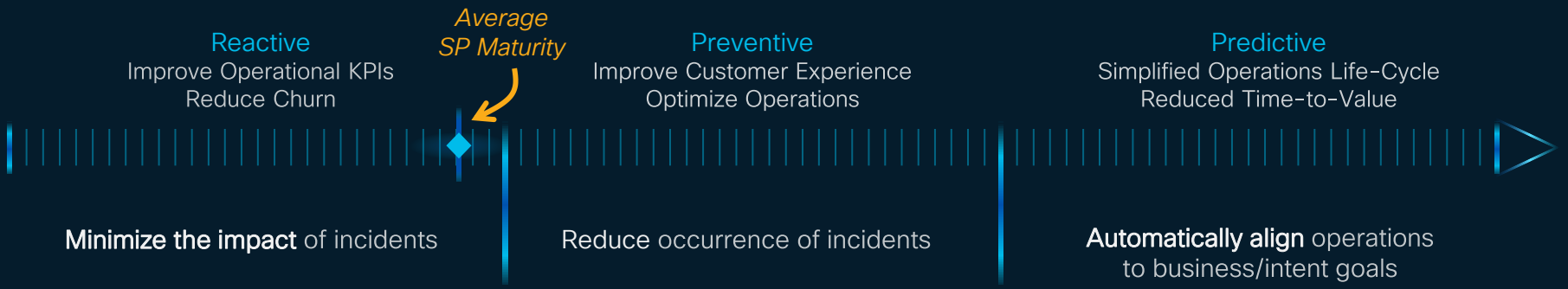


Complexity creates risk

The need for visibility and actionable insights has never been greater to protect against cyber threats, downtime, and poor experiences



From Reactivity to Proactivity



Our Vision for Operational Excellence

Building Blocks of Agile Services Networking

Simple & Sustainable Routing Infrastructure

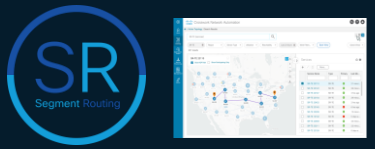
1

Cisco 8000
Cisco Silicon One
Unparalleled performance, TCO and Operational Simplicity

Routed Optical Networking

2

Cisco Routed Optical Networking
Dramatic cost and energy savings with coherent pluggable optics



Network Programmability

3

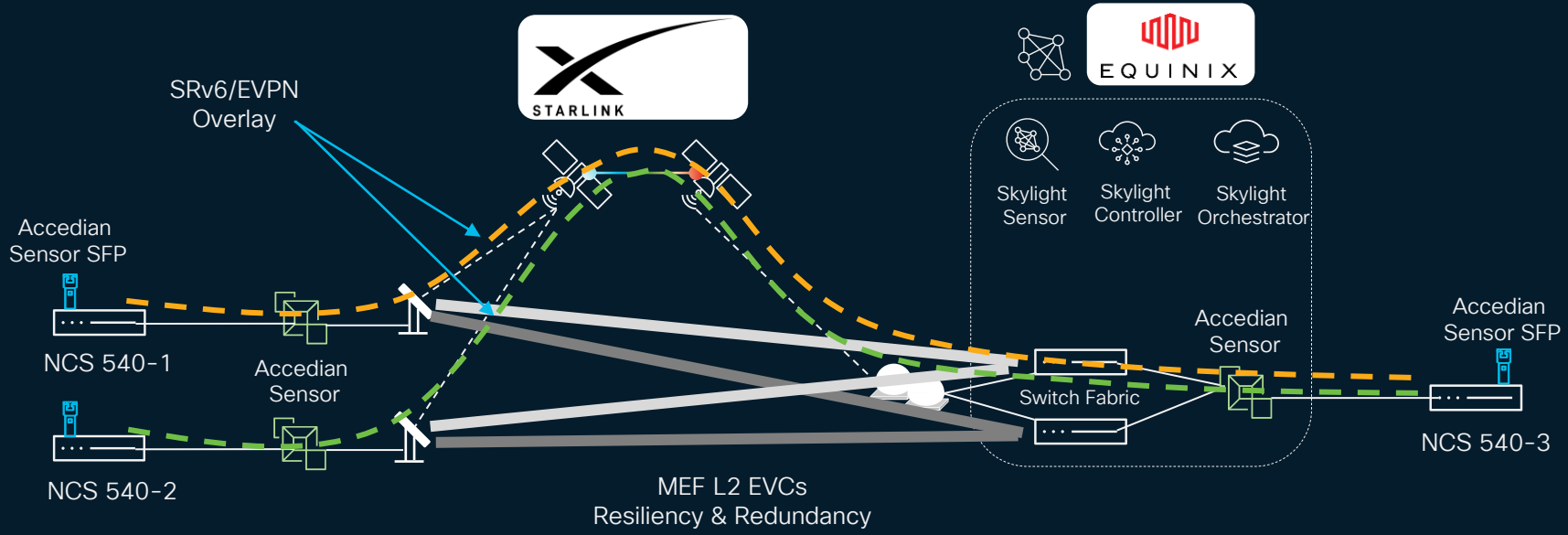
Cisco Crosswork Network Automation
SLA Differentiation and policy control across DC, access, metro, backbone and cloud

Observability and Insight

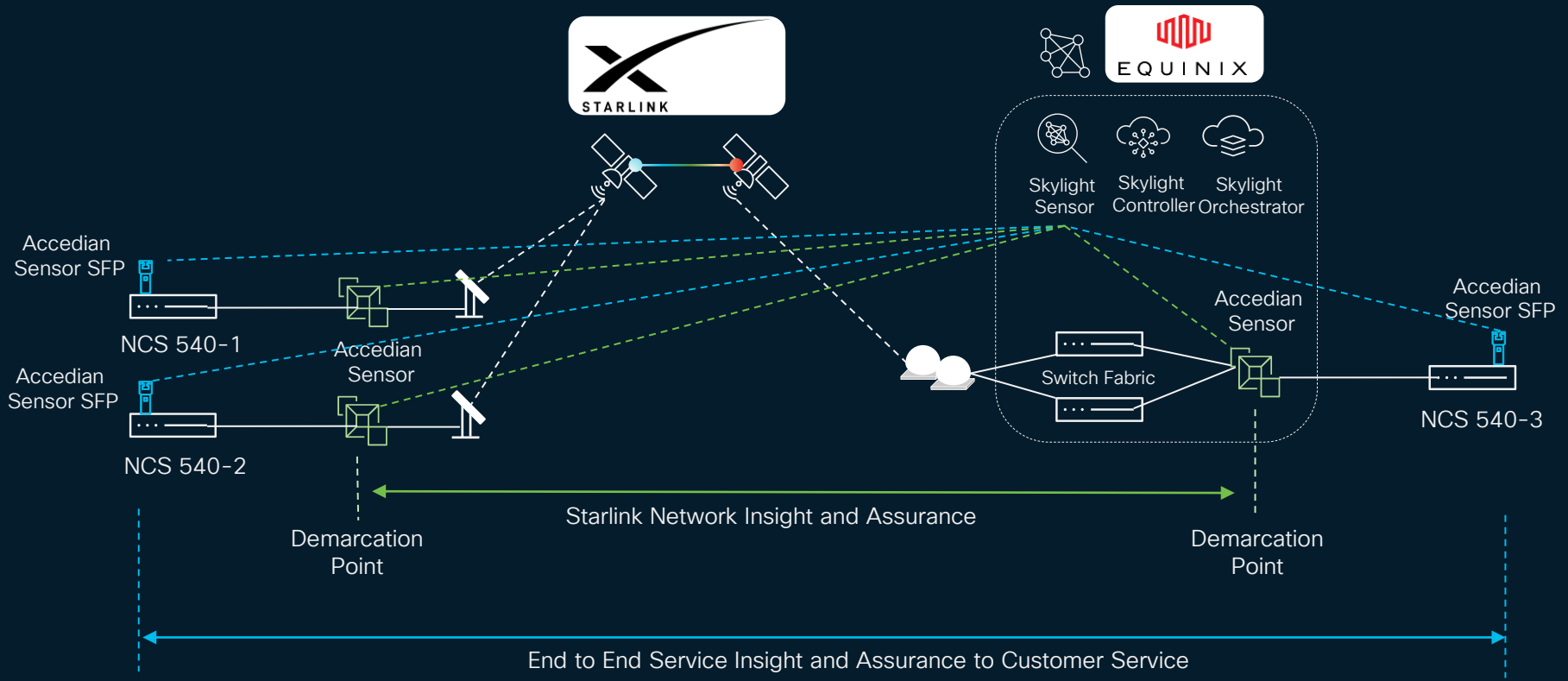
4

Cisco Provider Connectivity Assurance
Realtime visbility and insights for proactive and predictive experience assurance

Cisco Lab Topology



Cisco Lab Topology



Agile Services Networking for NTN Connectivity

Summary

There is growing demand for NTN connectivity Solutions

- Mobile Backhaul
- Network Redundancy & Resiliency
- Connecting un-connected networks

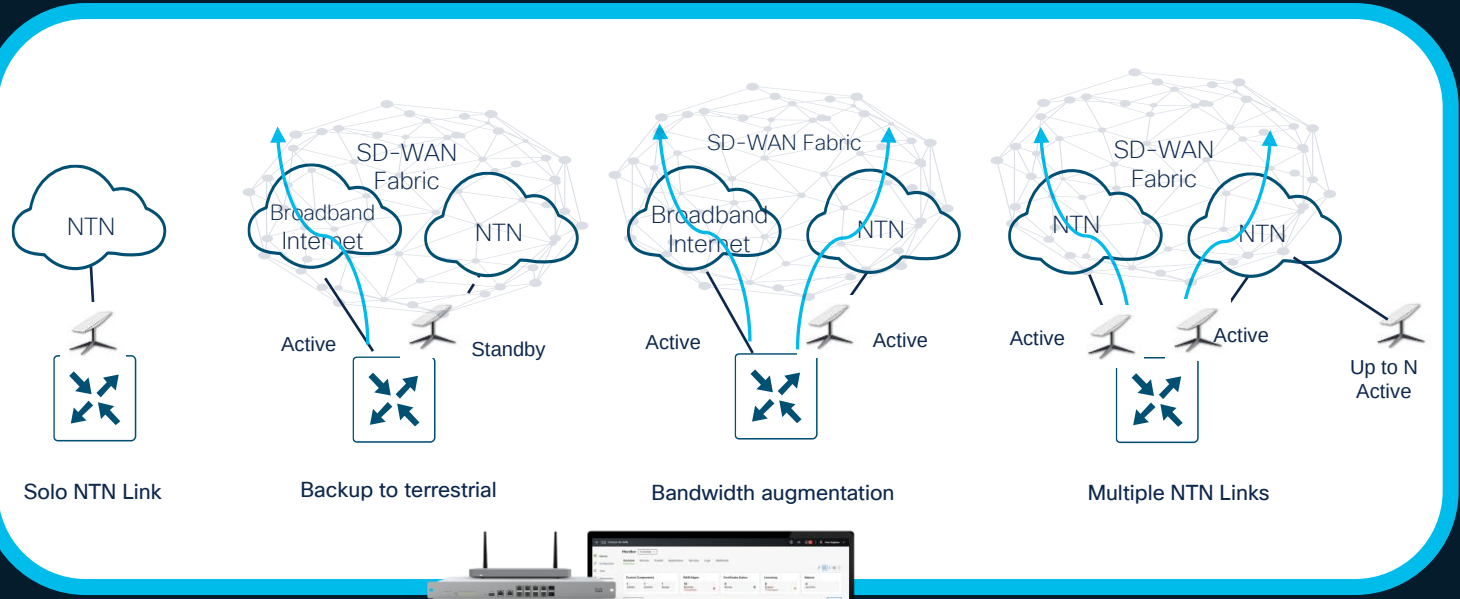
To converge NTN and TN, Service Centric Visibility is Critical

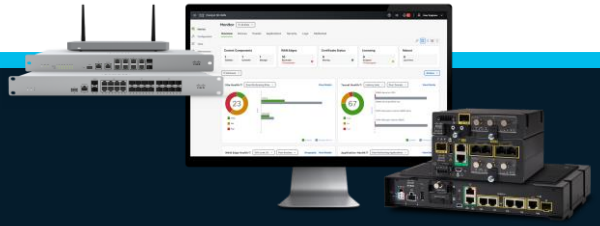
Cisco Agile Services Networking Approach

- Builds high performance networks
- Simplify Operations
- Provides network visibility and insights
- Improves cost and power savings

SD-WAN

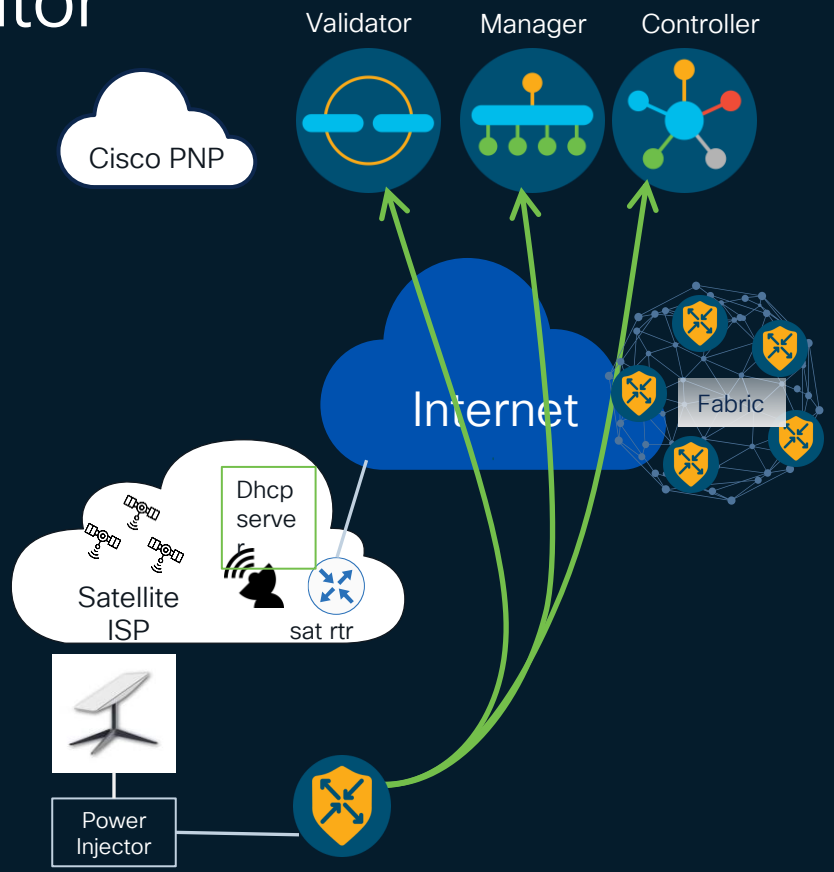
Cisco SD-WAN with NTN





SD-WAN Zero Touch provisioning with Satellite Network Operator

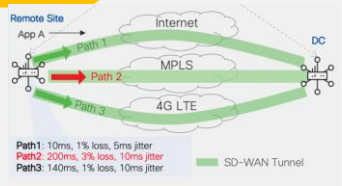
1. Catalyst WAN edge router connects to Satellite terminal over Ethernet handoff
   - SNO supplies proprietary USB-to-Ethernet cable that connects into power injector
2. WAN edge router learns IP address, gateway and DNS from Satellite provider via DHCP
3. WAN edge contacts Cisco cloud-hosted plug-and-play (PNP) server through Internet to discover the specific controllers it is associated with
   - WAN edge contacts Validator and authenticates with mutual certificate exchange
   - Once authenticated, Validator redirects WAN edge to Manager for day-0 configuration
   - Once configured, WAN edge connects to controller for route and policy exchange



Application Experience features

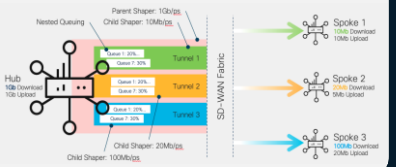
Application Aware routing

- Detects brownout conditions in overlay path.
- SLA based traffic steering
- Automatic failover to secondary path if primary path fails.



Quality of Service (QOS)

- Manage and avoid network congestion
- Guaranteed Bandwidth
- Traffic queueing and shaping
- Prioritize critical application traffic over other traffic.



Forward Error Correction

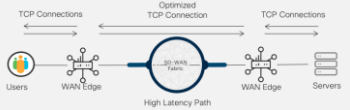
- Protects against packet loss
- Protocol agnostic (TCP/UDP)
- Enhances Application quality of experience

Packet Duplication

- Send duplicate packets over alternate path
- Mitigate packet loss for critical voice or video traffic
- Enhances Application quality of experience

TCP optimization

- BBR2 Congestion control algorithm
- Window scaling
- Large Initial windows
- Selective acknowledgement
- Helps in reducing latency and increase throughput



DRE, LZW

- Traffic optimization techniques
- Byte level caching & Data compression
- Protocol agnostic

Optimizing SD-WAN on Satellite Links

Problems

1. LEO satellite consumer connectivity have lower upload (2-20 Mbps) relative to download speeds of 25-250 Mbps.

2. SD-WAN control traffic can consume a high proportion of this bandwidth in heavily meshed topologies with default timers. This includes:
   - BFD probes over each IPSec tunnel (2.2 Kbps per tunnel)
   - OMP to/from Catalyst controllers (up to 80 Kbps)
   - Statistics upload to the Catalyst Manager (up to 1.2 Mbps)

3. Control traffic is automatically mapped to Q0 on the WAN edge, which can contend with user real-time traffic also in Q0 resulting in drops and instability

Solutions

- ✓ Hub-and-spoke or Dynamic OnDemand tunnel design
- ✓ QoS design with Adaptive QoS and 2-level policer / Split LLQ
- ✓ Last-resort-circuit in cases where Satellite is used for backup to terrestrial circuit(s)
- ✓ vManage connection preference 1 when Satellite is actively used alongside terrestrial circuit(s)
- ✓ Administration Settings for Statistics – disable unnecessary statistics collection when SNO is only transport

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)

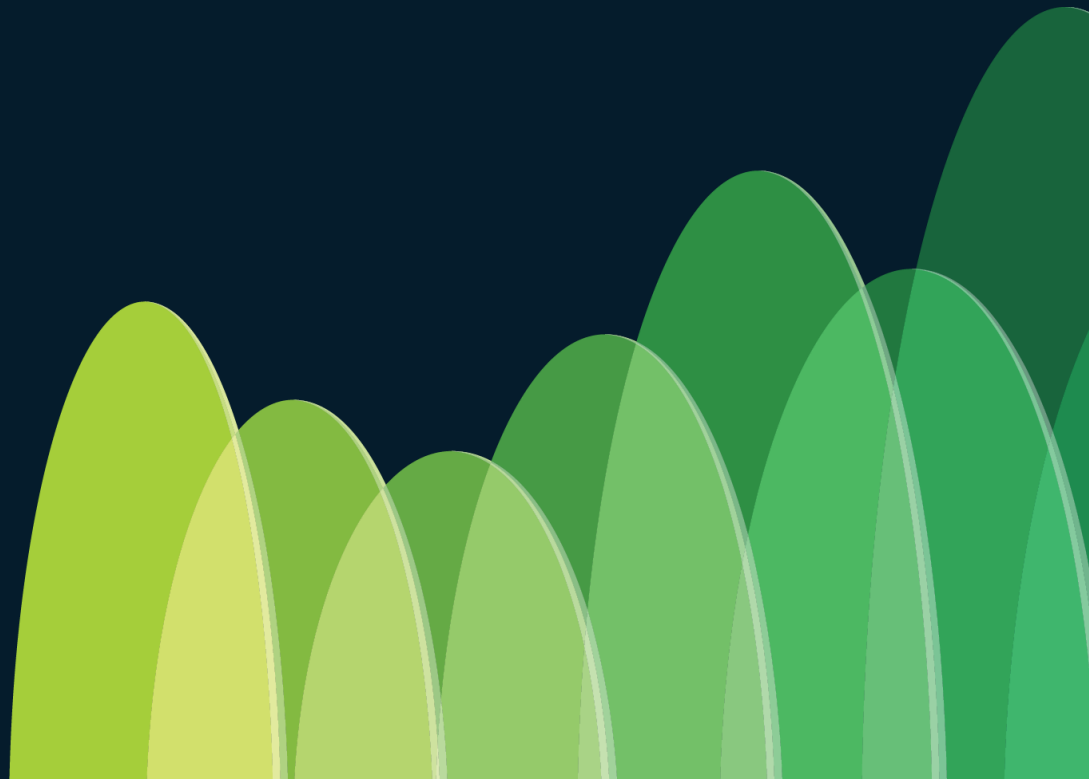
App-QoE Solutions

- 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

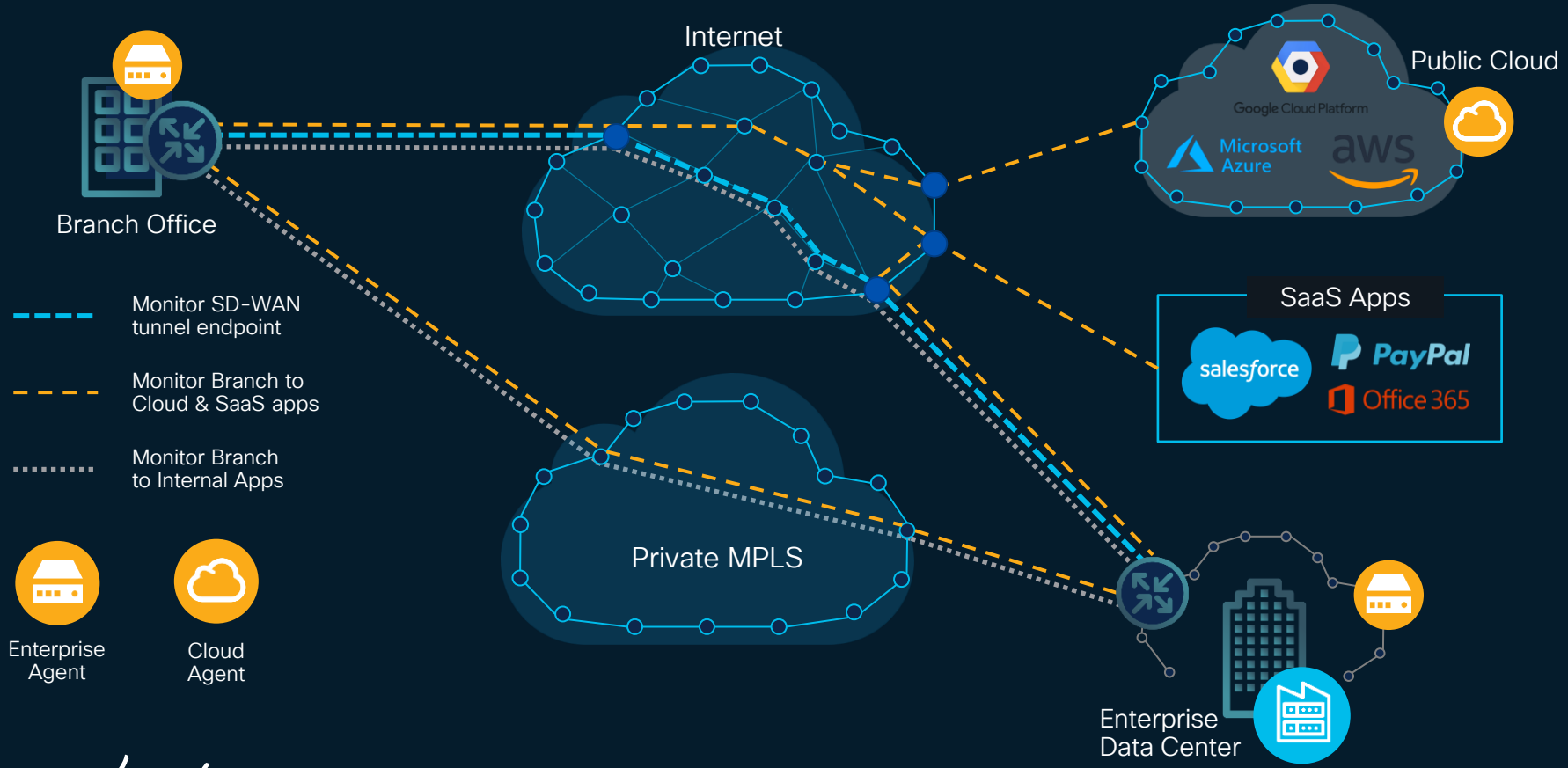
Performance Results

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)	

Improving with Thousand Eyes



SD-WAN Visibility needs; beyond the overlay

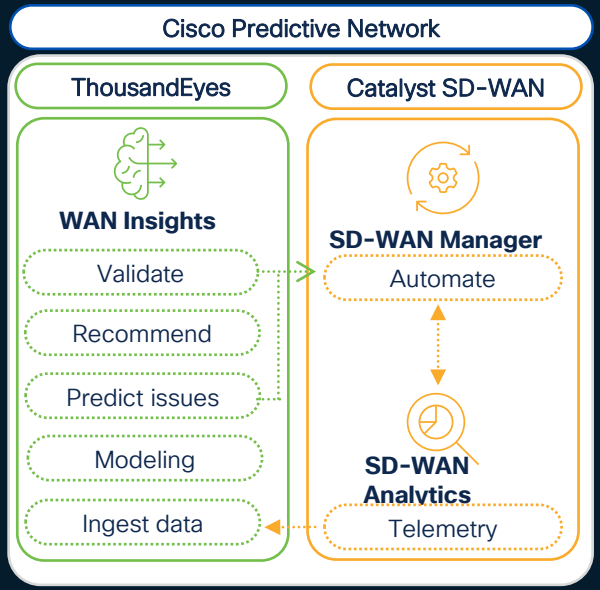


Predictive Path Recommendations

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)

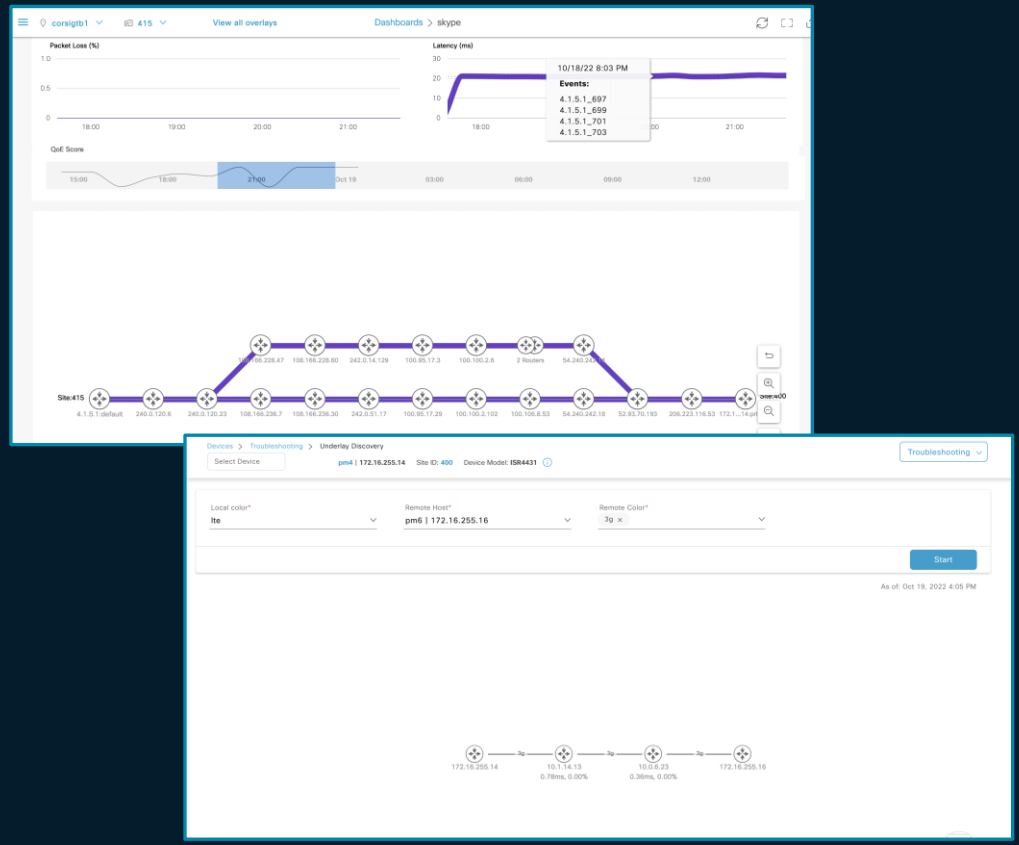
Benefits

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

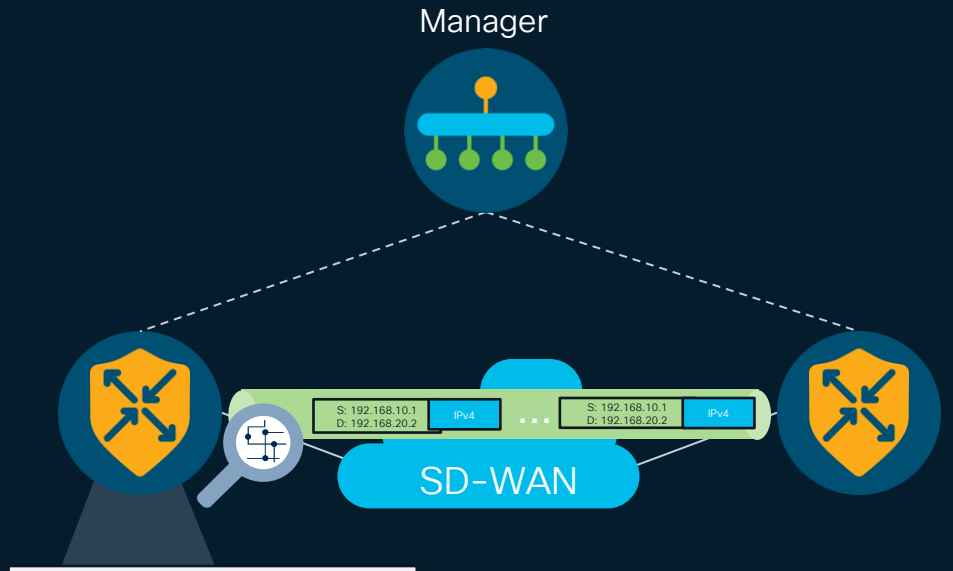


Network Wide Path Insight (NWPI)

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 over NTN

Summary

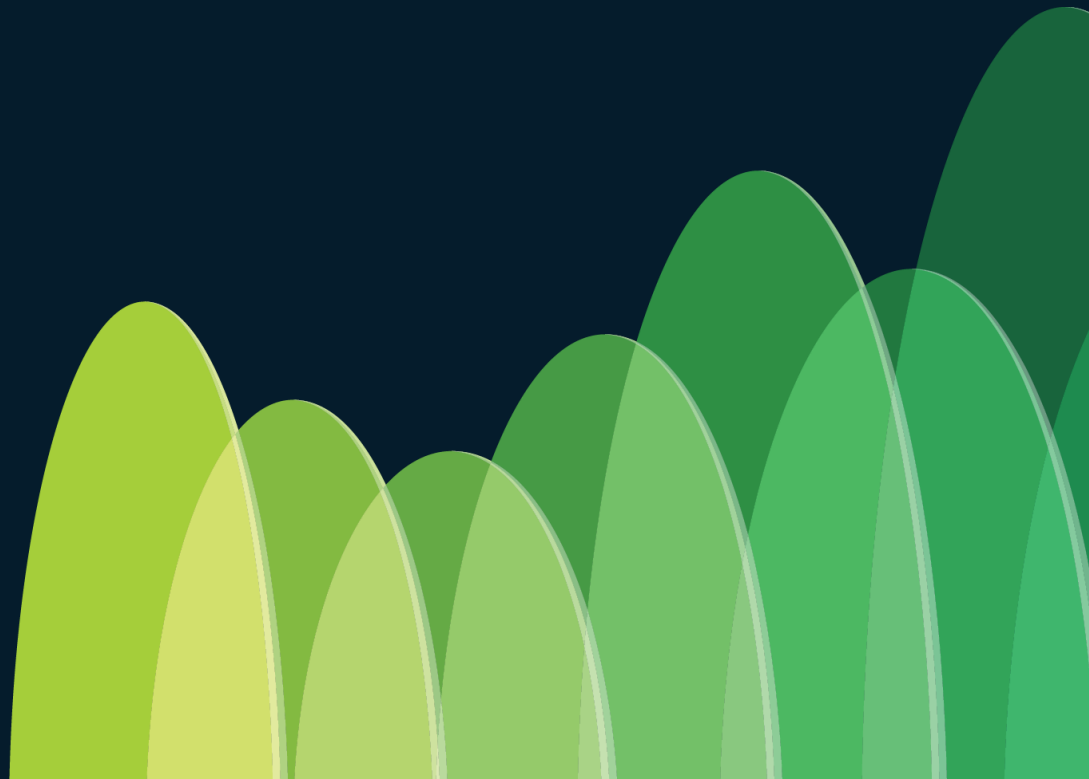
Cisco has validated design best practices to support SD-WAN over NTN

SD-WAN App-QoE features help improve NTN performance

SD-WAN with ThousandEyes:

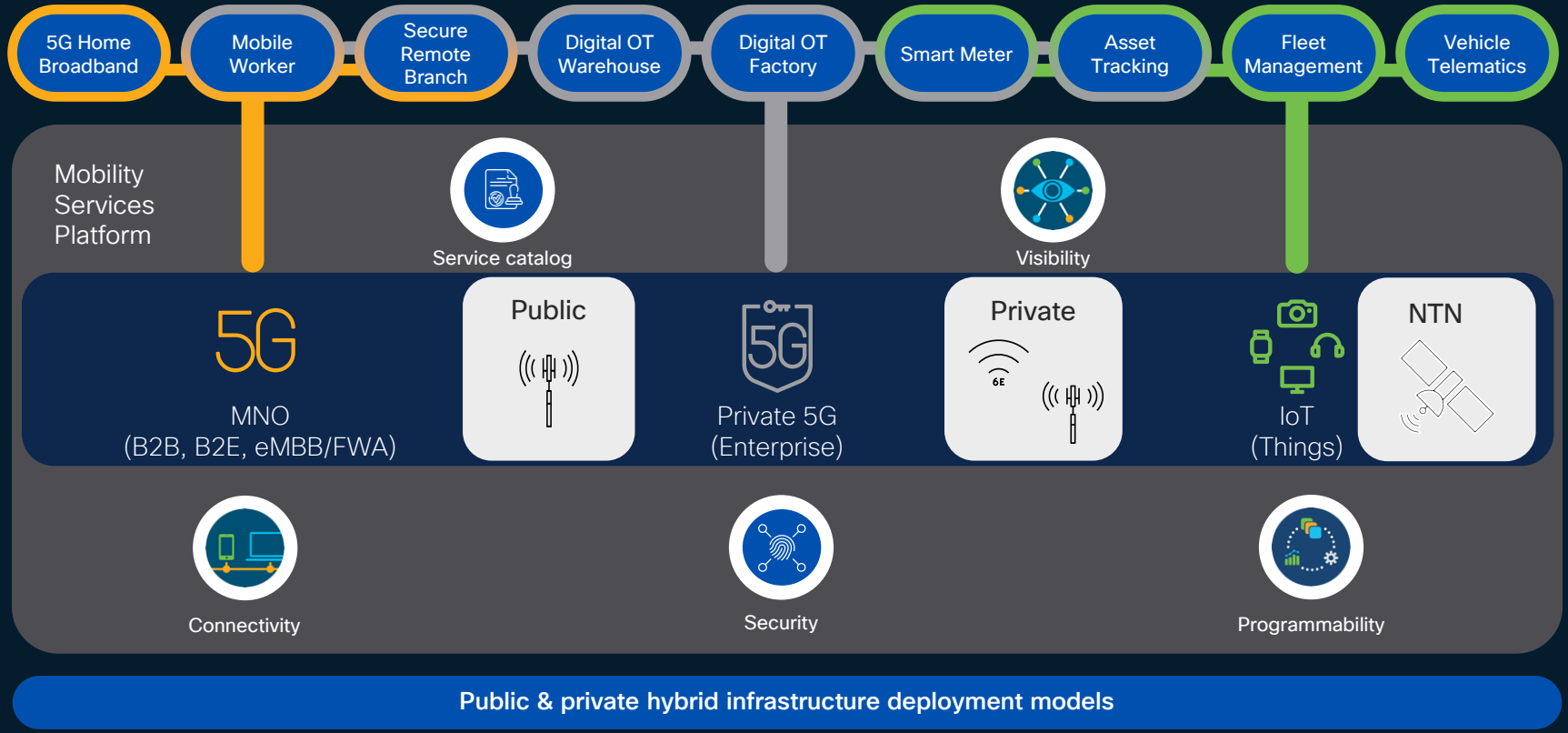
- Gives complete Visibility and Insight to a service
- Provides Traceability and,
- Close loop automation to improve application experience

Cisco Mobility

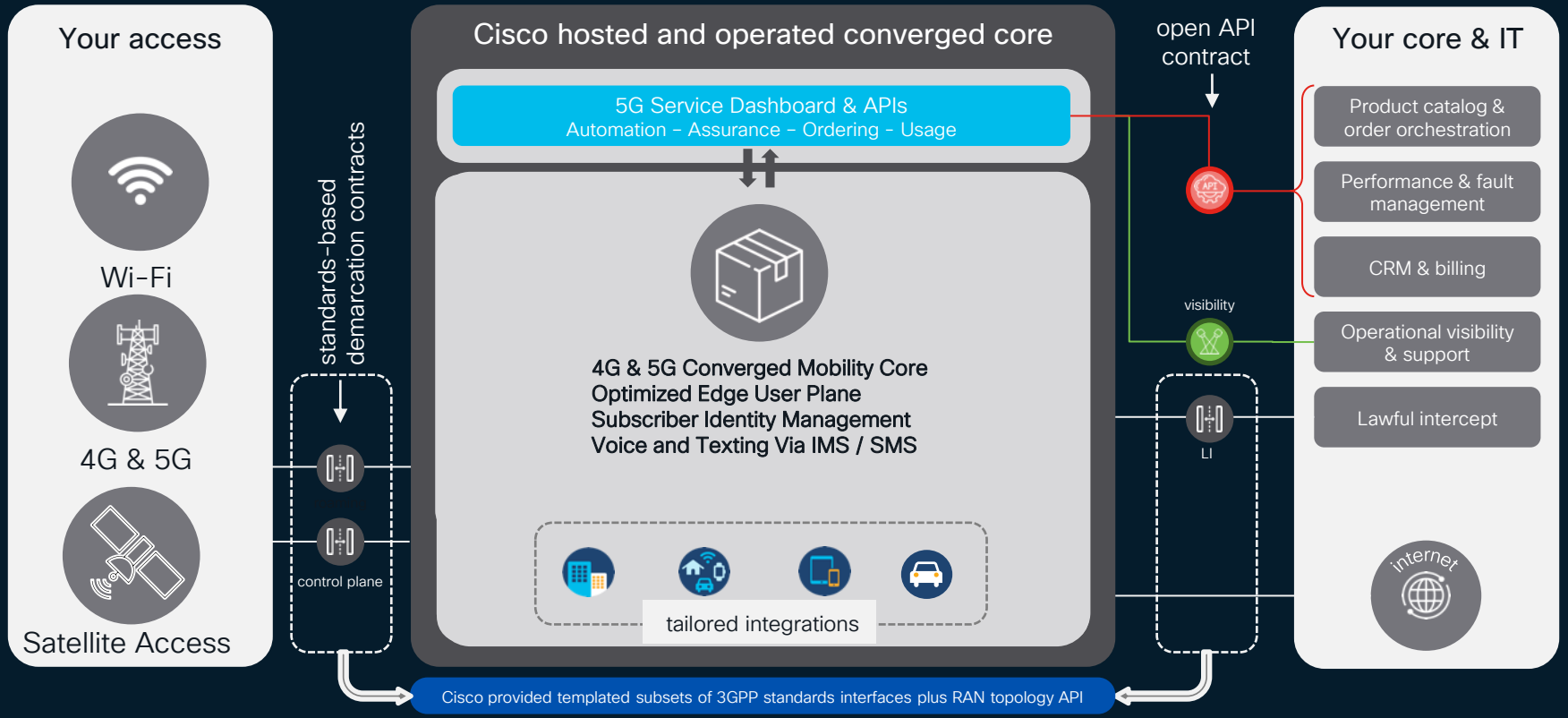


cisco Live!

Cisco Mobility Services Platform

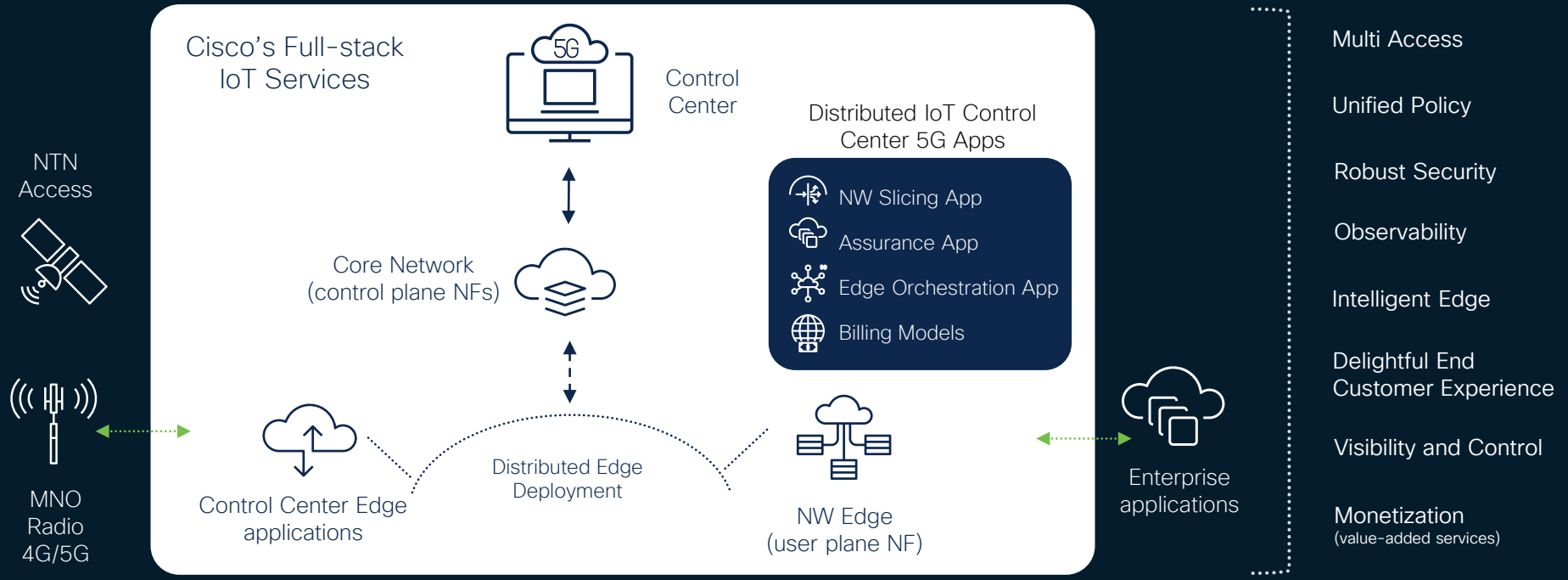


Cisco's Mobility Platform as a Service



Cisco Full-stack Service with IoT Contact Center

Enabling high value, Multiaccess, low latency mission critical use-cases



Control Center: Industry leading capability set

Feature rich, highly scalable, multi-tenant SaaS platform

SERVICES

- GPRS Data (2G, 3G)
- LTE Data
- NB-IoT Data
- SMS
- Voice / VoLTE
- IPv4 / IPv4v6 / IPv6 fixed/dynamic address
- Communication Profiles / Plans
- Roaming Restrictions
- Location Based Services
- Policy Plans (Traffic Management)
- 5G NSA Data
- 5G SA
- Wifi Support (alpha)

DEVICES

- Lifecycle Management
- Diagnostics
- Spotlight

ORDERS

- SIM Orders
- Marketplace

APIs

- Push / Pull
- REST / SOAP
- Webhook

BILLING

- Monthly / Pre-paid Plans
- Individual / Fixed / Flex. Pool Plans
- Event/Stacked/Add-on Plans
- Usage Limits / Zones
- Overage Charges
- Invoices
- Commitments / custom charges
- Adjustments / Proration
- Discounts / Adjustments
- Destination-Based Rating
- Retail Billing

AUTOMATION

- Basic Automation
- Advanced Automation
- Pricing Automation

ANALYTICS

- Standard (Dashboards)
- Business Dashboards
- Enterprise Reports
- Advanced Analytics
- Traffic Segmentation
- ML Proactive IOT – Anomaly detection , Cost Optimization, and Recommendation Engine

SECURITY

- Password Policies / 2-Step Verification
- IP Address Range Restrictions
- IMEI Change Rule / Secure SIM
- SMS/Voice/IMEI Filter
- Rogue Device Detection (ML)

USERS

- User Management
- RBAC
- User Mirroring
- Account Groups
- Account Peering

SUPPORT

- Knowledge Base
- Data Retention/Erasure
- Notifications
- Service Provider Links
- Support Contact Information
- Feedback
- Documentation

MISCELLANEOUS

- Fast Start Migration
- Starter Kit
- eSIM Flex

Go To Market with NTN IoT Solution

Cisco and NTN Service Providers Combined Offering for MNO's

Phase-1 starting with NTN NB-IoT low data rate services

Cisco NTN-Connected Car Solution in conjunction with Terrestrial Partnerships

Cisco NTN IoT Solution for Fleet Management, Commercial Maritime, Asset Tracking

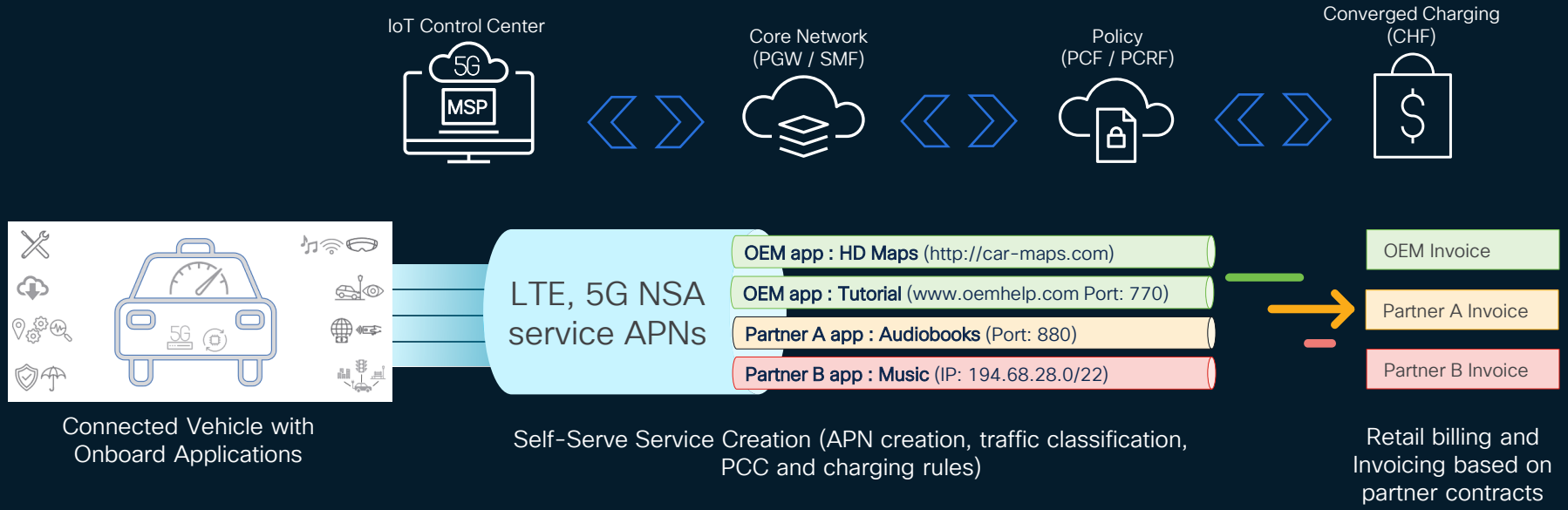
Cisco NTN IoT Solution for Agriculture Sector, Environmental Monitoring

Cisco NTN-IoT Solution for Utilities, Energy, Oil Rigs, Power Grids, Pipelines, Mining

*Vertical Partnership with industry players-Fleet Operators, Transportation, Agriculture, Utilities , Service bundling with Private Network Offering, and other services offering etc.

Dynamic Service Charging

Example: multi-party billing (using self-serve service creation)

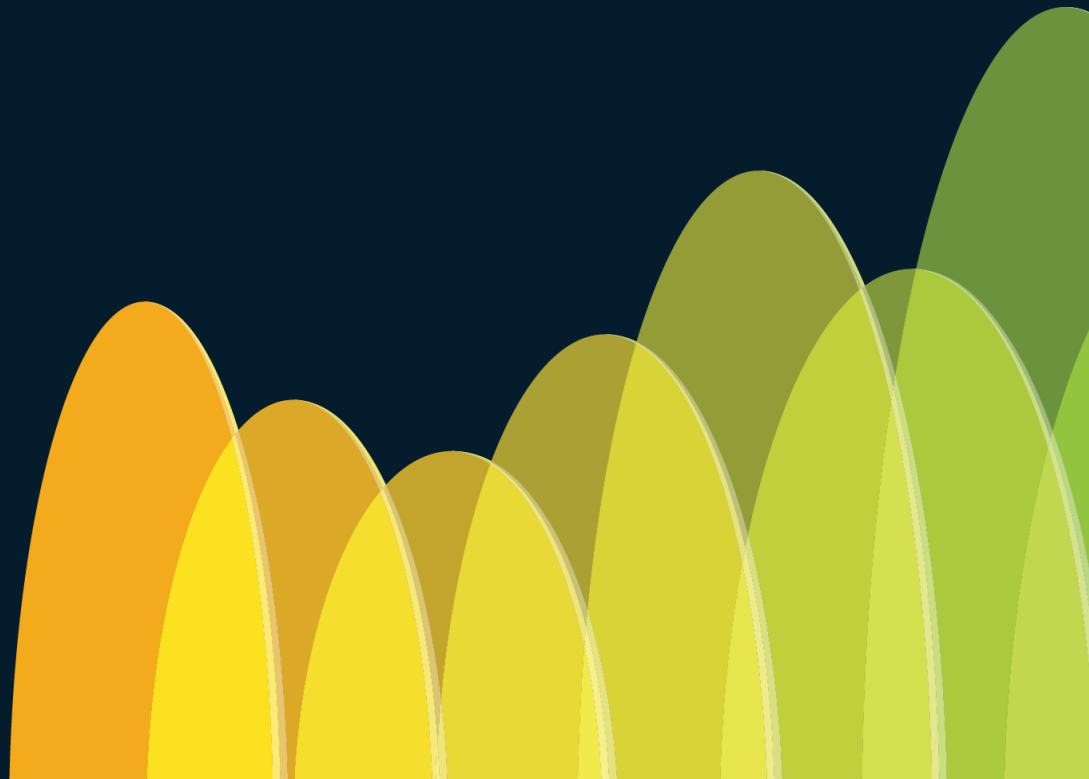


Connected Vehicle with Onboard Applications

Self-Serve Service Creation (APN creation, traffic classification, PCC and charging rules)

Retail billing and Invoicing based on partner contracts

Summary



Key Take-Aways

1. NTN has evolved as alternate transport layer to terrestrial networks
2. Cisco is strategically invested in capturing NTN market
3. Cisco has mature solution for
   - SNO and MNO integration
   - Backhaul and Enterprise VPN services
   - SD-WAN over NTN and,
   - NTN IoT

Learning Map

Feb 10th, 11th and 12th | 1:00 pm

CTF-1397

Elevate Your Network – Cisco SD-WAN meets Outer Space with Steller visibility

Feb 12 | 1:15 pm

BRKSPG-2315

Preparing Your Mobile Transport for 5G Advanced and Beyond

Feb 12 | 5:30 pm

BRKENT-2660

Customer Case Studies: Lessons Learned from the Cisco SD-WAN Design Council

Feb 13 | 12:15 am

BRKSPG-2046

On-the-Move Unified Wireless Network across 5G, Wi-Fi, and Satellite for Emergency Services

Feb 14 | 11:00 pm

BRKOPS-2071

Deploying LEOsat Use Cases, Leveraging Cisco Technologies

Further Reading

Cisco SD-WAN with Starlink
https://learningnetwork.cisco.com/s/article/cisco-catalyst-sd-wan-optimizations-for-starlink

MEF 23.2.2 Satellite Performance Tier
https://www.mef.net/resources/mef-23-2-2-satellite-performance-tier/

MEF LSO API
https://www.mef.net/service-automation/lso-apis/

NTN overview 3GPP
https://www.3gpp.org/technologies/ntn-overview

Webex App

Questions?

Use the Webex app to chat with the speaker after the session

How

1. Find this session in the Cisco Events mobile app
2. Click “Join the Discussion”
3. Install the Webex app or go directly to the Webex space
4. Enter messages/questions in the Webex space

Webex spaces will be moderated by the speaker until February 28, 2025.

Fill Out Your Session Surveys

Participants who fill out a minimum of 4 session surveys and the overall event survey will get a unique Cisco Live t-shirt.

(from 11:30 on Thursday, while supplies last)

All surveys can be taken in the Cisco Events mobile app or by logging in to the Session Catalog and clicking the ‘Participant Dashboard’

Content Catalog

Continue your education

- Visit the Cisco Showcase for related demos
- Book your one-on-one Meet the Engineer meeting
- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at ciscolive.com/on-demand. Sessions from this event will be available from March 3.

Contact me at: shajmeri@cisco.com


cisco
Thank you
cisco Live!

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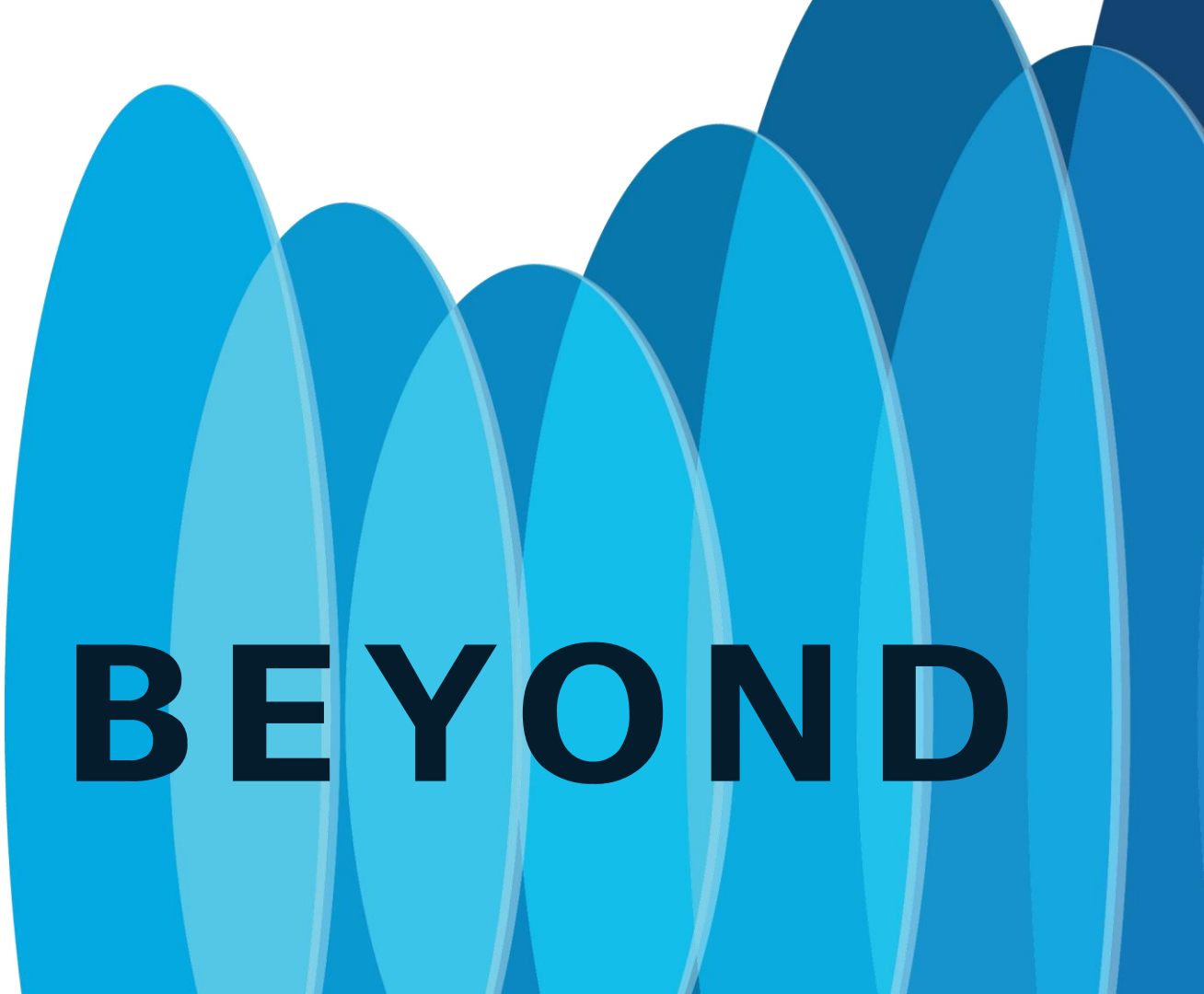

GO BEYOND