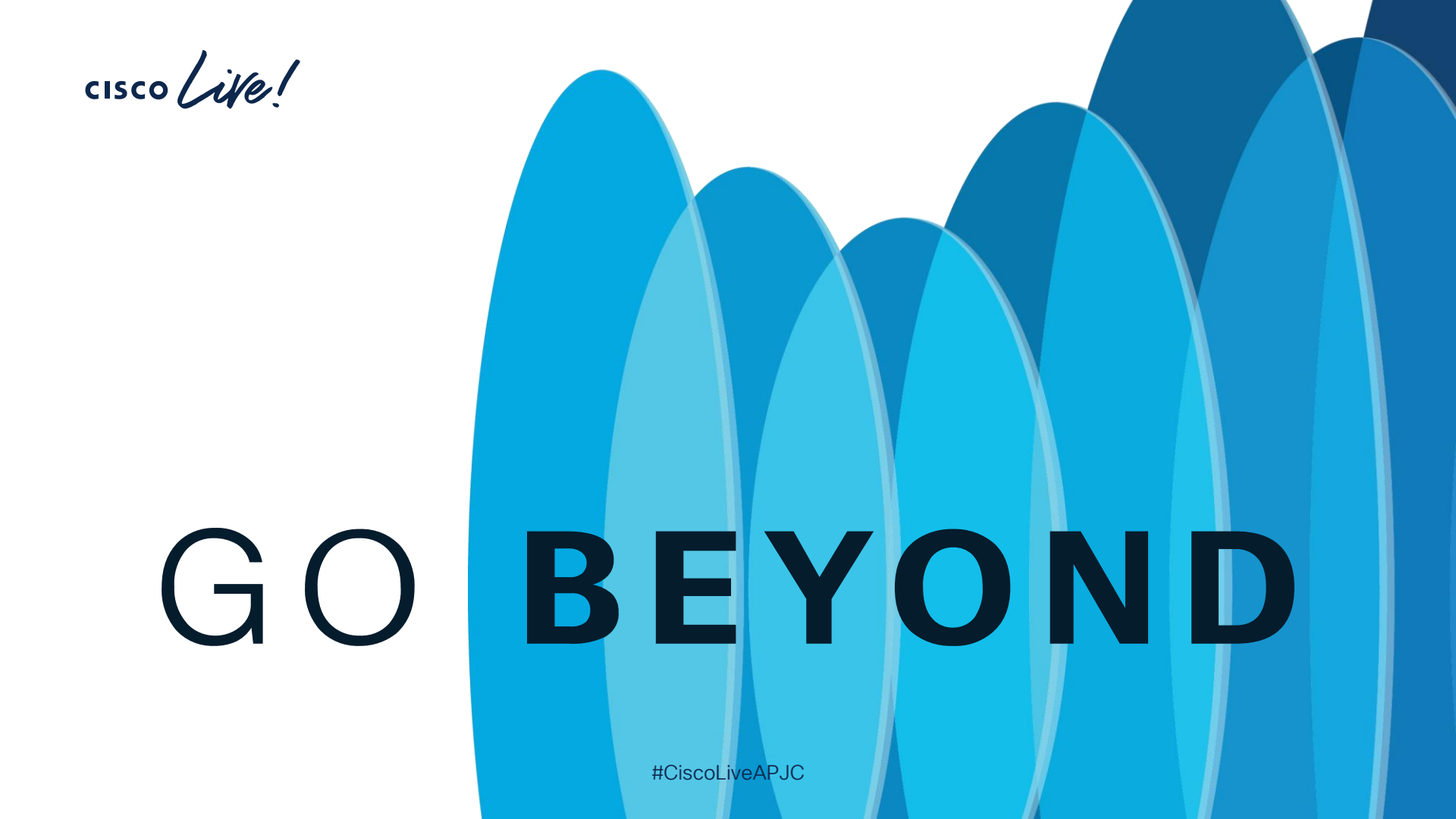
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Session ID

"Reconciliation"- Dustin Koa Art

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Extending Cisco SD-WAN to Industrial IoT solutions

Subtitle goes here

Chundury Jagadish, Customer Delivery Engineering Technical Leader
@https://x.com/ChunduryJagadis

BRKIOT-2261

Cisco Webex App

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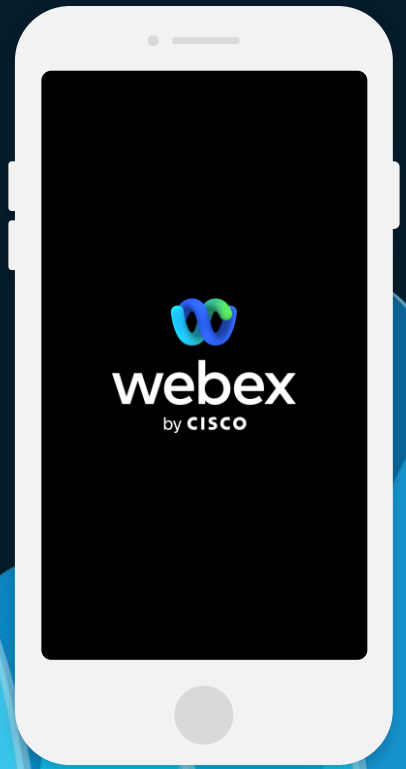

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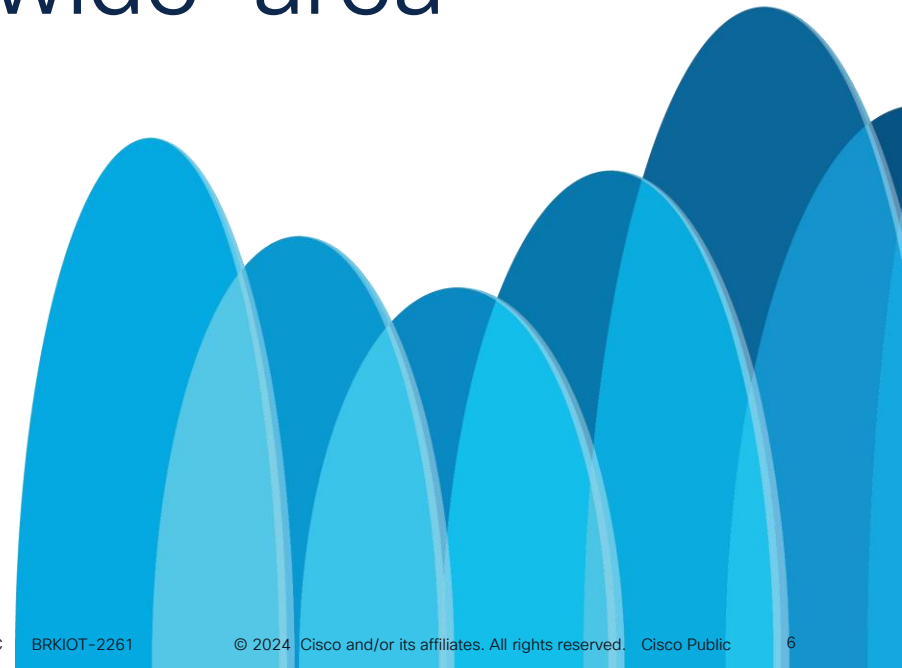
“Disruptions by digital transformation are driving adoption of SD-WAN at a pace that is unheard of in wide-area networking”

Gartner

https://www.gartner.com/document/3535717



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"The SD-WAN market is expected to witness a CAGR of 38.9% from 4B in 2023 to 42B in 2030”

SD-WAN market survey report 2024

Prescient & Strategic Intelligence

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Agenda

- Why SD-WAN is the Future of Networking?
- Cisco’s Industrial IoT portfolio
- Cisco’s SD-WAN extension for Industrial IoT

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Why SD-WAN is the Future of Networking?

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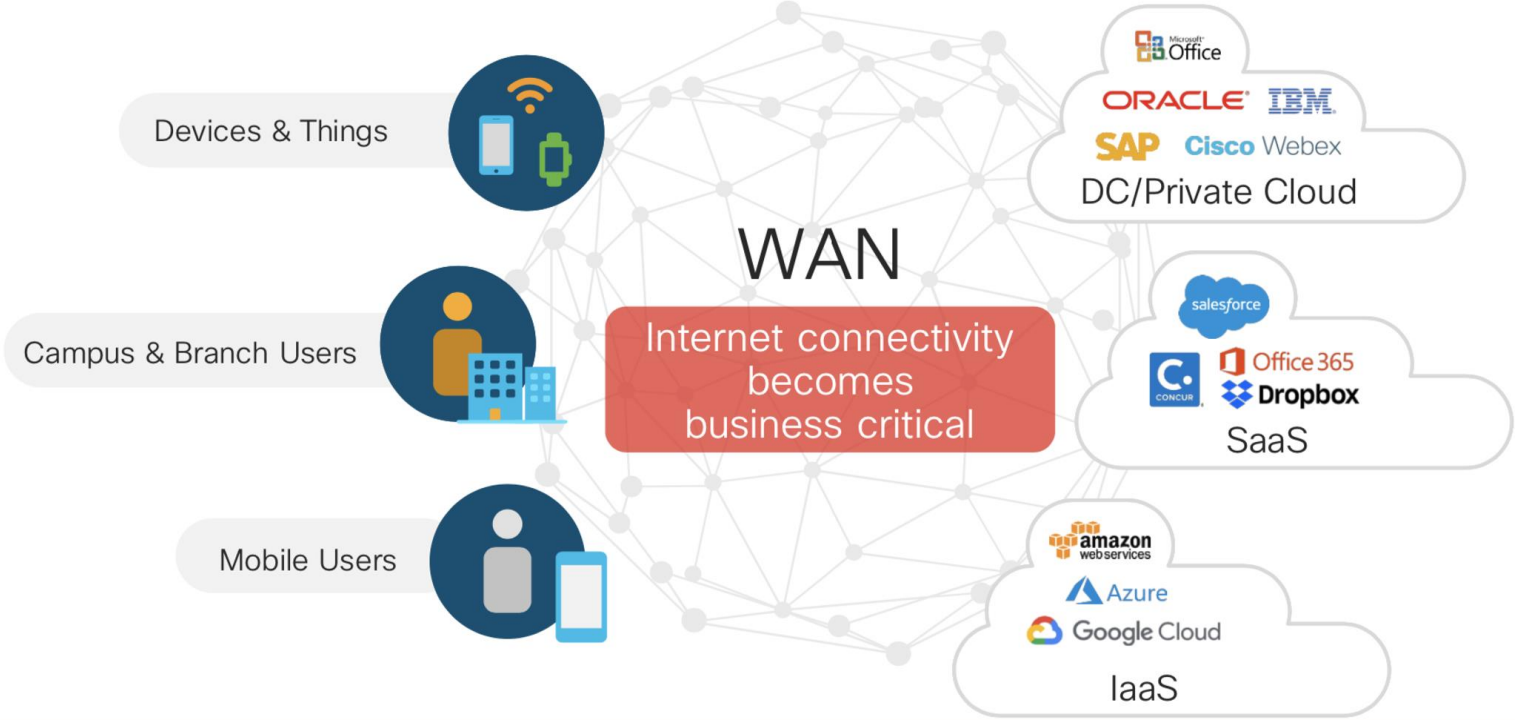
Applications Moving to Not one Cloud, But Many



More user, things and applications, everywhere

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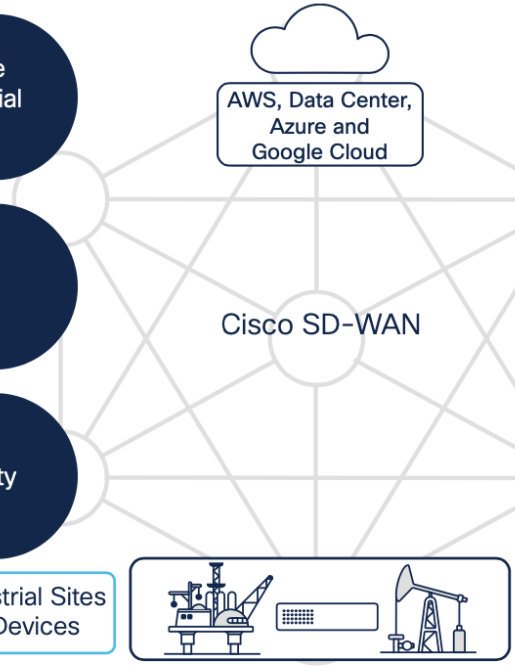
Significance of SD-WAN for Industrial solutions

Simplified Management using one pane of glass for both Enterprise and Industrial edge devices.

Security Policies pushed through to and enforced at the Industrial Edge

Both On-premises or Cloud-based options architectures providing flexibility to address customer preferences



Support for multiple WAN Transports providing resilient connectivity in wireless industrial settings

Rapid Head End Definition and Deployment using Cisco Enterprise routers on same network fabric as edge Industrial routers

Predictable Application Experience with policy, QoS and application aware routing

Resiliency of enterprise-grade scalable infrastructure foundation...
with the addition of features required for Industrial Verticals

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Customer objectives and challenges in IIoT

Customer objectives

1. Reduce security risk for devices in noncarpeted areas
2. Gain speed and agility
3. Extend connectivity to rugged, noncarpeted areas
4. Meet compliance and regulatory goals
5. Innovate and differentiate

Customer challenges

1. Security concerns
2. IT + OT
3. ROI
4. Control and complexity
5. Business process – people – tech – digital twins

Remote ATMs	Warehouses	Distribution centers	Ports	Remote POS

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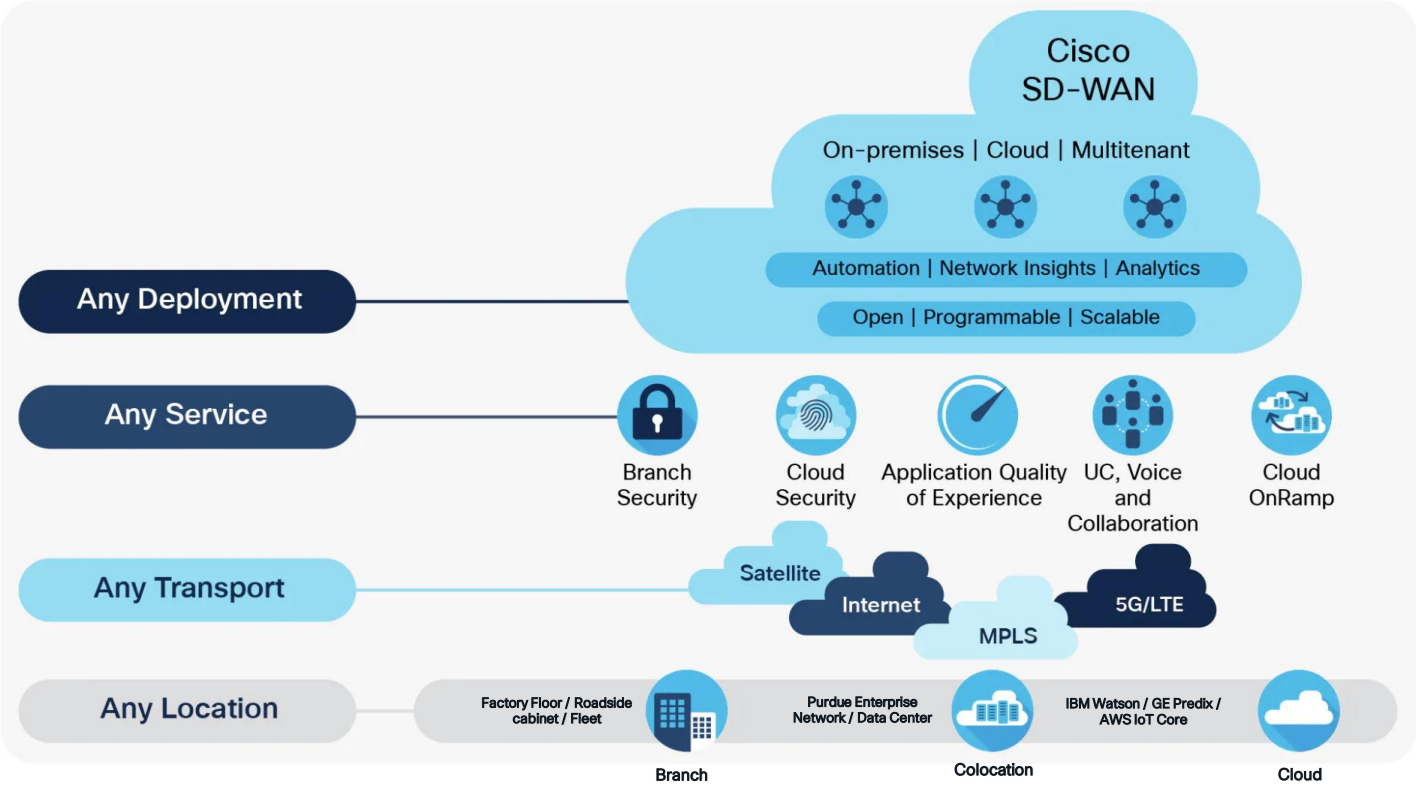
Cisco SD-WAN in a nutshell



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Industrial IoT

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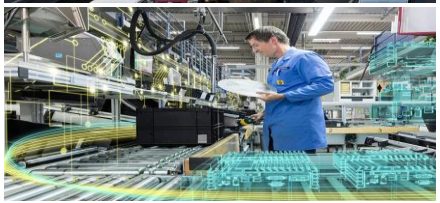
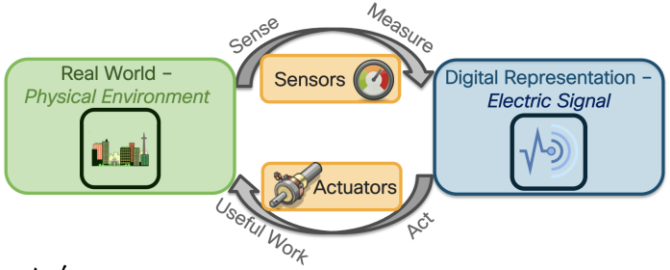
Real world and IT World





Product impact	Potential IT/OT applications
Physical ⟶ digital	• Sensors and controls • Wearables • Augmented reality
Digital	• Signal aggregation • Optimization and prediction • Visualization and POU delivery • Cognitive and high-performance computing
Digital ⟶ physical	• Additive manufacturing • Advanced materials • Autonomous robotics • Digital design and simulation

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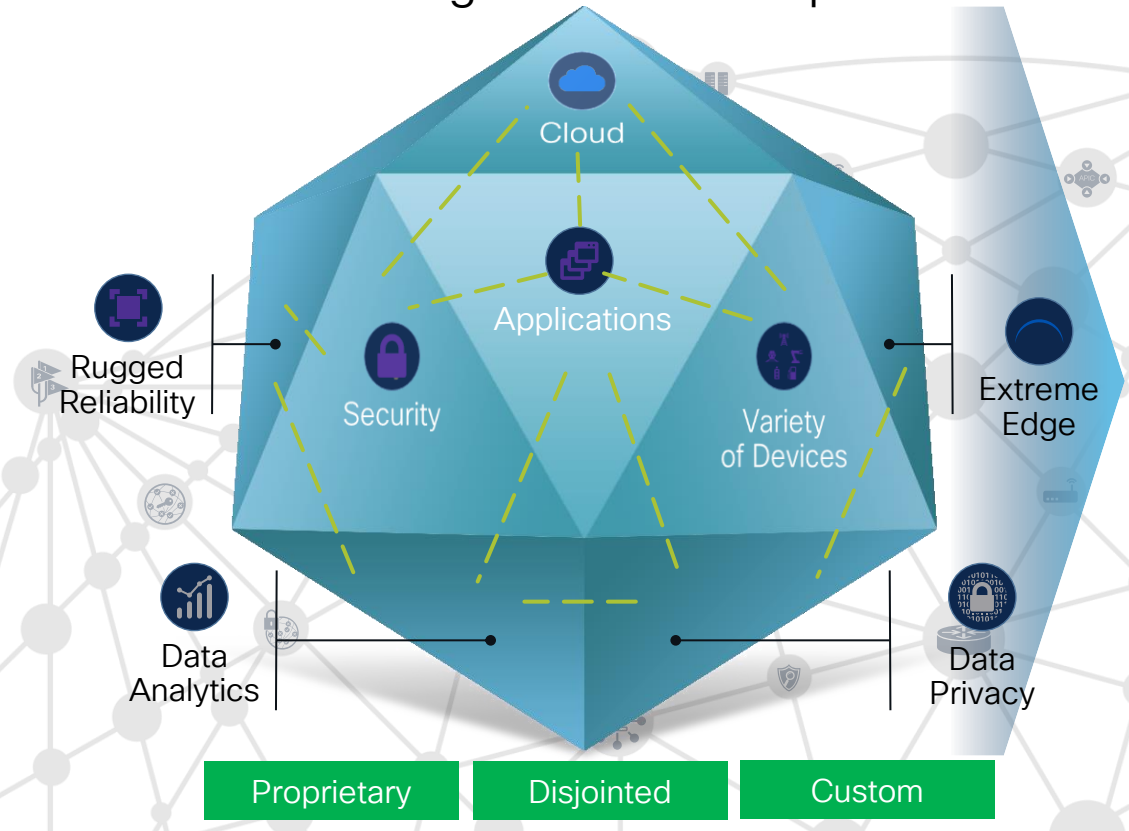
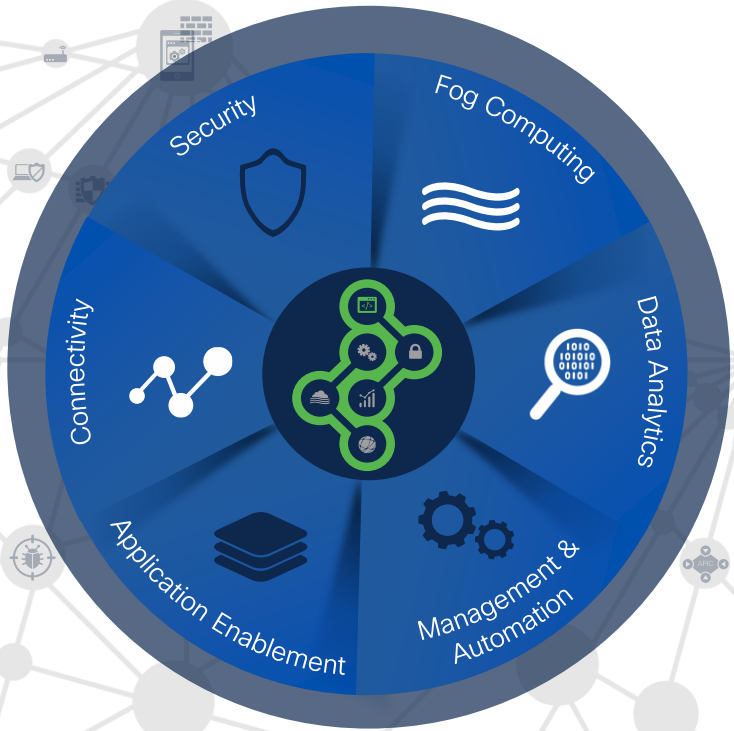
- Harsh environment
- Low Power
- Low bandwidth
- Mission critical
- Industrial Security
- Industrial Protocols

IoT Needs a Holistic Approach

From: Fragmented & Complex

To: Integrated IoT System





Traditional Networking Series

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Industrial Networking Series

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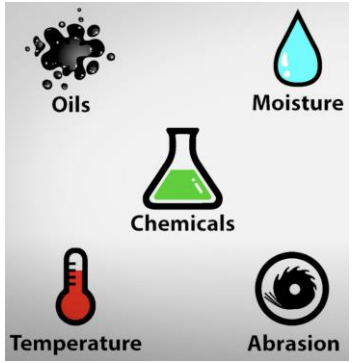
Ruggedized Devices and Connectors



Sample IP Rating

IP	6	8
"Ingress Protection"	First Digit: Solids Protection	Second Digit: Liquids Protection

	HAZARDOUS MATERIAL	CLASS	CLASS/DIVISION	GROUPS
	Gases or Vapors (acetylene, hydrogen, ethylene, propane)	Class I	Division 1 Division 2	A, B, C, D
	Combustible Dusts (electrically conductive dusts, carbonaceous dusts, agricultural dusts)	Class II	Division 1 Division 2	E, F, G
	Ignitable Fibers (cotton lint, flax, rayon)	Class III	Division 1 Division 2	No Equivalent

https://www.dsmt.com/resources/ip-rating-chart/

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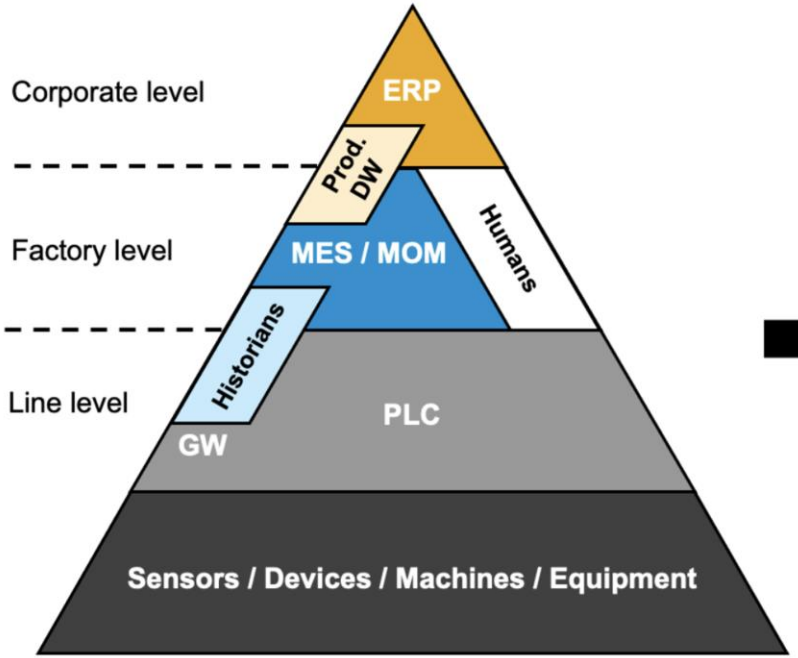
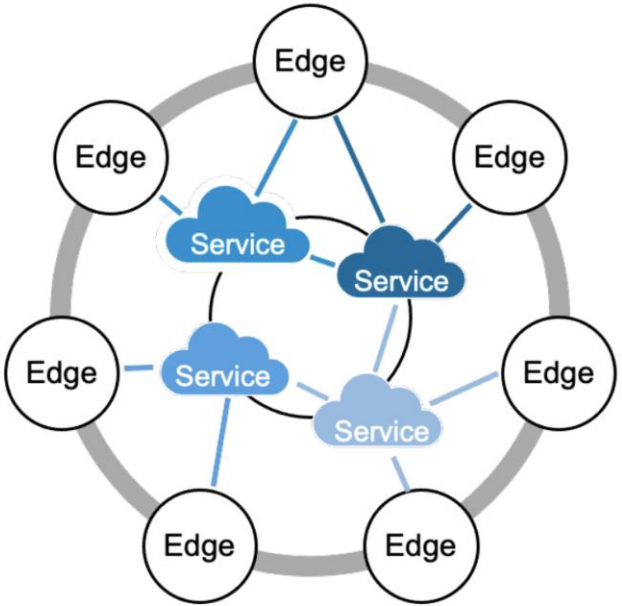
Industry 4.0: Centralised to Distributed systems



From traditional ISA-95 stack ...



...to highly distributed systems.

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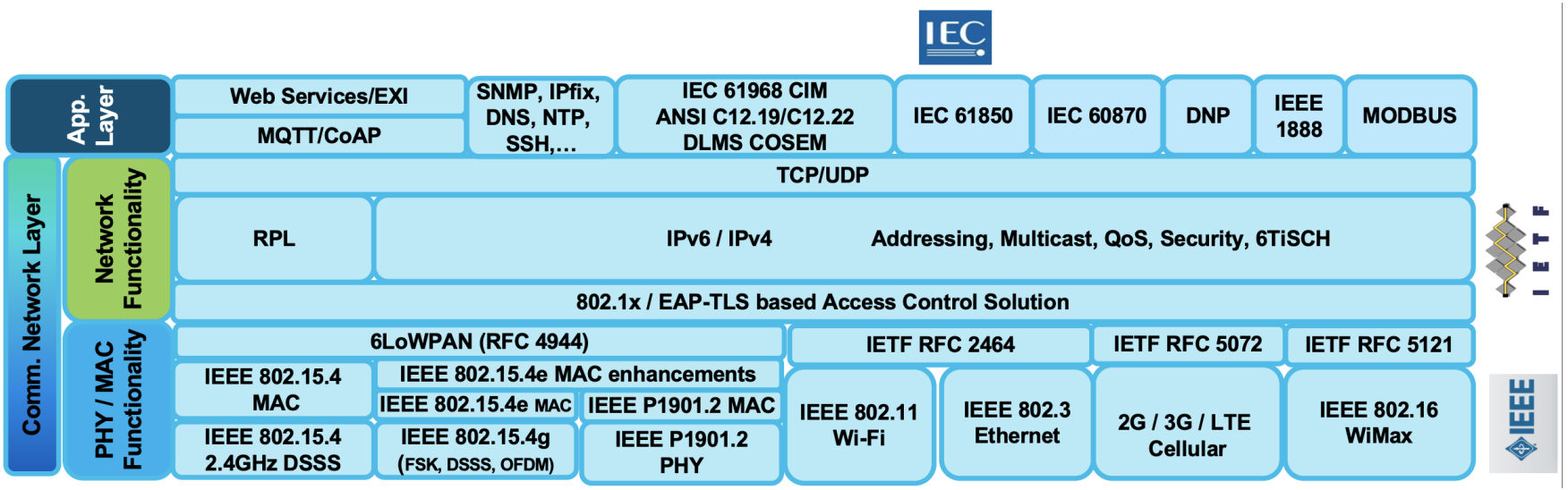
IoT Use of Open Standards



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Cisco Industrial Portfolio

Familiar experience with a **single IOS-XE operating system**

Industrial ethernet switches
DIN-Rail, IP67, and stackable rackmount

IE3100 IE3200 IE3300 IE3400 IE3400H IE9300

Industrial routers
Modular connectivity for remote and mobile assets

IR1100 IR1800 IR8300 IR8100

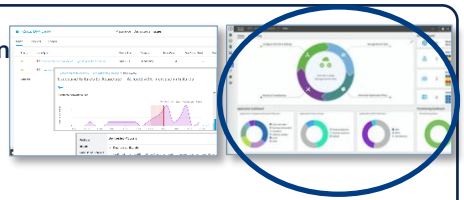
Embedded networking
Embedded routers and switches

ESR6300 ESS3300 ESS9300

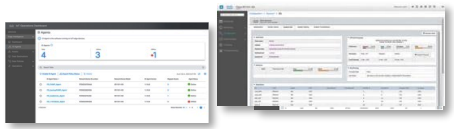
Industrial Wi-Fi, Ultra-Reliable Wireless Backhaul, and LoRaWAN
Wireless connectivity for industrial and outdoor

IW9165E LoRaWAN IW9165D IW9167i IW9167E IW9167E-HZ

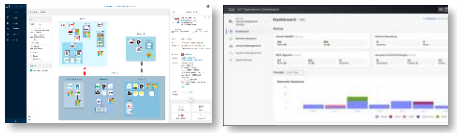
Management and automation
Cisco Catalyst Center
Cisco Catalyst SD-WAN Manager



Data control & exchange
Edge Intelligence
IOx



Industrial cybersecurity
Cyber Vision
Secure Equipment Access



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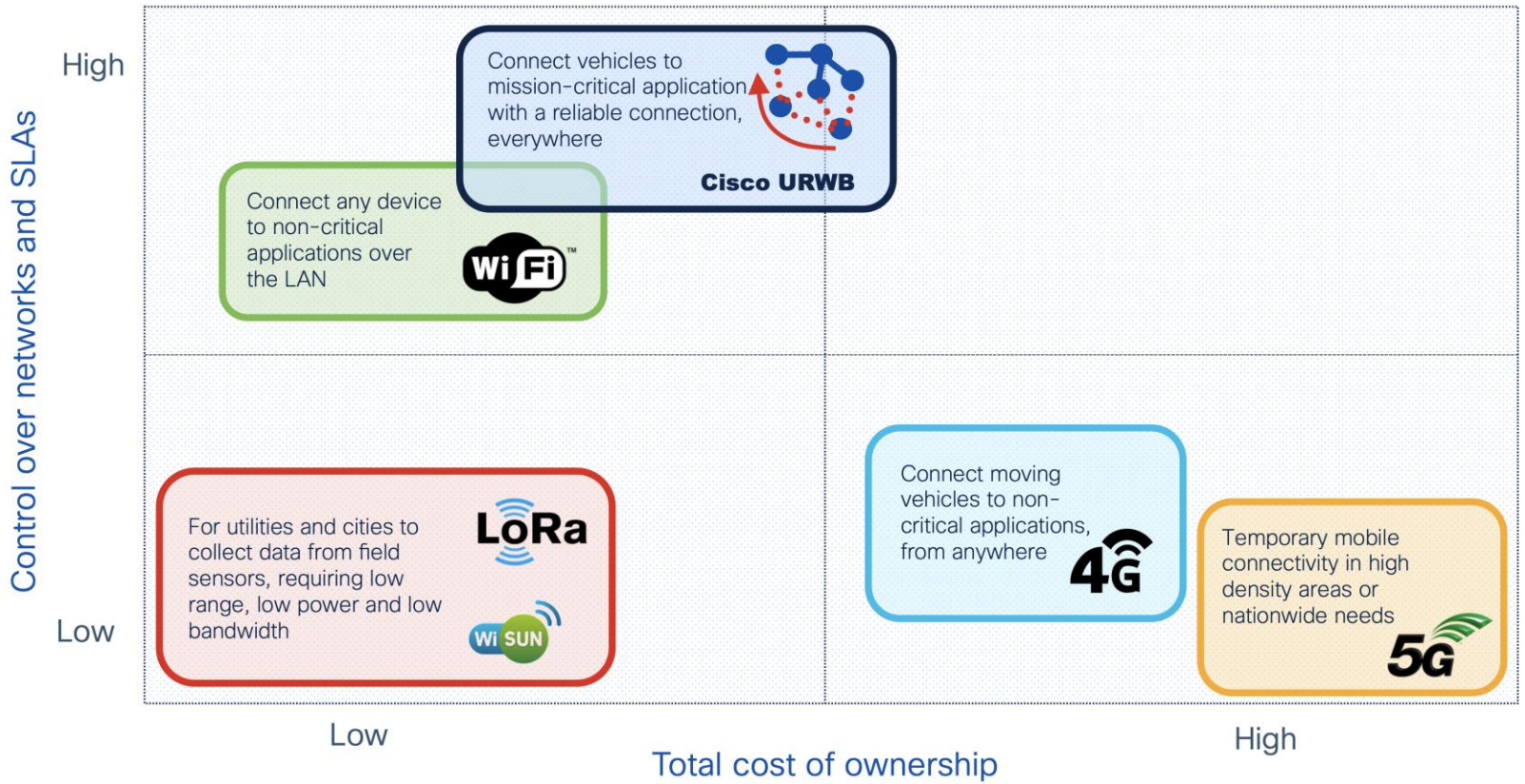
Cisco Industrial Wireless Portfolio



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Cisco Industrial IoT SD-WAN Portfolio

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Industrial Routers – SD-WAN Features Summary

IR8340

IR1101

IR1800

	IR8340	IR1101	IR1835	IR18xx
SD-WAN & SD-Routing	✓	✓	✓	✓
VPN, VRF, VLAN Segmentation	✓	✓	✓	✓
WAN Redundancy	✓	✓	✓	✓
Zero/One Touch Provisioning	✓	✓	✓	✓
Serial SCADA using RS-232 / Raw-Sockets	✓	✓	✓	✓
Field Pluggable Cellular Modems	✓	✓	✓	✓
Dual Fiber Uplink	✓	✓		
Unified Threat Defense Next Gen Firewall	✓		✓	
IEC61850-3, IEEE1613	✓	✓		
Precision Time Protocol	✓			
PRP, HSR Support	✓			
Dual Power Supply	✓			

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Catalyst SD-WAN

Industry-Compliant Certification

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Cisco’s IoT Routing Portfolio

Secured and Optimised for demanding, outdoor deployments

Demanding, mission critical deployments

ATMs, low voltage substations, roadside traffic cabinets, remote assets

IP67 sites, Remote monitoring, O&G streetlights, intersections

Fleet, first-responders, pipelines, DER sites – Solar, Wind and Storage

Factory, high voltage substations, Large Battery storage

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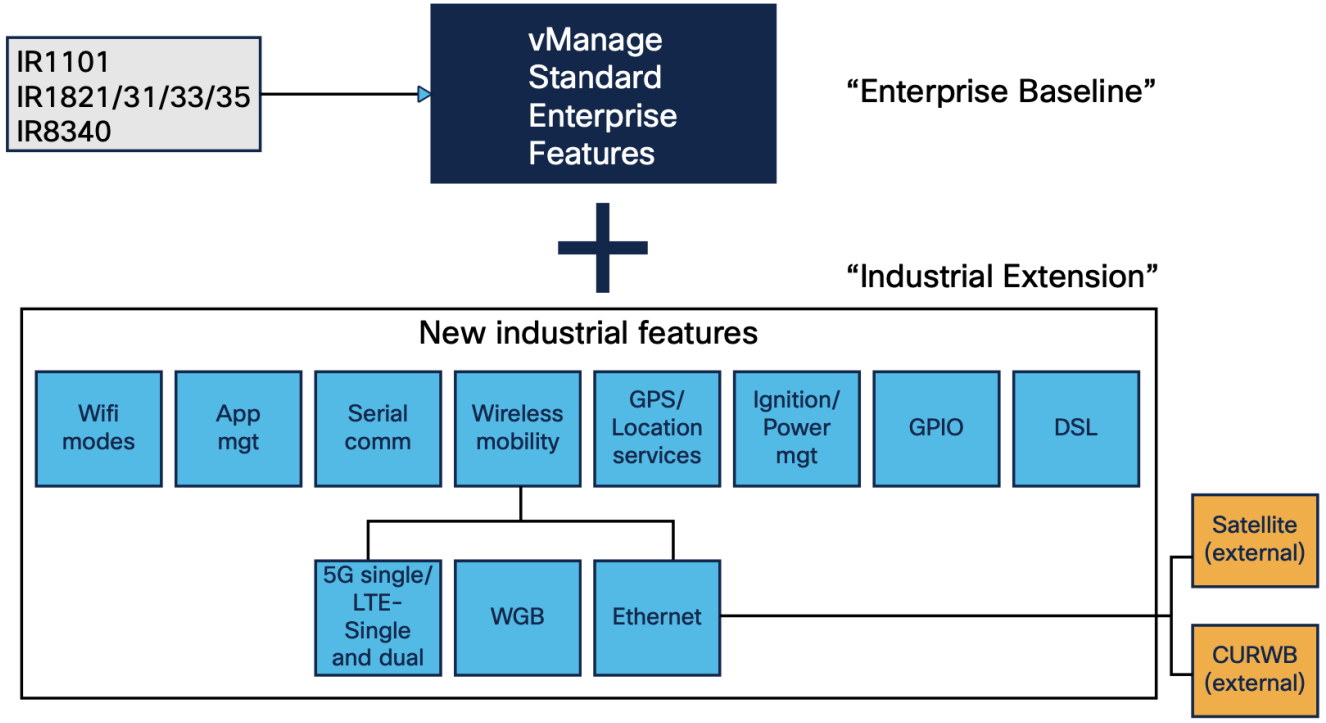
SD-WAN extension for industrial solutions



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Industrial extensions

Industrial router extension		Benefits and applicability
Wireless mobility	1	Dual 5G/LTE, WGB, CURWB roaming for transit
Ethernet extended WAN interfaces	2	Satellite, Broadband, DSL, Wifi for remote/mobile apps
Wi-Fi modes	3	Hot spot, remote office – fleet applications
DSL communications	4	Legacy wired interfaces for roadways and rail
Serial communications	5	SCADA, legacy devices – remote assets
GPS and location services	6	NMEA GPS data for location – based apps – fleet apps
Vehicle interfaces	7	Ignition Sense/Power Mgt – router power ctrl for fleets
General purpose I/O	8	Discrete sensors or external triggers – remote assets

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Cisco Catalyst Rugged Industrial Router comparison

Feature	IR1100	IR1800	IR8100	IR8300
Memory, Storage	4GB, 8GB eMMC – 4GB usable	4GB/8GB, 8GB eMMC – 4GB usable	4GB/8GB, 8GB eMMC – 4GB usable	4GB/8GB, 16GB Flash
IP rating	IP30	IP40 and IP54 with extension kit	IP67	IP30
Connectivity Options	Ethernet, LTE/5G, DSL, serial, CURWB (external radio)	Ethernet, Wi-Fi6, LTE/5G, DSL, serial, 30W PoE, CURWB (external radio)	Ethernet, LTE/5G	Ethernet, LTE/5G, serial NIM, T1/E1, 60W PoE, CURWB (external radio)
Ignition power management	No	Yes	No	No
IoT protocols support	N/A	CANbus	Wi-SUN	N/A
Alarm port (GPIO)	1 input (+4 GPIO)	4 GPIO on IR1835 only	2 GPIO	2 input, 1 output
GPS, GNSS	GPS from Cellular	GPS from Cellular, GNSS	GPS from Cellular, GNSS	GPS from Cellular, GNSS
Edge Compute	Yes	Yes	Yes	Yes
Cisco IOS-XE SDWAN	Yes	Yes	Yes	Yes
Cyber Vision	17.3.1	Roadmap	Roadmap	Roadmap
Edge Intelligence	17.3.1	Roadmap	Roadmap	Roadmap
Umbrella	17.1.1	17.6.1	17.6.1	Roadmap
LoRaWAN PIM support	Yes	Yes	Yes	No

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Understanding Cisco SD-WAN

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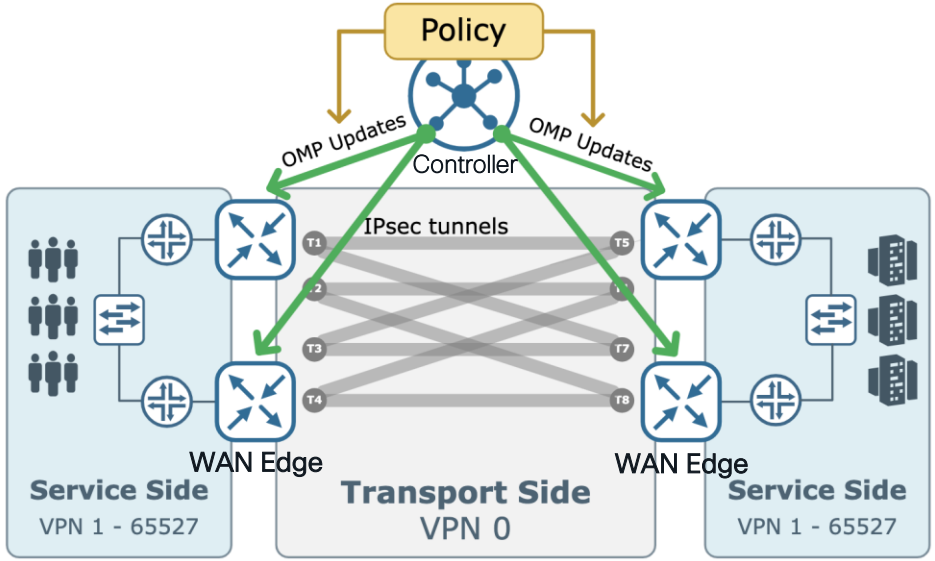
Key Concepts and Terminology

- **Transport Side** – WAN Edge Interface connected to WAN Side – Always VPN 0
- **Service Side** – WAN Edge interface attaching to the OT network (LAN side)
- **Service Side** – Router interface attaching to the OT network
- **TLOC** – Transport Location – Color (WAN interface), System IP, Encapsulation (IPsec/GRE)
- **OMP** – Overlay management Protocol (Fabric only) – Facilitates fabric routing control and connectivity
- **System-IP** – Unique identifier of an OMP Endpoint
- **Site-ID** – Identifies the Source Location of an advertised prefix
- **BFD**: Bidirectional Forwarding Detection
- **vRoute** – Routes learnt/connected on Service Side



WAN Edge: IR, ASR, ISR, CSR, CAT

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Cisco SD-WAN components renamed

Old Name	New Name (rebranding)	Documentation	Displayed on Screens	API/CLI - Documentation
Cisco SD-WAN	Cisco Catalyst SD-WAN	Cisco Catalyst SD-WAN	Cisco Catalyst SD-WAN	Cisco Catalyst SD-WAN
vManage	Cisco Catalyst SD-WAN Manager	SD-WAN Manager	Manager	vManage
vAnalytics	Cisco Catalyst SD-WAN Analytics	SD-WAN Analytics	Analytics	vAnalytics
vBond	Cisco Catalyst SD-WAN Validator	SD-WAN Validator	Validator	vBond
vSmart	Cisco Catalyst SD-WAN Controller	SD-WAN Controller	Controller	vSmart
Self Service Portal	Cisco Catalyst SD-WAN Portal	Cisco Catalyst SD-WAN Portal	Cisco Catalyst SD-WAN Portal	SD-WAN Portal
Cloud-Delivered Cisco SD-WAN	Cloud-Delivered Cisco Catalyst SD-WAN	Cloud-Delivered Cisco Catalyst SD-WAN	Cloud-Delivered Cisco Catalyst SD-WAN	NA

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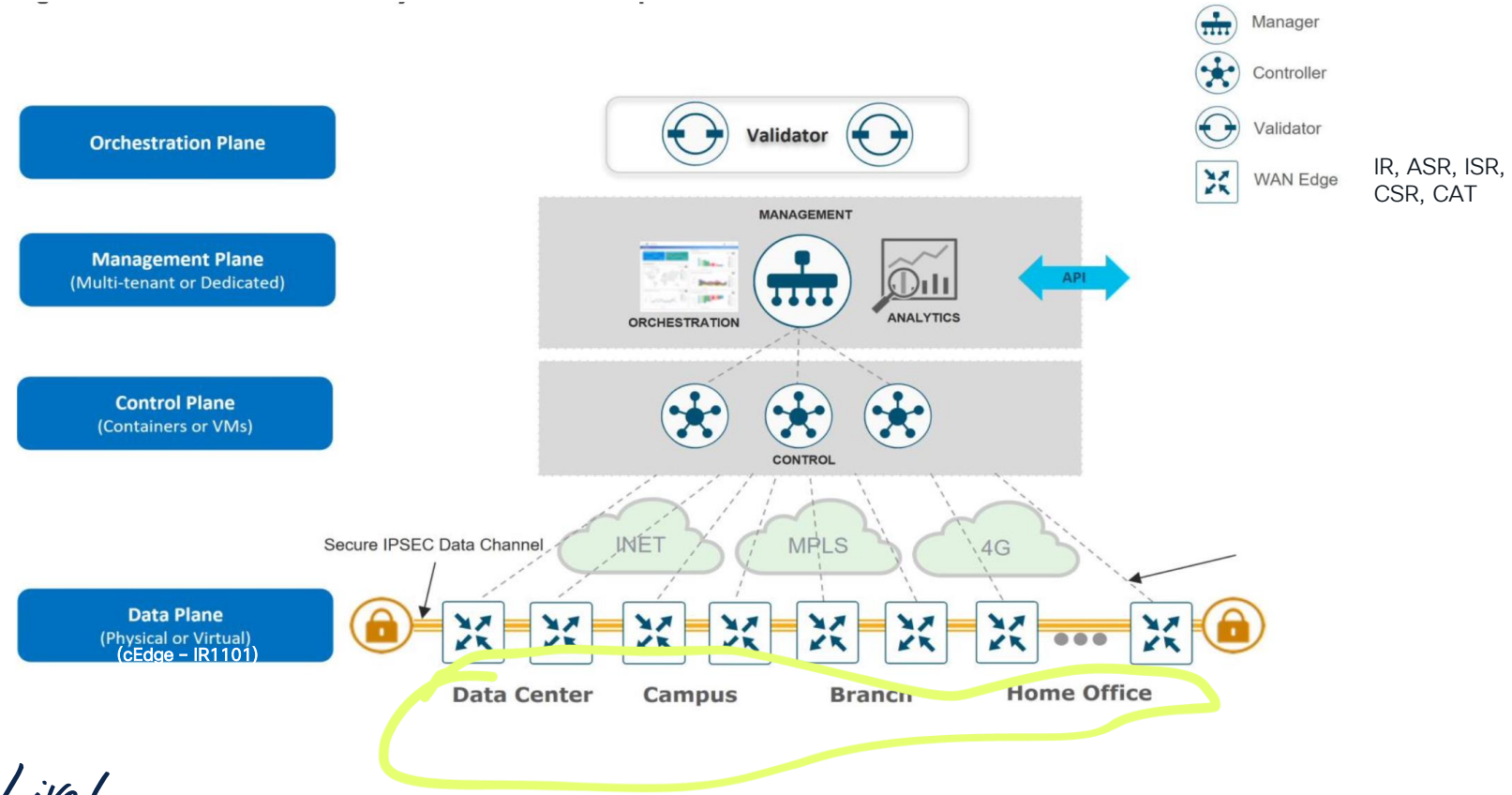
Cisco SD-WAN Architecture overview



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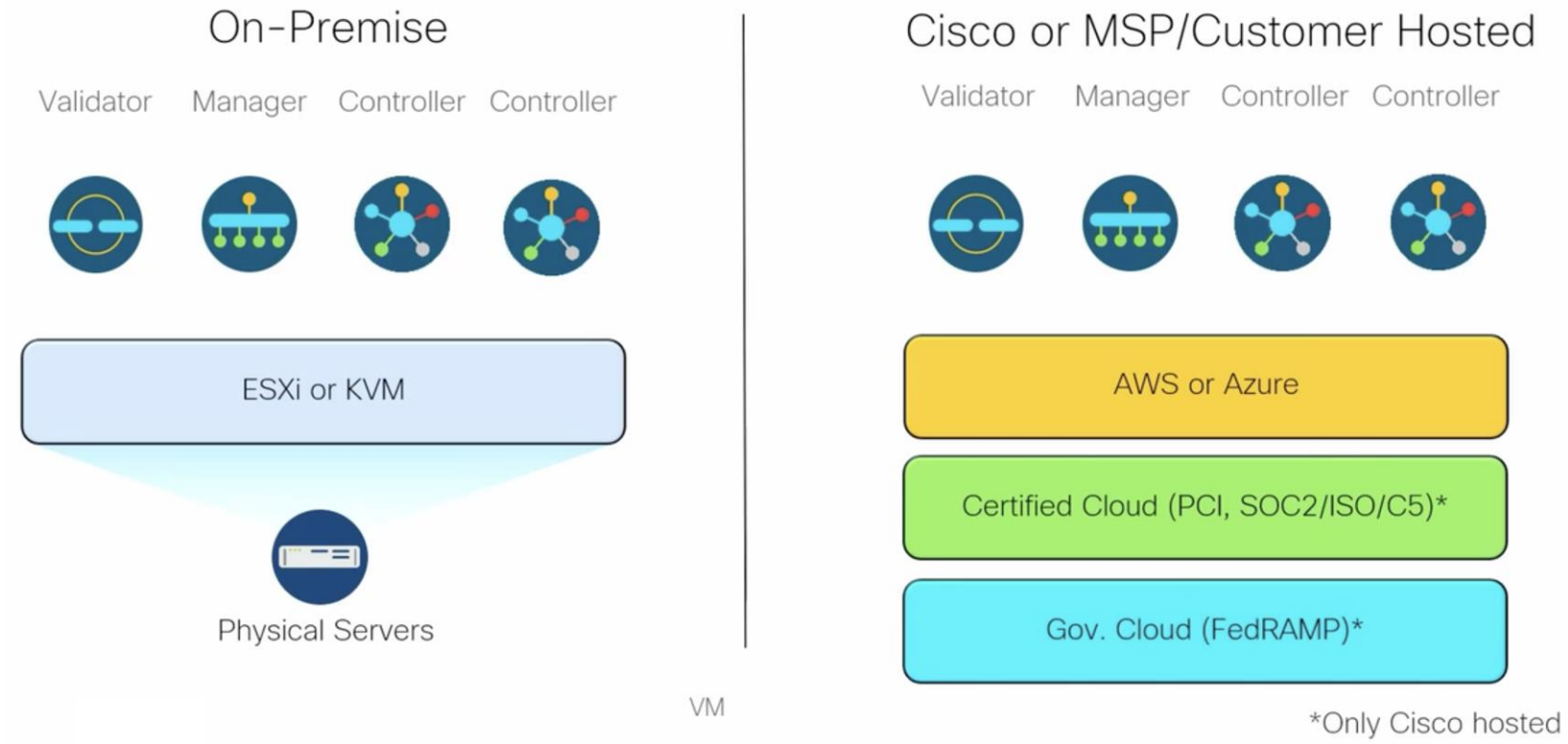
Controller deployment options



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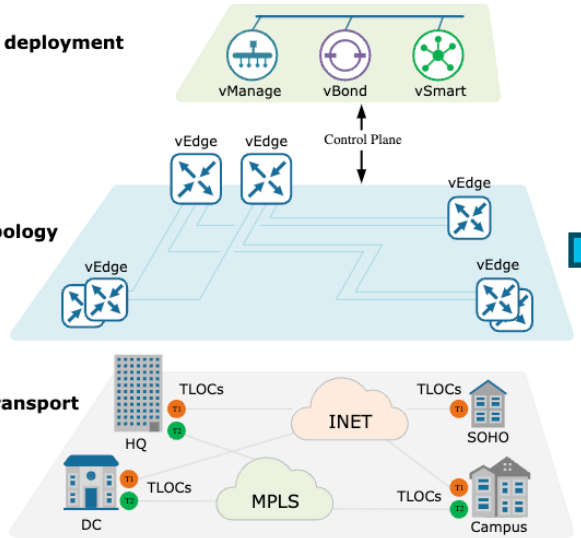
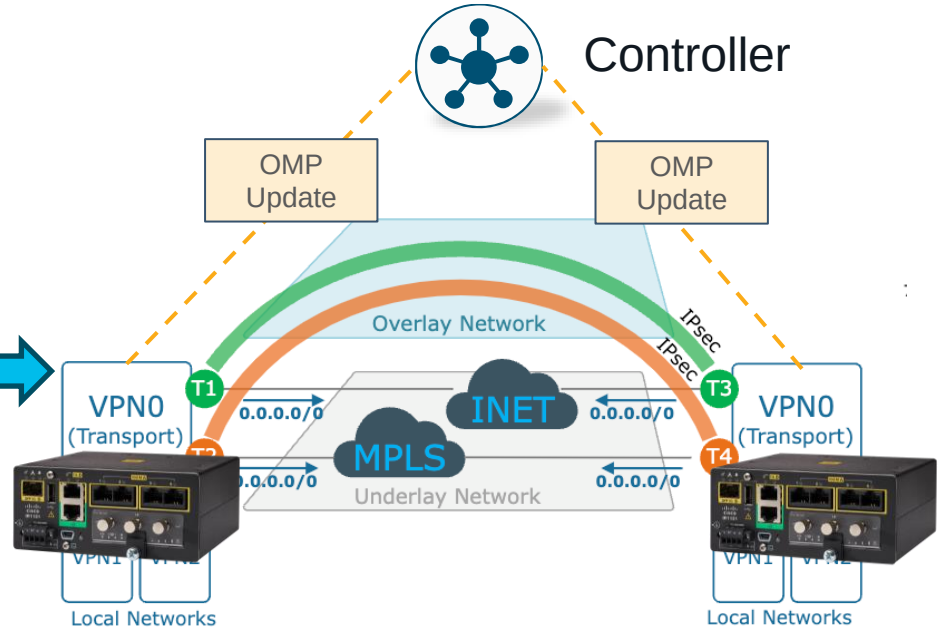
Overlay –Any transport, Any topology , Anywhere !!

Any controllers deployment
- Public Cloud
- Private Cloud
- On-premises

Any overlay topology
- Hub and Spoke
- Full mesh
- Partial Mesh

Any underlay transport
- Broadband
- MPLS
- 4G/5G





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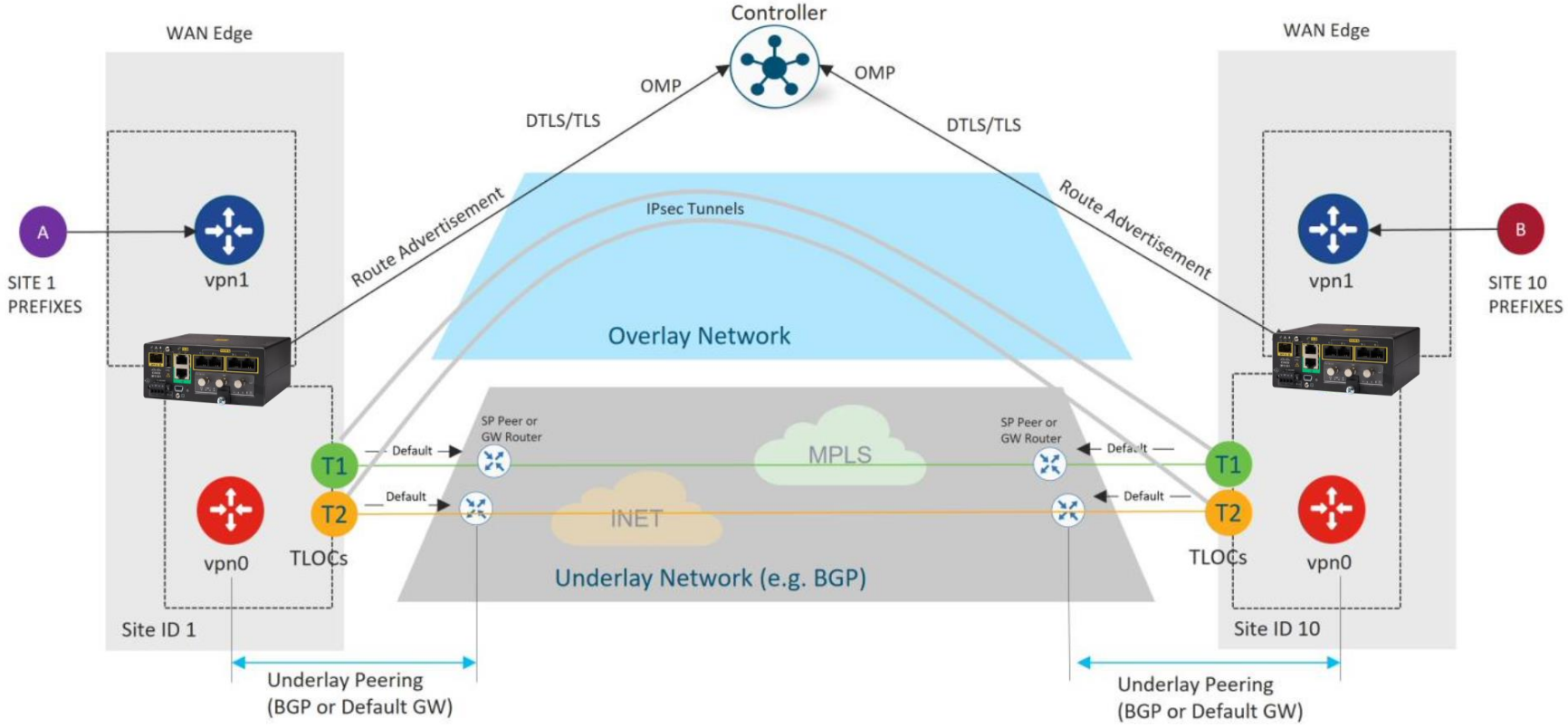
Underlay vs Overlay routing

WAN Edge: IR, ASR, ISR, CSR, CAT



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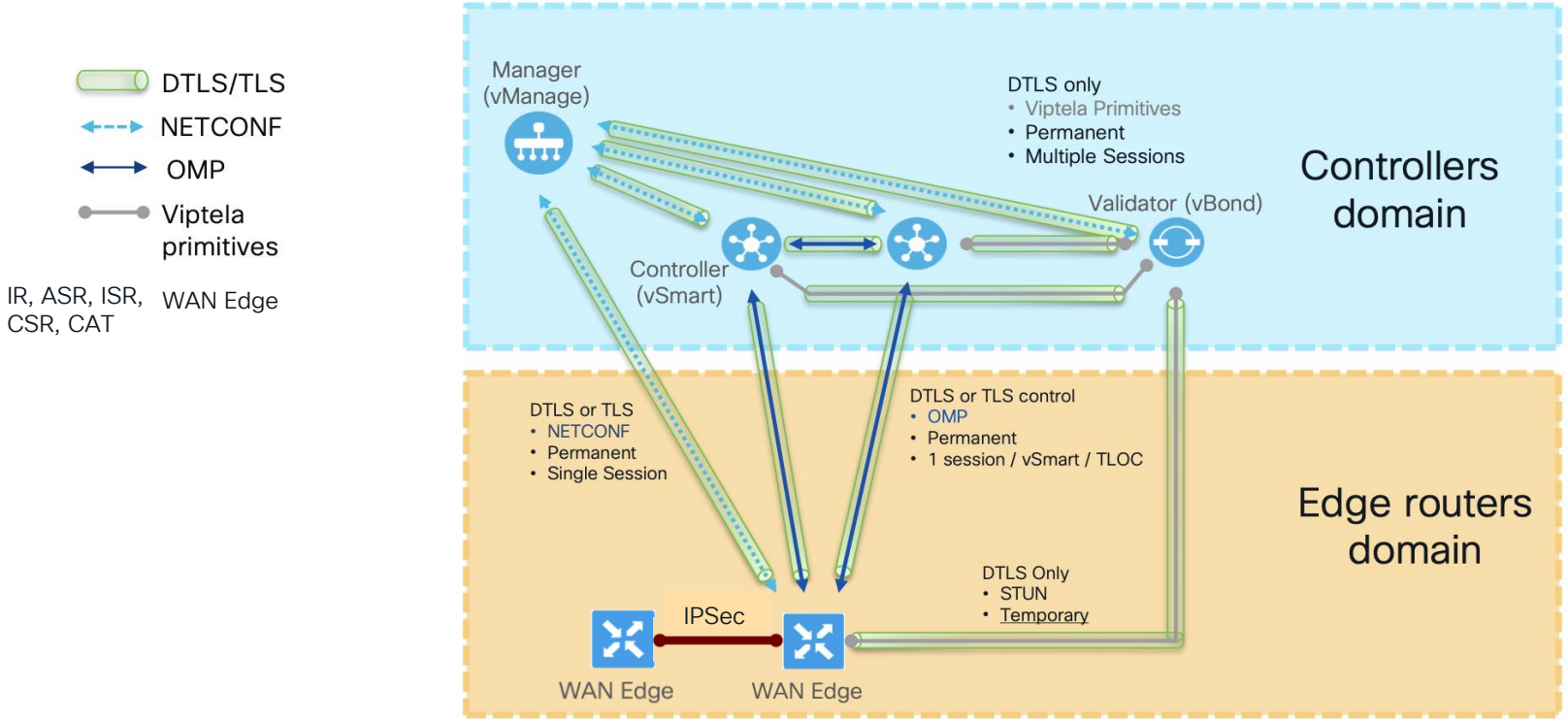
Secure control plane connections



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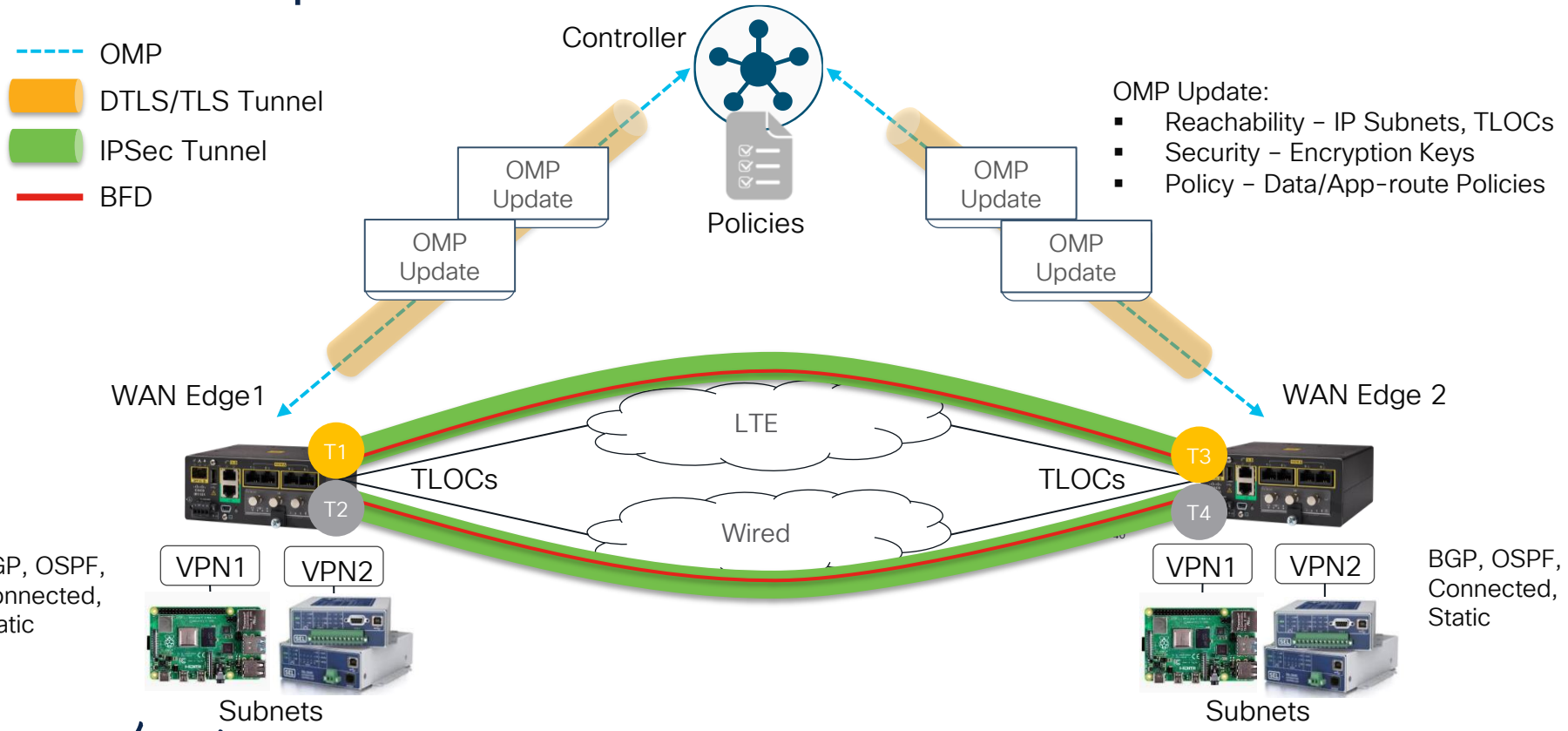
Fabric Operation



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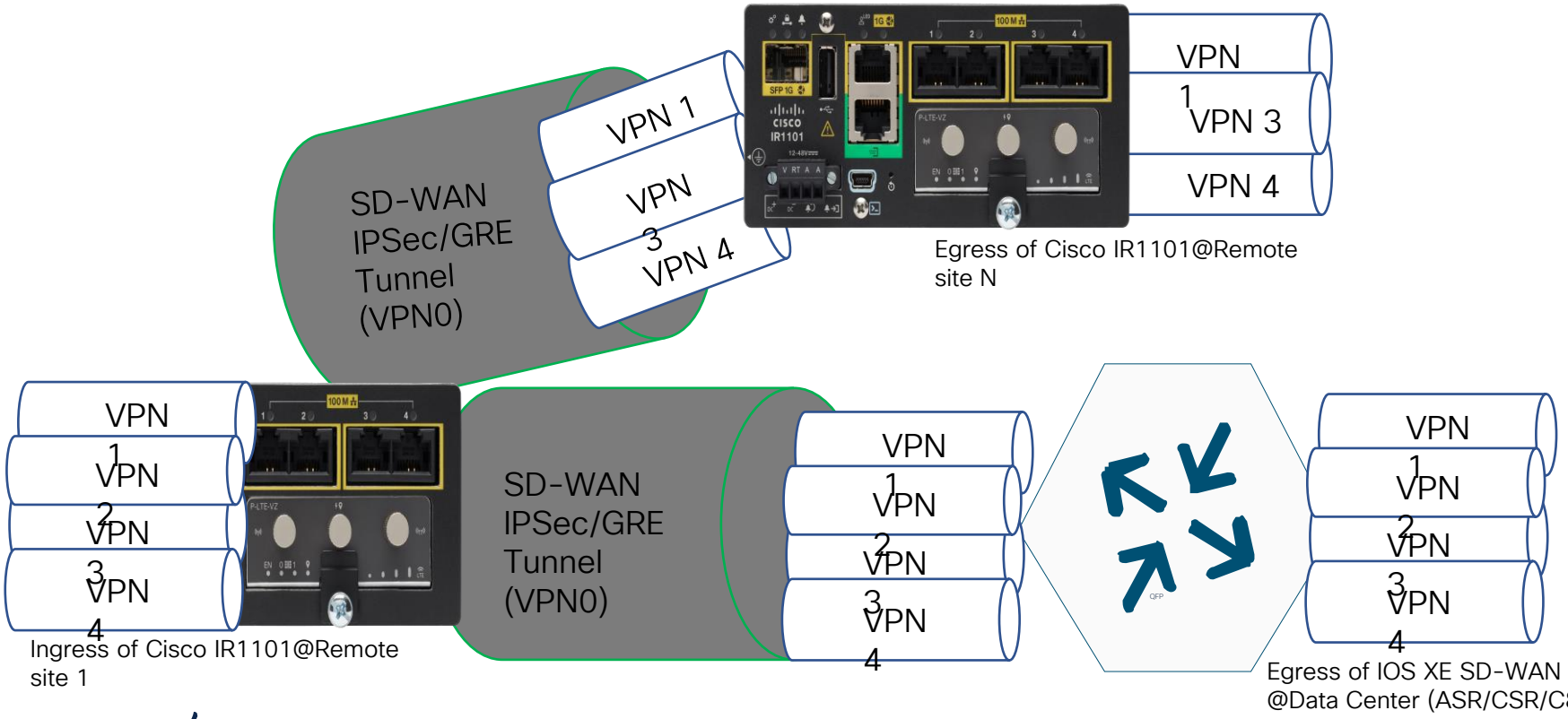
SD-WAN service VPN tunnels



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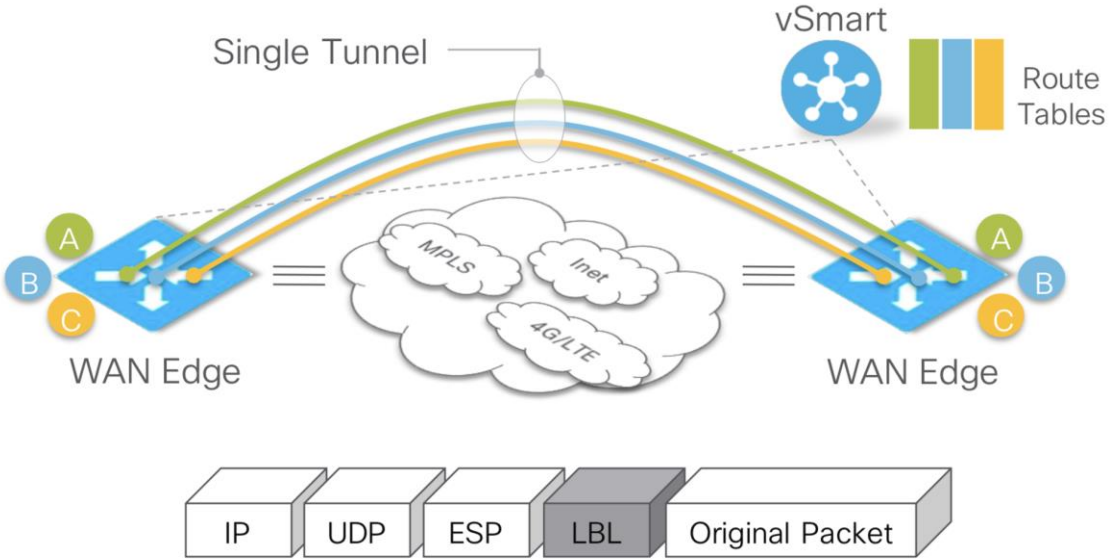
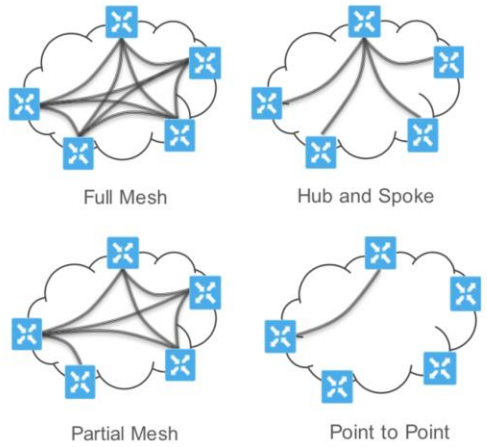
End-to-End Segmentation with Multi-Topology





- Segment connectivity across fabric w/o reliance on underlay transport
- WAN Edge routers maintain per-VPN routing table for complete control plane separation

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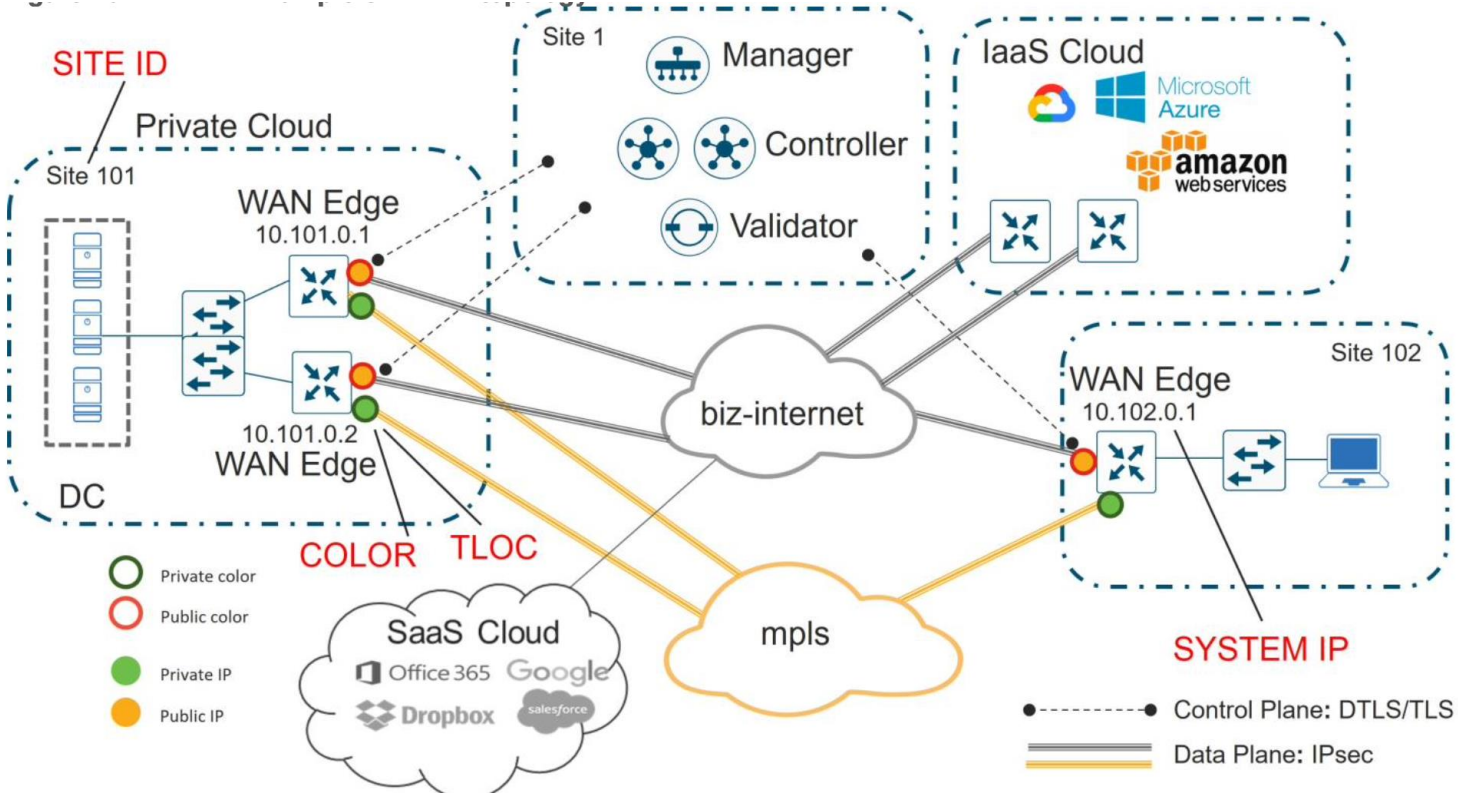
Sample SD-WAN topology



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Data plane status and quality

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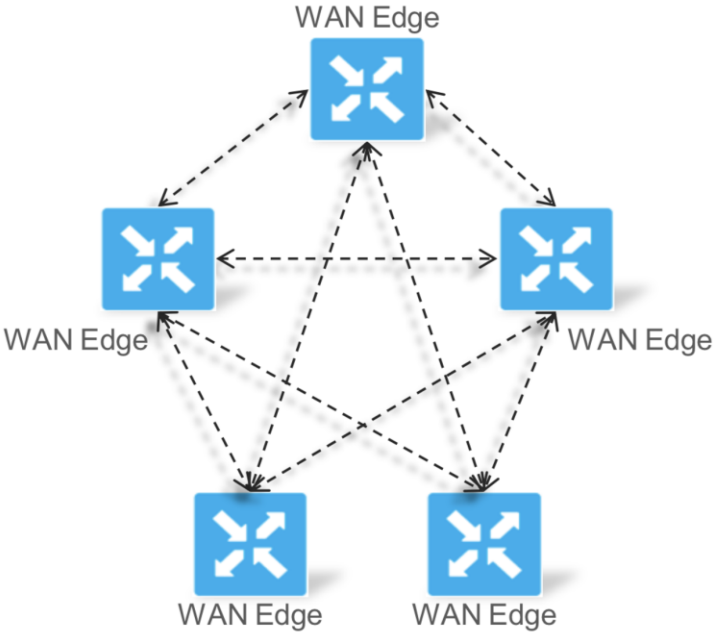
Data Plane Liveliness and Quality



WAN Edge: IR, ASR, ISR, CSR, CAT

- Bidirectional Forwarding Detection (BFD)
- Path liveliness and quality measurement
  - Up/Down, loss/latency/jitter, IPSec tunnel MTU
- Runs between all WAN Edge routers in the topology
  - Inside SD-WAN tunnels
  - Across all transports
  - Operates in echo mode
  - Automatically invoked at SD-WAN tunnel establishment
  - Cannot be disabled
- Uses hello (up/down) interval, poll (app-aware) interval and multiplier for detection
  - Fully customizable per-WAN Edge, per-transport

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App-QoE: Packet Loss Mitigation

- **Problem**: transactional data over WAN links, which has few percent packet loss (up to 10-20%).
  - **Main Goal**: 0 packet loss on the application level.
- **Solution 1**: Forward Error Correction (FEC) send additional parity packet for every 4 data packets, which will be used by the receiving router to reconstruct one lost packet.
- **Solution 2**: Packet Duplication will duplicate packets for critical apps over both WAN links.
  - **FEC-adaptive:** start FEC by 2% packet loss.
  - **FEC-always:** always-on FEC

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SD-WAN policy framework

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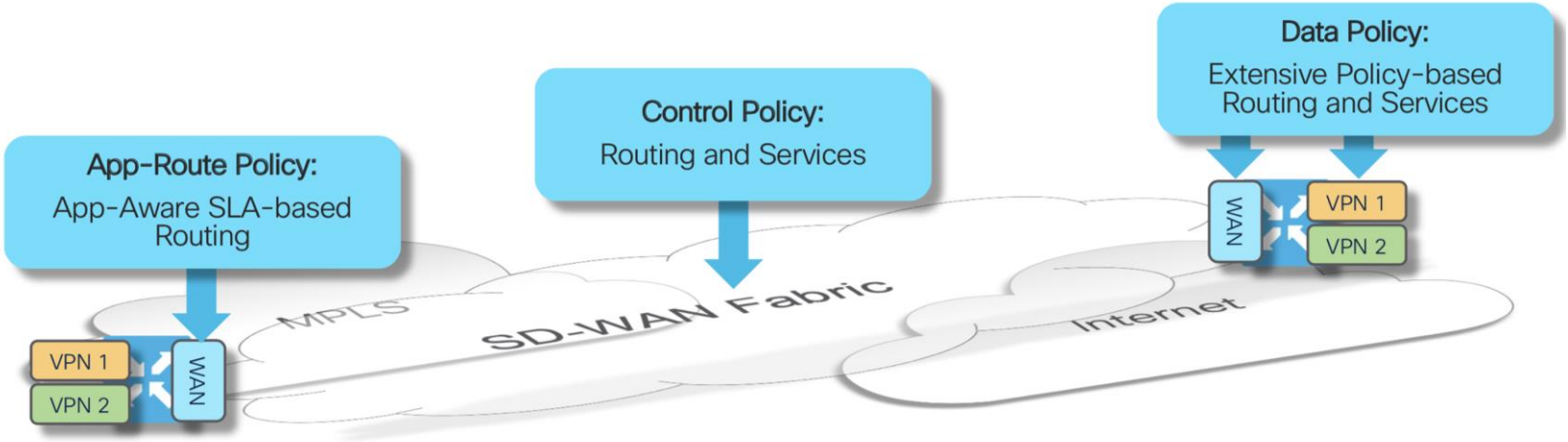
Cisco SD-WAN Policy Architecture

Suite of Policies to address different functional domains



- Control Policies are applied at Controller: Tailors routing information advertised to WAN endpoints
- App-Route Polices are applied to WAN Edge: SLA-driven path selection for applications
- Data Policies are applied at WAN Edge: Extensive Policy driven routing

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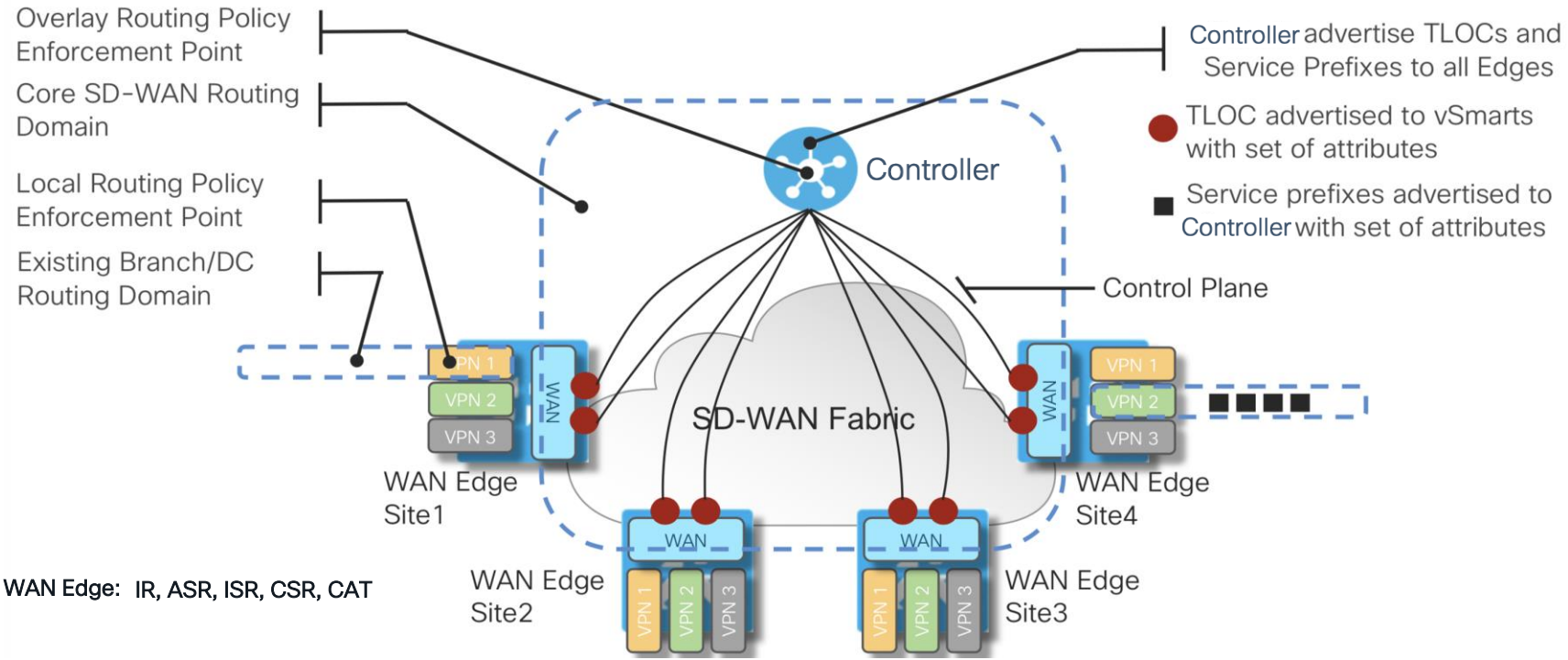
Cisco SD-WAN Overlay Routing

Multi-domain Routing Fabric

WAN Edge: IR, ASR, ISR, CSR, CAT



WAN Edge: IR, ASR, ISR, CSR, CAT

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Cisco SD-WAN Advanced Features and Capabilities

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SLA Monitoring

Bi-directional Forwarding Detection (BFD)

- Utilizes UDP port 3784
- Measures Loss, Latency and Jitter
- Each BFD packet is ~100 bytes

Hello-Interval

- Default, 1 BFD probe per second

Multiplier

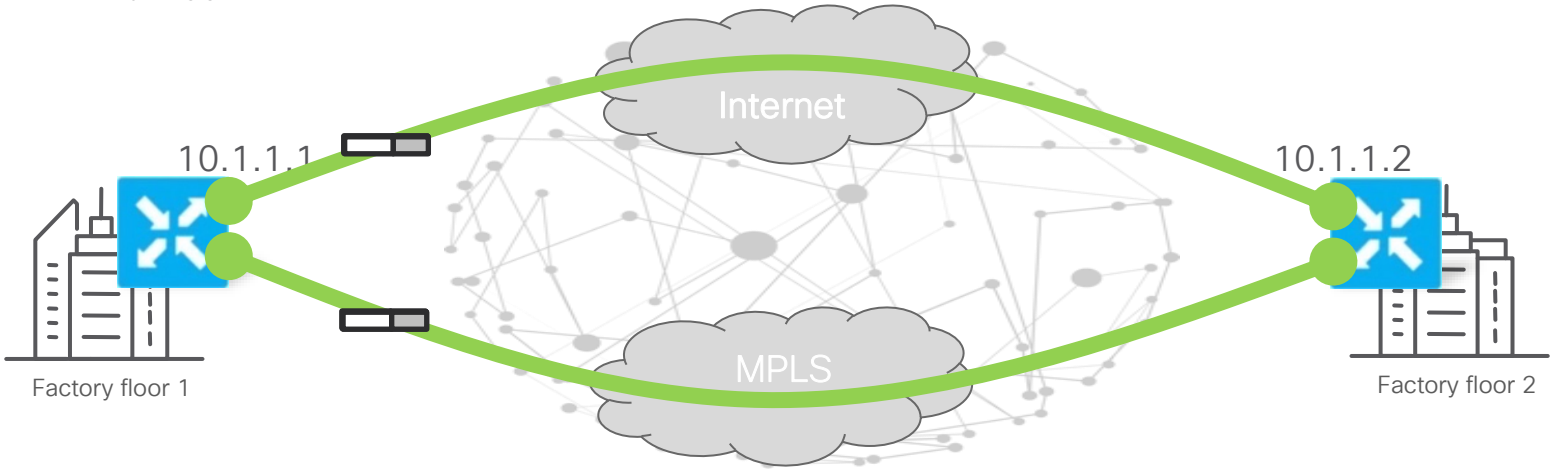
- Average Loss, Latency and Jitter over '*X*' Poll-Intervals
- Default, 6 poll-intervals

Poll-Interval

- Average Loss, Latency and Jitter over '*X*' period
- Default, 600 seconds

Rolling Average

Loss: 1%
Latency: 10ms
Jitter: 5ms



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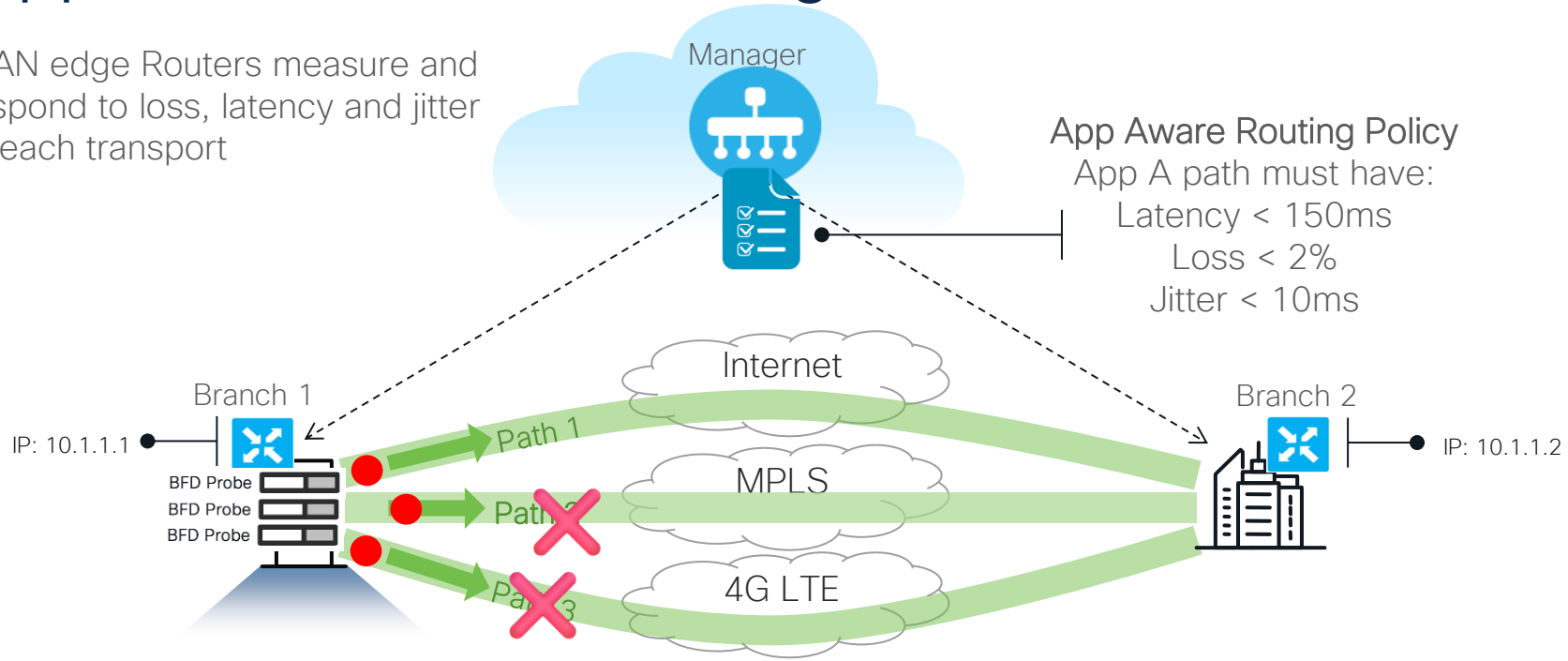
Application-Aware Routing

WAN edge Routers measure and respond to loss, latency and jitter of each transport



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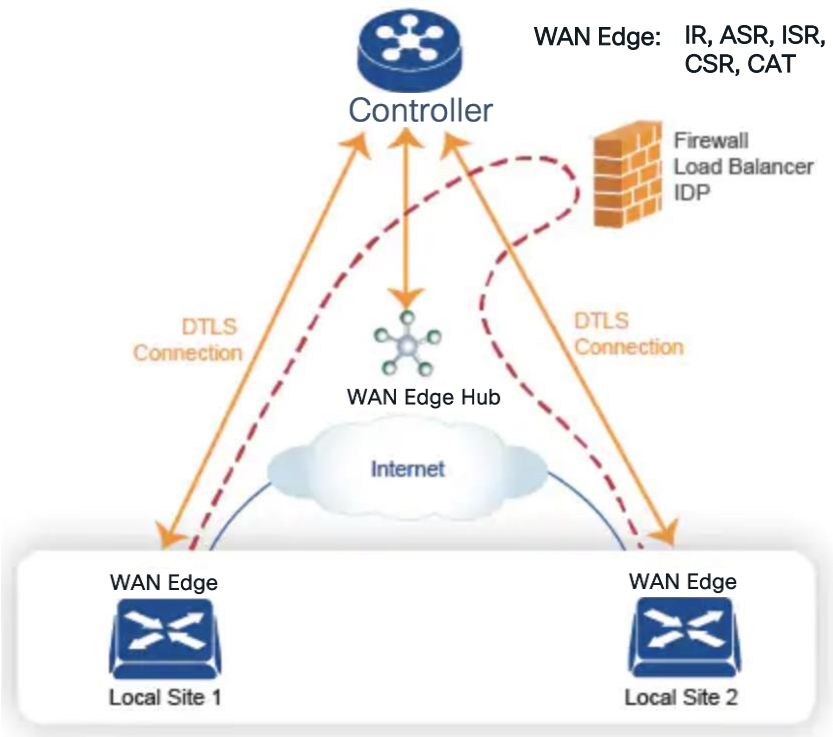
Service Chaining



- Reroute all/specific traffic through one or more services, such as firewall, load balancer, and intrusion detection and prevention (IDP) devices.
- Services may be internal, external or cloud based
- Example: in a campus, interdepartmental traffic might go through a firewall, while intradepartmental traffic might be routed directly.

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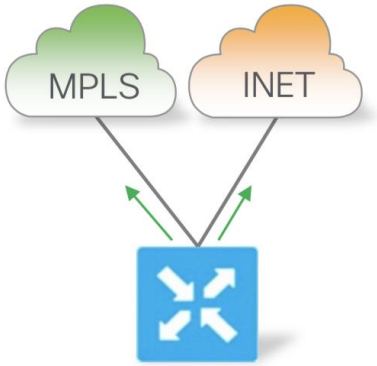
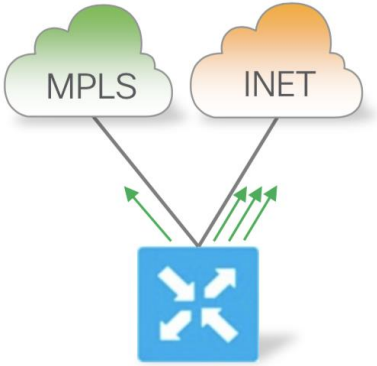
Traffic Engineering

Per-Session Load Sharing
Active/Active



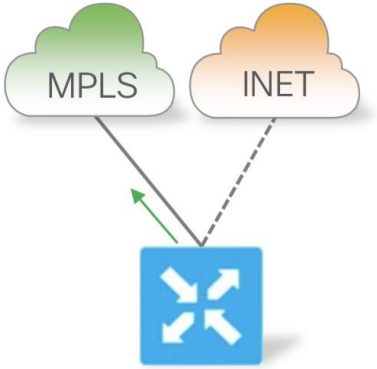
Default

Per-Session Weighted
Active/Active



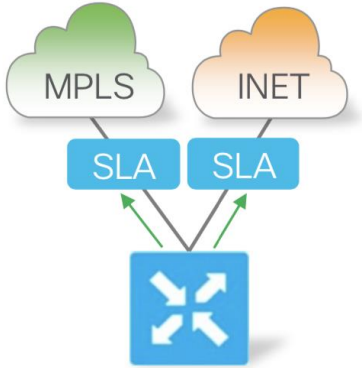
Device
Configurable

Application Pinning
Active/Standby



Policy
Enforced

Application Aware Routing
SLA Compliant



Policy
Enforced

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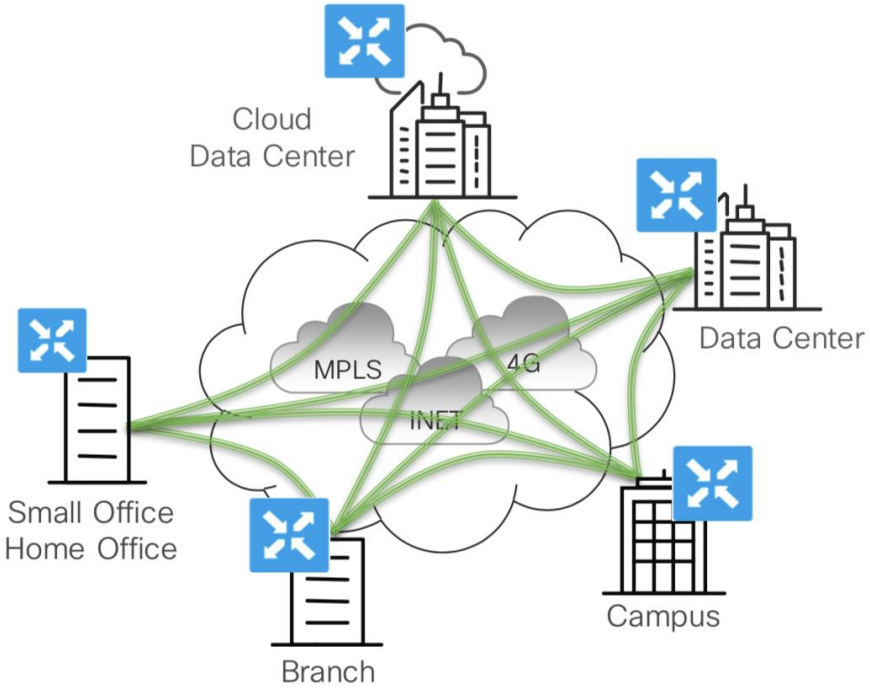
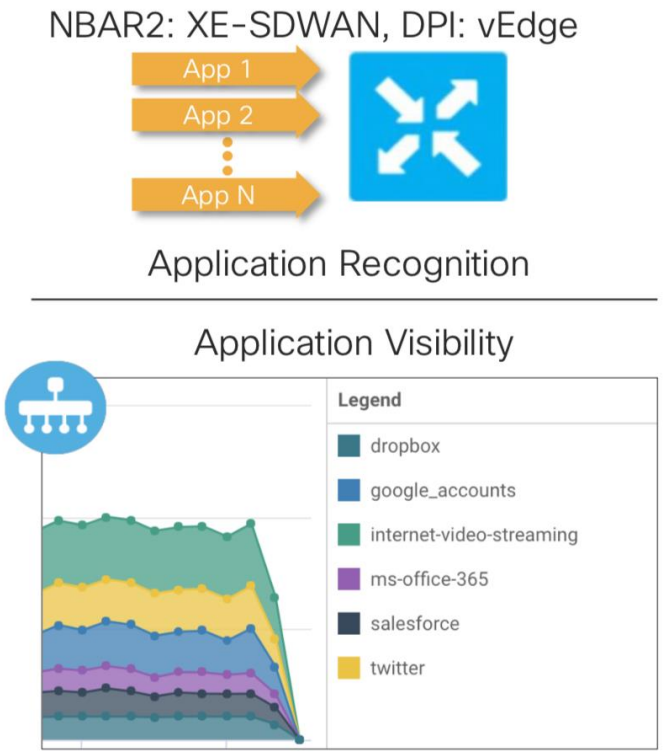
Application Visibility and Recognition





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Security features

- URL Filtering: Limit / restrict access specific URLs
- Zone-based firewall: Control access between zones
- Application Firewall
- IDS/IPS

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Cloud OnRamp

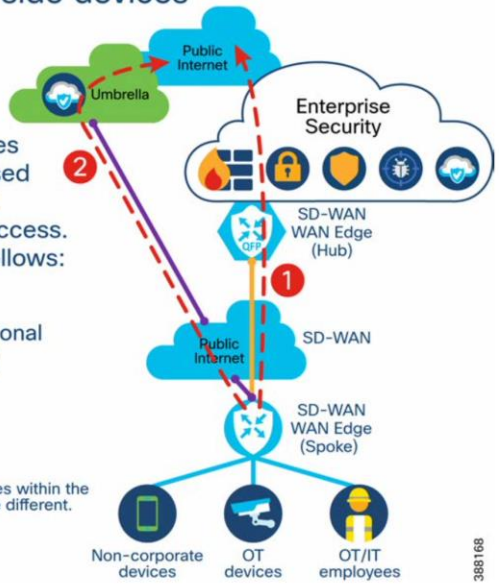
Direct Internet access vs Central Internet access

Internet access for LAN-side devices

Different methods are available, some more suited to certain cases than others; choice is largely based on combination of use-case and corporate approach to Internet access. Recommendation is priority as follows:

1. Centralized
   (ideally with Umbrella, or a traditional on-prem Internet security stack)
2. Local via Umbrella SIG*
3. Local (DIA) via ZBFW
   (and UTD in the future)*

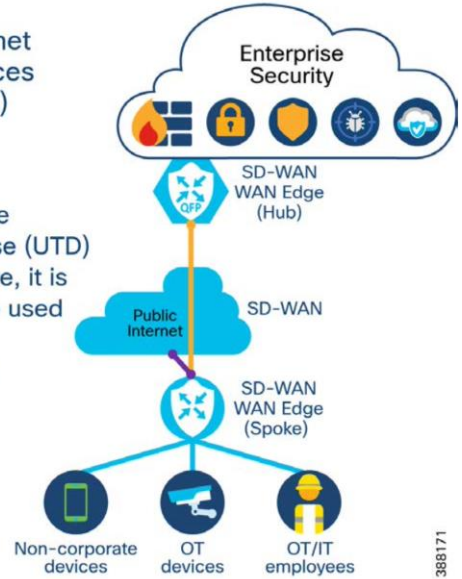
* 2 & 3 could be seen across different branch sites within the same deployment, e.g., where requirements are different.



Internet access for LAN-side devices - DIA

Supports the IR providing Internet access for non-corporate devices (e.g., passenger/guest devices) via DIA.

- Direct Internet Access (DIA)
- Configured via Feature template
- Currently Unified Threat Defense (UTD) is **not** available for IRs, therefore, it is recommended that DIA only be used for isolated browsing traffic, e.g., non-corporate devices in a separate Service VPN.



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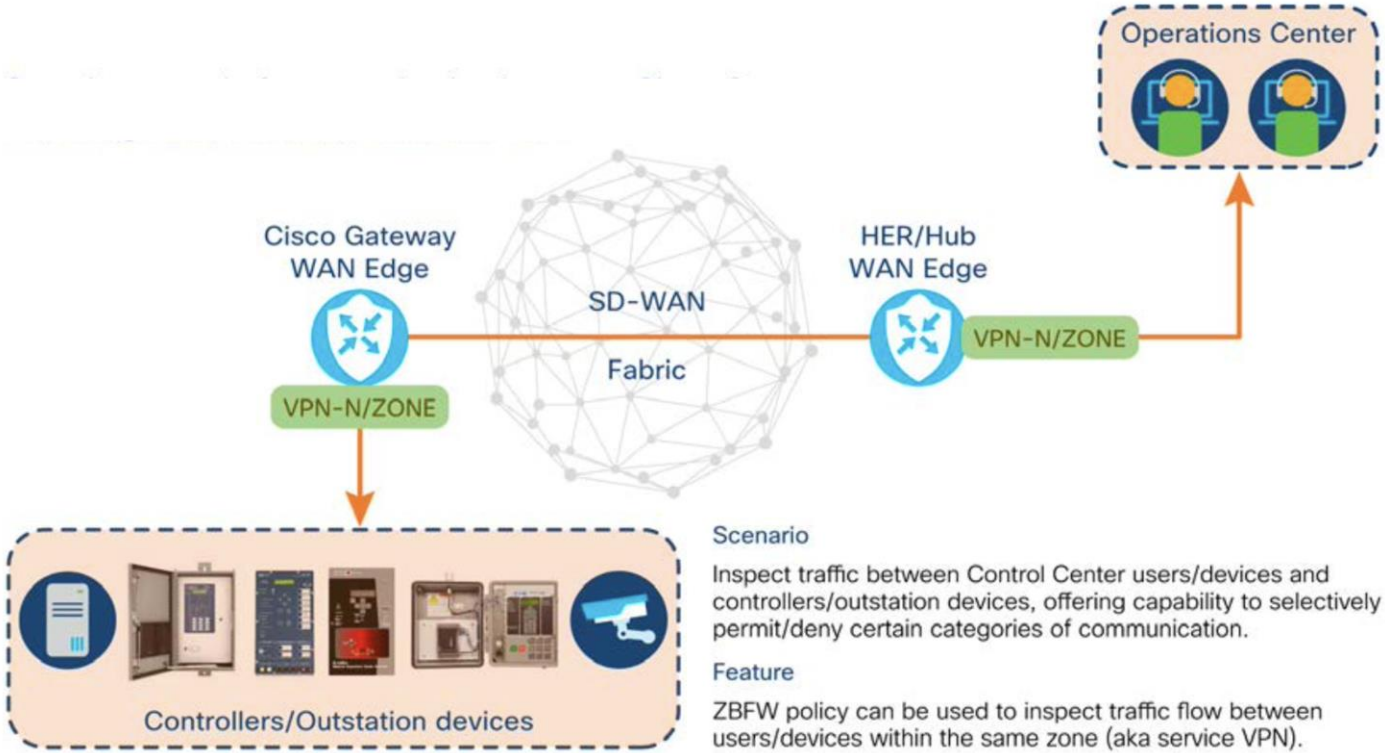
Intra-Zone (Intra-VPN) Firewall Security Policy



Scenario

Inspect traffic between Control Center users/devices and controllers/outstation devices, offering capability to selectively permit/deny certain categories of communication.

Feature

ZBFW policy can be used to inspect traffic flow between users/devices within the same zone (aka service VPN).

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SD-WAN IoT Edge device Onboarding

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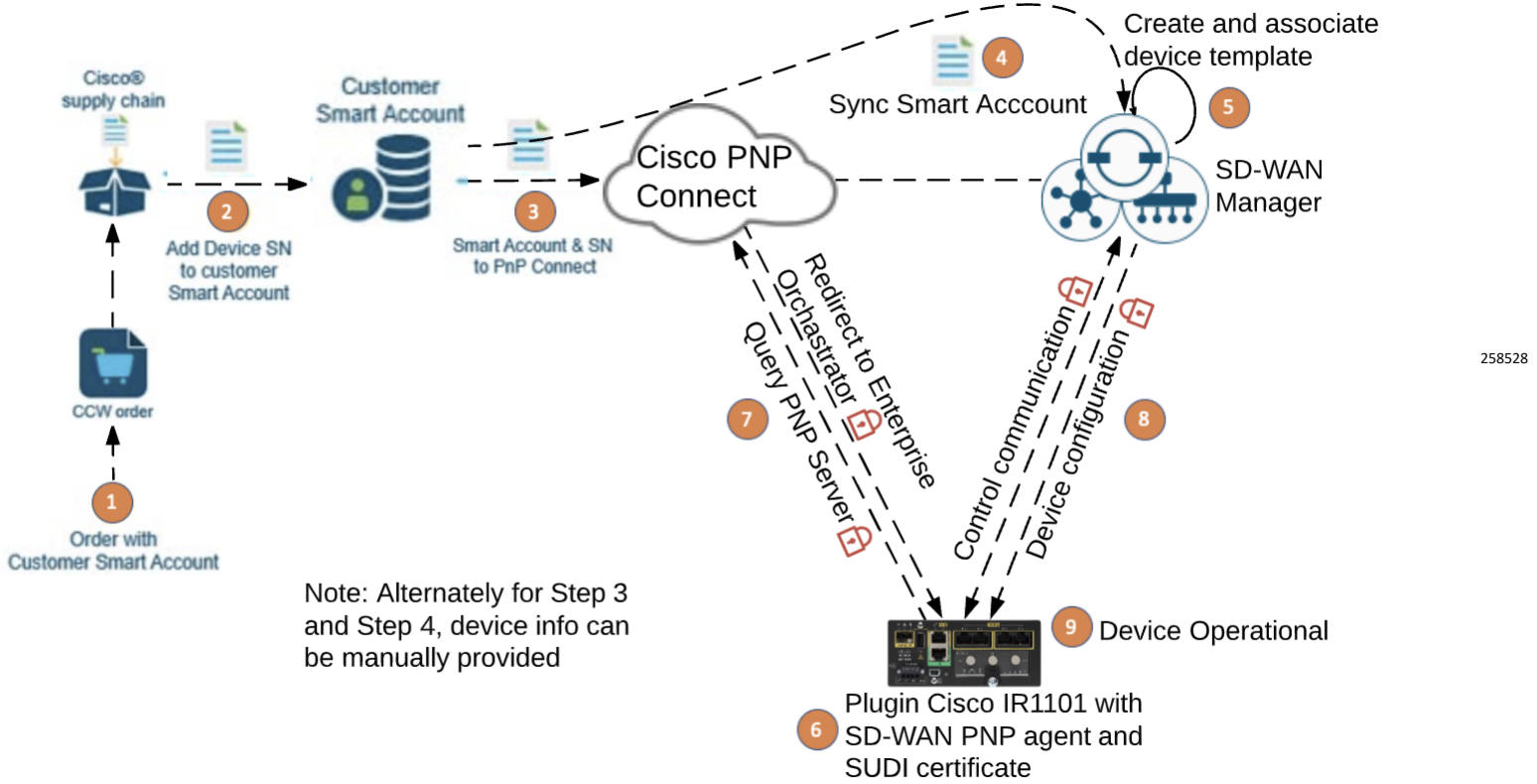
Onboarding workflow with PNP



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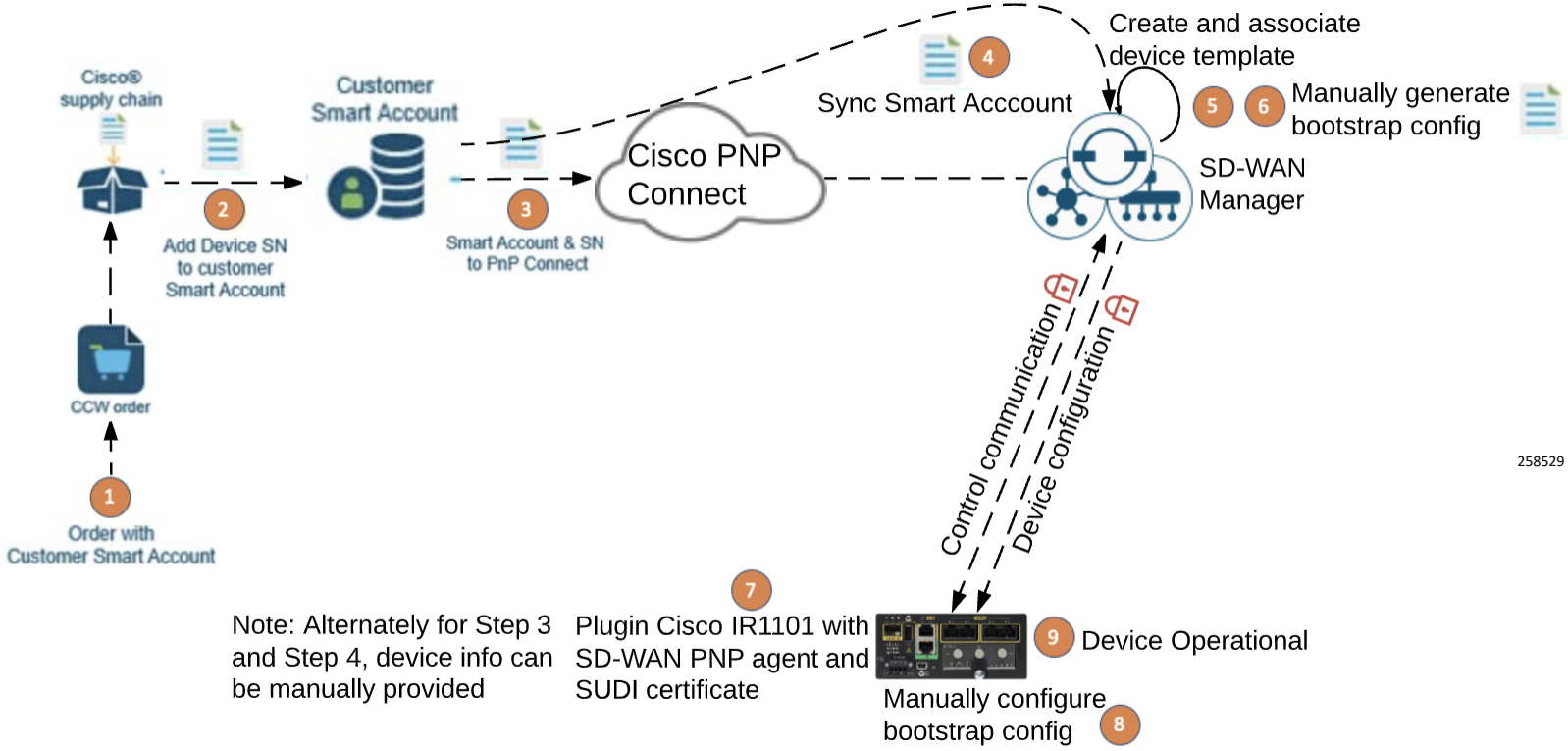
Onboarding workflow with Bootstrap



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SD-WAN IIoT Templates (Feature and CLI)

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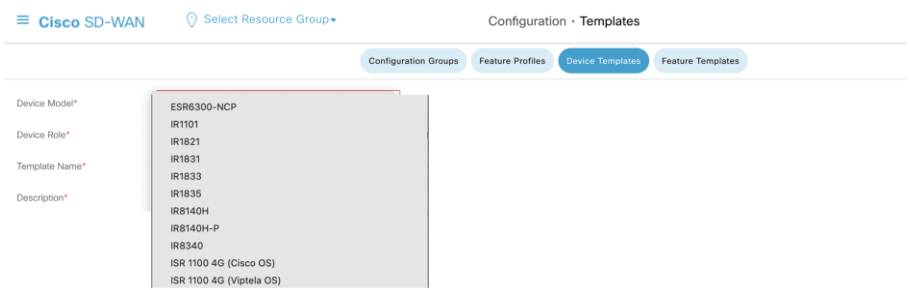
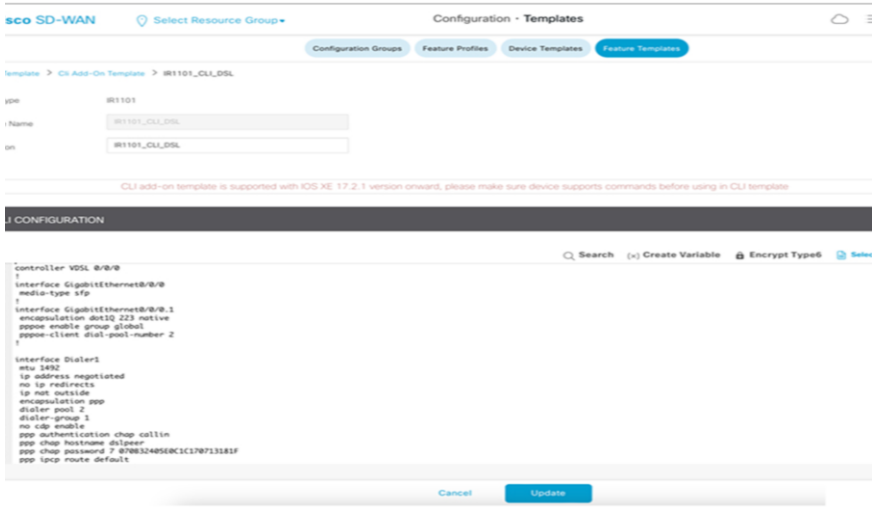
IoT device template creation

- ✓ Load running config from another device
- ✓ Load config from a local file
- ✓ Create variables
- ✓ Build and maintain your network more efficiently with Workflows



Feature template



CLI Template

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IIoT Transport & Service connectivity

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Transport and Service connectivity

Network Interfaces	IR1101	IR1800	IR8300
ETHERNET	✔	✔	✔
DSL	✔	✔	
LTE/5G CELLULAR (SINGLE OR DUAL)	✔	✔	✔
CURWB (EXTERNAL RADIO VIA ETHERNET)	✔	✔	✔
T1/E1			✔
Wi-Fi6			
Serial I/O Raw socket encapsulation			

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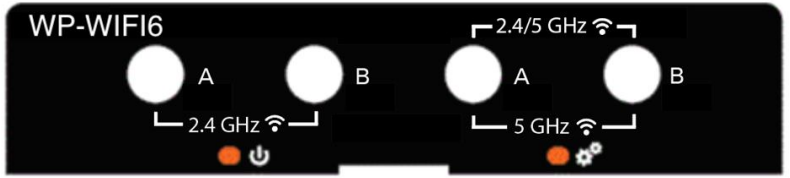
Wi-Fi 6 management



- Currently in the IoT routing portfolio compatible with Cisco vManage, only the IR1800 series includes Wi-Fi capabilities.
- The IR1800 series supports a Wi-Fi-6 module with 2x2 MIMO and 2 spatial streams based on the Cisco 9105AXI access point.
- Alternatively, in Embedded Wireless Controller (EWC) mode the access point registers to an integrated controller running locally on the same module that operates as a wireless hotspot. EWC hotspot mode is supported when the router is managed by the vManage SD-WAN controller.
- CLI Add-on template configuration is not support for the access point, which has its own CLI separate from the router.

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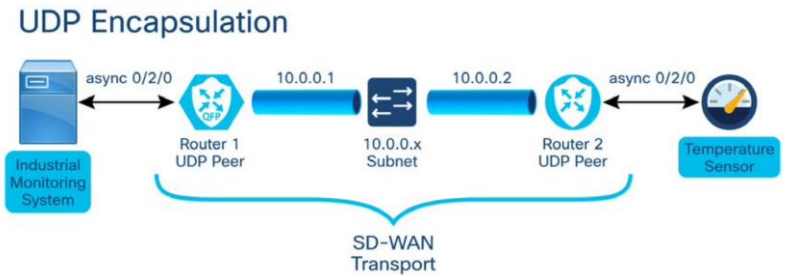
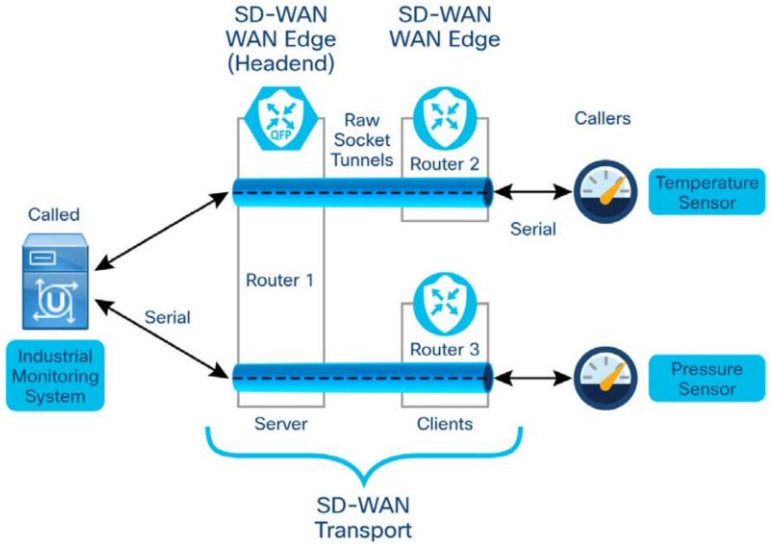
SCADA Serial Raw Socket Encapsulation

Raw UDP Socket Encapsulation





Raw TCP Socket Encapsulation

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SD-WAN Serial SCADA Support

IR8340

Up to 16 RS-232 Ports

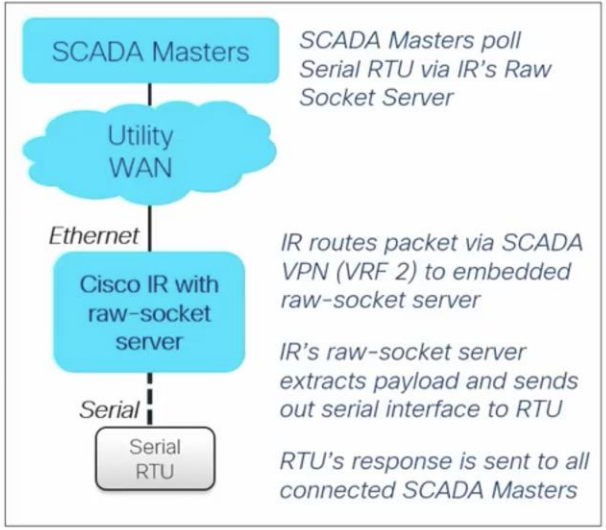
IR1101

1 RS-232 Port

1 RS-232 Port
4 RS-232/485 Ports

1 RS-232 Port
8 RS-232/485 Ports

Serial SCADA readily supported by Cisco SD-WAN



IR8340 SD-WAN Raw-Socket Config

```
69  interface Serial0/2/0
70   physical-layer async
71   vrf forwarding 2
72   no ip address
73   ip nbar protocol-discovery
74   encapsulation raw-tcp
75  !
76  line 0/2/0
77   raw-socket tcp server 20000 10.0.11.50
78   raw-socket packet-timer 500
79   raw-socket packet-length 1400
80   stopbits 1
81   speed 38400
```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Location tracking and geofencing

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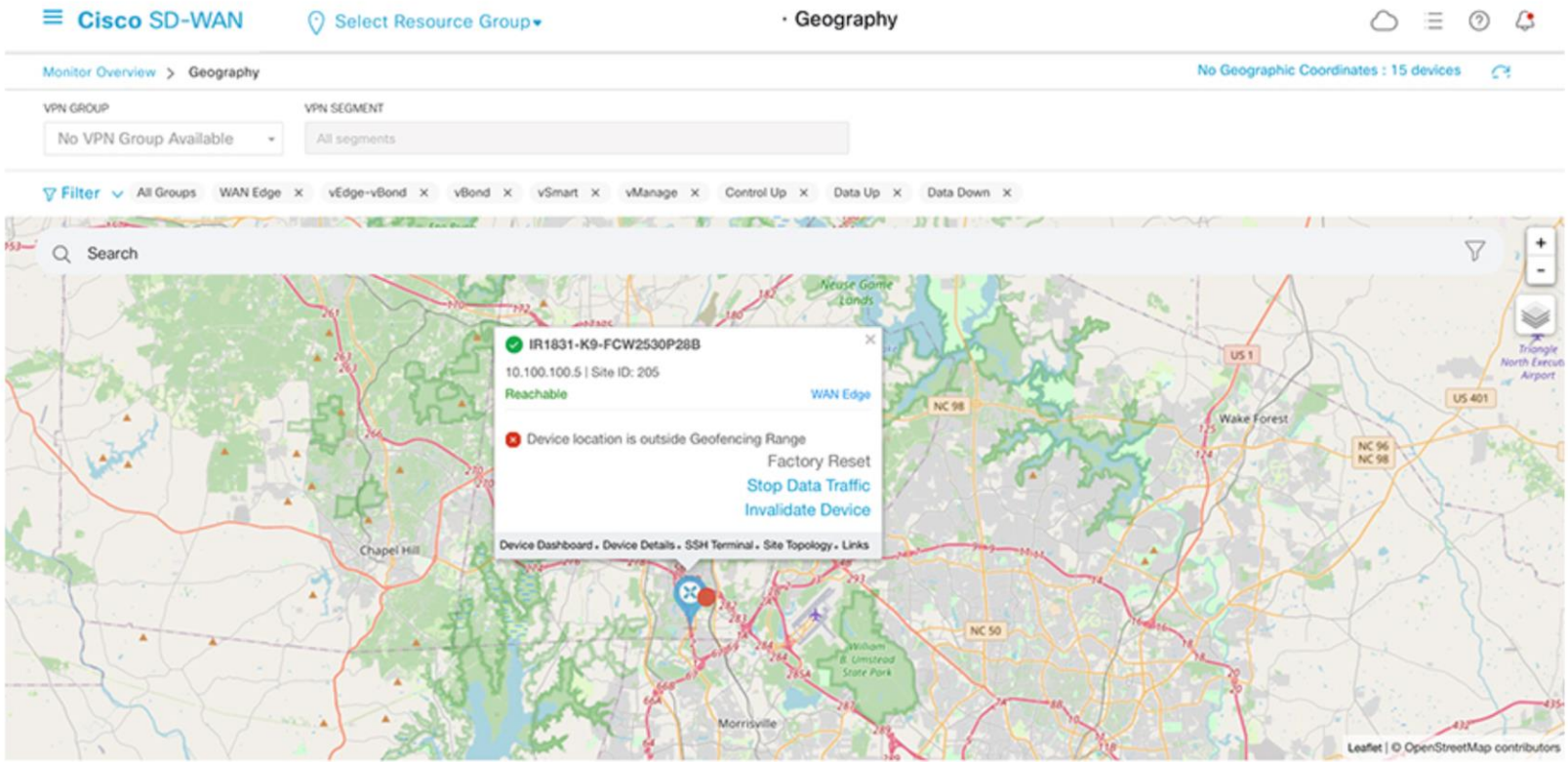
Location tracking and geofencing



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SD-WAN IoT Solution Architecture

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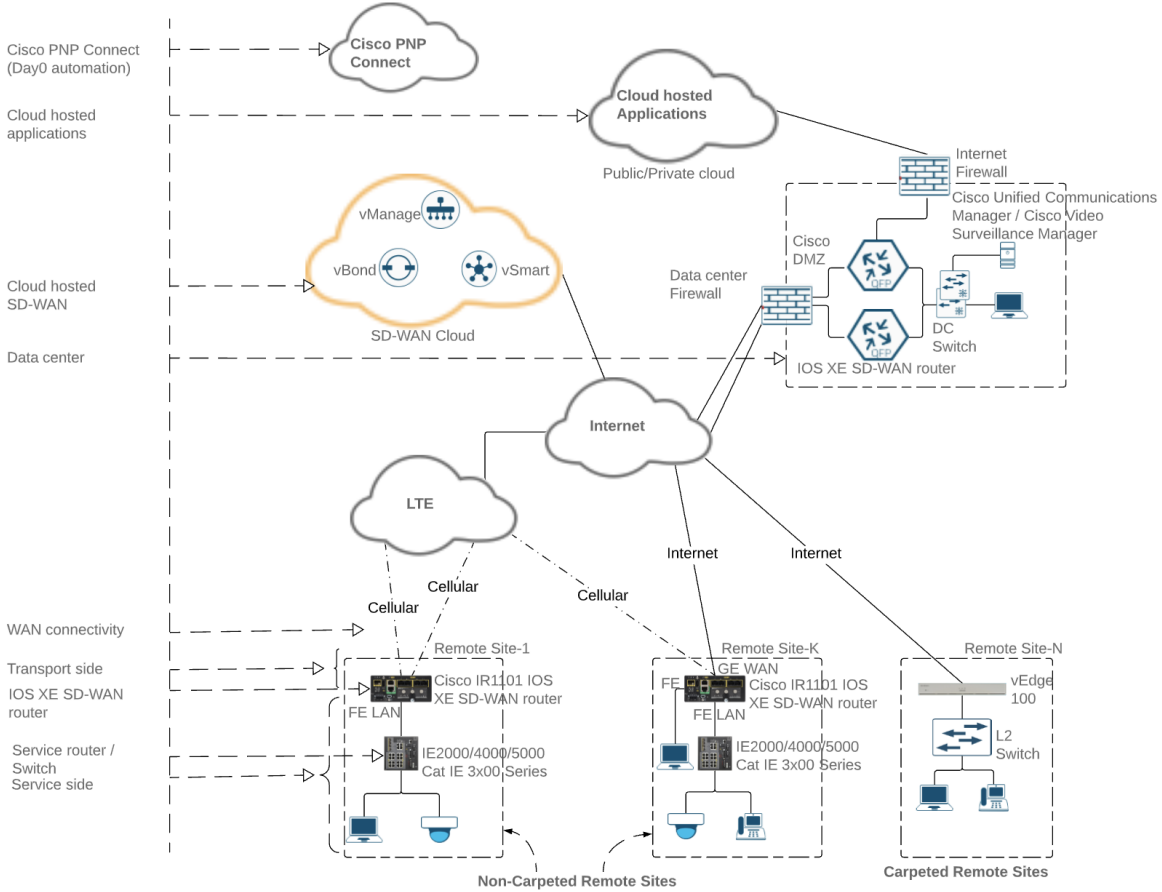
Cloud hosted SD-WAN Solution architecture



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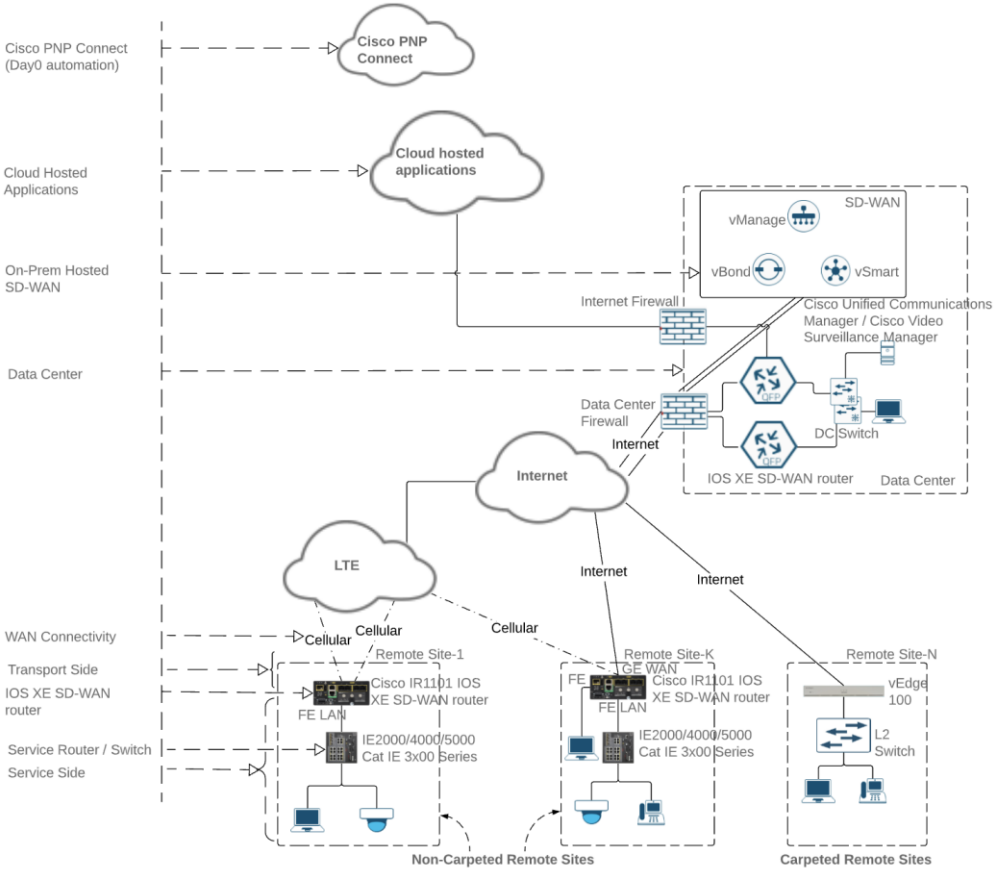
On-Prem hosted SD-WAN Solution architecture



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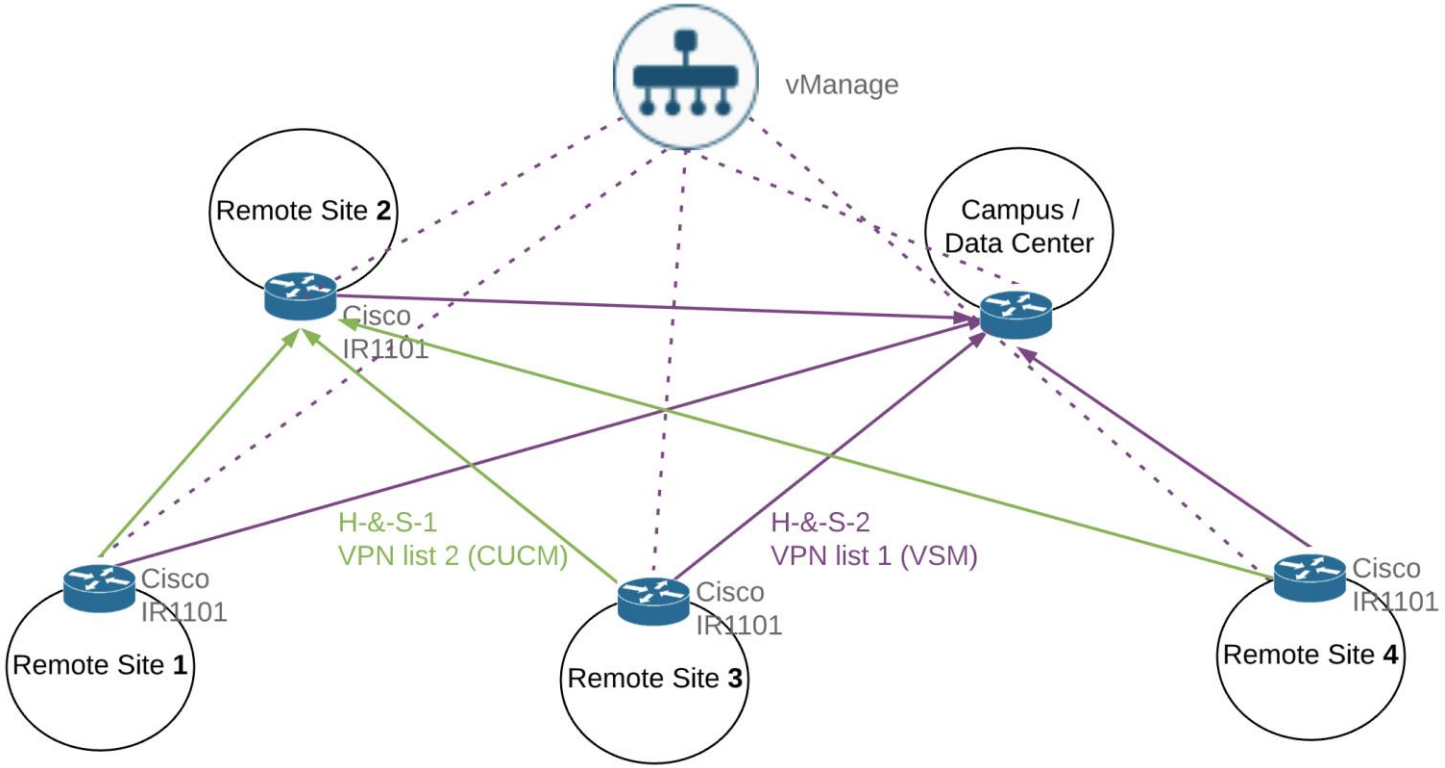
Hub-and-Spoke topology for service VPNs



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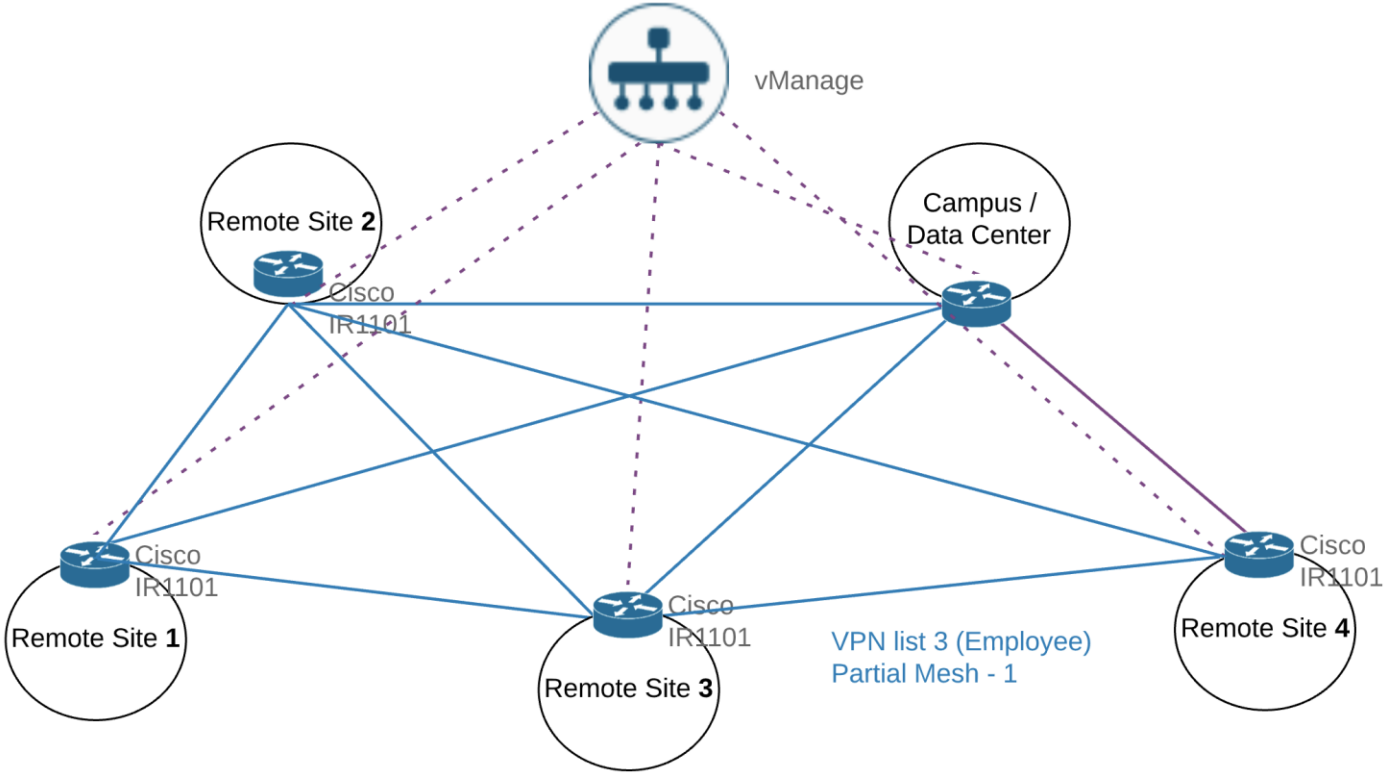
Mesh topology for service VPNs



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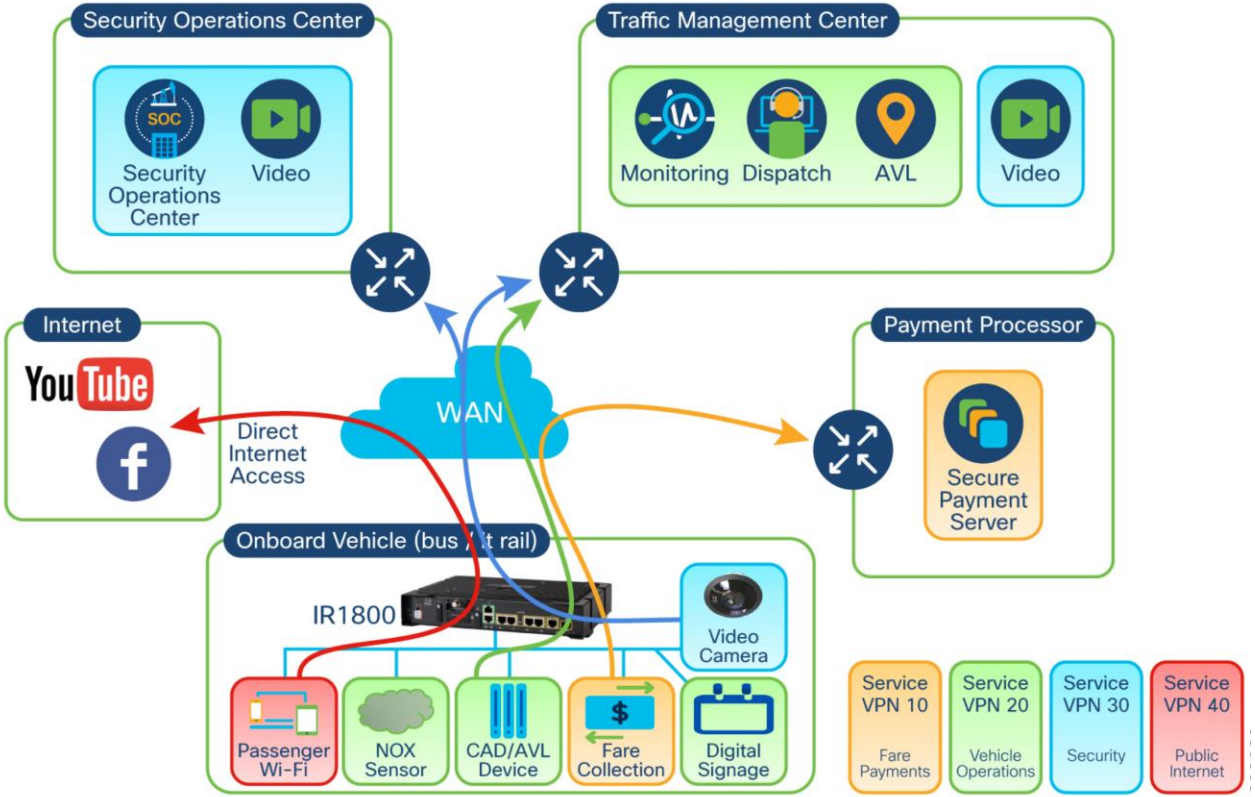
Macro-segmentation Through Service VPNs



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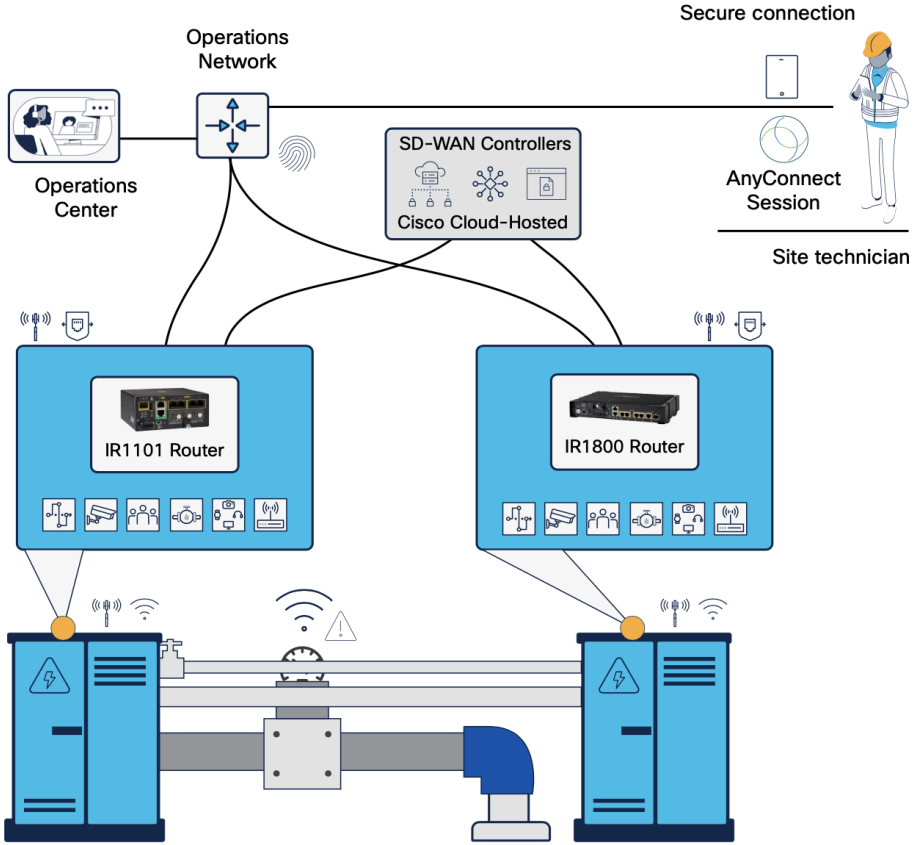
Asset management architecture block diagram



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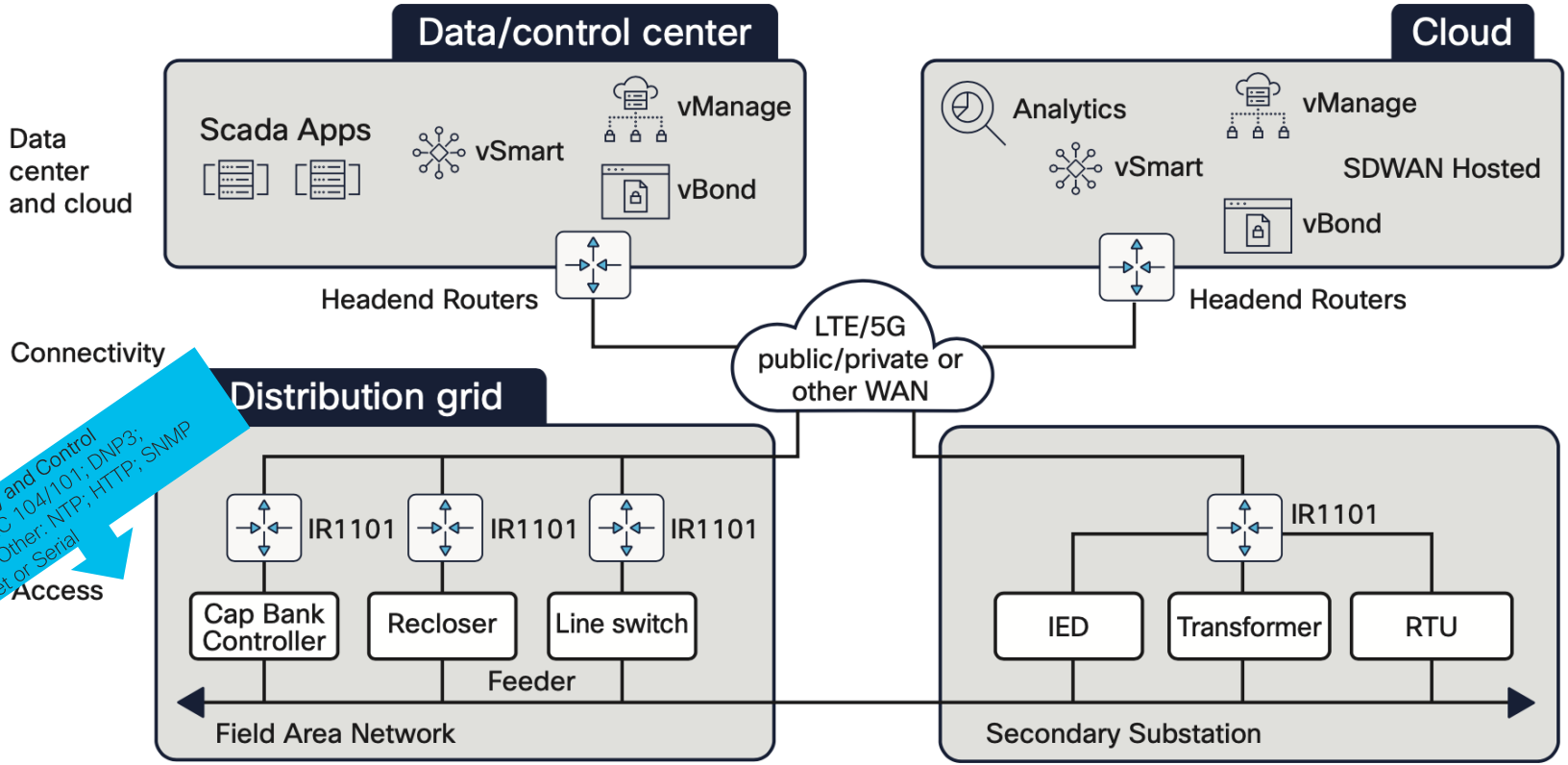
Distribution automation architecture block diagram



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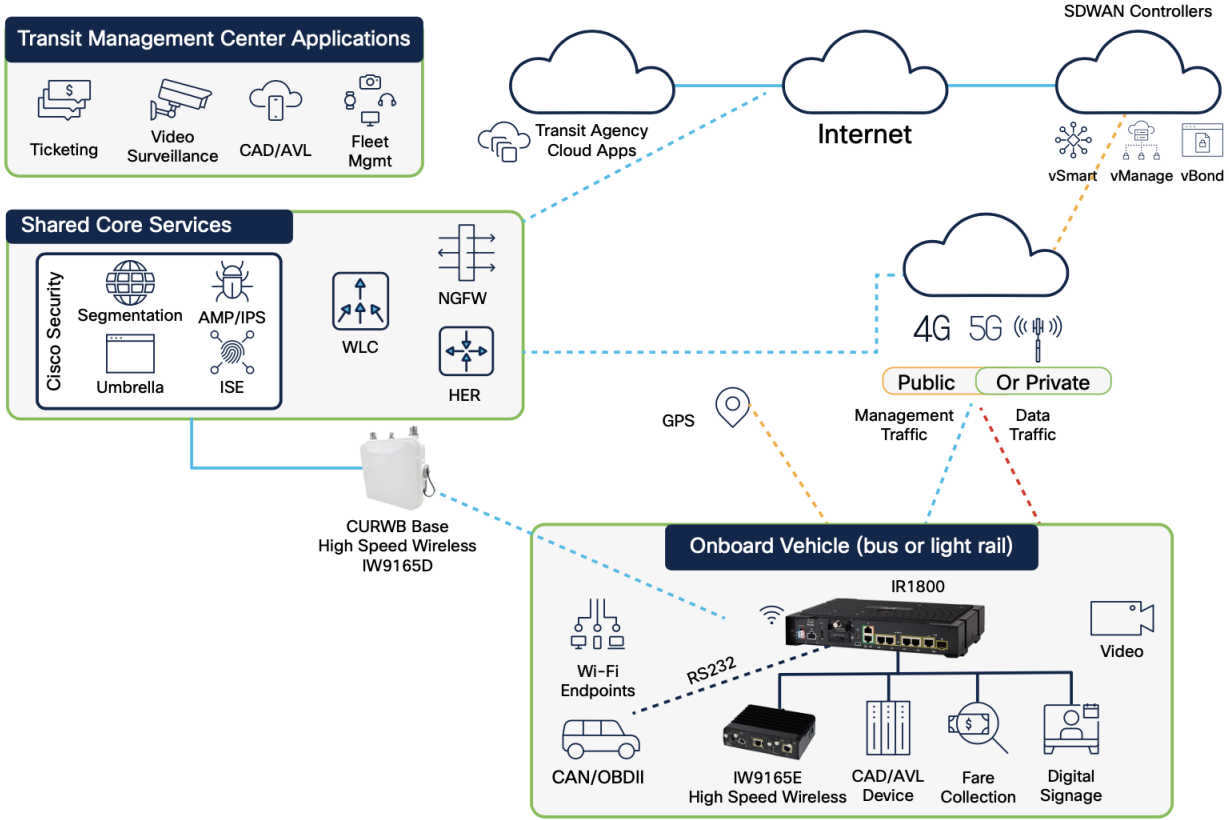
Fleet and Transit system architecture block diagram



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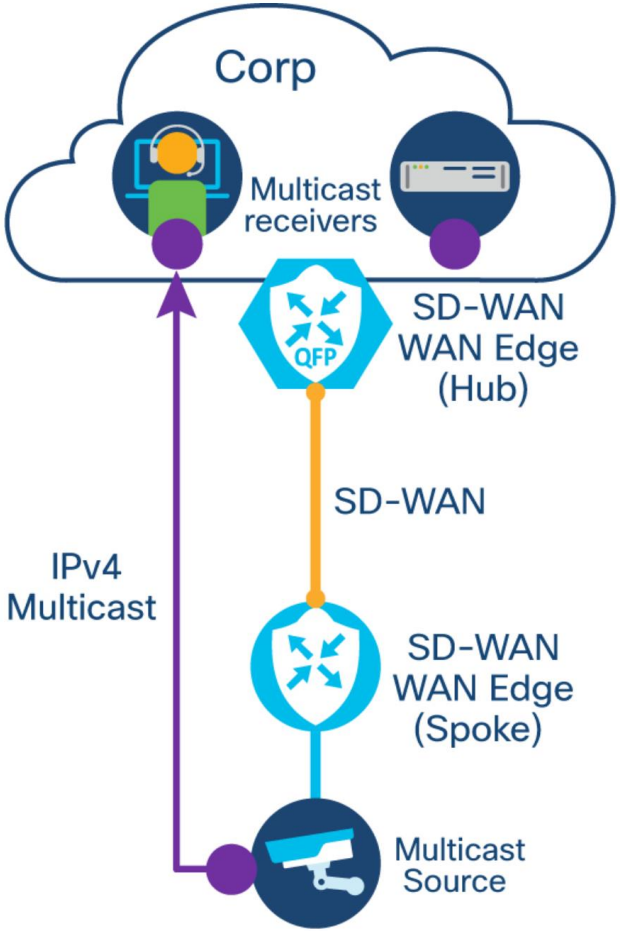
Multicast Video from Spoke to Hub



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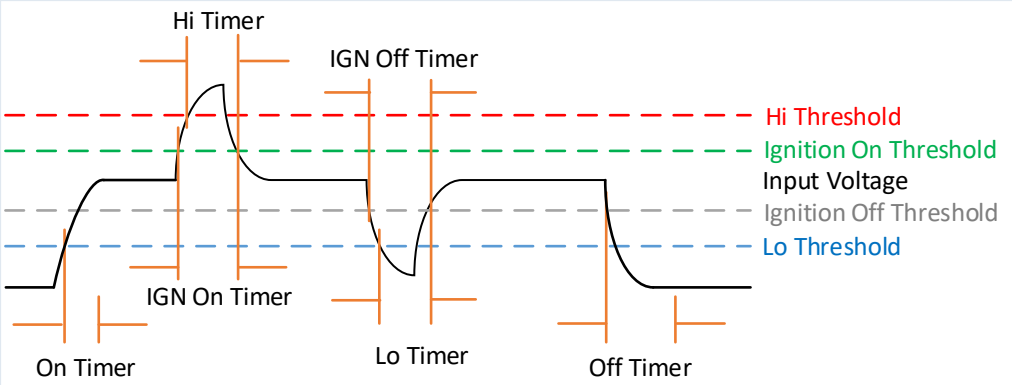
IR1800 Ignition Sense Overview

Ignition based on voltage (Analog Input)




```
IR1800_FCW2445P8H8#show ignition status
Ignition management: Enabled
Input voltage: 13.3 V
Ignition status: Power on
Ignition Sense: Enabled
Shutdown timer: 0.0 s to off [will begin power
down at ~100 sec]
Thresholds:
Undervoltage: 13.000 V
Overvoltage: 37.0 V
Undervoltage timer: 20.0 s
Overvoltage timer: 1.0 s
Ignition-Off timer: 300.0 s
```

	Input Voltage (DC)
Min	9.6V
Max	36V
Nominal	12V or 24V

	Ignition Sense Voltage	
	12V Battery	24V Battery
On	13V + 2%	26V + 2%
Off	13V -2%	26V - 2%

	Battery Voltage	
	12V Battery	24V Battery
UnderVoltage	11.5V	23V
Overvoltage	36V	36V

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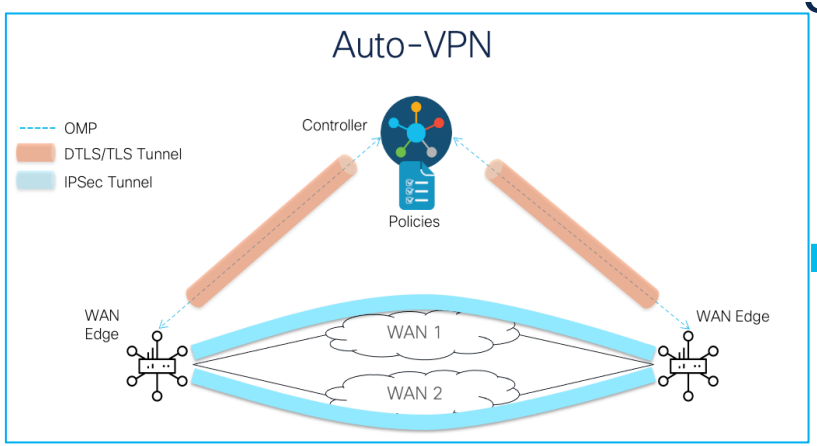
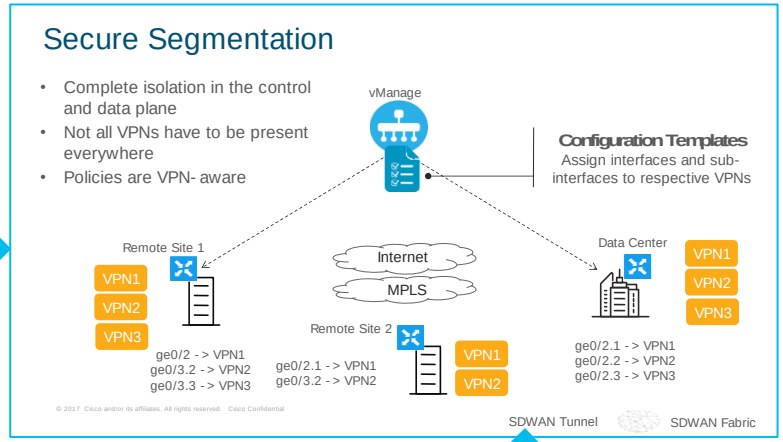
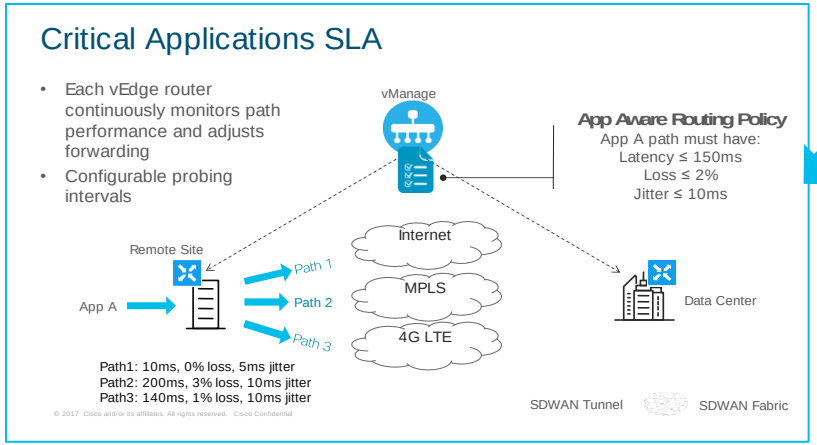
Cisco SD-WAN manager does best for OT!







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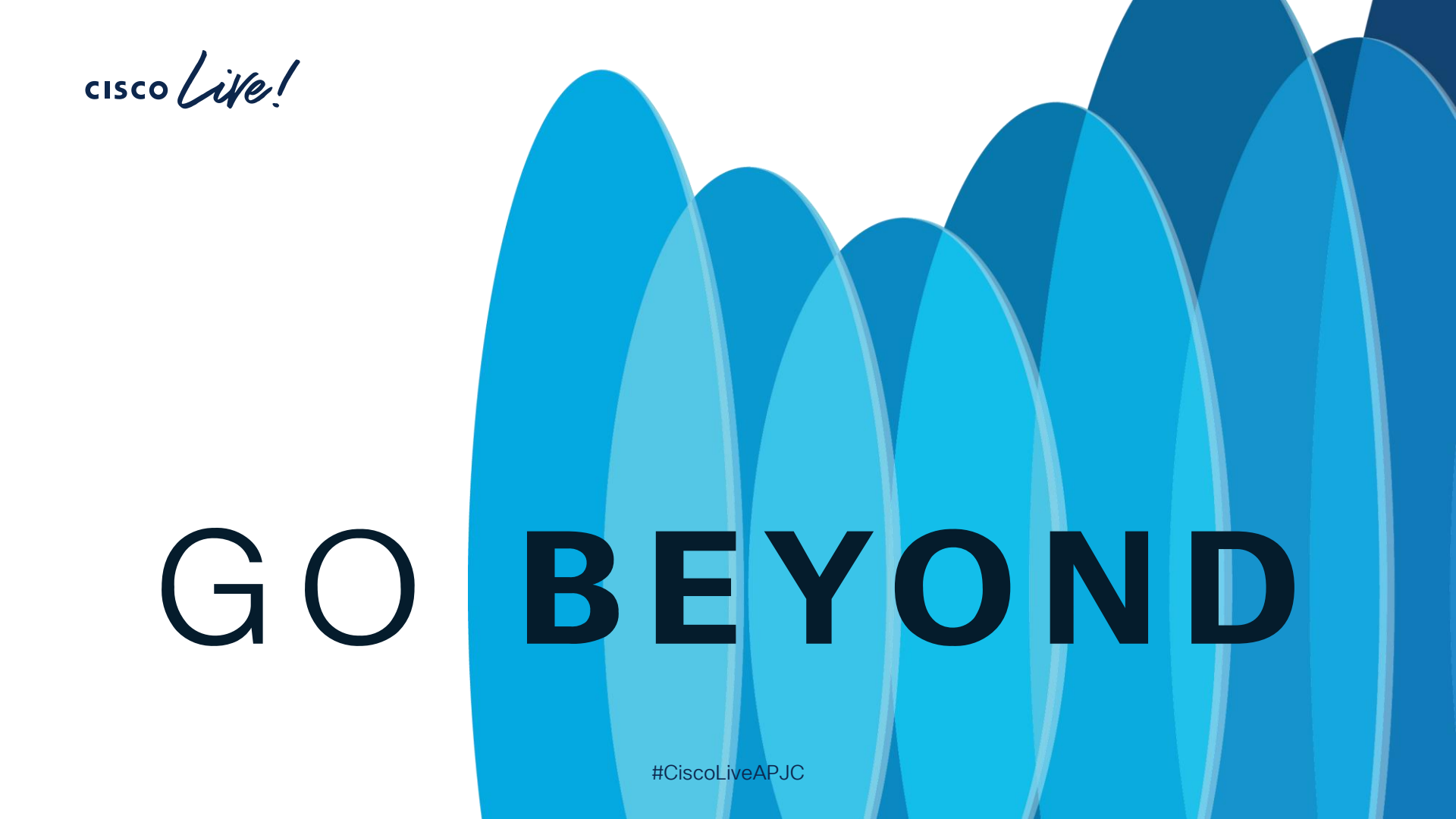
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