CHAPTER 8

GINI Experiments

8.1. Introduction

This chapter provides a set of experiments that can be performed using the GINI toolkit. These experiments are meant to familiarize the student with key concepts involved in setting up networks and services on the Internet. For example, this chapter presents experiments that require the students to configure single LAN and multiple LAN IP networks using GINI and observe their operation. Additionally, it provides various experiments that deal with naming services, emailing services, and different forms of file transfer services.

Each experiment is structured as follows. The *Objective* section that describes what should be accomplished to complete the experiment. Any prerequisite knowledge for experiment is either provided in the *Background* section or pointers to the relevant information sources are provided. The *Description* section provides a summary of the experiment. The *Experimental procedure* section provides a higher-level description of the suggested steps to complete the experiment. Finally, the *Review Questions* section gives a set of questions that should be answered in the *lab report* written after completing the experiments.

8.2. Single LAN IP Networks

8.2.1. Overview

The single LAN IP network is a very simple network to configure and maintain. Despite its simplicity it is useful in many situations. The simplest instance of a single LAN network is a home network. Other instances of single LAN networks include networks for interconnecting machines belonging to a single department, small business, or institution. While the single LAN for small networks (e.g., home networks) might be a single switch, for larger networks (e.g., institutional networks) might be made up of multiple interconnected switches. The drawbacks of single LAN IP networks stem from the restrictions imposed by the underlying broadcast LAN technologies. Some of the notable limitations include the extent of the network, administrative policies, and traffic isolation. These limitations make single LAN IP networks unsuitable for interconnecting hosts that belong to different organizations or are controlled by different administrative policies.

8.2.2. Objective

This experiment is about constructing an example single LAN IP network using the GINI toolkit and studying various aspects of it. In particular, the experiment focuses on studying the following concepts: (a) addressing, (b) address resolution process, (c) packet routing, (d) routes, and (e) basic operations supported by LANs.

8.2.3. Background Material

As part of the preparation for this experiment, read the literature on the following topics: (a) MAC and IP addresses, (b) address resolution protocol (ARP), and (c) static routes and routing table organization. The depth of coverage provided by the textbook and/or the reference books should be sufficient to carry out the experiment. Additional information on the concepts can be obtained from the RFCs (request for comments) that are available from the IETF website.

8.2.4. Description

Consider the single LAN IP network shown in Figure 8.1 where three stations are connected via a switch. We will use the GINI Toolkit to build a virtual network that corresponds to this setup. Once the connectivity is established, network-based applications such as `ssh` and `nc` (netcat) can be used to communicate between machines.

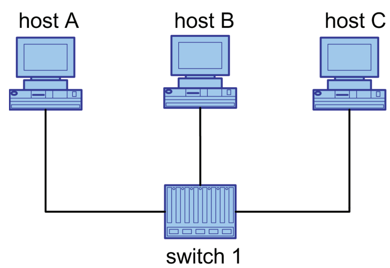

Figure 8.1: A single LAN IP network.

8.2.5. Useful Tools

- `arp` — modify the ARP cache
- `ifconfig` — configure network interfaces
- `nc` — create arbitrary TCP/IP connections
- `ping` — send ICMP ECHO_REQUESTS
- `route` — configure system routing tables

8.2.6. Experimental Procedure

This experiment can be completed by following the steps outlined below. By default `gBuilder` assigns IP and MAC addresses to the computers and routers so that routes can be setup among them. This default assignment can be overridden by the user in two different ways. The first option is for the user to select the sub network allocations for various parts of the topology. In this case, GINI assigns the IP and MAC addresses respecting the sub network allocations. The second option is for the user to completely specify all parameters (i.e., IP addresses, MAC addresses, sub network masks). The third option is to let gBuilder automatically assign the network addresses and selectively override some of the parameters by changing them at the machines and routers using commands such as `ifconfig` and `route`.

1. Configure the network using `gBuilder`, following the topology shown in Figure 8.1. Let `gBuilder` assign network parameters automatically. Start the topology and log into the machines.

2. Run the `arp -a` command and verify that the ARP caches are empty.

3. Run the `tcpdump` on `host B`. Use the `ping` command to communicate (an ECHO request and reply sequence) between `host A` and `host B`. What do you observe in the tcpdump running on `host B`?

4. Repeat the above experiment with the switch running on the `hub` mode and `bridge` modes.

5. The `gBuilder` would have assigned the hosts IP addresses from a sub network. Identify the *host* and *network* parts of the IP addresses. Note the simple procedure used by `gBuilder` for address assignment. Using the `ifconfig` command change the IP address of a host so that it gets a new address from the same network as the other machines. Does this address change disrupt the connectivity (i.e., ability of the hosts to reach one another) within the LAN? What type of connections would be disrupted by the address change?

6. As in the above step change the IP address of a host to a value outside the network used by other hosts in the LAN. For example, if `192.168.2/24` is the network address of the LAN, change the IP address of a host to `192.168.3.12`. Can the hosts connect to each other (i.e., send and receive packets). If not, what happens to the *sending* and *receiving*. An application such as `ping` requires both send and receive capabilities. If the address change breaks communication, which one is broken: send, receive, or both?

7. If the communication is broken, can it be restored without changing the IP address back to old value? There are multiple ways of restoring the communication. Some are easier than the others. Give the simplest change (hint: it might have to apply on all the machines).

8. Change the IP address of one of the hosts (e.g., `host A`) such it is same as one of the other hosts. Suppose `host A` and `host B` have same IP addresses, try to reach one of them from `host C`. Can you reach (i.e., a ping succeed)? If it succeeds, which host did you reach? One way of identifying an host is to look at the MAC address displayed by the `ifconfig` command.

9. Suppose `host C` was reaching `host A` in the above step. Can force `host C` to connect to `host B`? Demonstrate your solution.

8.2.7. Review Questions

Answer the following review questions after completing this experiment. Background reading and the knowledge gained through the experiments should be sufficient to answer the questions.

1. What is the packet routing process in a single IP LAN? Sketch it with all the details. What is the function of the address resolution protocol (ARP)?

2. What role does the switch play in routing packets?

3. Compare hub mode versus bridge mode in the switch. You can toggle between the two modes in the *Properties* menu of the switch. What are the security implications of hub mode? Does the bridge setting of the switch fix all these issues?

4. What is the structure of a MAC address? (You need to read related standards documents to answer this question). Can MAC addresses have duplicates?

5. How should we assign IP addresses to machines on a LAN? What are the constraints if the LAN is working in isolation (not connected to the Internet)?

6. Your report should include answers to questions from the *Experimental Procedure* that are not covered above.

8.3. Multiple LAN IP Networks

8.3.1. Overview

One way of overcoming the scalability limitations of single LAN IP networks is to interconnect several such networks to form multiple LAN IP networks. The interconnections among the LANs can be done at the network or data link layers. In this experiment, the LANs are interconnected using routers operating at the network layer. This approach provides network administrators the opportunity to setup routing rules that control the packet flows within the network. For example, sensitive traffic can be confined to the trusted part of the network.

8.3.2. Objective

This experiment is about constructing an example multiple LAN IP network using the GINI toolkit and studying various aspects of it. In particular, the experiment focuses on studying the following concepts: (a) addressing, (b) address resolution process, (c) packet routing, (d) routes, and (e) basic operations supported by routers.

8.3.3. Background Material

As part of the preparation for this experiment, read the literature on the following topics: (a) IP addresses, (b) address resolution protocol (ARP), (c) static routes and routing table organization, and (d) route processes. The depth of coverage provided by the textbook and/or the reference books should be sufficient to carry out the experiment. Additional information on the concepts can be obtained from the RFCs (request for comments) that are available from the IETF website.

8.3.4. Description

Consider the IP network shown in Figure 8.2, where three routers are used to interconnect five LAN segments. You will use `gBuilder` to build a virtual network that corresponds to this topology. Once the network is properly setup, network-based applications such as `ssh` and `nc` (netcat) can be used to establish application layer connectivity between the stations. If these applications fail to connect, network diagnostic tools such as `ping`, `traceroute`, `ifconfig`, and `route` should be used to troubleshoot the connectivity.

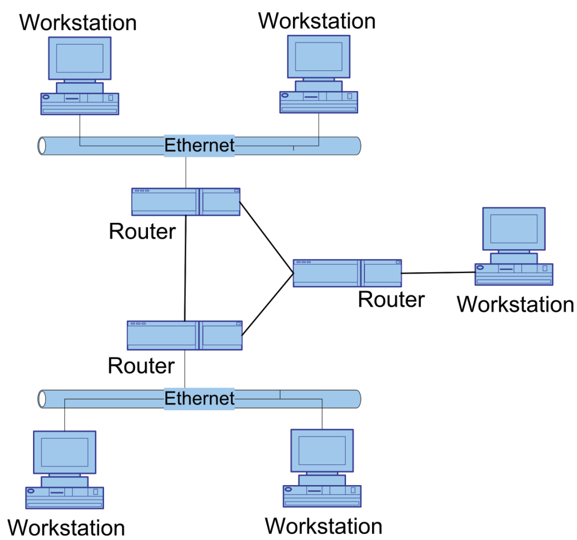

Figure 8.2: A multiple LAN IP network.

8.3.5. Useful Tools

- `nc` — create arbitrary TCP/IP connections
- `ifconfig` — configure network interfaces
- `ping` — send ICMP ECHO_REQUESTS
- `route` — configure system routing tables
- `ssh` — secure version of telnet

8.3.6. Suggested Experimental Procedure

This experiment can be completed by following the steps outlined below.

1. Configure the network using `gBuilder`, following the topology shown in Figure 8.2. Let `gBuilder` assign network parameters automatically. Start the topology and log into at least one machine from each LAN.

2. Run the `arp -a` command and verify that the ARP caches are empty.

3. Run the `tcpdump` on selected machines and a `wireshark` on a selected router. It is possible to run the wireshark packet visualizer on multiple routers if sufficient computing power is available. Use the `ping` command to communicate between machines on different LANs. Observe the traffic on wireshark and tcpdump.

4. The `gBuilder` would have assigned the hosts IP addresses from sub networks. Identify the *host* and *network* parts of the IP addresses. How are the sub networks chosen by the gBuilder to handle multiple LANs. Using the `ifconfig` command change the IP address of a host so that it gets a new address from the same network as the other machines in its LAN. Does this address change disrupt the connectivity (i.e., ability of the hosts to reach one another) with other machines? What type of connections would be disrupted by the address change?

5. As in the above step change the IP address of a host to a value outside the network used by other hosts in the LAN. For example, if `192.168.2/24` is the network address of a LAN, change the IP address of the host to `192.168.3.12`. Can the hosts connect to each other (i.e., send and receive packets). If not, what happens to the *sending* and *receiving*. An application such as `ping` requires both send and receive capabilities. If the address change breaks communication, which one is broken: send, receive, or both?

6. If the communication is broken, can it be restored without changing the IP address back to old value? There may be multiple ways of restoring the communication. Describe the possible ones.

7. Change the IP address of one of the hosts in a LAN such it is same as one of the other hosts in the LAN. How is the reachability affected? Does it affect outward and inward connectivity, or both? How can you fix this problem? Your solution may not work in GINI due to a limitation of the *gRouter*.

8.3.7. Review Questions

Answer the following review questions after completing this experiment. Background reading and the knowledge gained through the experiments should be sufficient to answer the questions.

1. What is the packet routing process in a multiple LAN IP network? Sketch it with all the details. How does the address resolution process and routing process interoperate to maintain communication between two stations on different LANs?

2. The IP network route lookup process performs a "longest prefix" matching to choose the route. Does this mechanism allow redundant routes? What are the advantages of using the longest prefix matching scheme? What are the disadvantages?

3. Do a `traceroute` from one station to another station on another LAN. Give a high-level trace of the packets that were generated due to this operation. Include the ARP packets, if there are any, in the discussion.

4. Do an `ssh` connection from one station to another station. Give a high-level trace of the packets that were generated due to this operation. Do not include any ARP packets in this discussion. Is this any different from the single LAN IP network? Explain your findings.

5. Your report should include answers to questions from the *Experimental Procedure* that are not covered above.