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Next Generation Campus Architectures

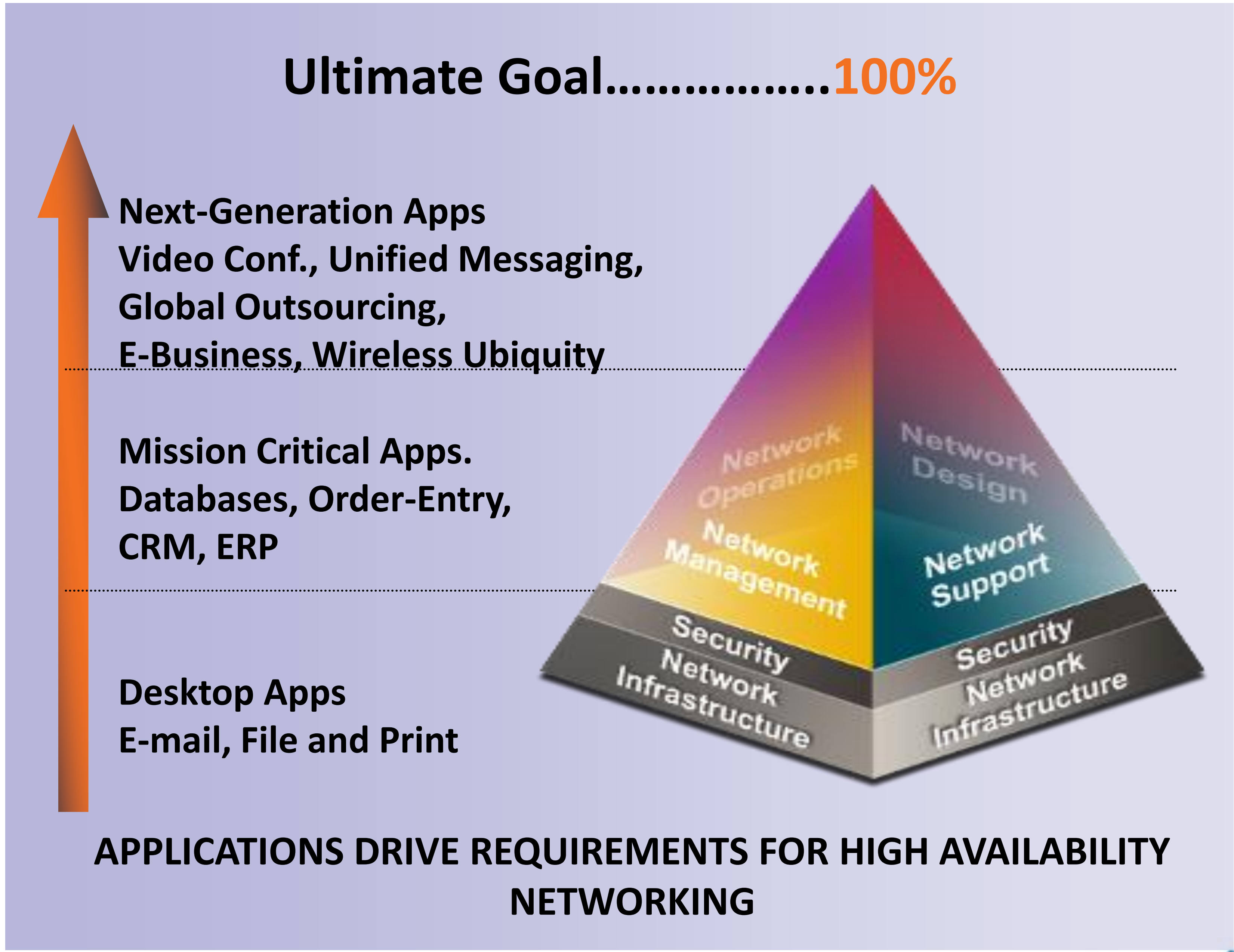
BRKCRS-2663

TOMORROW starts here.

Enterprise-Class Availability

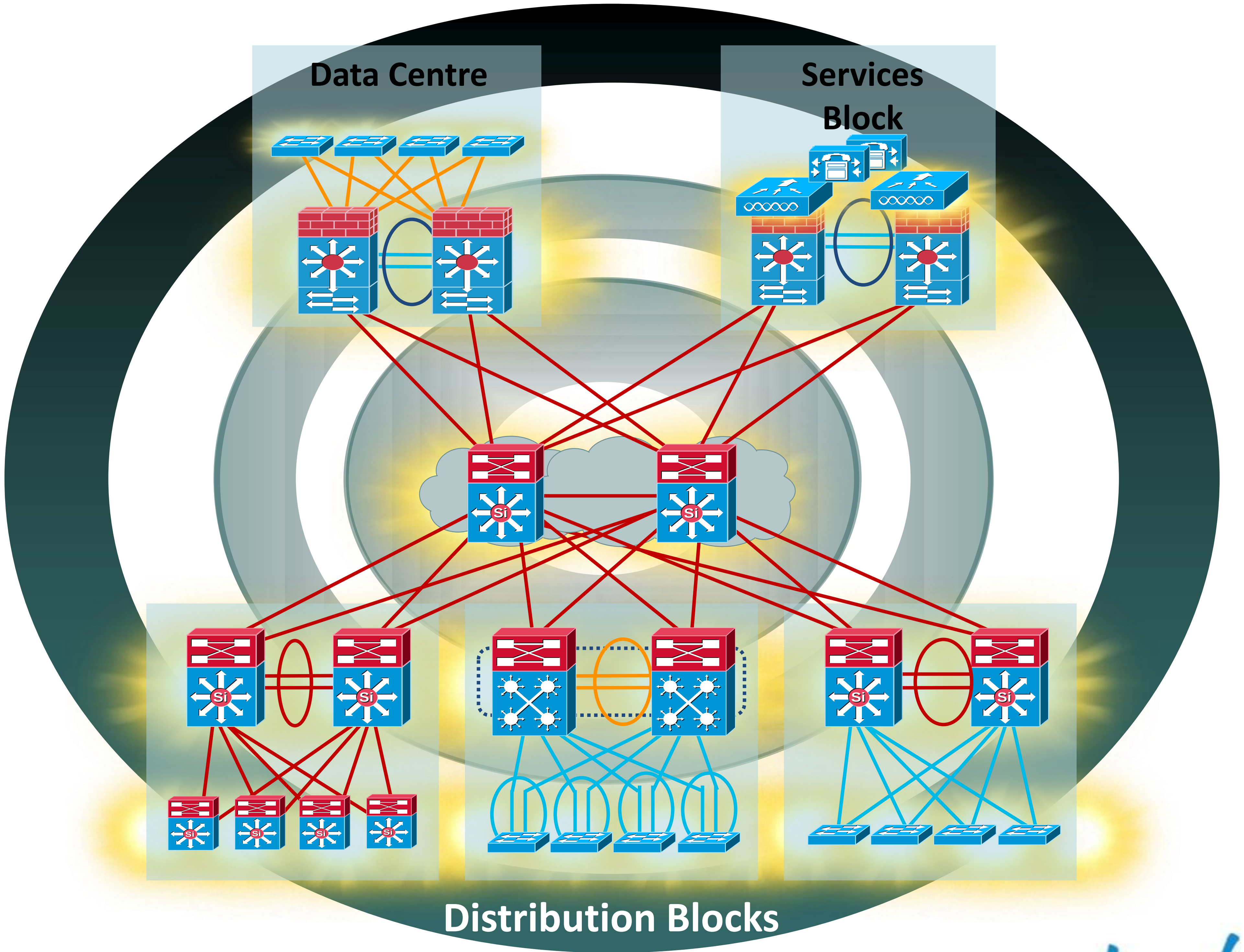
Resilient Campus Communication Fabric

- Network-level redundancy
- System-level resiliency
- Operational resiliency
- Human ear notices the difference in voice within 150–200 msec
- Video loss is even more noticeable
- 200-msec end-to-end campus convergence



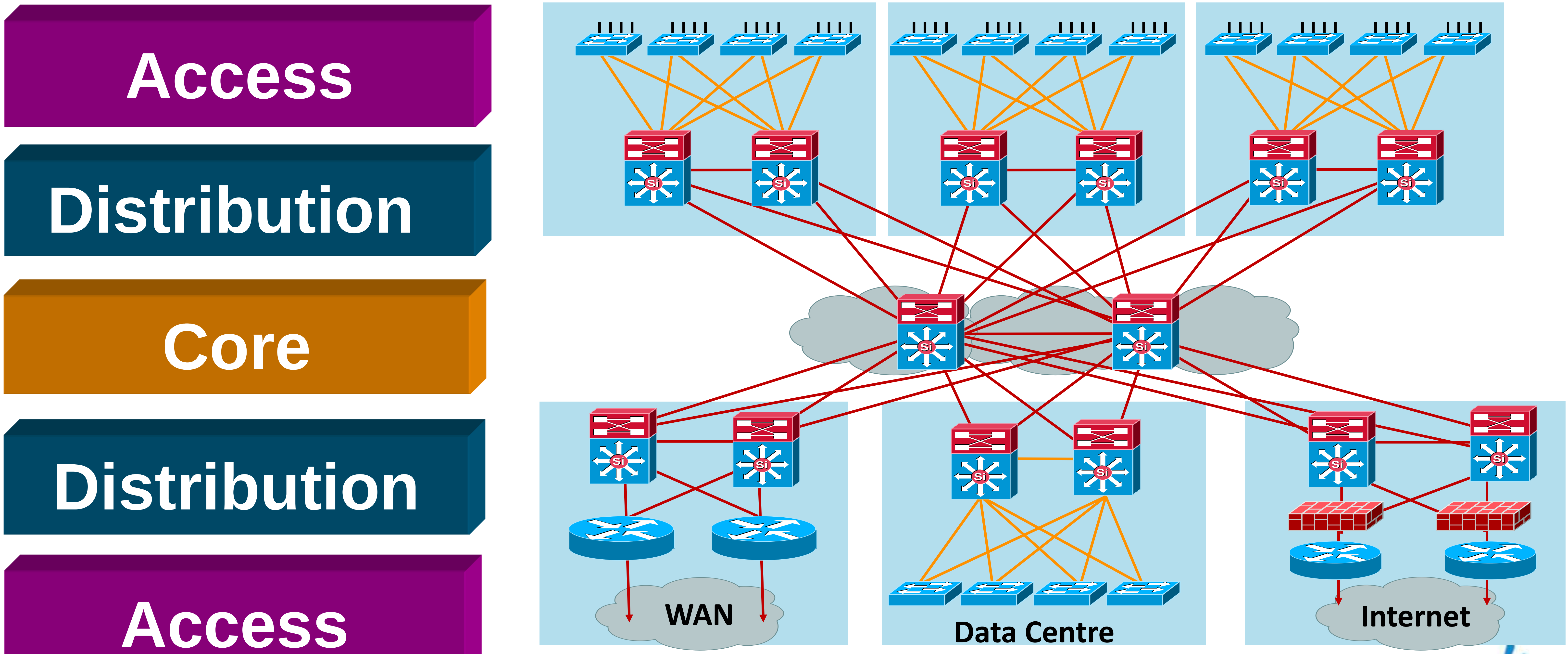
Agenda

- Multilayer Campus Design Principles
- Foundation Services
- Campus Design Best Practices
- Virtualisation techniques
- Security considerations
- What's next….
- Summary



High-Availability Campus Design

Structure, Modularity, and Hierarchy



Hierarchical Network Design

Without a Rock Solid Foundation the Rest Doesn't Matter

Access

Distribution

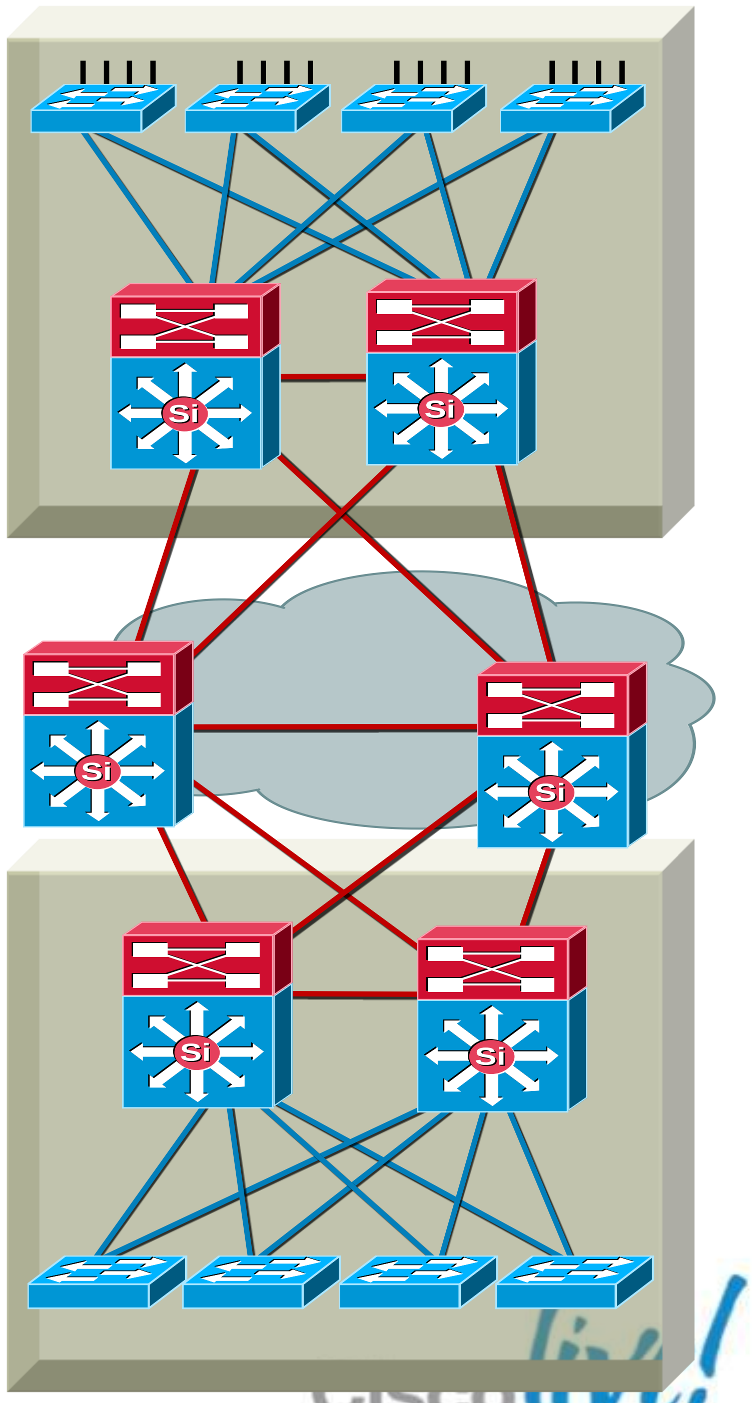
Core

Distribution

Access

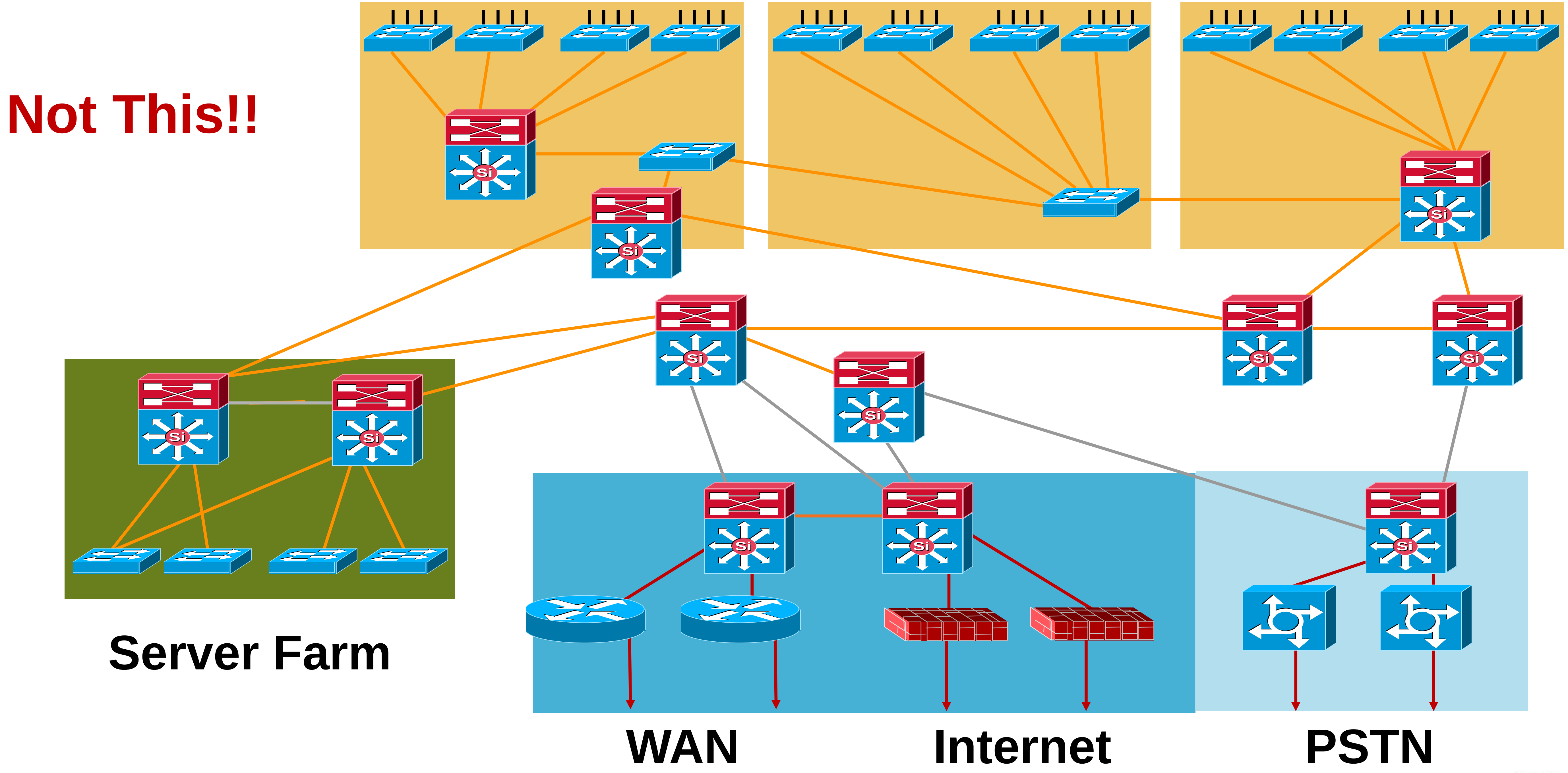
- Offers hierarchy - each layer has specific role
- Modular topology - building blocks
- Easy to grow, understand, and troubleshoot
- Creates small fault domains - clear demarcations and isolation
- Promotes load balancing and redundancy
- Promotes deterministic traffic patterns
- Incorporates balance of both Layer 2 and Layer 3 technology, leveraging the strength of both
- Utilises Layer 3 routing for load balancing, fast convergence, scalability, and control

Building Block



Hierarchical Campus Network

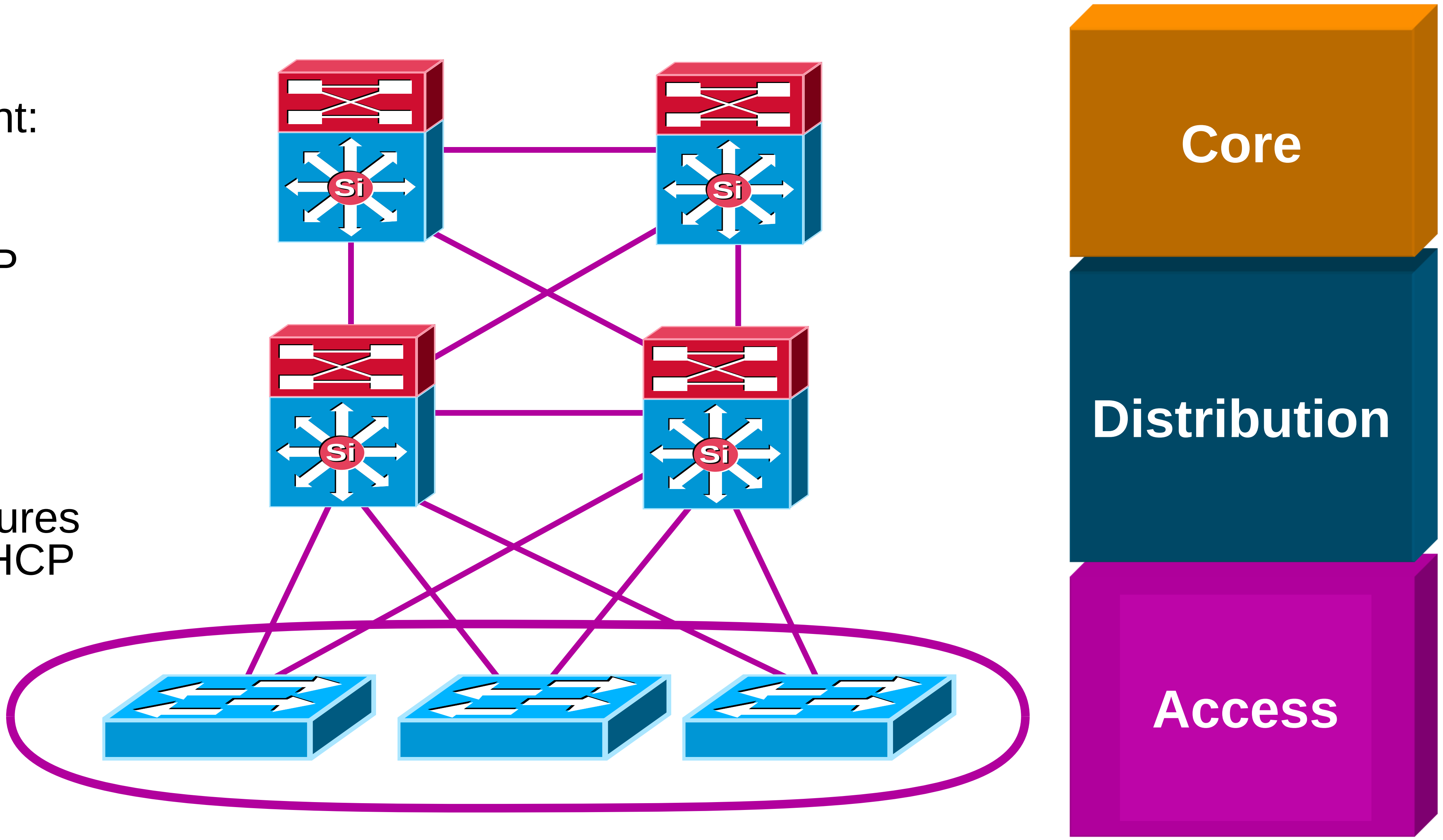
Structure, modularity and hierarchy



Access Layer

Feature rich environment

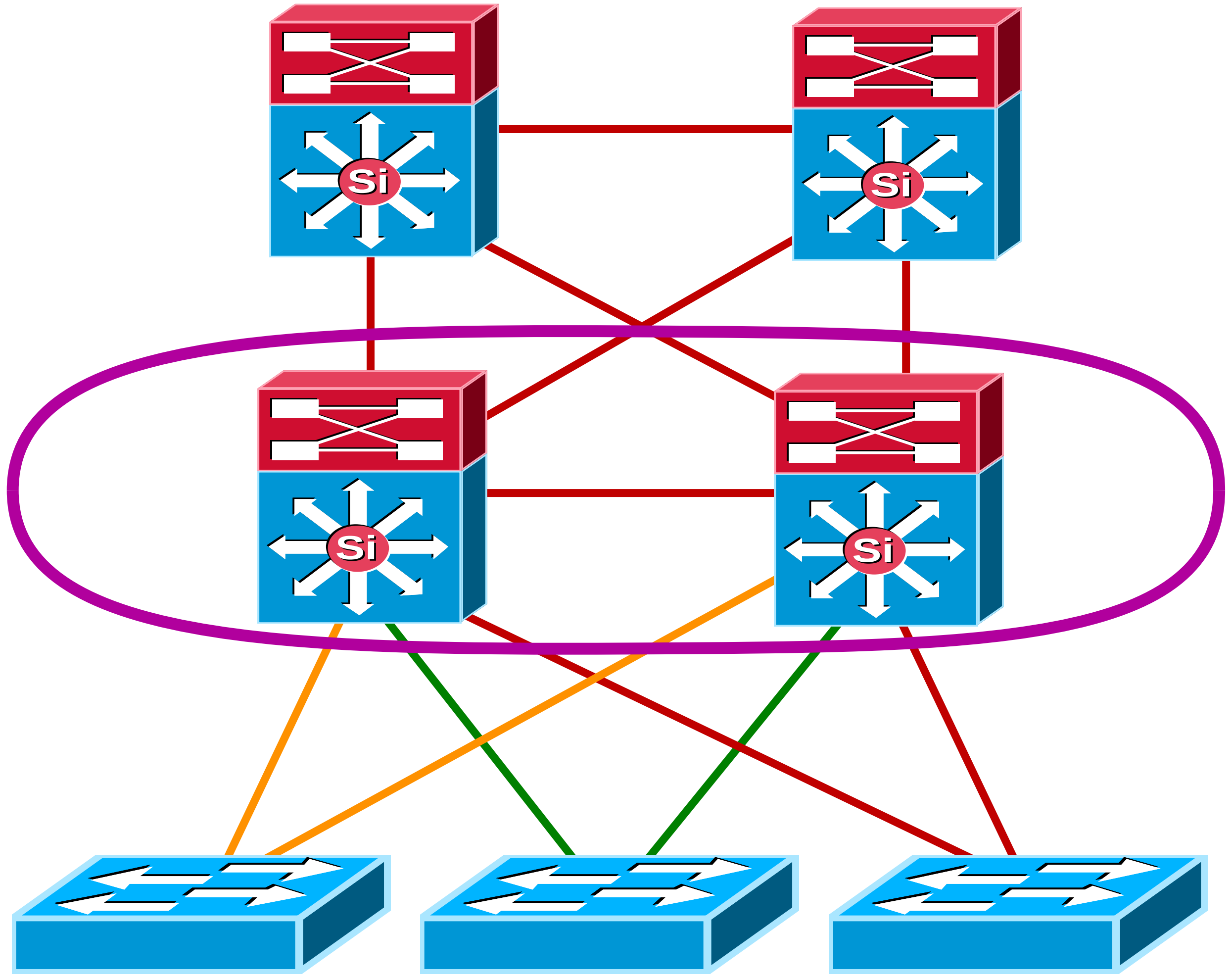
- It's not just about connectivity
- Layer 2/Layer 3 feature rich environment: convergence, HA, security, multicast
- Intelligent network services: QoS, trust boundary, broadcast suppression, IGMP snooping
- Intelligent network services: PVST+, Rapid PVST+, EIGRP, OSPF, DTP, PAgP/LACP, UDLD, FlexLink, etc.
- Cisco Catalyst® integrated security features IBNS (802.1x), (CISF): port security, DHCP snooping, DAI, IPSG, etc.
- Automatic phone discovery, conditional trust boundary, PoE, auxiliary VLAN, etc.
- Spanning tree toolkit: PortFast, UplinkFast, BackboneFast, LoopGuard, BPDU Guard, BPDU Filter, RootGuard, etc.



Distribution Layer

Policy, convergence, QoS and high availability

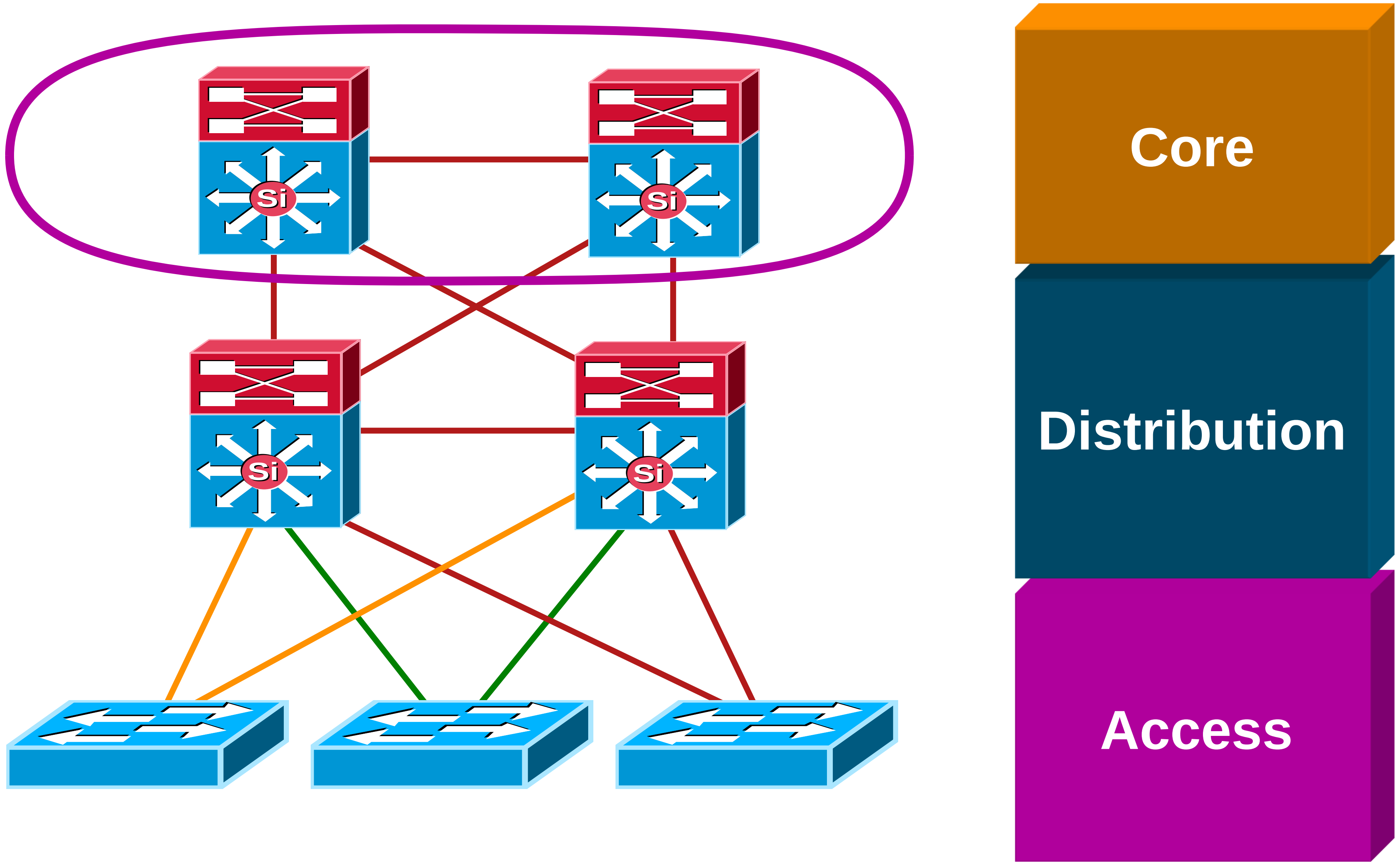
- Availability, load balancing, QoS and provisioning are the important considerations at this layer
- Aggregates wiring closets (access layer) and uplinks to core
- Protects core from high density peering and problems in access layer
- Route summarisation, fast convergence,
redundant path load sharing
- HSRP or GLBP to provide first hop redundancy



Core Layer

Scalability, high availability and fast convergence

- Backbone for the network—connects network building blocks
- Performance and stability vs. complexity— less is more in the core
- Aggregation point for distribution layer
- Separate core layer helps in scalability during future growth
- Keep the design technology-independent

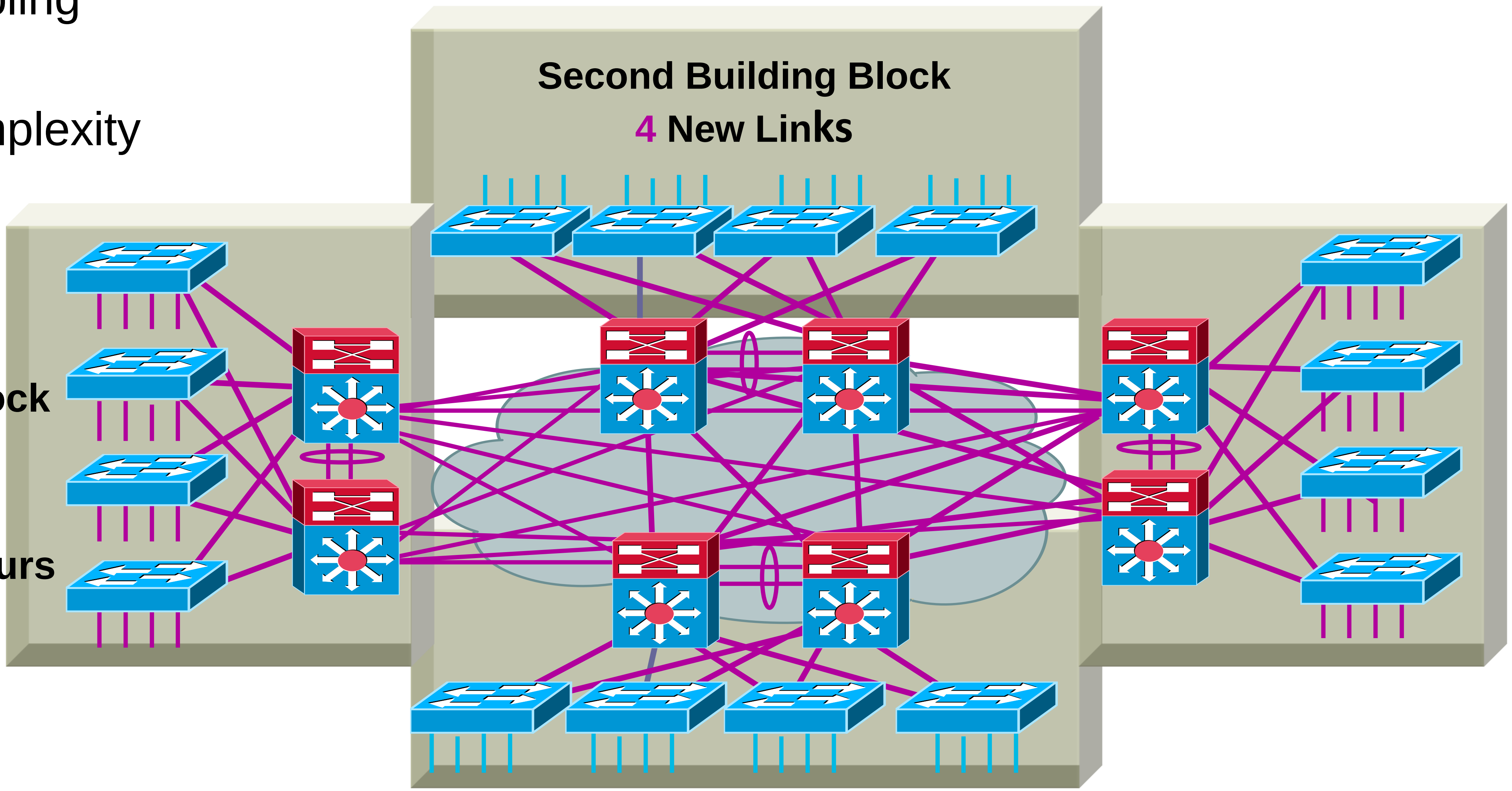


Do I Need a Core Layer?

It’s really a question of scale, complexity and convergence

No Core

- Fully-meshed distribution layers
- Physical cabling requirement
- Routing complexity

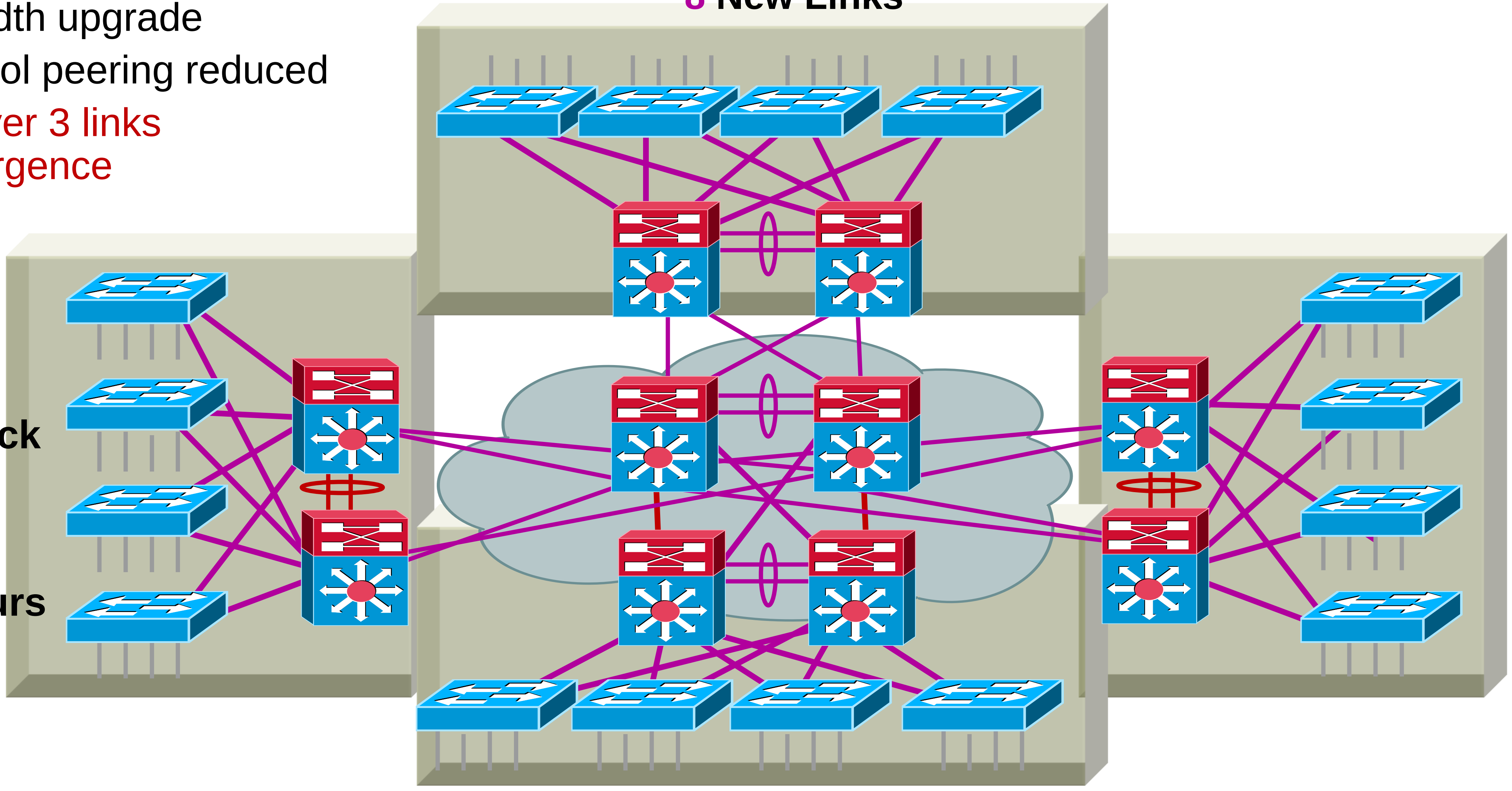


Do I Need a Core Layer?

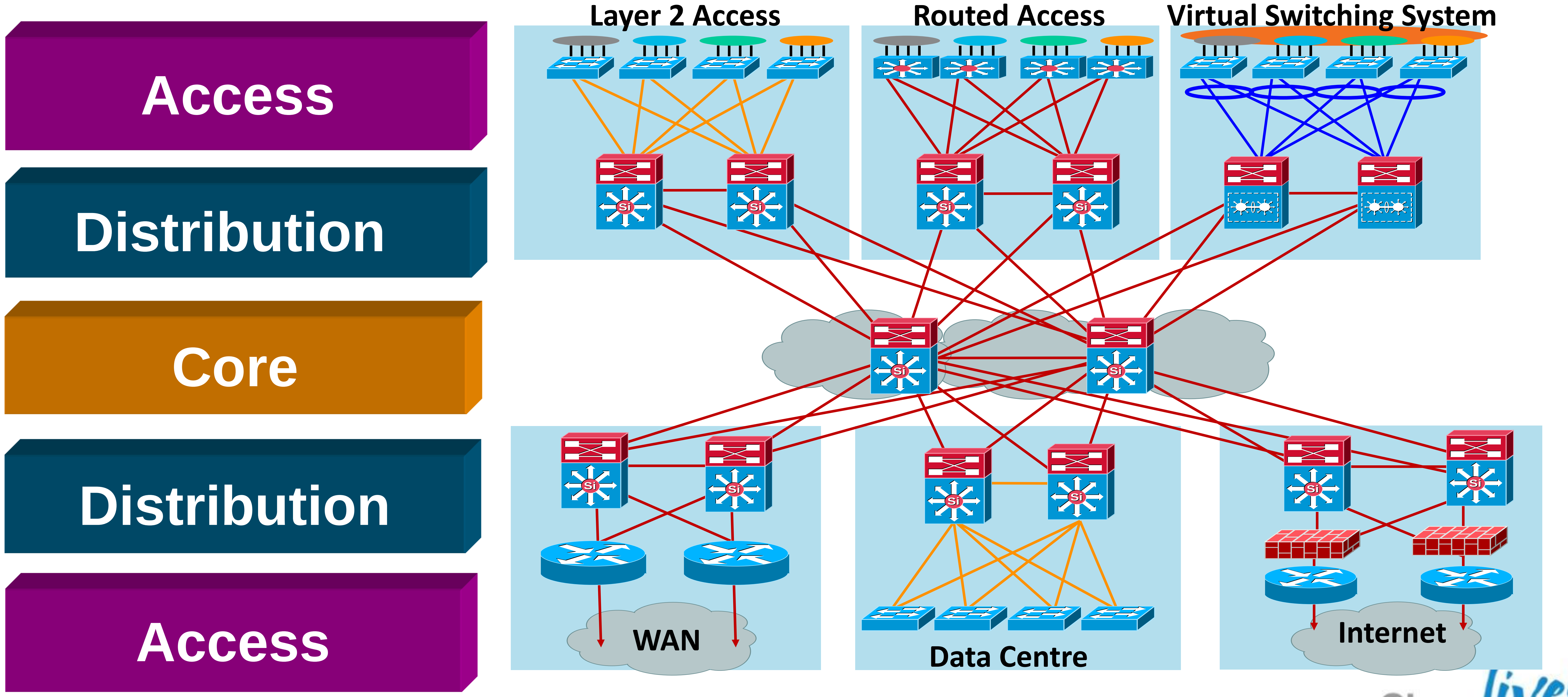
It's really a question of scale, complexity and convergence

Dedicated Core Switches

- Easier to add a module
- Fewer links in the core
- Easier bandwidth upgrade
- Routing protocol peering reduced
- Equal cost Layer 3 links for best convergence



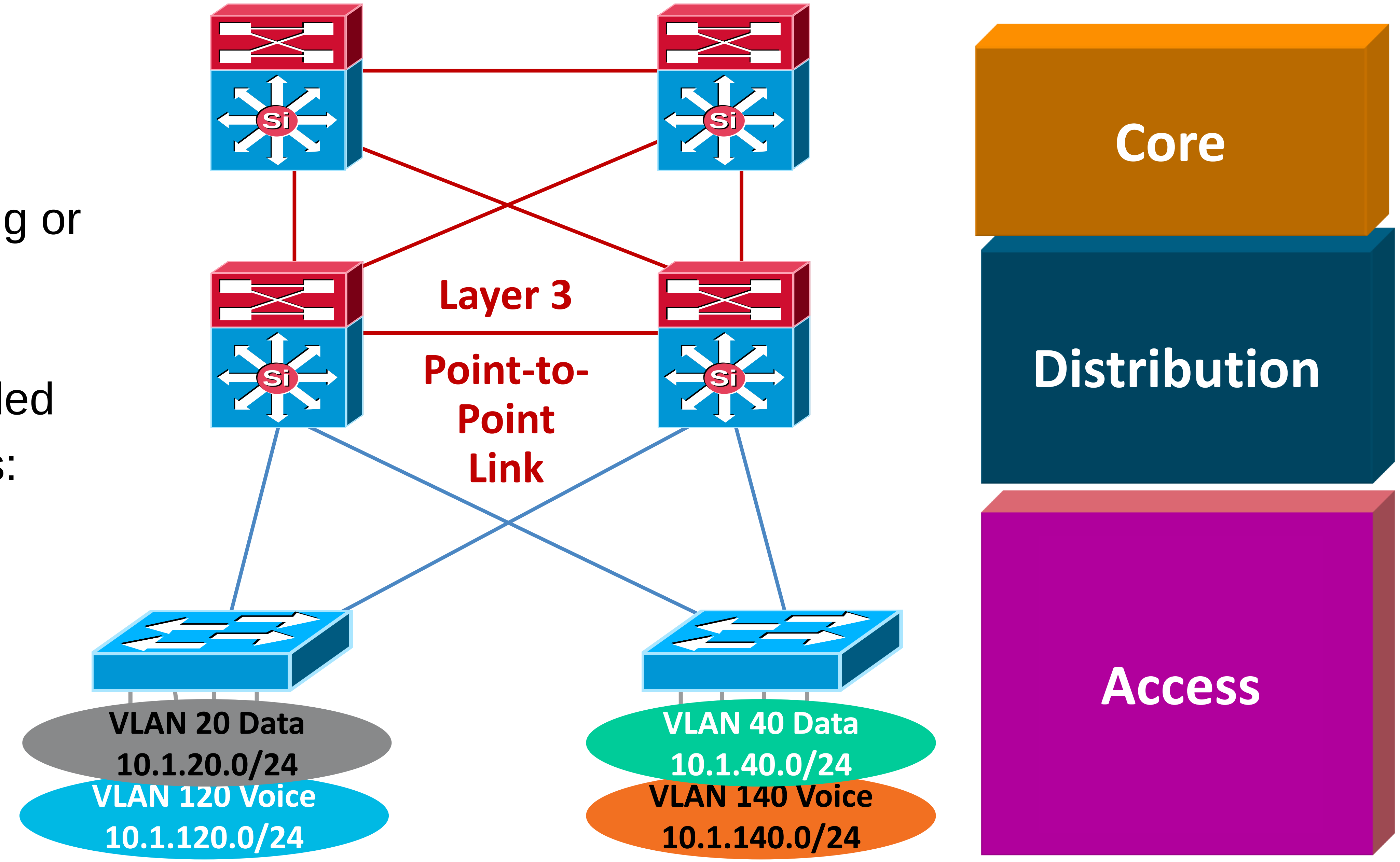
Design Alternatives Within a Building Block



Layer 3 Distribution Interconnection

Layer 2 Access – No VLANs span access layer

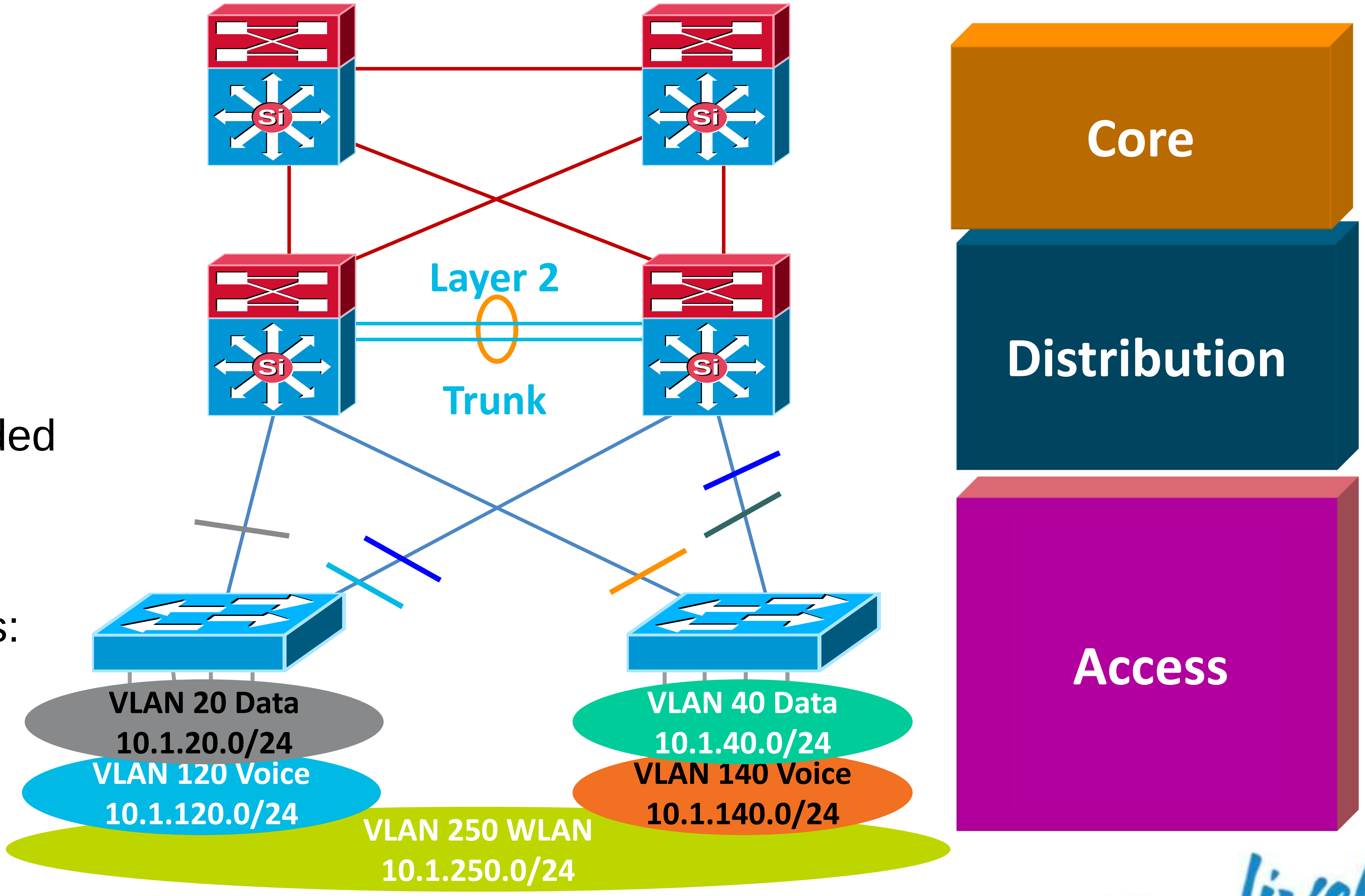
- Tune CEF load balancing
- Summarise routes towards core
- Limit redundant IGP peering
- STP Root and HSRP primary tuning or GLBP to load balance on uplinks
- Set trunk mode on/no-negotiate
- Disable EtherChannel unless needed
- Set port host on access layer ports:
  - Disable trunking
  - Disable EtherChannel
  - Enable PortFast
- RootGuard or BPDU-Guard
- Use security features



Layer 2 Distribution Interconnection

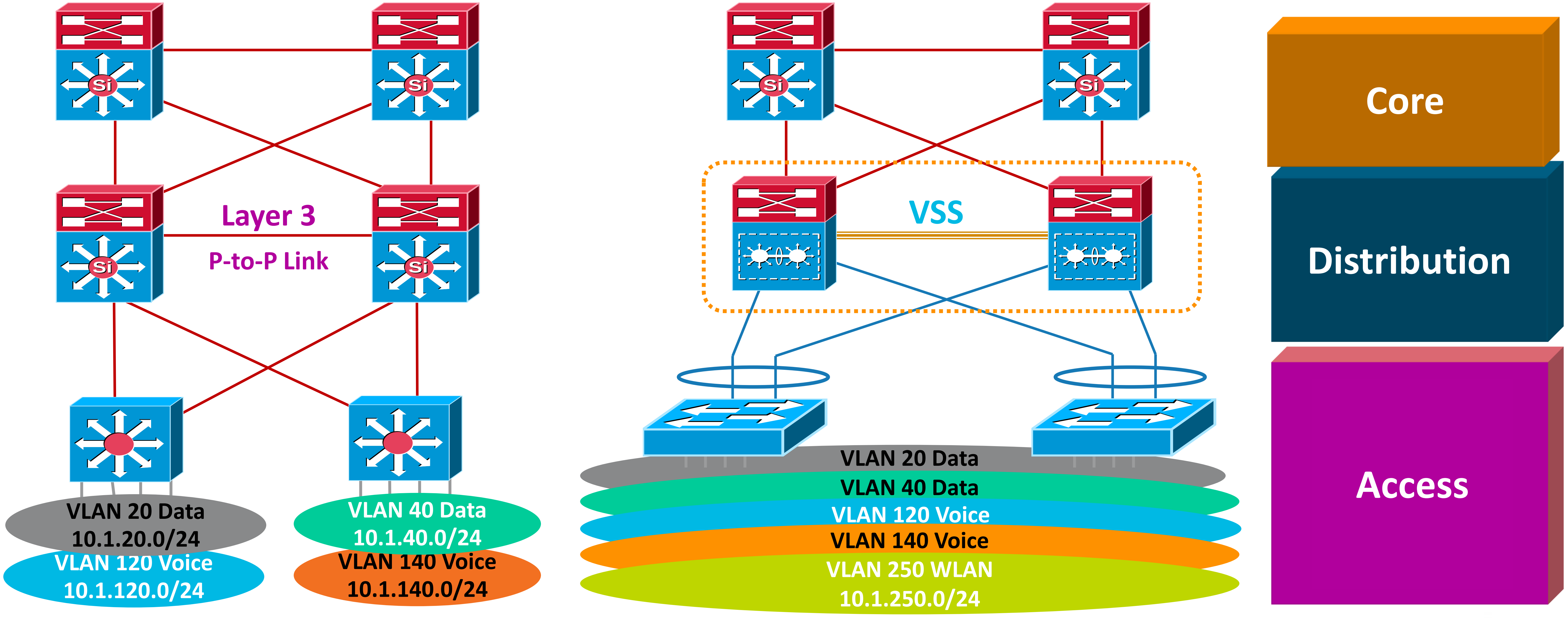
Layer 2 Access – Some VLANs span access layer

- Tune CEF load balancing
- Summarise routes towards core
- Limit redundant IGP peering
- STP Root and HSRP primary or GLBP and STP port cost tuning to load balance on uplinks
- Set trunk mode on/no-negotiate
- Disable EtherChannel unless needed
- RootGuard on downlinks
- LoopGuard on uplinks
- Set port host on access layer ports:
  - Disable trunking
    Disable EtherChannel
    Enable PortFast
- RootGuard or BPDU-Guard
- Use security features



Routed Access and VSS

Evolutions and improvements to existing designs



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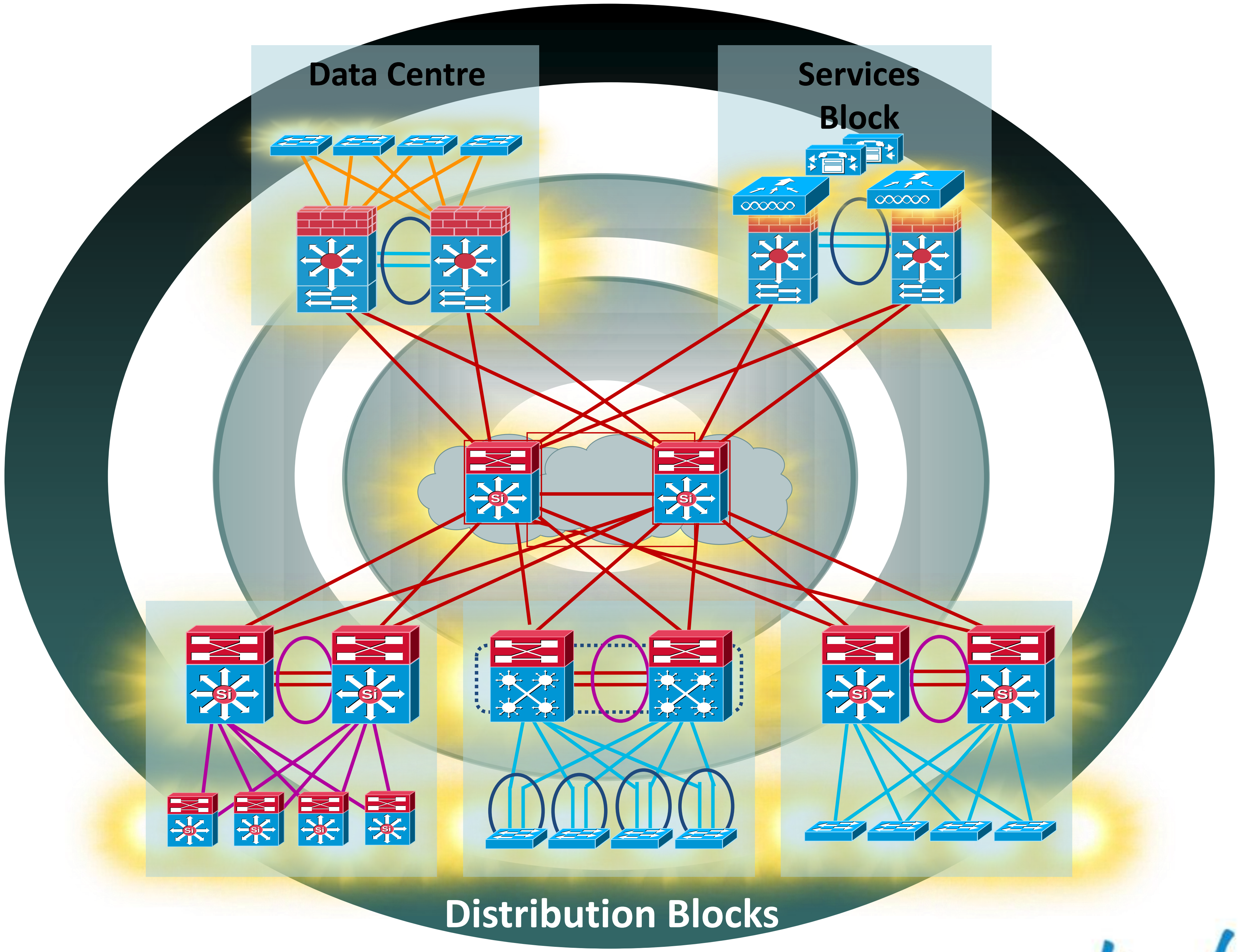
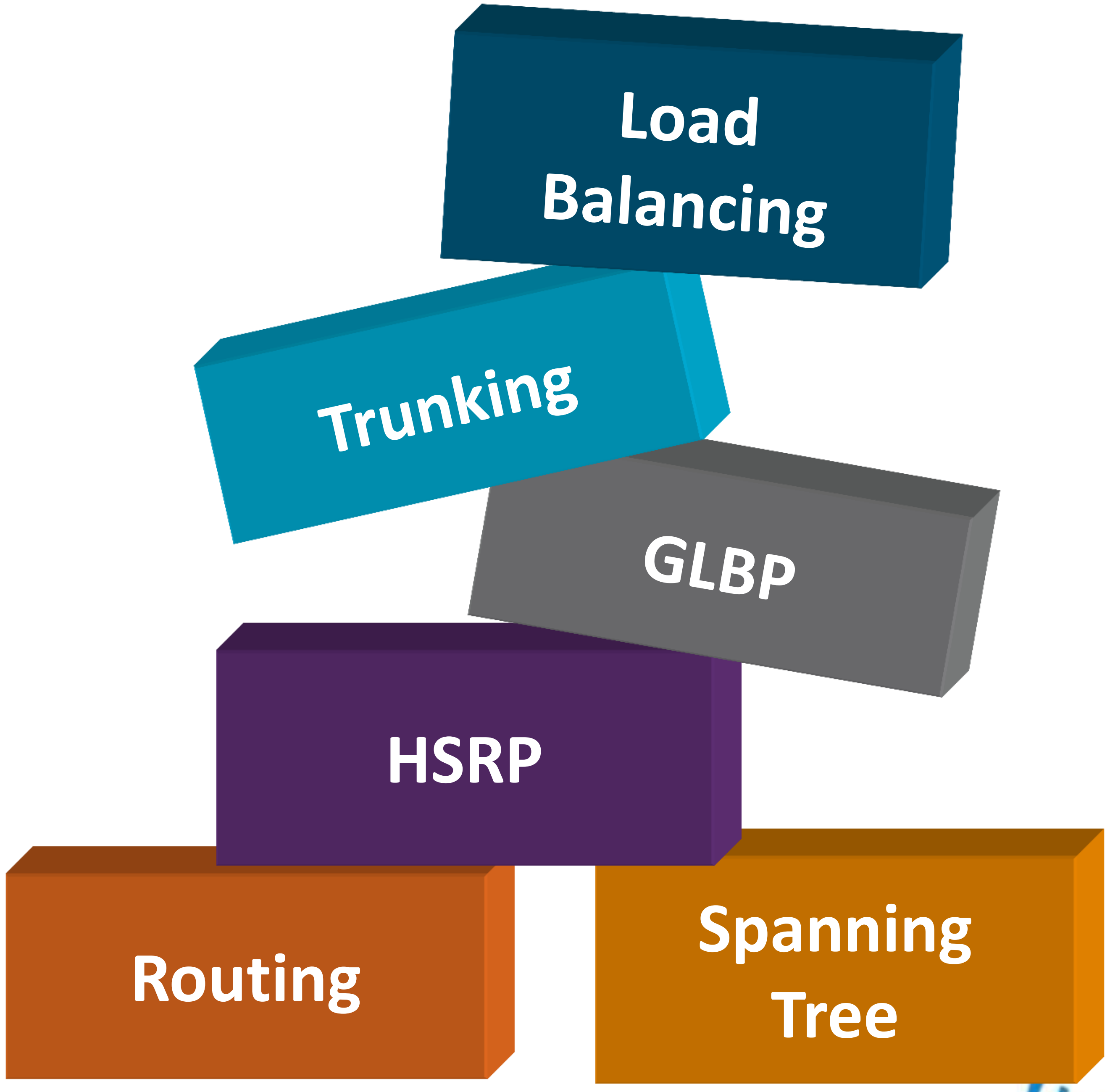


Foundation Services

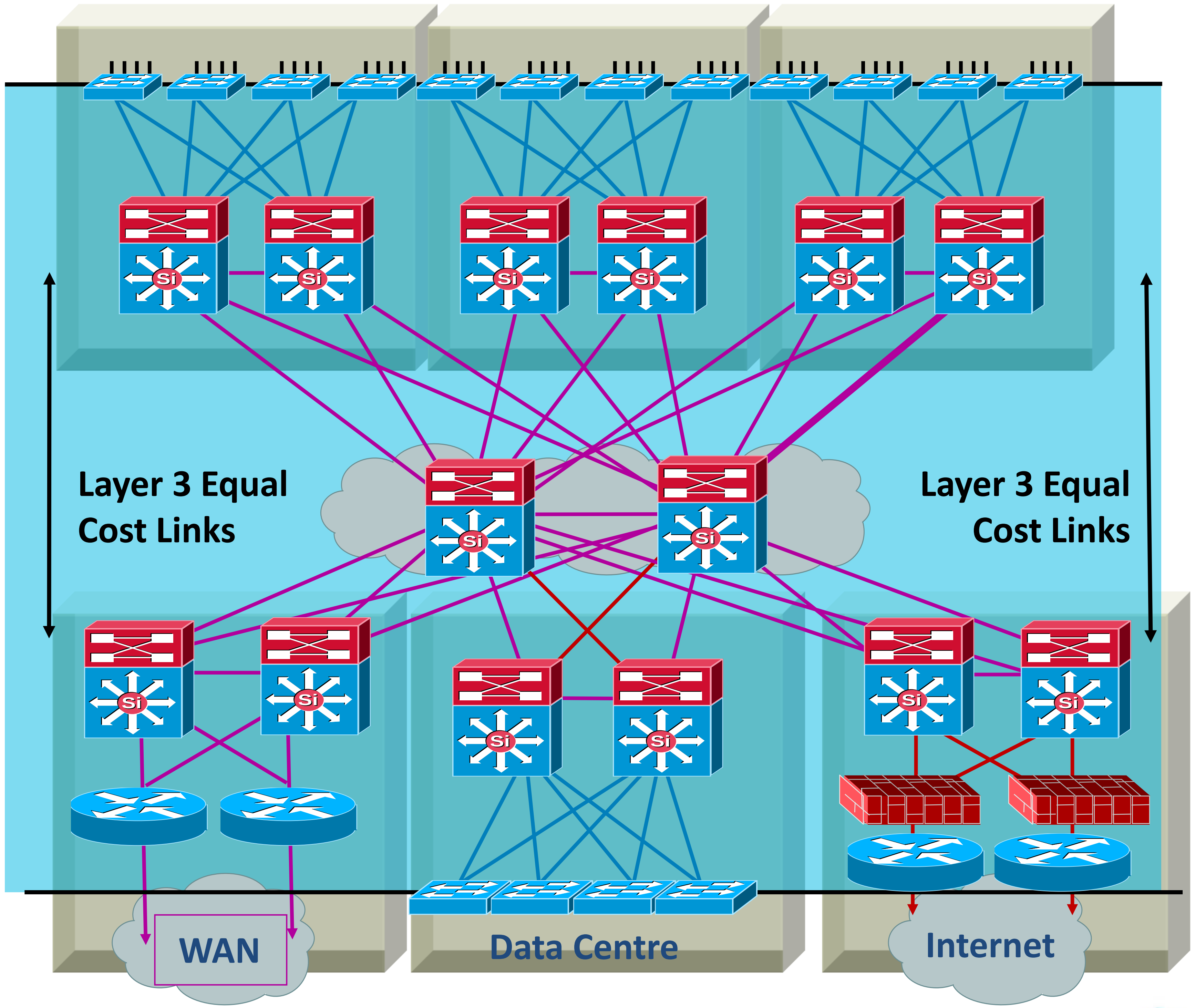
- Layer 1 physical things
- Layer 2 redundancy—spanning tree
- Layer 3 routing protocols
- Trunking protocols—(ISL/.1q)
- Unidirectional link detection
- Load balancing
  – EtherChannel link aggregation
  – CEF equal cost load balancing
- First hop redundancy protocols
  – VRRP, HSRP, and GLBP



Best Practices

Layer 1 Physical Things

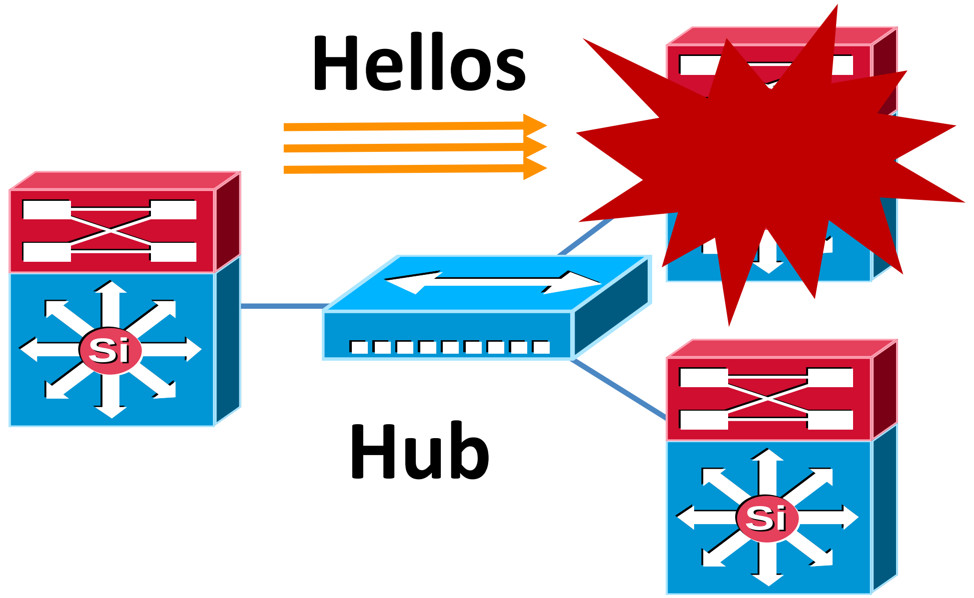
- Use point-to-point interconnections—no L2 aggregation points between nodes
- Use fibre for best convergence
- Tune carrier delay timer
- Use configuration on the physical interface not VLAN/SVI when possible

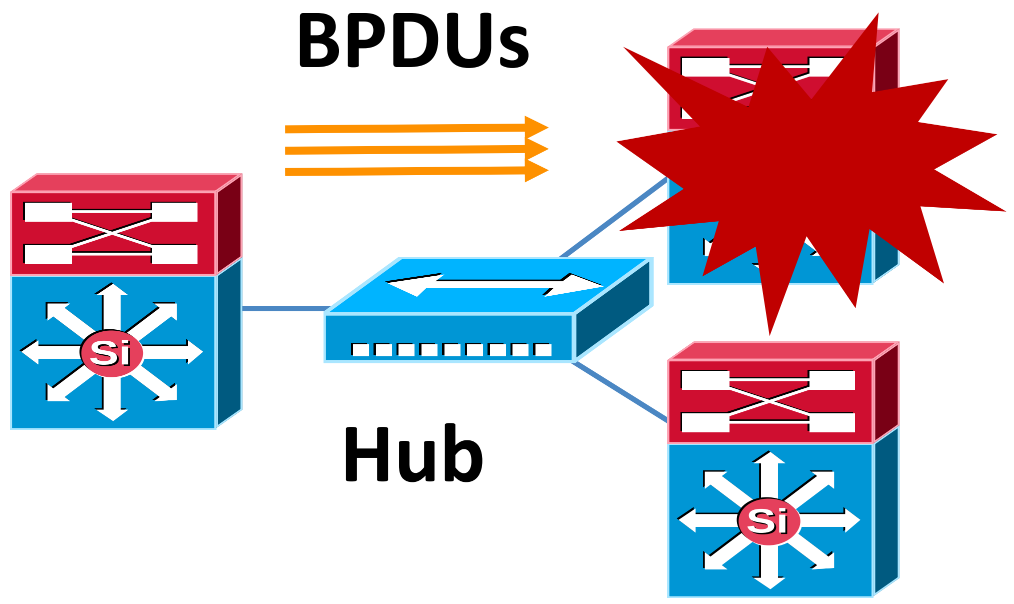


Redundancy and Protocol Interaction

Link Neighbour Failure Detection

- Indirect link failures are harder to detect
- With no direct HW notification
  of link loss or topology change
  convergence times are dependent on
  SW notification
- Indirect failure events in a bridged environment are detected by spanning tree hellos
- You should not be using hubs in a high-availability design

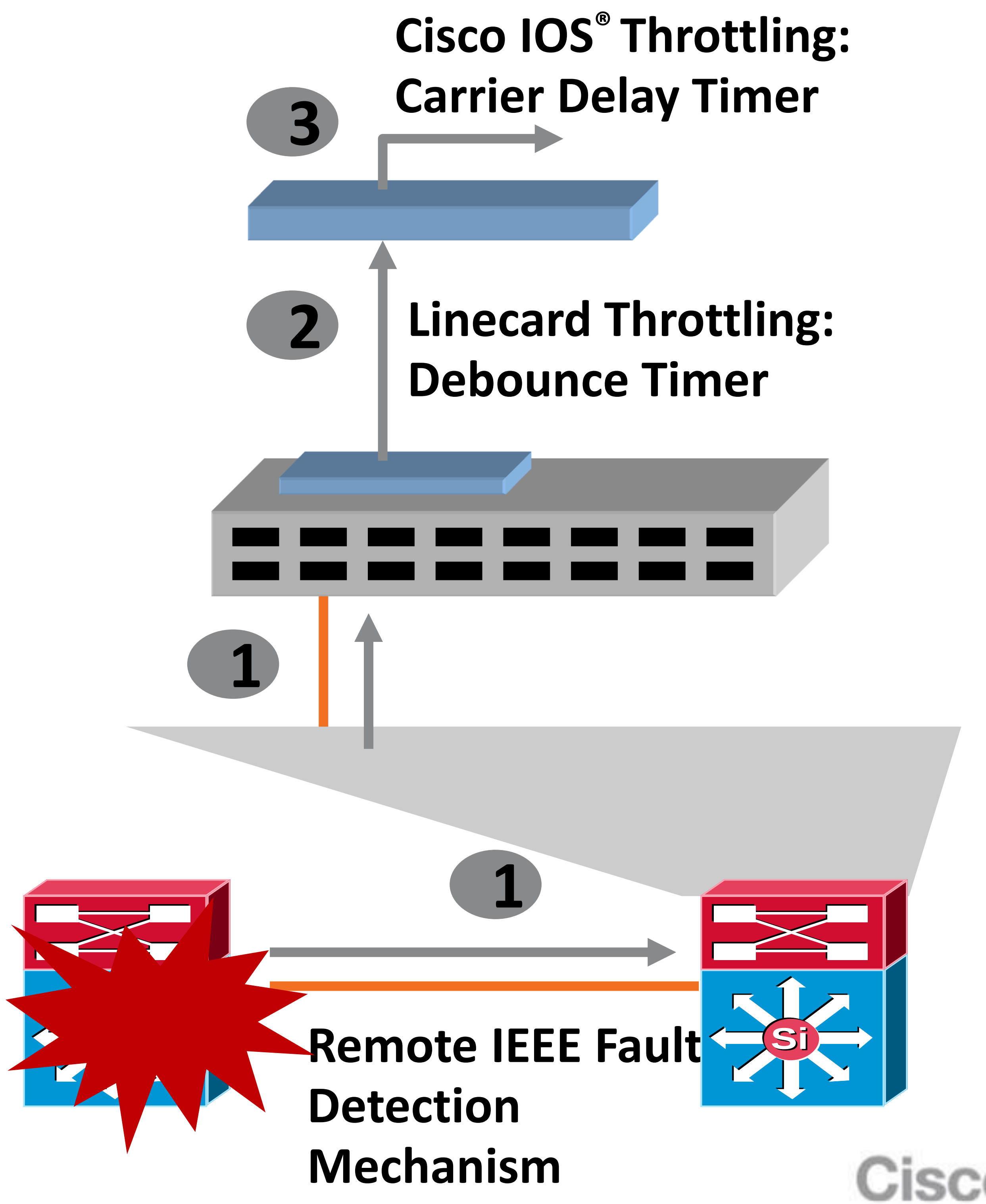




Redundancy and Protocol Interaction

Link redundancy and failure detection

- Direct point-to-point fibre provides for fast failure detection
- Do not disable auto-negotiation on GigE and 10GigE interfaces
- The default debounce timer on GigE and 10GigE fibre linecards is 10 msec
- The minimum debounce for copper is 300 msec



Redundancy and Protocol Interaction

Layer 2 and 3 – Why use routed interfaces over SVI's?

- Configuring L3 routed interfaces provides for faster convergence than an L2 switch port with an associated L3 SVI

1. Link Down
2. Interface Down
3. Routing Update

~ 8 msec loss

21:38:37.042 UTC: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet3/1, changed state to down
21:38:37.050 UTC: %LINK-3-UPDOWN: Interface GigabitEthernet3/1, changed state to down
21:38:37.050 UTC: IP-EIGRP(Default-IP-Routing-Table:100): Callback: route_adjust GigabitEthernet3/1

1. Link Down
2. Interface Down
3. Autostate
4. SVI Down
5. Routing Update

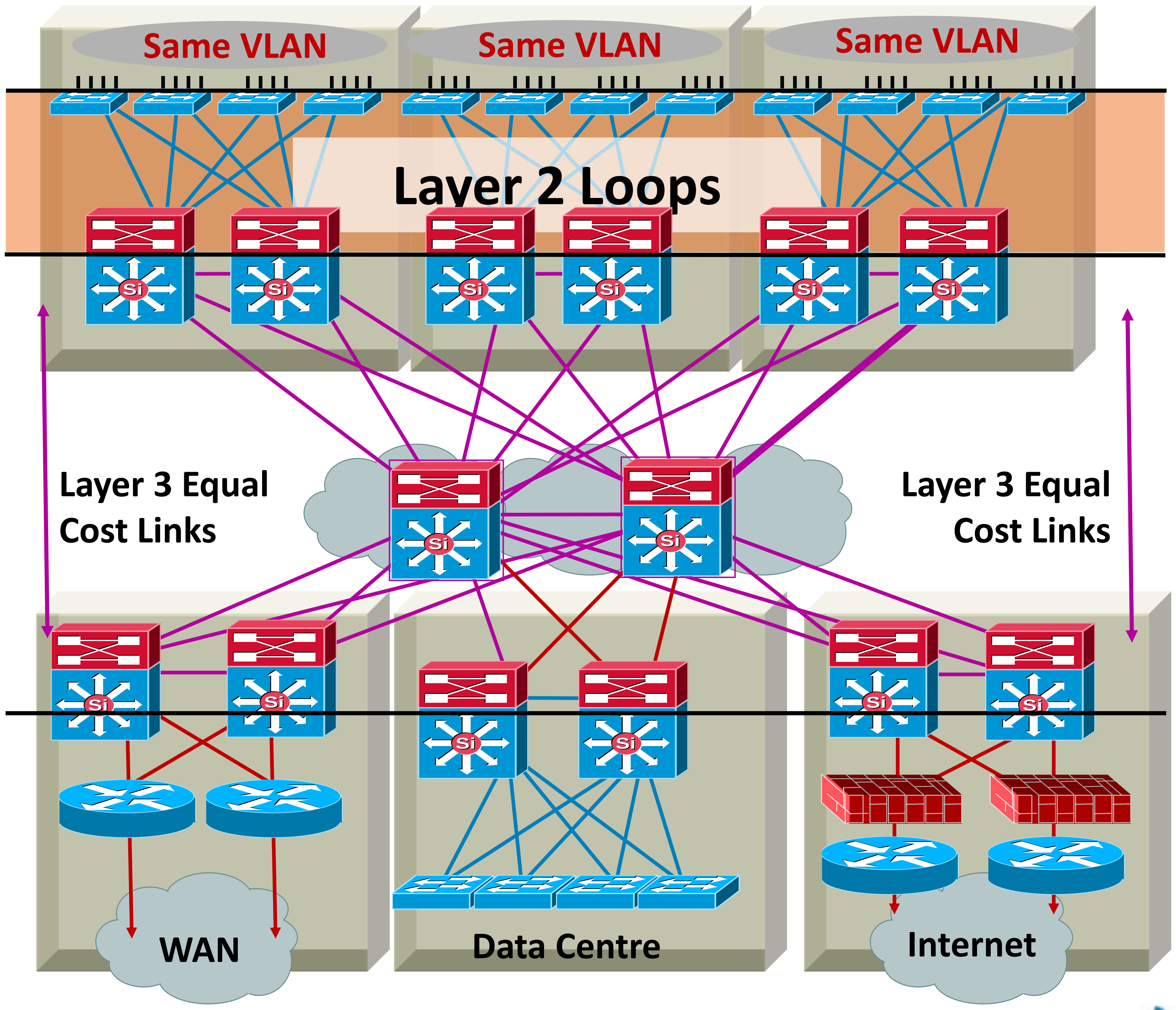
~ 150–200 msec loss

21:32:47.813 UTC: %LINEPROTO-5-UPDOWN: Line protocol on Interface GigabitEthernet2/1, changed state to down
21:32:47.821 UTC: %LINK-3-UPDOWN: Interface GigabitEthernet2/1, changed state to down
21:32:48.069 UTC: %LINK-3-UPDOWN: Interface Vlan301, changed state to down
21:32:48.069 UTC: IP-EIGRP(Default-IP-Routing-Table:100): Callback: route, adjust Vlan301

Best Practices

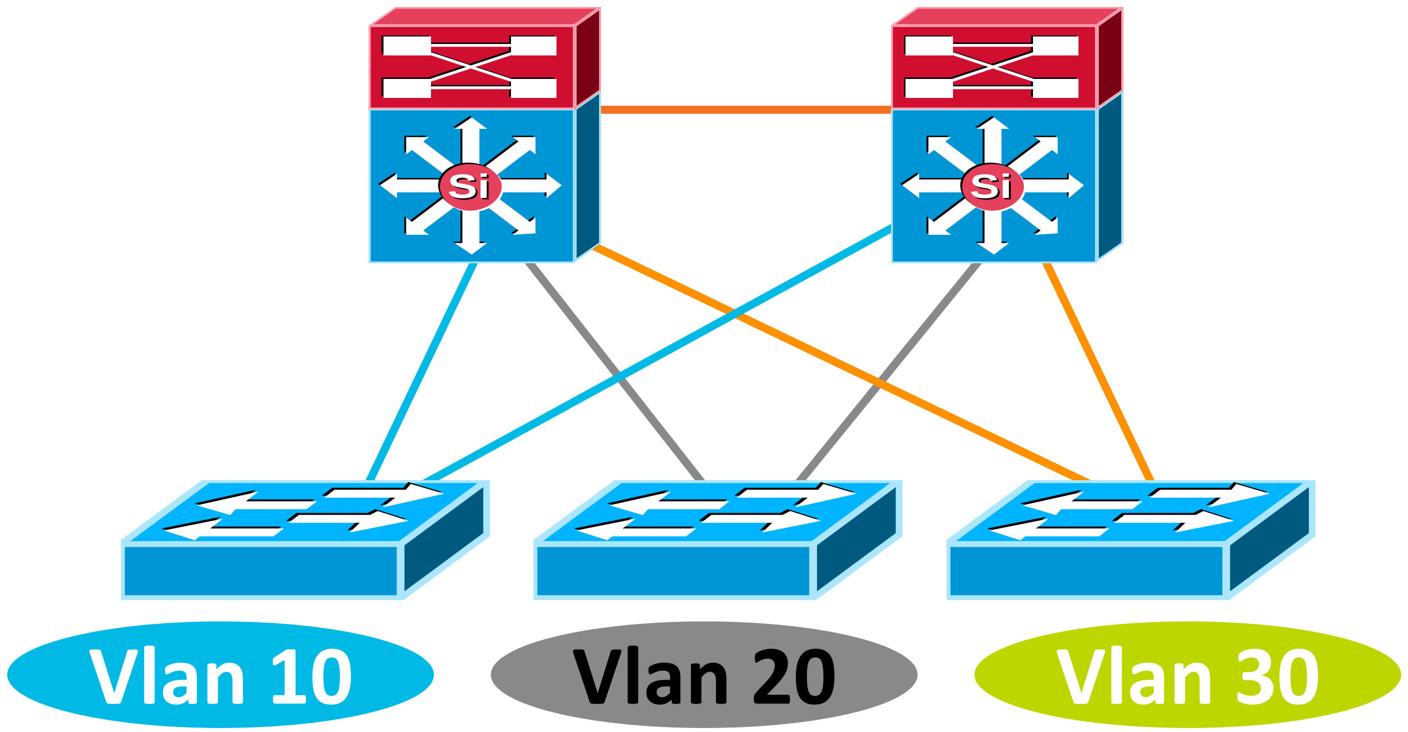
Spanning Tree Configuration

- **Only** span VLAN across multiple access layer switches when you have to!
- Use Rapid PVST+
- Required to protect against operational accidents (misconfiguration or hardware failure)
- Take advantage of the spanning tree toolkit

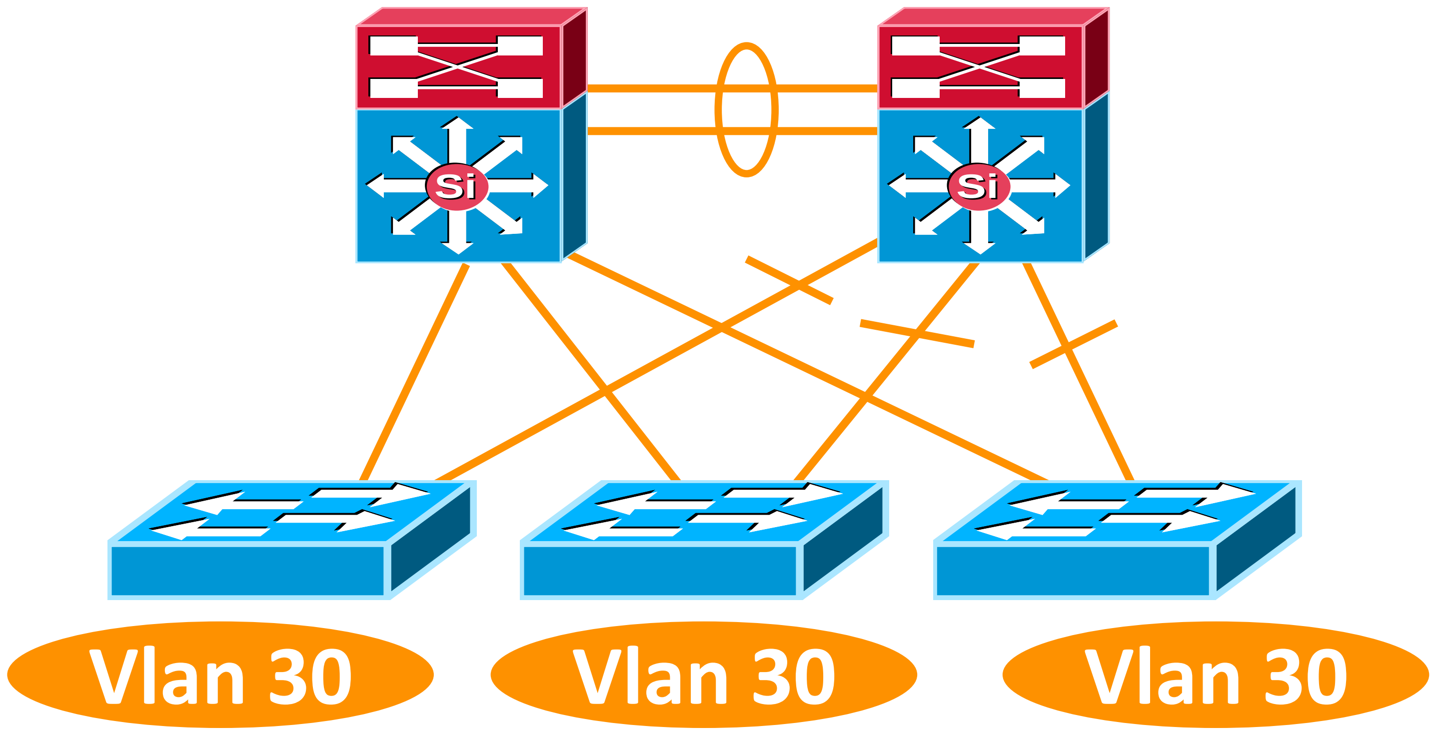


Multilayer Network Design

L2 access with L3 distribution



- Each access switch has unique VLANs
- No Layer 2 loops
- Layer 3 link between distribution
- No blocked links

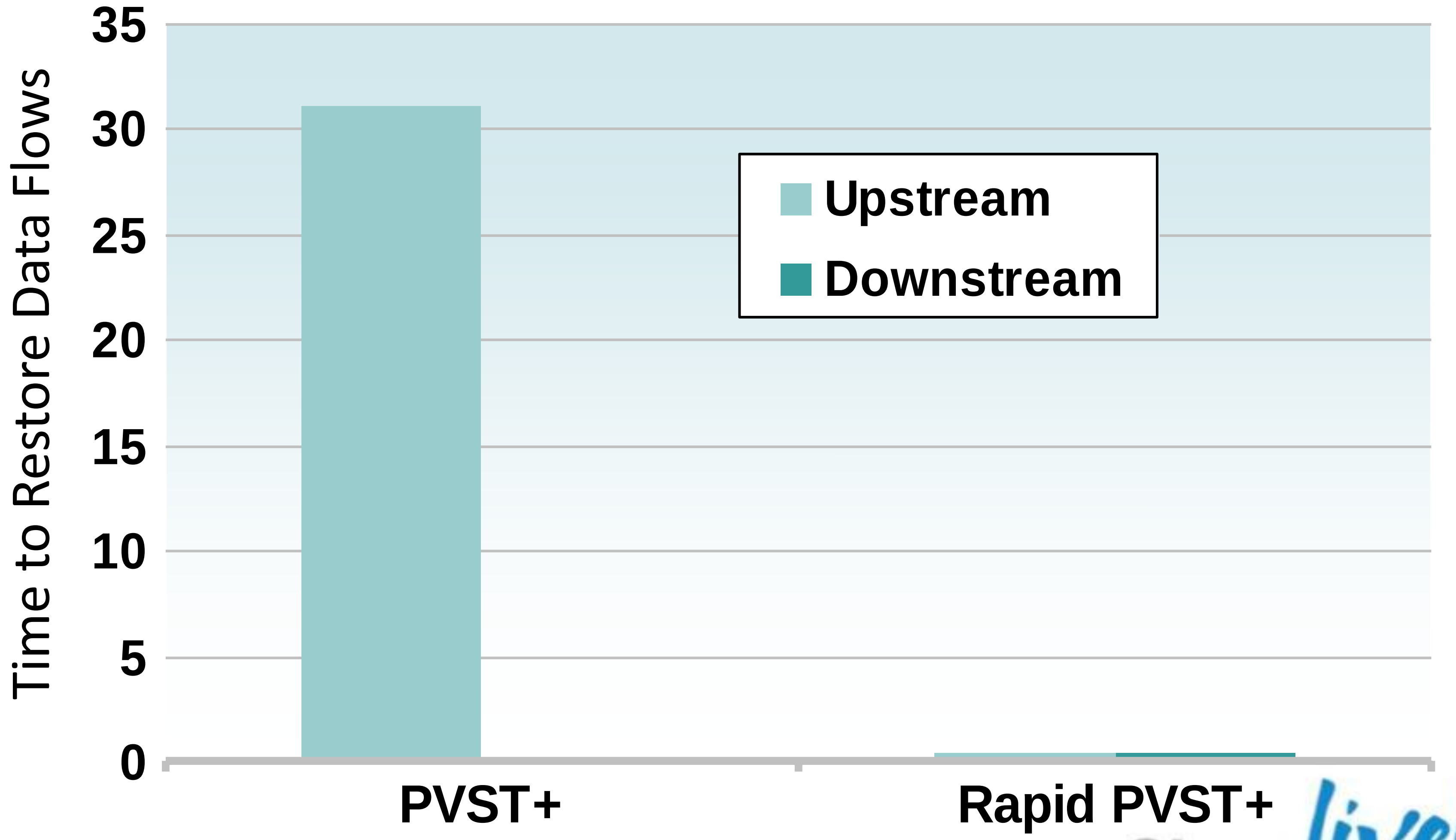


- At least some VLANs span multiple access switches
- Layer 2 loops, blocked links
- Layer 2 and 3 running over link between distribution

Optimising L2 Convergence

PVST+, Rapid PVST+ or MST

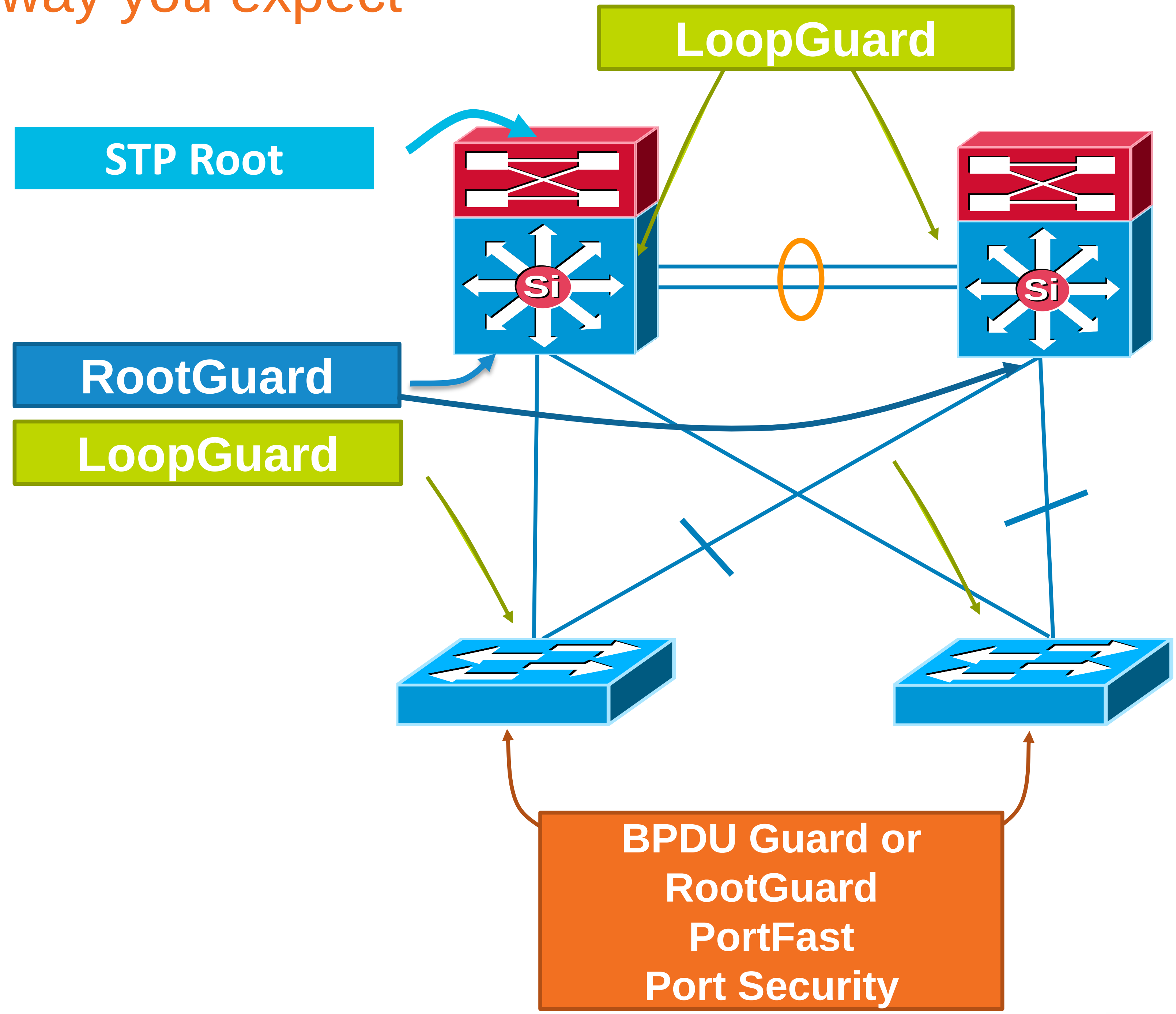
- Rapid-PVST+ greatly improves the restoration times for any VLAN that requires a topology convergence due to link UP
- Rapid-PVST+ also greatly improves convergence time over backbone fast for any indirect link failures
- PVST+ (802.1d)
  - –Traditional spanning tree implementation
- Rapid PVST+ (802.1w)
  - –Scales to large size (~10,000 logical ports)
  - –**Easy to implement, proven, scales**
- MST (802.1s)
  - –Permits very large scale STP implementations (~30,000 logical ports)
  - –**Not as flexible as rapid PVST+**



Layer 2 Hardening

Spanning Tree should behave the way you expect

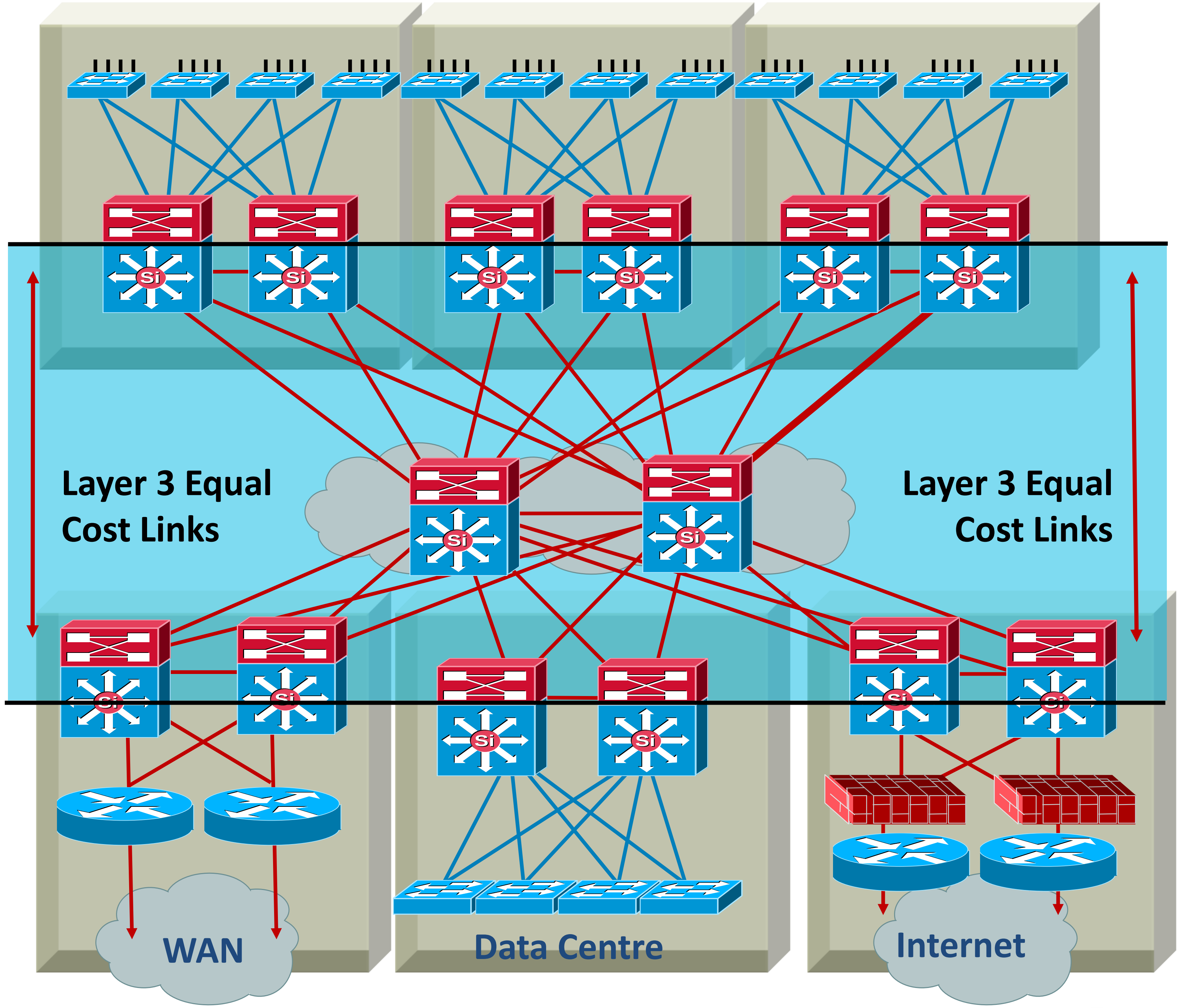
- Place the root where you want it
- The root bridge should stay where you put it
  - RootGuard
  - LoopGuard
  - UplinkFast
  - UDLD
- Only end-station traffic should be seen on an edge port
  - BPDU Guard
  - RootGuard
  - PortFast, PortSecurity



Best Practices

Layer 3 Routing Protocols

- Typically deployed in distribution to core, and core-to-core interconnections
- Used to quickly reroute around failed node/links while providing load balancing over redundant paths
- Build triangles not squares for deterministic convergence
- Summarise distribution to core to limit EIGRP query diameter or OSPF LSA propagation
- Tune CEF L3/L4 load balancing hash to achieve maximum utilisation of equal cost paths (CEF polarisation)

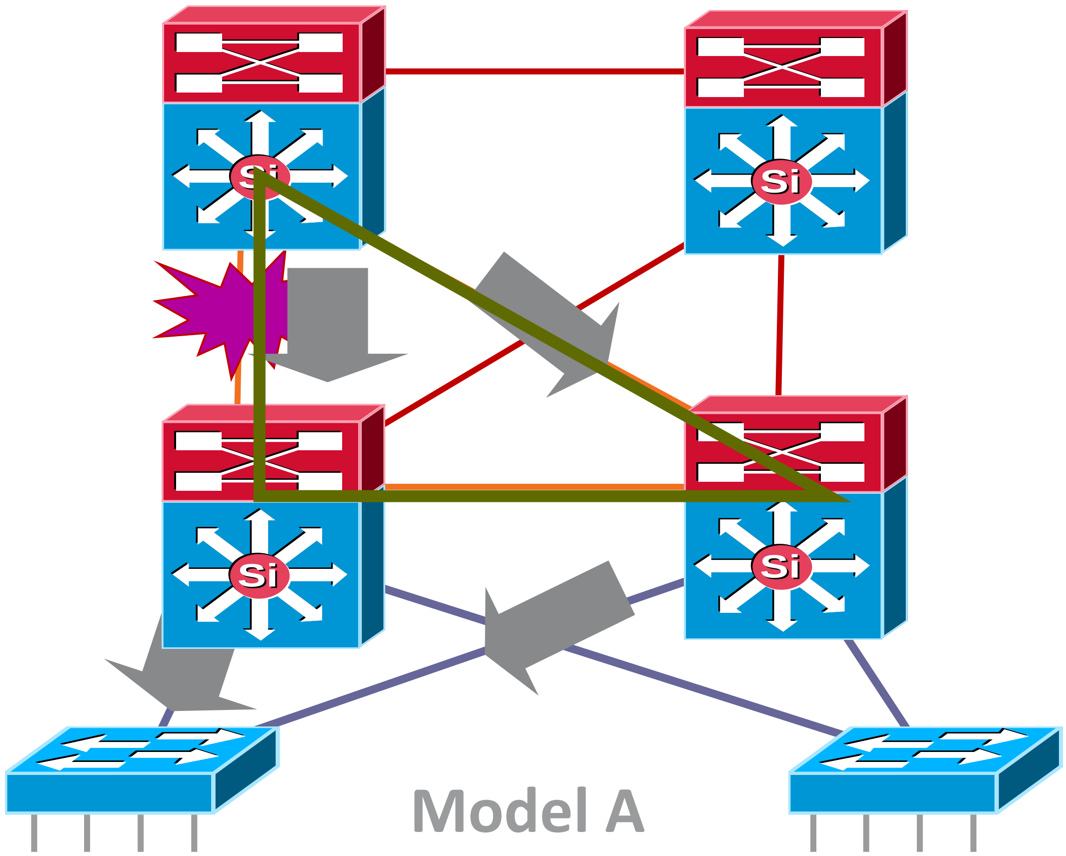


Best Practice

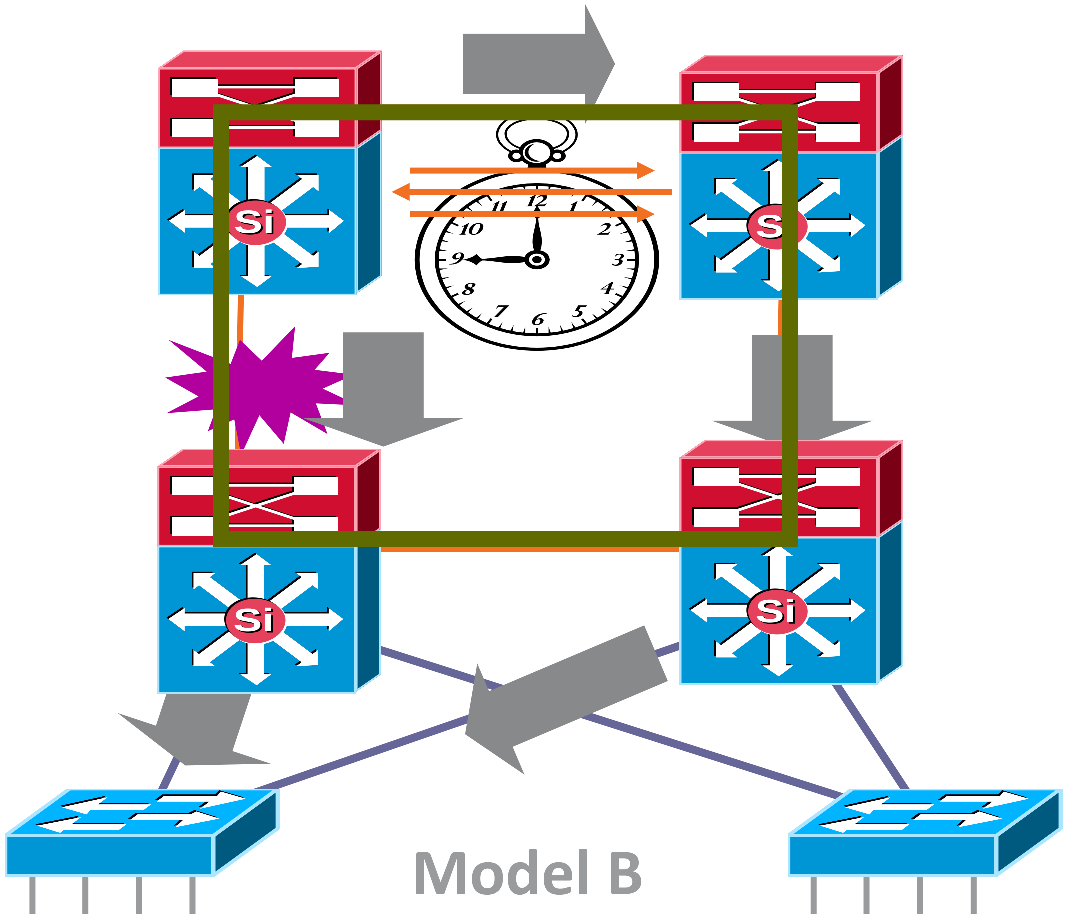
Build Triangles not Squares

Deterministic vs. Non-Deterministic

Triangles: Link/Box failure does not require routing protocol convergence



Squares: Link/Box failure requires routing protocol convergence



- Layer 3 redundant equal cost links support fast convergence
- Hardware based—fast recovery to remaining path
- Convergence is extremely fast (dual equal-cost paths: no need for OSPF or EIGRP to recalculate a new path)

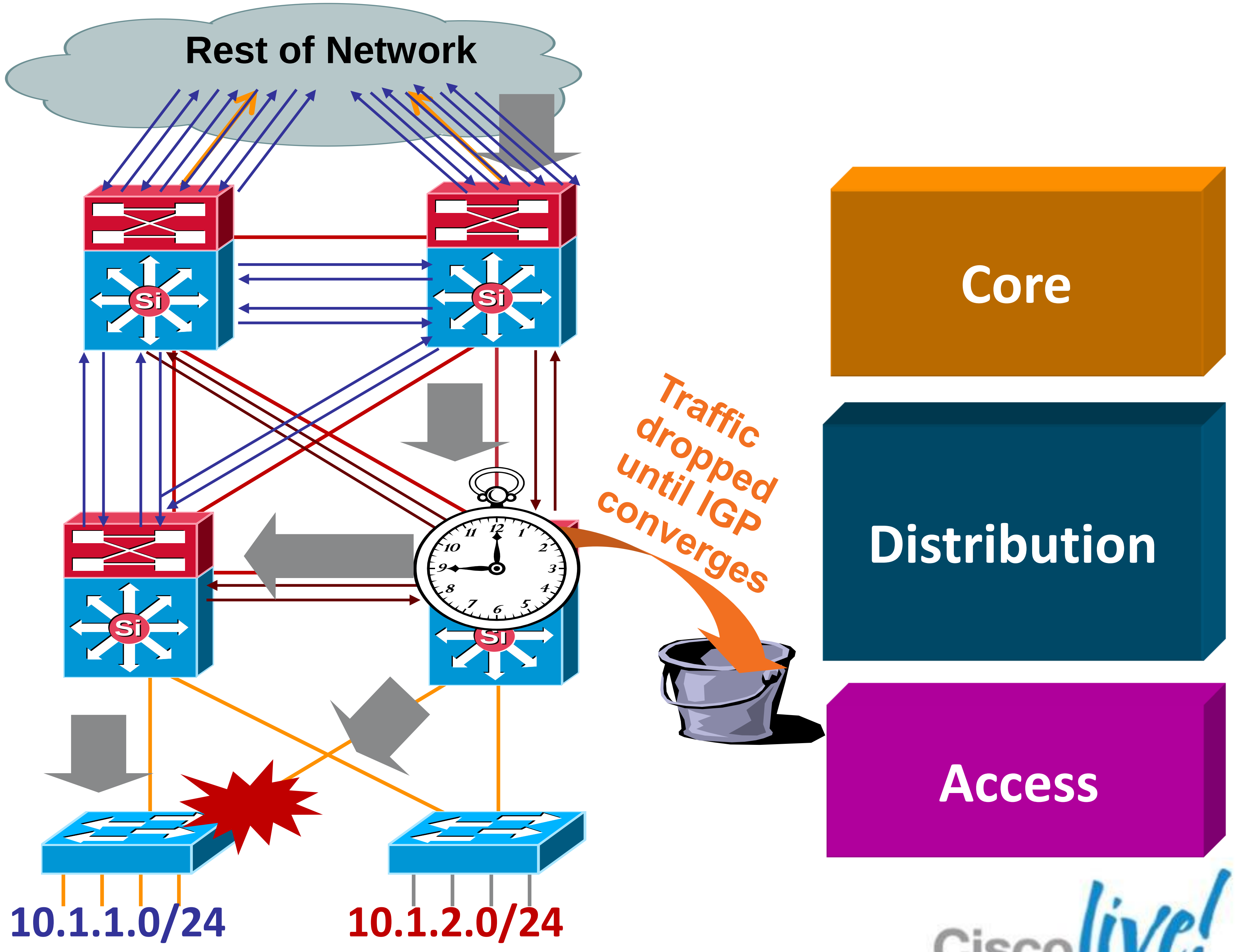
Summarise at the Distribution

Limit EIGRP queries and OSPF LSA propagation

- It is important to force summarisation at the distribution towards the core
- For return path traffic an OSPF or EIGRP re-route is required
- By limiting the number of peers an EIGRP router must query or the number of LSAs an OSPF peer must process we can optimise this reroute

EIGRP example:

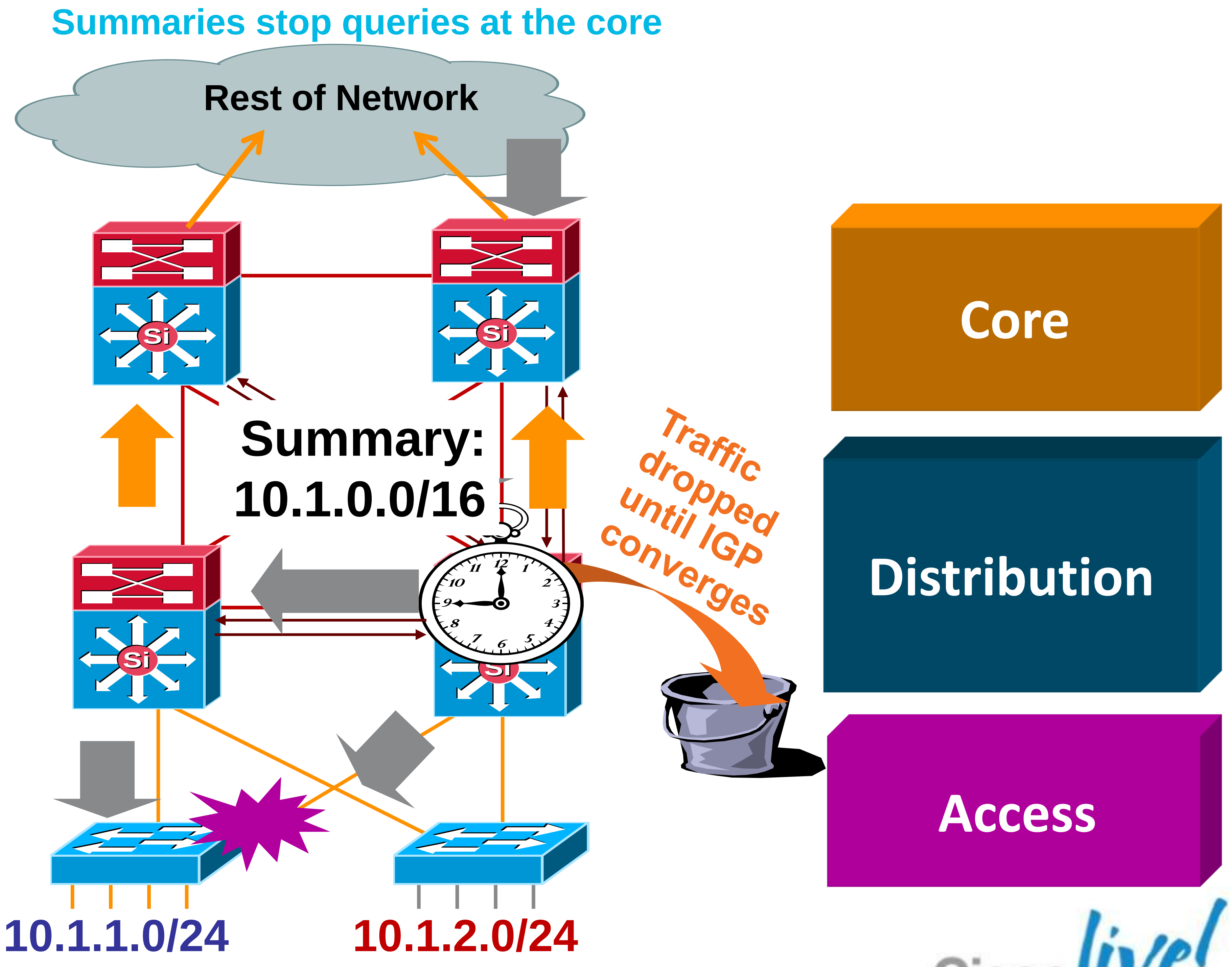
```
interface Port-channel1
   description to Core#1
   ip address 10.122.0.34 255.255.255.252
   ip hello-interval eigrp 100 1
   ip hold-time eigrp 100 3
   ip summary-address eigrp 100 10.1.0.0
    255.255.0.0 5
```



Summarise at the Distribution

Reduce the complexity of IGP convergence

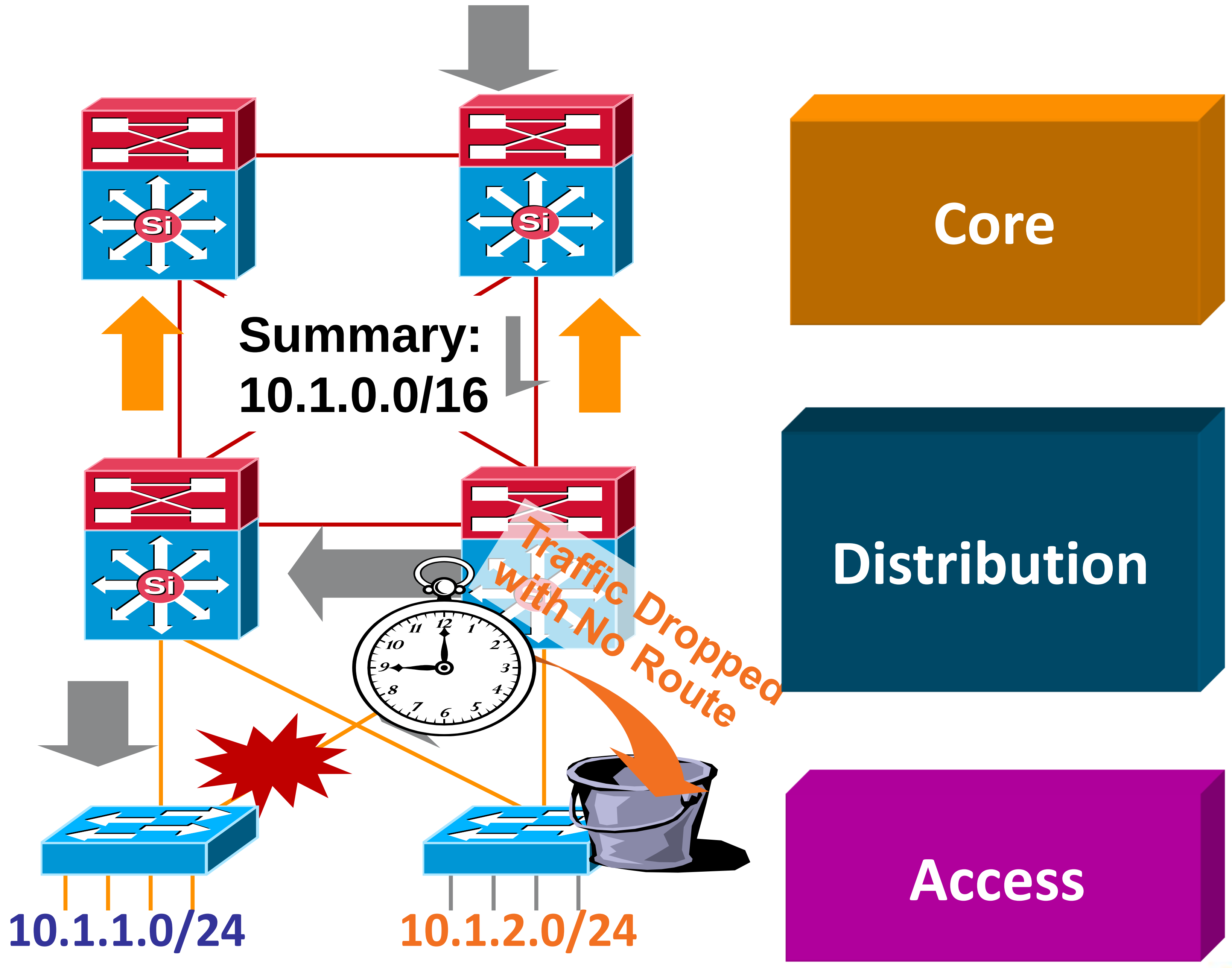
- It is important to force summarisation at the distribution towards the core
- For return path traffic an OSPF or EIGRP re-route is required
- By limiting the number of peers an EIGRP router must query or the number of LSAs an OSPF peer must process we can optimise his reroute
- For EIGRP if we summarise at the distribution we stop queries at the core boxes for an access layer flap
- For OSPF when we summarise at the distribution (area border or L1/L2 border) the flooding of LSAs is limited to the distribution switches; SPF now deals with one LSA not three



Summarise at the Distribution

Gotcha – Distribution to distribution link required

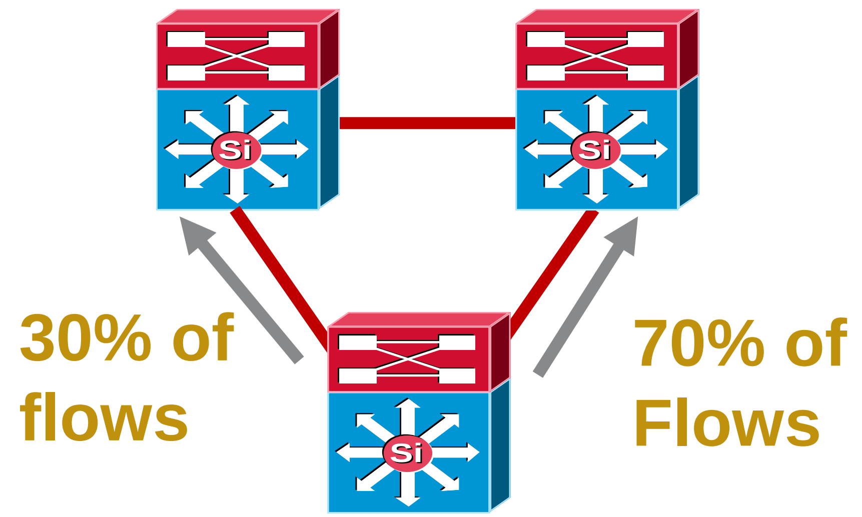
- Best practice - summarise at the distribution layer to limit EIGRP queries or OSPF LSA propagation
- Gotcha:
  - Upstream: HSRP on left distribution takes over when link fails
  - Return path: old router still advertises summary to core
  - Return traffic is dropped on right distribution switch
- **Summarising requires a link between the distribution switches**

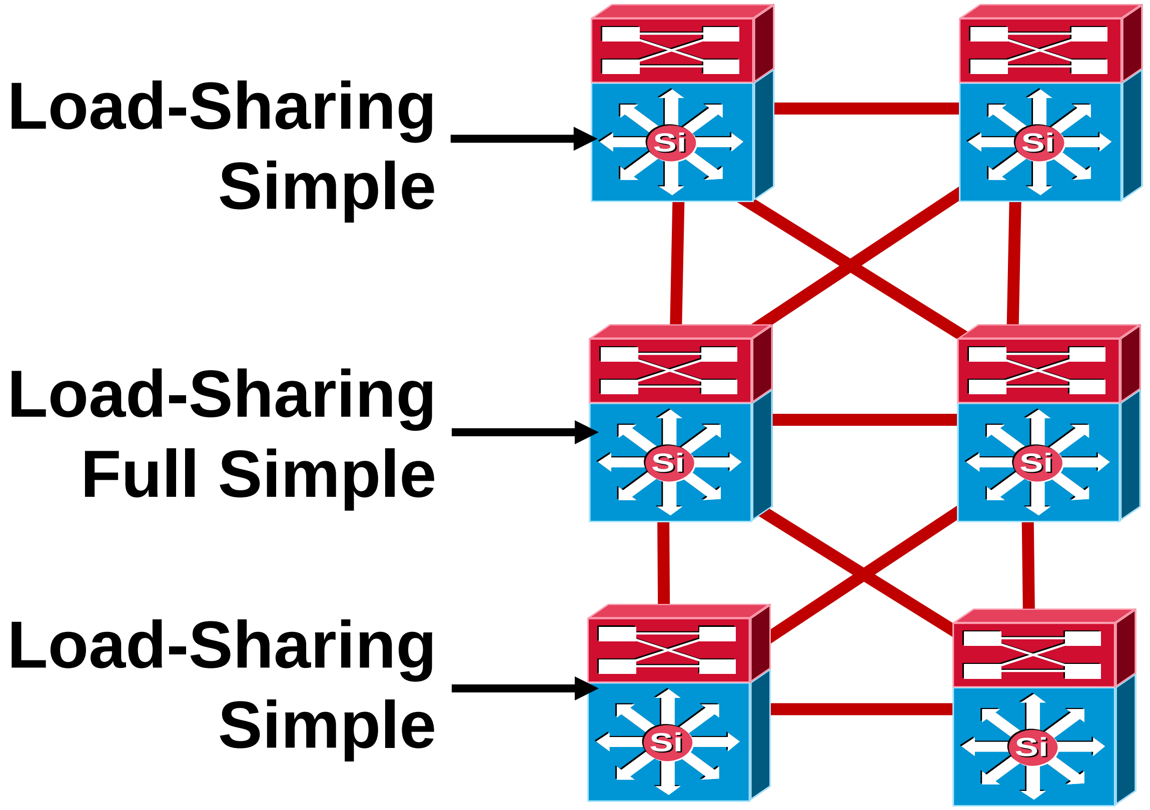


Equal-Cost Multipath

Optimising CEF load sharing

- Depending on the traffic flow patterns and IP addressing in use, one algorithm may provide better load-sharing results than another
- Be careful not to introduce polarisation in a multi-tier design by changing the default to the same thing in all tiers/layers of the network





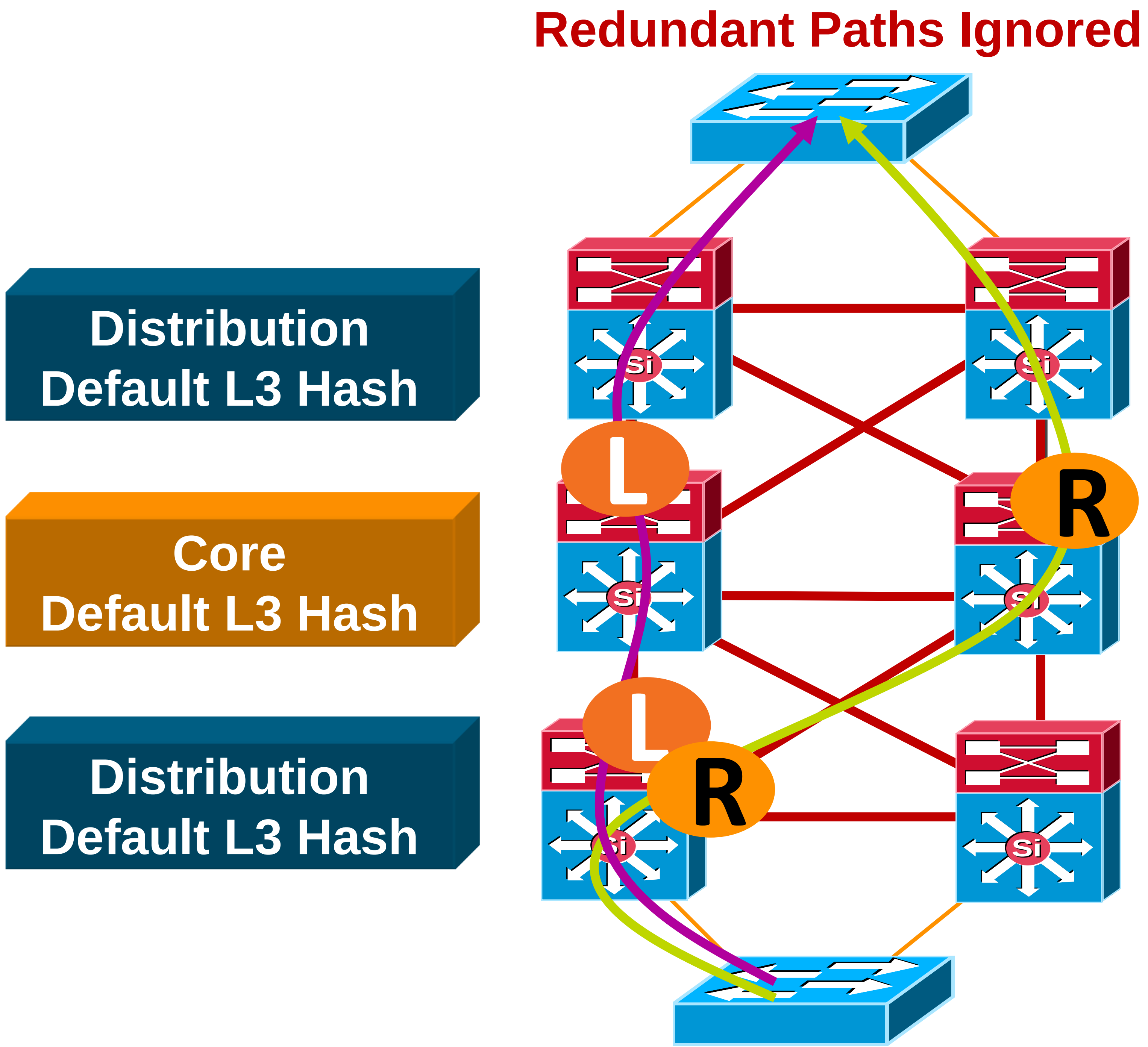
Catalyst 4500 Load-Sharing Options	
Original	Src IP + Dst IP
Universal*	Src IP + Dst IP + Unique ID
Include Port	Src IP + Dst IP + (Src or Dst Port) + Unique ID

Catalyst 6500 Load-Sharing Options	
Default*	Src IP + Dst IP + Unique ID
Full	Src IP + Dst IP + Src Port + Dst Port
Full Exclude Port	Src IP + Dst IP + (Src or Dst Port)
Simple	Src IP + Dst IP
Full Simple	Src IP + Dst IP + Src Port + Dst Port

* = Default Load-Sharing Mode

CEF Load Balancing

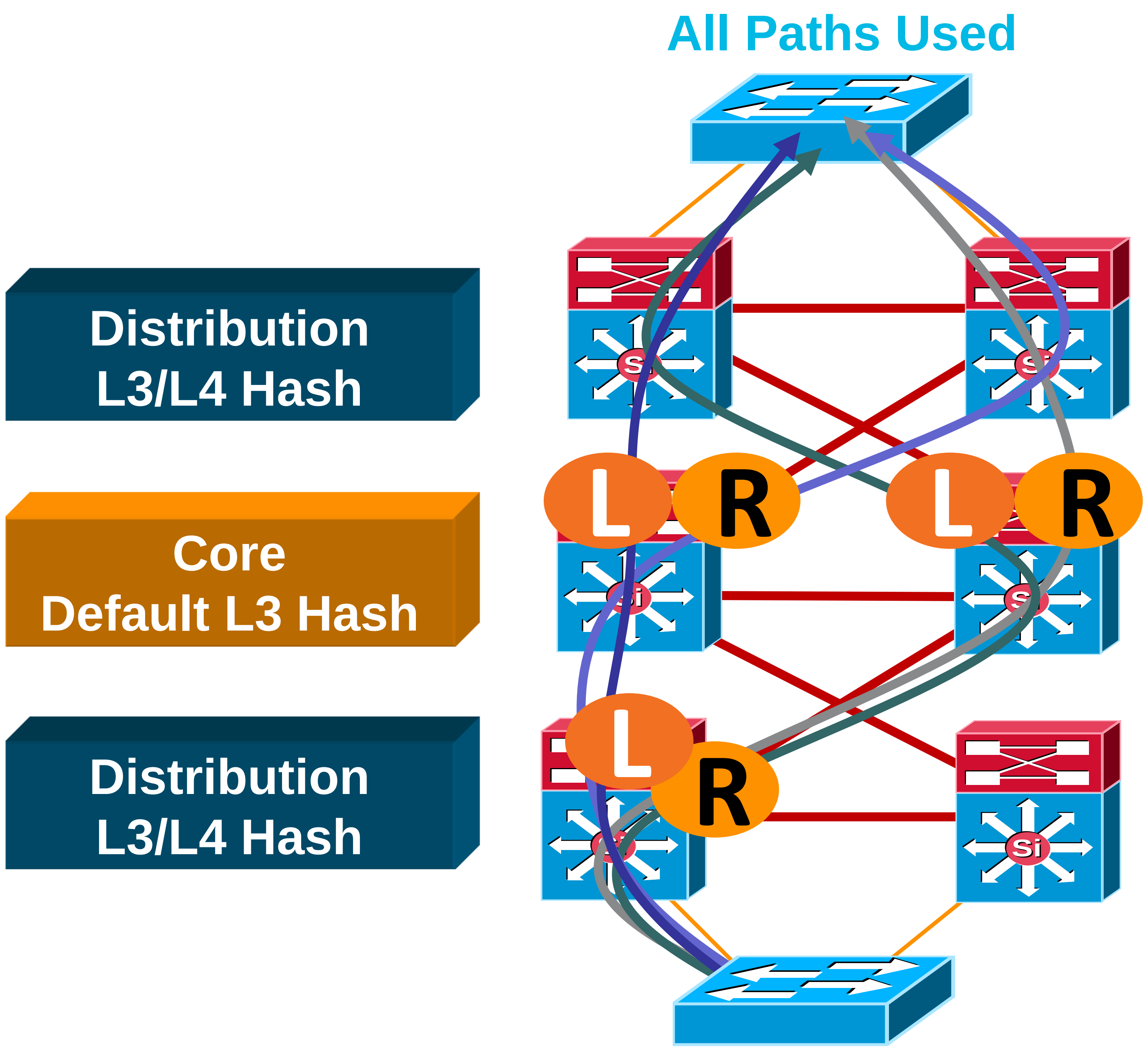
Avoid underutilising redundant L3 paths



- CEF polarisation: without some tuning CEF will select the same path left/left or right/right
- Imbalance/overload could occur
- Redundant paths are ignored/underutilised
- The default CEF hash input is L3
- We can change the default to use L3 + L4 information as input to the hash derivation

CEF Load Balancing

Avoid underutilising redundant L3 paths

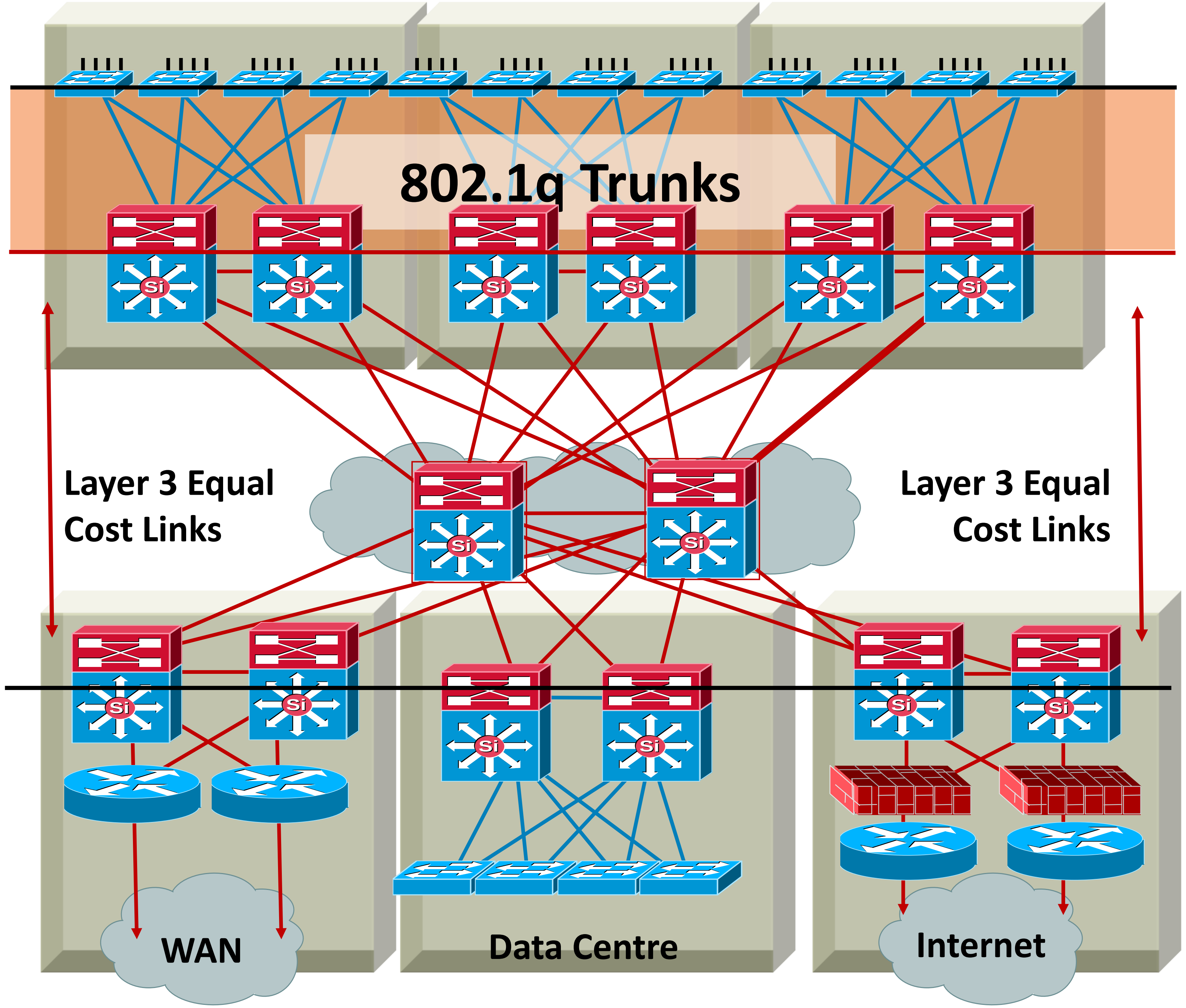


- Depending on IP addressing and flows, imbalance could occur
- Alternating L3/L4 hash and L3 hash will give us the best load balancing results
- Use **simple** in the core and **full simple** in the distribution to add L4 information to the algorithm at the distribution and maintain differentiation tier-to-tier

Best Practices

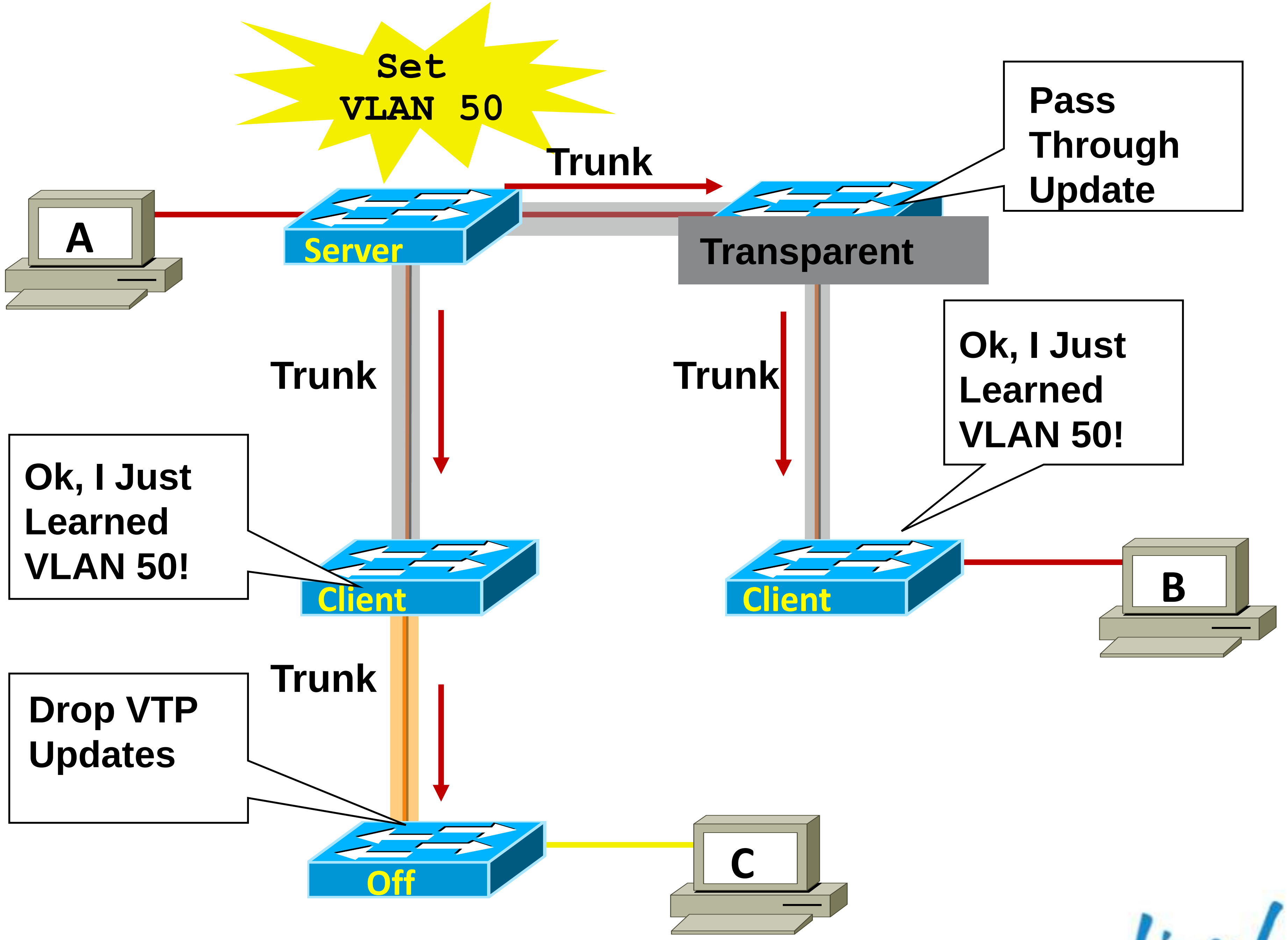
Trunk configuration

- Typically deployed on interconnection between access and distribution layers
- Use VTP transparent mode to decrease potential for operational error
- Hard set trunk mode to on and encapsulation negotiate off for optimal convergence
- Change the native VLAN to something unused to avoid VLAN hopping
- Manually prune all VLANS except those needed



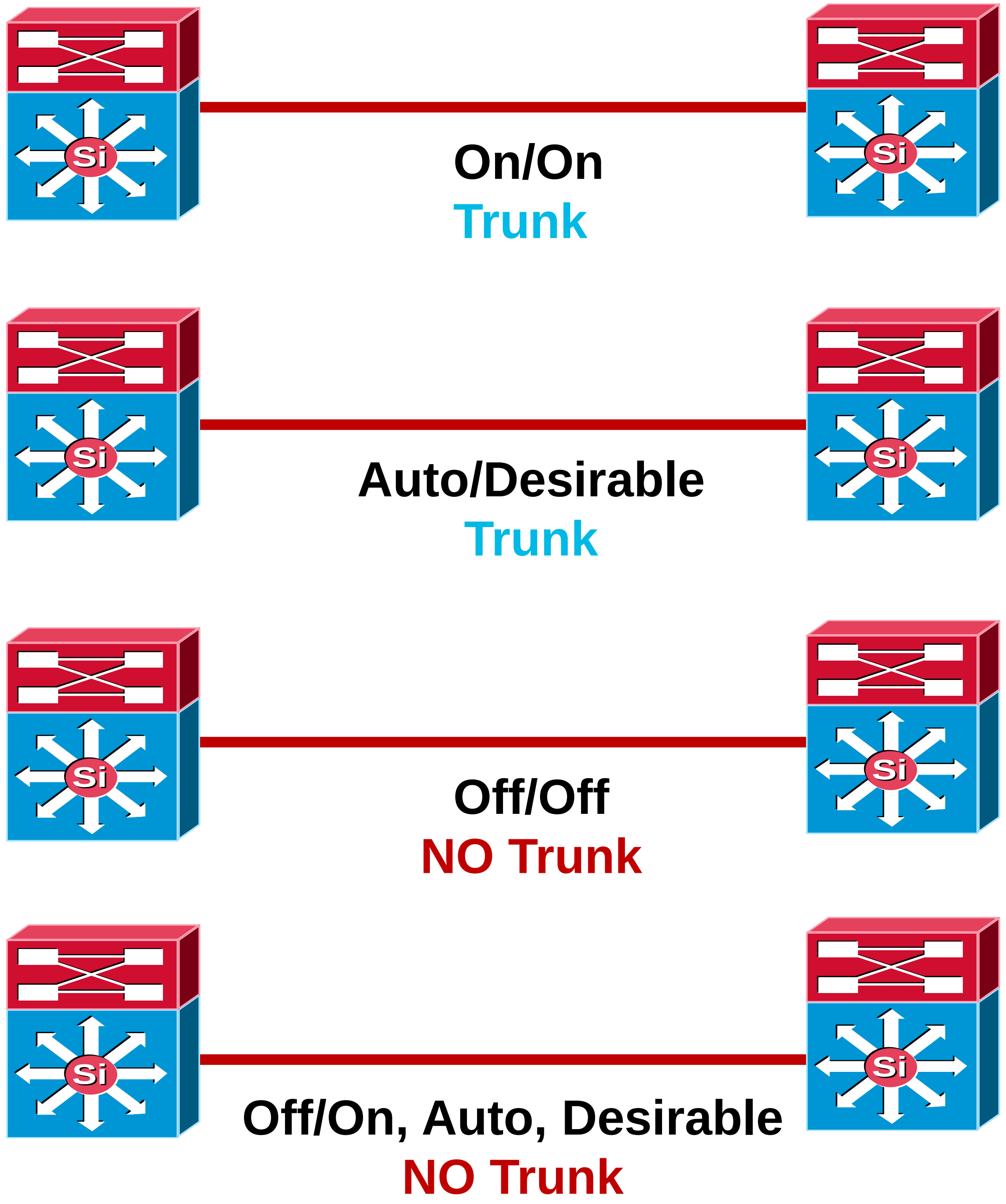
VTP Virtual Trunk Protocol

- Centralised VLAN management
- VTP server switch propagates VLAN database to VTP client switches
- Runs only on trunks
- Four modes:
  - **Server:** updates clients and servers
  - **Client:** receive updates - cannot make changes
  - **Transparent:** let updates pass through
  - **Off:** ignores VTP updates



DTP Dynamic Trunk Protocol

- Automatic formation of trunked switch-to-switch interconnection
  - On: always be a trunk
  - Desirable: ask if the other side can/will
  - Auto: if the other sides asks I will
  - Off: don’t become a trunk
- Negotiation of 802.1Q or ISL encapsulation
  - ISL: try to use ISL trunk encapsulation
  - 802.1q: try to use 802.1q encapsulation
  - Negotiate: negotiate ISL or 802.1q encapsulation with peer
  - Non-negotiate: always use encapsulation that is hard set



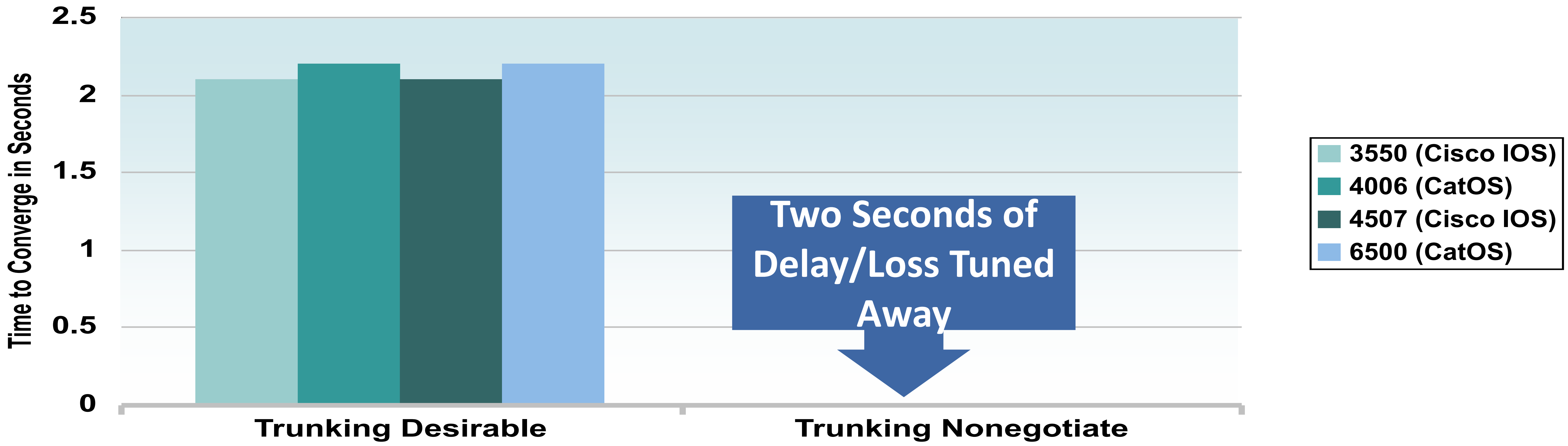
Optimising Convergence: Trunk Tuning

Trunk Auto/Desirable Takes Some Time

- DTP negotiation tuning improves link up convergence time

  IOS(config-if)# switchport mode trunk

  IOS(config-if)# switchport nonegotiate

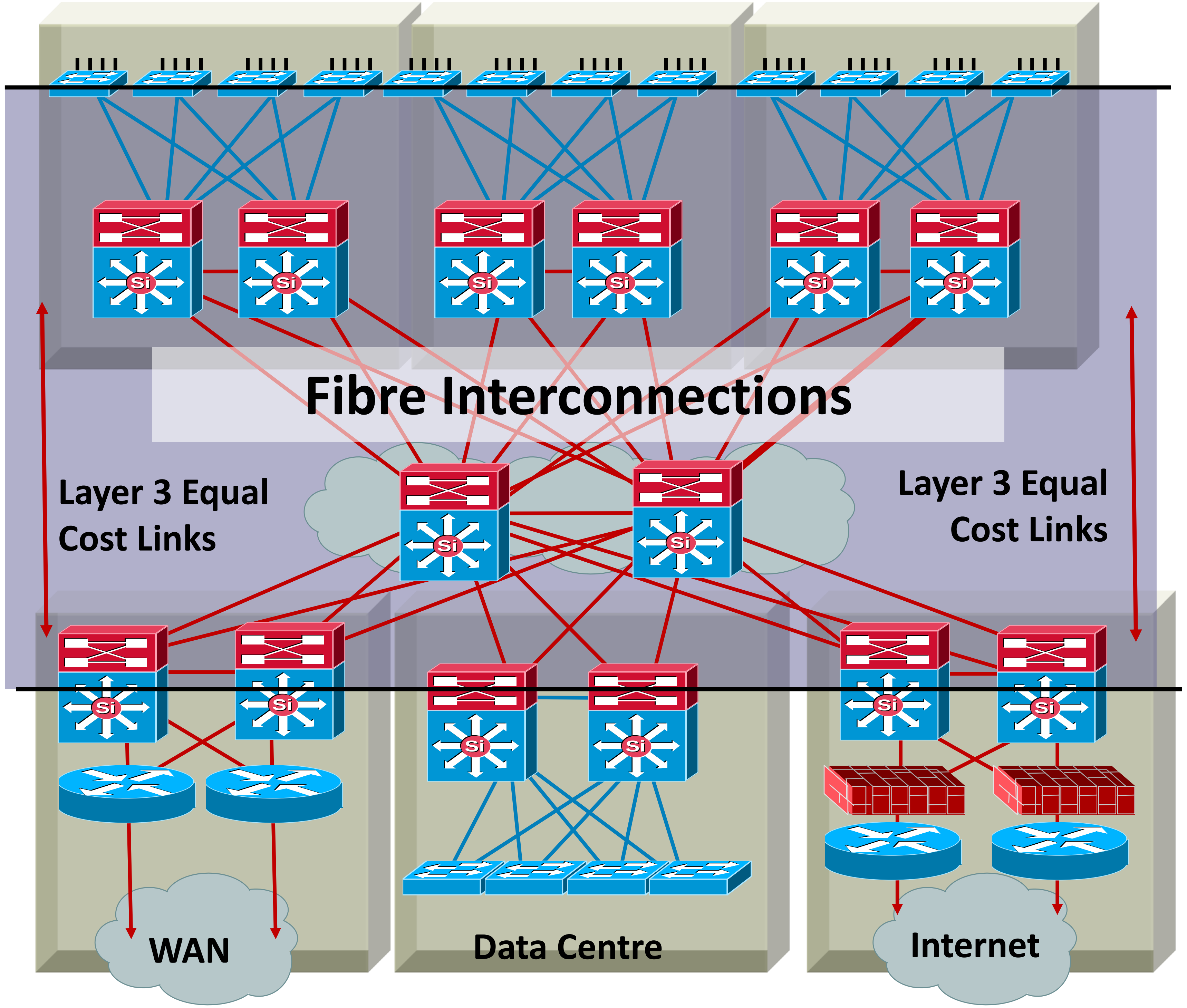


Best Practices

UDLD Configuration

- Typically deployed on any fibre optic interconnection
- Use UDLD aggressive mode for most aggressive protection
- Turn on in global configuration to avoid operational error/misses
- Config example

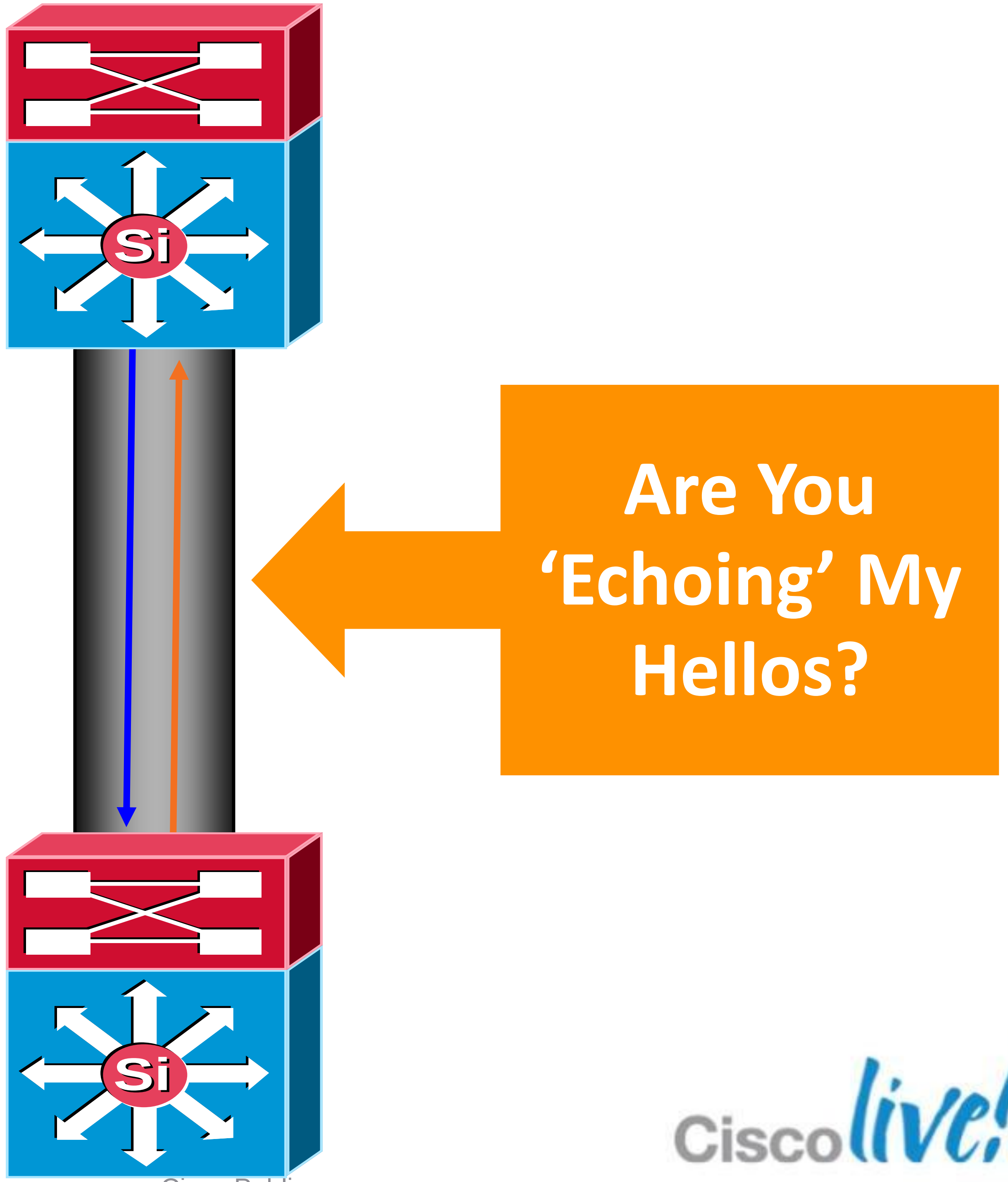
  IOS (config)# `udld aggressive`



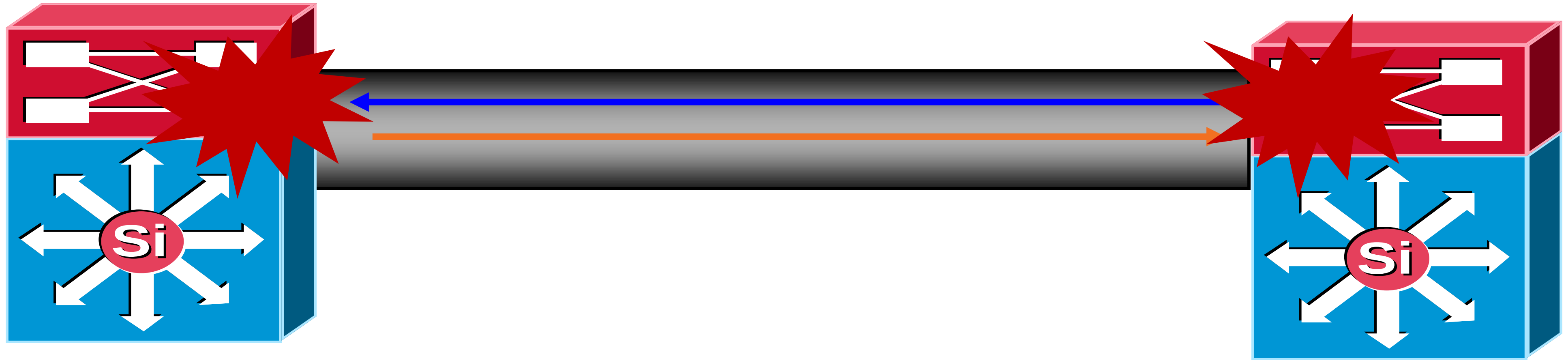
Unidirectional Link Detection

Protecting against one-way communication

- Protects against one-way communication or partially failed links and their effects on protocols like STP and RSTP
- Primarily used on fibre optic links where patch panel errors could cause link up/up with mismatched transmit/receive pairs
- Each switch port configured for UDLD will send UDLD protocol packets (at L2) containing the port's own device/port ID, and the neighbour's device/port IDs seen by UDLD on that port
- Neighbouring ports should see their own device/port ID (echo) in the packets received from the other side
- If the port does not see its own device/port ID in the incoming UDLD packets for a specific duration of time, the link is considered unidirectional and is shutdown



UDLD Modes: Aggressive and Normal

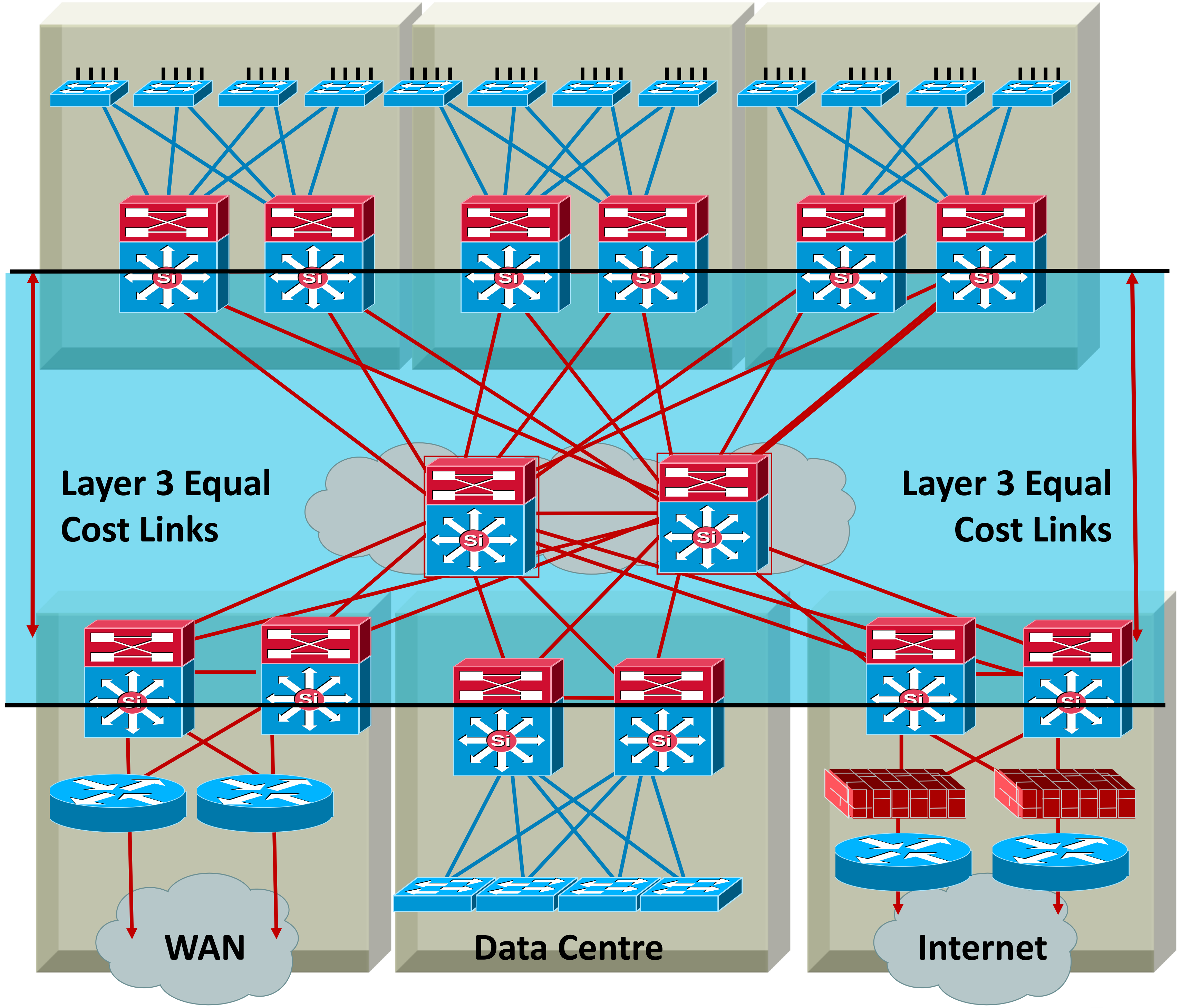


- Timers are the same - 15-second hellos by default
- UDLD Normal Mode - only err-disable the end where UDLD detected. The other end just sees the link go down
- UDLD Aggressive Mode - err-disable **both** ends of the connection. Could lead to complete loss of connectivity to remote site

Best Practices

EtherChannel Configuration

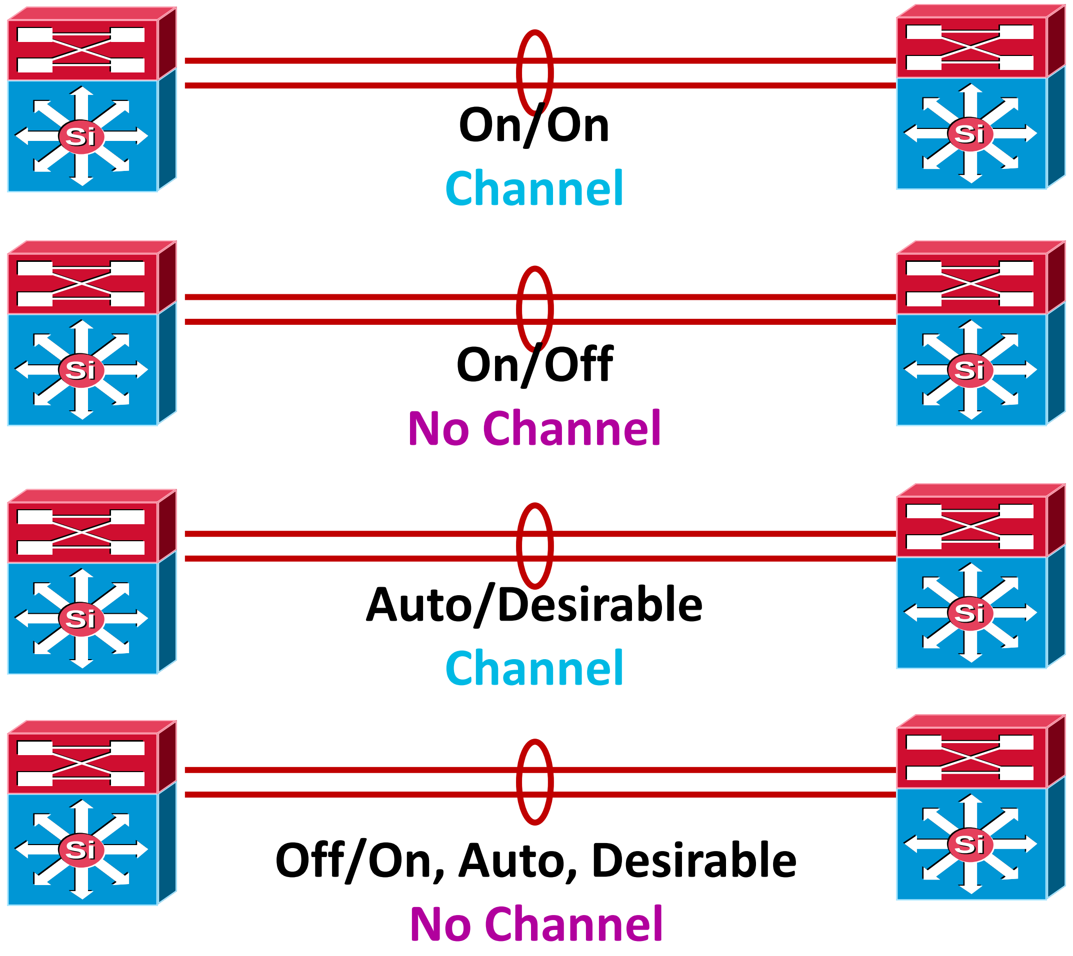
- Typically deployed in distribution to core, and core to core interconnections
- Used to provide link redundancy, while reducing peering complexity
- Tune L3/L4 load balancing hash to achieve maximum utilisation of channel members
- Deploy in powers of two (two, four, or eight)
- Match CatOS and Cisco IOS PAgP settings



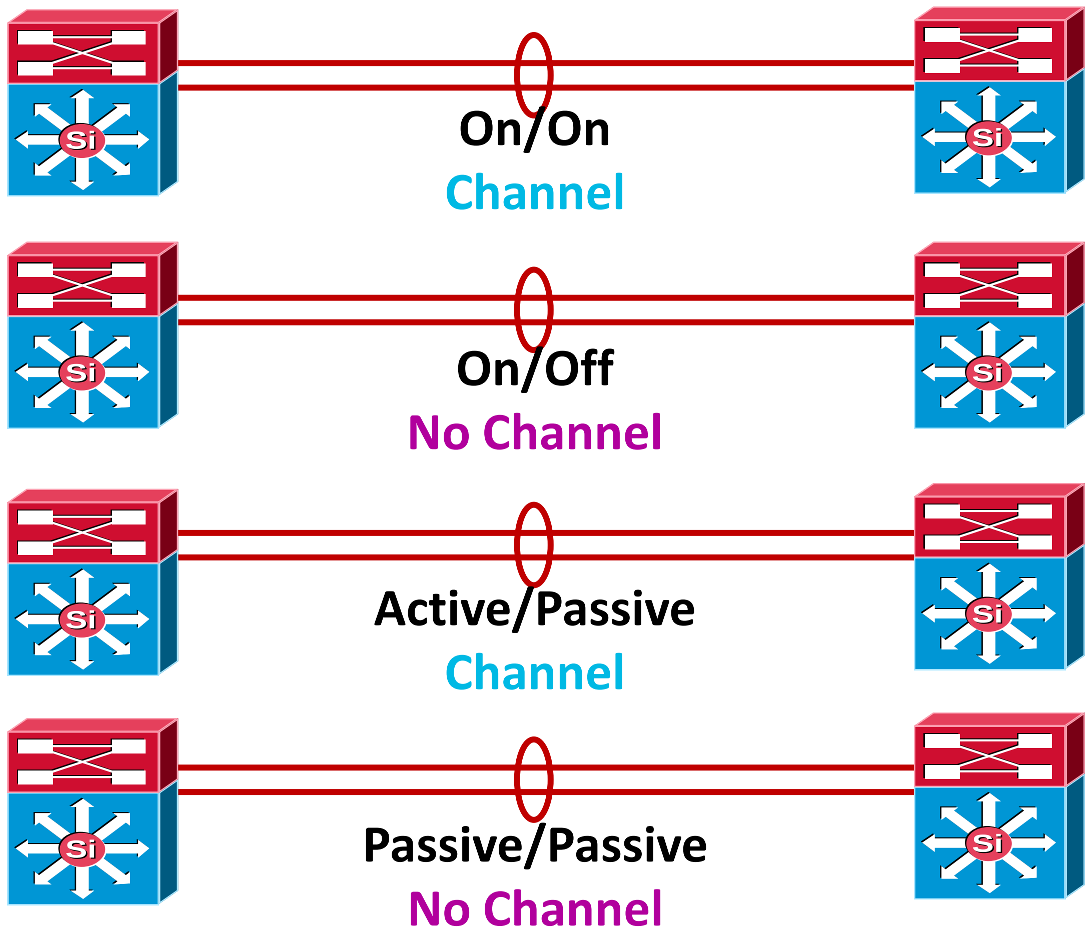
Understanding EtherChannel

Link Negotiation Options—PAgP and LACP

Port Aggregation Protocol



Link Aggregation Control Protocol



On: always be a channel/bundle member
Desirable: ask if the other side can/will
Auto: if the other side asks I will
Off: don't become a member of a channel/bundle

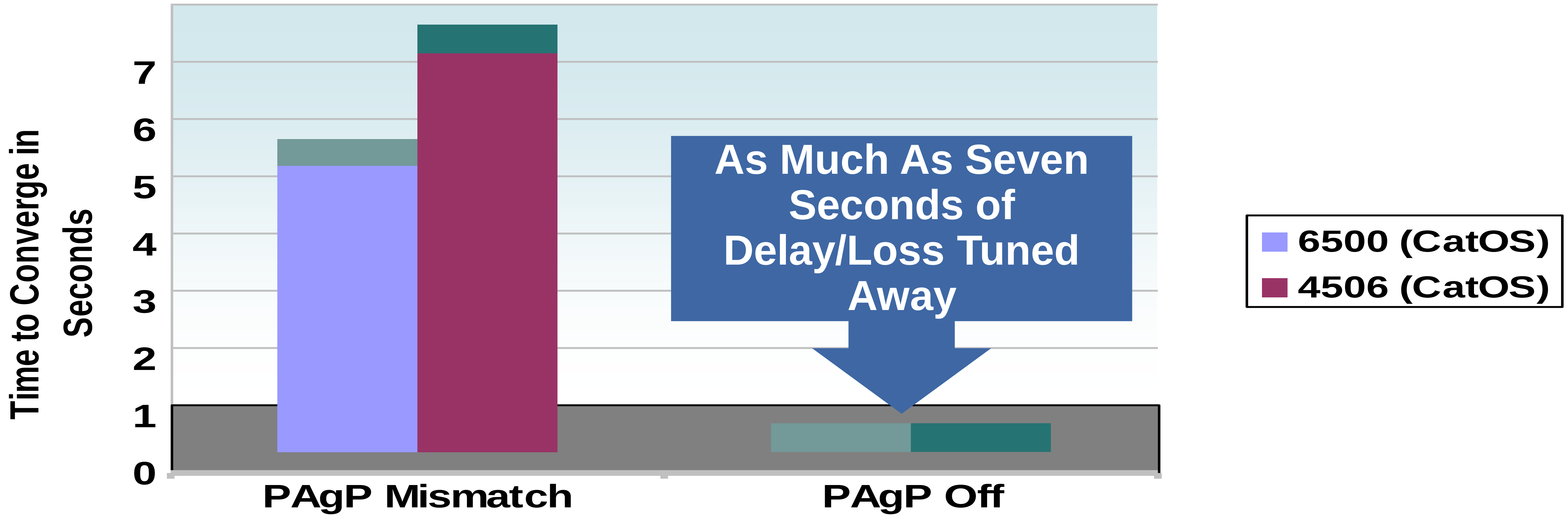
On: always be a channel/bundle member
Active: ask if the other side can/will
Passive: if the other side asks I will
Off: don't become a member of a channel/bundle

PAgP/LACP Tuning

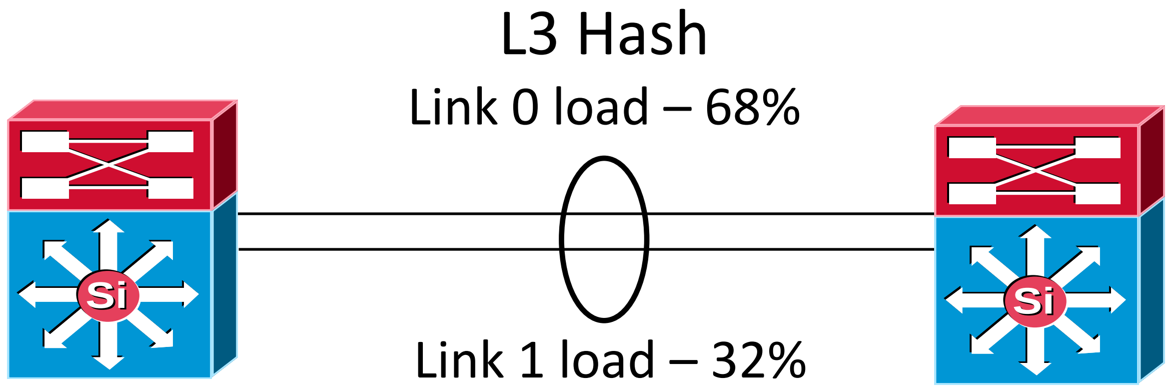
Configuration mismatches

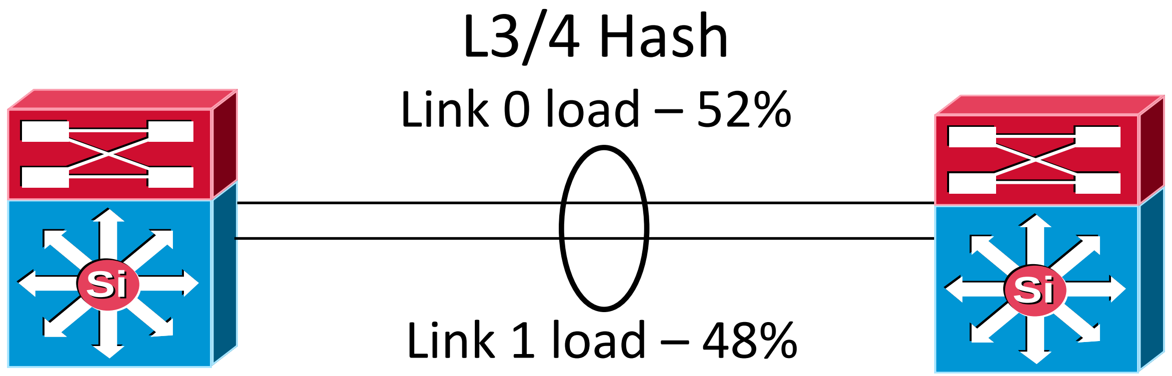
Matching EtherChannel configuration on both sides improves link restoration convergence times

CatOS-switch# set port channel <mod/port> off



EtherChannel link load sharing





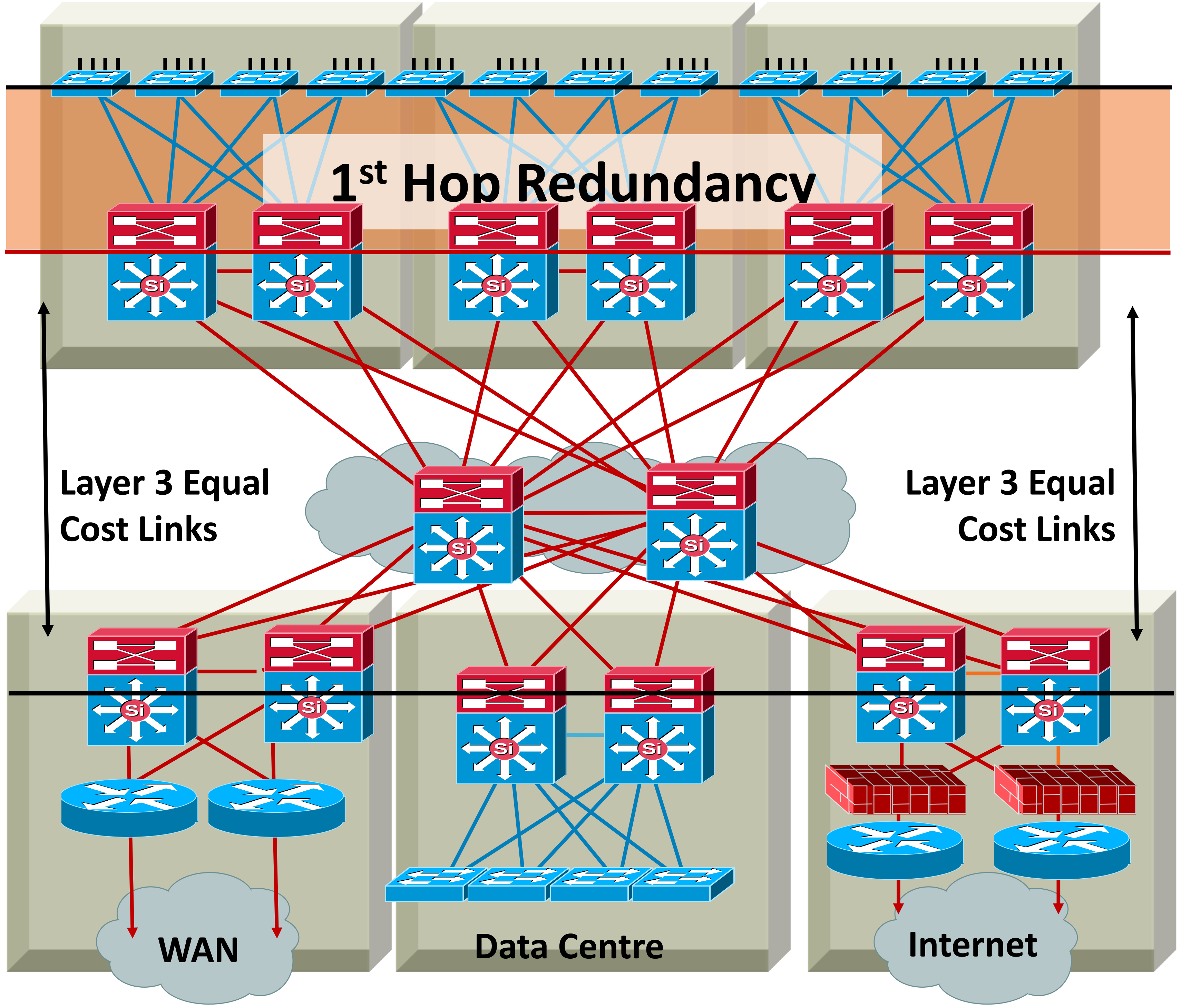
- Default L3 (src/dst IP) hash determines which link to use in etherchannel
  – Can lead to unbalanced utilisation
- Change default to include L4 information
  – Configured globally or on individual etherchannels.

Switch(config)# port-channel load-balance src-dst-port

Best Practices

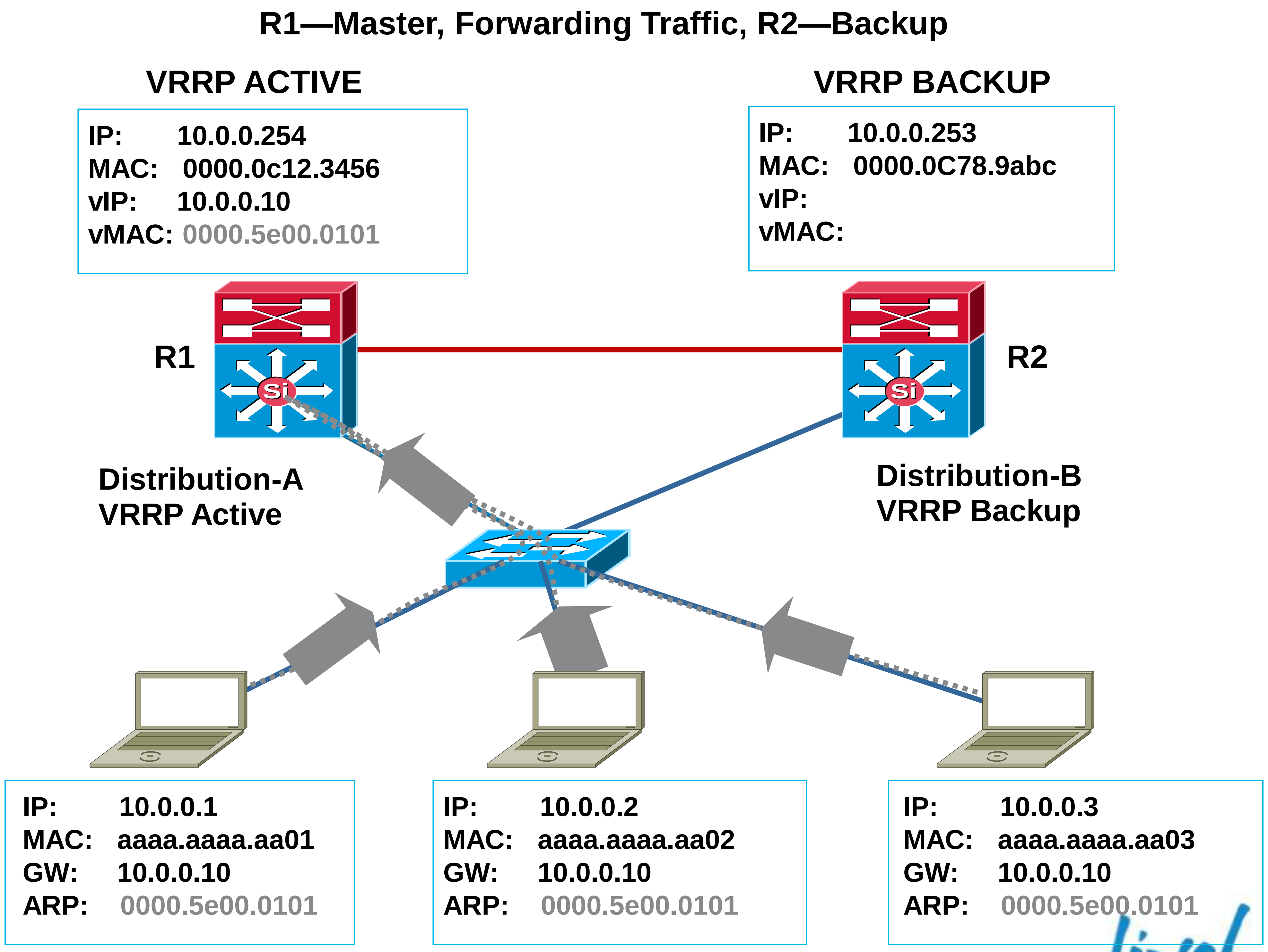
First Hop Redundancy

- Used to provide a resilient default gateway to end-stations
- HSRP, VRRP, and GLBP alternatives
- VRRP, HSRP, and GLBP provide millisecond timers and excellent convergence performance
- VRRP if you need multivendor interoperability
- GLBP facilitates uplink load balancing
- Preempt timers need to be tuned to avoid black-holed traffic



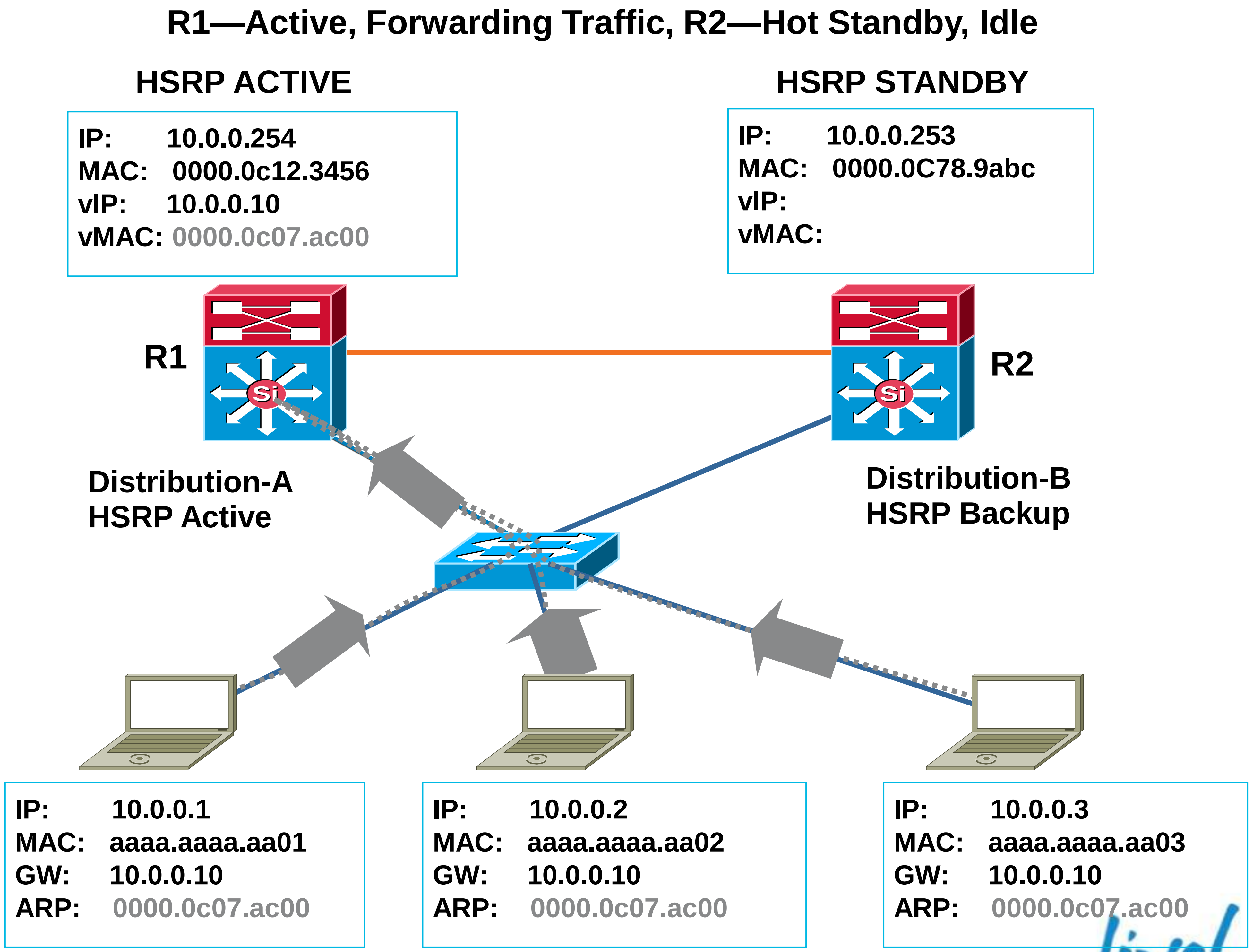
First Hop Redundancy with VRRP

- A group of routers function as one virtual router by sharing one virtual IP and MAC
- One (master) router performs packet forwarding for local hosts
- The rest of the routers act as back up in case the master router fails
- Backup routers stay idle as far as packet forwarding from the client side is concerned



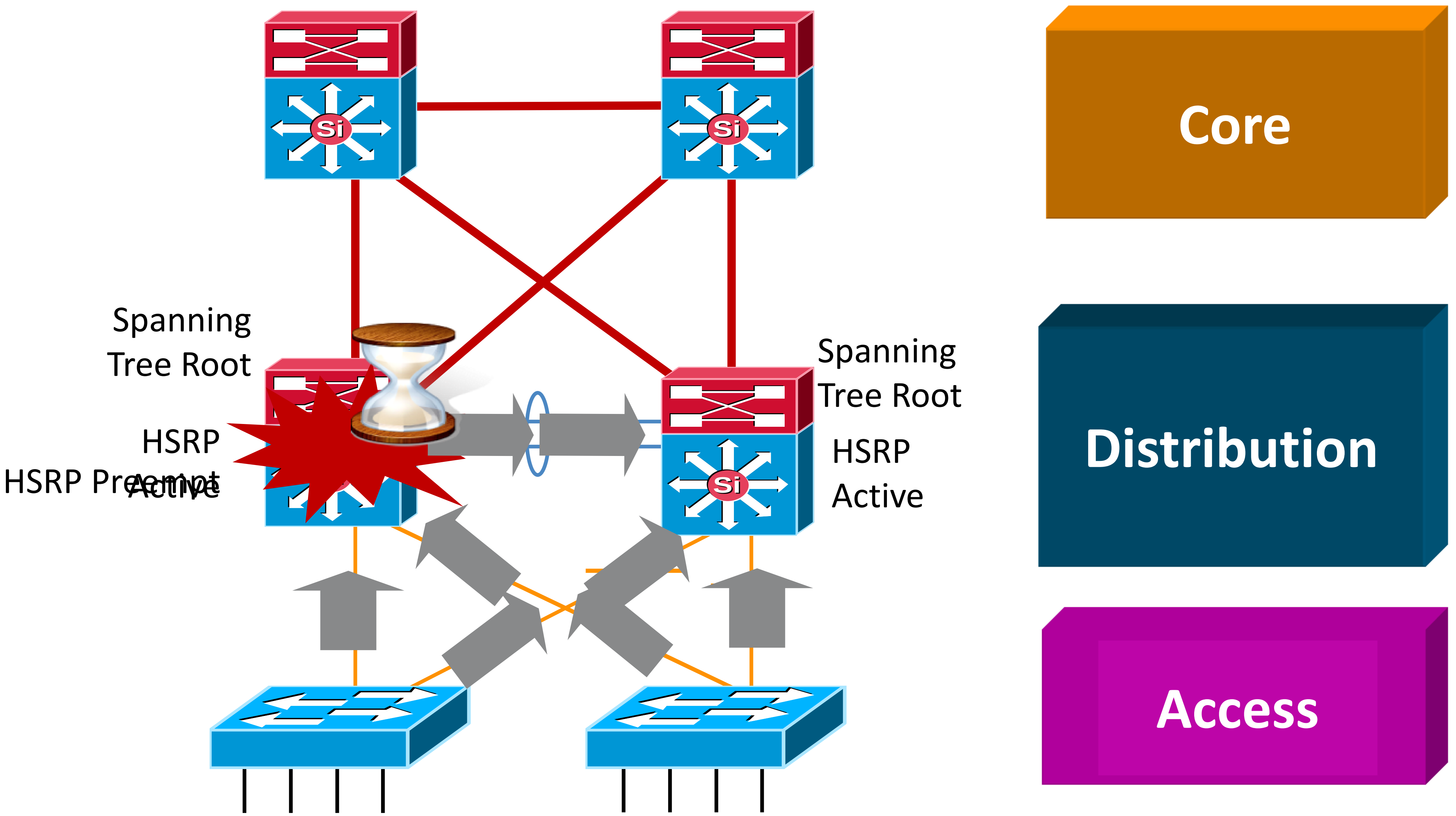
First Hop Redundancy with HSRP

- A group of routers function as one virtual router by sharing one virtual IP and MAC
- One (active) router performs packet forwarding for local hosts
- The rest of the routers provide hot standby in case the active router fails
- Standby routers stay idle as far as packet forwarding from the client side is concerned



Why You Want HSRP Preemption

- Spanning tree root and HSRP primary aligned
- When spanning tree root is re-introduced, traffic will take a two-hop path to HSRP active
- HSRP preemption will allow HSRP to follow spanning tree topology



Without preempt delay HSRP can go active before box completely ready to forward traffic due to L1 (Boards), L2 (STP), L3 (IGP Convergence)

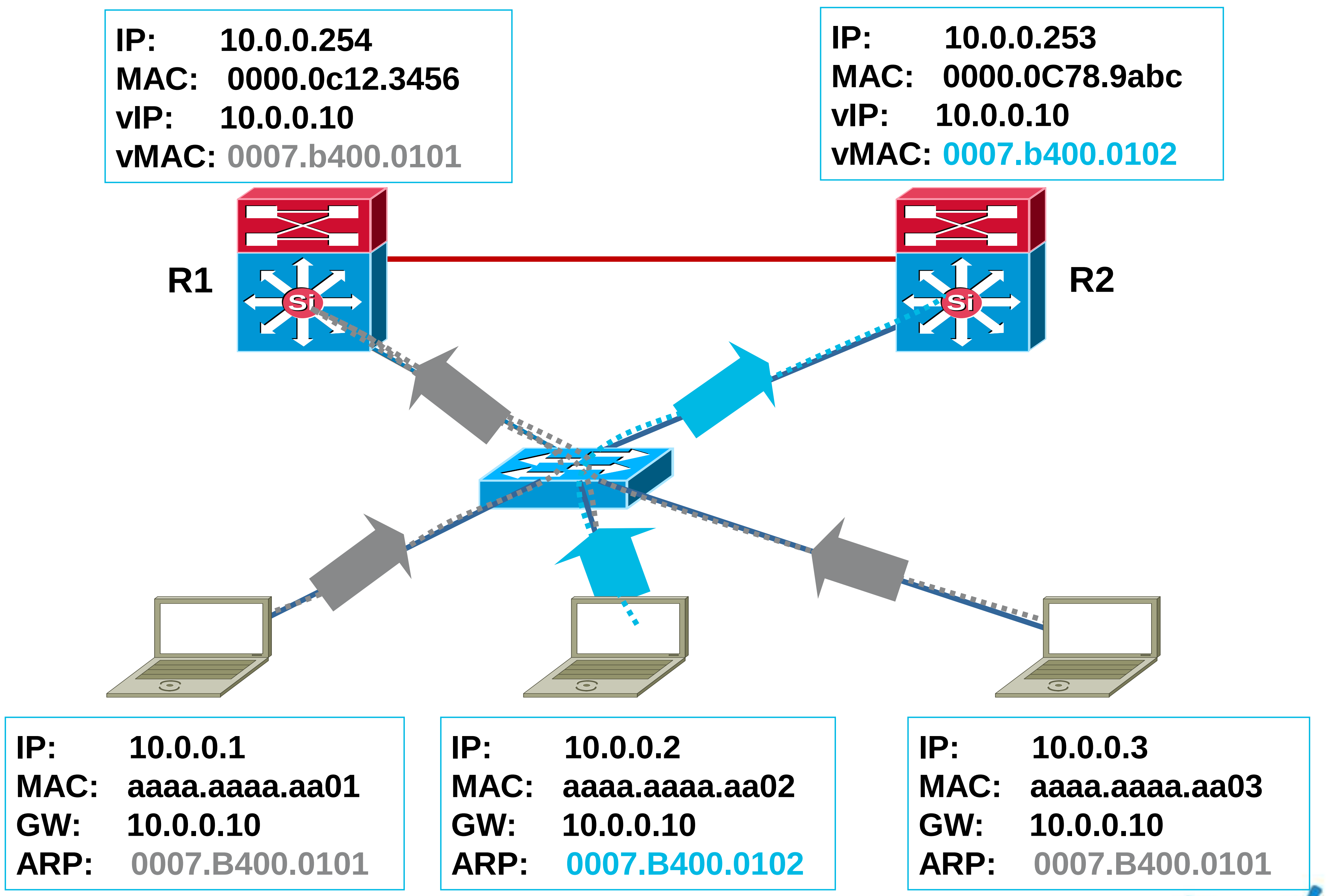
IOS (config-if)# **standby 1 preempt delay minimum 30**

First Hop Redundancy with GLBP

Cisco Proprietary, load sharing

- All the benefits of HSRP plus load balancing of default gateway, utilises all available bandwidth
- A group of routers function as one virtual router by sharing one virtual IP address but using multiple virtual MAC addresses for traffic forwarding
- Allows traffic from a single common subnet to go through multiple redundant gateways using a single virtual IP address

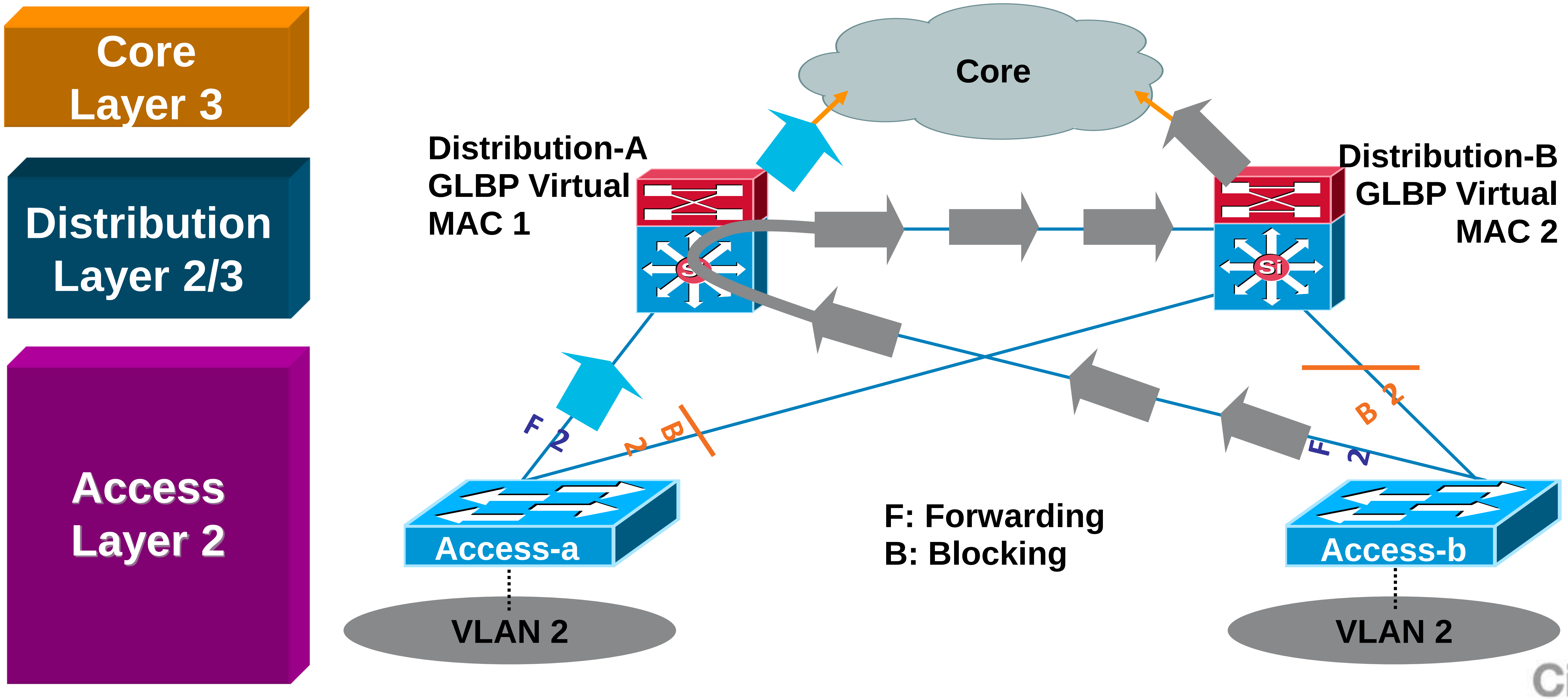
R1, R2 Both Forward Traffic



If You Span VLANS, Tuning Required

By Default, Half the Traffic Will Take a Two-Hop L2 Path

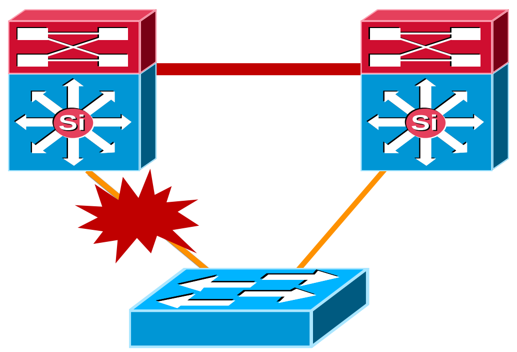
- Both distribution switches act as default gateway
- Blocked uplink caused traffic to take less than optimal path



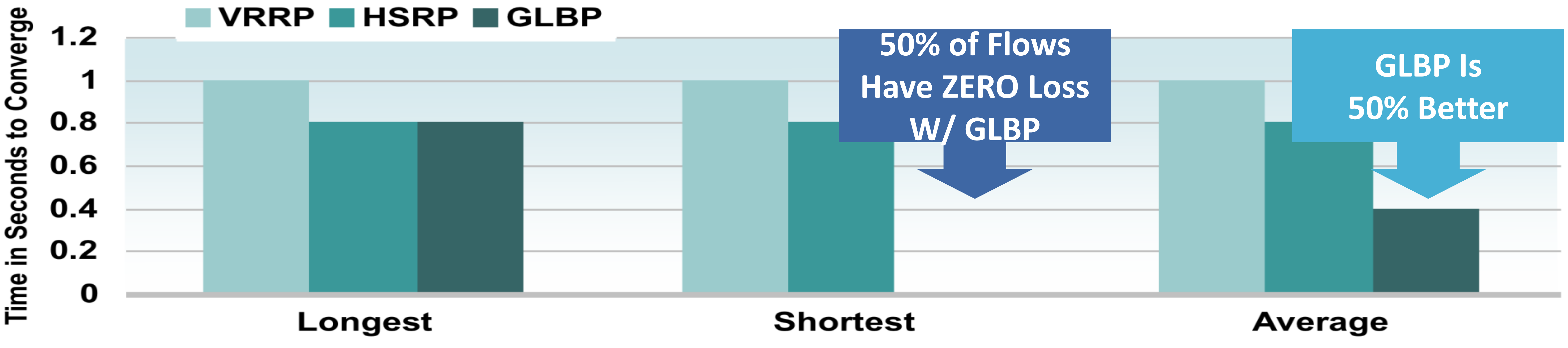
Optimising Convergence:

VRRP, HSRP, GLBP

- VRRP flows go through a common VRRP peer; mean, max, and min are equal
- HSRP has sub-second timers; however all flows go through same HSRP peer so there is no difference between mean, max, and min
- GLBP has sub-second timers and distributes the load amongst the GLBP peers; so 50% of the clients are not affected by an uplink failure



Distribution to access link failure, access to server farm



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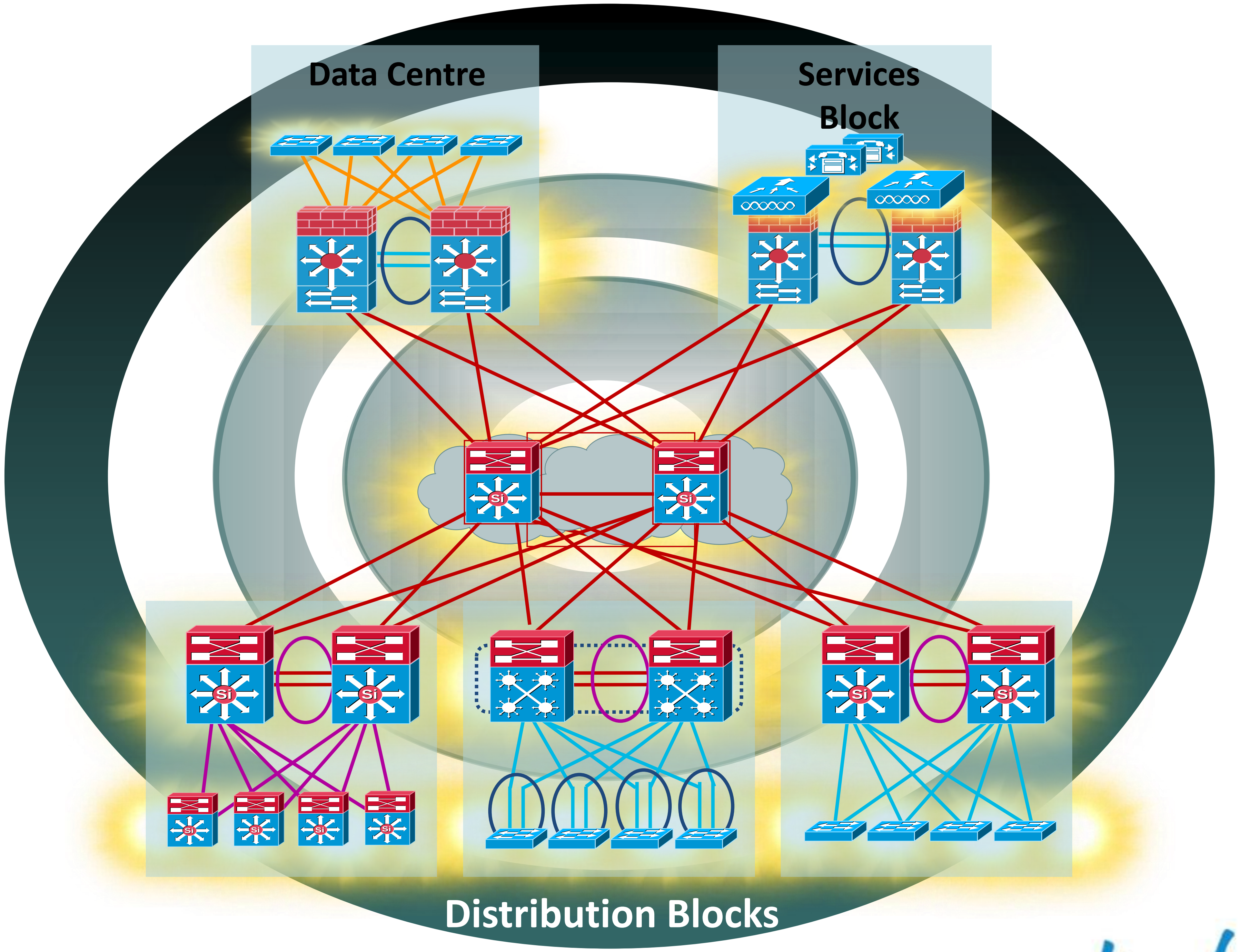
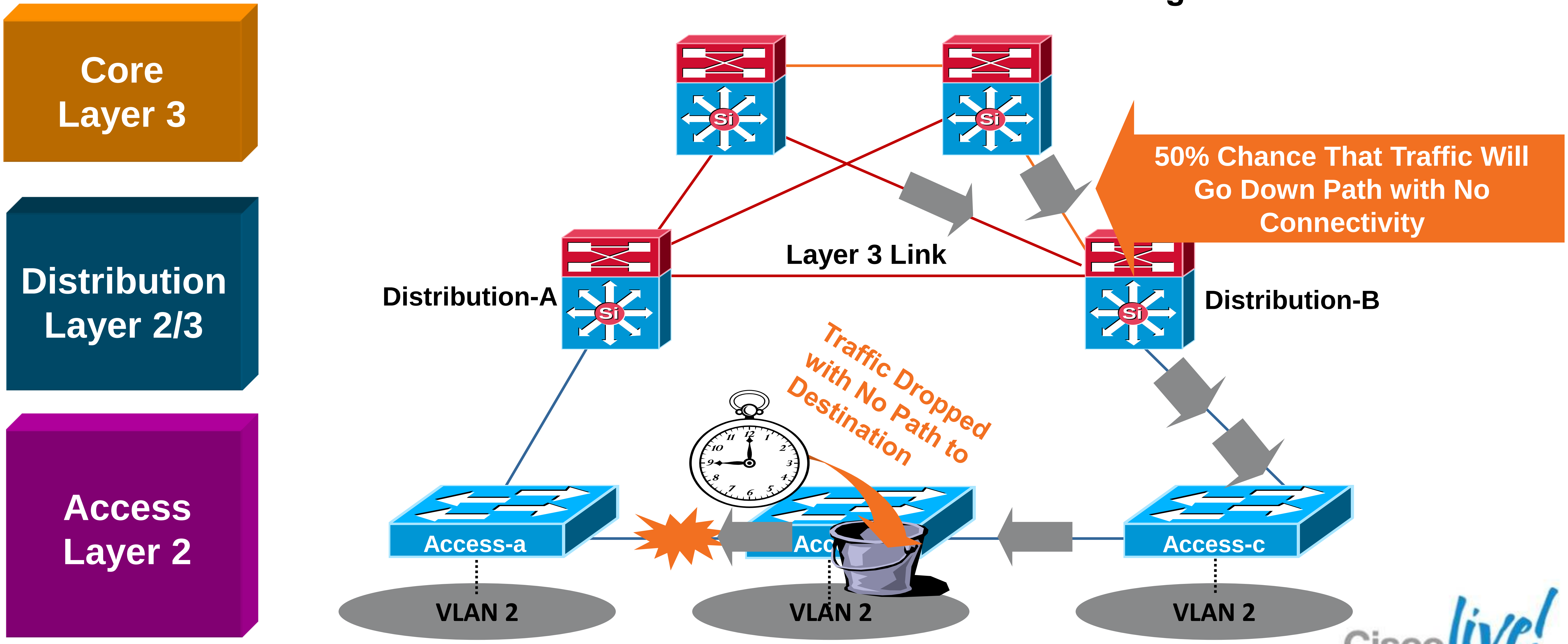
- Foundation Services
- Campus Design Best Practices
- Virtualisation techniques
- Security considerations
- What's next….
- Summary



Daisy Chaining Access Layer Switches

Avoid potential black holes

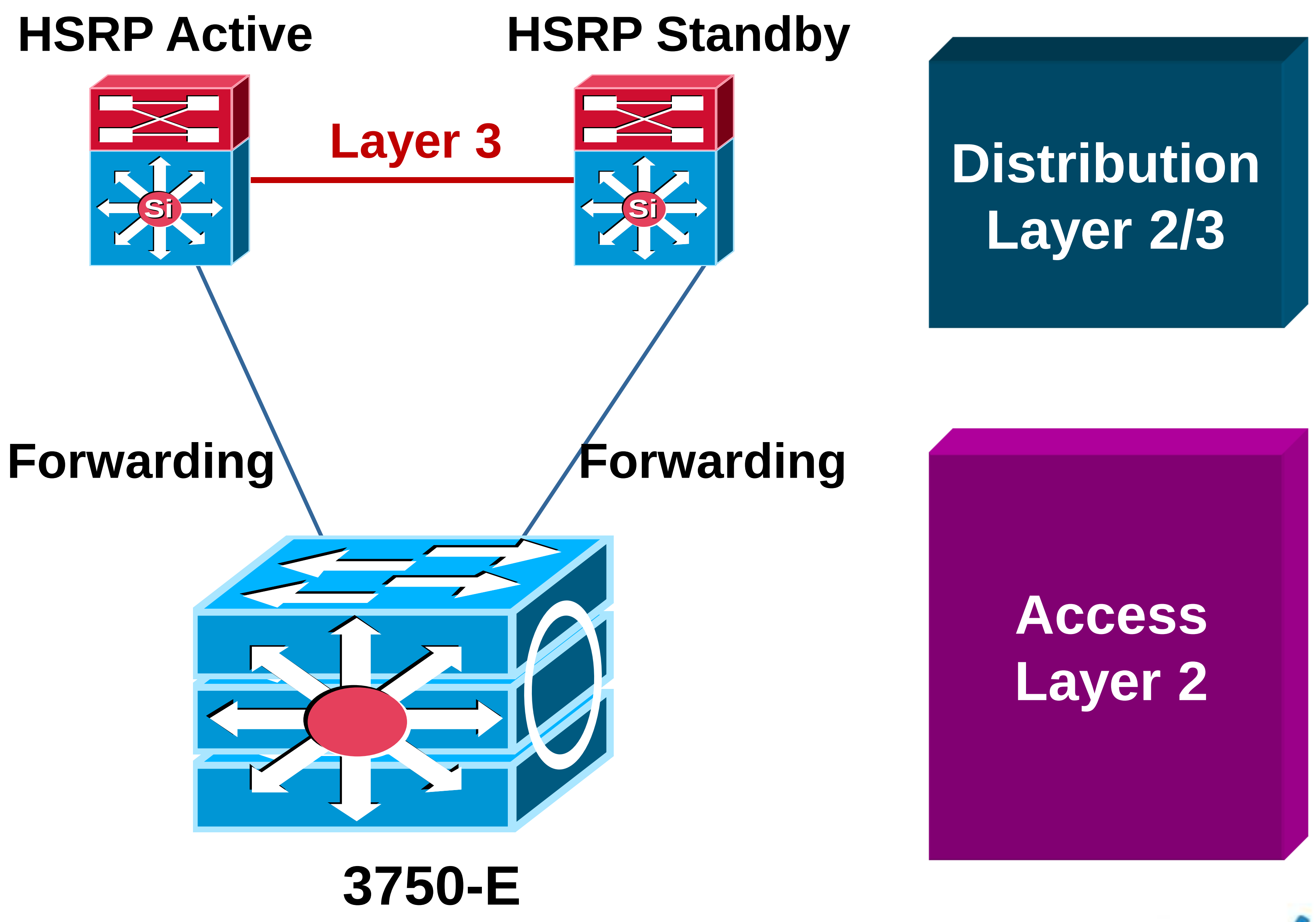
Return Path Traffic Has a 50/50 Chance of Being 'Black Holed'



Daisy Chaining Access Layer Switches

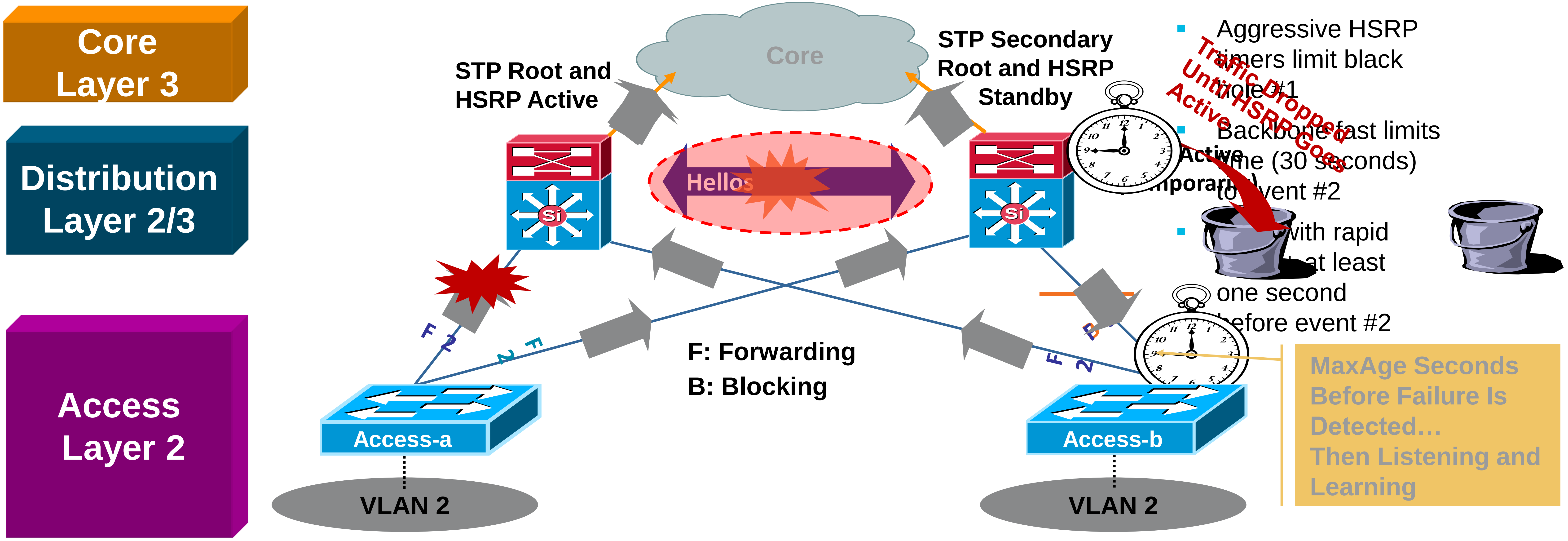
New technology addresses old problems

- **Stackwise/Stackwise-Plus** technology eliminates the concern
  - Loopback links not required
  - No longer forced to have L2 link in distribution
- If you use modular (chassis-based) switches, these problems are not a concern



What if you don’t link the distributions?

Black holes and multiple transitions …

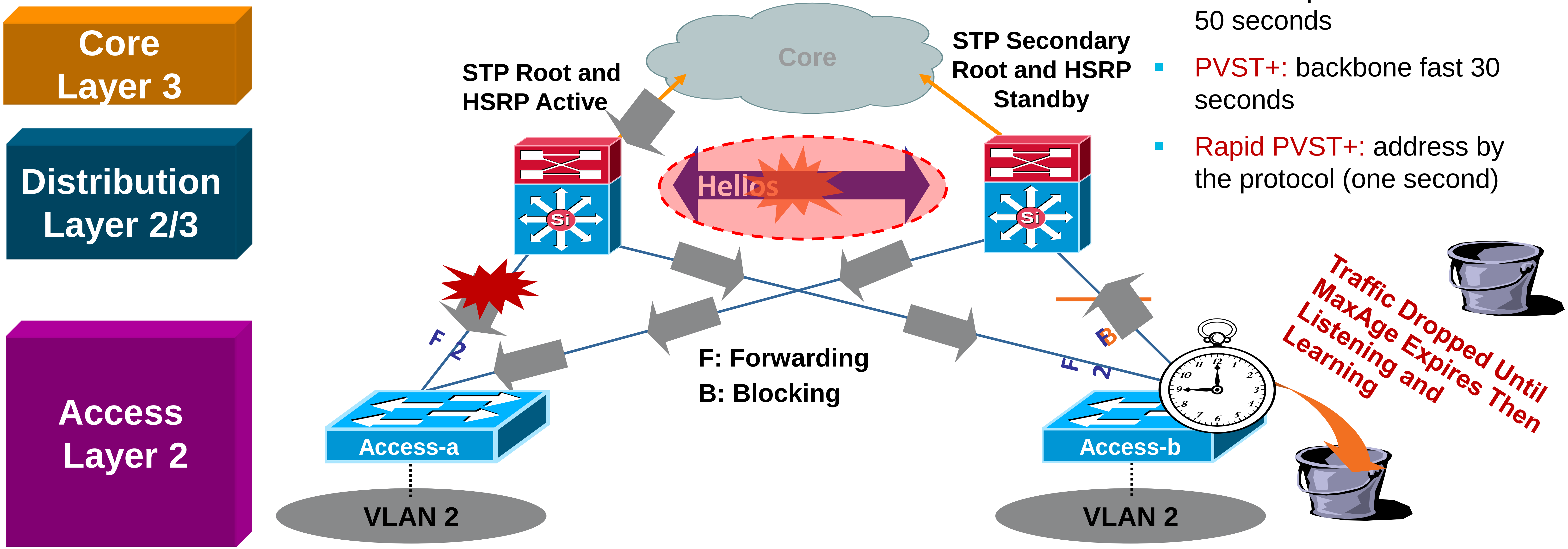


- **Blocking link on access-b will take 50 seconds to move to forwarding → traffic black hole until HSRP goes active on standby HSRP peer**
- **After MaxAge expires (or backbone fast or Rapid PVST+) converges HSRP preempt causes another transition**
- **Access-b used as transit for Access-a’s traffic**

What if you don’t link the distributions?

Return path traffic black-holed

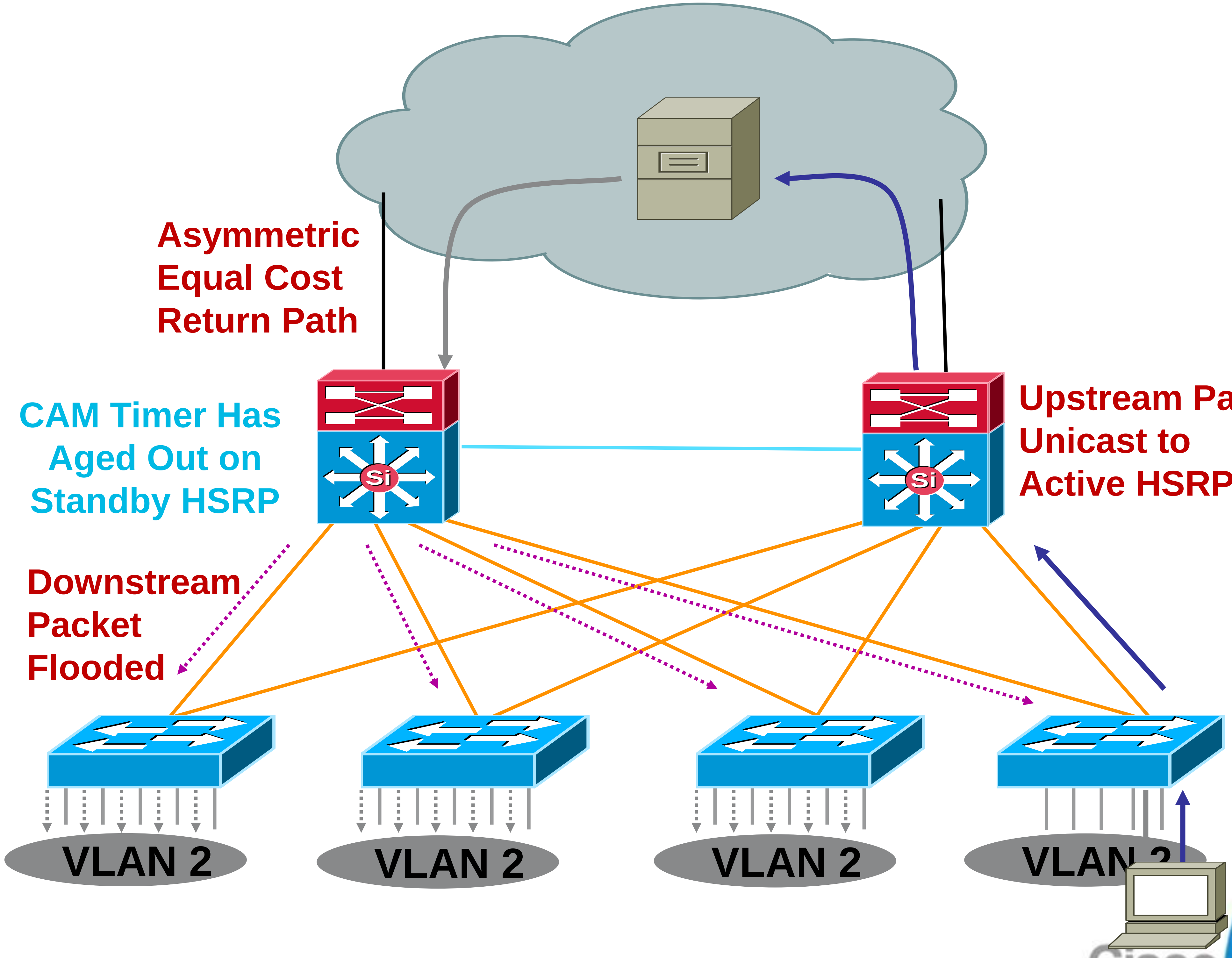
- 802.1d: up to 50 seconds
- PVST+: backbone fast 30 seconds
- Rapid PVST+: address by the protocol (one second)



- Blocking link on access-b will take 50 seconds to move to forwarding → return traffic black hole until then

Asymmetric Routing

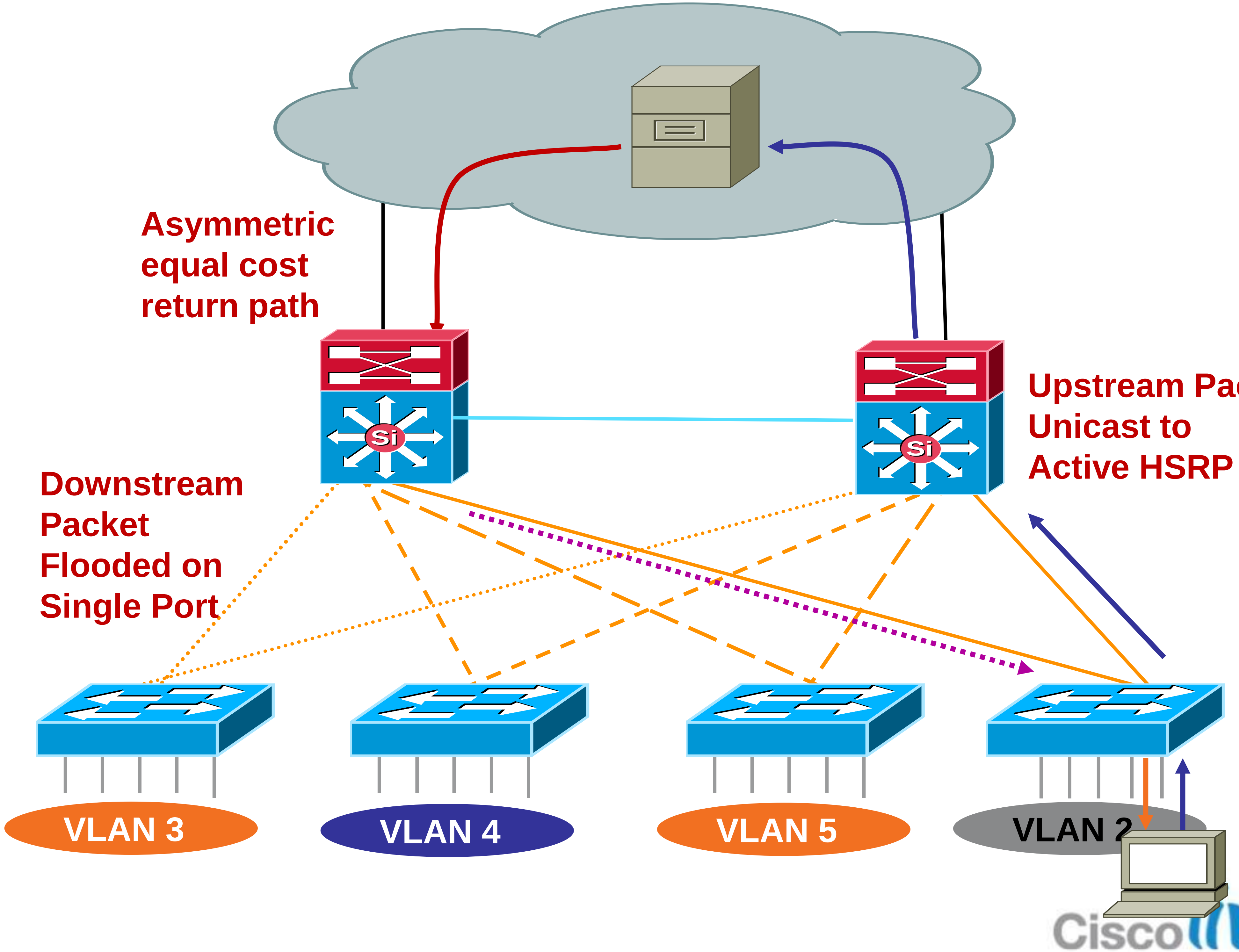
- Affects redundant topologies with shared L2 access
- One path upstream and two paths downstream
- CAM table entry ages out on standby HSRP
- Without a CAM entry packet is flooded to all ports in the VLAN



Asymmetric Routing

Best practice to prevent excessive flooding

- Assign one unique data and voice VLAN to each access switch
- Traffic is now only flooded down one trunk
- Access switch unicasts correctly; no flooding to all ports
- If you have to:
  - Tune ARP and CAM aging timers; CAM timer exceeds ARP timer
  - Bias routing metrics to remove equal cost routes



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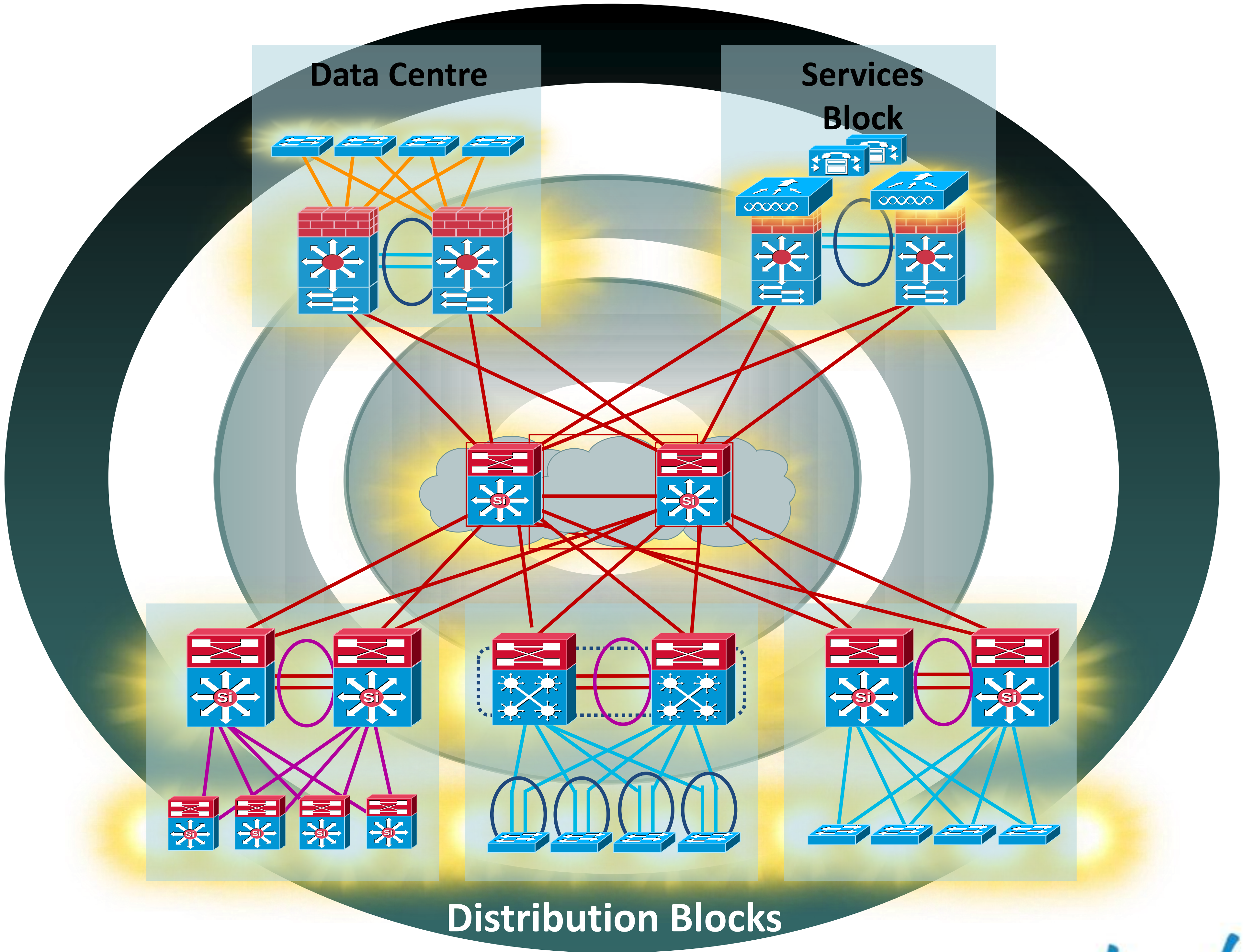
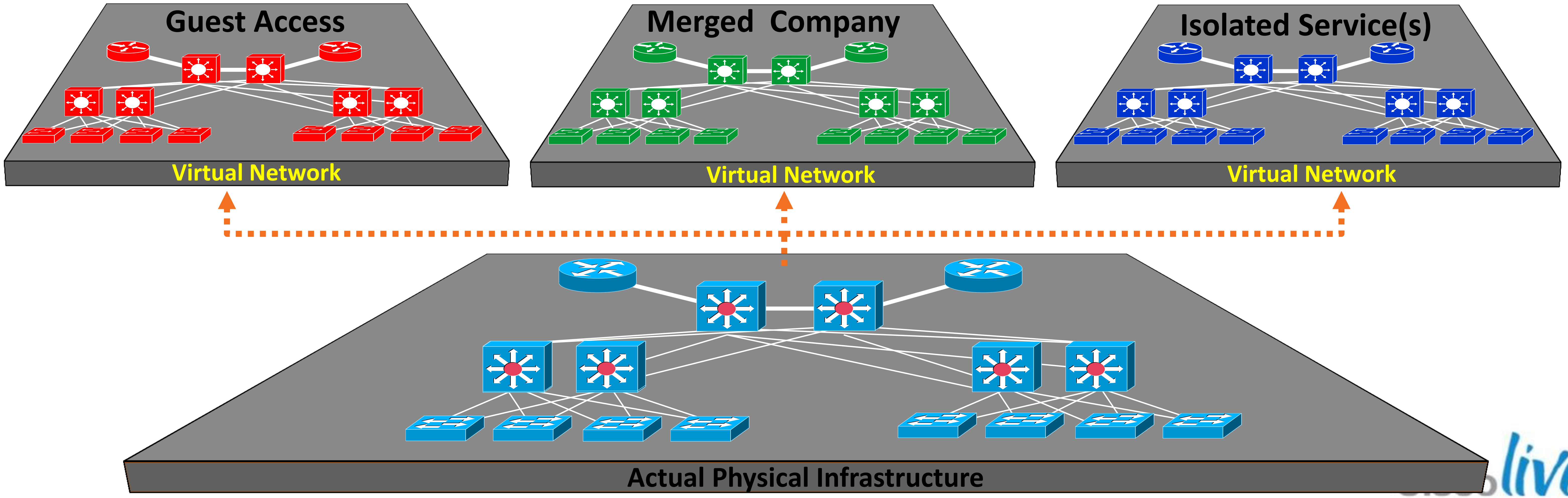


Why Virtualise?

Creates Logical Partitions

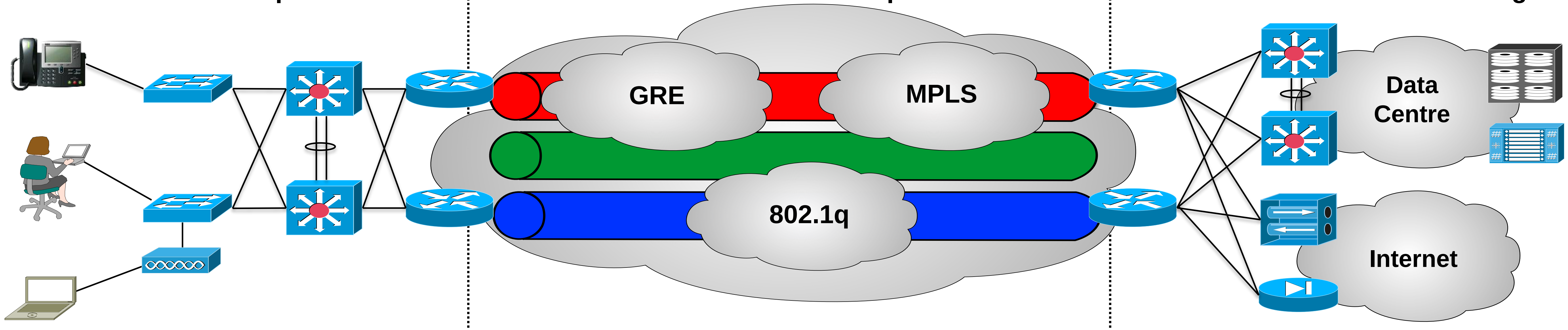
- Allows the use of unique security policies per logical domain
- Provides traffic isolation per application, group, service etc…
- The logical separation of traffic using one physical infrastructure



Network Virtualisation

Components

Service	Access Control	Path Isolation	Services Edge
	Branch – Campus	WAN – MAN – Campus	Data Centre – Internet Edge



Functions

Access Control

- Authenticate client (user, device, app) attempting to gain network access
- Authorise client into a partition (VLAN)
- Deny access to unauthenticated clients

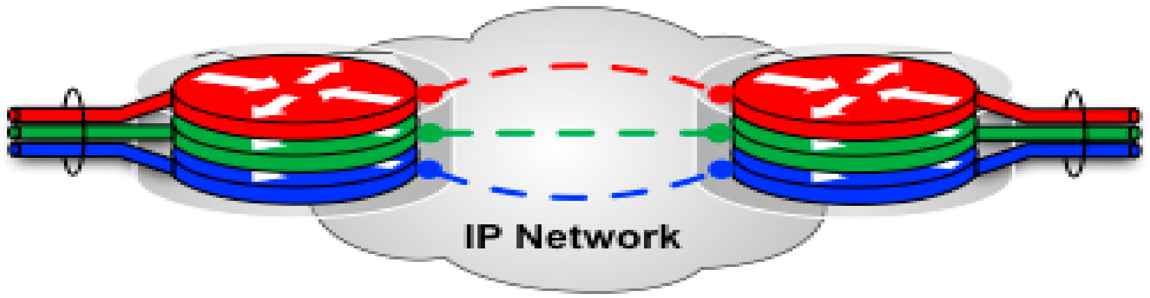
Path Isolation

- Maintain traffic partitioned over Layer 3 infrastructure
- Transport traffic over isolated Layer 3 partitions
- Map Layer 3 isolated path to VLANs / VRFs in access and services edge

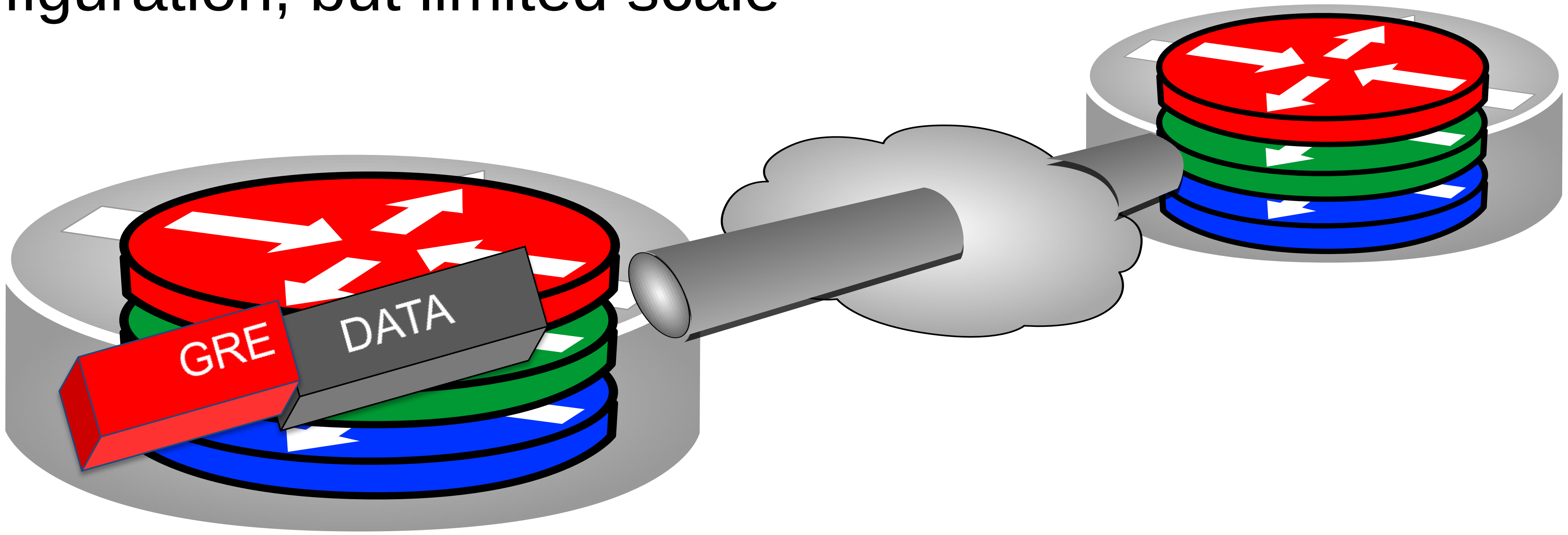
Services Edge

- Provide access to services
  - Shared
  - Dedicated
- Apply policy per partition
- Isolate application environments if necessary

VRF-Lite and GRE Tunnels



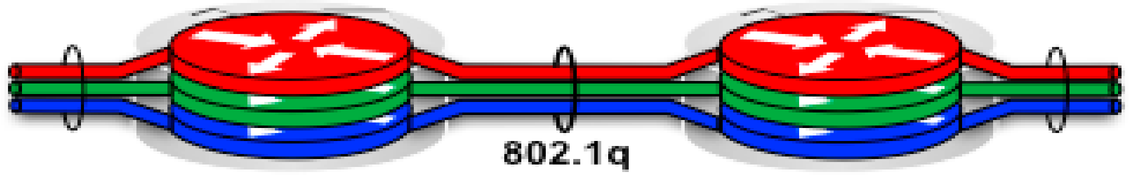
- Requires GRE tunnel, loopback and client side interface per VRF
- Easy configuration, but limited scale



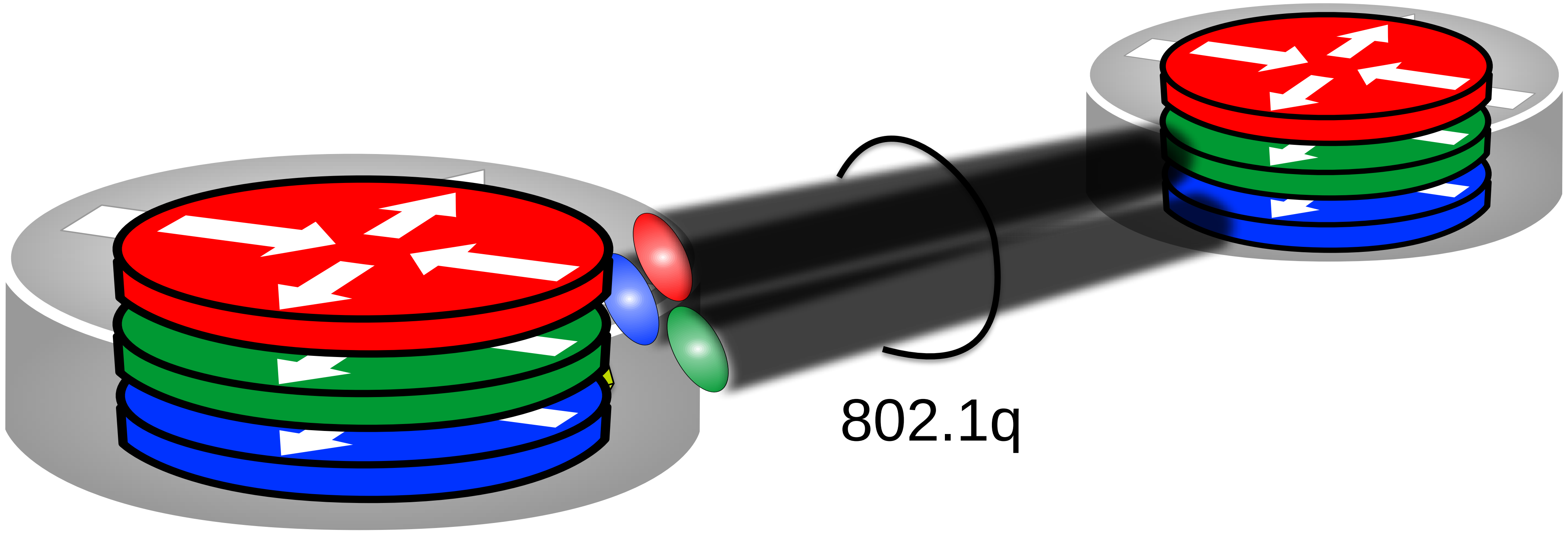
20 Byte IP Header	GRE Header 4/8 Bytes	Original Packet

GRE encapsulation represent 24 extra bytes or 28 if a key is present

VRF-Lite End-to-End

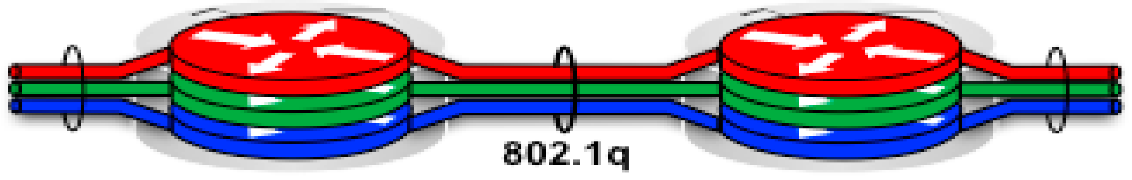


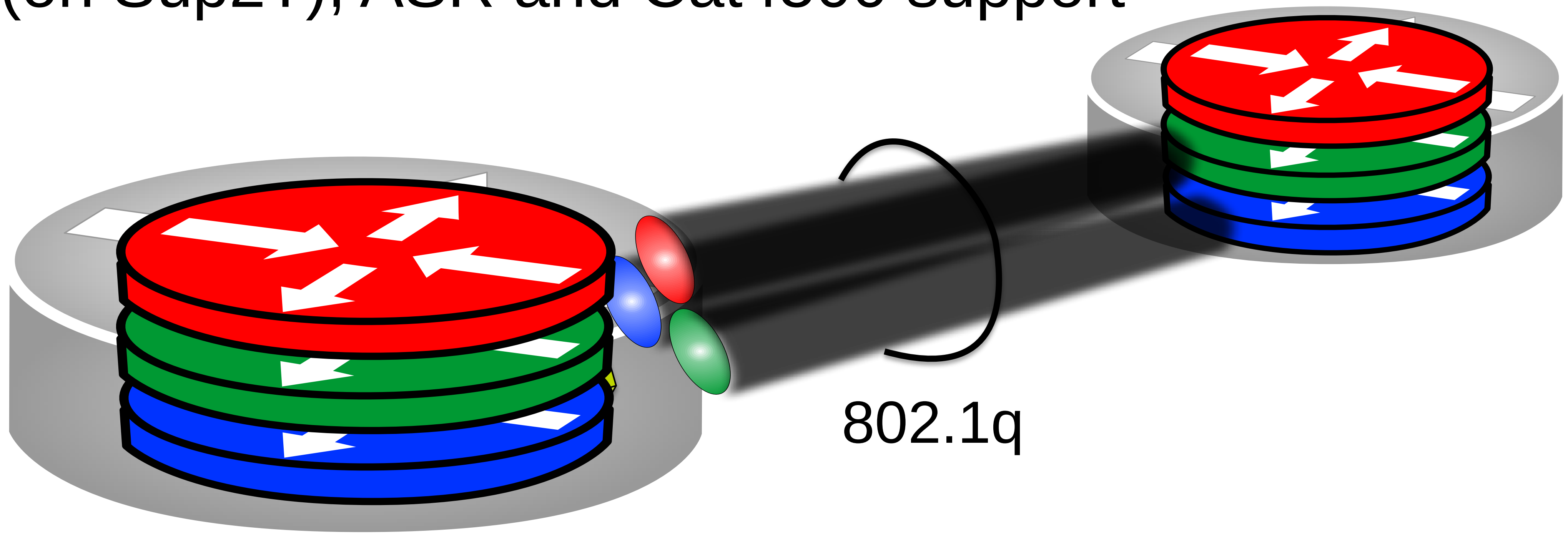
- Packets processed per VRF
- Unique control plane and data plane
- Requires sub-interfaces on L3 trunks (not supported on 4500)



EVN End-to-End

- Packets processed per VRF
- Unique control plane and data plane
- Automatic configuration of trunks
- Cat6500 (on Sup2T), ASR and Cat4500 support





Trunk configuration comparison

VRF-lite end-to-end example

```
vrf definition RED
 address-family ipv4
vrf definition GREEN
 address-family ipv4
Vrf definition BLUE
 address-family ipv4
!
interface GigabitEthernet0/0
 description Trunk interface
!
interface GigabitEthernet0/0.100
 vrf forwarding RED
 encapsulation dot1Q 100
 ip address 10.100.1.1 255.255.255.0
!
interface GigabitEthernet0/0.101
 vrf forwarding GREEN
 encapsulation dot1Q 101
 ip address 10.101.1.1 255.255.255.0
!
interface GigabitEthernet0/0.102
 vrf forwarding BLUE
 encapsulation dot1Q 102
 ip address 10.102.1.1 255.255.255.0
```

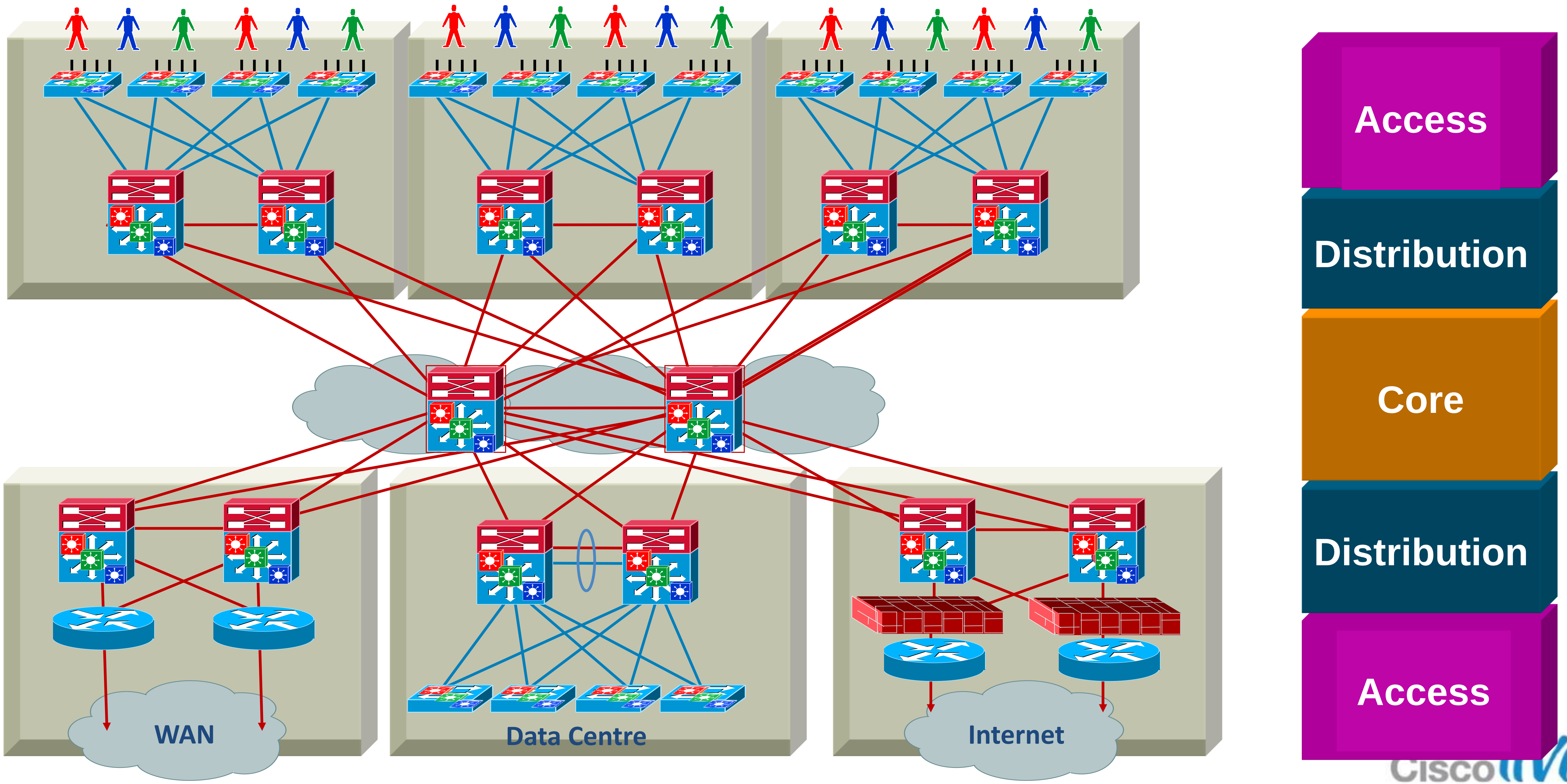
EVN example

```
vrf definition RED
 vnet tag 100
 address-family ipv4
vrf definition GREEN
 vnet tag 101
 address-family ipv4
vrf definition BLUE
 vnet tag 102
!
interface GigabitEthernet0/0
 description Trunk interface
 ip address 10.1.1.1 255.255.255.0
 vnet trunk
```

New command

Automatically creates sub-interfaces for each VRF.
"show derived-config gig0/0.100" will show sub-interface config.

Virtualised network



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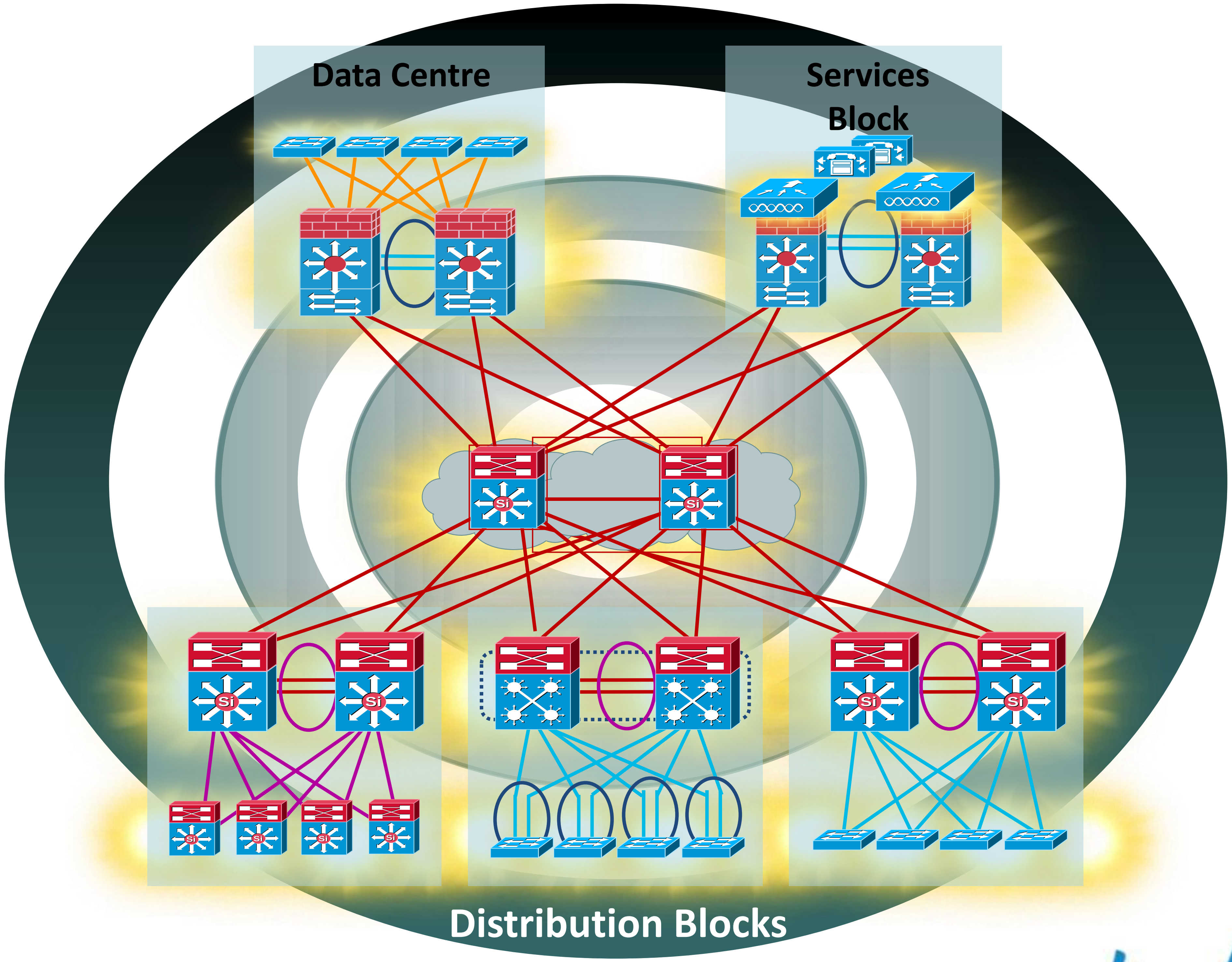
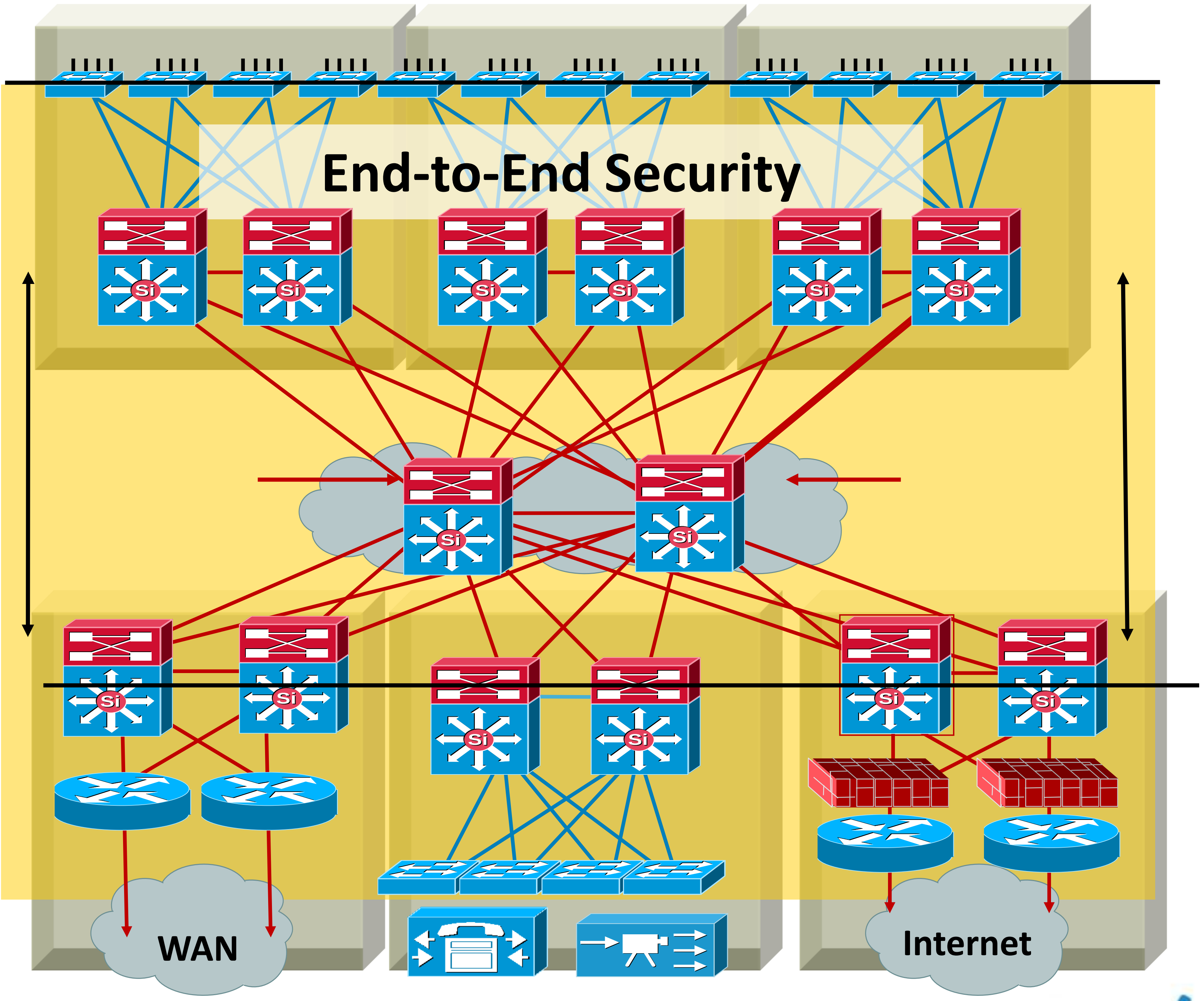


Best Practices—Campus Security

- Things you already know…
  - Use SSH to access devices instead of Telnet
  - Enable AAA and roles-based access control (RADIUS/TACACS+) for the CLI on all devices
  - Enable SYSLOG to a server. Collect and archive logs
  - When using SNMP use SNMPv3
  - Disable unused services:

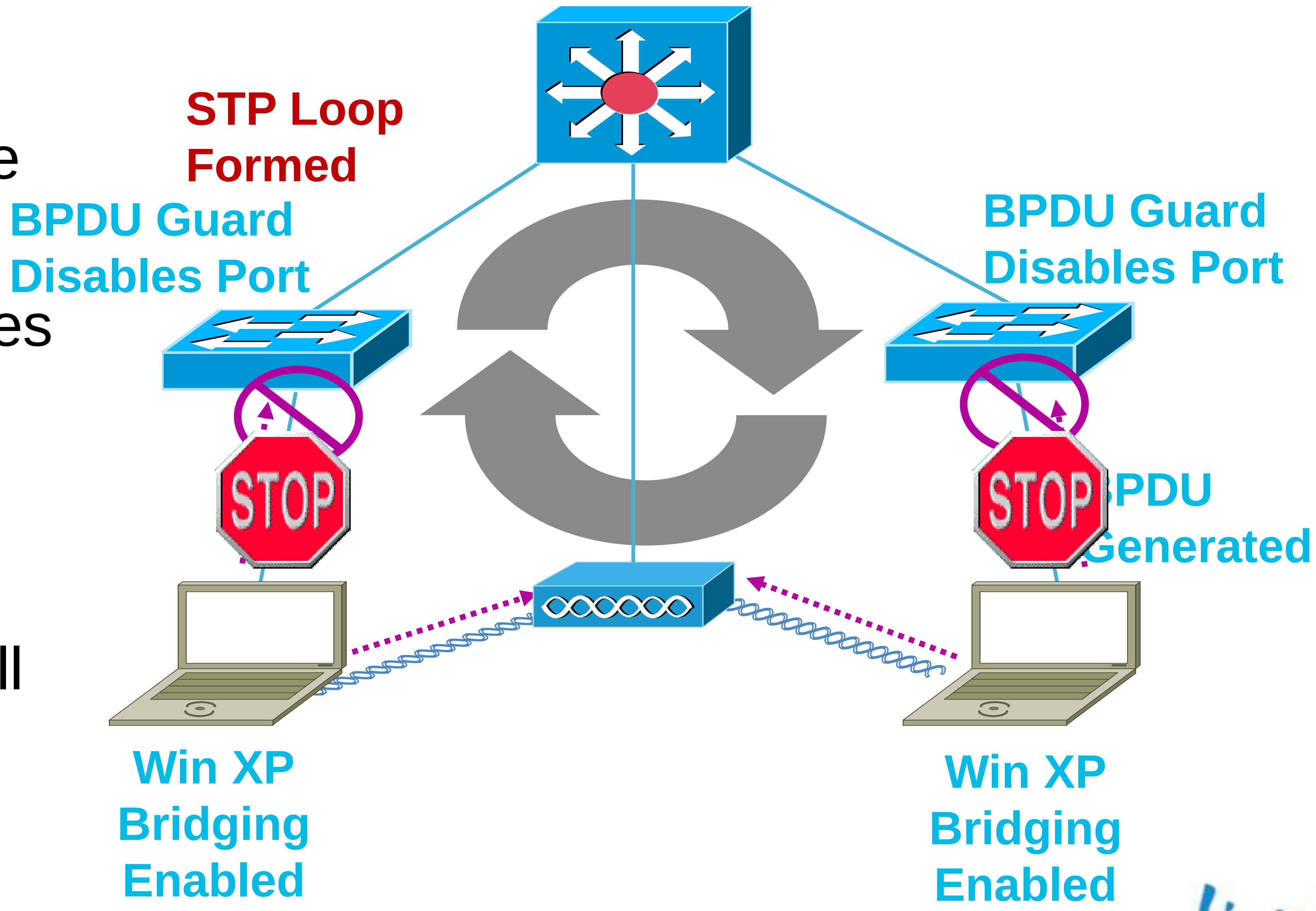
    No service tcp-small-servers
    No service udp-small-servers
  - Use FTP or SFTP (SSH FTP) to move images and configurations around—avoid TFTP when possible
  - Install VTY access-lists to limit which addresses can access management and CLI services
  - Enable control plane protocol authentication where it is available (EIGRP, OSPF, BGP, HSRP, VTP, etc.)



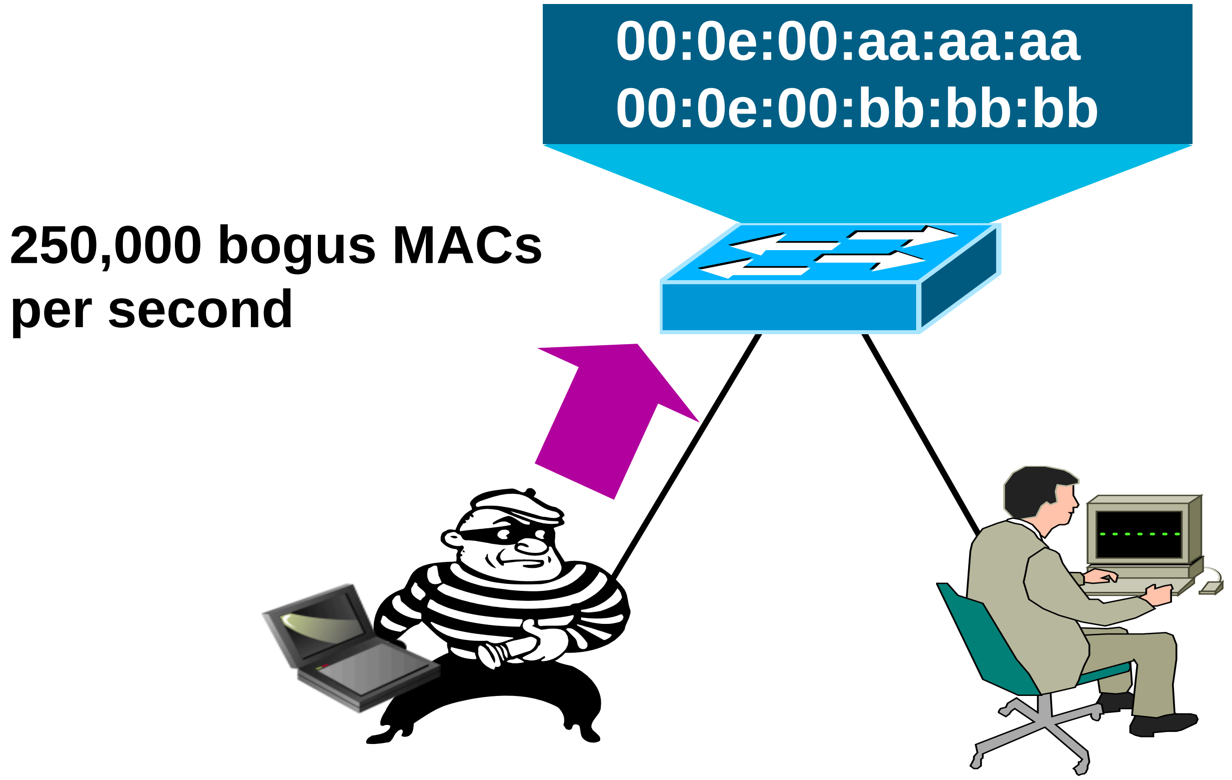
For More Details, See BRKSEC-2202 Session, Understanding and Preventing Layer 2 Attacks

BPDU Guard

- **Problem:**
  - Users can plug a switch in at their desk that tries to become root
  - Multiple Windows XP machines can create a loop in the wired VLAN via the WLAN
- **Solution:**
  - BPDU Guard configured on all end-station switch ports will prevent loop from forming



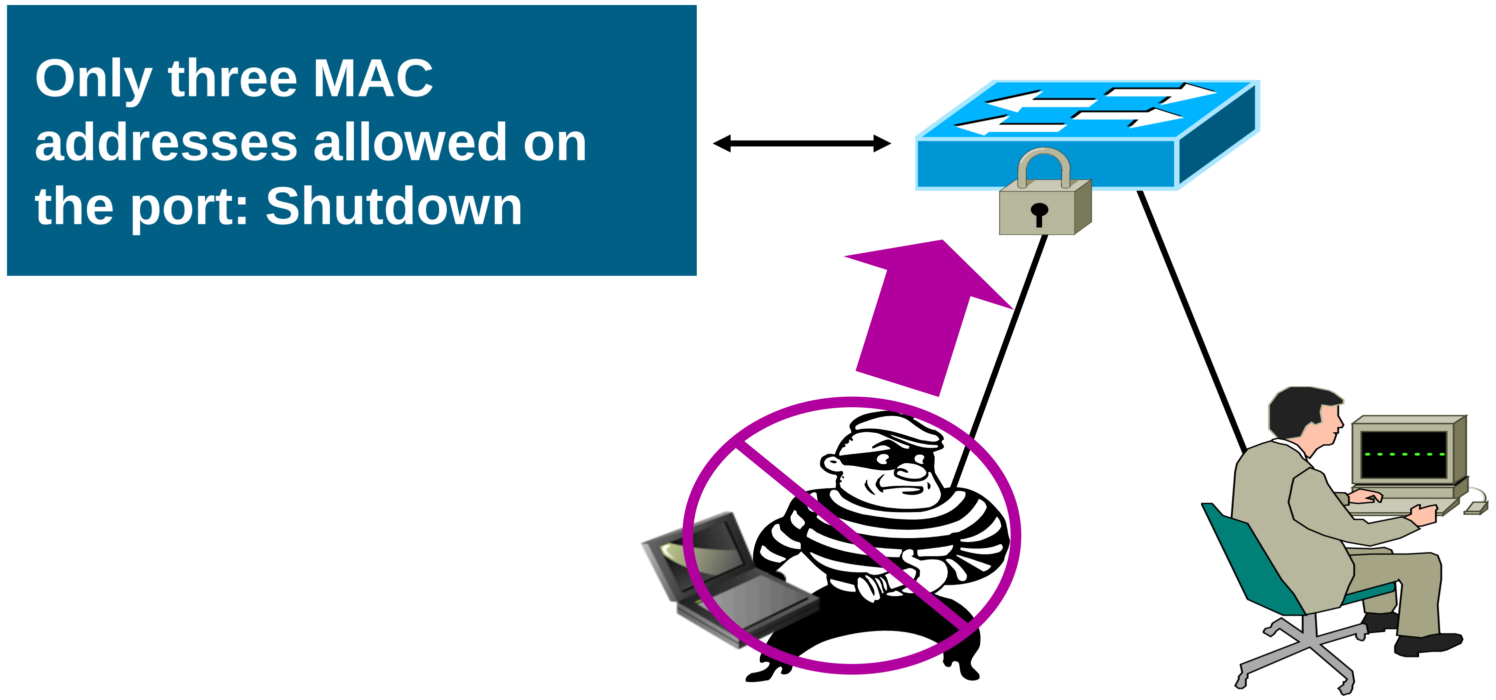
Securing Layer 2 from Surveillance Attacks Cutting Off MAC-Based Attacks



Problem:

Script Kiddie hacking tools enable attackers to flood switch CAM tables with bogus MACs; turning the VLAN into a hub and eliminating privacy

Switch CAM table limit is finite number of MAC addresses



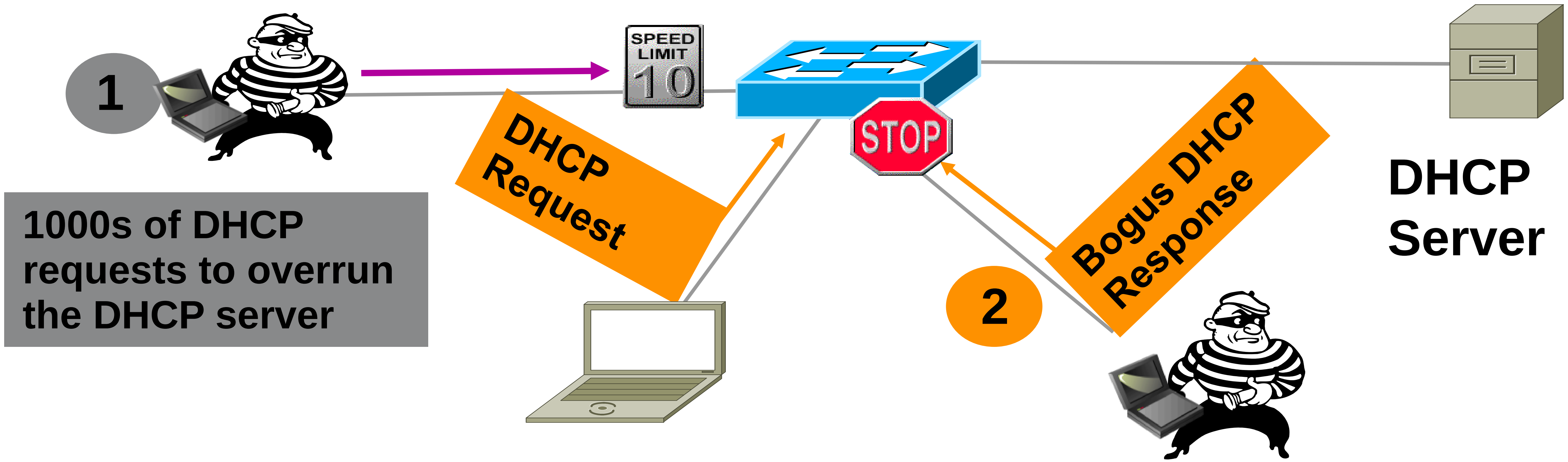
Solution:

Port Security limits MAC flooding attack by locking down port and sends an SNMP trap

```
switchport port-security
switchport port-security maximum 3
switchport port-security violation restrict
switchport port-security aging time 2
switchport port-security aging type inactivity
```


DHCP Snooping

Protection Against Rogue/Malicious DHCP Server

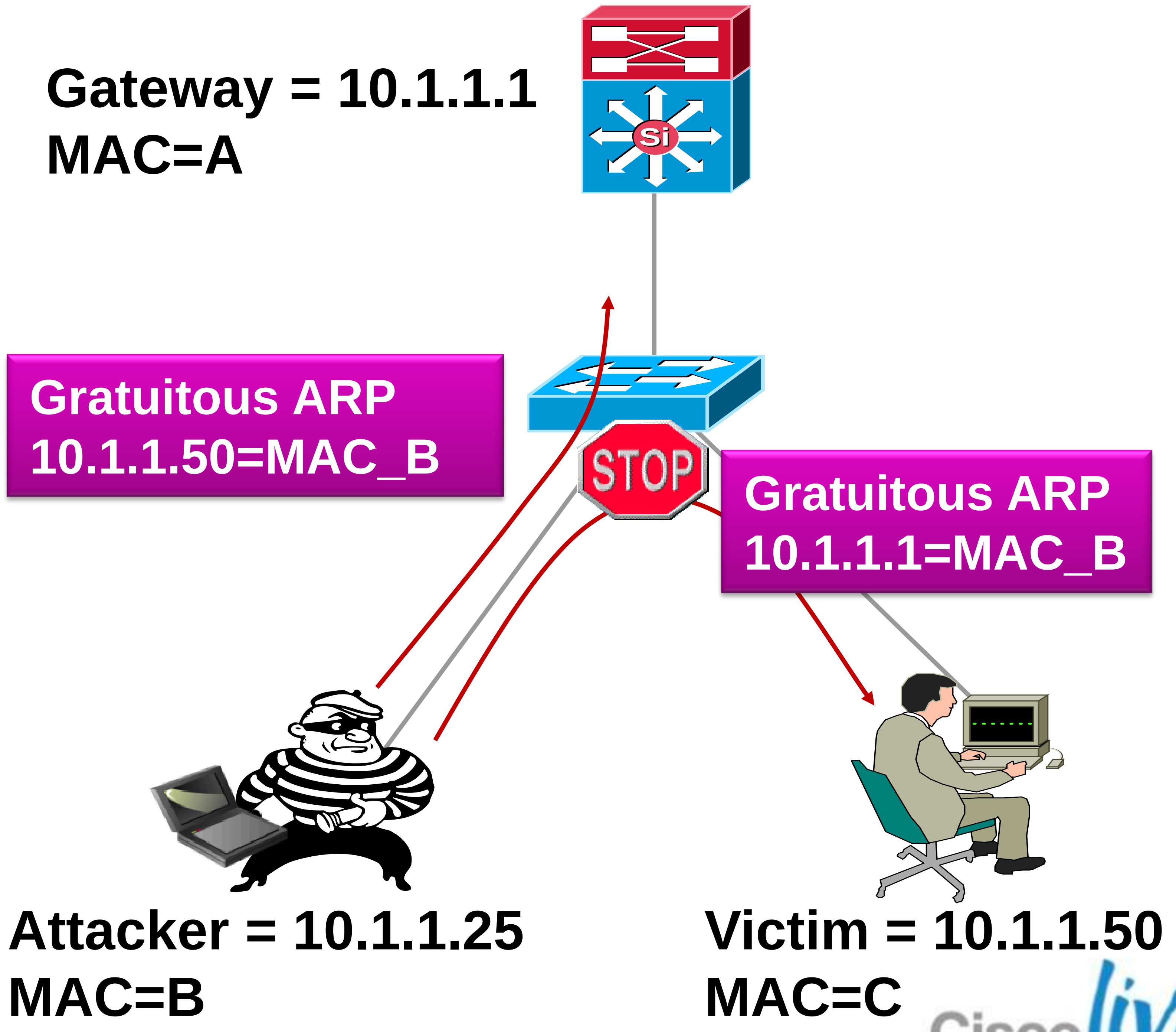


- DHCP requests (discover) and responses (offer) tracked
- Rate-limit requests on trusted interfaces; limits DoS attacks on DHCP server
- Deny responses (offers) on non trusted interfaces; stop malicious or errant DHCP server

Dynamic ARP Inspection

Protection Against ARP Poisoning

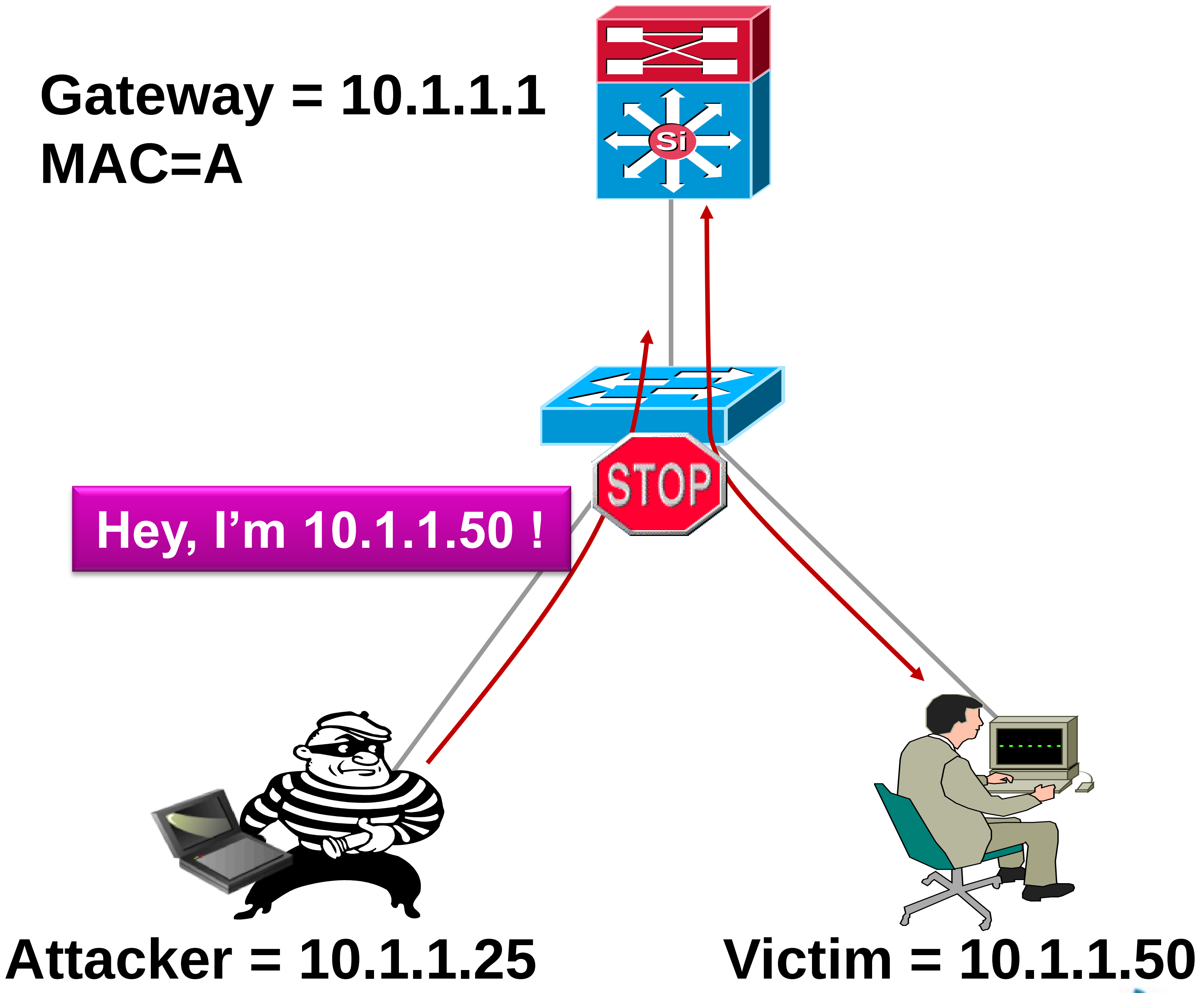
- Dynamic ARP inspection protects against ARP poisoning (ettercap, dsnif, arpspoof)
- Uses the DHCP snooping binding table
- Tracks MAC to IP from DHCP transactions
- Rate-limits ARP requests from client ports; stop port scanning
- Drop **bogus** gratuitous ARPs; stop ARP poisoning/MIM attacks



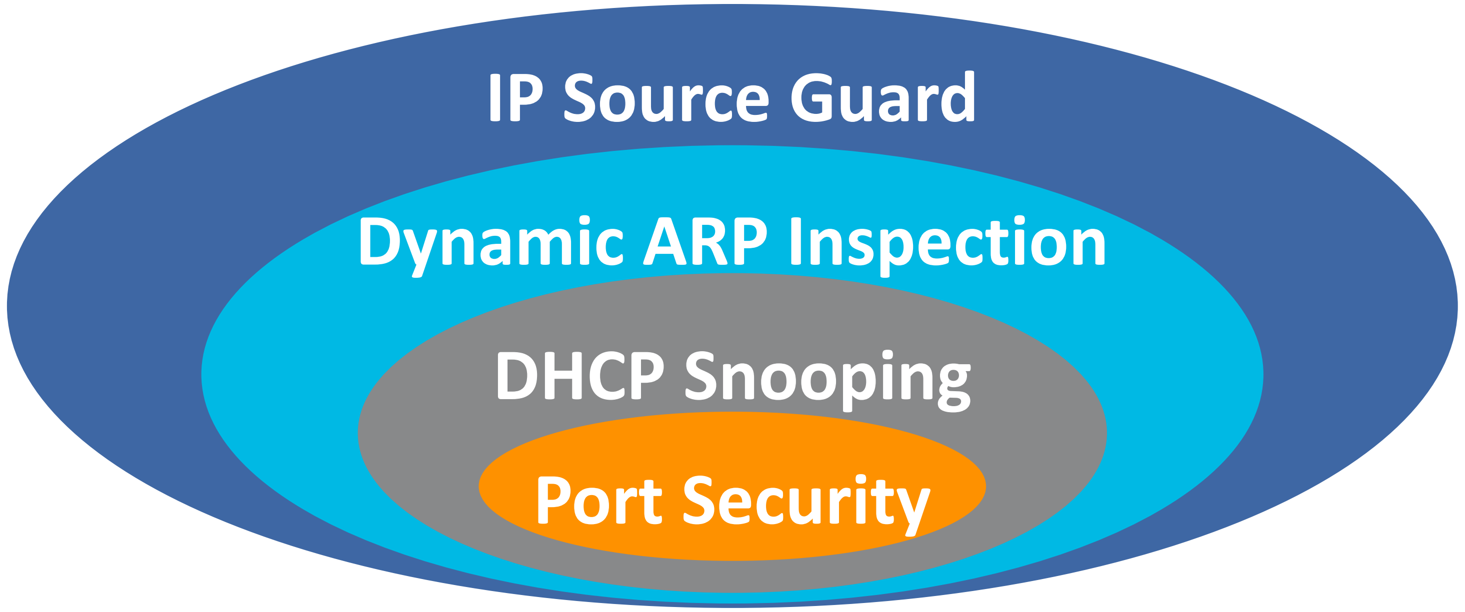
IP Source Guard

Protection Against Spoofed IP Addresses

- IP source guard protects against spoofed IP addresses
- Uses the DHCP snooping binding table
- Tracks IP address to port associations
- Dynamically programs port ACL to drop traffic not originating from IP address assigned via DHCP



Catalyst Integrated Security Features



- Port security prevents MAC flooding attacks
- DHCP snooping prevents client attack on the switch and server
- Dynamic ARP Inspection addssecurity to ARP using DHCP snooping table
- IP source guard adds security to IP source address using DHCP snooping table

```
ip dhcp snooping
ip dhcp snooping vlan 2-10
ip arp inspection vlan 2-10
!
interface FastEthernet3/1
 switchport port-security
 switchport port-security max 3
 switchport port-security violation restrict
 switchport port-security aging time 2
 switchport port-security aging type inactivity
 ip arp inspection limit rate 100
 ip dhcp snooping limit rate 100
 ip verify source vlan dhcp-snooping
!
interface GigabitEthernet1/1
 ip dhcp snooping trust
 ip arp inspection trust
```

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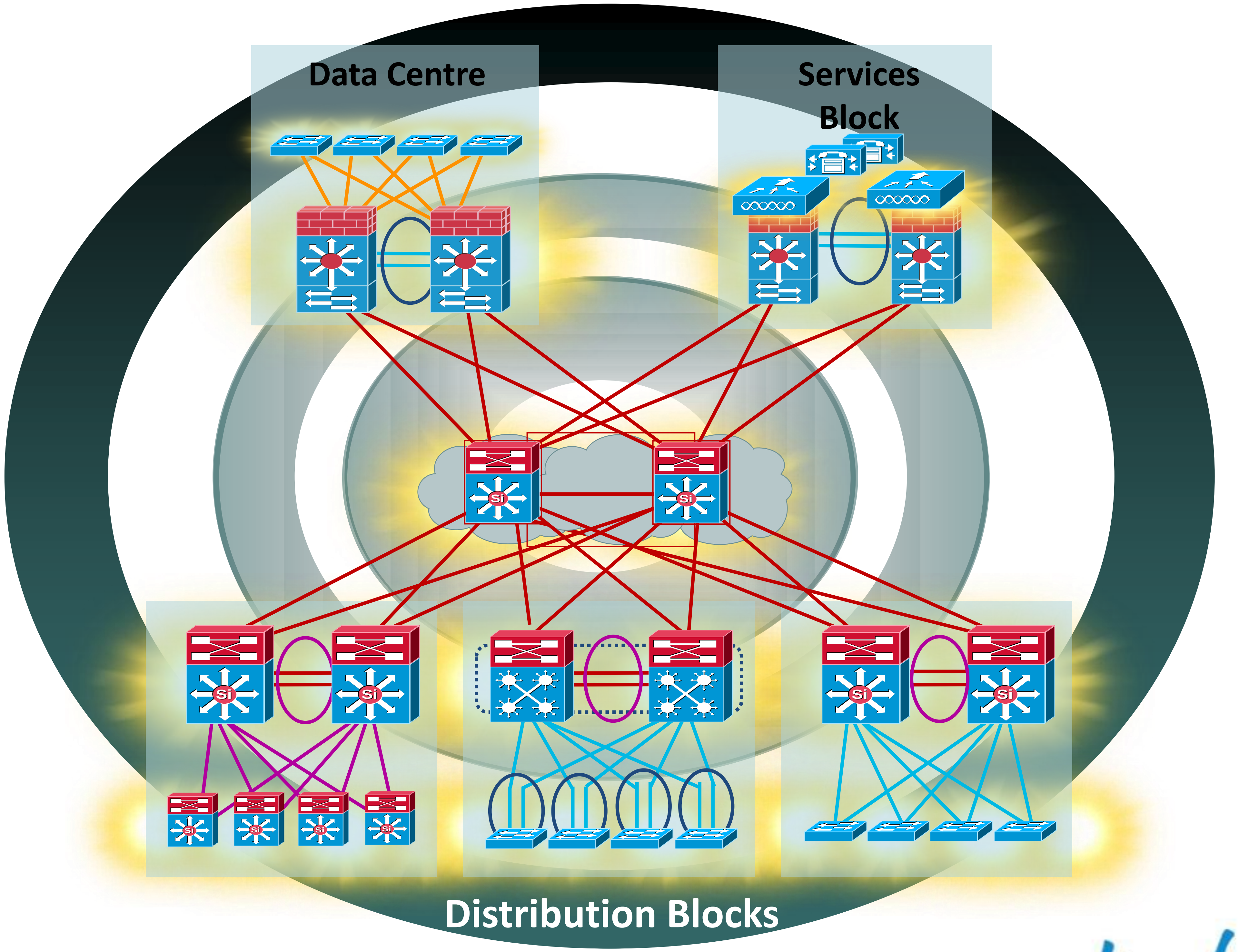
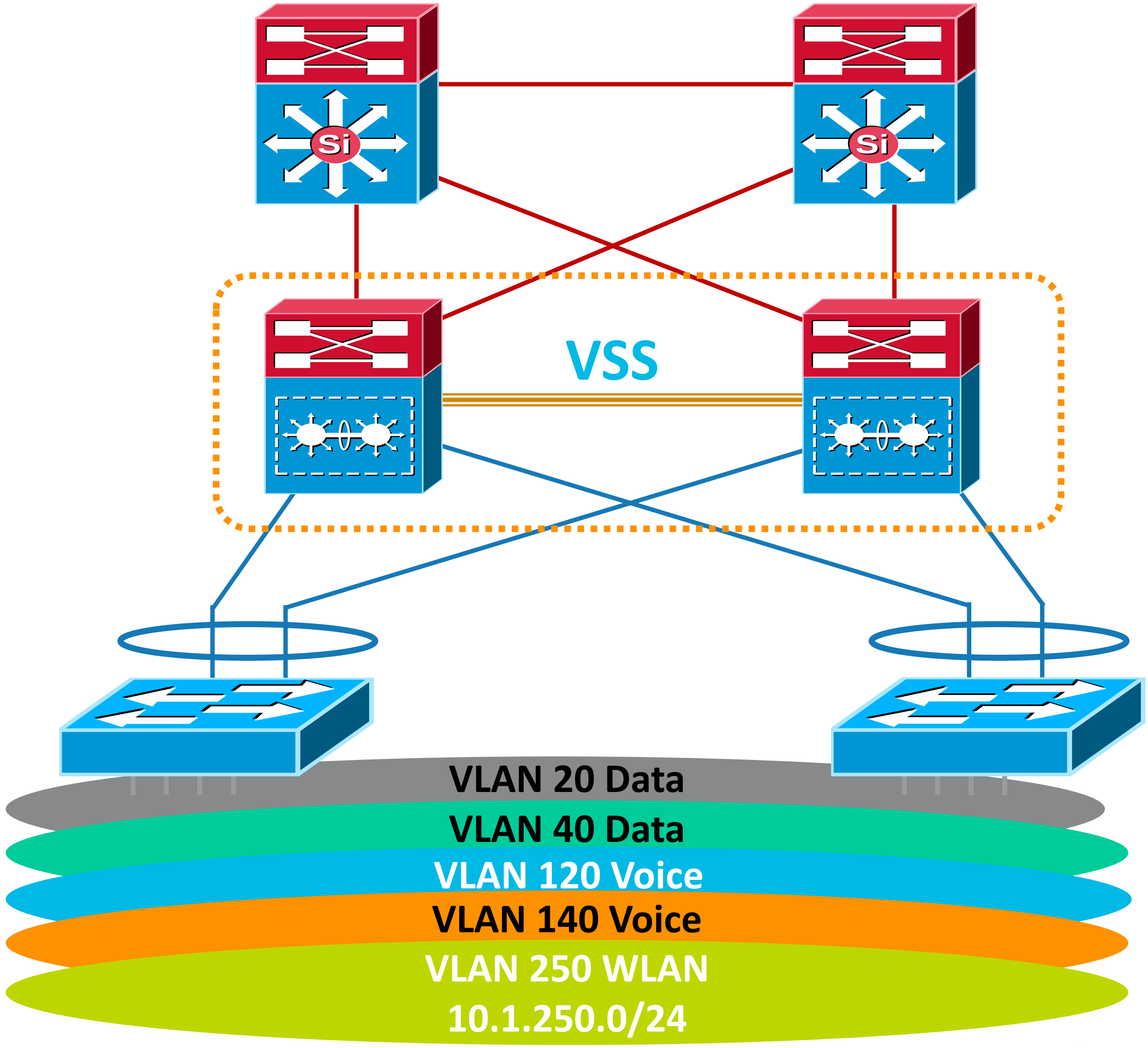


Reduction in Control Plane

Less management points

VSS

- Available now on 6500-E, 4500-X and 4500-E
- Useful in distribution layer



Reduction in Control Plane

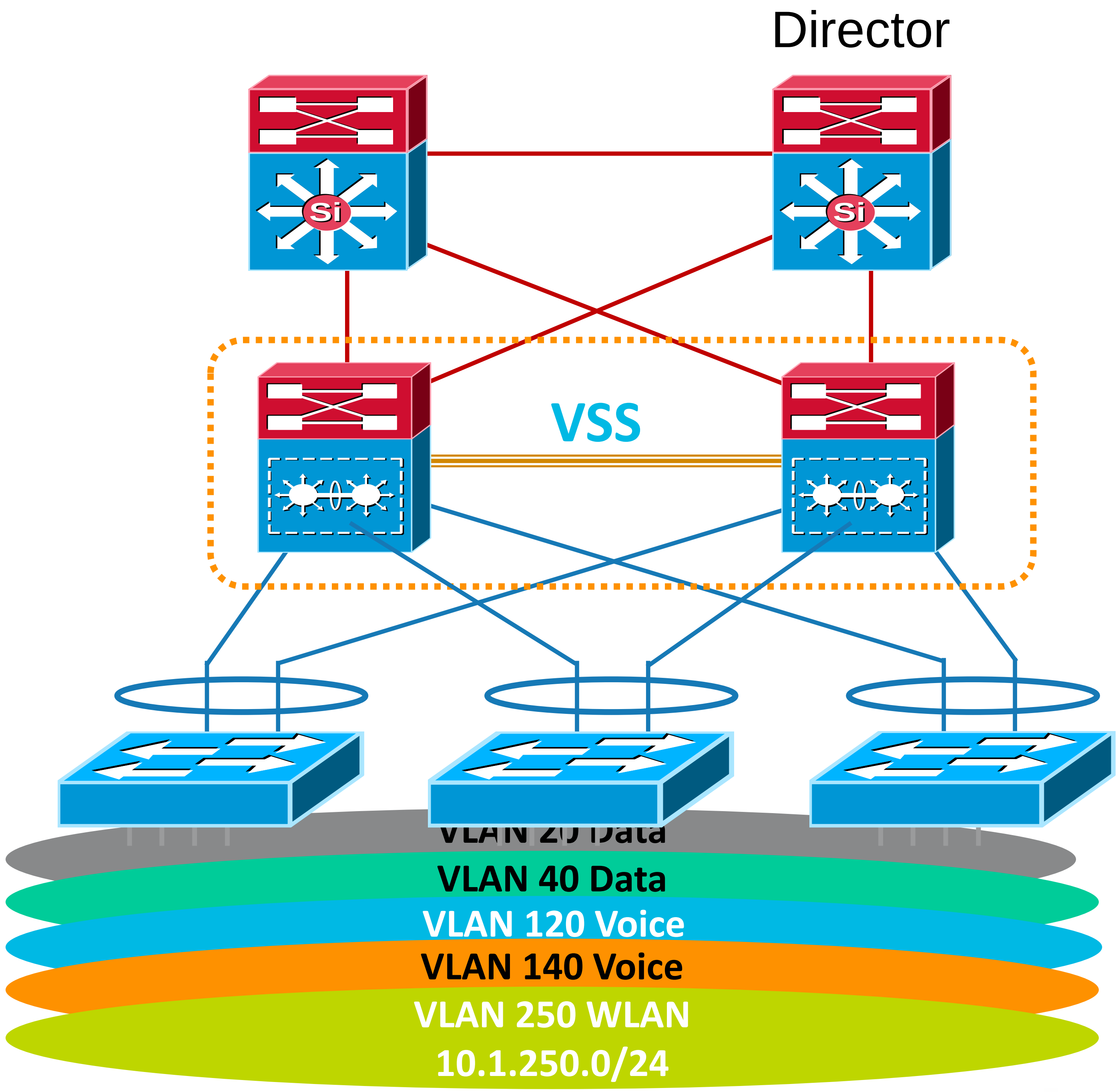
Less management points

VSS

- Available now on 6500-E, 4500-X and 4500-E
- Useful in distribution layer

Smart Install

- Zero-touch install of new devices
- Automatic SW updates
- Utilises DHCP to find new switches

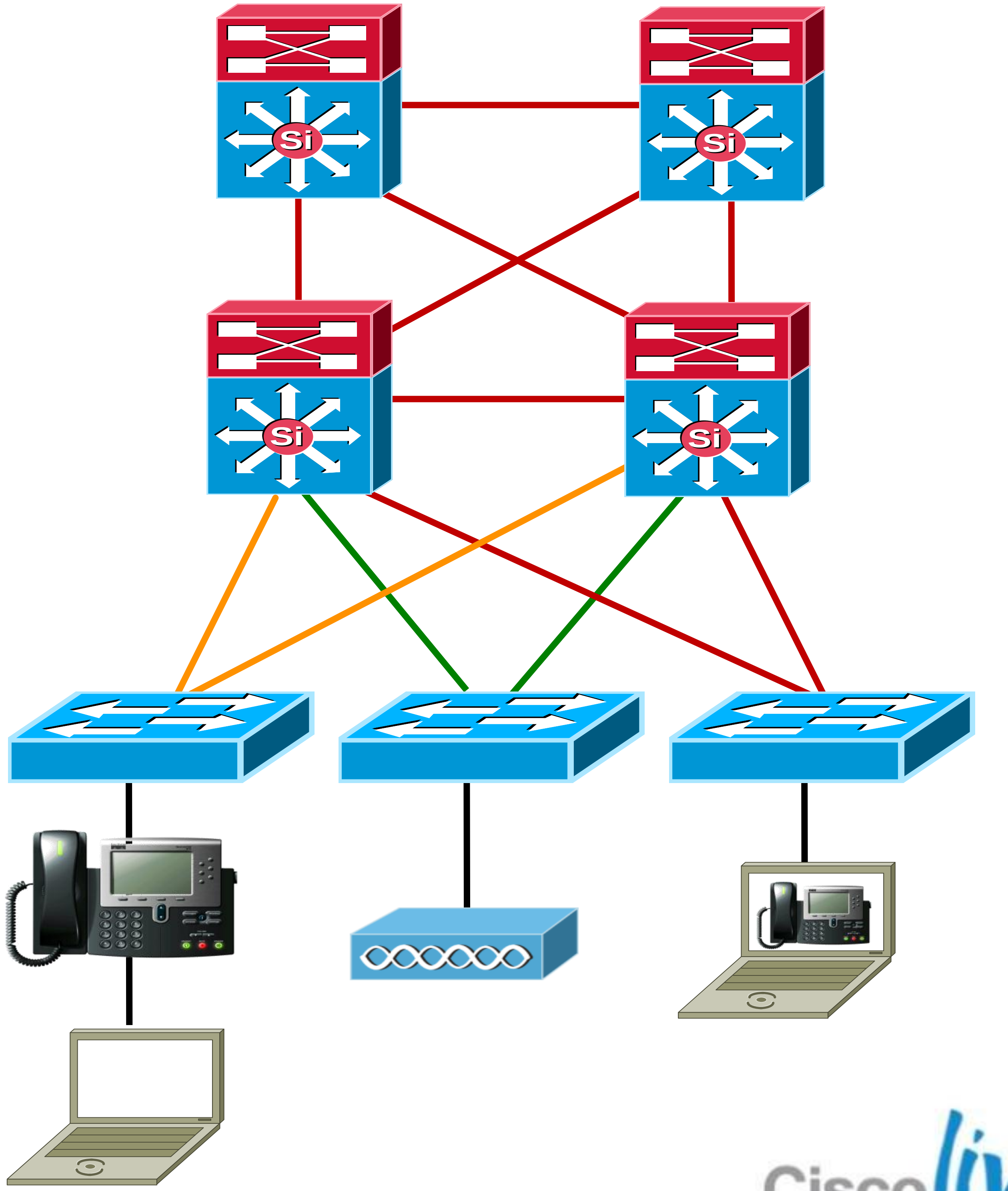


SmartPorts - Predefined Configurations

```
Access-Switch# show parser macro brief
    default global   : cisco-global
    default interface: cisco-desktop
    default interface: cisco-phone
    default interface: cisco-switch
    default interface: cisco-router
    default interface: cisco-wireless

Access-Switch(config-if)#$ macro apply cisco-phone $access_vlan 20 $voice_vlan 10

Access-Switch# show run int fa1/0/19
!
interface FastEthernet1/0/19
switchport access vlan 20
switchport mode access
switchport voice vlan 10
switchport port-security maximum 2
switchport port-security
switchport port-security aging time 2
switchport port-security violation restrict
switchport port-security aging type inactivity
srr-queue bandwidth share 10 10 60 20
srr-queue bandwidth shape  10  0  0  0
mls qos trust device cisco-phone
mls qos trust cos
 macro description cisco-phone
 auto qosvoipcisco-phone
 spanning-tree portfast
 spanning-tree bpduguard enable
end
```

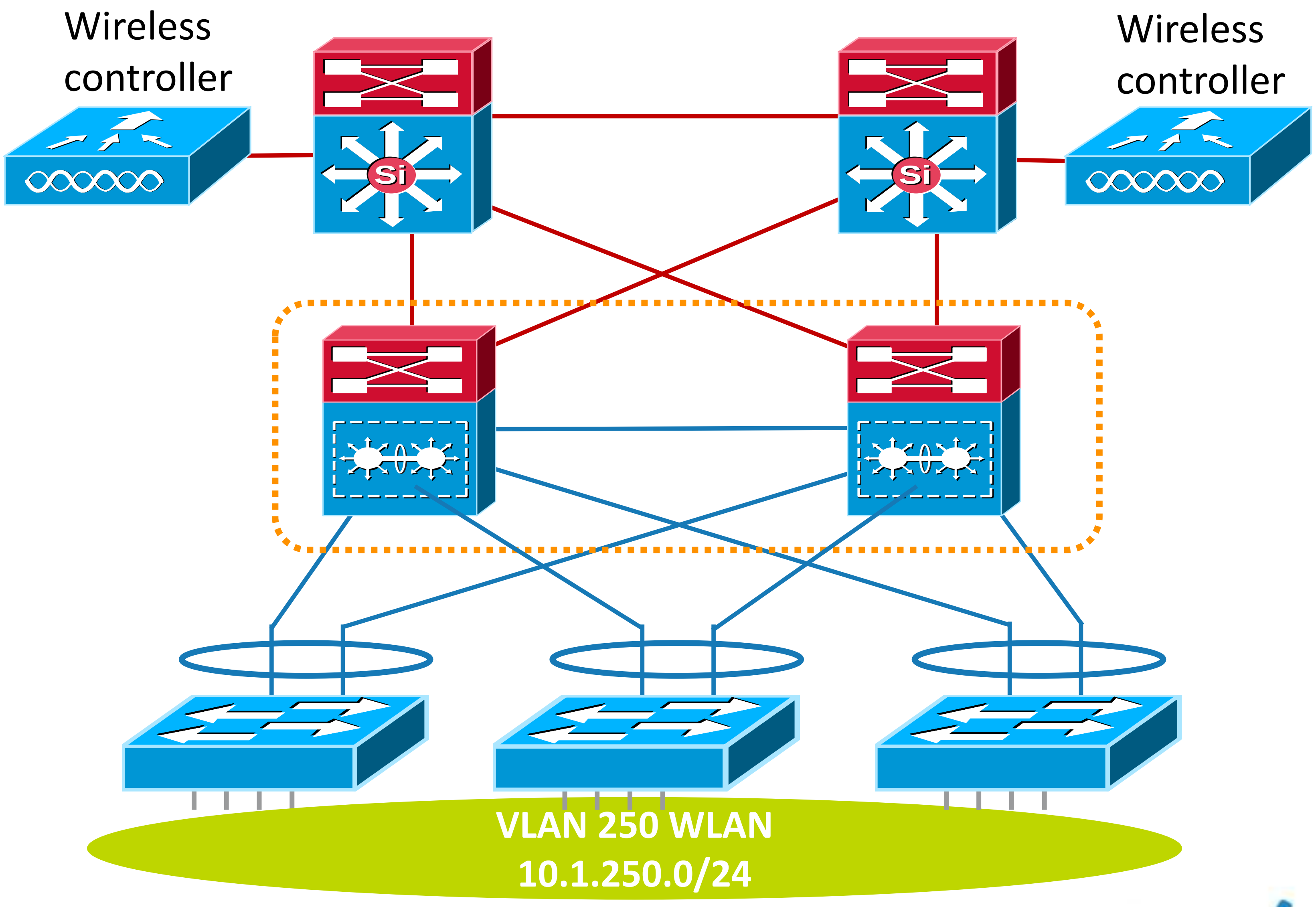


Unified Access

Localised wired and wireless connectivity

Centralised wireless controller

- All traffic trunked up to core



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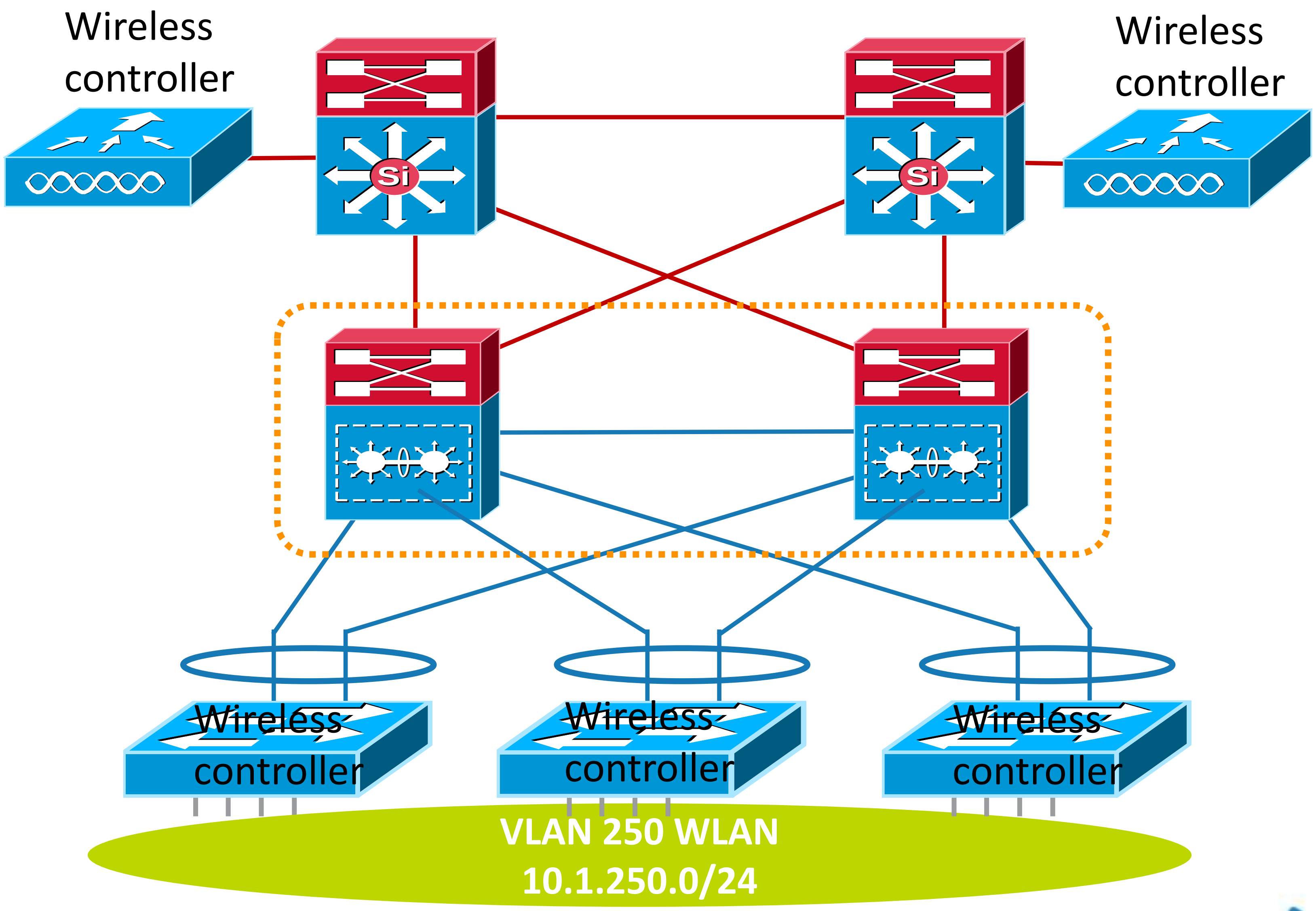
Local wireless termination

- Reduce spanning of VLANs across access layer



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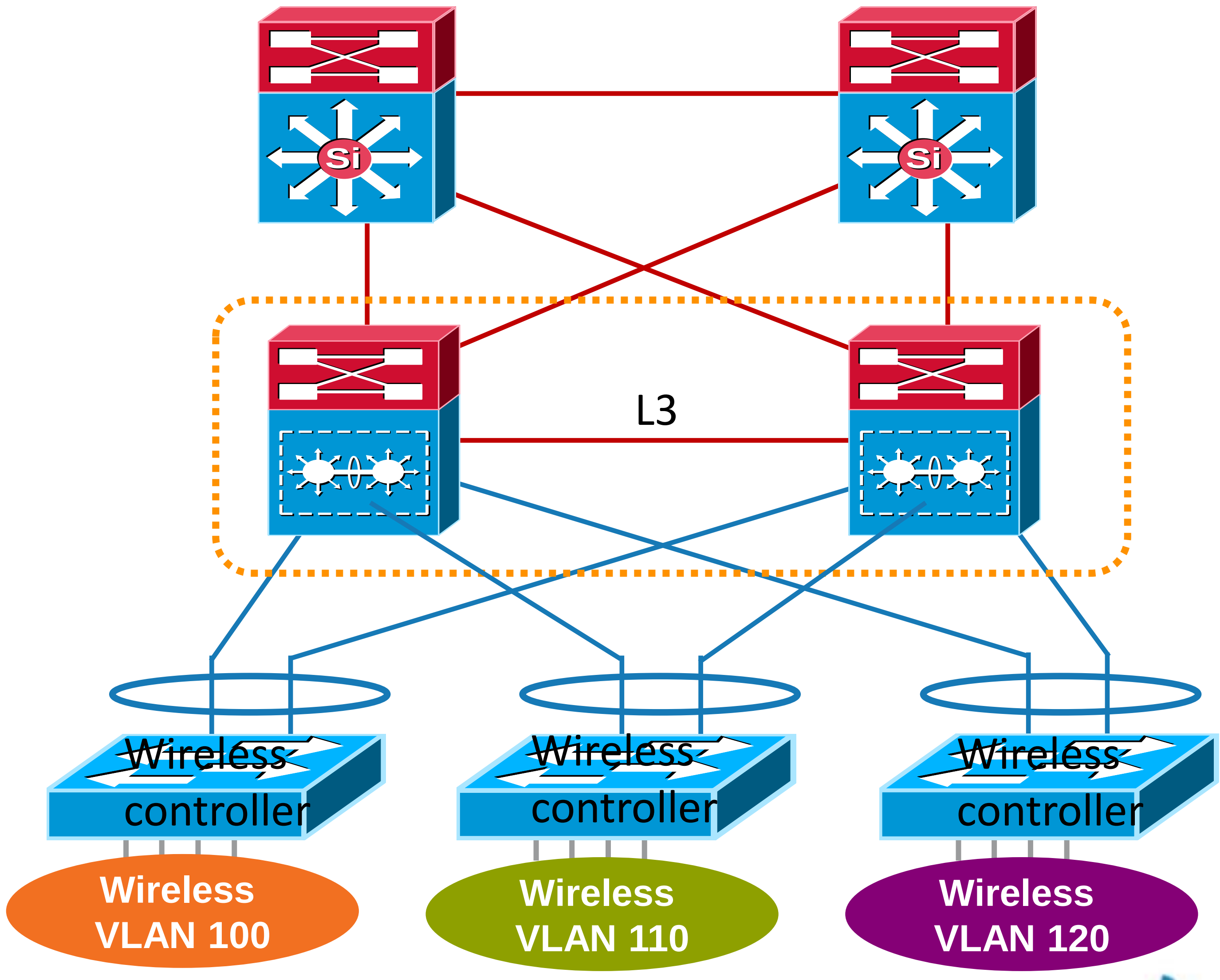
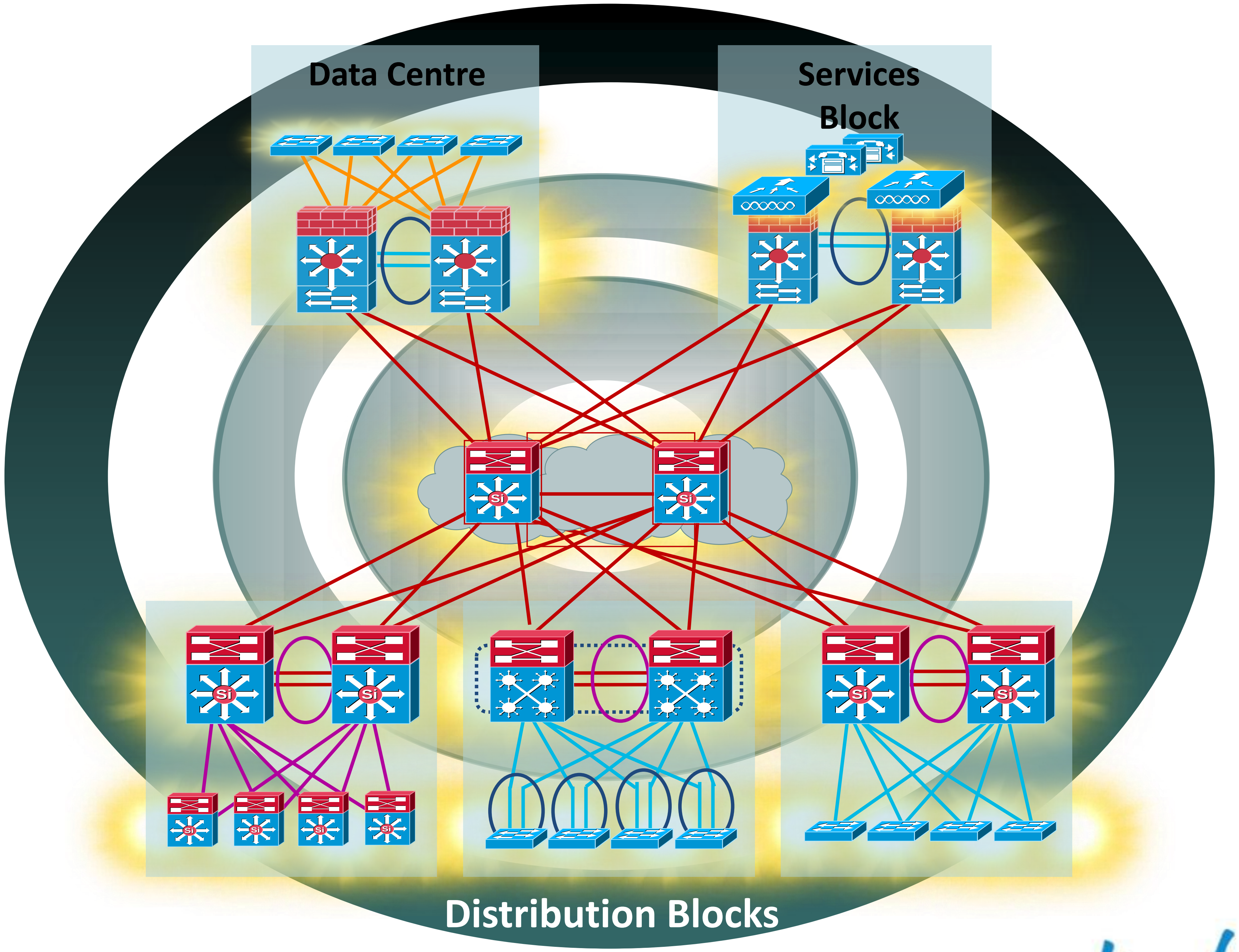


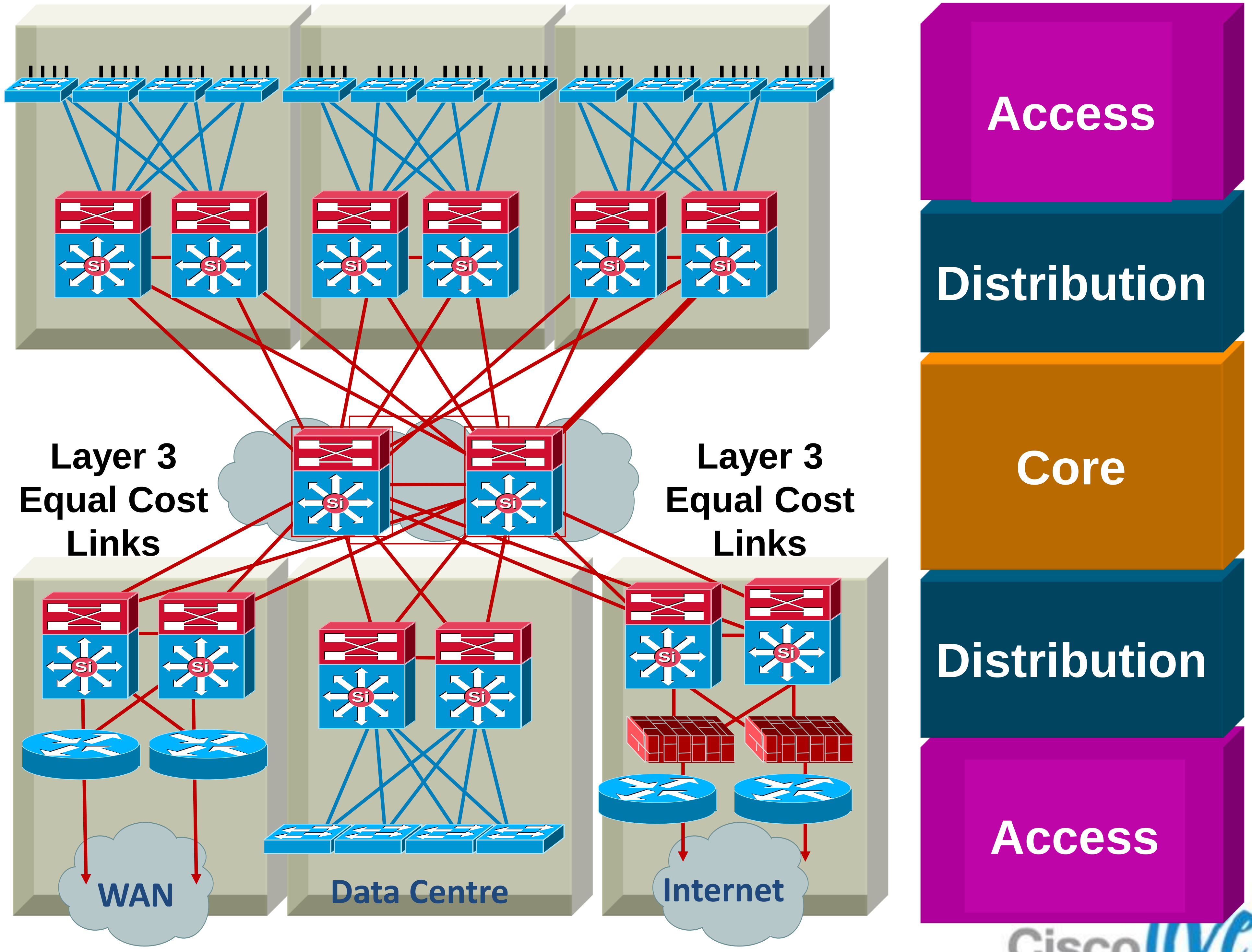
Agenda

- Multilayer Campus Design Principles
- Foundation Services
- Campus Design Best Practices
- Virtualisation techniques
- Security considerations
- What's next….
- Summary



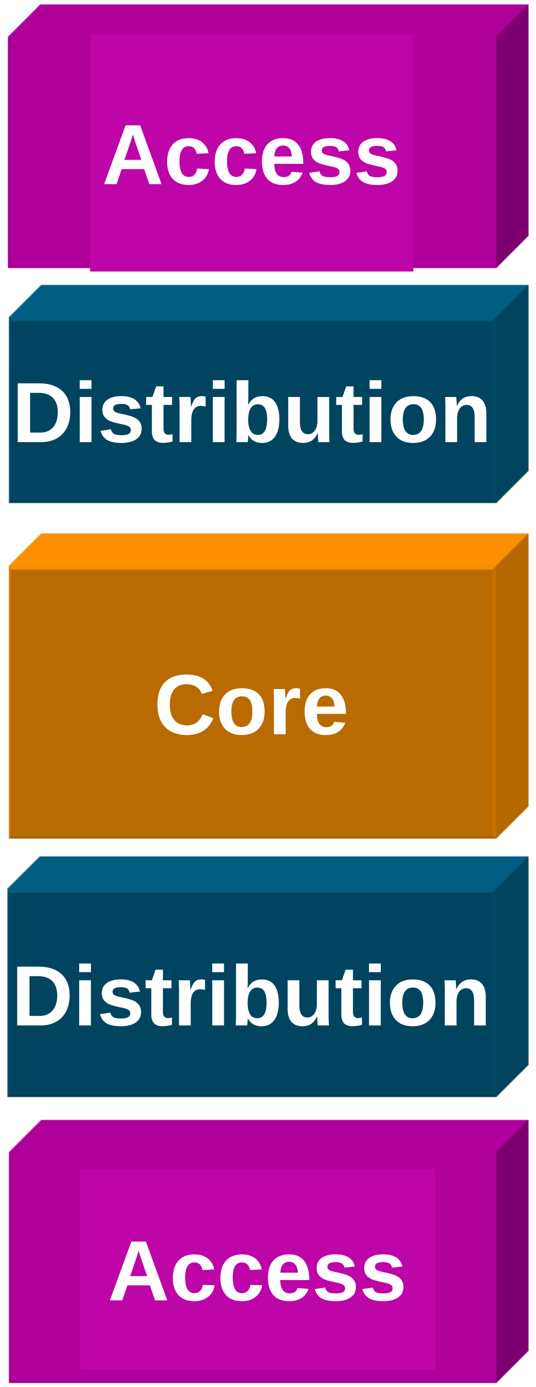
Summary

- Offers hierarchy—each layer has specific role
- Modular topology—building blocks
- Easy to grow, understand, and troubleshoot
- Creates small fault domains—clear demarcations and isolation
- Promotes load balancing and redundancy
- Promotes deterministic traffic patterns
- Incorporates balance of both Layer 2 and Layer 3 technology
- Utilises Layer 3 routing for load balancing, fast convergence, scalability, and control

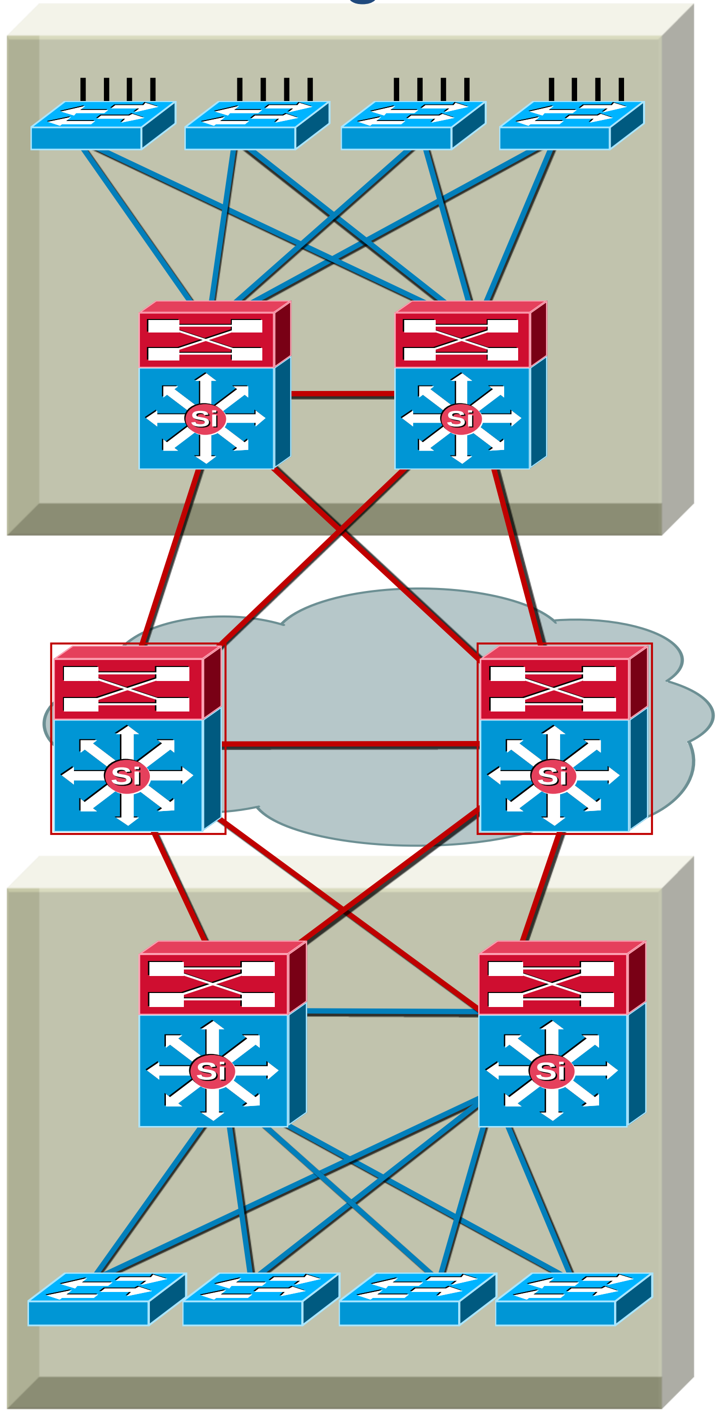


Hierarchical Network Design

Without a Rock Solid Foundation the Rest Doesn't Matter



Building Block



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