Cisco Catalyst 6500 in Borderless Networks

Introduction

What Is Borderless Networking?

Borderless networking is a set of technologies that span switching, routing, mobility, security, and application acceleration and promote service agility and business responsiveness, anywhere, any time, and to anyone. A borderless network is required to accommodate major trends that are reshaping the industry, touching many different aspects of the network. IT consumerization is driving new devices and new applications into the enterprise at an unprecedented rate. Mobility has enabled access to the network from a diverse set of devices. Organizations are taking in account their environmental responsibilities and are looking at optimizing their energy consumption. We are seeing tremendous adoption of everything delivered as service, driven by the cost advantage and flexibility it offers to an IT organization. Lastly, video is a powerful medium that is being used across enterprises for both internal and external applications.

Borderless Networking Requirements

Borderless enterprise requires a borderless network architected to meet these new needs. High-quality video traffic with devices such as Cisco TelePresence™ conferencing requires low delay, low jitter, and high-capacity transport. Smartphones can pose multiple security challenges when the border with the wireless provider is removed. Wireless devices also pose security and performances challenges. Saving energy at both the datacenter side and desktop side will require enforcing different sets of energy policies. Providing a highly dependable environment requires a set of functionalities that greatly reduce downtime during routine maintenance but also in case of unexpected failure.

Cisco Catalyst 6500 in a Borderless Network

The Cisco® Catalyst® 6500 is a versatile device that addresses the requirements of borderless networking. An higher level of available bandwidth is required to deliver video traffic, to carry data from collaborative applications, and to support virtualization within the data center. High-quality video and audio streams as well as other business-critical traffic should be prioritized adequately inside the network infrastructure, and a quality-of-service (QoS) strategy should be deployed. The Cisco Catalyst 6500 answers this challenge thanks to its hardware-accelerated QoS policies and queuing methodologies but also by providing traffic isolation at Levels 2 and 3. Inside a borderless network high availability should be provided to those new services to make them dependable. The Cisco Catalyst 6500 offers several levels of redundancy at both the hardware and software levels. Deployment, availability, and security concerns posed by wireless infrastructures are addressed by the dedicated wireless service module. The Cisco Catalyst 6500 is also capable of answering the challenges the next generation of IP protocols will pose and at another level the efficient usage of electrical resources.

QoS Requirement

To be able to support high-definition video, a minimum of 400 K buffering per port is required to minimize the effects of congestion. The latest generation of 10 Gigabit Ethernet cards for the Cisco Catalyst 6500 switch satisfies or exceeds this requirement.

The network latency is also an important factor; for example, the maximum latency required by Cisco TelePresence conferencing should not exceed 70 ms, and most of the Cisco Catalyst 6500 line cards provide a strict priority queue in transmit to minimize the latency effect otherwise incurred by the queuing process. The strict priority queue immediately assumes control of the scheduling process whenever a packet is placed into its queue.

The new 8-port and 16-port 10 Gigabit Ethernet line cards offer differentiated services code point (DSCP) based queuing; with DSCP-based queuing you can assign traffic to the available queue based on the 64 different DSCP values. This added granularity facilitates the support of new applications with various needs in priority, delay, and sensibility to loss.

Highly scalable QoS policies that can perform classification, marking, and policing to prevent congestion of sensible traffic are required. The Cisco Catalyst 6500 offers up to 32,000 access control entries in hardware.

In fact, the Cisco Catalyst 6500 PFC3B and higher perform all those operations in hardware to maximize switching performance and minimize latency for Cisco TelePresence conferencing and other sensible traffic. (See Table 1.)

Table 1. Buffers and Queues

Module	Transmit Buffer Size	Receive Buffer Size	Receive Queue Structure	Transmit Queue Structure	Queuing Assignment
WS-X6748	1.2 MB per port	166 KB per port	1Q8T (2Q8T with DFC)	1P3Q8T	COS/ToS
WS-X6724	1.2 MB per port	166 KB per port	1Q8T (2Q8T with DFC)	1P3Q8T	COS/ToS
WS-X6704	14 MB per port	2 MB per port	1Q8T (8Q8T with DFC)	1P7Q8T	COS/ToS
WS-X6708	128 MB per port	128 MB per port	8Q4T	1P7Q4T	COS/ToS/DSCP
WS-X6716	128 MB per 2 ports	128 MB per 2 ports	1P7Q2T	1P7Q4T	COS/ToS/DSCP
SUP720-10GE uplink	128 MB per 10GE port	128 MB per 10GE port	2Q4T	1P3Q4T	COS/ToS/DSCP
SUP720 uplink	432 KB per port	80 KB per port	1P2Q2T	1P1Q4T	COS/ToS

High Availability

The Cisco Catalyst 6500 is a highly dependable platform thanks to several levels of hardware and software redundancy.

Hardware Redundancy

The Cisco Catalyst 6500 chassis supports redundant power supplies, redundant fans, redundant supervisors, and redundant clocks. With the introduction of the “E” series chassis the redundancy has been extended to the out-of-band control system (EOBC), and the signal integrity has been improved to allow up to 80 Gb/s switching capacity per slot. The internal power rails have been enhanced to support a higher system power capacity (up to 8700W).

With the introduction of the Supervisor720-10G, the redundancy paradigm has been pushed to a new level with the virtual switching system (VSS). A VSS defines two physical Cisco Catalyst 6500 switches joined using a special link called a virtual switch link (VSL) that allows them to operate as a single logical switch.

Virtual Switching System

The Cisco Catalyst 6500 Series Virtual Switching System 1440 allows for the combination of two switches into a single, logical network entity from the network control-plane and management perspectives. To the neighboring devices, the Cisco Virtual Switching System appears as a single, logical switch or router.

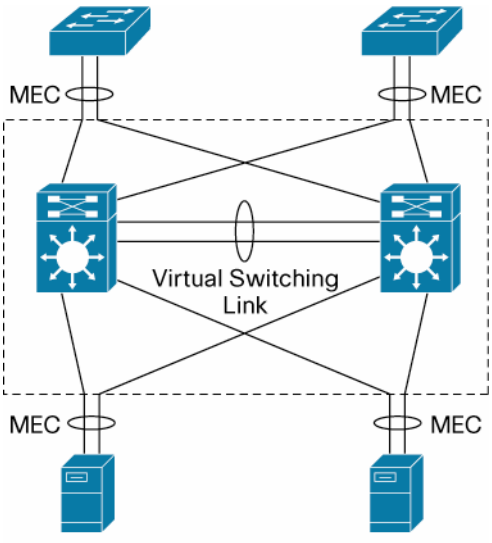
Within the Cisco Virtual Switching System, one chassis is designated as the active virtual switch, and the other is designated as the standby virtual switch. All control-plane functions, which include software data path functions are centrally managed by the active supervisor engine of the active virtual switch chassis. The supervisor engine on the active virtual switch is also responsible for programming the hardware forwarding information onto all the distributed forwarding cards (DFCs) across the entire Cisco Virtual Switching System as well as the policy feature card (PFC) on the standby virtual switch supervisor engine.

Cisco EtherChannel interfaces on the Cisco Catalyst 6500 platform represent a grouping of one or more physical ports into a single, logical port from the perspective of either a Layer 2 switching or Layer 3 routing environment.

With VSS the concept of EtherChannel has been extended to interfaces spanning more than a single physical switch, hence being referred to as Multichassis EtherChannel (MEC).

Cisco Virtual Switching System allows for the formation of this MEC link and allows all the dual-homed connections to and from the upstream and downstream devices to be configured as Cisco EtherChannel links, as opposed to individual links. As a result, MEC links allow for implementation of new network designs where true Layer 2 multipathing can be implemented without the reliance on Layer 2 redundancy protocols such as Spanning Tree Protocol. (See Figure 1.)

Figure 1. Multichassis Cisco EtherChannel Links



In an upcoming Cisco IOS® Software release, VSS 1440 will support up to two supervisors per chassis to provide highly available network connectivity and network bandwidth.

With a single supervisor in each switch, VSS 1440 will function at half its forwarding capacity within 300ms when faced with a supervisor failure.

With two supervisors in each switch, VSS 1440 will function at half its forwarding capacity within 300ms but will return to its full capacity forwarding state after the new active supervisor reloads.

Software Redundancy

Central to the high-availability function in the Cisco Catalyst 6500 are the concepts of Nonstop Forwarding (NSF) and Stateful Switchover (SSO); those concepts are applied to both single chassis with a redundant supervisor “intrachassis redundancy” but also to the Cisco Virtual Switching System “interchassis redundancy.”

In an SSO system, “high availability-aware” protocols and features synchronize events and state information from the active supervisor engine to the hot-standby supervisor engine. From a redundancy framework viewpoint, the active supervisor engine acts as a server, whereas the standby supervisor engine acts as the client. Information that is “high availability-aware” will be statefully synchronized between these entities such that in the event of a failover, the standby supervisor engine does not need to relearn this information, resulting in a minimal amount of outage time. If for any reason, an SSO switchover is invoked, the standby supervisor should assume the role of active supervisor in approximately 50ms.

Nonstop Forwarding (NSF) works in conjunction with SSO to help ensure Layer 3 integrity following a switchover. It allows a router experiencing the failure of an active supervisor to continue forwarding data packets along known routes while the routing protocol information is recovered and validated. Data-plane forwarding can continue to occur

even though peering arrangements with neighbor routers have been lost on the restarting router. NSF relies on the separation of the control plane and the data plane during supervisor switchover. The data plane continues to forward packets based on preswitchover Cisco Express Forwarding information. The control plane implements graceful restart routing protocol extensions to signal a supervisor restart to NSF-aware neighbor routers, giving it time to rebuild its neighbor adjacencies and its routing protocol database following a switchover.

An *NSF-capable* router implements the NSF functionality and continues to forward data packets after a supervisor failure.

An *NSF-aware router* understands the NSF graceful restart mechanisms: it does not tear down its neighbor relationships with the NSF-capable restarting router and can help a neighboring NSF-capable router restart thus avoiding unnecessary route flaps and network instability. An NSF-capable router is also NSF-aware.

For more information on NSF/SSO, visit
http://www.cisco.com/univercd/cc/td/doc/product/lan/cat6000/122sx/swcg/nsfsso.htm.

In-Service Software Upgrade

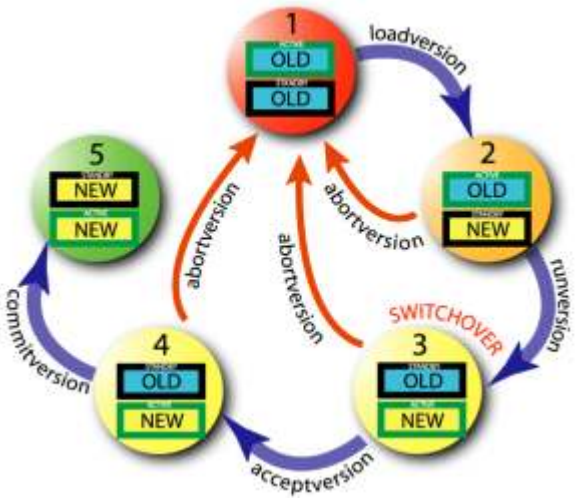
The combinations of NSF/SSO with inter- or intrachassis redundancy allows Cisco to deliver the first phase of In-Service Software Upgrade (ISSU) framework named Enhanced Fast Software Upgrade (EFSU).

Before EFSU, software upgrades required system downtime, because a software version mismatch between the active and the standby supervisor engines forces the system to boot in Route Processor Redundancy Mode (RPR), which is stateless and causes a hard reset of the all modules.

With EFSU, software is loaded onto the standby supervisor engine while the active supervisor engine continues to operate using the previous software. After the upgrade, the standby processor reaches the SSO standby hot stage. When the switchover occurs, and the upgraded standby becomes active, the line cards only undergo a warm reset, which takes less time. The upgrade procedure is finished after the new standby supervisor is upgraded.

The EFSU process follows the new ISSU set of CLI to facilitate the process (see Figure 2).

Figure 2. EFSU Process



For more information on EFSU, visit
http://www.cisco.com/en/US/docs/switches/lan/catalyst6500/ios/12.2SX/configuration/guide/issu_efsu.html.

EFSU is available for both VSS system and standalone system with redundant supervisor, with VSS the EFSU process has a smaller effect on adjacent nodes connected with a multichassis EtherChannel.

High-Capacity Switching Modules

The variety of network applications used in borderless network, including softphone for mobile workers and collaborative application with interactive video such as Cisco WebEx have driven the need of higher bandwidth, together with the availability of Gigabit Ethernet on laptop and desktop systems there is a need to provide gigabit connection to the end user.

The Cisco Catalyst 6500 answers that need with the WS-X6748, a fabric-attached line card that can be equipped with a centralized forwarding card (CFC) or the third generation of distributed forwarding card (DFC3B) for enhanced performance. The WS-X6748 takes full advantage of the 40 Gb/s fabric connection provided by both the Sup720 and the Sup720-10G. When equipped with the DFC3B all Layer 2 and Layer 3 forwarding decisions are performed at the line-card level, and a distributed system can operate at speed up to 400 Mpps, with CFC the forwarding decision is still made at the supervisor level, and the maximum performance will be up to 30 Mpps.

New servers that host multiple virtual machines are driving the need for 10 Gigabit Ethernet connectivity inside the data center; in the campus the Cisco Catalyst 6500 can be used to aggregate multiple 10 Gigabit Ethernet uplinks from access-level switches.

The WS-X6708 and the WS-X6716 are two line cards designed to fulfill the need for 10Gb connectivity both at the data center level and within the campus. They are both equipped with the newer DFC3C forwarding engine; the DFC3C is required to enable VSS.

The WS-X6708 provides 8 ports operating at 10 Gb/s using the X2 transceiver. When all 8 ports are enabled, the line card has an oversubscription ratio of 2:1 between the network-facing ports and the fabric connection. For more demanding environments, the card can be configured in performance mode; when activated 4 ports will be disabled and the oversubscription is removed.

With its deep buffers (see Table 1) the WS-X6708 is particularly effective in the most demanding environments, where up to 100 ms of buffering can be required.

The WS-X6716 provides 16 ports operating at 10 Gb/s using the X2 transceiver, with a 4:1 oversubscription ratio the WS-X6716 fits in environment where 10 Gb/s connectivity and high port density is required. Those environments include large access switches aggregation or large data center.

Security

When network boundaries are removed, users can access network resources from anywhere outside the well-controlled campus network with a variety of devices such as smartphones through a variety of gateways. Access has been so far limited to the user, not the user's location; as a result, encryption as well as strong authentication methods are now required, especially if the end user requests sensitive materials over unreliable networks. The Cisco Catalyst 6500 can integrate high-speed encryption modules such as the SSC-600, which is capable of time encryption with gigabit-level performance.

Within the campus resources may be shared with a variety of different user types; a flexible Identity style authentication system needs to be set in place to satisfy those different user types. The Cisco Catalyst 6500 supports identity-based authentication with Flexible Authentication (Flex Auth). Combined those methods allow the association of different classes of user with different authentication methods and place those users in an independent virtual network structure (see Network Virtualization chapter). As an example, a temporary worker could be authenticated using a web-based authentication method and subsequently associated with a specific virtual network, preventing that worker to access any corporate content. A regular employee will be authenticated using 802.1X and placed into a different virtual network with a greater access to corporate resources.

Wireless Access

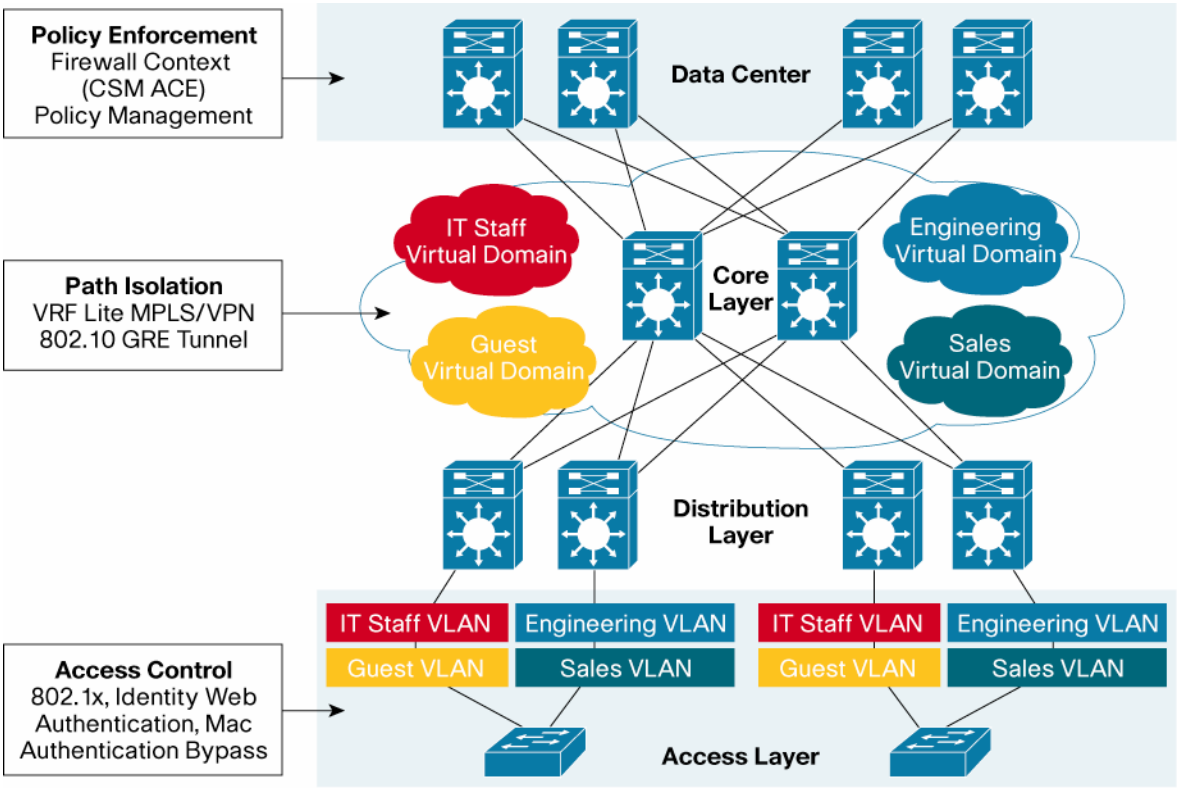
Wireless devices have their own set of challenges, notably a secure connection through shared media. The Wireless Switching Module (WiSM) makes wireless deployment easier and greatly enhances the wireless experience. The WiSM is compatible with the latest 802.1N draft and can support up to 10,000 clients per module. The WiSM relies on the Lightweight Access Point Protocol (LWAPP) to provide secure Layer 2 access from the access point to the Cisco Catalyst 6500 switch across a Layer 3 network. LWAPP also provides the capability to end devices to maintain their association transparently from one access point to another, and with little latency. The WiSM also provides Radio Resource Monitoring (RRM); this feature automatically detects and configures new lightweight access points as they are added to the network, and it also configure their radio channel and optimizes the radio power of nearby lightweight access points. RRM produces a network with optimal capacity, performance, and reliability without the cost of laborious historical data interpretation and individual lightweight access point reconfiguration. The WiSM supports the most robust Layer 2 security standards and supports both local and RADIUS-based authentication. Security can be further enhanced by using Layer 3 security solutions such as passthrough VPNs. Finally, the WiSM is capable of functioning in redundant mode across two Cisco Catalyst 6500 chassis.

Virtualization

With the vast variety of applications but also the vast variety of profiles that can access the networks, a high level of traffic separation needs to be applied at both Layer 2 and Layer 3 levels. Network virtualization is not new and has been widely applied at Layer 2 with the utilization of VLANs and private VLANs, but when deploying network virtualization end-to-end, the three main components need to be addressed accordingly (Figure 3).

- **Network access control and segmentation of classes of users**: This component identifies users who are authorized to access the network and then places them into the appropriate logical partition.
- **Path isolation**: This component maintains traffic partitioned over a routed infrastructure and transports traffic over and between isolated partitions. The function of mapping isolated paths to VLANs and to virtual services is also performed in this component.
- **Network services virtualization**: This component provides access to shared or dedicated network services such as address management (DHCP) and Domain Name System (DNS). It also applies policy per partition and isolates application environments, if required.

Figure 3. Cisco Network Virtualization Architecture



EnergyWise

The Cisco Catalyst 6500 switch can help distribute and control power to a variety of connected appliances such as wireless access point, IP video camera, IP phone, and so on that support the Power over Ethernet (PoE) standard and its derivatives.

The control of power delivery leads Cisco to create the EnergyWise concept; EnergyWise goal is to manage a disparate set of systems that control power in an enterprise building with a common view and set of policies.

Within EnergyWise the switches and their connected devices becomes entities that possess a unique identification. EnergyWise entities can have lateral (neighbor to neighbor) or hierarchical (parent to child) relations established between them (for example, an IP phone attached to a PoE switch).

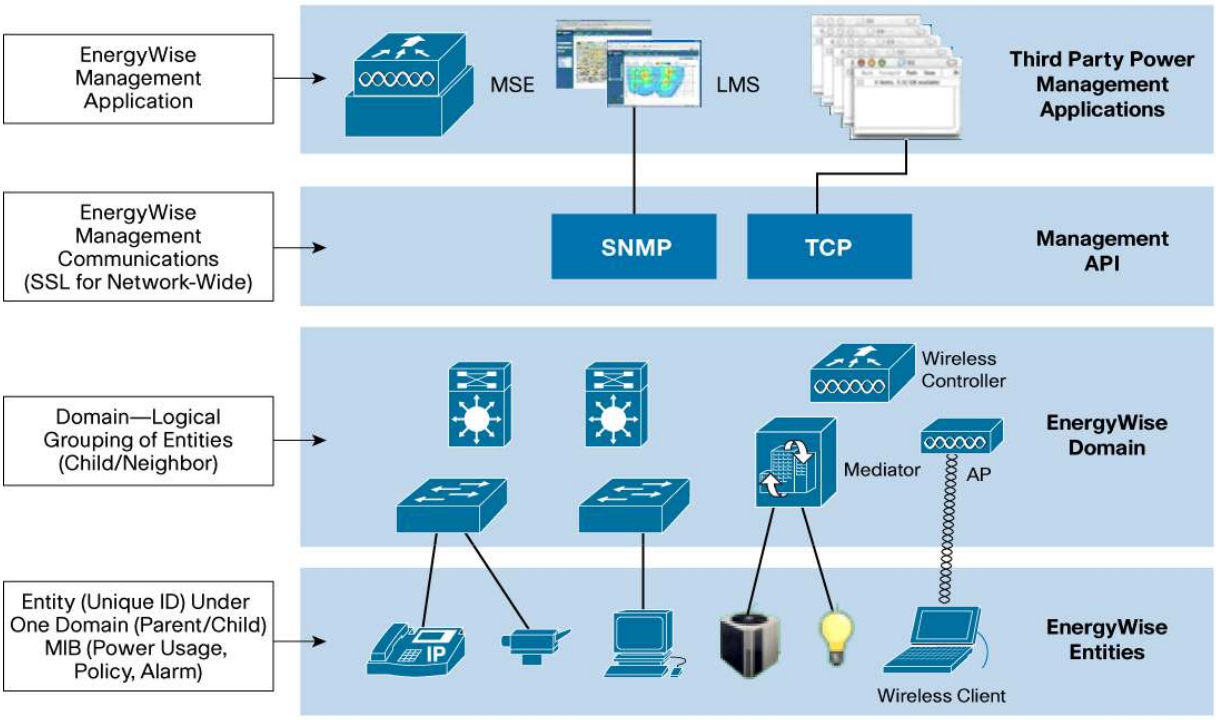
EnergyWise entities can become members of EnergyWise domains. Within the domain all members are visualized as units of power consumption. An additional Importance parameter creates differentiation between members inside a domain. Within the domain security features are enabled that authenticate the communication between members.

Query and set events can be used to retrieve information from members or to control them. Those events can be propagated throughout the network and can be answered by members individually or by proxy.

Graphical managers such as CiscoWorks LMS for EnergyWise or SolarWinds Orion are available application that can help with the configuration, reporting, and analysis of domains and their members. Cisco EnergyWise is designed as an extensible platform and will provide an open API to help integrate future devices, network applications, and management.

EnergyWise can promote companywide sustainability by reducing energy consumption across an entire corporate infrastructure and affecting more than 50 percent of global greenhouse gas emissions created by worldwide building infrastructure. (See Figure 4.)

Figure 4. EnergyWise



Moving Ahead to IPv6

With the availability of IPv4 addresses reaching an end, a number of solutions have been set in place, like Network Address Translation (NAT), that attempt to overcome the address space limitations, but NAT creates a lot of challenges when used for bidirectional communication required for voice and video.

The next-generation Internet Protocol, IPv6, has been designed to remediate several limitations that are present in IPv4. The most important one is the limited number of available addresses. IPv6 quadruples the number of network address bits from 32 bits in IPv4 to 128 bits. In addition to the large address space, IPv6 offers a large number of advantages over IPv4 like:

- Stateless and stateful autoconfiguration mechanism
- Better bandwidth utilization by using multicast and anycast in place of broadcast
- Better support for mobile application with the support of anycast
- Better QoS granularity with the use a flow class
- Unified security framework
- Faster handover, route optimization, and hierarchical mobility

The transition from IPv4 to IPv6 is not obvious and will require time and careful planning, but the Cisco Catalyst 6500 can be a primary component that can provide a smooth transition from IPv4 to IPv6.

The Cisco Catalyst 6500 supports dual-stack IPv4 and IPv6 and uses hardware-accelerated forwarding performance and benefits from a rich IPv6 features set. The Cisco Catalyst 6500 has been awarded the IPv6 Phase 2 Certification by the IPv6 forum (http://www.ipv6ready.org/).

Conclusions

With the deployment of new network architecture, there is a need for a versatile device flexible enough to satisfy the challenges of the new borderless infrastructure. The Cisco Catalyst 6500 offers a rich set of features that satisfy the security requirements, the power budget constraint, and the availability of numbers while performing virtualization, IPv6 forwarding, and quality of services at hardware speed.

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