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This guide is part of an older series of Cisco Smart Business Architecture designs. To access the latest Cisco SBA Guides, go to http://www.cisco.com/go/sba

Cisco strives to update and enhance SBA guides on a regular basis. As we develop a new series of SBA guides, we test them together, as a complete system. To ensure the mutual compatibility of designs in Cisco SBA guides, you should use guides that belong to the same series.

SBA

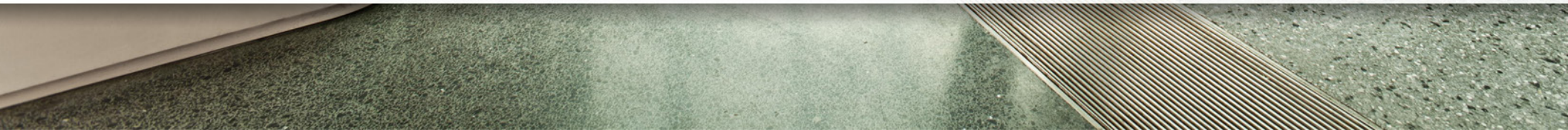
BORDERLESS NETWORKS

DEPLOYMENT GUIDE

LAN Deployment Guide

SMART BUSINESS ARCHITECTURE

August 2012 Series



Preface

Who Should Read This Guide

This Cisco® Smart Business Architecture (SBA) guide is for people who fill a variety of roles:

- Systems engineers who need standard procedures for implementing solutions
- Project managers who create statements of work for Cisco SBA implementations
- Sales partners who sell new technology or who create implementation documentation
- Trainers who need material for classroom instruction or on-the-job training

In general, you can also use Cisco SBA guides to improve consistency among engineers and deployments, as well as to improve scoping and costing of deployment jobs.

Release Series

Cisco strives to update and enhance SBA guides on a regular basis. As we develop a series of SBA guides, we test them together, as a complete system. To ensure the mutual compatibility of designs in Cisco SBA guides, you should use guides that belong to the same series.

The Release Notes for a series provides a summary of additions and changes made in the series.

All Cisco SBA guides include the series name on the cover and at the bottom left of each page. We name the series for the month and year that we release them, as follows:

month year Series

For example, the series of guides that we released in August 2012 are the "August 2012 Series".

You can find the most recent series of SBA guides at the following sites:

Customer access: http://www.cisco.com/go/sba

Partner access: http://www.cisco.com/go/sbachannel

How to Read Commands

Many Cisco SBA guides provide specific details about how to configure Cisco network devices that run Cisco IOS, Cisco NX-OS, or other operating systems that you configure at a command-line interface (CLI). This section describes the conventions used to specify commands that you must enter.

Commands to enter at a CLI appear as follows:

```
configure terminal
```

Commands that specify a value for a variable appear as follows:

```
ntp server 10.10.48.17
```

Commands with variables that you must define appear as follows:

```
class-map [highest class name]
```

Commands shown in an interactive example, such as a script or when the command prompt is included, appear as follows:

```
Router# enable
```

Long commands that line wrap are underlined. Enter them as one command:

```
wrr-queue random-detect max-threshold 1 100 100 100 100 100
100 100 100
```

Noteworthy parts of system output or device configuration files appear highlighted, as follows:

```
interface Vlan64
  ip address 10.5.204.5 255.255.255.0
```

Comments and Questions

If you would like to comment on a guide or ask questions, please use the SBA feedback form.

If you would like to be notified when new comments are posted, an RSS feed is available from the SBA customer and partner pages.

Table of Contents

What's In This SBA Guide

Cisco SBA Borderless Networks

Cisco SBA helps you design and quickly deploy a full-service business network. A Cisco SBA deployment is prescriptive, out-of-the-box, scalable, and flexible.

Cisco SBA incorporates LAN, WAN, wireless, security, data center, application optimization, and unified communication technologies—tested together as a complete system. This component-level approach simplifies system integration of multiple technologies, allowing you to select solutions that solve your organization's problems—without worrying about the technical complexity.

Cisco SBA Borderless Networks is a comprehensive network design targeted at organizations with up to 10,000 connected users. The SBA Borderless Network architecture incorporates wired and wireless local area network (LAN) access, wide-area network (WAN) connectivity, WAN application optimization, and Internet edge security infrastructure.

Route to Success

To ensure your success when implementing the designs in this guide, you should first read any guides that this guide depends upon—shown to the left of this guide on the route below. As you read this guide, specific prerequisites are cited where they are applicable.

About This Guide

This *deployment guide* contains one or more deployment chapters, which each include the following sections:

- **Business Overview**—Describes the business use case for the design. Business decision makers may find this section especially useful.
- **Technology Overview**—Describes the technical design for the business use case, including an introduction to the Cisco products that make up the design. Technical decision makers can use this section to understand how the design works.
- **Deployment Details**—Provides step-by-step instructions for deploying and configuring the design. Systems engineers can use this section to get the design up and running quickly and reliably.

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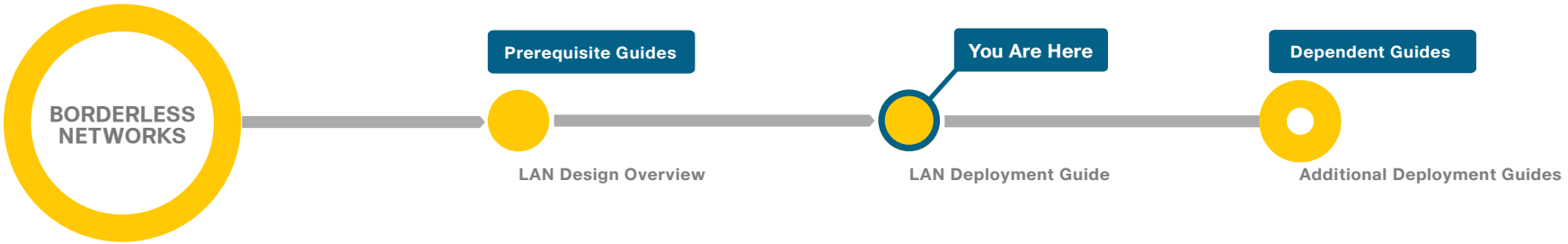


Introduction

The *Cisco SBA—Borderless Networks LAN Deployment Guide* describes how to deploy a wired network access with ubiquitous capabilities that scale from small environments with one to a few LAN switches to a large campus-size LAN. Resiliency, security, and scalability are included to provide a robust communications environment. Quality of service (QoS) is integrated to ensure that the base architecture can support a multitude of applications including low latency, drop-sensitive multimedia applications that coexist with data applications on a single network.

The Cisco SBA LAN architecture is designed to meet the needs of organizations with LAN connectivity requirements that range from a small remote-site LAN to up to 5,000 connected users at a single location.

Cisco SBA Borderless Networks is a solid network foundation designed to provide networks with up to 10,000 connected users the flexibility to support new users or network services without re-engineering the network. This is a prescriptive, out-of-the-box deployment guide that is based on best-practice design principles and that delivers flexibility and scalability.

Related Reading

The *Cisco SBA—Borderless Networks LAN Design Overview* orients you to the overall Cisco SBA design and explains the requirements that were considered when selecting specific products.

The *Cisco SBA—Borderless Networks Wireless LAN Deployment Guide* focuses on deploying Cisco Unified Wireless Network in multiple network locations and includes multiple scale models to meet the various LAN deployment sizes. The deployment guide uses a controller-based wireless design. By centralizing configuration and control on a Cisco wireless LAN controller (WLC), the wireless LAN can operate as an intelligent information network and support advanced services. This centralized deployment simplifies operational management by collapsing large numbers of managed endpoints and autonomous access points into a single managed system.

Design Goals

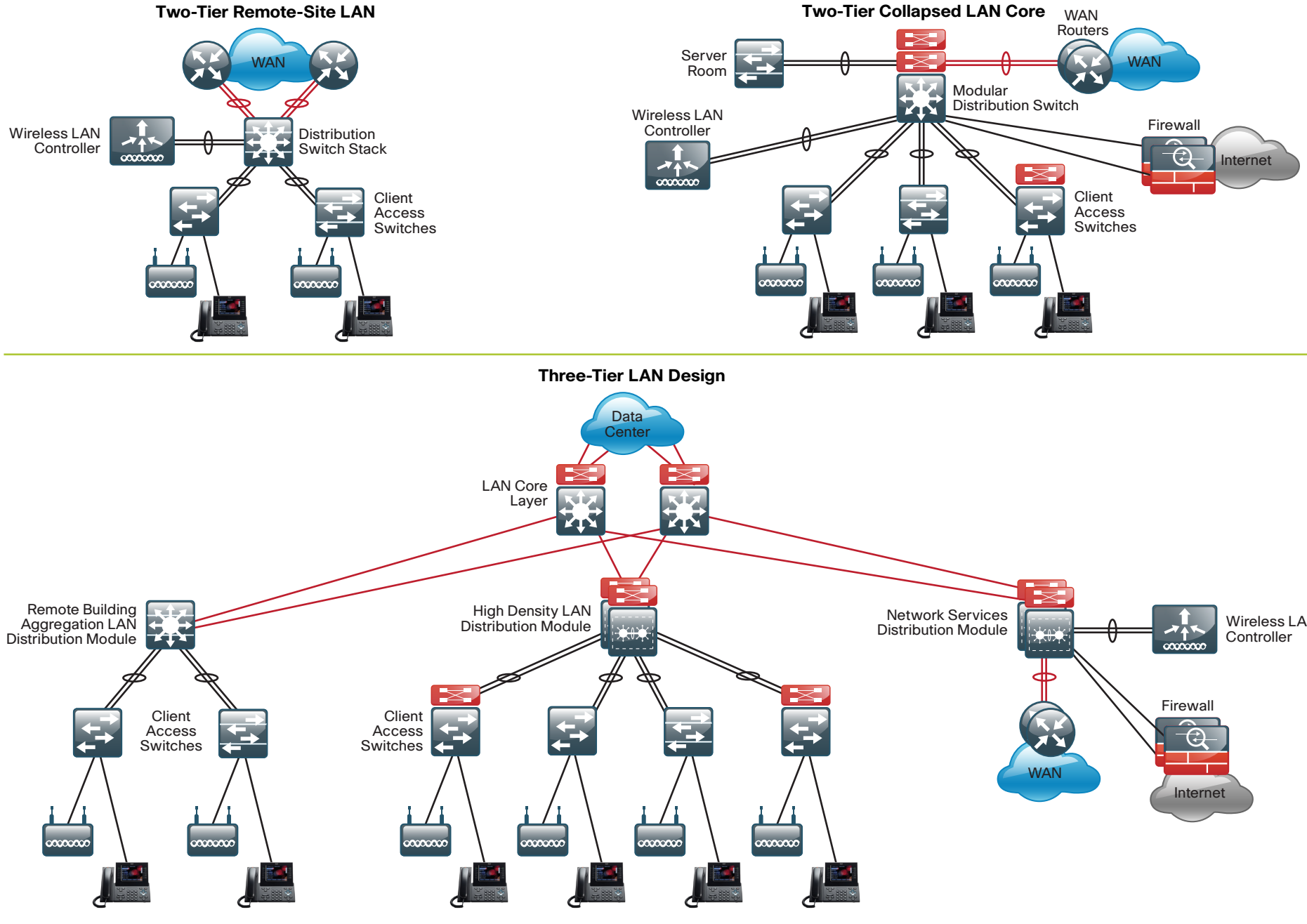
This architecture is based on requirements gathered from customers, partners, and Cisco field personnel for organizations with up to 10,000 connected users. When designing the architecture, Cisco considered the gathered requirements and the following design goals.

Ease of Deployment, Flexibility, and Scalability

Organizations with up to 10,000 users are often spread out among different geographical locations, making flexibility and scalability a critical requirement of the network. This design uses several methods to create and maintain a scalable network:

- By keeping a small number of standard designs for common portions of the network, support staff is able to design services for, implement, and support the network more effectively.
- This modular design approach enhances scalability. Beginning with a set of standard, global building blocks, you can assemble a scalable network to meet requirements.
- Many of the plug-in modules look identical for several service areas; this common look provides consistency and scalability so that you can use the same support methods to maintain multiple areas of the network. These modules follow standard core-distribution-access network design models and use layer separation to ensure that interfaces between the plug-ins are well defined.

Figure 1 - Scalable architecture to meet multiple requirements



The modular design of the Cisco SBA LAN architecture provides multiple scale points to meet your organization's specific requirements, including:

- A highly resilient and scalable distribution layer with two modular chassis-based platforms using the Cisco Catalyst 6500 Virtual Switching System (VSS), that acts as a single logical distribution layer platform. This design allows for high density aggregation of Gigabit Ethernet and 10 Gigabit Ethernet connected wiring closets and other platforms. Cisco Catalyst 6500 VSS provides the most advanced feature set and the highest resiliency of the available platforms.
- A resilient modular chassis distribution layer design for locations where there is a mix of Gigabit Ethernet or 10 Gigabit Ethernet connected wiring closets that need to be aggregated. Cisco Catalyst 4507 with dual supervisors and dual power supplies provides resiliency with Cisco IOS In-Service Software Upgrades (ISSU) and sub-second failover.
- A stackable Cisco Catalyst 3750-X distribution layer switch to accommodate locations where there is a small number of gigabit connected wiring closets and other platforms that need to be aggregated. Cisco Catalyst 3750-X provides a resilient platform with StackWise and StackPower.
- To accommodate the most demanding LAN requirements, a three tier network design incorporates one or many of the distribution layer designs connected to a highly-reliable Core layer. As the LAN design scales, the modules that make up the design remain consistent to provide a scalable environment.

Resiliency and Security

One of the keys to maintaining a highly available network is building the appropriate resilience into the network links and networking platforms to guard against single points of failure in the network. The SBA LAN architecture is carefully designed to avoid the complexity inherent in redundant systems.

With the addition of a significant amount of delay-sensitive and drop-sensitive traffic such as voice and video conferencing, Cisco also places a strong emphasis on recovery times. Choosing designs that reduce the time between failure detection and recovery is important for ensuring that the network stays available even in the face of a link or component failure.

Network security is also a strong component of the architecture. In a large network, there are many entry points and the SBA LAN design ensures that they are as secure as possible without making the network too difficult to use. Securing the network not only helps keep the network safe from attacks but is also a key component to network-wide resiliency.

Ease of Management

While this guide focuses on the deployment of the network foundation, the design takes next phase management and operation into consideration. The configurations in the deployment guides are designed to allow the devices to be managed via normal device management connections, such as SSH and HTTPS, as well as via the Network Management System (NMS). The configuration of the NMS is not covered in this guide.

Advanced Technology–Ready

Flexibility, scalability, resiliency, and security all are characteristics of an advanced technology-ready network. The modular design of the architecture means that technologies can be added when the organization is ready to deploy them. However, the deployment of advanced technologies, such as multimedia-based collaboration tools, is eased because the architecture includes products and configurations that are ready to support collaboration from day one. For example:

- Access switches provide Power over Ethernet (PoE) up to 60 watts per port for line-powered phone, camera, and virtual desktop deployments without the need for a local power outlet.
- The entire network is configured with QoS to support high-quality voice.
- Multicast is configured in the network to support efficient voice and broadcast-video delivery.

Business Overview

The *LAN Deployment Guide* is designed to address four primary requirements shared by organizations, including the need to:

- Offer reliable access to organization resources
- Minimize time required to absorb technology investments
- Provide a productive and consistent user experience
- Reduce operation costs

Offer Reliable Access to Organization Resources

Data networks are critical to an organization's viability and productivity. Online workforce-enablement tools are only beneficial if the data network provides reliable access to information resources. Collaboration tools and content distribution rely on high-speed, low-latency network infrastructure to provide an effective user experience. However, as networks become more complex, the level of risk increases for network availability loss or poor performance due to inadequate design, configuration errors, maintenance and upgrade outages, or hardware and software faults. The design and methods used in this deployment guide were created to minimize these risks.

Minimize Time Required to Absorb Technology Investments

New technology can impose significant costs, from the perspective of the investment in the equipment, as well as the time and workforce investment required to deploy the new technology and establish operational readiness. When new technology is introduced it takes time to understand how the technology operates, and to ascertain how to effectively integrate the new technology into the existing infrastructure. Over time the methods and procedures used to deploy a new technology are refined and become more efficient and accurate.

This deployment guide helps your organization reduce the cost of technology implementation by providing methods and procedures that have been developed and tested by Cisco. By applying the guidance within this document, you reduce the time required to assimilate the technology into the organization's network, and you can deploy the technology quickly and accurately, so your organization can achieve a head start in realizing the return on its investment.

Consistent User Experience

The number of users and locations in an organization can vary dramatically as an organization grows and adapts to changes in business activity. Providing a consistent user experience when users connect to the network increases their productivity. Whether users are sitting in an office at headquarters or working from a remote site, they require transparent access to the applications and files to perform their jobs. When the IT organization can offer a standardized and template-based LAN design that scales from small to large locations they can reduce their time to deploy new locations while maintaining a consistent access experience for their users.

Reduce Operational Costs

Organizations constantly pursue opportunities to reduce network operational costs, while maintaining the network's effectiveness for end users. Operational expenses include not only the cost of the physical operation (for example, power, cooling, etc.), but also the labor cost required to staff an IT department that monitors and maintains the network. Additionally, network outages and performance issues impose costs that are more difficult to quantify, in the form of loss of productivity and interruption of business continuity.

The network described by this deployment guide offers network resilience in its ability to tolerate failure or outage of portions of the network, along with a sufficiently robust-yet-simple design that staff should be able to operate, troubleshoot, and return to service in the event of a network outage.

Architecture Overview

The LAN is the networking infrastructure that provides access to network communication services and resources for end users and devices spread over a single floor or building. A campus network occurs when a group of building-based LANs that are spread over a small geographic area are interconnected.

The *LAN Deployment Guide* provides a design that enables communications between devices in a building or group of buildings, as well as interconnection to the WAN and Internet Edge modules at the network core.

Specifically, this document shows you how to deploy the network foundation and services to enable

- Tiered LAN connectivity for up to 5,000 connected users
- Wired network access for employees
- IP Multicast for efficient data distribution
- Wired infrastructure ready for multimedia services

Hierarchical Design Model

This architecture uses a hierarchical design model to break the design up into modular groups or layers. Breaking the design up into layers allows each layer to focus on specific functions, which simplifies the design and provides simplified deployment and management.

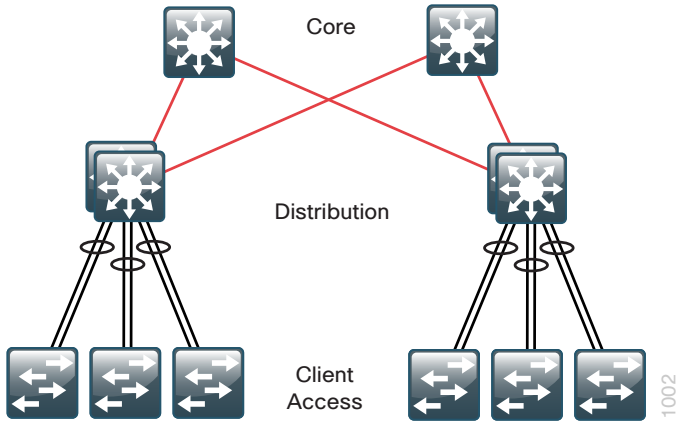
Modularity in network design allows you to create design elements that can be replicated throughout the network. Replication provides an easy way to scale the network as well as a consistent deployment method.

In flat or meshed network architectures, changes tend to affect a large number of systems. Hierarchical design helps constrain operational changes to a subset of the network, which makes it easy to manage as well as improve resiliency. Modular structuring of the network into small, easy-to-understand elements also facilitates resiliency via improved fault isolation.

A hierarchical design includes the following three layers:

- **Access layer**—Provides workgroup/user access to the network.
- **Distribution layer**—Aggregates access layers and provides connectivity to services.
- **Core layer**—Provides connection between distribution layers for large LAN environments.

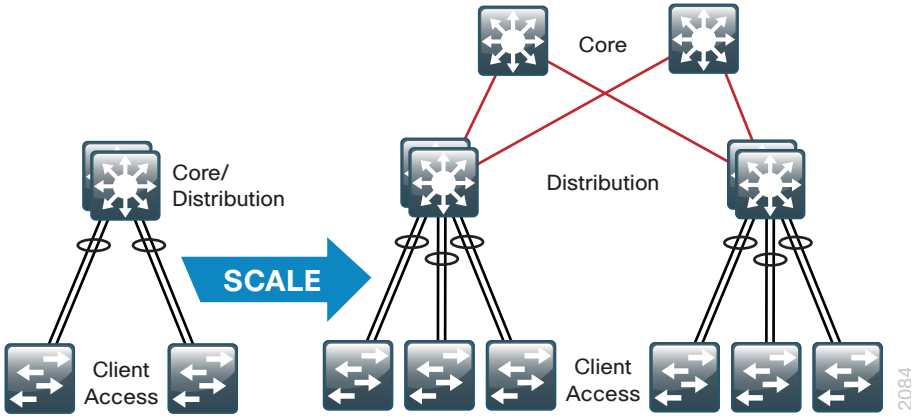
Figure 2 - LAN hierarchical design



The three layers—access, distribution, and core—each provide different functionality and capability to the network. Depending on the characteristics of the site where the network is being deployed, you might need one, two, or all three of the layers. For example, a remote site supporting only 10 users will only require an access layer. A site that occupies a single building might only require the access and distribution layers, while a campus of multiple buildings will most likely require all three layers.

Regardless of how many layers are implemented at a site, the modularity of this design ensures that each layer will always provide the same services, and in this architecture, will use the same deployment methods.

Figure 3 - Scalability by using a modular design



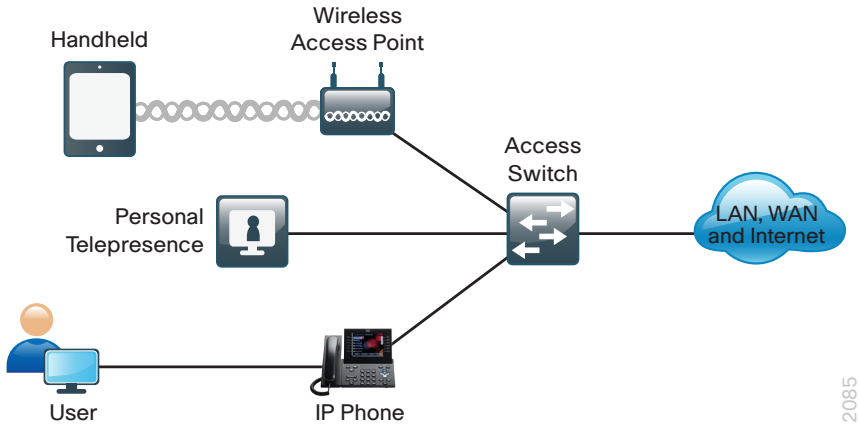
Access Layer

The access layer is the point at which user-controlled and user-accessible devices are connected to the network. The access layer provides both wired and wireless connectivity and contains features and services that ensure security and resiliency for the entire network.

Device Connectivity

The access layer provides high-speed user-controlled and user-accessible device connectivity. Once expensive options, high-speed access technologies like Gigabit Ethernet and 802.11n wireless are now standard configurations on end-user devices. While an end-user device in most cases will not use the full capacity of these connections for long periods of time, the ability to burst up to these high speeds when performing routine tasks does help make the network a transparent part of an end-users day-to-day job. The longer someone has to wait to back up their machine, send an email, or open a file off an internal web page the harder it is for the network to be transparent.

Figure 4 - Access layer connectivity



It is common for many different types of devices to connect at the access layer. Personal computers, IP phones, wireless access points, and IP video surveillance cameras all might connect to the same access layer switch. Since it can be beneficial for performance, management, and security reasons to segment these different devices, the access layer provides the capability to support many logical networks on one physical infrastructure.

Resiliency and Security Services

In general, the goal of the resiliency and security services in the infrastructure is to ensure that the network is available for use without impairment for everyone that needs it. Because the access layer is the connection point between the network and client devices, it plays a role in ensuring the network is protected from human error and from malicious attacks. This protection includes making sure the devices connecting to the network do not attempt to provide services to any end users that they are not authorized for, that they do not attempt to take over the role of any other device on the network, and, when possible, that they verify the device is allowed on the network.

Enabling these services in the access layer contributes not only to the overall security of the network, but also to the resiliency and availability of the network.

Advanced Technology Capabilities

Finally, the access layer provides a set of network services that support advanced technologies. Voice and video are commonplace in today's organizations and the network must provide services that enable these technologies. This includes providing specialized access for these devices, ensuring the traffic from these devices is not impaired by others, and providing efficient delivery of traffic that is needed by many devices in the network.

Distribution Layer

The distribution layer serves many important services for the LAN. The primary function is to serve as an aggregation point for multiple access layer switches in a given location or campus. In a network where connectivity needs to traverse the LAN end-to-end, whether between different access layer devices or from an access layer device to the WAN, the distribution layer facilitates this connectivity.

Scalability

In any network where multiple access layer devices exist at a location to serve end-user connectivity, it becomes impractical to interconnect each access switch as the access layer grows beyond two or three switches.

The distribution layer provides a logical point to summarize addressing and to create a boundary for protocols and features necessary for the access layer operation. Another benefit of the distribution layer boundary is that it creates fault domains that serve to contain failures or network changes to those parts of the network directly affected.

The end result to the organization is that the distribution layer can lower the cost of operating the network by making it more efficient, by requiring less memory, and by processing resources for devices elsewhere in the network. The distribution layer also increases network availability by containing failures to smaller domains.

Reduce Complexity and Increase Resiliency

This design uses a simplified distribution layer design, which consists of a single logical entity that can be implemented using a pair of physically separate switches operating as one device, a physical stack of switches operating as one device, or a single physical device with redundant components.

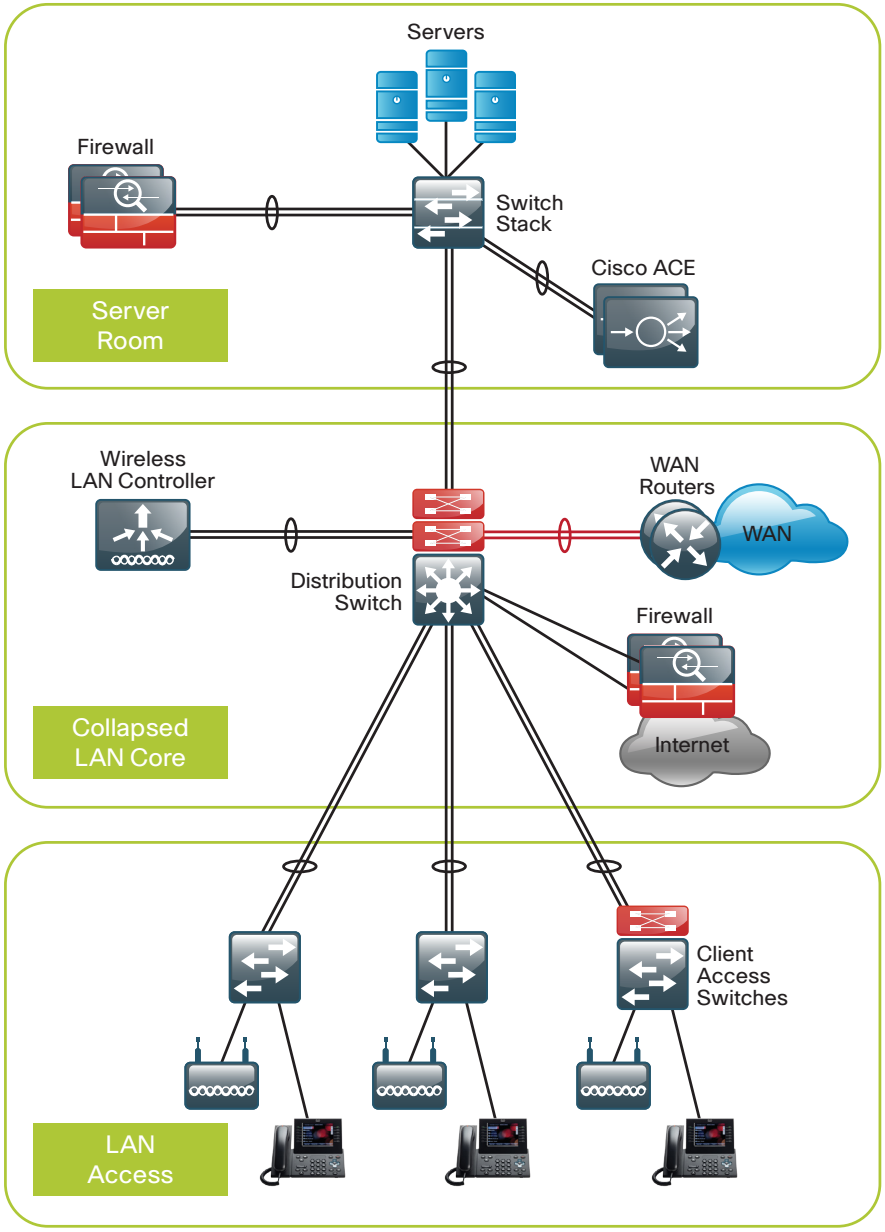
The benefit to the organization is the reduced complexity of configuring and operating the distribution layer as fewer protocols are required and little or no tuning is needed to provide near-second or sub-second convergence around failures or disruptions.

The design resiliency is provided by physically redundant components like power supplies, supervisors, and modules, as well as stateful switchover to redundant logical control planes. Reduced complexity and consistent design lower the operational cost of configuring and maintaining the network.

Flexible Design

The distribution layer provides connectivity to network-based services, to the WAN, and to the Internet Edge. Network-based services can include and are not limited to Wide Area Application Services (WAAS), and wireless LAN controllers. Depending on the size of the LAN, these services and the interconnection to the WAN and Internet Edge may reside on a distribution layer switch that also aggregates the LAN access layer connectivity. This is also referred to as a "collapsed Core" design because the distribution serves as the Layer 3 aggregation layer for all devices.

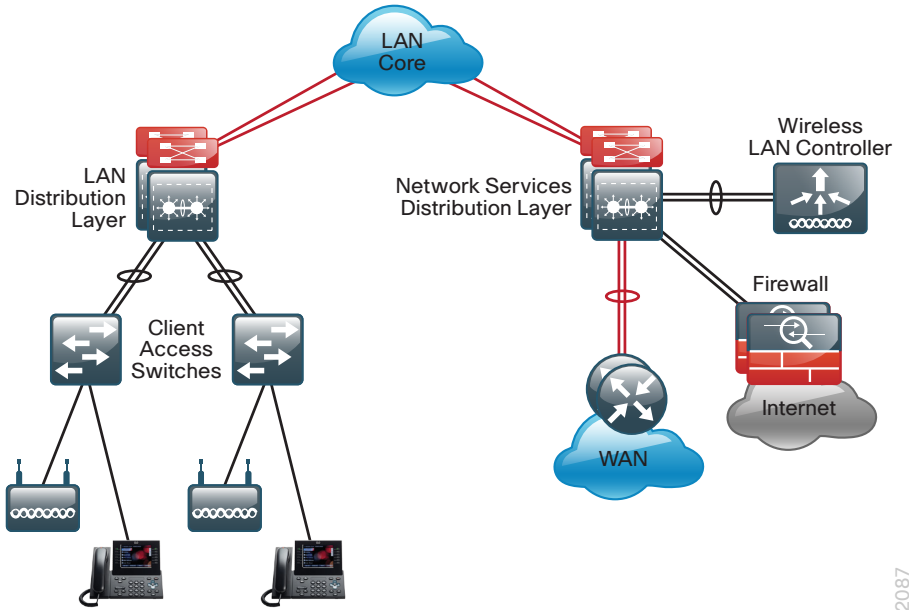
Figure 5 - Two tier design: Distribution layer functioning as a collapsed Core



Larger LAN designs require a dedicated distribution layer for network-based services connectivity versus sharing one with access layer devices. As the density of WAN routers, WAAS controllers, Internet Edge devices, and wireless LAN controllers grows, the ability to connect to a single distribution layer switch becomes hard to manage. There are a number of factors that drive LAN design with multiple distribution layer modules:

- The number of ports and port speed that the distribution layer platform can provide affects network performance and throughput.
- Network resilience is a factor when all LAN and network-based services rely on a single platform, regardless of that platform's design, it can present a siingle point of failure or an unacceptably large failure domain.
- Change control and frequency affects resilience. When all LAN, WAN, and other network services are consolidated on a single distribution layer, operational or configuration errors can affect all network operation.
- Geographic dispersion of the LAN access switches across many buildings in a larger campus facility would require more fiber optic interconnects back to a single collapsed Core.

Figure 6 - Network-services distribution layer



Like the access layer, the distribution layer also provides QoS for application flows to guarantee critical applications and multimedia applications perform as designed.

Core Layer

In a large LAN environment there often arises a need to have multiple distribution layer switches. One reason for this is that when access layer switches are located in multiple geographically dispersed buildings, you can save costly fiber-optic runs between buildings by locating a distribution layer switch in each of those buildings. As networks grow beyond three distribution layers in a single location, organizations should use a core layer to optimize the design.

Another reason to use multiple distribution layer switches is when the number of access layer switches connecting to a single distribution layer exceeds the performance goals of the network designer. In a modular and scalable design, you can collocate distribution layers for data center, WAN connectivity, or Internet Edge services.

In environments where multiple distribution layer switches exist in close proximity and where fiber optics provide the ability for high-speed interconnect, a core layer reduces the network complexity, as shown in the following two figures.

Figure 7 - LAN topology with a core layer

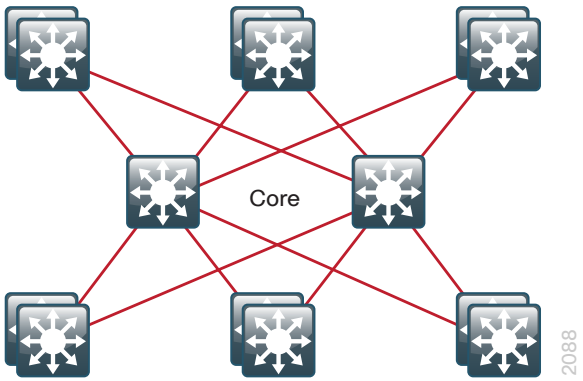
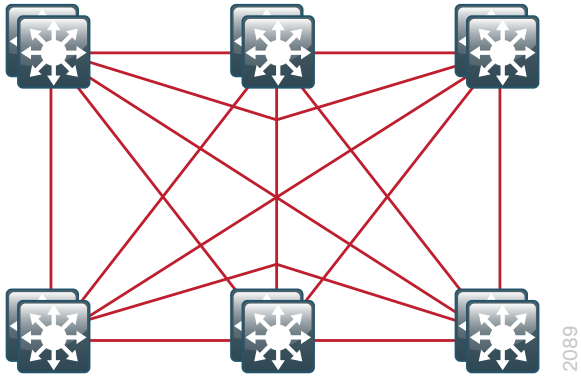


Figure 8 - LAN topology without a core layer



The core layer of the LAN is a critical part of the scalable network, and yet it is one of the simplest by design. The distribution layer provides the fault and control domains, and the core represents the 24x7x365 nonstop connectivity between them, which organizations must have in the modern business environment where connectivity to resources to conduct business is critical.

In this design, the core layer is based on two physically and logically separate switches. Connectivity to and from the core is Layer 3 only, which drives increased resiliency and stability. Since the core does not need to provide the same services or boundaries that the distribution layer does, the two-box design is not an issue of any significant increase in configuration or complexity.

Quality of Service (QoS)

Because real-time traffic is very sensitive to delay and drop, organizations need to provide special handling for it on the network. The network must ensure that this type of traffic is handled with priority so that the stream of audio or video is not interrupted.

QoS allows the organization to define different traffic types and to create more deterministic handling for real-time traffic. QoS is especially useful in congestion handling, where a full communications channel might prevent voice or video streams from being intelligible at the receiving side. It is important to note, however, that QoS does not create bandwidth; rather, it takes bandwidth from one class (that is, generally the default traffic class) to give some priority to another class.

Within this design the approach to using QoS capabilities is to keep the QoS profiles as simple as necessary to meet the goals for supporting applications that need special delivery. The primary goals of implementing QoS within the network are:

- Support and ensure first out-the-door service for supported, real-time applications.
- Provide business continuance for business-critical applications.
- Provide fairness between all other applications when congestion occurs.
- Build a trusted edge around the network to guarantee that users cannot inject their own arbitrary priority values and to allow the organization to trust marked traffic throughout the network.

To accomplish these goals, the design uses a three-step approach to implementing QoS across the network as follows:

- Establish a limited number of traffic classes (that is, one to eight classes) within the network that need special handling (for example, real-time voice, real-time video, high-priority data, interactive traffic, batch traffic, and default classes).
- Classify applications into the traffic classes.
- Apply special handling to the traffic classes to achieve intended network behavior.

In this design, QoS configurations are as simple as possible, and are applied only to those applications that require special handling.

This approach establishes a solid, scalable, and modular framework to implement QoS across the entire network.

Notes

Access Layer

Business Overview

To conduct business in today's competitive global economy, organizations rely on the flow of information. They must provide a dispersed workforce with access to applications that support informed business decisions and the ability to check email correspondence from internal and external associates. Therefore, the ability to move information around the organization is critical. By ensuring that users have the ability to access this information or push communications regardless of their location using an increasingly diverse set of communications devices, the organization is able to help the workforce become more productive. The speed, reliability, and availability of the transport are critical to success.

Transforming the communication of ideas and information from flat written text to a multimedia experience by adding audio and video improves the receivers' understanding and retention of that information. As organizations evolve their ability to deliver these richer modes of communication, they face the challenge of controlling the cost of deployment with a single infrastructure to accommodate what used to require multiple parallel single-purpose networks.

Technology Overview

The access layer is the point at which user-controlled and user-accessible devices are connected to the network and it is the one architecture component that is found in every LAN.

Infrastructure Security Features

Because the access layer is the connection point between network-based services and client devices it plays an important role in protecting other users, the application resources, and the network itself from human error and malicious attacks. Network resiliency and security in the access layer is achieved through the use of Cisco Catalyst Infrastructure Security Features (CISF) including DHCP snooping, IP Source Guard, port security, and Dynamic ARP Inspection.

MAC flooding attacks are used to force a LAN switch to flood all their traffic out to all the switch interfaces. Port security limits the number of MAC addresses that can be active on a single port to protect against such attacks.

Port security lets you to configure Layer 2 interfaces to allow inbound traffic from only a restricted set of MAC addresses. The MAC addresses in the restricted set are called secure MAC addresses. In addition, the device does not allow traffic from these MAC addresses on another interface within the same VLAN.

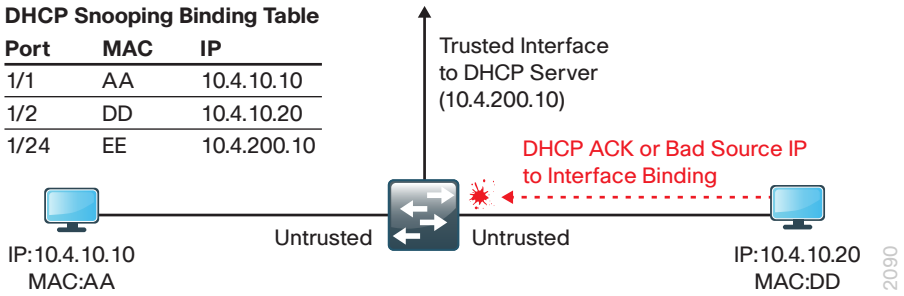
The number of MAC addresses that the device secures on each interface is configurable. For ease of management, the device can learn the addresses dynamically. Using the dynamic learning method, the device secures MAC addresses while ingress traffic passes through the interface. If the address is not yet secured and the device has not reached any applicable maximum, it secures the address and allows the traffic. The device ages dynamic addresses and drops them when the age limit is reached.

DHCP snooping is a DHCP security feature that blocks DHCP replies on an untrusted interface. An untrusted interface is any interface on the switch not specifically configured as a known DHCP server or path towards a known DHCP server.

The DHCP snooping feature helps simplify management and troubleshooting by tracking MAC address, IP address, lease time, binding type, VLAN number, and interface information that correspond to the local untrusted interfaces on the switch. DHCP snooping stores that information in the DHCP binding table.

Dynamic ARP inspection (DAI) mitigates ARP poisoning attacks. An ARP poisoning attack is a method by which an attacker sends false ARP information to a local segment. This information is designed to poison the ARP cache of devices on the LAN, allowing the attacker to execute man-in-the-middle attacks.

Figure 9 - DHCP snooping and ARP inspection



DAI uses the data generated by the DHCP snooping feature and intercepts and validates the IP-to-MAC address relationship of all ARP packets on untrusted interfaces. ARP packets that are received on trusted interfaces are not validated and invalid packets on untrusted interfaces are discarded.

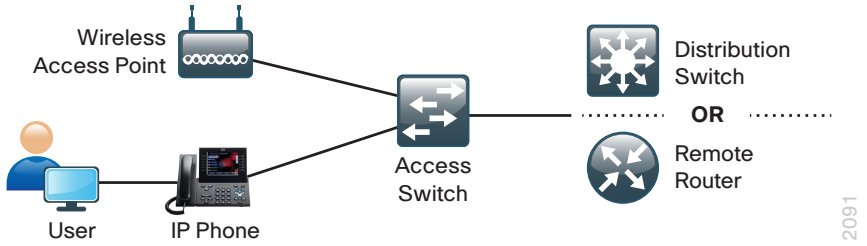
IP Source Guard is a means of preventing a packet from using an incorrect source IP address to obscure its true source, also known as *IP spoofing*. IP Source Guard uses information from DHCP snooping to dynamically configure a port access control list (PACL) on the interface that denies any traffic from IP addresses that are not in the DHCP binding table.

Common Deployment Method to Simplify Installation and Operation

To provide consistent access capabilities and simplify network deployment and operation, the design uses a common deployment method for all access layer devices, whether they are located in the headquarters or at a remote site. To reduce complexity, the access layer is designed so that you can use a single interface configuration for a standalone computer, an IP phone, an IP phone with an attached computer, or a wireless access point.

The LAN access layer provides high-speed connections to devices via 10/100/1000 Ethernet with both Gigabit and 10-Gigabit uplink connectivity options. The 10 Gigabit uplinks also support Gigabit connectivity to provide flexibility and help business continuity during a transition to 10 Gigabit Ethernet. The LAN access layer is configured as a Layer 2 switch, with all Layer 3 services being provided either by the directly-connected distribution layer or router.

Figure 10 - Access layer overview



Features to Support Voice and Video Deployment

Voice and video are enabled in the access layer via network services such as Power over Ethernet (PoE), QoS, multicast support, and Cisco Discovery Protocol with the voice VLAN.

PoE enables devices such as IP Phones, wireless access points, virtual desktops, and security cameras to be powered by the access layer device. This removes the expense of installing or modifying building power to support devices in difficult to reach locations and allows for the consolidation of back-up power supplies and Universal Power Supplies (UPSs) to the access closet.

To support the increasing requirements of devices powered by the network, all of the access layer devices support the IEEE 802.3at standard, also known as PoE+. The devices, and or line cards support all the previous implementations of PoE up to 20 watts per port as well as the new IEEE 802.3at implementation of up to 30 watts per port. For the most demanding PoE environments, like virtual desktops, the Catalyst 4500 in the access layer has the ability to provide up to 60 watts of power per port with Universal Power over Ethernet (UPoE) over the same cable plant as you use for PoE+.

Cisco Discovery Protocol supports voice and video device integration into the access layer. Cisco IP Phones that are plugged into the access layer communicate bidirectionally with the access layer switch via Cisco Discovery Protocol. Cisco Discovery Protocol provides the IP Phone with configuration information and provides the access layer switch with the IP Phones power requirements and the ability to selectively prioritize traffic from the IP Phone.

Access Layer Platforms

Wiring Closets Requiring up to 48 Ports

Cisco Catalyst 2960-S and 3560-X Series are both economical 10/100/1000 Ethernet fixed-port switches that provide flexibility and common features required for wiring closets that can be supported by a single fixed port switch. Cisco Catalyst 2960-S and 3560-X are available in both PoE+ and non-powered versions.

In addition to the capabilities supported by Catalyst 2960-S (other than stacking), Catalyst 3560-X supports modular uplinks, an upgradable Cisco IOS feature set, and enhanced enterprise capabilities like Cisco TrustSec and Medianet.

Wiring Closets Requiring Greater than 48 Ports

When a wiring closet requires greater interface density than can be provided by a single switch, an intelligent stack of fixed configuration switches or a modular switch is recommended.

Intelligent stacks or modular Ethernet switches provide the following major benefits:

- Single point of management—All switches in the stack are managed as one.
- Built-in redundancy and high availability—The high-speed dedicated stack connections provide redundant communication for each stack member.
- Scalable to fit network needs—As the need for additional access interfaces grows, adding a new switch to a stack or a module to a modular switch is easy.

The following series of Cisco Catalyst switches are used in this design when intelligent stacking or a modular deployment is required: Cisco Catalyst 2960-S, 3750-X, and 4500E Series.

Cisco Catalyst 2960-S Series are fixed-configuration, stackable, 10/10/1000 Ethernet switches, with PoE+ and non-powered versions designed for entry-level enterprise, midmarket, and remote site networks.

- Cisco FlexStack is implemented by adding a stacking module to the switch. This enables up to four Catalyst 2960-S series switches to be stacked together.
- Cisco FlexStack links are full duplex 10 Gigabit Ethernet links with recovery time between 1–2 seconds.

Cisco Catalyst 3750-X Series are fixed-port, stackable, 10/100/1000 Ethernet switches, with PoE+ and non-powered versions, that provide enhanced resiliency through StackWise Plus and StackPower technologies.

- Cisco StackWise Plus enables up to nine Cisco Catalyst 3750 switches to be stacked together using a 64-Gbps stack interconnect with near subsecond failure recovery.
- Cisco StackPower shares power across the Cisco Catalyst 3750-X switch stack. This allows the flexible arrangement of power supplies in the stack, and enables a zero-footprint redundant power supply deployment and intelligent load shedding.
- Cisco 3750-X Series have modular uplinks and support upgrading the Cisco IOS feature set and enhanced enterprise capabilities like TrustSec and Medianet, to ensure that the switch functionality grows as the organization grows.

Cisco Catalyst 4500 E-Series are modular switches that support multiple Ethernet connectivity options including 10/100/1000 Ethernet, 100-MB fiber, gigabit fiber, and 10-gigabit fiber. The Catalyst 4500 E-Series switches also have an upgradable supervisor module which enables future functionality to be added with a supervisor module upgrade while maintaining the initial investment in the chassis and the modules.

- All key switching and forwarding components are located on the supervisor module; upgrading the supervisor upgrades the line cards.
- The Catalyst 4500 E-Series Supervisor 7L-E has uplink interfaces that can be configured as Gigabit Ethernet or 10 Gigabit interfaces, allowing customers to easily increase bandwidth in the future.
- The Catalyst 4500 E-Series provides maximum PoE flexibility with support of IEEE 802.3af, 802.3at, and now UPoE that supplies up to 60 watts per port of PoE. UPoE linecards are backward compatible to earlier PoE and PoE+ connected end points as well.
- The Catalyst 4507R+E chassis supports redundant supervisor modules and power supplies, which increases system availability by providing 1:1 redundancy for all critical systems.
- The Catalyst 4507R+E supports stateful switchover which allows a supervisor switchover to occur with minimum disruption to the network.
- The entire software upgrade process is simplified ISSU. Not only does ISSU help eliminate errors in the software upgrade process, but additional checks are incorporated that allow the new software version to be tested and verified before completing the upgrade.

Deployment Details

As you review the *LAN Deployment Guide* you may find it useful to understand the IP addressing and VLAN assignments used. Although your design requirements may differ, by addressing the various distribution layers at a location with contiguous IP address space you can summarize the IP address range to the rest of the network. This design uses VLAN assignments that reflect the third octet of the IP address range for a given access layer switch for ease of reference. The LAN Core IP addressing is a combination of 30 bit subnets for point-to-point Layer 3 links, and 32 bit host addresses for loopback addresses.

Table 1 - IP addressing for LAN deployment guide

Distribution Block	VLAN	IP Addressing	Usage
LAN Access A	100	10.4.0.x/24	Data-Access Switch 1
	101	10.4.1.x/24	Voice-Access Switch 1
	102	10.4.2.x/24	Data-Access Switch 2
	103	10.4.3.x/24	Voice-Access Switch 2
	Continue through 114	10.4.4 - .14	alternate Data and Voice
	115	10.4.15.x/25	Management
LAN Access B	164	10.4.64.x/24	Data-Access Switch 1
	165	10.4.65.x/24	Voice-Access Switch 1
	166	10.4.66.x/24	Data-Access Switch 2
	167	10.4.67.x/24	Voice-Access Switch 2
	Continue through 178	10.4.68 - .78	alternate Data and Voice
	179	10.4.79.x/25	Management
LAN Access C	180	10.4.80.x/24	Data-Access Switch 1
	181	10.4.81.x/24	Voice-Access Switch 1
	182	10.4.82.x/24	Data-Access Switch 2
	183	10.4.83.x/24	Voice-Access Switch 2
	Continue through 195	10.4.84 - .94	alternate Data and Voice
	179	10.4.15.x/25	Management
Core	None	10.4.40.x	Core to Dist Links

Process

Configuring the Access Layer

1. Configure the platform
2. Configure LAN switch universal settings
3. Configure access switch global settings
4. Configure client connectivity
5. Connect to distribution or WAN router

Procedure 1 Configure the platform

Some platforms require a one-time initial configuration prior to configuring the features and services of the switch. If you do not have a platform listed in the following steps, you can skip those steps.

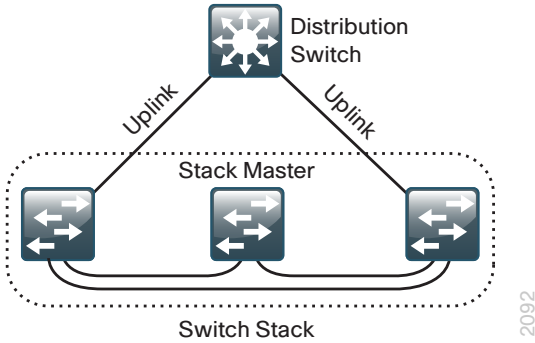
Option 1. Configure the Catalyst 2960-S, 3560-X, and 3750-X

Step 1: Set the stack master switch.

```
switch [switch number] priority 15
```

When there are multiple Catalyst 2960-S or 3750-X Series switches configured in a stack, one of the switches controls the operation of the stack and is called the stack master. When three or more switches are configured as a stack, configure the stack master switch functionality on a switch that does not have uplinks configured.

Figure 11 - Stack master placement in a switch stack



If you configure stack master switch priority on a Cisco Catalyst 2960-S or Cisco 3750-X switch stack, a single reboot is required to force the stack master to operate on the switch that you configured with the highest priority. Reboot the switch stack after all of your configuration is complete for this entire "Configuring the Access Layer" process.

Step 2: Run the **stack-mac persistent timer 0** command to ensure that the original master MAC address remains the stack MAC address after a failure. This command does not apply to the Catalyst 3560-X switch.

```
stack-mac persistent timer 0
```

The default behavior when the stack master switch fails is for the newly active stack master switch to assign a new stack MAC address. This new MAC address assignment can cause the network to reconverge because the link aggregation control protocol (LACP) and many other protocols rely on the stack MAC address and must restart.

Step 3: To make consistent deployment of QoS easier, each platform defines two macros that you will use in later procedures to apply the platform specific QoS configuration.

```
macro name AccessEdgeQoS
 auto qos voip cisco-phone
@
!
macro name EgressQoS
 mls qos trust dscp
 queue-set 1
 srr-queue bandwidth share 1 30 35 5
 priority-queue out
@
```

Option 2. Configure the Catalyst 4507R+E platform

Step 1: To make consistent deployment of QoS easier each platform defines two macros that you will use in later procedures to apply the platform specific QoS configuration.

```
class-map match-all VOIP_DATA_CLASS
 match cos 5
class-map match-all VOIP_SIGNAL_CLASS
 match cos 3
!
policy-map CISCOPHONE-POLICY
 class VOIP_DATA_CLASS
  set dscp ef
  police 128k bc 8000
   conform-action transmit
   exceed-action drop
 class VOIP_SIGNAL_CLASS
  set dscp cs3
  police 32k bc 8000
   conform-action transmit
   exceed-action drop
 class class-default
  set dscp default
  police 10m bc 8000
   conform-action transmit
   exceed-action set-dscp-transmit cs1
!
class-map match-any PRIORITY-QUEUE
  match  dscp ef
  match  dscp cs5
  match  dscp cs4
class-map match-any CONTROL-MGMT-QUEUE
  match  dscp cs7
  match  dscp cs6
  match  dscp cs3
  match  dscp cs2
class-map match-any MULTIMEDIA-CONFERENCING-QUEUE
  match  dscp af41  af42  af43
class-map match-any MULTIMEDIA-STREAMING-QUEUE
  match  dscp af31  af32  af33
class-map match-any TRANSACTIONAL-DATA-QUEUE
  match  dscp af21  af22  af23
class-map match-any BULK-DATA-QUEUE
  match  dscp af11  af12  af13
class-map match-any SCAVENGER-QUEUE
  match  dscp cs1
!
policy-map 1P7Q1T
 class PRIORITY-QUEUE
    priority
 class CONTROL-MGMT-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-CONFERENCING-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-STREAMING-QUEUE
    bandwidth remaining percent 10
 class TRANSACTIONAL-DATA-QUEUE
    bandwidth remaining percent 10
    dbl
 class BULK-DATA-QUEUE
    bandwidth remaining percent 4
```

```
    dbl
 class SCAVENGER-QUEUE
    bandwidth remaining percent 1
 class class-default
    bandwidth remaining percent 25
    dbl
!
policy-map 1P7Q1T_Access
 class PRIORITY-QUEUE
    priority
    police cir percent 30
 class CONTROL-MGMT-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-CONFERENCING-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-STREAMING-QUEUE
    bandwidth remaining percent 10
 class TRANSACTIONAL-DATA-QUEUE
    bandwidth remaining percent 10
    dbl
 class BULK-DATA-QUEUE
    bandwidth remaining percent 4
    dbl
 class SCAVENGER-QUEUE
    bandwidth remaining percent 1
 class class-default
    bandwidth remaining percent 25
    dbl
!
macro name AccessEdgeQoS
 qos trust device cisco-phone
 service-policy input CISCOPHONE-POLICY
 service-policy output 1P7Q1T_Access
@
!
macro name EgressQoS
 service-policy output 1P7Q1T
@
```

Step 2: When a Catalyst 4507R+E is configured with two Supervisor 7L-Es, configure the switch to use Stateful Switchover (SSO) when moving the primary supervisor functionality between modules. To enable a fast transparent data plane failover, SSO synchronizes active process information as well as configuration information between supervisor modules.

```
redundancy
  mode sso
```

To enable SSO mode you must have a license level of ipbase or entservices operating on the switch supervisors. You can check the current license level of operation with a **show version** command.

Procedure 2 Configure LAN switch universal settings

Within this design, there are features and services that are common across all LAN switches, regardless of the type of platform or role in the network. These are system settings that simplify and secure the management of the solution.

This procedure provides examples for some of those settings. The actual settings and values will depend on your current network configuration.

Table 2 - Common network services used in the deployment examples

Service	Address
Domain Name:	cisco.local
Active Directory, DNS, DHCP Server:	10.4.48.10
Authentication Control System:	10.4.48.15
Network Time Protocol Server:	10.4.48.17

Step 1: Configure the device hostname to make it easy to identify the device.

```
hostname [hostname]
```

Step 2: Configure VTP transparent mode. This deployment uses VTP transparent mode because the benefits of dynamic propagation of VLAN information across the network are not worth the potential for unexpected behavior that is due to operational error.

VLAN Trunking Protocol (VTP) allows network managers to configure a VLAN in one location of the network and have that configuration dynamically propagate out to other network devices. However, in most cases, VLANs are defined once during switch setup with few, if any, additional modifications.

```
vtp mode transparent
```

Step 3: Enable Rapid Per-VLAN Spanning-Tree (PVST+). Rapid PVST+ provides an instance of RSTP (802.1w) per VLAN. Rapid PVST+ greatly improves the detection of indirect failures or linkup restoration events over classic spanning tree (802.1D).

Although this architecture is built without any Layer 2 loops, you must still enable spanning tree. By enabling spanning tree, you ensure that if any physical or logical loops are accidentally configured, no actual layer 2 loops occur.

```
spanning-tree mode rapid-pvst
```

Step 4: Enable Unidirectional Link Detection (UDLD).

UDLD is a Layer 2 protocol that enables devices connected through fiber-optic or twisted-pair Ethernet cables to monitor the physical configuration of the cables and detect when a unidirectional link exists. When UDLD detects a unidirectional link, it disables the affected interface and alerts you. Unidirectional links can cause a variety of problems, including spanning-tree loops, black holes, and non-deterministic forwarding. In addition, UDLD enables faster link failure detection and quick reconvergence of interface trunks, especially with fiber, which can be susceptible to unidirectional failures.

```
udld enable
```

Step 5: Set EtherChannels to use the traffic source and destination IP address when calculating which link to send the traffic across. This normalizes the method in which traffic is load-shared across the member links of the EtherChannel. EtherChannels are used extensively in this design because of their resiliency capabilities.

```
port-channel load-balance src-dst-ip
```

Step 6: Configure DNS for host lookup.

At the command line of a Cisco IOS device, it is helpful to be able to type a domain name instead of the IP address for a destination.

```
ip name-server 10.4.48.10
```

Step 7: Configure device management protocols.

Secure HTTP (HTTPS) and Secure Shell (SSH) are more secure replacements for the HTTP and Telnet protocols. They use Secure Sockets Layer (SSL) and Transport Layer Security (TLS) to provide device authentication and data encryption.

The SSH and HTTPS protocols enable secure management of the LAN device. Both protocols are encrypted for privacy, and the nonsecure protocols, Telnet and HTTP, are turned off.

Specify the transport preferred none on vty lines to prevent errant connection attempts from the CLI prompt. Without this command, if the ip name server is unreachable, long timeout delays may occur for mistyped commands.

```
ip domain-name cisco.local
ip ssh version 2
no ip http server
ip http secure-server
!
line vty 0 15
  transport input ssh
  transport preferred none
```

Step 8: Enable Simple Network Management Protocol (SNMP) in order to allow the network infrastructure devices to be managed by a Network Management System (NMS), and then configure SNMPv2c both for a read-only and a read-write community string.

```
snmp-server community cisco RO
snmp-server community cisco123 RW
```

Step 9: If your network operational support is centralized, you can increase network security by using an access list to limit the networks that can access your device. In this example, only devices on the 10.4.48.0/24 network will be able to access the device via SSH or SNMP.

```
access-list 55 permit 10.4.48.0 0.0.0.255
line vty 0 15
  access-class 55 in
!
snmp-server community cisco RO 55
snmp-server community cisco123 RW 55
```

Caution

If you configure an access-list on the vty interface you may lose the ability to use ssh to login from one router to the next for hop-by-hop troubleshooting.

Step 10: Configure local login and password.

The local login account and password provides basic device access authentication to view platform operation. The enable password secures access to the device configuration mode. By enabling password encryption, you prevent the use of plain text passwords when viewing configuration files.

```
username admin password c1sco123
enable secret c1sco123
service password-encryption
aaa new-model
```

By default, https access to the switch will use the enable password for authentication.

Step 11: If you want to reduce operational tasks per device, configure centralized user authentication by using the TACACS+ protocol to authenticate management logins on the infrastructure devices to the Authentication, Authorization and Accounting (AAA) server.

As networks scale in the number of devices to maintain, there is an operational burden to maintain local user accounts on every device. A centralized Authentication, Authorization and Accounting (AAA) service reduces operational tasks per device and provides an audit log of user access for security compliance and root cause analysis. When AAA is enabled for access control, all management access to the network infrastructure devices (SSH and HTTPS) is controlled by AAA.

TACACS+ is the primary protocol used to authenticate management logins on the infrastructure devices to the AAA server. A local AAA user database is also defined on each network infrastructure device to provide a fallback authentication source in case the centralized TACACS+ server is unavailable.

```
tacacs server TACACS-SERVER-1
address ipv4 10.4.48.15
key SecretKey
!
aaa group server tacacs+ TACACS-SERVERS
  server name TACACS-SERVER-1
!
aaa authentication login default group TACACS-SERVERS local
aaa authorization exec default group TACACS-SERVERS local
aaa authorization console
ip http authentication aaa
```

Reader Tip

The AAA server used in this architecture is Cisco Authentication Control System. Configuration of ACS is discussed in the *Cisco SBA—Borderless Networks Device Management Using ACS Deployment Guide*.

Step 12: Configure a synchronized clock by programming network devices to synchronize to a local NTP server in the network. The local NTP server typically references a more accurate clock feed from an outside source. Configure console messages, logs, and debug output to provide time stamps on output, which allows cross-referencing of events in a network.

```
ntp server 10.4.48.17
ntp update-calendar
!
clock timezone PST -8
clock summer-time PDT recurring
!
service timestamps debug datetime msec localtime
service timestamps log datetime msec localtime
```

The **ntp update-calendar** command configures the switch to update the hardware clock from the ntp time source periodically. Since not all switches have a hardware clock, this command is not supported by all devices.

Procedure 3 Configure access switch global settings

The access layer devices use VLANs to separate traffic from different devices into the following logical networks:

- The data VLAN provides access to the network for all attached devices other than IP Phones.
- The voice VLAN provides access to the network for IP Phones.

  Both the data and the voice VLAN are configured on all user-facing interfaces.
- The management VLAN provides in-band access to the network for the switches management interface. The management VLAN is not configured on any user-facing interface and the VLAN interface of the switch is the only member.

Step 1: Configure VLANs on the switch.

Configure the data, voice, and management VLANs on the switch so that connectivity to clients, IP Phones, and the in-band management interfaces can be configured.

```
vlan [data vlan]
name Data
vlan [voice vlan]
name Voice
vlan [management vlan]
name Management
```

Tech Tip

If the switch is the only switch at the site and is directly connected to a router or firewall, do not configure a management VLAN. Instead, configure the in-band management interface on the data VLAN.

Step 2: Configure the switch with an IP address so that it can be managed via in-band connectivity.

```
interface vlan [management vlan]
  ip address [ip address] [mask]
  no shutdown
ip default-gateway [default router]
```

Do not use the **ip default-gateway** command on the Catalyst 4500 because it has IP routing enabled by default and this command will not have any affect. Instead use the following command on the Catalyst 4500.

```
ip route 0.0.0.0 0.0.0.0 [default router]
```

Step 3: Configure DHCP snooping and enable it on the data and voice VLANs. The switch intercepts and safeguards DHCP messages within the VLAN. This ensures that an unauthorized DHCP server cannot serve up addresses to end-user devices.

```
ip dhcp snooping vlan [data vlan],[voice vlan]
no ip dhcp snooping information option
ip dhcp snooping
```

Step 4: Configure ARP inspection on the data and voice VLANs.

```
ip arp inspection vlan [data vlan],[voice vlan]
```

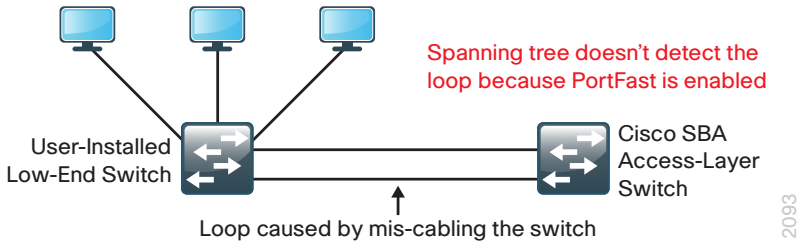
Step 5: Configure BPDU Guard globally to protect portfast enabled interfaces. This protects PortFast-enabled interfaces by disabling the port if another switch is plugged into the port.

```
spanning-tree portfast bpduguard default
```

BPDU guard protects against a user plugging a switch into an access port, which could cause a catastrophic undetected spanning-tree loop.

If a portfast configured interface receives a BPDU, an invalid configuration exists, such as the connection of an unauthorized device. The BPDU guard feature prevents loops by moving a nontrunking interface into an errdisable state when a BPDU is received on an interface when portfast is enabled.

Figure 12 - Scenario that BPDU Guard protects against



Procedure 4 Configure client connectivity

To make configuration easier when the same configuration will be applied to multiple interfaces on the switch, use the **interface range** command. This command allows you to issue a command once and have it apply to many interfaces at the same time. Since most of the interfaces in the access layer are configured identically, it can save a lot of time. For example, the following command allows you to enter commands on all 24 interfaces (Gig 0/1 to Gig 0/24) simultaneously.

```
interface range Gigabitethernet 0/1-24
```

Step 1: Configure switch interfaces to support clients and IP phones.

The host interface configurations support PCs, phones, or wireless access points. Inline power is available on switches that support 802.3AF/AT for capable devices.

```
interface range [interface type] [port number]-[port number]
  switchport access vlan [data vlan]
  switchport voice vlan [voice vlan]
```

Step 2: Because only end-device connectivity is provided at the access layer enable PortFast. PortFast shortens the time it takes for the interface to go into a forwarding state by disabling 802.1q trunking, and channel group negotiation.

```
  switchport host
```

Step 3: Enable QoS by applying the access edge QoS macro that was defined in the platform configuration procedure.

```
  macro apply AccessEdgeQoS
```

All client facing interfaces allow for an untrusted PC and/or a trusted Cisco IP phone to be connected to the switch and automatically set QoS parameters. When a Cisco Phone is connected, trust is extended to the phone, and any device that connects to the phone will be considered untrusted and all traffic from that device will be remarked to best-effort or class of service (CoS) 0.

Next, configure port security on the interface.

Step 4: Configure 11 MAC addresses to be active on the interface at one time; additional MAC addresses are considered to be in violation, and their traffic will be dropped.

```
  switchport port-security maximum 11
  switchport port-security
```

The number of MAC addresses allowed on each interface is specific to the organization. However, the popularity of virtualization applications, IP phones, and passive hubs on the desktop drives the need for the number to be larger than one might guess at first glance. This design uses a number that allows flexibility in the organization while still protecting the network infrastructure.

Step 5: Set an aging time to remove learned MAC addresses from the secured list after 2 minutes of inactivity.

```
  switchport port-security aging time 2
  switchport port-security aging type inactivity
```

Step 6: Configure the restrict option to drop traffic from MAC addresses that are in violation, but do not shut down the port. This configuration ensures that an IP phone can still function on this interface when there is a port security violation.

```
switchport port-security violation restrict
```

Step 7: Configure DHCP snooping and ARP inspection on the interface to process 100 packets per second of traffic on the port.

```
ip arp inspection limit rate 100
ip dhcp snooping limit rate 100
```

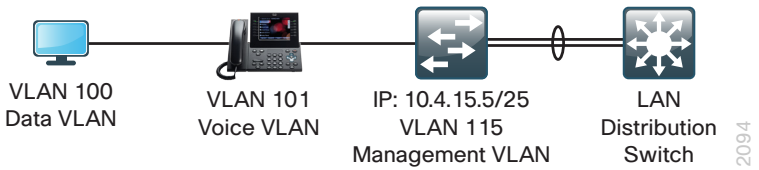
Step 8: Configure IP Source Guard on the interface. IP Source Guard is a means of preventing IP spoofing.

```
ip verify source
```

The Catalyst 4500 does not support the **ip verify source** command. Instead, use the following command:

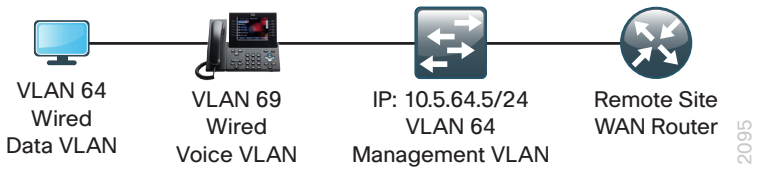
```
ip verify source vlan dhcp-snooping
```

Example: Connected to distribution layer




```
vlan 100
  name Data
vlan 101
  name Voice
vlan 115
  name Management
!
interface vlan 115
  description in-band management
  ip address 10.4.15.5 255.255.255.128
  no shutdown
!
ip default-gateway 10.4.15.1
!
ip dhcp snooping vlan 100,101
no ip dhcp snooping information option
ip dhcp snooping
ip arp inspection vlan 100,101
!
spanning-tree portfast bpduguard default
!
interface range GigabitEthernet 1/0/1-24
  switchport access vlan 100
  switchport voice vlan 101
  switchport host
  macro apply AccessEdgeQoS
  switchport port-security maximum 11
  switchport port-security
  switchport port-security aging time 2
  switchport port-security aging type inactivity
  switchport port-security violation restrict
  ip arp inspection limit rate 100
  ip dhcp snooping limit rate 100
  ip verify source
```

Example: Connected to WAN Router




```
vlan 64
  name WiredData
vlan 69
  name WiredVoice
!
interface vlan 69
  description in-band managementto WAN Router
```

```
  ip address 10.5.69.5 255.255.255.0
  no shutdown
!
ip default-gateway 10.5.69.1
!
ip dhcp snooping vlan 64,69
no ip dhcp snooping information option
ip dhcp snooping
ip arp inspection vlan 64,69
!
spanning-tree portfast bpduguard default
!
interface range GigabitEthernet 1/0/1-24
  switchport access vlan 64
  switchport voice vlan 69
  switchport host
  macro apply AccessEdgeQoS
  switchport port-security maximum 11
  switchport port-security
  switchport port-security aging time 2
  switchport port-security aging type inactivity
  switchport port-security violation restrict
  ip arp inspection limit rate 100
  ip dhcp snooping limit rate 100
  ip verify source
```

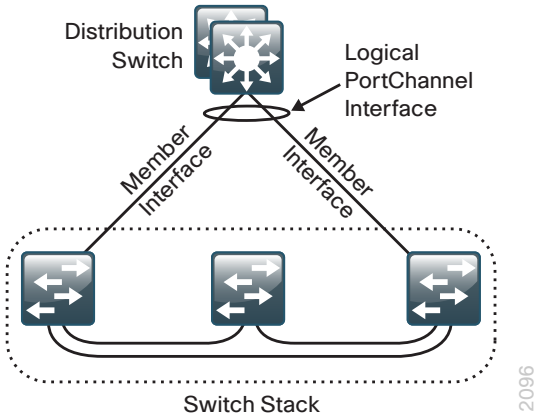
Procedure 5 Connect to distribution or WAN router

Access layer devices can be one component of a larger LAN and connect to a distribution switch, or, in the case of a small remote site, might be the only LAN device and connect directly to a WAN device. Unless the access layer device is a single fixed configuration switch connecting to a WAN router, Layer 2 EtherChannels are used to interconnect the devices in the most resilient method possible.

When using EtherChannel, the member interfaces should be on different switches in the stack or different modules in the modular switch for the highest resiliency.

The physical interfaces that are members of a Layer 2 EtherChannel are configured prior to configuring the logical port-channel Interface. This allows for minimal configuration because most of the commands entered to a port-channel interface are copied to its members' interfaces and do not require manual replication.

Figure 13 - EtherChannel example



Configure two or more physical interfaces to be members of the EtherChannel. It is recommended that they are added in multiples of two.

This procedure details how to connect any Cisco SBA access layer switch (Cisco Catalyst 4500, 3750-X, 3560-X, or 2960-S) to a distribution switch or WAN router. Where there are differences for configuring a specific switch it will be called out in the step.

Option 1. Configure EtherChannel to distribution switch

Step 1: Configure EtherChannel member interfaces.

When connecting to another switch set Link Aggregation Control Protocol negotiation to active on both sides to ensure a proper EtherChannel is formed. Also, apply the egress QoS macro that was defined in the platform configuration procedure to ensure traffic is prioritized appropriately.

Cisco Catalyst 2960S does not require the **switchport** command.

```
interface [interface type] [port 1]
  description Link to Distribution Layer port 1
interface [interface type] [port 2]
  description Link to Distribution Layer port 2
!
interface range [interface type] [port 1], [interface type]
[port 2]
  switchport
  macro apply EgressQoS
  channel-protocol lacp
  channel-group [number] mode active
  logging event link-status
  logging event trunk-status
  logging event bundle-status
```

Step 2: Configure the trunk.

An 802.1Q trunk is used for the connection to this upstream device, which allows the uplink to provide Layer 3 services to all the VLANs defined on the access layer switch. Prune the VLANs allowed on the trunk to only the VLANs that are active on the access switch. Set DHCP Snooping and ARP Inspection to trust. When using EtherChannel the interface type will be port-channel and the number must match channel-group configured in Step 1.

The Catalyst 3750 requires the **switchport trunk encapsulation dot1q** command.

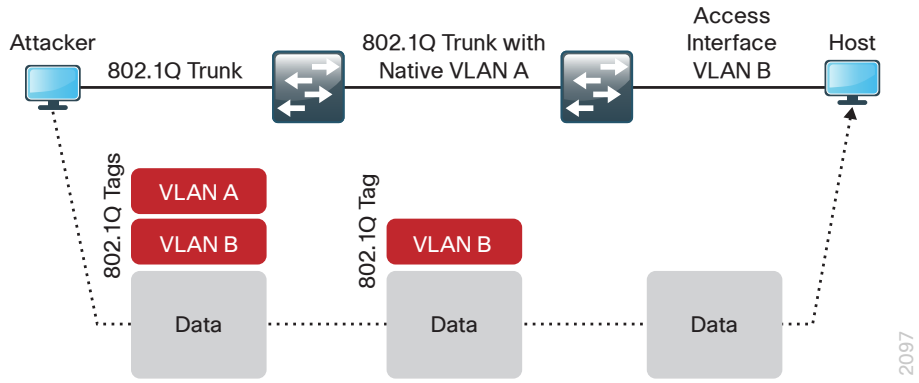
```
interface [interface type] [number]
  description EtherChannel link to Distribution Layer
  switchport trunk allowed vlan [data vlan],[voice vlan],
    [mgmt vlan]
  switchport mode trunk
  ip arp inspection trust
  ip dhcp snooping trust
  logging event link-status
  logging event trunk-status
  no shutdown
```

If the interface type is not a port-channel, you must configure an additional command **macro apply EgressQoS** on the interface.

Next, mitigate VLAN hopping on the trunk for switch-to-switch connections.

There is a remote possibility that an attacker can create a double 802.1Q encapsulated packet. If the attacker has specific knowledge of the 802.1Q native VLAN, a packet could be crafted that when processed, the first or outermost tag is removed when the packet is switched onto the untagged native VLAN. When the packet reaches the target switch, the inner or second tag is then processed and the potentially malicious packet is switched to the target VLAN.

Figure 14 - VLAN hopping attack



At first glance, this appears to be a serious risk. However, the traffic in this attack scenario is in a single direction and no return traffic can be switched by this mechanism. Additionally, this attack cannot work unless the attacker knows the native VLAN ID.

Step 3: To remove the remote risk of this type of attack,, configure an unused VLAN on all switch-to-switch 802.1Q trunk links from access layer to distribution layer. Using a hard to guess, unused VLAN for the native VLAN reduces the possibility that a double 802.1Q-tagged packet can hop VLANs. If you are running the recommended EtherChannel uplink to the LAN access layer switch, configure the **switchport trunk native vlan** on the port-channel interface.

```
vlan 999
!
interface [port-channel] [number]
  switchport trunk native vlan 999
```

Step 4: Save the running configuration that you have entered so it will be used as the startup configuration file when your switch is rebooted or power-cycled.

```
copy running-config startup-config
```

Step 5: If you have configured your access-layer Cisco Catalyst 2960-S or Cisco Catalyst 3750-X switch stack for an EtherChannel link to the distribution layer switch, reboot your switch stack now to ensure proper operation of EtherChannel. A single reboot of a newly configured switch is necessary to ensure that EtherChannel operates with other features configured on the switch stack.

```
reboot
```

Option 2. Configure EtherChannel to WAN router

If your access layer switch is a single fixed configuration switch connecting to a single remote-site router without using EtherChannel you can skip Step 1. If you have a remote-site with dual routers for resilience, see the *Cisco SBA—Borderless Networks WAN Deployment Guide* for configuration guidance for the access layer uplinks.

Step 1: Configure EtherChannel member interfaces.

When connecting to a network infrastructure device that does not support LACP, like a router, set the **channel-group mode** to forced on.

Also, apply the egress QoS macro that was defined in the platform configuration procedure to ensure traffic is prioritized appropriately.

Cisco Catalyst 2960S does not require the **switchport** command.

```
interface [interface type] [port 1]
  description Link to Router port 1
interface [interface type] [port 2]
  description Link to Router port 2
!
interface range [interface type] [port 1], [interface type]
[port 2]
  switchport
  macro apply EgressQoS
  channel-group [number] mode on
  logging event link-status
  logging event trunk-status
  logging event bundle-status
```

Step 2: Configure the trunk.

An 802.1Q trunk is used for the connection to this upstream device, which allows the router to provide Layer 3 services to all the VLANs defined on the access layer switch. Prune the VLANs allowed on the trunk to only the VLANs that are active on the access switch. Set DHCP snooping and ARP Inspection to trust. When using EtherChannel, the interface type will be port-channel, and the number must match channel-group configured in Step 1 in Option 2: of this procedure.

The Catalyst 3750 requires the **switchport trunk encapsulation dot1q** command.

```
interface [interface type] [number]
  description EtherChannel link to Router
  switchport trunk allowed vlan [data vlan],[voice vlan]
  switchport mode trunk
  ip arp inspection trust
  ip dhcp snooping trust
  spanning-tree portfast trunk
  logging event link-status
  logging event trunk-status
  no shutdown
```

If the interface type is not a port-channel, you must configure additional commands **switchport** and **macro apply EgressQoS** on the interface.

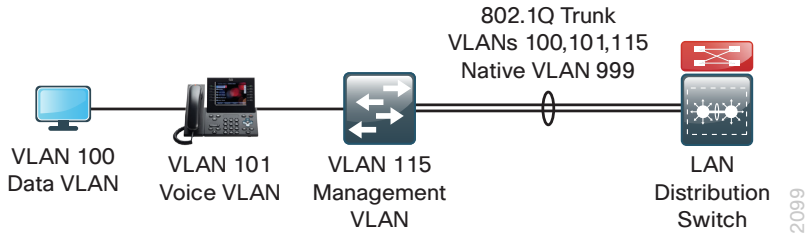
Step 3: Save the running configuration that you have entered so it will be used as the startup configuration file when your switch is rebooted or power-cycled.

```
copy running-config startup-config
```

Step 4: If you have configured your access layer Cisco Catalyst 2960-S or Cisco Catalyst 3750-X switch stack for EtherChannel to the WAN router, reboot your switch stack now to ensure proper operation of EtherChannel. A single reboot of a newly configured switch is necessary to ensure that EtherChannel operates with other features configured on the switch stack.

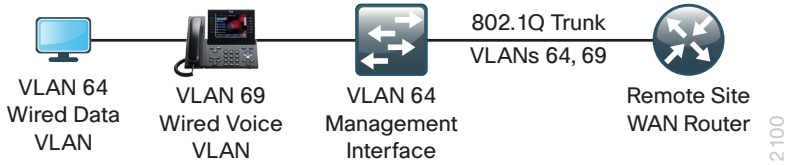
```
reboot
```

Figure 15 - Configuration Example Procedure 5 Option 1



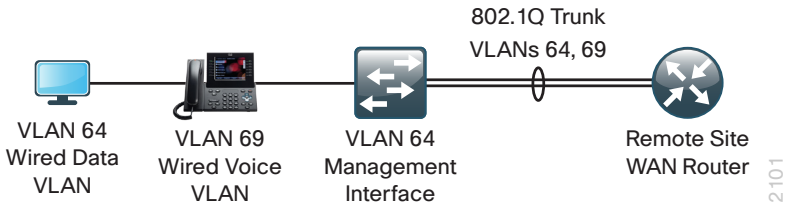

```
vlan 999
!
interface GigabitEthernet 1/0/25
  description Link to Distribution Layer port 1
interface GigabitEthernet 3/0/25
  description Link to Distribution Layer port 2
!
interface range GigabitEthernet 1/0/25, GigabitEthernet 3/0/25
  macro apply EgressQoS
  logging event link-status
  logging event trunk-status
  logging event bundle-status
  channel-protocol lacp
  channel-group 1 mode active
!
interface Port-channel 1
  description Etherchannel to Distribution Layer
  switchport trunk encapsulation dot1q
  switchport trunk native vlan 999
  switchport trunk allowed vlan 100,101,115
  switchport mode trunk
  ip arp inspection trust
  ip dhcp snooping trust
  no shutdown
```

Figure 16 - Configuration Example Procedure 5 Option 2




```
interface GigabitEthernet 1/0/24
  description Link to WAN Router
  macro apply EgressQoS
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 64,69
  switchport mode trunk
  ip arp inspection trust
  ip dhcp snooping trust
  spanning-tree portfast trunk
  no shutdown
```

Figure 17 - Configuration Example Procedure 5 Option 2 with EtherChannel




```
interface GigabitEthernet 1/0/25
  description Link to WAN Router port 1
interface GigabitEthernet 3/0/25
  description Link to WAN Router port 2
!
interface range GigabitEthernet 1/0/25, GigabitEthernet 3/0/25
  macro apply EgressQoS
  logging event link-status
  logging event trunk-status
  logging event bundle-status
  channel-group 1 mode on
!
interface Port-channel 1
  description EtherChannel to WAN Router
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 64,69
  switchport mode trunk
  ip arp inspection trust
  ip dhcp snooping trust
  spanning-tree portfast trunk
  no shutdown
```

Notes

Distribution Layer

Business Overview

The challenge for an organization to deliver reliable employee access to business services grows as the number of employees at a given location expands. As the number of access layer closets at a location grows, it creates the need to aggregate the connectivity at a common point. One of the benefits of aggregation is that you can reduce costs by reducing the number of interconnections from each access layer switch to the rest of the network, which is used to get to the applications and resources hosted in the center of the network or across the WAN.

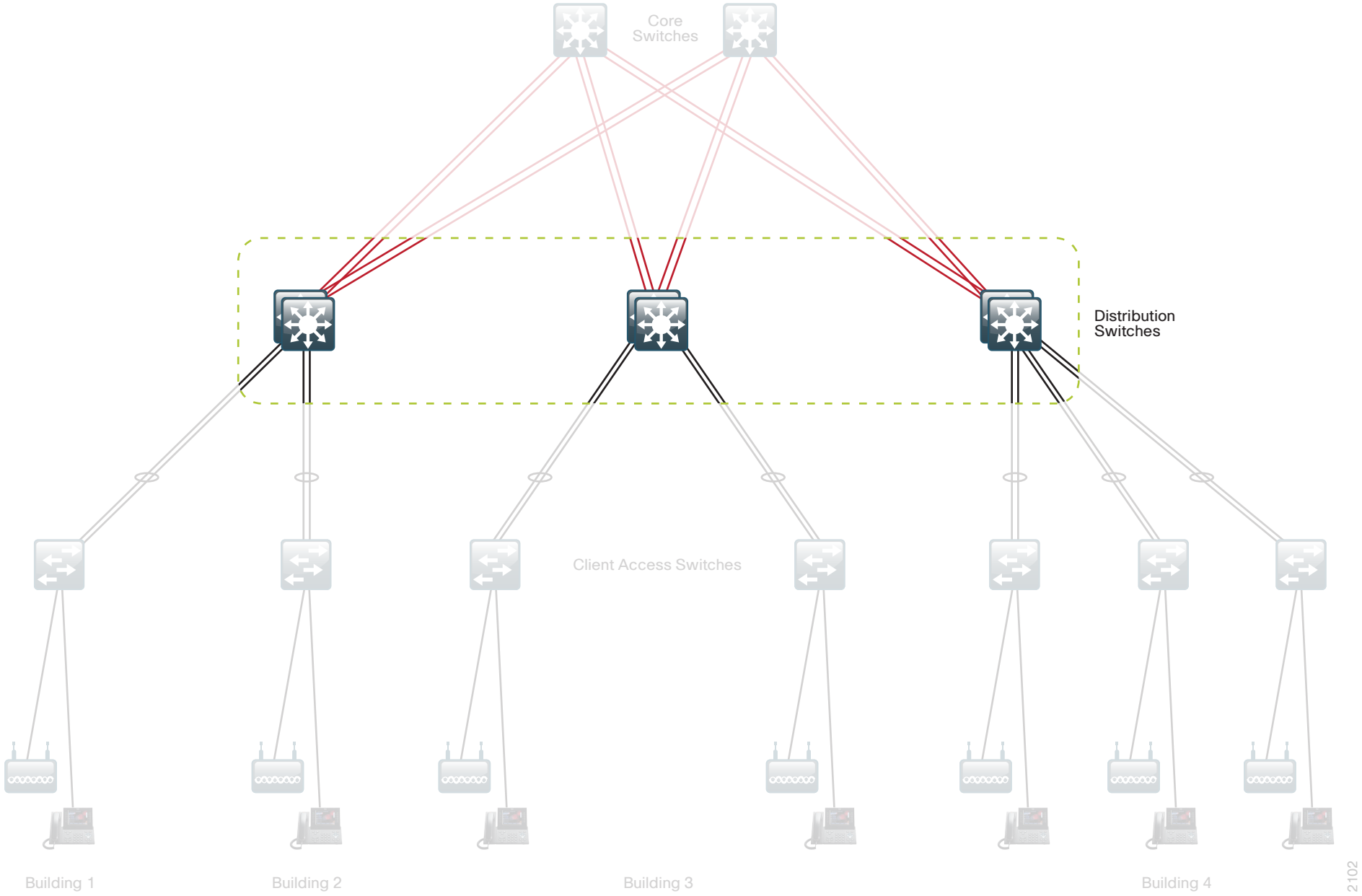
Traditional network design used parallel physical networks to transport different traffic types like voice or data, or to transport traffic with different security needs. To reduce costs IT organizations must create a single multi-use network infrastructure that can use multiple VLANs on a single physical infrastructure. The dominant internetwork protocol in use in networks today is IP, which allows a routed network topology, but some applications require that network connected endpoints be Layer 2 adjacent. IT must work to design networks that accommodate the application requirements without sacrificing the reliability or scalability of the network. The goal of the network foundation architecture is to provide a design that supports an ever-increasing number of services required from the LAN and to control the increasing complexity of delivering those services without eliminating essential functionality.

Technology Overview

The primary function of the distribution layer is to aggregate access layer switches in a given building or campus. The distribution layer provides a boundary between the Layer 2 domain of the access layer and the Layer 3 domain that provides a path to the rest of the network. This boundary provides two key functions for the LAN. On the Layer 2 side the distribution layer creates a boundary for Spanning Tree Protocol limiting propagation of Layer 2 faults. On the Layer 3 side the distribution layer provides a logical point to summarize IP routing information before it enters the network and reduce IP route tables for easier troubleshooting and faster recovery from failures.

The Cisco SBA LAN distribution layer uses a simplified distribution layer design that is easier to operate and troubleshoot than the traditional and routed access designs.

Figure 18 - Distribution layer overview



Traditional Distribution Layer Design

Traditional LAN designs deploy a multitier approach with Layer 2 from the access layer to the distribution layer, where the Layer 3 boundary exists. The connectivity from the access layer to the distribution layer can result in either a loop-free or looped design.

In the traditional network design, the distribution layer has two standalone switches for resiliency. It is recommended that you restrict a Layer 2 VLAN to a single wiring closet or access uplink pair to reduce or eliminate topology loops that Spanning Tree Protocol must block and that are a common point of failure in LANs. Restricting a VLAN to a single switch provides a loop-free design, but it does limit network flexibility.

To create a resilient IP gateway for VLANs in this design, you must use first-hop redundancy protocols, which provide hosts with a gateway IP for a VLAN on a healthy switch. Hot Standby Routing Protocol (HSRP) and Virtual Router Redundancy Protocol (VRRP) are the most common gateway redundancy protocols, but they only allow hosts to send data out one of the access uplinks to the distribution layer. Gateway Load Balancing Protocol (GLBP) does provide greater uplink utilization for traffic exiting the access layer by balancing load from hosts across multiple uplinks, but you can only use it in a non-looped topology.

All of these redundancy protocols require that you fine tune the default settings to allow for subsecond network convergence.

Some organizations require the same Layer 2 VLAN be extended to multiple access layer closets to accommodate an application or service. The looped design causes spanning tree to block links, which reduces the bandwidth from the rest of the network and can cause slower network convergence.

Figure 19 - Traditional loop-free design with a VLAN per access switch

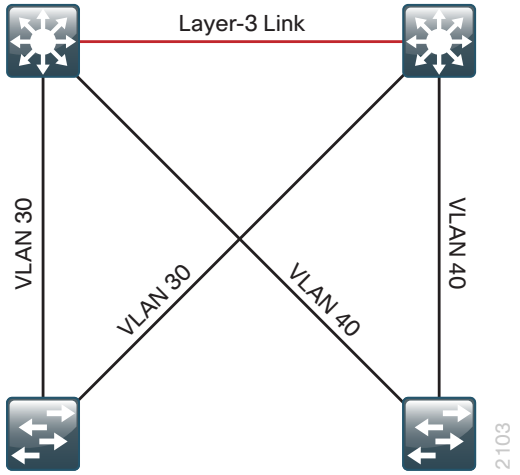
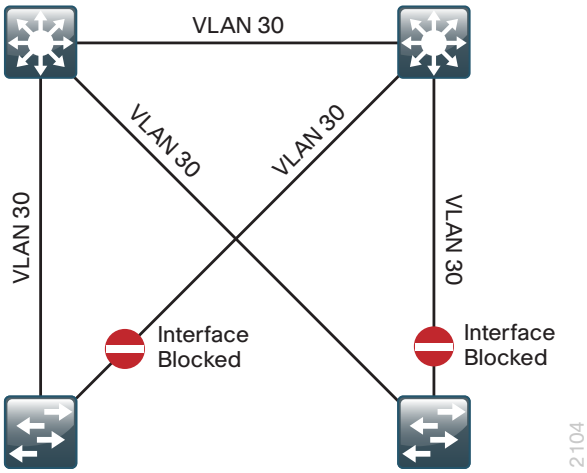


Figure 20 - Traditional looped design with VLANs spanning access switches



Routed Access Distribution Layer Design

In another approach to access and distribution layer design, you can use Layer 3 all the way to the access layer. The benefits of this design are that you eliminate spanning tree loops and reduce protocols because the IP gateway is now the access switch. Because there are no spanning tree blocking links, you can use both uplinks to the access layer and increase effective bandwidth available to the users.

The challenge with the routed access layer design is that the Layer 2 domains are confined to a single access closet, which limits flexibility for applications that require Layer 2 connectivity that extends across multiple access closets.

Simplified Distribution Layer Design

The distribution layer design in the Cisco SBA LAN design uses multiple physical switches that act as a single logical switch or a single, highly-redundant physical switch. One advantage of this design is that spanning tree dependence is minimized, and all uplinks from the access layer to the distribution are active and passing traffic. Even in the distributed VLAN design, spanning tree blocked links due to looped topologies are eliminated. You reduce dependence on spanning tree by using EtherChannel to the access layer with dual-homed uplinks. This is a key characteristic of this design and you can load balance up to eight links if needed for additional bandwidth.

Figure 21 - Simplified design with a VLAN per access switch

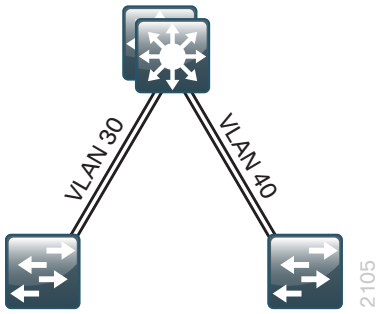
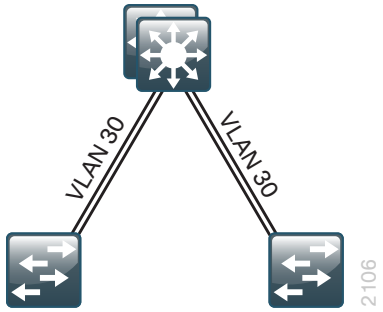


Figure 22 - Simplified design with VLANs spanning access switches



EtherChannel is a logical interface that can use a control plane protocol to manage the physical members of the bundle. It is better to run a channel protocol instead of using forced-on mode because a channel protocol performs consistency checks for interfaces programmed to be in the channel and provides protection to the system from inconsistent configurations. Cisco Catalyst switches provide both Port Aggregation Protocol (PAgP), which is a widely deployed Cisco designed protocol, and Link Aggregation Protocol (LACP) based on IEEE 802.3ad. This design uses LACP for EtherChannel because it is the only protocol supported in a Catalyst 3750 cross-stack configuration and can be used in all configurations in this design.

There are several other advantages to the simplified distribution layer design. You no longer need IP gateway redundancy protocols like HSRP, VRRP, and GLBP because the default IP gateway is now on a single logical interface and resiliency is provided by the distribution layer switch or switches. Also, the network will converge faster now that it is not depending on spanning tree to unblock links when a failure occurs because EtherChannel provides fast subsecond failover between links in an uplink bundle.

The topology of the network from the distribution layer to the access layer is logically a hub-and-spoke topology, which reduces complexity of design and troubleshooting. The hub-and-spoke topology design provides a more efficient operation for IP Multicast in the distribution layer because there is now a single logical designated router to forward IP Multicast packets to a given VLAN in the access layer.

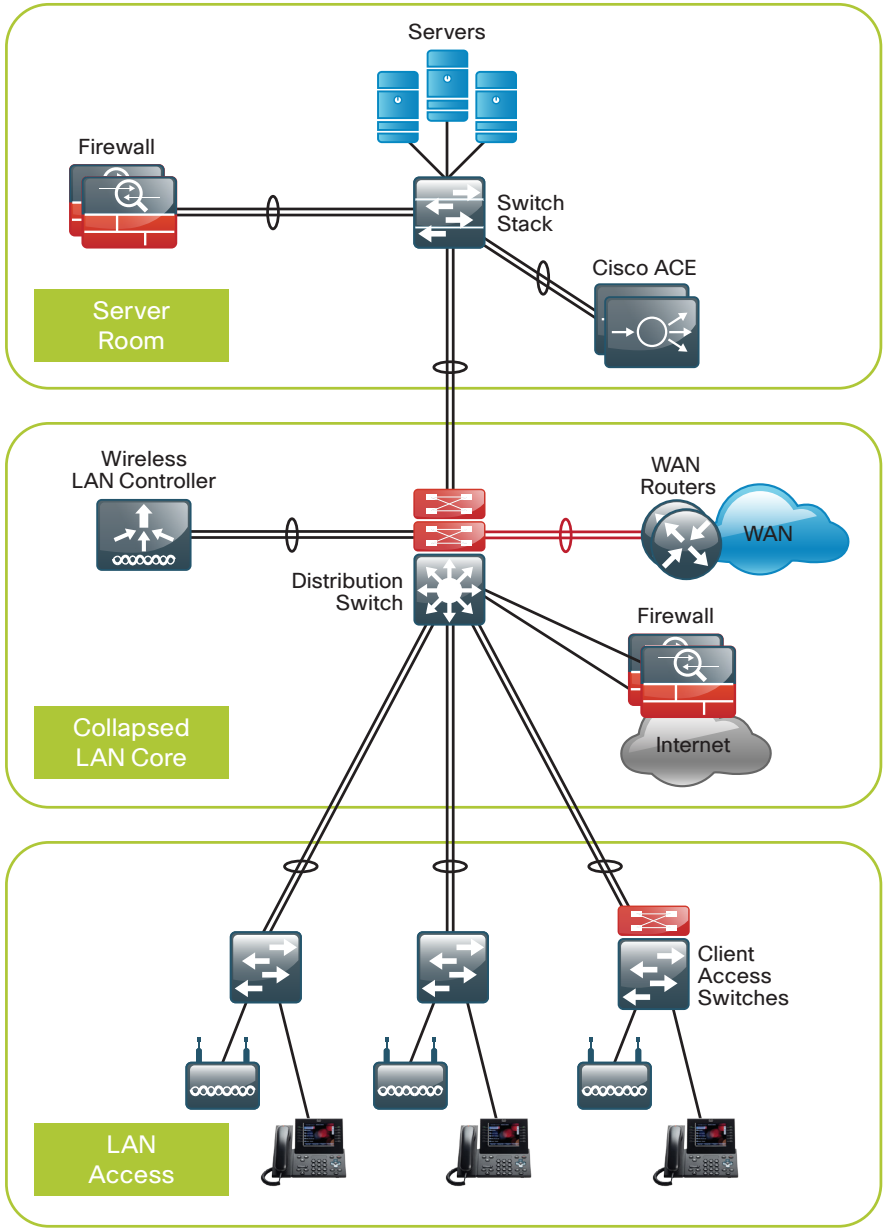
Finally, by using the single logical distribution layer design, there are fewer boxes to manage, which reduces the amount of time spent on ongoing provisioning and maintenance.

Distribution Layer Roles

Much emphasis has been placed on the distribution layer as the access layer aggregation point because this is the most common role. The distribution layer serves other roles in the SBA LAN deployments.

In many smaller locations, the WAN head end and Internet Edge terminate at the headquarters location, along with a server farm or small data center and the LAN access for user connectivity. In these situations a single distribution layer or "collapsed Core" design may be appropriate to allow the network to stay within budget limits while serving a smaller LAN access environment. Although the port density and configuration complexity may not be an issue, operational complexity of supporting many functions on one device must be monitored as the organization grows.

Figure 23 - Two tier Collapsed LAN Core design

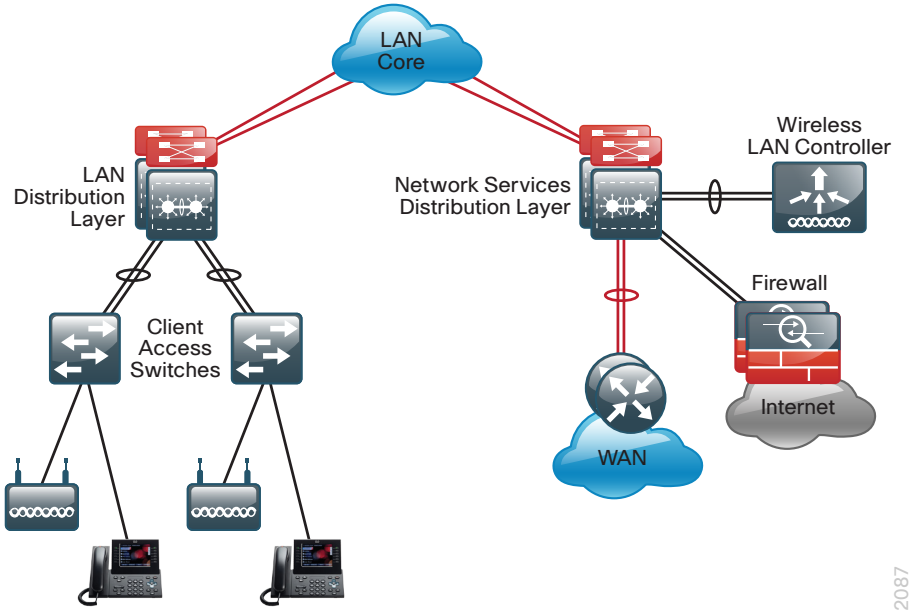


In larger LAN locations where the access layer density along with the number of network-service devices and WAN routers exceeds platform density or operational complexity additional distribution layer modules can break up the design.

The addition of a separate "services" distribution layer provides:

- Modular growth for high densities of WAN headend routers and WAN services like WAAS appliance.
- Wireless LAN controller termination in a central location for larger campus populations.
- Fault domains separate from the LAN access for a more resilient overall network.
- IP address summarization from WAN or Internet Edge toward the core of the network.

Figure 24 - Network services distribution layer



Whether the distribution layer role in your network design is serving as purely LAN access aggregation, a collapsed Core, or network-services aggregation, the Cisco SBA distribution layer configuration provides the processes and procedures to prepare this layer of the LAN for your application.

Distribution Layer Platforms

You can use multiple platforms to deploy the simplified distribution layer design. Physically, the distribution layer can be a Cisco Catalyst 6500 Virtual Switching System (VSS) 4T, a highly available Cisco Catalyst 4507R+E switch, or a stack of Cisco Catalyst 3750-X switches. It is important to note that although each switch has different physical characteristics, each appears to the rest of the network as a single node and provides a fully resilient design.

Cisco Catalyst 6500 VSS 4T

- Cisco Catalyst 6500 VSS 4T uses Cisco Catalyst 6500 Supervisor Engine 2T, which increases the per slot switching capacity to 80 Gbps, delivers better scalability, and provides enhanced hardware-enabled features. The increased performance enables the system to provide 40-gigabit Ethernet uplinks for core layer connectivity.
- Cisco 6500 Supervisor 2T supports the line cards enabled for Policy Feature Card 4 (PFC4), including the WS-X6816-10G WS-X6908-10G and WS-X6904-40G-2T, which provide enhanced capabilities. The WS-X6908-10G provides eight 10Gb Ethernet ports with 1:1 oversubscription. The WS-X6904-40G-2T provides up to four 40Gb Ethernet ports or up to sixteen 10Gb Ethernet ports using modular adapters for 10Gb or 40Gb Ethernet applications and can be programmed to run in 2:1 or 1:1 oversubscription mode. The existing WS-X6724 and WS-X6748 based gigabit Ethernet fiber optic cards are supported in CFC mode or the newer WS-X6824 and WS-X6848 PFC4-based cards.
- The Supervisor 2T-based switch enhances support for Cisco TrustSec (CTS) by providing MacSec encryption and role-based access control (RBAC) lists, and delivers improved control plane policing to address denial-of-service attacks.
- Effectively allows the clustering of two physical chassis into a logical entity that can be operated as a single device. This configuration provides redundant chassis, supervisors, line cards, and power supplies and can provide the highest density of the product options for Gigabit Ethernet, 10 Gigabit Ethernet, and now 40 Gigabit Ethernet EtherChannel uplinks using Cisco Multi-chassis EtherChannel.
- Provides stateful switchover between supervisors in each chassis for Nonstop Forwarding in the event of a failure and provides Enhanced Fast Software Upgrades for minimizing downtime for upgrades.

- The premier distribution layer platform in this design. It allows for high density aggregation of Gigabit Ethernet and 10 Gigabit Ethernet connected wiring closets, while providing an advanced feature set and the highest resiliency of the available platforms.

Cisco Catalyst 4507R+E Switch

- Cisco Catalyst 4507R+E switch has redundant supervisors, line cards, and power supplies. In this design, Cisco uses a single 4507R+E chassis configured with resilient components as a distribution layer platform. The Supervisor 7E has the ability to provide a medium density of Gigabit Ethernet and even 10 Gigabit Ethernet EtherChannel links to the access layer.
- Provides stateful switchover which is critical to Nonstop Forwarding in the event of a failure and allows in-service software upgrades for the system.
- Use it at locations where there is only a small number of Gigabit Ethernet or 10 Gigabit Ethernet connected wiring closets that need to be aggregated.

Cisco Catalyst 3750-X Stack

- Configured as a single unit, but has independent load-sharing power supplies and processor for each switch in the StackWise Plus stack. The Cisco SBA LAN architecture uses a pair of stacked 3750X-12S-E switches that provide Layer 2 and Layer 3 switching. The switches use Small Form-Factor Pluggable (SFP) transceivers for a port-by-port option of copper or fiber optic Gigabit Ethernet EtherChannel uplinks to access closets.
- Cisco StackWise Plus enables up to nine Cisco Catalyst 3750-X switches to be stacked together using a 64-Gbps stack interconnect with near subsecond failure recovery.
- Cisco StackPower shares power across the Cisco Catalyst 3750-X switch stack. This allows the flexible arrangement of power supplies in the stack, and enables a zero-footprint redundant power supply deployment and intelligent load shedding.
- Cisco 3750-X Series have modular uplinks for connectivity to the core layer at Gigabit or 10 Gigabit Ethernet speeds, and support upgrading the IOS feature set and enhanced enterprise capabilities like TrustSec and Medianet, to ensure that the switch functionality grows as the organization grows.
- Use it at locations where there is only a small number of gigabit connected wiring closets that need to be aggregated.

Deployment Details

The single, logical, resilient, distribution-layer design simplifies the distribution switch configuration over traditional dual system designs.

Process

Configuring the Distribution Layer

1. Configure the platform
2. Configure LAN switch universal settings
3. Configure distribution global settings
4. Configure IP unicast routing
5. Configure IP Multicast routing
6. Configure IP Multicast RP
7. Connect to access layer
8. Connect to LAN core or WAN router

Procedure 1 Configure the platform

Some platforms require a one-time initial configuration prior to configuring the features and services of the switch. If you do not have a platform listed in the following steps, you can skip those steps.

Option 1. Configure Cisco Catalyst 6500 Virtual Switching System 4T

Cisco Catalyst 6500 Virtual Switching System 4T clusters two physical 6500 switches with a single Supervisor 2T in each switch together as a single logical switch. One of the supervisors acts as the active control plane for both chassis by controlling protocols such as EIGRP, Spanning Tree, CDP, and so forth, while both supervisors actively switch packets in each chassis.

The following configuration example shows you how to convert two standalone Cisco Catalyst 6500 switches to a Virtual Switching System (VSS). If you are migrating your switches from an existing in-service dual chassis role

to a VSS system, go to www.cisco.com and search on "Migrate Standalone Cisco Catalyst 6500 Switch to Cisco Catalyst 6500 Virtual Switching System" for information that describes how to do this migration. For an in-depth VSS configuration guide and configuration options, go to www.cisco.com and search for the *Campus 3.0 Virtual Switching System Design Guide*.

When you set up the Cisco Catalyst 6500 Virtual Switching System 4T, connect two 10 Gigabit Ethernet links between the chassis to provide the Virtual Switch Link (VSL). Use at least two links. However, there are restrictions on which 10 Gigabit Ethernet interfaces you can use for the VSL. This design uses the two 10 Gigabit Ethernet interfaces on each supervisor. You must cable the interfaces together before you can configure the VSS.

This design uses IOS 15.0(1)SY1 with the IP Services Feature Set for all configuration examples.

Step 1: Convert standalone 6500s to VSS.

Configure a hostname on each switch so you can keep track of your programming steps.

On the Catalyst 6500 standalone switch #1:

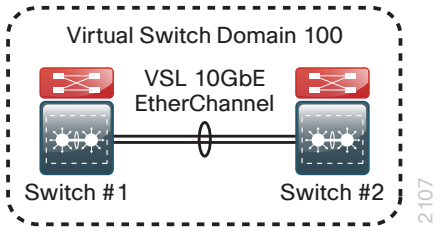
```
Router#config t
Router#(config)#hostname VSS-Sw1
```

On the Catalyst 6500 standalone switch #2:

```
Router#config t
Router#(config)#hostname VSS-Sw2
```

Each VSS switch pair must have a unique domain assigned that the pair shares. In this example, the domain number is 100. Each switch is also given a unique number in the domain, switch 1 or switch 2.

Figure 25 - VSS domain



On the standalone switch #1:

```
VSS-Sw1(config)#switch virtual domain 100
VSS-Sw1(config-vs-domain)# switch 1
```

On the standalone switch #2:

```
VSS-Sw2(config)#switch virtual domain 100
VSS-Sw2(config-vs-domain)# switch 2
```

Step 2: Configure the Virtual Switch Link (VSL).

The VSL is a critical component of the Virtual Switching System. Use unique port-channel numbers on each switch even though they connect to each other because both switches will soon become a single logical switch. This example uses port-channel number 101 on switch 1 and port-channel number 102 on switch 2. You must configure **channel-group mode on** for the VSL port channel. For the physical interfaces of the VSL EtherChannel, this example uses the 10 Gigabit Ethernet interfaces on the supervisor.

On standalone switch #1:

```
VSS-Sw1(config)#interface port-channel 101
VSS-Sw1(config-if)#switch virtual link 1
VSS-Sw1(config-if)#no shutdown
VSS-Sw1(config)#interface range tengigabit 5/4-5
VSS-Sw1(config-if)#channel-group 101 mode on
VSS-Sw1(config-if)#no shutdown
```

On standalone switch #2:

```
VSS-Sw2(config)#interface port-channel 102
VSS-Sw2(config-if)#switch virtual link 2
VSS-Sw2(config-if)#no shutdown
VSS-Sw2(config)#interface range tengigabit 5/4-5
VSS-Sw2(config-if)#channel-group 102 mode on
VSS-Sw2(config-if)#no shutdown
```

At this point you should be able to see that port-channel 101 and 102 are up, and both links are active on standalone switch #1 and standalone switch #2 respectively. The switches are not in VSS mode yet.

```
VSS-Sw1# show etherchannel 101 port
VSS-Sw2# show etherchannel 102 port
        Ports in the group:
        -------------------
Port: Te5/4
------------
Port state  = Up Mstr In-Bndl
Port: Te5/5
------------
Port state  = Up Mstr In-Bndl
```

Step 3: Enable virtual mode operation.

Now that a port-channel has been established between the switches, convert each switch to virtual mode operation. At the enable prompt (that is, not in configuration mode) on each switch, enter the following commands for each switch.

On standalone switch #1:

```
VSS-Sw1# switch convert mode virtual
```

On standalone switch #2:

```
VSS-Sw2# switch convert mode virtual
```

When asked if you want to proceed, answer yes.

Each switch now renumbers its interfaces from interface y/z (where y is the slot number and z is the interface number) to interface x/y/z (where x is the switch number, y is the module number in that switch, and z is the interface on that module). This numbering scheme allows the two chassis to be addressed and configured as a single system from a single supervisor, which is the supervisor with the active control plane.

Once the configuration changes, it prompts you to save the configuration to bootflash. Press Return <CR> or Enter to accept the destination filename and location on each switch.

Both switches reload and become a VSS and one of the switches is resolved as the ACTIVE supervisor for the VSS cluster. All configuration commands now must be entered on the single active switch console; the standby switch console displays the Standby prompt.

Use the following command to verify that both switches can see each other, that they are in SSO mode, and that the second supervisor is in standby hot status.

```
VSS-Sw1#show switch virtual redundancy
```

To recognize that the two Catalyst 6500 switches are now operating as a single VSS system, rename the switch hostname.

```
VSS-Sw1(config)#hostname 6500VSS
6500VSS(config)#
```

Step 4: Configure dual-active detection mechanism.

A critical aspect of the Cisco Catalyst 6500 VSS 4T is the control plane and data plane operating models. From a control plane standpoint the VSS uses an active-standby operating model. This means that one supervisor becomes the active control plane for the entire VSS while the other supervisor becomes the standby. The control plane handles protocol operations like EIGRP peering, route table updates, and spanning tree BPDUs. On the dataplane side, both supervisors are actively forwarding traffic in an active-active operating model. The VSL allows the supervisors to communicate and stay in synchronization. The VSS uses the Stateful Switchover (SSO) redundancy facility to keep the controlplane synchronized between the two supervisors.

In the event that the VSL is severed (that is, all links), or for any other reason communication is lost over the VSL, both supervisors would assume the active control plane role is creating a dual-active condition which can result in network instability.

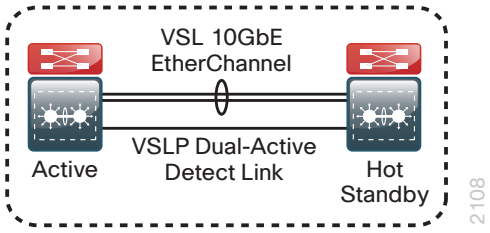
To prevent the dual-active scenario from causing an outage in the network, VSS supports multiple different dual-active detection mechanisms. The dual-active detection mechanisms are used to trigger a VSS recovery mode. In the VSS recovery mode only one supervisor is allowed to remain active, the other supervisor which is in recovery mode, shuts down all of its' interfaces except the VSL interfaces, thereby preventing instability in the network. Once the VSL is repaired, and communication over the VSL is reestablished, then the VSS would reboot the supervisor that was in the recovery mode and return the VSS to a normal operating state.

You can use the following methods to detect this dual-active condition:

- Ethernet Fast-Hello (VSLP) packet mode link
- Enhanced Port Aggregation Protocol (PAgP) hellos between an adjacent switch to the VSS

This design uses the Fast-Hello (VSLP) packet mode link for dual-active detection. To configure the link, use a Gigabit Ethernet interface on each VSS switch chassis and cable them together (similar to a VSL link) in a back-to-back fashion. This link does not require high bandwidth because it is only a detection link with control plane hellos on it.

Figure 26 - VSLP




```
6500-VSS(config)# switch virtual domain 100
6500-VSS(config-vs-domain)#dual-active detection fast-hello
6500-VSS(config)#interface range gigabit1/1/8, gigabit2/1/8
6500-VSS(config-if-range)#dual-active fast-hello
6500-VSS(config-if-range)#no shutdown
*Feb 25 14:28:39.294: %VSDA-SW2_SPSTBY-5-LINK_UP: Interface
Gi2/1/8 is now dual-active detection capable
*Feb 25 14:28:39.323: %VSDA-SW1_SP-5-LINK_UP: Interface
Gi1/1/8 is now dual-active detection capable
```

Step 5: Configure the system virtual MAC address.

By default, the VSS system uses the default chassis-based MAC-address pool assigned to the switch that is resolved to be the active switch when the switches initialize. Set a virtual MAC address for the VSS system so that either active supervisor will use the same MAC address pool, regardless of which supervisor is active, even across a system reboot.

```
6500-VSS(config)# switch virtual domain 100
6500-VSS(config-vs-domain)# mac-address use-virtual
Configured Router mac address is different from operational
value. Change will take effect after config is saved and
the entire Virtual Switching System (Active and Standby) is
reloaded.
```

Step 6: Save and reload the switch.

Save the running configuration and then reload the entire system (both chassis).

```
copy running-config startup-config
reload
```

When the switches initialize after this final reload, the VSS programming is complete.

Step 7: Configure QoS.

On the Catalyst 6500 Supervisor 2T based switches, QoS is enabled by default and policies for interface queuing are defined by attached service policies. The QoS policies are now defined using Cisco Common Classification Policy Language (C3PL) which is similar to Modular QoS CLI to reduce operational complexity.

All interface connections in the distribution and core are set to trust differentiated services code point (DSCP). Even though this design is configured to trust DSCP markings, it is a best practice to ensure proper mapping of CoS to DSCP for VoIP. This mapping is accomplished by overriding the default mapping of CoS 5 "voice bearer traffic" to DSCP 40, with DSCP 46, which is the EF per-hop behavior for voice.

Two separate egress QoS policies are configured for the Catalyst 6500 to accommodate the 10-Gigabit Ethernet cards which use a 1P7Q4T queuing architecture, and the Gigabit Ethernet cards which use a 1P3Q8T queuing architecture.

```
! Enable port-based QoS
auto qos default
! Class maps for 1P7Q4T 10Gb ports service policy
class-map type lan-queuing match-any PRIORITY-QUEUE
  match dscp ef
  match dscp cs5
  match dscp cs4
  match cos 5
class-map type lan-queuing match-any CONTROL-MGMT-QUEUE
  match dscp cs7
  match dscp cs6
  match dscp cs3
  match dscp cs2
  match cos 3 6 7
```

```
class-map type lan-queuing match-any MULTIMEDIA-CONFERENCING-
QUEUE
  match dscp af41 af42 af43
  match cos 4
class-map type lan-queuing match-any MULTIMEDIA-STREAMING-
QUEUE
  match dscp af31 af32 af33
class-map type lan-queuing match-any TRANSACTIONAL-DATA-QUEUE
  match dscp af21 af22 af23
  match cos 2
class-map type lan-queuing match-any BULK-DATA-QUEUE
  match dscp af11 af12 af13
class-map type lan-queuing match-any SCAVENGER-QUEUE
  match dscp cs1
  match cos 1
!
policy-map type lan-queuing 1P7Q4T
 class PRIORITY-QUEUE
  priority
 class CONTROL-MGMT-QUEUE
  bandwidth remaining percent 14
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 16 percent 60 70
  random-detect dscp-based
  random-detect dscp 24 percent 70 80
  random-detect dscp-based
  random-detect dscp 48 percent 80 90
  random-detect dscp-based
  random-detect dscp 56 percent 90 100
 class MULTIMEDIA-CONFERENCING-QUEUE
  bandwidth remaining percent 14
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 38 percent 70 80
  random-detect dscp-based
  random-detect dscp 36 percent 80 90
  random-detect dscp-based
  random-detect dscp 34 percent 90 100
 class MULTIMEDIA-STREAMING-QUEUE
  bandwidth remaining percent 14
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 30 percent 70 80
  random-detect dscp-based
  random-detect dscp 28 percent 80 90
  random-detect dscp-based
  random-detect dscp 26 percent 90 100
 class TRANSACTIONAL-DATA-QUEUE
  bandwidth remaining percent 14
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 22 percent 70 80
  random-detect dscp-based
  random-detect dscp 20 percent 80 90
  random-detect dscp-based
  random-detect dscp 18 percent 90 100
 class BULK-DATA-QUEUE
  bandwidth remaining percent 6
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 14 percent 70 80
  random-detect dscp-based
  random-detect dscp 12 percent 80 90
  random-detect dscp-based
  random-detect dscp 10 percent 90 100
 class SCAVENGER-QUEUE
  bandwidth remaining percent 2
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 8 percent 80 100
class class-default
  queue-buffers ratio 25
  random-detect dscp-based aggregate
```

```
  random-detect dscp values 0 1 2 3 4 5 6 7 percent 80 100
  random-detect dscp values 9 11 13 15 17 19 21 23 percent 80
100
  random-detect dscp values 25 27 29 31 33 35 37 39 percent 80
100
  random-detect dscp values 41 42 43 44 45 47 49 50 percent 80
100
  random-detect dscp values 51 52 53 54 55 57 58 59 percent 80
100
  random-detect dscp values 60 61 62 63 percent 80 100
!
table-map cos-discard-class-map
 map from 0 to 0
 map from 1 to 8
 map from 2 to 16
 map from 3 to 24
 map from 4 to 32
 map from 5 to 46
 map from 6 to 48
 map from 7 to 56
!
! Class maps for 1P3Q8T 1Gb ports service policy
class-map type lan-queuing match-any PRIORITY-QUEUE-GIG
 match cos 5 4
class-map type lan-queuing match-any CONTROL-AND-STREAM-MEDIA
 match cos 7 6 3 2
class-map type lan-queuing match-any BULK-DATA-SCAVENGER
 match cos 1
!
policy-map type lan-queuing 1P3Q8T
 class PRIORITY-QUEUE-GIG
  priority
  queue-buffers ratio 15
 class CONTROL-AND-STREAM-MEDIA
  bandwidth remaining percent 55
  queue-buffers ratio 40
  random-detect cos-based
  random-detect cos 2 percent 60 70
  random-detect cos-based
  random-detect cos 3 percent 70 80
  random-detect cos-based
  random-detect cos 6 percent 80 90
  random-detect cos-based
  random-detect cos 7 percent 90 100
 class BULK-DATA-SCAVENGER
  bandwidth remaining percent 10
  queue-buffers ratio 20
  random-detect cos-based
  random-detect cos 1 percent 80 100
 class class-default
  queue-buffers ratio 25
  random-detect cos-based
  random-detect cos 0 percent 80 100
!
!
macro name EgressQoSTenGig
  service-policy type lan-queuing output 1P7Q4T
@
!
macro name EgressQoS
  service-policy type lan-queuing output 1P3Q8T
@
```

Option 2. Configure the Catalyst 4507R+E platform

Step 1: To make consistent deployment of QoS easier, each platform defines two macros that you use in later procedures to apply the platform-specific QoS configuration.

```
class-map match-all VOIP_DATA_CLASS
 match cos 5
class-map match-all VOIP_SIGNAL_CLASS
 match cos 3
!
policy-map CISCOPHONE-POLICY
 class VOIP_DATA_CLASS
```

```
  set dscp ef
  police 128k bc 8000
   conform-action transmit
   exceed-action drop
 class VOIP_SIGNAL_CLASS
  set dscp cs3
  police 32k bc 8000
   conform-action transmit
   exceed-action drop
 class class-default
  set dscp default
  police 10m bc 8000
   conform-action transmit
   exceed-action set-dscp-transmit cs1
!
class-map match-any PRIORITY-QUEUE
  match  dscp ef
  match  dscp cs5
  match  dscp cs4
class-map match-any CONTROL-MGMT-QUEUE
  match  dscp cs7
  match  dscp cs6
  match  dscp cs3
  match  dscp cs2
class-map match-any MULTIMEDIA-CONFERENCING-QUEUE
  match  dscp af41  af42  af43
class-map match-any MULTIMEDIA-STREAMING-QUEUE
  match  dscp af31  af32  af33
class-map match-any TRANSACTIONAL-DATA-QUEUE
  match  dscp af21  af22  af23
class-map match-any BULK-DATA-QUEUE
  match  dscp af11  af12  af13
class-map match-any SCAVENGER-QUEUE
  match  dscp cs1
!
policy-map 1P7Q1T
 class PRIORITY-QUEUE
    priority
 class CONTROL-MGMT-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-CONFERENCING-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-STREAMING-QUEUE
    bandwidth remaining percent 10
 class TRANSACTIONAL-DATA-QUEUE
    bandwidth remaining percent 10
    dbl
 class BULK-DATA-QUEUE
    bandwidth remaining percent 4
    dbl
 class SCAVENGER-QUEUE
    bandwidth remaining percent 1
 class class-default
    bandwidth remaining percent 25
    dbl
!
policy-map 1P7Q1T_Access
 class PRIORITY-QUEUE
    priority
    police cir percent 30
 class CONTROL-MGMT-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-CONFERENCING-QUEUE
    bandwidth remaining percent 10
 class MULTIMEDIA-STREAMING-QUEUE
    bandwidth remaining percent 10
 class TRANSACTIONAL-DATA-QUEUE
    bandwidth remaining percent 10
    dbl
 class BULK-DATA-QUEUE
    bandwidth remaining percent 4
    dbl
 class SCAVENGER-QUEUE
    bandwidth remaining percent 1
```

```
 class class-default
    bandwidth remaining percent 25
    dbl
!
macro name AccessEdgeQoS
 qos trust device cisco-phone
 service-policy input CISCOPHONE-POLICY
 service-policy output 1P7Q1T_Access
@
!
macro name EgressQoS
 service-policy output 1P7Q1T
@
```

Step 2: When you configure a Catalyst 4507R+E with two Supervisor Engine 7-Es, configure the switch to use Stateful Switchover (SSO) when moving the primary supervisor functionality between modules. To enable a fast transparent data plane failover, SSO synchronizes active process information as well as configuration information between supervisor modules.

```
redundancy
  mode sso
```

To enable SSO mode you must have a license level of ipbase or entservices operating on the switch supervisors. You can check the current license level of operation with a **show version** command.

Option 3. Configure the Catalyst 3750-X platform

Step 1: When there are multiple switches configured in a stack, one of the switches controls the operation of the stack. This switch is called the stack master.

When three or more switches are configured as a stack, configure the stack master switch functionality on a switch that does not have uplinks configured.

```
switch [switch number] priority 15
```

If you configure stack master switch priority on Cisco 3750-X switch stack, a single reboot is required to force the stack master to operate on the switch that you configured with the highest priority. Reboot the switch stack after all of your configuration is complete for this entire "Configuring the Distribution Layer" process.

Step 2: By default, the newly active stack master switch assigns a new stack MAC address when the stack master switch fails. This new MAC address assignment can cause the network to reconverge because LACP and many other protocols rely on the stack MAC address and must restart. As such, you should use the **stack-mac persistent timer 0** command to ensure that the original master MAC address remains the stack MAC address after a failure.

```
stack-mac persistent timer 0
```

Step 3: To make consistent deployment of QoS easier, each platform defines two macros that will be used in later procedures to apply the platform specific QoS configuration. Since AutoQoS might not be configured on this device, manually configure the global QoS settings by running the following commands:

```
mls qos map policed-dscp  0 10 18 to 8
mls qos map cos-dscp 0 8 16 24 32 46 48 56
mls qos srr-queue input bandwidth 70 30
mls qos srr-queue input threshold 1 80 90
mls qos srr-queue input priority-queue 2 bandwidth 30
mls qos srr-queue input cos-map queue 1 threshold 2 3
mls qos srr-queue input cos-map queue 1 threshold 3 6 7
mls qos srr-queue input cos-map queue 2 threshold 1 4
mls qos srr-queue input dscp-map queue 1 threshold 2 24
mls qos srr-queue input dscp-map queue 1 threshold 3 48 49 50
51 52 53 54 55
mls qos srr-queue input dscp-map queue 1 threshold 3 56 57 58
59 60 61 62 63
mls qos srr-queue input dscp-map queue 2 threshold 3 32 33 40
41 42 43 44 45
mls qos srr-queue input dscp-map queue 2 threshold 3 46 47
mls qos srr-queue output cos-map queue 1 threshold 3 4 5
mls qos srr-queue output cos-map queue 2 threshold 1 2
mls qos srr-queue output cos-map queue 2 threshold 2 3
mls qos srr-queue output cos-map queue 2 threshold 3 6 7
mls qos srr-queue output cos-map queue 3 threshold 3 0
mls qos srr-queue output cos-map queue 4 threshold 3 1
mls qos srr-queue output dscp-map queue 1 threshold 3 32 33 40
41 42 43 44 45
mls qos srr-queue output dscp-map queue 1 threshold 3 46 47
```

```
mls qos srr-queue output dscp-map queue 2 threshold 1 16 17 18
19 20 21 22 23
mls qos srr-queue output dscp-map queue 2 threshold 1 26 27 28
29 30 31 34 35
mls qos srr-queue output dscp-map queue 2 threshold 1 36 37 38
39
mls qos srr-queue output dscp-map queue 2 threshold 2 24
mls qos srr-queue output dscp-map queue 2 threshold 3 48 49 50
51 52 53 54 55
mls qos srr-queue output dscp-map queue 2 threshold 3 56 57 58
59 60 61 62 63
mls qos srr-queue output dscp-map queue 3 threshold 3 0 1 2 3
4 5 6 7
mls qos srr-queue output dscp-map queue 4 threshold 1 8 9 11
13 15
mls qos srr-queue output dscp-map queue 4 threshold 2 10 12 14
mls qos queue-set output 1 threshold 1 100 100 50 200
mls qos queue-set output 1 threshold 2 125 125 100 400
mls qos queue-set output 1 threshold 3 100 100 100 3200
mls qos queue-set output 1 threshold 4 60 150 50 200
mls qos queue-set output 1 buffers 15 25 40 20
mls qos
!
macro name EgressQoS
 mls qos trust dscp
 queue-set 1
 srr-queue bandwidth share 1 30 35 5
 priority-queue out
@
!
```

Procedure 2 Configure LAN switch universal settings

In this design, there are features and services that are common across all LAN switches, regardless of the type of platform or role in the network. These are system settings that simplify and secure the management of the solution.

This procedure provides examples for some of those settings. The actual settings and values will depend on your current network configuration.

Table 3 - Common network services used in the deployment examples

Service	Address
Domain Name:	cisco.local
Active Directory, DNS, DHCP Server:	10.4.48.10
Authentication Control System:	10.4.48.15
Network Time Protocol Server:	10.4.48.17
EIGRP AS	100
Multicast Range	239.1.0.0/16

Step 1: Configure the device hostname to make it easy to identify the device.

```
hostname [hostname]
```

Step 2: Configure VTP transparent mode. This deployment uses VTP transparent mode because the benefits of dynamic propagation of VLAN information across the network are not worth the potential for unexpected behavior that is due to operational error.

VLAN Trunking Protocol (VTP) allows network managers to configure a VLAN in one location of the network and have that configuration dynamically propagate out to other network devices. However, in most cases, VLANs are defined once during switch setup with few, if any, additional modifications.

```
vtp mode transparent
```

Step 3: Enable Rapid Per-VLAN Spanning-Tree (PVST+). Rapid PVST+ provides an instance of RSTP (802.1w) per VLAN. Rapid PVST+ greatly improves the detection of indirect failures or linkup restoration events over classic spanning tree (802.1D).

Although this architecture is built without any Layer 2 loops, you must still enable spanning tree. By enabling spanning tree, you ensure that if any physical or logical loops are accidentally configured, no actual layer 2 loops occur.

```
spanning-tree mode rapid-pvst
```

Step 4: Set the distribution layer switch to be the spanning-tree root for all VLANs on access layer switches or appliances that you are connecting to the distribution switch.

```
spanning-tree vlan 1-4094 root primary
```

Step 5: Enable Unidirectional Link Detection (UDLD).

UDLD is a Layer 2 protocol that enables devices connected through fiber-optic or twisted-pair Ethernet cables to monitor the physical configuration of the cables and detect when a unidirectional link exists. When UDLD detects a unidirectional link, it disables the affected interface and alerts you. Unidirectional links can cause a variety of problems, including spanning-tree loops, black holes, and non-deterministic forwarding. In addition, UDLD enables faster link failure detection and quick reconvergence of interface trunks, especially with fiber, which can be susceptible to unidirectional failures.

```
udld enable
```

Step 6: Set EtherChannels to use the traffic source and destination IP address when calculating which link to send the traffic across. This normalizes the method in which traffic is load-shared across the member links of the EtherChannel. EtherChannels are used extensively in this design because of their resiliency capabilities.

```
port-channel load-balance src-dst-ip
```

Step 7: Configure DNS for host lookup.

At the command line of a Cisco IOS device, it is helpful to be able to type a domain name instead of the IP address for a destination.

```
ip name-server 10.4.48.10
```

Step 8: Configure device management protocols.

Secure HTTP (HTTPS) and Secure Shell (SSH) are more secure replacements for the HTTP and Telnet protocols. They use Secure Sockets Layer (SSL) and Transport Layer Security (TLS) to provide device authentication and data encryption.

The SSH and HTTPS protocols enable secure management of the LAN device. Both protocols are encrypted for privacy, and the nonsecure protocols, Telnet and HTTP, are turned off.

Specify the transport preferred none on vty lines to prevent errant connection attempts from the CLI prompt. Without this command, if the ip name server is unreachable, long timeout delays may occur for mistyped commands.

```
ip domain-name cisco.local
ip ssh version 2
no ip http server
ip http secure-server
!
line vty 0 15
  transport input ssh
  transport preferred none
```

Step 9: Enable Simple Network Management Protocol (SNMP) in order to allow the network infrastructure devices to be managed by a Network Management System (NMS), and then configure SNMPv2c both for a read-only and a read-write community string.

```
snmp-server community cisco RO
snmp-server community cisco123 RW
```

Step 10: If your network operational support is centralized, you can increase network security by using an access list to limit the networks that can access your device. In this example, only devices on the 10.4.48.0/24 network will be able to access the device via SSH or SNMP.

```
access-list 55 permit 10.4.48.0 0.0.0.255
line vty 0 15
  access-class 55 in
!
snmp-server community cisco RO 55
snmp-server community cisco123 RW 55
```

Caution

If you configure an access-list on the vty interface you may lose the ability to use ssh to login from one router to the next for hop-by-hop troubleshooting.

Step 11: Configure local login and password

The local login account and password provides basic device access authentication to view platform operation. The enable password secures access to the device configuration mode. By enabling password encryption, you prevent the use of plain text passwords when viewing configuration files.

```
username admin password c1sco123
enable secret c1sco123
service password-encryption
aaa new-model
```

By default, https access to the switch will use the enable password for authentication.

Step 12: If you want to reduce operational tasks per device, configure centralized user authentication by using the TACACS+ protocol to authenticate management logins on the infrastructure devices to the Authentication, Authorization and Accounting (AAA) server.

As networks scale in the number of devices to maintain, there is an operational burden to maintain local user accounts on every device. A centralized Authentication, Authorization and Accounting (AAA) service reduces operational tasks per device and provides an audit log of user access for security compliance and root cause analysis. When AAA is enabled for access control, all management access to the network infrastructure devices (SSH and HTTPS) is controlled by AAA.

TACACS+ is the primary protocol used to authenticate management logins on the infrastructure devices to the AAA server. A local AAA user database is also defined on each network infrastructure device to provide a fallback authentication source in case the centralized TACACS+ server is unavailable.

```
tacacs server TACACS-SERVER-1
address ipv4 10.4.48.15
key SecretKey
!
aaa group server tacacs+ TACACS-SERVERS
  server name TACACS-SERVER-1
!
aaa authentication login default group TACACS-SERVERS local
aaa authorization exec default group TACACS-SERVERS local
aaa authorization console
ip http authentication aaa
```

For Catalyst 6500 use the following set of commands to enable the same AAA functionality.

```
aaa authentication login default group tacacs+ local
aaa authorization exec default group tacacs+ local
aaa authorization console
ip http authentication aaa
tacacs-server host 10.4.48.15 key SecretKey
```

Reader Tip

The AAA server used in this architecture is Cisco Authentication Control System. Configuration of ACS is discussed in the *Device Management Using ACS Deployment Guide*.

Step 13: Configure a synchronized clock by programming network devices to synchronize to a local NTP server in the network. The local NTP server typically references a more accurate clock feed from an outside source. Configure console messages, logs, and debug output to provide time stamps on output, which allows cross-referencing of events in a network.

```
ntp server 10.4.48.17
ntp update-calendar
!
clock timezone PST -8
clock summer-time PDT recurring
!
service timestamps debug datetime msec localtime
service timestamps log datetime msec localtime
```

The **ntp update-calendar** command configures the switch to update the hardware clock from the ntp time source periodically. Since not all switches have a hardware clock, this command is not supported by all devices.

Procedure 3 Configure distribution global settings

Step 1: Configure BPDU Guard globally to protect portfast enabled interfaces.

In some scenarios a service appliance that requires spanning-tree portfast may be connected to the distribution layer. When an interface is set for portfast, BPDU guard protects against an accidental connection of another switch into a portfast enabled interface, which could cause a catastrophic undetected spanning-tree loop.

If a portfast configured interface receives a BPDU, an invalid configuration exists, such as the connection of an unauthorized device. The BPDU guard feature prevents loops by moving a nontrunking interface into an errdisable state when a BPDU is received on an interface when portfast is enabled.

Disable the interface if another switch is plugged into the portfast enabled interface.

```
spanning-tree portfast bpduguard default
```

On the Catalyst 6500 the global BPDU Guard command is slightly different.

```
spanning-tree portfast edge bpduguard default
```

Step 2: Configure an in-band management interface.

The loopback interface is a logical interface that is always reachable as long as the device is powered on and any IP interface is reachable to the network. Because of this capability, the loopback address is the best way to manage the switch in-band. Layer 3 process and features are also bound to the loopback interface to ensure process resiliency.

The loopback address is commonly a host address with a 32-bit address mask. Allocate the loopback address from the IP address block that the distribution switch summarizes to the rest of the network.

```
interface Loopback0
  ip address [ip address] 255.255.255.255
  ip pim sparse-mode
```

The need for the **ip pim sparse-mode** command will be explained further in Step 3 of Procedure 5 "Configure IP Multicast routing".

Step 3: Configure the SNMP and SSH processes to use the loopback interface address for optimal resiliency:

```
snmp-server trap-source Loopback 0
ip ssh source-interface Loopback 0
ip pim register-source Loopback 0
ip tacacs source-interface Loopback 0
ntp source Loopback 0
```

Procedure 4 Configure IP unicast routing

Enhanced IGRP (EIGRP) is the IP unicast routing protocol used in this design because it is easy to configure, does not require a large amount of planning, has flexible summarization and filtering, and can scale to large networks.

The single logical distribution layer design uses stateful switchover and non-stop forwarding to provide subsecond failover in the event of a supervisor data or control plane failure. This ability reduces packet loss in switchover to redundant logic and keeps packets flowing when the data plane is still intact to adjacent nodes. In the stack-based distribution layer approach, a single logical control point still exists and the master control plane in a stack can fail over to another member in the stack providing near-second or subsecond resiliency.

When the supervisor or master switch of a distribution platform switches over from the active to the hot-standby supervisor, it will continue switching IP data traffic flows in hardware. However, the supervisor requires time to reestablish control plane two-way peering with EIGRP routing neighbors and avoid the peer router from tearing down adjacencies due to missed hellos that would cause a reroute and disruption of traffic. To allow this time for the supervisor to recover, there is a Nonstop Forwarding (NSF) setting for the routing protocol to wait for the dual supervisor peer switch to recover. The neighboring router is said to be NSF-aware if it has a newer release of IOS that recognizes an NSF peer. All of the platforms used in this design are NSF-aware for the routing protocols in use.

The distribution layer switch must be configured to enable NSF for the protocol in use so that it can signal a peer when it switches over to a hot-standby supervisor for the peering neighbor to allow it time to reestablish the EIGRP protocol to that node. No tuning of the default NSF timers is needed in this network. Nothing has to be configured for an NSF-aware peer router.

Step 1: Enable EIGRP for the IP address space that the network will be using. If needed for your network, you can enter multiple network statements. Disable auto summarization of the IP networks and enable all routed links to be passive by default. The Loopback 0 IP address is used for the EIGRP router ID to ensure maximum resiliency.

```
ip routing
!
router eigrp 100
  network 10.4.0.0 0.1.255.255
  no auto-summary
  passive-interface default
  eigrp router-id [ip address of loopback 0]
  nsf
```

Cisco Catalyst 6500 does not require the **ip routing** command because it is enabled by default on that platform.

Tech Tip

Verify that **eigrp stub connected summary** is not configured in your EIGRP routing instance. This command may have been automatically configured if you have changed platform licensing from an ip base capable image.

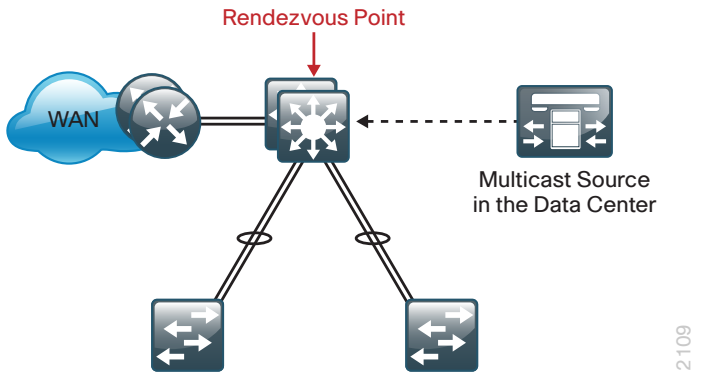
Procedure 5 Configure IP Multicast routing

IP Multicast allows a single IP data stream to be replicated by the infrastructure (that is, routers and switches) and sent from a single source to multiple receivers. Using IP Multicast is much more efficient than multiple individual unicast streams or a broadcast stream that would propagate everywhere. IP Telephony Music on Hold and IP Video Broadcast Streaming are two examples of IP Multicast applications.

To receive a particular IP Multicast data stream, end hosts must join a multicast group by sending an Internet Group Management Protocol (IGMP) message to their local multicast router. In a traditional IP Multicast design, the local router consults another router in the network that is acting as a Rendezvous Point (RP) to map the receivers to active sources so they can join their streams.

The RP is a control plane operation that should be placed in the core of the network or close to the IP Multicast sources on a pair of Layer 3 switches or routers. IP Multicast routing begins at the distribution layer if the access layer is Layer 2 and provides connectivity to the IP Multicast RP. In designs without a core layer, the distribution layer will perform the RP function.

Figure 27 - Rendezvous point placement in the network



In this design, which is based on sparse mode multicast operation, Cisco uses Anycast RP to provide a simple yet scalable way to provide a highly resilient RP environment.

Step 1: Configure IP Multicast routing on the platforms in the global configuration mode.

```
ip multicast-routing
```

Cisco Catalyst 3750 Series switches instead require the **ip multicast-routing distributed** command.

Step 2: Configure the switch to discover the IP Multicast RP.

Every Layer 3 switch and router must be configured to discover the IP Multicast RP with autorp. Use the **ip pim autorp listener** command to allow for discovery across sparse mode links. This configuration provides for future scaling and control of the IP Multicast environment and can change based on network needs and design.

```
ip pim autorp listener
```

Step 3: Configure ip pim sparse-mode. All Layer 3 interfaces in the network must be enabled for sparse mode multicast operation.

```
ip pim sparse-mode
```

Example

```
spanning-tree portfast bpduguard default
!
interface Loopback 0
  ip address 10.4.15.254 255.255.255.255
  ip pim sparse-mode
!
snmp-server trap-source Loopback 0
ip ssh source-interface Loopback 0
ip pim register-source Loopback 0
ip tacacs source-interface Loopback 0
ntp source Loopback 0
!
ip routing
!
router eigrp 100
  network 10.4.0.0 0.1.255.255
  no auto-summary
  passive-interface default
  eigrp router-id 10.4.15.254
  nsf
!
ip multicast-routing
ip pim autorp listener
!
```

Procedure 6 Configure IP Multicast RP

(Optional)

In networks without a core layer, the RP function can be placed on the distribution layer. If a core layer does exist follow the IP Multicast Procedure 4 in the core layer section to configure the RP function.

Every Layer 3 switch and router must know the address of the IP Multicast RP, including the core switches that are serving as the RP. This design uses AutoRP to announce candidate RPs, which are the core switches, to the rest of the network.

Step 1: Configure loopback interface for RP.

Configure a second loopback interface to be used as the RP interface. The interface uses a host address mask (32 bits). All routers then point to this common IP address on **loopback 1** for the RP.

```
interface Loopback 1
 ip address 10.4.15.253 255.255.255.255
 ip pim sparse-mode
```

Step 2: Configure AutoRP candidate RP.

The **send-rp-announce** command in conjunction with the **group-list** option advertises the RP address, with the multicast range the device is willing to serve, as a candidate RP to the AutoRP mapping agents.

```
access-list 10 permit 239.1.0.0 0.0.255.255
ip pim send-rp-announce Loopback 1 scope 32 group-list 10
```

Step 3: Configure AutoRP mapping agent.

The AutoRP mapping agent listens for candidate RPs and then advertises to the rest of the network the list of available RPs. The **send-rp-discovery** command enables this switch to act as an AutoRP mapping agent.

```
ip pim send-rp-discovery Loopback0 scope 32
```

In the event you add a core layer to your existing network and the RP is currently configured on a distribution layer, you may want to move the RP to the core. You can do this by following the IP Multicast section in the core layer IP Multicast procedure and program the RP address on the loopback 1 interfaces at the new location with the same ip address used on loopback 1 in this procedure, then enable and establish IP Multicast and MSDP peering.

All remote routers should still point to the same RP address, which simplifies the move and reduces disruption to the IP Multicast environment.

Procedure 7 Connect to access layer

The resilient, single, logical, distribution layer switch design is based on a hub-and-spoke or star design. The links to access layer switches and connected routers are Layer 2 EtherChannels. Links to other distribution layers, and the optional core are Layer 3 links or Layer 3 EtherChannels.

When using EtherChannel, the member interfaces should be on different switches in the stack or different modules in the modular switch for the highest resiliency.

The physical interfaces that are members of a Layer 2 EtherChannel are configured prior to configuring the logical port-channel Interface. This allows for minimal configuration because most of the commands entered to a port-channel interface are copied to its members' interfaces and do not require manual replication.

Configure two or more physical interfaces to be members of the EtherChannel. It is recommended that they are added in multiples of two.

If this distribution layer will be used as a network-services aggregation block, you likely will not have an access layer to connect.

Step 1: Configure VLANs.

Configure all VLANs for the access layer switches that you are connecting to the distribution switch.

```
vlan [data vlan]
name Data
vlan [voice vlan]
name Voice
vlan [management vlan]
name Management
```

Step 2: If there is no external central site DHCP server in the network, you can provide DHCP service in IOS by configuring the IOS DHCP server. This function can also be useful at a remote-site where you want to provide local DHCP service and not depend on the WAN link to an external central site DHCP server.

```
ip dhcp excluded-address 10.4.100.1 10.4.100.10
ip dhcp pool access
network 10.4.100.0 255.255.255.0
default-router 10.4.100.1
domain-name cisco.local
dns-server 10.4.48.10
```

The example configuration provides IP addresses via the IOS based DHCP service for the subnet 10.4.100.0/24 and prevents the server from assigning reserved addresses .1-.10.

Step 3: Configure EtherChannel member interfaces.

Cisco uses Layer 2 EtherChannels to connect all access layer switches to the distribution layer and thereby create the hub-and-spoke resilient design that eliminates spanning-tree loops.

Connect the access layer EtherChannel uplinks to separate switches in the distribution layer switches or stack, and in the case of Cisco Catalyst 4507R+E distribution layer, to separate redundant modules for additional resiliency.

Also, apply the egress QoS macro that was defined in the platform configuration procedure to ensure traffic is prioritized appropriately.

```
interface [interface type] [port 1]
  description Link to {your device here} port 1
interface [interface type] [port 2]
  description Link to {your device here} port 2
!
interface range [interface type] [port 1], [interface type]
[port 2]
  switchport
  macro apply EgressQoS
  channel-protocol lacp
  channel-group [number] mode active
  logging event link-status
  logging event trunk-status
  logging event bundle-status
```

Tech Tip

The Catalyst 6500 has two egress QoS macros, EgressQoS which is used for Gigabit Ethernet ports, and EgressQoSTenGig which is used for Ten Gigabit Ethernet ports. All other Cisco SBA distribution layer platforms have a single egress QoS macro that applies to Gigabit and Ten Gigabit Ethernet ports.

Step 4: Configure a trunk.

An 802.1Q trunk is used for the connection to the access layer, which allows the distribution switch to provide Layer 3 services to all the VLANs defined on the access layer switch. Prune the VLANs on the trunk to only the VLANs that are active on the access switch. When using EtherChannel the interface type will be port-channel and the number must match the channel group configured in Step 3 .

The Catalyst 3750 requires the **switchport trunk encapsulation dot1q** command.

```
interface [port-channel] [number]
  description EtherChannel link to {your device here}
  switchport trunk allowed vlan [data vlan],[voice vlan],
    [mgmt vlan]
  switchport mode trunk
  logging event link-status
  no shutdown
```

If the interface type is not portchannel, then the additional command macro apply EgressQoS must also be configured on the interface.

Next, mitigate VLAN hopping on the trunk for switch-to-switch connections.

There is a remote possibility that an attacker can create a double 802.1Q encapsulated packet. If the attacker has specific knowledge of the 802.1Q native VLAN, they could create a packet that when processed, removes the first or outermost tag when the packet is switched onto the untagged native VLAN. When the packet reaches the target switch, the inner or second tag is then processed and the potentially malicious packet is switched to the target VLAN.

At first glance, this appears to be a serious risk. However, the traffic in this attack scenario is in a single direction and no return traffic can be switched by this mechanism. Additionally, this attack cannot work unless the attacker knows the native VLAN ID.

Step 5: To remove the remote risk of this type of attack is to configure an unused VLAN on all switch-to-switch 802.1Q trunk links from access layer to distribution layer. By using a hard to guess, unused VLAN for the native VLAN you reduce the possibility that a double 802.1Q-tagged packet can hop VLANs.

```
vlan 999
!
interface [port-channel] [number]
  switchport trunk native vlan 999
```

Step 6: Configure Layer 3.

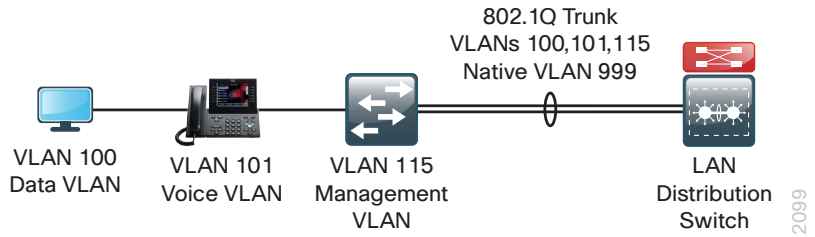
Configure a VLAN interface (SVI) for every access layer VLAN so devices in the VLAN can communicate with the rest of the network.

Use the **ip helper-address** command to allow remote DHCP servers to provide IP addresses for this network. The address that the **helper** command points to is the central DHCP server. If you have more than one DHCP server, you can list multiple helper commands on an interface.

```
interface vlan [number]
  ip address [ip address] [mask]
  ip helper-address [dhcp server ip]
  ip pim sparse-mode
  no shutdown
```

If you configured the IOS DHCP server function on this distribution layer switch in Step 2 of this procedure, the **ip helper-address** is not needed on the VLAN interface.

Example




```
vlan 100
  name Data
vlan 101
  name Voice
vlan 115
  name Management
spanning-tree vlan 1-4094 root primary
!
interface GigabitEthernet 1/1/1
  description Link to Access Switch port 1
interface GigabitEthernet 2/1/1
  description Link to Access Switch port 2
!
interface range GigabitEthernet 1/1/1, GigabitEthernet 2/1/1
  switchport
  macro apply EgressQoS
  channel-protocol lacp
```

```
  channel-group 10 mode active
  logging event link-status
  logging event trunk-status
  logging event bundle-status
  no shutdown
!
interface Port-channel 10
  description EtherChannel link to Access Switch
  switchport trunk native vlan 999
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 100,101,115
  switchport mode trunk
  no shutdown
!
interface vlan 100
  ip address 10.4.0.1 255.255.255.0
  ip helper-address 10.4.48.10
  ip pim sparse-mode
!
interface vlan 101
  ip address 10.4.1.1 255.255.255.0
  ip helper-address 10.4.48.10
  ip pim sparse-mode
!
interface vlan 115
  ip address 10.4.15.1 255.255.255.128
  ip helper-address 10.4.48.10
  ip pim sparse-mode
```

Procedure 8 Connect to LAN core or WAN router

Any links to connected WAN routers or a LAN core layer should be Layer 3 links or Layer 3 EtherChannels. The SBA LAN design does not extend Layer 2 VLANs beyond the distribution layer.

Option 1. Connect distribution layer switch to WAN router

When the LAN distribution layer connects to a WAN router this may present a number of scenarios:

- The distribution layer switch is a collapsed core HQ location connecting to one or more WAN headend routers.
- The distribution layer switch is collapsed core for a larger remote site with multiple WAN routers for survivability.
- The distribution layer switch is a WAN aggregation switch with a number of WAN headend routers connected to it for a modular block connecting to a LAN Core switch.

Because of the number of combinations, it is better to consult the *Cisco* SBA—Borderless Networks WAN deployment guides for the LAN connectivity that matches your deployment scenario.

Option 2. Connect distribution layer switch to LAN core switch

Step 1: Configure the Layer 3 interface.

If you are using an EtherChannel to connect to the LAN core, the interface type will be port-channel and the number must match the channel-group number you will configure in Step 3. When configuring a Layer 3 EtherChannel the logical port-channel interface is configured prior to configuring the physical interfaces associated with the EtherChannel.

```
interface [interface type] [number]
  description Link to {your device here}
  no switchport
  ip address [ip address] [mask]
  ip pim sparse-mode
  logging event link-status
  carrier-delay msec 0
  no shutdown
```

If the interface type is not a port-channel, then an additional command **macro apply EgressQoS** must also be configured on the interface.

Step 2: Configure IP address summarization on the links to the core.

As networks grow, the number of IP subnets or routes in the routing tables grows as well. To reduce the amount of bandwidth, processor speed, and memory necessary to carry large route tables and to reduce convergence time around a link failure, configure IP summarization on links where logical boundaries exist. If the connected device provides connectivity to another piece of the network (for example, the WAN, Internet, or LAN core), configure EIGRP summarization.

```
ip summary-address eigrp 100 [network] [mask]
```

Step 3: If you want to run EtherChannel links to the core layer, now configure EtherChannel member interfaces.

Configure the physical interfaces to tie to the logical port-channel using the **channel-group** command. The number for the port-channel and channel-group must match.

Also, apply the egress QoS macro that was defined in the platform configuration procedure to ensure that traffic is prioritized appropriately.

```
interface [interface type] [port 1]
  description Link to {your device here} port 1
interface [interface type] [port 2]
  description Link to {your device here} port 2
!
interface range [interface type] [port 1], [interface type]
[port 2]
  no switchport
  macro apply EgressQoS
  carrier-delay msec 0
  channel-protocol lacp
  channel-group [number] mode active
  logging event link-status
  logging event trunk-status
  logging event bundle-status
  no shutdown
```

Tech Tip

The Catalyst 6500 has two egress QoS macros, EgressQoS which is used for Gigabit Ethernet ports, and EgressQoSTenGig which is used for Ten Gigabit Ethernet ports. All other Cisco SBA distribution layer platforms have a single egress QoS macro that applies to Gigabit and Ten Gigabit Ethernet ports.

Step 4: Configure the EIGRP interface.

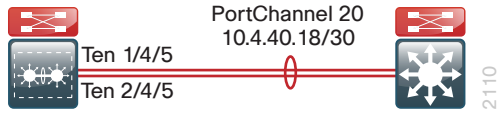
After you have configured the Layer 3 interfaces and Layer 3 port-channels connecting to other Layer 3 devices, allow EIGRP to form neighbor relationships across these interfaces to establish peering adjacencies and exchange route tables.

```
router eigrp 100
  no passive-interface [interface type] [number]
```

Step 5: Save the running configuration that you have entered so it will be used as the startup configuration file when your switch is rebooted or power-cycled.

```
copy running-config startup-config
```

Example




```
interface Port-channel 20
  description EtherChannel link to Core Switch
  no switchport
  ip address 10.4.40.18 255.255.255.252
  ip pim sparse-mode
  ip summary-address eigrp 100 10.4.0.0 255.255.240.0
  no shutdown
!
interface range TenGigabitEthernet 1/4/5, TenGigabitEthernet
2/4/5
  description EtherChannel link to Core Switch
  no switchport
  macro apply EgressQoSTenGig
  carrier-delay msec 0
  channel-group 20 mode on
  logging event link-status
  logging event trunk-status
  logging event bundle-status
  no shutdown
!
router eigrp 100
  no passive-interface Port-channel 20
```

Notes

Core Layer

Business Overview

Modern organizations require non-stop connectivity and uninterrupted access to the resources essential for conducting business. The risk of a single link outage or device failure cascading throughout the facility and disrupting communications for a large number of users increases as networks grow in size and scale at a given location. IT departments tasked with providing reliable access to resources require a network architecture that can provide a highly available service.

As the LAN environment at a larger facility grows it often creates the need to use multiple LAN distribution layer blocks. The physical layout of the site or the density of access layer switches connecting to a single distribution layer may necessitate the creation of multiple distribution layer blocks. As the number of required distribution layer blocks in a facility grows beyond two or three, a solution is required to reduce the need and cost of fully meshing all interconnectivity while maintaining a design that provides a reliable infrastructure.

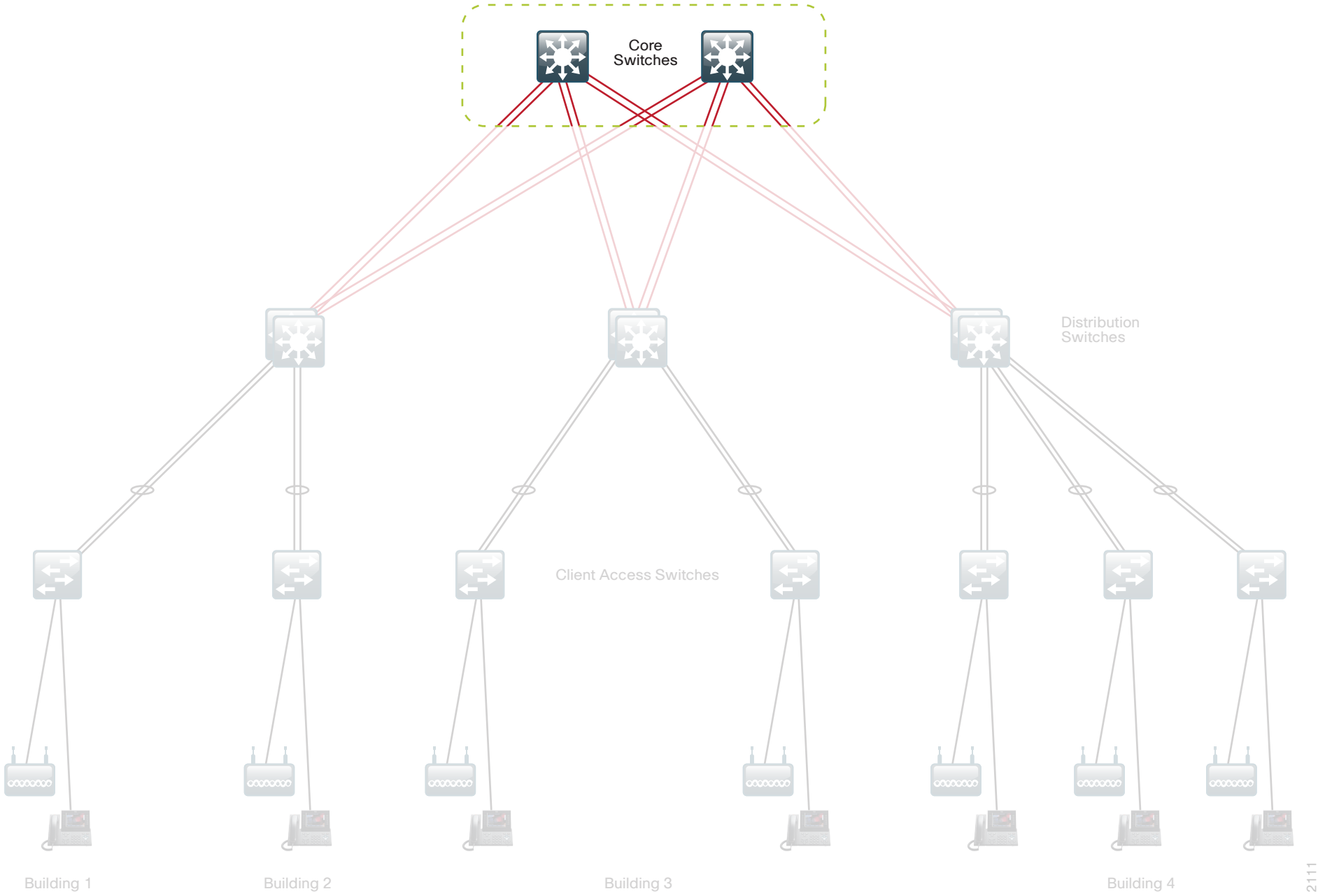
An important consideration when investing in new technology and services that drive business productivity is the time required to implement the technology in a usable fashion. Organizations must design an architecture of compute, storage, application, and network foundation that allows them to reduce the time required to use new technology investments by exploiting a flexible and scalable infrastructure.

Technology Overview

The core layer of the LAN is a critical part of the scalable network, yet by design, is one of the simplest. Like the distribution layer aggregates connectivity for multiple access layer switches, the core layer aggregates connectivity when there are multiple distribution blocks. As networks grow beyond three distribution blocks in a single location, a core layer should be used to optimize the design.

Beyond the simple aggregation of connectivity, the core layer serves to reduce the number of paths between distribution layers, which in turn lowers the time required to converge the network after a failure. By upgrading bandwidth between a distribution layer and the core, multiple distribution layer blocks can benefit from the increase versus the need to upgrade the bandwidth to every other device in a design without a core. The core layer is especially relevant to designs where the data center resources might be collocated with the LAN.

Figure 28 - Core layer overview



In large modular and scalable LAN designs, a core layer is used to aggregate multiple user connectivity distribution layer blocks and network-services distribution layer blocks. In designs with a collocated data center, the core provides high speed fan-out connectivity to the rest of the network. The core layer also serves as the connection between the Wide Area Network (WAN) and Internet Edge distribution layer blocks. Because of this central point of connectivity for all data flows, the core is part of the backbone IP routing address space and is designed to be highly resilient to protect from component-, power-, or operational-induced outages. The core layer should not contain highly complex or high touch services that require constant care and tuning, to avoid downtime required by complex configuration changes, increased software upgrades for new services, or links that toggle up/down as part of normal operations like user endpoint connectivity.

The core layer in the SBA design is based on two physically and logically separate switches. Connectivity to and from the core should be Layer 3 only. No VLANs should span the core to drive increased resiliency and stability. Since the core does not need to provide the same services or boundaries that the distribution layer does, the two-box design does not significantly increase the complexity of the solution. Because the Layer 3 core has no need to provide access layer services or Layer 2 connectivity, the single logical device approach used in the distribution layer to prevent spanning tree and reduce IP gateway protocols is not as beneficial.

The core is built on dual switches to provide a completely separate control plane housed on each switch, which provides redundant logic, line cards, hardware, and power for the backbone operation. Each distribution layer block, router, or other appliance connecting to the core should be dual homed with an EtherChannel or link to each core switch. This dual-homed approach provides Equal Cost Multiple Path (ECMP) load sharing of IP traffic across links for traffic traversing the core, and fast failover based on either EtherChannel or ECMP alternate routes without waiting for routing protocol topology changes to propagate the network.

The core is designed to be high speed and provides for connectivity ranging from Gigabit Ethernet, Gigabit EtherChannel, 10 Gigabit Ethernet, and up to 10 Gigabit EtherChannel. The core can provide non-blocking bandwidth based on design and configuration. EtherChannel links homed to a switch should be spread across line cards when possible.

The core switches can be provisioned with dual supervisors for Stateful Switchover (SSO) operation to protect the core bandwidth in the event that a control plane hardware or software failure occurs. The core switches are Nonstop Forwarding (NSF) aware to provide enhanced resilience for any dual supervisor connected devices and NSF capable if provisioned with dual supervisors per switch.

Core Layer Platforms

Cisco Catalyst 6500 Series switch, powered by the Supervisor 2T, is the premier LAN core platform. It delivers scalable performance, intelligence, and a broad set of features to address the needs of the most demanding enterprise deployments requirements for building a modular, resilient, scalable, and secure Layer 3 backbone solution.

- Uses Cisco Catalyst 6500 Supervisor Engine 2T, which increases the per slot switching capacity to 80 Gbps, and delivers better scalability and enhanced hardware-enabled features. The increased performance enables the system to provide 40 Gigabit Ethernet uplinks to satisfy the most demanding Distribution to Core Layer connectivity.
- Cisco 6500 Supervisor 2T supports the line cards enabled for Policy Feature Card 4 (PFC4), including the WS-X6816-10G WS-X6908-10G and WS-X6904-40G-2T, which provide enhanced QoS and security capabilities. The WS-X6908-10G provides eight 10Gb Ethernet ports with 1:1 oversubscription. The WS-X6904-40G-2T provides up to four 40Gb Ethernet ports or up to sixteen 10Gb Ethernet ports using modular adapters for 10Gb or 40Gb Ethernet applications and can be programmed to run in 2:1 or 1:1 oversubscription mode.
- The Supervisor 2T based switch enhances support for Cisco TrustSec (CTS) by providing MacSec encryption and role-based access control (RBAC) lists, and delivers improved control plane policing to address denial-of-service attacks.
- Supports high-density connectivity for Gigabit and 10 Gigabit Ethernet connectivity using copper or fiber optic media to provide the scale and versatility for the core of any network.

The Catalyst 6500 used in the core layer design can use the same supervisor engine, chassis, and power supplies as the Catalyst 6500 VSS 4T systems used for the distribution layer, which helps for sparing of parts and reduction of platforms to support.

The *Cisco SBA—Borderless Networks LAN and Data Center Collapsed Core Using Cisco Nexus 7000 Deployment Guide* discusses the use of Cisco Nexus 7000 Series Switch as the core layer platform when the LAN and data center core functionality are combined on one set of devices.

Deployment Details

The core layer uses a dual switch design for resiliency.

Process

Configuring the Core

1. Configure the platform
2. Configure LAN switch universal settings
3. Configure the core switch global settings
4. Configure IP Multicast routing
5. Connect to distribution layer

Procedure 1 Configure the platform

On the Catalyst 6500 Supervisor 2T-based switches, QoS is enabled by default and policies for interface queuing are defined by attached service policies. The QoS policies are now defined using Cisco Common Classification Policy (C3PL) which is similar to Modular QoS CLI to reduce operational complexity.

All interface connections in the distribution and core are set to trust DSCP. Even though this design is configured to trust DSCP markings, it is a best practice to ensure proper mapping of class of service (CoS) to DSCP for VoIP. This mapping is accomplished by overriding the default mapping of CoS 5 "voice bearer traffic" to DSCP 40, with DSCP 46, which is the EF per-hop behavior for voice.

Two separate egress QoS policies are configured for the Catalyst 6500 to accommodate the 10-Gigabit Ethernet cards which use a 1P7Q4T queuing architecture, and the Gigabit Ethernet cards which use a 1P3Q8T queuing architecture.

```
! Enable port-based QoS
auto qos default
! Class maps for 1P7Q4T 10Gb ports service policy
class-map type lan-queuing match-any PRIORITY-QUEUE
  match dscp ef
  match dscp cs5
  match dscp cs4
  match cos 5
class-map type lan-queuing match-any CONTROL-MGMT-QUEUE
  match dscp cs7
  match dscp cs6
  match dscp cs3
  match dscp cs2
  match cos 3 6 7
class-map type lan-queuing match-any MULTIMEDIA-CONFERENCING-
QUEUE
  match dscp af41 af42 af43
  match cos 4
class-map type lan-queuing match-any MULTIMEDIA-STREAMING-
QUEUE
  match dscp af31 af32 af33
class-map type lan-queuing match-any TRANSACTIONAL-DATA-QUEUE
  match dscp af21 af22 af23
  match cos 2
class-map type lan-queuing match-any BULK-DATA-QUEUE
  match dscp af11 af12 af13
class-map type lan-queuing match-any SCAVENGER-QUEUE
  match dscp cs1
  match cos 1
!
policy-map type lan-queuing 1P7Q4T
 class PRIORITY-QUEUE
  priority
 class CONTROL-MGMT-QUEUE
  bandwidth remaining percent 14
  queue-buffers ratio 10
  random-detect dscp-based
```

```
 random-detect dscp 16 percent 60 70
 random-detect dscp-based
 random-detect dscp 24 percent 70 80
 random-detect dscp-based
 random-detect dscp 48 percent 80 90
 random-detect dscp-based
 random-detect dscp 56 percent 90 100
class MULTIMEDIA-CONFERENCING-QUEUE
 bandwidth remaining percent 14
 queue-buffers ratio 10
 random-detect dscp-based
 random-detect dscp 38 percent 70 80
 random-detect dscp-based
 random-detect dscp 36 percent 80 90
 random-detect dscp-based
 random-detect dscp 34 percent 90 100
class MULTIMEDIA-STREAMING-QUEUE
 bandwidth remaining percent 14
 queue-buffers ratio 10
 random-detect dscp-based
 random-detect dscp 30 percent 70 80
 random-detect dscp-based
 random-detect dscp 28 percent 80 90
 random-detect dscp-based
 random-detect dscp 26 percent 90 100
class TRANSACTIONAL-DATA-QUEUE
 bandwidth remaining percent 14
 queue-buffers ratio 10
 random-detect dscp-based
 random-detect dscp 22 percent 70 80
 random-detect dscp-based
 random-detect dscp 20 percent 80 90
 random-detect dscp-based
 random-detect dscp 18 percent 90 100
class BULK-DATA-QUEUE
 bandwidth remaining percent 6
 queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 14 percent 70 80
  random-detect dscp-based
  random-detect dscp 12 percent 80 90
  random-detect dscp-based
  random-detect dscp 10 percent 90 100
 class SCAVENGER-QUEUE
  bandwidth remaining percent 2
  queue-buffers ratio 10
  random-detect dscp-based
  random-detect dscp 8 percent 80 100
class class-default
  queue-buffers ratio 25
  random-detect dscp-based aggregate
  random-detect dscp values 0 1 2 3 4 5 6 7 percent 80 100
  random-detect dscp values 9 11 13 15 17 19 21 23 percent 80
100
  random-detect dscp values 25 27 29 31 33 35 37 39 percent 80
100
  random-detect dscp values 41 42 43 44 45 47 49 50 percent 80
100
  random-detect dscp values 51 52 53 54 55 57 58 59 percent 80
100
  random-detect dscp values 60 61 62 63 percent 80 100
!
table-map cos-discard-class-map
 map from 0 to 0
 map from 1 to 8
 map from 2 to 16
 map from 3 to 24
 map from 4 to 32
 map from 5 to 46
 map from 6 to 48
 map from 7 to 56
!
! Class maps for 1P3Q8T 1Gb ports service policy
class-map type lan-queuing match-any PRIORITY-QUEUE-GIG
```

```
 match cos 5 4
class-map type lan-queuing match-any CONTROL-AND-STREAM-MEDIA
 match cos 7 6 3 2
class-map type lan-queuing match-any BULK-DATA-SCAVENGER
 match cos 1
!
policy-map type lan-queuing 1P3Q8T
 class PRIORITY-QUEUE-GIG
  priority
  queue-buffers ratio 15
 class CONTROL-AND-STREAM-MEDIA
  bandwidth remaining percent 55
  queue-buffers ratio 40
  random-detect cos-based
  random-detect cos 2 percent 60 70
  random-detect cos-based
  random-detect cos 3 percent 70 80
  random-detect cos-based
  random-detect cos 6 percent 80 90
  random-detect cos-based
  random-detect cos 7 percent 90 100
 class BULK-DATA-SCAVENGER
  bandwidth remaining percent 10
  queue-buffers ratio 20
  random-detect cos-based
  random-detect cos 1 percent 80 100
 class class-default
  queue-buffers ratio 25
  random-detect cos-based
  random-detect cos 0 percent 80 100
!
macro name EgressQoSTenGig
  service-policy type lan-queuing output 1P7Q4T
@
!
macro name EgressQoS
  service-policy type lan-queuing output 1P3Q8T
@
```

Procedure 2 Configure LAN switch universal settings

In this design, there are features and services that are common across all LAN switches, regardless of the type of platform or role in the network. These are system settings that simplify and secure the management of the solution.

This procedure provides examples for some of these settings. The actual settings and values depend on your current network configuration.

Table 4 - Common network services used in the deployment examples

Service	Address
Domain Name:	cisco.local
Active Directory, DNS, DHCP Server:	10.4.48.10
Authentication Control System:	10.4.48.15
Network Time Protocol Server:	10.4.48.17
EIGRP AS	100
Multicast Range	239.1.0.0/16

Step 1: Configure the device hostname to make it easy to identify the device.

```
hostname [hostname]
```

Step 2: Configure VTP transparent mode. This deployment uses VTP transparent mode because the benefits of dynamic propagation of VLAN information across the network are not worth the potential for unexpected behavior that is due to operational error.

VLAN Trunking Protocol (VTP) allows network managers to configure a VLAN in one location of the network and have that configuration dynamically propagate out to other network devices. However, in most cases, VLANs are defined once during switch setup with few, if any, additional modifications.

```
vtp mode transparent
```

Step 3: Enable Rapid Per-VLAN Spanning-Tree (PVST+). Rapid PVST+ provides an instance of RSTP (802.1w) per VLAN. Rapid PVST+ greatly improves the detection of indirect failures or linkup restoration events over classic spanning tree (802.1D).

Although this architecture is built without any Layer 2 loops, you must still enable spanning tree. By enabling spanning tree, you ensure that if any physical or logical loops are accidentally configured, no actual layer 2 loops occur.

```
spanning-tree mode rapid-pvst
```

Step 4: Enable Unidirectional Link Detection (UDLD).

UDLD is a Layer 2 protocol that enables devices connected through fiber-optic or twisted-pair Ethernet cables to monitor the physical configuration of the cables and detect when a unidirectional link exists. When UDLD detects a unidirectional link, it disables the affected interface and alerts you. Unidirectional links can cause a variety of problems, including spanning-tree loops, black holes, and non-deterministic forwarding. In addition, UDLD enables faster link failure detection and quick reconvergence of interface trunks, especially with fiber, which can be susceptible to unidirectional failures.

```
udld enable
```

Step 5: Set EtherChannels to use the traffic source and destination IP address when calculating which link to send the traffic across. This normalizes the method in which traffic is load-shared across the member links of the EtherChannel. EtherChannels are used extensively in this design because of their resiliency capabilities.

```
port-channel load-balance src-dst-ip
```

Step 6: Configure DNS for host lookup.

At the command line of a Cisco IOS device, it is helpful to be able to type a domain name instead of the IP address for a destination.

```
ip name-server 10.4.48.10
```

Step 7: Configure device management protocols.

Secure HTTP (HTTPS) and Secure Shell (SSH) are more secure replacements for the HTTP and Telnet protocols. They use Secure Sockets Layer (SSL) and Transport Layer Security (TLS) to provide device authentication and data encryption.

The SSH and HTTPS protocols enable secure management of the LAN device. Both protocols are encrypted for privacy, and the nonsecure protocols, Telnet and HTTP, are turned off.

Specify the transport preferred none on vty lines to prevent errant connection attempts from the CLI prompt. Without this command, if the ip name server is unreachable, long timeout delays may occur for mistyped commands.

```
ip domain-name cisco.local
ip ssh version 2
no ip http server
ip http secure-server
!
line vty 0 15
  transport input ssh
  transport preferred none
```

Step 8: Enable Simple Network Management Protocol (SNMP) in order to allow the network infrastructure devices to be managed by a Network Management System (NMS), and then configure SNMPv2c both for a read-only and a read-write community string.

```
snmp-server community cisco RO
snmp-server community cisco123 RW
```

Step 9: If your network operational support is centralized, you can increase network security by using an access list to limit the networks that can access your device. In this example, only devices on the 10.4.48.0/24 network will be able to access the device via SSH or SNMP.

```
access-list 55 permit 10.4.48.0 0.0.0.255
line vty 0 15
  access-class 55 in
!
snmp-server community cisco RO 55
snmp-server community cisco123 RW 55
```

Caution

If you configure an access-list on the vty interface you may lose the ability to use ssh to login from one router to the next for hop-by-hop troubleshooting.

Step 10: Configure local login and password.

The local login account and password provides basic device access authentication to view platform operation. The enable password secures access to the device configuration mode. By enabling password encryption, you prevent the use of plain text passwords when viewing configuration files.

```
username admin password c1sco123
enable secret c1sco123
service password-encryption
aaa new-model
```

By default, https access to the switch will use the enable password for authentication.

Step 11: If you want to reduce operational tasks per device, configure centralized user authentication by using the TACACS+ protocol to authenticate management logins on the infrastructure devices to the Authentication, Authorization and Accounting (AAA) server.

As networks scale in the number of devices to maintain, there is an operational burden to maintain local user accounts on every device. A centralized Authentication, Authorization and Accounting (AAA) service reduces operational tasks per device and provides an audit log of user access for security compliance and root cause analysis. When AAA is enabled for access control, all management access to the network infrastructure devices (SSH and HTTPS) is controlled by AAA.

TACACS+ is the primary protocol used to authenticate management logins on the infrastructure devices to the AAA server. A local AAA user database is also defined on each network infrastructure device to provide a fallback authentication source in case the centralized TACACS+ server is unavailable.

```
aaa authentication login default group tacacs+ local
aaa authorization exec default group tacacs+ local
aaa authorization console
ip http authentication aaa
tacacs-server host 10.4.48.15 key SecretKey
```

Reader Tip

The AAA server used in this architecture is Cisco Authentication Control System. Configuration of ACS is discussed in the *Device Management Using ACS Deployment Guide*.

Step 12: Configure a synchronized clock by programming network devices to synchronize to a local NTP server in the network. The local NTP server typically references a more accurate clock feed from an outside source. Configure console messages, logs, and debug output to provide time stamps on output, which allows cross-referencing of events in a network..

```
ntp server 10.4.48.17
ntp update-calendar
!
clock timezone PST -8
clock summer-time PDT recurring
!
service timestamps debug datetime msec localtime
service timestamps log datetime msec localtime
```

Procedure 3 Configure the core switch global settings

Step 1: Configure the in-band management interface.

The loopback interface for Cisco Layer 3 devices is a logical interface that is always reachable as long as the device is powered on and any IP interface is reachable to the network. Layer 3 process and features are also bound to the loopback interface to ensure resiliency of the processes. The loopback address is commonly a host address with a 32-bit address mask and has been allocated out of the core network address range. This example includes the **ip pim sparse-mode** command that will be explained further in Procedure 4.

```
interface loopback 0
 ip address [ip address] 255.255.255.255
 ip pim sparse-mode
```

Step 2: Configure the SNMP and SSH processes to use the loopback interface address for optimal resiliency:

```
snmp-server trap-source Loopback 0
ip ssh source-interface Loopback 0
ip pim register-source Loopback0
ip tacacs source-interface Loopback0
ntp source Loopback0
```

Step 3: Configure IP unicast routing

Enable EIGRP for the IP address space that the network will be using and disable auto summarization of the IP networks. If needed for your network, you can enter multiple network statements. The Loopback 0 IP address is used for the EIGRP router ID to ensure maximum resiliency.

```
router eigrp 100
 network 10.4.0.0 0.1.255.255
 no auto-summary
 eigrp router-id [ip address of loopback 0]
```

Procedure 4 Configure IP Multicast routing

IP Multicast allows a single IP data stream to be sent from a single source to multiple receivers and be replicated by the infrastructure (that is, routers and switches). Using IP Multicast is much more efficient than multiple unicast streams or a broadcast stream that would propagate everywhere. IP Telephony Music on Hold and IP Video Broadcast Streaming are two examples of IP Multicast applications.

To receive a particular IP Multicast data stream, end hosts must join a multicast group by sending an Internet Group Management Protocol (IGMP) message to their local multicast router. In a traditional IP Multicast design, the local router consults another router in the network that is acting as an RP to map receivers to active sources so they can join their streams.

The RP is a control-plane operation that should be placed in the core of the network or close to the IP Multicast sources on a pair of Layer 3 switches or routers. In this design, which is based on pim sparse mode multicast operation, Cisco uses Anycast RP to provide a simple yet scalable way to provide a highly resilient RP environment when two separate devices are used as RPs.

Step 1: Enable PIM.

Enable IP Multicast routing on the platforms in the global configuration mode.

```
ip multicast-routing
```

Step 2: Configure loopback interface for RP.

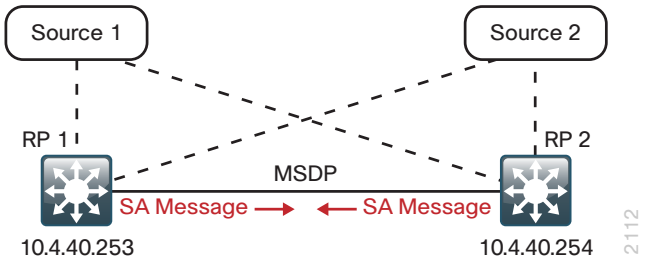
To enable Anycast RP operation, the first step is to configure a second loopback interface on each of the core switches. The key is that this second loopback interface has the same IP address on both core switches and uses a host address mask (32 bits). All routers then point to this common IP address on **loopback 1** for the RP. You configure the RP address from the core IP address space.

```
interface Loopback 1
 ip address 10.4.40.252 255.255.255.255
 ip pim sparse-mode
```

Step 3: Configure Multicast Source Discovery Protocol (MSDP).

The final step for the Anycast RP configuration is to enable Multicast Source Discovery Protocol (MSDP) to run between the two core RP switches.

Figure 29 - MSDP overview



To enable MSDP, you must use unique addresses at each end of the link. Therefore, you will use the loopback 0 addresses of each core router to configure the MSDP session.

On core switch #1:

```
ip msdp peer 10.4.40.253 connect-source Loopback0
ip msdp originator-id Loopback0
! The IP address listed above is the core switch #2 loopback
```

On core switch #2:

```
ip msdp peer 10.4.40.254 connect-source Loopback0
ip msdp originator-id Loopback0
! The IP address listed above is the core switch #1 loopback
```

The MSDP configuration is complete and convergence around a failed RP is now as fast as the unicast routing protocol (EIGRP) convergence. You will see the MSDP protocol session activate later on as you enable the routing links between the core switches and the distribution layer blocks establishing Layer 3 connectivity.

```
%MSDP-5-PEER_UPDOWN: Session to peer 10.4.40.253 going up
```

Every Layer 3 switch and router must know the address of the IP Multicast RP, including the core switches that are serving as the RP. This design uses AutoRP to announce candidate RPs, which are the core switches, to the rest of the network.

Step 4: Configure AutoRP candidate RPs.

The **send-rp-announce** command in conjunction with the **group-list** option advertises the RP address, with the multicast range the device is willing to serve, as a candidate RP to the AutoRP mapping agents.

```
access-list 10 permit 239.1.0.0 0.0.255.255
ip pim send-rp-announce Loopback1 scope 32 group-list 10
```

Step 5: Configure AutoRP mapping agent.

The AutoRP mapping agent listens for candidate RPs and then advertises to the rest of the network the list of available RPs. The **send-rp-discovery** command enables the core switches to act as AutoRP mapping agents.

```
ip pim send-rp-discovery Loopback0 scope 32
```

Step 6: Configure devices to listen to AutoRP announcements.

All Layer 3 switches and routers in the organization, including the RPs, must be configured to listen to the AutoRP announcements from the mapping agents.

```
ip pim auto-rp listener
```

Cisco Catalyst 6500 uses the command ip pim autorp listener.

In the event you add a core layer to your existing network and the RP is currently configured on a distribution layer, you may want to move the RP to the core.

With AnyCast RP, you can move the RP to a new location by programming the RP address on the loopback 1 interfaces at the new location, and enable and establish IP Multicast and MSDP peering.

All remote routers should still point to the same RP address, which simplifies the move and reduces disruption to the IP Multicast environment.

All Layer 3 interfaces in the network must be enabled for sparse mode multicast operation.

```
ip pim sparse-mode
```

Procedure 5 Connect to distribution layer

In this design, links in the core layer are configured as point-to-point Layer 3 routed links or Layer 3 routed EtherChannels. If you are using Cisco Catalyst 6500 VSS 4T system in the distribution layer, Cisco recommends that all peer-connected links are EtherChannel links. EtherChannel to the Catalyst 6500 VSS provides for optimal forwarding because a packet that is received on the switch will be forwarded out a link on that same switch in normal operation instead of traversing the VSL link.

Other benefits of EtherChannel to any single physical or logical device are that it makes it easier for you to grow bandwidth without changing the topology and that a single link failure uses EtherChannel recovery versus using ECMP or a routing topology change to reroute the data flows for fastest recovery.

Since the core links are point-to-point routed links, use 30-bit IP address subnets and masks and do not use Switched Virtual Interfaces (SVI).

Step 1: Configure the Layer 3 interface.

If you are using an EtherChannel to connect to a distribution layer platform, the interface type will be portchannel and the number must match the channel-group number you will configure in Step 2. When configuring a Layer 3 EtherChannel the logical port-channel interface is configured prior to configuring the physical interfaces associated with the EtherChannel.

```
interface [interface type] [number]
  description Link to {your device here}
  no switchport
  ip address [ip address] [mask]
  ip pim sparse-mode
  logging event link-status
  carrier-delay msec 0
  no shutdown
```

If the interface type is not a port-channel, then an additional command **macro apply EgressQoS** must also be configured on the interface.

Step 2: If you are connecting to the same distribution layer switch with multiple links, you can use a portchannel for added bandwidth over a single logical link. Configure the physical interfaces to tie to the logical port channel by using the **channel-group** command. The number for the port channel and channel group will match.

Also, apply the egress QoS macro that was defined in the platform configuration procedure to ensure traffic is prioritized appropriately.

Tech Tip

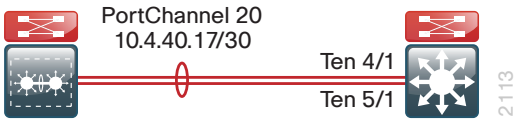
The Catalyst 6500 has two egress QoS macros, EgressQoS which is used for Gigabit Ethernet ports, and EgressQoSTenGig which is used for Ten Gigabit Ethernet ports. All other Cisco SBA distribution layer platforms have a single egress QoS macro that applies to Gigabit and Ten Gigabit Ethernet ports.

```
interface [interface type] [port 1]
  description Link to {your device here} port 1
interface [interface type] [port 2]
  description Link to {your device here} port 2
!
interface range [interface type] [port 1], [interface type]
[port 2]
  no switchport
  macro apply EgressQoS
  channel-protocol lacp
  channel-group [number] mode active
  logging event link-status
  logging event trunk-status
  logging event bundle-status
```

Step 3: Save the running configuration that you have entered so it will be used as the startup configuration file when your switch is rebooted or power-cycled.

```
copy running-config startup-config
```

Example




```
interface Port-channel 20
  description EtherChannel link to Distribution Switch
  no switchport
  ip address 10.4.40.17 255.255.255.252
  ip pim sparse-mode
  no shutdown
!
interface range TenGigabitEthernet 4/1, TenGigabitEthernet 5/1
  description EtherChannel link to Distribution Switch
  no switchport
  macro apply EgressQoSTenGig
  carrier-delay msec 0
  channel-group 20 mode on
  logging event link-status
  logging event trunk-status
  logging event bundle-status
  no shutdown
!
```

Appendix A: Product List

LAN Access Layer

Functional Area	Product Description	Part Numbers	Software
Modular Access Layer Switch	Cisco Catalyst 4507R+E 7-slot Chassis with 48Gbps per slot	WS-C4507R+E	3.3.0.SG(15.1-1SG) IP Base
	Cisco Catalyst 4500 E-Series Supervisor Engine 7L-E	WS-X45-SUP7L-E	
	Cisco Catalyst 4500 E-Series 48 Ethernet 10/100/1000 (RJ45) PoE+ ports	WS-X4648-RJ45V+E	
	Cisco Catalyst 4500 E-Series 48 Ethernet 10/100/1000 (RJ45) PoE+,UPoE ports	WS-X4748-UPOE+E	
Stackable Access Layer Switch	Cisco Catalyst 3750-X Series Stackable 48 Ethernet 10/100/1000 PoE+ ports	WS-C3750X-48PF-S	15.0(1)SE2 IP Base
	Cisco Catalyst 3750-X Series Stackable 24 Ethernet 10/100/1000 PoE+ ports	WS-C3750X-24P-S	
	Cisco Catalyst 3750-X Series Two 10GbE SFP+ and Two GbE SFP ports network module	C3KX-NM-10G	
	Cisco Catalyst 3750-X Series Four GbE SFP ports network module	C3KX-NM-1G	
Standalone Access Layer Switch	Cisco Catalyst 3560-X Series Standalone 48 Ethernet 10/100/1000 PoE+ ports	WS-C3560X-48PF-S	15.0(1)SE2 IP Base
	Cisco Catalyst 3560-X Series Standalone 24 Ethernet 10/100/1000 PoE+ ports	WS-C3560X-24P-S	
	Cisco Catalyst 3750-X Series Two 10GbE SFP+ and Two GbE SFP ports network module	C3KX-NM-10G	
	Cisco Catalyst 3750-X Series Four GbE SFP ports network module	C3KX-NM-1G	
Stackable Access Layer Switch	Cisco Catalyst 2960-S Series 48 Ethernet 10/100/1000 PoE+ ports and Two 10GbE SFP+ Uplink ports	WS-C2960S-48FPD-L	15.0(1)SE2 LAN Base
	Cisco Catalyst 2960-S Series 48 Ethernet 10/100/1000 PoE+ ports and Four GbE SFP Uplink ports	WS-C2960S-48FPS-L	
	Cisco Catalyst 2960-S Series 24 Ethernet 10/100/1000 PoE+ ports and Two 10GbE SFP+ Uplink ports	WS-C2960S-24PD-L	
	Cisco Catalyst 2960-S Series 24 Ethernet 10/100/1000 PoE+ ports and Four GbE SFP Uplink ports	WS-C2960S-24PS-L	
	Cisco Catalyst 2960-S Series Flexstack Stack Module	C2960S-STACK	

LAN Distribution Layer

Functional Area	Product Description	Part Numbers	Software
Modular Distribution Layer Virtual Switch Pair	Cisco Catalyst 6500 E-Series 6-Slot Chassis	WS-C6506-E	15.0(1)SY1 IP services
	Cisco Catalyst 6500 VSS Supervisor 2T with 2 ports 10GbE and PFC4	VS-S2T-10G	
	Cisco Catalyst 6500 16-port 10GbE Fiber Module w/DFC4	WS-X6816-10G-2T	
	Cisco Catalyst 6500 24-port GbE SFP Fiber Module w/DFC4	WS-X6824-SFP	
	Cisco Catalyst 6500 4-port 40GbE/16-port 10GbE Fiber Module w/DFC4	WS-X6904-40G-2T	
	Cisco Catalyst 6500 4-port 10GbE SFP+ adapter for WX-X6904-40G module	CVR-CFP-4SFP10G	
Modular Distribution Layer Switch	Cisco Catalyst 4507R+E 7-slot Chassis with 48Gbps per slot	WS-C4507R+E	3.3.0.SG(15.1-1SG) Enterprise Services
	Cisco Catalyst 4500 E-Series Supervisor Engine 7-E, 848Gbps	WS-X45-SUP7-E	
	Cisco Catalyst 4500 E-Series 24-port GbE SFP Fiber Module	WS-X4624-SFP-E	
	Cisco Catalyst 4500 E-Series 12-port 10GbE SFP+ Fiber Module	WS-X4712-SFP+E	
Stackable Distribution Layer Switch	Cisco Catalyst 3750-X Series Stackable 12 GbE SFP ports	WS-C3750X-12S-E	15.0(1)SE2 IP Services
	Cisco Catalyst 3750-X Series Two 10GbE SFP+ and Two GbE SFP ports network module	C3KX-NM-10G	
	Cisco Catalyst 3750-X Series Four GbE SFP ports network module	C3KX-NM-1G	

LAN Core Layer

Functional Area	Product Description	Part Numbers	Software
Modular Core Layer Switch	Cisco Catalyst 6500 E-Series 6-Slot Chassis	WS-C6506-E	15.0(1)SY1 IP services
	Cisco Catalyst 6500 VSS Supervisor 2T with 2 ports 10GbE and PFC4	VS-S2T-10G	
	Cisco Catalyst 6500 24-port GbE SFP Fiber Module w/DFC4	WS-X6824-SFP	
	Cisco Catalyst 6500 8-port 10GbE Fiber Module w/ DFC4	WS-X6908-10G-2T	

Appendix B: Changes

This appendix summarizes the changes to this guide since the previous Cisco SBA series.

- We combined into this guide the LAN deployment guidance formerly published in the following guides:
  - Cisco SBA for Midsize Organizations—Borderless Networks Foundation Deployment Guide
  - Cisco SBA for Enterprise Organizations—Borderless Networks LAN Deployment Guide
- We moved wireless LAN to a separate guide, the *Wireless LAN Deployment Guide*.
- For the Cisco Catalyst 6500 Series Switch, we did the following:
  - Updated QoS configurations for Catalyst 6500 to comply with newer IOS code versions.
  - Changed the QoS macro for Ten Gigabit Ethernet to EgressQoSTenGig.
  - Changed the QoS macro for Gigabit Ethernet to EgressQoS.
  - We tested the WS-X6904-40G-2T 40Gb/10Gb Ethernet module in the distribution layer for 10-Gb Ethernet access layer aggregation.
- For the Cisco Catalyst 4500 Series Switch, we updated QoS policy for access edge QoS policy to accommodate speeds from 10Mb, 100Mb, and Gigabit Ethernet connected devices.
- For the Cisco Catalyst 3750-X, 3560-X, and 2960-S Series Switches, we updated QoS policy for the Egress QoS macro to reference queue-set 1 to correct a configuration error.
- We updated centralized user authentication template to the newer method which allows IPv4 and IPv6 TACACS+ server definition. The older method will be deprecated from Cisco IOS overtime.
- In the distribution layer, we changed the **spanning-tree root primary** command to include all VLANs—for simplicity and reduced operational errors. You can do this because the design never passes Layer 2 VLANs beyond the distribution layer and the distribution layer should be the root for all connected access layer switches.
- Added more configuration examples and improved readability.

Notes

Feedback

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SMART BUSINESS ARCHITECTURE

Americas Headquarters
Cisco Systems, Inc.
San Jose, CA

Asia Pacific Headquarters
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