# Assignment 3

CS224M

**Note:** *Solve all problems on your own.* Upload your solutions as a single pdf file to Moodle. You can scan handwritten solutions and upload if required. Approach the instructor for clarifications.

1. We will try out some network diagnostic tools on Unix/Linux. Most of these tools will work on an Apple MAC machine (in case some information for the lab report is not easy to find on MAC osX, then just state that in the report). You may have to install some of the tools on your machine if they are not already installed by default (Google for installation instructions). If you have trouble installing, just post to the MS Team for CS224M and your friends and TAs will help you out.

   (a) (5 marks) `ifconfig` : Type "ifconfig" in any terminal window. It will show you a lot of information for each network interface in your machine. You might see a "loopback interface" such as "lo :" which is only a virtual interface (not a real network interface), and we will ignore the loopback for now. Identify which of the other interfaces corresponds to either Wired Ethernet or WiFi.

   In your report, for this interface (either one of Ethernet or WiFi) state what is the IPv4 address (and IPv6 address if any), the hardware address (MAC), and the MTU. You can find out more about ifconfig online (e.g. here ). State the number of bits used for IPv4 addresses, IPv6 addresses, and hardware address. State what MTU stands for and the units it (MTU) is expressed in. We talked about queues in one of the first lectures. State the transmit queue length on this interface, and give the units this is measured in.

   (b) (10 marks) `traceroute <dest host IP or name>`: This tool tries to find out all the IP addresses of layer-3 nodes (actually layer-3 interfaces; remember each router can have many interfaces) on the path from the machine running the traceroute command to the destination host. It uses a field called "TTL" (time-to-live) in the IP header cleverly to do this. TTL is decremented at each layer-3 router on the path, and if it reaches 0, the router drops the packet and send an "error" message to the source node using the ICMP protocol. The source IP address in the ICMP packets reveals the IP address of the interface of the intermediate router. By sending TTL of different values we can thus find out the IP addresses we are after. But not all routers may respond with error messages (this depends on how they are configured). You can read up more about traceroute online.

   You can be detectives by trying out traceroute from your own machines to different websites on the Internet. You can also use this link to run traceroute starting from machines in many cities around the world to any destination.

   In your report, mention the number of hops (routers) on the paths from your own machines and 5 cities using the URL give above (the cities are of your choice, preferably in different continents) to destinations (i) www.google.com, (ii) www.cnn.com, (iii) www.iitd.ac.in (note: I have chosen "iitd" rather than "iitb" deliberately; you can try both and see what you find). For each case also state the average round trip time (RTT) to the destination. Also, state if the destination IP address is the same for the same URL, no matter where the source of the traceroute is. In case the IP address is different, do some detective work online to find out why this might be the case and state briefly (in a paragraph or two) what you find out. In case a firewall prevents traceroute from working on your own machines, just mention that in your report.

(c) (5 marks) `ping <dest host>`: This command sends ICMP packets to the destination and gets back ICMP echo packets. It reports the RTTs observed. A quick way to find if is host is alive. It is possible that a host is configured not to reply to ping packets, so there is no guarantee that the host is dead if you don't get a reply.

In your report, give the average RTT obtained by pinging servers in different continents (hint: government servers are likely to be geographically located in their own countries) from each of your own machines and also using the ping utility at this link . In case you are behind a firewall, it is possible that the firewall blocks your ping packets, in which case just report that ping does not work from your machine. Comment on what you observe about the RTTs (For example, are pings to servers more if the server is geographically further away?)

2. AS1 in Figure 1 has the following characteristics.

- All routers run OSPF as the interior gateway protocol (IGP). Recall that OSPF is a link-state routing protocol.
- Only the border routers connecting AS1 to neighbouring ASes run BGP.
- Link weights are static and specified in the diagram.

*State any assumptions that you make to solve the problems.*

(a) (8 marks) Using Djikstra's algorithm determine the shortest path from R1 to all other routers within AS1. Give details of the different stages in creation of the routing tree using diagrams. Similarly determine the shortest path from R2 to all other routers, and show your working with diagrams.

(b) Corresponding to each of the ASes is an IP-prefix as shown. R14 of AS2 advertizes the paths `[151.128.32.0/24 AS2]`, `[142.13.0.0/16 AS2-AS4]` and `[130.12.1.0/24 AS2-AS4-AS3]` to router R4 of AS1. R13 of AS3 advertizes the paths `[130.12.1.0/24 AS3]`, `[142.13.0.0/16 AS3-AS4]` and `[151.128.32.0/24 AS3-AS4-AS2]` to R3 of AS1.

Suppose the administrator of AS1 has set LOCAL_PREF to the same value for all BGP advertisements and assume that the MED attribute has not been set in any of the advertisements.

i. (2 marks) Explain which NEXT_HOP router does each BGP router in AS1 use to send packets to destination prefix 151.128.32.0/24. Give the reasons for these choices. Recall that the NEXT_HOP router for a BGP advertisement is the router in the neighbouring AS which sent the corresponding advertisement to a router in AS1. Examples of these are R14, R13 etc.[1]

[1]Technically, the NEXT_HOP attribute is the IP address of the interface from which the BGP advertisement reached AS1. To simplify matters, we are here just using the router name instead of the IP address of its interface.

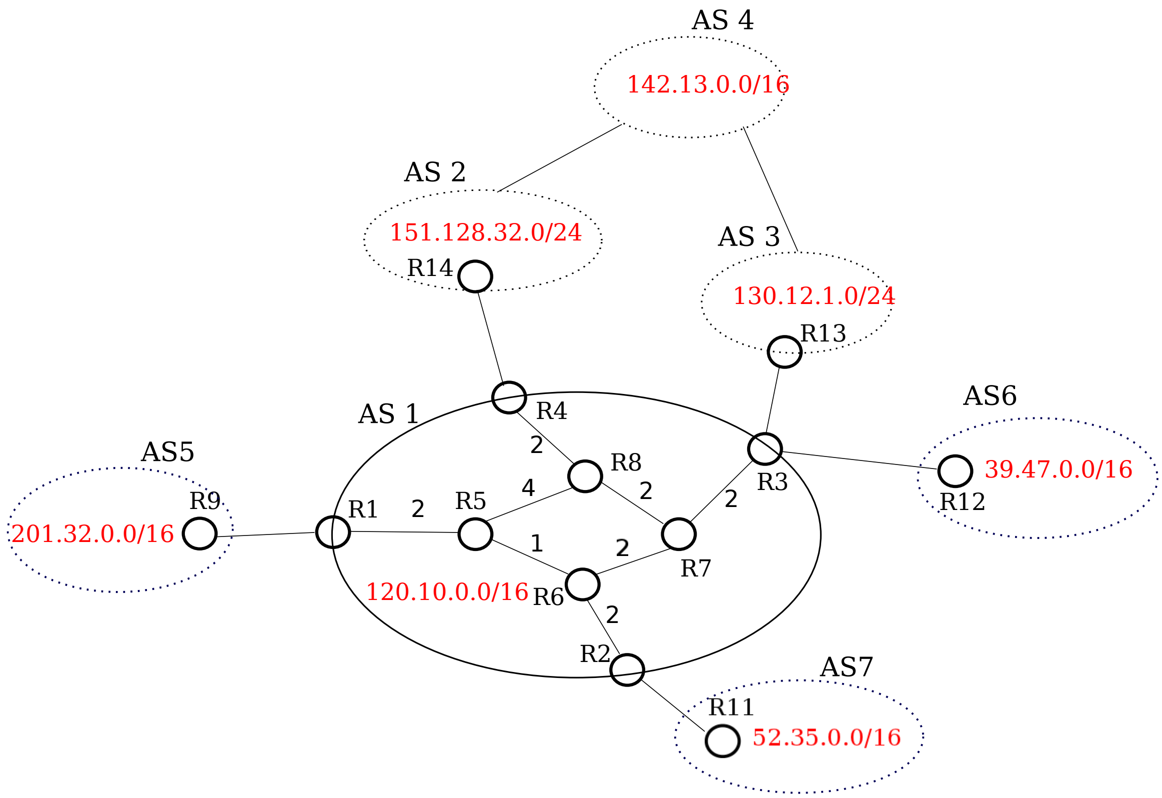


Figure 1: Routing topology

ii. (2 marks) Explain which NEXT_HOP router does each BGP router in AS1 use to send packets to destination prefix 130.12.1.0/24. Give reasons for these choices.

iii. (2 marks) Explain which NEXT_HOP router does each BGP router in AS1 use to send packets to destination prefix 142.13.0.0/16. Give reasons for these choices.

iv. (2 marks) In case the administrator of AS1 wants all BGP routers to use NEXT_HOP router R14 to send packets to destination prefix 142.13.0.0/16, how can he accomplish this by setting attributes of the BGP advertisement?

(c) Assume that Encapsulation is the solution used by AS1 for BGP-IGP interaction. The BGP routing table at each BGP speaker contains a list of IP prefixes learned using eBGP or iBGP and the corresponding exit routers. Every router in AS1 has an IGP (which is OSPF here) routing table which contains the IP address of all other routers within AS1 and the corresponding next hop on the shortest paths to those routers.

Suppose a packet P1 is forwarded to R1 from AS5 with destination 142.13.5.4. Explain how the routers of AS1 encapsulate and forward this packet toward its destination. Your answer should explain at each router along the path in AS1 the following.

i. (3 marks) Explain which router encapsulates P1 and which router eventually de-encapsulates it. Call the new packet formed after encapsulation P2. Explain which router the destination IP of P2 corresponds to.

ii. (3 marks) Which forwarding table(s) the various routers look up in order to find the next hop to forward P2 (you can say if it is IGP, BGP or both, and also state which router should be there in the next hop of the table)