Tele2310 – Computer Networks

Lab Assignment
Interior Gateway Protocols – RIP & OSPF

Before You Begin

- It is strongly recommended that you study this document before you begin your lab exercises and answer the questions in the "prelab" sections.
- Locate the routers and PCs in the lab for this experiment. All routers are placed inside of two black racks in Room 831.
- You will be asked to disconnect a cable as part of the experiment. Find this cable and make sure that it is connected when you begin the lab. There is a good chance that it is left unconnected by the person who worked on this lab before you.
- You will need to physically move the terminal serial cable from one router to another when you configure them.
- Read the appendix of this document and the Router Configuration Tutorial to understand the basics of configuring CISCO router equipment.
- It is strongly recommended that you run the steps described in sections 3 and 4 of the Appendix A (for RIP) and B (for OSPF) before you begin the experiment or whenever you have trouble getting a ping response back from the router interfaces.

Objectives

1. Construct intra-domain TCP/IP networks using the RIP and OSPF routing protocols
2. Observe routing information advertisement in RIP and OSPF
3. Observe RIP and OSPF operation in the event of a single link failure
4. Compare and contrast RIP vs OSPF in the following areas:
    a. Routing information exchanged
    b. Metrics used
    c. Time to update routing table

Equipment List

Routers: 3 Cisco 2500 series: 2514, 2511, 2503
2 Cisco 7000 series: 7000-1, 7000-2
Switches: 2 Ethernet Hubs

Other: PCs with packet analyzer software (*Ethereal*) :
TELE2310-Station 1, (IBM Computer – Name: Alpes)
TELE 2310-Station 2, (IBM Computer – Name: Everest)
Assorted cables

1 RIP ROUTING

1.1 Prelab

1. Prepare all parameters and information that are necessary to configure routers as shown in figure 1 on page 4. Fill out the following table.

Device	Interface	IP address
Example: Cisco 2514	Ethernet 1	192.168.50.2
Cisco 2503		
Cisco 7000-1		
Cisco 7000-2		
Cisco 2511		

2. Read the "Router Configuration Tutorial" to find out how to configure router and prepare commands that you will need to setup RIP in the network shown in figure 1. Additionally, answer the following questions:

2.1 What are the commands that you will use to configure each interface of each router so that all routers used in this lab will have the IP address as given in figure 1 (page 5)? (Hint: for all routers, you will use the same network mask = 255.255.255.0)

2.2 What are the commands that you will use to enable RIP routing on each router?

2.3 As a part of the command in 2.2, you will need to add network numbers on each router. What are the network numbers for each router? Fill out the following table. (Hint: see figure 1 page 4)

Device	Networks to add
Example: Cisco 2514	192.168.50.0
Cisco 2503	
Cisco 7000-1	
Cisco 7000-2	
Cisco 2511	

1.2 Introduction and Background

Interior Gateway Protocol (IGP) is the common routing protocol that passes routing information between routers within an autonomous system (AS). Examples of IGP include Routing Information Protocol (RIP) and Open Shortest Path First (OSPF). In this experiment, we will study RIP.

RIP is the original IGP. It is a distance-vector based routing protocol. Each router node maintains a distance vector, in the form <destination, cost>, one per destination network. In RIP, the cost is the current shortest distance in hops to that destination. A router or host running RIP periodically exchanges its distance vector with its neighbor routers by broadcasting the RIP packet to all of its network interfaces. The neighboring routers, also running RIP, update their routing tables using the distance vector algorithm such as the Bellman-Ford algorithm. When receiving the distance vector from any one of its neighbor, the node compares whether its cost to reach any destination would decrease if it routes packets to that destination through that neighbor. If so, it updates the cost to that destination to its neighbor's cost to reach that destination plus one. Any destination present in the received distance vector but not in its distance vector is simply added to its current distance vector (with the cost plus one as mentioned above). Eventually, each router will have the distance vector containing all other router nodes in the network.

1.3 RIP Lab Procedures

1. Construct an intra-domain TCP/IP network consisting of 5 routers, 1 switch and 2 hubs as shown in figure 1 (They are supposed to be connected correctly, but please make sure before the lab in case other people changed it). Configure IP addresses of routers and enable RIP routing on each of the routers. (Consult the Appendix and the Router configuration manual document for how to configure RIP)

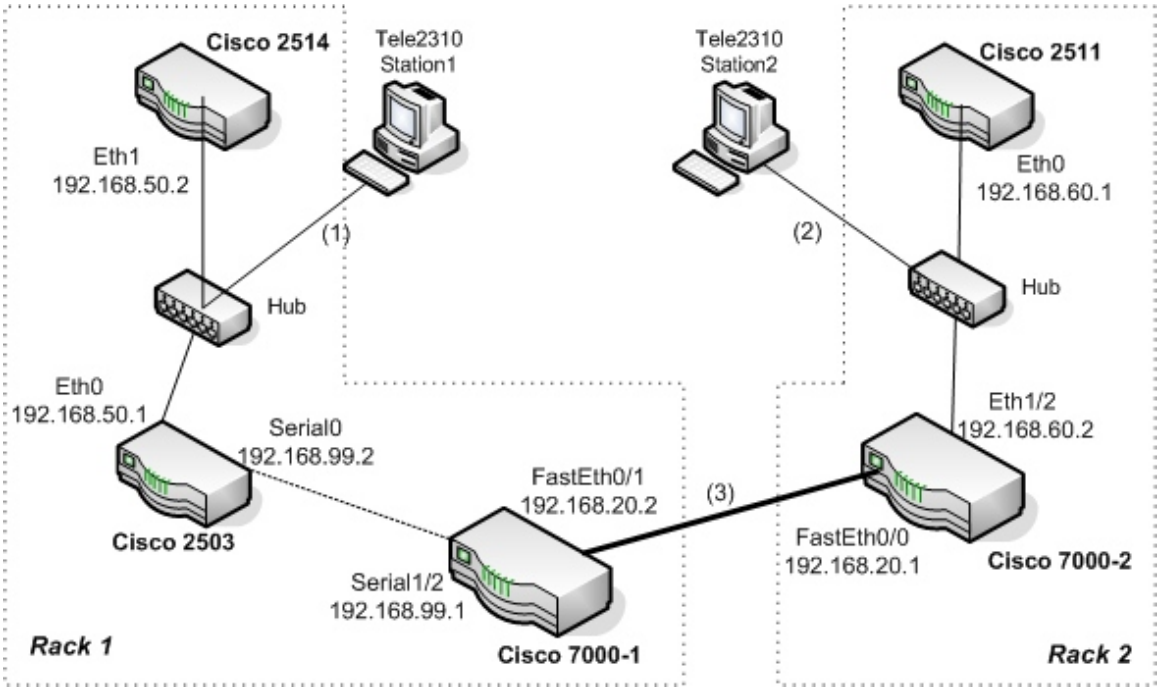


Figure 1 Network configuration

2. Fill in the following tables, which describe the routing tables for the Cisco 7000-1 and Cisco 2511. To find information for the table, at the console that is used to configure each router, execute **show ip route** command and **traceroute** command. (Consult Appendix for show ip route and traceroute command.)

Cisco 7000-1:

Destination IP address	Distance	Interface

Cisco 2511:

Destination IP address	Distance	Interface

3. Observe the RIP messages that are exchanged on network 192.168.50.0 by using the ***Ethereal*** software application on the TELE 2310-Station 1. Allow *Ethereal* to capture traffic for 2 minutes. Answer the following questions.

   (Consult Appendix for IP packet format, RIP message format and how to start capturing packets with the *Ethereal* software application)

   a. Describe RIP messages that are captured by *Ethereal* in Station 1. To observe only the RIP packets write **rip** in the filter section of the main screen. Expand the "Routing Information Protocol" section of each captured packet in order to see the RIP protocol information contained in the packet.

Frame	Time Stamp	IP address		RIP messages	
		Source	Destination	IP address of Net	Distance

Frame	Time Stamp	IP address		RIP messages	
		Source	Destination	IP address of Net	Distance

b. How frequently are the RIP messages exchanged?

c. What kind of packet carries RIP messages?

d. What information is advertised in a RIP message (information about all networks or only neighboring information)?)

4. Observe RIP messages that are exchanged on network 192.168.60.0 by using *Ethereal* on the Tele 2310-Station 2 to capture traffic as done previously. Allow *Ethereal* to capture traffic for 2 minutes. Answer the following questions.

   a. Describe RIP messages that are captured by *Ethereal*. To observe only the RIP packets write **rip** in the filter section of the main screen. Only write the details of the RIP packets that originated on any of the networks included in figure 1.

Frame	Time Stamp	IP address		RIP messages	
		Source	Destination	IP address of Net	Distance

b. Compare what you observe in this task and the previous task (on network 192.168.50.0), what can you summarize about RIP information exchange operation?

5. Next we will emulate a link failure situation. To observe the routing update process of RIP, at the TELE 2310-Station 2, start capturing traffic before disconnecting a link. Then disconnect a cable connecting a router Cisco 7000-1 and Cisco 7000-2. This cable has a dark blue color on equipment Rack 1 and is labeled "to 7000-2", it's cable (3) in figure 1. Allow *Ethereal* to capture traffic for 4 minutes beyond the simulated link failure event. Decode frames and observe the content of RIP frames to answer the following questions.

   a. Describe RIP messages that are captured by *Ethereal* at Station 2.

Frame	Time Stamp	IP address		RIP messages	
		Source	Destination	IP address of Net	Distance

b. What is the distance (in hops) for an unreachable network?

c. Approximately, how long does it take (in seconds) for the router to know that some networks become unreachable?

6. Leave cable (3) disconnected. Fill in the following tables, which describe routing table of Cisco 7000-1 and Cisco 2511. To find information for the table, at the console that is used to configure each router, execute **show ip route** command and **traceroute** command. (Consult Appendix for show ip route and traceroute command.)

Cisco 7000-1:

Destination IP address	Distance	Interface

Cisco 2511:

Destination IP address	Distance	Interface

7. Summarize what you have learnt about RIP in this lab.

8. Make a copy of your lab report and keep it with you because you will need to use information in this lab to compare with your result in the next lab (OSPF lab).

9. **Reconnect cable 3**.

10. Bring the routers back to the original state by executing the steps in **Appendix 3 and 4**.

2 OSPF ROUTING

Prepare all parameters and information that are necessary to configure routers as shown in figure 1 (page 4). Fill out the following table.

Device	Interface	IP address
Example: Cisco 2514	Ethernet 1	192.168.50.2
Cisco 2503		
Cisco 7000-1		
Cisco 7000-2		
Cisco 2511		

Read a tutorial on how to configure router and prepare command that you will need to setup OSPF network as show in figure 1 (page 4). Answer the following questions.

1. What are the commands that you will use to configure each interface of each router so that all routers used in this lab will have IP address as given in figure 1 (page 4)? (Hint: for all routers, you will use the same network mask = 255.255.255.0)

2. What are the commands that you will use to enable OSPF routing on each router? (use as wildcard-mask 0.0.0.255)

As a part of the commands in 2, you will need to add network numbers on each router. What are those network numbers for each router? Fill out the following table. (Hint: see figure 1)

Device	Network	Mask	Area-id
Example: Cisco 2514	192.168.50.0	255.255.255.0	0.0.0.0
Cisco 2503		255.255.255.0	0.0.0.0
		255.255.255.0	0.0.0.0
Cisco 7000-1		255.255.255.0	0.0.0.0
		255.255.255.0	0.0.0.0
Cisco 7000-2		255.255.255.0	0.0.0.0
		255.255.255.0	0.0.0.0
Cisco 2511		255.255.255.0	0.0.0.0
		255.255.255.0	0.0.0.0

Note: All routers use the same mask and area-id.

2.1 Introduction and Background

Interior Gateway Protocol (IGP) is a common routing protocol that passes routing information between routers within an autonomous system (AS). Examples of IGP include Routing Information Protocol (RIP) and Open Shortest Path First (OSPF). In this experiment, we will study OSPF.

Since RIP only works well in small systems and it also suffered from the count-to-infinity problem plus generally slow convergence, it was replaced in May 1979 by a link state protocol. In 1988, the Internet Engineering Task Force began working on OSPF and it became a standard in 1990.

OSPF is a link-state based routing protocol. Each router maintains link cost of its network interfaces. The router advertises this set of link costs to all other routers in the same area, not just neighboring routers. The router monitors its link status. Whenever there is a significant change (a link cost increases or decreases substantially, a new link is created, an existing link becomes unavailable), the router again advertises its set of link costs to all other routers in the area. Each router uses the link costs from all other routers to construct the topology of the entire area and calculate the shortest path to each destination network by using Dijkstra's algorithm. Then the router can construct its routing table, listing the first hop to each destination.

2.2 OSPF Lab Procedures

1. As in previous lab, construct the intra-domain TCP/IP network consisting of 5 routers, 1 switch and 2 hubs as shown in figure 1. Configure IP addresses of routers and enable OSPF routing on each of the routers. Before turning on OSPF, start capturing traffic using *Ethereal* on the TELE2310-Station 2 computer. Then allow protocol analyzer to capture traffic for 2 minutes. (consult the Appendix and the "Router Configuration Manual" on how to configure OSPF, also consult the appendix on how to start capturing packets with the Ethereal software application)

(Note: Depending on how long it takes you to turn OSPF on all routers, you should increase the capture buffer size of *Ethereal* to 2 MB so that you will be able to get all the transmitted packets while OSPF is being activated on the routers)

2. Let the capture run for two more minutes after you have finished turning on OSPF on al routers. Describe OSPF messages that are captured by *Ethereal* at Station 2. (Write **ospf** in the *Filter:* text field of *Ethereal* to see only the OSPF related packets)

Frame	Time Stamp	IP address		OSPF messages
		Source	Destination	Message type

a. How long is the interval between hello messages?

b. What kind of packet carries OSPF messages?

c. What type of OSPF messages are exchanged from the start up until the network becomes stable? When the network becomes stable, do the routers advertise information about the whole network as done in RIP?

3. Next we will emulate a link failure situation and observe the routing update process of OSPF. With *Ethereal* on the TELE2310-Station 2, start capturing traffic before disconnecting a link. Again disconnect the cable connecting routers Cisco 7000-1 and Cisco 7000-2 (as marked cable (3) in figure 1). Allow the protocol analyzer to capture the traffic for about 2 minutes after the disconnection. Decode frames and observe the content of OSPF frames to answer the following questions.

   a. Describe OSPF messages that are captured by the *Ethereal* at Station 2.

Frame	Time Stamp	IP address		OSPF messages
		Source	Destination	Message type

   b. Approximately, how long does it take (in seconds) for a router to realize that some networks become unreachable? (Hint: remember the time you disconnect the cable and find the time stamp of next link status update message)

   c. What type of OSPF messages are exchanged when routers notices about failure in the network? What kind of information contained in those messages?

d. Summarize what you have learned about OSPF operation

e. Compare and contrast RIP vs OSPF

4. **Reconnect cable 3**.

5. Bring the routers back to the original state by executing the steps in **Appendix 3 and 4**.

Appendix A. RIP Configuration

1. Configuring RIP:
If routers are not in enable mode (prompt '>')

C2511>**enable**
Password: ami
C2511#

First get into a configuration mode.

C2511#**configure terminal**

Then to enable a routing process for RIP on all interfaces in a router, use this command:

C2511(config)#**router rip**

You can add networks to each device with this command:

routername(config-router)#**network** *network_number*
C2511(config-router)#**network** *network_number*
C2511(config-router)#**network** *network_number*
…

To remove a network from the list:

C2511(config-router)#**no network** *network_router*

To shutdown the routing process:

C2511(config-router)#**no router rip**

2. Verify your RIP configuration:

- Check to see if the packets are getting routed by typing

  ping *ip_address*

  You should be able to get a reply to a ping from every interface on each of the routers. This is a simple way to verify that you can reach the other routers within the network. Or you use the command traceroute:

  traceroute *ip_address*

  You will see how a packet routed through the network to the destination.

- View the routers' current routing table by using the command:

show ip route

This command will give you a table listing all of the routes currently in the routing table.

- Other useful commands are:

show ip route rip

This command will only show the RIP routes in the table.

show ip route *network*

This command will give detailed routing information about the specified network.

show ip rip ?

This will show you a series of commands that will give you lots of information about the RIP process running on the router.

3. Cleaning up the interfaces.

If routers are not in an enable mode (prompt '>')

C2511>**enable**
Password: ami
C2511#

First, display the running configuration of the router

CS2511# **show running**

Make a note of interfaces that have the IP addresses being assigned to.

Give the following command to put those interfaces in a default setting:

CS2511# **configure terminal**
CS2511(config)# **default interfaces <interface> <slot/port>** (e.g. Ethernet 0/0)

If the above command fails, try the following:

CS2511(config)# **interfaces <interface> <slot/port>** (e.g. Ethernet 0/0)
CS2511(config-interfaces)# **default ip address**

4. Cleaning up the routing processes.

If routers are not in enable mode (prompt '>')

C2511>**enable**
Password: ami
C2511#

First, display the running configuration of the router

CS2511# **show running**

Find whether the RIP and/or OSPF routing processes are running. If OSPF is running, make a note of its process ID.

Give the following command to disable the RIP process:

CS2511# **configure terminal**
CS2511(config)# **no router rip**

Give the following command to disable the OSPF process:

CS2511# **configure terminal**
CS2511(config)# **no router ospf <process_id>**

5. IP packet format carrying RIP message:

RIP messages are carried via UDP datagrams. An IP packet that carried RIP message contains:

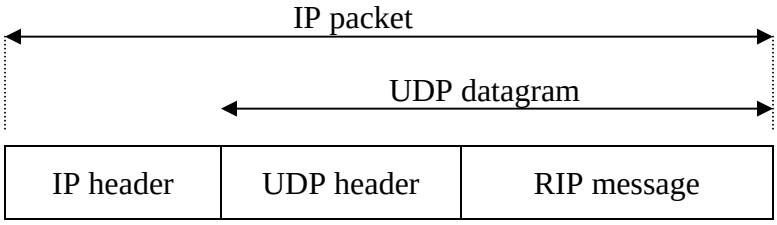


Figure A.

6. RIP message format:

Figure B shows the format of a RIP message. Each message includes a header with the following fields:

- Command: 1 for a request, 2 for a reply. Routing updates are sent as replies whether requested or not. When a node initializes RIP, it broadcasts a RIP request; each router receiving the request immediately sends out a reply.
- Version: 1 for the original RIP, 2 for RIP-2.

This header is followed by one or more blocks, each of which gives the path distance to a particular target network. The relevant fields are as follows:

- IP address: An IP address that has a nonzero network portion and a zero host portion. This uniquely defines a particular network.
- Metric: The path distance from this router to the identified network. The metric is a simple hop count.

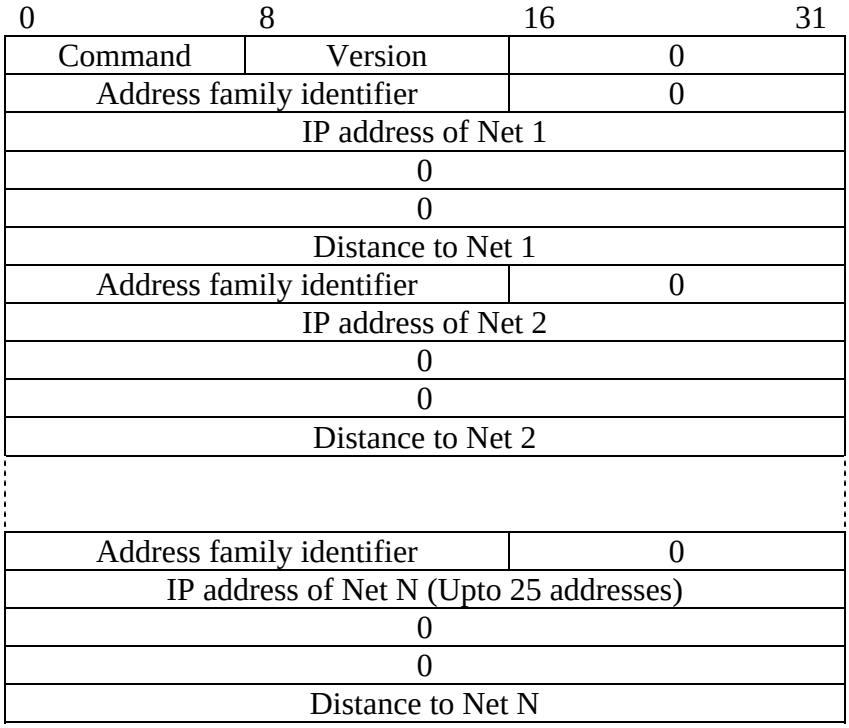


Figure B RIP message format

Appendix B: OSPF Routing Configuration

1. Configuring OSPF:
First get into a configuration mode as done in the RIP configuration.
Then to enable OSPF, you must create an OSPR routing process with this command:

C2511(config)#**router ospf** *process_id*

Then define the range of network addresses to be associated with the routing process and assign area IDs for those IP addresses with these commands:

C2511(config-router)#**network** *network_number wildcard_mask* **area** *area_id*
C2511(config-router)#**network** *network_number wildcard_mask* **area** *area_id*
…

2. Verifying your OSPF configuration

You may use the same commands used when verifying the RIP configuration such as **ping**, **show ip route**, of **traceroute**. In addition, you can use the following commands:

- To see OSPF routes in the table

  show ip route OSPF *processID*

- To see detailed routing information about the specified network

  show ip route *network*

- The command series of show ip ospf will give you lots of information about the OSPF process running on the router. You can explore by typing

  show ip ospf ?

3. Cleaning up the interfaces.

If routers are not in an enable mode (prompt '>')

C2511>**enable**
Password: ami
C2511#

First, display the running configuration of the router

CS2511# **show running**

Make a note of interfaces that have the IP addresses being assigned to.

Give the following command to put those interfaces in a default setting:

CS2511# **configure terminal**
CS2511(config)# **default interfaces <interface> <slot/port>** (e.g. Ethernet 0/0)

If the above command fails, try the following:

CS2511(config)# **interfaces <interface> <slot/port>** (e.g. Ethernet 0/0)
CS2511(config-interfaces)# **default ip address**

4. Cleaning up the routing processes.

If routers are not in an enable mode (prompt '>')
C2511>**enable**
Password: ami
C2511#

First, display the running configuration of the router

CS2511# **show running**

Find whether the RIP and/or OSPF routing processes are running. If OSPF is running, make a note of its process ID.

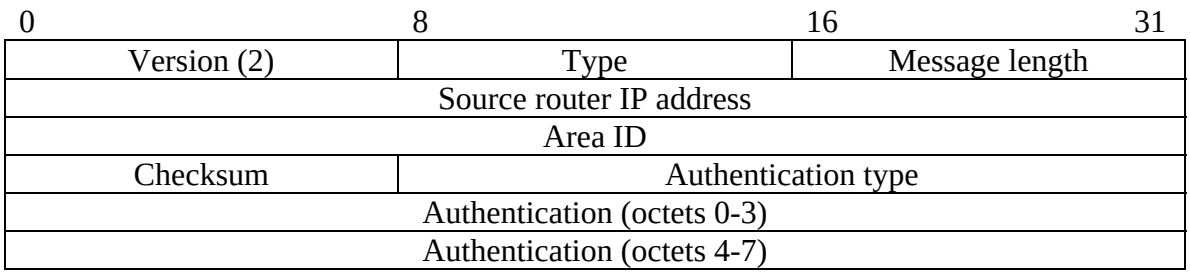
Give the following command to disable the RIP process:

CS2511# **configure terminal**
CS2511(config)# **no router rip**

Give the following command to disable the OSPF process:

CS2511# **configure terminal**
CS2511(config)# **no router ospf <process_id>**

5. OSPF message format:
OSPF uses IP directly: *protocol field = OSPF* in IP header.



Type	Meaning
1	Hello (used to test reachability)
2	Database description (topology)
3	Link status request
4	Link status update
5	Link status acknowledgement

Appendix C: Packet capture with Ethereal

7. **Running *Ethereal* to capture packets**

The software application *Ethereal* is installed on the TELE2310-Station 1 and TELE2310-Station 2 computers. To activate *Ethereal* and start a packet capture, do the following:

1. Login into each machine as **tele231**
   (the password is **networks**)
2. Activate the ***Ethereal*** icon that is on the Desktop
3. Go to the *Capture* menu and select the *Start* option
4. The Interface field should NOT be empty, if it is *Ethereal* will not work. Don't try to modify this field by yourself (leave it alone). Contact the GSA in case of trouble.
5. Click the OK button to start the capture. A capture progress window should pop-up.
6. Once enough packets have been captured or enough time has elapsed, click on the Stop button.
7. You should be able to recognize three different screen sections: The packet list section (upper section), the packet details section (middle section) and the packet bytes section (lower section). Each time you select a packet in the packet list section the other two sections will change accordingly. You can now analyze the captured packets as you wish.

Note: The **Filter:** text field on the main screen allows you to specify which packets should be displayed on the packet list section of the screen. Use this to get a view of only those packets that you are interested in.