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IP Multicast – Concepts, Design and Troubleshooting

BRKMPL-1261

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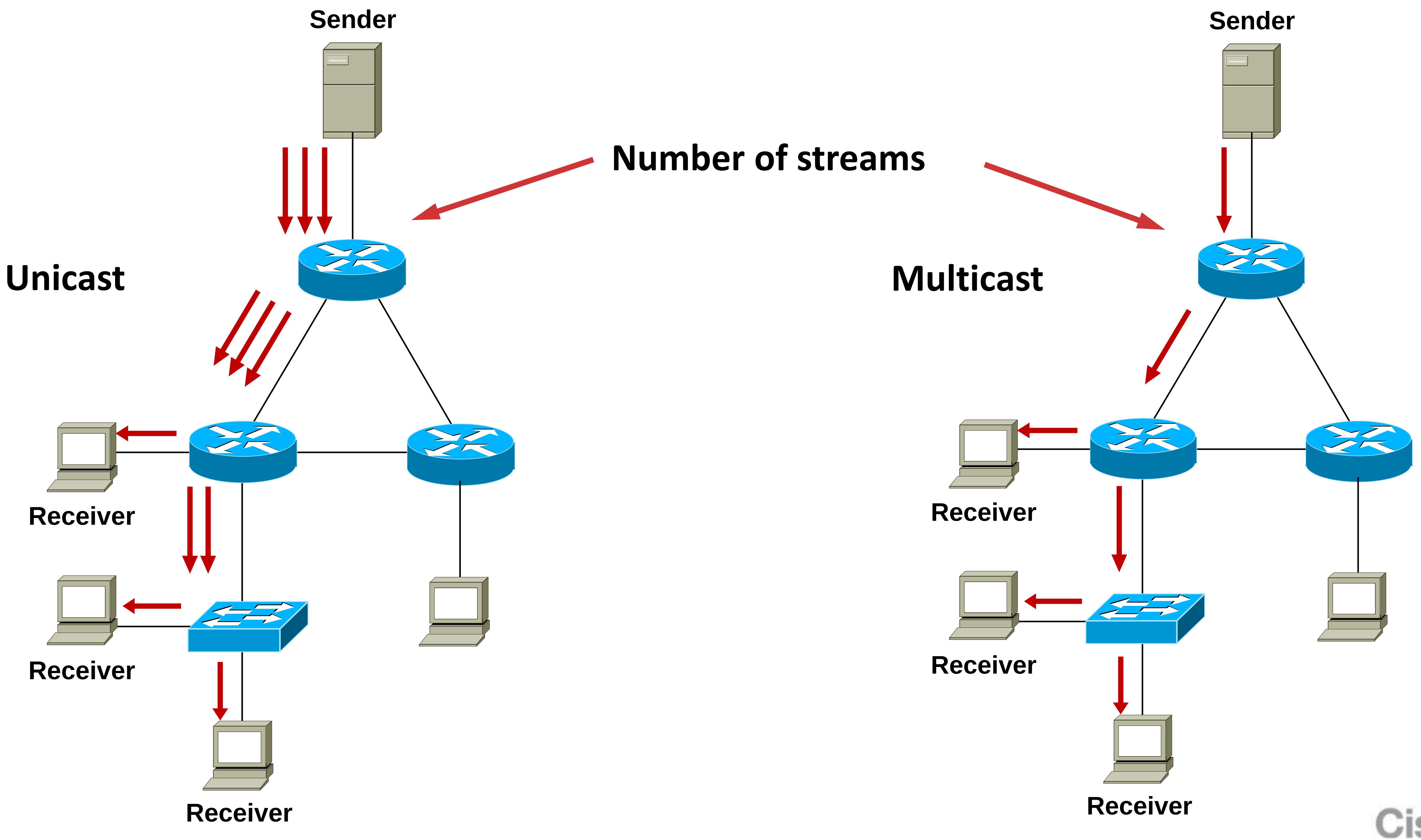
Agenda

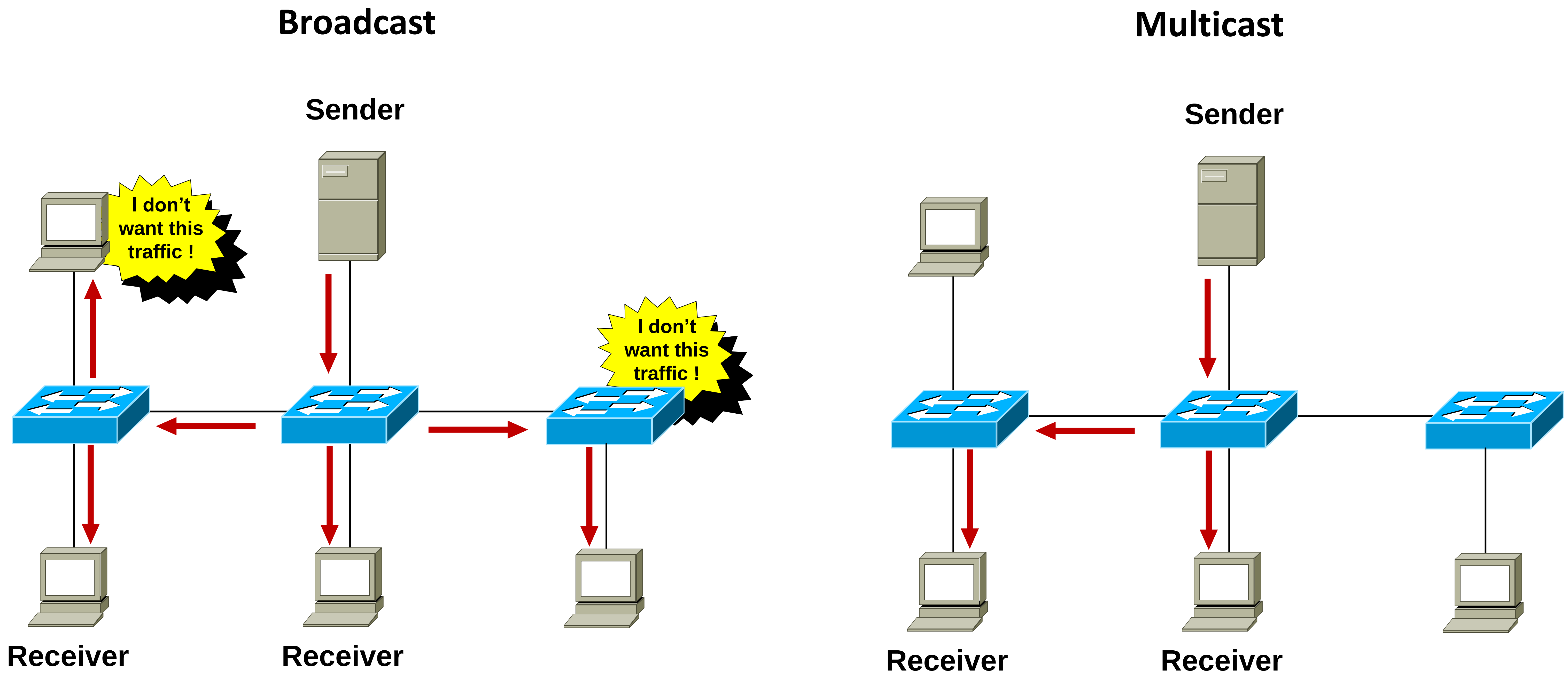
- Multicast overview
  - What is it and when would we use it ?
- Multicast fundamentals
  - Technical concepts and protocols
- Multicast Design and Configuration
  - 1 case study, 3 solutions
- Troubleshooting common multicast issues

Multicast Overview

Unicast Vs Multicast



Broadcast Vs Multicast



Multicast Uses

- Any situation where multiple endpoints need to receive identical information at the same time
  - Streaming video, IPTV
  - Music on hold
  - Data replication
  - Periodic data delivery - stock quotes, sports scores, news reports
- Most commonly used for one-to-many or some-to-many data flows

Multicast Advantages

- **Enhanced scalability:** Network utilisation is independent of the number of receivers
- **Reduced resource utilisation:** Controls network bandwidth and reduces server and router loads
- **Deterministic performance:** subscriber number 1 and subscriber number 10000 have identical experience

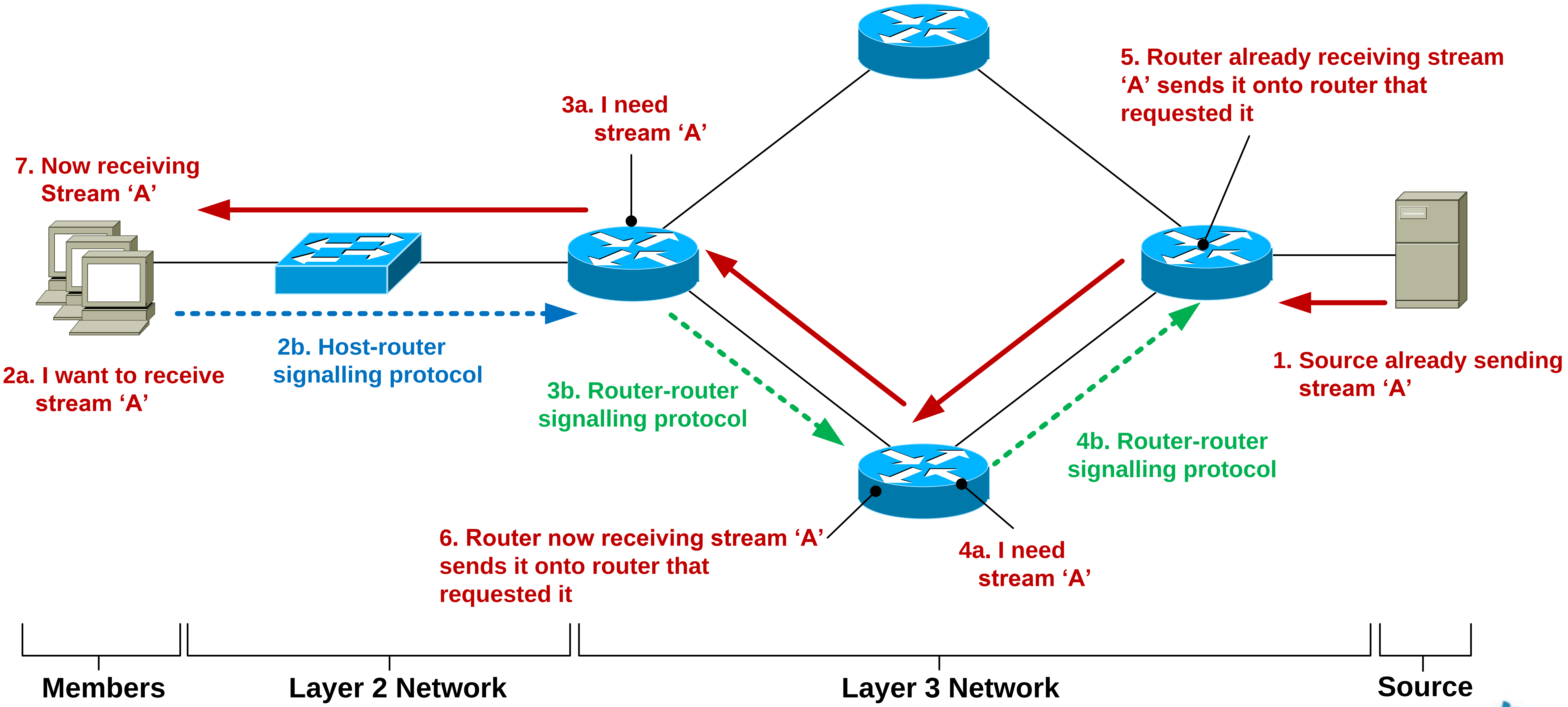
LOWER TCO

Multicast Considerations

- Multicast is UDP-based: No flow control, sequencing, error-correction, retransmissions.
- “Best effort” delivery: Sender has no idea if all subscribers have received the data. Subscribers don’t know if they have missed a packet. Applications should be handling missed packets.
- No congestion avoidance: Lack of TCP windowing and “slow-start” mechanisms may result in network congestions.
- Added Complexity: If you have the bandwidth available then unicast delivery model may be a simpler option.

Multicast Fundamentals

Multicast Service Model Overview



IP Multicast Source

- Any device that sends an IP packet with a destination address between 224.0.0.0 – 239.255.255.255
- A device can be a multicast sender and a multicast receiver at the same time
- There is no multicast control traffic between the sender and the network, or between the sender and receiver.

Q. So how does the source know when to send traffic ?

A. An application tells the source to start transmitting.

Multicast Addressing—224/4

- IANA Reserved addresses (never use these !)

224.0.0.0 – 224.0.0.255	Local network control block
224.0.1.0 – 224.0.1.255	Internetwork control block

- Other IANA allocated address ranges

232.0.0.0 – 232.255.255.255	Source Specific Multicast
233.0.0.0 – 234.255.255.255	GLOP/UBM Addressing
239.0.0.0 – 239.255.255.255	‘Private’ multicast range

- Check http://www.iana.org/assignments/multicast-addresses/multicast-addresses.xml

Multicast Addressing

Be Aware of the 32:1 Address Overlap for L3-L2 address mapping

32–IP Multicast Addresses

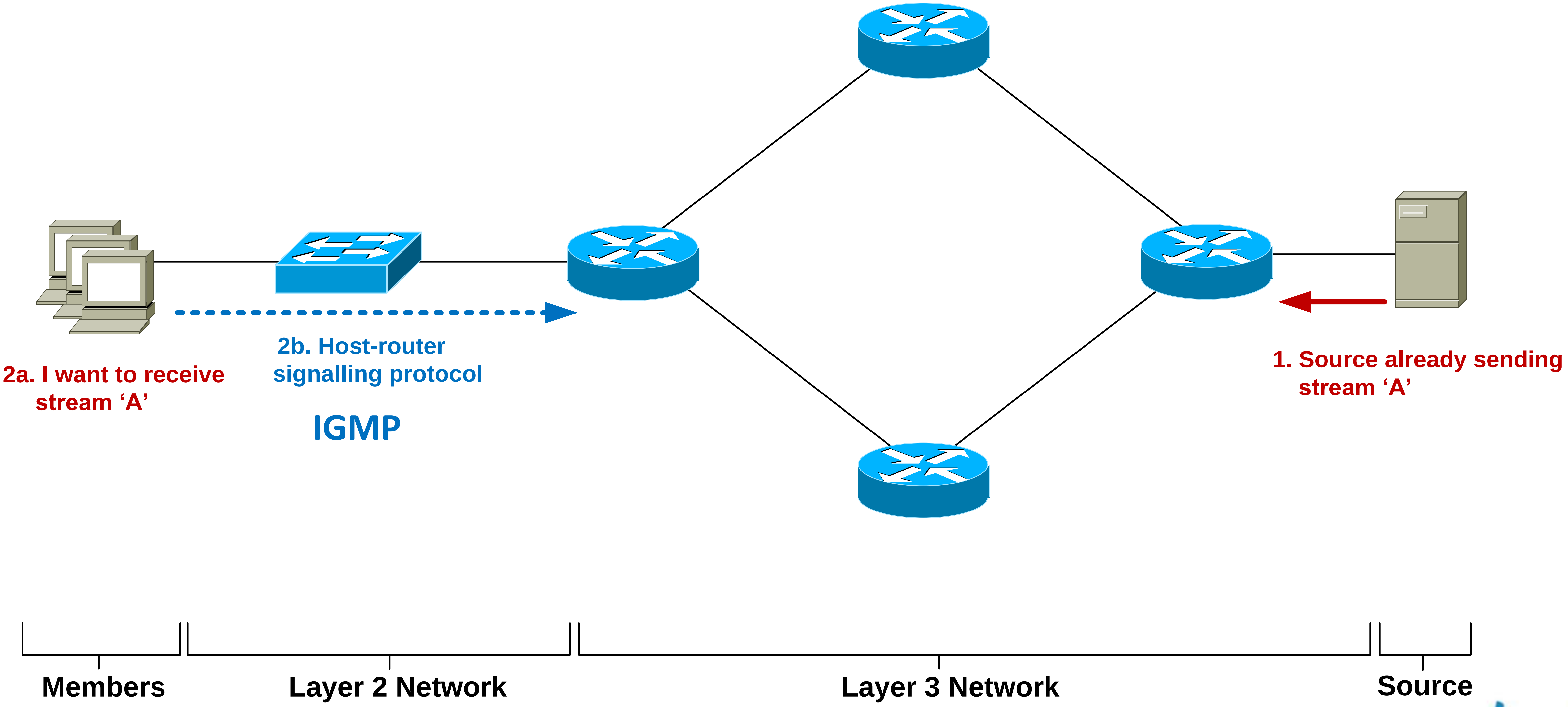
224.1.1.1
224.129.1.1
225.1.1.1
225.129.1.1
.
.
.
238.1.1.1
238.129.1.1
239.1.1.1
239.129.1.1

1–Multicast MAC Address

0x0100.5E01.0101

http://www.cisco.com/en/US/tech/tk828/technologies_white_paper09186a00802d4643.shtml

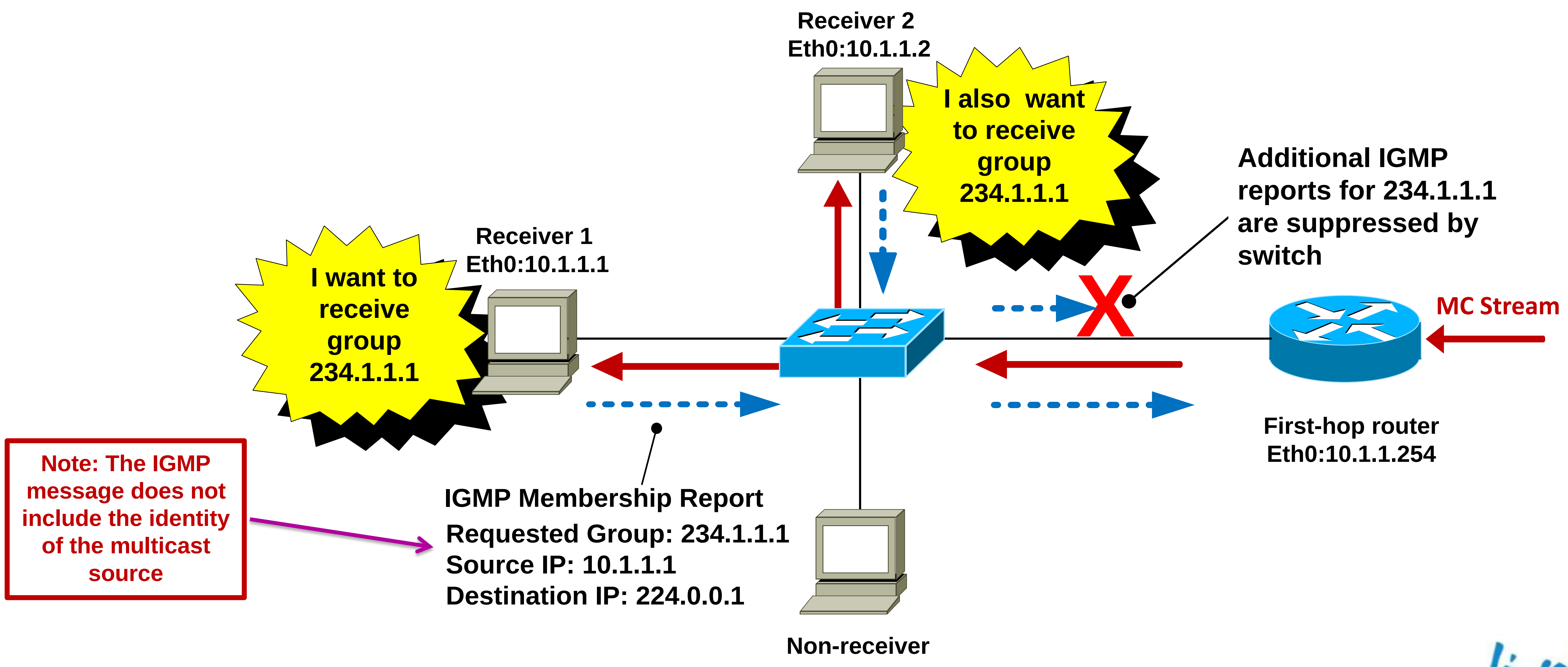
Multicast Service Model Overview – Layer 2



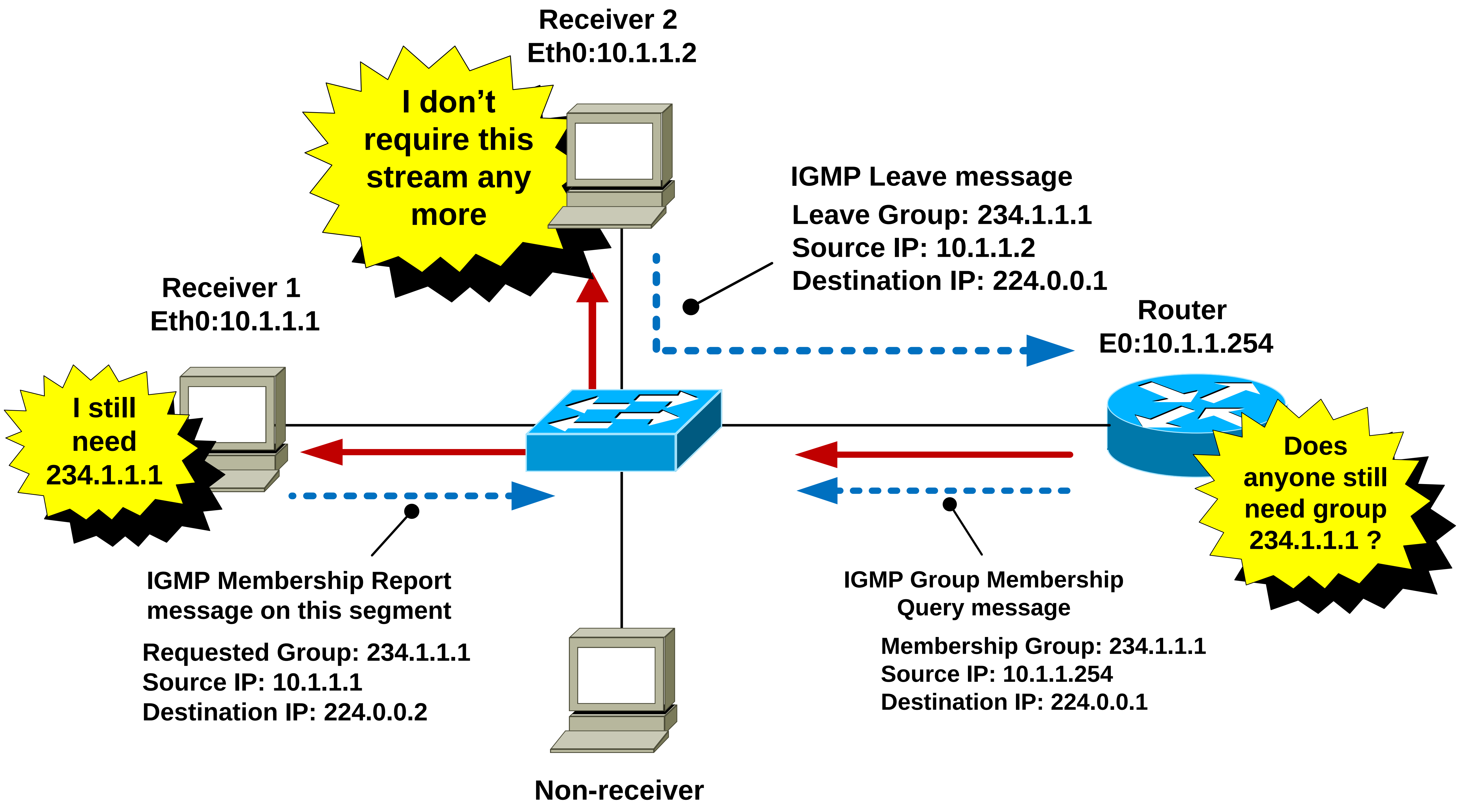
Host-Router Signalling: IGMP

- **I**nternet **G**roup **M**anagement **P**rotocol
- Used by a **host** to notify the local **router** that it wishes to receive (or stop receiving) multicast traffic for a given destination address or “group”.
- RFC 2236 specifies version 2 of IGMP
  - Most widely deployed and supported
- RFC 3376 specifies version 3 of IGMP
  - Good network support but host implementations still patchy

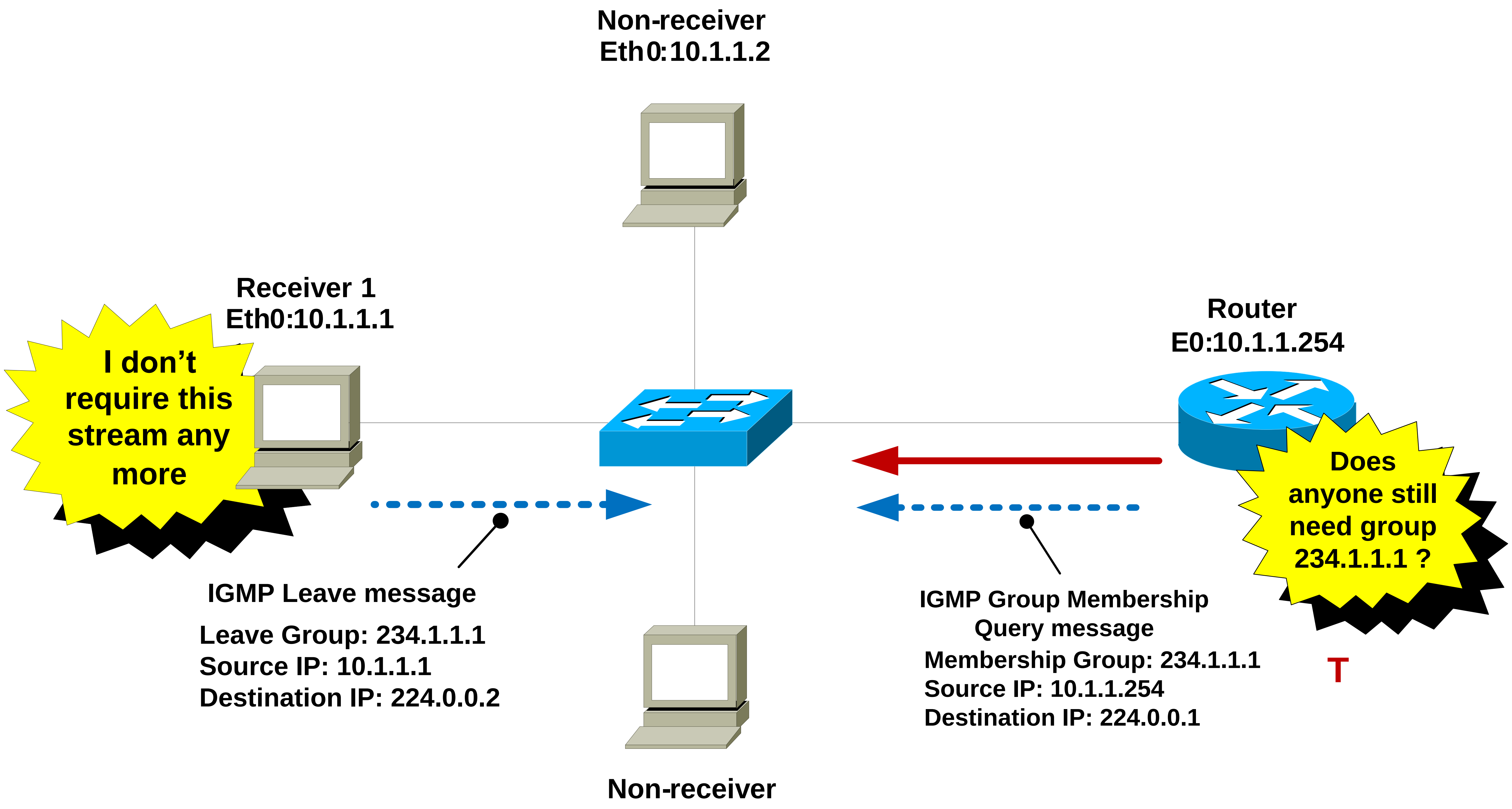
IGMPv2 – Joining a Group



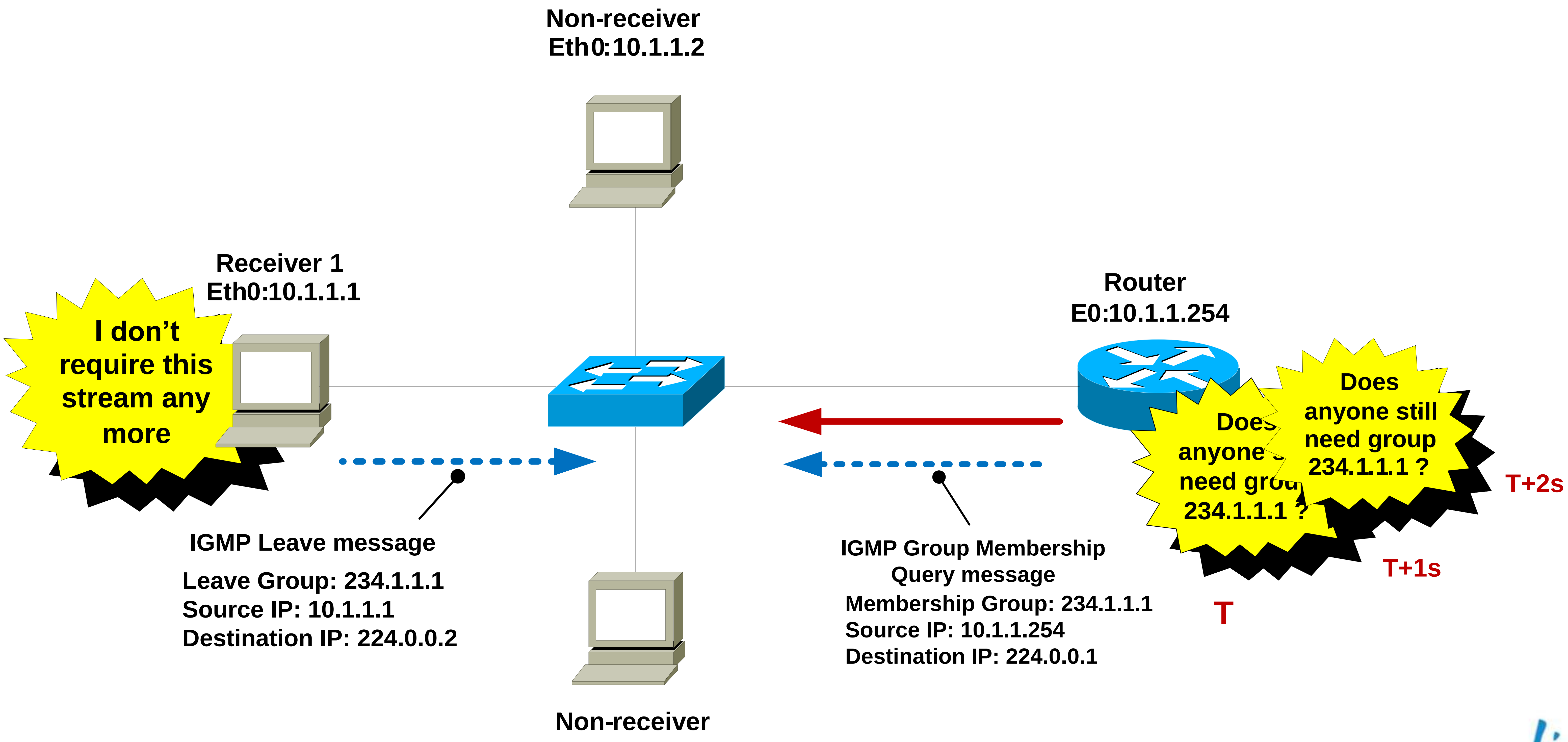
IGMPv2 – Maintaining a Group



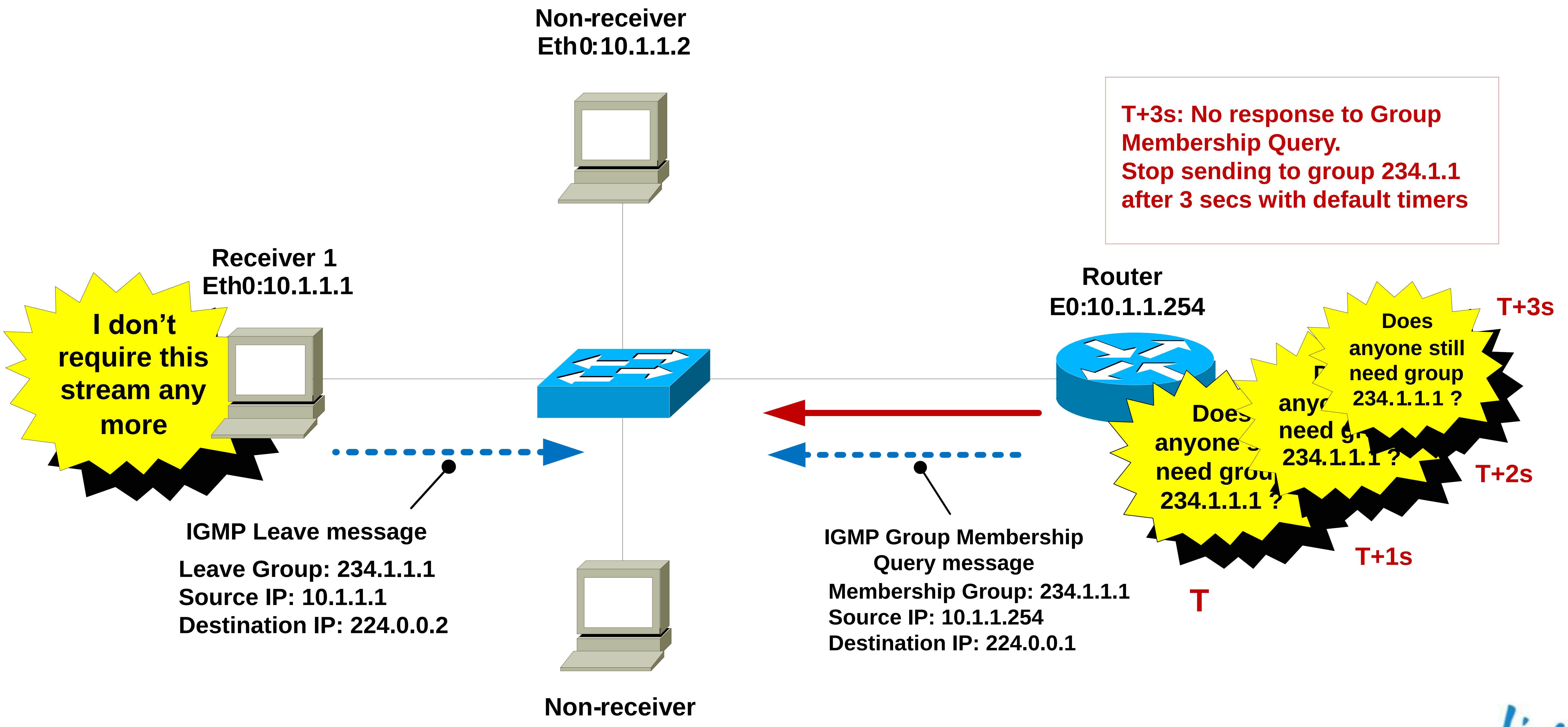
IGMPv2 – Leaving a Group



IGMPv2 – Leaving a Group



IGMPv2 – Leaving a Group



IGMP Snooping

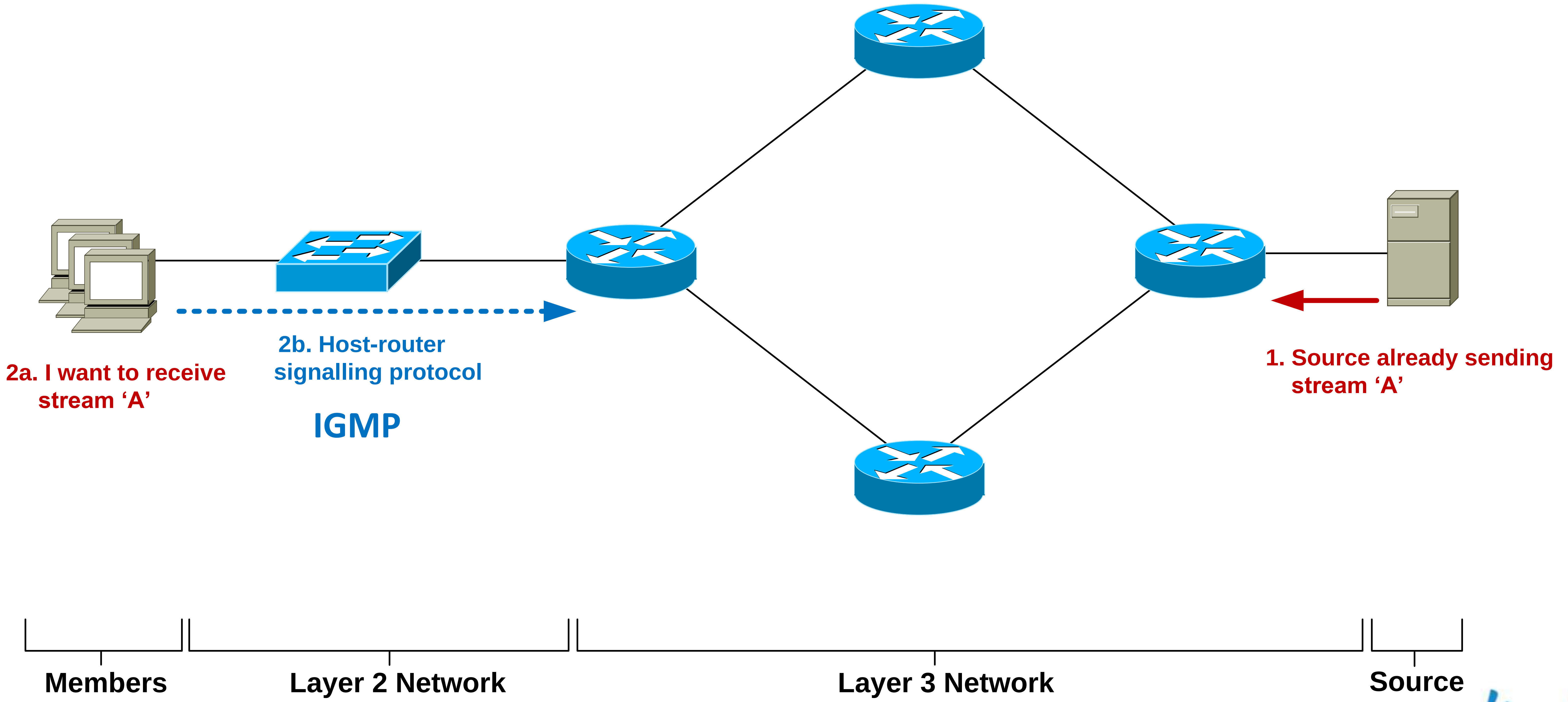
- By default, switches forward all layer 2 multicast frames to all ports (except the originating port)
- IGMP snooping eavesdrops on IGMP messaging
- Constrains MC to *only* ports that want it (key point)
- IGMP snooping is on by default in IOS-based switches
- Replaces Cisco Group Management Protocol (CGMP).

Advantages of IGMP Snooping

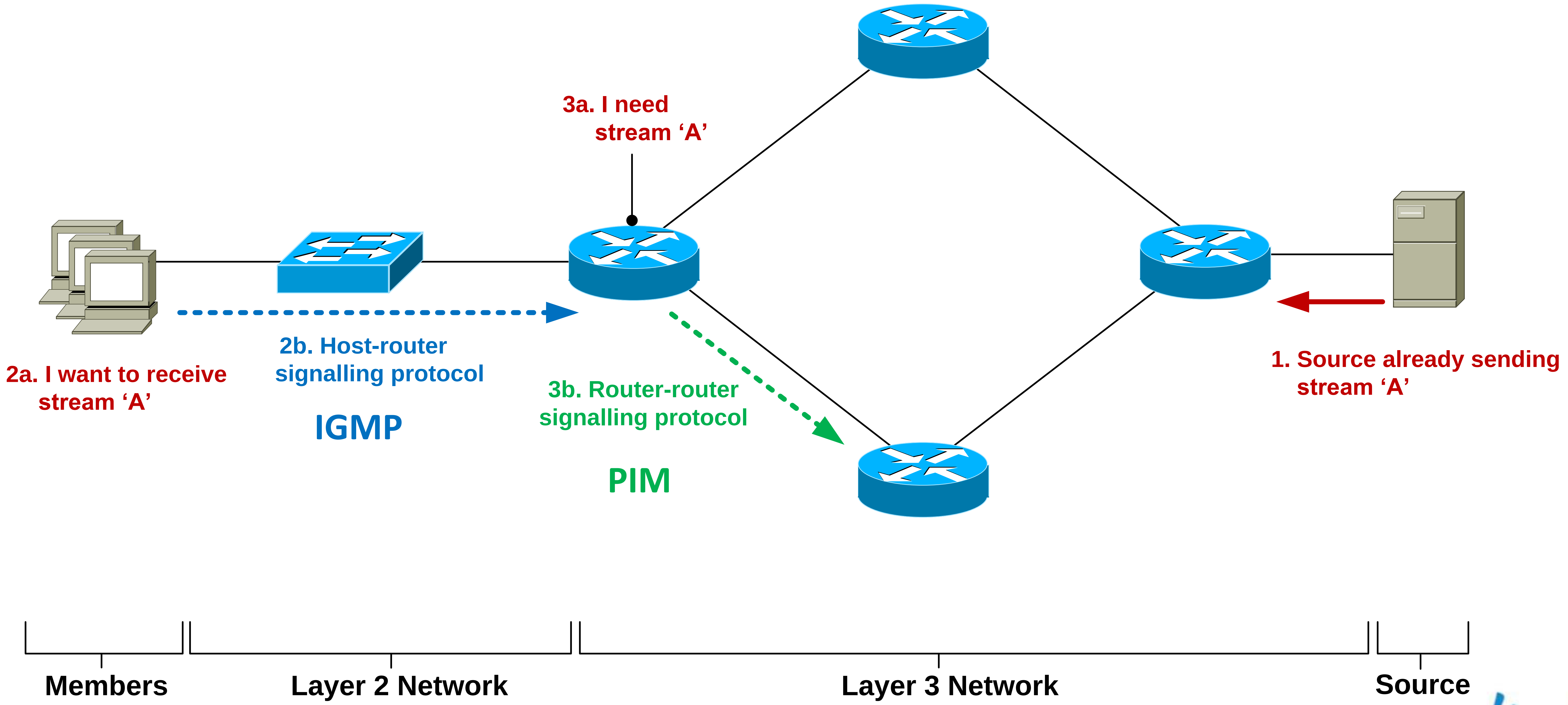
- Hosts only receive MC traffic that they request
- Report suppression – prevents first-hop router from being flooded with IGMP reports for the same group
- “Fast-leave” functionality – stop sending MC group as soon as switch hears a “leave” on an interface

Q. **When would IGMP snooping fast-leave be a bad idea ?**
A. **When there is more than 1 receiver attached to an interface**

Multicast Service Model Overview – Layer 3



Multicast Service Model Overview – Layer 3



Router-Router Signalling: PIM

- Protocol Independent Multicast
- Used by a router to notify an upstream router that it wishes to receive (or stop receiving) multicast traffic for a given group.
- 3 main classifications of PIM
  - Any Source Multicast (asm-pim) – 3 “modes”
    - Dense, sparse, sparse-dense
  - Source-Specific Multicast (pim-ssm)
  - Bidirectional (pim-bidir)

Router-Router Signalling: PIM

- **P**rotocol **I**ndependent **M**ulticast
- Used by a **router** to notify an upstream **router** that it wishes to receive (or stop receiving) multicast traffic for a given group.
- 3 main classifications of PIM

  Any Source Multicast (asm-pim) – 3 "modes"

  Legacy ← ~~Dense~~, sparse, ~~sparse-dense~~ → **Cisco Proprietary**

  Source-Specific Multicast (pim-ssm)

  ~~Bidirectional (pim-bidir)~~ → **Only for specific-use cases (many senders)**

Router-Router Signalling: PIM-SM

- Each PIM router forms neighbour relationship with adjacent PIM routers using PIM “hello” messages every 30 seconds.
- When a PIM router wants to receive a multicast stream, it sends a PIM “join” message towards the IP address of the multicast source.
- When a PIM router wants to stop receiving a multicast stream, it sends a PIM “prune” message towards the IP address of the multicast source.

RPF Mechanism

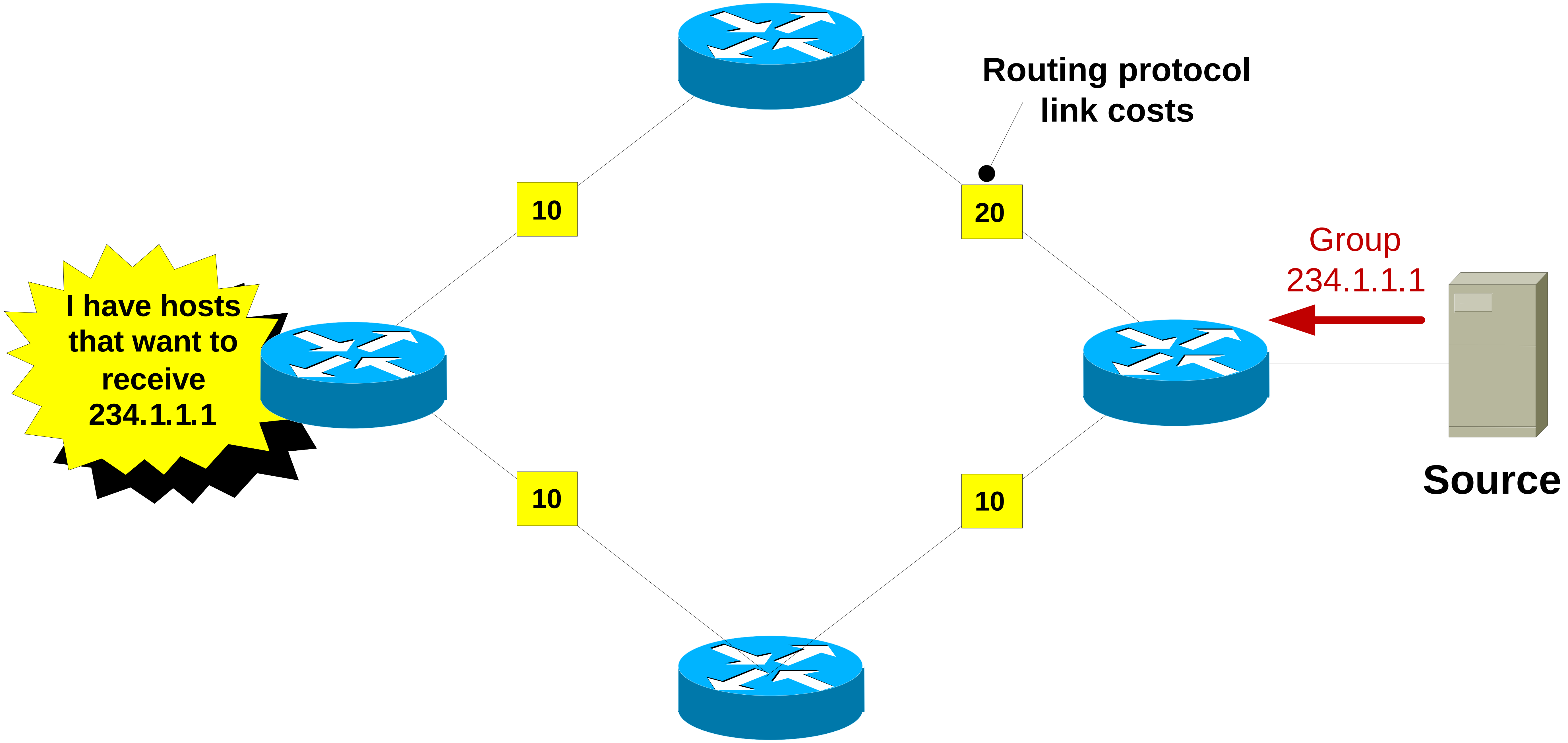
- Multicast traffic flows are checked from the sender back down the path created by the PIM messages. This is known as Reverse Path Forwarding (RPF).
- All received multicast traffic is subject to an **RPF check**

  Is the incoming MC traffic being received via the interface on which I have a route to the source?

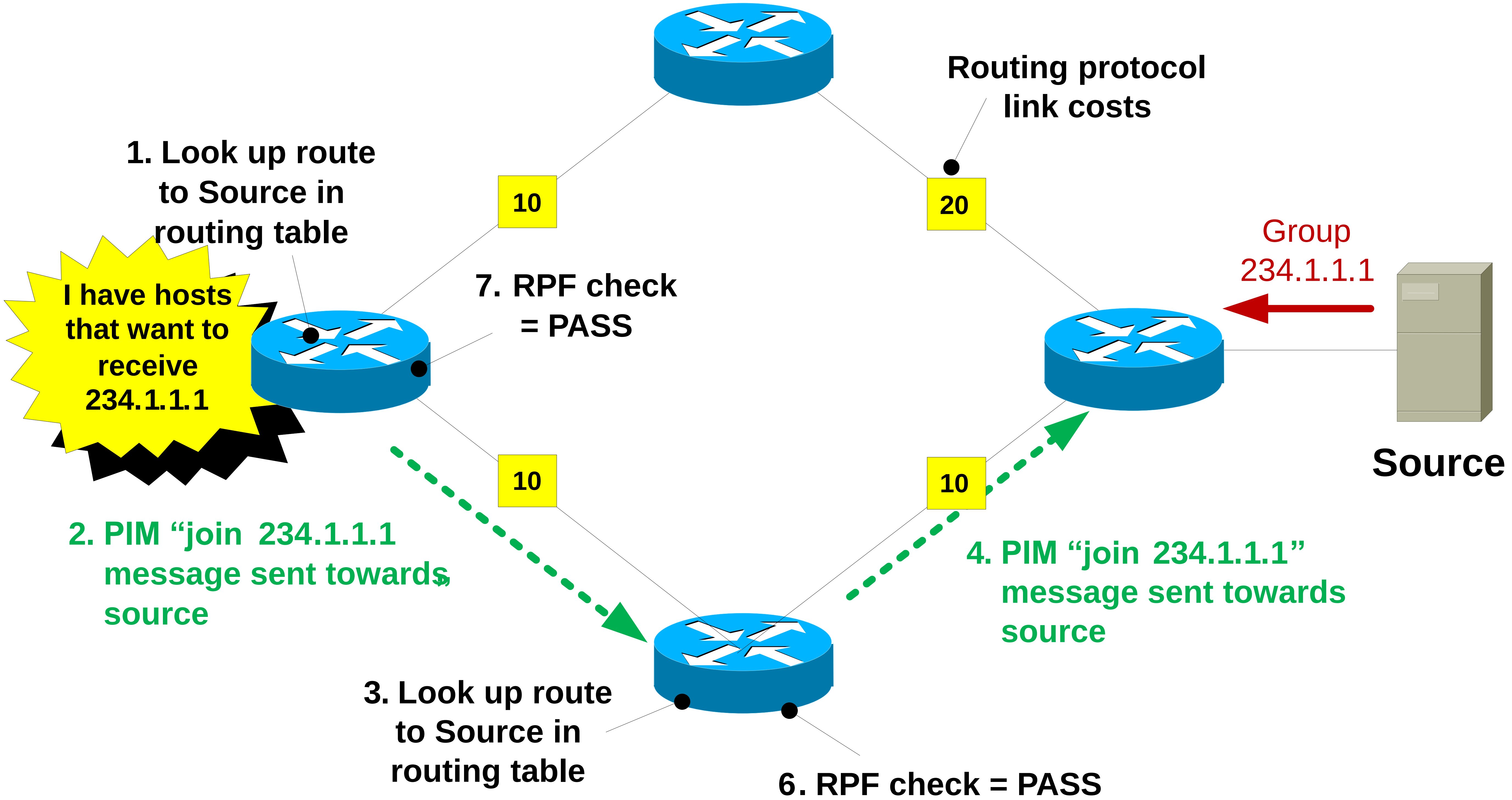
  RPF check **PASS** = accept MC traffic and send it on

  RPF check **FAIL** = drop traffic on floor
- Prevents loops and duplicate packets

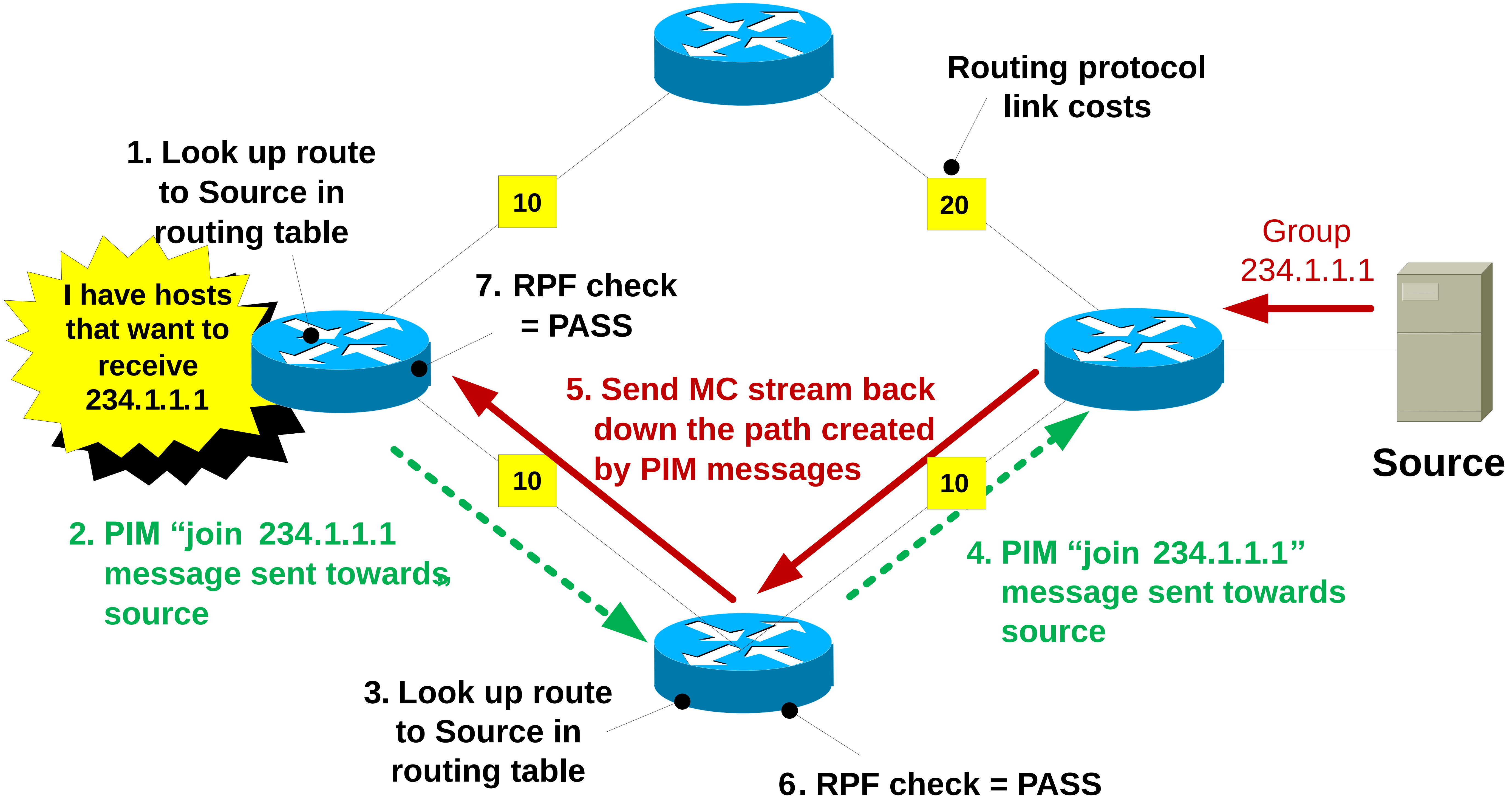
RPF Mechanism



RPF Mechanism



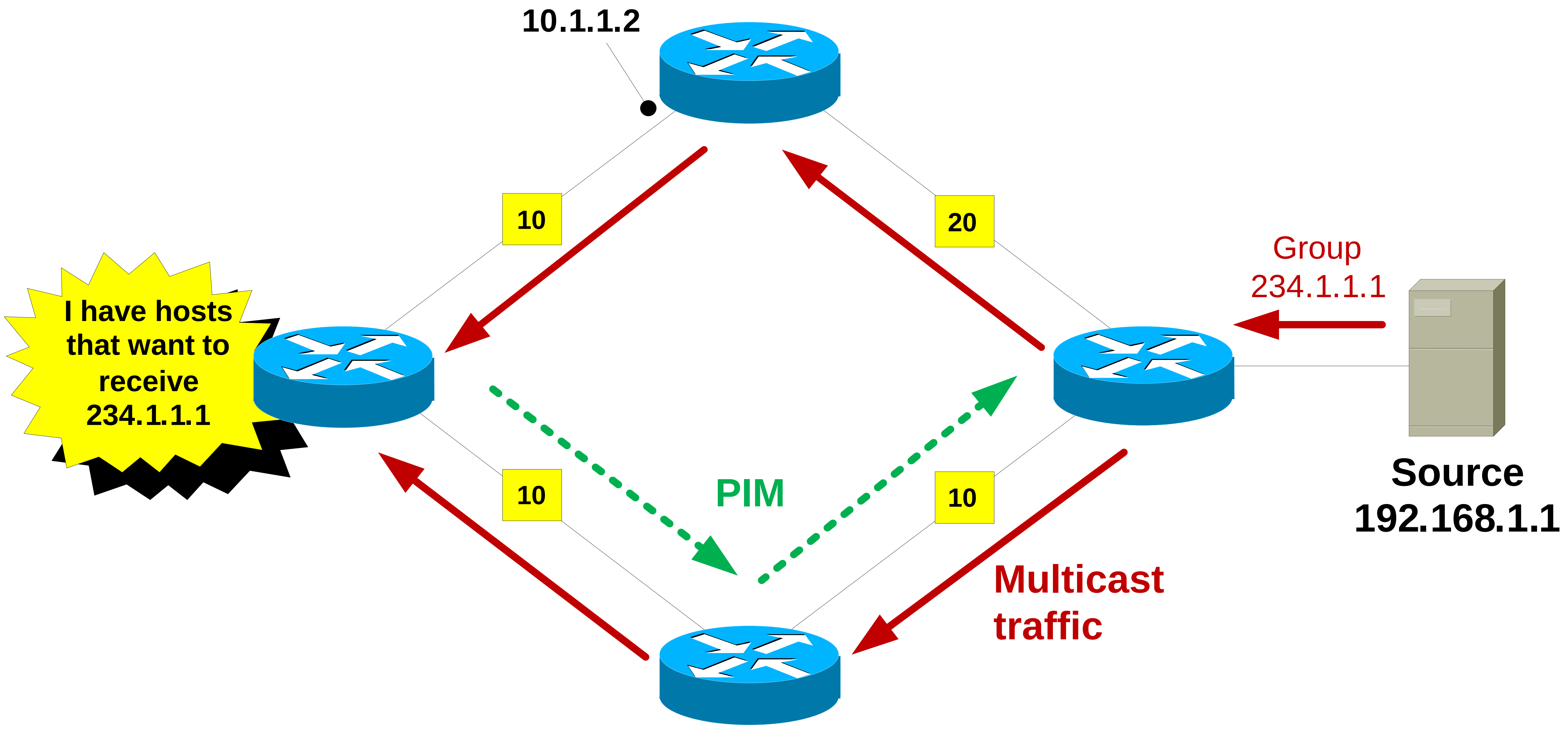
RPF Mechanism



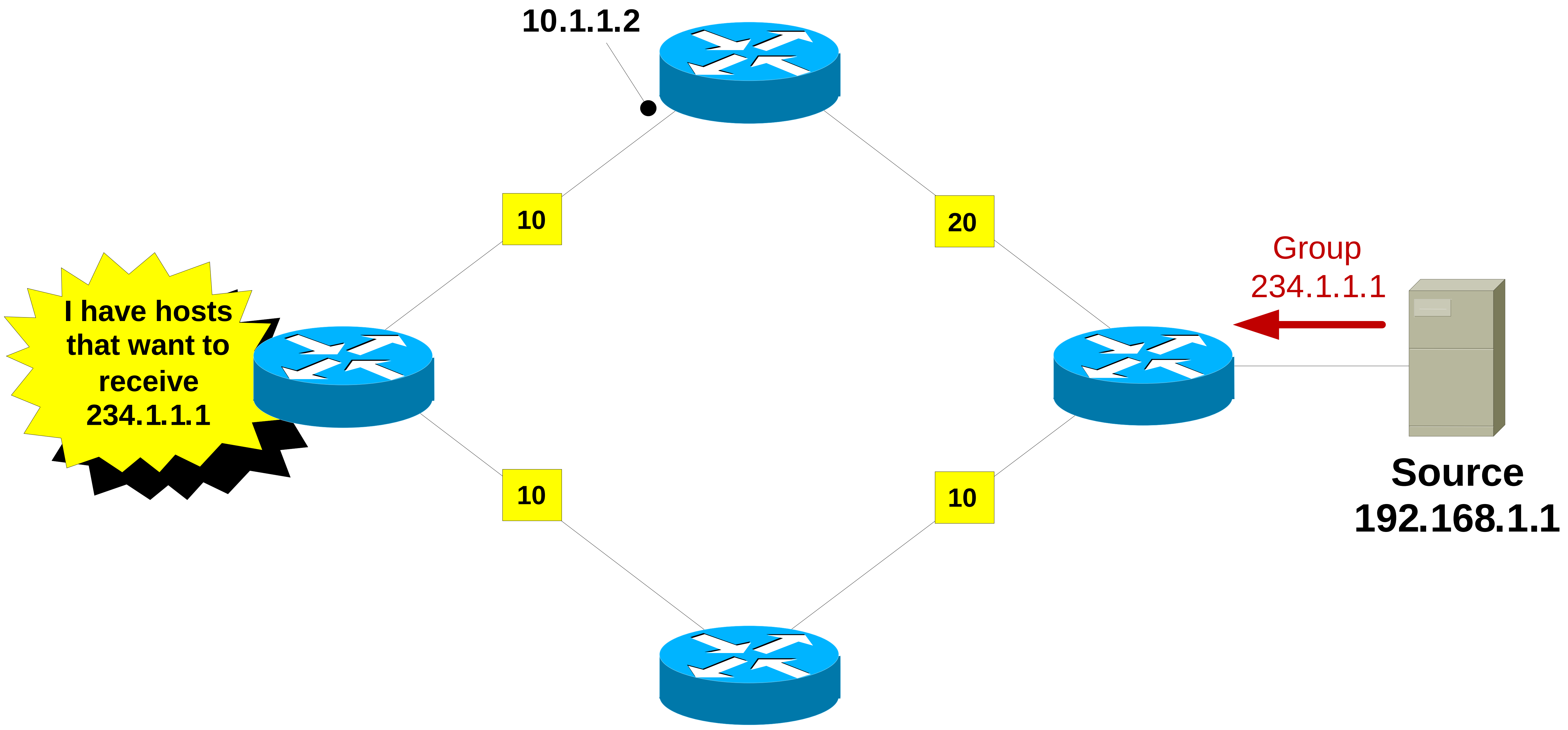
Static Multicast Routes

- Static multicast routes can be used to send PIM messages down a different path than would be selected from the unicast routing table.
- Useful if you want MC traffic to travel over different links to unicast traffic
- Best suited for small networks due to scalability issues managing many static routes.
- Be careful of creating PIM routing loops !

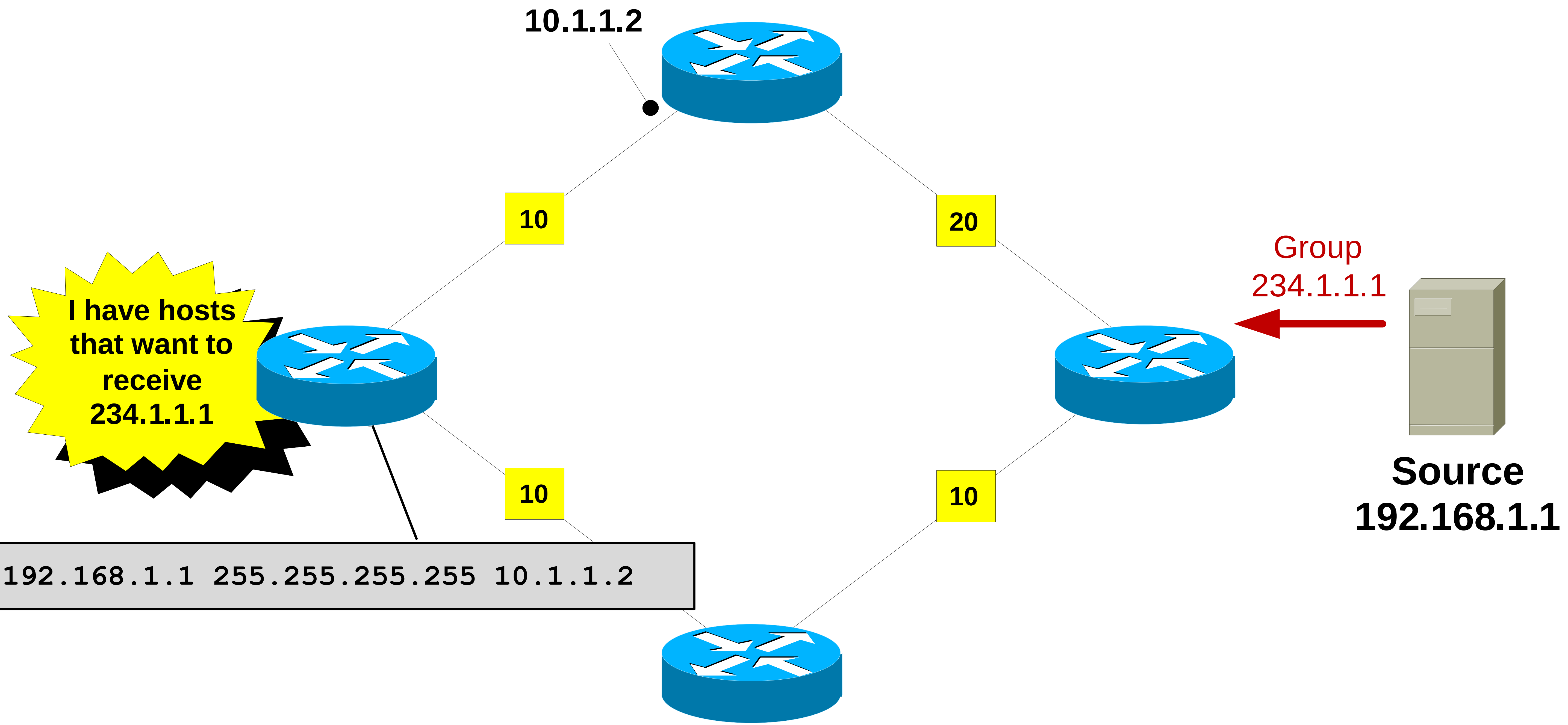
Static Multicast Routes



Static Multicast Routes

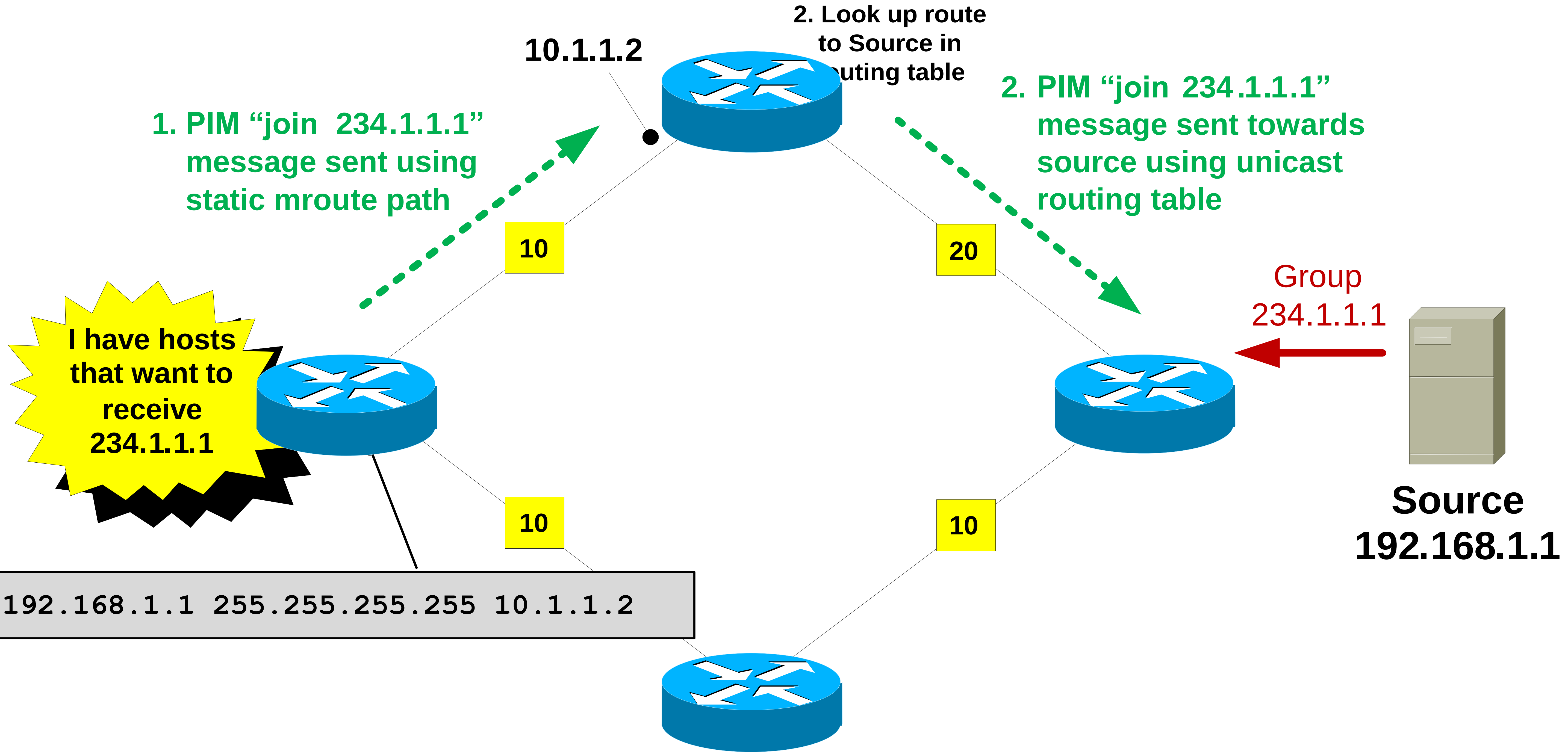


Static Multicast Routes




```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routes

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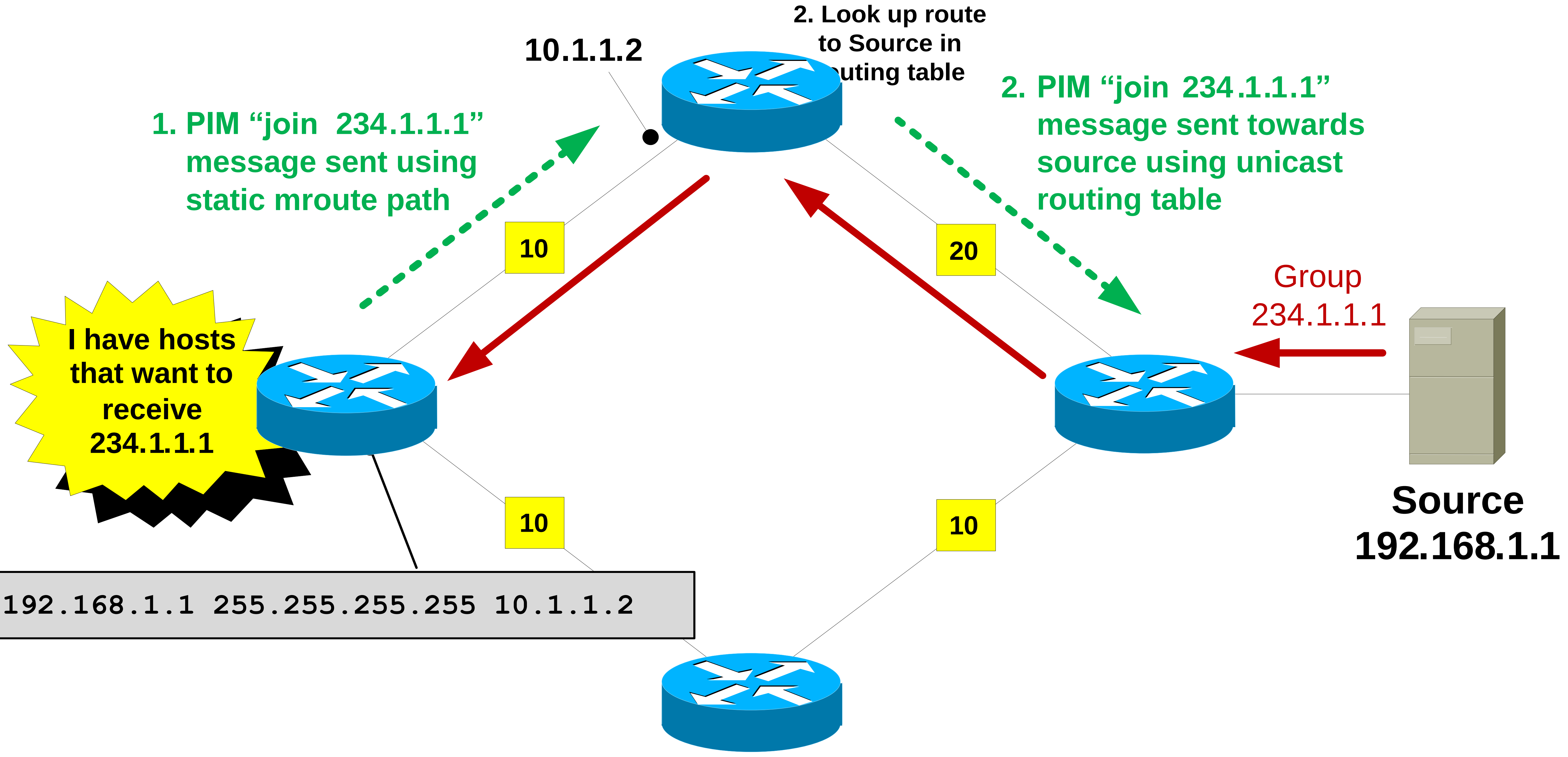
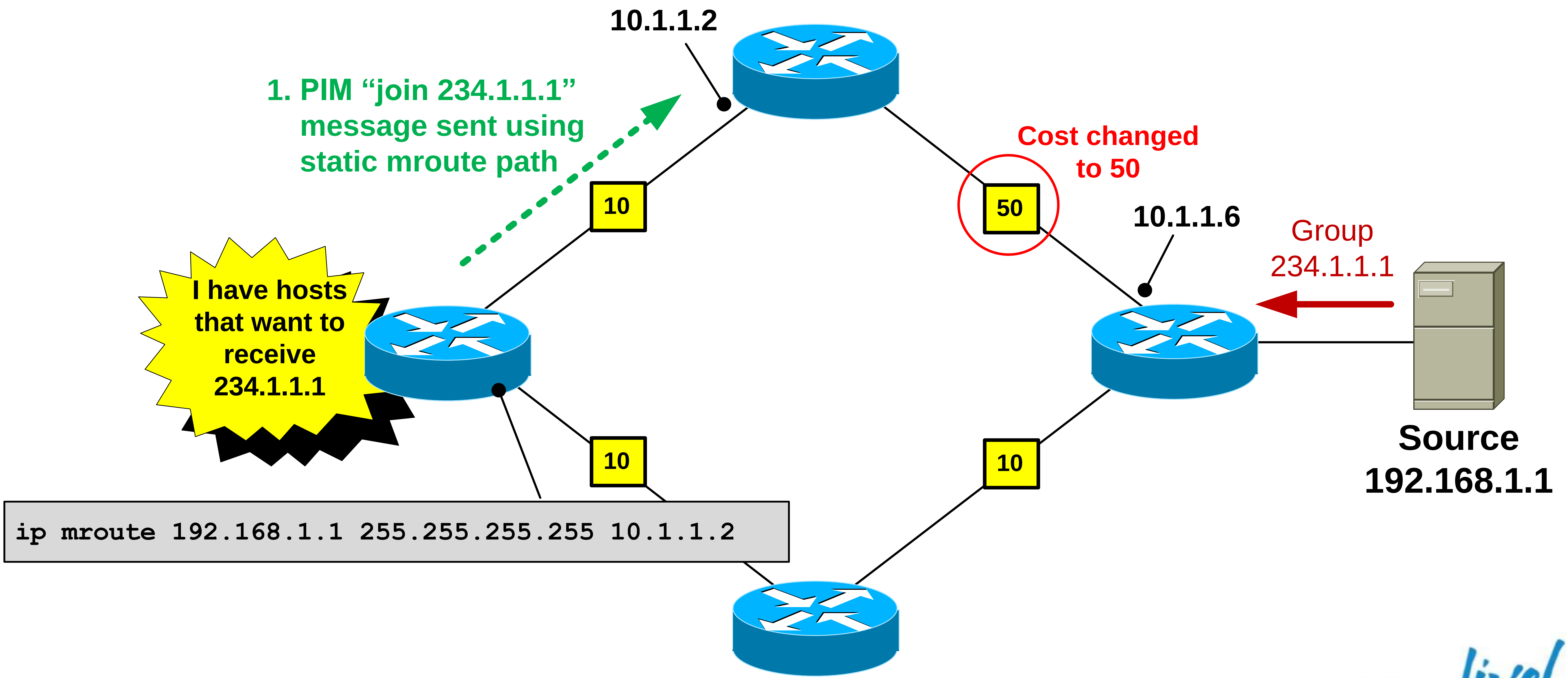
Static Multicast Routes




```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```


Static Multicast Routing Loop



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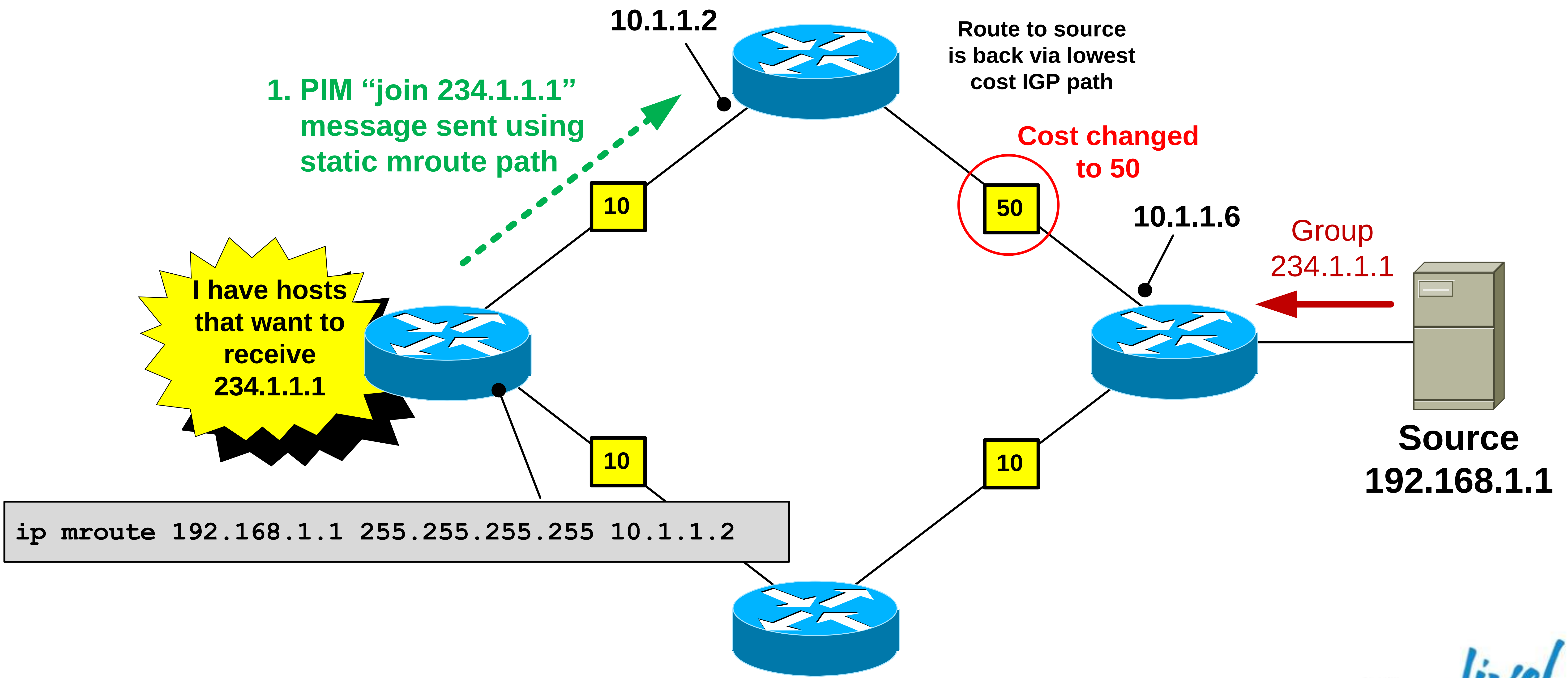

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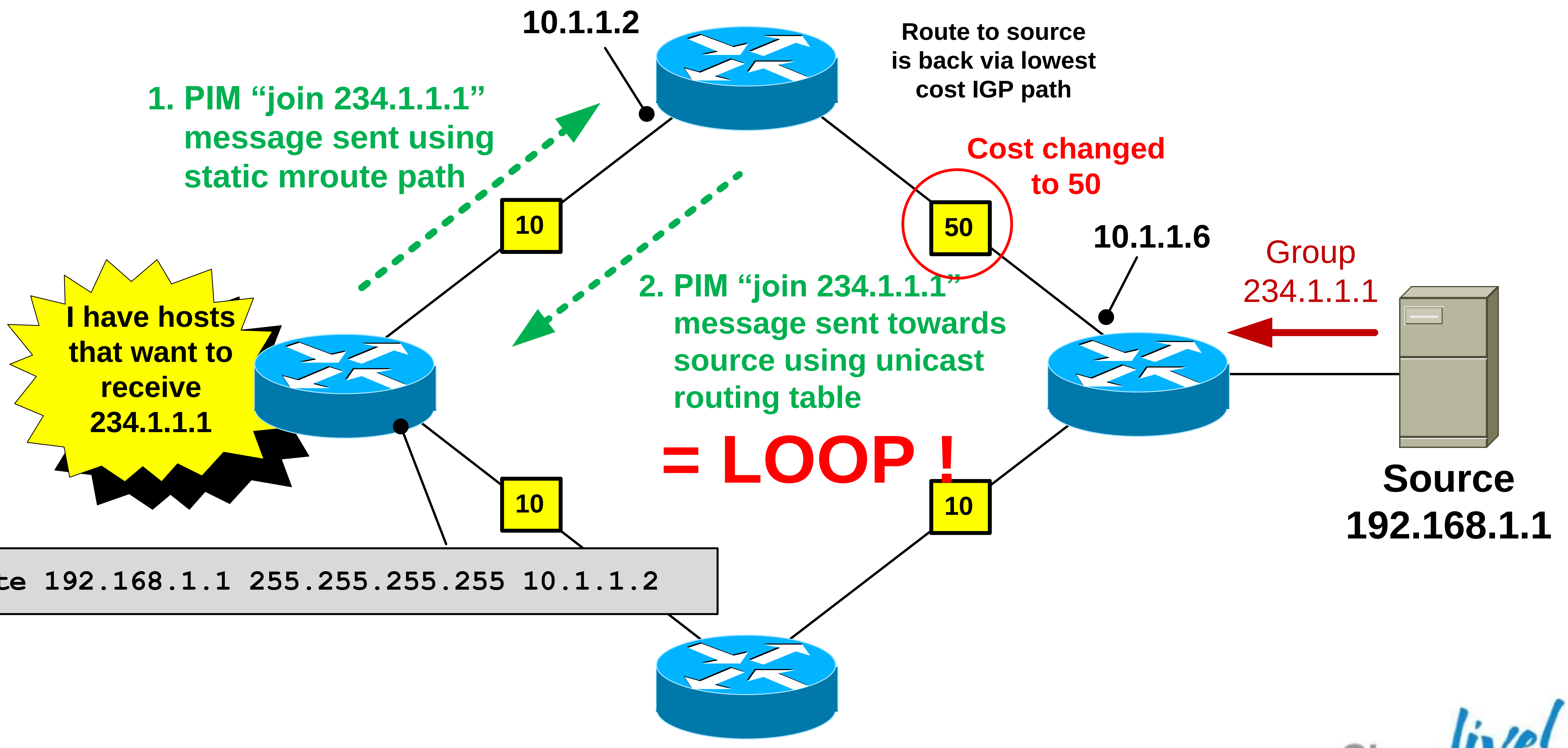


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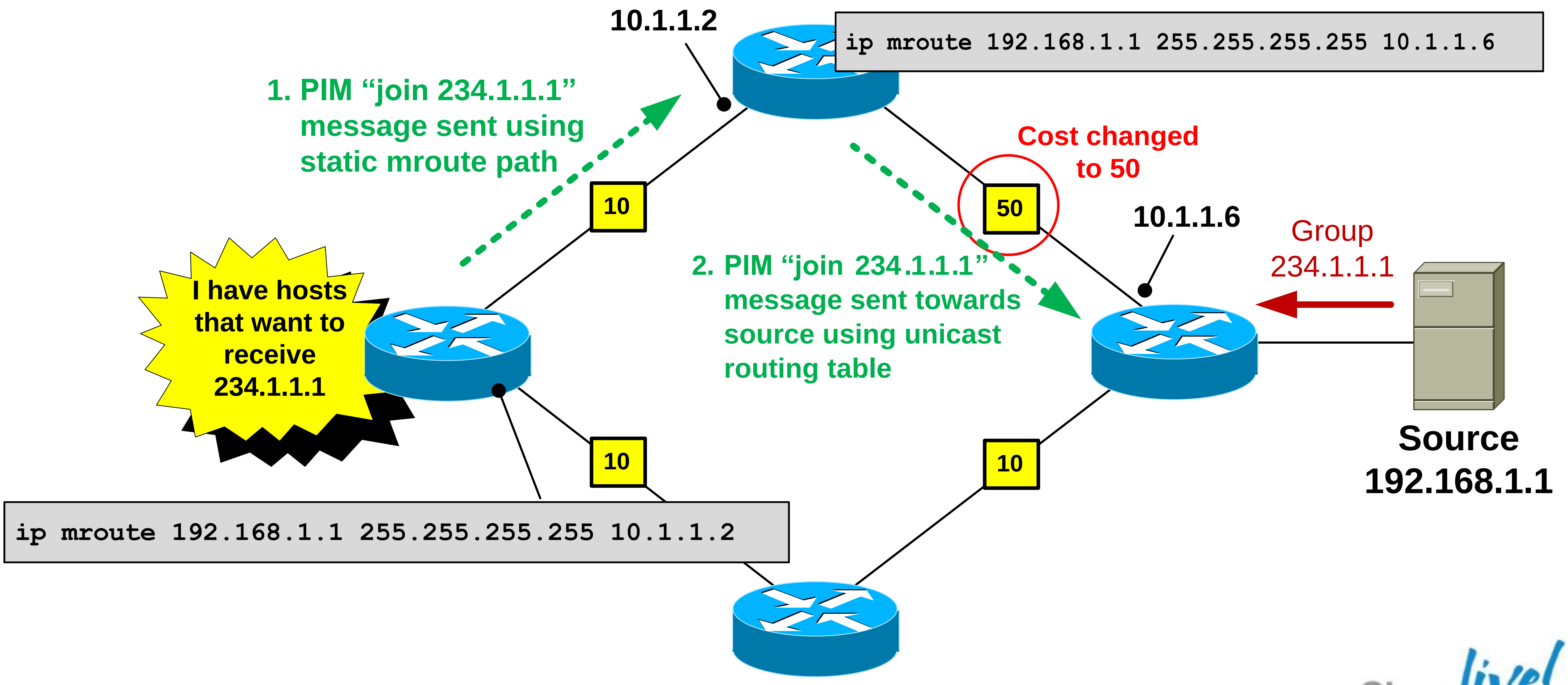

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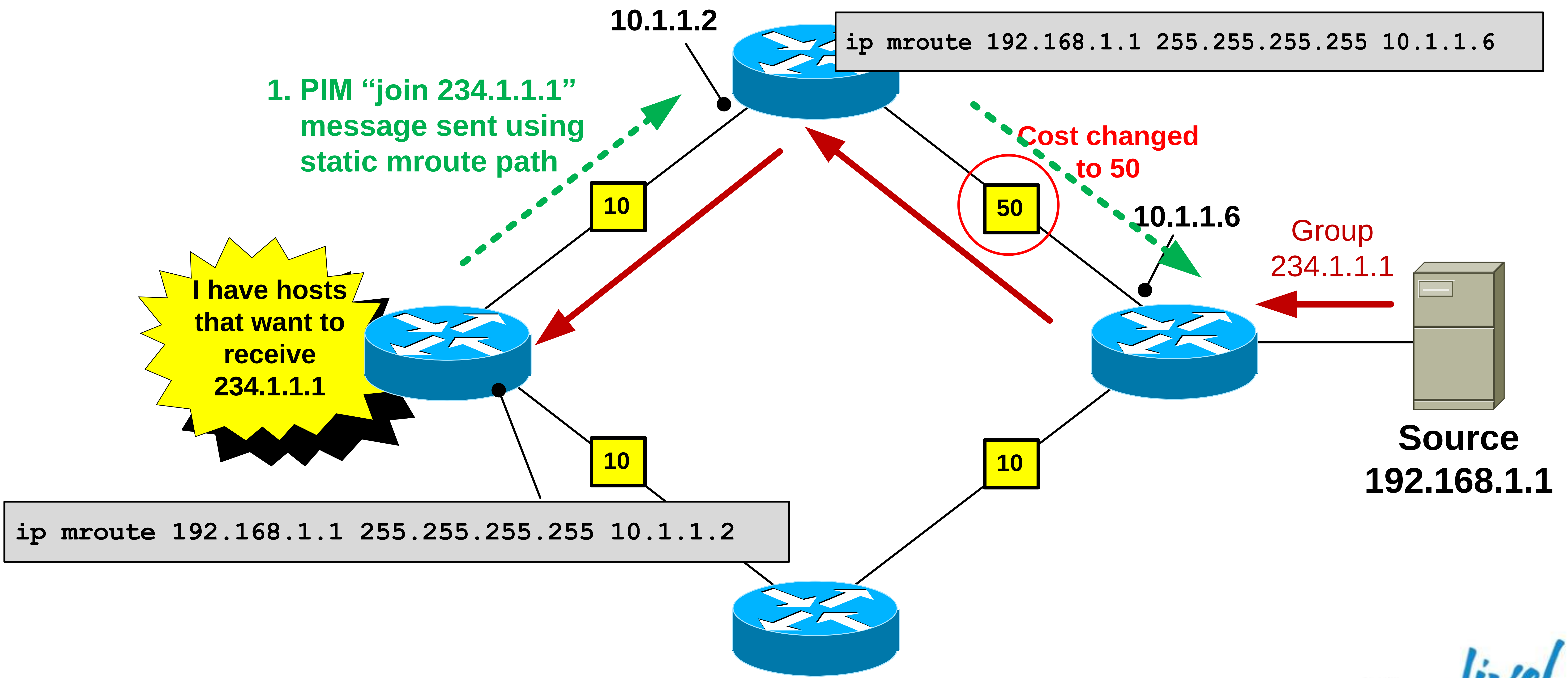
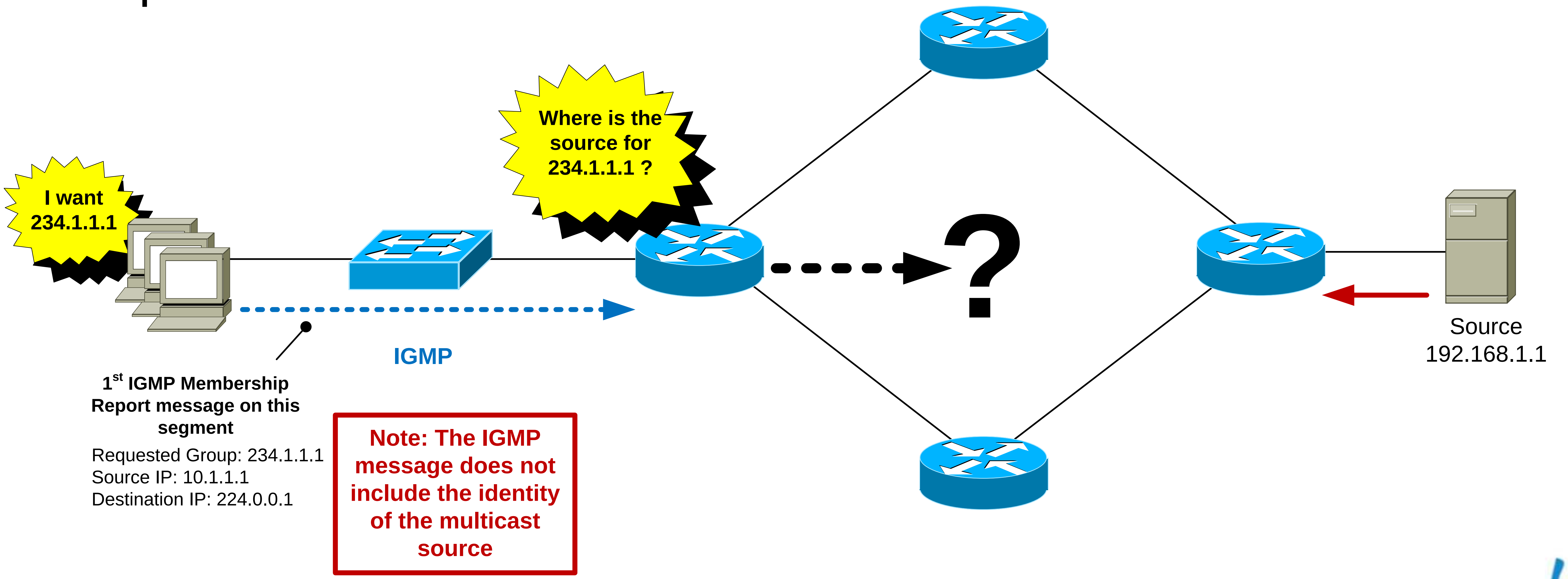


Router-Router Signalling: PIM-SM

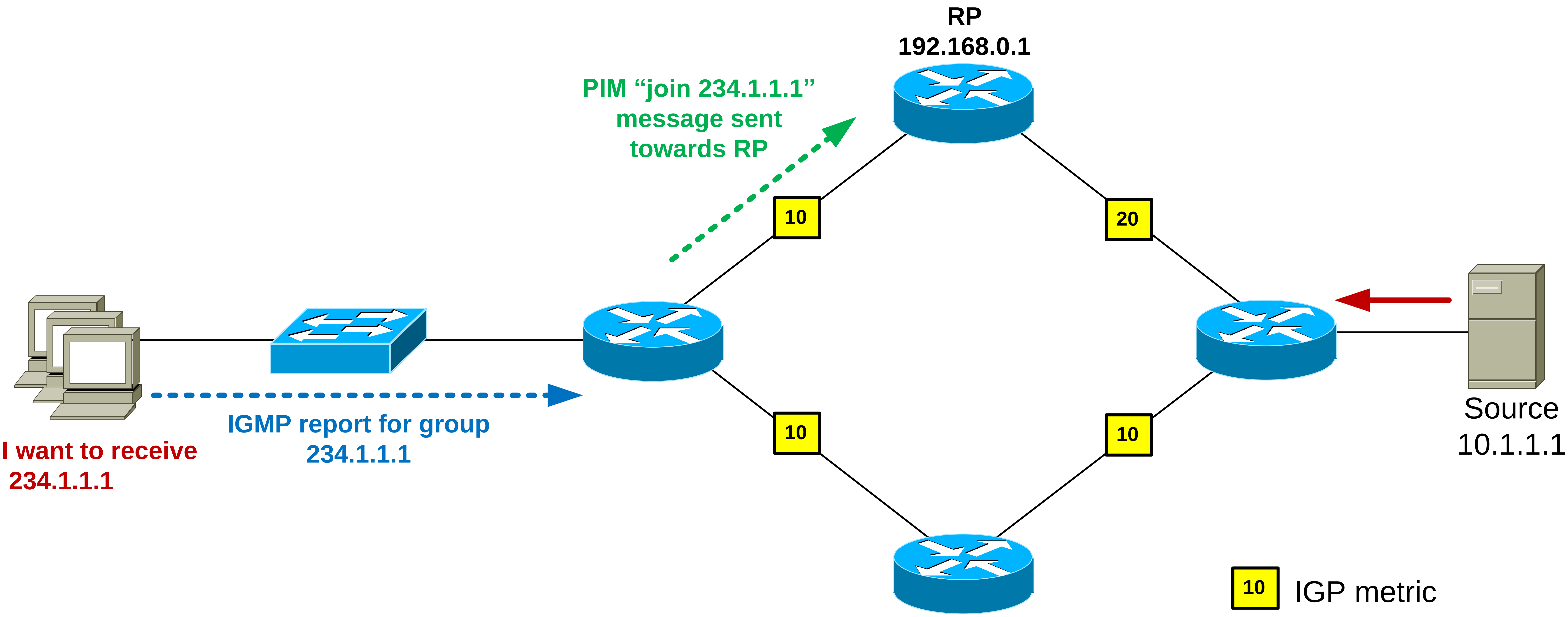
- But.....we have a problem. The receiver just told me the group it wants to join but didn’t identify the source! So in which direction is the “upstream” router ?



PIM-SM: Rendezvous Point (RP)

- PIM-SM uses a router called a Rendezvous Point (RP).
- The sole purpose of the RP is to allow the first-hop router to find out the IP address of the source for a particular group.
- The receivers don't know the source address and don't care - hence the term "Any Source Multicast".
- An RP is **mandatory** for PIM sparse-mode networks.

PIM-SM: Rendezvous Point (RP)



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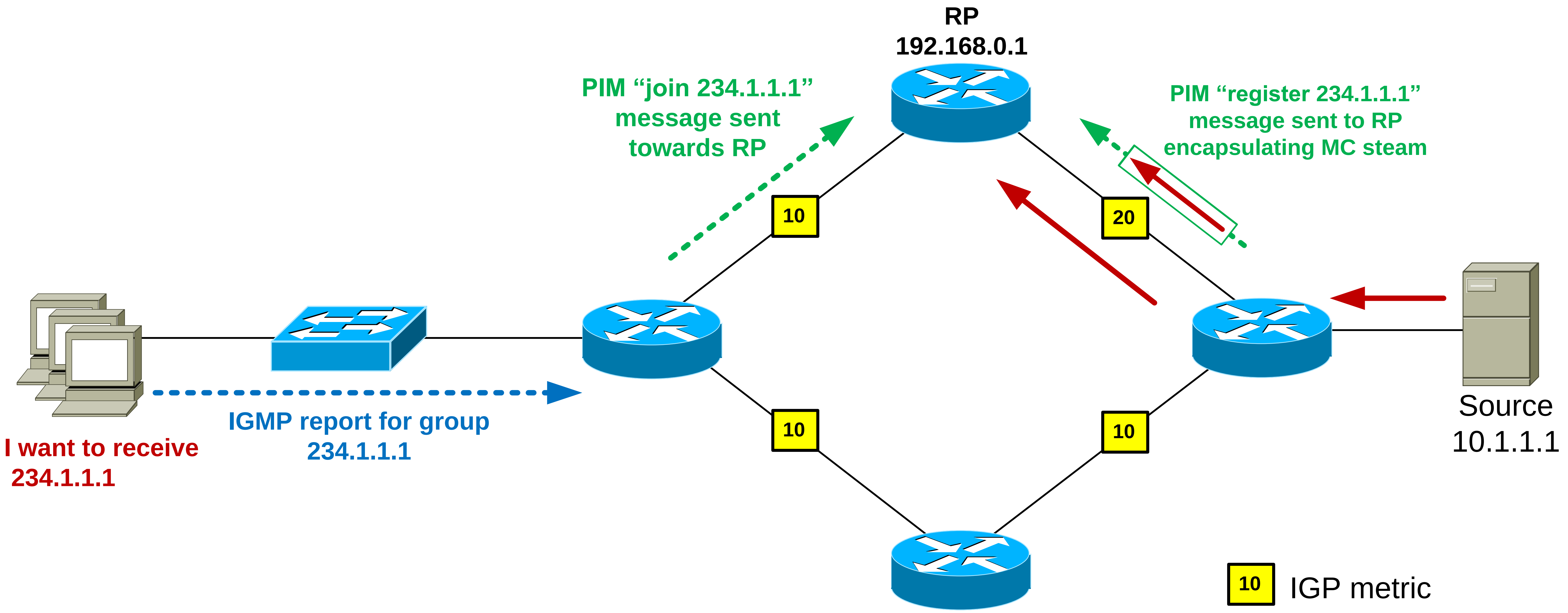

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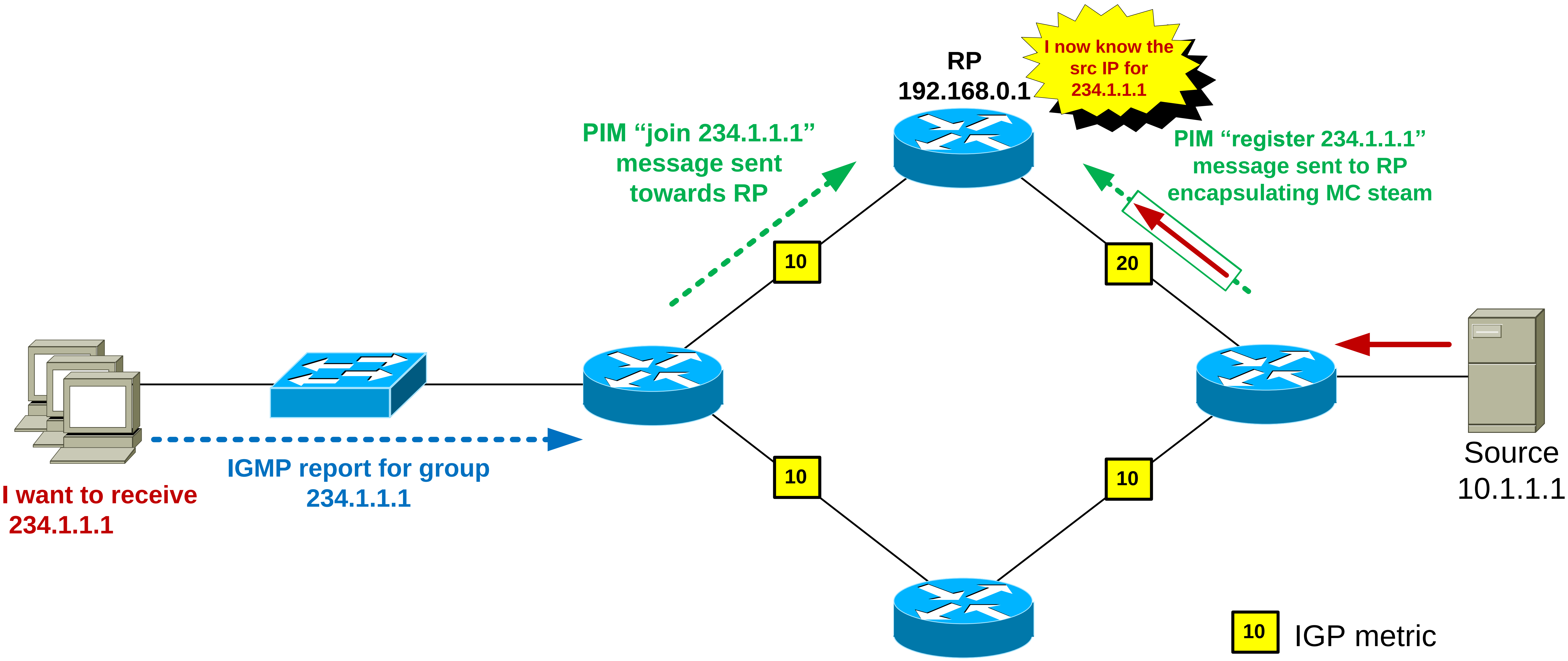

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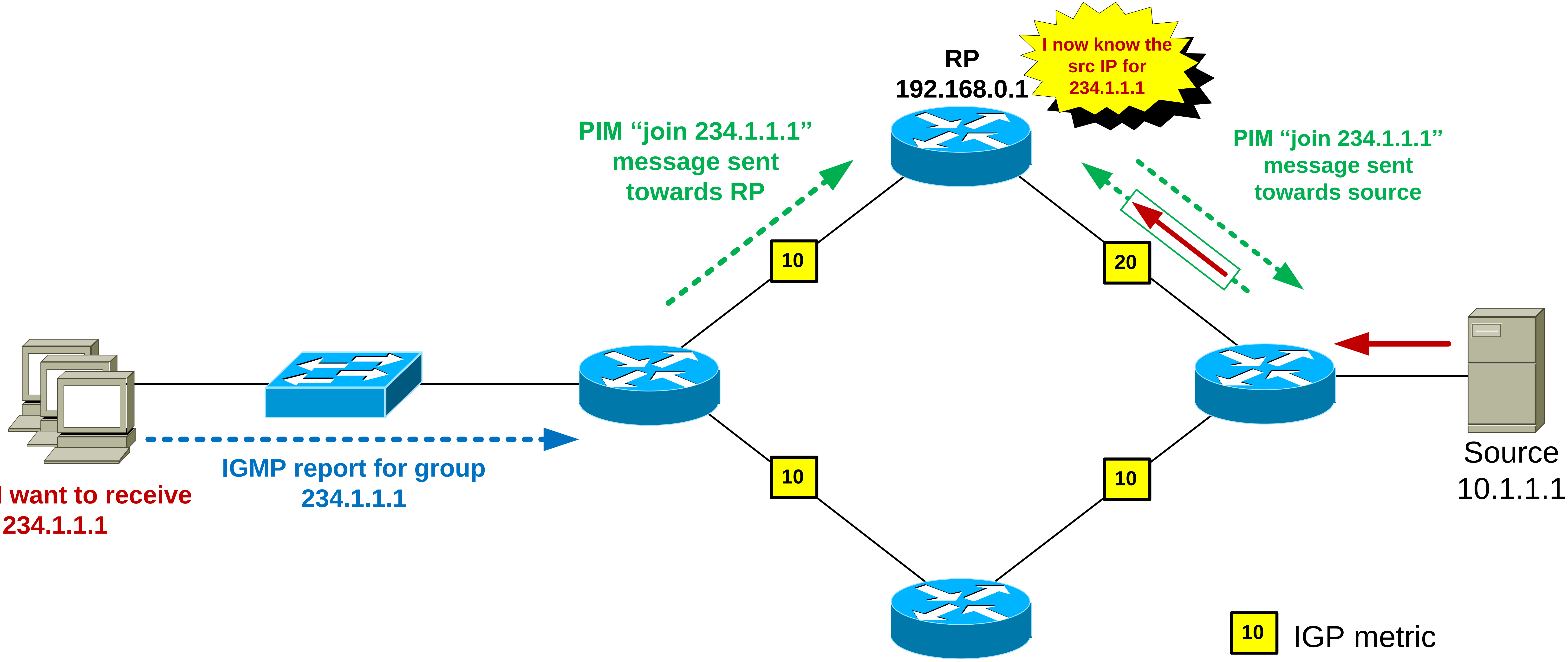

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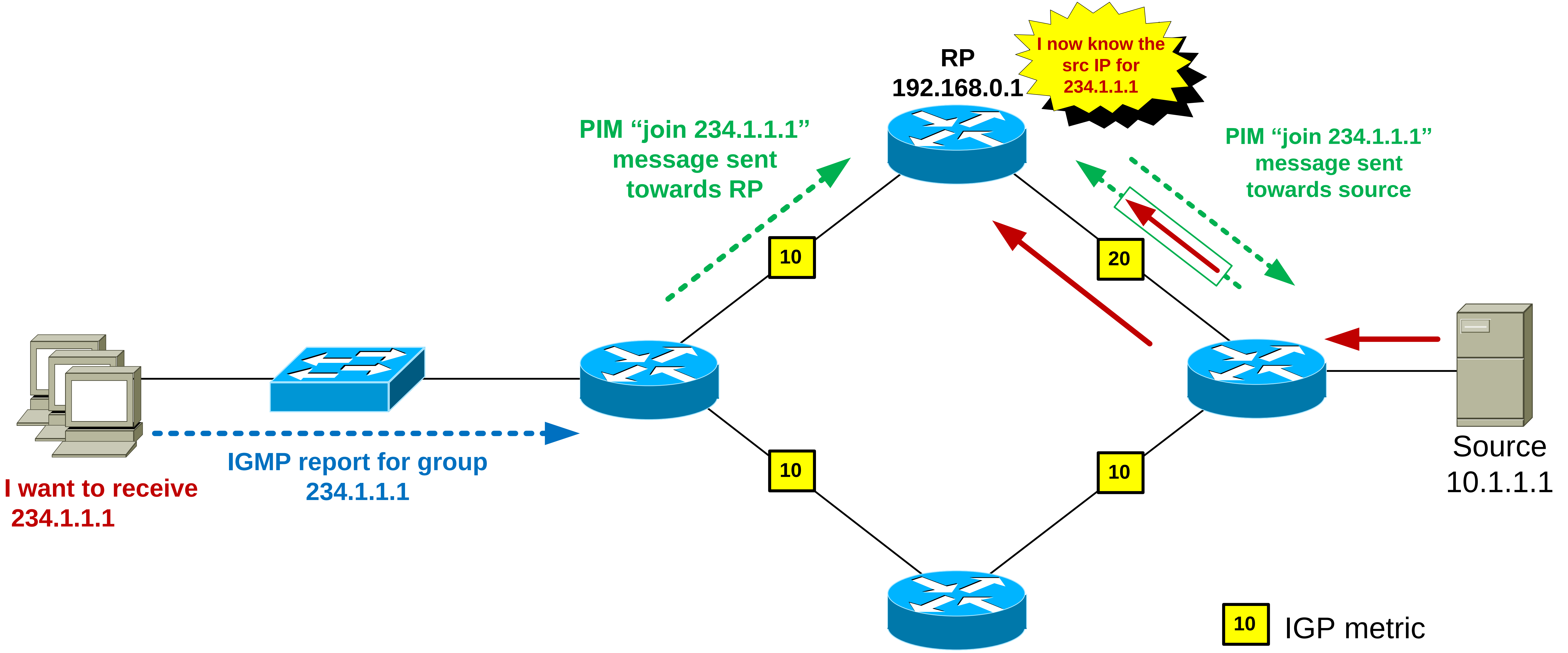

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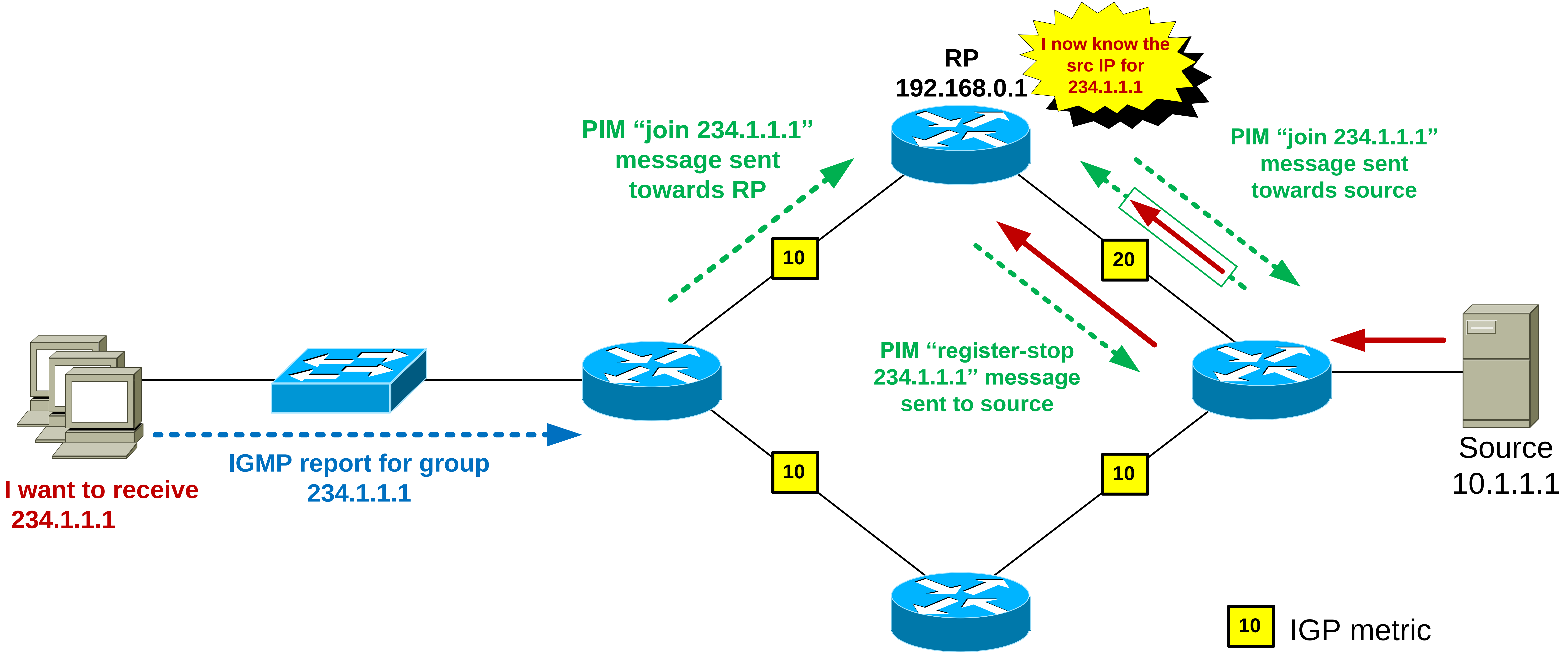

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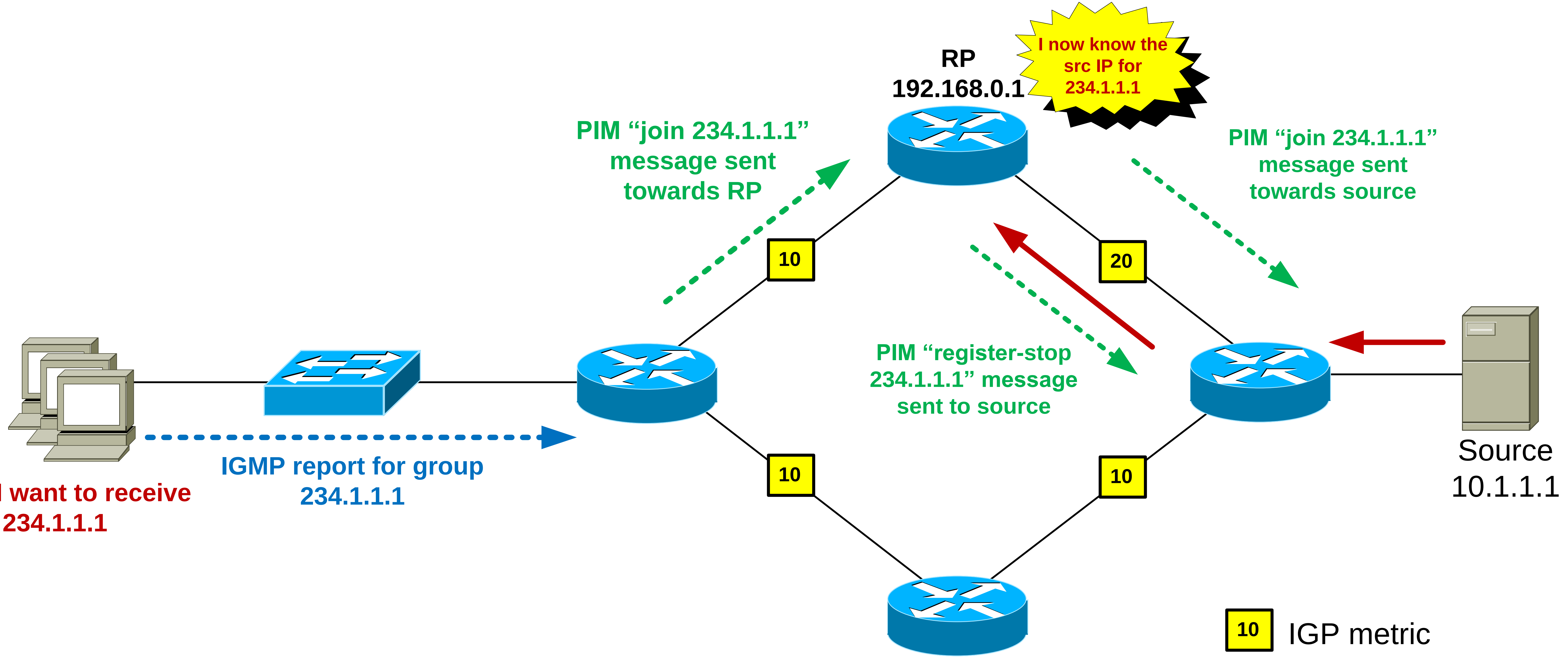

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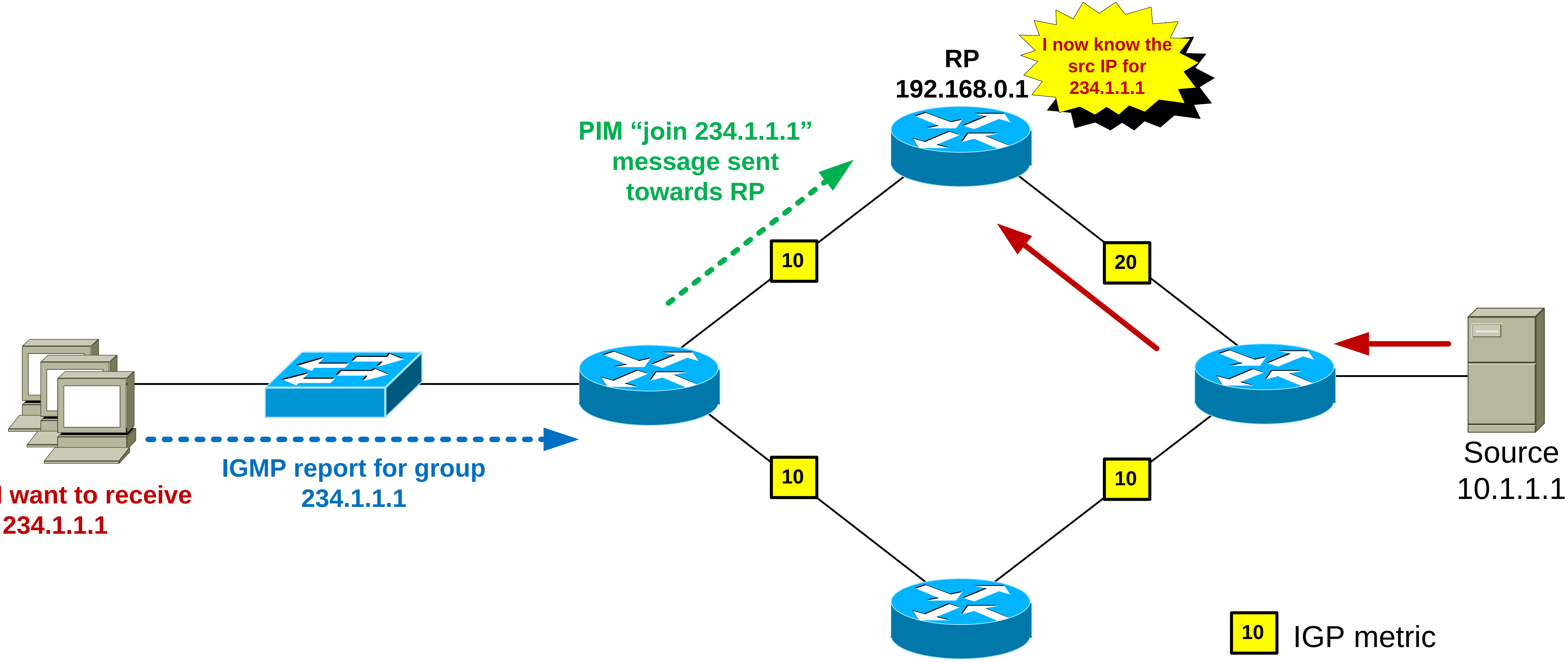

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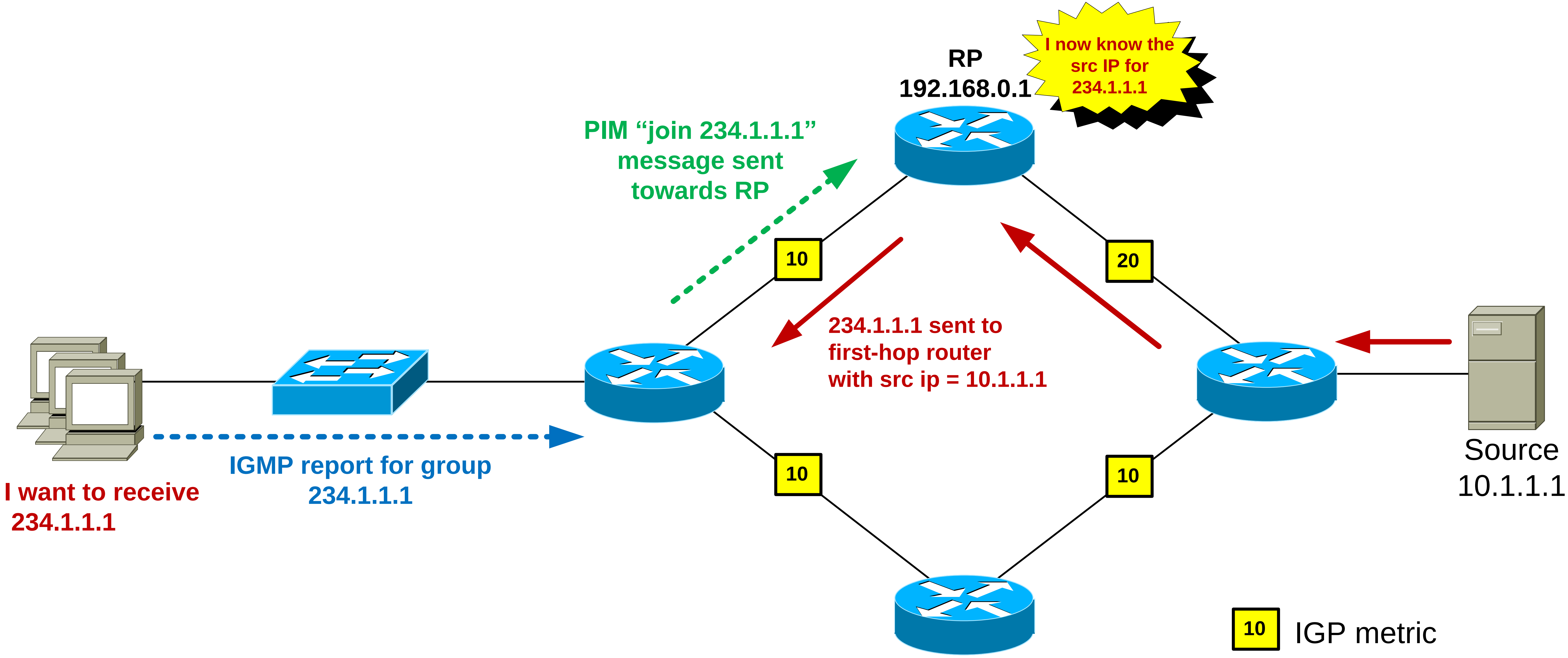

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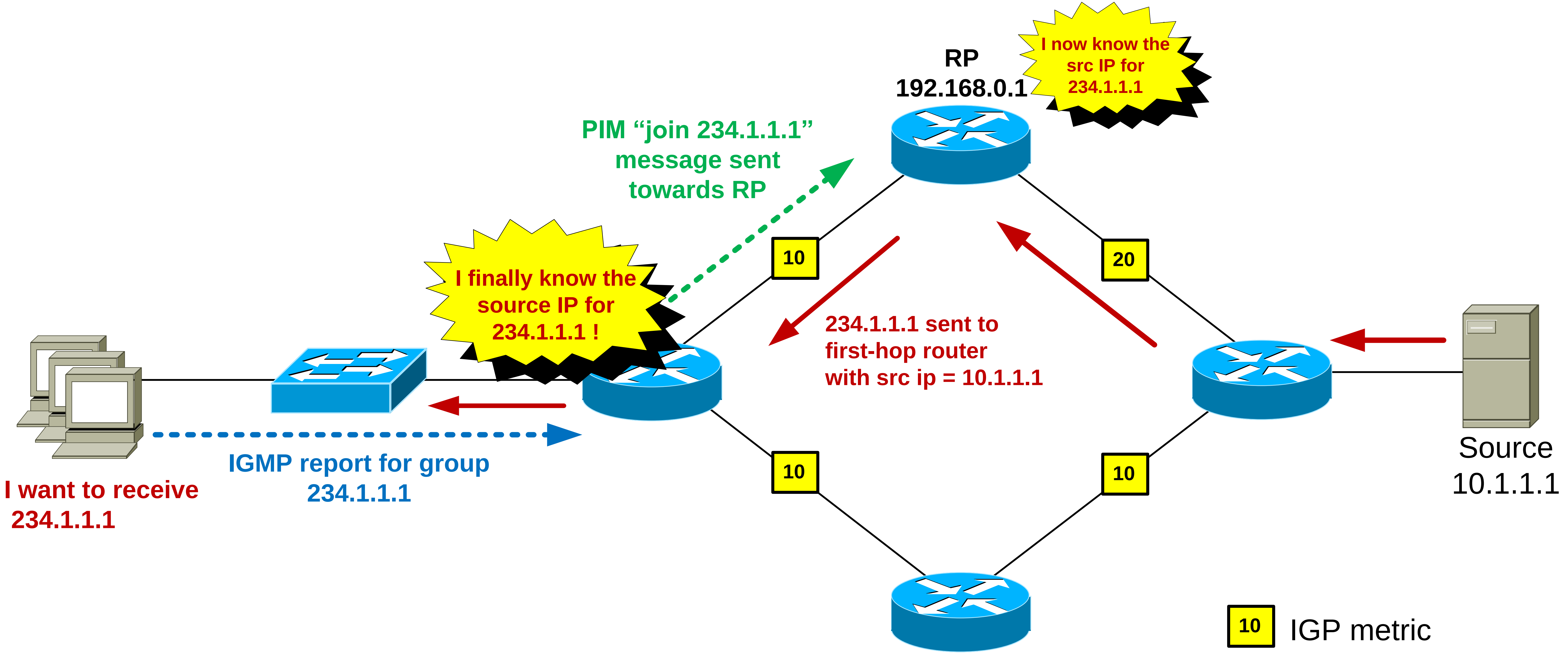
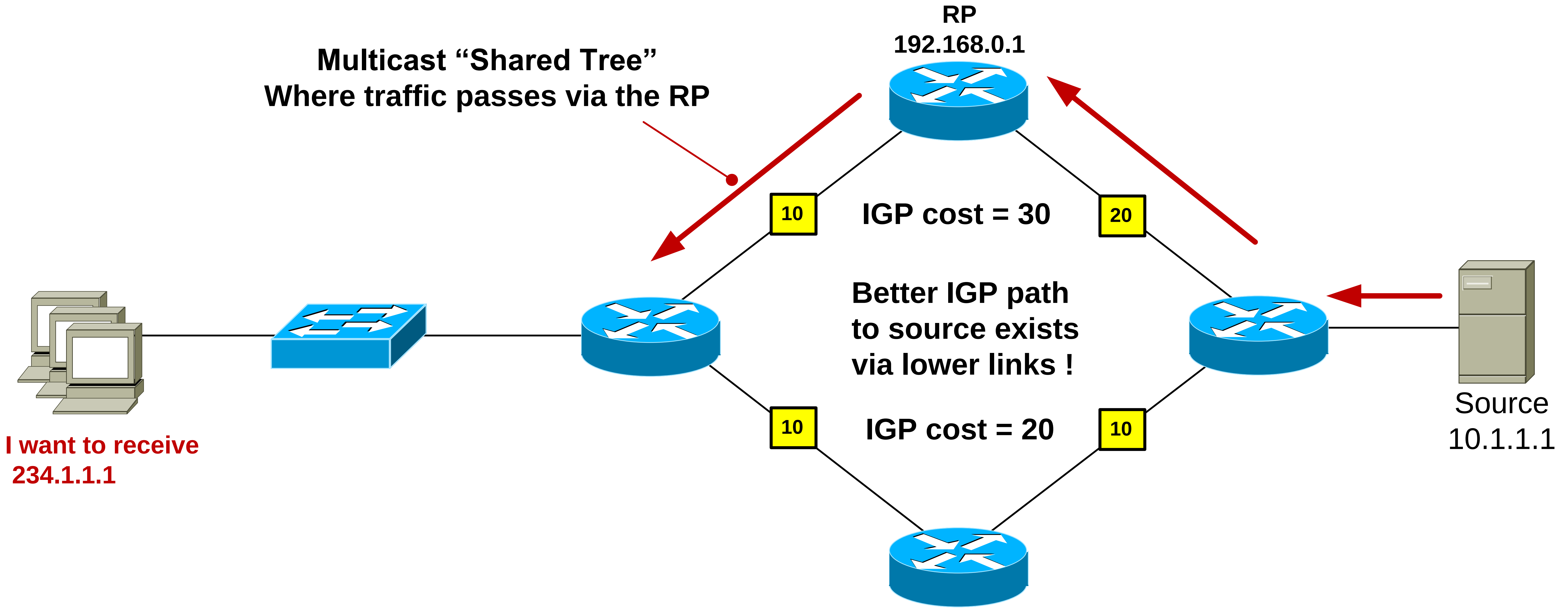


PIM-SM: Shortest Path Tree Switchover



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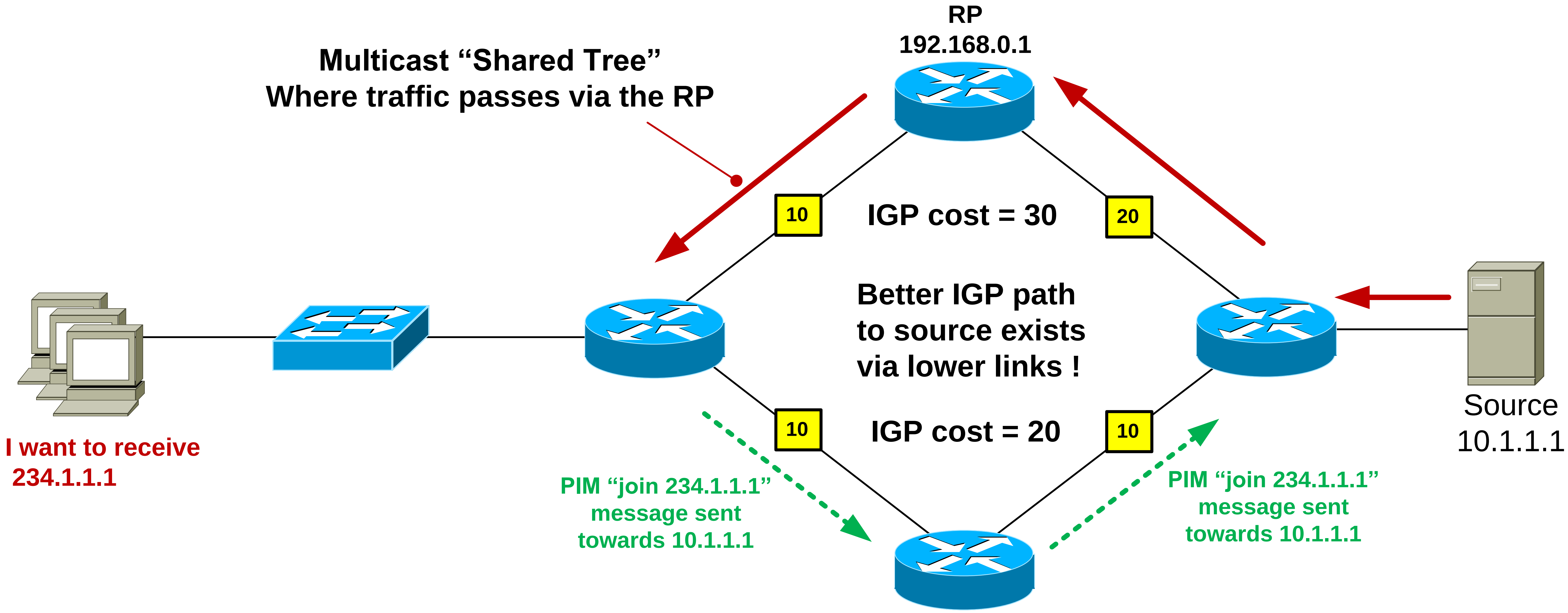

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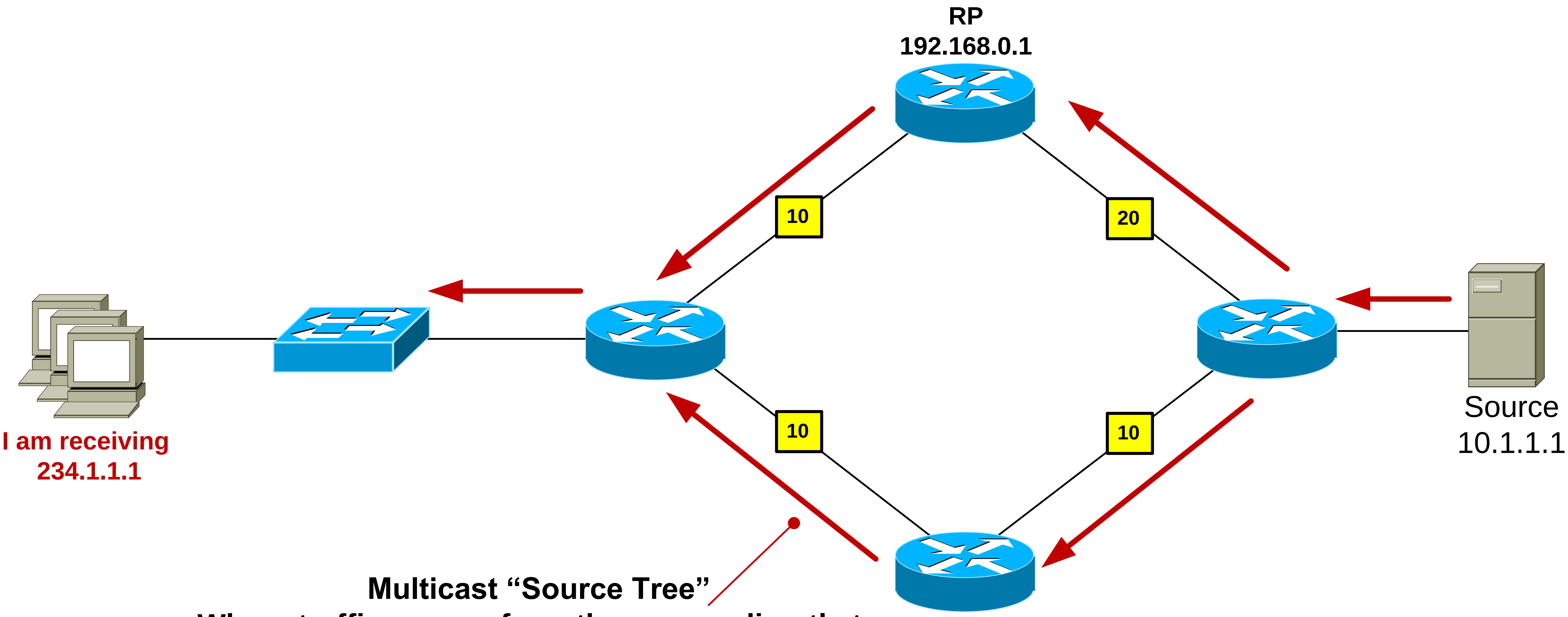
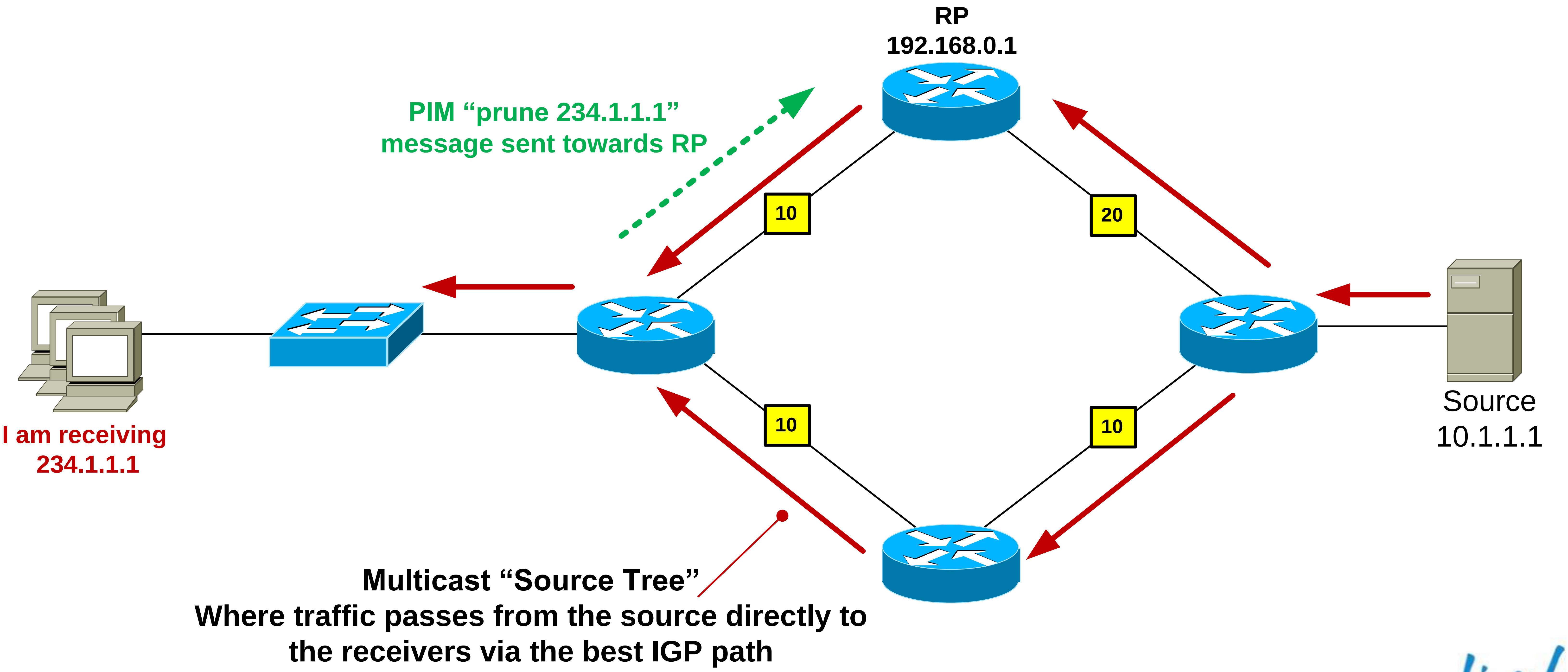


Multicast "Source Tree"
Where traffic passes from the source directly to the receivers via the best IGP path

PIM-SM: Shortest Path Tree Switchover



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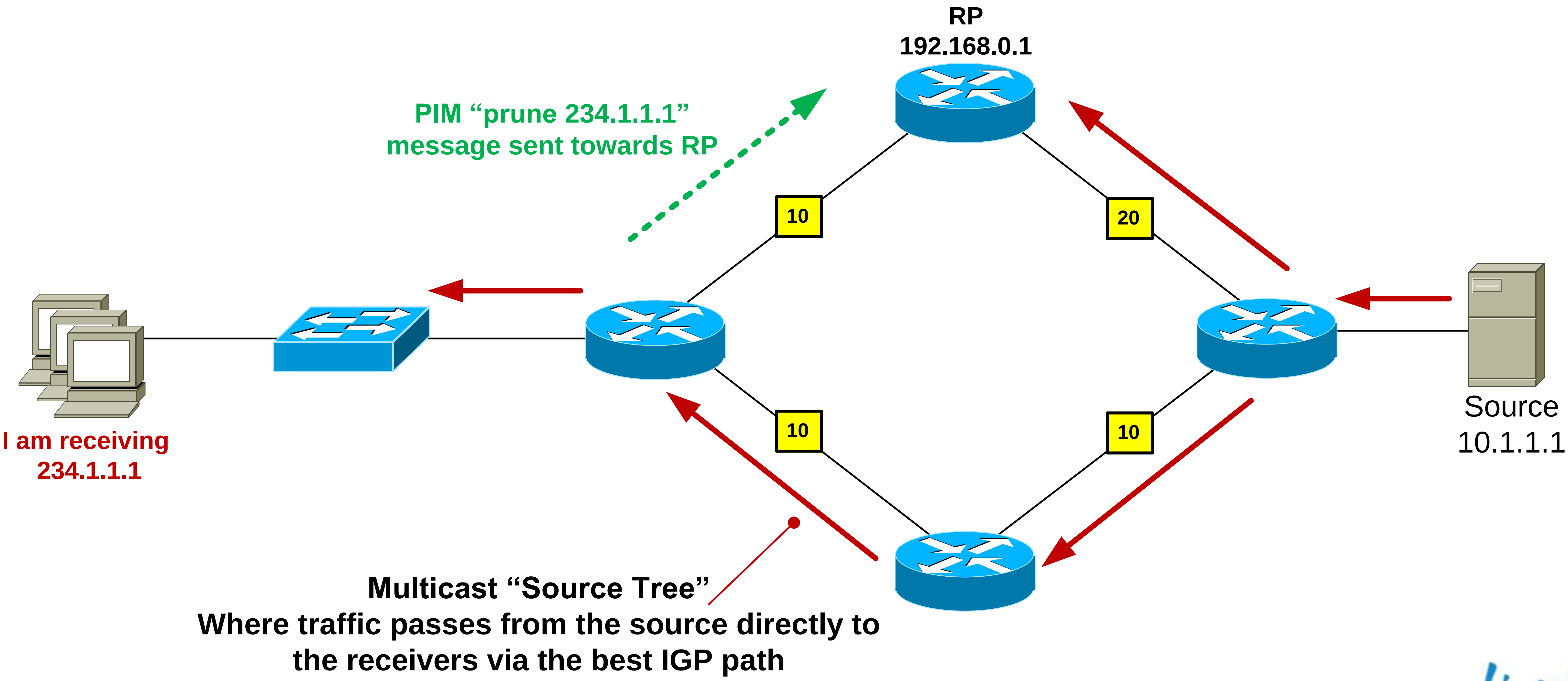

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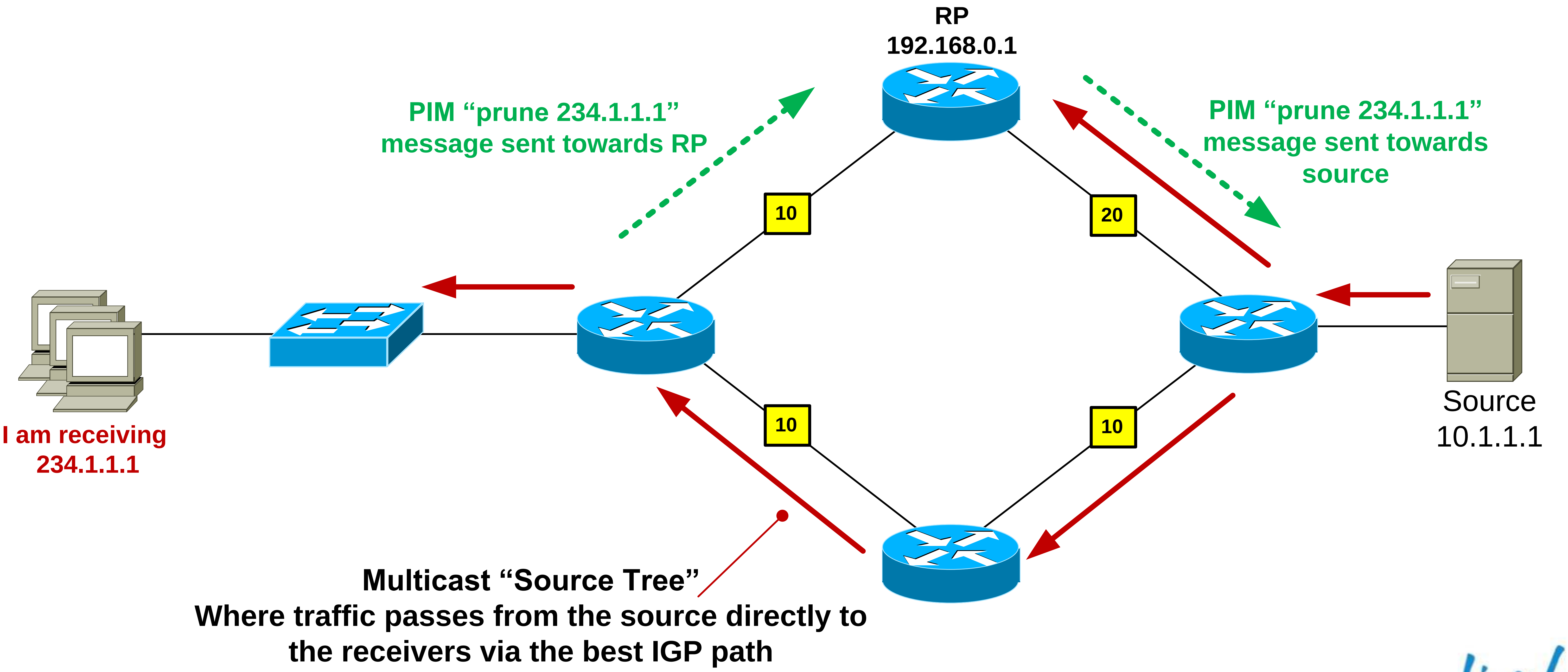

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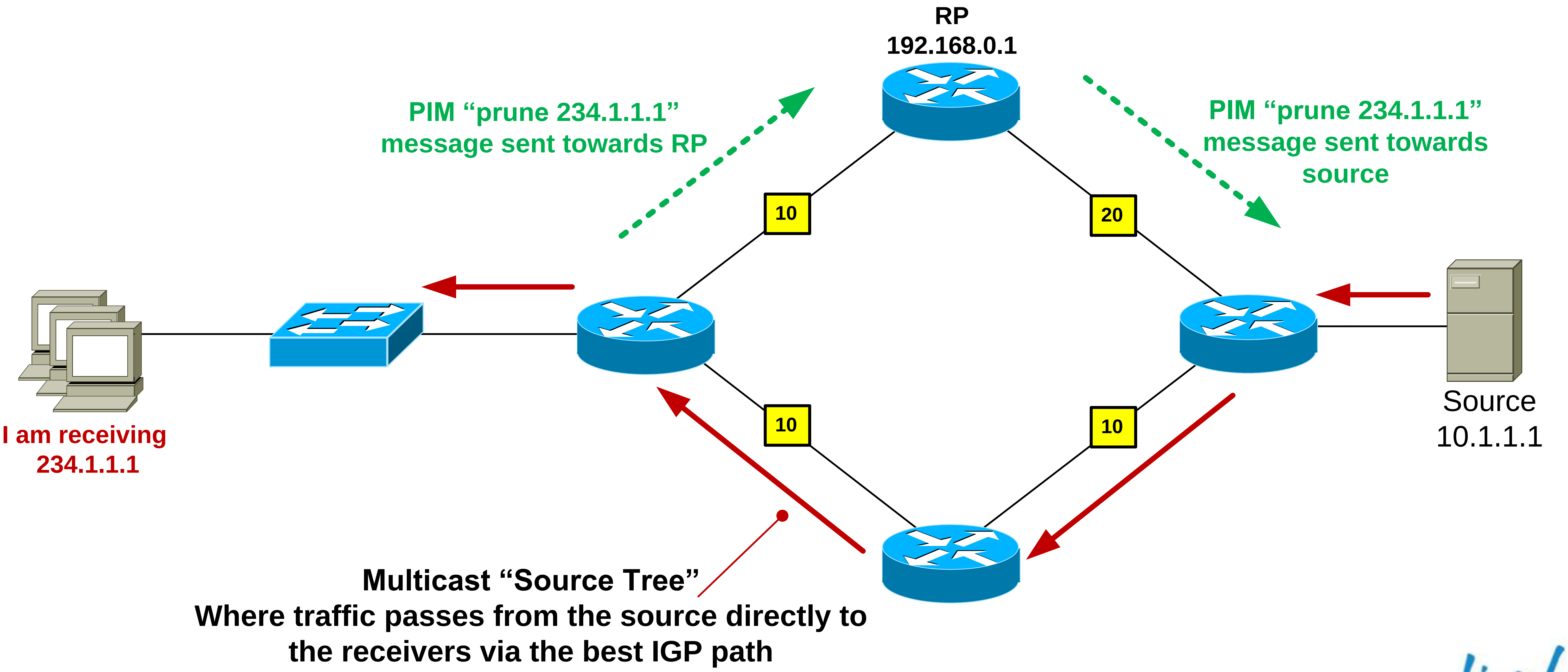


PIM-SM: Rendezvous Point Discovery

So how does the network know where the RP is ?

- Option 1: Static RP configuration

  Configure **all** routers in the network with the IP address of the RP

```
ip pim rp-address 192.168.0.1
```

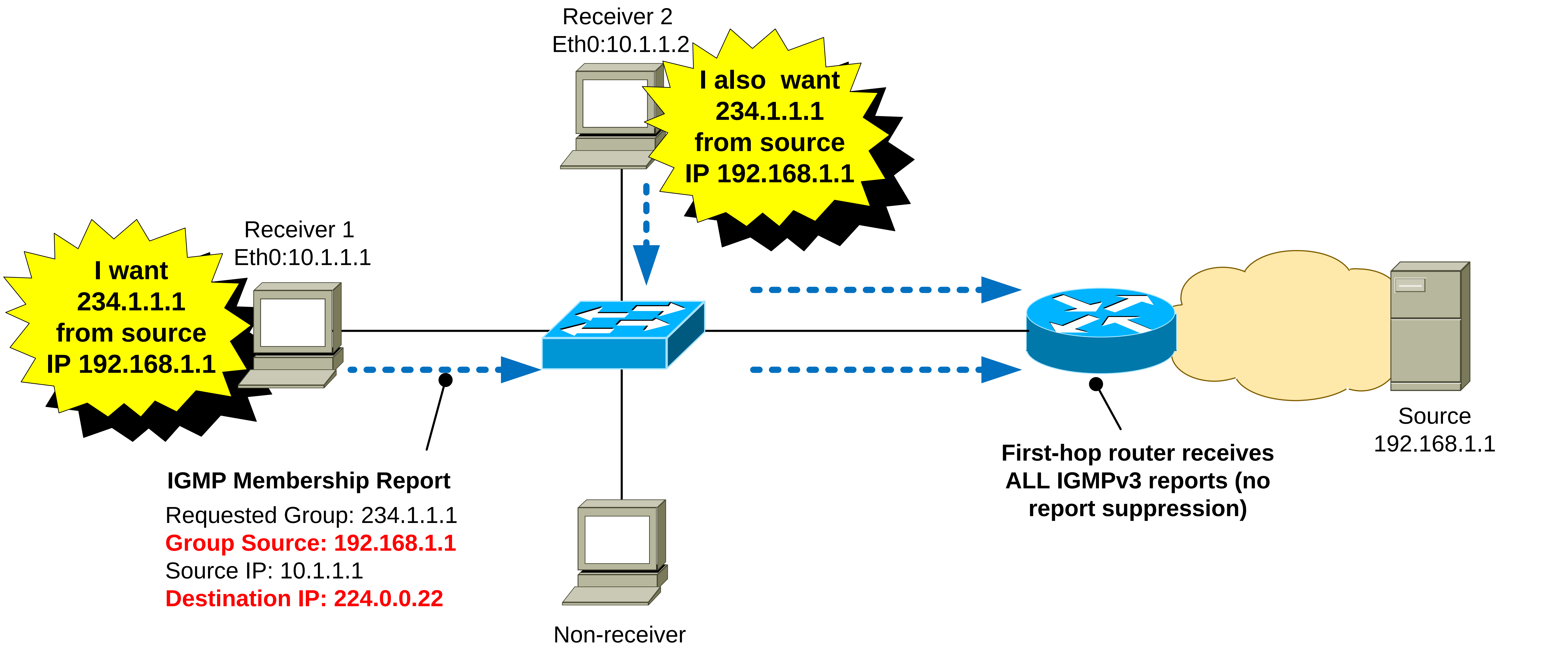
- Option 2: Dynamic RP configuration

  Configure the RP to tell all other routers that it is the RP

  Cisco proprietary mechanism is called “Auto-RP”

  IETF standard is known as Bootstrap Router (BSR) – RFC 5059

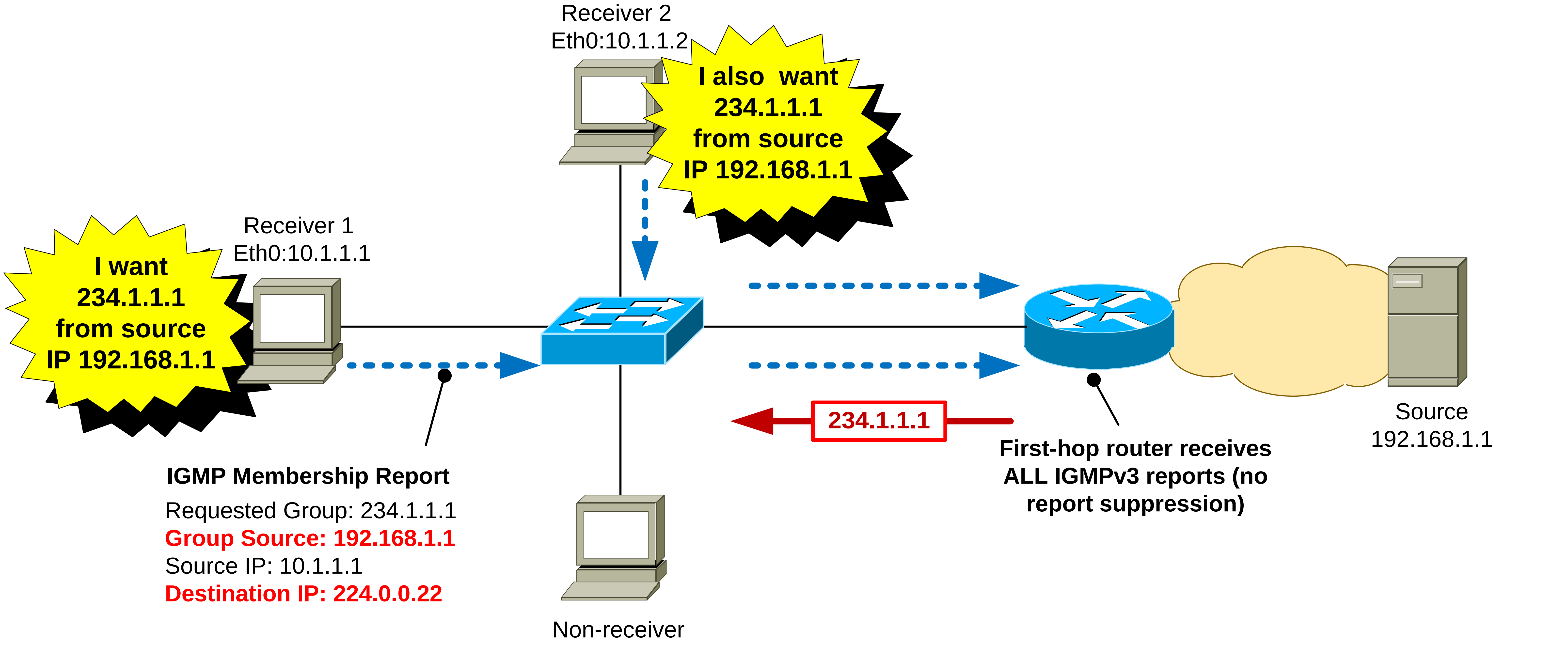
IGMPv3 – Joining a Group



IGMP Membership Report

Requested Group: 234.1.1.1
Group Source: 192.168.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.22

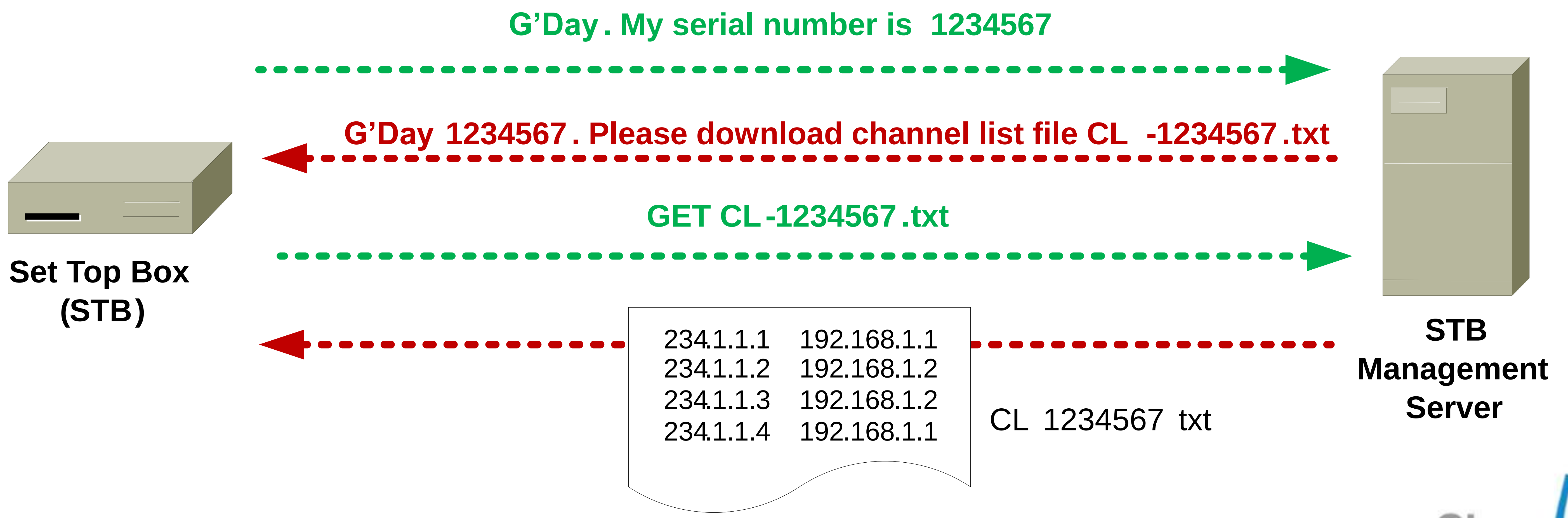
IGMPv3 – Joining a Group



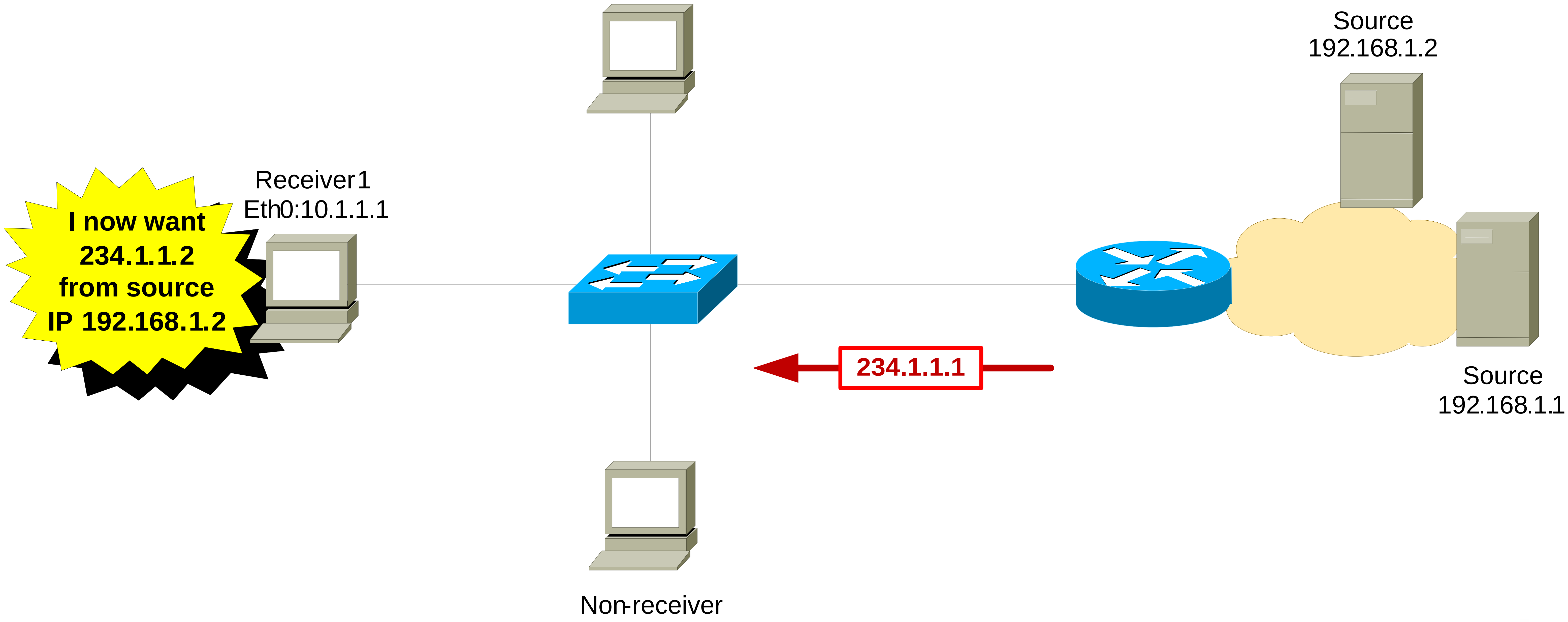
IGMPv3 Source Discovery

Q: How does the receiver know the source address for each group ?

A: The receiver app is pre-populated with this information.



IGMPv3 – Changing a Group



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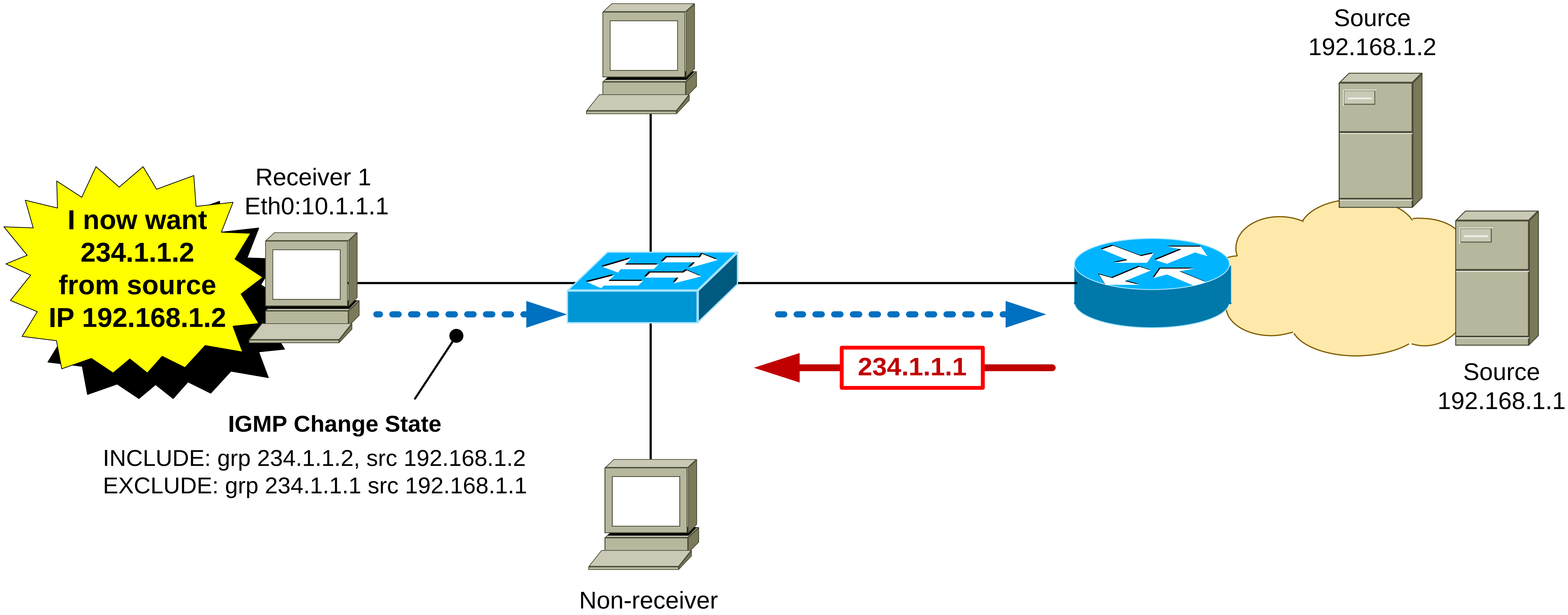

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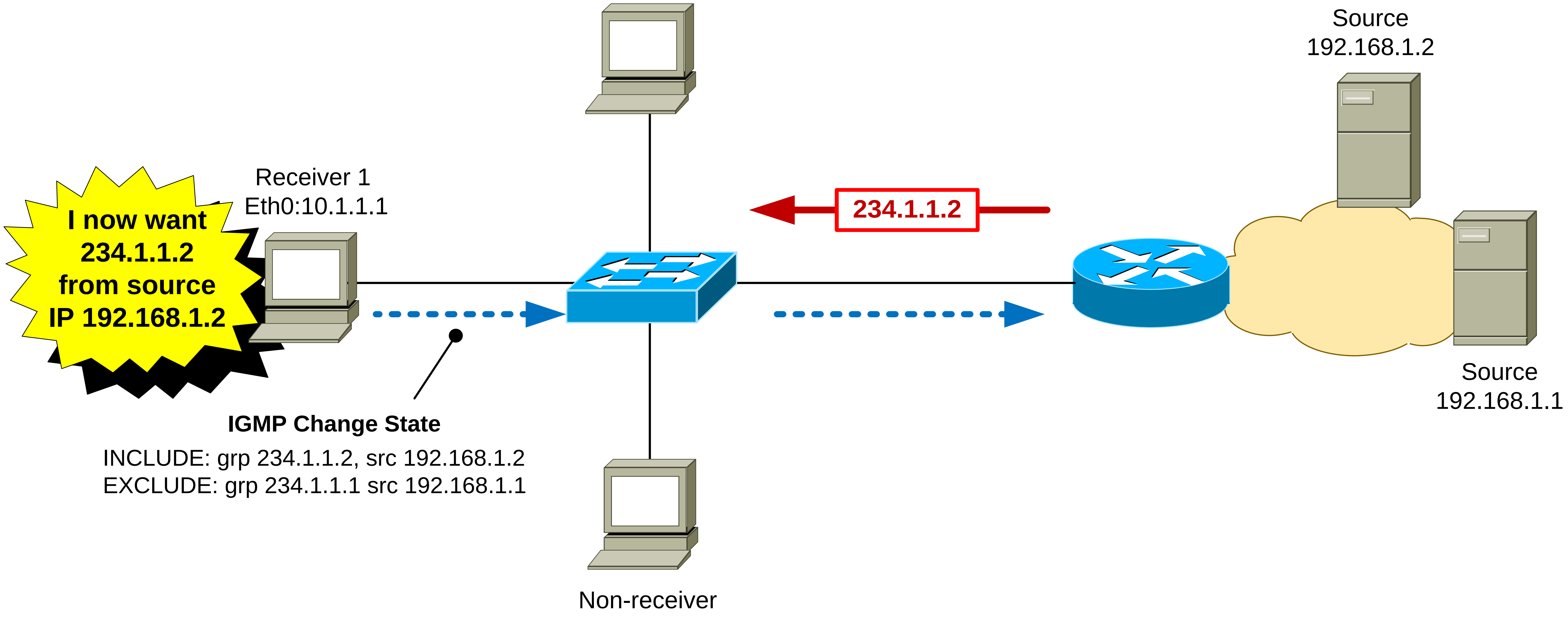


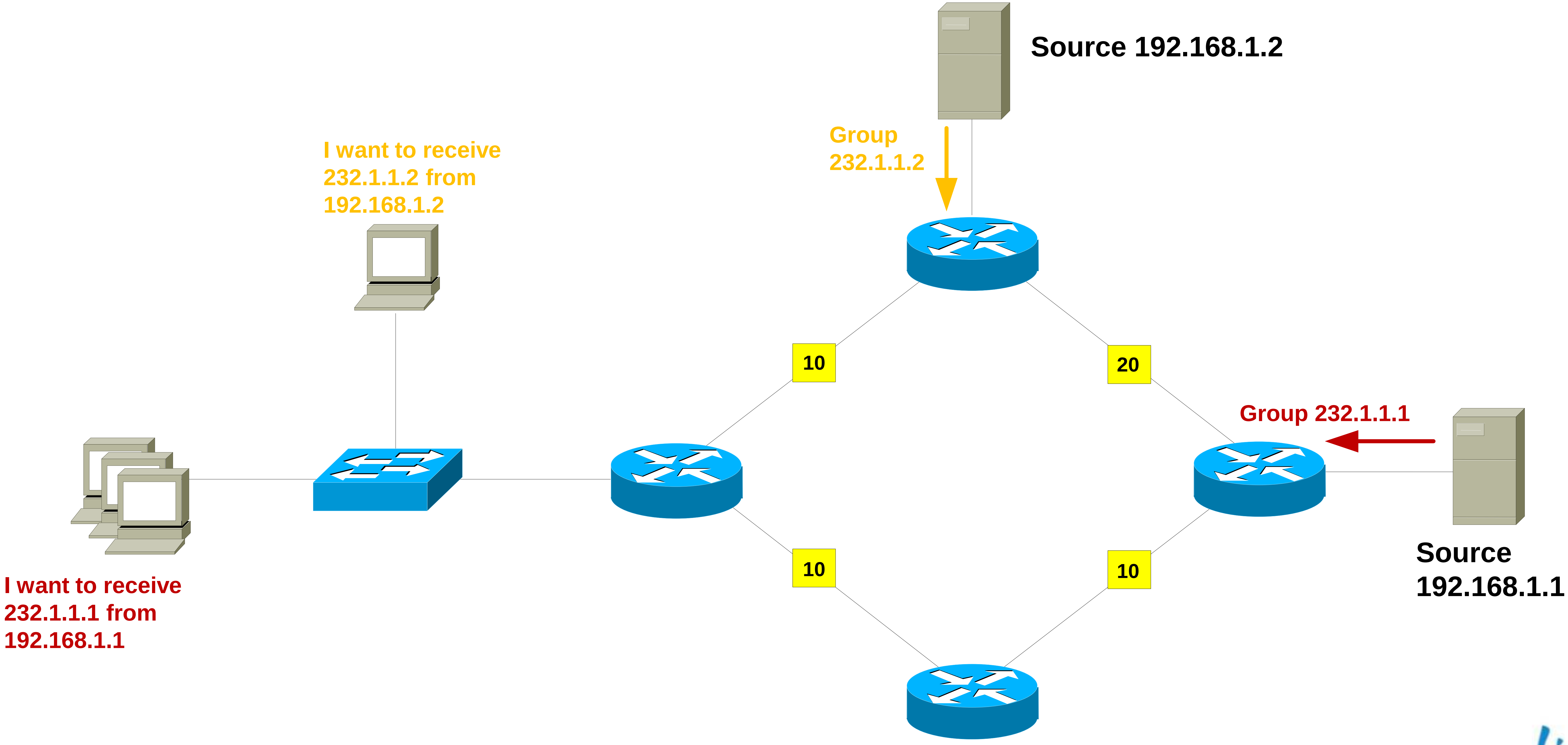
Advantages of IGMPv3

- Hosts can join one group and leave another in the same transaction. IGMPv2 requires separate report/leave messages.
- Reduces the likelihood of multicast group being spoofed by a rogue source.
- Eliminates overlapping multicast addresses.
- First-hop router immediately knows the source address, so no need for Rendezvous Point – can use PIM-SSM.

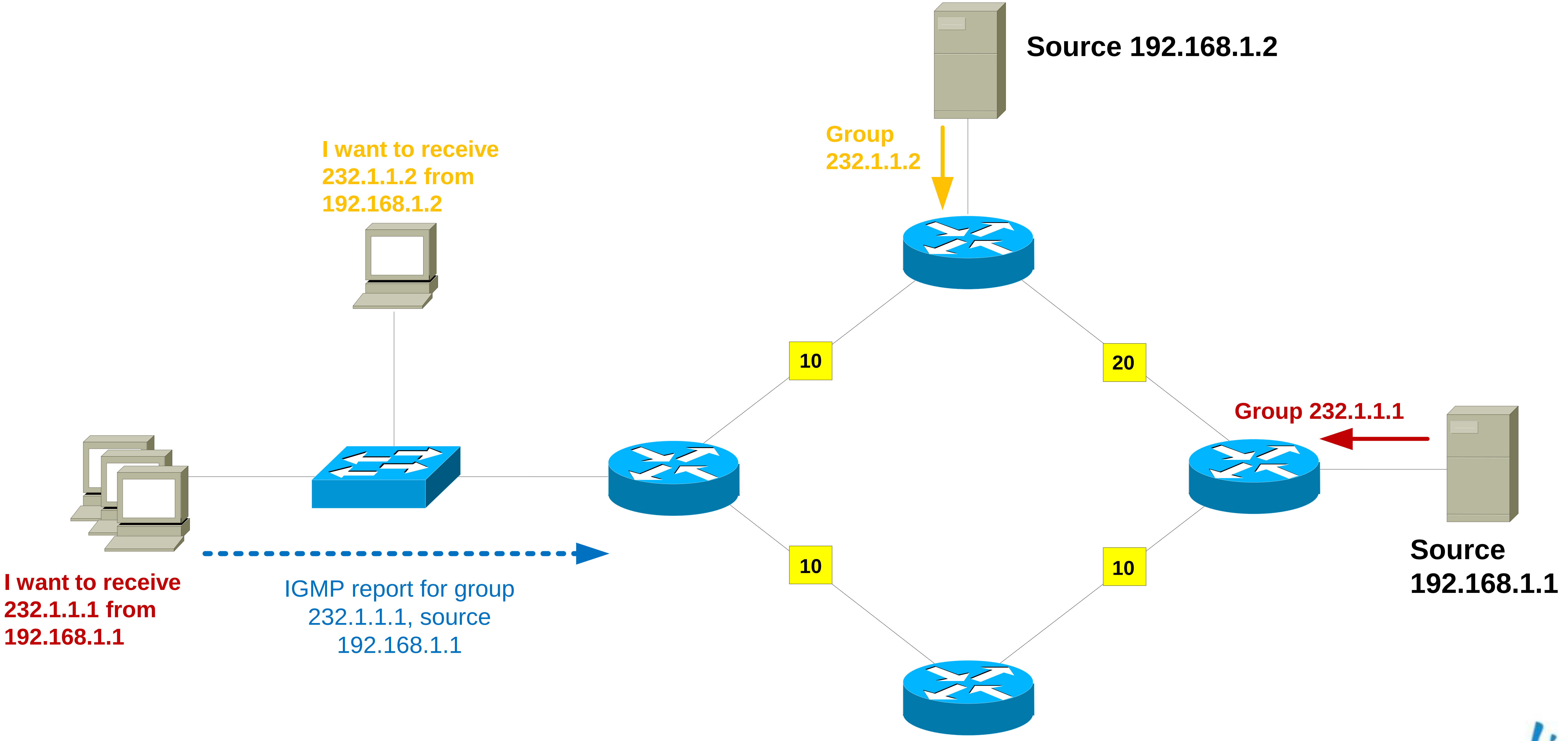
Router-Router Signalling: PIM-SSM

- **SSM = Source Specific Multicast**
- PIM-SSM requires the first-hop router to know the address of the MC source for each group
- PIM-SSM is usually deployed in conjunction with IGMPv3, where the receiver indicates the source address in the IGMPv3 report packet
- The first-hop router sends a PIM join **directly** towards the sender using the unicast routing table. There is no “Shared Tree” via an RP as in PIM-SM.

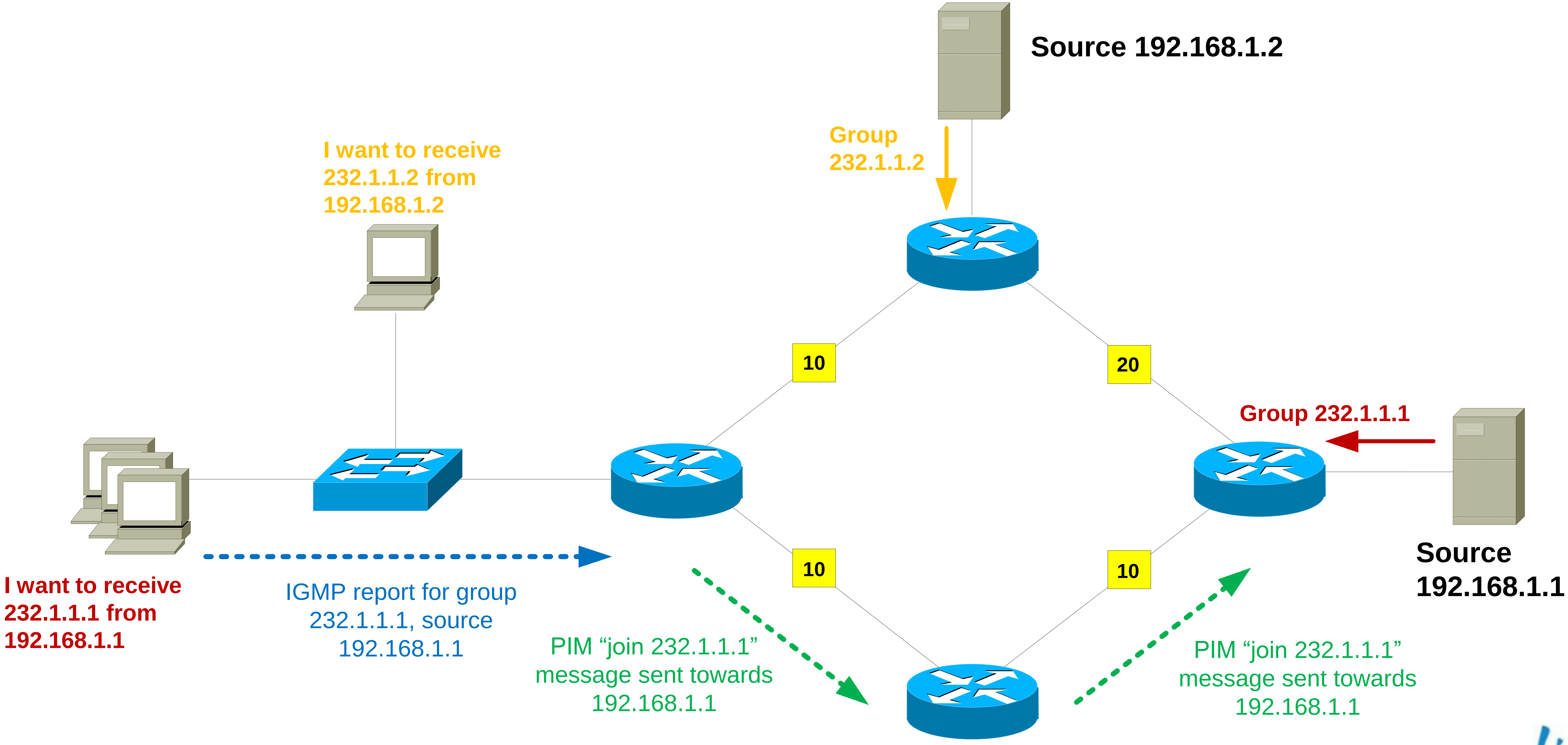
PIM-SSM: Operation



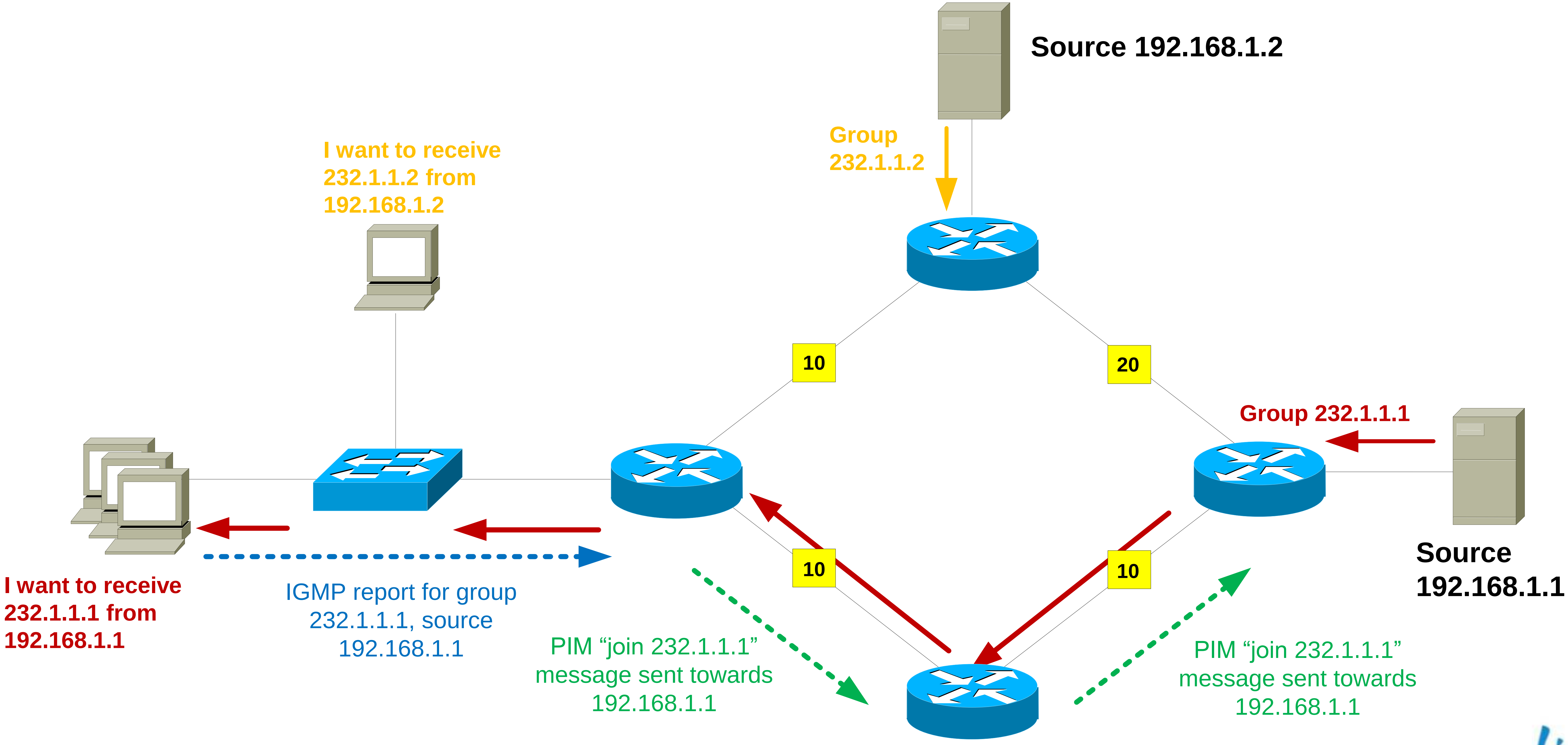
PIM-SSM: Operation



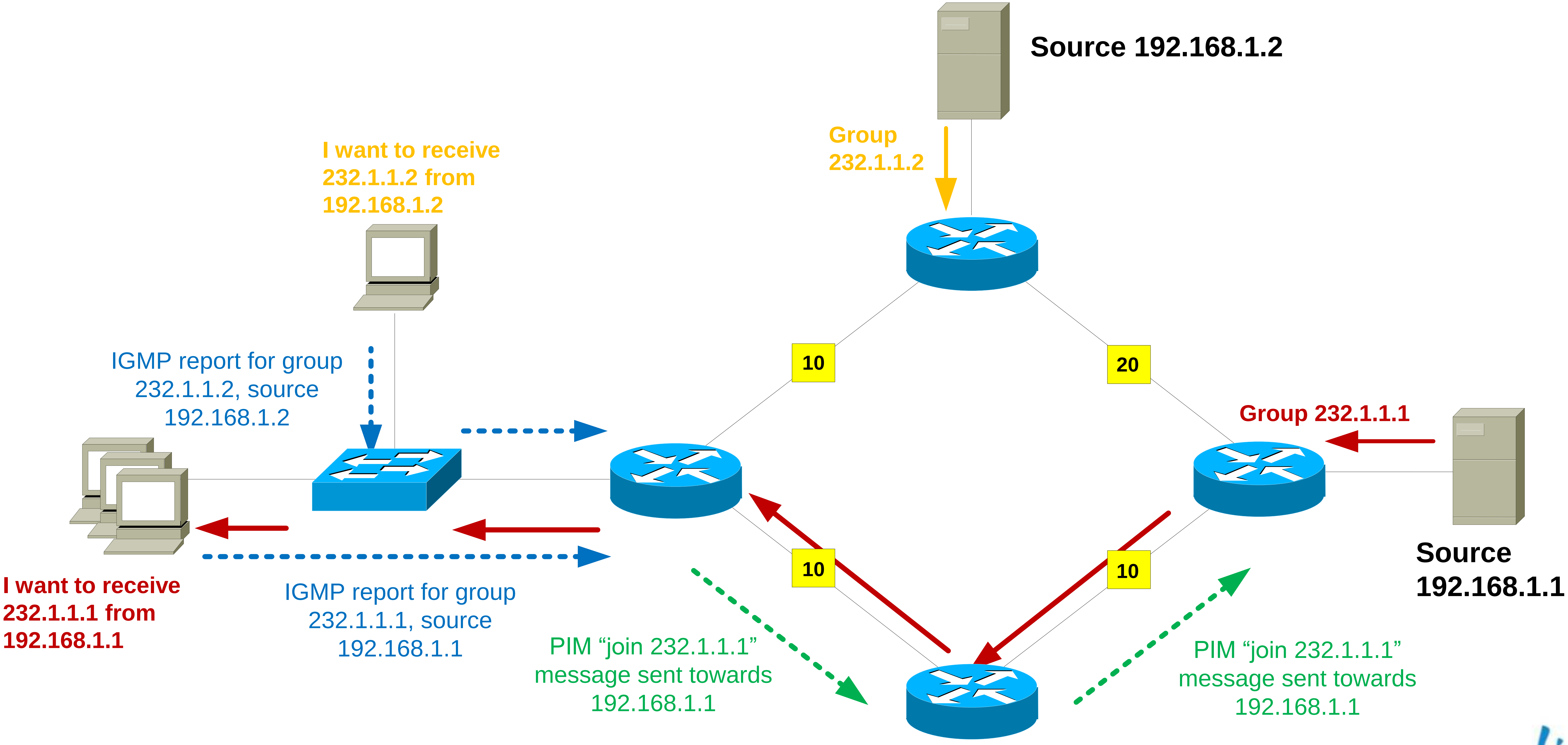
PIM-SSM: Operation



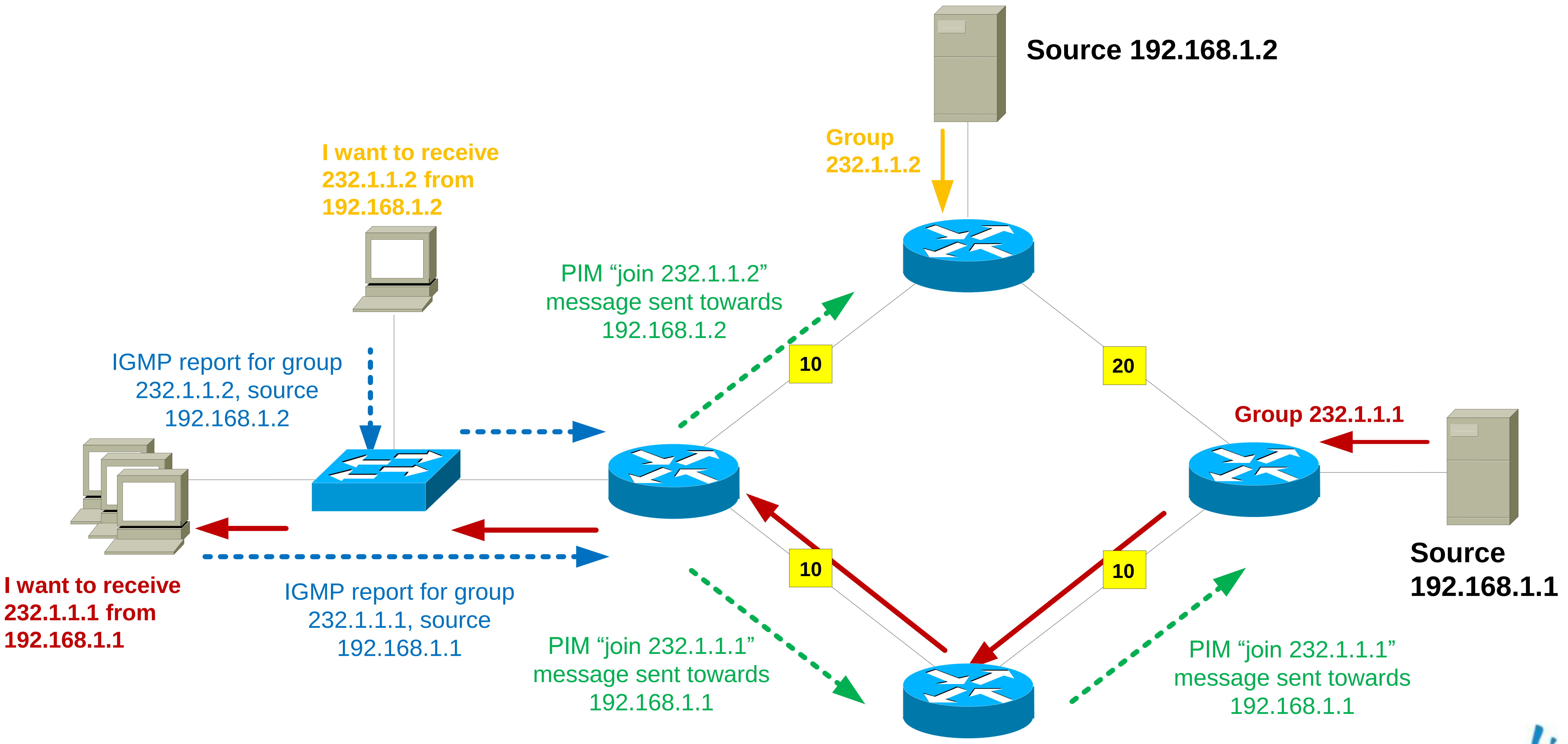
PIM-SSM: Operation



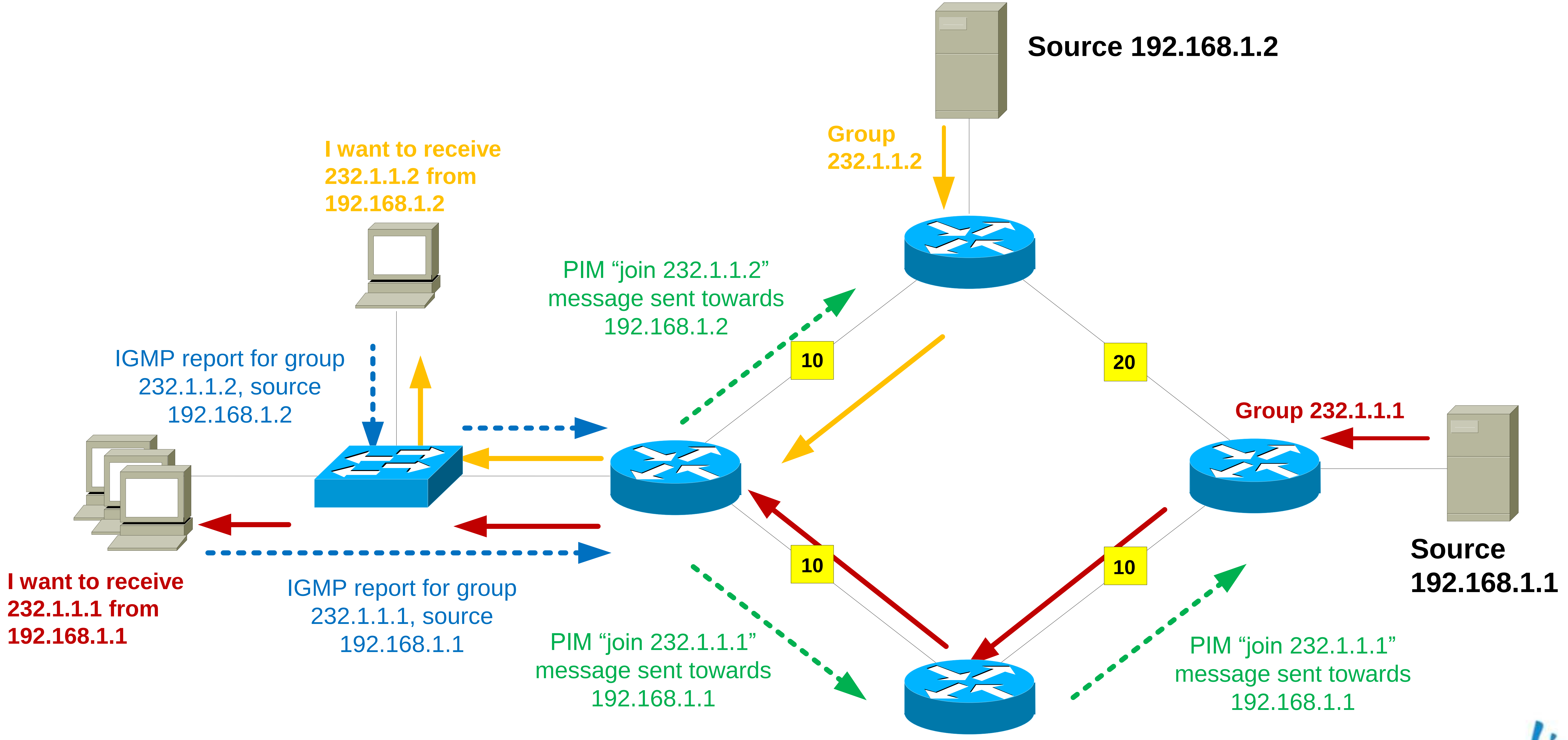
PIM-SSM: Operation



PIM-SSM: Operation



PIM-SSM: Operation



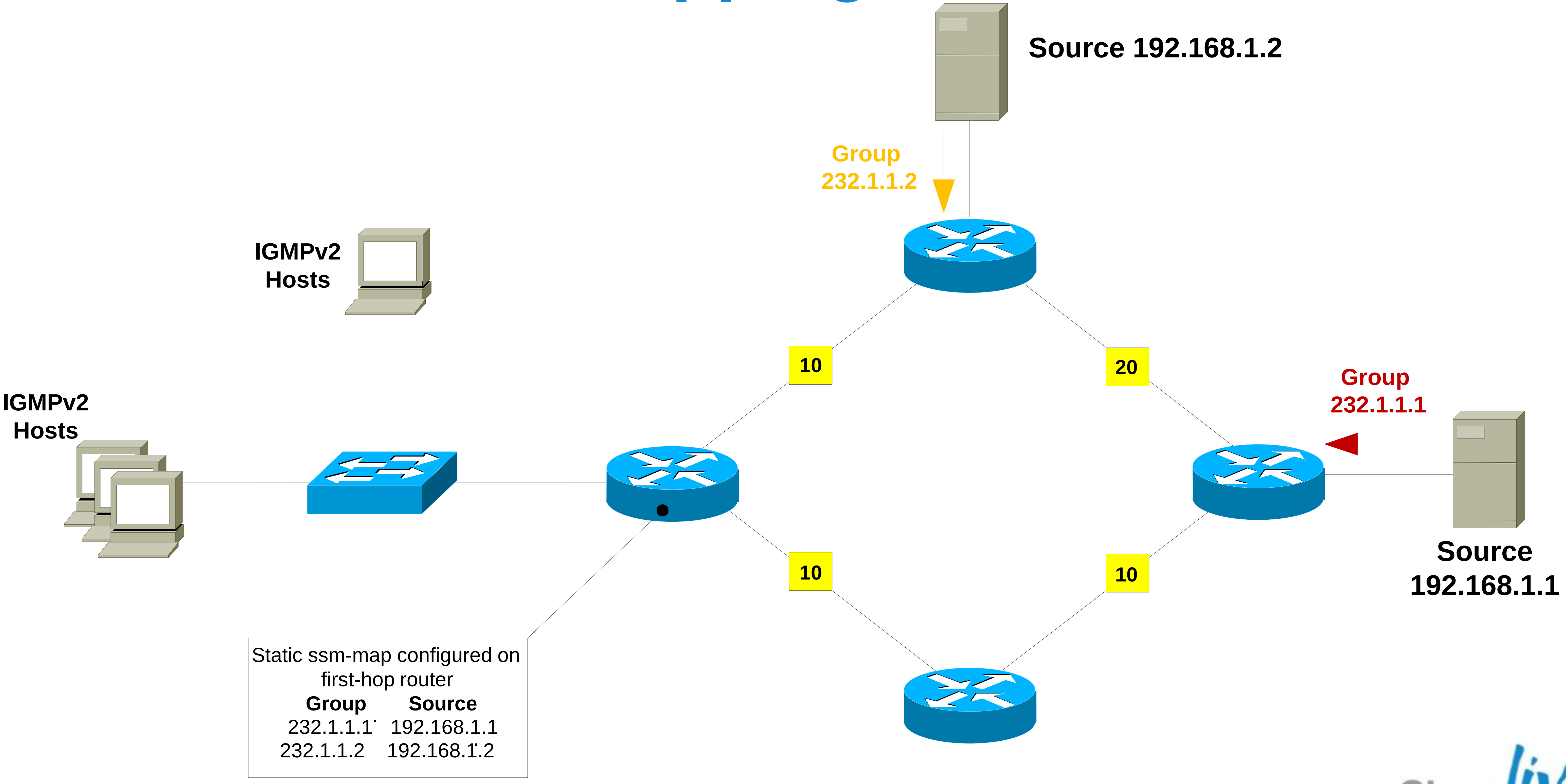
PIM-SSM Advantages

- Easy to configure and maintain
  - No RPs
  - No Multicast Source Discovery Protocol (MSDP) between redundant RPs
- Efficient network usage
  - Traffic is not routed temporarily via the RP
  - Most direct path from source to receiver is always used
- Enhanced security
  - Spoofing of MC stream is more difficult

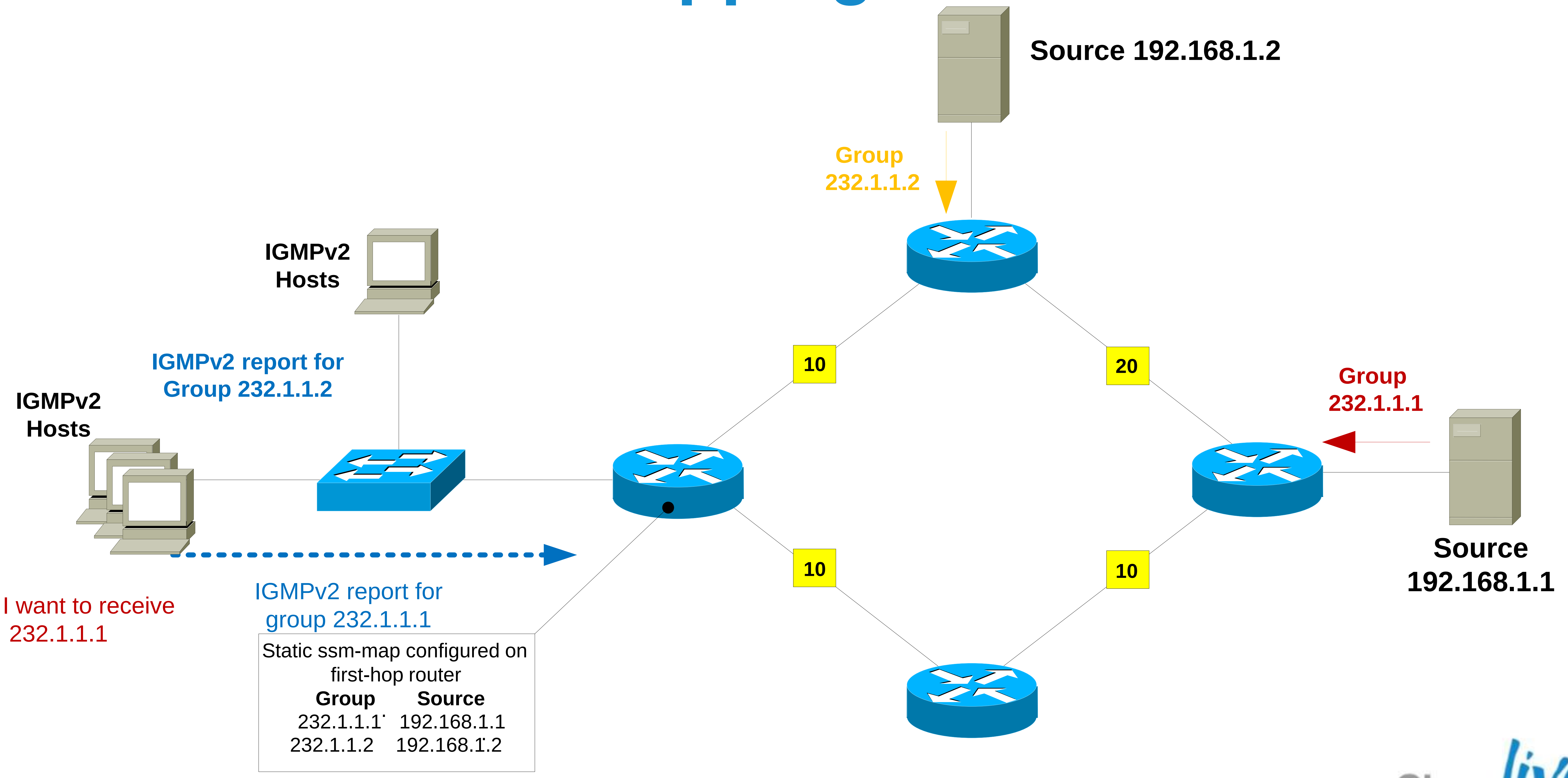
PIM-SSM Mapping

- The ideal SSM architecture uses IGMPv3 for host-router signalling and PIM-SSM for router-router signalling
- But...IGMPv3 host support is patchy, whereas IGMPv2 is ubiquitous
- Q: Is there a way to use PIM-SSM in the network when I have hosts that only support IGMPv2 ?
- A: Yes – its called PIM-SSM mapping
- PIM-SSM mapping can be used as an interim measure until IGMPv3 is supported on all hosts

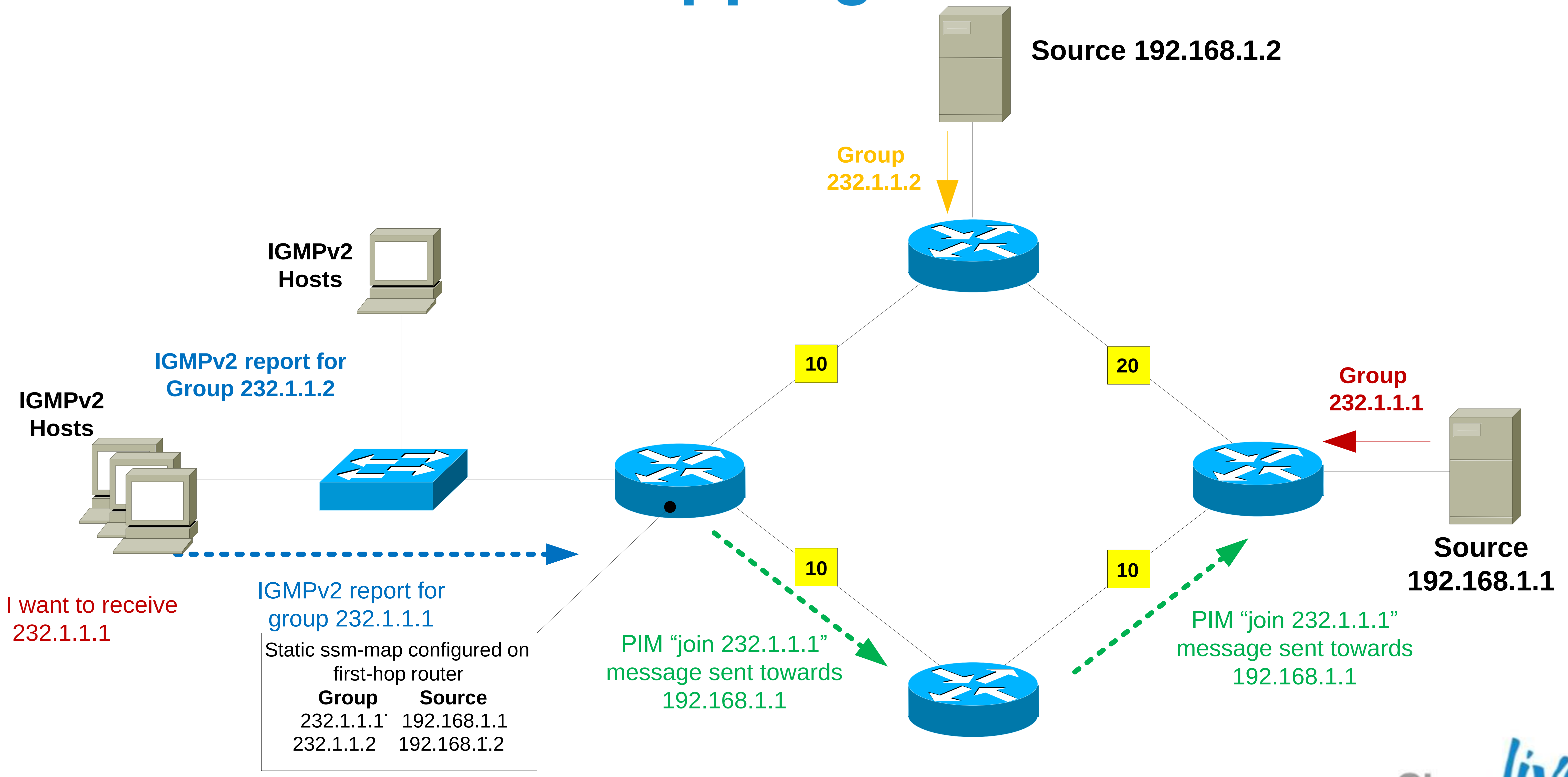
PIM-SSM Static Mapping



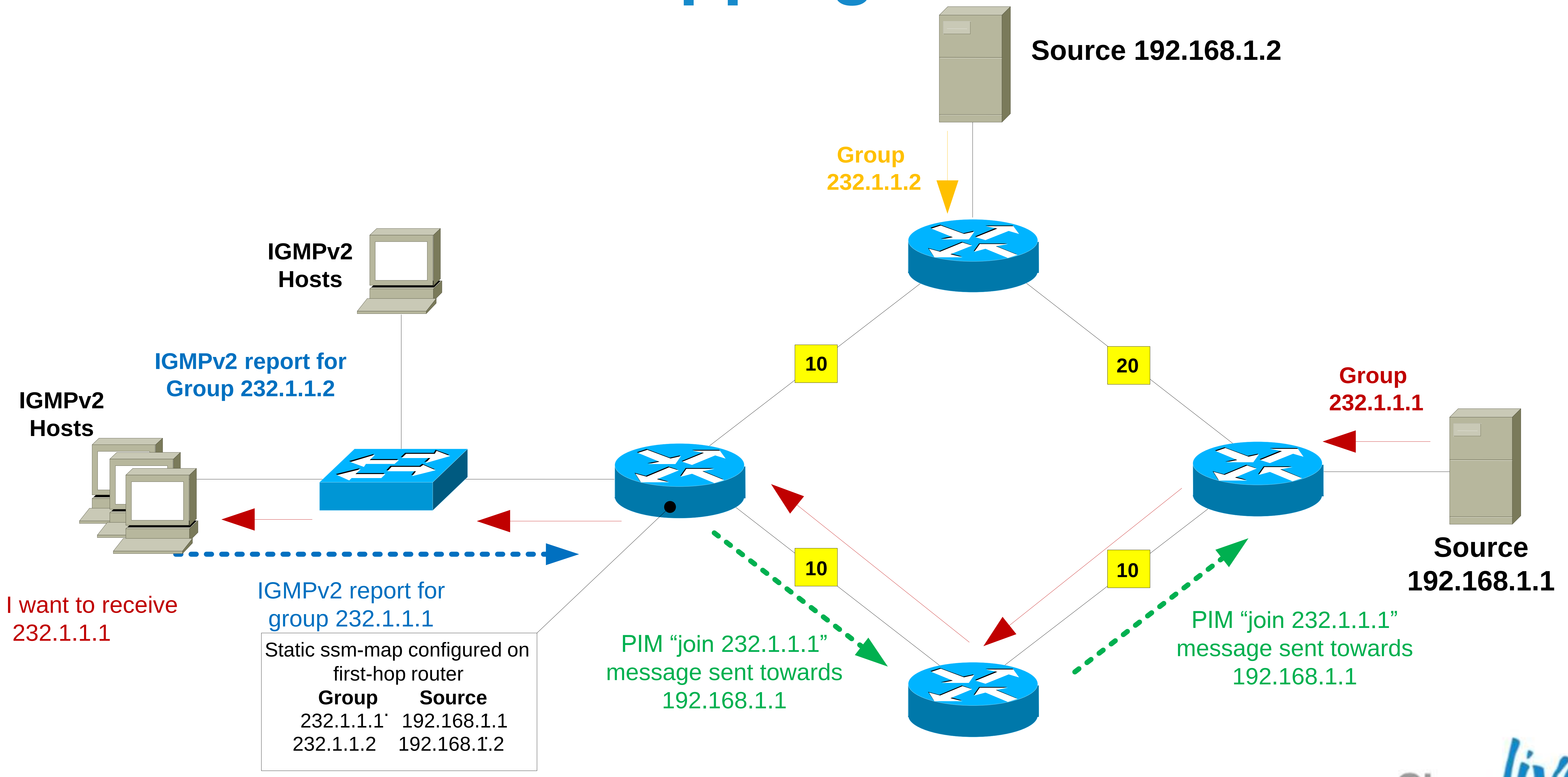
PIM-SSM Static Mapping



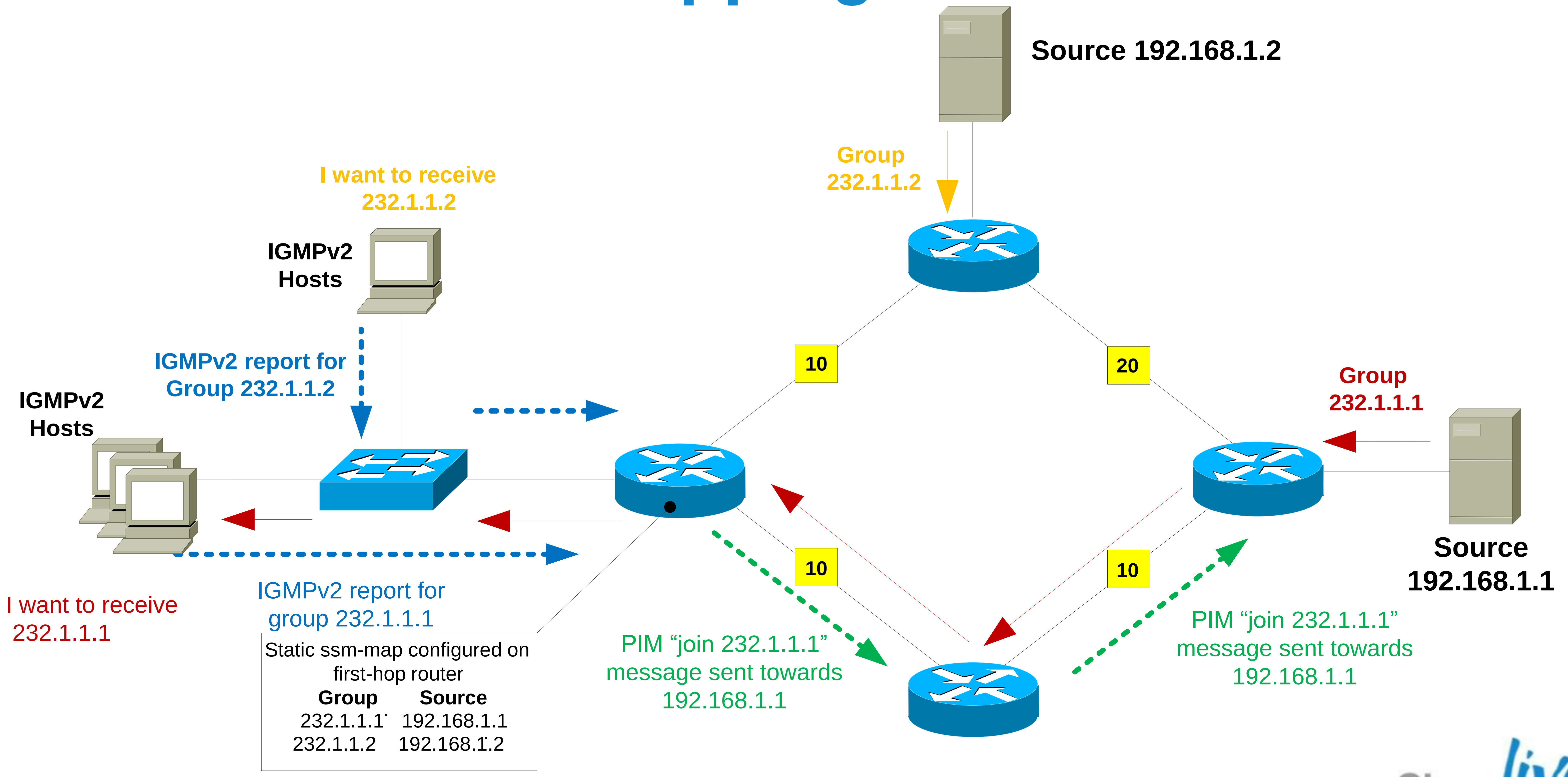
PIM-SSM Static Mapping



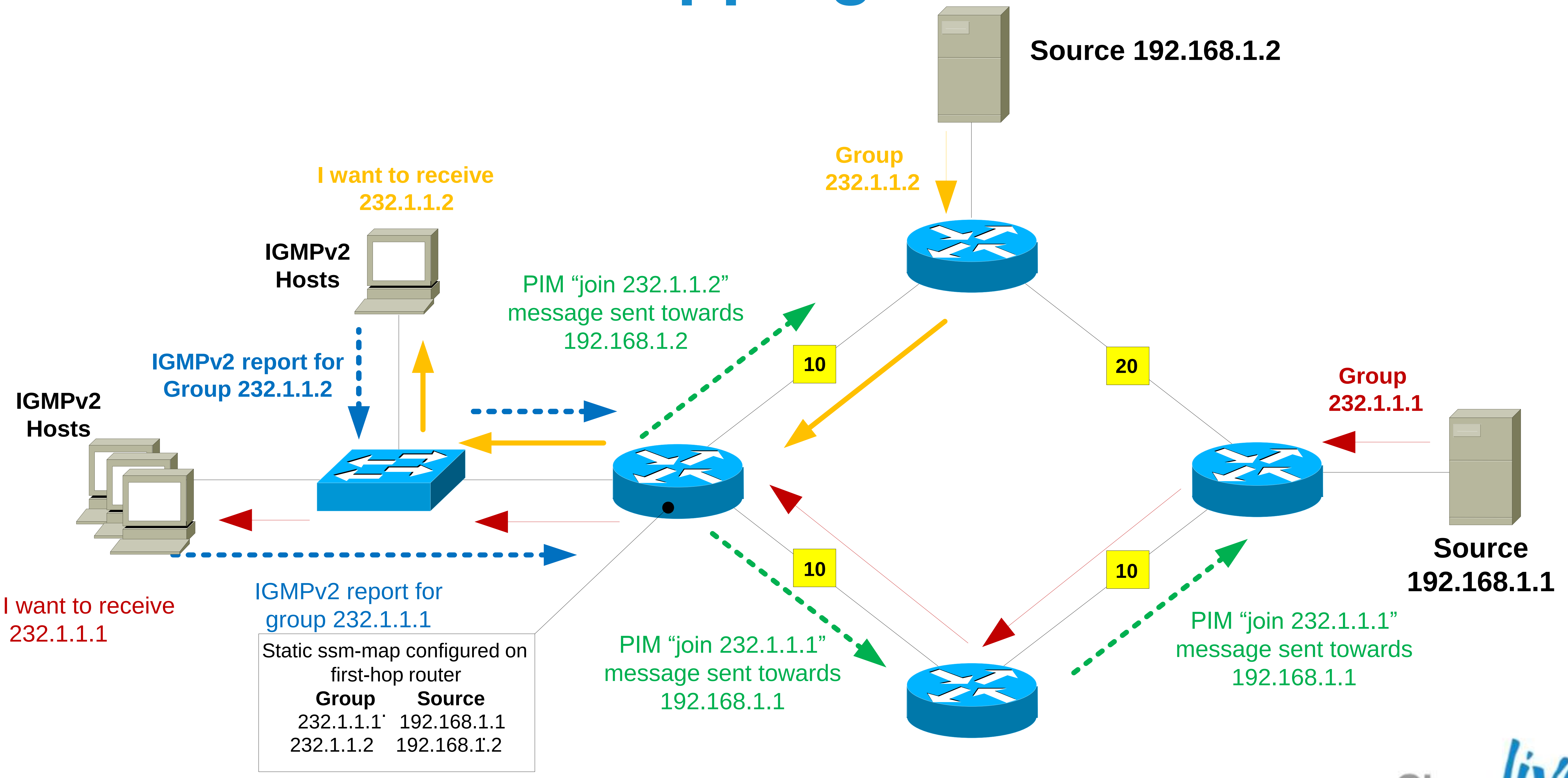
PIM-SSM Static Mapping



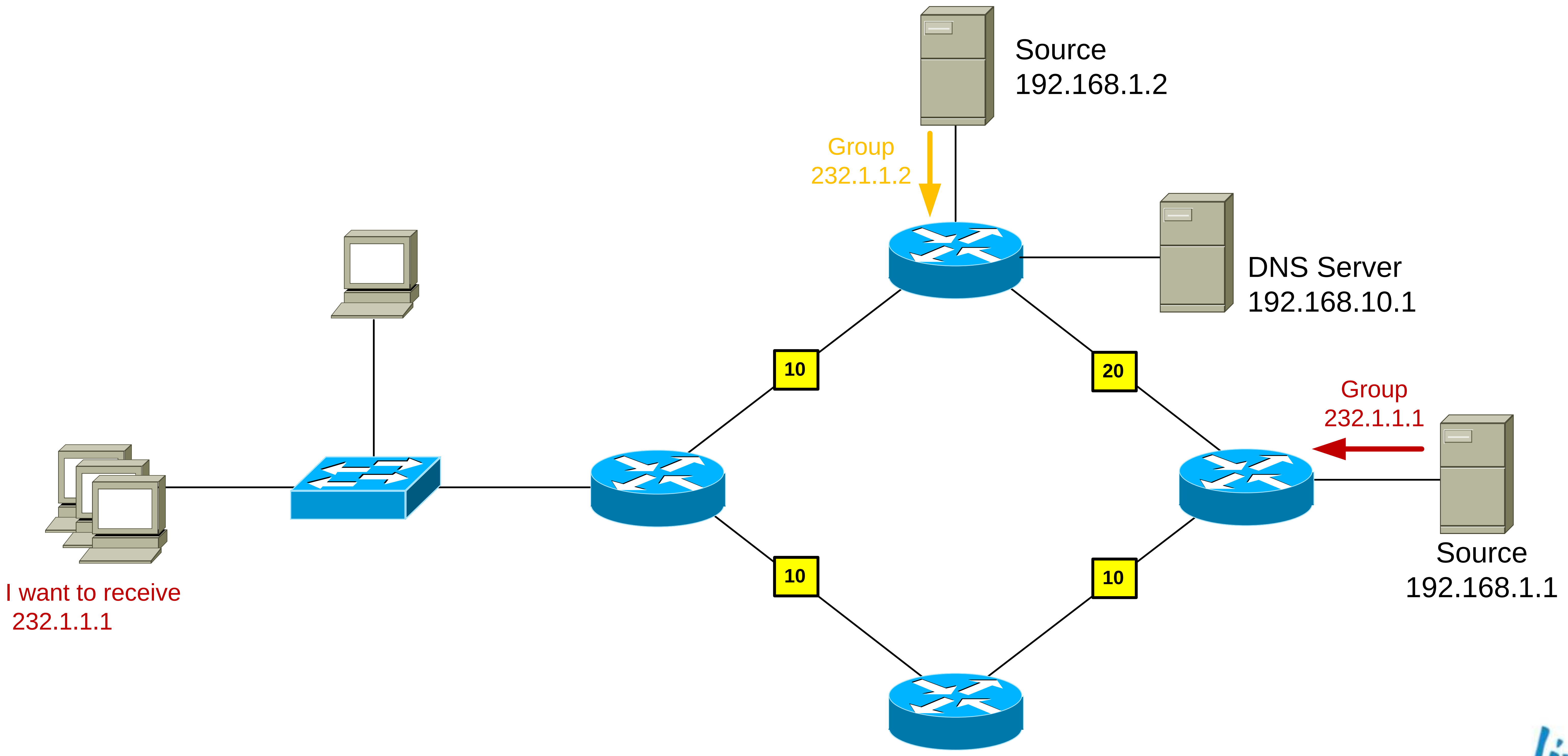
PIM-SSM Static Mapping



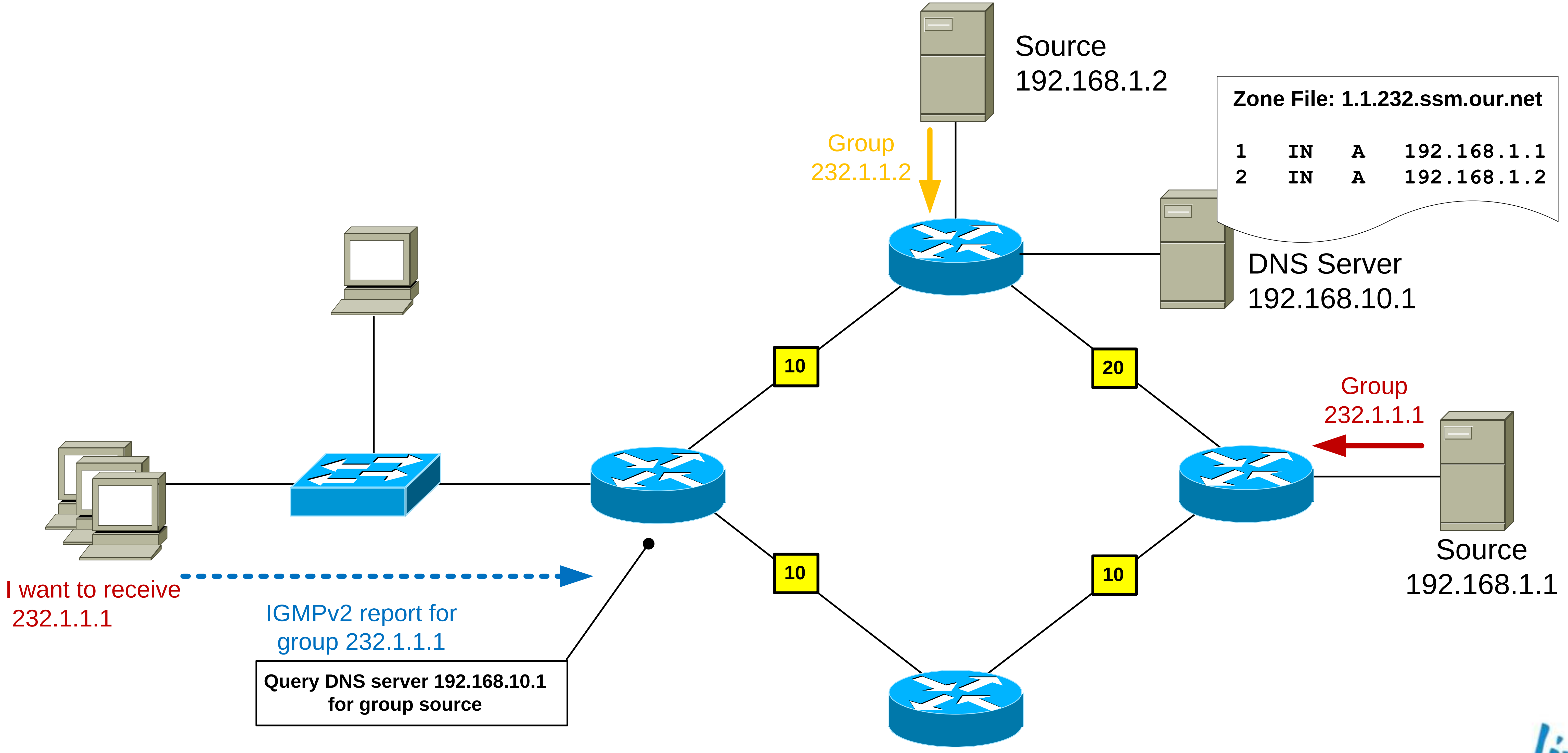
PIM-SSM Static Mapping



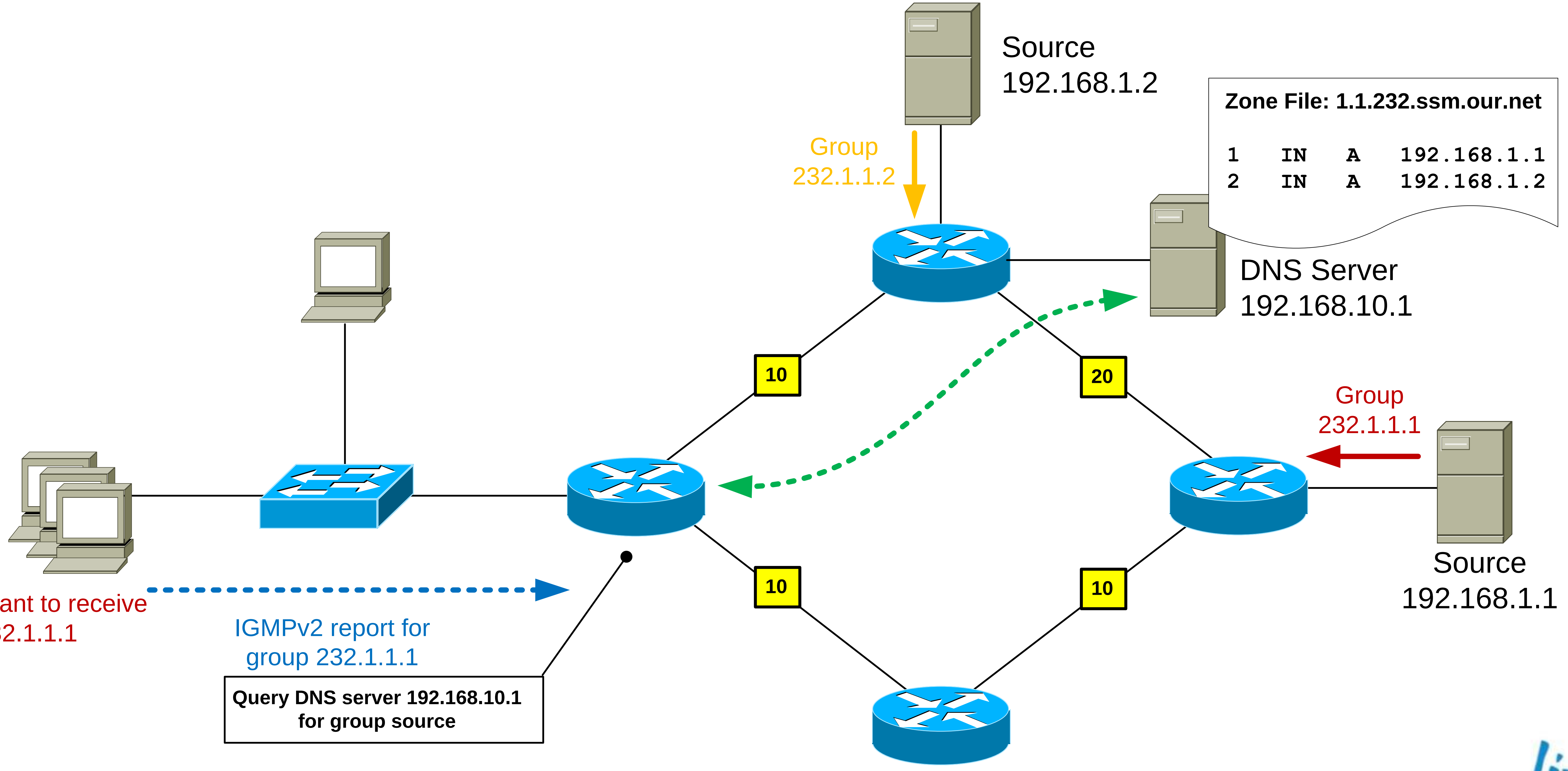
PIM-SSM Dynamic (DNS) Mapping



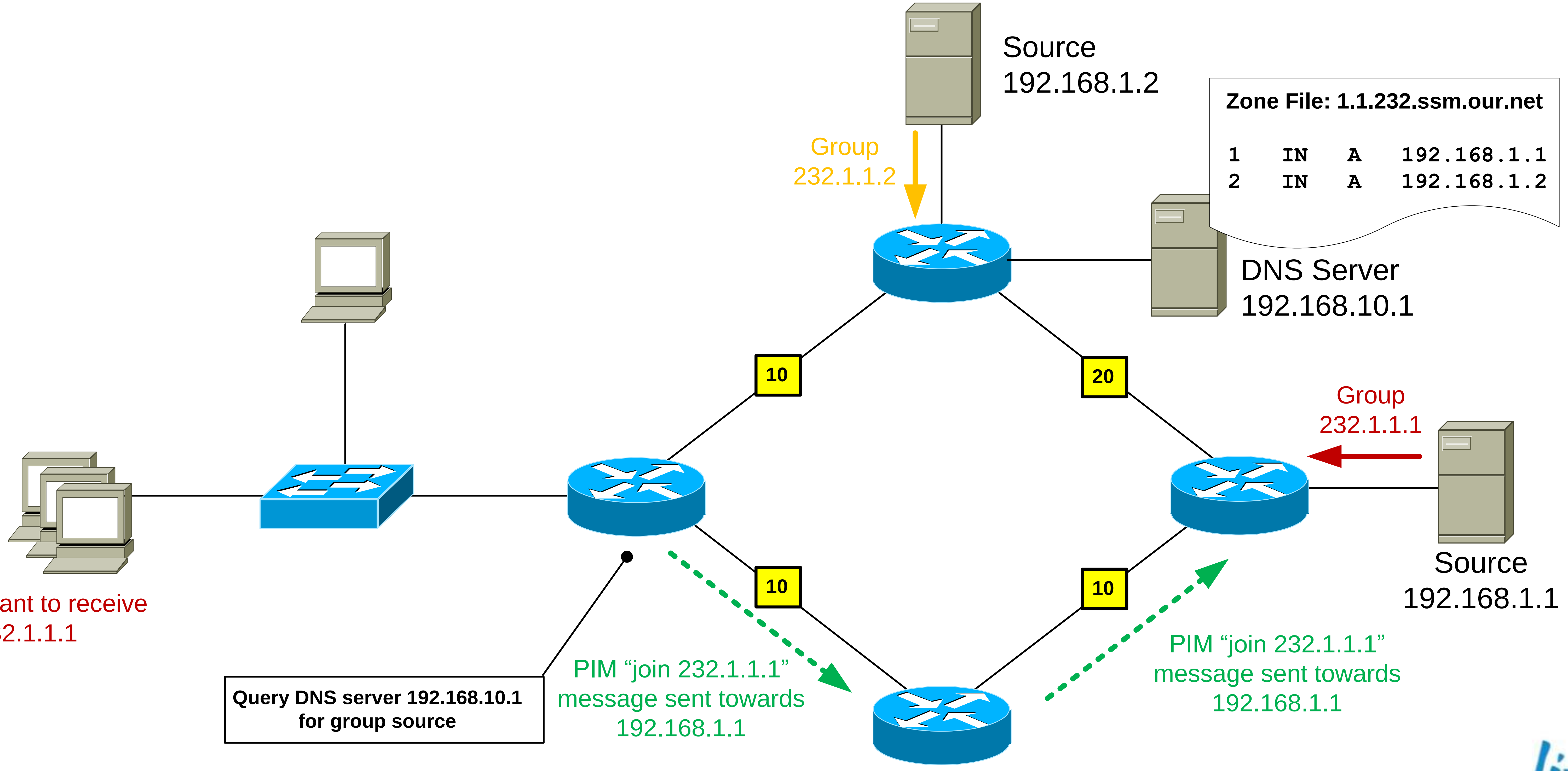
PIM-SSM Dynamic (DNS) Mapping



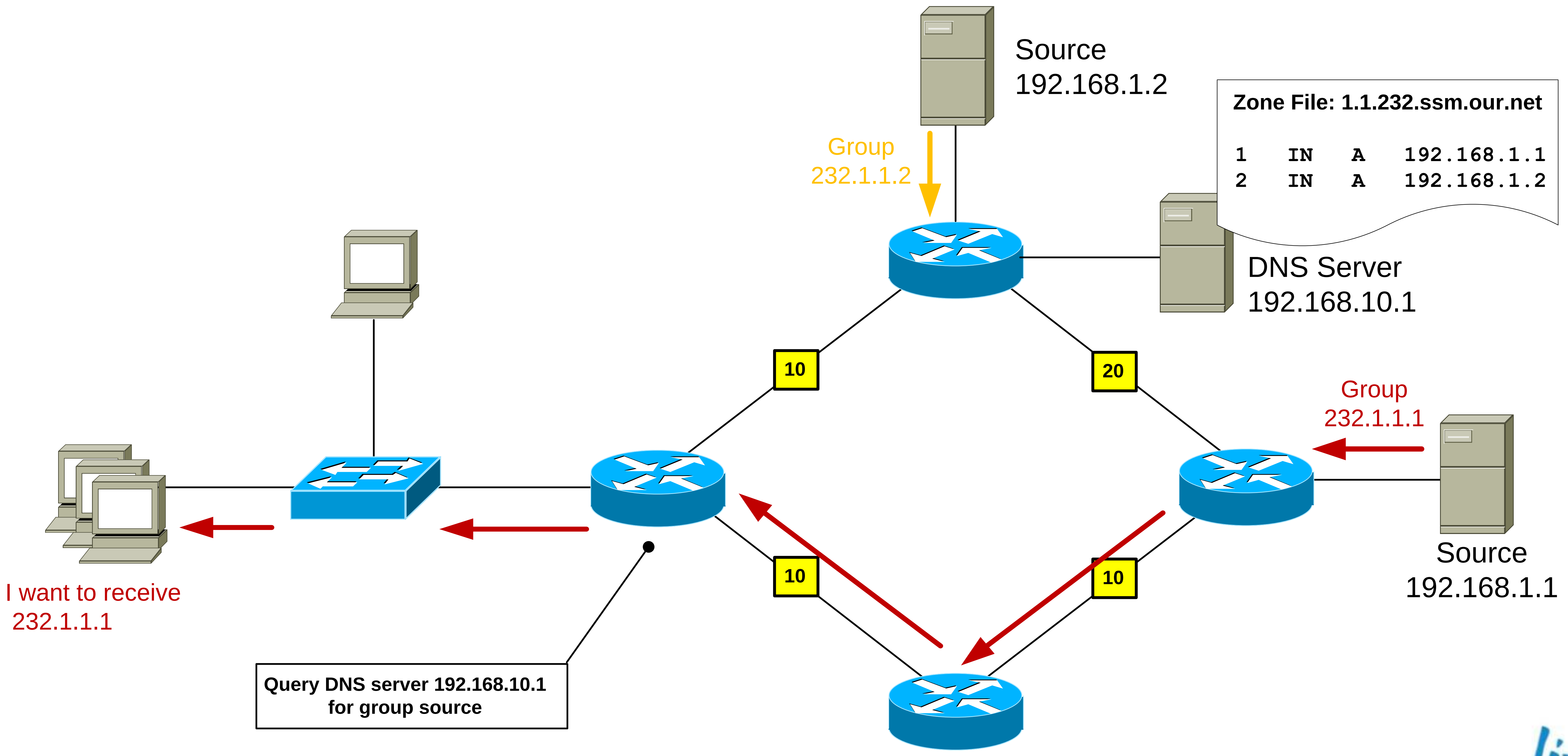
PIM-SSM Dynamic (DNS) Mapping



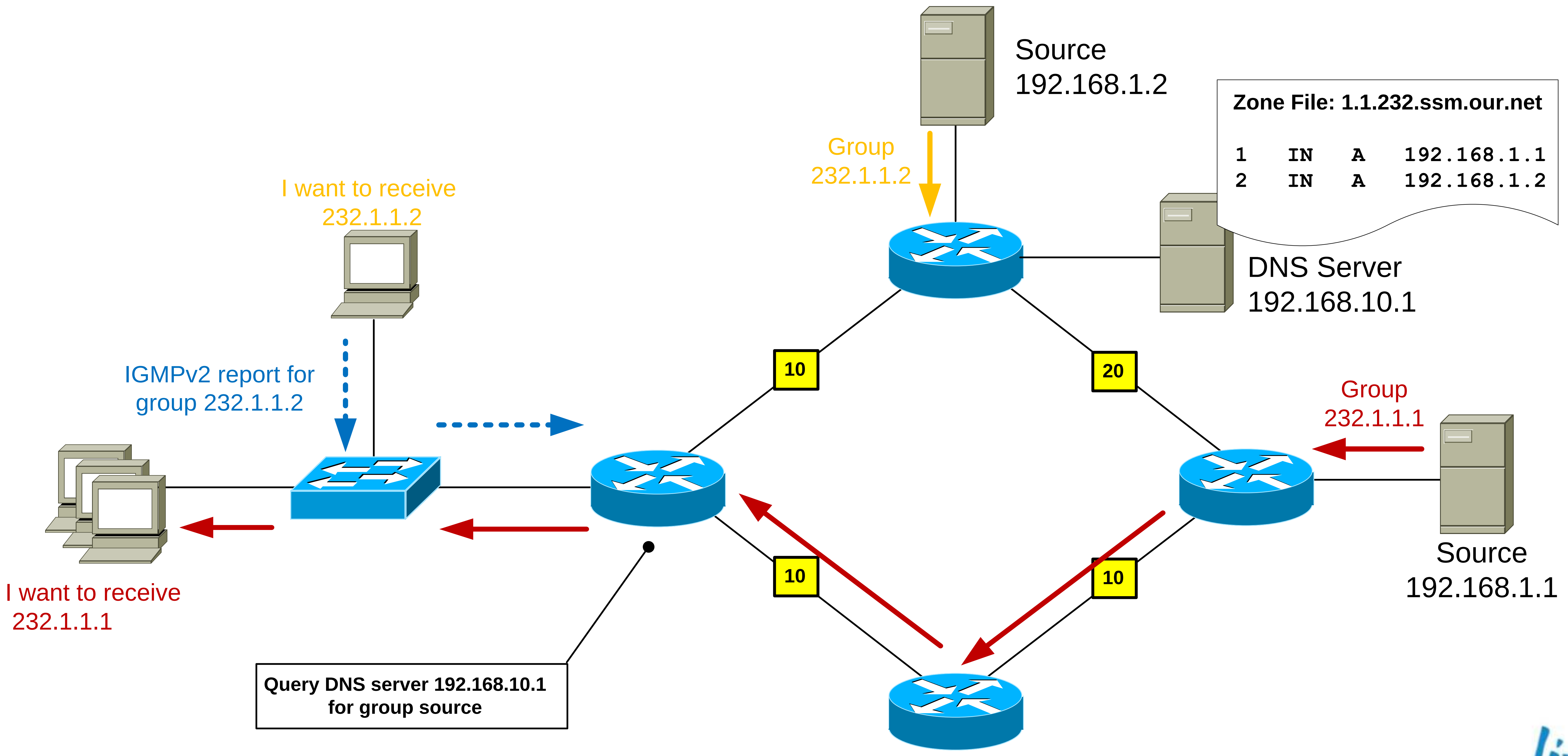
PIM-SSM Dynamic (DNS) Mapping



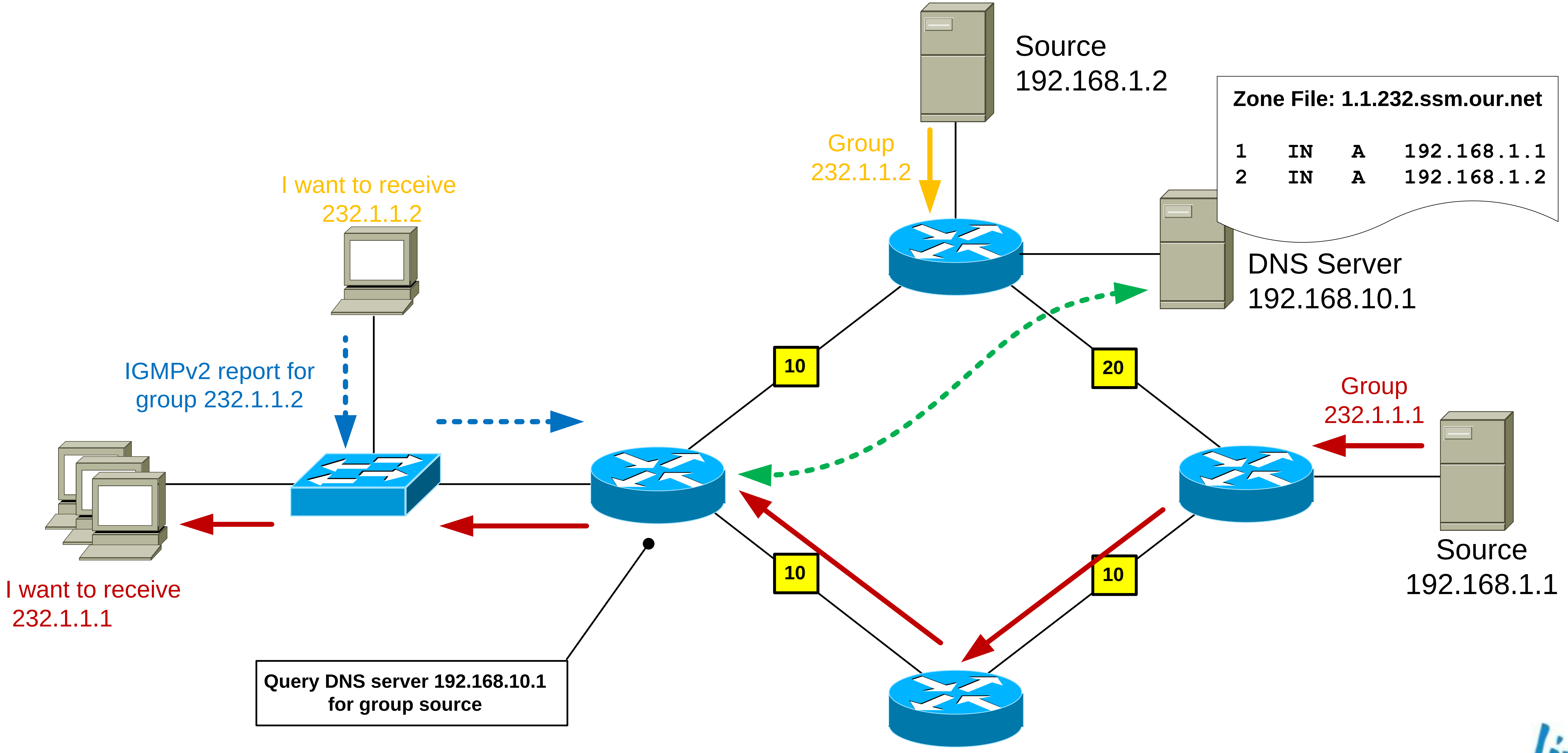
PIM-SSM Dynamic (DNS) Mapping



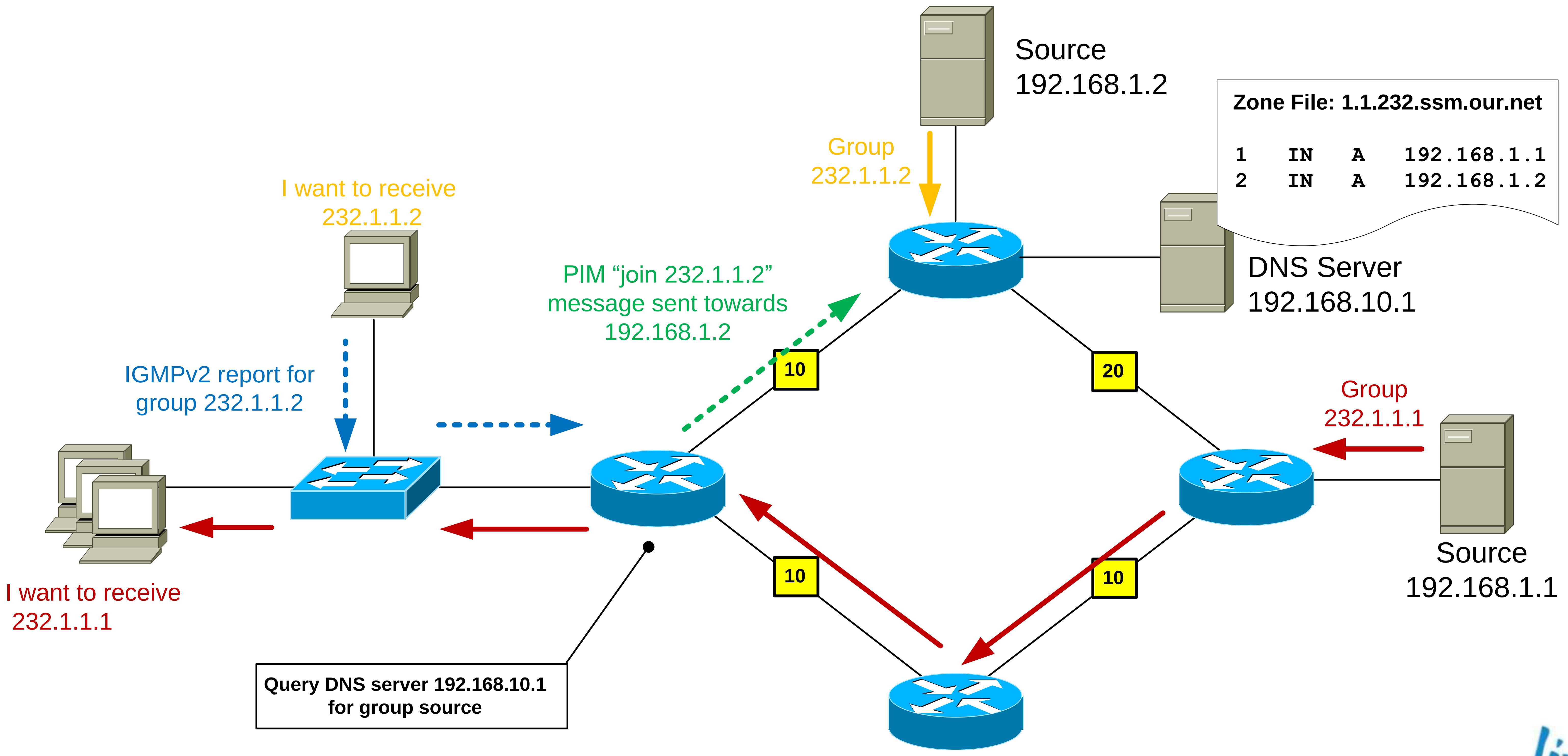
PIM-SSM Dynamic (DNS) Mapping



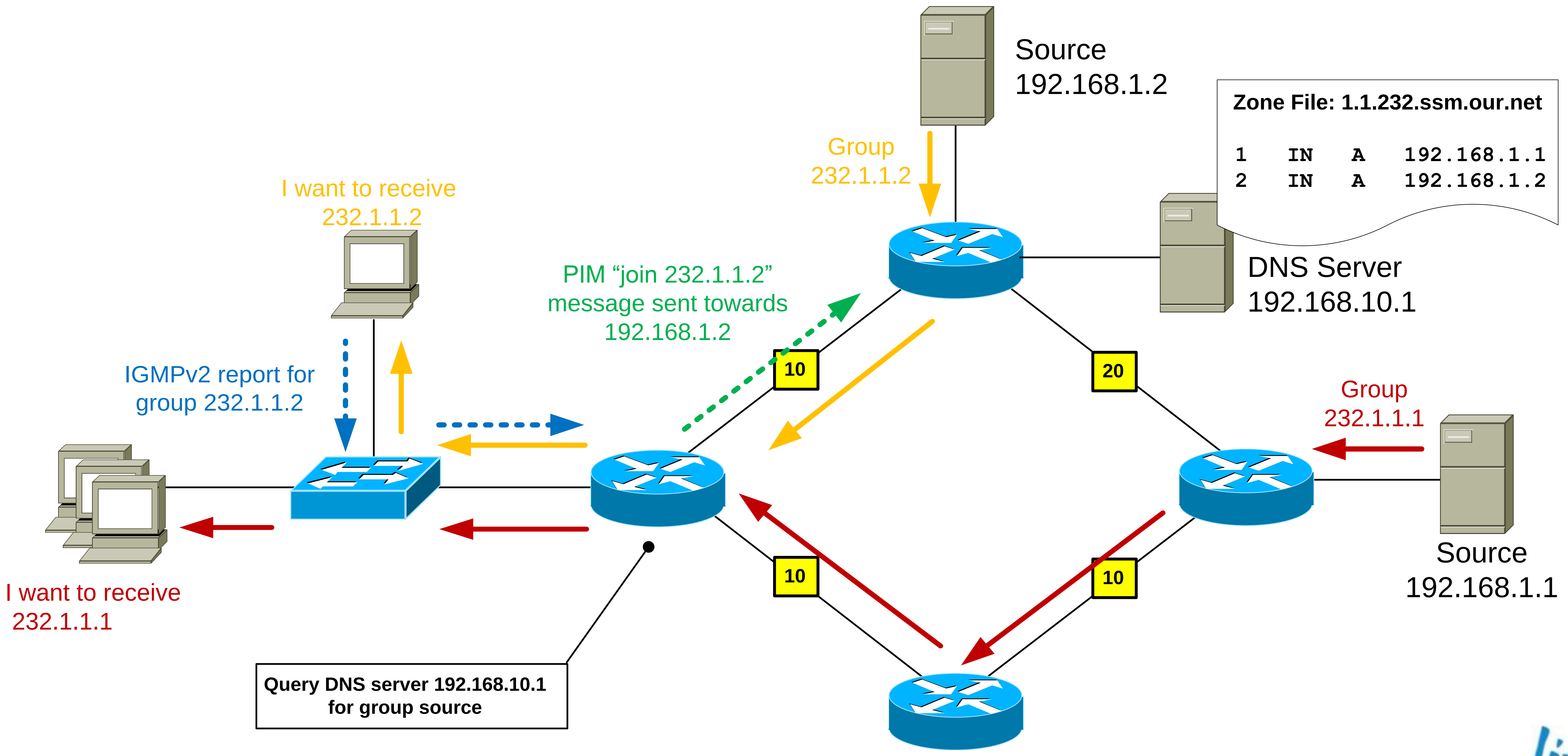
PIM-SSM Dynamic (DNS) Mapping



PIM-SSM Dynamic (DNS) Mapping



PIM-SSM Dynamic (DNS) Mapping



IPv4 vs. IPv6 Multicast. A Quick Glimpse

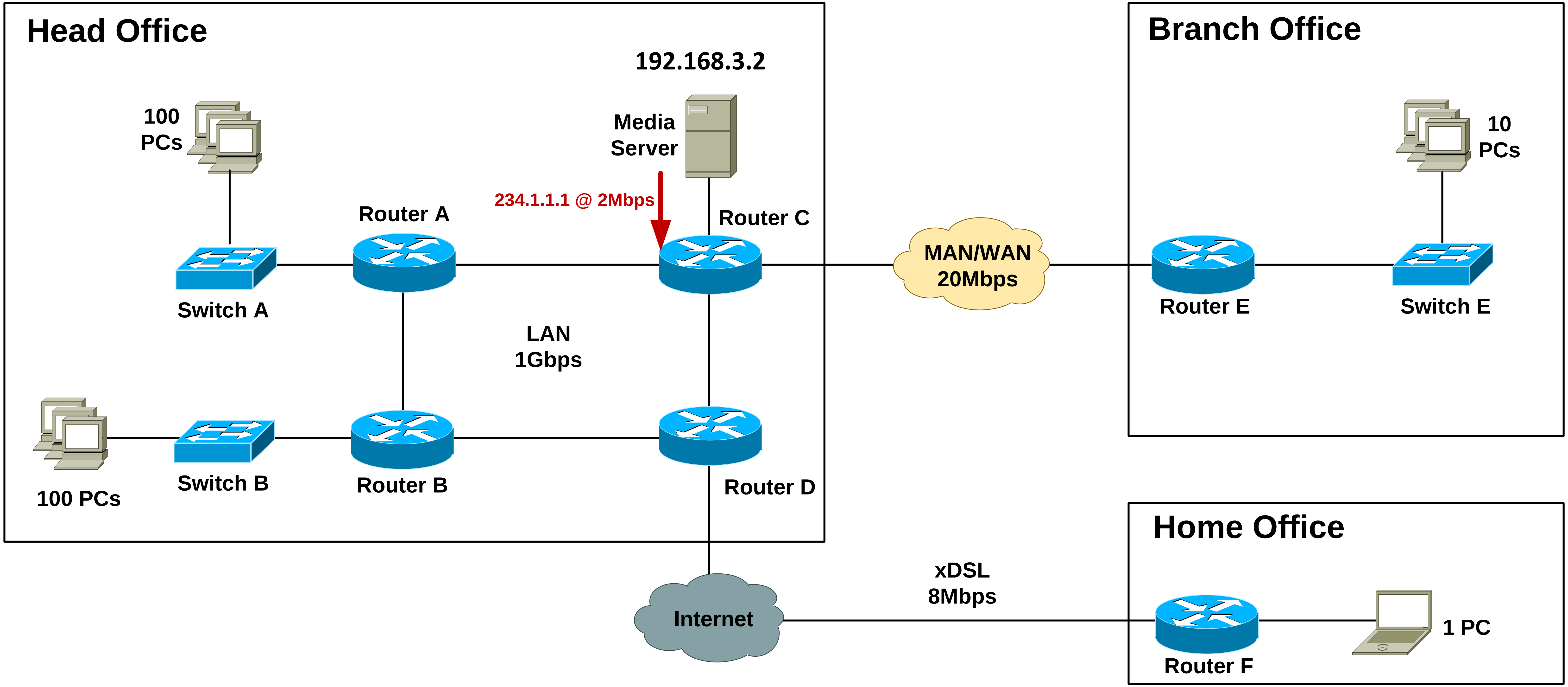
IP Service	IPv4 Solution	IPv6 Solution
Address Range	32-Bit, Class D	128-Bit (112-Bit Group)
Routing	Protocol-Independent All IGPs and BGPv4+	Protocol-Independent All IGPs and BGPv4+ with IPv6 Mcast SAFI
Forwarding	PIM-DM, PIM-SM: ASM, SSM, BiDir	PIM-SM: ASM, SSM, BiDir
Group Management	IGMPv1, v2, v3	Multicast Listener Discovery MLDv1, v2
Domain Control	Boundary/Border	Scope Identifier
Interdomain Source Discovery	MSDP Across Independent PIM Domains	Single RP Within Globally Shared Domains

Multicast Design

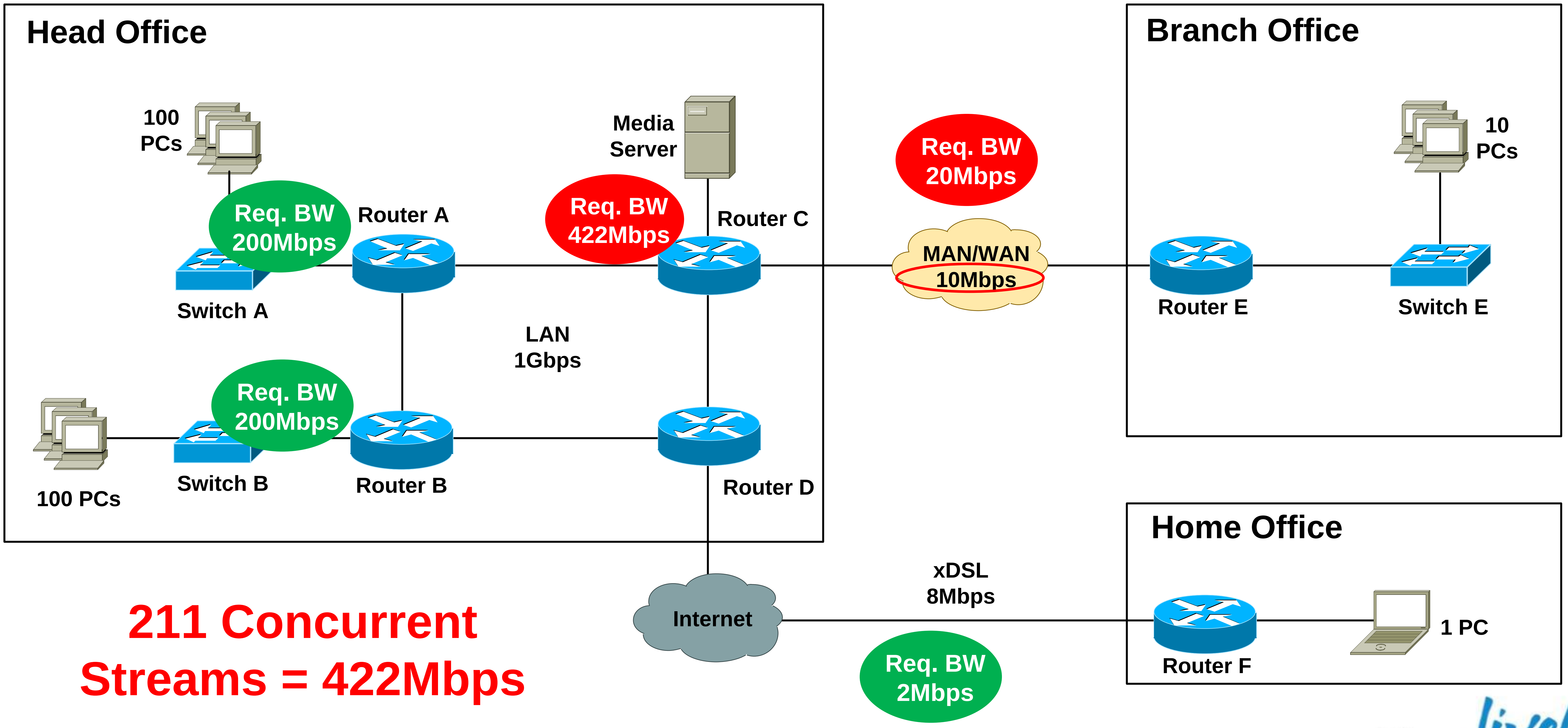
Case Study - Background

- Company has 1 head office with 200 staff, 1 branch office with 10 staff and occasional home users
- Management wants to deploy an in-house, always-on video channel that staff may watch at any time for the latest product releases and Company news
- Important events will require all users to watch the channel at the same time
- The video bitrate is 2 Mbps

Case Study – Network Topology

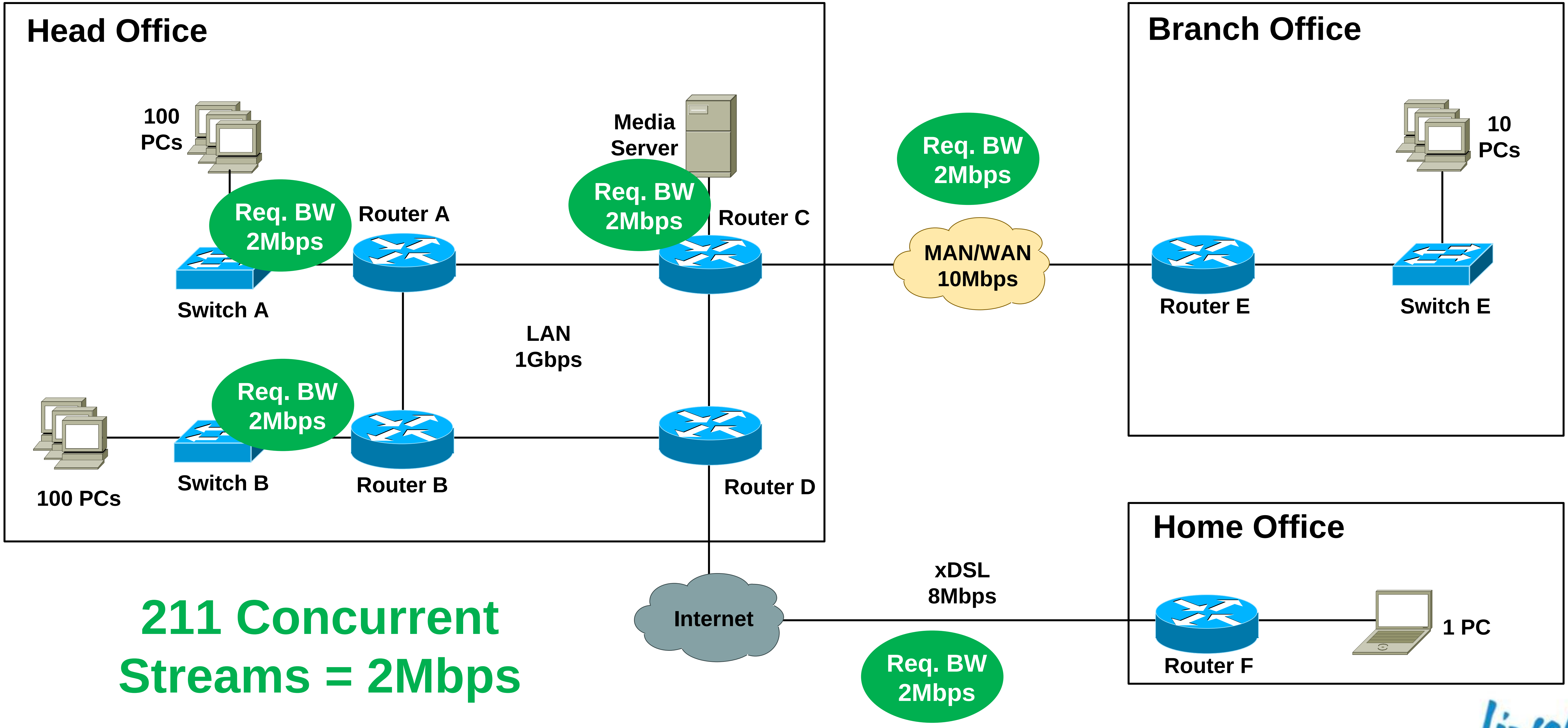


Case Study – Unicast Bandwidth Scenario



211 Concurrent Streams = 422Mbps

Case Study – Multicast Bandwidth Scenario



211 Concurrent Streams = 2Mbps

Case Study – Network Support for MC

- Cisco IOS provides broad platform support for PIM (all variants) and IGMPv1/2/3
- Check with WAN provider for MC support
  - Dark fibre, EoSDH, EoMPLS, Frame relay, ATM, SDH/SONET, leased-line services – usually no issues
  - Managed ethernet, L3VPN, VPLS – check with provider.
  - SP network generally needs to be configured for MC support
- No native support for multicast across the Internet
- No native IPSec support for multicast

Case Study – Design Options

- **Option 1: Any Source Multicast (ASM) design**

  Hosts run IGMPv2

  Network runs PIM-SM with RP

- Option 2: Source Specific Multicast (SSM) design

  Hosts run IGMPv3

  Network runs PIM-SSM

- Option 3: SSM design with IGMP mapping

  Hosts run IGMPv2

  Network runs PIM-SSM with source address mapping

Case Study – ASM

Step 1: Configure IGMP snooping on access switches

- IGMP snooping enabled by default on Cisco devices
- Configure
  "ip igmp snooping vlan <x> immediate-leave"
  for vlans with directly attached hosts only.

```
Switch_A#sh ip igmp snooping vlan 10
Vlan 10:
--------
IGMP snooping                          : Enabled
IGMPv2 immediate leave                 : Enabled
Multicast router learning mode         : pim-dvmrp
CGMP interoperability mode             : IGMP_ONLY
Robustness variable                    : 2
Last member query count                : 2
Last member query interval             : 1000

Switch_A#
```

Case Study – ASM

Step 2: Configure all routers for multicast

- Globally enable multicast routing:

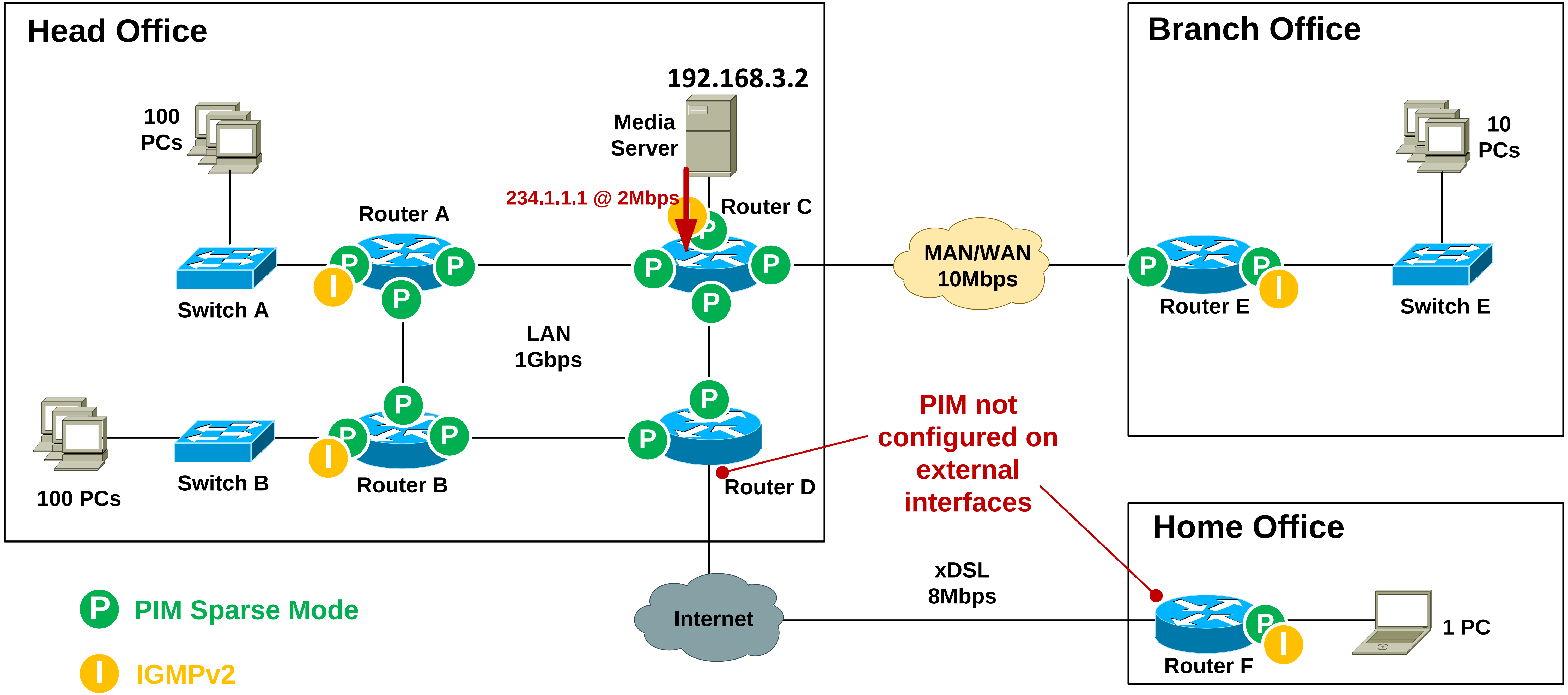
```
Router_A(config)#ip multicast-routing
Router_A(config)#do show ip multicast global
        Multicast Routing: enabled
        Multicast Multipath: disabled
        Multicast Route limit: No limit
        Multicast Triggered RPF check: enabled
        Multicast Fallback group mode: Sparse
Router_A(config)#
```

- Configure PIM on all internal router interfaces:

```
Router_A(config-if)#int fast 0/3
Router_A(config-if)#ip pim sparse-mode
Router_A(config-if)#
```

Case Study – ASM

Step 3: Configure all internal links for PIM-SM, IGMPv2



Case Study – ASM

Step 4: Verify PIM Neighbours

```
Router_A#sh ip pim neighbor
PIM Neighbor Table
Neighbor         Interface                Uptime/Expires    Ver   DR
Address                                                           Prio/Mode
10.0.0.5         FastEthernet0/3        1d02h/00:01:17    v2    1 / DR S
10.0.0.3         FastEthernet0/2        1d01h/00:01:31    v2    1 / DR
Router_A#
```

- Note: when PIM is enabled on an interface, IGMPv2 is also automatically enabled on that interface.

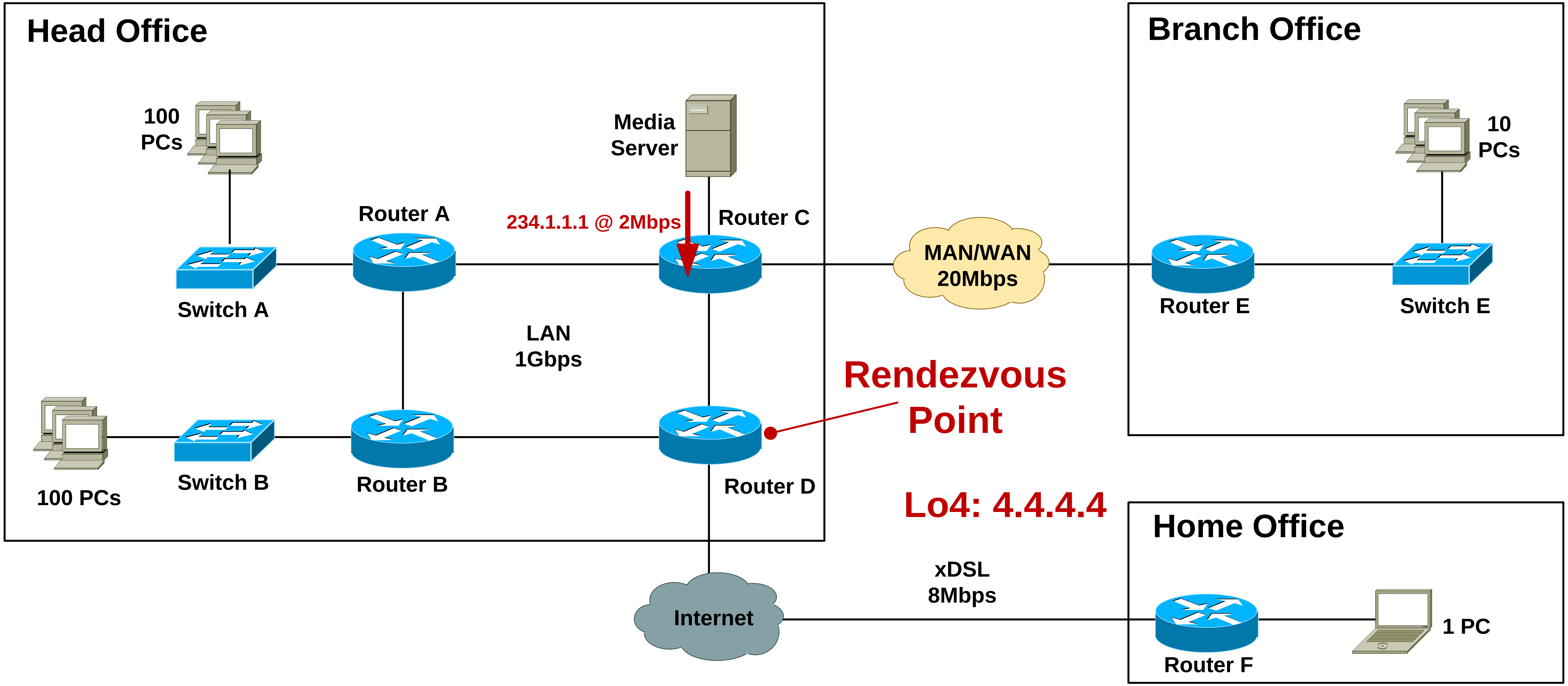
Case Study – ASM

Step 5: Select RP router

- RP should be in a central location between sender and receivers.
- CPU grunt not critical as RP processing overhead is low.
- Select a router that has high network availability.
- Ensure the RP has a /32 loopback address as the source.
- Recommended to assign loopback address dedicated for RP use only (not used for router ID etc).

Case Study - ASM

Step 5: Select RP router



Case Study – ASM

Step 6: Configure static RP on all routers (including the RP)

```
ip access-list standard MC_Group_1
  permit 234.1.1.0 0.0.0.255

Router_C#conf t
Enter configuration commands, one per line.  End with CNTL/Z.

Router_C(config)#ip pim rp-address 4.4.4.4 MC_Group_1
```

Step 7: Verify RP to Group mappings

```
Router_C#sh ip pim rp mapping

PIM Group-to-RP Mappings
Acl: MC_Group_1, Static
    RP: 4.4.4.4 (Router_D)
Router_C#
```

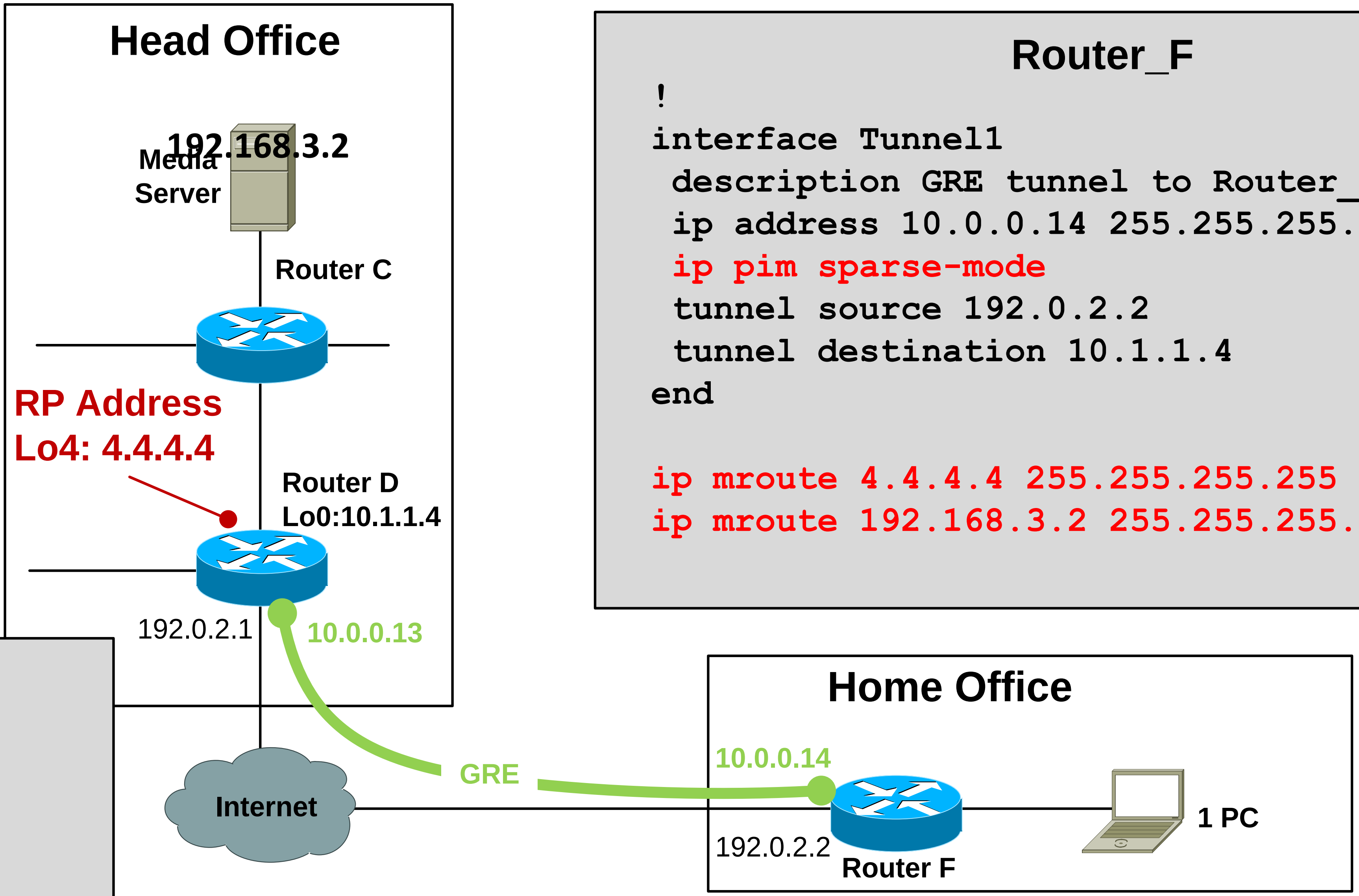
Case Study – ASM

Step 8: Enable multicast over non-multicast networks

- Use GRE, L2TPv3 to tunnel MC over non-MC networks
- Need a static mroute for **both** the RP address and the MC source address for RPF check to pass.
- http://www.cisco.com/en/US/tech/tk828/technologies_configuration_example09186a00801a5aa2.shtml

Case Study - ASM

Step 8: Enable multicast over non-multicast networks



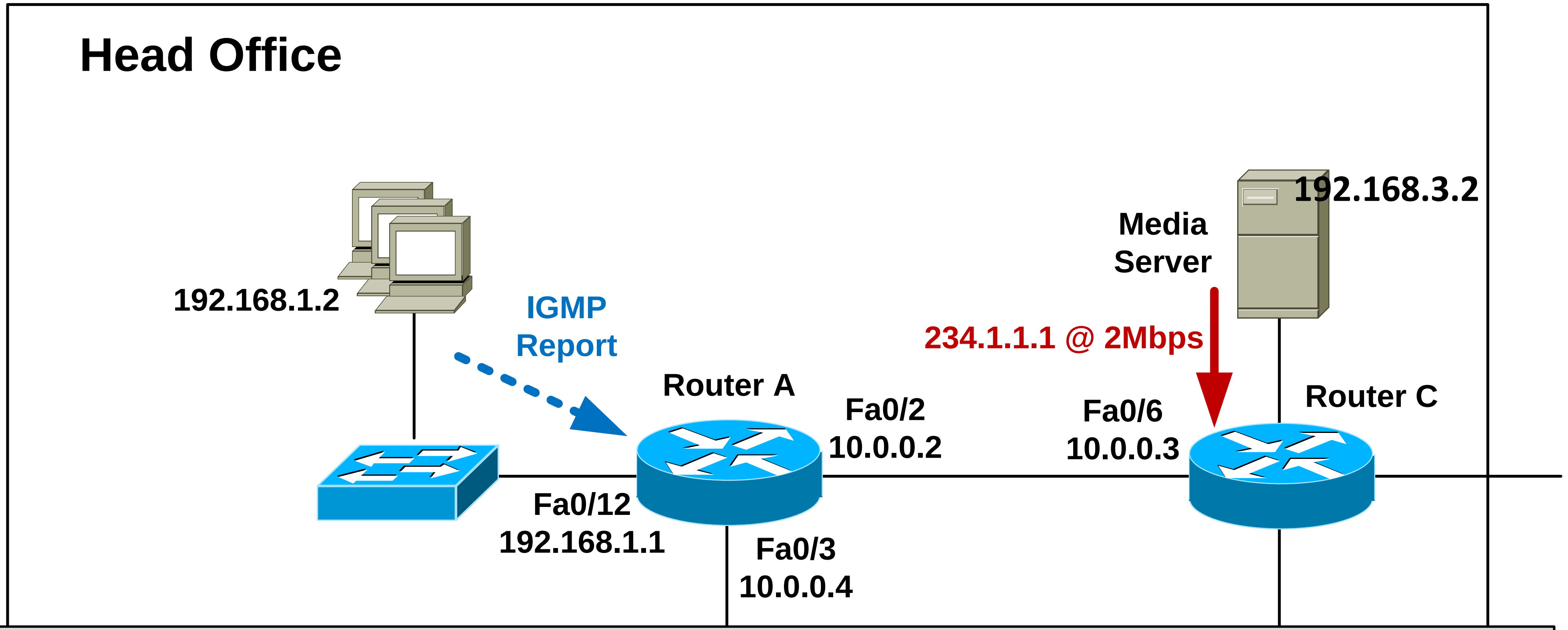
Router_F

```
!
interface Tunnel1
 description GRE tunnel to Router_D
 ip address 10.0.0.14 255.255.255.252
 ip pim sparse-mode
 tunnel source 192.0.2.2
 tunnel destination 10.1.1.4
end

ip mroute 4.4.4.4 255.255.255.255 Tunnel1
ip mroute 192.168.3.2 255.255.255.255 Tunnel1
```

Router_D

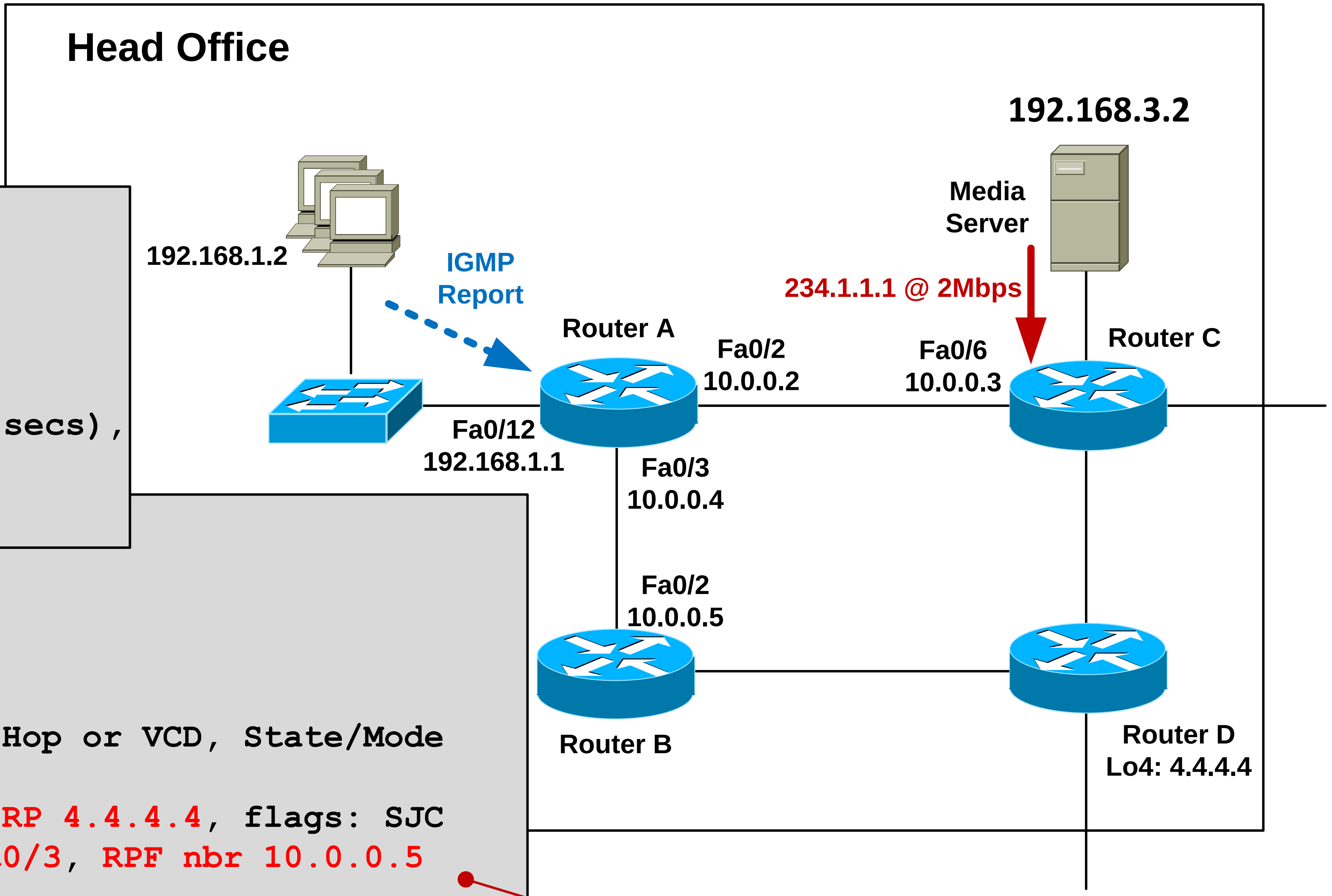
```
!
interface Tunnel1
 description GRE tunnel to Router_F
 ip address 10.0.0.13 255.255.255.252
 ip pim sparse-mode
 tunnel source 10.1.1.4
 tunnel destination 192.0.2.2
end
```

Case Study – ASM – IGMP Verification




```
Router_A#sh ip igmp membership
Flags: A  - aggregate, T - tracked
       L  - Local, S - static, V - virtual, R - Reported through v3
       I - v3lite, U - Urd, M - SSM (S,G) channel
       1,2,3 - The version of IGMP the group is in
 <snip>
 Channel/Group                  Reporter        Uptime   Exp.  Flags  Interface
 *,234.1.1.1                    192.168.1.2     00:00:12 02:47 2A     Fa0/12
 Router_A#
```

Case Study – ASM – Mroute Verification




```
Router_A#show ip mroute active
Active IP Multicast Sources - sending >= 4 kbps

Group: 234.1.1.1, (Stream_1)
   Source: 192.168.3.2 (Media_Server)
     Rate: 245 pps/1967 kbps(1sec), 1968 kbps(last 20 secs),
       1966 kbps(life avg)
Router_A#
```

```
Router_A#show ip mroute
IP Multicast Routing Table
<snip>
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 234.1.1.1), 00:08:40/stopped, RP 4.4.4.4, flags: SJC
  Incoming interface: FastEthernet0/3, RPF nbr 10.0.0.5
  Outgoing interface list:
    FastEthernet0/12, Forward/Sparse, 00:08:40/00:02:11

(192.168.3.2, 234.1.1.1), 00:08:40/00:02:56, flags: JT
  Incoming interface: FastEthernet0/2, RPF nbr 10.0.0.3
  Outgoing interface list:
    FastEthernet0/12, Forward/Sparse, 00:08:40/00:02:11
```

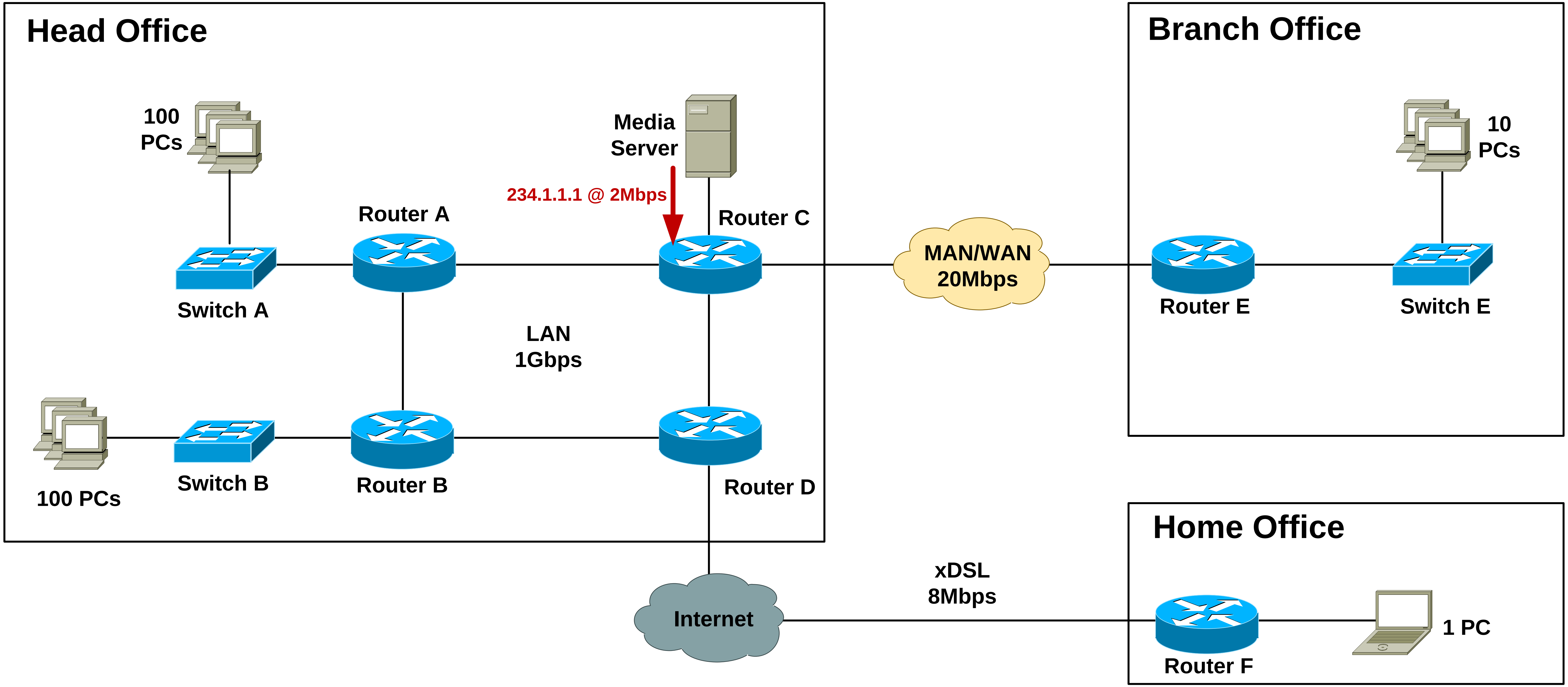
How Router_A receives MC traffic via the RP (src IP unknown)

How Router_A receives MC traffic directly from the source (src IP known)

Case Study – Design Options

- Option 1: Any Source Multicast (ASM) design
  - Hosts run IGMPv2
  - Network runs PIM-SM
- **Option 2: Source Specific Multicast (SSM) design**
  - Hosts run IGMPv3
  - Network runs PIM-SSM
- Option 3: SSM design with IGMP mapping
  - Hosts run IGMPv2
  - Network runs PIM-SSM with source address mapping

Case Study – SSM



Case Study – SSM

Step 1: Configure all routers for SSM

- Globally enable multicast routing:

```
Router_A(config)#ip multicast-routing
```

- Configure PIM-SSM ranges:

```
! Define ACL for SSM ranges (default is 232.0.0.0/8)

Router_A(config)#ip access-list standard SSM-Groups
Router_A(config-std-nacl)#permit 234.0.0.0 0.255.255.255

! Configure SSM range

Router_A(config-std-nacl)#ip pim ssm range SSM-Groups
Router_A(config)#
```

Case Study – SSM

Step 2: Configure IGMP

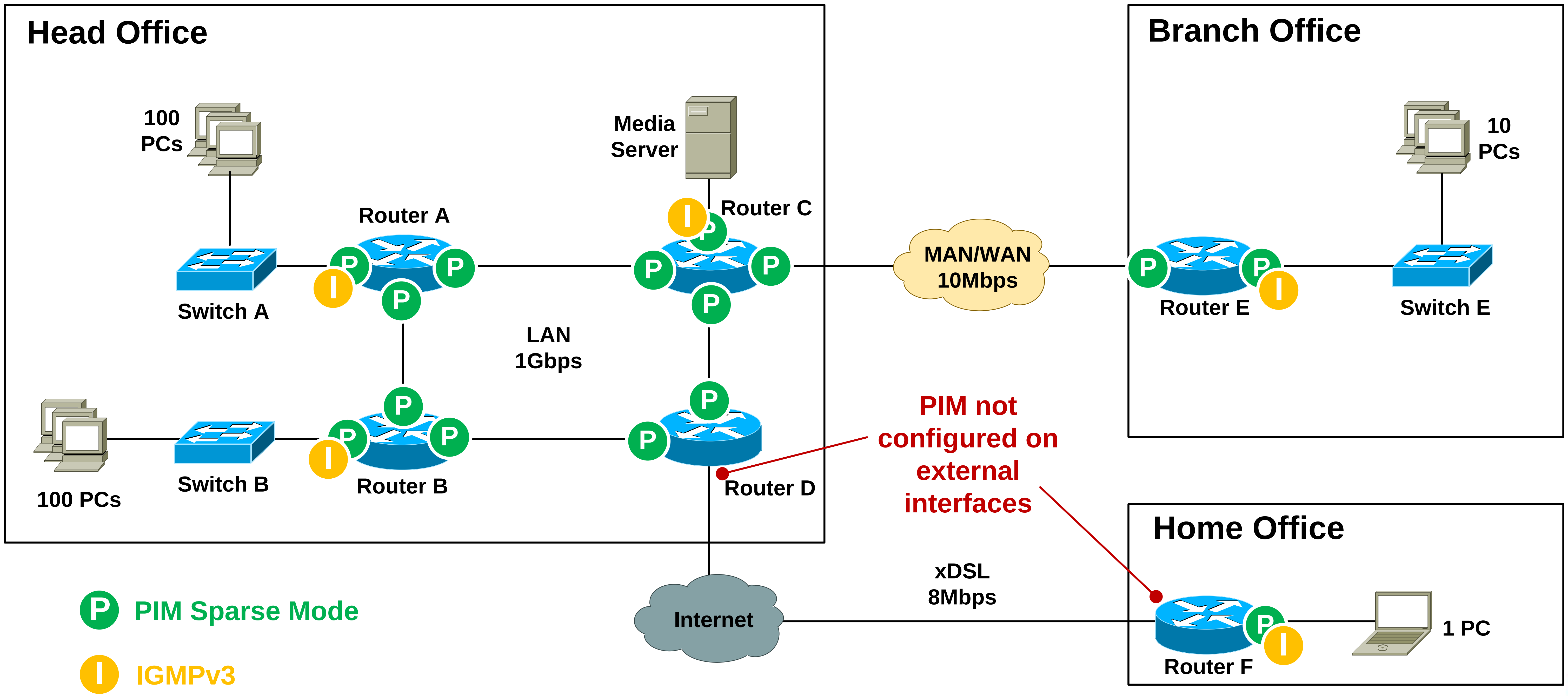
- IGMPv3 snooping enabled by default on Cisco devices
- Need to explicitly configure IGMPv3 on router interface that connects to LAN

```
Router_A(config)#int fast 0/12
Router_A(config-if)#ip igmp version 3
Router_A(config-if)#
```

```
Router_A#sh ip igmp interface fast 0/12
FastEthernet0/12 is up, line protocol is up
  Internet address is 192.168.1.1/24
  IGMP is enabled on interface
  Current IGMP host version is 3
  Current IGMP router version is 3
  IGMP query interval is 60 seconds
  IGMP querier timeout is 120 seconds
  <snip>
  Router_A#
```

Case Study – SSM

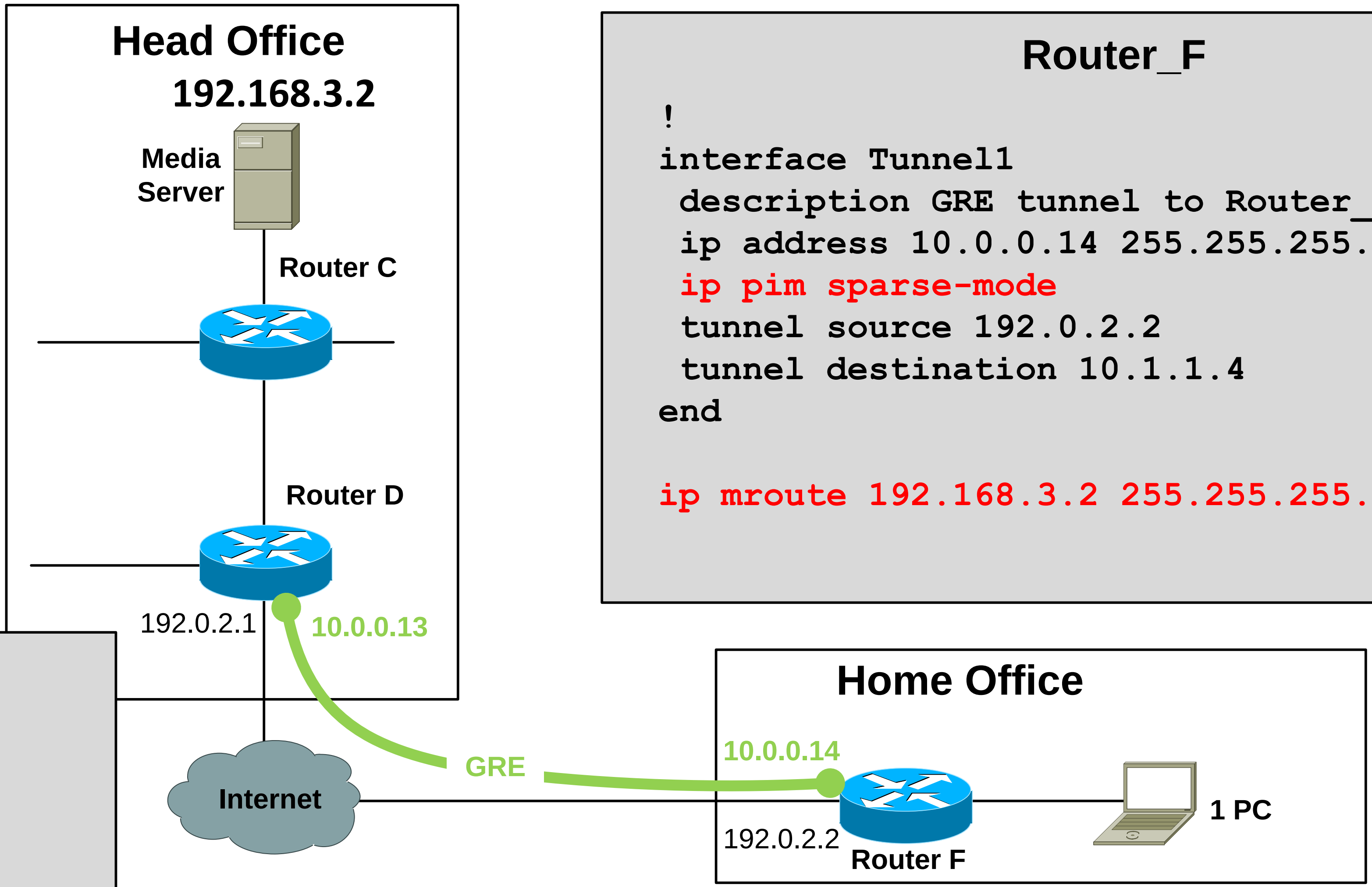
Step 3: Configure all internal links for PIM-SM



Case Study – SSM

Step 4: Enable multicast over non-multicast networks

- Need a static mroute for MC source only



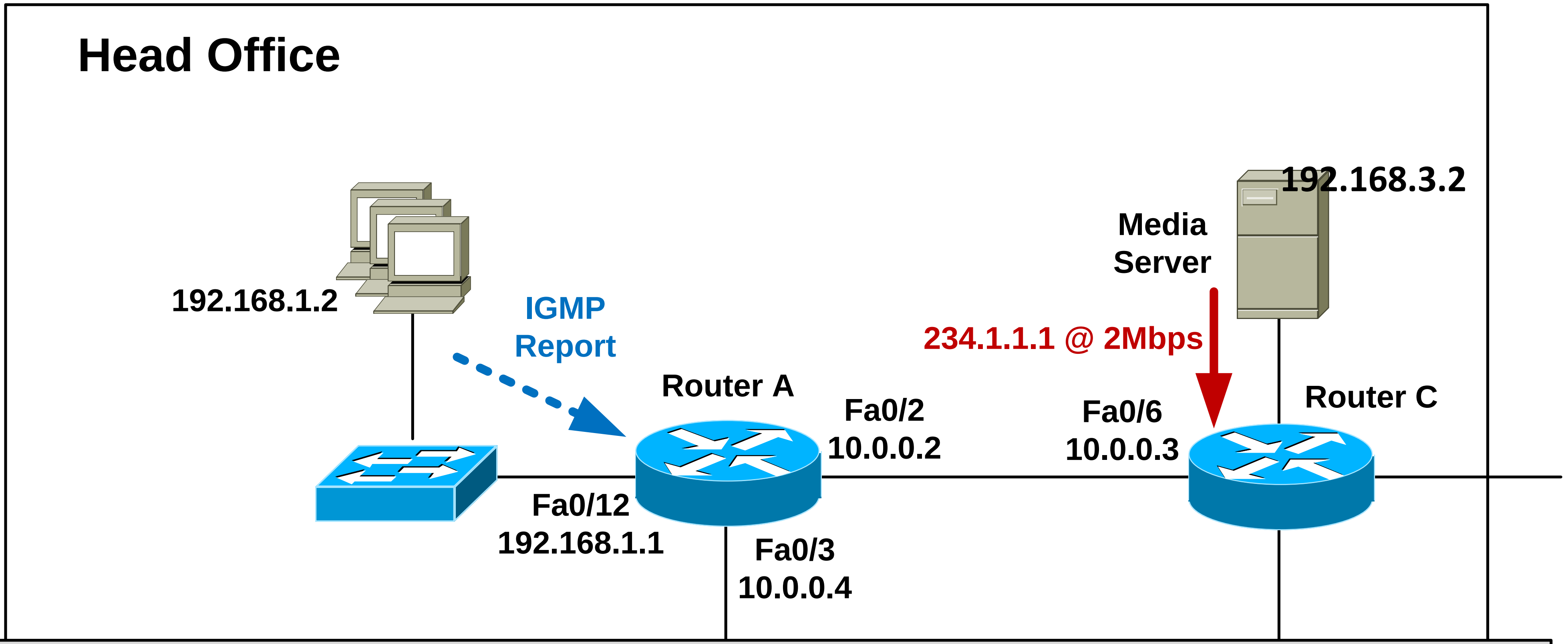
Router_F

```
!
interface Tunnel1
 description GRE tunnel to Router_D
 ip address 10.0.0.14 255.255.255.252
 ip pim sparse-mode
 tunnel source 192.0.2.2
 tunnel destination 10.1.1.4
end

ip mroute 192.168.3.2 255.255.255.255 Tunnel1
```

Router_D

```
!
interface Tunnel1
 description GRE tunnel to Router_F
 ip address 10.0.0.13 255.255.255.252
 ip pim sparse-mode
 tunnel source 10.1.1.4
 tunnel destination 192.0.2.2
end
```

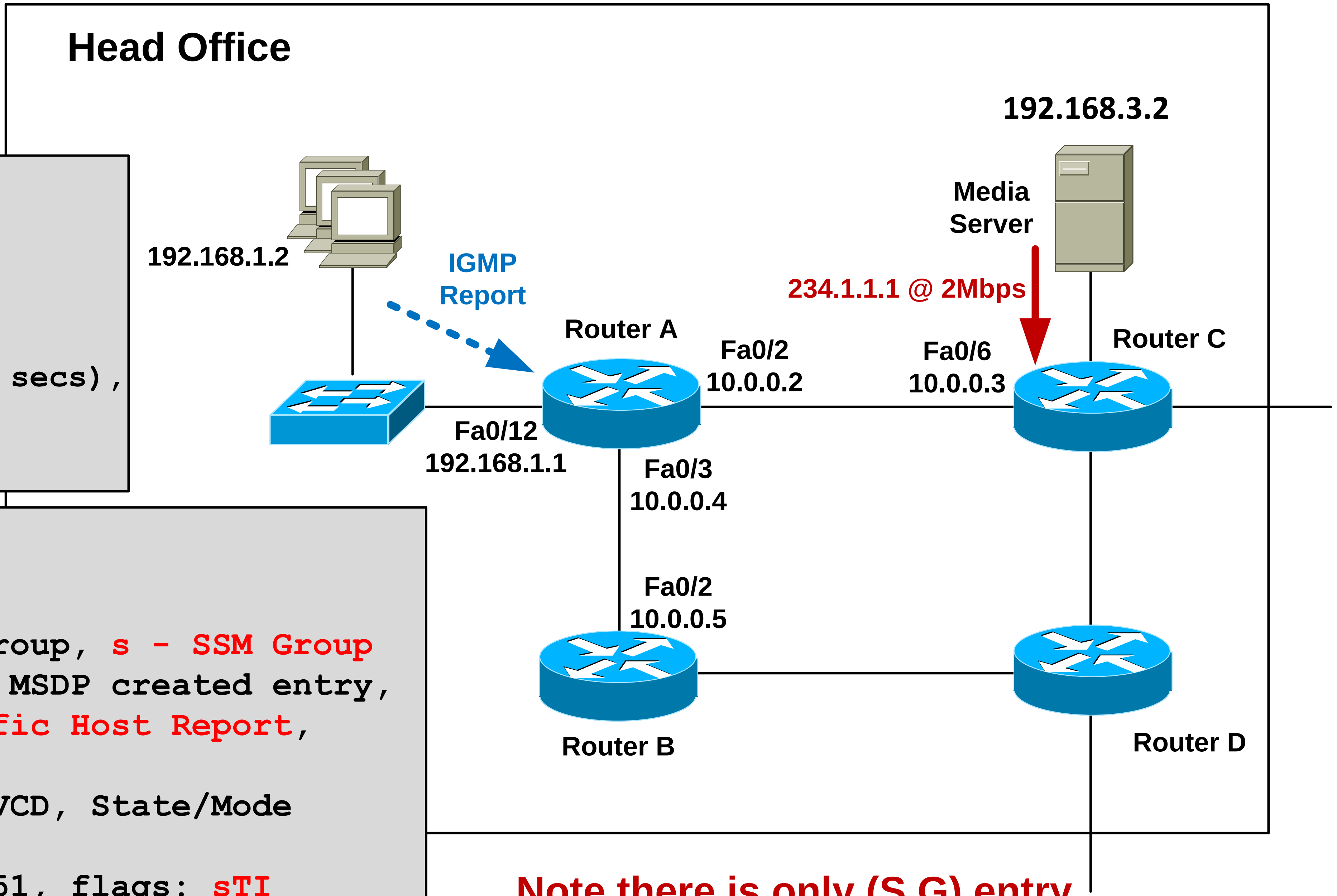
Case Study – SSM – IGMP Verification




```
Router_A#show ip igmp membership

Channel/Group-Flags:
        / - Filtering entry (Exclude mode (S,G), Include mode (*,G))

 Channel/Group                  Reporter        Uptime   Exp.  Flags  Interface
/*,234.1.1.1                    192.168.1.2     00:43:29 stop  3MA    Fa0/12
 192.168.3.2,234.1.1.1                          00:43:29 02:03 RA     Fa0/12

Router_A#
```

Case Study – SSM – Mroute Verification

```
Router_A#show ip mroute active
Active IP Multicast Sources - sending >= 4 kbps

Group: 234.1.1.1, (Stream_1)
   Source: 192.168.3.2 (Media_Server)
     Rate: 245 pps/1967 kbps(1sec), 1968 kbps(last 20 secs),
       1966 kbps(life avg)
Router_A#
```




```
Router_A#show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       U - URD, I - Received Source Specific Host Report,
       Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(192.168.3.2, 234.1.1.1), 00:59:25/00:02:51, flags: sTI
  Incoming interface: FastEthernet0/2, RPF nbr 10.0.0.3
  Outgoing interface list:
    FastEthernet0/12, Forward/Sparse, 00:59:01/00:02:05
```

Note there is only (S,G) entry and no (*,G) as no RP is present

Case Study – Design Options

- Option 1: Any Source Multicast (ASM) design
  - Hosts run IGMPv2
  - Network runs PIM-SM
- Option 2: Source Specific Multicast (SSM) design
  - Hosts run IGMPv3
  - Network runs PIM-SSM
- **Option 3: SSM design with IGMP mapping**
  - **Hosts run IGMPv2**
  - **Network runs PIM-SSM with source address mapping**

Case Study – IGMPv2 + PIM-SSM

Step 1: Configure IGMPv2 snooping on access switches

- IGMP snooping enabled by default on Cisco devices
- Configure "**`ip igmp snooping vlan <x> immediate-leave`**"

```
Switch_A#sh ip igmp snooping vlan 10
Vlan 10:
--------
IGMP snooping                          : Enabled
IGMPv2 immediate leave                 : Enabled
Multicast router learning mode         : pim-dvmrp
CGMP interoperability mode             : IGMP_ONLY
Robustness variable                    : 2
Last member query count                : 2
Last member query interval             : 1000

Switch_A#
```

Case Study – IGMPv2 + PIM-SSM

Step 2: Configure all routers for multicast

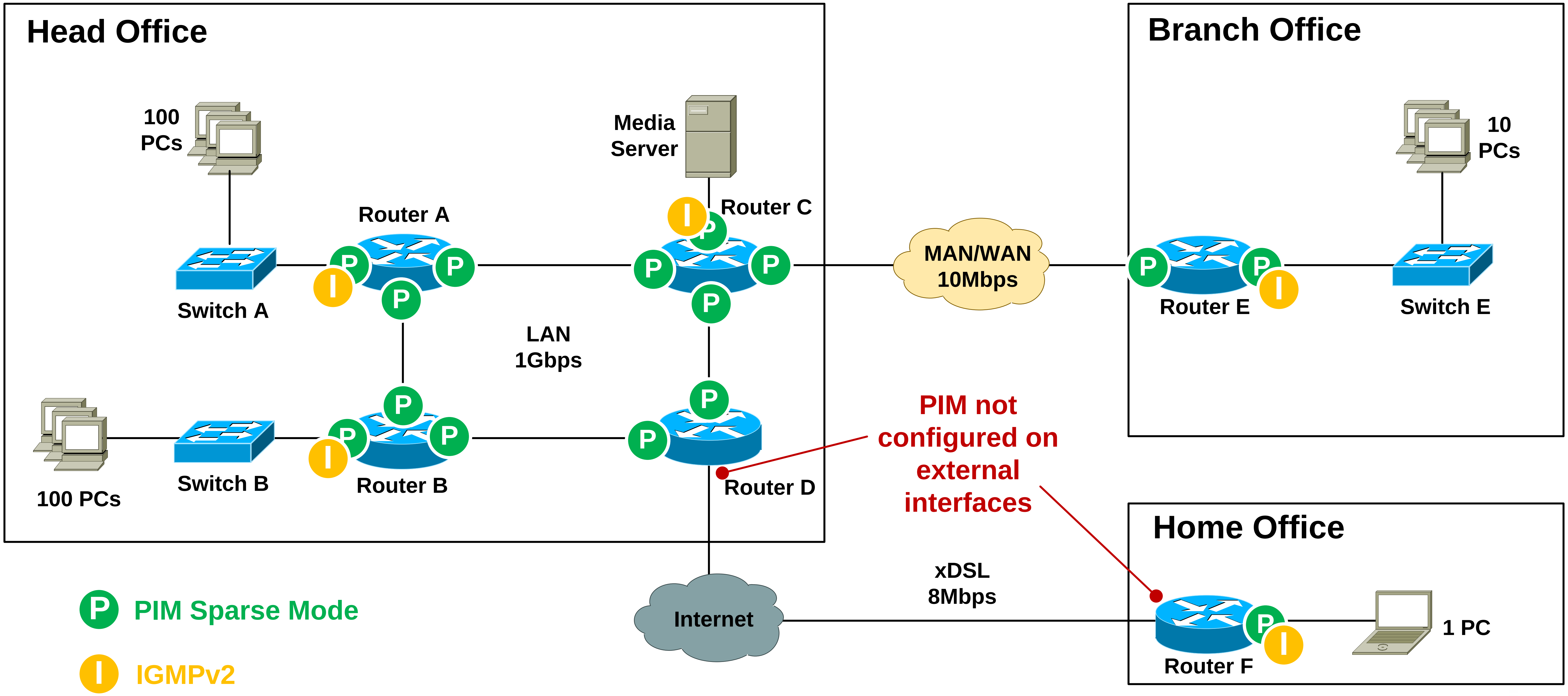
- Globally enable multicast routing:

```
Router_A(config)#ip multicast-routing
Router_A(config)#do show ip multicast global
        Multicast Routing: enabled
        Multicast Multipath: disabled
        Multicast Route limit: No limit
        Multicast Triggered RPF check: enabled
        Multicast Fallback group mode: Sparse
Router_A(config)#
```

- Configure PIM on all **internal** router interfaces:

```
Router_A(config-if)#int fast 0/3
Router_A(config-if)#ip pim sparse-mode
Router_A(config-if)#
```

Case Study – IGMPv2 + PIM-SSM



Case Study – IGMPv2 + PIM-SSM

Step 3: Configure all routers for SSM

- Configure PIM-SSM ranges:

```
! Define ACL for SSM ranges (default is 232.0.0.0/8)

Router_A(config)#ip access-list standard SSM-Groups
Router_A(config-std-nacl)#permit 234.0.0.0 0.255.255.255

! Configure SSM range

Router_A(config-std-nacl)#ip pim ssm range SSM-Groups
Router_A(config)#
```


Case Study – IGMPv2 + PIM-SSM

Step 4a: Configure static IGMP SSM mapping

- Globally enable IGMP mapping

```
Router_A(config)#ip igmp ssm-map enable
```

- Configure static group-to-source mapping using ACL:

```
Router_A(config)#no ip igmp ssm-map query dns
Router_A(config)#access-list 10 permit host 234.1.1.1
Router_A(config)#ip igmp ssm-map static 10 192.168.3.2
```

“When I see an IGMPv2 report for groups defined in ACL 10, assign the source address 192.168.3.2”

Case Study – IGMPv2 + PIM-SSM

Step 4b: Configure dynamic IGMP SSM mapping

- Globally enable IGMP mapping

```
Router_A(config)#ip igmp ssm-map enable
```

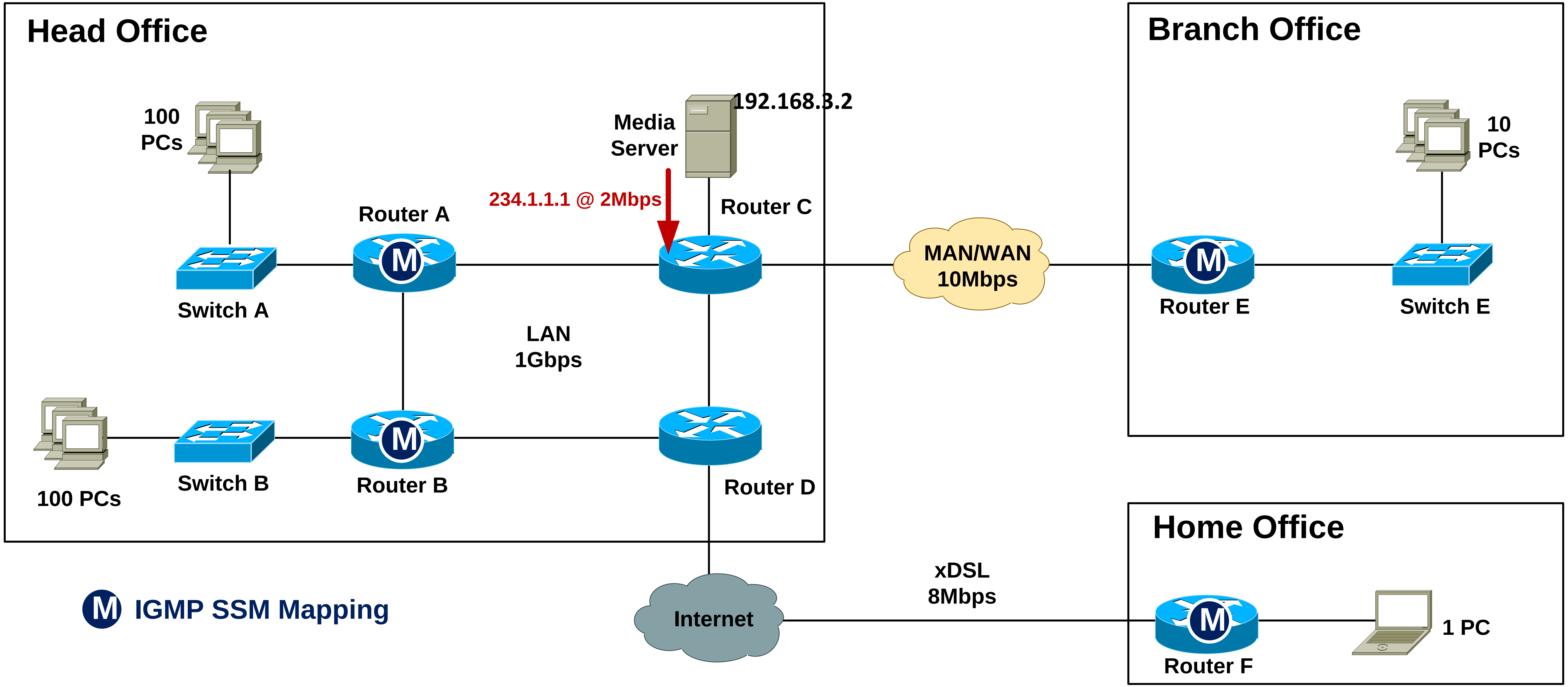
- Configure dynamic group-to-source mapping using DNS:

```
Router_A(config)#ip igmp ssm-map query dns
Router_A(config)#ip name-server 192.168.3.10
```

"When I see an IGMPv2 report for any group, perform a reverse DNS lookup to obtain the source address"

Case Study – IGMPv2 + PIM-SSM

IGMP SSM mapping configuration locations



Case Study – SSM Mapping Verification

Step 5: Verify IGMP mapping

- Static mapping

```
Router_A#sh ip igmp ssm-mapping 234.1.1.1
Group address: 234.1.1.1
Database      : Static
Source list   : 192.168.3.2
Router_A#
```

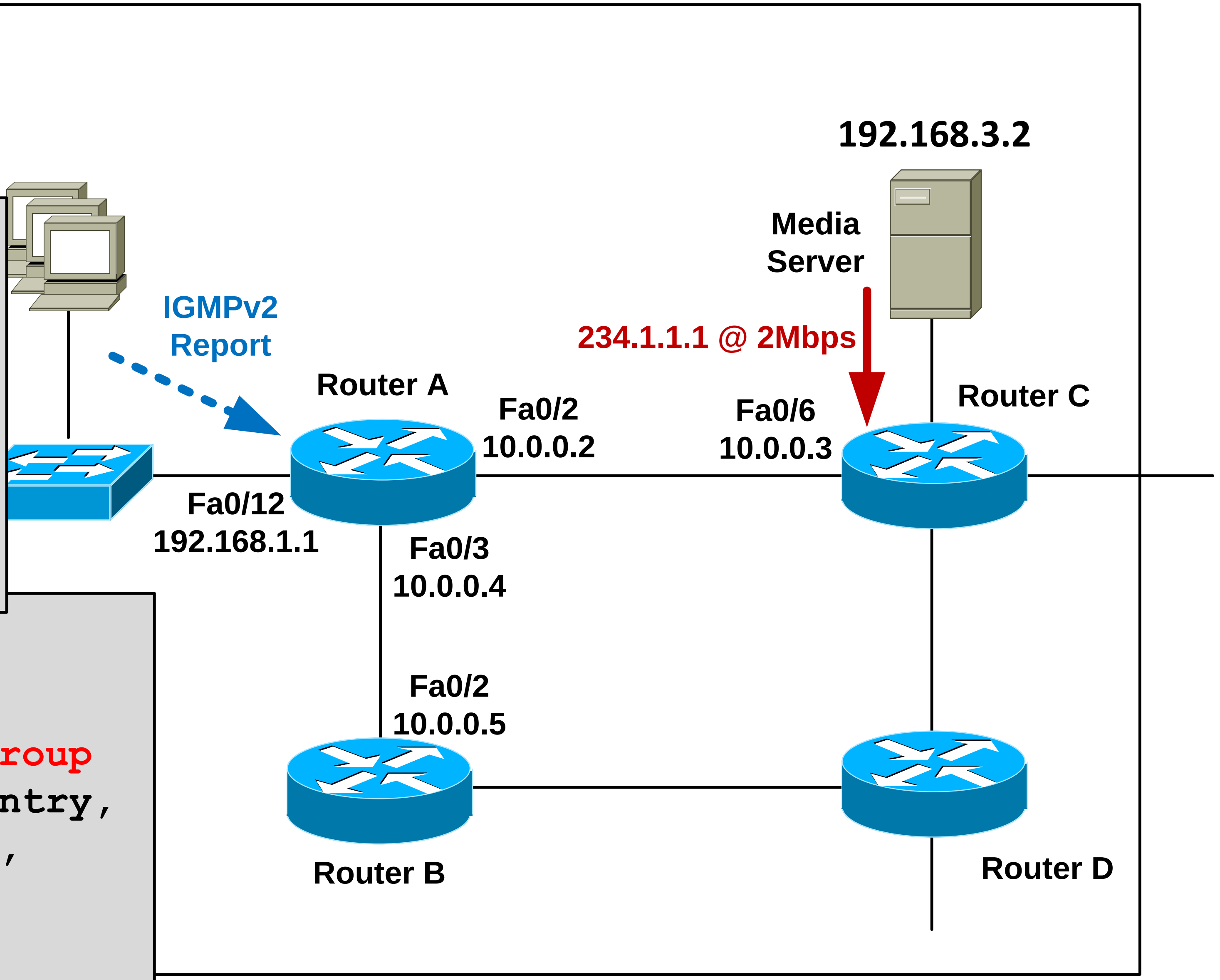
- Dynamic mapping

```
Router_A#sh ip igmp ssm-mapping 234.1.1.1
Group address: 234.1.1.1
Database      : DNS
DNS name      : 1.1.1.234.in-addr.arpa
Expire time   : 860000
Source list   : 192.168.3.2
Router_A#
```

Case Study – SSM Mapping – Verification

```
Router_A#show ip mroute active
Active IP Multicast Sources - sending >= 4 kbps

Group: 234.1.1.1, (Stream_1)
   Source: 192.168.3.2 (Media_Server)
     Rate: 245 pps/1968 kbps(1sec), 1968 kbps(last 20 secs),
       1967 kbps(life avg)
Router_A#
```

```
Router_A#show ip mroute
IP Multicast Routing Table
Flags: D - Dense, S - Sparse, B - Bidir Group, s - SSM Group
       T - SPT-bit set, J - Join SPT, M - MSDP created entry,
       U - URD, I - Received Source Specific Host Report,
       Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(192.168.3.2, 234.1.1.1), 01:23:13/00:02:29, flags: sTI
  Incoming interface: FastEthernet0/2, RPF nbr 10.0.0.3
  Outgoing interface list:
    FastEthernet0/12, Forward/Sparse, 00:09:01/00:02:12
```



IGMP ssm-mapping not evident in output

Router-Router Signalling: PIM Choices

- For simple MC deployments, use these guidelines:
  - If your hosts and MC application support IGMPv3, use PIM-SSM.
  - If IGMPv3 support is not an option, use PIM-SM and IGMPv2.
  - Consider IGMP mapping if IGMPv3 host and application support is “Coming Soon”.

Cisco live!

Troubleshooting

Mimicking a Multicast Source

- Use video streaming software on a PC such as VLC:

```
vlc --repeat filename.avi --sout '#standard{access=udp,mux=ts,dst=234.1.1.1:1234}
```

- Use a ping flood or traffic generator to fake it....

```
MC_Source#ping
Protocol [ip]:
Target IP address: 234.1.1.1
Repeat count [1]: 100000000000
Datagram size [100]: 1300
Timeout in seconds [2]: 0
Extended commands [n]: y
Interface [All]: FastEthernet1/0/24
Source address: 192.168.3.2
Type escape sequence to abort.
Sending 1215752192, 1300-byte ICMP Echos to 234.1.1.1,
 timeout is 0 seconds:
Packet sent with a source address of 192.168.3.2
...................................................
```

Mimicking a Multicast Receiver

- PC running VLC to join MC group

```
vlc udp:@234.1.1.1 (IGMPv2 report)
or
vlc udp:192.168.3.2@234.1.1.1 (IGMPv3 report)
```

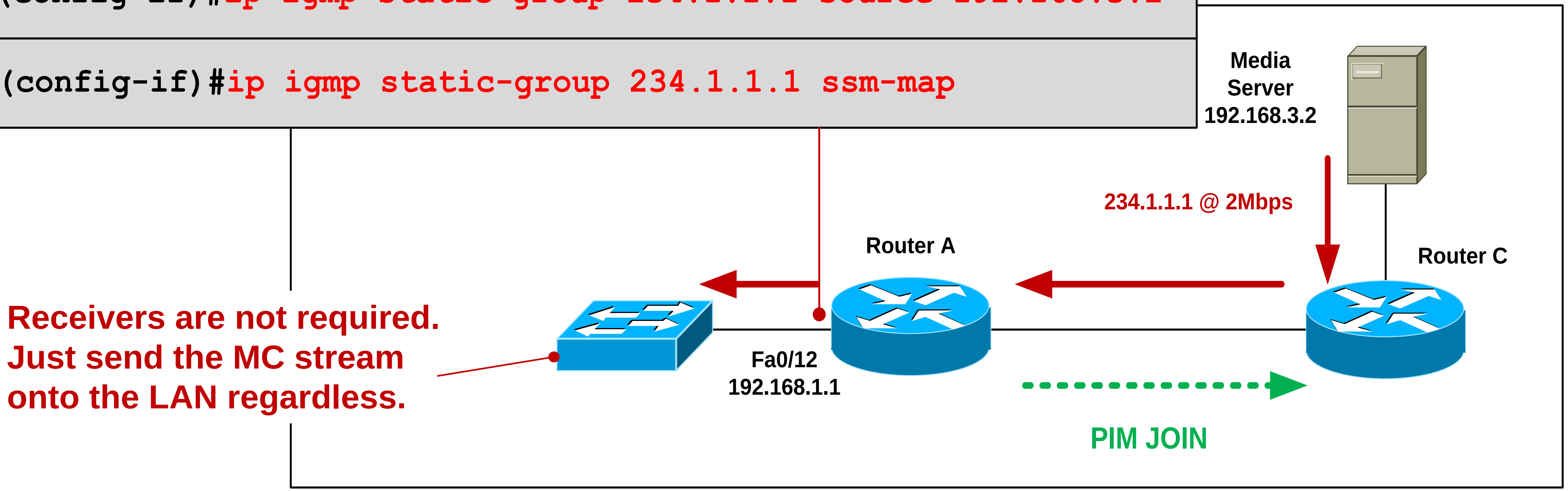
- Router joins MC group as if it were a receiver

```
! Send IGMPv2 report for 234.1.1.1
Router(config-if)#ip igmp version 2
Router(config-if)#ip igmp join-group 234.1.1.1

or

! Send IGMPv3 report for 234.1.1.1, source 192.168.3.2
Router(config-if)#ip igmp version 3
Router(config-if)#ip igmp join-group 234.1.1.1 source 192.168.3.2
```

Mimicking a Multicast Receiver

- Statically join a router interface to a group

```
Router(config-if)#ip igmp static-group 234.1.1.1
Router(config-if)#ip igmp static-group 234.1.1.1 source 192.168.3.2
Router(config-if)#ip igmp static-group 234.1.1.1 ssm-map
```



Common Causes of Multicast Problems

- Source problem

  Is the source sending the MC stream properly ?

- Receiver issue

  Is the client asking to receive the stream ?

- Underlying network issue

  Is the underlying network OK ?

- MC network misconfiguration

  Is the network configured correctly ?

Source Not Sending Stream Correctly

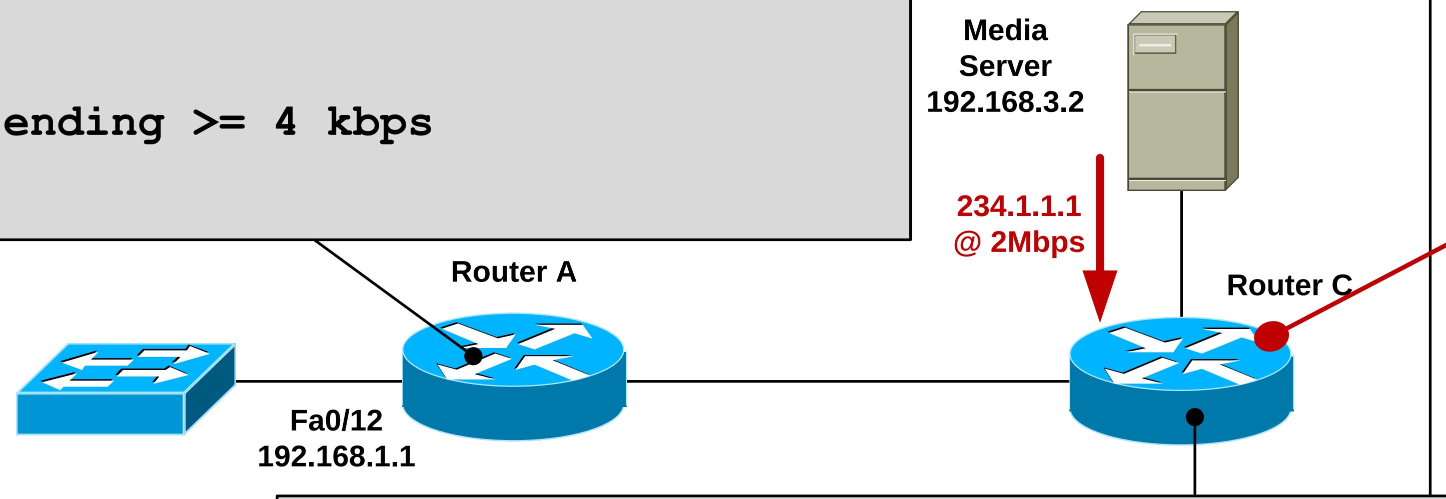
- Verify source is actually sending MC stream
  – tcpdump, Wireshark, SNMP
- Check first-hop router is receiving MC at correct bit-rate
  – compare current rate to baseline and historical rate

```
Router_C#sh ip mroute active
Active IP Multicast Sources - sending >= 4 kbps

Group: 234.1.1.1, (Stream_1)
   Source: 192.168.3.2 (Media_Server)
     Rate: 165 pps/1324 kbps(1sec), 1964 kbps(last 30 secs), 1963 kbps(life avg)
Router_C#
```

Source – Low TTL Value

- Incorrect source TTL can cause MC stream to be dropped

```
Router_A#show ip mroute
IP Multicast Routing Table
<snip>
 (192.168.3.2, 234.1.1.1), 1d18h/00:02:35, flags: sTI
  Incoming interface: FastEthernet0/2, RPF nbr 10.0.0.3
  Outgoing interface list:
    FastEthernet0/12, Forward/Sparse, 1d18h/00:02:35

Router_A#show ip mroute active
Active IP Multicast Sources - sending >= 4 kbps
Router_A#
```



Stream stops at first-hop router (TTL=1) or part-way into the network (TTL >1)

mroute is accurate but no active streams

```
Router_C#sh ip traffic | i bad hop count
        0 format errors, 0 checksum errors, 193949 bad hop count
Router_C#sh ip traffic | i bad hop count
        0 format errors, 0 checksum errors, 194069 bad hop count
Router_C#
```

Receiver Issue

- Use "**debug ip igmp**" to verify IGMP reports are being received.

```
IGMP(0): Received v2 Report on FastEthernet0/12 from 192.168.1.2 for 234.1.1.1
IGMP(0): Received Group record for group 234.1.1.2, mode 2 from 192.168.1.2 for 0 sources
IGMP(0): WAVL Insert group: 234.1.1.1 interface: FastEthernet0/12 Successful
IGMP(0): MRT Add/Update FastEthernet0/12 for (*,234.1.1.1)
```

- If not seeing reports come in, then use packet sniffer on receiver.

Underlying Network Issue

- The cause of most multicast problems is not multicast (!)

Q: Why might users report a general network issue as a multicast problem ?

A: Small amounts of packet loss, excessive latency or jitter, routing reconvergence are immediately evident to streaming audio/video users.

- Check for interface errors, link congestion, duplex mis-match, routing reachability – Networking 101 stuff !

Multicast Network Misconfiguration

- Verify
  - All internal links have pim sparse mode configured
  - RP is configured on all routers (including the RP itself)

Missing RP configuration

```
Router_F#sh ip mroute
IP Multicast Routing Table
<snip>
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 234.1.1.1), 00:06:17/stopped, RP 0.0.0.0, flags: SJC
  Incoming interface: Null, RPF nbr 0.0.0.0
  Outgoing interface list:
    FastEthernet0/1, Forward/Sparse, 00:06:17/00:02:44
```

Multicast Network Misconfiguration

- Verify
  - Network and hosts are running same IGMP version
  - Verify RPF check passes. ‘**sh ip mroute count | inc RPF failed|Other**

```
Router_F#sh ip mroute
IP Multicast Routing Table
<snip>
(*, 234.1.1.1), 00:15:01/stopped, RP 4.4.4.4, flags: SJC
  Incoming interface: Tunnel1, RPF nbr 10.0.0.13, Mroute
  Outgoing interface list:
    FastEthernet0/1, Forward/Sparse, 00:15:01/00:01:19

(192.168.3.2, 234.1.1.1), 00:04:40/00:02:33, flags: J
  Incoming interface: Null, RPF nbr 0.0.0.0, Mroute
  Outgoing interface list:
    FastEthernet0/1, Forward/Sparse, 00:04:40/00:01:19
Router_F#
```

RPF Check OK

RPF Check Failure
(should never be 0.0.0.0)

Where to From Here.....

- Rendezvous Point Auto-discovery
- High availability
  - Source Redundancy
  - RP Redundancy
  - Fast convergence
- Multicast Security
- Interdomain multicast
- IPv6 multicast

Additional Resources

- Cisco Live Virtual Breakout Sessions https://www.ciscoliveaustralia.com/portal/login.ww
  - –BRKEVT-2923: Optimising Enterprise Network Platform for Video
  - –BRKRST-2311: IPv6 Planning, Deployment and Operations
  - –BRKRST-2301: Enterprise IPv6 Deployments
  - –BRKSPV-1202: Introduction to IPTV and Service Provider Video Technologies
- Cisco Live "Meet the Expert" sessions
- CCO documentation: http://www.cisco.com/go/multicast

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