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123 – Enterprise Campus Wired Design Fundamentals

Back to Basics

Chris Courtelis – Solutions Engineer, VIC AUS
BRKENS-1501

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



Who am I?



Chris Courtelis

Solutions Engineer

7 Years in Cisco

2012 – UTS Electrical Engineering

2017 – Cisco Sydney TAC Engineer

2020 – Enterprise Network Specialist

2021 – Account Solutions Engineer

Who am I?



Chris Courtelis
Solutions Engineer
7 Years in Cisco

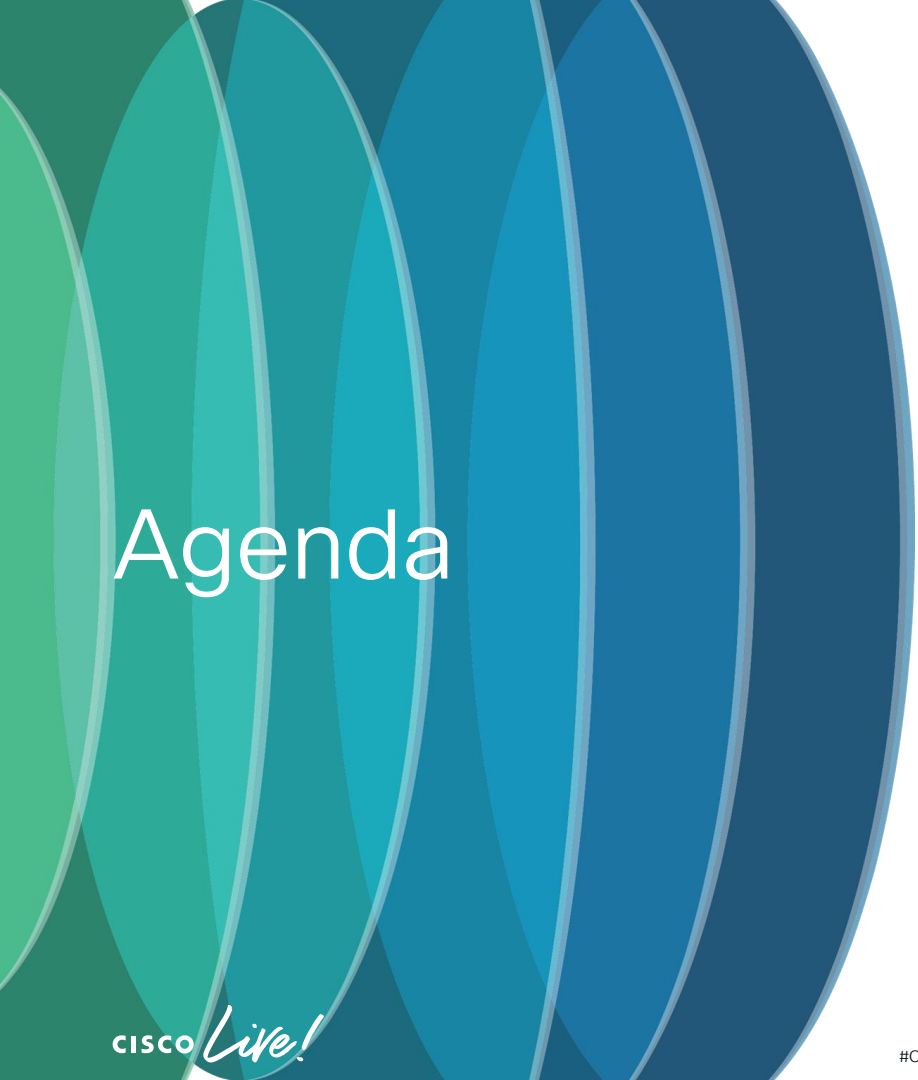
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This session is about enabling you to
understand network design decisions,
and assisting you to make those
design choices yourself

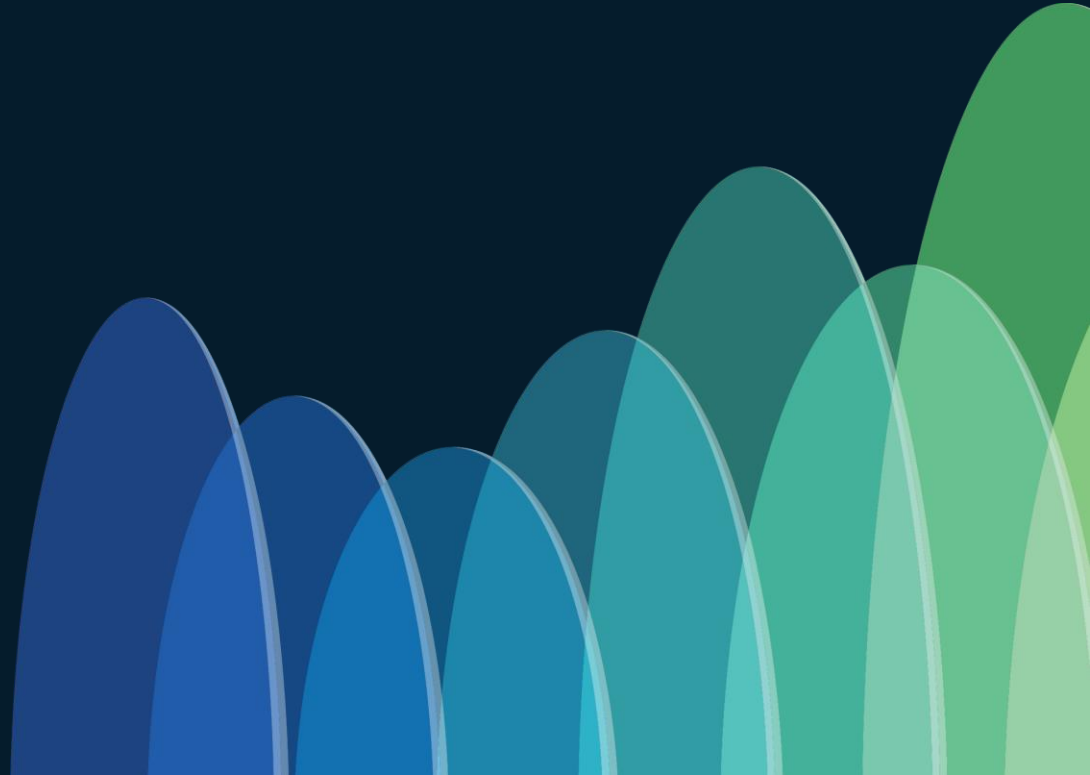
This session is **not a deep dive** or
Cisco product update



Agenda

- What is a Campus Network?
- 1-2-3 or 4+ Tier Design
- Control/Data Plane Resiliency
- Fabric Based Networks
- Wireless & Security Notes
- Summary & References

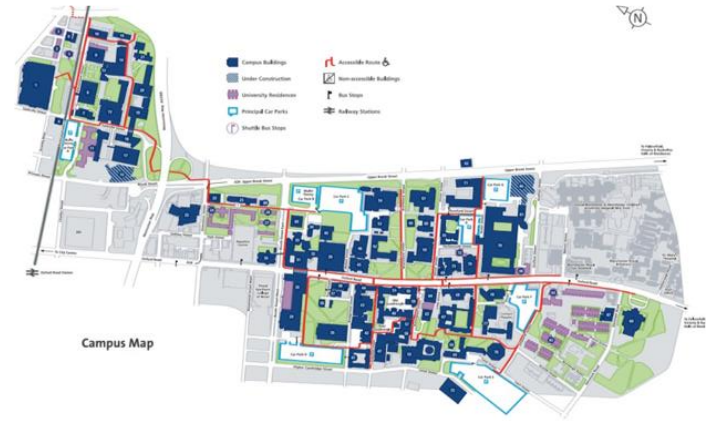
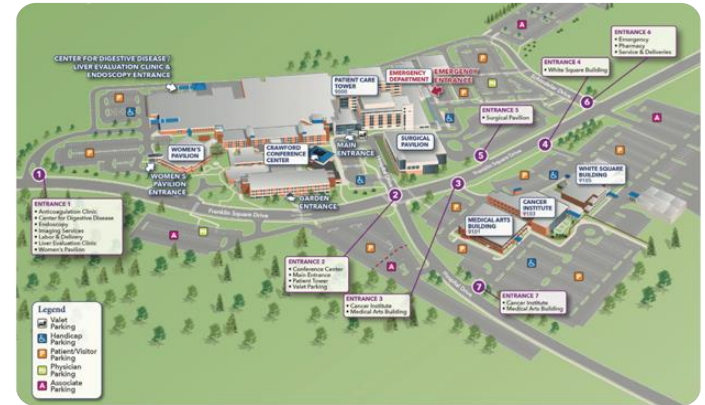
What is a Campus Network?



What is a “Campus”

A basic definition of a Campus is:

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



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Campus is focused on User Access

Campus = Geography



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Buildings are spread out. Multiple floors per building

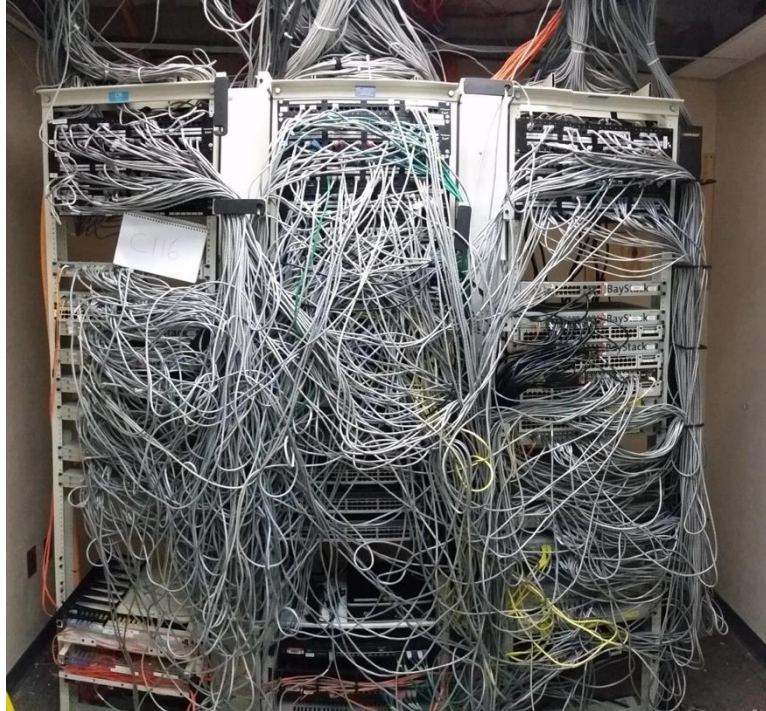
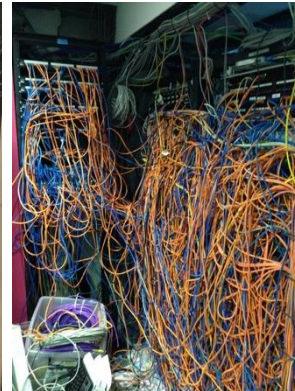
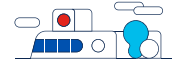
Campus ≠ Data Center



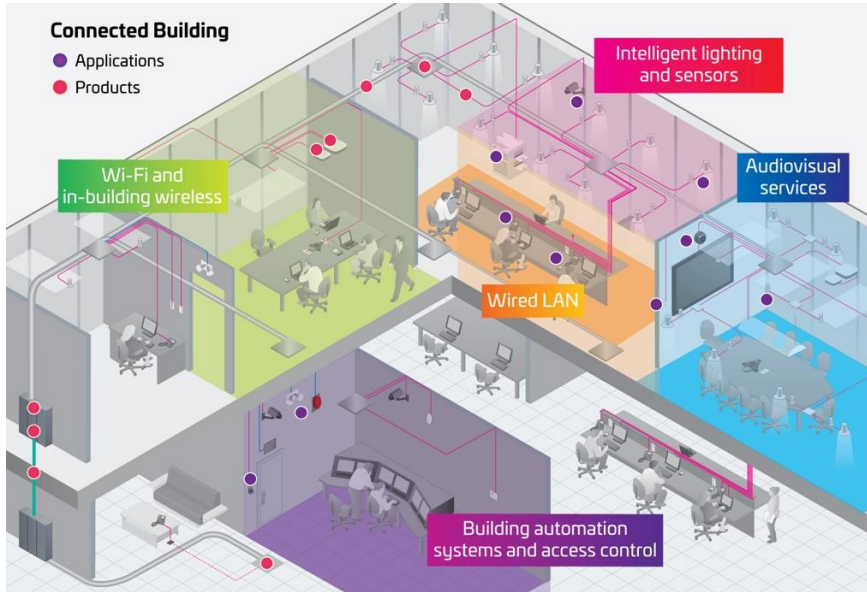
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One or few large buildings nearby. Usually a single floor.

Campus Networks - Real Life

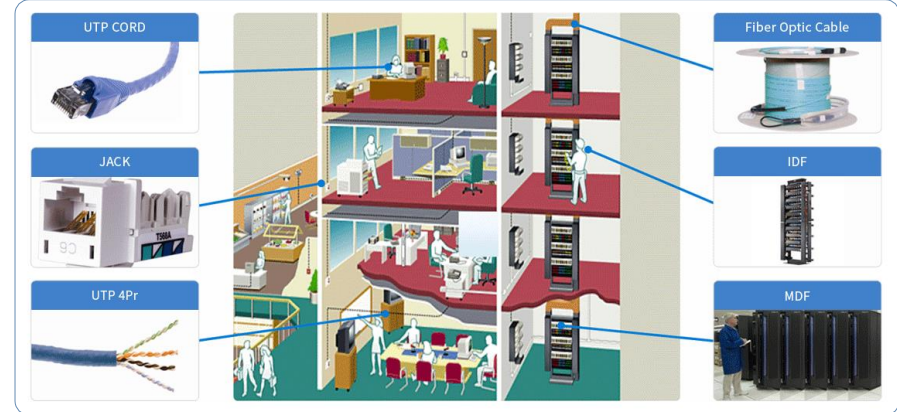


Campus Networks – MDF/IDF & Wiring Closets

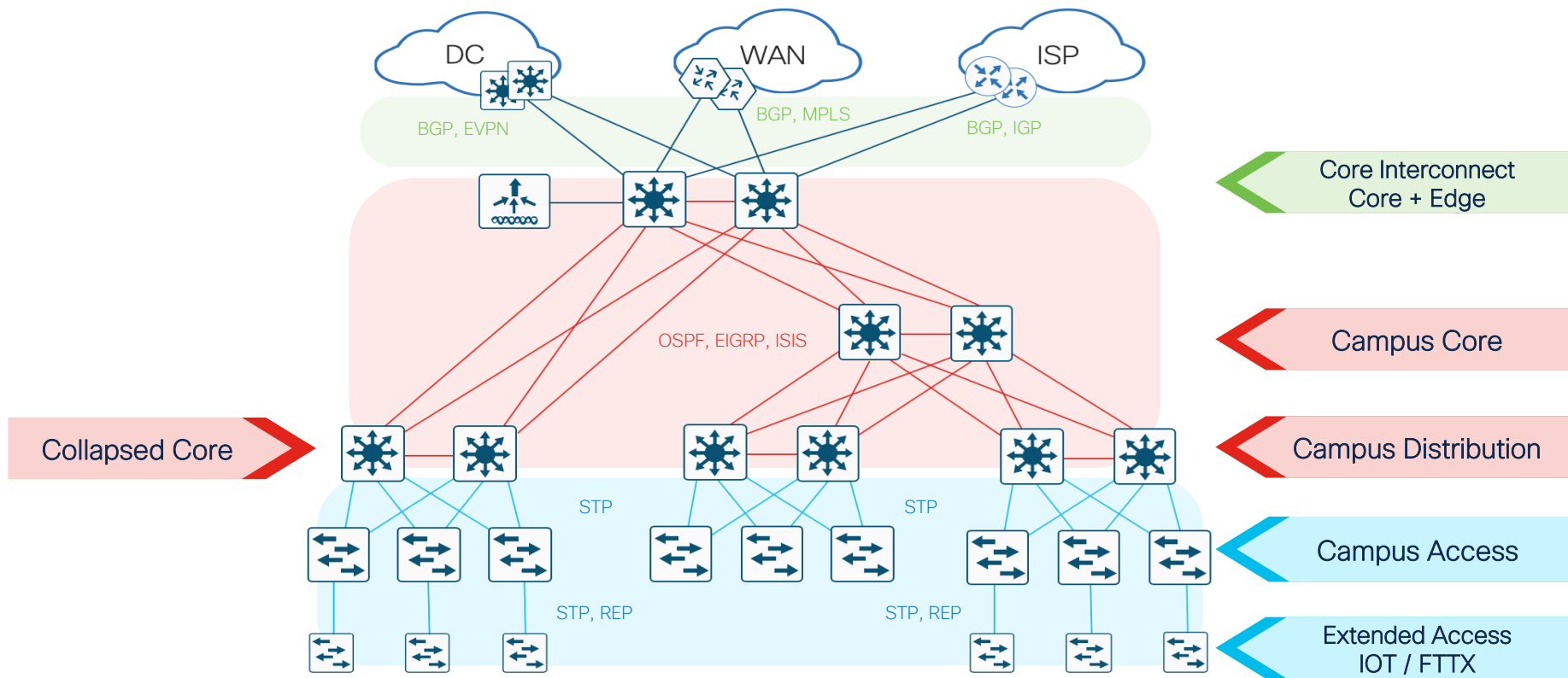


MDF = Main Distribution Framework (Core & Edge)

IDF = Intermediate Distribution Framework (Distro & Access)

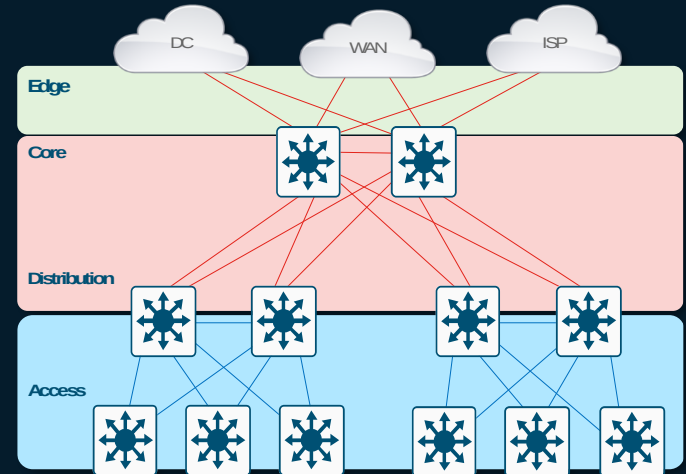


Campus 'Place in Network' (PINs) & Topology



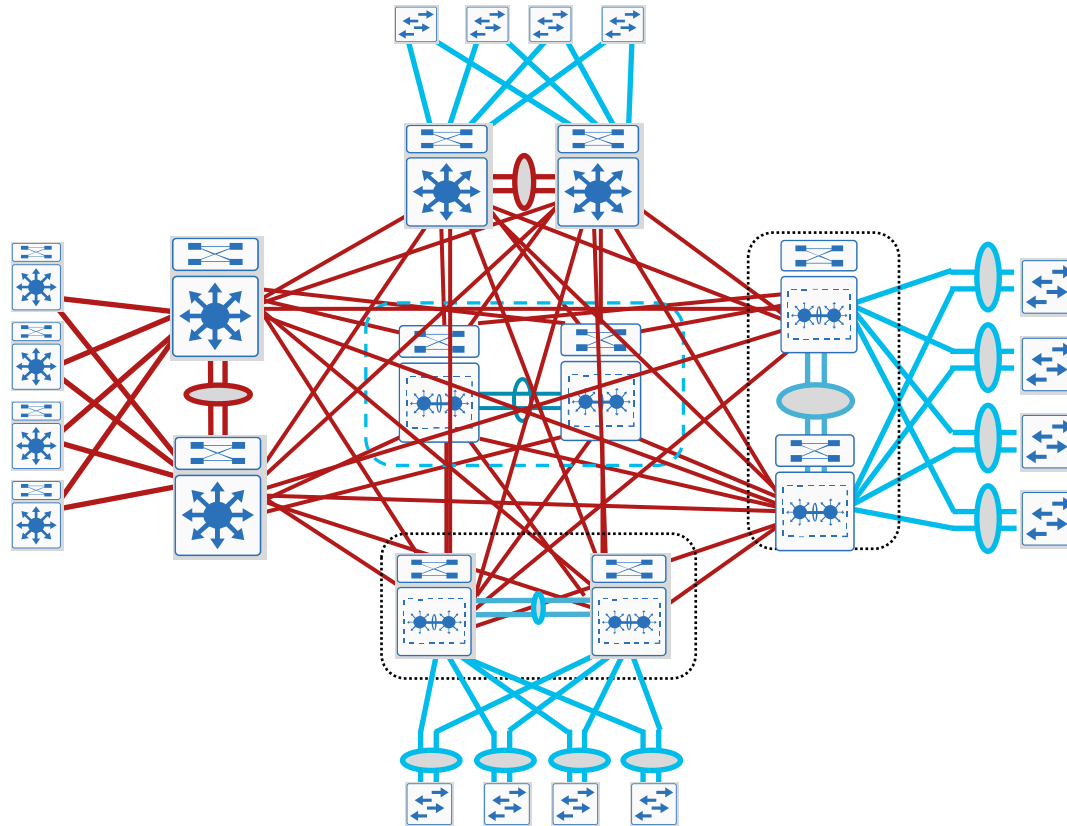
Campus Networks

- ❖ **Multi-Layer Model**
- ❖ **Chassis Considerations**
- ❖ **Port Considerations**
- ❖ **Cabling Considerations**
- ❖ **Feature Considerations**

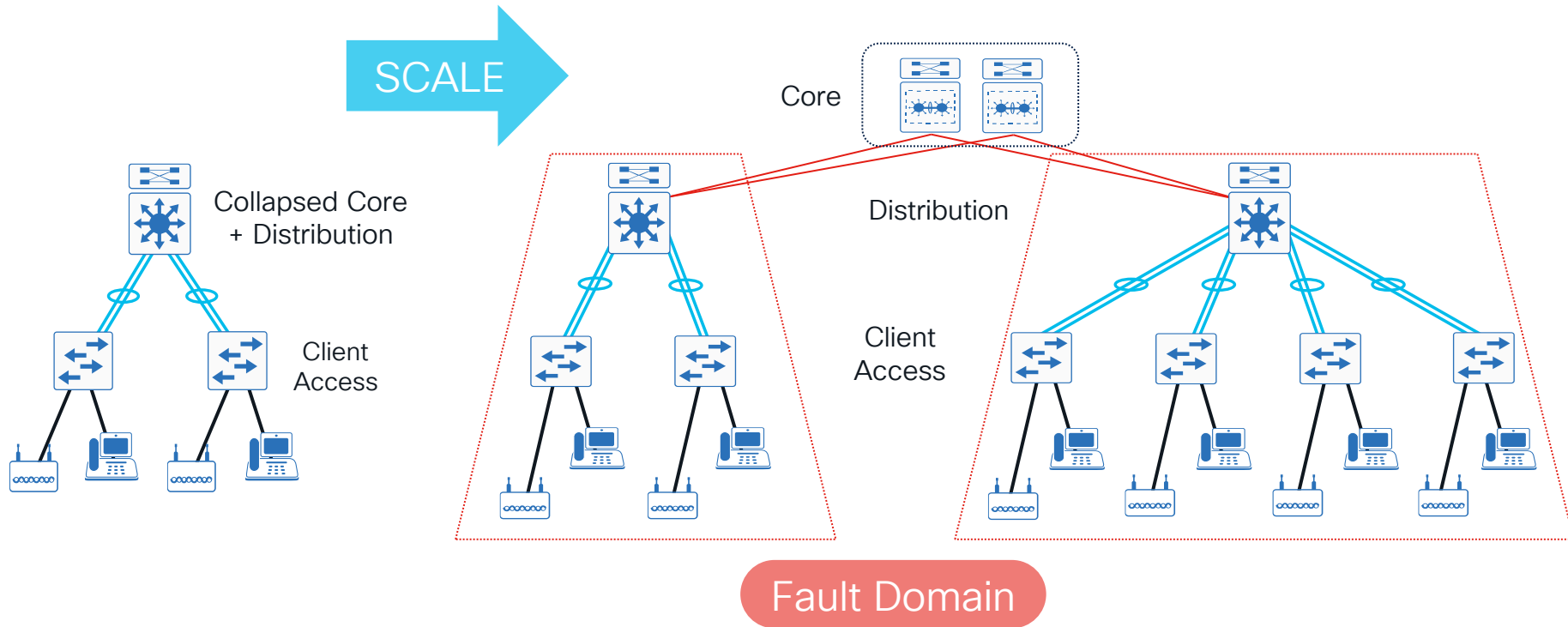


Why a two or three tier network?

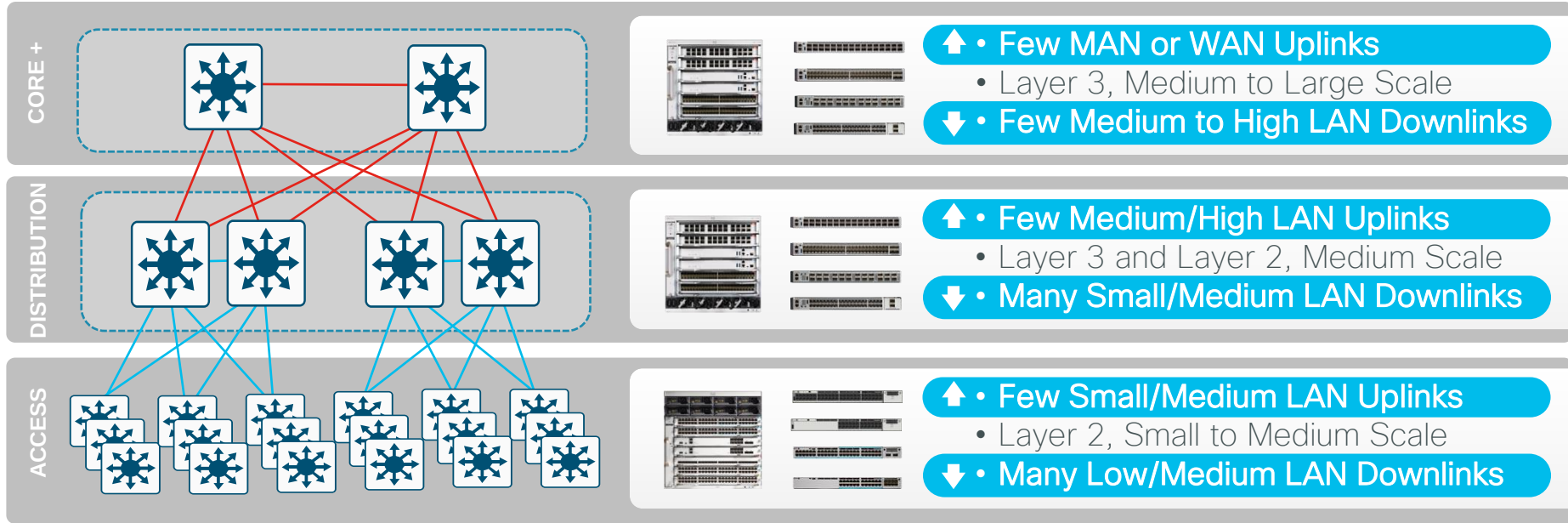
Campus Design Model – Simplicity



Campus Design Model – Scalability and Stability



Campus Design Model – Multiple Layers

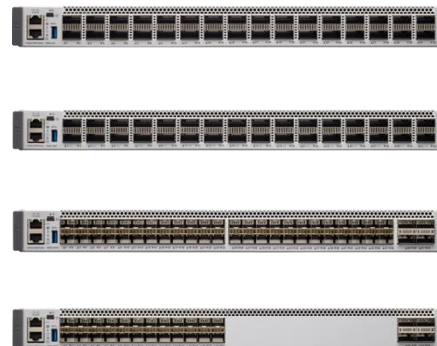


3 “Logical” Layers

- If you ‘collapse’ layers your device needs to support all ‘logical’ functions
- Each layer has a specific set of requirements and provides a specific set of functions

What's the right switch for the job?

Switching Chassis: 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

What kind of connectivity do I need?

Copper vs. Fiber Connectivity: Who, What, Where



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



OM3, OM4 & OM5

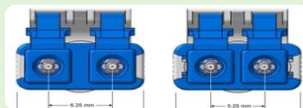
Multi-Mode (MMF)

Single-Mode (SMF)

Wave-Division
Multiplex (WDM)

SFP (Access & Distribution)

QSFP (Core & Edge)



SFP-LC
LC Duplex

mSFP
Mini LC Duplex



MMF



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

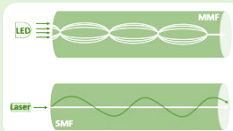
Single Mode

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



MPO12
12 Fibers

MPO24
24 Fibers



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

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Multigigabit: Beyond 1G Access Connectivity



Category 5, 6 & 7

Unshielded (UTP)

Shielded (STP)

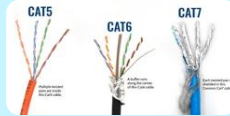
RJ45 (Access to Endpoints)



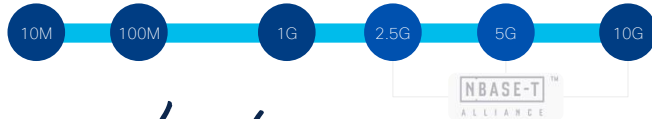
Cat6A
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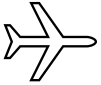


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The Ethernet Evolution

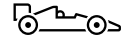
10GBASE-T 2006

10G



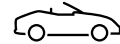
5GBASE-T 2016

5G



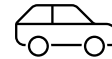
2.5GBASE-T 2016

2.5G



1000BASE-T 1999

1G



100BASE-T 1995

100M



10BASE-T 1990

10M

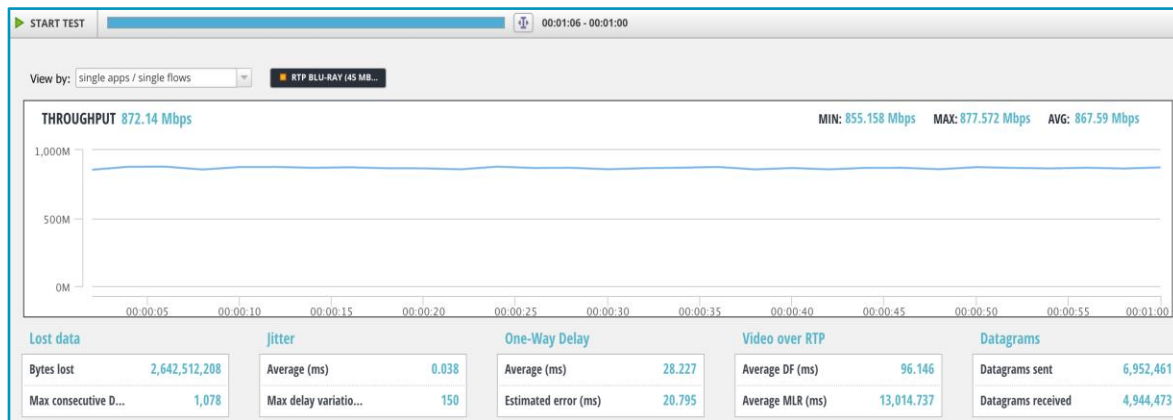


Multigigabit: The Need for Speed

3 clients on 2.4GHz @ 20MHz
15 clients on 5 GHz @ 80MHz

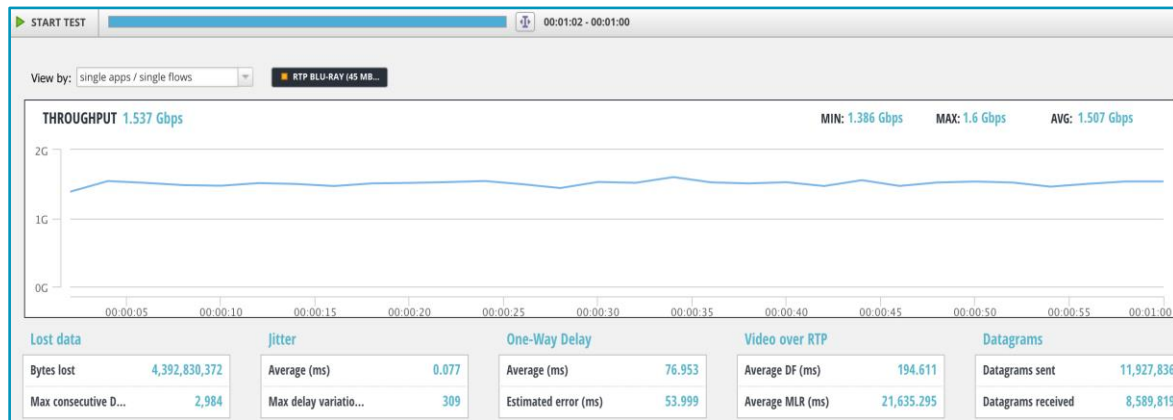
Wi-Fi 6 Performance with Gigabit switch

THROUGHPUT 872.14 Mbps

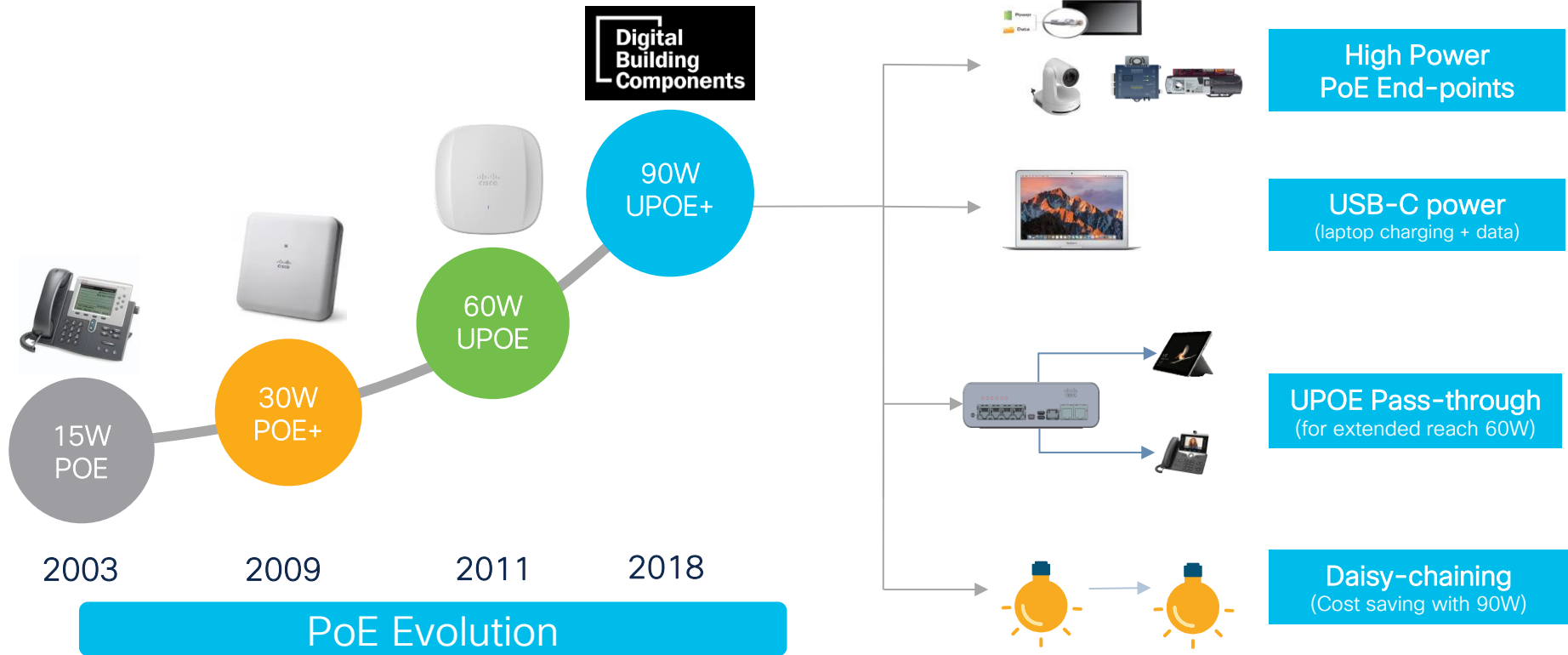


Wi-Fi 6 Performance with mGig switch

THROUGHPUT 1.537 Gbps



Power over Ethernet: Evolving Requirements



How about the feature set?

Campus Networks: L2/L3 Unicast Technologies

IPv4 Unicast

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

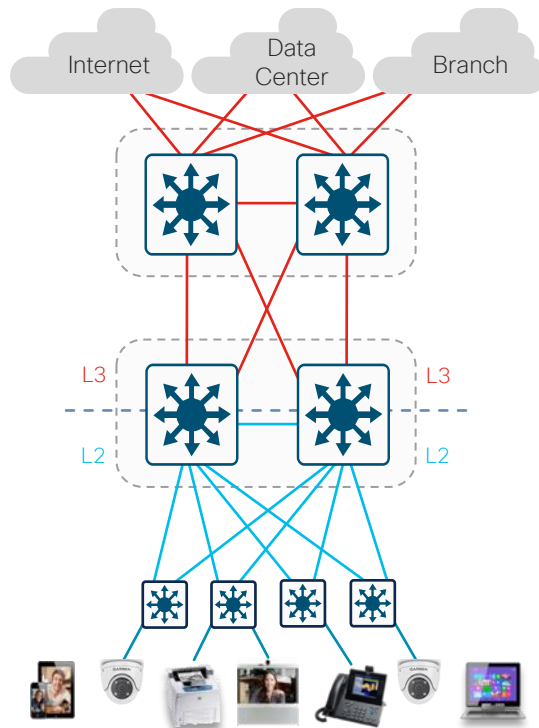
Core

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

Distribution

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

Access



IPv6 Unicast

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

Core

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

Distribution

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

Access

Campus Networks: L2/L3 Multicast Technologies

IPv4 Multicast

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

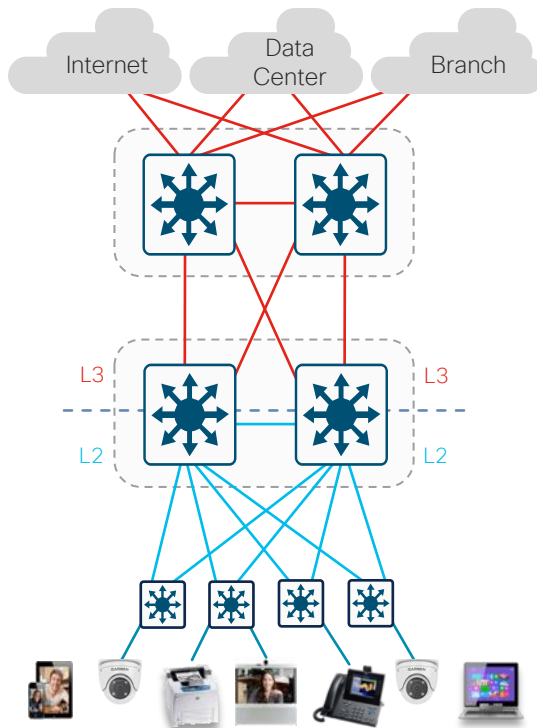
Core

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

Distribution

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

Access



IPv6 Multicast

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

Core

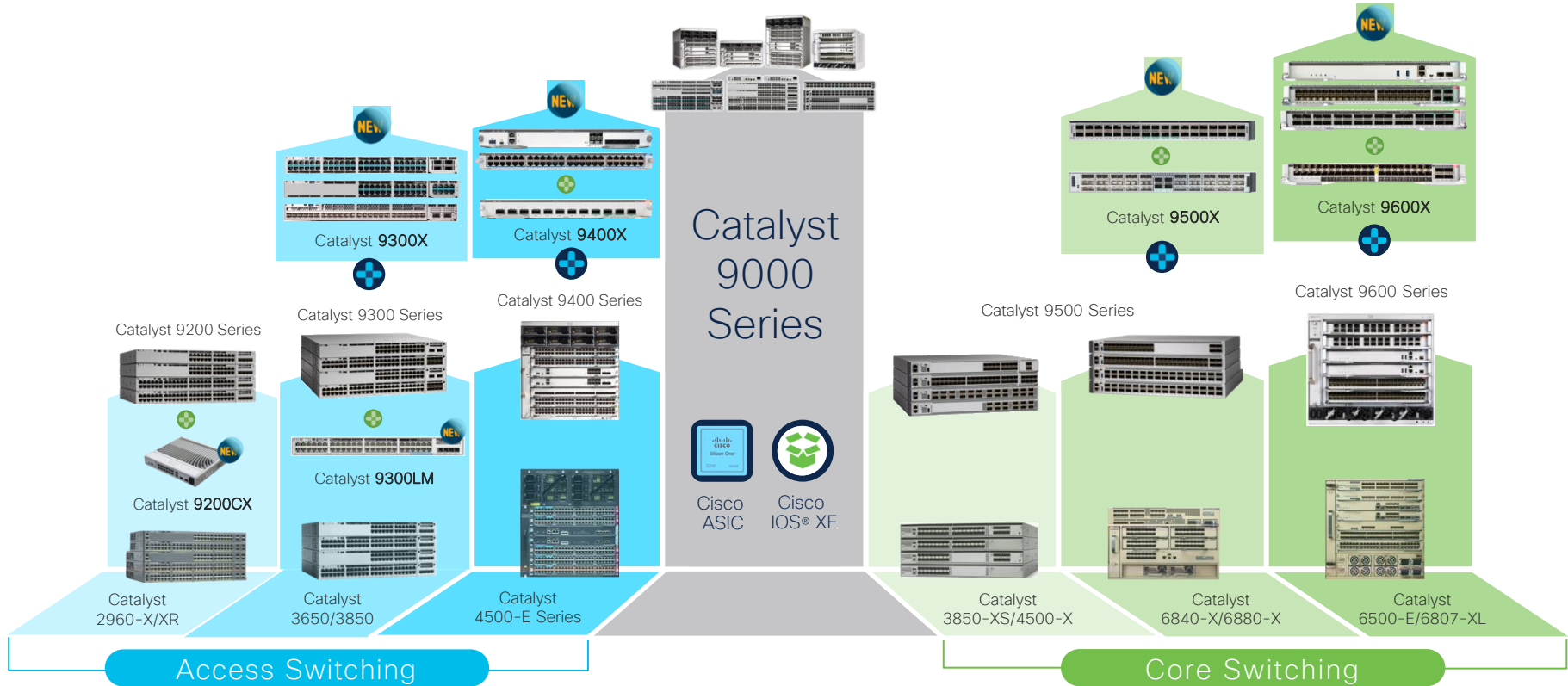
- Dual-stack IPv4 / IPv6
- PIM-SM and SSM
- MLDv1,v2 snooping
- HW register and RPF
- HSRP-aware PIM
- IPv6 multicast HA

Distribution

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

Access

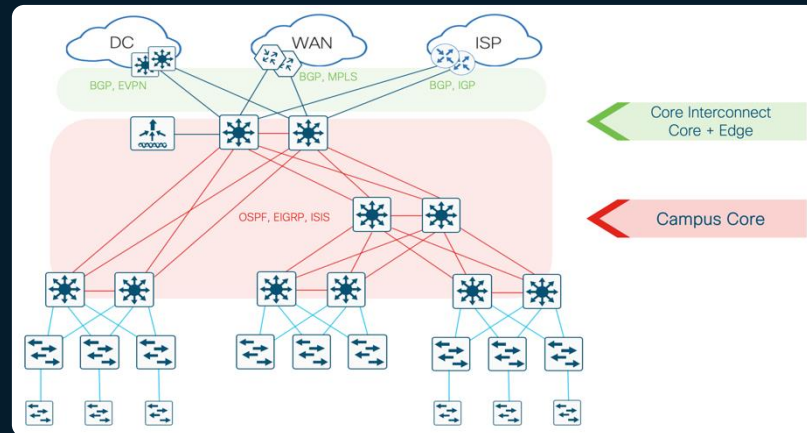
Cisco Catalyst 9000 Switching Portfolio



1-2-3 or 4+ Tier Design

Campus PINs

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

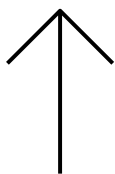


Campus Core (Baseline)

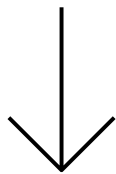
WHAT: Connects multiple Distribution layers to an Interconnect and/or other network domains

HOW: A simple, high-bandwidth, L3 transport between other network layers

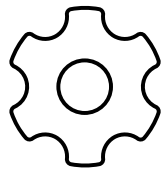
Considerations:



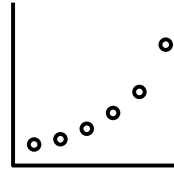
L3



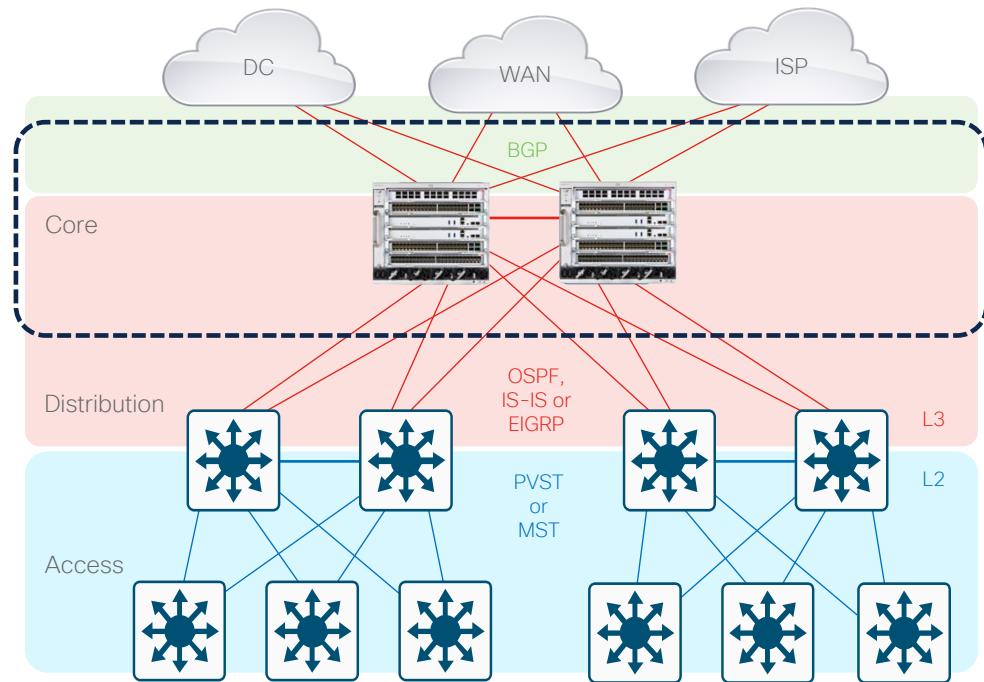
L3



Limited
Features



High Scale

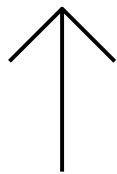


Campus Core Interconnect

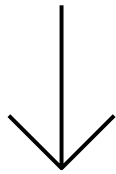
WHAT: Extension of the Core, used to connect multiple Core Layers and/or other network domains

HOW: Distribute the bandwidth and density requirements of multiple Cores

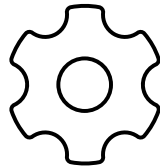
Considerations:



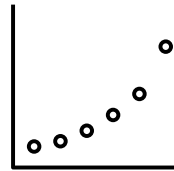
L3



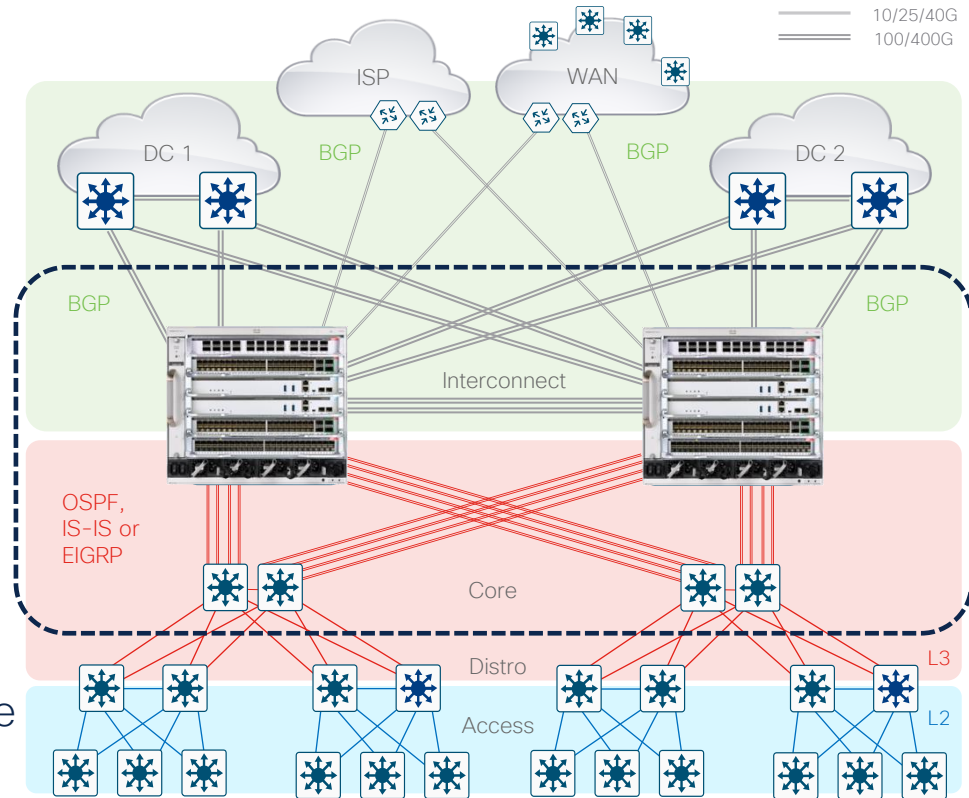
L3



Limited
Features



Higher Scale

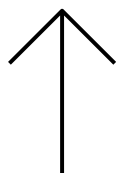


Campus Core + Edge (SP/WAN)

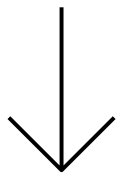
WHAT: Connecting multiple Campus areas to remote domains and/or the Internet

HOW: Collapse Core & Edge Layers

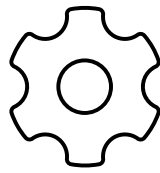
Considerations:



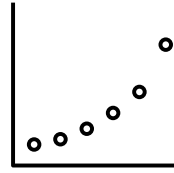
L3



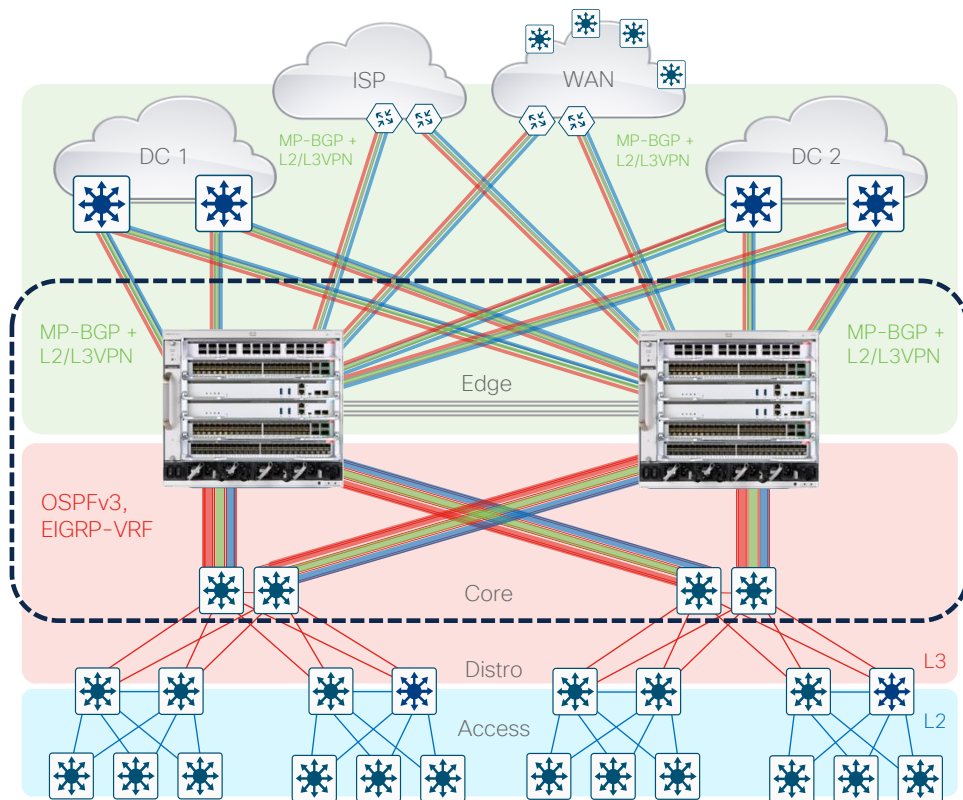
L3



Multiple
L3
Features



Highest
Scale

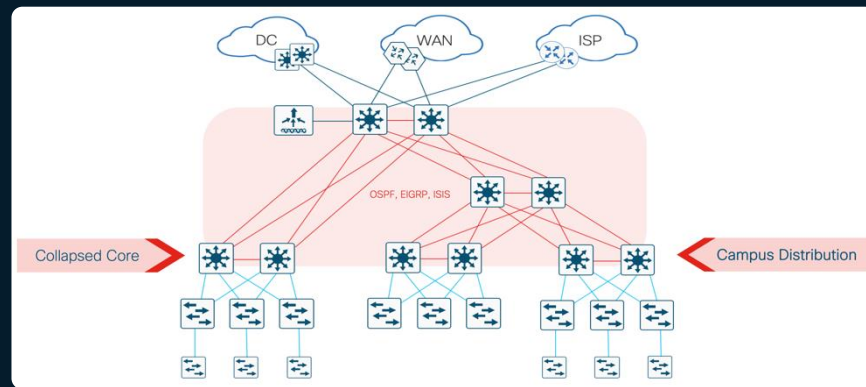


Campus PINs

❖ Campus Distribution (Baseline)

❖ Collapsed Core + Distribution

❖ Campus Distro + Extended Access

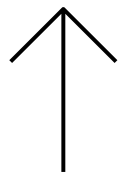


Campus Distribution (Baseline)

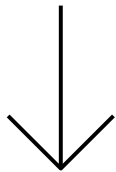
WHAT: Connecting multiple Access layers and the Core Layer

HOW: Distribute connectivity from Core/WAN to Access

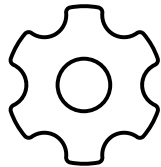
Considerations:



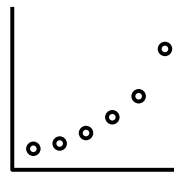
L3



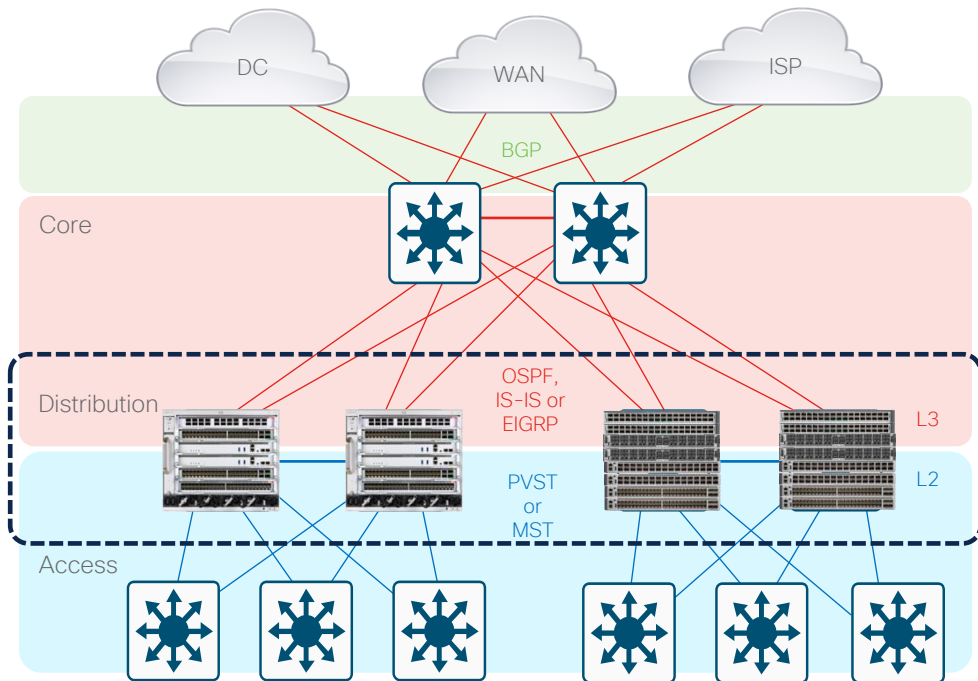
L2



Multiple
L2/L3
Features



Med to High
L2/L3 Scale

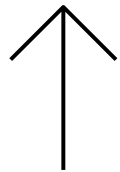


Campus Collapsed Core

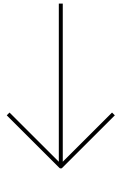
WHAT: Connecting multiple Access layers and the WAN/Edge layer

HOW: Collapse Core & Distribution layers into single layer

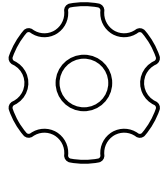
Considerations:



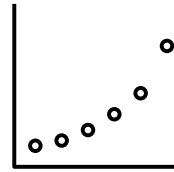
L3



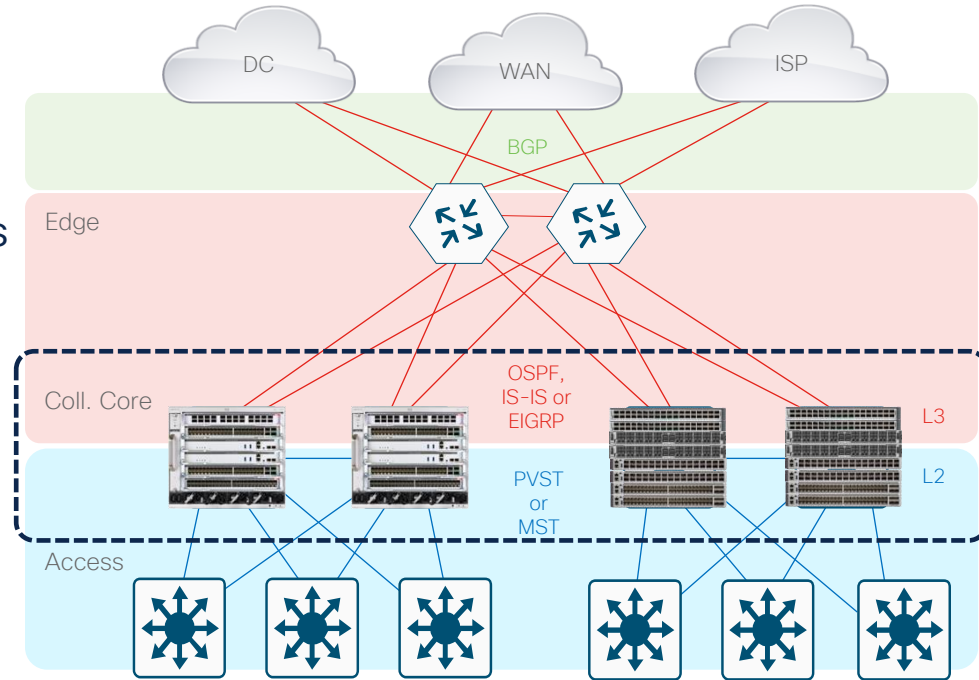
L2



Multiple
L2/L3
Features

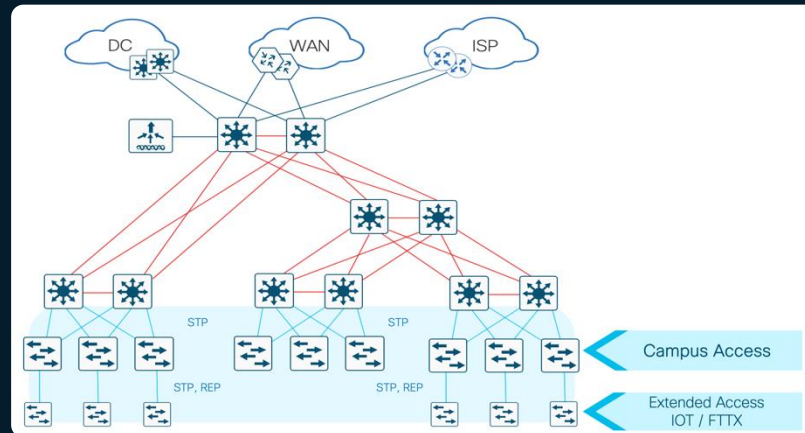


High L2/L3
Scale



Campus PINs

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

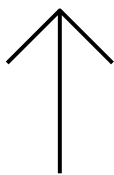


Campus Access (Baseline)

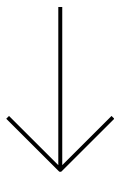
WHAT: Connecting Users & Devices to the Distribution layer

HOW: Connect users to the network

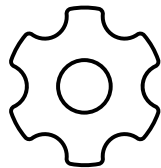
Considerations:



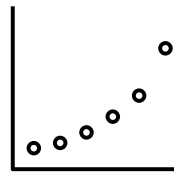
L2



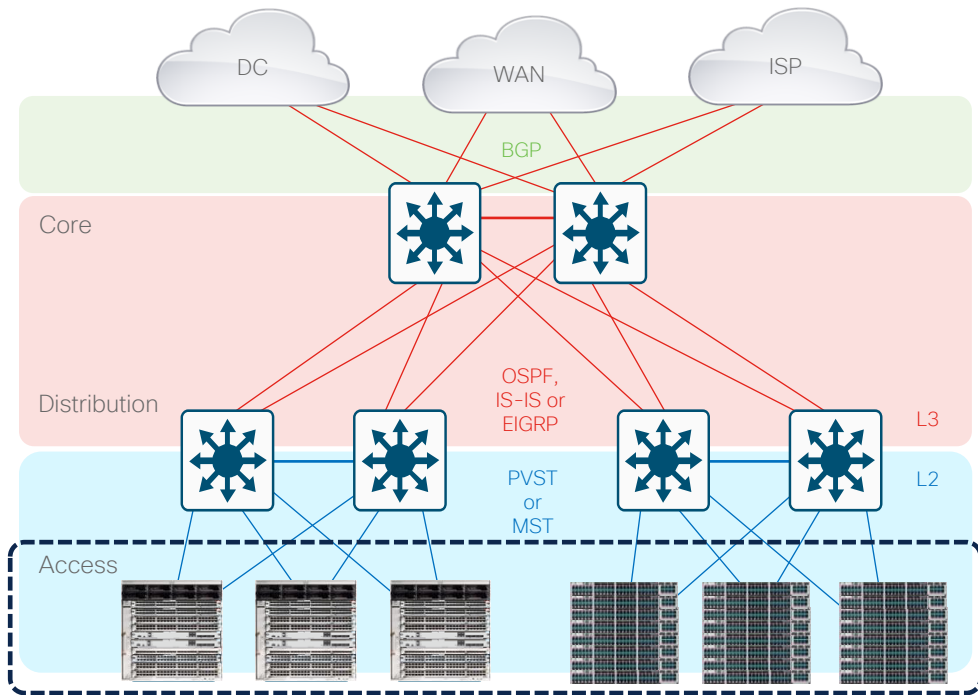
L2



Multiple
L2
Features



Low to Med
L2 Scale

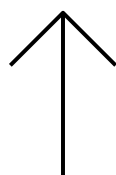


Extended Access (IOT / FTTX)

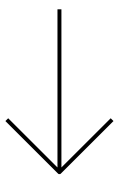
WHAT: Extension of the Access, to connect more devices or device types

HOW: Extend the size and scale of the Access layer and connect more hosts

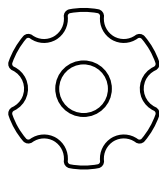
Considerations:



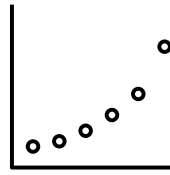
L2



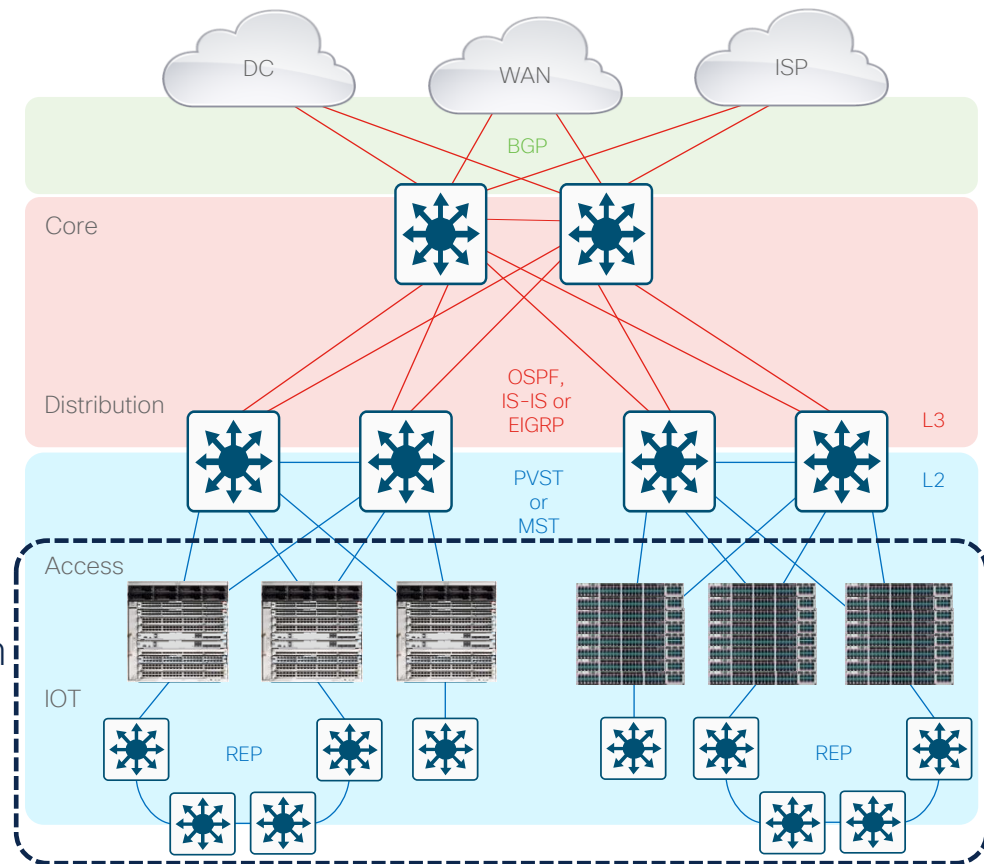
L2



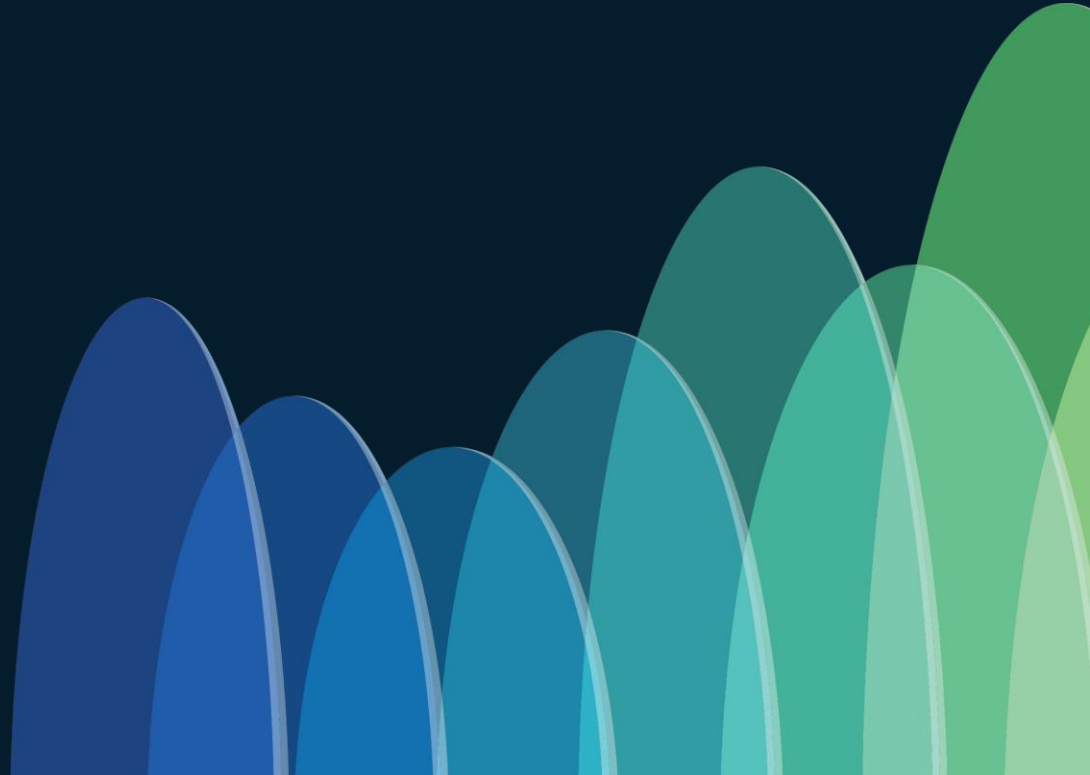
Multiple
L2
Features



Med to High
L2 Scale

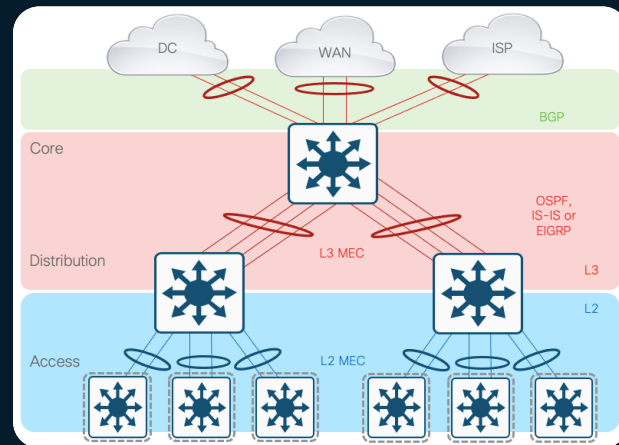


Control & Data Plane Resiliency



Campus Architecture

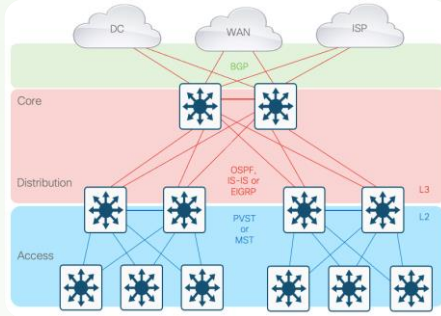
- ❖ **EtherChannel**
(Traditional)
- ❖ **StackWise**
(Access Stacking)
- ❖ **StackWise Virtual**
(Core/Distro Stacking)



Campus Architectures – Platform Resiliency

1

ECMP



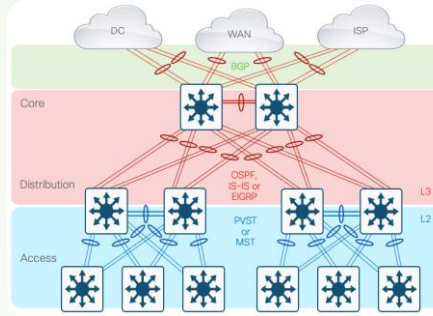
Node Level Redundancy

Protocol Load-Balancing

More Neighbors =
Requires Protocol Tuning

2

EtherChannel (L2/L3 LAG)



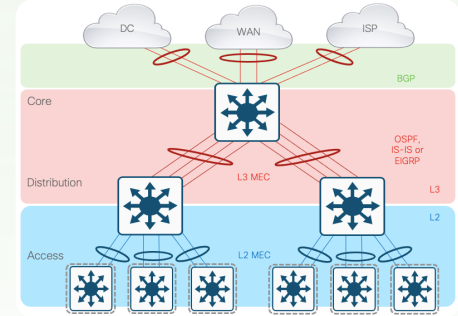
Node & Link Redundancy

EtherChannel Load-Balancing

More Neighbors =
Requires Protocol Tuning

3

StackWise (L2/L3 MEC)



Layer Level Redundancy

Multi-chassis EtherChannel

Fewer Neighbors = No
Protocol Tuning

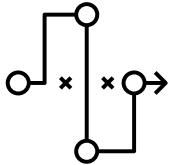


StackWise Virtual Core/Distribution

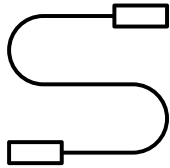
WHAT: Combines Core and/or Distribution into a single virtual switch to simplify and expand those layers

HOW: Stateful Switchover (SSO)

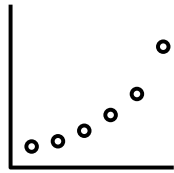
Considerations:



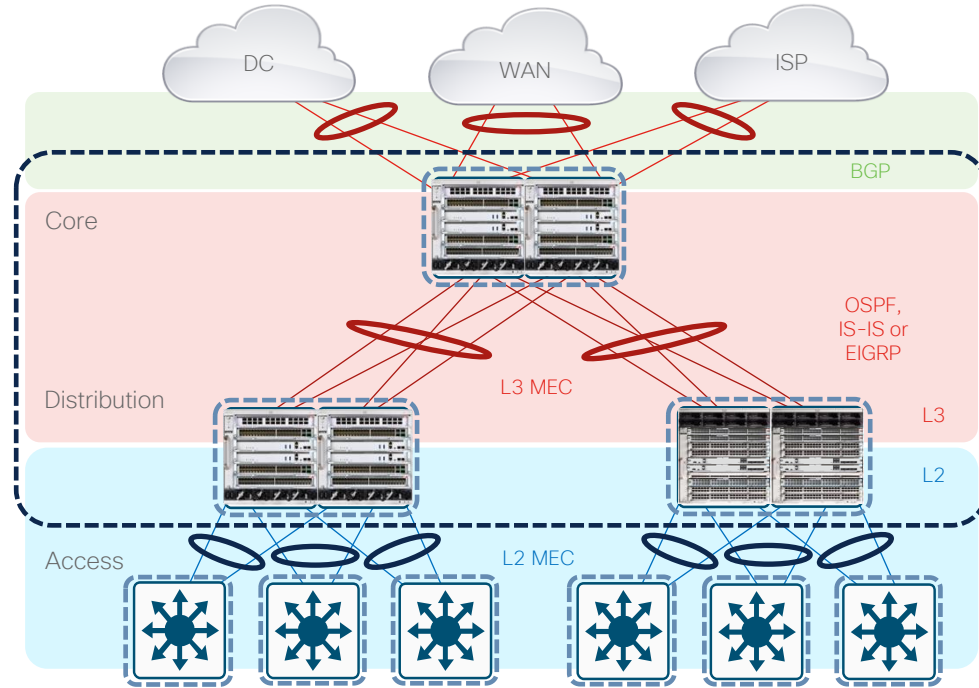
NSF/NSR
Protocols



L2 & L3
MEC



Med to High
L2/L3 Scale

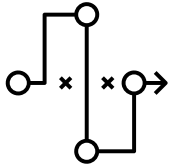
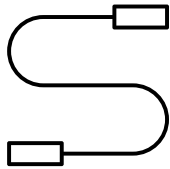
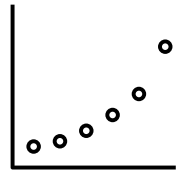
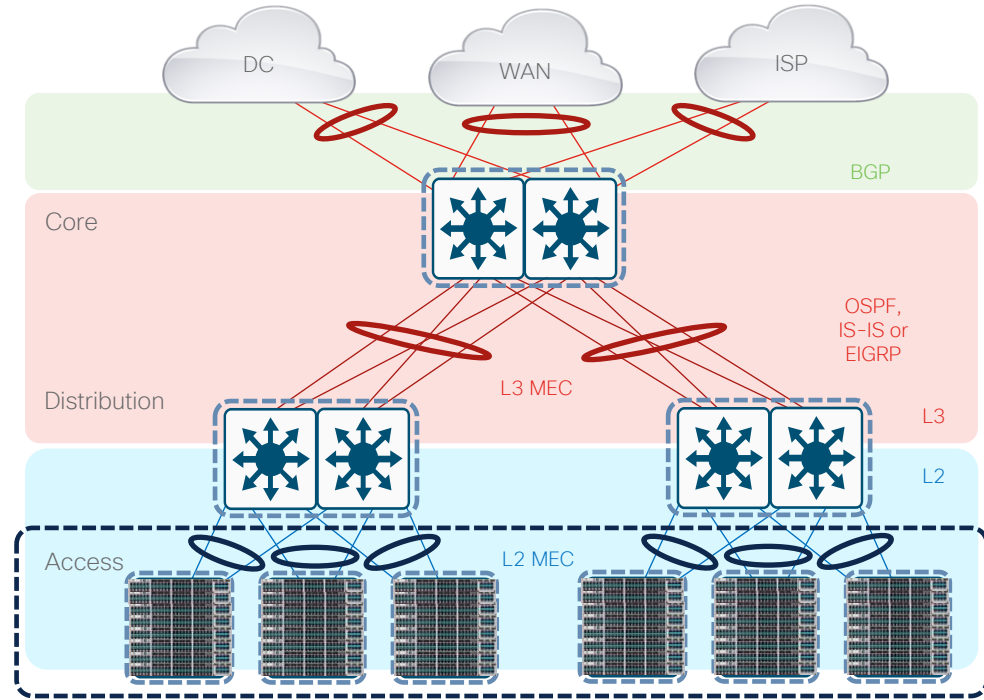


StackWise Access

WHAT: Combines multiple Access switches into a single virtual switch to expand port density of Access layer

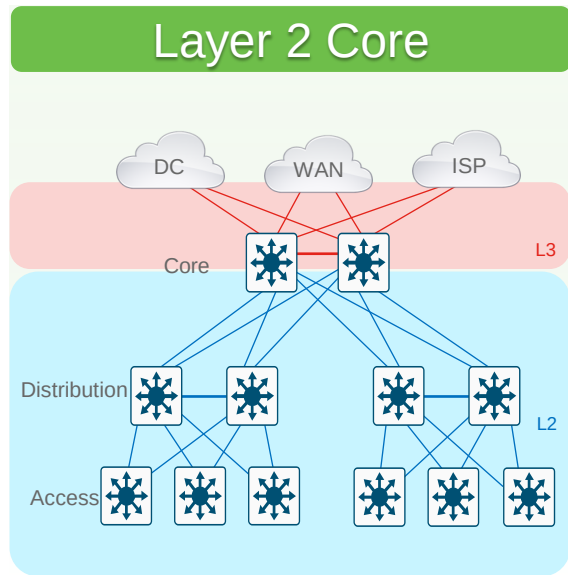
HOW: Stateful Switchover (SSO)

Considerations:

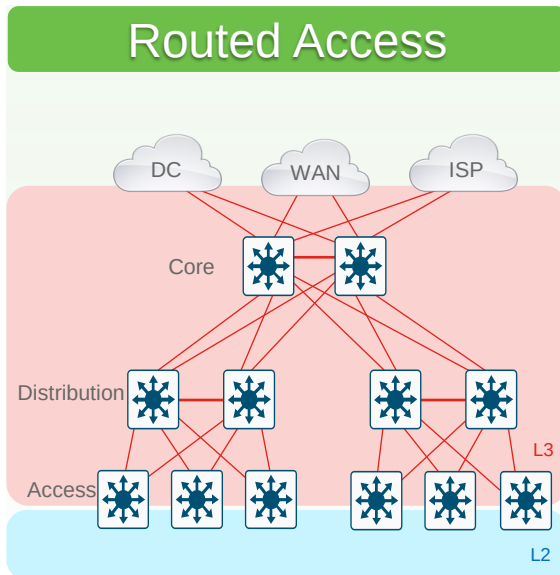


Fabric Based Networks

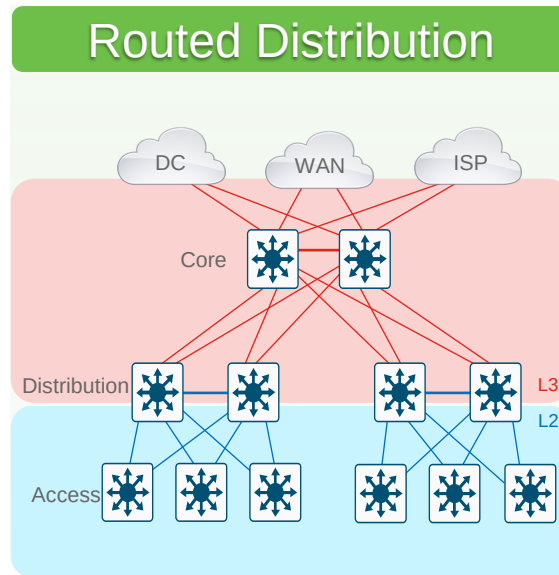
Layer 2 Demarcation – Understanding the History



Large L2 Domains



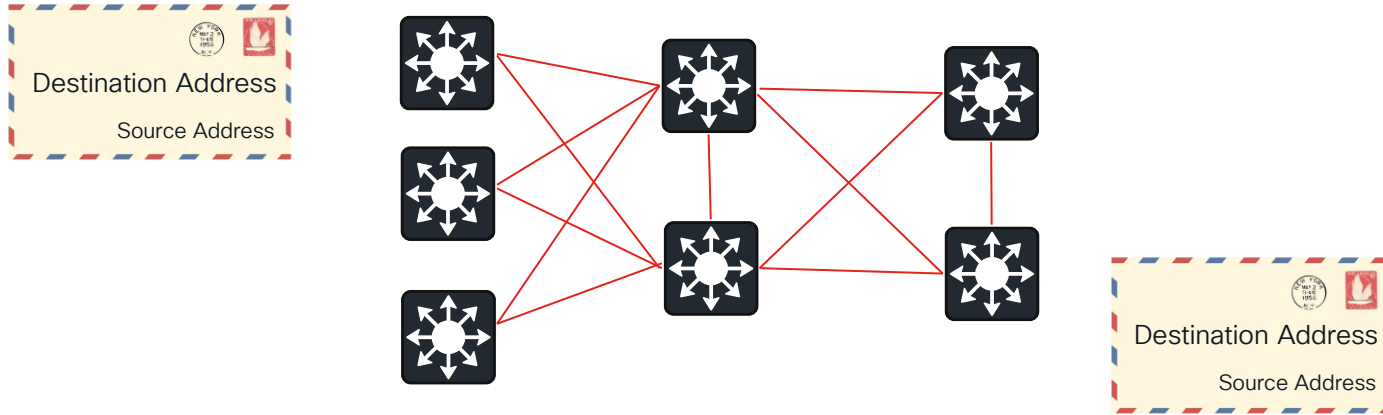
Confined VLANs



Balanced

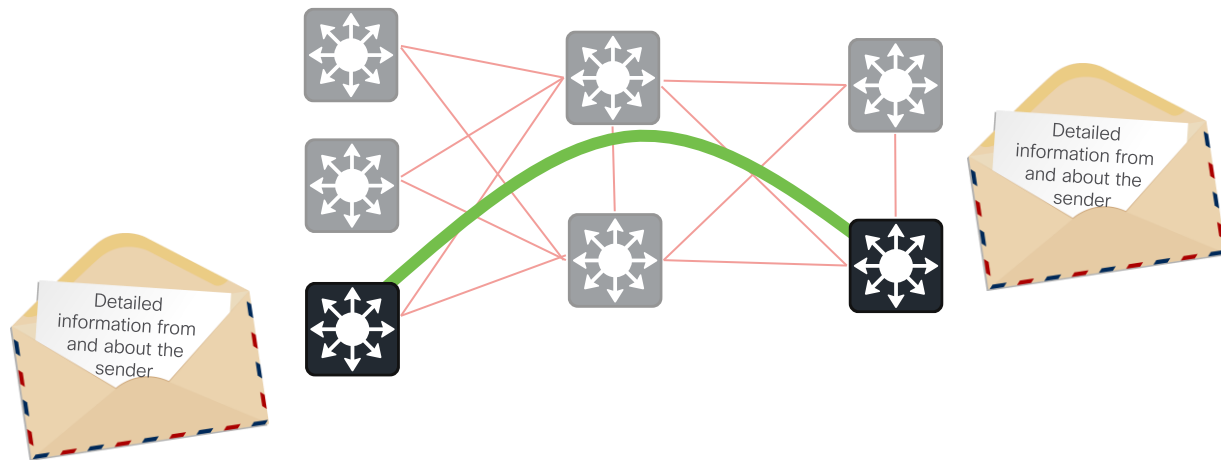
Is there a better way? Fabrics?

Fabrics: What is an Underlay?



Underlay Network = **Physical Infrastructure** to provide **IP reachability** with redundancy and **resiliency**.

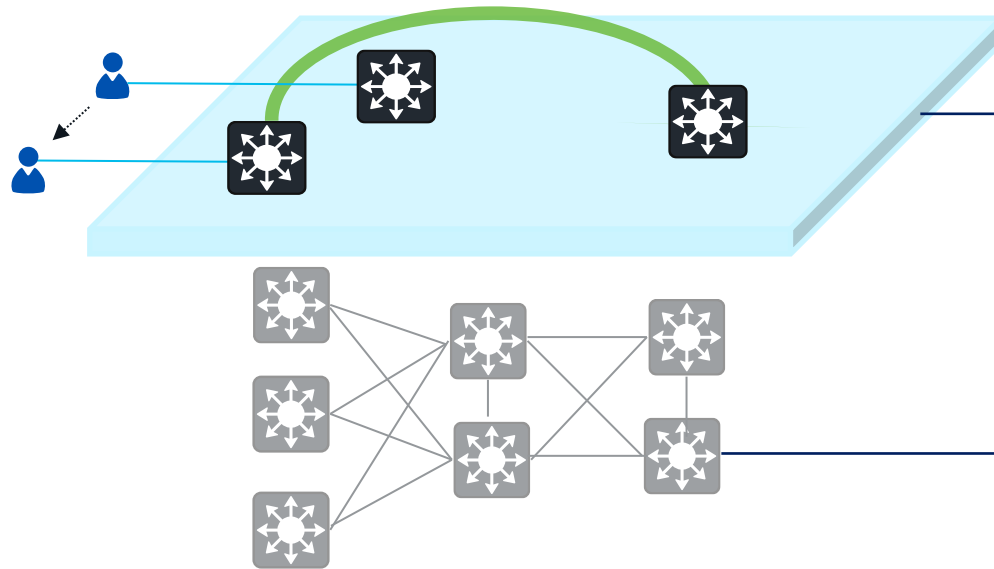
Fabrics: What is an Overlay?



Overlay Network = Logical topology used to virtually connect devices to provide additional services, not delivered by the Underlay.

Examples: GRE, CAPWAP, IPSEC, LISP, EVPN, VXLAN

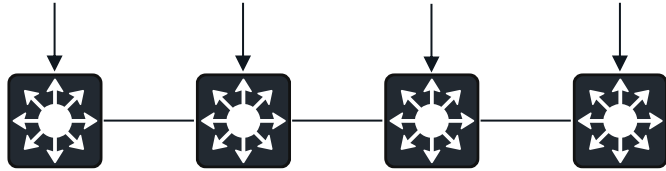
Fabrics: Why an Overlay?



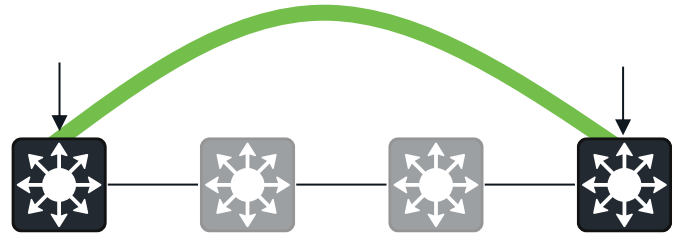
- **Overlay (Fabric):** Flexible, Scalable and Extensible. Easy to add/modify services. Optimizes mobility events.

- **Underlay:** Build and forget! Reliable, manageable, and simple.

Fabrics: Why an Overlay?

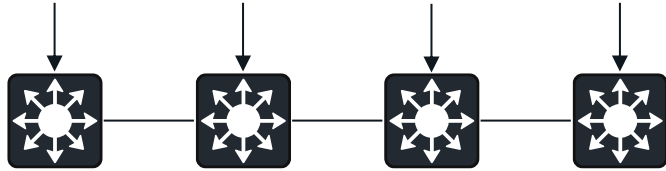


Would you rather configure
network segmentation
hop-by-hop?

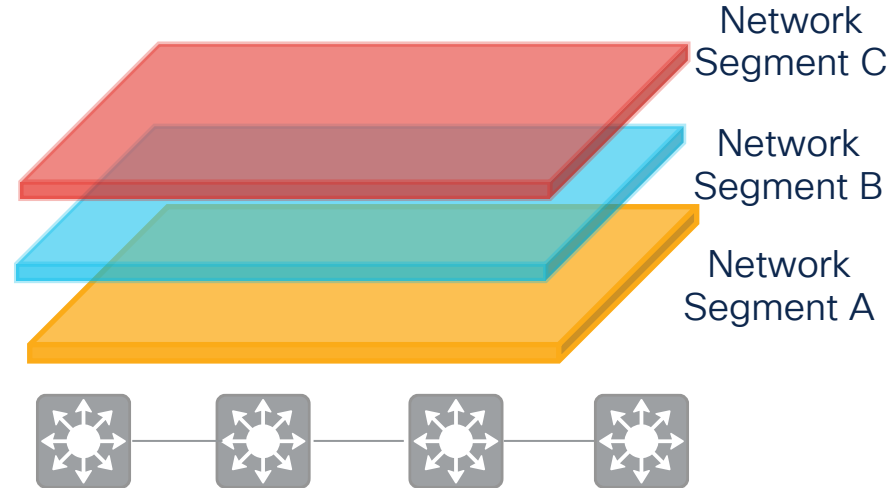


Or simply carry the
segmentation tags in the
overlay?

Fabrics: Why an Overlay?

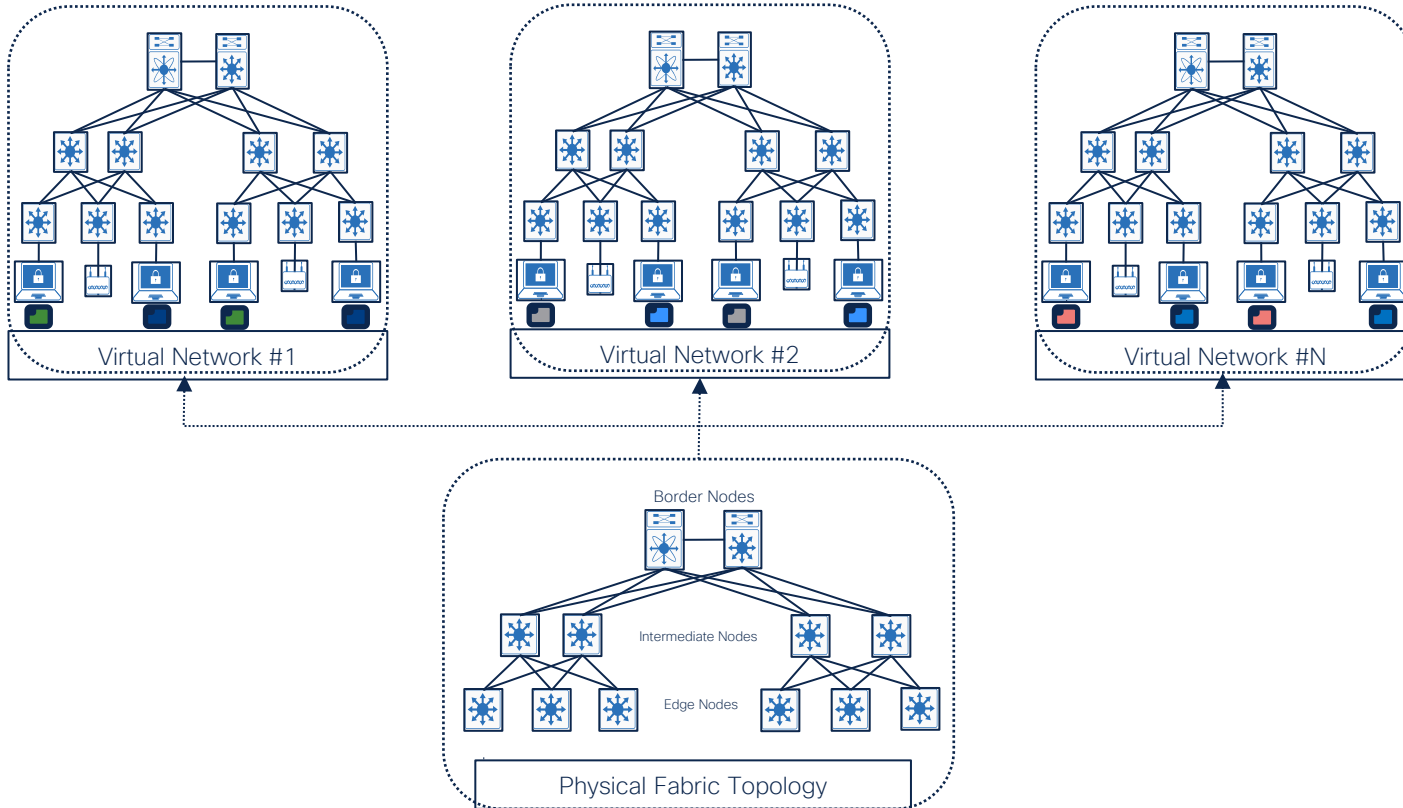


Would you rather configure
network segmentation
hop-by-hop?



Multiple segments in the overlay
that underlay is unaware of!

Fabrics: Virtual and Physical Topologies



Overlay

- Device Connectivity
- Authentication
- Authorization
- Policy
- Segmentation

Underlay

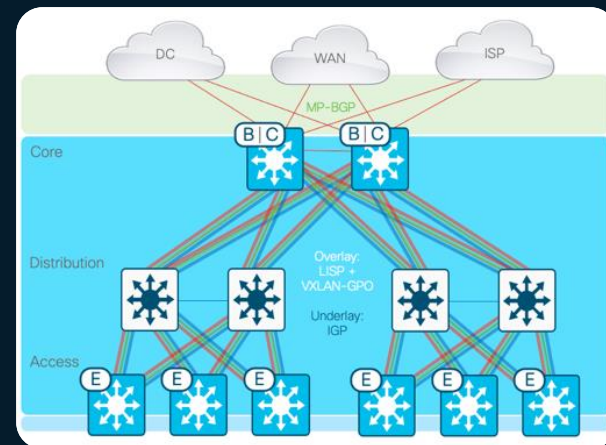
- Predictable
- Low Touch
- Stable
- Simple

Campus Solutions

❖ **MPLS / VPLS**
(L2/L3VPN)

❖ **EVPN + VXLAN**
(L2/L3VNI)

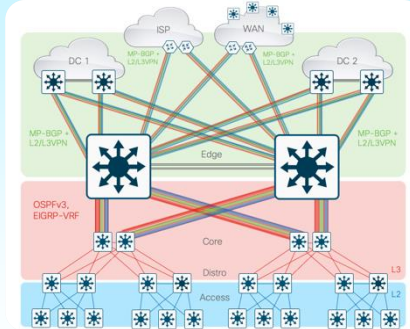
❖ **LISP + VXLAN**
(L2/L3VNI)



Campus Fabric Solutions & Designs

1

MPLS (L2/L3VPN)



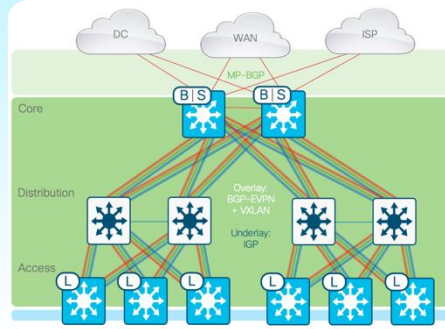
L3 VRF Segmentation

WAN/Edge + VPN Services

MPLS/VPLS, LDP

2

EVPN (L2/L3VNI)

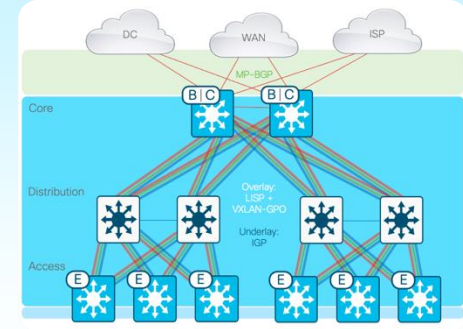


L2/L3 VNI Segmentation
Common WAN/LAN
Services

MP-BGP/EVPN, VXLAN

3

SDA (L2/L3VNI + SGT)



L2/L3 VNI + SGT Segments
LAN + Group-Based Policy

LISP, VXLAN, SGT

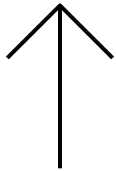


EVPN Border & Spine

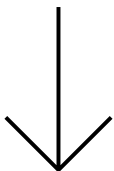
WHAT: Border and Spine connects EVPN Fabric to other network domains.

HOW: Border connects fabric to other network domains. Spine reflects the L2/L3 prefixes providing neighbor peering, learning and distribution point.

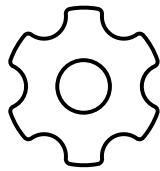
Considerations:



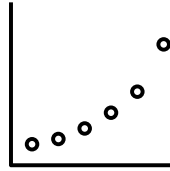
L3



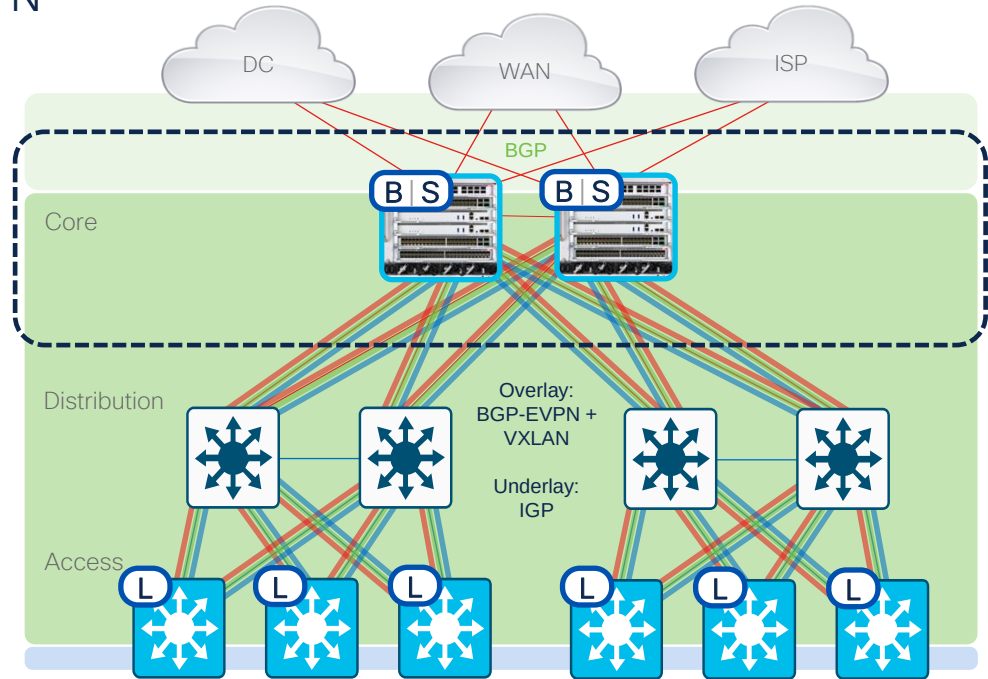
L3



Overlay
Features



High L2/L3
Scale

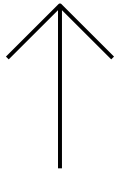


EVPN Leaf

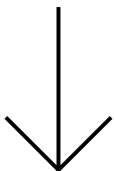
WHAT: Leaf node connects Wired endpoints to EVPN Fabric domain.

HOW: An origination and termination point of VXLAN enabled overlay network to connect wired endpoints.

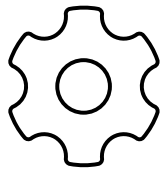
Considerations:



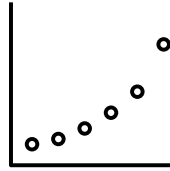
L3



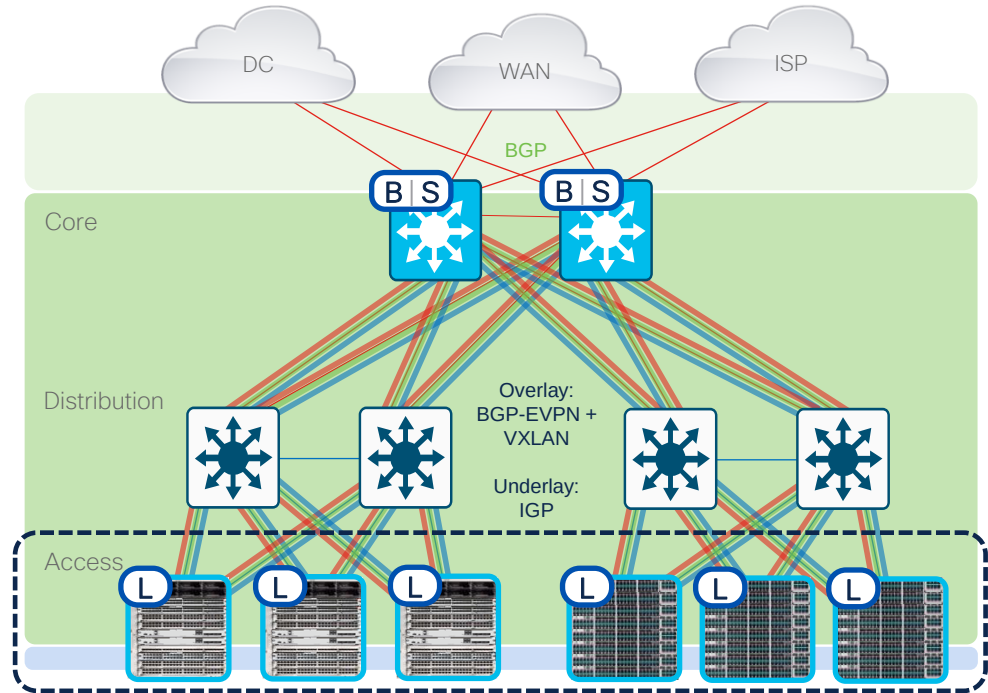
L2



Overlay
Features



Med-High
L2/L3 Scale

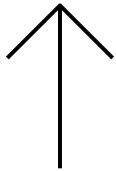


SD-Access Border & Control Plane Node

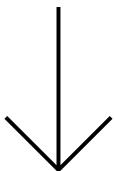
WHAT: Border connects SDA Fabric to other network domains. Control Plane provides forwarding lookup/table.

HOW: Border connects fabric to north bound networks, 'ends' fabric domain. Control is LISP database for lookups.

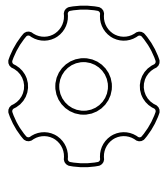
Considerations:



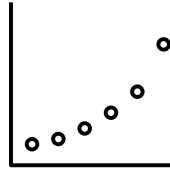
L3



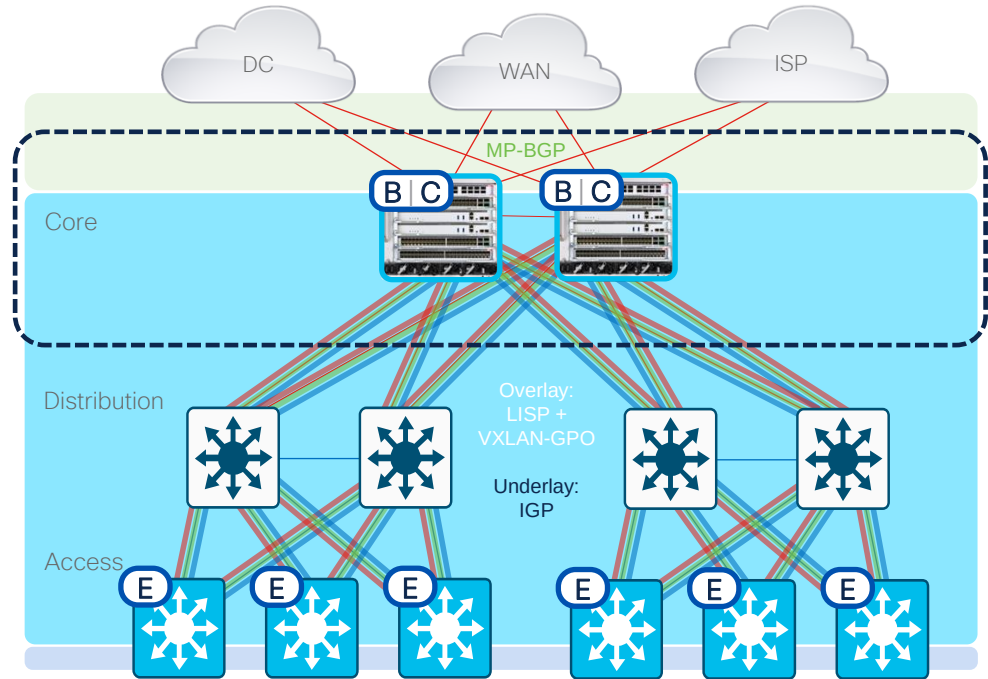
L3



Overlay
Features



Higher
L3 Scale

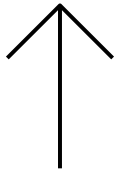


SD-Access Edge Node

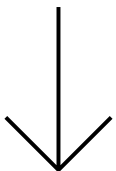
WHAT: Edge connects Wired/Wireless endpoints to SDA Fabric domain/network

HOW: Utilises an Anycast Gateway, and begins SDA fabric encapsulation for Wired and Wireless.

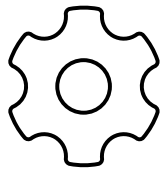
Considerations:



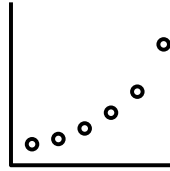
L3



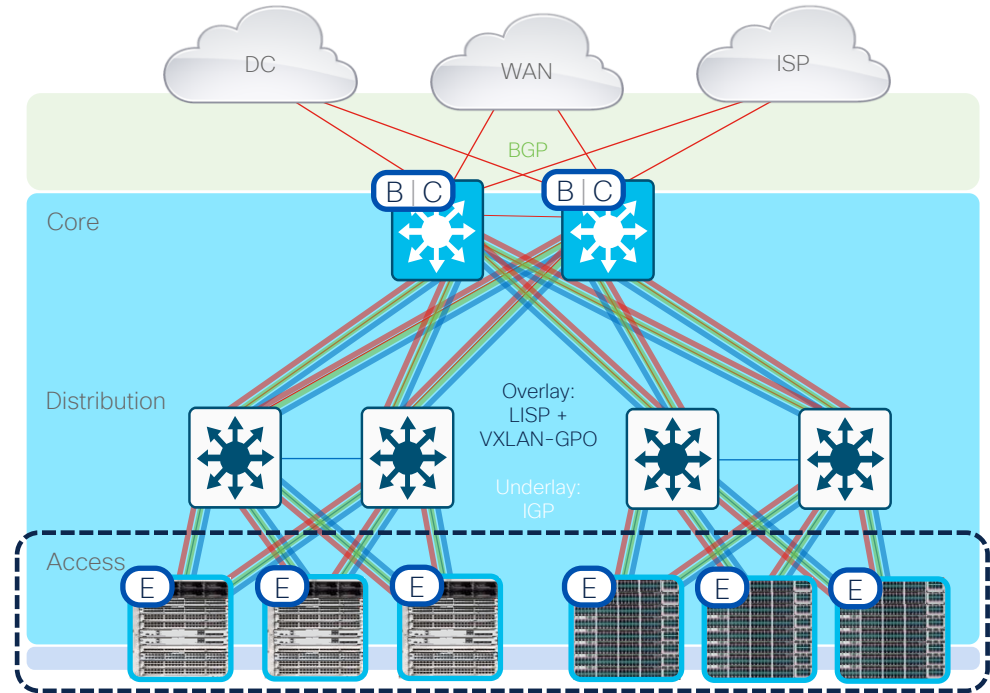
L2



Overlay
Features



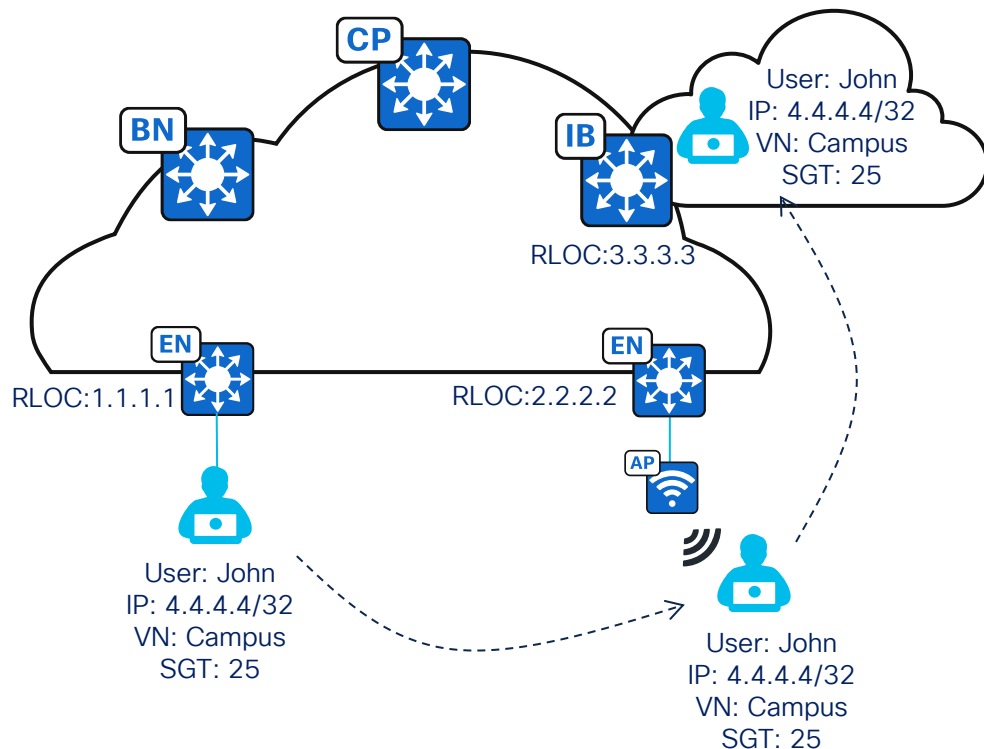
Higher
L3 Scale



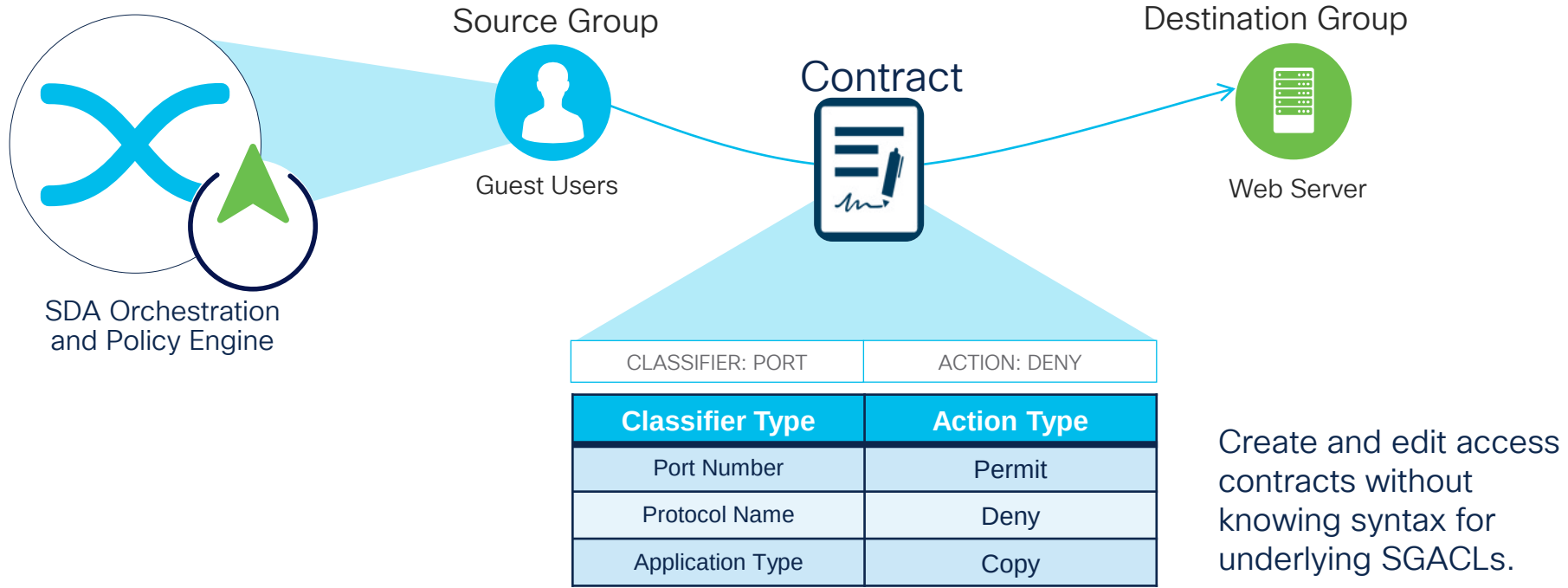
Why consider an SDA architecture?

SDA Control Plane (LISP): User Mobility by Design

Where you are in a network can change, but *who* you are in the network remains the same.

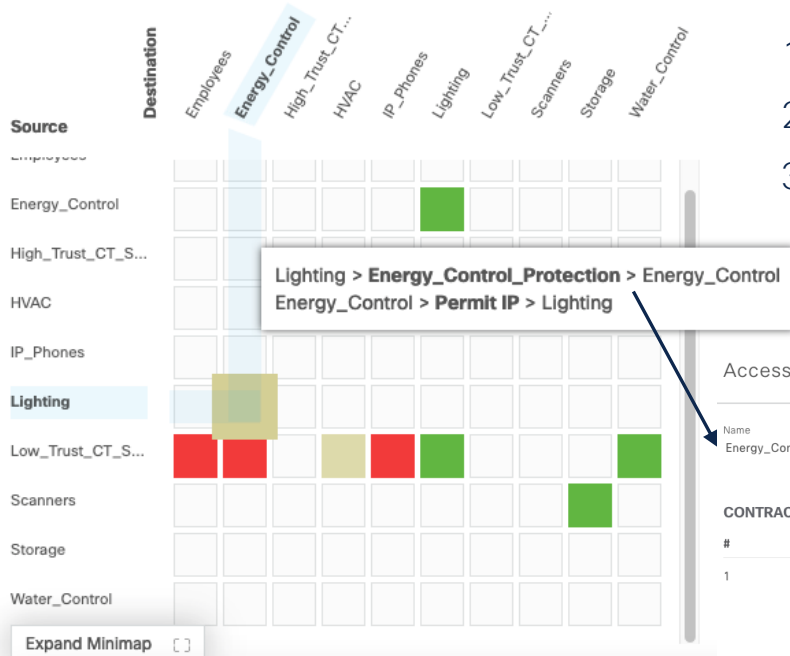


SDA Policy Plane: Group-Based Access Control



SDA Policy Plane: Group-Based Access Control

■ Permit ■ Deny ■ Custom □ Default



1. Select Source Group(s)
2. Select Destination Group(s)
3. Select Access Contract(s)

Access Contract

Name Description

Energy_Control_Protection

CONTRACT CONTENT (1)

#	Action	Application	Transport Protocol	Source / Destination	Port
1	Permit	https	TCP/UDP	Destination	443/443

Default Action Permit

Logging OFF

SDA: Protocol Simplification – Traditional vs Fabric

The *Traditional* Enterprise **Protocol** Stack

MPLS – VPLS – Pseudo Wire – MP-BGP – LDP – SXP – Sub Interfaces
VRF – VRF Lite

802.1w (PVST+) – 802.1s (Rapid STP) – BPDU Guard – Root Guard – Loop Guard – VLANs – VTP – EtherChannel – SVI's – HSRP – VSS – 802.1Q
Portfast – VSL – Dual Active Detection – SGT – Port Channel – IGMP

Macro

VRFs

Micro

VLANs

Micro

Per Distribution

Policy

IP ACLs

Deploy

Manual & Inconsistent

Wired/Wireless

Disparate

cisco *Live!*

NEW Enterprise Protocol *Stack* with **SDA**

ISIS – VXLAN – LISP

Macro

VNs

Micro

SGTs

Micro

Campus Wide

Policy

SG ACL

Deploy

Automated & Consistent

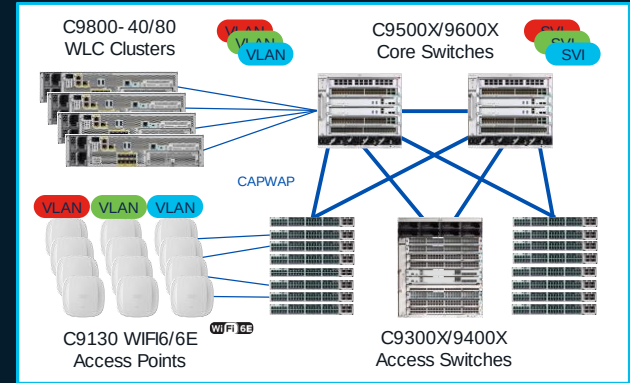
Wired/Wireless

Unified

Wireless & Security Considerations

Wireless & Firewall

- ❖ Central Wireless
- ❖ Firewalls, VRFs & ACLs

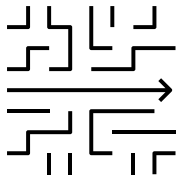


Wireless LAN

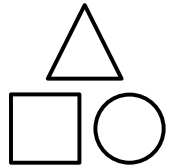
WHAT: Connecting APs centrally to one or multiple WLC. Thus, connecting Wireless Endpoints to the network

HOW: Tunnel L2 Overlay (CAPWAP)

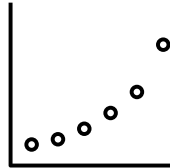
Considerations:



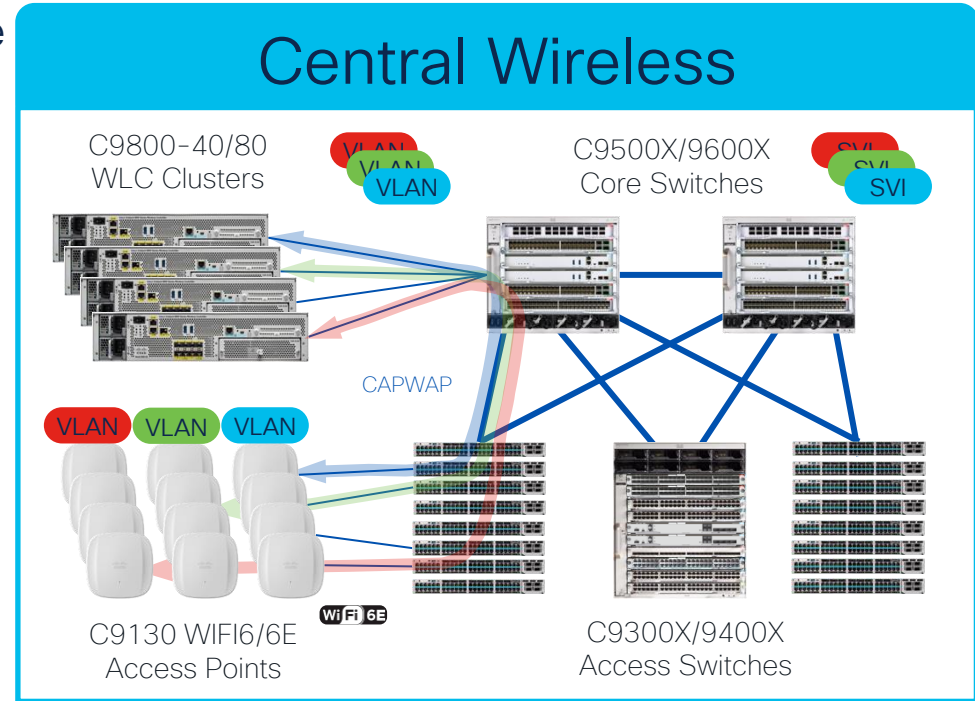
Pros/Cons
of Central



L2 WLAN
Features



Higher
L2/L3
Scale

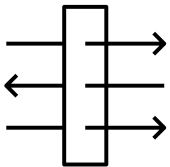


Firewalls, VRFs & ACLs

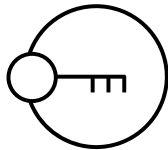
WHAT: Controlling access into or out of network areas. To prevent unauthorized access to different network segments.

HOW: Segmentation and Access Control as well as Inspection

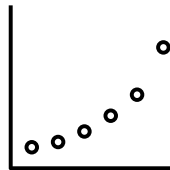
Considerations:



Inside & Outside

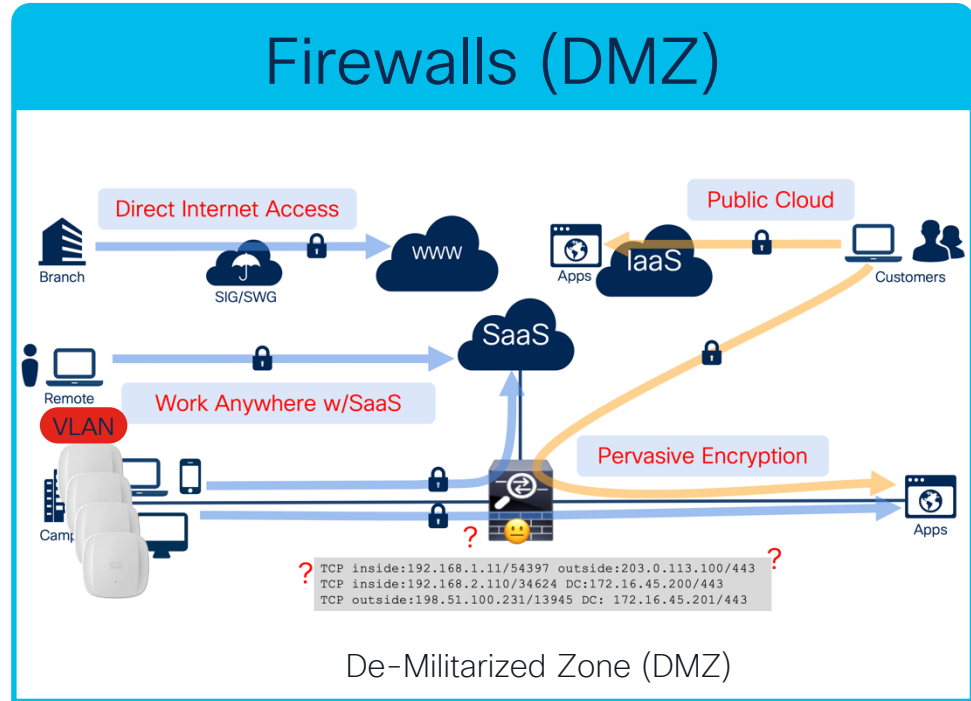


L2/L3 & L4-7 features

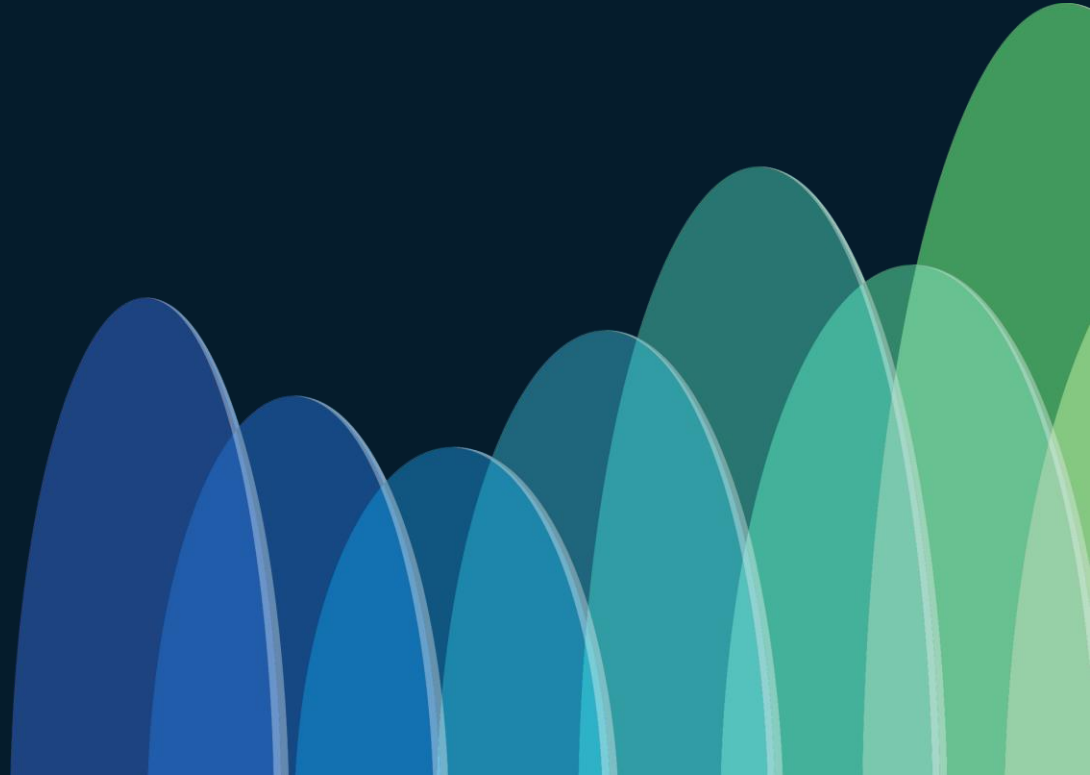


Med to High L2/L3 Scale

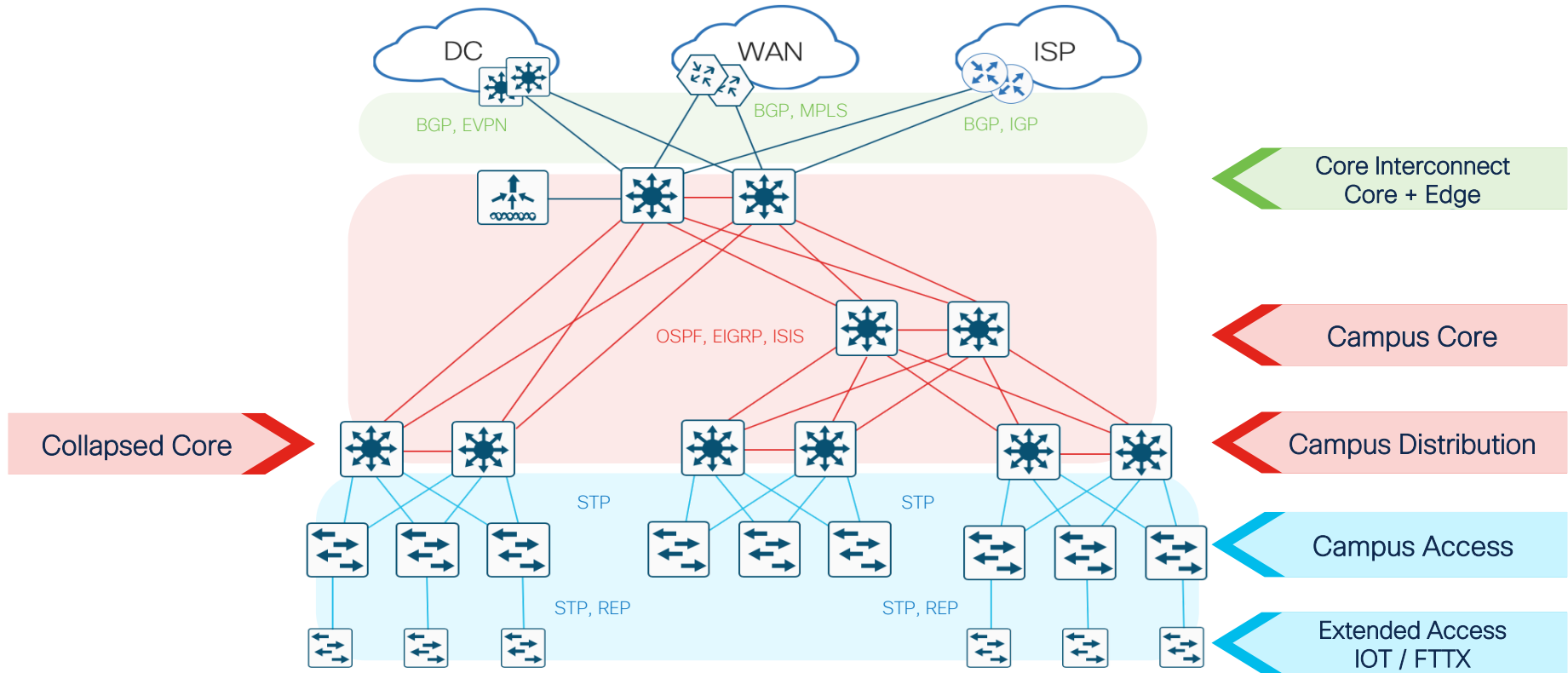
CISCO Live!



Summary & References

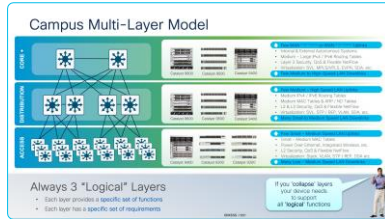


Remember: Campus PINs & Topology

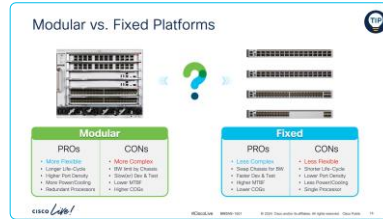


Remember: Campus Design Fundamentals

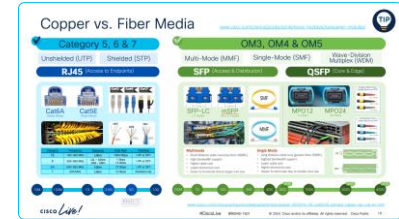
Collapse or Expand Layers?



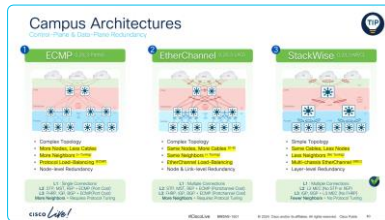
Modular or Fixed Platforms?



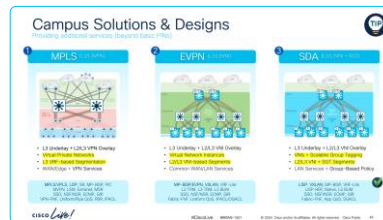
Fiber or Copper Links?



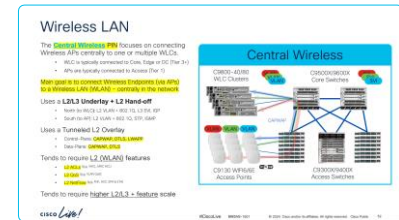
ECMP, EtherChannel or Stacking?



L2/L3 or MPLS or VXLAN?



Wireless or Security Included?



Keep Learning – Deeper Dive Sessions at CL

BRKENS-2188 – Tuesday, 4:15 PM – 5:45 PM AEDT – Room 219

Classical Three-Tier Architecture to BGP EVPN Campus Architecture: Evolution and Implementation

Switching:

BRKENS-2095 – Wednesday, 8:30 AM – 10:00 AM AEDT – Room 204

Designing Highly Available Networks Using Catalyst 9000 Switches

BRKEWN-1107 – Tuesday, 1:00 PM – 2:30 PM AEDT – Room 211

Cut the Cord: Design Principles to Deliver a Wireless-First Enterprise

Wireless:

BRKEWN-2104 – Wednesday, 1:00 PM – 2:30 PM AEDT – Room 211

Understanding Wireless Security and the Implications for Secure Wireless Network Design

BRKENS-2824 – Wednesday, 8:30 AM – 10:00 AM AEDT – Room 203

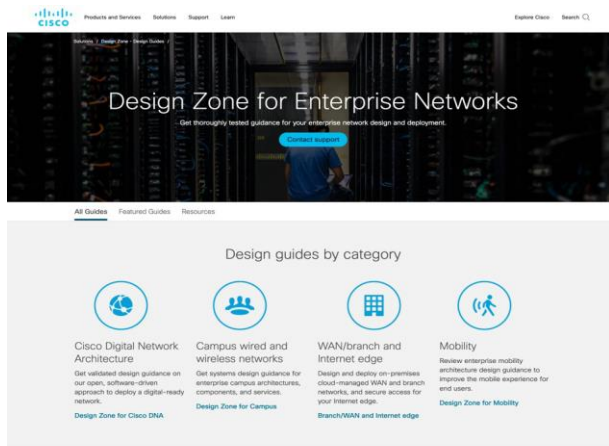
Deploying Your First Cisco SD-Access Project

SDA:

BRKENS-2700 – Wednesday, 3:00 PM – 4:00 PM AEDT – Room 219

Fabric Based Networking: What's the Fuss and What Are the Choices?

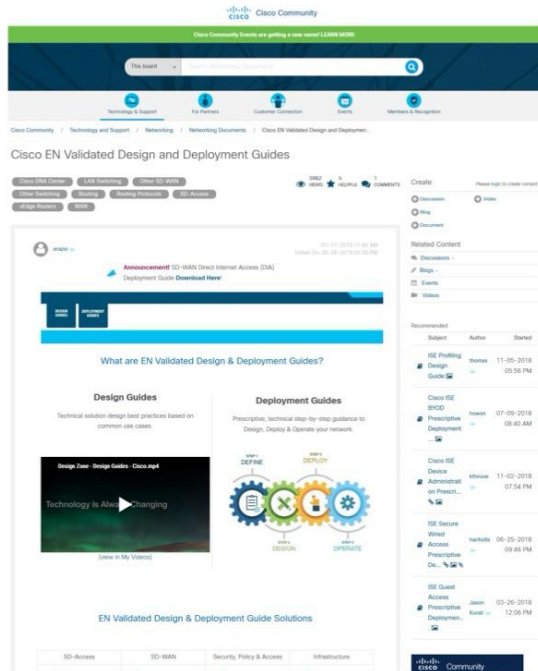
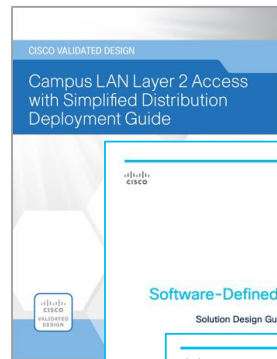
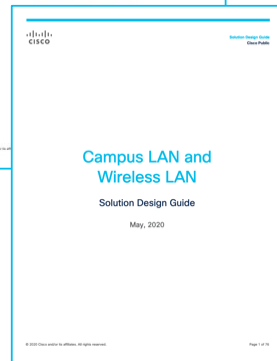
Keep Learning – Cisco Validated Design



Software-Defined Access
Design, provision, apply policy, and provide wired and wireless network assurance with a secure, intelligent campus fabric.
Software-Defined Access - Solution Design Guide
Software-Defined Access Management Infrastructure Deployment Guide
SD-Access Deployment Guide
SD-Access Segmentation Design Guide(PDF - 2.4 MB)



Software-Defined WAN
Use SD-WAN capabilities to deploy branches more quickly and deliver a great user experience.
SD-WAN Design Guide >



Keynote Deep Dives

Wednesday
10:30am – 11:30am



Experiences Amplified:
How AI Can Fuel
Better Employee
and Customer
Experiences

Level 1
Room 106



Smart, Secure,
Seamless:
Transforming
Experiences with
Next-Generation
Networking

Level 2
Room 204



Harness a Bold
New Era:
Transform Data
Centre and
Service Provider
Connectivity

Level 2
Room 203



Securing User to
Application and
Everything in
Between

Level 2
Melbourne Room 2



Unlocking
Digital Resilience
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- Visit the Cisco Networking Stands for related demos
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- Attend the interactive education with DevNet, Capture the Flag, and Walk-in Labs
- Visit the On-Demand Library for more sessions at www.CiscoLive.com/on-demand

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Thank you

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