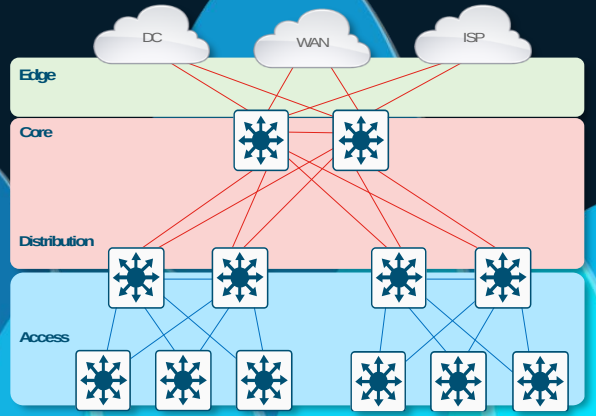
The bridge to possible

123 - Enterprise Campus Wired Design Fundamentals

Back to Basics



Shawn Wargo – Principal TME

BRKENS-1501

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https://ciscolive.ciscoevents.com/ciscolivebot/#BRKENS-1501

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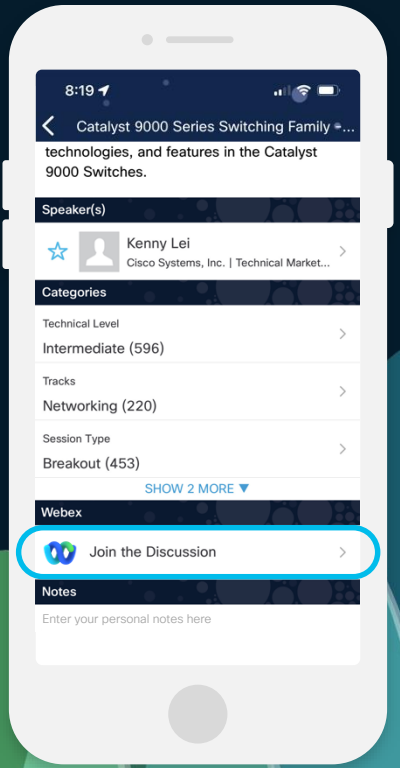

Who am I?

I'm a Principal Engineer of Technical Marketing (Principal TME) for Cisco Enterprise 'Network Experience' (NX) Product Management team. I've been with Cisco since 1999.

I mainly focus on Enterprise Switching & Routing technology areas, with a special emphasis on 'next generation' Hardware & Software products and solutions.

As a Principal TME, I'm currently working on the next generation of Catalyst Switching, Wireless & Routing products, and solutions like Software-Defined Access (SDA) & Cisco DNA.

Shawn Wargo
Principal TME
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What this session is NOT

This session is NOT intended as a Deep-Dive or CVD!

The goal is to understand *basic reasons* & *rationale* for each Campus design ☺

Please also review BRKENS-1500

- Introduction to Campus Wired LAN Deployment Using Cisco Validated Designs - BRKENS-1500

Other Related Sessions:

- Designing Highly Available Networks using Catalyst 9000 Series Switches - BRKENS-2095
- Enterprise Campus Design: Multilayer Architectures and Design Principles - BRKCRS-2031
- Building for the Campus of the Future - BRKENS-2599

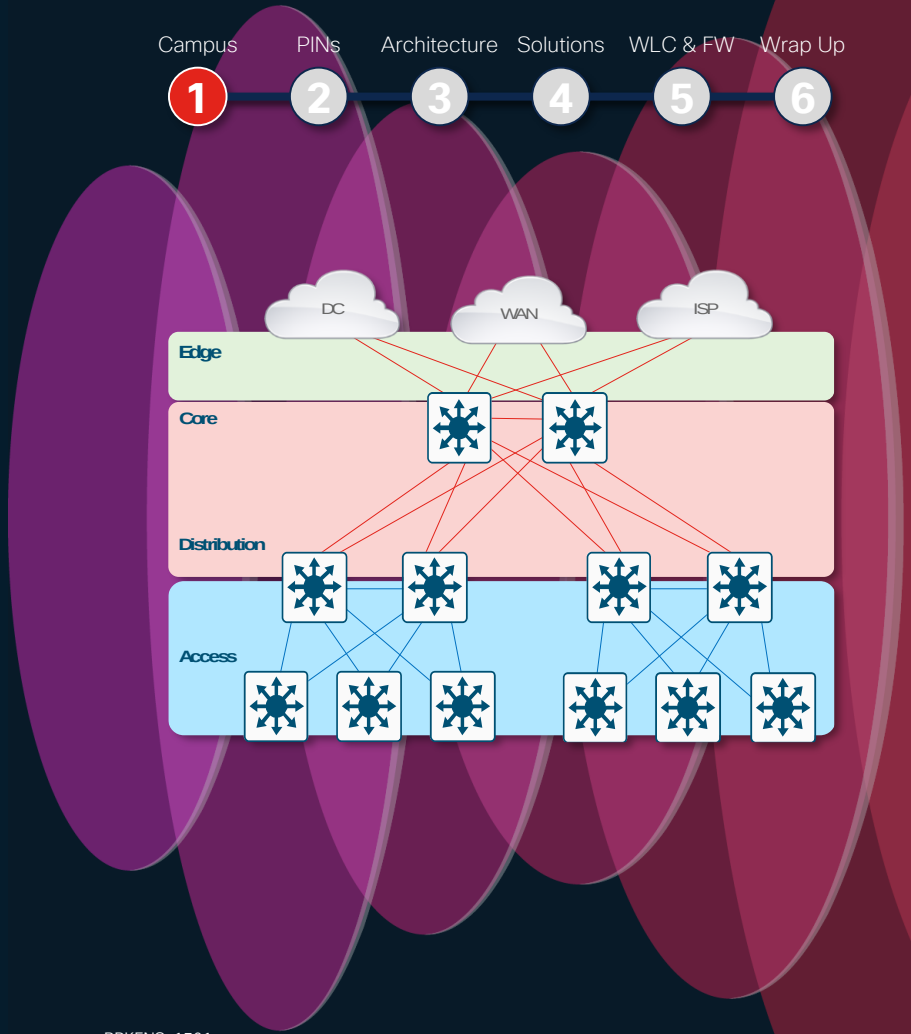
www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html

Agenda

1. What is a Campus Network?
2. 1-2-3 or 4+ Tier Design
3. ECMP vs. StackWise
4. MPLS vs. EVPN vs. SD-Access
5. Wireless & Security Notes
6. Summary & References

Campus Networks

- What is “Campus”?
- Place in Network (PIN)
- Multi-Layer Model
- Chassis Considerations
- Cabling Considerations
- Feature Considerations



What is a “Campus”?

A basic **Merriam-Webster** definition of a Campus is:

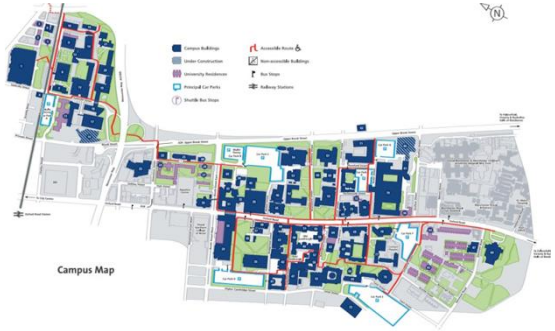
A group of one or more buildings, and surrounding grounds, where people and their belongings work together.

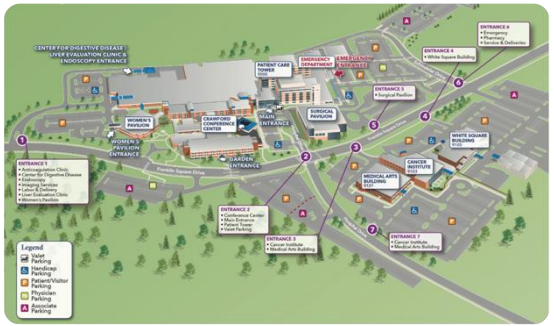
Common examples are **Corporate** & **Government Offices**, **Hospitals**, **Schools**, **Transportation**, **Manufacturing** & more.

Using this – it’s clear a Campus Network is focused on:

- ☑ **People** (*Users, Vendors, etc.*)
- ☑ **People's devices** (*PCs, Phones, Printers, etc.*)
- ☑ **Local geographic area** (*LAN, WLAN or MAN, etc.*)
- ☑ **Access other domains** (*WAN, ISP, DC & Cloud, etc.*)

This includes **many different network technology areas** (*Wired, Wireless, Security, QoS, Management, etc.*)





Campus is focused on **User Access**

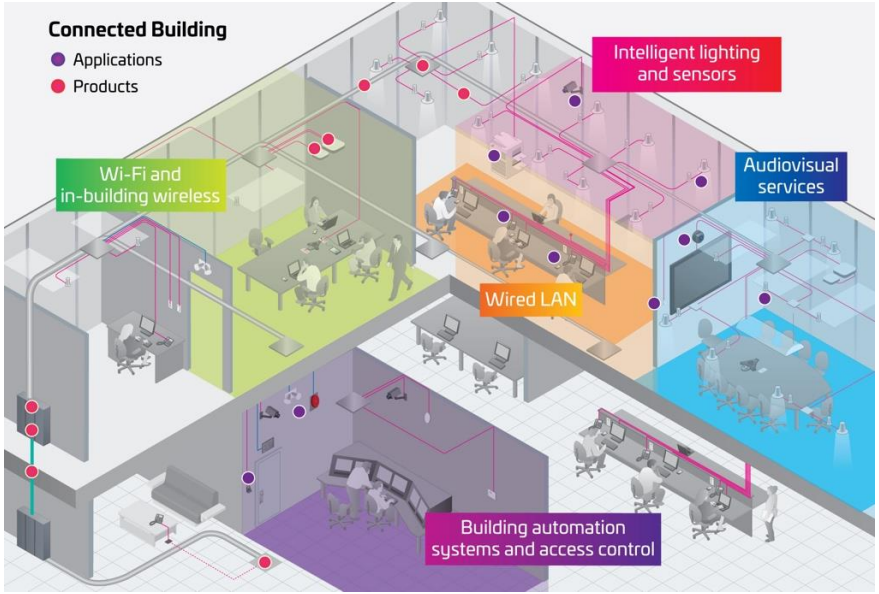
Campus = Geography

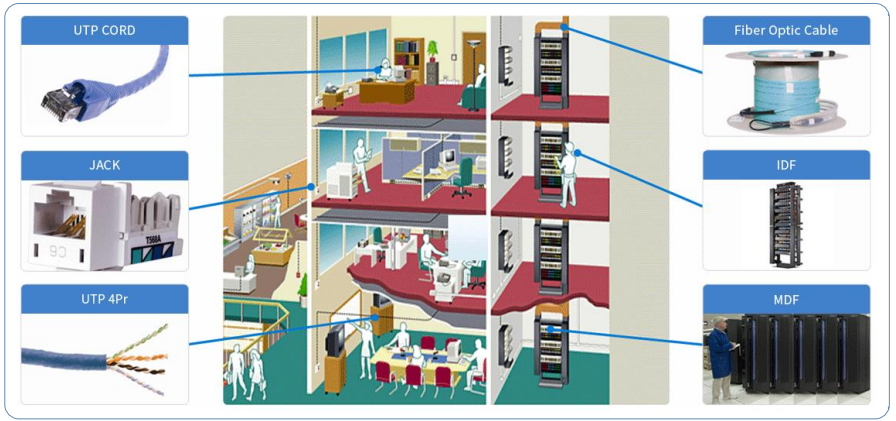
Buildings are spread out. Multiple floors per building

www.cisco.com/c/en/us/solutions/cisco-on-cisco/enterprise-networks.html

Campus Networks

Building MDF/IDF & Wiring Closets





MDF = Main Distribution Framework (Core & Edge)
IDF = Intermediate Distribution Framework (Distro & Access)

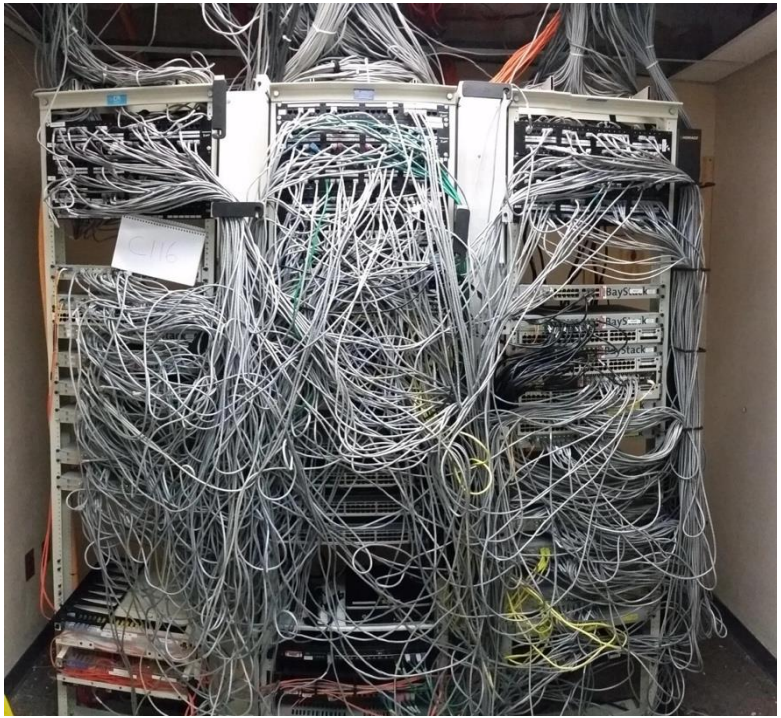
www.cisco.com/c/en/us/solutions/design-zone/networking-design-guides/campus-wired-wireless.html

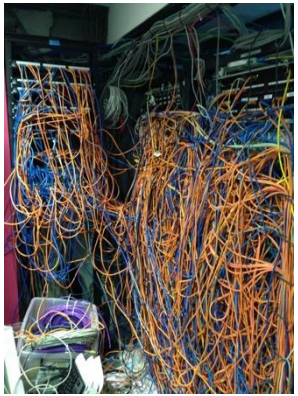
Campus ≠ Data-Center

One or few large buildings nearby. Usually a single floor.

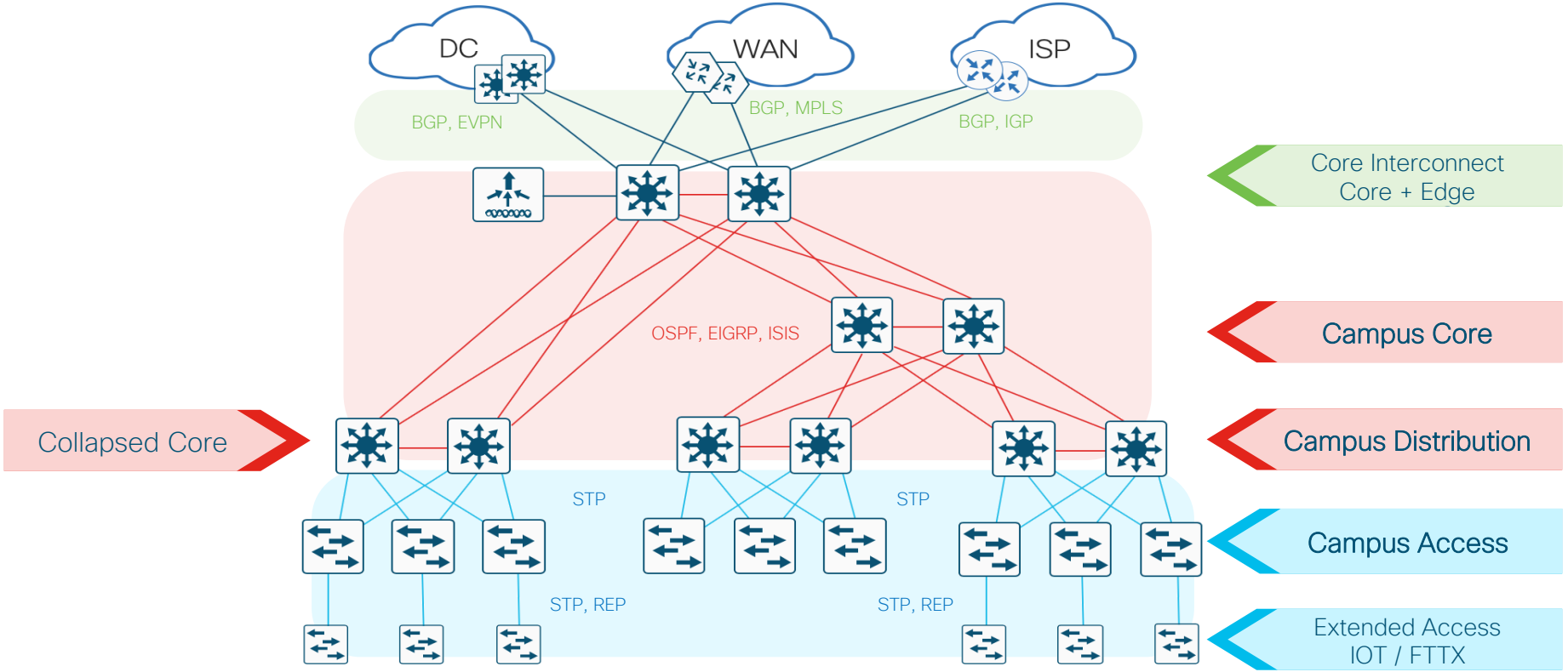
www.cisco.com/c/en/us/solutions/cisco-on-cisco/enterprise-networks.html

Campus Networks - Real Life

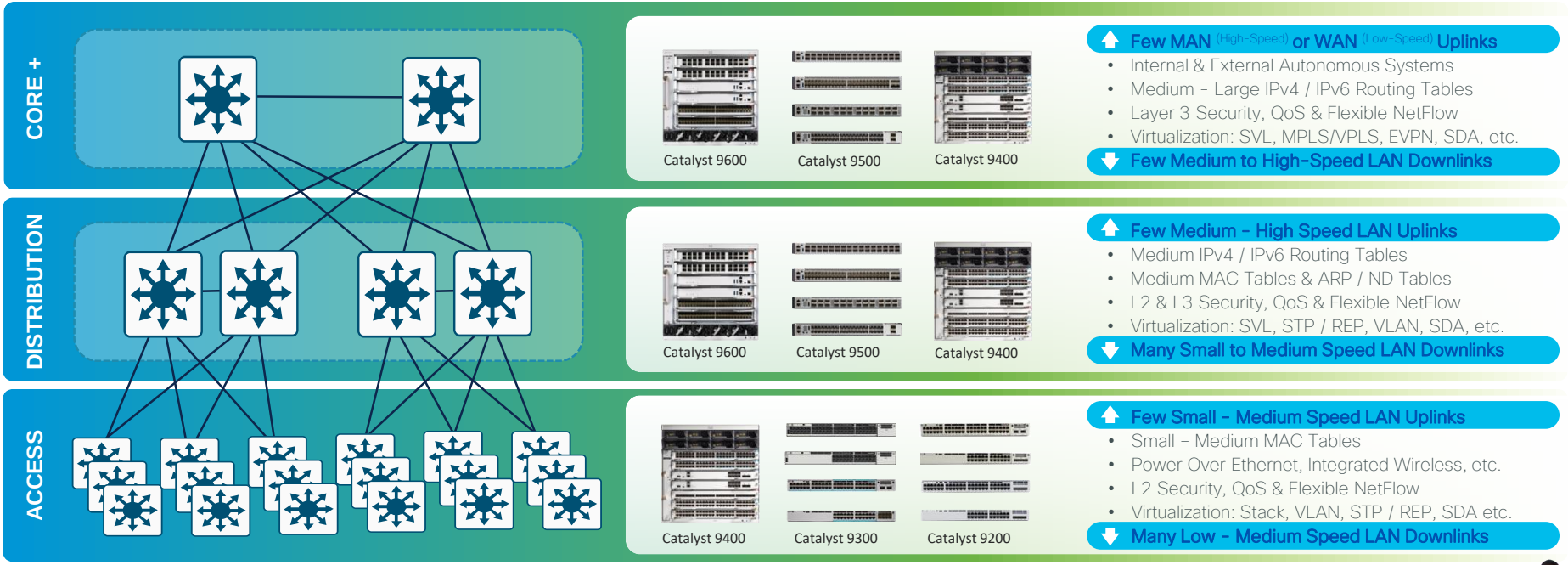




Campus PINs & Topology



Campus Multi-Layer Model



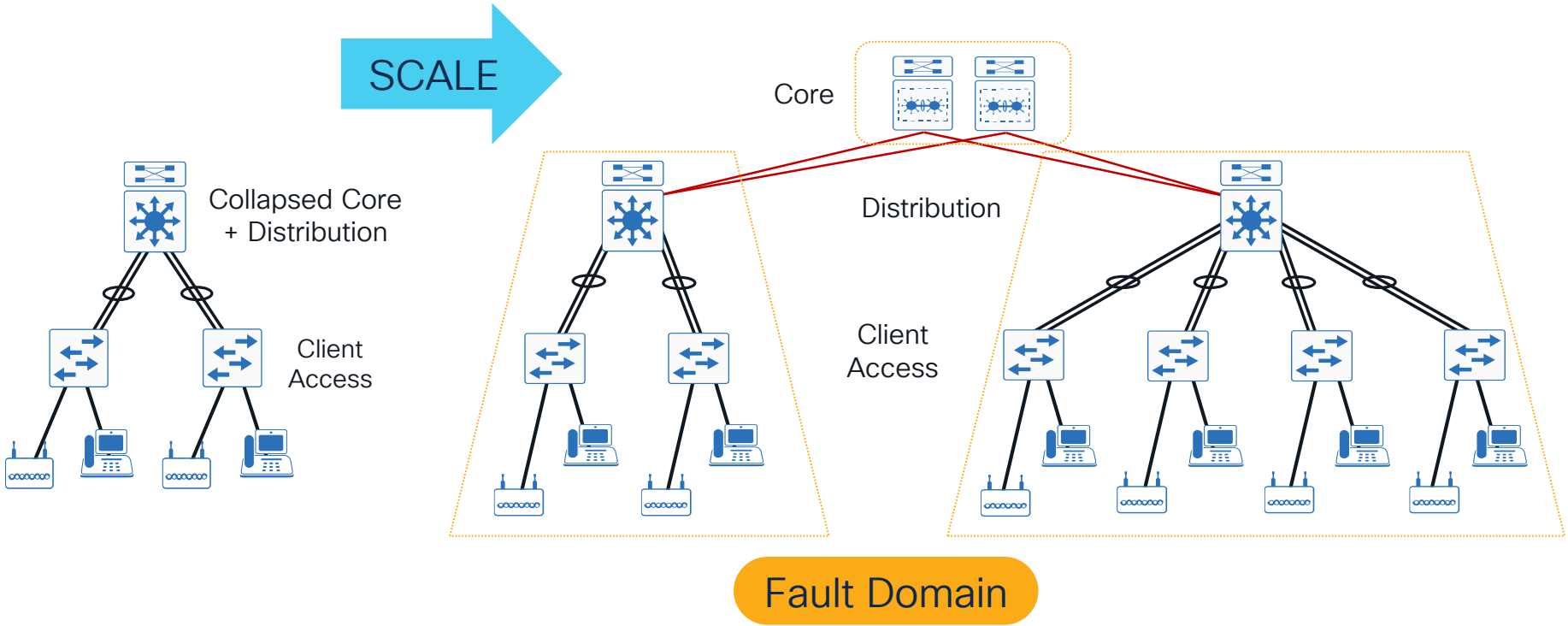
Always 3 “Logical” Layers

- Each layer provides a specific set of functions
- Each layer has a specific set of requirements

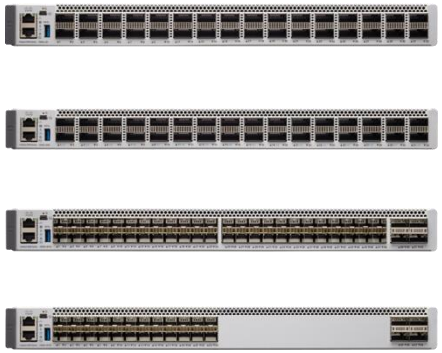
If you ‘collapse’ layers
your device needs
to support
all ‘**logical**’ functions

Campus Design Fundamentals

Hierarchical design model – Scalability & Stability



Modular vs. Fixed Platforms



Modular

PROs

- More Flexible
- Longer Life-Cycle
- Higher Port Density
- More Power/Cooling
- Redundant Processors

CONs

- More Complex
- BW limit by Chassis
- Slow(er) Dev & Test
- Lower MTBF
- Higher COGs

Fixed

PROs

- Less Complex
- Swap Chassis for BW
- Faster Dev & Test
- Higher MTBF
- Lower COGs

CONs

- Less Flexible
- Shorter Life-Cycle
- Lower Port Density
- Less Power/Cooling
- Single Processor

Modular Platform Features & Benefits

Redundancy, Expansion, Efficiency & Flexibility

Highest Resiliency

Redundant Supervisors

StackWise® Virtual

Easy Upgrades with ISSU & GIR

Redundant Fans (Fan-Tray)

Redundant PSUs (1:1, N+1)

Highest Flexibility

SUP1 for Small Designs

SUP2/XL for Large Designs

Custom ASIC Scale Templates

Traditional Multi-Layer Designs

Fabric Overlay Designs

Highest Efficiency

Lowest Watts per Port

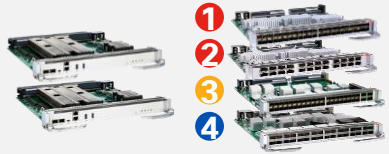
3000W Power Supplies

Titanium Rated (95%) PSUs

AC and/or DC Power

Configurable Power Priority

Longest Lifecycle



Start w/ SUP1 & few Gen1 LCs

Add Gen1 LCs as Access grows

Replace SUP1 with SUP2

Gen1 LCs get a 2X boost

Add new Gen2 LCs as Core grows

Most Port Options

Mixes of RJ45, SFP & QSFP

C9600-LC-40YL4CD

40x 50G SFP + 2x 100G + 2x 400G QSFP

C9600X-LC-32CD

32x 100G or 24x + 8x 400G QSFP

C9400-LC-48XS

48x 1/10G SFP

C9400-LC-48HX

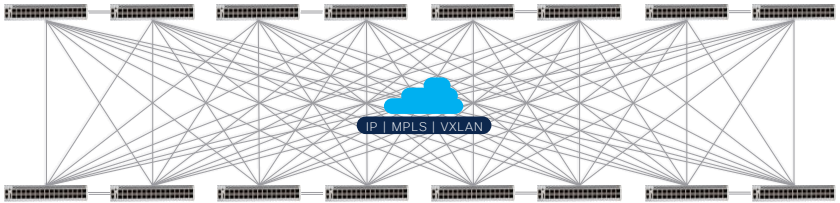
48 x 10G mGig + UPOE®

Modular Design for Large Campus

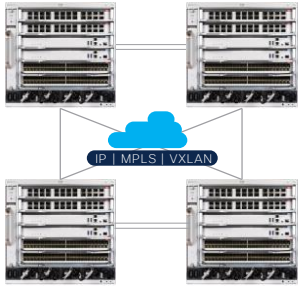
Architecture Perspective – Full Mesh vs. Hierarchical Design

Fixed System Design

- Static
- Costly
- Complex



Modular System Design



- Simple
- Scalable
- Sustainable

Modular System Benefits

Sustainable

Reduce Energy Demand
Reduce Carbon footprint
Environmental efficient

Cost

Reduce cost – CAPEX | OPEX
License & Service Management
Reduce product life-cycle TCO

Operation

Proven for large Enterprise
Day 0 – N scalable architecture
Simplified Tools and Management

Flexible

Pay-As-You-Grow model
Elastic Aggregation. Static Core.
Simple and large L2 boundaries

Resilient

Non-stop communication
Protected network performance
Reduced MTTR and MTBF

Copper vs. Fiber Media

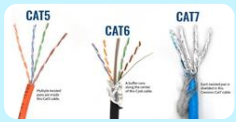
www.cisco.com/c/en/us/products/interfaces-modules/transceiver-modules/

Category 5, 6 & 7

Unshielded (UTP) | Shielded (STP)

RJ45 (Access to Endpoints)

Cat6A (Offset Wires) Cat5E (Flush Wires)



Category	Frequency	Distance	Data Rate	Shielding
5E	100-350 MHz	100m	1000 Mbps	UTP or STP
6	250-550 MHz	1G – 100m 10G - 50m	1 Gbps 10 Gbps	UTP or STP
6A	500-550 MHz	100m	10 Gbps	UTP or STP
7	600 MHz	100m	10 Gbps	Shielded only

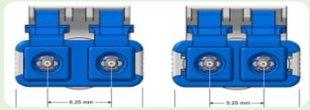
10M | 100M | 1G | 2.5G | 5G | 10G

NBASE-T ALLIANCE

OM3, OM4 & OM5

Multi-Mode (MMF) | Single-Mode (SMF) | Wave-Division Multiplex (WDM)

SFP (Access & Distribution) **QSFP** (Core & Edge)

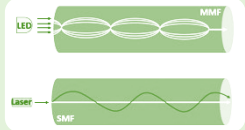


SFP-LC (LC Duplex) mSFP (Mini LC Duplex)

MPO12 (12 Fibers) MPO24 (24 Fibers)

Multimode
- Short distance cable runs (less than 1000ft.)
- High bandwidth support
- Higher cable cost
- Lower electronics cost
- Easier to terminate due to larger core size

Single Mode
- Long distance cable runs (greater than 1000ft.)
- Highest bandwidth support
- Lower cable cost
- Higher electronics cost
- Harder to terminate due to smaller core size



100M | 1G | 10G | 25G | 40G | 50G (NEW) | 100G | 200G (NEW) | 400G (NEW)

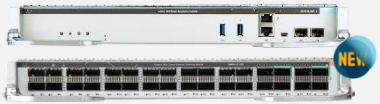
www.cisco.com/c/en/us/products/collateral/switches/catalyst-9000/nb-06-cat9000-panduit-cables-wp-cte-en.html

100GE & 400GE – A Better Alternative

Provide a seamless migration path from 40GE QSFP

Designation	Speed
D	400GE
C	100GE
Q	40GE

Catalyst 9600



C9600X-SUP2 & LC-32CD

C9600-SUP1 & LC-24C

Catalyst 9500

C9500X-28C8D

C9500-32C

Catalyst 9400

C9400X-SUP2XL

C9400-SUP1XL

Catalyst 9300

C9300X-NM-4C

C9300X-NM-2C

Reduced CapEx through reuse of existing cabling

Single-Lane optics provide port densities similar to 40G

Gradual migration options with support for Dual-Rate optics

Reduced OpEx through savings in power and cooling

25GE & 50GE – A Better Alternative

Provide a seamless migration path from 1/10GE SFP

Designation	Speed
L	50GE
Y	25GE
X	10GE

Catalyst 9600

C9600X-SUP2 & LC-40YL4CD

C9600-SUP1 & LC-48YL

Catalyst 9500

C9500X-60L4D

C9500-48Y4C

Catalyst 9400

C9400X-SUP2XL

C9400-SUP1XL-Y

Catalyst 9300

C9300X-NM-8Y

C9300-NM-2Y

Reduced CapEx through reuse of existing cabling

Single-Lane optics provide port densities similar to 10G

Gradual migration options with support for Dual-Rate optics

Reduced OpEx through savings in power and cooling

Campus Networks

L2/L3 Unicast Technologies

IPv4 **Unicast**

Core

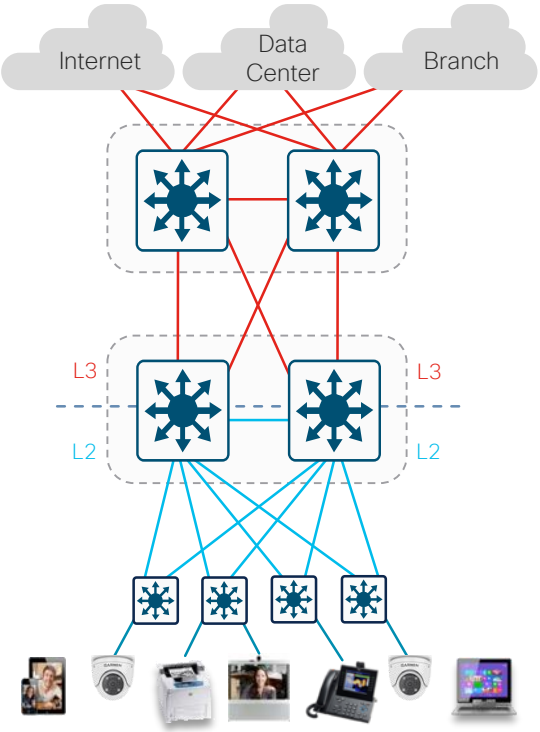
- MP-BGP, VPNv4
- Internet (v4), NAT, PBR
- MPLS-VPN, VRF-Lite
- IPv4 SSO, NSF/NSR, GIR

Distribution

- EIGRP, OSPFv2, ISIS, RIP
- SVI, HSRP/VRRP
- ARP, DHCP Relay
- IPDT/SISF, DAI
- BFD, Echo
- IPv4 SSO, NSF/NSR, GIR

Access

- PVST, MST, REP/RENN
- 802.1Q, DTP
- VLANs, VTP
- DHCP Snooping
- MAC Leaning
- L2 SSO



IPv6 **Unicast**

Core

- MP-BGP, VPNv6
- Internet2 (v6), NAT64, PBR
- MPLS-VPN, VRF-Lite
- IPv6 SSO, NSF/NSR, GIR

Distribution

- EIGRPv6, OSPFv3, ISISv6, RIPng
- SVI, HSRPv6/VRRPv6
- NDP, DHCPv6 Relay
- SISF (v4/v6), RA Guard
- BFDv6, Echo
- IPv6 SSO, NSF/NSR, GIR

Access

- PVST, MST, REP/RENN
- 802.1Q, DTP
- VLANs, VTP
- DHCPv6 Snooping
- MAC Leaning
- L2 SSO

Campus Networks

L2/L3 Multicast Technologies

IPv4 **Multicast**

Core

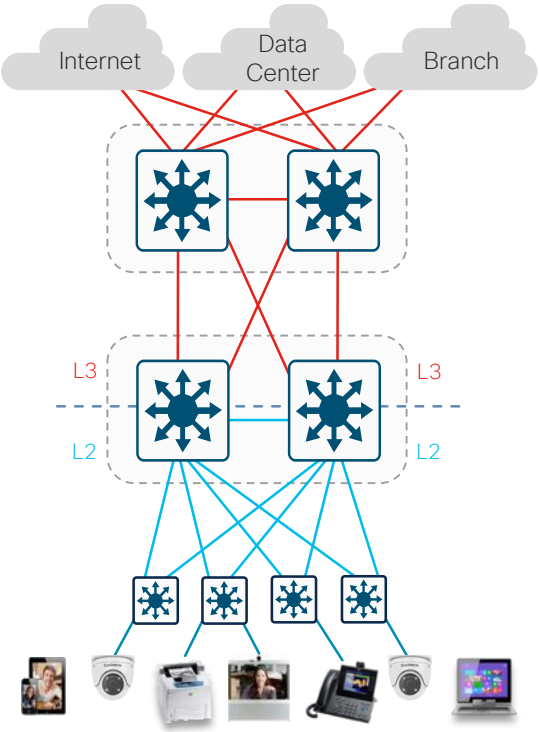
- PIM-SM, SSM and Bidir
- AutoRP, BSR RP, MSDP
- MVPN, Multicast VRF-Lite
- Multicast load splitting
- IPv4 multicast HA

Distribution

- Dual-stack IPv4 / IPv6
- PIM-SM, SSM and Bidir
- IGMPv2,v3 snooping
- Stub multicast routing
- PIM BFD
- IPv4 multicast HA

Access

- IGMP v1,v2,v3 snooping
- IPv4 multicast QoS & ACL
- IGMP v1,v2 filtering



IPv6 **Multicast**

Core

- PIM-SM and SSM
- IPv6 BSR RP
- IPv6 embedded RP
- IPv6 multicast HA

Distribution

- Dual-stack IPv4 / IPv6
- PIM-SM and SSM
- MLDv1,v2 snooping
- HW register and RPF
- HSRP-aware PIM
- IPv6 multicast HA

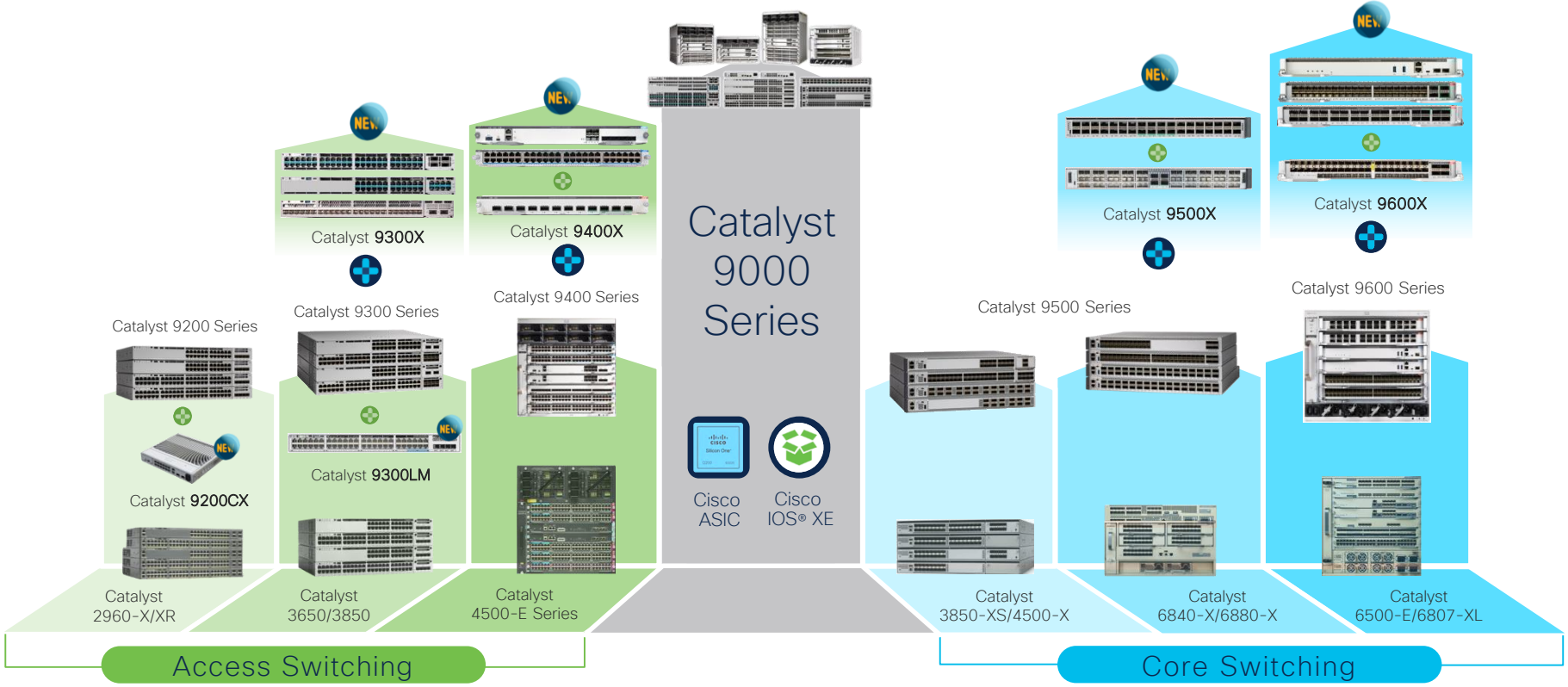
Access

- MLD v1,v2 snooping
- IPv6 multicast QoS & ACL
- MLD v1,v2 filtering

Cisco Catalyst 9000 Switching Portfolio

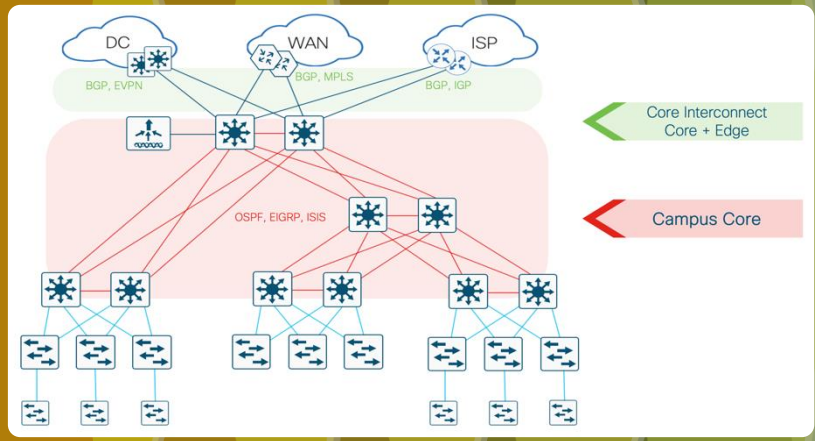
2022-2023 NEW

One Family from Access to Core – Common Hardware & Software



Campus PINs

- **Campus Core** (Baseline)
- **Campus Core +** Interconnect
- **Campus Core +** Edge



Campus Core (Baseline)

The **Core PIN** (Tier 3) focuses on connecting multiple Distribution layers to an Interconnect (if applicable) and/or other network domains

- Other names: MDF, BDF
- Common in Medium & Large Campus

Main goal is a simple, high-bandwidth, L3 transport between other network layers

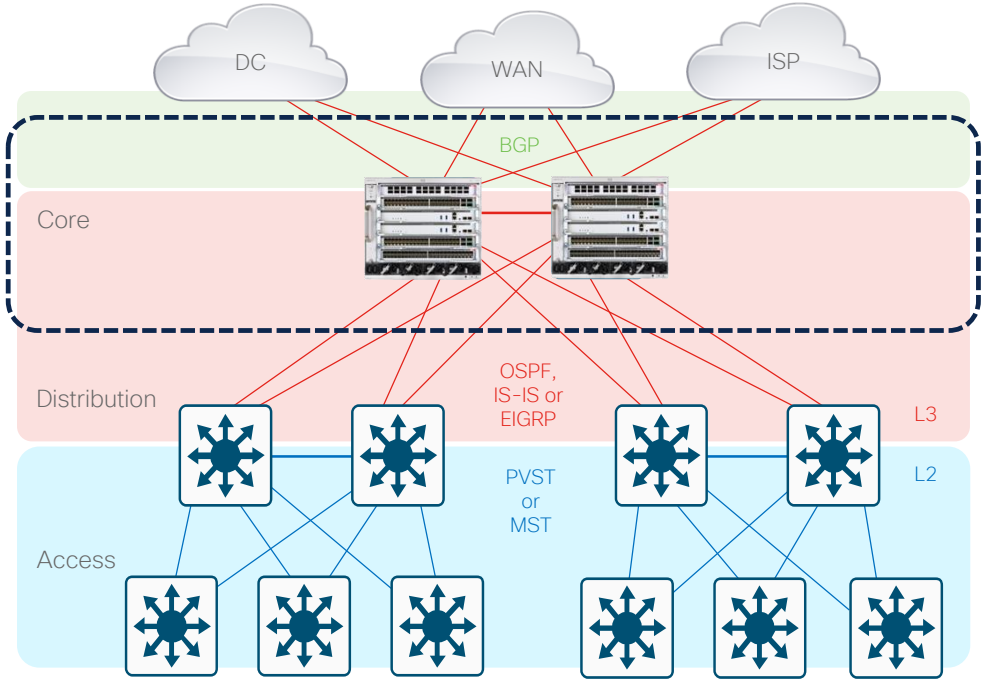
Tends to be **L3 routed** (north & south)

- North: BGP or IGP (ABR), PIM + MSDP
- South: OSPF, IS-IS or EIGRP, PIM

Tends to use minimal L3 features

- Limited ACLs (e.g. inter-area route-maps, remote access)
- Limited QoS (e.g. many-to-one WRED, aggregate policers)
- Limited NetFlow (e.g. inter-area, aggregate flows)

Tends to require high L3 forwarding scale

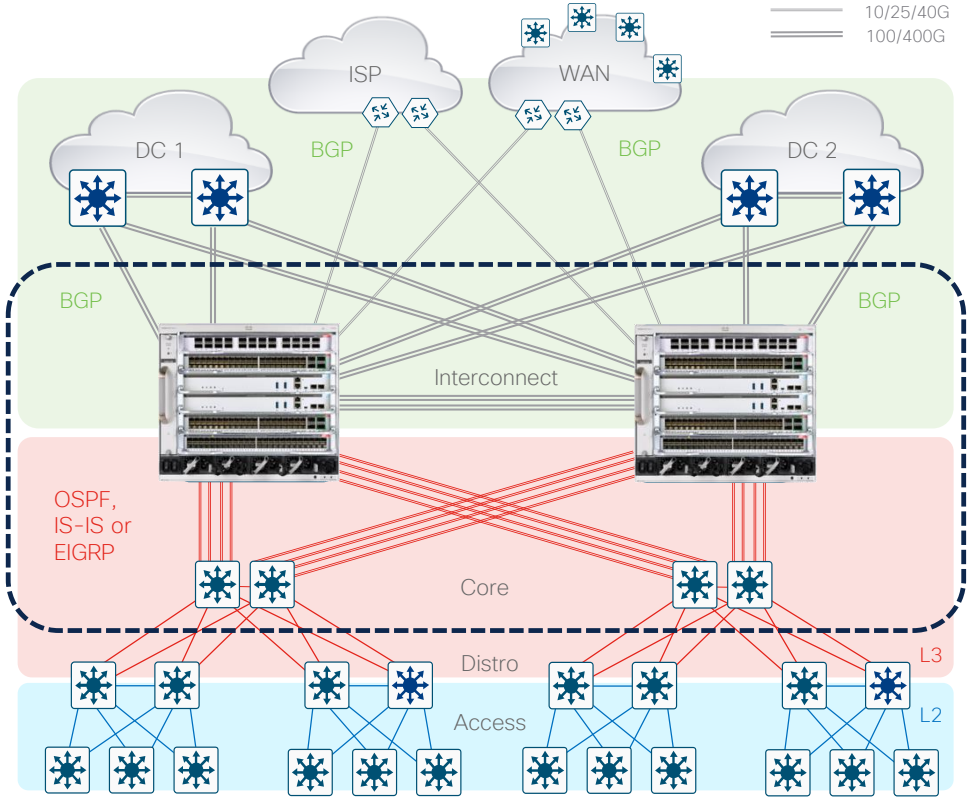


Campus Core Interconnect

The **Interconnect PIN** (Tier 4) is an extension of the Core, used to connect multiple Core layers (areas) and/or other network domains.

- Other names: Backbone, Super Core, MAN, DCI
- Common in Large & Very-Large Campus

- Main goal is to distribute the bandwidth and density requirements of multiple Core layers
  - Similar attributes & requirements as Core PIN
- Tends to be **L3 routed** (north & south)
  - North: BGP or IGP (ABR/ASBR), PIM + MSDP
  - South: OSPF, IS-IS or EIGRP, PIM
- Tends to use minimal L3 features
  - Limited ACLs (e.g. inter-area route-maps, remote access)
  - Limited QoS (e.g. many-to-one WRED, aggregate policers)
  - Limited NetFlow (e.g. inter-area, aggregate flows)
- Tends to require higher L3 scale



Campus Core + Edge (SP/WAN)

The **Core-Edge PIN** (Tier 4) focuses on connecting multiple Campus areas to remote domains (SP/WAN) and/or to the Internet.

- Other names: Edge Device, Internet Edge
- Common in Medium to Very-Large Campus

Main purpose is to collapse Core & Edge layers

Tends to be **L3 routed** (north & south)

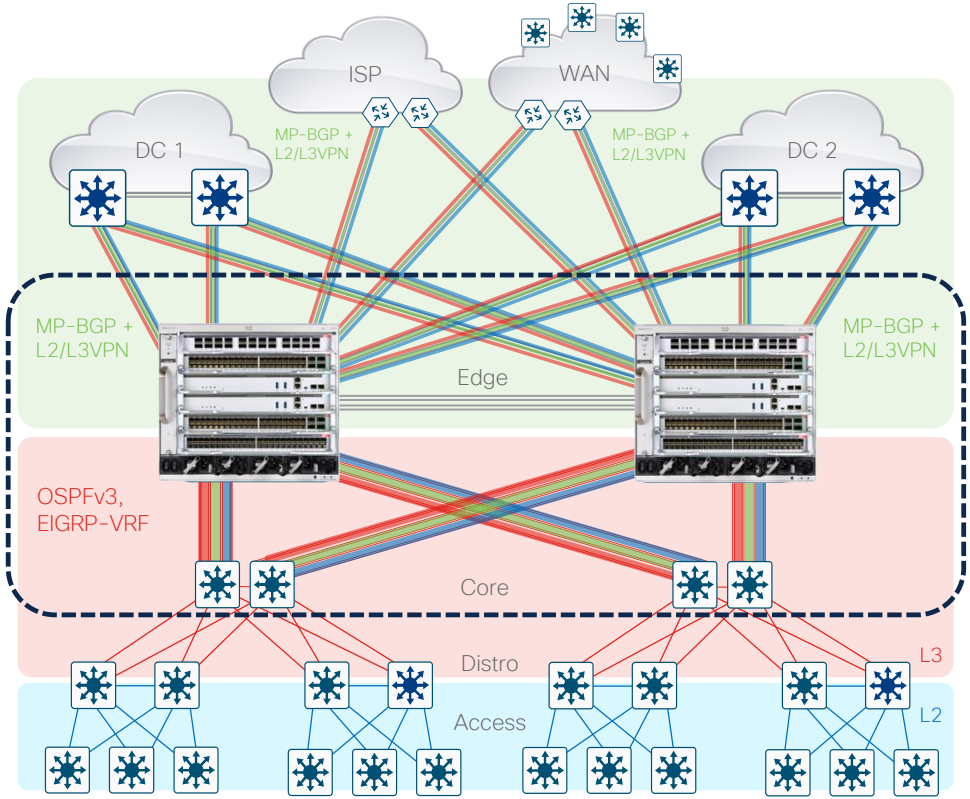
- North: MP-BGP + Inter-AS, NAT/PAT, PIM + MSDP
- South: BGP or IGP (ABR/ASBR), PIM + MSDP

Tends to use **Virtualization** & **Tunnels**

- VRF-Lite, MPLS/VPLS, SR, MVPN
- GRE/MGRE, IPsec, DMVPN
- QinQ, L2oMGRE, OTV, EVPN

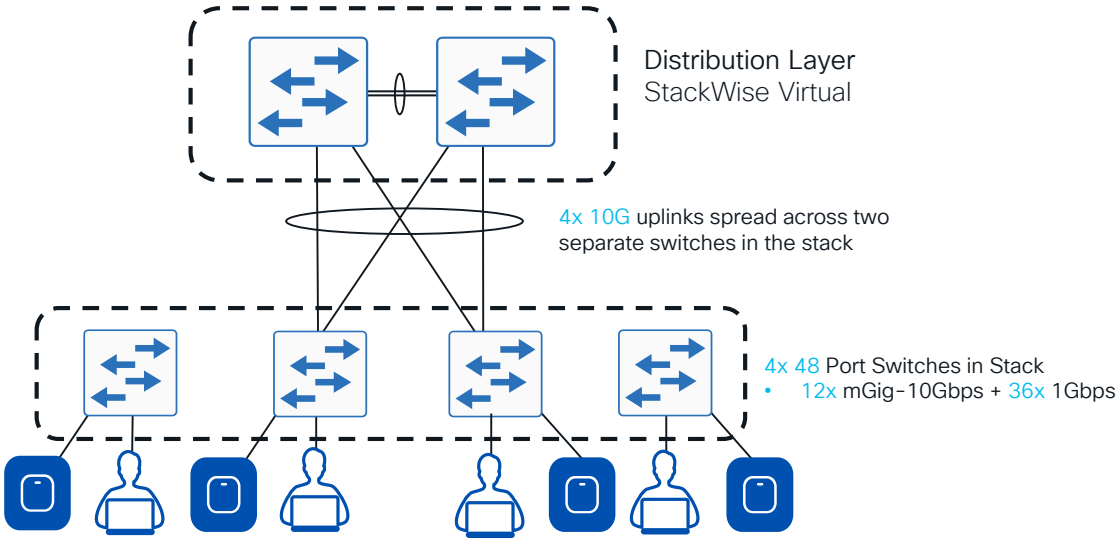
Tends to require highest L3/VRF & feature scale

- Edge Security ACLs (e.g. RACL, CBAC, ZBFW)
- Hierarchical QoS (e.g. Class-based Queuing, Shaping)
- Policy Based Routing (e.g. WAAS & WCCP)
- WAN NetFlow (e.g. L3/VRF FNF, WAN ETA)



Campus Design Fundamentals

Access Layer – Oversubscription Ratios



Soft recommendation for Access to Distribution ≤ 20:1

Access Uplinks: 40 Gbps

Potential Downlinks:

48 x 10 Gbps

\+ 144 x 1 Gbps

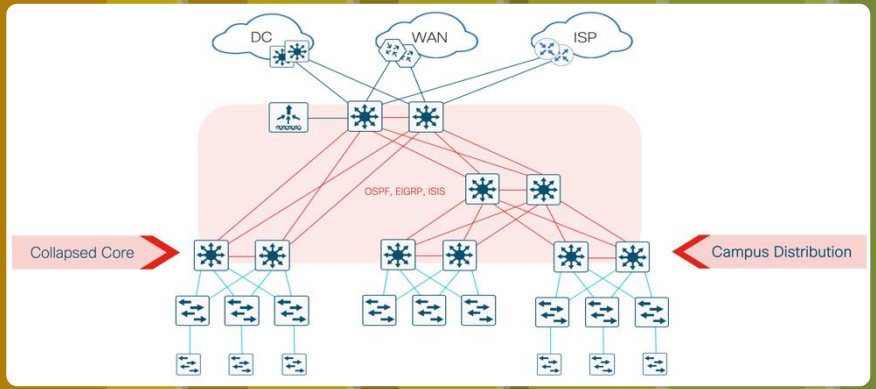
SUM: 624 Gbps

Oversubcription ratio:

~15.6 : 1

Campus PINs

- **Campus Distribution** (Baseline)
- **Collapsed Core +** Distribution
- **Campus Distro +** Extended Access



Campus Distribution (Baseline)

The **Distribution PIN** (Tier 2) focuses on connecting multiple Access layers and the Core layer.

- Other names: Collapsed Core, Aggregation, IDF
- Common in Small to Large Campus

Main purpose is to "distribute" connectivity (fan-out) from the Core/WAN to the Access

- Reduces need for high port-density in Core layer
- Also applicable to L3 Routed Access

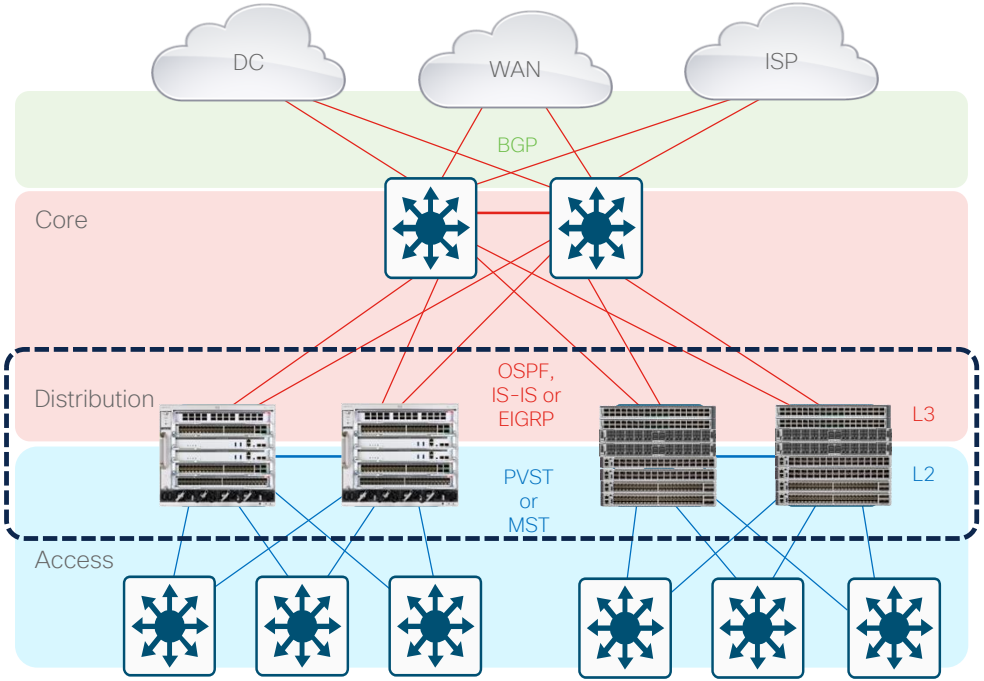
Tends to be both **L3 routed** (north) and **L2 switched** (south)

- North: SVI, HSRP/VRRP, ARP/ND, IGP, PIM
- South: VLAN, 802.1Q, STP, MAC, IGMP

Tends to use multiple L2 & L3 features

- Access Security (e.g. IPDT/SISF, VACLs, PACLs, etc)
- Access QoS (e.g. NBAR, Classification & Marking)
- Access NetFlow (e.g. AVC, FNF, EPA & ETA)

Tends to require med-high L2/L3 & feature scale



Campus Collapsed Core

The **Collapsed Core** (Tier 2) focuses on connecting multiple Access layers and the WAN/Edge layer.

- Other names : Distribution, BDF
- Common in Small Campus or Medium Branch

Main purpose is to collapse Core & Distribution layers

- Mostly for small(er) sites, with low(er) port density
- Similar attributes & requirements as Core + Distribution
- Also applicable to L3 Routed Access

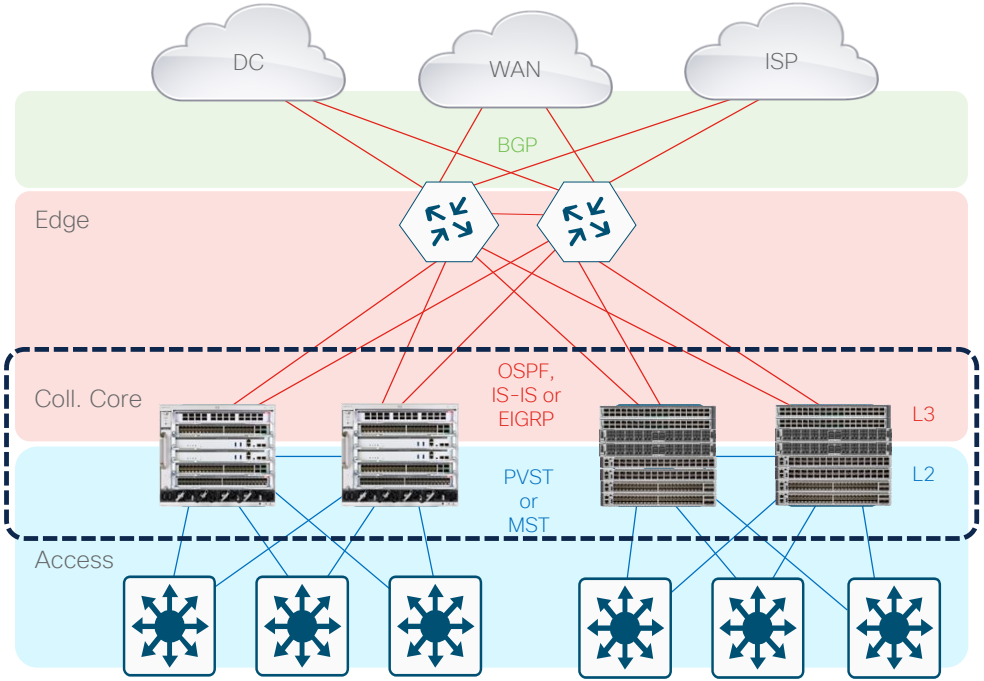
Tends to be **both L3 routed** (north) and **L2 switched** (south)

- North: SVI, HSRP/VRRP, ARP/ND, IGP, PIM
- South: VLAN, 802.1Q, STP, MAC, IGMP

Tends to use multiple L2 & L3 features

- Access Security (e.g. IPDT/SISF, VACLs, PACLs, etc)
- Access QoS (e.g. NBAR, Classification & Marking)
- Access NetFlow (e.g. AVC, FNF, EPA & ETA)

Tends to require high L2/L3 & feature scale



Campus Distro + Ext. Access

The **Distribution + Ext. Access PIN** (Tier 2+) focuses on connecting multiple Access layers, including an Extended Access (IOT/FTTX) layer, to the Core layer.

- Other names: Distribution, BDF
- Common in Very-Large Campus or Large Branch

Main purpose is to "distribute" connectivity (fan-out) from the Core/WAN to the Access + Ext. Access

- Reduces need for high port-density in Core layer

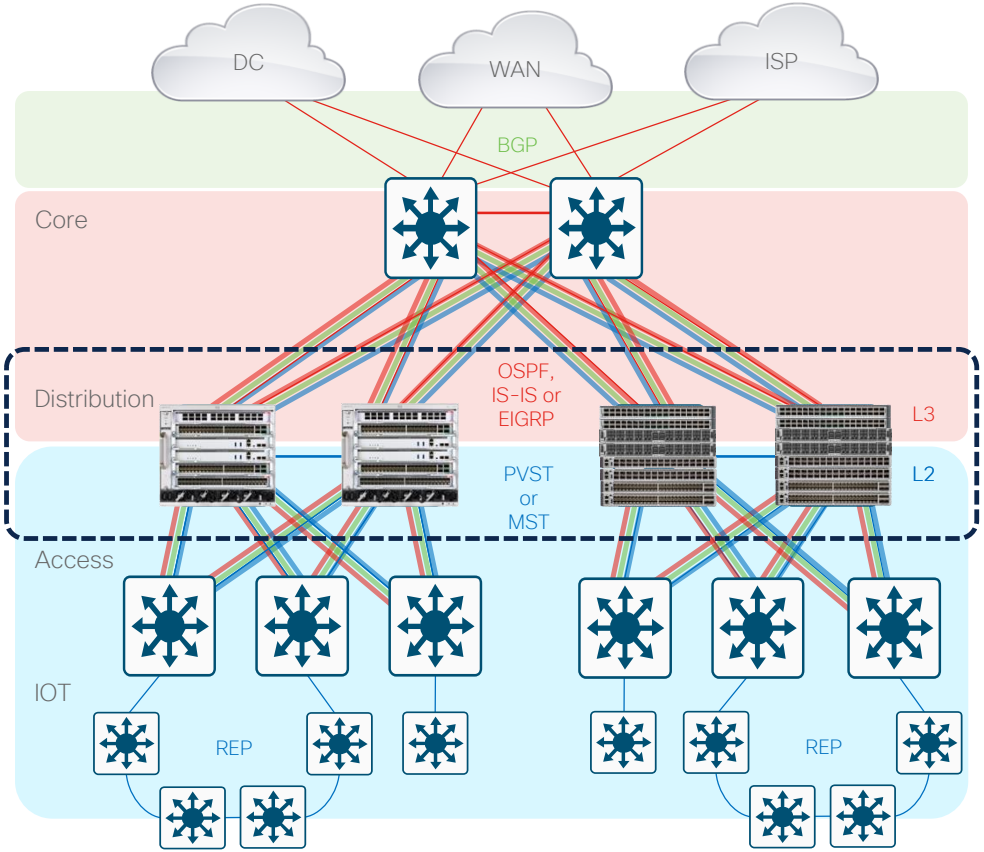
Tends to be both **L3 routed** (north) and **L2 switched** (south)

- North: VRF, SVI, HSRP/VRRP, ARP/ND, IGP, PIM
- South: VLAN, 802.1Q, STP, MAC, IGMP

Tends to use multiple L2 & L3 features

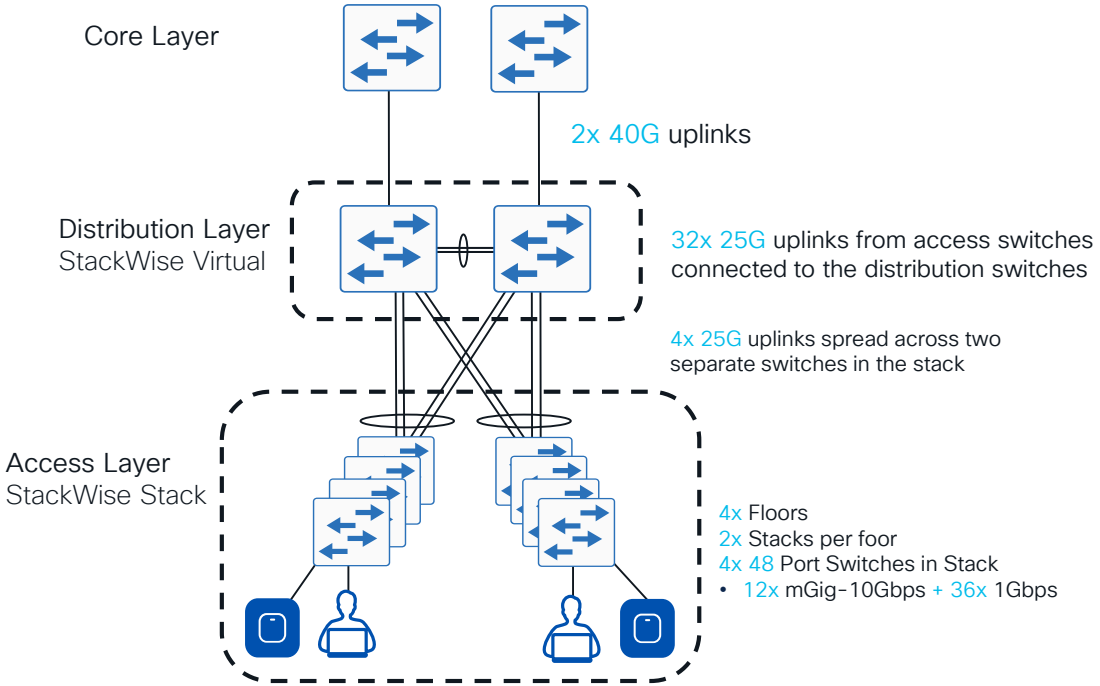
- Access Security (e.g. IPDT/SISF, VACLs, PACLs, etc)
- Access QoS (e.g. NBAR, Classification & Marking)
- Access NetFlow (e.g. AVC, FNF, EPA & ETA)

Tends to require highest L2/L3 & feature scale



Design Fundamentals

Distribution Layer – Oversubscription Ratios



Soft recommendation for Distribution to Core ≤ 4:1

Distribution Uplinks: 80 Gbps

From Access Layer:

4 x 2 x 4 x 25 Gbps

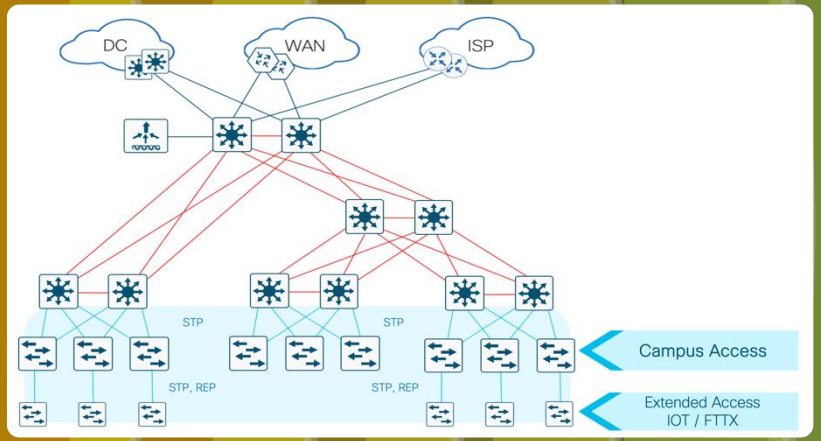
SUM: 800 Gbps

Oversubcription ratio:

10 : 1

Campus PINs

- **Campus Access** (Baseline)
- **Routed Access**
- **Extended Access +** IOT / FTTX



Campus Access (Baseline)

The **Access PIN** (Tier 1) focuses on connecting Users & Devices, or an Extended Access (if applicable), to the Distribution layer

- Other names: IDF, Wiring Closet
- Common in all Campus & Branch networks

Main purpose is to connect users to network

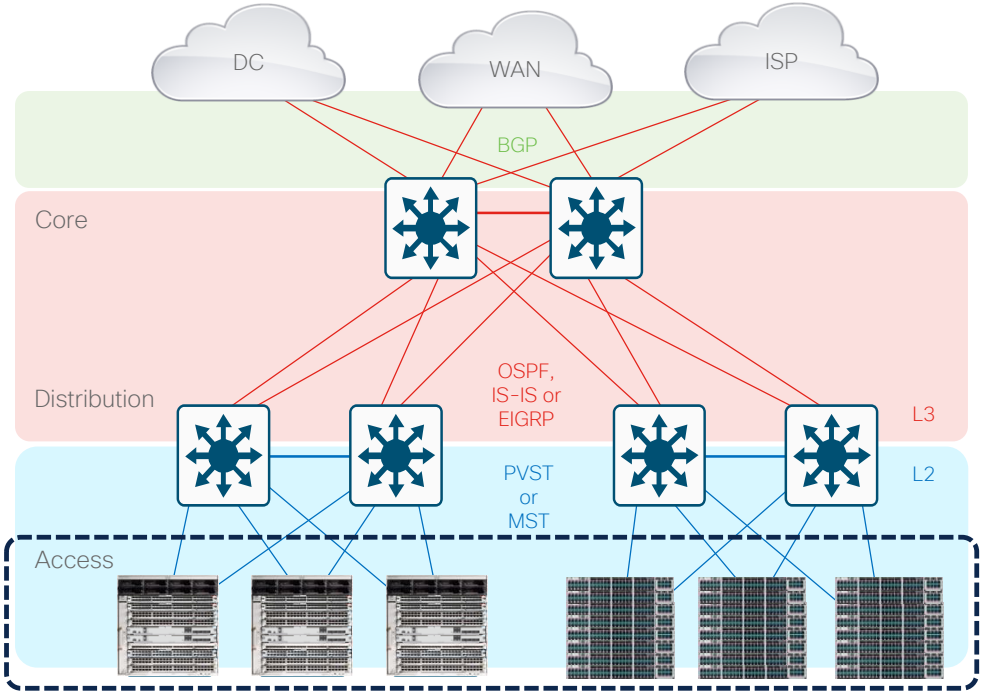
Tends to be **L2 switched** (north & south)

- North: VLAN, 802.1Q, STP, MAC, IGMP Snooping
- South: AAA, STP, Portfast, Storm-Control

Tends to use multiple L2 features & services

- Access Security (e.g. 802.1x, VACLs, PACLs, etc)
- Access QoS (e.g. L2 CoS, Classification & Marking)
- Access NetFlow (e.g. AVC, FNF, EPA & ETA)

Tends to require low-med L2 & feature scale



Routed Access

The **Routed Access PIN** (Tier 1) has the same purpose, but uses L3 IP routing to limit L2 scale

- Other names: IDF, Wiring Closet
- Semi-common in Campus & Branch networks

Main purpose is to connect users to network using L3 protocols to reduce L2 challenges.

- Mostly for network stability and simplicity of protocols
- Similar attributes & requirements as Distribution

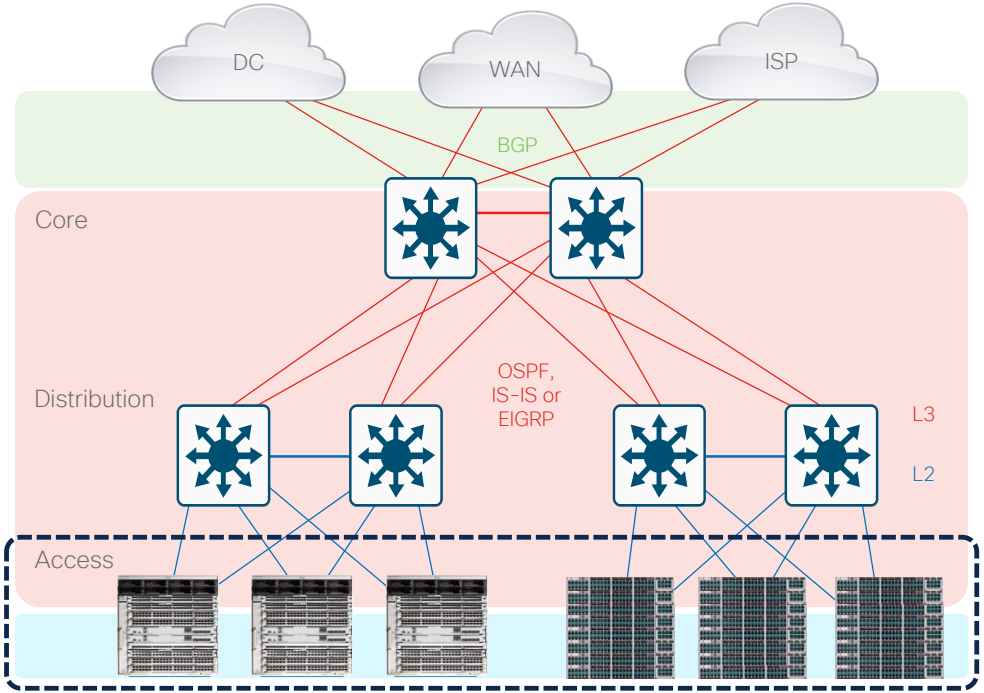
Tends to be both **L3 routed** (north) and **L2 switched** (south)

- North: SVI, HSRP/VRRP, ARP/ND, IGP, PIM
- South: VLAN, AAA, MAC, IGMP, STP Portfast

Tends to use multiple L2 & L3 features

- Access Security (e.g. IPDT/SISF, VACLs, PACLs, etc)
- Access QoS (e.g. NBAR, Classification & Marking)
- Access NetFlow (e.g. AVC, FNF, EPA & ETA)

Tends to require low-med L2 & L3 feature scale



Extended Access (IOT / FTTX)

The **Extended Access PIN** (Tier 1) is an extension of the Access, to connect multiple Access layers (areas) to the Distribution layer

- Other names: High-End Access, IOT, FTTX
- Common in Very-Large Campus or Large Branch

Main goal is to extend the size and scale of the Access layer and connect more hosts

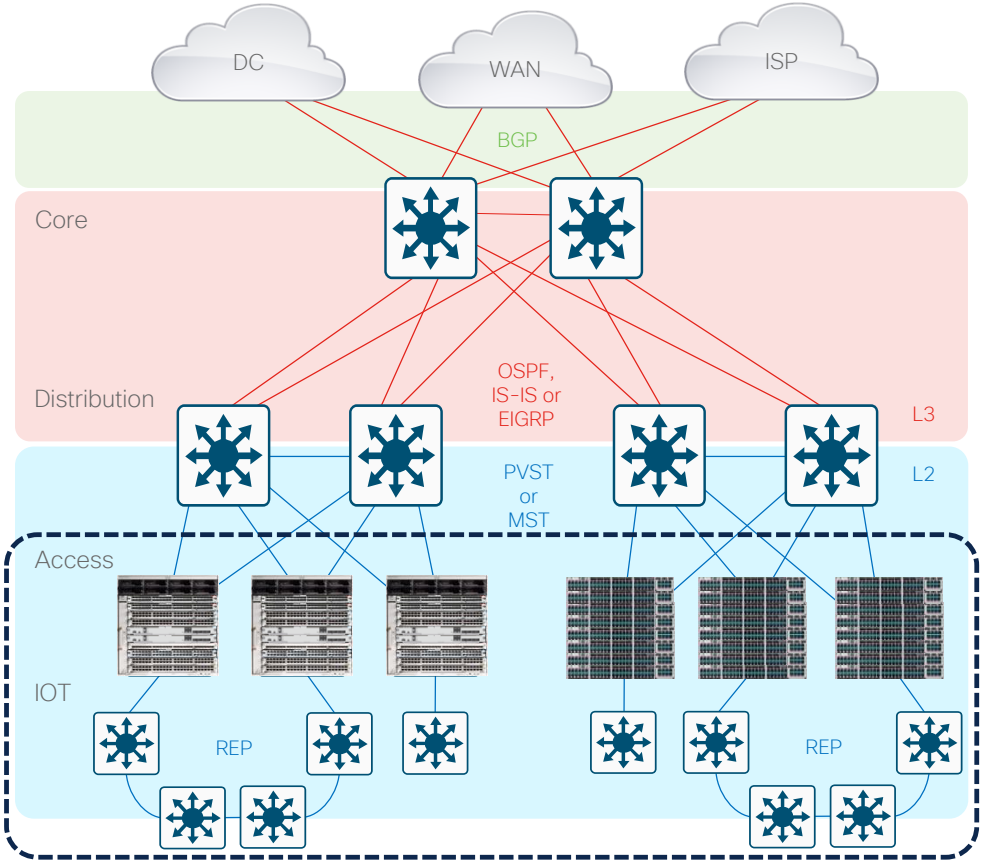
Tends to be **L2 switched** (north & south)

- North: VLAN, 802.1Q, STP/REP, MAC, IGMP Snooping
- South: AAA, STP/REP, Portfast, Storm-Control

Tends to use multiple L2 features & services

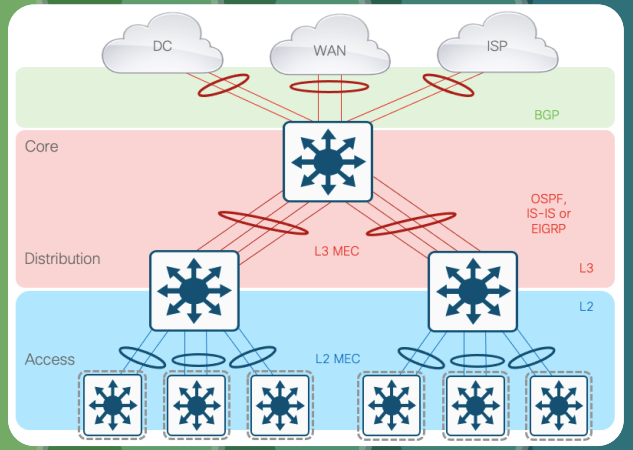
- Access Security (e.g. 802.1x, VACLs, PACLs, etc)
- Access QoS (e.g. L2 CoS, Classification & Marking)
- Access NetFlow (e.g. AVC, FNF, EPA & ETA)

Tends to require med-high L2 & feature scale



Campus Architecture

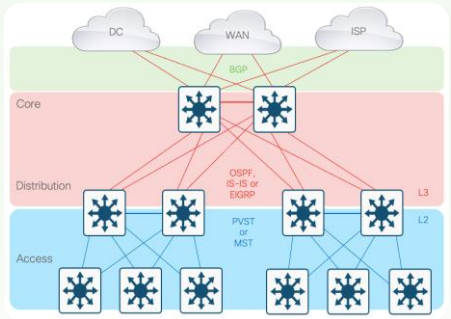
- **Equal Cost Multi-Path** (Traditional)
- **StackWise** (Access Stacking)
- **StackWise Virtual** (Core/Distro Stacking)



Campus Architectures

Control-Plane & Data-Plane Redundancy

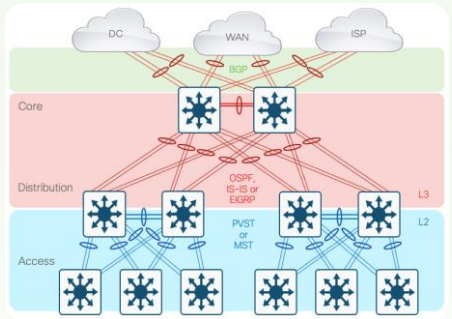
1 ECMP (L2/L3 Paths)



- Complex Topology
- More Nodes, Less Cables
- More Neighbors (+ Tuning)
- Protocol Load-Balancing (ECMP)
- Node-level Redundancy

L1 : Single Connections
L2: STP, MST, REP + ECMP (Port Cost)
L3: FHRP, IGP, BGP + ECMP(Port Cost)
More Neighbors = Requires Protocol Tuning

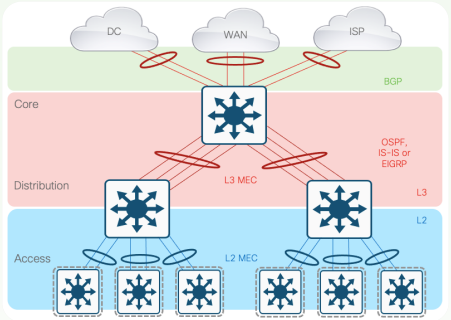
2 EtherChannel (L2/L3 LAG)



- Complex Topology
- Same Nodes, More Cables (2-8)
- Same Neighbors (+ Tuning)
- EtherChannel Load-Balancing
- Node & Link-level Redundancy

L1 : Multiple Connections
L2: STP, MST, REP + ECMP (Portchannel Cost)
L3: FHRP, IGP, BGP + ECMP (Portchannel Cost)
More Neighbors = Requires Protocol Tuning

3 StackWise (L2/L3 MEC)



- Simple Topology
- Same Cables, Less Nodes
- Less Neighbors (No Tuning)
- Multi-chassis EtherChannel (MEC)
- Layer-level Redundancy

L1 : Multiple Connections
L2: L2 MEC (No STP or REP)
L3: IGP, BGP + L3 MEC (No FHRP)
Fewer Neighbors = No Protocol Tuning

Campus + EtherChannel

Using **EtherChannel** focuses on combining multiple physical links into a single logical link

- Other names: Portchannel, Link-Aggregation (LAG)
- Common in Medium & Large Campus

Main goal is to increase bandwidth, and provide link-level redundancy between network layers

- Mostly for large(r) sites, with high(er) port density
- Similar attributes & requirements as existing PIN(s)

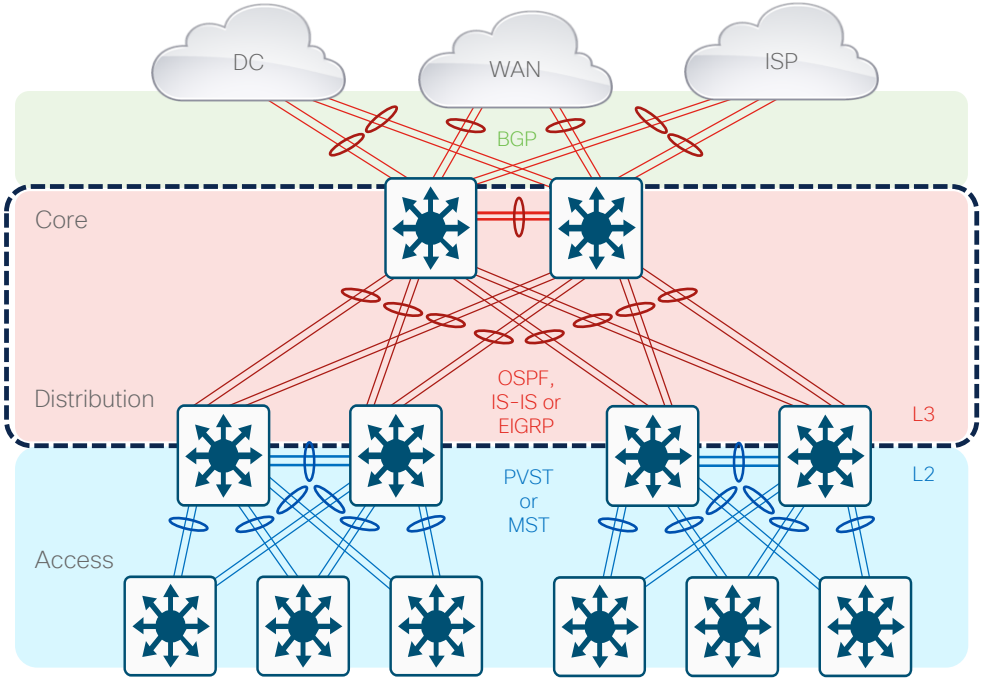
Can be used for both L2 & L3 links (north & south)

- North: BGP or IGP, PIM
- South: STP or REP, IGMP/MLD

Tends to require special L2/L3 features

- Portchannel ACLs (e.g. L2/L3 RACL)
- Portchannel QoS (e.g. L2/L3 aggregate policers)
- Portchannel NetFlow (e.g. L2/L3 FNF)

Tends to require less L2/L3 forwarding scale



StackWise Virtual Core/Distro

The **StackWise Virtual (SVL)** Core PIN focuses on combining Core and/or Distribution into a single virtual switch to connect to outside areas.

- Typically, the same layer as Distribution or Core (Tier 2-3)
- The same 'physical' topology as a multi-layer network

Main goal is to simplify and expand the Distribution and/or Core layer

Same L2/L3 protocols & features as Distro/Core

- North: SVI, ARP/ND, IGP/BGP, PIM
- South: VLAN, 802.1Q, MAC, IGMP (No STP)

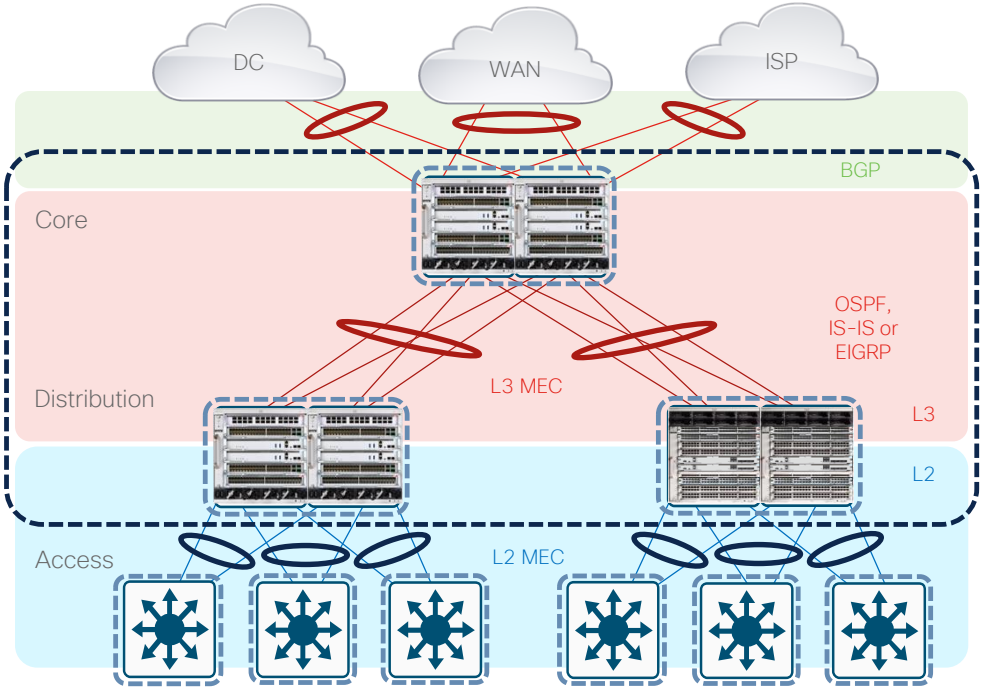
Leverages Stateful Switchover (SSO)

- Active/Standby Control-Plane (synchronized)
- Works with NSF/NSR for L3 protocols

Leverages Multi-chassis EtherChannel (MEC)

- Active/Active Data-Plane (both switches forwarding)
- L2 & L3 Portchannel (neighbor sees single neighbor)

Tends to require med-high L2, L3 & feature scale



StackWise Access

The **StackWise** Access PIN focuses on combining multiple Access switches into a single virtual switch to increase access-layer port density.

- Typically, the same layer as Access (Tier 1)
- The same 'physical' topology as a multi-layer network

Main goal is to expand port density of Access layer

Same L2 protocols & features as Access

- North: VLAN, 802.1Q, STP, MAC, IGMP Snooping
- South: AAA, STP, Portfast, Storm-Control

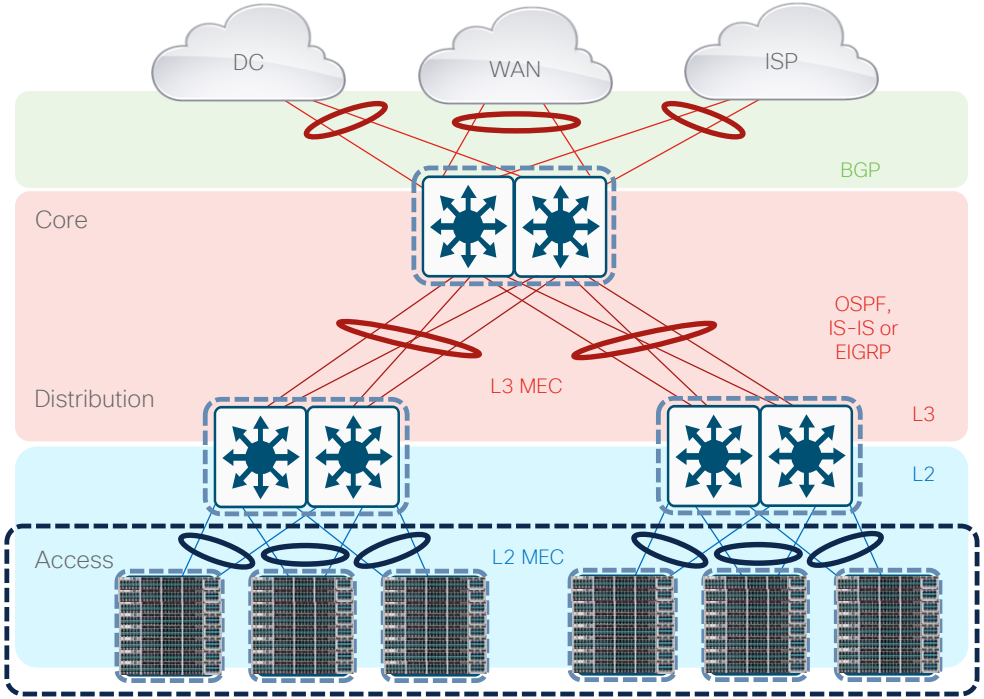
Leverages Stateful Switchover (SSO)

- Active/Standby Control-Plane (synchronized)
- Works with NSF/NSR for L3 protocols

Leverages Multi-chassis EtherChannel (MEC)

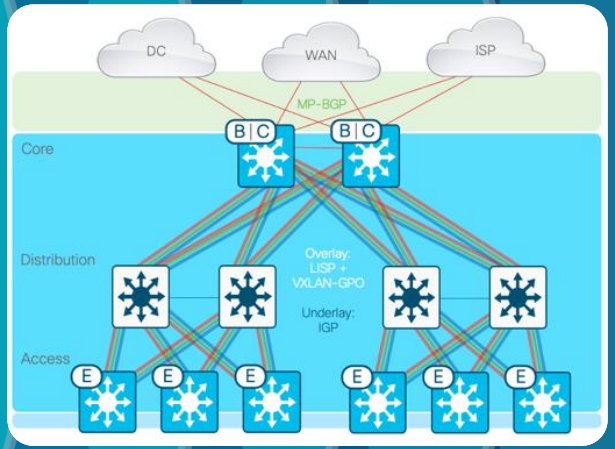
- Active/Active Data-Plane (both switches forwarding)
- L2 Portchannel (neighbor sees single neighbor)

Tends to require med-high L2 + feature scale



Campus Solutions

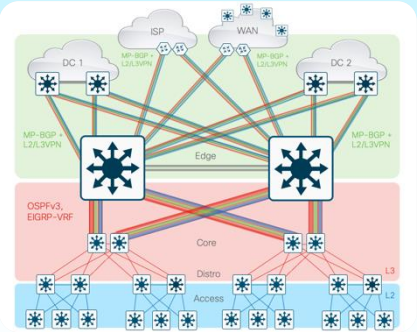
- **MPLS / VPLS**
  (L2/L3VPN)
- **EVPN + VXLAN**
  (L2/L3VNI)
- **LISP + VXLAN**
  (L2/L3VNI)



Campus Solutions & Designs

Providing additional services (beyond basic PINs)

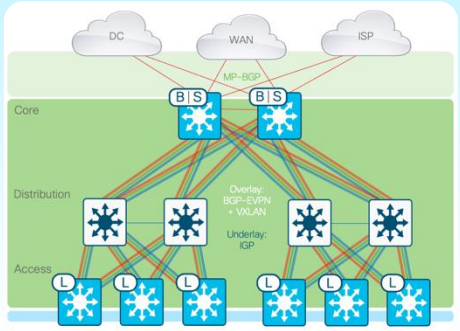
1 MPLS (L2/L3VPN)



- L3 Underlay + L2/L3 VPN Overlay
- Virtual Private Networks
- L3 VRF-based Segmentation
- WAN/Edge + VPN Services

MPLS/VPLS, **LDP**, SR, MP-BGP, PIC
MVPN, LSM, Extranet, MSR
SSO, NSF/NSR, ECMP, GIR
VPN-FNF, Uniform/Pipe QoS, PBR, IPACL

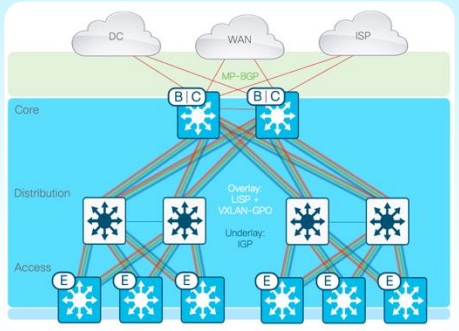
2 EVPN (L2/L3VNI)



- L3 Underlay + L2/L3 VNI Overlay
- Virtual Network Instances
- L2/L3 VNI-based Segments
- Common WAN/LAN Services

MP-BGP/EVPN, **VXLAN**, VRF-Lite
L2 TRM, L3 TRM, L2 BUM
SSO, NSF/NSR, ECMP, GIR
Fabric-FNF, Uniform QoS, IPACL/OGACL

3 SDA (L2/L3VNI + SGT)



- L3 Underlay + L2/L3 VNI Overlay
- VNIs + Scalable Group Tagging
- L2/L3 VNI + SGT Segments
- LAN Services + Group-Based Policy

LISP, **VXLAN**, MP-BGP, VRF-Lite
LISP HER, Native, L2 BUM
SSO, NSF/NSR, ECMP, GIR
Fabric-FNF, App QoS, SGACL

MPLS-VPN Provider Edge

The **Provider-Edge PIN** (Tier 3-4) focuses on connecting multiple Campus areas to remote domains (SP/WAN) using MPLS-VPN.

Main goal is to connect EVPN fabric to other networks

Uses a **L3 Underlay + L3 Hand-off**

- North (outside): L3 MP-BGP + Inter-AS, PIM + MSDP
- South (inside): L3 IGP, PIM + MSDP

Uses a **Virtualized L2/L3 Overlay**

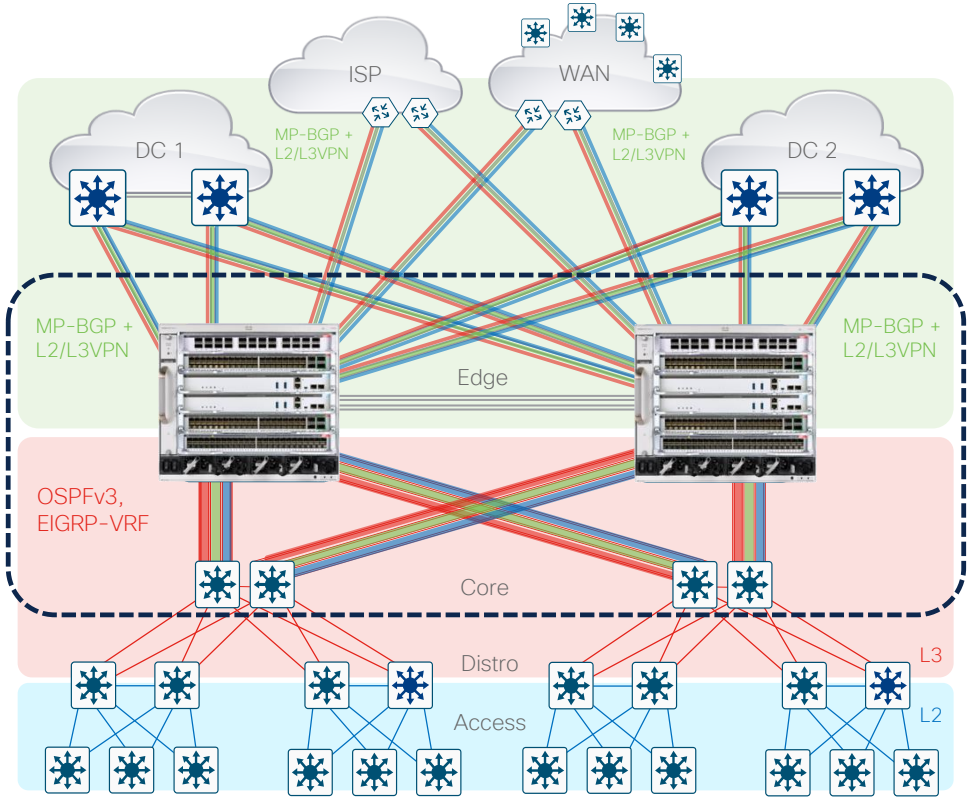
- Control-Plane: MPLS, EoMPLS/VPLS, MVPN
- Data-Plane: LDP, mLDP
- Policy-Plane: VPN ID

Tends to use Overlay-aware Features

- IP or OG ACLs (e.g. destined Outside)
- Uniform/Pipe QoS (e.g. separate Inner vs. Outer)
- Inter-VRF Routing (e.g. VRF-Lite, Leaking)
- MPLS-aware NetFlow (e.g. VPN ID in FNF)

May require multiple encapsulation(s)

Tends to require high L2/L3 & feature scale



EVPN Border & Spine

The **EVPN Border & Spine** PIN focuses on connecting an EVPN Fabric and/or other network domains.

- Typically, the same layer as Core or Edge (Tier 3-4)

Main goal is to connect EVPN fabric to other networks

Uses a **L3 Underlay + L3 Hand-off**

- North (outside): L3 MP-BGP + Inter-AS, PIM + MSDP
- South (inside): L3 IGP, PIM + MSDP

Uses a **Virtualized L2/L3 Overlay**

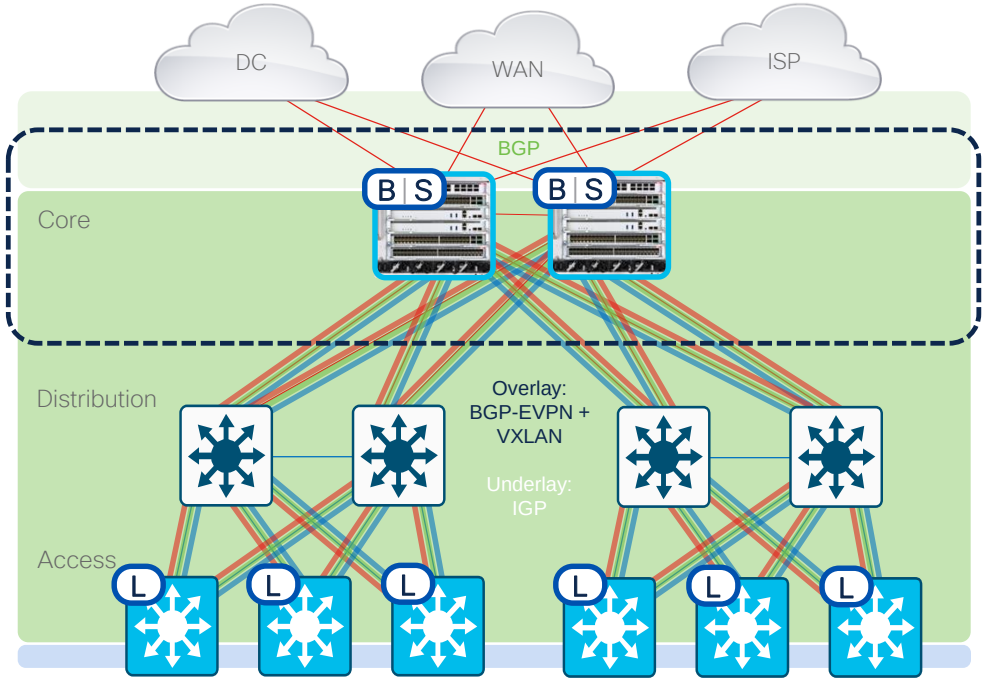
- Control-Plane: BGP-EVPN (RR), TRM
- Data-Plane: VXLAN
- Policy-Plane: L2/L3 VNID

Tends to use Overlay-aware Features

- IP/OG ACLs (e.g. destined Outside)
- Uniform QoS (e.g. copy Inner, queue Outer)
- Inter-VRF Routing (e.g. VRF-Lite, Leaking)
- Fabric NetFlow (e.g. VRF/VNID in FNF)

May require multiple encapsulation(s)

Tends to require high L2/L3 & feature scale



EVPN Leaf

The **EVPN Leaf** PIN focuses on connecting Wired endpoints to an EVPN Fabric domain.

- Typically, the same layer as Access or Extended (Tier 1)

Main goal is to connect Endpoints to EVPN network

Uses a **L3 Underlay + L2 Hand-off**

- North (inside): L3 IGP, PIM + MSDP
- South (outside): L2 VLAN (L3 SVI), STP, IGMP

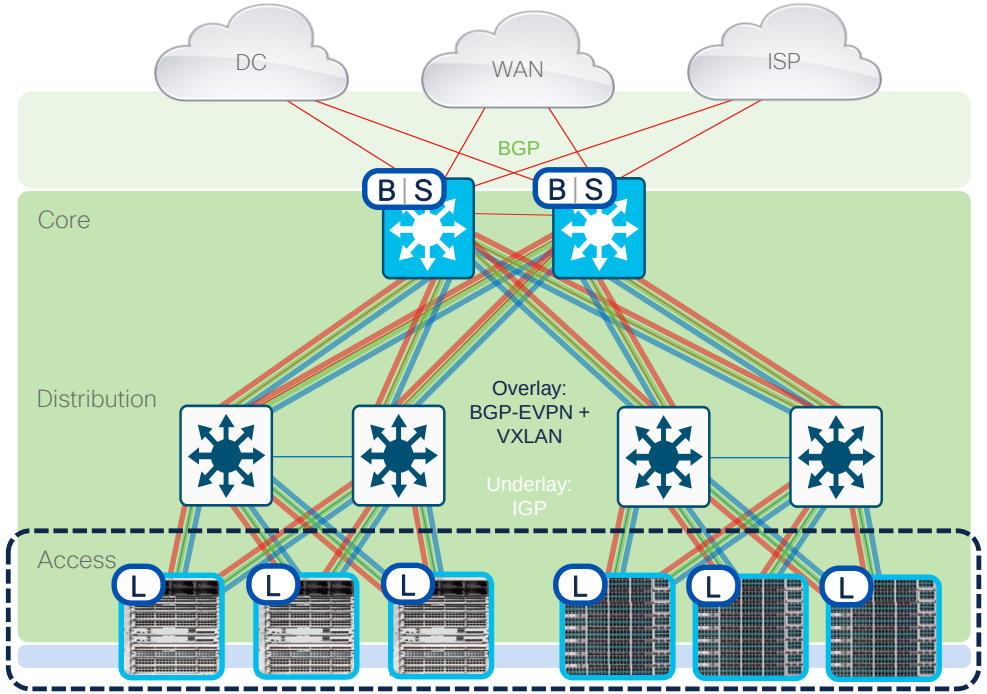
Uses a **Virtualized L2/L3 Overlay**

- Control-Plane: BGP-EVPN, TRM
- Data-Plane: VXLAN
- Policy-Plane: L2/L3 VNI

Tends to use Overlay-aware features

- IP/OG ACLs (e.g. destined outside)
- Uniform QoS (e.g. copy inner, queue outer)
- Inter-VRF Routing (e.g. VRF Leaking)
- Fabric NetFlow (e.g. FNF + VNID)

Tends to require med-high L2/L3 & feature scale



SD-Access Border & CP

The **SDA Border & CP PIN** focuses on connecting an SDA Fabric and/or other network domains.

- Typically, the same layer as Core or Core/Edge (Tier 3-4)

Main goal is to connect SDA fabric to other networks

Uses a **L3 Underlay + L3 Hand-off**

- North (outside): L3 MP-BGP + Inter-AS, PIM + MSDP
- South (inside): L3 IGP, PIM + MSDP

Uses a **Virtualized L2/L3 Overlay**

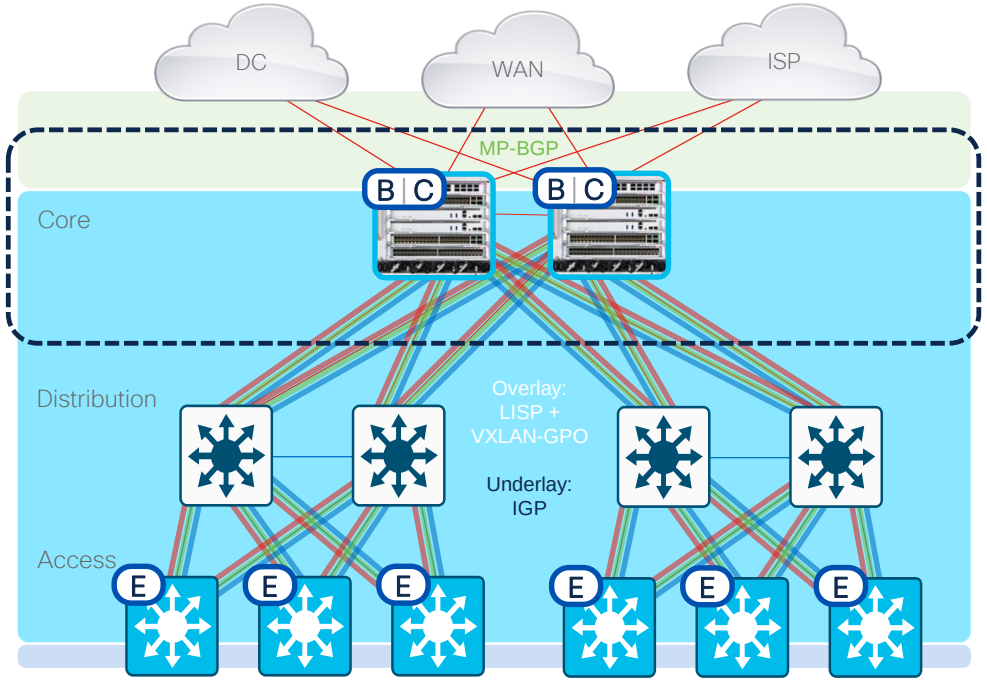
- Control-Plane: LISP (XTR, MS/MR), PIM
- Data-Plane: VXLAN-GPO
- Policy-Plane: L2/L3 VNI + SGT

Tends to use Overlay-aware features

- Security Group ACLs (e.g. destined outside)
- Uniform Pipe QoS (e.g. copy inner, queue outer)
- Inter-VRF Routing (e.g. VN Extranet, or VRF-Lite)
- Fabric NetFlow (e.g. VRF/VNID + SGT FNF, NaaS/ETA)

May require multiple encapsulation(s)

Tends to require higher L3 & feature scale



SD-Access Edge

The **SDA Edge** PIN focuses on connecting Wired/Wireless endpoints to an SDA Fabric domain.

- Typically, the same layer as Access or Extended (Tier 1)

Main goal is to connect Endpoints to SDA network

Uses a **L3 Underlay + L2 Hand-off**

- North (inside): L3 IGP, PIM + MSDP
- South (outside): L2 VLAN (L3 SVI), STP, IGMP

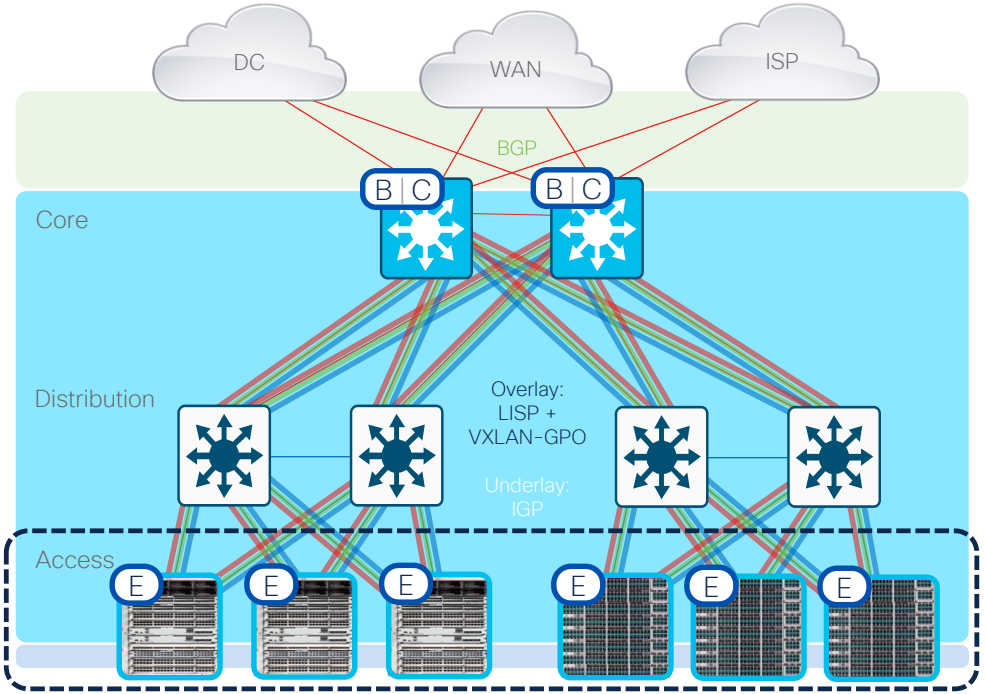
Uses a **Virtualized L2/L3 Overlay**

- Control-Plane: LISP (XTR), PIM
- Data-Plane: VXLAN-GPO
- Policy-Plane: VN + SGT

Tends to use Overlay-aware features

- Security Group ACLs (e.g. destined outside)
- Uniform Pipe QoS (e.g. copy inner, queue outer)
- Inter-VRF Routing (e.g. VN Extranet)
- Fabric NetFlow (e.g. FNF, NaaS)

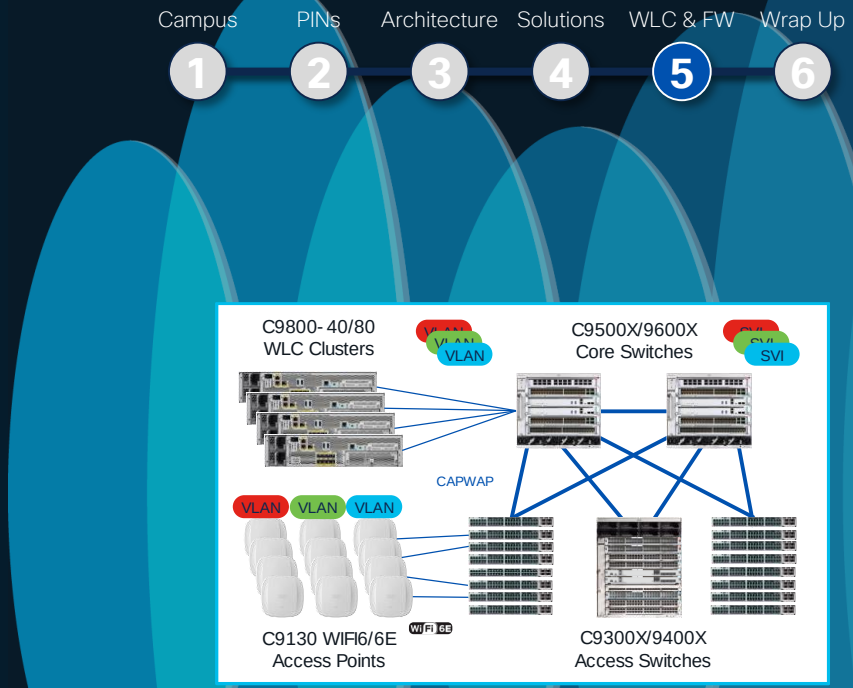
Tends to require higher L3 & feature scale



Campus Networks

Wireless & Firewall

- **Central Wireless**
- **Firewalls, VRFs & ACLs**



Wireless LAN

The **Central Wireless** PIN focuses on connecting Wireless APs centrally to one or multiple WLCs.

- WLC is typically connected to Core, Edge or DC (Tier 3+)
- APs are typically connected to Access (Tier 1)

Main goal is to connect Wireless Endpoints (via APs) to a Wireless LAN (WLAN) – centrally in the network

Uses a **L2/L3 Underlay + L2 Hand-off**

- North (to WLC): L2 VLAN + 802.1Q, L3 SVI, IGP
- South (to AP): L2 VLAN + 802.1Q, STP, IGMP

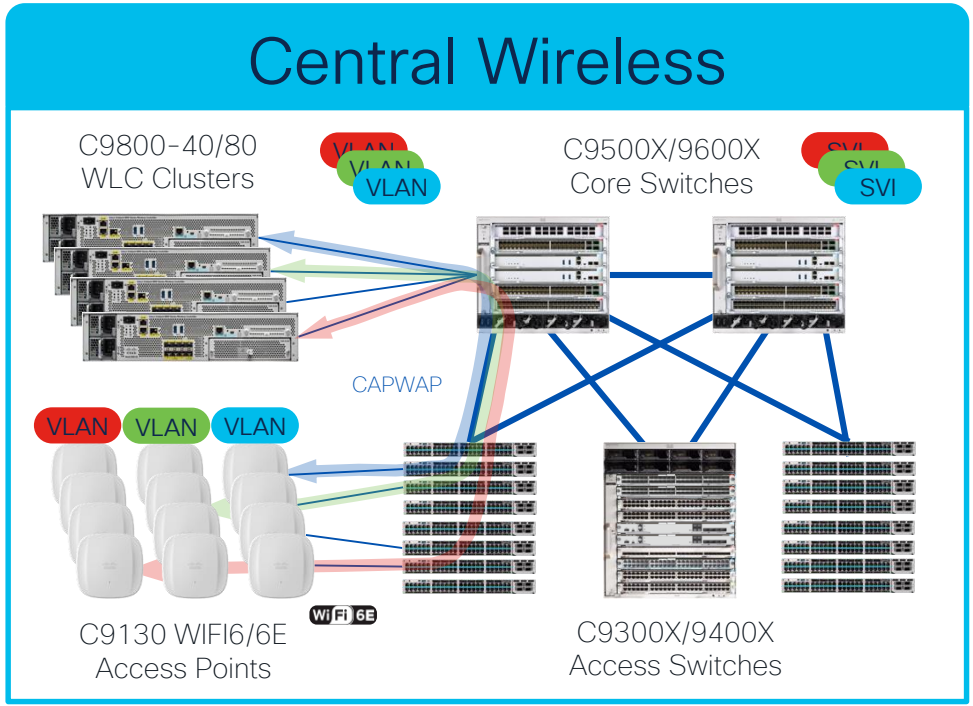
Uses a Tunneled L2 Overlay

- Control-Plane: CAPWAP, DTLS, LWAPP
- Data-Plane: CAPWAP, DTLS

Tends to require L2 (WLAN) features

- L2 ACLs (e.g. VACL, MAC ACL)
- L2 QoS (e.g. VLAN QoS)
- L2 NetFlow (e.g. FNF, AVC, EPA & ETA)

Tends to require higher L2/L3 + feature scale



Firewalls, VRFs & ACLs

The **Firewall (DMZ) PIN** focuses on controlling access into or out of different network areas.

- Typically connected to Core, Edge or DC (Tier 3+)
- Complex designs may use Distro or Access (Tier 1-2)

Main goal is to prevent unauthorized access to different network domains (segments).

- Evolved from "Edge" Access-Control Lists (ACLs)
- Can be either L2, L3 or VRF-aware
- Tends to focus on L4-L7 flows (with or w/o DPI)

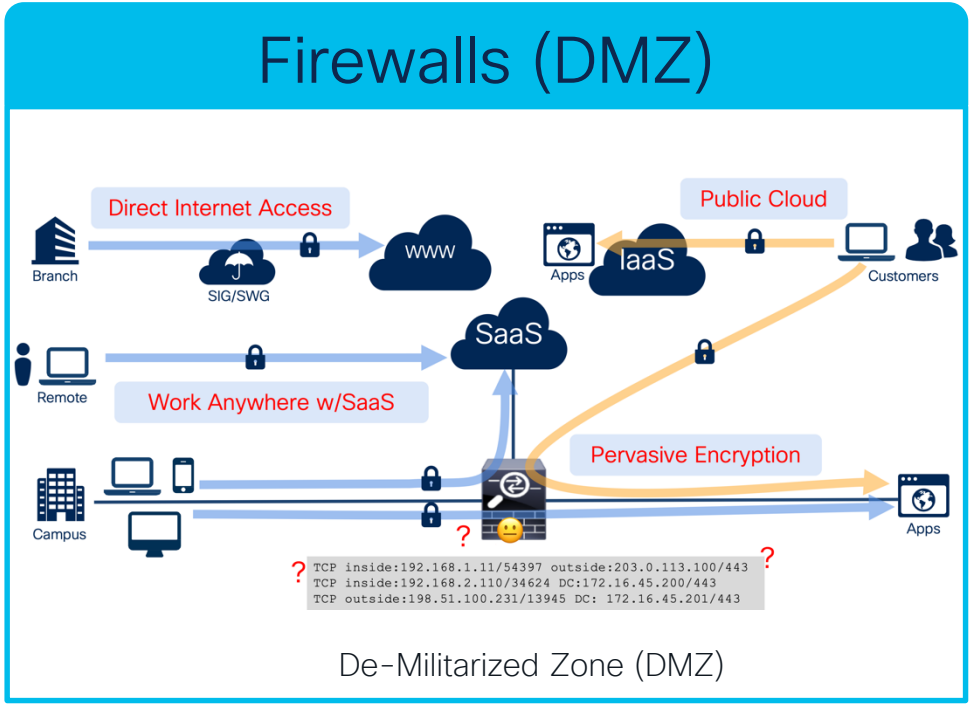
Uses a **L2 or L3/VRF + ACLs**

- North (outside): L2 802.1Q, L3 (SVI, Sub-Ints), IGP, BGP
- South (inside): L2 802.1Q, L3 (SVI, Sub-Ints), IGP, BGP

Tends to use L2 & L3/VRF + DPI & ACL features

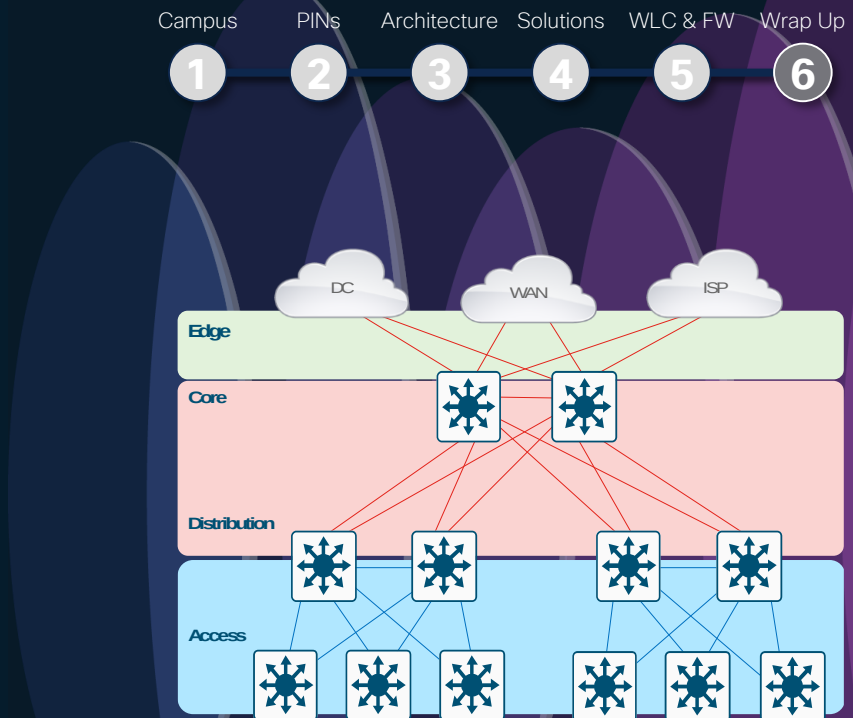
- L4/App ACLs (e.g. VACL, MAC ACL)
- L4/App QoS (e.g. VLAN QoS)
- L4/App NetFlow (e.g. FNF, AVC, EPA & ETA)

Tends to require med-high L2/L3 & feature scale



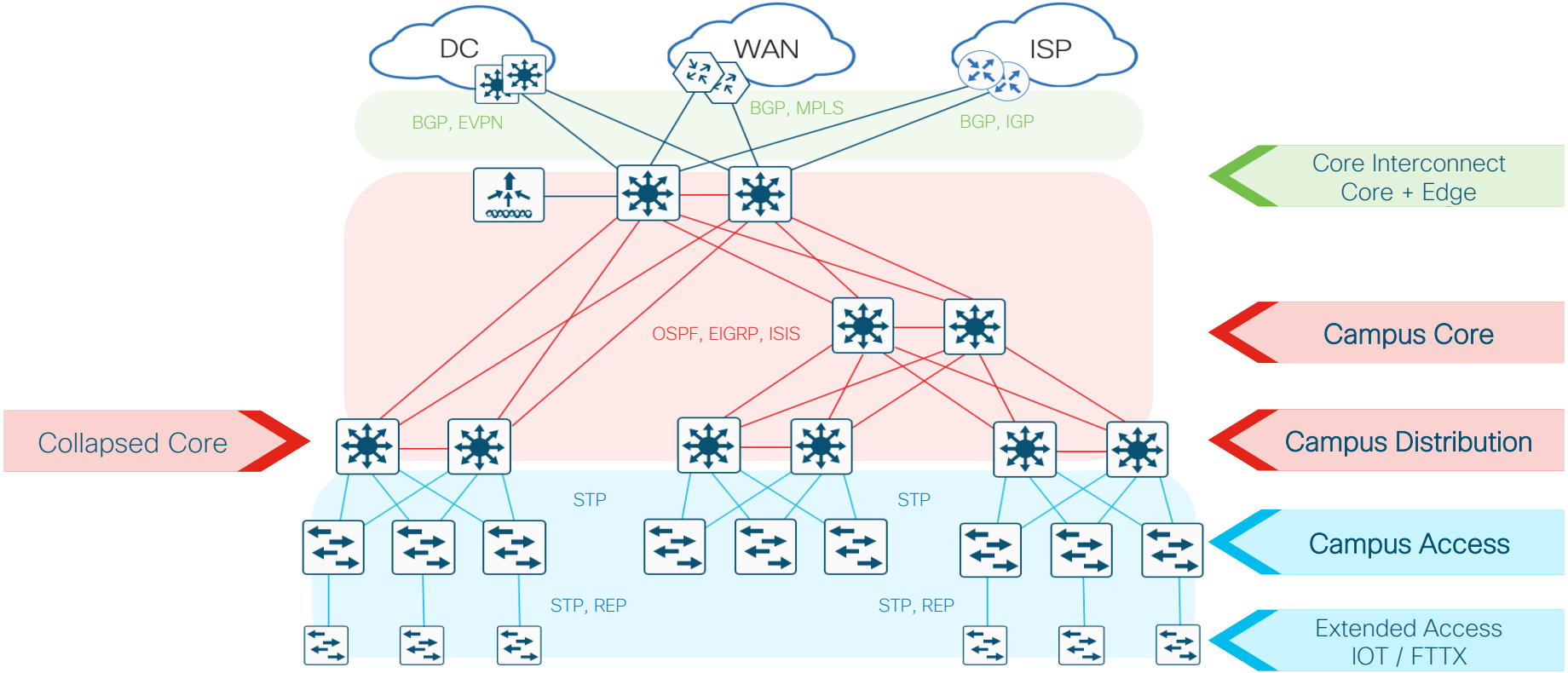
Wrap Up

- Know the Campus PINs
- Other References
- Keep Learning!! ☺



Remember: Campus PINs & Topology

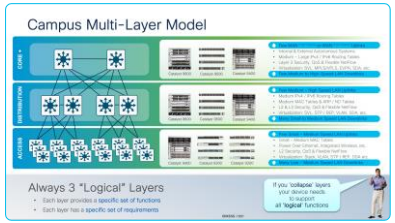
RECAP



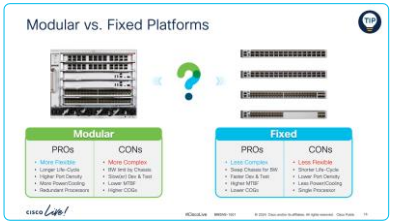
Remember: Campus Design Fundamentals

RECAP

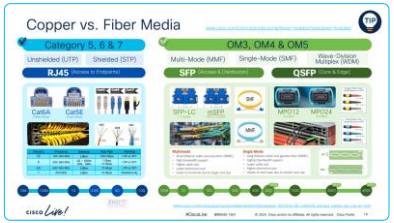
Collapse or Expand Layers?



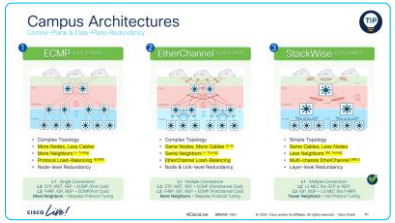
Modular or Fixed Platforms?



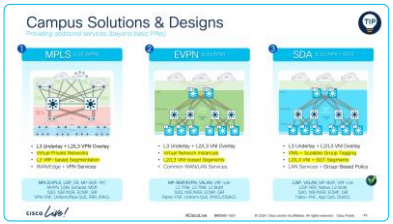
Fiber or Copper Links?



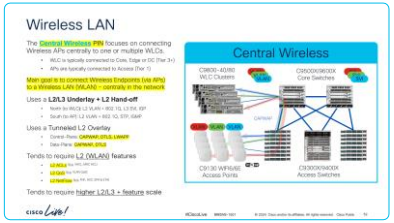
ECMP, EtherChannel or Stacking?



L2/L3 or MPLS or VXLAN?



Wireless or Security Included?



New Feature
Enhanced

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A Platform based Approach

Catalyst Center and Meraki Dashboard

28M Network Devices Managed

50% Y/Y

19M APs | 6M Switches | 2.5M Routers | 830M Clients

13M
Devices on Catalyst Center

15.3M
Devices on Meraki Dashboard

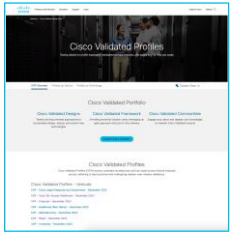
Catalyst 9000 Family

100,000+ Customers, Millions of Switches

"Catalyst 9K continues to be the fastest ramping product in the company's history"

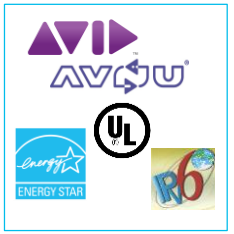
- Chuck Robbins, CEO Cisco Systems

Secure Networking	Digital Experience	Operational Simplicity
Common Policy	Campus Automation	Cloud Managed Catalyst
Secure Equipment Access	AI Endpoint Analytics	Infrastructure as a Code
SD-Access (LISP & EVPN)	ThousandEyes Digital Experience	S3 & CloudWatch Integration
High-speed Encryption	AI Ops & Assurance	Visibility, Control & Rollback

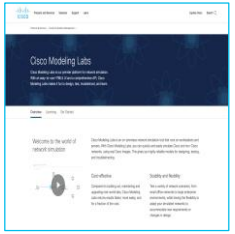


Cisco Validated Profiles (CVP)

Industry Validated Reports



Industry Certifications

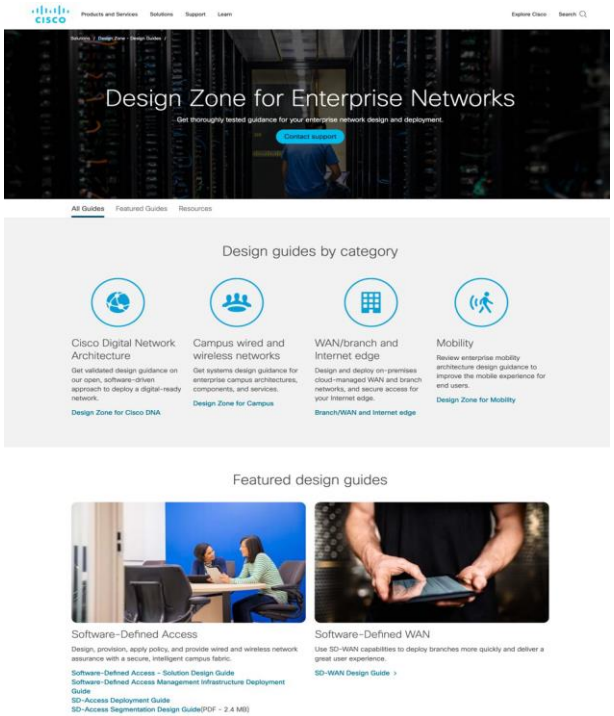


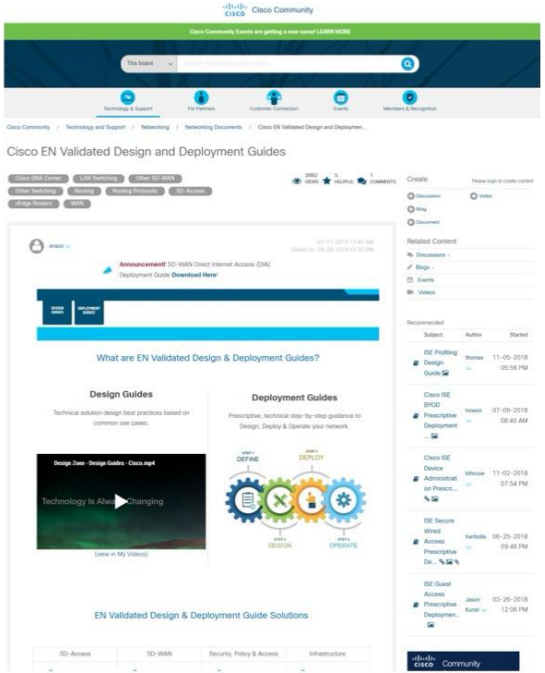
Cisco Modeling Labs

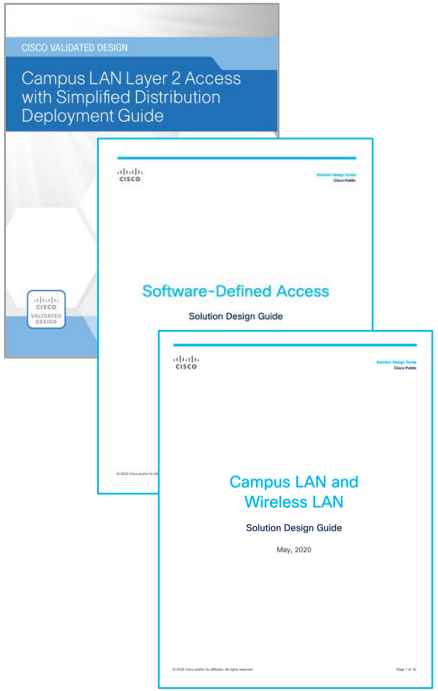
Keep Learning!

Cisco Validated Design (CVD)

cisco.com/go/cvd
cs.co/en-cvds







References – Multi-Layer Campus

Type	Sub-Type	References
General	Multi-Layer	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Campus/HA_campus_DG/hacampusdg.html www.ccexpert.us/network-design-2/designing-a-campus-network-design-topology.html networkdirection.net/articles/network-theory/hierarchicalnetworkmodel www.geeksforgeeks.org/types-of-area-networks-lan-man-and-wan/
Core	Edge	www.atlantic.net/managed-services/network-edge/ www.ccexpert.us/network-design/enterprise-edge-modules.html what-when-how.com/ipv6-for-enterprise-networks/enterprise-edge-network-design-ipv6/
	Interconnect	www.geeksforgeeks.org/difference-between-lan-and-man www.ti.com/solution/intra-dc-interconnect-metro en.wikipedia.org/wiki/Backbone_network
	Baseline	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#Corelayer www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Campus/HA_campus_DG/hacampusdg.html#wp1107724 www.ccexpert.us/network-design/campus-core-design-considerations.html en.wikipedia.org/wiki/Hierarchical_internetworking_model#Core_layer
Distribution	Collapsed Core	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#Twotierdesign www.econfigs.com/ccna-1-5-compare-and-contrast-collapsed-core-and-three-tier-architectures interestingtraffic.nl/2018/06/08/collapsed_core_design oreilly.com/library/view/ccna-data-center/9780133860429/ch01lev3sec4.html
	Baseline	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#Distributionlayer www.ccexpert.us/network-design/building-distribution-layer-design-considerations.html en.wikipedia.org/wiki/Hierarchical_internetworking_model#Distribution_layer
Access	Baseline	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#Accesslayer www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Campus/HA_campus_DG/hacampusdg.html#wp1107746 www.ccexpert.us/network-design/building-access-layer-design-considerations.html en.wikipedia.org/wiki/Hierarchical_internetworking_model#Access_layer
	Routed Access	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#Layer3routedaccesscampusdesign www.cisco.com/c/en/us/td/docs/solutions/Enterprise/Campus/HA_campus_DG/hacampusdg.html#wp1108952
	Extended/IOT	www.cisco.com/c/en/us/td/docs/solutions/Verticals/CCI/CCI/DG/cci-dg/cci-dg.html#99480 www.geeksforgeeks.org/5-layer-architecture-of-internet-of-things/

References – ECMP & StackWise(Virtual)

Type	Sub-Type	References
General	Redundancy	www.cisco.com/c/en/us/solutions/hybrid-work/what-is-high-availability.html#~infrastructure-elements www.ccexpert.us/network-design/designing-link-redundancy.html www.geeksforgeeks.org/redundant-link-problems-in-computer-network/
Core	ECMP	www.cisco.com/c/en/us/support/docs/ip/border-gateway-protocol-bgp/5212-46.html www.ccexpert.us/routing-protocols/equalcost-load-balancing.html en.wikipedia.org/wiki/Equal-cost_multi-path_routing
	EtherChannel	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#EtherChannel en.wikipedia.org/wiki/Link_aggregation#Network_backbone en.wikipedia.org/wiki/Multi-chassis_link_aggregation_group
	SVL	www.ciscolive.com/c/dam/r/ciscolive/emea/docs/2020/pdf/BRKCRS-2650.pdf www.cisco.com/c/en/us/products/collateral/switches/catalyst-9000/nb-06-cat-9k-stack-wp-cte-en.html www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#StackWiseVirtualTechnology
Distribution	ECMP	www.cisco.com/c/en/us/support/docs/ip/border-gateway-protocol-bgp/5212-46.html www.ccexpert.us/routing-protocols/equalcost-load-balancing.html en.wikipedia.org/wiki/Equal-cost_multi-path_routing
	EtherChannel	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#EtherChannel en.wikipedia.org/wiki/Link_aggregation en.wikipedia.org/wiki/Multi-chassis_link_aggregation_group
	SVL	www.ciscolive.com/c/dam/r/ciscolive/emea/docs/2020/pdf/BRKCRS-2650.pdf www.cisco.com/c/en/us/products/collateral/switches/catalyst-9000/nb-06-cat-9k-stack-wp-cte-en.html www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#StackWiseVirtualTechnology
Access	ECMP	www.cisco.com/c/en/us/support/docs/lan-switching/spanning-tree-protocol/10555-15.html en.wikipedia.org/wiki/Spanning_Tree_Protocol#Path_to_the_root_bridge en.wikipedia.org/wiki/Flex_links
	EtherChannel	www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#EtherChannel en.wikipedia.org/wiki/EtherChannel
	Stacking	www.ciscolive.com/c/dam/r/ciscolive/emea/docs/2020/pdf/BRKCRS-2650.pdf www.cisco.com/c/en/us/products/collateral/switches/catalyst-9300-series-switches/white-paper-c11-741468.html www.cisco.com/c/en/us/products/collateral/switches/catalyst-9200-series-switches/nb-06-stackwise-architecture-cte-en.html www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#SwitchStacksandCiscoStackWiseTechnology

References – SD-Access, EVPN & MPLS

Type	Sub-Type	References
General	SDN/IBN	www.cisco.com/c/en/us/solutions/intent-based-networking.html www.networkworld.com/article/3281447/a-new-era-of-campus-network-design.html www.geeksforgeeks.org/difference-between-software-defined-network-and-traditional-network/
Core	SDA	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKCRS-2810.pdf#page=27 www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-sda-design-guide.html#BorderNode www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-sda-design-guide.html#ControlPlaneNode
	EVPN	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2021/pdf/BRKENS-2003.pdf#page=12 www.cisco.com/c/en/us/td/docs/switches/lan/catalyst9500/software/release/17-7/configuration_guide/vxlan/b_177_bgp_evpn_vxlan_9500_cg/bgp_evpn_vxlan_overview.html#id_126799 www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#AlternativevirtualizationdesignforcampusBGPEVPNVXLAN
	MPLS	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKMPL-1100.pdf#page=48 www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKMPL-2112.pdf#page=42 www.geeksforgeeks.org/multi-protocol-label-switching-mpls/
Distribution	SDA	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKCRS-2810.pdf#page=19 www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-sda-design-guide.html#IntermediateNode
	EVPN	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2021/pdf/BRKENS-2003.pdf#page=12 www.cisco.com/c/en/us/td/docs/switches/lan/catalyst9500/software/release/17-7/configuration_guide/vxlan/b_177_bgp_evpn_vxlan_9500_cg/bgp_evpn_vxlan_overview.html#id_126799
	MPLS	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKMPL-1100.pdf#page=48 www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKMPL-2112.pdf#page=42 www.geeksforgeeks.org/multi-protocol-label-switching-mpls/
Access	SDA	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKCRS-2810.pdf#page=24 www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-sda-design-guide.html#EdgeNode www.cisco.com/c/dam/en/us/solutions/collateral/internet-of-things/nb-09-intent-based-iot-wp-cte-en.pdf www.cisco.com/c/en/us/td/docs/solutions/CVD/Campus/cisco-campus-lan-wlan-design-guide.html#CiscoSoftwareDefinedAccesscampusdesign
	EVPN	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2021/pdf/BRKENS-2003.pdf#page=12 www.cisco.com/c/en/us/td/docs/switches/lan/catalyst9500/software/release/17-7/configuration_guide/vxlan/b_177_bgp_evpn_vxlan_9500_cg/bgp_evpn_vxlan_overview.html#id_126799
	MPLS	www.ciscolive.com/c/dam/r/ciscolive/us/docs/2020/pdf/DGTL-BRKMPL-1100.pdf#page=48 www.geeksforgeeks.org/multi-protocol-label-switching-mpls/

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