ECE 4110 Internetwork Programming
Lab 6: Setting up a Network Using Cisco Routers, Switched and VLAN Technology

Group Number: _____

Member Names: _____ _____

Date Issued: 3/7/2008
Date Due: **3/28/2006 - Tuesday**
Last Edited: 3/7/2005

NOTICE: Because there are only three setups, each group will need to sign up for timeslots on the sheets attached to the lab door. You can only sign up for a total of 2 hours (4 slots) at a time, AND YOU MUST USE THE SAME SETUP FOR THE ENTIRE LAB. These can either be in a row or spread out, but no group can have more than 4 slots reserved at any one time. Once one of your slots has expired, you can sign up for another one. See Appendix C for instructions on how to save and reload your work if you need to leave and continue later.

Please read the entire lab before you show up to start working on it.

Fill this blank in after you make your reservation:
We signed up for PLAYSTATION #: _____

Lab Goals

- Configure switches and routers on a network
- Understand VLANs
- Understand routing and sub-interfaces

PART I

Section I: Logging into the Routers/Switches

All of the routers and switches are accessible from a Digi console CM32. There are three playstatations: playstation1 (Enterprise), playstation2 (Bad ISP/University), and playstation3 (Good ISP). From here on in, they will be referred to as **playstationX, where X is the number of the playstation you are working on**. The following instructions describe how to access the Digi console CM32 and log into a port which is in turn connected to the console port of the Cisco equipment:

You may use any free mini-net computer with your own hard drive inserted into it to communicate with the rack of equipment. In order to connect to the CM32 you need to set up your mini-net's machine network card to access its network:
 # ifconfig eth0:0 192.168.254.<100+group #>
So group 1 is 192.168.254.101, and so forth. **You will need to do this every time you power off your machine.** What this does is set up a virtual interface, so you have two IP addresses on one network card. This allows you access to two networks with only one interface card.

You will be using a series of scripts to help you set up the routers and save your work. These scripts are described in detail in Appendix C. First, go to Appendix C and install the scripts (you're your hard drive) according to the directions. Once this is done, MAKE SURE NO ONE ELSE IS USING THE PLAYSTATION YOU WANT TO USE. This is very important, as you are about to reset the equipment configuration, and all of their work will be lost.

Now that you are sure no one else is using the playstation, reset your chosen playstation by running the *reset_pX* script in the *mnet_tools_v1.5* directory. Several windows should pop up. **DO NOT CLOSE THEM UNTIL IT IS SAFE TO DO SO.** If you are on playstation 1 or 2, you will get an error in one of the windows about VPN or Firewall processing not being enabled; ignore this for now. Once all of the other windows say it is safe to close them, do so. Now run the *download_pX* script to save the current configuration. From now on, you'll run the *download_pX* script to save your work, and the *upload_pX* to restore the configuration of the playstation to the last saved state. Before running the upload script, **MAKE SURE NO ONE ELSE IS USING THE PLAYSTATION.**

Once you have reset your playstation, connect to the CM32:
#ssh playstationX@192.168.254.2
If it comes up, Type yes to the RSA question.
password: playstationX (Note X is a number)

The following screen appears:

```
================================================================
Port#    Port Title      Mode   Port#    Port Title      Mode
================================================================
1    Port Title #1       CS     2    Port Title #2       CS
3    Port Title #3       CS     4    Port Title #4       CS
5    Port Title #5       CS     6    Port Title #6       CS
7    Port Title #7       CS     8    Port Title #8       CS
9    Port Title #9       CS     10   Port Title #10      CS
11   Port Title #11      CS     12   Port Title #12      CS
13   Port Title #13      CS     14   Port Title #14      CS
15   Port Title #15      CS     16   Port Title #16      CS
17   Port Title #17      CS     18   Port Title #18      CS
19   Port Title #19      CS     20   Port Title #20      CS
21   Port Title #21      CS     22   Port Title #22      CS
23   Port Title #23      CS     24   Port Title #24      CS
25   Port Title #25      CS     26   Port Title #26      CS
27   Port Title #27      CS     28   Port Title #28      CS
29   Port Title #29      CS     30   Port Title #30      CS
31   Port Title #31      CS     32   Port Title #32      CS

 Enter command (1-32 serial port, others for exit)
 ------>
```

Each router/switch has a console port connected to a port on the digiconsole. The digiconsole port numbers are what identifies each router and are printed to the left of each machine on the racks in the back of the room.

Table 1. Console manager port assignments

Part	**Console Manger Port Assignment**
Playstation1	
Cisco 3550 Switch	5
Cisco 1760 Router (Mars)	7
Cisco 1760 Router (Saturn)	8
Cisco 1760 Router (Earth)	9
Playstation2	
Cisco 3550 Switch	14
Cisco 1760 Router (Mars)	16
Cisco 1760 Router (Saturn)	17
Cisco 1760 Router (Earth)	18

Playstation3	
Cisco 3550 Switch	23
Cisco 1760 Router (Mars)	25
Cisco 1760 Router (Saturn)	26
Cisco 1760 Router (Earth)	27

Go to the rack and locate the switch and 3 routers you will be using by the numbers in Table 1. Then, type in the number for the 3550 switch into the port selection screen. You may need to hit <ENTER> a few times to get a prompt. You are now logged into the network device at the port you specified. To log out of that device, type *control-Z* and then hit *x*.

Figure 1 shows the network topology that we will be creating with the switch and routers. It shows the three physical routers (Mars, Saturn, and Earth) as well as the 6 VLANs we will be creating on the switch. Go ahead and fill in the Digi #'s for the different components. Make sure you write down the number of the playstation you are working on. (You are only filling in four blanks Digi #_____ and the playstation blank at this point in the lab).

Section II: Switch Configuration

The switches we are using are Cisco 3550s.
From the vendor's web site:
http://www.cisco.com/en/US/products/hw/switches/ps646/ps3816/index.html



The Cisco Catalyst® 3550 48 EMI is a member of the Catalyst 3550 Series Intelligent Ethernet Switches, a line of enterprise-class, stackable, multilayer switches that provide high availability, security and quality of service (QoS) to enhance the operation of the network. With a range of Fast Ethernet and Gigabit Ethernet configurations, the Catalyst 3550 Series can serve as both a powerful access layer switch for medium enterprise wiring closets, as a backbone switch for mid-sized networks, and also for the edge of metro access networks. For the first time, customers can deploy network-wide intelligent services, such as advanced quality of service (QoS), rate-limiting, Cisco security access control lists, multicast management, and high-performance IP routing-while maintaining the simplicity of traditional LAN switching.

VLAN configuration is typically easy; however, there are a few things that you need to know to be successful. Cisco defines a VLAN as a broadcast domain within a switched network. VLANs allow you to segment your switched network so that broadcast domains are smaller, leaving more bandwidth for your end nodes. Devices that are in one VLAN do not received broadcasts from devices in another VLAN. For devices on different VLANs to communicate, a layer 3 devices (usually a router) must be used.

The first time you connect to Cisco equipment you will be in the **EXEC-Mode** and the prompt should have the form *equipment_name*>. The EXEC-Mode provides a very limited subset of commands. To get a list of commands type '?'.

To enter the **Privileged EXEC-Mode** from the EXEC-Mode, type *enable*<ENTER>. If a password is requested, enter the password owen. The prompt should be of the form *equipment_name#*. To get a list of the commands available in this mode type '?'.

The **Global Configuration Mode** allows you to make changes to the running configuration. To enter the Global Configuration Mode, type *configure terminal*<ENTER>. When in the Global Configuration Mode the prompt is of the form *equipment_name(config)*. To exit back to Privileged EXEC-Mode, type *exit*.

Note: You have to be in the Privileged EXEC-Mode to enter the Global Configuration Mode.

In any of the modes, you can hit '?' to see a list of commands. This even works for multiple word commands. Try *configure ?* in Privileged EXEC-Mode to see what all the possible arguments are.

Refer to Appendix A for a list of switch configuration commands and their descriptions.

While in Privileged EXEC-Mode, you can view the running configuration by typing show *running-config*. This contains information about all the interfaces and vlans you've set up.

Table 2 lists the different switch interfaces we will be using, along with their respective VLAN connections. Consulting this table, label the router interfaces in Figure 1 with their respective switch interface assignments. For example, VLAN 6 is assigned across two switch interfaces, FastEthernet0/2 and FastEthernet0/5. In Figure 1, there are two router interfaces which connect to VLAN 6, so assign switch interface 0/2 to one, and switch interface 0/5 to the other.

Table 2. Switch interfaces and assigned VLANs

Switch Interface	**VLAN Assignment**
Fastethernet0/1	VLAN 4
Fastethernet0/2	VLAN 6
Fastethernet0/3	VLAN 7
Fastethernet0/4	VLAN 5
Fastethernet0/5	VLAN 6
Fastethernet0/6	VLAN 3
Fastethernet0/7	VLAN 4
Fastethernet0/9	VLAN 2
Fastethernet0/11	VLAN 3

To create VLANs inside the switch, follow these simple steps:
SwitchA# vlan database <ENTER>
SwitchA(vlan)# vlan <vlan_number> <ENTER>
SwitchA(vlan)# exit

Do this for each of the vlans in Table 2. Now configure the interfaces to access those vlans:
SwitchA# configure terminal <ENTER>
SwitchA(config)# interface fastethernet <interface_number> <ENTER>
SwitchA(config-if)# switchport mode access <ENTER>
SwitchA(config-if)# switchport access vlan <enter a number here> <ENTER>

In the next command, <SPEED> depends on the router interface connected to it. Consulting the completed Figure 1, configure the interface speed to 10 for Ethernet interfaces and 100 for FastEthernet interfaces. For example, if you are configuring switch interface 0/5, and it corresponds to interface Ethernet 0/0 on one of the routers, <SPEED> equals 10; if it corresponds to interface FastEthernet 0/0, <SPEED> equals 100.
SwitchA(config-if)# speed <SPEED> <ENTER>
SwitchA(config-if)# duplex full <ENTER>
SwitchA(config-if)#no shutdown
SwitchA(config-if)# end

Use the above configuration procedure to configure each of the switch interfaces listed in Table 2. **(Do this on the switch, not on the routers).** Once you are done, it is a good idea to download your configuration so you do not lose it.

Note: VLAN 1 (one) is used for the management VLAN, so any VLANs created should be numbered 2 to 1000.

Section III: Router Configuration

We are using Cisco 1760 routers. From the vendor's web page:
http://www.cisco.com/en/US/products/hw/routers/ps221/ps227/

The Cisco 1760 Modular Access Router offers small to medium sized businesses and small enterprise branch offices a 19-inch rack-mount access solution designed to embrace the productivity benefits of business applications. A modular router optimized for multi-service integration of voice, video, data and fax traffic, the Cisco 1760 provides businesses with the most complete functionality and flexibility to deliver secure Internet and Intranet access. The router offers a wide array of WAN access options, Voice over IP, high-performance routing with Quality of Service, inter-virtual LAN routing, and VPN access with firewall options. Powered by Cisco IOS, the Cisco 1760 allows simplified management and traffic prioritization, ensuring that the most strategic business and time-sensitive applications perform as expected.

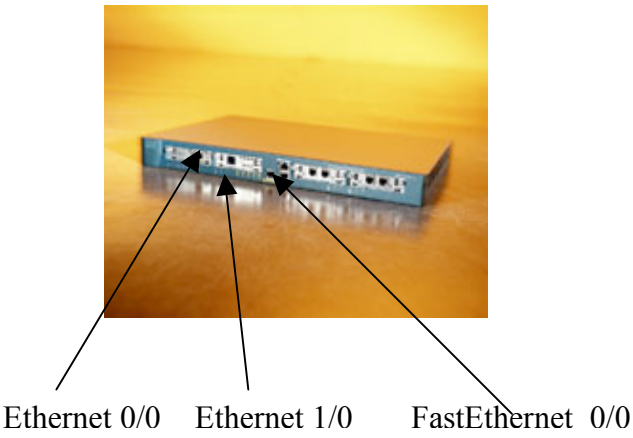


Table 3. Routers and their respective enable passwords

Router	Enable Password
Cisco 1760 (Mars)	owen
Cisco 1760 (Saturn)	owen
Cisco 1760 (Earth)	owen

To log into the routers, simply type their number at the console manager screen (see Table 1). If you are still logged into the switch, hit <*CTRL+z*> and then *x* to go back to the console manager screen (do the same to log out of any of the routers).

Navigating the router is exactly the same as navigating the switch. That is, you start in **EXEC-Mode**, and enter **Privileged EXEC-Mode** by typing *enable* followed by the enable password. To enter **Global Configuration Mode**, type *configure terminal* in Privileged EXEC-Mode.

Refer to Appendix B for a list of router configuration commands and their descriptions.

Using the following configuration example you should be able to configure the routers. **(Use the topology diagram as a guide, use the router port interface assignments given in Figure 1 showing which router interface you must assign to which IP address)**

To configure a router with interfaces Ethernet0/0, Ethernet1/0, and FastEthernet0/0 to route packets between subnetworks 10.1.1.0, 10.1.2.0, and 10.1.3.0, you would have to use the following command sequences from Global Configuration mode.

Note: This is only an example and will NOT set up your interfaces correctly. Look at Figure 1 to determine which interfaces should get which IP addresses.

Router(config)# interface Ethernet 0/0 <ENTER>
Router(config-if)# ip address 10.1.1.1 255.255.255.0 <ENTER>
Router(config-if)# full-duplex <ENTER>
Router(config-if)# no shutdown <ENTER>
Router(config-if)# interface Ethernet 1/0 <ENTER>
Router(config-if)# ip address 10.1.2.1 255.255.255.0 <ENTER>
Router(config-if)# full-duplex <ENTER>
Router(config-if)# no shutdown <ENTER>
Router(config-if)# interface FastEthernet 0/0 <ENTER>
Router(config-if)# ip address 10.1.3.1 255.255.255.0 <ENTER>
Router(config-if)# speed auto <ENTER>
Router(config-if)# full-duplex <ENTER>
Router(config-if)# no shutdown <ENTER>
Router(config-if)# end <ENTER>

To show what you have in the device use the command in **Privileged EXEC-Mode**:
show running-config

You need to repeat the above configuration for each of the three routers. Once again, look at Figure 1 to determine which interfaces are assigned which IP addresses. Once you are done, download your configuration so you do not lose it.

Section IV: Physically Connecting the Network

We have now set up everything for our network except physically connecting the routers to the switch. In the network topology diagram the routers are connected to each other. In reality the routers will be logically connected to each other through the switch, and the VLANs allow virtual networks to exist.

Before you start, there should only be one cable connected to each piece of equipment (including equipment you are not using). The routers should only have one cable going to the Console port (the switch console ports are on the back). All other cables should be removed and stored in the box marked playstationX, where X is the number of the playstation you are using. **Only use the cables located in this box to wire up your playstation, and place them back in the box when you are finished.**

Consulting Figure 1, wire the three interfaces on each router to their corresponding interfaces on the switch. On each router, Ethernet 0/0 is the left interface card (labeled 10 BT ETHERNET), Ethernet 1/0 is the right interface card (labeled 10 BT ETHERNET), and FastEthernet 0/0 is the port labeled 10/100 ETHERNET. The wires should only go from the routers to the switch, i.e. no two routers should be physically connected together.

Example:

From the topology diagram, router Mars' Ethernet 0/0 port is connected to VLAN 4 (10.1.3.0/24). When configuring the router, this port should have been assigned an IP address from VLAN4 (10.1.3.1). You should also have assigned this port a corresponding interface port on the switch (lets say FastEthernet0/1). All that remains to do is to connect the Ethernet 0/0 port on the router to the FastEthernet0/1 port (port 1) on the switch. The light for port 1 should turn orange, and after about half a minute change to green. Repeat this process for all three interfaces on all three routers. When you are done, there should be nine green lights on the switch (not counting the green light for port 24).

If the lights do not turn from orange to green after a long time, there may be a problem with the network you set up. Log into the router that is having the problem and type *show running-config* in Privileged EXEC-Mode to check that all three interfaces have been set up correctly.

As a second turn in figure, draw lines in figure 2 at the back of the lab handout in the turn in section to show what you physically wired to what.

Once all the lights are green, you should be able to have the routers ping each other; simply log into Privileged EXEC-Mode and type *ping <IP>*, where <IP> is the IP address of the interface you want to ping. Ping the two neighboring interfaces from each router (i.e. from Mars, ping the interfaces on Earth and Saturn connected to VLAN4 and VLAN3).

Section V: Setting Up Routing

From Earth:

1. Ping the 10.1.5.1 interface in vlan6 on Saturn.
2. Ping the 10.1.2.2 interface in vlan3 on Saturn.
3. Ping the 10.1.4.1 interface in vlan5 on Saturn.

You should be able to ping the interface in vlan6 from Earth because Earth is directly connected to vlan6. vlan3 and vlan5 are not directly connected to Earth and the Earth router does not contain a route to these vlans in its routing table. First, you must enable ip routing on each of the three routers. Ip routing performs the packet switching and routing protocol processes on these devices.

To enable ip routing on Earth, log into Global Configuration Mode and type:
Earth(config)# ip routing

To view the routing table of the Earth router: (you need to exit the "global configuration mode)
Earth# show ip route

```
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, * - candidate default
       U - per-user static route, o - ODR

Gateway of last resort is not set

    10.0.0.0/24 is subnetted, 3 subnets
C       10.1.3.0 is directly connected, Ethernet1/0
C       10.1.6.0 is directly connected, Fastethernet0/0
C       10.1.5.0 is directly connected, Ethernet0/0
```

The *show ip route* command provides invaluable information to the network administrator. It allows you to determine what path a packet takes through the network. The first section of output is the legend for the first column of the table itself. It tells us where a route was derived from. In the above example, a C tells us that the route is from a directly connected operational interface. The gateway of last resort is the network address of the router to which packets destined for outside this network should be sent when there is no specific routing information on how to reach that destination. In this example, Earth has not learned a gateway of last resort because no static routes have been configured and no dynamic protocols are running.

The last section is the routing table itself. The output shows that this router has learned four subnet routes along with the respective interface name. It is important to note that the network or sub-network addresses, not the IP address of the individual devices, are listed in the routing table.

Both static and dynamic routing information can be used to build up the routing table and, therefore, the network path information. Static routes do have some drawbacks, such as the inability to adapt when a data circuit goes down or when the network topology changes. Later we will explore dynamic routing but for now we will use static routes.

Configuring static routes is performed by using the global configuration command *ip route*. The command takes several parameters, including the network address and the associated network mask, as well as information on where the router should send packets destined for that network. The destination information can take on several forms:

- A specific IP address of the next router in the path
- The network address of another route in the routing table to which packets should be forwarded

The second option will be used later in the lab. The first option is straightforward, and it is the predominant way in which static routes are entered. The following is an example of entering a static route on the Earth router. This route directs packets destined to the network 10.1.4.0/24 (vlan5) over vlan6 to the Saturn router, which has an address of 10.1.5.1:

Earth# configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Earth(config)# ip route 10.1.4.0 255.255.255.0 10.1.5.1
Earth(config)# exit
Earth# show ip route

You should now see an additional entry in Earth's routing table:
S 10.1.4.0 [1/0] via 10.1.5.1

Use these static routing commands to configure static routes on each router in the network so that you can ping from any subnet in the network to any other subnet in the network (i.e.; each router should be able to ping the 3 interfaces on each of the other two routers). View the routing tables of each router to observe the changes made to the routing tables as static routes are added. SAVE YOUR WORK!

Show the TA your working network and have the TA do some ping tests. Have the TA sign you off (on the turn in sheet at the back of the lab handout) as completing Part I. You will need to turn in the diagrams after completion of Part II.

Part 1 Check-off point: show the lab TA your working network and routing tables.

See turn in sheet at the back of this handout.

PART II

Section V: Setting up Sub-Interfaces

Suppose you need to add an additional three VLANs to the Saturn router because of enterprise changes etc. The only problem is that the Saturn router does not have three additional available ports. IEEE 802.1q encapsulation protocol and the use of sub-interfaces will be used to overcome these obstacles. This technique only works on Fastethernet ports when using Cisco equipment.

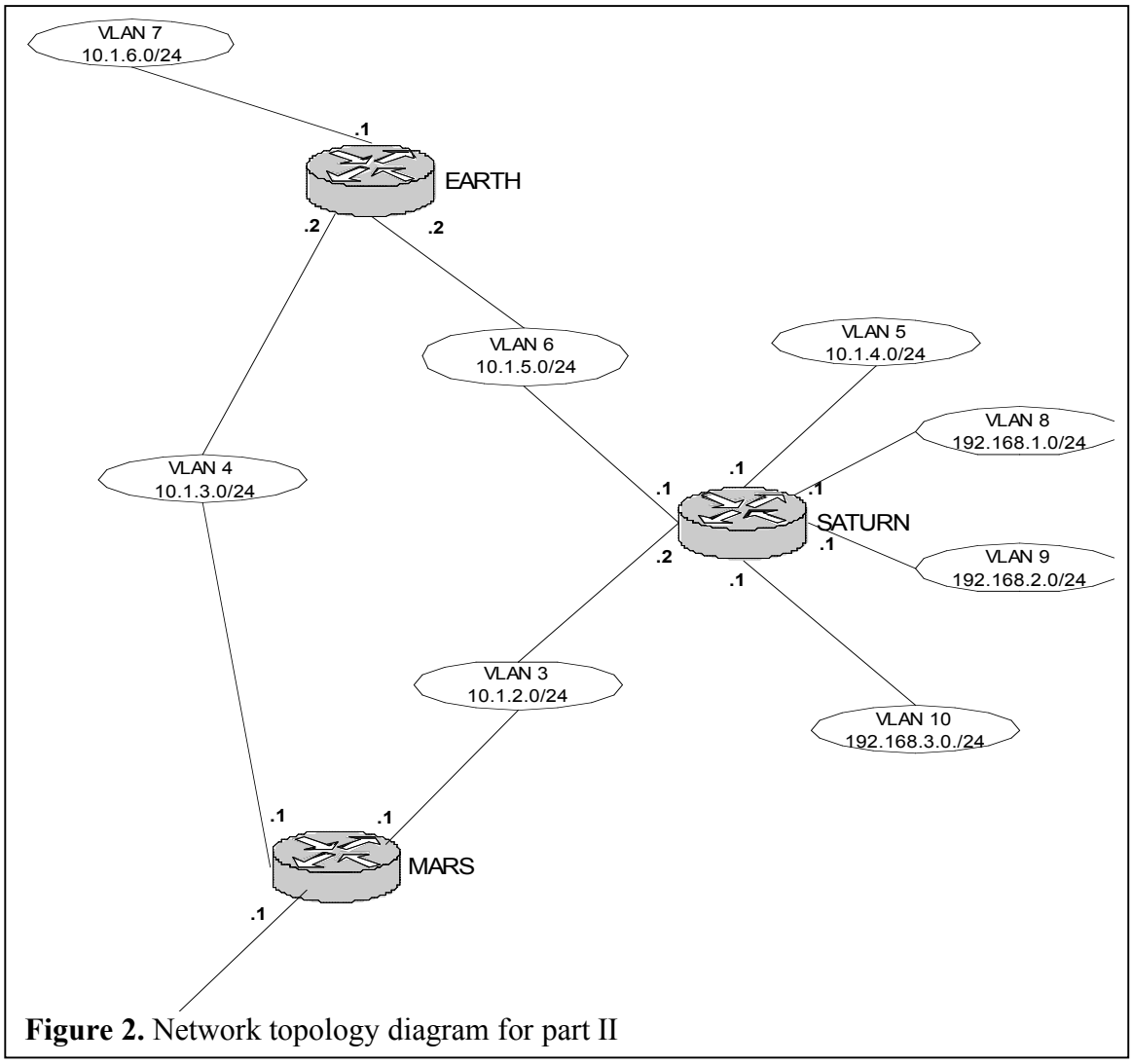


Figure 2. Network topology diagram for part II

Log into the Saturn router. The Fastethernet0/0 port currently assigned to vlan5 will be used to add vlans 8,9, and 10. To configure one physical interface to route packets between sub-networks 10.1.4.0, 192.168.1.0, 192.168.2.0, and 192.168.3.0, you will have to use the following sequence of commands from the Global Configuration mode.

Router(config) interface FastEthernet 0/0 <ENTER>
Router(config-if) no ip address <ENTER>
Router(config-if) no ip mroute-cache <ENTER>
Router(config-if) no speed auto <ENTER>
Router(config-if) full-duplex <ENTER>

Router(config-if) no shutdown <ENTER>
Router(config-if) interface FastEthernet 0/0.1<ENTER>
Router(config-subif) encapsulation dot1Q <vlan_number1> <ENTER>
Router(config-subif) ip address 10.1.4.1 255.255.255.0 <ENTER>
Router(config-subif) no shutdown <ENTER>
Router(config-subif) interface FastEthernet 0/0.2 <ENTER>
Router(config-subif) encapsulation dot1Q <vlan_number2> <ENTER>
Router(config-subif) ip address 192.168.1.1 255.255.255.0 <ENTER>
Router(config-subif) no shutdown <ENTER>
Router(config-subif) interface FastEthernet 0/0.3 <ENTER>
Router(config-subif) encapsulation dot1Q <vlan_number3> <ENTER>
Router(config-subif) ip address 192.168.2.1 255.255.255.0 <ENTER>
Router(config-subif) no shutdown <ENTER>
Router(config-subif) interface FastEthernet 0/0.4 <ENTER>
Router(config-subif) encapsulation dot1Q <vlan_number3> <ENTER>
Router(config-subif) ip address 192.168.3.1 255.255.255.0 <ENTER>
Router(config-subif) no shutdown <ENTER>
Router(config-subif) end <ENTER>

You will have replace <vlan_numberX> with the corresponding vlan as shown in the network diagram.

For VLAN information to be passed between the switch and the Saturn router, trunking must be configured on the switch port. VLAN trunking allows a port to pass traffic from multiple VLANs between the two switches or between a switch and a router. Frames traveling over a trunk are tagged to identify which VLAN the frames belong to.

To setup trunking on the switch port, use the following commands:
SwitchA(config)# interface fastethernet <interface_number> <ENTER>
SwitchA(config-if)# switchport trunk encapsulation dot1q <ENTER>
SwitchA(config-if)# switchport mode trunk <ENTER>
SwitchA(config-if)# end

Now test your connections, from Earth:

1. Ping the 10.1.4.1 interface on Saturn
2. Ping the 192.168.1.1 interface on Saturn
3. Ping the 192.168.2.1 interface on Saturn
4. Ping the 192.168.3.1 interface on Saturn

You should be able to ping the 10.1.4.1 interface because of the configuration setup in scenario one, but you should not be able to ping any of the other three interfaces. This is because there are no routes setup on the Earth router (or the Mars router) to the three new vlans. In order to enable communication with the new vlans we will be employing default routes.

Summary or default routes provide default reachability information within a given address space. The default route is typically used to provide default reachability information about subnets that are not specifically found in the routing table but that exist within the intranet. In the network diagram, for example, the route 192.168.0.0/16 would be considered a summary route. If a router encountered a packet destined for 192.168.1.1 but does not find a specific route, such as 192.168.1.0/24, it usually discards the packet. If in this situation there were a summary route 192.168.0.0/16 in the routing table, the packet would be forwarded out the interface toward to next-hop destination for the summary route.

The goal of the default route is to direct packets toward other routers within the intranet that have more complete routing information. The summary route can be configured using the IOS global configuration command ***ip route***. When the ip route command is used, the summary route, the network mask, and the non-connected subnet are supplied as parameters.

To create a default route on Earth to the 192.168.0.0 networks on Saturn type:

Earth# configure terminal
Earth(config)# ip route 192.168.0.0 255.255.0.0 10.1.5.0
Earth(config)# exit

After this is configured the summary route appears in the ip routing table. Use the **show ip route** command to view the routing table:

Earth# show ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
E1 - OSPF external type 1, E2 - OSPF external type 2
i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
ia - IS-IS inter area, * - candidate default, U - per-user static route
o - ODR, P - periodic downloaded static route

Gateway of last resort is not set

10.0.0.0/24 is subnetted, 6 subnets
C 10.1.3.0 is directly connected, Ethernet1/0
S 10.1.2.0 [1/0] via 10.1.5.1
[1/0] via 10.1.3.1
S 10.1.1.0 [1/0] via 10.1.3.1
C 10.1.6.0 is directly connected, FastEthernet0/0
C 10.1.5.0 is directly connected, Ethernet0/0
S 10.1.4.0 [1/0] via 10.1.5.1
S 192.168.0.0/16 [1/0] via 10.1.5.0
Earth#

In order for packets to reach the 192.168.0.0/16 network, a route to the 10.1.5.0/24 network must be in the routing table. Packets for 192.168.0.0/16 are forwarded out the same interface from which packets destined for 10.1.5.0/24 are forwarded.

Now try pinging the new interfaces on configured on the Saturn router from Earth.

Setup a default route to the 192.168.0.0 vlans on Saturn from the Mars router. Again, ensure that you can now ping all of the interfaces in the network from any of the network routers. **SAVE YOUR WORK!**

Show the TA your working network and have the TA do some ping tests. Have the TA sign you off as completing Part II (see the turin in sheet at the back of this handout) . You will need to turn in the diagrams after the sign off. **Also, take a screen-shot of the final routing tables (after Part 2) for the three routers (Earth, Mars, and Saturn) and turn them in.**

Part 2 Check-off point: show the lab TA your working network and routing tables.

See the turn in sheet at the back of this handout.

Appendix A: Basic Cisco Switch Commands

About this document

The purpose of this document is to give you a quick overview of how the switch user interface works, so you can have a quick start for lab setups and troubleshooting. Also, a VLAN tutorial is included in this document.

Similarities between routers and switches

Switches share many commands with routers; in other words, you can use many of the router commands to interact with switches and the results will be the same. For examples, *Switch# show running-config <ENTER>* will have the same effect on both devices. Therefore, make sure that you read *'Basic Cisco Router Commands.doc'* before you continue reading this document.

VLANS in the MiniNet Network

Vlan configuration is typically easy; however, there are a few things that you need to know to be successful. Cisco defines a VLAN as a broadcast domain within a switched network. VLANs allow you to segment your switched network so that broadcast domains are smaller, leaving more bandwidth for your end nodes. Devices that are in one VLAN do not received broadcasts from devices in another VLAN. For devices on different VLANs to communicate, a layer 3 devices (usually a router) must be used.

How to create vlans follow these simple steps:

SwitchA# vlan database <ENTER>
SwitchA(vlan)# vlan <vlan_number> name <vlan_name> <ENTER>
SwitchA(vlan)# exit
SwitchA# configure terminal <ENTER>
SwitchA(config)# interface fastethernet <interface_number> <ENTER>
SwitchA(config-if)# switchport mode access <ENTER>
SwitchA(config-if)# switchport access vlan 2 <ENTER>
SwitchA(config-if)# end

Note: VLAN 1 (one) is used for the management VLAN, so any VLANs created should be numbered 2 to 1000.

For VLAN information to be passed between switches, trunking must be configured between switches. VLAN trunking allows a port to pass traffic from multiple VLANs between the two switches. Frames traveling over a trunk are tagged to identify which VLAN the frames belong to. When implementing trunking between switches, the ports at either end of the connection must be set up for trunk mode and the trunk encapsulation mode must match. Trunk encapsulation dictates the manner that frames are identified (tagged) on a trunk and defines the VLAN services available. There are four types of trunking encapsulations: 1) Inter-Switch Link Protocol (ISL) Cisco proprietary trunking protocol; 2) IEEE 802.1Q (dot1q) Industry standard trunking protocol; 3) LAN Emulation (LANE) Used for trunking VLANs over ATM links; and 4) IEEE 802.10 (dot10q) Cisco proprietary method for transporting VLAN information inside standard FDDI frames.

To setup trunking between two switches, use the following commands:
SwitchA(config)# interface fastethernet <interface_number> <ENTER>
SwitchA(config-if)# switchport mode trunk <ENTER>
SwitchA(config-if)# switchport trunk encapsulation dot1q <ENTER>
SwitchA(config-if)# end

Then, go to the other switch, and repeat these commands on the respective interface. This is important, otherwise, both switches will not be able to communicate to each other.

To limit which VLANs will be allowed to pass information on the port you can use the following commands:

SwitchA(config)# interface fastethernet <interface_number> <ENTER>
SwitchA(config-if)# switchport trunk allowed vlan remove 1-1005 <ENTER>
SwitchA(config-if)# switchport trunk allowed vlan add 1-3 <ENTER>

Then, you will have to repeat these commands on the other switch.

The previous commands remove the default of all VLANs, and adds back support for VLANs 1-3.

Finally, to avoid having to reconfigure your VLANs in case the switches are rebooted, type the following:

RouterA# copy running-config startup-config <ENTER>

Appendix B: Basic Cisco Router Commands

References on the www and hardcopy
http://www.cisco.com/univercd/cc/td/doc/product/software/ios120/12cgcr/rbkixol.htm
Cisco Router Configuration, 2nd Edition, A practical Introduction to Cisco IOS Software configuration.

About this document
The purpose of this document is to give you a quick overview of how the router interface works, so you can have a quick start for lab setups and troubleshooting.

Configuring a Router from Scratch

If the router is turned on for the first time or if the router has a missing startup-config file, then, you will see a message that says:
Would you like to enter the initial configuration dialog? [yes/no]:
At this message just type *no* and press the <*ENTER*> key.
You will see the router prompt as *'Router>'*. This means that the default running configuration was loaded; in other words, the router is not configured. To configure it, you will have to type *'enable'* followed by pressing the *'<ENTER>'* key. It will not ask you for a password since it has not been set up since starting from scratch. Now you will see the router prompt as *'Router#'*.

Editing Commands
The following command or key-strokes are used to move around the command line inside the router.

Command	Description
<CTRL>+A	Moves to the beginning of the command line
<ESC>+B	Moves back one word
<CTRL>+B or Left Arrow key	Moves back one character
<CTRL>+E	Moves to the end of the command line
<CTRL>+F or Right Arrow key	Moves forward one character
<ESC>+F	Moves forward one word
<CTRL>+k	Deletes all characters from the cursor until the end of the line
<CTRL>+p or Up Arrow key	Recalls last (previous) command
<CTRL>+n or Down Arrow key	Recalls most recent command
>show history or #show history	Shows command buffer
<TAB>	Command completion – completes a partial command name
?	Displays all available commands or command parameters

Three command modes used in routers are EXEC-Mode, Privileged EXEC-Mode, and Global Configuration Mode. There other command modes, but these are the main ones.

EXEC-Mode Commands
Provides a limited subset of commands. The first time you connect to a router, this is the mode that you will be in. The command prompt has the form *'Router>'*
To get a list of commands type '?'. If you see --*More*--, that means that the screen can be advanced by pressing either <*ENTER*> key, scrolls one line up, or <*SPACE*>, scrolls one page up.

Privileged EXEC-Mode Commands

Provides access to all commands in the router. To enter Privileged EXEC-Mode from EXEC-Mode, type *enable<ENTER>*. If a password has been setup for Privileged EXEC-Mode, you will be asked for it. It is assumed that the router has been reset to its default settings, and that it does not have any passwords setup.

Some of the commands that you will need to use are shown in the following table.

Command	Description
configure terminal	Enters Global Configuration Mode.
copy	Copies configuration or image data
copy running-config startup-config	Stores the current configuration in RAM into NVRAM
copy running-config <file_name>	Copies the current configuration in RAM into <file_name> located in flash: device
dir [device]	List the files on a given device, use *dir ?* for a list of possible parameters for device
disable	Turns off privileged commands
enable password	Sets a local password to control access to various privileged levels
enable secret	Specifies an additional layer or security over the enable password command
erase startup-config	Erases the content of NVRAM
erase	Erases Flash or configuration memory
exit	Exits any configuration mode, or closes an active terminal session and terminates the EXEC
reload	Halts and performs a cold return; reloads the operating system. It will also reload the startup-config file if available.
ping	Sends an echo request; diagnoses basic network connectivity
show [options]	This is a very important command since you can display a great variety of router information. Type *'show ?'* to display all your possible options.
show running-config	Displays the current configuration in RAM
show interfaces	Displays statistics for all interfaces configured on the router
show ip interface	Displays the status and global parameters associated with an interface
show ip protocols	Displays the parameters and current state of the active routing protocol process
show startup-config	Displays the saved configuration, which is the contents of NVRAM
more	Displays the contents of a file
setup	Enters the setup command facility
?	Displays all available commands or command parameters

Global Configuration Mode

This mode allows you to make changes to the running configuration. You will need to know more about this mode that anything else. From here you can configure routing protocols, interfaces, sub-interfaces, and more. To enter Global Configuration Mode, you will need to be in Privileged ECEX-Mode. Then, type *'configure terminal <ENTER>'*.

From this mode, you can have access to two sub-modes: the Interface Configuration mode and the Sub-interface Configuration mode. To enter either of these modes, you will need to type the interface command followed by a interface or a subinterface.

Notice that some routers have three physical interface, but other routers have only one physical interface. In the case of routers with only one interface, subinterfaces are created on top of the physical interface(more details on this are given later on). In addition, interfaces are named as either EthernetX/Y or FastEthernetX/Y where X will normally take numbers between 0-1, and Y will normally take values like 0,1,2,3,0.1,0.2, or 0.3 (the values for X and Y given here apply to our lab setup only; they could be

different in other network setups). Also, routers have a mixture of Ethernet and FastEthernet interfaces whereas switches (in our lab network) have FastEthernet interfaces. Take a look at the *'ece4110-2004-02-Fall-labs-7-and-8-LabSetup.xls'* file to get familiar with the router interface names.

The following table shows some commands and subcommands that you can use in Global Configuration mode.

Command	Description
interface	Configures an interface type and enters configuration mode.
ip address	Assigns and address and a subnet mask and starts IP processing on an interface
ip default-network	Establishes a default route
ip host	Makes a static name-to-address entry in the router's configuration file
ip route	Establishes static routes
line	Identifies a specific line for configuration and starts the line configuration command collection mode.
login	Logs in as a particular user. Enables password checking at login
network	Assigns a Network Information Center-based address to which the router is directly connected.
no shutdown	Restarts a disabled interface
router	Starts a routing process by first defining an IP routing protocol. For example, *router rip* selects RIP as the routing protocol
encapsulation	Set encapsulation type for an interface This is used to attach a sub-interface to a specific vlan.
full-duplex	Configure full-duplex operational mode
half-duplex	Configure half-duplex and related commands
?	Displays all available commands or command parameters

Configuration Examples

To configure router with interfaces Ethernet0, Ethernet1, and FastEthernet0 to route packes between subnetworks 10.1.1.0, 10.1.2.0, and 10.1.3.0, you will have to use the following command sequences from Global Configuration mode.

Router(config)# interface Ethernet0 <ENTER>
Router(config-if)#ip address 10.1.1.1 255.255.255.0 <ENTER>
Router(config-if)full-duplex <ENTER>
Router(config-if) no shutdown <ENTER>
 # It is optional to type exit after you have configured one interface and before
 # configuring the next one
Router(config-if)interface Ethernet1 <ENTER>
Router(config-if)ip address 10.1.2.1 255.255.255.0 <ENTER>
Router(config-if)full-duplex <ENTER>
Router(config-if) no shutdown <ENTER>
Router(config-if)interface FastEthernet0 <ENTER>
Router(config-if)ip address 10.1.3.1 255.255.255.0 <ENTER>
Router(config-if)speed auto <ENTER>
Router(config-if)full-duplex <ENTER>
Router(config-if) no shutdown <ENTER>
Router(config-if) end <ENTER>

To configure a router with interfaces Ethernet0/0, Ethernet1/0, and FastEthernet0/0 to route packes between subnetworks 10.1.1.0, 10.1.2.0, and 10.1.3.0, you will have to replace the respective interface names on the command lines shown above.

To configure a router with interface with only one physical interface FastEthernet0/0 to route packets between subnetworks 10.1.1.0, 10.1.2.0, and 10.1.3.0, you will have to use the following command sequences from Global Configuration mode.

*Router(config)*interface FastEthernet0/0 <*ENTER*>
*Router(config-if)*no ip address <*ENTER*>
*Router(config-if)*no ip mroute-cache <*ENTER*>
*Router(config-if)*speed auto <*ENTER*>
*Router(config-if)*full-duplex <*ENTER*>
Router(config-if) no shutdown <*ENTER*>
*Router(config-if)*interface FastEthernet0/0.1<*ENTER*>
*Router(config-if)*encapsulation dot1Q <vlan_number1> <*ENTER*>
*Router(config-if)*ip address 10.1.1.1 255.255.255.0 <*ENTER*>
Router(config-if) no shutdown <*ENTER*>
*Router(config-if)*interface FastEthernet0/0.2 <*ENTER*>
*Router(config-if)*encapsulation dot1Q <vlan_number2> <*ENTER*>
*Router(config-if)*ip address 10.1.2.1 255.255.255.0 <*ENTER*>
Router(config-if) no shutdown <*ENTER*>
*Router(config-if)*interface FastEthernet0/0.3 <*ENTER*>
*Router(config-if)*encapsulation dot1Q <vlan_number3> <*ENTER*>
*Router(config-if)*ip address 10.1.3.1 255.255.255.0 <*ENTER*>
Router(config-if) no shutdown <*ENTER*>
Router(config-if) end <*ENTER*>

you will have to replace <vlan_numberX> with the corresponding VLAN

Appendix C: Saving and restoring your configurations

The scripts for uploading and downloading configurations are located on the NAS in the Lab6 directory. They are in a tarball named *mnet_tools_v1.5.tar*. Copy this file to your /root directory, and unpack it using:
 # tar –xf mnet_tools_v1.5.tar
 # cd mnet_tools_v1.5

Before these scripts will work, the following two perl modules must be installed:

IO-Tty-1.02.tar.gz
Expect-1.15.tar.gz

Here's how to install the modules:

First install IO-Tty-1.02.tar.gz
 # tar -zxvf IO-Tty-1.02.tar.gz
 # cd IO-Tty-1.02
 # perl Makefile.PL
 # make
 # make install

Then install Expect-1.15.tar.gz
 # tar -zxvf Expect-1.15.tar.gz
 # cd Expect-1.15
 # perl Makefile.PL
 # make
 # make install

Now you can run minictrl.pl to make sure it is working correctly. The program should output it's usage and exit.
 # ./minictrl.pl

Now, some notes on the actual scripts:
Extension "p1", "p2", and "p3" on scripts below refer to playstation #1, playstation #2, and playstation #3 respectively. Each group of files is described below.

Download and upload of configurations is based on a perl Expect module. The nature of this module is complex and finicky. Therefore, sometimes it is necessary to run an upload or download script multiple times in order to successfully upload or download. Currently, three tries are given for each upload and download. Therefore, you may see errors in the download or upload process. However, at the end of the script, you should see a successful message printed indicating that one of the three tries was successful.
Run the scripts using:
#./<script_name>
in the directory the script is located. The scripts are described below.

download_reset_p1
download_reset_p2
download_reset_p3
These scripts are used to download reset configuations. The network devices should be configured to their reset configuation before running these scripts. Then, these scripts can be executed to store a "reset" configuration. **YOU NEVER NEED TO RUN THIS SCRIPT. The reset configurations are included in the tarball: reset1, reset2, and reset3.**

reset_p1
reset_p2

reset_p3
These scripts return the playstations to a "reset" configuration, which must be downloaded using the download_reset scripts above first.

download_p1
download_p2
download_p3
These scripts are used to download all network device configurations for the devices in the give playstation. The configurations are stored in files in a subfolder called playstation1, playstation2, and playstation3 respectively. Download time can vary from 30-60 seconds

upload_p1
upload_p2
upload_p3
These scripts are used to restore device configurations. They can only be executed after succesfully downloading configurations using the download scripts. Upload time can vary from 3-5 minutes because the network devices must be reloaded, which takes several minutes.

CM_Library.pm
Library used by minictrl to download, upload, and connect to digi.

minictrl.pl
Tool that does the downloading and uploading of configurations.

single_cmd
Internal wrapper tool.

ECE 4110 Internetwork Programming
Turn in sheet
Lab 6: Setting up a Network Using Cisco Routers, Switched and VLAN Technology

Group Number: _____

Member Names: _____ _____

Date: _____

Part 1 Check-off point: show the lab TA your working network and routing tables.

TA Signature _____ DATE _____

Part 2 Check-off point: show the lab TA your working network and routing tables.

TA Signature _____ DATE _____

Turn-in List

1. The turn in sheet from the back of the lab
2. Figure 1: Completed Network Topology
3. Figure 2: Physical Cabling Diagram
4. Three Screenshots: Routing tables for the three routers

PLAYSTATION #: _____

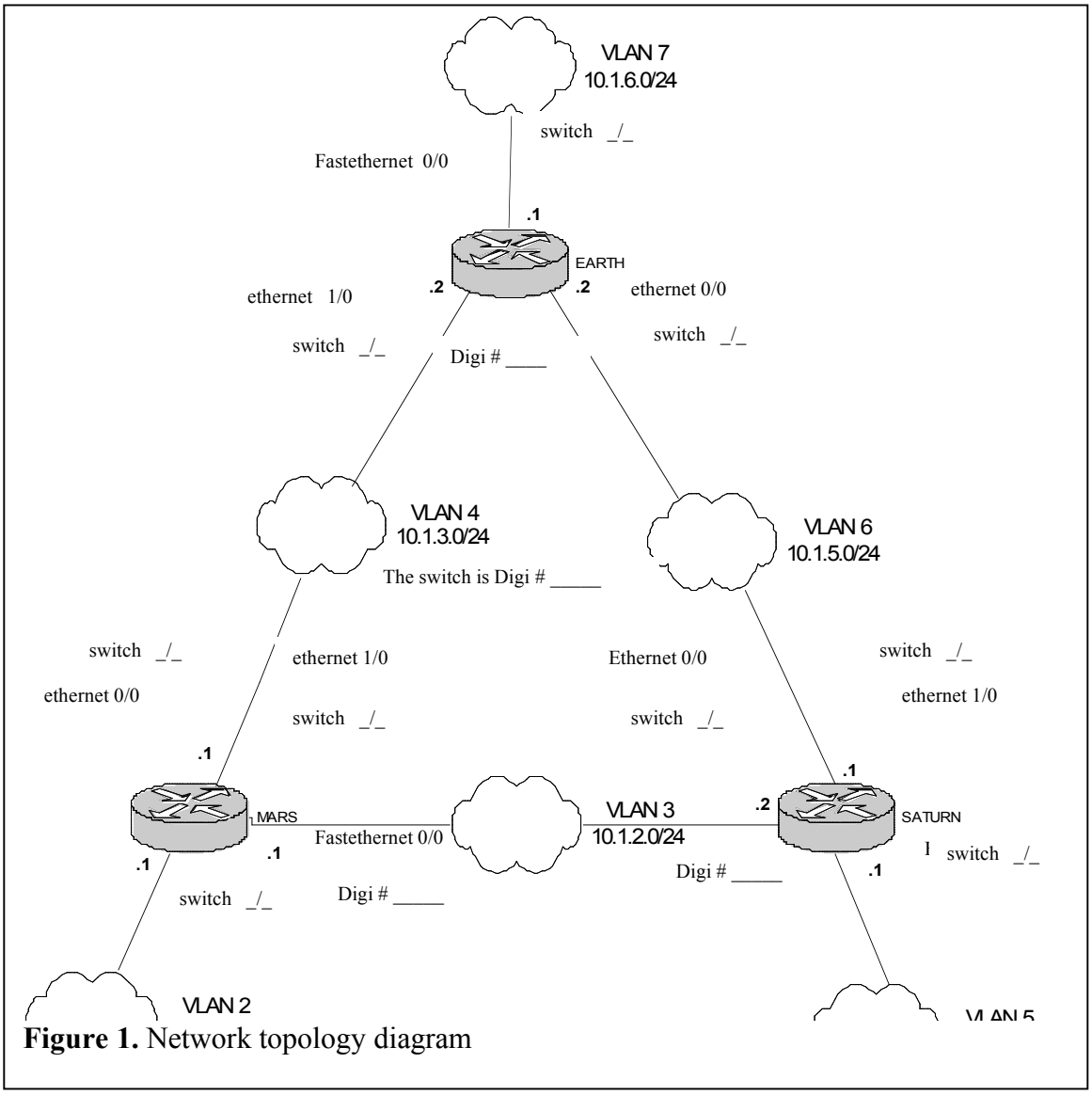


Figure 1. Network topology diagram

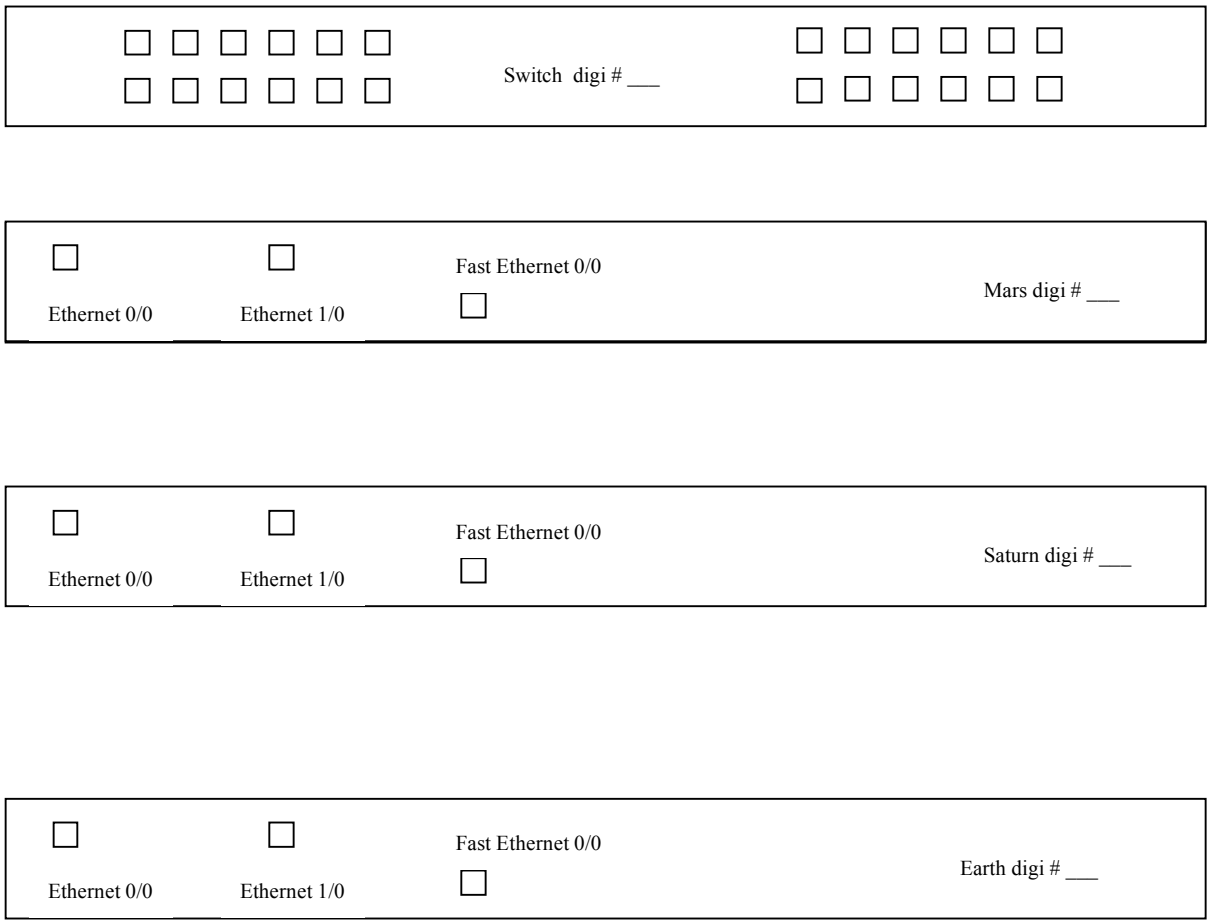


Figure 2. Physical cabling diagram.