

## Lab 5 Postlab: CSPF

Or: Opaque LSAs, administrative link colouring, and Constrained LSPs

### What you will do:

1. Review and repeat the MPLS Lab guide lab #5.1 on MySRLab
2. Examine the resulting opaque database and LSP details more closely
3. Save configs & enter your answers for each task on Blackboard

### Things that you will need to know or learn:

1. Material in sections 14.1-4, and 14.7 (p. 720-725) in the **NRS-II** textbook
2. CLI commands for configuring Traffic Engineering in OSPF
3. CLI commands for configuring administrative link colouring
4. CLI commands for configuring a constrained LSP which includes or excludes some links

### What you need to submit and when:

1. Complete the "Lab 5 Post-lab" exercise on Blackboard with answers from your work, **before** your next lab period.

### Required Equipment:

- Credentials for booking a MySRLab session
- An actual MySRLab booking
- A PC with internet access, Java, and terminal program; eg. Putty (provided by you)

### Marks:

This post lab is worth 65% of the mark for Lab 5.  
10% of your final mark is for labs done during the course of the semester.

### References and Resources:

- MPLS Lab guide, Lab 5.1 and associated command reference summary
- MPLS courseware, Module 5
- Command references provided in previous labs
- BGP configuration commands provided in this lab (below)
- MySRLab: remote-access lab facility hosted at the Nokia Kanata campus

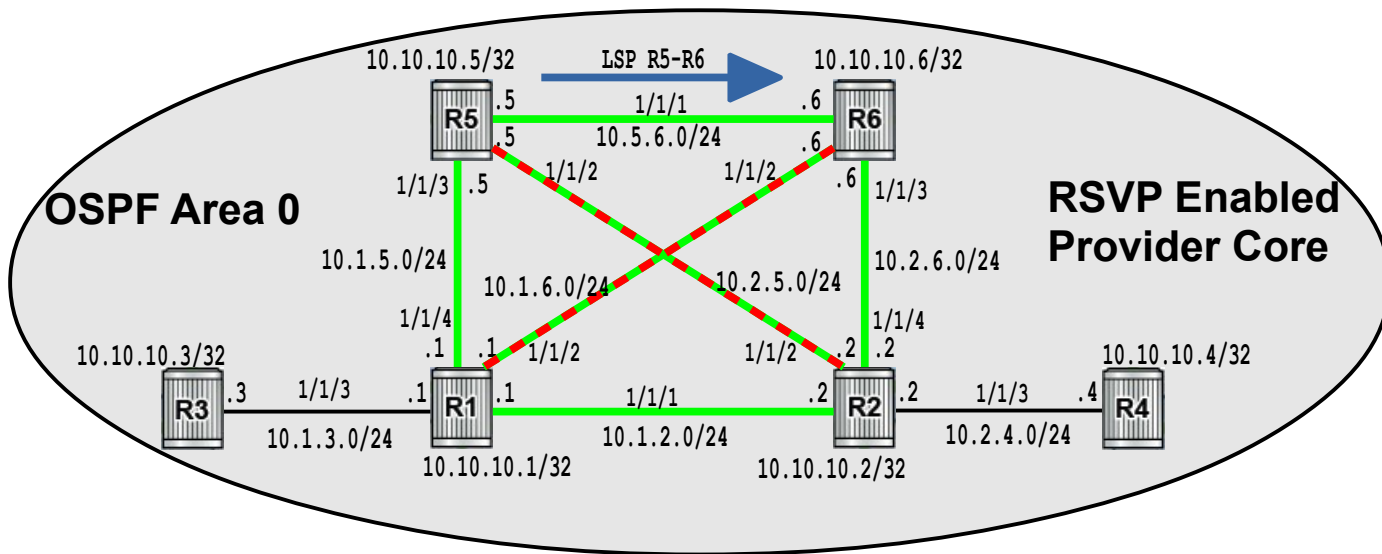
**NB:** The NRS II textbook was published in 2011 and used SR OS ~ver 8; we are using ver 13. Some of the commands have changed format and now reside in a different command context. These changed commands are indicated in **bold** in the command reference below.

SR OS ver 12 supported both old & new formats(mostly); ver 13 **only** supports the new format.

In short: the **courseware slidedecks** have the **correct** command syntax and context; the **NRS II** textbook is now only **mostly correct**.

## Topology

This is the MySRLab network topology that is used for this lab. It is similar to the **bottom** half of the Edu topology from the weekly in-lab. **NOTE: only some** links are configured and activated!



## Addressing Table for MySRLab Practice Labs

**ALL** routers are IPv4 addresses in the range **192.168.X.Y** with **X.Y** as given in the table below.

	PL3	PL4	PL5	PL6	PL7	PL8
R1	188.4	188.36	188.68	188.100	188.132	188.164
R2	188.5	188.37	188.69	188.101	188.133	188.165
R3	188.6	188.38	188.70	188.102	188.134	188.166
R4	188.7	188.39	188.71	188.103	188.135	188.167
R5	188.8	188.40	188.72	188.104	188.136	188.168
R6	188.9	188.41	188.73	188.105	188.137	188.169
PC1	188.10	188.42	188.74	188.106	188.138	188.170

The Ixia tester PC is accessed via the Remote Desktop Protocol (RDP), with clients available for Windows (built-in as "mstsc.exe"), Linux (rdesktop), and OSX (<http://cord.sourceforge.net/>)

Practice Lab	User ID	Password
PL3	See pages 4-5 of the <i>MySRLab Technical Primer</i> and page 8 of the <i>MySRLab Getting Started Guide</i> (available on Blackboard) for connectivity & login details.	
PL4		
PL5		
PL6		
PL7		
PL8		



## Command Reference

configure • router • ospf • traffic-engineering

configure • router • **if-attribute** • **admin-group** <grp-name> **value** <bit-flag>

configure • router • mpls • interface <int-name> • admin group <group-name> # max 5 groups

configure • router • mpls • lsp <lsp-name> • cspf

configure • router • mpls • lsp <lsp-name> • {primary | secondary} <path-name> • include <group>

configure • router • mpls • lsp <lsp-name> • {primary | secondary} <path-name> • exclude <group>

tools • perform • router • mpls • cspf • to {ip-addr}

[from {ip-addr}] [include-bitmap {bit#}] [exclude-bitmap {bit#}]

tools • perform • router • mpls • resignal • lsp <lsp-name> • path <path-name>

show • router • ospf • status

# We want to examine **more** details in the output!

show • router • ospf • area detail

# We want to examine **more** details in the output!

show • router • ospf • opaque-database

# Display type 10 LSAs

show • router • ospf • opaque-database • adv-router <router-ID> detail

show • router • **mpls-labels** • label {first-label-value} {last-label-value} • in-use # SR OS 13

show • router • **mpls** • label {first-label-value} {last-label-value} • in-use # SR OS 10

show • router • **if-attribute** • **admin-group**

show • router • mpls • interface

show • router • mpls • lsp <lsp-name> • path • detail

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### Task 1: Configure the base topology

- Start from a **clean** configuration (**no** LDP, MPLS, or RSVP configuration!)
- Configure the base topology shown above so that all routers have **14 routes** in OSPF.
- On all routers, enable MPLS and RSVP, and add all interfaces into MPLS (but no TE yet!)
- Since all of the required configuration commands are a repeat from previous labs and post-labs, you may copy & paste initial configs from below (see last page).

Verify your configuration:

- Test by pinging to ensure you have full IP reachability from edge to edge.
- Check that all routers have the expected number of OSPF adjacencies:  
R3-R4 = 1 only; R5-R6 = 3; R1-R2 = 4
- Check whether Nokia routers support the propagation of Opaque LSAs by default by digging through the output of: **show router ospf status**
- Check whether Nokia routers support the generation of Opaque LSAs (ie. Traffic Engineering) by default by digging through the output of: **show router ospf status**
- Display the actual opaque database, using the appropriate command (see above). Is the output the same on every router? Why or why not?
- Confirm the number of Opaque LSAs being propagated by digging through the output of: **show router ospf area detail**
- How many labels is MPLS using? (Hint: Label values could start at 32 and end at 524287)

Questions to answer:

- How many routes are in the routing table? (Hint: 14)
- Do Nokia routers support Opaque LSA propagation by default?
- Do Nokia routers support generating Opaque LSAs by default?
- How many Opaque LSAs exist in the database, with default configuration settings?
- How many Labels are in-use, with MPLS & RSVP enabled but no LSPs?

## Task 2: Configure Traffic Engineering

In this task, you'll enable the Traffic-Engineering extensions in OSPF on a router-by-router basis, and then examine the network for changes in the number of type 10 LSAs and opaque database.

- Step 1. Enable Traffic Engineering on **both Edge** routers (ie. R3-R4) **only** (Lab 5.1 phase 1, 4)
- Step 2. Use a "show" command to confirm that Traffic Engineering is successfully enabled. What is the (best) command to confirm it that TE is enabled on the *local* router?
- Step 3. Use a show command to determine the number of type 10 opaque LSAs on **Core** routers (eg. R1-2, R5-6) Is the number the same on every router? Why or why not? Why has this value increased from Task 1, even though TE isn't enabled on **Core** routers?
- Step 4. Add Traffic Engineering on all Core routers, so that **all** routers have it enabled. Use a show command to confirm that TE is enabled on all routers (Lab 5.1 phase 1, step 6)
- Step 5. Use a "show" command to determine the number of type 10 opaque LSAs on each router. Is the number the same on every router? Why or why not?
- Step 6. **Two** "show" commands include a line indicating the total number of opaque LSAs. What are those two commands? Which one has the least amount of output, thereby making it quicker & easier to see the total number of opaque LSAs?

Questions to answer:

- What is the best command to confirm TE is enabled locally?
- In step 3, how many type 10 LSAs existed in the opaque database?
- In step 3, is the number of opaque LSAs the same on Core and Edge routers?
- In step 5, how many type 10 LSAs existed in the opaque database?
- In step 5, is the number of opaque LSAs the same on Core and Edge routers?
- What command, with the least output, gives the total # opaque LSAs?

## Task 3: Examine and Understand Opaque LSAs

There are two types of Traffic Engineering Opaque LSA: the Router-ID type and Link Info type. In this task, you will examine Opaque LSAs in detail. Refer to MPLS Lab 5.1 for additional info.

- Step 1. On an Edge router (eg. R3), examine locally generated Opaque LSAs: (L 5.1 ph 1, s 8)  
**show router ospf opaque-database adv-router 10.10.10.3 detail**
- Step 2. In the output, find the portion corresponding to each of the **two** LSA types. For each type, find the **name** of the TLV and the **size** (length) of the data. Record the information.
- Step 3. On the other Edge router, repeat the exact same command to view Opaque LSAs generated by the first Edge router. Find the TLV names and sizes. Is this information *consistent* between the two Edge routers?
- Step 4. On a Core router, repeat the exact same command again, to view the Opaque LSAs generated by the first Edge router. Find the TLV names and sizes. Is this information *consistent* between *all* routers?
- Step 5. Locate and record the *default* value of the "ADMIN\_GROUP" field.

Questions to answer:

- What is the exact name and size of the **two** LSA TLV types?
- Is the name and size of the LSA the same across all routers?
- What is the default value of the "ADMIN\_GROUP" field?

## Task 4: Configure Administrative Groups

The terms "Administrative Group" and "Link Colouring" are synonymous. They provide a method of marking links (interfaces) with an attribute that is meaningful only to (human) administrators. LSP paths can then be defined which necessarily include or exclude links with a specific marking.

Step 1. On all Core routers, configure two administrative groups: one called "green" with a group value of 1, and the other called "red" with a group value of 2. Assign group green to all Core outer ring MPLS interfaces, and assign both groups red and green to the diagonal Core interfaces. See the topology diagram above for a colour illustration (L 5.1 ph 2, step 1)

Step 2. Use **two** "show" commands to confirm that you have correctly and successfully applied the link colouring. (Lab 5.1 phase 2, step 2)

Step 3. Find the resulting ADMIN\_GROUP values by examining the details of Opaque LSAs for a Core router and record the exact value for both an outer ring (green only) link and a diagonal link (both red and green). Which value represents which colouring?

```
show router ospf opaque-database adv-router {rtr-id} detail
```

Step 4. Why are neither of the ADMIN\_GROUP values the same as the values you used in defining the red and green groups in MPLS? (Lab 5.1 phase 2, step 3A)

Questions to answer:

- What is the full command to show admin group values?
- What is the full command to show interface colourings?
- What is the ADMIN\_GROUP value for green (only) links?
- What is the ADMIN\_GROUP value for links that are both red + green?

## Task 5: Configure a CSPF LSP using link colouring constraints

You'll need your knowledge of creating MPLS paths and LSPs to make use of link colouring. Refer to your lecture notes, MPLS courseware, and NRS-II textbook for help in this task.

Step 1. On R5 (top left Core), configure an LSP with the following characteristics:

- a totally loose path;
- an LSP terminating on R6 (top right Core);
- with CSPF enabled for the LSP;
- the primary consists of the totally loose path, **and**
  - include admin group "green" (ie. insist that **every** link used has that marking)
  - exclude admin group "red" (ie. insist that **no** link have that marking)

... and be sure that everything is *no shutdown* ! (Lab 5.1 phase 2, step 4)

Step 2. Wait a few moments; many timers are at work!

Step 3. Examine the state of the LSP on R5 & R6 using some familiar commands & **save the output**: `show router RSVP session` and `show router tunnel-table`

If you did everything correctly in the previous steps, but the LSP still isn't Up/Up, try:

```
tools perform router mpls resignal lsp <lsp-name> path <path-name>
```

Step 4. Use a "show" command to display *complete* path details of the resulting LSP.

Step 5. Pay particular attention to sections titled: ExplicitHops, Actual Hops, ComputedHops  
You must be able to correlate these with hops specified by: `path`, the CSPF, and the RRO

Step 6. In the same output, find the value for the CSPF metric. Find the equivalent IGP metric. Are they the same or different?

Step 7. Use a show command on R5 and R6 to determine the number of labels "in-use".

**Save a copy** & correlate that information with the output from the previous step.

Questions to answer:

- What is the "preference]" (i.e. Admin Distance) for an *RSVP* tunnel? (Compare with a pref of **9** for an LDP tunnel.)
- If there is both an RSVP and LDP tunnel to a given destination, which one will be chosen/used based on the above values?
- Do *both* R5 and R6 have a tunnel? Why or why not??
- What is the exact "Failure Code" for a *successful* LSP path?
- What is the CSPF metric for this simple LSP path? Is it the same as the IGP?
- How many labels are now *in-use* on R5? What are their values? Why is this? ... Is R5 *offering* labels, or *receiving* labels?
- How many labels are now *in-use* on R6? What are their values?
- Who (what) is the "Label Owner" for any label(s) you identified on R6?

## Task 6: Examining CSPF path re-calculation

We can examine CSPF in action by manually disabling a link, so that the LSP path needs to be re-calculated using the specified constraints. The field "Failure Code" indicates whether or not a path was found, and "Failure Node" indicates where CSPF hit a brick wall if no path was found.

- Step 1. On R5, shut down the interface connecting directly to R6. (Lab 5.1 phase 2, step 6)
- Step 2. Wait a few moments; many timers are at work!
- Step 3. Re-run the "show" command you used in the last task to display the path details of the new LSP. If the LSP still isn't Up/Up, you can try:  
`tools perform router mpls resignal lsp <lsp-name> path <path-name>`
- Step 4. Compare the results of `traceroute` and `oam lsp-trace` to determine whether or not the new LSP path follows the IGP. Why or why not?
- Step 5. Did the CSPF metric change? Why or why not? How does this compare with IGP?
- Step 6. How many labels are "in-use" on each of the Core routers? Can you explain why?
  
- Step 7. Now shut down the interface connecting R5 directly to R1. (Lab 5.1 phase 2, step 7)
- Step 8. Wait a few moments; many timers are at work!
- Step 9. Guarantee that the LSP has had a chance to be re-established by running:  
`tools perform router mpls resignal lsp <lsp-name> path <path-name>`
- Step 10. Re-run the "show" command to display the path details of the new LSP. Record the exact values for the Failure Code and Failure Node (how far did CSPF get?).
- Step 11. Is there still an IGP route to the tail-end router of the LSP? Test it!
- Step 12. How many labels are "in-use" on each of the Core routers? Can you explain why?

Questions to answer:

- With only the link R5-R6 shutdown, how many labels are in-use on each Core router?
- What is the "Failure Code" for an *unsuccessful* LSP path?
- With two links shutdown, how many labels are in-use on each Core router?
- With two links shutdown, what is the Failure Node for the LSP details?
- In this task, does the value given for the CSPF Metric match the IGP metric?

## Task 7: Save all your configs

As always, **save your final configs** in MySRLab so that you can refer to them later for practice

# Initial Configurations

## R1

```
exit all
environment no more
configure port 1/1/[1..4] no shut
configure system name CSPF-PostLab5-R1
configure router
#-----
echo "IP Configuration"
#-----
    interface "system"
        address 10.10.10.1/32
    exit
    interface "toR2"
        address 10.1.2.1/24
        port 1/1/1
    exit
    interface "toR3"
        address 10.1.3.1/24
        port 1/1/3
    exit
    interface "toR5"
        address 10.1.5.1/24
        port 1/1/4
    exit
    interface "toR6"
        address 10.1.6.1/24
        port 1/1/2
    exit
    router-id 10.10.10.1
#-----
echo "OSPFv2 Configuration"
#-----
    ospf
        area 0.0.0.0
            interface "system"
                exit
            interface "toR3"
                interface-type point-to-point
            exit
            interface "toR5"
                interface-type point-to-point
            exit
            interface "toR2"
                interface-type point-to-point
            exit
            interface "toR6"
                interface-type point-to-point
            exit
        exit
    exit
```

## R2

```
exit all
environment no more
configure port 1/1/[1..4] no shut
configure system name CSPF-PostLab5-R2
configure router
#-----
echo "IP Configuration"
#-----
    interface "system"
        address 10.10.10.2/32
    exit
    interface "toR1"
        address 10.1.2.2/24
        port 1/1/1
    exit
    interface "toR4"
        address 10.2.4.2/24
        port 1/1/3
    exit
    interface "toR5"
        address 10.2.5.2/24
        port 1/1/2
    exit
    interface "toR6"
        address 10.2.6.2/24
        port 1/1/4
    exit
    router-id 10.10.10.2
#-----
echo "OSPFv2 Configuration"
#-----
    ospf
        area 0.0.0.0
            interface "system"
                exit
            interface "toR4"
                interface-type point-to-point
            exit
            interface "toR6"
                interface-type point-to-point
            exit
            interface "toR1"
                interface-type point-to-point
            exit
            interface "toR5"
                interface-type point-to-point
            exit
        exit
    exit
```



### R3

```
exit all
environment no more
configure port 1/1/[1..4] no shut
configure system name CSPF-PostLab5-R3
configure router
#-----
echo "IP Configuration"
#-----
    interface "system"
        address 10.10.10.3/32
    exit
    interface "toR1"
        address 10.1.3.3/24
        port 1/1/3
    exit
#-----
echo "OSPFv2 Configuration"
#-----
    ospf
        area 0.0.0.0
            interface "system"
                exit
            interface "toR1"
                interface-type point-to-point
            exit
        exit
    exit
```

### R4

```
exit all
environment no more
configure port 1/1/[1..4] no shut
configure system name CSPF-PostLab5-R4
configure router
#-----
echo "IP Configuration"
#-----
    interface "system"
        address 10.10.10.4/32
    exit
    interface "toR2"
        address 10.2.4.4/24
        port 1/1/3
    exit
#-----
echo "OSPFv2 Configuration"
#-----
    ospf
        area 0.0.0.0
            interface "system"
                exit
            interface "toR2"
                interface-type point-to-point
            exit
        exit
    exit
```

## R5

```
exit all
environment no more
configure port 1/1/[1..4] no shut
configure system name CSPF-PostLab5-R5
configure router
#-----
echo "IP Configuration"
#-----
    interface "system"
        address 10.10.10.5/32
    exit
    interface "toR1"
        address 10.1.5.5/24
        port 1/1/3
    exit
    interface "toR2"
        address 10.2.5.5/24
        port 1/1/2
    exit
    interface "toR6"
        address 10.5.6.5/24
        port 1/1/1
    exit
    router-id 10.10.10.5
#-----
echo "OSPFv2 Configuration"
#-----
    ospf
        area 0.0.0.0
            interface "system"
                exit
            interface "toR1"
                interface-type point-to-point
            exit
            interface "toR2"
                interface-type point-to-point
            exit
            interface "toR6"
                interface-type point-to-point
            exit
        exit
    exit
```

## R6

```
exit all
environment no more
configure port 1/1/[1..4] no shut
configure system name CSPF-PostLab5-R6
configure router
#-----
echo "IP Configuration"
#-----
    interface "system"
        address 10.10.10.6/32
    exit
    interface "toR1"
        address 10.1.6.6/24
        port 1/1/2
    exit
    interface "toR2"
        address 10.2.6.6/24
        port 1/1/3
    exit
    interface "toR5"
        address 10.5.6.6/24
        port 1/1/1
    exit
    router-id 10.10.10.6
#-----
echo "OSPFv2 Configuration"
#-----
    ospf
        area 0.0.0.0
            interface "system"
                exit
            interface "toR2"
                interface-type point-to-point
            exit
            interface "toR1"
                interface-type point-to-point
            exit
            interface "toR5"
                interface-type point-to-point
            exit
        exit
    exit
```