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IP Multicast – Concepts, Design and Troubleshooting

BRKMPL-1261

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Network Consulting Engineer

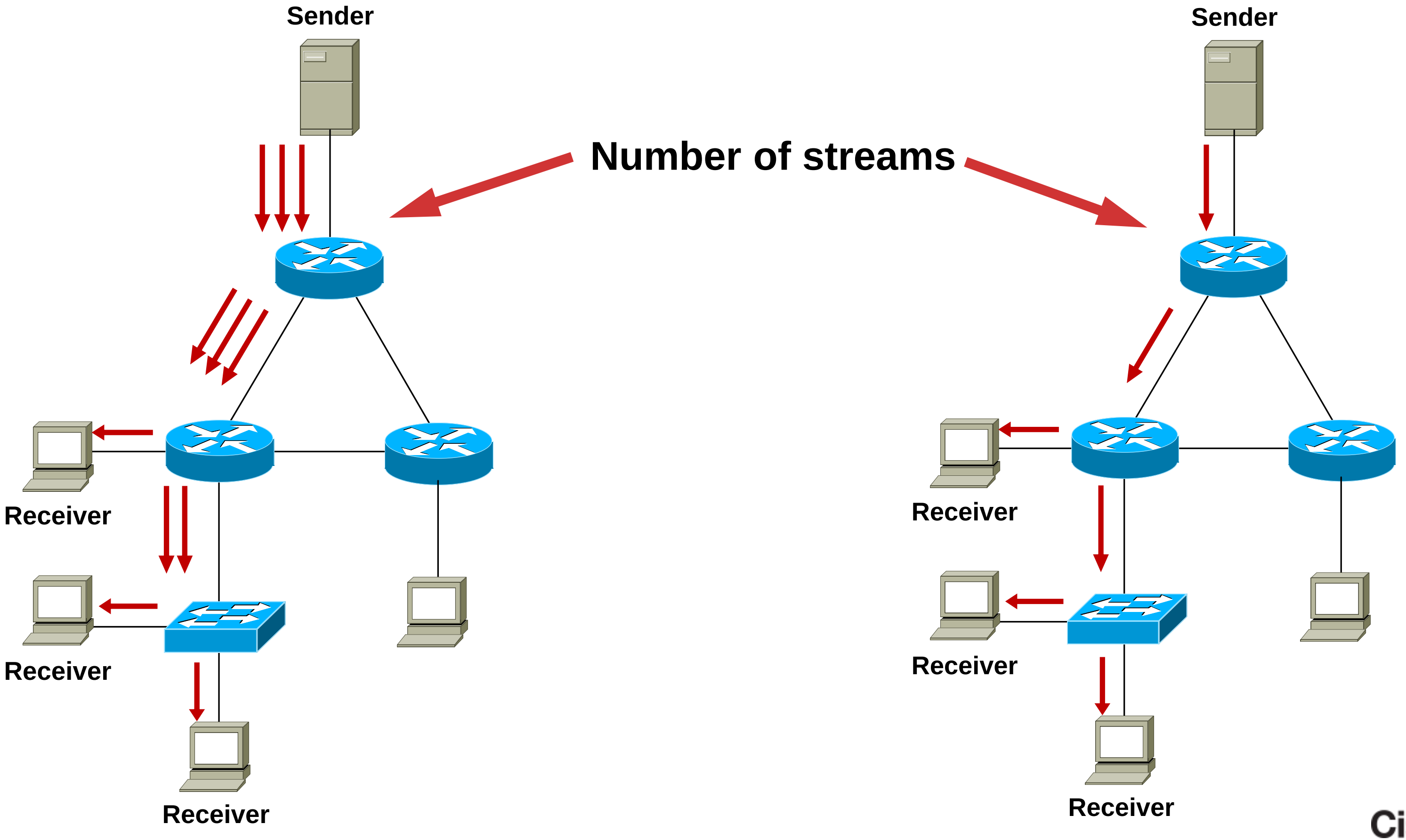
Cisco live!

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



Sender

Number of streams

Sender

Receiver

Receiver

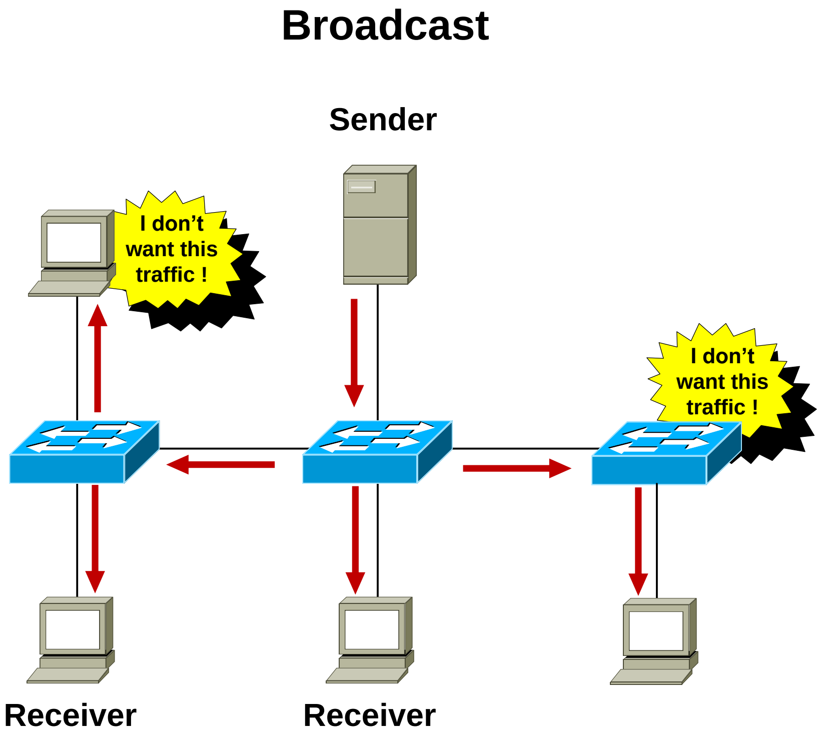
Receiver

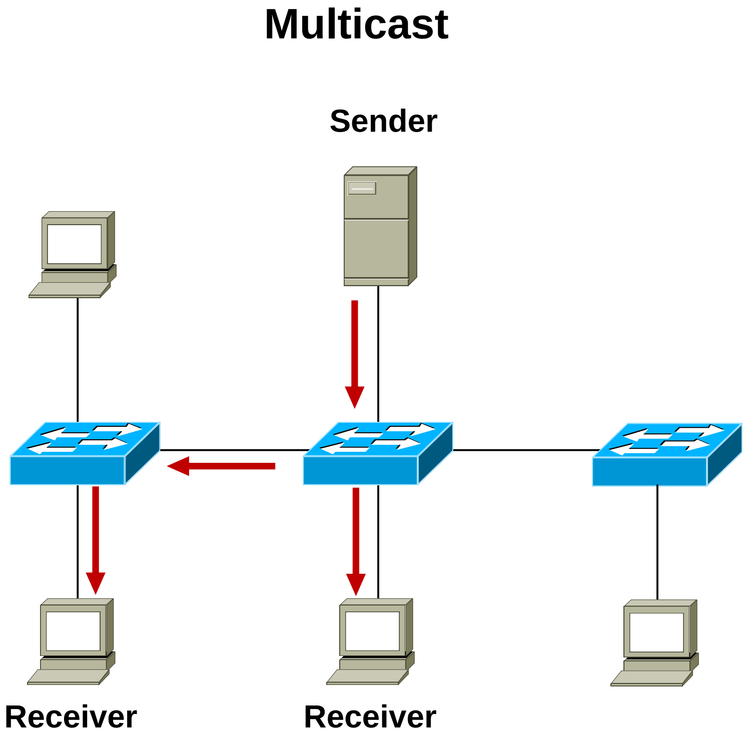
Receiver

Receiver

Receiver

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

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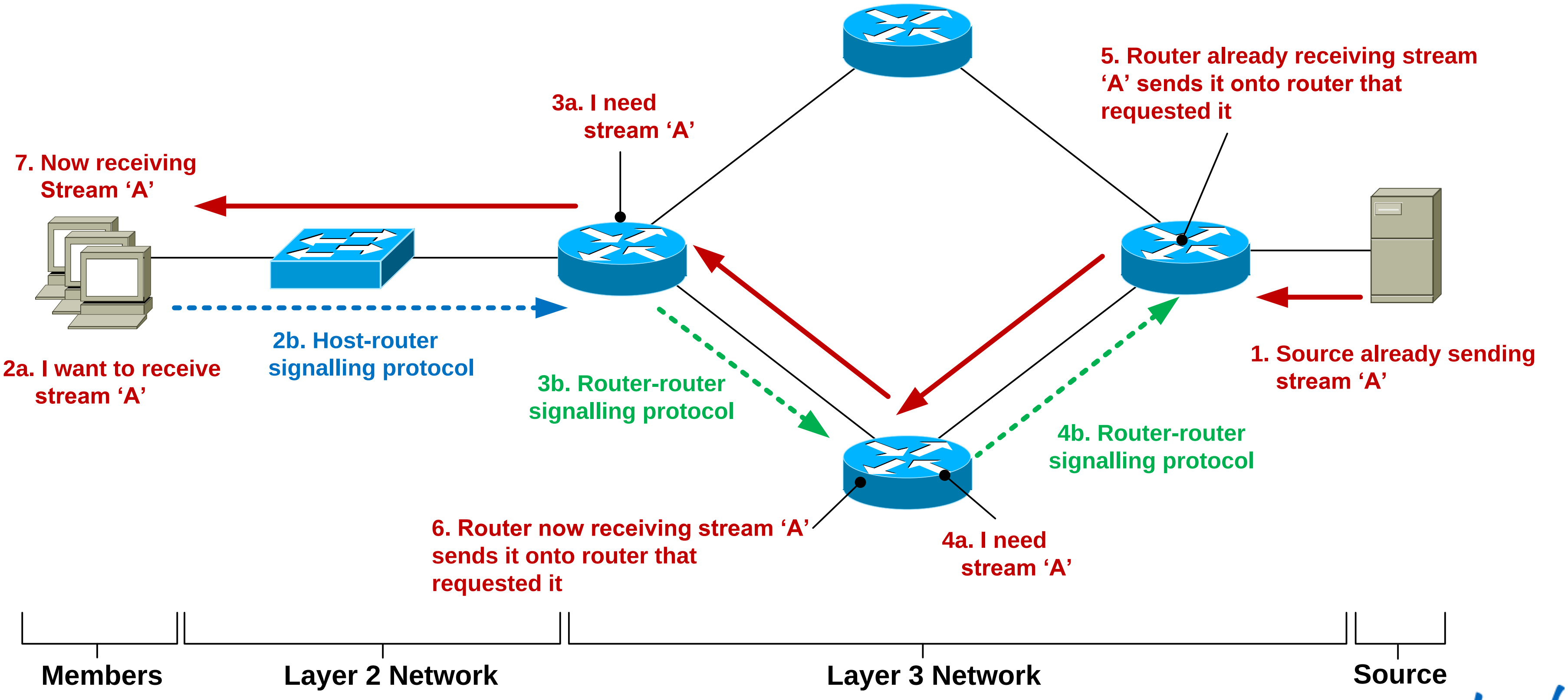
LOWER TCO

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


5. Router already receiving stream 'A' sends it onto router that requested it
3a. I need stream 'A'
7. Now receiving Stream 'A'
2a. I want to receive stream 'A'
2b. Host-router signalling protocol
3b. Router-router signalling protocol
4b. Router-router signalling protocol
1. Source already sending stream 'A'
6. Router now receiving stream 'A' sends it onto router that requested it
4a. I need stream 'A'
Members
Layer 2 Network
Layer 3 Network
Source

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.

IP Multicast Source

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

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- 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 !)

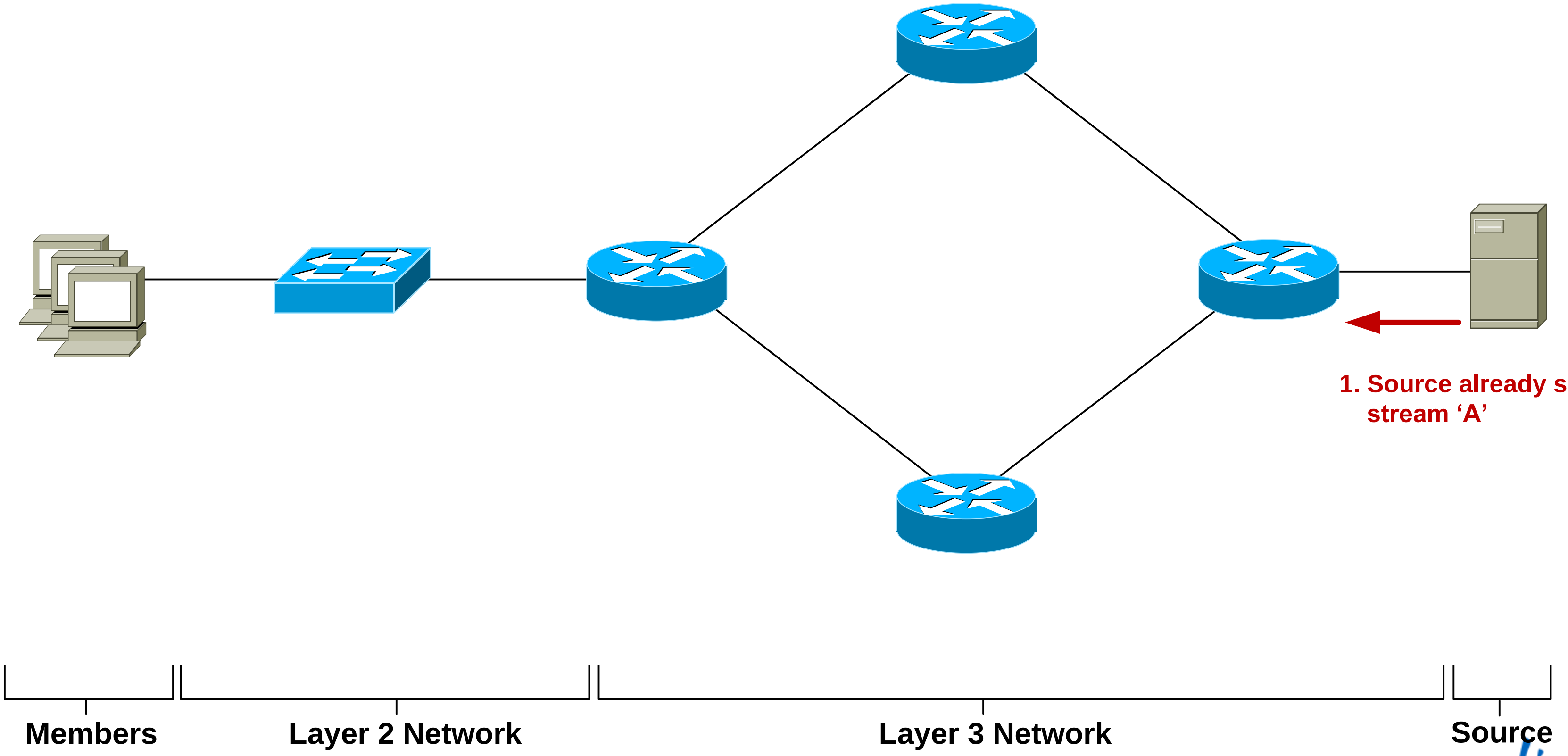
224.0.0.0 – 224.0.0.255	Local network control block
224.0.1.0 – 224.0.1.255	Internetwork control block

- 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

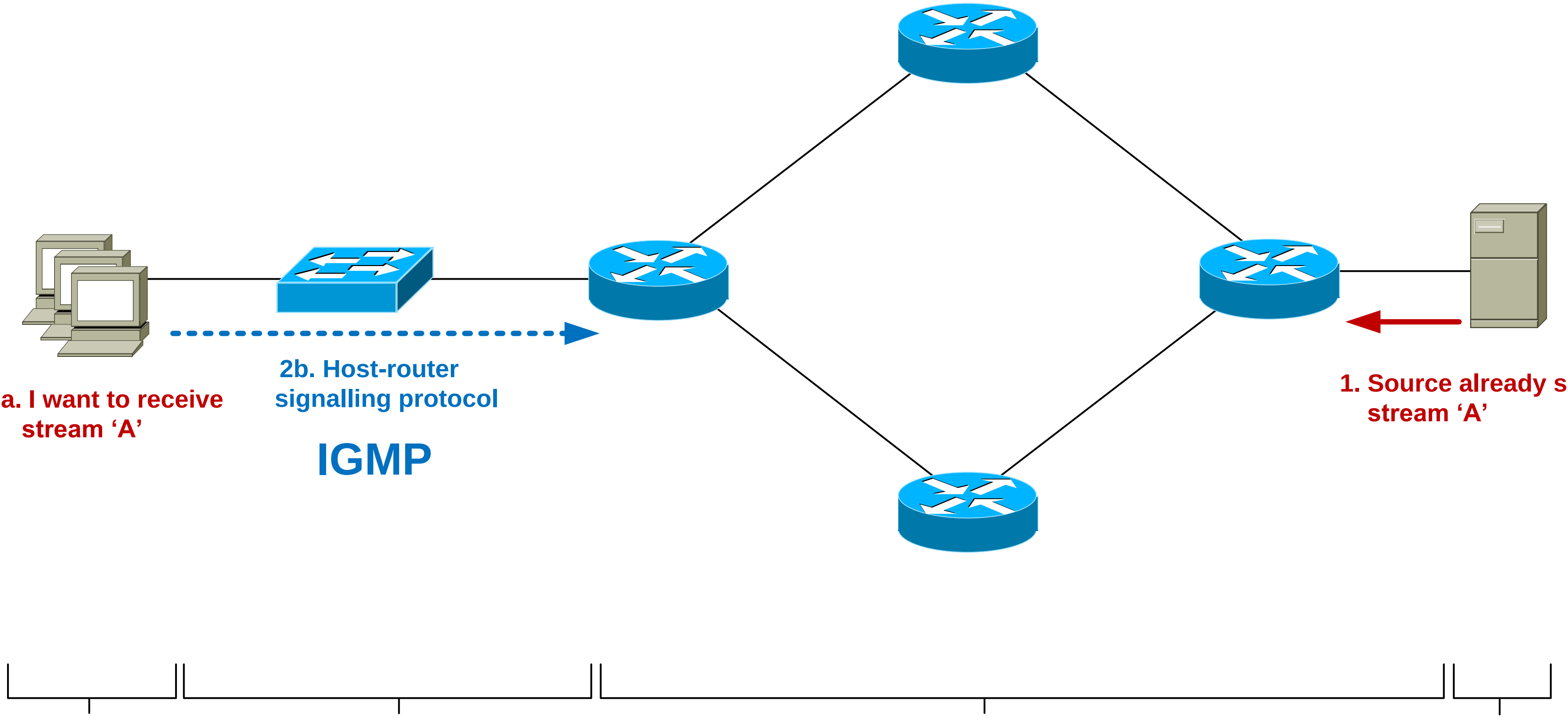
- Check http://www.iana.org/assignments/multicast-addresses/multicast-addresses.xml

Multicast Service Model Overview – Layer 2



1. Source already sending stream 'A'

Multicast Service Model Overview – Layer 2



2a. I want to receive stream 'A'

2b. Host-router signalling protocol

IGMP

1. Source already sending stream 'A'

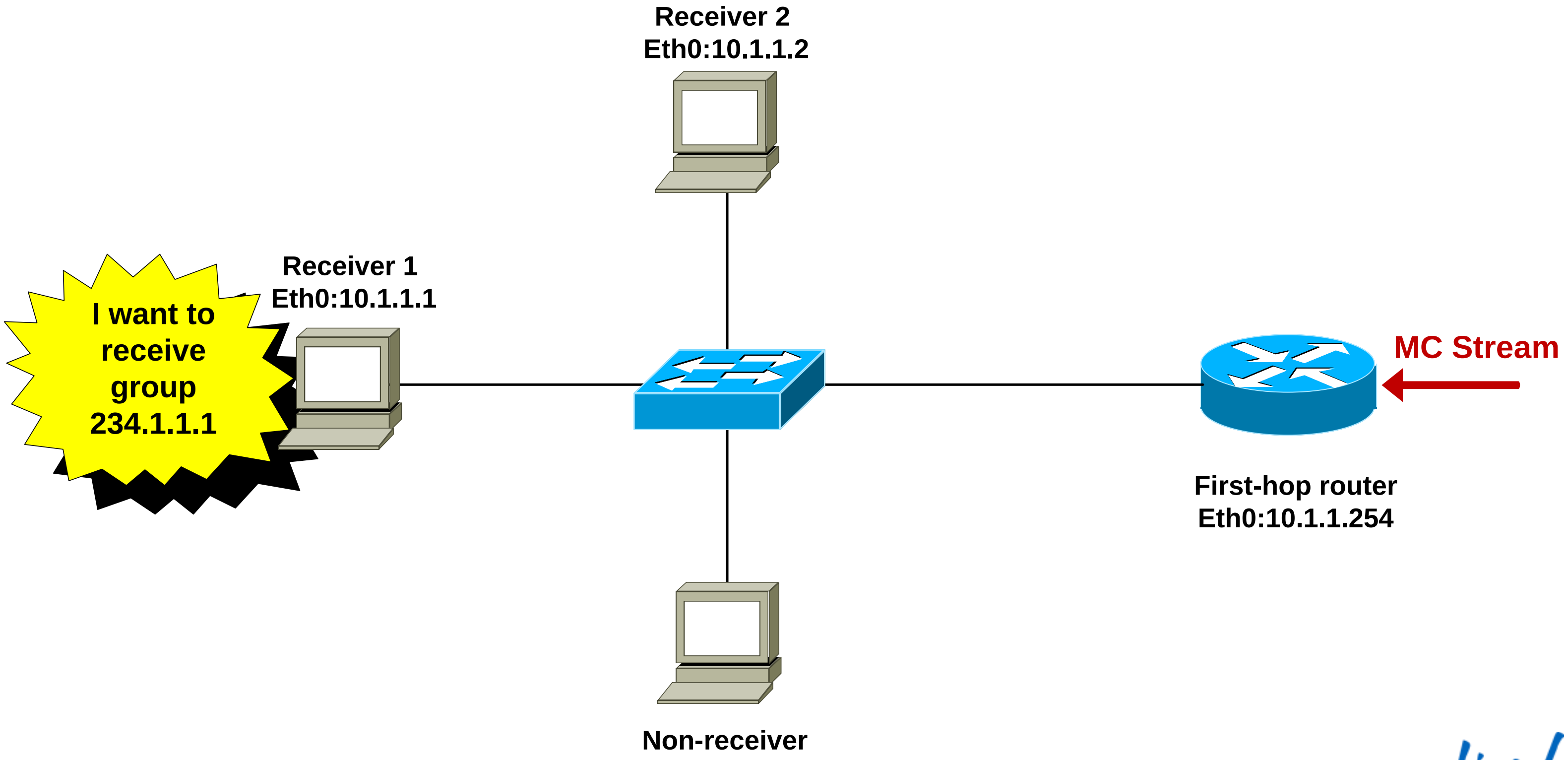
Host-Router Signalling: IGMP

- **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



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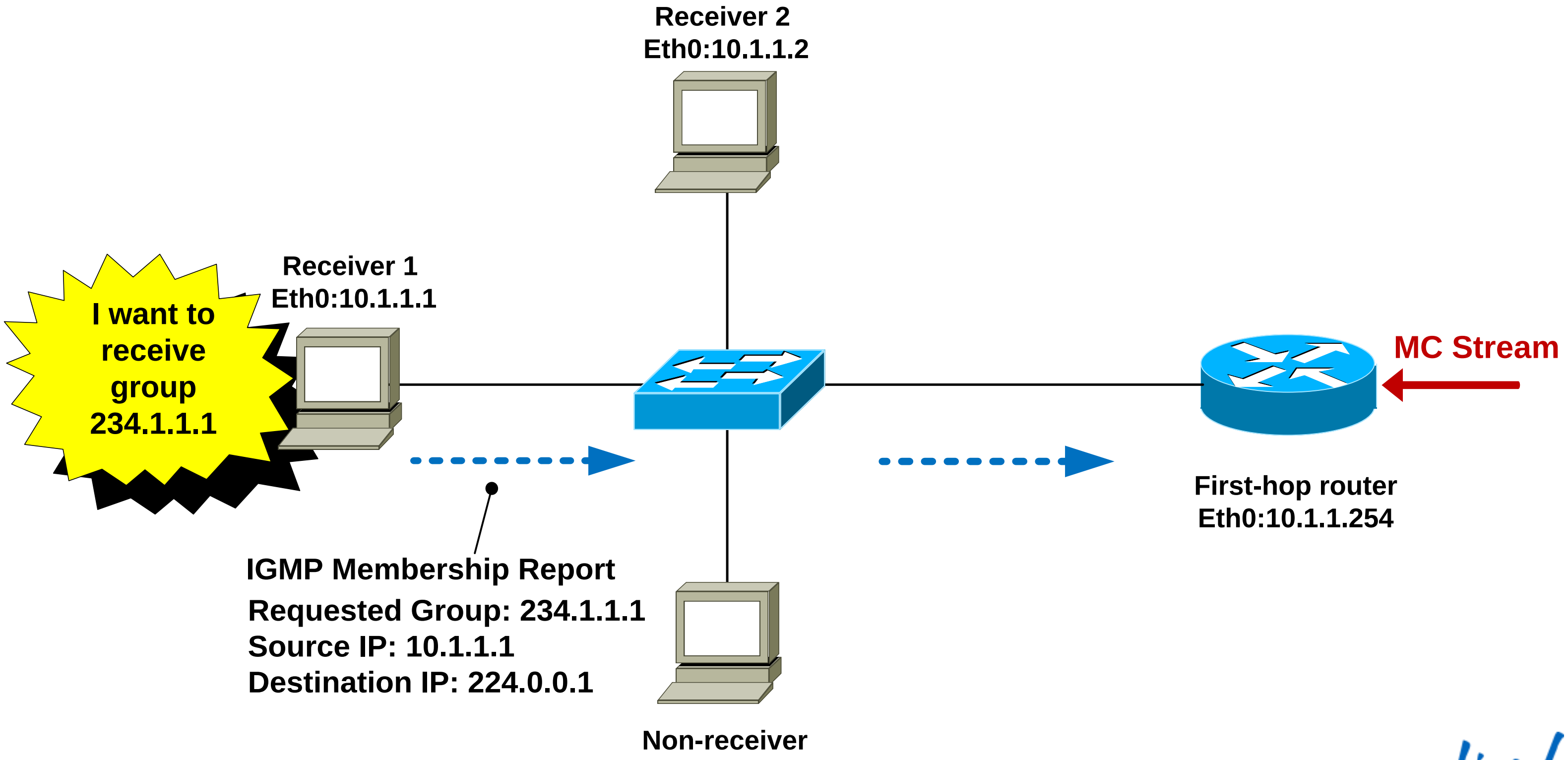


Receiver 2
Eth0:10.1.1.2

I want to receive group 234.1.1.1

Receiver 1
Eth0:10.1.1.1

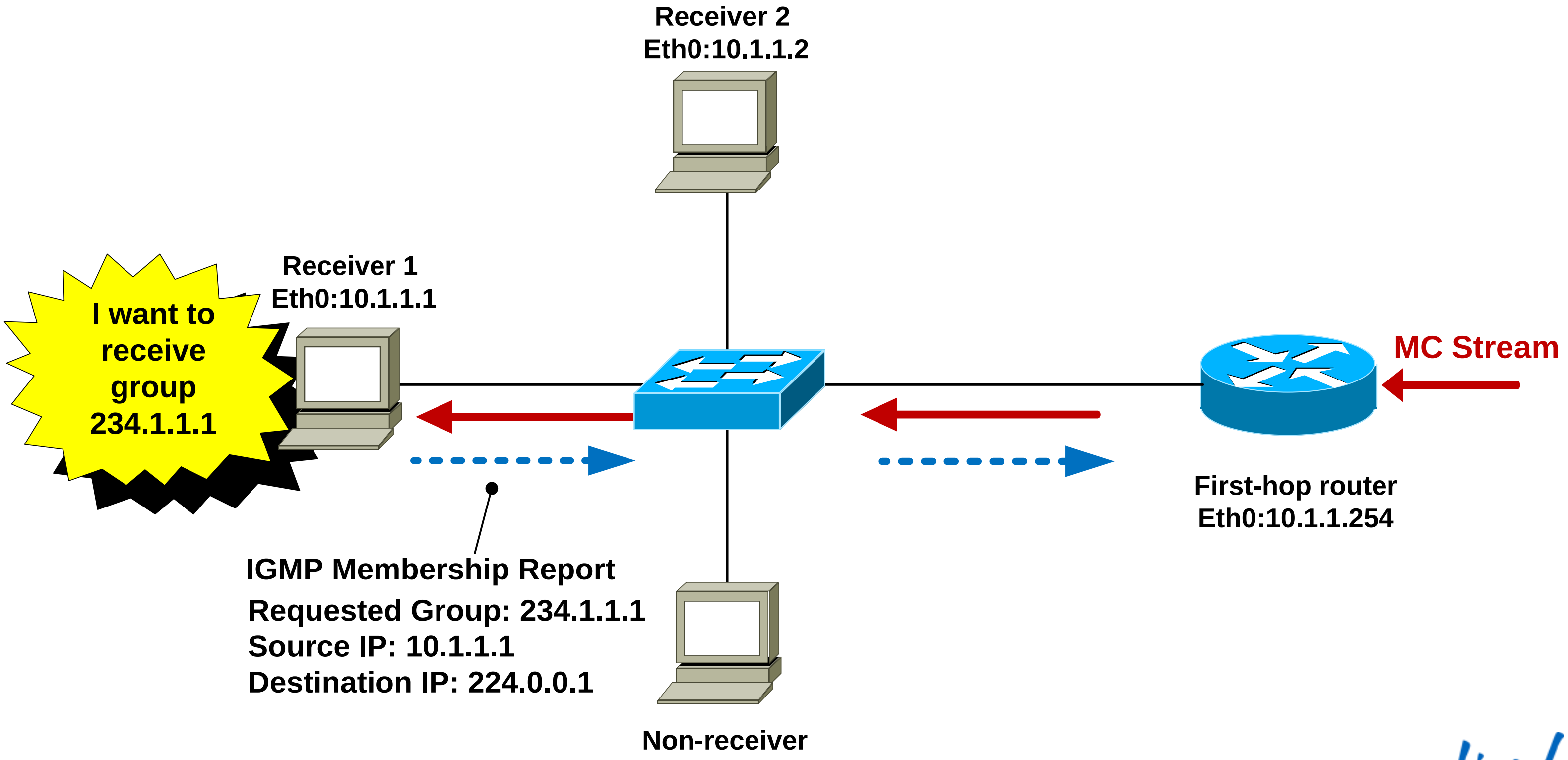
MC Stream

First-hop router
Eth0:10.1.1.254

IGMP Membership Report
Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.1

Non-receiver

IGMPv2 – Joining a Group



IGMP Membership Report

Requested Group: 234.1.1.1
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Destination IP: 224.0.0.1

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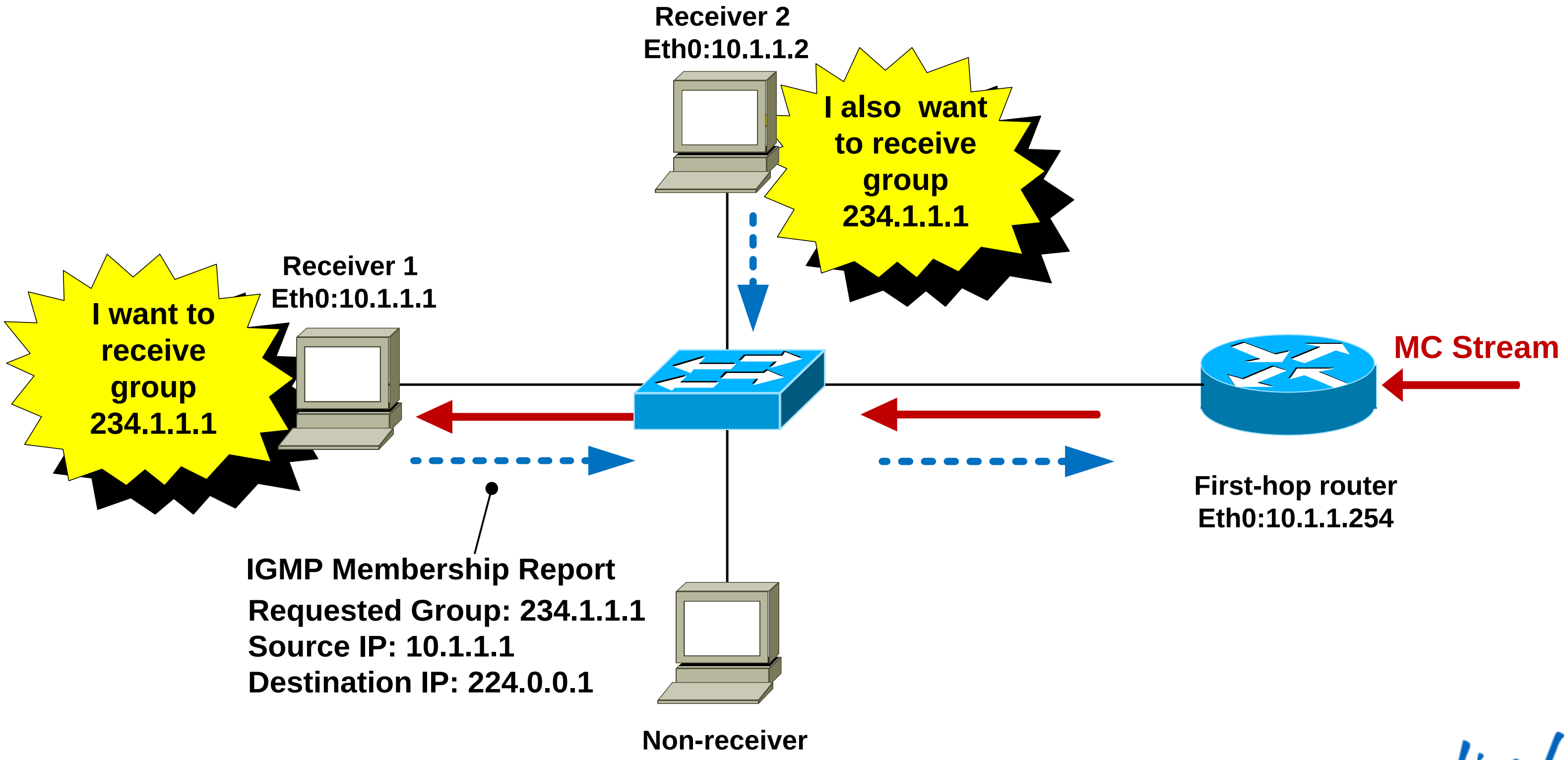

IGMP Membership Report

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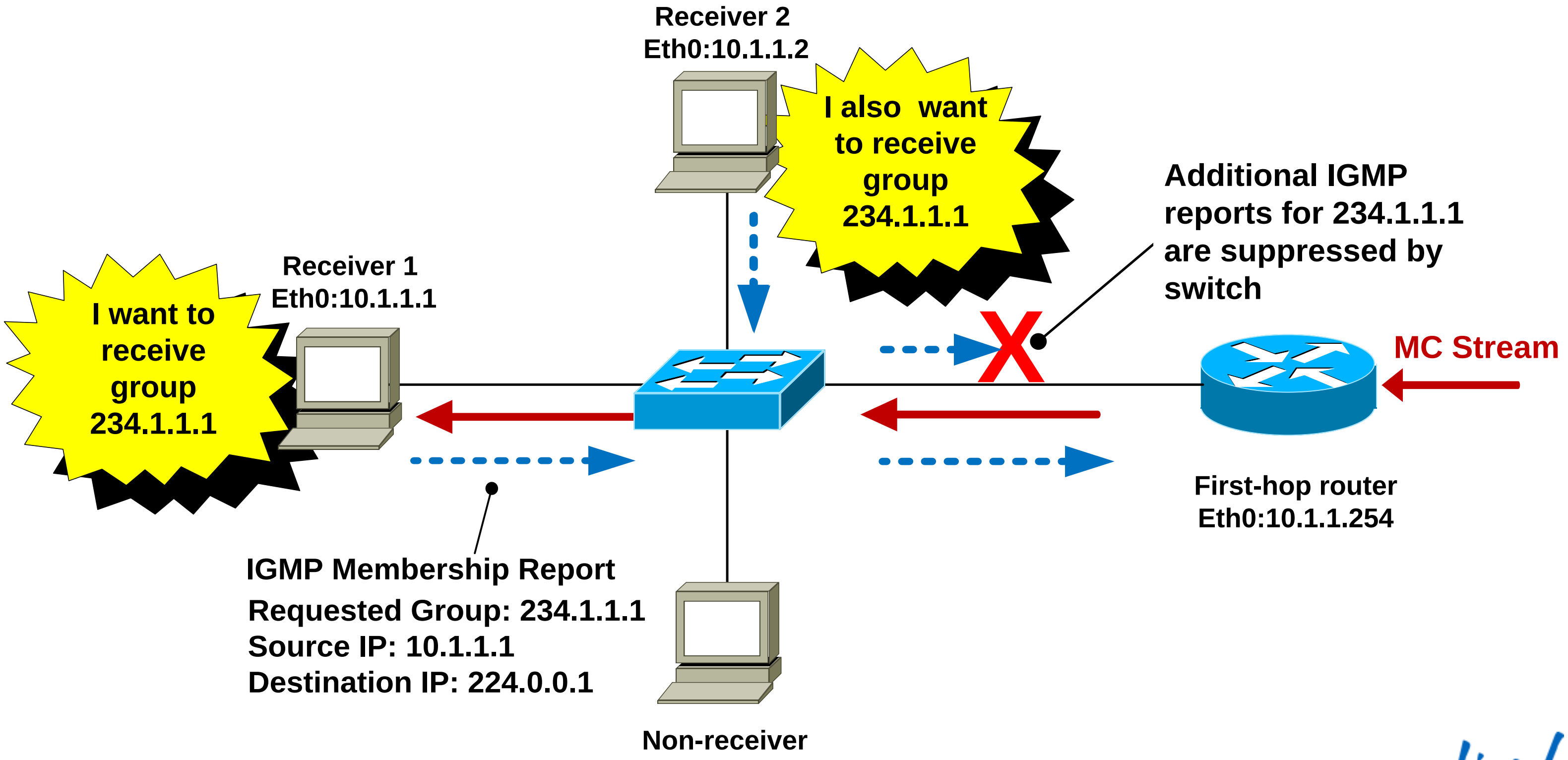
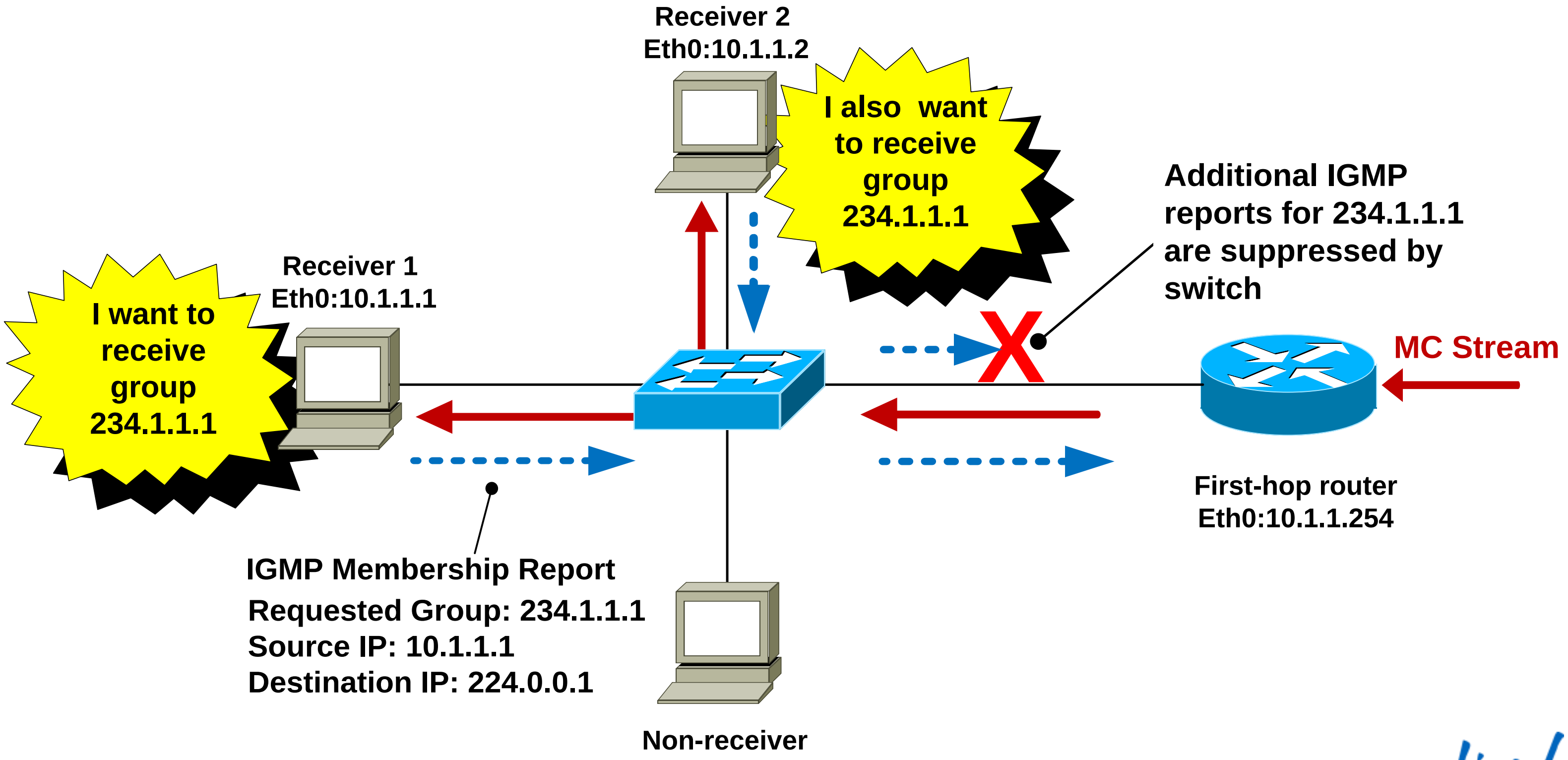


Additional IGMP reports for 234.1.1.1 are suppressed by switch

IGMP Membership Report
Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.1

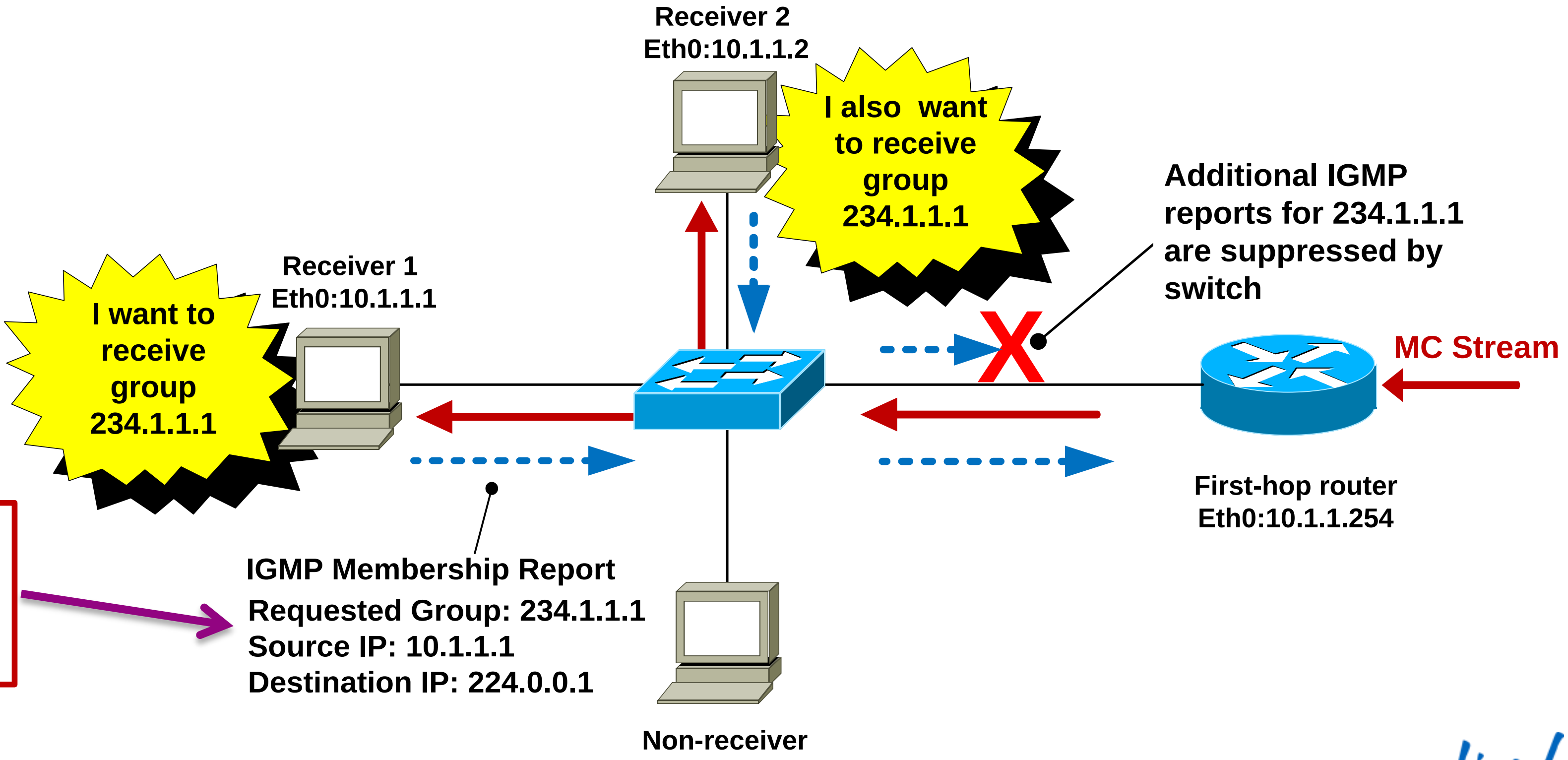
IGMPv2 – Joining a Group


Receiver 2
Eth0:10.1.1.2
I also want to receive group 234.1.1.1
Additional IGMP reports for 234.1.1.1 are suppressed by switch
MC Stream
Receiver 1
Eth0:10.1.1.1
I want to receive group 234.1.1.1
First-hop router
Eth0:10.1.1.254
Non-receiver

IGMP Membership Report

Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.1

IGMPv2 – Joining a Group

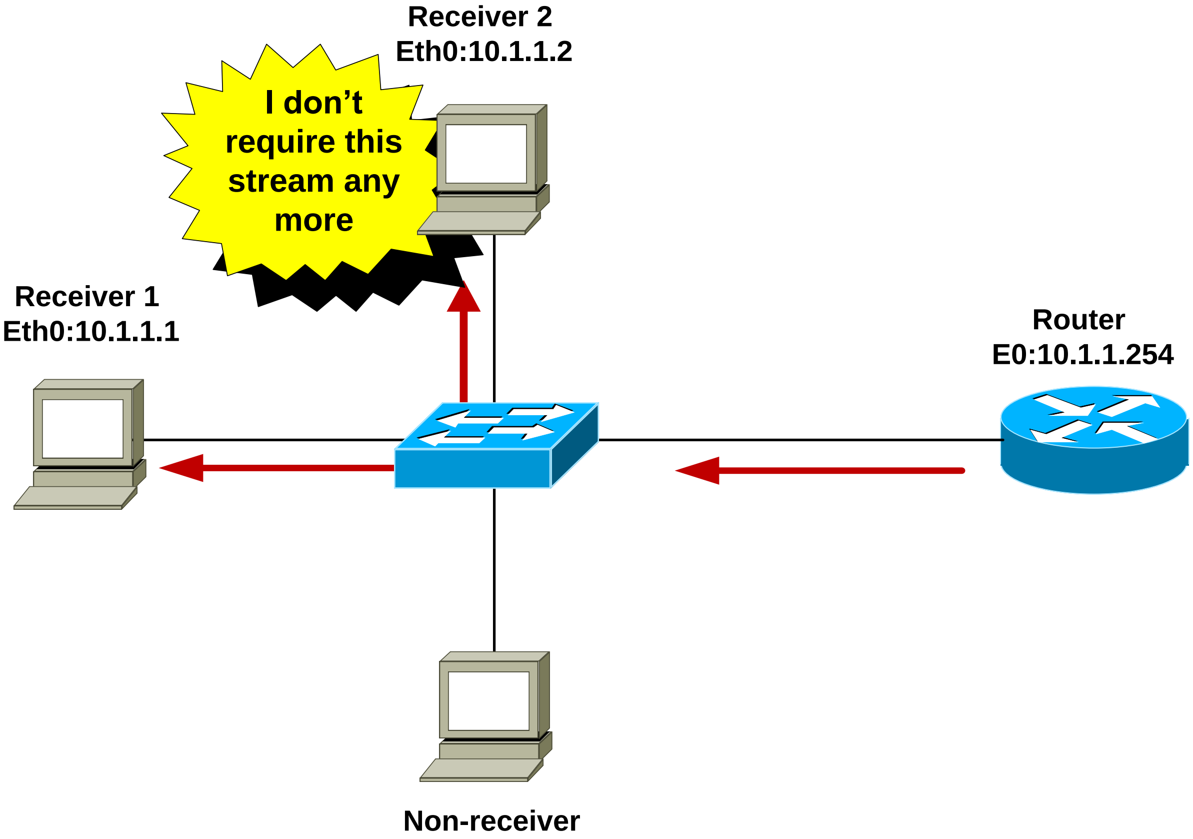


Additional IGMP reports for 234.1.1.1 are suppressed by switch

IGMP Membership Report
Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.1

Note: The IGMP message does not include the identity of the multicast source

IGMPv2 – Maintaining a Group



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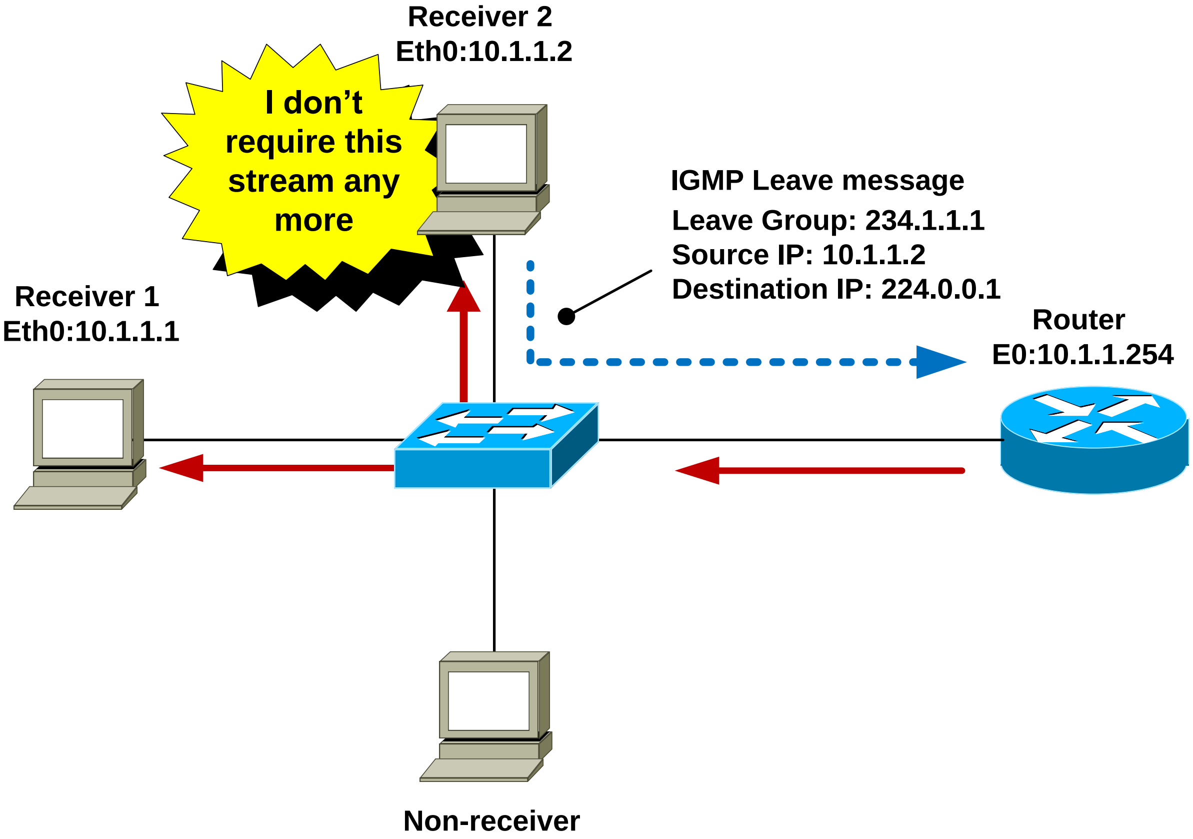

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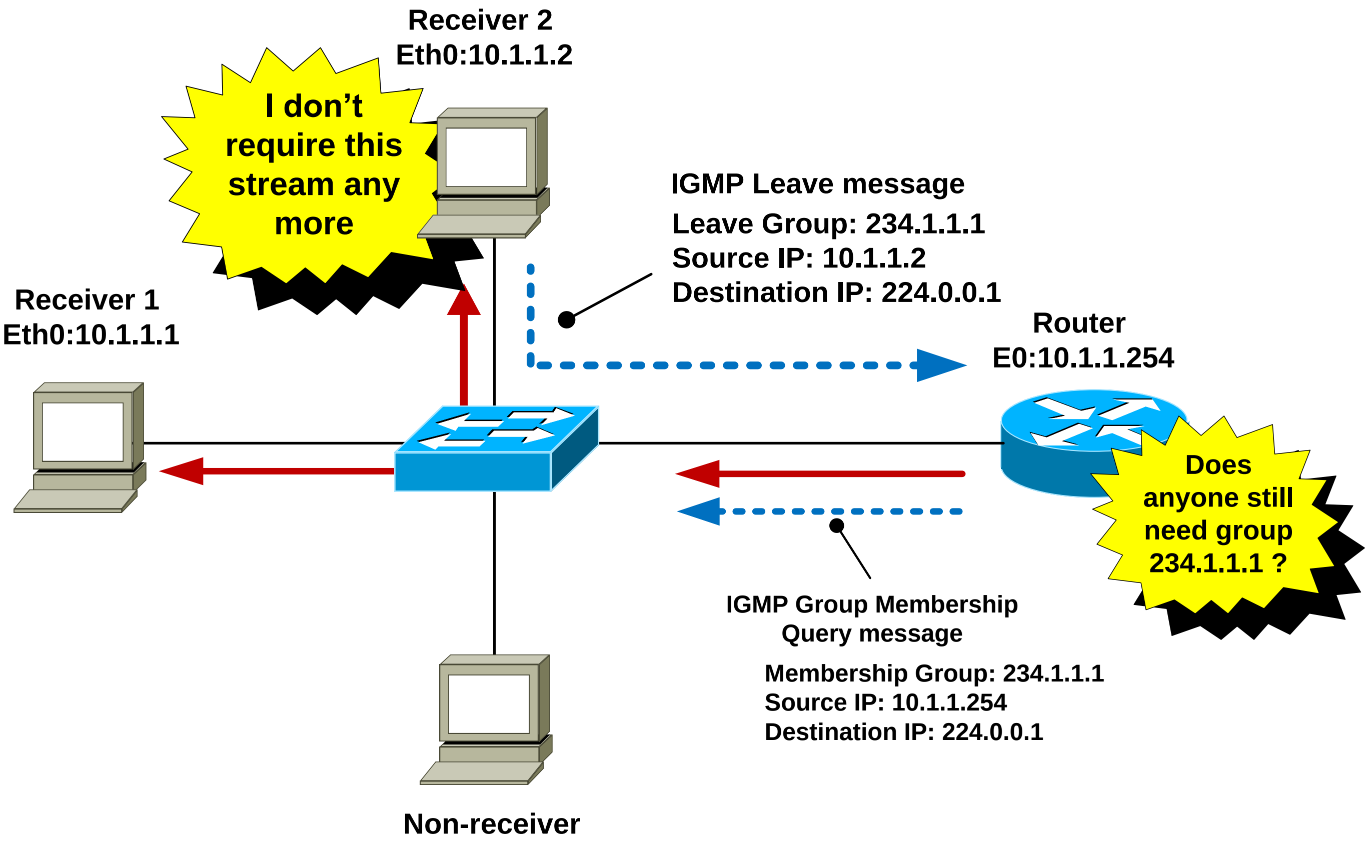


Receiver 2
Eth0:10.1.1.2

I don’t require this stream any more

IGMP Leave message

Leave Group: 234.1.1.1
Source IP: 10.1.1.2
Destination IP: 224.0.0.1

Receiver 1
Eth0:10.1.1.1

Router
E0:10.1.1.254

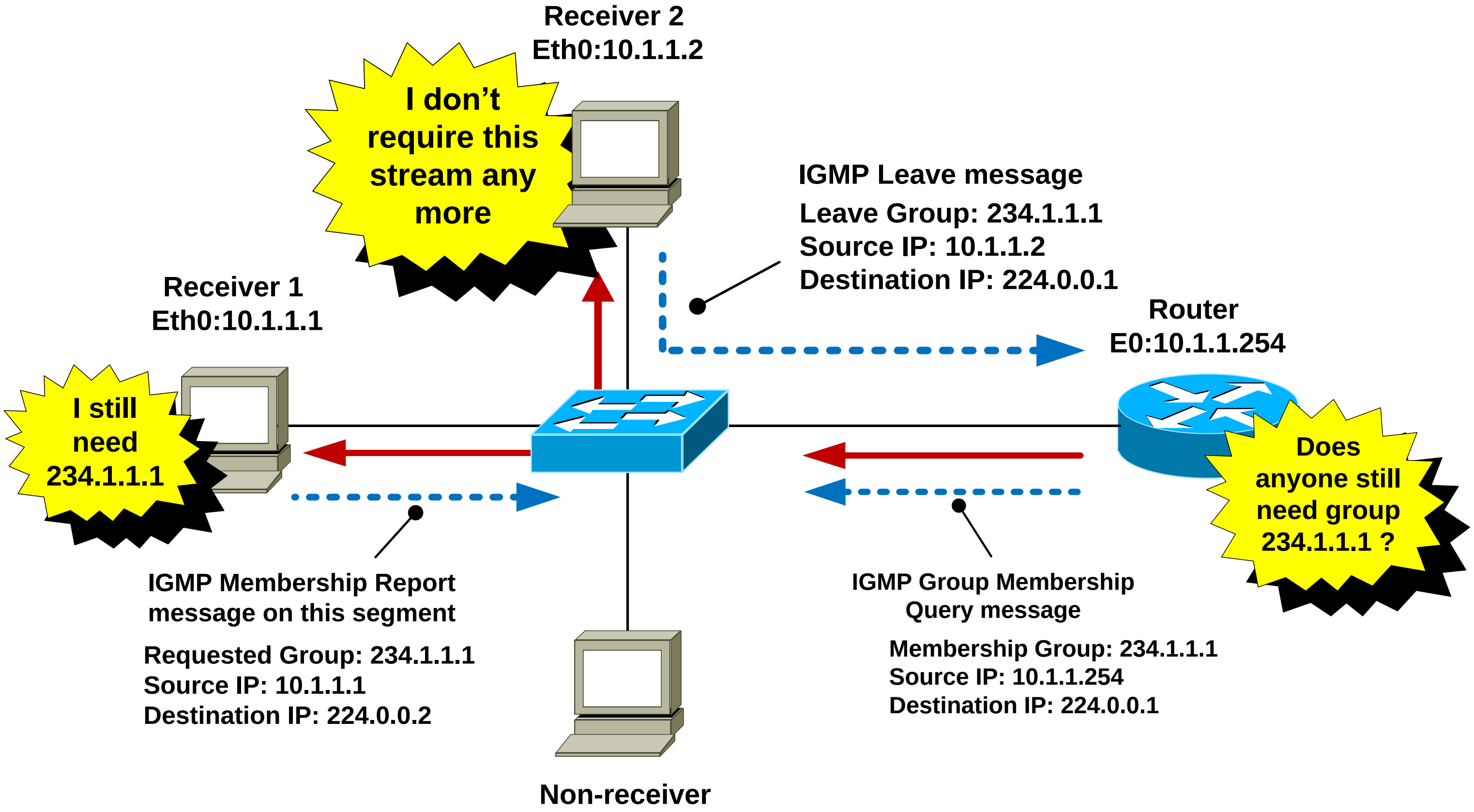
Does anyone still need group 234.1.1.1 ?

IGMP Group Membership Query message

Membership Group: 234.1.1.1
Source IP: 10.1.1.254
Destination IP: 224.0.0.1

Non-receiver

IGMPv2 – Maintaining a Group



IGMP Leave message

Leave Group: 234.1.1.1
Source IP: 10.1.1.2
Destination IP: 224.0.0.1

IGMP Membership Report message on this segment

Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.2

IGMP Group Membership Query message

Membership Group: 234.1.1.1
Source IP: 10.1.1.254
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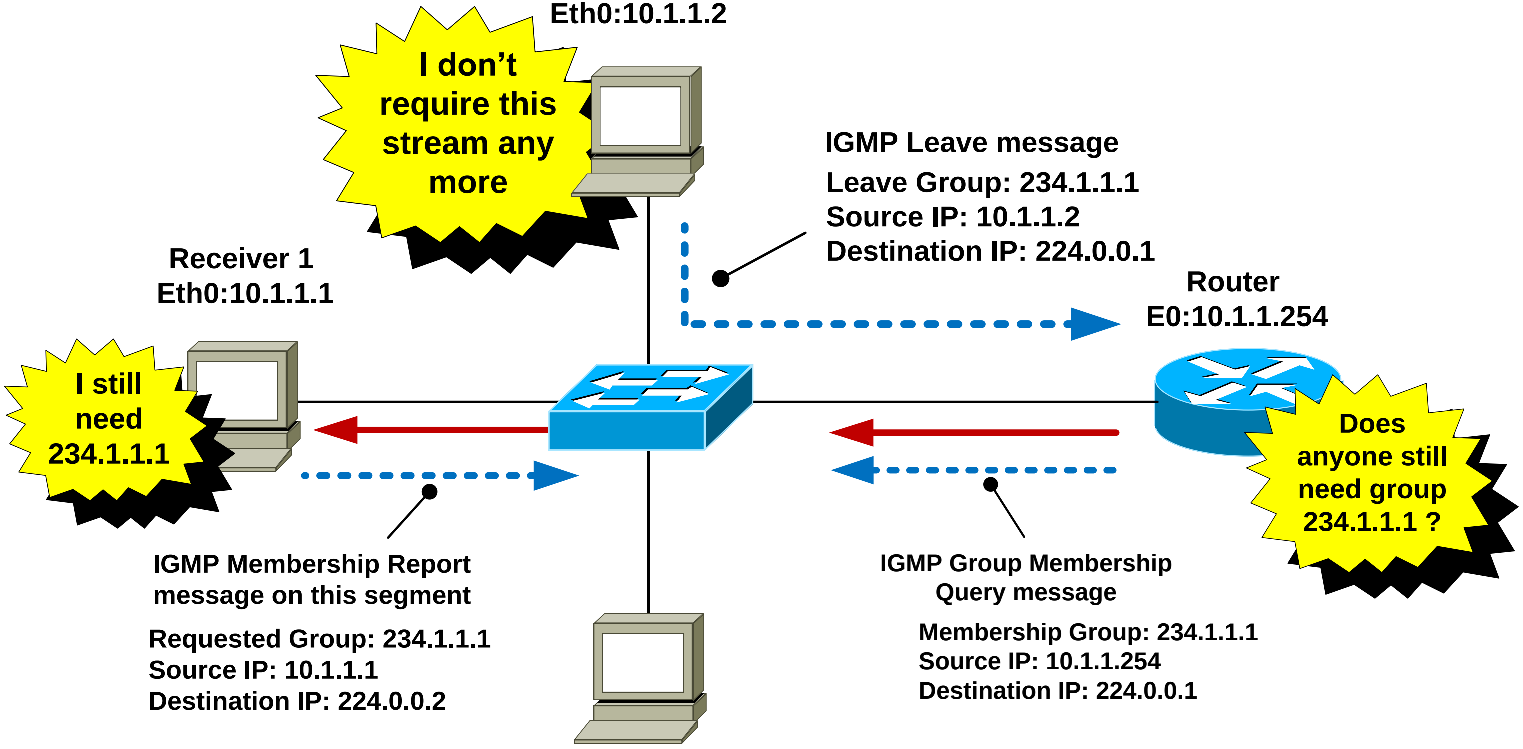

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Does anyone still need group 234.1.1.1 ?

IGMP Membership Report message on this segment

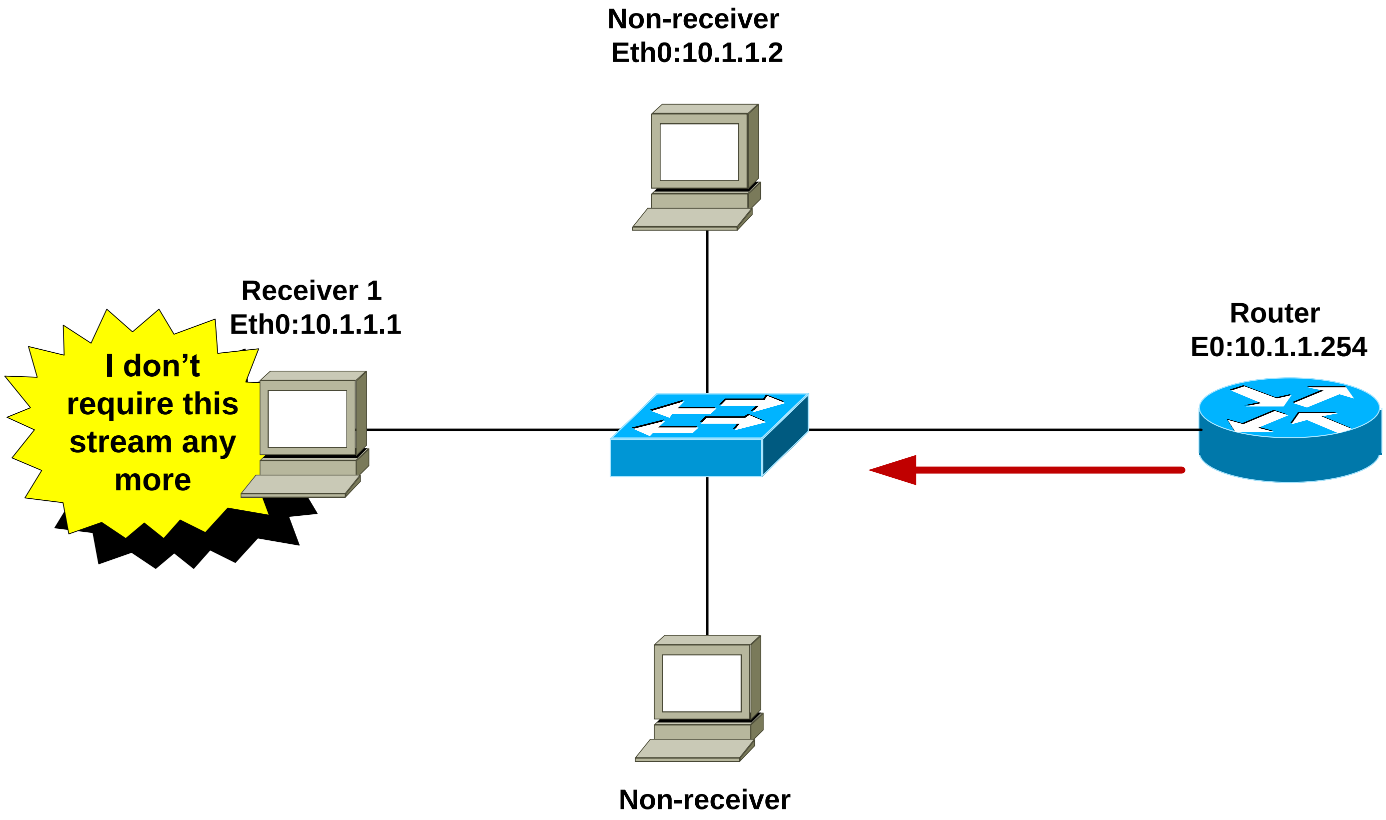
Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.2

IGMP Group Membership Query message

Membership Group: 234.1.1.1
Source IP: 10.1.1.254
Destination IP: 224.0.0.1

Non-receiver

IGMPv2 – Leaving a Group



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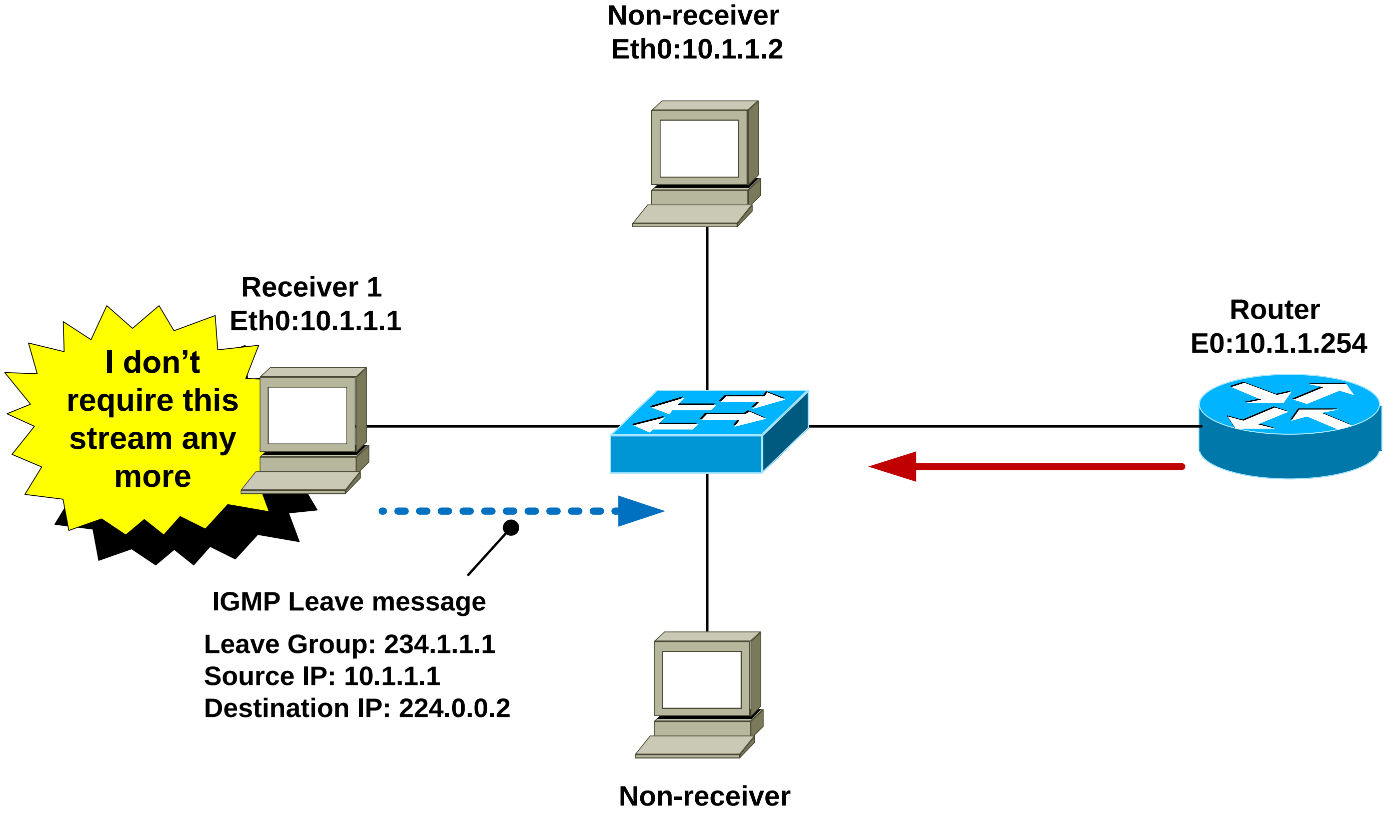

Leave Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.2

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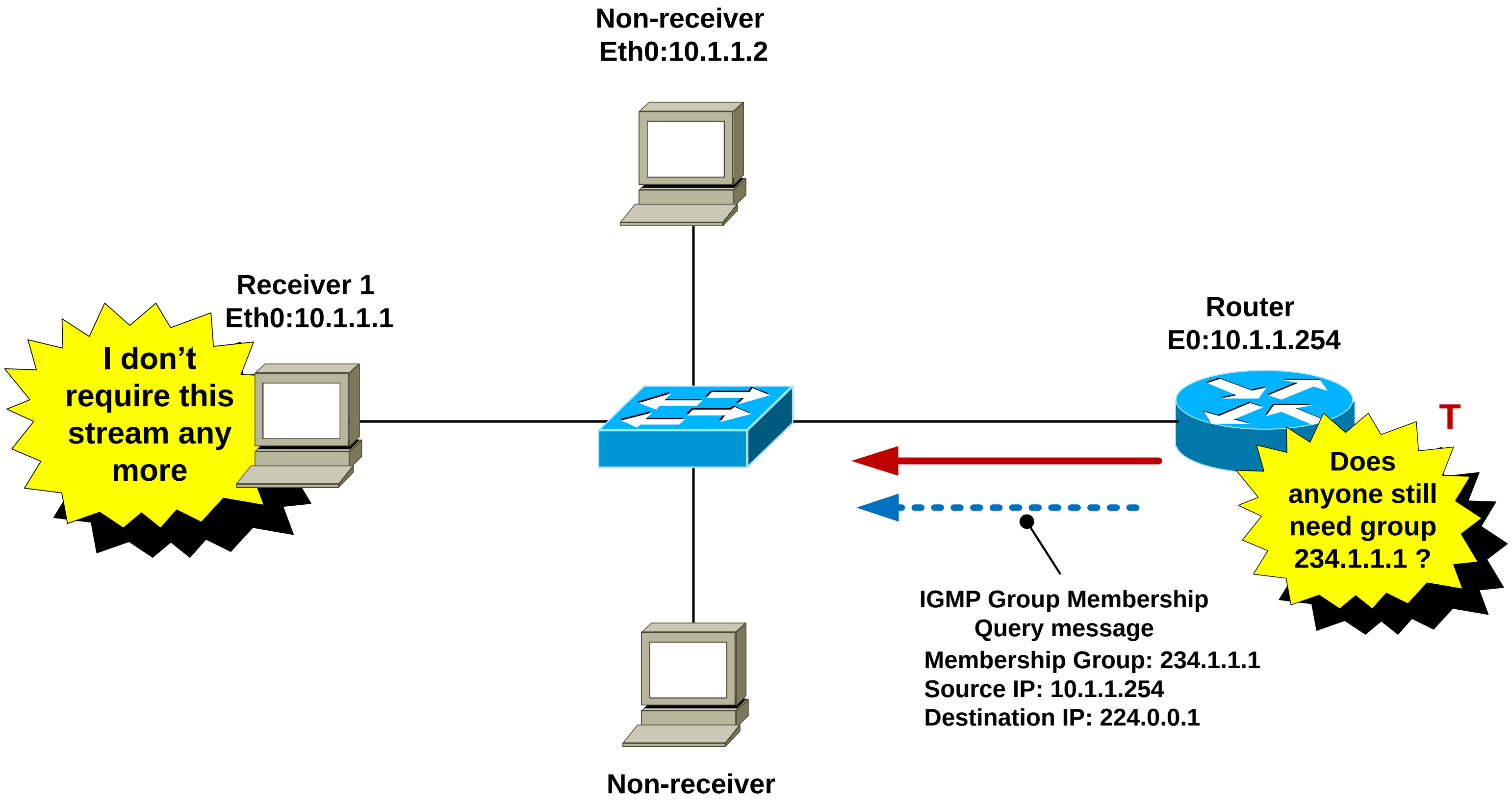
Non-receiver
Eth0:10.1.1.2
Receiver 1
Eth0:10.1.1.1
I don’t require this stream any more
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E0:10.1.1.254
T
Does anyone still need group 234.1.1.1 ?
IGMP Group Membership Query message
Membership Group: 234.1.1.1
Source IP: 10.1.1.254
Destination IP: 224.0.0.1
Non-receiver

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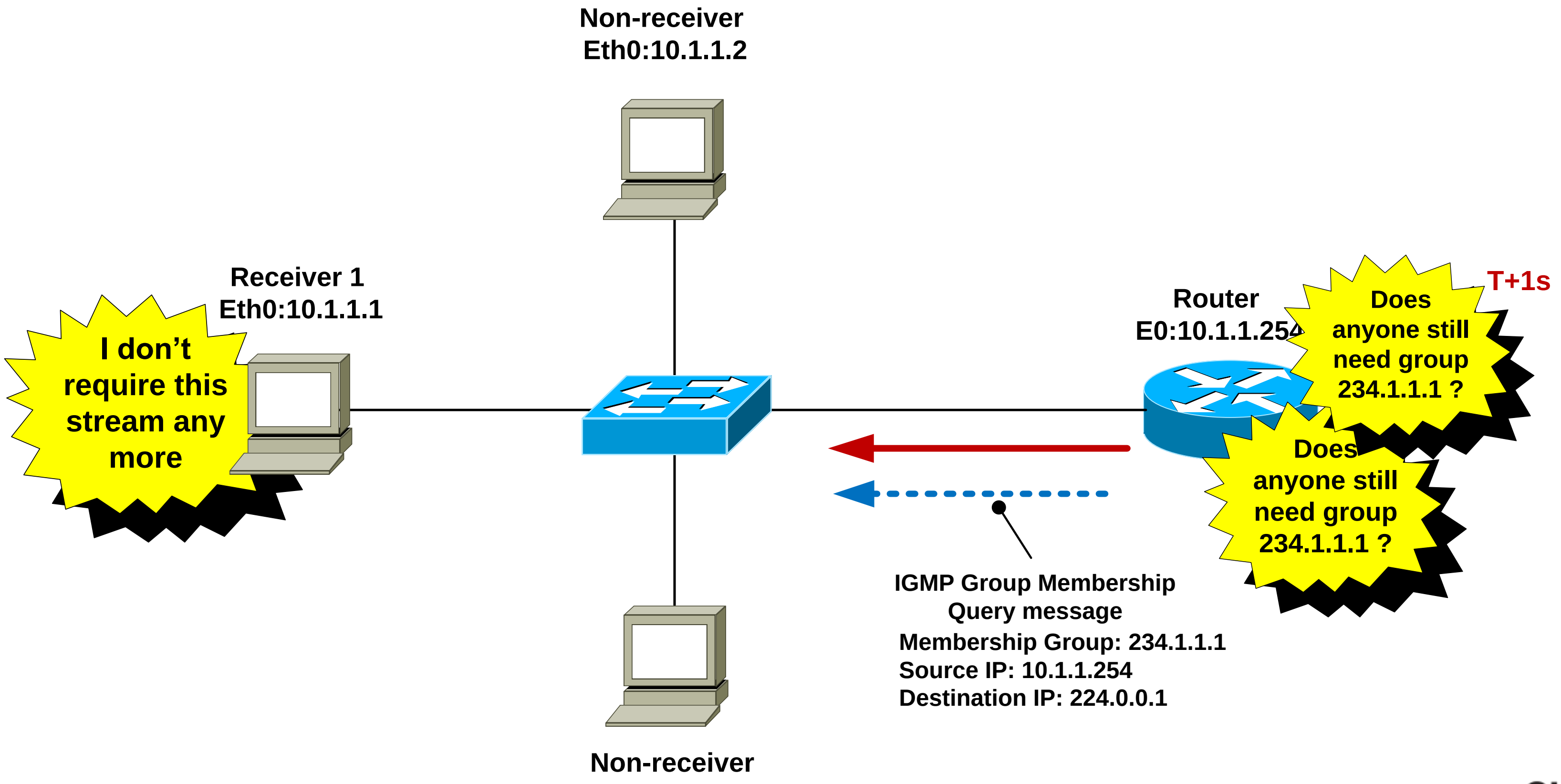
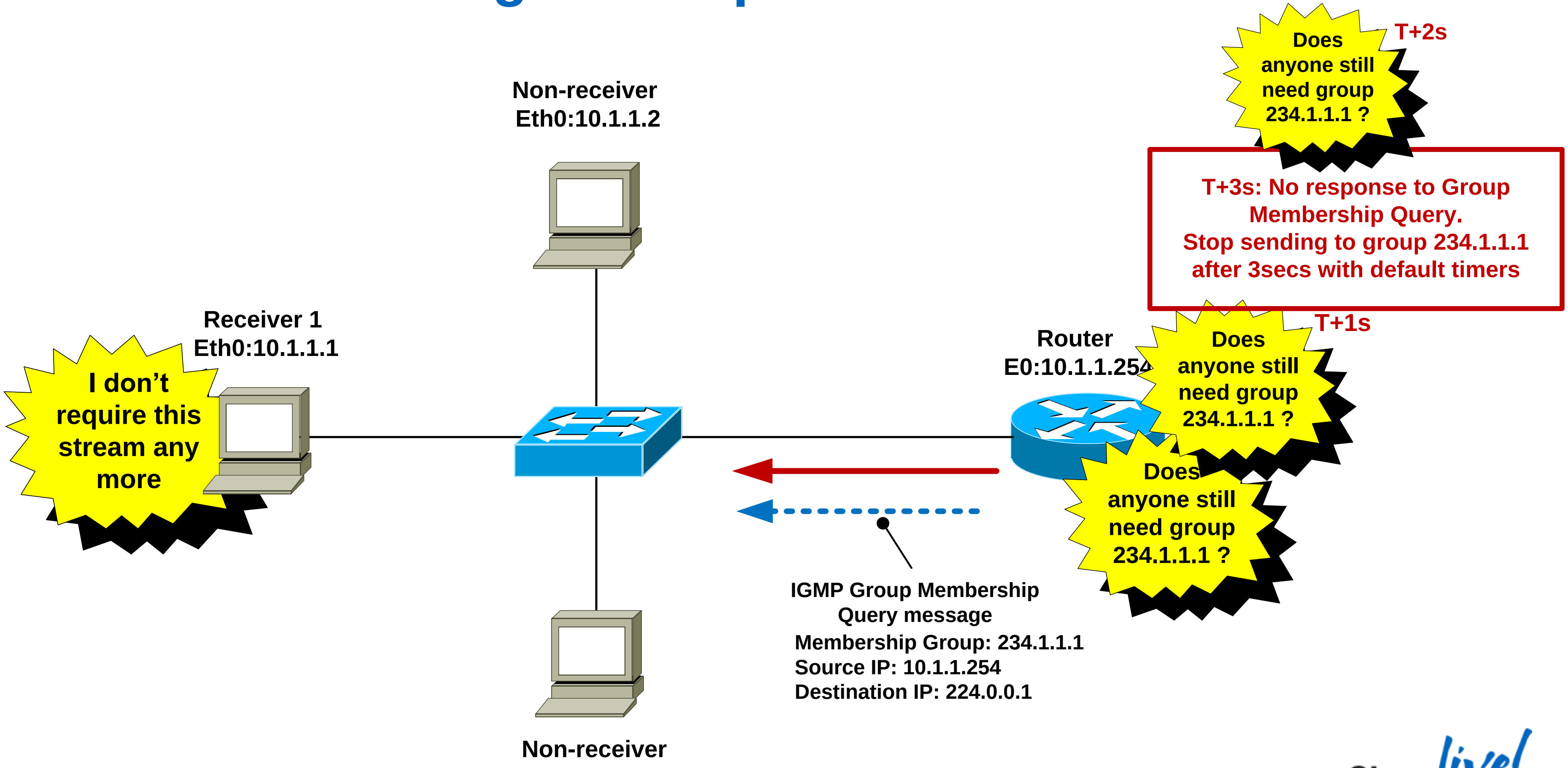


Non-receiver
Eth0:10.1.1.2
Receiver 1
Eth0:10.1.1.1
I don’t require this stream any more
Router
E0:10.1.1.254
T+1s
Does anyone still need group 234.1.1.1 ?
Does anyone still need group 234.1.1.1 ?
Non-receiver

IGMP Group Membership Query message

Membership Group: 234.1.1.1
Source IP: 10.1.1.254
Destination IP: 224.0.0.1

IGMPv2 – Leaving a Group


Does anyone still need group 234.1.1.1 ?
T+2s
T+3s: No response to Group Membership Query.
Stop sending to group 234.1.1.1 after 3secs with default timers
Non-receiver
Eth0:10.1.1.2
Receiver 1
Eth0:10.1.1.1
I don't require this stream any more
Router
E0:10.1.1.254
T+1s
Does anyone still need group 234.1.1.1 ?
Does anyone still need group 234.1.1.1 ?
IGMP Group Membership Query message
Membership Group: 234.1.1.1
Source IP: 10.1.1.254
Destination IP: 224.0.0.1
Non-receiver

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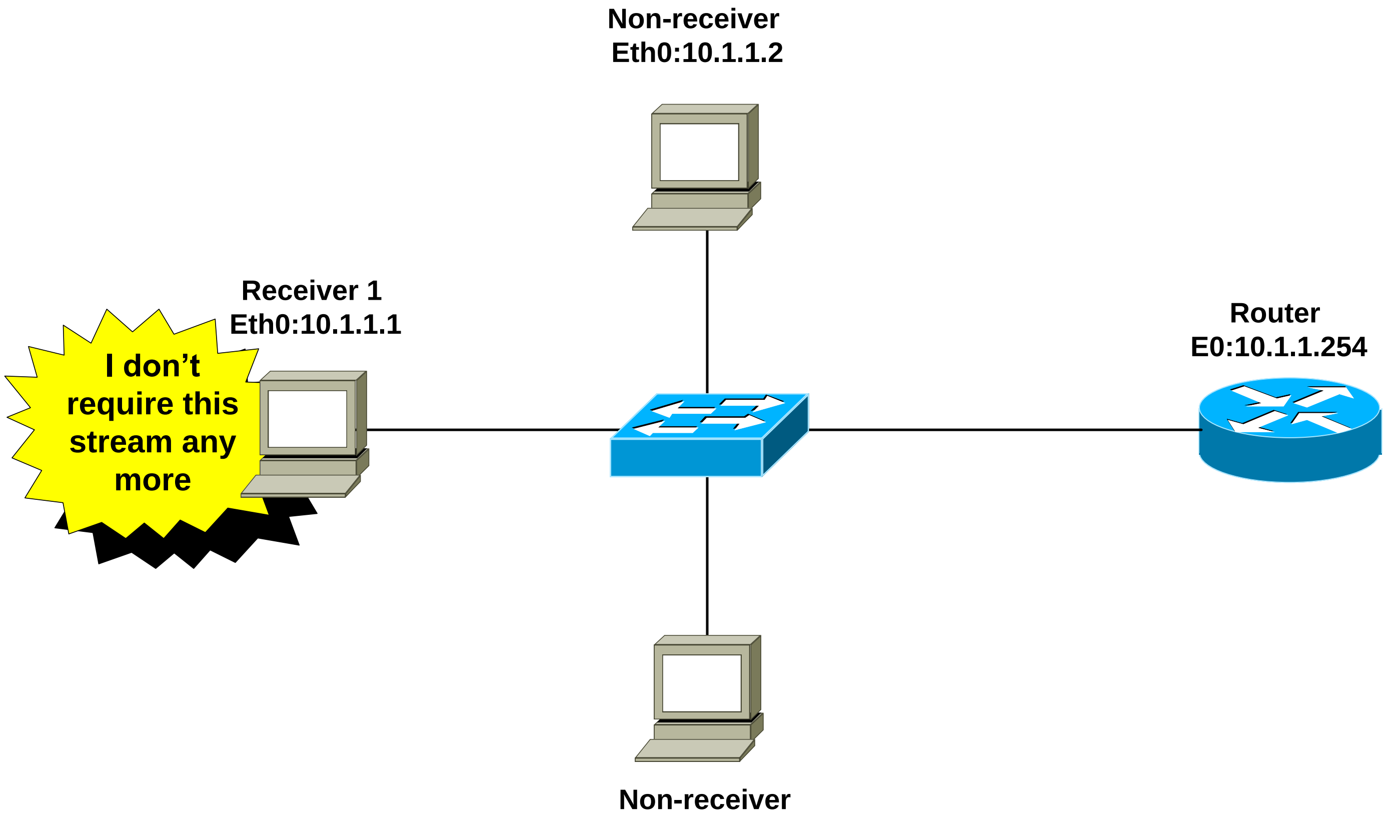

IGMP Snooping

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

Advantages of IGMP Snooping

- Hosts only receive MC traffic that they request
- Report suppression – switch acts as a IGMP middleman, 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

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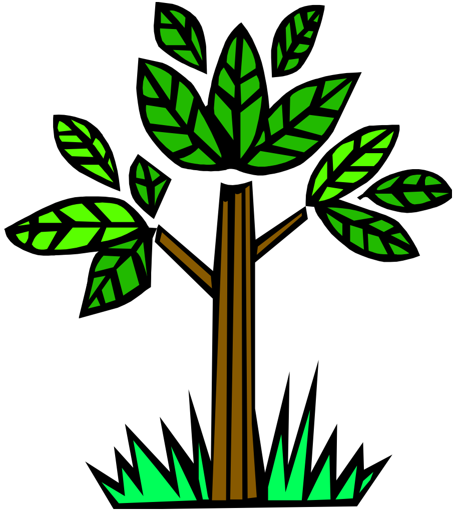
Q. When would IGMP snooping fast-leave be a bad idea ?

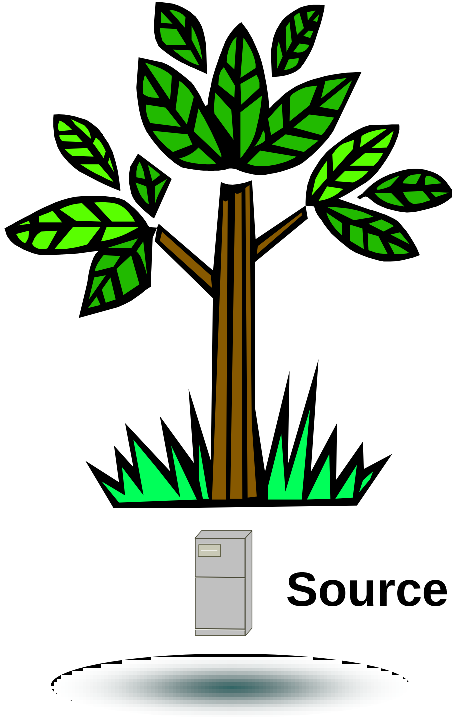
A. When there is more than 1 receiver attached to an interface

Its all about Trees!



- Mechanism for transmitting information from a single source (root) to many receivers (leaves)
- Single copy of a datagram is sent from the source and replicated through the tree to receivers
- Two Tree Types: Source and Shared

Its all about Trees!



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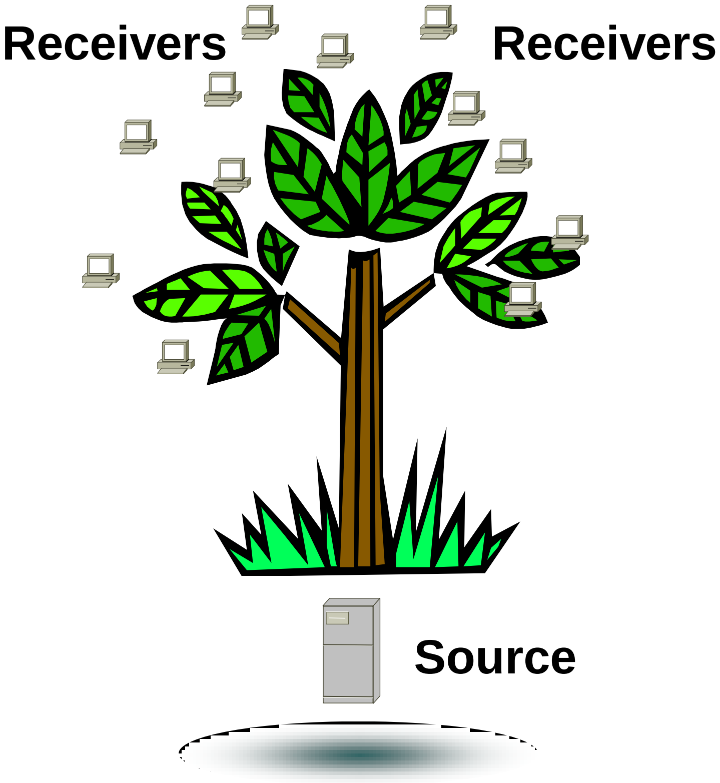

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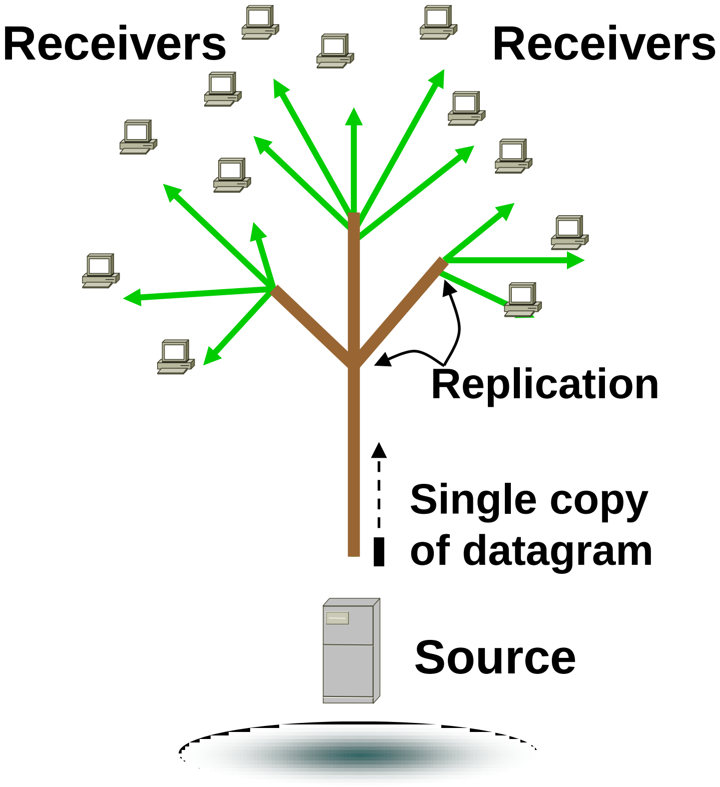

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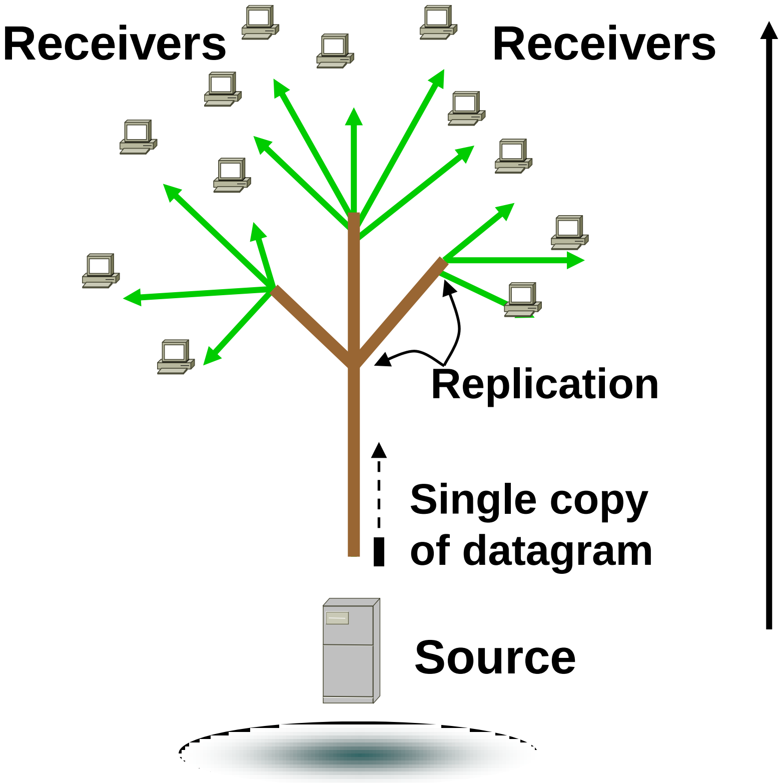

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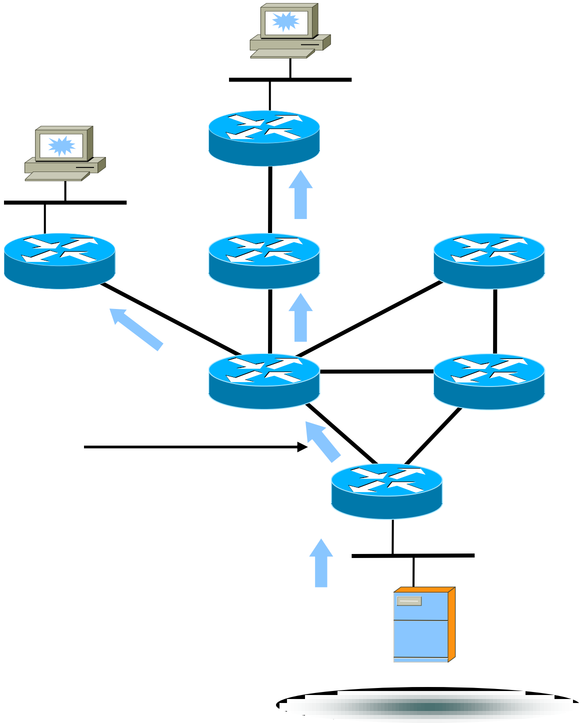
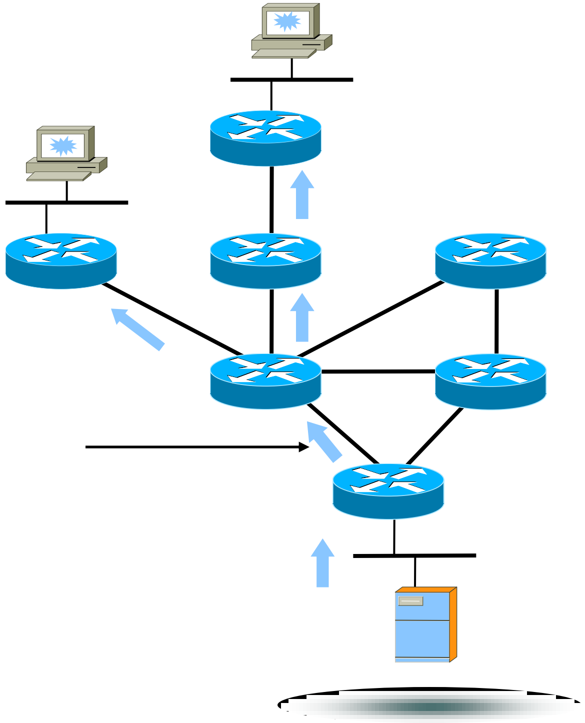
Source Tree

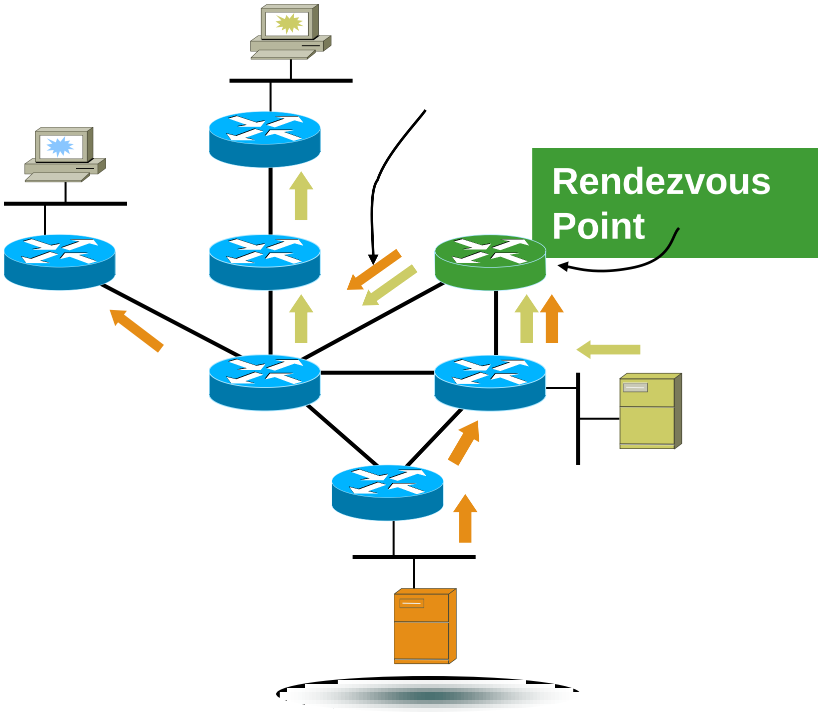


Source Tree

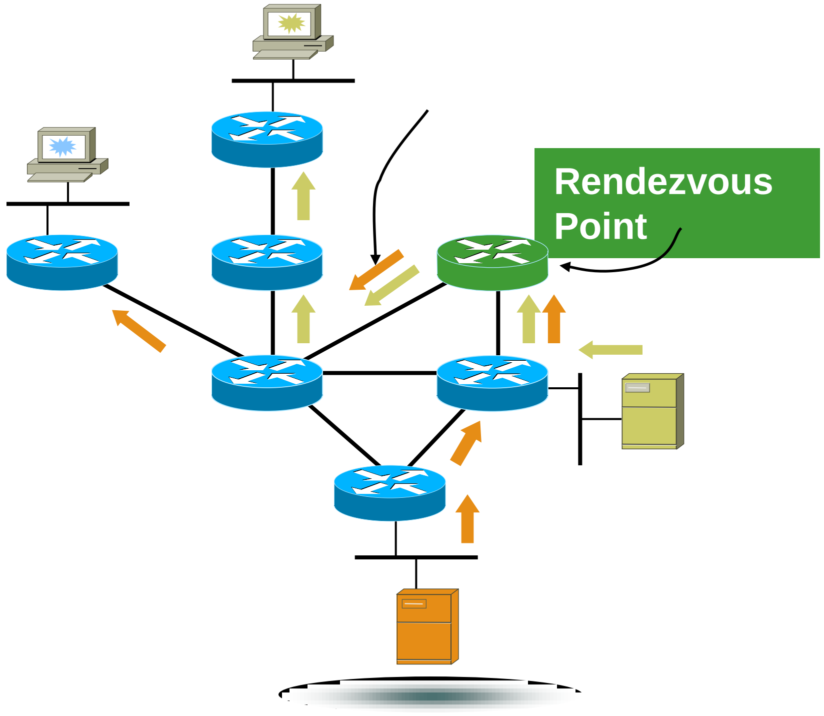


- Simplest form of tree
  - Receiver requires knowledge of source
- Traffic travels from source (root) to receivers (leaves), shortest path taken
- Packets replicated at branch point
- Fwding entry states represented as (S, G) in mroute table
- Provides Optimal routing
  - At the expense of more state (S, G)

Shared Tree

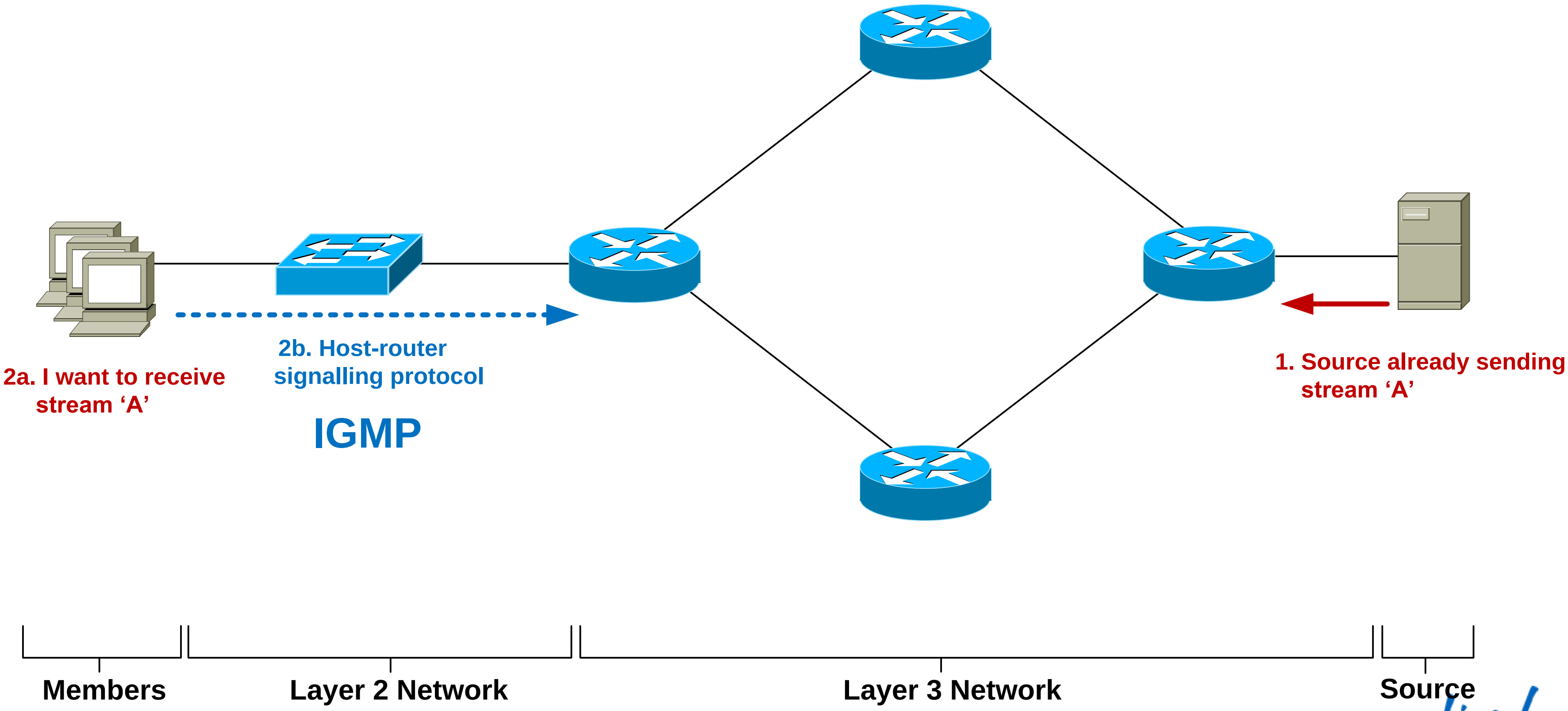


Shared Tree



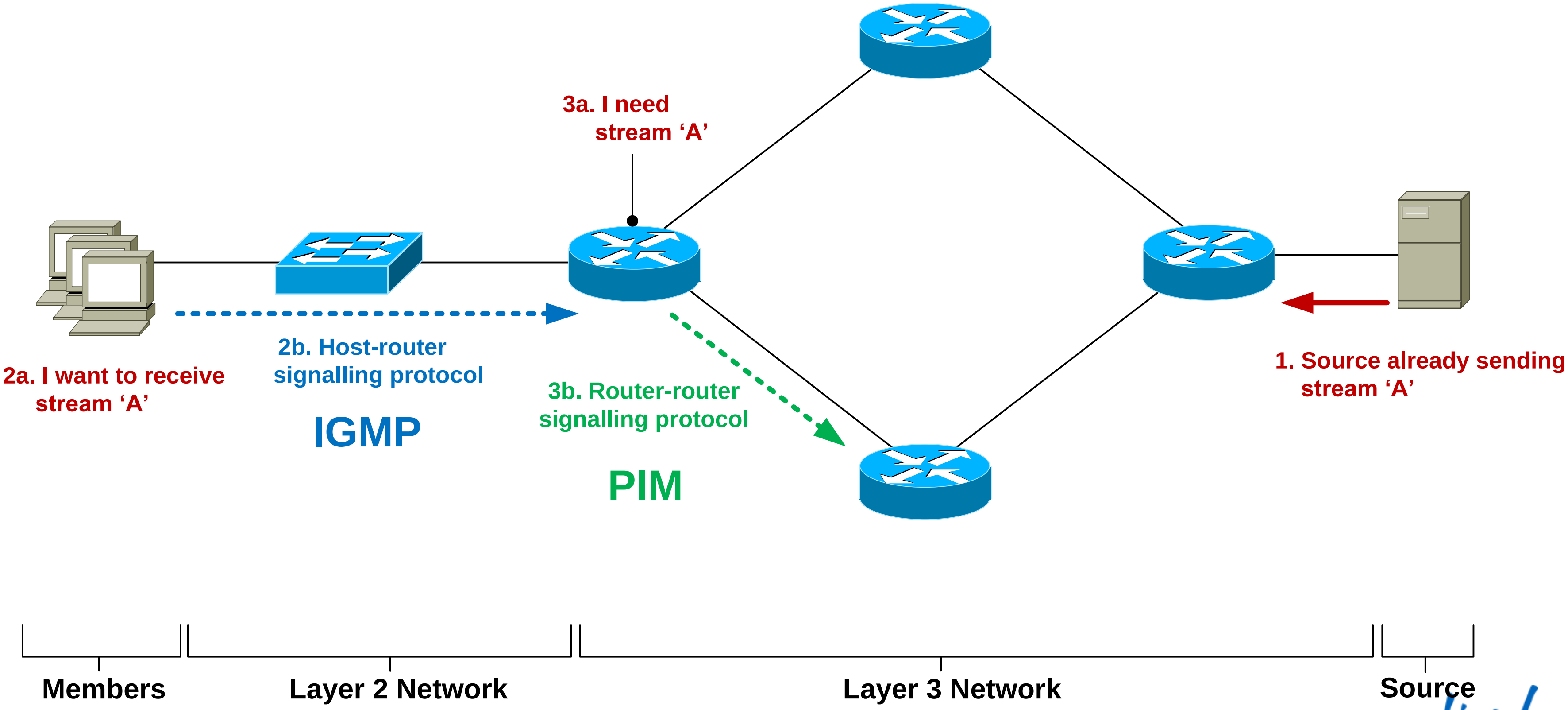
- Root is a common point
  - Rendezvous Point
  - Many multicast groups at RP
- Receivers join RP
  - To learn of sources
- Sources only transmit to RP
  RP forward to receivers
- Forwarding represented as (*, G) in mroute table
- Less state required
  - At expense of optimal routing

Multicast Service Model Overview – Layer 3



2b. Host-router signalling protocol
2a. I want to receive stream ‘A’
IGMP
1. Source already sending stream ‘A’
Members
Layer 2 Network
Layer 3 Network
Source

Multicast Service Model Overview – Layer 3


3a. I need stream 'A'
2a. I want to receive stream 'A'
2b. Host-router signalling protocol
IGMP
3b. Router-router signalling protocol
PIM
1. Source already sending stream 'A'
Members
Layer 2 Network
Layer 3 Network
Source

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 (G).
- 3 main classifications of PIM

Any Source Multicast (asm-pim) – 3 “submodes”

Dense, sparse, sparse-dense

Source-Specific Multicast (pim-ssm)

Bidirectional (pim-bidir)

Router-Router Signalling: PIM

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  Any Source Multicast (asm-pim) – 3 “submodes”

  Legacy ~~Dense~~, sparse, ~~sparse-dense~~ **Cisco Specific**

  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

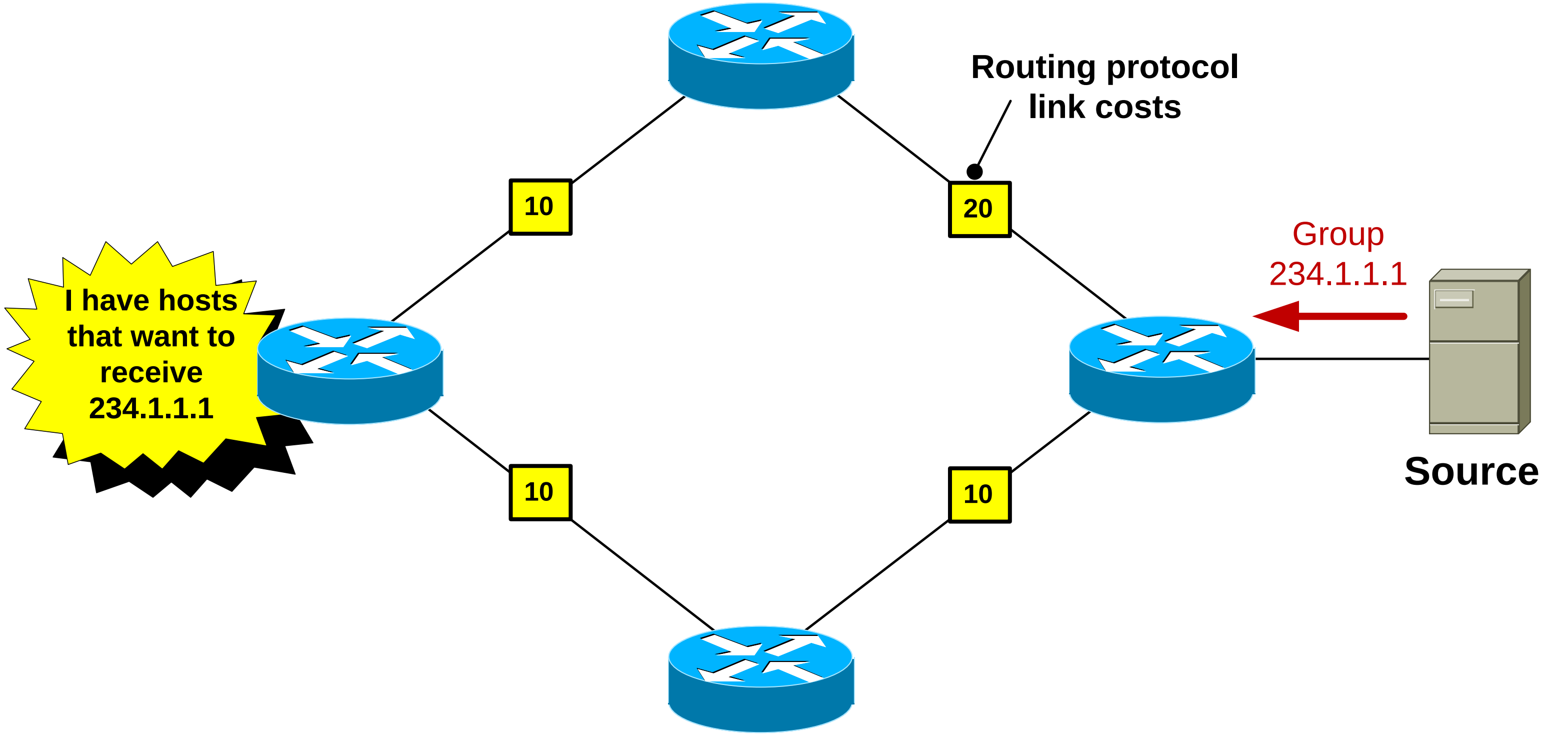
- Multicast traffic flows are checked from the sender back down the path created by the PIM messages. This is known as Reverse Path Forwarding (RPF).
- All received multicast traffic is subject to an **RPF check**

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

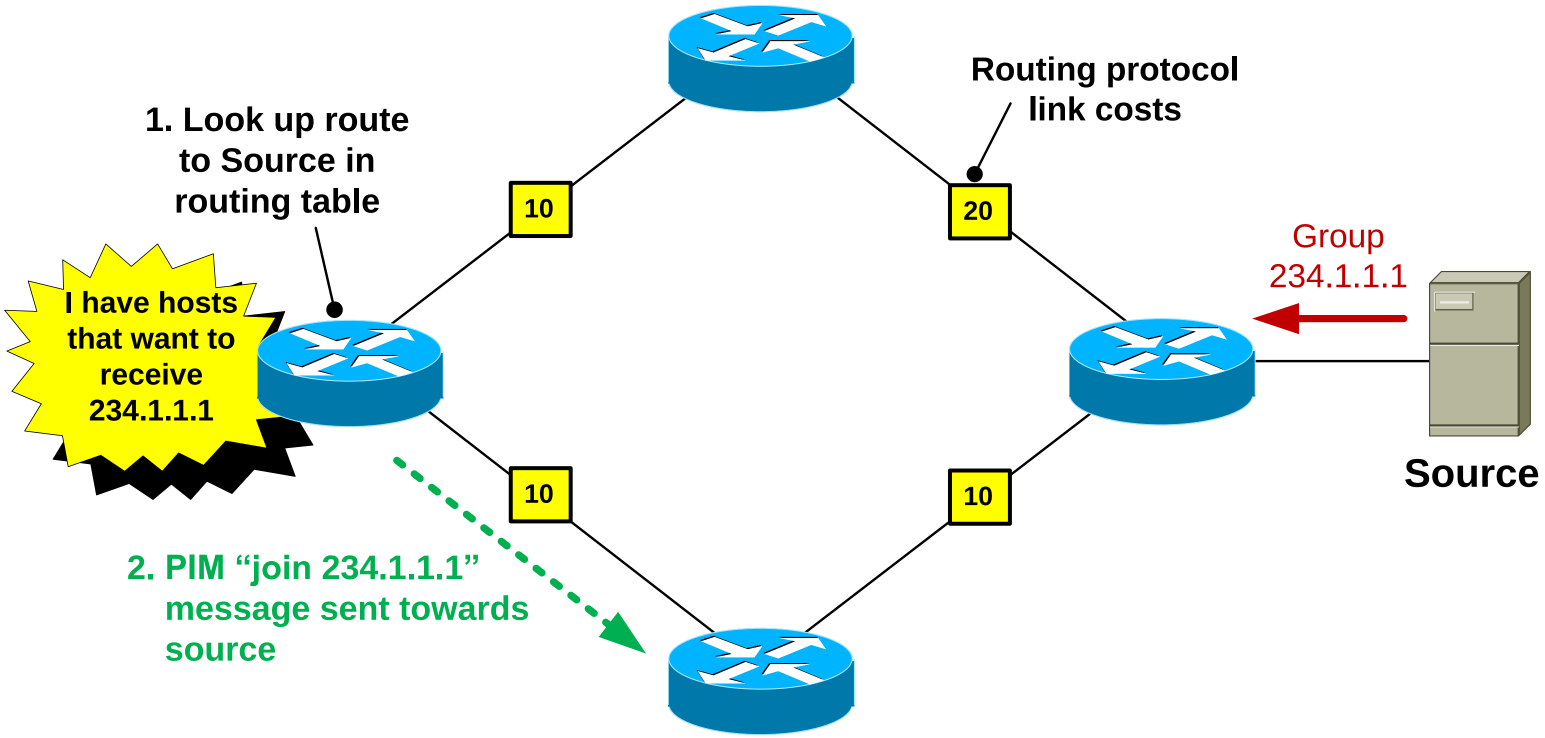
  RPF check **PASS** = accept MC traffic and send it on

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

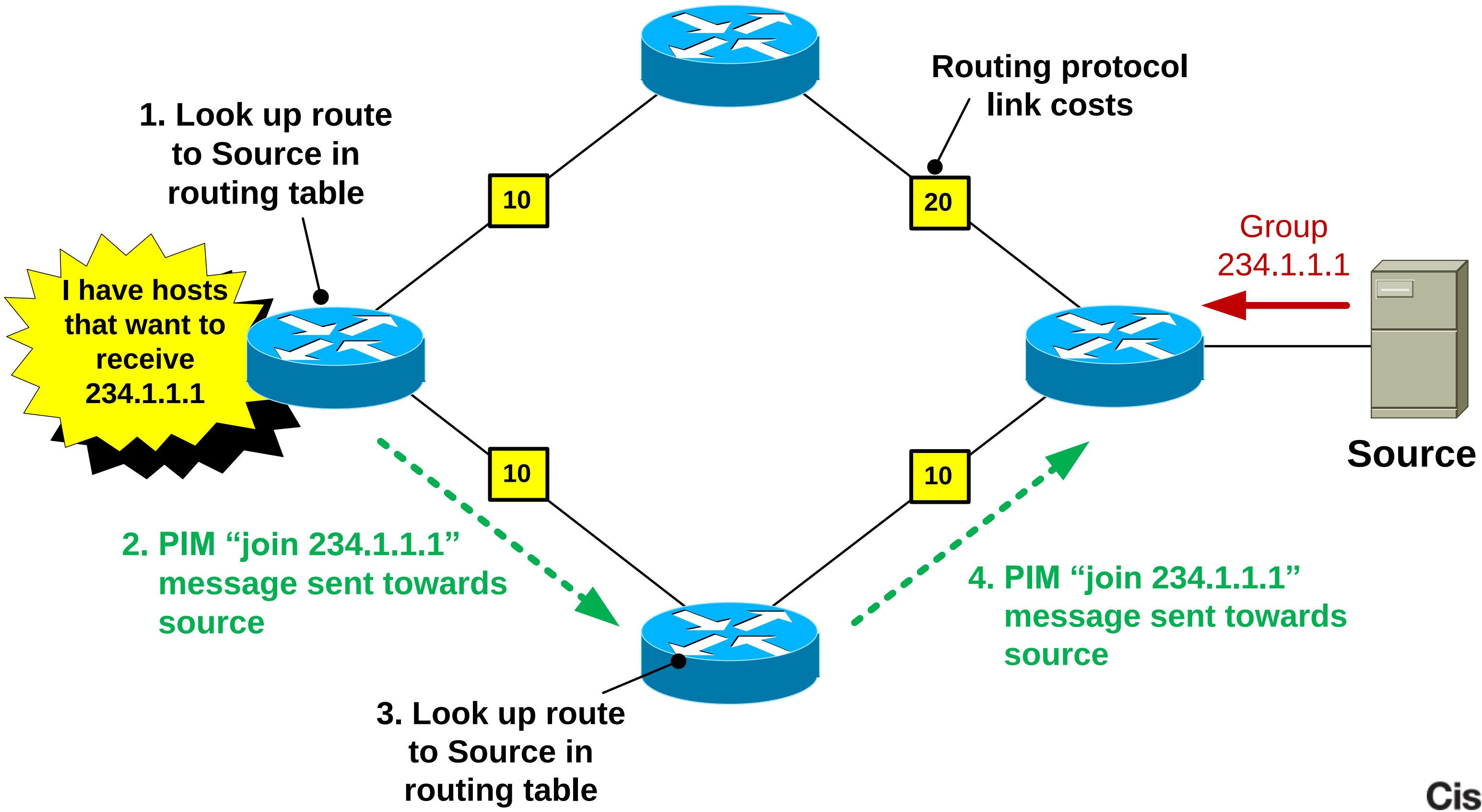
RPF Mechanism


Routing protocol link costs
10
20
10
10
Group 234.1.1.1
I have hosts that want to receive 234.1.1.1
Source

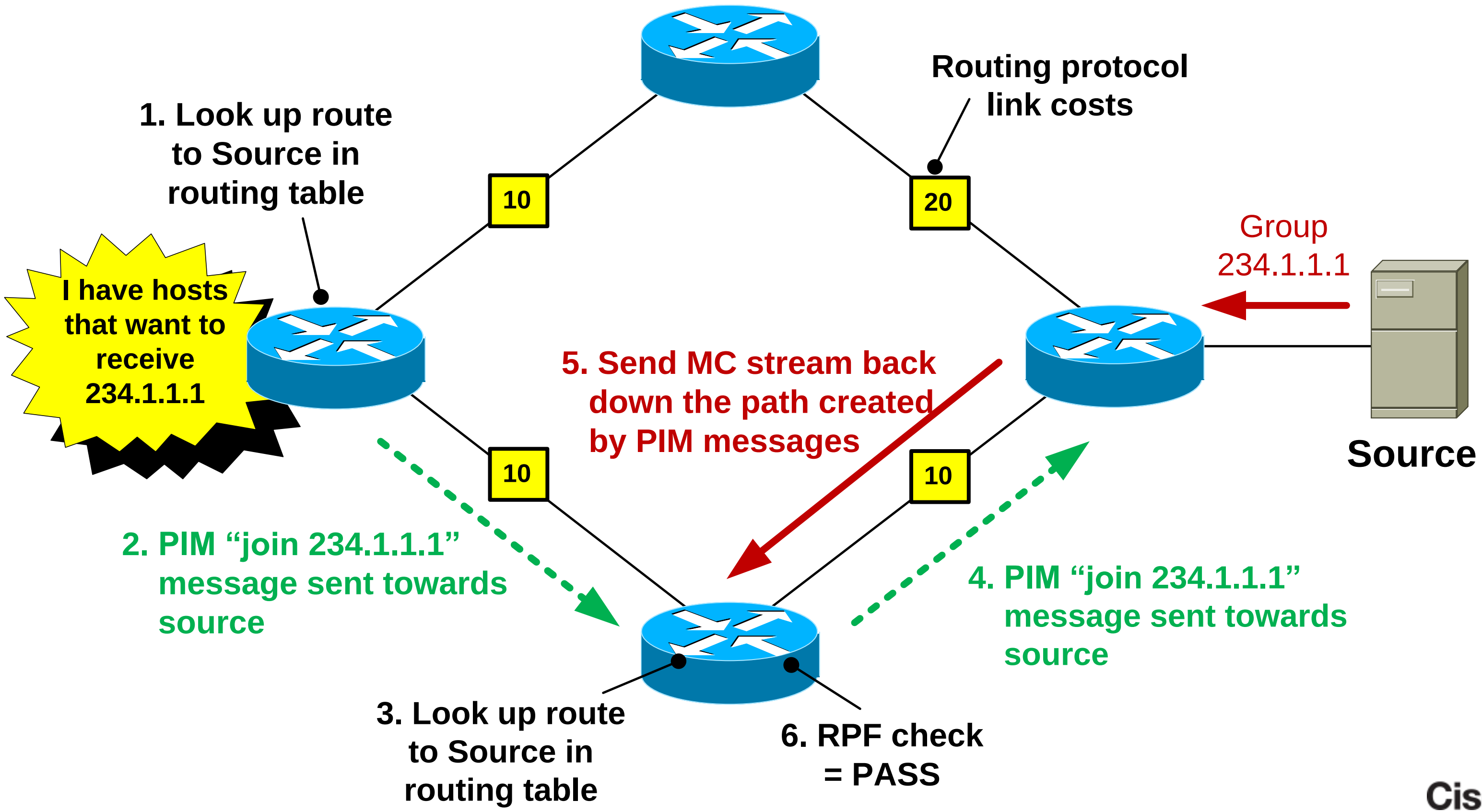
RPF Mechanism


1. Look up route to Source in routing table
Routing protocol link costs
I have hosts that want to receive 234.1.1.1
10
20
10
10
Group 234.1.1.1
Source
2. PIM "join 234.1.1.1" message sent towards source

RPF Mechanism


1. Look up route to Source in routing table
Routing protocol link costs
10
20
I have hosts that want to receive 234.1.1.1
Group 234.1.1.1
Source
10
10
2. PIM "join 234.1.1.1" message sent towards source
4. PIM "join 234.1.1.1" message sent towards source
3. Look up route to Source in routing table

RPF Mechanism



1. Look up route to Source in routing table

I have hosts that want to receive 234.1.1.1

2. PIM “join 234.1.1.1” message sent towards source

3. Look up route to Source in routing table

4. PIM “join 234.1.1.1” message sent towards source

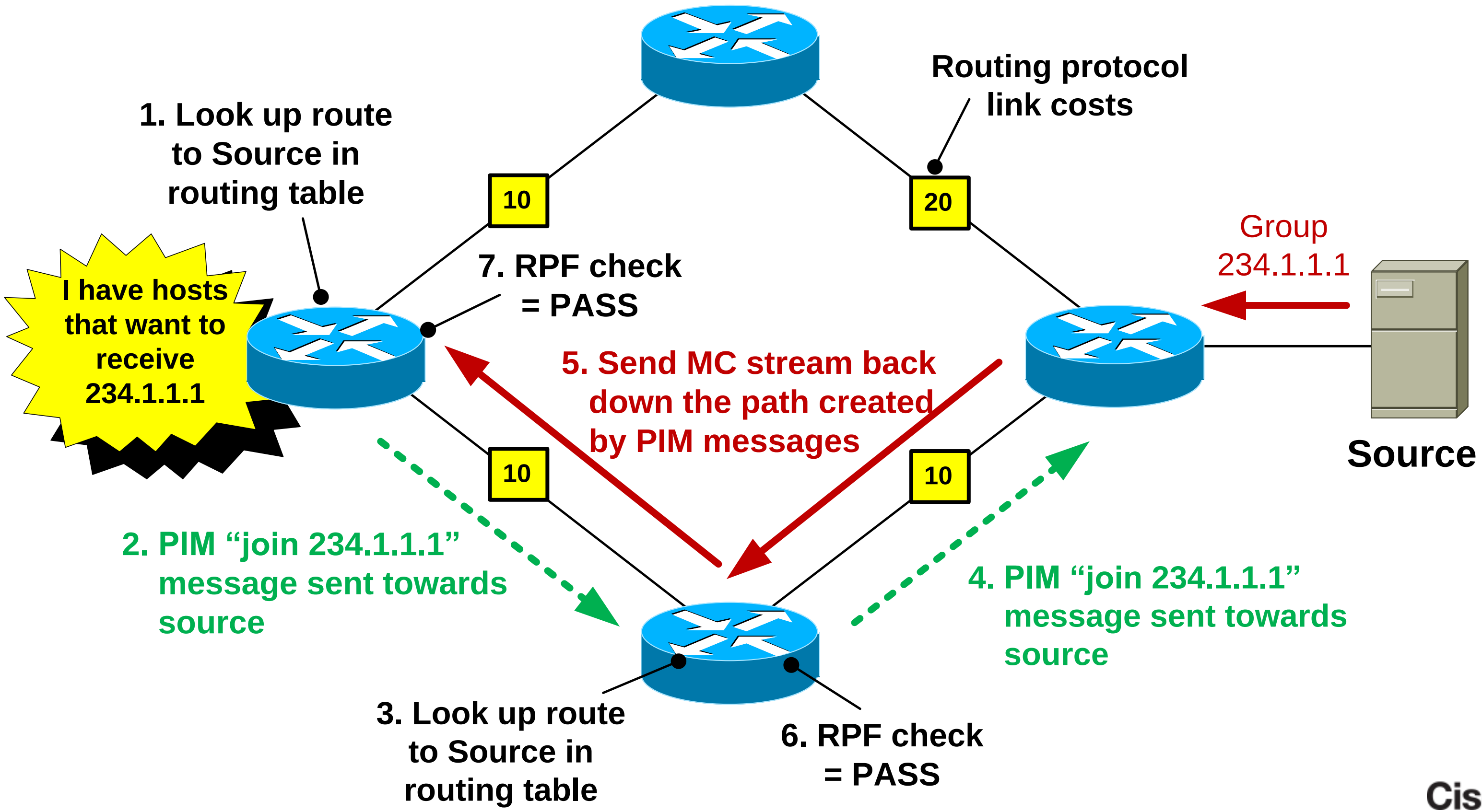
5. Send MC stream back down the path created by PIM messages

6. RPF check = PASS

Routing protocol link costs

Group 234.1.1.1

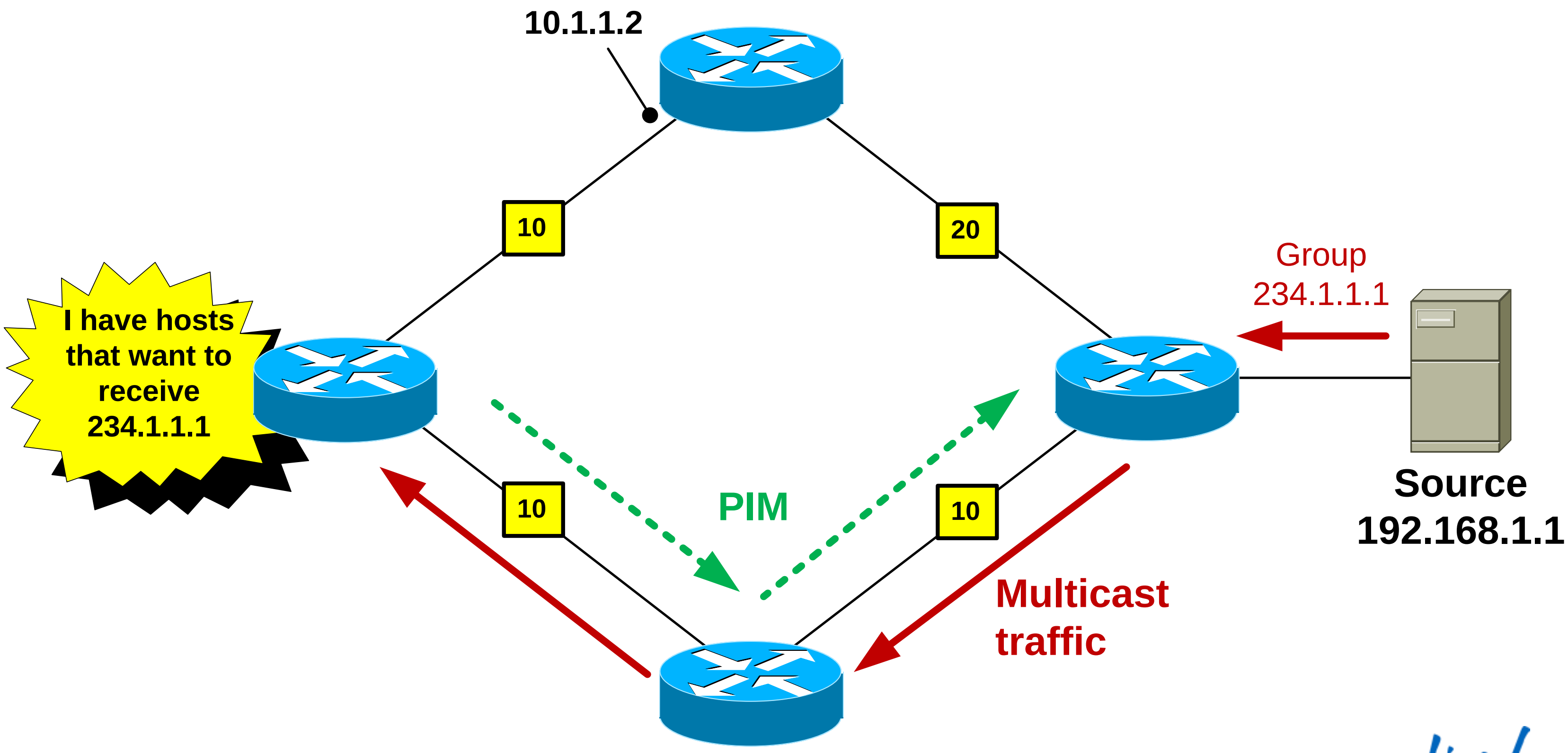
RPF Mechanism


1. Look up route to Source in routing table
I have hosts that want to receive 234.1.1.1
10
20
10
10
Routing protocol link costs
7. RPF check = PASS
Group 234.1.1.1
Source
5. Send MC stream back down the path created by PIM messages
2. PIM "join 234.1.1.1" message sent towards source
4. PIM "join 234.1.1.1" message sent towards source
3. Look up route to Source in routing table
6. RPF check = PASS

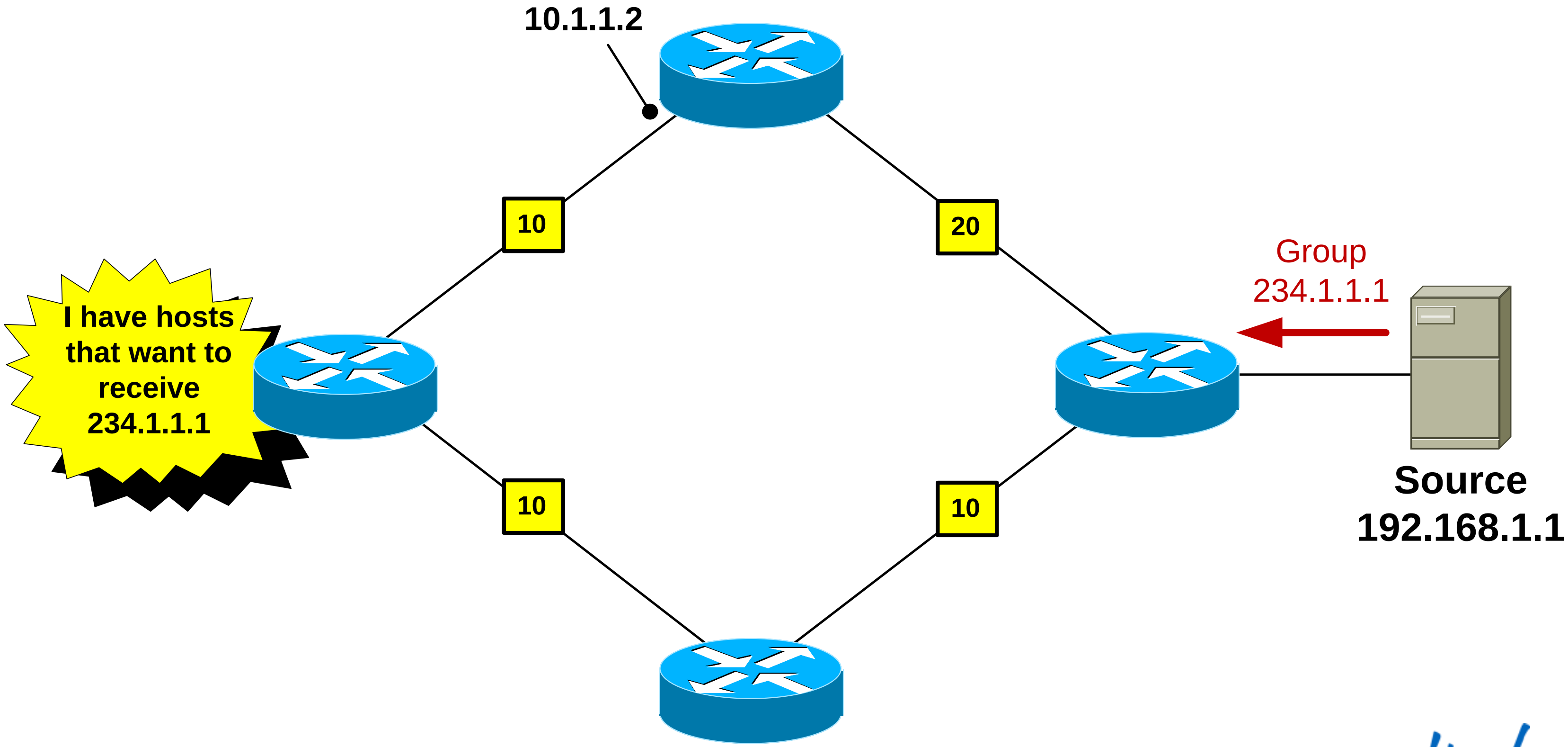
Static Multicast Routes

- 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 !

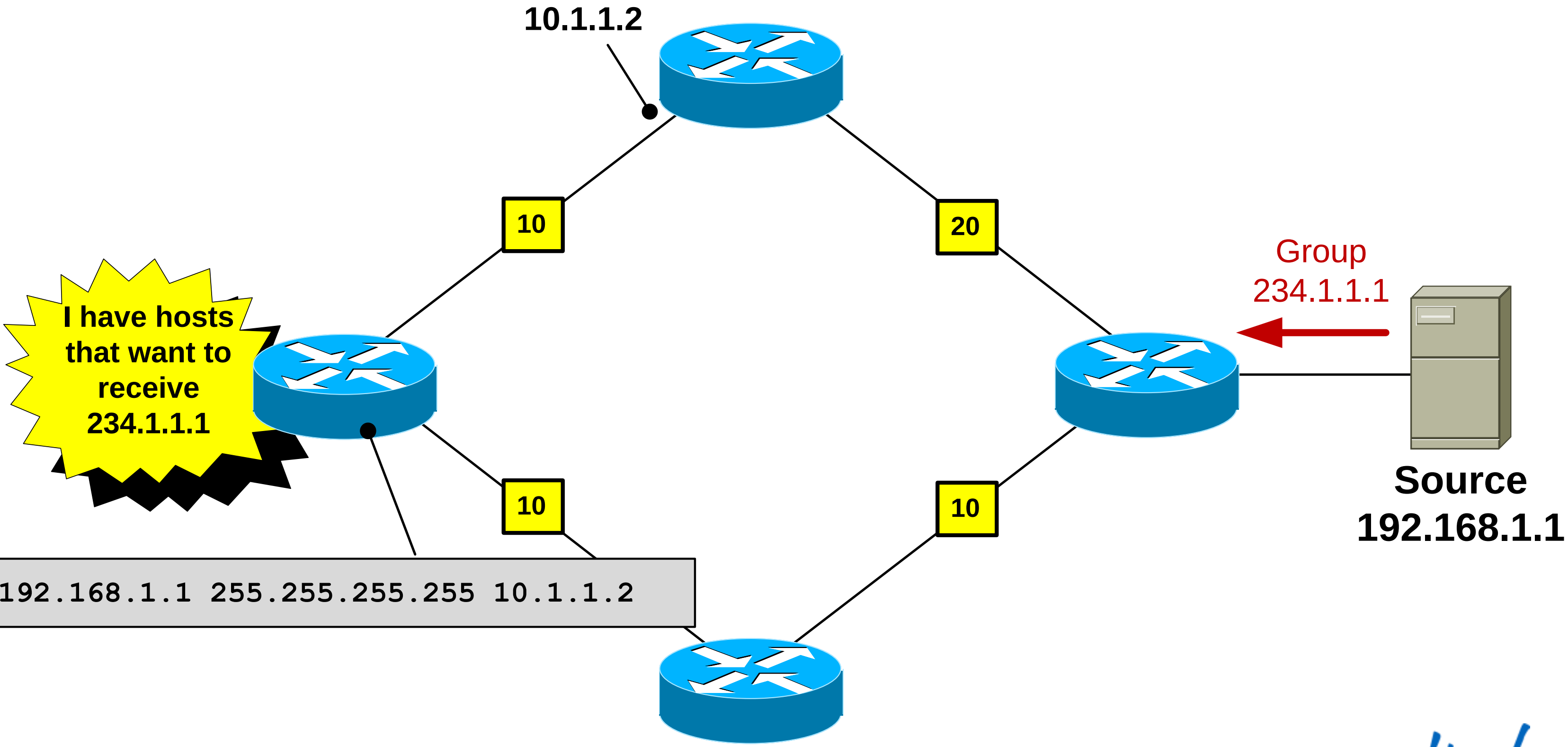
Static Multicast Routes



Static Multicast Routes

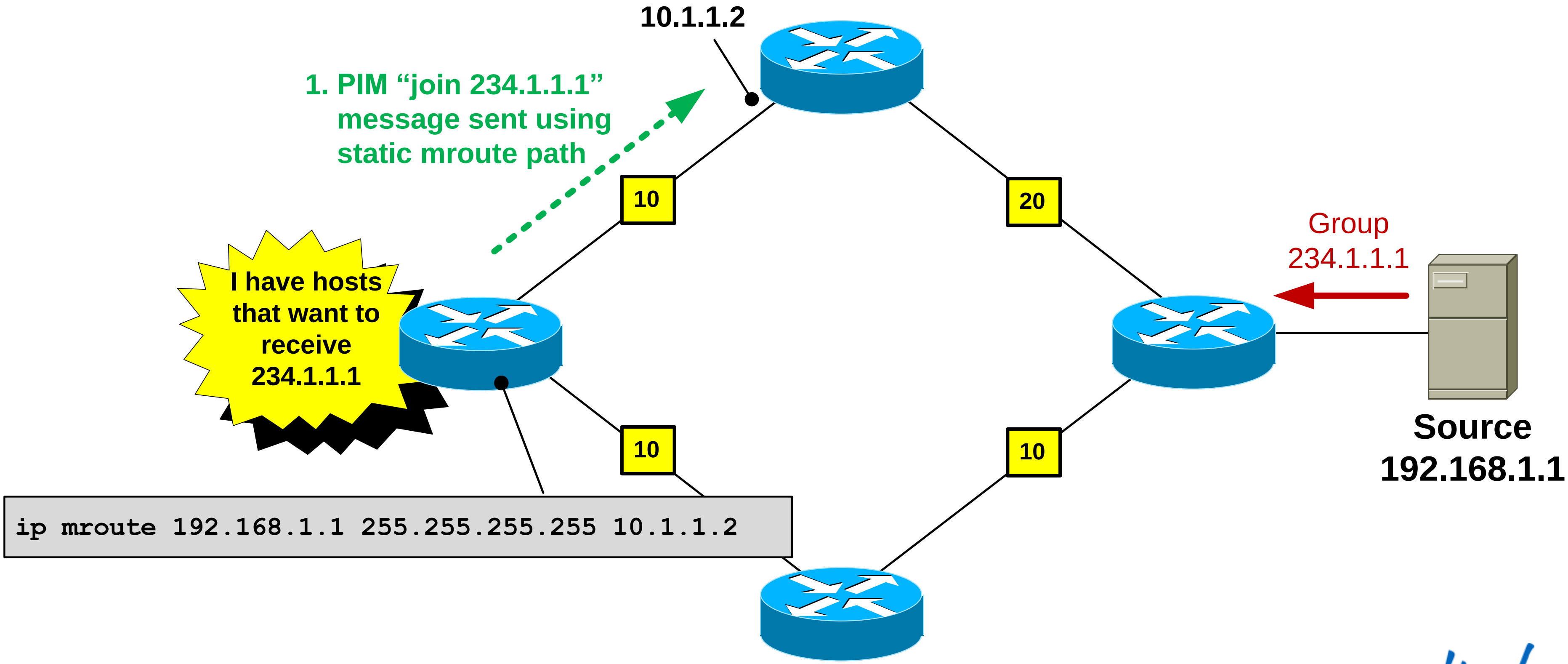


Static Multicast Routes



```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

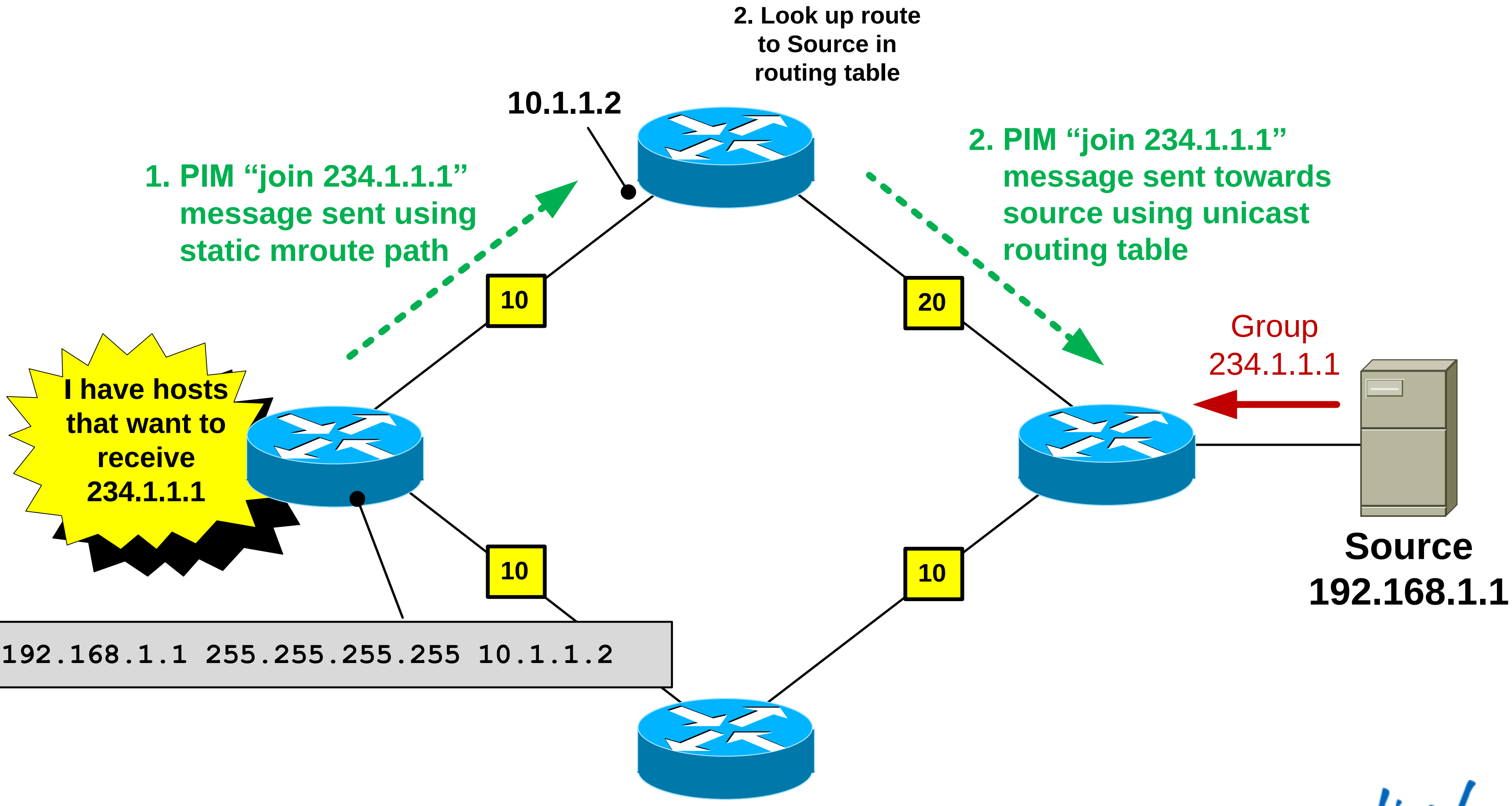
Static Multicast Routes



1. PIM “join 234.1.1.1” message sent using static mroute path

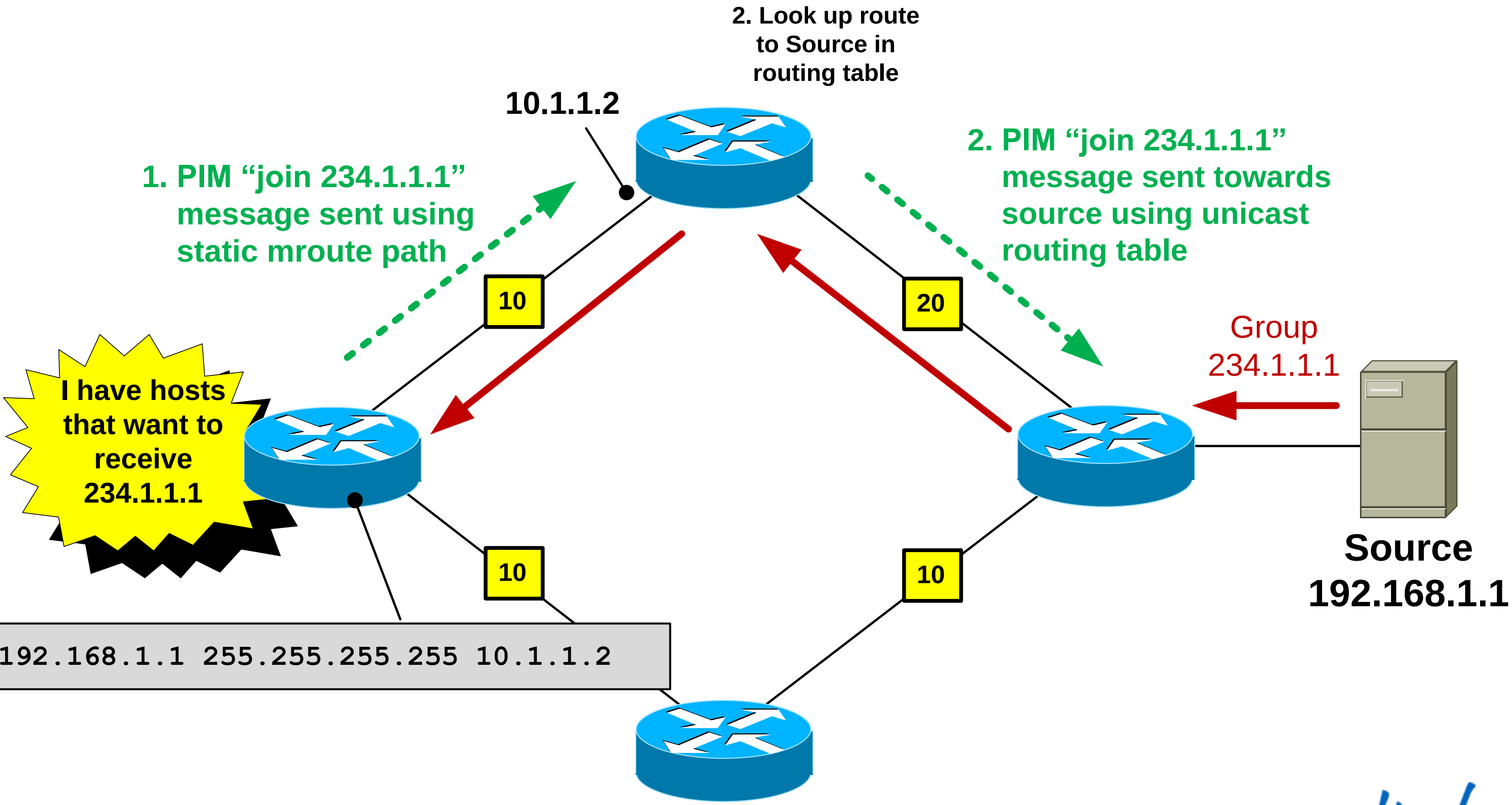
```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routes



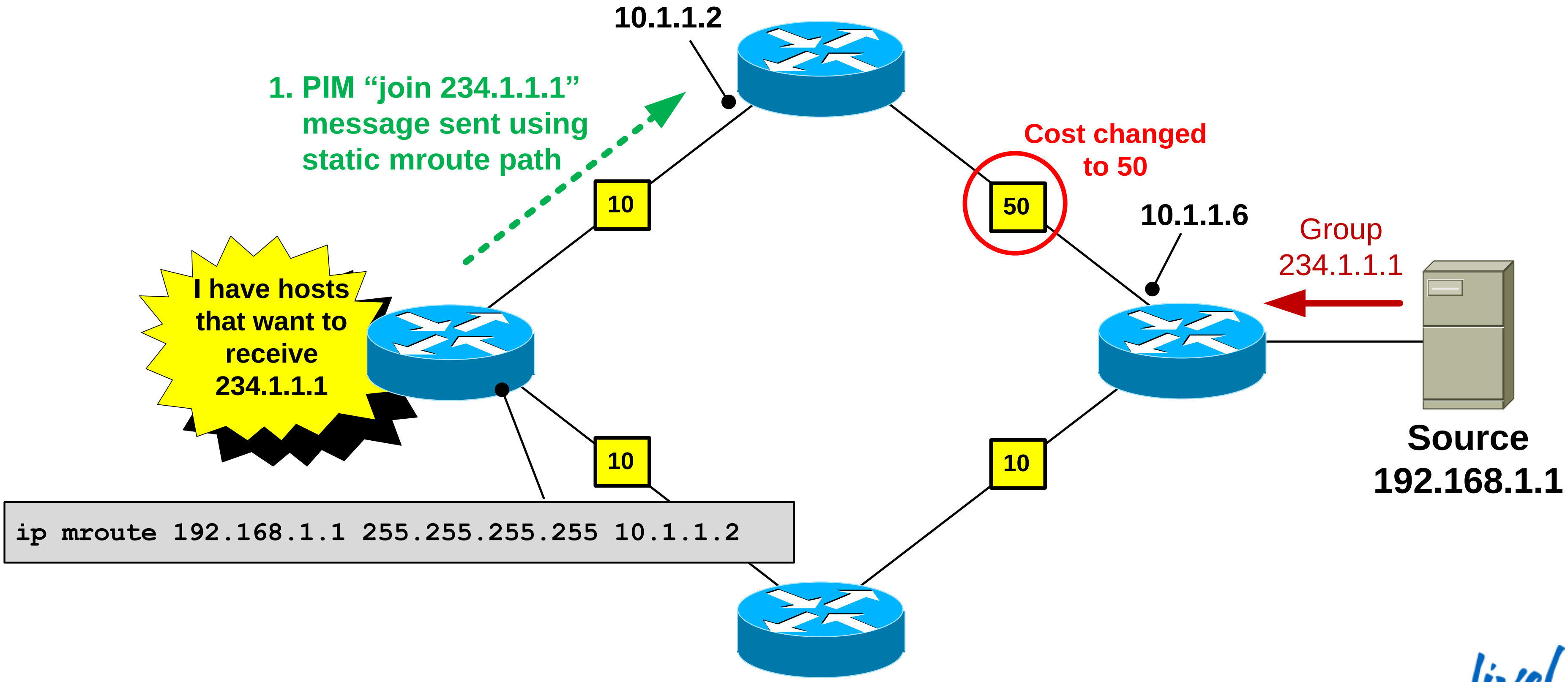
```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routes


2. Look up route to Source in routing table
10.1.1.2
1. PIM "join 234.1.1.1" message sent using static mroute path
2. PIM "join 234.1.1.1" message sent towards source using unicast routing table
10
20
Group 234.1.1.1
I have hosts that want to receive 234.1.1.1
10
10
Source 192.168.1.1

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routing Loop



10.1.1.2

1. PIM “join 234.1.1.1” message sent using static mroute path

Cost changed to 50

10.1.1.6

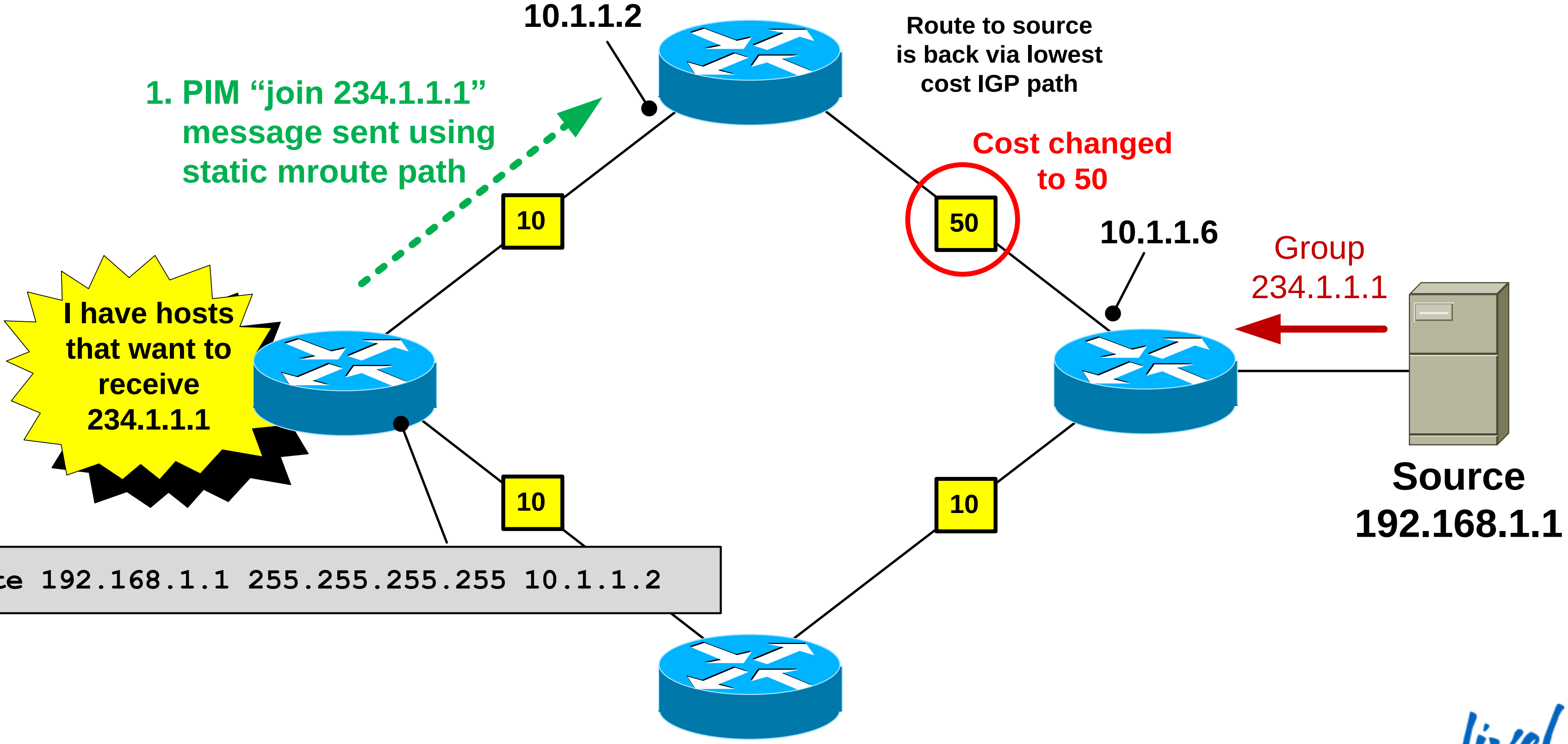
Group 234.1.1.1

I have hosts that want to receive 234.1.1.1

Source 192.168.1.1

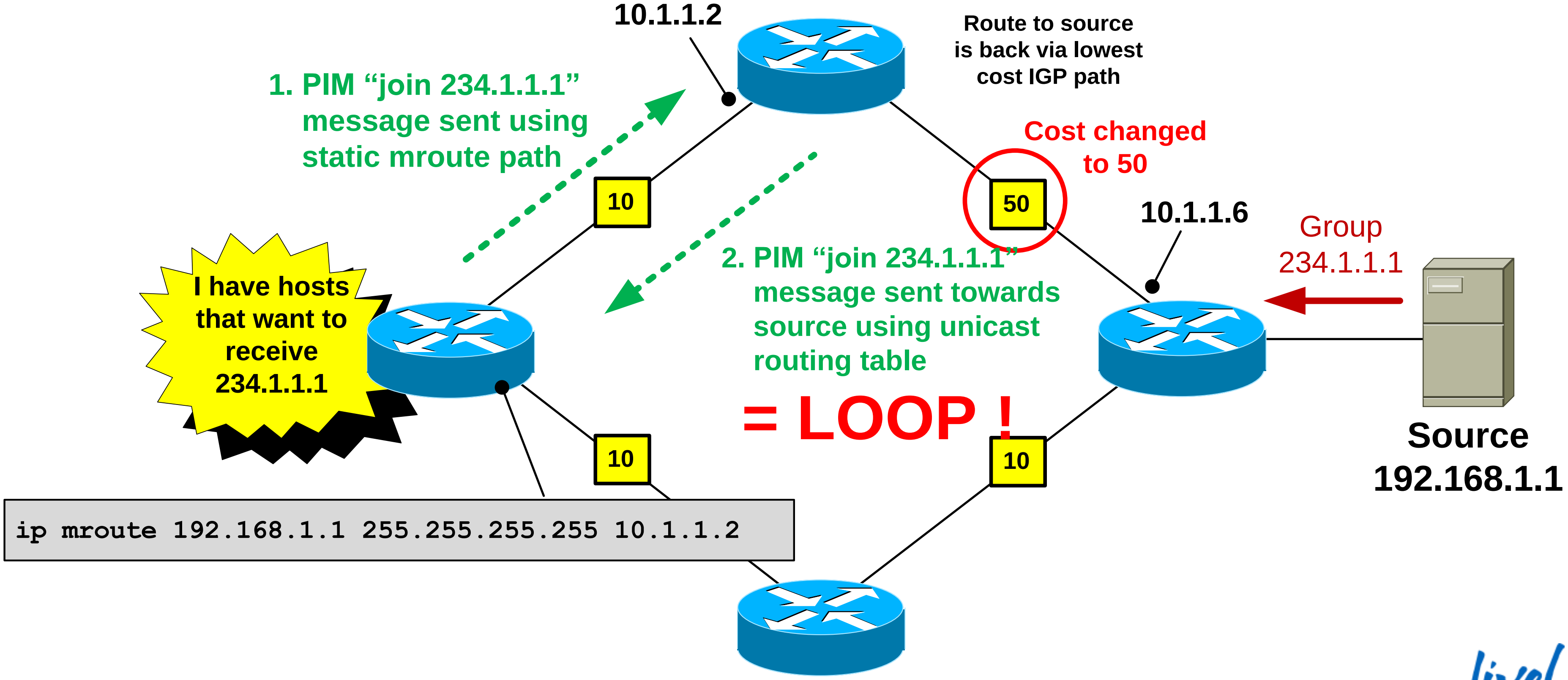
```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routing **Loop**


10.1.1.2
Route to source is back via lowest cost IGP path
1. PIM "join 234.1.1.1" message sent using static mroute path
10
Cost changed to 50
50
10.1.1.6
Group 234.1.1.1
I have hosts that want to receive 234.1.1.1
10
10
Source 192.168.1.1

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routing Loop



1. PIM “join 234.1.1.1” message sent using static mroute path

Route to source is back via lowest cost IGP path

Cost changed to 50

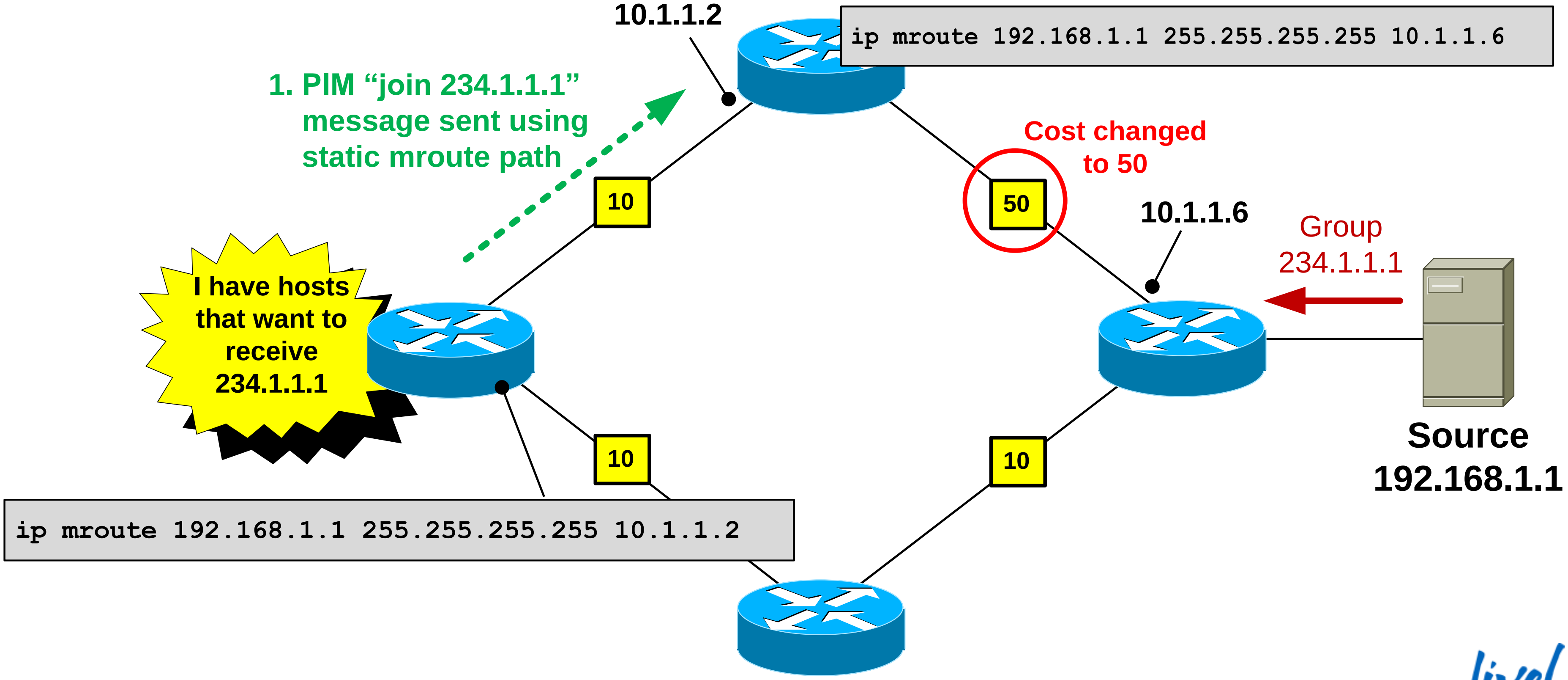
I have hosts that want to receive 234.1.1.1

2. PIM “join 234.1.1.1” message sent towards source using unicast routing table

= LOOP !

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routing Loop



10.1.1.2

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.6
```

1. PIM “join 234.1.1.1” message sent using static mroute path

Cost changed to 50

10.1.1.6

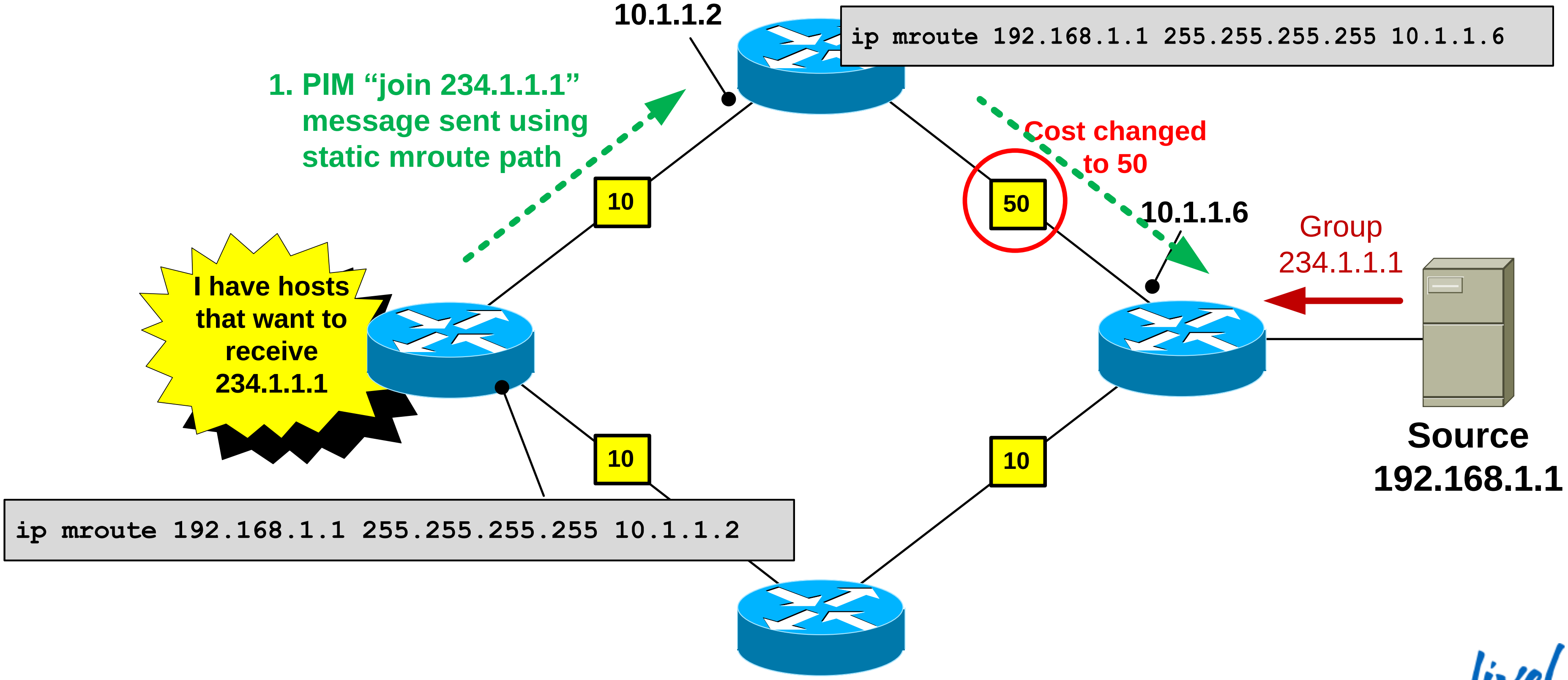
Group 234.1.1.1

I have hosts that want to receive 234.1.1.1

Source 192.168.1.1

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

Static Multicast Routing Loop

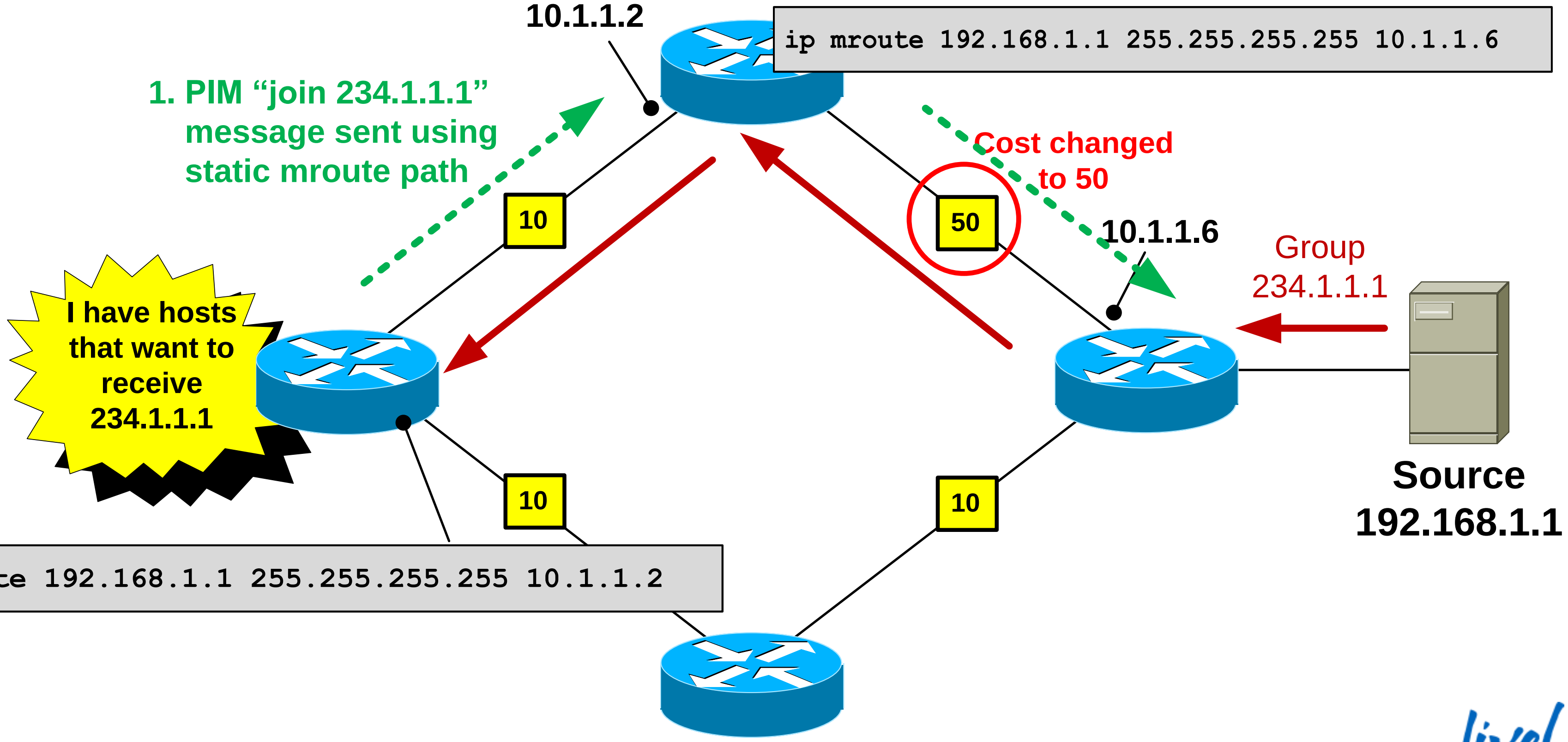


```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.6
```

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

1. PIM "join 234.1.1.1" message sent using static mroute path

Static Multicast Routing Loop



```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.6
```

```
ip mroute 192.168.1.1 255.255.255.255 10.1.1.2
```

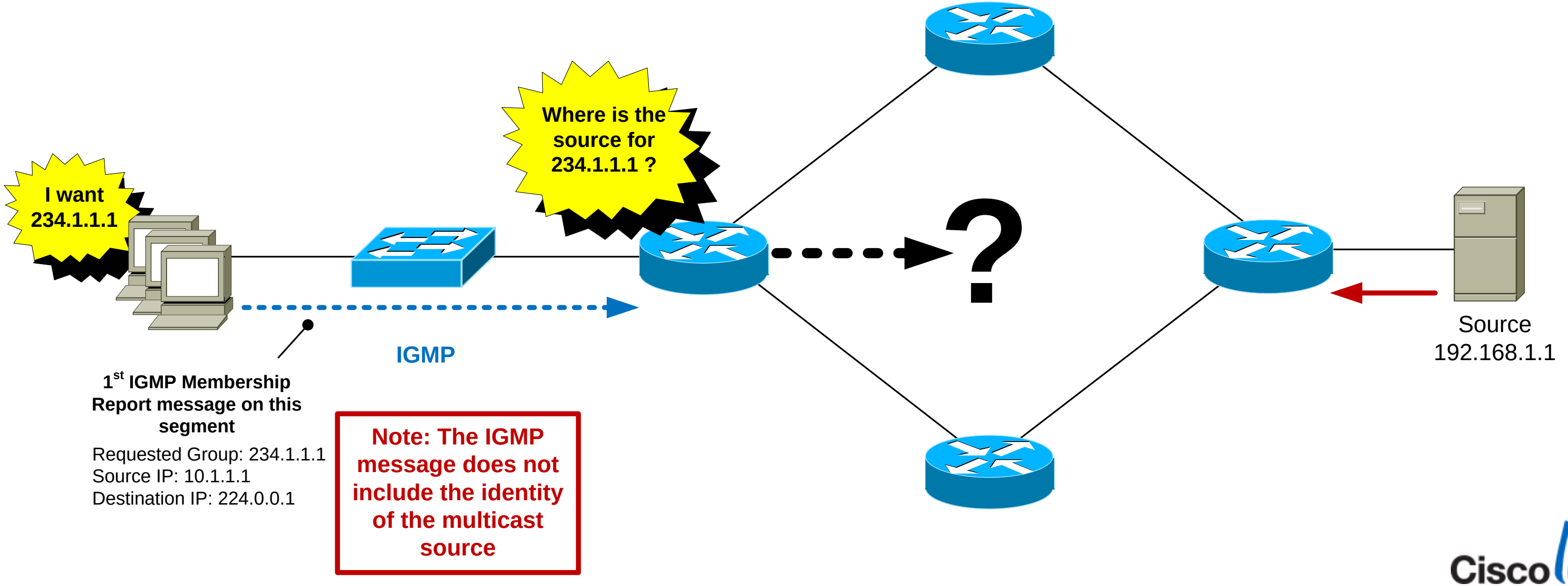
1. PIM “join 234.1.1.1” message sent using static mroute path

Cost changed to 50

I have hosts that want to receive 234.1.1.1

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 ?



1st IGMP Membership Report message on this segment

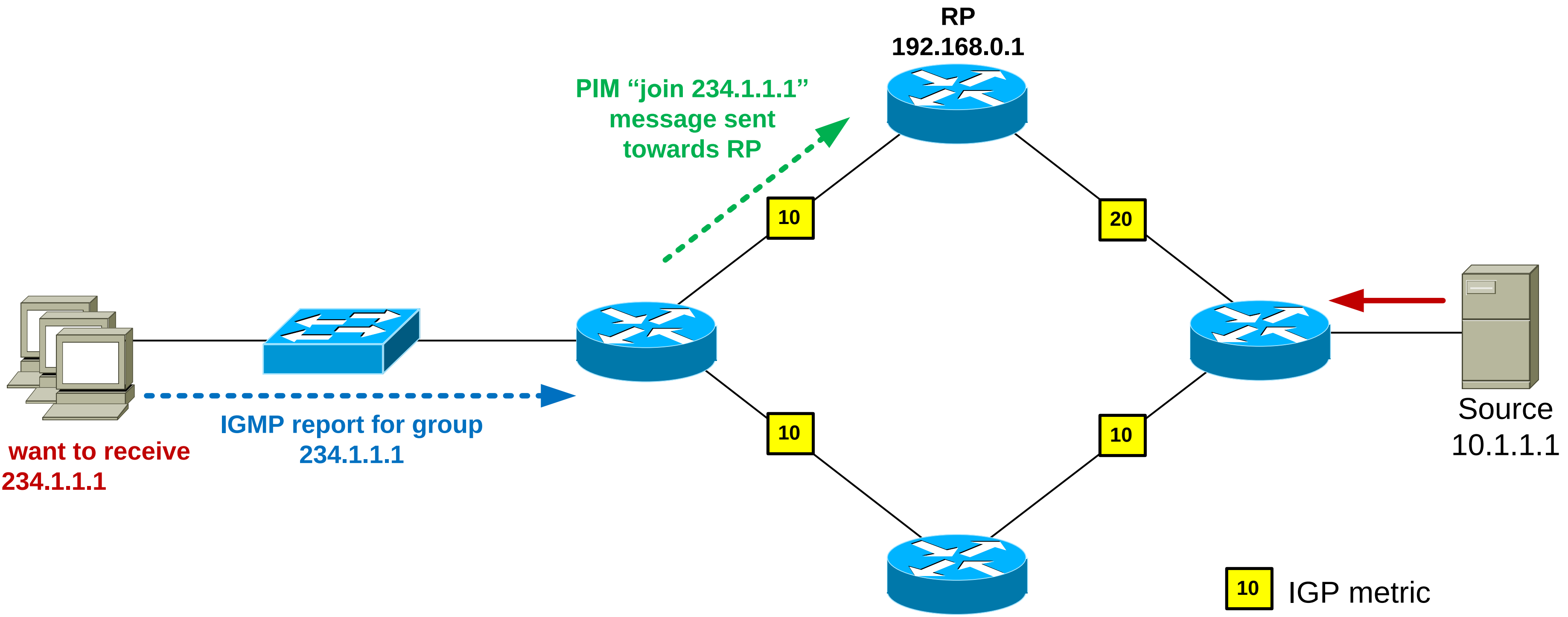
Requested Group: 234.1.1.1
Source IP: 10.1.1.1
Destination IP: 224.0.0.1

Note: The IGMP message does not include the identity of the multicast source

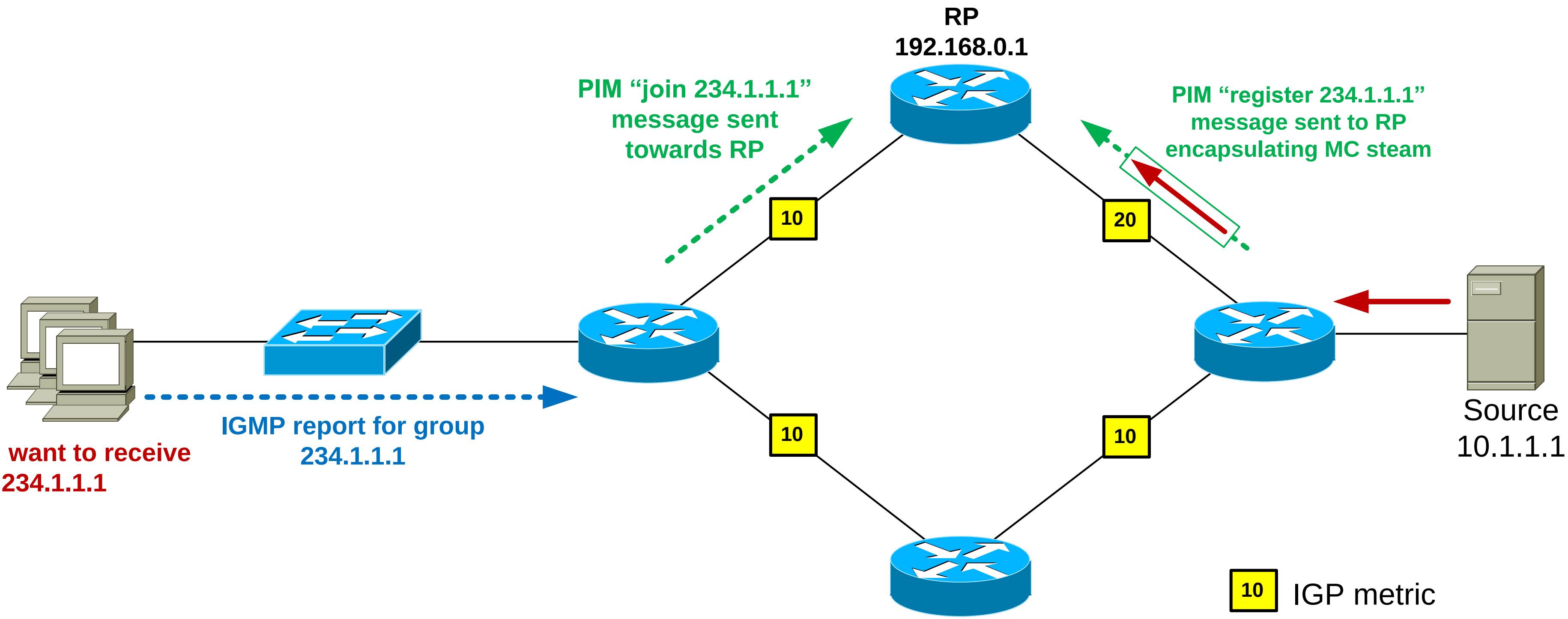
PIM-SM: Rendezvous Point (RP)

- 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.

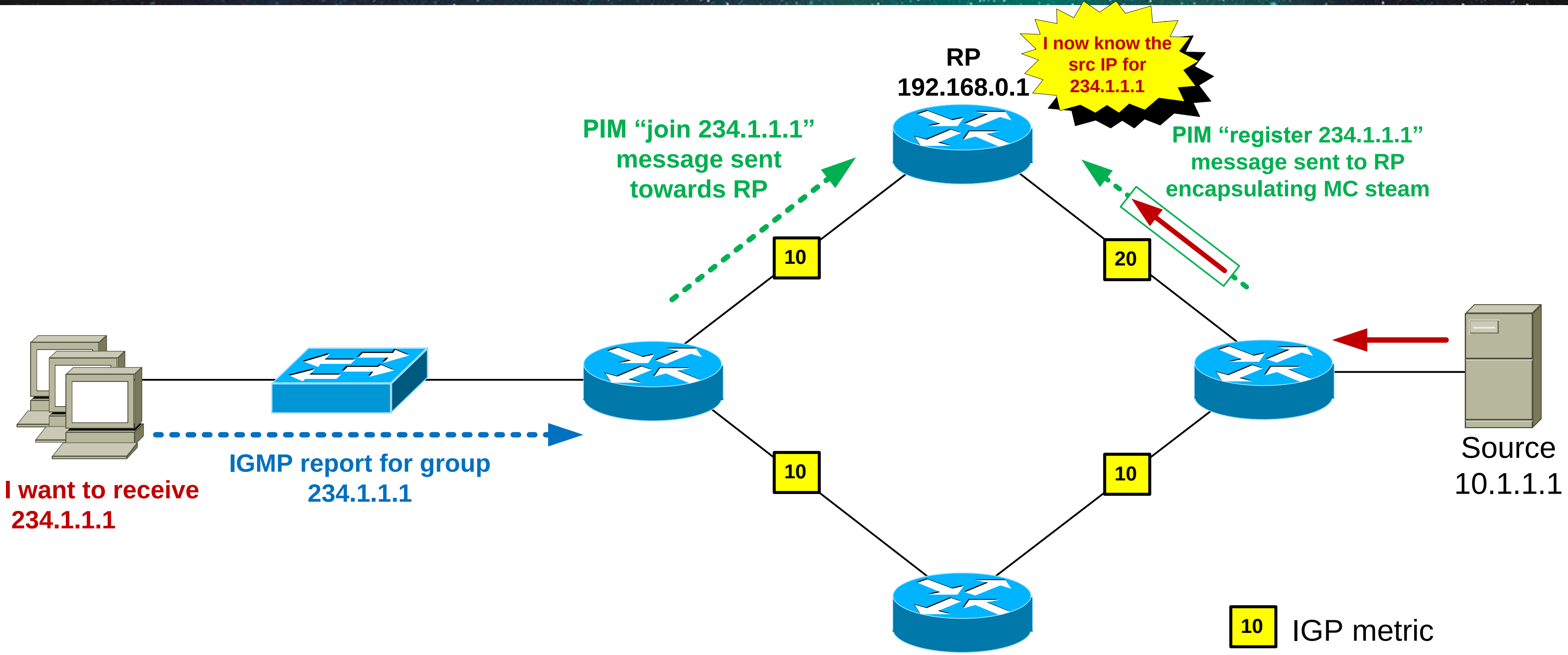
PIM-SM: Rendezvous Point (RP)


RP
192.168.0.1
PIM "join 234.1.1.1" message sent towards RP
10
20
10
10
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
Source
10.1.1.1
10 IGP metric

PIM-SM: Rendezvous Point (RP)

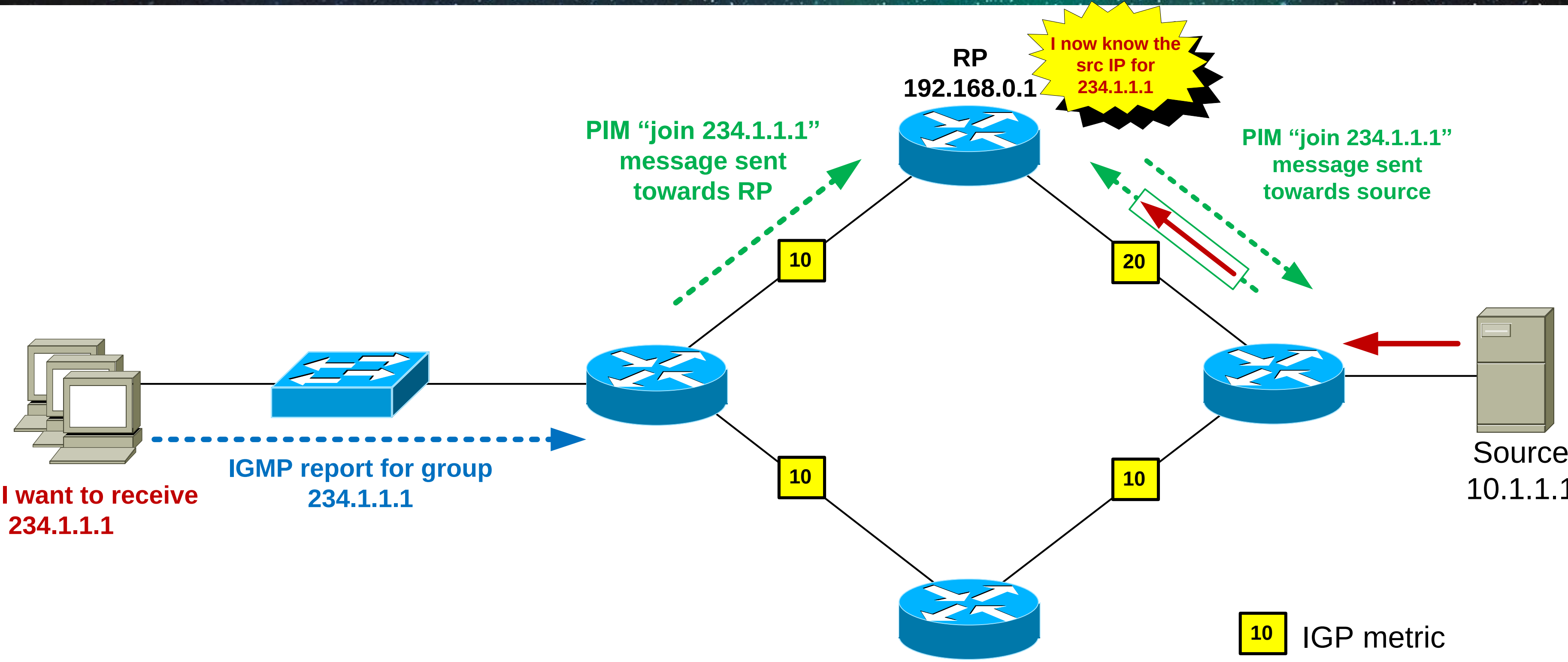

RP
192.168.0.1
PIM “join 234.1.1.1” message sent towards RP
PIM “register 234.1.1.1” message sent to RP encapsulating MC steam
10
20
10
10
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
Source
10.1.1.1
10
IGP metric

PIM-SM: Rendezvous Point (RP)



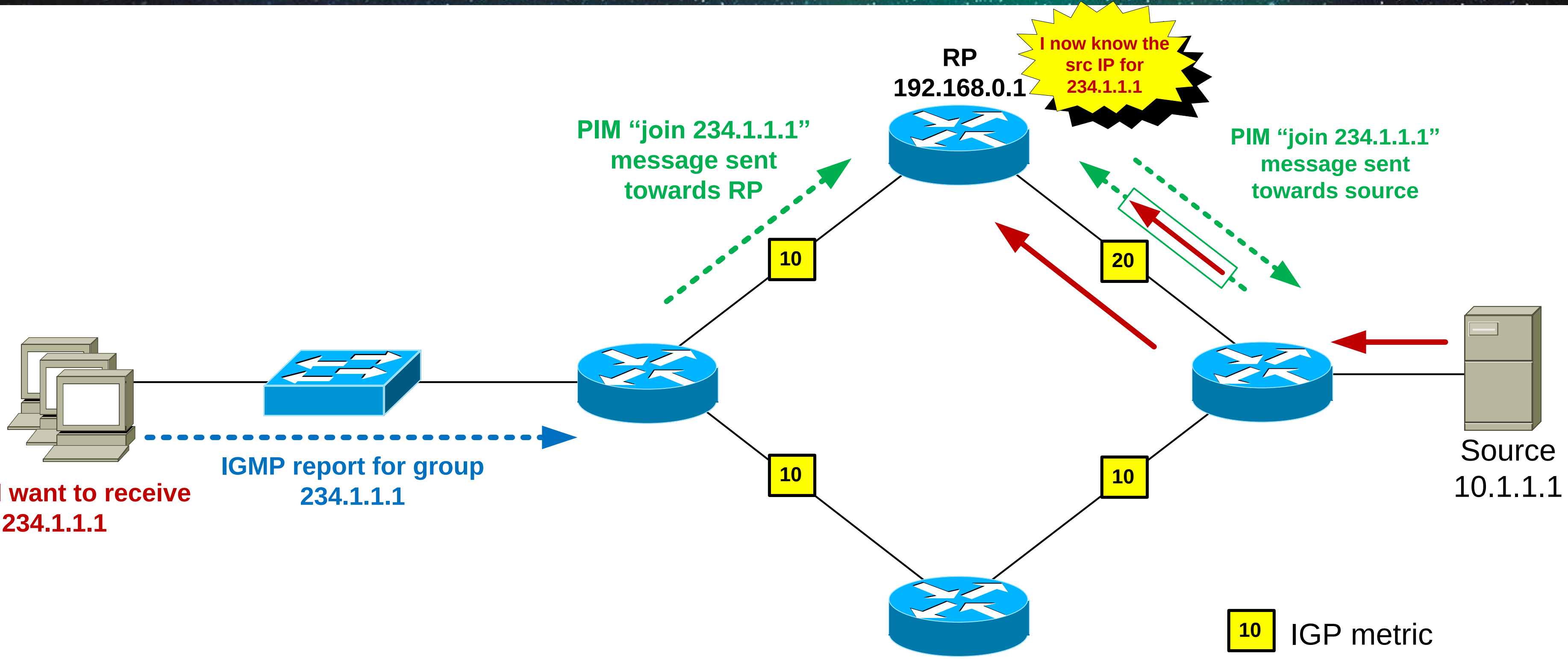
RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM "join 234.1.1.1" message sent towards RP
PIM "register 234.1.1.1" message sent to RP encapsulating MC steam
10
20
10
10
Source
10.1.1.1
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
10
IGP metric

PIM-SM: Rendezvous Point (RP)

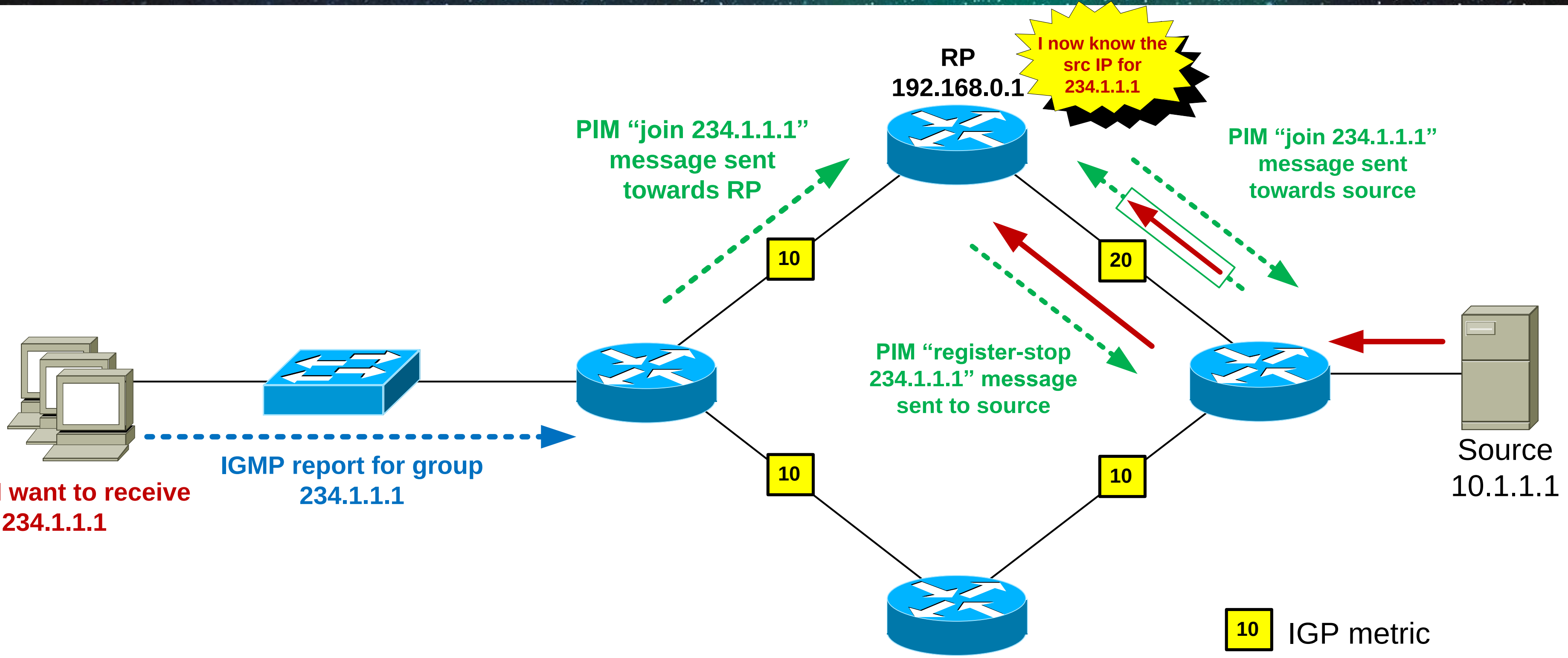


RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM “join 234.1.1.1” message sent towards RP
PIM “join 234.1.1.1” message sent towards source
10
20
10
10
IGMP report for group 234.1.1.1
I want to receive 234.1.1.1
Source
10.1.1.1
10
IGP metric

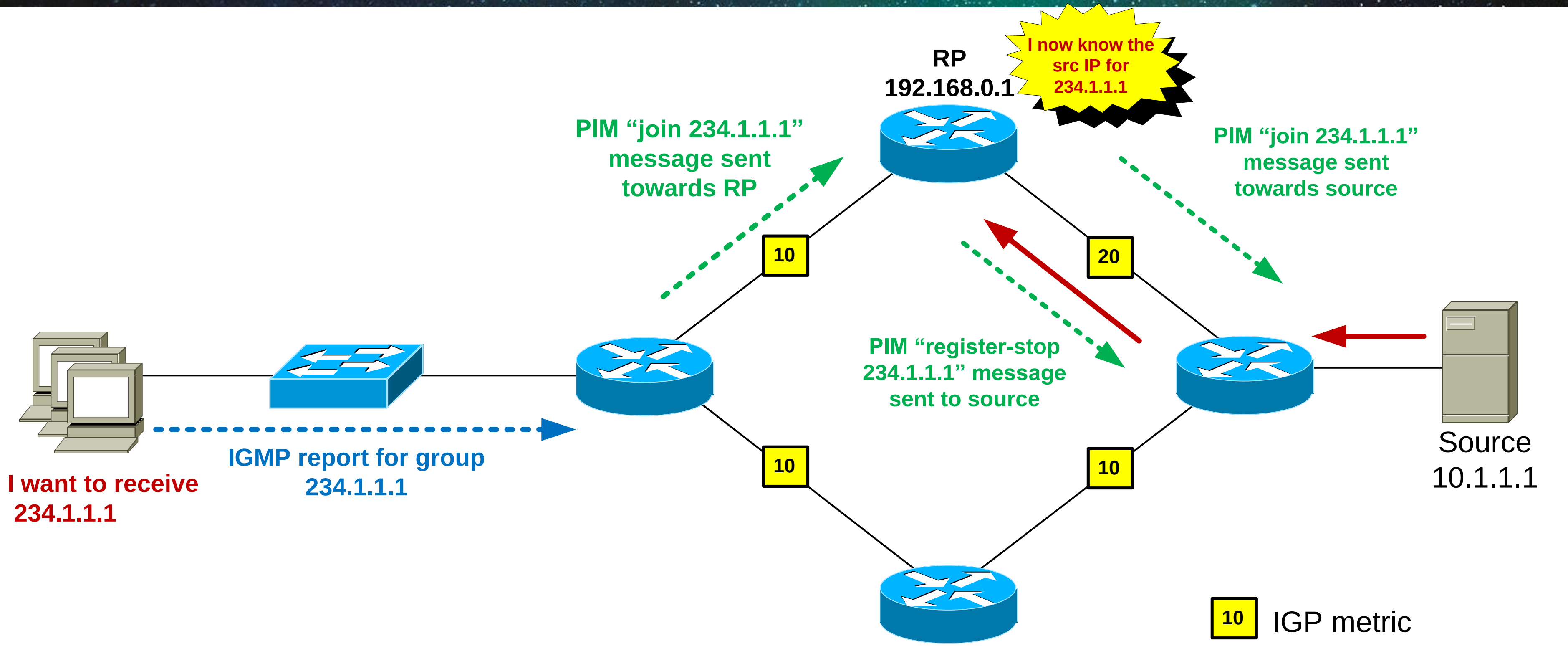
PIM-SM: Rendezvous Point (RP)


I now know the src IP for 234.1.1.1
RP
192.168.0.1
PIM “join 234.1.1.1” message sent towards RP
PIM “join 234.1.1.1” message sent towards source
10
20
10
10
Source
10.1.1.1
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
10
IGP metric

PIM-SM: Rendezvous Point (RP)

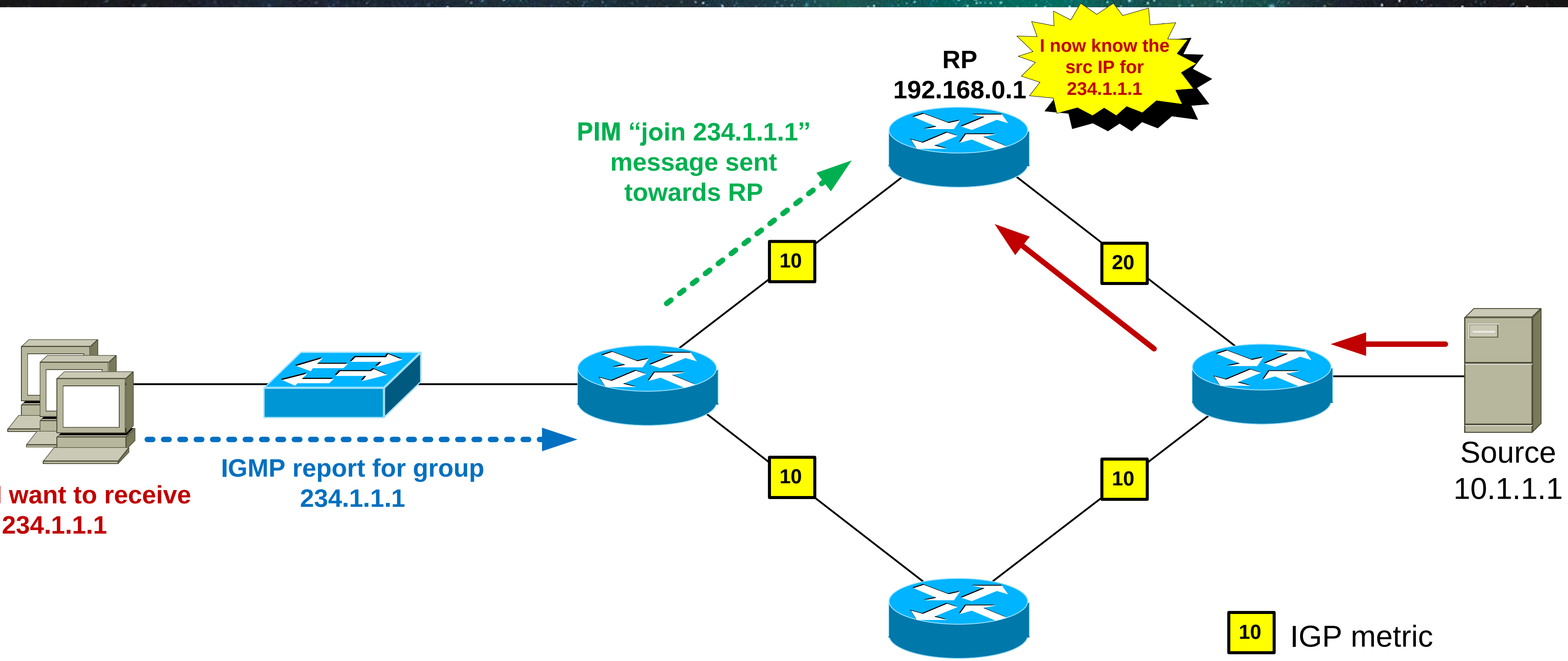

RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM "join 234.1.1.1" message sent towards RP
PIM "join 234.1.1.1" message sent towards source
PIM "register-stop 234.1.1.1" message sent to source
10
20
10
10
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
Source
10.1.1.1
10
IGP metric

PIM-SM: Rendezvous Point (RP)

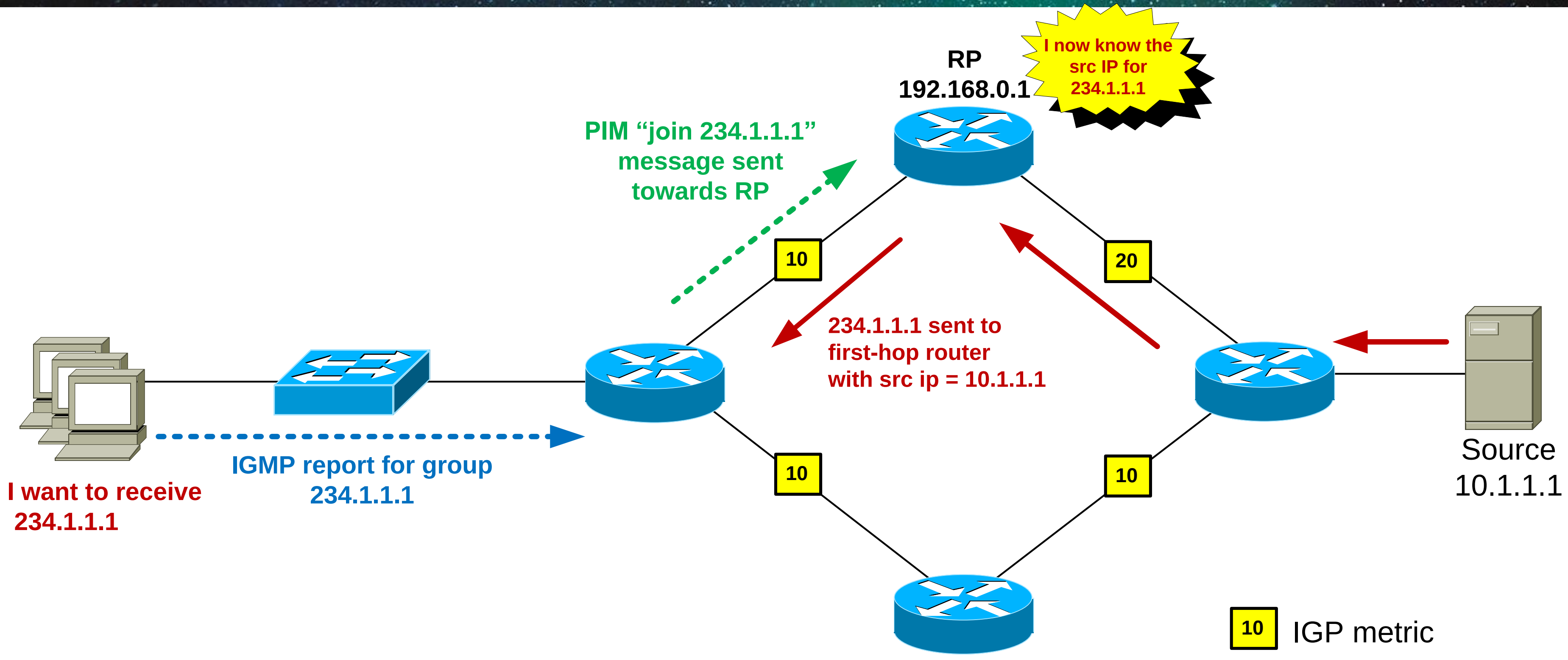


RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM “join 234.1.1.1” message sent towards RP
PIM “join 234.1.1.1” message sent towards source
PIM “register-stop 234.1.1.1” message sent to source
10
20
10
10
IGMP report for group 234.1.1.1
I want to receive 234.1.1.1
Source
10.1.1.1
10
IGP metric

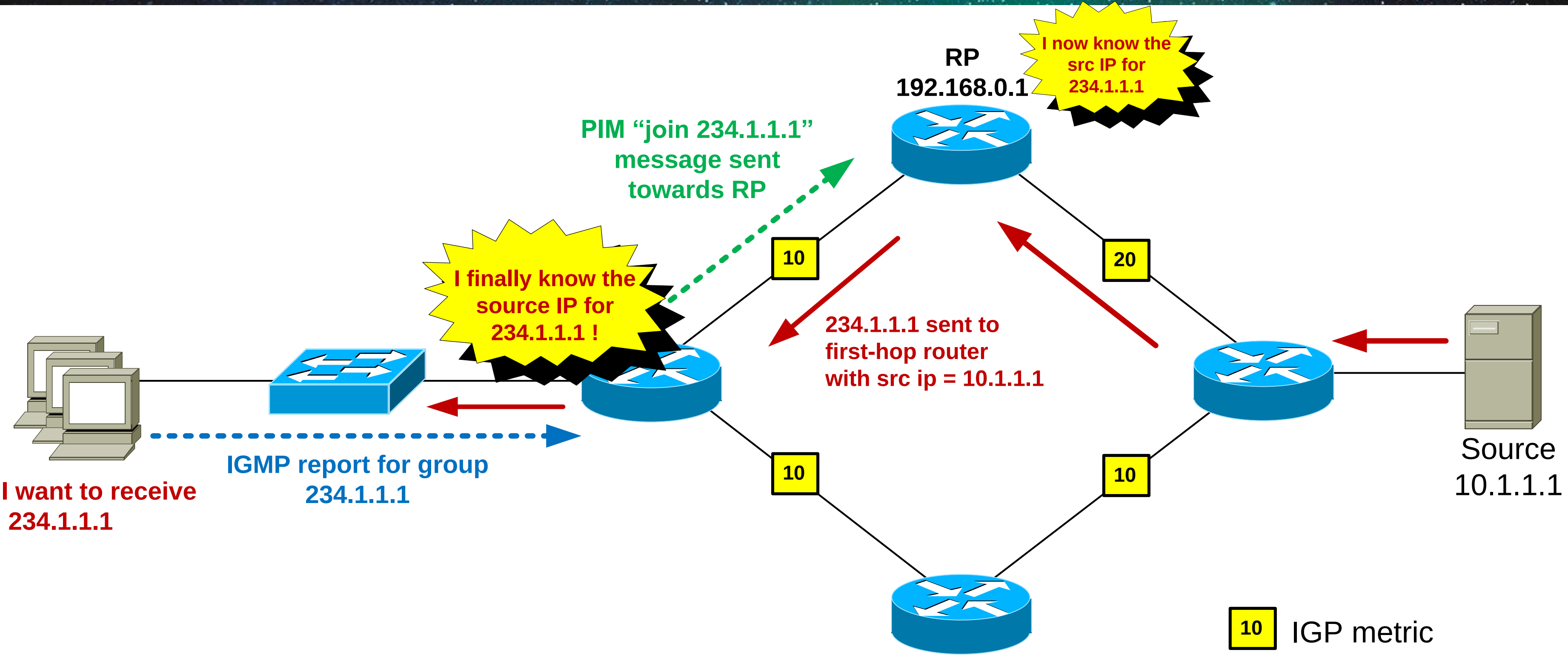
PIM-SM: Rendezvous Point (RP)


RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM “join 234.1.1.1” message sent towards RP
10
20
10
10
IGP metric
Source
10.1.1.1
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1

PIM-SM: Rendezvous Point (RP)

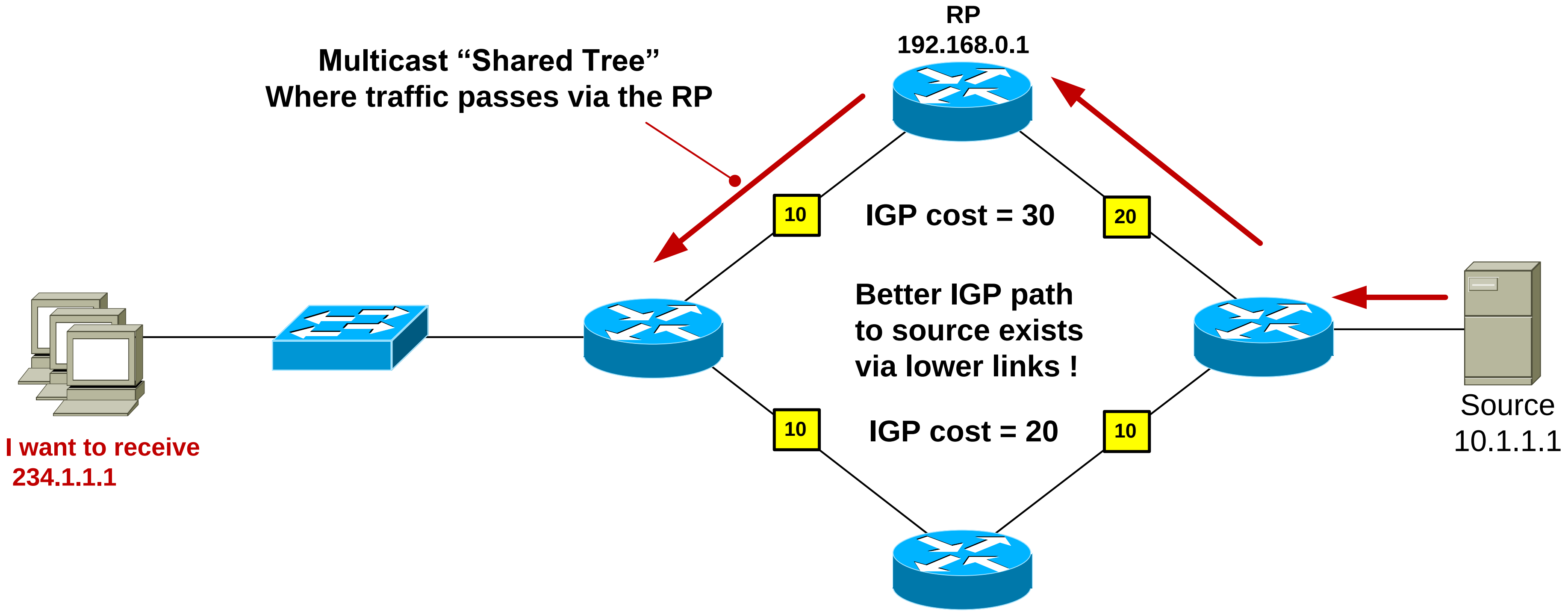

RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM "join 234.1.1.1" message sent towards RP
10
20
234.1.1.1 sent to first-hop router with src ip = 10.1.1.1
10
10
Source
10.1.1.1
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
10
IGP metric

PIM-SM: Rendezvous Point (RP)



RP
192.168.0.1
I now know the src IP for 234.1.1.1
PIM “join 234.1.1.1” message sent towards RP
10
20
I finally know the source IP for 234.1.1.1 !
234.1.1.1 sent to first-hop router with src ip = 10.1.1.1
I want to receive 234.1.1.1
IGMP report for group 234.1.1.1
10
10
Source
10.1.1.1
10
IGP metric

PIM-SM: Shortest Path Tree Switchover



Multicast “Shared Tree”
Where traffic passes via the RP

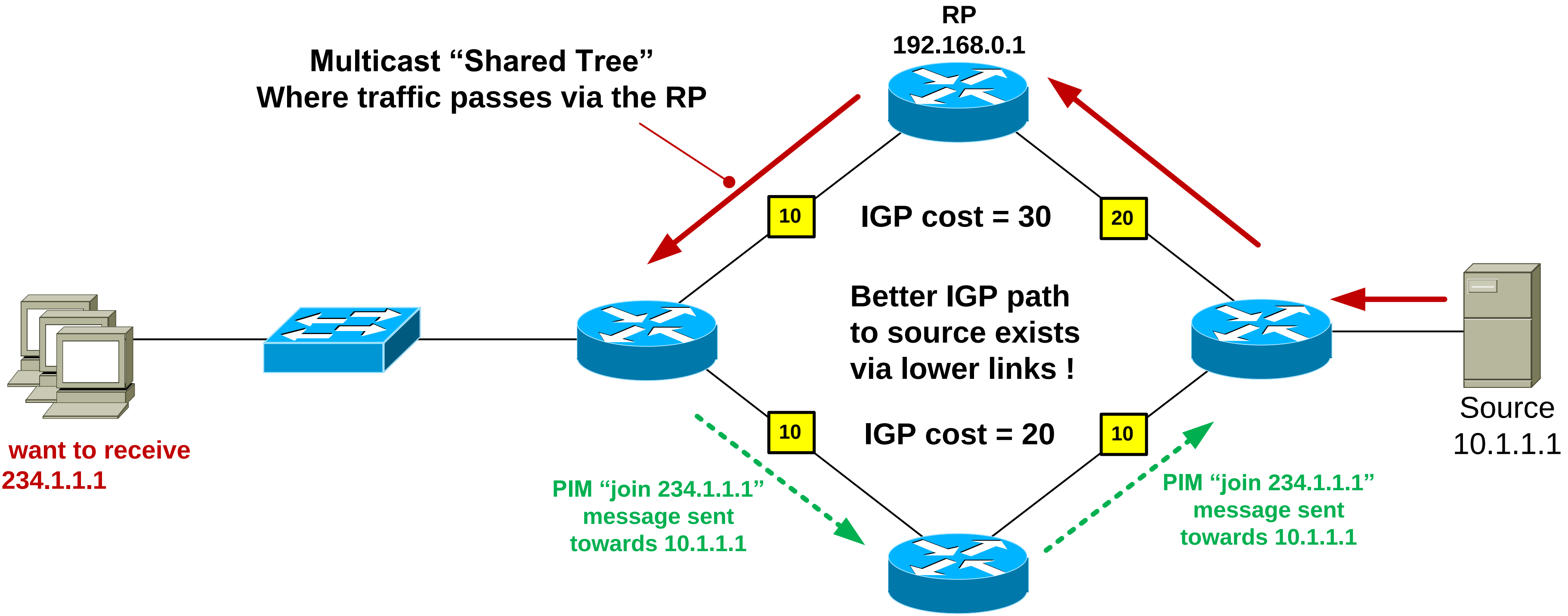
IGP cost = 30

Better IGP path
to source exists
via lower links !

IGP cost = 20

I want to receive
234.1.1.1

PIM-SM: Shortest Path Tree Switchover



RP
192.168.0.1

Multicast “Shared Tree”
Where traffic passes via the RP

IGP cost = 30

Better IGP path to source exists via lower links !

IGP cost = 20

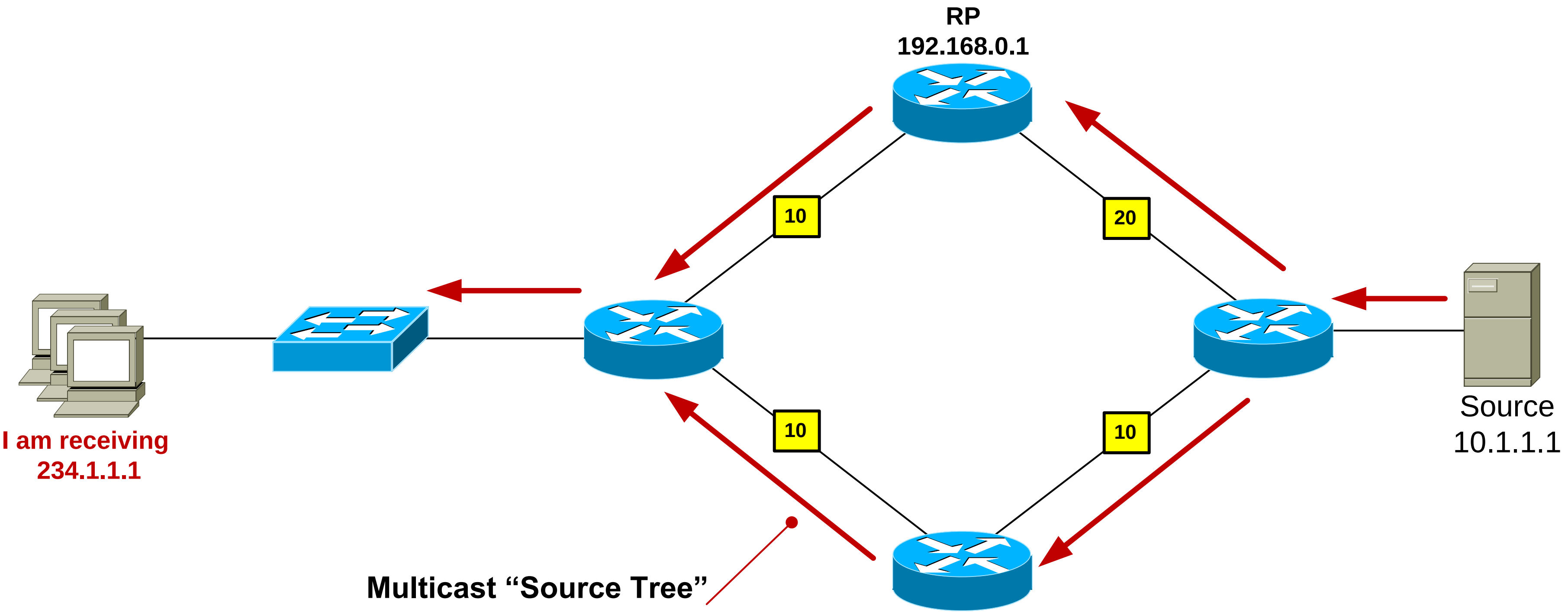
I want to receive 234.1.1.1

Source 10.1.1.1

PIM “join 234.1.1.1” message sent towards 10.1.1.1

PIM “join 234.1.1.1” message sent towards 10.1.1.1

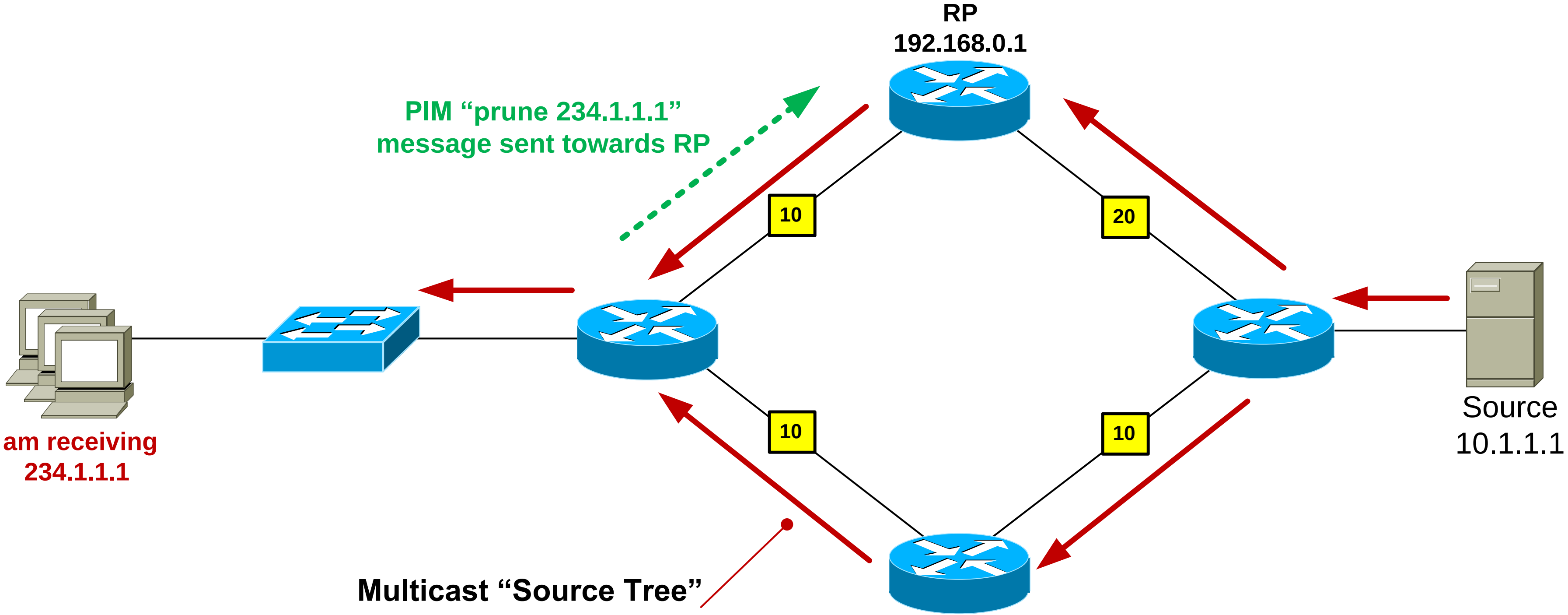
PIM-SM: Shortest Path Tree Switchover



I am receiving
234.1.1.1

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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Where traffic passes from the source directly to the receivers via the best IGP path

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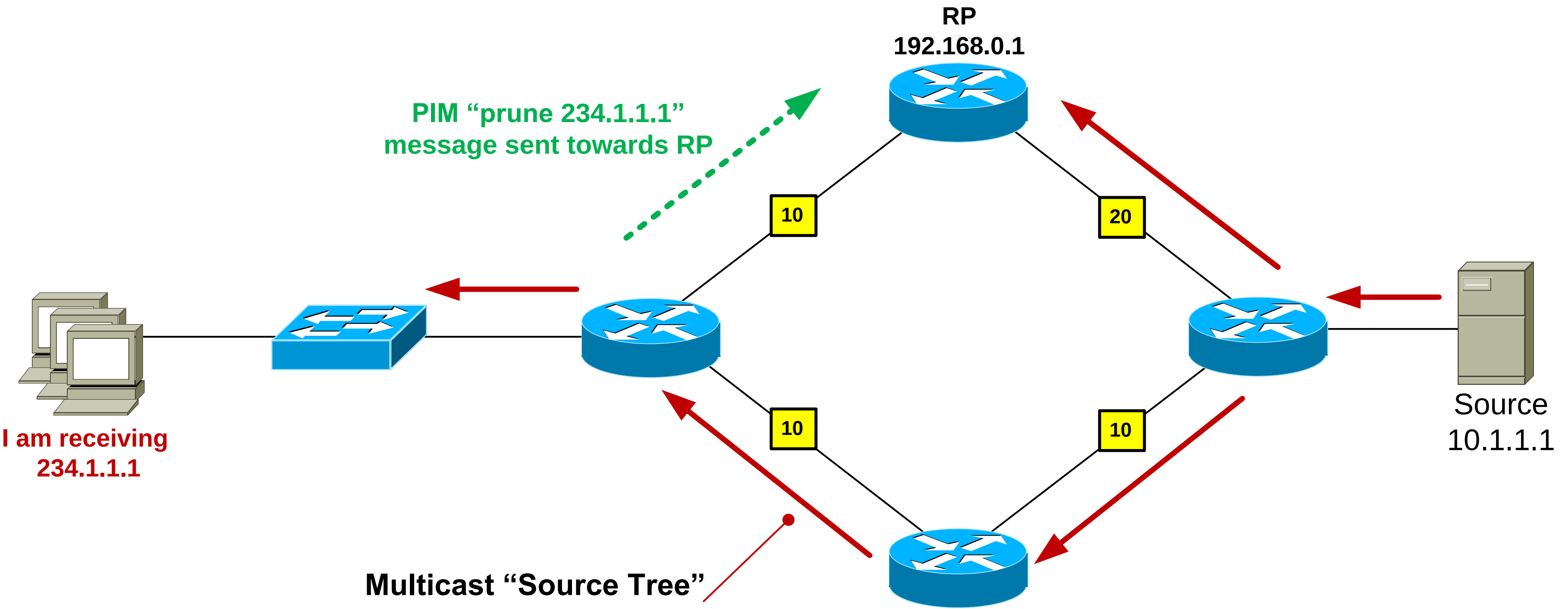
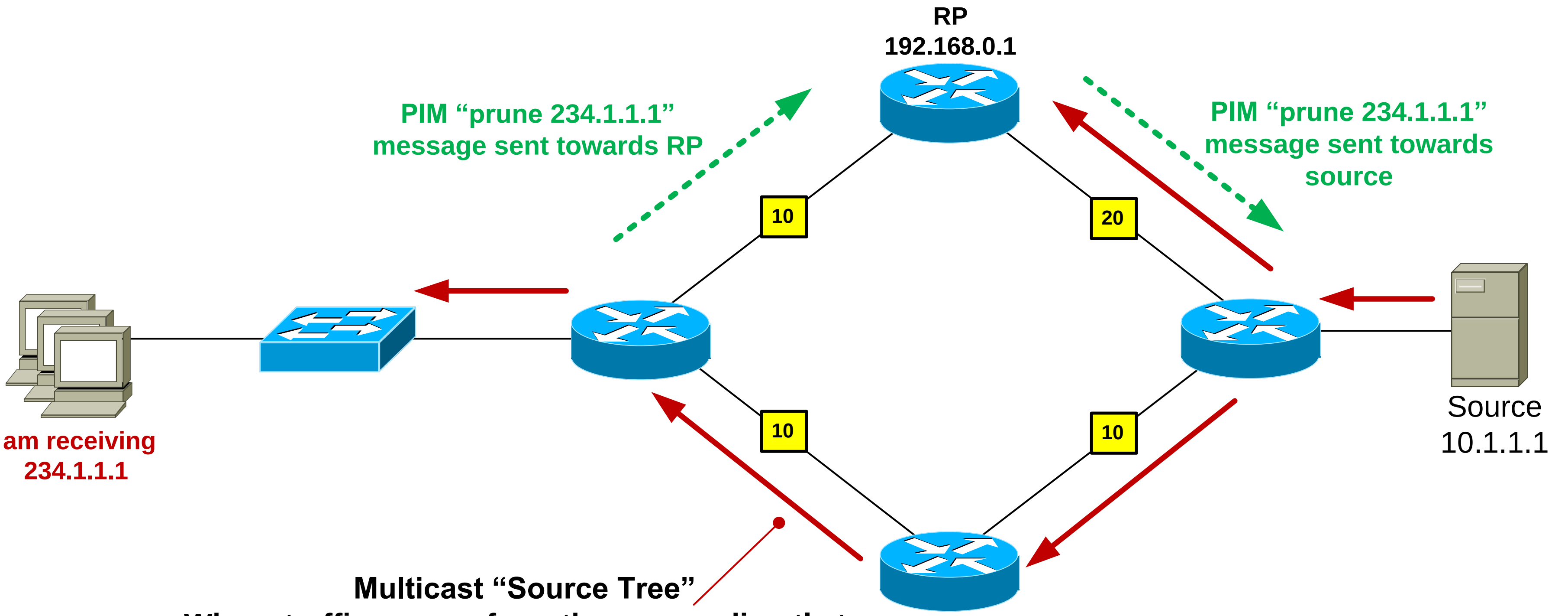


Multicast “Source Tree”
Where traffic passes from the source directly to the receivers via the best IGP path

PIM-SM: Shortest Path Tree Switchover



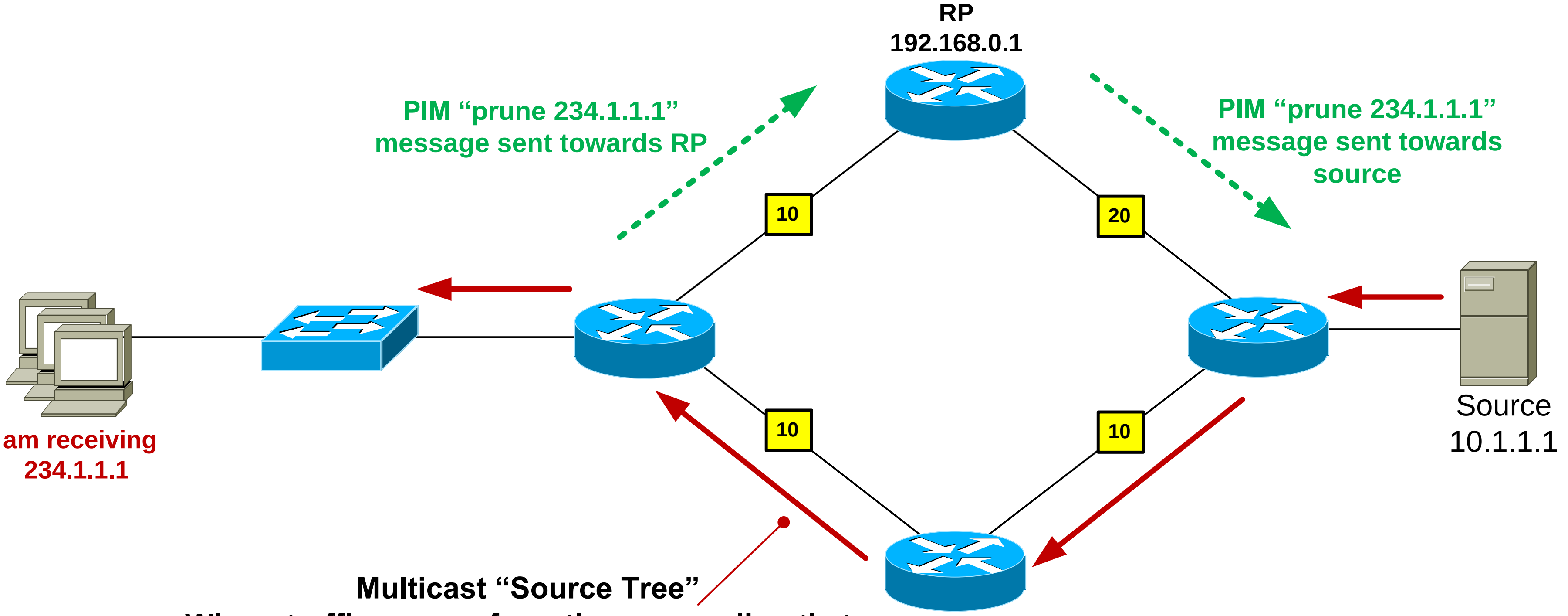
PIM “prune 234.1.1.1” message sent towards RP

PIM “prune 234.1.1.1” message sent towards source

I am receiving 234.1.1.1

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

PIM-SM: Shortest Path Tree Switchover


RP
192.168.0.1
PIM “prune 234.1.1.1” message sent towards RP
PIM “prune 234.1.1.1” message sent towards source
10
20
10
10
I am receiving 234.1.1.1
Source
10.1.1.1

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

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

PIM-SM: Rendezvous Point Discovery

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```

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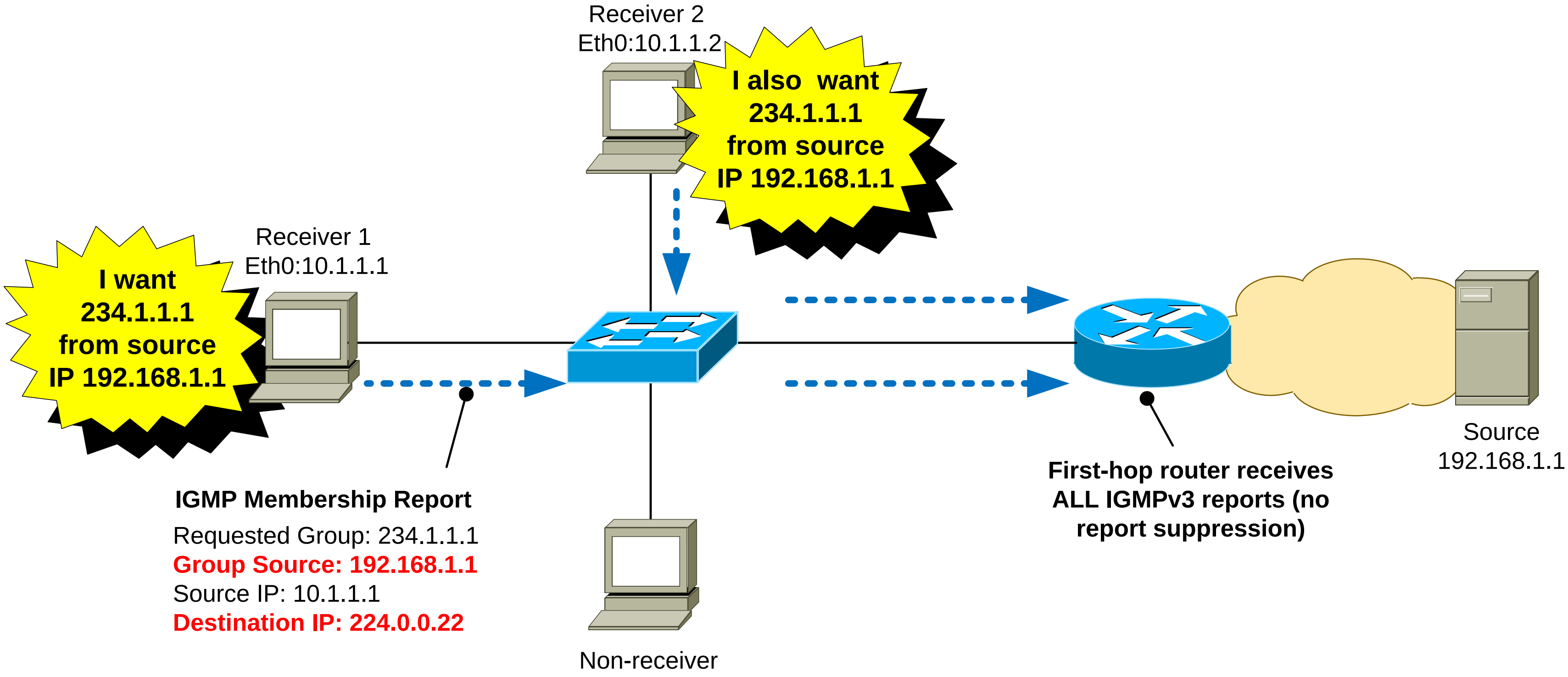
  Configure the RP to tell all other routers that it is the RP

  - Cisco proprietary mechanism is called “Auto-RP”
  - IETF standard is known as Bootstrap Router (BSR) – RFC 5059

Q: What if receivers router knew the source from the start?....

IGMPv3 – Joining a Group



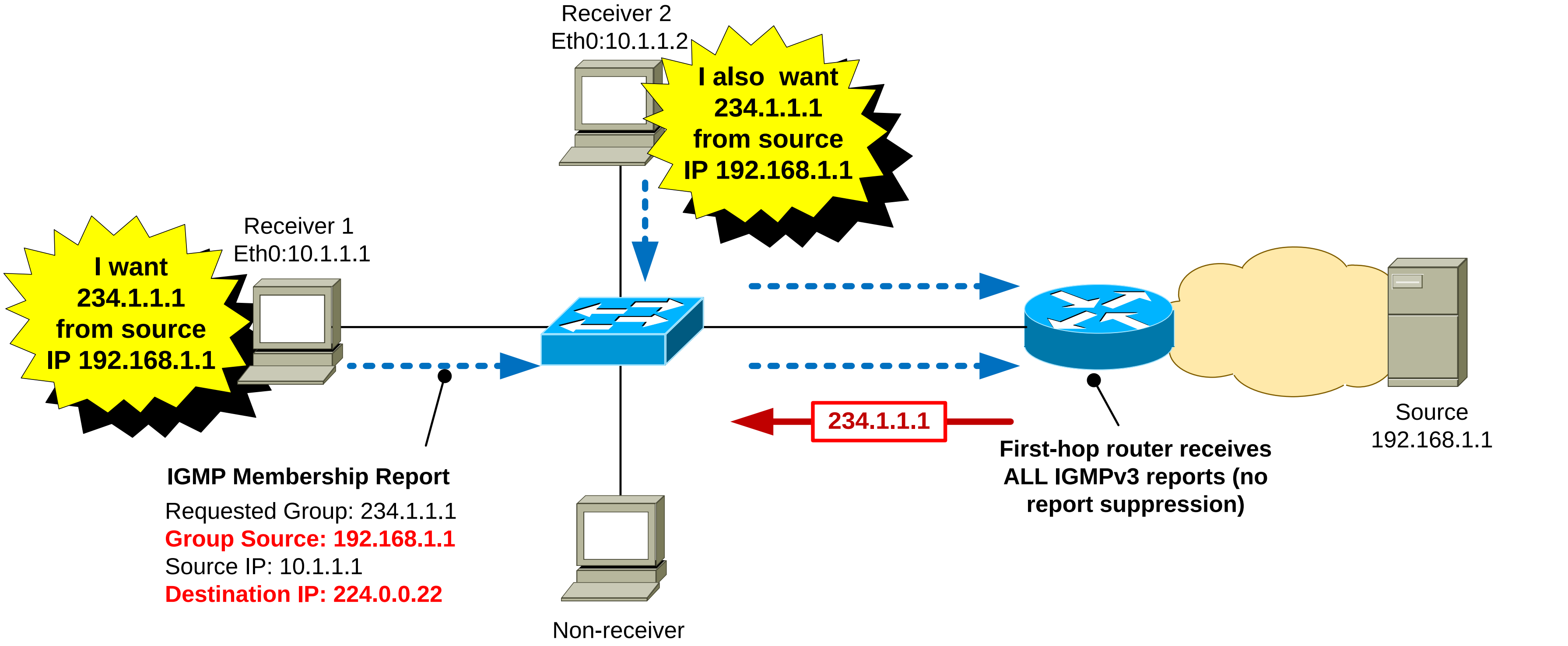
Receiver 2
Eth0:10.1.1.2
I also want 234.1.1.1 from source IP 192.168.1.1
Receiver 1
Eth0:10.1.1.1
I want 234.1.1.1 from source IP 192.168.1.1
Source
192.168.1.1
Non-receiver

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

First-hop router receives ALL IGMPv3 reports (no report suppression)

IGMPv3 – Joining a Group


Receiver 2
Eth0:10.1.1.2
I also want 234.1.1.1 from source IP 192.168.1.1
Receiver 1
Eth0:10.1.1.1
I want 234.1.1.1 from source IP 192.168.1.1
234.1.1.1
Source
192.168.1.1
Non-receiver

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

First-hop router receives ALL IGMPv3 reports (no report suppression)

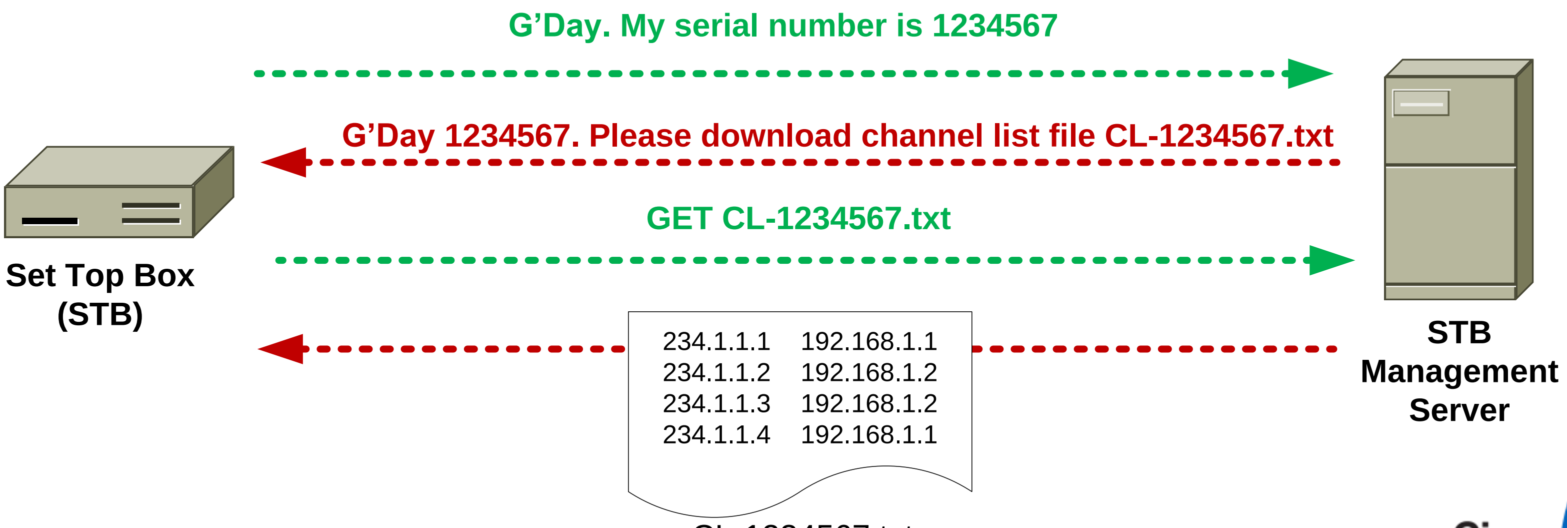
IGMPv3 Source Discovery

Q: How does the receiver know the source address for each 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.



G'Day. My serial number is 1234567

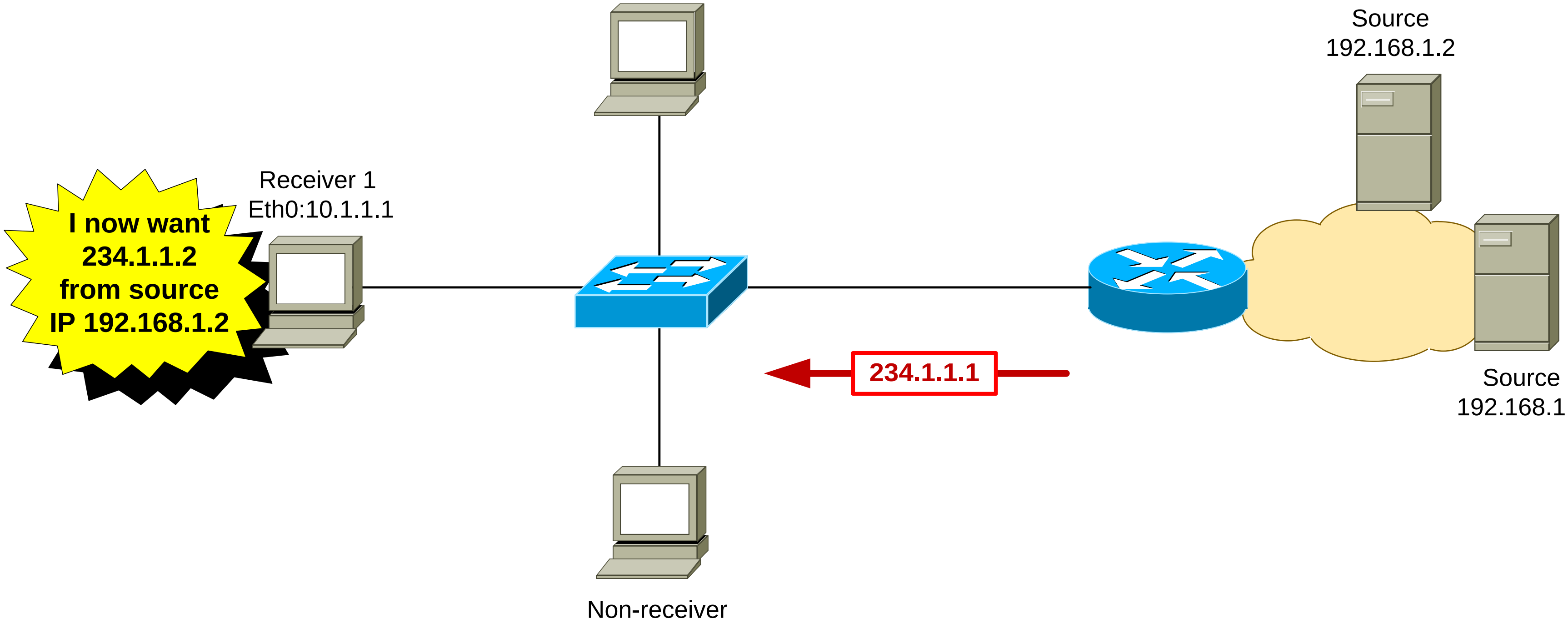
G'Day 1234567. Please download channel list file CL-1234567.txt

GET CL-1234567.txt

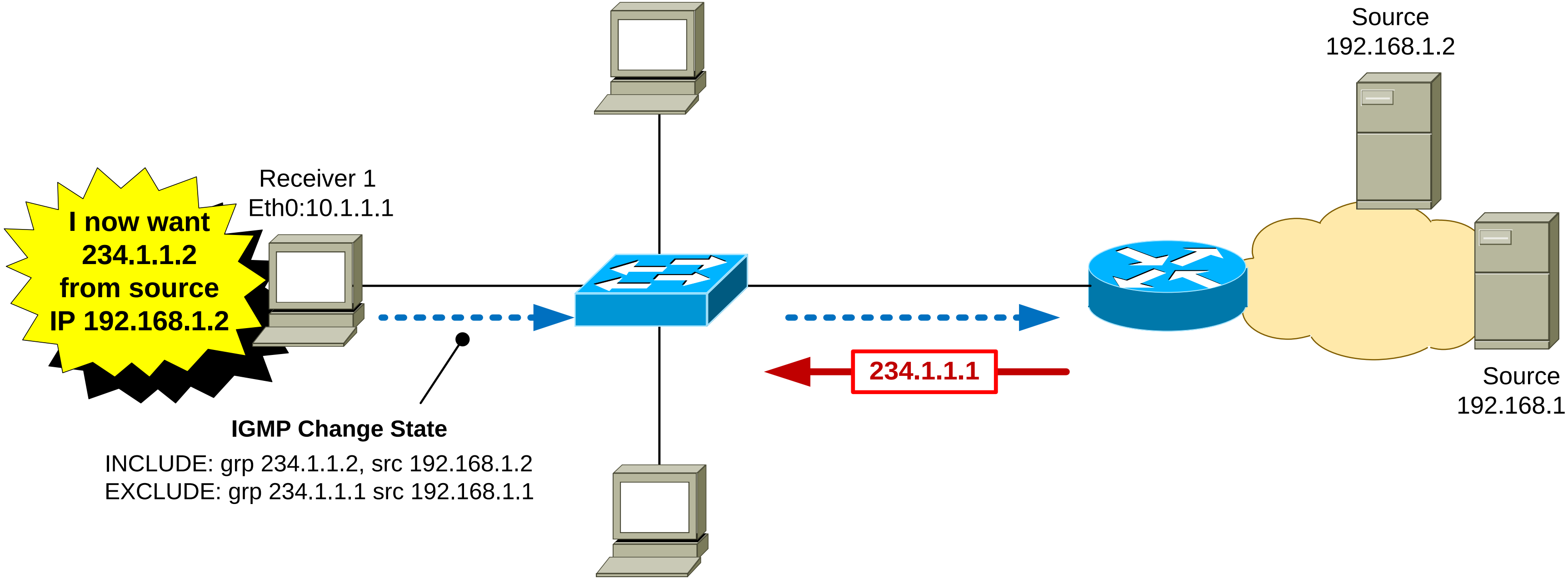
234.1.1.1	192.168.1.1
234.1.1.2	192.168.1.2
234.1.1.3	192.168.1.2
234.1.1.4	192.168.1.1

CL-1234567.txt

IGMPv3 – Changing a Group



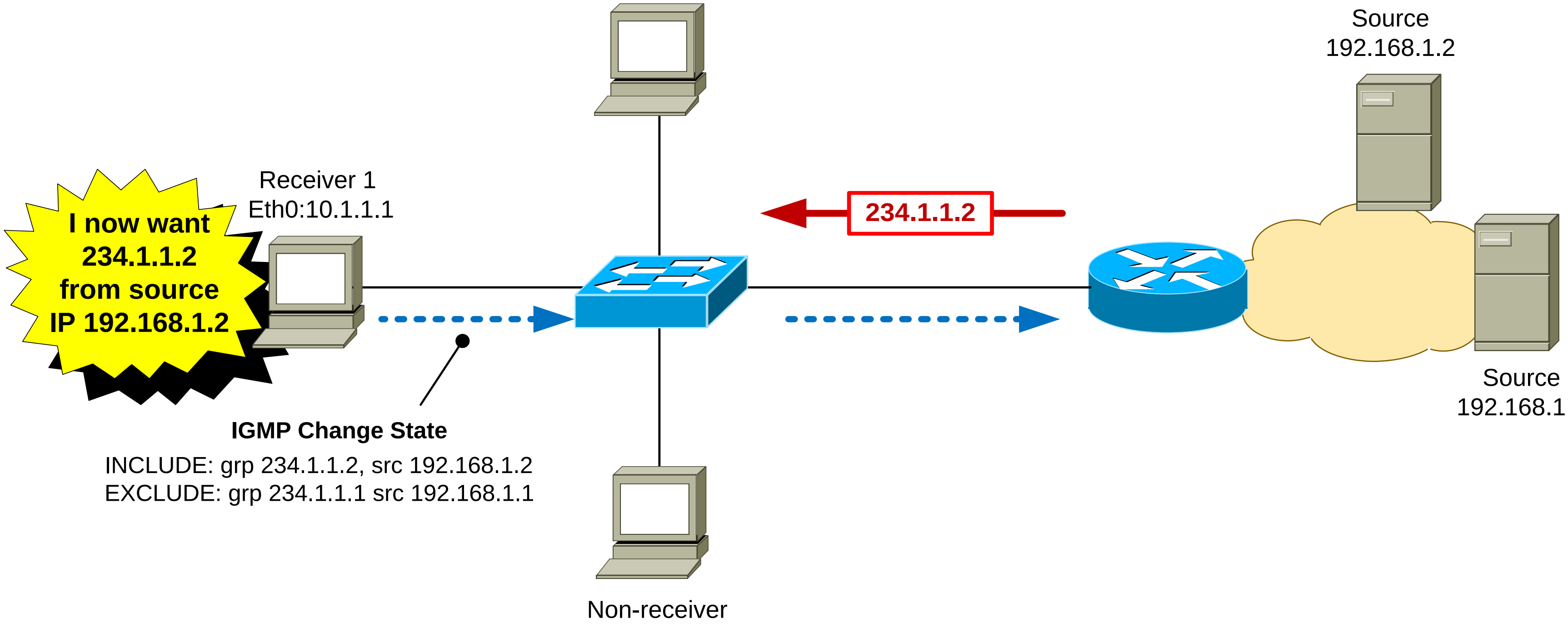
IGMPv3 – Changing a Group



IGMP Change State

INCLUDE: grp 234.1.1.2, src 192.168.1.2
EXCLUDE: grp 234.1.1.1 src 192.168.1.1

IGMPv3 – Changing a Group



IGMP Change State

INCLUDE: grp 234.1.1.2, src 192.168.1.2
EXCLUDE: grp 234.1.1.1 src 192.168.1.1

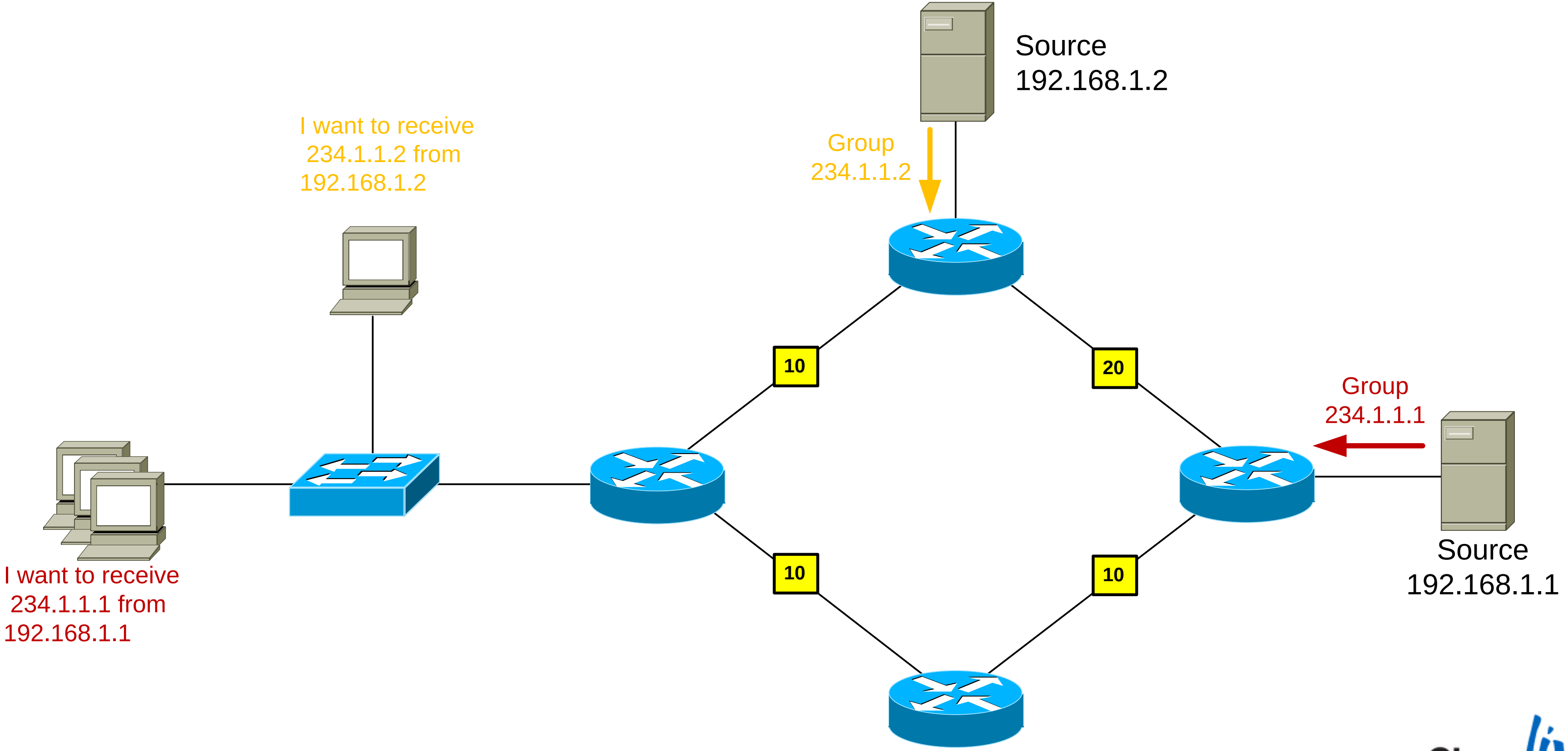
Advantages of IGMPv3

- 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

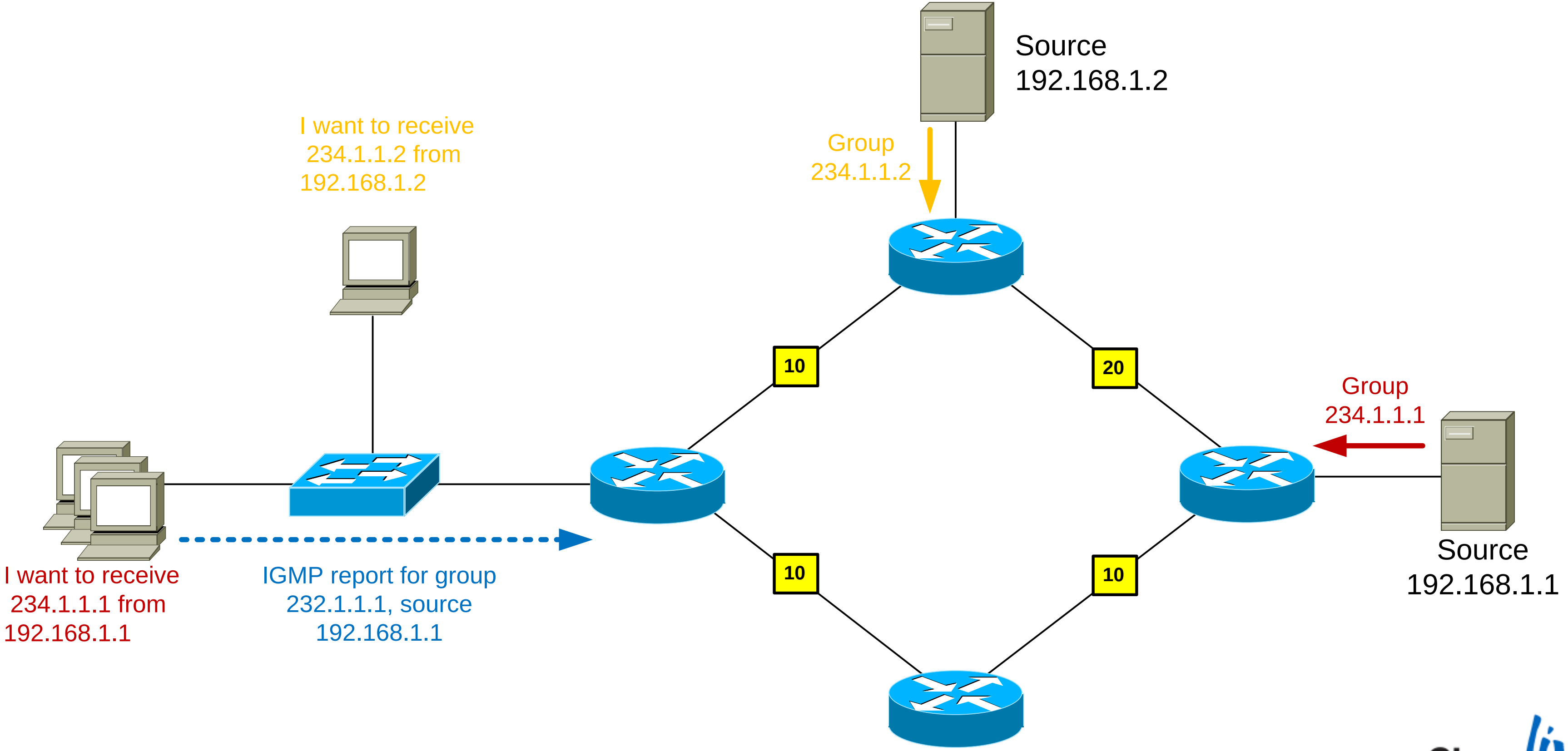
Router-Router Signalling: PIM-SSM

- **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.

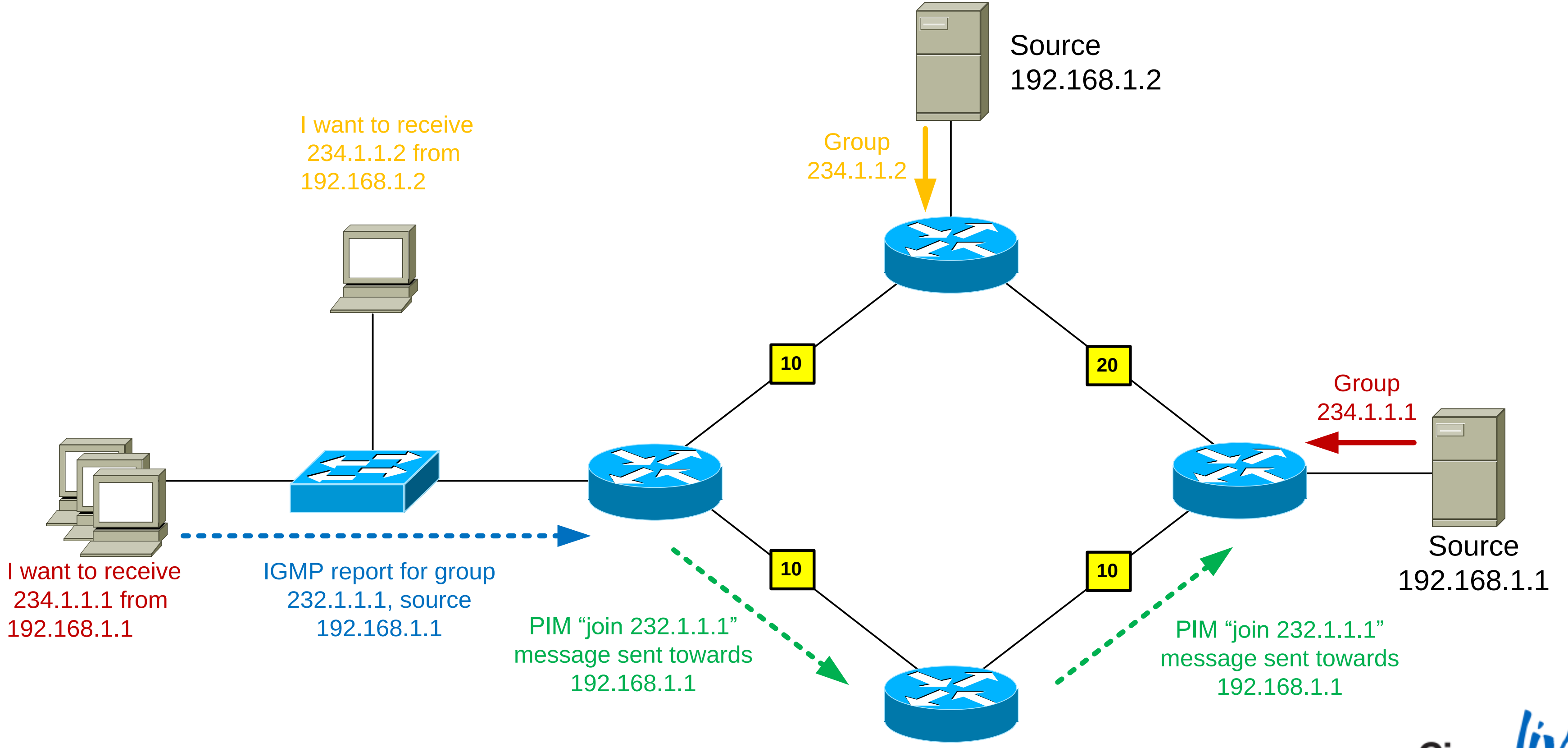
PIM-SSM: Operation



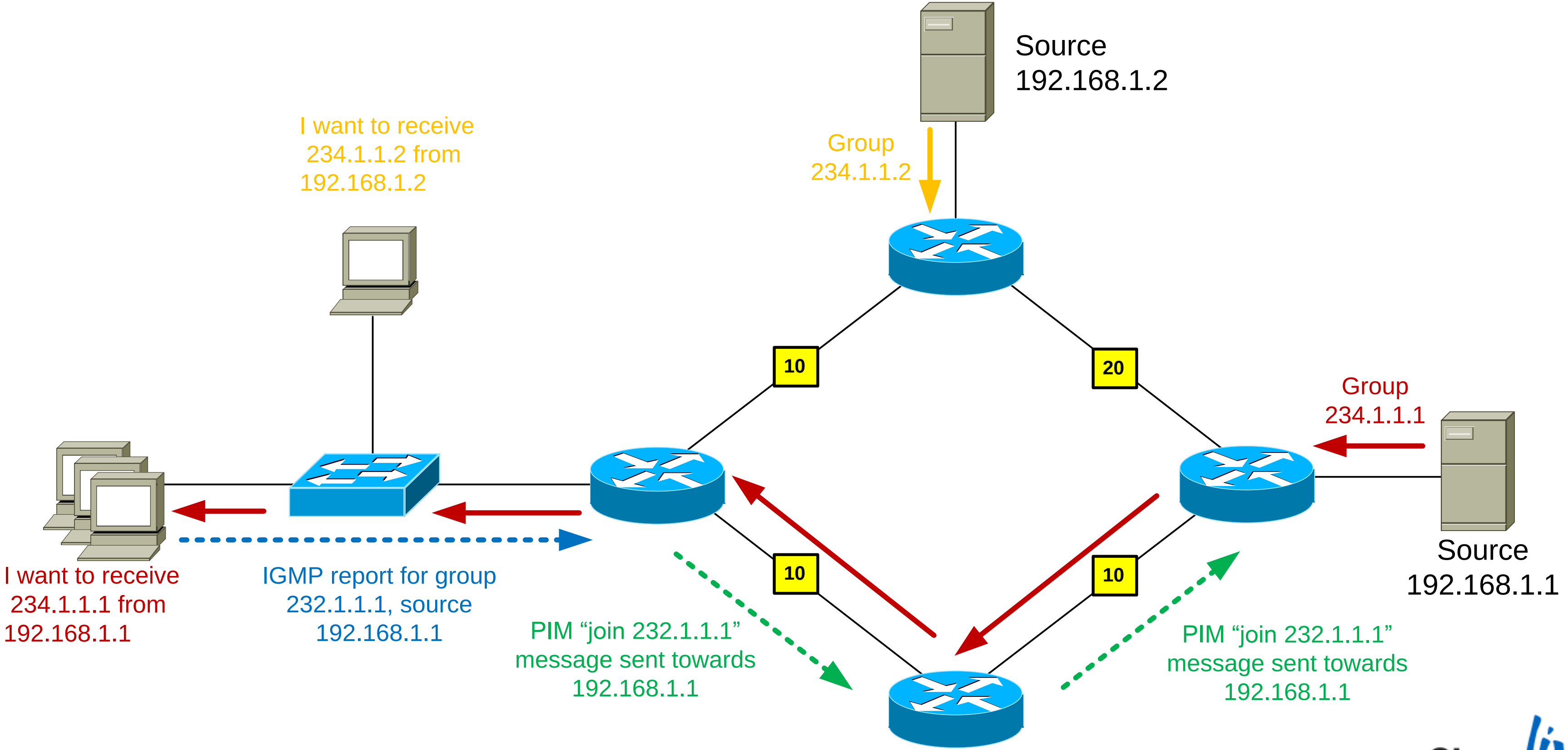
PIM-SSM: Operation



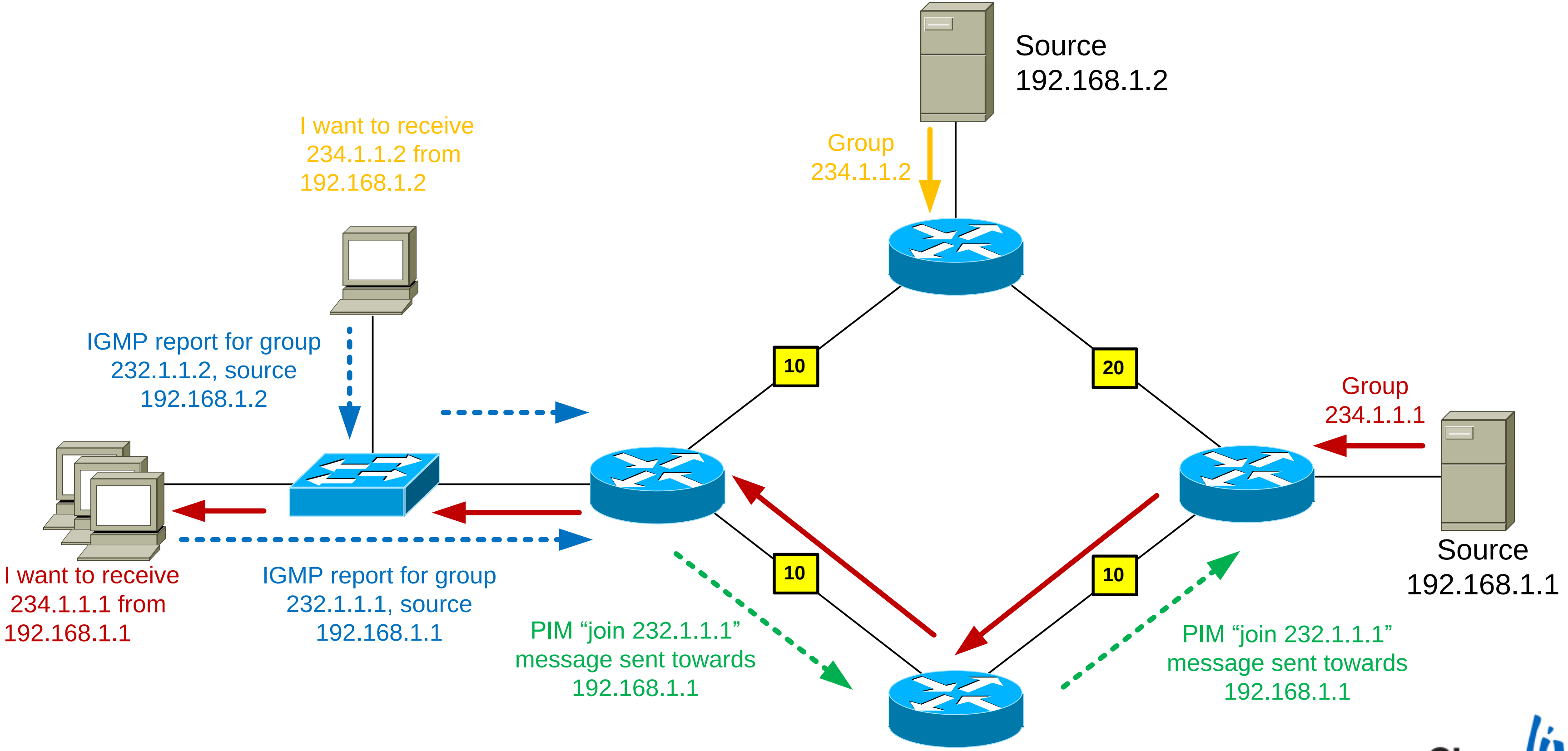
PIM-SSM: Operation



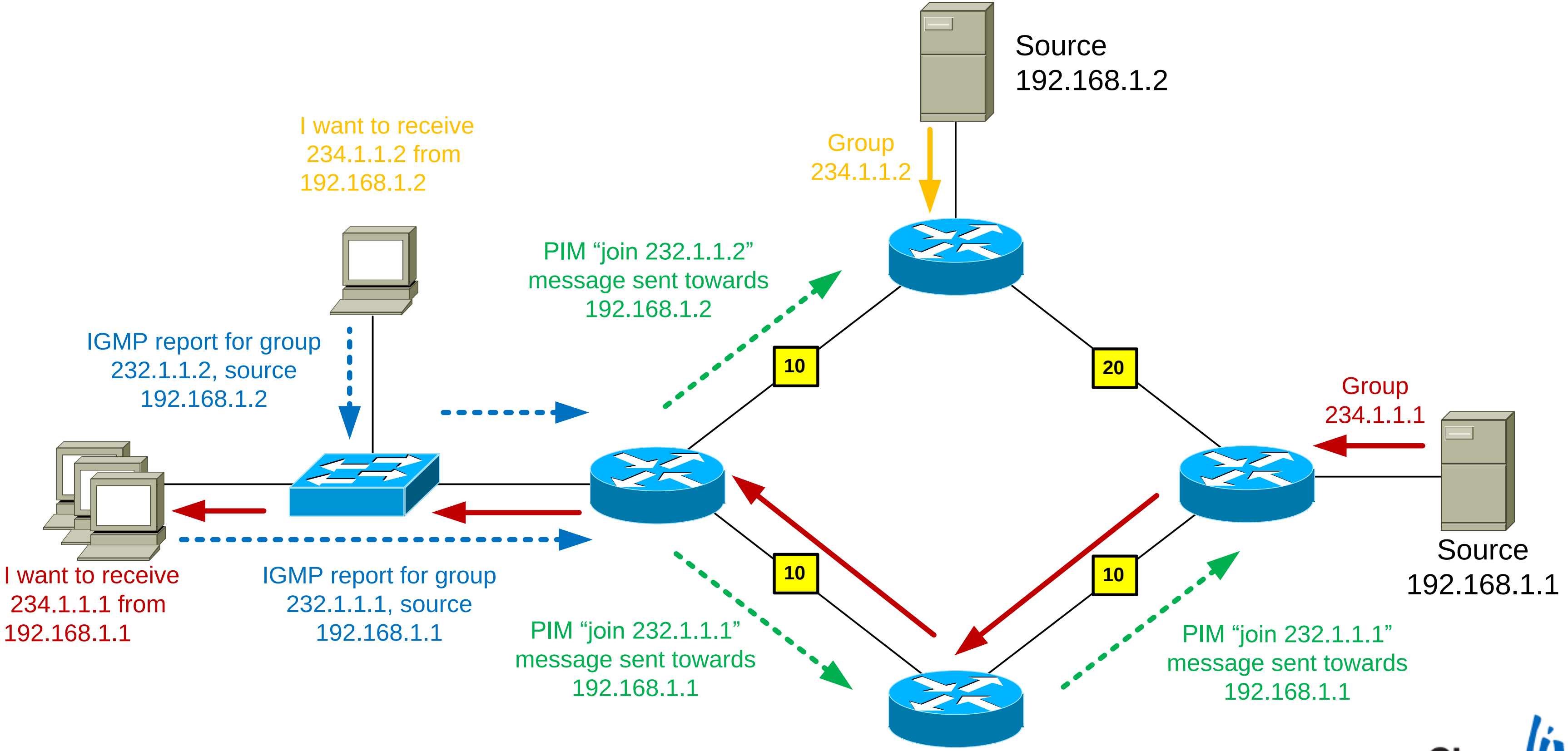
PIM-SSM: Operation



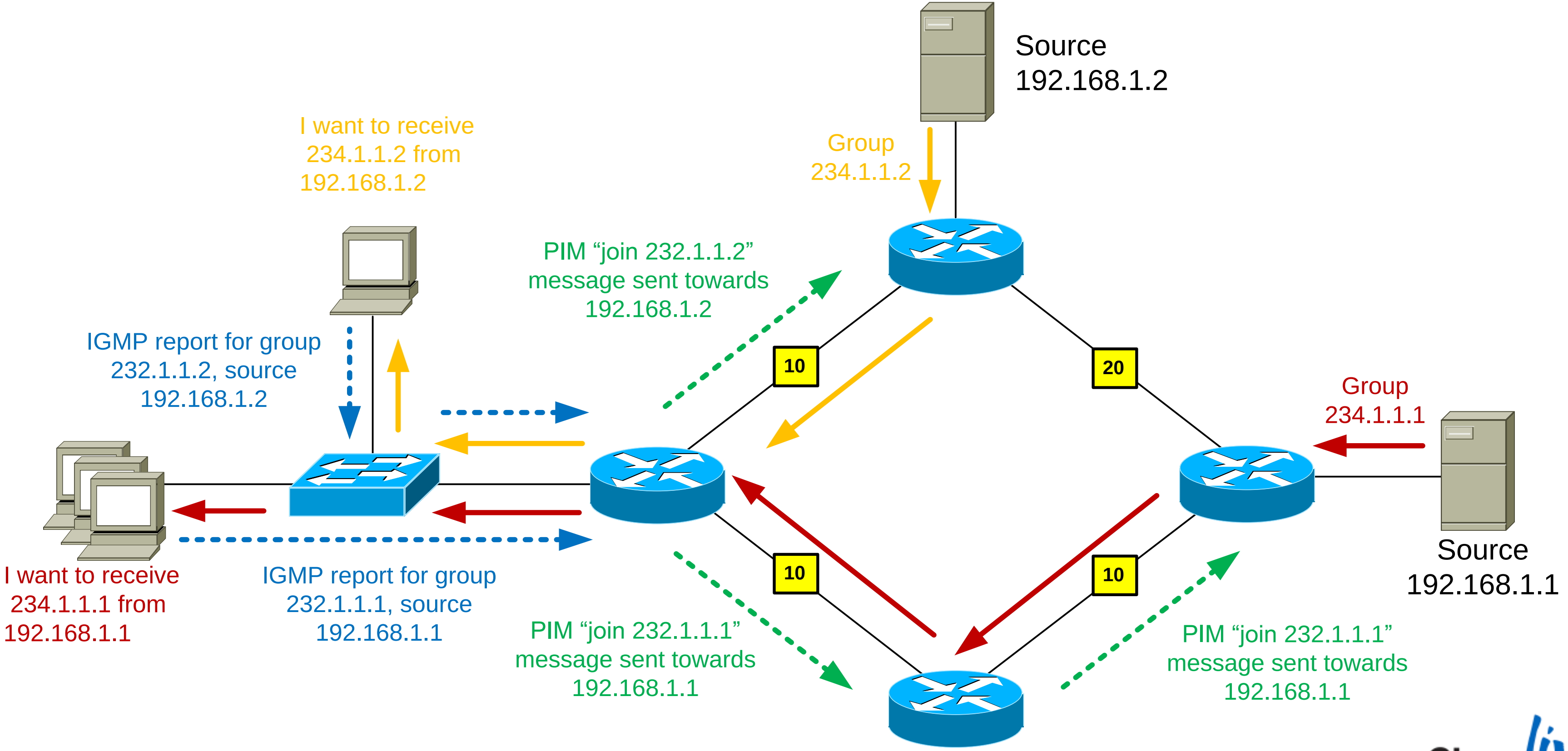
PIM-SSM: Operation



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 ?

PIM-SSM Mapping

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PIM-SSM Mapping

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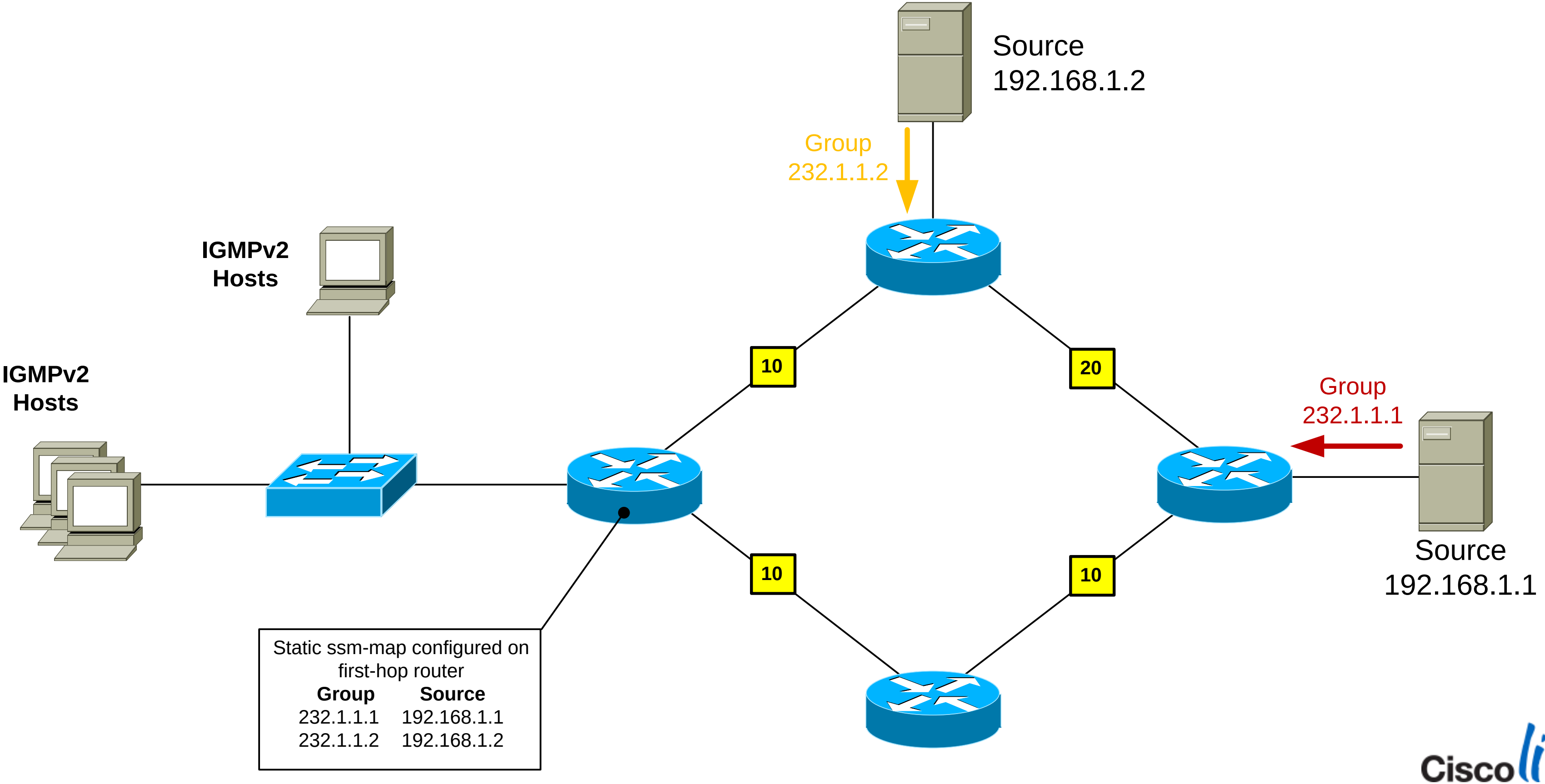
- But...IGMPv3 host support is patchy, whereas IGMPv2 is ubiquitous
- Q: Is there a way to use PIM-SSM in the network when I have hosts that only support IGMPv2 ?
- A: Yes – its called PIM-SSM mapping
- PIM-SSM mapping can be used as an interim measure until IGMPv3 is supported on all hosts

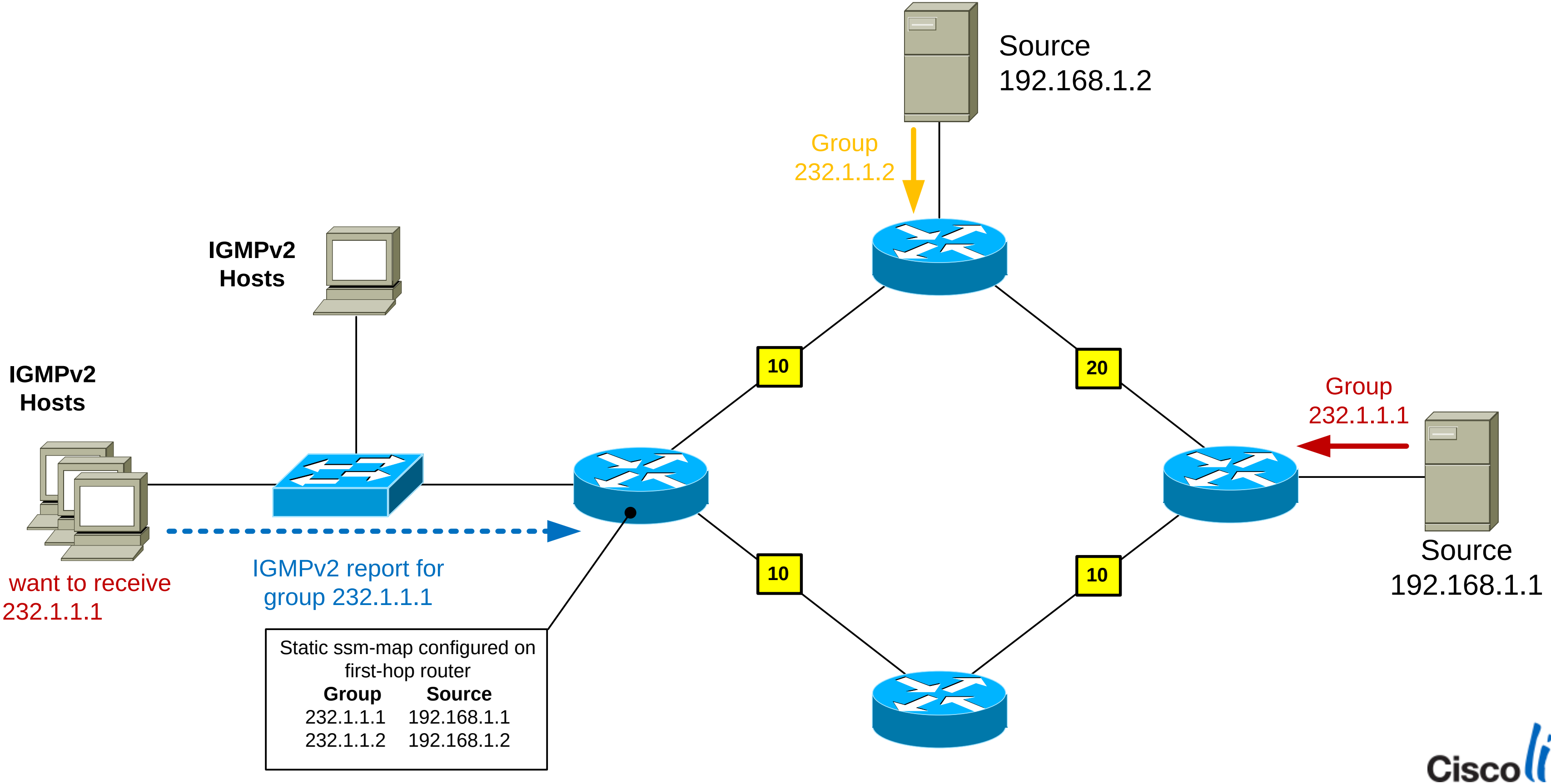
PIM-SSM Static Mapping



Static ssm-map configured on first-hop router

Group	Source
232.1.1.1	192.168.1.1
232.1.1.2	192.168.1.2

PIM-SSM Static Mapping



Source
192.168.1.2

Group
232.1.1.2

IGMPv2
Hosts

IGMPv2
Hosts

Group
232.1.1.1

Source
192.168.1.1

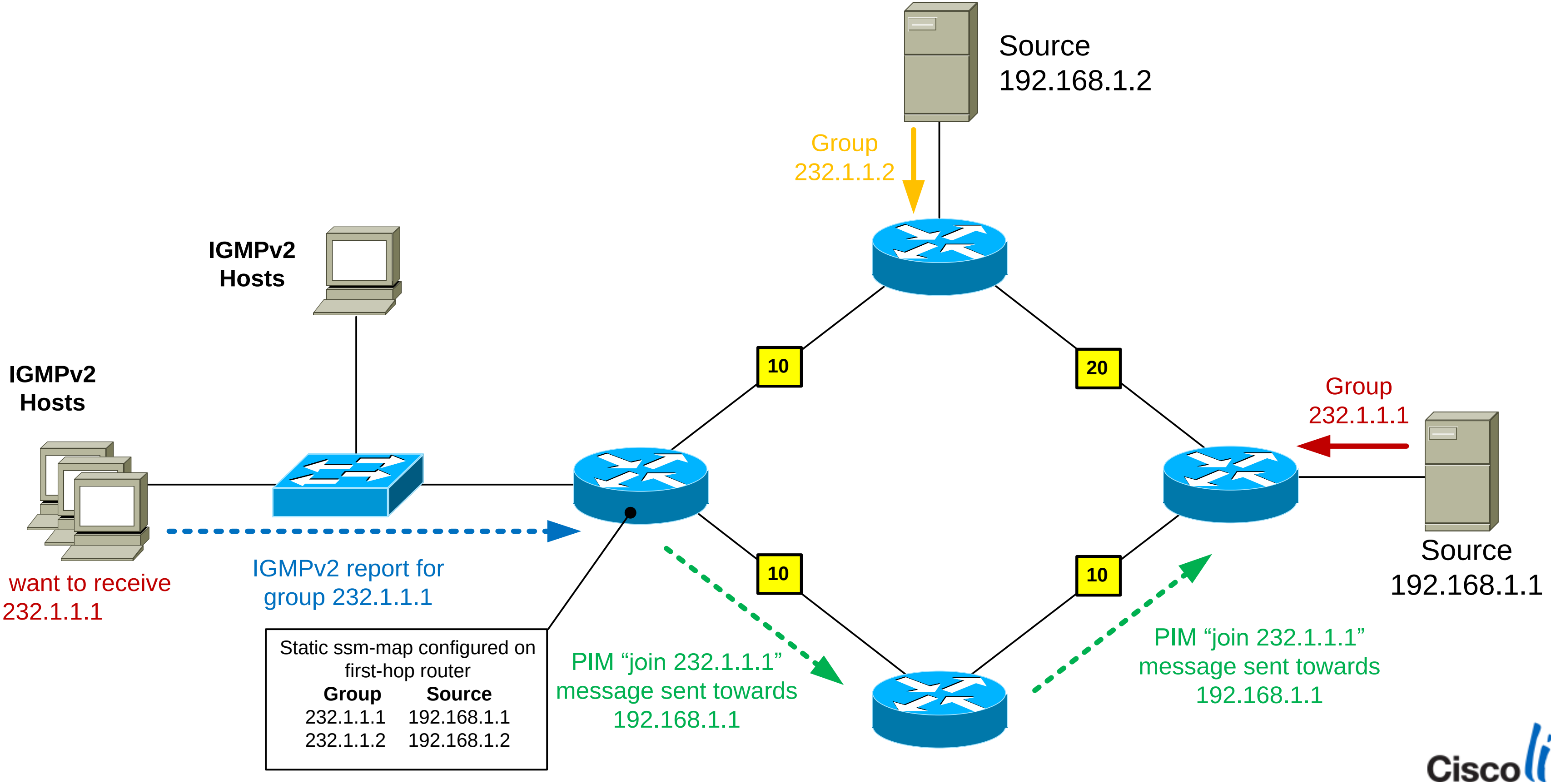
I want to receive
232.1.1.1

IGMPv2 report for
group 232.1.1.1

Static ssm-map configured on
first-hop router

Group	Source
232.1.1.1	192.168.1.1
232.1.1.2	192.168.1.2

PIM-SSM Static Mapping



I want to receive 232.1.1.1

IGMPv2 report for group 232.1.1.1

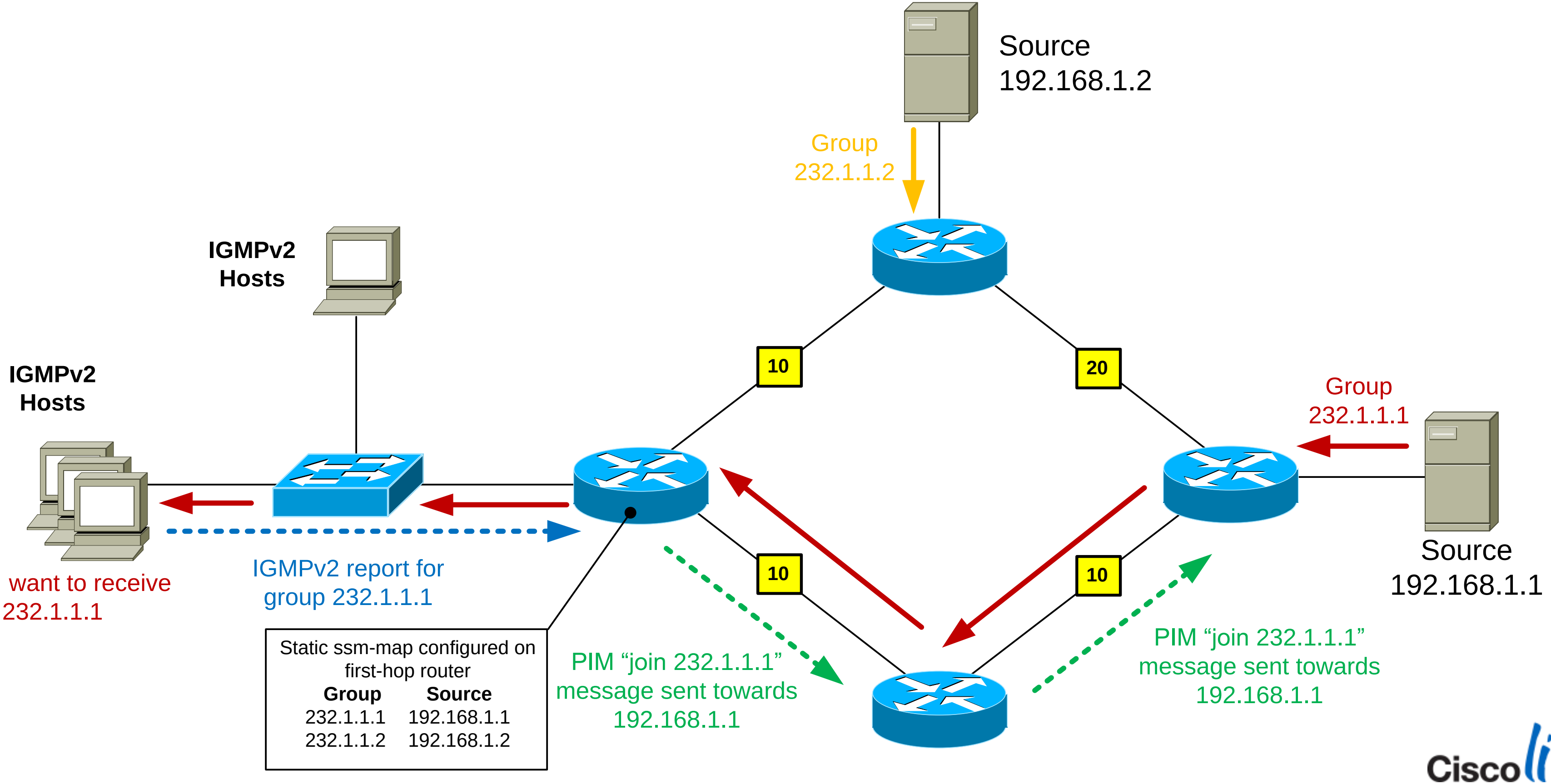
PIM "join 232.1.1.1" message sent towards 192.168.1.1

PIM "join 232.1.1.1" message sent towards 192.168.1.1

Static ssm-map configured on first-hop router

Group	Source
232.1.1.1	192.168.1.1
232.1.1.2	192.168.1.2

PIM-SSM Static Mapping



Source 192.168.1.2

Group 232.1.1.2

IGMPv2 Hosts

IGMPv2 Hosts

Group 232.1.1.1

Source 192.168.1.1

I want to receive 232.1.1.1

IGMPv2 report for group 232.1.1.1

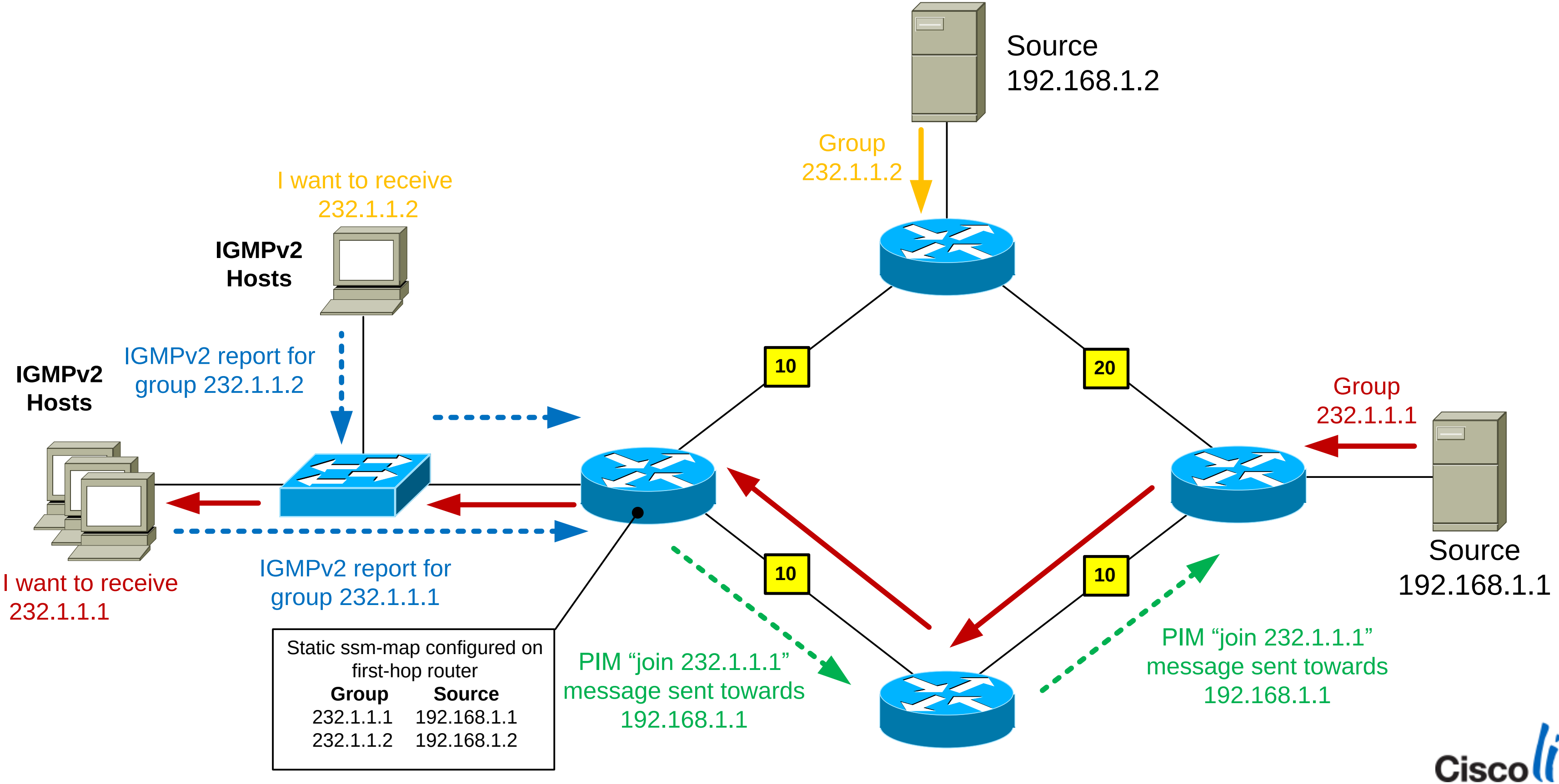
PIM “join 232.1.1.1” message sent towards 192.168.1.1

PIM “join 232.1.1.1” message sent towards 192.168.1.1

Static ssm-map configured on first-hop router

Group	Source
232.1.1.1	192.168.1.1
232.1.1.2	192.168.1.2

PIM-SSM Static Mapping



Source
192.168.1.2

Group
232.1.1.2

I want to receive
232.1.1.2

IGMPv2
Hosts

IGMPv2 report for
group 232.1.1.2

IGMPv2
Hosts

I want to receive
232.1.1.1

IGMPv2 report for
group 232.1.1.1

Group
232.1.1.1

Source
192.168.1.1

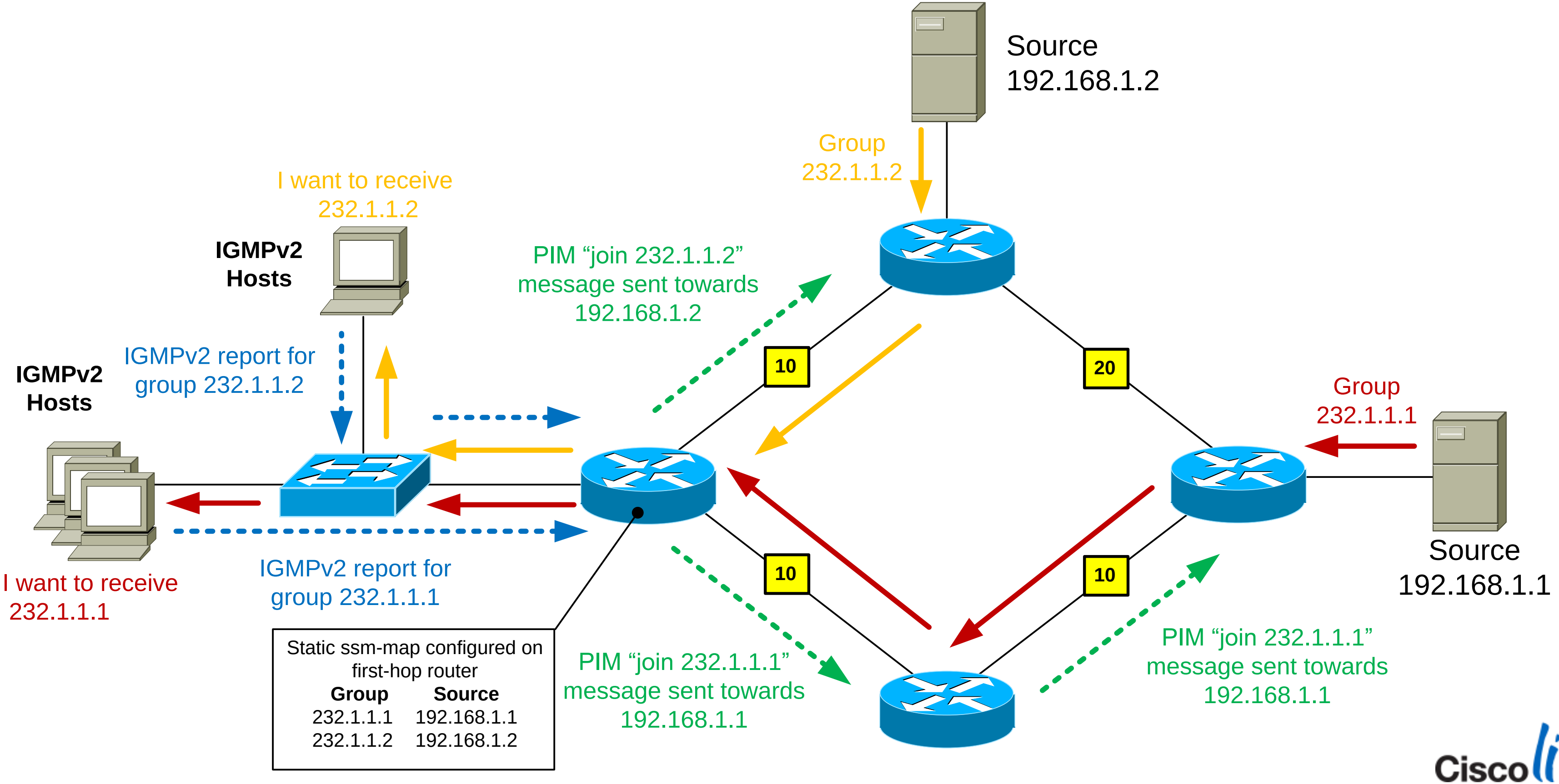
PIM "join 232.1.1.1"
message sent towards
192.168.1.1

PIM "join 232.1.1.1"
message sent towards
192.168.1.1

Static ssm-map configured on first-hop router

Group	Source
232.1.1.1	192.168.1.1
232.1.1.2	192.168.1.2

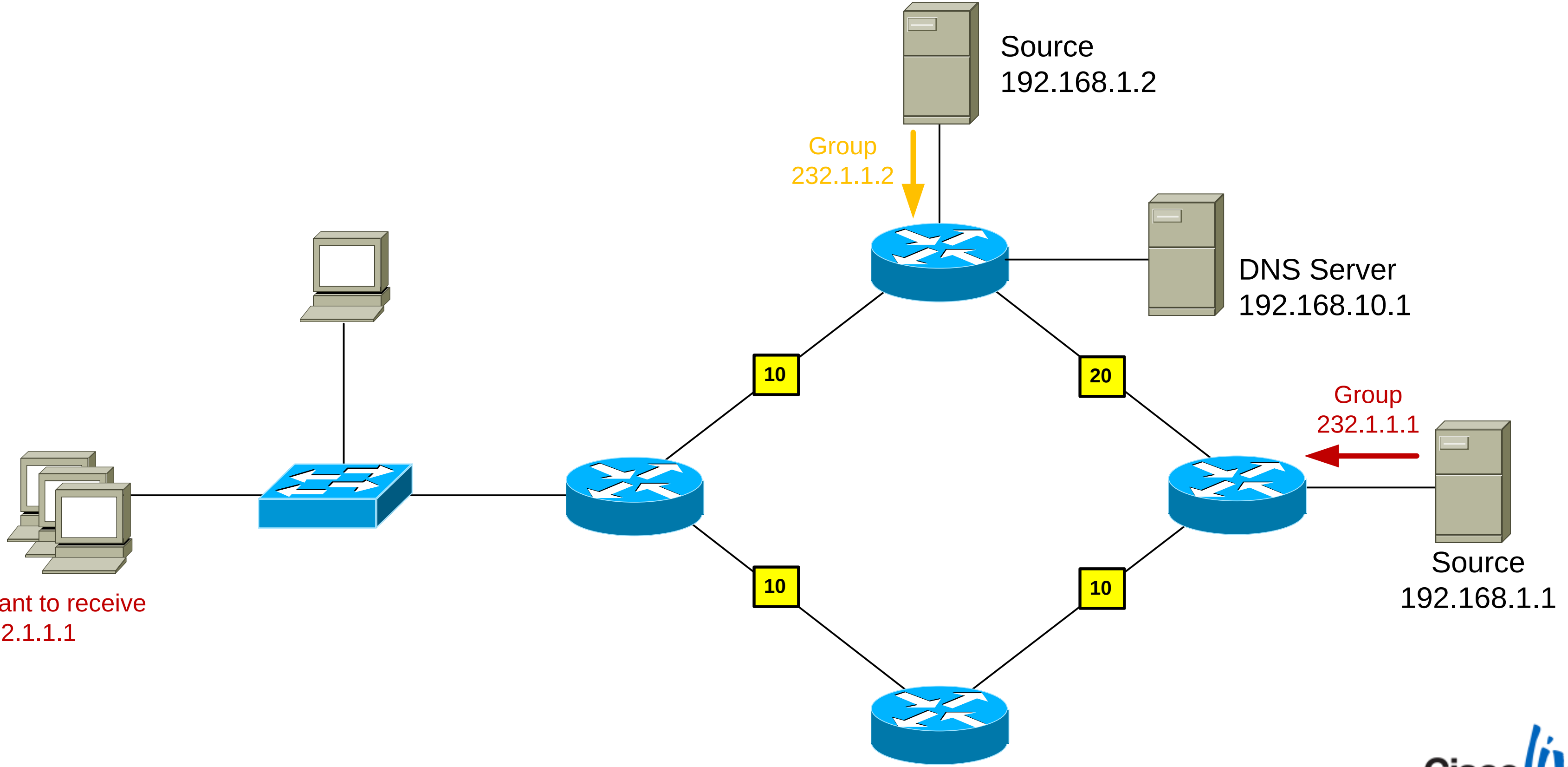
PIM-SSM Static Mapping



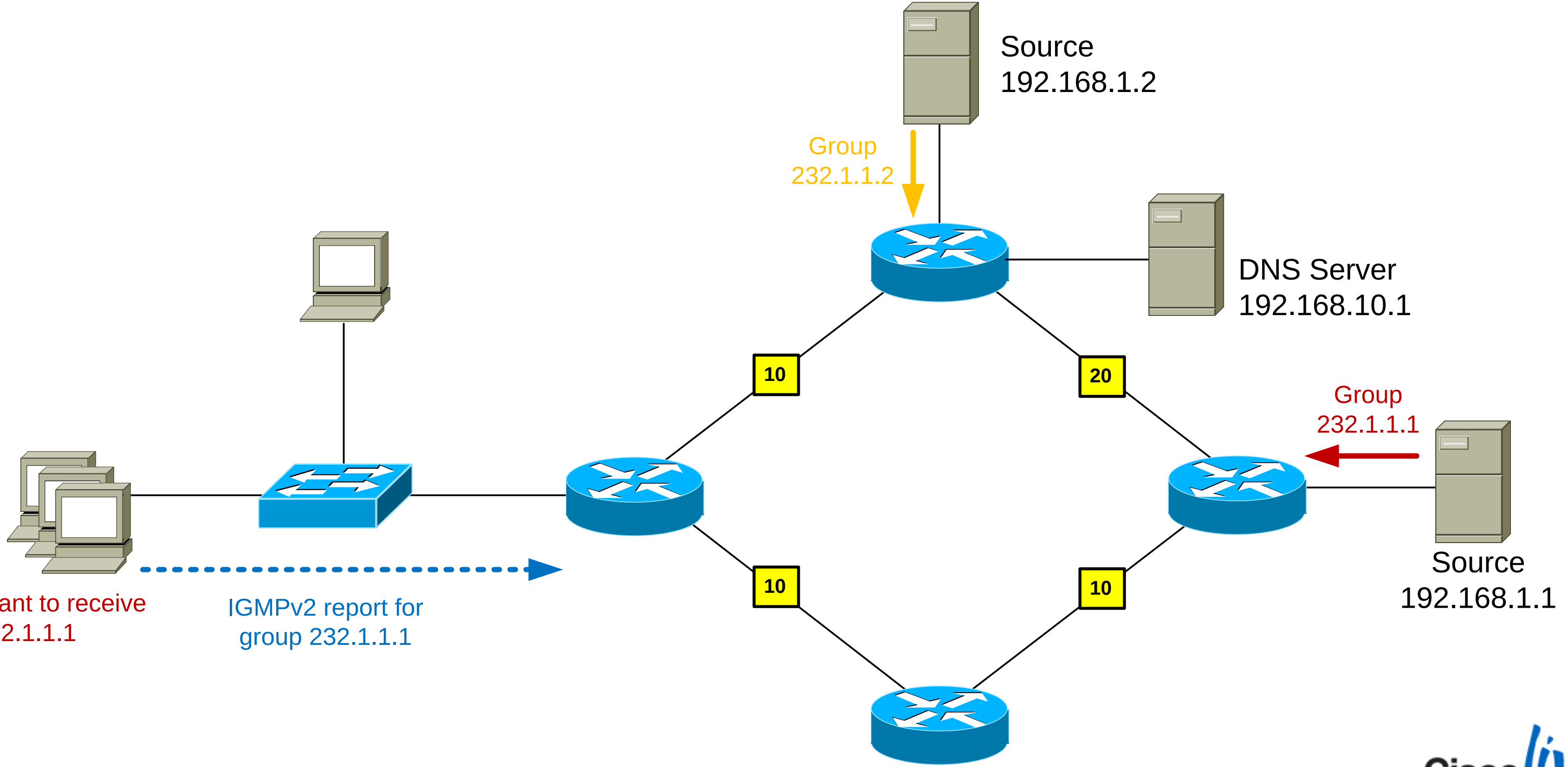
Static ssm-map configured on first-hop router

Group	Source
232.1.1.1	192.168.1.1
232.1.1.2	192.168.1.2

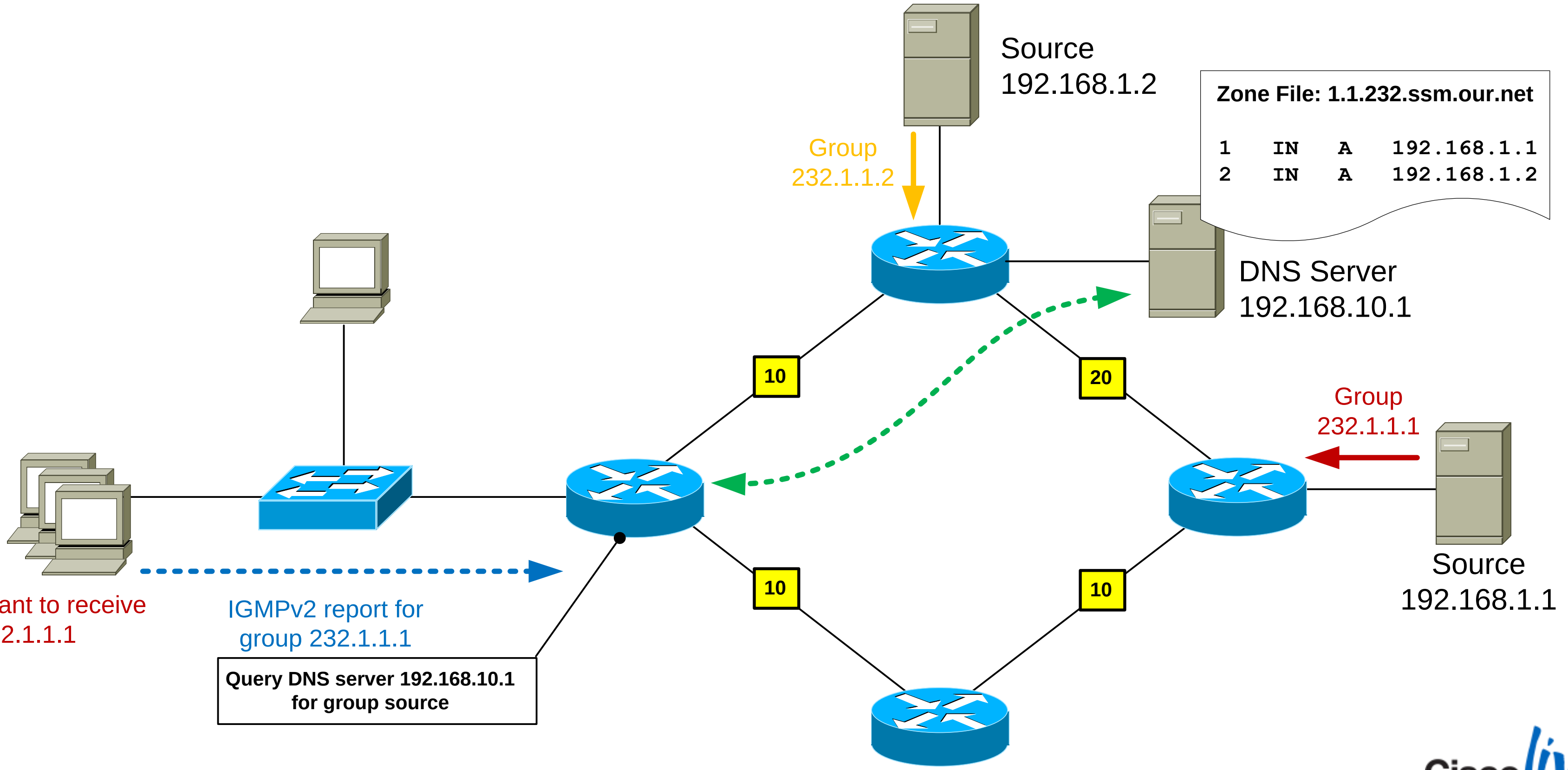
PIM-SSM Dynamic (DNS) Mapping



PIM-SSM Dynamic (DNS) Mapping



PIM-SSM Dynamic (DNS) Mapping

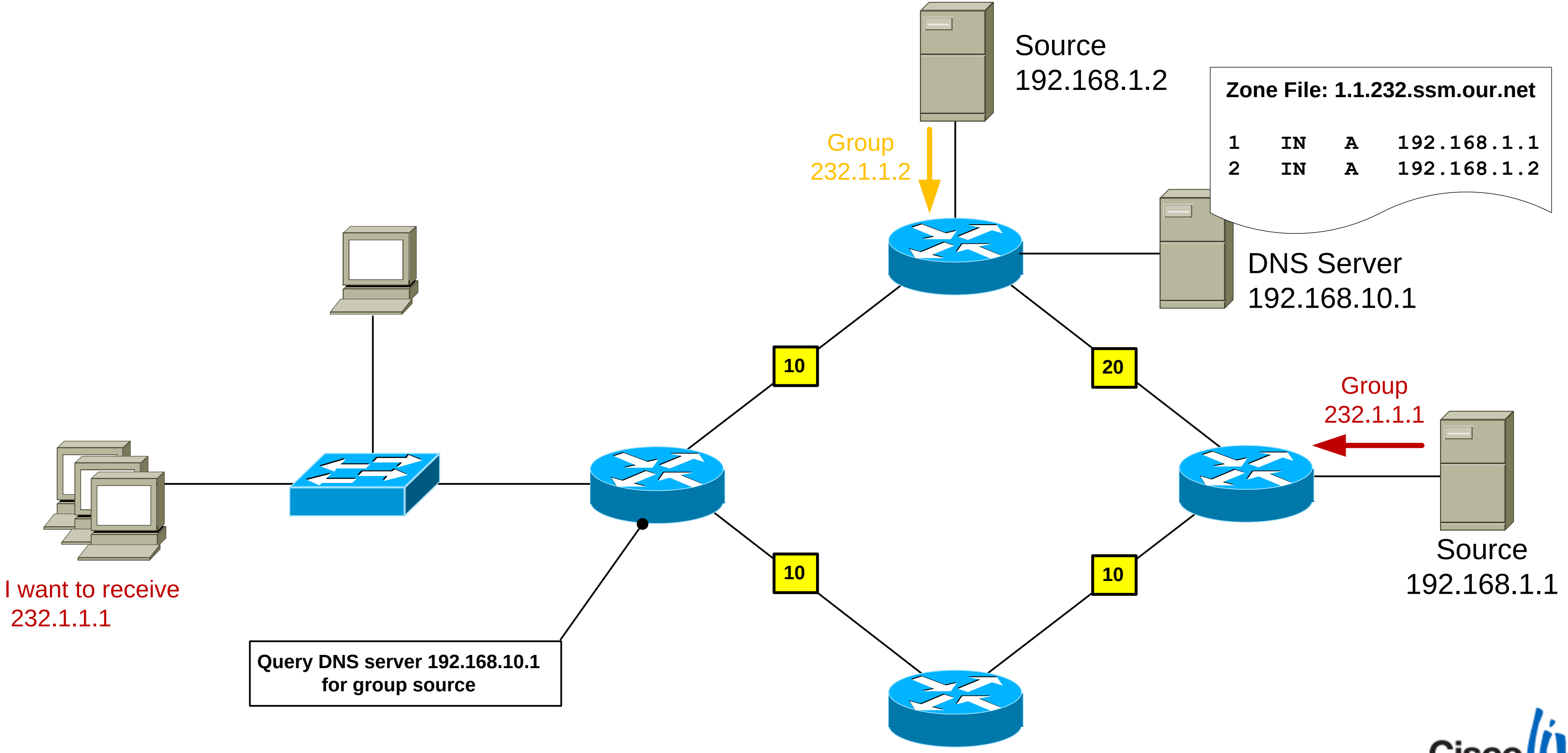


Zone File: 1.1.232.ssm.our.net

```
1   IN   A   192.168.1.1
2   IN   A   192.168.1.2
```

Query DNS server 192.168.10.1 for group source

PIM-SSM Dynamic (DNS) Mapping

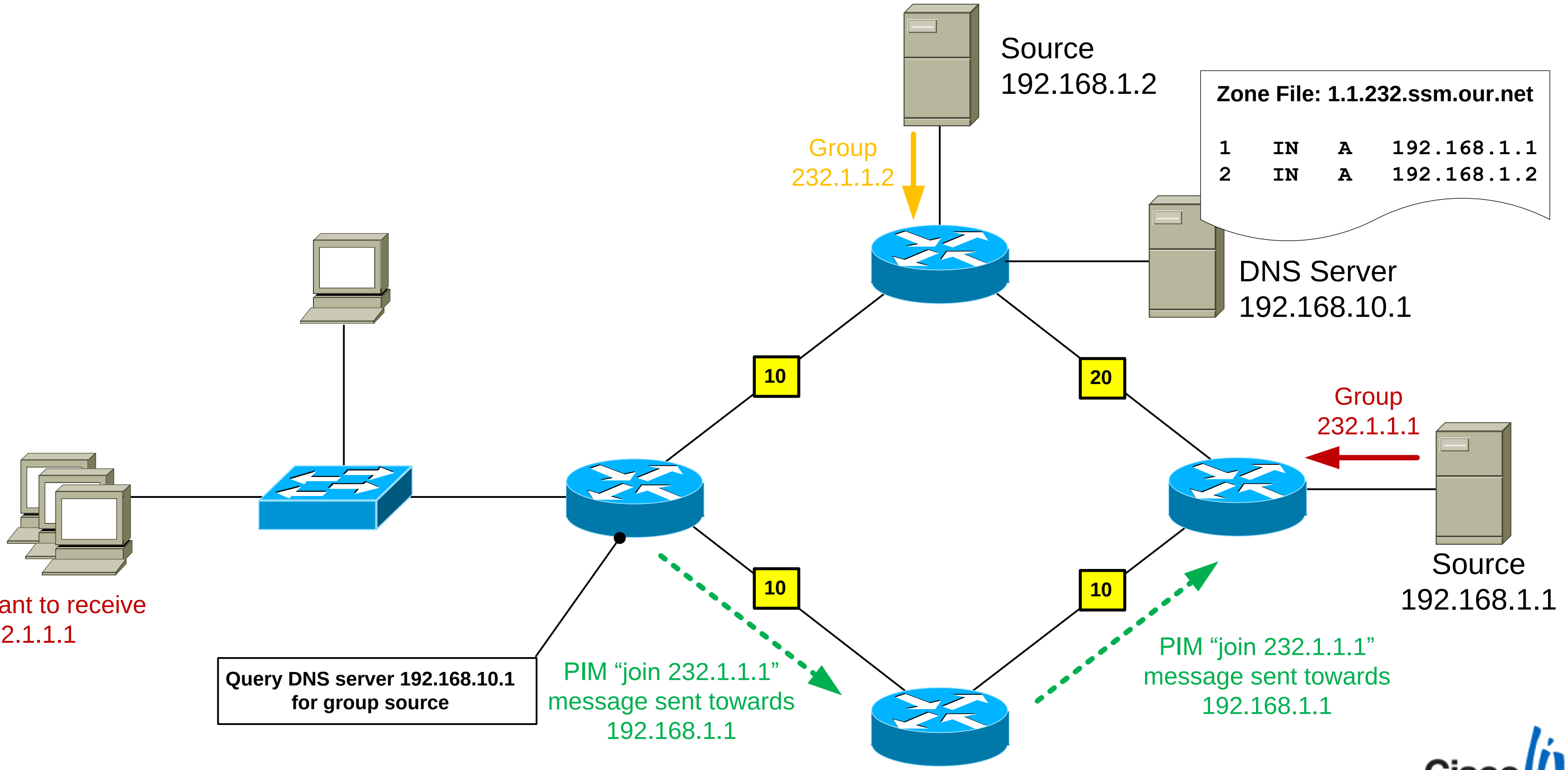


Zone File: 1.1.232.ssm.our.net

```
1   IN   A    192.168.1.1
2   IN   A    192.168.1.2
```

Query DNS server 192.168.10.1 for group source

PIM-SSM Dynamic (DNS) Mapping



Source
192.168.1.2

Group
232.1.1.2

Zone File: 1.1.232.ssm.our.net

```
1    IN    A    192.168.1.1
2    IN    A    192.168.1.2
```

DNS Server
192.168.10.1

Group
232.1.1.1

Source
192.168.1.1

I want to receive
232.1.1.1

Query DNS server 192.168.10.1 for group source

PIM “join 232.1.1.1” message sent towards 192.168.1.1

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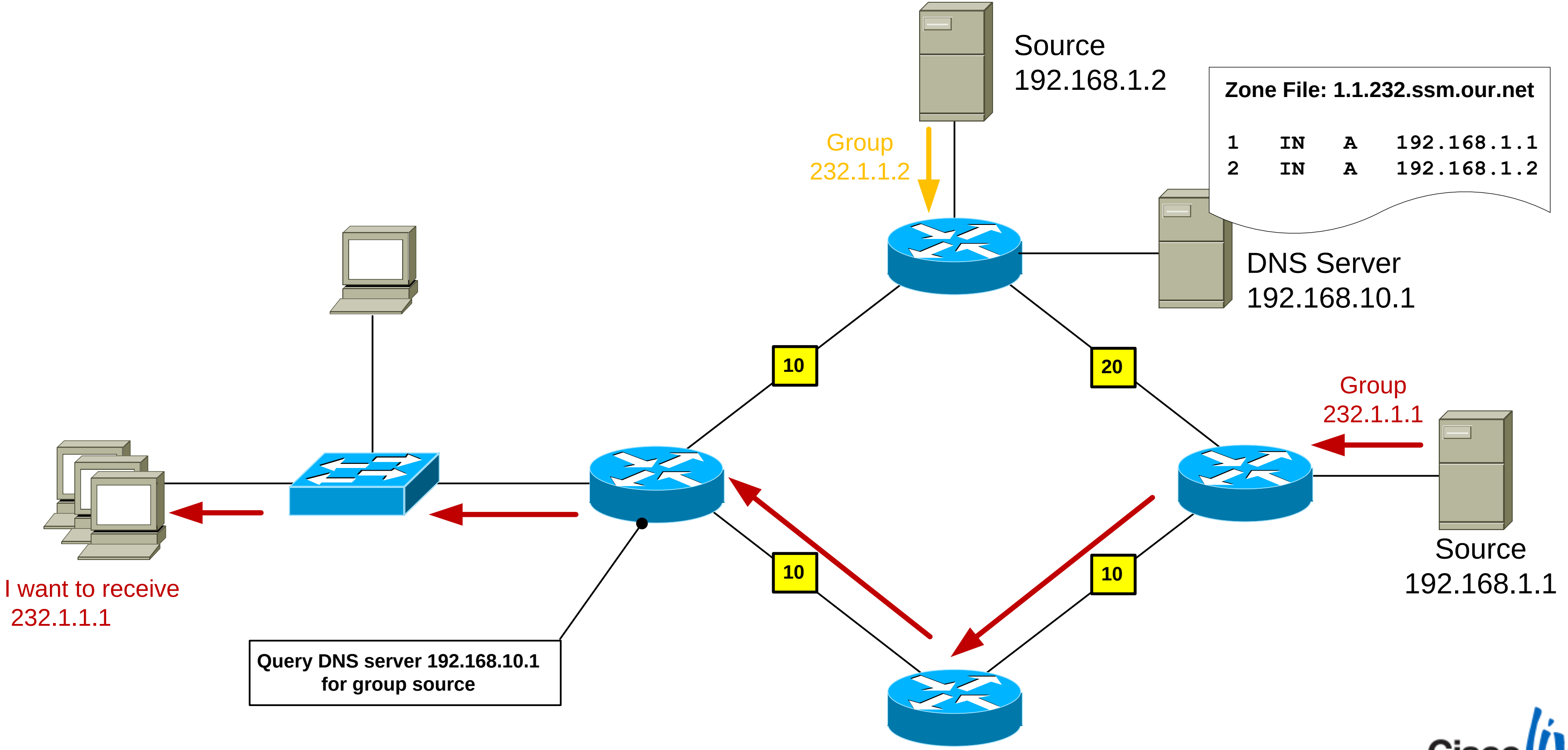
PIM-SSM Dynamic (DNS) Mapping

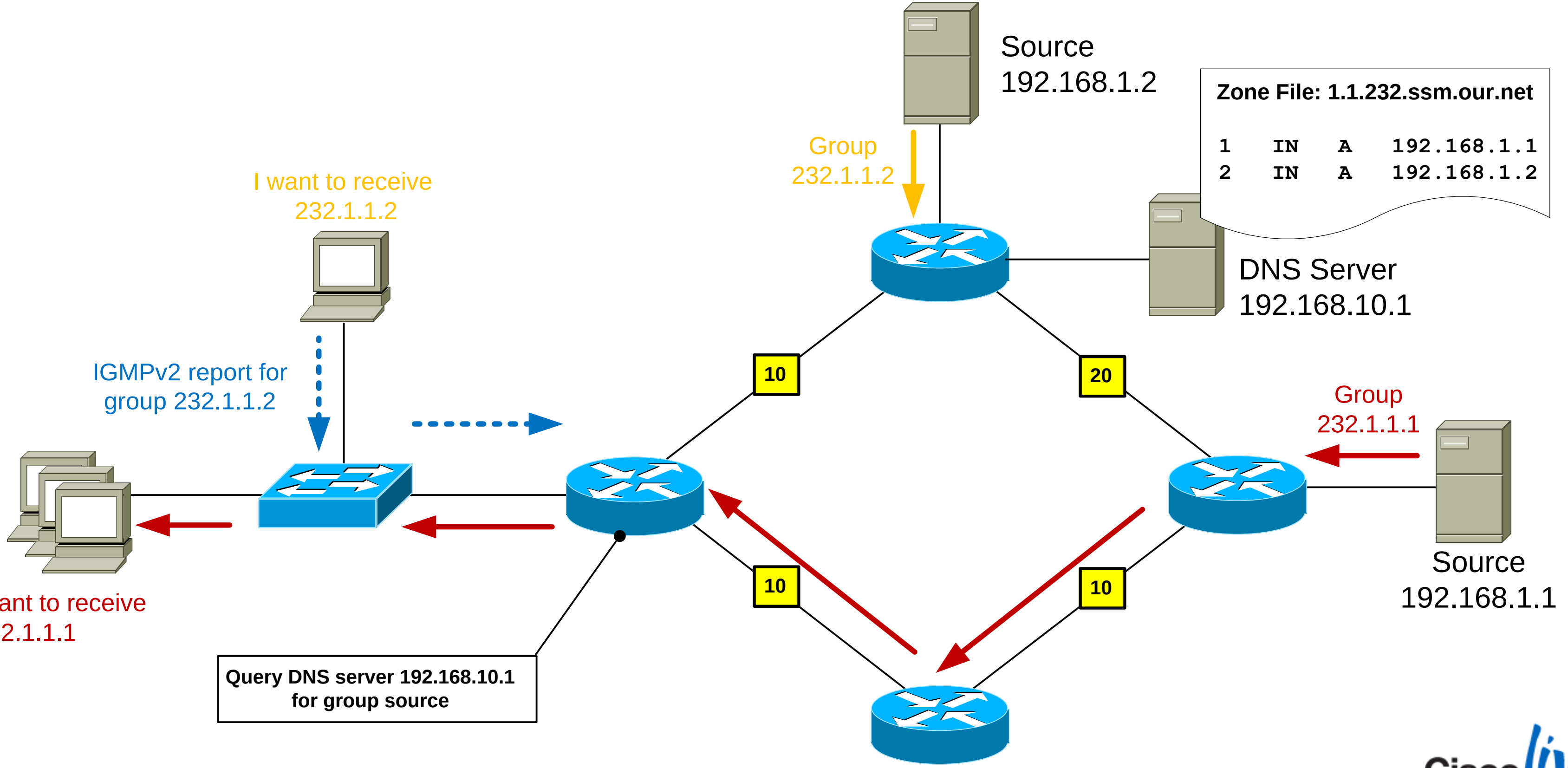


Zone File: 1.1.232.ssm.our.net

```
1   IN   A   192.168.1.1
2   IN   A   192.168.1.2
```

Query DNS server 192.168.10.1 for group source

PIM-SSM Dynamic (DNS) Mapping

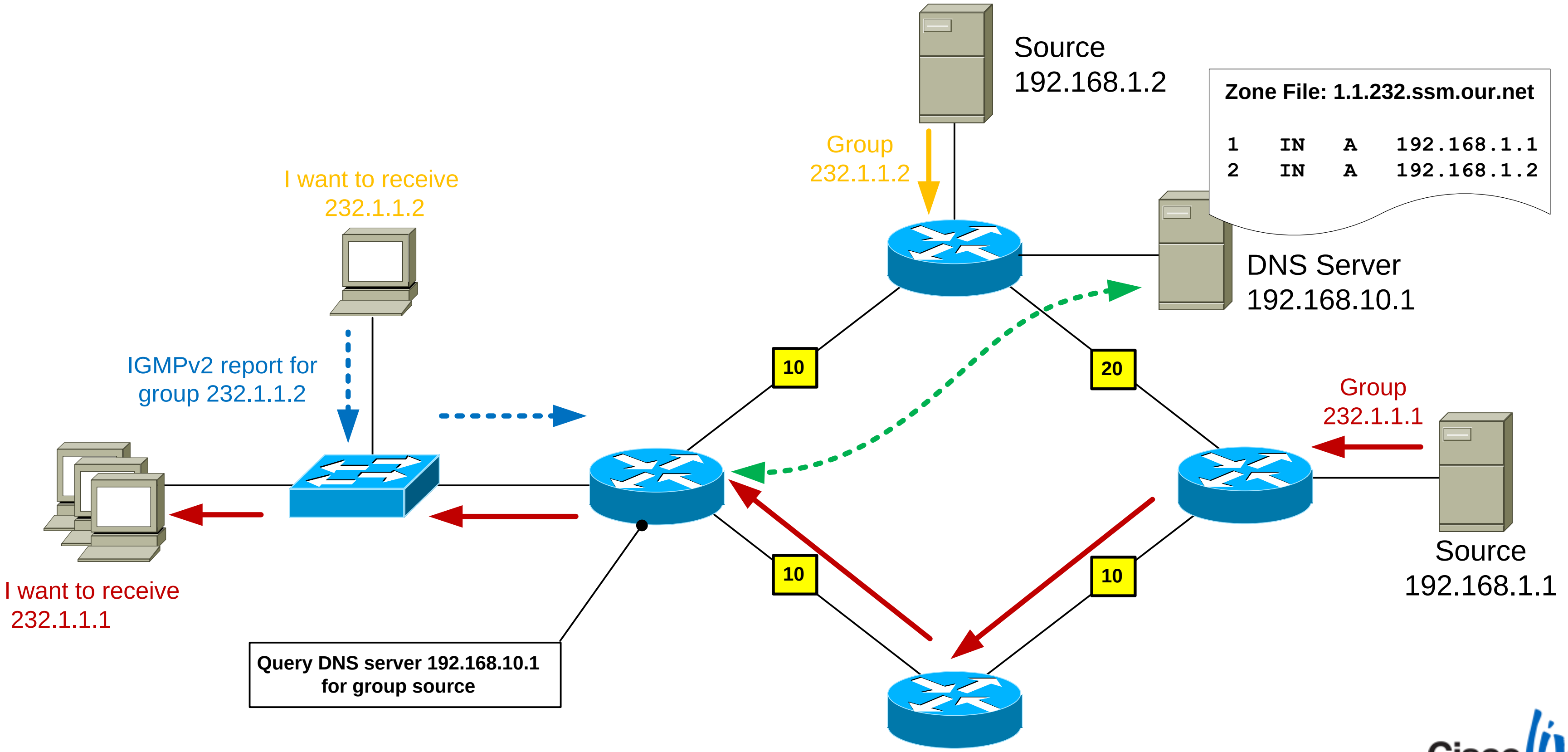


Zone File: 1.1.232.ssm.our.net

```
1    IN    A    192.168.1.1
2    IN    A    192.168.1.2
```

Query DNS server 192.168.10.1 for group source

PIM-SSM Dynamic (DNS) Mapping



Source 192.168.1.2

Group 232.1.1.2

Zone File: 1.1.232.ssm.our.net

```
1    IN    A    192.168.1.1
2    IN    A    192.168.1.2
```

DNS Server 192.168.10.1

I want to receive 232.1.1.2

IGMPv2 report for group 232.1.1.2

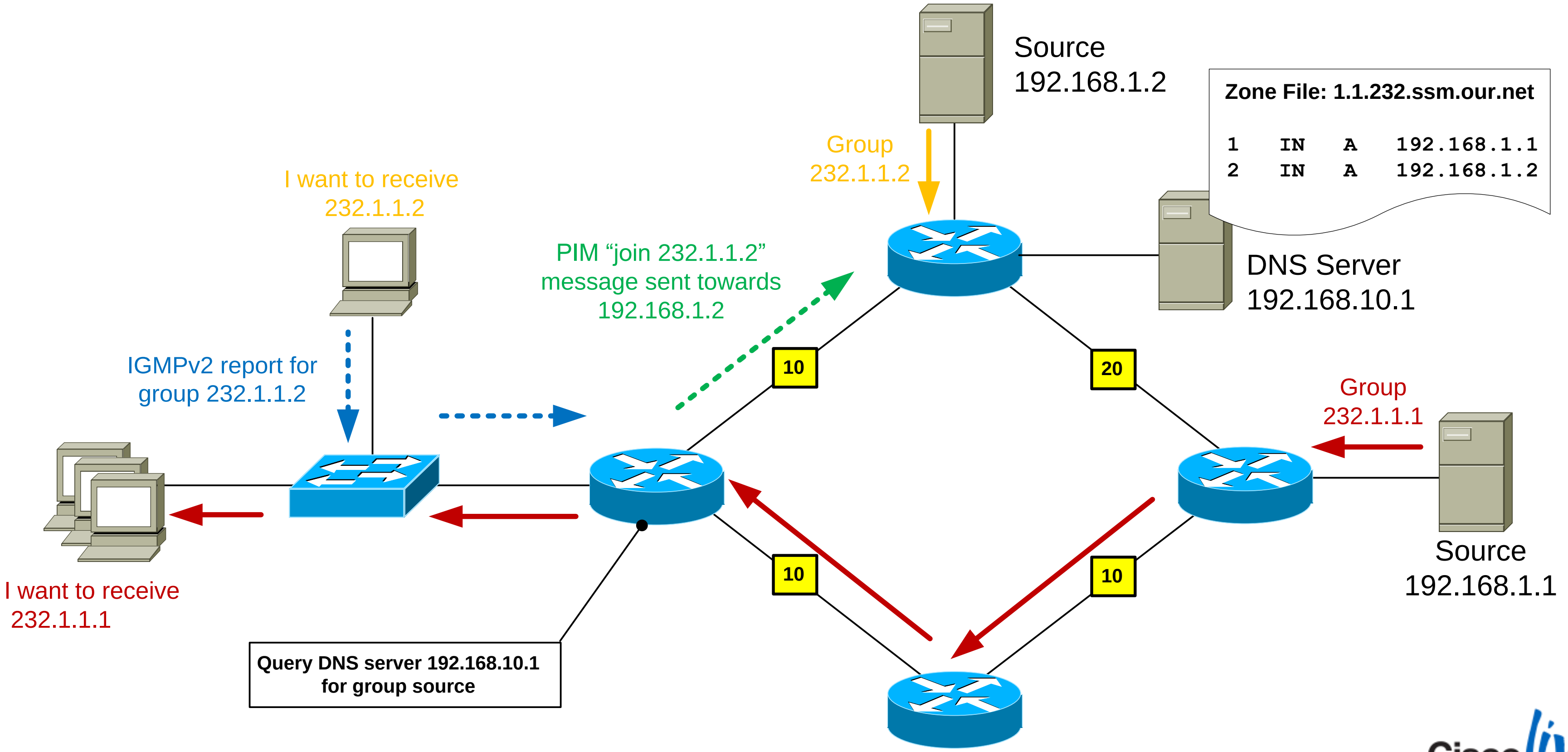
Group 232.1.1.1

Source 192.168.1.1

I want to receive 232.1.1.1

Query DNS server 192.168.10.1 for group source

PIM-SSM Dynamic (DNS) Mapping



Source
192.168.1.2

Zone File: 1.1.232.ssm.our.net

```
1    IN    A    192.168.1.1
2    IN    A    192.168.1.2
```

Group
232.1.1.2

I want to receive
232.1.1.2

PIM "join 232.1.1.2" message sent towards 192.168.1.2

DNS Server
192.168.10.1

IGMPv2 report for group 232.1.1.2

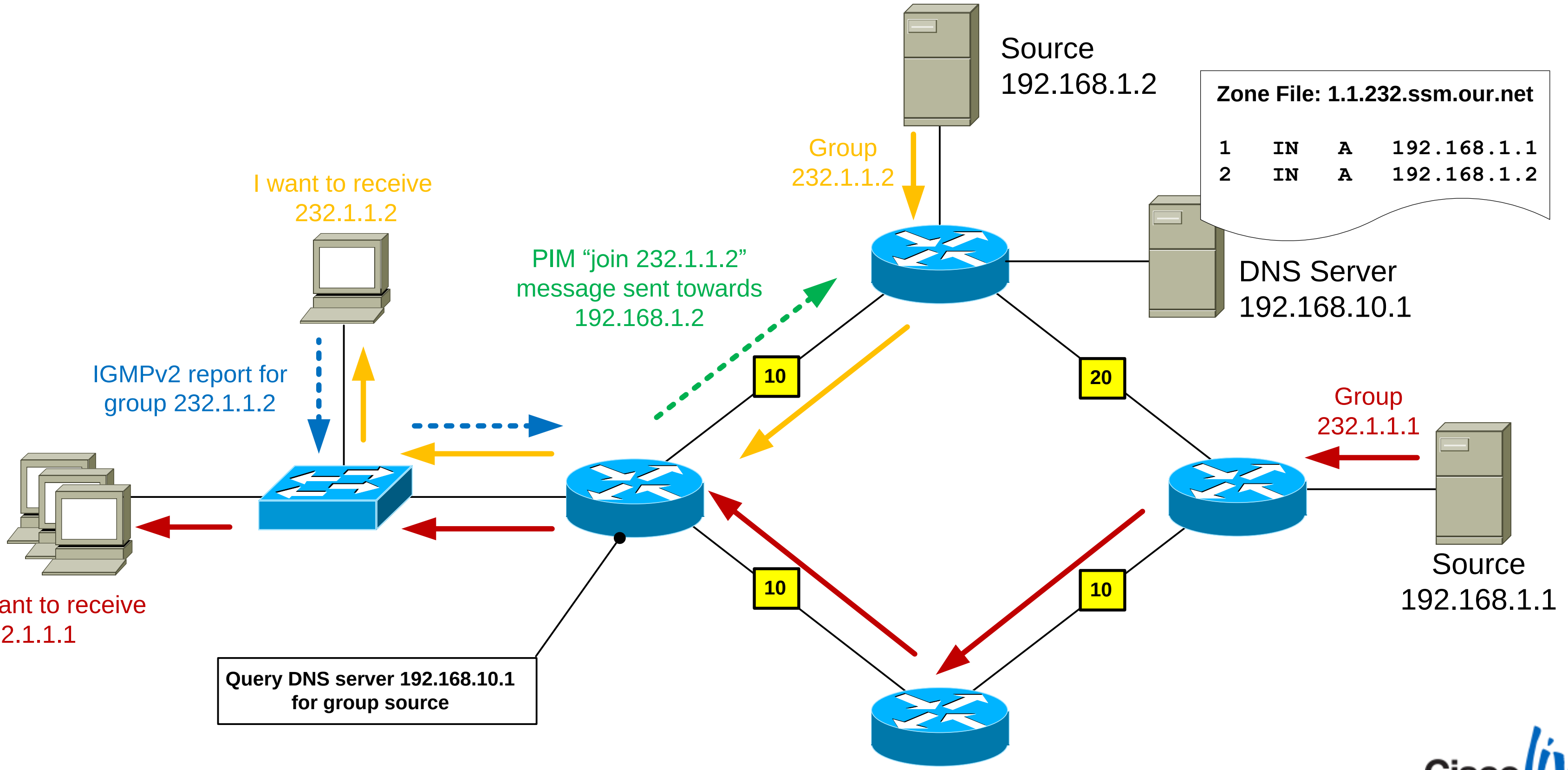
Group
232.1.1.1

Source
192.168.1.1

I want to receive
232.1.1.1

Query DNS server 192.168.10.1 for group source

PIM-SSM Dynamic (DNS) Mapping



Source
192.168.1.2

Zone File: 1.1.232.ssm.our.net

```
1    IN    A    192.168.1.1
2    IN    A    192.168.1.2
```

Group
232.1.1.2

I want to receive
232.1.1.2

PIM “join 232.1.1.2”
message sent towards
192.168.1.2

DNS Server
192.168.10.1

IGMPv2 report for
group 232.1.1.2

Group
232.1.1.1

Source
192.168.1.1

I want to receive
232.1.1.1

Query DNS server 192.168.10.1
for group source

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

IPv4 vs. IPv6 Multicast

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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

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

IPv4 vs. IPv6 Multicast

A quick glimpse

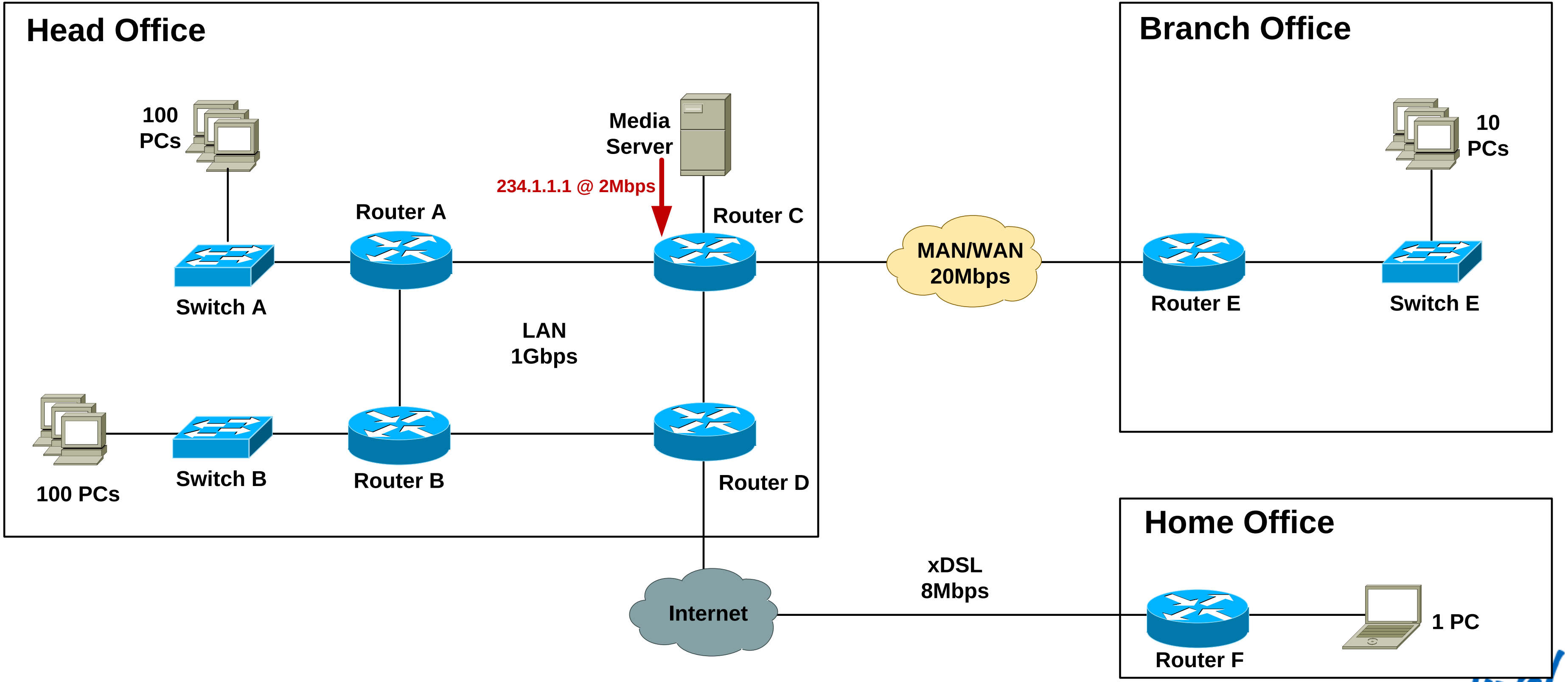
IP Service	IPv4 Solution	IPv6 Solution
Address Range	32-Bit, Class D	128-Bit (112-Bit Group)
Routing	Protocol-Independent All IGPs and BGPv4+	Protocol-Independent All IGPs and BGPv4+ with IPv6 Mcast SAFI
Forwarding	PIM-DM, PIM-SM: ASM, SSM, BiDir	PIM-SM: ASM, SSM, BiDir
Group Management	IGMPv1, v2, v3	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

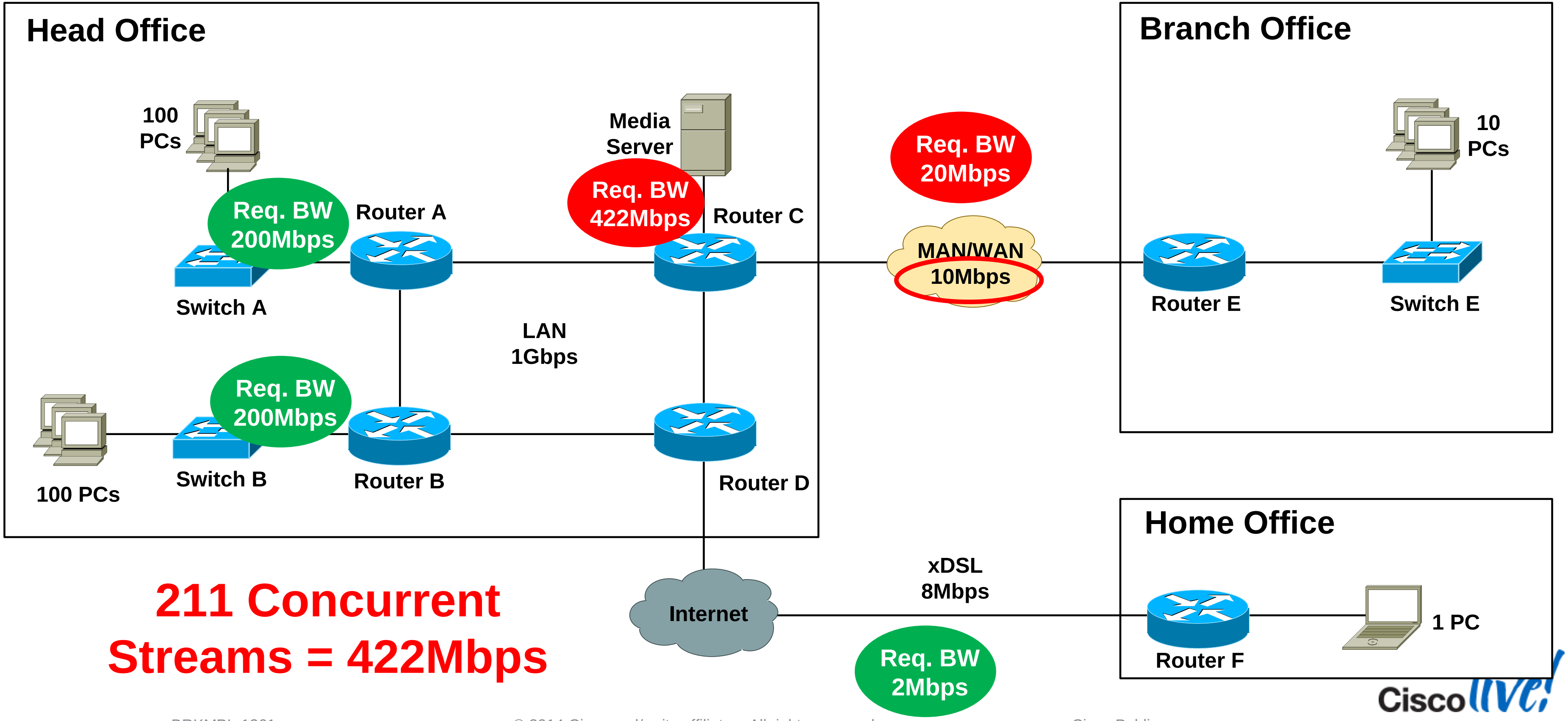
Case Study - Background

- 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

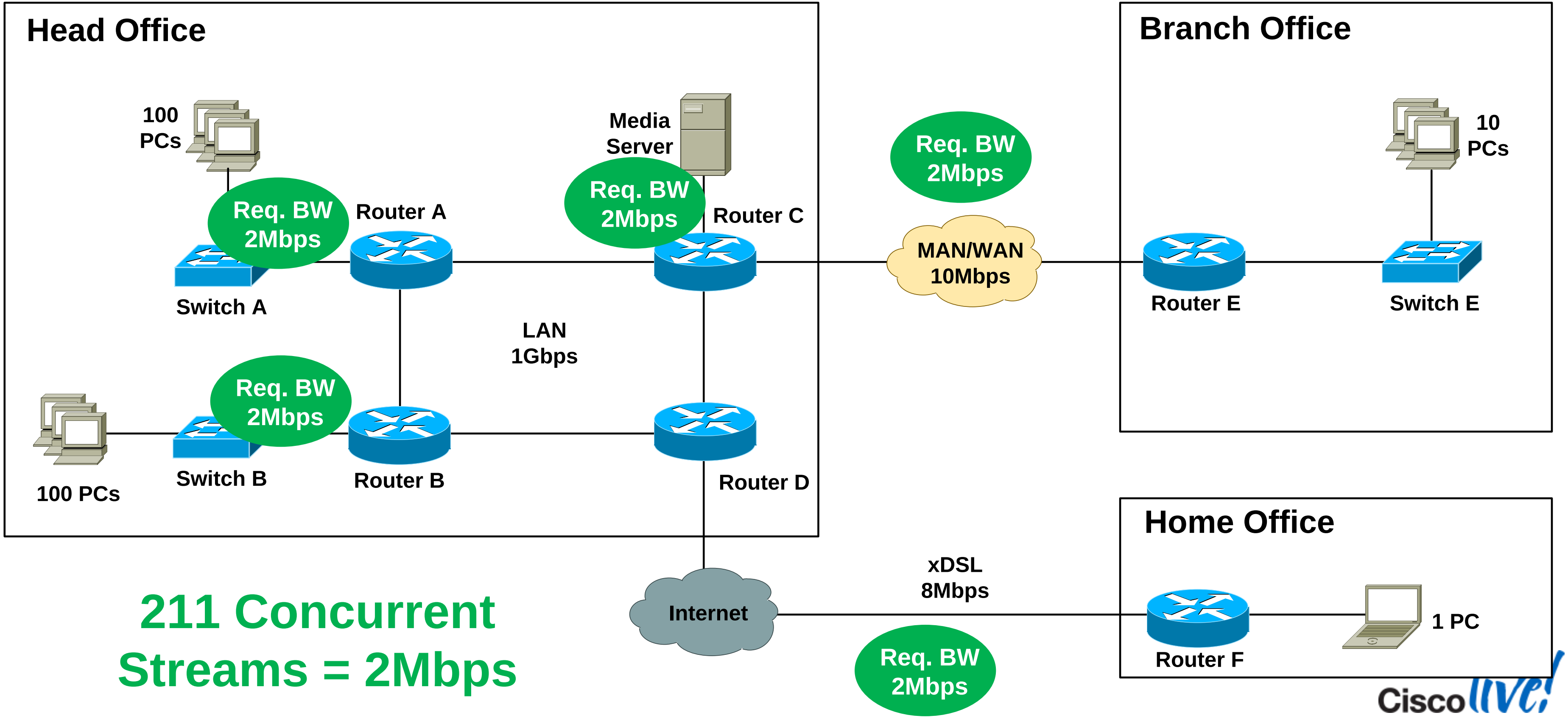


Case Study – Unicast Bandwidth Scenario



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:

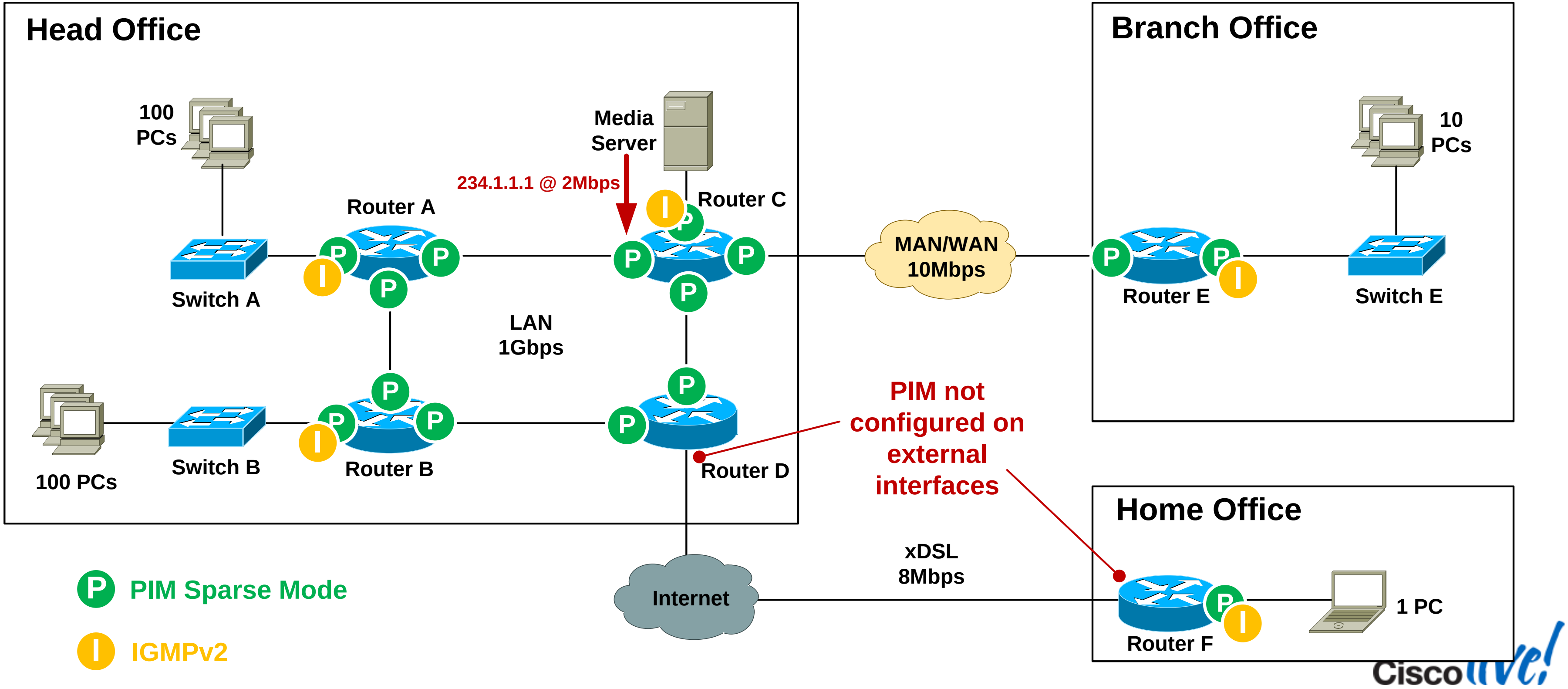
```
Router_A(config)#ip multicast-routing
Router_A(config)#do show ip multicast global
        Multicast Routing: enabled
        Multicast Multipath: disabled
        Multicast Route limit: No limit
        Multicast Triggered RPF check: enabled
        Multicast Fallback group mode: Sparse
Router_A(config)#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

- Configure P

```
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#
```

- enabled on that interface.

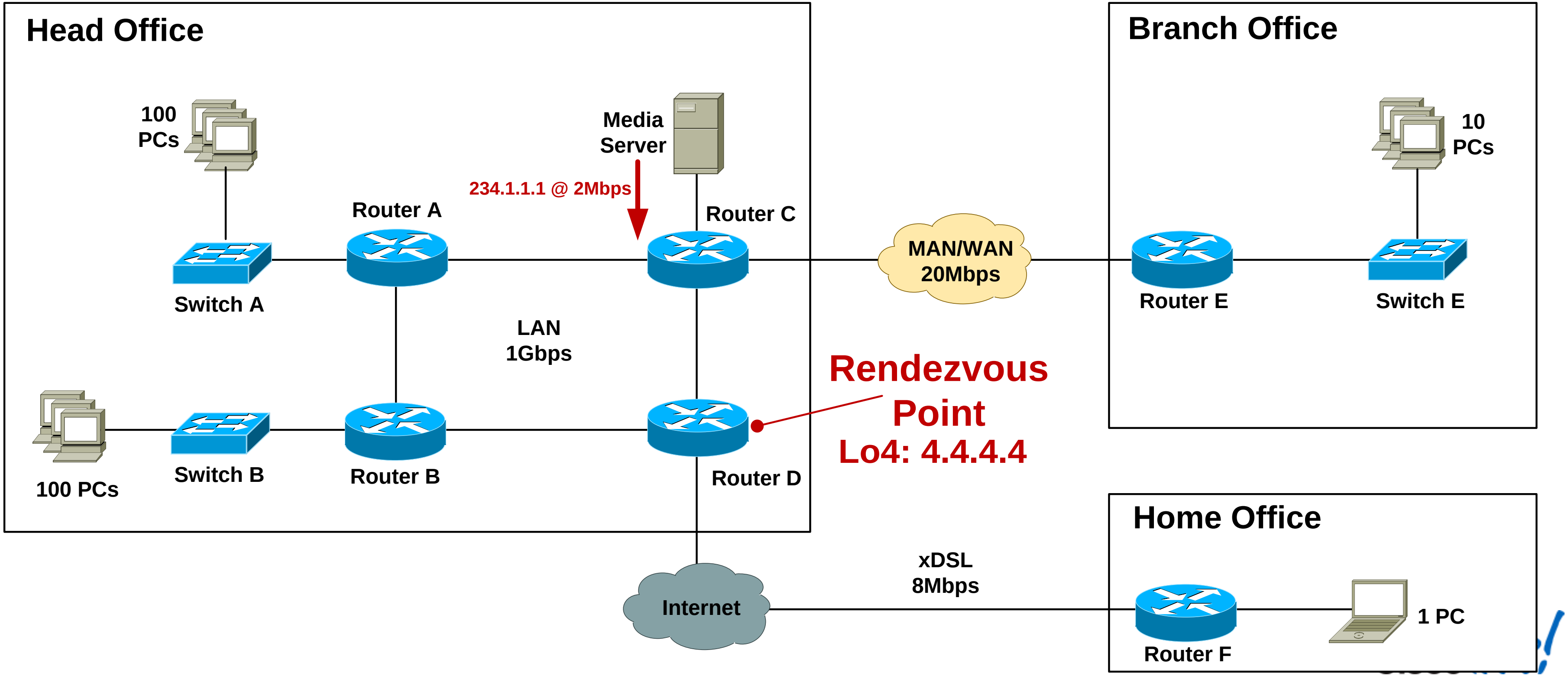
Case Study – ASM

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#
```

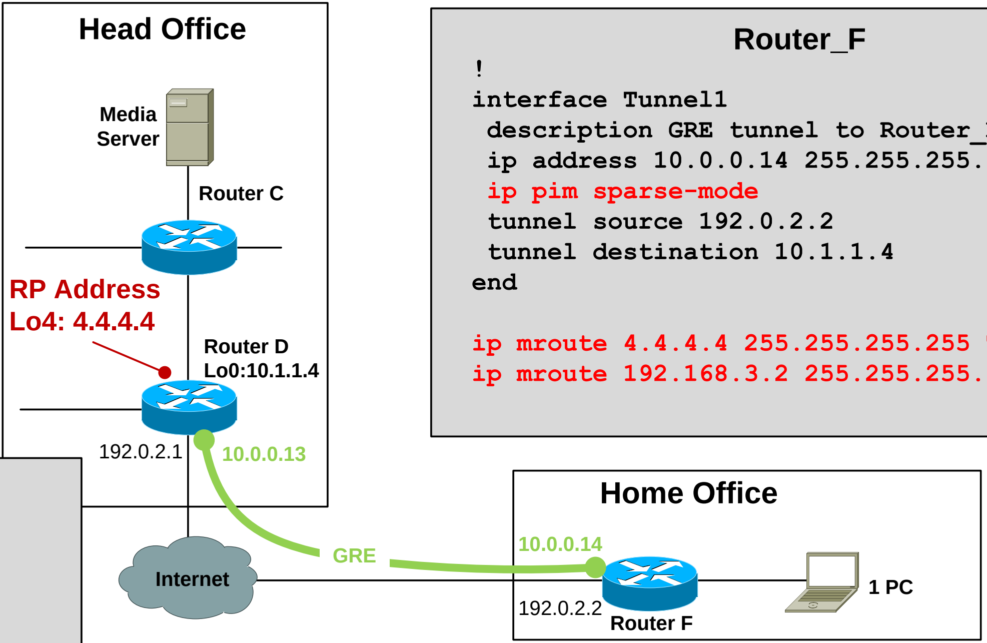
Case Study – ASM

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

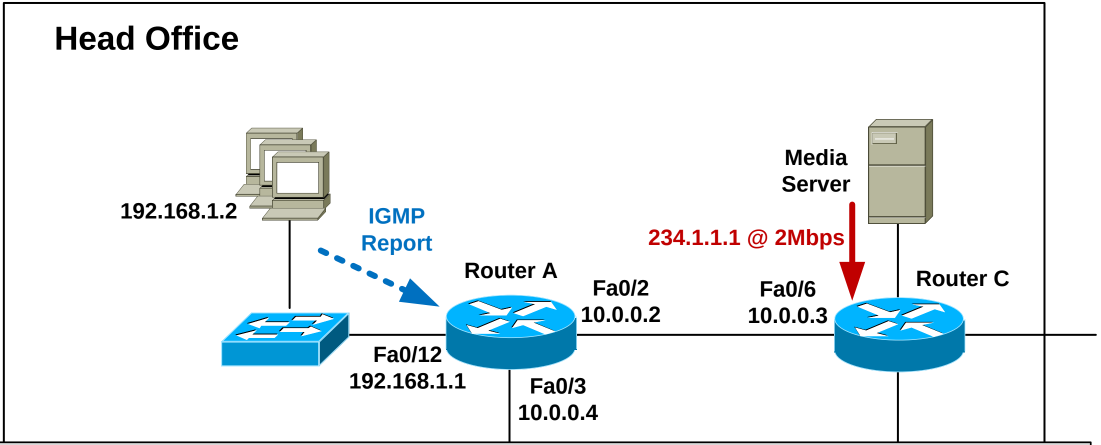
```
!
interface Tunnel1
 description GRE tunnel to Router_D
 ip address 10.0.0.14 255.255.255.252
 ip pim sparse-mode
 tunnel source 192.0.2.2
 tunnel destination 10.1.1.4
end

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

Router_D

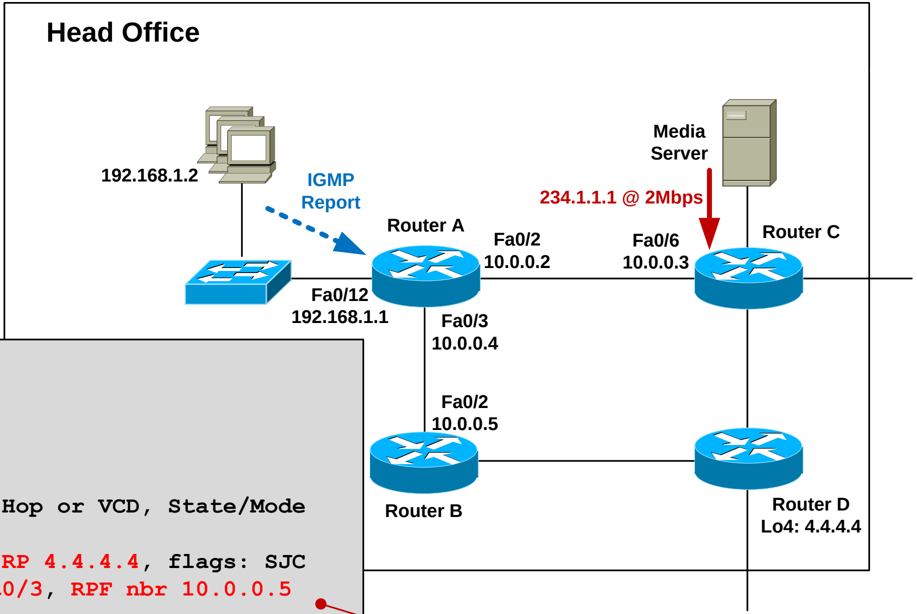
```
!
interface Tunnel1
 description GRE tunnel to Router_F
 ip address 10.0.0.13 255.255.255.252
 ip pim sparse-mode
 tunnel source 10.1.1.4
 tunnel destination 192.0.2.2
end
```

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
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
```

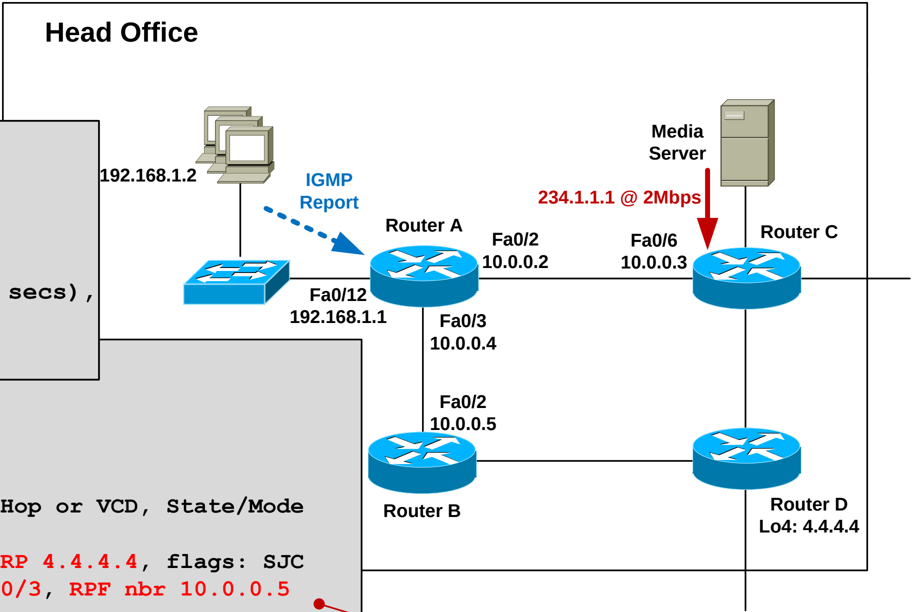
How Router_A receives MC traffic via the RP (src IP unknown)

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

Case Study – 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

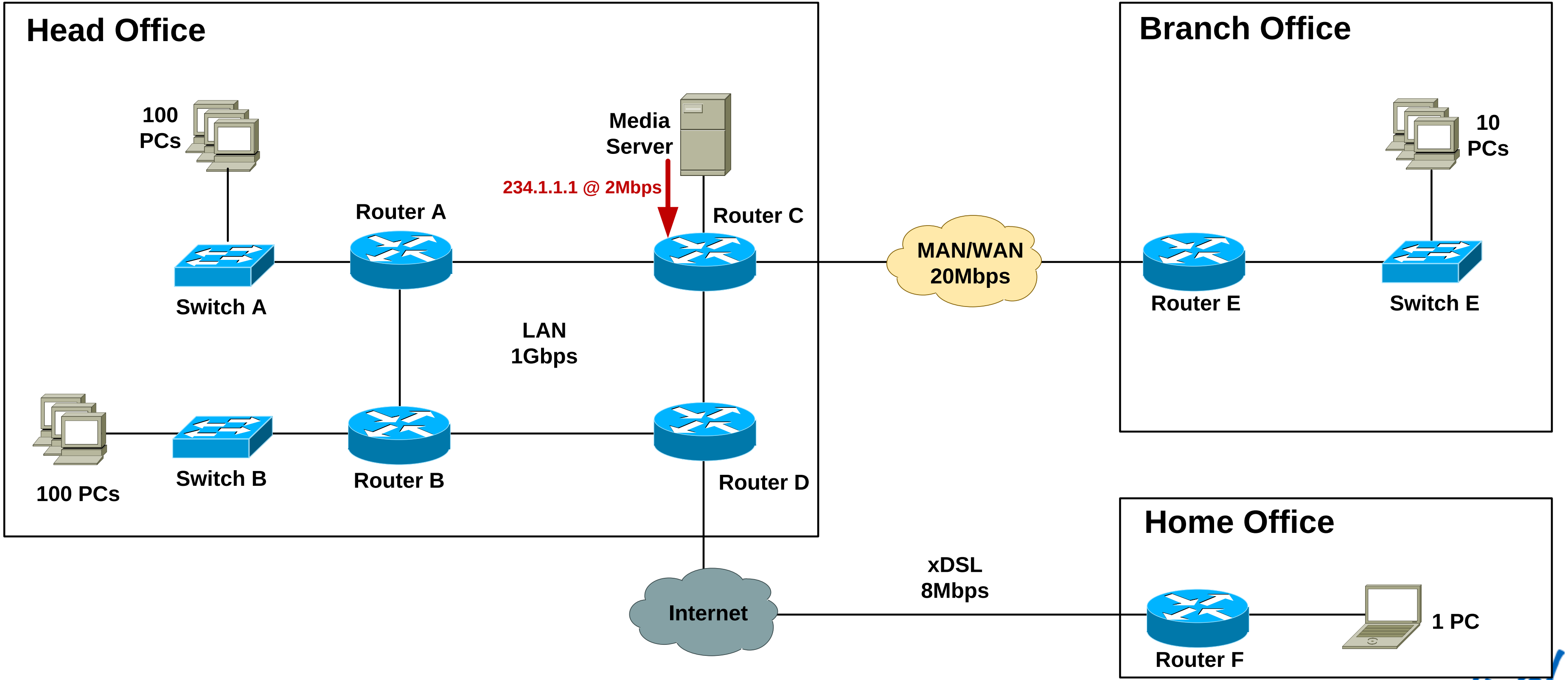
  Network runs PIM-SSM

- 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

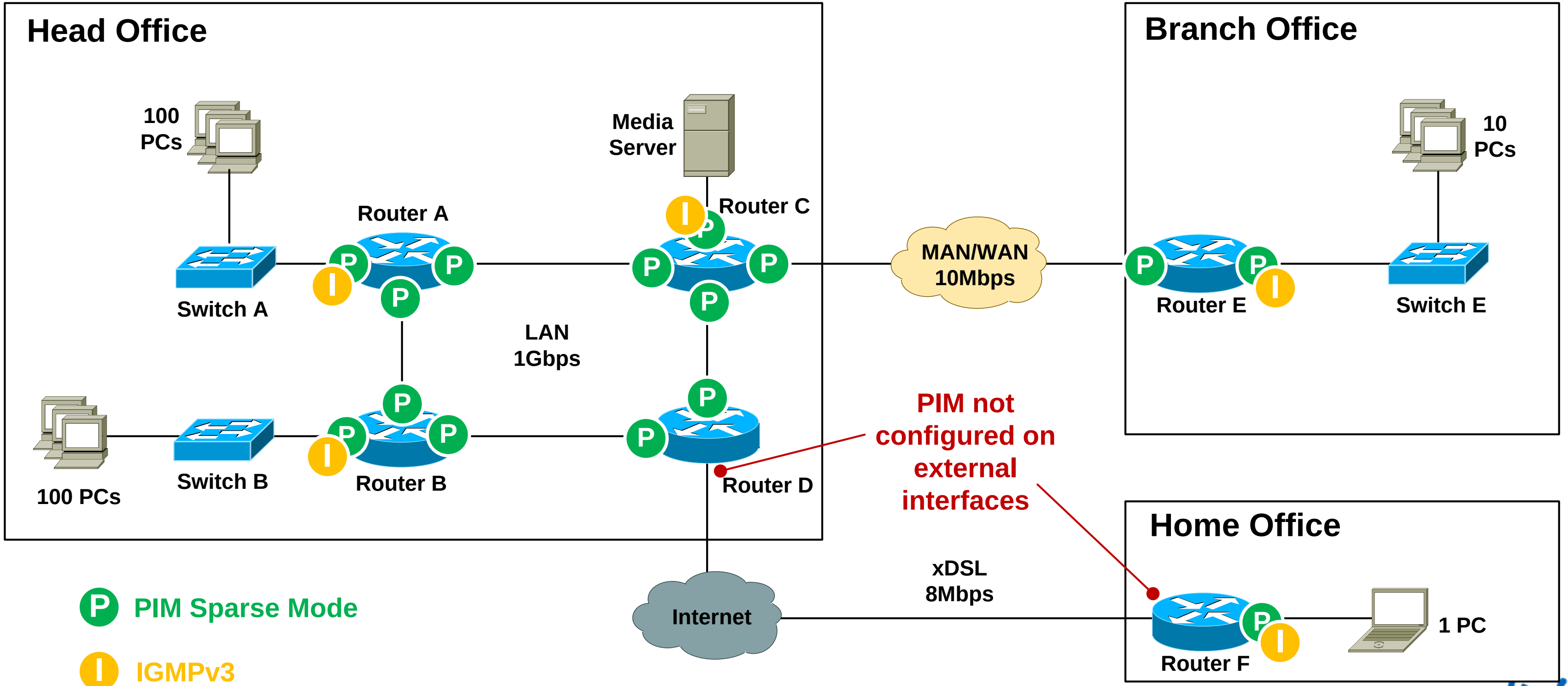
- IGMPv3 snooping enabled by default on Cisco devices
- Need to explicitly configure IGMPv3 on router interface that connects to LAN

```
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



PIM not configured on external interfaces

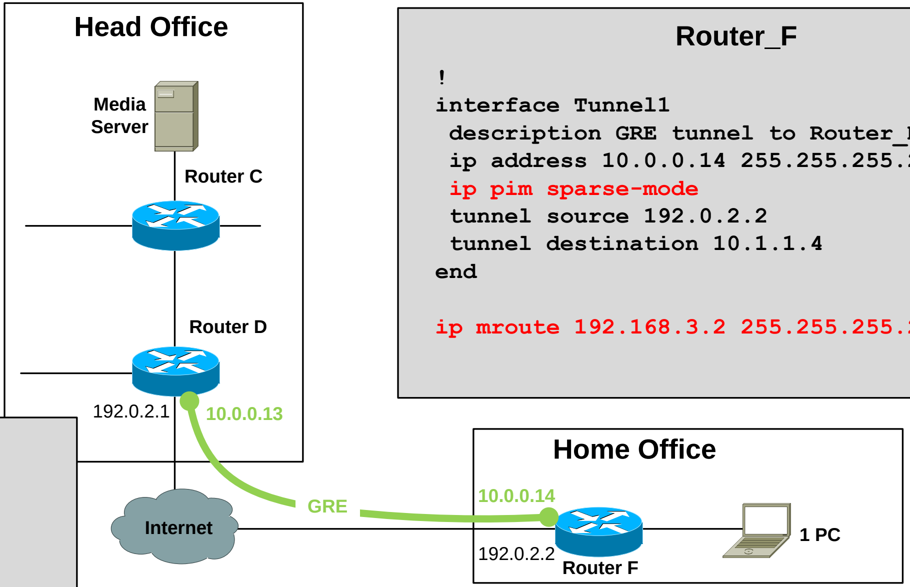
P PIM Sparse Mode

I IGMPv3

Case Study – SSM

Step 4: Enable multicast over non-multicast networks

- Need a static mroute for MC source only



Router_F

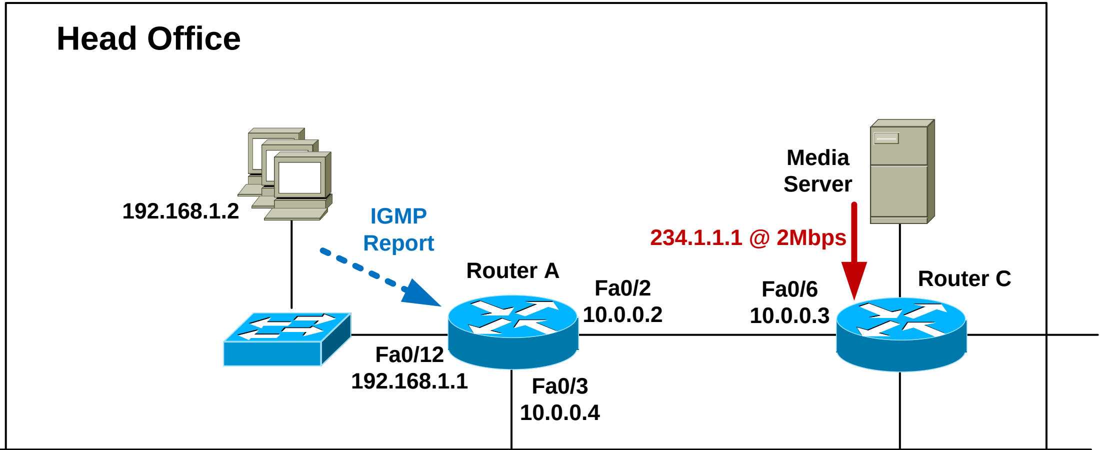
```
!
interface Tunnel1
 description GRE tunnel to Router_D
 ip address 10.0.0.14 255.255.255.252
 ip pim sparse-mode
 tunnel source 192.0.2.2
 tunnel destination 10.1.1.4
end

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



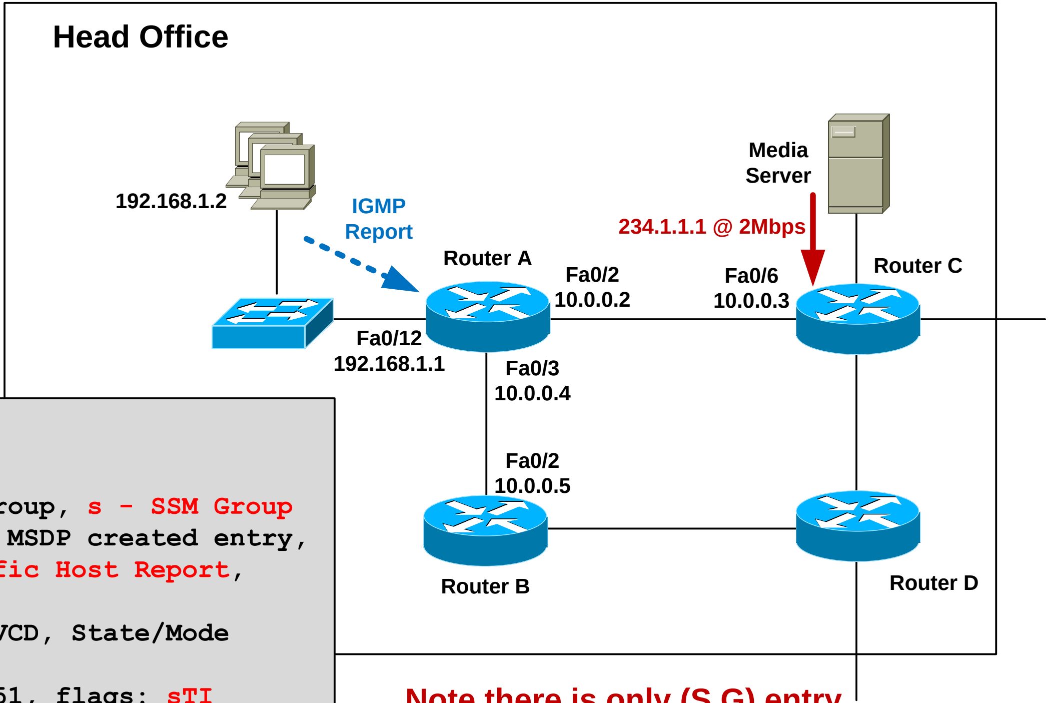
```
Router_A#show ip igmp membership

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
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

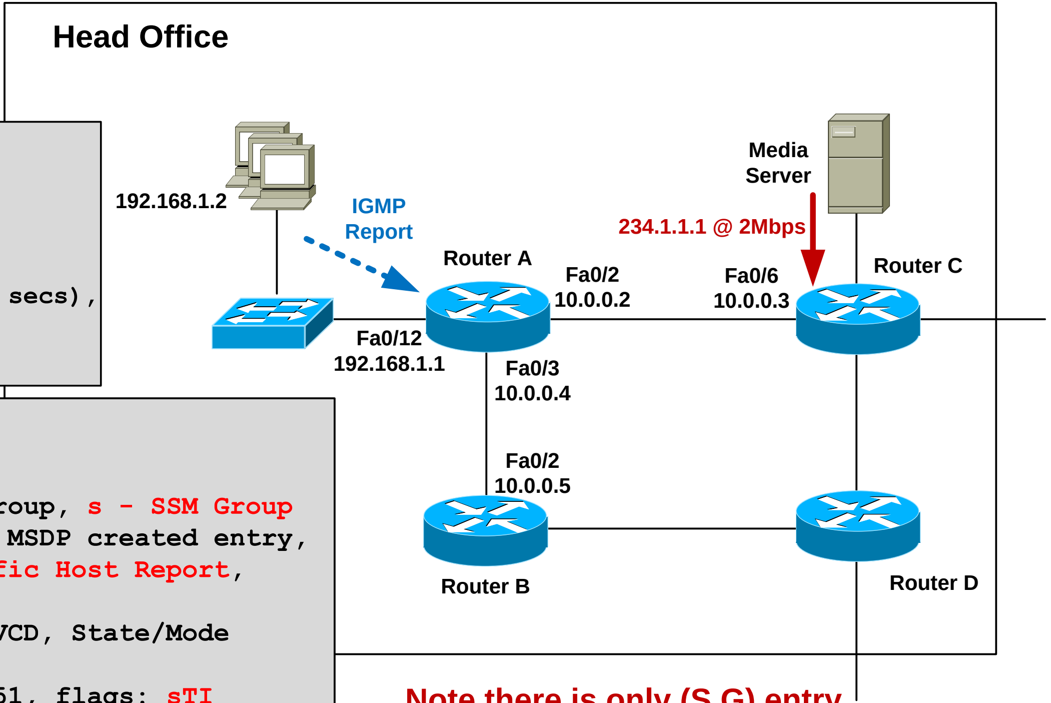
(192.168.3.2, 234.1.1.1), 00:59:25/00:02:51, flags: sTI
  Incoming interface: FastEthernet0/2, RPF nbr 10.0.0.3
  Outgoing interface list:
    FastEthernet0/12, Forward/Sparse, 00:59:01/00:02:05
```

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

Case Study – 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

Step 2: Configure all routers for multicast-routing

Step 3: Enable PIM-SM (even though we are using SSM)
on all internal interfaces)

Case Study – IGMPv2 + PIM-SSM

Step 4: 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 5a: 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 5b: Configure dynamic IGMP SSM mapping

- Globally enable IGMP mapping

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

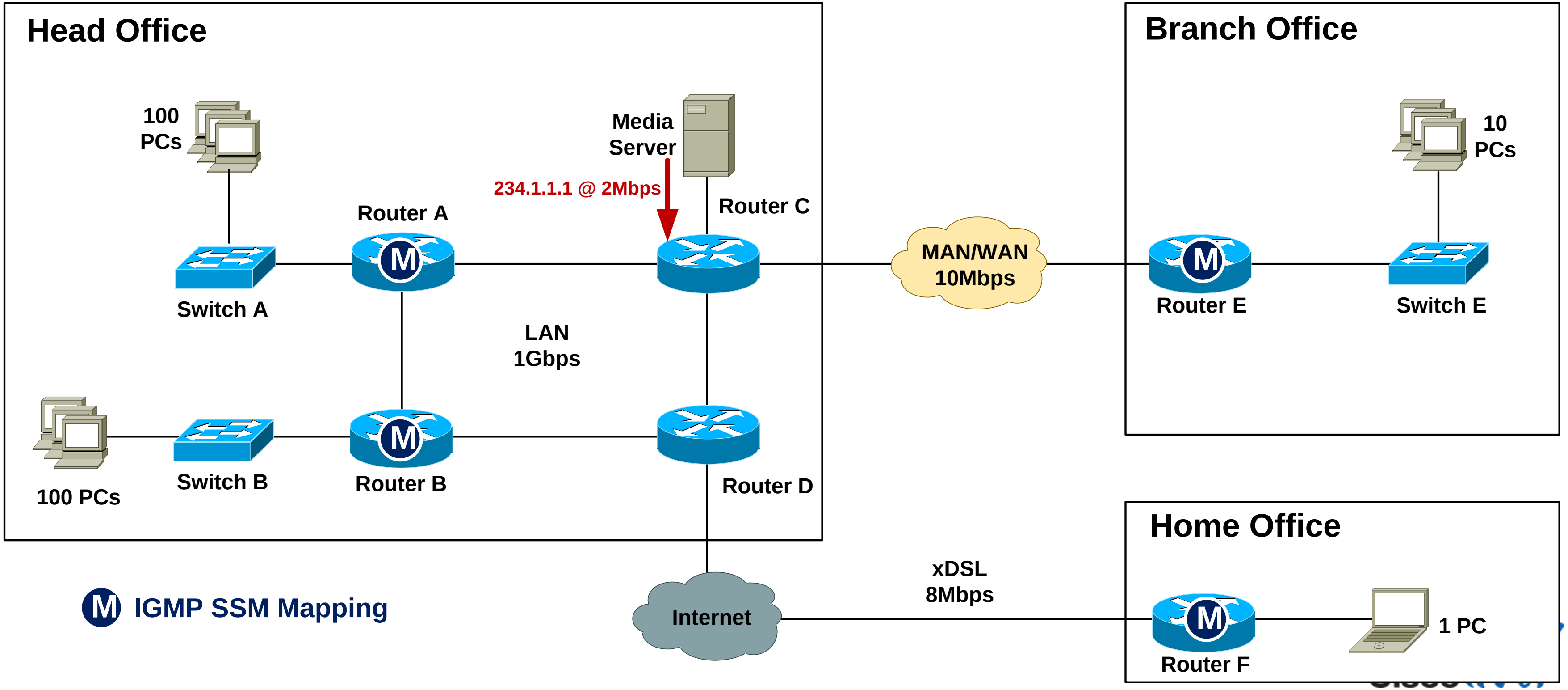
- Configure dynamic group-to-source mapping using DNS:

```
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#
```

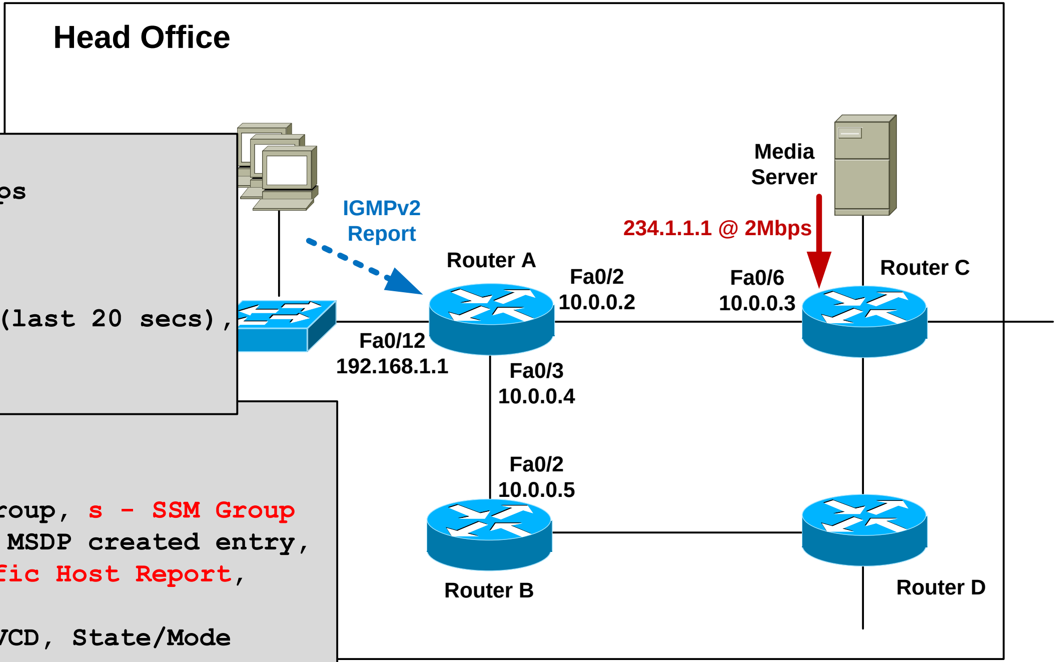
Case Study – SSM Mapping – Verification

```
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

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

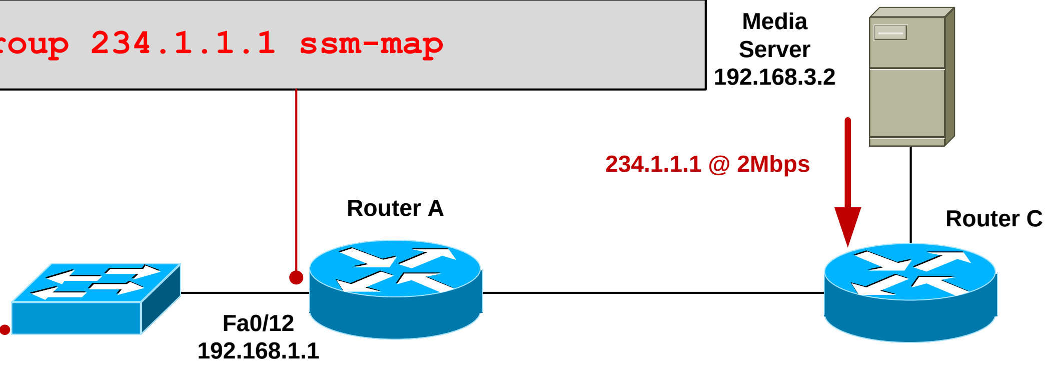
or

! 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
```

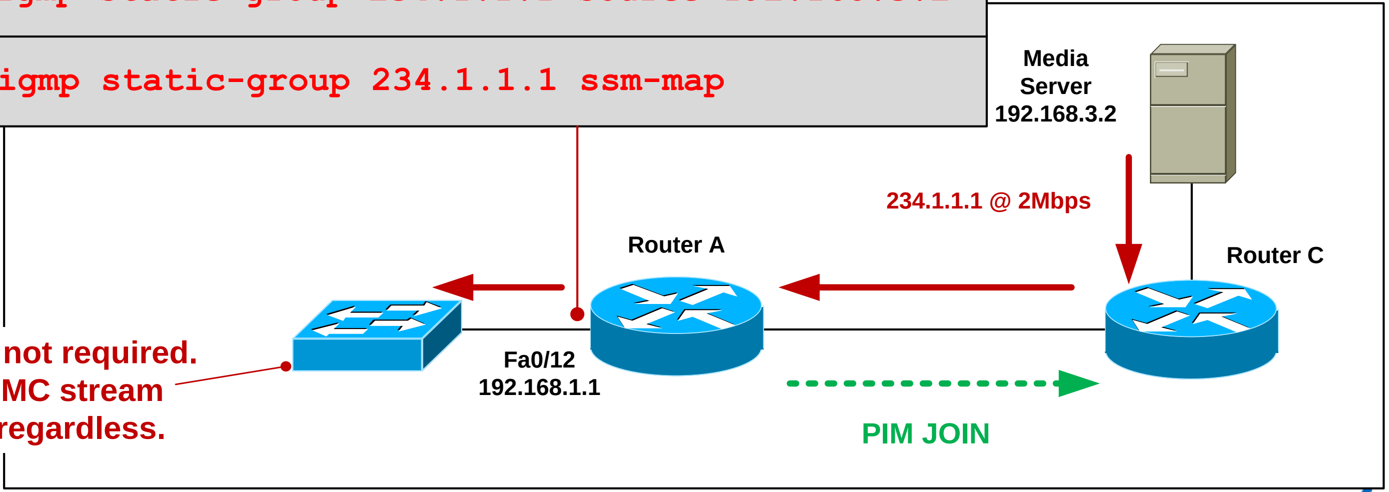


Receivers are not required. Just send the MC stream onto the LAN regardless.

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
```



Receivers are not required. Just send the MC stream onto the LAN regardless.

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

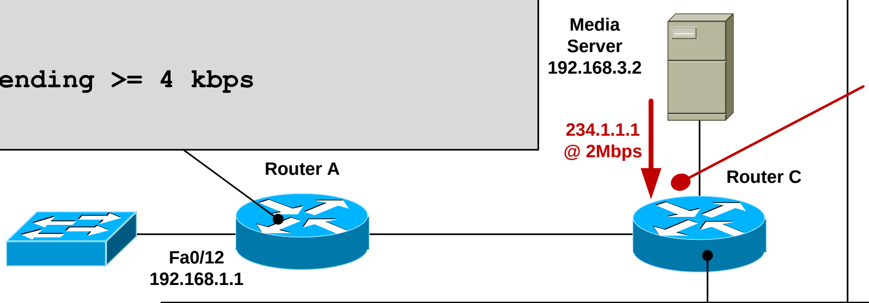
Group: 234.1.1.1, (Stream_1)
   Source: 192.168.3.2 (Media_Server)
     Rate: 165 pps/1324 kbps(1sec), 1964 kbps(last 30 secs), 1963 kbps(life avg)
Router_C#
```

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 (!)

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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)

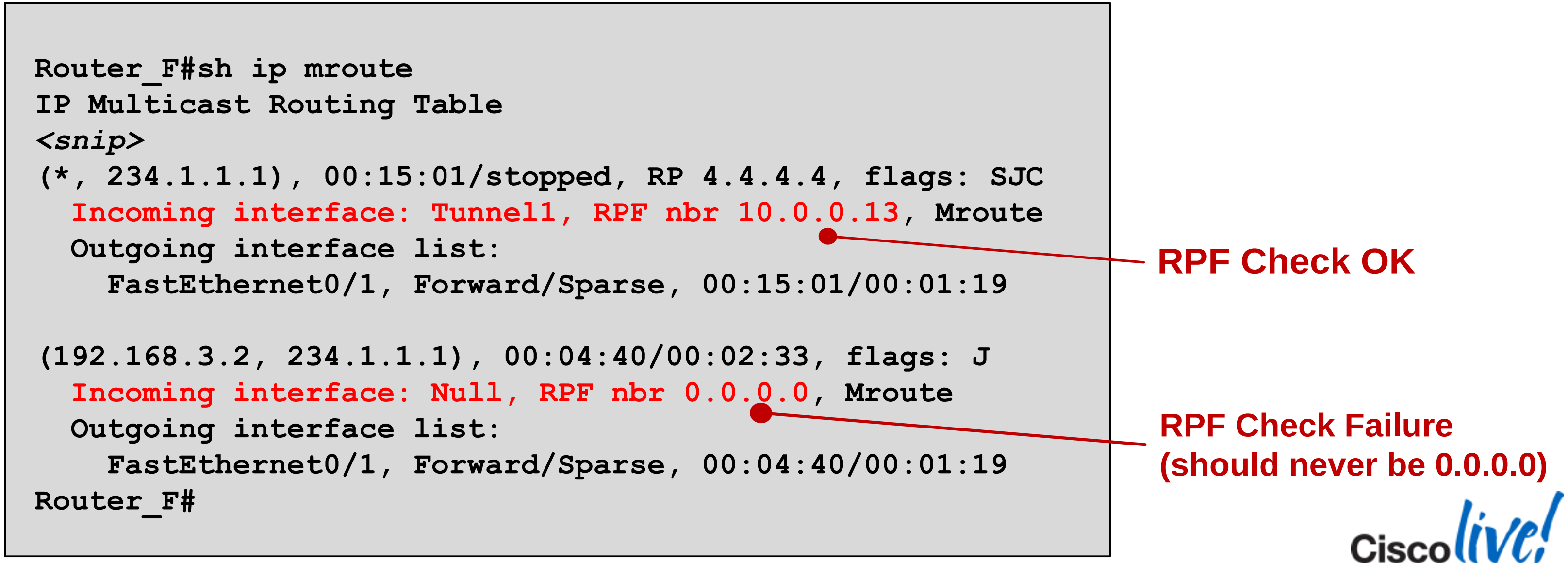
```
Router_F#sh ip mroute
IP Multicast Routing Table
<snip>
 Timers: Uptime/Expires
 Interface state: Interface, Next-Hop or VCD, State/Mode

(*, 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
```

Missing RP configuration

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-2615: Implementing Enterprise TelePresence and Video Communications Solutions
  - BRKRST-2311: IPv6 Planning, Deployment and Operations
  - BRKRST-1069: Understanding IPv6
  - BRKSPV-1999: IPTV and Over-the-Top Video
- Cisco Live “Meet the Expert” sessions
- CCO documentation: http://www.cisco.com/go/multicast

Q & A

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