Redes de Computadores (RCOMP) – 2017/2018 Laboratory Class Script – PL17	
• Layer three redundancy. • Dynamic routeing with RIP, EIGRP and OSPF.	• Cisco Packet Tracer

1. About dynamic routeing

In a set of interconnected IPv4 networks there may be alternative paths for packets to travel between two IPv4 networks. This is a good thing, it can be used to provide fault tolerance and traffic load balancing.

Yet, if static routeing tables are used routers won't be able to take advantage of alternative paths. If routeing tables are static, traffic always follows the same path. This will happen even if there is a broken link on the used path and an alternative path is available, or even if the used path is highly congested and there is an idle alternative path.

By opposition, **dynamic routeing** means routeing tables will be always changing to reflect the network infrastructure situation. Creating and keeping updated dynamic routeing tables on routers along the network infrastructure is what **routeing protocols** have been designed for.

With alternative paths, two columns routeing tables become ineffective. On the following example at this router there are three alternative next-hops to reach network 192.160.20.0/24:

Destination	Next-hop
192.168.20.0/24	172.18.30.2
192.168.20.0/24	10.30.42.11
192.168.20.0/24	172.30.104.151

When alternative paths exist, some routers' routeing tables will have more than one line for the same destination (network) each with a different next.-hop. There must be a criterion for selecting the best alternative, that criterion is called metric or cost. Smaller metric value or cost means the best option.

Destination	*Next-hop*	**Metric/Cost**
192.168.20.0/24	172.18.30.2	**4**
192.168.20.0/24	10.30.42.11	**8**
192.168.20.0/24	172.30.104.151	**2**

Each routeing protocol has its own metric calculation algorithm, consequently, different protocols metric values cannot be compared. However, within the same routeing protocol, the best path always corresponds to the lower metric value. In the above table traffic to network 192.168.20.0/20 would be sent to next-hop 172.30.104.151.

If due to some network problem, the 172.30.104.151 neighbour router becomes unreachable, the routeing protocol removes the line from the routeing table, thus, from that instant on, the 172.13.30.2 next-hop would be used instead.

The elapsed time since something changes on the network until the routeing protocol is able to reflect that on all routeing tables is called **convergence time**.

2. Routeing Information Protocol (RIP)

RIP is a very simple and a rather old dynamic routeing protocol. To build routeing tables, RIP uses a distance vector algorithm. The main idea is routeing tables are built gradually as routeing tables are transmitted between neighbour routers. Received routing tables are merged with the already existing routeing table hold by the router.

The RIP metric is the number of routers required to be crossed to reach the destination network, this can also be called the number of hops. This is because with RIP, usually, each link (router interface) is assigned with cost one and when a routing table is received from a neighbour router the link cost is added to each rule.

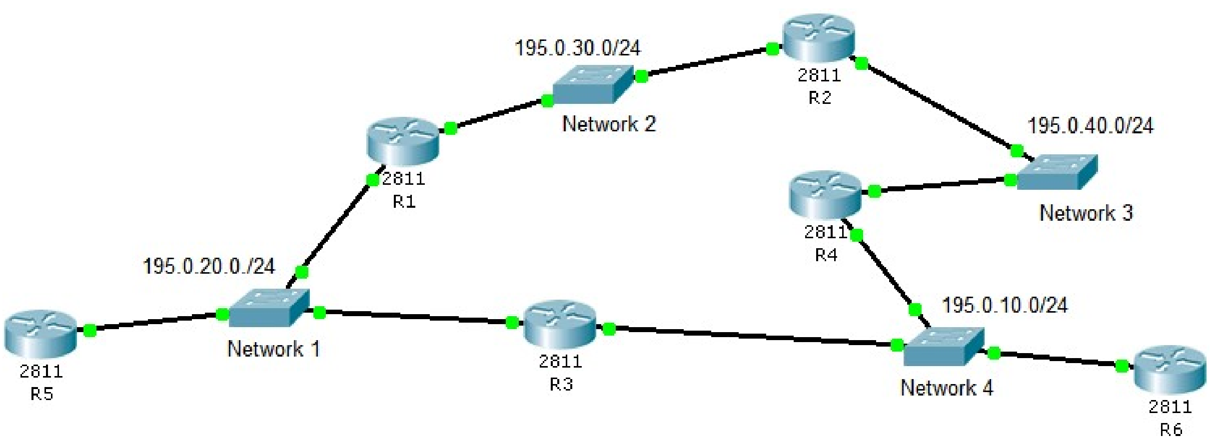
The original RIP standard is at present called RIP version one (RIPv1). Because RIPv1 messages don't carry network prefixes it can only be used in classful infrastructures.

RIPv2 overcomes this issue and supports classless addressing (CIDR –Classless Inter-Domain Routing). RIPv2 also spreads information to neighbour routers by using multicast instead of broadcast used in RIPv1.

Both RIPv1 and RIPv2 have a scaling limit problem because they cannot cope with metric values over 15, in fact, metric value 16 is used to represent an unreachable destination. This, of course, confines the use of RIP to network infrastructures only up to some dimension. Even if, as usual, all interfaces have cost one, there can't be more than 15 routers between two networks.

This problem gets worse because RIP does not support autonomous system identifiers. Thus, dividing the infrastructure into several RIP autonomous systems is not totally straightforward. The issue here is a border router can use RIP on only one of the connected autonomous systems.

3. RIP practical exercise. Create the following diagram on Packet Tracer.



a) Assign to every router (R1 to R6) valid IPv4 addresses in each connected network.

b) For every router, activate RIP in all interfaces.

For RIP configuration we can use the Packet Tracer graphical interface.

If we wait a while (convergence time) all routeing tables will be filled. Overall we have four networks, thus each routeing table should also have four lines. We can use the Inspect tool (magnifying glass) to view each router routeing table.

Surprise! R5 and R6 routeing tables have five and not four lines. Take a closer look to these two routeing tables and try to explain why they have five lines.

Remember, the routeing tables we are seeing have already been optimized by the router, they only contain the best option (lower metric) for each destination.

c) In simulation mode send an ICMP echo request from R5 to R6.

   Check the path followed by ICMP packets.

d) Shutdown one of R3 network interfaces.

   This is going to make it impossible for packets to follow the previous path.

   Now, we must wait for convergence, you'd better be in real mode, otherwise, it will take quite a long time. Use again the Inspect tool to know when routeing tables have been changed by RIP.

e) In simulation mode, again, send and ICMP echo request from R5 to R6 to check how packets are traveling now.

f) Now let's go back to the starting point. Enable again the shutdown interface on R3.

   Wait for convergence and check that routeing tables are now restored to the initial state.

4. EIGRP (Enhanced Interior Gateway Routeing Protocol)

It's a Cisco proprietary protocol, so it might not be adequate for an infrastructure where there are other vendors' routers that are not able to support it.

Although in essence, it's also a distance-vector protocol, it includes some typical link-state features, it's, therefore, usually classified as a hybrid protocol.

EIGRP metric calculation is far more complex than for RIP. For each alternative path, the metric expresses the total path delay and the lowest transmission rate along the path.

Unlike RIP, EIGRP has support for autonomous systems identifiers. EIGRP autonomous systems identifiers are numbers between one and 65535. The goal is confining the scope of a dynamic routeing protocol to a portion of the infrastructure. **Routeing tables built within one autonomous system are not spread to other autonomous systems**.

One border router can be connected to several networks, use EIGRP in all of them, and yet, each can be a different autonomous system. Of course, different EIGRP autonomous systems identifiers must be used in each.

For instance, if we have a router connected to networks A and B, and we are using EIGRP on both, we can think about two different settings:

> **We want** EIGRP built routeing tables to be transferred between networks A and B.
>
> For this purpose we will configure a single EIGRP autonomous system and add to it both networks. Networks A and B will belong to the same autonomous system.

> **We don't want** EIGRP built routeing tables to be transferred between networks A and B. Networks A and B will belong, therefore, to different autonomous systems. This router becomes an autonomous systems border router.
>
> To achieve this we will configure two EIGRP autonomous systems (each with a different identifier) and add network A to one of them, and network B to the other.

When configuring a set of routers attached to the same EIGRP autonomous system, we must be sure we use the same identifier on all of them.

In autonomous systems border routers, the construction of routeing tables is broken because routeing protocols packets are not forwarded. What will happen is that routeing tables, built within and autonomous system will not have any information regarding networks existing outside that autonomous system.

Main Cisco IOS commands for EIGRP configuration

To create, or edit an existing, EIGRP autonomous system configuration, we can use the following command:

```
(config)#router eigrp AS-IDENTIFIER-NUMBER
(config-router)#
```

Remember, this is only useful if we are going to configure this same EIGRP autonomous system (same AS-IDENTIFIER-NUMBER) all other local routers. Also, this configuration will only have a practical effect after we assign networks to it.
Within the EIGRP router configuration level (config-router), we can now enable EIGRP on directly connected networks by running the following command for each:

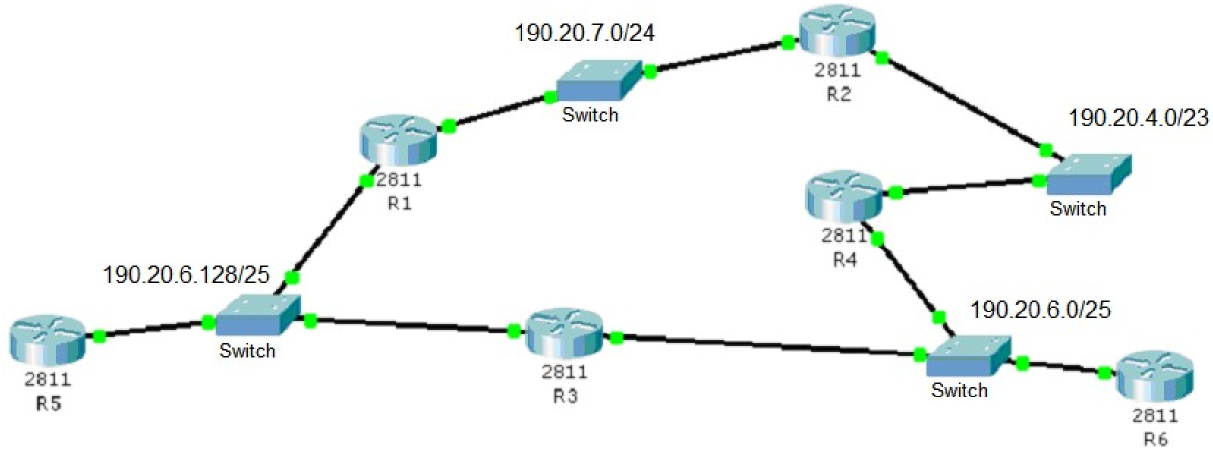
```
(config-router)#network NETWORK-ADDRESS [NETWORK-WILDCARD]
```

Each provided NETWORK-ADDRESS is matched with the router's interfaces addresses, every interface with an address belonging to the network will have EIGRP enforced. This means a single command can be used to enforce EIGRP on several interfaces.
If NETWORK-WILCARD is not specified, then the provided NETWORK-ADDRESS is assumed to be classful and the corresponding mask is used. The NETWORK-WILCARD is the inverted network mask, but you may also use the normal network mask in dot-decimal representation.
Once a router network interface is assigned to the EIGRP configuration, incoming EIGRP routeing tables with matching AS-IDENTIFIER-NUMBER will be incorporated, likewise, the current router's routeing table will be sent to other routers available through the interface.

By default Cisco routers EIGRP configuration assumes we want to aggregate networks to classful, this is called auto-summary. However, this will be a disaster if we have dispersed classless networks belonging to the same classful address space.
Therefore, unless all networks belonging to the same classful network are attached to the same router, we should always disable this feature:

```
(config-router)#no auto-summary
```

5. EIGRP practical exercise. Create the following diagram on Packet Tracer.



a) Assign to every router (R1 to R6) valid IPv4 addresses in each connected network.

b) Configure EIGRP autonomous system 200 on all routers and assign all interfaces to it. Notice we are using classless addresses, therefore, auto-summary should be disabled.

Use the Inspect tool (magnifying glass) to view each router routeing table. All routers routeing tables should have four lines except for R5 and R6 that, again, will have 5 lines.

c) In simulation mode send an ICMP echo request from R5 to R6.

Check the path followed by ICMP packets.

d) Shutdown one of R3 network interfaces.

This is going to make it impossible for packets to follow the previous path.

Now, we must wait for convergence. Use again the Inspect tool to know when routeing tables have been changed by RIP.

e) In simulation mode, again, send and ICMP echo request from R5 to R6 to check how packets are traveling now.

f) Now let's go back to the starting point. Enable again the shutdown interface on R3.

Wait for convergence and check that routeing tables are now restored to the initial state.

6. OSPF (Open Shortest Path First)

Unlike EIGRP, this is a pure link-state protocol, it is also a public standard. Being a link-state protocol means routeing tables are not transmitted from a router to its neighbours. Instead, each router informs other routers about the network around it (neighbour networks and available neighbour routers in each).

Ultimately this results in every router knowing the whole network infrastructure, at that point each router can build its own routeing table.

OSPF also supports autonomous systems. Of course, in relation to other protocols OSPF is always an autonomous system. But a one OSPF autonomous system can be divided in areas, each OSPF area is grossly equivalent to an autonomous system.

OSPF areas are identified by 32-bits numbers, sometimes they as represented in dot-decimal as if they were IPv4 addresses. OSPF area zero is reserved for the backbone and must be the first area to be configured, other OSPF areas must be neighbours of area zero.

Main Cisco IOS commands for OSPF configuration

Configuring OSPF in a Cisco router is somewhat similar to EIGRP (and also RIP):

```
(config)#router ospf PROCESS-ID
(config-router)#
```

In this configuration PROCESS-ID is used to identify this specific configuration, and makes it possible to have several OSPF configurations running at the same time on the same router.
Nevertheless, PROCESS-ID works as an internal identifier, it has nothing to do with autonomous systems or OSPF areas. The configurations we are going to create are rather simple and a single OSPF configuration per router is enough. You can use PROCESS-ID value one, or any other value, but it may be different in different routers of the same area.
The same way we have seen with EIGRP, we must then assign local networks to our OSPF configuration:

```
(config-router)#network NETWORK-ADDRESS NETWORK-WILDCARD area AREA-NUMBER
```

As you can see, the NETWORK-WILDCARD is now required, and the area number is defined for each assigned network.

7. OSPF practical exercise.

a) Reuse the diagram from EIGRP practical exercise. Disable EIGRP on all routers (R1 to R6).

```
(config)#no router eigrp 200
```

b) Configure OSPF on all routers and assign all interfaces to it on area zero.

Use the Inspect tool (magnifying glass) to view each router routeing table. All routers routeing tables should have four lines except for R5 and R6 that, again, will have 5 lines.

c) In simulation mode send an ICMP echo request from R5 to R6.

Check the path followed by ICMP packets.

d) Shutdown one of R3 network interfaces.

This is going to make it impossible for packets to follow the previous path.

Now, we must wait for convergence. Use again the Inspect tool to know when routeing tables have been changed by RIP.

e) In simulation mode, again, send and ICMP echo request from R5 to R6 to check how packets are traveling now.

f) Now let's go back to the starting point. Enable again the shutdown interface on R3.

Wait for convergence and check that routeing tables are now restored to the initial state.