- Routing Information Protocol -

RIP (Routing Information Protocol)

RIP is a standardized Distance Vector protocol, designed for use on smaller networks. RIP was one of the first true Distance Vector routing protocols, and is supported on a wide variety of systems.

RIP adheres to the following Distance Vector characteristics:

- RIP sends out periodic routing updates (every **30 seconds**)
- RIP sends out the full routing table every periodic update
- RIP uses a form of distance as its metric (in this case, **hopcount**)
- RIP uses the Bellman-Ford Distance Vector algorithm to determine the best "path" to a particular destination

Other characteristics of RIP include:

- RIP supports IP and IPX routing.
- RIP utilizes UDP port 520
- RIP routes have an administrative distance of **120**.
- RIP has a maximum hopcount of **15 hops.**

Any network that is 16 hops away or more is considered unreachable to RIP, thus the maximum diameter of the network is 15 hops. A metric of 16 hops in RIP is considered a **poison route** or **infinity metric.**

If multiple paths exist to a particular destination, RIP will load balance between those paths (by default, up to **4**) only if the metric (hopcount) is **equal**. RIP uses a round-robin system of load-balancing between equal metric routes, which can lead to **pinhole congestion**.

For example, two paths might exist to a particular destination, one going through a 9600 baud link, the other via a T1. If the metric (hopcount) is equal, RIP will load-balance, sending an equal amount of traffic down the 9600 baud link and the T1. This will (obviously) cause the slower link to become congested.

* * *

RIP Versions

RIP has two versions, **Version 1** (**RIPv1**) and **Version 2** (**RIPv2**).

RIPv1 (RFC 1058) is **classful**, and thus does not include the subnet mask with its routing table updates. Because of this, RIPv1 does not support **Variable Length Subnet Masks (VLSMs**). When using RIPv1, networks must be contiguous, and subnets of a major network must be configured with identical subnet masks. Otherwise, route table inconsistencies (or worse) will occur.

RIPv1 sends updates as **broadcasts** to address 255.255.255.255.

RIPv2 (RFC 2543) is **classless**, and thus *does* include the subnet mask with its routing table updates. RIPv2 fully supports VLSMs, allowing discontiguous networks and varying subnet masks to exist.

Other enhancements offered by RIPv2 include:

- Routing updates are sent via **multicast**, using address **224.0.0.9**
- Encrypted authentication can be configured between RIPv2 routers
- Route tagging is supported (explained in a later section)

RIPv2 can interoperate with RIPv1. By default:

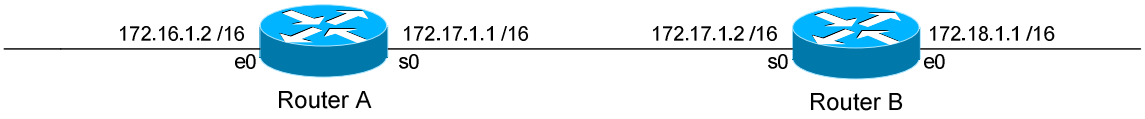
- RIPv1 routers will sent only Version 1 packets
- RIPv1 routers will receive both Version 1 and 2 updates
- RIPv2 routers will both send and receive only Version 2 updates

We can control the version of RIP a particular interface will "send" or "receive."

Unless RIPv2 is manually specified, a Cisco will default to RIPv1 when configuring RIP.

* * *

RIPv1 Basic Configuration



Routing protocol configuration occurs in Global Configuration mode. On Router A, to configure RIP, we would type:

Router(config)# *router rip*
Router(config-router)# *network 172.16.0.0*
Router(config-router)# *network 172.17.0.0*

The first command, *router rip*, enables the RIP process.

The *network* statements tell RIP which networks you wish to advertise to other RIP routers. We simply list the networks that are directly connected to our router. Notice that we specify the networks at their classful boundaries, and we do not specify a subnet mask.

To configure Router B:

Router(config)# *router rip*
Router(config-router)# *network 172.17.0.0*
Router(config-router)# *network 172.18.0.0*

The routing table on Router A will look like:

RouterA# *show ip route*

```
<eliminated irrelevant header>

Gateway of last resort is not set

C     172.16.0.0 is directly connected, Ethernet0
C     172.17.0.0 is directly connected, Serial0
R     172.18.0.0 [120/1] via 172.17.1.2, 00:00:00, Serial0
```

The routing table on Router B will look like:

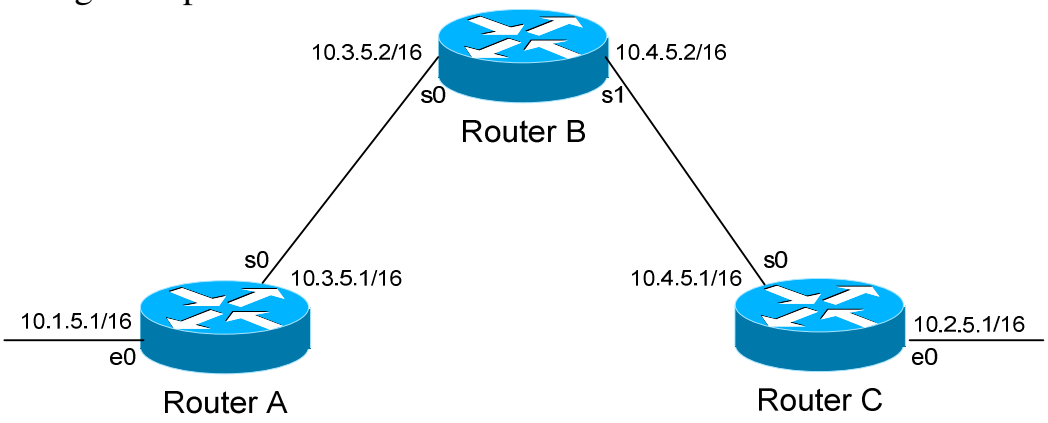
RouterB# *show ip route*

```
<eliminated irrelevant header>

Gateway of last resort is not set

C     172.17.0.0 is directly connected, Serial0
C     172.18.0.0 is directly connected, Ethernet0
R     172.16.0.0 [120/1] via 172.17.1.1, 00:00:00, Serial0
```

* * *

Limitations of RIPv1

The example on the previous page works fine with RIPv1, because the networks are contiguous and the subnet masks are consistent. Consider the following example:



This particular scenario will *still* work when using RIPv1, despite the fact that we've subnetted the major 10.0.0.0 network. Notice that the subnets are contiguous (that is, they belong to the same major network), and use the same subnet mask.

When Router A sends a RIPv1 update to Router B via Serial0, it will not include the subnet mask for the 10.1.0.0 network. However, because the 10.3.0.0 network is in the same major network as the 10.1.0.0 network, it will **not summarize** the address. The route entry in the update will simply state "10.1.0.0".

Router B will accept this routing update, and realize that the interface receiving the update (Serial0) belongs to the same major network as the route entry of 10.1.0.0. It will then apply the subnet mask of its Serial0 interface to this route entry.

Router C will similarly send an entry for the 10.2.0.0 network to Router B. Router B's routing table will thus look like:

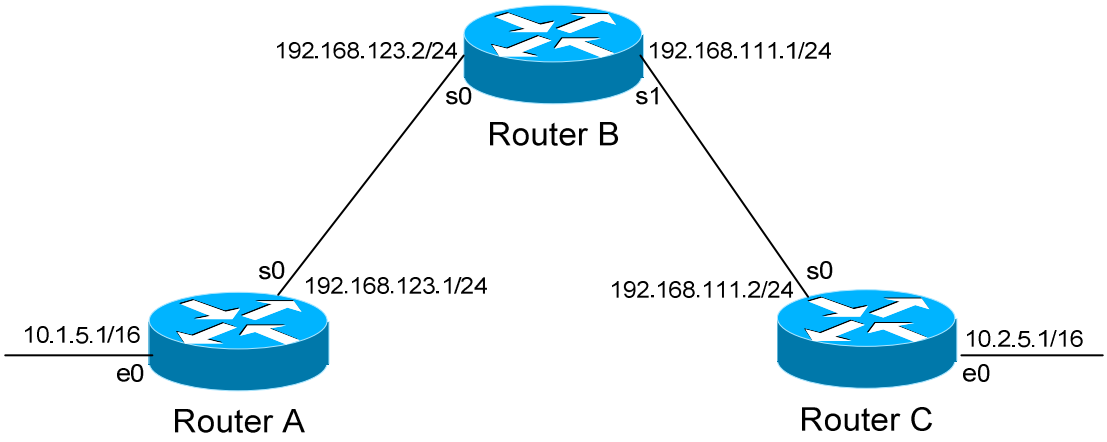
RouterB# *show ip route*

```
Gateway of last resort is not set

       10.0.0.0/16 is subnetted, 4 subnets
C      10.3.0.0 is directly connected, Serial0
C      10.4.0.0 is directly connected, Serial1
R      10.1.0.0 [120/1] via 10.3.5.1, 00:00:00, Serial0
R      10.2.0.0 [120/1] via 10.4.5.1, 00:00:00, Serial1
```

* * *

Limitations of RIPv1 (continued)

Consider the following, slightly altered, example:



We'll assume that RIPv1 is configured correctly on all routers. Notice that our networks are no longer contiguous. Both Router A and Router C contain *subnets* of the 10.0.0.0 major network (10.1.0.0 and 10.2.0.0 respectively).

Separating these networks now are two Class C subnets (192.168.123.0 and 192.168.111.0).

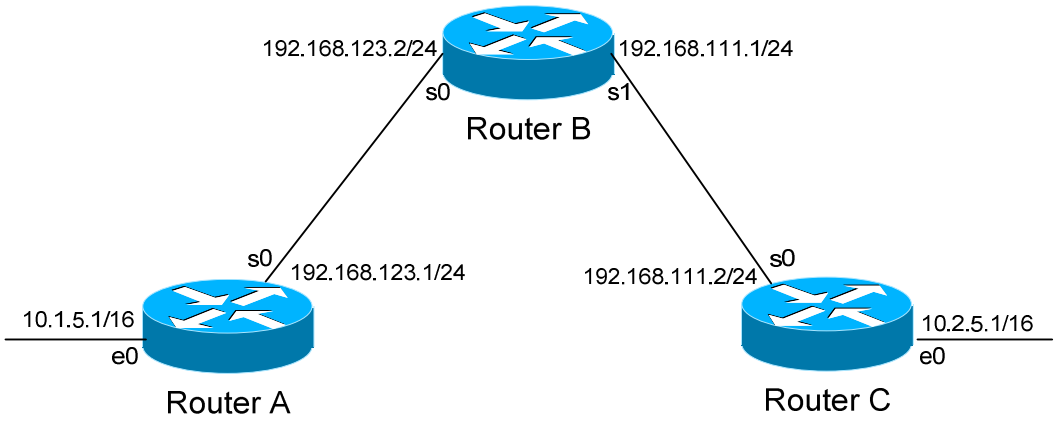
Why is this a problem? Again, when Router A sends a RIPv1 update to Router B via Serial, it will not include the subnet mask for the 10.1.0.0 network. Instead, Router A will consider itself a **border** router, as the 10.1.0.0 and 192.168.123.0 networks *do not* belong to the same major network. Router A will **summarize** the 10.1.0.0/16 network to its classful boundary of 10.0.0.0/8.

Router B will accept this routing update, and realize that it does not have a directly connected interface in the 10.x.x.x scheme. Thus, it has no subnet mask to apply to this route. Because of this, Router B will install the summarized 10.0.0.0 route into its routing table.

Router C, similarly, will consider itself a border router between networks 10.2.0.0 and 192.168.111.0. Thus, Router C will *also* send a summarized 10.0.0.0 route to Router B.

* * *

Limitations of RIPv1 (continued)



Router B's routing table will then look like:

RouterB# *show ip route*

```
Gateway of last resort is not set

C     192.168.123.0 is directly connected, Serial0
C     192.168.111.0 is directly connected, Serial1
R     10.0.0.0 [120/1] via 192.168.123.1, 00:00:00, Serial0
               [120/1] via 192.168.111.2, 00:00:00, Serial1
```

That's right, Router B now has two *equal* metric routes to get to the summarized 10.0.0.0 network, one through Router A and the other through Router C. Router B will now *load balance* all traffic to *any* 10.x.x.x network between routers A and C. Suffice to say, this is not a good thing. ☺

It gets better. Router B then tries to send routing updates to Router A and Router C, including the summary route of 10.0.0.0/8. Router A's routing table looks like:

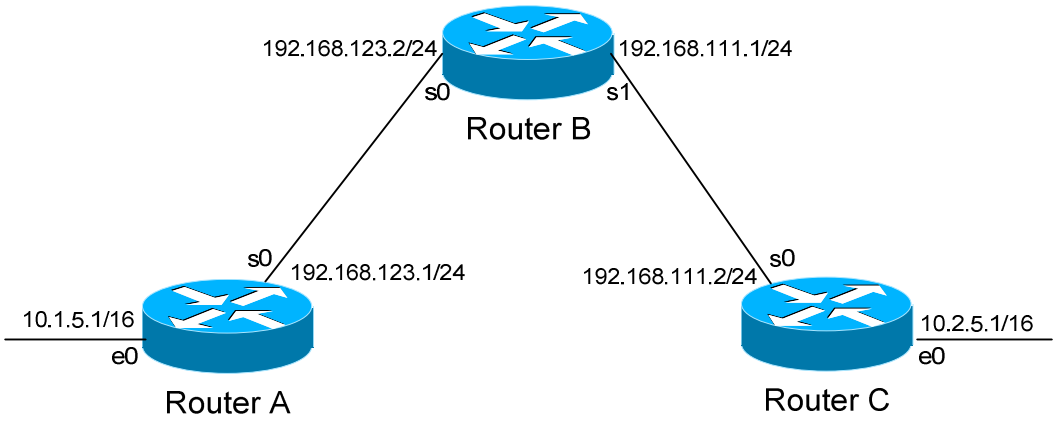
RouterA# *show ip route*

```
Gateway of last resort is not set

C     192.168.123.0 is directly connected, Serial0
       10.0.0.0/16 is subnetted, 1 subnet
C     10.1.0.0 is directly connected, Ethernet0
```

Router A will receive the summarized 10.0.0.0/8 route from Router B, and will reject it. This is because it already has the summary network of 10.0.0.0 in its routing table, and it's directly connected. Router C will respond exactly the same, and the 10.1.0.0/16 and 10.2.0.0/16 networks will *never* be able to communicate.

* * *

RIPv2 Configuration



RIPv2 overcomes the limitations of RIPv1 by including the subnet mask in its routing updates. By default, Cisco routers will use RIPv1. To change to Version 2, you must type:

Router(config)# *router rip*
Router(config-router)# *version 2*

Thus, the configuration of Router A would be:

RouterA(config)# *router rip*
RouterA(config-router)# *version 2*
RouterA(config-router)# *network 10.0.0.0*
RouterA(config-router)# *network 192.168.123.0*

Despite the fact that RIPv2 is a classless routing protocol, we still specify networks at their classful boundaries, without a subnet mask.

However, when Router A sends a **RIPv2** update to Router B via Serial0, by default it will still **summarize** the 10.1.0.0/16 network to 10.0.0.0/8. Again, this is because the 10.1.0.0 and 192.168.123.0 networks *do not* belong to the same major network. Thus, RIPv2 acts like RIPv1 in this circumstance…

…unless you disable **auto summarization:**

RouterA(config)# *router rip*
RouterA(config-router)# *version 2*
RouterA(config-router)# *no auto-summary*

The *no auto-summary* command will prevent Router A from summarizing the 10.1.0.0 network. Instead, Router A will send an update that includes both the subnetted network (10.1.0.0) and its subnet mask (255.255.0.0).

* * *

RIP Timers

RIP has four basic timers:

Update Timer (default **30 seconds**) – indicates how often the router will send out a routing table update.

Invalid Timer (default **180 seconds**) – indicates how long a route will remain in a routing table before being marked as invalid, if no new updates are heard about this route. The invalid timer will be reset if an update is received for that particular route *before* the timer expires.

A route marked as invalid is *not* immediately removed from the routing table. Instead, the route is marked (and advertised) with a metric of 16, indicating it is unreachable, and placed in a **hold-down** state.

Hold-down Timer (default **180 seconds**) – indicates how long RIP will "suppress" a route that it has placed in a **hold-down** state. RIP will not accept any new updates for routes in a hold-down state, until the hold-down timer expires.

A route will enter a hold-down state for one of three reasons:

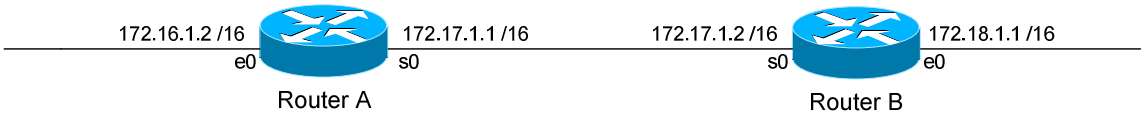
- The invalid timer has expired.
- An update has been received from another router, marking that route with a metric of 16 (or *unreachable*).
- An update has been received from another router, marking that route with a *higher* metric than what is currently in the routing table. This is to prevent loops.

Flush Timer (default **240 seconds**) **–** indicates how long a route can remain in a routing table before being flushed, if no new updates are heard about this route. The flush timer runs **concurrently with the invalid timer**, and thus will flush out a route 60 seconds after it has been marked invalid.

RIP timers must be identical on **all** routers on the RIP network, otherwise massive instability will occur.

* * *

RIP Timers Configuration and Example



Consider the above example. Router A receives a RIP update from Router B that includes network 172.18.0.0. Router A adds this network to its routing table:

RouterA# *show ip route*

```
Gateway of last resort is not set

C     172.16.0.0 is directly connected, Ethernet0
C     172.17.0.0 is directly connected, Serial0
R     172.18.0.0 [120/1] via 172.17.1.2, 00:00:00, Serial0
```

Immediately, Router A sets an **invalid** timer of 180 seconds and **flush** timer of 240 seconds to this route, which run concurrently. If no update for this route is heard for 180 seconds, several things will occur:

- The route is marked as invalid in the routing table.
- The route enters a **hold-down** state (triggering the hold-down timer).
- The route is advertised to all other routers as unreachable.

The hold-down timer runs for 180 seconds *after* the route is marked as invalid. The router will not accept any new updates for this route until this hold-down period expires.

If no update is heard *at all*, the route will be removed from the routing table once the flush timer expires, which is 60 seconds after the route is marked as invalid. Remember that the invalid and flush timers run concurrently.

To configure the RIP timers:

Router(config)# *router rip*
Router(config-router)# *timers basic 20 120 120 160*

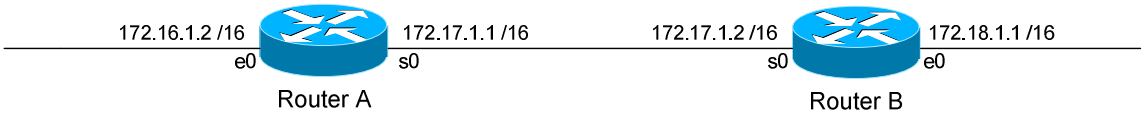
The *timers basic* command allows us to change the update (*20*), invalid (*120*), hold-down (*120)*, and flush *(240)* timers. To return the timers back to their defaults:

Router(config-router)# *no timers basic*

* * *

RIP Loop Avoidance Mechanisms

RIP, as a Distance Vector routing protocol, is susceptible to loops.



Let's assume no loop avoidance mechanisms are configured on either router. If the 172.18.0.0 network fails, Router B will send out an update to Router A within 30 seconds (whenever its update timer expires) stating that route is unreachable (metric = 16).

But what if an update from Router A reaches Router B *before* this can happen? Router A believes it can reach the 172.18.0.0 network in one hop (through Router B). This will cause Router B to believe it can reach the failed 172.18.0.0 network in **two hops**, through Router A. Both routers will continue to increment the metric for the network until they reach a hop count of **16**, which is unreachable. This behavior is known as **counting to infinity**.

How can we prevent this from happening? There are several loop avoidance mechanisms:

Split-Horizon – Prevents a routing update from being sent out the interface it was received on. In our above example, this would prevent Router A from sending an update for the 172.18.0.0 network *back* to Router B, as it originally learned the route from Router B. Split-horizon is **enabled** by default on Cisco Routers.

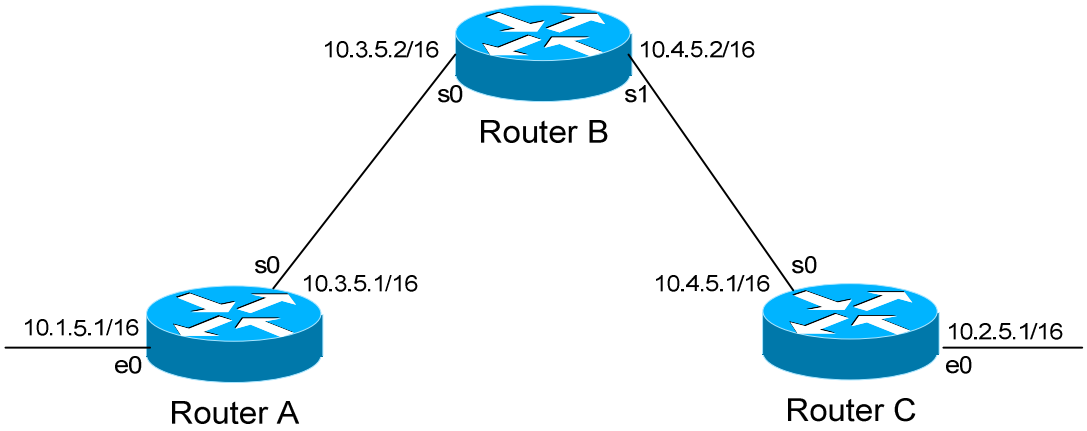
Route-Poisoning – Works in conjunction with split-horizon, by **triggering** an automatic update for the failed network, without waiting for the update timer to expire. This update is sent out all interfaces with an infinity metric for that network.

Hold-Down Timers – Prevents RIP from accepting any new updates for routes in a hold-down state, until the hold-down timer expires. If Router A sends an update to Router B with a *higher* metric than what is currently in Router B's routing table, that route will be placed in a hold-down state. (Router A's metric for the 172.18.0.0 network is 1; while Router B's metric is 0).

* * *

RIP Passive Interfaces

It is possible to control which router interfaces will participate in the RIP process.



Consider the following scenario. Router C does not want to participate in the RIP domain. However, it still wants to *listen* to updates being sent from Router B, just not *send* any updates back to Router B:

RouterC(config)# *router rip*
RouterC(config-router)# *network 10.4.0.0*
RouterC(config-router)# *network 10.2.0.0*
RouterC(config-router)# *passive-interface s0*

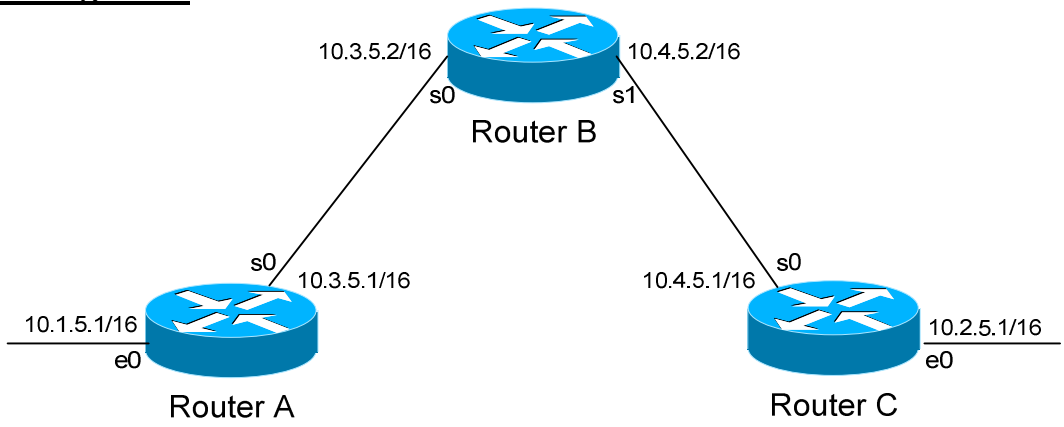
The *passive-interface* command will prevent updates from being **sent** out of the Serial0 interface, but Router C will still **receive** updates on this interface.

We can configure **all** interfaces to be passive using the *passive-interface default* command, and then individually use the *no passive-interface* command on the interfaces we **do** want updates to be sent out:

RouterC(config)# *router rip*
RouterC(config-router)# *network 10.4.0.0*
RouterC(config-router)# *network 10.2.0.0*
RouterC(config-router)# *passive-interface default*
RouterC(config-router)# *no passive-interface e0*

* * *

RIP Neighbors



Recall that RIPv1 sends out its updates as **broadcasts**, whereas RIPv2 sends out its updates as **multicasts** to the 224.0.0.9 address. We can configure specific RIP *neighbor* commands, which will allow us to **unicast** routing updates to those neighbors.

On Router B:

RouterB(config)# *router rip*
RouterB(config-router)# *network 10.3.0.0*
RouterB(config-router)# *network 10.4.0.0*
RouterB(config-router)# *neighbor 10.3.5.1*
RouterB(config-router)# *neighbor 10.4.5.1*

Router B will now unicast RIP updates to Router A and Router C.

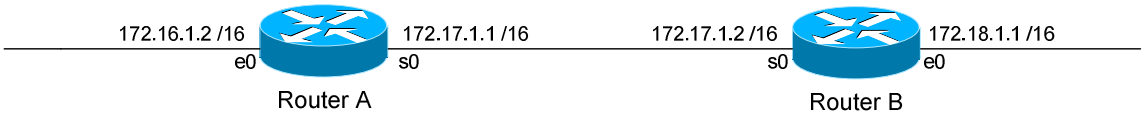
However, Router B will still broadcast (if RIPv1) or multicast (if RIPv2) its updates, in addition to sending unicast updates to its neighbors. In order to prevent broadcast/multicast updates, we must also use **passive interfaces**:

RouterB(config)# *router rip*
RouterB(config-router)# *passive-interface s0*
RouterB(config-router)# *passive-interface s1*
RouterB(config-router)# *neighbor 10.3.5.1*
RouterB(config-router)# *neighbor 10.4.5.1*

The *passive-interface* commands prevent the updates from being broadcasted or multicasted. The *neighbor* commands still allow unicast updates to those specific neighbors.

* * *

RIPv2 Authentication



RIPv2 supports authentication to secure routing updates.

The first step is creating a shared authentication *key* that must be identical on both routers. This is accomplished in global configuration mode:

RouterA(config)# *key chain MYCHAIN*
RouterA(config-keychain)# *key 1*
RouterA(config-keychain-key)# *key-string MYPASSWORD*

RouterB(config)# *key chain MYCHAIN*
RouterB(config-keychain)# *key 1*
RouterB(config-keychain-key)# *key-string MYPASSWORD*

The first command creates a *key chain* called *MYCHAIN*. We must then associate a *key* to our keychain. Then we actually configure the shared key using the *key-string* command.

We then apply our key chain to the interface connecting to the other router:

RouterA(config)# *interface s0*
RouterA(config-if)# *ip rip authentication key-chain MYCHAIN*

RouterB(config)# *interface s0*
RouterB(config-if)# *ip rip authentication key-chain MYCHAIN*

If there was another router off of Router B's Ethernet port, we could create a *separate* key chain with a different key-string. Every router on the RIP domain does not need to use the same key chain, only interfaces directly connecting two (or more) routers.

The final step in configuring authentication is identifying which encryption to use. By default, the key is sent in clear text:

RouterA(config)# *interface s0*
RouterA(config-if)# *ip rip authentication mode text*

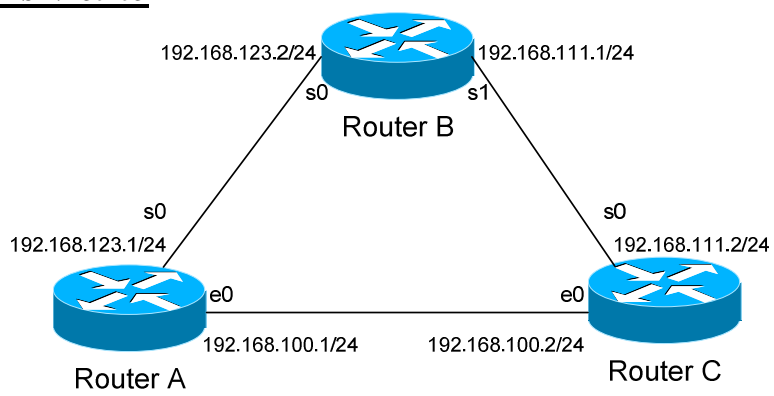
Or we can use MD5 encryption for additional security:

RouterA(config)# *interface s0*
RouterA(config-if)# *ip rip authentication mode md5*

Whether text or MD5 is used, it **must** be the same on both routers.

* * *

Altering RIP's Metric



Consider the above example. Router B has two paths to get to the 192.168.100.0 network, via Router A and Router C. Because the metric is equal (1 hop), Router B will load balance between these two paths.

What if we wanted Router B to only go through Router A, and use Router C only as a backup? To accomplish this, we can adjust RIP's metric to make one route more preferred than the other.

The first step is creating an access-list on Router B that defines which route we wish to alter:

RouterB(config)# *ip access-list standard MYLIST*
RouterB(config-std-nacl)# *permit 192.168.100.0 0.0.0.255*

Next, we tell RIP how much to **offset** this route if received by Router C:

RouterB(config)# *router rip*
RouterB(config-router)# *offset-list MYLIST in 4 s1*

We specify an *offset-list* pointing to our access list named *MYLIST*. We will increase the routing metric by *4* for that route coming *in*bound to interface *Serial 1*.

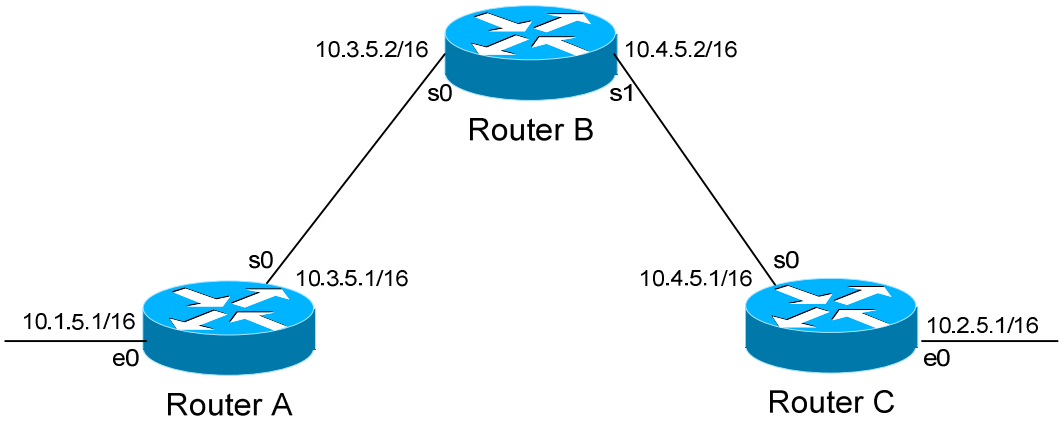
Thus, when Router C sends an update to Router C for the 192.168.100.0 network, Router B will increase its metric of 1 hop to 5 hops, thus making Router A's route preferred.

We could have also configured Router C to **advertise** that route with a higher metric (notice the *out* in the *offset-list* command):

RouterC(config)# *ip access-list standard MYLIST*
RouterC(config-std-nacl)# *permit 192.168.100.0 0.0.0.255*
RouterC(config)# *router rip*
RouterC(config-router)# *offset-list MYLIST out 4 s0*

* * *

Interoperating between RIPv1 and RIPv2



Recall that, with some configuration, RIPv1 and RIPv2 can interoperate. By default:

- RIPv1 routers will sent only Version 1 packets
- RIPv1 routers will receive both Version 1 and 2 updates
- RIPv2 routers will both send and receive only Version 2 updates

If Router A is running RIP v1, and Router B is running RIP v2, some additional configuration is necessary.

Either we must configure Router A to send Version 2 updates:

RouterA(config)# *interface s0*
RouterA(config-if)# *ip rip send version 2*

Or configure Router B to accept Version 1 updates.

RouterB(config)# *interface s0*
RouterB(config-if)# *ip rip receive version 1*

Notice that this is configured on an interface. Essentially, we're configuring the version of RIP on a per-interface basis.

We can also have an interface send or receive both versions simultaneously:

RouterB(config)# *interface s0*
RouterB(config-if)# *ip rip receive version 1 2*

We can further for RIPv2 to send broadcast updates, instead of multicasts:

RouterB(config)# *interface s0*
RouterB(config)# *ip rip v2-broadcast*

* * *

Triggering RIP Updates

On point-to-point interfaces, we can actually force RIP to only send routing updates if there is a change:

RouterB(config)# *interface s0.150 point-to-point*
RouterB(config-if)# *ip rip triggered*

Again, this is only applicable to **point-to-point** links. We cannot configure RIP triggered updates on an Ethernet network.

Troubleshooting RIP

Various troubleshooting commands exist for RIP.

To view the IP routing table:

Router# *show ip route*

```
<eliminated irrelevant header>

Gateway of last resort is not set

C     172.16.0.0 is directly connected, Ethernet0
C     172.17.0.0 is directly connected, Serial0
R     172.18.0.0 [120/1] via 172.17.1.2, 00:00:15, Serial0
R     192.168.123.0 [120/1] via 172.16.1.1, 00:00:00, Ethernet0
```

To view a specific route within the IP routing table:

Router# *show ip route 172.18.0.0*

```
Routing entry for 172.18.0.0/16
      Known via "rip", distance 120, metric 1
      Last update from 172.17.1.2 on Serial 0, 00:00:15 ago
```

To debug RIP in real time:

Router# *debug ip rip*

* * *

Troubleshooting RIP (continued)

To view information specific to the RIP protocol:

Router# *show ip protocols*

```
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 20 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Incoming routes will have 4 added to metric if on list 1
  Redistributing: connected, static, rip
  Default version control: send version 1, receive any version
    Interface             Send  Recv  Triggered RIP  Key-chain
    Ethernet0             1     1 2
    Serial0               1 2   1 2
  Automatic network summarization is in effect
  Maximum path: 4
  Routing for Networks:
    172.16.0.0
    172.17.0.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    172.17.1.2           120      00:00:17
  Distance: (default is 120)
```

This command provides us with information on RIP timers, on the RIP versions configured on each interface, and the specific networks RIP is advertising.

To view *all* routes in the RIP database, and not just the entries added to the routing table:

Router# *show ip rip database*

```
7.0.0.0/8    auto-summary
7.0.0.0/8
    [5] via 172.16.1.1, 00:00:06, Ethernet0
172.16.0.0/16    directly connected, Ethernet0
172.17.0.0/16    directly connected, Serial0
```

* * *