



Routerlab SoSe 2018 Worksheet 9: Border Gateway Protocol (BGP)

The purpose of this worksheet is to introduce the Border Gateway Protocol (BGP), which is the dynamic routing protocol used for inter-domain routing and one of the basic building blocks of the Internet.

Table 1: Device and Address Overview

Cloud	Aachen	Köln	Leverkusen
Router	aac-rc1, aac-rj1, aac-rj2	cgn-rc1, cgn-rj1, cgn-rj2	lev-rc1, lev-rj1, lev-rj2
Switches	aac-sc1, aac-sj1	cgn-sc1, cgn-sj1	lev-sc1, lev-sj1
IPv4 range		10.Z.0.0/16	
Loadgens		groupX-lg1,2,3	

Note: Replace X with the number of your group with leading zero, e.g., $X = 03$ for group 3. Finally replace Z with the decimal group number without leading zero, e.g., $Z = 3$ for group 3.

Question 1: (30 (3+2+5+2+3+2+3+5+5) Points) *BGP Basics*

Read Section 5 of the BGP RFC 4271, then answer the following:

- List the categories of attributes of a path and explain each one briefly.
- Which are the mandatory attributes?
- Is BGP a pure distance-vector or a pure link-state routing protocol? Explain in 2 or 3 sentences.
- What is the default local-preference value for BGP routes?
- When should the attribute `ATOMIC_AGGREGATE` be included in an announcement?

Read Section 9.1.2.2 of the BGP RFC 4271, then have a look at the following dump of a BGP Routing Information Base (RIB):

```
BGP table version is 35, local router ID is 10.13.5.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
               r RIB-failure, S Stale, m multipath, b backup-path, f RT-Filter,
               x best-external, a additional-path, c RIB-compressed,
Origin codes: i - IGP, e - EGP, ? - incomplete
RPKI validation codes: V valid, I invalid, N Not found
```

```

Network          Next Hop           Metric LocPrf Weight Path
*   10.13.2.0/24   10.13.4.2          0 65003 65002 i
*>  10.13.5.2     10.13.5.2          0 65004 65002 i
```

- Which of the above two routes is the best one (ignore attributes that are not listed)?
- Which rule of section 9.1.2.2 of RFC 4271 makes the tie-break?
- Explain briefly (4 - 6 sentences) what a *Route-Reflector* is and how it is used.

i) Explain briefly (2-3 sentences) what a *Looking Glass* server is and what is its purpose.

Question 2: (40 (6+3+2+12+3+3+3+4+4) Points) *Basic BGP Configuration*

In this question, we will develop a simple BGP configuration to establish a BGP session between each pair of routers.

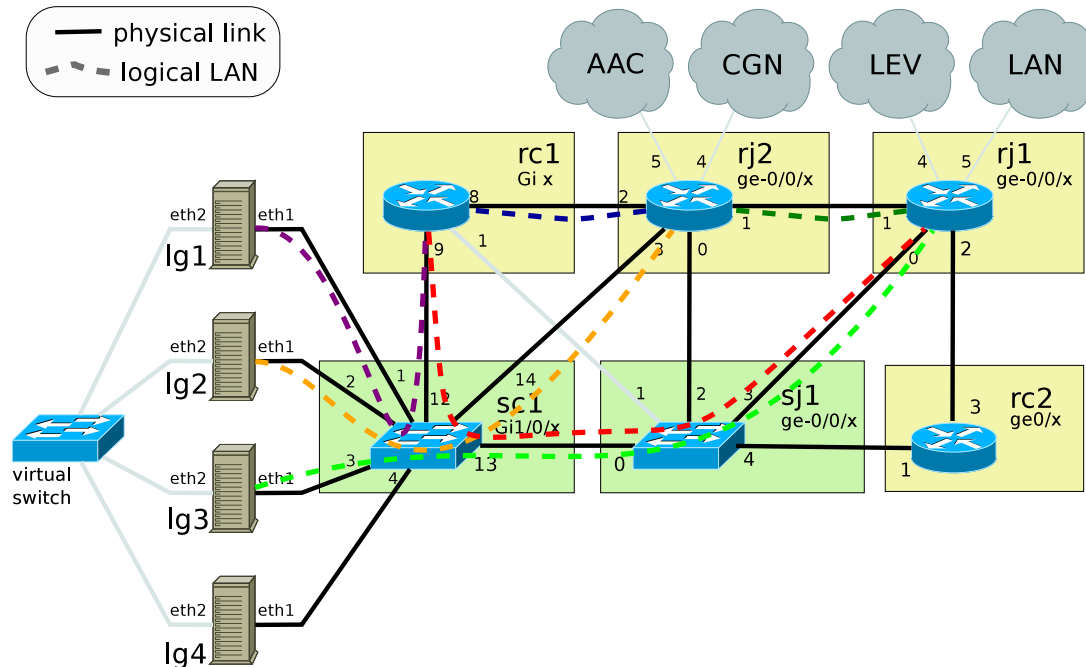


Figure 1: Topology: Mapping of VLANs to physical links.

Enable IP connectivity between adjacent routers/loadgens in a similar manner as in the previous worksheet. For this purpose, please have a look at Figure 1, where each colored dashed line indicates a different logical subnetwork. Establish IP connectivity between any two devices that are inside the same logical subnetwork. Draw a topology map that shows your IP address assignment. Your configuration must satisfy the following conditions:

- When necessary, configure separate VLANs.
- Assign IP addresses in such a way that there is no overlap in IP address range. The IP address ranges used for interfaces on different virtual links in Figure 1 must be disjoint.
- All pairs of routers connected with some interfaces in the same VLAN must be able to ping each other.

Note that routing between subnetworks is not yet enabled.

- Provide a topology map and all the details of your configuration including the specification of which kind of VLAN (trunk/access) is used on each link.
- Using *traceroute*, test the connectivity from each loadgen of your cloud to every other configured interface (restricting to the ones to which *you* have given IP addresses, and ignoring the interfaces pre-configured by the administrators) of the routers and loadgens in your cloud. Provide the connectivity matrix and the traceroute output.
- Which interfaces of your cloud are reachable from *lg1*? Which are not? Why?

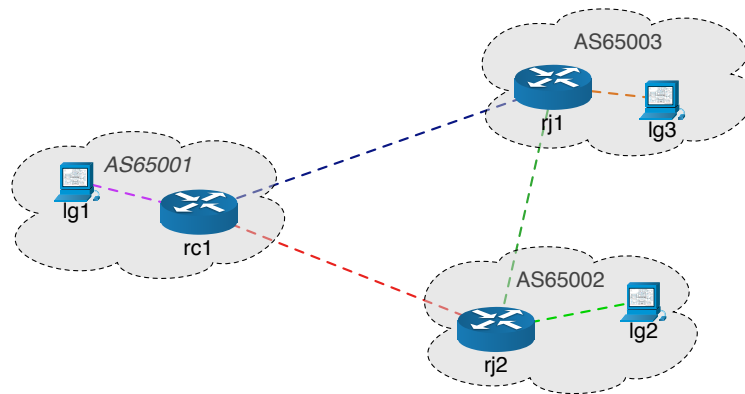


Figure 2: Topology – BGP Configuration.

Per Figure 2, each router-loadgen pair is assigned to an AS. Altogether, we have three ASes, 65001, 65002 and 65003, with all ASes connected to each other in a mesh.

- d) Configure the routers to establish BGP sessions between every two pairs, hence providing full connectivity to all subnetworks. Focus on the *minimum configurations* to establish a BGP session between two routers.
- e) Using *traceroute*, test the connectivity from each loadgen of your cloud to every other configured interface of the routers and loadgens in your cloud. Provide the connectivity matrix and the traceroute output.

Provide a dump of the BGP routing table of *rc1*. Using this table dump, answer the following questions.

- f) How many routes are available toward each loadgen?
- g) Among the available routes to each loadgen, which one is used and why?

In this part, we will focus on issues arising out of misconfigurations.

- h) What does *RIB-Failure* in BGP tables mean and why would a route be marked as such?
- i) Show the minimum required configuration to observe routes marked with RIB-Failure in your table dump at *rc1*.

Question 3: (30 (6+2+6+3+8+2+3) Points) BGP Routing Policies

Network operators may not always desire to send packets along the shortest path (i.e., fewest number of AS hops) to the destination. Economic aspects (e.g., cost of a link between routers), for instance, may need to be considered by the network operators. The following part illustrates how policies can be used to prefer one route to another and how inconsistent policy configurations may cause routing instabilities.

- a) Let's assume that AS65001 intends to send as much traffic as possible over AS65002. Use the *local-preference* attribute to achieve this behavior. What can you see in the BGP routing tables of all three routers?
- b) Using *traceroute*, test the connectivity from each loadgen of your cloud to every other configured interface of the routers and loadgens in your cloud. What do the routes from *lg1* to *lg3*, and vice-versa look like? Explain the output.
- c) Now, let's assume that AS65003 also mimics the behavior of AS65001 and sends as much traffic as possible over AS65002. Again, use the *local-preference* attribute to achieve this behavior. What can you see in the BGP routing tables of all three routers, now?
- d) Using *traceroute*, test the connectivity from each loadgen of your cloud to every other configured interface of the routers and loadgens in your cloud. Provide the connectivity matrix and the traceroute output.

Now, let's assume that AS65002 notices that ASes 65001 and 65003 send all their traffic over it. Therefore, it wants to prevent some routes from being announced to other ASes.

- e) Configure AS65002 such that routes originated by the other two ASes are not announced. What can you see in the BGP routing tables of all three routers, now?
- f) Which routes are now used by AS65001 and AS65003? Provide the BGP routing tables of all routers.
- g) Using *traceroute*, test the connectivity from each loadgen of your cloud to every other configured interface of the routers and loadgens in your cloud. Provide the connectivity matrix and the traceroute output.

Submission details (more in ISIS):

Please submit an archive (.tar.gz or .zip) containing a *directory*, which contains all files you want to submit. Please have *your group number* in the file name and the directory name.

A report (one single PDF file, named *worksheet(num)-group(num).pdf*) containing the following elements is mandatory:

- Your group number on the first page
- Topology map with relevant routers, switches, *loadgens*, and interfaces, IPs and subnet masks (CIDR).
- For each question, the written answers with the **relevant** portions of output from all commands such as *ping*, *tcpdump*, etc in a text format. **No** screenshots of terminal windows are accepted. For *ping* 3-4 lines of *ping* requests are usually sufficient.
- For each question all commands needed to configure the *loadgens*.
- For each question all **changed parts** in the configuration of routers and switches (differences to the default config).
- **Never** include the full verbatim switch or router configuration in the pdf report.
- For all questions, state your assumptions, say what you did, describe what you observed, explain your conclusions.

Additionally, please include your config files in the archive.

For each question, please provide the full switch and router configuration in a separate text file named after the device and question, e.g.: *q01-config-sc1.txt*. This makes it easier for us to reproduce your configuration and understand what you did.

We can only grade what we find in your submission and what we understand. Please state your assumptions and observations as clearly as possible.

Due Date: 5th July 2018, 11:55 PM