



Introduction to IP Multicast

RST-1261

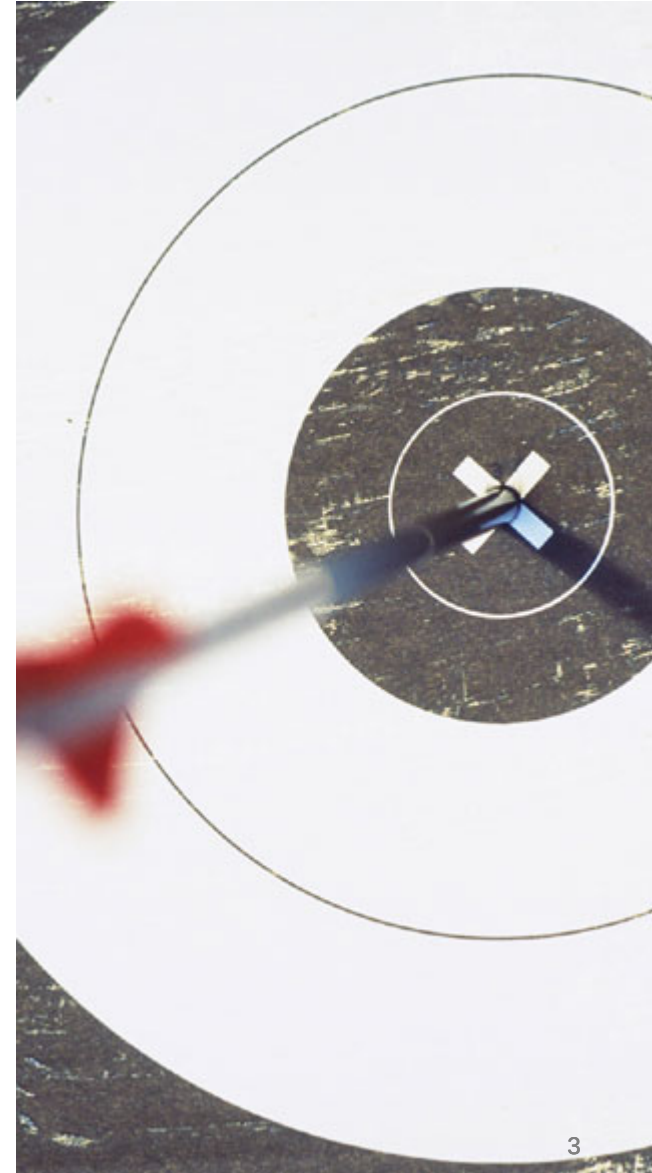
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IP Multicast at Networkers 2006

- **RST-1261 Introduction to IP Multicast**
- **RST-2261 Deploying IP Multicast**
- **RST-2262 Multicast Security**
- **RST-2263 Multicast Network Management**
- **RST-3261 Advanced IP Multicast**
- **RST-3262 IP Multicast Architecture & Troubleshooting for the Catalyst 6500**
- **TECRST-1008 Enterprise IP Multicast**

Session Goal

To provide you with a thorough understanding of the concepts, mechanics and protocols used to build IP Multicast networks



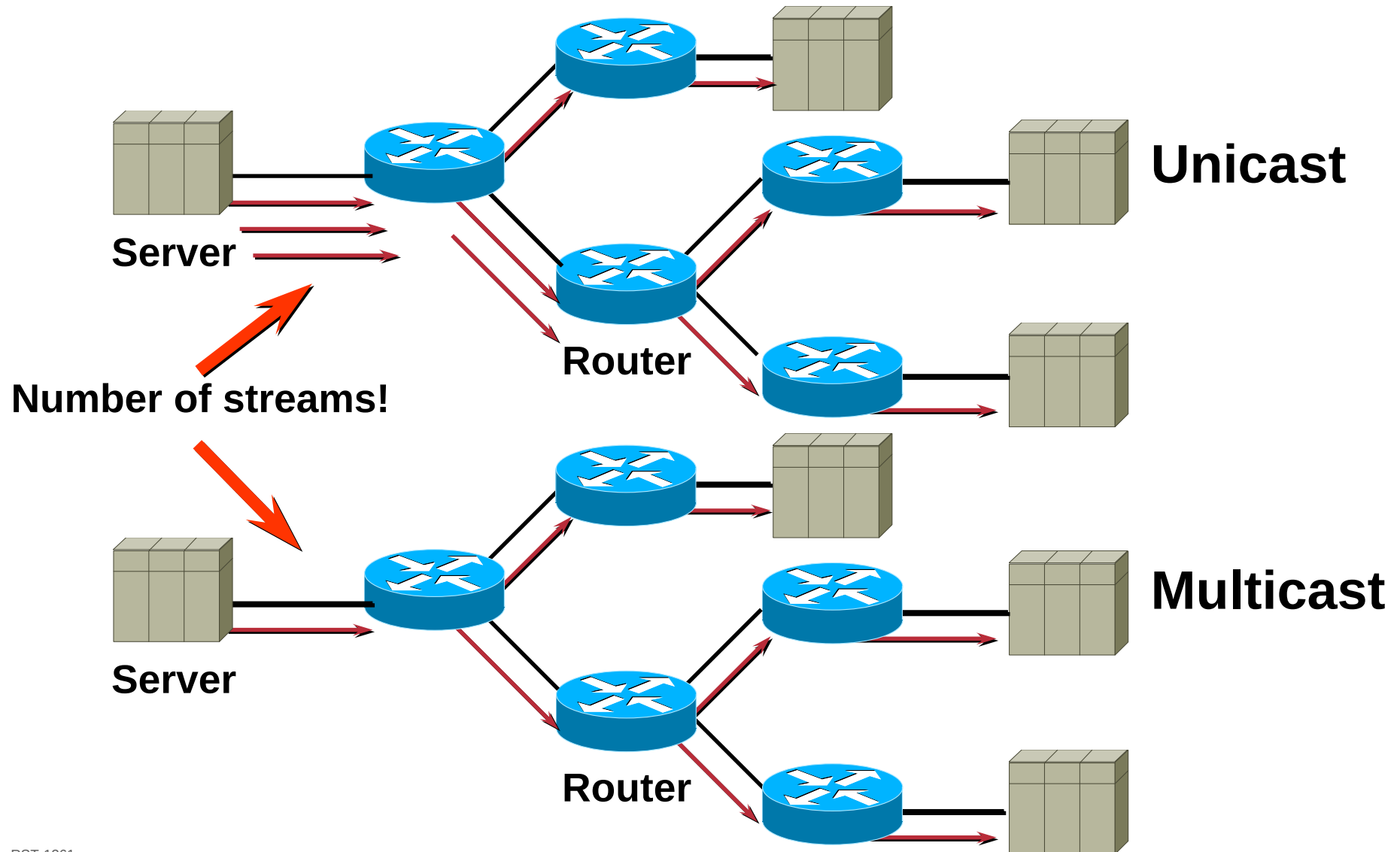
Agenda

- **Why Multicast?**
- **Multicast Fundamentals**
- **PIM Protocols**
- **RP choices**
- **Multicast at Layer 2**
- **Interdomain IP Multicast**
- **Latest Additions**

Why Multicast?



Unicast vs. Multicast



Unicast vs. Multicast

- **TCP Unicast but NOT Multicast**
 - TCP is connection orientated protocol
 - Requires 3 way Handshake
 - Reliable due to sequence numbers + Ack
 - Flow control
- **UDP Unicast and Multicast**
 - Connectionless
 - Unreliable (application layer awareness)
- **Unicast Protocols**
 - ARP not applicable
 - HSRP etc are not applicable

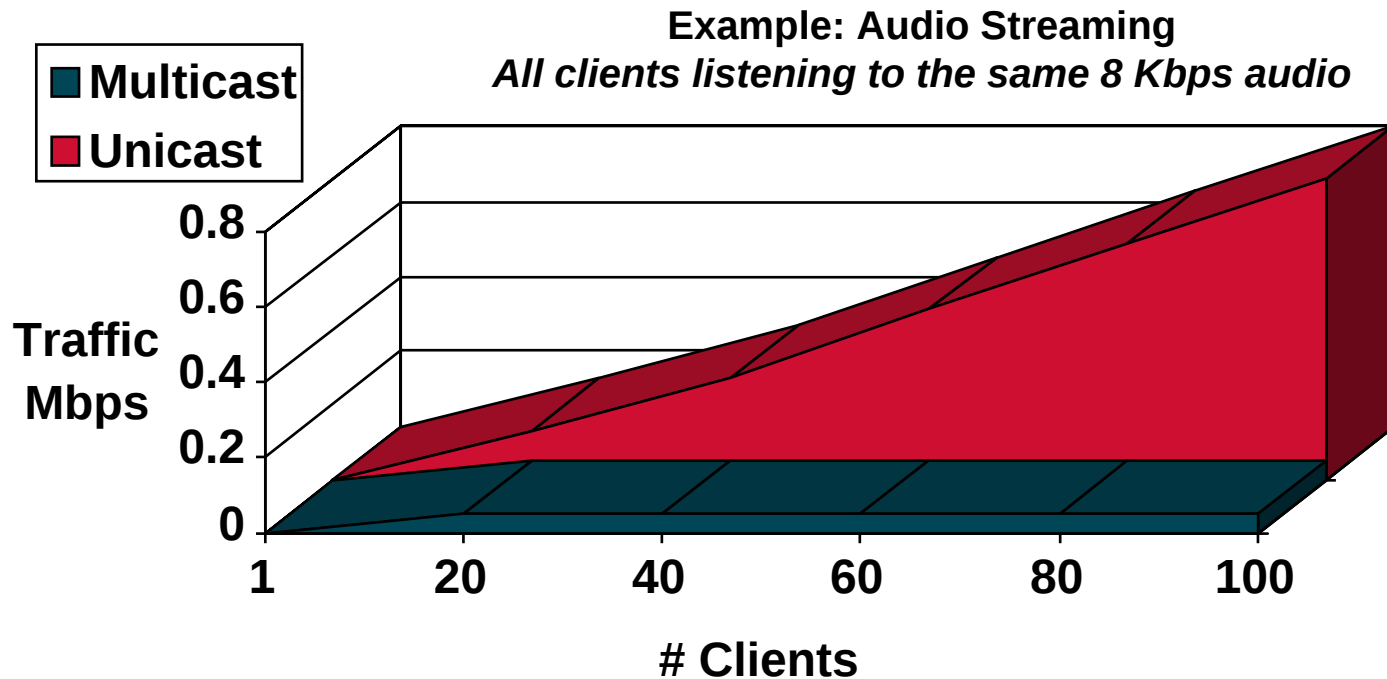
Multicast Disadvantages

Multicast Is UDP Based!!!

- ***Best Effort Delivery***: Drops are to be expected. Multicast applications should not expect reliable delivery of data and should be designed accordingly. Reliable Multicast is still an area for much research. Expect to see more developments in this area. **PGM offers reliability!**
- ***No Congestion Avoidance***: Lack of TCP windowing and “slow-start” mechanisms can result in network congestion. If possible, Multicast applications should attempt to detect and avoid congestion conditions.
- ***Duplicates***: Some multicast protocol mechanisms (e.g. Asserts, Registers and SPT Transitions) result in the occasional generation of duplicate packets. Multicast applications should be designed to expect occasional duplicate packets.
- ***Out of Order Delivery*** : Some protocol mechanisms may also result in out of order delivery of packets.

Multicast Advantages

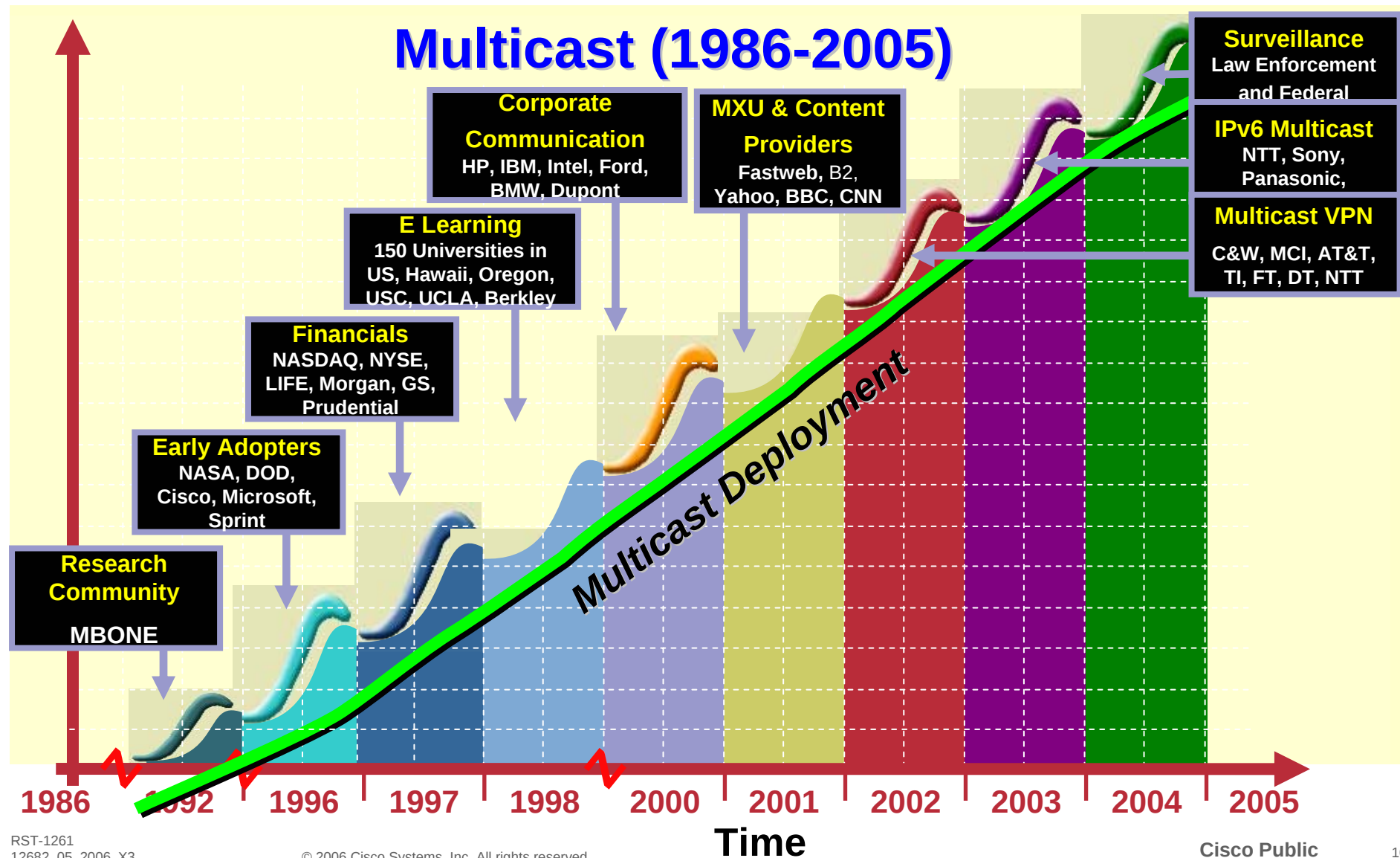
- **Enhanced *Efficiency***: Controls network traffic and reduces server and CPU loads
- **Optimized *Performance***: Eliminates traffic redundancy
- **Distributed *Applications***: Makes multipoint applications possible



Multicast Adoption

Past, Present, and Future

Multicast (1986-2005)

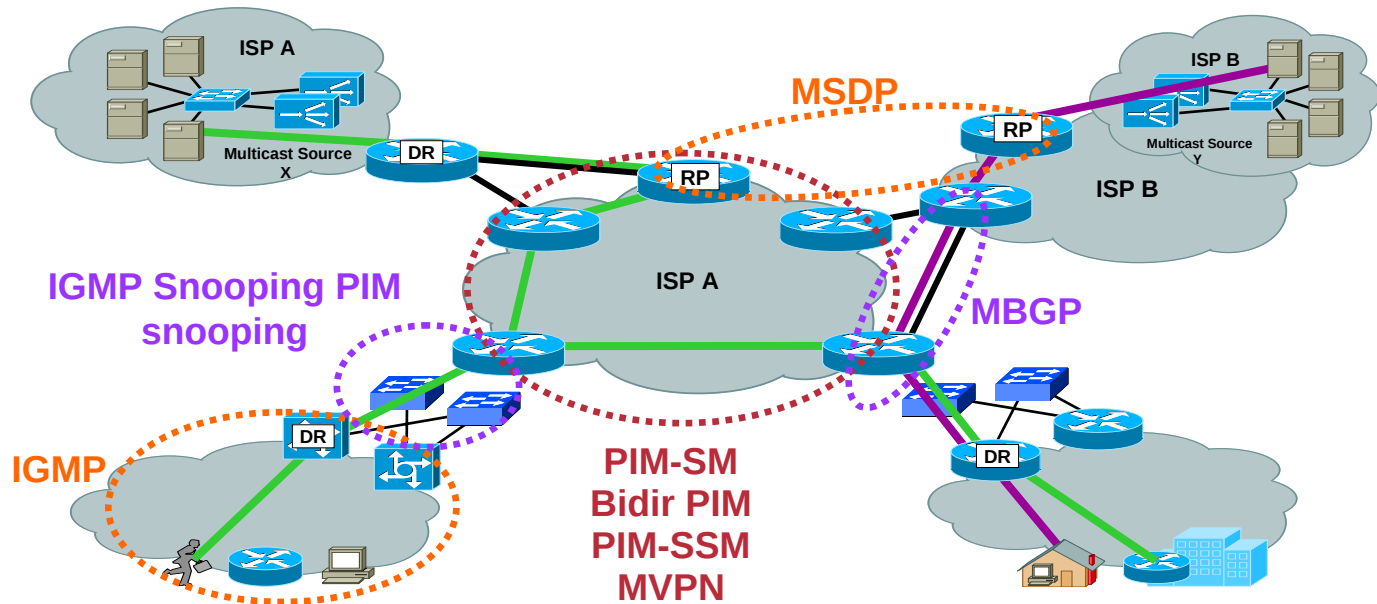


Multicast Fundamentals



Multicast Components

Cisco End-to-End Architecture



Campus Multicast

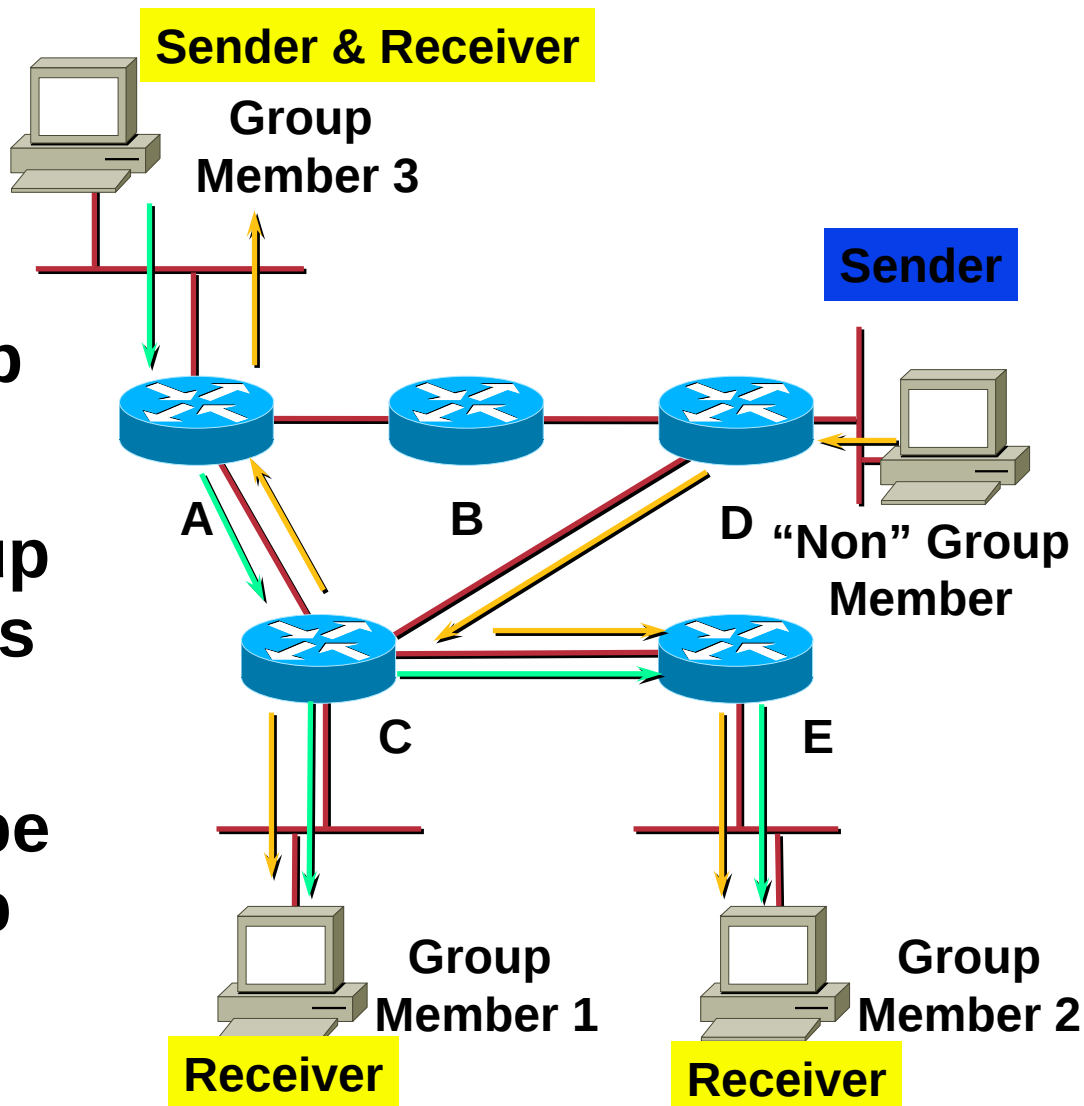
- End Stations (hosts-to-routers):
 - IGMP
- Switches (Layer 2 Optimization):
 - IGMP Snooping PIM snooping
- Routers (Multicast Forwarding Protocol):
 - PIM Sparse Mode or Bidirectional PIM

Interdomain Multicast

- Multicast routing across domains
 - MBGP
- Multicast Source Discovery
 - MSDP with PIM-SM
- Source Specific Multicast
 - PIM-SSM

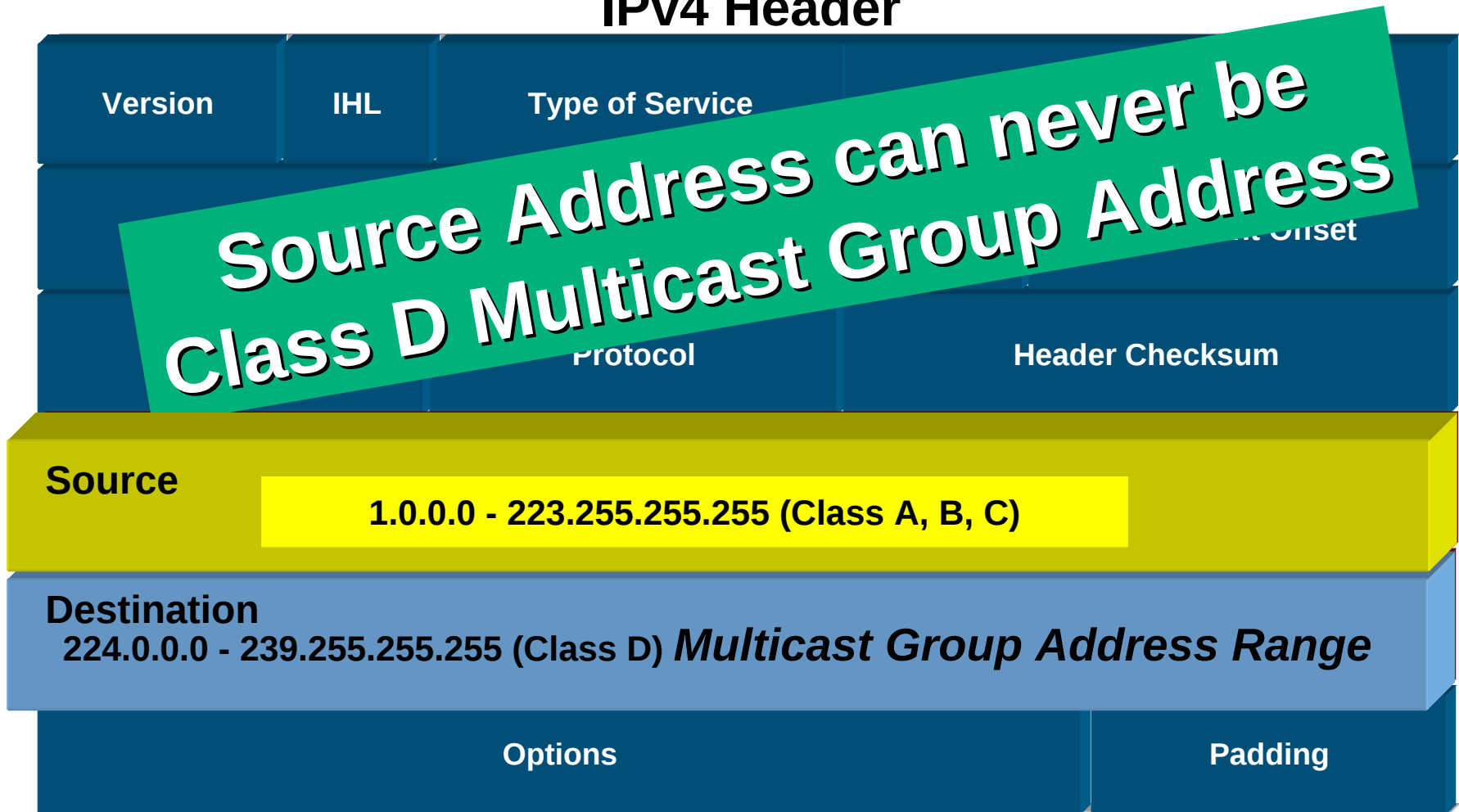
IP Multicast Group Concept

1. You must be a “member” of a group to receive its data
2. If you send to a group address, all members receive it
3. You do not have to be a member of a group to send to a group



Multicast Addressing

IPv4 Header



Multicast Group Address range

224.0.0.0 - 239.255.255.255 (Class D)

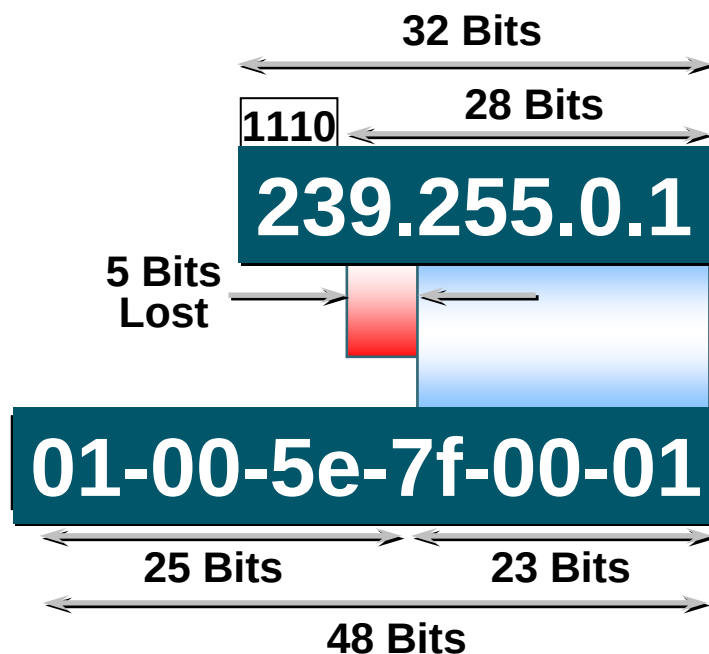
- **Reserved Link-Local Addresses**
 - **224.0.0.0 – 224.0.0.255**
 - **Transmitted with TTL = 1**
 - **Examples:**
 - **224.0.0.1** **All systems on this subnet**
 - **224.0.0.2** **All routers on this subnet**
 - **224.0.0.5** **OSPF routers**
 - **224.0.0.13** **PIMv2 Routers**
 - **224.0.0.22** **IGMPv3**
- **Other Reserved Addresses**
 - **224.0.1.0 – 224.0.1.255**
 - **Not local in scope (Transmitted with TTL > 1)**
 - **Examples:**
 - **224.0.1.1** **NTP Network Time Protocol**
 - **224.0.1.32** **Mtrace routers**
 - **224.0.1.78** **Tibco Multicast1**

Multicast Addressing

- **Administratively Scoped Addresses**
 - **239.0.0.0 – 239.255.255.255**
 - **Private address space**
 - **Similar to RFC1918 unicast addresses**
 - **Not used for global Internet traffic**
 - **Used to limit “scope” of multicast traffic**
 - **Same addresses may be in use at different locations for different multicast sessions**
 - **Examples**
 - **Site-local scope: 239.255.0.0/16**
 - **Organization-local scope: 239.192.0.0/14**
- **SSM (Source Specific Multicast) Range**
 - **232.0.0.0 – 232.255.255.255**
 - **Primarily targeted for Internet style Broadcast**

Multicast Addressing

IP Multicast MAC Address Mapping (FDDI and Ethernet)

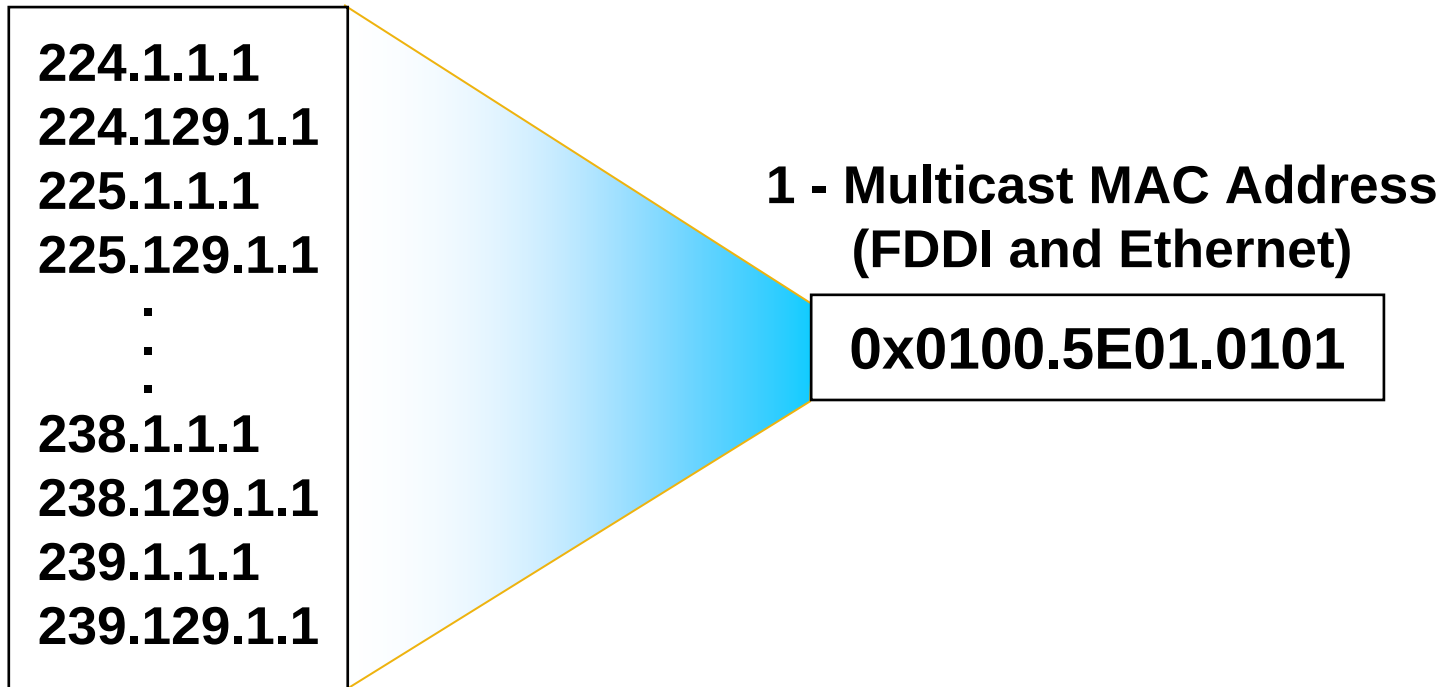


Multicast Addressing

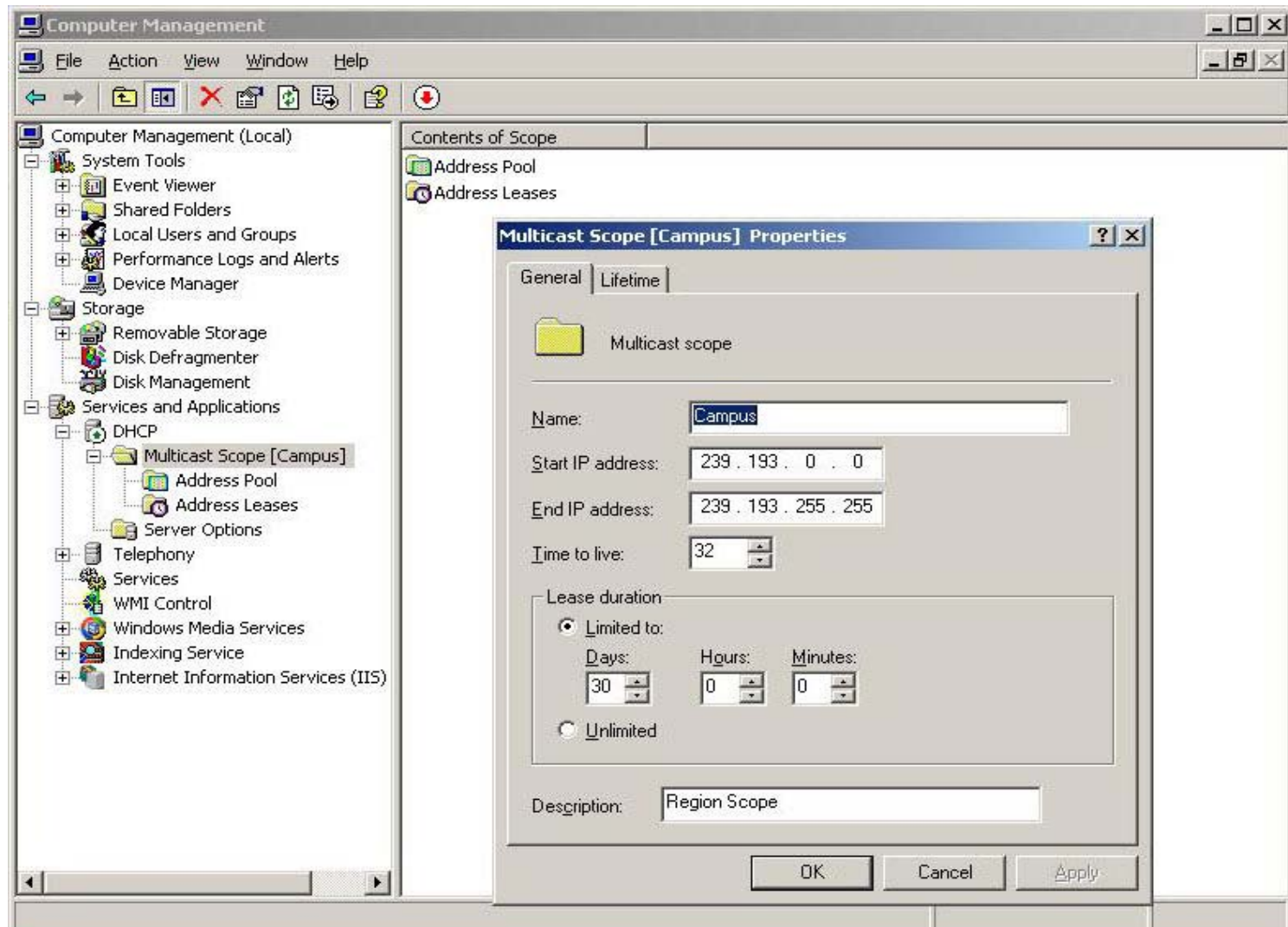
IP Multicast MAC Address Mapping (FDDI & Ethernet)

Be Aware of the 32:1 Address Overlap

32 - IP Multicast Addresses



Madcap in MS Server



How are Multicast Addresses Assigned?

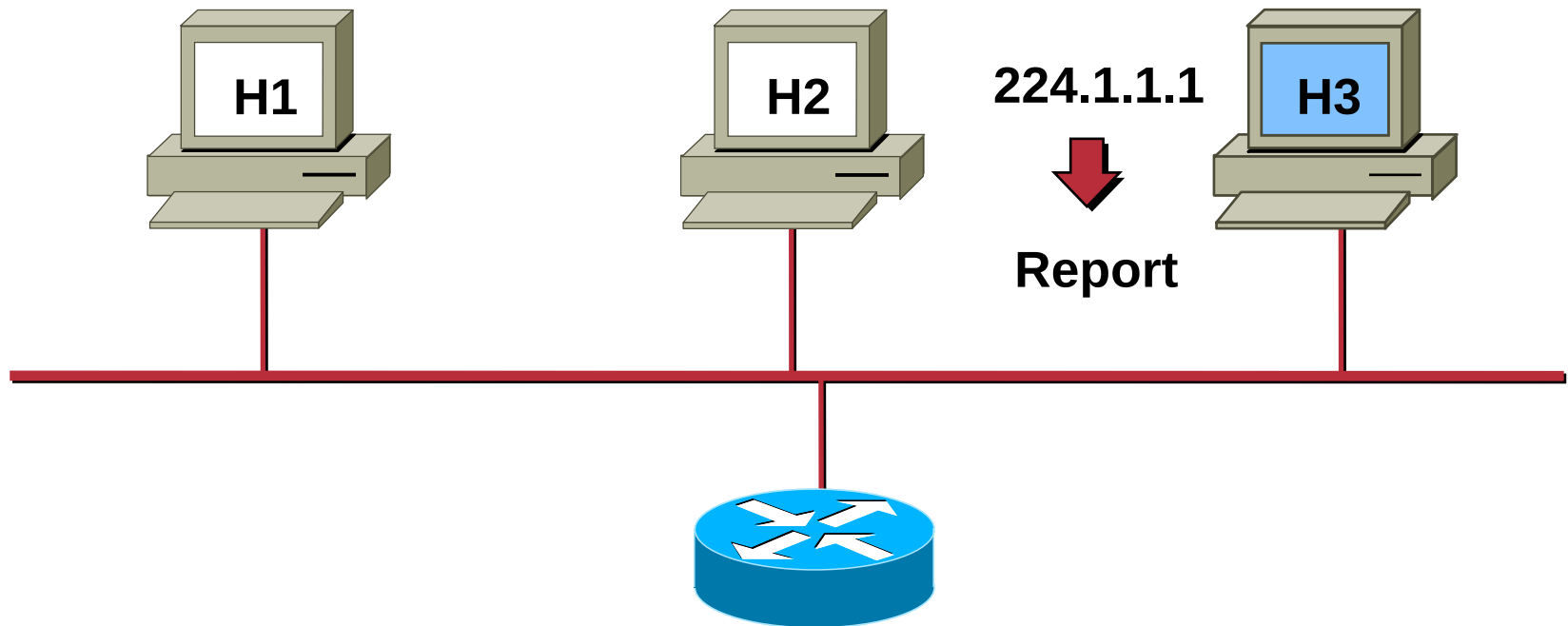
- **Static Global Group Address Assignment**
 - Temporary method to meet immediate needs
 - Group range: 233.0.0.0 – 233.255.255.255
 - Your AS number is inserted in middle two octets
 - Remaining low-order octet used for group assignment
 - Defined in RFC 2770
 - “GLOP Addressing in 233/8”
- **Manual Address Allocation by the Admin !!**
 - Is still the most common practice

Host-Router Signaling: IGMP

- **How hosts tell routers about group membership**
- **Routers solicit group membership from directly connected hosts**
- **RFC 1112 specifies version 1 of IGMP**
 - Supported on Windows 95
- **RFC 2236 specifies version 2 of IGMP**
 - Supported on latest service pack for Windows and most UNIX systems
- **RFC 3376 specifies version 3 of IGMP**
 - Supported in Window XP and various UNIX systems
 -

Host-Router Signaling: IGMP

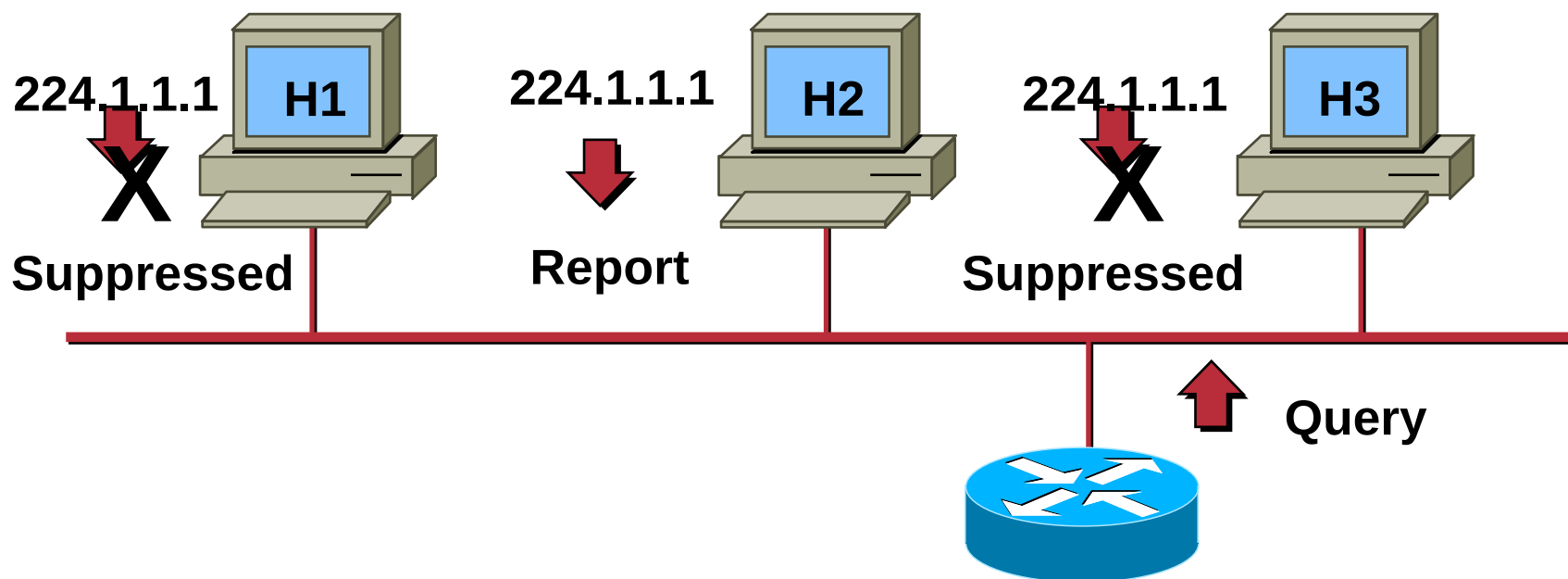
Joining a Group



- Host sends IGMP Report to join group

Host-Router Signaling: IGMP

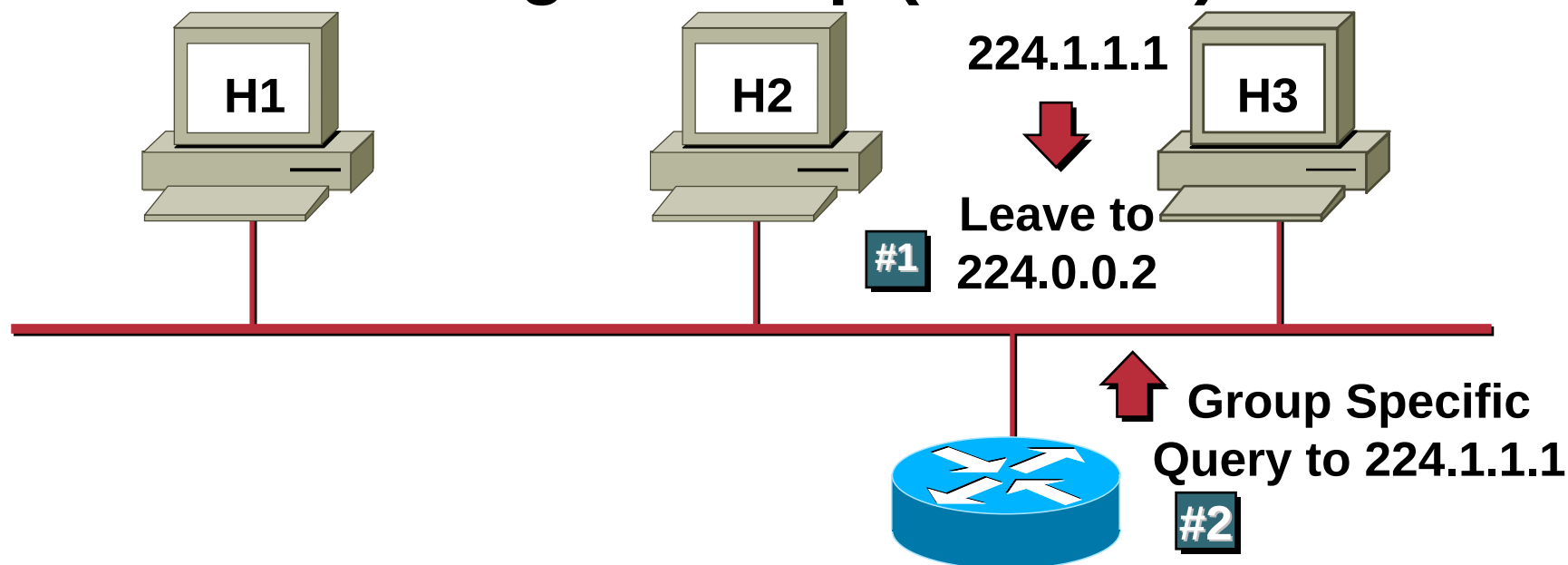
Maintaining a Group



- Router sends periodic Queries to 224.0.0.1
- One member per group per subnet reports
- Other members suppress reports

Host-Router Signaling: IGMP

Leaving a Group (IGMPv2)



1. Host sends Leave message to 224.0.0.2
2. Router sends Group specific query to 224.1.1.1
3. No IGMP Report is received within ~3 seconds
4. Group 224.1.1.1 times out

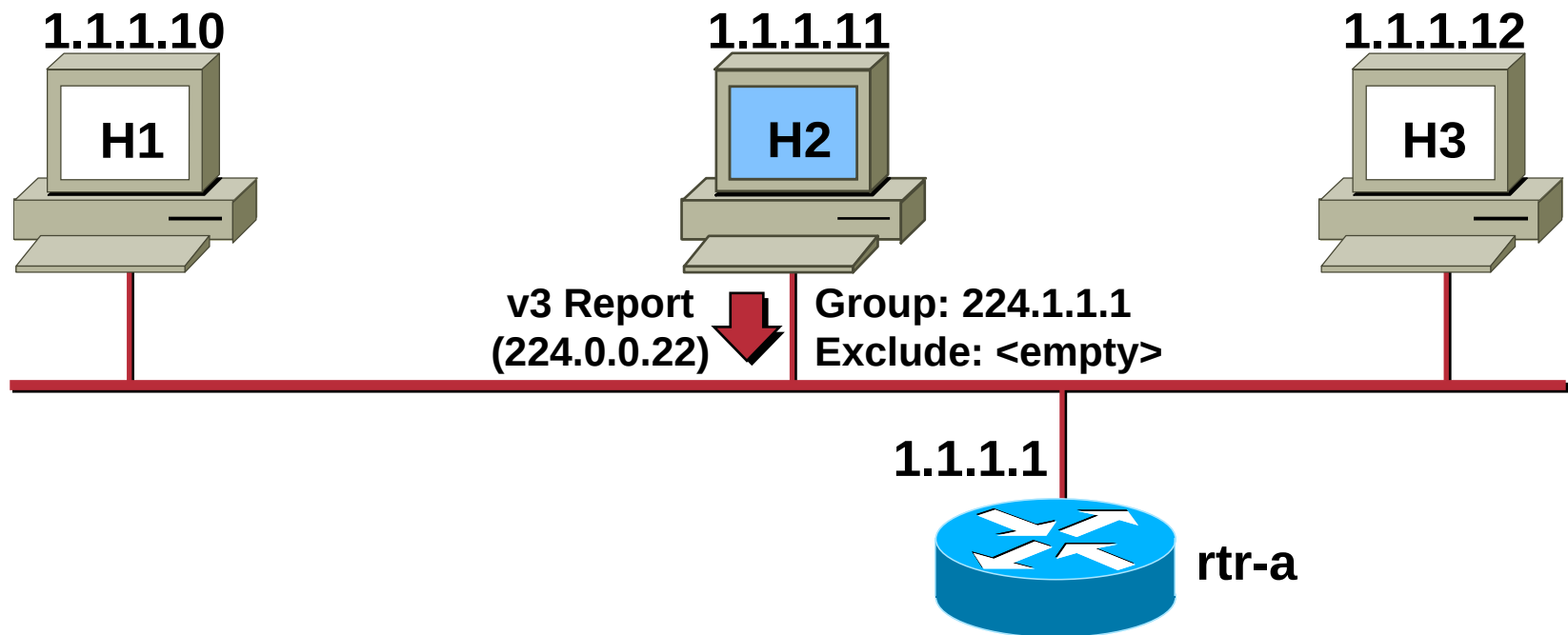
Host-Router Signaling: IGMPv3

- **RFC 3376**
 - **Adds Include/Exclude Source Lists**
 - **Enables hosts to listen only to a specified subset of the hosts sending to the group**
 - **Requires new 'IPMulticastListen' API**
 - **New IGMPv3 stack required in the O/S.**
 - **Apps must be rewritten to use IGMPv3 Include/Exclude features**

Host-Router Signaling: IGMPv3

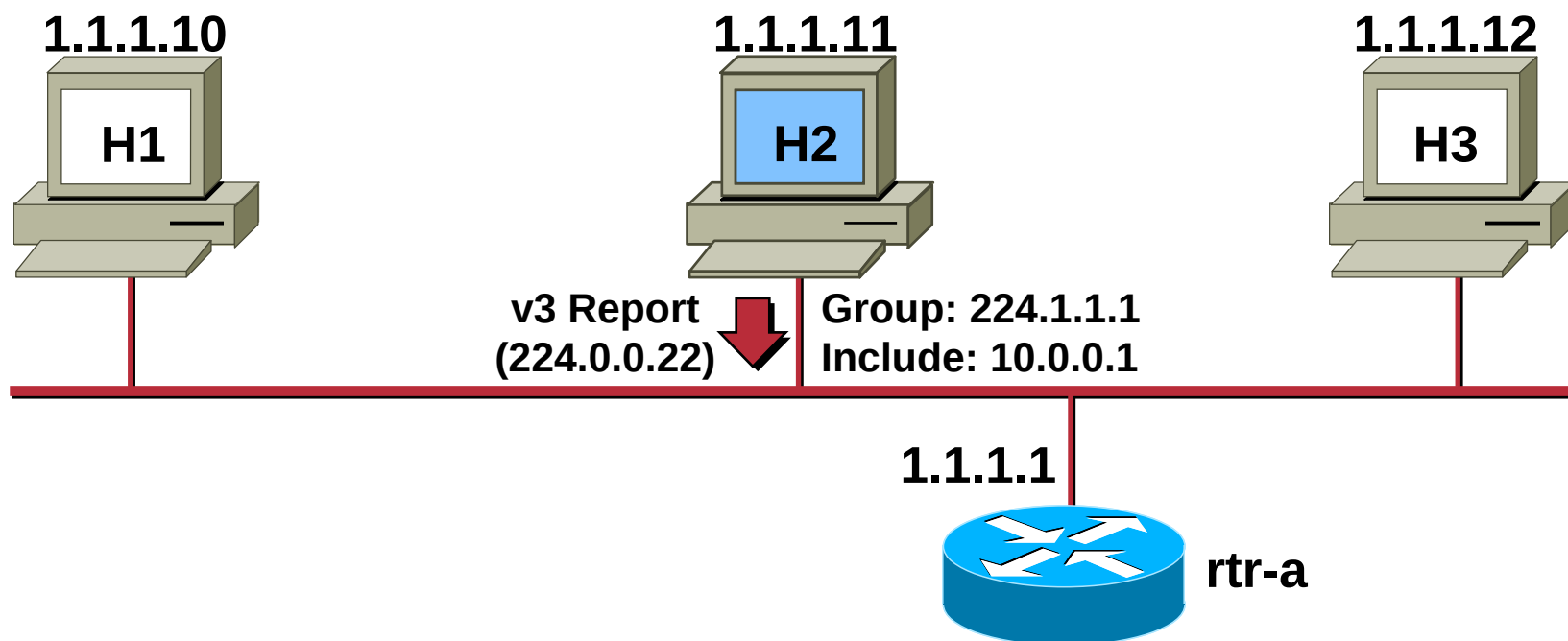
- **New Membership Report address**
 - **224.0.0.22 (IGMPv3 Routers)**
 - **All IGMPv3 Hosts send reports to this address**
 - » Instead of the target group address as in IGMPv1/v2
 - **All IGMPv3 Routers listen to this address**
 - **Hosts do not listen or respond to this address**
 - **No Report Suppression**
 - **All Hosts on wire respond to Queries**
 - » Host's complete IGMP state sent in single response
 - **Response Interval may be tuned over broad range**
 - » Useful when large numbers of hosts reside on subnet

IGMPv3—Joining a Group



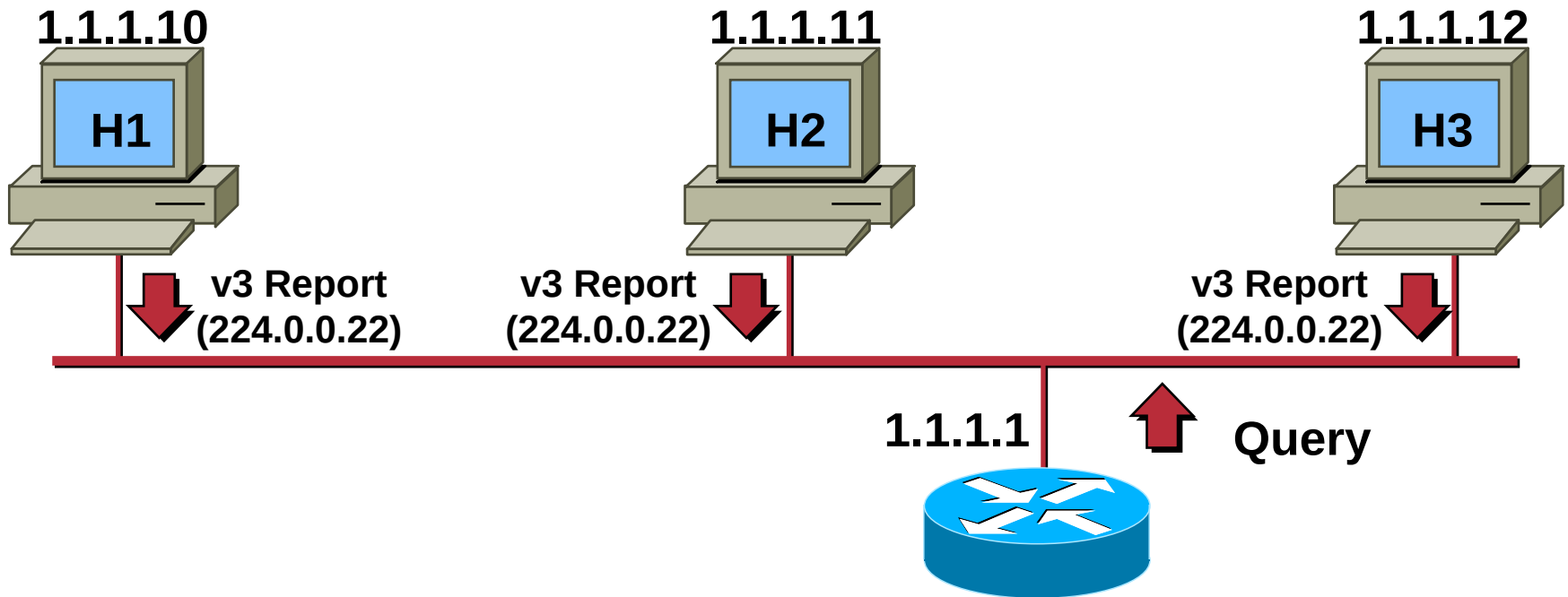
- **Joining member sends IGMPv3 Report to 224.0.0.22 immediately upon joining**

IGMPv3—Joining specific Source(s)



- **IGMPv3 Report contains desired source(s) in the Include list.**
- **Only “Included” source(s) are joined.**

IGMPv3—Maintaining State



- Router sends periodic queries
- All IGMPv3 members respond
- Reports contain multiple Group state records

Multicast L3 Forwarding

- **Multicast Routing is backwards from Unicast Routing**
 - **Unicast Routing is concerned about where the packet is going.**
 - **Multicast Routing is concerned about where the packet came from.**

Unicast vs. Multicast Forwarding

- **Unicast Forwarding**

- **Destination IP address directly indicates where to forward packet.**
- **Forwarding is hop-by-hop.**
 - **Unicast routing table determines interface and next-hop router to forward packet.**

Unicast vs. Multicast Forwarding

- **Multicast Forwarding**

- **Destination IP address (group) doesn't directly indicate where to forward packet.**
- **Forwarding is connection-oriented.**
 - **Receivers must first be “connected” to the source before traffic begins to flow.**
 - » **Connection messages (PIM Joins) follow unicast routing table toward multicast source.**
 - » **Build Multicast Distribution Trees that determine where to forward packets.**
 - » **Distribution Trees rebuilt dynamically in case of network topology changes.**

Reverse Path Forwarding (RPF)

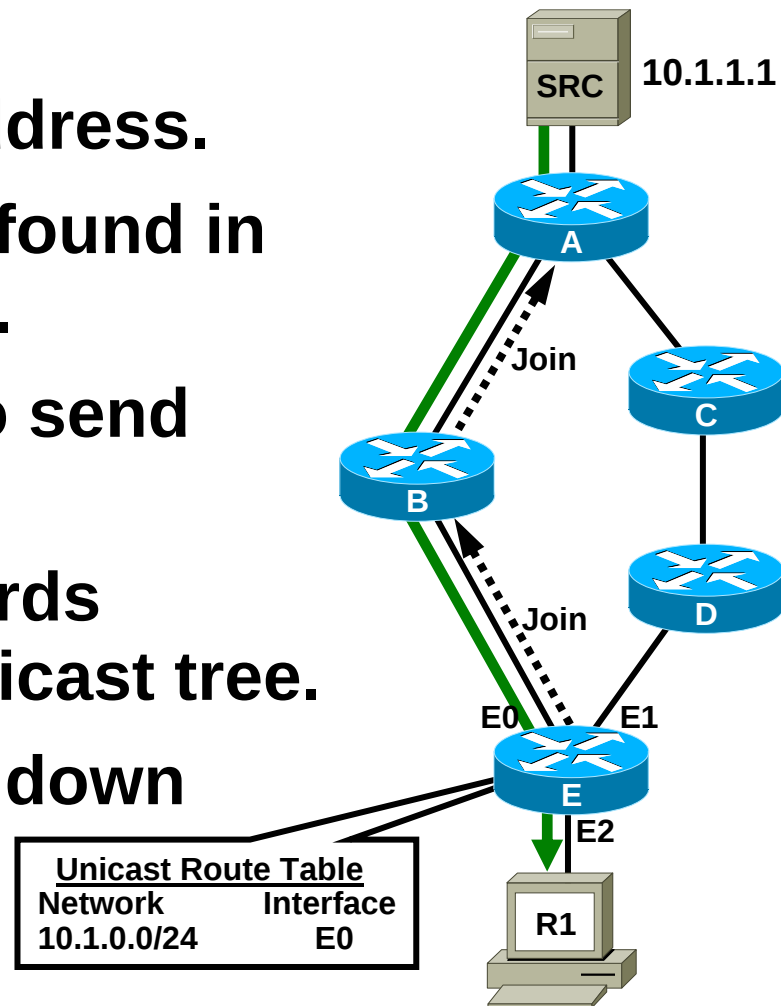
- **The RPF Calculation**

- **The multicast source address is checked against the unicast routing table.**
- **This determines the interface and upstream router in the direction of the source to which PIM Joins are sent.**
- **This interface becomes the “Incoming” or RPF interface.**
 - **A router forwards a multicast datagram only if received on the RPF interface.**

Reverse Path Forwarding (RPF)

- **RPF Calculation**

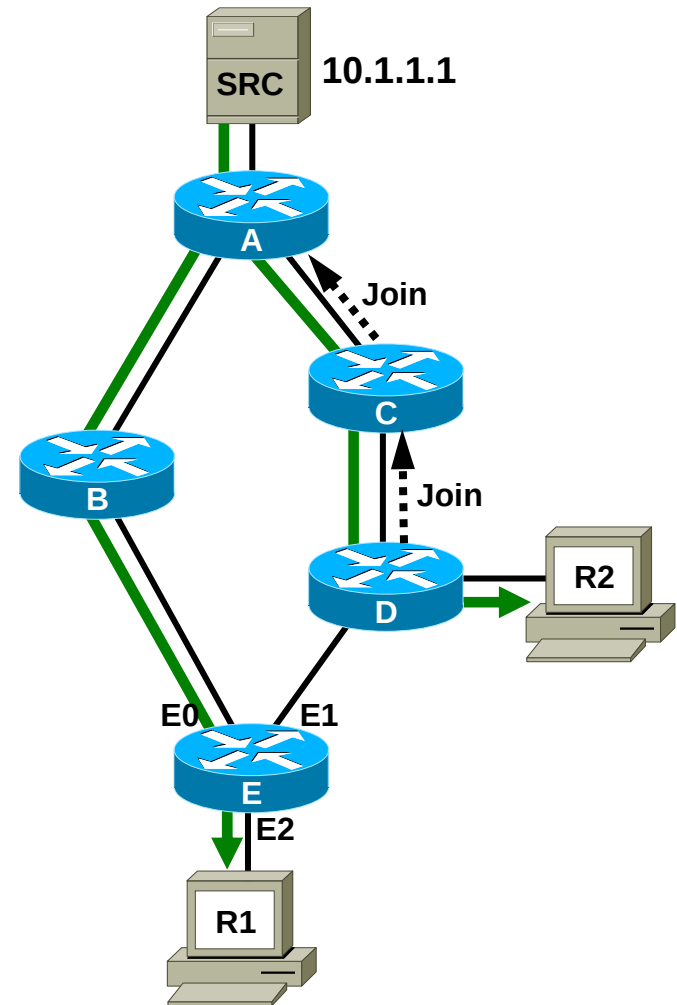
- Based on Source Address.
- Best path to source found in Unicast Route Table.
- Determines where to send Join.
- Joins continue towards Source to build multicast tree.
- Multicast data flows down tree.



Reverse Path Forwarding (RPF)

- **RPF Calculation**

- Based on Source Address.
- Best path to source found in Unicast Route Table.
- Determines where to send Join.
- Joins continue towards Source to build multicast tree.
- Multicast data flows down tree.
- Repeat for other receivers.



Reverse Path Forwarding (RPF)

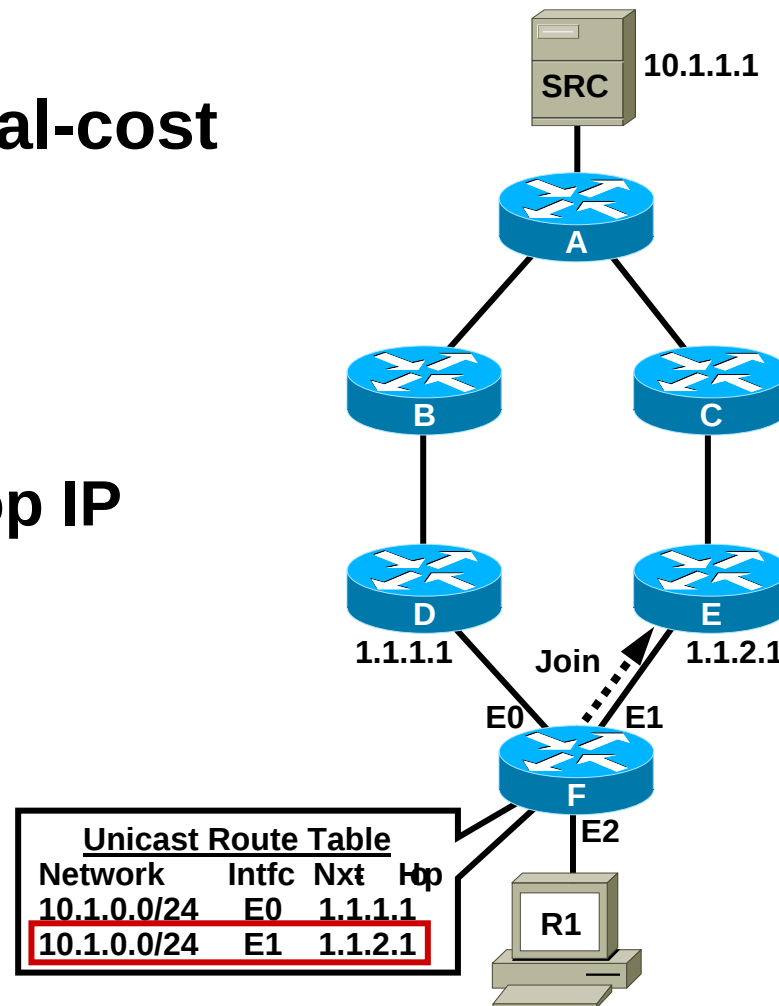
- **RPF Calculation**

- What if we have equal-cost paths?

- We can't use both.

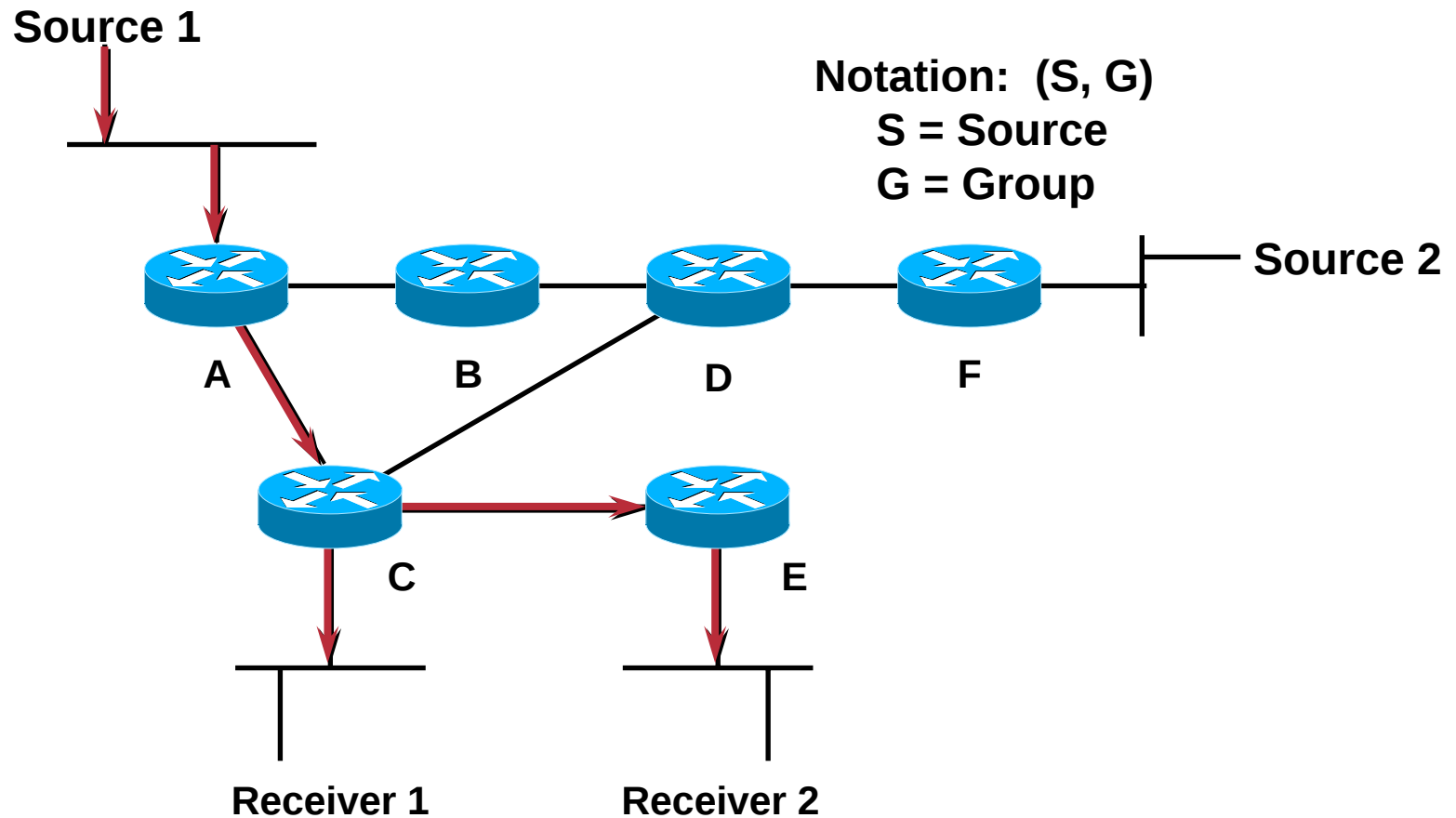
- Tie-Breaker

- Use highest Next-Hop IP address.



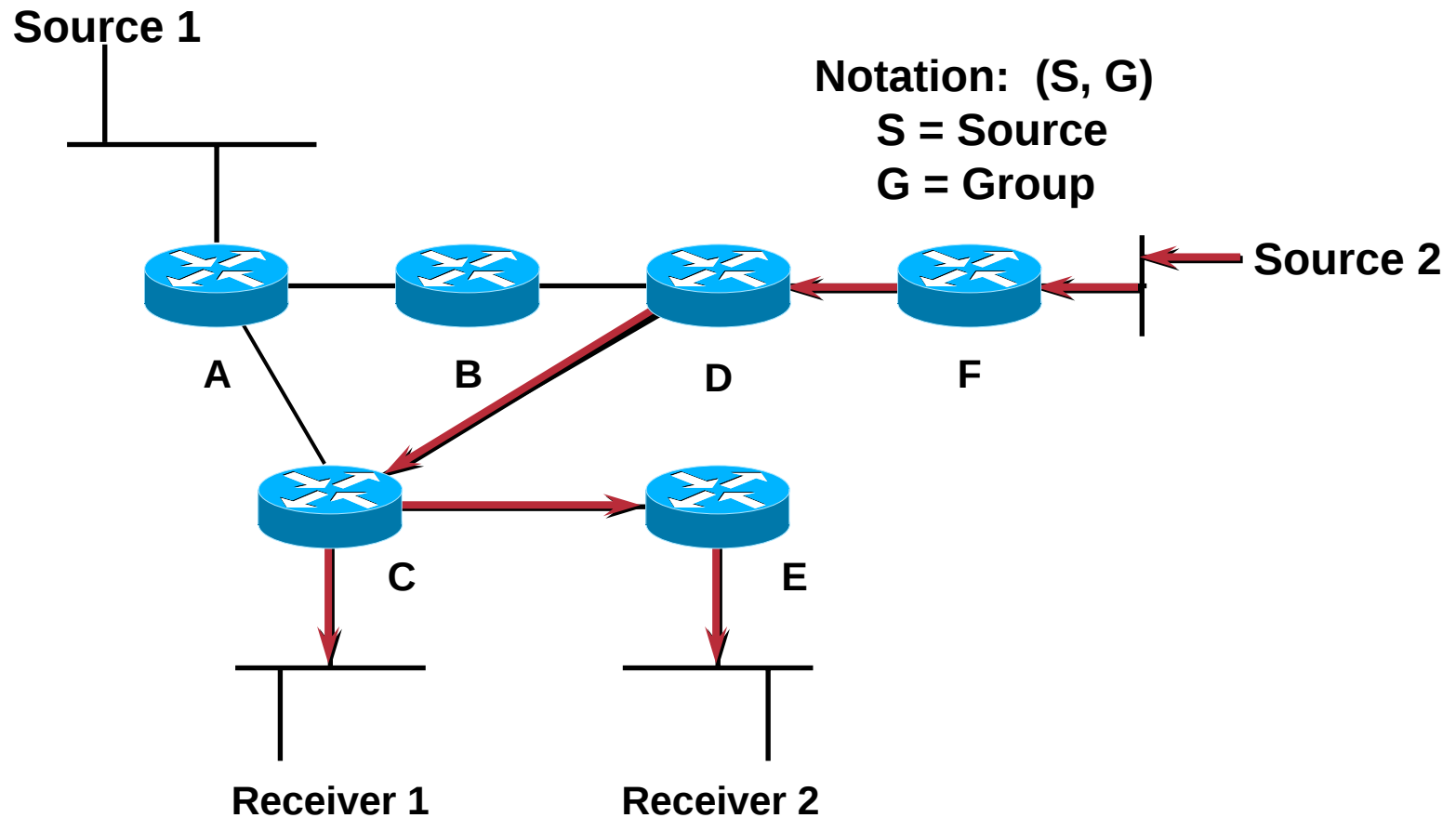
Multicast Distribution Trees

Shortest Path or Source Distribution Tree



Multicast Distribution Trees

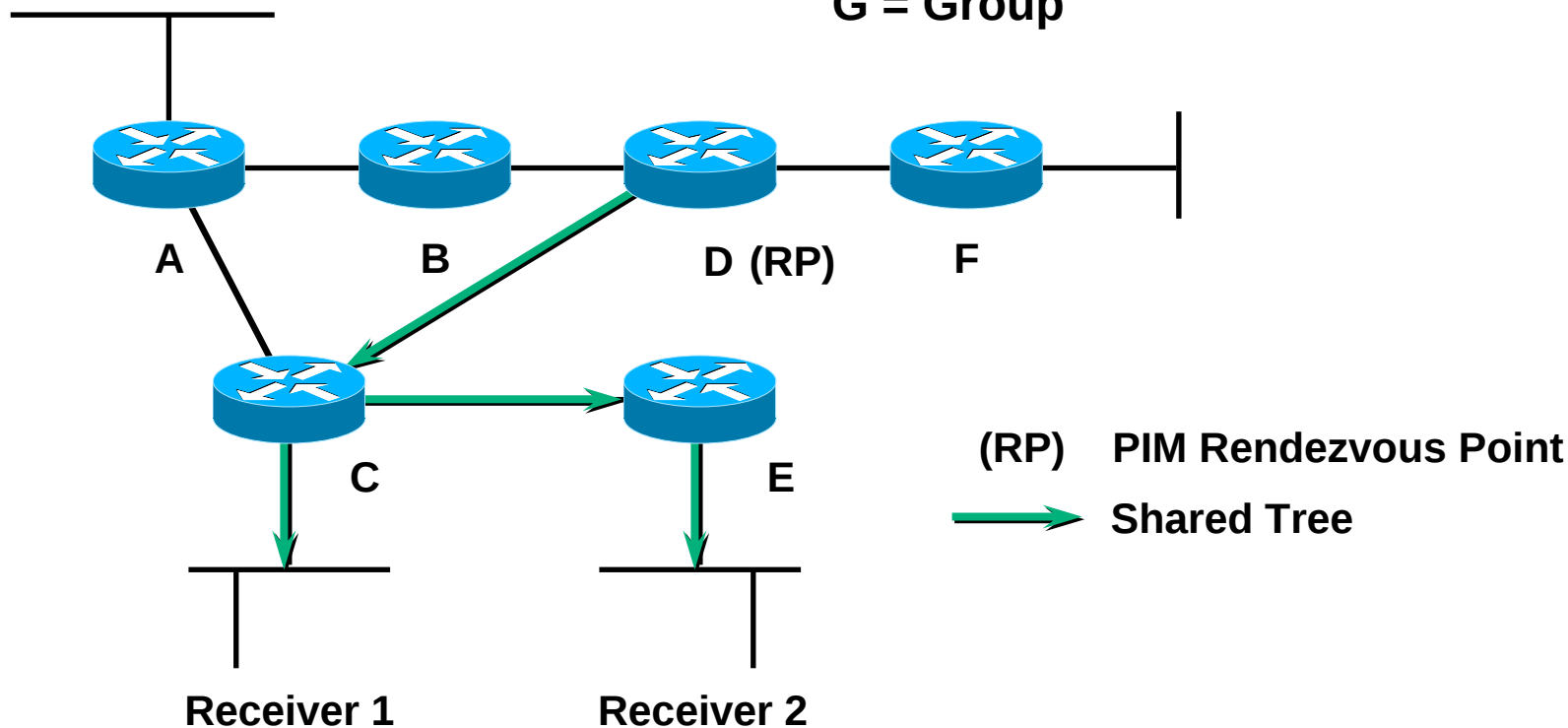
Shortest Path or Source Distribution Tree



Multicast Distribution Trees

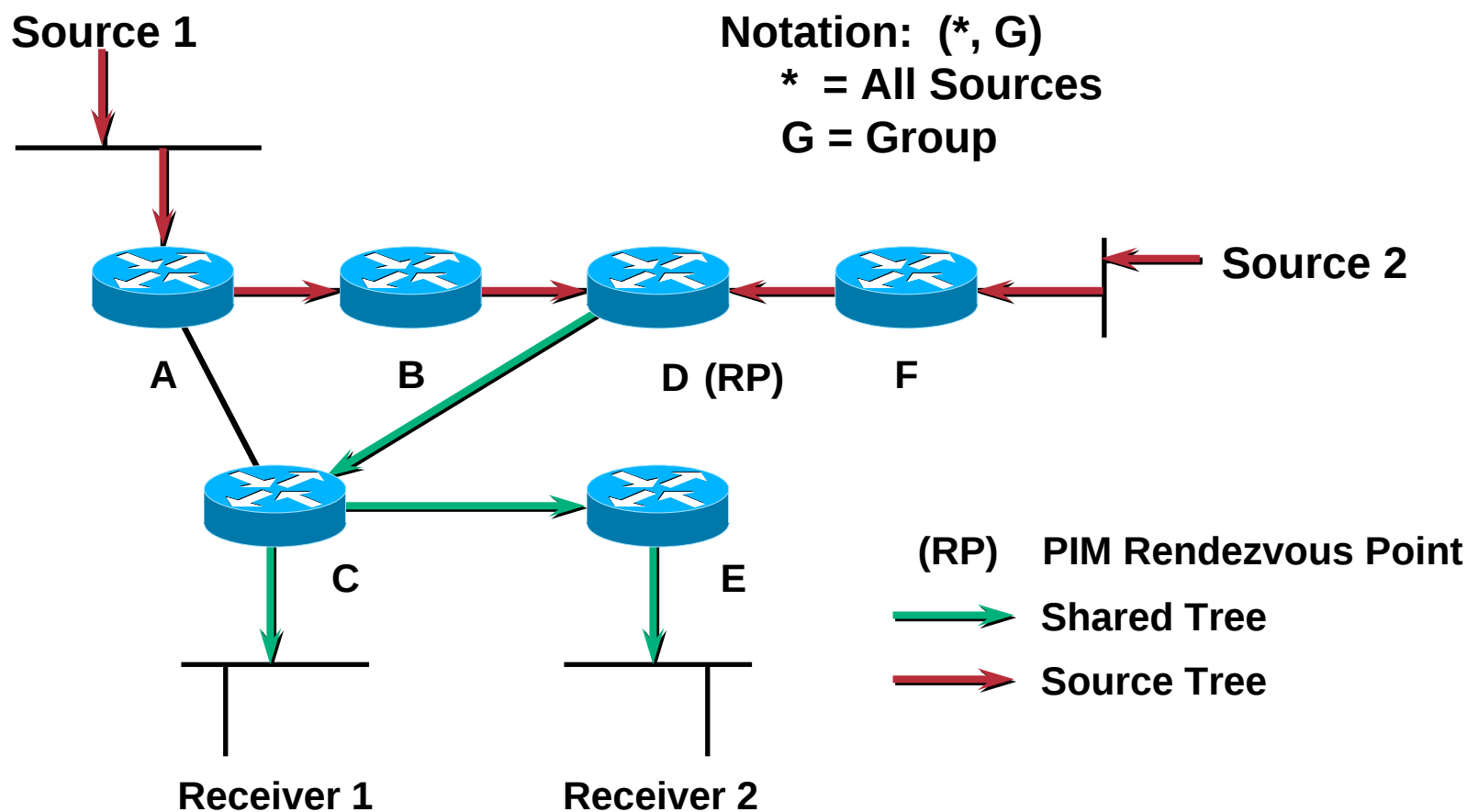
Shared Distribution Tree

Notation: (*, G)
* = All Sources
G = Group



Multicast Distribution Trees

Shared Distribution Tree



Multicast Distribution Trees

Characteristics of Distribution Trees

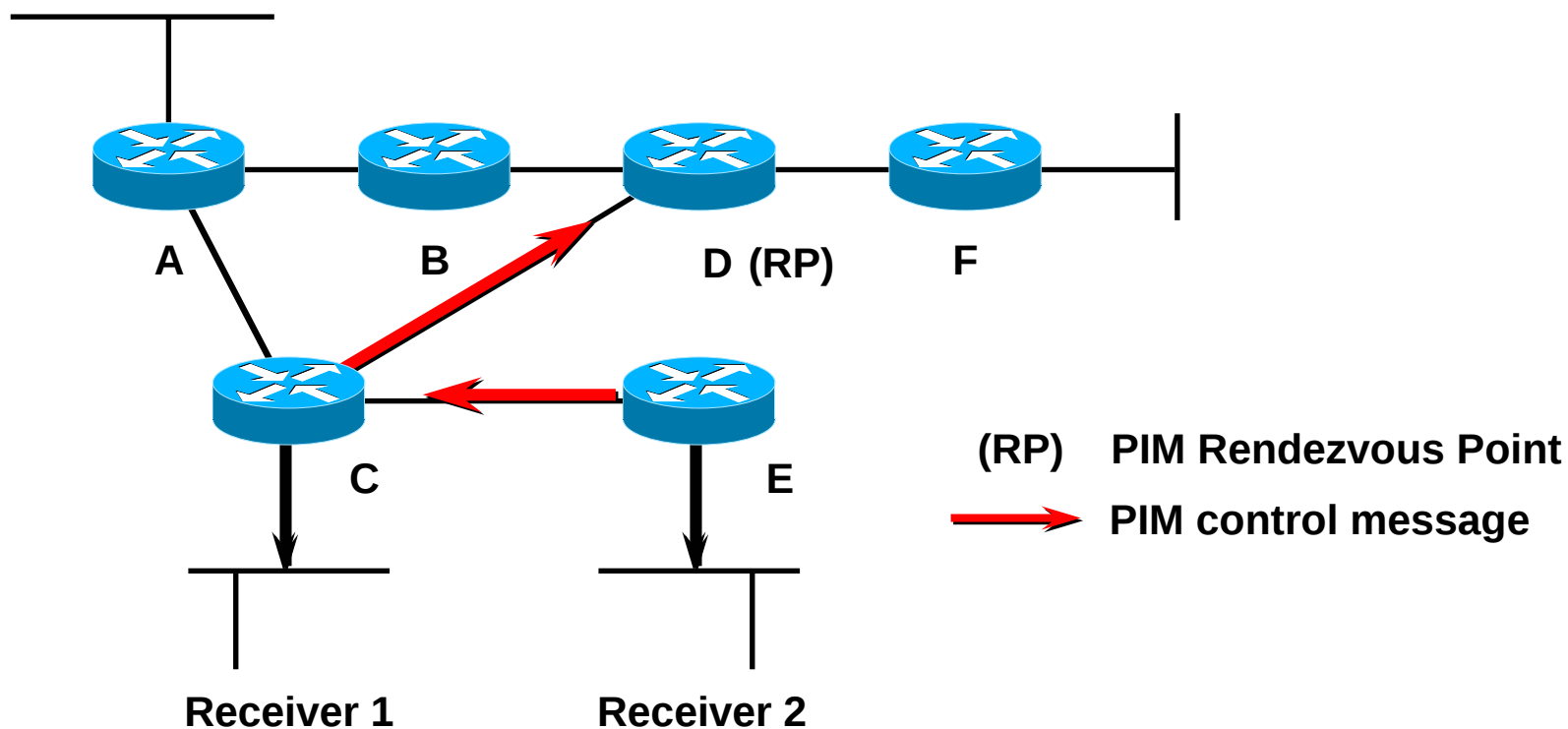
- **Source or Shortest Path trees**
 - Uses more memory $O(S \times G)$ but you get optimal paths from source to all receivers; minimizes delay
- **Shared trees**
 - Uses less memory $O(G)$ but you may get sub-optimal paths from source to all receivers; may introduce extra delay

Multicast Tree creation

- **PIM Join/Prune Control Messages**
 - Used to create/remove Distribution Trees
- **Shortest Path trees**
 - PIM control messages are sent toward the Source
- **Shared trees**
 - PIM control messages are sent toward RP

Multicast Distribution Tree creation

Shared Tree Example



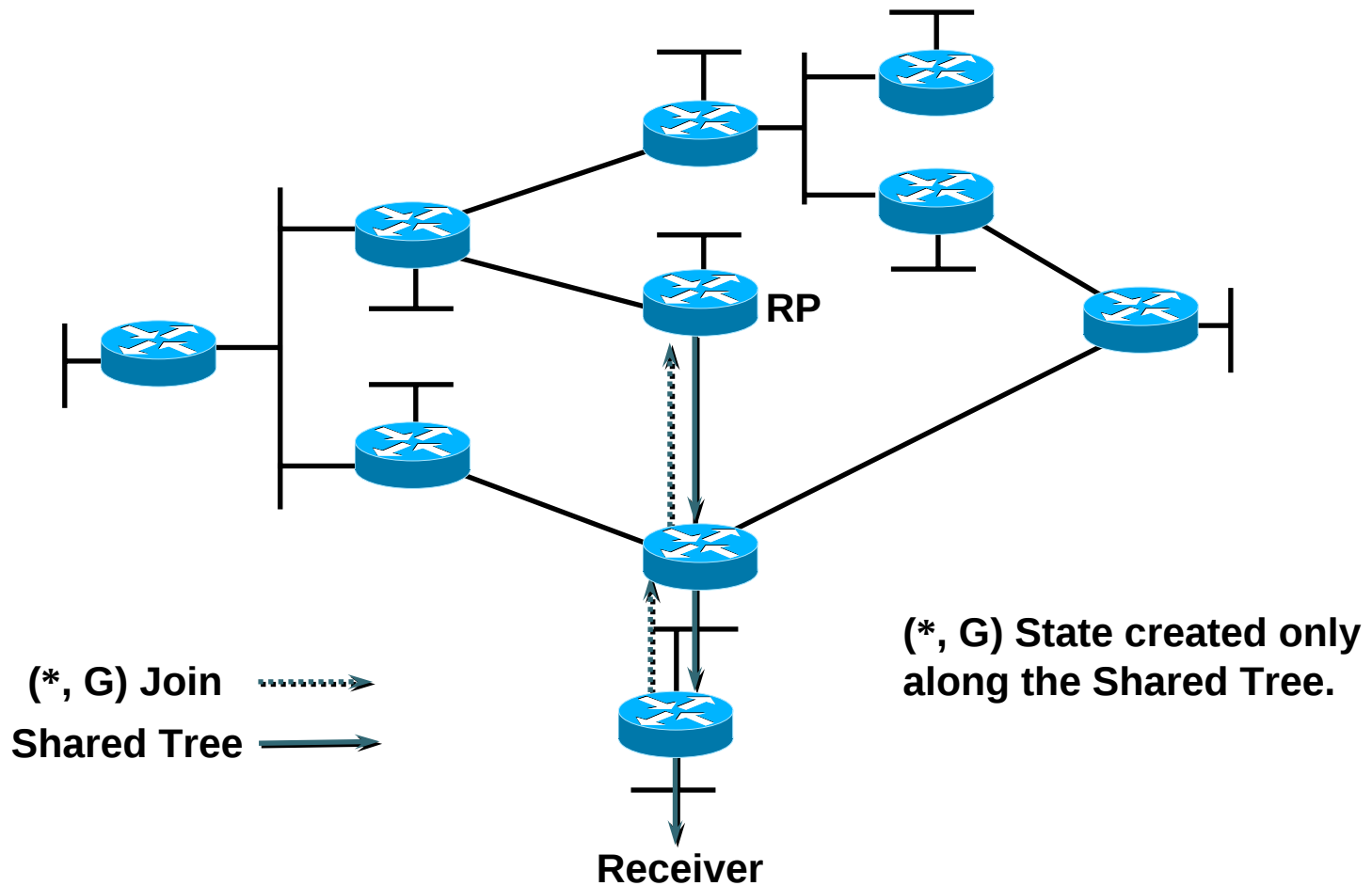
PIM Protocol Variants



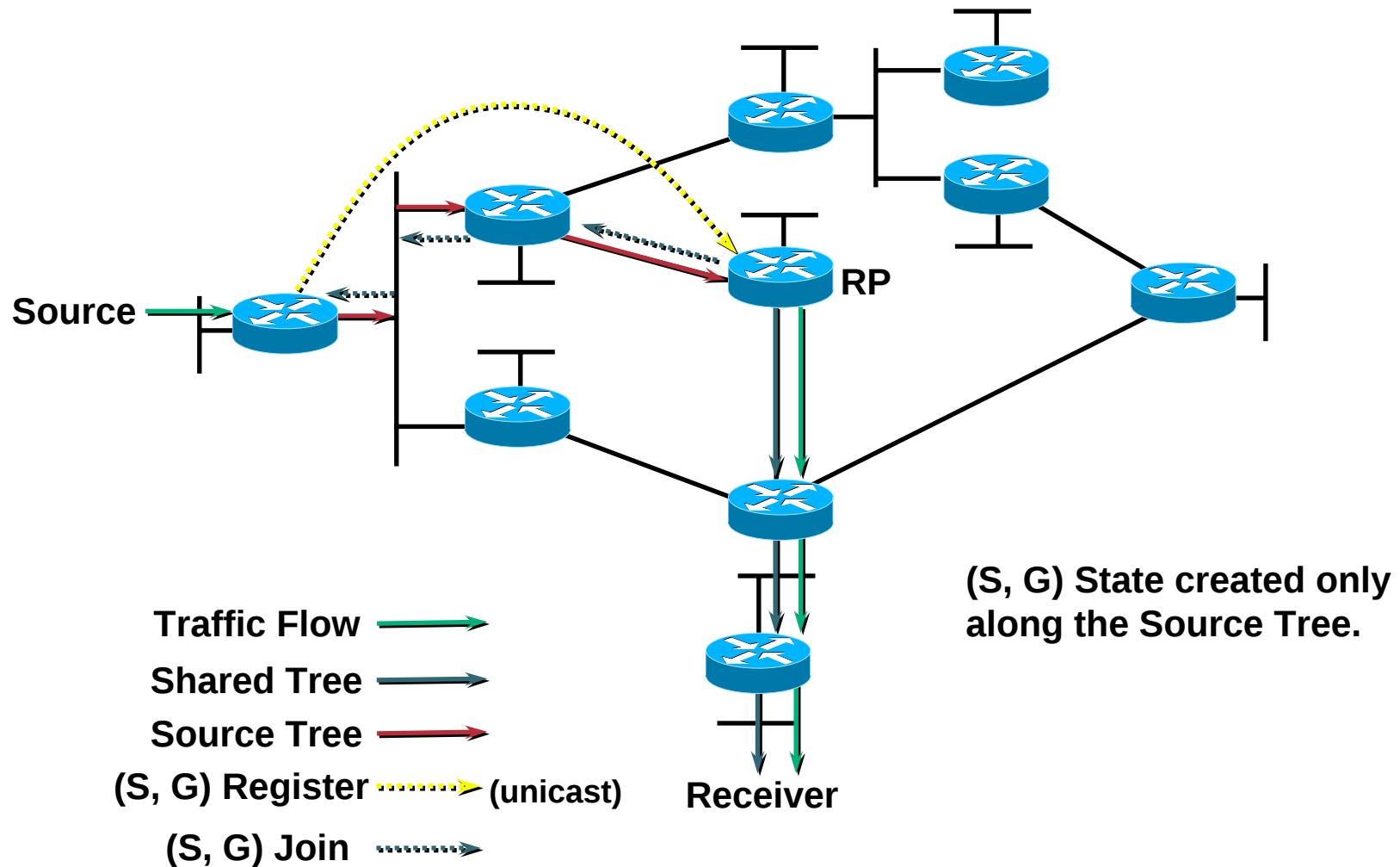
Major deployed PIM variants

- **PIM ASM**
 - Sparse mode / RP / SPT / Shared Tree
- **PIM SSM**
 - Source Specific Multicast, no RP, SPT only
- **PIM BiDir**
 - BiDirectional PIM, no SPT, Shared tree only

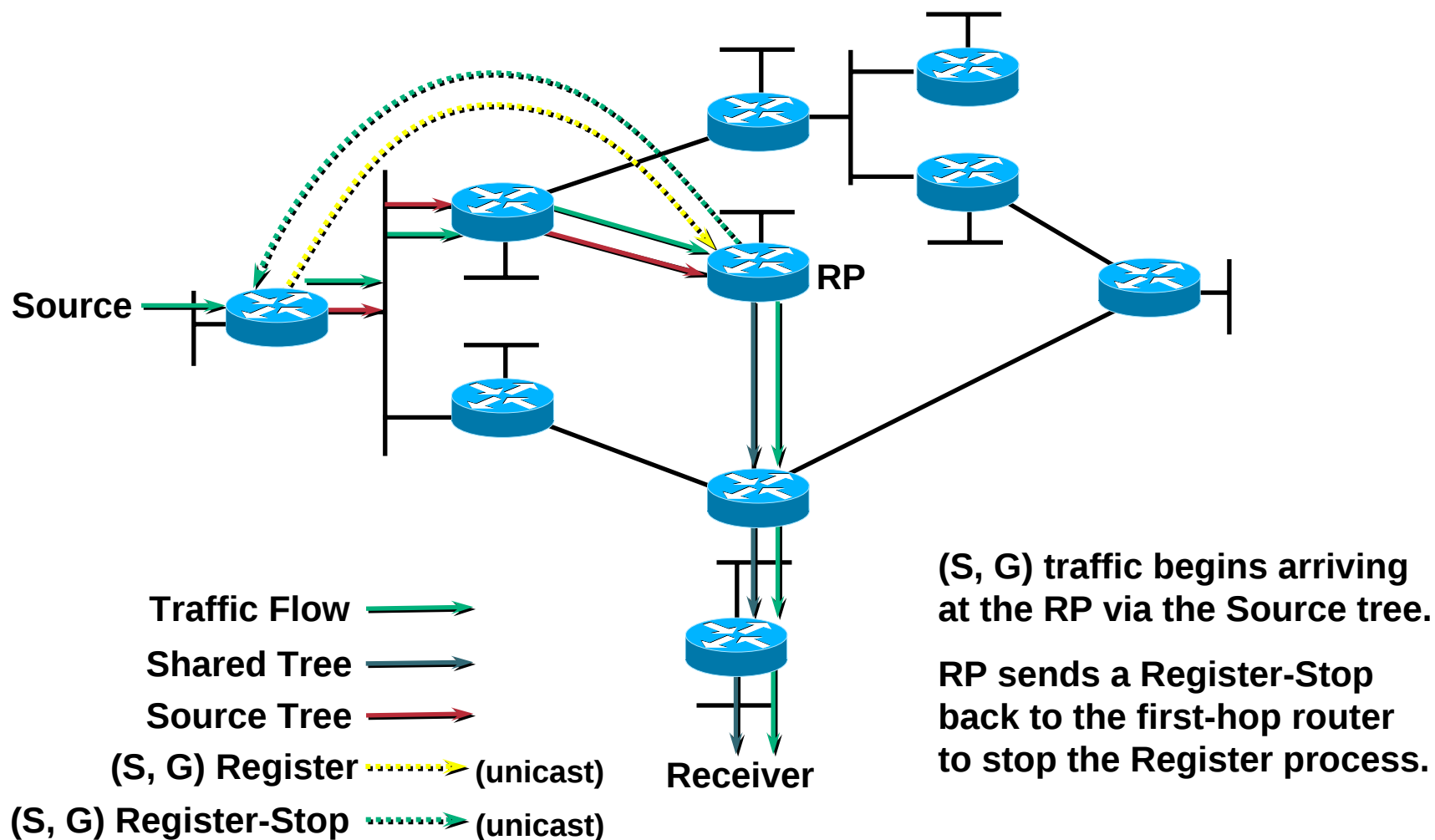
PIM-SM Shared Tree Join



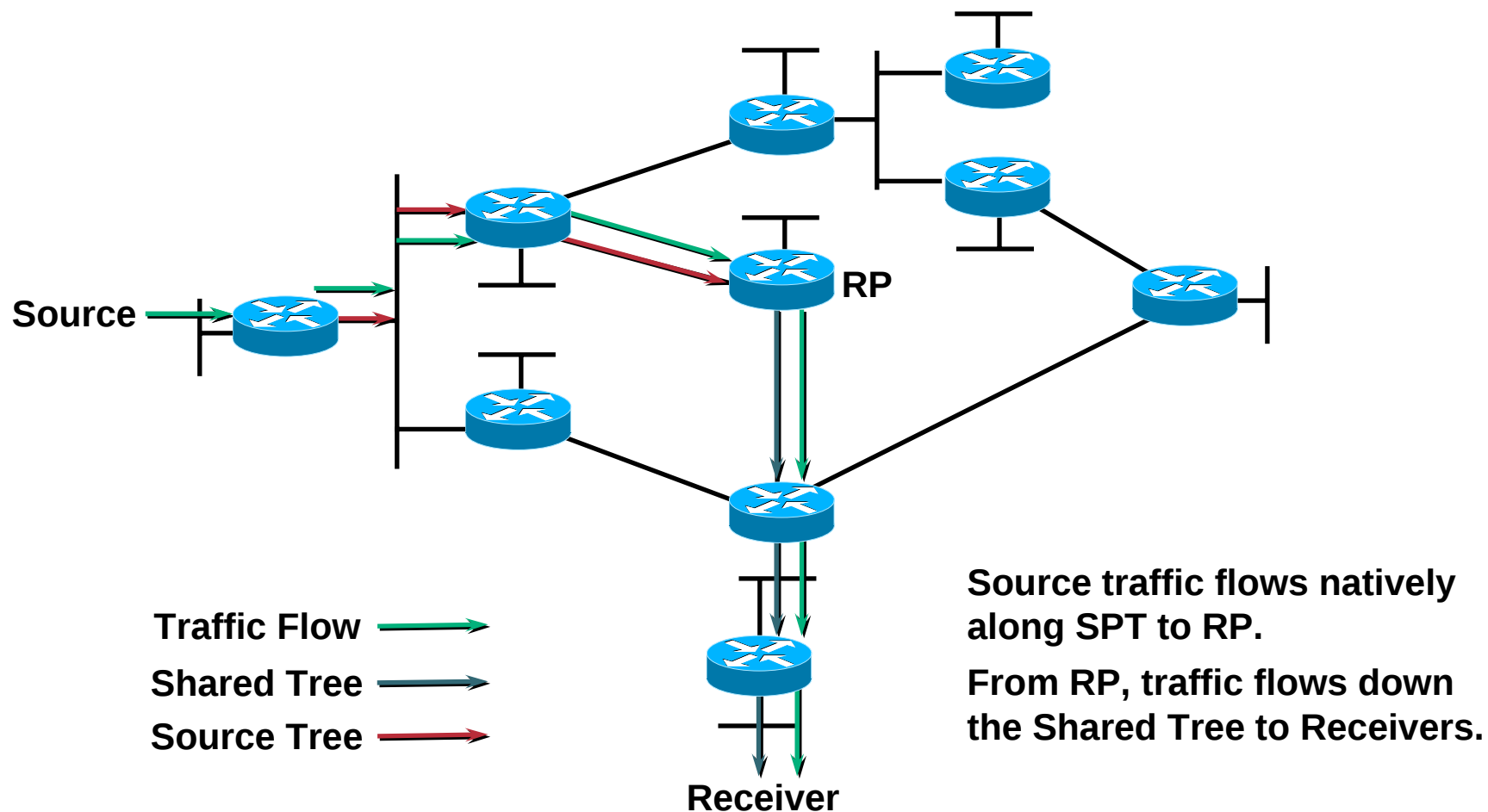
PIM-SM Sender Registration



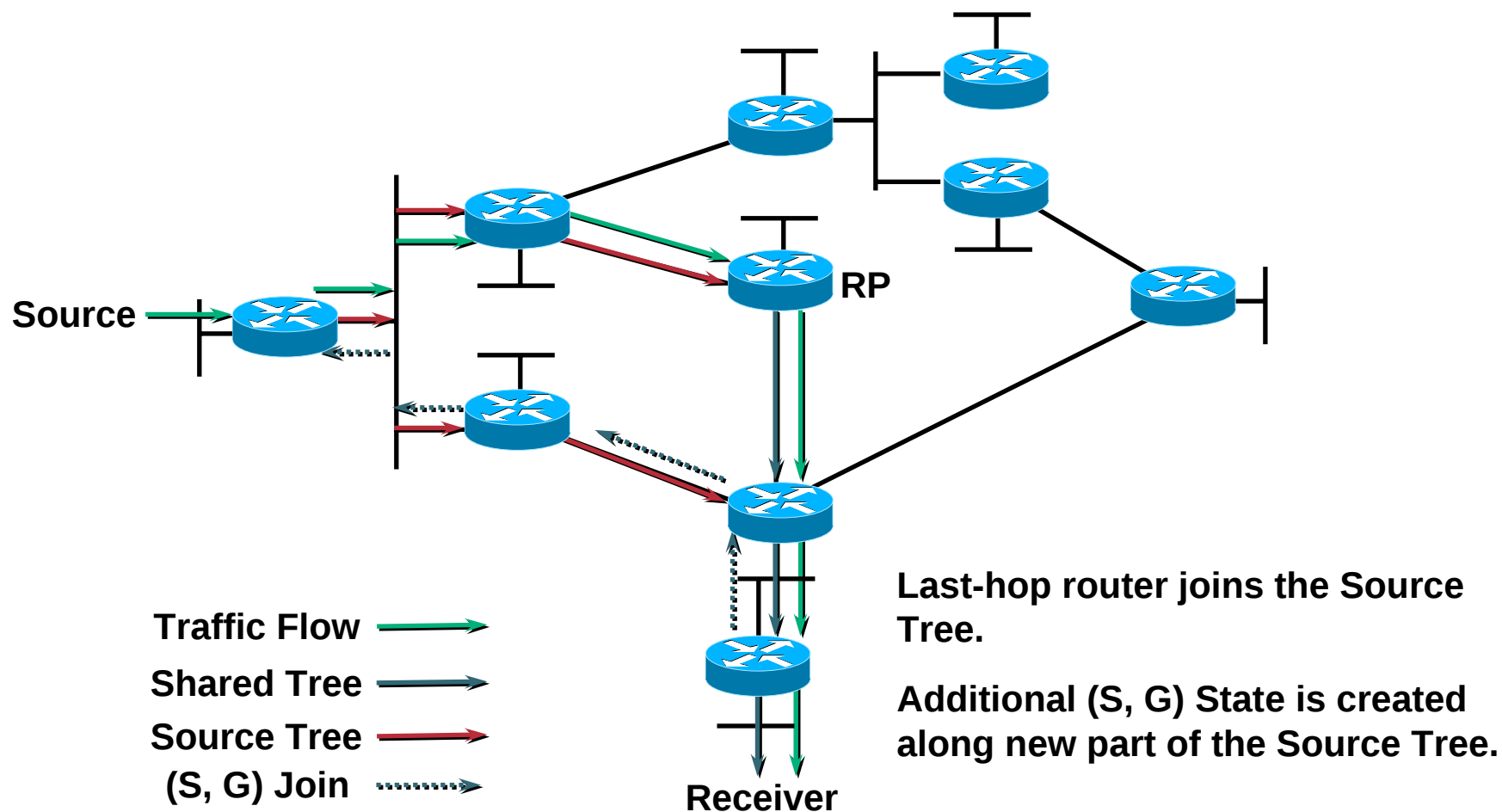
PIM-SM Sender Registration



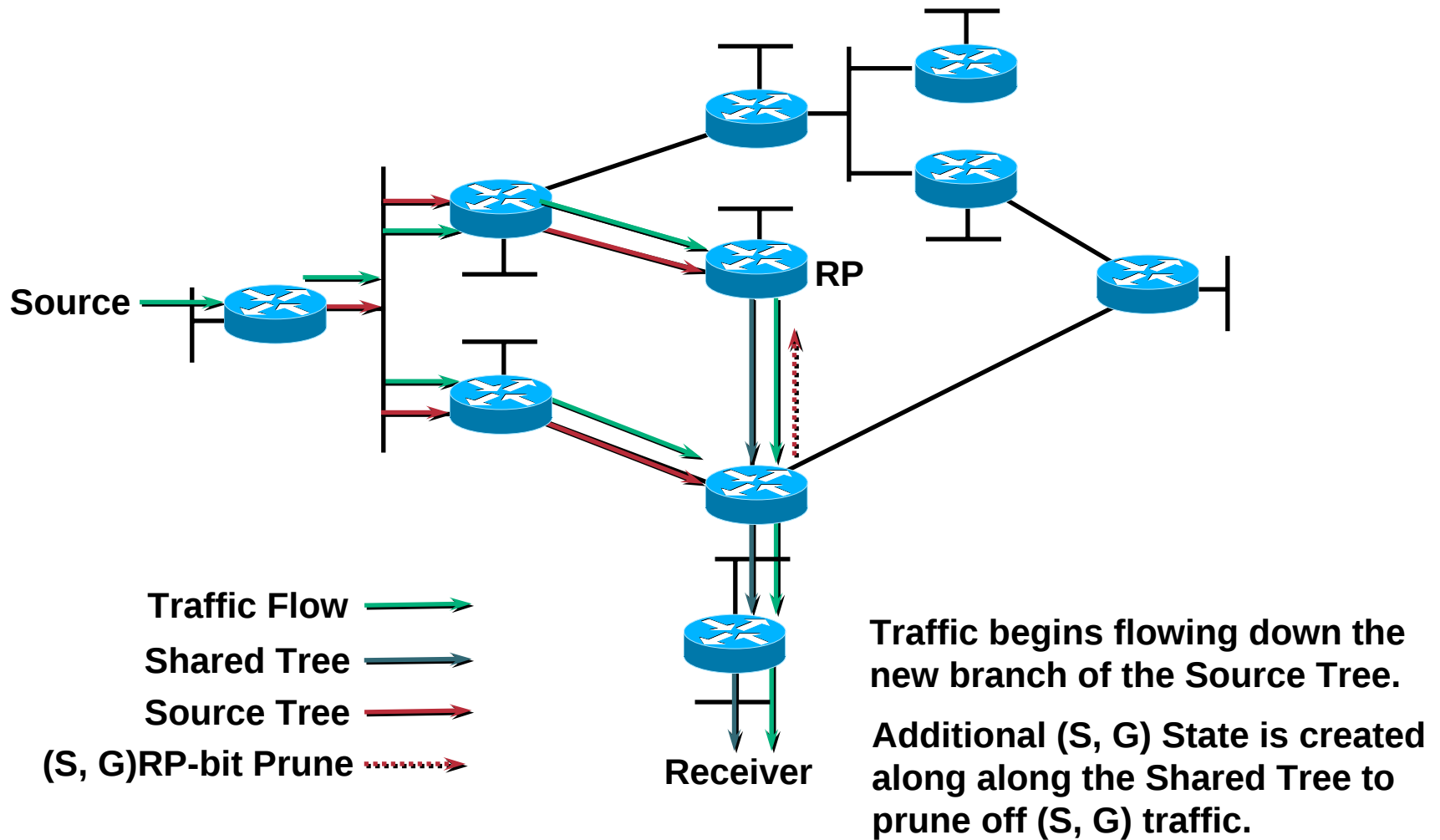
PIM-SM Sender Registration



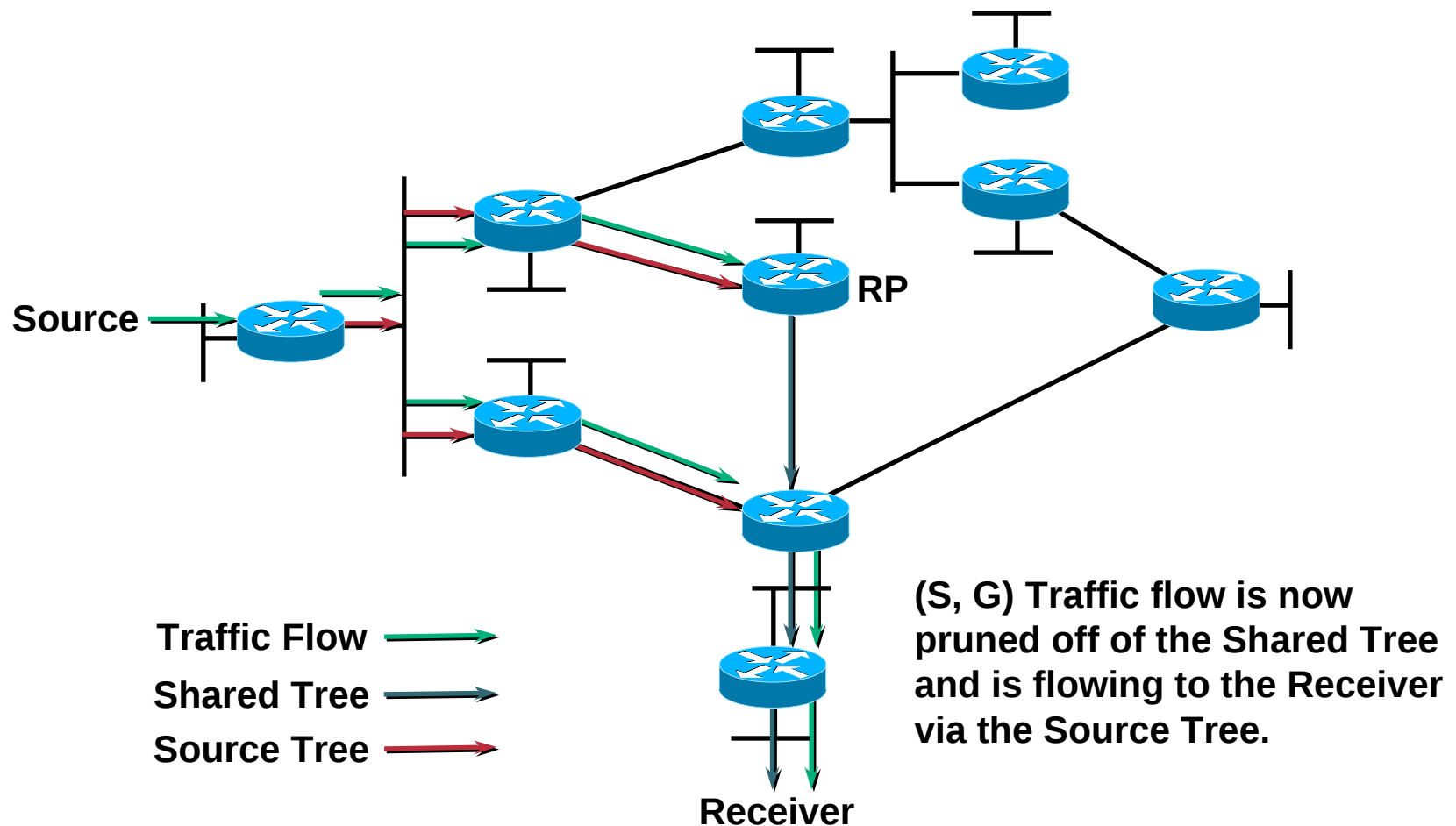
PIM-SM SPT Switchover



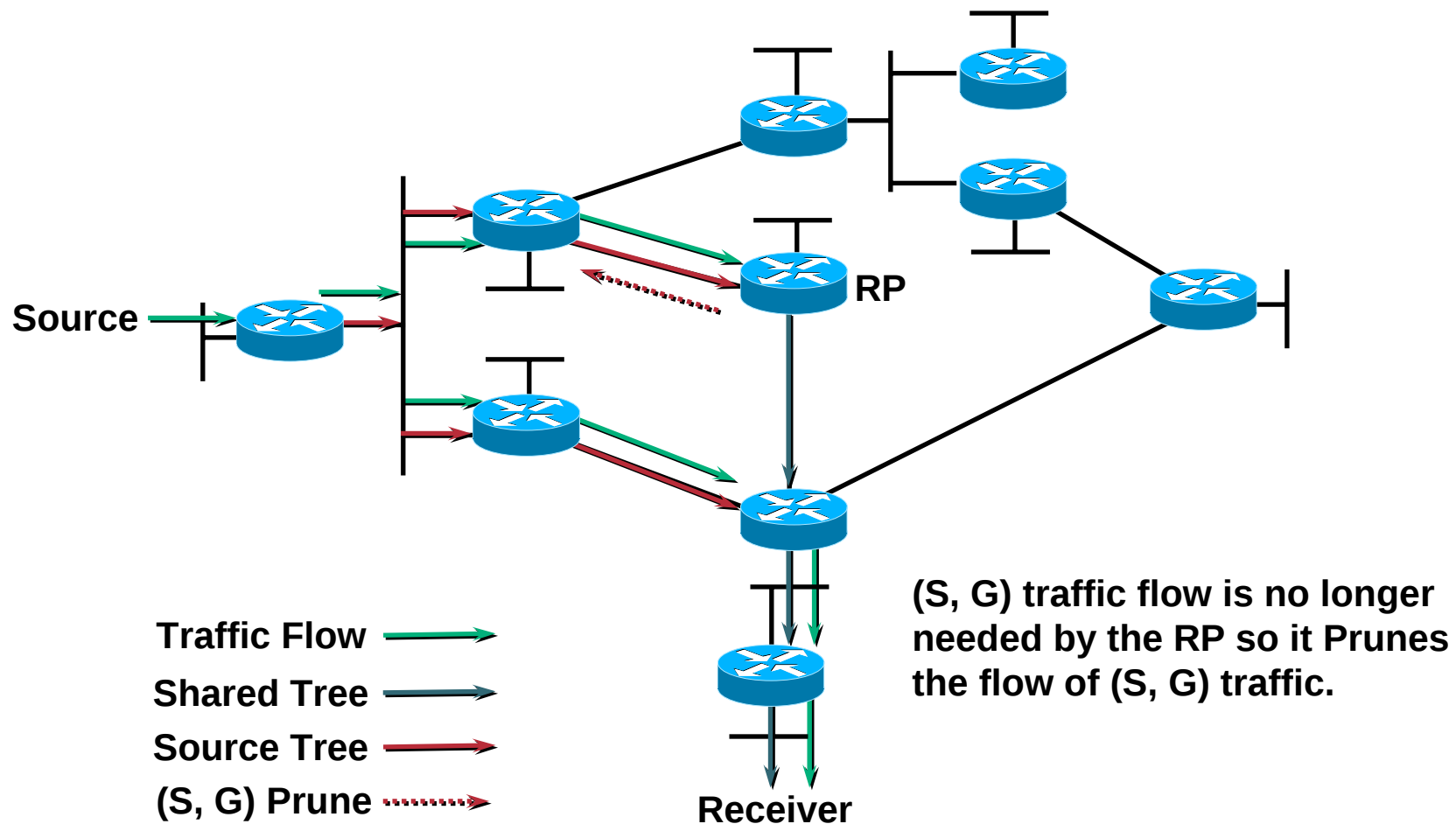
PIM-SM SPT Switchover



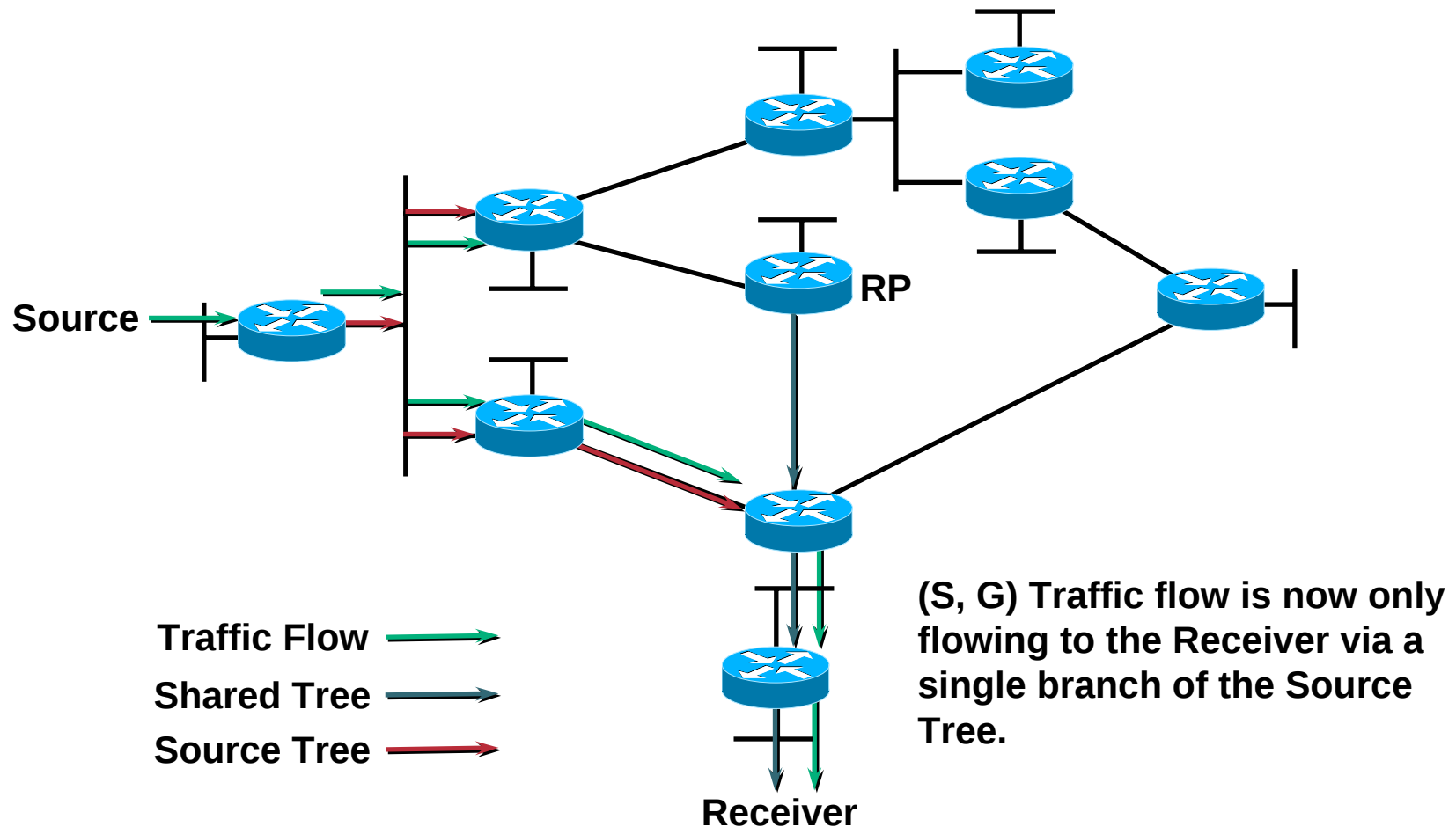
PIM-SM SPT Switchover



PIM-SM SPT Switchover



PIM-SM SPT Switchover



PIM-SM FFF

“ The default behavior of PIM-SM is that routers with directly connected members will join the Shortest Path Tree as soon as they detect a new multicast source.”

PIM-SM Frequently Forgotten Fact

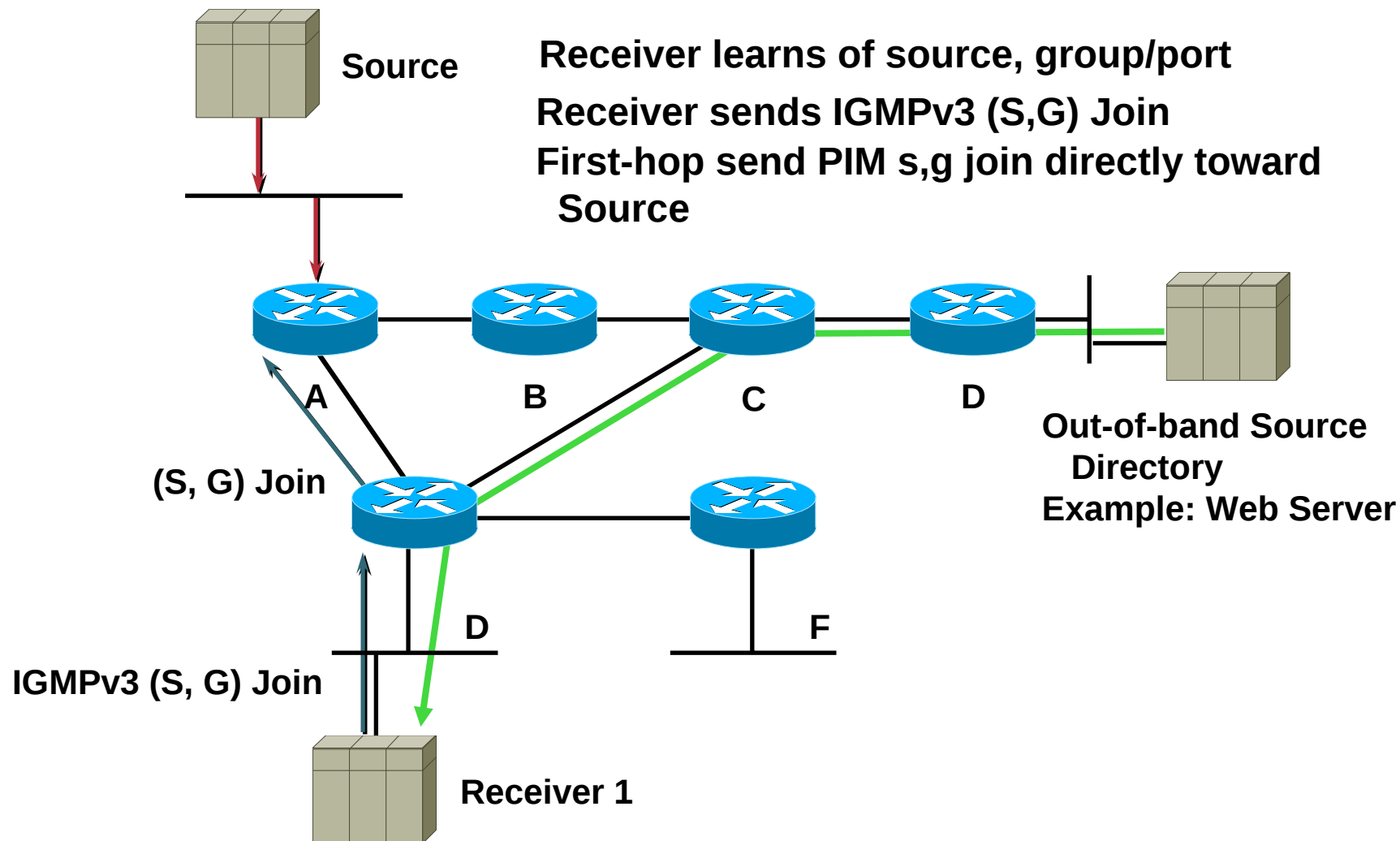
PIM-SM—Evaluation

- **Effective for Sparse or Dense distribution of multicast receivers**
- **Advantages:**
 - Traffic only sent down “joined” branches
 - Can switch to optimal source-trees for high traffic sources dynamically
 - Unicast routing protocol-independent
 - Basis for inter-domain multicast routing
 - When used with MBGP, MSDP and/or SSM

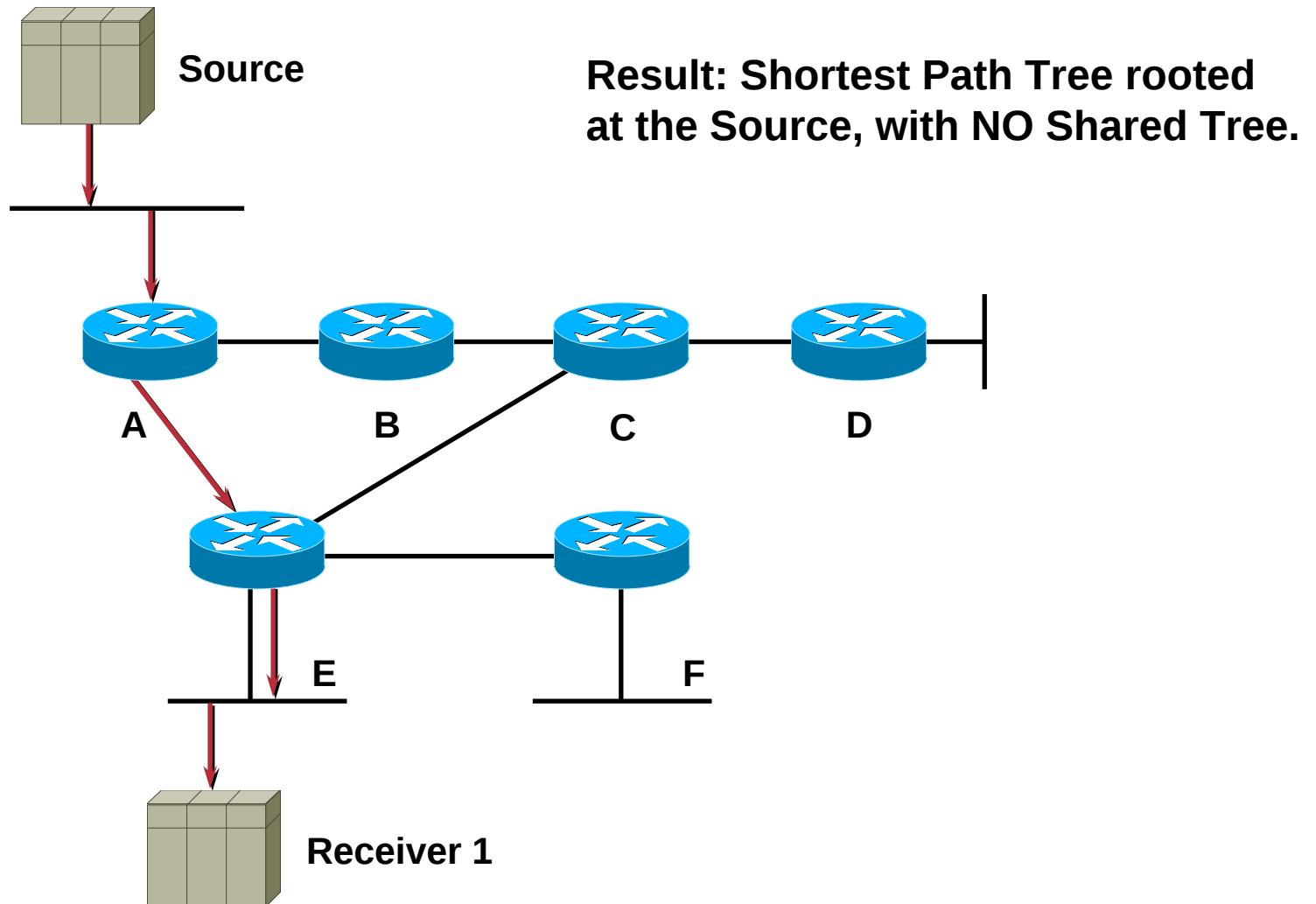
Source Specific Multicast

- **Assume a One-to-Many Multicast Model.**
 - **Example: Video/Audio broadcasts, Stock Market data**
- **Why does PIM-SM need a Shared Tree?**
 - **So that hosts and 1st hop routers can learn who the active source is for the group.**
- **What if this was already known?**
 - **Hosts could use IGMPv3 to signal exactly which (S,G) SPT to join.**
 - **The Shared Tree & RP wouldn't be necessary.**
 - **Different sources could share the same Group address and not interfere with each other.**
- **Result: Source Specific Multicast (SSM)**
- **RFC 3569 An Overview of Source-Specific Multicast (SSM)**

PIM Source Specific Mode



PIM Source Specific Mode



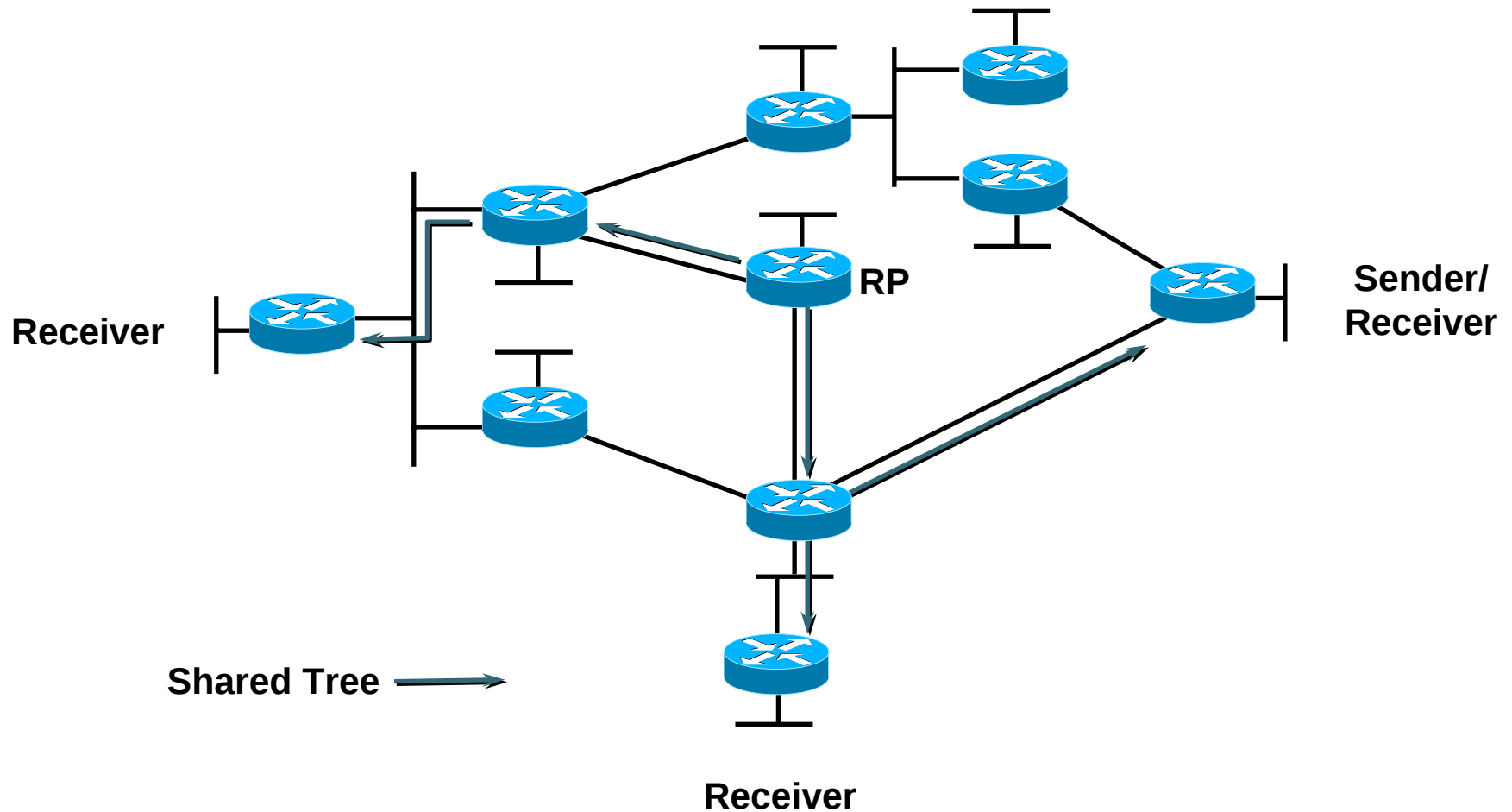
PIM-SSM - Evaluation

- **Ideal for applications with one source sending to many receivers**
- **Solves multicast address allocation problems.**
 - Flows differentiated by both source and group.
 - Not just by group.
 - Content providers can use same group ranges.
 - Since each (S,G) flow is unique.
- **Helps prevent certain DoS attacks**
 - “Bogus” source traffic:
 - Can’t consume network bandwidth.
 - Not received by host application.

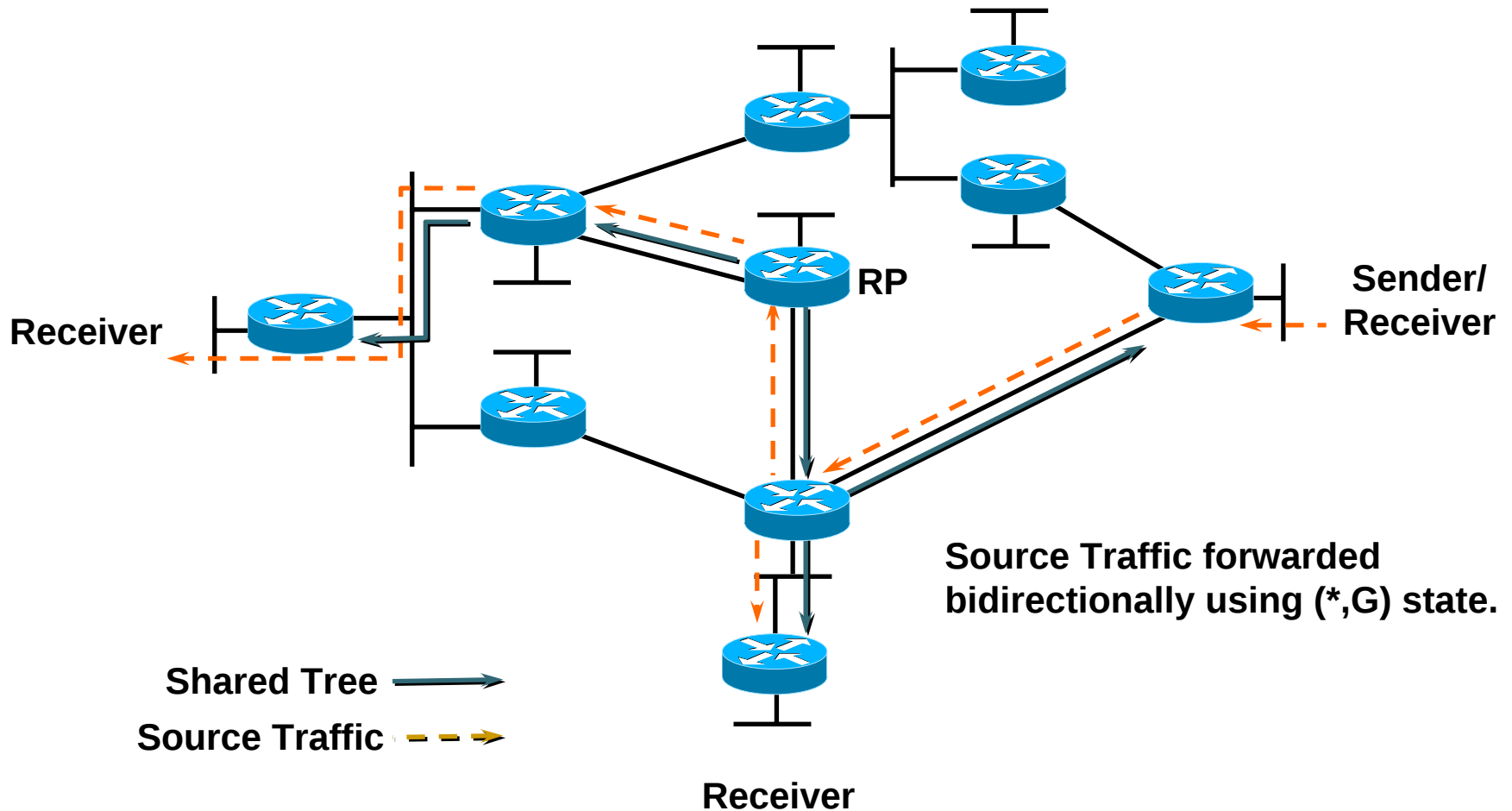
Many-to-Any State Problem

- **Creates huge amounts of (S,G) state**
 - **State maintenance workloads skyrocket**
 - **High OIL fanouts make the problem worse**
 - **Router performance begins to suffer**
- **Using Shared-Trees only.**
 - **Provides some (S,G) state reduction**
 - **Results in (S,G) state only along SPT to RP**
 - **Frequently still too much (S,G) state**
 - **Need a solution that only uses (*,G) state**

Bidirectional PIM—Overview



Bidirectional PIM—Overview



Bidir PIM–Evaluation

- **Ideal for Many to Many applications**
- **Drastically reduces network mroute state.**
 - **Eliminates ALL (S,G) state in the network.**
 - **SPT's between sources to RP eliminated.**
 - **Source traffic flows both up and down Shared Tree.**
 - **Allows Many-to-Any applications to scale.**
 - **Permits virtually an unlimited number of sources.**

RP choices



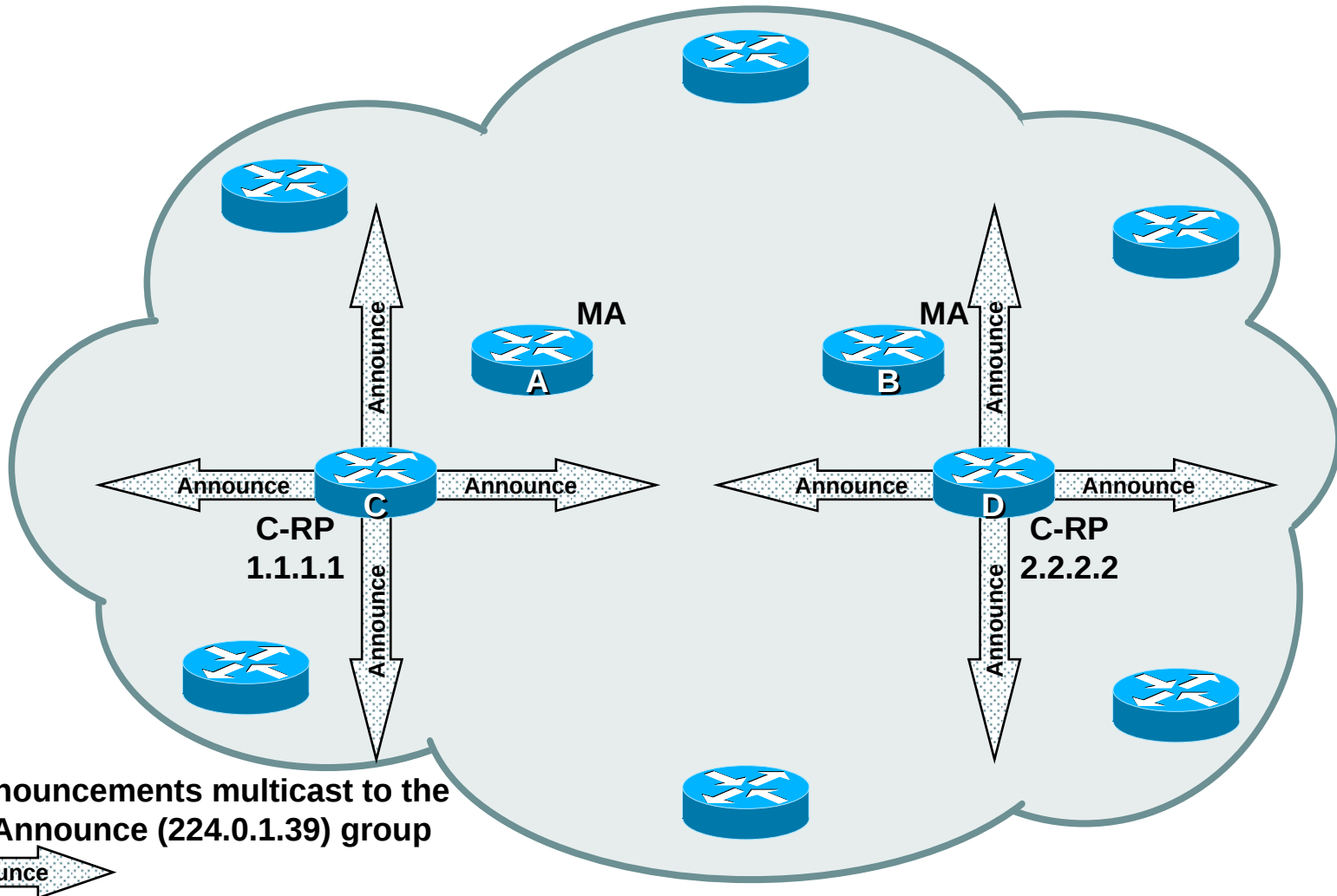
How does the network know about the RP ?

- **Static configuration**
- **AutoRP**
- **BSR**
- **MSDP Anycast**

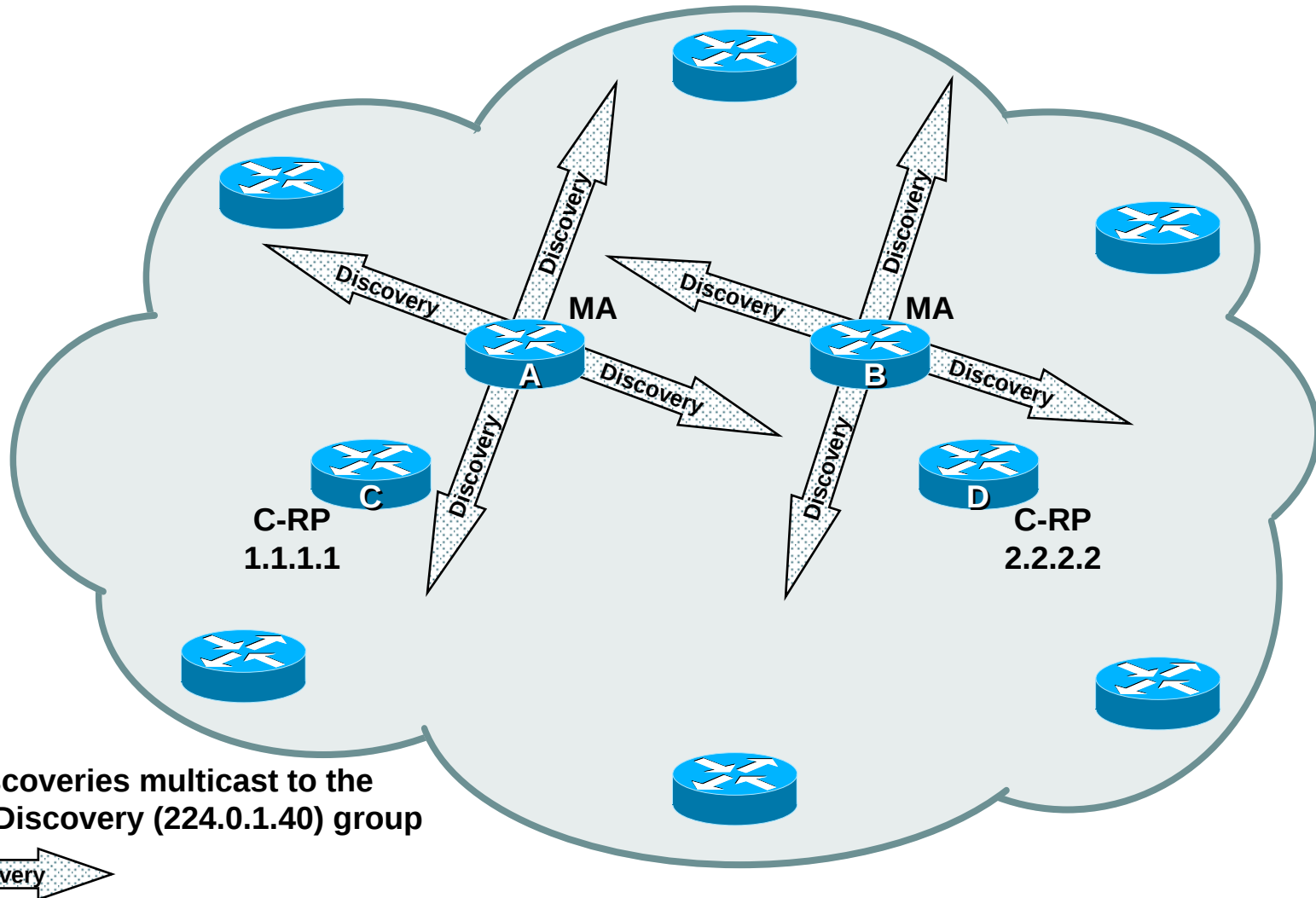
Static RP's

- **Hard-coded RP address**
 - When used, must be configured on every router
 - All routers must have the same RP address
 - RP fail-over not possible
 - Exception: If Anycast RPs are used.
- **Command**
 - `ip pim rp-address <address> [group-list <acl>] [override]`
 - Optional group list specifies group range
 - Default: Range = 224.0.0.0/4 (**Includes Auto-RP Groups!!!!**)
 - Override keyword “overrides” Auto-RP information
 - Default: Auto-RP learned info takes precedence

Auto-RP—From 10,000 Feet



Auto-RP—From 10,000 Feet

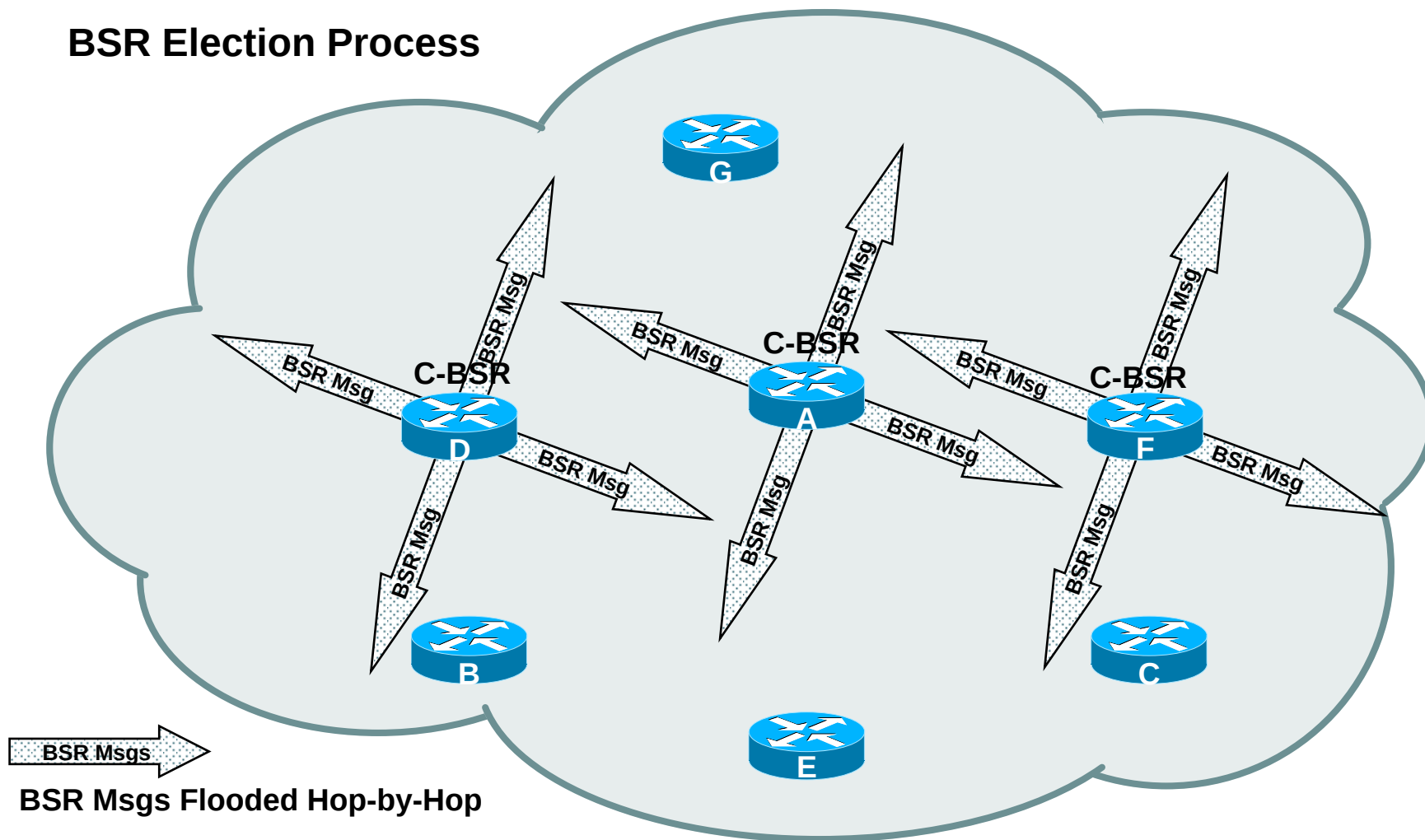


BSR Overview

- **A single Bootstrap Router (BSR) is elected**
 - **Multiple Candidate BSR's (C-BSR) can be configured**
 - Provides backup in case currently elected BSR fails
 - **C-RP's send C-RP announcements to the BSR**
 - C-RP announcements are sent via unicast
 - BSR stores ALL C-RP announcements in the "RP-set"
 - **BSR periodically sends BSR messages to all routers**
 - BSR Messages contain entire RP-set and IP address of BSR
 - Messages are flooded hop-by-hop throughout the network away from the BSR
 - **All routers select the RP from the RP-set**
 - All routers use the same selection algorithm; select same RP
- **BSR cannot be used with Admin-Scoping**

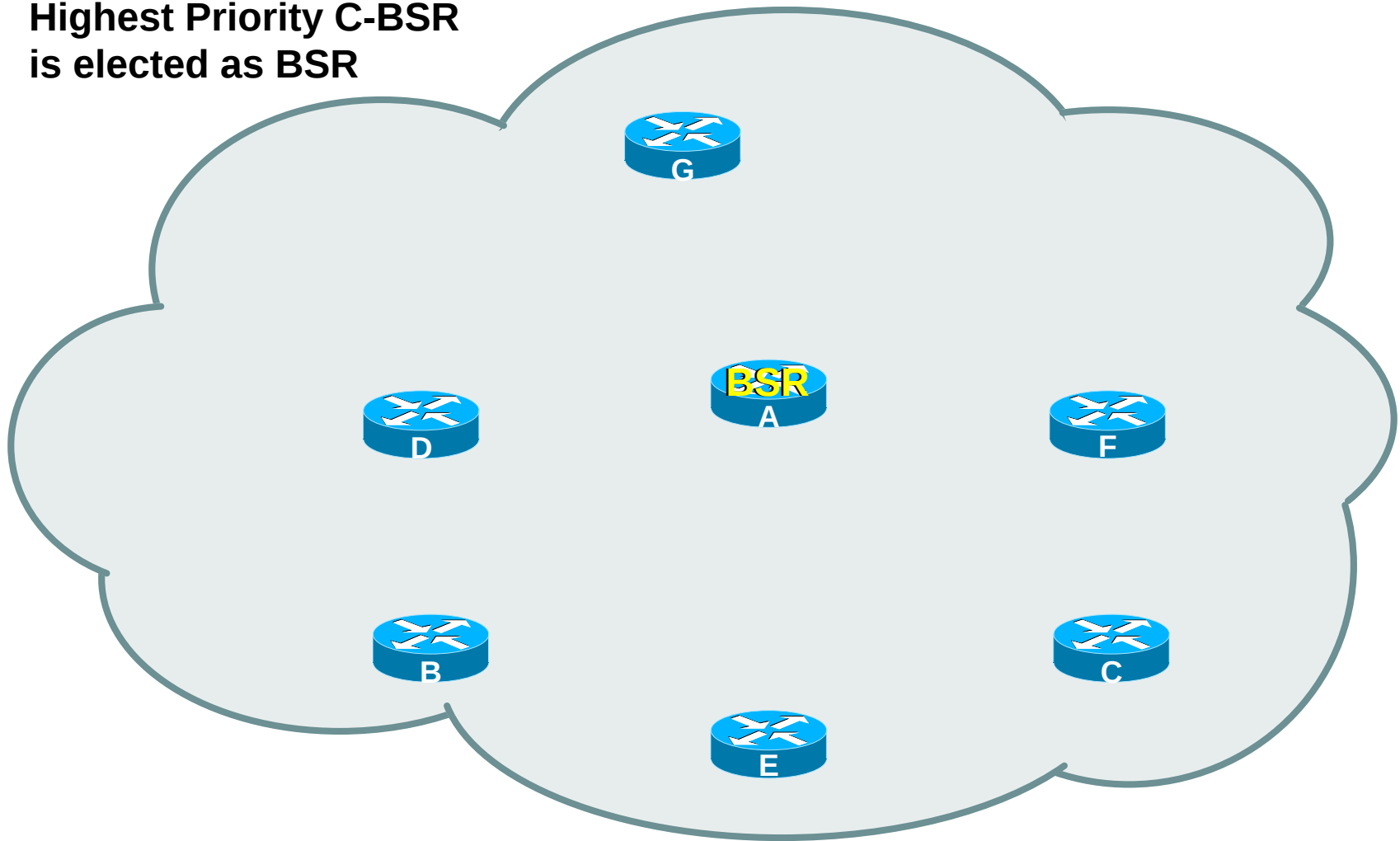
BSR – From 10,000 Feet

BSR Election Process

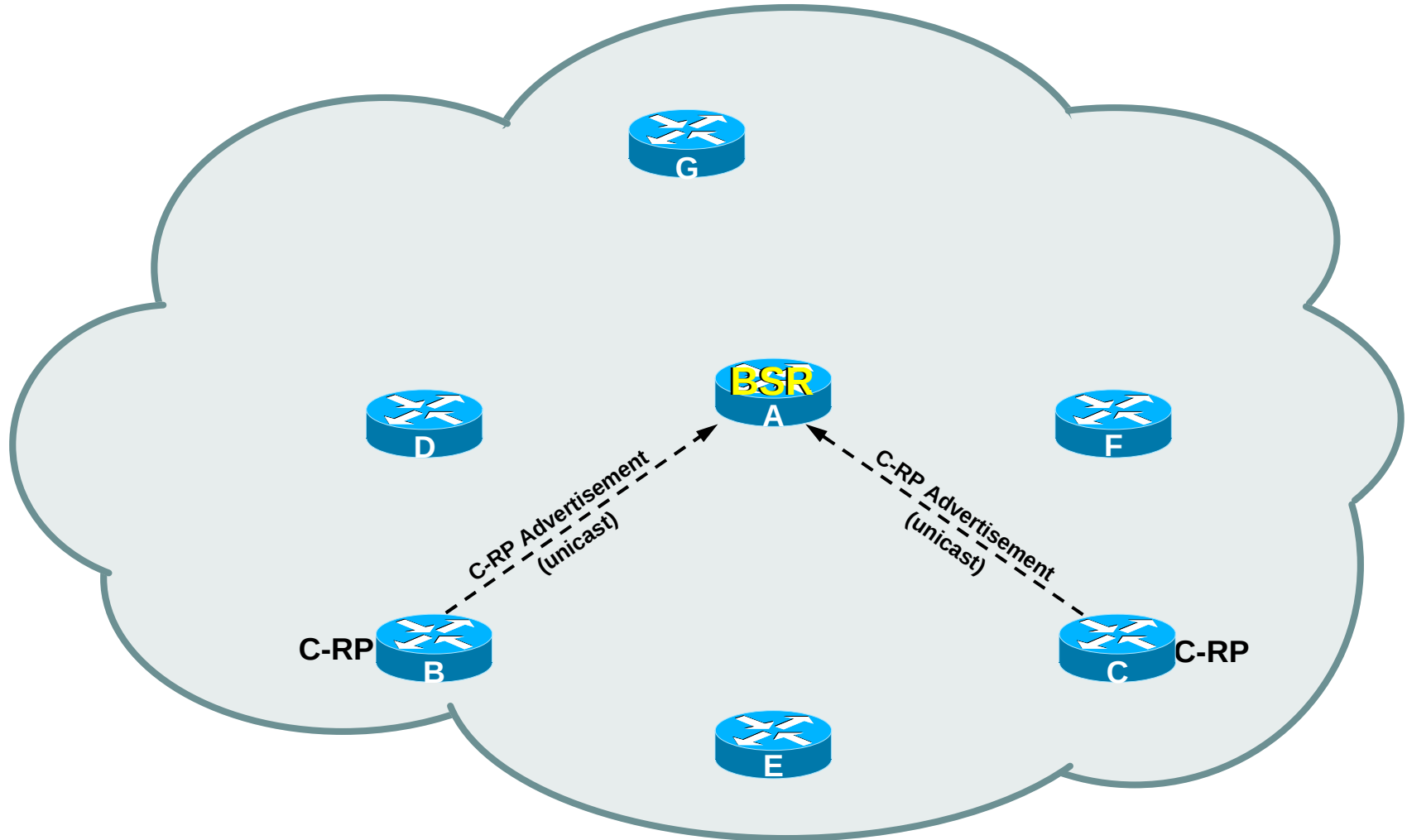


BSR – From 10,000 Feet

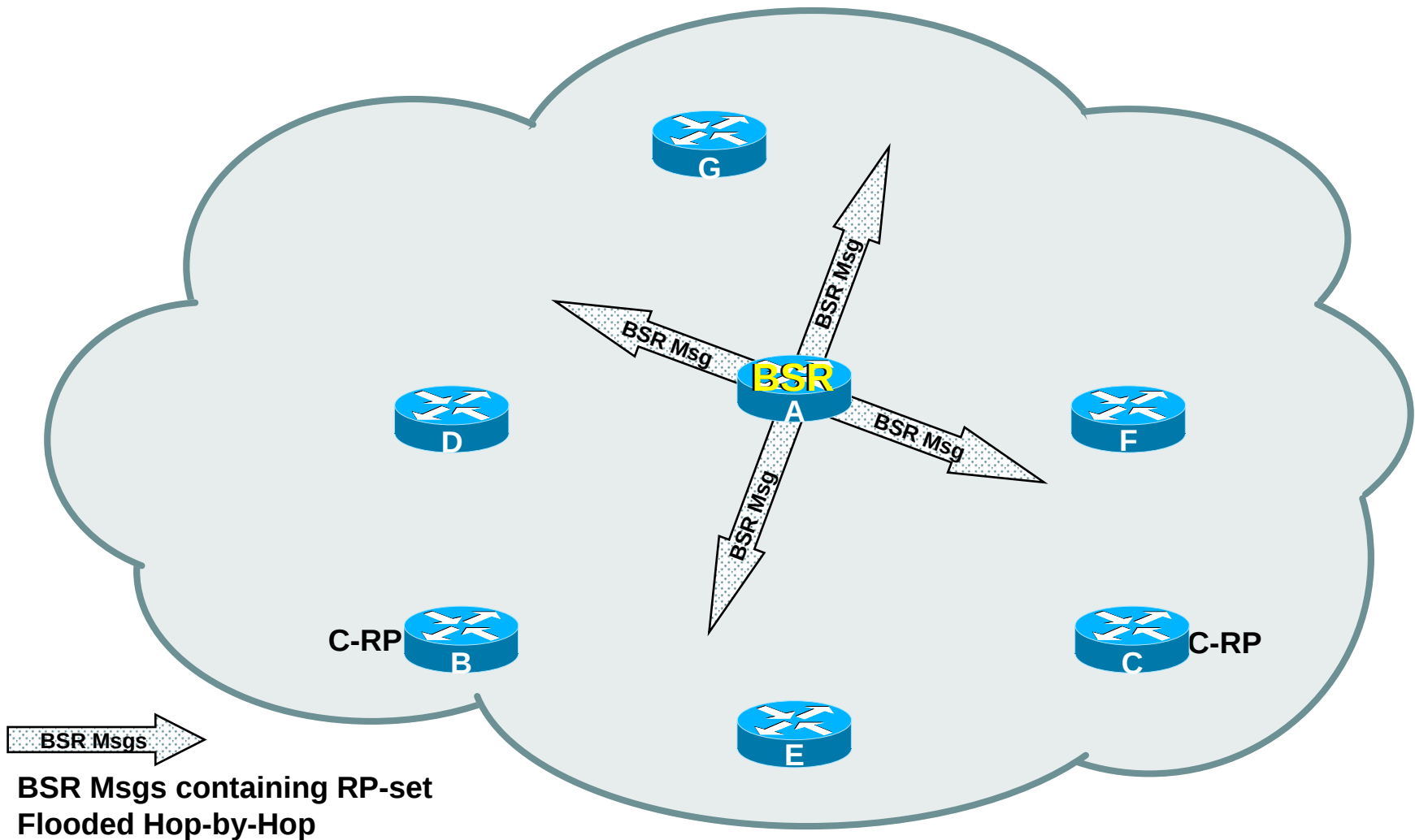
**Highest Priority C-BSR
is elected as BSR**



BSR – From 10,000 Feet



BSR – From 10,000 Feet



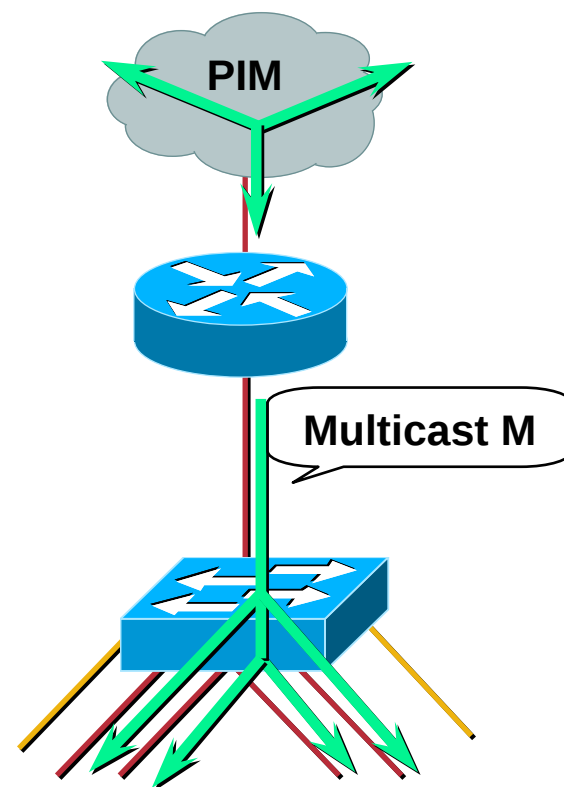
Multicast at Layer 2



L2 Multicast Frame Switching

Problem: Layer 2 Flooding of Multicast Frames

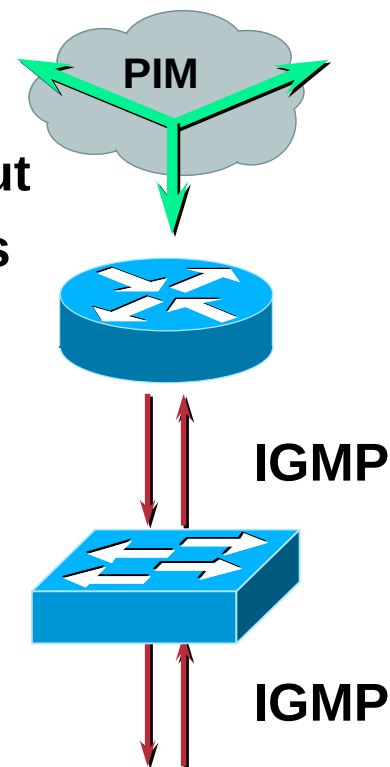
- Typical L2 switches treat multicast traffic as unknown or broadcast and must “flood” the frame to every port
- Static entries can sometimes be set to specify which ports should receive which group(s) of multicast traffic
- Dynamic configuration of these entries would cut down on user administration



L2 Multicast Frame Switching

IGMPv1-v2 Snooping

- Switches become “IGMP” aware
- IGMP packets intercepted by the NMP or by special hardware ASICs
 - Requires special hardware to maintain throughput
- Switch must examine contents of IGMP messages to determine which ports want what traffic
 - IGMP membership reports
 - IGMP leave messages
- Impact on low-end Layer-2 switches:
 - Must process ALL Layer 2 multicast packets
 - Admin. load increases with multicast traffic load
 - Generally results in switch **Meltdown** !!!



L2 Multicast Frame Switching

- **Impact of IGMPv3 on IGMP Snooping**
 - **IGMPv3 Reports sent to separate group (224.0.0.22)**
 - Switches listen to just this group.
 - Only IGMP traffic – no data traffic.
 - *Substantially* reduces load on switch CPU.
 - Permits low-end switches to implement IGMPv3 Snooping
 - **No Report Suppression in IGMPv3**
 - Enables individual member tracking
 - **IGMPv3 supports Source-specific Includes/Excludes**
 - Permits (S,G) state to be maintained by switch
 - » Currently not implemented by any switches.
 - May be necessary for full IGMPv3 functionality

Summary—Frame Switches

- **IGMP snooping**

- Switches with Layer 3 aware Hardware/ASICs
 - High-throughput performance maintained
 - Increases cost of switches
- Switches without Layer 3 aware Hardware/ASICs
 - Suffer serious performance degradation or even **Meltdown!**
 - » Shouldn't be a problem when IGMPv3 is implemented

Interdomain IP Multicast



MBGP Overview

- **MBGP: Multiprotocol BGP**
 - Defined in RFC 2858 (extensions to BGP)
 - Can carry different types of routes
 - Unicast
 - Multicast
 - Both routes carried in same BGP session
 - Does **not** propagate multicast state info
 - Same path selection and validation rules
 - AS-Path, LocalPref, MED, ...

MBGP Overview

- Separate BGP tables maintained
 - **U**nicast **R**outing **I**nformation **B**ase (URIB)
 - **M**ulticast **R**outing **I**nformation **B**ase (MRIB)
- URIB
 - Contains unicast prefixes for unicast forwarding
 - Populated with BGP unicast NLRI
 - AFI = 1, Sub-AFI = 1
- MRIB
 - Contains *unicast* prefixes for RPF checking
 - Populated with BGP multicast NLRI
 - AFI = 1, Sub-AFI = 2

MBGP Overview

- **MBGP allows divergent paths and policies**
 - Same IP address holds dual significance
 - Unicast routing information
 - Multicast **RPF information**
 - For same IPv4 address two different NLRI with different next-hops
 - Can therefore support both congruent and incongruent topologies

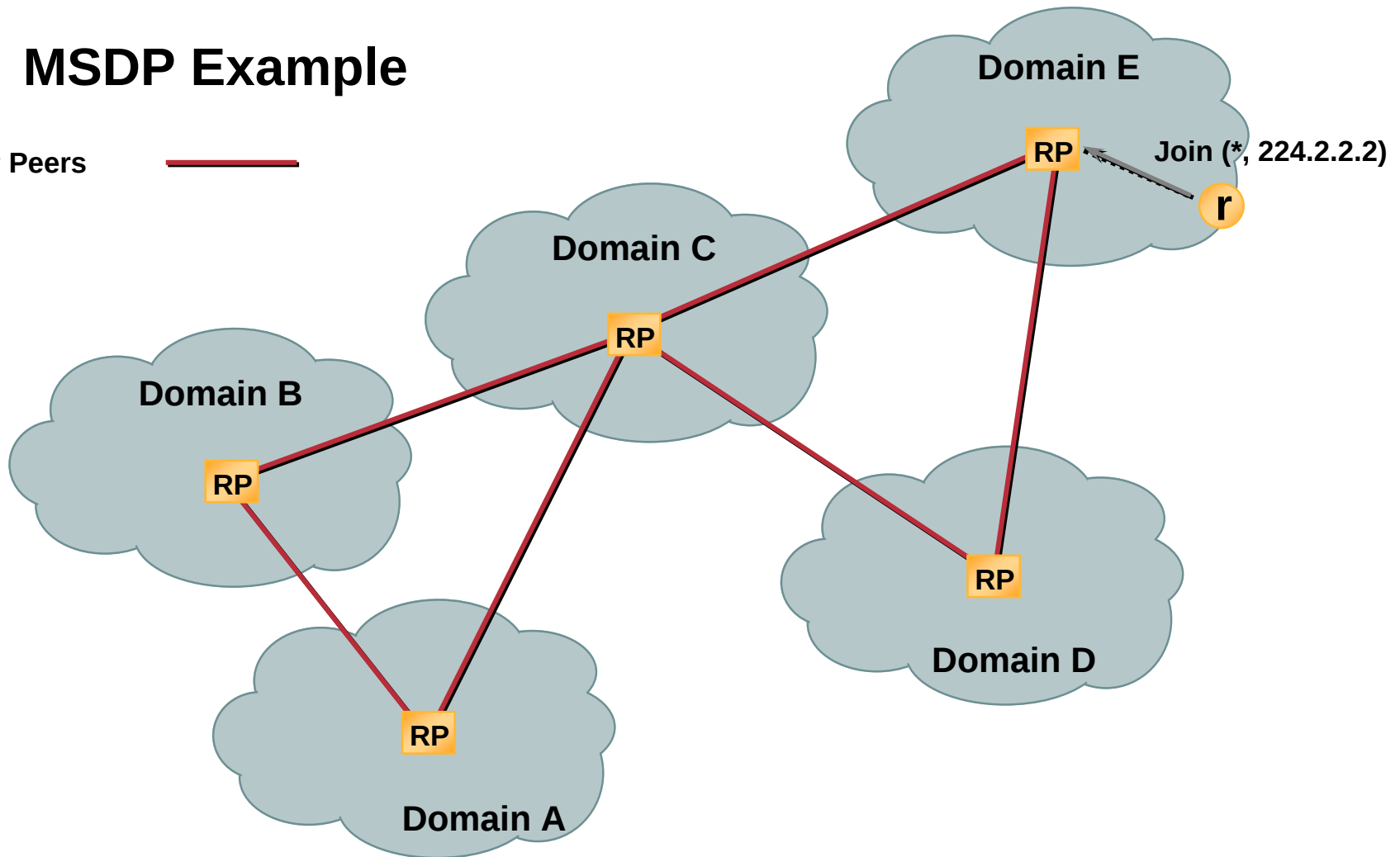
MSDP

- **Based on RFC 3618**
- **Works with PIM-SM only**
 - **RP's knows about all sources in their domain**
 - **Sources cause a “PIM Register” to the RP**
 - **Tell RP's in other domains of it's sources**
 - » **Via MSDP SA (Source Active) messages**
 - **RP's know about receivers in a domain**
 - **Receivers cause a “(*, G) Join” to the RP**
 - **RP can join the source tree in the peer domain**
 - » **Via normal PIM (S, G) joins**

MSDP Overview

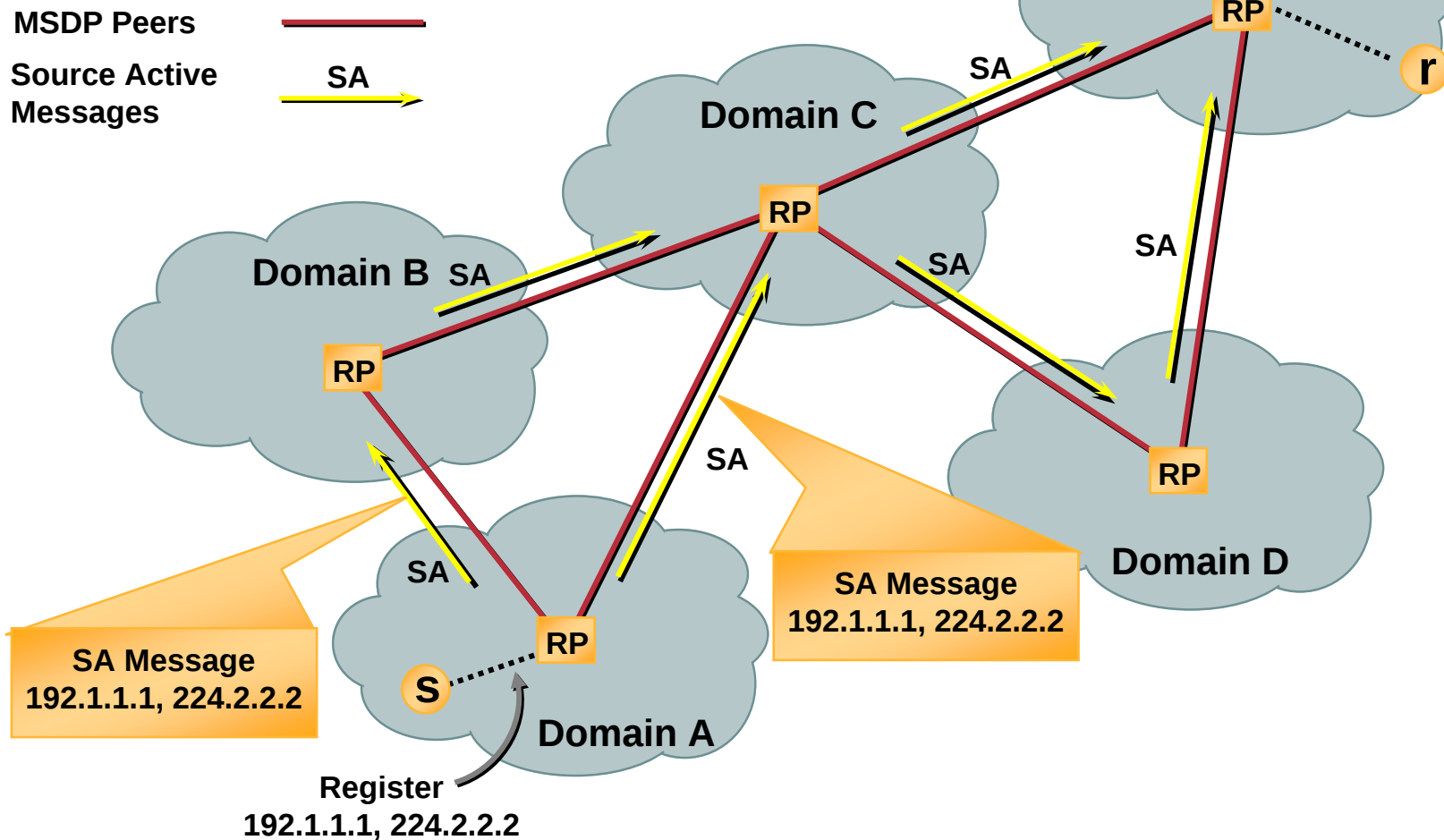
MSDP Example

MSDP Peers



MSDP Overview

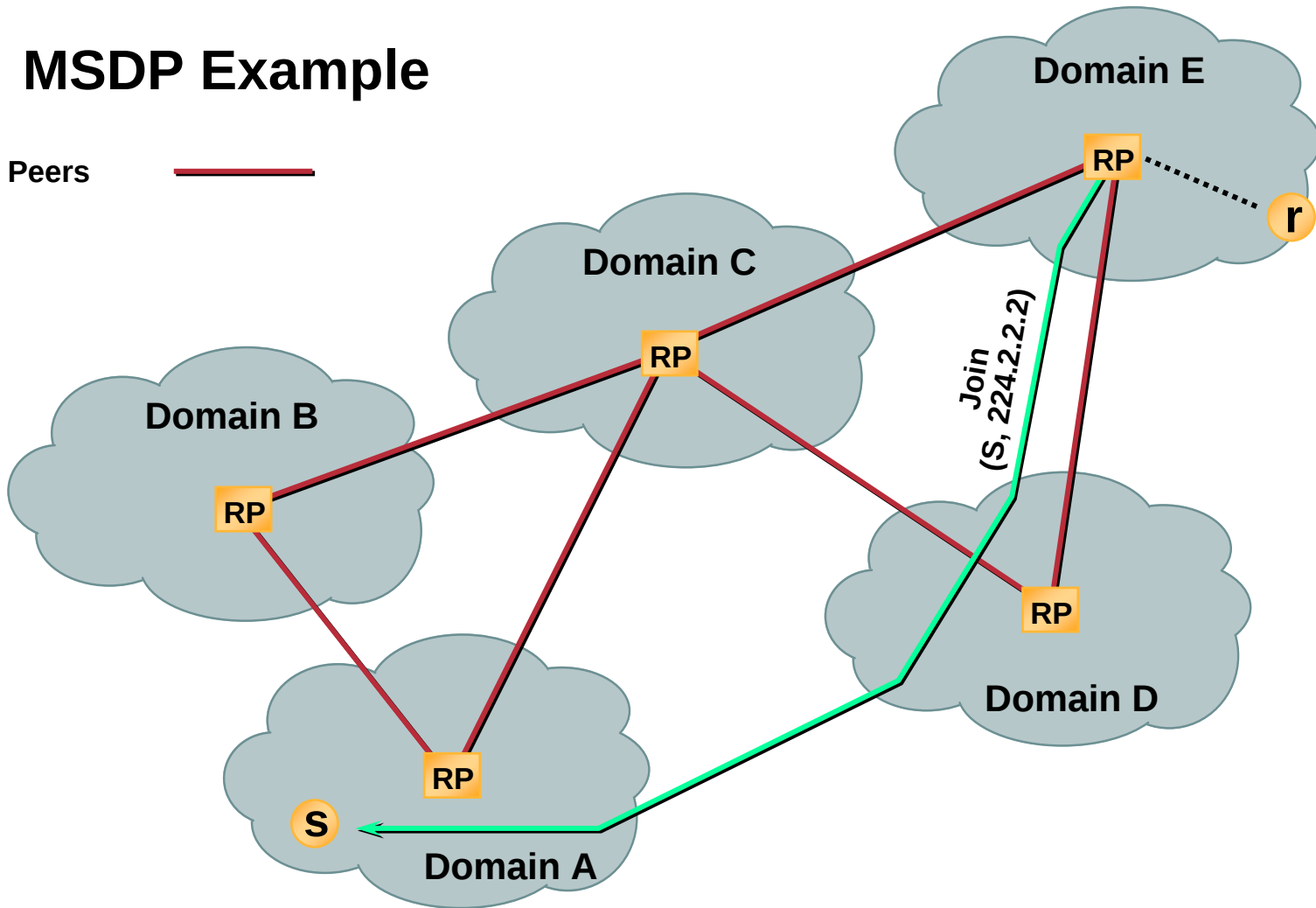
MSDP Example



MSDP Overview

MSDP Example

MSDP Peers



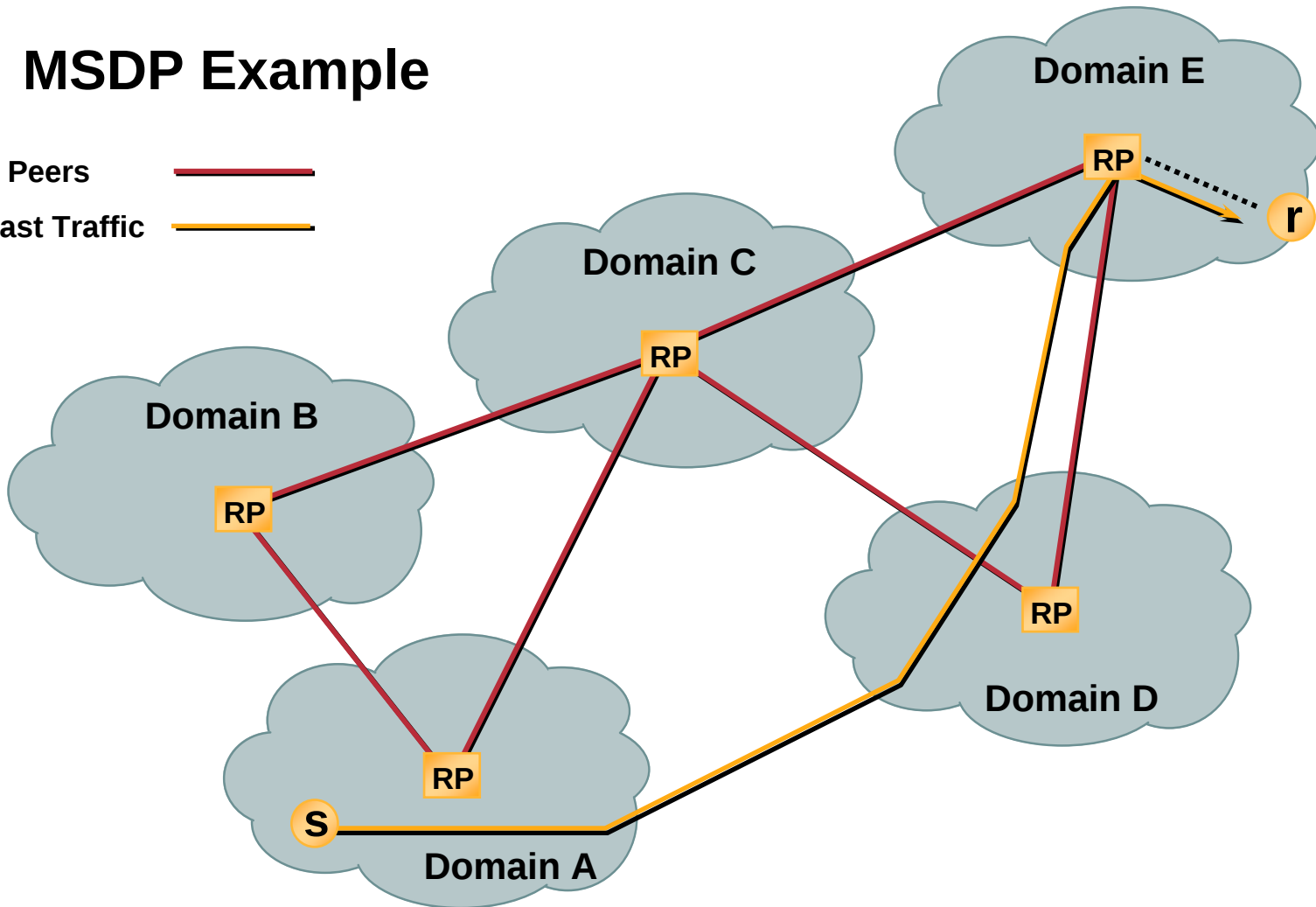
MSDP Overview

MSDP Example

MSDP Peers



Multicast Traffic



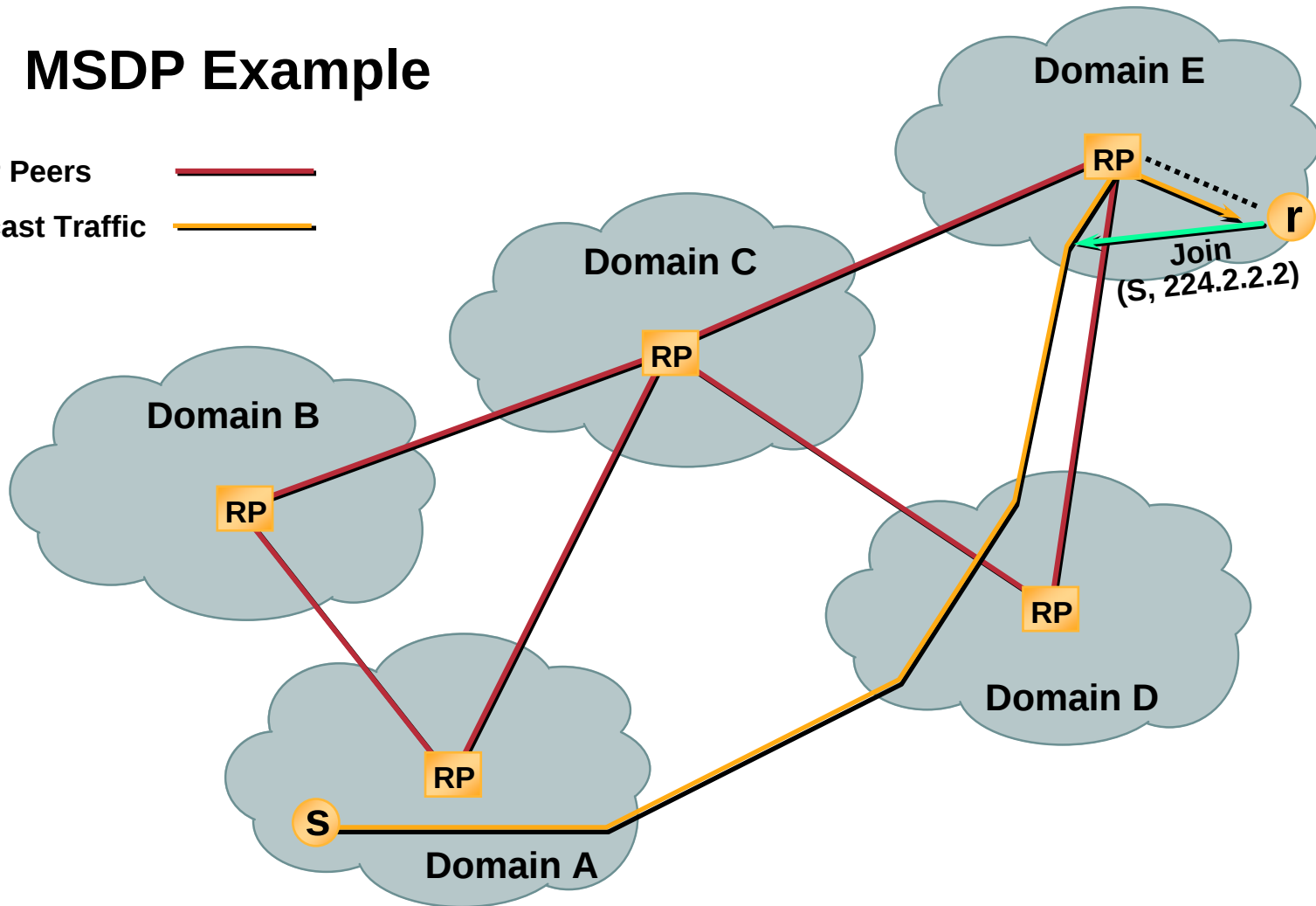
MSDP Overview

MSDP Example

MSDP Peers



Multicast Traffic



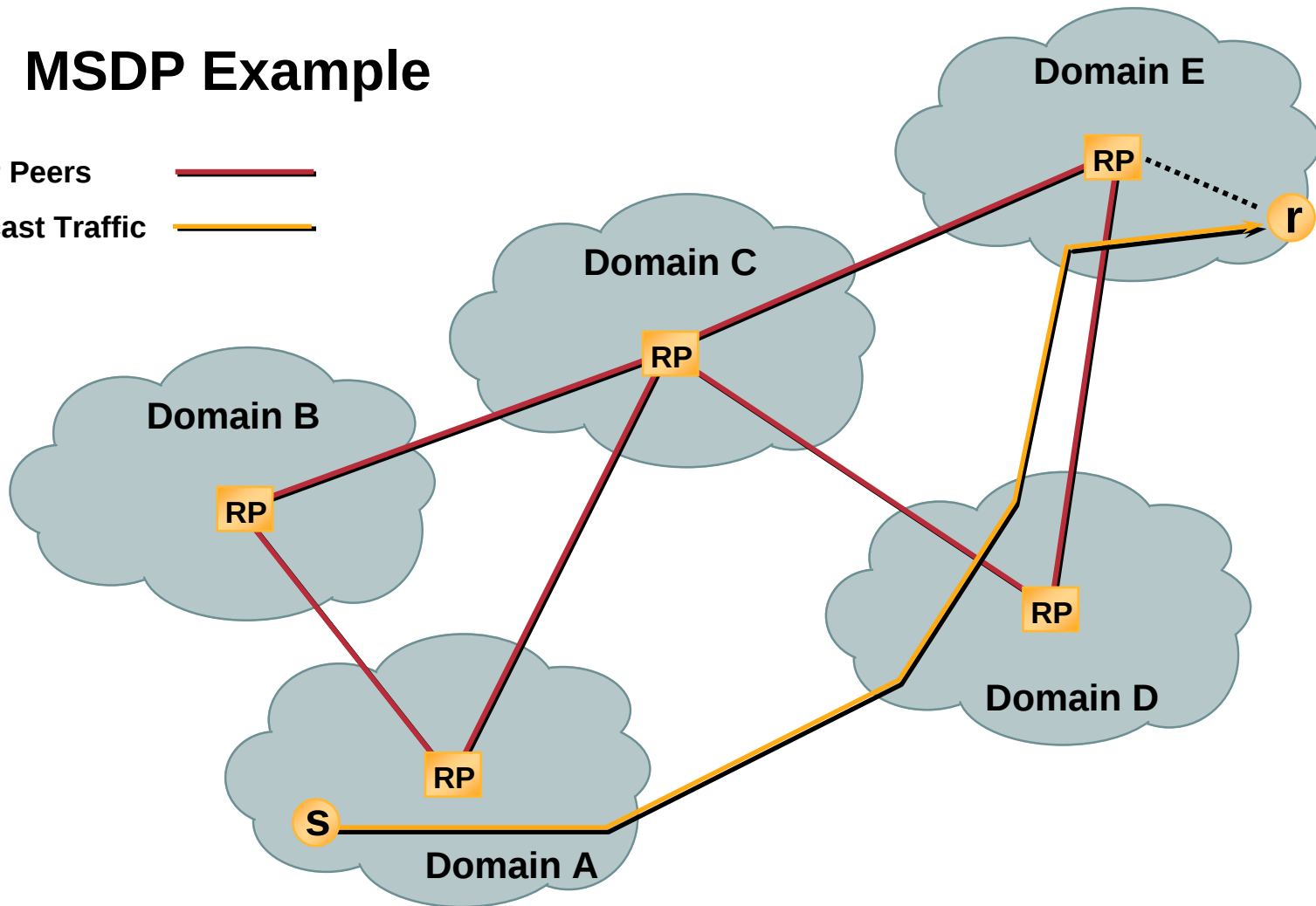
MSDP Overview

MSDP Example

MSDP Peers



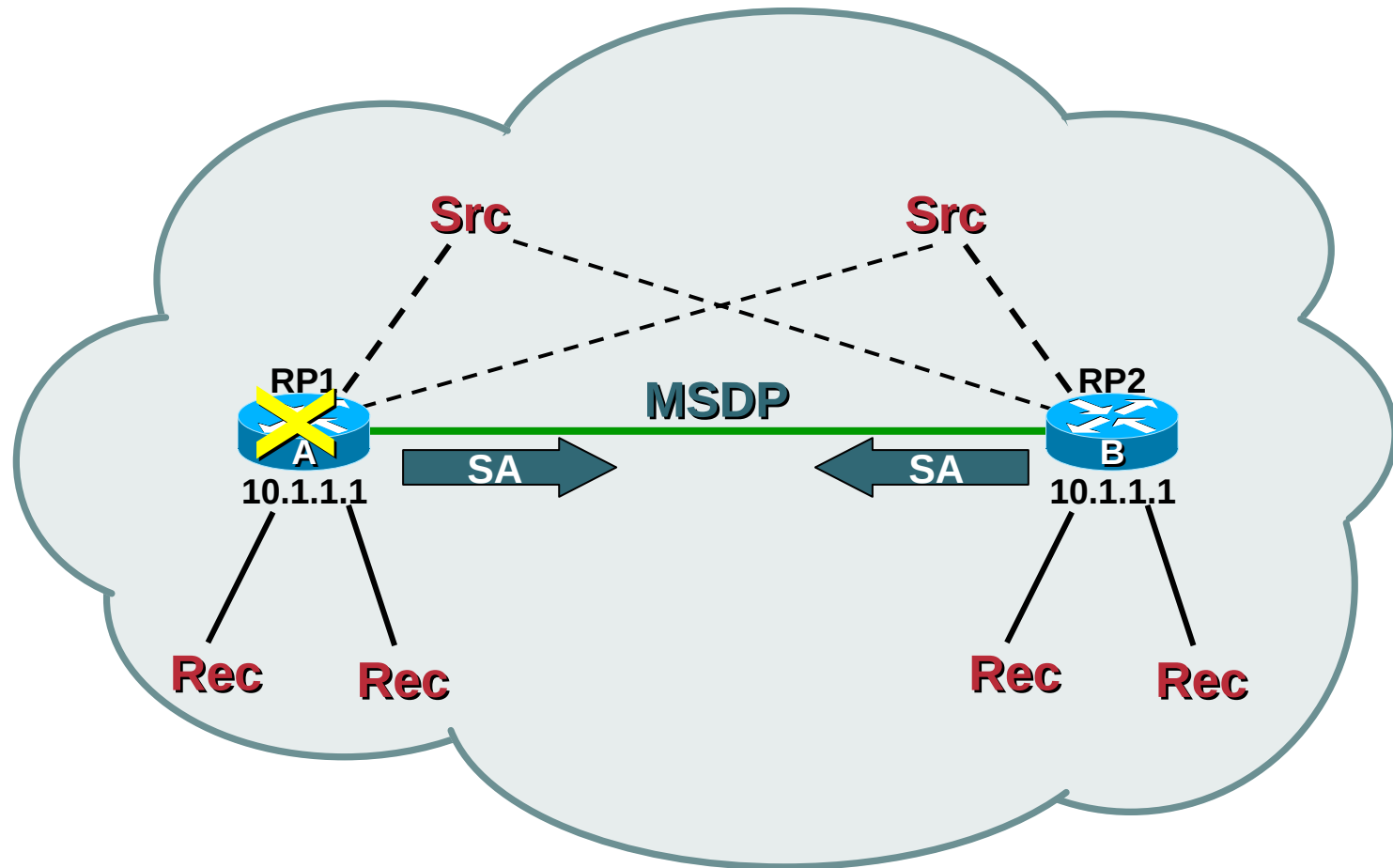
Multicast Traffic



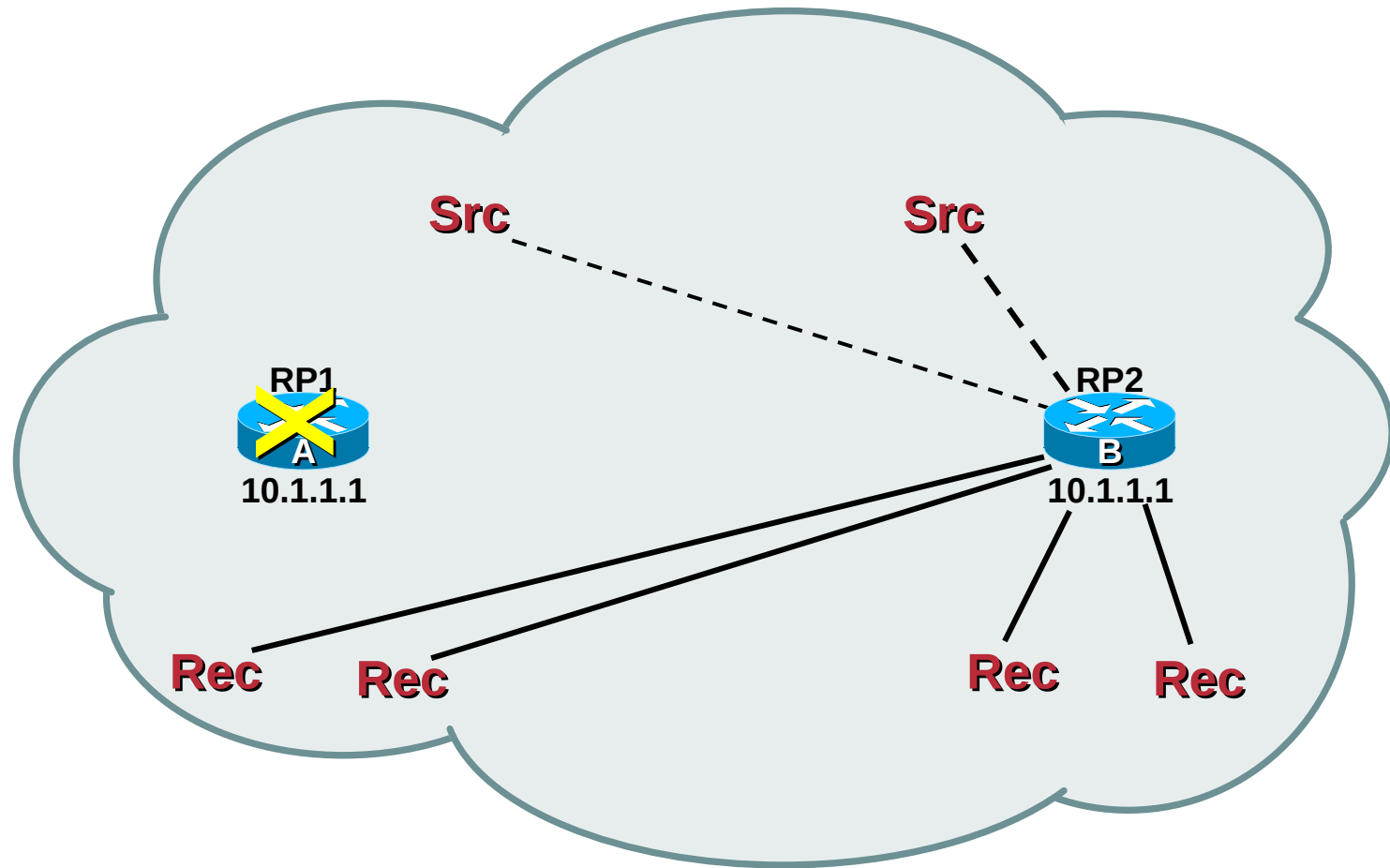
Anycast RP – Overview

- **Uses single defined RP address**
 - Two or more routers have same RP address
 - RP address defined as a Loopback Interface.
 - Loopback address advertised as a Host route.
 - Senders & Receivers Join/Register with closest RP
 - Closest RP determined from the unicast routing table.
 - Can **never** fall back to Dense mode.
 - Because RP is statically defined.
- **MSDP session(s) run between all RPs**
 - Informs RPs of sources in other parts of network
 - RPs join SPT to active sources as necessary

Anycast RP – Overview



Anycast RP – Overview

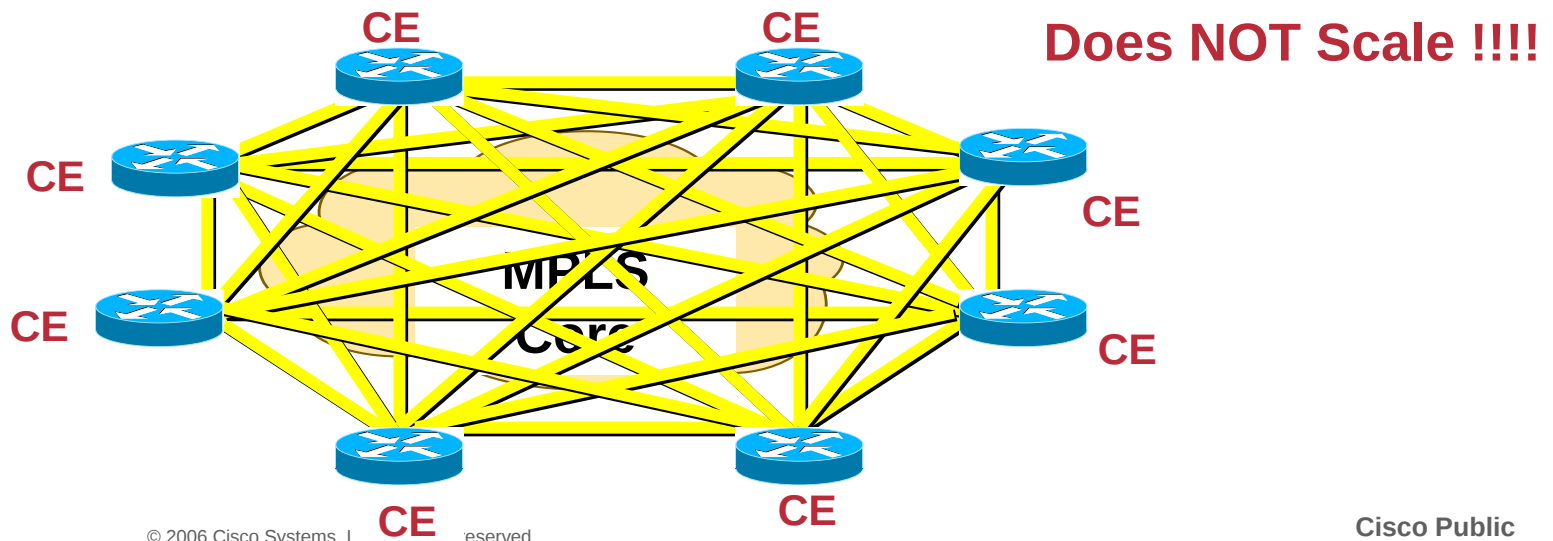


Latest Additions



Multicast VPN – Customer Requirement

- MPLS VPN customers want to run multicast within their VPNs
- Multicast deployment is expanding
- MPLS VPNs do not support multicast today
- Multicast options in MPLS VPNs today
 - GRE tunnels from CE to CE



Multicast VPN (MVPN)

- Allows an ISP to provide its MPLS VPN customers the ability to transport their **Multicast traffic** across **MPLS** packet-based core networks
- Requires IPmc enabled in the core
- MPLS still used to support unicast
- A scalable architecture solution for MPLS networks based on native multicast deployment in the core
- Uses **draft-rosen-vpn-mcast** encapsulation and signaling to build MVPN Multicast VPN (MVPN)

Multicast VPN – Terminology used

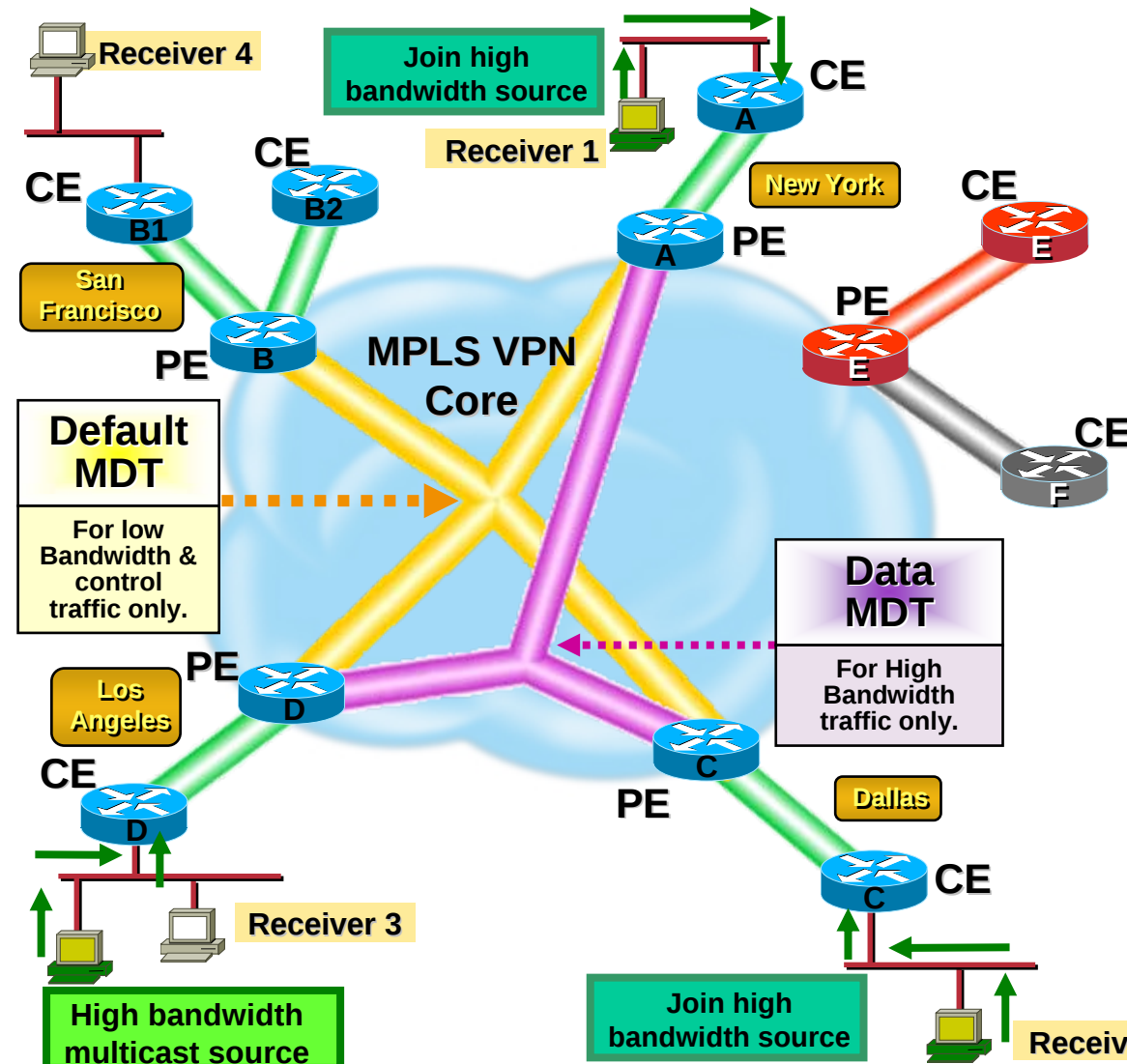
- **VPN: Virtual Private Network**
 - Although different VPN models exist, the discussion here is for MPLS based VPNs
- **MVPN: Multicast VPN**
 - A VPN that supports multicast natively
- **VRF: VPN Routing and Forwarding**
 - per-site forwarding tables
- **MVRF: Multicast VRF**
 - A VRF that supports unicast and multicast tables

Multicast VPN – Terminology used

- **MDT: Multicast Distribution Tree**
 - A multicast tree, built in the core network between PE and P routers that distributes multicast traffic between sites
- **Default-MDT:**
 - Default MDT group used for control traffic and flooding channel for dense mode and low bandwidth groups.
- **Data-MDT:**
 - MDT group created on demand for MVPN (S,G) pairs, usually high bandwidth traffic

Multicast VPN (MVPN)

Concept & Fundamentals



- Customer CE devices joins the MPLS Core through provider's PE devices
- The MPLS Core forms a Default MDT for a given Customer
- A High-bandwidth source for that customer starts sending traffic
- Interested receivers 1 & 2 join that High Bandwidth source
- Data-MDT is formed for this High-Bandwidth source

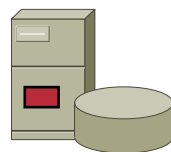
PGM: Specifications

- **RFC 3208 : Pragmatic Generic Multicast**
(PGM) Reliable Transport Protocol Specification (experimental)
 - Defines an industry standard protocol for scalable, reliable multicast
 - PGM guarantees that a receiver in the group either receives all data packets from transmissions and repairs,
or is able to detect unrecoverable data packet loss
(just like TCP, but for IP multicast !)
- **draft-ietf-rmt-bb-pgmcc:** PGM congestion control (PGM-CC)
 - Provides TCP compatible flow control (eg: RED) based on slowest receiver (with minimum rate). Without CC, source app. controls rate.

PGM: Components

Server

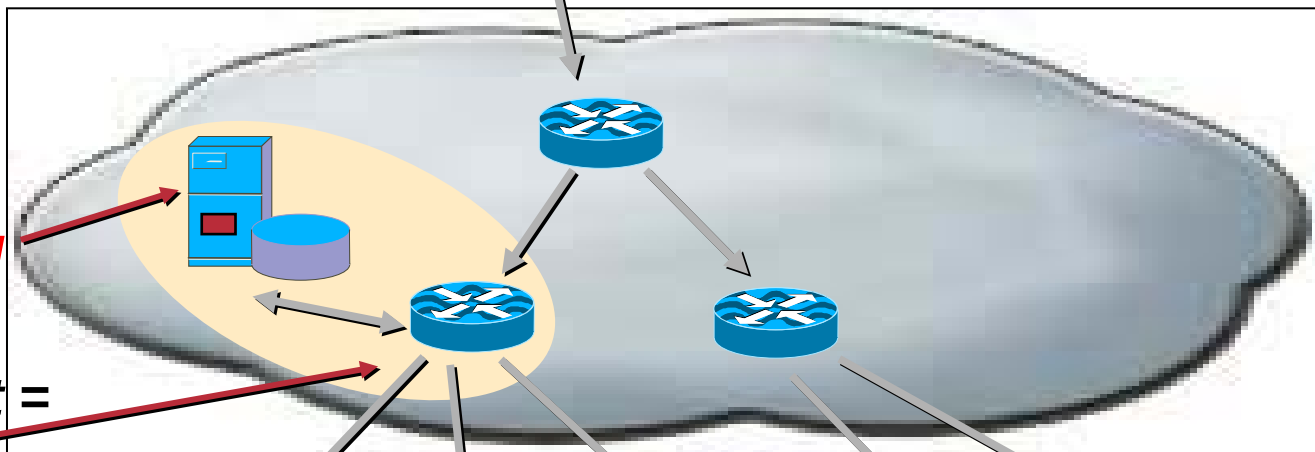
PGM
(Server/Source) Stack



Network

Optional PGM
functions
**DLR: Designated
Local Repairer**

**Network Element =
Router Assist**



Host

PGM
(Host/Receiver) Stack



PGM: Network Functions

- **PGM Network Element**

A PGM Network Element is an IP multicast router with PGM router assist.

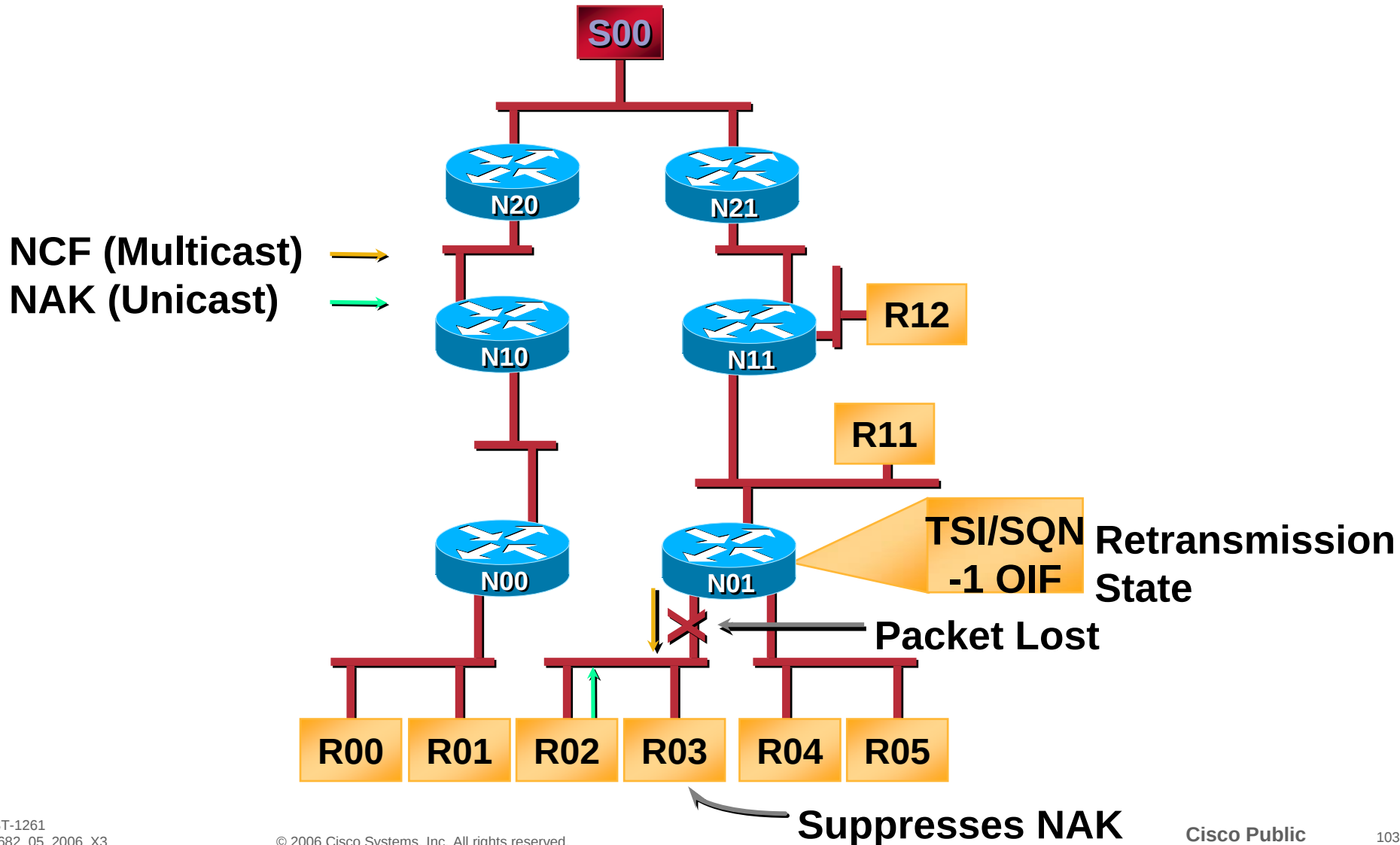
- Can be deployed on specific routers in the path when needed.
- Provides NAK suppression (inhibits NAK implosion)
- Provides constrained retransmission (only those receivers that need retransmission will receive it)

- **DLR: Designated Local Repairer:**

- Can be host or special network element
- Buffers data from source and provides for retransmissions for all receiver hosts below it in the distribution tree.

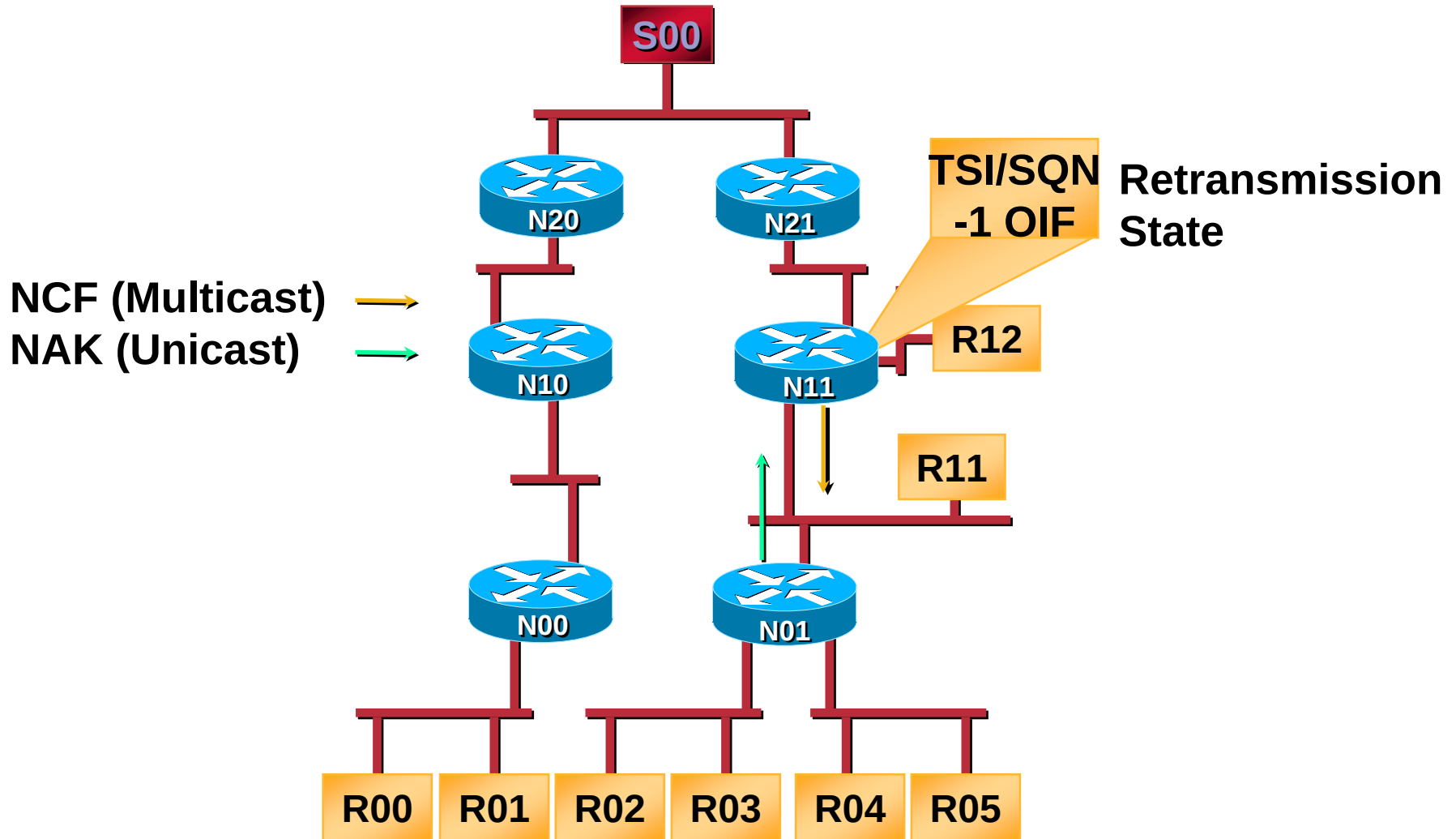
PGM Router Assist

NAK elimination and constrained retransmission (1)



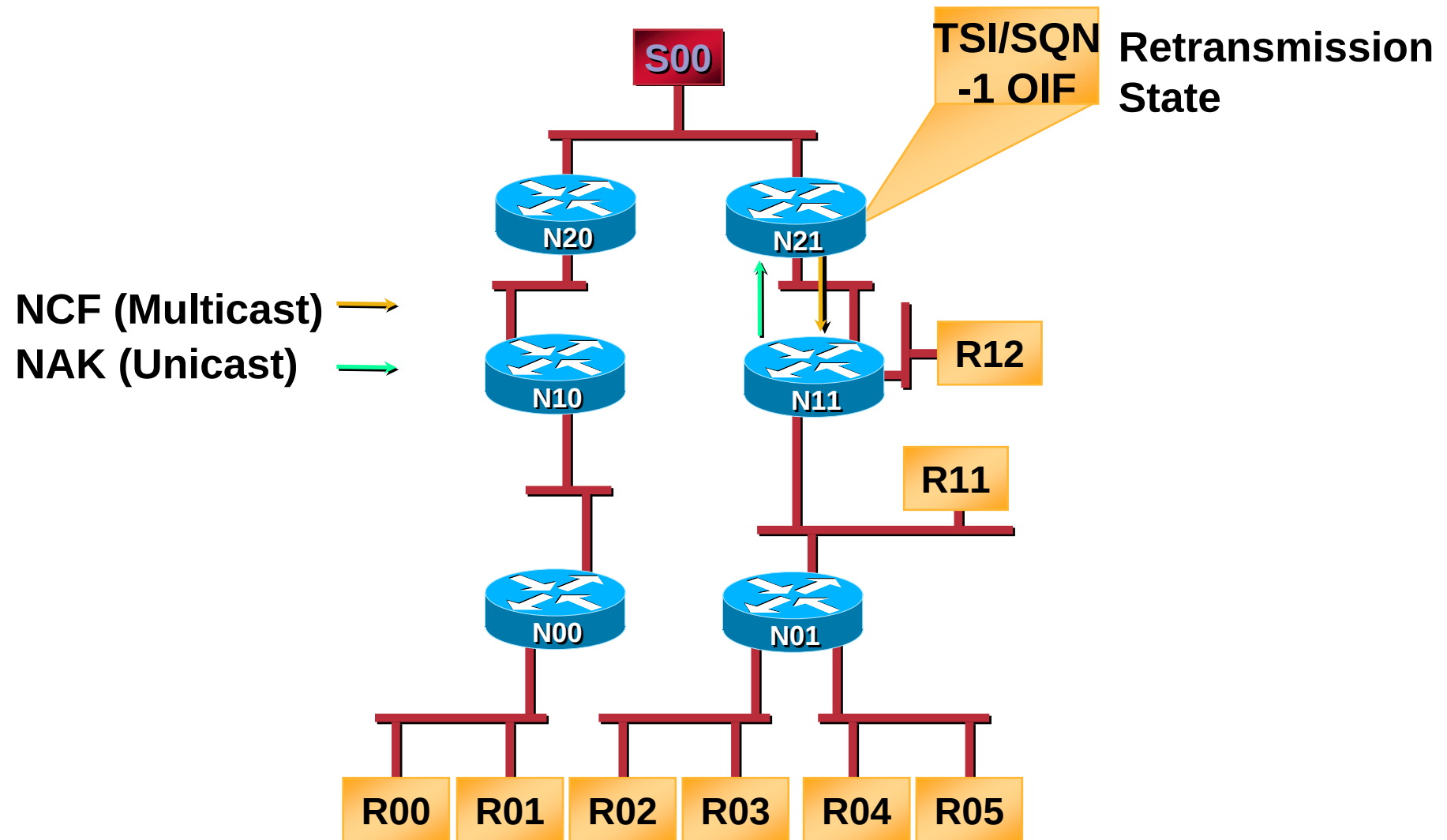
PGM Router Assist

NAK elimination and constrained retransmission (2)



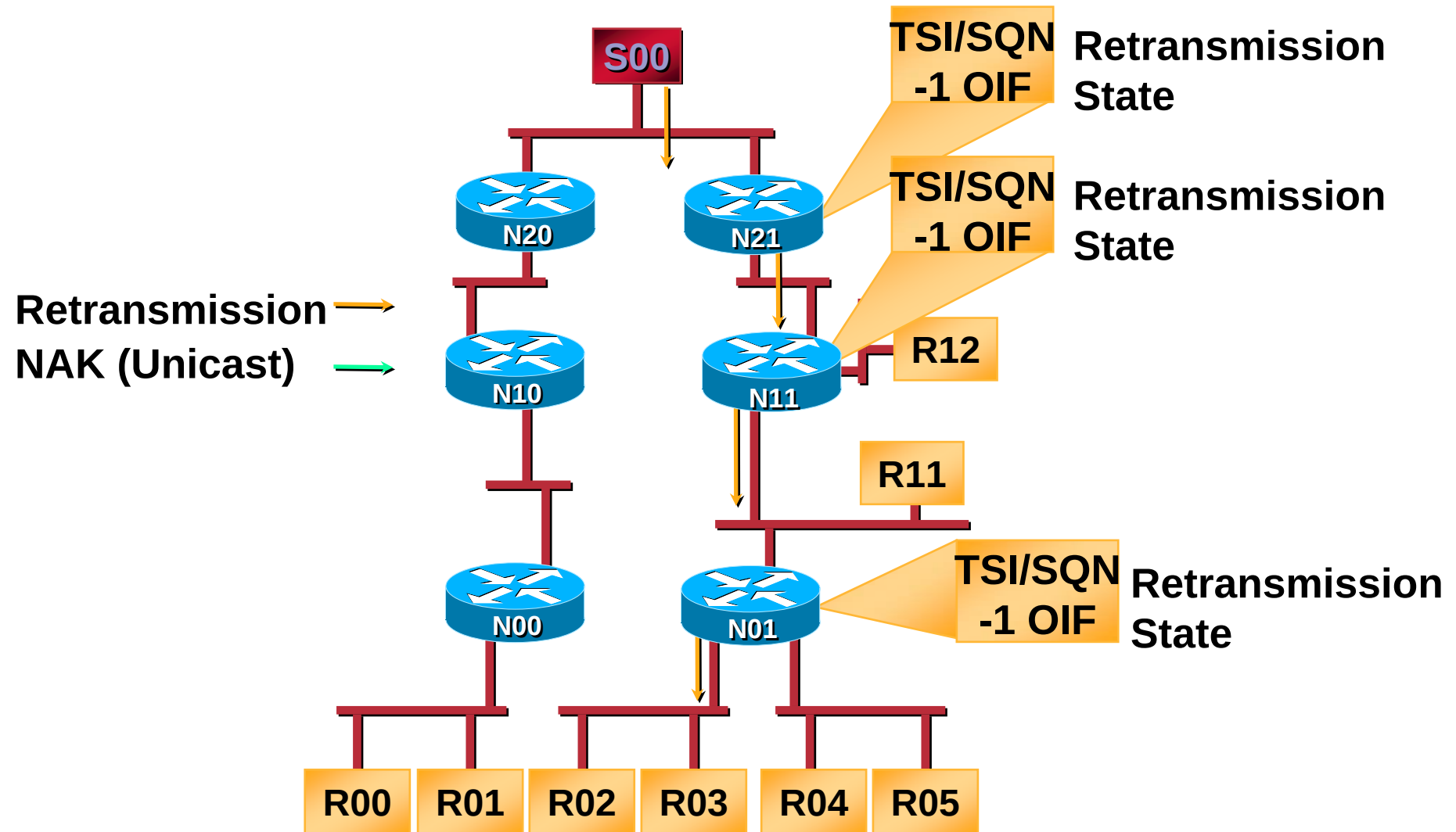
PGM Router Assist

NAK elimination and constrained retransmission (3)



PGM Router Assist

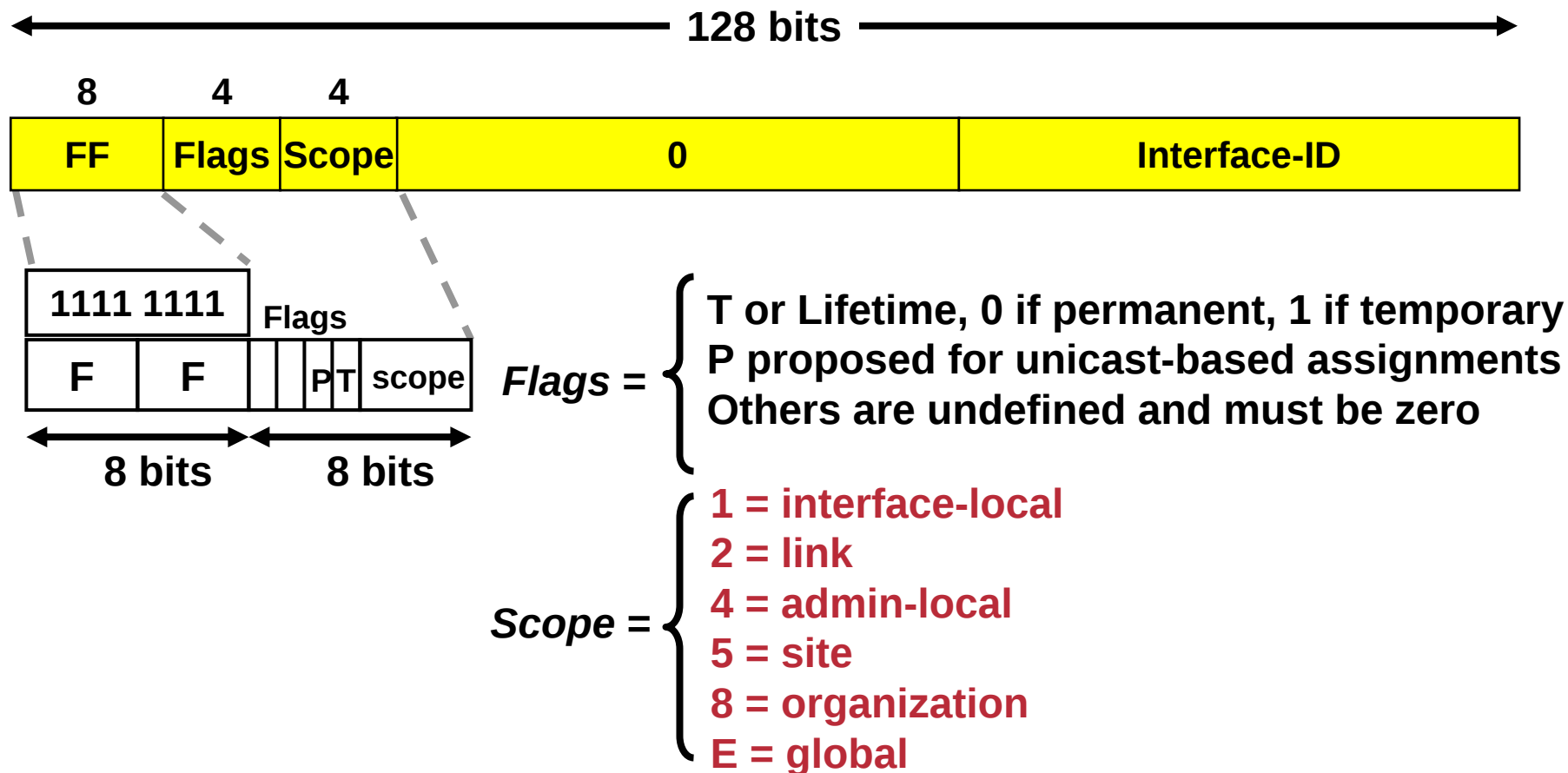
NAK elimination and constrained retransmission (4)



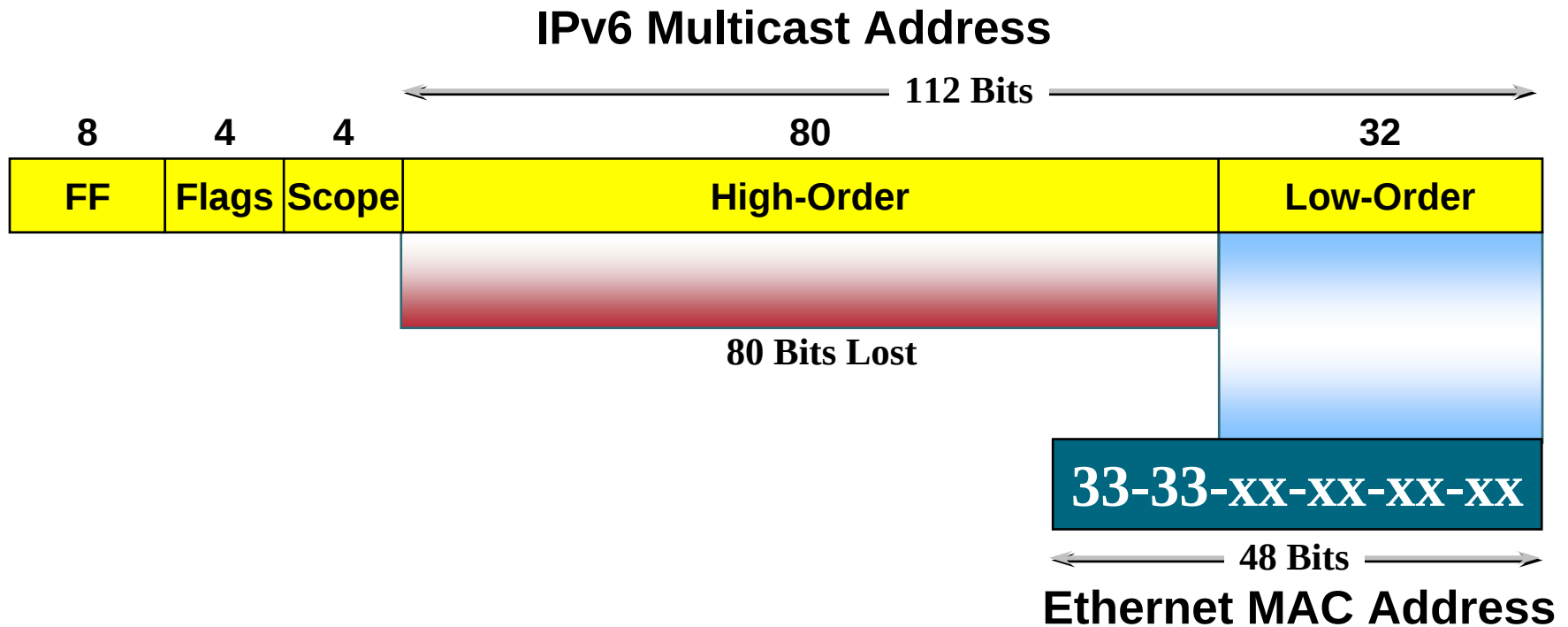
IPv4 versus IPv6 Multicast

IP Service	IPv4 Solution	IPv6 Solution
Address Range	32-bit, class D	128-bit (112-bit Group)
Routing	Protocol Independent All IGPs, and BGP4+	Protocol Independent All IGPs, and BGP4+ with v6 mcast SAFI
Forwarding	PIM-DM , PIM-SM, PIM-SSM, PIM-bidir	PIM-SM, PIM-SSM, PIM-bidir
Group Management	IGMPv1, v2, v3	MLDv1, v2
Domain Control	Boundary/Border	Scope Identifier
Inter-domain Solutions	MSDP across Independent PIM Domains	Single RP within Globally Shared Domains

IPv6 Multicast Addresses (RFC 3513)



IPv6 Layer 2 Multicast Addressing Mapping



Unicast-based Multicast addresses

8	4	4	8	8	64	32
FF	Flags	Scope	Rsvd	Plen	Network-Prefix	Group-ID

- **RFC 3306 – Unicast-based Multicast Addresses**

- Similar to IPv4 GLOP Addressing
- Solves IPv6 global address allocation problem.
- Flags = 00PT

P = 1, T = 1 => Unicast-based Multicast address

- **Example:**

- Content Provider's Unicast Prefix

1234:5678:9abc::/64

- Multicast Address

FF36:0030:1234:5678:9abc::0001

IP Routing for Multicast

- RPF based on reachability to v6 source same as with v4 multicast
- RPF still protocol independent:
 - Static routes, mroutes
 - Unicast RIB: BGP, ISIS, OSPF, EIGRP, RIP, etc
 - Multi-protocol BGP (mBGP)
 - - support for v6 mcast sub-address family
 - - provide translate function for non-supporting peers

IPv6 Multicast Forwarding

- **PIM-Sparse Mode (PIM-SM)**
 - draft-ietf-pim-sm-v2-new-11.txt,
- **PIM-Source Specific Mode (PIM-SSM)**
 - RFC3569 SSM overview (v6 SSM needs MLDv2)
 - unicast prefix based multicast addresses ff30::/12
 - SSM range is ff3X::/32
 - Current allocation is from ff3X::/96
- **PIM-bidirectional Mode (PIM-bidir)**
 - draft-ietf-pim-bidir-07.txt

RP mapping mechanisms for IPv6 PIM-SM

- **Static RP assignment**
- **BSR**
- **Auto-RP – no current plans**
- **Embedded RP**

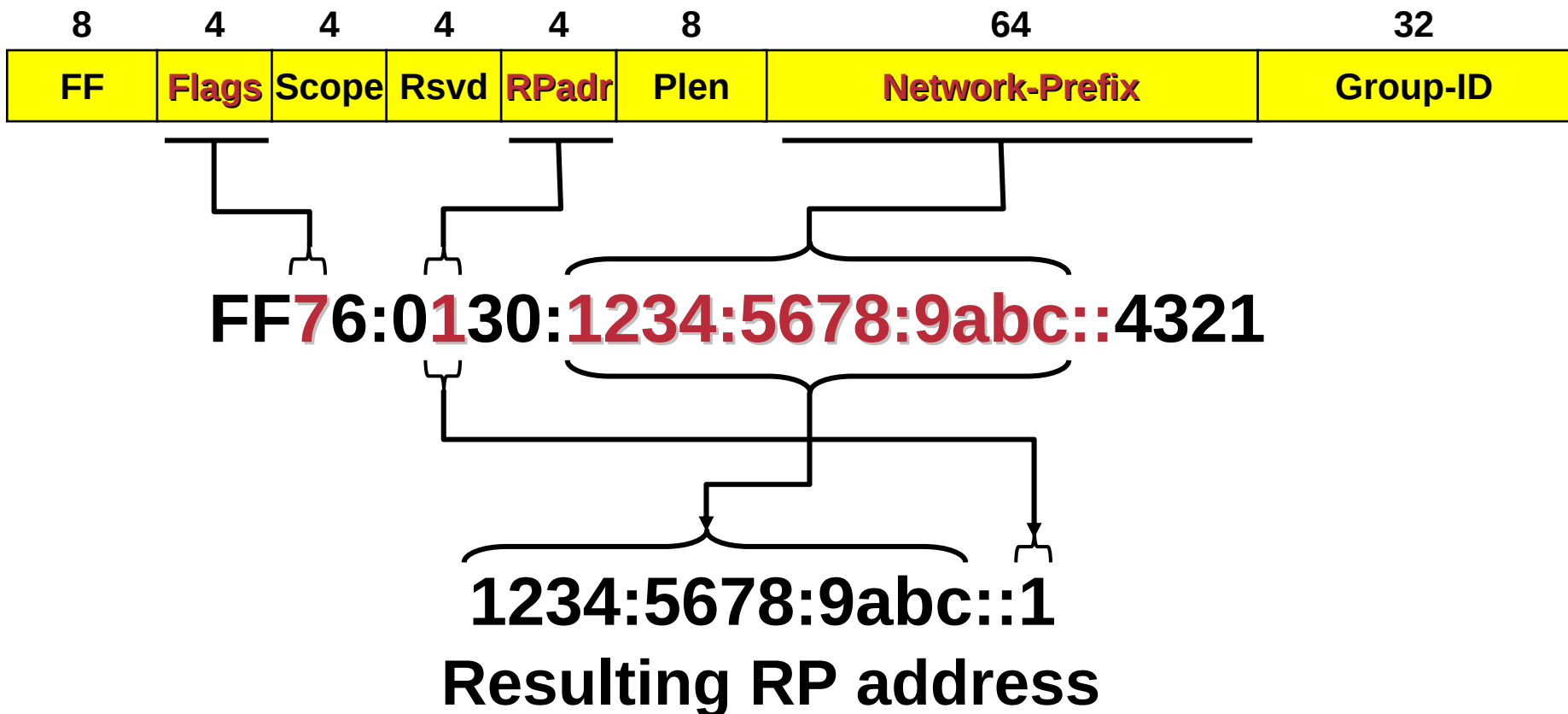
Embedded RP Addressing – RFC3956

8	4	4	4	4	8	64	32
FF	Flags	Scope	Rsvd	RPadr	Plen	Network-Prefix	Group-ID

- **Proposed new multicast address type**
 - Uses Unicast-Based Multicast addresses (RFC 3306)
- **RP Address is embedded in multicast address.**
- **Flag bits = 0RPT**
 $R = 1, P = 1, T = 1 \Rightarrow$ Embedded RP Address
- **Network-Prefix::RPadr = RP address**
- **For each Unicast prefix you own, you now also own:**
 - 16 RPs for each of the 16 Multicast Scopes (256 total) with 2^{32} multicast groups assigned to each RP (2^{40} total)

Embedded RP Addressing – Example

Multicast Address with Embedded RP address



Multicast Listener Discover – MLD

- **MLD is equivalent to IGMP in IPv4**
- **MLD messages are transported over ICMPv6**
- **Version number confusion:**
 - **MLDv1 corresponds to IGMPv2**
 - **RFC 2710**
 - **MLDv2 corresponds to IGMPv3, needed for SSM**
 - **RFC 3810**
- **MLD snooping**
 - **draft-ietf-magma-snoop-12.txt**

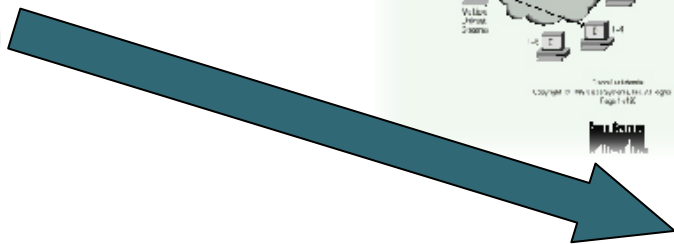
Now you know...

- **Why Multicast?**
- **Multicast Fundamentals**
- **PIM Protocols**
- **RP choices**
- **Multicast at Layer 2**
- **Interdomain IP Multicast**
- **Latest Additions IPv6, PGM and MVPN**

More Information

- White Papers
- Web and Mailers
- Cisco Press

RTFB

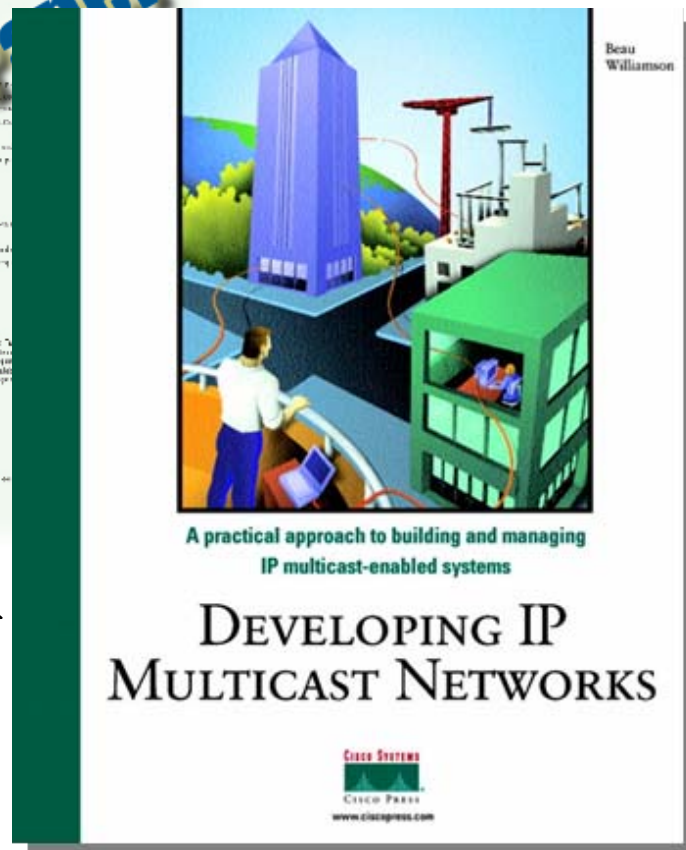
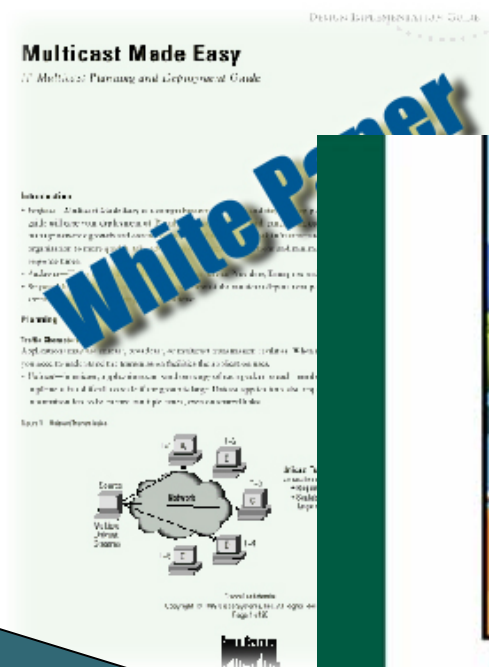


CCO Multicast page:

<http://www.cisco.com/go/ipmulticast>

Customer Support Mailing List:

tac@cisco.com

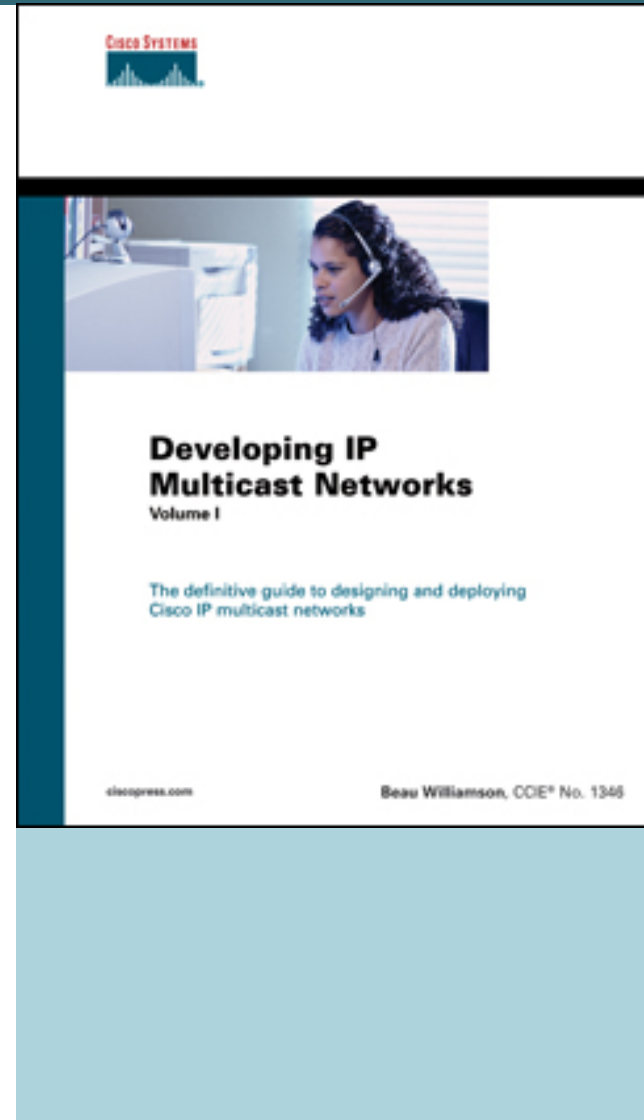


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 - **Tuesday, June 20 at 12:15 p.m.**
 - **Wednesday, June 21 at 12:15 p.m.**
 - **Thursday, June 22 at 12:15 p.m. and 2:00 p.m.**



