# WANem 1.1

# Wide Area Network Emulator

# Performance Engineering Research Centre

13th June 2007

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## Revision History

| Date | Document Version | Tool Version | Description | Author |
|---|---|---|---|---|
| 27-Apr-2007 | 1.1 | 1.1 | Everything about TCS WANem | M K Nambiar |
| 03-May-2007 | 1.2 | 1.1 | Some updates on setup and troubleshooting and corrections. | M.K.Nambiar |
| 22-May-2007 | 1.3 | 1.1 | Updates with bug fixes on DHCP and introduction of Basic mode in WANem | M.K.Nambiar |
| 13-Jun-2007 | 1.4 | 1.1 | TCS WANALYSER | H.K.Kalita |

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# 1 Introduction

## 1.1 Purpose

### Need for wide area network (WAN) emulation[1]

Applications rolled out by TCS developers face a lot of performance issues when deployed in production. High response times are experienced by the end users of these applications. Often the reason for such poor performance has been attributed to the network.

Hence it is important for the developers to know the behaviour of their applications on various types of networks users will access the application from. Access to such networks is restricted to a developer who tests his application over a local network. A local network often has more than the required bandwidth required by an application. Hence a device, which will emulate various network behaviours is required, something which will help developers to better understand the behaviour of their application on various networks.

In response to this need, TCS Innovations Lab - Performance Engineering Research Center (PERC) has released WANem which can emulate real networks in a development or test environment.

## 1.2 General Questions regarding Need for WANem

**1. What is WANem? Why should I use it in my project?**

**Ans**: When you develop a system that is accessed across the internet[2] or a remote network, how often do you test it for performance using the internet?

When you test within the comfort of your development environment which is contained within the LAN everything seems to work in a jiffy – do you have any idea what kind of response times the users of your applications are experiencing?

You may say what is the point – First you will say that the application is not rolled out yet so we cannot test it over the internet. Only once it is tested will it go to the internet. But how can you roll out an application unless you test its performance over the internet. Sound's like a chicken & egg problem – right! That is one problem.

Even if you have access how can you repeat the tests and expect to measure the same results. The internet is a very unstable network. Anything can happen at any time and you don't really know what's going on.

Well, WANem is a tool which brings the internet into your development/test/lab environment. It emulates internet like conditions within your control, so that you can check if your application performance and availability is internet ready.

**2. So you say that WANem can bring the internet to my development environment and that too in my control. Please elaborate?**

**Ans**: What does the internet do to your packets? Well, to list a few
    a. It takes time to deliver the packets to the other end

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[1] The terms WAN emulator and network emulator have been used interchangeably in this document.
[2] Internet is used a metaphor. More formally, it can be understood as any wide area network between to communicating hosts.

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b. Sometimes it drops packets
c. It gives you only so much bandwidth.
d. It gets disconnect every now and then
And more …..

All these effects tend to increase overall response times and decrease application throughput. So essentially you want something that will emulate such behavior in a controlled manner with your development or test environment. This is exactly what WANem lets you do. For more details on the network characteristics please refer to chapter 4.

## 1.3  What is TCS WANALYSER?

TCS WANALYSER v1.0 is an indigenous product of TCS Innovation Lab – Performance Engineering, Mumbai. It is designed for calibrating Wide Area Network Characteristics. This is a very simple to use tool which can measure available bandwidth, latency, loss and jitter of a wide area network in a few seconds, given the IP Address of a remote host as input. Measuring the characteristics help in giving realistic input to the WANem.

TCS WANALYSER is distributed along with WANem.

### Document Overview

This document explains all about WANem. The next chapter lists out scenarios in which WANem will be useful. Then it presents the setup and use of WANem. Chapter 4 talks about various network characteristics supported by WANem. It is followed by WANem feature listing and a then some frequently asked questions and troubleshooting tips. The last chapter answers frequently asked questions.

## 1.4  Glossary of Terms

| TERM/ACRONYM | DEFINITION |
|---|---|
| ADSL | Asynchronous Digital Subscriber Line |
| CPU | Central Processing Unit |
| GUI | Graphical User Interface |
| IP | Internet Protocol |
| LAN | Local Area Network |
| NIC | Network Interface Card |
| QOS | Quality of service |
| RAM | Random Access Memory |
| RTT | Round Trip Time |
| TCS | Tata Consultancy Services Ltd |
| WAN | Wide Area Network |

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# 2 WANem Usage Scenarios

This section lists the scenarios in which WANem can be useful, especially for TCS.

## 2.1 Developer Unit Testing mode
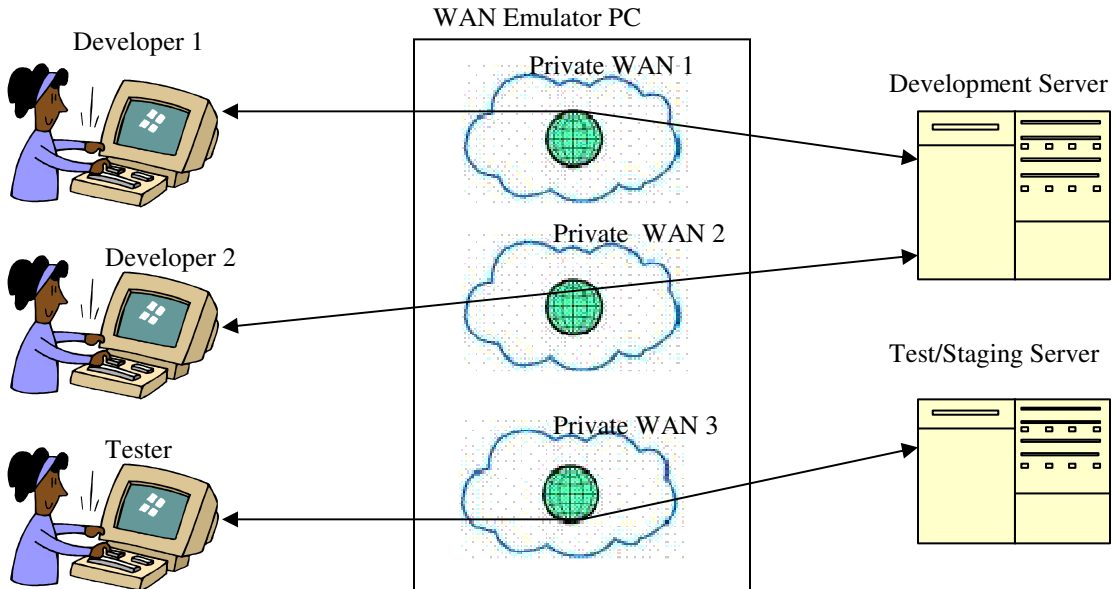


**Figure 1 – Unit Testing Mode**

In this model the WAN emulator should give each user his own private network, with its own set of network characteristics. This is accomplished by using separate rule sets provided by WANem. Each rule set defines a set of network characteristics (a private WAN) In other words the WAN emulator will allocate a certain portion of its resources for a developer. One developer's network will not affect others. Each developer can use different rule sets for testing the performance of a single user.

## 2.2 Performance Testing with Server Side ISP (WAN) link emulation

WAN Emulator PC

Server Side WAN

Test/Staging Server



Virtual users

**Figure 2 – Performance Testing Server side ISP emulation**

Any front ending application server accessed by users across the internet will have its own internet WAN link provided by an ISP. This mode will be useful for application performance testing where all users or a group of users will be accessing the application via the server side WAN.

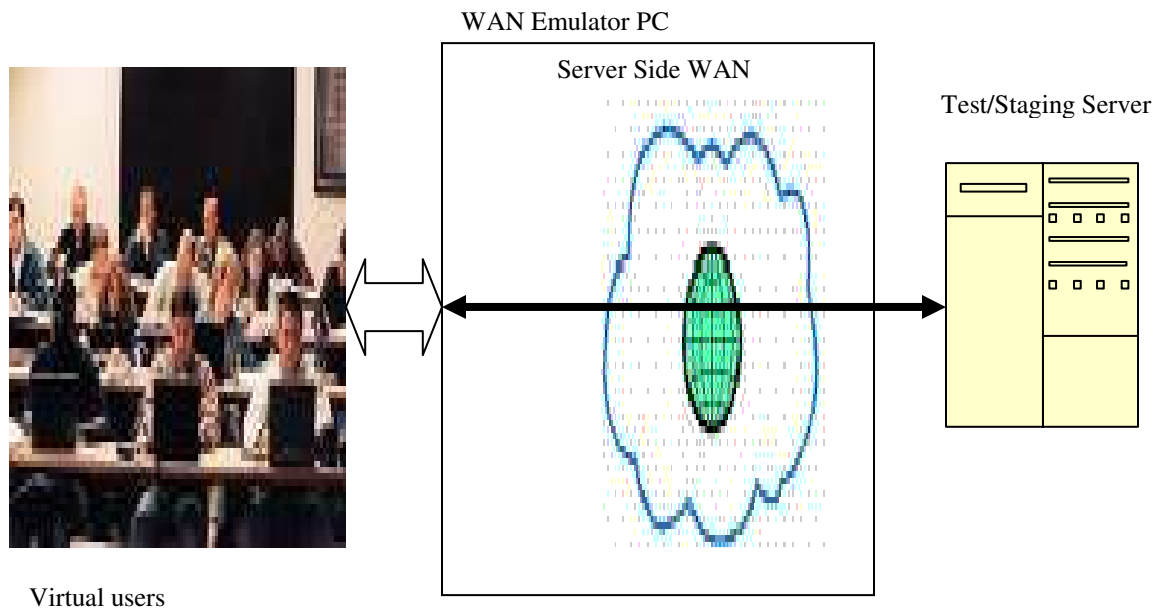**TATA** CONSULTANCY SERVICES

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## 2.3   Performance Testing with users at multiple locations
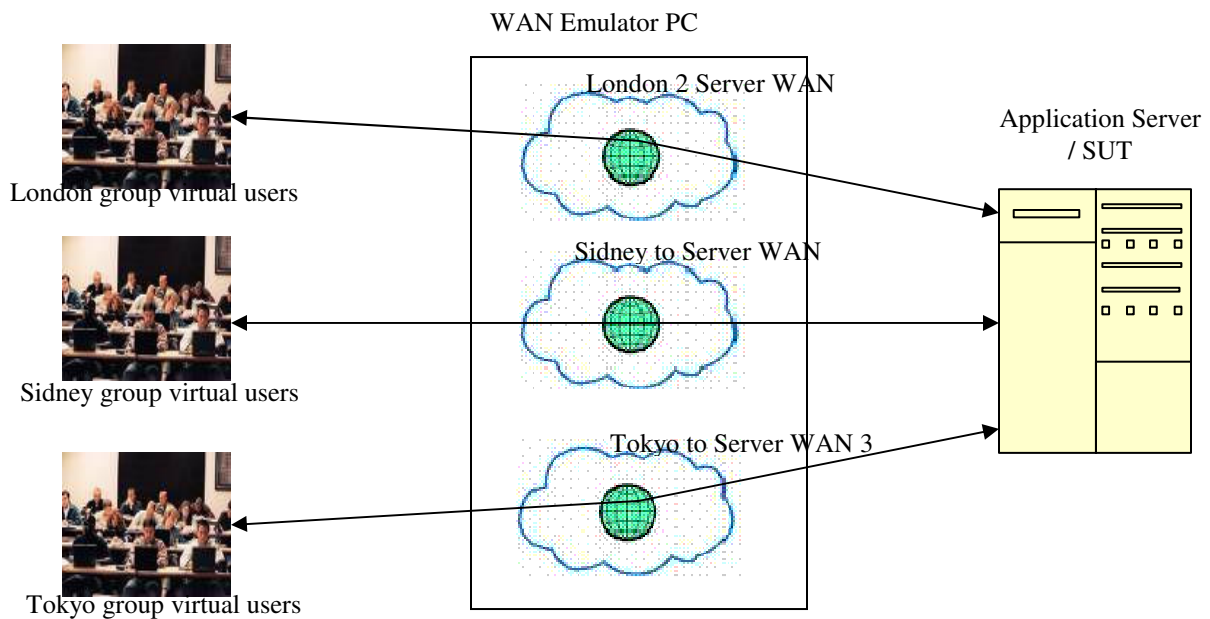


**Figure 3 – Performance Testing with users at multiple locations**

Many centralized enterprise applications will be accessed from remote offices. Each office will have its own network connectivity to the server. And each such network will have it's own network characteristics. WANem rule sets can used to define the network characteristics of various locations. So the results obtained with WANem included in performance tests will also include the response time perception of each group of users.

Applications supported by the WANem will include but not limited to
   1. Web applications,
   2. Video Streaming
   3. Interactive applications – telnet like application

In fact WANem will support any application that uses IP for communication.

# 3 Setting up WANem

WANem is distributed in the form of a bootable CD with Linux Knoppix O/S. This CD comes with WANem pre-installed. No there are no installation steps. When an i386 architecture based PC is booted with the PC WANem is ready for use.

## 3.1 How to start WANem

The distribution is in the form of a bootable CD. No installation is required. Just insert the CD into any i386 PC/Server and reboot using the CD. The PC will boot up in the Knoppix Linux OS. We will call this the WANem PC. After the PC boots up, it automatically starts the IP address configuration screen

Following are the general steps to be followed after WANem boots up
1    You get a Knoppix screen with a prompt in the bottom left called "boot:"  Just press "Enter"
2    After Knoppix boots up a question is prompted if you want to configure all the network interfaces of the PC using dhcp. If the PC is connected to a dhcp network, then it is recommended to enter "y" and move on to step 5.
3    Otherwise you will be automatically taken to a network setup screen.
4    Set up the IP address for the Ethernet interface (most likely eth0). Call this **"wanemip".** You have to select this interface and set up the ip address, network mask and default gateway.  This screen is part of the reset command available in the WANem PC console. Details on this command can be found in section 3.3.1
5    WANem will prompt you to enter the password for user "perc".  It will also prompt you to re-enter the password. Using this userid and password will allow you to remote login to the WANem PC with programs like putty or ssh.
6    Setup the routes between the two endpoints (say client and server) such that their packets are routed via the WANem PC when the two communicate with each other. For more details refer to section 3.4 "How to make packets go via WAN emulator".
7    From another Windows PC on the network open Internet Explorer and type the URL http://wanemip/WANem. [Ensure that your screen resolution is set to 1024 x 765 for best viewing.]
8    Now, WANem is ready for use.

## 3.2 Using WANem Graphical user interface

In the WANem start page you will see 2 boxes  -
    a) Enter Basic Mode
    b) Enter Advanced Mode. In this box you will also see a drop down selection of network interfaces.

### 3.2.1 Basic Mode

If the basic mode is selected then only 1 set of network characteristics can be applied for each network interface. Each such set is called a rule set. In the basic mode each rule set will allow the user to specify only the following network characteristics
    • Bandwidth
    • Latency
These characteristics are explained in more detail in chapter 4. Illustrated in Figure 4-1 is a screenshot of the WANem GUI in basic mode with one network interface.

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**Figure 4-1 – WANem GUI Basic Mode**

### 3.2.2 Advanced Mode Operation

If you want to use the advanced mode select the correct network interface in advanced mode and click the "Start" button. Typically eth0 is the default Ethernet network interface you want to use. You can confirm this with your system/network administrator. You get a screen as shown in Figure 4-2.

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**Figure 4-2 – WANem GUI Advanced Mode**

1) The above screen shows the form for one rule set. All fields barring the ones in the last row represent various network characteristics. So a rule set identifies a set of network characteristics or a Private WAN which was used in the illustrations in chapter 2. Fill in the relevant network characteristics. These characteristics are explained in more detail in chapter 4.
2) The last row (circled in the figure) in the form starting with "IP source addr" determines the packets to which the rules apply. There are 3 possibilities here
   a) You want the same rule set to apply to any packet that passes via WANem. In this case you can leave this row as it is.
   b) You want the rule set to apply to all traffic between 2 end hosts (regardless of whether they are client or server). Then fill in the specific IP addresses or the 2 hosts. You can set the subnets to 32. Leave the "Application port" to "any".
   c) You want the rule set to apply to all traffic between 2 end hosts which are client and server for a given application. Then fill in the specific IP addresses of the client in "IP source addr". And the address of the server in "IP destination addr". You can set the subnets to 32. Set the "Application port" to the server port.
3) To add one more rule set then click "Add a rule set" and repeat from step 2..

4) Click "Apply Settings" to start WANem.
5) Click "Refresh Settings" immediately to ensure that the settings have taken effect.

Saving all your network characteristics for later reuse is a useful feature to have. This will be supported in the next release of WANem.

## 3.3 WANem Console commands

Following commands are available in the WANem Console
- reset
- wanemreset
- status
- assign
- clear
- restart
- shutdown

The WANem PC can be either operated from the console. Or you can connect to the WANem PC with "putty" or ssh utilities. For remote login you can use the user id perc and the password set during the WANem boot setup. Either way all the listed commands will be available.

### 3.3.1 reset
The "reset" command allows the user to specify IP addresses and other details for each network interface on the WANem PC.
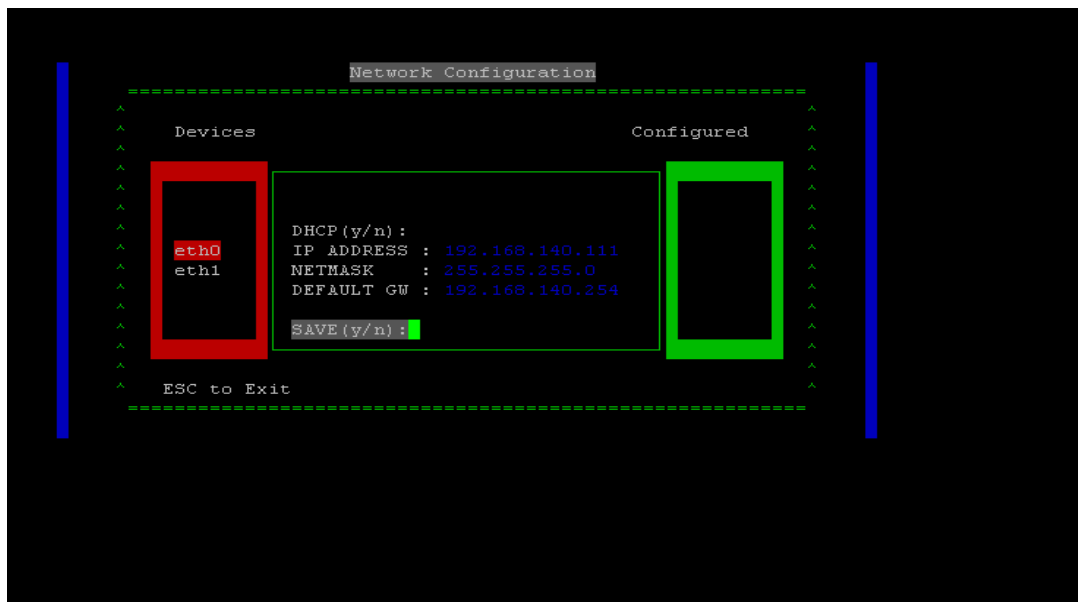


**Figure 5 – Network setup screen**

This screen allows the user to configure the ip address for each and every interface in the PC. In the above figure there are two interfaces eth0 and eth1. The current selected interface is eth1 and the IP ADDRESS and other parameters relate to eth1. After the parameters are entered entering "y" saves the settings and returns control to the WANem prompt which looks like "**WANemControl@PERC>**". If dhcp is to be used for network address the please enter yes when the DHCP question is popped for the interface.

If in case you do not want to add or change any settings hit "Enter" key till "SAVE(y/n)" is displayed on the screen. Enter 'n'. Then enter 'C' for cancelling the changes.

If you want to add or change any settings fill in the values and hit "Enter" key till "SAVE(y/n)" is displayed on the screen. Enter y. Then type 'S' for saving the changes.

One limitation in this program is that the previous values will not be displayed. For knowing the previous values use the "status" command described in section status3.3.2.

Pls note that if you change the IP address over a remote login session then your session will be disconnected. In such a case you will have to relogin to WANem using the new ip address.

### 3.3.2 status

This command will list the network settings of all the network interfaces. IP addresses and other settings are displayed. The status will also display the routing table entries within the WANem PC. In case there are multiple network cards in the WANem PC, these entries will be useful to see the distribution of end hosts across network interfaces. In the end the command requests the user to enter an IP address to check connectivity. It is an optional step and it can be used to test network connectivity of the WANem PC itself.

### 3.3.3 assign

The assign command is used to assign an end host to a specific network interface in the WANem PC. It is useful if there are multiple network cards in the WANem PC. No need to use this command if there is only one network interface. The syntax of this command is **assign <end host ip> <interface>**. For e.g. if we want to assign host 192.168.140.34 to interface eth0 run "**assign 192.168.140.34 eth0**". More details on multiple network interfaces in section 10.

### 3.3.4 wanemreset

This command can be used to reset all the WANem settings previously set using the WANem GUI. This can be done in case the user is facing trouble accessing the WANem GUI using Internet Explorer. More details regarding why this happens can be found in section 7.

### 3.3.5 clear

This command is used to clear the WANem console screen

### 3.3.6 restart

This command is used to restart the WANem PC

### 3.3.7 shutdown

This command is used to shutdown the WANem PC

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## 3.4 How to make packets go via WAN emulator
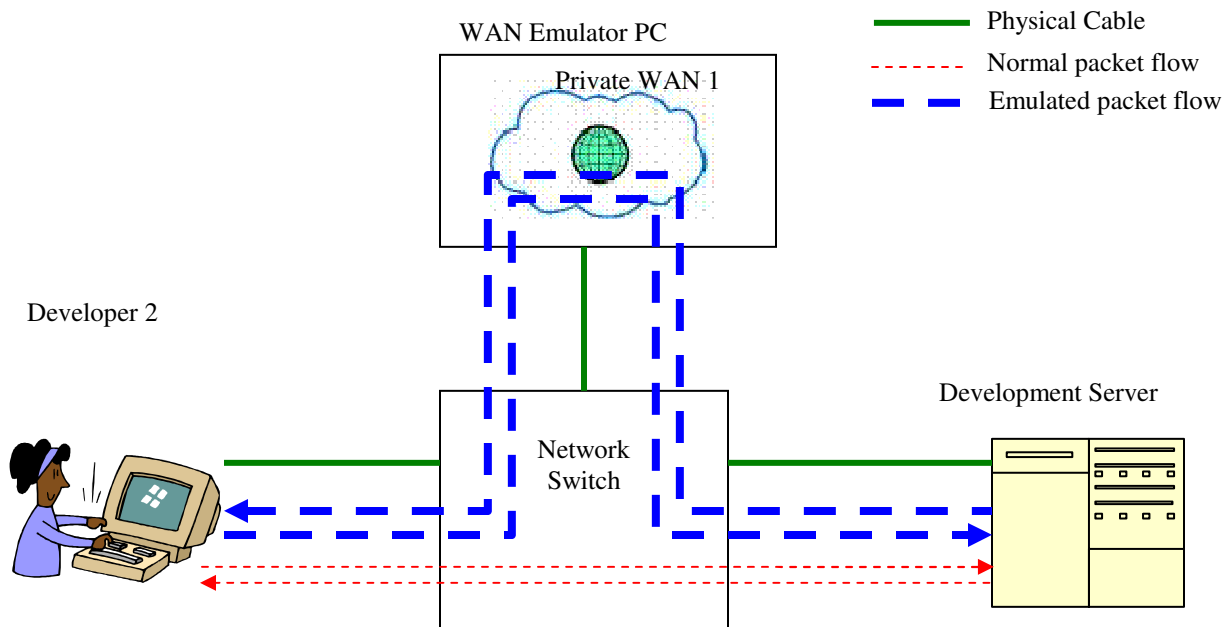


**Figure 6 – Routing packets thru WANem**

A WAN emulator emulates a wide area network between any two hosts. In order for a wide area network conditions to be emulated between hosts their communication should flow via the WAN emulator. In other words the packets from one host to another and vice versa should be routed via WANem. This is illustrated in the figure above in which the two hosts are the Developer's PC and the Development Server. Under normal situations the packets between 2 hosts flow directly via the switch. In order to introduce emulation the routing tables in the hosts need to need to be changed.

Please note that in order to use WANem it is not necessary that both the hosts are connected to the same switch. They just need to be in the same local area network or in the same Ethernet broadcast domain. One way to check this is ping one host from another. The ping response should be less than 10 ms. Another method to check this is using tracroute utility (tracert on Windows). The traceroute from 1 host to another should ideally show only 1 hop.

### 3.4.1 Changing Routes

In the following examples we will setup the network traffic between two hosts to flow via WANem. Following rules will be used for illustrating routing change examples.
1. IP address of host 1 is 192.168.140.12
2. IP address of host 2 is 192.168.140.14
3. IP address of WANem PC is 192.168.140.20

It is assumed that the user is logged in to the machines using Administrator or root privileges.

**Example 1:** Both host1 and host 2 run the Windows O/S

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1. Run this command host 1 "route add **192.168.140.14** mask 255.255.255.255 **192.168.140.20**
2. Run this command host 2 "route add **192.168.140.12** mask 255.255.255.255 **192.168.140.20**

Following table gives a listing of commands for changing routes where the end hosts run different combinations operating systems

| Example Scenario | Host 1 operating system | Change route to WANem command on Host 1 | Host 2 operating system | Change route to WANem command on Host 2 |
|---|---|---|---|---|
| Two Windows hosts communicate via WANem | Windows | route add **192.168.140.14** mask 255.255.255.255 **192.168.140.20** | Windows | route add **192.168.140.12** mask 255.255.255.255 **192.168.140.20** |
| Windows and Linux communication via WANem | Windows | route add **192.168.140.14** mask 255.255.255.255 **192.168.140.20** | Linux | route add –host **192.168.140.12** netmask 0.0.0.0 gw **192.168.140.20** |
| Linux and IBM AIX communicate via WANem | Linux | route add –host **192.168.140.14** netmask 0.0.0.0 gw **192.168.140.20** | IBM AIX | route add **192.168.140.12** **192.168.140.20** |
| IBM AIX and Solaris communicate via WANem | IBM AIX | route add **192.168.140.12** **192.168.140.20** | Solaris | route add **192.168.140.12** **192.168.140.20** |

### 3.4.2 How do you know change of routing table is working?
For checking this we need to use the command traceroute. In Windows O/S use the command tracert.
1. From host 1 run the command "traceroute **<ip2>**" - ip2 is the IP address of host 2. In the output you should be able to see the route passing thru "wanemip", the IP address of the WANem PC.
2. From host 2 run the command "traceroute **<ip1>** - ip1 is the IP address of host 1. In the output you should be able to see the route passing thru "wanemip", the IP address of the WANem PC.

### 3.4.3 How to check if WANem works between the two hosts

We are assuming that by now you have sorted the routing of packets via WANem.
Using the WANem GUI enter a delay of 100 ms and click on "Apply settings".

If you are using multiple rule sets - then you will have to first add a new rule set and set the Source IP address and Destination IP address with Symmetrical network set to yes. For this testing purpose please leave port = "any" even if your project needs to specify a real port. You can do that later once you confirm that WANem works between the host 1 and host 2.

Run the following commands
1. From host 1 run the command "ping **<ip2>**" - In the output you should be able to see a ping response equal to or above 200 ms.
2. From host 2 run the command "traceroute **<ip1>** - In the output you should be able to see a ping response equal to or above 200 ms.

## 3.5 Using TCS WANALYSER in Graphical User Interface

The distribution of TCS WANALYSER v1.0 comes with the same bootable CD of WANem. Initial procedure of installation is therefore same with WANem. Once the WANem box is running, TCS WANALYSER V1.0 is also ready to use from the same box.

To open TCS WANALYSER V1.0, type URL http://wanemip/wanc in Internet Explorer of any Windows PC on the network

First page of TCS WANALYSER V1.0 is as shown in the Figure 7.
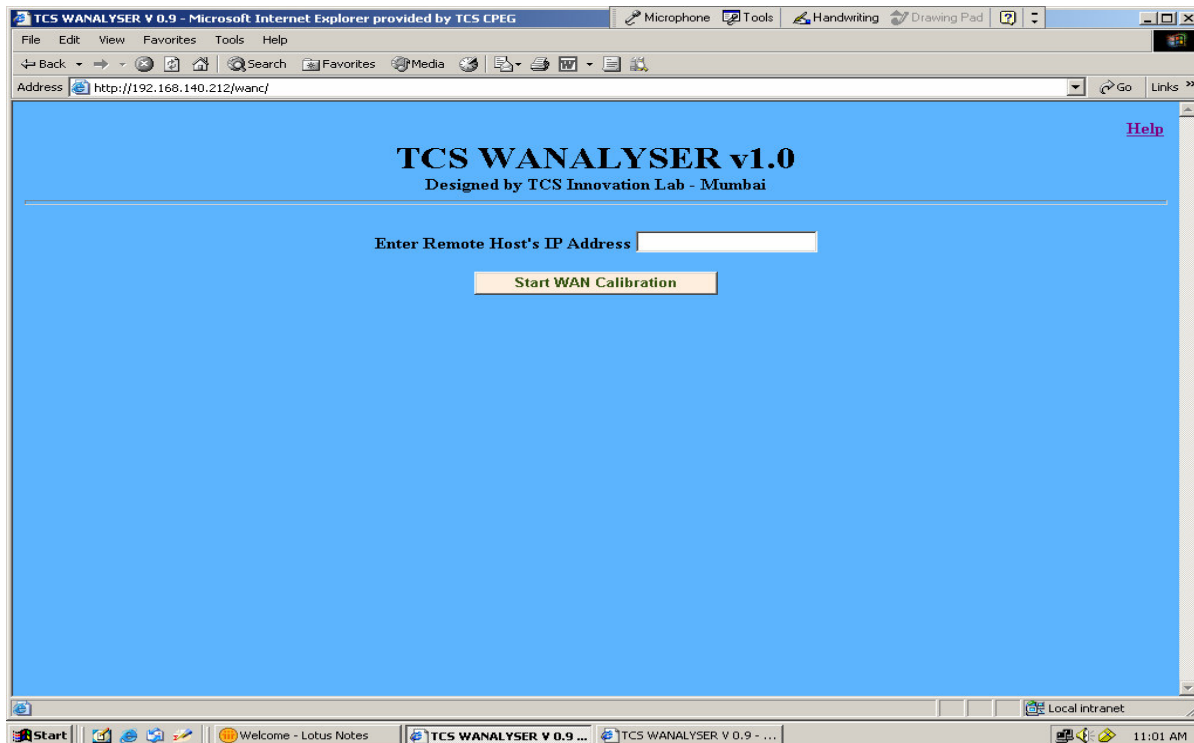


**Figure 7 – TCS WANALYSER start up screen**

To start with one needs to enter the IP address of a host so that available bandwidth between the WANem box and the host can be estimated. After entering the IP address it needs to start WAN Calibration by pressing the command button.

TCS WANALYSER then produces results as shown in Figure 8.
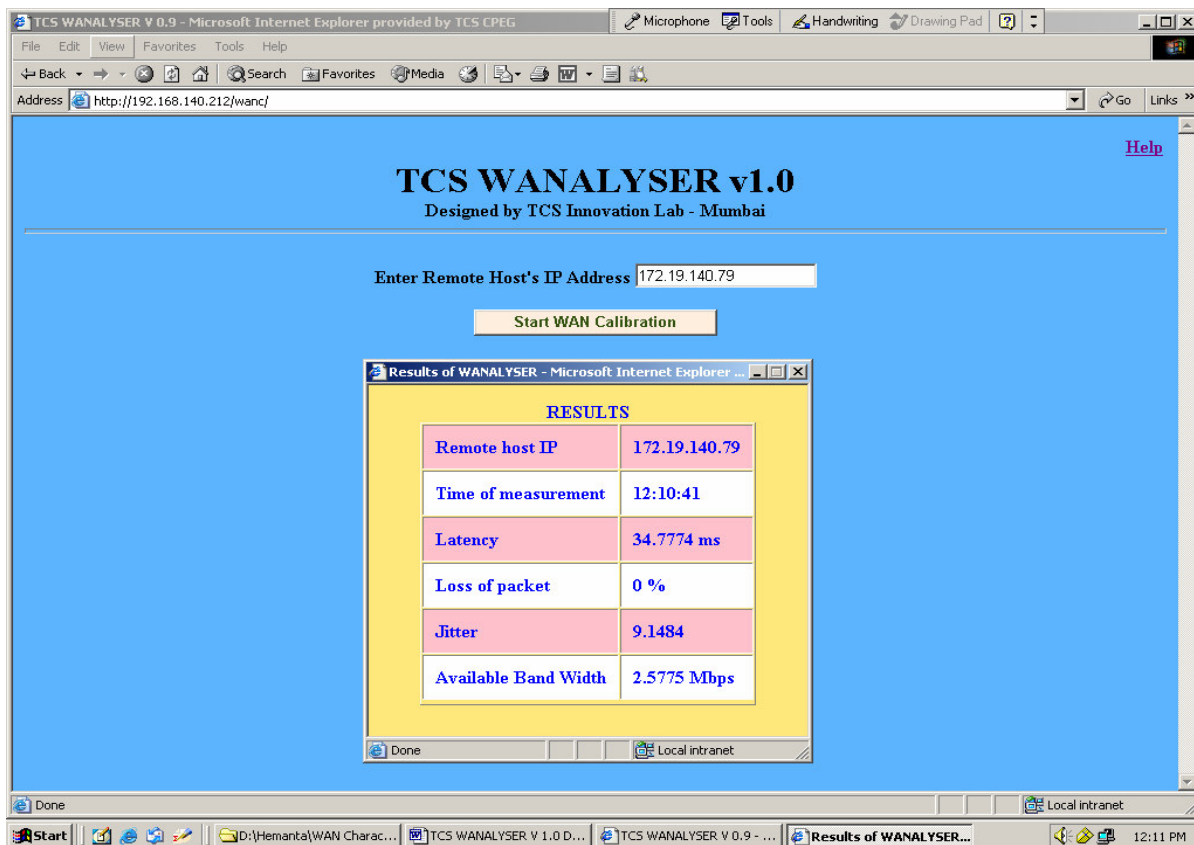
**Figure 8 – TCS WANALYSER after probe**

# 4  Network Characteristics supported by WANem

The figure reprinted below contains all the characteristics supported by WANem



## 4.1  Packet Limit

Most network devices like routers and switches maintain a queue for each interface to forward packets. When the queue exceeds it limit packets are dropped. The entire netword can be considered as one network device with one such queue. This is what the "Limit" input field in the GUI emulates. The limit is specified in number of packets. If the output forwarding queue for the selected interface exceeds this limit then WANem drops packets. By default it will be set to 1000 bytes. If you would not want to limit packets this way then set this to a large number say 99999999.

## 4.2  Symmetrical Network

WANem provides a Symmetrical Network feature (circled in the figure). If this is set to yes then it means that all the network settings in the rule set will be apply in both directions of traffic flow. If this is set to "No" then it will apply to only one direction of flow i.e. it will apply on to packets flowing from the host identified in "IP source addr" to the host identified by "IP destination addr". If a valid port is mentioned then the setting will affect the packets from 1 host to the other only for the application identified by the port. This is useful when an asymmetric network like ADSL needs to be emulated.

## 4.3 Delay

Delay (sometimes called) Latency is the one way delay from one node to another. The ping utility measures round trip time (RTT/2). Latency is proportional to the physical distance covered by the route taken by a packet from source to destination. It can be approximated to RTT/2.
WANem currently provides a delay resolution of 10 ms. This means that the delay values supported accurately are those in multiples of 10 ms.

• **Jitter** – Real networks show variation in delay. For e.g. if delay is 100ms and Jitter is set to 10 ms. So the delay applied is 100 + 10 ms or 100 – 10 ms in random.
• **Correlation** – It is a measure of the dependency of the delay applied on the next packet to that on the previous packet. For e.g a correlation value of 25 % with delay and jitter to be 100ms and 10 ms respectively means that the delay applied to the next packet is 100 (+ / -) 10 ms depending 25% to that applied to the previous packet. Note that this correlation is only an approximation to pure mathematical correlation.

## 4.4 Loss

Sometimes the networks drop packets for various reasons, congestion and signal loss being common factors. In WANem the packet loss is specified in percent. The smallest possible non-zero value is:

$$\frac{1}{2^{32}} = 0.0000000232\%$$

A loss value of 0.1 causes 1 out of 1000 packets to be randomly dropped.

Please remember that if a very high loss (with out any filters) is specified then WANem GUI might fail to respond – because it may affect the communication between your browser and the WANem PC. Please refer to the troubleshooting FAQ in section 7.

• **Correlation** - This causes the random number generator for loss to be less random and can be used to emulate packet burst losses. For e.g. a loss of 0.3% with a correlation of 33.33% will cause 0.3% of packets to be lost, and each successive probability depends by about a third on the last one.

$$Prob_n = Prob_{n-1} \cdot \frac{33.33}{100} + Rand() \cdot \left(1 - \frac{33.33}{100}\right)$$

## 4.5 Duplication –

Networks also sometimes duplicate packets. This means that a single packet sent by the sender will arrive multiple times at the receiver. This results in waste of network bandwidth. In WAnem packet duplication is specified in the same way as packet loss.
Correlation for Duplication is similar to the correlation defined for Loss.

## 4.6 Corruption

Transmission errors, Signal attenuation, Noise and sometime faulty network devices introduce errors in to networks packets. This is termed corruption. In WANem, Random noise can be emulated. This introduces a single bit error at a random offset in the packet. It is specified in the same way as packet loss. However no correlation parameter is accepted.

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## 4.7 Reordering –

Packets also get reordered by various network conditions, (especially highly unstable routing), causing them to arrive out of sequence at the receiver. There are different ways to specify reordering

- o The first method gap uses a fixed sequence and reorders every Nth packet. A gap value of 5 with a delay of 10 ms will cause every 5th (10th, 15th, ...) packet to go to be sent immediately and every other packet to be delayed by 10ms.
- o The second form reorder of re-ordering is more like real life. It causes a certain percentage of the packets to get mis-ordered. When reorder is specified as 25% with a correlation of 50 %, then, 25% of packets (with a correlation of 50%) will get sent immediately, others will be delayed by 10ms.
- o Pls note that WANem will also re-order packets if the random delay values are out of order. For example specifying a delay of 100 ms with a jitter of 75 ms will cause some reordering in the following way -
    - ▪ If the first packet gets a random delay of 100ms (100ms base - 0ms jitter) and the second packet is sent 1ms later and gets a delay of 50ms (100ms base - 50ms jitter); the second packet will be sent first. This is because the packets are queued in order by time to send.

### Note regarding Reordering

- o Mixing forms of reordering may lead to unexpected results
- o Any method of reordering to work, some delay is necessary.
- o If the delay is less than the inter-packet arrival time then no reordering will be seen.

## 4.8 Bandwidth

This parameter emulates available bandwidth between two network nodes. The minimum bandwidth that can be accurately emulated by WANem is 120 kbps (kilobits / sec) to 50 Mbps (in a single direction with 1 100 Mbps NIC)

## 4.9 Disconnection

This feature models the unreliability of a network. When an end host sends packets in a disconnected network it gets ICMP error messages or TCP reset messages. 3 types of disconnects are supported by WANem

### 4.9.1 Idle timer disconnection

The most common sources of this kind of disconnections are firewalls. When a TCP connection has been idle for more than a preset duration, then that connection is reset or disconnected. The parameters available for idle timer disconnect are

- o **Idle Timer (secs)** – is the time a connection can remain idle before it is disconnected
- o **Disconnect Duration (secs)** – time for which the disconnection for the given connection is in force
- o **Disconnect Type** – The specific error message that will go out in response to a packet that cannot cross a disconnected network. If set to "none" then Idle time disconnection will not be enabled. Following are the options available –
    - ▪ tcp-reset – applies to packets belonging to matching tcp connections.
    - ▪ icmp-net-unreachable
    - ▪ icmp-host-unreachable
    - ▪ icmp-port-unreachable

- icmp-proto-unreachable
- icmp-net-prohibited
- icmp-host-prohibited
- icmp-admin-prohibited

### 4.9.2   Random Disconnect

A random disconnection causes a temporary disconnection between any to network nodes or between a client and an application server. This type of disconnection is not related to any particular packet event. The parameters available for Random disconnect are

- o **MTTF Low** – Also know as the minimum Mean time to Failure specified in seconds.
- o **MTTF High** – Also known as the maximum Mean time to Failure specified in seconds. The time between any two disconnections (Or the mean time to failure) is a random value between MTTF Low and MTTF High
- o **MTTR Low** – Also know as the minimum Mean time to Recovery specified in seconds.
- o **MTTR High** – Also known as the maximum Mean time to Recovery specified in seconds. The time for which a disconnection lasts (Or the mean time to failure) is a random value between MTTR Low and MTTR High.
- o **Disconnect Type** – If set to none the Random disconnect will be disabled. Other details same as Disconnect type in Idle timer disconnection.

### 4.9.3   Random Connection Disconnect

In distributed applications it is not uncommon to see multiple connections between any two network nodes. One example is an application server holding a pool of connections with a remote database server. Only one of the connections is randomly axed. The parameters available for Random disconnect are

- o **MTTF Low** – Also know as the minimum Mean time to Failure specified in seconds.
- o **MTTF High** – Also known as the maximum Mean time to Failure specified in seconds. The time between any two random connection disconnections (Or the mean time to failure) is a random value between MTTF Low and MTTF High
- o **MTTR Low** – Also know as the minimum Mean time to Recovery specified in seconds.
- o **MTTR High** – Also known as the maximum Mean time to Recovery specified in seconds. The time for which a disconnection lasts (Or the mean time to failure) is a random value between MTTR Low and MTTR High.
- o **Disconnect Type** – If set to none the Random disconnect will be disabled. Other details same as Disconnect type in Idle timer disconnection.

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## 5 Network Characteristics supported by TCS WANALYSER

The network characteristics supported by TCS WANALYSER are –

- – Latency
- – Loss of packets
- – Jitter
- – Bandwidth available

# 6 Features

1. Can emulate a variety of network characteristics including Bandwidth, Delay, Loss and Disconnection.

2. WANem allow creation of separate private networks within a single WANem PC. Each private network has its own set of network characteristics.

3. It is not required to physically connect the systems under test to WANem. This bring a lot of flexibility regarding the usage of WANem.

4. Easy to use Web Based user interface.

5. Comes with a WAN characterization tool called TCS WANALYSER.

6. WANem can handle as much as 10000 packets per second with 1 100Mbps Network interface card.

7. Distributed in the form of a bootable CD. It can be run on any i386 architectures based machine. Examples are Intel Pentium, Intel Xeon, AMD Opteron.

8. Integrates seamlessly within any development, test or demo environment.

9. Supports all Internet Protocol (IP) applications including TCP, UDP etc.

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# 7   Frequently Asked Questions

**1.   Why is WANem not emulating network congestion?**

**Ans**: Network congestion can manifest itself thru the following effects
1. Increase in latency
2. Increase in packet drops/loss
3. Reduction in available bandwidth between the two end hosts.

All the above effects can be emulated using WANem. So there is little need for a separate congestion parameter.

**2.   What are the requirements for using WANem?**

**Ans**: You will need minimum an i386 based PC with 1 CPU, 512 MB RAM and 1 Network interface card – 100 Mbps (preferably 1 Gbps)

**3.   How easy is it to install?**

**Ans**: There is nothing to install. WANem is distributed in the form of a bootable CD. Just insert this CD in you CD ROM drive and restart the PC. While restarting, ensure that the PC is booted using the CD ROM.

**4.   What after restarting the PC with WANem?**

**Ans**:  Just 2 more steps before using it
   a.   Add an IP address to the Network interface. This is explained in section 3.1 in more detail.
   b.   Make the packets between your communicating hosts (mos probably between your client and server) to pass through WANem. This is explained in section 3.4.

**5.   OK done – Now how do I start using WANem?**

**Ans**: This is the simplest part. Use the WANem GUI. It is self explanatory. Check out section 3.2 for more details.

**6.   I want to emulate a network between pt A & pt B. How do I know what input to feed into WANem?**
**Ans:** For that use TCS WANALYSER between A and B. It will give you four basic network characteristics (Loss, Latency, Jitter and Bandwidth) that exist between A and B.  These values then can be given as input to the emulator.

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# 8 Troubleshooting Guide

First please read section 3 carefully to ensure that no step has been missed in the setup and use of WANem.

**1. I am not able to ping the WANem PC?**

**Ans**: First please check if the WANem PC is connected to the local area network (LAN). If WANem is connected then some green/orange lights should be seen at the point where the LAN cable connects to the PC. Also verify that the IP address, network mask and the default gateway are set correctly. This can be done using the status command in the WANem console. This command also lets you to test connectivity by allowing you to enter an IP address to test for connectivity.

**2. I cannot remote login to the WANem PC. I forgot my password. How do I change it?**

**Ans**: Password once setup for user "perc" during WANem boot up cannot be changed. If you forget the password you still have the option of running the WANem console commands from the WANem PC itself. If remote access to WAnem PC is a must then you have to restart the WANem PC.

**3. Help! I followed all the steps you mentioned in the setup. I set a delay of 100 ms and I am getting a ping response time of 200 ms. What do I do?**

**Ans**: Nothing! This is how it should be. ping involves two messages – a request and response. Both the messages are delayed by WANem to give you a 200 ms response time.

**4. Help! I set a delay of 100 ms and I am getting a ping response time of 100 ms. This document says that I should get 200 ms. I have defined a Symmetric Network in my rule set. What is happening?**

**Ans**: You might have made a mistake in your routing setup. This is a classic case of asymmetric routing. In other words packets in only one direction are passing through the WAN emulator. Do a traceroute from each end to the other to check the routing anomaly. Use of traceroute is covered in section 3.4

**5. Help! The WANem GUI is not coming up? OR The WANem GUI is taken too much time to load? It was working just fine before I applied the new settings?**

**Ans**: There can be a combination of reasons why this can be happening
   a. The Network characteristics specified are extreme – for e.g. very high loss (say greater than 50%) or large latencies, etc
   b. No filter or IP address matching criteria has been specified while setting a rule
First it is essential to check whether the settings applied are realistic. If they are then it is essential that these characteristics are restricted to a certain set of hosts. The PC from which WANem GUI is being invoked should not be in this set. In order to rectify this problem following steps need to be executed
   a. From the console of the WANem PC, reset the network settings using the command. Enter the command wanemreset
   b. From your PC use Internet Explorer to access the WANemGUI and enter your network settings. Ensure that IP address matching criteria has been specified. This will ensure that the settings will apply only to the network between two hosts.
   c. Click on "Apply Settings"

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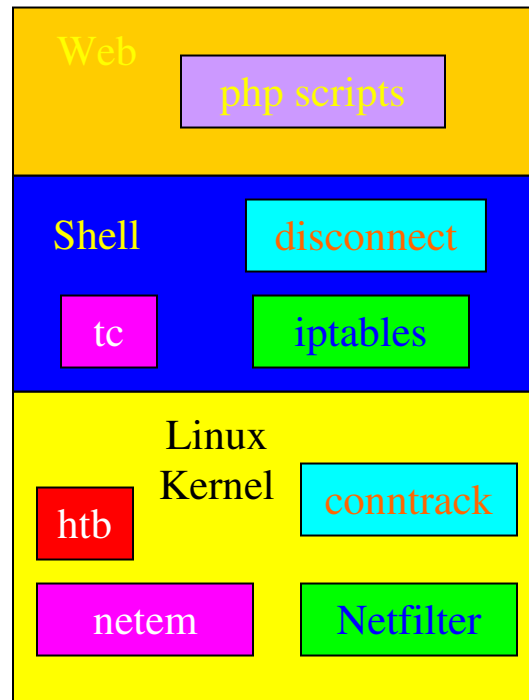
# 9   Appendix A - Architecture



**Figure 7 – WANem Architecture**

WANem is a combination of the following functionalities

1. **Netem** – netem is an open source network emulator which is available as a module in the linux kernel. It's functionality is invoked by the shell command tc.
2. **HTB** – Hierarchical token bucket queuing discipline is also available in the linux kernel. It is used for it's bandwidth limiting functionality and it's services are invoked from the shell using tc.
3. **Netfilter** – Netfilter is the name given to the packet filtering architecture in the Linux kernel. It is used by iptables which is used to implement Linux based firewalls.
4. **Conntrack** – Conntrack is a connection tracking modules used to track TCP/IP connections.
5. **Disconnect** – disconnect is a script developed to implement emulation of the network disconnection characteristics. It uses conntrack and iptables to implement its functionality.
6. **Php scripts** – The Web interface for WANem has been developed using php scripts. These php scripts are a modified version of the open source PHPNetemGUI to support more functionality.The apache http server is used to serve the WANem pages.

# 10  Appendix B – Using Multiple NIC cards on WANem PC

In this situation the WANem PC has two active network interface cards. In other words both Network cards are connected to a switch on the LAN. This can be used to advantage as it will increase the capacity of WANem to handle more packets per second. The idea is distribute end hosts to accross interface cards in the WANem PC.

This is illustrated in the following figure. Since each end host is assigned to one interface card Symmetrical private WANs will be composed of two rule sets – one for either interface.
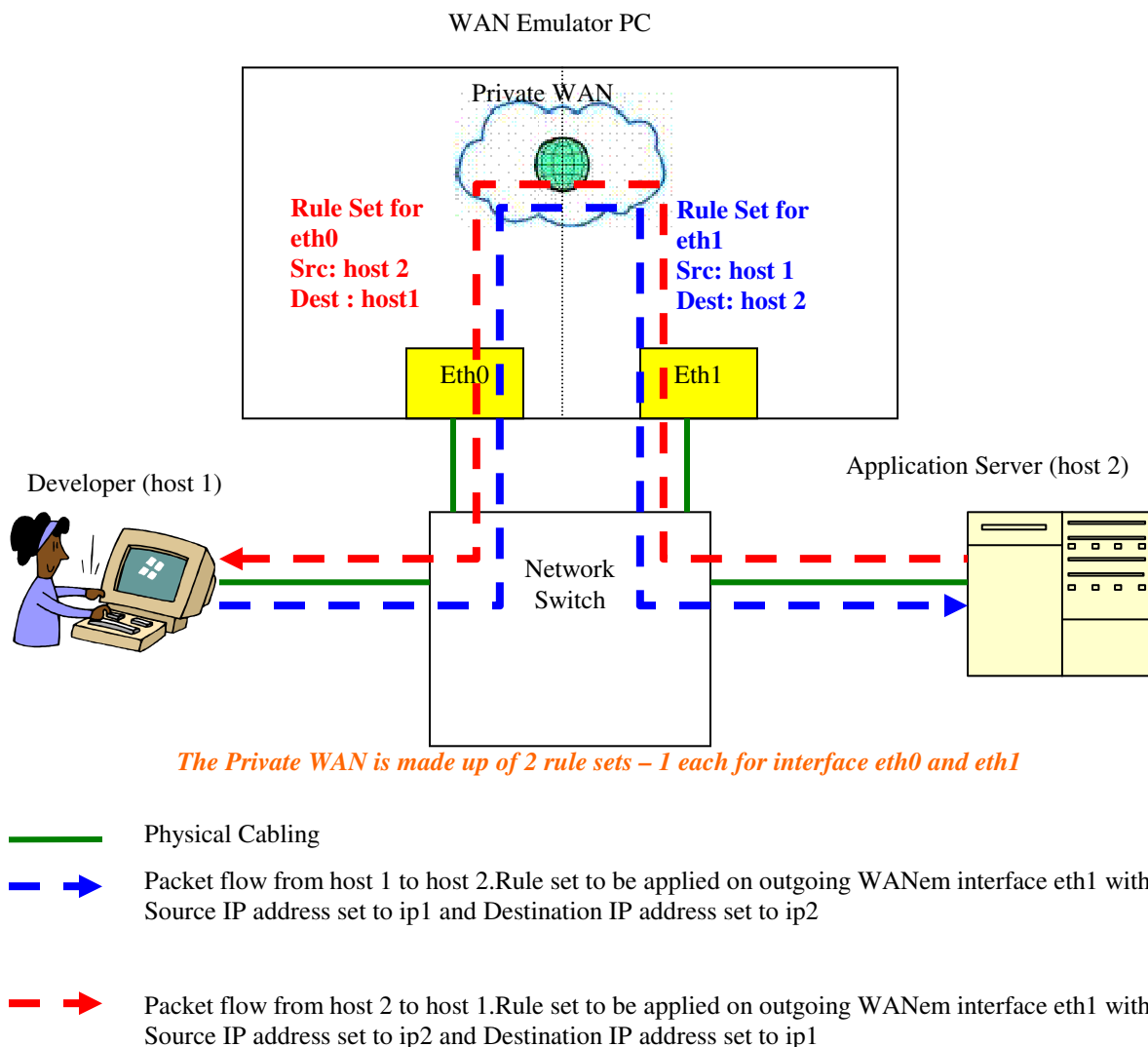
WAN Emulator PC

Private WAN

Rule Set for eth0
Src: host 2
Dest : host1

Rule Set for eth1
Src: host 1
Dest: host 2

Eth0

Eth1

Developer (host 1)

Application Server (host 2)

Network Switch

*The Private WAN is made up of 2 rule sets – 1 each for interface eth0 and eth1*

———— Physical Cabling

- - - ► Packet flow from host 1 to host 2.Rule set to be applied on outgoing WANem interface eth1 with Source IP address set to ip1 and Destination IP address set to ip2

- - - ► Packet flow from host 2 to host 1.Rule set to be applied on outgoing WANem interface eth1 with Source IP address set to ip2 and Destination IP address set to ip1

**Figure 7 – Routing packets thru WANem PC with 2 Network interface cards**

It is important to ensure that there is one IP address assigned to each network card. As before assume that the IP address for host 1 is ip1 and that for host 2 is ip2. This is normally done during when the WANem PC boots up. If

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this has not been done the reset command can be used to set IP addresses. In order to configure WANem in this scenario

1. If network addresses have not been set on all the network interfaces, then run command "reset" on the WANem PC console. Otherwise use the status command to know the IP address of each interface. The output of this command will list all the interfaces. For e.g. If there are two active Ethernet interfaces then there will eth0 and eth1.
2. Select an ip address for eth0. Call this wanemip1. Also enter default gateway and network mask[3].
3. Select an ip address for eth1. Call this wanemip2. Also enter default gateway and network mask.
4. Enter yes to "Save and quit" prompt
5. Assign host 1 to eth0 on WANem PC by running the command "assign **<ip1>** eth0"
6. Assign host 2 to eth1 on WANem PC by running the command "assign **<ip2>** eth1"
7. On host 1 add a route to host2 using IP address wanemip1. This will cause packets originating from host 1 and destined to host 2 to enter WANem PC via interface eth0. The commands required for doing the same have been illustrated for different OSes in previous sections. For e.g. if host1 is Windows run the command - "route add **<ip2>** mask 255.255.255.255 **<wanemip1>**"
8. Similarly on host 2 add a route to host1 using IP address wanemip2. This will cause packets originating from host 2 and destined to host 1 to enter WANem PC via interface eth1.
9. Using the WANem GUI select interface eth1. Add a new rule set with source IP address set to ip1 and Destination IP address set to ip2. All the network characteristics set will apply for packets flowing from host 1 to host 2. This is because the WANem network characteristics are applied only when the packet is about to exit the WANem PC via the outgoing interface which in this case is eth1.
10. Using the WANem GUI select interface eth0. Add a new rule set with source IP address set to ip2 and Destination IP address set to ip1. All the network characteristics will apply for packets flowing from host 1 to host 2. Reasoning is similar to the point above.

Suppose there are 2 more hosts, host 3 (with IP address ip3) and host 4 (with IP address ip4) which require WAN emulation then it will be a good idea to assign host 3 to WANem PC eth0 and host 4 to WANem PC eth1. With this strategy repeat the steps above.

Once that is done host 1 and host 3 share eth0 on WANem PC and host 2 and host 2 and host 4 will share eth1 on the WANem PC.

With this setup there can be 4 sets of Private WANs (or rule sets) that can be defined in WANem

1. Private WAN 1 - Between host 1 and host 2
2. Private WAN 2 - Between host 3 and host 4
3. Private WAN 3 – Between host 1 and host 3
4. Private WAN 4 – Between host 2 and host 4
5. Private WAN 5 – Between host 1 and host 4
6. Private WAN 6 – Between host 2 and host 3

In the above list Private WANs 1,2,5 and 6 will have some limitations/differences in functionality

1. These private WANs or rule sets will have to be defined twice – one for each interface if a Symmetrical Network is required on the Private WAN. This should be done keeping in mind that the WANem rules on an interface will apply only to packets using the interface as an outgoing link after it enters the WANem PC.
2. The Symmetrical Networks option is best set to "No"
3. The port will have to be set to "any". This is a current limitation. Please note that the WANem GUI will not enforce any of these rules.

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[3] Your network engineer will be able to provide you with this data.

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