NETROPY® NETWORK EMULATOR

USER’S GUIDE

Firmware Version 2.2

APPOSITE® TECHNOLOGIES

Netropy® Network Emulator User's Guide

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Apposite® Technologies, Inc.

11500 W. Olympic Blvd., Suite 510	tel:	1.310.477.9955
Los Angeles, CA 90064 USA	fax:	1.310.477.9956
www.apposite-tech.com	email:	info@apposite-tech.com

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Contents

1 Overview

Thank you for purchasing the Apposite Technologies Netropy network emulator. This *User's Guide* describes the installation, configuration, and operation of the Netropy product. A companion *Hardware Guide* describes the Netropy hardware for each specific model. A separate *Quick Start Guide* provides a walk-through for first time configuration.

The Netropy network emulator attaches to an Ethernet network and simulates the bandwidth, delay, loss and other conditions of the wide-area network to test the performance of applications in the lab.

1.1 Netropy Configuration

The Netropy network emulator is usually configured through the browser-based Netropy GUI (Graphical User Interface). The GUI is accessible through a dedicated management port from any PC or other device with a standard web browser using HTTP or HTTPS.

In addition to the GUI, the Netropy network emulator includes a command line interface (CLI) that can be accessed via a serial console port or over the network using Telnet or SSH. The CLI can be used to set the IP address of the management interface if the GUI is not accessible over the network, and to modify emulated link conditions for integration with scripting and test automation tools.

1.2 Netropy Operation

Configuration and operation of the Netropy network emulator via the browser-based GUI requires only a few simple steps:

1. **Open the GUI**
   Connect to Netropy with a standard web browser through the dedicated management port.

2. **Select the Emulation Engine**
   Depending on hardware model, the Netropy unit will include between one and four separate Emulation Engines. Each Emulation Engine acts as an independent network emulation system connecting a pair of Ethernet ports.

3. **Add Paths**
   Create separate WAN paths to carry packets between the two Ethernet ports. Each Emulation Engine can simulate 15 separate paths.

4. **Configure WAN conditions for each path**
   Configure each path with bandwidth, delay, loss, and other WAN conditions.

5. **Classify Packets**
   Assign packets to the paths by IP source and destination address range, VLAN, MAC address, TCP/UDP port numbers, MPLS label, or other packet identifier.

6. **Start the Emulation Engine**
   Turn on emulation to begin testing.

7. **Monitor traffic**
   View the graphs and link statistics to monitor application performance.

8. **Change configuration**
   The configuration can be changed on the fly by adding or deleting paths, modifying path conditions, or updating the packet classification rules.

1.3 Netropy Models

The five current Netropy models, the N61, N91, 10G1, 10G2, and 40G offer identical functionality and differ only in capacity and number and type of network interfaces. Earlier models, the N60, N80, N90, and 10G, have been superseded by newer models and are no longer in production, but run the same firmware described in this manual. This *User's Guide* applies to all models.

2 Installation and Set-Up

To configure and operate the Netropy network emulator through its browser-based GUI, the dedicated Ethernet management port must first be configured with an appropriate IP address and subnet mask. For convenience, the MGMT interface comes pre-configured with an IP address of 10.0.0.10, and is accessible from a directly-connected host on the 10.0.0.0/255.0.0.0 subnet. The IP address and subnet mask of the MGMT interface can be changed through the Netropy GUI or through the command-line interface.

2.1 Preparation

Management of the Netropy device through the GUI requires a PC running a web browser with Flash version 10 or later installed.

Initial configuration of the management interface requires either:

- a PC running a supported web browser that can be configured and placed on the 10.0.0.0/255.0.0.0 network.
- a PC with an RS-232 serial port running terminal emulation software such as HyperTerminal or PuTTY.

2.2 Hardware Installation

Plug in a standard power cord (a U.S. power cord is supplied with the unit) and turn on the power. The system will be available for use within 90 seconds.

For additional hardware installation details, please see the *Hardware Guide* for your model.

2.3 IP Address Configuration via the Netropy GUI

To configure the MGMT interface using the Netropy GUI:

❶ Configure a PC running a supported web browser with the IP address 10.0.0.2 or other address on the 10.0.0.0/255.0.0.0 subnet.

❷ Connect an Ethernet cable between the PC and the MGMT port on the Netropy unit.

❸ Open the browser on the PC and enter `http://10.0.0.10`.

❹ Review the License Agreement. The Netropy GUI will be displayed once the License Agreement is accepted.

❺ Click on the Administration link at the top of the page and select the Network Settings tab. Set the IP address, subnet mask, and optional default gateway for the management interface, then click the *Apply Changes* button.

❻ After the management interface has been configured, use the Ethernet cable to connect the MGMT port to the management network.

2.4 IP Address Configuration via the Serial Console

To configure the MGMT interface using the serial console:

❶ Using the provided serial cable, connect the serial port of a PC running terminal emulation software to the CONSOLE port of the Netropy unit. Set the serial port parameters to 9600 baud, 8 bits, no parity, 1 stop bit, and disable flow control. For more details on connecting to the serial console, see the *Hardware Guide* for your model.

❷ Press `[ENTER]` to display a login prompt. At the prompt, log in as "`admin`". There is initially no password.

```
netropy login: admin
```

❸ Use the following commands to set the IP address, netmask, and default gateway of the MGMT port:

```
mgmt set addr <ip-address> netmask <mask>
mgmt set gw <default-gateway>
```

IP addresses and subnet masks are entered in dotted-decimal format. For example:

```
[netropy]> mgmt set addr 192.168.1.1 netmask 255.255.255.0
```

❹ Once the MGMT interface has been configured, use an Ethernet cable to connect the MGMT port to the management network. Open a browser and enter the IP address of the MGMT port in the address bar. The Netropy End User License Agreement will be displayed.

❺ Review the License Agreement. The Netropy GUI will be displayed once the License Agreement is accepted.

2.5 Network Installation

Each Netropy Emulation Engine is installed between two LAN segments and acts as a bridge or router between those two segments. Packets received on one port of the Emulation Engine are subjected to configured emulation conditions before being forwarded or routed to the opposite port.

If configured as a layer 2 bridge, install each Engine on an Ethernet network in a location where the traffic that is to be sent over the emulated WAN will be forced to flow through the device. If configured as a router, install the Engine between two separate subnets and configure static routes to pass traffic through the Engine. Each Engine is configured separately as a bridge or router.

2.6 Registration

For access to firmware upgrades, documentation, and other support materials, register your unit on-line at: http://www.apposite-tech.com/register.html.

Registered users will receive email notification whenever new firmware images are released.

3 Configuration

Configuration of the Netropy network emulator is aided by understanding a few basic concepts and terminology.

3.1 Emulation Engine

The Netropy Emulation Engine forwards packets and applies the configured emulation conditions between a pair of Ethernet ports.

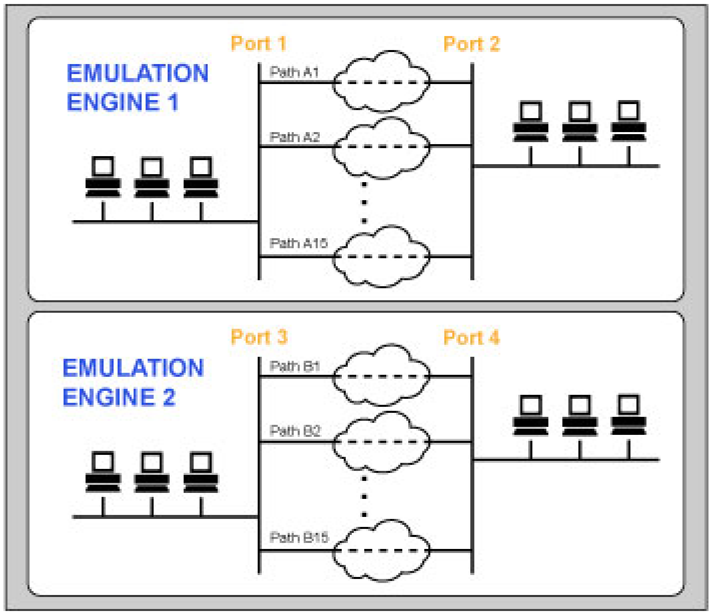


Figure 1: Two separate Emulation Engines, each with 15 paths between each pair of ports.

Depending on hardware model, the Netropy unit contains between one and four separate Emulation Engines. Each engine operates independently of the others, and can be thought of as a completely separate emulation device. Each engine has its own Ethernet ports, a network architecture that may include multiple paths and classifiers, and separate traffic statistics and graphs.

See Section 4 for more details on the Emulation Engine.

3.2 Paths

Paths are emulated WAN links between ports. Each path is configured with its own bandwidth, delay, loss, and other WAN properties. Up to 15 separate paths may be configured within each Emulation Engine.

Each path consists of three components: a WAN access link connecting the LAN to the WAN on each side and traversal of the WAN.

The WAN can be any type of wide-area network connection between two sites including terrestrial private lines, shared networks such as the Internet, and specialized satellite or wireless networks. The WAN is characterized primarily by its latency, jitter, and loss conditions.

Each WAN access link connects a LAN to the WAN. Bandwidth constraints and conditions that affect bandwidth availability are configured in the WAN access link.

See Section 5 for more details on configuring paths.

3.3 Classifiers

Classifiers are sets of rules or filters that specify which packets are sent over which paths. Each port has its own classifier to direct the packets that arrive on that port. Most users will classify packets by IP source and destination address range, but packets can instead be classified by IPv6 address, VLAN, MPLS label, MAC address, TCP or UDP port number, or any other packet field or combination.

Each classification rule includes an action that specifies whether matching packets are sent over one of the configured paths, dropped, or forwarded without emulation.

See Section 7 for more details on configuring classifiers.

3.4 GUI and CLI

Most users will find the browser-based graphical user interface to be the most convenient way to configure and operate the Netropy network emulator. However, a CLI is also available for integration with test automation tools.

The device can be managed and any of the path emulation parameters can be set and modified through the CLI. However, the configuration of the emulated WAN architecture, including creating paths and building classification rules, must first be completed through the GUI.

See Section 11 for more details on the CLI.

4 Emulation Engine

4.1 Overview of Emulation Engines

The Netropy Emulation Engine forwards packets and applies the configured emulation conditions between a pair of Ethernet ports.

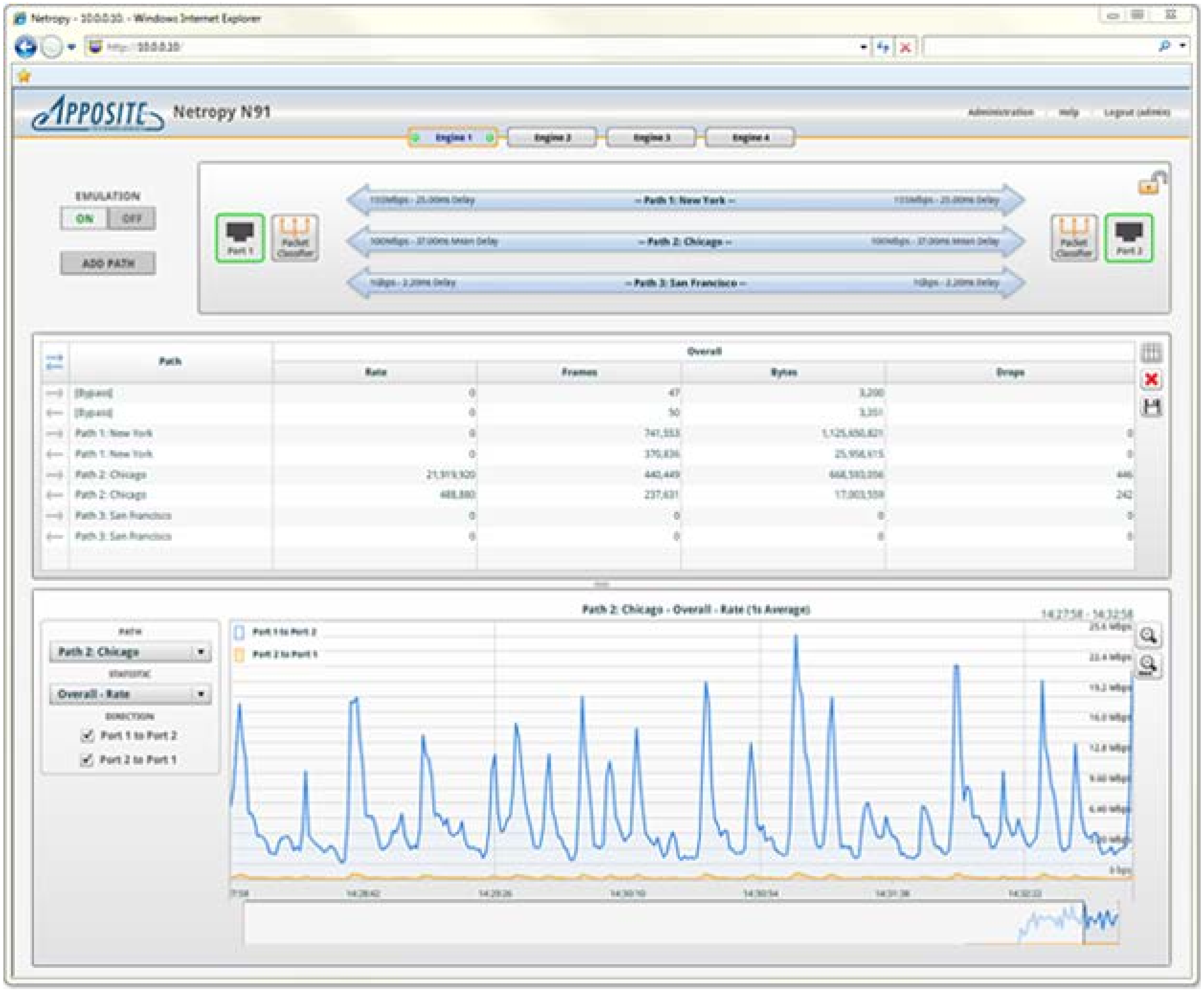
Depending on hardware model, the Netropy unit contains between one and four separate Emulation Engines. Each engine operates independently of the others, and can be thought of as a completely separate emulation device. Each engine has its own Ethernet ports, a network architecture that may include multiple paths and classifiers, and separate traffic statistics and graphs.

To configure a particular Emulation Engine from the Netropy GUI, click on the corresponding Engine button at the top of the main page.

Each Emulation Engine can be turned on or off independently. Emulation is initially turned off on all engines after reboot or power cycle. Emulation can be turned on or off from the main page of the GUI or through the CLI. When emulation is off, all packets are forwarded directly between the Emulation Engine’s two ports, bypassing any emulation.

Throughput graphs and statistics can be viewed for emulated paths, as well as for the bypass traffic.

The entire configuration of any Emulation Engine can be downloaded to a local file from the Save tab of the Administration window. This configuration file can then be used to reconfigure any Engine.



	Path	Overall			
		Rate	Frames	Bytes	Drops
→	[Bypass]	0	47	3,200	
←	[Bypass]	0	50	3,351	
→	Path 1: New York	0	741,553	1,125,650,821	0
←	Path 1: New York	0	370,836	25,958,615	0
→	Path 2: Chicago	21,919,920	440,449	668,593,056	446
←	Path 2: Chicago	488,880	237,631	17,003,559	242
→	Path 3: San Francisco	0	0	0	0
←	Path 3: San Francisco	0	0	0	0

PATH: Path 2: Chicago

STATISTIC: Overall - Rate

DIRECTION

☑ Port 1 to Port 2

☑ Port 2 to Port 1

Figure 2: Main Page of the GUI

4.2 Emulation Engines on Each Hardware Model

The ports used for the different Emulation Engines on the various Netropy models are listed in the table below.

Engine	Netropy Model					
	N60 & N61	N80, N90, & N91	10G1	10G2	10G	40G
1	Ports 1, 2	Ports 1, 2	Ports 1, 2	Ports 1, 2	Ports 3, 5	Ports 1, 2
2		Ports 3, 4		Ports 3, 4	Ports 4, 6	
3		Ports 5, 6			Ports 1, 2	
4		Ports 7, 8				

4.3 Engine Locking

Users can lock individual Emulation Engines to prevent any changes made to the configuration by other users. Only the user who locked the engine and the *admin* user can modify the configuration of a locked engine or unlock the engine. Locking is specific to each individual engine. Different users can lock different engines, or a single user can lock multiple engines.

To lock an Emulation Engine, click the 🔓 lock icon. To unlock, click again.

For details on creating and administering users, see Section 10.2.

4.4 Engine Self-Monitoring

The Netropy Emulation Engine performs continuous self-monitoring to ensure that test results have not been affected by limitations on the processing or buffering resources of the Netropy engine.

The current status of the Netropy engine is indicated by the LEDs on each engine selection button. The LED on the left shows engine processing resources and the LED on the right shows engine buffering resources. Resource availability is indicated by the LED color:

> Green: Engine is functioning normally with sufficient resources for the current processing and buffering load.
>
> Yellow: Resources are running low. Engine is functioning without error and tests are valid, but if processing or buffering load increases further, the engine is in danger of reaching overload conditions.
>
> Red: Overload fault. Sufficient processing or buffering resources were not available and test results may have been affected. If a fault occurs, please review the error message in the log.

If an overload of processing or buffering occurs, the LEDs will remain red to indicate an error until the log message has been marked as read or the log has been cleared.

Hovering over the engine button displays a tool tip with details of the current status.

5 PATHS

5.1 Overview of Paths

Paths are emulated WAN links between ports. Each path is configured with its own bandwidth, delay, loss, and other WAN properties. Up to 15 separate paths may be configured within each Emulation Engine.

Each path consists of three sections:

- WAN access link connecting Site 1 to the WAN line or cloud.
- WAN line or cloud
- WAN access link connecting Site 2 to the WAN line or cloud

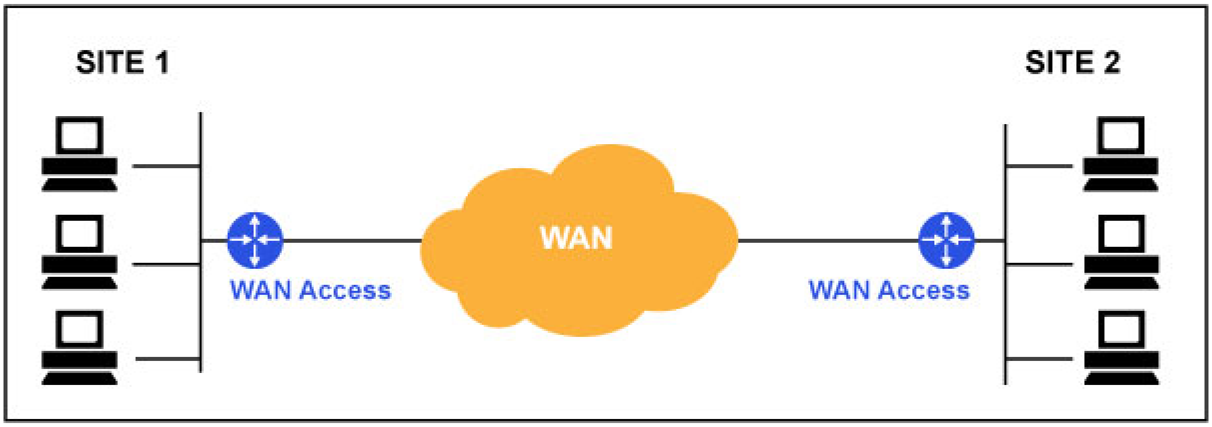


Figure 3: Path Components

The WAN can be any type of wide-area network connection between two sites including terrestrial private lines, shared networks such as the Internet, and specialized satellite or wireless networks. The WAN is characterized primarily by its latency, jitter, and loss conditions.

Each WAN access link connects a site to the WAN. Bandwidth constraints and conditions that affect bandwidth availability are configured on the WAN access links.

The GUI must be used to add or delete paths.

5.2 Path Types

Most network connections can be characterized as either point-to-point or cloud-based.

Private lines such as T1 or OC-3 lines directly connecting two sites are point-to-point connections. The bandwidth out-bound from one site is the same as the bandwidth in-bound at the other site, and typically the latency is constant. On these links, the bandwidth is throttled in the outbound direction from each site, and there is generally no need to configure the in-bound WAN access parameters.

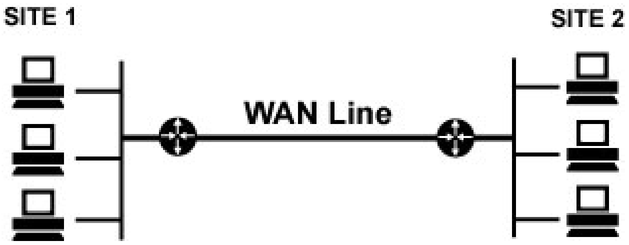


Figure 4: Point-to-Point Line

Network connections that consist of an access link to a shared network such as the Internet, an MPLS network, or a Metro Ethernet ring, can be thought of as a cloud. Cloud networks typically have limited bandwidth access to a high- speed WAN, and frequently different speed access to the WAN at each site. In these situations, traffic can hit a bandwidth bottleneck both out-bound from a site to the WAN and in-bound from the WAN to the other site, making it necessary to configure both out-bound and in-bound WAN access parameters. Similarly, if there is variable delay in the WAN cloud, it may be necessary to configure the in-bound WAN access parameters to rate-limit the resulting flow.

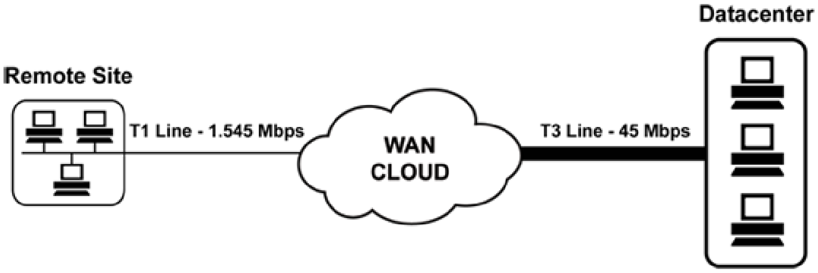


Figure 5: Cloud Network

5.3 Configuring Paths

Each path is displayed on the main page of the Netropy GUI using an arrow labeled with its name. To configure a path, click on the arrow to open the Path Configuration window.

The Path Configuration window is used to rename the path, choose whether the path is bi-directional or uni-directional, and configure the WAN and WAN access conditions of the path.

To rename a path, click the existing name to edit it.

To set a path to be bi-directional or uni-directional, use the direction selectors on the top button bar. A path can be set to uni-directional only if the unused direction is not referenced by any classifier actions. The WAN and WAN access conditions of a path are configured independently in each direction of a bi-directional path.

When finished, click the *Apply Changes* button. If the Path Configuration window is closed without clicking the *Apply Changes* button, any unapplied changes will be lost.

Changes to the WAN and WAN Access conditions can be made from the CLI, but the path name and directionality can only be set from the GUI.

5.4 Adding and Deleting Paths

To add a new path, click the *Add Path* button on the main page.

To delete an unneeded path, click the path to enter the Path Configuration window and use the delete button on the top button bar to remove. Paths cannot be deleted while they are being used in any classifier rule.

6 Path Parameters:

Configuring Emulation Conditions

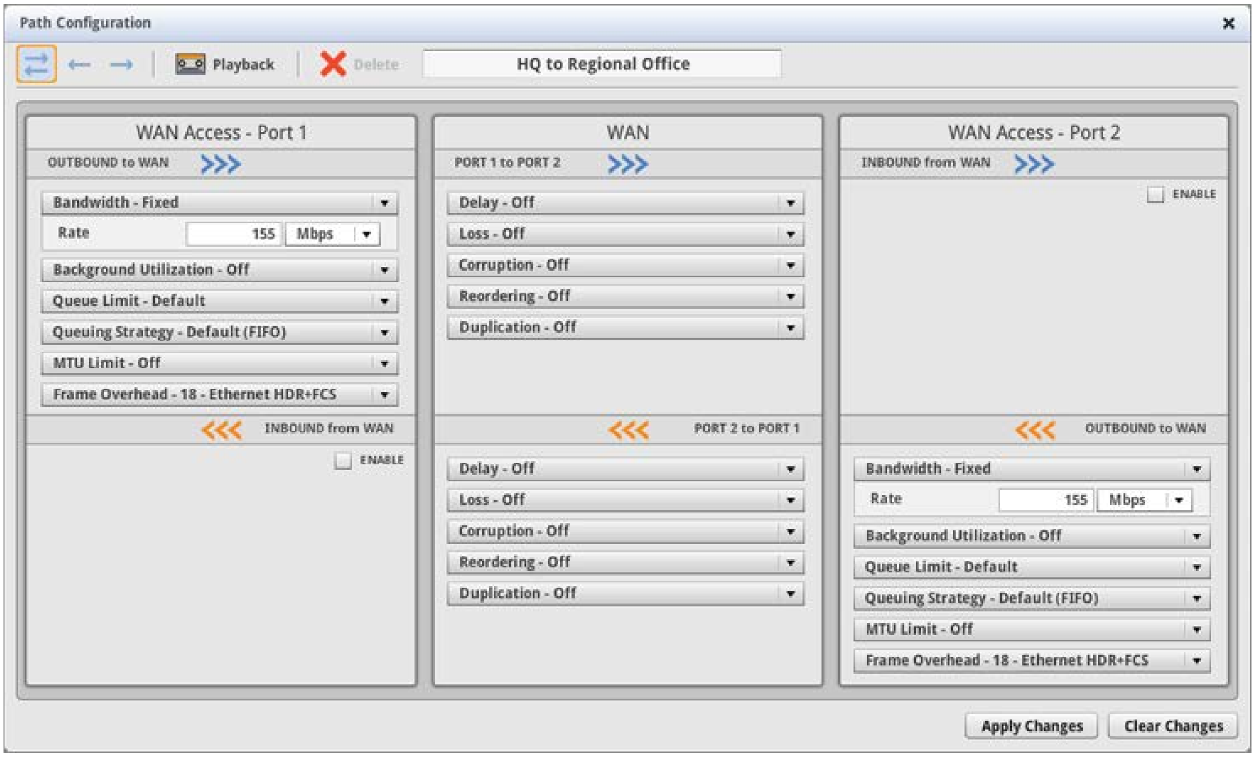
6.1 Configuring Path Parameters

Each path consists of three sections:

- WAN access link connecting a LAN to the WAN
- Traversal of the WAN line or cloud
- WAN access connecting the opposite LAN to the WAN

The active configuration is not modified until the *Apply Changes* button is pressed. The *Apply Changes* button is grayed out when there are no changes to apply or if there are any invalid entries.

Final validation of the configuration is performed when the *Apply Changes* button is pressed. If there are no errors in the configuration, the new configuration immediately takes effect. If there are any errors in the configuration, a red box is displayed around the invalid panel. Hovering over the panel displays a description of the error.



HQ to Regional Office

WAN Access - Port 1

OUTBOUND to WAN >>>

Bandwidth - Fixed

Rate 155 Mbps

Background Utilization - Off

Queue Limit - Default

Queuing Strategy - Default (FIFO)

MTU Limit - Off

Frame Overhead - 18 - Ethernet HDR+FCS

<<< INBOUND from WAN

□ ENABLE

WAN

PORT 1 to PORT 2 >>>

Delay - Off

Loss - Off

Corruption - Off

Reordering - Off

Duplication - Off

<<< PORT 2 to PORT 1

Delay - Off

Loss - Off

Corruption - Off

Reordering - Off

Duplication - Off

WAN Access - Port 2

INBOUND from WAN >>>

□ ENABLE

<<< OUTBOUND to WAN

Bandwidth - Fixed

Rate 155 Mbps

Background Utilization - Off

Queue Limit - Default

Queuing Strategy - Default (FIFO)

MTU Limit - Off

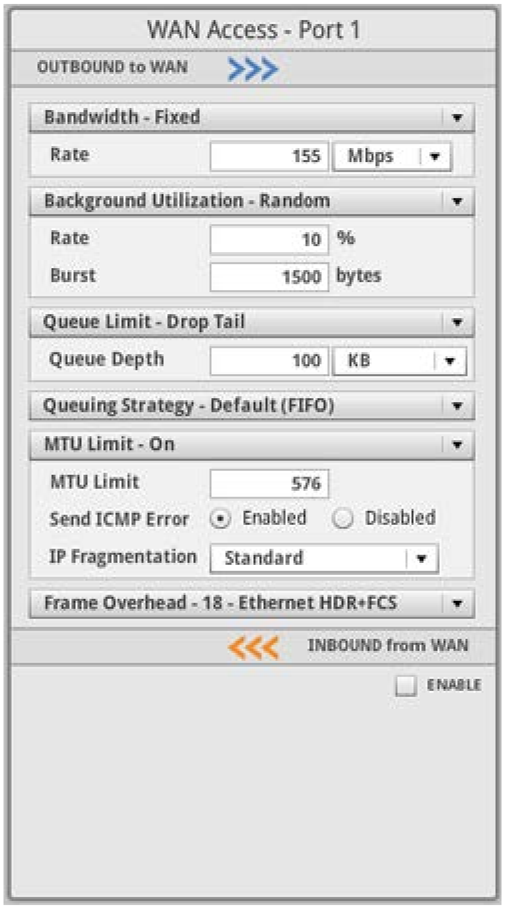
Frame Overhead - 18 - Ethernet HDR+FCS

Figure 6: Path Configuration Window

6.2 WAN Access Parameters

The WAN Access panel configures the parameters that affect bandwidth availability for traffic from the LAN to the WAN, and optionally for traffic coming into the LAN from the WAN. There are separate panels for the WAN Access link on either side of the WAN. Parameters that affect bandwidth availability include the rate at which data can be sent, amount and type of queuing, and utilization of the link by competing traffic at that bottleneck.

Conditions for traffic out-bound from the LAN to the WAN must always be configured, while configuration for traffic in-bound from the WAN to the LAN is optional.



WAN Access - Port 1

OUTBOUND to WAN >>>

Bandwidth - Fixed ▾
Rate 155 Mbps ▾

Background Utilization - Random ▾
Rate 10 %
Burst 1500 bytes

Queue Limit - Drop Tail ▾
Queue Depth 100 KB ▾

Queuing Strategy - Default (FIFO) ▾

MTU Limit - On ▾
MTU Limit 576
Send ICMP Error ● Enabled ○ Disabled
IP Fragmentation Standard ▾

Frame Overhead - 18 - Ethernet HDR+FCS ▾

<<< INBOUND from WAN

□ ENABLE

Figure 7: WAN Access Configuration Panel

6.2.1 Bandwidth

The Bandwidth panel is used to configure the rate of the WAN access link.

The rate is set in increments of 1 bit per second, with a minimum rate of 100 bps and a maximum rate determined by the installed license key. (See Section 10.11 for details on viewing and upgrading the license key.)

To emulate a link outage, set the packet loss rate to 100% instead of attempting to set the bandwidth to 0 bps.

If the entered rate is larger than the licensed rate, a red error box will be drawn around the panel when the *Apply Changes* button is pressed, and the changes will not be applied.

6.2.2 Background Utilization

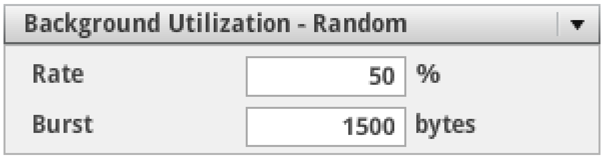
The Background Utilization panel is used to create extra traffic that competes for bandwidth with the real application traffic passing through the WAN access link. Background traffic only affects the WAN access link on which it is configured, and is not transmitted through the other components of the path or outside the Netropy device. To have background traffic compete for bandwidth on the opposite WAN access link, create an identical background traffic configuration on the WAN access link inbound to the opposite port.

Background traffic can be useful for testing the performance of particular applications over links that are congested with other traffic, and for inducing jitter to test real-time applications. Background traffic can either be created with random packets based on an average link utilization rate or by replaying imported PCAP packet capture files.

6.2.2.1 Random Background Traffic

The Netropy Emulation Engine can generate random background traffic to compete with the real application traffic for bandwidth across the emulated WAN link. Random background traffic is specified as a link utilization rate and a traffic burst size.

The link utilization rate specifies the average percentage of bandwidth consumed by the background traffic. The link utilization rate can be set to 0 – 100% of the bandwidth in increments of 0.01%.


Background Utilization - Random

Rate 50 %

Burst 1500 bytes

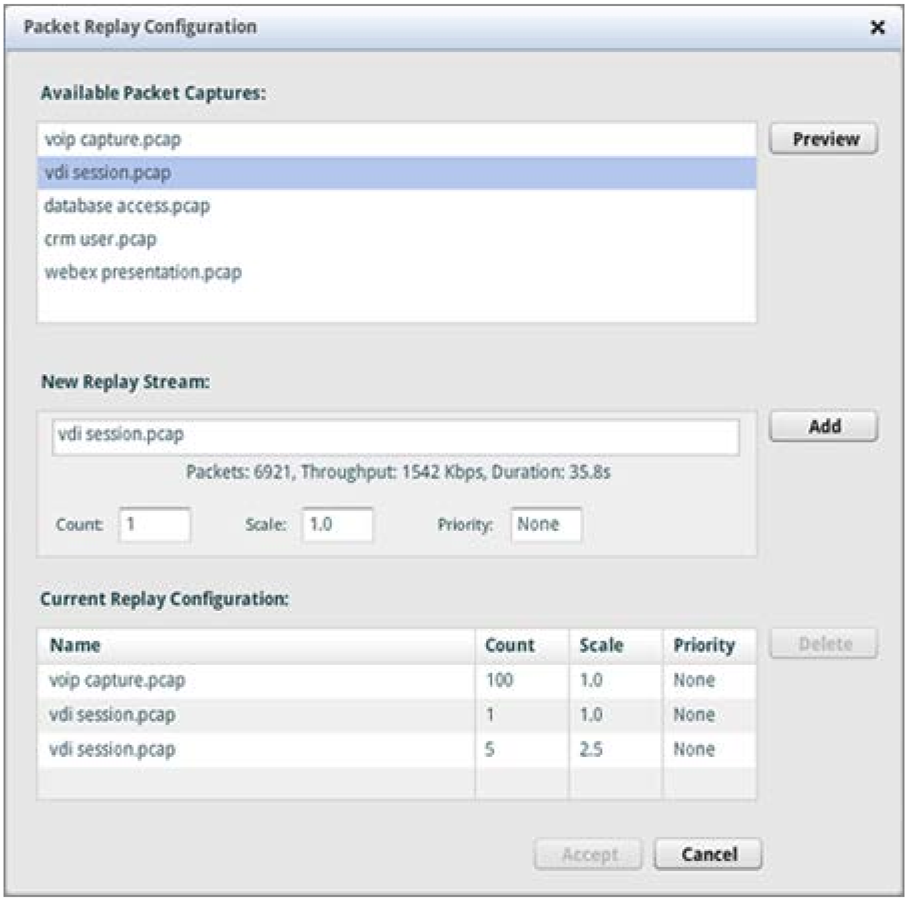
Figure 8: Background Utilization - Random

The burst size sets the size of the background traffic blocks and is specified in bytes from 64 – 2,000,000 bytes. The default value is 1500 bytes. Larger bursts of background traffic induce greater jitter in the actual traffic.

Random background traffic is modeled as a Poisson process in which bursts of data of a fixed size are transmitted at an average rate such that the bandwidth will be occupied at the specified link utilization rate. Because it is a random process, over short periods the actual background utilization rate may vary from the configured value.

6.2.2.2 Packet Replay Using PCAP Files

The Netropy Emulation Engine can replay PCAP packet capture files as background traffic to compete for bandwidth with the real application traffic.



Available Packet Captures:

- voip capture.pcap
- vdi session.pcap
- database access.pcap
- crm user.pcap
- webex presentation.pcap

New Replay Stream:

vdi session.pcap

Packets: 6921, Throughput: 1542 Kbps, Duration: 35.8s

Count: 1 Scale: 1.0 Priority: None

Current Replay Configuration:

Name	Count	Scale	Priority
voip capture.pcap	100	1.0	None
vdi session.pcap	1	1.0	None
vdi session.pcap	5	2.5	None

Figure 9: Packet Replay Configuration

Network traffic can be captured and saved to a PCAP file by Wireshark, tcpdump, or other protocol analyzer or network monitor tool. PCAP files are imported into Netropy through the Packet Captures tab of the Administration window (Section 10.6).

Any valid PCAP file can be used to generate background traffic, including individual streams, all traffic between two devices, all traffic from one device to any other device, or all traffic on the network over a period of time.

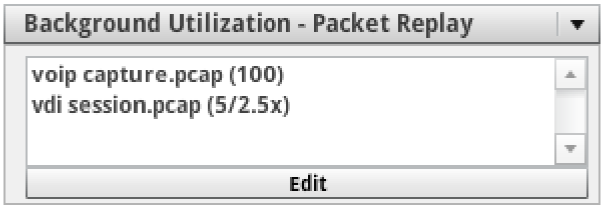
All packets in the PCAP file are replayed in a single direction. Bidirectional packet captures generally need to be split into two unidirectional capture files.

Multiple packet capture files can be replayed simultaneously, and each file can be replicated to simulate large numbers of streams or scaled to adjust the timing and bandwidth usage.

Each packet capture file can be up to 10 MB in size, with the total for all packet capture and recording files limited to 40 MB.

To configure PCAP replay background traffic, select packet replay on the Background Traffic panel and click *edit* to open the Packet Replay Configuration window.

The top of the Packet Replay Configuration window displays a list of available PCAP files previously imported into the Netropy device. Click a file to configure replay of a stream based on that packet capture. The *preview* button displays a graph of the data rate of the stream.



voip capture.pcap (100)
vdi session.pcap (5/2.5x)

Figure 10: Background Utilization – Packet Replay

The New Replay Stream section of the window displays the number of packets in the selected file, its average data rate, and time duration of the capture. Configure replay with the following parameters:

- Count: Number of separate copies of the stream to run. By default, one copy is run but the same stream can be replicated up to 20,000 copies to simulate multiple users or clients. If multiple copies are run, each copy will start at a random location in the stream.
- Scale: Time scaling factor between 0.001 and 1000 that adjusts the speed of the packet reply. The default value of 1.0 replays the stream at the same speed as the original transmission. A value of 2.0 replays the stream at twice the original speed, thereby doubling the data rate. A value of 0.1 replays the stream at a tenth of original speed.
- Priority: A value between 0-7 used for IP Precedence or VLAN PCP priority level for all packets in the file when strict prioritization or round robin queuing strategy is enabled. If the default value of ‘none’ is selected, the original IP Precedence or VLAN PCP value of each packet is used.

Click the *add* button to add the file to the replay configuration. The list of files to be replayed is displayed in the Current Replay Configuration table. A file can be removed from the configuration by selecting the file and clicking the *delete* button. Click *accept* to complete configuration of packet capture replay and return to the Path Configuration window. Packet replay begins when the changes to the path configuration are accepted if emulation is already enabled, or when emulation is next turned on.

Up to 20 separate playback entries can be created. Multiple copies of the same file can be used with the same or different count, scale, and priority settings. A single PCAP file could therefore be used, for example, to simulate ten streams at half speed, two streams at the original speed, and five streams at twice the original speed.

Packet replay files and parameters can be changed on the fly while emulation is on. If the count, scale, or priority parameters for any stream are changed, playback for only that stream will start from the beginning when the path configuration changes are accepted, and any other running playback streams will not be affected.

Packet replay only generates background traffic to compete with actual application traffic from external sources. Packets from the PCAP files are not transmitted out of the Netropy device.

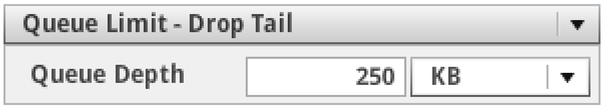
Packet replay consumes Netropy resources equivalent to traffic from external sources and must be included when considering packet forwarding and buffering limits of the device.

6.2.3 Queue Limit

The Queue Limit panel is used to select the queue management algorithm and configure the associated queuing parameters. The queue management algorithm controls the buffering and discarding of packets when they arrive faster than the rate of the WAN access link. The queue management algorithm and parameters can be set to match the configuration of an existing WAN access router.

There are three choices for the Queue management algorithm:

- Drop Tail
  The Drop Tail algorithm (also called tail drop) is a simple FIFO queue of a configured maximum size. When the buffer is full, any additional packets that arrive are discarded. Using Drop Tail, specify the size of the buffer in KB or packets.

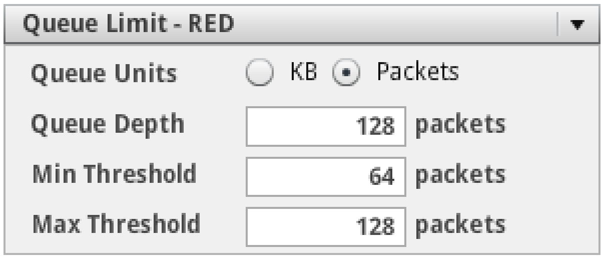


Queue Limit - Drop Tail ▼

Queue Depth 250 KB ▼

Figure 11: Queue Limit – Drop Tail

- RED
  Random Early Detection (RED) is an active queue management algorithm that monitors the average queue size and begins randomly dropping a small number of packets before the queue is full to create smoother flows and fairer drops. RED begins dropping packets at the configured minimum threshold, with the probability of drop increasing linearly until the configured maximum threshold, after which all packets are dropped. Configure the total buffer size, minimum threshold, and maximum threshold in KB or packets. For more details on RED, see http://www.icir.org/floyd/red.html. The value used for max_p is 0.1 and for w_q is 1/512.



Queue Limit - RED ▾

Queue Units ○ KB ● Packets

Queue Depth 128 packets

Min Threshold 64 packets

Max Threshold 128 packets

Figure 12: Queue Limit – RED

- Default
  The default option sets the queue management algorithm to Drop Tail and configures the queue depth to the equivalent of 250 ms at the currently configured bandwidth rate. For example, if the bandwidth is set to 100 Mbps, the default queue depth will be 3.125 MB. Changes to the bandwidth will automatically adjust the queue depth.

If priority queuing is selected under Queuing Strategy, the specified queue limits apply separately to the queue for each priority level.

All entries for queue depth and thresholds are limited to 100,000 packets or 100,000 KB.

6.2.4 Queuing Strategy

The queuing strategy panel determines the manner in which packets are queued and transmitted. The three options are a single FIFO queue, Priority queuing, and Round Robin.

- Default (FIFO)
  The default option uses a single FIFO queue. Packets are transmitted in the order they arrive, with no prioritization of packets.

- Priority
  For class of service prioritization, incoming packets can be directed onto eight separate priority queues based on the priority setting in the packet. Packets are transmitted based on strict priority: if there are any packets on a higher priority queue, they will be transmitted before any packets on a lower priority queue. Queues are numbered from highest (7) to lowest (0).

  The queue management algorithm and settings specified in the Queue Limit panel applies separately to each of the eight priority queues. For example, if Drop Tail is selected with a queue depth of 100 KB, each of the eight priority levels will consist of its own 100 KB queue.

  There are two options for specifying the field to use for the priority level of the packets:

  > IP Precedence: the three bits of precedence in the ToS field of IPv4 packets, or the three bits of precedence in the traffic classifier of IPv6 packets.
  >
  > VLAN PCP: the three bit Priority Code Point field in the VLAN header.

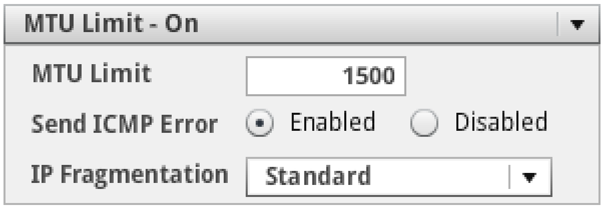
- Round Robin
  Similar to Priority queuing, incoming packets are directed onto eight separate queues based on the IP Precedence or VLAN PCP priority value of each packet. Packets are pulled from each queue and transmitted in round robin order.

  As in Priority queuing, the queue management algorithm and settings specified in the Queue Limit panel applies separately to each of the eight queues.

6.2.5 MTU Limit

The MTU limit panel allows the setting of a path MTU (Maximum Transmission Unit), specifies whether ICMP error messages are sent, and specifies whether IPv4 packets larger than the MTU limit are fragmented.

If MTU limits are enabled, any IPv4 packet that exceeds the MTU can either be dropped or fragmented, depending on the IP Fragmentation setting:



MTU Limit - On

MTU Limit: 1500

Send ICMP Error: ● Enabled ○ Disabled

IP Fragmentation: Standard

Figure 13: MTU Limit

- Standard
  IPv4 packets without the Don't Fragment (DF) bit set are fragmented and all other packets are dropped.

- Never – Drop Only
  Packets larger than the MTU limit are always dropped.

- Always – Ignore DF
  Packets larger than the MTU limit are always fragmented regardless of the setting of the DF bit. This option should only be used when specifically required for testing.

All non-IPv4 packets larger than the MTU limit are dropped. IPv6 packets are never fragmented.

The MTU limit can be set to any value between 68 bytes and 9216 bytes.

The sending of IPv4 ICMP Destination Unreachable Fragmentation Needed or IPv6 PKTTOOBIG error messages to the originator of the packet can be enabled or disabled. When enabled, ICMP error messages are transmitted out the interface on which the original packet was received switching the source and destination Ethernet and IP addresses of the original packet.

ICMP error messages are limited to 15 packets per second (per path per direction), with short term bursts of up to 15 packets.

6.2.6 Frame Overhead

Frame overhead is the number of additional bytes required by a link-layer technology when transmitting a packet of data. Typically, the frame overhead consists of link-layer addressing and error checking information.

To emulate a link-layer technology with a particular frame overhead, select the value from the drop-down list, if available, or choose C*ustom* and enter the specific value.

To emulate the traversal of a frame over the WAN, Netropy calculates the effective size of the frame as the payload of the Ethernet frame (without the Ethernet header or FCS) plus the specified frame overhead.

There are three choices for frame overhead:

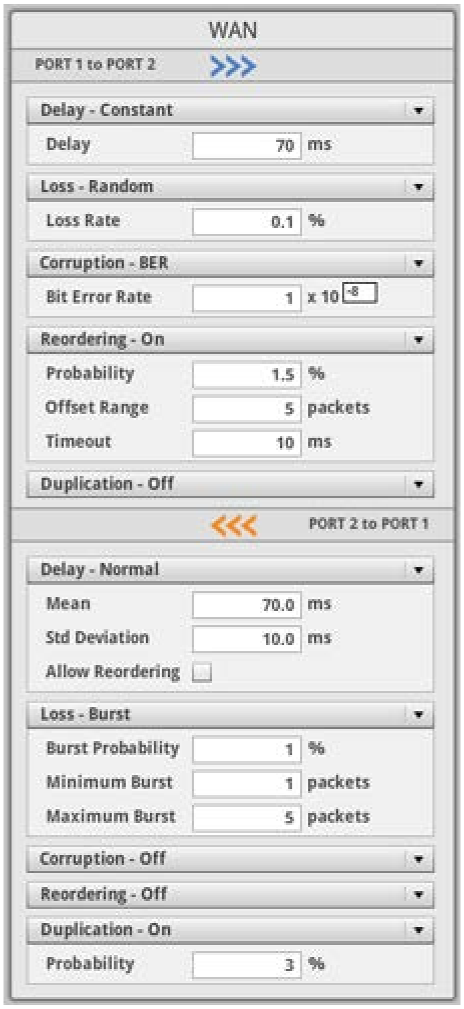
- Ethernet (header + FCS)
  This option emulates a WAN link layer with an Ethernet-like frame of 18 bytes of header and frame check sequence (FCS). This is the default option and is a reasonable choice if the properties of the link layer are unknown.

- Ethernet (header, FCS, preamble, pad)
  This option emulates an actual Ethernet link, including the preamble and padding between Ethernet frames. Select this option to emulate an Ethernet-based WAN network.

- Custom
  This option allows the specification of any link layer frame overhead in bytes per packet up to a maximum of 300 bytes. Select this option if the link layer frame overhead is known.

6.3 WAN Parameters

WAN delay, loss, reordering, and duplication parameters are configured on the WAN section of the Path Configuration window. The conditions are set separately for the two directions.



WAN

PORT 1 to PORT 2 >>>

Delay - Constant ▾
Delay 70 ms

Loss - Random ▾
Loss Rate 0.1 %

Corruption - BER ▾
Bit Error Rate 1 x 10 $^{-8}$

Reordering - On ▾
Probability 1.5 %
Offset Range 5 packets
Timeout 10 ms

Duplication - Off ▾

<<< PORT 2 to PORT 1

Delay - Normal ▾
Mean 70.0 ms
Std Deviation 10.0 ms
Allow Reordering □

Loss - Burst ▾
Burst Probability 1 %
Minimum Burst 1 packets
Maximum Burst 5 packets

Corruption - Off ▾

Reordering - Off ▾

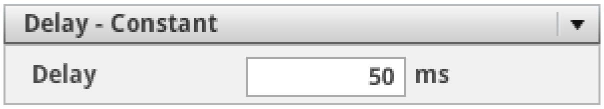
Duplication - On ▾
Probability 3 %

Figure 14: WAN Parameter Configuration Panel

6.3.1 Delay

The Delay panel sets the latency and jitter in each direction. For variable latency distributions, a short delay applied to a later packet may cause it to have a calculated transmission time prior to that of earlier packets with a longer delay. By default, packets are transmitted in the order received, which can skew the actual amount of delay applied. If "Allow Reordering" is selected, the order of the packets can be changed.

- Off: No latency added.
- Constant: A single, fixed value for latency.

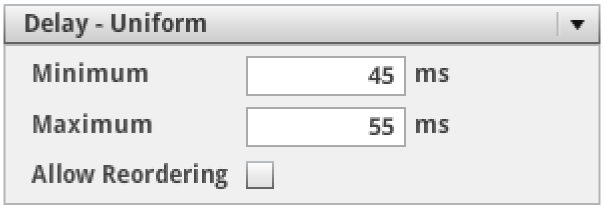


Delay - Constant

Delay 50 ms

Figure 15:
Delay - Constant

- Uniform: A uniform distribution of latency ranging between the configured minimum and maximum values. The Minimum value must be less than or equal to the Maximum.



Delay - Uniform

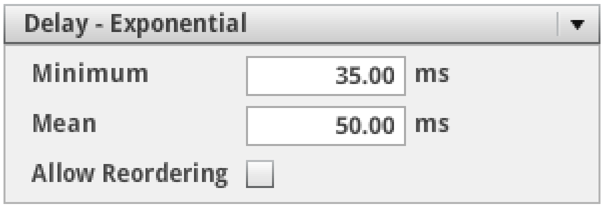
Minimum 45 ms

Maximum 55 ms

Allow Reordering □

Figure 16:
Delay – Uniform Distribution

- Exponential: An exponential distribution curve, with a specified minimum and mean.



Delay - Exponential

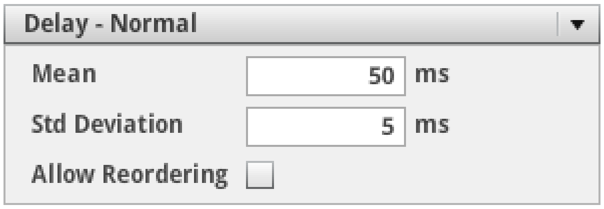
Minimum 35.00 ms

Mean 50.00 ms

Allow Reordering □

Figure 17:
Delay – Normal Distribution

- Normal: A normal (Gaussian) distribution, with a specified mean and standard deviation (jitter). To avoid negative latencies, the mean must be at least 3 times the Std Deviation.



Delay - Normal

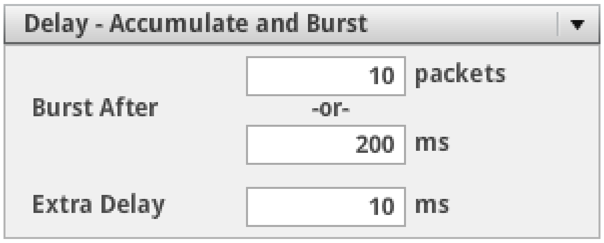
Mean 50 ms

Std Deviation 5 ms

Allow Reordering □

Figure 18:
Delay – Normal Distribution

- Accumulate & Burst: Packets are held until either a packet count or time threshold is reached, then optionally delayed by an additional configured 'extra delay,' then transmitted as a burst. The timer for the time threshold is started when the first packet in the burst is received. The maximum packet count threshold is 1000 packets, and the maximum time threshold is 10000 ms (10 seconds).



Delay - Accumulate and Burst ▼

Burst After 10 packets
-or-
200 ms

Extra Delay 10 ms

Figure 19:
Delay - Accumulate and Burst

All delay values are specified in milliseconds in increments of 0.01 ms.

By default, frames are not reordered even if subjected to differing delays using a uniform or normal distribution. To allow packets to be reordered, check the “Allow Reordering” option. For example, if the delay is set as a uniform distribution between 10 and 100 ms and the first frame is subjected to a 90 ms delay and the second frame is subjected to a 20 ms delay, by default, the second frame cannot be transmitted until after the first frame has been transmitted. If “Allow Reordering” is selected, (and assuming no congestion) the second frame will be transmitted 20 ms after arrival and the first frame will be transmitted 90 ms after arrival, causing the order of the packets to be switched.

To specify jitter, use either the normal or uniform distribution. Use the normal distribution to specify jitter as the standard deviation from the mean delay. Use the uniform distribution to specify peak-to-peak jitter between the minimum and maximum values of delay.

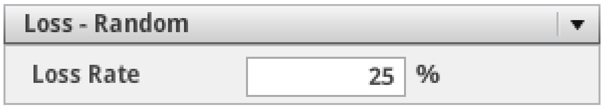
The various Netropy hardware models have different limits on the ability to process high packet rates combined with large latencies. For details, see the *Hardware Guide* for your model.

> ☞ The end-to-end round trip time (RTT) is a combination of four separate delays in each direction: the propagation delay, transmission delay, queuing delay, and reordering delay.

6.3.2 Loss

The Loss panel configures packet loss each direction. The options are:

- Off: No packet loss.
- Random: Random packet loss. Specify a single value for the probability that each packet will be lost. Rates can be set from 0 – 100% in increments of 0.0001%.

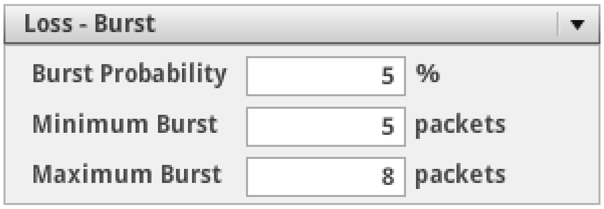


Loss - Random

Loss Rate 25 %

Figure 20:
Loss - Random

- Burst: Burst loss. Specify the probability that each packet will begin a burst of lost packets, and a minimum and maximum number of packets that will be lost in sequence. For a fixed burst size, set the minimum and maximum to the same value. Probabilities can be set from 0 – 100% in increments of 0.0001%.

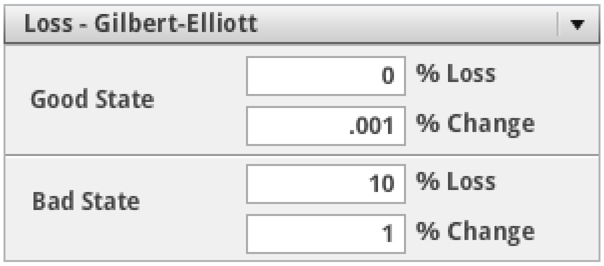


Loss - Burst

Burst Probability 5 %
Minimum Burst 5 packets
Maximum Burst 8 packets

Figure 21:
Loss - Burst

- Gilbert-Elliott: Gilbert-Elliott two-state loss. Specify the packet loss rates for the “good” and “bad” states, and specify the per-packet probability of transitioning from each state to the other. All rates are specified as percentages set from 0 – 100% in increments of 0.0001%. When Gilbert-Elliott loss is first configured and each time emulation is subsequently turned on, loss starts in the good state.



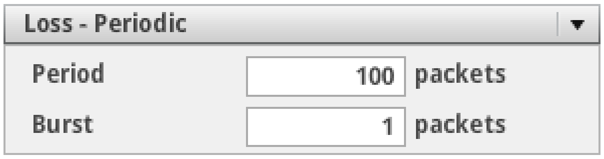
Loss - Gilbert-Elliott

Good State 0 % Loss
.001 % Change

Bad State 10 % Loss
1 % Change

Figure 22:
Loss – Gilbert-Elliott

- Periodic: Periodic packet loss. Specify the loss period and burst size in numbers of packets. For example, a period of 1000 packets with a burst size of 10 packets would result in a fixed pattern of 990 packets forwarded followed by 10 packets dropped.



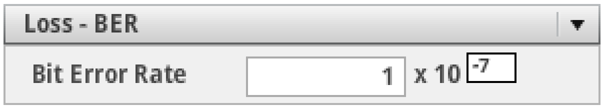
Loss - Periodic ▾

Period 100 packets

Burst 1 packets

Figure 23: Loss - Periodic

- BER: Loss due to bit errors. Set the coefficient and exponent. Bit error rates can take values of 1x10^{-18} or greater and are entered in scientific notation. The coefficient of the rate must be entered as a value greater than or equal to 1 and less than 10. All packets that contain a bit error are discarded – to transmit corrupted packets, use the Corruption emulation.



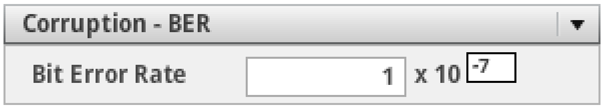
Loss - BER ▾

Bit Error Rate 1 x 10^{-7}

Figure 24: Loss - BER

6.3.3 Corruption

The Corruption panel is used to insert bit errors into forwarded packets at the specified bit error rate. Set the BER coefficient and exponent. Bit error rates can take values of 1x10^{-18} or greater and are entered in scientific notation. The coefficient of the rate must be entered as a value greater than or equal to 1 and less than 10.



Corruption - BER ▾

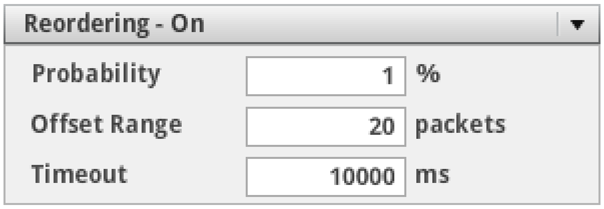
Bit Error Rate 1 x 10^{-7}

Figure 25: Corruption

Corruption only affects the contents of received Ethernet frames. Neither the Ethernet header (including EtherType and optional VLAN tag) nor the Ethernet FCS will be corrupted.

6.3.4 Reordering

The Reordering panel specifies the probability for each packet that it is reordered, and how far back in the data stream the reordered packet is moved from its original position. If a packet is randomly selected for reordering, it is held until the offset number of packets arrive and reinserted into the data stream at that point. For example, if the offset is 5 packets, any packet that is reordered will be held and reinserted after the fifth subsequent packet.



Reordering - On

Probability 1 %

Offset Range 20 packets

Timeout 10000 ms

Figure 26: Packet Reordering

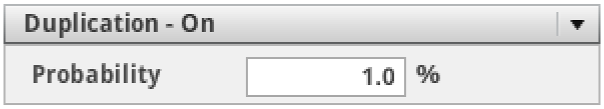
To configure packet reordering, set:

- Probability: the likelihood that each frame will be reordered. Probability can be set from 0 – 100% in increments of 0.0001%.
- Offset Range: the number of packets that the reordered packet is moved back in the data stream. Either a single value or a range of values can be configured. To specify a range, input the minimum and maximum reordering offsets separated by a dash, i.e. 5-12.
- Timeout: the maximum amount of time to wait for the number of offset packets to arrive. For example, if the offset is set to 1000 packets and the timeout set to 5 ms, if 1000 packets do not arrive within 5 ms, the packet will be reinserted in the packet stream at that expiration of the 5 ms period. The default value for timeout is 10,000 ms. The timeout value is specified in ms in increments of 0.01 ms.

Only one packet can be held for reordering at any time. While a packet is waiting for reinsertion, the arriving packets are not subject to reordering. For example, if a packet is randomly selected for reordering with an offset of 5 packets, the next five packets that arrive cannot also be reordered.

6.3.5 Duplication

The Duplication panel specifies the probability for each packet that it is duplicated.



Duplication - On

Probability 1.0 %

Figure 27: Packet Duplication

Duplicate packets are inserted into the data stream immediately after the original packet. Duplicate packets are then subjected to delay, loss, and reordering independently of the original packet.

The duplication probability can be set from 0 – 100% in increments of 0.0001%.

7 PACKET CLASSIFIERS

7.1 Overview of Packet Classification

Classifiers are ordered sets of rules or filters that specify which packets are sent over which paths. Each port has one classifier that directs all packets arriving on that port to the appropriate path. The first rule in order that matches the packet is used to specify the action for the packet.

Each classification rule consists of two components: match and action. Packets may be matched by source and destination IP address (IPv4 or IPv6), VLAN, MPLS label, MAC address, TCP or UDP port number, or any other packet field or combination. Packets that match the rule then follow the configured action. There are three options for the action of each rule:

- Use path: Packets matching the rule are sent over the specified path.
- Drop: Packets matching the rule are dropped.
- Bypass: Packets matching the rule are forwarded without emulation.

Each classifier also includes a default action that specifies the action for packets that do not match any of the explicit rules.

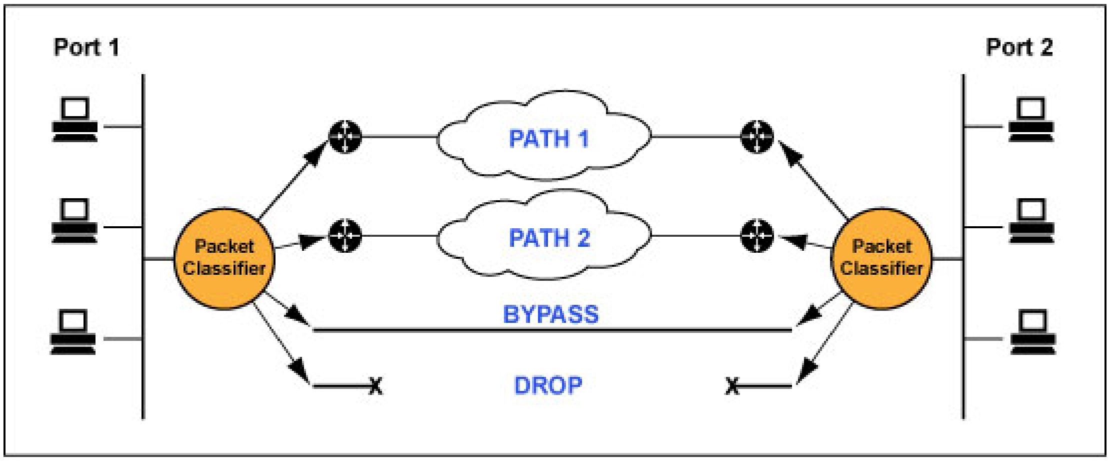


Figure 28: Packet Classification

To configure the classifier, click the *Packet Classifier* button next to either port on the main window. Either button opens the Classifier Configuration window to set the classifier for both ports. Select the classification method for each port, then add rules. Up to 30 separate rules can be created for each port.

Only one of the classification methods can be used on each port. To make rules for more than one classification type, such as both IPv4 and IPv6 packets, to build complex rules with multiple criteria such as a specific IP address within a specific VLAN, or to create rules based on any arbitrary field or identifier in the packets, use the flexible Combination Classifier.

For symmetric configurations, configure rules on one port and use the *mirror* button to automatically create rules for the opposite port.

To forward ARP packets without impairment, check the "ARP Frame Bypass Emulation" option in the Bridge/Route tab of the Administration window (Section 10.3.1). When this option is enabled, all ARP packets are forwarded directly between the ports bypassing emulation regardless of any classification rules that would otherwise apply to the packets.

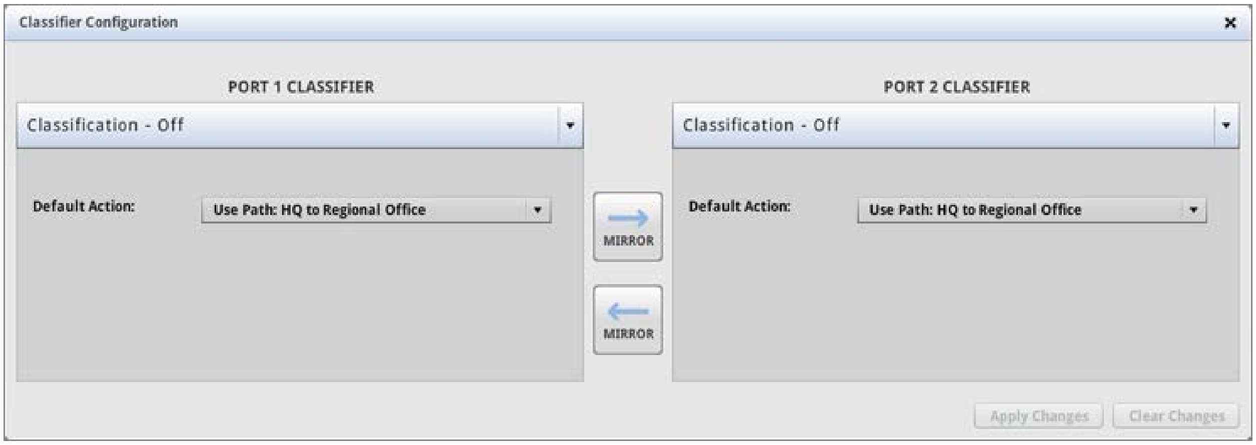
Classifiers can only be set in the GUI and cannot be created or modified in the CLI.

7.2 Classification Methods

Packets may be classified by source and destination IP address (IPv4 or IPv6) range, VLAN, MPLS label, MAC address, TCP or UDP port number, or any other packet field. Use the drop-down menu to select the classification method for each port. Only one classification method may be selected for all packets arriving on the port. The “Combination” classifier allows packets to be classified based on multiple classification types, a combination of fields, or to any arbitrary header field or packet identifier.

7.2.1 Classification Off

With classification turned off, a single specified action is applied to all packets.



Classifier Configuration

PORT 1 CLASSIFIER

Classification - Off

Default Action: Use Path: HQ to Regional Office

PORT 2 CLASSIFIER

Classification - Off

Default Action: Use Path: HQ to Regional Office

Figure 29: Classification Off

7.2.2 IP Address Classification

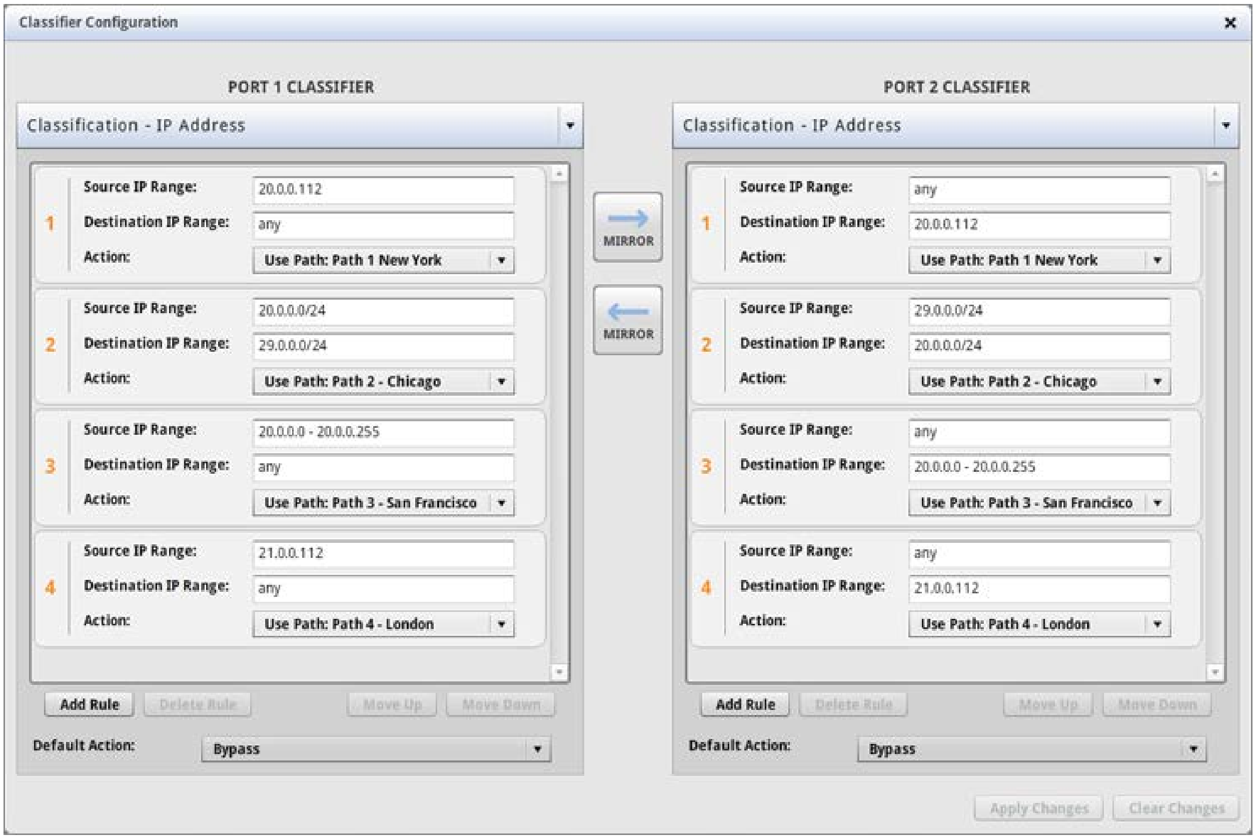
IP address classification matches packets by source and destination IPv4 address or range of addresses. For a packet to match a rule, both the source and destination address of the packet must fall within the configured source and destination address ranges of the rule.

IP address ranges may be specified in the following formats:

- as a single address in dotted decimal notation
  ex. 10.0.0.10
- as a range of IP addresses separated by a dash
  ex. 10.0.0.0 – 10.255.255.255
- as a range of IP addresses represented by an address and prefix length
  ex. 10.0.0.0/24
- using the wildcard 'any' to match any IP address

Non-IP packets and IP packets that do not match any of the numbered rules follow the separately configured Default Action.

For classification based on the Precedence or DSCP Type of Service (ToS) field in the IP header, use the Combination Classifier.



PORT 1 CLASSIFIER

Classification - IP Address

1
Source IP Range: 20.0.0.112
Destination IP Range: any
Action: Use Path: Path 1 New York

2
Source IP Range: 20.0.0.0/24
Destination IP Range: 29.0.0.0/24
Action: Use Path: Path 2 - Chicago

3
Source IP Range: 20.0.0.0 - 20.0.0.255
Destination IP Range: any
Action: Use Path: Path 3 - San Francisco

4
Source IP Range: 21.0.0.112
Destination IP Range: any
Action: Use Path: Path 4 - London

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - IP Address

1
Source IP Range: any
Destination IP Range: 20.0.0.112
Action: Use Path: Path 1 New York

2
Source IP Range: 29.0.0.0/24
Destination IP Range: 20.0.0.0/24
Action: Use Path: Path 2 - Chicago

3
Source IP Range: any
Destination IP Range: 20.0.0.0 - 20.0.0.255
Action: Use Path: Path 3 - San Francisco

4
Source IP Range: any
Destination IP Range: 21.0.0.112
Action: Use Path: Path 4 - London

Default Action: Bypass

Figure 30: Classification by IP Address

7.2.3 IPv6 Address Classification

IPv6 address classification matches packets by source and destination IPv6 address or range of addresses. For a packet to match a rule, both the source and destination address of the packet must fall within the configured source and destination address ranges of the rule.

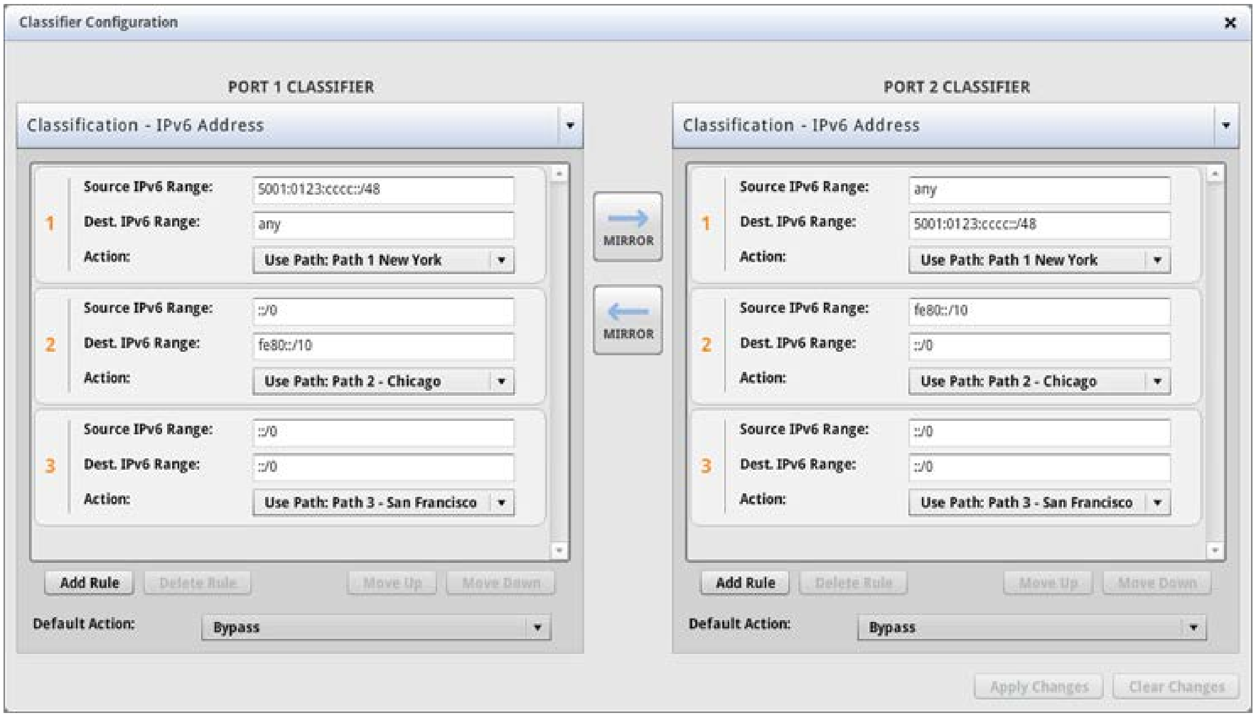
IPv6 address ranges may be specified in the following formats:

- as a single IPv6 address
  ex. 5001:0123:cccc::1
- as a range of IPv6 addresses represented by an address and prefix length
  ex. 5001:0123:cccc::/48
- using the wildcard 'any' to match any IPv6 address

The standard abbreviation "::" can be used for one or more 16 bit all zero quantities.

Non-IPv6 packets and IPv6 packets that do not match any of the numbered rules follow the separately configured Default Action.

For classification based on the Traffic Class field in the IPv6 header, use the Combination Classifier instead.



Classifier Configuration

PORT 1 CLASSIFIER

Classification - IPv6 Address

1
Source IPv6 Range: 5001:0123:cccc::/48
Dest. IPv6 Range: any
Action: Use Path: Path 1 New York

2
Source IPv6 Range: ::/0
Dest. IPv6 Range: fe80::/10
Action: Use Path: Path 2 - Chicago

3
Source IPv6 Range: ::/0
Dest. IPv6 Range: ::/0
Action: Use Path: Path 3 - San Francisco

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - IPv6 Address

1
Source IPv6 Range: any
Dest. IPv6 Range: 5001:0123:cccc::/48
Action: Use Path: Path 1 New York

2
Source IPv6 Range: fe80::/10
Dest. IPv6 Range: ::/0
Action: Use Path: Path 2 - Chicago

3
Source IPv6 Range: ::/0
Dest. IPv6 Range: ::/0
Action: Use Path: Path 3 - San Francisco

Default Action: Bypass

Figure 31: Classification by IPv6 Address

7.2.4 VLAN Classification

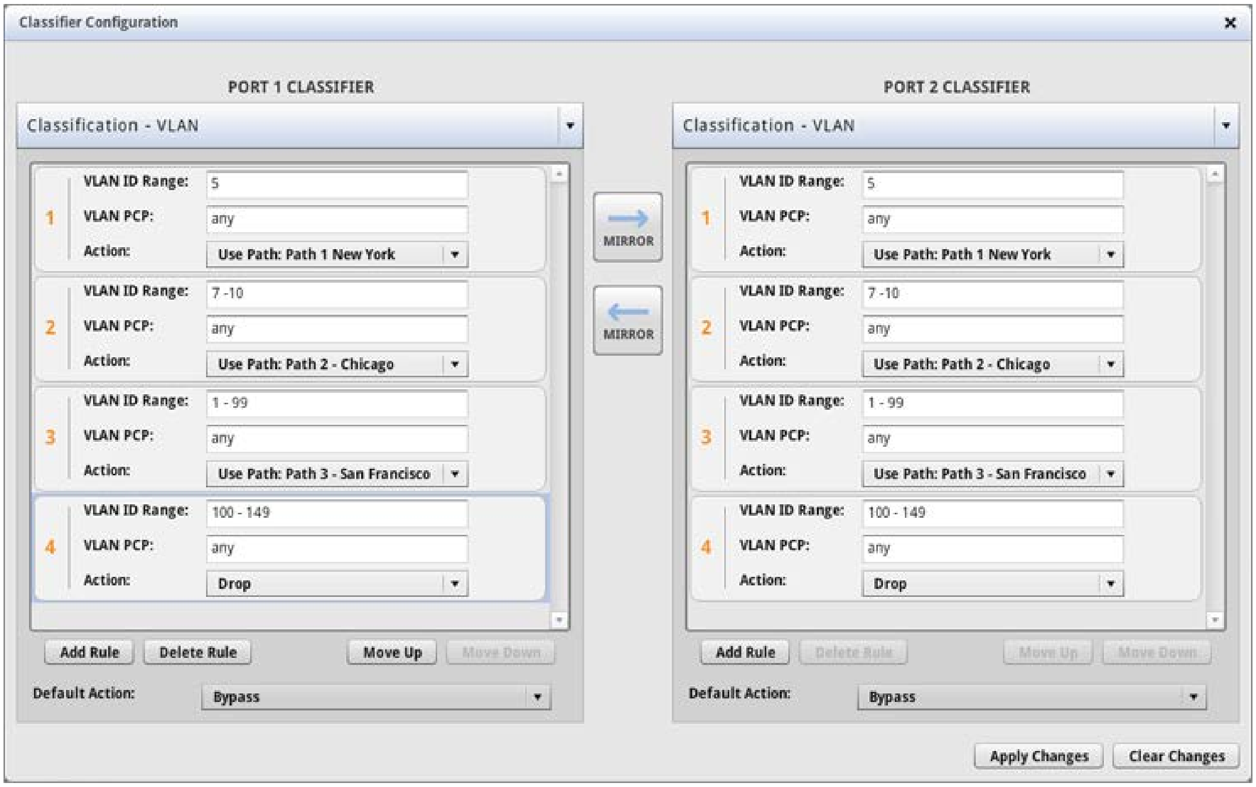
VLAN classification matches packets by the VLAN ID and PCP value in the IEEE 802.1Q VLAN tag.

The VLAN ID may be specified as a single value between 0 and 4095, or as a range of values separated by a hyphen. The wildcard ‘any’ can be used to match any value.

The PCP (priority code point) is a 3-bit field in the VLAN tag used for prioritization. The VLAN PCP is specified as a single value between 0 and 7, or the wildcard ‘any’. To ignore the VLAN PCP, use ‘any’ so that any PCP value will match.

VLAN classification matches the 802.1Q VLAN header of which there can be only one in any packet. Any stacked service VLAN (SVLAN) 802.1ad headers are ignored by the VLAN classifier, but can be used for classification with the raw data filters of the Combination Classifier.

Packets that do not have a VLAN tag or do not match any of the numbered rules follow the configured Default Action.



Classifier Configuration

PORT 1 CLASSIFIER

Classification - VLAN

1
VLAN ID Range: 5
VLAN PCP: any
Action: Use Path: Path 1 New York

2
VLAN ID Range: 7 -10
VLAN PCP: any
Action: Use Path: Path 2 - Chicago

3
VLAN ID Range: 1 - 99
VLAN PCP: any
Action: Use Path: Path 3 - San Francisco

4
VLAN ID Range: 100 - 149
VLAN PCP: any
Action: Drop

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - VLAN

1
VLAN ID Range: 5
VLAN PCP: any
Action: Use Path: Path 1 New York

2
VLAN ID Range: 7 -10
VLAN PCP: any
Action: Use Path: Path 2 - Chicago

3
VLAN ID Range: 1 - 99
VLAN PCP: any
Action: Use Path: Path 3 - San Francisco

4
VLAN ID Range: 100 - 149
VLAN PCP: any
Action: Drop

Default Action: Bypass

Figure 32: Classification by VLAN

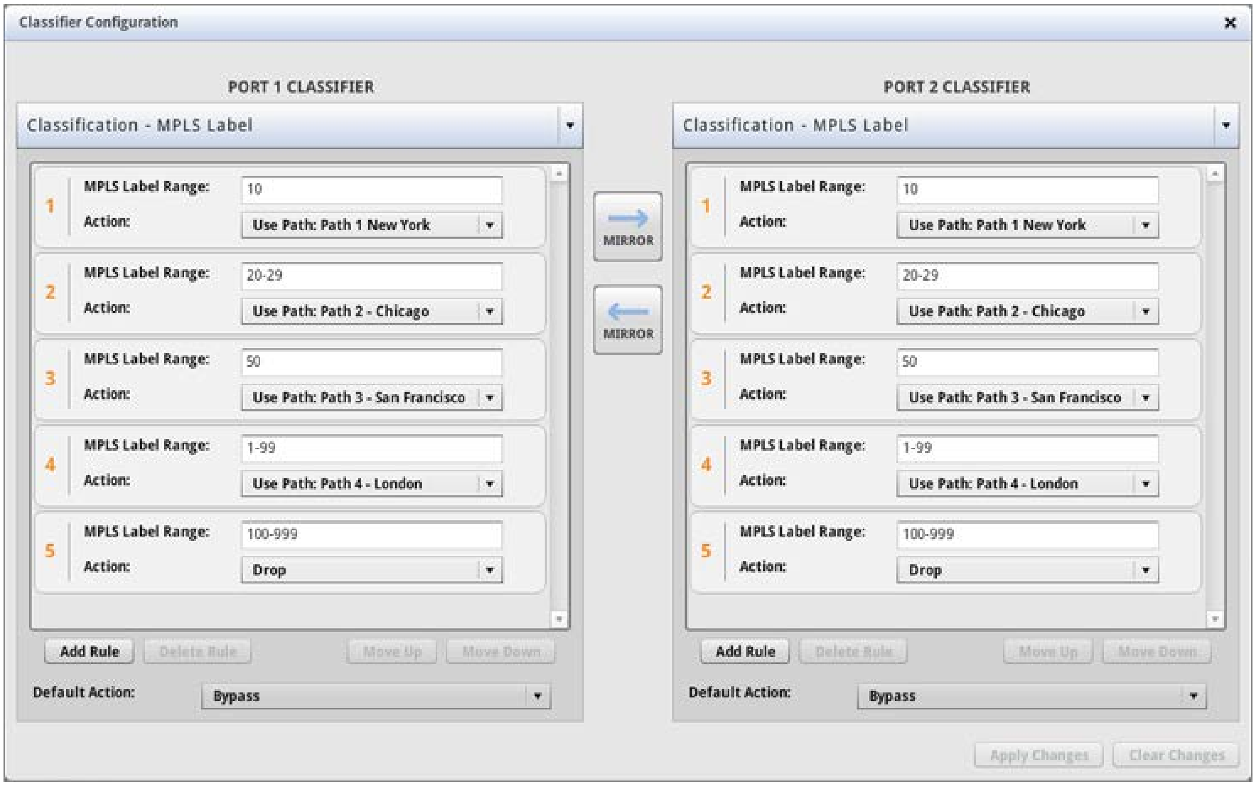
7.2.5 MPLS Label Classification

MPLS label classification matches packets by the MPLS label of each packet.

The MPLS label may be specified as a single value between 0 and 1048575, or as a range of values separated by a hyphen. The wildcard ‘any’ can be used to match any value.

Stacked MPLS labels are supported, but MPLS label classification is always based on the outermost label (the label acted on by the next router in line). Other MPLS labels can be used for classification with the raw data filters of the Combination Classifier.

Packets that do not have an MPLS label or do not match any of the numbered rules follow the configured Default Action.



Classifier Configuration

PORT 1 CLASSIFIER

Classification - MPLS Label

1 MPLS Label Range: 10
Action: Use Path: Path 1 New York

2 MPLS Label Range: 20-29
Action: Use Path: Path 2 - Chicago

3 MPLS Label Range: 50
Action: Use Path: Path 3 - San Francisco

4 MPLS Label Range: 1-99
Action: Use Path: Path 4 - London

5 MPLS Label Range: 100-999
Action: Drop

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - MPLS Label

1 MPLS Label Range: 10
Action: Use Path: Path 1 New York

2 MPLS Label Range: 20-29
Action: Use Path: Path 2 - Chicago

3 MPLS Label Range: 50
Action: Use Path: Path 3 - San Francisco

4 MPLS Label Range: 1-99
Action: Use Path: Path 4 - London

5 MPLS Label Range: 100-999
Action: Drop

Default Action: Bypass

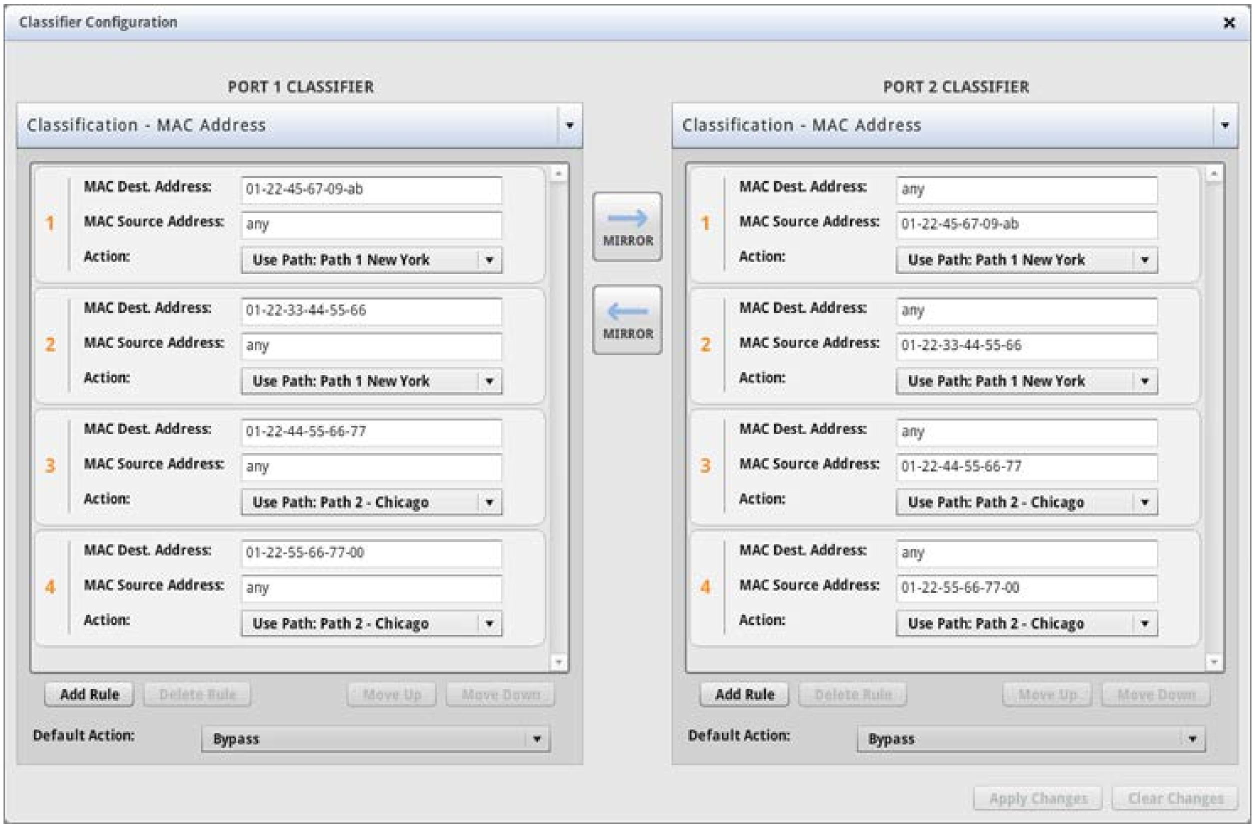
Figure 33: Classification by MPLS Label

7.2.6 MAC Address Classification

MAC address label classification matches packets by the source and destination MAC address of each packet.

The MAC address is specified as six groups of hexadecimal digits separated by hyphens. The wildcard 'any' can be used to match any MAC address.

Packets that do not match any of the numbered rules follow the separately configured Default Action.



Classifier Configuration

PORT 1 CLASSIFIER

Classification - MAC Address

1 MAC Dest. Address: 01-22-45-67-09-ab
MAC Source Address: any
Action: Use Path: Path 1 New York

2 MAC Dest. Address: 01-22-33-44-55-66
MAC Source Address: any
Action: Use Path: Path 1 New York

3 MAC Dest. Address: 01-22-44-55-66-77
MAC Source Address: any
Action: Use Path: Path 2 - Chicago

4 MAC Dest. Address: 01-22-55-66-77-00
MAC Source Address: any
Action: Use Path: Path 2 - Chicago

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - MAC Address

1 MAC Dest. Address: any
MAC Source Address: 01-22-45-67-09-ab
Action: Use Path: Path 1 New York

2 MAC Dest. Address: any
MAC Source Address: 01-22-33-44-55-66
Action: Use Path: Path 1 New York

3 MAC Dest. Address: any
MAC Source Address: 01-22-44-55-66-77
Action: Use Path: Path 2 - Chicago

4 MAC Dest. Address: any
MAC Source Address: 01-22-55-66-77-00
Action: Use Path: Path 2 - Chicago

Default Action: Bypass

Figure 34: Classification by MAC Address

7.2.7 TCP/UDP Port Classification

TCP/UDP Port classification matches packets by the combination of source and destination IP address and TCP or UDP port number. The TCP/UDP Port classification is generally used to apply impairments selectively to traffic from one or more specific applications while allowing other application traffic to be forwarded without impairment.

For a packet to match a rule, the IP address, transport layer protocol (TCP or UDP), and application port number must all match the specified values for both source and destination.

Use the Protocol radio button to specify either a TCP or UDP packet. Each rule must be either TCP or UDP.

The source and destination addresses can be any valid IPv4 or IPv6 address or address range.

- as a single IPv4 or IPv6 address
  ex. 10.0.0.10
  ex. 5001:0123:cccc::1

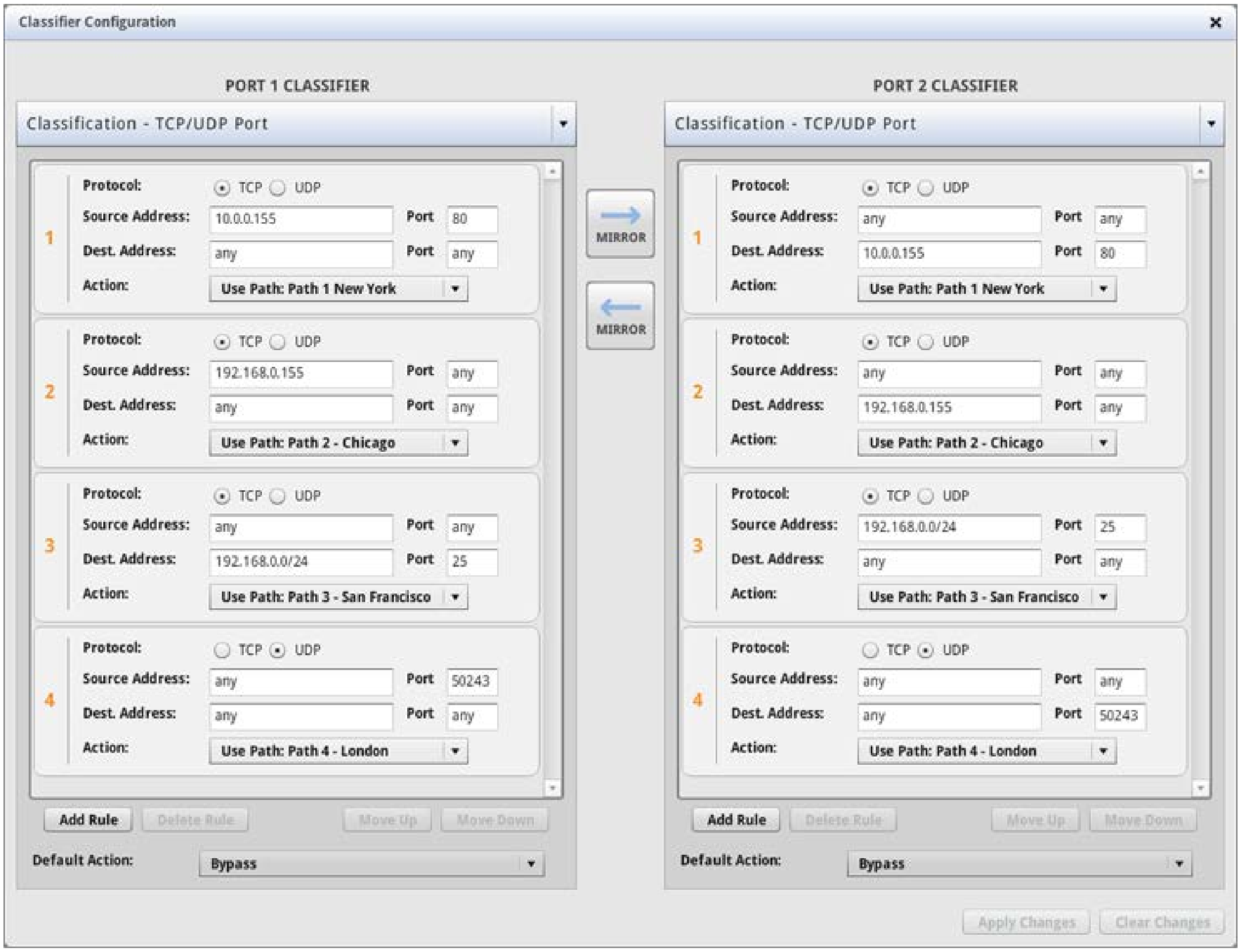
- as a range of IPv4 addresses separated by a dash
  ex. 10.0.0.0 – 10.255.255.255

- as a range of IPv4 or IPv6 addresses represented by an address and prefix length
  ex. 10.0.0.0/24
  ex. 5001:0123:cccc::/48

- using the wildcard ‘any’ to match any IPv4 or IPv6 address

The port number is a single value or range of values separate by a dash between 0 and 65535, or the wildcard ‘any’ to match any port number.

Non-IP packets and IP packets that do not match any of the numbered rules follow the separately configured Default Action.



PORT 1 CLASSIFIER

Classification - TCP/UDP Port

1
Protocol: ● TCP ○ UDP
Source Address: 10.0.0.155 Port 80
Dest. Address: any Port any
Action: Use Path: Path 1 New York

2
Protocol: ● TCP ○ UDP
Source Address: 192.168.0.155 Port any
Dest. Address: any Port any
Action: Use Path: Path 2 - Chicago

3
Protocol: ● TCP ○ UDP
Source Address: any Port any
Dest. Address: 192.168.0.0/24 Port 25
Action: Use Path: Path 3 - San Francisco

4
Protocol: ○ TCP ● UDP
Source Address: any Port 50243
Dest. Address: any Port any
Action: Use Path: Path 4 - London

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - TCP/UDP Port

1
Protocol: ● TCP ○ UDP
Source Address: any Port any
Dest. Address: 10.0.0.155 Port 80
Action: Use Path: Path 1 New York

2
Protocol: ● TCP ○ UDP
Source Address: any Port any
Dest. Address: 192.168.0.155 Port any
Action: Use Path: Path 2 - Chicago

3
Protocol: ● TCP ○ UDP
Source Address: 192.168.0.0/24 Port 25
Dest. Address: any Port any
Action: Use Path: Path 3 - San Francisco

4
Protocol: ○ TCP ● UDP
Source Address: any Port any
Dest. Address: any Port 50243
Action: Use Path: Path 4 - London

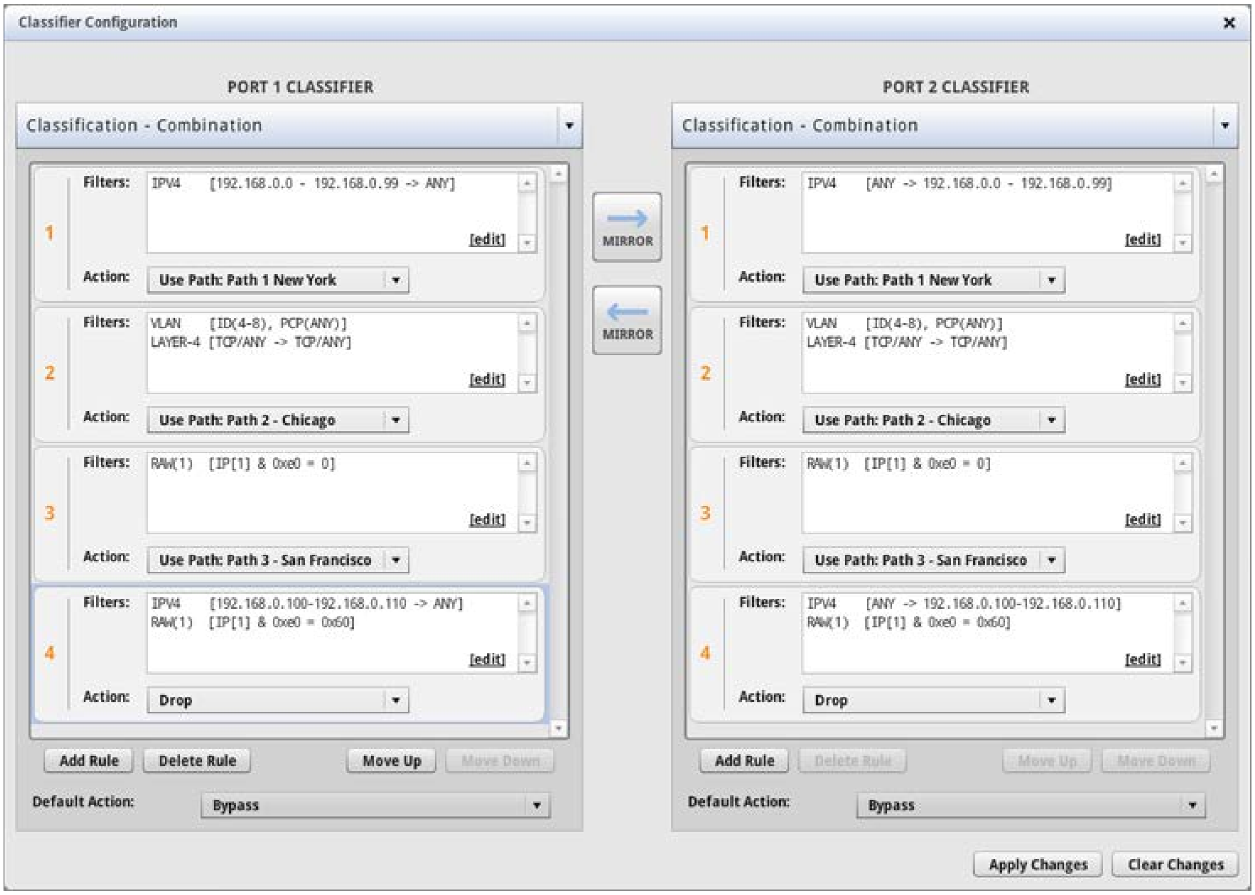
Default Action: Bypass

Figure 35: Classification by TCP or UDP Port Number

7.2.8 Combination Classification

The Combination Classifier is a flexible classifier that allows packets to be classified using multiple types of rules, such as both IPv4 and IPv6 addresses, or to create complex rules combining multiple well-known fields such as a specific IP address range within one VLAN. In addition, the Combination Classifier includes a Raw Data classification feature which allows packets to be identified and classified based on any arbitrary matching criteria.

Each rule of the Combination Classifier consists of one or more filters and an action. Configured filters are shown in summary form in the Classifier Configuration screen. To build a rule, or to modify the filters of an existing rule, click on the *edit* link within the filter's summary box to open the Combination Rule Editor window.



Classifier Configuration

PORT 1 CLASSIFIER

Classification - Combination

1 Filters:
```
IPV4     [192.168.0.0 - 192.168.0.99 -> ANY]
```
Action: Use Path: Path 1 New York

2 Filters:
```
VLAN     [ID(4-8), PCP(ANY)]
LAYER-4 [TCP/ANY -> TCP/ANY]
```
Action: Use Path: Path 2 - Chicago

3 Filters:
```
RAW(1)  [IP[1] & 0xe0 = 0]
```
Action: Use Path: Path 3 - San Francisco

4 Filters:
```
IPV4     [192.168.0.100-192.168.0.110 -> ANY]
RAW(1)  [IP[1] & 0xe0 = 0x60]
```
Action: Drop

Default Action: Bypass

PORT 2 CLASSIFIER

Classification - Combination

1 Filters:
```
IPV4     [ANY -> 192.168.0.0 - 192.168.0.99]
```
Action: Use Path: Path 1 New York

2 Filters:
```
VLAN     [ID(4-8), PCP(ANY)]
LAYER-4 [TCP/ANY -> TCP/ANY]
```
Action: Use Path: Path 2 - Chicago

3 Filters:
```
RAW(1)  [IP[1] & 0xe0 = 0]
```
Action: Use Path: Path 3 - San Francisco

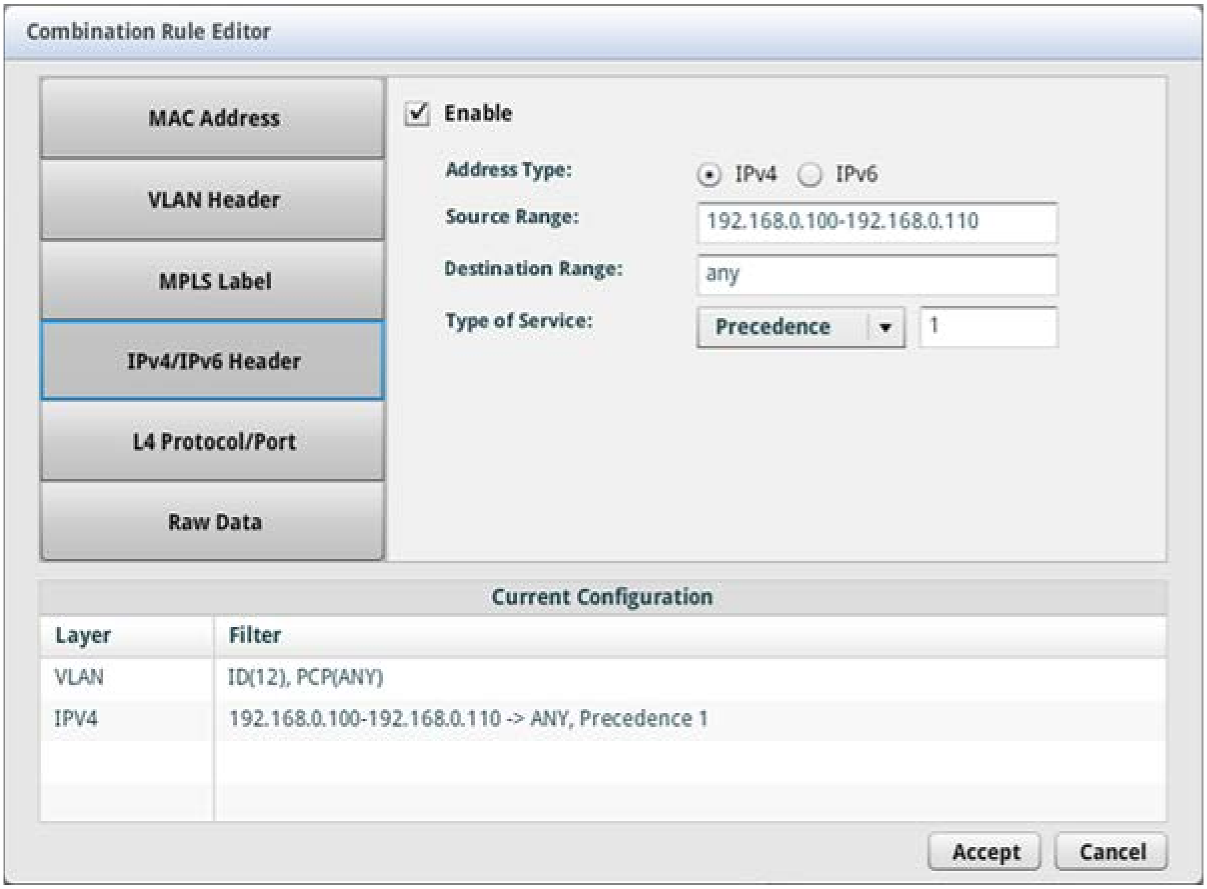
4 Filters:
```
IPV4     [ANY -> 192.168.0.100-192.168.0.110]
RAW(1)  [IP[1] & 0xe0 = 0x60]
```
Action: Drop

Default Action: Bypass

Figure 36: Combination Classification

The Combination Rule Editor window has separate tabs for each packet layer, along with a Raw Data filter tab. To add a filter, click on the tab for the desired packet layer, check the enable box, and enter the criteria to match. Valid entries for each layer are the same as described earlier in this chapter for the simple classifiers. Click the *accept* button when complete.

The Combination Classifier allows filtering on multiple criteria, for example, packets on VLAN 12 with an IP source address between 192.168.0.100 to 192.168.0.110. For this example, click the "IPv4/IPv6 Header" tab, check the *enable* box to turn on IP layer filters, select address type of IPv4, set the source address of 192.168.0.100 – 192.168.0.110 and set the destination address to "any". Then click on the VLAN Header tab, check the *enable* box, and enter the VLAN ID range of 12 with a PCP value of "any".



☑ Enable

Address Type: ● IPv4 ○ IPv6

Source Range: 192.168.0.100-192.168.0.110

Destination Range: any

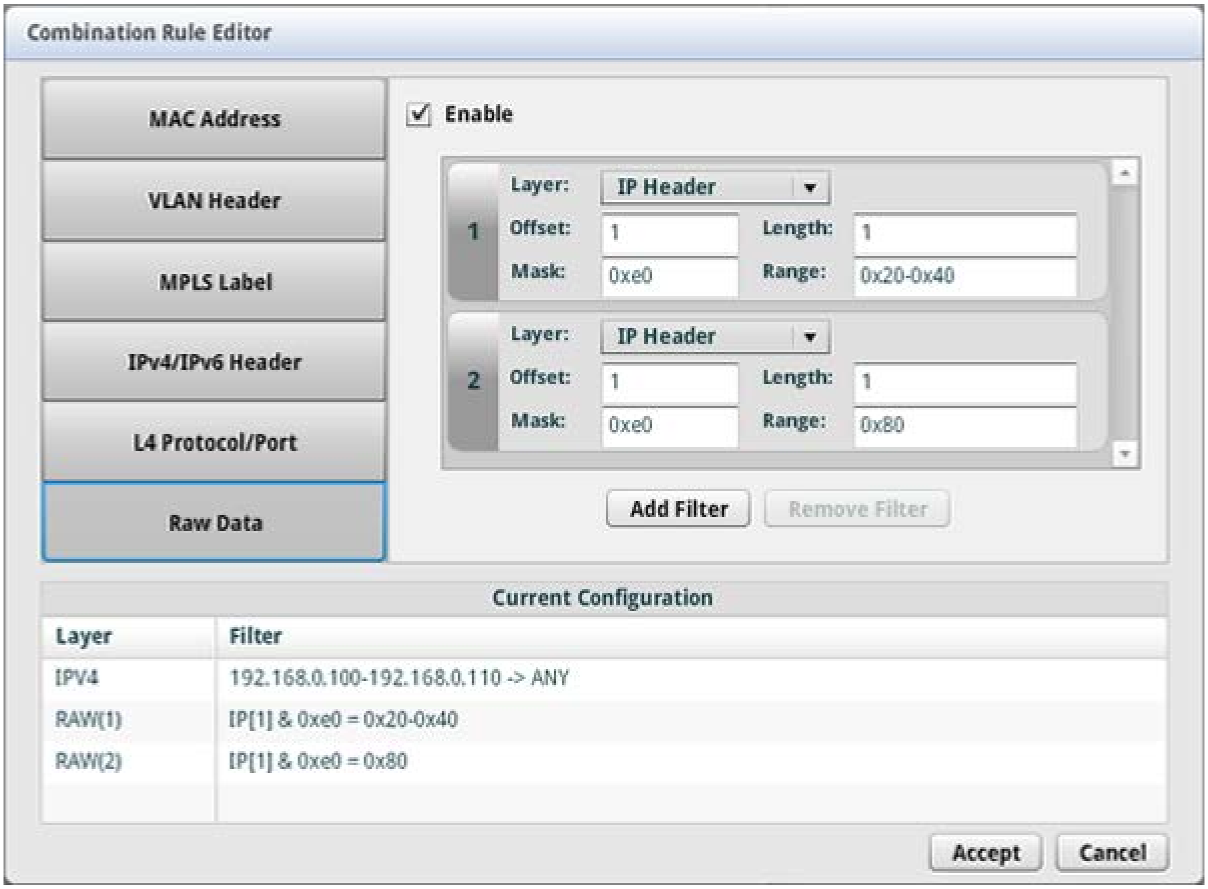
Type of Service: Precedence ▾ 1

Current Configuration

Layer	Filter
VLAN	ID(12), PCP(ANY)
IPV4	192.168.0.100-192.168.0.110 -> ANY, Precedence 1

Figure 37: Combination Rule Editor

The Raw Data classifier allows any portion of the packet contents to be used for filtering. The layer, offset, and length values together specify the packet data on which to filter. This data is combined in a bitwise AND with the supplied mask, and the result is compared with the supplied range.



☑ Enable

1
Layer: IP Header
Offset: 1 Length: 1
Mask: 0xe0 Range: 0x20-0x40

2
Layer: IP Header
Offset: 1 Length: 1
Mask: 0xe0 Range: 0x80

Current Configuration

Layer	Filter
IPV4	192.168.0.100-192.168.0.110 -> ANY
RAW(1)	IP[1] & 0xe0 = 0x20-0x40
RAW(2)	IP[1] & 0xe0 = 0x80

Figure 38: Raw Data Rules

If the specified layer does not exist, the filter does not match. For example, if TCP Header layer is selected, but the packet is a UDP datagram, the match will fail.

The offset can be any arbitrary length and can extend past the end of the header. Selecting the Ethernet layer allows selection of any set of bytes from the beginning of the packet. If the length extends beyond the end of the packet, the match will fail.

Each filter that has been created for the rule is listed in the Current Configuration. There can be filters for each of the five layers, plus up to eight Raw Data filters, though it is unlikely that filters for more than two different layers would be needed.

For a packet to match a rule, all filters must match. If any filter does not match the specified criteria, the rule is ignored and the next rule in order is tested for a match. The action specified in the first rule that matches all of the filter criteria is used.

⚠ Matching on multiple filters using the combination classifier is processor intensive and can reduce the maximum packet processing rate of the system.

7.3 Rule Order

Rules may overlap each other. The first matching rule in numerical order is used. The *Move Up* and *Move Down* buttons are used to adjust rule order. The default action specifies what happens to packets that do not match any numbered rule.

Example: consider the following set of IP Address Classification rules for Port 1:

Rule 1	Source IP Range:	10.0.0.10
	Destination IP range:	any
	Action:	Use Path: Link A
Rule 2	Source IP Range:	10.0.0.0/24
	Destination IP range:	any
	Action:	Use Path: Link B
Rule 3	Source IP Range:	10.0.0.0 – 10.255.255.255
	Destination IP range:	any
	Action:	Use Path: Link C
Default Action:		bypass

In this example, any packet that arrives on Port 1 with source address of 10.0.0.10 will be sent over Link A. Any other packet with source address on the 10.0.0.x subnet will be sent over Link B. And any packet with a source address on the 10.x.x.x subnet that is not on the 10.0.0.x subnet will be sent over Link C.

All IP packets not on the 10.x.x.x subnet and all non-IP packets will be forwarded directly to the opposite port, bypassing the emulated WAN network.

8 RECORDINGS

8.1 Overview of Recordings

Path delay, loss, and bandwidth conditions that fluctuate over time can be simulated using a time-series of values from a user-supplied recording file usually generated by the Netropy Recorder for Windows and Linux or the Apposite Recorder for Android™ software. This provides a convenient method of capturing the conditions of a live network link and reproducing those conditions in the lab.

The Netropy Recorder is an application for Windows and Linux available for free download from the Apposite website. The Apposite Recorder for Android provides similar functionality on Android-based phones and tablets and is available for free download on Google Play™. The Netropy or Apposite Recorder sends ICMP Echo Requests from the device on which it is running to a specified destination on the other side of the network, then records the reported delay and loss values to a recording file. For more information on the Recorder software, please consult the *Netropy Recorder User's Guide* or the Help text within the Apposite Recorder for Android.

Users can also create their own recording files to generate any desired time sequence of emulated conditions. Although the Recorder software does not record bandwidth, the recording file can include values for bandwidth as well as latency and loss. To create a recording file, or to edit a recording file created by the Recorder, refer to the Recording File Format description in Section 8.4.

The use of recordings is a 2-step process. First, recording files are loaded into the Netropy network emulator for use by any Path of any engine. Then, available recordings can be selected for playback within the configuration of any Path.

Recordings represent the conditions for a single direction, and consequently, all data represent one-way, not round trip values.

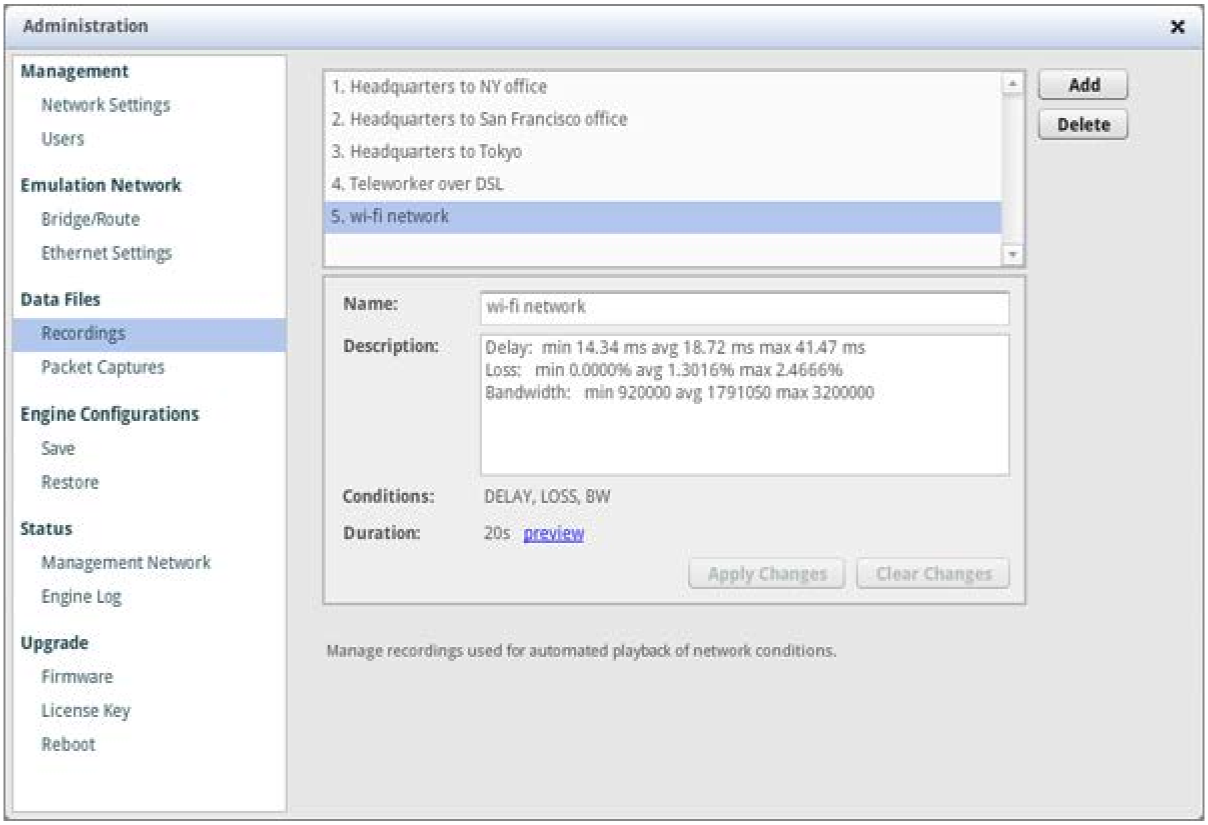
8.2 Managing Recordings

Use the Recordings tab of the Administration window to add and delete recording files.

To add a new recording file, click the *add* button and browse to the recording file stored on the management PC or a locally accessible file server. To remove a recording file, select the file and click the *delete* button.

Selecting a previously loaded recording displays a summary of the delay and loss characteristics of the data, as well as the length of the recording. Clicking the *preview* link displays a graph of the data. Separate graphs will be displayed for each condition included in the file.

Each recording file can be up to 10 MB in size, with the total for all packet capture and recording files limited to 40 MB.



1. Headquarters to NY office
2. Headquarters to San Francisco office
3. Headquarters to Tokyo
4. Teleworker over DSL
5. wi-fi network

Name: wi-fi network

Description:
Delay: min 14.34 ms avg 18.72 ms max 41.47 ms
Loss: min 0.0000% avg 1.3016% max 2.4666%
Bandwidth: min 920000 avg 1791050 max 3200000

Conditions: DELAY, LOSS, BW

Duration: 20s preview

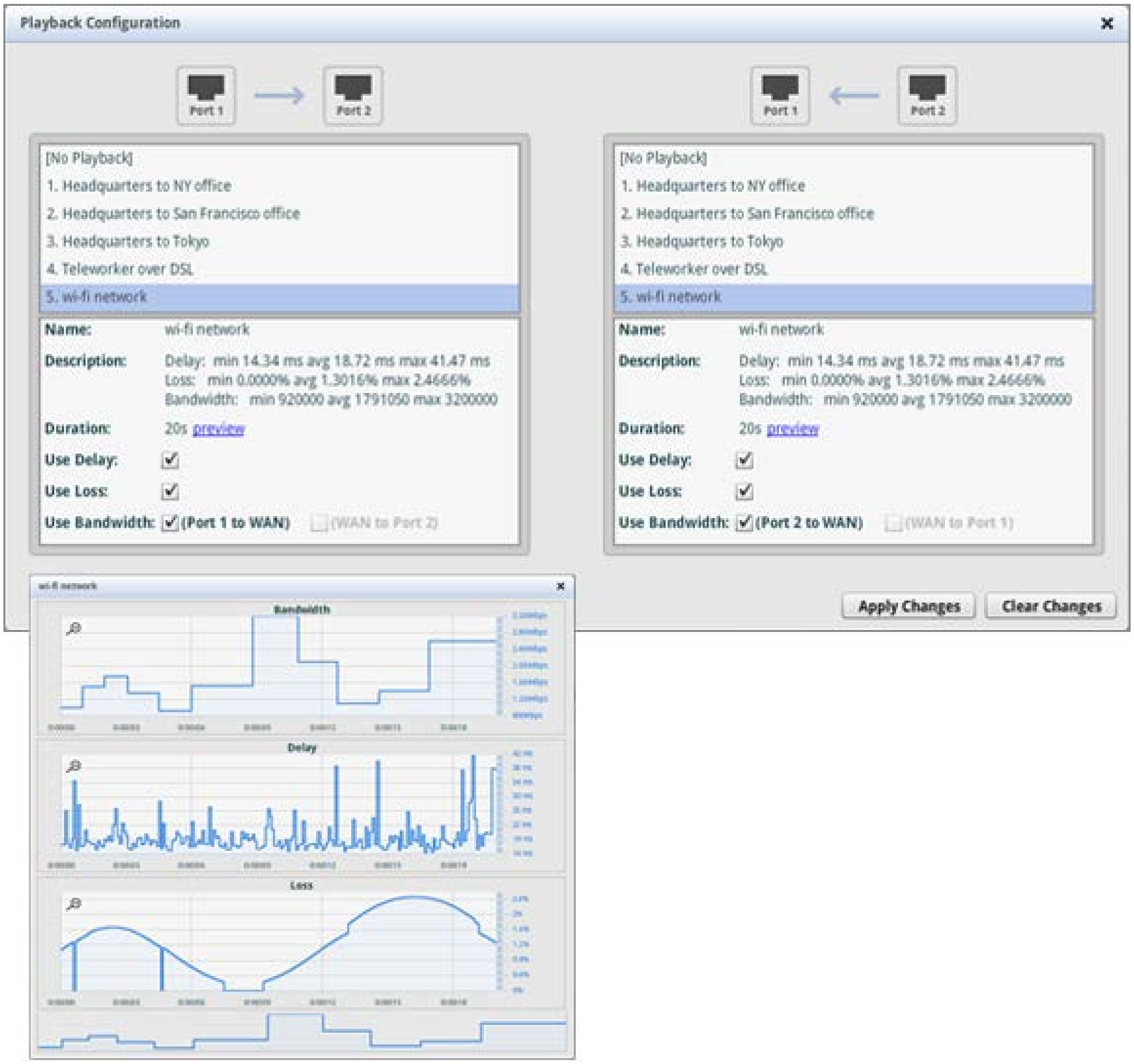
Manage recordings used for automated playback of network conditions.

Figure 39: Recording Administration

8.3 Recording Playback

To playback a recording, first turn off emulation for the engine. Playback can only be configured while emulation is off. Then click on the Path to open the Path Configuration window. Click the Playback button on the top button bar to configure recording playback.

Select the recording to use for each direction. Playback is configured separately in each direction. The same recording can be used in each direction, different recordings can be used in each direction, or a recording can be used in one direction with non-recorded conditions in the other direction.



[No Playback]
1. Headquarters to NY office
2. Headquarters to San Francisco office
3. Headquarters to Tokyo
4. Teleworker over DSL
5. wi-fi network

Name: wi-fi network
Description: Delay: min 14.34 ms avg 18.72 ms max 41.47 ms
Loss: min 0.0000% avg 1.3016% max 2.4666%
Bandwidth: min 920000 avg 1791050 max 3200000
Duration: 20s preview
Use Delay: ☑
Use Loss: ☑
Use Bandwidth: ☑ (Port 1 to WAN) □ (WAN to Port 2)

[No Playback]
1. Headquarters to NY office
2. Headquarters to San Francisco office
3. Headquarters to Tokyo
4. Teleworker over DSL
5. wi-fi network

Name: wi-fi network
Description: Delay: min 14.34 ms avg 18.72 ms max 41.47 ms
Loss: min 0.0000% avg 1.3016% max 2.4666%
Bandwidth: min 920000 avg 1791050 max 3200000
Duration: 20s preview
Use Delay: ☑
Use Loss: ☑
Use Bandwidth: ☑ (Port 2 to WAN) □ (WAN to Port 1)

Figure 40: Recording Playback Configuration

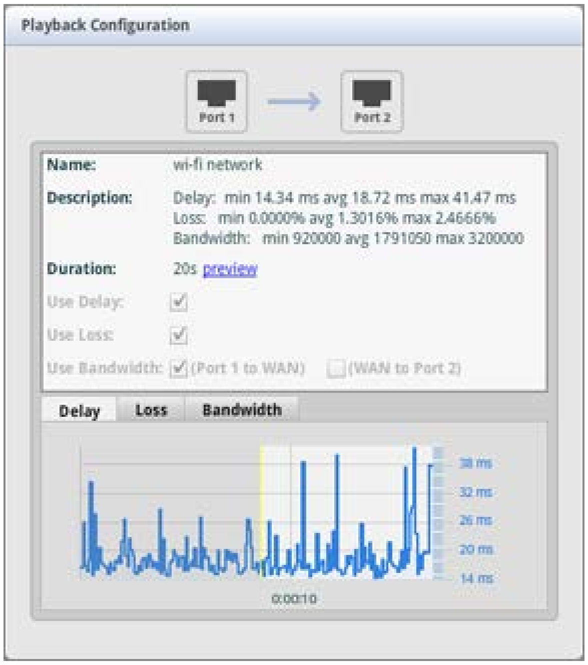
Click the check boxes to select whether to use recorded delay, loss, and/or bandwidth. Any parameters not included in the recording are grayed out. By default, all available conditions are selected.

For each path direction, recorded bandwidth can be used to set bandwidth from a port outbound to the WAN, from the WAN inbound to a port, or both. The option to use recorded bandwidth from the WAN inbound to a port will be enabled only if the inbound side of the corresponding WAN Access has been enabled.

Apply changes to return to the Path Configuration window and configure any other emulation parameters if needed.

Playback of the recording begins when emulation is turned on. When playback reaches the end of the recording, it restarts at the beginning and continues looping until emulation is disabled.

To view the progress of the recording playback, return to the Playback Configuration window. While playback is running, a graph of the recording is displayed showing the progress of the playback.



Playback Configuration

Name: wi-fi network

Description: Delay: min 14.34 ms avg 18.72 ms max 41.47 ms
Loss: min 0.0000% avg 1.3016% max 2.4666%
Bandwidth: min 920000 avg 1791050 max 3200000

Duration: 20s preview

Use Delay: ☑

Use Loss: ☑

Use Bandwidth: ☑ (Port 1 to WAN) □ (WAN to Port 2)

Figure 41: Recording Playback Progress

8.4 Recording File Format

Recordings are text files with the format described in the table below. The recording file may contain up to 100,000 lines of data.

Line Type	Syntax and Description

`metadata`	`# <attribute> : <value>`
	A list of attributes of the recording and their values. Must be at the beginning of the file, prior to any recording data, and preceded by a "#" symbol. Defined attributes are:
	`# name (or # title) : <recording name/title>`
	The title of the recording displayed above the recording graphs.
	`# description : <recording description>`
	A detailed description of the recording. If no description is included in the file, the computed min/avg/max delay and loss values will be displayed as the description of the recording.
	`# contents : <impairment 1, impairment 2, ..., impairment n>`
	An ordered, comma-separated list of impairment names that defines the fields of the data section. Valid impairment names are limited to BW, DELAY, and LOSS. For example:
	`# contents : DELAY,LOSS`
	`# contents : DELAY`
	`# contents : BW,DELAY,LOSS`
	If the contents are not specified, "DELAY,LOSS" is assumed.

`Data`	`<start time> <impairment 1 value> [<impairment 2 value>] [<impairment 3 value>]` Start time is the time in seconds, relative to the beginning of the recording, when the delay and loss values of the line take effect. Start time is a floating point number and must be at least 0.001 seconds greater than the start time of the previous line. There cannot be more than 10 lines in any one second period. On the final line in the recording file, the start time is used only to determine the duration of the previous line with delay and loss values ignored. Delay values are specified as latency in milliseconds with a resolution of 0.01 ms. Loss values are specified as the packet loss rate in percent (without the percent sign) between 0.0000 and 100.0000. Bandwidth values are specified in bits per second.

8.5 Example Recording File

The following is a short example recording file with bandwidth, delay, and loss parameters. Within the first second, the loss values change five times, then remain constant for 19 seconds, then the bandwidth and delay values change over the next 30 seconds.

```
# Name : Example Recording
# Contents : BW,DELAY,LOSS
0, 2000000, 52.5, 0
0.2, 2000000, 52.5, 25.0
0.4, 2000000, 52.5, 50.0
0.6, 2000000, 52.5, 75.0
0.8, 2000000, 52.5, 50.0
1.0, 2000000, 52.5, 25.0
20.0, 2000000, 52.5, 0
25.0, 4000000, 52.5, 0
30.0, 8000000, 60.0, 0
40.0, 8000000, 75.0, 0
50.0, 8000000, 100.0, 0
```

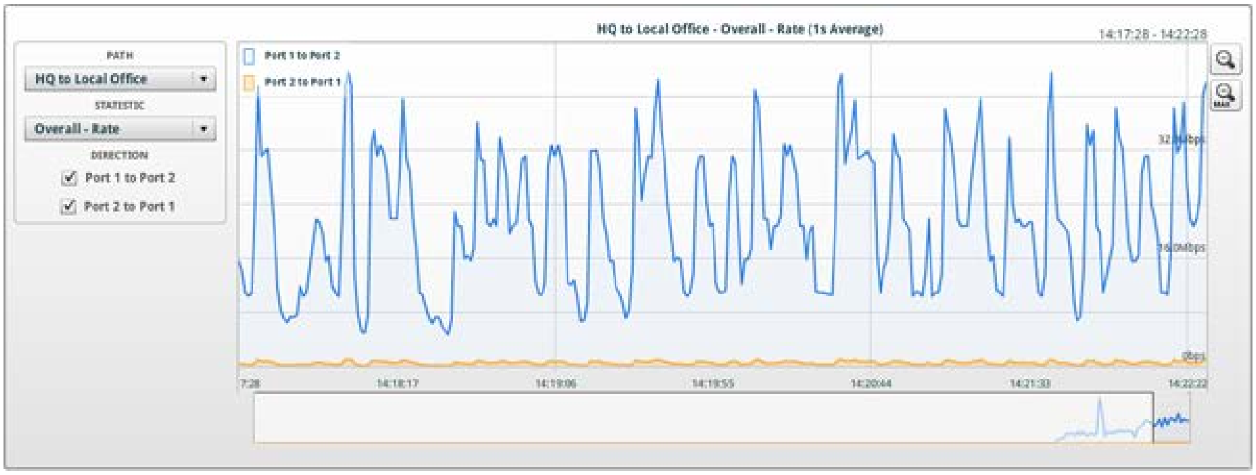
9 Monitoring & Statistics Download

The GUI displays real-time statistics and throughput graphs for the traffic over each of the emulated links.

9.1 Graphs

The data visualization section of the main window displays a graph of any of the traffic statistics, such as throughput, over any path. Use the drop-down menus to select the statistic and path to view. The graph can display the statistics in either direction of a path or overlay both directions.

Statistics for background traffic is shown separately from real traffic entering the Engine from external sources.


PATH: HQ to Local Office

STATISTIC: Overall - Rate

DIRECTION:

- ☑ Port 1 to Port 2
- ☑ Port 2 to Port 1

Figure 42: Statistics Graph

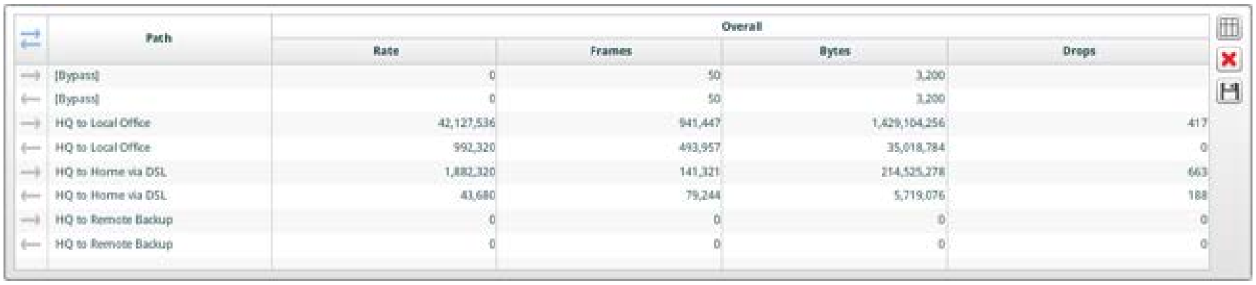
To zoom on any portion of the graph, place the cursor over the edge of the area of interest and click and drag to zoom onto that segment. Use the slider under the graph to pan to earlier or later time periods, and use the *zoom out* buttons to reduce the zoom level. When fully zoomed out, the graph displays the previous two hours.

> ☞ A 24 hour graph of any statistic with zoom and pan controls is also available by clicking the Download Statistics button in the statistic panel, then clicking the Time Picker button.

9.2 Statistics

The statistics section of the main window displays statistics for each path and for bypass traffic. By default, only overall throughput rate, frames and bytes transmitted, and packets dropped are displayed. To view other statistics, click the column configuration icon to the right of the table.

Rates are displayed as averages over the past one second interval. Counters are displayed as cumulative values since the last reset. Rebooting or power cycling the device resets all values. The *reset totals* button resets values displayed in the statistics panel.



⇄	Path	Overall			
		Rate	Frames	Bytes	Drops
→	[Bypass]	0	50	3,200	
←	[Bypass]	0	50	3,200	
→	HQ to Local Office	42,127,536	941,447	1,429,104,256	417
←	HQ to Local Office	992,320	493,957	35,018,784	0
→	HQ to Home via DSL	1,882,320	141,321	214,525,278	663
←	HQ to Home via DSL	43,680	79,244	5,719,076	188
→	HQ to Remote Backup	0	0	0	0
←	HQ to Remote Backup	0	0	0	0

Figure 43: Path Statistics

☞ The *reset totals* button resets statistics for its browser window only. Opening a new browser window or reloading the current page will restore the statistics. Use the *erase statistics* button on the Statistics Selection and Download window to reset all values permanently. A reboot or power cycle of the Netropy unit will also reset all values.

⚠ Statistics cannot be recovered after a reboot or power cycle of the device.

Data available for display for each path in each direction are described in the table below.

Segment	Statistic	Description
Overall	Rate	current transmission rate for traffic delivered across the WAN over the previous 1 sec. interval.
	Bytes/Frames	cumulative number of bytes and packets delivered across the path.
	Drops	cumulative sum of packets dropped as a result of queuing limits on both the outbound and inbound WAN Access links and the frames dropped due to configured WAN loss parameters.
WAN Access	Tx Rate	current transmission rate for traffic delivered across the WAN Access link over the previous 1 sec. interval. Does not include background traffic.
	Tx Bytes/Frames	cumulative number of bytes and packets transmitted over the WAN access link. Does not include background traffic.
	Queue Length – Bytes/Frames	number of bytes and packets currently in the transmit queue, including estimated queue occupancy of background utilization traffic, when configured.
	Queue Drops	cumulative number of packets dropped due to configured queuing limits. Does not include drops of background traffic.
	Background Bytes/Frames	cumulative number of bytes and packets injected as background traffic on the WAN Access link.
	Background Queue Drops	cumulative number of packets of background traffic dropped due to configured queuing limits.
WAN	Loss Drops	cumulative number of packets dropped due to configured loss parameters.
	Frames Reordered	cumulative number of packets reordered.
	Duplicated	cumulative number of packets duplicated.
	Corrupted	cumulative number of packets that contain one or more errors.

9.2.1 Statistics Download

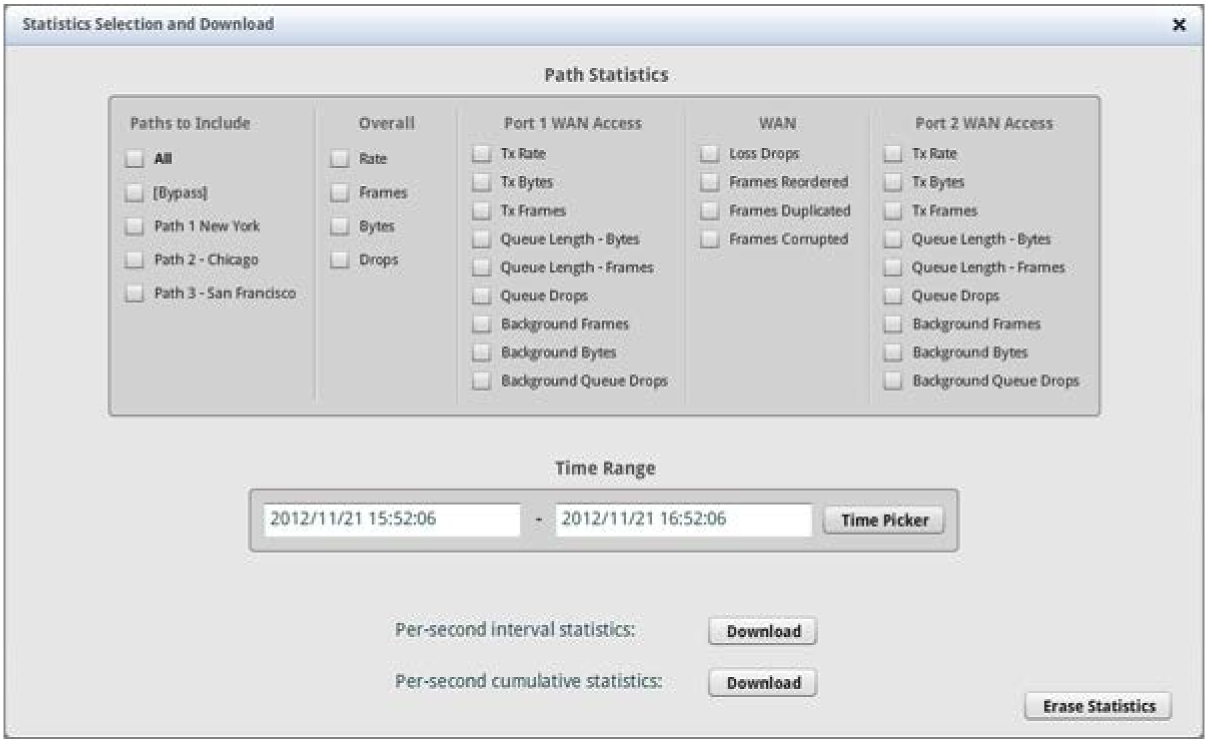
Depending on the number of configured paths, up to 24 hours of statistics, in 1 second intervals, are available for download to a file. To download, click the *Download Statistics* button to open the Statistics Download window.

In the Statistics Download window, select the paths and statistics. The time period for the statistics can either be entered manually or selected graphically using the Time Picker. The Time Picker displays a throughput graph of up to 24 hours with zoom and pan controls to assist in finding and selecting periods of interest.

After selecting the time period, click on the download button for per-second interval counters or cumulative counters, and choose a location to save the file.

The data can be downloaded as either:

- Per-second interval counters: separate values of the number of packets, bytes, or other counters within each one second interval
- Per-second cumulative counters: cumulative values for the number of packets, bytes, or other counters since the beginning of the selected time period reported each second.



Statistics Selection and Download ✕

Path Statistics

Paths to Include	Overall	Port 1 WAN Access	WAN	Port 2 WAN Access
□ **All**	□ Rate	□ Tx Rate	□ Loss Drops	□ Tx Rate
□ [Bypass]	□ Frames	□ Tx Bytes	□ Frames Reordered	□ Tx Bytes
□ Path 1 New York	□ Bytes	□ Tx Frames	□ Frames Duplicated	□ Tx Frames
□ Path 2 - Chicago	□ Drops	□ Queue Length - Bytes	□ Frames Corrupted	□ Queue Length - Bytes
□ Path 3 - San Francisco		□ Queue Length - Frames		□ Queue Length - Frames
		□ Queue Drops		□ Queue Drops
		□ Background Frames		□ Background Frames
		□ Background Bytes		□ Background Bytes
		□ Background Queue Drops		□ Background Queue Drops

Time Range

2012/11/21 15:52:06 - 2012/11/21 16:52:06 Time Picker

Per-second interval statistics: Download

Per-second cumulative statistics: Download

Erase Statistics

Figure 44: Statistics Download

The downloaded statistics are saved as a comma separated value (CSV) file that can be imported into Microsoft Excel or other data visualization application.

The statistics file consists of comma separated values. The first three rows are headings, followed by a separate row for each one second time interval during the selected period.

The three heading rows identify the contents of columns.

Within each row of data, the first two columns show the number of seconds since the last statistics reset or power cycle and the corresponding clock time on the management device that downloaded the file.

For WAN statistics, the direction of packet flow is indicated using the port numbers. For example, "Port 1 - Port 2" indicates traffic flowing from the Port 1 side to the Port 2 side.

For WAN Access statistics, the direction of packet flow is indicated by the port number and whether it is in-bound or out-bound from that port. For example, "Port 1 WAN Access Outbound" indicates packets flowing from the LAN attached to Port 1 out to the WAN.

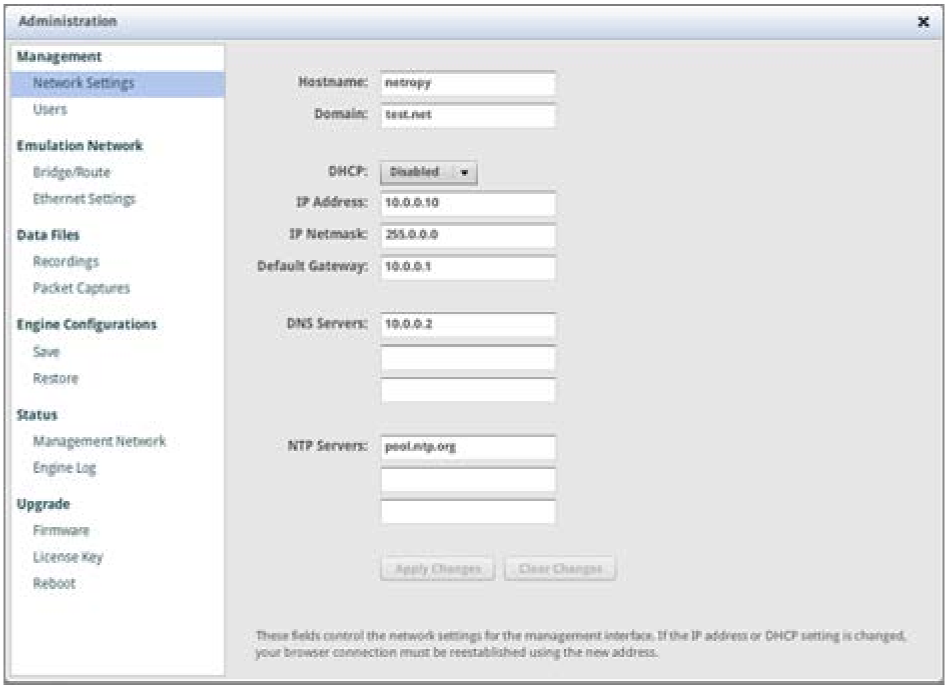
The statistic name identifies the particular statistic. Interval statistics are followed by "(I)", and cumulative statistics are followed by "(C)".

10 ADMINISTRATION

The Netropy network emulator is administered via a separate window accessed by clicking the *Administration* link at the top of the main page.

10.1 Network Settings

The IP address of the management interface of the Netropy device and other network settings are configured in the Network Settings tab.



Hostname: netropy

Domain: test.net

DHCP: Disabled

IP Address: 10.0.0.10

IP Netmask: 255.0.0.0

Default Gateway: 10.0.0.1

DNS Servers: 10.0.0.2

NTP Servers: pool.ntp.org

These fields control the network settings for the management interface. If the IP address or DHCP setting is changed, your browser connection must be reestablished using the new address.

Figure 45: Network Settings Tab

IP address, netmask, and default gateway, as well as DNS and NTP servers may be configured manually or using DHCP.

A default gateway is optional.

All IP addresses are entered in dotted-decimal notation. Entries are checked for validity and consistency before changes are applied.

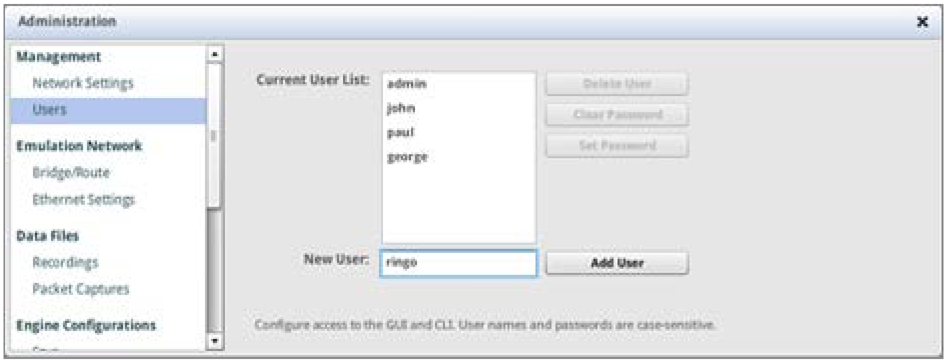
When the IP address is changed, connectivity to the device will be lost and must be reestablished using the new address.

Up to 3 DNS servers and up to 3 NTP servers may be configured. DNS or NTP servers configured manually will override any servers set automatically through DHCP.

> ⚠ If you cannot regain connectivity to the device after changing the network settings, use the CONSOLE interface to verify or change the network settings.

10.2 Users

Usernames and passwords are administered in the Users tab.



Current User List: admin
john
paul
george

New User: ringo

Configure access to the GUI and CLI. User names and passwords are case-sensitive.

Figure 46: User Administration Tab

Initially, the device has a single user, *admin*, with no password. Additional users can be added or deleted by *admin*. Passwords for each user can be set or cleared by the individual user or by *admin*.

Users other than *admin* are unprivileged, and can make configuration changes but cannot make system administrative changes.

Usernames and passwords created in either the GUI or through the CLI apply to access to both the GUI and CLI.

10.3 Bridge/Route

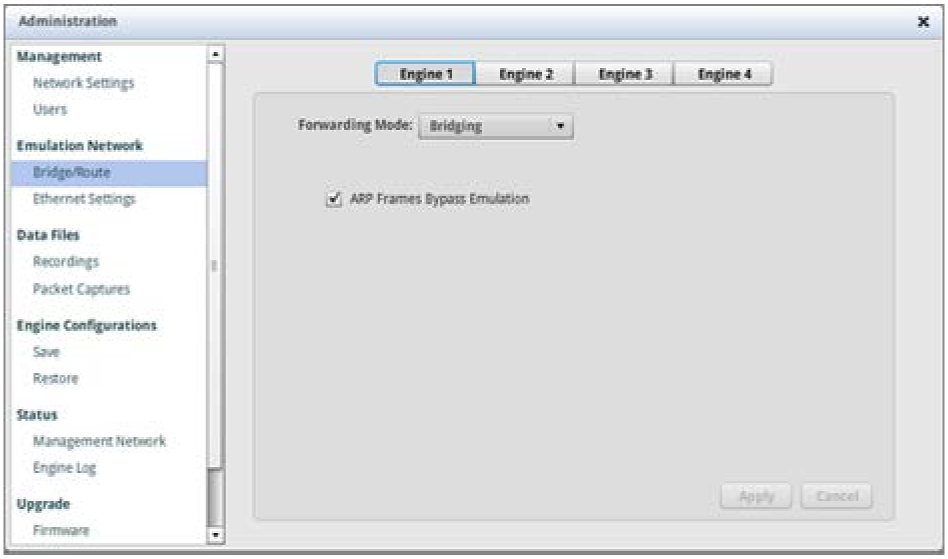
The Netropy emulator can be installed as either a bridge or router to forward frames between the two ports of each Emulation Engine. By default, each Engine is configured as a bridge, and this mode is recommended for simplicity unless the two ports need to be on separate subnets.

Use the Forwarding Mode drop-down selector on the Bridge/Route tab to choose between bridging and routing. This selection is made separately for each Emulation Engine.

Bridge/Route settings are saved with the Engine configuration and are updated when a saved Engine configuration is restored.

10.3.1 Bridging

In Bridging Mode, the Netropy Engine functions as a bridge between the Ethernet segments connected to the two Ethernet ports. In this mode, it can forward any Ethernet-based frame regardless of network layer protocol.



Forwarding Mode: Bridging

☑ ARP Frames Bypass Emulation

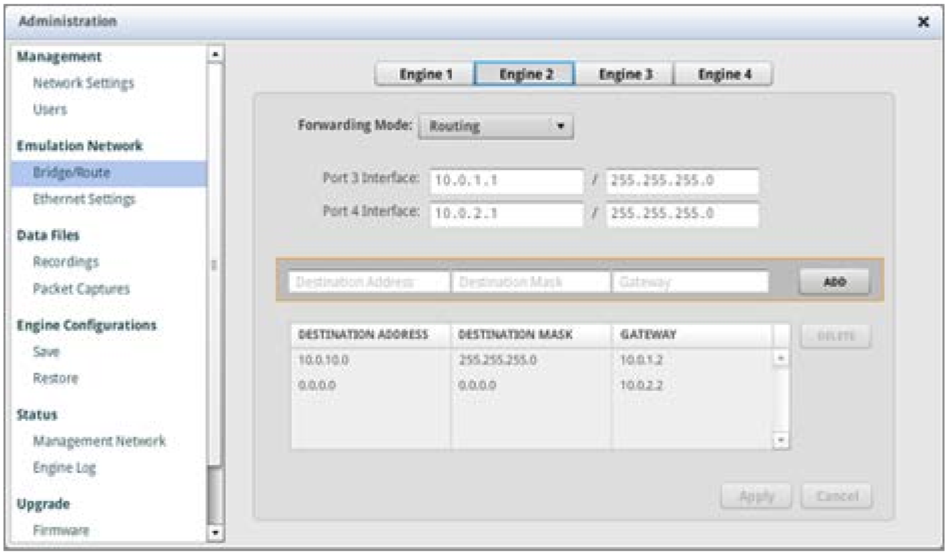
Figure 47: Bridging

By default, all frames are assumed to be part of the WAN traffic and are subjected to the configured emulation conditions. This includes ARP packets, which on a production network may be processed or filtered prior to traversal of the WAN. Check the *ARP Frames Bypass Emulation* box to have those packets forwarded directly between the two ports with no impairment regardless of the configuration of the Emulation Engine.

10.3.2 Routing

In Routing Mode, the Netropy Engine functions as a router between the Ethernet segments connected to the two ports of the Engine. Configure the IP address and netmask of the two interfaces. If necessary, add static routes to off-link destinations. All addresses are entered in dotted-decimal notation.

Routing Mode supports only the forwarding of IPv4 frames and does not support multicast forwarding.



Forwarding Mode: Routing

Port 3 Interface: 10.0.1.1 / 255.255.255.0

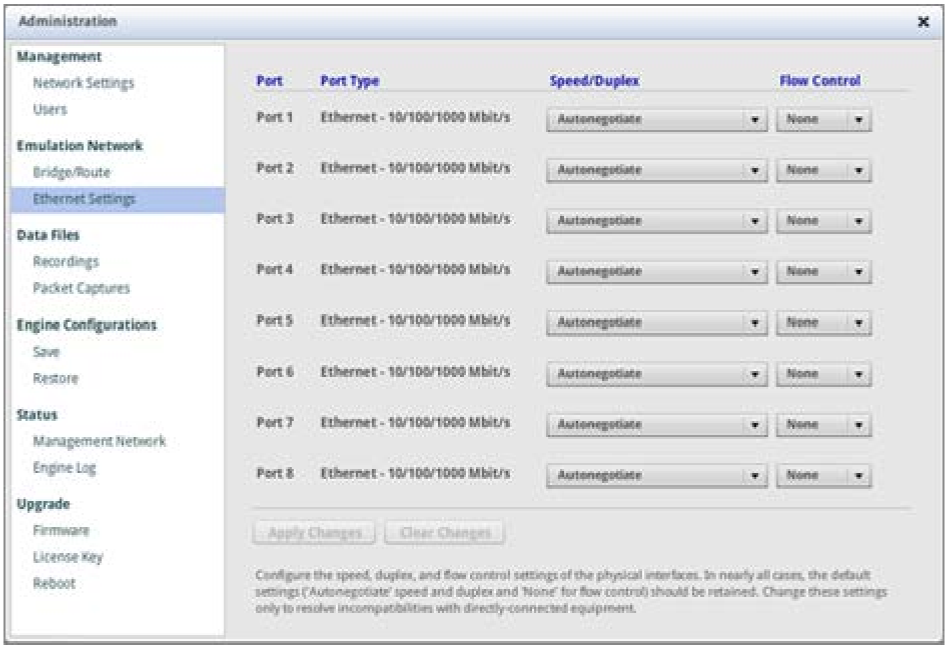
Port 4 Interface: 10.0.2.1 / 255.255.255.0

DESTINATION ADDRESS	DESTINATION MASK	GATEWAY
10.0.10.0	255.255.255.0	10.0.1.2
0.0.0.0	0.0.0.0	10.0.2.2

Figure 48: Routing

10.4 Ethernet Settings

The speed, duplex, and flow control settings for the Ethernet ports used for emulation are configured in the Ethernet Settings tab.



Port	Port Type	Speed/Duplex	Flow Control
Port 1	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 2	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 3	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 4	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 5	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 6	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 7	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None
Port 8	Ethernet - 10/100/1000 Mbit/s	Autonegotiate	None

Configure the speed, duplex, and flow control settings of the physical interfaces. In nearly all cases, the default settings ('Autonegotiate' speed and duplex and 'None' for flow control) should be retained. Change these settings only to resolve incompatibilities with directly-connected equipment.

Figure 49: Ethernet Settings Tab

By default, the Ethernet ports are set to auto-negotiate the proper speed and duplex settings, and flow control is turned off. On the 10/100/1000baseT emulation ports, auto-negotiation can be disabled and the ports forced to a particular speed and duplex setting via the drop-down menu. In nearly all cases, the default settings should be used and should only be changed to resolve incompatibilities with directly-connected equipment.

Auto-negotiation cannot be disabled on SFP and 10 Gbps ports, although flow control can be turned on if needed. Auto-negotiation cannot be disabled on the MGMT port.

Jumbo frames of up to 9 KB are supported on all emulation ports.

> ⚠ If the speed and duplex setting of an interface is selected manually, the device the port is connected to must also be forced to the same setting.

10.5 Recordings

Importing and deleting Recording files for automated playback of a time series of latency and loss conditions is managed through the Recordings tab. For more details on the use of recordings, see Section 8: Recordings.

10.6 Packet Captures

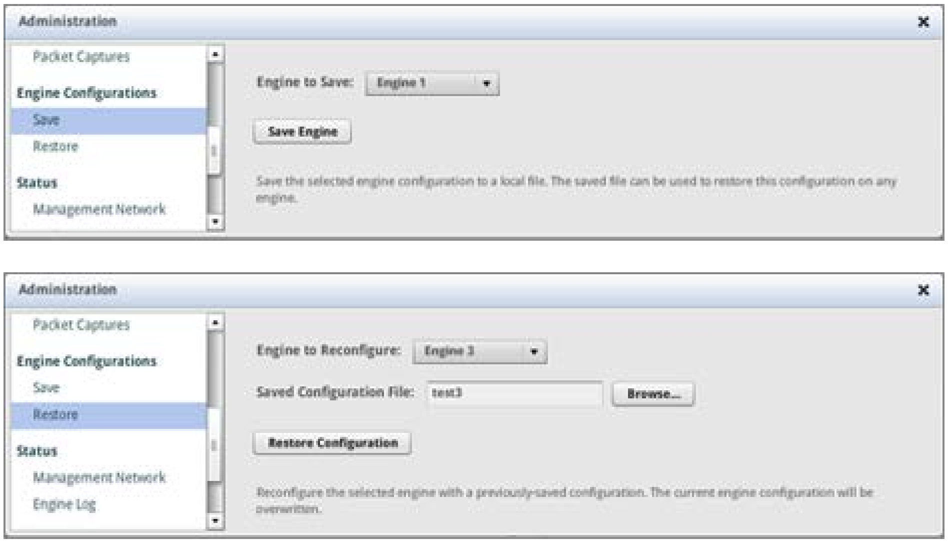
Importing and deleting PCAP packet capture files for generation of background traffic is managed through the Packet Captures tab. For more details on the use of packet capture files, see Section 6.2.2.2: Packet Replay.

10.7 Save and Restore Engine Configurations

The configuration of a selected Emulation Engine can be saved to a file on the management PC from the Save tab. The stored configuration file can then be loaded into any Emulation Engine from the Restore tab of the same Netropy unit or onto a different Netropy unit regardless of model. The restore operation overwrites the current configuration of the Engine.

Recording and PCAP files are included in the configuration file if they are used in any path in the Engine. This can cause configuration files to be very large.

The bridging or routing settings are saved with the Engine configuration and are updated when a saved Engine configuration is restored.



Engine to Save: Engine 1

Save the selected engine configuration to a local file. The saved file can be used to restore this configuration on any engine.

Engine to Reconfigure: Engine 3

Saved Configuration File: test3

Reconfigure the selected engine with a previously-saved configuration. The current engine configuration will be overwritten.

Figure 50: Save and Restore Tabs

10.8 Management Network Status

The Management Network status screen shows the current configuration for the IP address and netmask, default gateway, network domain, and DNS and NTP servers. Press the refresh button to update with the latest status.

10.9 Engine Log

A log file of error messages and warnings is shown on the Engine Log tab. A separate log is maintained for each Engine. Each line includes a sequence number and the time in GMT. Log messages will be generated at most once per second.

If there are any error conditions that could affect the validity of the test results, the LEDs on the Engine tab on the main configuration window remain red until the log message has been marked as read or the log cleared.

Error conditions reported in the log are:

`timing error exceeded <#>us`

The engine has detected that the error in emulation timing has exceeded the indicated number of microseconds.

`<#> frames lost`

The engine has been overload and was unable to process all received frames, with the indicated number of frames dropped.

`out of buffers - <#> events`

The engine ran out of buffer space to receive new frames from the network. The number of failed attempts to allocate buffer space is reported.

`automatic engine shutdown`

Emulation was aborted. The current engine configuration requires more resources than supported by the hardware.

`redundant power supply failure`

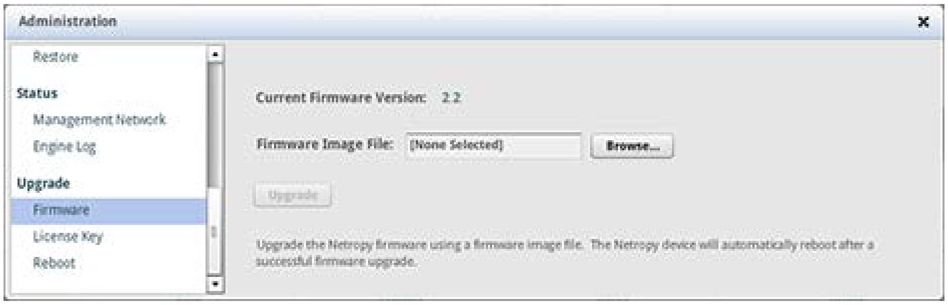
A power supply module has failed and requires replacement. The system is running on a secondary power supply. Applicable only to the Netropy 10G2 with a redundant power supply.

10.10 Firmware

The version of the Netropy firmware currently installed is displayed in the Firmware tab.

To upgrade the firmware, first download the new image to the management PC or a local file server from the support section of the Apposite Technologies website at: http://www.apposite-tech.com. Then use the *browse* button to select the file, and click *upgrade* to install.

The Netropy device will automatically reboot after a successful firmware upgrade.



Current Firmware Version: 2.2

Firmware Image File: [None Selected]

Upgrade the Netropy firmware using a firmware image file. The Netropy device will automatically reboot after a successful firmware upgrade.

Figure 51: Firmware Tab

☞ The same procedure can be used to restore an older version of firmware if necessary. However, when downgrading to an older release, emulation and administrative configuration may not be preserved.

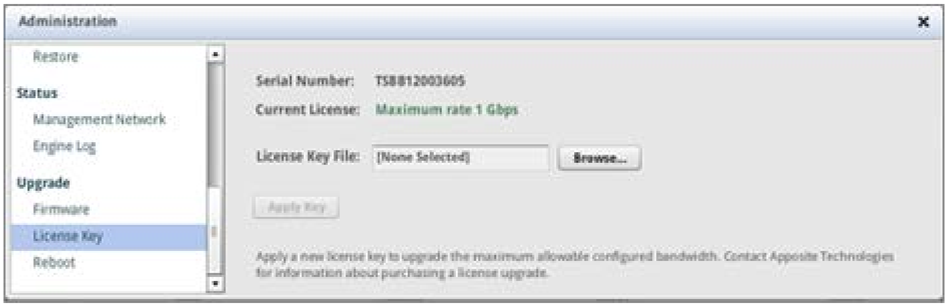
☞ A maintenance contract is required to access support resources on the Apposite website including firmware upgrade images.

10.11 License Key

The serial number and licensed speed of the unit are displayed in the License Key tab.

The license key controls the maximum bandwidth that can be configured for any path in either direction. To upgrade the license to a higher speed, contact Apposite Technologies or your local Apposite reseller.

To install a new license key, save the new license key file to the management PC or a local file server, then use the *browse* button to select the license key file and click *apply key* to install.



Serial Number: TS8812003605

Current License: Maximum rate 1 Gbps

License Key File: [None Selected]

Apply a new license key to upgrade the maximum allowable configured bandwidth. Contact Apposite Technologies for information about purchasing a license upgrade.

Figure 52: License Key Tab

10.12 Date and Time

System date and time can be set using Network Time Protocol (NTP) (Section 10.1), or using the *clock* command in the CLI (Section 11.3). The date and time are used only for the timestamp on log messages. The time displayed on the graphs and used for statistics download is based on the local time of the management device.

11 COMMAND LINE INTERFACE

The Netropy command line interface (CLI) can be accessed via the CONSOLE interface or through a Telnet or SSH connection.

The following management features are not available through the CLI and must be completed within the GUI:

- Addition or removal of paths
- Modification of packet classification rules

The following management features are only available through the CLI:

- ARP and PING commands
- Manually set system clock
- Reinitialize the unit to factory settings
- LDAP authentication
- Packet capture

To access the CLI, log into the device at the prompt as "`admin`" or other configured username.

The SSH and Telnet services can be enabled or disabled through the CLI using the `telnet` and `ssh` commands. By default, both are enabled. Multiple simultaneous sessions are allowed.

SSH can be used to execute a single command or to log in for an on-going session similar to Telnet.

11.1 CLI Help

The CLI includes several levels of help. The "`help`" command by itself displays a list of commands. "`help`" with a command name displays the syntax and options for the command.

When entering commands, the <Tab> key can be used to complete a partially entered command name. If there are multiple possible completions, pressing the <Tab> key again will display a list of options.

For most commands, typing "?" after a partially entered command provides context-specific help.

11.2 Navigation within the CLI

Engine Command Mode

All emulation configuration commands require an emulation engine to be selected. Use the top-level 'engine <#>' command to select an engine and enter engine command mode:

```
[admin@netropy]> engine 1
[admin@netropy/Engine 1]>
```

While in engine command mode, all engine-level commands are applied to the currently selected engine. Use the 'exit' command to exit engine configuration mode and return to the top-level commands, for instance to select a different engine.

```
[admin@netropy/Engine 1]> exit
[admin@netropy]>
```

Engine commands can also be executed without entering engine command mode by specifying the entire command, including engine number, from the top level.

Path Command Mode

Each emulation engine can be configured with up to 15 sets of emulation conditions called *paths*. Use the 'path <#>' command from engine command mode to select a path for configuration and enter path command mode.

```
[admin@netropy/Engine 1]> path 2
[admin@netropy/Engine 1/Path 2]>
```

While in path command mode, all path-level commands such as changes to emulation conditions are applied to the currently selected path. Use the 'exit' command to exit path configuration mode and return to engine command mode, for instance, to select a different path.

```
[admin@netropy/Engine 1/Path 2]> exit
[admin@netropy/Engine 1]>
```

Path commands can also be executed without entering path command mode by specifying the entire command, including the engine and path numbers, from the top level.

11.3 CLI Top Level Commands

Command	Syntax and Description
`arp`	`arp show` Displays a table of IP addresses and associated MAC addresses for the MGMT interface.
`capture`	`capture port <port> [raw|detail] [arp|ip <address>] [snaplen <len>] [filter <filter string>]` Displays frames received by and sent from the specified port until control-C is pressed. See Section 11.3.2 for a detailed description.

`clock`	`clock show`
	Displays the current system time and date.
	`clock set <hh>:<mm>:<ss> <YYYY>-<MM>-<DD>`
	Sets the time and date used for log messages. All fields are required. Clock settings are permanent and survive reboots and power cycles of the device.
	If an NTP server is configured, it will override the settings from this `clock` command.

`engine`	`engine <#> [emulation {on|off} | show | lock | unlock | backup | restore | statistics | log | autostart | path ... | router ...]`
	Enters engine command mode, or executes a command for the specified engine. See 11.4 for syntax of the engine subcommands.
	`engine list`
	Displays a list of available emulation engines.

`help`	`{help | ?} [<command>]` Displays a list of available commands or syntax of a specified command. A question mark after any command also displays the syntax for that command.

`http`	`http load <ssl-certificate-url>`
	Installs an SSL certificate. FTP, HTTP, and TFTP services are supported for upload. Uploaded certificate replaces the self-signed certificate supplied in the firmware.
	Ex: `http load ftp://192.168.0.100/certs/certificate.crt`
	`http {on | off}`
	Enables or disables unsecured access to the GUI via HTTP. HTTP service is on by default. Secured access to the GUI via HTTPS is always enabled.

`init`	`init config` Returns the configuration to factory default settings. Takes effect upon reboot unless the configuration is saved prior to reboot.
`logout`	`logout` Logout from the command line interface.

`mgmt`	`mgmt show`
	Displays the IP address and other management information.
	`mgmt show ldap`
	Displays the current LDAP configuration.
	`mgmt show ntp associations`
	Displays the synchronization state with the configured NTP servers.
	`mgmt set addr {dhcp | addr <addr> netmask <mask>}`
	Sets the IP address and netmask of the MGMT interface either manually or using DHCP. If DHCP is enabled, DHCP sets the default gateway.
	`mgmt set domain <domain>`
	Sets the network domain name of the device.
	`mgmt set gw <addr>`
	Sets a default gateway for the MGMT interface.
	`mgmt set hostname <name>`
	Sets the hostname of the device.
	`mgmt set ldap ...`
	See Section 11.3.1 for LDAP configuration syntax.
	`mgmt set nameserver <addr> [<addr2> [<addr3>]]`
	Sets up to three DNS servers for the device. This command overrides any nameservers set through DHCP and any DNS servers previously configured.
	`mgmt set ntp server <server> [<server2> [<server3>]]`
	Sets up to three network time protocol servers for the device. This command overrides any NTP servers set through DHCP and any NTP servers previously configured.
	`mgmt clear ldap`
	Turns off LDAP authentication and clears the LDAP configuration.
	`mgmt clear nameserver`
	Clears all manually configured DNS servers. Does not change any DNS servers set through DHCP.
	`mgmt clear ntp server`
	Clears all manually configured NTP servers. Does not change any NTP servers set through DHCP.

`packet-captures`	`packetcaptures list`
	Displays a list of imported PCAP files, their ID numbers, and size in bytes.
	`packetcaptures add <packet-capture-url>`
	Imports a PCAP packet capture file. FTP, HTTP, and TFTP services are supported.
	Ex: `packetcaptures add http://192.168.0.100/captures/voipstream.pcap`
	`packetcaptures delete <id>`
	Deletes the specified packet capture file.

`password`	`password clear [<user-id>]`
	Clears the password for the specified user. If no user is specified, command applies to the user executing this command. Only *admin* can specify a user other than himself.
	`password set [<user-id>]`
	Prompts for a new password for the specified user. If no user is specified, command applies to the user executing this command. Only *admin* can specify a user other than himself.

`ping`	`ping <ip-address> [<size>]` Pings from the device to the IP `address` with the specified sized packets using the MGMT interface. Use CTRL-C to stop.
`reboot`	`reboot` Reboots the device. Returns user to the login prompt after reboot.

`recordings`	`recordings list`
	Displays a list of imported recording files and their ID numbers.
	`recordings add <recording-url>`
	Imports a recording file of delay, loss, and bandwidth conditions. FTP, HTTP, and TFTP services are supported.
	Ex: `recordings add http://192.168.0.100/recordings/wireless.txt`
	`recordings delete <id>`
	Deletes the specified recording file.

`serialnumber`	`serialnumber` Displays the serial number of the unit.
`ssh`	`ssh [enable | disable | fingerprint]` Enables or disables SSH service, or displays the fingerprint of the SSH server's public keys. If service is disabled, any sessions in progress are terminated. With no argument, '`ssh`' reports current status of the service.
`telnet`	`telnet [enable | disable]` Enables or disables telnet service. If Telnet is disabled, any sessions in progress are terminated. With no argument, the command reports current status of Telnet service.
`upgrade`	`upgrade <upgrade-image-url>` Upgrades the Netropy firmware. FTP, HTTP, and TFTP services are supported. Ex: `upgrade ftp://server/netropy-image`
`user`	`user [add <user-id> | delete <user-id> | list]` Adds, deletes, or lists usernames.
`version`	`version` Displays the operating firmware version.

11.3.1 LDAP Management Commands

CLI commands for LDAP authentication are listed in the table below:

`show`	`mgmt show ldap` Displays the current LDAP configuration.

`set`	`mgmt set ldap server <server> [port <#>]`
	Identifies the LDAP server by IP address or host name. Optionally specifies a non-standard port to connect to. The default port is 389.
	Ex.: `mgmt set ldap server ldapserver.example.com`
	`mgmt set ldap basedn <search-base-DN>`
	Identifies the Distinguished Name of the search base in the remote LDAP database. If there are embedded spaces in the base DN string, the string must be enclosed in quotation marks.
	Ex.: `mgmt set ldap basedn dc=example,dc=com`
	`mgmt set ldap filter attribute <string> [<LDAP-search-string>]`
	Specifies the attribute that contains the username and optionally an additional LDAP search string. The LDAP search string must be compatible with the formal definition found in RFC 4515. If there are embedded spaces in the search string, the string must be enclosed in quotation marks.
	Ex.: `mgmt set ldap filter attribute uid (&(gidNumber=20)(class=Expert))`
	The resulting search string will be `(&(uid=user)(&(gidNumber=20)(class=Expert)))` where "user" is replaced by the login name.
	`mgmt set ldap security {disable | enable}`
	Enable or disable Transport Level Security. TLS is enabled by default.
	`mgmt set ldap bind dn <bind-DN> [password <password>]`
	Specifies a Distinguished Name and password with which to bind to the LDAP server before performing a search operation. If not configured, an anonymous bind will be used.
	Ex. `mgmt set ldap bind dn cn=user,dc=example,dc=com`
	`mgmt set ldap {on | off}`
	Turns LDAP authentication on or off.

`clear`	`mgmt clear ldap` Turns off LDAP authentication and clears the LDAP configuration.

11.3.2 Capture Command

The ‘capture’ command displays packets received or transmitted through the emulation ports.

This feature is intended to be used for examining and troubleshooting network connectivity. At high packet rates, the capture command will not capture all packets and may cause packet loss or timing errors for forwarded traffic.

This feature is only available through the CLI.

The capture command is unrelated to the packetcapture feature used to import and replay PCAP files as emulated background traffic.

Capture Command Syntax:

```
capture port <port> [raw|detail] [arp|ip <address>] [snaplen <len>]
[filter <tcpdump filter string>]
```

Displays frames received by and sent from the specified port until control-C is pressed. Only one running capture can be active per port. Options are described below:

- None: a timestamp and summary description are displayed for each frame.
- `detail`: the Ethernet header and additional details about the contents of the frame are displayed.
- `raw`: binary PCAP data is output. Using this ‘raw’ option, it is possible to save a packet capture file on a PC by running the capture command via ssh. The resulting file can then be read by a packet analyzer such as Wireshark. For example, a Linux command could be:

  ```
  ssh admin@netropy capture port 1 raw > port_1_packets.pcap
  ```

  It is also possible to display packets in real-time in Wireshark with the command (on Linux):

  ```
  ssh admin@netropy capture port 1 raw | wireshark -k -i -
  ```

- `arp|ip <address>`: adds a high speed pre-filter for lossless capture of a subset of packets matching a specific IP address or all ARP packets from a high packet rate stream.
- `snaplen`: limits frame capture to the first 'len' bytes of the frame.
- `filter`: controls which frames will be captured. Tcpdump-style filter options are accepted. For example, "`filter ip host 10.0.0.1`" captures all frames with IP source or destination address of 10.0.0.1.

11.4 CLI Engine Mode Commands

All emulation configuration commands require an emulation engine to be selected. Use the top-level 'engine <#>' command to select an engine and enter engine command mode.

While in engine command mode, all engine-level commands are applied to the currently selected engine. Use the 'exit' command to exit engine configuration mode and return to the top-level commands, for instance, to select a different engine.

On Netropy models with a single Emulation Engine, the engine number is 1. On models with multiple Emulation Engines, a list of available engine numbers is shown with the top level '`engine list`' command.

Command	**Syntax and Description**
`autostart`	`[engine <#>] autostart {on|off}` Sets whether emulation is on or off for each engine when the system boots up. Autostart is off by default.
`backup`	`[engine <#>] backup` Displays the XML configuration of the selected engine for use in saving the engine configuration. Either copy and paste the terminal output or run a command that stores the output to a file. Ex: `ssh admin@netropy engine 1 backup > netropy-engine-1.xml`
`emulation`	`[engine <#>] emulation {on|off}` Turns emulation on or off for the specified engine.
`exit`	`exit` Exits engine configuration mode and returns to the top-level commands.
`lock`	`[engine <#>] lock` Locks the engine configuration from changes by any other user except admin.

`log`	`[engine <#>] log read [unread | all]`
	Displays engine log messages. By default only previously unread log messages are displayed.
	Log messages are displayed in the format: `<sequence #>||<time>||<message>`
	Ex: `1||Nov 19 05:20:09||timing error exceeded 20us`
	`[engine <#>] log clear`
	Clears all messages for this engine from the log.

`path`	`[engine <#>] path <#> [show | set...]` Enters path command mode, or executes a command for the specified path. See Section 11.5 for path command mode syntax.
`restore`	`[engine <#>] restore <saved-engine-url>` Loads the specified XML engine configuration file and restores the configuration to the selected engine. FTP, HTTP, and TFTP services are supported.

`router`	`[engine <#>] router {on|off}`
	Turns routing on or off for the engine. If routing is off, the engine functions as a transparent bridge and forwards all traffic between the two interfaces of the engine. Routing is off by default.
	`[engine <#>] router show`
	Displays the current routing status and the ARP table for the engine.
	`[engine <#>] router interface list`
	Displays the interface name, MAC address, IP address, and netmask for both ports of the engine.
	`[engine <#>] router interface set <name> addr <addr> netmask <mask>`
	Sets the IP address and netmask for the named interface. Interface names are PORT_<#> and shown using the `router interface list` command.
	`[engine <#>] router route add <addr>[/<prefix-length>] gw <gw-addr>`
	Adds a static route to the specified address range via the specified next-hop gateway. For a default route, use a prefix length of 0. Each engine may be configured with up to 20 static routes. There can only be one gateway for each unique destination.
	Ex: `[admin@netropy]> engine 1 router route add 10.0.1.0/24 gw 10.0.0.1`
	`[engine <#>] router route list`
	Displays the list of static routes for the engine.
	`[engine <#>] router route delete <addr>[/<prefix-length>}`
	Deletes the specified static route.
	`[engine <#>] router route flush`
	Clears all static routes.

`show`	`[engine <#>] show` Displays the emulation on/off state, port numbers and connectivity, configured path numbers and names, and whether the engine is locked.

`statistics`	`[engine <#>] statistics [total | interval | cumulative] [full]`
	Reports statistics for all paths in the selected engine. Statistics are displayed as a single line of current totals, or one line for each one second sample using either cumulative or non-cumulative interval counters.
	By default, only the overall rate, frames, bytes, and drops are displayed for each direction of each path. To display all statistics, use the 'full' option.
	For more flexibility in selecting specific statistics and time ranges, use the statistics download feature in the GUI.
	`[engine <#>] statistics reset`
	Resets all statistics for the selected engine.

`unlock`	`[engine <#>] unlock` Unlocks the specified engine.

11.5 CLI Path Mode Commands

Command	Syntax and Description
`show`	`[engine <#> path <#>] show` Displays the current configuration of the specified path.
`set`	`[engine <#> path <#>] set...` Configures emulation properties for the specified path. See Section 11.5.1 for command syntax to set emulation properties.

11.5.1 CLI Set Emulation Parameters

Commands to set the emulation parameters are listed below and entered in the form:

```
[engine <#> path <#>] set...
```

The syntax for each command is listed in the table below.

- Emulation parameters that are percentages may be entered as either a number between 0 and 100 with a % sign (i.e. 27.1%) or as a number between 0 and 1 (i.e. "0.271" or ".271").
- Attributes of the WAN portion of the path (delay, loss, duplication, reordering) must specify a direction from one port to another, i.e. "port 1 to port 2".
- Attributes of the interface between LAN and WAN (bandwidth, background utilization, queuing, and frame overhead) must specify the port number and whether the condition is outbound or inbound between WAN and LAN. By default, inbound rate control is disabled, and inbound attributes are not used.

Command	Syntax and Description

`bg`	`set bg none port <#> {out|in}`
	Turns off background traffic generation for the specified port and direction.
	`set bg random <percent> burst <bytes> port <#> {out|in}`
	Creates random background traffic with the specified link utilization rate and burst size for the specified port and direction.
	`set bg replay pcap {id <id> [count <#>] [scale <factor>] [priority <0-7>]}... port <#> {out|in}`
	Replays imported packet capture files as background traffic for the specified port and direction. Use ‘`packetcaptures list`’ from the top command level to view a list of available PCAP files and their ID numbers. Multiple PCAP files can be run simultaneously
	Each file optionally be can be modified with a count to replicate multiple copies of the same stream, a scaling factor to modify the playback speed, and a priority level to use for priority and round robin queuing. See Section 6.2.2.2 for details on PCAP replay parameters.

`bw`	`set bw fixed <value> [bps|Kbps|Mbps|Gbps] port <#> {out|in}`
	Sets a fixed value for the outbound or inbound bandwidth on the specified port. The entered value is in bps if no units are specified.
	`set bw recorded port <#> {out|in}`
	Uses the bandwidth values from the recording file previously selected with the `playback` command.

`corruption`	`set corruption none port <#> to port <#>`
	Turns off data corruption in the specified direction.
	`set corruption ber <rate> port <#> to port <#>`
	Sets data corruption as a bit error rate in exponential or floating point notation.

`delay`	`set delay none port <#> to port <#>`
	Disables latency emulation in the specified direction.
	`set delay constant <ms> port <#> to port <#>`
	Sets latency emulation to a constant value in milliseconds.
	`set delay uniform <min> <max> [reordering {enabled|disabled}] port <#> to port <#>`
	Sets latency emulation to a uniform distribution between the specified minimum and maximum values in milliseconds. Enables or disables reordering of packets with different delays (default is no reordering).
	`set delay normal <mean> <stddev> [reordering {enabled|disabled}] port <#> to port <#>`
	Sets latency emulation to a normal distribution with mean and standard deviation specified in milliseconds. Enables or disables reordering of packets with different delays (default is no reordering).
	`set delay exponential <min> <max> [reordering {enabled|disabled}] port <#> to port <#>`
	Sets latency emulation to an exponential distribution with the specified minimum and mean values in milliseconds. Enables or disables reordering of packets with different delays (default is no reordering).
	`set delay accumulate-and-burst <count> [extra-delay <ms>] [timeout <ms>] port <#> to port <#>`
	Packets are held until either the packet count or an optional timeout is reached, then are optionally delayed by an additional 'extra delay,' and transmitted in a burst. If a timeout is not specified, the default 10,000 ms will be used.
	`set delay recorded port <#> to port <#>`
	Uses delay values from the recording file previously selected with the `playback` command.

`duplication`	`set duplication none port <#> to port <#>`
	Turns off packet duplication in the specified direction.
	`set duplication random <percent> port <#> to port <#>`
	Specifies the probability for random packet duplication set in increments of 0.0001%.

`inbound-rate-control`	`set inbound-rate-control {enable|disable} port <#>` Turns on or off controls on bandwidth, background utilization, queue management, and framing overhead for traffic arriving in-bound from the WAN to the specified port number. Turned off by default.

loss	`set loss none port <#> to port <#>`
	Disables packet loss emulation in the specified direction.
	`set loss random <percent> port <#> to port <#>`
	Sets loss emulation as a random packet loss rate set in increments of 0.0001%.
	`set loss burst <percent> min <min-burst-packets> max <max-burst-packets> port <#> to port <#>`
	Sets burst packet loss emulation as a burst probability and minimum and maximum burst size in packets. The percentage can be set in increments of 0.0001%.
	`set loss periodic <period> [burst <count>] port <#> to port <#>`
	Sets periodic loss emulation as a loss period in packets. An optional burst count specifies the number of packets to be lost in a row in each cycle, and is set to one packet by default.
	`set loss ber <rate (1e-18 – 9.999999e-1)> port <#> to port <#>`
	Sets packet loss emulation as a bit error rate in exponential or floating point.
	Ex. `set loss ber 1.0e-8 port 1 to port 2`
	`set loss gilbert-elliott good-state loss <pct> change <pct> bad-state loss <pct> change <pct> port <#> to port <#>`
	Sets packet loss separately for a good state and bad state and the probability of transitioning between the two states.
	`set loss recorded port <#> to port <#>`
	Uses packet loss rates from the recording file previously selected with the `playback` command.

mtu	`set mtu-limit fixed <length> [send-icmp {enabled|disabled}] [fragmentation {standard|never|ignore-df}] port <#> {out|in}`
	Limits the MTU to the specified length in bytes. Sending of ICMP Destination Unreachable Fragmentation Needed messages can be enabled or disabled. Select '`fragmentation standard`' to have fragmentation follow the Don't Fragment (DF) bit setting, '`fragmentation never`' to drop all packets larger than the MTU length, or '`fragmentation ignore-df`' to fragment regardless of the DF setting. If unspecified, `send-icmp` is enabled and `fragmentation` set to '`standard.`'
	`set mtu-limit none port <#> {out|in}`
	Disables MTU limitations on the specified port.

name	`set name <path-name>` Sets the name of the path.
overhead	`set overhead fixed <bytes> port <#> {out|in}` Sets the framing overhead in bytes for each packet for the specified port and direction.

`playback`	`set playback none port <#> to port <#>`
	Turns off use of recordings in the specified direction.
	`set playback recording <id> port <#> to port <#>`
	Selects the recoding to use for delay, loss, and/or bandwidth conditions in the specified direction. Use the `recordings` command to display a list of available recording IDs. `playback` can only be run while emulation is off. After the recording has been selected, use the `set delay`, `set loss`, and `set bandwidth` commands to use the recorded values of delay and loss.

`queue`	`set queue default port <#> {out|in}`
	Returns the maximum queue depth setting to the default value for specified port and direction.
	`set queue droptail <value> {packets|KB} port <#> {out|in}`
	Sets the queue management algorithm to Drop Tail with the maximum queue depth specified in packets or kilobytes.
	`set queue red depth <value> min <min> max <max> {packets|KB} port <#> {out|in}`
	Sets the queue management algorithm to RED. Specifies the maximum queue depth and RED minimum and maximum thresholds in either packets or kilobytes.

`queuing-strategy`	`set queuing-strategy fifo port <#> {out|in}`
	Returns the queuing strategy to the default FIFO, with no prioritization.
	`set queuing-strategy priority {ip-precedence | vlan-pcp} port <#> {out|in}`
	Sets the queuing strategy to prioritize packets based on either IP precedence or VLAN PCP bits.
	`set queuing-strategy round-robin {ip-precedence|vlan-pcp} port<#> {out|in}`
	Sets the queuing strategy to round-robin packets between queues, with packets assigned to different queues based on either IP Precedence or VLAN PCP bits.

`reordering`	`set reordering none port <#> to port <#>`
	Turns off packet reordering for the configured engine/path in the specified direction.
	`set reordering random <percent> min <min-offset-pkts> max <max-offset-pkts> [timeout <ms>] port <#> to port <#>`
	Specifies the probability for random packet reordering and the minimum and maximum offset for reordered packets. The percentage can be set in increments of 0.0001%. An optional timeout value specifies the maximum amount of time to wait for the offset packets to arrive. If a timeout value is not specified, the default of 10,000 ms will be used.

12 Security

12.1 Users and Passwords

Initially, the Netropy system has a single configured user, *admin*, with no password. Additional users can be added or deleted by the *admin* user through the Administration window of the GUI or through the CLI. Passwords for each user can be set or cleared by the individual user or by *admin*. Usernames and passwords created in either the GUI or through the CLI apply to access to both the GUI and CLI. LDAP server can also be used for user authentication.

12.2 Engine Locking

Users can lock individual Emulation Engines to prevent any changes made to the configuration by other users. The user that locked the engine can continue changing the configuration of a locked engine, as can the *admin* user. Locked engines can only be unlocked by the user that locked the engine or by the *admin* user.

Locking is specific to each individual engine. Different users can lock different engines, or a single user can lock multiple engines.

12.3 Recovering from a Lost Admin Password

If the *admin* password has been lost, boot to the recovery firmware to gain access to the device and reset the configuration to factory defaults:

1. Connect to the serial console port.
2. Power cycle the unit. Type “`recovery`” at the boot prompt to load the recovery image.

   ```
   boot: recovery
   ```

3. At the prompt, log in as “admin”.

   ```
   netropy login: admin
   ```

4. Reset the configuration.

   ```
   [admin@netropy]> init config
   ```

5. Reboot or power cycle the unit and return to the regular operating firmware with no configuration. The management interface will also be reset to the default of 10.0.0.10.

12.4 SSL

The Netropy GUI is accessible via HTTP or HTTPS. HTTPS allows administration of the GUI using SSL security. Netropy includes a non-unique, self-signed certificate. Use of this self-signed certificate may generate an error in the browser that the signing certificate authority is unknown and not trusted. Either ignore this error or install your own certificate.

To install a new certificate, use the “http” command from the CLI:

```
http load <url>
```

For example:

```
netropy> http load http://192.168.0.100/certs/certificate.crt
```

By default, the Netropy GUI is accessible via unsecured HTTP. However, HTTP service can be disabled using the “http off” command from the CLI. HTTPS service is always enabled.

12.5 SSH

The Netropy CLI is accessible over the network via SSH. To verify the identity of the Netropy SSH server, use the “`ssh fingerprint`” command to display the fingerprints of the SSH server's public keys.

12.6 LDAP

An LDAP server can be used for user authentication. When LDAP authentication is enabled, it is used in addition to local authentication for GUI and CLI access.

LDAP can only be configured through the command line interface. See Section 11.3.1 for LDAP command syntax.

To authenticate a user via LDAP, the following steps are performed:

1. A connection to the LDAP server is initiated. If LDAP security is enabled, a TLS session is negotiated.

2. An initial bind operation is performed on the connection. If a 'bind DN' has been configured, then the configured 'bind DN' and password are used for the bind. Otherwise an anonymous bind is attempted.

3. A search is performed to find the database entry that corresponds to the user's username. The search parameters consist of a configurable 'base DN' and a search filter. The 'base DN' specifies the root of the subtree that will be searched. The default search filter requires an exact match between the username and the 'uid' attribute. An alternate attribute for this

comparison can be configured. For a more specific search, a full LDAP search string can be ANDed to this filter.

4. If a matching entry is returned by the server, then a new bind is attempted for authentication. This bind uses the DN found in the returned entry and the password supplied by the user. The "Simple" authentication method is requested.

5. If the bind is successful, then authentication is successful.

Notes:

Only one matching entry will be returned by the LDAP search even if there are multiple database entries that match the search filter.

For locally-defined users, the local authentication is always attempted before LDAP authentication.

Only the user *admin* has administrative privileges.

13 Apposite Support

13.1 Registration

For access to firmware upgrades, documentation, and other support materials, register your unit on-line at: http://www.apposite-tech.com/register.html.

Registered users will receive email notification whenever new firmware images are released.

13.2 Customer Support

If you experience any problem with the Netropy hardware, consult the *Hardware Guide* for your model. If you have any questions about the firmware not answered in this *User's Guide*, please check the Apposite Technologies website at http://www.apposite-tech.com for updated firmware and documentation. If your question is not answered, please contact Apposite Support.

Purchase of the Netropy products comes with one year of support and maintenance, including all upgrades to the firmware. Extended maintenance packages are available from Apposite or your Netropy reseller.

If you believe the firmware is not functioning properly, please upgrade to the latest firmware release. If the problem persists, please contact Apposite Support at:

support@apposite-tech.com
1.310.477.9955 ext. 2

When contacting Apposite Support, please include the following information:

- Netropy model
- Serial number
- Your e-mail address and phone number
- Installed firmware version
- A detailed description of the problem

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LightTPD

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