IP Multicast Workshop SANOG XII 2008 Kathmandu

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Agenda

Multicast Intro	Day1
Multicast Fundamentals (Addressing, IGMP)	
PIM (PIM-SM, SSM)	
PIM Lab	Day2
Inter-domain Multicast (MSDP, MBGP)	Day3
Inter-domain Multicast Lab	Day4
MVPN	
MVPN Lab	Day5
IPv6 multicast	

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Agenda

- **Introduction**
- Multicast addressing
- Group Membership Protocol
- PIM-SM / SSM
- MBGP
- MSDP
- Summary

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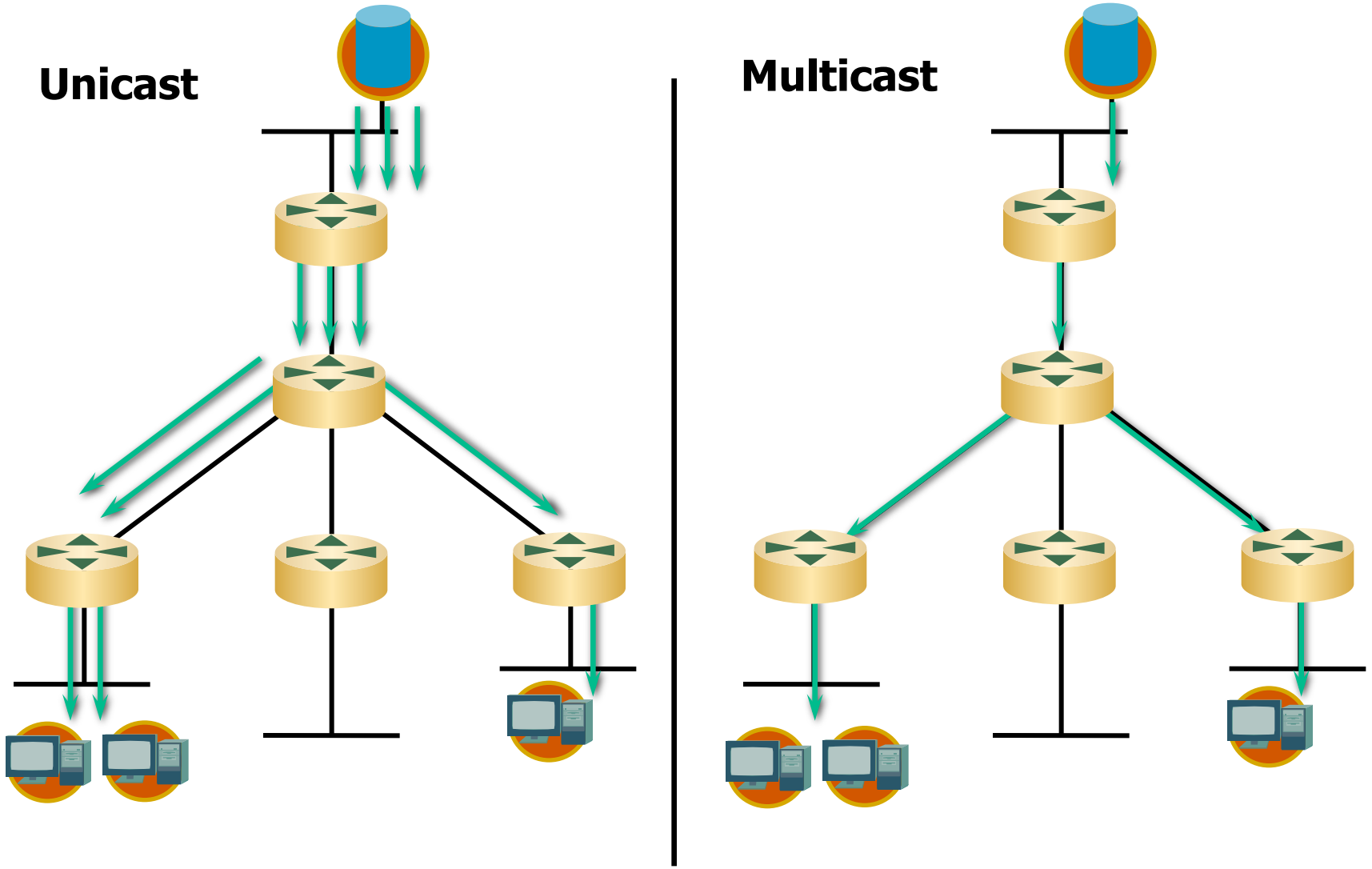
What is Multicasting?



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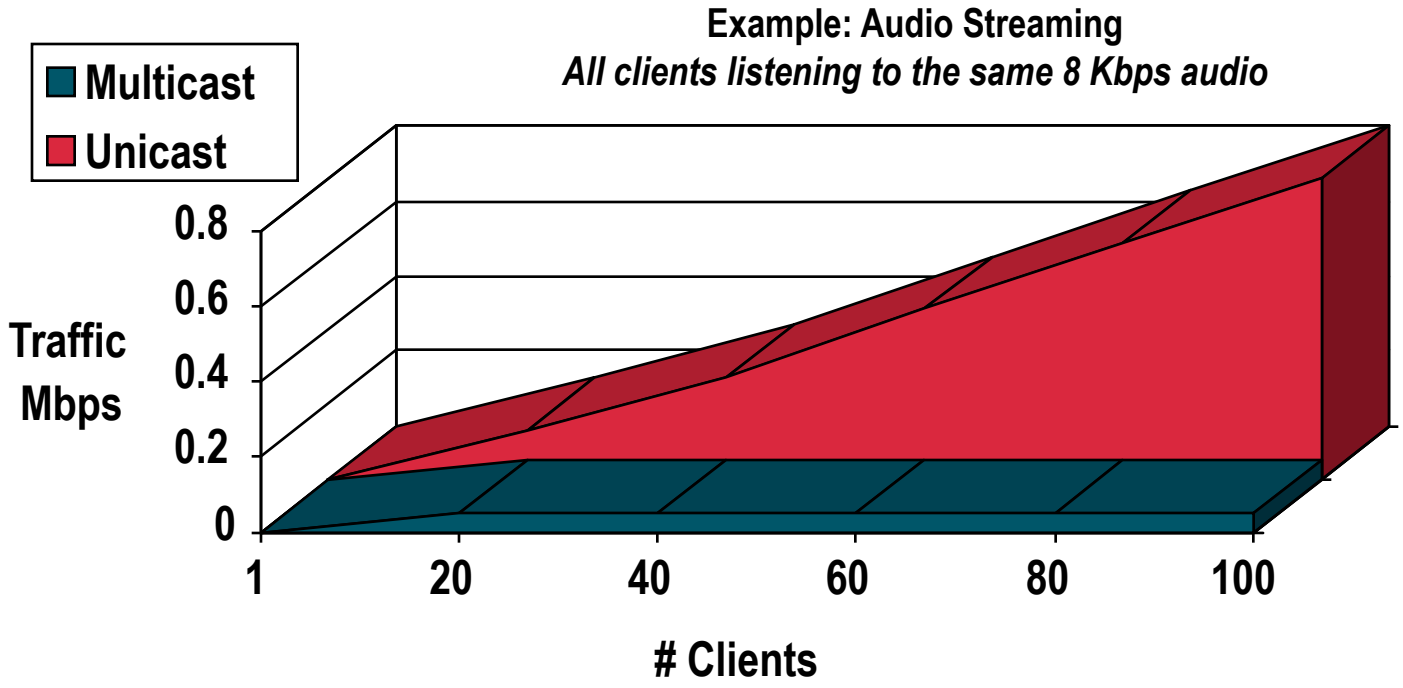
Multicast Advantages

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



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Multicast Disadvantages

Most Multicast Applications are 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, FEC, QoS**
- ***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.**

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Multicast Uses

- Any Applications with multiple receivers
  - 1-to-many or many-to-many
- Live Video distribution
- Collaborative groupware
- Periodic Data Delivery - "Push" technology
  - stock quotes, sports scores, magazines, newspapers, adverts
- Server/Web-site replication
- Reducing Network/Resource Overhead
  - more than multiple point-to-point flows
- Resource Discovery
- Distributed Interactive Simulation (DIS)
  - wargames
  - virtual reality

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Multicast Uses

	Real Time	Non-Real Time
Multimedia	• Live Video • Video conferencing • Live Internet Audio • Hoot & Holler	Replication Video, Web servers Kiosks • Content delivery
Data-only	• Stock Quotes • News Feeds • Whiteboarding • Interactive Gaming	• Information Delivery Server to Serve, Server to Desktop • Database replication • Software distribution

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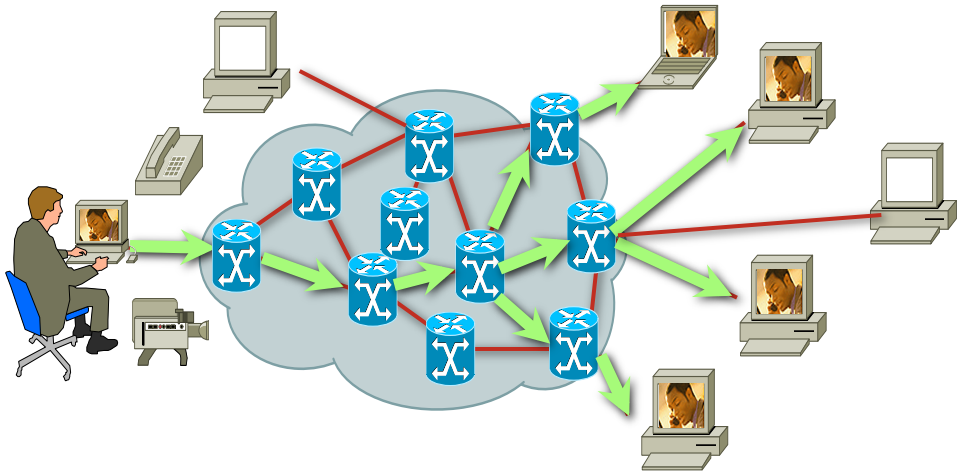
IP Multicast : Business Problem

Distribute information to large audiences over an IP network



Benefits:

- Increase Productivity & Save Cost
- Generate New Revenue Stream

Applications		
Service Provider	**Enterprise**	**Small/Medium Business**
• Mulitcast VPN • Triple Play & Video Broadcast	• Stock trading, Corporate communications, e-learning, Hoot-and-holler over IP, Video Conferencing, content delivery, conferencing	• E-Learning • IP surveillance • Content delivery • Video conferencing

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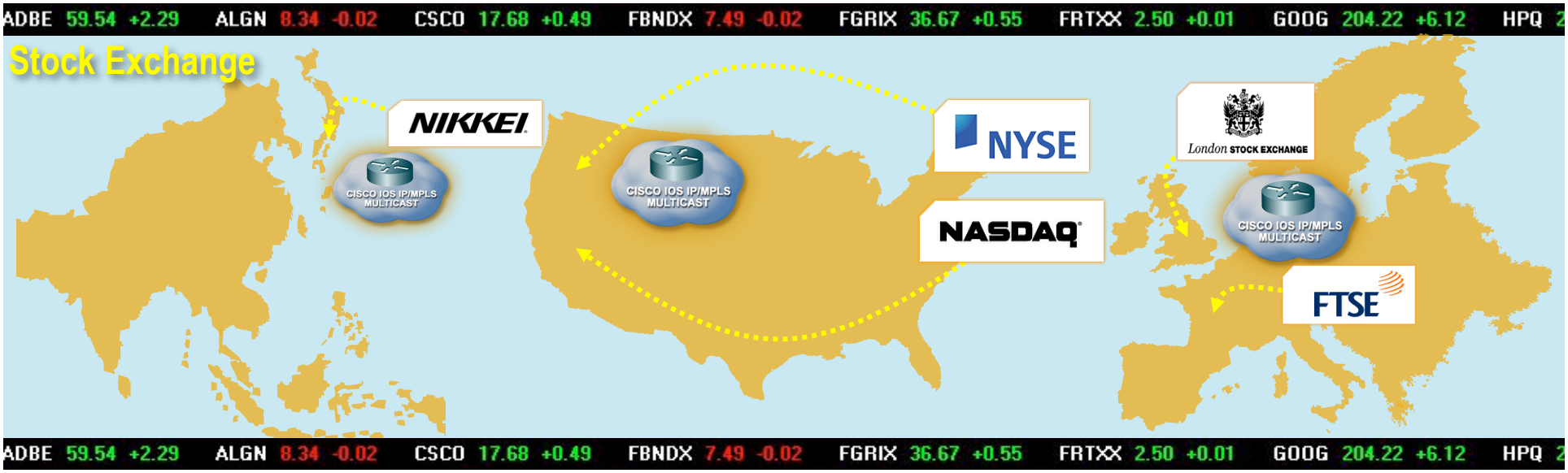
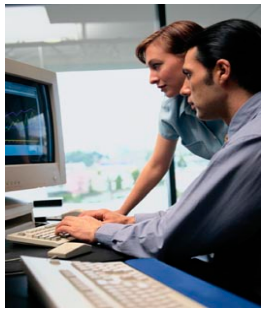
Finance



Trading Floor



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Hoot and Holler

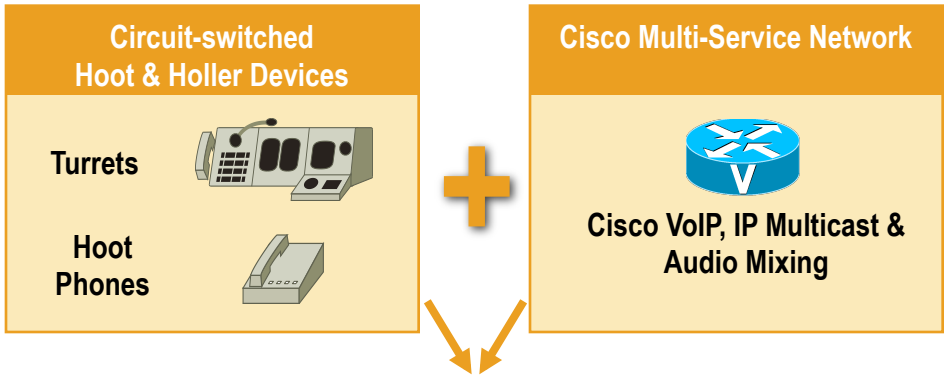
Reliable Transport of TDM Audio over Packet Networks

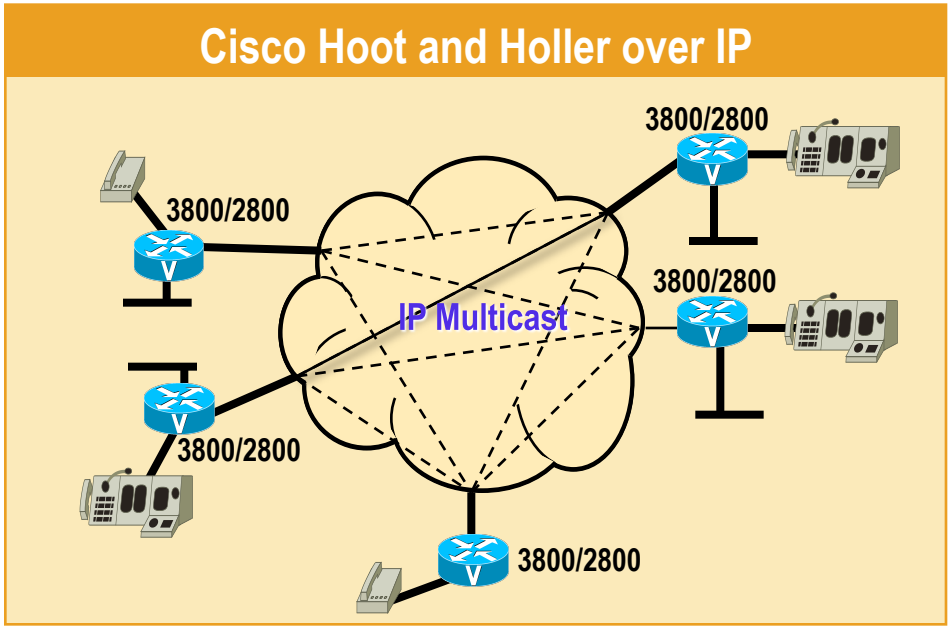
Traditional Hoot and Holler:

- Broadcast audio network
- Specialized analog 4-wire phones (Hoot phones) and digital turrets
- Used in brokerage houses, publishing / media companies, mass transit

Cisco IP Multicast Value:

1. Eliminate expensive leased-lines by enabling customers to run hoot applications on data networks
2. Continue to use existing Hoot and Holler end user equipment
3. Enable future applications such as IP phones, IP turrets, and multicast clients





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Entertainment

Animatronics

Video games

Half-Life, Counter-Strike

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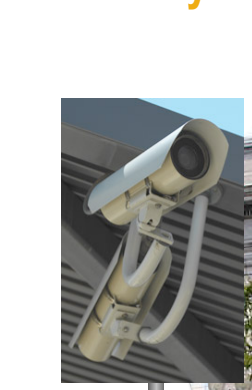
Surveillance

Security



School Security

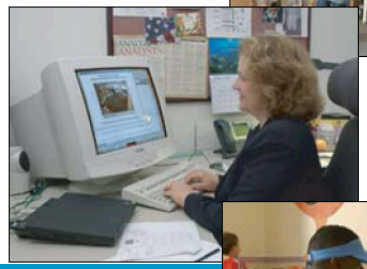
Bank security

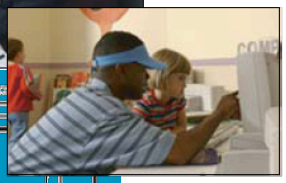
IP Cameras

CISCO IOS IP/MPLS MULTICAST

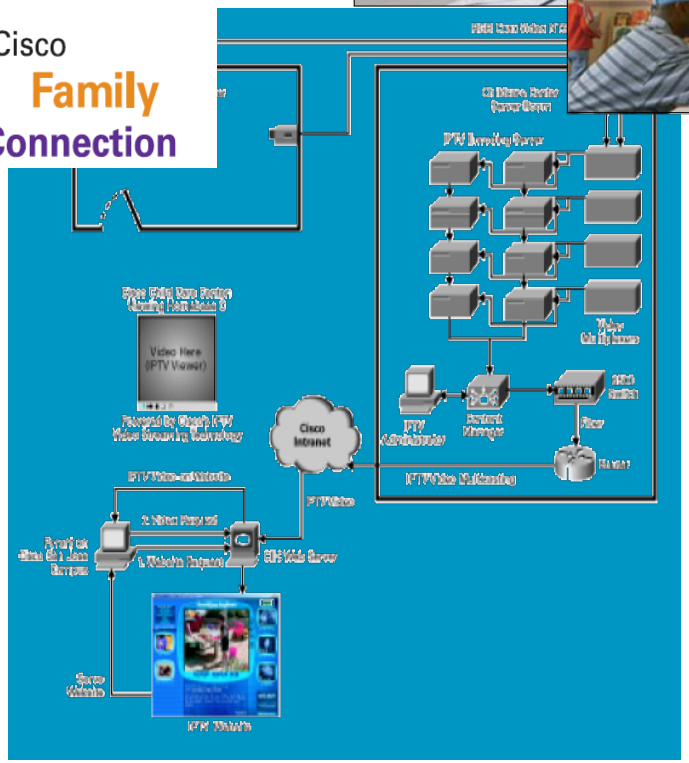
Retail behavior

Childcare





Cisco Family Connection



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Enterprise

Corporate Communication

Video Conferencing

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Reliable Content Distribution

Data Distributions

Applications		
Norton Ghost	Datarunner	Digital Fountain
Cisco CDN (ACNS)	zBand	RemoteWare

Retail catalog distribution

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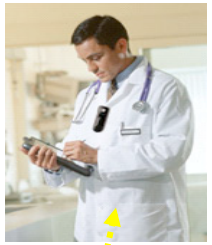
Wireless Multicast

Healthcare



Vanderbilt Medical Center
School of Medicine

Live Web Cast of
Minimally-Invasive Hip Replacement

Military

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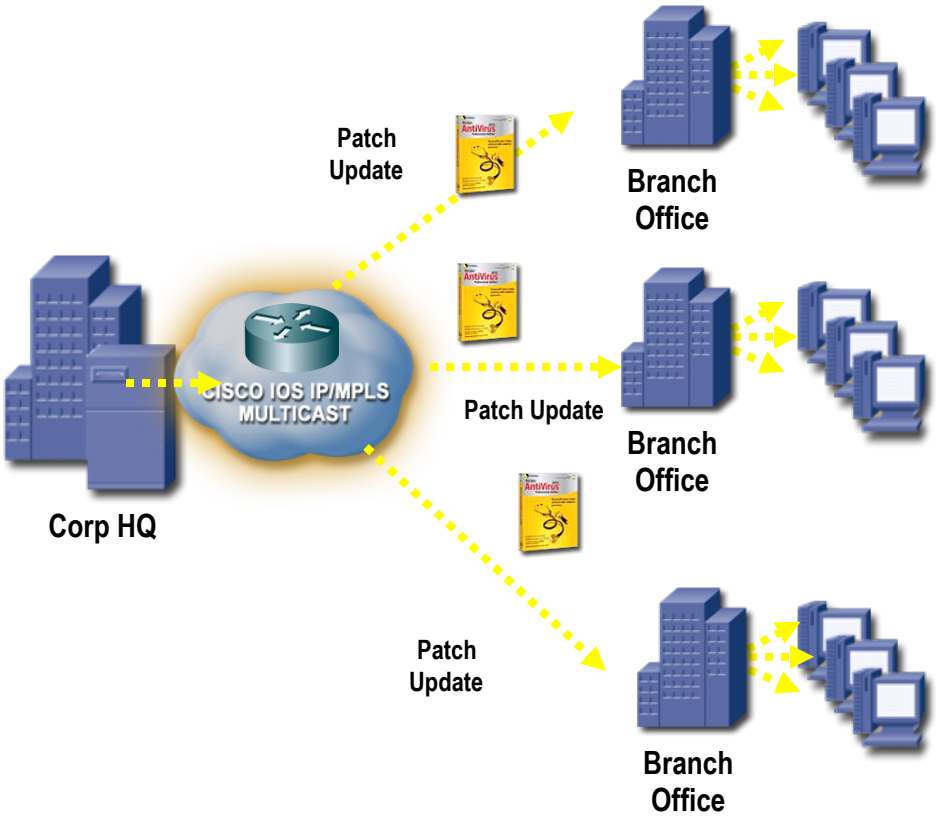
Information Sharing

E-Learning

Software Distribution



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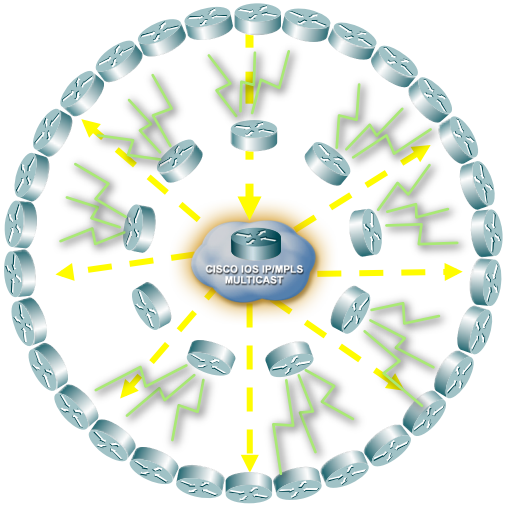
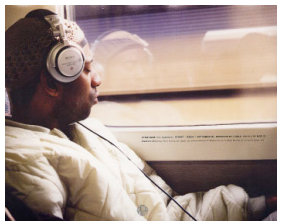
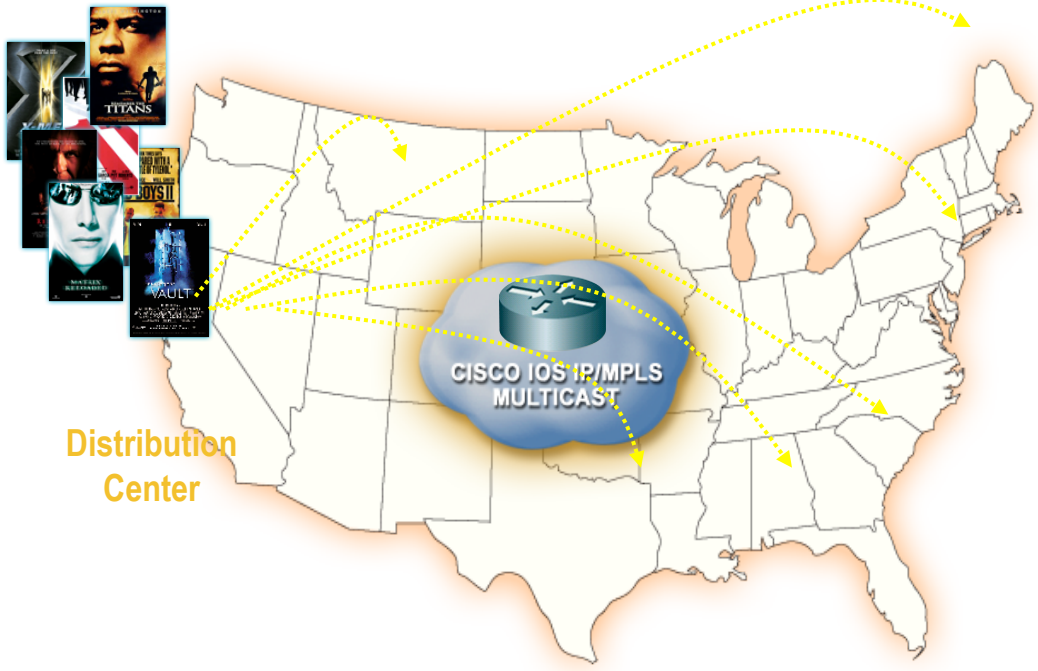
Media

Radio





Video on demand



1. Multicast to the Regional Video Servers
2. Multicast VOD to STB using Digital Fountain Technology

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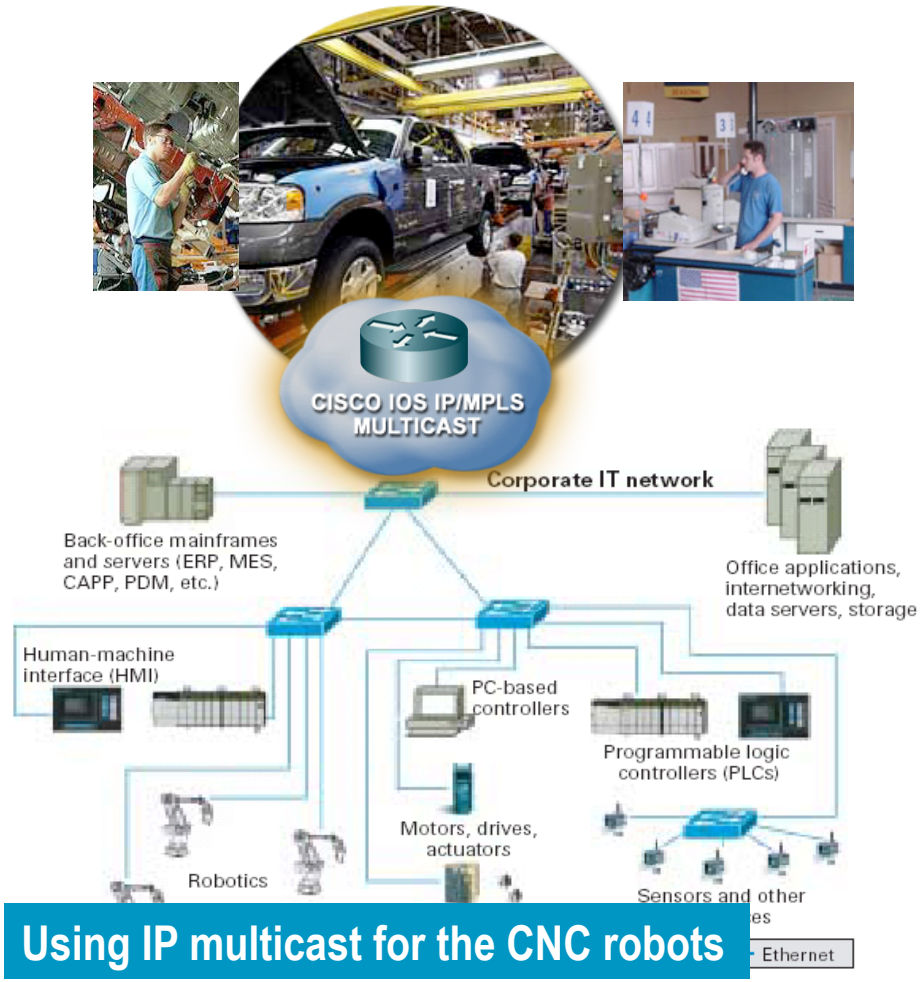
Manufacturing

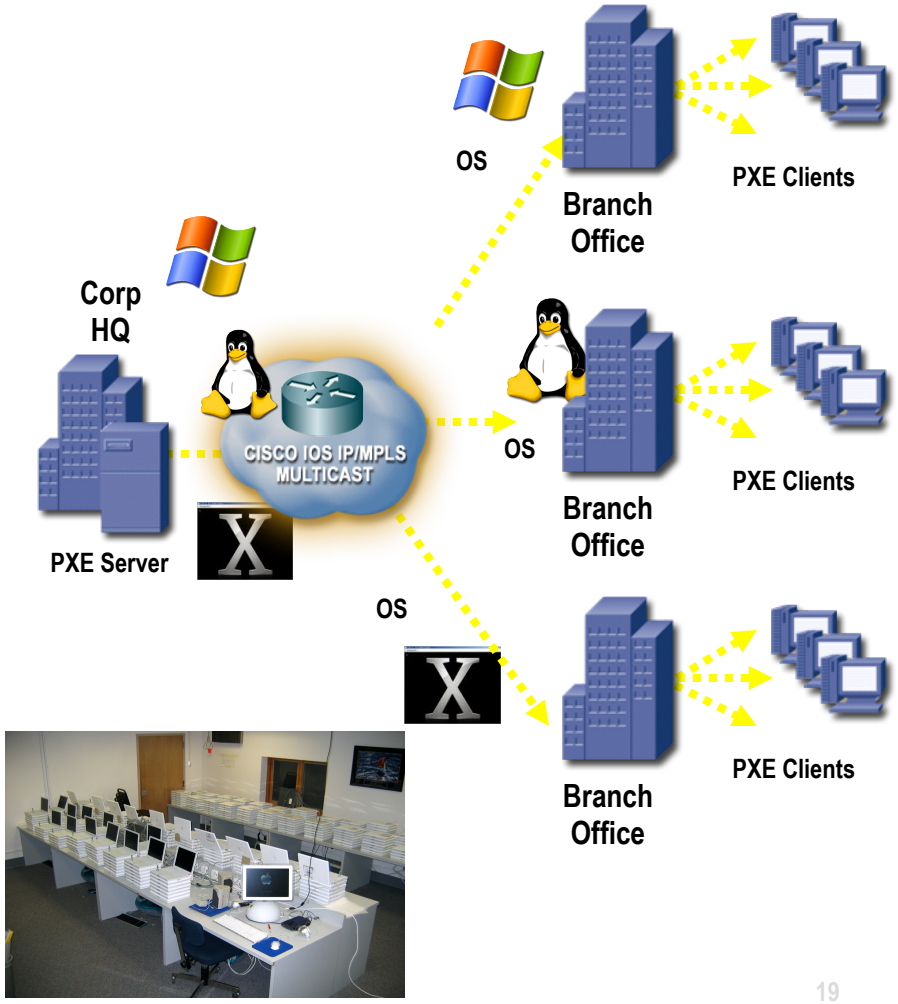
Manufacturing Floor



Using IP multicast for the CNC robots

Laptop Manufacturing

OS Download : Preboot eXecution Environment



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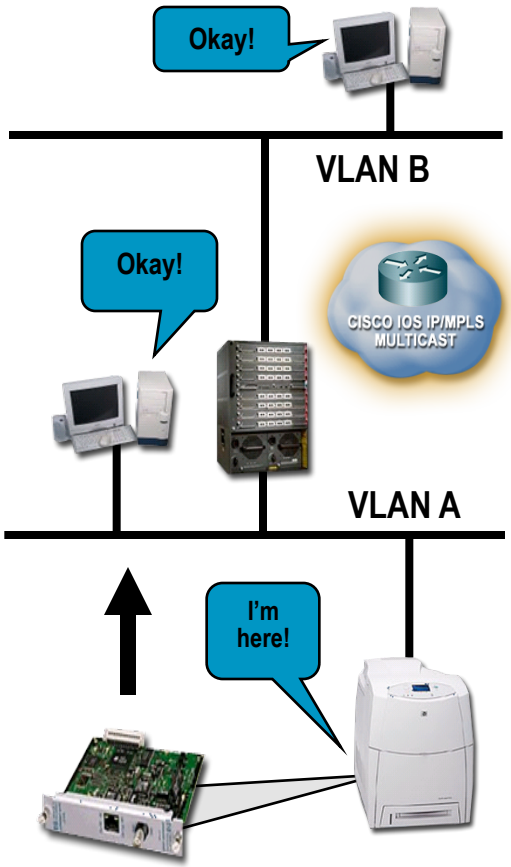
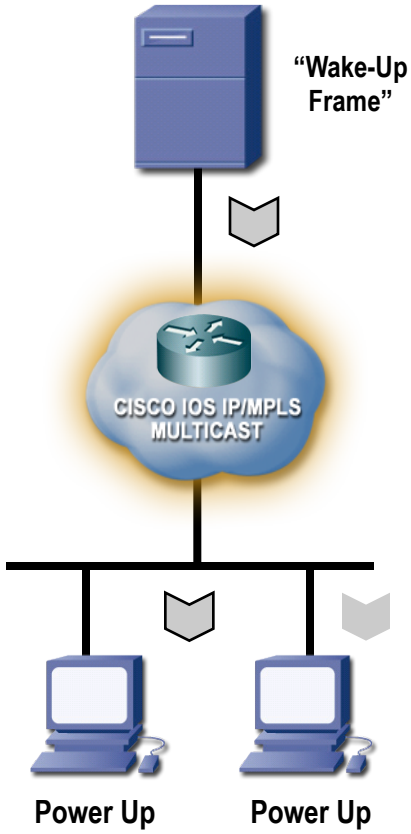
Office Applications

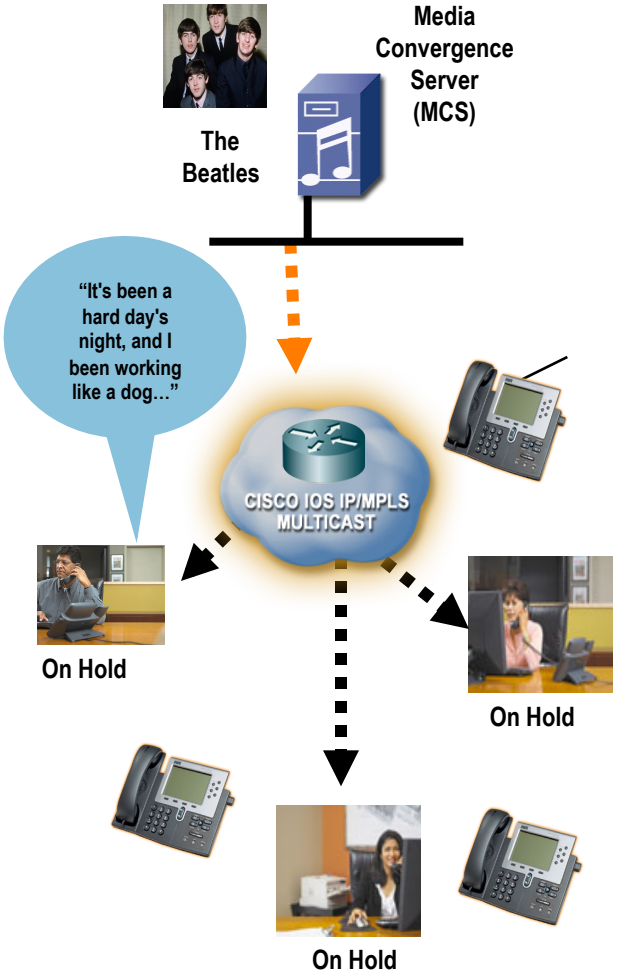
HP JetDirect Print Server(s)



Wake on LAN (WOL)



Music on Hold



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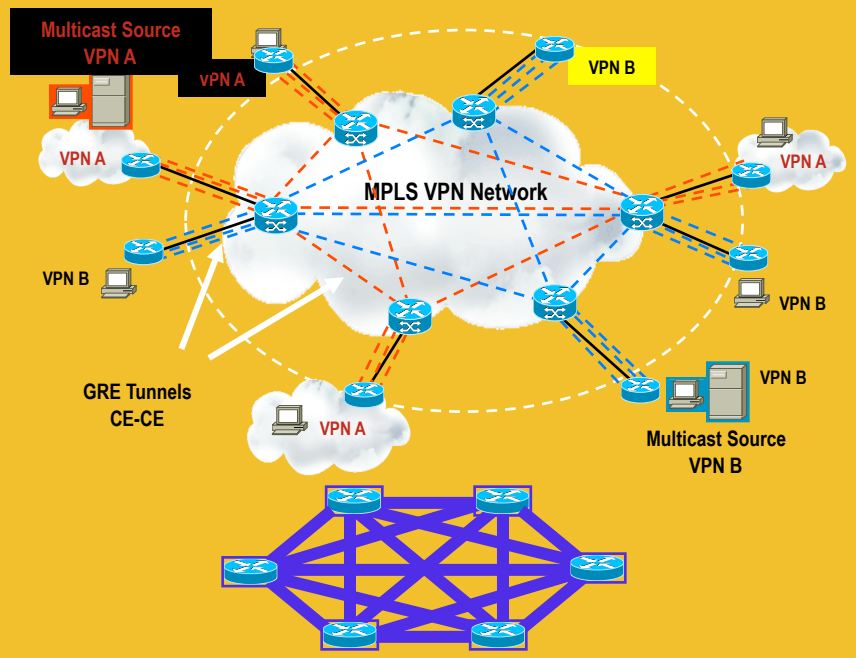
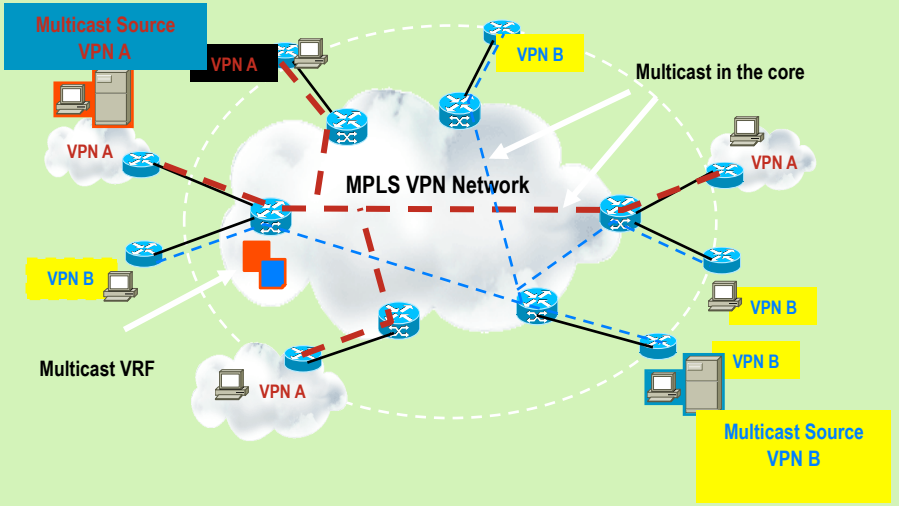
Multicast VPN

Before



- Scalability – an issue (N^2 problem)
- Highly inefficient

After: Multicast VPN (mVPN)



- Allows MPLS VPN customers to access Multicast content
- Highly efficient – Multicast tree built dynamically in the core
- Uses “Ships in the night” approach
- Standards based

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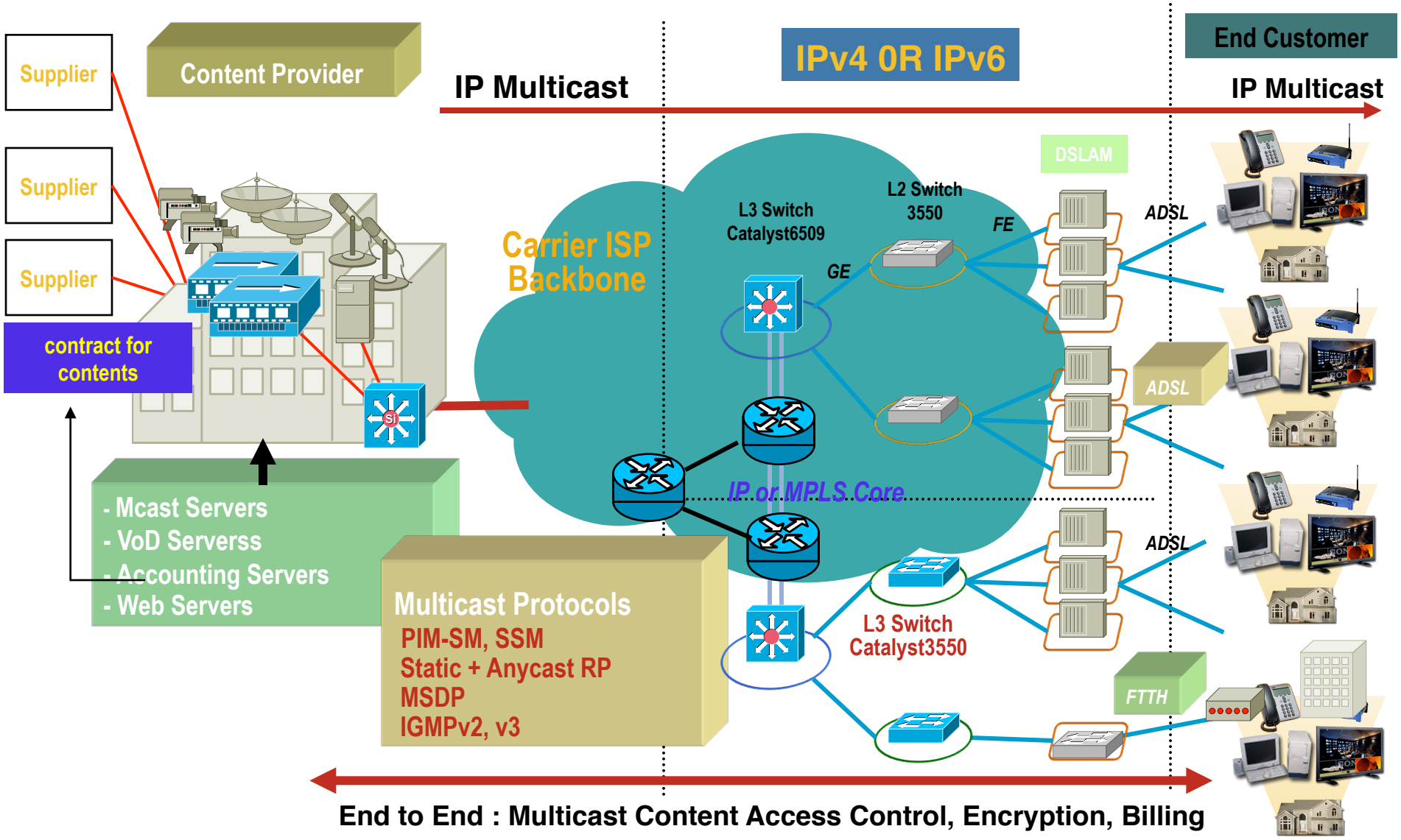
Triple Play : Multicast Architecture



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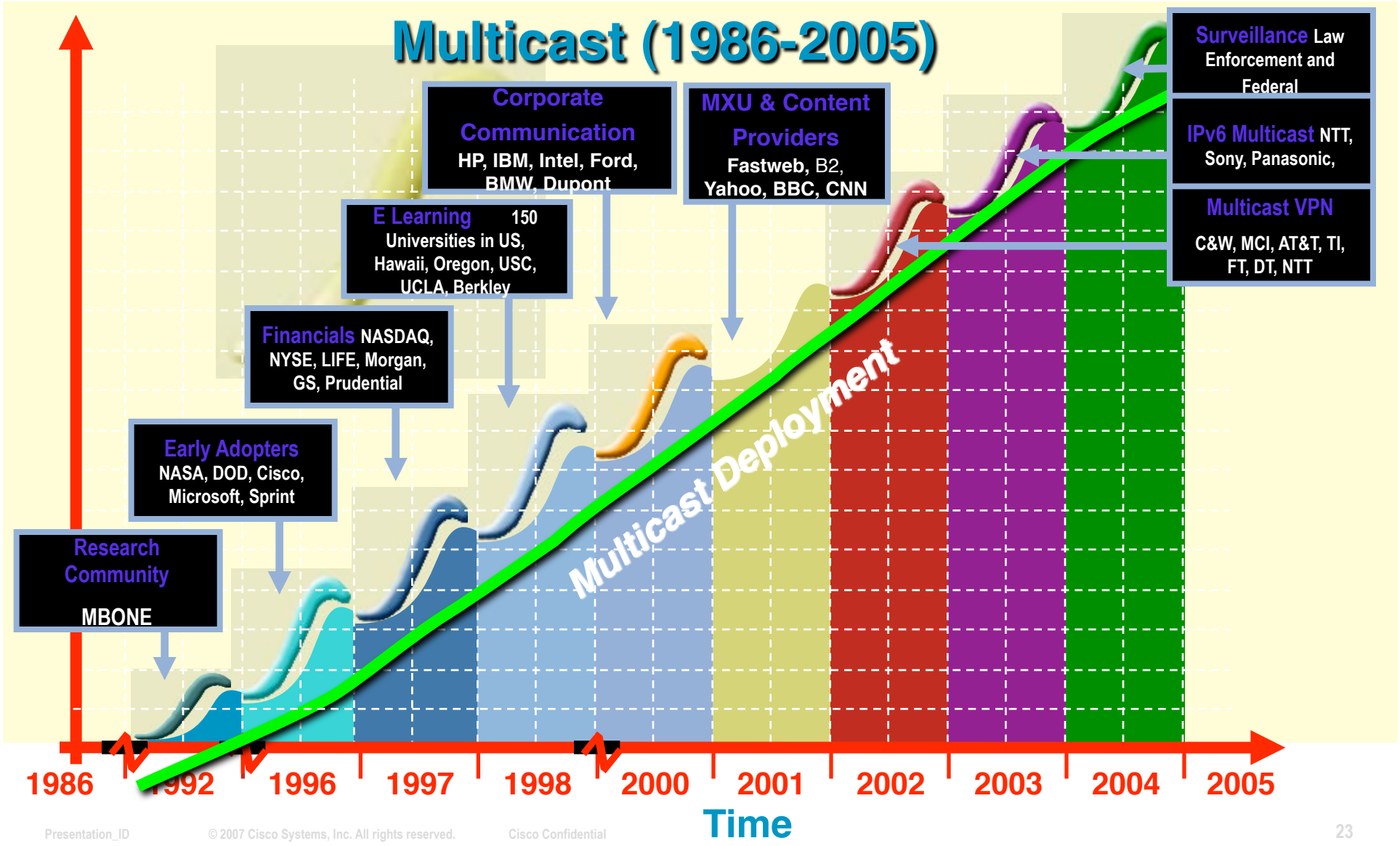
Multicast Adoption

Past, Present & Future



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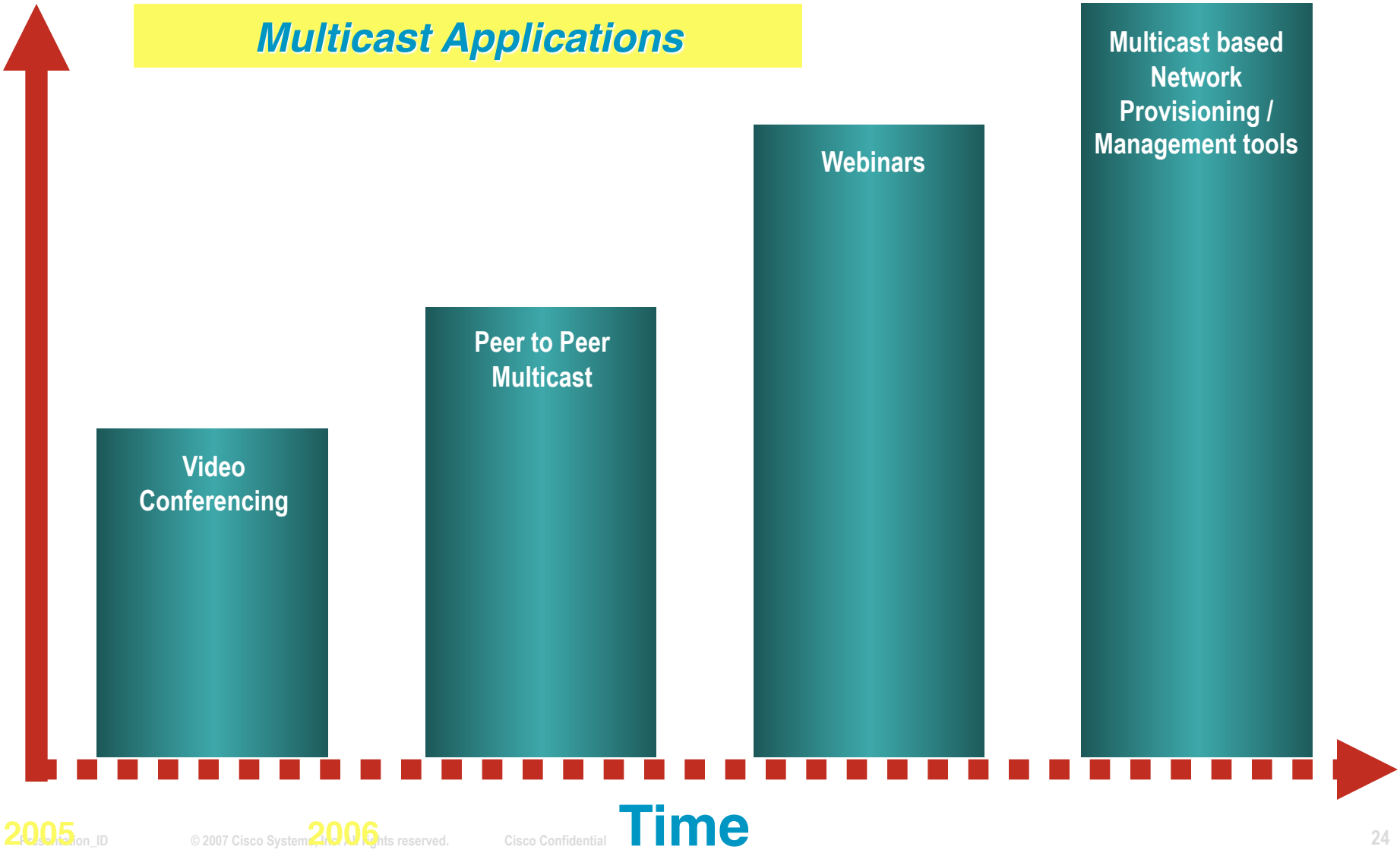
Next Wave of Multicast Applications



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Multicast in NGN Architecture

Three Key Service Trends	Multicast Component
Broadband Consumer Service Enablement	***YES***
Triple-play, gaming, content delivery	*Video component in Triple Play service is 90% Multicast Video*
Peer-to-Peer Applications	
Mass delivery of customized services	*Multicast Games: Half-Life, Counter-Strike*
Flexible Service bundling	*Peer-to-Peer : Multicast Kazaa, Bit-Torrent*
Evolution of current SP offerings to Enterprises	***YES***
L1 bandwidth, L2VPN, L3VPN with value-added services	*Multicast VPN as a L3VPN Service for IPv4 and IPv6*
Improving OPEX associated with delivery of ATM, FR ..	*Multicast over ATOM, VPLS, PWS*
Customized Service delivery and bundling	
Converged Wireless and Wire line Services	***YES***
Enhanced mobility between fixed and wireless services	*Multicast and Mobile IP Integration : Department of Defense, Emergency Services, Hospitals*
IMS, 2G transition to 3G & Integration of Fixed & Mobile	*Multicast support for 3G chipset in CDMA*

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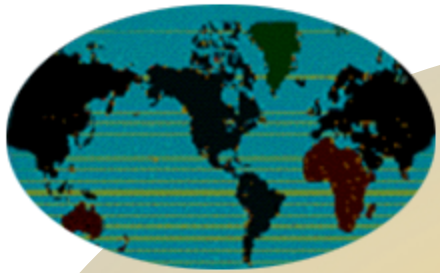
Multicast Market Segment

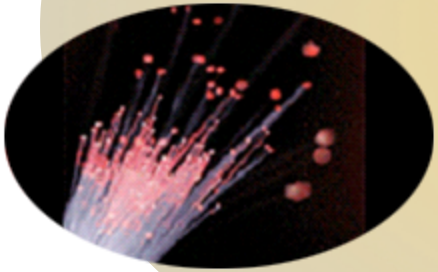


Global Enterprise

Finance

Content Providers

Multicast Enables



MTU/MDU
Broadband
Entertainment

Education

Global Internet ISP

NEW
Security / IP
Surveillance

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Multicast Fundamentals

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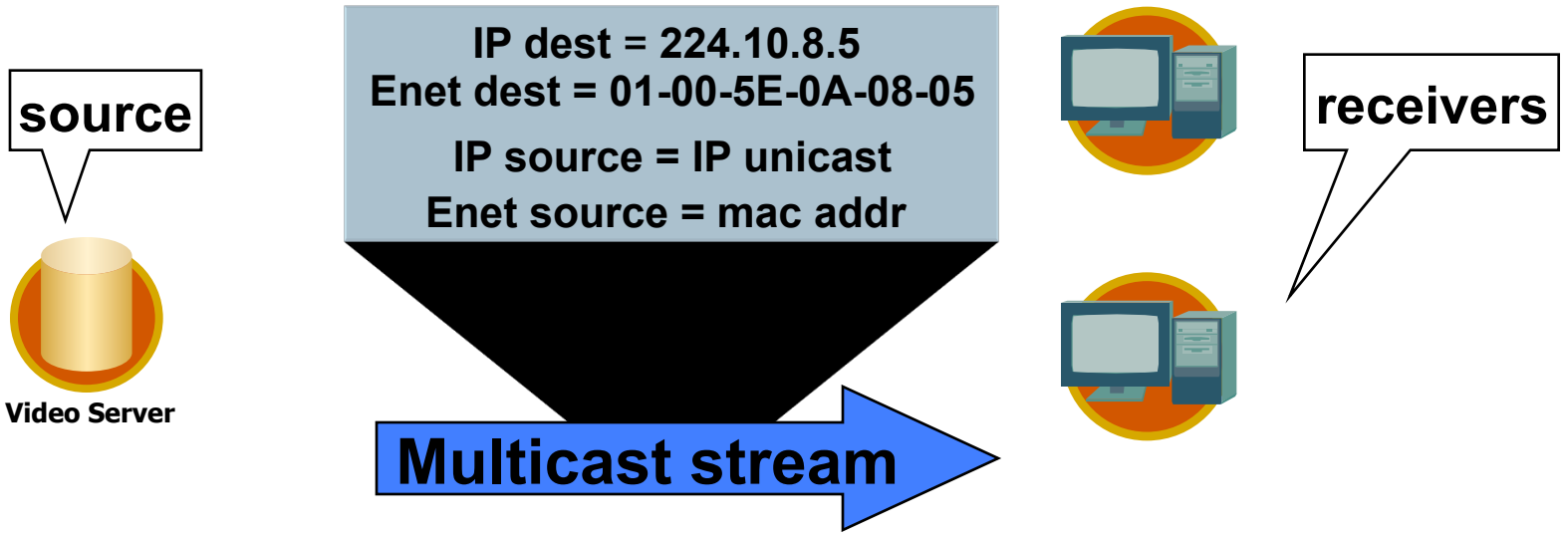
Glossary of Terms: the basics



- Source = source of multicast stream
- Multicast stream = IP packet with multicast address as IP destination address. a.k.a. multicast group.

  s,g (unicast source, group) reference

  UDP packets (TTL > 1 for routed nets)
- Receiver = receiver (s) of multicast stream

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IP Multicast building blocks

- The SENDERS send

  Multicast Addressing - rfc1700

  class D (224.0.0.0 - 239.255.255.255)

- The RECEIVERS inform the routers what they want to receive

  Internet Group Management Protocol (IGMP) - rfc2236 -> version 2; rfc3376 -> version 3

- The ROUTERS make sure the packets make it to the correct subnets.

  Multicast Routing Protocols (PIM-SM/SSM)

  RPF (reverse path forwarding)

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Multicast 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.

- Multicast Routing uses “Reverse Path Forwarding”: RPF

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Reverse Path Forwarding (RPF)

- RPF Calculation

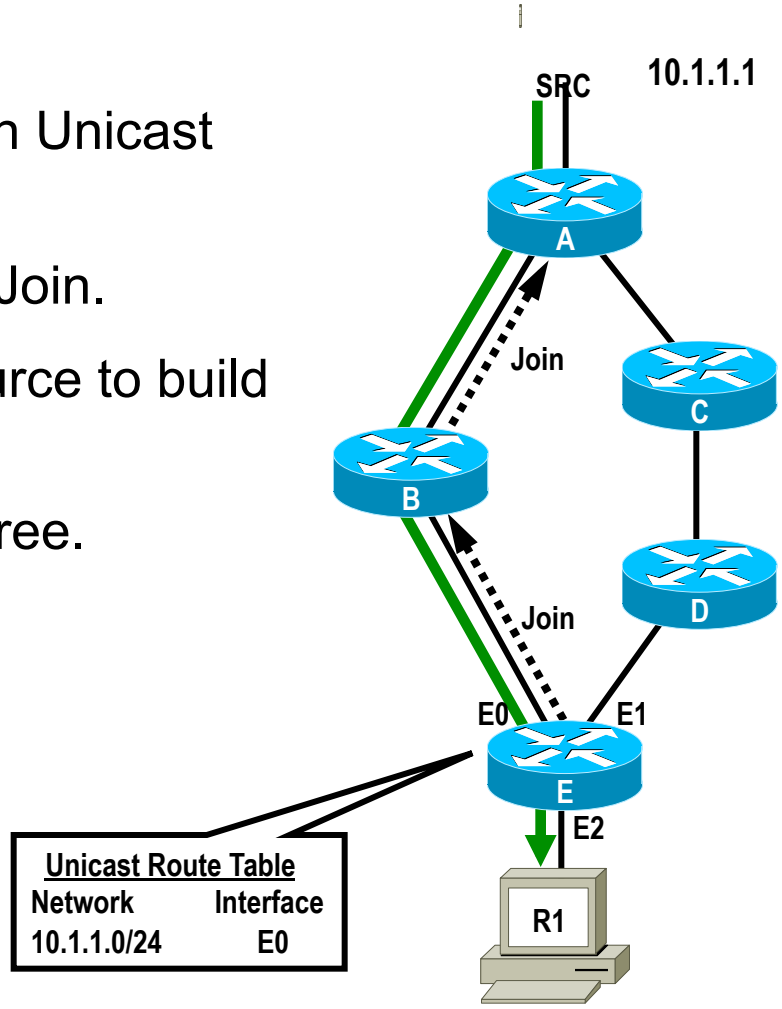
  Based on Source Address.

  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.



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Reverse Path Forwarding (RPF)

- RPF Calculation

  Based on Source Address.

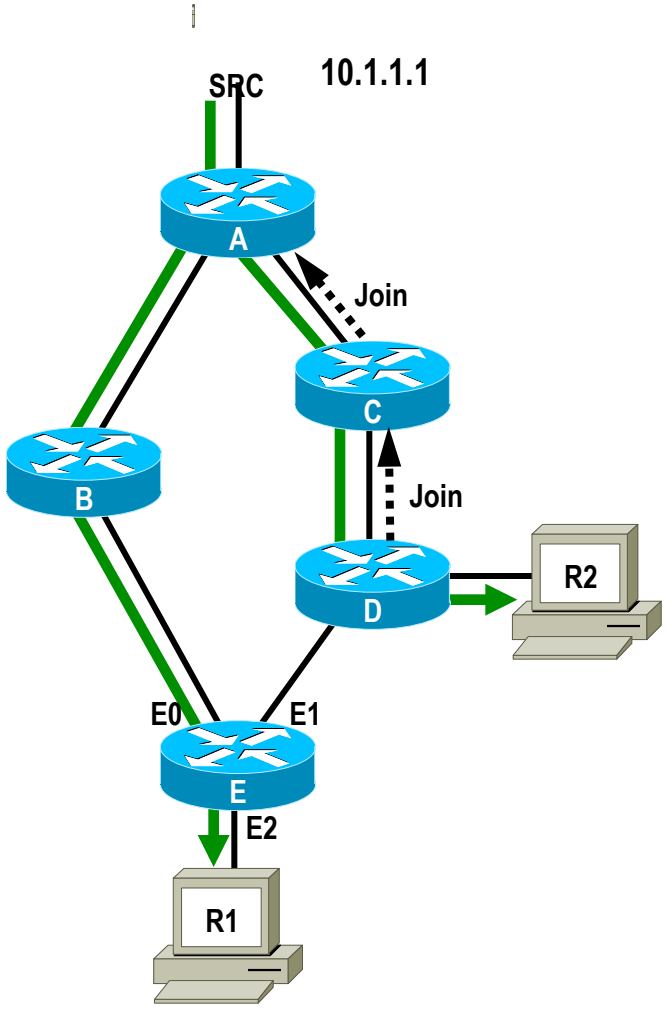
  Best path to source found in Unicast Route Table.

  Determines where to send Join.

  Joins continue towards Source to build multicast tree.

  Multicast data flows down tree.

  Repeat for other receivers.



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IP Multicast Components

- Group Membership Protocol - enables hosts to dynamically join/leave multicast groups. Membership info is communicated to nearest router
  - IGMPv1/v2
  - IGMPv3: specify the source also
  - Between receivers and “Last-hop” router
- Multicast Routing Protocol - enables routers to build a delivery tree between the sender(s) and receivers of a multicast group
  - PIM is the default protocol
  - Several “flavors” of PIM
    - Sparse
    - Dense: considered obsolete by many
    - Bidir
    - Source-Specific (SSM)

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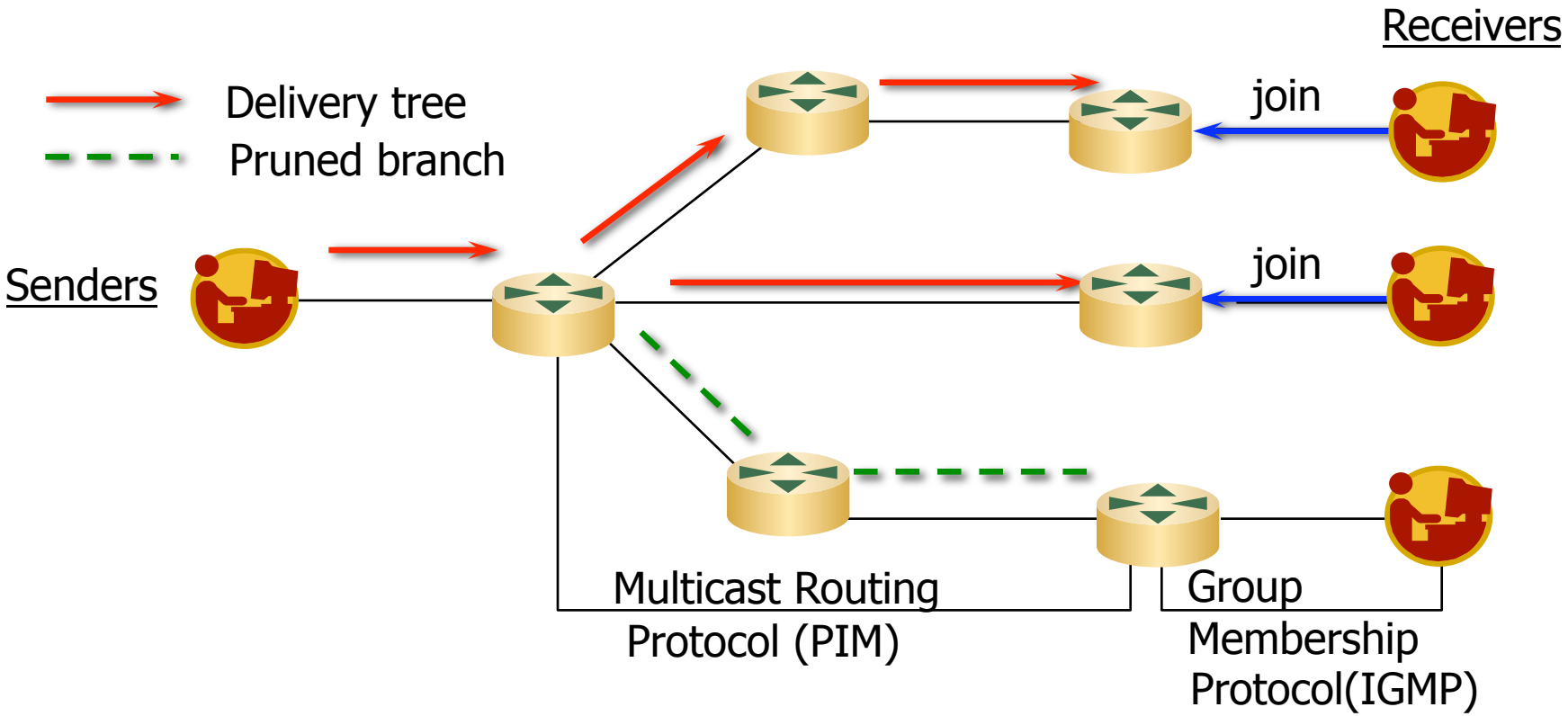
IP Multicast Components



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Multicast Distribution Trees

- **Shared path**
  - **All sources use the same path: (*,G)**
  - **The root of the tree is common for all sources.**
  - **Called RPT: Rendezvous Point Tree because of PIM**
  - **How the source packets arrive at the root of the shared tree is defined by the specific protocol.**
- **Shortest path**
  - **Each source has a unique path: (S,G)**
  - **Called SPT: Shortest Path tree**
  - **The root of the tree is the source itself**
- **Bi Directional**
  - **Allows for upstream forwarding on the shared path**

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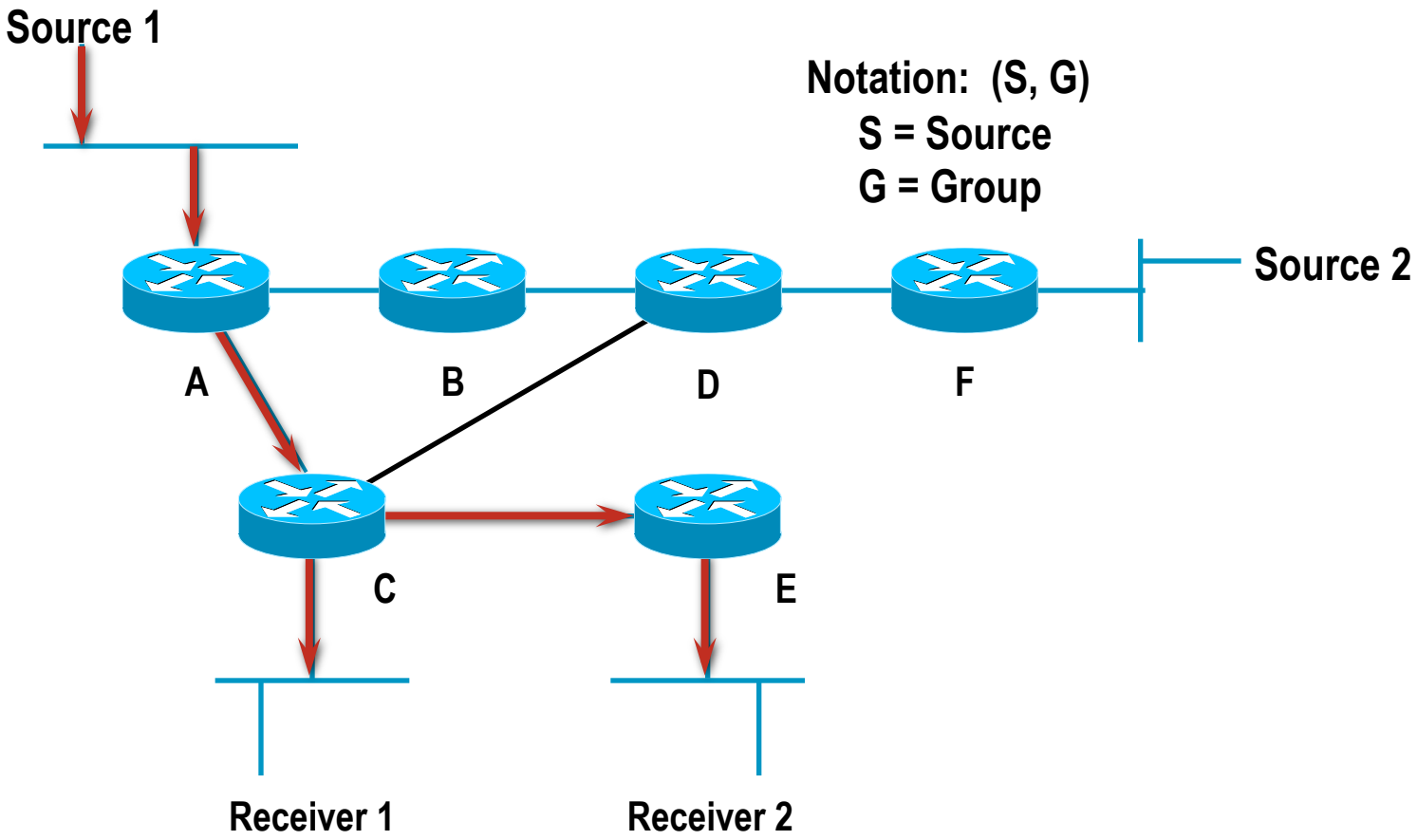
Multicast Distribution Trees

Shortest Path or Source Distribution Tree



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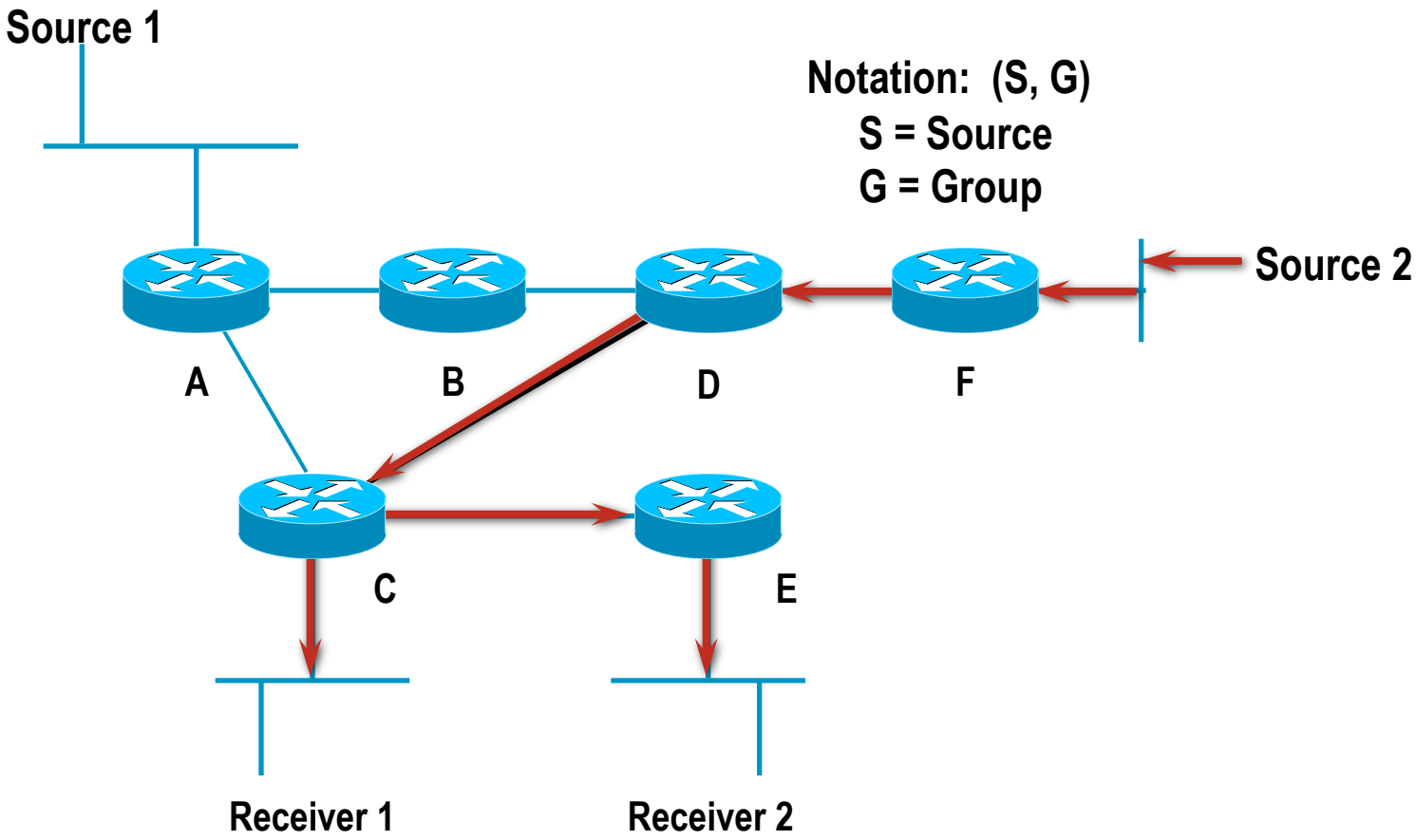
Multicast Distribution Trees

Shortest Path or Source Distribution Tree



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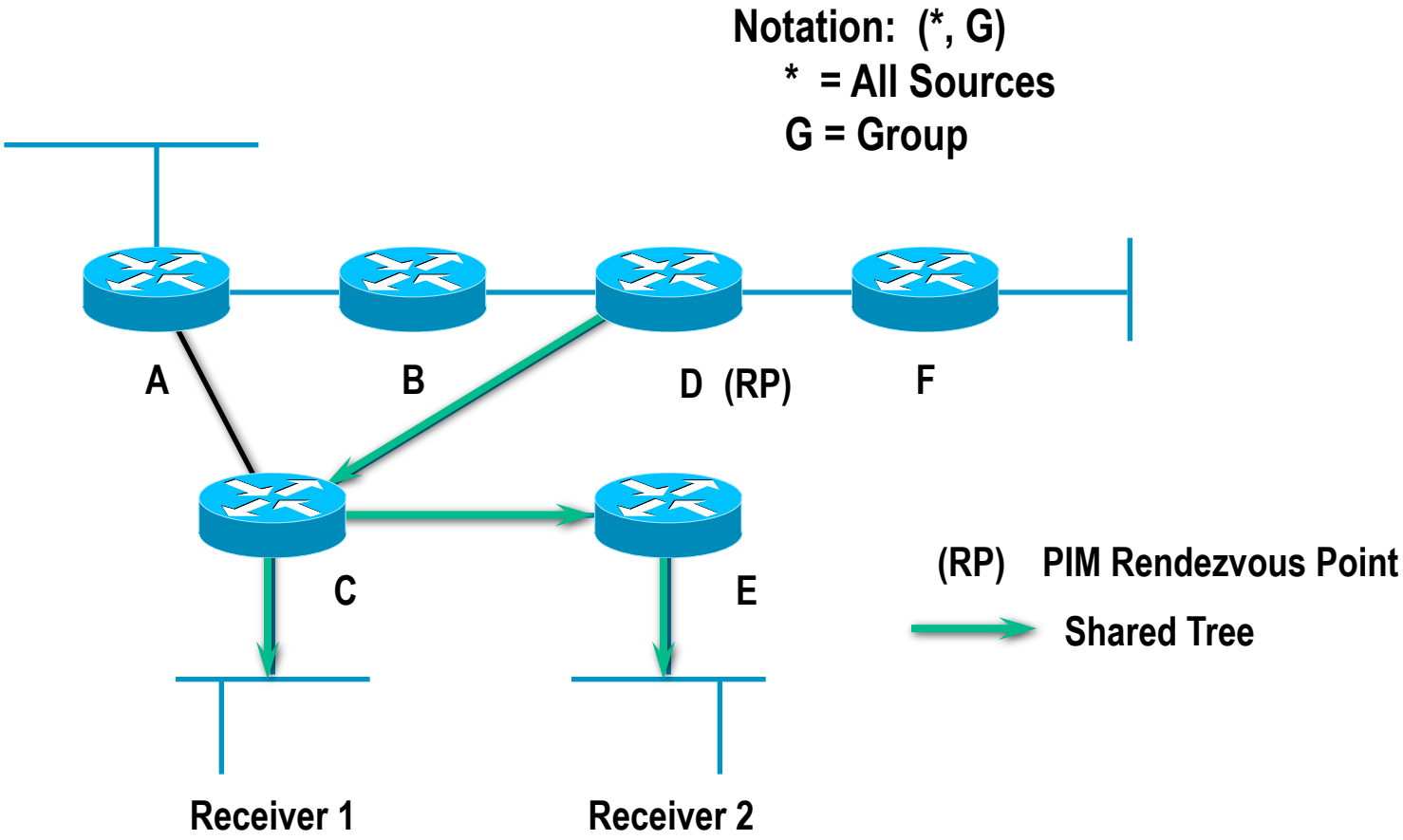
Multicast Distribution Trees

Shared Distribution Tree



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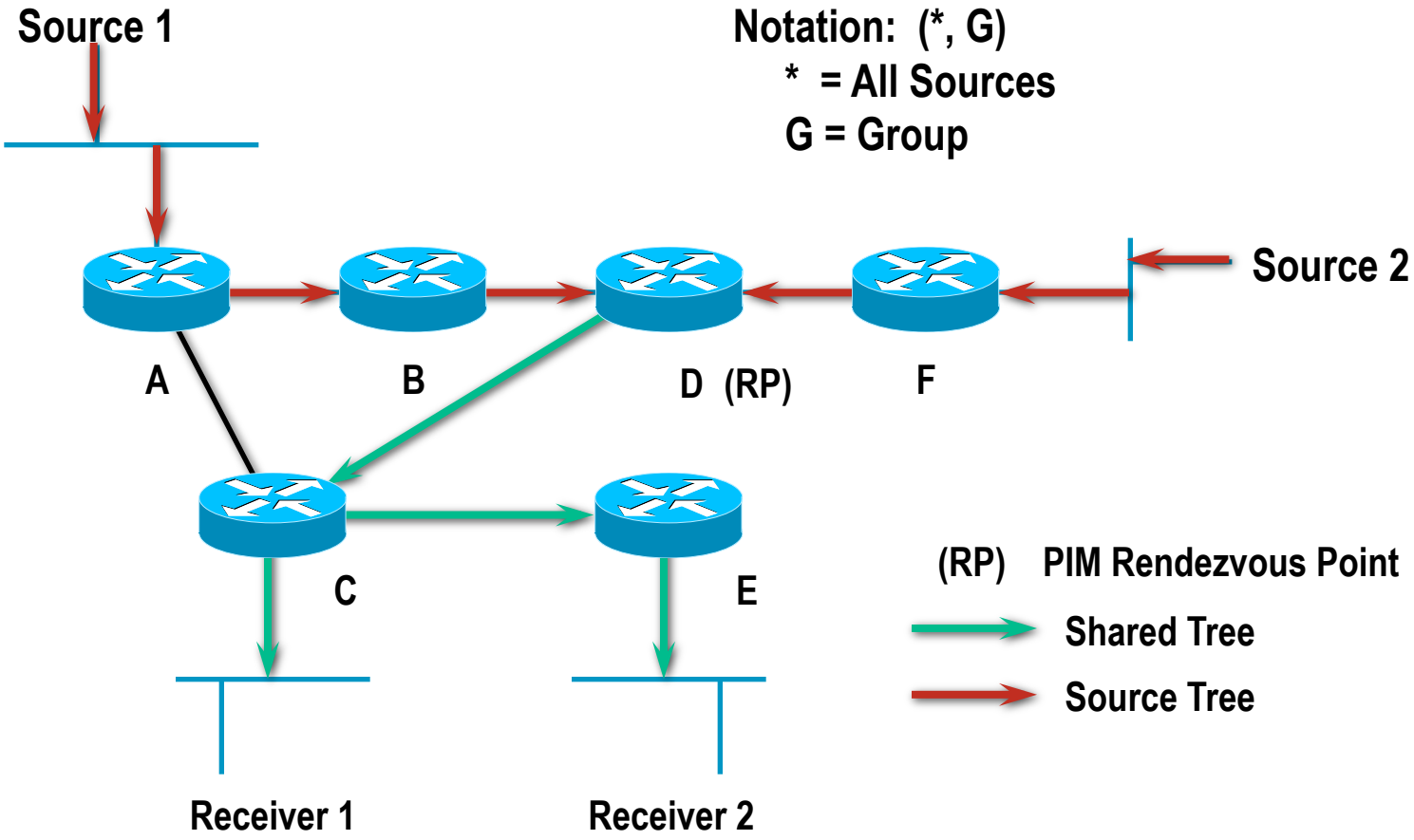
Multicast Distribution Trees

Shared Distribution Tree



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Multicast Distribution Trees

- **Source or Shortest Path trees**

  More resource intensive; requires more state→ n(S x G)

  You get optimal paths from source to all receivers, minimizes delay

  Best for one-to-many distribution

- **Shared or trees**

  Uses fewer resources; less memory →n(G)

  You may get sub optimal paths from source to all receivers, depending on topology

  The RP (core) itself and its location *may* affect performance

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PIM varieties

- **Dense**
  - Considered obsolete
- **Sparse**
  - Widely deployed
  - Complicated
  - Would like to see obsolete
- **Source Specific Multicast (SSM)**
  - No problems building the tree to anywhere in the Multicast-enabled Internet
- **Bidir**
  - Saves state

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Agenda

- Introduction
- **Multicast addressing**
- Group Membership Protocol
- PIM-SM / SSM
- MBGP
- MSDP
- Summary

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Multicast Addressing

- **IP Multicast Group Addresses**
  - **224.0.0.0–239.255.255.255**
  - **Class “D” Address Space**
    - **High order bits of 1st Octet = “1110”**
- **Use of the address space is being more tightly defined.**
- **RFC 3171:IANA Guidelines for IPv4 Multicast Address Assignments**
  - **Link-local**
  - **Internetwork control block**
  - **SSM**
  - **GLOP**

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Multicast Addressing

- http://www.iana.org/assignments/multicast-addresses
- Examples of Reserved & Link-local Addresses

  224.0.0.0 - 224.0.0.255 reserved & not forwarded

  239.0.0.0 - 239.255.255.255 Administrative Scoping

  224.0.0.1 - All local hosts

  224.0.0.2 - All local routers

  224.0.0.4 - DVMRP

  224.0.0.5 - OSPF

  224.0.0.6 - Designated Router OSPF

  224.0.0.9 - RIP2

  224.0.0.13 - PIM

  224.0.0.15 - CBT

  224.0.0.18 - VRRP

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Internet Network Control Block

- 224.0.1.x
- Addresses in the Internetwork Control block are used for protocol control that must be forwarded through the Internet.

  Examples include 224.0.1.1 (NTP [RFC2030]) and 224.0.1.68 (mdhcpdiscover [RFC2730]).

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Dynamic Address Allocation

- SDR The defacto

  224.2.0.0 – 224.2.255.255 (224.2/16) SDP/SAP Block

- Still used, but not required
- Will not scale well

  Limited address space

  Single directory application for ALL content?!?!?

- Web links should prevail

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Multicast Addressing

- Administratively Scoped Addresses – rfc2365
  - 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: 239.253.0.0/16
    - Organization-local scope: 239.192.0.0/14

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Multicast Addressing

- **GLOP addresses**
  - **Provides globally available private Class D space**
  - **233.x.x/24 per AS number**
  - **RFC3180 (obsoletes 2770)**

How?

- **AS number = 16 bits**
  - **Insert the 16 ASN into the middle two octets of 233/8**

Online Glop Calculator:

http://www.shepfarm.com/multicast/glop.html

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Multicast Addressing

- SSM - RFC 4607: Source-Specific Multicast for IP
  - 232/8 – IANA assigned
  - One-to-many ONLY (no shared trees)
  - Guaranties ONE source on any delivery tree
    - Content security (no 'Captain Midnight')
  - Reduced protocol dependence – more later..
  - Solves address allocation issues for interdomain one-to many
    - ~tree address is 64 bits – S,G
  - Host must learn of source address out-of-band (web page)
  - Requires host-to-router source AND group request
    - IGMPv3 include-source list
  - Hard-coded behavior in 232/8 in most router implementations
    - RFC 4608: Source-Specific Protocol Independent Multicast in 232/8
    - Configurable to expand range

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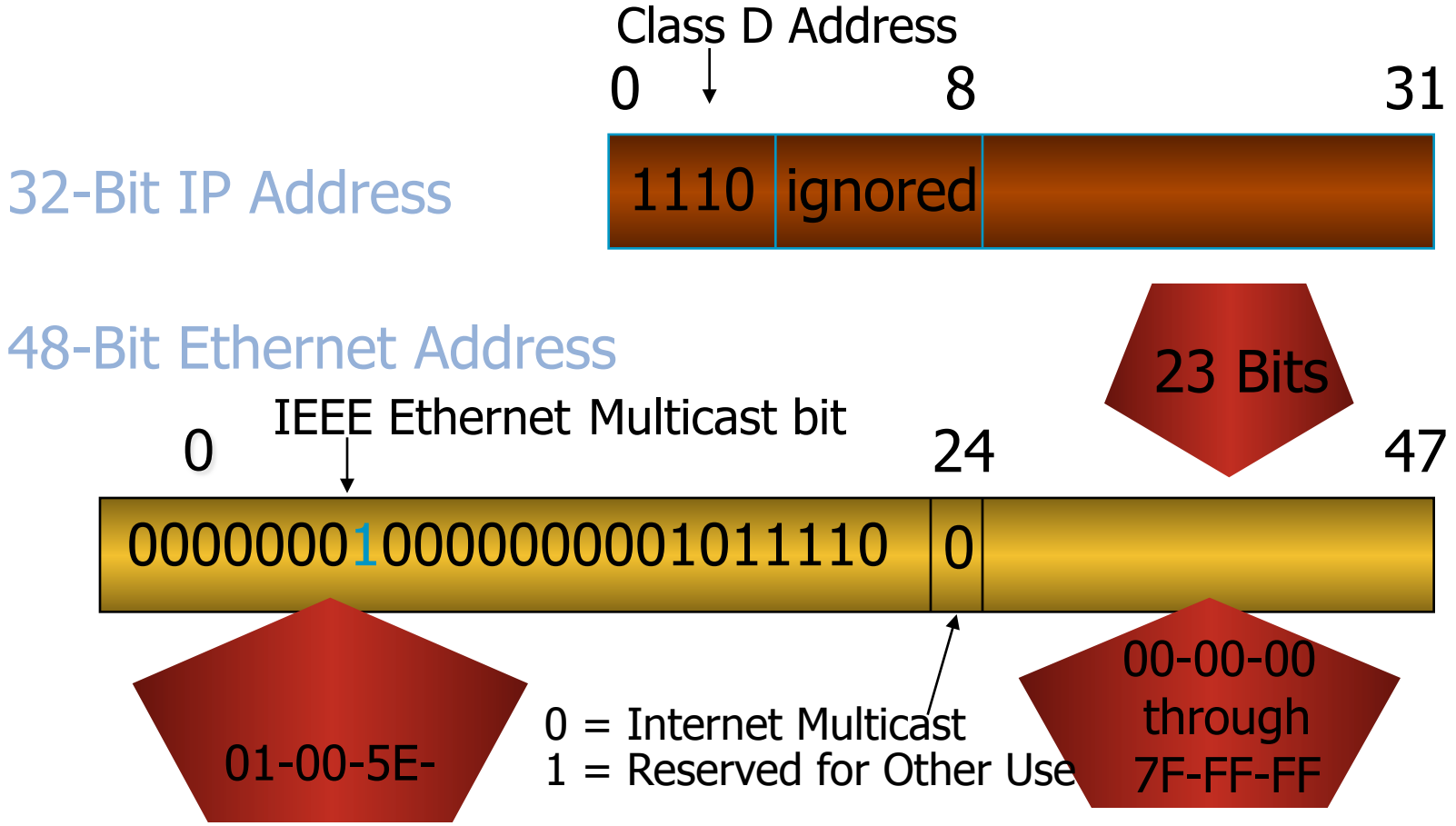
Ethernet Multicast Addressing

- IANA Owns 01-00-5E Vendor Address Block
- Half of It Assigned for IP Multicast



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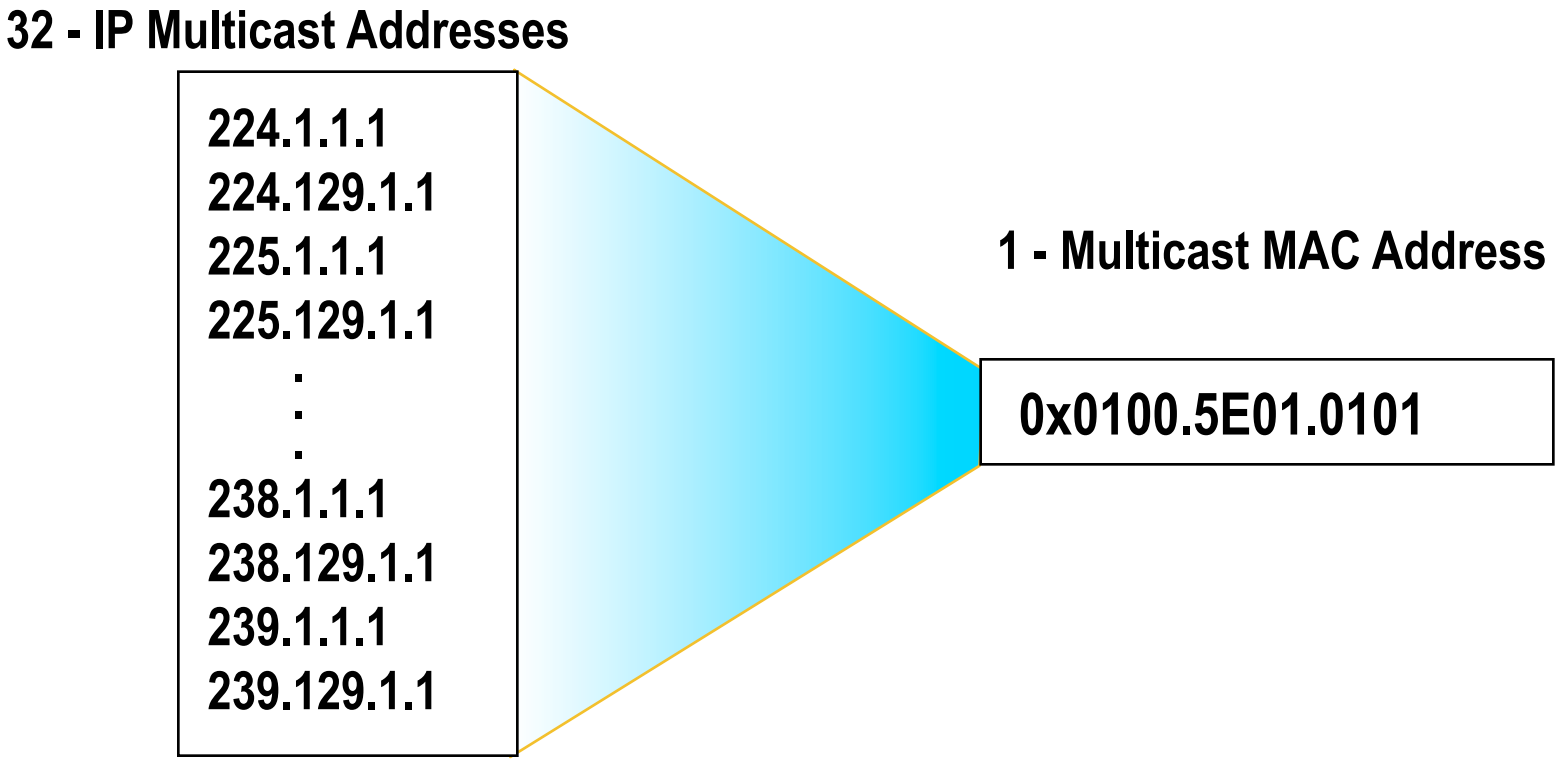
Multicast Addressing

IP Multicast MAC Address Mapping

Be Aware of the 32:1 Address Overlap



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Mac address mcast mapping

				1110	0000	0000	0000	0000	0000	0000	0000
				mcast	Wanted to map this 32-4 = 28bit						
0000	0001	0000	0000	0101	1110	0000	0000	0000	0000	0000	0000
OUI(24bit)						NIC specific(24bit)					

0 for Dr. Deering's reserch = Internet mcast
1 for other students.

01-00-5E cost $1000
If you want 01-00-50 through 01-00-5E, it costs 2^4 = $ 16,000

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Internet Group Membership(management) Protocol

- Routers solicit group membership from directly connected hosts
- RFC 2236 specifies version 2 of IGMP
  - Widely supported
- RFC 3376 specifies version 3 IGMP
  - provides source include-list capabilities (SSM!)
  - Host support:
    - Linux 2.6(16.1), Window XP
    - FreeBSD patch
    - NOT IN MacOSX!! Send Bug reports to Apple.

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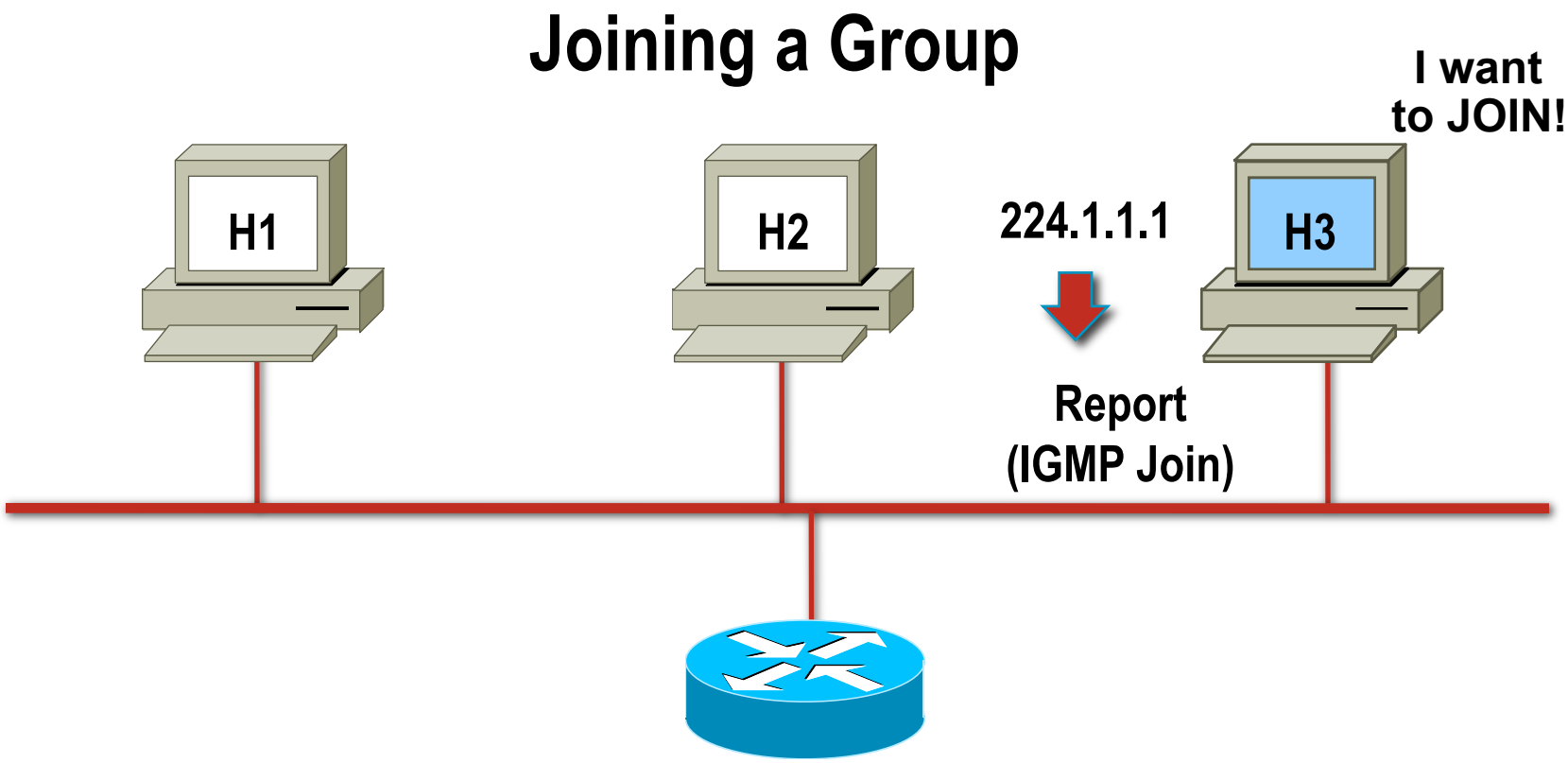
Host-Router Signaling: IGMP (Join)



- Host sends IGMP Report to join group

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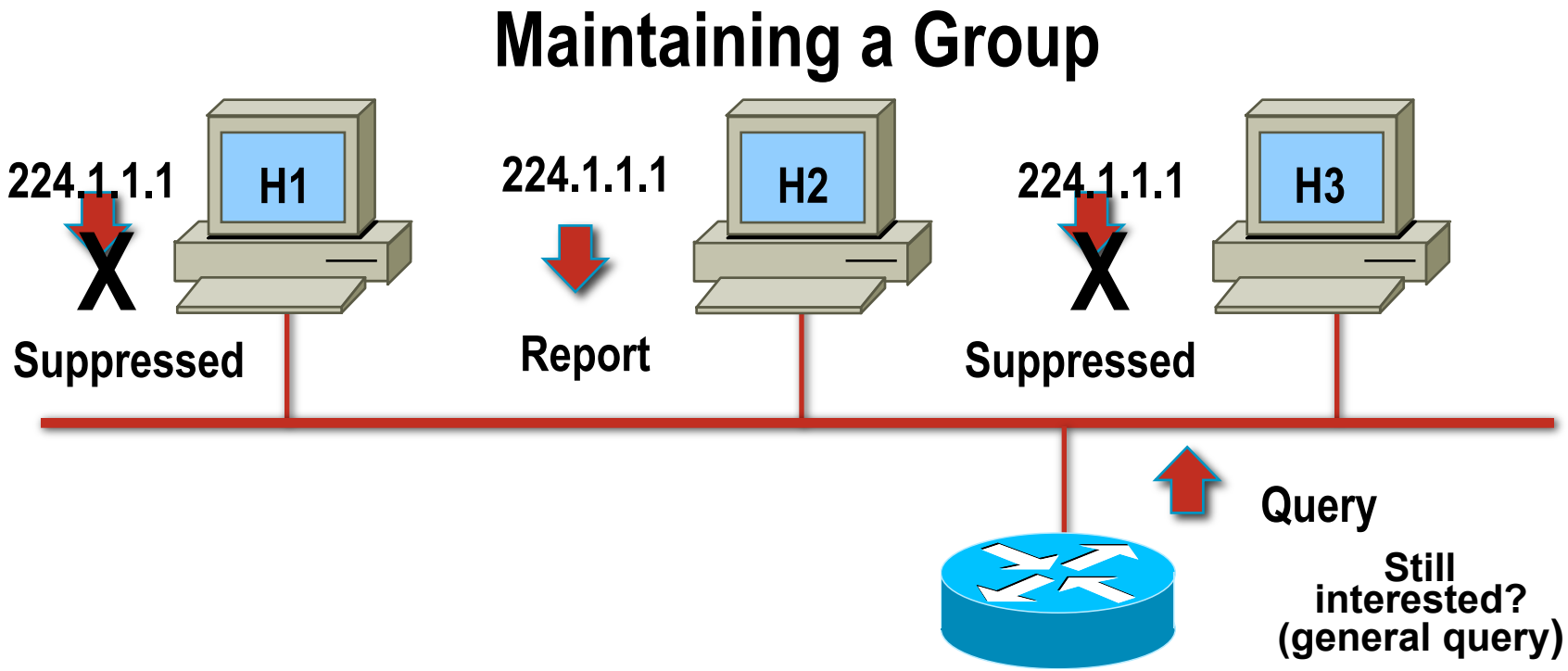
Host-Router Signaling: IGMP (Query)



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

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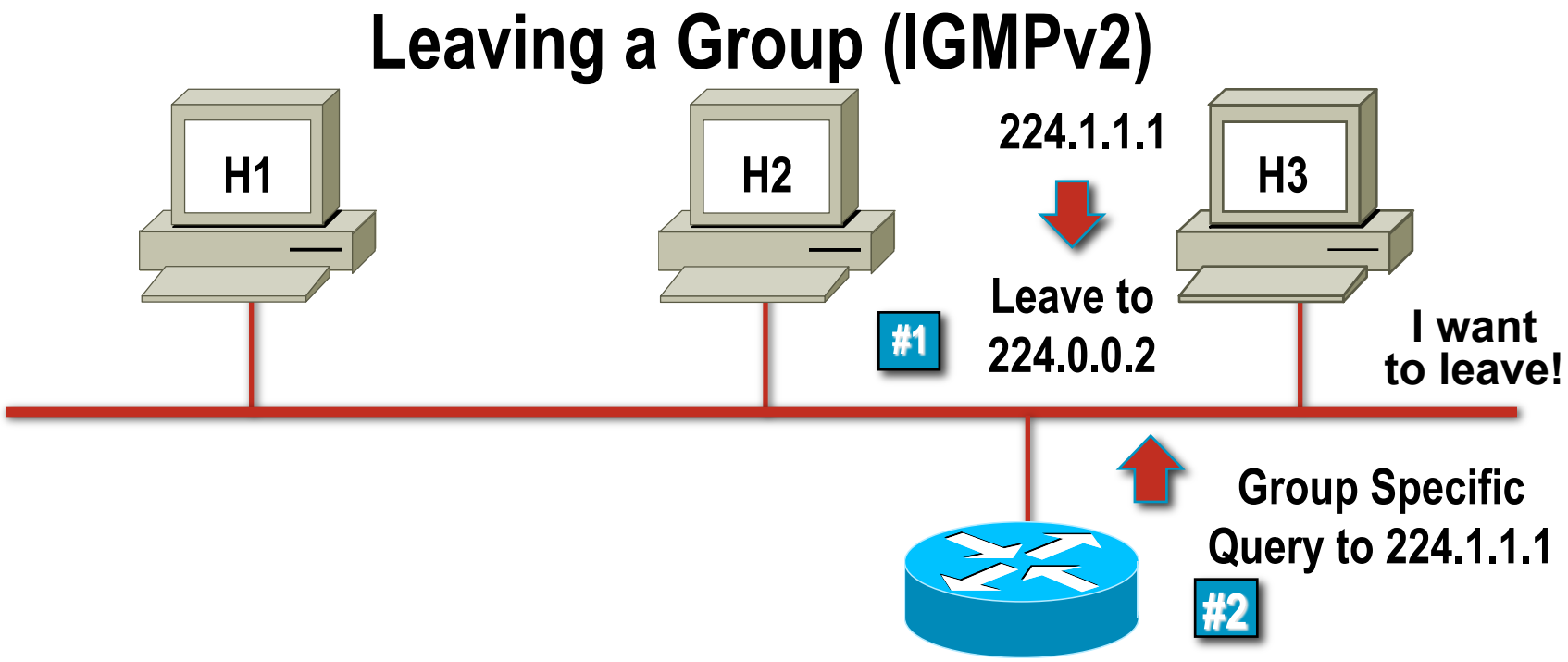
Host-Router Signaling: IGMP



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

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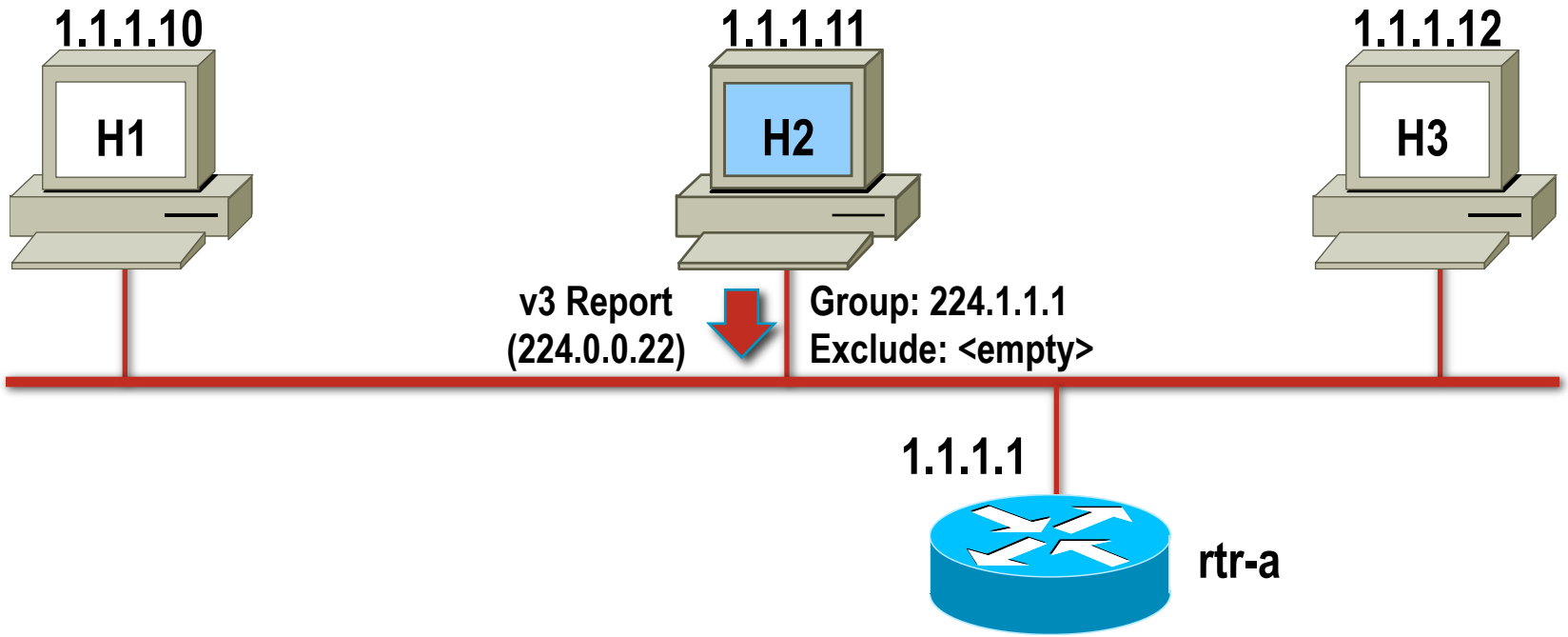
IGMPv3—Joining a Group



- Joining member sends IGMPv3 Report to 224.0.0.22 immediately upon joining

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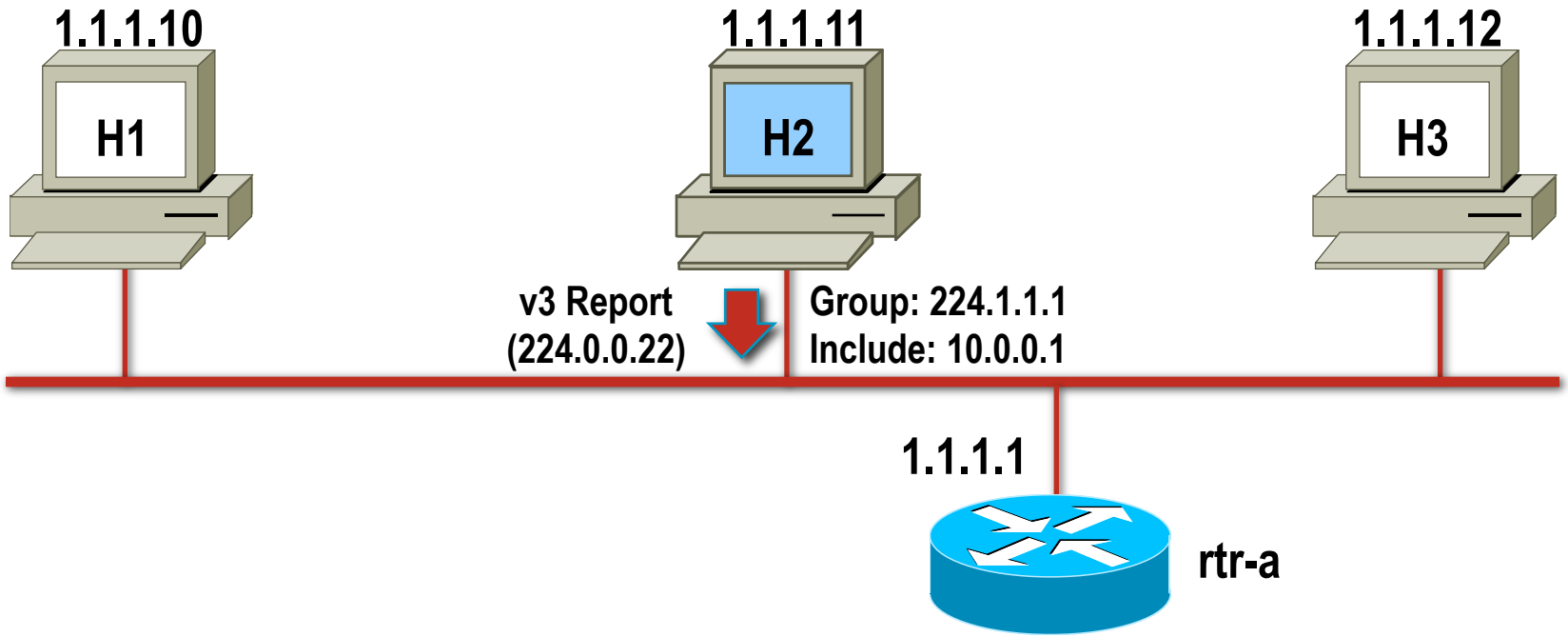
IGMPv3—Joining specific Source(s)



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

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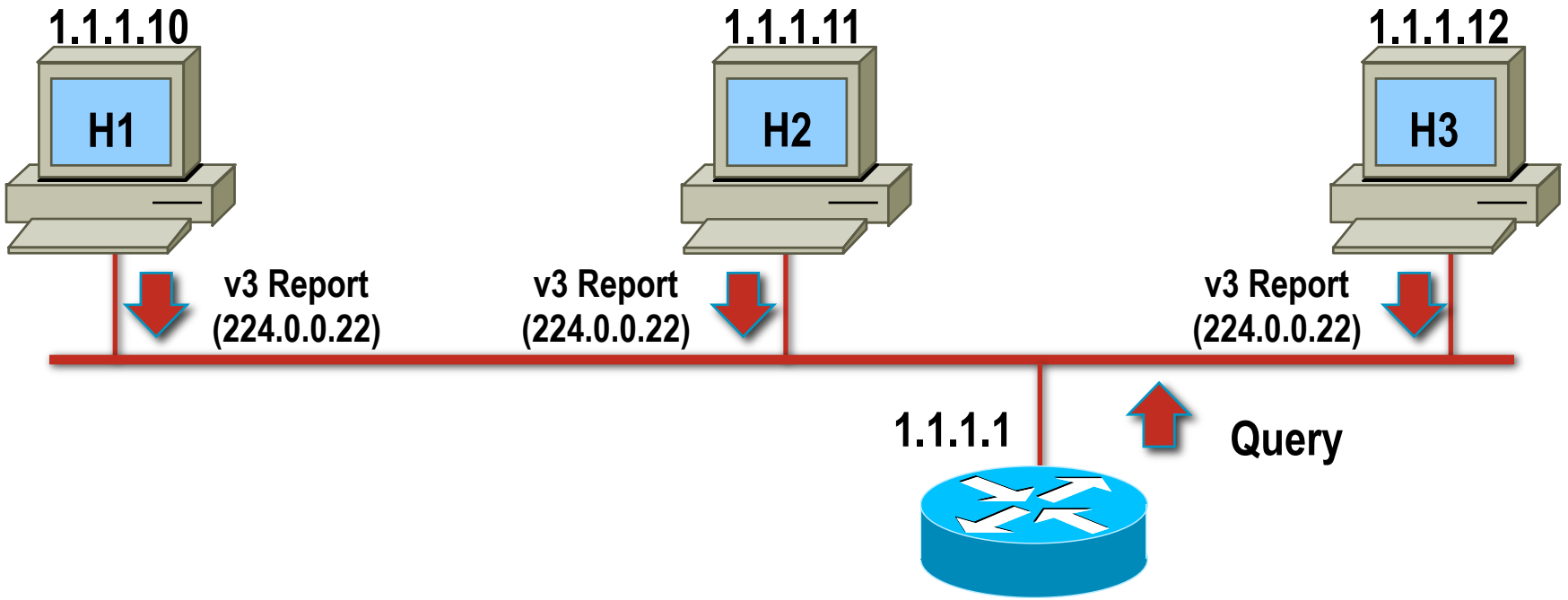
IGMPv3—Maintaining State



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

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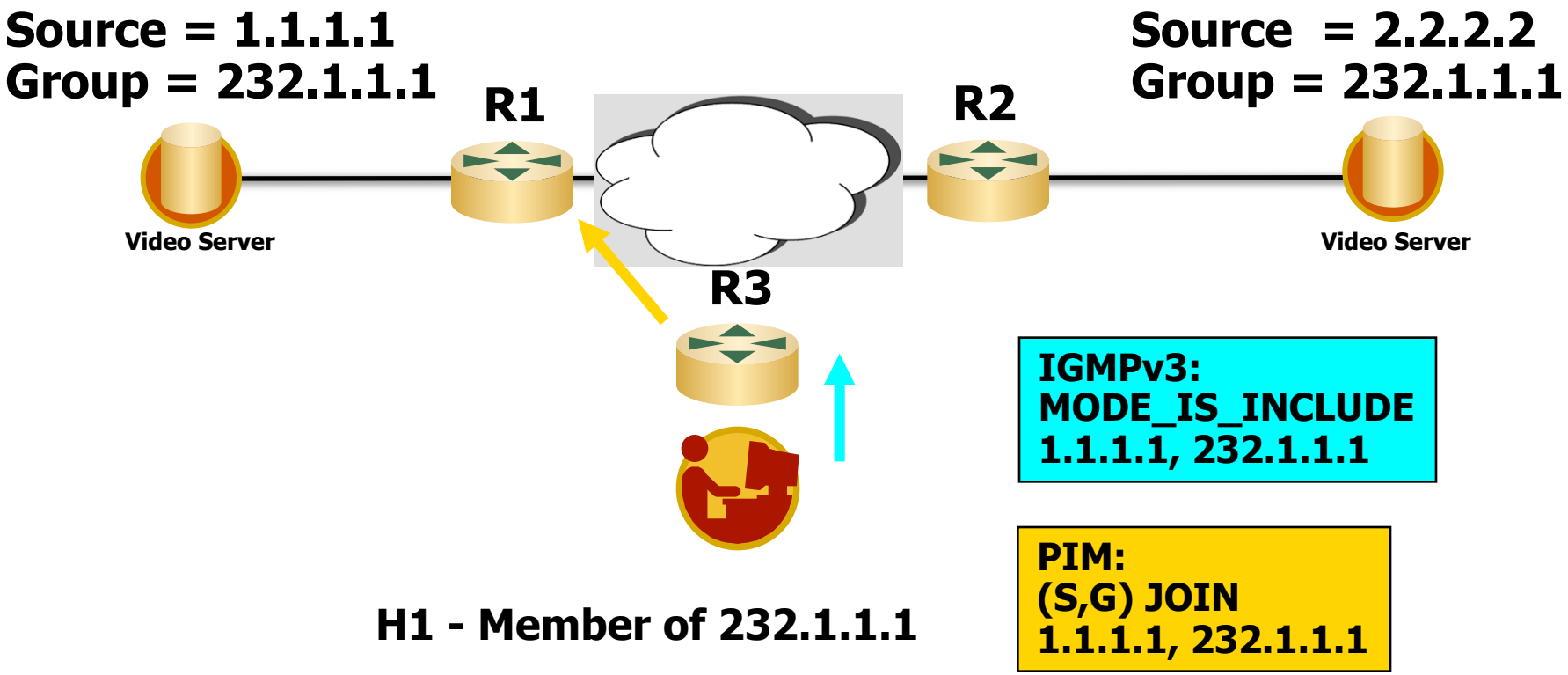
IGMPv3

RFC3376

Hosts to listen only to a specified subset of sources



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IGMP Details

- **Router:**

  Sends Membership Query messages to All Hosts (224.0.0.1)

  query-interval = 125 secs default

  Router with lowest IP address is Querier

  PIM DR listens for reports and adds group to membership list for that interface (Implementation specific)

  Timeout (Group member interval) default:

  (robust-count x query-interval) + (1 x query-response-interval) = **260 sec**

  Robust-count - provides fine-tuning to allow for expected packet loss on a subnet. Default = 2

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IGMPv2 Details

- **Host:**

  Sends Membership Report,

    waits 0-10 sec (default) after receiving a query.

    Hosts listen to other host reports

    Only 1 host responds

  Membership reports are sent to the group address (e.g. 224.10.8.5)

  Leave messages to All Routers (224.0.0.2)

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IGMP Enhancements

- **IGMP Version 2**

  Multicast router with lowest IP address is elected querier IGMPv1 was mcast protocol specific and potentially conflicted.

  Group-Specific Query message is defined. Enables router to transmit query to specific multicast address rather than to the "all-hosts" address of 224.0.0.1

  Leave Group message is defined. Last host in group wishes to leave, it sends Leave Group message to the "all-routers" address of 224.0.0.2. Router then transmits Group-Specific query and if no reports come in, then the router removes that group from the list of group memberships for that interface

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IGMPv3 Enhancements

- Include: list the specific sources in a group to receive

  Include {NULL} is equivalent to an IGMPv2 group leave

  Include (S,G): I want this source and group
- Exclude: list the specific sources in a group to NOT receive

  Exclude {NULL) is equivalent to an IGMPv2 group join

  Exclude (S,G): I want everything -except- this source and group.
- Reports are sent to 224.0.0.22, NOT to the group address

  Works better with L2 switches. No snooping required.
- No report suppression: explicit tracking

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PIM

- **Protocol Independent Multicast**

  http://ietf.org/html.charters/pim-charter.html

  RFC 3973: PIM-Dense Mode

  RFC 4601: PIM-Sparse Mode

  RFC 4602: Proposed Standard Requirements Analysis

  RFC 4610: PIM Anycast-RP

  Draft-ietf-pim-sm-bsr-09: bootstrap router, RP distribution

  draft-ietf-pim-bidir-08.txt: bi-directional PIM

- **Depends on Unicast Routing table for forwarding decision**

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PIM-DM

- Data is flooded to the boundaries of the PIM domain and pruned back
- Current RFC has a “state-refresh” mechanism that avoids periodic flood-and-prune requirements of original design
- Implementations are either non-existent or based on old RFC
- Considered obsolete by most, but appears very useful in some networks. (Talk to the RFC authors)
- Can not be used interdomain without a lot of trouble

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PIM-SM

- Receiver initiated
- Explicit join: data sent only to locations where receivers exist
- Rendezvous Point (RP) is used for source discovery
- All routers in a PIM domain must have RP mapping
- Last-hop router initiates join to the SPT.
- May remain on the shared-tree
  - Useful for some topologies
  - Being replaced by bi-dir
- Source-tree state is refreshed when data is forwarded and with Join/Prune control messages
- Can be used interdomain with MSDP

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PIM-SSM (source specific multicast)

- Uses only the SPT
- Source discovery is not part of the protocol
- Requires IGMPv3 on the receivers
  - Some work-arounds
- Very simple to deploy and understand
- Works interdomain without any other special configurations
- Can be used with Automatic Multicast Tunnels (AMT)

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PIM-Bidir (bi-directional)

- Uses only the shared-tree
- Reduces state on the routers by at least an order of magnitude

  Amazon.com went from thousands of (S,G) entries to less than 200 (*,G) routes
- Currently only useful within a contiguous domain
- The root of the tree is virtual (does not require a physical RP) so can be moved easily and rapidly within an enterprise
- With a well-implemented BSR, backup and resource allocation is very easy and reliable.

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Which PIM do you want to use?

- **SSM**
  - Easiest to understand
  - Easiest to deploy
  - Most reliable
  - Interdomain
- **Bidir**
  - Within a domain with many, many sources
- **Sparse-mode**
  - If receivers can not do IGMPv3
- **Never use dense**

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When to use which PIM

- **SSM**
  - One-to-many applications with well-known sources
  - a good source discovery protocol (TBD)
- **Bidir**
  - Many-to-many applications with transient sources
  - When supporting 100,000+ sources
  - To keep routing simple
- **Sparse-mode**
  - One-to-many when receivers are not IGMPv3 capable
  - Few-to-few and no source discovery protocol works
  - Try to avoid

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PIM Sparse-mode operation

- We cover sparse-mode because it has all the basic concepts required to understand the other modes
- It is the most widely deployed
- Even though we may want it to go away, it won't be any time soon

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PIM-SM Operation
Designated Router (DR)

- **Neighboring PIM-SM routers multicast periodic "Hello" messages to each other - default 30 secs.**
  - **Hello-interval tunable for faster convergence**
- **On receipt of a Hello message**
  - **a router stores the IP address and priority for that neighbor**
- **Router with highest Priority is selected as the DR**
  - **If the priorities are the same, highest IP address**
- **DR is only important on first-hop and last hop**
  - **On last-hop sends "Join/Prune" messages toward RP/ source**
  - **On first-hop: send "Register" messages to the RP**

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PIM Sparse-Mode:RP

- Allows Source Trees or Shared Trees
- Rendezvous Point (RP)
  - Provides network source discovery
  - Root of shared tree
- Typically use shared tree to bootstrap source tree
- RP's can be learned via:
  - Static configuration
  - Auto-RP
  - Bootstrap Router
    - DCOS has an excellent BSR implementation.

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Setting up PIM forwarding

The following slides provide a basic overview of how PIM-SM works and only provides a general overview

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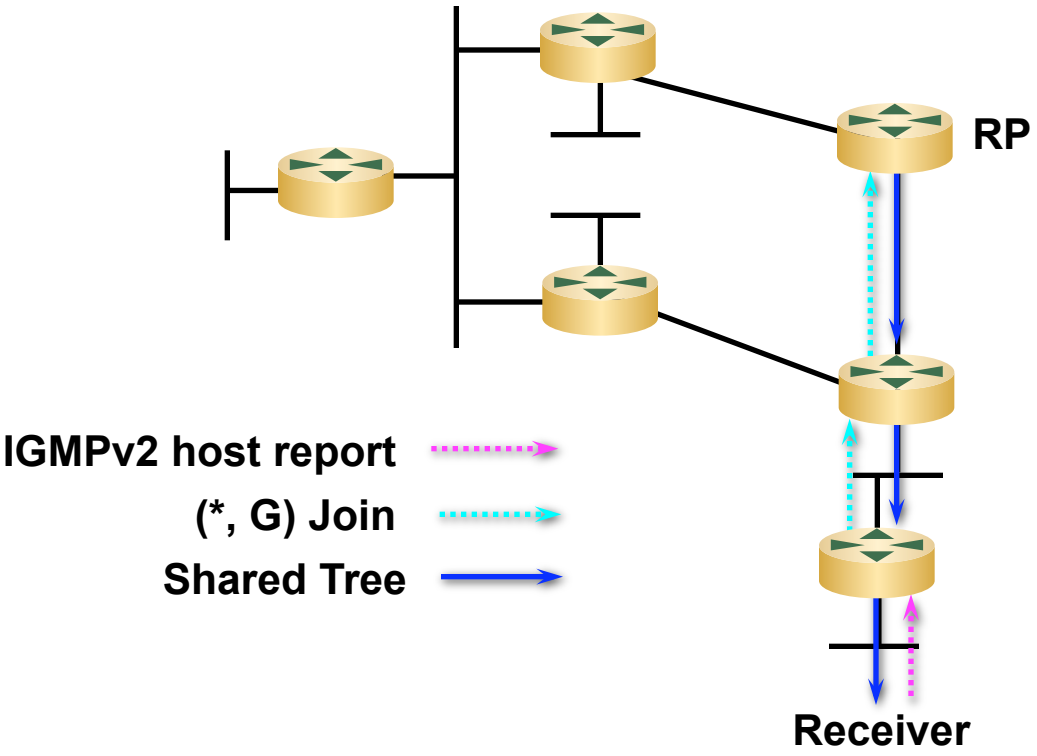
PIM-SM Shared Tree Join



Receiver announces desire to join group G with igmpv2 host report – (*,G).

(*, G) State created from the RP to the receiver.

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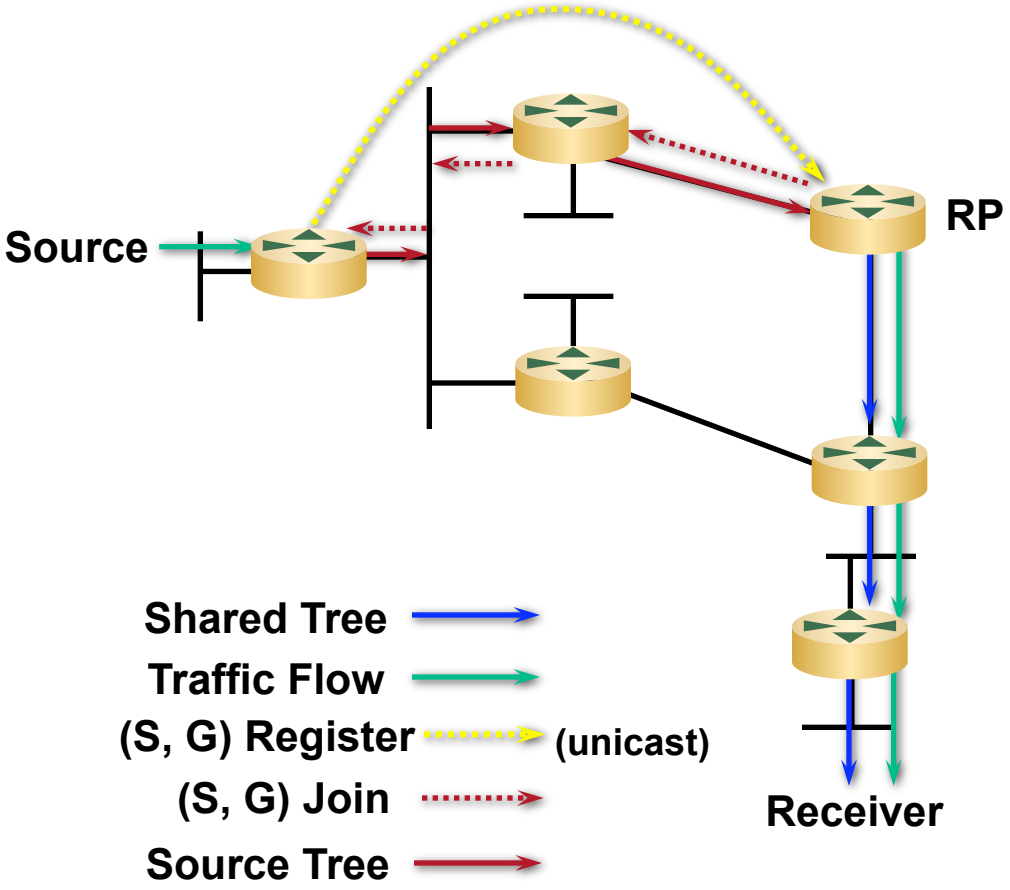
PIM-SM Sender Registration



(S, G) State created only along the Source Tree.

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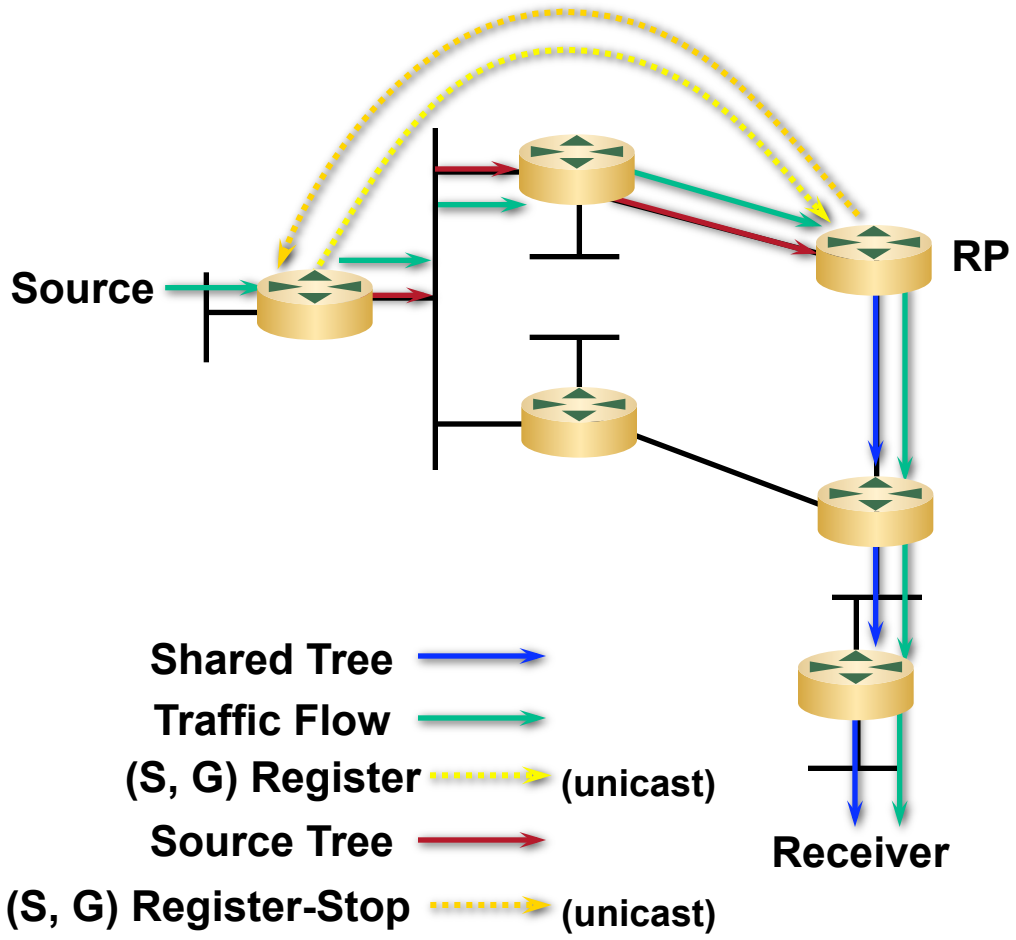
PIM-SM Sender Registration



(S, G) traffic begins arriving at the RP via the Source tree.

RP sends a Register-Stop back to the first-hop router to stop the Register process.

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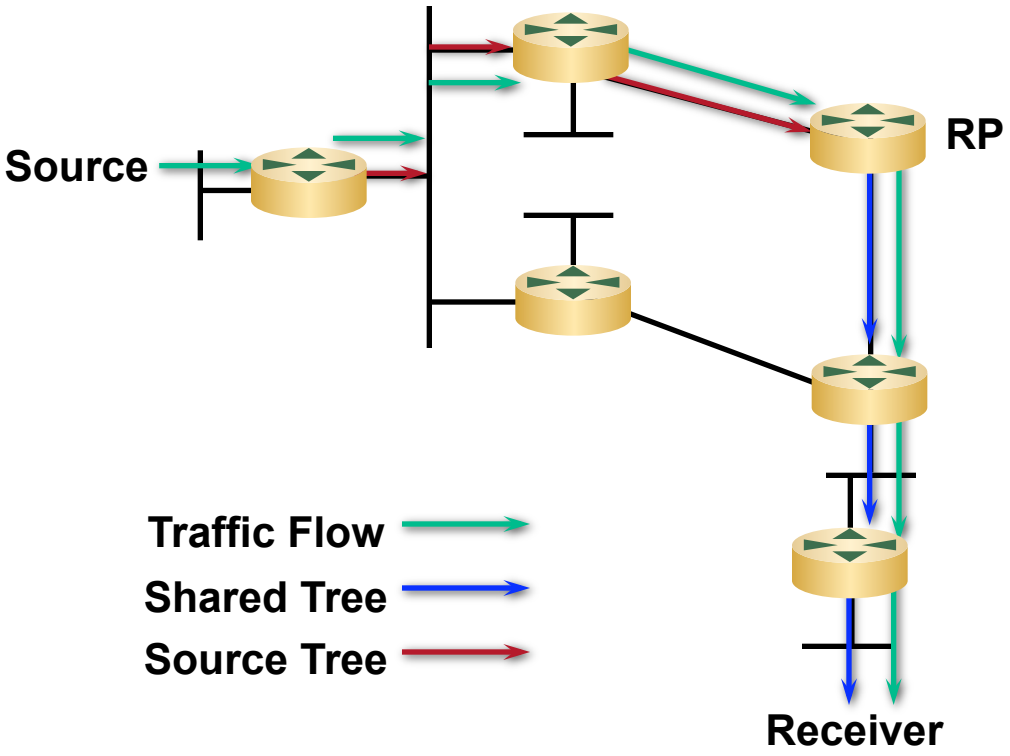
PIM-SM Sender Registration



Source traffic flows natively along SPT to RP.

From RP, traffic flows down the Shared Tree to Receivers.

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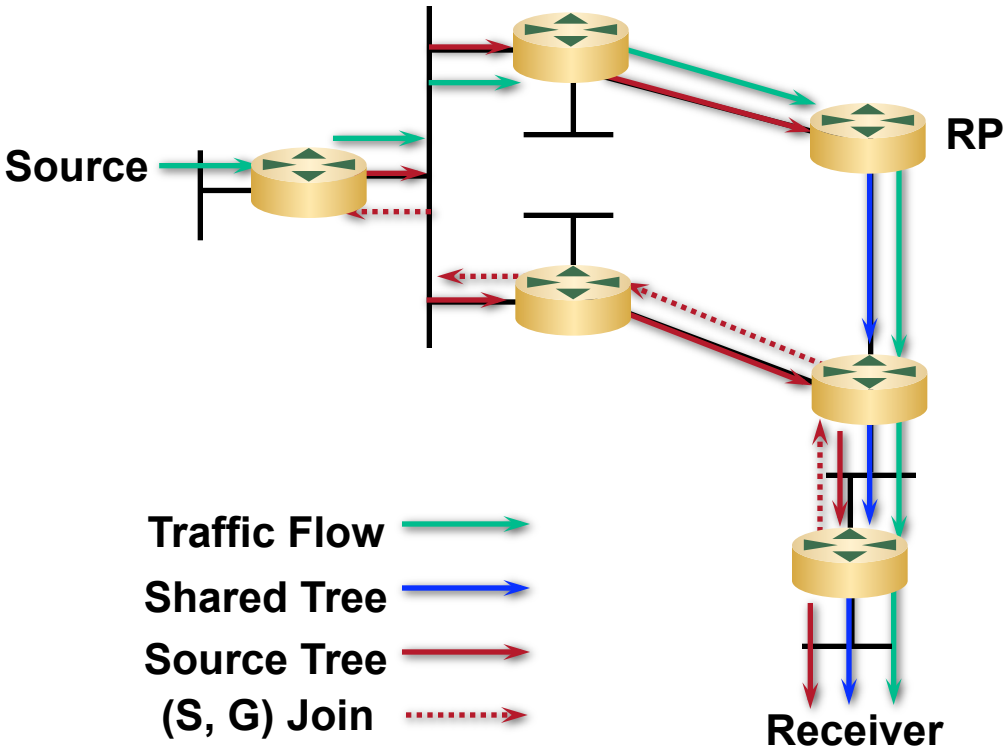
PIM-SM SPT Cutover



Last-hop router joins the Source Tree.

Additional (S, G) State is created along new part of the Source Tree.

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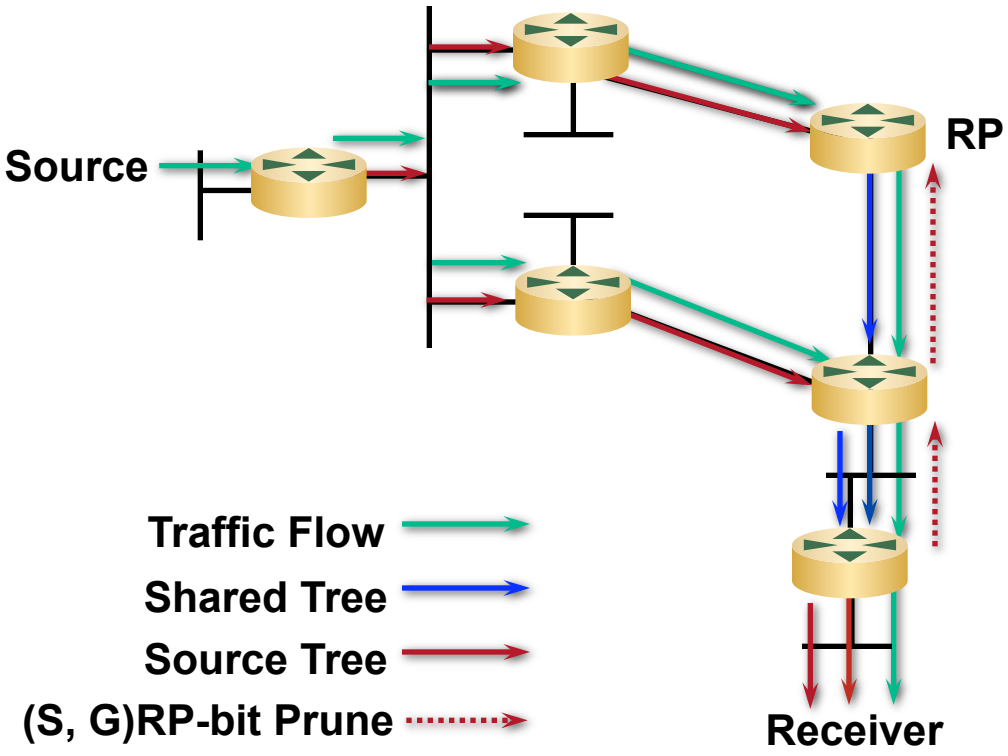
PIM-SM SPT Cutover



Traffic begins flowing down the new branch of the Source Tree.

Additional (S, G) State is created along the Shared Tree to prune off (S, G) traffic.

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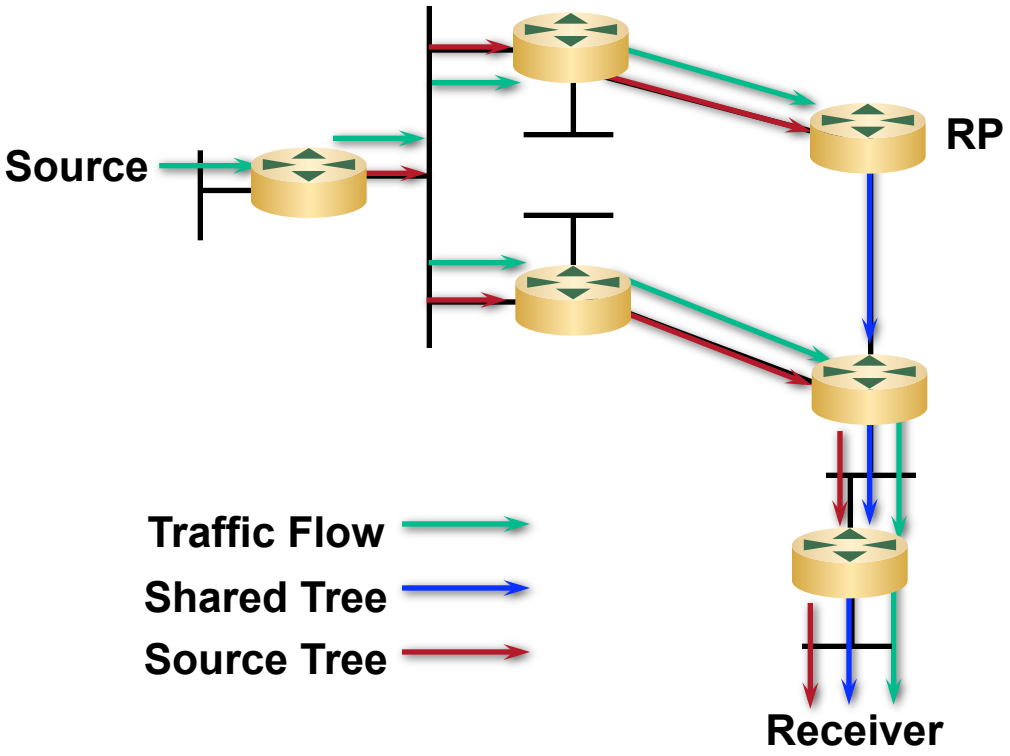
PIM-SM SPT Cutover



(S, G) Traffic flow is now pruned off of the Shared Tree and is flowing to the Receiver via the Source Tree.

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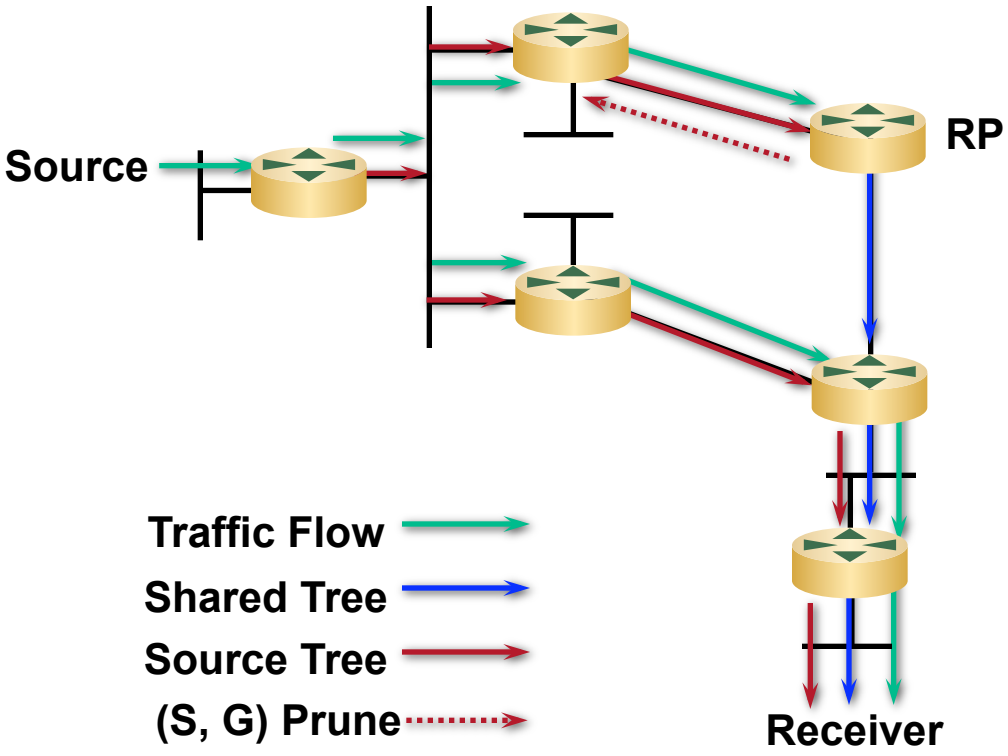
PIM-SM SPT Cutover



(S, G) traffic flow is no longer needed by the RP so it Prunes the flow of (S, G) traffic.

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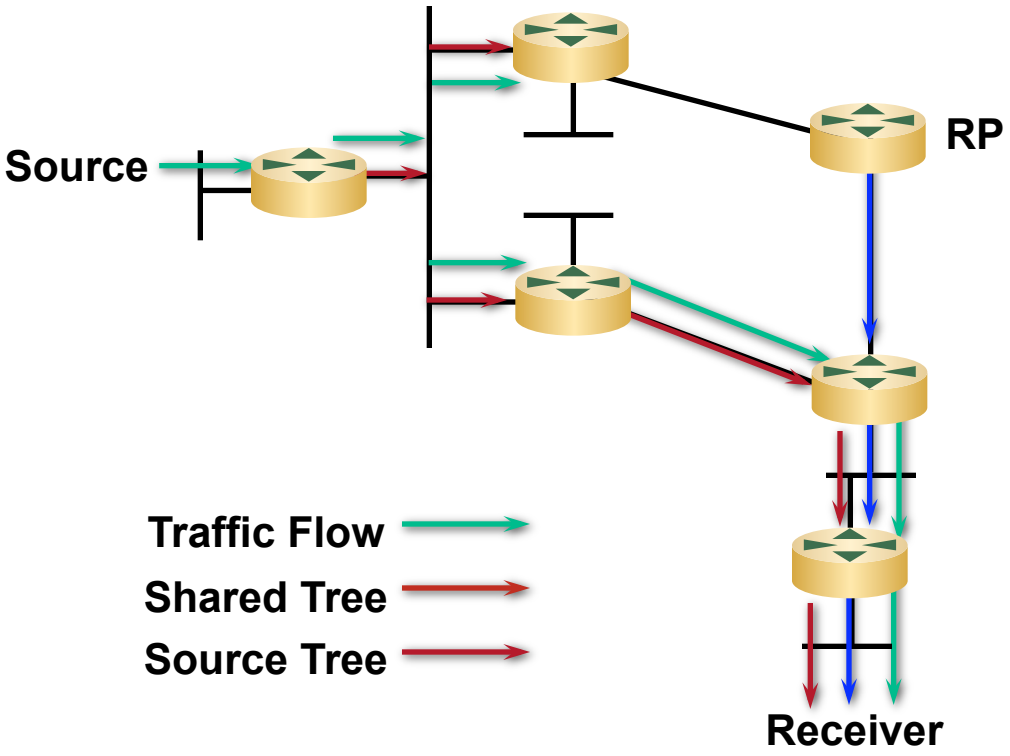
PIM-SM SPT Cutover



(S, G) Traffic flow is now only flowing to the Receiver via a single branch of the Source Tree.

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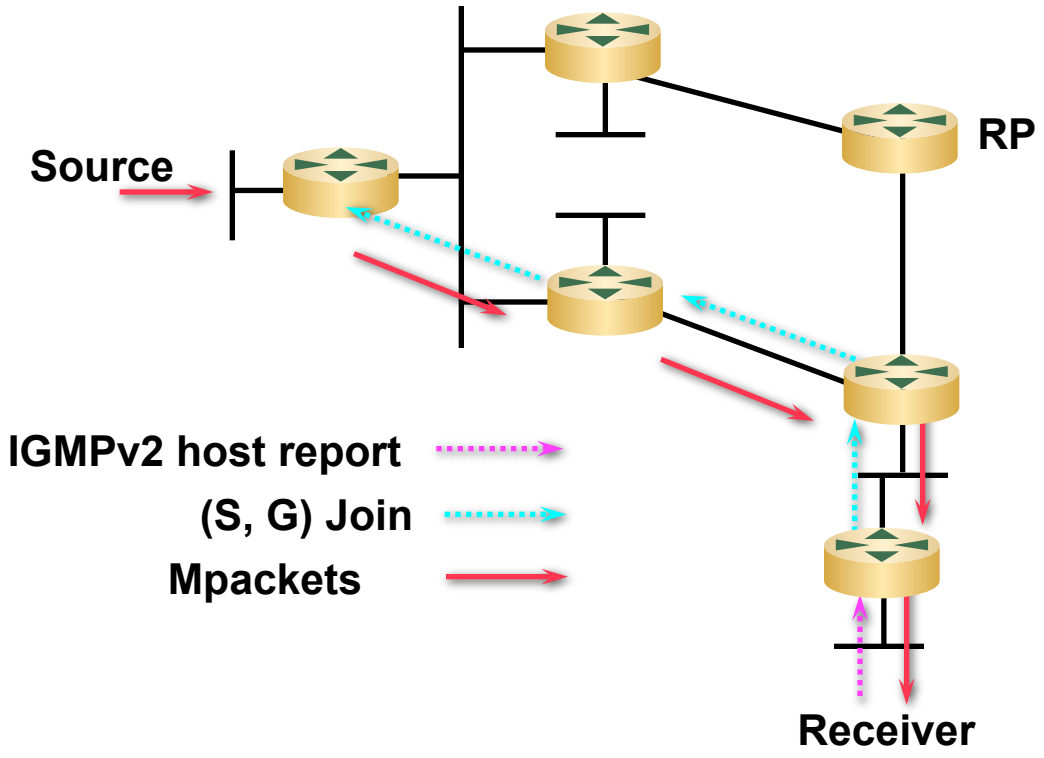
PIM-SSM Source Tree Join



Source is sending

Receiver announces desire to join group G with igmpv3 host report – (S,G).

Pim Joins sent toward the source create (S, G) State.

Mpackets flow

Exactly like joining the SPT in PIM-SM

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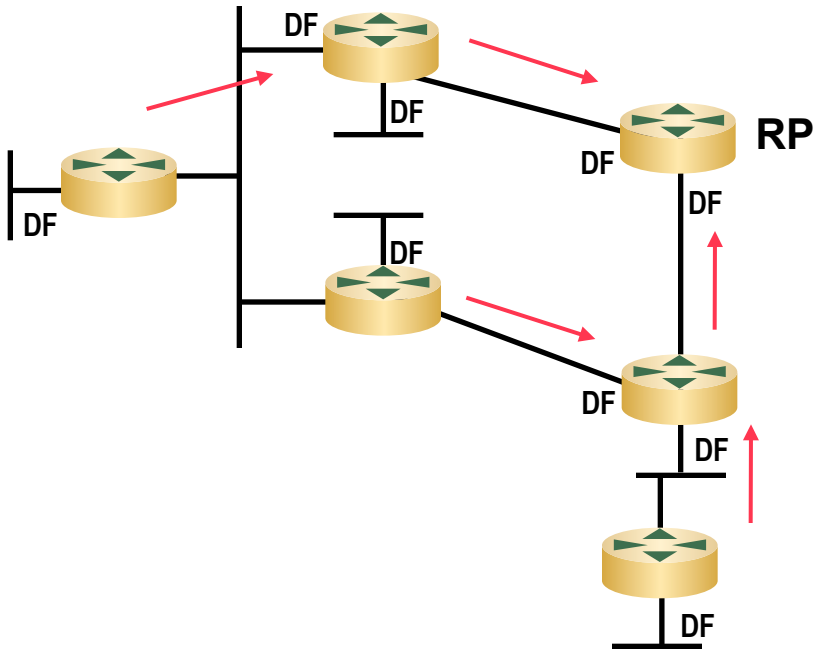
PIM-BiDir



- RP is announced
- DF elected per LAN
- Upstream forwarding is set

- Downstream forwarding is exactly like PIM-SM -except- (*,G) joins are sent to the DF

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PIM Configuration

All Modes of PIM

```
interface <interface>
 ip pim sparse-mode
```

Sparse-mode and Bidir require an RP

```
ip pim rp-address 198.58.3.254 [bidir]
```

SSM: 232/8 is the default

```
ip pim ssm-range <range>
```


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PIM RP Configuration

- **Options**
  - **Static: often recommended, especially for ISPs**
  - **Auto-RP: IOS only, becoming obsolete**
  - **Bootstrap router: RFC standard, works well in enterprise**

- **Static RP Configuration on ALL routers in PIM domain**

```
ip pim rp-address 198.58.3.254
```

- **Bootstrap Router (BSR): on just the BSR**

```
ip pim rp-candidate loopback 0
ip pim bsr-candidate loopback 0
```


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PIM Routing Triangle

- **PIM Sparse-mode routing is a triangle**
  - **Shortest-path from the RP to the receiver, Shared-tree or RP-tree (RPT)**
  - **Shortest-path from the Source to the receiver (SPT)**
  - **Shortest-path from the Source to the RP (X-line)**
    - **X on IOS mroutes shows the router is a “turnaround” router**
- **Know which forwarding path you are on or you *will* be confused.**

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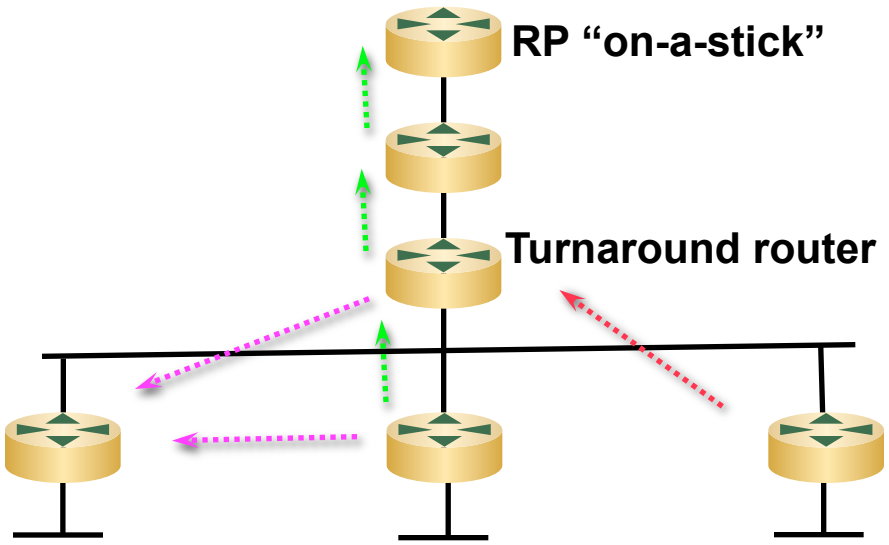
The ‘turnaround’ router

- Also known as “router on a stick”
- Occurs when the shared-path and the shortest-path intersect on a LAN
- Most noticeable when one receiver stays on the shared-tree while another joins to the shortest-path tree
  - (*,G) joins are forwarded up to the RP removing (S,G) RP-bit
  - RP joins to the SPT creating (S,G) state: RPF toward source
  - A second receiver causes (S,G,RP-bit) prunes changing state again
- This repeats over and over with mpackets periodically being received at the RP and pruned back again.

The ‘turnaround’ router



In IOS the “Turnaround router” sets the X-flag and sends (S,G) joins toward the source, blocking (*,G) only joins from being sent to the RP.

(S,G) Join

(*,G) Join

(*,G) Join with RP-bit prune

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LAB #1
PIM-SM Mechanics - SSM / ASM / BiDir

- Get your username and password from the instructor
- Once your are logged in, DO NOT start the lab until instructed
- Lab templates or cfgs: PIM-Mechanics
- Refer to your lab handout

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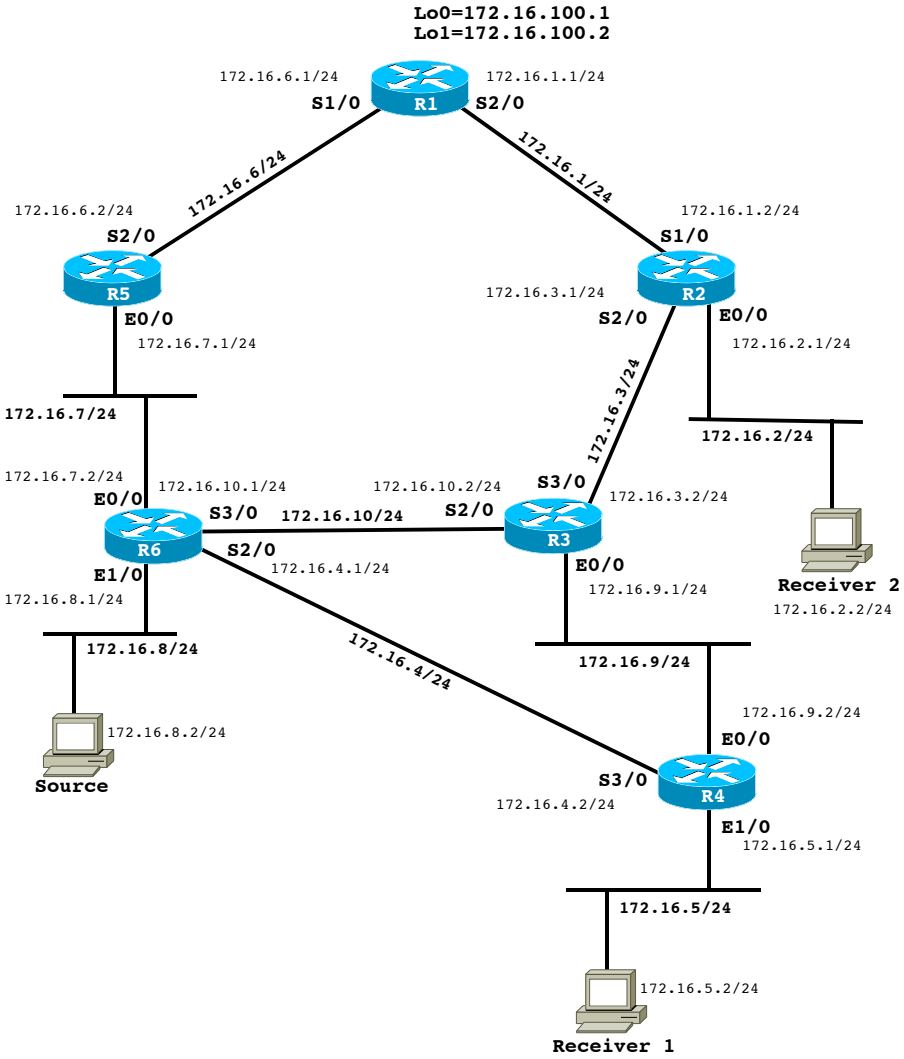
LAB #1
PIM-SM Mechanics - SSM / ASM / BiDir



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Inter Domain Multicast

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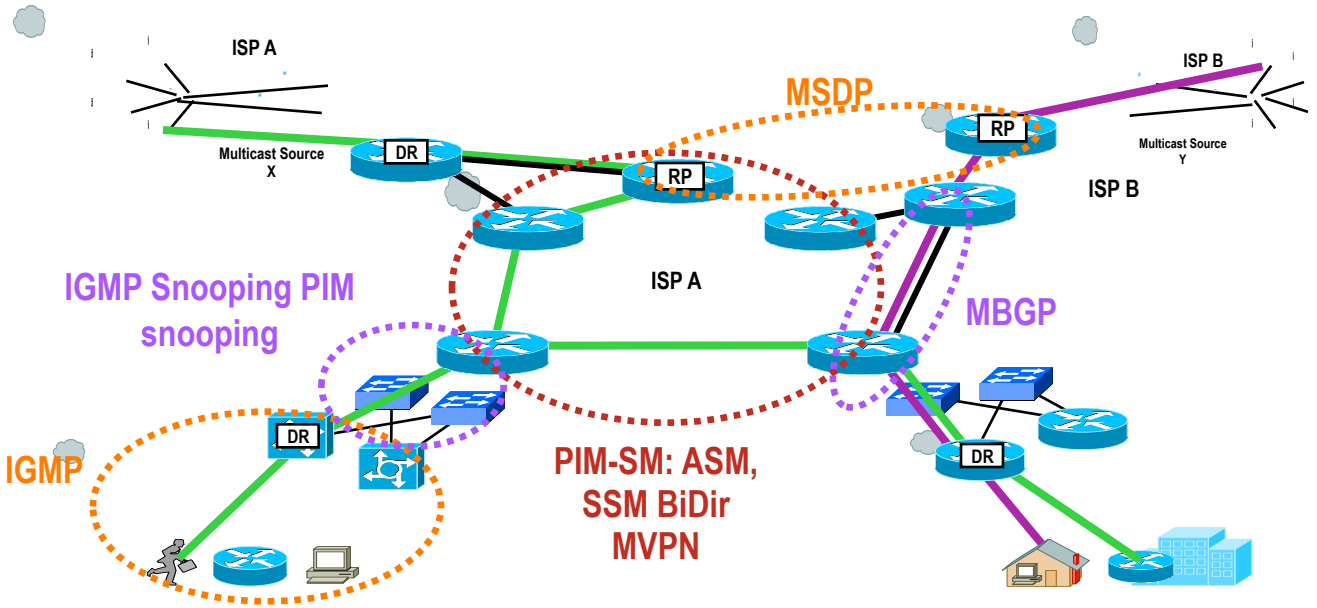
Multicast Components

Cisco End-to-End Architecture



- End Stations (hosts-to-routers): IGMP
- Multicast routing across domains MBGP

Campus Multicast

Switches (Layer 2 Optimization):
IGMP Snooping PIM snooping

Routers (Multicast Forwarding Protocol):
PIM Sparse Mode or Bidirectional PIM

Interdomain Multicast

Multicast Source Discovery
MSDP with ASM

Source Specific Multicast
SSM

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MSDP/MBGP

- MSDP (Multicast Source Discovery Protocol)
  - Exchanging source/group information between RPs in different domains
- MBGP (Multiprotocol BGP for multicast)
  - Carrying a routing information only for multicast RPF checking.

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Agenda

- Introduction
- Multicast addressing
- Group Membership Protocol
- PIM-SM / SSM
- **MBGP**
- MSDP
- Summary

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MBGP—Multiprotocol BGP

- MBGP overview
- MBGP capability negotiation
- MBGP NLRI exchange
- Configuration guidelines

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[Review] Reverse Path Forwarding (RPF)

- RPF Calculation

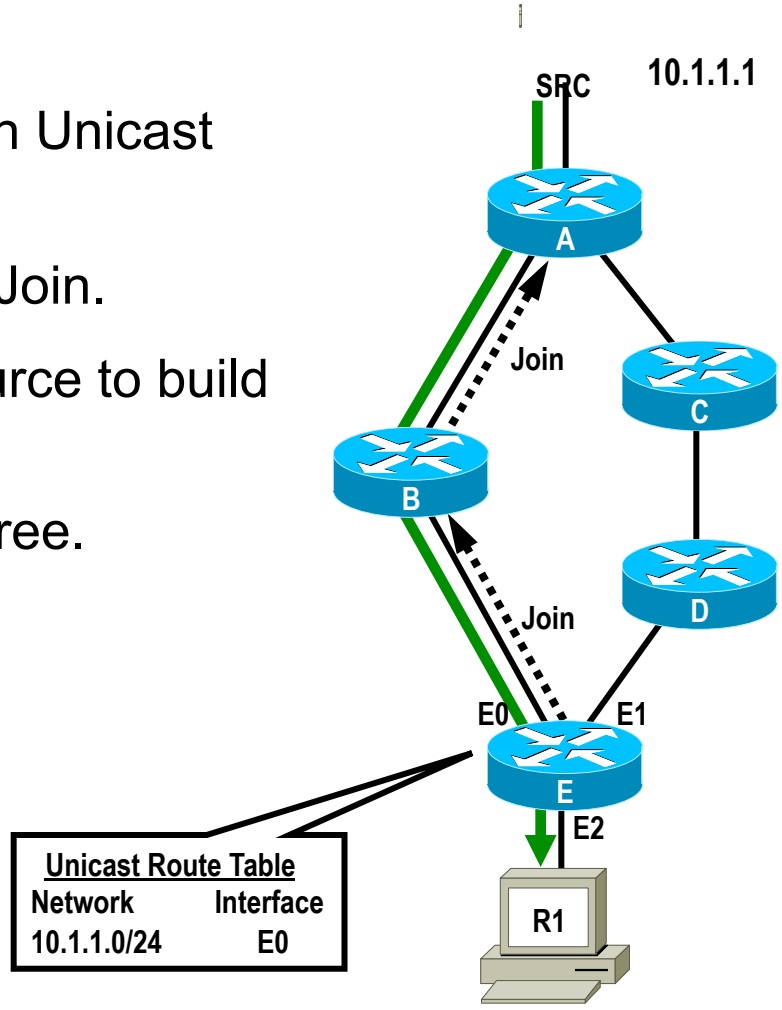
  Based on Source Address.

  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.



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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
    - That's PIMs job
  - Same path selection and validation rules
    - AS-Path, LocalPref, MED, …

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MBGP Overview

- Separate BGP tables maintained
  - Unicast prefixes for unicast forwarding
  - Unicast prefixes for multicast RPF checking
- AFI = 1, Sub-AFI = 1(address family ipv4 unicast)
  - Contains unicast prefixes for unicast forwarding
  - Populated with BGP unicast NLRI
- AFI = 1, Sub-AFI = 2(address family ipv4 multicast)
  - Contains unicast prefixes for RPF checking
  - Populated with BGP multicast NLRI

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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

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MBGP—Capability Negotiation

- BGP routers establish BGP sessions through the OPEN message
- OPEN message contains optional parameters
- BGP session is terminated if OPEN parameters are not recognised
- New parameter: CAPABILITIES
  - Multiprotocol extension
  - Multiple routes for same destination
- Configures router to negotiate either or both NLRI
  - If neighbor configures both or subset, common NRLI is used in both directions
  - If there is no match, notification is sent and peering doesn't come up
  - If neighbor doesn't include the capability parameters in open, session backs off and reopens with no capability parameters
    - Peering comes up in unicast-only mode

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MBGP—Summary

- **Solves part of inter-domain problem**
  - **Can exchange unicast prefixes for multicast RPF checks**
  - **Uses standard BGP configuration knobs**
  - **Permits separate unicast and multicast topologies if desired**
- **Still must use PIM to:**
  - **Build distribution trees**
  - **Actually forward multicast traffic**
  - **PIM-SM recommended**

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MBGP configuration

Your ASN

Configure prefixes to advertise in both SAFI-1 and SAFI-2

Your peer's ASN

Local address for the BGP peering session

```
router bgp <id>
neighbor <addresses> remote-as <asn>
neighbor <addresses>  update-source Loopback1

address-family ipv4 multicast
neighbor { <addresses> | <peer-group-name> } activate
network <address> [mask <mask>] [route-map <map>]
exit-address-family

address-family ipv4 unicast
neighbor { <addresses> | <peer-group-name> } activate
network <address> [mask <mask>] [route-map <map>]
exit-address-family
```


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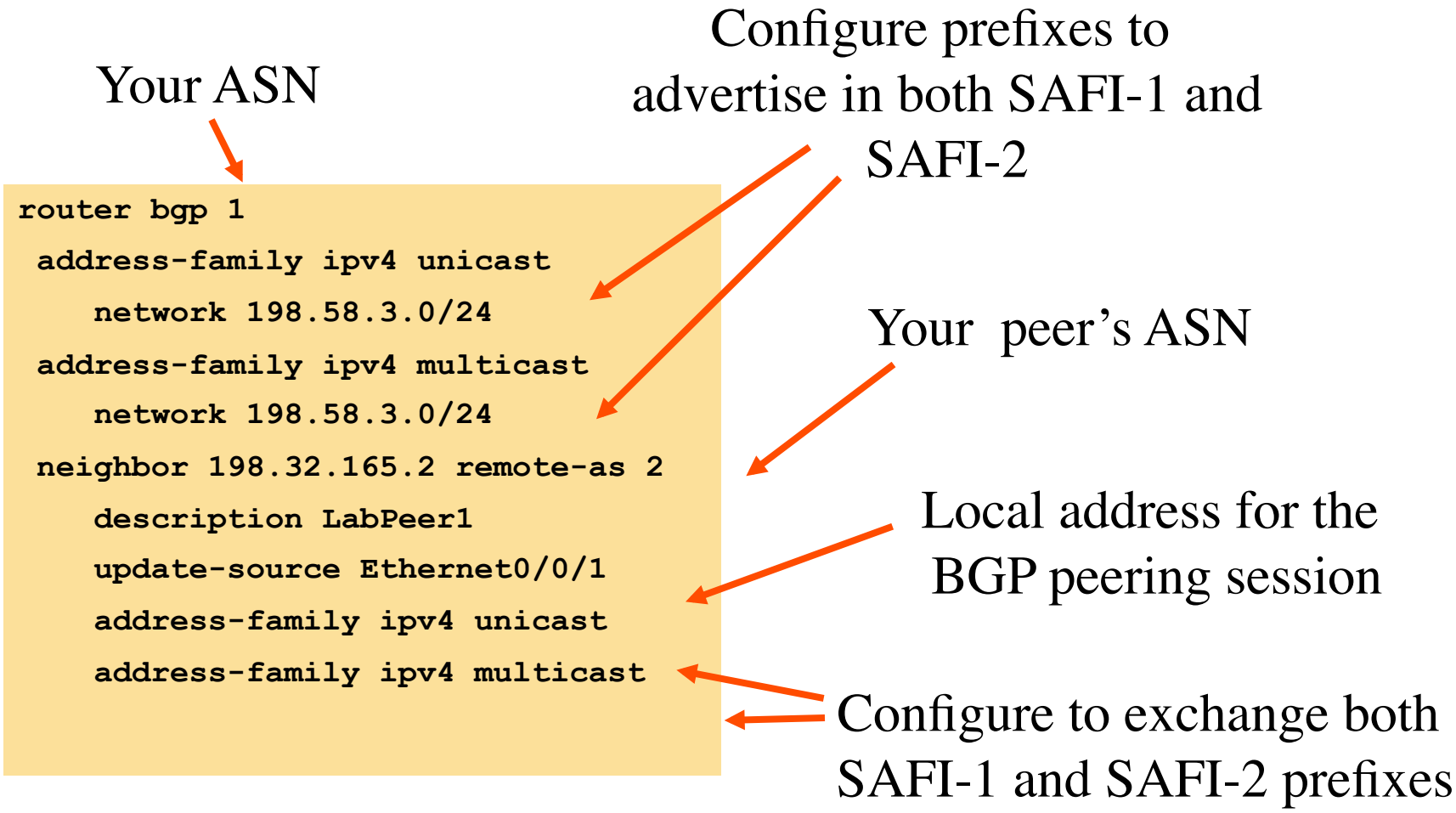
MBGP configuration



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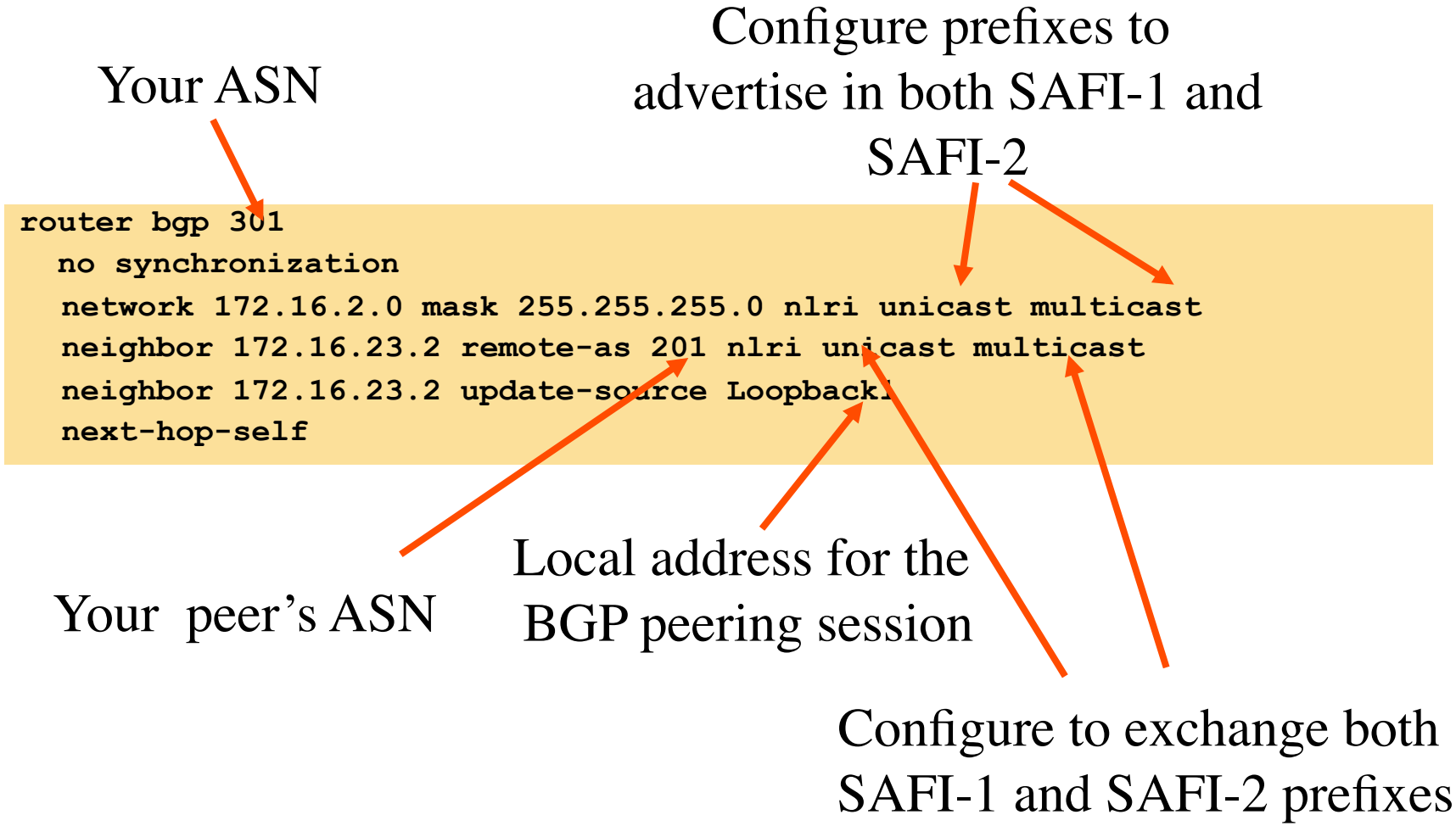
MBGP configuration (original)



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Agenda

- Introduction
- Multicast addressing
- Group Membership Protocol
- PIM-SM / SSM
- MBGP
- **MSDP**
- Summary

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MSDP Overview

- Uses inter-domain source trees only.
  - RP's know about all sources in their domain
    - Sources cause a "PIM Register" to the RP
    - Can tell RP's in other domains of its sources
      - Via MSDP SA (Source Active) messages
  - RP's know about receivers in their 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
      - Only necessary if there are receivers for the group
    - Last-hop routers then join source tree directly.

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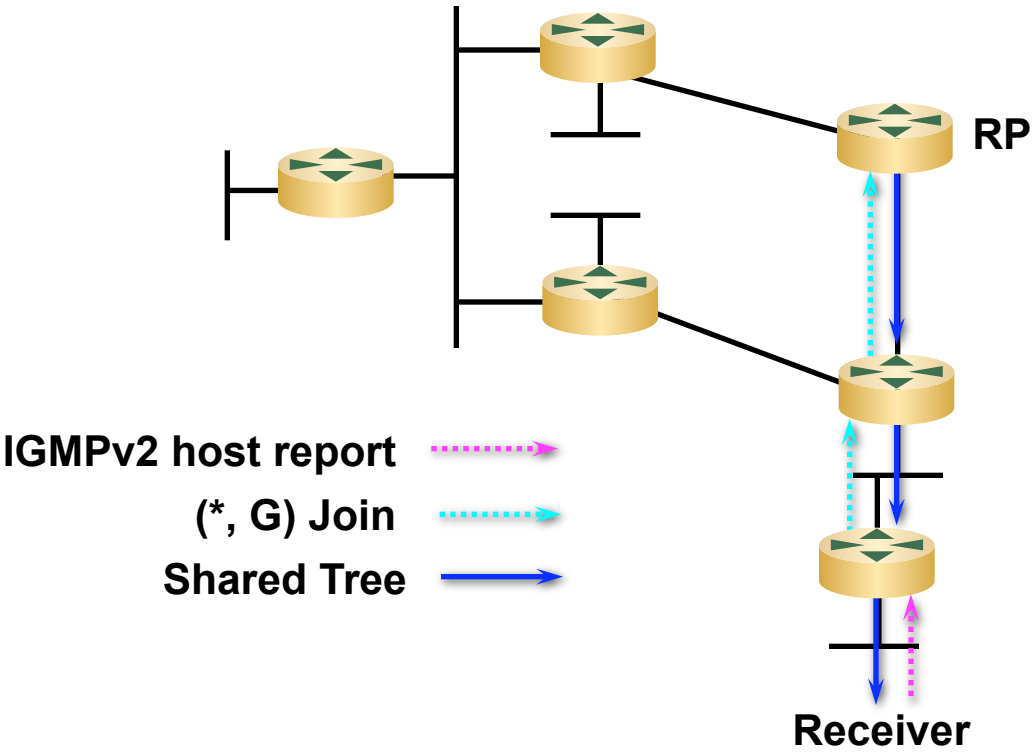
[Review]PIM-SM Shared Tree Join



Receiver announces desire to join group G with igmpv2 host report – (*,G).

(*, G) State created from the RP to the receiver.

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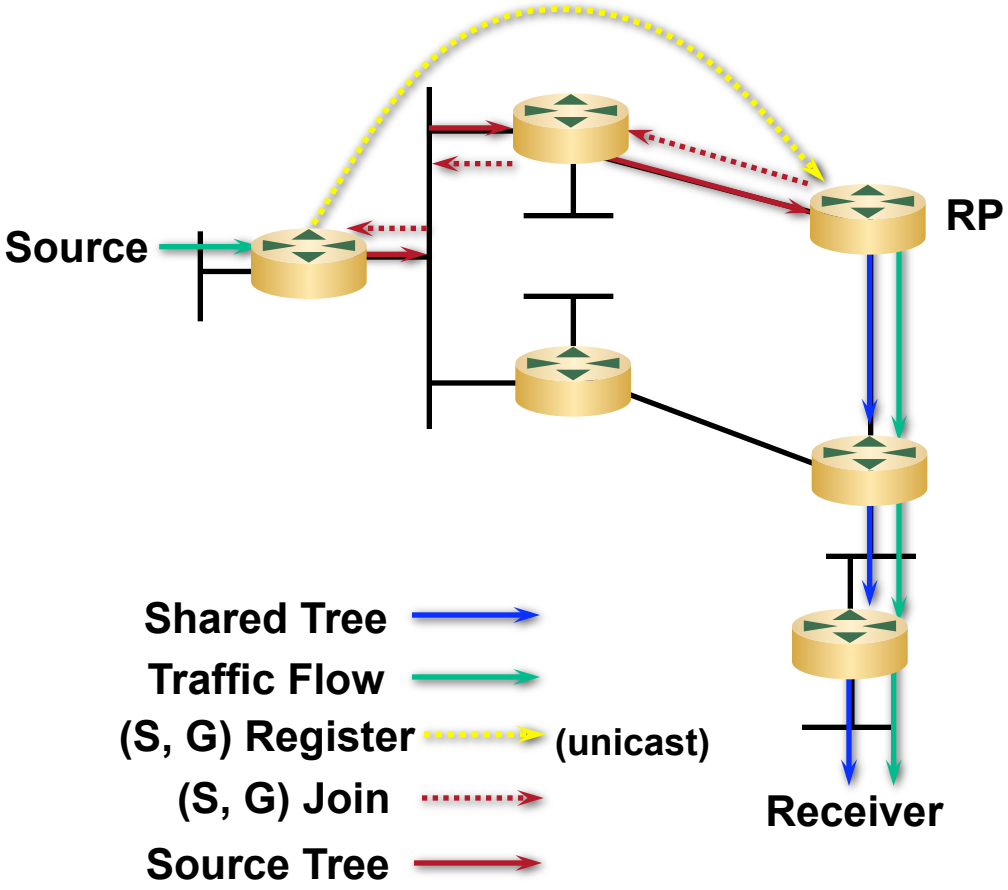
[Review]PIM-SM Sender Registration



(S, G) State created only along the Source Tree.

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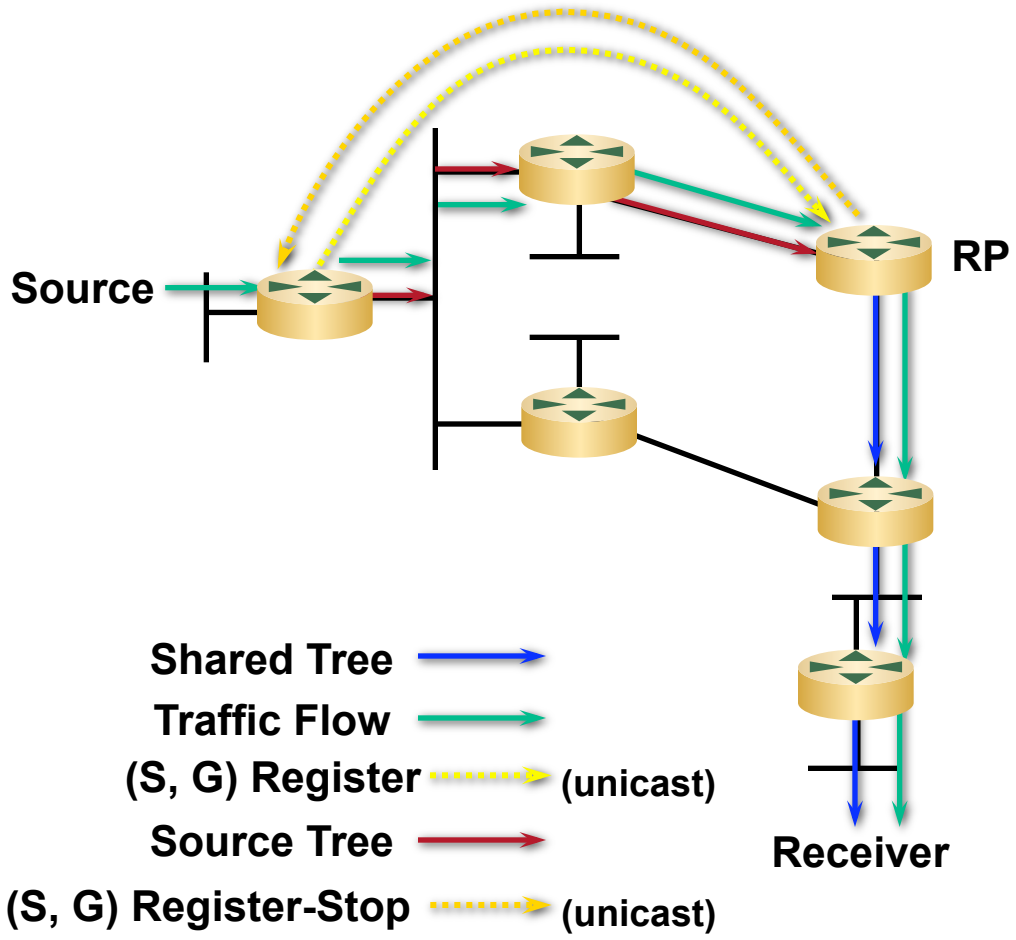
[Review]PIM-SM Sender Registration



(S, G) traffic begins arriving at the RP via the Source tree.

RP sends a Register-Stop back to the first-hop router to stop the Register process.

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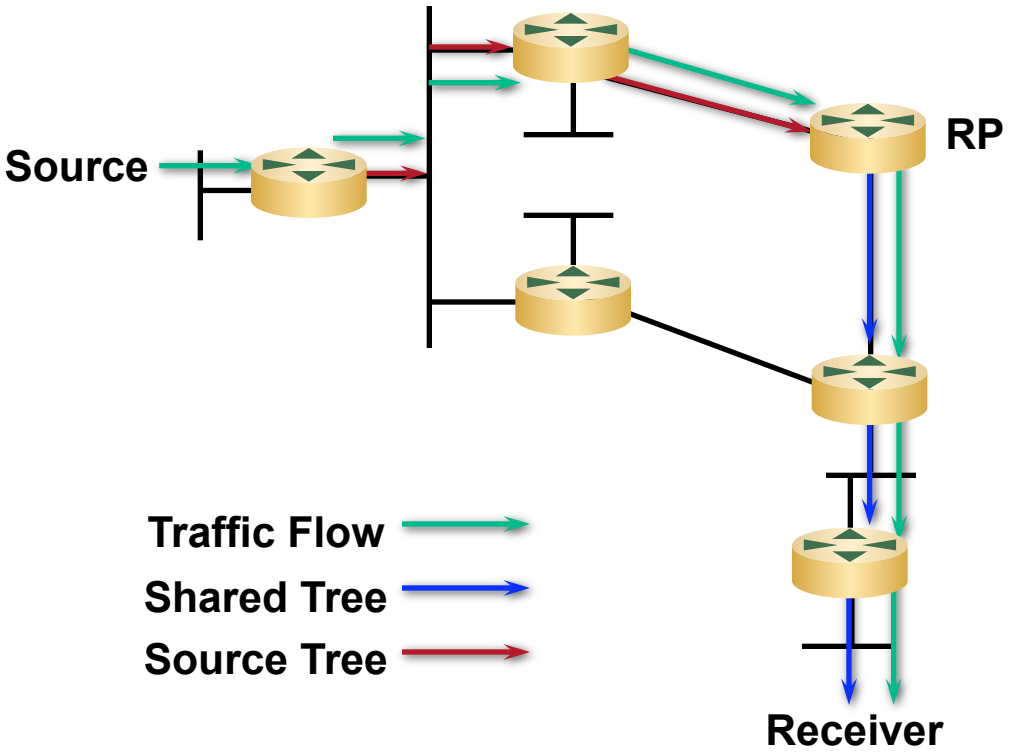
[Review]PIM-SM Sender Registration



Source traffic flows natively along SPT to RP.

From RP, traffic flows down the Shared Tree to Receivers.

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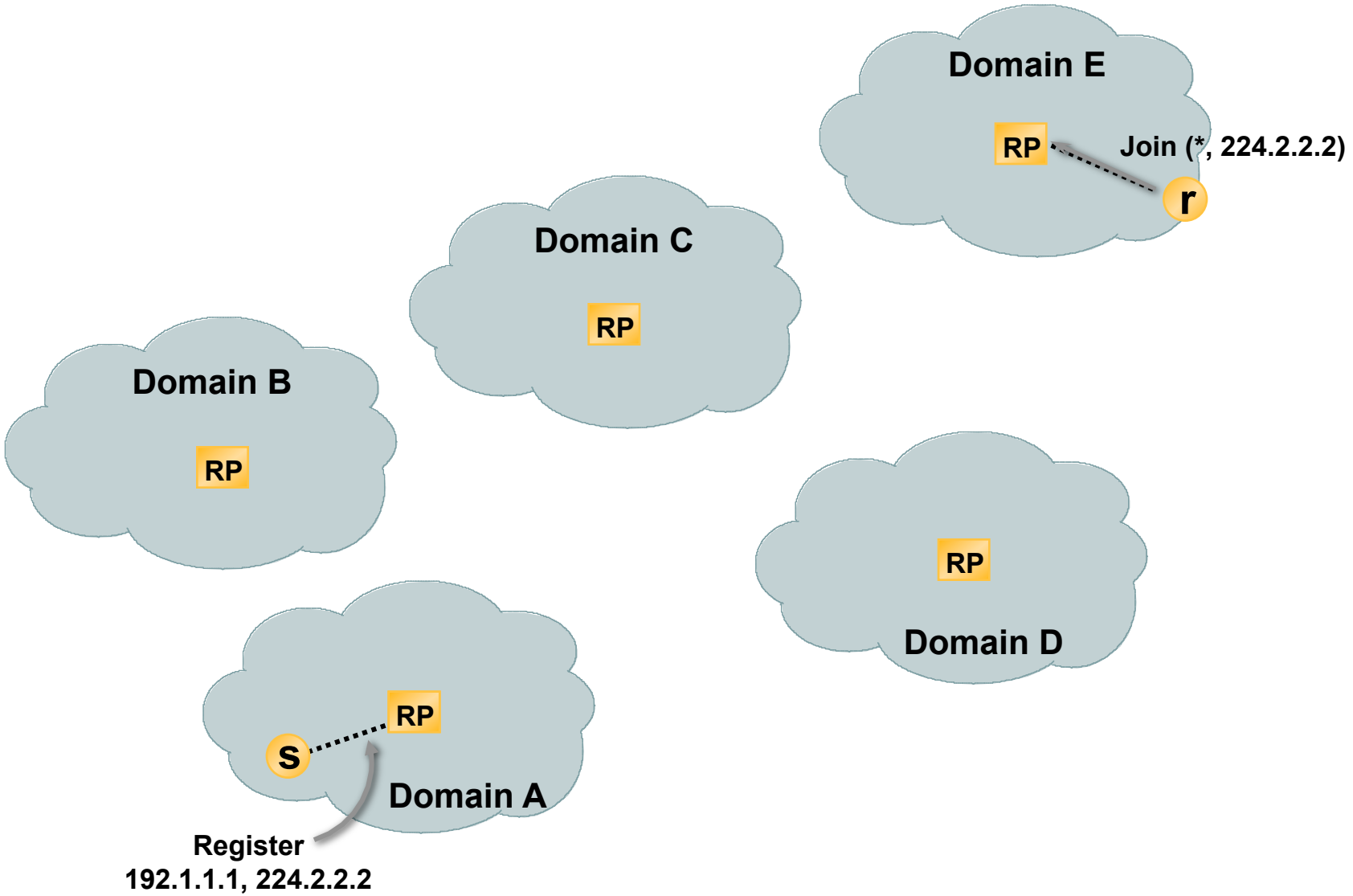
MSDP Overview



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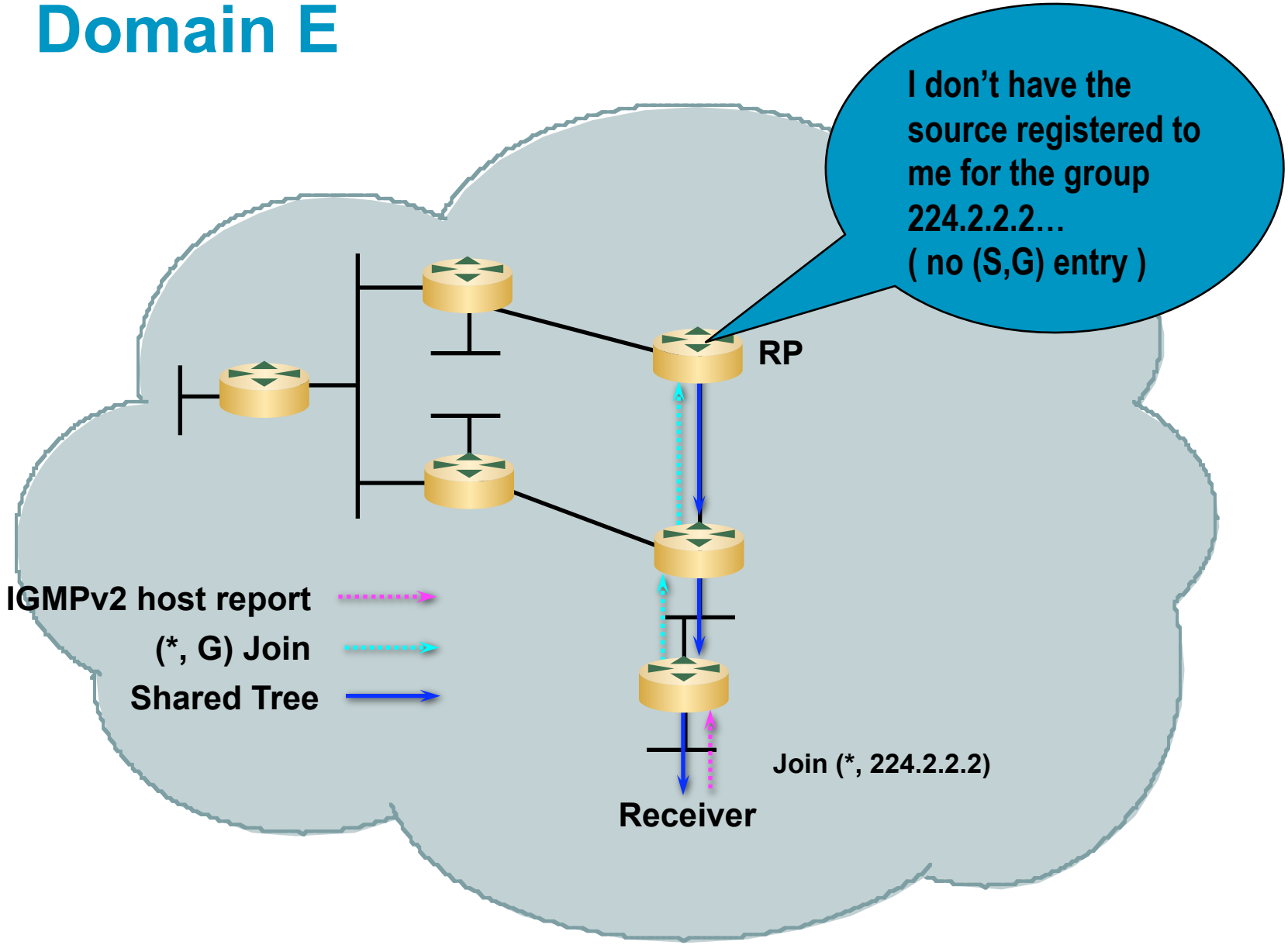
Domain E



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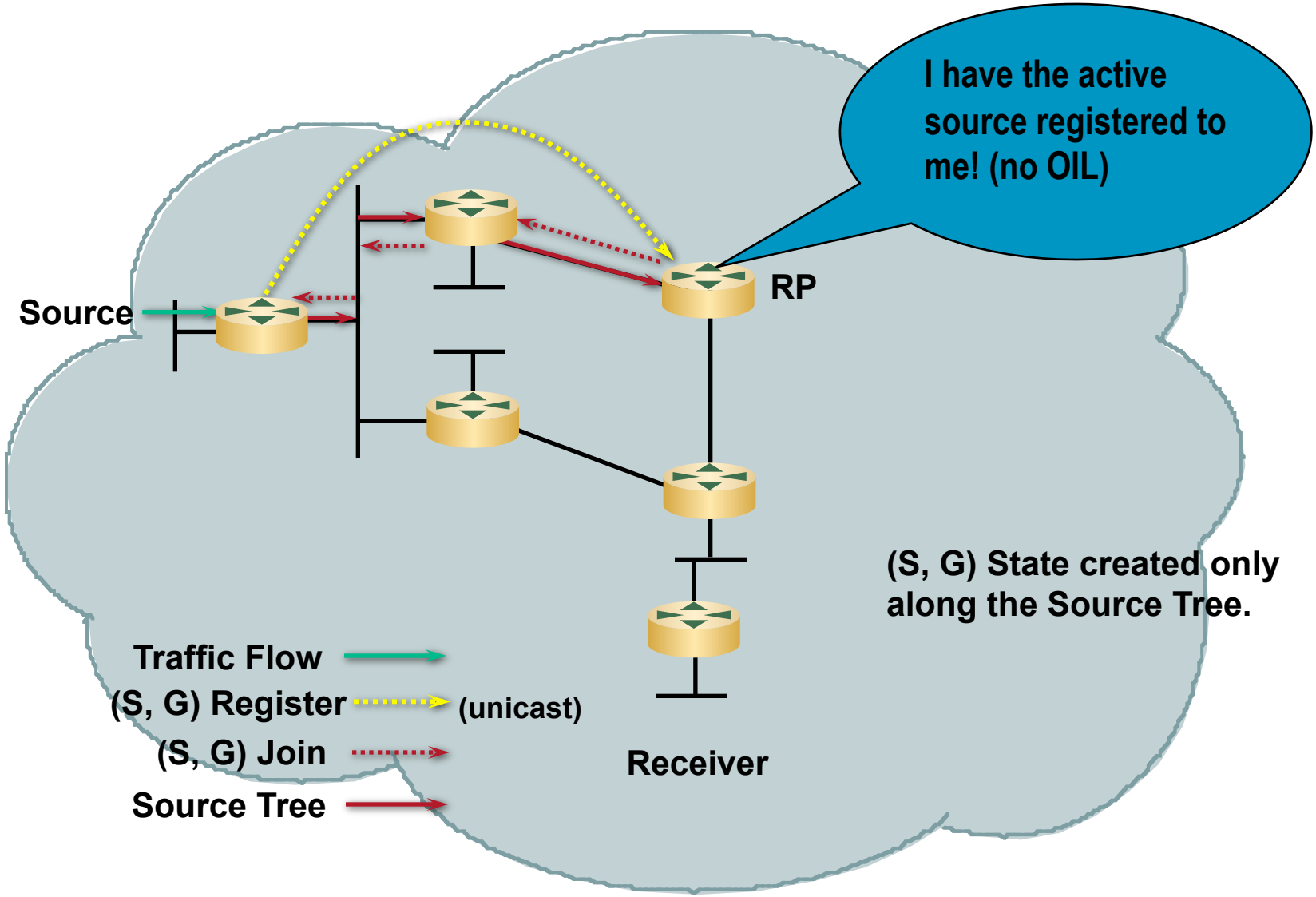
Domain A



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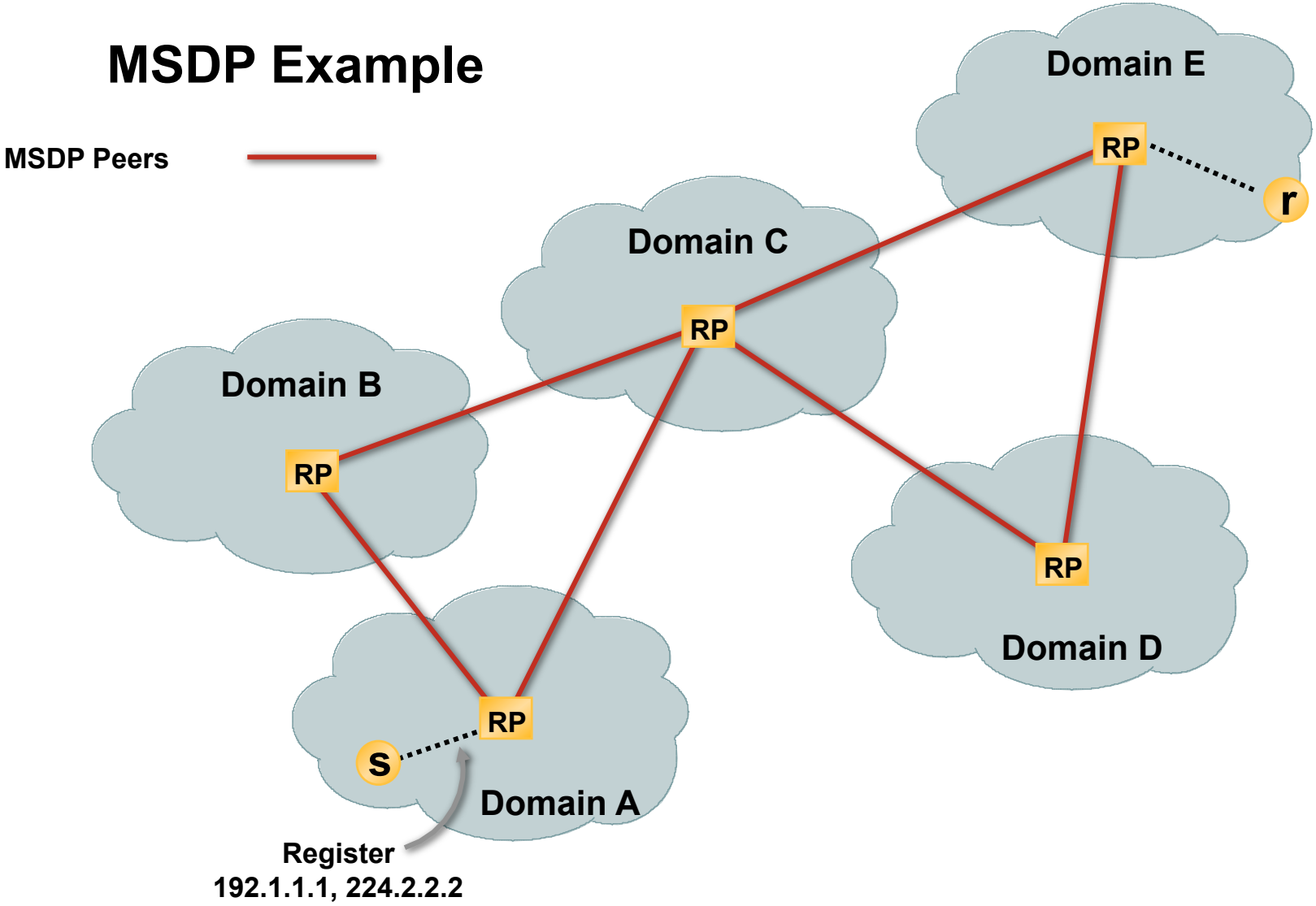
MSDP Overview



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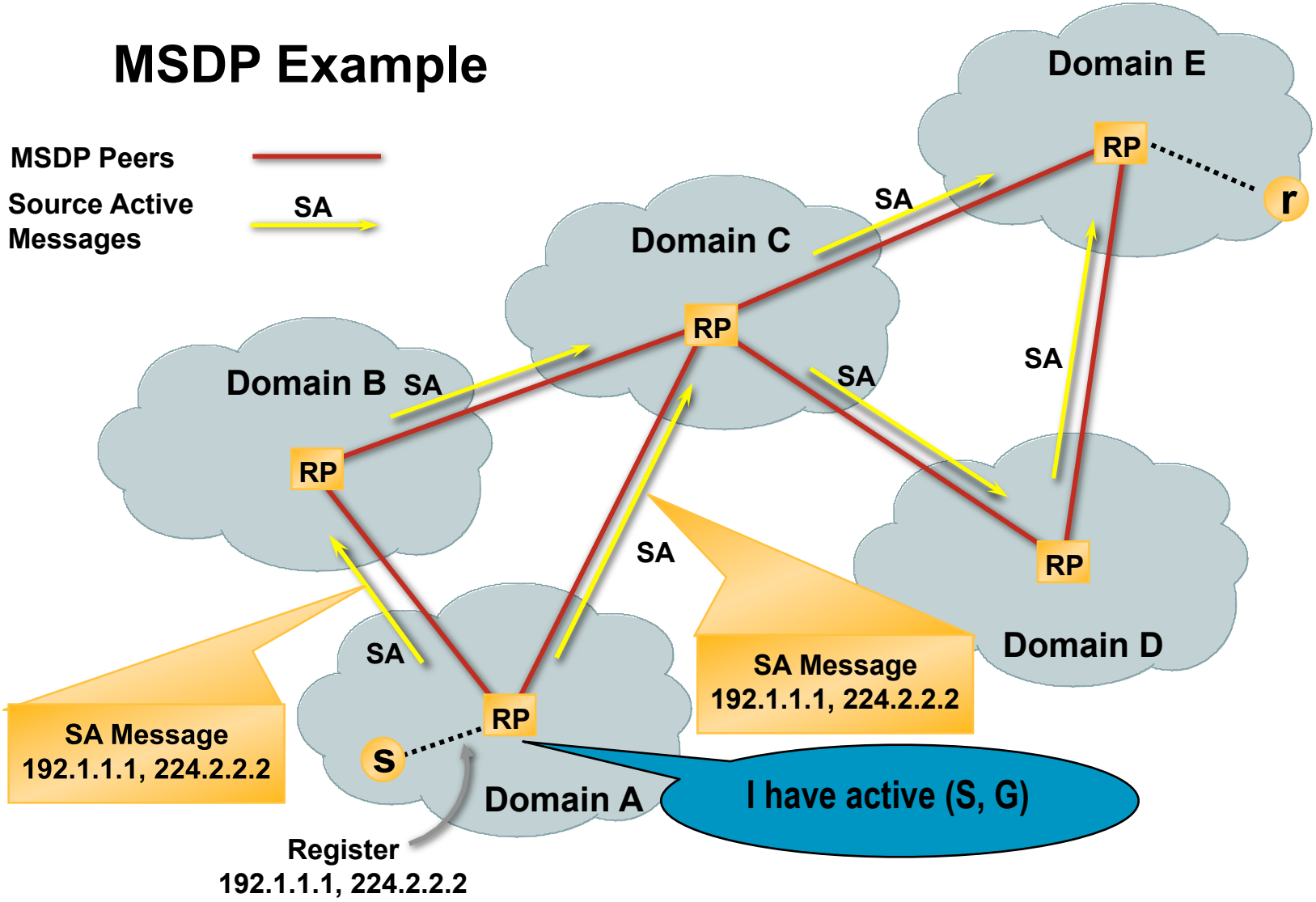
MSDP Overview



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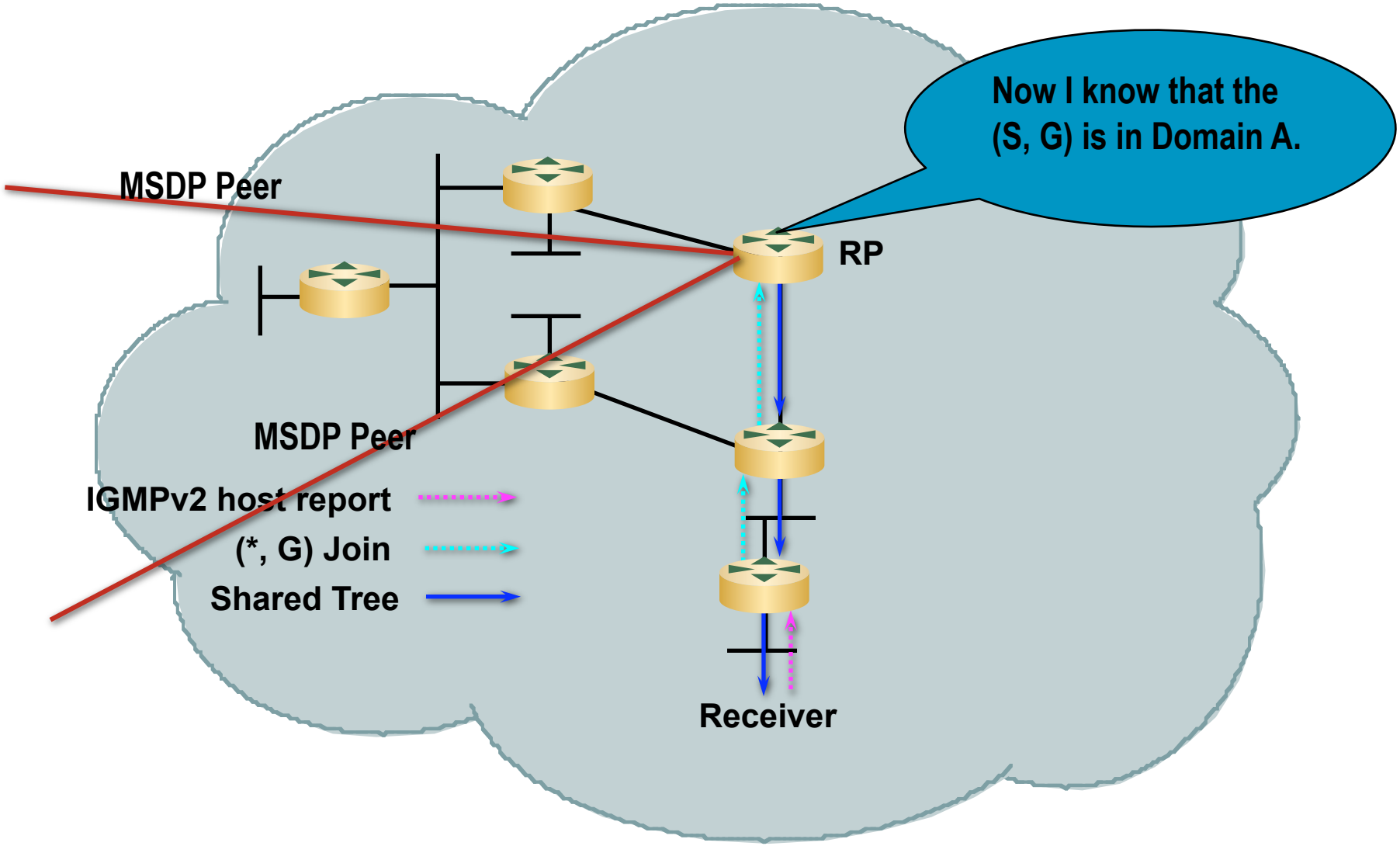
Domain E



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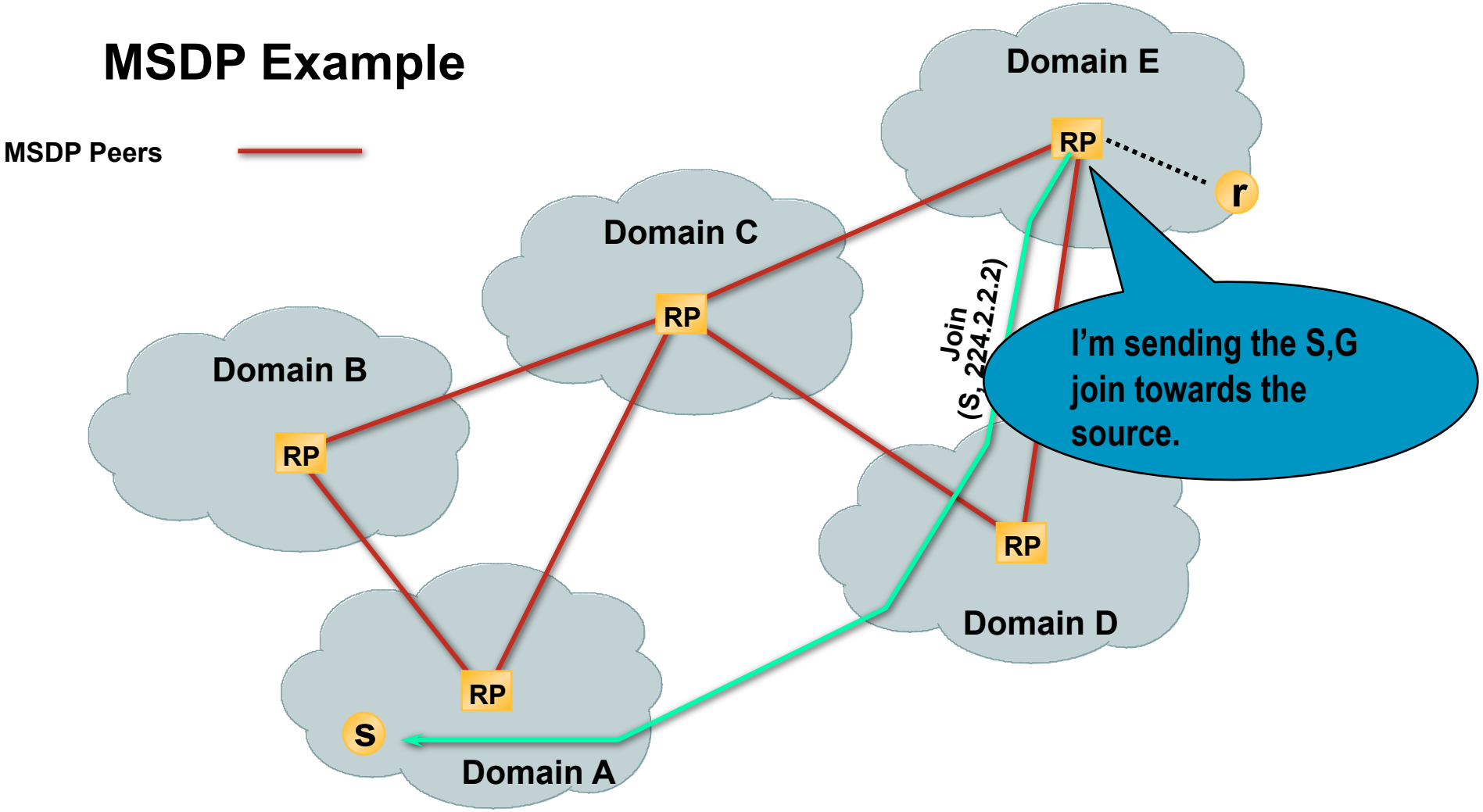
MSDP Overview



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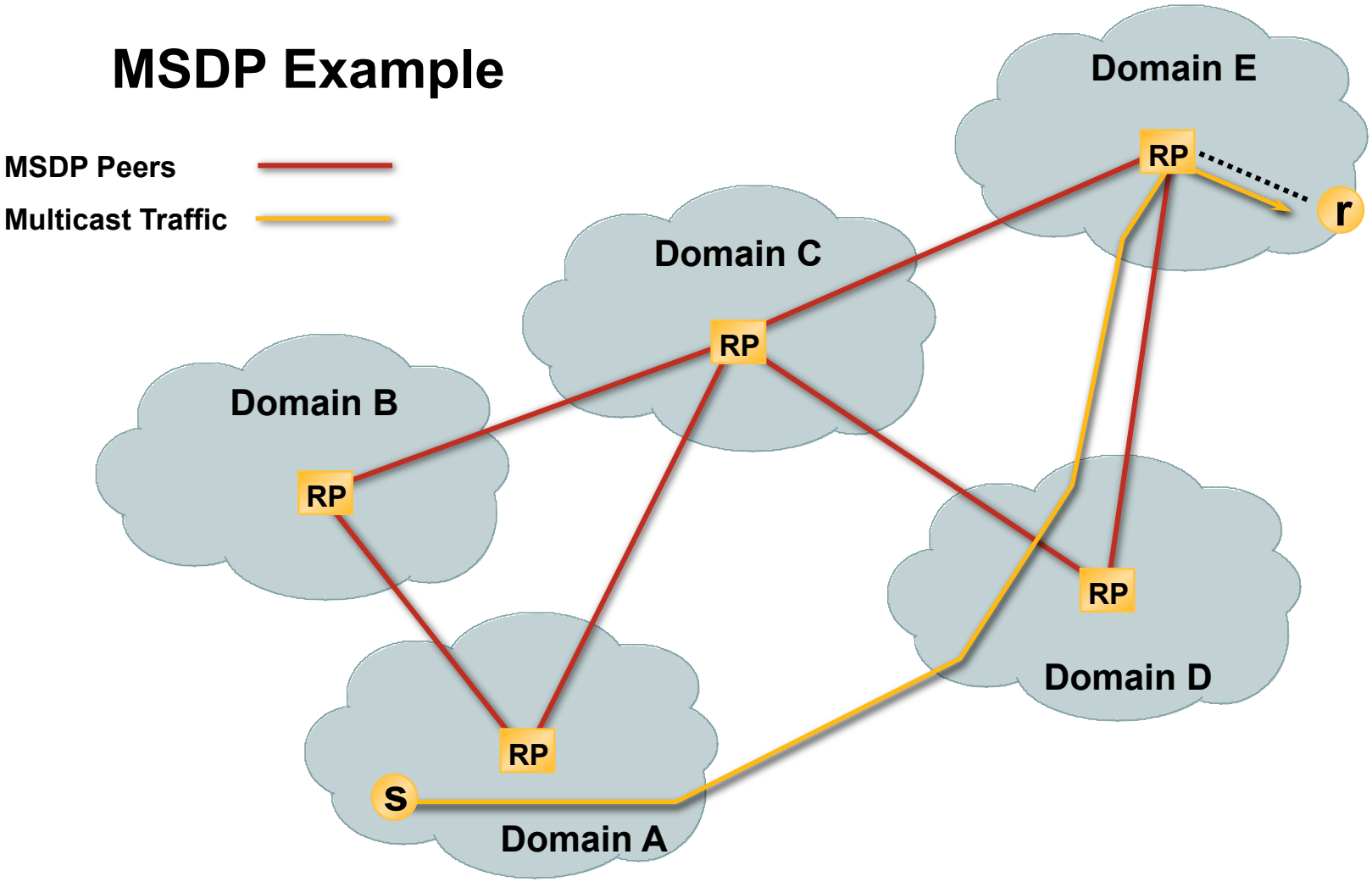
MSDP Overview



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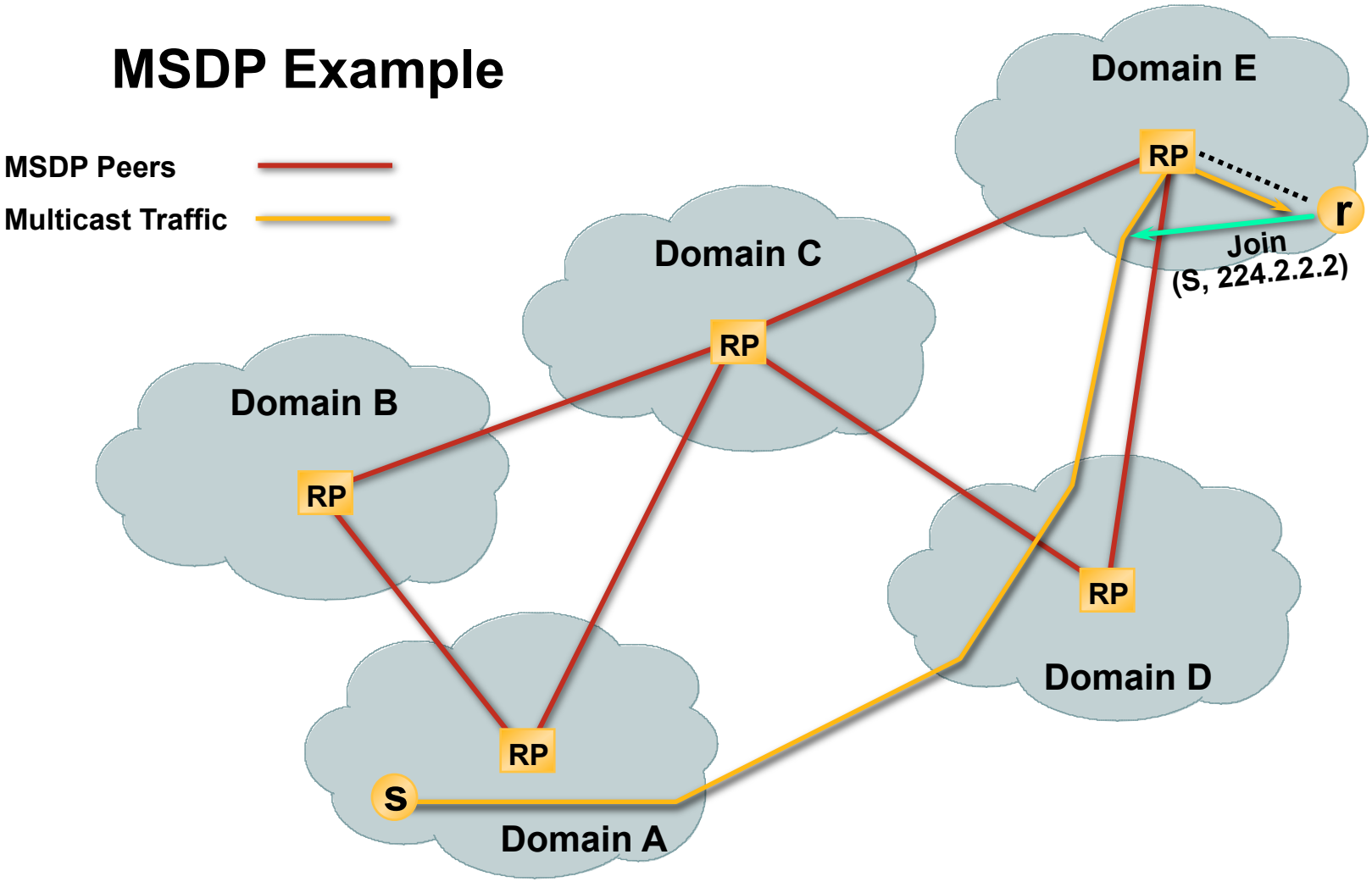
MSDP Overview



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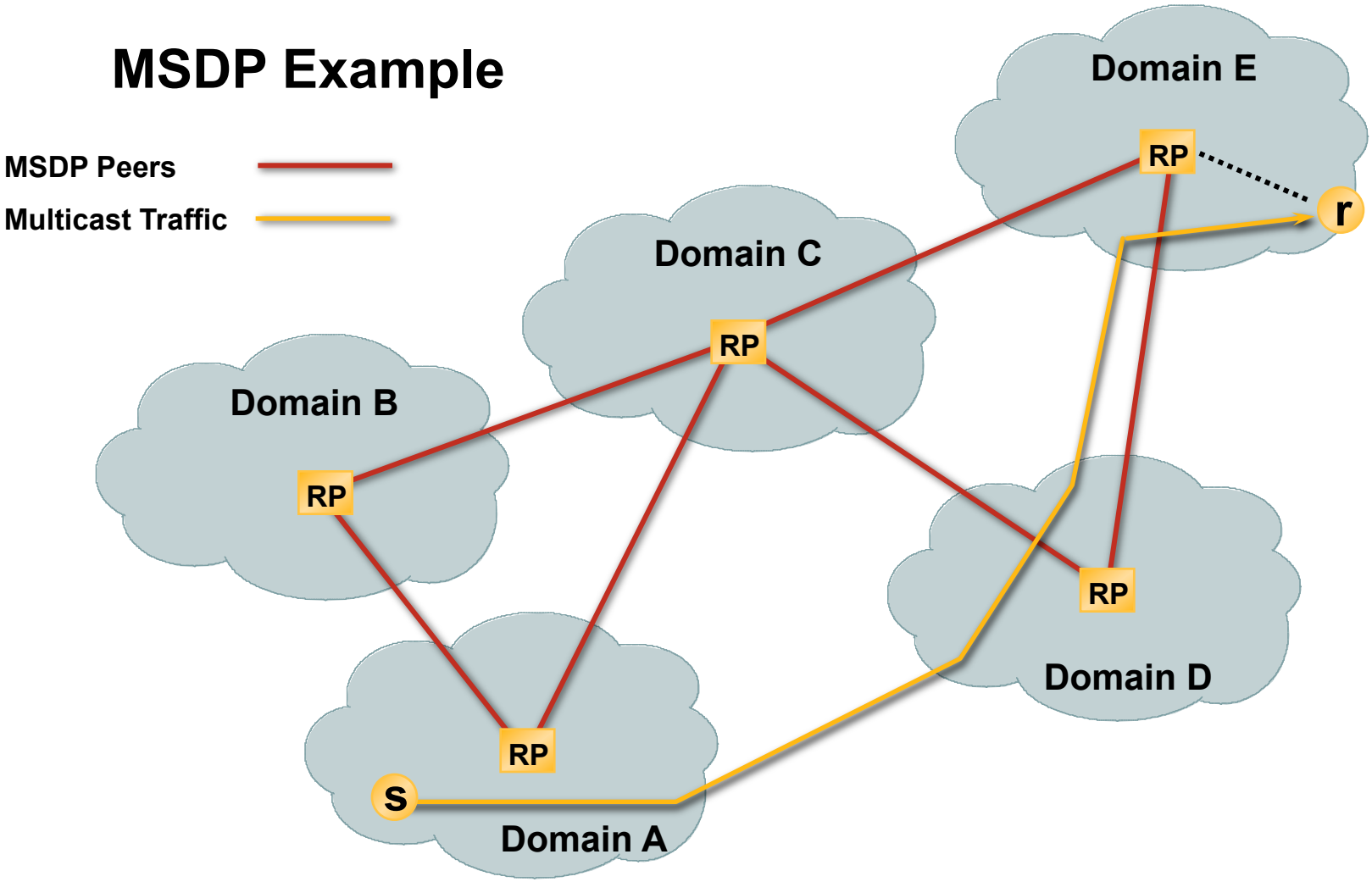
MSDP Overview



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MSDP Peers

- MSDP Peers configured similar to BGP
- MSDP peering with other RPs, either directly or via an intermediate MSDP peer
- Peers connect using TCP port 639
  - Lower address peer initiates connection
  - Higher address peer waits in LISTEN state
- Peers send keepalives every 60 secs.
- Connection reset after 75 seconds
  - If no MSDP packets or keepalives are received

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MSDP Peers

- **MSDP peers normally *must* run BGP!**
  - **BGP NLRI is used to RPF check SA messages.**
    - **May use NLRI from M-Table, U-Table or both.**
  - **RPF check prevents SA's from looping.**
    - **(More on that later.)**
- **Exceptions:**
  - **When peering with only a single MSDP peer.**
  - **When using an MSDP Mesh-Group.**

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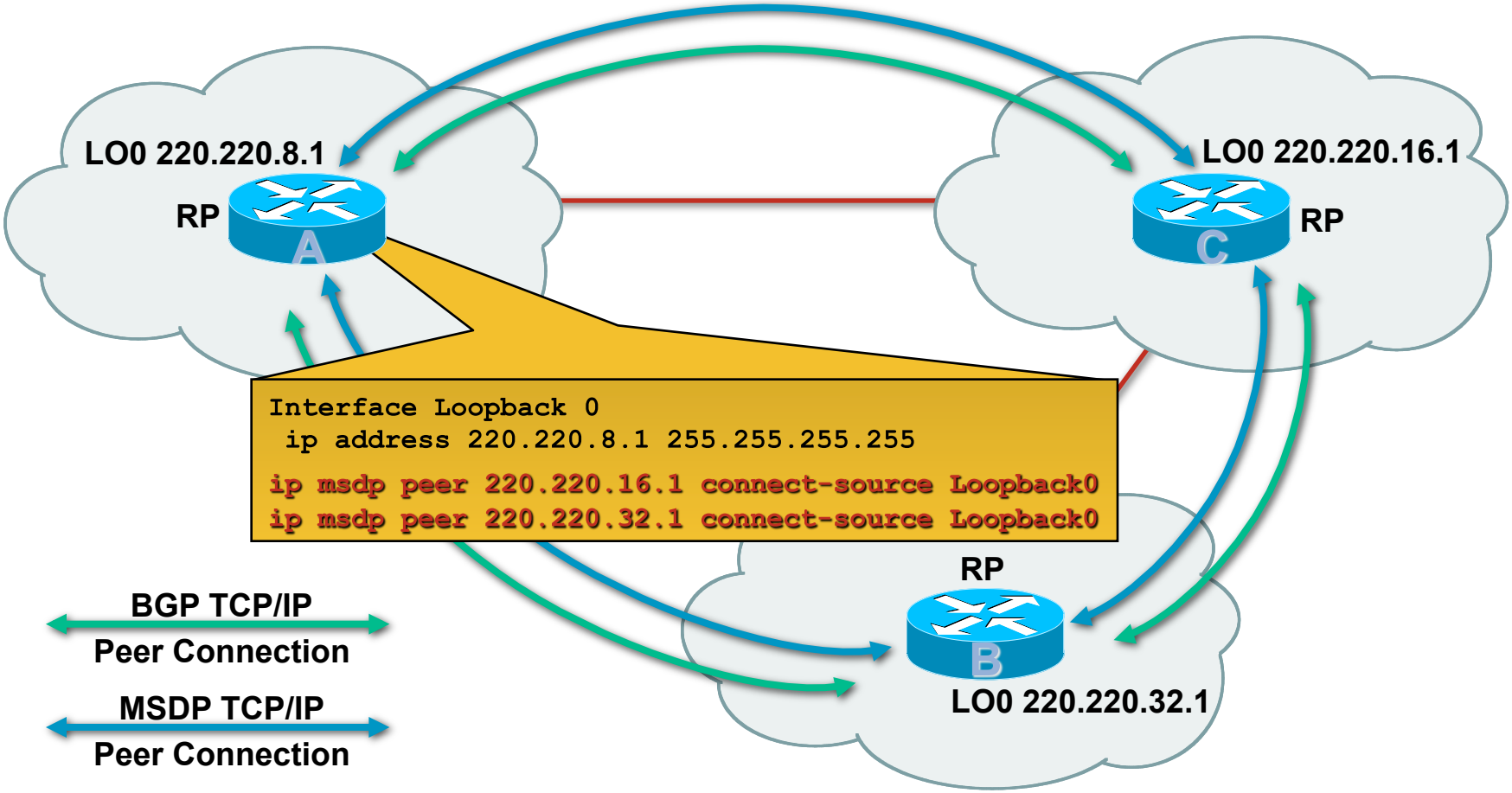
MSDP Peers



- **MSDP peer connections are established using the MSDP "peer" configuration command**

```
ip msdp peer <ip-address> [connect-source <intfc>]
```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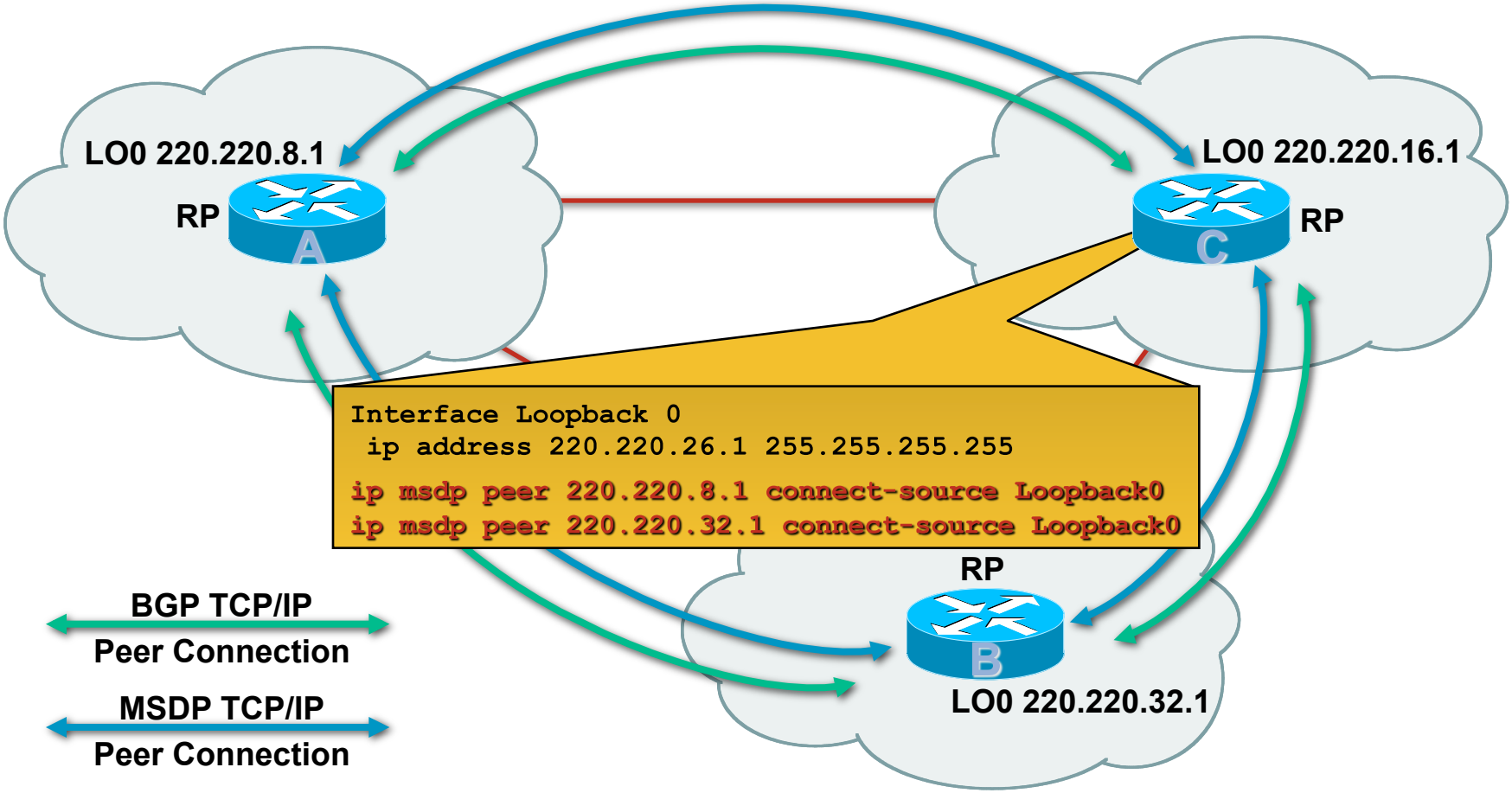
MSDP Peers



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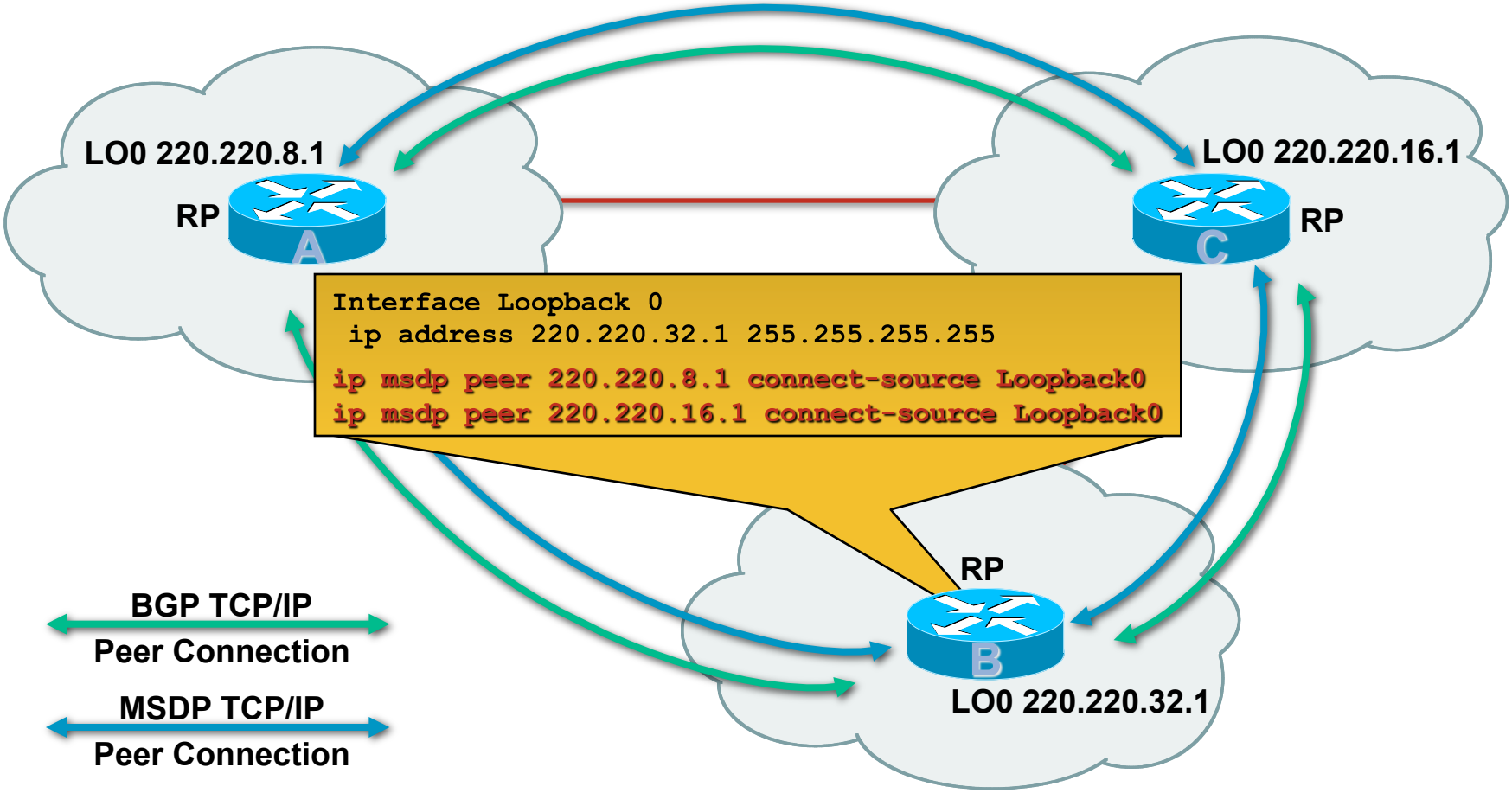
MSDP Peers



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```


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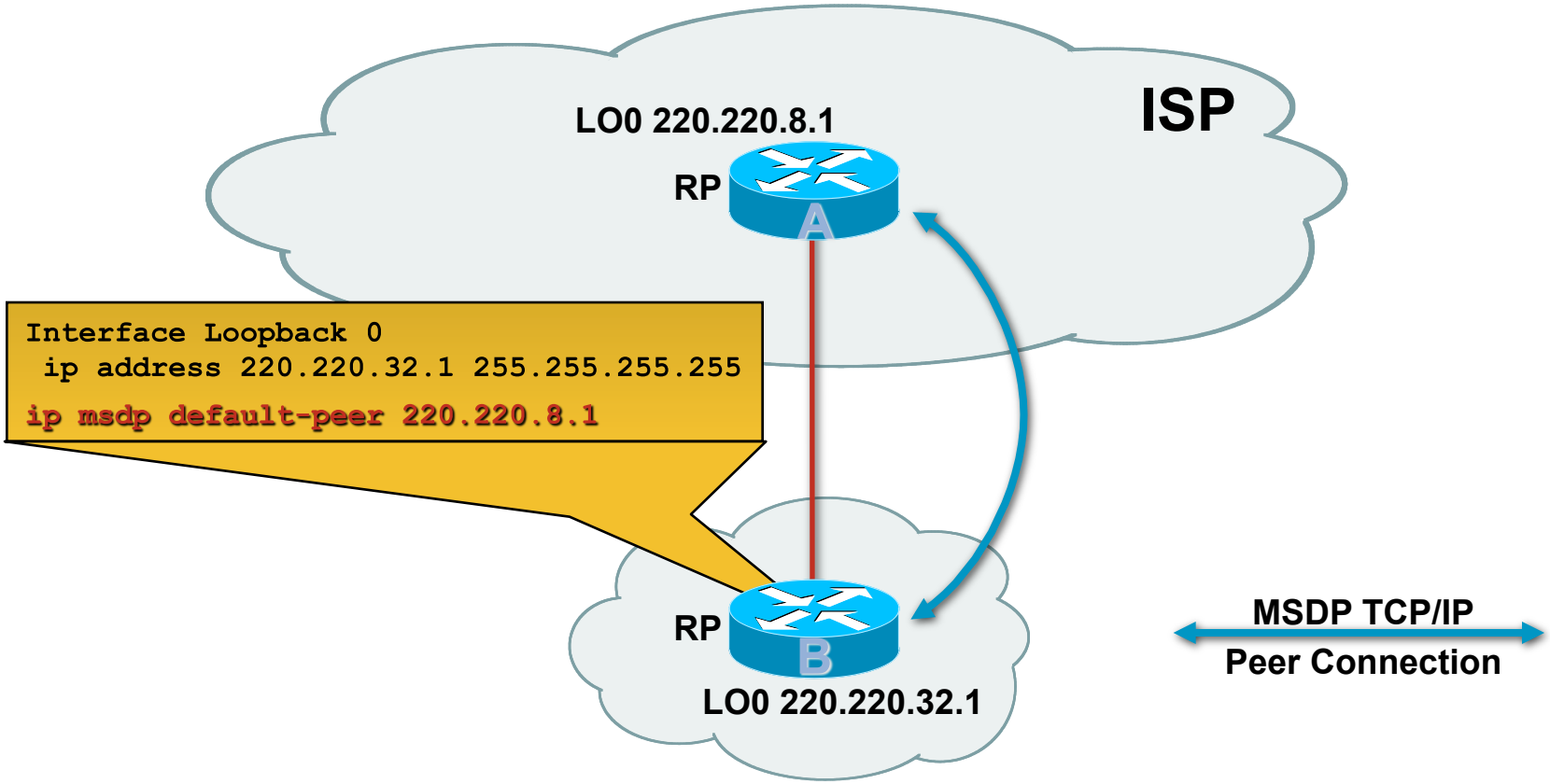
MSDP Peers



- **Stub-networks may use "default" peering without being a BGP peer by using the MSDP "default-peer" configuration command.**

```
ip msdp default-peer <ip-address>
```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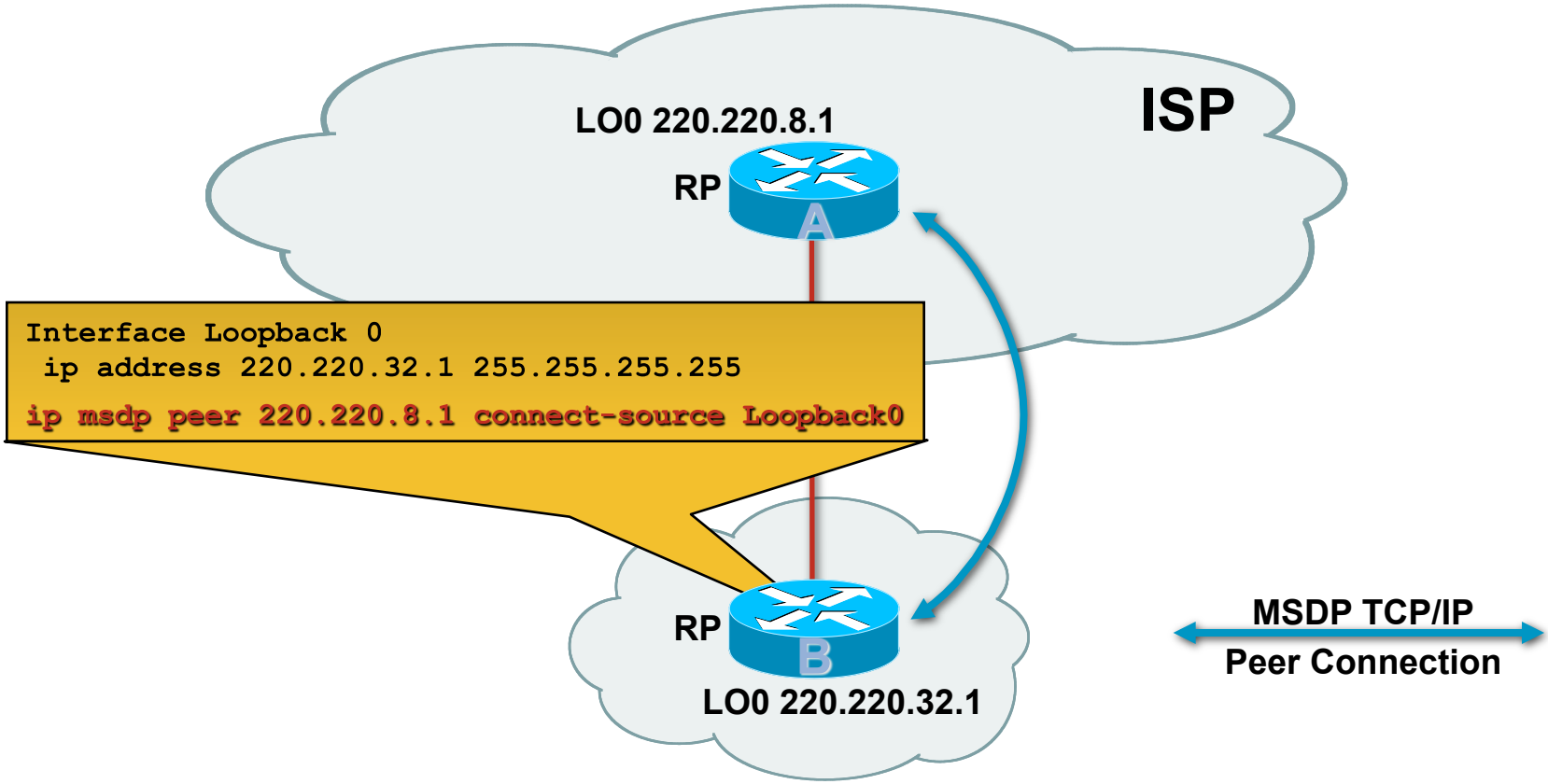
MSDP Peers



- Stub-networks configured with only a single MSDP peer are treated in the same manner as when a single "default-peer" is configured. (i.e. BGP is not required.)

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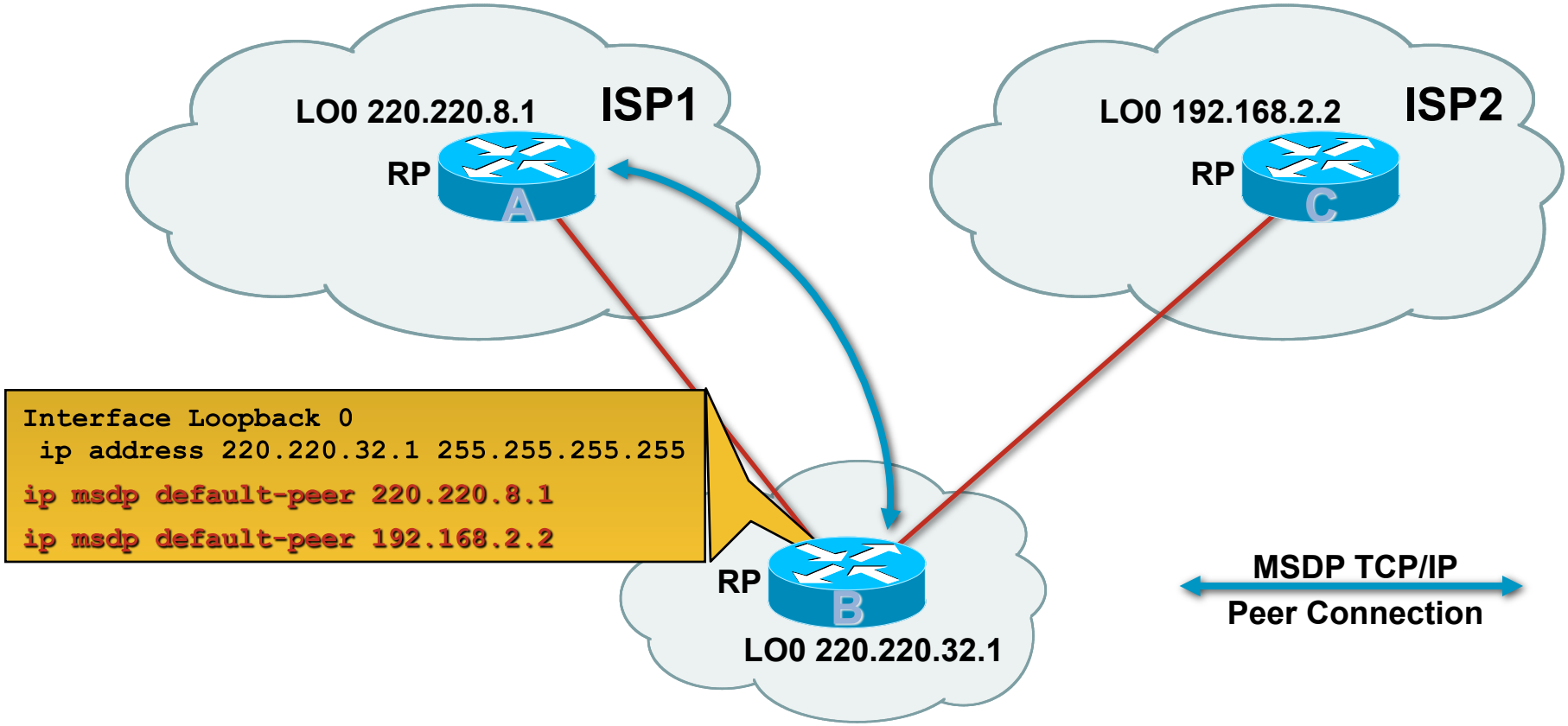
MSDP Peers



- Multiple “default-peers” may be configured in case connection to first default-peer goes down.

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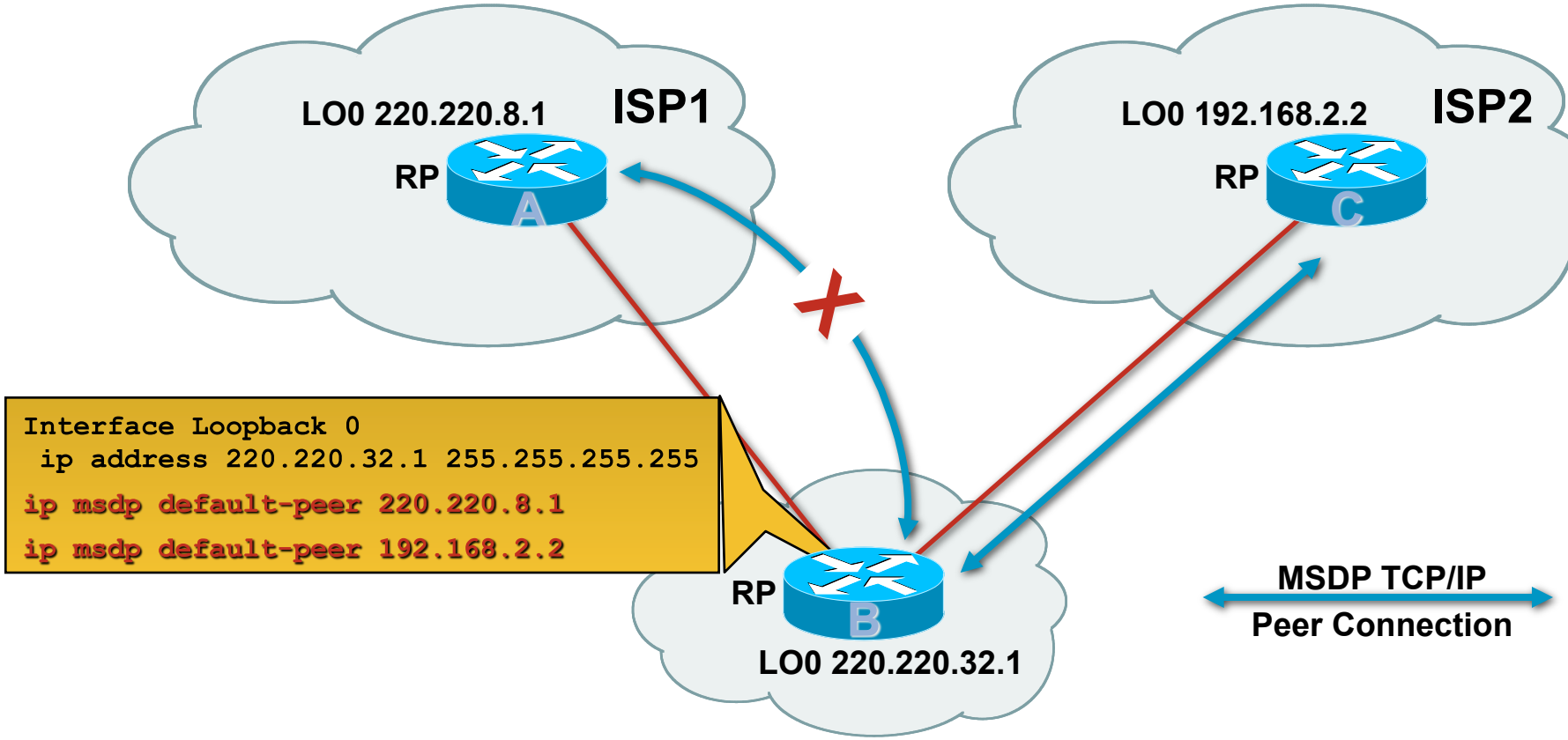
MSDP Peers



- When connection to first ‘default-peer’ is lost, the next one in the list is tried.

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SA Message Contents

- **MSDP Source Active (SA) Messages**
  - Used to advertise active Sources in a domain
  - Can also carry 1st multicast packet from source
    - Hack for Bursty Sources (a'la SDR)
  - SA Message Contents:
    - IP Address of Originating RP
    - Number of (S, G)'s pairs being advertised
    - List of active (S, G)'s in the domain
    - Encapsulated Multicast packet [optional]

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Originating SA Messages

- **Local Sources**

  RP's only originate SA's for local sources

    Denoted by the "A" flag on an (S,G) entry on RP

  A source is local if:

    The RP received a "Register" for (S, G), or

    The source is directly connected to RP

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Originating SA Messages

- **Use ‘msdp redistribute’ to control what SA’s are originated.**
  - **Think of this as ‘msdp sa-originate-filter’ function**

```
ip msdp redistribute [list <acl>]
                     [asn <aspath-acl>]
                     [route-map <map>]
```

    - **Filter by (S,G) pair using ‘list <acl>’**
    - **Filter by AS-PATH using ‘asn <aspath-acl>’**
    - **Filter based on route-map ‘<map>’**
  - **Omitting all acl’s stops all SA origination**

```
Example: ip msdp redistribute
```

  - **Default: Originate SA’s for all local sources**
    - **If ‘msdp redistribute’ command is not configured**

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Originating SA Messages

- **SA messages are triggered when any new source in the local domain goes active.**
  - **Initial multicast packet is encapsulated in an SA message.**
    - **This is an attempt at solving the bursty-source problem**

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Originating SA Messages

- **Encapsulating Initial Multicast Packets**
  - **Can bypass TTL-Thresholds**
    - **Original TTL is inside of data portion of SA message**
    - **SA messages sent via Unicast with TTL = 255**
- **Requires special command to control**

```
ip msdp ttl-threshold <peer-address> <ttl>
```

Encapsulated multicast packets with a TTL lower than <ttl> for the specific MSDP peer are not forwarded or originated.

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Originating SA Messages

- **Once a minute**

  Router scans mroute table

  If group = sparse AND router = RP for group

  For each (S,G) entry for the group:

  If the ‘`msdp redistribute`’ filters permits

  AND if the source is a local source

  Then originate an SA message for (S,G)

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Receiving SA Messages

If SA message RPF checks OK

- Store in SA Cache
- If new SA cache entry
  - Immediately flood SA downstream
  - Set entry's SA-expire-timer to 6 minutes.
  - If RP for group and receivers exist
    - Create (S,G) entry and trigger (S,G) Join
- If existing entry
  - Reset entry's SA-expire-timer to 6 minutes.
    - When timer = zero, entry has expired and is deleted.

Else

- Discard SA

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SA Message Cache

- **Enabling SA Caching**

```
ip msdp cache-sa-state [list <acl>]
```

Caching is now on by default.

Beginning with IOS versions 12.1(7), 12.0(14)S1.

Cannot be turned off.

Router caches all SA messages.

Cached (S, G) entries timeout after 6 minutes.

If not refreshed by another (S,G) SA message.

Once per minute, router scans SA cache.

Sends SA downstream for each entry in cache.

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SA Message Caching

- **Listing the contents of the SA Cache**

```
show ip msdp sa-cache [<group-or-source>] [<asn>]
```

```
sj-mbone# show ip msdp sa-cache
MSDP Source-Active Cache - 1997 entries
(193.92.8.77, 224.2.232.0), RP 194.177.210.41, MBGP/AS 5408, 00:01:51/00:04:09
(128.119.167.221, 224.77.0.0), RP 128.119.3.241, MBGP/AS 1249, 06:40:59/00:05:12
(147.228.44.30, 233.0.0.1), RP 195.178.64.113, MBGP/AS 2852, 00:04:48/00:01:11
(128.117.16.142, 233.0.0.1), RP 204.147.128.141, MBGP/AS 145, 00:00:41/00:05:18
(132.250.95.60, 224.253.0.1), RP 138.18.100.1, MBGP/AS 668, 01:15:07/00:05:55
(128.119.40.229, 224.2.0.1), RP 128.119.3.241, MBGP/AS 1249, 06:40:59/00:05:12
(130.225.245.71, 227.37.32.1), RP 130.225.245.71, MBGP/AS 1835, 1d00h/00:05:29
(194.177.210.41, 227.37.32.1), RP 194.177.210.41, MBGP/AS 5408, 00:02:53/00:03:07
(206.190.42.106, 236.195.60.2), RP 206.190.40.61, MBGP/AS 5779, 00:07:27/00:04:04
                                .
                                .
                                .
```

- **Clearing the contents of the SA Cache**

```
clear ip msdp sa-cache [<group-address> | group-name]
```


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Filtering Incoming/Outgoing SA Messages

- **SA Filter Command:**

```
ip msdp sa-filter {in|out} <peer-address> [list <acl>]
                                          [route-map <map>]
```

  Filters (S,G) pairs to / from peer based on specified ACL.

  Can filter based on AS-Path by using optional route-map clause with a path-list acl.

  You can filter flooded and originated SA's based on a specific peer, incoming and outgoing.

- **Caution: Filtering SA messages can break the Flood and Join mechanism!**

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Recommended MSDP SA Filter

```
! domain-local applications
access-list 111 deny   ip any host 224.0.2.2     !
access-list 111 deny   ip any host 224.0.1.3     ! Rwhod
access-list 111 deny   ip any host 224.0.1.24    ! Microsoft-ds
access-list 111 deny   ip any host 224.0.1.22    ! SVRLOC
access-list 111 deny   ip any host 224.0.1.2     ! SGI-Dogfight
access-list 111 deny   ip any host 224.0.1.35    ! SVRLOC-DA
access-list 111 deny   ip any host 224.0.1.60    ! hp-device-disc
!-- auto-rp groups
access-list 111 deny   ip any host 224.0.1.39
access-list 111 deny   ip any host 224.0.1.40
!-- scoped groups
access-list 111 deny   ip any 239.0.0.0 0.255.255.255
!-- loopback, private addresses (RFC 1918)
access-list 111 deny   ip 10.0.0.0 0.255.255.255 any
access-list 111 deny   ip 127.0.0.0 0.255.255.255 any
access-list 111 deny   ip 172.16.0.0 0.15.255.255 any
access-list 111 deny   ip 192.168.0.0 0.0.255.255 any
access-list 111 permit ip any any
!-- Default SSM-range. Do not do MSDP in this range
access-list 111 deny   ip any 232.0.0.0 0.255.255.255
access-list 111 permit ip any any
```

See “ftp://ftpeng.cisco.com/ipmulticast/config-notes/msdp-sa-filter.txt” for the latest updates to this list.

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SA Message RPF Checking

- **Purpose**
  - Accept SA's via a single deterministic path
    - Ignore all other arriving SA's
    - Necessary to prevent SA's from looping endlessly
- **Problem**
  - Need to know MSDP topology of Internet
    - But, MSDP does not distribute topology data!
- **Solution**
  - Use BGP data to *infer* MSDP topology.
    - Impact:
      - The MSDP topology must follow BGP topology.
      - An MSDP peer must *generally* also be an BGP peer.

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SA Message RPF Checking

- **RPF Check Rules depend on peering**

  Rule 1: Sending MSDP peer = iBGP peer

  Rule 2: Sending MSDP peer = eBGP peer

  Rule 3: Sending MSDP peer != BGP peer

- **Exceptions:**

  RPF check is skipped when:

  Sending MSDP peer = Originating RP

  Sending MSDP peer = Mesh-Group peer

  Sending MSDP peer = only MSDP peer

  (i.e. the ‘default-peer’ or the only ‘msdp-peer’ configured.)

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SA Message RPF Checking

- **Determining Applicable RPF Rule**

  Use IP address of sending MSDP peer

  Find BGP neighbor w/matching IP address

  IF (no match found)

  Apply Rule 3

  IF (matching neighbor = iBGP peer)

  Apply Rule 1

  ELSE {matching neighbor = eBGP peer}

  Apply Rule 2

- ***Implication***

  The MSDP peer address must be configured using the same IP address as the BGP peer!

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RPF Check Rule 1

- When MSDP peer = iBGP peer
  - Find “Best Path” to RP in BGP Tables
    - Search M-Table first then U-Table.
    - If no path to Originating RP found, RPF Fails
  - Note “BGP Neighbor” that advertised path
    - (i.e IP Address of BGP peer that sent us this path)
    - *Warning:*
      - *This is not the same as the Next-hop of the path!!!*
      - *iBGP peers normally do not set Next-hop = Self.*
      - *This is also not necessarily the same as the Router-ID!*
  - Rule 1 Test Condition:
    - MSDP Peer address = BGP Neighbor address?
      - If Yes, RPF Succeeds

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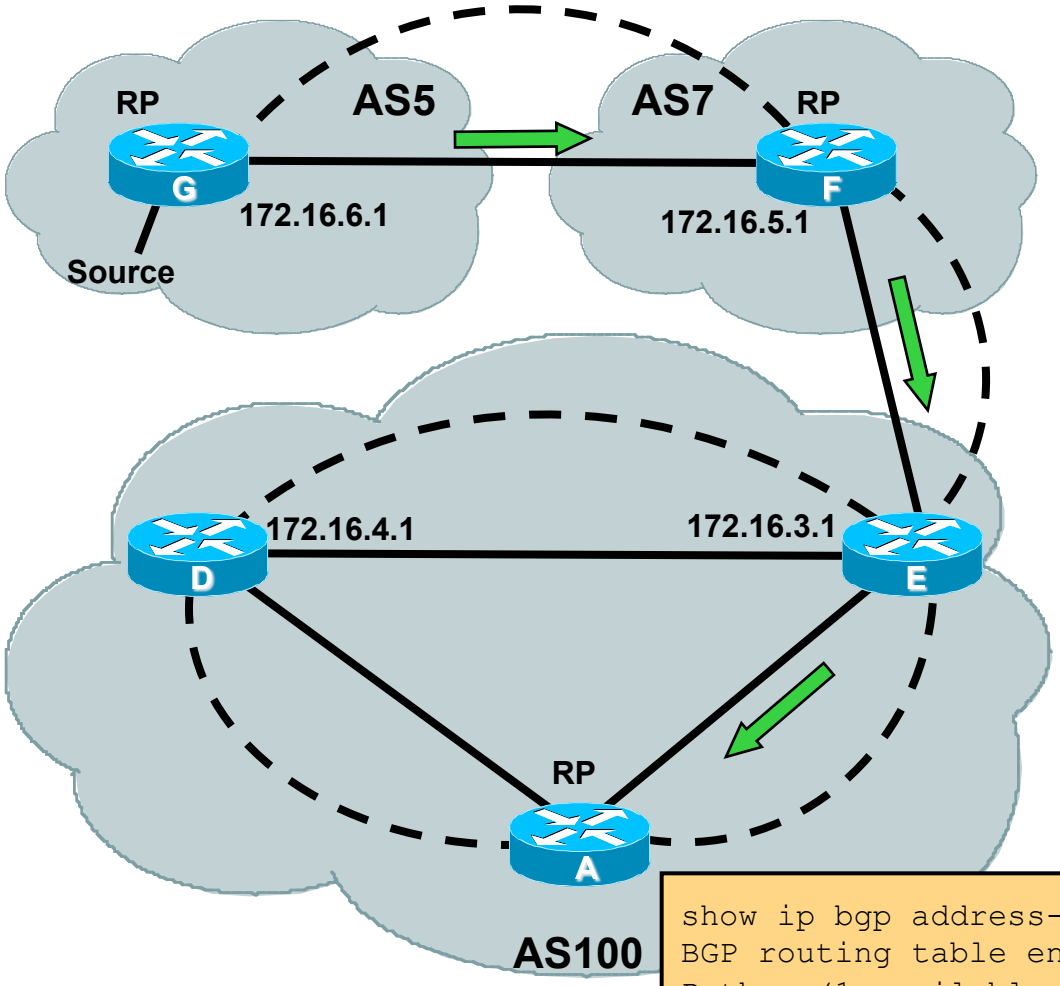
Rule1: MSDP peer = iBGP peer



iBGP peer address = 172.16.3.1
(advertising best-path to RP)

MSDP Peer address = 172.16.3.1

MSDP Peer address = iBGP Peer address

SA RPF Check Succeeds

```
show ip bgp address-family ipv4 multicast 172.16.6.1
BGP routing table entry for 172.16.6.0/24, version 8745118
Paths: (1 available, best #1)
7 5, (received & used)
    172.16.5.1 (metric 68096) from 172.16.3.1 (172.16.3.1)
```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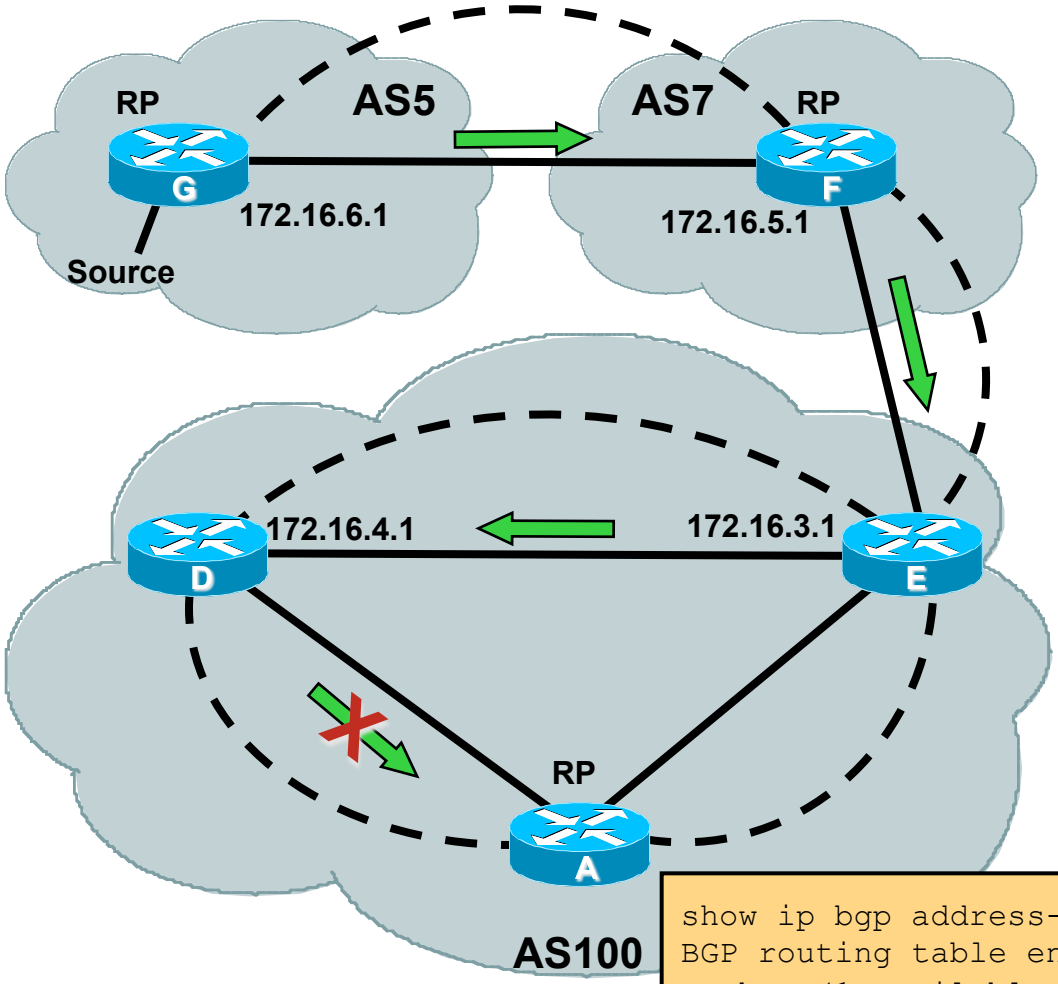
Rule1: MSDP peer = iBGP peer



iBGP Peer address = 172.16.3.1
(advertising best-path to RP)

MSDP Peer address = 172.16.4.1

MSDP Peer address != iBGP Peer address

SA RPF Check Fails

```
show ip bgp address-family ipv4 multicast 172.16.6.1
BGP routing table entry for 172.16.6.0/24, version 8745118
Paths: (1 available, best #1)
7 5, (received & used)
    172.16.5.1 (metric 68096) from 172.16.3.1 (172.16.3.1)
```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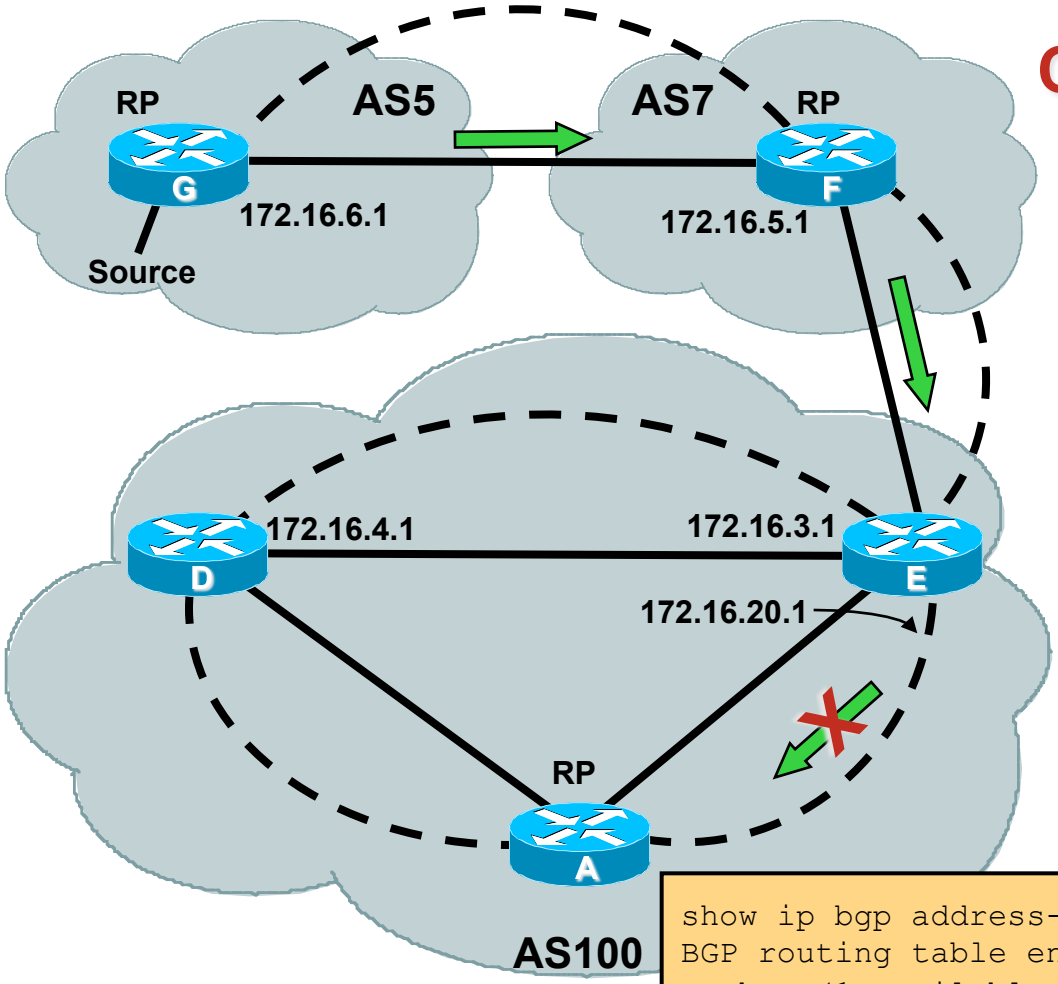
Rule1: MSDP peer = iBGP peer



Common Mistake #1:

Failure to use same addresses for MSDP peers as iBGP peers!

iBGP Peer address = 172.16.3.1
(advertising best-path to RP)

MSDP Peer address = 172.16.20.1

MSDP Peer address != iBGP Peer address

SA RPF Check Fails

```
show ip bgp address-family ipv4 multicast 172.16.6.1
BGP routing table entry for 172.16.6.0/24, version 8745118
Paths: (1 available, best #1)
7 5, (received & used)
    172.16.5.1 (metric 68096) from 172.16.3.1 (172.16.3.1)
```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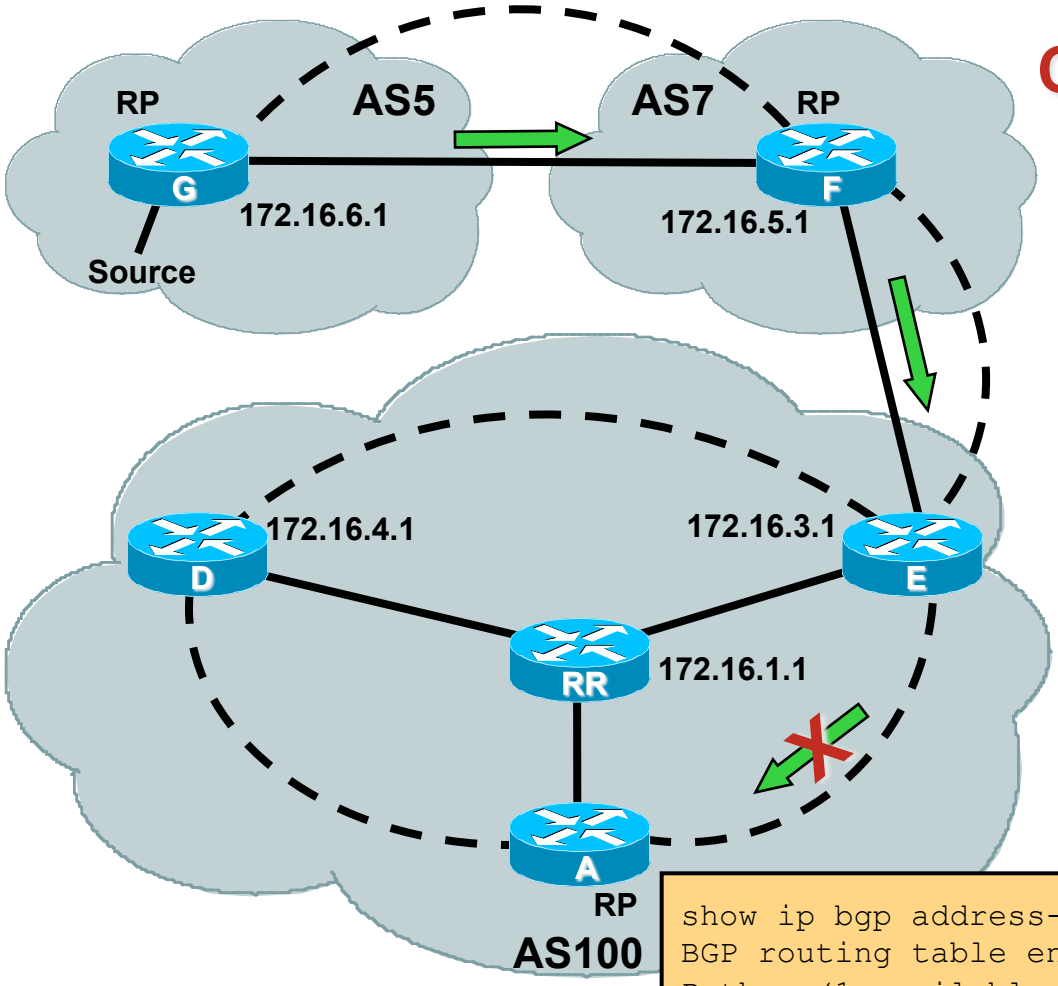
Rule1: MSDP peer = iBGP peer



Common Mistake #2:

Failure to follow iBGP topology!
Can happen when RR's are used.

iBGP Peer address = 172.16.1.1
(advertising best-path to RP)

MSDP Peer address = 172.16.3.1

MSDP Peer address != iBGP Peer address

SA RPF Check Fails

```
show ip bgp address-family ipv4 multicast 172.16.6.1
BGP routing table entry for 172.16.6.0/24, version 8745118
Paths: (1 available, best #1)
7 5, (received & used)
    172.16.5.1 (metric 68096) from 172.16.1.1 (172.16.1.1)
```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RPF Check Rule 2

- **When MSDP peer = eBGP peer**
  - **Find BGP "Best Path" to RP**
    - **Search M-Table first then U-Table.**
      - **If no path to Originating RP found, RPF Fails**
  - **Rule 2 Test Condition:**
    - **First AS in path to the RP = AS of eBGP peer?**
      - **If Yes, RPF Succeeds**

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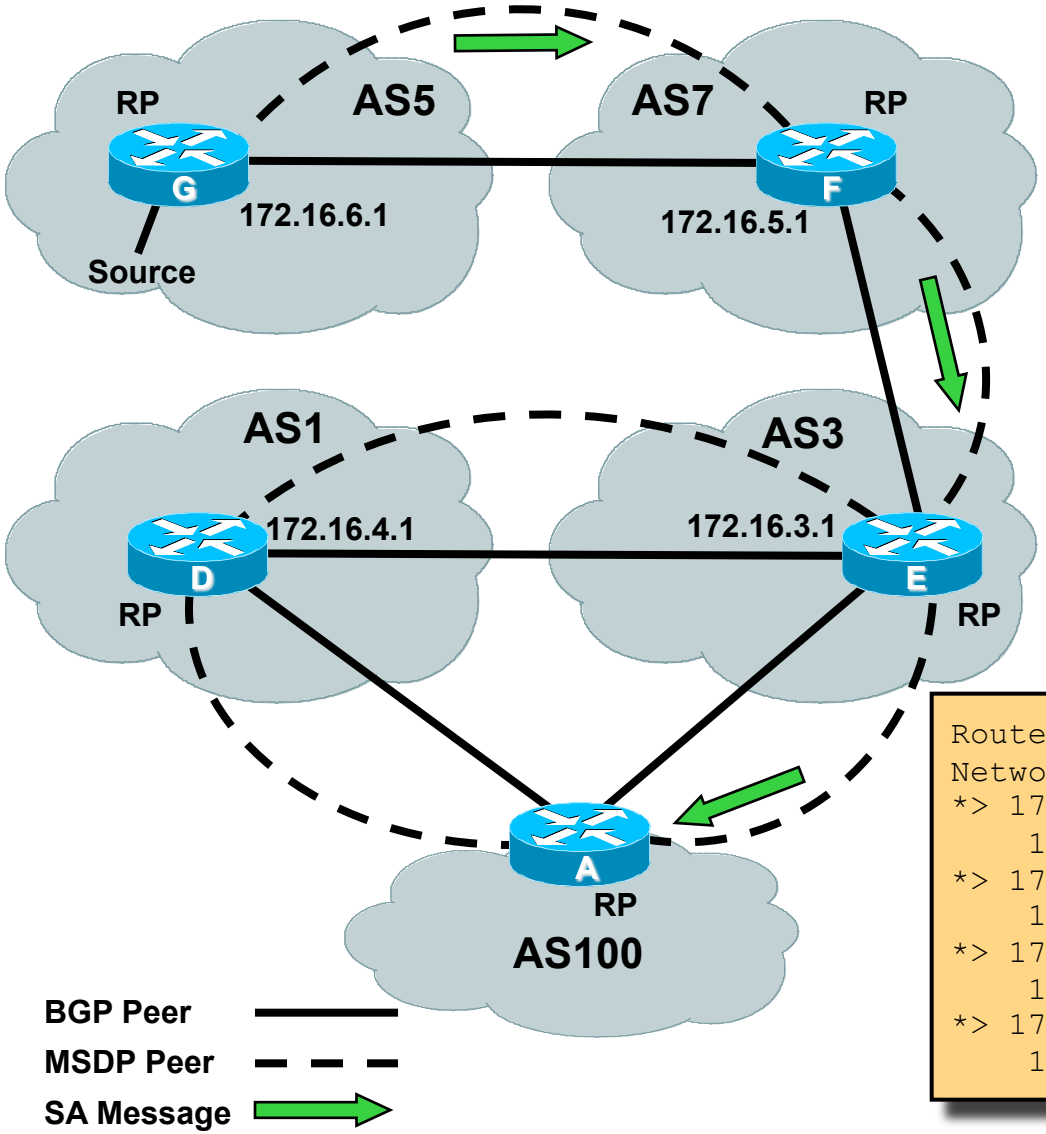
Rule2: MSDP peer = eBGP peer



First-AS in best-path to RP = 3
AS of MSDP Peer = 3

First-AS in best-path to RP = AS of eBGP Peer

SA RPF Check Succeeds

```
Router A's ipv4 multicast BGP Table
Network              Next Hop       Path
*> 172.16.3.0/24     172.16.3.1     3 i
    172.16.3.0/24     172.16.4.1     1 3 i
*> 172.16.4.0/24     172.16.4.1     1 i
    172.16.4.0/24     172.16.3.1     3 1 i
*> 172.16.5.0/24     172.16.3.1     3 7 i
    172.16.5.0/24     172.16.4.1     1 3 7 i
*> 172.16.6.0/24     172.16.3.1     3 7 5 i
    172.16.6.0/24     172.16.4.1     1 3 7 5 i
```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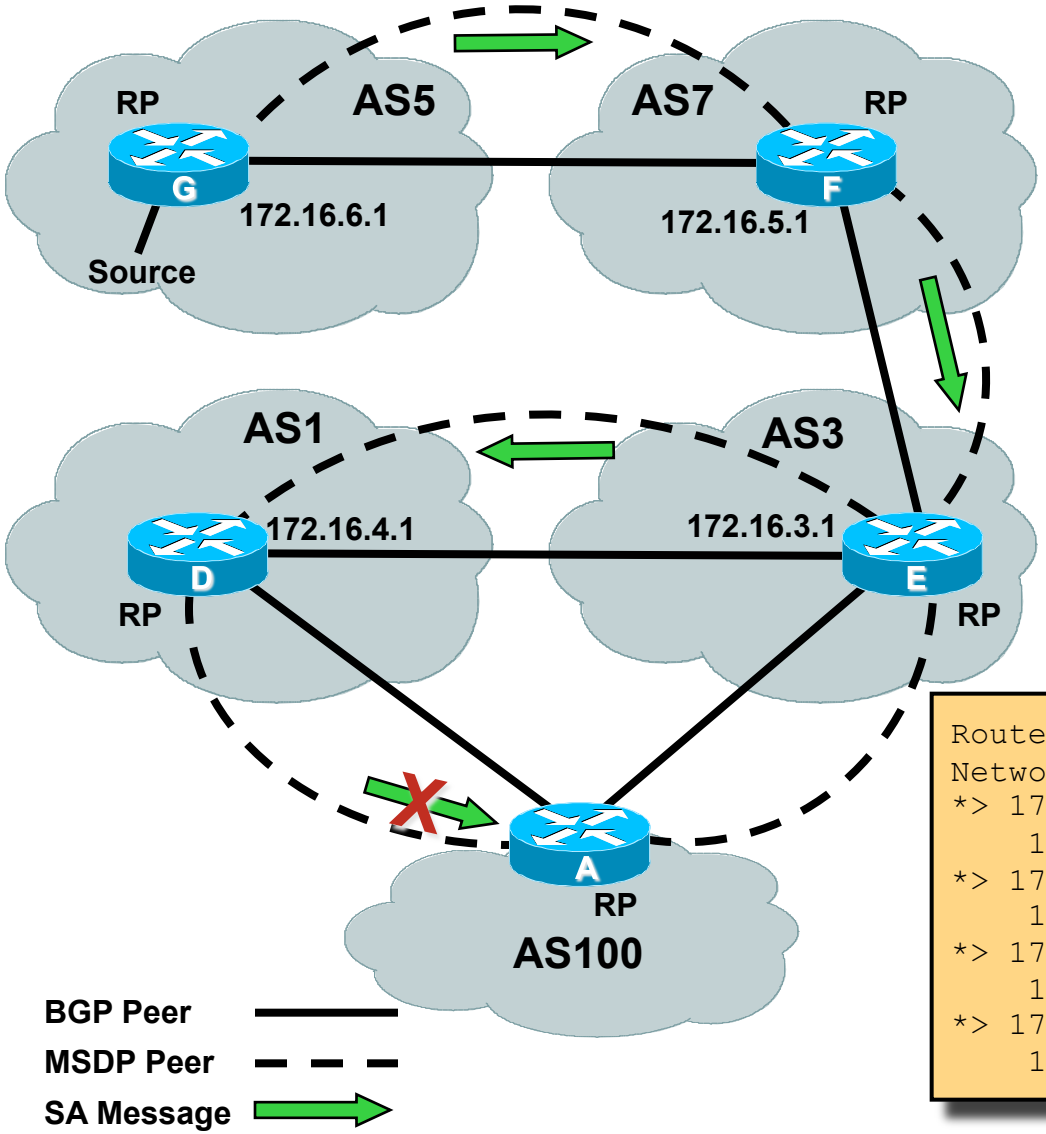
Rule2: MSDP peer = eBGP peer



First-AS in best-path to RP = 3
AS of eBGP Peer = 1

First-AS in best-path to RP != AS of eBGP Peer

SA RPF Check Fails!

```
Router A's ipv4 multicast BGP Table
Network              Next Hop       Path
*> 172.16.3.0/24     172.16.3.1     3 i
    172.16.3.0/24     172.16.4.1     1 3 i
*> 172.16.4.0/24     172.16.4.1     1 i
    172.16.4.0/24     172.16.3.1     3 1 i
*> 172.16.5.0/24     172.16.3.1     3 7 i
    172.16.5.0/24     172.16.4.1     1 3 7 i
*> 172.16.6.0/24     172.16.3.1     3 7 5 i
    172.16.6.0/24     172.16.4.1     1 3 7 5 i
```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RPF Check Rule 3

- When MSDP peer != BGP peer
  - Find BGP “Best Path” to RP
    - Search M-Table first then U-Table.
      - If no path to Originating RP found, RPF Fails
  - Find BGP “Best Path” to MSDP peer
    - Search M-Table first then U-Table.
      - If no path to sending MSDP Peer found, RPF Fails
  - Note AS of sending MSDP Peer
    - Origin AS (last AS) in AS-PATH to MSDP Peer
  - Rule 3 Test Condition:
    - First AS in path to RP = Sending MSDP Peer AS ?
      - If Yes, RPF Succeeds

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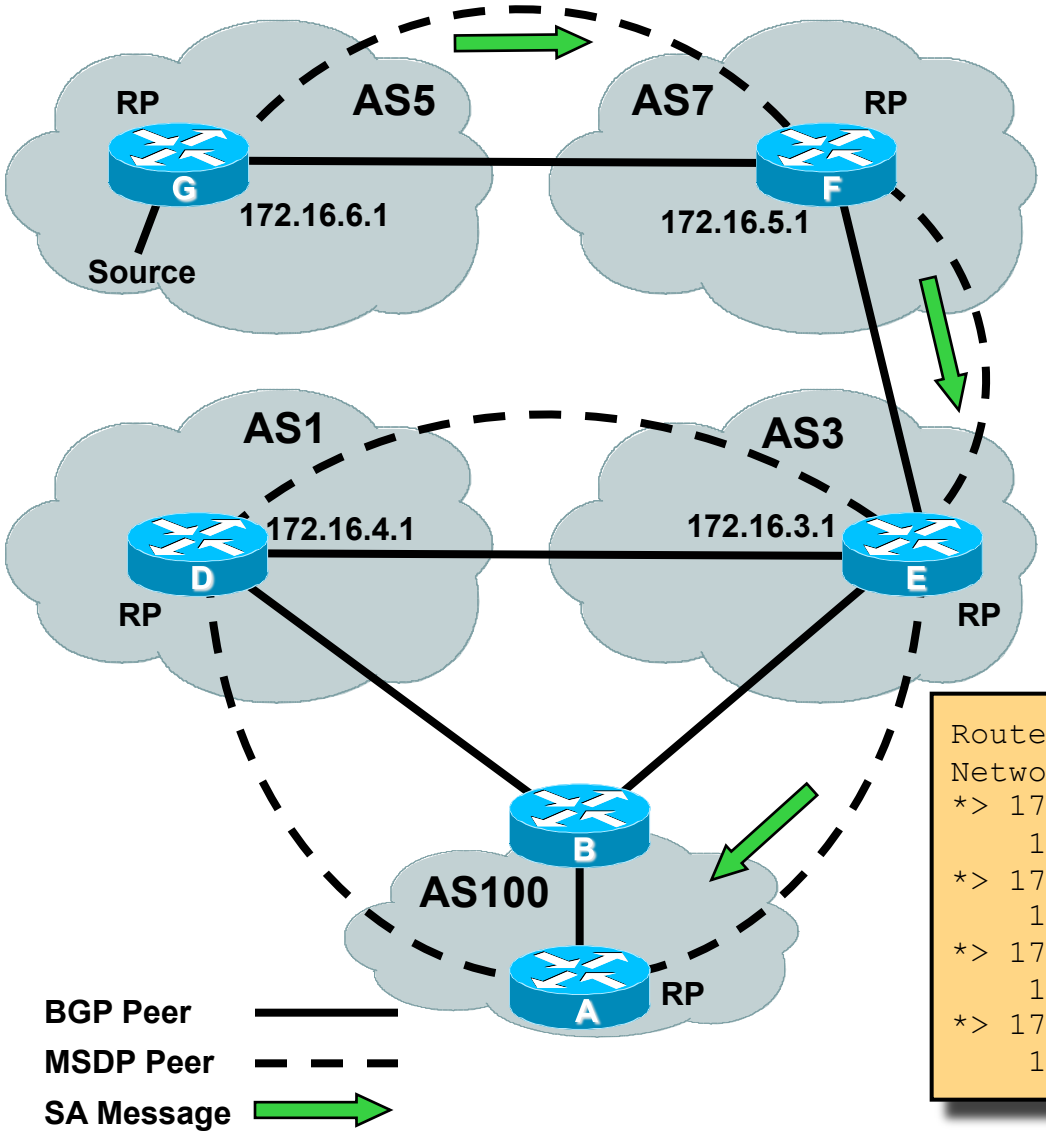
Rule3: MSDP peer != BGP peer



First-AS in best-path to RP = 3
AS of MSDP Peer = 3

First-AS in best-path to RP = AS of MSDP Peer

SA RPF Check Succeeds

```
Router A's ipv4 multicast BGP Table
Network              Next Hop       Path
*> 172.16.3.0/24     172.16.3.1     3 i
    172.16.3.0/24     172.16.4.1     1 3 i
*> 172.16.4.0/24     172.16.4.1     1 i
    172.16.4.0/24     172.16.3.1     3 1 i
*> 172.16.5.0/24     172.16.3.1     3 7 i
    172.16.5.0/24     172.16.4.1     1 3 7 i
*> 172.16.6.0/24     172.16.3.1     3 7 5 i
    172.16.6.0/24     172.16.4.1     1 3 7 5 i
```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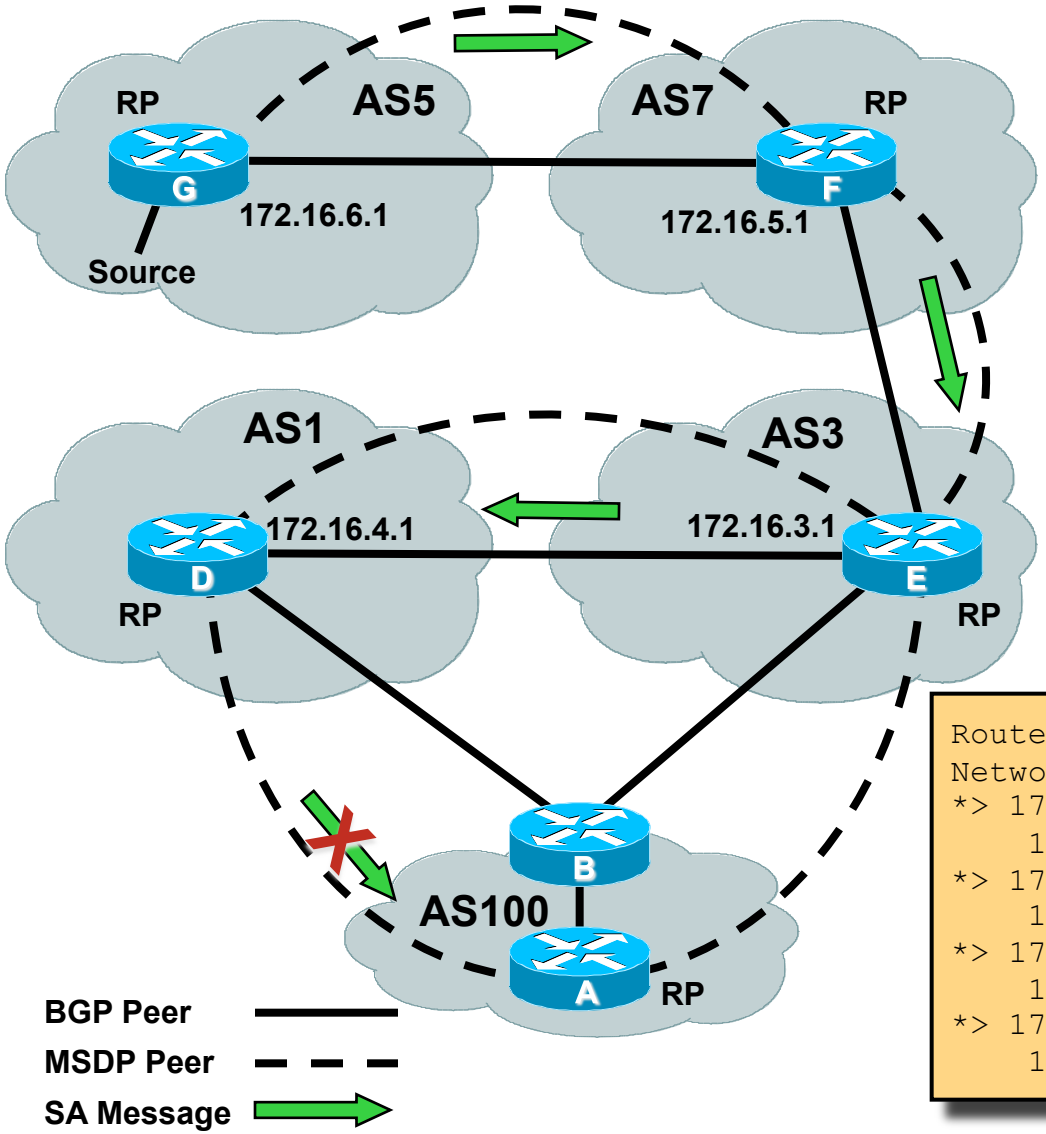
Rule3: MSDP peer != BGP peer



First-AS in best-path to RP = 3
AS of MSDP Peer = 1

First-AS in best-path to RP != AS of MSDP Peer

SA RPF Check Fails

```
Router A's ipv4 multicast BGP Table
Network              Next Hop       Path
*> 172.16.3.0/24     172.16.3.1     3 i
    172.16.3.0/24     172.16.4.1     1 3 i
*> 172.16.4.0/24     172.16.4.1     1 i
    172.16.4.0/24     172.16.3.1     3 1 i
*> 172.16.5.0/24     172.16.3.1     3 7 i
    172.16.5.0/24     172.16.4.1     1 3 7 i
*> 172.16.6.0/24     172.16.3.1     3 7 5 i
    172.16.6.0/24     172.16.4.1     1 3 7 5 i
```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MSDP Mesh-Groups

- **Optimises SA flooding.**
  - **Useful when 2 or more peers are in a group.**
  - **Requires full mesh of mesh group peers.**
- **Reduces amount of SA traffic in the net.**
  - **SA's not flooded to other mesh-group peers.**
- **Suspends RPF check of SA messages.**
  - **When received from a mesh-group peer.**
  - **SA's always accepted from mesh-group peers.**
  - **Eliminates need for BGP.**

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MSDP Mesh-Groups

- **Configured with:**

```
ip msdp mesh-group <name> <peer-address>
```

- **Peers in the mesh-group must be fully meshed.**
- **Multiple mesh-groups per router are supported.**

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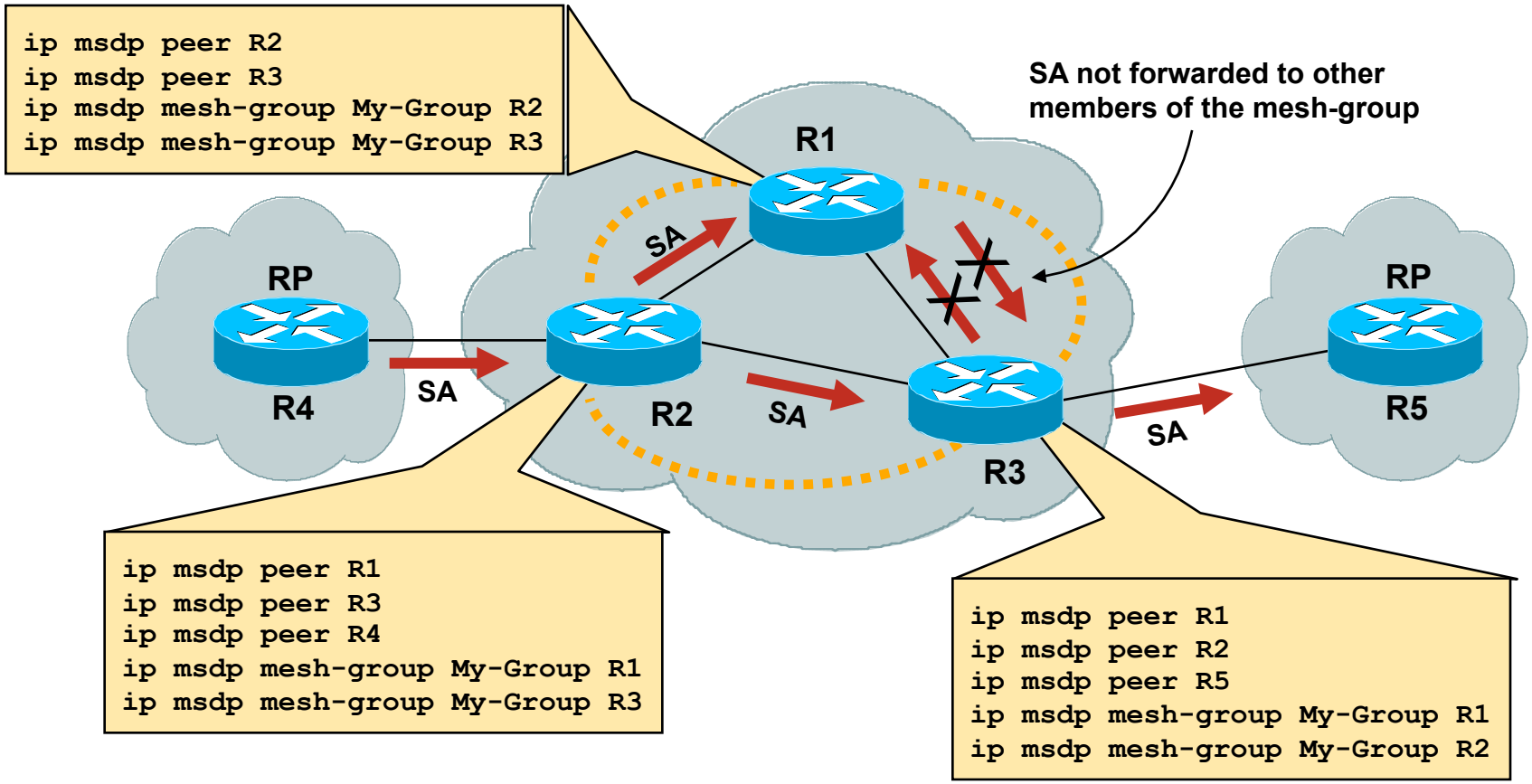
MSDP Mesh-Group Example



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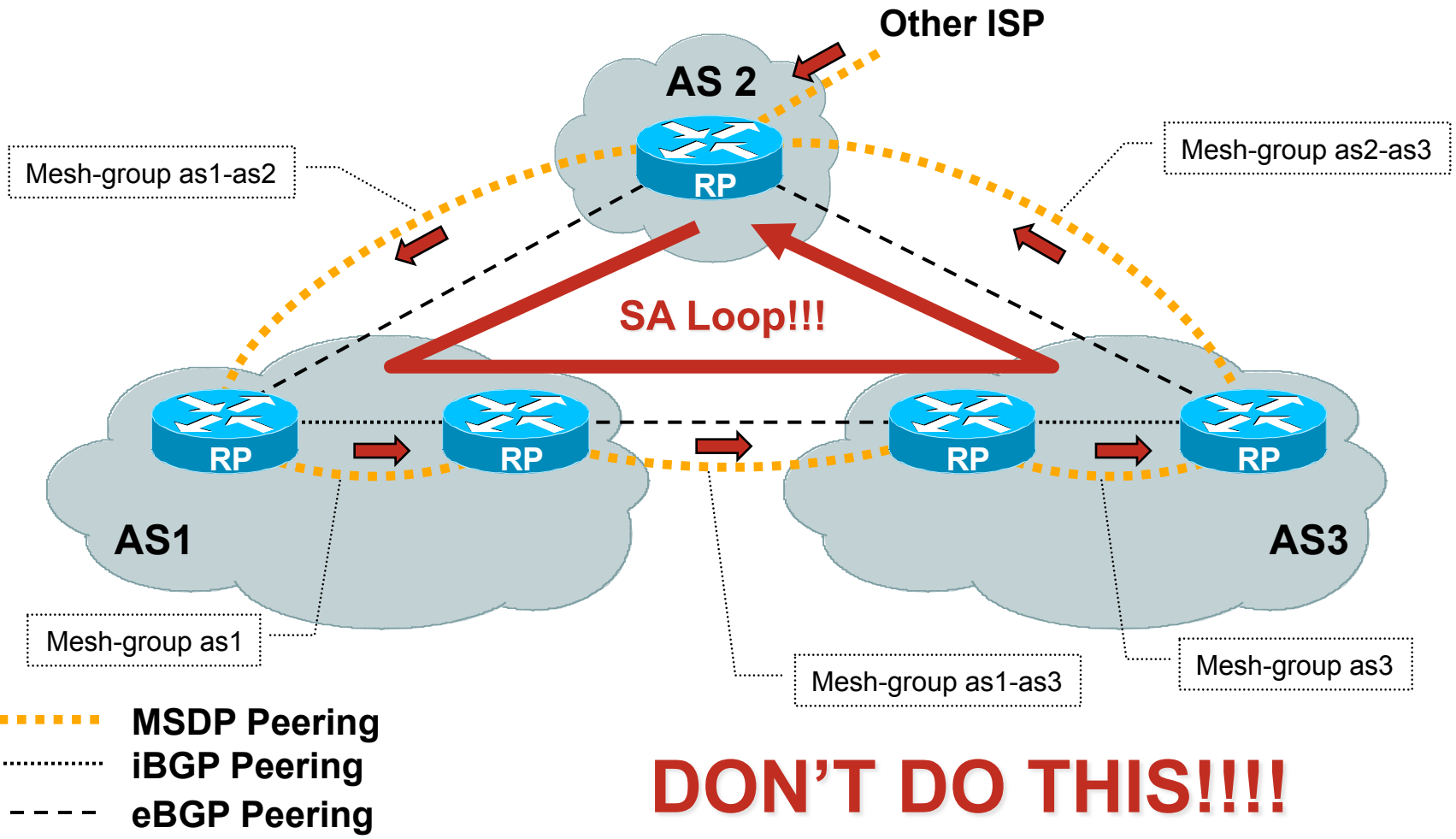
Avoid Mesh-Group Loops!!!

WARNING: There is no RPF check between Mesh-groups!!!



DON'T DO THIS!!!!

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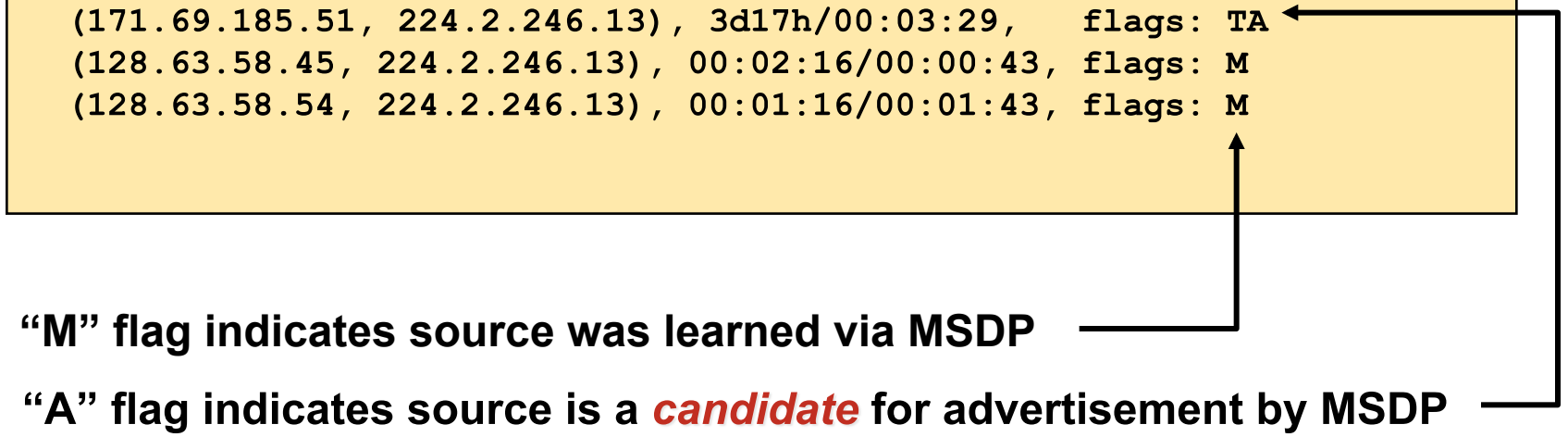
MSDP Mroute Flags

New ‘mroute’ Flags for MSDP

```
sj-mbone#show ip mroute summary
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, C - Connected, L - Local, P - Pruned
       R - RP-bit set, F - Register flag, T - SPT-bit set, J - Join SPT
       M - MSDP created entry, X - Proxy Join Timer Running
       A - Advertised via MSDP
Timers: Uptime/Expires
Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 224.2.246.13), 5d17h/00:02:59, RP 171.69.10.13, flags: S
  (171.69.185.51, 224.2.246.13), 3d17h/00:03:29,   flags: TA
  (128.63.58.45, 224.2.246.13), 00:02:16/00:00:43, flags: M
  (128.63.58.54, 224.2.246.13), 00:01:16/00:01:43, flags: M
```



“M” flag indicates source was learned via MSDP

“A” flag indicates source is a *candidate* for advertisement by MSDP

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MSDP Enhancements

- **New IOS command**

```
ip msdp new-rpf-rules
```

MSDP SA RPF check using IGP

Accept SA's from BGP NEXT HOP

Accept SA's from closest peer along the best path to the originating RP

"show ip msdp rpf"

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MSDP RPF check using IGP

- **When MSDP peer = IGP peer (No BGP)**

  Find best IGP route to RP

  Search URIB

  If route to Originating RP found and:

  If IGP next hop (or advertiser) address for RP is the MSDP peer and in UP state, then that is the RPF peer.

  If route not found: Fall through to the next rule.

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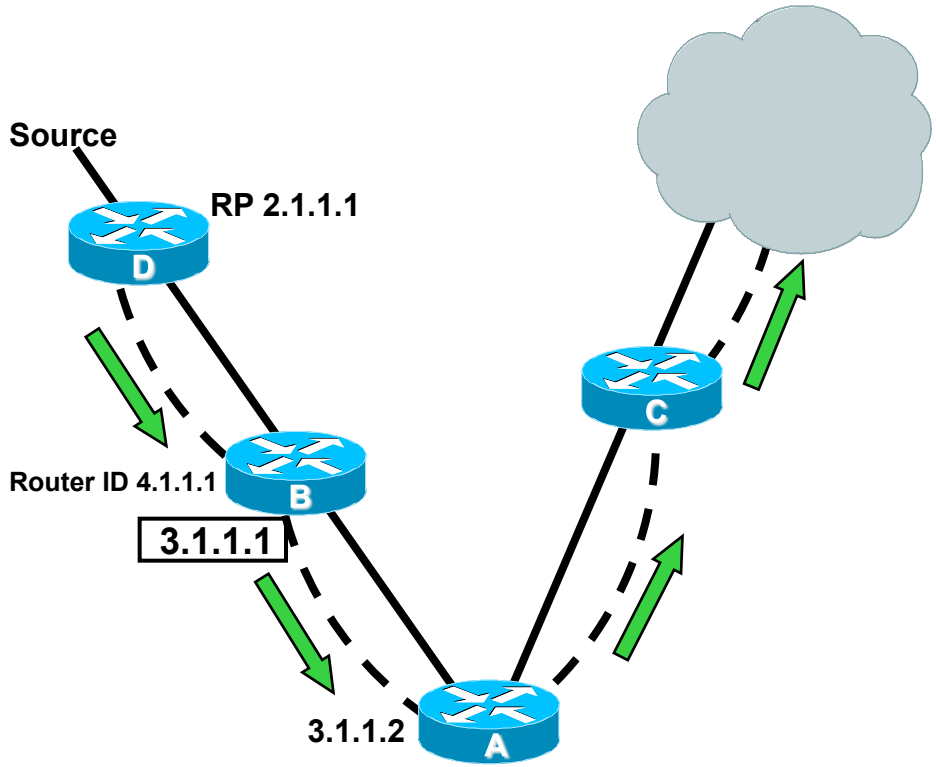
IGP Rule: MSDP peer = IGP peer (Next hop)



MSDP Peer = 3.1.1.1

IGP next hop to originating RP = 3.1.1.1

IGP next hop to originating RP = MSDP peer

SA RPF Check Succeeds

OSPF neighbor

MSDP Peer

SA Message

```
RouterA#show ip route 2.1.1.1
Routing entry for 2.1.1.0/24
  Known via "ospf 1", distance 110, metric 20, type intra area
  Last update from 3.1.1.1 on Ethernet2, 00:35:10 ago
  Routing Descriptor Blocks:
  * 3.1.1.1, from 4.1.1.1, 00:35:10 ago, via Ethernet2
      Route metric is 20, traffic share count is 1
```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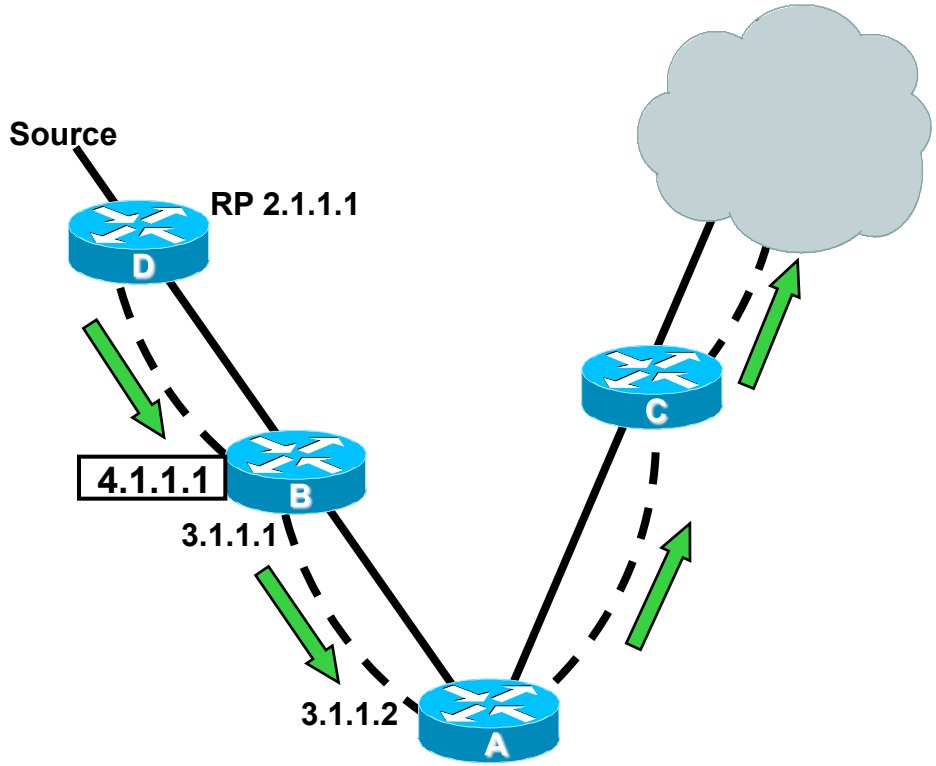
IGP Rule: MSDP peer = IGP peer (Advertiser)



MSDP Peer = 4.1.1.1

IGP next hop to originating RP = ~~3.1.1.1~~

IGP advertiser to originating RP = 4.1.1.1

IGP advertiser to originating RP = MSDP peer

SA RPF Check Succeeds

OSPF neighbor

MSDP Peer

SA Message

```
RouterA#show ip route 2.1.1.1
Routing entry for 2.1.1.0/24
  Known via "ospf 1", distance 110, metric 20, type intra area
  Last update from 3.1.1.1 on Ethernet2, 00:35:10 ago
  Routing Descriptor Blocks:
  * 3.1.1.1, from 4.1.1.1, 00:35:10 ago, via Ethernet2
      Route metric is 20, traffic share count is 1
```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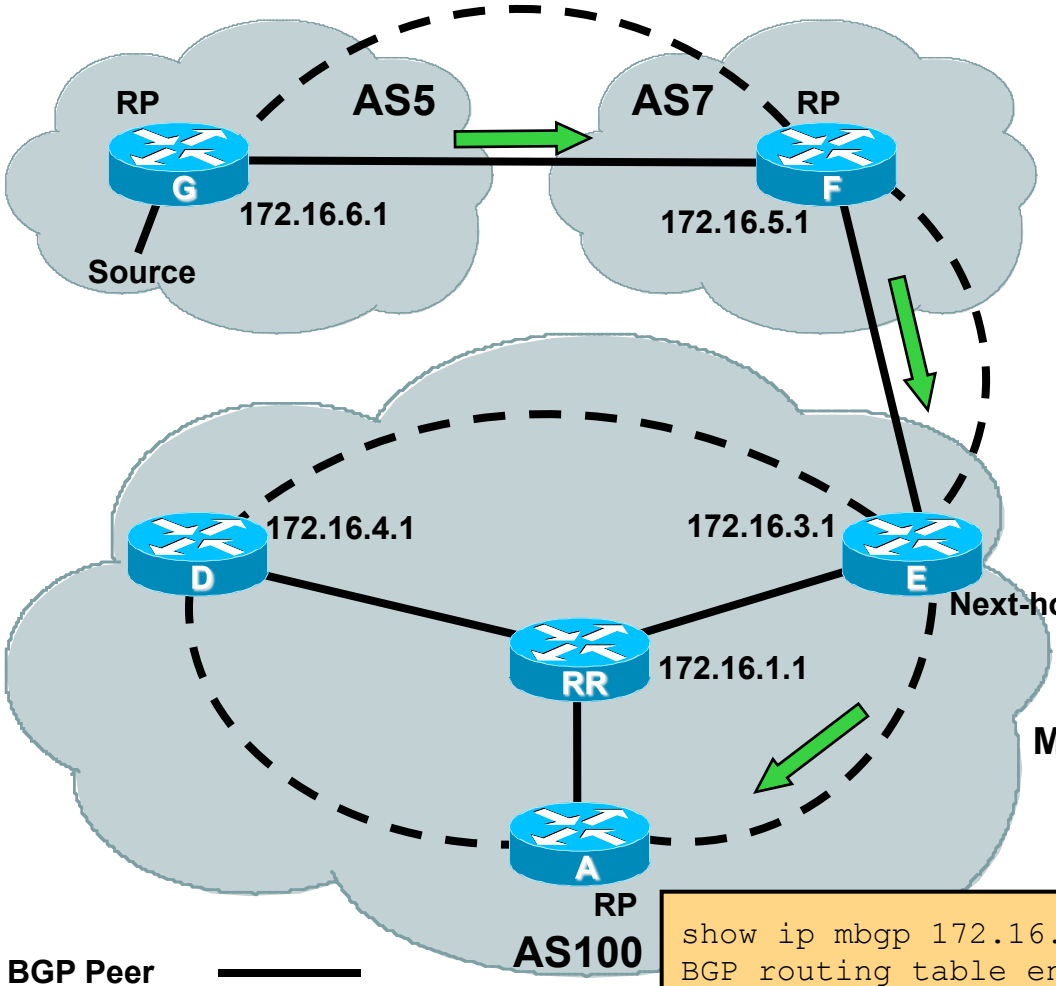
SA's accepted from Next Hop



BGP Peer

MSDP Peer

SA Message

i(m)BGP Peer address = 172.16.1.1
(Advertiser of next hop)

MSDP Peer address = 172.16.3.1

But, BGP next hop = 172.16.3.1

MSDP Peer address = BGP next hop address

SA RPF Check Succeeds

```
show ip mbgp 172.16.6.1
BGP routing table entry for 172.16.6.0/24, version 8745118
Paths: (1 available, best #1)
7 5, (received & used)
    172.16.3.1 (metric 68096) from 172.16.1.1 (172.16.1.1)
```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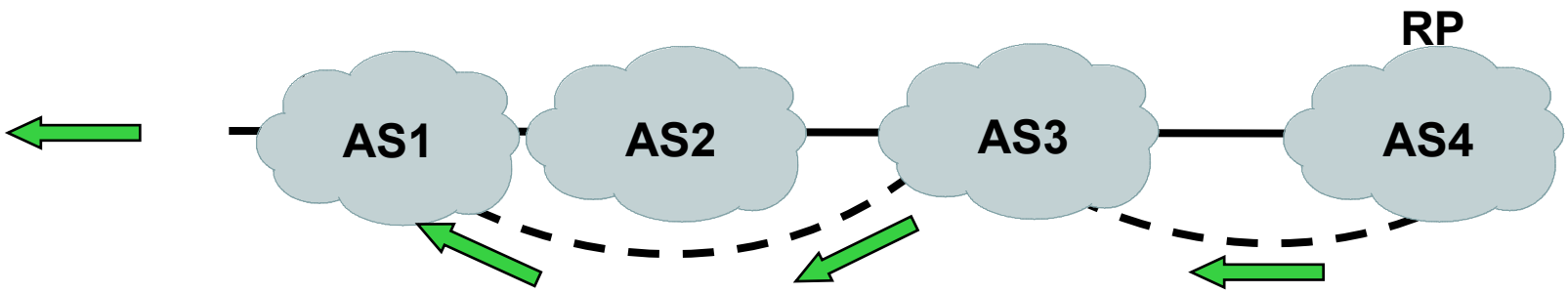
Accept SA along RPF path



Existing Rule: If first AS in best path to the RP != MSDP peer
RPF Fails

New code: Choose peer in CLOSEST AS along best AS path to the RP.
Loosens rule a bit.

RPF Succeeds.

BGP Peer
MSDP Peer
SA Message

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New MSDP RPF command

```
Router-A# show ip msdp rpf 2.1.1.1
RPF peer information for Router-B (2.1.1.1)
  RPF peer: Router-C (3.1.1.1)
  RPF route/mask: 2.1.1.0/24
  RPF rule: Peer is IGP next hop of best route
  RPF type: unicast (ospf 1)
```


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Anycast-RP

- RFC 3446
- Within a domain, deploy more than one RP for the same group range
- Sources from one RP are known to other RPs using MSDP
- Give each RP the same /32 IP address
- Sources and receivers use closest RP, as determined by the IGP
- Used intra-domain to provide redundancy and RP load sharing, when an RP goes down, sources and receivers are taken to new RP via unicast routing

  Fast convergence!

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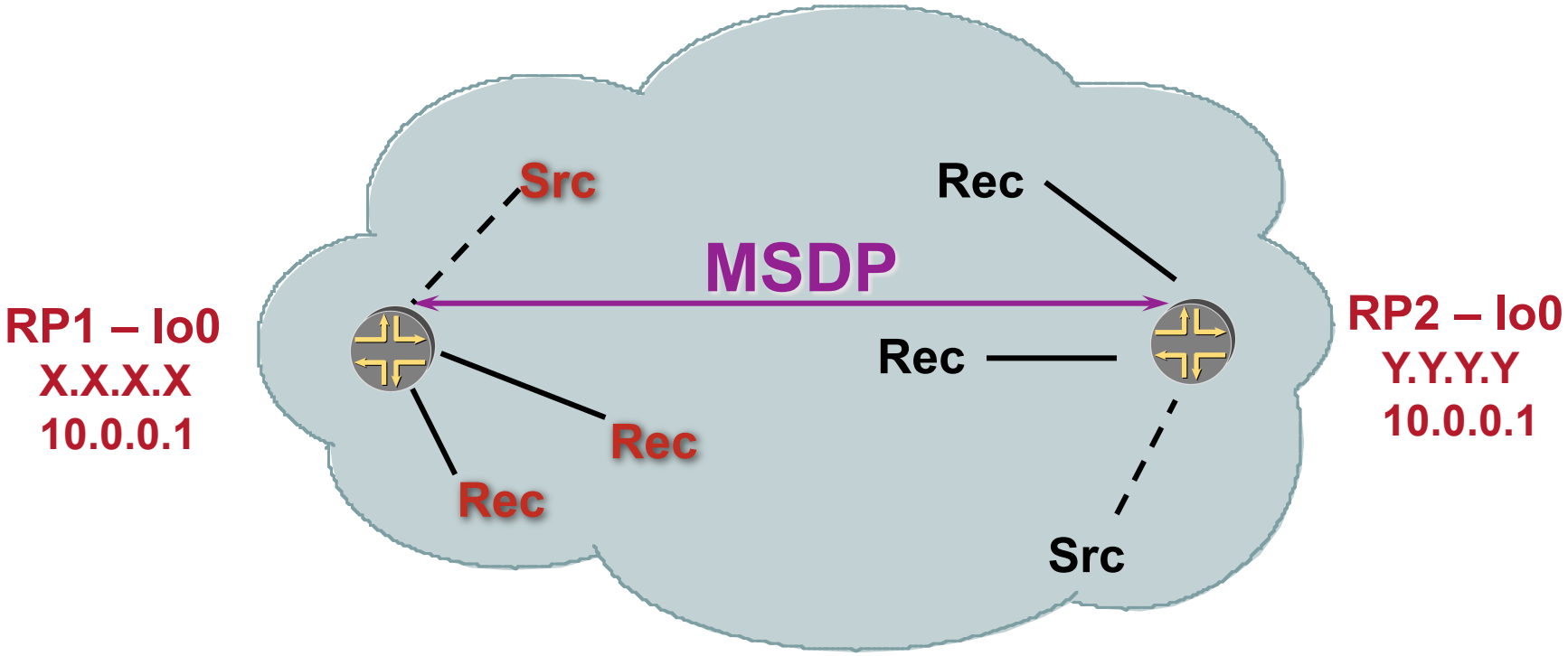
Anycast-RP



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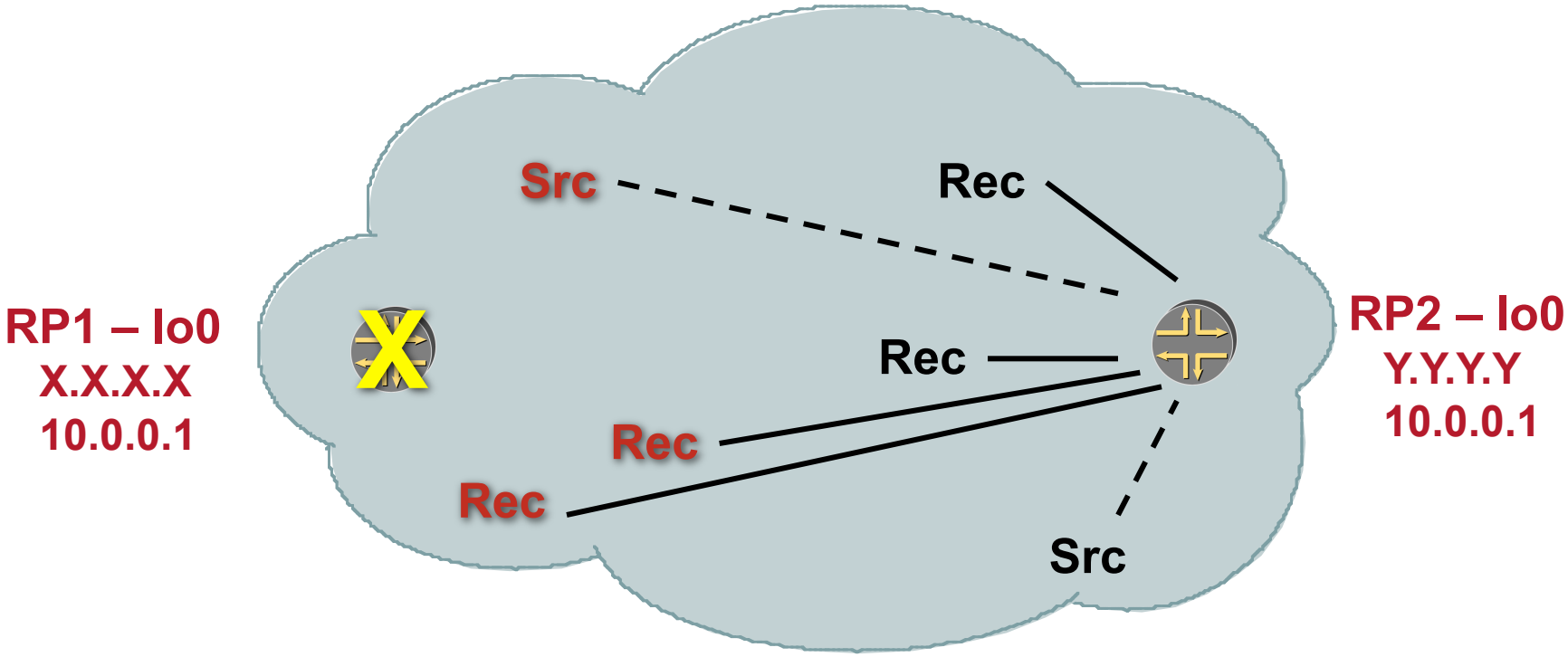
Anycast-RP



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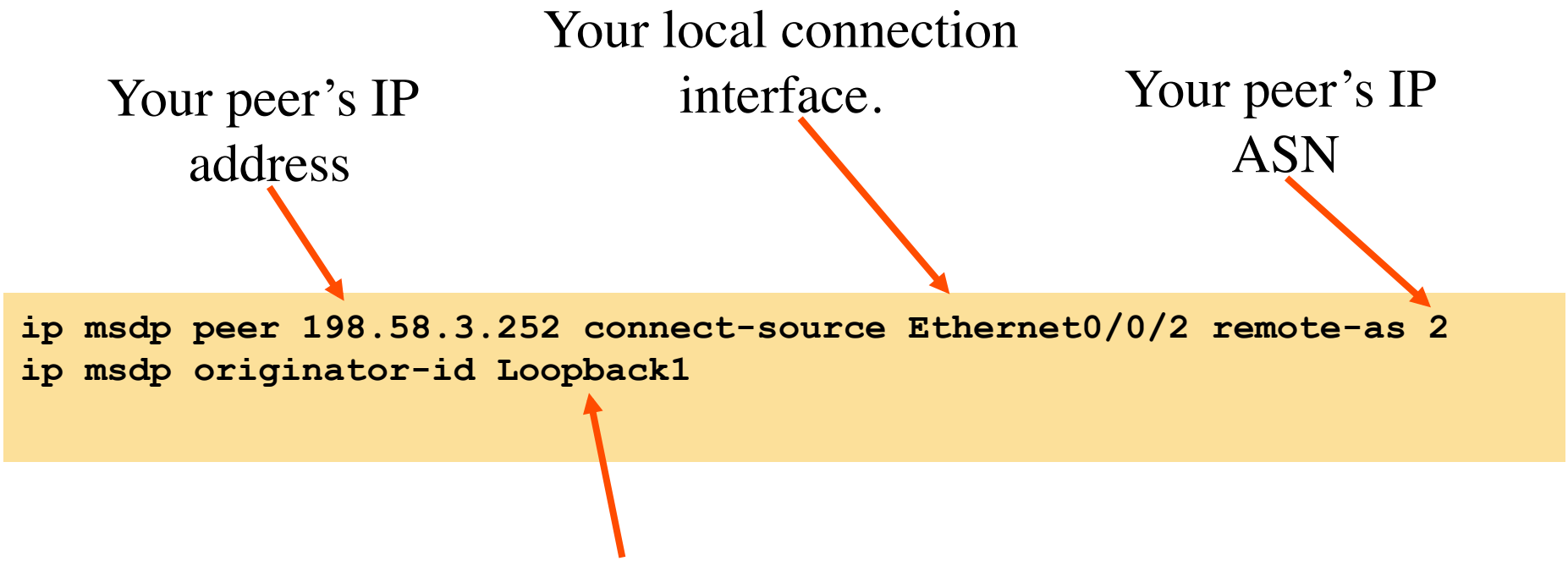
MSDP Configuration



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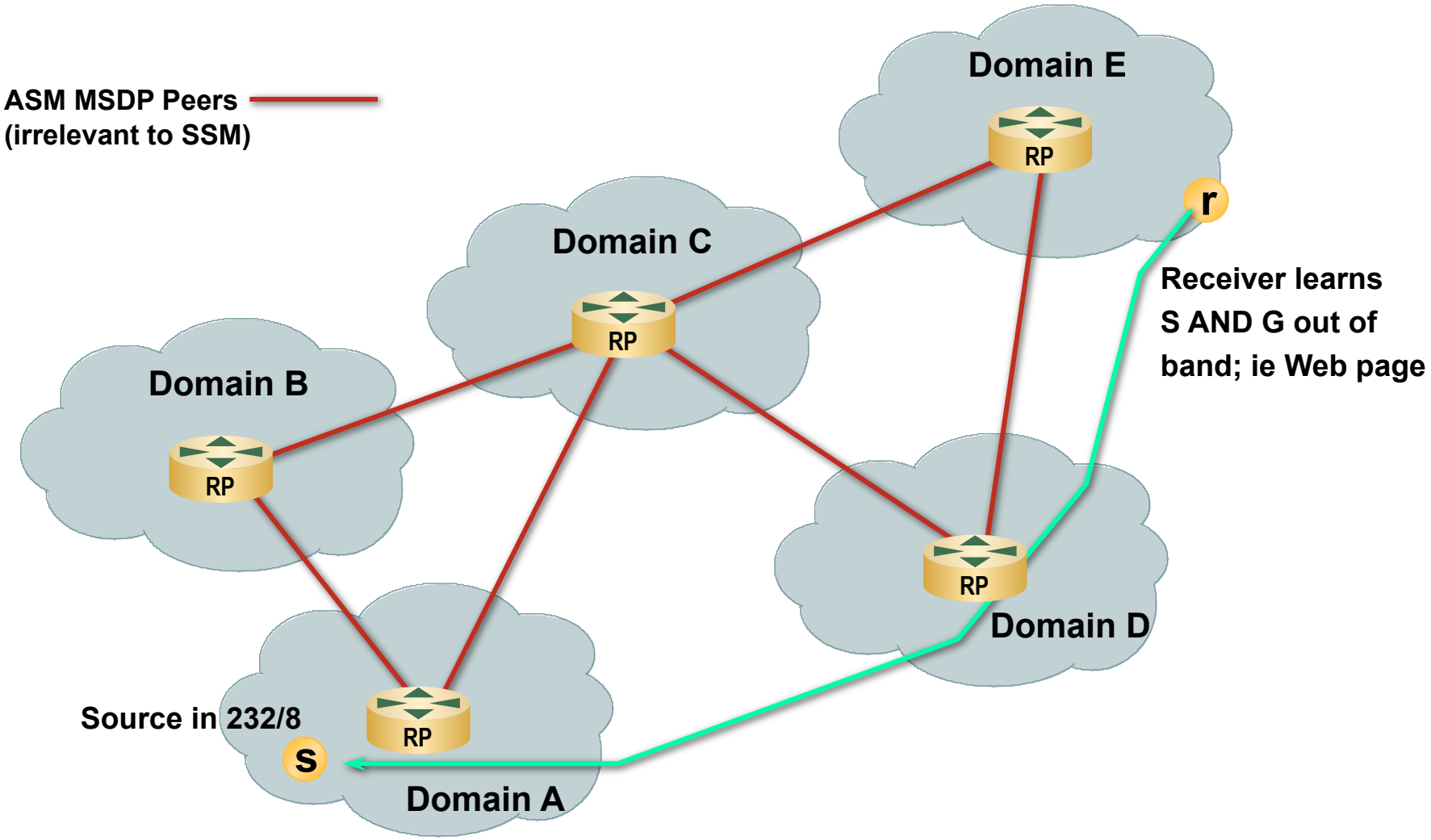
MSDP wrt SSM – Unnecessary!



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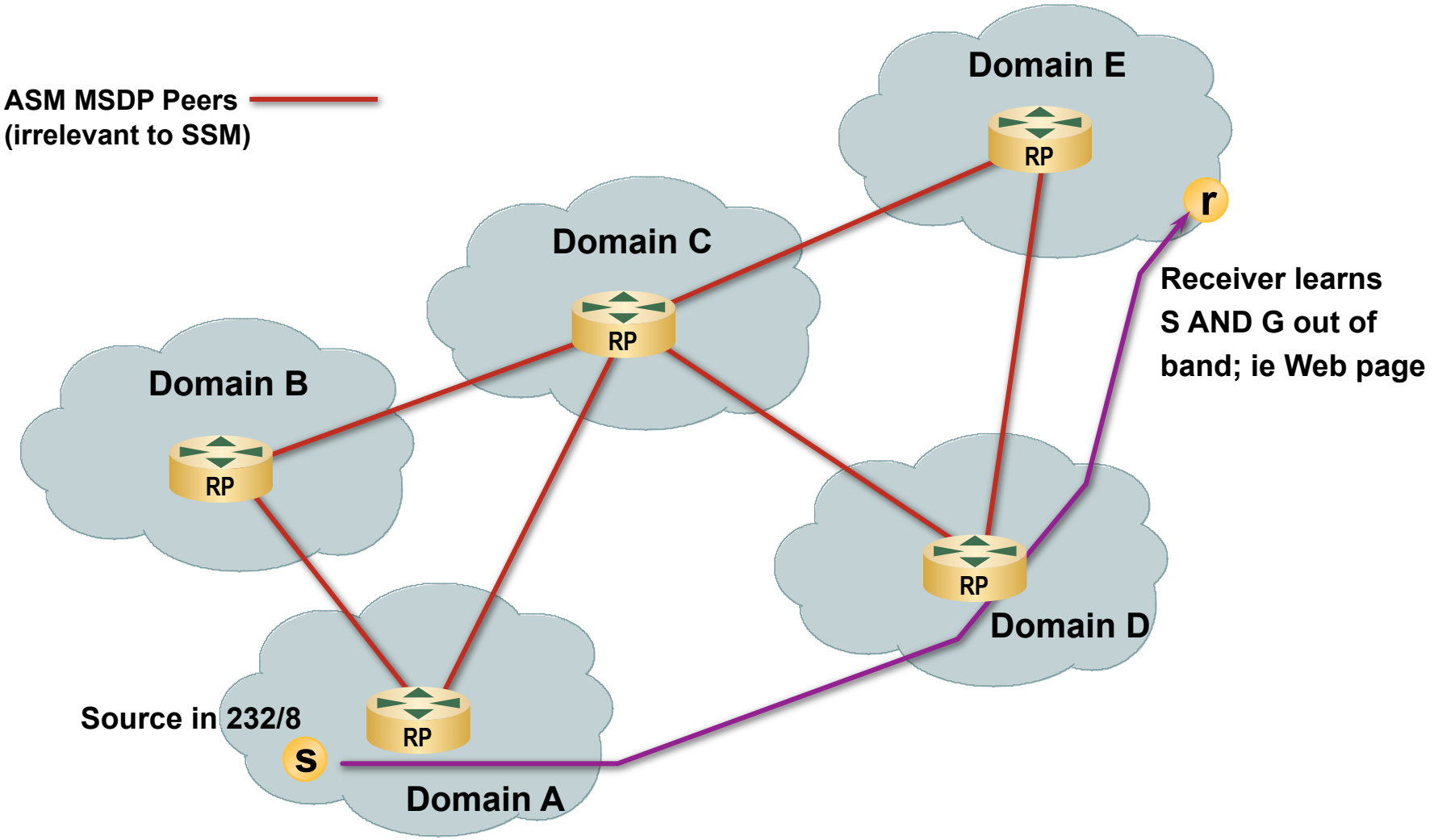
MSDP wrt SSM – Unnecessary!



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LAB #2
Interdomain Multicast

- Do not launch lab until instructred to do so.
- Lab templates or cfgs: Interdomain-Multicast
- Refer to your lab handout

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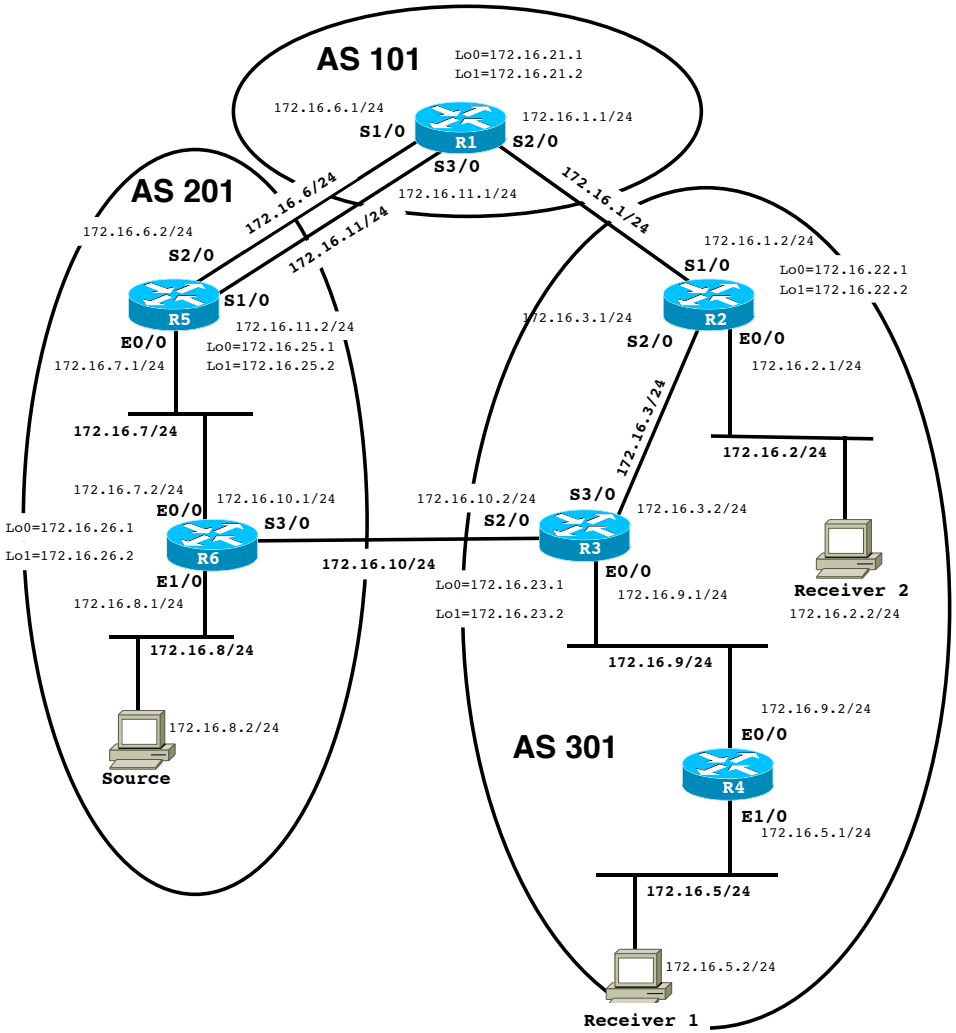
LAB #2
Interdomain Multicast



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Agenda

- Introduction
- Multicast addressing
- Group Membership Protocol
- PIM-SM / SSM
- MSDP
- MBGP
- **Summary**

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The Soup

- **IGMP** - Internet Group Management Protocol is used by hosts and routers to tell each other about group membership.
- **PIM-SM** - Protocol Independent Multicast-Sparse Mode is used to propagate forwarding state between routers.
- **SSM** - Source Specific Multicast utilizes a subset of PIM's functionality to guaranty source-only trees in the 232/8 range.
- **MBGP** - Multiprotocol Border Gateway Protocol is used to exchange routing information for interdomain RPF checking.
- **MSDP** - Multicast Source Discovery Protocol is used to exchange ASM active source information between RPs.

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Multicast Transit Design Objectives

- **PIM Border Constraints**
  - Confine registers within domain
  - Confine local groups
  - Confine RP announcements
  - Control SA advertisements via MSDP
- **Border RPF check**
  - RPF check against unicast routes to multicast sources
- **MSDP RPF check**
  - RPF check toward RP in received SAs

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Internet IPMulticast

What worked?

What didn’t work?

What’s being done to fix it?

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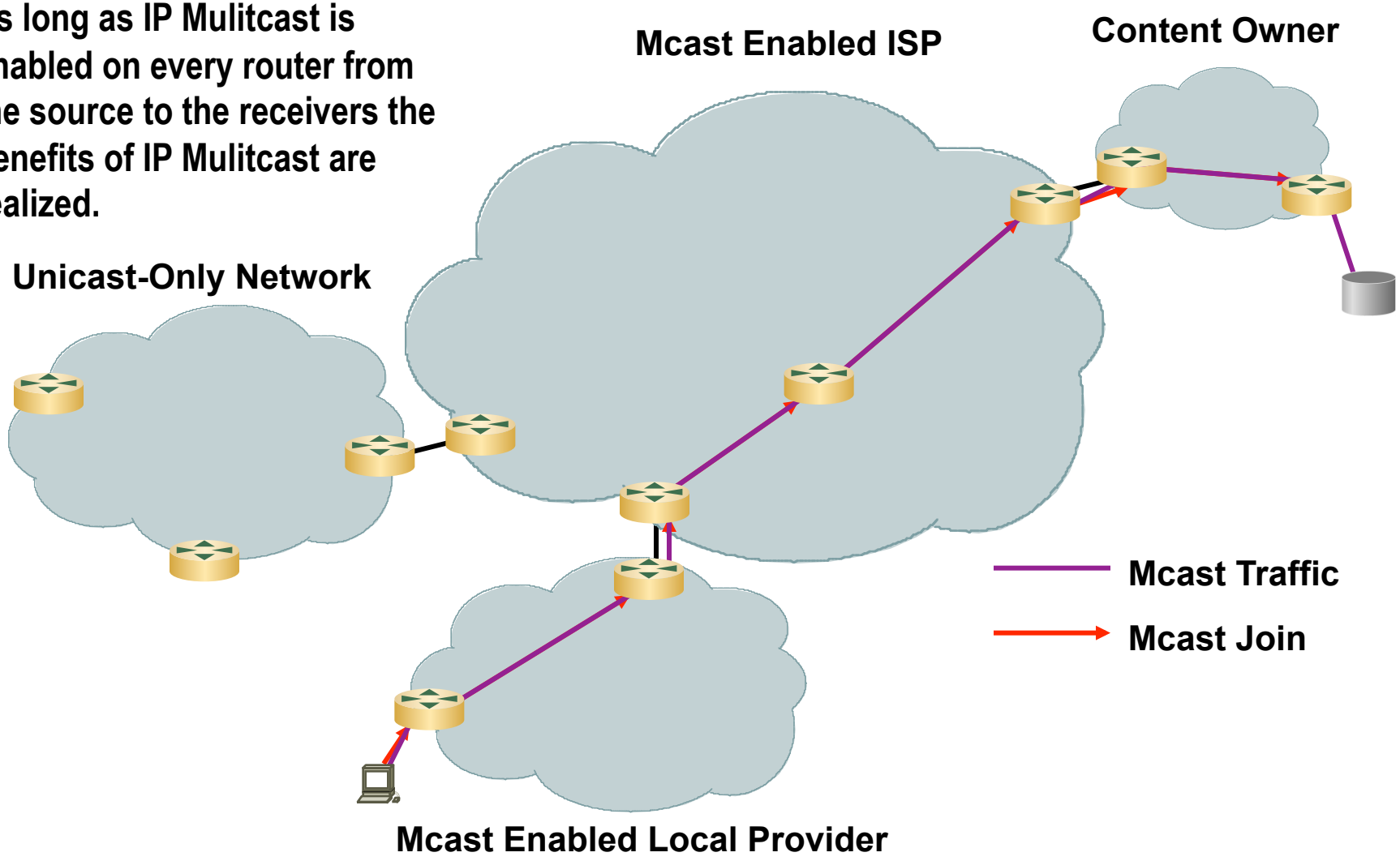
What Worked?

As long as IP Mulitcast is enabled on every router from the source to the receivers the benefits of IP Mulitcast are realized.



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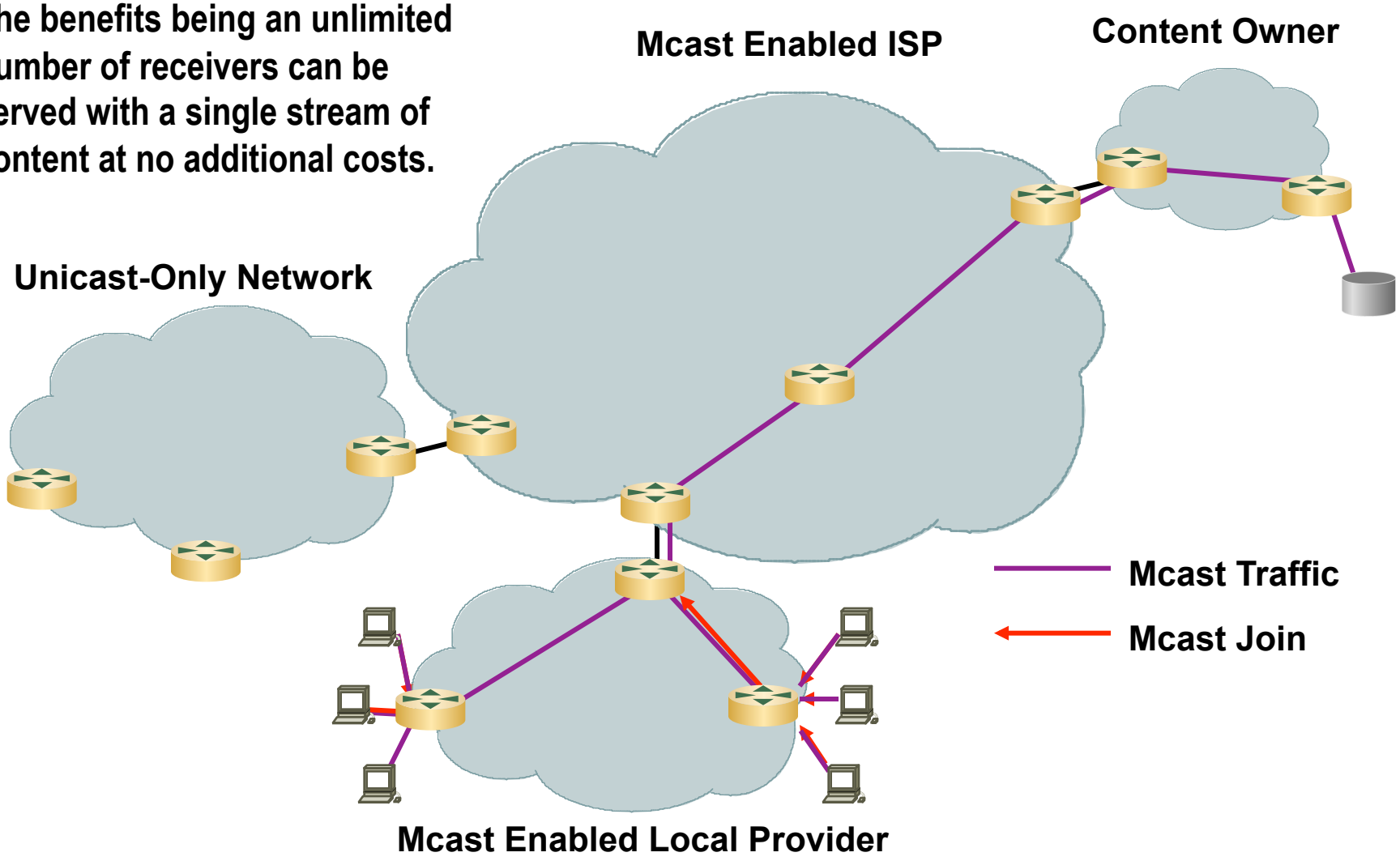
What Worked?

The benefits being an unlimited number of receivers can be served with a single stream of content at no additional costs.



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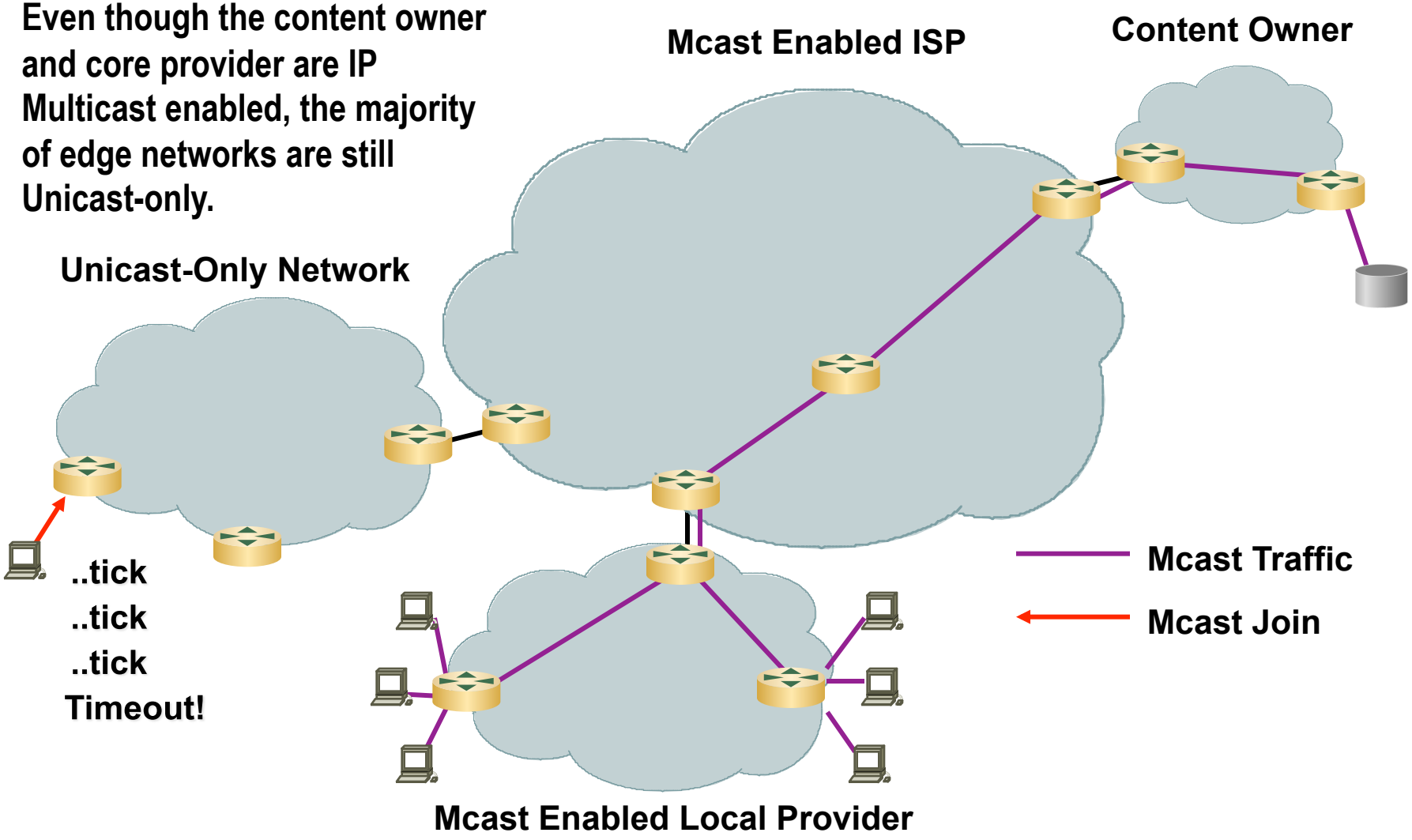
What Didn't?

Even though the content owner and core provider are IP Multicast enabled, the majority of edge networks are still Unicast-only.



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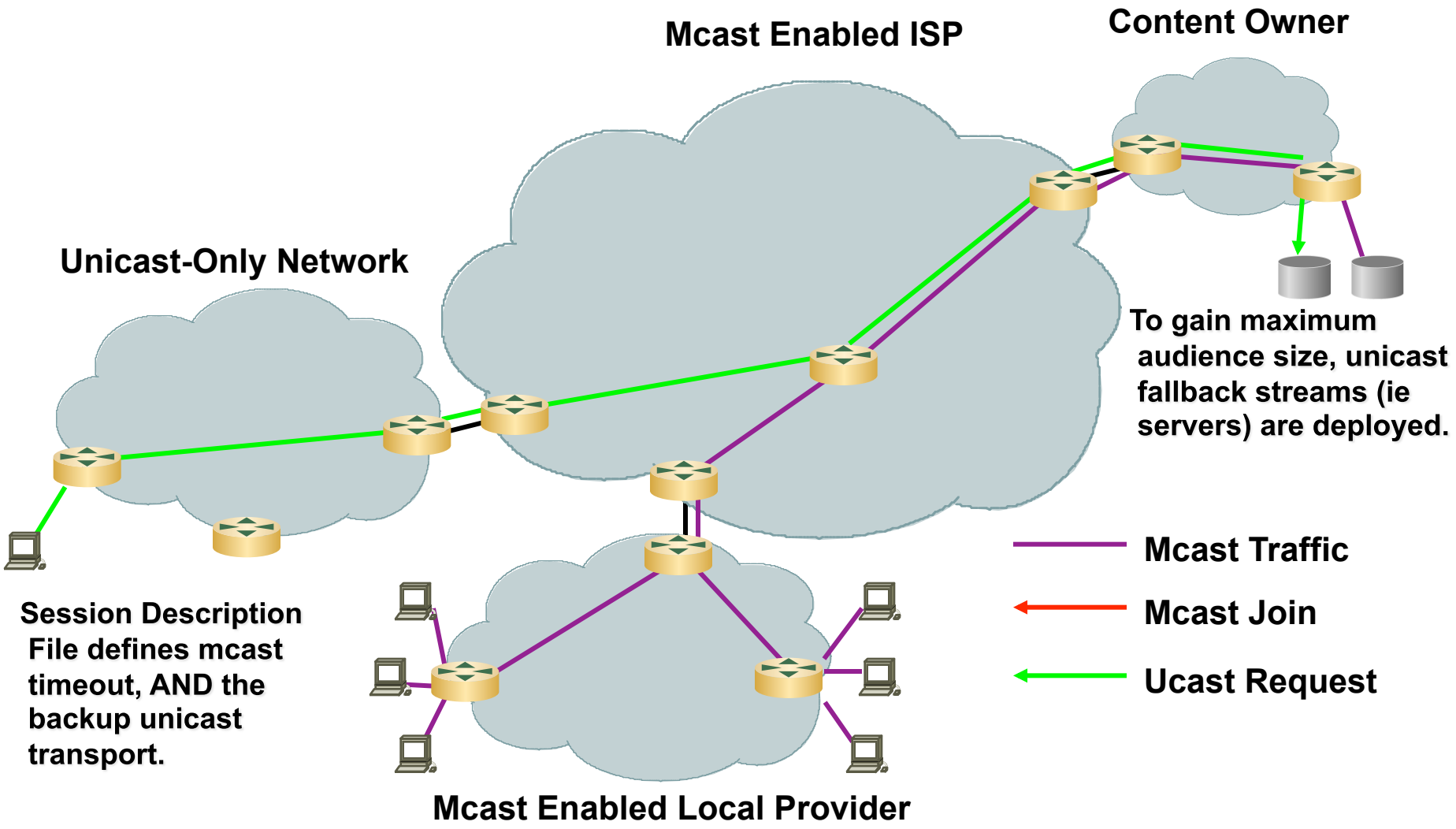
What Didn't?



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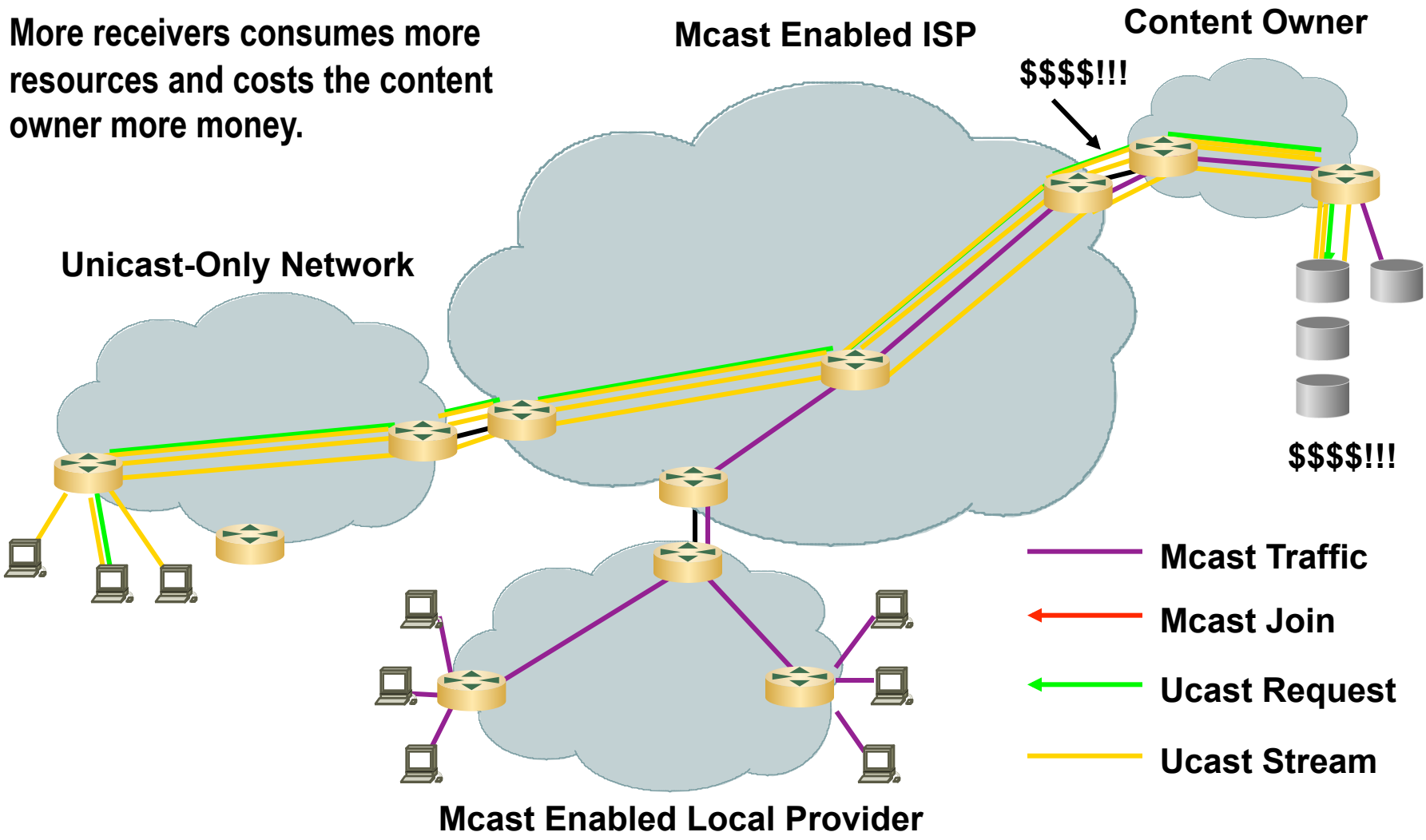
What Didn't?

More receivers consumes more resources and costs the content owner more money.



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What's Wrong?

- **Multicast in the Internet is an all-or-nothing solution**
  - **Each receiver must be on an IP Multicast enabled path.**
  - **Many core networks have IP Multicast enabled - but few edge networks do.**
- **Even Mcast-aware content owners are forced to provide unicast streams to gain audience size**
- **Unicast will never scale for streaming content**
  - **Splitters/Caches just distribute the problem**
    - **Still has a cost-per-user**
  - **As receiver BW increases, problem gets worse.**
  - **Creates a non-functional business model**
  - **Will never bring rich content to IP.**

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But multicast is being deployed, right?

- **Edge (eyeball) Networks**
  - **Locally injected video content only**
  - **No external multicast peering**
  - **Mostly large established business models**
    - **Affiliate content monopoly**
    - **Cisco's primary efforts are focused at preserving these models**
- **Externally Sourced Video - Over The Top Video**
  - **Think Content Owner (not provider)**
  - **Established owners understand the benefits of mcast/bcast model**
  - **Newcomers need the benefits of mcast to compete**
  - **Mcast/ucast dynamic edge transition (AMT)**

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AMT
Automatic Multicast Tunneling

- **Automatic IP Multicast without explicit Tunnels**

  http://www.ietf.org/internet-drafts/draft-ietf-mboned-auto-multicast-05.txt

- **Allow multicast content distribution to extend to unicast-only connected receivers.**

  Bring the flat scaling properties of multicast to the Internet

- **Provide the benefits of multicast wherever multicast is deployed.**

  Let the networks which have deployed multicast benefit from their deployment.

- **Work seamlessly with existing applications**

  No OS kernel changes

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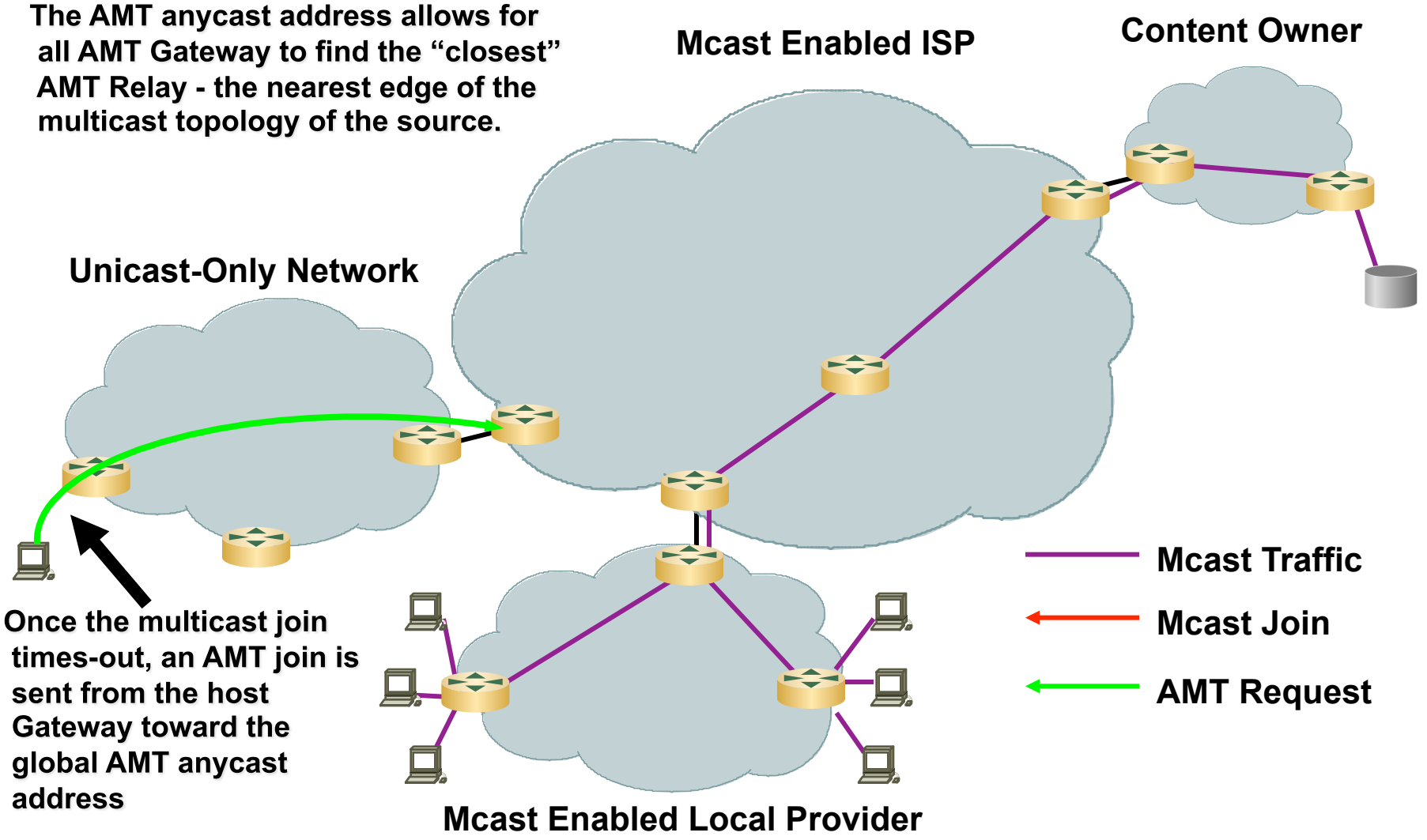
AMT
Automatic Multicast Tunneling

The AMT anycast address allows for all AMT Gateway to find the "closest" AMT Relay - the nearest edge of the multicast topology of the source.



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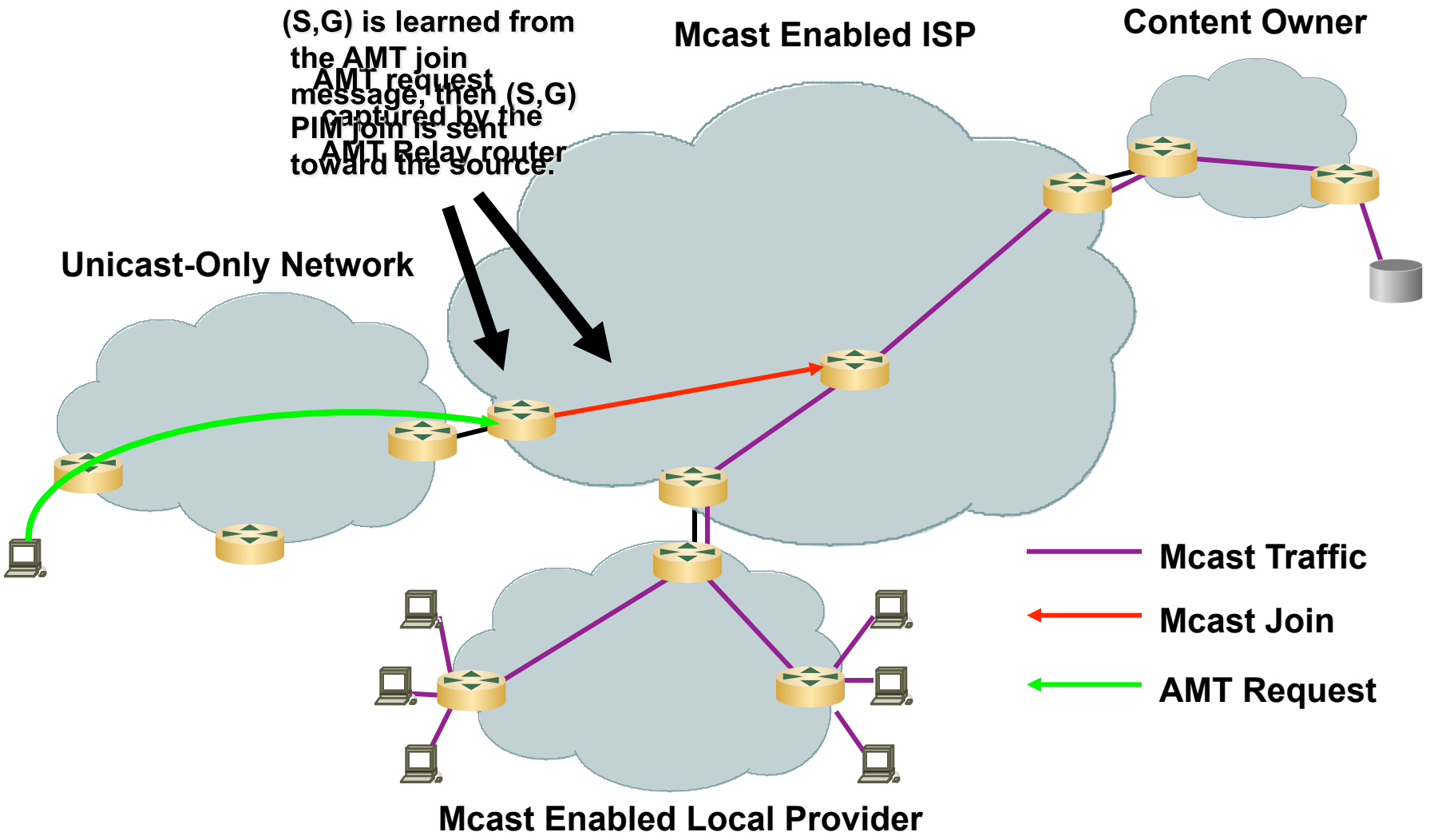
AMT
Automatic Multicast Tunneling



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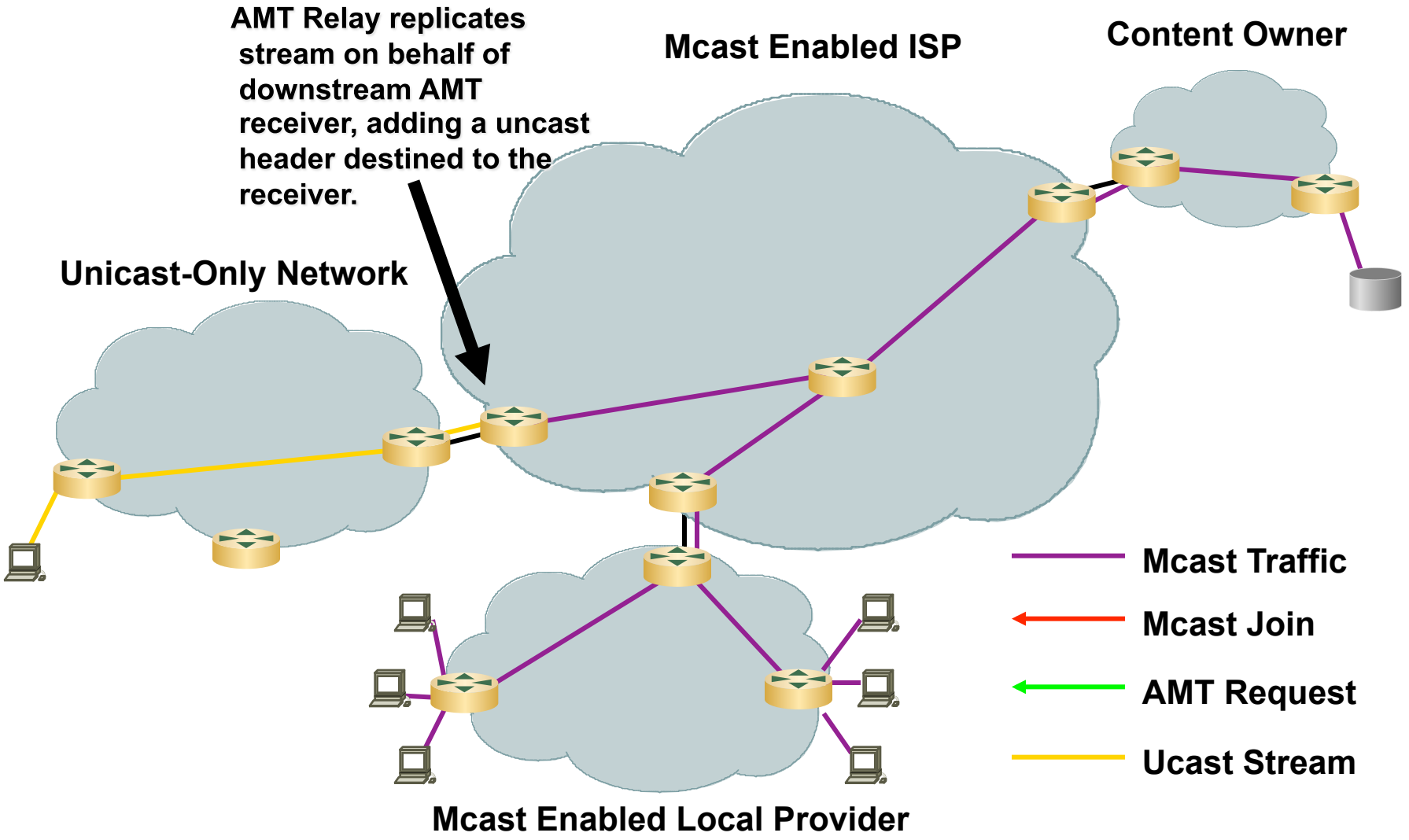
AMT
Automatic Multicast Tunneling



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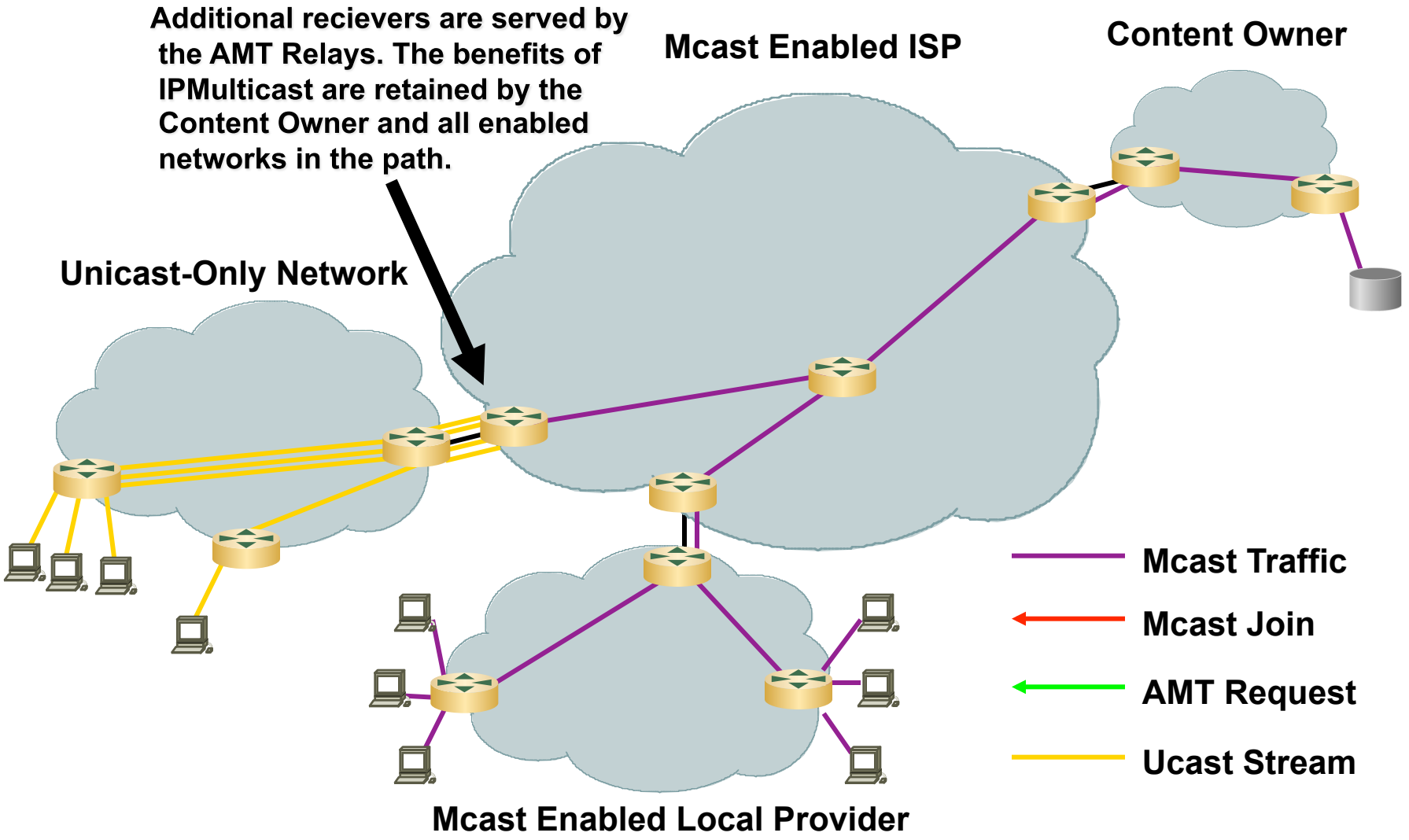
AMT
Automatic Multicast Tunneling



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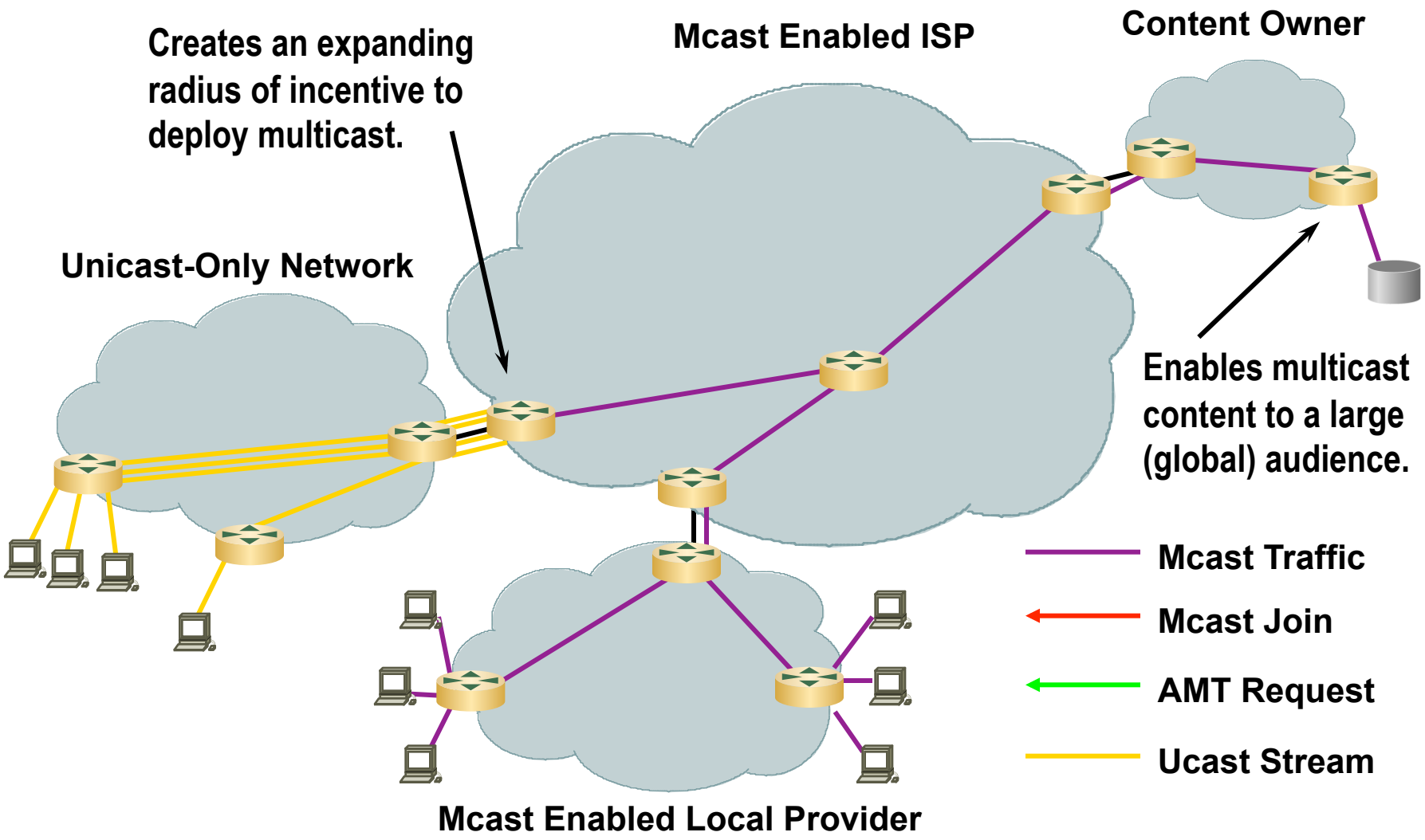
AMT
Automatic Multicast Tunneling



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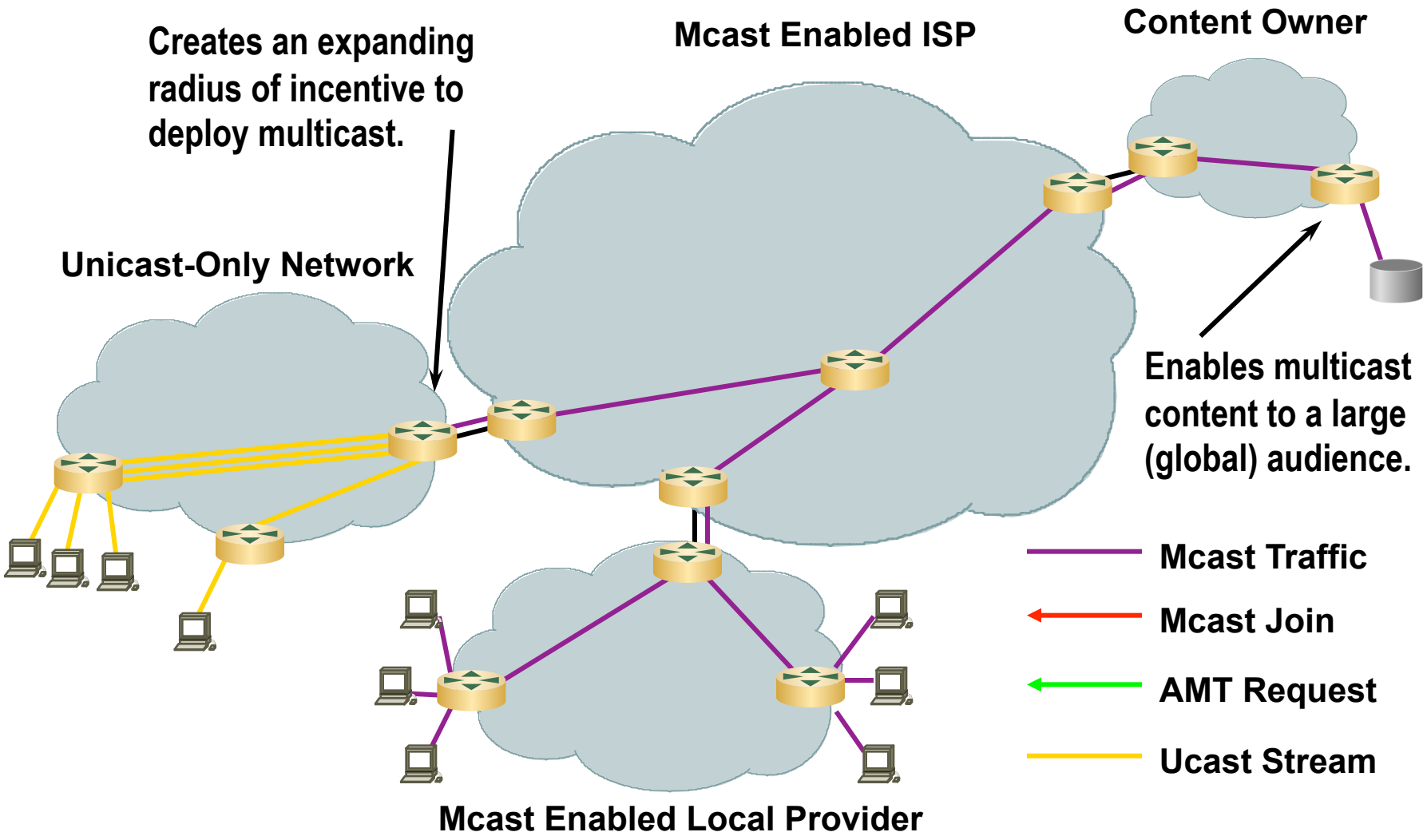
AMT
Automatic Multicast Tunneling



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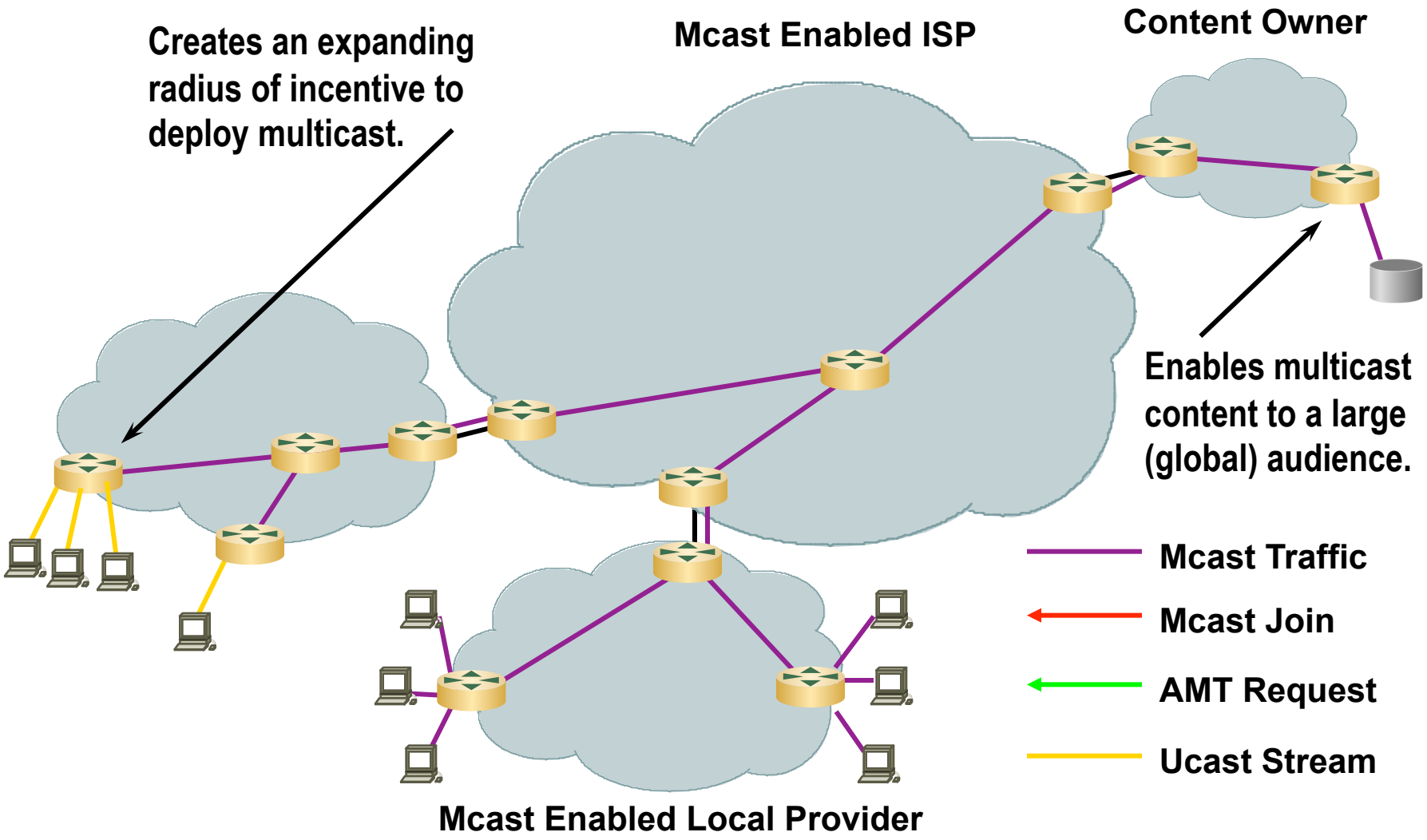
AMT
Automatic Multicast Tunneling



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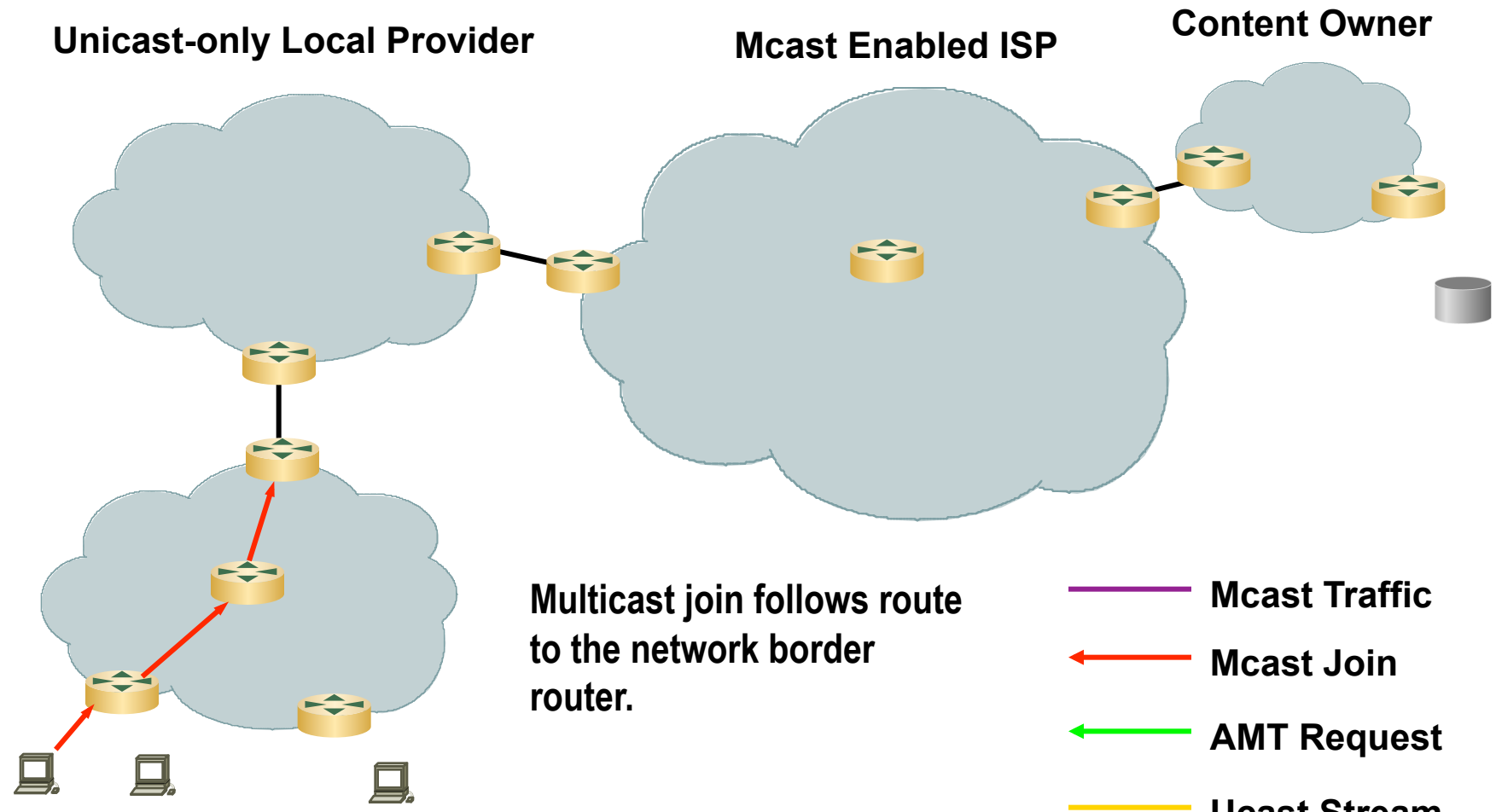
AMT
Connecting Multicast Islands



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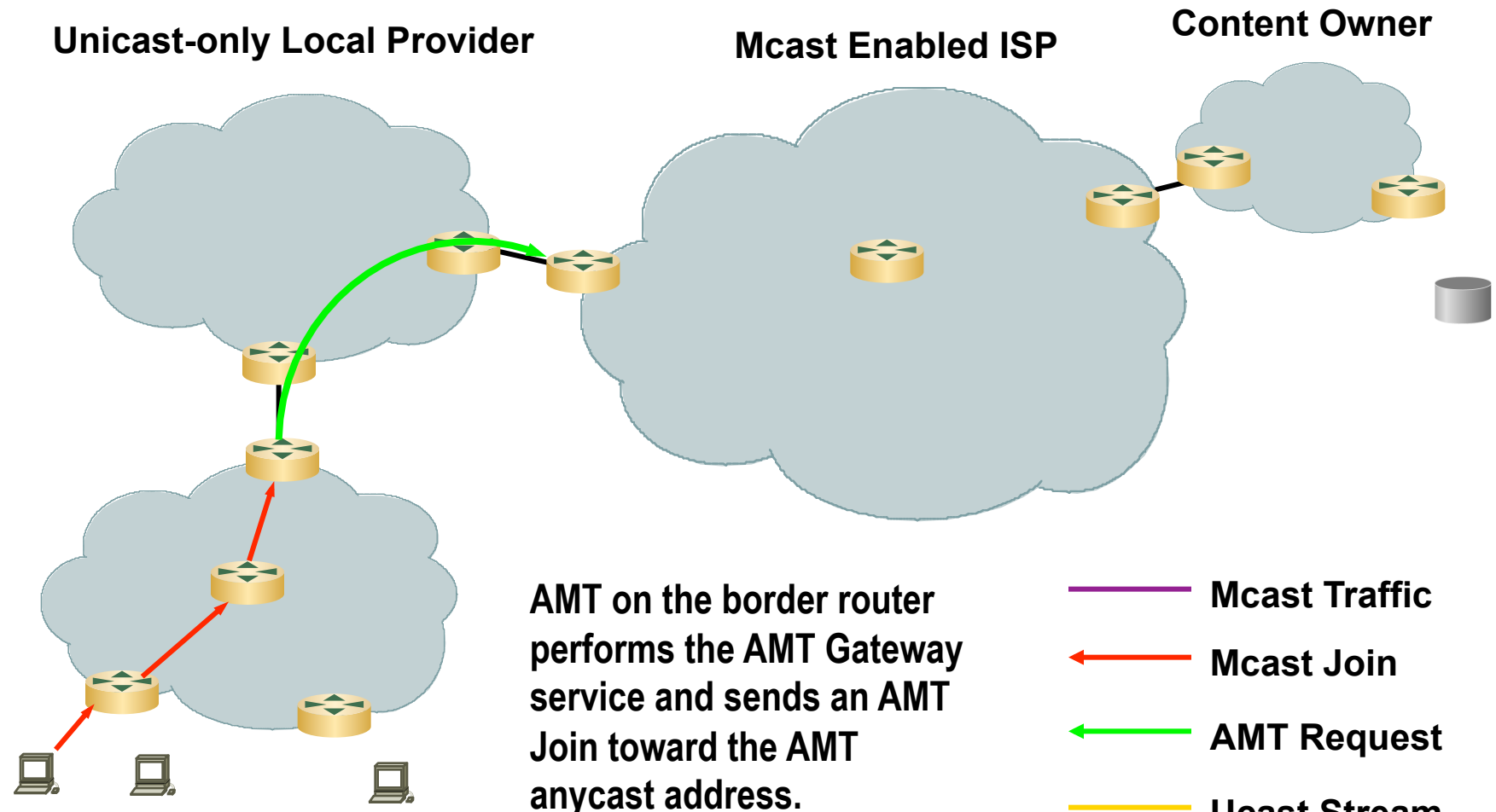
AMT
Connecting Multicast Islands



AMT on the border router performs the AMT Gateway service and sends an AMT Join toward the AMT anycast address.

- Mcast Traffic
- Mcast Join
- AMT Request
- Ucast Stream

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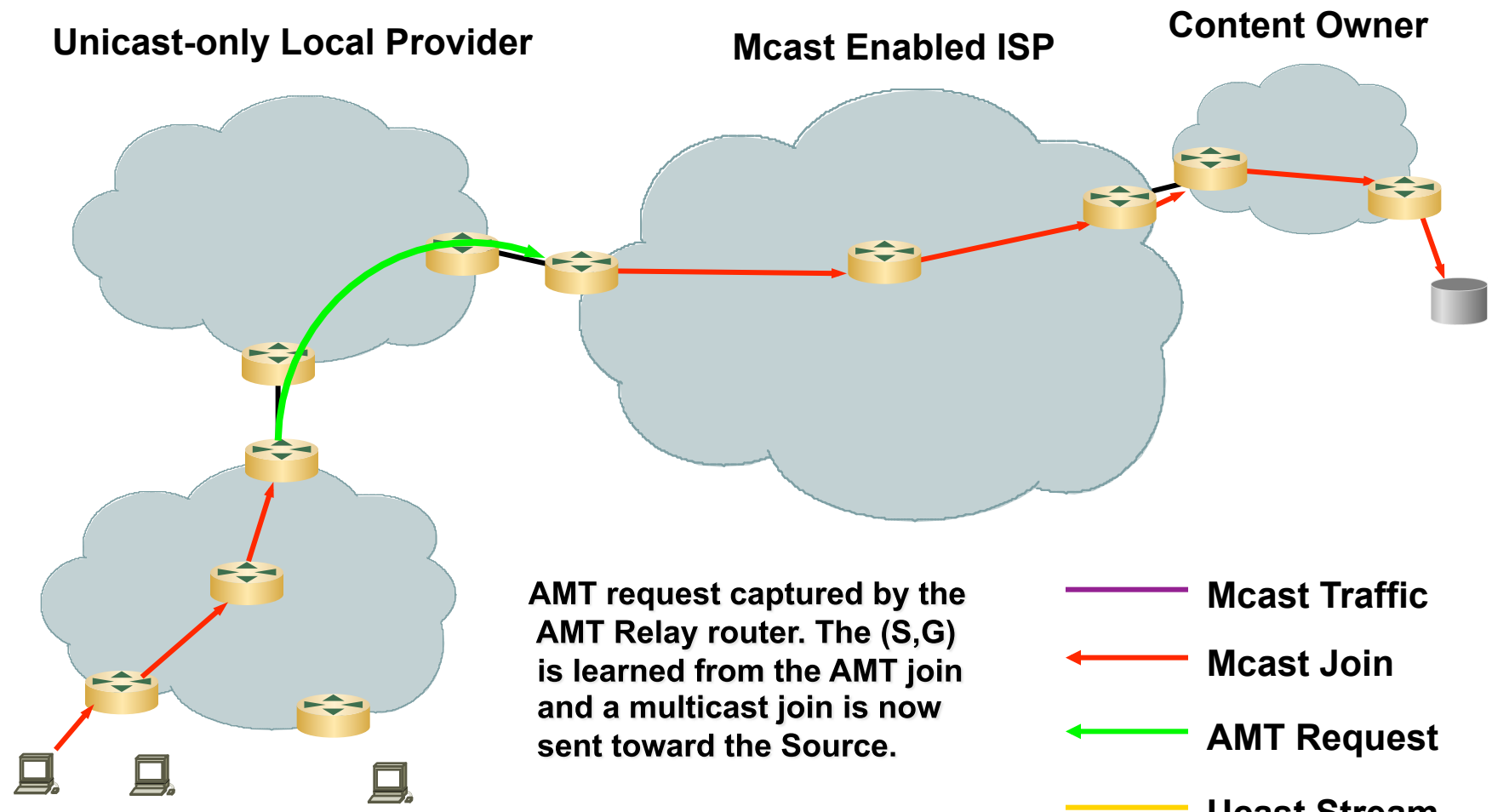
AMT
Connecting Multicast Islands



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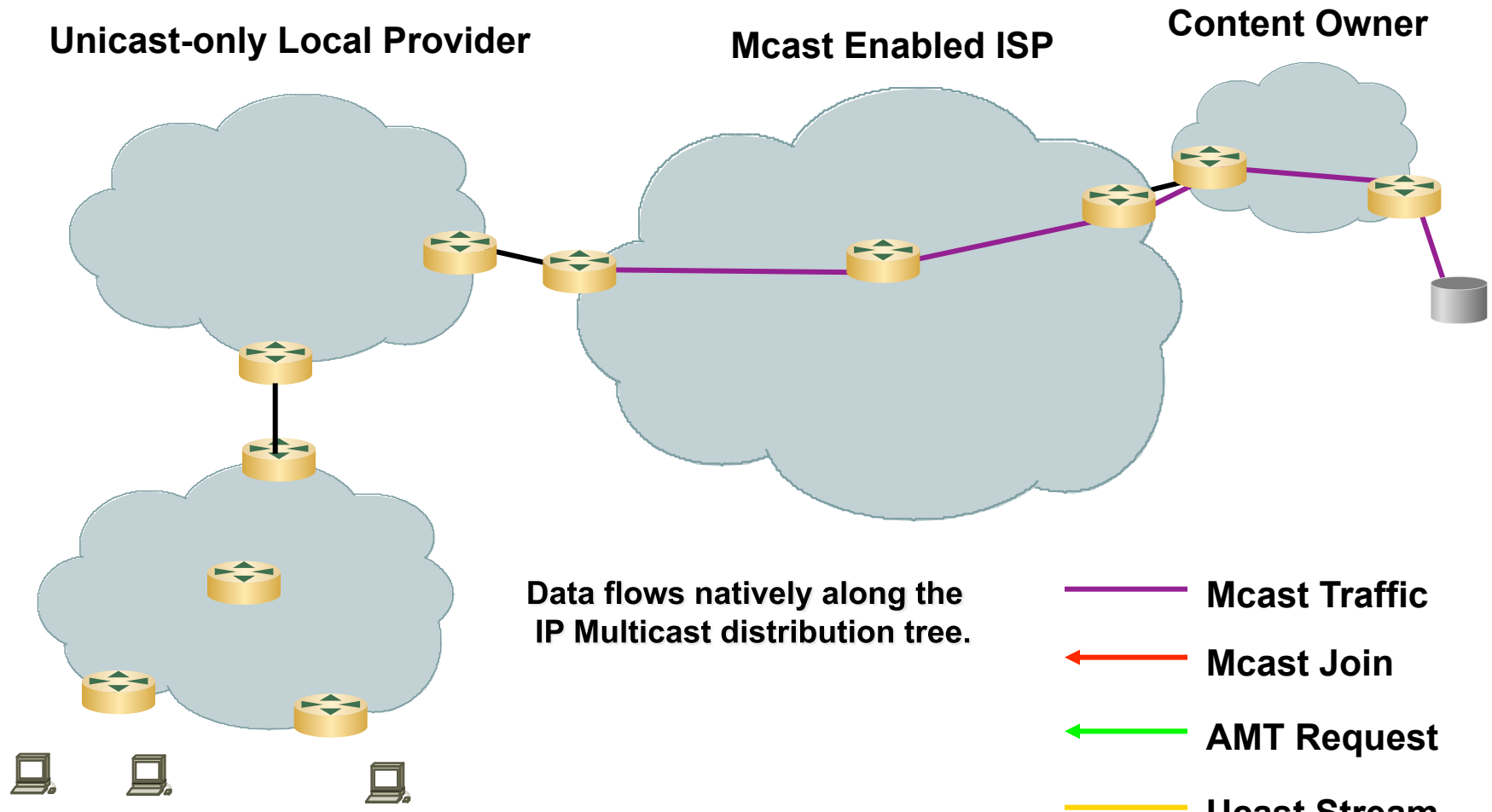
AMT
Connecting Multicast Islands



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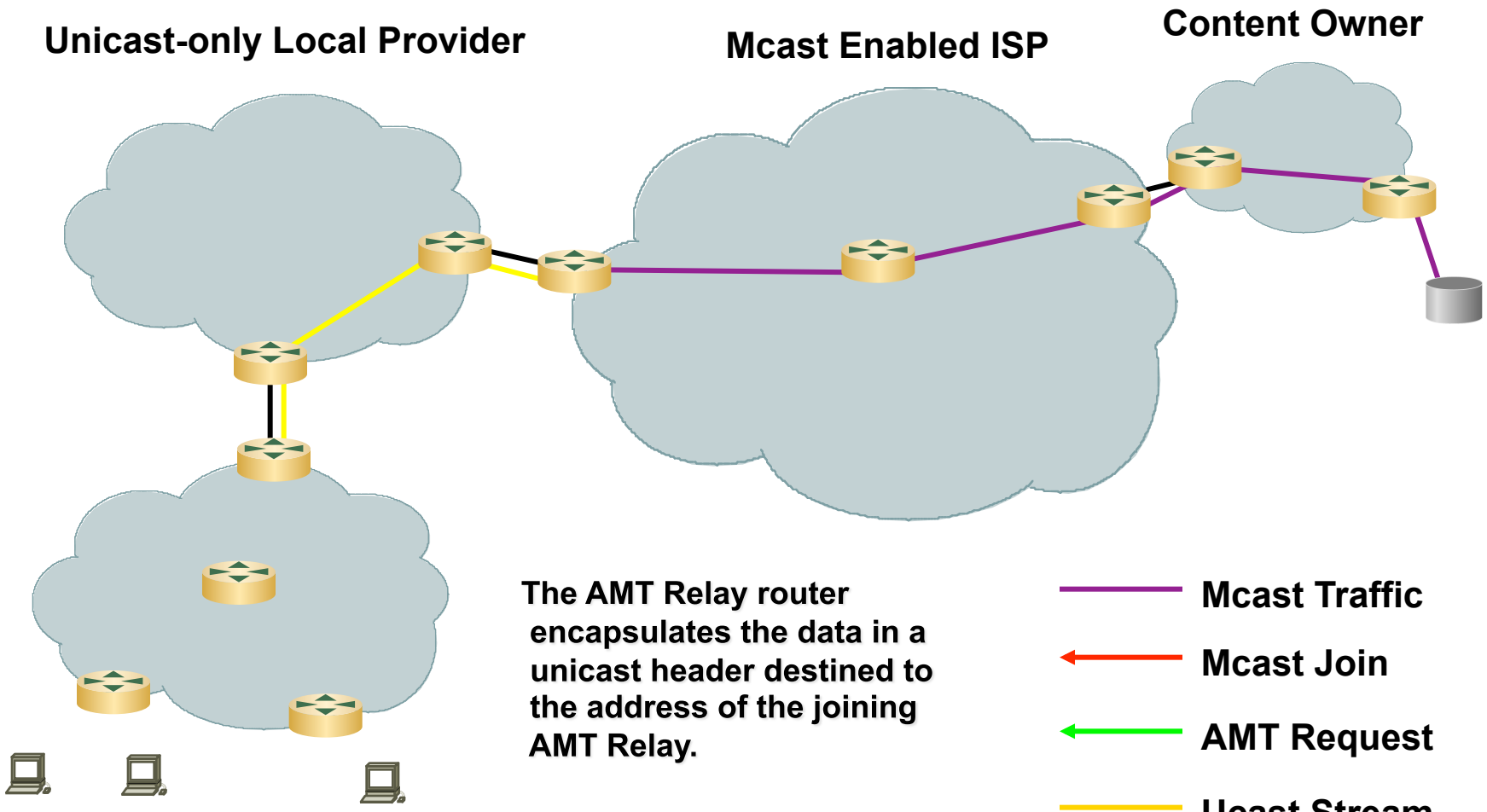
AMT
Connecting Multicast Islands



The AMT Relay router encapsulates the data in a unicast header destined to the address of the joining AMT Relay.

Mcast Traffic

Mcast Join

AMT Request

Ucast Stream

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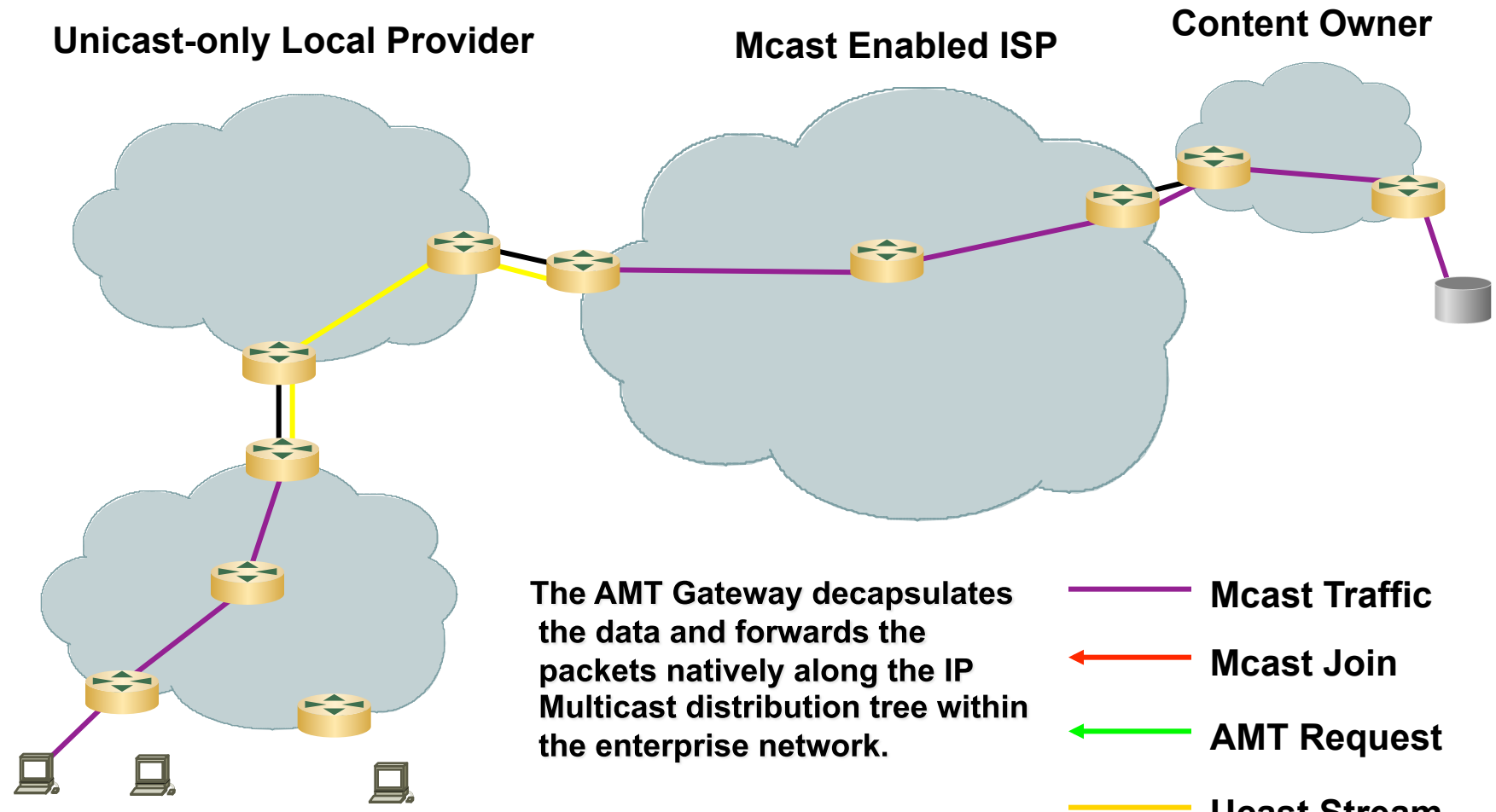
AMT
Connecting Multicast Islands



The AMT Gateway decapsulates the data and forwards the packets natively along the IP Multicast distribution tree within the enterprise network.

- Mcast Traffic
- Mcast Join
- AMT Request
- Ucast Stream

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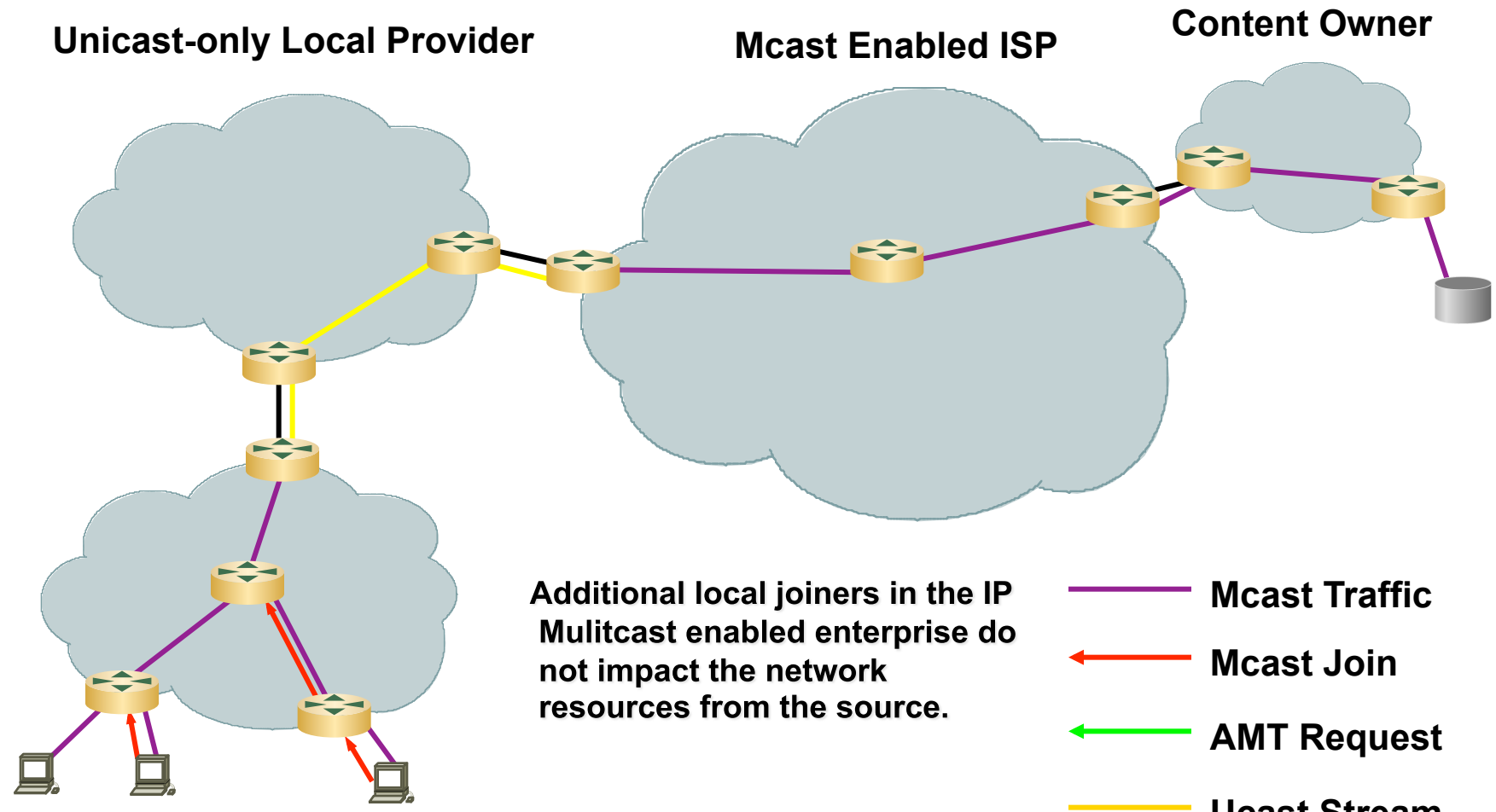
AMT
Connecting Multicast Islands



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Multicast Myths

- **It's too hard / to complicated**

  It's being used today in many mission-critical applications with success.

  It just hasn't been a requirement (yet) for many people

- **Provider – "If multicast catches on, my customers will stop buying big circuits."**

  Wrong (next slide)

- **Vendor – "If multicast catches on, no one will need big routers and high-speed interfaces."**

  Wrong (next slide)

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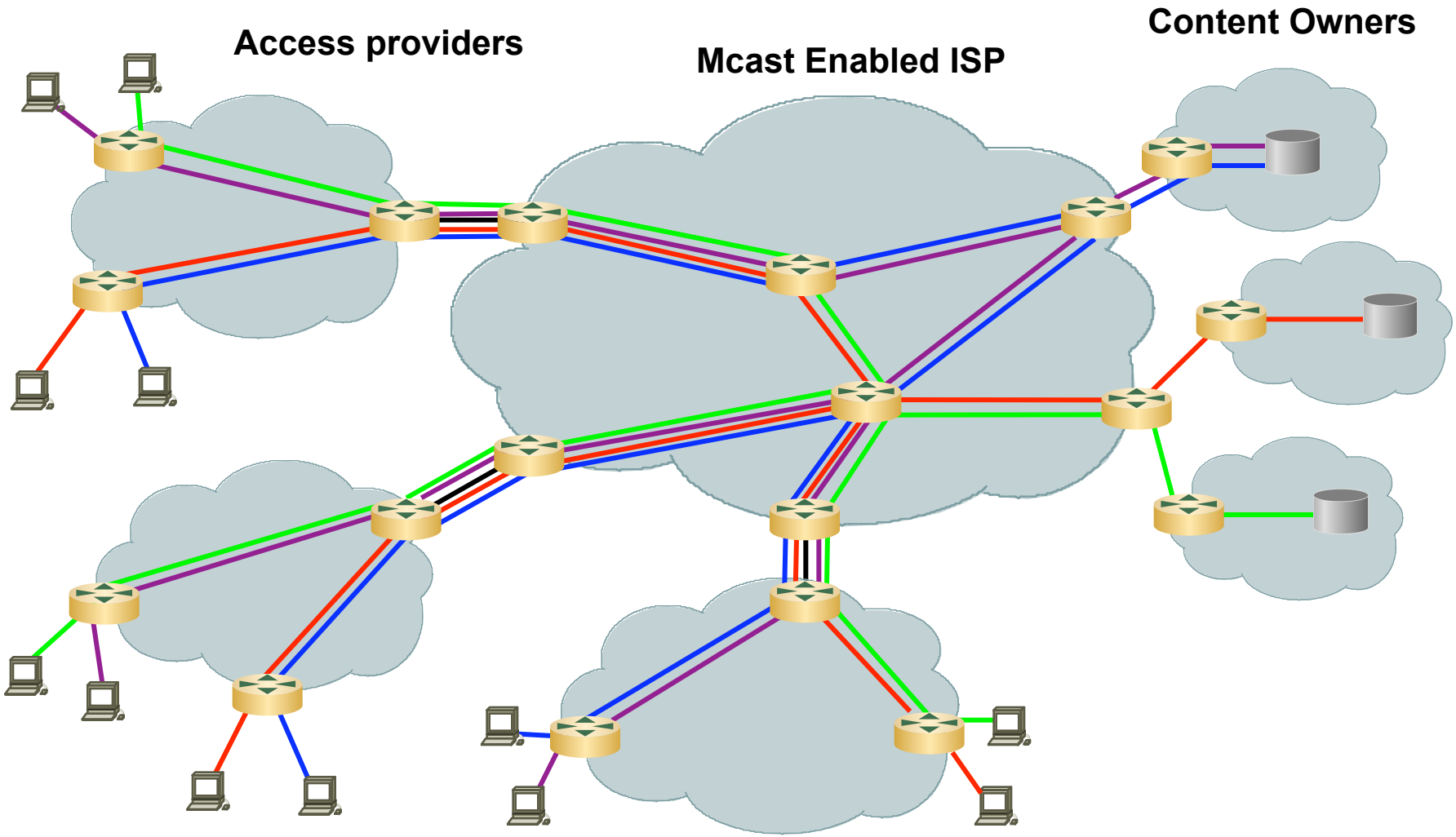
When the world deploys IPMulticast



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When the world deploys IPMulticast

- A successful multicast business model makes IP profitable for content owners
  - Success brings MORE content
    - Higher bit-rate
    - More channels
- Access networks of tomorrow look like provider networks of today
  - Few large circuits upstream, many small circuits downstream.
    - (see previous slide)
- Provider revenue model is inverted
  - Few small circuits (relative) from content networks, many large circuits down to access networks.
    - (see previous slide)

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THANK YOU!

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