# Simulation of Packet Telephony in Mobile Adhoc Networks Using Network Simulator

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***Abstract*—Packet Telephony has been regarded as an alternative to existing circuit switched fixed telephony. To propagate new idea regarding Packet Telephony researchers need to test their ideas in real or simulated environment. Most of the research in mobile ad-hoc networks is based on simulation. Among all available simulation tools, Network Simulator (ns2) has been most widely used for simulation of mobile ad-hoc networks. Network Simulator does not directly support Packet Telephony. The authors are proposing a technique to simulate packet telephony over mobile ad-hoc network using network simulator, ns2.**

***Keywords-Network Simulator; Mobile Ad-hoc Networks; Packet Telephony; Simulator; Voice over Internet Protocol.***

## I. Introduction

The problem of extending the reach of fixed telephonic system over an area using mobile ad-hoc network is one of the research area that has got the attention of Computer Science research fraternity. One obvious solution to the problem comes in form of Packet Telephony, used interchangeably with Voice over Internet Protocol in this work. In packet telephony real time voice conversations are transmitted from source to destination using packet switched data networks rather than a circuit switched telephone network. With the help of Packet Telephony over mobile ad-hoc networks one can extend the reach of existing fixed telephony. This whole mechanism of extending the reach of fixed telephony is also termed as Fixed to Mobile Convergence (FMC) [1]. When this extension of fixed telephony is done over a mobile ad-hoc network, the problem becomes unique due to underlying characteristics of mobile ad-hoc network. The very nature of mobile ad-hoc networks makes the extension of telephonic call multi-hop where each intermediate node acts as potential router. The solution of extending the reach of wired telephony becomes highly beneficial with use of license free ISM band for implementing FMC. To summarize this would help forwarding telephonic call to a mobile node without any cost.

The effective extension of telephonic call over the mobile ad-hoc network is constrained by various Quality of Service requirements as recommended by United Nations Consultative Committee for International Telephony & Telegraphy (CCITT). A number of Quality of Service, QoS parameters for implementation of fixed to mobile convergence in mobile ad-hoc networks has been suggested. These parameters include End to End Delay, Packet Delivery Rate, Packet Drop Rate, Throughput, Channel Utilization, Jitter etc. Any proposed system should follow strict QoS requirements to become practically viable. For example the End to End delay must be less than 250 ms otherwise the system may appear to be half duplex and user may complain about distortion and echo. In other words, QoS plays an important role in implementing Packet Telephony over Mobile Ad-hoc Networks.

Main deterrents in realizing the QoS based services over Mobile Ad-hoc Networks are a) Limited bandwidth of Mobile Ad-hoc Network b) Dynamic Topology of Mobile Ad-hoc Networks c) Limited Processing & Storing Capabilities of mobile nodes. Numbers of research works are in progress for ensuring QoS based Packet Telephony over Mobile Ad-hoc Networks.

It is not always feasible to develop a real time environment for conducting research. Then researchers have to resort on secondary means like simulation. In mobile ad-hoc network research, simulation techniques have been widely used. A number of simulation tools for developing mobile ad-hoc network environment are available. Most notable among these are Network Simulator (ns2), MATLAB, CSIM, OPNET, Qualinet, GoMoSlim etc. Out of these ns2 is most widely used tool for the simulation of mobile ad-hoc networks.

Network Simulator does not support VoIP or Packet Telephony directly. So a need was felt by the authors to devise a technique for the simulation of Packet Telephony with network simulator, ns2. The technique proposed should help users to test performance of the mobile ad-hoc network under different permutations and combinations of various network parameters.

## II. Related Work

Kurkowski et al. [2] have conducted a survey on the techniques employed by various authors for research on mobile ad-hoc networks. The authors have observed that out of 60%

authors resorting to simulation based techniques, 44% have used ns2 for drawing their conclusions.

Paolo Giacomazzi et al. [3] have worked on the issue of feasibility of fixed to mobile convergence using a mobile ad-hoc network. The authors have proposed complete system architecture for their implementation. The proposed architecture was then evaluated by the authors in terms of various quality of service (QoS) parameters like Call Drop Rate, MOS etc.

## III. BACKGROUND

A Mobile Ad-hoc Network, MANET, may be defined as a collection of autonomous nodes that communicate with each other by forming multi-hop networks and maintaining connectivity in decentralized manner. All nodes in the Mobile Ad-hoc Network are of dynamic nature. This means that the topology of mobile ad-hoc networks keeps on changing.

Mobile Ad-hoc Networks do not have fixed routers. All nodes in these networks can act as routers. Apart from this mobile ad-hoc networks are characterizes by a number of other salient features like range limitation, unreliable media, interference from other sources, dependency on the willingness of intermediate nodes, scarcity of power and vulnerability to security threats etc.

Mobile Ad-hoc Networks have been found to be very useful in emergency search and rescue operations. The reason behind this is their small deployment time. Moreover their deployment cost is also small.

Voice over Internet Protocol represents a set of rules and techniques to transport telephonic conversation over Internet Protocol. VoIP has proved to be one of the most admired and utilized application of internet these days. VoIP can prove to be a very beneficiary application. VoIP can help in achieving Fixed to Mobile Convergence (FMC) over mobile ad-hoc networks. The process behind this idea of achieving FMC over mobile ad-hoc network is illustrated in figure 2. In this figure various nodes are encircled representing their range. Various nodes with coinciding ranges may be termed as neighbors. In this figure node B is neighbor to nodes A and C. Different neighbors can exchange data through the channel. The extension of call from the fixed telephone to the node E can be explained as:

Initially analog voice conversations are digitized and then compressed using some suitable codec. Afterwards these compressed conversations are packetized in form of IP packets and then transported to E using underlined routing protocol. At E the packet are converted back to analog telephonic conversations. The main hurdle in implementing FMC over MANETs comes from the dynamic nature (see figure 1) and limited node range in these networks.

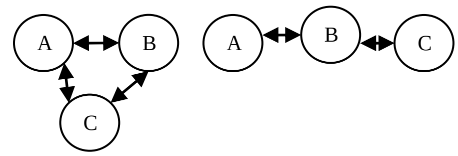


Figure 1. Dynamic Topology of MANETs

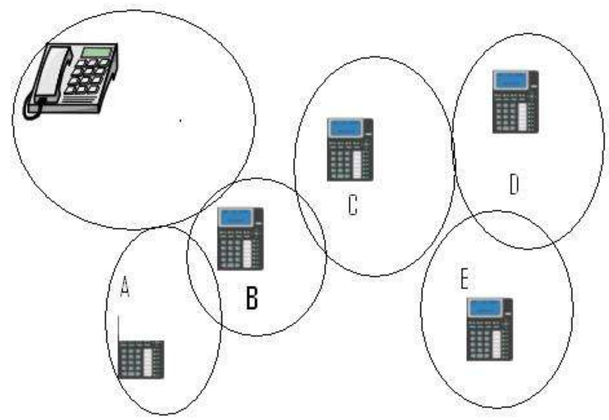


Figure 2. Fixed to Mobile Convergence over Mobile ad-hoc network

## IV. SYSTEM ARCHITECTURE

System architecture represents the protocol layer used for the implementation of a network. During this work we have used a system architecture[4]-[5] composed of five network layers (see figure 3). Various responsibilities are distributed between layers as below:

### *A. Application Layer*

The functions provided by this layer consist of digitizing & compressing the telephonic conversations in accordance with the available bandwidth. As already mentioned major constraint in implementing Packet Telephony [6] and hence FMC over the mobile ad-hoc networks comes from the limited bandwidth these networks posses. Some effective compression technique is required to overcome this limitation. A number of compression algorithms have been suggested by the International Telecommunication Union, ITU. Out of these G .729 codec [7] working at 8 kbps has been found to be most useful in scenarios where available bandwidth is small compared to the overall traffic load.

### *B. Transport Layer*

One needs to choose between TCP and UDP for implementing transport layer. TCP is connection oriented protocol whereas UDP is comparatively unreliable connectionless protocol. The implementation of TCP would require higher bandwidth as compared to implementation of

UDP. In case of wireless mobile ad-hoc networks with limited available bandwidth UDP is the obvious choice. To overcome the limitations of UDP in relatively unreliable mobile ad-hoc network RTP (Real Time Transport Protocol) is run on the top of UDP. RTP provides services like payload identification, sequence numbering etc to the UDP. Almost every device uses a standard RTP to transmit audio and video.

### C. *Network Layer*

Network layer in case of the mobile ad-hoc networks plays a central and pivotal role owing to the decentralized nature of mobile ad-hoc networks. All nodes participating in a mobile ad-hoc network acts as a potent router and forward the packets received from neighbors. A number of routing algorithms for mobile ad-hoc networks have been proposed. The routing algorithms for mobile ad-hoc networks have been classified [9]-[13] into two categories viz. topology based routing algorithms and position based routing algorithms. Due to various limitations most practical mobile ad-hoc networks employ topology based routing algorithms. Some major algorithms belonging to this category are DSR [14], DSDV [15], AODV [16], TORA.

### D. *MAC Layer*

MAC layer plays a critical role in the successful implementation of mobile ad-hoc networks. Mobile ad-hoc networks have scarcity of available channel bandwidth. Moreover MAC layer not only has the responsibility of channel sharing but also hides the complexity of wireless network from upper layers.

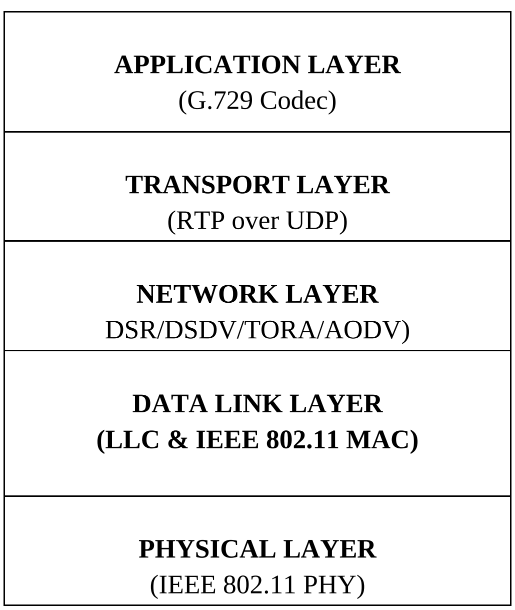


Figure 3. The Network Architecutre

So, intelligent selection of MAC layer is very important. A number of MAC solutions are available these days. A good survey on these can be found in [17]-[21]. IEEE based MAC solutions have been most widely used in practical mobile ad-hoc networks.

### E. *Physical Layer*

The responsibility with physical layer is to take data from source to destination. A number of physical layer solutions like IEEE 802.11 PHY [22]-[24], UTLA-TDD[25] are available. During this work we have implemented legacy IEEE 802.11 based physical layer.

## V. SIMULATION WITH NS2

To test new ideas researchers resort to one of two underlined techniques i.e. either testing new ideas in real time environment or testing them in simulated environment. Creation of real time environment may not be always possible. In such cases authors have to depend upon the simulation tools. In case of mobile ad-hoc networks it has been observed that around 60% of work is done using simulation tools. Ns2 is most widely used tool among various available simulation tools. This can be attributed to a number of facts like:

- Ns2 is open & its source is freely available
- A full-fledged community is working on the development of this tool.
- A number of forums exist that provide for the patches to overcome the shortage in tool.
- It is easy to interpret its results with the help of easily available tools.
- Acceptability of results generated using this is very high when compared with real environment results.

Ns2 provides a number of inbuilt features while working on mobile ad-hoc networks like:

- Propagation Model: ns2 supports Friss-Space model for short distances and approximated Two Ray Ground model for long distances.
- MAC Layer: The IEEE 802.11 Distributed Coordination Function (DCF) has been implemented in ns2.
- Network Layer: ns2 supports all popular protocols like DSR, DSDV, TORA, AODV etc.
- Transport Layer: ns2 supports all popular transport layer protocols like TCP, UDP as well as RTP.

## VI. PACKET TELEPHONY SIMULATION

The successful implementation of Packet Telephony is constrained with predefined range of various Quality of Service parameters as listed in table I.

Step 1: We propose following algorithm for implementing Packet Telephony over mobile ad-hoc network using network Physical Layer Simulation: To simulate a mobile ad-hoc network using IEEE 802.11 based physical layer working at 2.4 GHz we need to set 'phyType' variable to Phy/WirelessPhy during node configuration and then initializing various ns2 variables as in table II .

Step 2: MAC Layer Simulation: We are using IEEE 802.11 based MAC, it can be setup, while configuring nodes, by initializing 'macType' variable to Mac/802_11.

Step 3: Network Layer Simulation: Main function performed by the network layer is routing. We can configure routing algorithm of our choice by setting 'adhocRouting' variable during node configuration to the desired routing algorithm and changing the values of 'ifq' & ' ifqLen' variables accordingly.

Step 4: Transport Layer Simulation: The transport layer is simulated by attaching corresponding agent with every communication between given source and destination.

Step 5: Node Configuration: Network is made of nodes. Node configuration includes creation of nodes, initialization of nodes and mobility modeling[26] of nodes. During creation of node ns2 is informed on their radius, motion type etc. During initialization a number of node related parameters are set as in table III. The node movements are created in a separate input file that is loaded when the simulator is run. The schematic representation of 'mobilenode' in ns2 is given in figure 4.

TABLE I. QOS PARAMETERS

| Acceptable Range for QoS Parameters to successfully implement Packet Telephony | |
|---|---|
| ***Critical QoS Parameter*** | ***Acceptable Range*** |
| End to End Delay | <= 120 ms |
| Jitter | <= 40 ms |
| Packet Delivery Rate | >= 95% |
| Packet Drop Rate | < = 5% |
| Packet Loss Rate | <= 5% |

TABLE II. SETTING PHYSICAL LAYER PARAMETERS

| **Physical Layer Parameter** | **Value** |
|---|---|
| CPThresh_ | 10.0 |
| CSThresh_ | 1.559e-11 |
| RXThresh_ | 2.28289e-11 |
| Rb_ | 2.1e6 |
| Pt_ | 0.2818 |
| freq_ | 240e+6 |
| L_ | 1.0 |

TABLE III. NODE CONFIGURATION

| **Node Parameter** | **Explanation** |
|---|---|
| AdhocRouting | Type of routing algorithm |
| llType | Logical Link layer setting |
| macType | Mac layer setting |
| antType | Type of antenna with node |
| propType | Propagation/Mobility model |
| phyType | Physical Layer type |

Step 6: Scenario Generation: A mobile ad-hoc network is composed of nodes that are capable of moving within the premises of the network. So, next step is to create scenario that defines the positions of various nodes at a given time during simulation. The scenario data file is separately linked to the simulator during simulation run.

Step 7: Traffic Generation: In this work authors have proposed to use G .729 Codec for digitization and compression of telephonic conversations. Each compressed packet will be of 20B and packets will be transmitted at 50 packet/sec, hence an overall traffic of 8kbps will be generated. The connection between source and destination during the conversation will be maintained as two alternative pareto connections for transporting data in each directions. The detailed setting of traffic between source and destination are given in table-IV.

TABLE IV. Traffic Generation

| **Traffic Parameter** | **Explanation** |
|---|---|
| Type | Application/Traffic/Pareto |

| | |
|---|---|
| rate_ | 8 kbps |
| packetSize_ | 20 |
| burst_time | <Generated randomly> |
| idle_time_ | <Generated randomly> |

Traffic can be modeled in a separate input file that is loaded when simulator is run.

Step 8: Running the Simulator: Finally, the simulator created using the above steps is run and traces are collected in respective trace files.

Step 9: Analysis of output: Finally, various types of traces are analyzed using tools like NAM and MS Excel to draw conclusions. The results of trace analysis by authors are depicted in figures 5 & 6.

## VII. CONCLUSIONS

Packet Telephony is one of the most attended research topic in mobile ad-hoc networks. With the help of packet telephony telephonic calls can be extended to some mobile node in the network without any additional cost. A number of wireless solutions working in ISM band around 2.4 GHz are available in market The major problem with mobile ad-hoc networks is the limited range of its nodes, dynamic topology and scarcity of power. These limitations make study of voice over internet protocol, VoIP in mobile ad-hoc networks unique.

To establish a new idea one needs to test his idea and testing can be done either in real time environment or in simulated environment.

To test ideas on a simulated environment one must establish the authenticity of the simulation tool. For mobile ad-hoc networks network simulator, ns2 has been most extensively used for simulation of these networks.

Even the latest version of network simulator, ns-2.34 does not support VoIP directly. So, authors felt a need to propose a technique for simulation of Packet Telephony in ns2.For this purpose complete system architecture was first defined to implement packet telephony in a mobile ad-hoc network. Then a procedure was specified to perform simulation of packet telephony in network simulator.

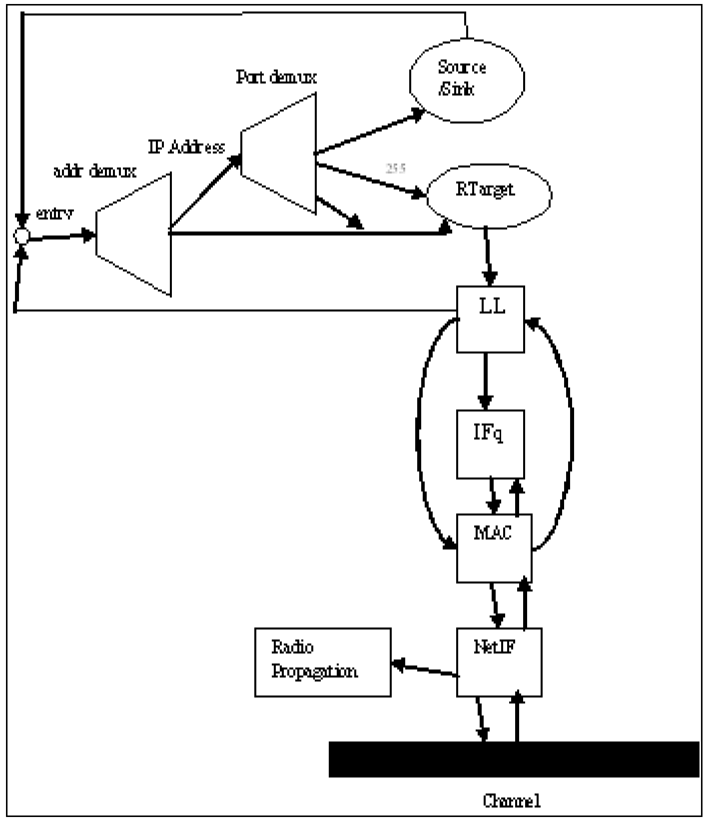


Figure 4. MobileNode in ns2 (taken from ns2 documentation)

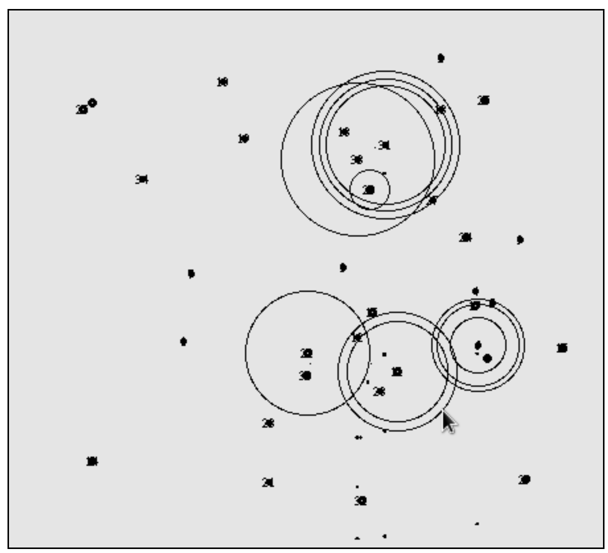

Figure 5. NAM trace output of VoIP simulation with ns2

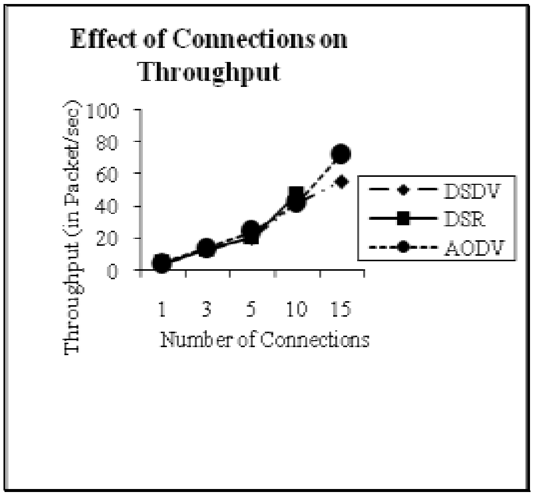


Figure 6. A Plot to compare various routing algorithms using the trace output resulting from ns2 based VoIP simulation run

## VIII. FUTURE SCOPE

In this work possible extension for ns2 to implement Packet Telephony was proposed. The overall system comprises of five layers including application, transport, network, data link and physical layers. Authors encourage proposing techniques to further extend network simulator, ns2 by proposing algorithms for other possibilities in various layers. For an example authors can provide algorithms for more realistic mobility models that are not directly supported in network simulator, ns2. These extensions would help better evaluation of packet telephony based applications.

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