Cisco Catalyst 3850 Series Switches StackWise-480 Architecture
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The network access model in the enterprise campus has evolved remarkably from basic connectivity to an intelligent, powerful, and high-speed building block. A broad set of Cisco® innovations have been developed to address next-generation business demands. Enterprise IT staff are empowered to transition new, collaborative workspace technologies such as video, pervasive mobility, and the evolutionary Internet of Things (IoT) into cost-effective, connected network infrastructure with more IP-enabled intelligent devices.

Wireless technology is the industry’s new megatrend, and it presents a multi-dimensional challenge to the enterprise IT organizations. This swiftly growing technology, with exponentially increasing numbers of mobile devices with high-performance demands, is rapidly changing the landscape of network infrastructure and its reliability. IT requires involuntary re-assessment of traditional network models and assembly of network designs that can respond with a broad set of evolutionary architectures.

The traditional IEEE 802.11 standards are proven, traditional WLAN technologies; however, with a market transition toward high-density mobility with next-generation business applications, it is imperative for advanced wireless technologies to meet future demands. The IEEE is ratifying multi-phase 802.11ac development to accelerate application performance at multi-Gigabit throughput with many benefits.

As wired and wireless Gigabit evolution begins at the access layer, user and application demands will increase to high-speed, low-latency data switching for optimal performance. Cisco has built a system architecture to support such innovations. Cisco Catalyst® 3850 Series Switches are next-generation, campus access-layer switches that were developed to support the next evolution. The Catalyst 3850 is completely revamped, with internal hardware architecture from previous-generation products to support high-performance wired and wireless switching load in converged access designs.
Next-Generation Cisco StackWise-480 System Architecture

New Cisco Stack Design for Catalyst 3850 and 3650 Series Switches

The fixed configuration Cisco Catalyst 3750-X Series Switches introduced stacking architecture to expand form factors, switching capacity, and redundancy in the wiring closet. Cisco StackWise® Plus Technology is a proven and widely deployed, cost-effective solution that provides a pay-as-you-grow model. More importantly, it delivers performance, resiliency, and operational simplicity. The hardware and software architecture of the Catalyst 3750-X was designed based on its predecessor, Catalyst 3750-E Series Switches, which double the backplane throughput from 32 Gbps to 64 Gbps with spatial-reuse technology. The application-specific integrated circuit (ASIC) capability in the Catalyst 3750-X Series is limited to meet future application, scale, and performance demands.

The stack switching architecture of new Cisco Catalyst 3850 and 3650 switches are completely re-designed, and represent a major shift in performance and reliability with new hardware and software capabilities. The fundamental reason for deploying stacking does not change with Catalyst 3850 and 3650 switches. The primary factors of cost and operation remain the same, however, new Cisco innovation introduces many new capability options to build next-generation network architecture. The Catalyst 3850 and 3650 are built upon the next-generation Cisco Unified Access™ Data Plane (UADP) ASIC. This technology is flexible, modular, and evolutionary, and it delivers Cisco IOS® Software feature capabilities with hardware acceleration to every port.

This document is primarily focused on the Cisco StackWise architecture for Catalyst 3850 Series Switches. The Catalyst 3650 switch is built using the same UADP ASIC, uses the same operating system - Cisco IOS-XE - and supports the same StackWise architecture with the same set of features. The Cisco Catalyst 3650 requires a stacking kit that includes two data stack adapters and one stacking cable per switch to enable stacking. This stacking kit is optional and can be ordered separately. The stacking module has another form factor and terminates only one stacking cable with 40-Gbps bandwidth for each direction (the Catalyst 3850 stack port terminates three 40-Gbps bandwidth cables for each direction). Hence, StackWise-480 for Catalyst 3850 and StackWise-160 for Catalyst 3650 are not compatible. StackWise for Catalyst 3650 offers a stacking bandwidth of only 160 Gbps non-blocking.

Scalable StackWise-480 Architecture

Catalyst 3850 Series Switches are supported in three different form factor models: 48 ports 10/100/1000, 24 ports 10/100/1000, and 12/24 Ethernet small form-factor pluggable (SFP) ports. The hardware design of each model is cost-effective to support different network capacity load and switching performance. For consistent converged access capabilities with rich Unified Access network services in the wiring closet, the software parity remains common in Catalyst 3850 switch models. The new StackWise-480 architecture builds high-speed, 480 Gbps per stack switch member in the stack ring. This speed is much higher than the traditional StackWise Plus design in the Catalyst 3750X Series platform.

The Cisco IOS XE 3.3 software release brings parity of the nine-members-switch-stack capability that can be physically connected in a ring to form a single, unified, virtual stack system. Depending on the port density requirement in each stack switch, the Catalyst 3850 hardware provides flexibility for mix-mode support between 48-, 24-, and 12-port systems in single stack ring. The Catalyst 3850 deployed in stack mode is designed to deliver deterministic and non-blocking switching performance for up to 468 ports, including wired and wireless network devices. The switching performance delivers hardware-accelerated, integrated borderless network services such Power over Ethernet (PoE) and PoE Plus, quality of service (QoS), access control lists (ACLs), Flexible Netflow, and many more services on every port.
StackWise-480 supports a mixed stack of any Catalyst 3850 models (48 ports 10/100/1000, 24 ports 10/100/1000, and 12/24 Ethernet SFP ports; see Figure 1). You can mix the switches with different number of access ports (48, 24, and 12), different type of access ports (copper and fiber, PoE, and non-PoE-capable), and different network modules. But all switches in one stack must have the same version of IOS XE and the same feature set license. A mixed stack of LAN base switches with IP base or IP services is not supported. Catalyst 3850 Series Switches with a LAN base feature set can only stack with other Catalyst 3850 Series LAN base switches. The same applies to IP base and IP services as well.

**Figure 1.** Catalyst 3850 StackWise-480 Technology

Next-Generation Cisco ASIC Technology

The Catalyst 3850 switch is completely redesigned with Cisco industry-leading UADP ASIC technology to meet future demands without major cost restructure. The new Cisco ASIC delivers deep analysis of various application characteristics, network demands, scale, and performance for next-generation networks. The Cisco UADP ASIC provides superior investment protection because it can seamlessly support future innovations such as software-defined networking (SDN) with the powerful Cisco IOS-XE software architecture.

The fundamental architecture and capabilities of the Cisco UADP ASIC in the Catalyst 3850 switch are phenomenally different from its predecessor, the Catalyst 3750-X Series Ethernet switches. The Cisco UADP ASIC is flexible for development of new technologies and is an ideal solution for evolving next-generation enterprise networks without major re-investment. The foundation of Catalyst 3850 is built on the Cisco UADP ASIC. This ASIC continues the stack architecture momentum and integrates the next-generation application demands at multi-fold scalability delivering superior performance.

Primary benefits of the Cisco UADP ASIC for the Catalyst 3850 switch:

- **Performance** - Designed to allow for an architectural shift from a centralized unified wireless network (CUWN) to a new, distributed, converged access wireless networking model. The Cisco Converged Access solution included with the Catalyst 3850 helps customers to build a solid network foundation with increased port-density and non-blocking switching performance ranging from 10 Mbps to 10 Gbps. The distributed wired and wireless architecture with solid performance provides investment protection as enterprise networks evolve with new innovations such as IEEE 802.11ac.
• **Integrated rich technologies** - Optimize wired or wireless user applications and network performance with hardware-accelerated and integrated Cisco IOS Software technologies, such as deep packet inspection using Application Visibility and Control (AVC) and Flexible Netflow. The Catalyst 3850 is a cost-effective product to natively implement the advanced features such as Flexible Netflow across all physical ports at wire speed.

• **Flexibility** - The modularized and multi-threaded software design with next-generation Cisco IOS XE Software provides the capability to fully utilize distributed system hardware and network resources. Cisco IOS XE software operates transparently over the underlying Linux operating system to help enable flexibility to host services and integrated Cisco applications such as Cisco IOS Software, Cisco Wireless Control Systems, and open-source or third-party application such Wireshark.

• **Total cost of ownership** - The high-performance hardware ASIC with intelligent software capability of the Catalyst 3850 introduces cost-effective and simplified services integration in branch and campus access-layer networks. Depending on scale, Catalyst 3850 switches can be deployed in converged access mode to terminate wired and wireless endpoints without deploying Cisco wireless LAN controllers (WLCs).

• **Intelligence** - The new Cisco UADP ASIC architecture is flexible in design to optimally perform forwarding decisions. The Catalyst 3850 switch provides granular forwarding decisions for wired or wireless users based on device profile, user identity, and deep application lookups without compromising scale and performance.

In delivery of non-oversubscribed switching performance between various Catalyst 3850 form factor switches, the integrated UADP ASIC count is different. The 48-port series is equipped with dual UADP ASICS to serve wire-rate switching performance across all 48 front-panel ports and all four 1/10 Gb uplink ports of a pluggable network module. The 24-port series delivers the same performance across all 24 front-panel and all four 1-Gb or two 10-Gb uplink ports of a pluggable network module.

Figure 2 illustrates the UADP ASIC architecture difference between Catalyst 3850 24- and 48-port switches.

**Figure 2.** A Catalyst 3850 Switch’s Internal ASIC Architecture
High-Speed Stacking Throughput

The internal hardware layer in the Cisco Catalyst 3850 is fully redesigned compared to earlier Catalyst 3750-X Series Switches. When the Catalyst 3850 switch is operating in a counter-rotating physical ring network design it can deliver high-speed performance throughput of 480 Gbps by each stack-member switch. This multi-fold performance improvement is possible by combining the new internal ASIC and dual stack ports.

The high-speed backplane of the Catalyst 3850 stack-ring fabric is constructed by daisy-chaining the stack-member switches with Cisco proprietary cables that connect rear-side stack ports. The Cisco stack fabric consists of multiple uni-directional data transmission rings. The aggregated throughput that a stack of switches support is a combination of two major factors:

- **Total transmission rings** - Each stack connector bundles multiple individual cables that carry data across the stack ring. The new interface and cabling structure with StackWise-480 increases the number of stack rings to three-fold support, compared to traditional StackWise Plus Technology. This new hardware design significantly improves the data transmit performance of each stack port of the Catalyst 3850.

- **Maximum throughput per ring** - In addition to an increased number of internal stack-ring transmission cables, the maximum throughput of each cable that can transmit data is further increased to 40 Gbps. This can enable an aggregated throughput from each stack port of up to 240 Gbps (up to 480 with Spatial Reuse Protocol [SRP]). The Catalyst 3850 makes the network design compatible with future versions to optimally utilize backplane capacity up to 7.5 times higher than StackWise Plus.

Table 1 describes the major stacking architectural differences and benefits between the Catalyst 3850 StackWise-480, Catalyst 3650 StackWise-160, and StackWise Plus on Catalyst 3750-X switches.

### Table 1. Cisco StackWise Architecture Comparison

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Stack ports per switch</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Ring per stack port</td>
<td>6</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Throughput per ring (bi-directional)</td>
<td>40 Gbps</td>
<td>40 Gbps</td>
<td>16 Gbps</td>
</tr>
<tr>
<td>Throughput per stack port/ASIC</td>
<td>240 Gbps</td>
<td>80 Gbps</td>
<td>32 Gbps</td>
</tr>
<tr>
<td>Throughput per switch (dual stack ports) with SRP</td>
<td>480 Gbps</td>
<td>160 Gbps</td>
<td>64 Gbps</td>
</tr>
</tbody>
</table>

To retain the overall stack software architecture in StackWise-480 and StackWise-160, the fundamental mechanism of the overall stack-ring design is consistent with StackWise Plus. When Catalyst 3850 and 3650 switches are deployed in the stacking mode the control plane dynamically detects the neighboring switch, performs a compatibility check, and allows online switch insertion and removal from the stack ring without causing network disruption. The control and data path development process is handled by single switch within the stack, however with the distributed forwarding architecture each stack member switch dynamically selects the stack port to forward the traffic.
Figure 3 provides a graphical illustration of the Catalyst 3850 StackWise-480 internal forwarding architecture.

**Figure 3.** Catalyst 3850 StackWise-480 Internal Forwarding Architecture

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**Unified System Operation**

The system architecture of the Cisco Catalyst 3850 is designed for evolutionary, converged wired and wireless infrastructure and other, major industry-trending technologies such as SDN. As the network expands with new technologies, IT staff need simplified and scalable approaches to manage complex network solutions.

Cisco StackWise Technology provides a pay-as-you-grow model that allows IT to expand according to port-density demands without network operation complexity. Starting from Cisco IOS-XE 3.3 software release version, the single, unified stack of the Catalyst 3850 can physically group up to nine switches to simplify network operation and topologies. The software system management architecture and the network control plane process are aligned with Cisco modular Catalyst switching systems such as Catalyst 4500E and 6500E.

The Cisco StackWise-480 provides a robust, distributed forwarding architecture through each stack member switch. In parallel with the fully centralized control and management plane, it simplifies operations in a large-scale wiring closet network design. From the stack ring a single switch is elected into the ACTIVE role that centrally manages the management plane of the entire stack from a network and user perspective. Figure 4 shows physical and logical views of a system in stack configuration mode.

**Figure 4.** Simplified Cisco Catalyst 3850 Physical and Logical Views

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The system roles in the resilient StackWise-480 architecture can be verified using a consistent command-line interface (CLI) as a traditional stack model.
The network administrator can identify the current state of each stack-member switch in the stack ring and identify the STANDBY switch, which in HOT-STANDBY mode will transition into the ACTIVE role upon detecting failure of the primary ACTIVE switch.

```
3850-Stack# show switch
Switch/Stack Mac Address : 2037.06ce.0c00
Mac persistency wait time: Indefinite
```

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>Version</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Member</td>
<td>2037.06ce.0c40</td>
<td>1</td>
<td>P6A</td>
<td>Ready</td>
</tr>
<tr>
<td>*2</td>
<td>Active</td>
<td>2037.06ce.0c00</td>
<td>15</td>
<td>P6A</td>
<td>Ready</td>
</tr>
<tr>
<td>3</td>
<td>Standby</td>
<td>2037.064d.2000</td>
<td>14</td>
<td>P6A</td>
<td>Ready</td>
</tr>
<tr>
<td>4</td>
<td>Member</td>
<td>2037.06ce.0c80</td>
<td>1</td>
<td>P6A</td>
<td>Ready</td>
</tr>
</tbody>
</table>

**Plug-N-Play Stack Deployment**

One flexible option the stack architecture offers is that it allows network expansion when a higher number of port counts is required in the wiring closet. The hardware and software architecture of the Catalyst 3850 continues to provide backward compatibility to dynamically insert a new Catalyst 3850 switch in the stack ring without major network disruption. The system and management operation, network configuration, and topologies remain transparent for network upgrade and non-stop business communication.

The Cisco IOS-XE high-availability framework is by default enabled on Catalyst 3850 switches when deployed in StackWise-480 mode. The newly provisioned Catalyst 3850 switch automatically discovers and dynamically joins the stack ring. Key, system-level N1 high availability that Cisco StackWise-480 offers can enable flexibility to dynamically roll SSO ACTIVE or HOT-STANDBY roles between any systems deployed in a stack ring.

To enable such multi-system resiliency in the StackWise-480 architecture, the network administrator must make sure each system is deployed with a common Cisco IOS XE Software version and license. Figure 5 illustrates the new system roles and operation of StackWise-480 when modularizing Catalyst 3850 switches with a stack cable.

**Figure 5.** Plug-n-Play Catalyst 3850 System Role Designation

The unique high-availability architecture in the StackWise-480 design can enable the ability to load share and to provide system-level redundancy with any stack-member switches.
To determine the single ACTIVE and STANDBY switch role during the complete stack reboot process, all switches are required to go through an election process. Several criteria, such as switch priority and MAC addresses, are compared to elect single ACTIVE and STANDBY switching in the stack ring.

For deterministic system role election it is recommended to adjust the default switch priority for all stack switches. This configuration step is a one-time process and it may be altered at any time, but it is typically done during the initial switch configuration process. The switch priorities are immediately set in ROMMON configuration for each individual switch in the stack ring. The switch priority configuration from ROMMON is parsed during the boot cycle instead of reading from the startup-configuration stored in NVRAM.

Thus, the switch priority configuration cannot be verified from startup or the running configuration as it is programmed into a different configuration component. This Catalyst 3850 software design is consistent with the Catalyst 3750-X switch.

However, the Catalyst 3850 introduces new implementation changes for this CLI. The network administrator must modify the default switch priority and switch number from EXEC mode instead of from global configuration mode. Table 2 outlines the implementation difference between the Catalyst 3850 and 3750-X switches.

Table 2. Implementing a Switch CLI Between Catalyst 3850 and Catalyst 3750-X Switches

<table>
<thead>
<tr>
<th>Catalyst 3850</th>
<th>Catalyst 3750-X</th>
</tr>
</thead>
<tbody>
<tr>
<td>3850&gt;enable</td>
<td>3750-X-enable</td>
</tr>
<tr>
<td>3850#switch &lt;number&gt; priority 15</td>
<td>3750-X(config)#switch &lt;number&gt; priority 15</td>
</tr>
<tr>
<td></td>
<td>!Set priority 15 to elect switch in ACTIVE role</td>
</tr>
<tr>
<td>3850#switch &lt;number&gt; priority 14</td>
<td>3750-X(config)#switch &lt;number&gt; priority 14</td>
</tr>
<tr>
<td></td>
<td>!Set priority 14 to elect switch in STANDBY role</td>
</tr>
<tr>
<td>3850#switch &lt;number&gt; priority 13</td>
<td>3750-X(config)#switch &lt;number&gt; priority 13</td>
</tr>
<tr>
<td></td>
<td>!Set priority 13 to elect switch in next STANDBY role</td>
</tr>
<tr>
<td>3850#switch &lt;number&gt; priority 12</td>
<td>3750-X(config)#switch &lt;number&gt; priority 12</td>
</tr>
<tr>
<td></td>
<td>!Set priority 12 to elect switch in next STANDBY role</td>
</tr>
<tr>
<td>3850&gt;enable</td>
<td>3750-X-enable</td>
</tr>
<tr>
<td>3850#switch &lt;number&gt; renumber &lt;number&gt;</td>
<td>3750-X(config)#switch &lt;number&gt; renumber &lt;number&gt;</td>
</tr>
<tr>
<td></td>
<td>!Statically renumber switch in stack-ring</td>
</tr>
</tbody>
</table>

3850-Stack# show switch
Switch/Stack Mac Address : 2037.06ce.0c40
Mac persistency wait time: Indefinite

<table>
<thead>
<tr>
<th>Switch#</th>
<th>Role</th>
<th>Mac Address</th>
<th>Priority</th>
<th>Version</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>2037.06ce.0c40</td>
<td>15</td>
<td>P6A</td>
<td>Ready</td>
</tr>
<tr>
<td>*2</td>
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<tr>
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<td>2037.064d.2000</td>
<td>13</td>
<td>P6A</td>
<td>Ready</td>
</tr>
<tr>
<td>4</td>
<td>Member</td>
<td>2037.06ce.0c80</td>
<td>12</td>
<td>P6A</td>
<td>Ready</td>
</tr>
</tbody>
</table>
Unified Control and Management Plane Architecture

The Layer 2 and Layer 3 network control protocol processing on the Catalyst 3850 switch is fully centralized for all of the member switches. The new control-plane software design on the Catalyst 3850 is changing with the next-generation Cisco IOS XE operating system and modular-class, high-availability architecture. The Catalyst 3850 is fundamentally aligned with modular systems to help enable centralized, resilient control and management plane operation on the ACTIVE switch. The new software design control-plane handling procedure is changing the fundamental way that hybrid control plane processing is done in Catalyst 3750-X-based StackWise Plus systems.

Table 3 details the control plane processing differences between Catalyst 3750-X StackWise Plus and Catalyst 3850 StackWise-480 technologies.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 2 network</td>
<td>MAC learning</td>
<td>Distributed</td>
<td>Centralized</td>
</tr>
<tr>
<td></td>
<td>Spanning Tree Protocol (SPT)</td>
<td>Distributed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cisco Discovery Protocol (CDP)</td>
<td>Centralized</td>
<td></td>
</tr>
<tr>
<td></td>
<td>VLAN database</td>
<td>Centralized</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EtherChannel - Port Aggregation Protocol Plus (PAgP+) and Link Aggregation Control Protocol (LACP)</td>
<td>Centralized</td>
<td></td>
</tr>
<tr>
<td>Layer 3 network</td>
<td>Layer 3 management (SNMP, Telnet, Syslog, etc.)</td>
<td>Centralized</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Layer 3 routing (Enhanced Interior Gateway Routing Protocol [EIGRP], Protocol Independent Multicast [PIM], etc.)</td>
<td>Centralized</td>
<td></td>
</tr>
</tbody>
</table>

The centralized control and management plane with high-speed distributed forwarding architecture is proven on modular systems. Taking full advantage of the same fundamentals in the new StackWise-480 design helps to enable consistent user experience, simplifies the operation, and builds a resilient control plane for non-stop network communication. The ACTIVE switch in the StackWise-480 ring communicates with neighboring peer devices to dynamically discover and build network routing and switching topologies. And with a unified management plane the entire StackWise-480 network becomes virtualized and represented by the ACTIVE switch as one single logical switch.

When a Catalyst 3850 switch detects a new switch joining through stack ports it automatically enables control-plane redundancy without any type of user intervention. The Layer 2 or Layer 3 protocol state machines are automatically synchronized on the HOT-STANDBY switch in the stack to provide stateful redundancy. All switches in the stack ring transparently forward the network control and management traffic to the ACTIVE switch for centralized processing.

Software Auto-Upgrade Best Practices

The software resiliency in Cisco Catalyst 3850 and 3650 switches is based on the Cisco IOS Software high-availability framework when these switches are stacked together in StackWise mode. These next-generation fixed-configuration switches support 1+1 high-availability SSO functions in modular-class platforms such as the Catalyst 4500E switch. Thus, it is imperative to have consistent Cisco IOS Software and licenses installed on the switches of each stack member to provide 1+1 as well as N:1 ACTIVE stack system redundancy.

If a new Catalyst 3850 or 3650 switch running an inconsistent software version joins the stack ring with the current running version, then that switch will force the stack ring down to a route processor redundancy (RPR) state. In such a state the system remains completely down.
As a best practice, the newly joined switch can automatically receive consistent software versions from an ACTIVE switch and bring the system online without any user intervention. To automatically download consistent software versions to newly joined switches you can use this command from global configuration mode:

```
3850-Stack# software auto-upgrade enable
```

**Modular System Design and Operation**
The new StackWise-480 is fundamentally designed to function similar to modular systems. In stacking architectures the stack-port interfaces can be classified as system internal ports between ACTIVE and member switches. This hardware design provides flexibility and modularity to network administrators to dynamically add a new member switch in the ring as the network expands.

The stack interfaces can be classified as system internal ports between ACTIVE and member switches. To build and provide a single logical view to the end user, the stack control plane negotiates the system role and ownerships during the system-reset phase. From the network architecture and the topological perspective all inter-stack connectivity and communication between member switches remain completely transparent. Each peering system identifies StackWise-480 as a single logical switch due to its unified control and management capabilities.

The new model of control, management, and data plane architecture in Catalyst 3850 StackWise-480 aligns with how Cisco modular systems are designed and deployed in enterprise networks. The ACTIVE supervisor centrally manages the network control and management planes, while the line card or network module interfaces to the edge and core to build high-speed, distributed, forwarding infrastructure. The wired or wireless users and devices can independently attach to any stack member switches; the ACTIVE switch centrally performs the client discovery, policy identification, protocols processing, and more. Based on developed Layer 2 or Layer 3 network topology, the ACTIVE switch starts building and synchronizing the forwarding tables for distributed switching.

Table 4 outlines the type of expected traffic that will traverse through a StackWise-480 ring.

**Table 4. Data Traffic in a Catalyst 3850 Stack Ring**

<table>
<thead>
<tr>
<th>Data</th>
<th>Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>System control traffic</td>
<td>Stack Link Aggregation Protocol (SLAP)</td>
</tr>
<tr>
<td></td>
<td>Stack control protocols</td>
</tr>
<tr>
<td></td>
<td>Ethernet Management Port (EMP)</td>
</tr>
<tr>
<td>Network control traffic</td>
<td>Out-of-band management (Simple Network Management Protocol [SNMP], Telnet, Syslog, etc.)</td>
</tr>
<tr>
<td></td>
<td>Layer 2 STP, CDP, PAgP+ and LACP, VLAN Trunking Protocol (VTP), etc.</td>
</tr>
<tr>
<td></td>
<td>Layer 3 routing (EIGRP, PIM, etc.)</td>
</tr>
<tr>
<td>Wired data traffic</td>
<td>Unicast, multicast, and broadcast</td>
</tr>
<tr>
<td>Wireless data traffic</td>
<td>Control and provisioning of wireless access points (CAPWAP) multicast tunnel</td>
</tr>
<tr>
<td></td>
<td>CAPWAP mobility tunnel</td>
</tr>
<tr>
<td></td>
<td>CAPWAP guest anchor tunnel</td>
</tr>
</tbody>
</table>

** Unified Converged Access Network Design  
Simplified Multilayer Network Design**
The enterprise customer relies on real-time business applications such as voice, video, and others. The system reliability and network availability becomes a core, integrated service requirement to deliver non-stop communication in the network.
The StackWise-480 architecture can enable a device-pooling to build a resilient wiring-closet network. When the access layer environment becomes highly dense, the StackWise-480 pools up to nine physical chassis into a single logical system from a network design perspective. As the number of access-layer network infrastructure expands, the device-pooling capability with Cisco StackWise-480 technology significantly simplifies operations and the network architecture itself.

Cisco recommends designing and deploying the multilayer distribution block with four major elements in overall architecture: Reduced fault domain, increased network security, deterministic forwarding paths, and optimal resiliency. In order to design and develop a wiring closet with this architecture requires isolated broadcast domains or VLANs for each workgroup category, device, and application type. This network design needs to apply consistently throughout the wiring closet network. This type of network design provides solid network security, stability, and reliability, and depending on the access layer network size, it may increase operational and troubleshooting complexity due to the increased number of VLANs, subnets, neighbor counts, etc.

The Catalyst 3850 StackWise-480 device-pooling design retains Cisco’s multilayer design principles. It also simplifies the operational challenges with reduced number of VLANs, STP instances, subnets, neighbor counts, etc. at the access and distribution layer system. Figure 6 shows the simplified network design and operation data points between Catalyst 3850 switches deployed in standalone mode in comparison to Cisco StackWise-480 mode.

**Figure 6.** Simplified Catalyst 3850 StackWise-480 Multilayer Network Design

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**Scalable StackWise-480 Cross-Stack EtherChannel Design**

The StackWise-480 can enable the ability to build a single uplink EtherChannel interface by bundling up to eight parallel physical links, which could then be distributed evenly across all stack switches. Multiple uplinks from a mission-critical access layer switch are a base requirement for reliable networks to provide high-speed data load sharing and to deliver 1+1 path redundancy upon failures.

However, from a forwarding perspective the Layer 2 network becomes sub-optimal when multiple parallel interfaces are deployed between two Layer 2 Ethernet switches.
The cross-stack EtherChannel interface simplifies STP topology over the logical interface and builds loop-free forwarding paths across all bundled uplink ports. If the Catalyst 3850 switch is deployed in routed access mode, then the cross-stack EtherChannel can also be deployed as a Layer 3 uplink interface to simplify unicast or multicast neighbor adjacencies and simplified network topology with one forwarding table. Independent of the Catalyst 3850’s deployed mode (multilayer or routed access), during the member switch or member link failure the EtherChannel does not disrupt network topology tables and delivers deterministic, hardware-driven, sub-second network recovery process.

Cisco Catalyst 3850, 3650, 3750-X, and 2960 Series Switches support up to four physical uplink ports to connect distribution-layer switches. Typically, up to two physical uplink interfaces are deployed from access-layer switches for optimal load balancing and redundancy in the wiring closet.

When these switches are deployed in stack configuration mode, maintaining the same uplink connection design principle as a dual stack-member system is recommended. For example, nine Cisco Catalyst 3850 switches deployed in a stack ring would have two diversified uplink ports from switch 1, and two diversified uplink ports from switch 9. The remaining seven switches forward the data toward the core using a high-speed stack backplane.

This recommended uplink port design offers various benefits, from application performance to optimal user experience:

- Improved application performance by increasing aggregated stack switching capacity with multiple, distributed, high-speed 10-Gbps uplinks between stack member Catalyst switches
- Enhanced bidirectional traffic engineering with intelligent network data load sharing within the stack ring and across all distributed uplink physical ports
- Improved system and application performance by utilizing the distributed forwarding architecture advantage of hardware resources: buffers, queues, ternary content-addressable memory (TCAM), and others
- Protection of stack and network-level redundancy and reduction in congestion between distributed aggregation systems caused during a major outage at the access or distribution layer

Figure 7 illustrates a sample Catalyst 3850 StackWise-480 uplink network design of the distribution layer system.

Figure 7. Catalyst 3850 StackWise-480 Uplink Design Best Practices
Optimal StackWise-480 Cross-Stack Forwarding EtherChannel Design

The egress data load forwarding from Catalyst 3850 StackWise-480 is determined based on how upstream network is designed. The loop-free forwarding topology utilizes all available paths to switch data traffic based on pre-computed Cisco Express Forwarding (CEF) or EtherChannel hash results. In a distributed forwarding architecture the Catalyst 3850 stack switches verify the Layer 2 to Layer 3 data variables from incoming traffic to determine the best physical uplink ports prior forwarding traffic to the upstream system.

The Catalyst 3850 switch requires more variables in packet tuples to perform granular switching decisions. In a large-scale design the source MAC address-based EtherChannel load-sharing mode may deliver adequate results to utilize all upstream member links. However, in mid- to low-scale networks, the Catalyst 3850 may not have enough variable points to compute the best egress uplink path. In this case, in order to optimize the switching performance with granular packet forwarding decisions across all available cross-stack uplink paths the default EtherChannel hash computation can be tuned to include Layer 2 to Layer 3 address variables.

The next-generation Catalyst 3850 is designed to support a large number of EtherChannel hash variables to deliver optimal upstream egress forwarding decisions. Compared to a traditional CUWN network architecture, when a Catalyst 3850 switch is deployed in converged access mode the new EtherChannel load-sharing capability inherently optimizes converged wired and wireless client data load sharing across all available uplink forwarding paths. Table 5 outlines the supported Layer 2 to Layer 4 EtherChannel hash algorithm.

<table>
<thead>
<tr>
<th>Layer</th>
<th>EtherChannel Hash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-IP</td>
<td>src-mac (default)</td>
</tr>
<tr>
<td>Layer 2</td>
<td>src-mac (default)</td>
</tr>
<tr>
<td></td>
<td>dst-mac</td>
</tr>
<tr>
<td></td>
<td>src-dst-mac</td>
</tr>
<tr>
<td>Layer 3</td>
<td>src-ip</td>
</tr>
<tr>
<td></td>
<td>dst-ip</td>
</tr>
<tr>
<td></td>
<td>src-dst-ip</td>
</tr>
<tr>
<td>Layer 4</td>
<td>src-port</td>
</tr>
<tr>
<td></td>
<td>dst-port</td>
</tr>
<tr>
<td></td>
<td>src-dst-port</td>
</tr>
<tr>
<td>Layer 3 plus Layer 4</td>
<td>src-mixed-ip-port</td>
</tr>
<tr>
<td></td>
<td>dst-mixed-ip-port</td>
</tr>
<tr>
<td></td>
<td>src-dst-mixed-ip-port</td>
</tr>
</tbody>
</table>

The network administrator can adjust the default EtherChannel hash algorithm from a global configuration mode as demonstrated in the sample code that follows.

```
3850-Stack#show etherchannel load-balance
EtherChannel Load-Balancing Configuration:
src-mac
EtherChannel Load-Balancing Addresses Used Per-Protocol:
Non-IP: Source MAC address
IPv4: Source MAC address
IPv6: Source MAC address
```
3850-Stack#configure terminal
3850-Stack(config)#port-channel load-balance src-dst-mixed-ip-port

3850-Stack#show etherchannel load-balance
EtherChannel Load-Balancing Configuration:
src-dst-mixed-ip-port
EtherChannel Load-Balancing Addresses Used Per-Protocol:
Non-IP: Source XOR Destination MAC address
IPv4: Source XOR Destination IP address and TCP/UDP (layer-4) port number
IPv6: Source XOR Destination IP address and TCP/UDP (layer-4) port number

Reliable StackWise-480 Cross-Stack Forwarding EtherChannel Design
The link aggregation protocols build stateful, consistent, and reliable EtherChannel communication between two systems. To successfully establish a logical EtherChannel interface between two systems the link aggregation protocol performs several link parameter checks to assure each member link is equipped to deliver consistent switching performance and network service in the event of failure. During the EtherChannel startup process each end of the system verifies capabilities of each local and remote member link, including attributes such as speed, duplex, protocols dependencies, QoS capabilities, and more.

Cisco recommends bundling the cross-stack Etherchannel interface using link aggregation protocols such as Cisco PAgP+ or IEEE 802.1AD LACP. The Cisco Catalyst 3850 deployed in StackWise-480 supports both link aggregation protocols (Figure 8), however Cisco PAgP+ is recommended if any of the upstream aggregation systems such as Catalyst 4500E, 4500X or 6500-E switches are deployed in Cisco Virtual Switching System (VSS) mode.

Figure 8. Catalyst 3850 Cross-Stack EtherChannel Design
StackWise-480 in Converged Access Mode

The Catalyst 3850 with StackWise-480 in converged access mode offers network, operational, and management-level simplicity. Customers gain a:

- **Unified converged access switch** - This large Catalyst 3850 system in multi-function role acts as a high-speed modular Ethernet switch and integrated, scalable wireless LAN controller.

- **Scalable system** - Enjoy a simplified and centralized user interface to configure and troubleshoot up to 208 Ethernet ports, 50 Cisco wireless access points (WAPs), and 2000 wireless clients.

- **Simplified wireless network design** - Get a logical WLC to manage a large number of Cisco WAPs for broader wireless network coverage. Our design simplifies Cisco WAP software management and network architecture with reduced configuration complexity and a relevant control plane (RF, SSID, VLANs, subnet, etc.).

- **Resilient architecture** - Get system- and network-level redundancy with 1+1 stateful power and control plane redundancy to Cisco WAPs during an abnormal ACTIVE switch failure event.

This document does not cover Cisco Converged Access solutions in-depth. To better understand the Catalyst 3850 StackWise-480 architectural benefit in the new mobility context it is critical to understand the three-tier, hierarchical, Cisco mobility architecture and the system roles and functions in the overall network design. To gain a better understanding of next-generation Cisco converged access architecture visit:


Cisco StackWise-480 Forwarding Architecture

The forwarding architecture in Catalyst 3850 Series Switches is designed to support similar stacking capabilities in the Catalyst 3750-X Series Switches; the software architecture uses the credit-based token algorithm. To optimally forward the traffic within the stack ring the packet-stripping function is performed on the destination switch instead of on the source or ingress switch. This mechanism is known as the spatial-reuse forwarding mechanism.

It allows multiple flows to co-exist to enable parallel forwarding design. The spatial-reuse capability significantly boosts data-plane switching performance in the stack-ring switching architecture. The broadcast and multicast packets are still required to do source-stripping since the location of the destination device is known and there could be multiple multicast listener devices within stack ring.

Distributed Forwarding Architecture

The forwarding architecture is designed to provide distributed switching across all member switches in the stack, as implemented in distributed, modular Cisco platforms. To optimize data-plane performance by utilizing hardware resources from each Catalyst 3850 stack member switches the network services likes QoS, Security ACL etc are fully distributed and programmed to locally enforce on network ports. This distributed hardware resource utilization process delivers wire-speed switching performance that increases overall system resource capacity, prevents centralized overload processing on the ACTIVE switch, and optimizes stack-ring bandwidth capacity.

Since Cisco StackWise-480 Technology is designed to offer modular-class system redundancy in stack design, it requires centralized control and a management plane with a distributed forwarding architecture. To logically appear as a single virtual switch, the IOS daemon (IOSd) process on the ACTIVE switch centrally manages all management plane and network control plane operations with Layer 2 and Layer 3 protocols, including STP, IP routing, CEF, PBR, and others.
Depending on the implemented network protocols, the ACTIVE switch communicates with the rest of the multilayer, routed, or converged wireless access infrastructure to dynamically develop the wired and wireless forwarding tables. The ACTIVE switch also updates all member switches for hybrid forwarding information. The distributed forwarding capability provides local switching lookup for the switching decision process. All ingress and egress wired data plane traffic is fully distributed in a StackWise-480-based system design.

Independent of the IOSd operational state, the hardware forwarding information base (WFIB) is actively programmed in ASICs across all stack-member switches in a stack ring. Figure 9 shows the Catalyst 3850 system architecture with centralized processing for control and management functions and distributed forwarding.

**Figure 9.  Catalyst 3850 and Centralized Processing**

![Catalyst 3850 StackWise-480 NSF/SSO Architecture](image)

**Catalyst 3850 StackWise-480 NSF/SSO Architecture**

The highly resilient nonstop forwarding and stateful switchover (NSF/SSO) technology is a widely deployed solution in mission-critical campus and branch network designs. The key advantage of NSF/SSO is that it constantly delivers network availability without compromising performance and scalability during planned or unplanned network outages. The StackWise-480 architecture takes advantage of the same technology to maintain state machines and gracefully recover during an ACTIVE switch failure.

**Catalyst 3850 StackWise-480 NSF/SSO Overview**

StackWise-480 SSO technology expands route processor redundancy (RPR) capabilities to provide transparent failover of several high-availability-aware Layer 2 and 3 protocols and Cisco IOS Software applications when the ACTIVE switchover occurs.
The state machines of non-high-availability-aware protocols and applications are not synchronized from ACTIVE to STANDBY - something the Catalyst 3850 switch requires to rebuild adjacencies and forwarding entries during an ACTIVE switch failure.

The NSF is a high-availability feature that can ensure continuous Layer 2 and 3 packet forwarding, which continues when an ACTIVE route processor switches over to a STANDBY switch. It effectively increases network availability by eliminating network downtimes in the event of scheduled maintenance or of an unexpected failure of the switch. The NSF is used in conjunction with SSO. NSF enhances the Cisco Express Forwarding logic to allow Catalyst 3850 switches in StackWise-480 to continue using their last known forwarding information base data when a newly elected ACTIVE switch is learning routes.

Figure 10 shows the NSF/SSO architecture in Cisco Catalyst 3850 StackWise-480 mode, deployed in converged access mode.

**Figure 10.** Cisco Catalyst 3850 StackWise-480 NSF/SSO Architecture

**Catalyst 3850 StackWise-480 NSF/SSO Benefits**

Catalyst 3850 switches support a wide range of Layer 2, Layer 3, and wireless stateful capabilities to provide nonstop network communication. In real time, the Cisco IOSd process operating in an ACTIVE state synchronizes the protocol state machines, software forwarding tables, and system configuration to another IOSd instance running on a STANDBY switch. Table 6 details the broad categories of protocols in which the Catalyst 3850 provides NSF/SSO capabilities.

**Table 6.** Catalyst 3850 StackWise-480 NSF/SSO Capabilities

<table>
<thead>
<tr>
<th>Layer</th>
<th>HA-Aware Protocols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 2</td>
<td>STP, VLAN, VTP, Dynamic Trunking Protocol (DTP), Cisco Discovery Protocol, Unidirectional Link Detection Protocol (UDLD), Switched Port Analyzer (SPAN) and Remote SPAN (RSPAN), 802.1x, PAgP and LACP, Internet Group Management Protocol (IGMP) Snooping, and more</td>
</tr>
<tr>
<td>Layer 3 - IPv6</td>
<td>EIGRPv6, OSPFv3, IS-ISv3, BGPv6</td>
</tr>
</tbody>
</table>
Layer | HA-Aware Protocols
--- | ---
Wireless | Mobility Agent, Mobility Controller, CAPWAP tunnels (data, mobility, multicast, guest)
Services | QoS, ACL, PBR, NetFlow, Port Security, and more

**Implementing Catalyst 3850 StackWise-480 NSF/SSO**

To increase the availability, the SSO capability is enabled by default when Catalyst 3850 Series Switches are deployed in StackWise-480 mode. No additional user intervention is required to enable the SSO capability on a Catalyst 3850 system. The user can verify that SSO is configured and that the operational state is using a consistent CLI as a modular Catalyst system. The following example shows the sample output of SSO redundancy in the StackWise-480-based network design.

```
3850-Stack#show redundancy state
    my state = 13 -ACTIVE
    peer state =  8 -STANDBY HOT
    Mode = Duplex
    Unit ID = 2
    Redundancy Mode (Operational) = SSO
    Redundancy Mode (Configured) = SSO
    Redundancy State = SSO
    Manual Swact = enabled
    Communications = Up
< snip >
```

The NSF capability on Catalyst 3850 Series Switches can perform as an NSF helper system. However, with SSO protocol synchronization the Catalyst 3850 system becomes an NSF-capable system as a modular Catalyst system. To enable the graceful restart capability for supported protocols, the network administrator must manually enable the graceful restart capability under a routing instance; otherwise the system may not gracefully recover protocol state machines and impact high recovery time during an ACTIVE switch failure event.

```
3850-Stack(config)#router eigrp 100
3850-Stack(config-router)#nsf

3850-Stack#show ip protocols
 *** IP Routing is NSF aware ***

Routing Protocol is "eigrp 100"
< snip>
  EIGRP-IPv4 Protocol for AS(100)
    Metric weight K1=1, K2=0, K3=1, K4=0, K5=0
    NSF-aware route hold timer is 240

  EIGRP NSF enabled
    NSF signal timer is 20s
    NSF converge timer is 120s
```
Summary
Next-generation Catalyst 3850 Switches are designed to meet the future demands in wiring closet networks. As more technologies are integrated into the system the Catalyst 3850 offers operational simplicity, scalability, and performance with excellent resiliency. The new software architecture of Cisco StackWise-480 technology delivers superior performance and best-in-class resiliency.

This document is primarily focused on the Cisco StackWise architecture for Catalyst 3850 switches. The Catalyst 3650 supports the same StackWise architecture with the same set of features, with the only difference being stack adapters. Catalyst 3650 switches provide a lesser 160 Gbps stack bandwidth. A switch stack containing a mix of Catalyst 3850 and Catalyst 3650 switches will not work in a network design.