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A Study of Simulation Tools & Techniques for Adhoc Wireless Network

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ABSTRACT: This paper focuses on study of various simulation tools used for carrying out research work in the fields of wireless networking. Details of network simulator version NS 2.34, network components, mobility models, writing of OTCL/TCL scripts, setting up of simulation parameters, creation of nodes/objects, defining node properties, attaching nodes to channels, specifying movements of nodes, specifying traffic flow between nodes using CBR/FTP, running OTCL/TCL scripts over simulator, generation of nam and trace files and process of analysis of results using name/trace files have been studied in length and breadth. OTCL/TCL script describes different kinds of network scenarios for mobile adhoc networking environment. The performance of MANET protocols can be analyzed using above-mentioned process.

KEYWORDS: Adhoc, Mobility, Network, OTCL, Simulation, TCL, Tool

I. NETWORK SIMULATOR

This simulator [1] is established by University of California, Berkeley. NS 2.34 version of network simulator provides facilities for simulation using both UDP and TCP traffic agents. Network Simulator consists of following two components [2]:-

- Object Oriented Simulator
- OTCL (Extension of TCL)

One can define the following in OTCL/TCL script:-

- Specific protocol to simulate e.g AODV and DSR
- Specific application to simulate e.g. cbr and ftp
- Network type and topology e.g. wired/wireless/bus/star/ring
- Network elements e.g. mobile nodes, mobility modes, queue models, links
- Desired output

Any text editor is used to write OTCL/TCL scripts. NAM file and Trace file is generated as simulator output. The trace file is further examined using various tools like filtering, awk, matlab, GNUplot etc. in order to compute various types of performance evaluation metrics for MNET protocols. Figure 1 depicts the functionality of NS-2.

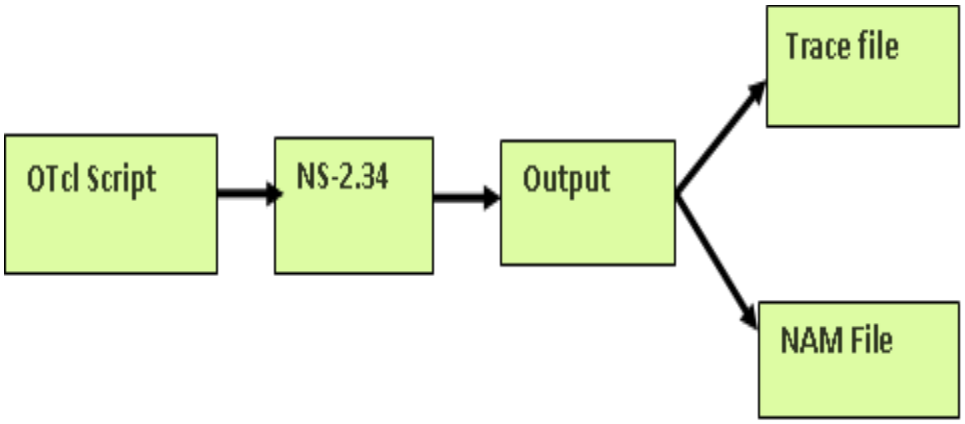

Figure 1: Functionality of NS-2

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II. NETWORK COMPONENTS

The packet propagation model depicting various network components [2,3] is shown in figure 2. If the packet received by MAC layer is free of errors, it sends the packet to entry point. Then, the packet is passed to De-multiplexer. It checks whether packet has reached to its destination or not. If the packet has reached to its destination, then the application for which packet should be delivered is decided. If the packet has not reached to its destination, it is forwarded again and entire process is repeated with the help of routing agent.

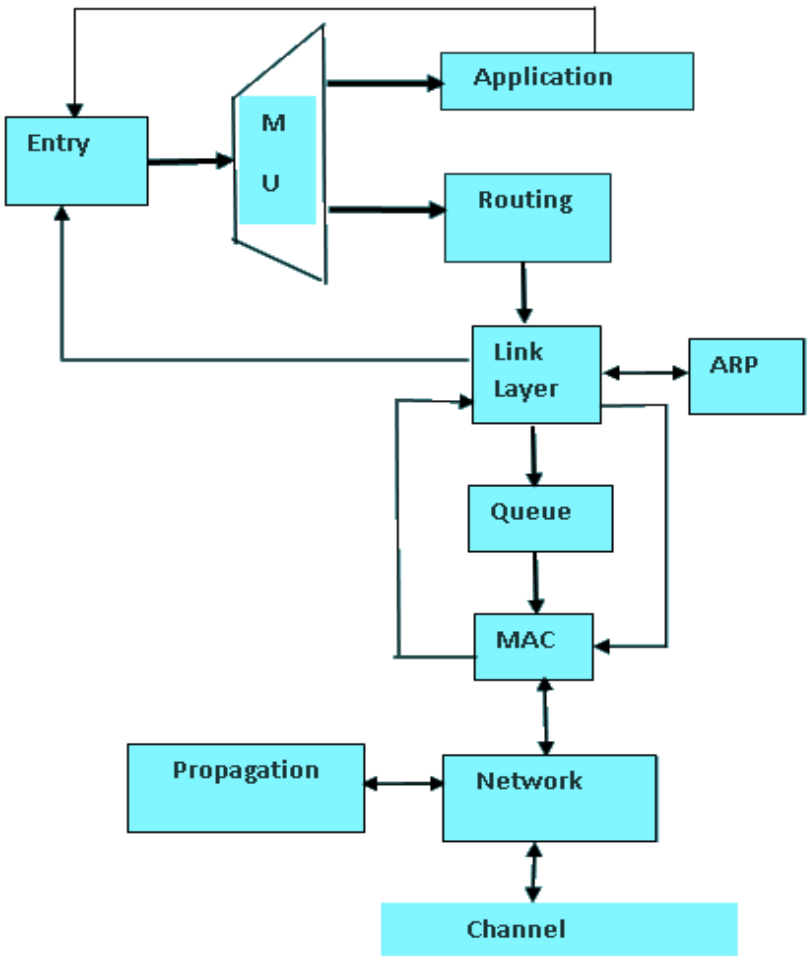

Figure 2: Network Components

III. SIMULATION PARAMETERS

Few parameter needs to be setup while carrying out experiment/simulation [4,5] over network simulator which is given below:-

a) Mobility Models

There are different types of mobility models [6,7] which are described below:-

Random Waypoint

In this model, movement is totally random. Future movement of a node is totally independent of its past movements. Figure 3 and 4 depicts Random Waypoint Model.

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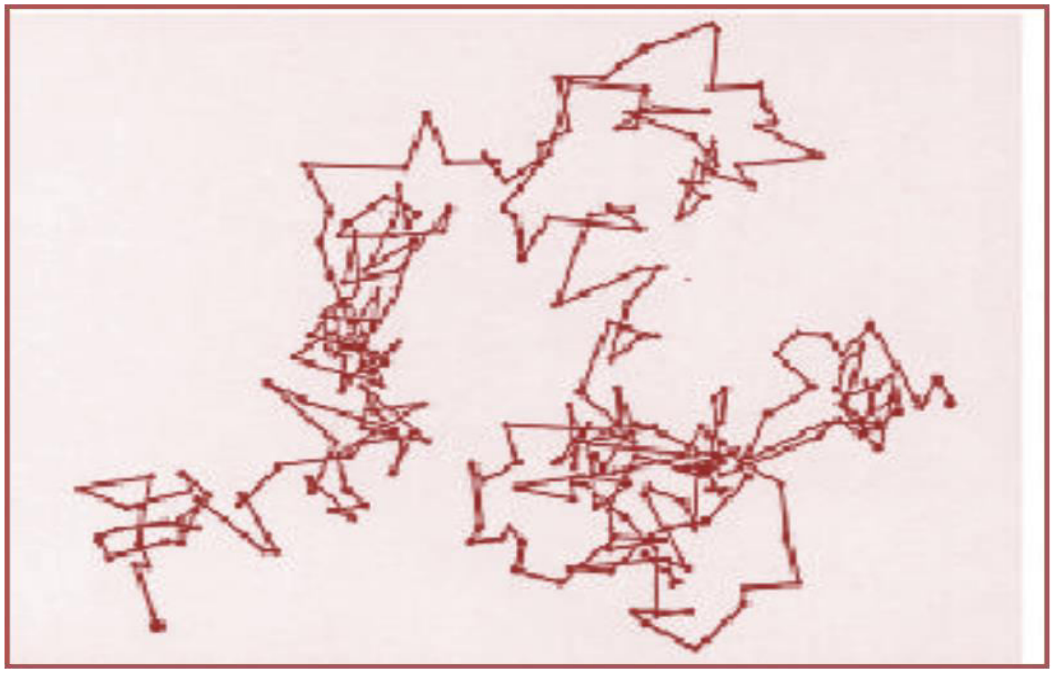

Figure 3: Mobility Patterns

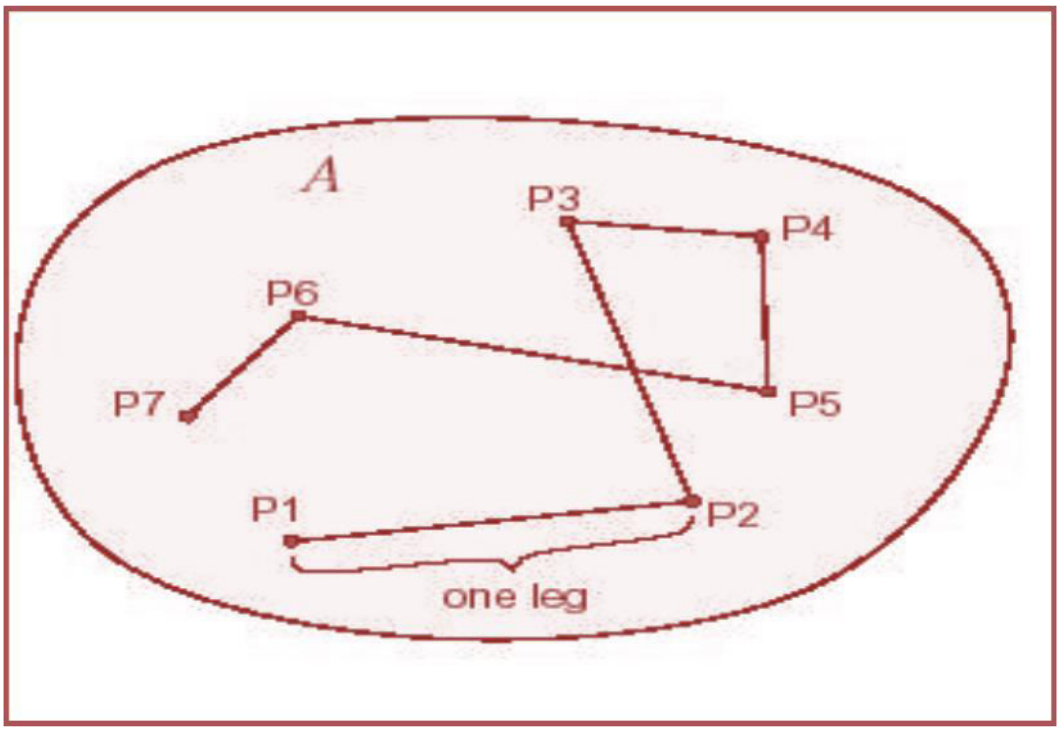

Figure 4: Movement of Nodes

Random Point Group Mobility (RPGM)

Figure 5 depicts positioning of mobile nodes w.r.t this model. This model is widely used by the military personnel for communication in battlefield. Group of nodes with group leaders are formed in this model.

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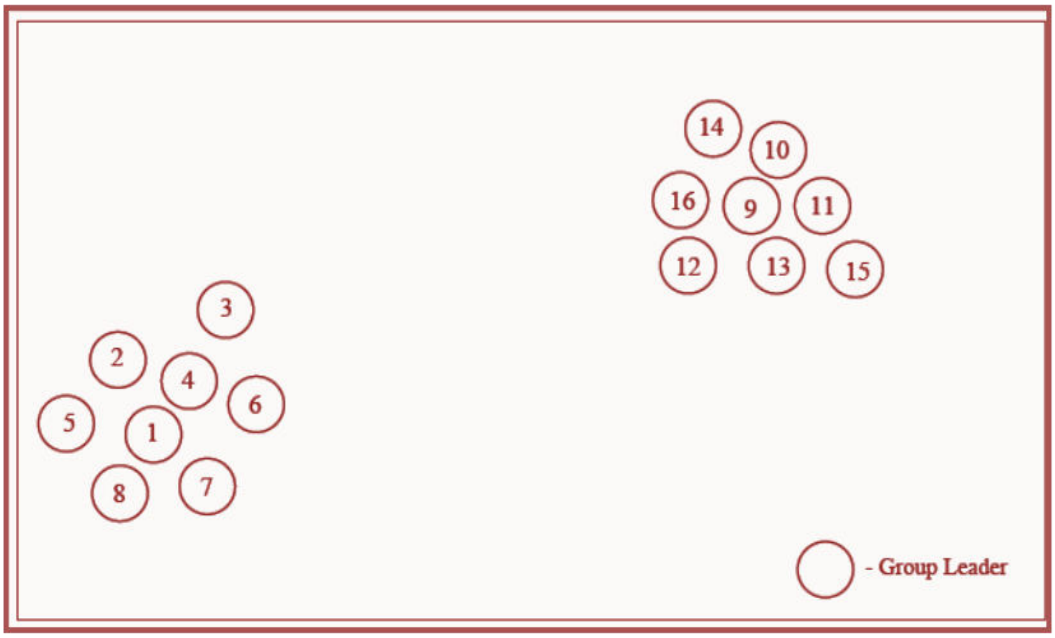

Figure 5: Positioning of Nodes

Freeway Mobility

Figure 6 depicts Freeway Mobility Model whereby mobility of mobile nodes is geographically constrained to its own lane only.

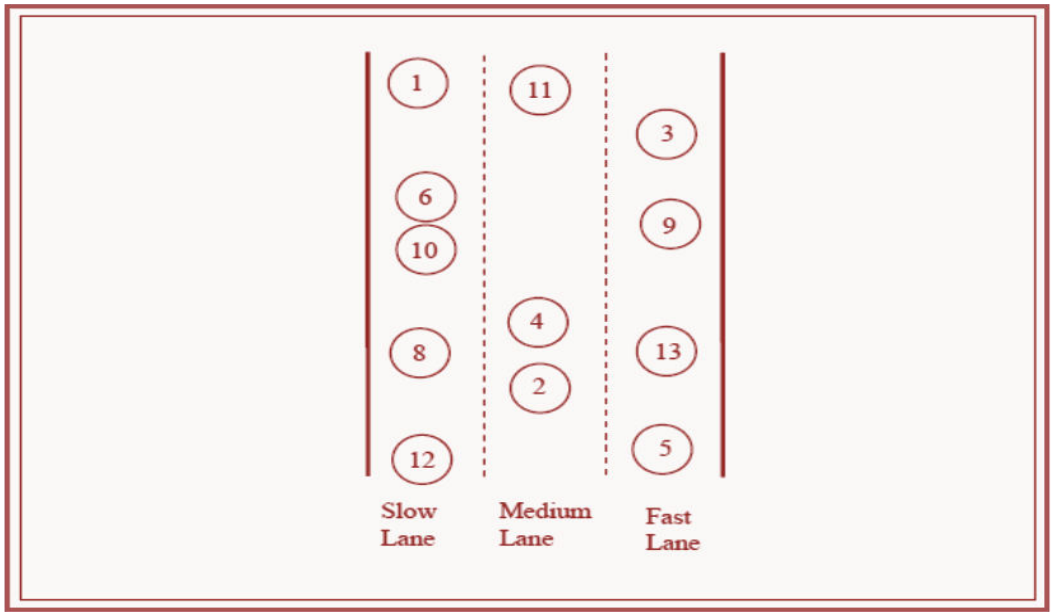

Figure 6: Geographic Lane Restriction

Manhattan Mobility Model

Figure 7 represents the functionality of this model whereby mobile nodes make use of concept of streets for their movement.

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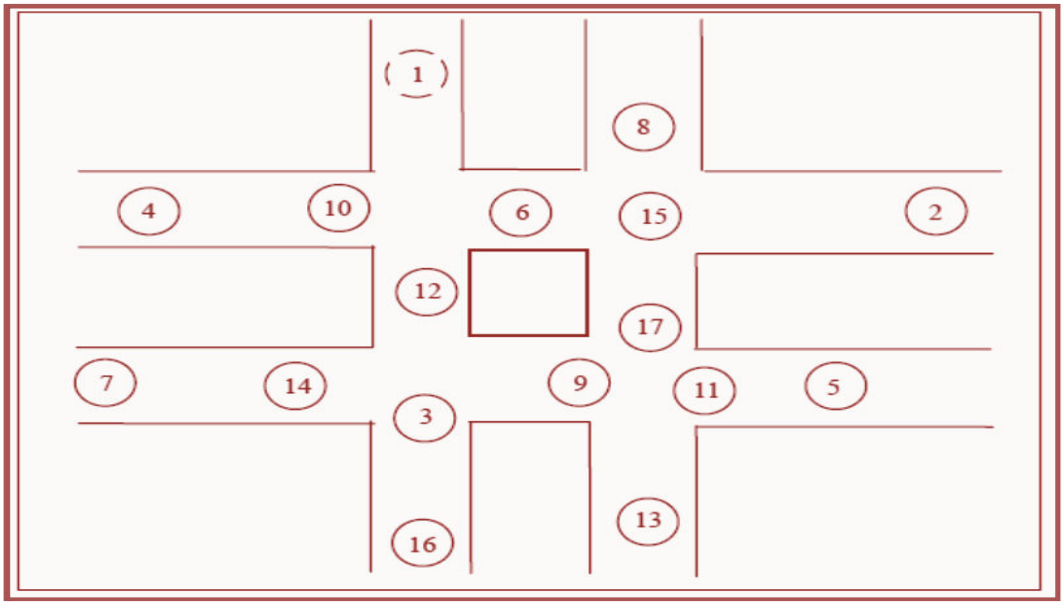

Figure 7: Nodes Movement restricted to Streets

b) OTCL/TCL script and Traffic Patterns

The basic steps in writing/executing an OTCL/TCL script [8,9] are presented below:-

1) Setting up of simulation parameters
2) Creation of nodes/objects using simulator
3) Defining node properties
4) Attaching nodes to channels
5) Specifying movements of nodes
6) Specifying traffic flow between nodes using CBR/FTP
7) Running OTCL/TCL script/simulation
8) Generation of nam and trace files
9) Analysis of results using name/trace files

The code snippets from OTCL/TCL script are given in the form of Table 1, Table 2 and Table 3 w.r.t simulation scenario shown in figure 8.

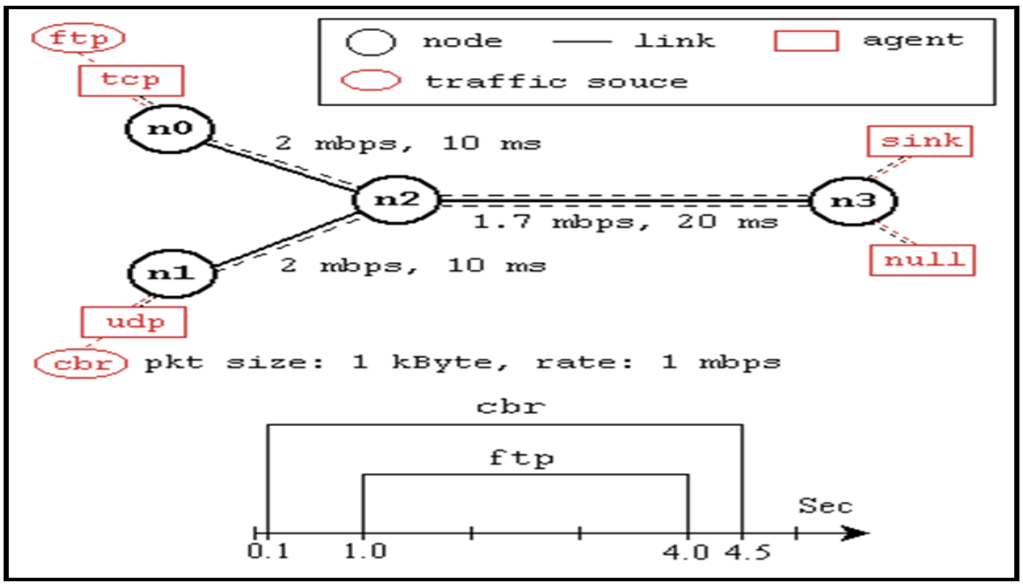

Figure 8: Network Simulation Scenario

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Table 1: Code Snippet (Basic OTCL/TCL script)

```
#Creation of nodes/Simulator Objects
set ns [new Simulator]
set nf [open amandeep.nam w]
$ns namtrace-all $nf
set n0 [$ns node]
set n1 [$ns node]
set n2 [$ns node]
set n3 [$ns node]

#Creating links between mobile nodes
$ns duplex-link $n0 $n2 2Mb 10ms DropTail
$ns duplex-link $n1 $n2 2Mb 10ms DropTail
$ns duplex-link $n2 $n3 1.7Mb 20ms DropTail
#Setting Queue Size
$ns queue-limit $n2 $n3 10
#Node positioning
$ns duplex-link-op $n0 $n2 orient right-down
$ns duplex-link-op $n1 $n2 orient right-up
$ns duplex-link-op $n2 $n3 orient right
#Monitoring queue
$ns duplex-link-op $n2 $n3 queuePos 0.5

# UDP connection
set udp [new Agent/UDP]
$ns attach-agent $n1 $udp
set null [new Agent/Null]
$ns attach-agent $n3 $null
$ns connect $udp $null
$udp set fid_ 2
# CBR over UDP connection
set cbr [new Application/Traffic/CBR]
$cbr attach-agent $udp
$cbr set type_ CBR
$cbr set packet_size_ 1000
$cbr set rate_ 1mb
$cbr set random_ false
```

```
# TCP connection
set tcp [new Agent/TCP]
$tcp set class_ 2
$ns attach-agent $n0 $tcp
set sink [new Agent/TCPSink]
$ns attach-agent $n3 $sink
$ns connect $tcp $sink
$tcp set fid_ 1
# FTP over TCP connection
set ftp [new Application/FTP]
$ftp attach-agent $tcp
$ftp set type_ FTP
#Scheduling of events
$ns at 0.1 "$cbr start"
$ns at 1.0 "$ftp start"
$ns at 4.0 "$ftp stop"
$ns at 4.5 "$cbr stop"
#Detach tcp and sink agents
$ns at 4.5 "$ns detach-agent $n0 $tcp ;
$ns detach-agent $n3 $sink"
# Finish procedure
proc finish {}
{    global ns nf
     $ns flush-trace
     #Close the NAM trace file
     close $nf
     #Execute NAM on the trace file
     exec nam amandeep.nam &
     exit 0     }
#Calling finish procedure
$ns at 5.0 "finish"
#Print CBR packet size/interval
puts "CBR packet size = [$cbr set packet_size_]"
puts "CBR interval = [$cbr set interval_]"
#Running simulation
$ns run
```

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Table 2: Code Snippet 1 (Advanced OTCL/TCL script)

```
# Setting up Simulation Parameters & Defining Constants
set val(chan)         Channel/WirelessChannel;
set val(ll)           LL;
set val(ant)          Antenna/OmniAntenna;
set val(prop )        Propagation/TwoRayGround;
set val(netif)        Phy/WirelessPhy;
set val(mac)          Mac/802_11;
set val(nn)           10;
set val(ifqlen)       50;
set val(ifq)          Queue/DropTail/PriQueue ;
set val(rp)           AODV;
# set val(ifq)        CMUPriQueue;
# set val(rp)         DSR;
set val(x)              1000;
set val(y)              1000;
set val(cp) [traffic pattern file]
set val(sc) [mobility scenario file]
#  Creation of simulator objects

set ns_[new Simulator]
set tracefd     [open amandeepUDP.tr w]
$ns_ trace-all $tracefd
set namtrace [open amandeepUDP.nam w]
$ns_ namtrace-all-wireless $namtrace $val(x) $val(y)
set topo       [new Topography]
$topo load_flatgrid $val(x) $val(y)
create-god $val(nn)
# Defining node properties
$ns_ node-config -ad hocRouting $val(rp) \
                 -llType $val(ll) \
                 -macType $val(mac) \
                 -ifqType $val(ifq) \
                 -ifqLen $val(ifqlen) \
                 -antType $val(ant) \
                 -propType $val(prop) \
                 -phyType $val(netif) \
                 -topoInstance $topo \
                 -agentTrace ON \
                 -routerTrace ON \
                 -macTrace ON \
                 -movementTrace OFF \
```

```
# Attaching nodes to channel along with specification of movements
set chan_0_ [new $val(chan)]
set chan_1_ [new $val(chan)]
set chan_2_ [new $val(chan)]
set chan_3_ [new $val(chan)]
.
# node(0) is attached to channel #1
# node needs to be configured
$ns_ node-config -ad hocRouting $val(rp) \
                 -llType $val(ll) \
                 -macType $val(mac) \
                 -ifqType $val(ifq) \
                 -ifqLen $val(ifqlen) \
                 -antType $val(ant) \
                 -propType $val(prop) \
                 -phyType $val(netif) \
                 -topoInstance $topo \
                 -agentTrace ON \
                 -routerTrace ON \
                 -macTrace ON \
                 -movementTrace OFF \
                 -channel $chan_1_
.
set node_(0) [$ns_ node]
$node_(0) color "red"
$node_(0) shape "circle"
.
$node_(0) random-motion 0
# Nodes Movements
$ns_ at 100 "$node_(0) color blue "
$ns_ at 100 "$node_(0) setdest 254.0 400.0 5.0  "
$ns_ at 100 "$node_(1) color red"
$ns_ at 100 "$node_(1) setdest 50.0 40.0 5.0 "
$ns_ at 100 "$node_(4) color purple"
$ns_ at 100 "$node_(4) setdest 48.0 28.0 5.0"
$ns_ at 100 "$node_(2) color blue"
$ns_ at 100  "$node_(2) setdest 52.0 435.0 5.0"
$ns_ at 100 "$node_(6) setdest 90.0 460.0 5.0"
$ns_ at 100 "$node_(7) color tan"
$ns_ at 100 "$node_(7) setdest 110.0 190.0 5.0"
$ns_ at 100 "$node_(5) color red"
$ns_ at 100 "$node_(5) setdest 370.0 20.0 5.0"
$ns_ at 100 "$node_(8) setdest 520.0 410.0 5.0 "
```

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Table 3: Code Snippet 2 (Advanced OTCL/TCL script)

```
$ns_ duplex-link $node_(0) $node_(1) 5Mb 5ms DropTail
$ns_ duplex-link $node_(1) $node_(0) 5Mb 5ms DropTail
$ns_ duplex-link-op $node_(0) $node_(1) orient down
$ns_ duplex-link-op $node_(1) $node_(0) orient left-
down
$ns_ duplex-link $node_(4) $node_(7) 5Mb 2ms DropTail
$ns_ duplex-link $node_(7) $node_(4) 5Mb 2ms DropTail
$ns_ duplex-link-op $node_(4) $node_(7) orient down
$ns_ duplex-link-op $node_(7) $node_(4) orient right-
down
# Traffic Flow using CBR/FTP
set udp [new Agent/UDP]
$ns_ attach-agent $node_(0) $udp
set null [new Agent/Null]
$ns_ attach-agent $node_(1) $null
set cbr [new Application/Traffic/CBR]
$cbr set packetSize_ 512
$cbr set interval_ 4.0
$cbr set random_ 1
$cbr set maxpkts_ 10000
$cbr attach-agent $udp
$ns_ connect $udp $null
$ns_ at  3.0  "$cbr start"

set udp [new Agent/UDP]
$ns_ attach-agent $node_(3) $udp
set null [new Agent/Null]
$ns_ attach-agent $node_(5) $null
set cbr [new Application/Traffic/CBR]
$cbr set packetSize_ 512
$cbr set interval_ 4.0
$cbr set random_ 1
$cbr set maxpkts_ 10000
$cbr attach-agent $udp
$ns_ connect $udp $null
$ns_ at  8.5  "$cbr start"
```

```
set tcp1 [new Agent/TCP]
$tcp1 set class_ 1
set sink [new Agent/TCPSink]
$ns_ attach-agent $node_(0) $tcp1
$ns_ attach-agent $node_(1) $sink
$ns_ connect $tcp1 $sink
set ftp [new Application/FTP]
$ftp attach-agent $tcp1
$ns_ at 3.0 "$ftp start"

set tcp2 [new Agent/TCP]
$tcp2 set class_ 2
set sink [new Agent/TCPSink]
$ns_ attach-agent $node_(3) $tcp2
$ns_ attach-agent $node_(5) $sink
$ns_ connect $tcp2 $sink
set ftp [new Application/FTP]
$ftp attach-agent $tcp2
$ns_ at 8.5 "$ftp start"
.
# Finishing-up / Running simulation
for {set i 0} {$i < $val(nn) } {incr i}
{
   $ns_ at 500.0 "$node_($i) reset";
}
$ns_ at 500.0 "stop"
$ns_ at 500.01 "puts \"NS EXITING...\" ; $ns_
halt"
proc stop {} {
   global ns_ tracefd
   $ns_ flush-trace
   close $tracefd
}

puts "Starting Simulation..."
$ns_ run
```

IV. TRACE FILE AND ITS ANALYSIS

After carrying out simulation, one must know reading the trace file [10] for proper analysis. Figure 9 depicts trace file w.r.t adhoc wireless network.

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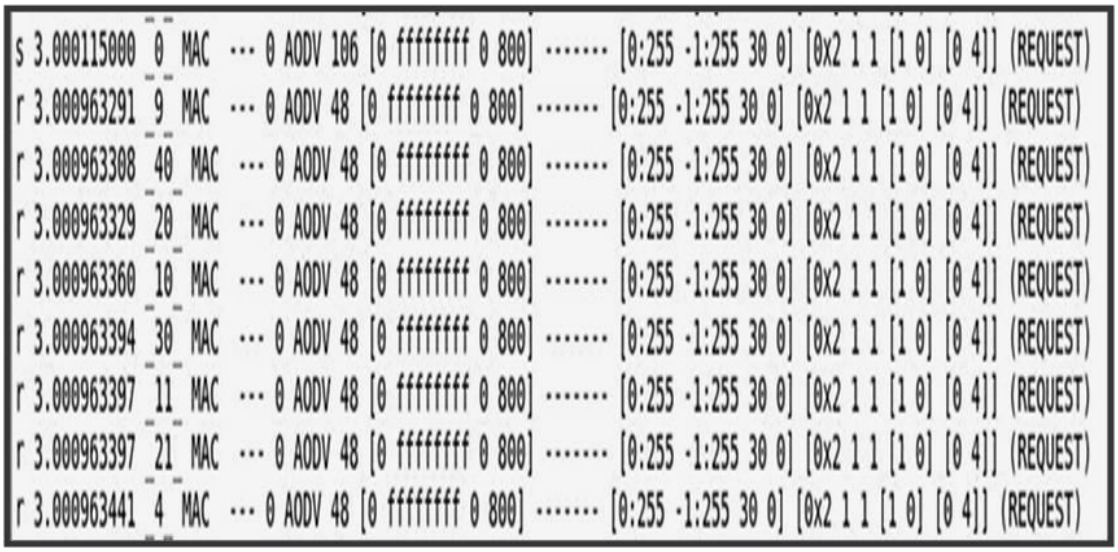

Figure 9: Trace File

The data columns/data values shown in the trace file generated during simulation of adhoc wireless network is mentioned in table 4:-

Table 4: Data Columns/Data Values in Trace File

Data Column with Data Type	Data Value
s, char r, char d, char f, char	s: Send r: Receive d: Drop f: Forward
t, double	Time
N_i , int	Node
N_x, double	X Value of Node
N_y, double	Y Value of Node
N_z, double	Z Value of Node
N_l, int	MAC, RTR, AGT
N_w, int	Reason for Network Drop
H_s, int	Hop Node - Source
H_d, int	Hop Node - Destination
M_a, hexadecimal	Time Duration
M_s, hexadecimal	Ethernet Address of Source
M_d, hexadecimal	Ethernet Address of Destination
M_t, hexadecimal	Ethernet Type
P, string	Protocol Type
P_n, string	Packet Type - UDP / TCP Packet

Here "N represents Node Property, I represents IP Level Packet Information, H represents Next Hop Information, M represents MAC Level Packet Information and P represents Packet Specific Information". The .awtscript is used to analyze the trace file with which the different types of performance metrics can be computed for different MANET

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protocols viz. "Packet Delivery Fraction/Ratio, Packet Loss, End to End Delay, Network Throughput, Normalized Routing Load, Energy Consumed by Node and Energy Left in Node"

V. CONCLUSION

In this chapter, focus is on the simulation environment which is used to implement and test the MANET protocols. A brief overview of network simulator, network components, mobility models, writing of OTCL/TCL scripts, setting up of simulation parameters, creation of nodes/objects, defining node properties, attaching nodes to channels, specifying movements of nodes, specifying traffic flow between nodes using CBR/FTP, running OTCL/TCL scripts over simulator, generation of nam and trace files and process of analysis of results using name/trace files have been presented which is used to generate network scenarios for adhoc networking environment. The performance of MANET protocols can be analyzed using this process.

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