Vanguard Managed Solutions

Vanguard Applications Ware
IP and LAN Feature Protocols

Open Shortest Path First (OSPF)

Notice

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Part No. T0100-04, Rev G
Publication Code: DS
First Printing: November 1998

Manual is current for Release 6.2 of Vanguard Applications Ware.

To comment on this manual, please send e-mail to LGEN031@vanguardms.com

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OSPF Basics

Overview

What is OSPF?

The Open Shortest Path First Protocol (OSPF) is an Interior Gateway Protocol (IGP) used to distribute information among routers belonging to an autonomous system (AS). Utilitizing the link state protocol, each OSPF router maintains identical databases describing the AS topology. Routers use this database to calculate and create shortest path routing tables. Routers supporting OSPF share and update information using Link State Advertisements (LSA). OSPF routers quickly learns and distributes routing information, which includes the set of all routers and links between them and the cost of each link.

RFC

RFC 1583 defines OSPF Version 2.

OSPF Features and Benefits

Benefits and features of OSPF routing include:

- Least cost routing — Lets you configure path costs based on any combination of network parameters, for example, bandwidth, delay, and dollar cost.
- Scaliability - OSPF works with large networks and has no limitation to the routing metric or hop count.
- Area routing — Decreases the resources, such as memory and network bandwidth, consumed by the protocol and provides an additional level of routing protection.
- TOS routing - Packet routing based on Type of Service (TOS).
- Variable Length Subnet Masks — Lets you break an IP address into variable size subnets, conserving IP address space.
- Routing authentication — Provides additional routing security.
- CIDR — Classless Interdomain Routing.
- OSPF supports IP subnetting and the tagging of externally derived routing information. It uses IP multicast when sending or receiving packets.

OSPF Routing Environment

Introduction

This section describes the AS (Autonomous System) or the OSPF domain including concepts such as:

- Division of the AS into OSPF areas, OSPF backbone area, and stub areas.
- Variable-length subnetting.
- Functions of internal routers, neighboring routers, Area Border Routers (ABRs), and AS Boundary Routers (ASBRs).
- Use of Hello protocol.
- Definition of Virtual Links when the OSPF backbone area is not contiguous.

Information about how to configure the areas and routers is provided in later sections.

Network Example with Areas and Routers

Figure 1-1 shows an AS with defined areas, backbone area, and routers.

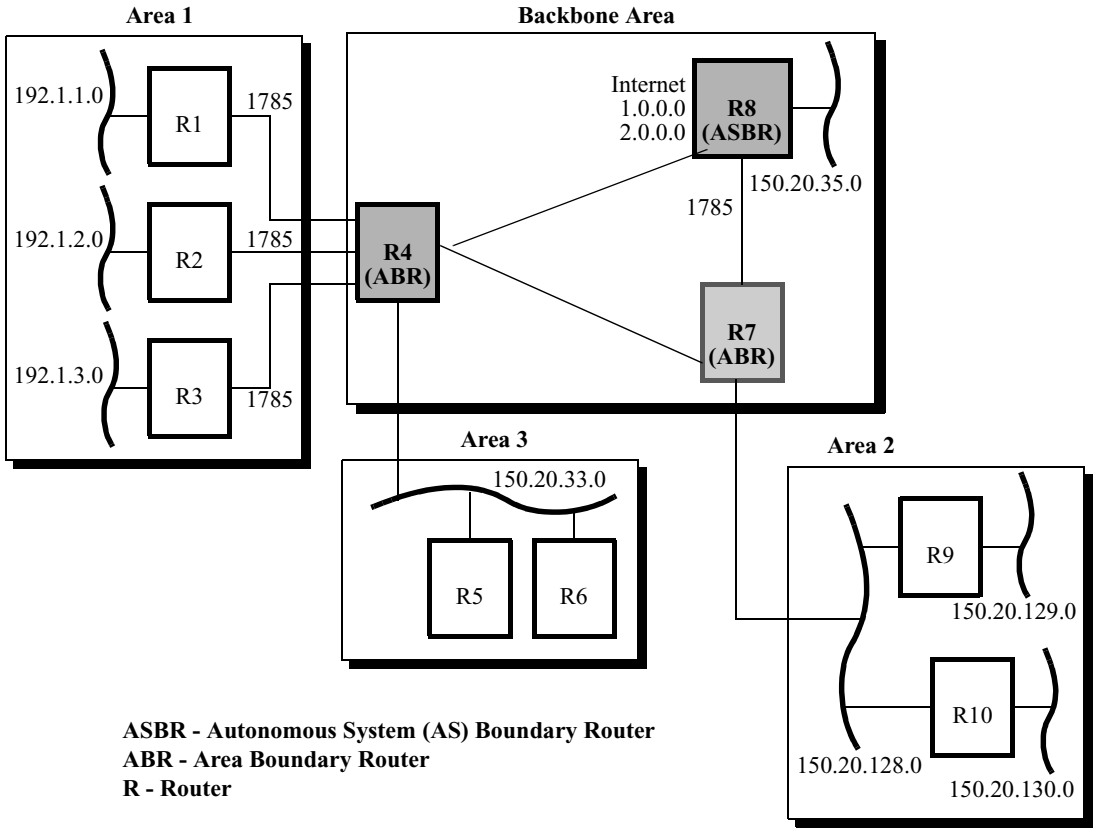

Figure 1-1. An Autonomous System (AS) with Areas and Routers

Area

An area is a collection of contiguous networks and hosts together with one or more IP network address ranges. Each address range is an [address, mask] pair. OSPF lets you summarize all the networks in an area into one or a few IP address ranges. Then you assign the area a 32-bit area number.

The topology of any one area is hidden from that of the other areas, which reduces routing traffic and protects routing within an area from outside influence.

Backbone Area

The backbone area is the set of contiguous networks that interconnect all areas. All OSPF domains must have at least one backbone network. The backbone area distributes inter-area routing information. The backbone has an area ID of 0.0.0.0 and consists of any of the following:

- Networks belonging to Area 0.0.0.0.
- Routers attached to those networks.
- Routers belonging to multiple areas.
- Configured virtual links (see the “Virtual Links” section).

Many small- to medium-sized OSPF networks consist of all networks connected to the backbone.

Stub Area

A stub area is an area that does not allow advertisement of external routes.

Frequently, branch offices are configured as stub areas and are connected in a star configuration to a hub router. We recommend that when there are more than 40 routers running OSPF, you should define the OSPF areas to limit the OSPF algorithm completely. Typically, you configure the set of branch routers connected to a central hub router as a separate OSPF area.

Internal Routers

Internal routers have all their directly connected networks belonging to the same area. Routers with only backbone interfaces belong to this category. These routers run a single copy of the basic routing algorithm.

Area Border Router (ABR)

An Area Border Router (ABR) connects an area to the backbone. This connection to the backbone can be direct or through a virtual link (see “Virtual Links”, below) and summarizes the area contents by advertising a single route for each address range.

If an ABR is attached to multiple areas, it can run multiple copies of the basic algorithm, one copy for each attached area and an additional copy for the backbone. ABRs condense the topology information of attached areas for distribution to the backbone. The backbone distributes the information to other ABRs.

AS Boundary Router (ASBR)

An AS Boundary Router (ASBR) exchanges information with routers that belong to other autonomous systems. Such a router has AS external routes that are advertised throughout the AS. External routes are any routes learned by means of static routing and Routing Information Protocol (RIP).

Hello Protocol

The Hello protocol is the part of OSPF used to establish and maintain neighbors. This protocol is used to form neighbors, establish bidirectional communication, and elect a DR and a backup DR on multi-access networks.

Designated Router (DR)

Each multi-access network having at least two attached routers has a Designated Router (DR). The DR generates a link state advertisement (LSA) for the multi-access network and has other special responsibilities in the running of the protocol. The DR is elected by the Hello protocol. Having a DR reduces the number of adjacencies required on a multi-access network. This in turn reduces the amount of routing protocol traffic.

Backup DR

The backup DR is elected on a multi-access network to ease the transition of DRs when the current DR becomes inactive.

Virtual Links

What are Virtual Links?

The backbone must be contiguous so that all areas are reachable. Virtual links are OSPF neighbor adjacencies established between two ABRs to maintain backbone connectivity. The virtual link forms a logical point-to-point serial connection between the endpoints and is a part of the backbone.

When you need to configure a virtual link, configure the following in both ABRs:

- The virtual link.
- The virtual endpoint, which is the other ABR.
- The non-backbone area that the routers have in common, which is called the transit area.

Note

A virtual link cannot transit though a stub area.

Example of Virtual Link

Figure 1-2 shows that the Ethernet connecting R4 to R6 is part of Area 3. Because no backbone network connects the ABRs R4 and R7, a virtual link is required. In the example, the virtual link has a single “transit network” through which it connects the ABRs on the edges. Area 3 is considered the transit network of the virtual link between R4 and R7.

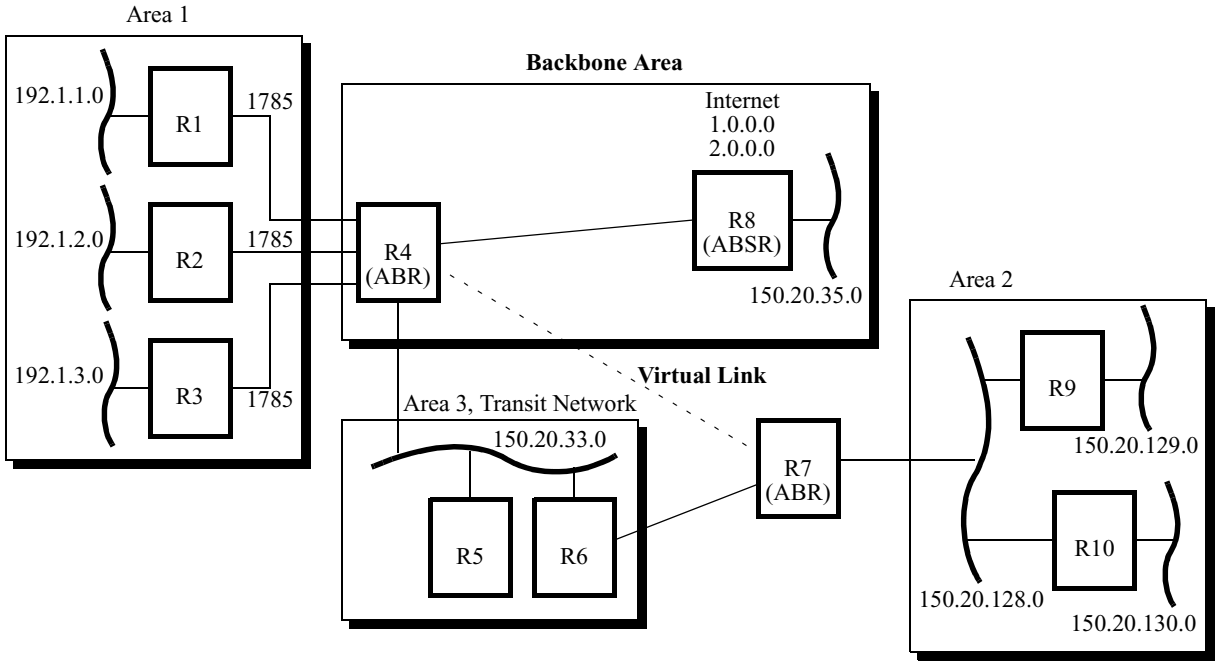

Figure 1-2. Example of Virtual Link

Types of Routing

Introduction

The three types of OSPF routing are:

- Intra-area
- Inter-area
- External

Intra-Area Routing

Intra-area routing occurs when a packet's source and destination addresses are in the same area within an AS. The router sends Hello packets to its neighbors and in turn receives their Hello packets.

The router attempts to form adjacencies with some of its newly acquired neighbors. The topological databases are synchronized between pairs of adjacent routers.

On multi-access networks, the DR determines which routers should become adjacent. Adjacencies control the distribution of routing protocol packets. Routing protocol packets are sent and received only on adjacencies. In particular, distribution of topological database updates proceeds along adjacencies.

Inter-Area Routing

Inter-area routing occurs when the packet's source and destination addresses are in different areas within an AS. The ABRs form the adjacencies and synchronize the topological database.

External Routing

Routers that have information regarding other autonomous systems can flood this information throughout an AS. This external routing information is distributed to every router except for those connecting to stub areas.

OSPF Operation

How OSPF Works

This table describes how OSPF works.

Step	Action		Description/Result
1	At initialization, a router uses the Hello protocol to send hello packets to its neighbors.		The neighbors respond by sending acknowledgment packets to the router.
	If...	*Then...*	
	The network is point-to-point or broadcast	The router dynamically detects its neighboring routers by sending the Hello packets to the multicast address "All Shortest Path First [SPF] Routers", which is the multicast reserved address for all routers that support OSPF.	In a multicast network (broadcast), the Hello protocol elects a Designated Router (DR) for the network. In a point-to-point network, there is no DR.
	The network is non-broadcast	You must configure information to help the router discover its neighbors.	In a multicast network (non-broadcast), the Hello protocol elects a DR for the network.
2	The DR attempts to form adjacencies with its neighbors, which are other routers that are one hop away, to synchronize their topological databases.		Adjacencies control the sending and receiving of the routing packets and the distribution of the topological database updates. In a non-broadcast multi-access network the DR determines which routers become adjacent.
3	The DR periodically advertises its status or link state (link state advertisements) to its adjacencies.		Link state advertisements (LSAs) ensure that all routers have the same topological database.

Step	Action (continued)	Description/Result
4	Using the information in the database, each router calculates a shortest path tree using the Dijkstra Algorithm with itself designated as the working node, or root, to all other routers and networks in the area.	The shortest path tree generates the routing tables.

OSPF Link State Advertisements

Description

A Link State Advertisement (LSA) describes a link from a router to its interface, including the metric. An LSA is flooded to all routers in an area to form the area database describing the topology of the area. It is originated on a delta basis, whenever information changes, or at least every 30 minutes otherwise.

From this database, each router generates a Shortest Path First (SPF) route with itself as the route of the tree. Then the router forms the routing table.

LSA Format

An LSA is sent in LS update packets that are queued on LS Retransmit queues. Each LSA must be explicitly acknowledged in an LS Acknowledgment packet or it is retransmitted at the retransmission interval (5 seconds).

Each LSA has a sequence number established by its originator. Sequence numbers are signed 32-bit integers starting at -2**32 -1 (0x8000001) and incrementing to 2**32-1 (0x7FFFFFF).

LSA Components

An LSA has:

- Link State (LS) type (8 bits) — values 1 to 5.
- Link State ID (32 bits) — the destination of the link.
- Advertising Router (32 bits) — the source of the link.

LSA Types

This table describes the LSA types.

LSA Type	*Description*
Router Link	Originated by all routers and flooded throughout a single area only. It describes a router's interfaces to a network or a router's links to another router.
Network Link	Generated for multi-access advertisement networks by the DR. It contains the list of the attached routers to the network.
Net Summary	Sent by the ABR summarizing net and mask of all networks in the area.
ASBR	Sent by the ABR and contains the routes to the ASBRs.
External	Sent by ASBRs and contains AS external routes. It is flooded into all but stub areas.

When Are LSAs Generated?

LSAs are generated in these cases:

- The LS refresh time expires.
- An interface's state changes.
- An attached network's DR changes.
- One of the neighboring routers changes to or from full state.

LSAs are generated by ABRs when:

- An intra-area route (see the "Types of Routing" section) has been added, deleted, or modified in the routing table.
- An inter-area route has been added, deleted, or modified in the routing table.
- The router becomes newly attached to an area.

LSA Example

Figure 1-3 shows a network where R4 sends LSAs into Area 1 and also into the backbone area. For a description of the LSAs, see the sections that follow this figure.

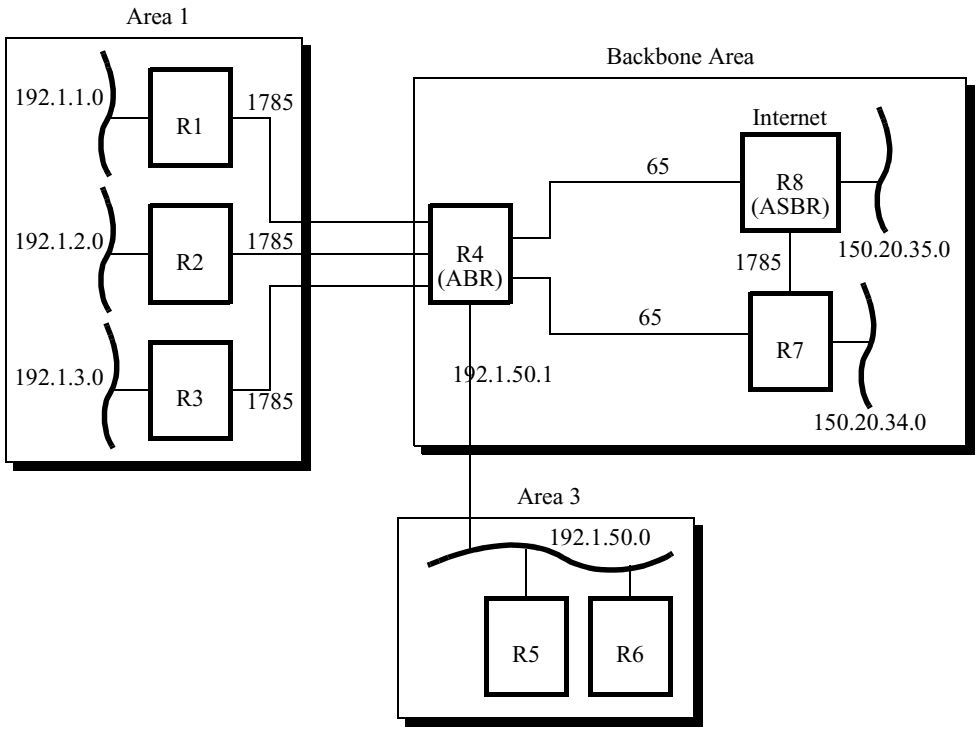

Figure 1-3. R4 Sending LSAs

Types of LSAs Sent into Area 1

This table shows the types of LSAs sent into Area 1 by R4 (Figure 1-3):

<table>
<tr><th colspan="2">Action</th><th>Description</th></tr>
<tr><td colspan="2">R4 sends a Router Link LSA for R4’s area 1 links only.</td><td>• Pt-to-Pt to R1, cost 1785
• Pt-to-Pt to R2, cost 1785
• Pt-to-Pt to R3, cost 1785</td></tr>
<tr><td colspan="2">R4 sends a summary for the backbones address range (150.20.0.0, FFFF0000).</td><td rowspan="3"></td></tr>
<tr><th>If...</th><th>Then...</th></tr>
<tr><td>Area 1 is a stub area</td><td>R4 sends a default summary (0.0.0.0,0.0.0.0).</td></tr>
<tr><td>Area 1 is not a stub area</td><td>R4 sends:
• ASBR LSA for R8.
• Externals learned or configured by R8.</td></tr>
</table>

Types of LSAs Sent into the Backbone

This table shows the types of LSAs sent into the backbone by R4 (Figure 1-3):

Action	Description
R4 sends Router Links LSA for R4's links to the backbone.	• Transit Network 192.1.50.0 (DR is 192.1.50.1) • Pt-to-Pt to R7, cost 65 • Pt-to-Pt to R8, cost 65
R4 sends a network LSA for 192.1.50.0, since R4 is the DR for attached router IDs R5 and R6.	
Summary for Area 1's area range (192.1.0,FFFFF000)	

Variable-Length Subnetting

Introduction

OSPF attaches an IP address mask to each advertised route. The mask indicates the range of addresses being described by the particular route. Including the mask with each advertised destination enables variable-length subnetting. This means that you can break a single IP class A, B, or C number into many subnets of various sizes.

A key advantage of defining OSPF areas is that you can summarize the networks at the area with a single variable-length subnet advertisement.

Example of VLSM

An area that contains networks with IP net numbers 128.185.1.0 to 128.185.31.0 may be summarized in a single advertisement of the network 128.185.0.0 with a mask of 255.255.224.0. The Area Summary Statistics defines how an Area Border Router (see “Area Border Router (ABR)” section on page 1-3) summarizes the networks in its area when advertising on the OSPF backbone. In this example, the ABR sends one network summary advertisement rather than 32 individual network advertisements.

CIDR Support for OSPF

Introduction

As of release 5.2, Classless Interdomain Routing (CIDR) is supported for OSPF.

Note

For general information of CIDR and classless addressing refer to the *IP Routing Manual* (Part Number T0100-03).

CIDR Feature

CIDR support for OSPF includes the following:

- Enhancements of the area range configuration to allow aggregation of routes on a classless boundary.
- Configuration of a mask on each interface to allow a classless boundary. Configuration of the classless mask on the IP interface allows aggregation of directly connected multiple networks on that interface. The router LSA will contain classless routes only if the interface is not a point-to-point interface. The router LSA will be built as specified by the RFC and would use the configured classless mask.
- Support for external route aggregation on classbased or classless boundary.

Advertisement of Classless Routes

Figure 1-4 illustrates a network supporting classless and classbased routing.

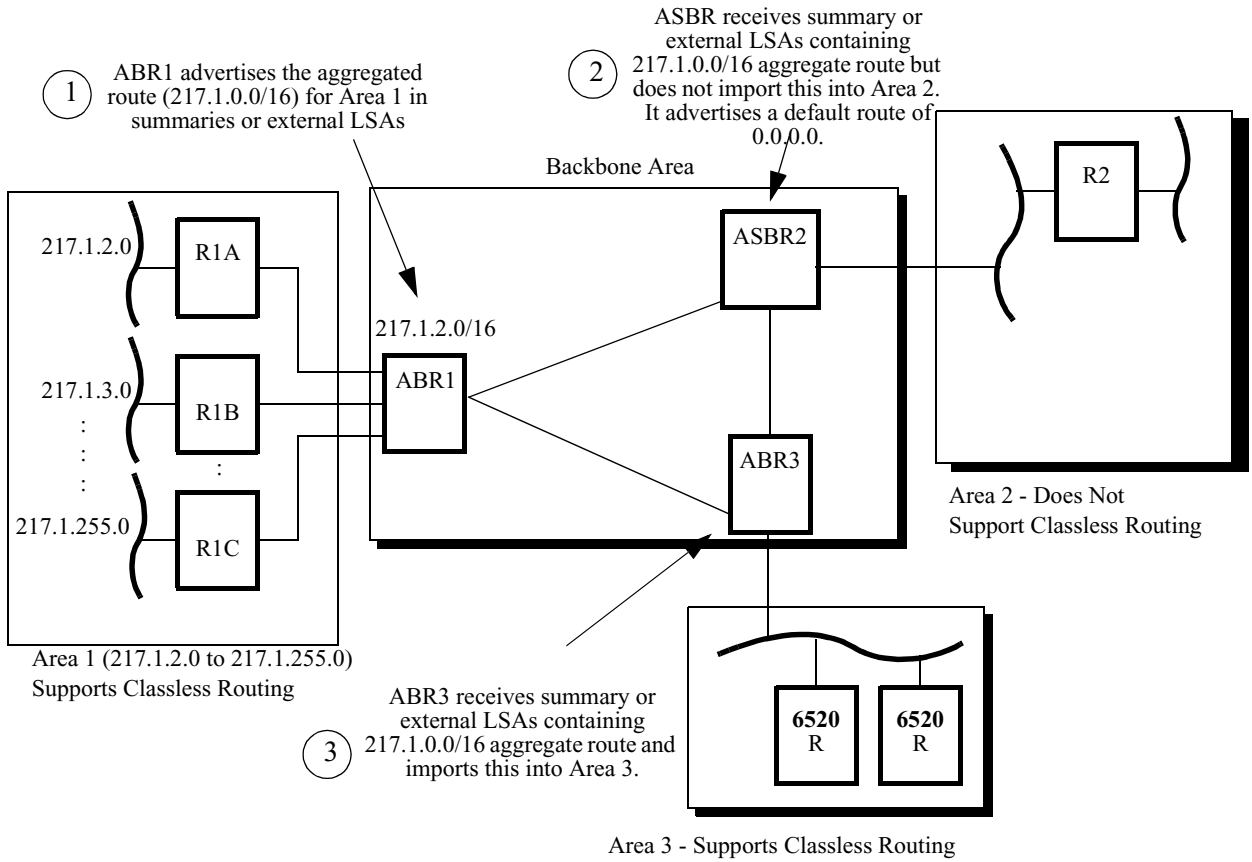

Figure 1-4. Areas supporting Classless or Classbased Routing

Within an area, for example Area 1, router links and networks links are advertised with the configured classless or classbased mask. The area boundary router (ABR) can summarize classless aggregate routes in network summaries. The ASBR can summarize external routes before advertising the information to the OSPF domain. The ABR does not explode aggregate routes, i.e., it advertises all classless aggregated routes into the area. When a routing table is generated from OSPF LSA, it will contain classless routes only if it is in the LSA. The router will not perform additional aggregation.

Interoperation of Classless and Classful Areas

For example, the ASBR2 in Area 2 supports classless routing but is configured so that it does not import classless routing summaries back into Area 2 which does not support classless routing. R2 advertises a default route of 0.0.0.0 to all routers (R) within area 2.

For example, a host connection to a router (R2) inside Area 2 attempts to send a packet destined for a host in Area 1. Router (R2) does not support aggregate routing and sends the packet to the default route 0.0.0.0. The ASBR2, however, supports classless routing and contains information within its routing table so that it can forward the packet to 217.1.0.0, the aggregate route advertised by ABR1 in Area 1. The routing table in the ABR1 in Area 1 contains the route for the host in Area 1 and forwards the packet.

Summarizing External Route

An AS Boundary Router (ASBR) exchanges information with routers that belong to other autonomous systems. Such a router has AS external routes that are advertised throughout the AS.

The ASBR aggregates external routes and advertises the aggregated route only when at least one component in the area is reachable. Routes converted from RIP to OSPF can be aggregated by configuring the external range table. However, routes converted from OSPF to RIP cannot be de-aggregated, i.e., broken down into the classless addresses, and default route (0.0.0.0) will be used for this traffic.

Configuring Aggregation

The Vanguard node supports CIDR as soon as the Release 5.2 or higher software is loaded on the node. The Vanguard will understand classless IP addresses and masks, and install classless IP addresses in the routing table and use these addresses for routing.

To configure aggregation, configure a classless mask for the IP address mask parameter in the IP interface, OSPF area range or OSPF external range table.

Vanguard OSPF Support

Overview

Vanguard implementation of OSPF supports different physical network types.

Point-to-Point OSPF Network (WANView)

Point to point OSPF networks use a communication line to join a single pair of routers. Point to point OSPF networks can function over a 56-kbps serial line.

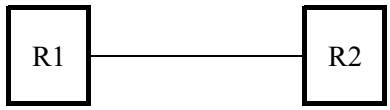

Figure 1-5. Point-to-Point OSPF Network

Broadcast OSPF Network (WANView)

Broadcast OSPF networks are networks that support more than two attached routers and is capable of addressing and sending a single physical message to all attached routers. Broadcast OSPF networks can function over Token Ring or Ethernet LANs.

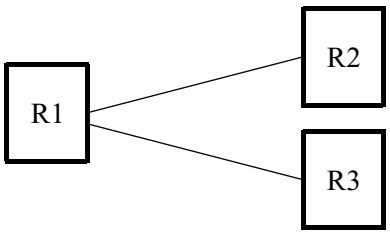

Figure 1-6. Broadcast OSPF Network

Non-Broadcast Multiple Access (NMBA) (LANView)

Non-broadcast multiple access (NMBA) networks supports more than two attached routers but has no broadcast capabilities. For NMBA OSPF to work properly, a designated router (DR) and backup designated router (BDR) must be elected. The DR and BDR must have full connectivity with all other routers in the network. In addition, the DR and BDR must maintain static lists of all other routers in the network. This non-broadcast network requires extra configuration on OSPF routers attached to the network.

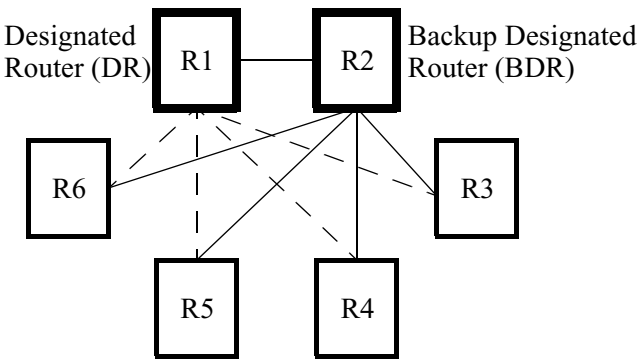

Figure 1-7. Non-Broadcast Multiple Access (NMBA) OSPF Networks

Point-to-Multipoint for Non-Broadcast Networks

Point-to-Multipoint Non-Broadcast OSPF networks supports more than two attached routers but has no broadcast capabilities. For this network type, a non-broadcast network is treated as a collection of point-to-point links. The point-to-point links can be in the same subnet or different subnets. There are no DR or BDRs as in NMBA networks. Figure 1-8 illustrates a point-to-multipoint network over a partial mesh Frame Relay or X.25 subnet.

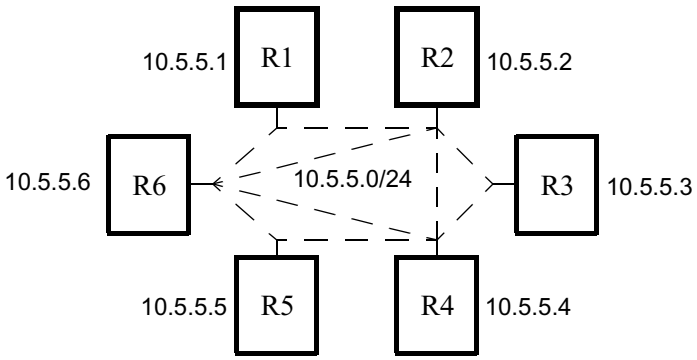

Figure 1-8. Point-to-Multipoint Non-Broadcast OSPF Networks

Difference Between NMBA and Point-to-Multipoint Non-Broadcast Networks

NMBA and Point-to-Multipoint OSPF networks are both non-broadcast networks. Each has different network topologies, advantages and disadvantages as outlined in the table below:

	NMBA	***Point-to-Multipoint***
Network Topology	All the attached routers should have full physical connectivity with every other router on the NBMA network or at least with DR and BDR of the network.	No topological restrictions in the network. All the links in network work like normal Point-to-Point links.
Designated Router (DR)/ Backup Designated router (BDR)	DR and BDR are elected.	DR and BDR are not used.
Robustness	Less robust. Connectivity of all routers are via the DR or BDR. If a router loses its adjacency to a DR or BDR, it cannot communicate with other routers even if it has a direct physical connection with another router.	More robust. All routers interconnect by separate point-to-point links.
Adjacency Formation	All attached routers form adjacency with DR and BDR only.	Adjacency formed between all attached neighboring routers.
Hello Protocol	Hello packets are send to all neighbors with which the interface can communicate directly using unicast addresses.	Hello packets are send to all neighbors with which the interface can communicate directly using unicast addresses.

	NMBA	Point-to-Multipoint
Efficiency	More efficient. Neighbor maintenance, data synchronization, and database representation are reduced from the order of n^2 to n, where 'n' is number of attached neighbors in NBMA network.	Less efficient. Neighbor maintenance, data synchronization, and database representation are of the order n^2, where 'n' is number of attached neighbors in Point-to-Multipoint network.
IP Addressing model	When partial mesh network is broken into multiple full-mesh NBMA networks, all the meshes should have different IP subnets.	Entire Point-to-Multipoint network can be a single IP subnet.
Neighbor Discovery	All the neighbors of a NBMA interface should be configured statically in the routing table.	Neighbors can be configured statically or can be discovered dynamically. IP addresses of neighbors are discovered using Inverse ARP. Dynamic neighbor discovery is possible on Frame Relay and PPP networks but not on X.25 networks.
Unnumbered Interfaces	NBMA model does not work on unnumbered interfaces.	Point-to-Multipoint networks support use of unnumbered interfaces. Internal IP address of each router is used for unnumbered interface.
Configuration and Maintenance	Configuration and maintenance is complex in NBMA networks. DR and BDR should be selected in such a way that all the attached routers in the network should have direct physical connectivity with them. DR priority should be carefully assigned to the NBMA interfaces so that proper DR and BDR are quickly elected in the event of current DR and BDR failures.	Configuration and maintenance is simple compared to NBMA. No interface priority need to be configured. No network topological restrictions. Neighbors need not be configured.
Metric per neighbor	All the links to neighbors of an interface are same cost and equal to the interface cost.	Links to neighbors can have different costs on different interfaces.
Routing Table/ Router LSA size	Only a stub route entry (IP subnet) is generated for NBMA network and this does not depend on the number of routers attached to the NBMA network. Routing tables do not have host routes of all neighbors in the network.	Multiple host routes are generated for all attached neighbors. This result in large routing tables with many host routes in side entire OSPF network.
Network LSAs	Network LSA is generated by DR of NBMA network.	No Network LSA is generated for Point-to-Multipoint networks.

Unnumbered IP Interfaces

Typically each IP interface of a router will have its own IP address. To conserve IP addresses, unnumbered IP interface addresses can be used. An unnumbered IP interface will have an IP address in the form 0.0.0.n-1, where n is the interface numbered. For example, the IP interface 5 will have an IP address of 0.0.0.4.

For OSPF routers, you can configure the IP interface with unnumbered IP addresses for point-to-point or point-to-multipoint networks. NMBA or broadcast network links cannot use unnumbered IP addresses.

When using unnumbered IP addresses we recommend that you configure the internal IP address for the router. In event that a link to the router is down, the router is still accessible via its internal IP address. The internal IP address of the router must be advertised.

Chapter 2
Configuring OSPF

Overview

Introduction

This chapter describes how to configure the Vanguard to support OSPF routing. Configuration examples, detailed parameter and menu descriptions are provided.

Note about Configuration Examples

Before you configure OSPF parameters you should know how to configure the following:

- LAN and WAN ports
- Route Selection Table
- LAN Connection (LCONs)
- Mnemonic Table
- IP Router Interfaces
- IP Router Parameters

For more information on configuring node and port parameters refer to the *Vanguard Configuration Basic Manual* (Part Number T0113).

Configuration Guideline

The number of interfaces per area per Vanguard node cannot exceed 18.

Accessing the OSPF Parameter Records

Configure Routers Menu

Figure 2-1 shows the Configure Routers menu. Select Configure OSPF to access the Configure OSPF menu.

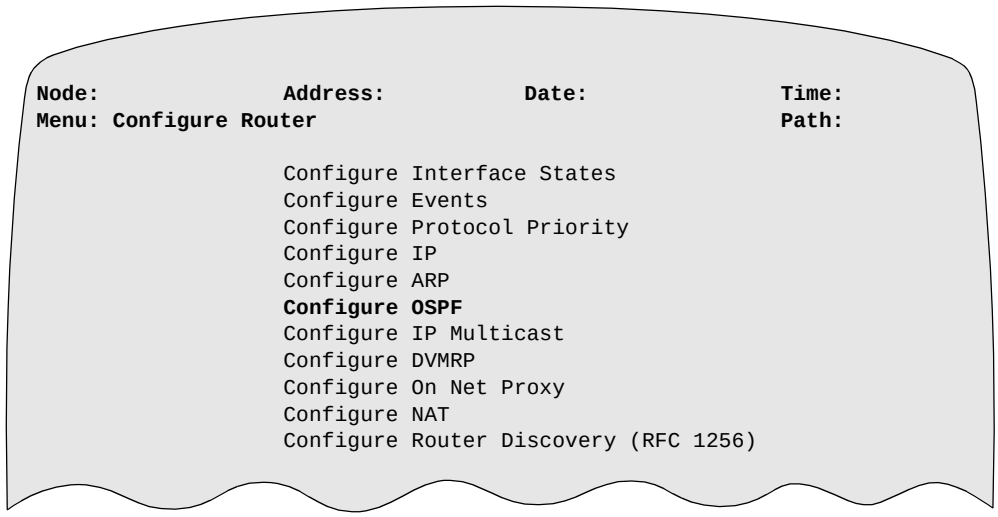

Figure 2-1. Configure Router Menu

Configure OSPF Menu

Figure 2-2 shows the Configure OSPF menu.

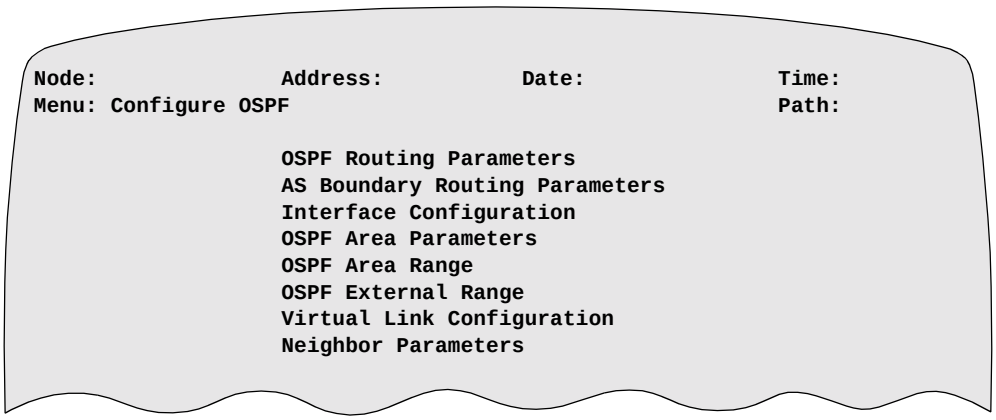

Figure 2-2. Configure OSPF Menu

Configuration Tasks and Records

This table correlates the common OSPF configuration tasks with the configuration records:

To....	*Complete This Record...*
Enable the OSPF protocol and indicate the number of OSPF routes and external routes.	OSPF Routing Parameters
Configure the AS Boundary Router to allow the importing of external routes to the AS.	AS Boundary Routing Parameter
Define the router's OSPF network interfaces.	Interface Configuration
Define the OSPF areas attached to a router.	OSPF Area Parameters
Define the range of the OSPF area. An area may have networks within several IP address ranges.	OSPF Area Range
Defines the OSPF external range.	OSPF External Range
Defines the virtual links required to maintain backbone connectivity. You can configure virtual links between any two ABRs that share common non-backbone and non-stub areas.	Virtual Link Configuration
Define the neighboring routers that are part of the network.	Neighbor Parameters

Configuring OSPF Routing Parameters

Introduction

This section describes how to configure the parameters to enable OSPF routing.

What You See in This Record

Figure 2-3 shows the OSPF Routing Parameters record.

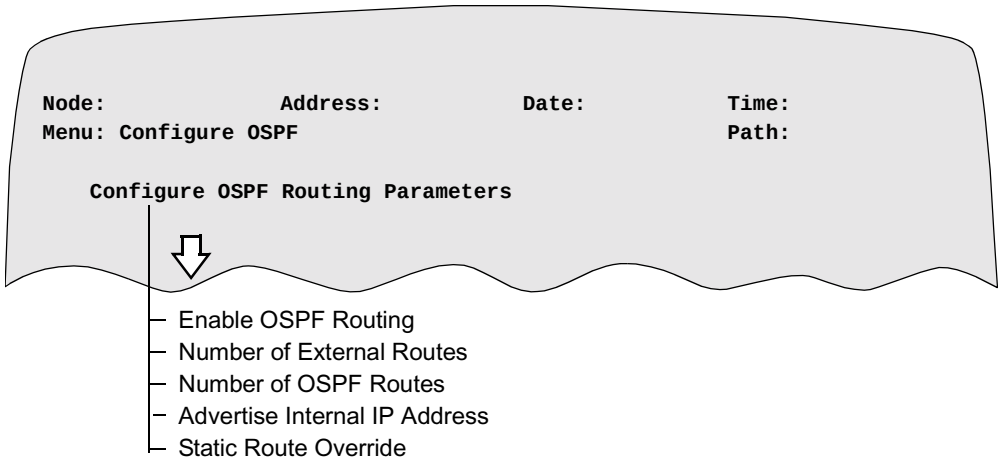

Figure 2-3. OSPF Routing Parameters Record

Parameters

This tables describe the parameters that make up the Configure OSPF Routing Parameters record:

Note

Unless otherwise indicated, you must Boot OSPF Parameters for changes to these parameters to take effect. See "Booting OSPF Parameters and Menus" on page 27.

Enable OSPF Routing

Range:	Enable, Disable
Default:	Disable
Description:	Enables or disables the OSPF routing parameters.

Number of External Routes

Range:	0 to 2048
Default:	1000
Description:	Specifies the maximum number of AS external routes or external global internet addresses that are imported into the OSPF routing domain. The sum of this parameter and the number of OSPF routers should not exceed size of the IP routing table.

Number of OSPF Routes

Range:	0 to 2048
Default:	50
Description:	Specifies the maximum number of routers allowed in the organization's OSPF routing domains. Sum of this parameter and the value of Number of External Routes should not exceed the size of the IP routing table.

Internal IP Address Advertisement

Range:	YES or NO
Default:	YES
Description:	YES allows the router to advertise the internal IP address to other routers in an OSPF domain. If the router's internal address is advertised, the router can be accessed remotely over any reachable interface. Other routers will save this internal IP address in routing tables. If the node can be accessed by other means, i.e. by an X.25 address, the internal IP address does not need to be advertised. Enter NO to disable advertisement. **Note** If the internal IP address in the IP parameters record is configured with a unique IP address and if this parameter is set to NO, Ping will not work from the node. Ping uses internal IP address as source address for ICMP packets and as there is no routing entry for this internal IP address in other routers routing tables, ICMP replies get dropped and Ping fails.

Static Route Override

Range:	Enabled, Disabled
Default:	Enabled
Description	When this parameter is enabled, calculated OSPF routes will override static routes in the Routing Table. On RIP enabled interface, RIP updates will advertise new OSPF routes. When this parameter is disabled, static routes will override OSPF routes in the Routing Table. On RIP enabled interfaces, RIP updates will advertise new static routes.

Configuring AS Boundary Routing Parameters

Introduction

This section describes how to configure the AS Boundary Router to allow the importing of external routes to the AS.

What You See in This Record

Figure 2-4 shows the AS Boundary Routing Parameters record.

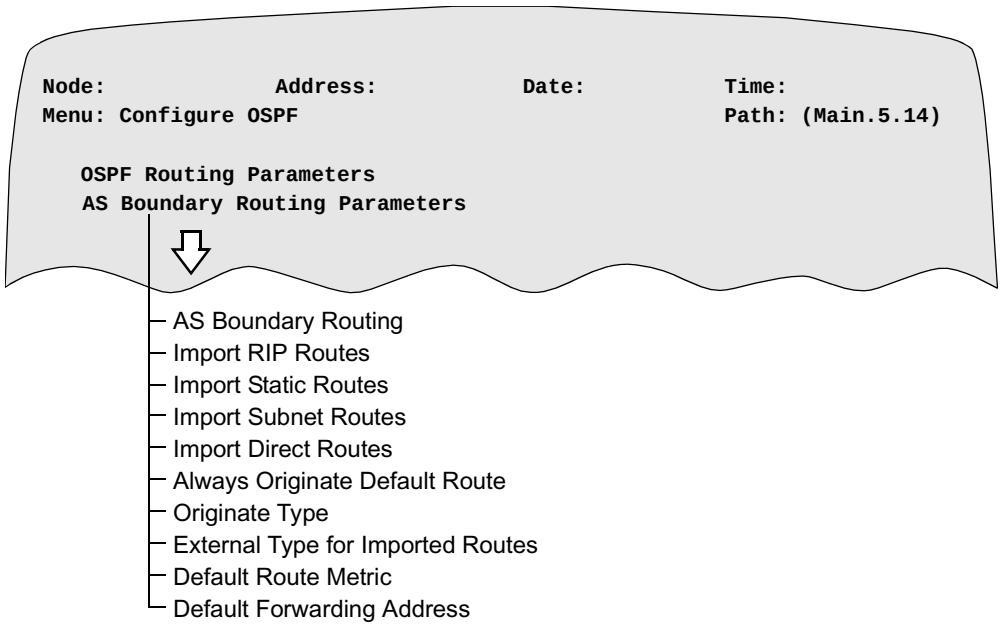

Figure 2-4. AS Boundary Routing Parameters Record

Parameters

These tables describe the parameters that make up the AS Boundary Routing Parameters record:

Note

Unless otherwise indicated, you must Boot OSPF Parameters for changes to these parameters to take effect. See "Booting OSPF Parameters and Menus" on page 27.

AS Boundary Routing

Range:	ENABLE, DISABLE
Default:	DISABLE
Description:	Enables the AS boundary routing parameters.

Import RIP Routes

Range:	Yes, No
Default:	No
Description:	Allows routes learned from RIP on the backbone interface into the OSPF domain.

Import Static Routes

Range:	Yes, No
Default:	No
Description:	Allows static routes configured to the backbone interface to be advertised in the OSPF domain.

Import Subnet Routes

Range:	Yes, No
Default:	No
Description:	Allows subnet routes learned from the backbone interface to be re-advertised in the local OSPF domain.

Import Direct Routes

Range:	Yes, No
Default:	No
Description:	Allows directs routes into the OSPF domain.

Always Originate Default Route

Range:	Yes, No
Default:	No
Description:	Causes the router to always advertise a route of 0.0.0.0, the “default route.” This can cause other routers to treat this router as their default gateway.

Originate Type

Range:	1 to 2
Default:	2
Description:	Selects the OSPF external route type at which the default route is advertised.

External Type for Imported Routes

Range:	1 to 2
Default:	2
Description:	Selects the OSPF external route type for routes learned by non-OSPF means, such as RIP and statically configured routes. All OSPF routers must be configured with the same “External Type for Imported Routes” parameter. Type 1 external metric means that it is comparable directly (without translation) to the link state metric, and Type 2 external metric means that the metric is considered larger than any link state path.

Default Route Metric

Range:	1 to 65536
Default:	1
Description:	An OSPF cost metric advertised for the cost of the default route onto the backbone. A typical value is 1.

Default Forwarding Address

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies the value of the “forwarding address” field of the default external route advertisements originated by the AS Boundary Router. It should be 0.0.0.0 for the usual case where external routes are forwarded through the AS Boundary router itself.

Configuring the Interface

Introduction

This section describes how to configure the OSPF parameters for the router's network interface.

What You See in This Record

Figure 2-5 shows the Interface Configuration record.

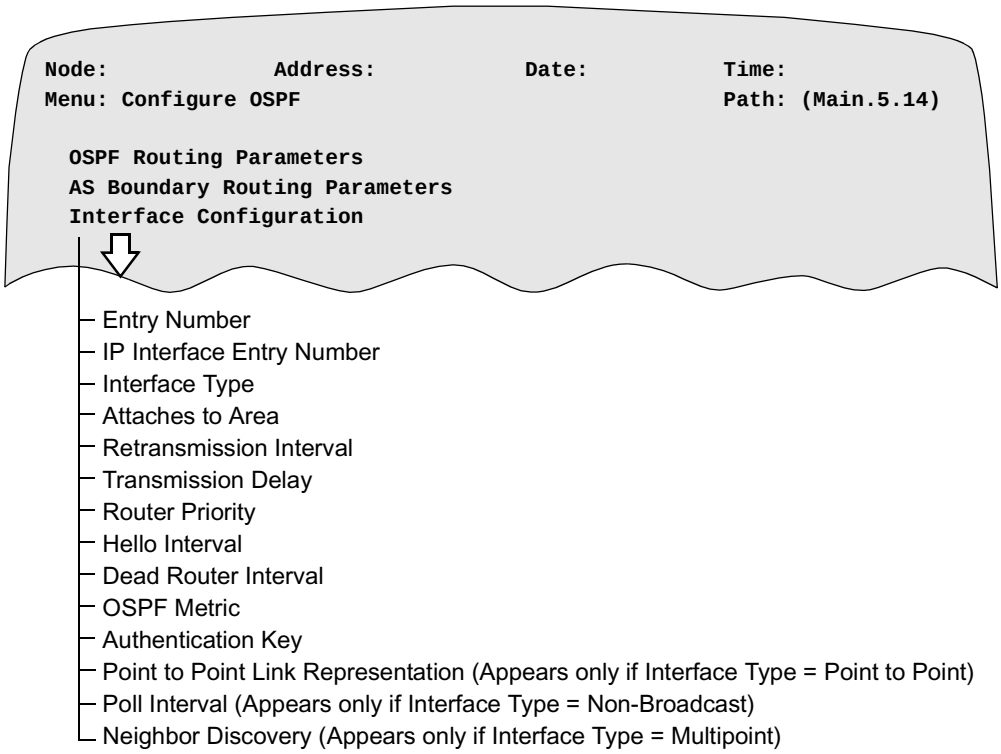

Figure 2-5. Interface Configuration Record

Parameters

These tables describe the parameters that make up the Interface Configuration record:

Note

Unless otherwise indicated, you must Boot OSPF Parameters for changes to these parameters to take effect. See "Booting OSPF Parameters and Menus" on page 27.

Entry Number

Range:	1 to 255
Default:	1
Description:	Entry number used to reference this table record.

IP Interface Entry Number

Range:	1-255
Default:	1
Description:	Indicates the entry number of the IP Interface Configuration Table record. The Vanguard node will search the IP Interface Configuration Table for this entry number and use the configured IP address as the address of this interface. Effective Release 5.4, Vanguard supports unnumbered IP interfaces for OSPF networks. Access the IP Interface Configuration Table record from this menu sequence: **Configure -> Configure Router -> Configure IP ->Interface**

Interface Type

Range:	Point-to-Point, Broadcast, NBMA, Multipoint
Default:	Point-to-Point
Description:	Specifies the OSPF interface type.

Attaches to Area

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies (in dotted notation) the OSPF area number in which the interface's network is assigned. All organization networks must be assigned to an area, if only a default area of 0.0.0.0.

Retransmission Interval

Range:	1 to 65535
Default:	5
Description:	Specifies the interval in seconds between transmission attempts of changed routing information. A typical value for a LAN interface is five seconds.

Transmission Delay

Range:	1 to 65535
Default:	1
Description:	Specifies the transmission delay in seconds. This delay is added to an LSA during flooding. A typical value for a LAN interface is one second.

Router Priority

Range:	0 to 255
Default:	1
Description:	Specifies the integer priority of this gateway (used in selecting a DR or backup DR). The higher value indicates a higher priority. A 0 value disables the router from becoming a DR. **Note** If this interface is a remote LANView connection, Router Priority must be set to 0 indicating that this router can not be the DR.

Hello Interval

Range:	1 to 255
Default:	10
Description:	Specifies the normal period, in seconds, between hello messages. (You must enter the same value for all routers attached to a common network.) The recommendations are 10 seconds for a LAN and 30 seconds for a WAN.

Dead Router Interval

Range:	1 to 65535
Default:	40
Description:	Specifies the time, in seconds, after which a nonresponding neighbor is considered dead. You must enter the same value for all routers attached to a common network. The recommendations are 40 seconds for a LAN and 160 seconds for a WAN.

OSPF Metric

Range:	0 to 65535	
Default:	0	
Description:	Indicates an OSPF cost metric for the cost of sending IP Type of Service class 0 frames on the interface. If this parameter is 0, then the router automatically calculates the value of the OSPF metric for the interface. Recommended value is 10**8/(link speed).	
Example:	***Link Speed***	***Recommended Value***
	16 Mbps	6
	10 Mbps	10
	4 Mbps	25
	2.048 Mbps (E1)	48
	1.544 Mbps (T1)	65
	64 kbps	1562
	56 kbps	1785

Authentication Key

Range:	0 to 8 alphanumeric characters; use the space character to blank field.
Default:	(blank)
Description:	Specifies an authentication key of 0 to 8 ASCII characters for authorizing OSPF routing updates on the network for the interface. All routers on the network must have the same authentication key. **Note** You must also set the Authentication Type parameter in the Area Parameters to 1.

Point-to-Point Link Representation

Range:	Host or Network
Default:	Host
Description:	This parameter applies to point-to-point interfaces only. It appears only when the Interface Type parameter is configured as Point-to- Point. If Host is entered, both ends (i.e. the host routes) of the point-to-point link are added to the routing tables of routers in the attached areas. If Network is entered, only the subnet of the link is added to the routing table of routers in the attached area.

Poll Interval

Range:	1 to 65535
Default:	120
Description:	Indicates the OSPF poll interval (in seconds) during which Hello messages are sent to non-responding neighbors on the non-broadcast network. A typical value for X.25 networks is 120 seconds. **Note** Set this value to a lower value than the default if you want the OSPF network to converge quickly. **Note** This parameter appears only if the Interface Type parameter is configured as Non-Broadcast.

Neighbor Discovery

Range:	Dynamic, Static
Default:	Dynamic
Description:	This parameter allows you to specify how neighbor routers are discovered. If configured as: • Static - The neighboring routers must be defined in the Neighbor Parameter Table. • Dynamic - The neighboring routers are discovered using Inverse ARP. You *can* specify static neighbors in the Neighbor Parameter Table even if Neighbor Discovery is set to Dynamic. A neighboring router already defined statically can still be discovered dynamically, however, the static entry will have precedence. **Note** Dynamic discovery does not work on an X.25 network. **Note** This parameter appears only if the Interface Type parameter is configured as Multipoint.

Configuring OSPF Area Parameters

Introduction

This section describes how to configure the parameters to define an OSPF area.

What You See in This Record

Figure 2-6 shows the OSPF Area Parameters Table.

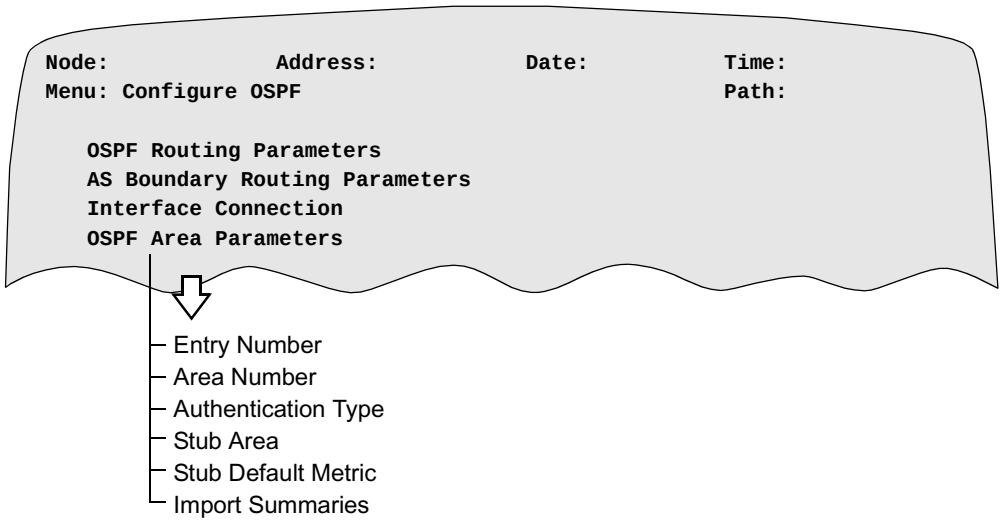

Figure 2-6. OSPF Area Parameters Record

Parameters

These tables describe the parameters that make up the OSPF Area Parameters record:

Note

Unless otherwise indicated, you must Boot OSPF Parameters for changes to these parameters to take effect. See "Booting OSPF Parameters and Menus" on page 27.

Entry Number

Range:	1 to 255
Default:	1
Description:	Entry number used to reference this table record.

Area Number

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies a 32-bit number, in dotted notation, identifying an OSPF area number to which the router directly attaches. The AS backbone is designated as area 0.0.0.0. A router with a connection to a backbone area is called an ABR.

Authentication Type

Range:	0 to 1
Default:	0
Description:	Selects a security scheme for authorizing proper route updates. Enter 1 for simple password or 0 for no authentication. **Note** If you set this parameter to 1, all the neighbors on a common network within the area must have the same authentication key set on this interface.

Stub Area

Range:	Yes, No
Default:	No
Description:	Defines whether the area is designated a “stub” area. If it is, the area does not receive any AS external link advertisements, thereby reducing the size of internal routing tables. Stub areas may not contain an AS boundary router and may not have OSPF virtual links defined to transit through them. It is recommended that you set this parameter to Yes for stub areas to eliminate external advertisements.

Default Stub Metric

Range:	1 to 65536
Default:	10
Description:	All routers within a stub area are configured to send non-local-area packets to the area boundary router, which advertises a default route (to 0.0.0.0). This parameter defines the cost of that default route.

Import Summaries

Range:	Yes, No
Default:	Yes
Description:	Controls whether summary link advertisements are imported by an ABR from the backbone into an area. Areas with a single ABR may disable such advertisements and use default routing to the (one) ABR instead.

Configuring the OSPF Area Range

Introduction

This section explains how to configure the parameters describing the range of the OSPF area. An area may have networks within several IP address ranges. You summarize each range within an OSPF Area Range record.

The record is optional. You can use it to summarize several routes in a single advertisement. Typically, you configure these parameters in an ABR.

Example of Using the OSPF Area Range Record

A stub area contains Class C routes 192.1.32.0 through 192.1.63.0. These parameters summarize all the routes in a single LSA of 192.1.32.0. The following shows the range of routes in dotted decimal notation and equivalent binary notation. Using the binary notation, a mask of 255.2.55.224.0 can be applied.

192.1.32.0	= 1100	0000.	0000	0001.	0010	0000.	0000	0000
192.1.63.0	= 1100	0000.	0000	0001.	0011	1111.	0000	0000
192.1.32.0	= 1100	0000.	0000	0001.	0010	0000.	0000	0000

What You See in This Record

Figure 2-7 shows the Configure OSPF Area Range record.

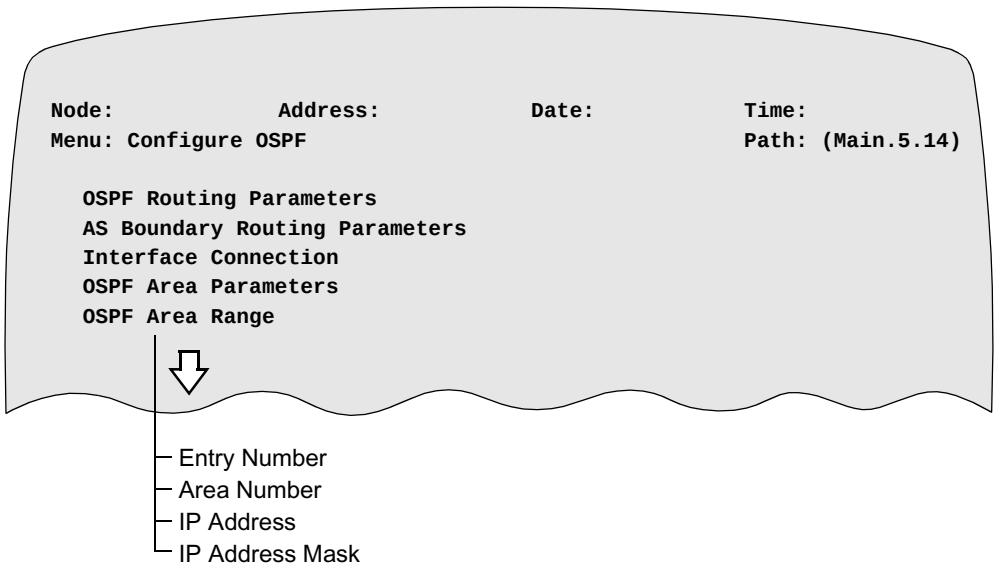

Figure 2-7. OSPF Area Range Record

Parameters

These tables describe the parameters that make up the OSPF Area Range record:

Note

Unless otherwise indicated, you must Boot OSPF Menu for changes to these parameters to take effect. See "Booting OSPF Parameters and Menus" on page 27.

Entry Number

Range:	1 to 255
Default:	1
Description:	Entry number used to reference this table record.

Area Number

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies an area number, in dotted notation, to which the router attaches. It must correspond to an Area defined in the Configure OSPF -> OSPF Area Parameters record.

IP Address

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies an IP address in dotted notation that provides the common IP network and subnetwork address for all networks in the area described by this entry. For example, this could be the class B address 128.185.0.0.

IP Address Mask

Range:	A valid IP Address mask in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies an IP address mask in dotted notation that defines which bits of the IP Address represent the networks in the area. For example, if the IP Address is a class B address 128.185.0.0, this IP Address Mask is 255.255.0.0. For classless addressing, enter a prefix mask as defined in the *IP Routing Manual* (Part Number T0100-03).

Configuring the OSPF External Range

Introduction

This section describes how to configure the parameters to define an OSPF external range.

What You See in This Record

Figure 2-8 shows the OSPF External Range Record.

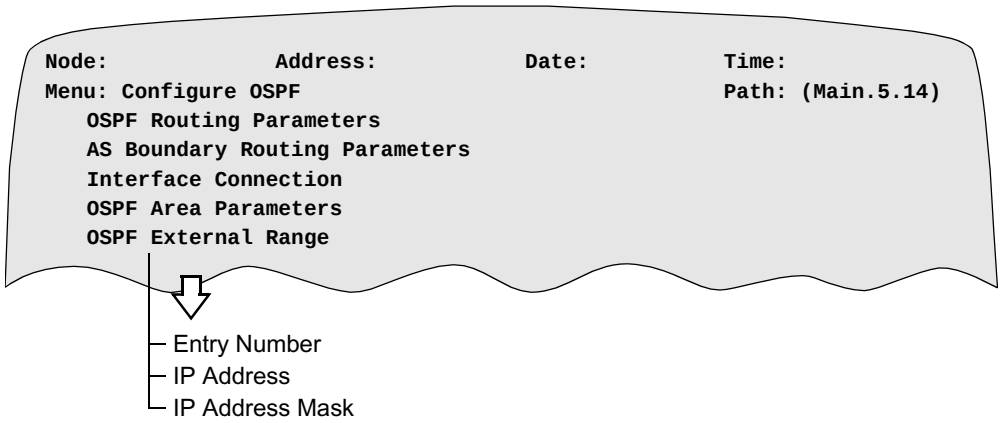

Figure 2-8. OSPF External Range Record

Parameters

These tables describe the OSPF External Range Parameters record:

Note

Unless otherwise indicated, you must Boot OSPF menu for changes to these parameters to take effect. See "Booting OSPF Parameters and Menus" on page 27.

Entry

Range:	1 to 255
Default:	1
Description:	Entry number used to reference this table record.

IP Address

Range:	A valid IP Address mask in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies an IP address in dotted notation that provides the common IP network and subnetwork address for all networks in the External range described by this entry. For example, this could be the class B address 128.185.0.0.

IP Address Mask

Range:	A valid IP Address mask in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies IP address mask in dotted notation that defines which bits of the IP Address in this entry are common for all networks in the range. For example, if the IP Address was the class B 128.185.0.0 this IP address mask would be 255.255.0.0. For classless addressing, enter a prefix mask as defined in the *IP Routing Manual* (Part Number T0100-03).

Configuring Virtual Links

Introduction

This section describes how to configure parameters for virtual links required to maintain backbone connectivity. You can configure virtual links between any two ABRs that share common non-backbone and non-stub areas.

What You See in This Record

Figure 2-9 shows the Virtual Link Configuration record.

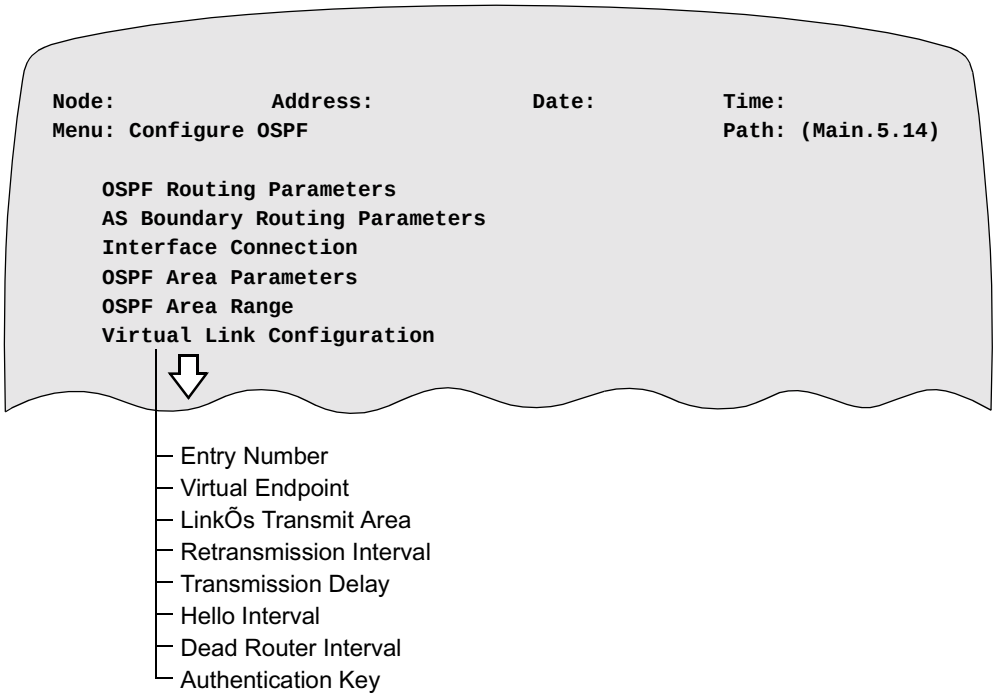

Figure 2-9. Virtual Link Configuration Record

Parameters

These tables describe the parameters that make up the Virtual Link Configuration record:

Note

Unless otherwise indicated, you must Boot OSPF Parameters for changes to these parameters to take effect. See “Booting OSPF Parameters and Menus” on page 27.

Entry Number

Range:	1 to 255
Default:	1
Description:	Entry number used to reference this table record.

Virtual Endpoint

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Indicates the OSPF Router ID (in dotted notation) of the remote router to which a virtual link is to be established. The OSPF Router ID is set with either the Configure IP -> Parameters ->Router ID parameter, or with the Configure IP ->Parameters -> Internal IP Address parameter. If neither of the IP Router ID and Internal IP Address parameters is set, the IP Address of the lowest-numbered OSPF Interface is used.

Link's Transmit Area

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.1
Description:	Specifies the OSPF Area ID (in dotted notation) assigned to the area through which the link traverses. You must have configured this router and the remote router to have an area bordering the Link Transit Area.

Retransmission Interval

Range:	1 to 65535
Default:	10
Description:	Specifies the retransmission interval in seconds. A typical value is 10 seconds for a virtual link.

Transmission Delay

Range:	1 to 65535
Default:	5
Description:	Specifies the transmission delay in seconds. A typical value is five seconds for a virtual link.

Hello Interval

Range:	1 to 255
Default:	30
Description:	Specifies the normal period, in seconds, between hello messages. You must enter the same value for all routers attached to a common network. A typical value is 30 seconds for a virtual link.

Dead Router Interval

Range:	1 to 65535
Default:	180
Description:	Specifies the time, in seconds, after which a nonresponding neighbor is considered dead. You must enter the same value for all routers attached to a common network. A typical value for a virtual link is 180 seconds.

Authentication Key

Range:	0 to 8 alphanumeric characters; use the space character to blank field.
Default:	(blank)
Description:	Specifies an authentication key of 0 to 8 ASCII characters for this virtual link. This must be configured the same on both endpoints.

Configuring Neighbor Parameters

Introduction

This section describes how to configure parameters for neighbor routers. You complete this table to describe the neighbors of the router in this network. You should have already configured the router in the OSPF Interface Configuration Parameters record.

What You See in This Record

Figure 2-10 shows the Neighbor Parameters record.

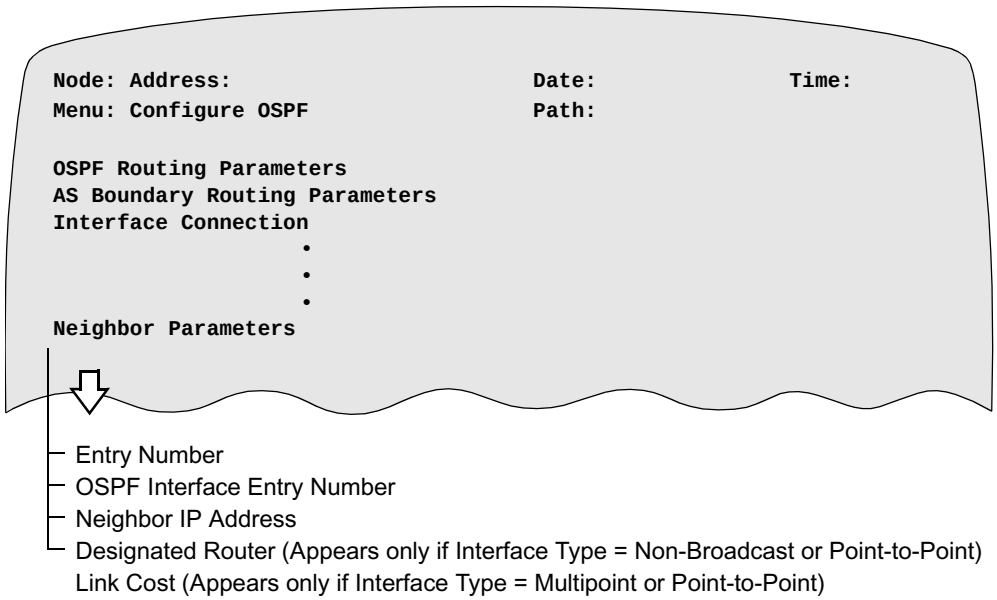

Figure 2-10. Neighbor Parameters Record

Note

You can configure up to eight neighbors for each entry in the Neighbor Parameter record.

Parameters

These tables describe the parameters that make up the Neighbors Parameters record:

Note

Unless otherwise indicated, you must Boot OSPF Parameters for changes to these parameters to take effect. See “Booting OSPF Parameters and Menus” on page 27.

Entry Number

Range:	1 to 255
Default:	1
Description:	Entry number used to reference this table record.

OSPF Interface Entry Number

Range:	1-255
Default:	1
Description:	Specifies the OSPF Interface for which you will be entering neighbor router information. Each OSPF interface can have a total of eight neighbors, i.e., each entry can have eight neighbors. This will be reflected by #n before each of the subsequent parameters (where n equals 1 to 8).

Neighbor IP Address

Range:	A valid IP Address in dotted notation in the format X.X.X.X, where X can take a maximum value of 255.
Default:	0.0.0.0
Description:	Specifies the IP address of a router neighbor on the non-broadcast network to which the Interface IP Address parameter of this entry is attached (from the Group LCON record). If the neighbor is connected over an unnumbered link, configure the neighbor's router ID.

Designated Router

Range:	Yes, No
Default:	Yes
Description:	Specifies if the remote neighbor identified by the Neighbor IP Address parameter of this entry is allowed to become the "designated router" of the non-broadcast network. **Note** Set this parameter to Yes for concentrator nodes and No for endpoint nodes in a star network. **Note** This parameter only appears in Interface Type is configured as Point to Point or Non-broadcast.

Link Cost

Range:	0 to 65535
Default:	0
Description:	Specifies the cost metric for sending IP Type of Service Class 0 frames to the neighboring router. If this Link Cost parameter is set to 0 (default), the OSPF Metric configured for the OSPF interface will be used. Refer to the OSPF Metric parameter under **Configure OPSF -> Interface Configuration** on page 2-9. **Note** This parameter only appears in Interface Type is configured as Point to Point or Multipoint.

Booting OSPF Parameters and Menus

Introduction

After configuring the OSPF parameters, it may be necessary to boot either the parameter or menu. This section explains how to perform these functions.

Accessing the Boot OSPF Parameters and Menu Screen

Figure 2-11 shows the Boot OSPF Parameters and Boot OSPF Menu screen.

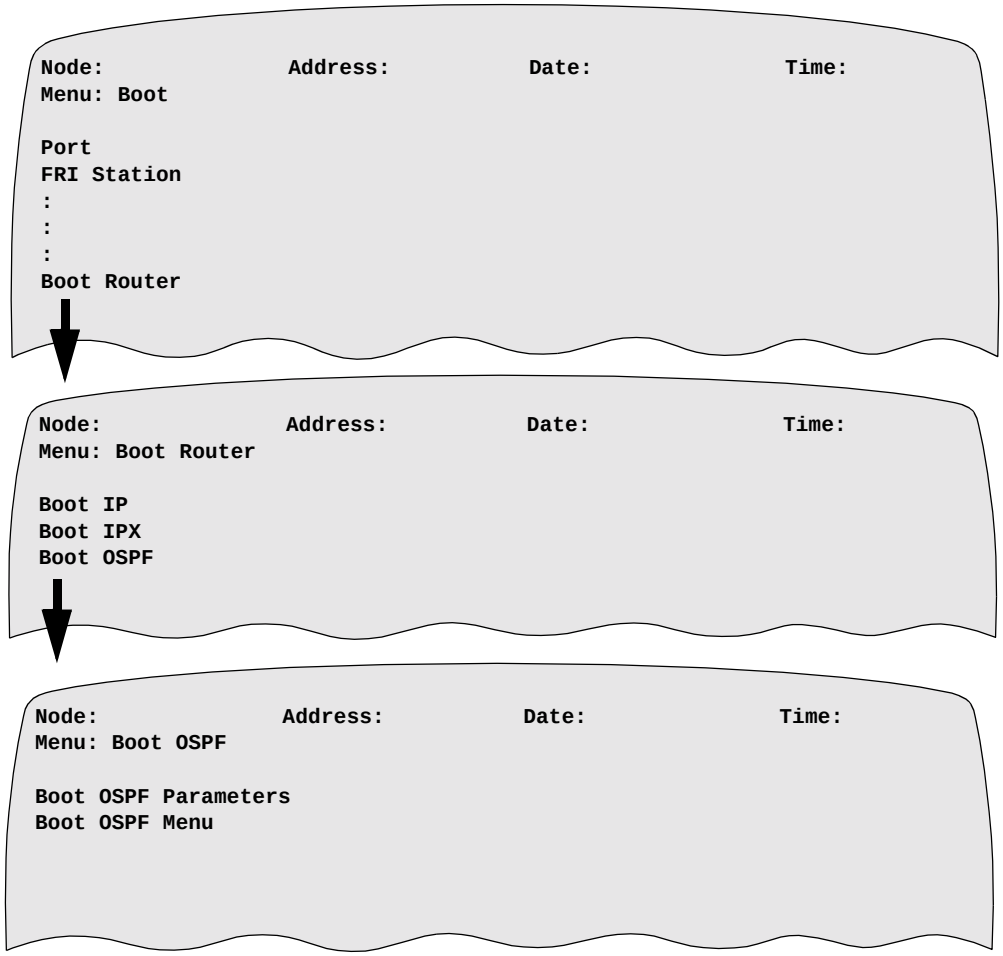

Figure 2-11. Boot OSPF Parameter and Boot OSPF Menu

The modified parameters or menus will be booted and all changes made will be implemented.

Configuration Example

Introduction

This section contains a sample application that you can use as a reference.

The network shown in Figure 2-12 is a nonbroadcast, multi-access (NBMA), LANview network. In this example, one AS, configured as one area, is running OSPF but also imports Routing Information Protocol (RIP) routes from another AS.

Note

The configuration shows critical parameters only. You should be familiar with the configuration procedures for the Network Access Products before configuring OSPF. Refer to the preceding sections in this document for information on configuring OSPF parameters. You can also refer to the *Vanguard Basic Configuration Manual* (Part Number T0113) for additional configuration information.

Vanguard Configuration Procedure

Before configuring OSPF for the example shown in Figure 2-12, you need to perform this configuration for all five Vanguard nodes:

Step	*Action*
1	Configure LAN and WAN (for example, Frame Relay or X.25) ports.
2	Configure Frame Relay stations if using Frame Relay.
3	Configure Network Services -> Route Selection Table.
4	Configure the LAN Connection Type in the LAN Connection Table Configuration as GROUP for this example because the area is a LANview. **Note** Figure 2-14 shows the LCON and Frame Relay configurations for node 1, the central node in a frame relay network (shown in Figure 2-12). With LANView, the four LCONs are grouped together on a single router interface.
5	Configure Network Services -> Mnemonic Table in the node that is placing the LCON calls.
6	Configure interfaces 1 and 5 as Enable in the Configure Router -> Configure Router Interface States record.
7	Configure the parameters as default in the Configure Router -> Configure IP -> Parameters ->Configure IP Parameters record and save the record. **Note** RIP is enabled now. After OSPF learns the RIP routes, you can disable RIP in all nodes in the OSPF area except for the ASBR.
8	Configure the parameters in the Configure Router -> Configure IP ->Interfaces record to identify IP addresses and masks.
9	Perform a Node boot (warm).

Step	*Action (continued)*
10	Use the Status/Statistics ->LAN Connection Statistics -> LAN Connection Summary Stats to check that all LCONs are up.
11	Check the Dest net field in the Status/Statistics ->Router Stats ->IP Stats -> Routing Table Stats to ensure that all remote networks are learned using RIP.
12	Check Dest net field in the Status/Statistics ->Router Stats ->IP Stats -> Routing Table Stats to ensure that all subnets are seen by the router.

Description of the Configuration Example

Figure 2-12 shows an NBMA LANview network where the WAN is treated as a single subnetwork. Node #1 is an ASBR that joins two autonomous systems: one running RIP and one running OSPF.

The ASBR performs two tasks:

1) Takes the OSPF routes learned from OSPF Area 0, converts them to RIP routes, and sends them to the RIP Router #1.

2) Takes the RIP routes from RIP Router #1, converts them to OSPF routes, and propagates them to the remote Nodes #2, #3, #4, and #5.

The network is assigned an area range of 16 contiguous subnets, 134.33.0.0 through 134.33.15.0. All nets in the OSPF area are in this range. Since only a single area is defined in this example, it is the OSPF backbone and is assigned number 0.0.0.0.

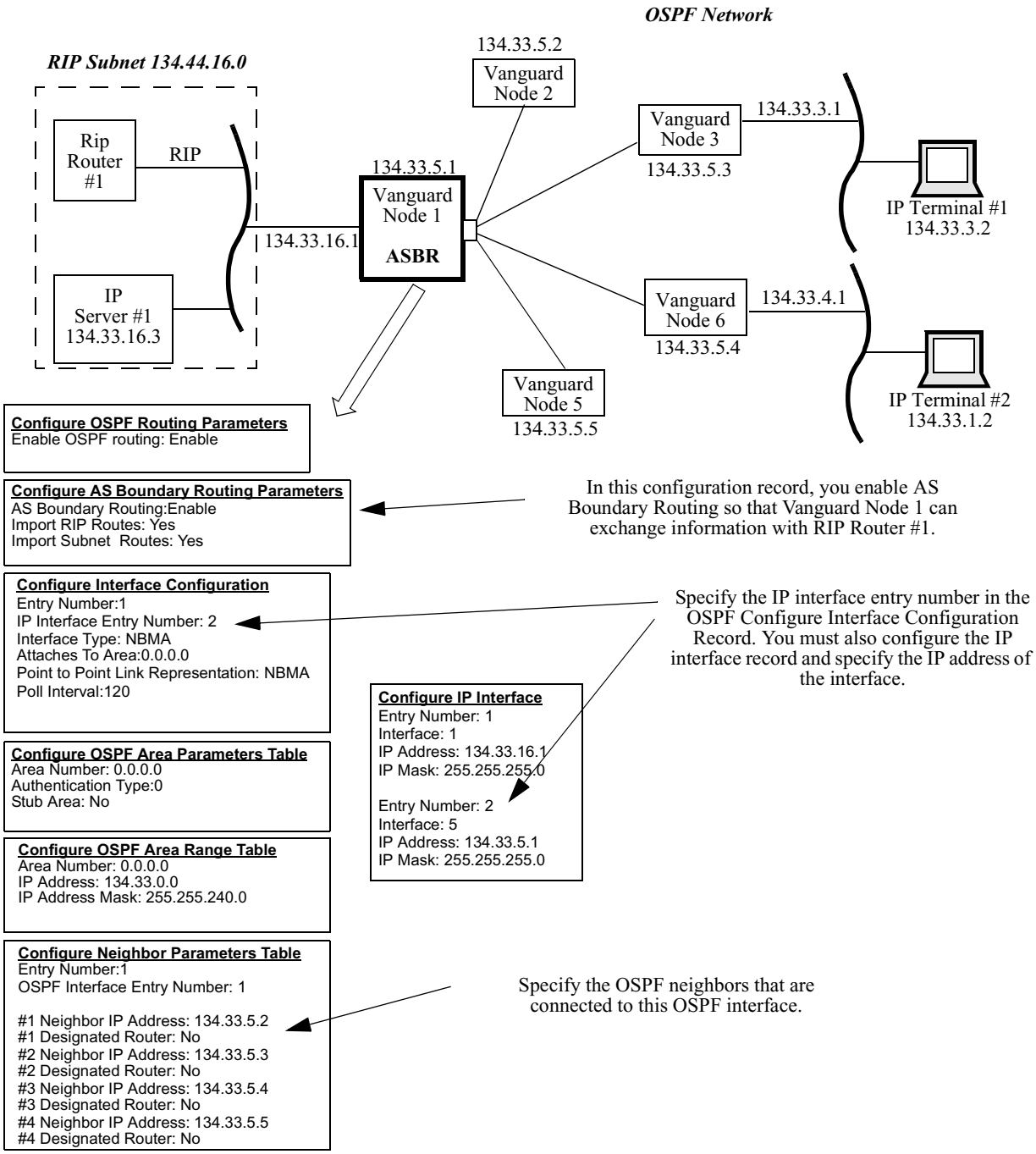

Figure 2-12. OSPF and IP Interface Configuration for Vanguard Node 1

Figure 2-13 illustrates the OSPF and IP Interface configuration parameters for Vanguard Node 3. The OSPF and IP Interface configuration for Vanguard Node 2, 4, and 5 are similar to Node 3. When configuring Node 2, 4, and 5, follow the example shown in Figure 2-13 and update the Configure IP Interface parameters.

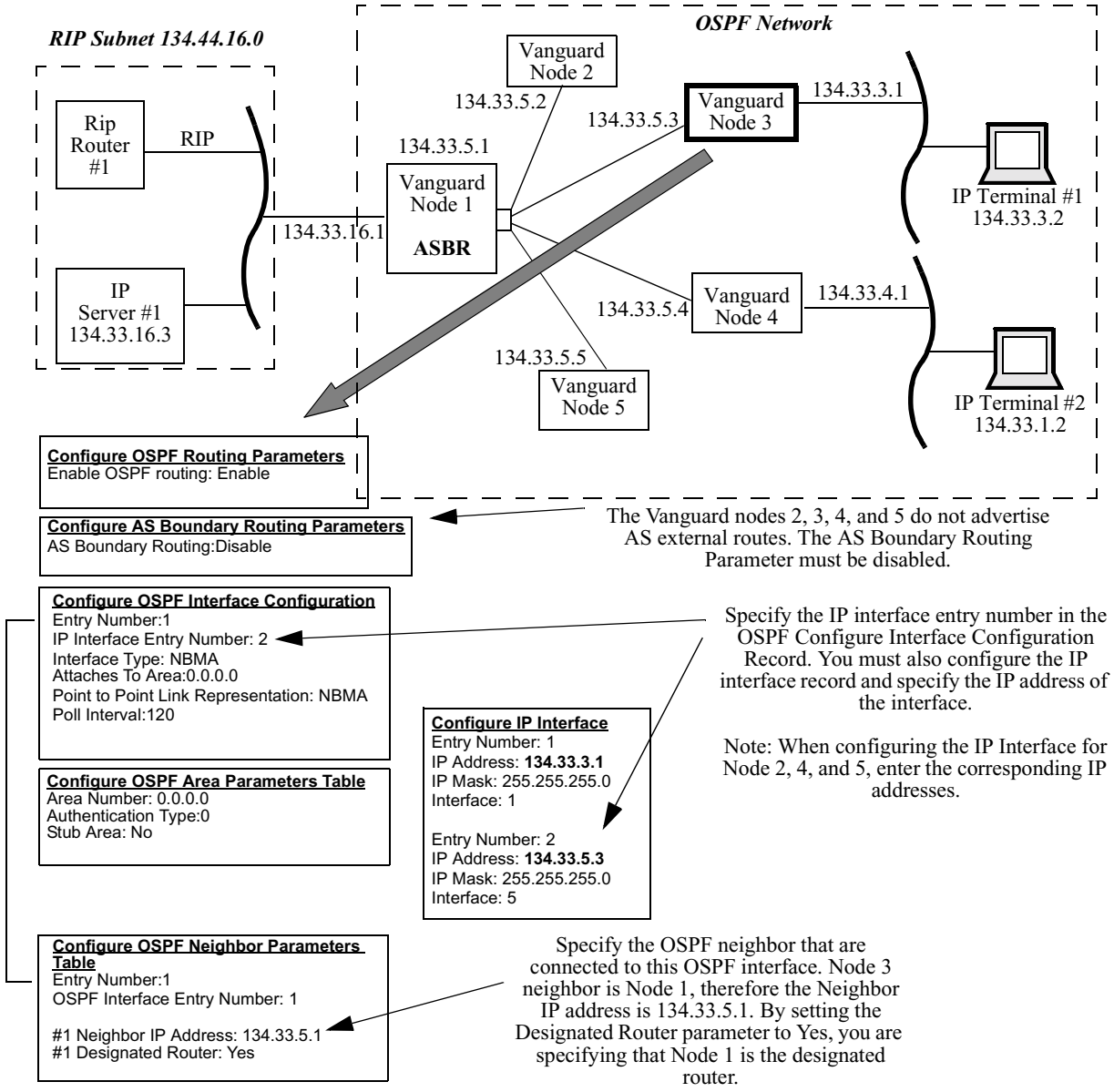

Figure 2-13. OSPF and IP Interface Configuration for Vanguard Node 3

LANView Configuration

Figure 2-14 shows the LANView configuration for Vanguard Node 1.

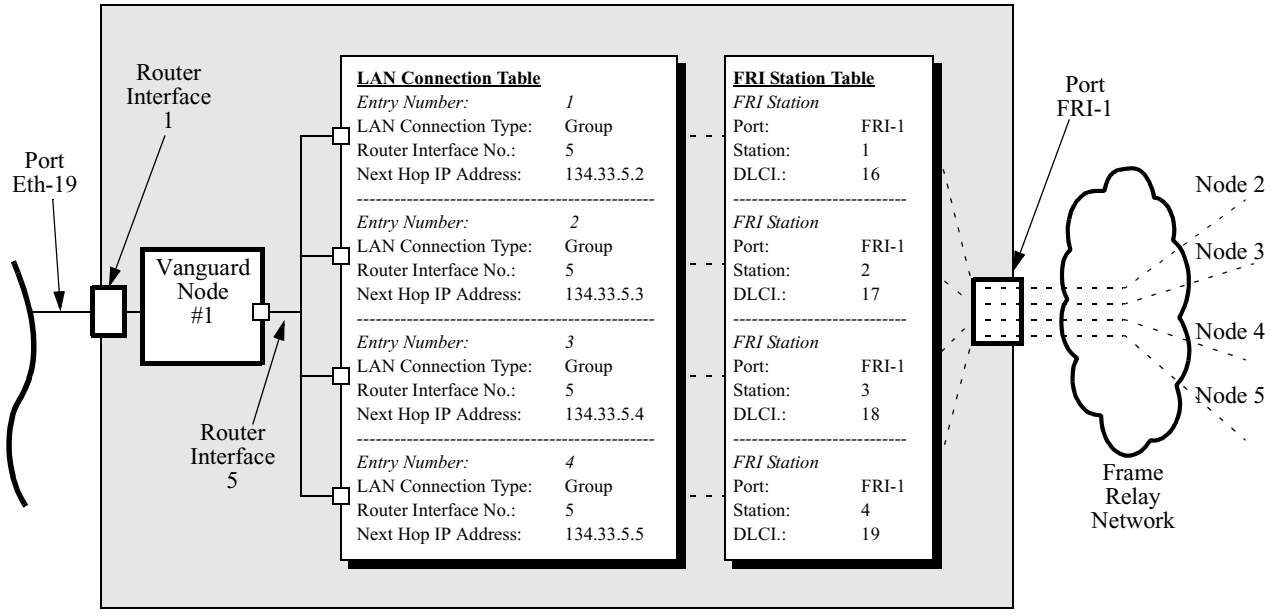

Figure 2-14. LANView Configuration for Vanguard Node 1

Figure 2-15 illustrates the LANView configuration for Vanguard Node 3. The LANView configuration for Vanguard Node 2, 4, and 5 are similar.

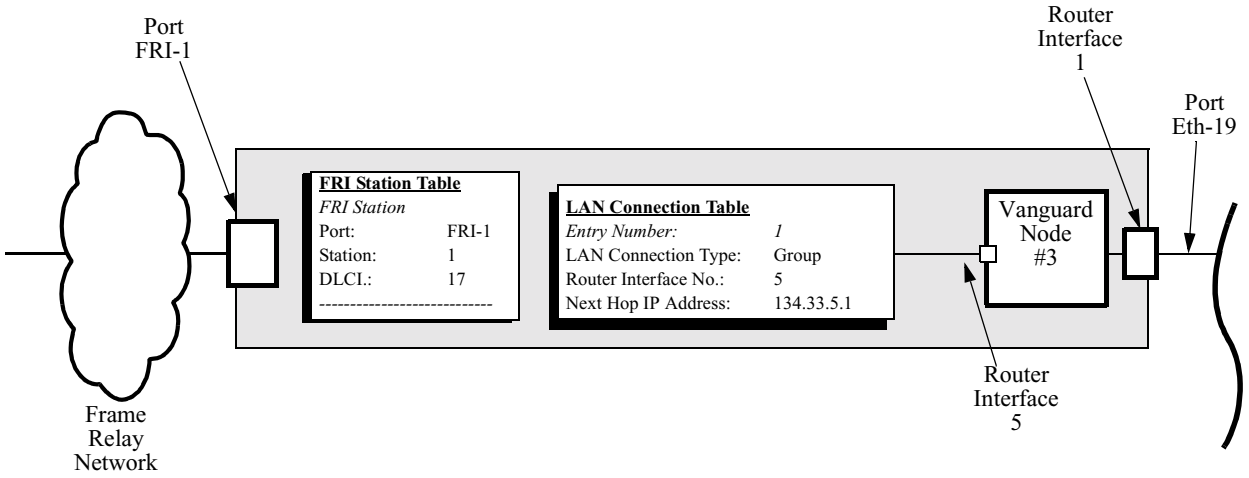

Figure 2-15. LANView Configuration for Vanguard Node 3

Chapter 3
Statistics

Introduction

These sections describe the OSPF statistics.

Router Stats Menu

Figure 3-1 shows the Router Stats menu. You can access OSPF Stats from this menu.

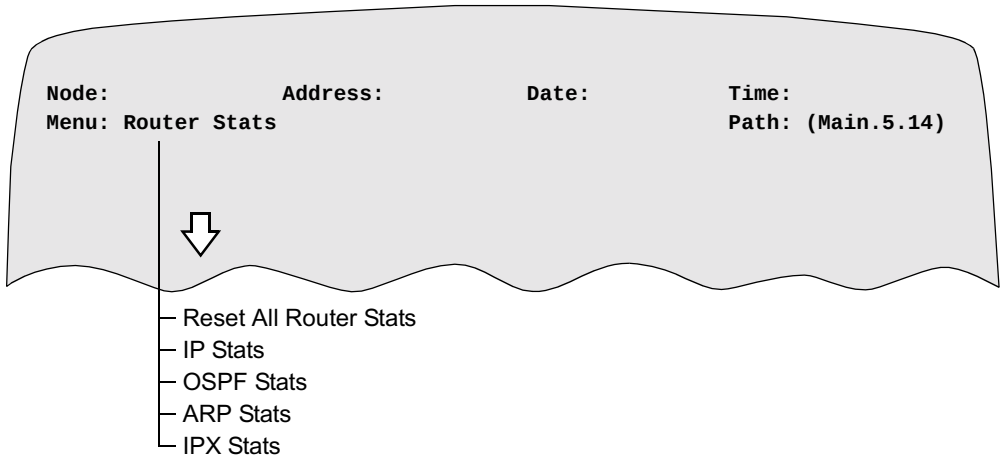

Figure 3-1. Router Stats Menu

OSPF Stats

Figure 3-2 shows the OSPF Stats menu. You can select the type of statistics that you want to view.

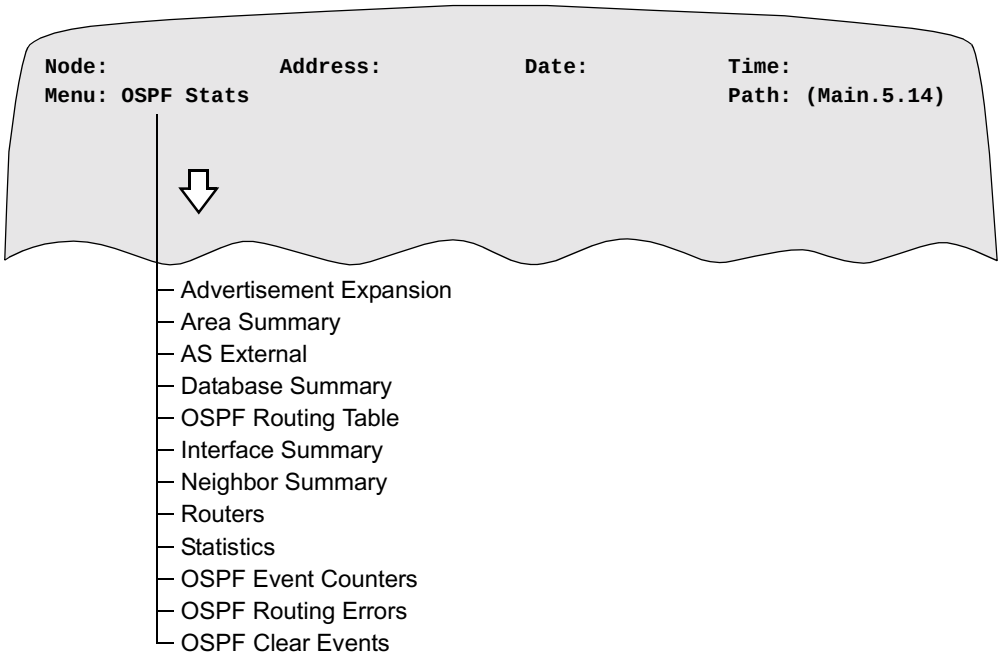

Figure 3-2. OSPF Stats Menu

Using the Advertisement Expansion Statistics

Introduction

The Advertisement Expansion Statistics provide the details of a single Link State Advertisement (LSA) contained in the OSPF database. You can specify the link state type.

Statistics for Router Link State

Figure 3-3 shows the statistics for a router link state. The terms are described in a table at the end of the section.

```
Node:              Address:           Date:          Time:
Advertisement Expansion


Link state type: 1/
Link state ID (destination): 0.0.0.0/134.33.1.1
For which area: 0.0.0.0/0.0.0.1

LS age:     1437
LS options:  0x2
LS type:     1
LS destination (ID): 134.33.1.1
LS originator:   134.33.1.1
LS sequence no:  0x80000093
LS checksum:     0x6a9a
LS length:       36
Router type:  Area-border  AS-boundary
# router ifcs:   1
Link ID:          134.33.10.1
Link Data:        134.33.10.1
Interface type:   2
No. of metrics: 0
TOS 0 metric:   1

Press any key to continue ( ESC to exit ) ...
```

Figure 3-3. Statistics for a Router Link State

Statistics for Network Link State

Figure 3-4 shows the statistics for a network link state. The terms are described in a table at the end of the section.

```
Node:              Address:           Date:          Time:
Advertisement Expansion

Link state type: 1/2
Link state ID (destination): 0.0.0.0/134.33.10.1
For which area: 0.0.0.0/0.0.0.1

LS age:     1346
LS options:  0x2
LS type:     2
LS destination (ID): 134.33.10.1
LS originator:   134.33.1.1
LS sequence no:  0x80000095
LS checksum:     0xc723
LS length:       44
Network mask:  255.255.255.0
Attached Router: 134.33.1.1
Attached Router: 134.33.7.1
Attached Router: 134.33.10.3
Attached Router: 134.33.10.2
Attached Router: 134.33.8.1
Attached Router: 0.0.0.0
Attached Router: 0.0.0.0
Attached Router: 0.0.0.0

Press any key to continue ( ESC to exit ) ...
```

Figure 3-4. Statistics for a Network Link State

Statistics for Net Summary

Figure 3-5 shows the Statistics for Net Summary. The terms are described in a table at the end of the section.

```
Node:              Address:           Date:          Time:
Advertisement Expansion

Link state type: 1/3
Link state ID (destination): 0.0.0.0/134.2.1.0
Link state originator: 0.0.0.0/134.22.251.1
For which area: 0.0.0.0/0.0.0.1

   LS age:     246
   LS options:  0x2
   LS type:     3
   LS destination (ID): 134.2.1.0
   LS originator:   134.22.251.1
   LS sequence no:  0x8000000d
   LS checksum:     0x35f2
   LS length:       28
   Network mask:  255.255.255.0
   TOS 0 metric:   3576




Press any key to continue ( ESC to exit ) ...
```

Figure 3-5. Statistics for Net Summary

Statistics for AS External Link

Figure 3-6 shows the statistics for the AS External link. The terms are described in a table at the end of the section.

```
Node:              Address:           Date:          Time:
Advertisement Expansion

Link state type: 1/5
Link state ID (destination): 0.0.0.0/?
This field identifies the routing domain that is being
described by the advertisement.Depending on the adverisement's LS type,
enter the following values for the Link State ID :
1)For LS type 1 --> the Originating router's Router ID.
2)For LS type 2 --> The IP interface address of the Network's DR.
3)For LS type 3 --> The destination network's IP address.
4)For LS type 4 --> The Router ID of the described AS boundary router.
5)For LS type 5 --> The destination network's IP address.

Link state ID (destination): 0.0.0.0/134.33.9.0
Link state originator: 0.0.0.0/134.33.1.1

LS age:     1566
LS options:  0x2
LS type:     5
LS destination (ID): 134.33.9.0
LS originator:   134.33.1.1
LS sequence no:  0x80000092
LS checksum:     0x3da7
LS length:       36
Network mask:  255.255.255.0
TOS 0 metric:   2, External type 2
Forwarding addr:  0.0.0.0
External tag:     0
```

Figure 3-6. Statistics for AS External Link

Description of Terms

This table describes the terms used in the Advertisement Expansion Statistics screens:

Term	*Description*
LS age	Indicates the age of the advertisement. An advertisement is aged out after 60 minutes.
LS options	Indicates the optional OSPF capabilities supported by the piece of the routing domain described by the advertisement.
LS type	Classifies the advertisement and dictates its contents: • 1 — router links advertisement • 2 — network link advertisement • 3 — summary link advertisement • 4 — summary ASBR advertisement • 5 — AS external link

Term	Description (continued)
LS destination (ID)	Identifies what is being described by the advertisement. The ID depends on the advertisement type: • For router links and ASBR summaries, it is the OSPF Router ID. • For network links, it is the IP address of the network's Designated Router. • For summary links and AS externals, it is a network or subnet number. • For group membership advertisements, it is a particular multicast group.
LS originator	Indicates the OSPF Router ID of the originating router.
LS sequence no	Used to distinguish separate instances of the same advertisement. Should be looked at as a signed 32-bit integer. Starts at 0x80000001 and increments by 1 each time the advertisement is updated.
LS checksum	Indicates a checksum of advertisement contents used to detect data corruption.
LS length	Indicates the size of the advertisement in bytes.
Router type	Indicates the level of functionality of the router. ASBR means that the router is an AS boundary router, and ABR means that the router is an area border router.
# router ifcs	Indicates the number of the router interface described in the advertisement.
Link ID	Indicates the type of connection to the interface. The ID depends on the interface type: • For interfaces to routers (for example, point-to-point links), the link ID is the neighbor's Router ID. • For interfaces to transit networks, the link ID is the IP address of the network's Designated Router. • For interfaces to stub networks, the link ID is the network's network or subnet number.
Link Data	Indicates four bytes of extra information concerning the link. It is either the IP address of the interface (for interfaces to point-to-point networks) or the subnet mask.
Interface type	Indicates one of the following types of interfaces: 1. Point-to-point 2. Transit Net 3. Stub network 4. Virtual link
No. of metrics	Identifies the number of non-zero TOS values for which metrics are provided for this interface.
TOS O metrics	Identifies the cost of the interface. The reverse cost, which is derived from another advertisement, is in parentheses.

Term	***Description*** *(continued)*
Network mask	Provided by a router links advertisement to a stub broadcast network. This number with the router interface ID makes up the IP network number.
Forwarding addr	Specifies a router, other than the originating router, to which an ASBR directs OSPF routes.
External tag	Specifies a tag associated with an imported route, which is maintained when re-advertising the route within the OSPF domain.

Using the Area Summary Statistics

Introduction

The Area Summary Statistics summarize the contents of the area database.

Display OSPF Areas

Figure 3-7 shows the area summary statistics on the Display OSPF Areas screen.

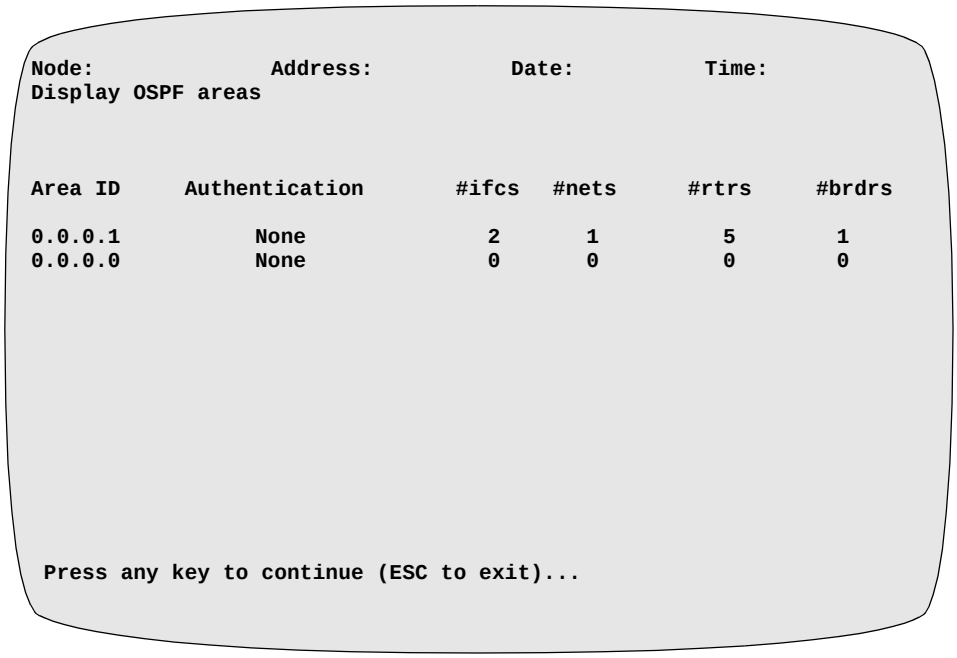

Figure 3-7. Display OSPF Areas

Description of Terms

This table describes the terms used in the Area Summary Statistics screen:

Term	*Description*
Area ID	Indicates the area ID for the area being monitored.
Authentication	Indicates authorization for routing updates.
#ifcs	Indicates the number of router interfaces attached to the particular area. These interfaces are not necessarily functional.
#nets	Indicates the number of transit networks that have been found while doing the SPF tree calculation for this area.
#rtrs	Indicates the number of routers that have been found when doing the SPF tree calculation.
#brdrs	Indicates the number of area border routers that have been found when doing the SPF tree calculation for this area.

Using the AS External Statistics

Introduction

The AS External Statistics lists all external advertisements in the OSPF database.

AS External Statistics

Figure 3-8 shows the AS External Statistics.

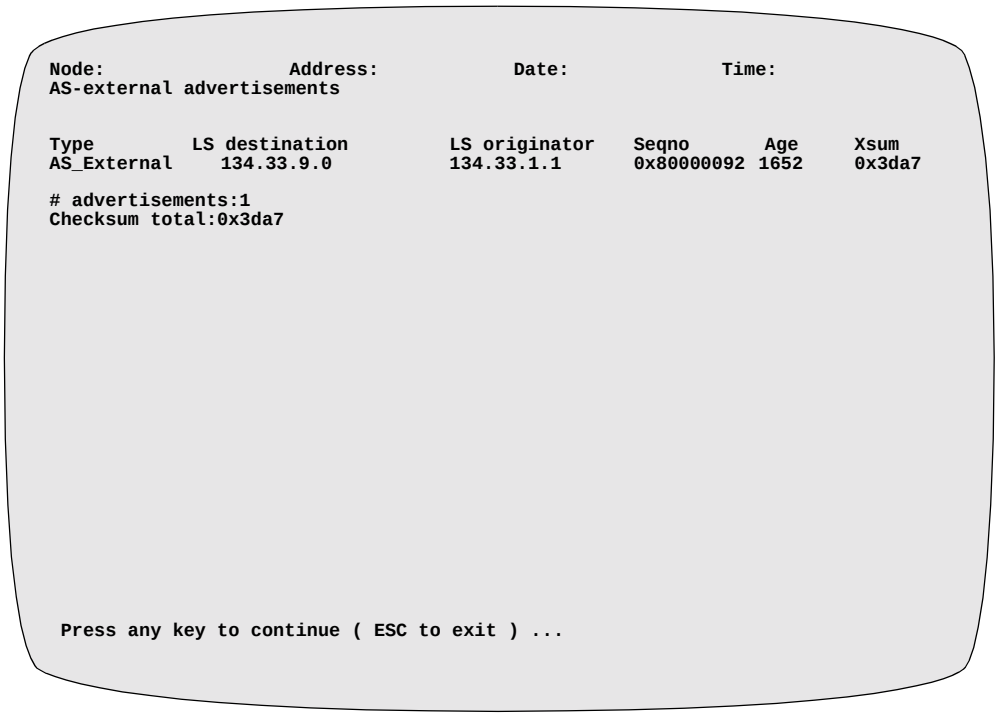

Figure 3-8. AS External Statistics

Description of Terms

This table describes the terms used in the AS External statistics screen:

Term	*Description*
Type	Always AS_External (5) for AS external advertisements.
LS destination	Indicates an IP network or subnet number. These network numbers belong to other Autonomous Systems.
LS originator	Indicates the advertising router.
Seqno	Indicates the sequence number of the LSA.
Age	Indicates the age of the LSA.
Xsum	Checksum computed over all LS advertisements in the database. All routers should have the same checksum value.
#advertisements	Indicates the total number of advertisements listed.
checksum total	The 32-bit sum of the individual advertisements' LS checksum fields. Used to determine if two OSPF routers have synchronized databases.

Using the Database Summary Statistics

Introduction

The Database Summary Statistics display all LSAs in the database for a given area. You need to provide the area number and the LSA type.

Database Summary Statistics

Figure 3-9 shows the screen for the Database Summary Statistics.

```
Node:            Address:        Date:          Time:
Display Database Summary


Type     LS destination   LS originator   Seqno       Age   Xsum
Router   134.33.1.1       134.33.1.1      0x80000093  1678  0x6a9a
Router   134.33.7.1       134.33.7.1      0x80000094  1668  0x79be
Router   134.33.8.1       134.33.8.1      0x80000094  1549  0x8aa9
Router   134.33.10.2      134.33.10.2     0x80000094  1681  0x44ef
Router   134.33.10.3      134.33.10.3     0x80000094  1678  0x57d8
Network  134.33.10.1      134.33.1.1      0x80000095  1559  0xc723
Summary  134.33.1.0       34.33.1.1       0x80000092  1724  0x55b

# advertisements:7
Checksum total:0x2d846




 Press any key to continue (ESC to exit)...
```

Figure 3-9. Database Summary Statistics

Description of Terms

This table describes the terms used in the Database Summary Statistics screen:

Term	*Description*
Type	Separate LS types are numerically displayed: • 1 — router links advertisements • 2 — network links advertisement) • 3 — network summaries • 4 — AS boundary router summaries • 5 — AS external links advertisements

Term	***Description*** *(continued)*
LS destination	Identifies that piece of the internet environment that is being described by the advertisement. The contents of this field depend on the advertisement's LS type. • For link state advertisement types 1 and 4, it is a Router ID. • For Types 3 and 5, it is an IP network number. • For Type 2, it is the IP interface address of the Designated Router.
LS originator	Indicates the advertising router.
Seqno	Indicates the sequence number of the LSA.
Age	Indicates the age of the LSA.
Xsum	Indicates the checksum computed over all LS advertisements in the database. All routers should have the same checksum value.
#advertisements	Indicates the total number of advertisements listed.
checksum total	Indicates the 32-bit sum of the individual advertisements' LS checksum fields. Used to determine if two OSPF routers have synchronized databases.

Using the OSPF Routing Table Statistics

Introduction

The OSPF Routing Table Statistics provide the paths to all known destinations.

OSPF Routing Table Statistics

Figure 3-10 shows the screen that displays the OSPF Routing Table statistics.

```
Node:              Address:          Date:            Time:
OSPF Routing Table

          * Transitory Next Hop

DType RType Destination       Mask         Metric    Next hop(s)

 Net  SPF   134.33.8.0       ffffff00        1       TKR/1
 Net  SPF   134.33.10.0      ffffff00        1       SL/5
 Net  SPF   134.33.6.0       ffffff00        2       134.33.10.3
 Net  SPF   134.33.5.0       ffffff00        2       134.33.10.2
 Net  SPF   134.33.7.0       ffffff00        2       134.33.10.4
 Net  SPIA  134.33.1.0       ffffff00       26       134.33.10.1
 Net  SPE2  134.33.9.0       ffffff00        2       134.33.10.1

Routing table currently uses 7 of the 1050 routes available.




Press any key to continue ( ESC to exit ) ...
```

Figure 3-10. OSPF Routing Table Statistics

Description of Terms

This table describes the terms used in the OSPF Routing Table Statistics screen:

Term	*Description*
Dtype	Indicates destination type. Net indicates that the destination is a network.
Rtype	Indicates route type and how the route was derived. • Shortest Path First (SPF) indicates that the route is an intra-area route (comes from the Dijkstra calculation) • Shortest Path Inter Area (SPIA) indicates that it is an inter-area route (comes from considering summary links advertisements) • Shortest Path External (SPE) 1 and SPE2 indicate OSPF external routes (types 1 and 2 respectively). • Range indicates that this is an active area address range and is not used in forwarding packets.
Destination	Indicates the destination host or network.
Mask	Displays the entry's subnet mask.
Metric	Displays the route cost.
Next hop(s)	Address of the next router on the path towards the destination host.

Using the Interface Summary Statistics

Introduction

The Interface Summary Statistics summarize the details of all the OSPF interfaces.

Interface Summary Statistics

Figure 3-11 shows the screen displaying the Interface Summary statistics.

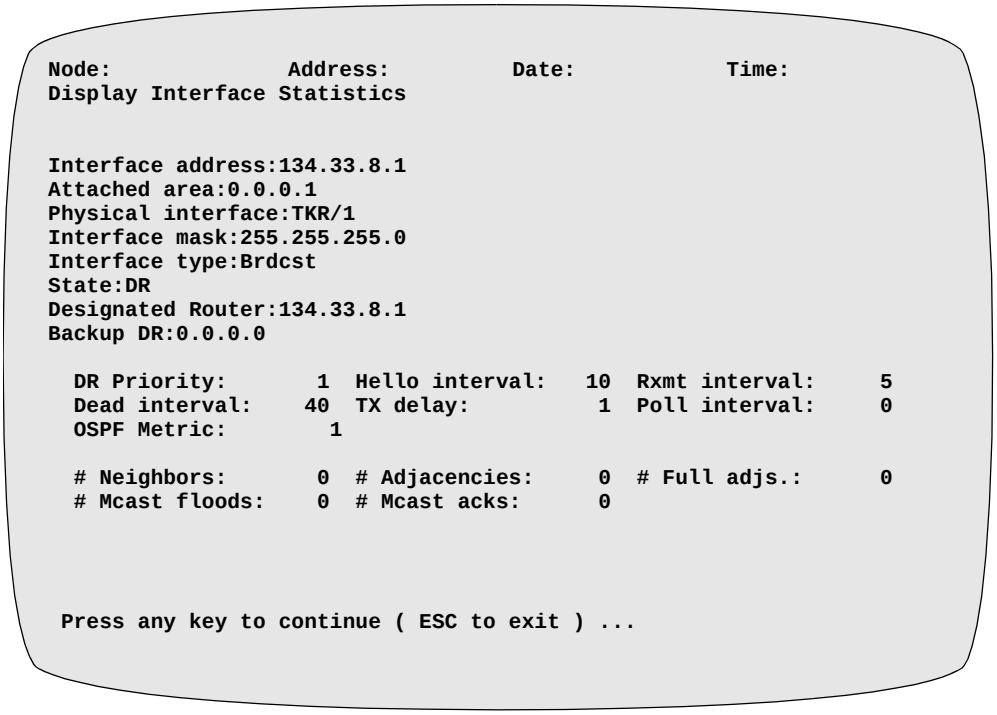

Figure 3-11. Interface Summary Statistics

Description of Terms

This table describes the terms used in the Interface Summary Statistics screen:

Term	*Description*
Interface Address	Interface IP address.
Attached area	Attached area ID.
Physical interface	Displays physical interface type and number.
Interface mask	Displays interface subnet mask.

Term	Description (continued)
Interface type	Can be one of the following: • Brdcst (broadcast, for example, an Ethernet interface) • P-P (a point-to-point network, for example, a synchronous serial line) • P-MP (a point-to-multipoint network) • NBMA (a non-broadcast multiple access network) • VLink (an OSPF virtual link)
State	Can be one of the following: • Down (1) • LoopBack (2) • Waiting (4) • Pt-to-Pt (8) • Dr Other (16) • Backup (32) • DR (64)
Designated router	IP address of the Designated router.
Backup DR	IP address of the backup designated router.
DR Priority	Displays priority assigned to designated router.
Dead Interval	Displays the current dead interval value.
OSPF Metric	Displays the interface's OSPF Metric.
Hello interval	Displays the current hello interval value.
Tx delay	Displays the current transmission delay value.
RXmt interval	Displays the current retransmission interval value.
Poll interval	Displays the current poll interval value.
# neighbors	Number of neighbors. This is the number of routers whose hellos have been received plus those that have been configured.
# Mcast floods	Number of link state updates flooded out the interface (not counting retransmissions).
# Adjacencies	Number of neighbors in state exchange or greater.
# Mcast acks	Number of acknowledgments to the link state update flooding.
# Full adjs	Number of full adjacencies. The number of full adjacencies is the number of neighbors whose state is Full (and therefore, with which the router has synchronized databases).

Using the Neighbor Summary Statistics

Introduction

The Neighbor Summary Statistics summarizes the statistics of all the neighbors.

Neighbor Summary Statistics

Figure 3-12 shows a screen displaying the Neighbor Summary Statistics.

```
Node:              Address:          Date:            Time:
Display Neighbor Statistics


Neighbor IP address:134.33.10.1
OSPF Router ID:134.33.1.1
Neighbor State:Full
Physical interface:SL/5
DR choice:134.33.10.1
Backup choice:134.33.10.3
DR Priority:5

  DB summ qlen:      0  LS rxmt qlen:      0  LS req qlen:       0
  Last hello:        5

  # LS rxmits:       2  # Direct acks:     1  # Dup LS rcvd:   147
  # Old LS rcvd:     0  # Dup acks rcv:  145  # Nbr losses:      0
  # Adj. resets:     0




 Press any key to continue ( ESC to exit ) ...
```

Figure 3-12. Neighbor Summary Statistics

Description of Terms

This table describes the terms used in the Neighbor Summary Statistics screen:

Term	*Description*
Neighbor IP address	Neighbor IP address.
OSPF Router ID	Neighbor's OSPF router ID.
Neighbor state	Can be one of the following: • Down (1) • Attempt (2) • Init (4), 2-Way (8) • ExStart (16) • Exchange (32) • Loading (64) • Full (128)

Term	***Description*** *(continued)*
Physical interface	Displays physical interface type and number of the router and neighbor's common network.
DR choice	The value seen in the last hello received from the neighbor indicating the DR choice.
Backup choice	The value seen in the last hello received from the neighbor indicating backup DR choice.
DR priority	The value seen in the last hello received from the neighbor indicating DR priority.
DB summ qlen	Indicates the number of advertisements waiting to be summarized in Database Description packets. It should be zero except when the neighbor is in state exchange.
LS rx mt qlen	Indicates the number of advertisements that have been flooded to the neighbor, but not yet acknowledged.
LS req qlen	Indicates the number of advertisements that are being requested from the neighbor in state loading.
Last hello	Indicates the number of seconds since a hello has been received from the neighbor.
#LS rxmits	Indicates the number of retransmissions that have occurred during flooding.
#Direct acks	Indicates responses to duplicate link state advertisements.
#Dup LS recvd	Indicates the number of duplicate retransmissions that have occurred during flooding.
#Old LS rcvd	Indicates the number of old advertisements received during flooding.
#Dup acks rcvd	Indicates the number of duplicate acknowledgments received.
#Nbr losses	Indicates the number of times the neighbor has transitioned to Down state.
#Adj resets	Counts entries to state Exstart.

Using the Routers Statistics

Introduction

The Router Statistics summarize the routers visible to the local router.

Router Statistics

Figure 3-13 shows a screen displaying the Router statistics.

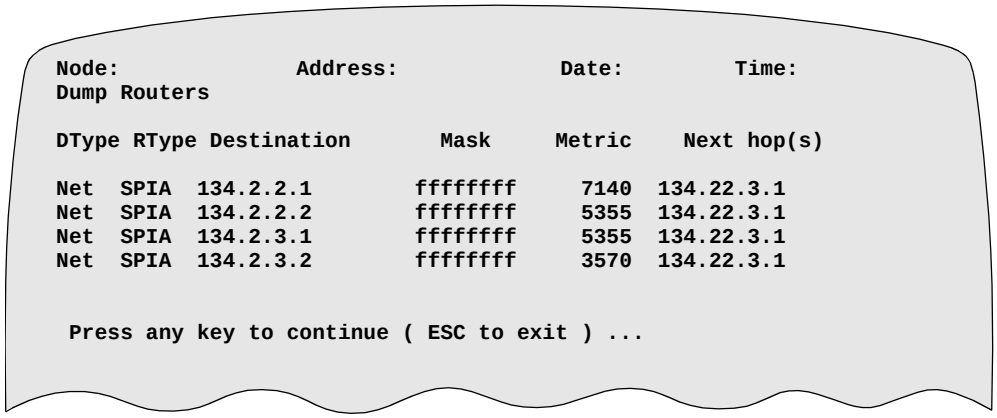

Figure 3-13. Router Statistics

Description of Terms

This table describes the terms used in the Router Statistics screen:

Term	*Description*
Dtype	Indicates destination type. • Net indicates that the destination is a network. • ASBR indicates that the destination is an AS boundary router. • ABR indicates that the destination is an area border router.
Rtype	Indicates route type and how the route was received. SPF indicates that the route is an intra-area route (comes from the Dijkstra calculation), SPIA indicates that it is an inter-area route (comes from considering summary link advertisements).
Destination	Destination router's OSPF router ID.
Mask	Always displayed as ffffffff.
Metric	Displays the route cost.
Next hop(s)	Address of the next router on the path towards the destination host.

Point-to-Point Link Representation in IP Routing Table Statistics

Introduction

There are two options for Point-to-Point Link representation in routing tables. Point-to-Point links can be represented by:

- Hosts - both ends (i.e. the host routes) of the point-to-point link are added to the routing tables of routers in the attached areas. Refer to Figure 3-15.

OR

- Network -only the subnet of the link is added to the routing table of routers in the attached area. Refer to Figure 3-16.

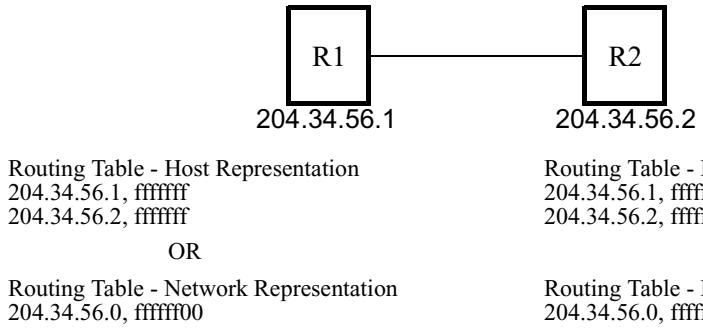

Figure 3-14. Point-to-Point Routes Represented in Routing Table

Statistics

Figure 3-15 and Figure 3-16 illustrate IP Routing Table statistics for OSPF routes with different point-to-point link representation.

```
Node:              Address:            Date:         Time:

IP Routing Table

* Static/Direct Route
% Accept RIP Route

Type      Dest net          Mask         Metric    Age  Next hop(s)

SPF       204.34.56.1       ffffffff     2         1    204.34.56.2
SPF*      204.34.56.2       ffffffff     1         1    204.34.56.2

 Press any key to continue ( ESC to exit ) ...
```

Figure 3-15. IP Routing Table Statistics for Point-to-Point Link Representation by Host

```
Node:              Address:             Date:         Time:

IP Routing Table

* Static/Direct Route
% Accept RIP Route

Type      Dest net          Mask         Metric    Age  Next hop(s)

SPF*      204.34.56.0       ffffff00     1         1    SL/5

 Press any key to continue ( ESC to exit ) ...
```

Figure 3-16. IP Routing Table Statistics for Point-to-Point Link Representation by Network

Using Statistics

Introduction

The Statistics screen summarizes the overall operation of the OSPF protocol.

Statistics

Figure 3-17 shows the Statistics screen.

```
Node:              Address:              Date:        Time:
Display Statistics
S/W version:2.1
OSPF Router ID:134.33.8.1
External type for Imported Routes:Type 2
AS boundary capability:No
Import external routes:None
Orig. default route:No (0,0.0.0.0)
Default route metric:(1, Type 2)
Default forward. addr:0.0.0.0

  Attached areas:                  1
  OSPF packets rcvd:           27580  OSPF packets rcvd w/ errs:        0
  Transit nodes allocated:       892  Transit nodes freed:            884
  LS adv. allocated:             298  LS adv. freed:                  295
  LS adv. aged out:                0  LS adv. flushed:                  1
  Queue headers alloc:            32  Queue headers avail:             32

  # Dijkstra runs:                23  Incremental summ. updates:        0
  Incremental VL updates:          0  Buffer alloc failures:            0
  Incremental ext. updates:        1


Press any key to continue ( ESC to exit ) ...
```

Figure 3-17. Statistics

Description of Terms

This table describes the terms used in the Statistics screen:

Term	*Description*
S/W version	Displays the current OSPF software revision level.
OSPF Router ID	Displays the router's OSPF ID.
External type for Imported Routes	Displays the external route type used by the router when importing external routes.
AS boundary capability	Displays whether external routes will be imported.
Import external routes	Displays which external routes will be imported.
Orig default route	Displays whether the router will advertise an OSPF default route.
Default route metric	Displays the cost and type of the default route (if advertised).

Term	Description (continued)
Default forward. addr	Displays the forwarding address specified in the default route (if advertised).
Attached areas	Indicates the number of areas to which the router has active interfaces.
OSPF packets rcvd	Indicates the number of OSPF packets received. See the OSPF Event Counters screen for more information.
OSPF packets rcvd w/ errs	Indicates the number of OSPF packets received with errors. See the OSPF Routing Errors screen for more information.
Transit nodes allocated	Indicates the number of transit nodes allocated to store router links and network links advertisements.
Transit nodes freed	Indicates the number of transit nodes that are freed from storing router links and network links advertisements.
LS adv allocated	Indicates the number of link state advertisements allocated to store summary link and AS external link advertisements.
LS adv freed	Indicates the number of link state advertisements freed from storing summary link and AS external link advertisements.
LS adv aged out	Counts the number of advertisements that have reached 60 minutes. Link state advertisements are aged out after 60 minutes. Usually they will be refreshed before this time.
LS adv flushed	Indicates number of advertisements removed (and not replaced) from the link state database.
Queue headers alloc Queue headers avail	OSPF frequently forms queues of link state advertisements, which are used in the flooding and database exchange process. Each queued LSA requires a queue header. If the number of queue headers allocated is not equal to the number available, database synchronization is in progress with some neighbors.
Dijkstra runs	Indicates how many times the OSPF routing table starts its calculations again.
Incremental VL updates	Indicates that new summary link advertisements have caused the routing table to be partially rebuilt.
Incremental ext updates	Displays number of changes to external destinations that are incrementally installed in the routing table.
Incremental summ updates	Indicates that new summary link advertisements have caused the routing table to be partially rebuilt.
Buffer alloc failures	Indicates buffer allocation failures. The OSPF system will recover from temporary lack of packet buffers.

Using the Event Counters

Event Counters

Figure 3-18 shows the Event Counters screen.

```
Node:              Address:          Date:             Time:
OSPF Event Counters

     Count  Description                          Code
     27101  Received OSPF Packets                SPF.10
         0  Sending Unicast Packets              SPF.11
     26993  Sending Multicast Packets            SPF.12
         0  Retransmitting Packets               SPF.13
         0  Interface State Changes              SPF.15
         0  Neighbor State Changes              SPF.21
         0  Self Updates                         SPF.29
      1002  New Advertisements                   SPF.30
         0  Old Acks for Advertisements          SPF.31
         0  LS Update Retransmissions            SPF.33
         0  LS Acks sent directly                SPF.34
         0  Advertisements Flushed               SPF.35
       143  Advertisements Originated            SPF.36
         0  New Routes                           SPF.37
     25812  NBMA hellos sent                     SPF.38



 Press any key to continue ( ESC to exit ) ...
```

Figure 3-18. Event Counters

Description of Terms

This table describes the terms used in the Event Counters screen:

Term	*Description*
Count	Indicates a number of a packet type.
Description	Describes the packet type.
Code	Identifies the event or messages displayed on the CTP or in SNMP traps.

Using the OSPF Routing Errors

Introduction

The OSPF Routing Errors screen provides a count of unusual or error events.

Error Counters

Figure 3-19 shows the OSPF Routing Errors screen.

```
Node:              Address:          Date:          Time:
OSPF Routing Errors

     Count     Description                          Code
     0         Duplicate LS ack received            SPF.430
     0         Bad Packet Length                    SPF.1
     0         Bad Packet Checksum                  SPF.2
     0         Bad OSPF Version                     SPF.3
     0         Duplicate Router ID                  SPF.4
     0         No matching ifc for packet           SPF.5
     0         Authentication failure               SPF.6
     0         No matching neighbor for packet      SPF.7
     0         Bad packet type                      SPF.8
     0         No buffer for multicast              SPF.9
     0         No FSM match on interface            SPF.14
     0         No match for hello on VL             SPF.17
     0         Hello interval mismatch              SPF.18
     0         Dead interval mismatch               SPF.19
     0         No FSM match on neighbor             SPF.20
     0         Outstanding DD not avble for nbr     SPF.22
     0         Unable to send packet                SPF.23
     0         Received bad length LSA              SPF.24


Press any key to continue ( ESC to exit ) ...
```

Figure 3-19. OSPF Routing Errors

Clear OSPF Events

This option lets you clear all the OSPF events.

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