



Cisco IOS Profile Release 12.1(13)E7 and 12.2(12)b System Testing for Financial Enterprise Customers

Version History

Version Number	Date	Notes
1	June 10, 2003	This document was created. The term “Safe Harbor” was changed to “Profile Release.”

Executive Summary

The nEverest program focuses on satisfying customer requirements in key vertical markets. The program links and expands several existing Cisco quality programs that were designed to address customer quality issues. It also coordinates system-level and regression testing of Cisco IOS releases that are targeted for specific vertical markets. The nEverest program ensures that Cisco takes a “holistic” approach to the general improvement of Cisco IOS software. *Cisco IOS Profile Release 12.1(13)E7 and 12.2(12)b System Testing for Financial Enterprise Customers* documents the system level tests used to verify the performance, scalability, and reliability of IP multicast, QoS, and other features applicable for financial enterprise customers for the nEverest program. The purpose of this document is to provide financial enterprise customers with a characterization of a set of baseline features to aid in network design and implementation on selected stable Cisco IOS releases.

This document describes the testing environment, test plan, and test cases, and provides a summary of the test results. Complete device configurations and the logs that show actual test results are not part of this document.



Note

The software versions listed in this document were tested using the test procedures described. All relevant unresolved DDTs found during testing are listed in the Test Results Summary table. In addition to the information contained in this report, we highly recommend that you review the Release Notes for each release to see the latest list of open caveats for specific features not tested or caveats found after publication.

This document contains the following sections:

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About Financial Enterprise System Testing

The goal of financial enterprise system testing was to provide improved network stability, reliability, and performance with respect to Cisco IOS software. Financial enterprise system testing involved testing the feature sets and protocols in particular Cisco IOS E and mainline release images on certain platforms to provide high-quality code for the financial services business. This combination of features, hardware, and images was tested in a laboratory environment that simulated the end-to-end financial services business network environment. For information on the hardware tested and the network setup of the test environment, see the [“Financial Enterprise Topology” section on page 5](#).

[Table 1](#) lists the software versions used for the testing described in this document.

Table 1 *Platforms and Software Versions Used in Financial Enterprise System Testing*

Device Type	Software Version
Cisco Catalyst 6500 with Multilayer Switching Feature Card (MSFC)	Cisco IOS Release 12.1(13)E7 (Native)
Cisco 2600, Cisco 3600, Cisco 7200, Cisco 7500 series routers	Cisco IOS Release 12.2(12b)
Cisco Catalyst 4000 and Cisco Catalyst 6500 family switches	Cisco Catalyst OS Release 7.2(2)
Cisco Catalyst 2950 switches	Cisco IOS Release 12.1(9)EA1
Cisco Catalyst 3550 switches	Cisco IOS Release 12.1(8)EA1c

The groups of feature sets that were tested included the following: hardware redundancy, Layer 2 features, hardware forwarding features, Layer 3 routing features, and network management features. Regression tests were conducted to validate existing features and ensure that functionality was maintained. Negative tests were designed and conducted to stress the features and their interoperability. For information on each set of features tested and their testing procedures, see the [“Test Suites” section on page 15](#).

During the testing, the network was placed under loads that are consistent with those in a financial services network. A standard suite of tools (for example, Spirent Communications' Smartbits or IXIA's traffic generation systems) was used to generate network traffic. Network testing included a combination

of automated and manual tests. Simple Network Management Protocol (SNMP) was used to poll the network during the tests, and all tests results were analyzed. For a summary of the test results, see the [“Test Results Summary” section on page 13](#).



Note

Financial enterprise system testing did not address any issues that might exist in the customer change control and operations processes.

Validated Network Design Scenario

Validated design scenarios are the result of extensive network integration testing performed on a particular set of features, platforms, and Cisco IOS software releases. The implementation lessons and performance metrics that resulted from this testing are useful to network architects and designers that are developing designs that comprise similar topologies and functionality.

Validating network features and services within a specific topology should be a standard procedure, and testing features and services with network applications would appear to be a natural extension of the function of networking equipment makers. Established networking companies do conduct extensive testing on products; however, it is also true that each service provider and financial enterprise customer environment holds its own unique requirements and challenges. For every networking company to test every feature set and combination of feature sets for every application for every customer would be both costly and time-consuming.

Building the Operational Profile

To mitigate the impossibility of testing all possible, or even deployed, combinations, Cisco Systems (through the nEverest program) determined the scope, context, feature sets, and applications covered in system-level testing by developing an operational profile.

- Select customers to represent a wider customer base—The first step was to select a core set of customers that represented a particular market segment, in this case the financial enterprise market.
- Identify network elements and features for the model—The next step was to abstract the major network elements and features that were common to each of the customers and essential to the network operation.
- Build the reference design to serve as the operational profile—These elements were then used to develop a reference design that consists of a network topology, features, and recommendations. This reference design became the operational profile that was used to develop the system test plan; it also served as the basis for Cisco design recommendations for each market segment.

As the number of network features grow, and as the application of those features reaches into new and more demanding environments, the need for design guidance in the scaling, bandwidth control, and resiliency planning for large-scale networks has become an essential cost-saving benefit. Companies such as Cisco Systems with its broad product line and depth of experience, customer service support, and wide range of network and application experience are ideally suited to help deploy and integrate leading IP technology features into their large-scale networks in less time, at less cost, and with less risk.

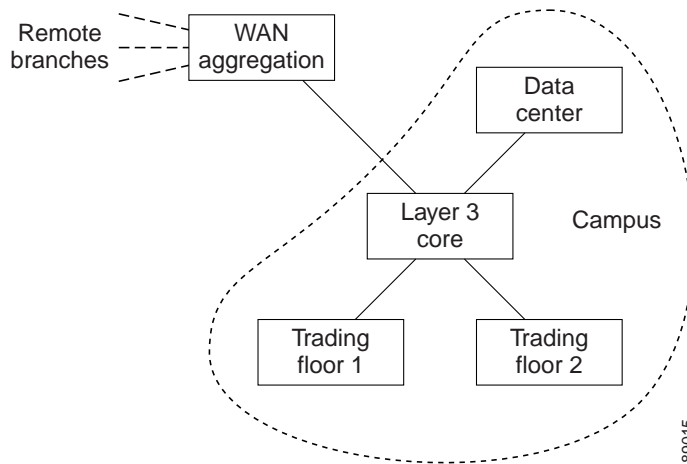
Logical Financial Enterprise Topology

The logical design for the financial enterprise topology is based on large Financial Services companies that have these components:

- A Corporate headquarters that consists of a campus network with several trading floors, a data center, and a Layer 3 core
- A WAN network that consists of many remote branches

These components are shown in Figure 1.

Figure 1 *Logical Financial Enterprise Topology*



This design is hierarchical and flexible enough to handle tens of thousands of users. The campus network is the central hub for company-wide applications such as e-mail, corporate communications, and hoot-and-holler.

Corporate communications consists of high-quality, full-motion video of internal news and announcements that employees can run on their desktops using applications such as IP/TV.

Hoot-and-holler is a voice application commonly used in the trading environment that uses Voice over IP (VoIP) over IP multicast.

Real-time market data applications are also run on the campus, with the users primarily being on the trading room floors.

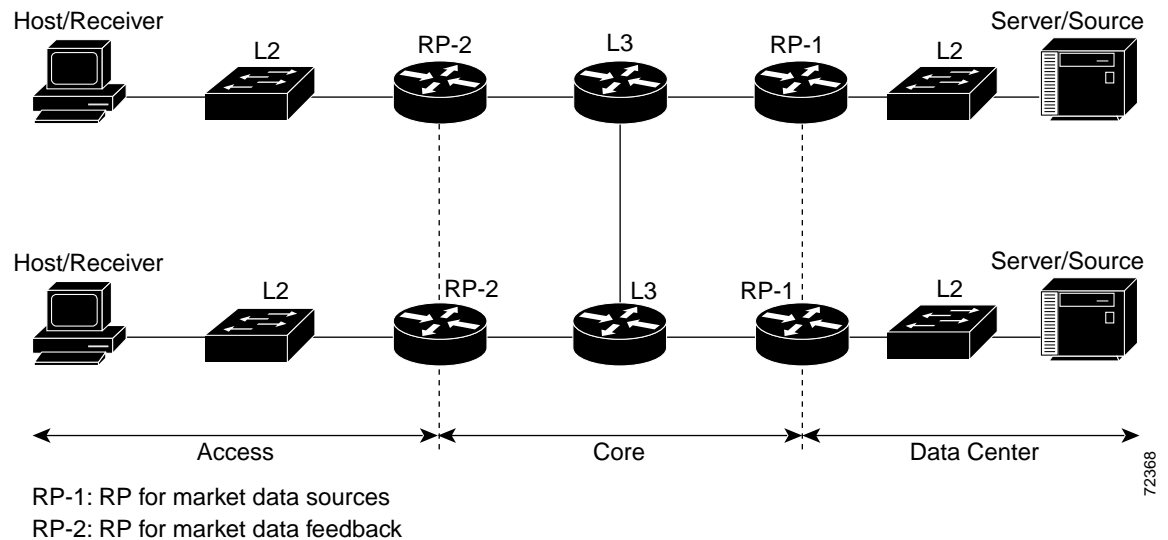
Corporate Communications, hoot-and-holler, and other company-wide applications are distributed out to the remote branches through the WAN aggregation routers and either the Frame Relay network with Stratacom switches or point-to-point connections using leased lines with PPP or high-level data link control (HDLC).

Logical Financial Campus Topology

The logical design for the campus topology was targeted at large finance companies with trading applications. The trading applications that are run on these networks are real-time market data applications that have been developed with TIBCO RV middleware. Data applications developed using TIBCO RV middleware were deployed using IP multicast. The real-time market data deployments are extremely business-critical and require the highest degree of availability and resiliency.

Figure 2 shows the logical components of the financial campus topology. This diagram illustrates the function of the access layer, the distribution layer (including the rendezvous point (RP) function), and the core layer in relation to both the server and host. Explanation for the use of separate RPs for the market data sources and feedback groups can be found in the [“IP Multicast Deployment Strategy”](#) section on page 11 and in the [“Financial Enterprise Application Implementation”](#) section on page 12.

Figure 2 Logical Financial Campus Topology



Financial Enterprise Topology

This section describes the financial enterprise topology, the Cisco products that were selected, the roles they performed in the network, and why these products were well-suited for these roles. Figure 3 shows the base financial lab topology used for these tests.

The financial enterprise topology represents a large campus deployment requiring a high level of availability and redundancy as is the norm with financial networks that deal with real-time market data applications. Enhanced Interior Gateway Routing Protocol (EIGRP) and Open Shortest Path First (OSPF) were chosen as the Interior Gateway Protocols (IGPs) for these deployments.

IP multicast testing was performed using both routing protocols. Unless otherwise specified, all routers were configured to run Protocol Independent Multicast sparse mode (PIM-SM). Static RPs were defined for campus trading applications; redundant RPs ran Multicast Source Discovery Protocol (MSDP) to facilitate Anycast RP. The Shortest Path Trees (SPT) threshold was set to infinity to ensure that multicast traffic used only shared trees. The **mls ip multicast stub** command was enabled on all access router user interfaces on the nondesignated routers.

For hoot-and-holler and corporate communications (such as IP/TV) the RPs were advertised with Auto-RP using PIM-SM and the **ip pim autorp listener** command. The RPs were also configured as Anycast RPs for redundancy.

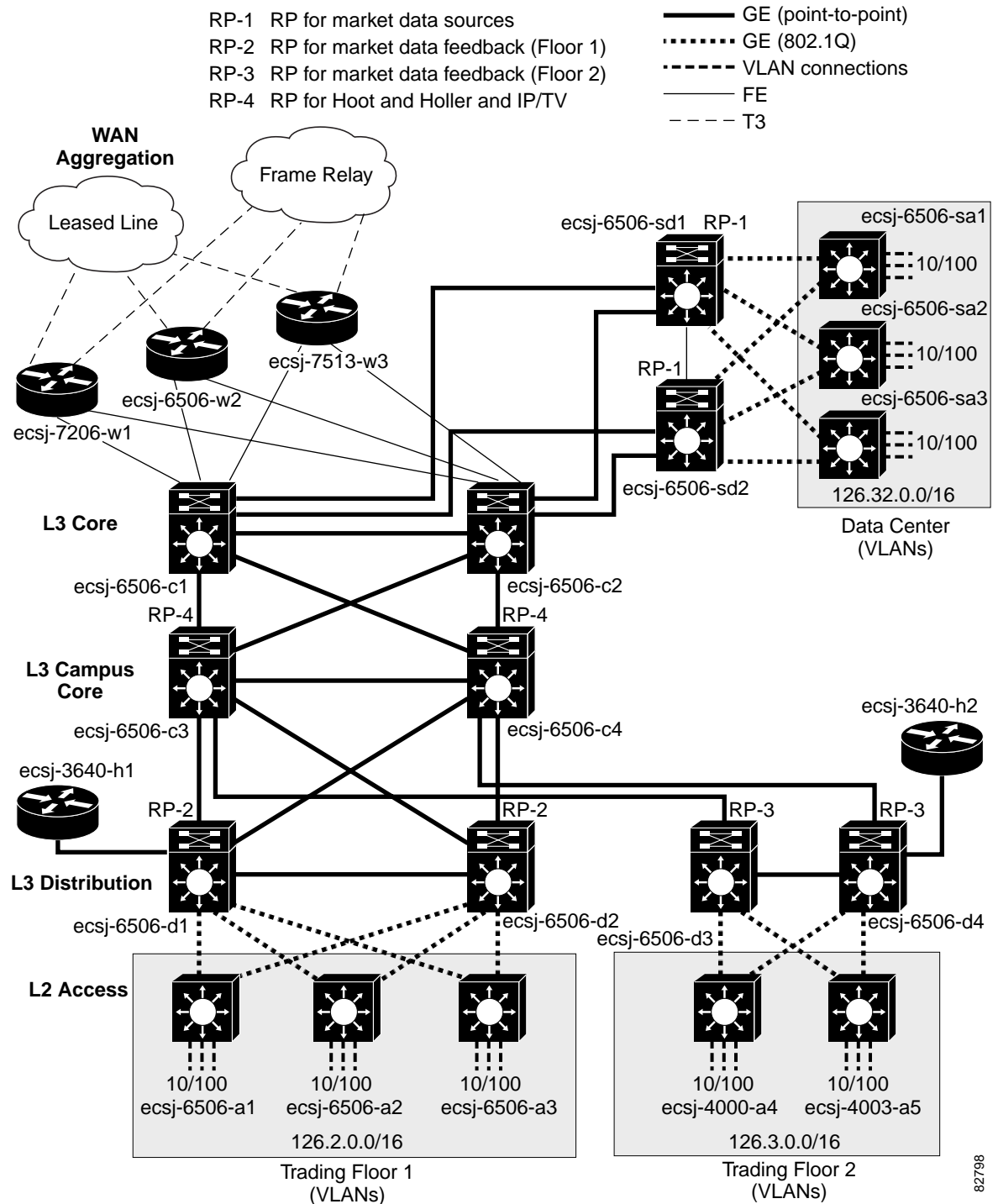
Corporate communications, hoot-and-holler, and other company-wide application traffic was distributed out to the remote branches through the WAN aggregation routers and either the Frame Relay network with Stratacom switches or point-to-point connections using leased lines with PPP or HDLC. During any

particular test the WAN links were configured for either Frame Relay or leased line. [Figure 4](#) shows the network topology for the remote branches with the Frame Relay configuration. [Figure 5](#) shows the network topology for the remote branches with the leased-line configuration.

All tests were performed in an integrated environment. Every attempt was made to simulate a real customer network as closely as possible with real traffic running wherever possible. This enterprise topology was designed to handle at least 5000 users connected to the distribution layer, and the traffic levels were adjusted to match this requirement.

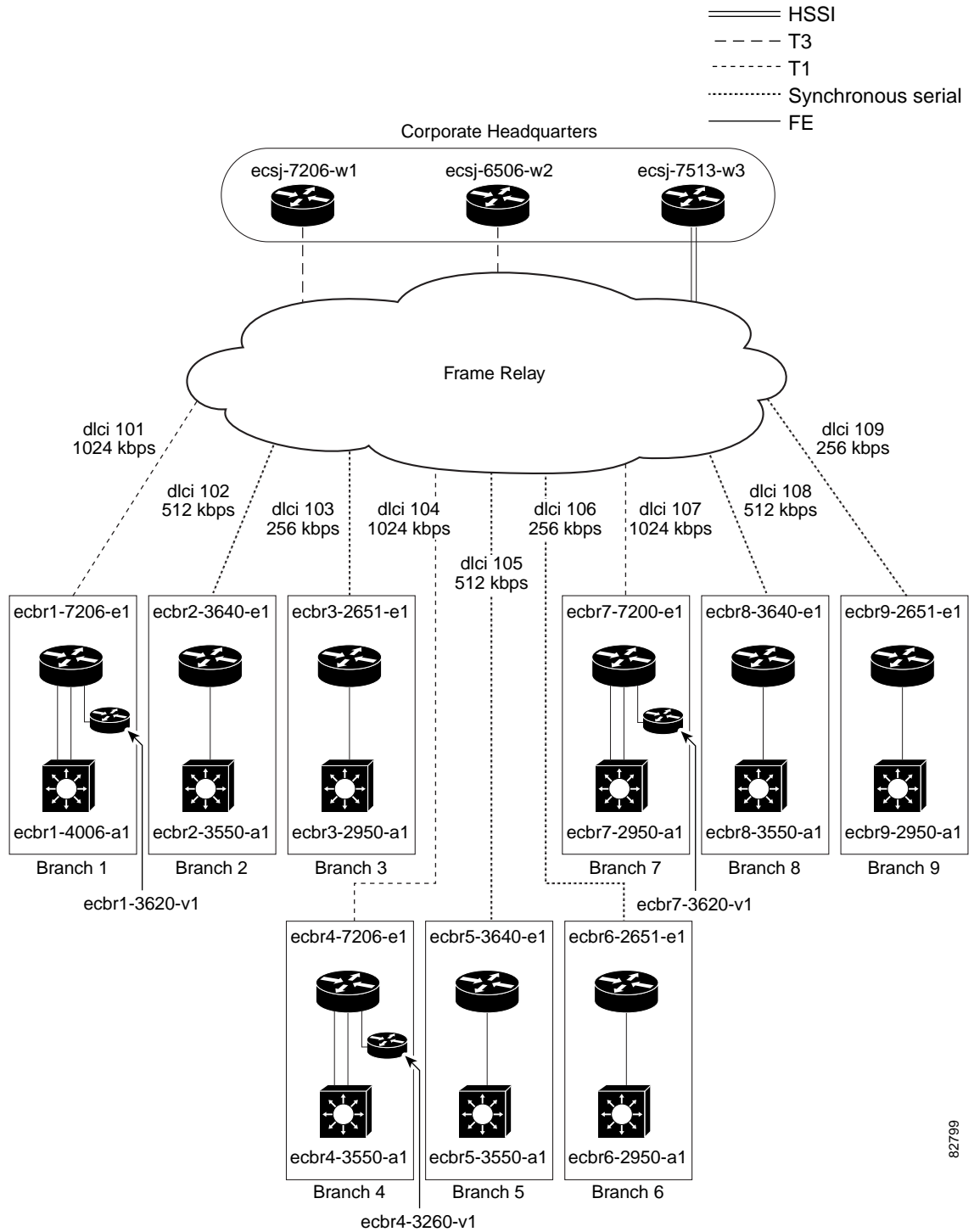
Basic network management features were configured and the router logs were monitored for error messages. After the test environment was built and operational, “sanity tests” were run to verify that everything was working as expected. Basic connectivity tests verified that the network and protocols were behaving normally. Application traffic (IP multicast market data simulated with Smartbits applications) was added to verify end-to-end application functionality. Additional clients were simulated and routes were injected to increase the network load to the appropriate levels to support at least 5000 users. Background traffic was also generated to simulate a real network environment.

Figure 3 Physical Financial Campus Topology



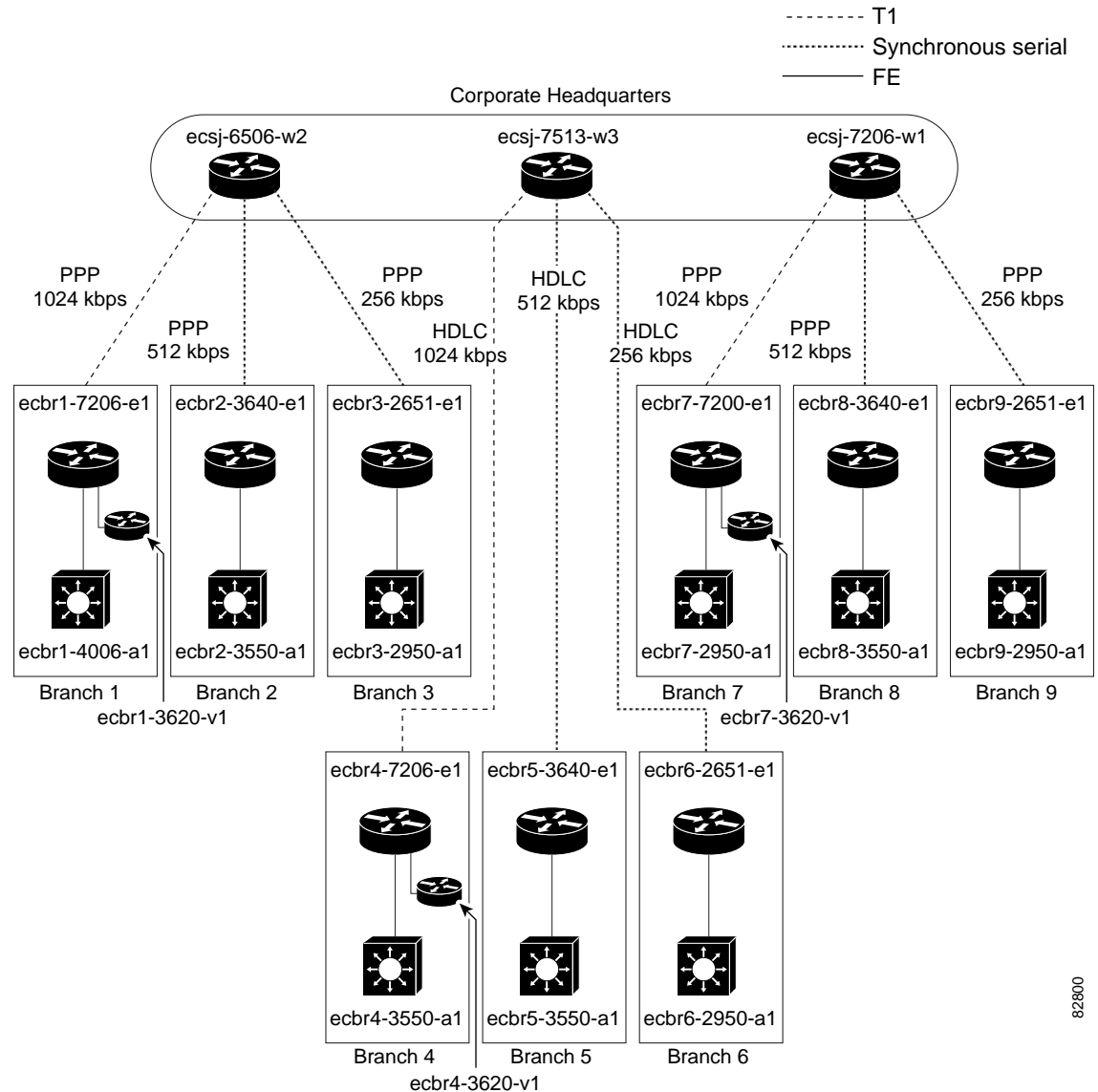
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Figure 4 Remote Branch Topology with Frame Relay Configuration



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Figure 5 Remote Branch Topology for Leased-Line Configuration



In the Layer 2 areas of the financial enterprise topology, the Catalyst 6500 family switch was used with the Multilayer Switching Feature Card 2 (MSFC2) and the Supervisor Engine II. The Catalyst 6500 family is the leading product group of Cisco switches and is the device of choice in financial trading network environments. The Catalyst 6500 family offers strong IP multicast performance through hardware switching. In this scenario, native mode Cisco IOS software was used.

To address interoperability issues, a Catalyst 5000 family switch and Catalyst 4000 family switches were used in addition to Catalyst 6000 family switches in the access layer of the financial campus scenario.

The following sections further describe the different areas that were configured in the lab to simulate the financial enterprise system test environment.

Access

The Layer 2 access switches were the Catalyst 6500, Catalyst 5000, Catalyst 4000, Catalyst 3550, and Catalyst 2950 switches. Each of these switches was configured with Fast Ethernet (FE) ports to the hosts. IEEE 802.1Q trunking-enabled Gigabit Ethernet (GE) interfaces were used for the access switches in the campus.

The Catalyst 6500, Catalyst 5000, Catalyst 3550, and Catalyst 2950 switches support Internet Group Management Protocol (IGMP) snooping. The Catalyst 4000 family of switches supports CGMP only, not IGMP snooping.

Campus Core

The Layer 3 core switches were the Catalyst 6500 family of switches. Each of these switches was configured with point-to-point GE interfaces.

The Layer 3 distribution switches and the Data Center switches were configured with point-to-point GE interfaces toward the core and IEEE 802.1Q trunking-enabled GE interfaces toward the access layer and Data Center, respectively.

Data Center

The Layer 2 access switches were the Catalyst 6000 family of switches. Each switch was configured with FE ports to the hosts and IEEE 802.1Q trunking-enabled GE interfaces toward the core.

WAN Aggregation and Remote Branches

Nine remote branches were connected to the Corporate Headquarters across WAN connections. The WAN connections used the following three protocols: Frame Relay, HDLC, and PPP. Only one protocol was used at any given time. To switch between each of the three protocols, a script was used to enable and disable the designated interfaces.

The frame relay cloud shown in [Figure 3](#) and [Figure 4](#) consisted of a network of Cisco MGX 8850 multiservice switches. The interface cards used to provide the frame relay service on the Cisco MGX 8850 were the frame relay service modules FRSM-8T1 and FRSM-2CT3.

Inside the Cisco MGX 8850 network, the frame relay frames were converted to ATM cells through an MGX 8800 PXM1 processor switch module. The ATM cells were reassembled into frame relay frames and delivered to the destination routers transparently.

The following three Cisco hardware platforms were used to represent large, medium-size, and small branch offices, respectively: Cisco 7200 series, Cisco 3600 series, and Cisco 2600 series. One access switch was also used for each branch office, either a Cisco Catalyst 4000, Cisco Catalyst 3550, or Cisco Catalyst 2950, as shown in [Figure 4](#) and [Figure 5](#).

[Table 2](#) shows which WAN interface hardware was tested on each platform in the WAN Aggregation and Remote Branch areas.

Not every combination of WAN encapsulation and platform was tested. [Table 3](#) shows which WAN encapsulations were tested on each platform.

Table 2 *WAN Interfaces Tested*

Device	Synchronous Serial Interfaces	CT1 Interfaces	CT3 Interfaces
Cisco 7200 series	PA-4T+	PA-MC-4T1	PA-MC-T3
Cisco 7500 series	PA-H/VIP4-80 PA-4T+/VIP4-80	Not tested	Not tested
Cisco 6500 series	PA-4T+ FlexWAN	PA-MC-4T1 FlexWAN	PA-MC-T3 FlexWAN
Cisco 2600 and Cisco 3600 series	WIC-2T	Not tested	Not tested

Table 3 lists the WAN encapsulation types that were tested.

Table 3 *WAN Encapsulations Tested*

Protocol	Cisco 7200 Series	Cisco 6500 Series	Cisco 7500 Series	Cisco 2600 and Cisco 3600 Series
Frame Relay	Tested	Tested	Tested	Tested
PPP	Tested	Tested	Not tested	Tested
HDLC	Not tested	Not tested	Tested	Tested

IP Multicast Deployment Strategy

Applications that use IP multicast may have different operational models and therefore different network design requirements. The following two main types of applications are deployed in many corporate networks and in the financial enterprise environment described in this document:

- Many-to-many applications
- One-to-many applications

The features used to deploy IP multicast in the financial enterprise network were as follows:

- Many-to-many applications:
 - PIM-SM
 - Shared tree (SPT threshold infinity)
 - Static RP configuration
 - Anycast RP
- One-to-many applications:
 - PIM-SM
 - Auto-RP with listener function
 - Anycast RP

For more information about the multicast features discussed in this document, refer to the following URL:

http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/mcst_ovr.htm

The multicast implementation will be updated in future enterprise financial test efforts as new Cisco IOS features become available. For example, many-to-many applications could be implemented using Bidirectional PIM, which is not available in Cisco IOS Release 12.1(13)E7.

Financial Enterprise Application Implementation

The many-to-many and one-to-many applications used in the financial enterprise implementation are as follows:

- Many-to-many applications:
 - Real-time market data that uses the TIBCO middleware
- One-to-many applications:
 - Hoot-and-holler over IP
 - Corporate communications (IP/TV with all RTCP feedback turned off)

Real-time market data that uses the TIBCO middleware is classified as a many-to-many application because each client sends feedback information to the server for acknowledgments that are used for retransmission. The feedback traffic is also called “subscribe” traffic and is sent using different multicast groups than those used for the actual market data. The actual market data is sent from servers in the Data Center. This traffic is called the “publish” traffic and is sent using different multicast groups than those used for the feedback traffic.

Hoot-and holler over IP is classified as a one-to-many application. In a typical Hoot-and holler over IP environment, one person speaks and all other clients listen. Hoot-and-holler over IP can also be deployed as a many-to-many application, but for the purposes of this implementation, it will be configured as a one-to-many application.

Corporate communications is classified as a one-to-many application. For the financial campus implementation, IP/TV was used and all RTCP feedback was turned off.

Implementation Details

For the trading applications (TIBCO-based market data) in the financial enterprise campus, static RPs were defined. Redundant RPs were configured with MSDP to facilitate Anycast RP. Separate RPs were defined for the publish groups and the subscribe groups from each trading floor. The routers ecsj-6506-sd1 and ecsj-6506-sd2 were the RPs for the publish groups that were sourced from the Data Center, ecsj-6506-d1 and ecsj-6506-d2 were the RPs for the subscribe groups on Floor 1, and ecsj-6506-d3 and ecsj-6506-d4 were the RPs for the subscribe groups on Floor 2. [Figure 3](#) shows the location of the configured RPs in the network topology.

The SPT threshold value was set to infinity to ensure that multicast traffic used only the shared tree and the **mls ip multicast stub** command was enabled on all user interfaces of the access routers. Accept register filters were placed on the RPs so that they accepted sources originating only from the subnets they serve. MSDP source active (SA) filters were also configured on each RP so that they accepted SA messages only from groups they serve.

For Hoot-and-holler over IP and corporate communications (IP/TV), the RPs were advertised with Auto-RP using PIM-SM and the **ip pim autorp listener** command. The RPs were also configured as Anycast RPs for redundancy. The RPs for hoot-and-holler over IP and IP/TV were the routers ecsj-6506-c3 and ecsj-6506-c4. The SPT threshold value was set to the default value to enable the use of the SPT.

Test Results Summary

[Table 4](#) summarizes the results of all the testing that was completed as part of the Cisco IOS financial enterprise system test initiative. [Table 4](#) provides the following information:

- The categories of features tested (the test suites)
- The feature set to which the feature or function belongs
- The tests for each feature or function
- The results of the feature or function tests (pass or fail)
- Any DDTs found during the financial enterprise system testing



Note

These test results are specific to the technologies covered and the actual test scenarios in which they were tested. Financial enterprise system testing is designed to cover critical path areas and augment ongoing regression and systems testing.

Table 4 *Financial Enterprise System Test Results Summary*

Test Suites	Feature Sets Tested	Tests	Results	DDTS/Comments
IP Routing	Layer 2 Spanning Tree, page 19	Spanning Tree, page 19	Pass	—
		Broadcast Suppression, page 20	Pass	—
	HSRP, page 21	Basic HSRP, page 21	Pass	—
		HSRP Failover, page 22	Pass	—
	Routing, page 23	Route Verification, page 23	Pass	—
		Route Convergence—Corporate Headquarters, page 23	Pass	—
		Route Convergence—Remote Branches, page 26	Pass	—
		EIGRP Route Summarization, page 27	Pass	—

Table 4 Financial Enterprise System Test Results Summary (continued)

Test Suites	Feature Sets Tested	Tests	Results	DDTS/Comments
System Test	Layer 2 Multicast, page 28	IGMP, page 30	Pass	—
		IGMP Snooping, page 31	Pass	—
		CGMP, page 32	Pass	—
		MMLS, page 33	Pass	—
		MMLS Multicast Stub, page 34	Pass	—
	Layer 3 Multicast, page 35	PIM Sparse Mode, page 40	Pass	—
		SPT Threshold Infinity, page 41	Pass	—
		PIM Neighbor Filters, page 42	Pass	—
		Accept Register Filters, page 43	Pass	—
		MSDP with Anycast RP, page 43	Pass	—
		MSDP SA Filters, page 44	Pass	—
		Basic Auto-RP, page 44	Pass	—
		DR Priority, page 45	Pass	—
		Basic PGM, page 46	Pass	—
		Hoot-and-holler over IP, page 46	Pass	—
		IP/TV, page 49	Pass	—
	Negative Testing, page 50	RP and Designated Router Failover and Convergence—Market Data, page 50	Pass	—
		Reverse Path Forwarding Failover and Convergence—Corporate Headquarters, page 52	Pass	—
		RP Failover and Convergence—Remote Branches, page 55	Pass	—
		PIM Dense Mode Negative Testing, page 56	Pass	—
		IGMP DOS Attack, page 57	Pass	—
		Multicast Suppression, page 58	Pass	—
		Multicast Suppression with Router Alert, page 60	Pass	—
	Network Management, page 61	SNMP MIB Walk, page 62	Pass	—
		Syslog and NTP, page 63	Pass	—
		SNMP Traps, page 64	Pass	—
	Quality of Service, page 64	Baseline Traffic Queueing, page 68	Pass	—
		Traffic Congestion, page 69	Pass with exception	—

Table 4 *Financial Enterprise System Test Results Summary (continued)*

Test Suites	Feature Sets Tested	Tests	Results	DDTS/Comments
Multicast Scalability	Layer 2 Multicast Scalability, page 70	IGMP Join and Leave Latency—Corporate Headquarters, page 71	Pass	—
		IGMP Join and Leave Latency—Remote Branches, page 71	Pass	—
	Layer 3 Multicast Scalability, page 72	Multicast State, page 72	Pass	—
		MSDP with Anycast RP, page 72	Pass	—
		Scalability with RP/DR and RPF Failover and Convergence, page 73	Pass	—
Performance	Unicast Throughput, page 76	Unicast Throughput, page 76	Pass	—
	Multicast Throughput, page 77	Multicast Throughput, page 77	Pass	—
Reliability	150-Hour Duration Reliability, page 79	150-Hour Duration Reliability, page 79	Pass	—

Test Suites

This section describes the validation criteria for this test sequence and summarizes the tasks performed for each of the tests. For a definition of the validation criteria, see the [“Expected Results for the Entire Test Sequence”](#) section on page 15.

The feature sets tested are described in the following sections:

- [IP Routing, page 16](#)
- [System Tests for Financial Enterprises, page 28](#)
- [Multicast Scalability Tests for Financial Enterprises, page 70](#)
- [Performance Tests for Financial Enterprises, page 75](#)
- [Reliability Tests for Financial Enterprises, page 79](#)

Expected Results for the Entire Test Sequence

Although some tests have additional validation criteria, the success of each test was determined with the following minimal criteria:

- None of the following events should occur:
 - Router or switch crashes
 - Triggered reloads
 - Excessive CPU utilization (CPU utilization must not exceed 75 percent on any device)
 - Memory allocation errors
 - Unexpected interface toggles
- Routing tables must show all IP routes correctly

- All multicast and unicast client/server traffic must be routed without data corruption or any data loss for the duration of the test

IP Routing

This section provides details of the tests performed for the financial enterprise system testing of IP routing using EIGRP and OSPF as the unicast routing protocol. It includes the detailed procedure for executing the tests, the traffic profile, and the pass or fail criteria for each test.

The routing features tested are described in the following sections:

- [Layer 2 Spanning Tree, page 19](#)
- [HSRP, page 21](#)
- [Routing, page 23](#)

Configurations Used for IP Routing Tests—Corporate Headquarters

A total of 8 unique VLANs were configured on each Layer 2 switch and 8 access switches were included in the enterprise campus topology, resulting in a total of 64 access VLANs. Access VLANs were numbered consecutively with the assignments as shown in [Table 5](#).

Table 5 *IP Routing Configurations*

Layer 2 Access Switch	VLANs
ecs-j-6506-a1	2, 3, 4, 5, 6, 7, 8, 9
ecs-j-6505-a2	65, 66, 67, 68, 69, 70, 71, 72
ecs-j-6506-a3	129, 130, 131, 132, 133, 134, 135, 136
ecs-j-4000-a4	201, 202, 203, 204, 205, 206, 207, 208
ecs-j-4003-a5	265, 266, 267, 268, 269, 270, 271, 272
ecs-j-6506-sa1	301, 302, 303, 304, 305, 306, 307, 308
ecs-j-6506-sa2	365, 366, 367, 368, 369, 370, 371, 372
ecs-j-6506-sa3	429, 430, 431, 432, 433, 434, 435, 436

The following sections describe the router and switch configurations needed for the IP routing tests.

The speed and duplex settings were hardcoded on all trunk interfaces so that there was no negotiation. In addition, no trunk encapsulation or port channel negotiation was allowed, as shown in the following sections:

Native Cisco IOS Software Configuration

```
interface GigabitEthernet2/4
  duplex full
  speed 1000
  switchport trunk encapsulation dot1q
  switchport nonnegotiate
```

Cisco Catalyst OS Configuration

```
set port speed 1/1 1000
```



```

set port duplex 1/1 full
set trunk 2/1 nonegotiate dot1q 301-308
set port channel 1/1 mode off
set port flow 1/1 receive off
set port flow 1/1 send off

```

The diagnostic level was set to “minimal” to decrease the boot time (and therefore, downtime) during a router reload, as shown in the following sections:

Native Cisco IOS Software Configuration

```
diagnostic level minimal
```

Cisco Catalyst OS Configuration

```
set test diaglevel minimal
```

One of the redundant distribution routers was configured as the active Hot Standby Router Protocol (HSRP) router for the even-numbered VLANs and the other for the odd-numbered VLANs. The HSRP timers for the *hellotime* and *holdtime* settings were set to 1 and 3 seconds, respectively, to decrease convergence time.

HSRP interface tracking was configured so that if the active HSRP router lost both of its uplink interfaces the standby router would become active, as shown in the following sections:

Odd-Numbered Distribution Routers Configuration

(ecsj-6506-sd1, ecsj-6506-d1, ecsj-6506-d3)

```

interface vlan odd
  standby ip 126.2.1.3
  standby priority 110 preempt
  standby timers 1 3
  standby track GigabitEthernet0 19
  standby track GigabitEthernet1 19

interface vlan even
  standby ip 126.2.2.3
  standby priority 90 preempt
  standby timers 1 3
  standby track GigabitEthernet0 11
  standby track GigabitEthernet1 11

```

Even-Numbered Distribution Routers Configuration

(ecsj-6506-sd2, ecsj-6506-d2, ecsj-6506-d4)

```

interface vlan odd
  standby ip 126.2.1.3
  standby priority 90 preempt
  standby timers 1 3
  standby track GigabitEthernet0 11
  standby track GigabitEthernet1 11

interface vlan even
  standby ip 126.2.2.3
  standby priority 110 preempt
  standby timers 1 3
  standby track GigabitEthernet0 19
  standby track GigabitEthernet1 19

```

All user access interfaces were set to passive mode for EIGRP. The following commands illustrate the configuration:

```
router eigrp 1
  passive-interface FastEthernet0
  passive-interface FastEthernet1
```

The loopback addresses for the Anycast RP were tuned for the nondesignated routers so that the designated router (DR) would have a preferred route:

```
interface loopback0
  delay 600
```

The active HSRP router was configured to be the primary STP root bridge. The standby router was configured as the secondary STP root bridge. The devices described in the following sections were used for the IP routing tests:

Odd-Numbered Distribution Routers Configuration

(ecsj-6506-sd1, ecsj-6506-d1, ecsj-6506-d3)

```
spanning-tree vlan odd root primary
spanning-tree vlan even root secondary
```

Even-Numbered Distribution Routers Configuration

(ecsj-6506-sd2, ecsj-6506-d2, ecsj-6506-d4)

```
spanning-tree vlan odd root secondary
spanning-tree vlan even root primary
```

The **spanning-tree portfast** command was configured on the trunk interfaces to minimize the spanning tree convergence delay:

Native Cisco IOS Software Configuration

```
interface GigabitEthernet1/2
  spanning-tree portfast trunk
```

Cisco Catalyst OS Configuration

```
set spantree portfast 2/1 enable trunk
```

If the **spanning-tree portfast** command was not supported in the native Cisco IOS software or Cisco Catalyst OS version under test, then the spanning-tree timers were tuned instead as described next.

On the root bridge, the spanning-tree hello timers were tuned to 1 second and the forwarding delay timers to 4 seconds. Those timer changes were automatically propagated to other bridges in the same VLAN, which reduced the spanning-tree convergence and forwarding time:

Native Cisco IOS Software Configuration

```
spanning-tree vlan 301 hello 1
spanning-tree vlan 301 maxage 6
spanning-tree vlan 301 forward-time 4
```

Cisco Catalyst OS Configuration

```
set spantree hello 1 301
set spantree maxage 6 301
```

```
set spantree fiddelay 4 301
```

The enterprise campus topology was injected with 2000 EIGRP routes using a route simulator; 400 routes were injected into each core router (ecsj-6506-c1, ecsj-6506-c2, ecsj-6506-c3, ecsj-6506-c4); and another 400 routes were injected into ecsj-6506-sd2. The routes consisted of networks with network masks of several different lengths.

The **no ip directed-broadcast** command was configured on the access VLANs. Each router had a unique address assigned to its loopback interface. The unique address was used for MSDP peer connections.

Configurations Used for IP Routing Tests—Remote Branches

A total of nine remote branches were connected to the corporate headquarters across WAN connections. The WAN connections used the following three protocols: Frame Relay, HDLC, and PPP—only one protocol was used at any given time. To switch between each of the three protocols, a script was used to enable and disable the designated interfaces.

The following three Cisco hardware platforms were used to represent large, medium-size, and small branch offices, respectively: Cisco 7200 series, Cisco 3600 series, and Cisco 2600 series. One access switch was also used for each branch office. The large branch offices had two VLANs and the medium-size and small branch offices had one VLAN. In addition, the large branch offices had a dedicated voice-enabled router (Cisco 3620 router).

On branch routers, all user access interfaces were set to passive mode for EIGRP and OSPF. The following commands illustrate the configuration:

```
router eigrp 1
  passive-interface FastEthernet0/1
```

To reduce the number of routes populated to the branch routers from the corporate headquarters, EIGRP route summarization was configured on each outbound interface of the WAN aggregation routers in the corporate headquarters. The following commands illustrate the configuration:

```
ip summary-address eigrp 1 222.0.0.0 255.0.0.0 5
ip summary-address eigrp 1 126.0.0.0 255.0.0.0 5
ip summary-address eigrp 1 7.0.0.0 255.0.0.0 5
```

Layer 2 Spanning Tree

The tests performed for Layer 2 spanning tree are described in the following sections:

- [Spanning Tree, page 19](#)
- [Broadcast Suppression, page 20](#)

Spanning Tree

This test verified that the spanning-tree root bridge was assigned to the correct device. The active root bridge was coordinated with the active HSRP router and the active HSRP router was the active root bridge.

Test Plan

The procedure used to perform the [Spanning Tree](#) tests follows:

- Step 1 Verify that the active HSRP router is the root bridge. Use the **show spanning-tree root port** command and check the status.

Results

Table 6 shows the [Spanning Tree](#) test results.

Table 6 [Spanning Tree](#) Test Results

Tests	Results
Spanning Tree	Pass

Broadcast Suppression

This test measured the ability of the routers to manage traffic when a broadcast storm occurred.

Test Plan

The procedure used to perform the [Broadcast Suppression](#) tests follows:

- Step 1 Set the broadcast suppression level on device ecsj-6506-d1's trunk interface to device ecsj-6506-a1. Use the **storm-control broadcast level 1** command.
- Step 2 Use a traffic generator to generate Layer 2 broadcast packets with the speed of 1000, 5000, 10,000, 15,000, and 20,000 packets per second (pps).
- Step 3 Monitor ports to verify how much traffic is being received on other ports on the switch. Use the **show mac port number** command and record the percentage of CPU utilization on the appropriate access router. Broadcast suppression metrics are shown in [Table 7](#).

Table 7 [Broadcast Suppression](#) Test Results

Layer 2 Broadcast (pps)	CPU Utilization (5-Minute Average)
1000	5 percent
5000	9 percent
10,000	14 percent
15,000	26 percent
20,000	32 percent

- Step 4 Increase the traffic rate and record the corresponding percentage of CPU utilization on the corresponding router.
- Step 5 Stop the broadcast traffic.

Results

Table 8 shows the [Broadcast Suppression](#) test results.

Table 8 *Broadcast Suppression Test Results*

Tests	Results
Broadcast Suppression	Pass

HSRP

The HSRP tests verified the correct operation of HSRP. The basic HSRP verification test confirmed that the active and standby HSRP routers were correctly distributed between the redundant routers. The HSRP failover test verified that the standby router was activated when the primary failed.

The tests performed for HSRP are described in the following sections:

- [Basic HSRP, page 21](#)
- [HSRP Failover, page 22](#)

Basic HSRP

This test verified that each distribution router was the active HSRP router for half of the VLANs in the test network.

Test Plan

The procedure used to perform the [Basic HSRP Verification](#) tests follows:

- Step 1** Verify that each distribution router is the active HSRP router for half of the VLANs. Use the **show standby** and **show standby brief** commands.

Output from the **show standby brief** command follows. Notice that the state alternates between active and standby.

```
ecs-j-6506-d2# show standby brief
```

```

                                P indicates configured to preempt.
                                |
Interface  Grp  Prio  P State   Active addr   Standby addr   Group addr
Vl12      0    110   P Active   local         126.2.2.15     126.2.2.3
Vl13      0    90    P Standby  126.2.3.15    local          126.2.3.3
Vl14      0    110   P Active   local         126.2.4.15     126.2.4.3
Vl15      0    90    P Standby  126.2.5.15    local          126.2.5.3
Vl16      0    110   P Active   local         126.2.6.15     126.2.6.3
Vl17      0    90    P Standby  126.2.7.15    local          126.2.7.3
Vl18      0    110   P Active   local         126.2.8.15     126.2.8.3
Vl19      0    90    P Standby  126.2.9.15    local          126.2.9.3
Vl165     0    90    P Standby  126.2.65.15   local          126.2.65.3
Vl166     0    110   P Active   local         126.2.66.15    126.2.66.3
Vl167     0    90    P Standby  126.2.67.15   local          126.2.67.3
Vl168     0    110   P Active   local         126.2.68.15    126.2.68.3
Vl169     0    90    P Standby  126.2.69.15   local          126.2.69.3
Vl170     0    110   P Active   local         126.2.70.15    126.2.70.3
Vl171     0    90    P Standby  126.2.71.15   local          126.2.71.3
Vl172     0    110   P Active   local         126.2.72.15    126.2.72.3
Vl1129    0    90    P Standby  126.2.129.15  local          126.2.129.3
Vl1130    0    110   P Active   local         126.2.130.15   126.2.130.3
Vl1131    0    90    P Standby  126.2.131.15  local          126.2.131.3
Vl1132    0    110   P Active   local         126.2.132.15   126.2.132.3

```

Vl1133	0	90	P Standby	126.2.133.15	local	126.2.133.3
Vl1134	0	110	P Active	local	126.2.134.15	126.2.134.3
Vl1135	0	90	P Standby	126.2.135.15	local	126.2.135.3
Vl1136	0	110	P Active	local	126.2.136.15	126.2.136.3

Results

Table 9 shows the [Basic HSRP](#) test results.

Table 9 Basic HSRP Test Results

Tests	Results
Basic HSRP	Pass

HSRP Failover

This test verified that each distribution router assumed routing for the other as expected when one router was disabled.

Test Plan

The procedure used to perform the [HSRP Failover](#) tests follows:

- Step 1 Shut down the ecsj-6506-d1 router.
- Step 2 Verify that the backup router (ecsj-6506-d2) is in an active state and that it takes over for the previously failed router. Verify that all of the VLANs supported by the failed router are now being supported by the backup router.
- Step 3 Capture debug information for the failover. Use the **debug standby events** and **debug standby events detail** commands.
- Step 4 Restart the previously failed router (ecsj-6506-d1).
- Step 5 Verify that the primary router resumes an active state and that it is supporting half of the VLANs in the lab environment. Use the **show standby** and **show standby brief** commands.
- Step 6 Capture debug information for the router restart. Use the **debug standby events** and **debug standby events detail** commands.
- Step 7 On one of the distribution routers (ecsj-6506-d1 or ecsj-6506-d2), shut down both of the interfaces to the core routers (ecsj-6506-d3 and ecsj-6506-d4).
- Step 8 Verify that the second distribution router becomes active and is supporting all of the VLANs. Use the **show standby** and **show standby brief** commands.
- Step 9 Restart the previously failed router (ecsj-6506-d1 or ecsj-6506-d2).
- Step 10 Capture debug information for the transition. Use the **debug standby events** and **debug standby events detail** commands.
- Step 11 Verify that the primary router resumes an active state and that it is supporting half of the VLANs in the lab environment. Use the **show standby** and **show standby brief** commands.
- Step 12 Capture debug information for the restart and recovery of the failed router. Use the **debug standby events** and **debug standby events detail** commands.

Results

Table 10 shows the [HSRP Failover](#) test results.

Table 10 *HSRP Failover Test Results*

Tests	Results
HSRP Failover	Pass

Routing

The routing tests verified that basic IP routing functioned as expected. Testing procedures addressed route verification and convergence and are described in the following sections:

- [Route Verification, page 23](#)
- [Route Convergence—Corporate Headquarters, page 23](#)
- [Route Convergence—Remote Branches, page 26](#)
- [EIGRP Route Summarization, page 27](#)

Route Verification

This test verified that the expected number of routes was seen on the core and distribution routers.

Test Plan

The procedure used to perform the [Route Verification](#) tests follows:

-
- | | |
|--------|--|
| Step 1 | Verify that the expected number of routes are being processed on the core and distribution routers. Use the show ip route summary command to display these results. |
|--------|--|
-

Results

Table 11 shows the [Route Verification](#) test results.

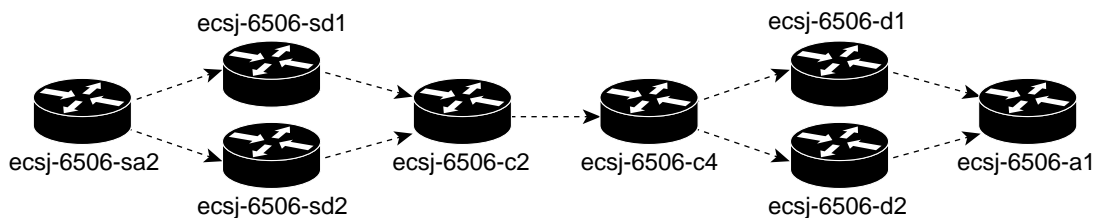
Table 11 *Route Verification Test Results*

Tests	Results
Route Verification	Pass

Route Convergence—Corporate Headquarters

In this route convergence test, network convergence was measured from the data source to the receiver (end-to-end network convergence). Smartbits was used to send a data stream with sequenced packets at a specified data rate. A corresponding convergence time was associated with each packet dropped during network convergence. For example, a data packet rate of 1000 pps corresponded to 1 millisecond (ms) convergence time for each packet dropped.

The data path used for testing route convergence is shown in [Figure 6](#).

Figure 6 Data Path for Testing Route Convergence

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Test Plan

The procedure used to perform the [Route Convergence—Corporate Headquarters](#) tests follows:

-
- Step 1** Fail ecsj-6506-d2 by bringing it to the RMON prompt. Measure the convergence time.
 - Step 2** Restart ecsj-6506-d2. Measure the convergence time.
 - Step 3** Fail ecsj-6506-d1 by bringing it to the RMON prompt. Measure the convergence time.
 - Step 4** Restart ecsj-6506-d1. Measure the convergence time.
 - Step 5** Fail ecsj-6506-sd2 by bringing it to the RMON prompt. Measure the convergence time.
 - Step 6** Restart ecsj-6506-sd2. Measure the convergence time.
 - Step 7** Fail ecsj-6506-sd1 by bringing it to the RMON prompt. Measure the convergence time.
 - Step 8** Restart ecsj-6506-sd1. Measure the convergence time.
 - Step 9** Fail ecsj-6506-c2 by bringing it to the RMON prompt. Measure the convergence time.
 - Step 10** Restart ecsj-6506-c2. Measure the convergence time.
 - Step 11** Fail the link between ecsj-6506-c4 and ecsj-6506-d2 by closing the interface on ecsj-6506-d2. Measure the convergence time.
 - Step 12** Bring back the link between ecsj-6506-c4 and ecsj-6506-d2 by opening the interface on ecsj-6506-d2.
 - Step 13** Fail the link between ecsj-6506-c2 and ecsj-6506-c4 by closing the interface on ecsj-6506-c4. Measure the convergence time.
 - Step 14** Bring back the link between ecsj-6506-c2 and ecsj-6506-c4 by opening the interface on ecsj-6506-c4.
 - Step 15** Repeat all convergence tests defined in Steps 1 through 14 and measure the reverse flow of data.
-

Results

[Table 12](#) shows the [Route Convergence—Corporate Headquarters](#) test results.

Table 12 Route Convergence—Corporate Headquarters Test Results

Tests	Results
Route Convergence—Corporate Headquarters	Pass

Detailed metrics for each device tested in route convergence are shown in [Table 13](#). All results in this table are shown in seconds.

Table 13 *Unicast Route Convergence Test Results—Corporate Headquarters (Results Shown in Seconds)*

Step	Test Description	EIGRP		OSPF	
		Data Center to Access	Reverse Path	Data Center to Access	Reverse Path
1	ecsj-6506-d2 down	1.54	0.00	1.22	0.00
2	ecsj-6506-d2 up	0.00	0.89	0.00	42.29
3	ecsj-6506-d1 down	0.00	0.00	0.00	0.00
4	ecsj-6506-d1 up	0.00	0.00	0.00	0.00
5	ecsj-6506-sd2 down	0.00	3.20	0.00	2.65
6	ecsj-6506-sd2 up	0.00	2.57	45.99	0.00
7	ecsj-6506-sd1 down	0.00	0.00	0.00	0.00
8	ecsj-6506-sd1 up	0.00	0.00	0.00	0.00
9	ecsj-6506-c2 down	3.19	1.16	2.01	1.10
10	ecsj-6506-c2 up	0.00	0.00	0.28	0.00
11	Fail the link between ecsj-6506-c4 and ecsj-6506-d2	1.73	0.00	1.48	0.25
12	Bring back the link between ecsj-6506-c4 and ecsj-6506-d2	0.00	0.00	0.00	0.00
13	Fail the link between ecsj-6506-c2 and ecsj-6506-c4	1.17	0.01	1.05	0.16
14	Bring back the link between ecsj-6506-c2 and ecsj-6506-c4	0.00	0.00	0.00	0.00

Result Analysis for Network Convergence

The network convergence test results are intended as a guide to assist network architects in gaining a general idea of what type of convergence to expect in an actual deployment. The results are not meant to imply any guarantee of specific performance in an actual deployment.

Many factors may affect the outcome of convergence testing. Even in a controlled lab environment with simulated traffic and close attention to detail, these factors can still cause the results to vary from one test run to another. Some of the reasons for this type of inconsistent and nondeterministic behavior are described in the following paragraphs.

The actual convergence time may be affected by the following factors:

- Due to the complexity of a large distributed network, consistent behavior is difficult to achieve from what may seem to be a deterministic set of events. The reality is that a network with 30 routers has at least 30 processors with many types of memory, buffers, line cards, and drivers—all running independently in a distributed fashion. The start of data forwarding depends on the timing of dozens of successful protocol negotiations at Layer 2 and Layer 3, including SPT, HSRP, EIGRP neighbors negotiation, OSPF designated router negotiation, PIM designated router negotiation, and so on.
- Line cards and the individual ports on the line cards are controlled by dedicated processors and come up at different times—usually in the order of the slot and port. We are not testing with the highest slot and port combination on the router.

- The number of line cards in any router or switch will affect the amount of time required to completely boot. The network convergence tests were not performed with fully loaded routers and switches.
- In a Catalyst 6500 family switch, router and switch packets are forwarded based on hardware shortcuts that are created based on a hash algorithm that considers the source and destination address (flow-based). In other words, depending on the hashed value of the actual IP address, the packets may flow over one equal-cost path versus another. This factor was minimized by using the same IP addresses, same ports, and the same environment whenever possible. However, there are some cases in which the values of the IP addresses can create some behavior in unicast convergence that seems inconsistent.
- Each individual data stream will take slightly different times to converge, depending on how the routing updates are built and installed into the forwarding table. Only one stream of thousands was measured for convergence. It may not be the slowest stream to converge.

Despite these factors, the test results are useful as a guide in network design. The tests were run in a test network that was assembled and configured using the current best practices for a financial services organization. The traffic streams and data rates were typical to those that would be used in a financial environment. The results were also typical of the expected behavior during normal operation and failure scenarios.

Route Convergence—Remote Branches

In this route convergence test, network convergence was measured from the data source to the receiver (end-to-end network convergence). Smartbits was used to send a data stream with sequenced packets at a specified data rate. A corresponding convergence time was associated with each packet dropped during network convergence. For example, a data packet rate of 1000 pps corresponded to 1 ms convergence time for each packet dropped.

To test route convergence, bidirectional data paths were verified between the following corporate headquarters devices and remote branch devices:

- Frame Relay between ecsj-6506-sa1 (Data Center) and eabr1-4006-a1 (branch 1)
- PPP between ecsj-6506-sa1 (Data Center) and eabr7-2950-a1 (branch 7)
- HDLC between ecsj-6506-sa1 (Data Center) and eabr4-3550-a1 (branch 4)

Test Plan

The procedure used to perform the [Route Convergence—Remote Branches](#) tests follows:

-
- | | |
|---------------|---|
| Step 1 | Fail ecsj-6506-sd1 by bringing it to the RMON prompt. Measure the convergence time. |
| Step 2 | Restart ecsj-6506-sd1. Measure the convergence time. |
| Step 3 | Fail ecsj-6506-sd2 by bringing it to the RMON prompt. Measure the convergence time. |
| Step 4 | Restart ecsj-6506-sd2. Measure the convergence time. |
-

Results

Table 14 shows the [Route Convergence—Remote Branches](#) test results.

Table 14 *Route Convergence—Remote Branches Test Results*

Tests	Results
Route Convergence—Remote Branches	Pass

Detailed metrics for each device tested in route convergence are shown in [Table 15](#). All results in this table are shown in seconds.

Table 15 *Unicast Route Convergence Test Results—Remote Branches (Results Shown in Seconds)*

Step	Test Description	EIGRP		OSPF	
		Data Center to Access	Reverse Path	Data Center to Access	Reverse Path
Frame Relay					
1	ecsj-6506-sd1 down	0.00	3.16	0.00	1.90
2	ecsj-6506-sd1 up	0.00	1.32	46.11	0.08
3	ecsj-6506-sd2 down	0.00	0.00	0.00	0.01
4	ecsj-6506-sd2 up	5.36	4.96	0.00	0.07
PPP					
1	ecsj-6506-sd1 down	0.00	3.15	0.00	1.94
2	ecsj-6506-sd1 up	0.02	1.47	45.76	0.02
3	ecsj-6506-sd2 down	0.00	0.00	0.00	0.00
4	ecsj-6506-sd2 up	3.33	5.21	0.00	0.02
HDLC					
1	ecsj-6506-sd1 down	0.00	3.13	0.00	1.93
2	ecsj-6506-sd1 up	0.00	3.20	46.29	0.00
3	ecsj-6506-sd2 down	0.00	0.00	0.00	0.00
4	ecsj-6506-sd2 up	6.14	4.96	0.00	0.00

For a discussion of the convergence results shown in [Table 15](#), see the “[Result Analysis for Network Convergence](#)” section on page 25.

EIGRP Route Summarization

This test verified that all the subnets of the 7.0.0.0, 126.0.0.0, and 222.0.0.0 networks were properly summarized on all branch routers.

Test Plan

The procedure used to perform the [EIGRP Route Summarization](#) tests follows:

- Step 1** Perform an EIGRP routes summarization for the 7.0.0.0, 126.0.0.0, and 222.0.0.0 networks on all branch routers. Use the **ip summary-address eigrp** command. The following commands illustrate the configuration:

```
ip summary-address eigrp 1 222.0.0.0 255.0.0.0 5
ip summary-address eigrp 1 126.0.0.0 255.0.0.0 5
ip summary-address eigrp 1 7.0.0.0 255.0.0.0 5
```

- Step 2** Use the **show ip route summary** command and verify in the output that the appropriate routes were summarized.

Results

Table 16 shows the [EIGRP Route Summarization](#) test results.

Table 16 *EIGRP Route Summarization Test Results*

Tests	Results
EIGRP Route Summarization	Pass

System Tests for Financial Enterprises

System tests included configuring the IGMP, IGMP snooping, and Cisco Group Management Protocol (CGMP), and enabling multicast multilayer switching (MMLS) on the Catalyst switches. Also tested were some more advanced multicast features of PIM-SM, such as the **ip pim spt-threshold infinity** command, PIM neighbor filters, accept register filter, MSDP with Anycast RP, basic Auto-RP, candidate RP filters, and Pragmatic General Multicast (PGM).

Once the Catalyst switches were configured, multicast traffic was passed end-to-end from the data servers to the clients, and vice versa. Smooth delivery of application traffic without any disruptions in the network was required.

An SNMP MIB “walk” was used to periodically poll the network devices for state, and data was collected for SNMP traps and syslog commands. Some negative testing was done to observe router performance and to ensure that devices did not crash or that the CPU did not freeze in a hostile environment. Details of the tests are provided in the following sections:

- [Layer 2 Multicast, page 28](#)
- [Layer 3 Multicast, page 35](#)
- [Negative Testing, page 50](#)
- [Network Management, page 61](#)
- [Quality of Service, page 64](#)

Layer 2 Multicast

The following sections describe the configurations and the series of tests performed to test Layer 2 multicast:

- [Configurations Used for Layer 2 Multicast Tests, page 29](#)

- [IGMP, page 30](#)
- [IGMP Snooping, page 31](#)
- [CGMP, page 32](#)
- [MMLS, page 33](#)
- [MMLS Multicast Stub, page 34](#)

Configurations Used for Layer 2 Multicast Tests

The following configurations were used for the Layer 2 multicast tests. Any configurations customized for specific tests are described within the descriptions for those tests.

The following configurations were verified to be present on the indicated routers and switches before commencing this section of the test.

IGMP Snooping

(ecsj-6506-sd1, ecsj-6506-sd2, ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4, ecsj-6506-sa1, ecsj-6506-sa2, ecsj-6506-sa3, ecsj-6506-a1, ecsj-6506-a2, ecsj-6506-a3, ecbr1-4006-a1, ecbr2-3550-a1, ecbr3-2950-a1, ecbr4-3550-a1, ecbr5-3550-a1, ecbr6-2950-a1, ecbr7-2950-a1, ecbr8-3550-a1, ecbr9-2950-a1)

Configure the following command on all switches running Cisco Catalyst OS software:

```
set igmp enable
```

Configure the following command on all switches running Cisco IOS software:

```
ip igmp snooping
```

CGMP

(ecsj-6506-d3, ecsj-6506-d4, ecsj-4000-a4, ecsj-4000-a5)

Configure the following command on all switches running Cisco Catalyst OS software:

```
set cgmp enable
```

Configure the following commands on all switches running Cisco IOS software:

```
interface interface
 ip cgmp
```

MMLS Configuration

(ecsj-6506-sd1, ecsj-6506-sd2, ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4, ecsj-6506-c1, ecsj-6506-c2, ecsj-6506-c3, ecsj-6506-c4)

MMLS should be configured by default in native Cisco IOS software and in the Cisco Catalyst OS when multicast is configured globally.

MMLS Multicast Stub Configuration

(ecsj-6506-sd1, ecsj-6506-d1, ecsj-6506-d3)

Configure the following commands on the nondesignated router access interfaces:

```
interface Vlan vlan-interface-number
 mls ip multicast stub
```

The **mls ip multicast stub** command must be configured because of the redundant router design at the distribution layer. In this design, all multicast traffic forwarded on the access LANs will be dropped by the nondesignated router. The **mls ip multicast stub** command enables this function to be performed by hardware instead by software. For more information about this feature, refer to the Cisco application note *Redundant Router Issues with IP Multicast in Stub Networks* located at the following URL:

http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/ipst_an.htm

IGMP

This test verified that IGMP was working correctly on the access routers and switches. The appropriate multicast groups should appear and disappear when IGMP receivers join and leave the groups. This task was performed on the following routers and switches.

(ecsj-6506-sd1, ecsj-6506-sd2, ecsj-6506-sa1, ecsj-6506-sa2, ecsj-6506-sa3, ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-a1, ecsj-4000-a2, ecsj-5500-a3, ecsj-6506-d3, ecsj-6506-d4, ecsj-4000-a4, ecsj-6506-a5)

Test Plan

The procedure used to perform the **IGMP** tests follows:

- Step 1** Turn on IGMP receivers and observe that groups appear. Enter the commands as listed in [Table 17](#):

Table 17 *show Commands Used to Verify IGMP Receiver Test*

Device	Command
Layer 3 switch	show ip igmp groups show ip igmp interface
Layer 2 switch	show igmp statistics show multicast protocols status
Catalyst 4000 switch	show cgmp statistics

- Step 2** Turn off IGMP receivers and use the [Table 17](#) commands to verify that groups disappear.

Results

[Table 18](#) shows the **IGMP** test results.

Table 18 *IGMP Test Results*

Tests	Results
IGMP	Pass

IGMP Snooping

This test verified that [IGMP Snooping](#) was working properly in the lab environment. The following configurations were verified to be present on the indicated routers and switches before commencing this section of the test.

(ecsj-6506-sd1, ecsj-6506-sd2, ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4, ecsj-6506-sa1, ecsj-6506-sa2, ecsj-6506-sa3, ecsj-6506-a1, ecsj-6506-a2, ecsj-6506-a3, ecbr1-4006-a1, ecbr2-3550-a1, ecbr3-2950-a1, ecbr4-3550-a1, ecbr5-3550-a1, ecbr6-2950-a1, ecbr7-2950-a1, ecbr8-3550-a1, ecbr9-2950-a1)

Test Plan

The procedure used to perform the [IGMP Snooping](#) tests follows:

-
- Step 1** Configure the following command on all switches running Cisco Catalyst OS software:
- **set igmp enable**
- Step 2** Configure the following command on all switches running Cisco IOS software:
- **ip igmp snooping**
- Step 3** Verify that IGMP snooping is working correctly on the designated switches. Use the following command on switches running Cisco Catalyst OS software:
- **show igmp mode**
- Use the following command on switches running Cisco IOS software:
- **show ip igmp snooping**
- Step 4** Verify that the correct multicast router has been learned by the switch. Use the following command on switches running Cisco Catalyst OS software:
- **show multicast router igmp**
- Use the following command on switches running Cisco IOS software:
- **show ip igmp snooping mrouter**
- Step 5** Verify that the correct multicast addresses are present. Use the following command on switches running Cisco Catalyst OS software:
- **show multicast group *mac_addr***
- Use the following command on switches running Cisco IOS software:
- **show mac-address-table multicast**
- Use the following commands on routers running Cisco IOS software:
- **show ip igmp groups**
 - **show ip igmp interface**
-

Results

Table 19 shows the IGMP Snooping test results.

Table 19 *IGMP Snooping Test Results*

Tests	Results
IGMP Snooping	Pass

CGMP

This test verified that CGMP was working properly between the routers and the Catalyst switches. The following configurations were verified to be present on the indicated routers and switches before commencing this section of the test.

(ecsj-6506-d3, ecsj-6506-d4, ecsj-4000-a4, ecsj-4000-a5)

Test Plan

The procedure used to perform the CGMP tests follows:

-
- | | |
|---------------|--|
| Step 1 | Configure the following command on all switches running Cisco Catalyst OS software: <ul style="list-style-type: none"> • set cgmp enable |
| Step 2 | Configure the following commands on all switches running Cisco IOS software: <ul style="list-style-type: none"> • interface <i>interface</i> <li style="padding-left: 40px;">ip cgmp |
| Step 3 | Verify that CGMP is working correctly on the distribution routers. Use the debug ip cgmp command and observe the output to verify that CGMP messages are being sent and that there is no conflict between CGMP and HSRP. For more information about possible conflicts between CGMP and HSRP, refer to the application note <i>How CGMP Leave Processing Functions</i> found at the following URL:

http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/cgmp_an.htm |
| Step 4 | Verify the multicast group and port entries for CGMP on the switch by entering the following commands on the switch: <ul style="list-style-type: none"> • show cam static • show cgmp statistic • show cgmp leave • show multicast group cgmp • show multicast group count |
-

Results

Table 20 shows the [CGMP](#) test results.

Table 20 [CGMP](#) Test Results

Tests	Results
CGMP	Pass

MMLS

This test verified that MMLS was working correctly and that hardware shortcuts were installed in the high-speed switching ASICs. This task was performed on the following routers and switches.

(ecsj-6506-sd1, ecsj-6506-sd2, ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4, ecsj-6506-c1, ecsj-6506-c2, ecsj-6506-c3, ecsj-6506-c4)

Test Plan

The procedure used to perform the [MMLS](#) tests follows:

- Step 1** Verify that MMLS is active. Enter the following commands and look for the expected message in the output display as indicated next:
- Use the **show mls ip multicast** command to verify that the display contains “RPF-MFD installed,” in boldface in the following sample output:

```
ecsj-6506-d2# show mls ip multicast

Multicast hardware switched flows:
(126.2.133.57, 239.254.1.25) Incoming interface: Vlan133, Packets switched: 8679
Hardware switched outgoing interfaces: GigabitEthernet2/1
RPF-MFD installed...
```
 - Use the **show ip pim interface count** command and verify that the output display indicates that the hardware is switched, in boldface in the following example. Notice that the letter “H” in boldface type appears in this display. The possible states are defined in the key that immediately follows the **show** command.

```
ecsj-6506-d2# show ip pim interface count

State: * - Fast Switched, D - Distributed Fast Switched
H - Hardware Switched
Address Interface FS Mpackets In/Out
126.2.2.16 Vlan2 * H 14181110/516510
126.2.3.16 Vlan3 * H 14181126/345897
126.2.4.16 Vlan4 * H 14181110/175296...
```
 - Use the **show ip interface** command to verify that the message “IP multicast multilayer switching is enabled.” appears in the output display.

- d. Use the **show ip mroute** command to verify that “hardware switched” is set for all appropriate flows listed in the output data (indicated by the letter “H” in boldface type); also verify that “RPF-MFD” is set for all appropriate flows in the output data. These messages are both present in the following example output:

```
ecs-j-6506-d2# show ip mroute

IP Multicast Routing Table
Flags: D - Dense, S - Sparse, s - SSM Group, C - Connected, L - Local,
P - Pruned, R - RP-bit set, F - Register flag, T - SPT-bit set,
J - Join SPT, M - MSDP created entry, X - Proxy Join Timer Running
A - Advertised via MSDP, U - URD, I - Received Source Specific Host Report
Outgoing interface flags: H - Hardware switched
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode
(*, 239.254.1.0), 16:55:49/00:02:58, RP 126.0.1.1, flags: SC
Incoming interface: GigabitEthernet2/1, RPF nbr 126.1.11.14, RPF-MFD
Outgoing interface list:
Vlan129, Forward/Sparse, 16:55:44/00:02:56, H
Vlan2, Forward/Sparse, 16:55:49/00:02:47, H
Vlan65, Forward/Sparse, 16:55:49/00:02:58, H
```

- Step 2** Turn on debugging to verify that MMLS is working correctly. Use the **debug mls ip multicast events** and **debug mls ip multicast messages** commands.
- Step 3** Clear a particular (S, G) multicast route entry and verify that it is removed and re-added, as shown in this example:

```
ecs-j-6506-d5# clear ip mroute 239.254.1.64 126.4.1.52

MLSM: build sc delete: (126.4.1.52, 239.254.1.64, 501) tlv_size 16
MLSM: del ack (126.4.1.52, 239.254.1.64, 501),D
MLSM: Drop orphan FE_OIF_ADD (126.4.1.52, 239.254.1.64, 501) +4089
MLSM: build ins (126.4.1.52, 239.254.1.64, 501), tlv_size 18 OIF:4089
MLSM: ins ack(126.4.1.52, 239.254.1.64, 501), OLEN 2,H OIF: +4089(0x0)I
```

Results

Table 21 shows the MMLS test results.

Table 21 MMLS Test Results

Tests	Results
MMLS	Pass

MMLS Multicast Stub

This test verified that the stub network filter was active and working properly. MMLS is configured by default when multicast is configured globally. This task was performed on the following routers and switches.

(ecs-j-6506-sd1, ecs-j-6506-sd2, ecs-j-6506-d1, ecs-j-6506-d2, ecs-j-6506-d3, ecs-j-6506-d4)

The following configurations were verified to be present on the indicated nondesignated routers and switches before commencing this section of the test.

(ecsj-6506-sd1, ecsj-6506-d1, ecsj-6506-d3):

```
interface interface
  mls ip multicast stub
```

Test Plan

The procedure used to perform the [MMLS Multicast Stub](#) tests follows:

- Step 1** Use the **show mls ip multicast summary** command and verify that the display lists the correct VLANs, in boldface in the following sample output:

```
ecsj-6506-d1# show mls ip multicast summary
```

```
7888 MMLS entries using 1036528 bytes of memory
Number of partial hardware-switched flows:0
Number of complete hardware-switched flows:7888
Directly connected subnet entry install is enabled
Hardware CEF based rate-limiting of RPF failures is enabled
Aggregation of routed oif is enabled
Multicast Stub enabled interface(s)
Vlan2, Vlan3, Vlan4, Vlan5, Vlan6, Vlan7, Vlan8, Vlan9, Vlan65, Vlan66, Vlan67, Vlan68,
Vlan69, Vlan70, Vlan71, Vlan72, Vlan129, Vlan130, Vlan131, Vlan132, Vlan133, Vlan134,
Vlan135, Vlan136
```

- Step 2** Use the **show ip mroute** command on a nondesignated router and verify in the output that the appropriate routes are present.

Results

Table 22 shows the [MMLS Multicast Stub](#) tests results.

Table 22 *MMLS Multicast Stub Test Results*

Tests	Results
MMLS Multicast Stub	Pass

Layer 3 Multicast

For Layer 3 multicast testing, IP multicast features such as PIM-SM, SPT threshold infinity, PIM neighbor filters, accept register filters, MSDP with Anycast RP verification, MSDP SA filters, basic Auto-RP, and PGM basic were configured. Once configured, multicast traffic was passed end-to-end from the data servers to the clients, and vice versa, to verify smooth delivery of application traffic without any disruptions in the network.

The network devices were monitored periodically to verify correct operation. IP multicast testing was performed with both EIGRP and OSPF IP routing protocols. Unless otherwise specified, all the routers ran PIM-SM.

To facilitate the trading applications on the financial campus, the network was configured as follows:

- Static RPs were defined.

- Redundant RPs ran MSDP to facilitate Anycast RP.
- The SPT threshold was set to infinity to ensure that multicast traffic used shared tree only.
- The **mls ip multicast stub** command was enabled on all of the user interfaces on the access routers.
- Accept register filters were configured on the RPs so that they accepted only sources originating from the subnets they served.
- MSDP SA filters were configured on each RP so that they accepted SA messages only from the groups they served.

To facilitate hoot-and-holler over IP and corporate communications applications, the network was configured as follows:

- The **ip pim autorp listen** command was configured on PIM-SP interfaces so that Auto-RP was enabled.
- Redundant RPs ran MSDP to facilitate Anycast RP.
- The SPT threshold was set to zero (the default setting) so that hoot-and-holler over IP and corporate communications would use the SPT.
- The **mls ip multicast stub** command was enabled on all the user interfaces on the access routers.
- MSDP SA filters were configured on the RPs so that they accepted the SA messages only from the groups they served.

Layer 3 multicast system configurations and testing are described in the following sections:

- [Prerequisite Configurations, page 36](#)
- [Configurations Used for Layer 3 Multicast System Tests, page 37](#)
- [PIM Sparse Mode, page 40](#)
- [SPT Threshold Infinity, page 41](#)
- [PIM Neighbor Filters, page 42](#)
- [Accept Register Filters, page 43](#)
- [MSDP with Anycast RP, page 43](#)
- [MSDP SA Filters, page 44](#)
- [Basic Auto-RP, page 44](#)
- [DR Priority, page 45](#)
- [Basic PGM, page 46](#)
- [Hoot-and-holler over IP, page 46](#)
- [IP/TV, page 49](#)

Prerequisite Configurations

Layer 3 multicast testing included the following devices:

Multicast Routers—Corporate Headquarters

ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4, ecsj-6506-c1, ecsj-6506-c2, ecsj-6506-c3, ecsj-6506-c4, ecsj-6506-sd1, ecsj-6506-sd2, ecsj-3640-h1, ecsj-3640-h2, ecsj-7206-w1, ecsj-6506-w2, ecsj-7513-w3

Multicast Routers—Remote Branches

ecbr1-7206-e1, ecbr2-3640-e1, ecbr3-2651-e1, ecbr4-7206-e1, ecbr5-3640-e1, ecbr6-2651-e1, ecbr7-7206-e1, ecbr8-3640-e1, ecbr9-2651-e1, ecbr1-3620-v1, ecbr4-3620-v1, ecbr7-3620-v1

RP Routers

ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4, ecsj-6506-sd1, ecsj-6506-sd2, ecsj-6506-c3, ecsj-6506-c4

Configurations Used for Layer 3 Multicast System Tests

The following configurations were verified to be present on the indicated routers and switches before commencing this section of the test.

All Multicast Routers

Enable multicast routing and Auto-RP listener:

```
ip multicast-routing
ip pim autorp listener
```

Set SPT threshold to infinity for all multicast groups except for hoot-and-holler over IP and IP/TV groups:

```
ip pim spt-threshold infinity group-list 6
access-list 6 deny 239.254.2.0 0.0.0.255
access-list 6 deny 239.254.3.0 0.0.0.255
access-list 6 permit any
```

Statically define the RPs for market data publish and subscribe groups:

```
ip pim rp-address 126.0.1.1 1
access-list 1 permit 239.254.1.0 0.0.0.15 log
ip pim rp-address 126.0.1.2 2
access-list 2 permit 239.254.1.16 0 0.0.0.15 log
ip pim rp-address 126.0.1.3 3
access-list 3 permit 239.254.1.32 0 0.0.0.15 log
```

Enable PIM-SM on all router interfaces:

```
interface interface
  ip pim sparse-mode
  ip pim query-interval 1
! Configure the ip pim query-interval command only on access interfaces with
! redundant routers. The default value for the query interval is 30 seconds.
```

RP Routers for Hoot-and-holler over IP and IP/TV Sessions:

Define Auto-RP parameters on devices ecsj-6506-c3 and ecsj-6506-c4:

```
ip pim send-rp-announce Loopback0 scope 16 group-list 7
ip pim send-rp-discovery Loopback1 scope 16
access-list 7 permit 239.254.2.0 0.0.0.15 log
access-list 7 permit 239.254.3.0 0.0.0.15 log
```

WAN Aggregation Routers

Configure a multicast boundary on each outgoing WAN interface of the WAN aggregation routers (ecsj-7206-w1, ecsj-6506-w2, ecsj-7513-w3) to allow Auto-RP, hoot-and-holler over IP, and IP/TV traffic to flow to the remote branches:

```
interface Serial0
  ip multicast boundary 10 filter-autorp
```

```
access-list 10 permit 224.0.1.39
access-list 10 permit 224.0.1.40
access-list 10 permit 239.254.2.0 0.0.0.255
access-list 10 permit 239.254.3.0 0.0.0.255
```

RP Routers for MSDP with Anycast RP

Floor 1 Configuration

Configure the following commands on device ecsj-6506-d1:

```
interface loopback0
  ip address 126.0.1.2 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.15 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.16 connect-source loopback 1
ip msdp originator-id loopback 1
```

Configure the following commands on device ecsj-6506-d2:

```
interface loopback0
  ip address 126.0.1.2 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.16 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.15 connect-source loopback 1
ip msdp originator-id loopback 1
```

Floor 2 Configuration

Configure the following commands on device ecsj-6506-d3:

```
interface loopback0
  ip address 126.0.1.3 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.17 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.18 connect-source loopback 1
ip msdp originator-id loopback 1
```

Configure the following commands on device ecsj-6506-d4:

```
interface loopback0
  ip address 126.0.1.3 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.18 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.17 connect-source loopback 1
ip msdp originator-id loopback 1
```

Data Center Configuration

Configure the following commands on device ecsj-6506-sd1:

```
interface loopback0
  ip address 126.0.1.1 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.19 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.20 connect-source loopback 1
ip msdp originator-id loopback 1
```

Configure the following commands on device ecsj-6506-sd2:

```
interface loopback0
  ip address 126.0.1.1 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.20 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.19 connect-source loopback 1
ip msdp originator-id loopback 1
```

Hoot-and-holler over IP and IP/TV RP Configuration

Configure the following commands on device ecsj-6506-c3:

```
interface loopback0
  ip address 126.0.1.5 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.13 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.14 connect-source loopback 1
ip msdp originator-id loopback 1
```

Configure the following commands on device ecsj-6506-c4:

```
interface loopback0
  ip address 126.0.1.5 255.255.255.255
  ip pim sparse-mode

interface loopback 1
  ip address 126.0.1.14 255.255.255.255
  ip pim sparse-mode

ip msdp peer 126.0.1.13 connect-source loopback 1
ip msdp originator-id loopback 1
```

Accept Register Filters Configuration

Configure the following commands on devices ecsj-6506-d1 and ecsj -6506-d2:

```
ip pim accept-register list only-floor1
ip access-list extended only-floor1
permit ip 126.2.0.0 0.0.255.255 any
```

Configure the following commands on devices ecsj-6506-d3 and ecsj-6506-d4:

```
ip pim accept-register list only-floor2
ip access-list extended only-floor2
permit ip 126.3.0.0 0.0.255.255 any
```

Configure the following commands on devices ecsj-6506-sd1 and ecsj-6506-sd2:

```
ip pim accept-register list only-DC
ip access-list extended only-DC
permit ip 126.32.0.0 0.0.255.255 any
```

MSDP SA Filters Configuration

Configure the following commands on devices ecsj-6506-d1 and ecsj-6506-d2:

```
ip msdp sa-filter in peer_address list 111
ip msdp sa-filter out peer_address list 111
access-list 111 permit ip 126.2.0.0 0.0.255.255 239.254.1.16 0.0.0.15
access-list 111 deny ip any any log
```

Configure the following commands on devices ecsj-6506-d3 and ecsj-6506-d4:

```
ip msdp sa-filter in peer_address list 111
ip msdp sa-filter out peer_address list 111
access-list 111 permit ip 126.3.0.0 0.0.255.255 239.254.1.32 0.0.0.15
access-list 111 deny ip any any log
```

Configure the following commands on devices ecsj-6506-sd1 and ecsj-6506-sd2:

```
ip msdp sa-filter in peer_address list 111
ip msdp sa-filter out peer_address list 111
access-list 111 permit ip 126.32.0.0 0.0.255.255 239.254.1.0 0.0.0.15
access-list 111 deny ip any any log
```

Configure the following commands on devices ecsj-6506-c3 and ecsj-6506-c4:

```
ip msdp sa-filter in peer_address list 111
ip msdp sa-filter out peer_address list 111
access-list 111 permit ip 126.0.0.0 0.255.255.255 239.2.0.0 0.0.255.255
access-list 111 permit ip 126.0.0.0 0.255.255.255 239.3.0.0 0.0.255.255
access-list 111 deny ip any any
```

PIM Sparse Mode

This test ensured that PIM-SM was working properly.

Test Plan

The procedure used to perform the [PIM Sparse Mode](#) tests follows:

-
- Step 1** Start Smartbits multicast source and IGMP receivers client traffic streams for simulated TIBCO servers. Smartbits interfaces are configured to simulate the TIBCO sources in the Data Centers sending to the ten data publishing groups (IP addresses 239.254.1.0 through 239.254.1.9) and the receivers on the access networks. The distribution routers are additionally stressed by IGMP receivers, which are configured to also subscribe to the Data Center sources on the VLANs not covered by Smartbits.

Start multicast traffic for hoot-and-holler over IP and IP/TV sessions. Receivers are located in remote branches, Floor 1, and Floor 2.

- Step 2** Use a traffic generator in the access networks to generate traffic to the feedback groups. The feedback group includes IGMP receivers clients emulated in the Data Center.
- Step 3** Verify that PIM-SM basic is working properly. Use the following **show** commands and verify that the output displays as indicated:
- Use the **show ip pim interface command** to verify that PIM-SM is enabled on all interfaces.
 - Use the **show ip pim neighbor** command to verify that all required neighbors are listed and that no unknown routers appear in the output display.
 - Use the **show ip pim rp** command to verify that the correct RP is shown for all groups.
 - Use the **show ip mroute** command to verify that the correct groups have the correct incoming and outgoing interfaces.
- Step 4** Stop the sources for the market data and hoot-and-holler over IP. Use the **show ip mroute group** and **show ip mroute active** commands to verify that the state disappears.
- Step 5** Restart the sources for the market data and hoot-and-holler over IP. Use the **show ip mroute group** and **show ip mroute active** commands to verify that the state is regenerated.

Results

Table 23 shows the [PIM Sparse Mode](#) test results.

Table 23 *PIM Sparse Mode Test Results*

Tests	Results
PIM Sparse Mode	Pass

SPT Threshold Infinity

This test used the **ip pim spt-threshold infinity** configuration option to verify that specified traffic stayed on the shared tree.

Test Plan

The procedure used to perform the [SPT Threshold Infinity](#) tests follows:

- Step 1** Verify that only the RP routers have an (S, G) multicast route entry for a particular source. The RP routers must have knowledge of every active source for the multicast groups that they service. Use the **show ip mroute summary** command.
- Step 2** Verify that the SPT threshold value is set to infinity only for the range of IP addresses defined in access list 6 (the market data sources). All routers should have the SPT threshold value set to zero for the groups not defined in access list 6.
- Step 3** Verify that the non-RP routers have only a (*, G) multicast route entry for the market data sources. The RP routers should have an (S, G) multicast route entry for all the market data sources.

- Step 4** Verify that each of the hoot-and-holler over IP and IP/TV groups have an (S, G) multicast route entry for every router along the data path. All routers along the data path should have an (S, G) multicast route entry for the hoot-and-holler over IP and IP/TV sources because the hoot-and-holler over IP and IP/TV groups are explicitly denied in access list 6 when the SPT threshold value is set to infinity.

Results

Table 24 shows the [SPT Threshold Infinity](#) test results.

Table 24 *SPT Threshold Infinity Test Results*

Tests	Results
SPT Threshold Infinity	Pass

PIM Neighbor Filters

This test created PIM neighbor filters for edge routers in the user access areas (ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-d3, ecsj-6506-d4) to prevent an incorrectly configured PIM neighbor or a hostile device from participating in the PIM forwarding decisions in the network. The filters were tested and removed.

Test Plan

The procedure used to perform the [PIM Neighbor Filters](#) test follows:

- Step 1** Verify that all PIM neighbor relationships are working. Use the **show ip pim neighbor** command and verify the output.
- Step 2** Change the access list so that the edge routers should not recognize each other. Change the configuration on router ecsj-6506-d1 to deny messages from router ecsj-6506-c4 on interface Gigabit Ethernet 2/2 with IP address 126.1.10.14 as shown in the following example:
- ```
interface GigabitEthernet 2/2
 ip pim neighbor-filter 5

access-list 5 deny 126.1.10.14
access-list 5 permit any
```
- Step 3** Capture debugging output to verify that the filter is ignoring the neighbor messages. Use the **debug ip pim** command and logging commands to display the required information.
- Step 4** Remove the filters so that neighbor relationships work again.

## Results

Table 25 shows the [PIM Neighbor Filters](#) test results.

**Table 25** *PIM Neighbor Filters Test Results*

| Tests                                | Results |
|--------------------------------------|---------|
| <a href="#">PIM Neighbor Filters</a> | Pass    |

## Accept Register Filters

Register filters were created to prevent unauthorized sources from registering with the RP. This test verified that the appropriate register-stop messages were sent for unauthorized sources such as Floor 2 sources sending traffic to Floor 1 feedback groups. This test was performed for market data feedback groups only.

### Test Plan

The procedure used to perform the [Accept Register Filters](#) tests follows:

- 
- Step 1** Verify that Floor 1 sources on the user LANs can register to the Floor 1 feedback groups. Use the **show ip mroute 239.254.1.16** command.
- Step 2** Verify that Floor 2 sources can register to the Floor2-feedback groups.
- Step 3** Turn on the Floor 2 traffic generator multicast feedback group source to send traffic to the Floor 1 groups. Verify that this source cannot register with the RP. The traffic generator configuration for the interface connected to ecsj-6506-a4 is shown in the following example output:
- ```
create udp stream
layer2-destination-address 0100.5e7e.0110
layer3-source-address 126.3.1.49
layer3-destination-address 239.254.1.16
rate 100 pps
```
- Step 4** Enable debugging on ecsj-6506-d1 and ecsj-6506-d2 to verify that a register-stop message is sent to the first-hop routers (ecsj-6506-d3 and ecsj-6506-d4). Use the **debug ip pim 239.254.1.16** command.
-

Results

Table 26 shows the [Accept Register Filters](#) test results.

Table 26 *Accept Register Filters Test Results*

Tests	Results
Accept Register Filters	Pass

MSDP with Anycast RP

This test verified that RPs in different domains were sharing information about their local active sources.

Test Plan

The procedure used to perform the [MSDP with Anycast RP](#) tests follows:

-
- Step 1** Verify that basic [MSDP with Anycast RP](#) is working properly on devices ecsj-6506-d1, ecsj-6506-d2, ecsj-6506-c3, and ecsj-6506-c4. Use the following commands for this test:
- Use the **show ip msdp peer** command to verify that peers are operational.
 - Use the **show ip msdp sa-cache** command to verify that an SA cache entry exists for each source.
 - Use the **show ip msdp summary** command to verify MSDP peer and SA information.

Results

Table 27 shows the [MSDP with Anycast RP](#) test results.

Table 27 *MSDP with Anycast RP Test Results*

Tests	Results
MSDP with Anycast RP	Pass

MSDP SA Filters

This test verified that the MSDP SA filters correctly denied or allowed sources.

Test Plan

The procedure used to perform the [MSDP SA Filters](#) tests follows:

-
- | | |
|--------|--|
| Step 1 | Verify that the SA filters are working correctly by looking into the SA cache entry and verifying access list logs. Use the show ip msdp sa-cache command |
| Step 2 | Change access list 111 to ecsj-6506-d1 to ignore 239.254.1.20. Use the access-list 111 deny any 239.254.1.20 0.0.0.0 log command. |
| Step 3 | Verify that the SA cache entry for 239.254.1.20 disappears. Use the show ip msdp sa-cache command. |
| Step 4 | Enable debugging with the debug ip msdp routes command and verify that it is ignored. |
| Step 5 | Restore access list 111 to the same state as it was before Step 2. Verify that the SA entry (previously verified in Step 1) returns. |
-

Results

Table 28 shows the [MSDP SA Filters](#) test results.

Table 28 *MSDP SA Filters Test Results*

Tests	Results
MSDP SA Filters	Pass

Basic Auto-RP

This test verified that the correct RP information was being propagated throughout the corporate headquarters and across the WAN connections to the remote branches.

Test Plan

The procedure used to perform the [Basic Auto-RP](#) tests follows:

-
- Step 1** Verify that all routers learn about RP mapping information. Use the **show ip pim rp mapping** command and verify that the hoot-and-holler over IP and IP/TV groups (239.254.2.x and 239.254.3.x) are advertised with Auto-RP.
-

Results

[Table 29](#) shows the [Basic Auto-RP](#) test results.

Table 29 [Basic Auto-RP Test Results](#)

Tests	Results
Basic Auto-RP	Pass

DR Priority

This test verified that the **ip pim dr-priority** command correctly overrode the default DR election process of selecting the PIM neighbor with the highest IP address.



Note

The **ip pim dr-priority** command is supported in Cisco IOS Release 12.2, not in Release 12.1 E. This test was performed only on routers running Cisco IOS Release 12.2.

Test Plan

The procedure used to perform the [DR Priority](#) tests follows:

-
- Step 1** Verify that the PIM neighbor with the highest IP address is selected as the DR. Use the **show ip pim interface** command and verify on router ecbr1-7206-e1 that router ecbr1-3620-v1 (the PIM neighbor with the highest IP address) is the DR on the 126.101.2.0 network.
- Step 2** Configure the **ip pim dr-priority** command on FastEthernet interface 0/0 of router ecbr1-7206-e1, as shown in the following example:
- ```
interface FastEthernet0/0
 ip pim dr-priority 5
```
- Step 3** Verify that the DR priority value is set to 5 and that router ecbr1-7206-e1 is the DR. Use the **show ip pim interface** command.
- Step 4** Restore the DR priority default setting. Use the **no ip pim dr-priority** command.
- Step 5** Verify that the default state is restored. Use the **show ip pim interface** command.
- 

## Results

[Table 30](#) shows the [DR Priority](#) test results.

*Table 30 DR Priority Test Results*

| Tests       | Results |
|-------------|---------|
| DR Priority | Pass    |

## Basic PGM

The basic PGM tests verified that normal IP multicast traffic continued to flow with PGM enabled. Specific features and operation of PGM were not tested.

### Test Plan

The procedure used to perform the [Basic PGM](#) tests follows:

- 
- |        |                                                                                                                                                       |
|--------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step 1 | Configure all multicast router interfaces using the <b>ip pgm router</b> command.                                                                     |
| Step 2 | Verify that normal multicast data is unaffected on ecsj-6506-d1 and ecsj -6506-d2. Use the <b>show ip mroute count</b> command and verify the output. |
| Step 3 | Verify that PGM is operating normally. Use the <b>show ip pgm router</b> command.                                                                     |
- 

### Results

[Table 31](#) shows the [Basic PGM](#) test results.

*Table 31 Basic PGM Test Results*

| Tests     | Results |
|-----------|---------|
| Basic PGM | Pass    |

## Hoot-and-holler over IP

This test verified the general operation and reliability of the Cisco hoot-and-holler over IP feature (also known as VoIP over multicast) in an end-to-end system test environment.

hoot-and-holler over IP was tested in the following configurations:

- Hoot-and-holler over IP phones connected to router E&M voice ports
- Standard analog phones connected to router FXS voice ports
- IP/TV clients running on PCs (receive only)

Additional hoot-and-holler over IP sessions were simulated with Smartbits and call generators. Both G.711 and G.729 voice codecs were tested.

The hootie sessions were sourced and received as shown in [Table 32](#).

**Table 32** *Hootie Session Sources and Receivers*

| Hoot-and-holler over IP Session | Type            | Source       | Receivers                                   |
|---------------------------------|-----------------|--------------|---------------------------------------------|
| hootie-one                      | R <sup>1</sup>  | ecsj-3640-h1 | ecbr1-7206-e1, ecbr3-2651-e1, ecbr5-3640-e1 |
| hootie-two                      | R <sup>1</sup>  | ecsj-3640-h1 | ecbr9-2651-e1, ecbr7-7200-e1, ecbr4-7206-e1 |
| hootie-three                    | R <sup>1</sup>  | ecsj-3640-h2 | ecbr1-7206-e1, ecbr4-7206-e1                |
| hootie-four                     | R <sup>1</sup>  | ecsj-3640-h2 | ecbr6-2651-e1, ecbr7-7200-e1                |
| hootie-five                     | SC <sup>2</sup> | ecsj-3640-h1 | ecbr2-3640-e1, ecbr8-3640-e1                |
| hootie-six                      | SS <sup>3</sup> | ecsj-3640-h2 | ecbr1-7206-e1                               |

1. “Real” hoot-and-holler over IP session with hoot-and-holler over IP phones or analog phones.
2. Simulated hoot-and-holler over IP session with call generator.
3. Simulated hoot-and-holler over IP session with Smartbits.

The hoot-and-holler over IP sessions used IP multicast addresses in the 239.254.2/24 range. The test streams were assigned with address 239.254.2.1 through 239.254.2.10. The UDP ports for hoot-and-holler over IP were in the 16384 through 24576 range.

The hoot-and-holler over IP sessions used the settings shown in [Table 33](#):

**Table 33** *Hoot-and-holler over IP Session Settings*

| Hoot-and-holler over IP Session | Codec | Multicast Address | UDP Port |
|---------------------------------|-------|-------------------|----------|
| hootie-one                      | G.711 | 239.254.2.1       | 17010    |
| hootie-two                      | G.711 | 239.254.2.2       | 17020    |
| hootie-three                    | G.711 | 239.254.2.3       | 17030    |
| hootie-four                     | G.729 | 239.254.2.4       | 17040    |
| hootie-five<br>(Call generator) | G.729 | 239.254.2.5       | 17050    |
| hootie-six<br>(Smartbits)       | —     | 239.254.2.6       | 17060    |

## Test Plan

The procedure used to perform the [Hoot-and-holler over IP](#) tests follows:

### Step 1 Configure hoot-and-holler over IP.

Configure hoot-and-holler over IP on the routers defined in [Table 32](#). The following example shows how to configure the hoot-and-holler over IP session one (hootie-one) on router ecsj-3640-h1:

```
voice class permanent 1
signal timing oos timeout disabled
signal keepalive 65535

interface Vif1
 ip address 126.1.27.6 255.255.255.0
 ip access-group block-RTCP in
```

```

ip accounting output-packets
ip pim sparse-mode
load-interval 30

! The following access list blocks RTCP feedback (see note at the end of this example).

ip access-list extended block-RTCP
deny udp host 126.1.27.7 host 239.254.2.3 eq 17031
deny udp host 126.1.27.7 host 239.254.2.1 eq 17011
permit ip any any

voice-port 2/0/0
voice-class permanent 1
playout-delay maximum 150
timeouts wait-release 3
connection trunk 111
music-threshold -30
operation 4-wire

dial-peer voice 1 voip
destination-pattern 111
voice-class permanent 1
session protocol multicast
session target ipv4:239.254.2.1:17010
playout-delay maximum 150
codec g711ulaw
ip precedence 5
vad aggressive

```

**Note**

RTCP packets consist of statistical data on the activity of an RTP session. In Cisco's hoot-and-holler over IP implementation, RTCP packets are not used or required. RTCP traffic can contribute up to 5% of the total RTP traffic for the session. In the case of a large deployment, some RTCP traffic will be generated even when no real voice traffic is present. Therefore, it is recommended to block RTCP traffic when bandwidth is tight. To disable RTCP packets, use an access list in the input queue of the Vif1 interface.

- Step 2** Verify that all hoot-and-holler over IP sessions are up. Use the **show ip mroute** command and verify that the (S, G) multicast route entries for the hoot-and-holler over IP groups (239.254.2.x) display the correct flags. Each hoot-and-holler over IP endpoint becomes a multicast source and therefore should create an (S, G) multicast route entry.
- Step 3** Manually test hoot-and-holler over IP session one (hootie-one) for voice quality:
- Start traffic flow between the three phones by taking the phones off hook.
  - Speak into phones and measure voice quality. Measure voice quality on a scale from 1 (very bad) to 5 (very good).
  - Use the **show ip rtp header-compression** command on router eabr5-3640-e1 and verify that no errors or drops are displayed in the output.
  - Use the **show interface serial slot:port** command on routers eabr1-7206-e1 and eabr5-3640-e1 and verify that no errors or drops are displayed in the output.
- Step 4** Test hoot-and-holler over IP session five (hootie-five) for voice quality with call generator. Use a call generator that can generate and receive DTMF tones and measure the sound quality. Configure the call generator to send DTMF tones bidirectionally between ecsj-3640-h1, eabr2-3640-e1, and eabr8-3640-e1:
- Verify that no calls or traffic are dropped during the call generator connectivity test.



- b. Verify that all the DTMF tones are received at an acceptable level of quality.

## Results

Table 34 shows the [Hoot-and-holler over IP](#) test results.

**Table 34** *Hoot-and-holler over IP Test Results*

| Tests                                   | Results |
|-----------------------------------------|---------|
| <a href="#">Hoot-and-holler over IP</a> | Pass    |

## IP/TV

IP/TV was used to test corporate communications. This test verified the general operation and reliability of IP/TV in an end-to-end system test environment.

Two high bandwidth (1 Mb) test streams for local viewing in the corporate headquarters and two low bandwidth (64 kbps) test streams for viewing across the WAN connections were used. An IP/TV server was set up in the Data Center to source the four test streams.

IP/TV receivers were configured at all the remote branch offices. The offices with T1 connections received both 64 kbps streams. The lower bandwidth offices received one 64 kbps stream. The IP/TV sessions used IP multicast addresses in the 239.254.3.0/24 range. The UDP port for IP/TV was in the 24577 through 32767 range.

The IP/TV sessions used the settings shown in [Table 35](#):

**Table 35** *IP/TV Session Settings*

| IP/TV Session         | Bandwidth (kbps) | Multicast Address | UDP Port |
|-----------------------|------------------|-------------------|----------|
| iptv-one              | 1024             | 239.254.3.1       | 25010    |
| iptv-two              | 1024             | 239.254.3.2       | 25020    |
| iptv-three            | 64               | 239.254.3.3       | 25030    |
| iptv-four             | 64               | 239.254.3.4       | 25040    |
| iptv-five (Smartbits) | 64               | 239.254.3.5       | 25050    |

## Test Plan

The procedure used to perform the [IP/TV](#) tests follows:

- 
- Step 1** Verify that all four IP/TV sources are up in routers ecsj-6506-c3 and ecsj-6506-c4. Use the **show ip mroute 239.254.3.x** command and verify that all (S, G) multicast route entries appear in the output.
- Step 2** Verify overall quality of IP/TV session two (iptv-two) within corporate headquarters:
- Verify that IP/TV session two (iptv-two) sources and receivers are up in routers ecsj-6506-c4, ecsj-6506-sd2, and ecsj-6506-d2. Use the **show ip mroute 239.254.3.2** command.
  - Verify traffic rate (1 Mbps stream). Use the **show ip mroute 239.254.3.2 active** command.

- c. Observe the audio and video quality of IP/TV session two (iptv-two) on an IP/TV viewer connected to an access VLAN in Floor 1.
- Step 3** Verify overall quality of IP/TV session three (iptv-three) between the Data Center and branch routers.
- a. Verify that IP/TV session three (iptv-three) sources and receivers are up in routers ecsj-6506-c4 and eabr1-7206-e1. Use the **show ip mroute 239.254.3.3** command.
- b. Verify traffic rate (64 kbps stream). Use the **show ip mroute 239.254.3.3 active** command.
- c. Observe the audio and video quality of IP/TV session three (iptv-three) on an IP/TV viewer connected to an access VLAN in branch 1.
- d. Repeat Step 3a through Step 3c for branches 2 and 3.

## Results

Table 36 shows the IP/TV test results.

**Table 36** IP/TV Test Results

| Tests | Results |
|-------|---------|
| IP/TV | Pass    |

## Negative Testing

Some negative testing was done to observe router performance and to ensure that devices did not crash and that the CPU did not freeze in a hostile environment. Negative tests are described in the following sections:

- [RP and Designated Router Failover and Convergence—Market Data, page 50](#)
- [Reverse Path Forwarding Failover and Convergence—Corporate Headquarters, page 52](#)
- [RP Failover and Convergence—Remote Branches, page 55](#)
- [PIM Dense Mode Negative Testing, page 56](#)
- [IGMP DOS Attack, page 57](#)
- [Multicast Suppression, page 58](#)
- [Multicast Suppression with Router Alert, page 60](#)

### RP and Designated Router Failover and Convergence—Market Data

This test measured the network convergence for multicast streams originating in the Data Center and being received in the Floor 1 access switches. Unless this test was being run as part of the test described in the “[Multicast Scalability Tests for Financial Enterprises](#)” section on page 70, it was run with the baseline of 7500 (S, G) mroutes.

To measure the multicast convergence the RPs in the network were disrupted and the time for convergence was measured in terms of seconds and the number of packets lost. Also, the failed router was rebooted and observed to determine if any disruptions were caused by reintroduction of the RP.

## Test Plan

Use the Smartbits application to generate traffic and measure packet loss for this test. The following two scripts control the Smartbits and collect the data: RPDR90 and RPDR240. Both scripts are configured identically, however, RPDR90 sends for 90 seconds and RPDR240 sends for 240 seconds. RPDR240 is specifically designed to run long enough for the router to reload completely.

Observe two convergence measurements: first when the backup router assumes the DR role, and second when the primary router is restarted and resumes the DR role.

The procedure used to perform the [RP and Designated Router Failover and Convergence—Market Data](#) tests follows:

- 
- Step 1** Verify that the test network is stable and that all multicast traffic is working correctly. Use the Smartbits Script RPDR90 to validate that multicast traffic is working correctly.
- Step 2** Check the DR information in ecsj-6506-sd1 and ecsj-6506-sd2. Use the **show ip pim neighbor** command.
- Step 3** Simulate a network outage on router ecsj-6506-sd2. Measure convergence time.
- The outage is simulated by using the **reload** command to simulate a router crash. For the **reload** command the config-register on ecsj-6506-sd2 is set to 0x0 so that the router remains at the ROM monitor prompt.
- Start IP multicast traffic flowing from the Data Center to the Floor 1 access switches. Use the Smartbits script RPDR90. After the Smartbits begins sending, reload the router and measure the convergence time. Verify that Smartbits has begun sending before shutting down the router.
  - During the simulated outage of ecsj-6506-sd2, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RP convergence time (Tc) is calculated based on the traffic rate and packet loss (that is,  $Tc = \text{packet loss} / \text{traffic rate}$ ). Verify that the convergence time is less than 8 seconds.
- Step 4** Start a new source with group address of 239.254.1.14. Verify that it gets recognized and forwarded correctly with the backup DR and RP.
- Step 5** Restart ecsj-6506-sd2. Measure the convergence time as it resumes the DR and RP roles.
- When recovering ecsj-6506-sd2, start the Smartbits script RPDR240, verify that the Smartbits has begun sending, and then restart the router. Measure the convergence time.
  - When restarting the primary router, capture the debug output using the **debug ip pim 239.254.1.2** command on the backup DR to measure how fast it can become a DR.
  - During the network convergence of ecsj-6506-sd2, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RP convergence time (Tc) is calculated based on the traffic rate and packet loss (that is,  $Tc = \text{packet loss} / \text{traffic rate}$ ). Verify that the convergence time is less than 8 seconds.
- Step 6** Check Smartbits and the traffic generator and IGMP receivers to verify that there is no interruption in existing traffic flow. Specifically, there can be no packet loss.
- Step 7** Start a new source with the group address of 239.254.1.15. Verify the network operation. Then stop the two new traffic streams.
- Step 8** Repeat Steps 1 through 7 for routers ecsj-6506-sd1, ecsj-6506-d2, and ecsj-6506-d1.
-

## Results

Table 37 shows the [RP and Designated Router Failover and Convergence—Market Data](#) test results.

**Table 37** *RP and Designated Router Failover and Convergence—Market Data Test Results*

| Tests                                                                         | Results |
|-------------------------------------------------------------------------------|---------|
| <a href="#">RP and Designated Router Failover and Convergence—Market Data</a> | Pass    |

Table 38 shows the convergence results for the [RP and Designated Router Failover and Convergence—Market Data](#) tests. All results in this table are shown in seconds.

**Table 38** *RP and Designated Router Failover and Convergence—Market Data for 7500 (S, G) Multicast Routes*

| Test Description   | 7500 (S, G) Multicast Routes |                   |
|--------------------|------------------------------|-------------------|
|                    | EIGRP (in seconds)           | OSPF (in seconds) |
| ecsj-6506-sd2 down | 4.76                         | 3.14              |
| ecsj-6506-sd2 up   | 4.28                         | 0.26              |
| ecsj-6506-sd1 down | 0.00                         | 0.00              |
| ecsj-6506-sd1 up   | 0.00                         | 0.00              |
| ecsj-6506-d2 down  | 3.38                         | 3.89              |
| ecsj-6506-d2 up    | 0.00                         | 0.80              |
| ecsj-6506-d1 down  | 0.00                         | 0.00              |
| ecsj-6506-d1 up    | 0.00                         | 0.00              |


## Reverse Path Forwarding Failover and Convergence—Corporate Headquarters

This test measured RPF failover convergence for the routers in the path of the shared tree. This test included link failures and router shutdowns and reloads. Unless this test was being run as part of the test described in the [“Multicast Scalability Tests for Financial Enterprises”](#) section on page 70, it was run with the baseline of 7500 (S, G) mroutes.

### Test Plan

The procedure used to perform the [Reverse Path Forwarding Failover and Convergence—Corporate Headquarters](#) tests follows:

- 
- Step 1** Verify that all the multicast traffic streams are working correctly. Use Smartbits script RPDR90 to confirm the multicast traffic.

- Step 2** Simulate a link failure on router ecsj-6506-sd2. Measure the convergence time.
- For the link-shutdown test, use Gigabit Ethernet interface 1/2, the interface that connects to ecsj-6506-c2.
  - Start IP multicast traffic flowing from the Data Center to the Floor 1 access switches. Use the Smartbits script RPDR90. After the Smartbits begins sending, shut down the Gigabit Ethernet interface 1/2 and measure the convergence time. Verify that Smartbits has begun sending before shutting down the interface.
  - During the simulated outage of ecsj-6506-sd2, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RPF convergence time ( $T_c$ ) is calculated based on the traffic rate and packet loss (that is,  $T_c = \text{packet loss} / \text{traffic rate}$ ). Verify that the convergence time is less than 8 seconds.
- Step 3** Bring back the link and measure the convergence time.
- Start IP multicast traffic flowing from the Data Center to the Floor 1 access switches. Use the Smartbits script RPDR90. After the Smartbits begins sending, use the **no shut** command on Gigabit Ethernet interface 1/2 and measure the convergence time. Verify that Smartbits has begun sending prior to using the **no shut** command on the interface.
  - During the network convergence, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RPF convergence time is calculated based on the traffic rate and packet loss. Verify that the convergence time is less than 8 seconds.
- Step 4** Repeat Steps 1 through 3 with ecsj-6506-c2, ecsj-6506-c4, and ecsj-6506-d2.
- Step 5** Simulate a network outage on router ecsj-6506-c2. Measure the convergence time.
- The outage is simulated by using the **reload** command to simulate a router crash. For the **reload** command the config-register on ecsj-6506-c2 is set to 0x0 so that the router remains at the ROM monitor prompt.
  - Start IP multicast traffic flowing from the Data Center to the Floor 1 access switches. Use the Smartbits script RPDR90. After the Smartbits begins sending, reload the router and measure the convergence time. Verify that Smartbits has begun sending prior to shutting down the router.
  - During the simulated outage of ecsj-6506-c2, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RP convergence time is calculated based on the traffic rate and packet loss. Verify that the convergence time is less than 8 seconds.
- Step 6** Restart ecsj-6506-c2. Measure the convergence time.
- When recovering ecsj-6506-c2, start the Smartbits script RPDR240, verify that the Smartbits has begun sending, and then restart the router. Measure the convergence time.
  - During the network convergence of ecsj-6506-c2, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RPF convergence time is calculated based on the traffic rate and packet loss. Verify that the convergence time is less than 8 seconds.
- Step 7** Start a new source with the group address of 239.245.1.15. Verify the network operation. Record any changes.
- 
-  **Note** Step 7 will not be executed when these steps are repeated for the [“Multicast Scalability Tests for Financial Enterprises”](#) section on page 70.
- 
- Step 8** Repeat Steps 5 through 7 with router ecsj-6506-c4.
-

## Results

Table 39 shows the Reverse Path Forwarding Failover and Convergence—Corporate Headquarters test results.

**Table 39** *Reverse Path Forwarding Failover and Convergence—Corporate Headquarters Test Results*

| Tests                                                                   | Results |
|-------------------------------------------------------------------------|---------|
| Reverse Path Forwarding Failover and Convergence—Corporate Headquarters | Pass    |

Table 40 shows the convergence results for the Reverse Path Forwarding Failover and Convergence—Corporate Headquarters tests. All results are shown in seconds.

**Table 40** *Reverse Path Forwarding Failover and Convergence—Corporate Headquarters for 7500 (S, G) Multicast Routes*

| Test Description                                           | 7500 (S, G) Multicast Routes |                   |
|------------------------------------------------------------|------------------------------|-------------------|
|                                                            | EIGRP (in seconds)           | OSPF (in seconds) |
| Fail the link between ecsj-6506-sd2 and ecsj-6506-c2       | 0.63                         | 6.05              |
| Bring back the link between escj-6506-sd2 and escj-6506-c2 | 0.06                         | 0.08              |
| Fail the link between ecsj-6506-c2 and ecsj-6506-c4        | 1.61                         | 1.72              |
| Bring back the link between escj-6506-c2 and escj-6506-c4  | 0.10                         | 0.08              |
| Fail the link between ecsj-6506-c4 and ecsj-6506-d2        | 0.55                         | 0.76              |
| Bring back the link between escj-6506-c4 and escj-6506-d2  | 0.10                         | 0.04              |
| ecsj-6506-c2 down                                          | 1.62                         | 1.55              |
| ecsj-6506-c2 up                                            | 0.25                         | 0.07              |
| ecsj-6506-c4 down                                          | 1.60                         | 2.08              |
| ecsj-6506-c4 up                                            | 4.47                         | 2.66              |

## RP Failover and Convergence—Remote Branches

This test measured the RP failover convergence for the corporate communication (IP/TV) and hoot-and-holler over IP applications that were sent to the remote branches. The RPs for these applications were routers ecsj-6506-c3 and ecsj-6506-c4. These routers were shut down and restarted during an active session and the convergence time was measured.

Convergence time was measured between router ecsj-3640-h2 and branch routers ecb1-7206-e1, ecb4-7206-e1, and ecb7-7200-e1. Branch 1 was used to test Frame Relay convergence, branch 7 for PPP convergence, and branch 4 for HDLC convergence.

### Test Plan

The procedure used to perform the [RP Failover and Convergence—Remote Branches](#) tests follows:

- 
- Step 1** Verify that all the multicast traffic streams are working properly between router ecsj-3640-h2 and the remote branch routers. Use Smartbits script RPDR90 to confirm the multicast traffic.
- Step 2** Simulate a network outage on router ecsj-6506-c4. Measure the convergence time. The outage is simulated using the **reload** command to simulate a router crash. For the **reload** command the config-register on ecsj-6506-c4 is set to 0x0 so that the router remains at the ROM monitor prompt.
- Start IP multicast traffic flowing from router ecsj-3640-h2 to the branch routers. Use the Smartbits script RPDR90. After the Smartbits begins sending, reload the router and measure the convergence time. Verify that Smartbits has begun sending prior to shutting down the router.
  - During the simulated outage of ecsj-6506-c4, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RP convergence time (Tc) is calculated based on the traffic rate and packet loss (that is,  $Tc = \text{packet loss} / \text{traffic rate}$ ). Verify that the convergence time is less than 8 seconds.
- Step 3** Restart ecsj-6506-c4. Measure the convergence time.
- When recovering ecsj-6506-c4, start the Smartbits script RPDR240, verify that the Smartbits has begun sending, and then restart the router. Measure the convergence time.
  - During the network convergence of ecsj-6506-c4, record the number of packets lost for the multicast traffic stream generated by Smartbits. The RPF convergence time is calculated based on the traffic rate and packet loss. Verify that the convergence time is less than 8 seconds.
- Step 4** Repeat Steps 2 through 3 with router ecsj-6506-c3.
- 

### Results

Table 41 shows the [RP Failover and Convergence—Remote Branches](#) test results.

**Table 41** *RP Failover and Convergence—Remote Branches Test Results*

| Tests                                                       | Results |
|-------------------------------------------------------------|---------|
| <a href="#">RP Failover and Convergence—Remote Branches</a> | Pass    |

Table 42 shows the convergence results for the [RP Failover and Convergence—Remote Branches](#) tests. All results are shown in seconds.

**Table 42** *RP Failover and Convergence—Remote Branches for 7500 (S, G) Multicast Routes*

| Test Description   | 7500 (S, G) Multicast Routes |                   |
|--------------------|------------------------------|-------------------|
|                    | EIGRP (in seconds)           | OSPF (in seconds) |
| <b>Frame Relay</b> |                              |                   |
| ecsj-6506-c4 down  | 6.75                         | 3.14              |
| ecsj-6506-c4 up    | 4.74                         | 3.98              |
| ecsj-6506-c3 down  | 0.00                         | 0.00              |
| ecsj-6506-c3 up    | 0.00                         | 0.00              |
| <b>PPP</b>         |                              |                   |
| ecsj-6506-c4 down  | 6.76                         | 3.15              |
| ecsj-6506-c4 up    | 5.73                         | 4.00              |
| ecsj-6506-c3 down  | 0.02                         | 0.00              |
| ecsj-6506-c3 up    | 0.43                         | 0.39              |
| <b>HDLC</b>        |                              |                   |
| ecsj-6506-c4 down  | 2.88                         | 3.14              |
| ecsj-6506-c4 up    | 4.79                         | 3.98              |
| ecsj-6506-c3 down  | 0.00                         | 0.00              |
| ecsj-6506-c3 up    | 0.00                         | 0.00              |

## PIM Dense Mode Negative Testing

This test verified that test traffic was forwarded normally through the network and measured the CPU performance with varying loads of traffic.

### Test Plan

The procedure used to perform the [PIM Dense Mode Negative Testing](#) tests follows:

- 
- Step 1** Stop all IP multicast traffic in the network and wait for all state to time out.
  - Step 2** Configure every router interface to sparse-dense mode with the **ip pim sparse-dense** interface command.
  - Step 3** Start the baseline multicast traffic and verify that it is working correctly.
  - Step 4** Using Smartbits, start a new traffic stream at 1 Mbps with group address 225.1.1.100. This new multicast traffic is forwarded in dense mode because no RP is available for this group in this testing scenario. Verify that all multicast groups are still working correctly.
  - Step 5** Increase the rate of that new traffic stream to 10, 20, 30, 40, and 50 Mbps, then verify that all multicast traffic groups are still working correctly. Use the **show processes cpu** command and record the CPU level on all routers for each traffic level.
  - Step 6** Verify that the regular traffic streams are not affected by this testing traffic.
  - Step 7** After all of the necessary data is recorded, stop the multicast traffic started previously in Step 4.



- Step 8** Revert to the original basic configurations as shown in the “[System Tests for Financial Enterprises](#)” section on page 28.

## Results

Table 43 shows the [PIM Dense Mode Negative Testing](#) test results.

**Table 43** *PIM Dense Mode Negative Testing Test Results*

| Tests                                           | Results | Comments |
|-------------------------------------------------|---------|----------|
| <a href="#">PIM Dense Mode Negative Testing</a> | Pass    |          |

## IGMP DOS Attack

This test measured the router performance metrics under an IGMP denial of service (DOS) attack.

Sending multicast traffic over the Internet makes the network vulnerable to IGMP attacks because a sender to any multicast group is not required to be subscribed to the particular group. Hence, a rogue source can actually monopolize bandwidth or penalize the router performance by simply sending unwanted multicast traffic to any particular group that has interested receivers.

## Test Plan

The procedure used to perform the [IGMP DOS Attack](#) tests follows:

- Step 1** Verify that all the multicast traffic is being forwarded correctly. Use Smartbits script RPDR90 to confirm the multicast traffic as done in Step 1 of the “[RP and Designated Router Failover and Convergence—Market Data](#)” section on page 50.
- Step 2** Using a traffic generator, send 500, 1000, 1500, and 2000 IGMP join messages per second, rotating from each group, turn from 239.254.1.16 to 239.254.1.47 to the distribution layer routers, ecsj-6506-d1 and ecsj-6506-d2.
- The following is an example of the IGMP join test stream:
- ```
create igmp stream
rate 500 pps
layer2-source-address source_MAC_address
layer2-destination-address increment 0100.5e7e.0110 to 0100.5e7e.012f by 0x1
layer3-source-address 126.2.1.99
layer3-destination-address increment 239.254.1.16 to 239.254.1.47 by 0.0.0.1
layer4-group-address increment 239.254.1.16 to 239.254.1.47 by 0.0.0.1
layer4-version 1
layer4-type 6
```
- Step 3** Start the traffic generator with IGMP join traffic. Verify that all the existing multicast traffic can still work correctly. Use the **show processes cpu** command and record the CPU level for all of the distribution layer routers.
- Step 4** Repeat Step 3, using the rates of 1000, 5000, 10,000, 15,000, and 20,000 pps.
- Step 5** Verify that the regular traffic streams are not affected by this test traffic.
- Step 6** After all necessary data is recorded, stop the IGMP join messages started in Step 3.

Results

Table 44 shows the [IGMP DOS Attack](#) test results.

Table 44 *IGMP DOS Attack Test Results*

Tests	Results
IGMP DOS Attack	Pass

Table 45 shows the results of CPU utilization recorded during the [IGMP DOS Attack](#) tests.

Table 45 *Results of IGMP DOS Attack Tests*

IGMP Joins per Second	ecsj-6506-d1 CPU Utilization	ecsj-6506-d2 CPU Utilization
500	61 percent	64 percent
1000	55 percent	84 percent
5000	49 percent	95 percent
10,000	42 percent	93 percent
15,000	35 percent	64 percent
20,000	37 percent	51 percent

Multicast Suppression

This test verified that regular traffic was not affected by large amounts of misdirected multicast traffic.

Test Plan

The procedure used to perform the [Multicast Suppression](#) tests follows:

-
- Step 1** Verify that all the multicast traffic is being forwarded correctly.
 - Step 2** Configure the traffic generator to send multicast traffic from a Floor 2 subnet (VLAN 265) to a Floor 1 feedback group (239.254.1.31).
 - Step 3** Configure the traffic generator with the following parameters:


```
create udp stream
layer2-source-address source_MAC_address
layer2-destination-address 0100.5e7e.011f
layer3-source-address 126.3.65.99
layer3-destination-address 239.254.1.31
rate 500 pps
```
 - Step 4** Start the traffic generator. As shown in the configuration described in the [“Layer 3 Multicast”](#) section on [page 35](#), the source and the RP are on the same floor; therefore, the source cannot register with the RP. Record the CPU level of the target RP (ecsj-6506-d2) and that of the first-hop router (ecsj-6506-d4).
 - Step 5** Increase the traffic rate to 1000, 1500, 2000, 4000, 6000, 8000, 10000, 12000, 14000, 16000, 18000, 20000, 22000, 24000, and 26000 pps, respectively. Record the CPU level of the target RP (ecsj-6506-d2) and that of the first-hop router (ecsj-6506-d4).
 - Step 6** Verify that the regular traffic streams are not affected by this test traffic.

Step 7 Stop the test traffic started in Step 4.

Results

Table 46 shows the [Multicast Suppression](#) test results.

Table 46 *Multicast Suppression Test Results*

Tests	Results
Multicast Suppression	Pass

Table 47 shows the results of CPU utilization recorded during the [Multicast Suppression](#) tests measuring packet delivery.

Table 47 *CPU Utilization Results from the Multicast Suppression Test*

Packets per Second	ecsj-6506-d2 CPU Utilization	ecsj-6506-d4 CPU Utilization
500	1 percent	1 percent
1000	3 percent	1 percent
1500	2 percent	1 percent
2000	1 percent	1 percent
4000	1 percent	1 percent
6000	1 percent	1 percent
8000	1 percent	1 percent
10000	4 percent	1 percent
12000	2 percent	1 percent
14000	1 percent	1 percent
16000	1 percent	1 percent
18000	1 percent	1 percent
20000	1 percent	1 percent
22000	1 percent	1 percent
24000	1 percent	1 percent
26000	1 percent	1 percent

Multicast Suppression with Router Alert

This test verified that regular traffic was not affected by large amounts of misdirected multicast traffic with the router alert option set.

Test Plan

The procedure used to perform the [Multicast Suppression with Router Alert](#) tests follows:

-
- Step 1** Verify that all multicast traffic is being forwarded correctly.
- Step 2** Configure the traffic generator to send multicast traffic from a Floor 2 subnet (VLAN 265) to a Floor 1 feedback group (239.254.1.31).
- Step 3** Configure the traffic generator with the following parameters including the router alert option in the IP header:
- ```
create udp stream
layer2-source-address source_MAC_address
layer2-destination-address 0100.5e7e.011f
layer3-source-address 126.3.65.99
layer3-destination-address 239.254.1.31
layer3-option-length 4
layer3-option-data 0 94 04 0 0
rate 500 pps
```
- Step 4** Start the traffic generator. As shown in the configuration described in the [“Layer 3 Multicast”](#) section on [page 35](#), the source and the RP are on the same floor; therefore, the source cannot register with the RP. Record the CPU level of the target RP (ecsj-6506-d2) and that of the first-hop router (ecsj-6506-d4).
- Step 5** Increase the traffic rate to 1000, 1500, 2000, 4000, 6000, 8000, 10000, 12000, 14000, 16000, 18000, 20000, 22000, 24000, and 26000 pps, respectively. Record the CPU level of the target RP (ecsj-6506-d2) and that of the first-hop router (ecsj-6506-d4).
- Step 6** Verify that the regular traffic streams are not affected by this test traffic.
- Step 7** Stop the multicast stream started in Step 4.
- 

### Results

[Table 48](#) shows the [Multicast Suppression with Router Alert](#) test results.

**Table 48** *Multicast Suppression with Router Alert Test Results*

| Test                                                    | Results |
|---------------------------------------------------------|---------|
| <a href="#">Multicast Suppression with Router Alert</a> | Pass    |

[Table 49](#) shows the CPU utilization results recorded during the [Multicast Suppression with Router Alert](#) tests measuring packet delivery.

**Table 49** CPU Utilization Results from the *Multicast Suppression with Router Alert Test*

| Packets per Second | ecsj-6506-d2<br>CPU Utilization | ecsj-6506-d4<br>CPU Utilization |
|--------------------|---------------------------------|---------------------------------|
| 500                | 3 percent                       | 5 percent                       |
| 1000               | 2 percent                       | 6 percent                       |
| 1500               | 1 percent                       | 10 percent                      |
| 2000               | 2 percent                       | 14 percent                      |
| 4000               | 1 percent                       | 20 percent                      |
| 6000               | 1 percent                       | 27 percent                      |
| 8000               | 3 percent                       | 38 percent                      |
| 10000              | 2 percent                       | 47 percent                      |
| 12000              | 1 percent                       | 57 percent                      |
| 14000              | 1 percent                       | 67 percent                      |
| 16000              | 1 percent                       | 78 percent                      |
| 18000              | 1 percent                       | 84 percent                      |
| 20000              | 3 percent                       | 88 percent                      |
| 22000              | 2 percent                       | 90 percent                      |
| 24000              | 2 percent                       | 92 percent                      |
| 26000              | 2 percent                       | 95 percent                      |

## Network Management

Both fault management tests are covered in this phase. Fault management facilitates detection and isolation of abnormal operation and events using traps as they occur in the network elements.

The lab devices are periodically polled for state, and data is collected for the tests described in the following sections:

- [SNMP MIB Walk, page 62](#)
- [Syslog and NTP, page 63](#)
- [SNMP Traps, page 64](#)

Before beginning these tests, verify that the following configurations exist on all routers and switches:

### SNMP MIB Configuration

```
snmp-server engineID local
snmp-server community encore RO
```

### SNMP MIB for Cisco Catalyst OS Configuration

```
set snmp community read-only encore
set snmp enable
```

**Syslog Configuration**

```
logging 223.255.9.101
logging trap informational
service timestamps log datetime msec localtime show-timezone
service timestamps debug datetime msec localtime show-timezone
```

**NTP Router Configuration**

```
ntp update-calendar
ntp server 223.255.9.101 v1
clock summertime PDT recurring
clock timezone PST -8
```

**NTP Cisco Catalyst OS Configuration**

```
set ntp broadcastclient enable
set ntp client enable
set ntp server 126.1.20.50
set timezone PST -8 0
set ntp summertime enable recurring
```

**SNMP Traps for Cisco IOS Release 12.2(12b) Configuration**

```
snmp-server enable traps ipmulticast
snmp-server enable traps msdp
snmp-server host 126.1.1.1
```

**SNMP MIB Walk**

The test for MIB walk involved running a script to “walk through” some of the common SNMP MIBs, such as Cisco MIB, Cisco Process MIB, Interface MIB, and Frame Relay DTE MIB. The IP multicast-specific MIBs were also tested (based on their support in specific Cisco IOS software versions), such as IGMP MIB, Mroute MIB, PIM MIB, and MSDP MIB. For more information regarding IP multicast MIB support, refer to the following URL:

[http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst\\_sol/mibs.htm](http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/mibs.htm)

During this test the test network was running at about 50 percent utilization. CPU and memory usage for the network elements under test were monitored while the SNMP MIB walk was performed.

**Test Plan**

The procedure used to perform the [SNMP MIB Walk](#) tests follows:

- 
- Step 1** Verify that all the routers are configured for SNMP Version 2.0.
- Step 2** Perform an SNMP MIB walk of the following MIBs:
- Cisco MIB OID: 1.3.6.1.4.1.9.2.1
  - Cisco Process MIB OID: 1.3.6.1.4.1.9.9.109.1
  - Interface MIB OID: 1.3.6.1.2.1.2
  - Frame Relay DTE MIB OID: 1.3.6.1.2.1.10
  - Cisco Classed Based QoS MIB OID: 1.3.6.1.4.1.9.9.166
  - Cisco HSRP MIB OID: 1.3.6.1.4.1.9.9.106
  - Cisco VTP MIB OID: 1.3.6.1.4.1.9.9.46
  - Cisco OSPF MIB OID: 1.3.6.1.2.1.14

- BGP4 MIB OID: 1.3.6.1.2.1.15
- Cisco IPsec MIB OID: 1.3.6.1.4.1.9.10.62
- Cisco IPsec Flow Monitor MIB OID: 1.3.6.1.4.1.9.9.171
- Cisco Voice Dial Control MIB OID: 1.3.6.1.4.1.9.9.63
- IGMP MIB OID: 1.3.6.1.3.59.1.1
- Mroute MIB OID: 1.3.6.1.3.60.1.1
- PIM MIB OID: 1.3.6.1.3.61.1.1
- MSDP MIB OID: 1.3.6.1.3.92.1.1

- Step 3** Examine the output from the **show processes cpu** command. Verify that the CPU usage from the SNMP processes does not adversely affect packet forwarding or other operations on the router.

## Results

Table 50 shows the [SNMP MIB Walk](#) test results.

**Table 50** *SNMP MIB Walk Test Results*

| Tests                         | Results |
|-------------------------------|---------|
| <a href="#">SNMP MIB Walk</a> | Pass    |

## Syslog and NTP

This test verified that the syslog traps were set up to report any error messages or warnings and were monitored for accuracy.

## Test Plan

The procedure used to perform the [Syslog and NTP](#) tests follows:

- Step 1** Set up the ec-sun2 server in the Data Center as the UNIX NTP and syslog server.
- Step 2** Verify that the syslogd daemon is running on the UNIX server and configured to record all syslog messages to the syslog-info file.
- Step 3** Verify that the network elements are configured to log syslog information to the ec-sun2 server.
- Step 4** Verify that the network elements run NTP to synchronize their clocks with the NTP server.
- Step 5** Verify that the time-stamped syslog events are logged in the syslog server.

## Results

Table 51 shows the [Syslog and NTP](#) test results.

**Table 51** *Syslog and NTP Test Results*

| Tests          | Results |
|----------------|---------|
| Syslog and NTP | Pass    |

## SNMP Traps

This test verified that the SNMP traps were configured properly and that SNMP trap messages were received.

### Test Plan

The procedure used to perform the [SNMP Traps](#) tests follows:

- 
- Step 1 Configure an SNMP trap receiver on the ec-sun2 server.
  - Step 2 Verify that all routers are configured to send SNMP traps to the ec-sun2 server.
  - Step 3 Trigger a network change that will generate each SNMP trap and verify that it is received.
- 

### Results

[Table 52](#) shows the [SNMP Traps](#) test results.

**Table 52** *SNMP Traps Test Results*

| Tests      | Results |
|------------|---------|
| SNMP Traps | Pass    |

## Quality of Service

The following sections describe the configurations and the series of tests performed to test quality of service (QoS):

- [Baseline Traffic Queueing, page 68](#)
- [Traffic Congestion, page 69](#)

Before beginning these tests, verify that the configurations shown in the following sections exist on all routers. The bandwidth requirements and QoS test matrix for the testbed devices are shown in [Table 53](#) and [Table 54](#).

**Table 53** *Bandwidth Requirements*

| Traffic Class                 | Remote Branches with 256 kbps | Remote Branches with 512 kbps | Remote Branches with 1024 kbps |
|-------------------------------|-------------------------------|-------------------------------|--------------------------------|
| Hoot-and-holler over IP       | 50% / 128 kbps                | 25% / 128 kbps                | 25% / 256 kbps                 |
| IP/TV Corporate Communication | 25% / 64 kbps                 | 25% / 128 kbps                | 25% / 256 kbps                 |
| Best Effort                   | 25% / 64 kbps                 | 50% / 256 kbps                | 50% / 512 kbps                 |



**Table 54 QoS Test Matrix**

| Protocol    | Cisco 7200 Series                                     | Cisco 6500 Series                   | Cisco 7500 Series                             | Cisco 2600 and Cisco 3600 Series |
|-------------|-------------------------------------------------------|-------------------------------------|-----------------------------------------------|----------------------------------|
| Frame Relay | LLQ<br>FRTS<br>FRF.12<br>Class-based policing<br>cRTP | dLLQ<br>dTS<br>Class-based policing | dLLQ<br>dTS<br>FRF.12<br>Class-based policing | LLQ<br>FRTS<br>FRF.12<br>cRTP    |
| PPP         | LLQ<br>LFI/MLP<br>Class-based policing<br>cRTP        | LLQ<br>Class-based policing         | Not tested                                    | LLQ<br>LFI/MLP<br>cRTP           |
| HDLC        | Not tested                                            | Not tested                          | dLLQ<br>Class-based policing                  | LLQ<br>cRTP                      |

**Note**

- FRF.12 is not supported on the Cisco Catalyst 6500 series switches in Cisco IOS Release 12.1 E.
- LFI/MLP with LLQ is not supported on the Cisco Catalyst 6500 series switches in Cisco IOS Release 12.1 E.
- LFI/MLP with LLQ is not supported on the Cisco 7500 series routers in Cisco IOS Release 12.2.
- cRTP is not supported with IP multicast in distributed mode on the Cisco 6500 and Cisco 7500 series routers (refer to DDTS CSCdz09819).

**Access List for Traffic Class Configuration**

```
access-list 101 permit ip any 239.254.2.0 0.0.0.255
access-list 102 permit ip any 239.254.3.0 0.0.0.255
```

**Class Maps Configuration**

```
class-map match-all hootie
 match access-group 101
class-map match-all iptv
 match access-group 102
```

**Policy Map for LLQ Configuration**

```
policy-map hootie_policy_1024
 class hootie
 priority 256
 class iptv
 bandwidth 256
 class class-default
 fair-queue
policy-map hootie_policy_256
```

```

class hootie
 priority 128
class iptv
 bandwidth 64
class class-default
 fair-queue
policy-map hootie_policy_512
 class hootie
 priority 128
 class iptv
 bandwidth 128
 class class-default
 fair-queue

```

### Policy Map for LLQ with Class-Based Policing Configuration

```

policy-map hootie_policy_1024
 class hootie
 priority 256
 class iptv
 bandwidth 256
 police 256000 8000 8000 conform-action transmit exceed-action drop
 class class-default
 fair-queue
policy-map hootie_policy_256
 class hootie
 priority 128
 class iptv
 bandwidth 64
 police 64000 2000 2000 conform-action transmit exceed-action drop
 class class-default
 fair-queue
policy-map hootie_policy_512
 class hootie
 priority 128
 class iptv
 bandwidth 128
 police 128000 4000 4000 conform-action transmit exceed-action drop
 class class-default
 fair-queue

```

### Policy Map for LLQ with dTS Configuration

```

policy-map hootie_dts_256
 class class-default
 shape average 256000 1024 1024
 service-policy hootie_policy_256
policy-map hootie_dts_512
 class class-default
 shape average 512000 2048 2048
 service-policy hootie_policy_512
policy-map hootie_dts_1024
 class class-default
 shape average 1024000 4096 4096
 service-policy hootie_policy_1024

```

### Frame Relay Map Class Configuration

```

map-class frame-relay hootie_llq_1024
 frame-relay cir 1024000
 frame-relay bc 10240
 frame-relay mincir 1024000
 no frame-relay adaptive-shaping
 service-policy output hootie_policy_1024

```

```

map-class frame-relay hootie_llq_512
 frame-relay cir 512000
 frame-relay bc 5120
 frame-relay mincir 512000
 no frame-relay adaptive-shaping
 service-policy output hootie_policy_512
 frame-relay fragment 640

map-class frame-relay hootie_llq_256
 frame-relay cir 256000
 frame-relay bc 2560
 frame-relay mincir 256000
 no frame-relay adaptive-shaping
 service-policy output hootie_policy_256
 frame-relay fragment 320

```

### Frame Relay Map Class Configuration—Interfaces

```

interface Serial1/0/1:0
 no ip address
 encapsulation frame-relay
 no fair-queue
 frame-relay traffic-shaping
 no frame-relay broadcast-queue

interface Serial1/0/1:0.101 point-to-point
 bandwidth 1024
 ip address 126.101.20.8 255.255.255.0
 frame-relay interface-dlci 101
 class hootie_llq_1024

interface Serial1/0/2:0
 no ip address
 encapsulation frame-relay
 frame-relay traffic-shaping

interface Serial1/0/2:0.102 point-to-point
 bandwidth 512
 ip address 126.102.20.8 255.255.255.0
 frame-relay interface-dlci 102
 class hootie_llq_512
 frame-relay ip tcp header-compression
 frame-relay ip rtp header-compression

```

### PPP Configuration

```

interface Serial4/0/1
 bandwidth 1024
 ip address 126.101.21.9 255.255.255.0
 encapsulation ppp
 service-policy output hootie_policy_512

```

### HDLC Configuration

```

interface Serial3/0
 bandwidth 1024
 ip address 126.107.21.8 255.255.255.0
 service-policy output hootie_policy_1024
 serial restart-delay 0
 clockrate 1612800

```

### LLQ with LFI/MLP Configuration

```

interface Multilink2

```

```

bandwidth 512
ip address 126.102.21.9 255.255.255.0
ip pim sparse-mode
ip tcp header-compression iphc-format
service-policy output hootie_policy_512
no cdp enable
ppp multilink
ppp multilink fragment-delay 10
ppp multilink interleave
multilink-group 2
ip rtp header-compression iphc-format
.
.
.
interface Serial4/0/1
bandwidth 512
ip address 126.102.21.9 255.255.255.0
encapsulation ppp
multilink-group 2
no fair-queue

```

## Baseline Traffic Queueing

This test verified that the QoS features were operating correctly with the baseline traffic flows within the bandwidth requirements shown in [Table 53](#). Tests were performed with Frame Relay, PPP, and HDLC as described in [Table 54](#).

### Test Plan

The procedure used to perform the [Baseline Traffic Queueing](#) tests follows:

- 
- |        |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Step 1 | Verify that all WAN encapsulations are configured with Frame Relay.                                                                                                                                                                                                                                                                                                                                                                                                                |
| Step 2 | Verify that the traffic is classified and queued correctly by using the following commands: <ul style="list-style-type: none"> <li>• <b>show frame-relay fragment</b></li> <li>• <b>show ip rtp header-compression</b></li> <li>• <b>show traffic-shape</b></li> <li>• <b>show class-map</b></li> <li>• <b>show policy-map</b></li> <li>• <b>show policy-map interface</b></li> <li>• <b>show policy-map interface multilink 2</b></li> <li>• <b>show ppp multilink</b></li> </ul> |
| Step 3 | Change the WAN encapsulation on the appropriate routers to PPP and repeat Step 2.                                                                                                                                                                                                                                                                                                                                                                                                  |
| Step 4 | Change the WAN encapsulation on the appropriate routers to HDLC and repeat Step 2.                                                                                                                                                                                                                                                                                                                                                                                                 |
- 

### Results

[Table 55](#) shows the [Baseline Traffic Queueing](#) test results.

**Table 55** *Baseline Traffic Queueing Test Results*

| Tests                     | Results |
|---------------------------|---------|
| Baseline Traffic Queueing | Pass    |

## Traffic Congestion

This test verified that the QoS features correctly classify, police, shape, and queue according to the configured policies. This test was performed for three different WAN encapsulations between the corporate headquarters and remote branches (see [Table 56](#)). Spirent SmartFlow was used to test the throughput of different traffic streams based on the bandwidth requirement shown in [Table 53](#).

**Table 56** *Congestion Tests*

| Remote Branch | WAN Encapsulation |
|---------------|-------------------|
| 1, 2, 3       | Frame Relay       |
| 4, 5, 6       | HDLC              |
| 7, 8, 9       | PPP               |

## Test Plan

The procedure used to perform the [Traffic Congestion](#) tests follows:

- 
- Step 1** Verify that the active WAN encapsulation is Frame Relay.
- Step 2** Use SmartFlow to send the hoot-and-holler over IP and IP/TV corporate communications traffic at or below the QoS guidelines shown in [Table 53](#). Send the best effort traffic at 125 percent of the QoS guidelines (see [Table 57](#)).

**Table 57** *Best Effort Oversubscription Rates*

| Traffic Class | Remote Branches | QoS Policy (kbps) | 125% of QoS Policy (kbps) |
|---------------|-----------------|-------------------|---------------------------|
| Best Effort   | 1, 4, 7         | 512               | 640                       |
|               | 2, 5, 8         | 256               | 320                       |
|               | 3, 6, 9         | 64                | 80                        |

- Step 3** Verify that the throughput of different traffic streams is the same as the defined QoS policy.
- Step 4** Change the WAN encapsulation to PPP and HDLC as defined in [Table 56](#).
- Step 5** Repeat Steps 2 and 3 for HDLC and PPP testing.
- Step 6** Change the WAN encapsulation back to Frame Relay.
-

## Results

Table 58 shows the [Traffic Congestion](#) test results.

**Table 58** *Traffic Congestion Test Results*

| Test                               | Results              | Comments                                                                    |
|------------------------------------|----------------------|-----------------------------------------------------------------------------|
| <a href="#">Traffic Congestion</a> | Pass with exception. | See “ <a href="#">Results Analysis for QoS Testing</a> ” section on page 70 |

## Results Analysis for QoS Testing

LLQ guarantees that the high priority traffic will always be delivered without packet drops as long it is within the bandwidth allocated to the priority queue. If there is no other traffic on the interface, the high priority traffic can use all the available bandwidth up to the link bandwidth with the exception of when MLP or FRF.12 is configured.

High priority traffic that exceeds the allocated bandwidth will be marked with a nonconforming flag. With MLP or FRF.12 configured, packets that are marked as nonconforming will be dropped if there is congestion. When there is variation in the interval between subsequent packets, a link may become momentarily congested and the nonconforming packets will be dropped.

Under these circumstances, priority traffic sent through a link whose bandwidth is still less than the link bandwidth but higher than the bandwidth allocated for LLQ will experience packet loss.

# Multicast Scalability Tests for Financial Enterprises

The purpose of the scalability test was to stress the environment designed to deliver real-time market data in a TIBCO RV deployment. The limiting factor for most of the deployments in the financial enterprise customer environment is the amount of multicast state created in the network by the feedback groups from clients. The state for the feedback groups is partly controlled by using the shared tree instead of the shortest path tree (through configuration of the `ip pim spt-threshold` command and setting of the SPT threshold value to infinity). The state is also partly controlled by dividing the feedback groups into logical sections and assigning them to different RPs in different areas of the network. Using these methods to control the state for the feedback groups will greatly increase the multicast scalability.

IP multicast services place an extra load on the network with regard to memory and CPU resources. Network response and performance degrade as the demand for resources increases. These tests determined the upper bounds of IP multicast resource demands that can be utilized and still achieve an acceptable level of operation for an active real-world financial enterprise customer environment.

The scalability tests described in the following sections were performed:

- [Layer 2 Multicast Scalability, page 70](#)
- [Layer 3 Multicast Scalability, page 72](#)

## Layer 2 Multicast Scalability

The tests described in the following sections were performed to test Layer 2 multicast scalability:

- [IGMP Join and Leave Latency—Corporate Headquarters, page 71](#)
- [IGMP Join and Leave Latency—Remote Branches, page 71](#)

## IGMP Join and Leave Latency—Corporate Headquarters

This test on the user LANs verified that the join and leave latency on any particular port was less than 200 ms. The [IGMP Join and Leave Latency—Corporate Headquarters](#) test was run only with the baseline configuration of 7500 (S, G) multicast route entries.

### Test Plan

The procedure used to perform the [IGMP Join and Leave Latency—Corporate Headquarters](#) tests follows:

- 
- Step 1** Use the IGMP join and leave test in the Spirent SmartMulticastIP application to determine the join and leave latency. Perform this test end-to-end from the Data Center to a Floor 1 access VLAN (specifically, routers ecsj-6506-sa1 and ecsj-6506-a1).
- 

### Results

Table 59 shows the [IGMP Join and Leave Latency—Corporate Headquarters](#) test results.

**Table 59** [IGMP Join and Leave Latency—Corporate Headquarters](#) Test Results

| Tests                                                              | Results |
|--------------------------------------------------------------------|---------|
| <a href="#">IGMP Join and Leave Latency—Corporate Headquarters</a> | Pass    |

## IGMP Join and Leave Latency—Remote Branches

This test on the user LANs verified that the join and leave latency on any particular port was less than 200 ms. The [IGMP Join and Leave Latency—Remote Branches](#) test was run with the configuration of six hoot-and-holler over IP sessions and four IP/TV sessions.

### Test Plan

The procedure used to perform the [IGMP Join and Leave Latency—Remote Branches](#) tests follows:

- 
- Step 1** Use the IGMP join and leave test in the Spirent SmartMulticastIP application to determine the join and leave latency.
- 

### Results

Table 60 shows the [IGMP Join and Leave Latency—Remote Branches](#) test results.

**Table 60** [IGMP Join and Leave Latency—Remote Branches](#) Test Results

| Tests                                                       | Results |
|-------------------------------------------------------------|---------|
| <a href="#">IGMP Join and Leave Latency—Remote Branches</a> | Pass    |

## Layer 3 Multicast Scalability

Layer 3 multicast scalability testing simulated 7500, 9500, and 11,000 (S, G) multicast route entries in the network and measured the CPU utilization and memory levels. This test case characterized how well the RPs serviced four different levels of user demands. This test simulated 5000 users sending feedback for up to 10 groups, creating an excess of 11,000 (S, G) multicast route entries on the RPs.

A traffic generator was used to simulate the users sending feedback to 6, 7, and 10 groups simultaneously—creating 7500, 9500, and 11,000 (S, G) multicast route entries, respectively, on each of the redundant RPs.

The tests described in the following sections were run at the two new levels of state: 9500 and 11,000:

- [Multicast State, page 72](#)
- [MSDP with Anycast RP, page 72](#)
- [Scalability with RP/DR and RPF Failover and Convergence, page 73](#)

### Multicast State

This test verified that multicast traffic continued to be forwarded as expected when the multicast state increased.

#### Test Plan

The procedure used to perform the [Multicast State](#) test follows:

- 
- Step 1** Measure CPU and memory levels with each level of state.
- Step 2** Verify that the output of each of the following commands is correct:
- **show ip mroute count**
  - **show mac multicast igmp-snooping**
  - **show mls ip multicast**
  - **show ip mroute**
- 

#### Results

[Table 61](#) shows the [Multicast State](#) test results.

**Table 61** *Multicast State Test Results*

| Tests                           | 7500 (S, G) | 9500 (S, G) | 11,000 (S, G) |
|---------------------------------|-------------|-------------|---------------|
| <a href="#">Multicast State</a> | Pass        | Pass        | Pass          |

### MSDP with Anycast RP

This test verified that MSDP with Anycast RP continued to work as expected with the larger multicast forwarding table.



## Test Plan

The procedure used to perform the [MSDP with Anycast RP](#) tests follows:

- 
- Step 1** Verify that an SA cache entry is present for each source. Use the **show ip msdp sa-cache** command.
- 

## Results

Table 62 shows the [MSDP with Anycast RP](#) test results.

**Table 62** [MSDP with Anycast RP](#) Test Results

| Test                                 | 7500 (S, G) | 9500 (S, G) | 11,000 (S, G) |
|--------------------------------------|-------------|-------------|---------------|
| <a href="#">MSDP with Anycast RP</a> | Pass        | Pass        | Pass          |

## Scalability with RP/DR and RPF Failover and Convergence

This test verified RP/DR and RPF failover and convergence under the increased traffic conditions.

## Test Plan

The procedure used to perform the [Scalability with RP/DR and RPF Failover and Convergence](#) tests follows:

- 
- Step 1** Increase the (S, G) multicast state to 9500 and 11,000 and perform the tests described in the “[RP and Designated Router Failover and Convergence—Market Data](#)” section on page 50 and the “[Reverse Path Forwarding Failover and Convergence—Corporate Headquarters](#)” section on page 52.
- 

## Results

Table 63 shows the [Scalability with RP/DR and RPF Failover and Convergence](#) test results.

**Table 63** [Scalability with RP/DR and RPF Failover and Convergence](#) Test Results

| Tests                                                                   | 7500 (S, G) | 9500 (S, G) | 11,000 (S, G) |
|-------------------------------------------------------------------------|-------------|-------------|---------------|
| <a href="#">Scalability with RP/DR and RPF Failover and Convergence</a> | Pass        | Pass        | Pass          |

## Result Analysis for Scalability Tests

A total of 7500 (S, G) multicast route entries is at the very high end of IP multicast deployments today at financial enterprise customer sites. At this level of IP multicast state, the network delivered solid performance and resiliency during equipment failures and extreme conditions. A total of 11,000 (S, G) multicast route entries created a resource demand on the network that is substantially more than that seen in any typical customer today. At 11,000 (S, G) multicast route entries, the network behaved very

reliably during equipment failures and extreme conditions. After more than 11,000 (S, G) multicast route entries the network started to become unreliable and did not achieve an acceptable level of performance required for financial enterprise customers.

Table 64 lists the convergence results from the [RP and Designated Router Failover and Convergence—Market Data](#) tests for multicast scalability.

**Table 64** Test Results for [RP and Designated Router Failover and Convergence—Market Data](#) Scalability Tests for 9500 and 11,000 (S, G) Multicast Routes

| Test Description   | 9500 (S, G)<br>Multicast Routes |                   | 11,000 (S, G)<br>Multicast Routes |                   |
|--------------------|---------------------------------|-------------------|-----------------------------------|-------------------|
|                    | EIGRP (in seconds)              | OSPF (in seconds) | EIGRP (in seconds)                | OSPF (in seconds) |
| ecsj-6506-sd2 down | 4.98                            | 3.03              | 5.20                              | 2.34              |
| ecsj-6506-sd2 up   | 4.49                            | 0.29              | 4.35                              | 0.32              |
| ecsj-6506-sd1 down | 0.00                            | 0.00              | 0.00                              | 0.00              |
| ecsj-6506-sd1 up   | 0.00                            | 0.00              | 0.00                              | 0.00              |
| ecsj-6506-d2 down  | 3.52                            | 3.50              | 3.81                              | 3.90              |
| ecsj-6506-d2 up    | 0.00                            | 0.00              | 0.06                              | 0.24              |
| ecsj-6506-d1 down  | 0.00                            | 0.00              | 0.00                              | 0.00              |
| ecsj-6506-d1 up    | 0.00                            | 0.00              | 0.00                              | 0.00              |

Table 65 shows the test results of multicast scalability effects on RPF failover and convergence.

**Table 65** Multicast Scalability RPF Failover and Convergence

| Test Description                                           | 9500 (S, G)<br>Multicast Routes |                   | 11,000 (S, G)<br>Multicast Routes |                   |
|------------------------------------------------------------|---------------------------------|-------------------|-----------------------------------|-------------------|
|                                                            | EIGRP (in seconds)              | OSPF (in seconds) | EIGRP (in seconds)                | OSPF (in seconds) |
| Fail the link between ecsj-6506-sd2 and ecsj-6506-c2       | 0.84                            | 6.44              | 0.85                              | 6.30              |
| Bring back the link between ecsj-6506-sd2 and ecsj-6506-c2 | 0.08                            | 0.08              | 0.07                              | 0.08              |
| Fail the link between ecsj-6506-c2 and ecsj-6506-c4        | 1.88                            | 1.72              | 1.89                              | 1.71              |
| Bring back the link between ecsj-6506-c2 and ecsj-6506-c4  | 0.08                            | 0.08              | 0.08                              | 0.08              |
| Fail the link between ecsj-6506-c4 and ecsj-6506-d2        | 0.55                            | 0.65              | 0.55                              | 0.66              |

**Table 65** Multicast Scalability RPF Failover and Convergence (continued)

| Test Description                                             | 9500 (S, G)<br>Multicast Routes |                      | 11,000 (S, G)<br>Multicast Routes |                      |
|--------------------------------------------------------------|---------------------------------|----------------------|-----------------------------------|----------------------|
|                                                              | EIGRP (in<br>seconds)           | OSPF (in<br>seconds) | EIGRP (in<br>seconds)             | OSPF (in<br>seconds) |
| Bring back the link between ecsj-6506-c4 and<br>ecsj-6506-d2 | 0.01                            | 0.00                 | 0.00                              | 0.00                 |
| ecsj-6506-c2 down                                            | 1.44                            | 1.32                 | 1.42                              | 1.71                 |
| ecsj-6506-c2 up                                              | 0.11                            | 0.31                 | 0.07                              | 0.28                 |
| ecsj-6506-c4 down                                            | 1.33                            | 2.01                 | 1.34                              | 2.03                 |
| ecsj-6506-c4 up                                              | 0.25                            | 0.23                 | 0.25                              | 0.27                 |

For a discussion of the convergence results shown in [Table 64](#) and [Table 65](#), see the “[Result Analysis for Network Convergence](#)” section on page 25.

## Performance Tests for Financial Enterprises

Network performance is measured by the throughput of traffic streams delivered by the network under test. The throughput for these performance tests was measured as the line throughput, which must be distinguished from the Layer 3 data throughput and the actual data throughput, which vary depending on the frame size.

For example, a 64-byte Ethernet frame contains only 46 bytes of frame payload, which is where the IP datagram is contained. The rest of the frame includes 12 bytes of source and destination MAC addresses, 2 bytes for a type (or length) field, and a 4-byte CRC checksum. In addition, the 8 bytes preamble and 12 bytes interframe gap also must be considered, which adds up to 84 bytes total. Therefore, the Layer 3 data throughput of 64-byte packets at 100 percent line utilization rate will be:

$$100\% \text{ line utilization} * 46/84 = 55\% \text{ Layer 3 data throughput}$$

If the Ethernet frame size is changed to 1500 bytes with the same line rate, the Layer 3 data throughput will be:

$$100\% \text{ line utilization} * 1482/1520 = 97.5\% \text{ Layer 3 data throughput}$$

The actual data throughput—what a user can expect to get through—is even less because all the overhead introduced by IP must be accounted for.

All of the tests described in this section were performed with EIGRP as the IGP. A subset of these tests was also performed with OSPF, although the OSPF tests were not as exhaustive as the tests run with EIGRP because there is not necessarily a dependency on the underlying unicast routing protocol for some of the features. These tests were run after the configurations were entered and tested for the basic IP, Layer 2 multicast, Layer 3 multicast, and network management tests. All of the baseline features from those areas must be configured during the tests covered in the performance testing.

All of the performance tests described in this section were run in the system test environment that simulated users and background traffic. For details about these tests, see the “[System Tests for Financial Enterprises](#)” section on page 28.

The following sections describe the performance tests that were performed:

- [Unicast Throughput, page 76](#)
- [Multicast Throughput, page 77](#)

## Unicast Throughput

This test verified the performance of unicast throughput in the corporate headquarters from the Data Center to the user access areas. Smartbits was used to perform the unicast throughput test. The switches that were used for this test were ecsj-6506-sa2 in the Data Center and ecsj-6506-a1, ecsj-6506-a2, and ecsj-6506-a3 in the Floor 1 user access area.

This test was first performed manually using the graphical user interface (GUI) to get baseline results. Scripts were then used to facilitate the test automation.

This test was performed when all the baseline traffic (IP multicast market data traffic, IP multicast feedback traffic, and IP unicast background traffic) was active on the testbed. The throughput was measured between the Smartbits sending ports and receiving ports.

### Test Plan

The procedure used to perform the [Unicast Throughput](#) tests follows:

- 
- Step 1** Measure the unicast throughput.
- Determine the maximum transmission rate at which the network under test can forward IP traffic with no frame loss.
  - Run this test five times to determine the maximum throughput rates for packet sizes of 64, 128, 256, 512, and 1024 bytes.
- 

### Results

[Table 66](#) shows the [Unicast Throughput](#) test results.

**Table 66** *Unicast Throughput Test Results*

| Tests                              | Results |
|------------------------------------|---------|
| <a href="#">Unicast Throughput</a> | Pass    |

[Table 67](#) shows the specific results of the [Unicast Throughput](#) tests based on packet size.

**Table 67** *Unicast Throughput Based on Packet Size*

| Packet Size (bytes) | Percent of 100 Mbps Throughput |
|---------------------|--------------------------------|
| 64                  | 100                            |
| 128                 | 100                            |
| 256                 | 100                            |

**Table 67**    *Unicast Throughput Based on Packet Size*

| Packet Size (bytes) | Percent of 100 Mbps Throughput |
|---------------------|--------------------------------|
| 512                 | 100                            |
| 1024                | 100                            |

## Multicast Throughput

This test verified the performance of multicast throughput in the corporate headquarters from the Data Center to the user access areas. Smartbits was used to simulate and verify the multicast data delivery. The switches that were used in this test were ecsj-6506-sa2 in the Data Center and ecsj-6506-a1 in the Floor 1 user access area.

This test was first performed manually using the graphical user interface (GUI) to get baseline results. Then scripts were used to facilitate the test automation.

Two different versions of this test were performed. The first set of tests was done using one multicast destination address. The second set was done using ten multicast destination addresses. Both sets of tests measured throughput using packets sizes of 64, 128, 256, 512, 1024, and 1500 bytes. In addition, both sets of tests were run first with receivers on only one user VLAN and then again with receivers on all 24 user VLANs. These additional tests were done to determine the performance impact of multicast packet replication with a large fan-out.

The multicast feedback from the user access area to the Data Center was turned off for the performance tests. All other background traffic was also turned off.

### Test Plan

The procedure used to perform the [Multicast Throughput](#) tests using one multicast destination address follows:

- 
- Step 1**    Measure multicast throughput with receivers on only one user VLAN.
- Determine the maximum transmission rate at which the network under test could forward IP multicast traffic with no frame loss. Use the market data group 239.254.1.0.
  - Run this test six times to determine the maximum throughput rates for packet sizes of 64, 128, 256, 512, 1024, and 1500 bytes.
- Step 2**    Measure multicast throughput with receivers on all 24 user VLANs.  
Repeat the test described in Step 1 with IGMP receivers on all 24 VLANs.
- 

The procedure used to perform the [Multicast Throughput](#) tests using ten multicast destination addresses follows:

- 
- Step 1**    Measure multicast throughput with receivers on only one user VLAN.
- Determine the maximum transmission rate at which the network under test could forward IP multicast traffic with no frame loss. Use the Market Data groups 239.254.1.0 through 239.254.1.9.
  - Run this test six times to determine the maximum throughput rates for packet sizes of 64, 128, 256, 512, 1024, and 1500 bytes.

- Step 2** Measure multicast throughput with receivers on all 24 user VLANs.  
Repeat the test described in Step 1 with IGMP receivers on all 24 VLANs.

## Results

Table 68 shows the [Multicast Throughput](#) test results.

**Table 68** *Multicast Throughput Test Results*

| Tests                                | Results |
|--------------------------------------|---------|
| <a href="#">Multicast Throughput</a> | Pass    |

Table 69 shows the specific results of the [Multicast Throughput](#) test using one multicast destination address.

**Table 69** *Multicast Throughput Test Results Using One Multicast Destination Address*

| 1 Receiver VLAN |      | 24 Receiver VLANs |      |
|-----------------|------|-------------------|------|
| Packet Size     | Mbps | Packet Size       | Mbps |
| 64              | 100  | 64                | 100  |
| 128             | 100  | 128               | 100  |
| 256             | 100  | 256               | 100  |
| 512             | 100  | 512               | 100  |
| 1024            | 100  | 1024              | 100  |
| 1500            | 100  | 1500              | 100  |

Table 70 shows the specific results of the [Multicast Throughput](#) test using ten multicast destination addresses.

**Table 70** *Multicast Throughput Test Results Using Ten Multicast Destination Addresses*

| 1 Receiver VLAN |      | 24 Receiver VLANs |      |
|-----------------|------|-------------------|------|
| Packet Size     | Mbps | Packet Size       | Mbps |
| 64              | 100  | 64                | 100  |
| 128             | 100  | 128               | 100  |
| 256             | 100  | 256               | 100  |
| 512             | 100  | 512               | 100  |
| 1024            | 100  | 1024              | 100  |
| 1500            | 100  | 1500              | 100  |

# Reliability Tests for Financial Enterprises

The system testing described in the “[System Tests for Financial Enterprises](#)” section on page 28 was run for a period of 150 hours with a network load of at least 50 percent. This testing period required that no severe defects were found during the consecutive testing time. All error logs were monitored and the routers were periodically checked for memory leaks. The reliability test described in the following section was performed:

- [150-Hour Duration Reliability](#), page 79

## 150-Hour Duration Reliability

This reliability test ensured that the multicast features configured for the release remained stable and reliable in the test environment during the 150-hour test period.

### Test Plan

The procedure used to perform the [150-Hour Duration Reliability](#) tests follows:

**Step 1** Start all baseline traffic. Verify normal operation.

All of the baseline features described in the previous sections are configured for this test. The generated traffic is running IP and IP multicast traffic at 50 percent network utilization. Various network management scripts are run during this cycle to monitor and verify normal network operation. The following router and traffic statistics are periodically collected and monitored for any problems:

- Router CPU utilization
- Memory utilization
- Router uptime
- Logs—examined for exceptions
- IP routes
- IP multicast routes
- MSDP SA cache entries
- MLS hardware shortcuts
- SNMP data
- Connectivity (ping) tests

### Results

[Table 71](#) shows the [150-Hour Duration Reliability](#) test results.

**Table 71** [150-Hour Duration Reliability Test Results](#)

| Test                                          | Results |
|-----------------------------------------------|---------|
| <a href="#">150-Hour Duration Reliability</a> | Pass    |

# Supplementary Information

This section contains additional information about the financial enterprise system testing. It includes device characteristics for the devices used in the lab environment.

## Device Characteristics

Tables 72 through Table 98 contain the device characteristics for the devices used in the financial enterprise campus testbed.

[Table 72](#) shows the device characteristics for ecsj-6506-sd1.

**Table 72** *Device Characteristics for ecsj-6506-sd1*

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |
|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Hostname             | ecsj-6506-sd1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |  |
| Platform             | Cisco Catalyst 6500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |  |
| Memory               | 512 Mb                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |  |
| Interfaces/Addresses | Vlan301 126.32.1.19/24<br>Vlan302 126.32.2.19/24<br>Vlan303 126.32.3.19/24<br>Vlan304 126.32.4.19/24<br>Vlan305 126.32.5.19/24<br>Vlan306 126.32.6.19/24<br>Vlan307 126.32.7.19/24<br>Vlan308 126.32.8.19/24<br>Vlan365 126.32.65.19/24<br>Vlan366 126.32.66.19/24<br>Vlan367 126.32.67.19/24<br>Vlan368 126.32.68.19/24<br>Vlan369 126.32.69.19/24<br>Vlan370 126.32.70.19/24<br>Vlan371 126.32.71.19/24<br>Vlan372 126.32.72.19/24<br>Vlan429 126.32.129.19/24<br>Vlan430 126.32.130.19/24<br>Vlan431 126.32.131.19/24<br>Vlan432 126.32.132.19/24<br>Vlan433 126.32.133.19/24<br>Vlan434 126.32.134.19/24<br>Vlan435 126.32.135.19/24<br>Vlan436 126.32.136.19/24<br>GigabitEthernet1/1 126.1.13.19/24<br>GigabitEthernet1/2 126.1.15.19/24<br>GigabitEthernet2/4 126.1.17.19/24<br>FastEthernet3/48 223.255.9.19/24<br>Loopback0 126.0.1.1/32<br>Loopback1 126.0.1.19/32 |  |



**Table 72** *Device Characteristics for ecsj-6506-sd1 (continued)*

| Hardware | Mod Ports Card Type        |                                  |                                        |             | Model       |                 | Serial No.   |        |
|----------|----------------------------|----------------------------------|----------------------------------------|-------------|-------------|-----------------|--------------|--------|
|          | 1                          | 2                                | Catalyst 6000 supervisor 2 (Active)    |             |             | WS-X6K-SUP2-2GE | SAD055104ZZ  |        |
|          | 2                          | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 |             |             | WS-X6516-GE-TX  | SAD0550081N  |        |
|          | 3                          | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   |             |             | WS-X6548-RJ-45  | SAD054504NR  |        |
|          | Mod MAC addresses          |                                  |                                        | Hw          | Fw          | Sw              | Status       |        |
|          | 1                          | 0002.7e38.68a4 to 0002.7e38.68a5 |                                        |             | 3.2         | 6.1(3)          | 7.5(0.6)HUB6 | Ok     |
|          | 2                          | 0002.7ee1.2d30 to 0002.7ee1.2d3f |                                        |             | 2.0         | 6.1(3)          | 7.5(0.6)HUB6 | Ok     |
|          | 3                          | 0001.63d3.0f22 to 0001.63d3.0f51 |                                        |             | 1.1         | 6.3(1)          | 7.5(0.6)HUB6 | Ok     |
|          | Mod Sub-Module             |                                  |                                        | Model       |             | Serial          | Hw           | Status |
|          | 1                          | Policy Feature Card 2            |                                        | WS-F6K-PFC2 |             | SAD054907M7     | 3.0          | Ok     |
| 1        | Cat6k MSFC 2 daughterboard |                                  | WS-F6K-MSFC2                           |             | SAD0551025C | 1.3             | Ok           |        |

Table 73 shows the device characteristics for ecsj-6506-sd2.

**Table 73** *Device Characteristics for ecsj-6506-sd2*

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |  |
|----------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|
| Hostname             | ecsj-6506-sd2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |  |
| Platform             | Cisco Catalyst 6500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |
| Memory               | 512 Mb                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |  |
| Interfaces/Addresses | Vlan301 126.32.1.20/24<br>Vlan302 126.32.2.20/24<br>Vlan303 126.32.3.20/24<br>Vlan304 126.32.4.20/24<br>Vlan305 126.32.5.20/24<br>Vlan306 126.32.6.20/24<br>Vlan307 126.32.7.20/24<br>Vlan308 126.32.8.20/24<br>Vlan365 126.32.65.20/24<br>Vlan366 126.32.66.20/24<br>Vlan367 126.32.67.20/24<br>Vlan368 126.32.68.20/24<br>Vlan369 126.32.69.20/24<br>Vlan370 126.32.70.20/24<br>Vlan371 126.32.71.20/24<br>Vlan372 126.32.72.20/24<br>Vlan429 126.32.129.20/24<br>Vlan430 126.32.130.20/24<br>Vlan431 126.32.131.20/24<br>Vlan432 126.32.132.20/24<br>Vlan433 126.32.133.20/24<br>Vlan434 126.32.134.20/24<br>Vlan435 126.32.135.20/24<br>Vlan436 126.32.136.20/24<br>GigabitEthernet1/1 126.1.14.20/24<br>GigabitEthernet1/2 126.1.16.20/24<br>GigabitEthernet2/4 126.1.17.20/24<br>FastEthernet3/1 126.1.55.20/24<br>FastEthernet3/2 126.1.45.20/24<br>FastEthernet3/48 223.255.9.20/24<br>Loopback0 126.0.1.1/32<br>Loopback1 126.0.1.20/32 |  |

**Table 73** *Device Characteristics for ecsj-6506-sd2 (continued)*

| Hardware | Mod                              | Ports        | Card Type                              | Model           | Serial No.  |
|----------|----------------------------------|--------------|----------------------------------------|-----------------|-------------|
|          | 1                                | 2            | Catalyst 6000 supervisor 2 (Active)    | WS-X6K-SUP2-2GE | SAD055003RJ |
|          | 2                                | 16           | SFM-capable 16 port 10/100/1000mb RJ45 | WS-X6516-GE-TX  | SAD055007Y5 |
|          | 3                                | 48           | 48 port 10/100 mb RJ45                 | WS-X6348-RJ-45  | SAL0548F3TQ |
| Mod      | MAC addresses                    | Hw           | Fw                                     | Sw              | Status      |
| 1        | 0001.6415.a40a to 0001.6415.a40b | 3.2          | 6.1(3)                                 | 7.5(0.6)HUB6    | Ok          |
| 2        | 0002.7ee1.3220 to 0002.7ee1.322f | 2.0          | 6.1(3)                                 | 7.5(0.6)HUB6    | Ok          |
| 3        | 0005.740b.f870 to 0005.740b.f89f | 6.0          | 5.4(2)                                 | 7.5(0.6)HUB6    | Ok          |
| Mod      | Sub-Module                       | Model        | Serial                                 | Hw              | Status      |
| 1        | Policy Feature Card 2            | WS-F6K-PFC2  | SAD055000NP                            | 3.0             | Ok          |
| 1        | Cat6k MSFC 2 daughterboard       | WS-F6K-MSFC2 | SAD0549063K                            | 1.3             | Ok          |
| 3        | Inline Power Module              | WS-F6K-PWR   |                                        | 1.0             | Ok          |

Table 74 shows the device characteristics for ecsj-6506-c1.

**Table 74** *Device Characteristics for ecsj-6506-c1*

| Hostname             | ecsj-6506-c1                     |                 |                                        |                 |             |
|----------------------|----------------------------------|-----------------|----------------------------------------|-----------------|-------------|
| Platform             | Cisco Catalyst 6500              |                 |                                        |                 |             |
| Memory               | 512 Mb                           |                 |                                        |                 |             |
| Interfaces/Addresses | GigabitEthernet1/1               | 126.1.13.11/24  |                                        |                 |             |
|                      | GigabitEthernet1/2               | 126.1.14.11/24  |                                        |                 |             |
|                      | GigabitEthernet2/1               | 126.1.3.11/24   |                                        |                 |             |
|                      | GigabitEthernet2/2               | 126.1.2.11/24   |                                        |                 |             |
|                      | GigabitEthernet2/3               | 126.1.1.11/24   |                                        |                 |             |
|                      | GigabitEthernet2/4               | 126.1.33.11/24  |                                        |                 |             |
|                      | FastEthernet3/1                  | 126.1.51.11/24  |                                        |                 |             |
|                      | FastEthernet3/2                  | 126.1.41.11/24  |                                        |                 |             |
|                      | FastEthernet3/3                  | 126.1.31.11/24  |                                        |                 |             |
|                      | FastEthernet3/4                  | 126.1.35.11/24  |                                        |                 |             |
|                      | FastEthernet3/47                 | 126.1.21.51/24  |                                        |                 |             |
|                      | FastEthernet3/48                 | 223.255.9.11/24 |                                        |                 |             |
|                      | Loopback1                        | 126.0.1.11/32   |                                        |                 |             |
| Hardware             | Mod                              | Ports           | Card Type                              | Model           | Serial No.  |
|                      | 1                                | 2               | Catalyst 6000 supervisor 2 (Active)    | WS-X6K-SUP2-2GE | SAD055101EF |
|                      | 2                                | 16              | SFM-capable 16 port 10/100/1000mb RJ45 | WS-X6516-GE-TX  | SAD055007T0 |
|                      | 3                                | 48              | 48 port 10/100 mb RJ45                 | WS-X6348-RJ-45  | SAL0548EW0P |
| Mod                  | MAC addresses                    | Hw              | Fw                                     | Sw              | Status      |
| 1                    | 0001.c9da.d824 to 0001.c9da.d825 | 3.2             | 6.1(3)                                 | 7.5(0.6)HUB6    | Ok          |
| 2                    | 0002.7ee1.3060 to 0002.7ee1.306f | 2.0             | 6.1(3)                                 | 7.5(0.6)HUB6    | Ok          |
| 3                    | 0005.7466.bf58 to 0005.7466.bf87 | 6.0             | 5.4(2)                                 | 7.5(0.6)HUB6    | Ok          |
| Mod                  | Sub-Module                       | Model           | Serial                                 | Hw              | Status      |
| 1                    | Policy Feature Card 2            | WS-F6K-PFC2     | SAD055000GU                            | 3.0             | Ok          |
| 1                    | Cat6k MSFC 2 daughterboard       | WS-F6K-MSFC2    | SAD055102C2                            | 1.3             | Ok          |
| 3                    | Inline Power Module              | WS-F6K-PWR      |                                        | 1.0             | Ok          |

Table 75 shows the device characteristics for ecsj-6506-c2.

**Table 75** Device Characteristics for ecsj-6506-c2

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|--|
| Hostname             | ecsj-6506-c2                                                                                                                                                                                                                                                                                                                                                                                                                                                      |  |  |  |  |
| Platform             | Cisco Catalyst 6500                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |  |  |  |
| Memory               | 512 Mb                                                                                                                                                                                                                                                                                                                                                                                                                                                            |  |  |  |  |
| Interfaces/Addresses | GigabitEthernet1/1 126.1.15.12/24<br>GigabitEthernet1/2 126.1.16.12/24<br>GigabitEthernet2/1 126.1.5.12/24<br>GigabitEthernet2/2 126.1.4.12/24<br>GigabitEthernet2/3 126.1.1.12/24<br>GigabitEthernet2/4 126.1.34.12/24<br>FastEthernet3/1 126.1.52.12/24<br>FastEthernet3/2 126.1.42.12/24<br>FastEthernet3/3 126.1.32.12/24<br>FastEthernet3/4 126.1.36.12/24<br>FastEthernet3/47 126.1.20.12/24<br>FastEthernet3/48 223.255.9.12/24<br>Loopback1 126.0.1.12/32 |  |  |  |  |
| Hardware             | Mod Ports Card Type Model Serial No.<br>-----<br>1 2 Catalyst 6000 supervisor 2 (Active) WS-X6K-SUP2-2GE SAD0551050R<br>2 16 SFM-capable 16 port 10/100/1000mb RJ45 WS-X6516-GE-TX SAD0549021B<br>3 48 SFM-capable 48-port 10/100 Mbps RJ45 WS-X6548-RJ-45 SAD055108AV                                                                                                                                                                                            |  |  |  |  |
|                      | Mod MAC addresses Hw Fw Sw Status<br>-----<br>1 0001.c9da.da30 to 0001.c9da.da31 3.2 6.1(3) 7.5(0.6)HUB6 Ok<br>2 0002.7ee0.f020 to 0002.7ee0.f02f 2.0 6.1(3) 7.5(0.6)HUB6 Ok<br>3 0001.63d4.0f72 to 0001.63d4.0fa1 4.0 6.3(1) 7.5(0.6)HUB6 Ok                                                                                                                                                                                                                     |  |  |  |  |
|                      | Mod Sub-Module Model Serial Hw Status<br>-----<br>1 Policy Feature Card 2 WS-F6K-PFC2 SAD0549043M 3.0 Ok<br>1 Cat6k MSFC 2 daughterboard WS-F6K-MSFC2 SAD055101ZK 1.3 Ok                                                                                                                                                                                                                                                                                          |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |  |  |  |  |

Table 76 shows the device characteristics for ecsj-6506-c3.

**Table 76** Device Characteristics for ecsj-6506-c3

|          |                     |
|----------|---------------------|
| Hostname | ecsj-6506-c3        |
| Platform | Cisco Catalyst 6500 |
| Memory   | 512 Mb              |

**Table 76**    *Device Characteristics for ecsj-6506-c3 (continued)*

|                      |                     |                                  |                                        |              |                 |              |        |
|----------------------|---------------------|----------------------------------|----------------------------------------|--------------|-----------------|--------------|--------|
| Interfaces/Addresses | GigabitEthernet1/1  | 126.1.46.1/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet1/2  | 126.1.24.13/24                   |                                        |              |                 |              |        |
|                      | GigabitEthernet2/1  | 126.1.3.13/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet2/2  | 126.1.4.13/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet2/3  | 126.1.6.13/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet2/4  | 126.1.7.13/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet2/5  | 126.1.8.13/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet2/6  | 126.1.9.13/24                    |                                        |              |                 |              |        |
|                      | GigabitEthernet2/7  | 126.1.22.13/24                   |                                        |              |                 |              |        |
|                      | FastEthernet3/1     | 126.1.53.13/24                   |                                        |              |                 |              |        |
|                      | FastEthernet3/2     | 126.1.43.13/24                   |                                        |              |                 |              |        |
|                      | FastEthernet3/13    | 126.13.1.13/24                   |                                        |              |                 |              |        |
|                      | FastEthernet3/14    | 126.13.2.13/24                   |                                        |              |                 |              |        |
|                      | FastEthernet3/15    | 126.13.3.13/24                   |                                        |              |                 |              |        |
|                      | FastEthernet3/47    | 10.0.0.2/24                      |                                        |              |                 |              |        |
|                      | FastEthernet3/48    | 223.255.9.13/24                  |                                        |              |                 |              |        |
|                      | Loopback0           | 126.0.1.5/32                     |                                        |              |                 |              |        |
|                      | Loopback1           | 126.0.1.13/32                    |                                        |              |                 |              |        |
| Hardware             | Mod Ports Card Type |                                  | Model                                  |              | Serial No.      |              |        |
|                      | -----               |                                  |                                        |              |                 |              |        |
|                      | 1                   | 2                                | Catalyst 6000 supervisor 2 (Active)    |              | WS-X6K-SUP2-2GE | SAD055104TZ  |        |
|                      | 2                   | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 |              | WS-X6516-GE-TX  | SAD0549023M  |        |
|                      | 3                   | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   |              | WS-X6548-RJ-45  | SAD0546002T  |        |
|                      |                     |                                  |                                        |              |                 |              |        |
|                      | Mod                 | MAC addresses                    |                                        | Hw           | Fw              | Sw           | Status |
|                      | -----               |                                  |                                        |              |                 |              |        |
|                      | 1                   | 0002.7e38.693c to 0002.7e38.693d |                                        | 3.2          | 6.1(3)          | 7.5(0.6)HUB6 | Ok     |
|                      | 2                   | 0002.7ee0.e510 to 0002.7ee0.e51f |                                        | 2.0          | 6.1(3)          | 7.5(0.6)HUB6 | Ok     |
|                      | 3                   | 0001.63d3.04f2 to 0001.63d3.0521 |                                        | 1.1          | 6.3(1)          | 7.5(0.6)HUB6 | Ok     |
|                      |                     |                                  |                                        |              |                 |              |        |
|                      | Mod                 | Sub-Module                       |                                        | Model        | Serial          | Hw           | Status |
|                      | -----               |                                  |                                        |              |                 |              |        |
|                      | 1                   | Policy Feature Card 2            |                                        | WS-F6K-PFC2  | SAD054904BM     | 3.0          | Ok     |
|                      | 1                   | Cat6k MSFC 2 daughterboard       |                                        | WS-F6K-MSFC2 | SAD0551022F     | 1.3          | Ok     |

Table 77 shows the device characteristics for ecsj-6506-c4.

**Table 77**    *Device Characteristics for ecsj-6506-c4*

|                 |                     |
|-----------------|---------------------|
| <b>Hostname</b> | ecsj-6506-c4        |
| <b>Platform</b> | Cisco Catalyst 6500 |
| <b>Memory</b>   | 512 Mb              |

**Table 77** Device Characteristics for *ecsj-6506-c4* (continued)

|                      |                            |                                  |                                        |                 |             |              |        |
|----------------------|----------------------------|----------------------------------|----------------------------------------|-----------------|-------------|--------------|--------|
| Interfaces/Addresses | GigabitEthernet1/1         | 126.1.47.1/24                    |                                        |                 |             |              |        |
|                      | GigabitEthernet1/2         | 126.1.25.14/24                   |                                        |                 |             |              |        |
|                      | GigabitEthernet2/1         | 126.1.5.14/24                    |                                        |                 |             |              |        |
|                      | GigabitEthernet2/2         | 126.1.2.14/24                    |                                        |                 |             |              |        |
|                      | GigabitEthernet2/3         | 126.1.6.14/24                    |                                        |                 |             |              |        |
|                      | GigabitEthernet2/4         | 126.1.10.14/24                   |                                        |                 |             |              |        |
|                      | GigabitEthernet2/5         | 126.1.11.14/24                   |                                        |                 |             |              |        |
|                      | GigabitEthernet2/6         | 126.1.12.14/24                   |                                        |                 |             |              |        |
|                      | GigabitEthernet2/7         | 126.1.23.14/24                   |                                        |                 |             |              |        |
|                      | FastEthernet3/1            | 126.1.54.14/24                   |                                        |                 |             |              |        |
|                      | FastEthernet3/2            | 126.1.44.14/24                   |                                        |                 |             |              |        |
|                      | FastEthernet3/47           | 10.0.0.1/24                      |                                        |                 |             |              |        |
|                      | FastEthernet3/48           | 223.255.9.14/24                  |                                        |                 |             |              |        |
|                      | Loopback0                  | 126.0.1.5/32                     |                                        |                 |             |              |        |
|                      | Loopback1                  | 126.0.1.14/32                    |                                        |                 |             |              |        |
| Hardware             | Mod Ports                  |                                  | Card Type                              | Model           |             | Serial No.   |        |
|                      | -----                      |                                  |                                        |                 |             |              |        |
|                      | 1                          | 2                                | Catalyst 6000 supervisor 2 (Active)    | WS-X6K-SUP2-2GE |             | SAD055104T8  |        |
|                      | 2                          | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 | WS-X6516-GE-TX  |             | SAD055007WD  |        |
|                      | 3                          | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   | WS-X6548-RJ-45  |             | SAD0551085B  |        |
|                      | -----                      |                                  |                                        |                 |             |              |        |
|                      | Mod                        | MAC addresses                    |                                        | Hw              | Fw          | Sw           | Status |
|                      | -----                      |                                  |                                        |                 |             |              |        |
|                      | 1                          | 0002.7e38.68f0 to 0002.7e38.68f1 |                                        | 3.2             | 6.1(3)      | 7.5(0.6)HUB6 | Ok     |
|                      | 2                          | 0001.63d3.9f4a to 0001.63d3.9f59 |                                        | 2.0             | 6.1(3)      | 7.5(0.6)HUB6 | Ok     |
|                      | 3                          | 0001.63d3.ed8a to 0001.63d3.edb9 |                                        | 4.0             | 6.3(1)      | 7.5(0.6)HUB6 | Ok     |
|                      | -----                      |                                  |                                        |                 |             |              |        |
|                      | Mod                        | Sub-Module                       |                                        | Model           | Serial      | Hw           | Status |
|                      | -----                      |                                  |                                        |                 |             |              |        |
|                      | 1                          | Policy Feature Card 2            |                                        | WS-F6K-PFC2     | SAD05510453 | 3.0          | Ok     |
| 1                    | Cat6k MSFC 2 daughterboard |                                  | WS-F6K-MSFC2                           | SAD0549031L     | 1.3         | Ok           |        |

Table 78 shows the device characteristics for *ecsj-6506-d1*.

**Table 78** Device Characteristics for *ecsj-6506-d1*

|                 |                     |
|-----------------|---------------------|
| <b>Hostname</b> | ecsj-6506-d1        |
| <b>Platform</b> | Cisco Catalyst 6500 |
| <b>Memory</b>   | 512 Mb              |

**Table 78** Device Characteristics for *ecsj-6506-d1* (continued)

|                      |                     |                                  |                                        |                 |             |              |    |
|----------------------|---------------------|----------------------------------|----------------------------------------|-----------------|-------------|--------------|----|
| Interfaces/Addresses | Vlan2               | 126.2.2.15/24                    |                                        |                 |             |              |    |
|                      | Vlan3               | 126.2.3.15/24                    |                                        |                 |             |              |    |
|                      | Vlan4               | 126.2.4.15/24                    |                                        |                 |             |              |    |
|                      | Vlan5               | 126.2.5.15/24                    |                                        |                 |             |              |    |
|                      | Vlan6               | 126.2.6.15/24                    |                                        |                 |             |              |    |
|                      | Vlan7               | 126.2.7.15/24                    |                                        |                 |             |              |    |
|                      | Vlan8               | 126.2.8.15/24                    |                                        |                 |             |              |    |
|                      | Vlan9               | 126.2.9.15/24                    |                                        |                 |             |              |    |
|                      | Vlan65              | 126.2.65.15/24                   |                                        |                 |             |              |    |
|                      | Vlan66              | 126.2.66.15/24                   |                                        |                 |             |              |    |
|                      | Vlan67              | 126.2.67.15/24                   |                                        |                 |             |              |    |
|                      | Vlan68              | 126.2.68.15/24                   |                                        |                 |             |              |    |
|                      | Vlan69              | 126.2.69.15/24                   |                                        |                 |             |              |    |
|                      | Vlan70              | 126.2.70.15/24                   |                                        |                 |             |              |    |
|                      | Vlan71              | 126.2.71.15/24                   |                                        |                 |             |              |    |
|                      | Vlan72              | 126.2.72.15/24                   |                                        |                 |             |              |    |
|                      | Vlan129             | 126.2.129.15/24                  |                                        |                 |             |              |    |
|                      | Vlan130             | 126.2.130.15/24                  |                                        |                 |             |              |    |
|                      | Vlan131             | 126.2.131.15/24                  |                                        |                 |             |              |    |
|                      | Vlan132             | 126.2.132.15/24                  |                                        |                 |             |              |    |
|                      | Vlan133             | 126.2.133.15/24                  |                                        |                 |             |              |    |
|                      | Vlan134             | 126.2.134.15/24                  |                                        |                 |             |              |    |
|                      | Vlan135             | 126.2.135.15/24                  |                                        |                 |             |              |    |
|                      | Vlan136             | 126.2.136.15/24                  |                                        |                 |             |              |    |
|                      | Vlan193             | 126.2.193.15/24                  |                                        |                 |             |              |    |
|                      | Vlan194             | 126.2.194.15/24                  |                                        |                 |             |              |    |
|                      | Vlan195             | 126.2.195.15/24                  |                                        |                 |             |              |    |
|                      | Vlan196             | 126.2.196.15/24                  |                                        |                 |             |              |    |
|                      | Vlan197             | 126.2.197.15/24                  |                                        |                 |             |              |    |
|                      | Vlan198             | 126.2.198.15/24                  |                                        |                 |             |              |    |
|                      | Vlan199             | 126.2.199.15/24                  |                                        |                 |             |              |    |
|                      | Vlan200             | 126.2.200.15/24                  |                                        |                 |             |              |    |
|                      | GigabitEthernet2/1  | 126.1.9.15/24                    |                                        |                 |             |              |    |
|                      | GigabitEthernet2/2  | 126.1.10.15/24                   |                                        |                 |             |              |    |
|                      | GigabitEthernet2/3  | 126.1.18.15/24                   |                                        |                 |             |              |    |
|                      | GigabitEthernet2/16 | 126.1.29.15/24                   |                                        |                 |             |              |    |
|                      | FastEthernet3/48    | 223.255.9.15/24                  |                                        |                 |             |              |    |
|                      | Loopback0           | 126.0.1.2/32                     |                                        |                 |             |              |    |
|                      | Loopback1           | 126.0.1.15/32                    |                                        |                 |             |              |    |
| Hardware             | Mod Ports Card Type |                                  | Model                                  |                 | Serial No.  |              |    |
|                      | -----               |                                  |                                        |                 |             |              |    |
|                      | 1                   | 2                                | Catalyst 6000 supervisor 2 (Active)    | WS-X6K-SUP2-2GE | SAD055101FN |              |    |
|                      | 2                   | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 | WS-X6516-GE-TX  | SAD055007WZ |              |    |
|                      | 3                   | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   | WS-X6548-RJ-45  | SAD0551084N |              |    |
|                      | Mod MAC addresses   |                                  | Hw                                     | Fw              | Sw          | Status       |    |
|                      | -----               |                                  |                                        |                 |             |              |    |
|                      | 1                   | 0001.c9da.d850 to 0001.c9da.d851 |                                        | 3.2             | 6.1(3)      | 7.5(0.6)HUB6 | Ok |
|                      | 2                   | 0002.7ee1.2d40 to 0002.7ee1.2d4f |                                        | 2.0             | 6.1(3)      | 7.5(0.6)HUB6 | Ok |
|                      | 3                   | 0001.63d3.fcd2 to 0001.63d3.fd01 |                                        | 4.0             | 6.3(1)      | 7.5(0.6)HUB6 | Ok |
|                      | Mod Sub-Module      |                                  | Model                                  | Serial          | Hw          | Status       |    |
|                      | -----               |                                  |                                        |                 |             |              |    |
|                      | 1                   | Policy Feature Card 2            | WS-F6K-PFC2                            | SAD055104GN     | 3.0         | Ok           |    |
|                      | 1                   | Cat6k MSFC 2 daughterboard       | WS-F6K-MSFC2                           | SAD05510290     | 1.3         | Ok           |    |

Table 79 shows the device characteristics for *ecsj-6506-d2*.

Table 79 Device Characteristics for ecsj-6506-d2

|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                  |                                        |              |                 |
|----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|----------------------------------------|--------------|-----------------|
| Hostname             | ecsj-6506-d2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                  |                                        |              |                 |
| Platform             | Cisco Catalyst 6500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                  |                                        |              |                 |
| Memory               | 512 Mb                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                  |                                        |              |                 |
| Interfaces/Addresses | Vlan2 126.2.2.16/24<br>Vlan3 126.2.3.16/24<br>Vlan4 126.2.4.16/24<br>Vlan5 126.2.5.16/24<br>Vlan6 126.2.6.16/24<br>Vlan7 126.2.7.16/24<br>Vlan8 126.2.8.16/24<br>Vlan9 126.2.9.16/24<br>Vlan65 126.2.65.16/24<br>Vlan66 126.2.66.16/24<br>Vlan67 126.2.67.16/24<br>Vlan68 126.2.68.16/24<br>Vlan69 126.2.69.16/24<br>Vlan70 126.2.70.16/24<br>Vlan71 126.2.71.16/24<br>Vlan72 126.2.72.16/24<br>Vlan129 126.2.129.16/24<br>Vlan130 126.2.130.16/24<br>Vlan131 126.2.131.16/24<br>Vlan132 126.2.132.16/24<br>Vlan133 126.2.133.16/24<br>Vlan134 126.2.134.16/24<br>Vlan135 126.2.135.16/24<br>Vlan136 126.2.136.16/24<br>Vlan193 126.2.193.16/24<br>Vlan194 126.2.194.16/24<br>Vlan195 126.2.195.16/24<br>Vlan196 126.2.196.16/24<br>Vlan197 126.2.197.16/24<br>Vlan198 126.2.198.16/24<br>Vlan199 126.2.199.16/24<br>Vlan200 126.2.200.16/24<br>GigabitEthernet2/2 126.1.8.16/24<br>GigabitEthernet2/3 126.1.18.16/24<br>FastEthernet3/48 223.255.9.16/24<br>Loopback0 126.0.1.2/32<br>Loopback1 126.0.1.16/32 |                                  |                                        |              |                 |
| Hardware             | Mod Ports                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                  | Card Type                              |              | Model           |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                  |                                        |              | Serial No.      |
|                      | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 2                                | Catalyst 6000 supervisor 2 (Active)    |              | WS-X6K-SUP2-2GE |
|                      | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 |              | WS-X6516-GE-TX  |
|                      | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   |              | WS-X6548-RJ-45  |
|                      | Mod MAC addresses                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                  | Hw                                     | Fw           | Sw              |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                  | Status                                 |              |                 |
|                      | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0002.7e38.68e8 to 0002.7e38.68e9 |                                        | 3.2          | 6.1(3)          |
|                      | 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0002.7ee0.ace0 to 0002.7ee0.acef |                                        | 2.0          | 6.1(3)          |
|                      | 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 0001.63d3.f1c2 to 0001.63d3.f1f1 |                                        | 4.0          | 6.3(1)          |
|                      | Mod Sub-Module                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                  | Model                                  |              | Serial          |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                  |                                        |              | Hw              |
|                      |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                  |                                        |              | Status          |
|                      | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Policy Feature Card 2            |                                        | WS-F6K-PFC2  | SAD0551044X     |
|                      | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Cat6k MSFC 2 daughterboard       |                                        | WS-F6K-MSFC2 | SAD0551023H     |

Table 80 shows the device characteristics for ecsj-6506-d3.

**Table 80** Device Characteristics for *ecsj-6506-d3*

|                      |                     |                                  |                                        |                 |             |              |        |
|----------------------|---------------------|----------------------------------|----------------------------------------|-----------------|-------------|--------------|--------|
| Hostname             | ecsj-6506-d3        |                                  |                                        |                 |             |              |        |
| Platform             | Cisco Catalyst 6500 |                                  |                                        |                 |             |              |        |
| Memory               | 512 Mb              |                                  |                                        |                 |             |              |        |
| Interfaces/Addresses | Vlan201             | 126.3.1.17/24                    |                                        |                 |             |              |        |
|                      | Vlan202             | 126.3.2.17/24                    |                                        |                 |             |              |        |
|                      | Vlan203             | 126.3.3.17/24                    |                                        |                 |             |              |        |
|                      | Vlan204             | 126.3.4.17/24                    |                                        |                 |             |              |        |
|                      | Vlan205             | 126.3.5.17/24                    |                                        |                 |             |              |        |
|                      | Vlan206             | 126.3.6.17/24                    |                                        |                 |             |              |        |
|                      | Vlan207             | 126.3.7.17/24                    |                                        |                 |             |              |        |
|                      | Vlan208             | 126.3.8.17/24                    |                                        |                 |             |              |        |
|                      | Vlan265             | 126.3.65.17/24                   |                                        |                 |             |              |        |
|                      | Vlan266             | 126.3.66.17/24                   |                                        |                 |             |              |        |
|                      | Vlan267             | 126.3.67.17/24                   |                                        |                 |             |              |        |
|                      | Vlan268             | 126.3.68.17/24                   |                                        |                 |             |              |        |
|                      | Vlan269             | 126.3.69.17/24                   |                                        |                 |             |              |        |
|                      | Vlan270             | 126.3.70.17/24                   |                                        |                 |             |              |        |
|                      | Vlan271             | 126.3.71.17/24                   |                                        |                 |             |              |        |
|                      | Vlan272             | 126.3.72.17/24                   |                                        |                 |             |              |        |
|                      | GigabitEthernet2/1  | 126.1.7.17/24                    |                                        |                 |             |              |        |
|                      | GigabitEthernet2/2  | 126.1.19.17/24                   |                                        |                 |             |              |        |
|                      | FastEthernet3/48    | 223.255.9.17/24                  |                                        |                 |             |              |        |
| Loopback0            | 126.0.1.3/32        |                                  |                                        |                 |             |              |        |
| Loopback1            | 126.0.1.17/32       |                                  |                                        |                 |             |              |        |
| Hardware             | Mod                 | Ports                            | Card Type                              | Model           | Serial No.  |              |        |
|                      | 1                   | 2                                | Catalyst 6000 supervisor 2 (Active)    | WS-X6K-SUP2-2GE | SAD05510520 |              |        |
|                      | 2                   | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 | WS-X6516-GE-TX  | SAD054901ZH |              |        |
|                      | 3                   | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   | WS-X6548-RJ-45  | SAD06180036 |              |        |
|                      | Mod                 | MAC addresses                    |                                        | Hw              | Fw          | Sw           | Status |
|                      | 1                   | 0001.6477.3276 to 0001.6477.3277 |                                        | 3.2             | 6.1(3)      | 7.5(0.6)HUB6 | Ok     |
|                      | 2                   | 0001.63d3.4d22 to 0001.63d3.4d31 |                                        | 2.0             | 6.1(3)      | 7.5(0.6)HUB6 | Ok     |
|                      | 3                   | 0003.fea8.c34c to 0003.fea8.c37b |                                        | 4.3             | 6.3(1)      | 7.5(0.6)HUB6 | Ok     |
|                      | Mod                 | Sub-Module                       |                                        | Model           | Serial      | Hw           | Status |
|                      | 1                   | Policy Feature Card 2            |                                        | WS-F6K-PFC2     | SAD055104K2 | 3.0          | Ok     |
|                      | 1                   | Cat6k MSFC 2 daughterboard       |                                        | WS-F6K-MSFC2    | SAD055101Y5 | 1.3          | Ok     |

Table 81 shows the device characteristics for ecsj-6506-d4.

**Table 81** Device Characteristics for *ecsj-6506-d4*

|          |                     |
|----------|---------------------|
| Hostname | ecsj-6506-d4        |
| Platform | Cisco Catalyst 6500 |
| Memory   | 512 Mb              |



**Table 81** *Device Characteristics for ecsj-6506-d4 (continued)*

|                      |                                      |                                  |                                        |                 |             |              |    |
|----------------------|--------------------------------------|----------------------------------|----------------------------------------|-----------------|-------------|--------------|----|
| Interfaces/Addresses | Vlan201                              | 126.3.1.18/24                    |                                        |                 |             |              |    |
|                      | Vlan202                              | 126.3.2.18/24                    |                                        |                 |             |              |    |
|                      | Vlan203                              | 126.3.3.18/24                    |                                        |                 |             |              |    |
|                      | Vlan204                              | 126.3.4.18/24                    |                                        |                 |             |              |    |
|                      | Vlan205                              | 126.3.5.18/24                    |                                        |                 |             |              |    |
|                      | Vlan206                              | 126.3.6.18/24                    |                                        |                 |             |              |    |
|                      | Vlan207                              | 126.3.7.18/24                    |                                        |                 |             |              |    |
|                      | Vlan208                              | 126.3.8.18/24                    |                                        |                 |             |              |    |
|                      | Vlan265                              | 126.3.65.18/24                   |                                        |                 |             |              |    |
|                      | Vlan266                              | 126.3.66.18/24                   |                                        |                 |             |              |    |
|                      | Vlan267                              | 126.3.67.18/24                   |                                        |                 |             |              |    |
|                      | Vlan268                              | 126.3.68.18/24                   |                                        |                 |             |              |    |
|                      | Vlan269                              | 126.3.69.18/24                   |                                        |                 |             |              |    |
|                      | Vlan270                              | 126.3.70.18/24                   |                                        |                 |             |              |    |
|                      | Vlan271                              | 126.3.71.18/24                   |                                        |                 |             |              |    |
|                      | Vlan272                              | 126.3.72.18/24                   |                                        |                 |             |              |    |
|                      | GigabitEthernet2/1                   | 126.1.12.18/24                   |                                        |                 |             |              |    |
|                      | GigabitEthernet2/2                   | 126.1.19.18/24                   |                                        |                 |             |              |    |
|                      | GigabitEthernet2/3                   | 126.3.130.18/24                  |                                        |                 |             |              |    |
|                      | GigabitEthernet2/16                  | 126.1.30.18/24                   |                                        |                 |             |              |    |
|                      | FastEthernet3/48                     | 223.255.9.18/24                  |                                        |                 |             |              |    |
|                      | Loopback0                            | 126.0.1.3/32                     |                                        |                 |             |              |    |
|                      | Loopback1                            | 126.0.1.18/32                    |                                        |                 |             |              |    |
| Hardware             | Mod Ports Card Type Model Serial No. |                                  |                                        |                 |             |              |    |
|                      | -----                                |                                  |                                        |                 |             |              |    |
|                      | 1                                    | 2                                | Catalyst 6000 supervisor 2 (Active)    | WS-X6K-SUP2-2GE | SAD055003UW |              |    |
|                      | 2                                    | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 | WS-X6516-GE-TX  | SAD055007TP |              |    |
|                      | 3                                    | 48                               | 48 port 10/100 mb RJ45                 | WS-X6348-RJ-45  | SAL0547EQK8 |              |    |
|                      |                                      |                                  |                                        |                 |             |              |    |
|                      | Mod MAC addresses                    |                                  | Hw                                     | Fw              | Sw          | Status       |    |
|                      | -----                                |                                  |                                        |                 |             |              |    |
|                      | 1                                    | 0001.6415.a41e to 0001.6415.a41f |                                        | 3.2             | 6.1(3)      | 7.5(0.6)HUB6 | Ok |
|                      | 2                                    | 0002.7ee1.3350 to 0002.7ee1.335f |                                        | 2.0             | 6.1(3)      | 7.5(0.6)HUB6 | Ok |
|                      | 3                                    | 0005.7466.32b8 to 0005.7466.32e7 |                                        | 6.0             | 5.4(2)      | 7.5(0.6)HUB6 | Ok |
|                      |                                      |                                  |                                        |                 |             |              |    |
|                      | Mod Sub-Module                       |                                  | Model                                  | Serial          | Hw          | Status       |    |
|                      | -----                                |                                  |                                        |                 |             |              |    |
|                      | 1                                    | Policy Feature Card 2            | WS-F6K-PFC2                            | SAD055000RY     | 3.0         | Ok           |    |
|                      | 1                                    | Cat6k MSFC 2 daughterboard       | WS-F6K-MSFC2                           | SAD0549067G     | 1.3         | Ok           |    |
|                      | 3                                    | Inline Power Module              | WS-F6K-PWR                             |                 | 1.0         | Ok           |    |

Table 82 shows the device characteristics for ecsj-7206-w1.

**Table 82** *Device Characteristics for ecsj-7206-w1*

|          |               |
|----------|---------------|
| Hostname | ecsj-7206-w1  |
| Platform | Cisco 7206VXR |
| Memory   | 128 Mb        |

**Table 82**    *Device Characteristics for ecsj-7206-w1 (continued)*

|                      |                         |                 |
|----------------------|-------------------------|-----------------|
| Interfaces/Addresses | FastEthernet0/0         | 126.1.31.8/24   |
|                      | FastEthernet0/1         | 126.1.32.8/24   |
|                      | Serial1/0/1:0.101       | 126.101.20.8/24 |
|                      | Serial1/0/2:0.102       | 126.102.20.8/24 |
|                      | Serial1/0/3:0.103       | 126.103.20.8/24 |
|                      | FastEthernet2/0         | 126.1.48.8/24   |
|                      | FastEthernet2/1         | 223.255.9.50/24 |
|                      | Loopback1               | 126.0.1.8/32    |
| Hardware             | Slot 0: C7200-I/O-2FE/E |                 |
|                      | Slot 1: PA-MC-T3        |                 |
|                      | Slot 2: PA-2FE-TX       |                 |
|                      | Slot 3: PA-4T+          |                 |
|                      | Slot 4: PA-MC-4T1       |                 |

Table 83 shows the device characteristics for ecsj-6506-w2.

**Table 83**    *Device Characteristics for ecsj-6506-w2*

|                      |                     |                                  |                                        |                 |                 |              |             |
|----------------------|---------------------|----------------------------------|----------------------------------------|-----------------|-----------------|--------------|-------------|
| Hostname             | ecsj-6506-w2        |                                  |                                        |                 |                 |              |             |
| Platform             | Cisco Catalyst 6500 |                                  |                                        |                 |                 |              |             |
| Memory               | 512 Mb              |                                  |                                        |                 |                 |              |             |
| Interfaces/Addresses | GigabitEthernet2/1  |                                  |                                        | 126.1.33.9/24   |                 |              |             |
|                      | GigabitEthernet2/2  |                                  |                                        | 126.1.34.9/24   |                 |              |             |
|                      | FastEthernet3/47    |                                  |                                        | 126.1.49.9/24   |                 |              |             |
|                      | FastEthernet3/48    |                                  |                                        | 223.255.9.51/24 |                 |              |             |
|                      | Serial4/1/0/1:0.104 |                                  |                                        | 126.104.20.9/24 |                 |              |             |
|                      | Serial4/1/0/2:0.105 |                                  |                                        | 126.105.20.9/24 |                 |              |             |
|                      | Serial4/1/0/3:0.106 |                                  |                                        | 126.106.20.9/24 |                 |              |             |
|                      | Loopback1           |                                  |                                        | 126.0.1.9/24    |                 |              |             |
| Hardware             | Mod                 | Ports                            | Card Type                              |                 | Model           |              | Serial No.  |
|                      | -----               |                                  |                                        |                 |                 |              |             |
|                      | 1                   | 2                                | Catalyst 6000 supervisor 2 (Active)    |                 | WS-X6K-SUP2-2GE |              | SAD062102CK |
|                      | 2                   | 16                               | SFM-capable 16 port 10/100/1000mb RJ45 |                 | WS-X6516-GE-TX  |              | SAD062501CN |
|                      | 3                   | 48                               | SFM-capable 48-port 10/100 Mbps RJ45   |                 | WS-X6548-RJ-45  |              | SAD0616055P |
|                      | 4                   | 0                                | 2 port adapter FlexWAN                 |                 | WS-X6182-2PA    |              | SAD053004KZ |
|                      | 5                   | 0                                | 2 port adapter FlexWAN                 |                 | WS-X6182-2PA    |              | SAD061904XN |
|                      | Mod                 | MAC addresses                    |                                        | Hw              | Fw              | Sw           | Status      |
|                      | -----               |                                  |                                        |                 |                 |              |             |
|                      | 1                   | 0001.c9db.3970 to 0001.c9db.3971 |                                        | 3.7             | 6.1(3)          | 7.5(0.6)HUB6 | Ok          |
|                      | 2                   | 0003.fea9.fa26 to 0003.fea9.fa35 |                                        | 2.1             | 6.3(1)          | 7.5(0.6)HUB6 | Ok          |
|                      | 3                   | 0002.7ee3.1e60 to 0002.7ee3.1e8f |                                        | 4.2             | 6.3(1)          | 7.5(0.6)HUB6 | Ok          |
|                      | 4                   | 0002.fdb2.ae80 to 0002.fdb2.aebf |                                        | 1.4             | 12.1(13)E1      | 12.1(13)E1   | Ok          |
|                      | 5                   | 0007.ecd1.blc0 to 0007.ecd1.blff |                                        | 1.5             | 12.1(13)E1      | 12.1(13)E1   | Ok          |
|                      | Mod                 | Sub-Module                       |                                        | Model           | Serial          | Hw           | Status      |
|                      | -----               |                                  |                                        |                 |                 |              |             |
|                      | 1                   | Policy Feature Card 2            |                                        | WS-F6K-PFC2     | SAD061902WH     | 3.2          | Ok          |
|                      | 1                   | Cat6k MSFC 2 daughterboard       |                                        | WS-F6K-MSFC2    | SAD062102W7     | 2.3          | Ok          |

Table 84 shows the device characteristics for ecsj-7513-w3.

**Table 84** *Device Characteristics for ecsj-7513-w3*

|                             |                                                                                                                                                                               |                  |
|-----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <b>Hostname</b>             | ecsj-7513-w3                                                                                                                                                                  |                  |
| <b>Platform</b>             | Cisco 7500                                                                                                                                                                    |                  |
| <b>Memory</b>               | 128 Mb                                                                                                                                                                        |                  |
| <b>Interfaces/Addresses</b> | Hssi2/0/0.107                                                                                                                                                                 | 126.107.20.10/24 |
|                             | Hssi2/0/0.108                                                                                                                                                                 | 126.108.20.10/24 |
|                             | Hssi2/0/0.109                                                                                                                                                                 | 126.109.20.10/24 |
|                             | FastEthernet3/0/0                                                                                                                                                             | 126.1.35.10/24   |
|                             | FastEthernet3/0/1                                                                                                                                                             | 126.1.36.10/24   |
|                             | FastEthernet4/1/0                                                                                                                                                             | 126.1.50.10/24   |
|                             | FastEthernet4/1/1                                                                                                                                                             | 223.255.9.52/24  |
|                             | Loopback1                                                                                                                                                                     | 126.0.1.10/32    |
| <b>Hardware</b>             | Slot 2: VIP4-80<br>Bay 0: PA-H<br><br>Slot 3: VIP4-80<br>Bay 0: PA-2FE-TX<br>Bay 1: PA-2FE-TX<br><br>Slot 4: VIP4-80<br>Bay 0: PA-4T+<br>Bay 1: PA-2FE-TX<br><br>Slot 7: RSP8 |                  |

Table 85 shows the device characteristics for ecsj-3640-h1.

**Table 85** *Device Characteristics for ecsj-3640-h1*

|                             |                                                                                                                                                                |                 |
|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| <b>Hostname</b>             | ecsj-3640-h1                                                                                                                                                   |                 |
| <b>Platform</b>             | Cisco 3640                                                                                                                                                     |                 |
| <b>Memory</b>               | 128 Mb                                                                                                                                                         |                 |
| <b>Interfaces/Addresses</b> | FastEthernet0/0                                                                                                                                                | 126.1.29.6/24   |
|                             | FastEthernet0/1                                                                                                                                                | 223.255.9.48/24 |
|                             | FastEthernet1/0                                                                                                                                                | 126.1.37.1/24   |
|                             | Loopback0                                                                                                                                                      | 126.0.1.6/32    |
|                             | Vif1                                                                                                                                                           | 126.1.27.6/24   |
| <b>Hardware</b>             | Slot 0: NM-2FE2W<br><br>Slot 1: NM-1FE2W<br><br>Slot 2: NM-2V<br>WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS<br><br>Slot 3: NM-2V<br>WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS |                 |

Table 86 shows the device characteristics for ecsj-3640-h2.

**Table 86**    *Device Characteristics for ecsj-3640-h2*

|                      |                                                                                                                                                                                 |                 |
|----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------|
| Hostname             | ecsj-3640-h2                                                                                                                                                                    |                 |
| Platform             | Cisco 3640                                                                                                                                                                      |                 |
| Memory               | 128 Mb; 124928K                                                                                                                                                                 |                 |
| Interfaces/Addresses | FastEthernet0/0                                                                                                                                                                 | 126.1.30.7/24   |
|                      | FastEthernet0/1                                                                                                                                                                 | 223.255.9.49/24 |
|                      | FastEthernet1/0                                                                                                                                                                 | 126.1.38.1/24   |
|                      | Loopback0                                                                                                                                                                       | 126.0.1.7/32    |
|                      | Vif1                                                                                                                                                                            | 126.1.28.7/24   |
| Hardware             | Slot 0: NM-2FE2W<br><br>Slot 1: NM-1FE2W<br>WIC 0: WIC-1T<br><br>Slot 2: NM-2V<br>WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS<br><br>Slot 3: NM-2V<br>WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS |                 |

[Table 87](#) shows the device characteristics for ecbr1-7206-e1.

**Table 87**    *Device Characteristics for ecbr1-7206-e1*

|                      |                                                                                     |                 |
|----------------------|-------------------------------------------------------------------------------------|-----------------|
| Hostname             | ecbr1-7206-e1                                                                       |                 |
| Platform             | Cisco 7206VXR                                                                       |                 |
| Memory               | 128 Mb                                                                              |                 |
| Interfaces/Addresses | FastEthernet0/0                                                                     | 126.101.2.1/24  |
|                      | FastEthernet0/1                                                                     | 126.101.3.1/24  |
|                      | Serial1/0:0.101                                                                     | 126.101.20.1/24 |
|                      | FastEthernet2/0                                                                     | 126.101.4.1/24  |
|                      | FastEthernet2/1                                                                     | 223.255.9.53/24 |
|                      | Loopback0                                                                           | 126.101.0.1/32  |
| Hardware             | Slot 0: C7200-I/O-2FE/E<br>Slot 1: PA-MC-4T1<br>Slot 2: PA-2FE-TX<br>Slot 4: PA-4T+ |                 |

[Table 88](#) shows the device characteristics for ecbr1-3620-v1.

**Table 88**    *Device Characteristics for ecbr1-3620-v1*

|          |               |  |
|----------|---------------|--|
| Hostname | ecbr1-3620-v1 |  |
| Platform | Cisco 3620    |  |
| Memory   | 64 Mb         |  |

**Table 88** *Device Characteristics for ecbr1-3620-v1 (continued)*

|                      |                  |                 |
|----------------------|------------------|-----------------|
| Interfaces/Addresses | FastEthernet0/0  | 126.101.2.2/24  |
|                      | FastEthernet0/1  | 223.255.9.54/24 |
|                      | Loopback1        | 126.101.0.2/32  |
|                      | Vif1             | 126.101.1.2/24  |
| Hardware             | Slot 0: NM-2FE2W |                 |
|                      | Slot 1: NM-2V    |                 |
|                      | WIC 0: VIC-2E/M  |                 |
|                      | WIC 1: VIC-2FXS  |                 |

[Table 89](#) shows the device characteristics for ecbr2-3640-e1.

**Table 89** *Device Characteristics for ecbr2-3640-e1*

|                      |                   |                 |
|----------------------|-------------------|-----------------|
| Hostname             | ecbr2-3640-e1     |                 |
| Platform             | Cisco 3640        |                 |
| Memory               | 128 Mb            |                 |
| Interfaces/Addresses | FastEthernet0/0   | 126.102.2.1/24  |
|                      | Serial0/0.102     | 126.102.20.1/24 |
|                      | Ethernet1/0       | 223.255.9.56/24 |
|                      | Loopback1         | 126.102.0.1/32  |
|                      | Vif1              | 126.102.1.2/24  |
| Hardware             | Slot 0: NM-2FE2W  |                 |
|                      | WIC 0: WIC-2T     |                 |
|                      | Slot 1: NM-1E1R2W |                 |
|                      | Slot 2: NM-2V     |                 |
|                      | WIC 0: VIC-2E/M   |                 |
|                      | WIC 1: VIC-2FXS   |                 |

[Table 90](#) shows the device characteristics for ecbr3-2651-e1.

**Table 90** *Device Characteristics for ecbr3-2651-e1*

|                      |                             |                 |
|----------------------|-----------------------------|-----------------|
| Hostname             | ecbr3-2651-e1               |                 |
| Platform             | Cisco 2651                  |                 |
| Memory               | 64 Mb                       |                 |
| Interfaces/Addresses | FastEthernet0/0             | 126.103.2.1/24  |
|                      | Serial0/0.103               | 126.103.20.1/24 |
|                      | FastEthernet0/1             | 223.255.9.58/24 |
|                      | Loopback1                   | 126.103.0.1/32  |
|                      | Vif1                        | 126.103.1.2/24  |
| Hardware             | Slot 0: CISCO2651 Mainboard |                 |
|                      | WIC 0: WIC-2T               |                 |
|                      | Slot 1: NM-2V               |                 |
|                      | WIC 0: VIC-2E/M             |                 |
|                      | WIC 1: VIC-2FXS             |                 |

Table 91 shows the device characteristics for ecbr4-7206-e1.

**Table 91**    *Device Characteristics for ecbr4-7206-e1*

|                      |                                                                                     |                 |
|----------------------|-------------------------------------------------------------------------------------|-----------------|
| Hostname             | ecbr4-7206-e1                                                                       |                 |
| Platform             | Cisco 7206VXR                                                                       |                 |
| Memory               | 128 Mb                                                                              |                 |
| Interfaces/Addresses | FastEthernet0/0                                                                     | 126.104.2.1/24  |
|                      | FastEthernet0/1                                                                     | 126.104.3.1/24  |
|                      | Serial1/0:0.104                                                                     | 126.104.20.1/24 |
|                      | FastEthernet2/0                                                                     | 126.104.4.1/24  |
|                      | FastEthernet2/1                                                                     | 223.255.9.60/24 |
|                      | Loopback1                                                                           | 126.104.0.1/32  |
| Hardware             | Slot 0: C7200-I/O-2FE/E<br>Slot 1: PA-MC-4T1<br>Slot 2: PA-2FE-TX<br>Slot 4: PA-4T+ |                 |

Table 92 shows the device characteristics for ecbr4-3620-v1.

**Table 92**    *Device Characteristics for ecbr4-3620-v1*

|                      |                                                                             |                 |
|----------------------|-----------------------------------------------------------------------------|-----------------|
| Hostname             | ecbr4-3620-v1                                                               |                 |
| Platform             | Cisco 3620                                                                  |                 |
| Memory               | 64 Mb                                                                       |                 |
| Interfaces/Addresses | FastEthernet0/0                                                             | 126.104.2.2/24  |
|                      | FastEthernet0/1                                                             | 223.255.9.61/24 |
|                      | Loopback1                                                                   | 126.104.0.2/32  |
|                      | Vif1                                                                        | 126.104.1.2/30  |
| Hardware             | Slot 0: NM-2FE2W<br><br>Slot 1: NM-2V<br>WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS |                 |

Table 93 shows the device characteristics for ecbr5-3640-e1.

**Table 93**    *Device Characteristics for ecbr5-3640-e1*

|                      |                 |                 |
|----------------------|-----------------|-----------------|
| Hostname             | ecbr5-3640-e1   |                 |
| Platform             | Cisco 3640      |                 |
| Memory               | 128 Mb          |                 |
| Interfaces/Addresses | FastEthernet0/0 | 126.105.2.1/24  |
|                      | Serial0/0.105   | 126.105.20.1/24 |
|                      | FastEthernet0/1 | 223.255.9.63/24 |
|                      | Loopback1       | 126.105.0.1/32  |
|                      | Vif1            | 126.105.1.2/24  |

**Table 93** *Device Characteristics for ecbr5-3640-e1 (continued)*

|          |                                    |
|----------|------------------------------------|
| Hardware | Slot 0: NM-2FE2W                   |
|          | WIC 0: WIC-2T                      |
|          | Slot 2: NM-2V                      |
|          | WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS |

Table 94 shows the device characteristics for ecbr6-2651-e1.

**Table 94** *Device Characteristics for ecbr6-2651-e1*

|                      |                                    |                 |
|----------------------|------------------------------------|-----------------|
| Hostname             | ecbr6-2651-e1                      |                 |
| Platform             | Cisco 2651                         |                 |
| Memory               | 64 Mb                              |                 |
| Interfaces/Addresses | FastEthernet0/0                    | 126.106.2.1/24  |
|                      | Serial0/0.106                      | 126.106.20.1/24 |
|                      | FastEthernet0/1                    | 223.255.9.65/24 |
|                      | Loopback1                          | 126.106.0.1/32  |
|                      | Vif1                               | 126.106.1.2/24  |
| Hardware             | Slot 0: CISCO2651 Mainboard        |                 |
|                      | WIC 0: WIC-2T                      |                 |
|                      | Slot 1: NM-2V                      |                 |
|                      | WIC 0: VIC-2E/M<br>WIC 1: VIC-2FXS |                 |

Table 95 shows the device characteristics for ecbr7-7206-e1.

**Table 95** *Device Characteristics for ecbr7-7206-e1*

|                      |                         |                 |
|----------------------|-------------------------|-----------------|
| Hostname             | ecbr7-7206-e1           |                 |
| Platform             | Cisco 7206VXR           |                 |
| Memory               | 256 Mb                  |                 |
| Interfaces/Addresses | FastEthernet0/0         | 126.107.2.1/24  |
|                      | FastEthernet0/1         | 126.107.3.1/24  |
|                      | FastEthernet2/0         | 126.107.4.1/24  |
|                      | FastEthernet2/1         | 223.255.9.67/24 |
|                      | Serial4/0.107           | 126.107.20.1/24 |
|                      | Loopback1               | 126.107.0.1/32  |
| Hardware             | Slot 0: C7200-I/O-2FE/E |                 |
|                      | Slot 1: PA-MC-4T1       |                 |
|                      | Slot 2: PA-2FE-TX       |                 |
|                      | Slot 4: PA-4T+          |                 |

Table 96 shows the device characteristics for ecbr7-3620-v1.

**Table 96**    *Device Characteristics for ecbr7-3620-v1*

|                      |                  |                 |
|----------------------|------------------|-----------------|
| Hostname             | ecbr7-3620-v1    |                 |
| Platform             | Cisco 3620       |                 |
| Memory               | 64 Mb            |                 |
| Interfaces/Addresses | FastEthernet0/0  | 126.107.2.2/24  |
|                      | FastEthernet0/1  | 223.255.9.68/24 |
|                      | Loopback1        | 126.107.0.2/32  |
|                      | Vif1             | 126.107.1.2/24  |
| Hardware             | Slot 0: NM-2FE2W |                 |
|                      | Slot 1: NM-2V    |                 |
|                      | WIC 0: VIC-2E/M  |                 |
|                      | WIC 1: VIC-2FXS  |                 |

Table 97 shows the device characteristics for ecbr8-3640-e1.

**Table 97**    *Device Characteristics for ecbr8-3640-e1*

|                      |                  |                 |
|----------------------|------------------|-----------------|
| Hostname             | ecbr8-3640-e1    |                 |
| Platform             | Cisco 3640       |                 |
| Memory               | 128 Mb           |                 |
| Interfaces/Addresses | FastEthernet0/0  | 126.108.2.1/24  |
|                      | Serial10/0.108   | 126.108.20.1/24 |
|                      | FastEthernet0/1  | 223.255.9.70/24 |
|                      | Loopback1        | 126.108.0.1/32  |
|                      | Vif1             | 126.108.1.2/24  |
| Hardware             | Slot 0: NM-2FE2W |                 |
|                      | WIC 0: WIC-2T    |                 |
|                      | Slot 2: NM-2V    |                 |
|                      | WIC 1: VIC-2FXS  |                 |

Table 98 shows the device characteristics for ecbr9-2651-e1.

**Table 98**    *Device Characteristics for ecbr9-2651-e1*

|                      |                 |                 |
|----------------------|-----------------|-----------------|
| Hostname             | ecbr9-2651-e1   |                 |
| Platform             | Cisco 2651      |                 |
| Memory               | 64 Mb           |                 |
| Interfaces/Addresses | FastEthernet0/0 | 126.109.2.1/24  |
|                      | Serial10/0.109  | 126.109.20.1/24 |
|                      | FastEthernet0/1 | 223.255.9.72/24 |
|                      | Loopback1       | 126.109.0.1/32  |
|                      | Vif1            | 126.109.1.2/24  |



**Table 98**    *Device Characteristics for ecbr9-2651-e1 (continued)*

|                 |                             |
|-----------------|-----------------------------|
| <b>Hardware</b> | Slot 0: CISC02651 Mainboard |
|                 | WIC 0: WIC-2T               |
|                 | Slot 1: NM-2V               |
|                 | WIC 0: VIC-2E/M             |
|                 | WIC 1: VIC-2FXS             |

## See Also

For additional information, refer to the following Cisco documents:

| Resource or Publication Title                  | Location                                                                                                                                                                      |
|------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>IP Multicast Technology Overview</i>        | <a href="http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/mcst_ovr.htm">http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/mcst_ovr.htm</a> |
| <i>Anycast RP</i>                              | <a href="http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/anycast.htm">http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/anycast.htm</a>   |
| <i>How CGMP Leave Processing Functions</i>     | <a href="http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/cgmp_an.htm">http://www.cisco.com/warp/public/cc/pd/iosw/prodlit/cgmp_an.htm</a>                                 |
| <i>IP Multicast Network Management</i>         | <a href="http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/mibs.htm">http://www.cisco.com/univercd/cc/td/doc/cisintwk/intsolns/mcst_sol/mibs.htm</a>         |
| Cisco IOS Software Multicast Services web page | <a href="http://www.cisco.com/go/ipmulticast">http://www.cisco.com/go/ipmulticast</a>                                                                                         |

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