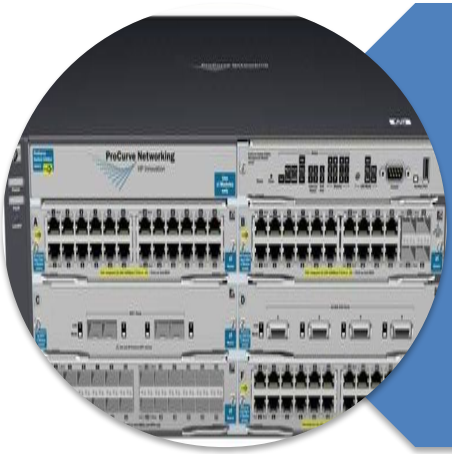
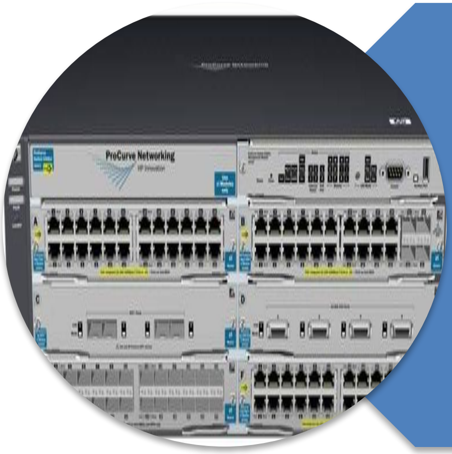
Lecture 6



Routing

Objectives



Routing

Layer 3 Router

routing takes place

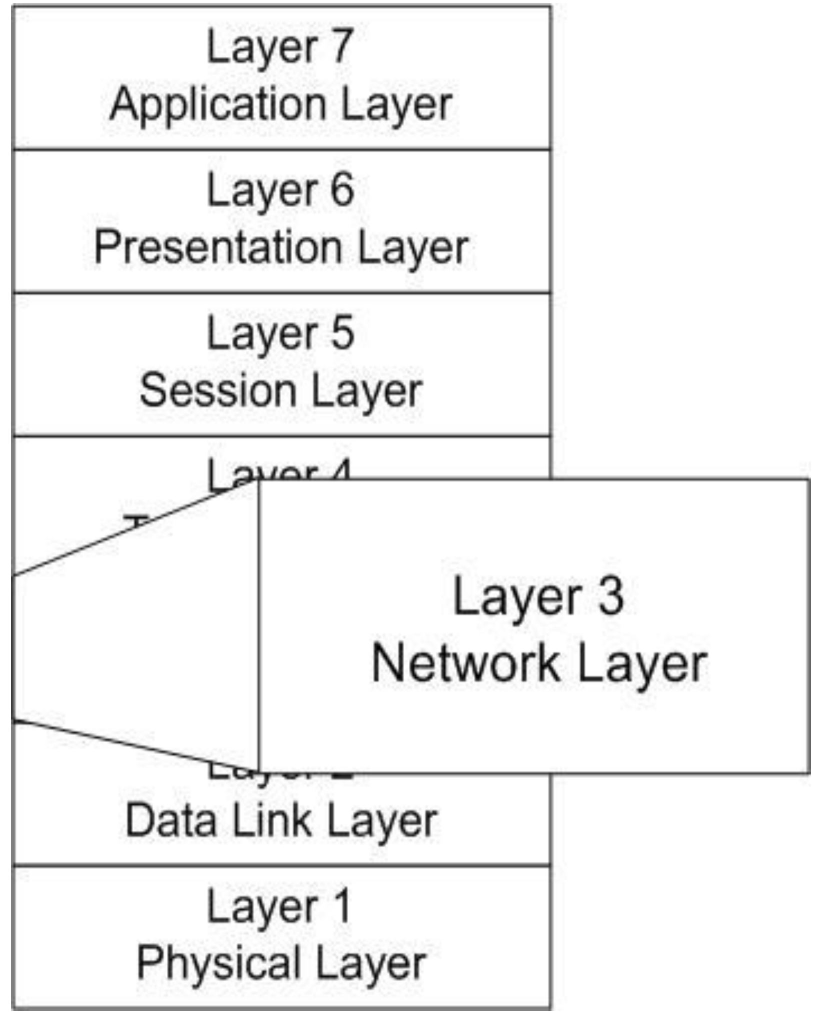
Any network protocol

can

support routing

known as a router

Layer 3 routing



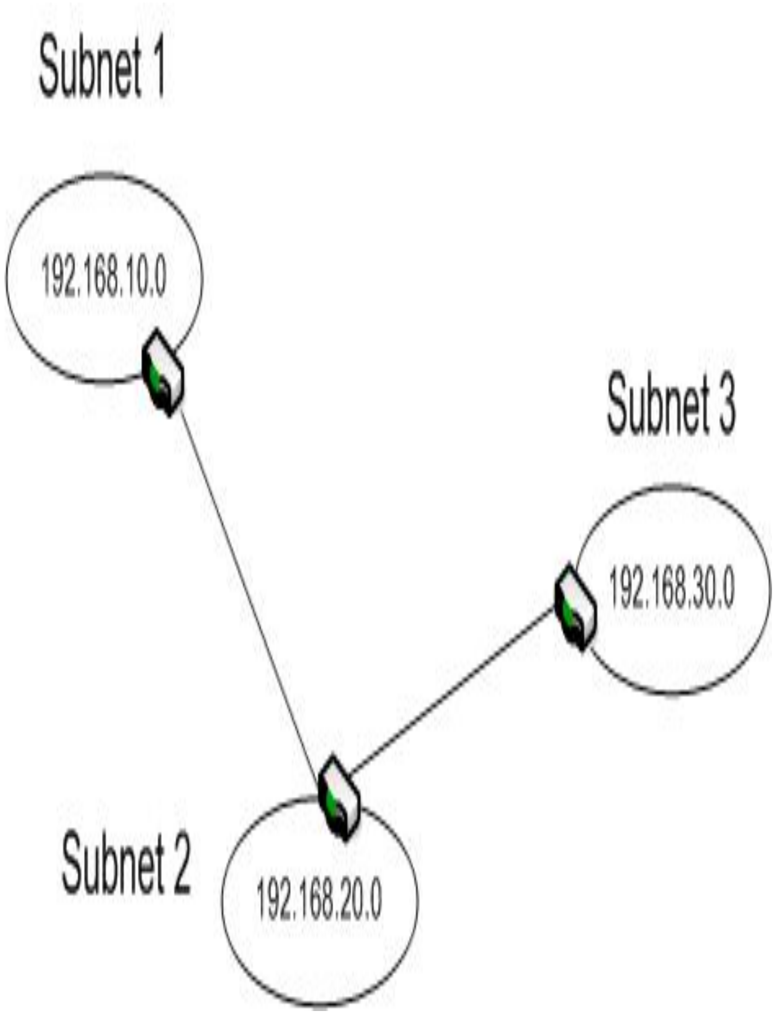
Simple Routed Network

used to divide a network into separate subnets

also referred to as a gateway

with a default gateway

checks the destination address



Router use

Traditionally

- **Manage network traffic.**
- **Isolate network segments.**

supply additional functionality

- **NAT**
- **VPN endpoint**
- **Firewall**
- **Proxy server**

Basic Router Types

software-based hardware-based.

Software router

- Software that implements router services
- Additional services as configured
- Potentially at risk from attacks on Windows
- Possible performance concerns

Hardware router

- Specialized hardware and software
- Improved performance and reliability
- Additional functionally depends on a model.
- Can be very expensive

Software router

standard PC
implements router services

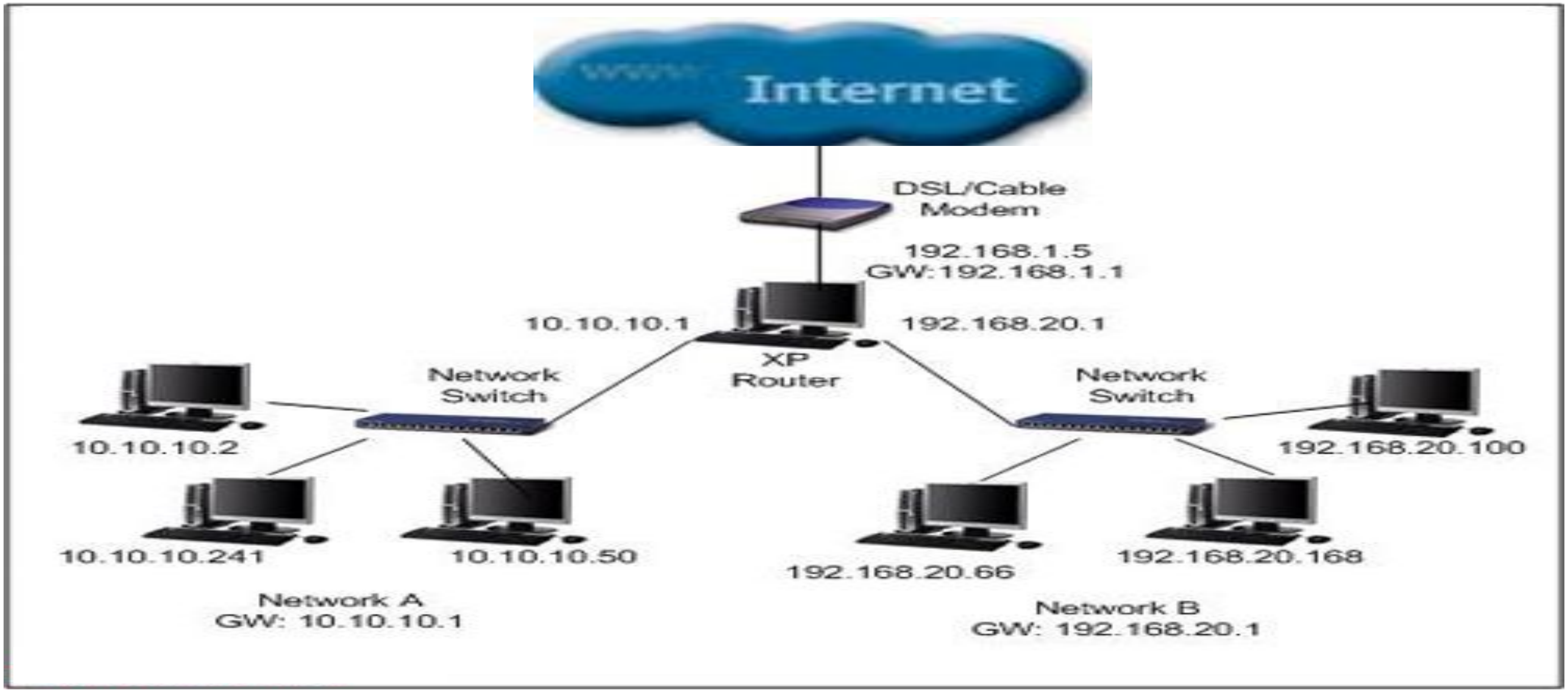
support the RRAS service

Routing and Remote Access (RRAS).

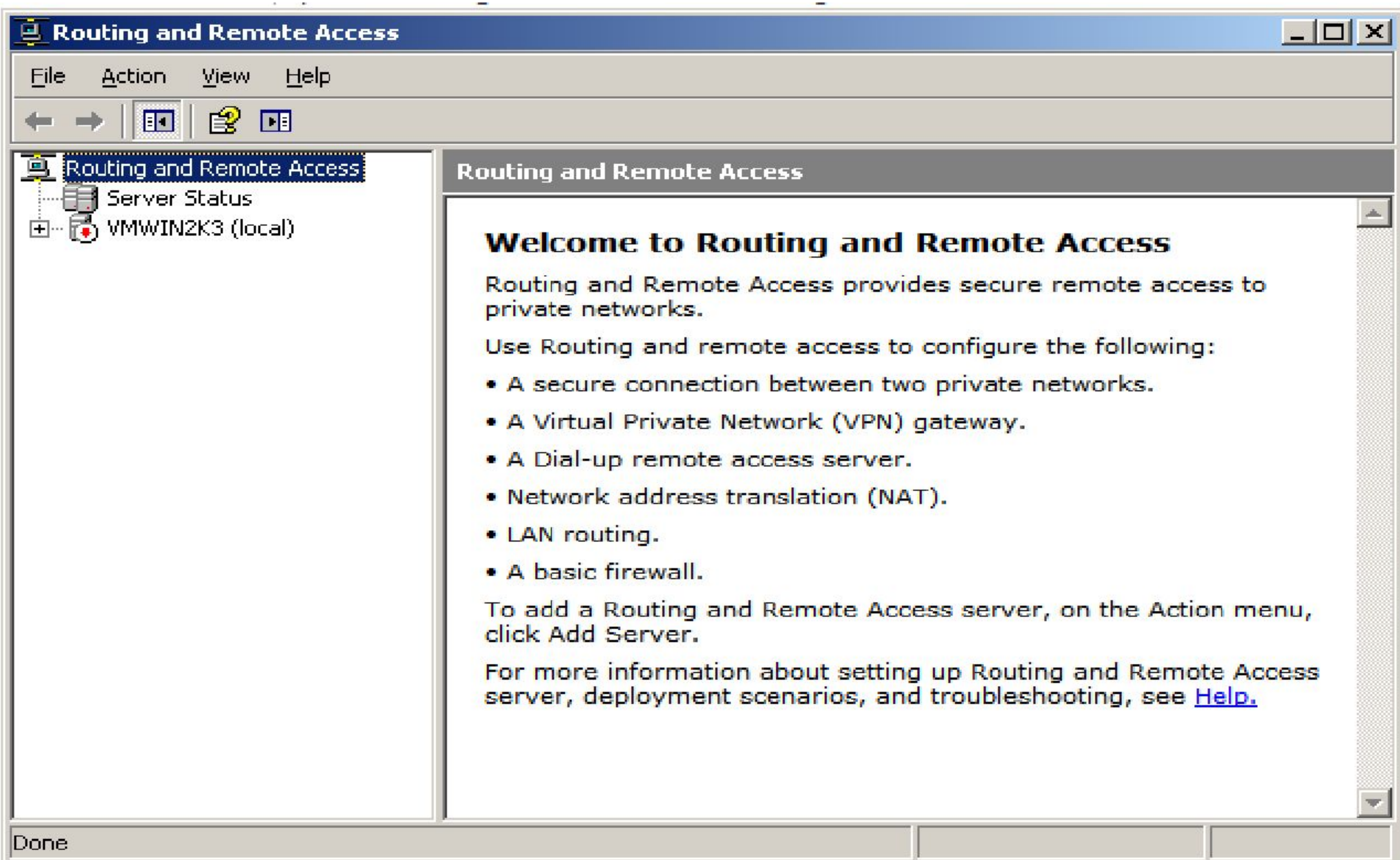
- **Network service that ships with Windows Server operating systems and allows you to configure a server to act as a router. It also provides other network services.**

Routing and Remote Access (RRAS)

which routes IP packets between networks



RRAS Functionality



Hardware router

It is a specialized computer with hardware designed and optimized specifically for routing network traffic. functionality is still provided through software

Dedicated router.

- Network device deployed specifically as a router.

HP Hardware router

- MSR20, MSR30, MSR50,

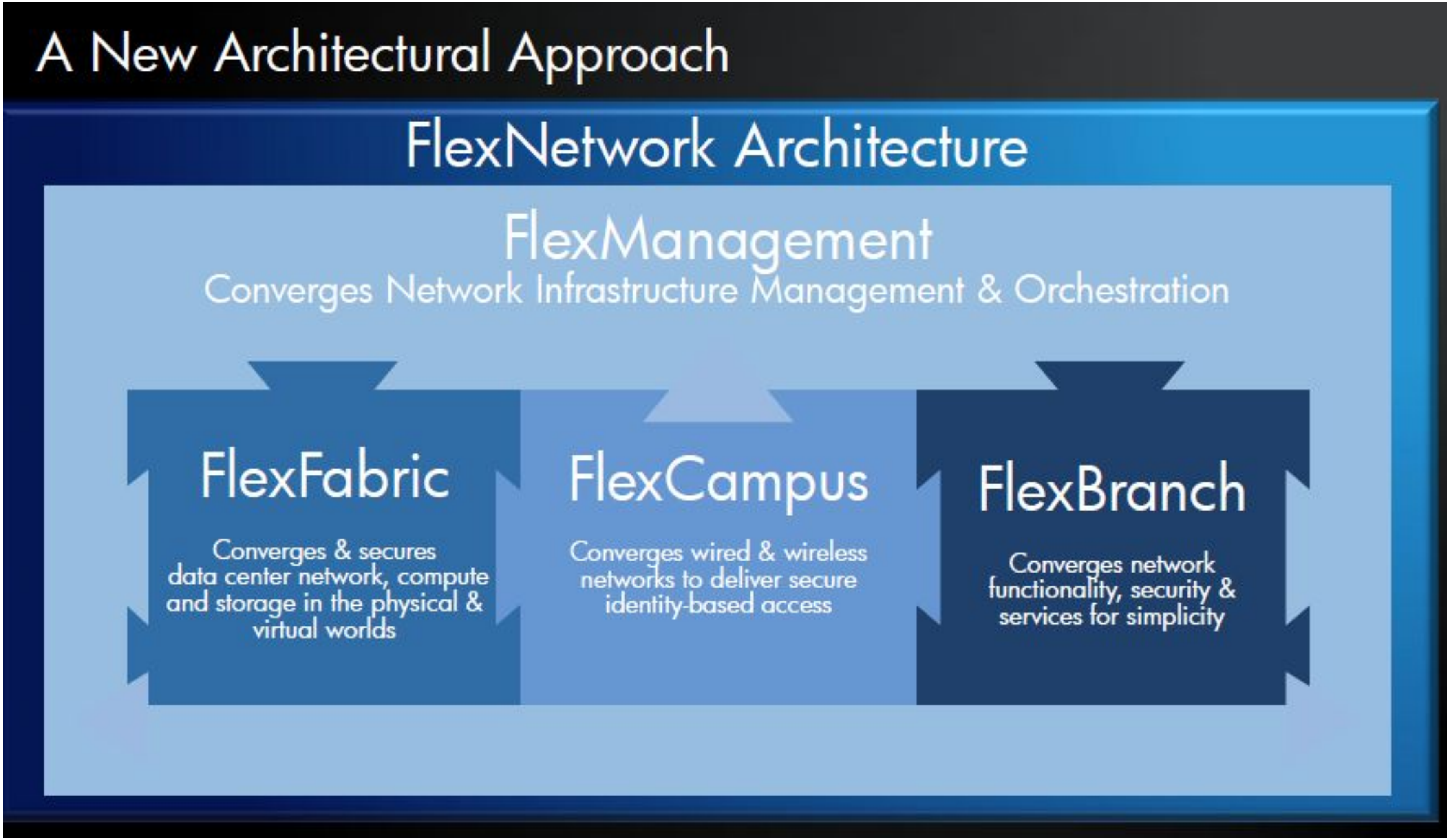
- MSR1000, MSR2000, MSR3000, MSR4000, MSR900, MSR93x

- HSR6600 Router Series, 6600 Router Series

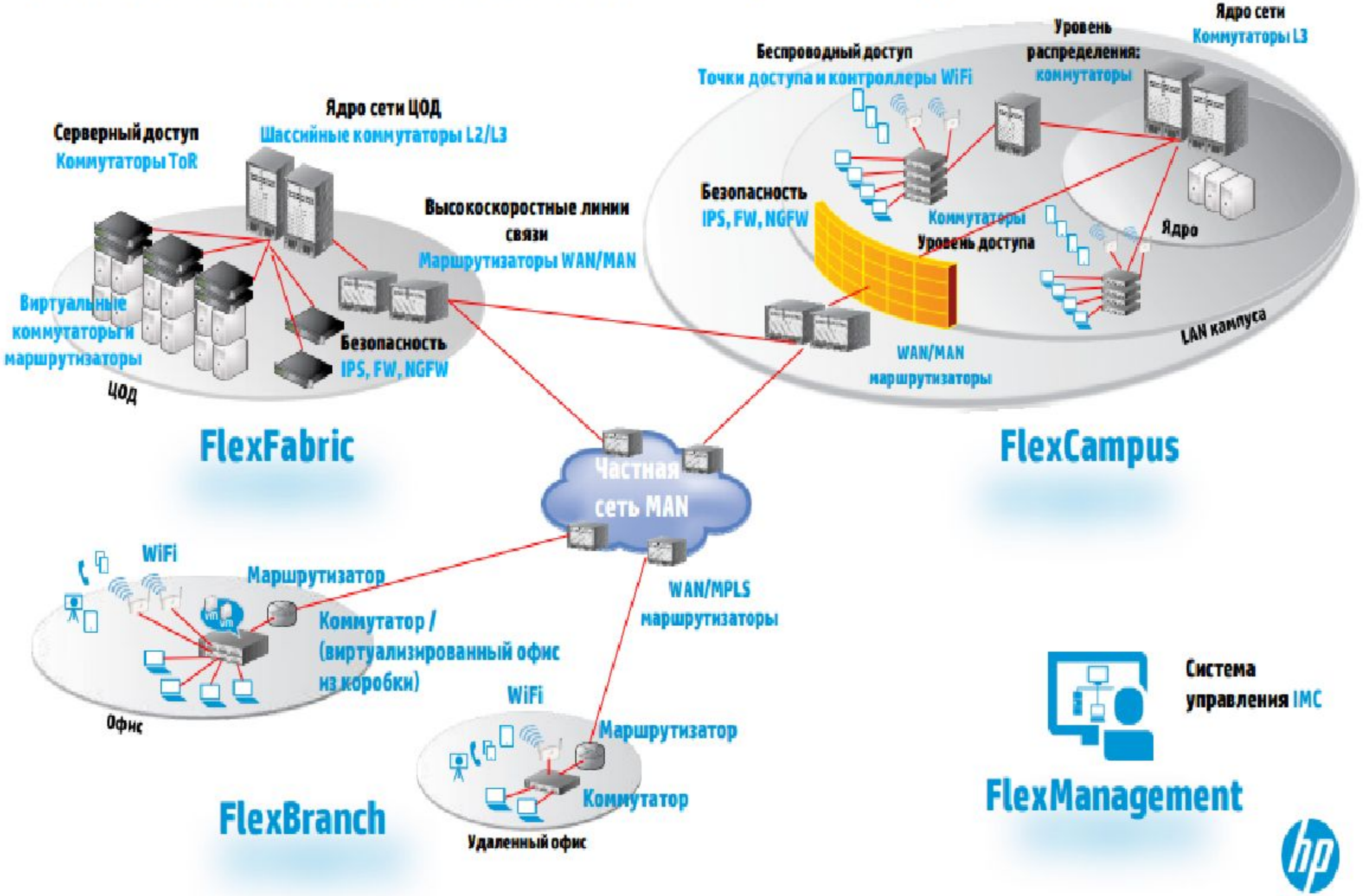
- HSR6800 Router Series, 8800 Router Series

HP MSR20 Series Router

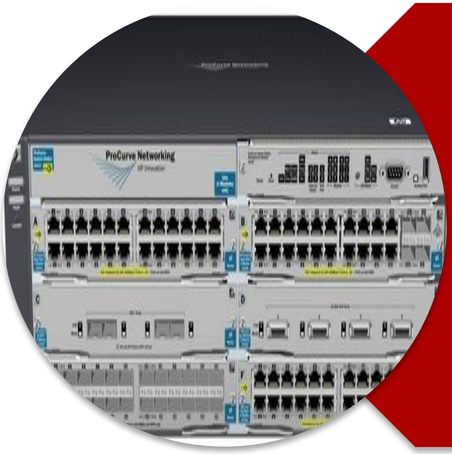
HP FlexNetwork architecture



Решения HP FlexNetwork   Архитектура FlexNetwork



HP FlexNetwork architecture benefits



Routing

Routing

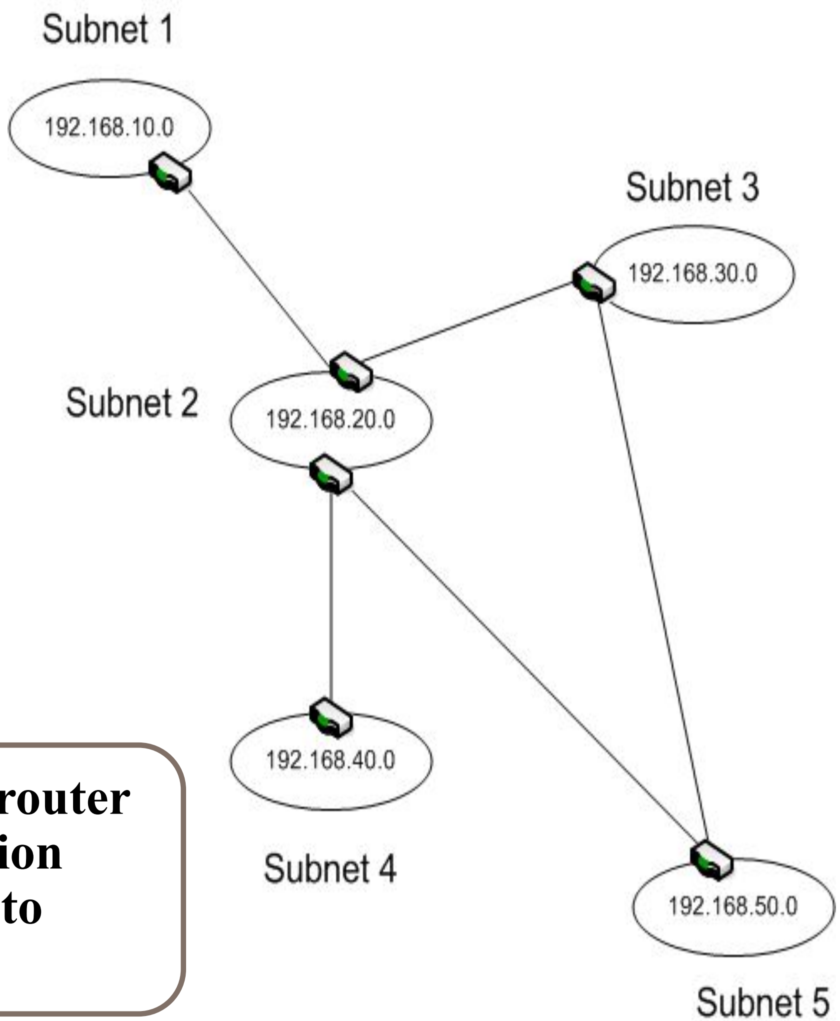
the process of forwarding a packet from its source to its destination

about the destination host's physical location

Route Information

Routers maintain information about routes in an RIB or routing table.

known subnets



- **Table maintained in a router that contains information about routes and used to direct packets.**

Routing table

At minimum, a routing table includes the following

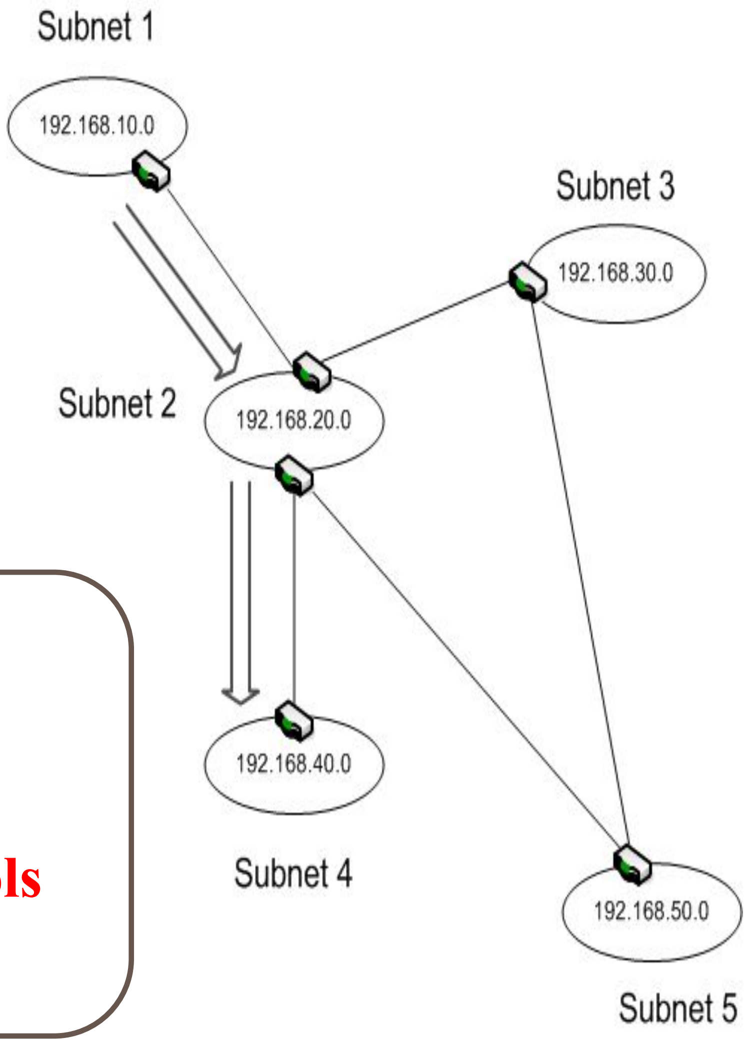
- Destination network ID (IP address and subnet mask)
- Cost (weighting used to determine best router)
- Next hop (next router in the path to the destination)

If the destination is not listed in the routing table, the packet is forwarded to the router's default route (called default gateway).

Unicast Routing Example

Because there are multiple paths, the router must make a decision about the best route to take.

dynamic routing protocols

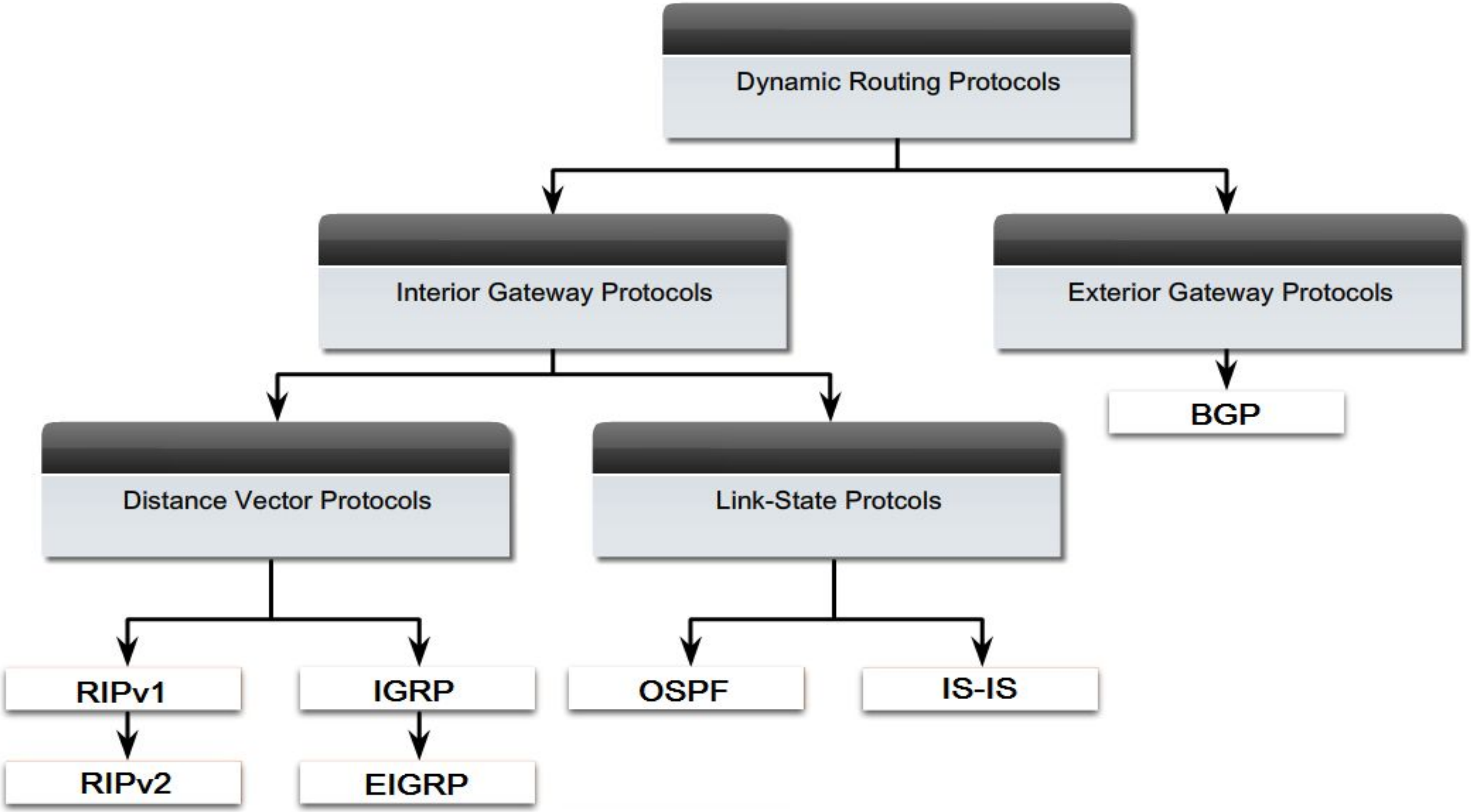


Routing Protocols

two basic types of dynamic routing protocols.

Interior Gateway Protocols (IGP)	• Routing protocols designed to support routers deployed in LAN and WAN environments.
Exterior Gateway Protocols (EGP)	• Routing protocols used to support Internet routers.

Dynamic routing protocols



Interior Gateway Protocols (IGP)

- **Routing Information Protocol.** **Is one of the oldest distance-vector routing protocols which employ the hop count as a routing metric. RIP prevents routing loops by implementing a limit on the number of hops allowed in a path from source to destination.**

- **Open Shortest Path First.** **Is most often used to dynamically manage network routes in large enterprise network. OSPF use link-state algorithms to send routing information to all nodes in an internetwork by calculating the shortest path to each node based on a topology of the Internet constructed by each node.**

- **Interior Gateway Routing Protocol.** **Is a distance vector interior routing protocol (IGP) developed by Cisco. It is used by routers to exchange routing data within an autonomous system.**

- **Intermediate System to Intermediate System.** **Is a routing protocol designed to move information efficiently within a computer network, a group of physically connected computers or similar devices. It accomplishes this by determining the best route for datagrams through a packet-switched network.**

Routing Information Protocol (RIP)

Routing Information Protocol (RIP)

within a single autonomous system

is a distance-vector protocol

uses hop count to determine the best route

It is slow to converge and forces routers to learn network information only from neighbors.

Routing Updates

RIP sends its complete routing table out to all active interfaces

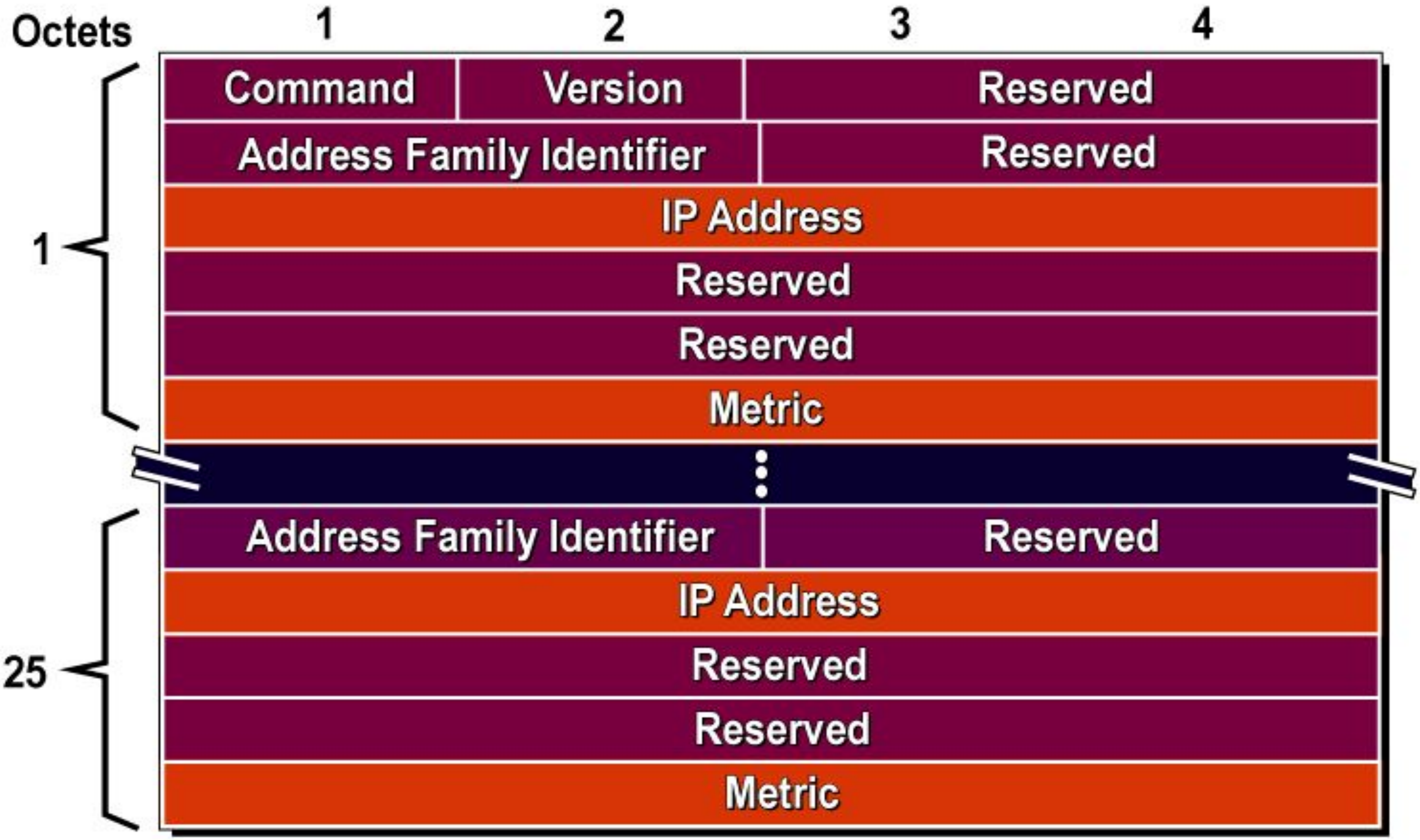
The metric value for the path is increased by one.

the network destination is considered unreachable.

After updating its routing table

[IE-RIP-WP1-08]

RIP Message Format



RIP

- **Command**: Is set to either a Request Message or Response Message
- **Version**: Will be set to one from RIPv1, set to 2 for RIPv2
- **Address Family ID**: Is set to 2 for IP. The exception been is a request for a routers full route table.
- **IP Address**: The IP address of the destination of the route.
- **Metric**: A hop count between 1 and 16.
- **Timer**: The amount of time since the entry was last updated. RIP uses four timers: Update; Invalid; Flush; Hold-down.

RIP Mechanisms

Split horizon	• When a router receives an update through an interface, it is prevented from advertising the route information back out through the same interface. This is done to prevent the creation of routing loops.
poison reverse	• A mechanism used to identify a route as unreachable. This is done by setting the route metric to 16 (which is treated as infinite) before advertising the route. Routers receiving this announcement will remove the route from their routing tables.
Hold-down	• A router will start a timer the first time it receives an update telling it that a route is unreachable. While that timer is counting, the router will ignore any messages that identify the route as reachable. The router can receive updates for the route after the timer expires. The timer defaults to 180 seconds for RIP.

RIP Versions

RIPv1	• Original specification, designed to support classful networks only.
RIPv2	• Released as a replacement for RIPv1, includes added support for CIDR and variable-length subnet masks.
RIPng	• Designed to support IPv6 routing.

RIPv2

similarities between

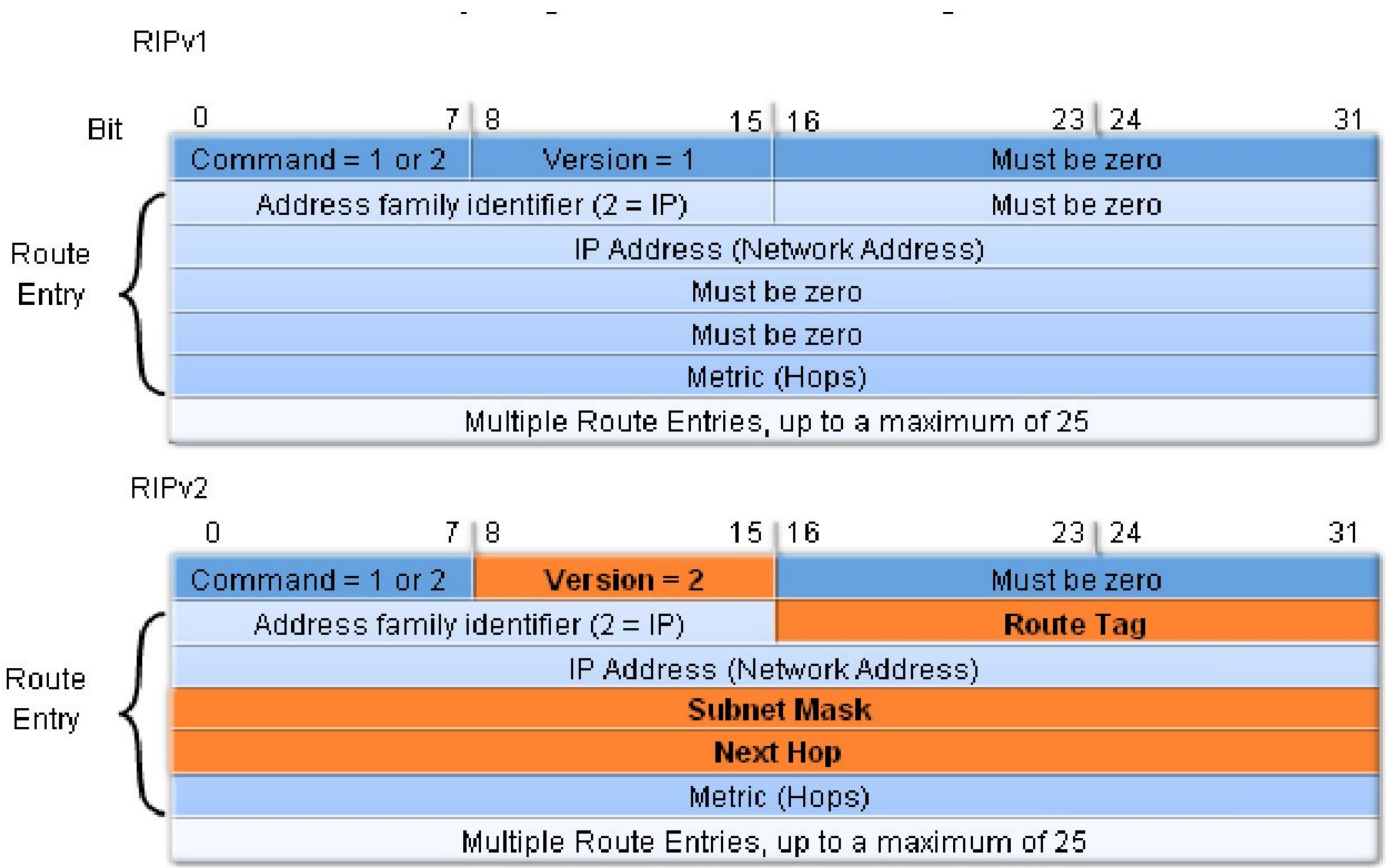
- **Use of the triggered updates while there is the change in a topology for the faster convergence.**
- **Use of the split horizon with poison reverse or split horizon to prevent the routing loops.**
- **Use of the timers and hold-down to prevent the routing loops.**
- **The maximum hop count of 15, with 16 hop count signifying as an unreachable.**

RIPv2

enhanced features

- **RIPv2 added support for variable-length subnet masks and for CIDR.**
- **Next hop addresses are included in a routing update.**
- **Authentication option available, allows packets to be authenticated via either an insecure plain text password or a secure MD5 hash based authentication.**
- **Use of the multicast address in the sending updates. RIPv2 sends updates through multicast transmissions to address 224.0.0.9, reaching all adjacent routers.**

Comparing RIPv1 and RIPv2 Message Formats



RIPng

next generation

distance vector algorithm

entirely separate routing protocol

for IPv6-based networks

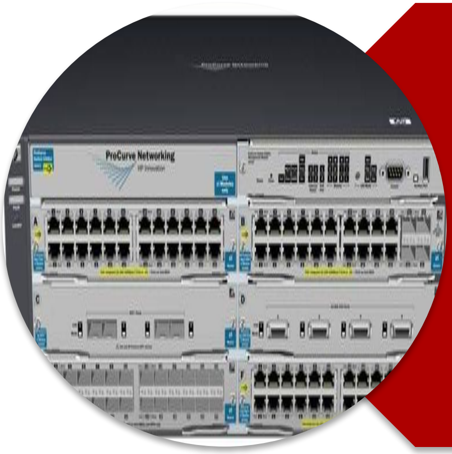
Distance-vector protocols problems

Distance-vector protocols are susceptible to two main problems.

- **First, they can form routing loops.**
- **Second, they can be slow to converge.**

Convergence

The limitations inherent in distance-vector protocols such as RIP and the lack of a standard routing protocol suitable for use in large internets are in large part responsible for the development of OSPF.



Routing

OSPF definition

open-standard

large

enterprise network

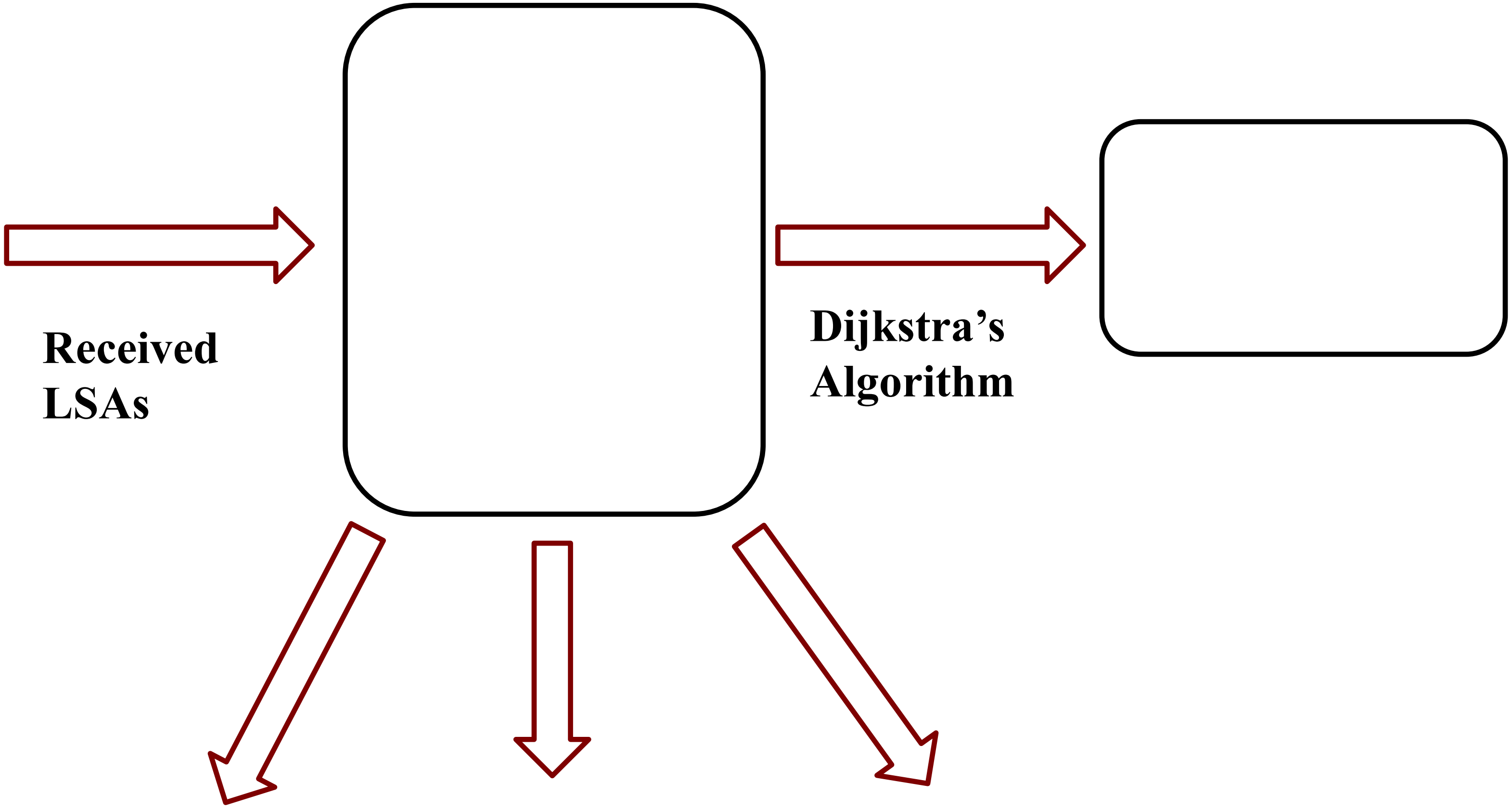
a link-state routing protocol

can make more informed routing decisions

Link State Routing: Basic principles

- OSPF employs a hierarchical network design using Areas.
- OSPF will form neighbor relationships with adjacent |əˈdʒeɪs(ə)nt| routers in the same Area.
- OSPF advertises |ˈadvətʌɪz| the status of directly connected links using Link-State Advertisements |ədˈvəːtɪzm(ə)nt| (LSAs).
- OSPF sends updates (LSAs) when there is a change to one of its links, and will only send the change in the update. LSAs are additionally refreshed every 30 minutes.
- OSPF traffic is multicast either to address 224.0.0.5 (all OSPF routers) or 224.0.0.6 (all Designated Routers).
- Each router maintains a database of all received LSAs (LSDB), which describes the network has a graph with weighted.
- OSPF uses the Dijkstra Shortest Path First algorithm to determine the shortest path.

Operation of a Link State Routing protocol

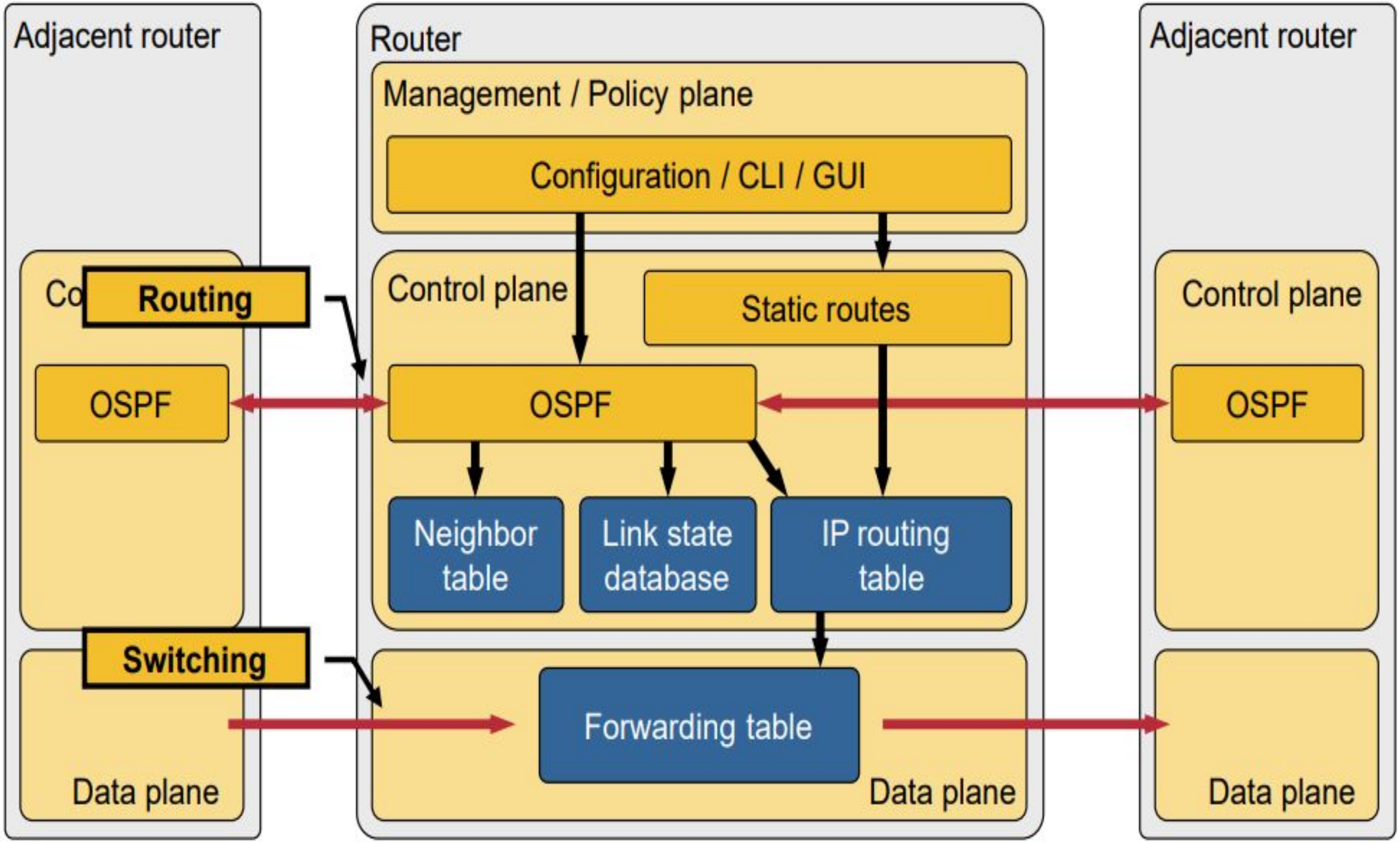


LSAs are flooded to other interfaces

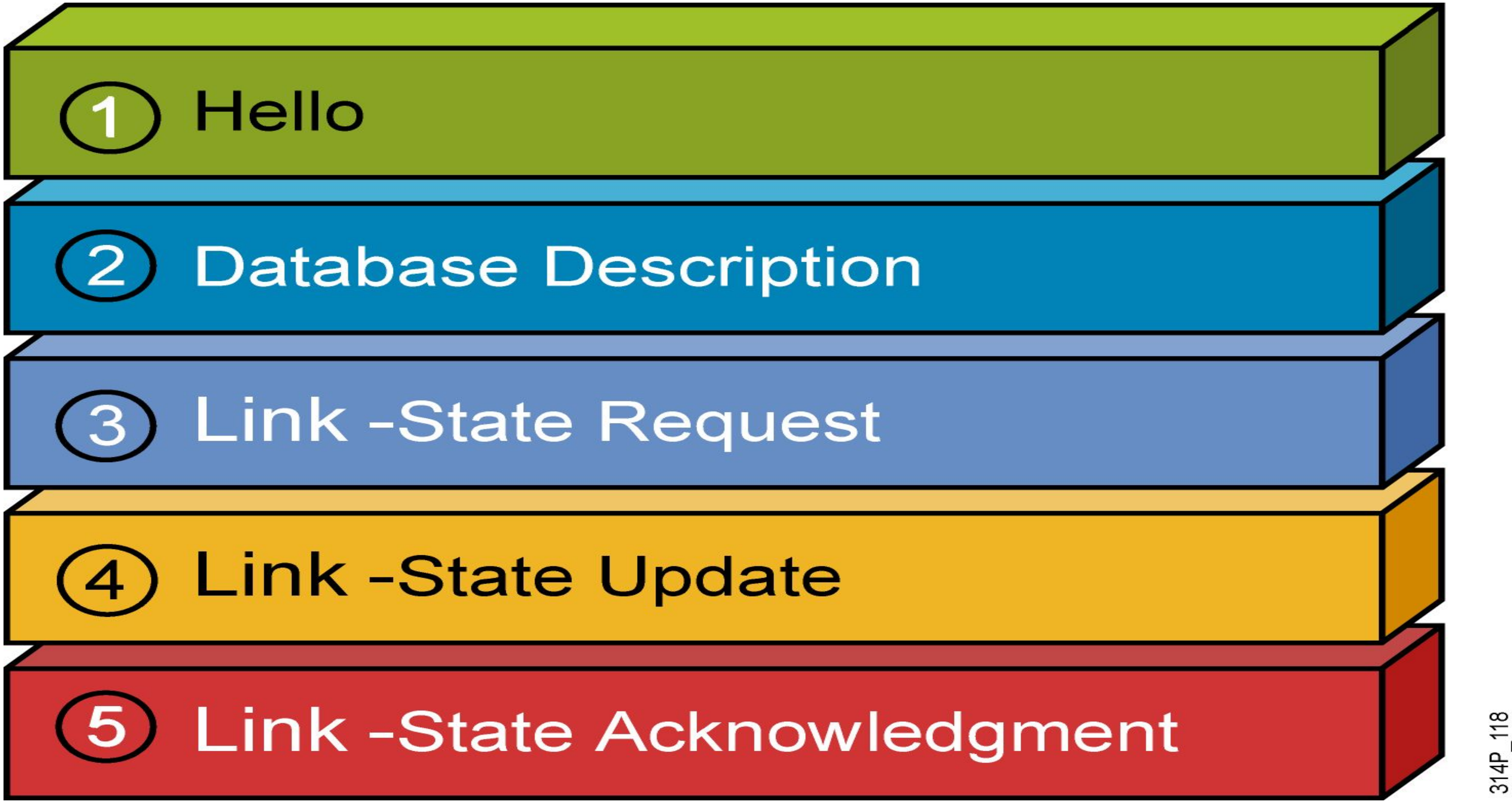
The OSPF process builds and maintains three separate tables:

- **A neighbor table – contains a list of all neighboring routers.**
- **A topology table (Link State Database (LSDB) – contains a list of all possible routes to all known networks within an area.**
- **A routing table – contains the best route for each known network.**

Operation of a Link State Routing protocol



OSPF uses five types of routing protocol packets



OSPF uses five types of routing protocol packets

Hello packets

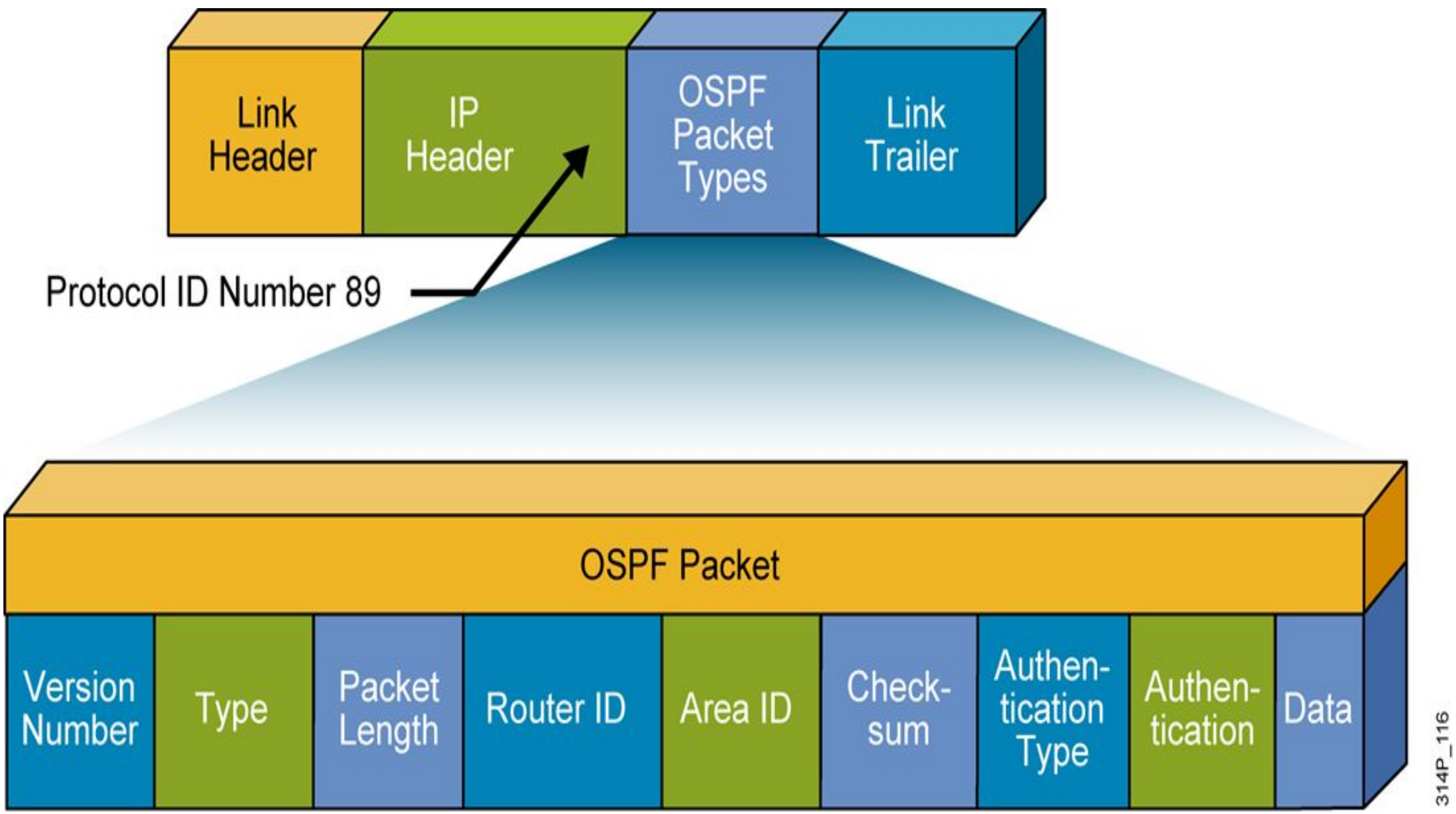
Database Descriptor (DBD)

Link State Requests (LSR)

Link State update (LSU)

Link-state acknowledgements (LSAck)

OSPF Packet Format

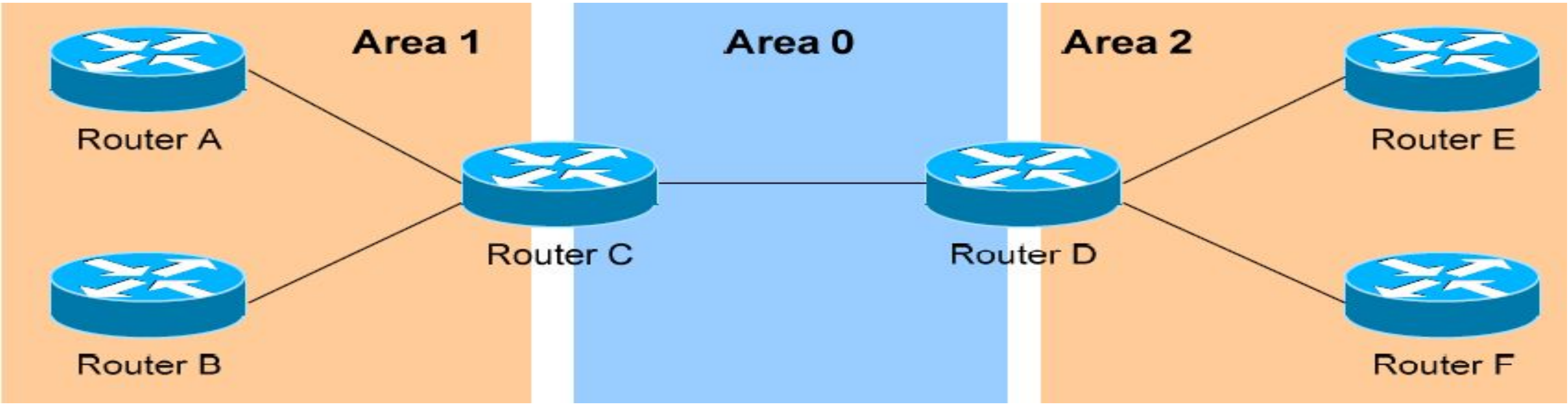


- **Version** - All packets are assumed to be version 2.
- **Type** - There are five packet types, numbered 1 to 5.
- **Packet Length** - The length in bytes.
- **Router ID** - 32-bit identifier for the router.
- **Area ID** - 32-bit identifier for the area.
- **Checksum** - Standard 16-bit checksum.
- **Authentication Type** - OSPFv2 supports three authentication methods: no authentication; plaintext passwords; MD5 hashes.
- **Authentication Data** - 64-bit data, either empty, with a plain-text word, or with a “message digest” of a shared secret.
- **Data** - Values being communicated.

How OSPF Packet Processes Work

The OSPF Hierarchy

separates an Autonomous System into individual areas.



Topology Database

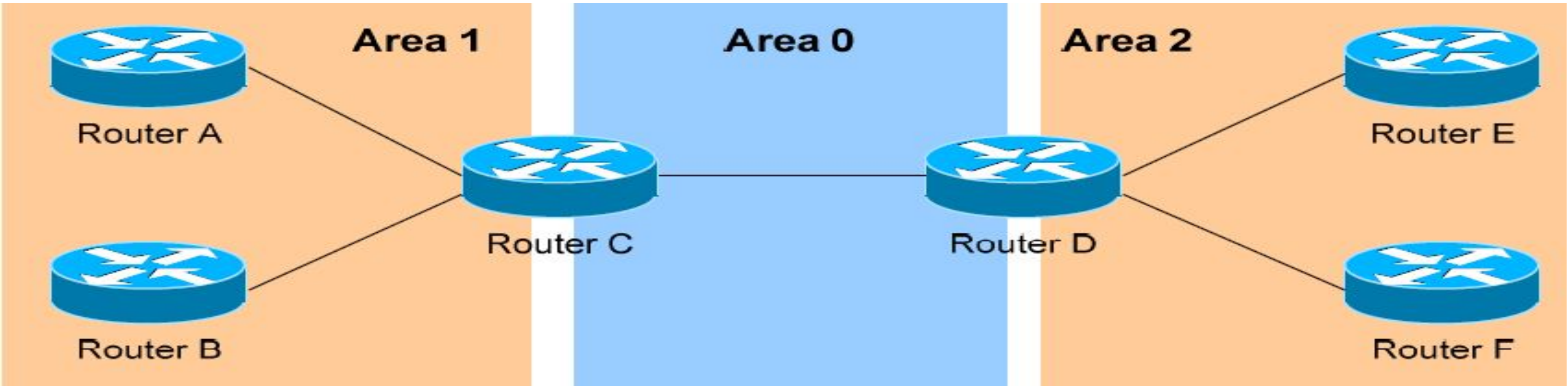
all routers within an area will have an identical topology database

conserves bandwidth and reduces CPU loads

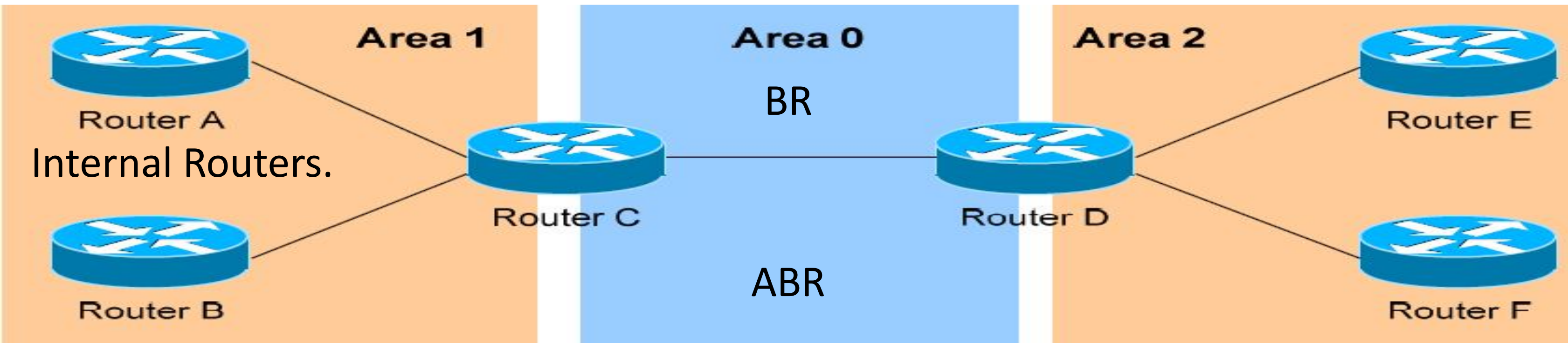
The OSPF Hierarchy

"Backbone" area

Area 0 is often referred to as the transit area to connect all other areas.



The OSPF Hierarchy



Area 0, Area 1, and Area 2.

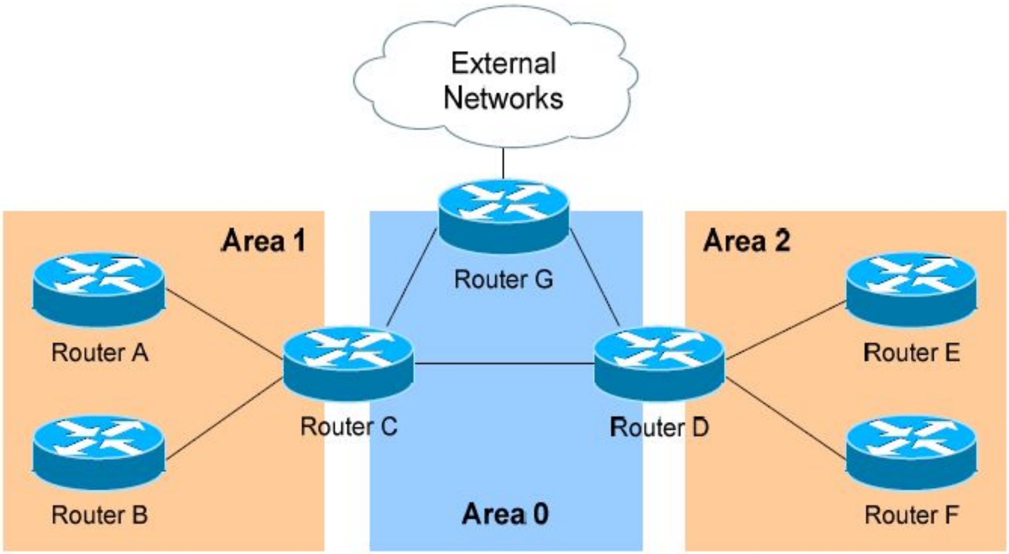
backbone area

Internal Routers.

Area Border Routers (ABR) and will thus contain separate Topology databases for each area.

Backbone Router (BR).

The OSPF Hierarchy



Router G

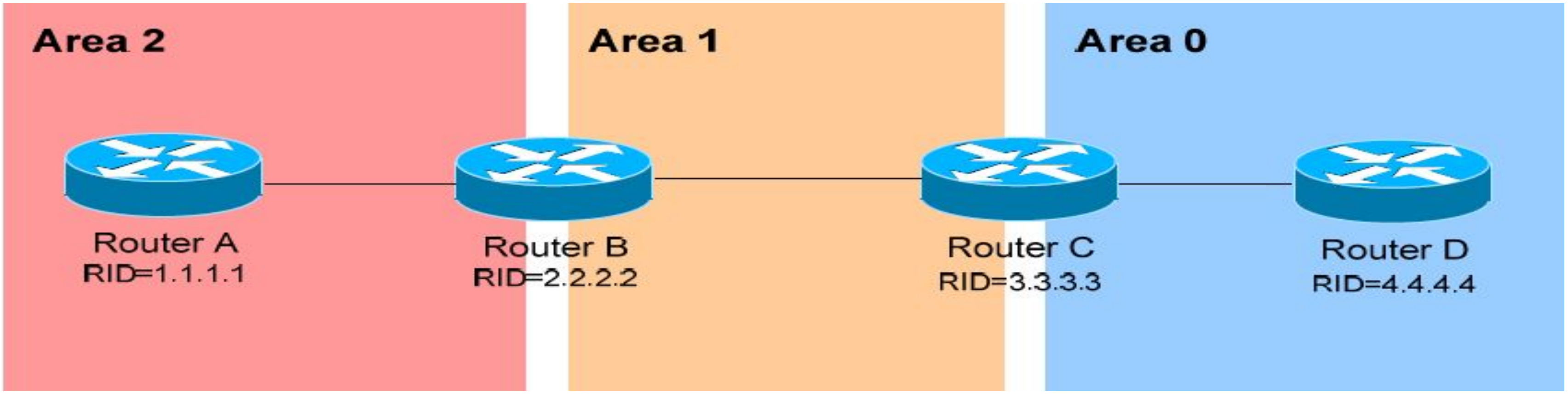
Autonomous System Border Router (ASBR).

Type 2 (E2)	• **Includes only the external cost to the destination network. External cost is the metric being advertised from outside the OSPF domain.**
Type 1 (E1)	• **Includes both the external cost, and the internal cost to reach the ASBR. Type 1 routes are always preferred over Type 2 routes to the same destination.**

OSPF router types

Internal Routers	• all router interfaces belong to only one Area.
Area Border Routers (ABRs)	• contains interfaces in at least two separate areas
Backbone Routers	• contain at least one interface in Area 0
Autonomous System Border Routers (ASBRs)	• contain a connection to a separate Autonomous System

OSPF Virtual Links



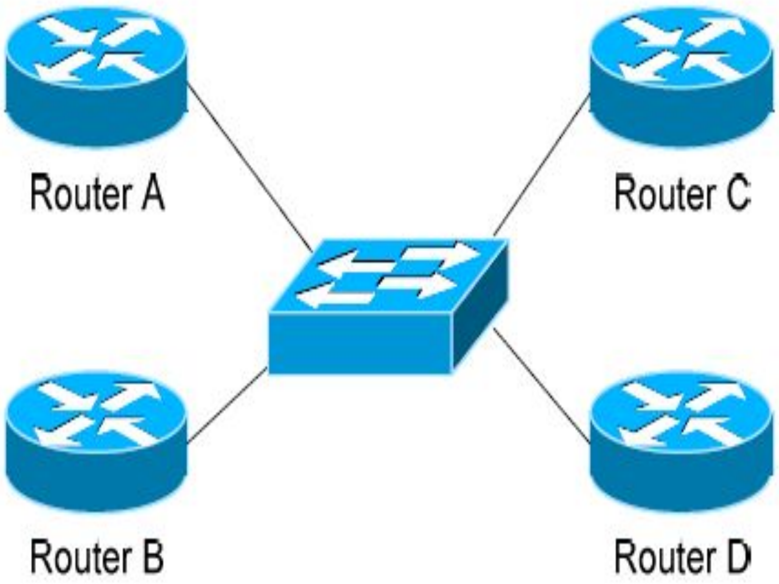
all areas must directly connect into Area 0
Area 2 has no direct connection to Area 0

Virtual links can be used as a workaround, to logically connect separated areas to Area 0.
create a tunnel from Area 2 to Area 0, using Area 1 a transit area.

OSPF Designated Routers

many neighbor relationships on the same physical segment

Six separate adjacencies are needed for a fully meshed network



Designated Router (DR)

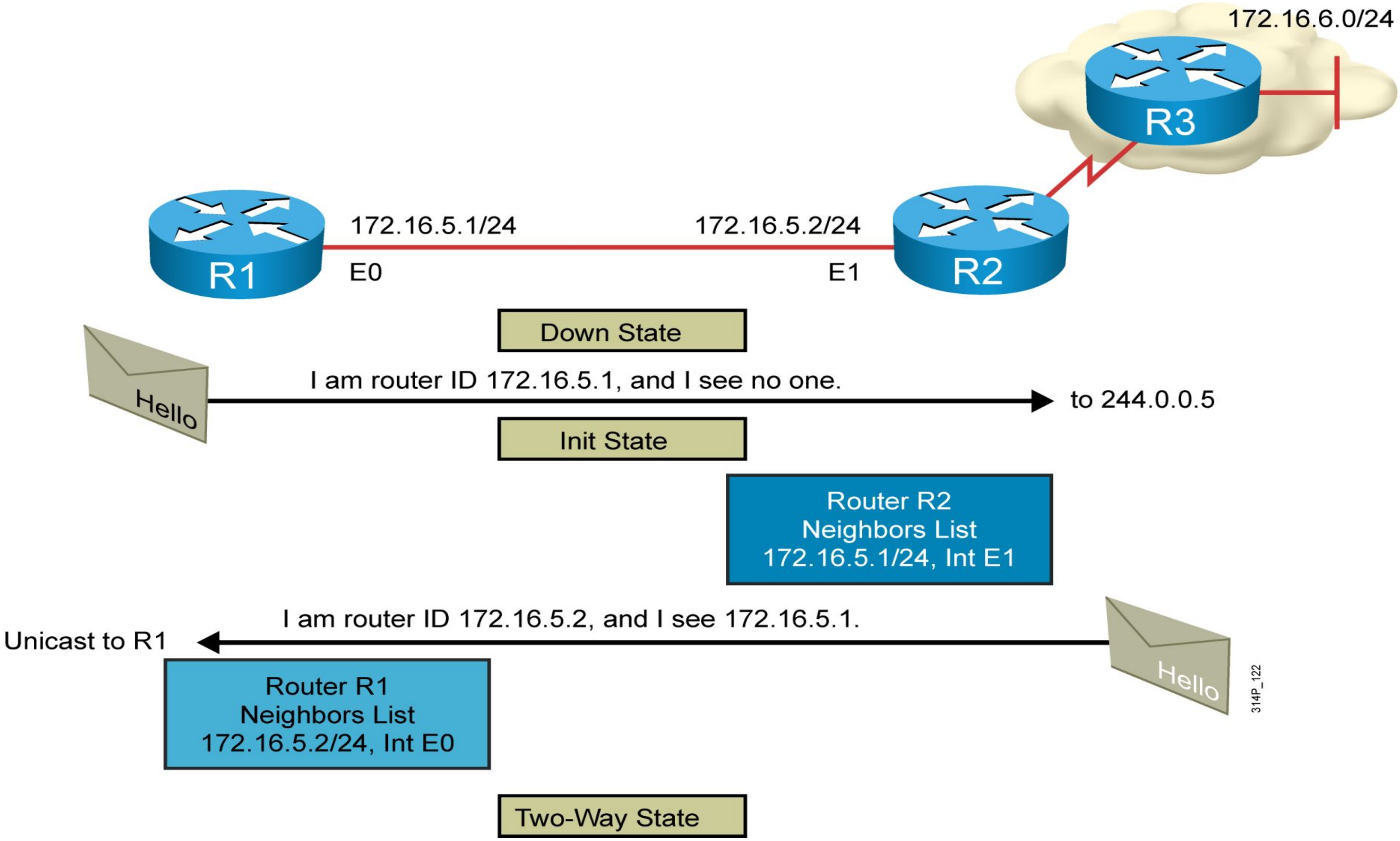
Backup Designated Router (BDR)

OSPF Routing Update Packets

LSDB synchronization process

- Discover neighbor
- Establish bidirectional communication
- Elect a designated router, if desired
- Form an adjacency
- Discover the network routes
- Update and synchronize link-state databases

Establishing Bidirectional Communication



OSPF Neighbor States

- **Down:** no active neighbor detected
- **INIT [ɪˈnɪʃ]:** hello packet received
- **Two-way:** indicates that bidirectional communication has been established, Designated and Backup Designated Routers are elected

OSPF Neighbors

forms neighbor relationships
in the same Area by exchanging Hello packets

, Hello packets are sent out OSPF-enabled interfaces
every 10 seconds and
30 seconds

Dead Interval

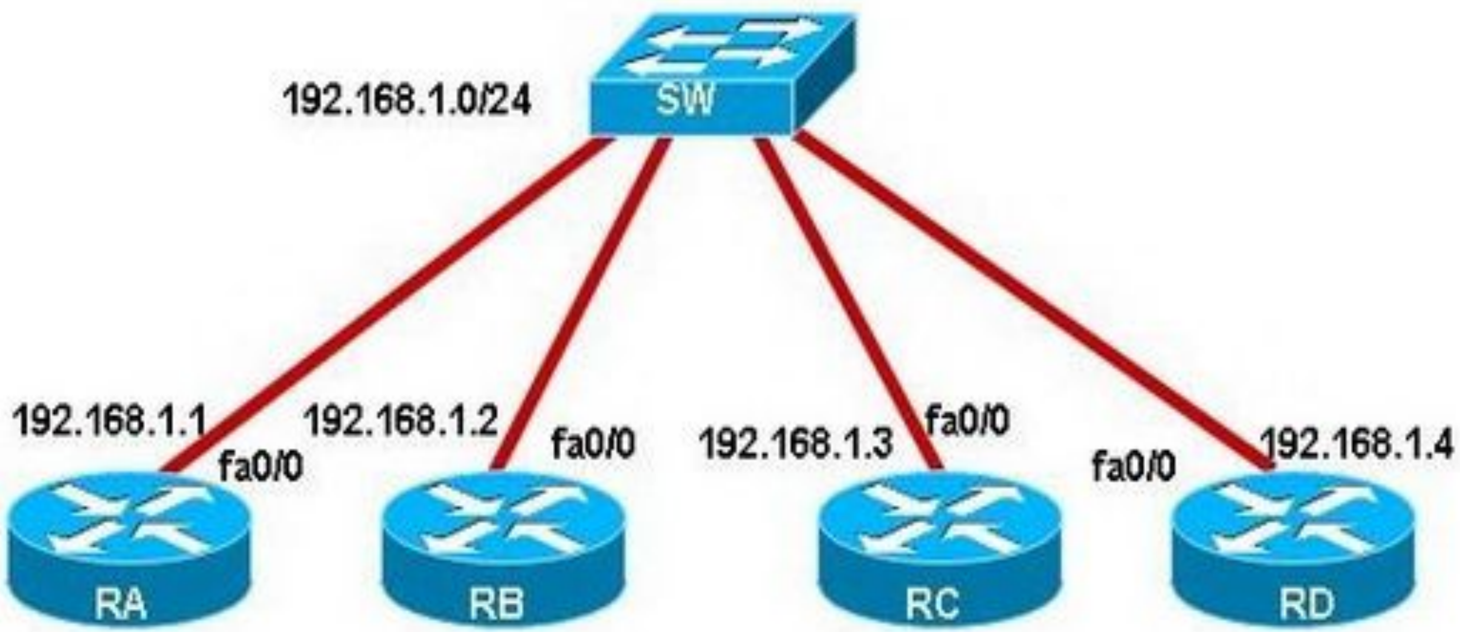
40 seconds
for broadcast and point-to-point interfaces, and 120 seconds

Neighbor table

A neighbor table is constructed from the OSPF Hello packets

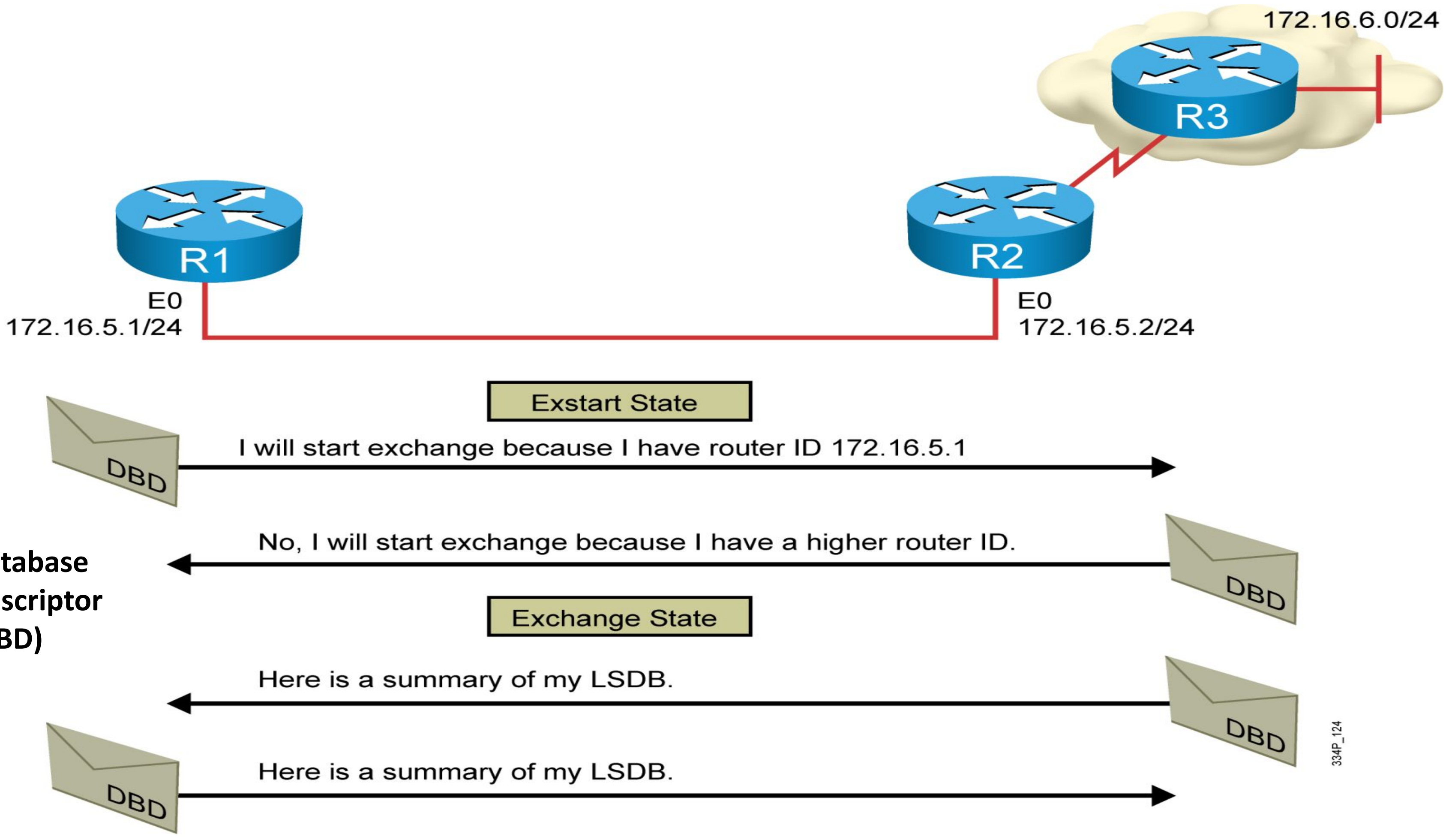
- **The Router ID of each neighboring router**
- **The current "state" of each neighboring router**
- **The interface directly connecting to each neighbor**
- **The IP address of the remote interface of each neighbor**

Neighbor table




```
RA# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
192.168.1.3       1   FULL/BDR        00:00:32    192.168.1.3     FastEthernet0/0
192.168.1.2       1   2WAY/DROTHER    00:00:32    192.168.1.2     FastEthernet0/0
192.168.1.4       1   FULL/DR         00:00:32    192.168.1.4     FastEthernet0/0
```

Discovering the Network Routes

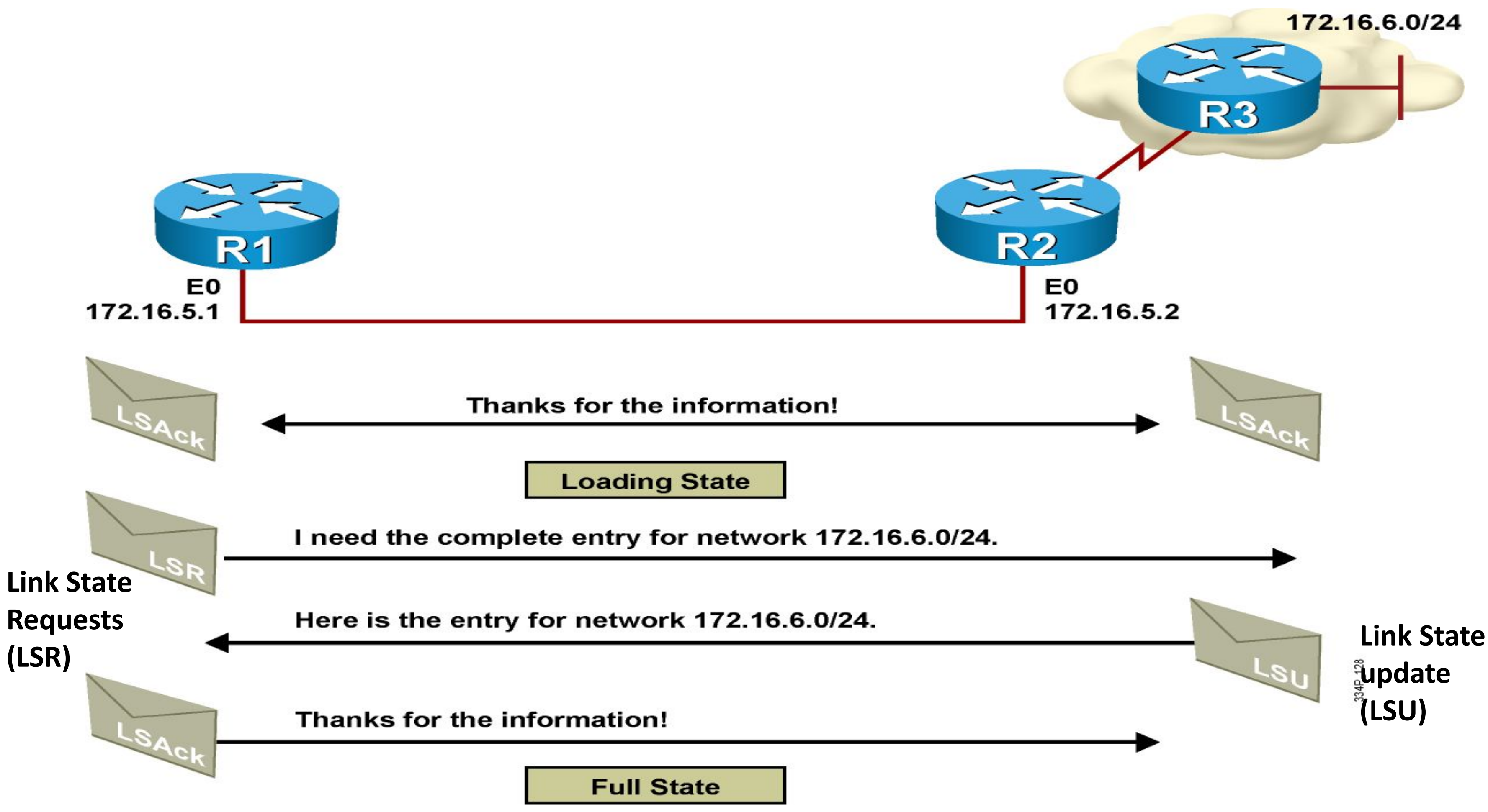


Database Descriptor (DBD)

OSPF Neighbor States

- **Exstart:** indicates that the routers are preparing to share link state information, master and slave roles determined
- **Exchange:** indicates that the routers are exchanging Database Descriptors (DBDs), DBDs contain a description of the router's Topology Database

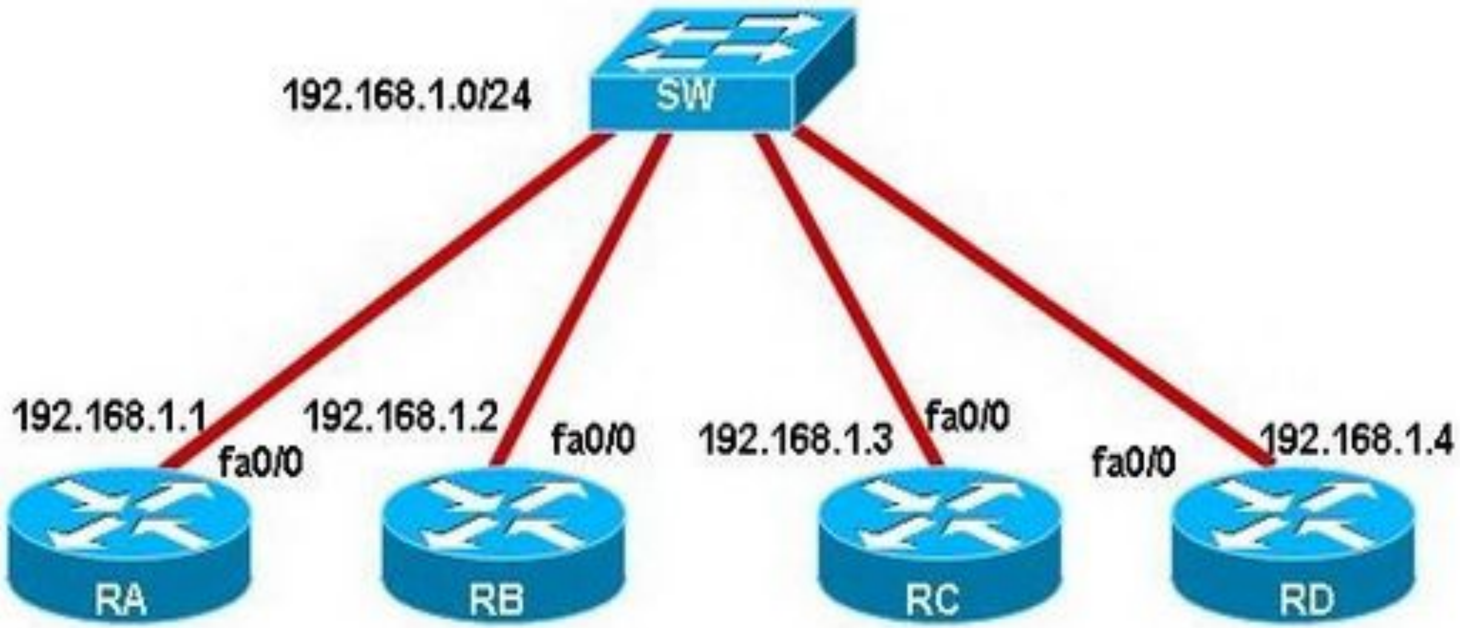
Adding the Link-State Entries



OSPF Neighbor States

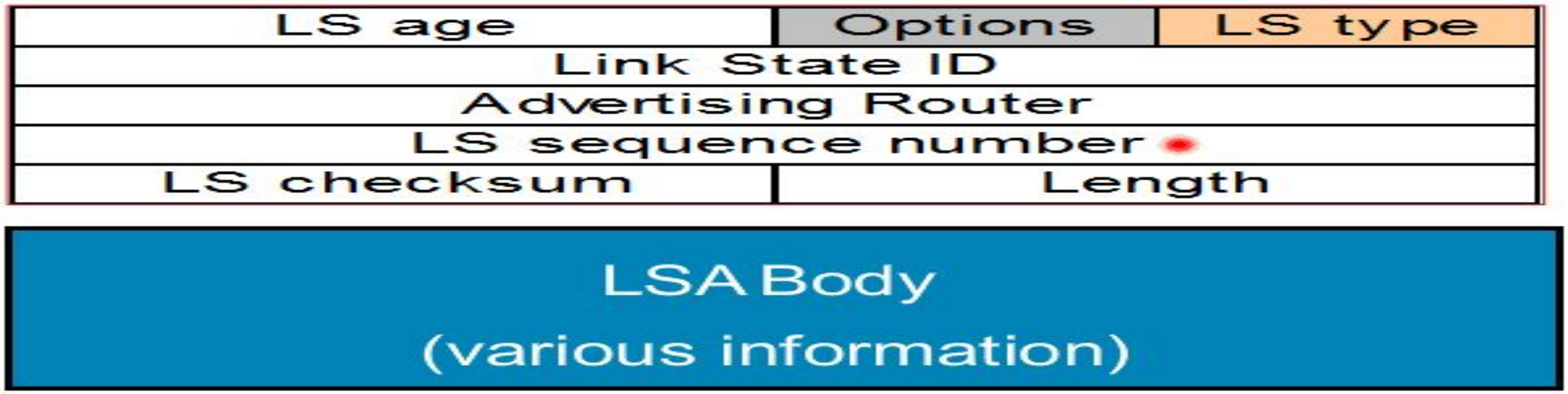
- **Loading:** indicates the routers are finally exchanging Link State Advertisements (LSA), containing information about all links connected to each router, exchange of LSRs and LSUs
- **Full:** indicates that the routers are fully synchronized, the topology table of all routers in the area should now be identical. Its databases are synchronized with adjacent routers.

Neighbor table




```
RA# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time    Address         Interface
192.168.1.3       1   FULL/BDR        00:00:32     192.168.1.3     FastEthernet0/0
192.168.1.2       1   2WAY/DROTHER    00:00:32     192.168.1.2     FastEthernet0/0
192.168.1.4       1   FULL/DR         00:00:32     192.168.1.4     FastEthernet0/0
```

Link State Advertisements (LSA)



LS Age: By default an LSA has a maximum age of 3600 seconds.
Options: (E-bit) -Indicates that this area allows external LSAs, this is a normal area and it is not a stub area.
LS Type: Type of LSA
Link State ID: Varies depending on the kind of LSA.
Advertising Router: Router that is advertising this LSA. This is a 32 bit number.
LS Sequence number: Initial Sequence number of an LSA.
LS Checksum
Length

LSA Body

the specific fields of which depend on the value of the LS Type field

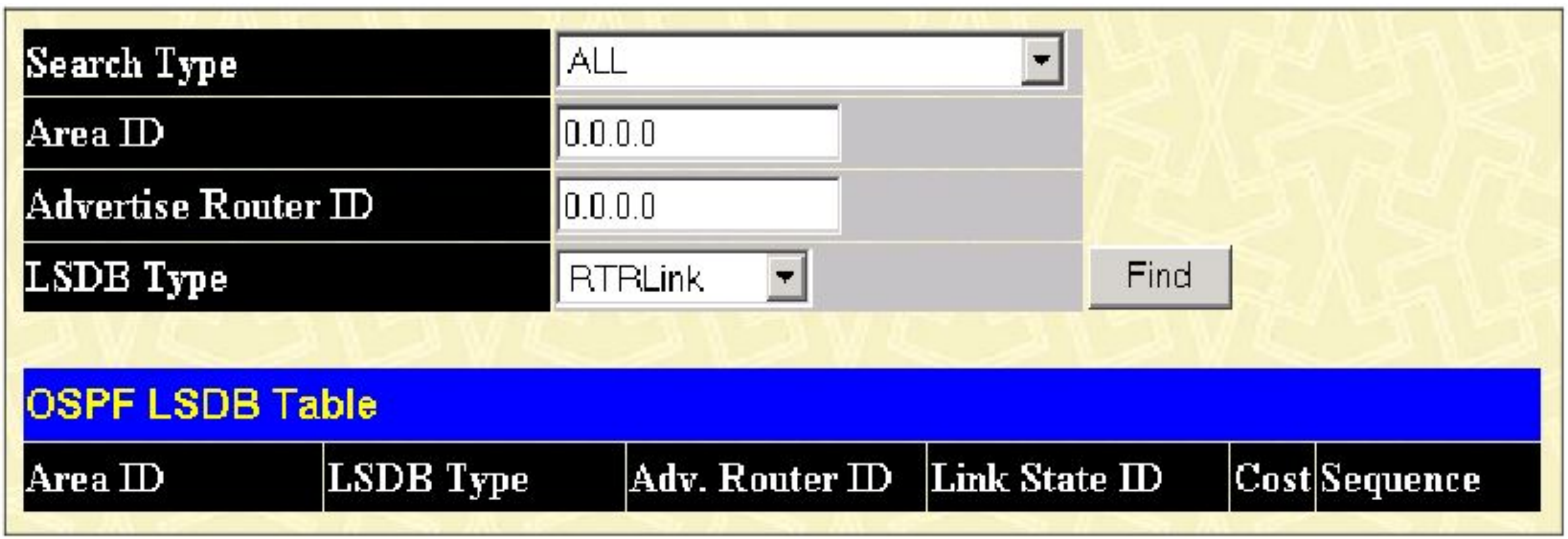
- For normal links to a router, the LSA includes an identification of the router and the metric to reach it, as well as details about the router such as whether it is a boundary or area border router.
- LSAs for networks include a subnet mask and information about other routers on the network.
- Summary LSAs include a metric and a summarized address, as well as a subnet mask.
- External LSAs include a number of additional fields to allow the external router to be communicated.

LSA types

- Represents a router
- Represents the designated router for a multi access link
- A network link summary (internal route)
- Represents an ASBR
- A route external to the OSPF domain
- Used in stub areas in place of a type 5 LSA

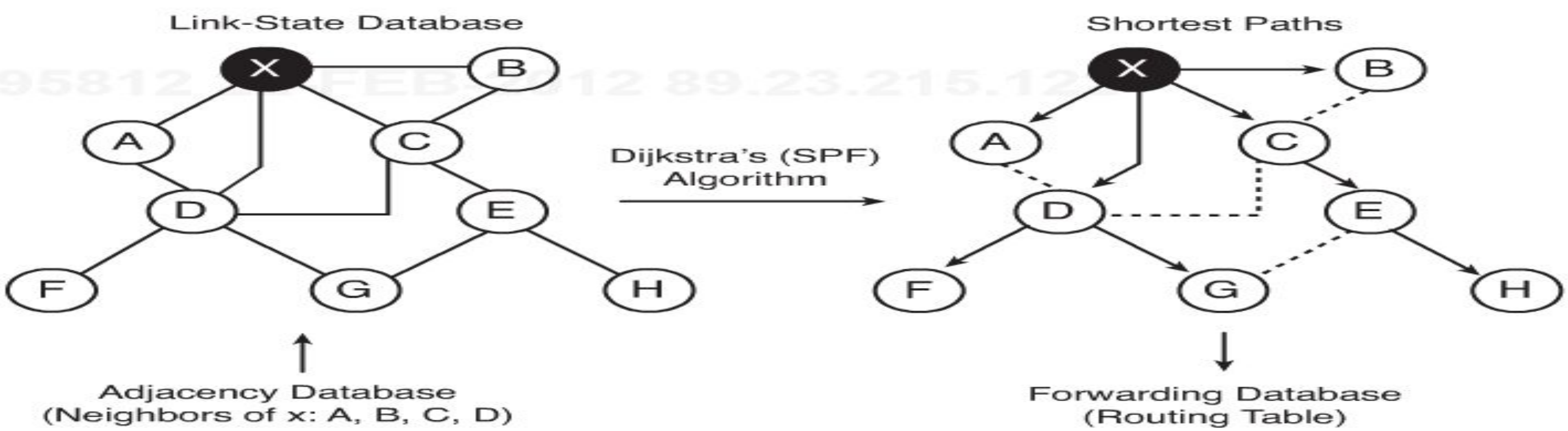
Link State Database (LSDB)

is a database of all OSPF router LSAs



Use SPF algorithm to select best path

it runs the Dijkstra Shortest Path First algorithm



•Assume all links are FastEthernet, with an OSPF cost of 1.

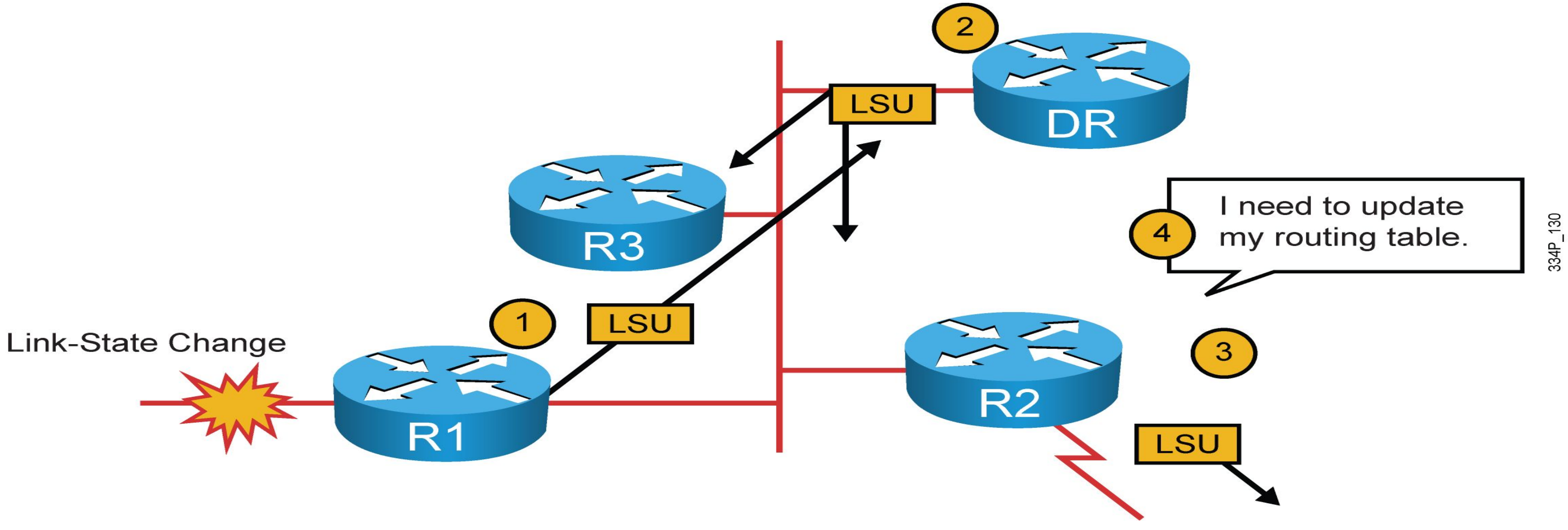
Routing table

RRAS-ROUTER1 - IP Routing Table

Destination	Network mask	Gateway	Interface	Metric	Protocol
10.57.76.0	255.255.255.0	10.57.76.1	Local Area C...	1	Local
10.57.76.1	255.255.255.255	127.0.0.1	Loopback	1	Local
10.255.255.255	255.255.255.255	10.57.76.1	Local Area C...	1	Local
127.0.0.0	255.0.0.0	127.0.0.1	Loopback	1	Local
127.0.0.1	255.255.255.255	127.0.0.1	Loopback	1	Local
192.168.45.0	255.255.255.0	192.168.45.1	Local Area C...	1	Local
192.168.45.1	255.255.255.255	127.0.0.1	Loopback	1	Local
224.0.0.0	224.0.0.0	192.168.45.1	Local Area C...	1	Local
224.0.0.0	224.0.0.0	10.57.76.1	Local Area C...	1	Local
255.255.255.255	255.255.255.255	192.168.45.1	Local Area C...	1	Local
255.255.255.255	255.255.255.255	10.57.76.1	Local Area C...	1	Local

Flooding Changes in Topology

- Router R1 notifies all OSPF neighbors using 224.0.0.5, or, on LAN links, all OSPF DRs and BDRs using 224.0.0.6.
- The DR notifies others on 224.0.0.5.
- The LSDBs of all routers must be synchronized.



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