STUDY AND IMPLEMENTATION OF AD-HOC ROUTING PROTOCOLS

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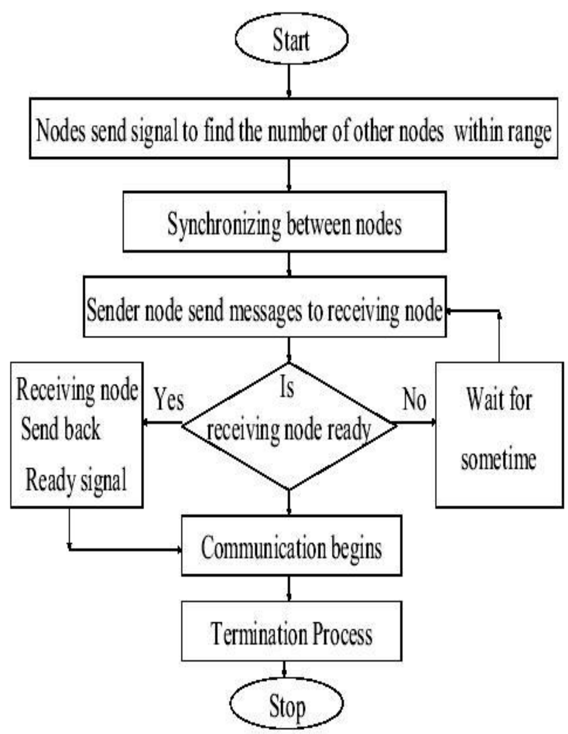
Abstract

Ad-hoc networks are characterized by a lack of infrastructure, and by a random and quickly changing network topology; thus the need for a robust dynamic routing protocol that can accommodate such an environment. Consequently, many routing algorithms have come in to existence to satisfy the needs of communications in such networks. This project work presents a performance comparison between two categories of routing protocols, table-driven (Proactive) and on-demand (Reactive) routing protocols, this two categories were illustrated by using two different examples of routing protocols, first example is DSDV (Destination Sequenced Distance-Vector) from the Proactive family and the second example is AODV (Ad Hoc On-Demand Distance Vector) from the Reactive family. Both protocols were simulated by using NS-2 (network simulator-2) package. Both routing protocols were compared in terms of average throughput (packets delivery ratio) and packet loss ratio, while varying number of nodes and by using the Trace file. Although DSDV perfectly scales to small networks with low node speeds, AODV is preferred due to its more efficient use of bandwidth.

I. INTRODUCTION

Mobile Ad Hoc Network (MANET) is a collection ofcommunication devices or nodes that wish to communicatewithout any fixed infrastructure and pre-determinedorganization of available links. The nodes in MANETthemselves are responsible for dynamically discovering othernodes to communicate. It is a self-configuring network ofmobile nodes connected by wireless links the union of whichforms an arbitrary topology. The nodes are free to moverandomly and organize themselves arbitrarily; thus, thenetwork's wireless topology may change rapidly andunpredictably

Flow Chart of generalAdhoc Network



Characteristics of MANET

1- Does not rely on a fixed infrastructure for its

operation autonomous transitory association of mobile

nodes.

2- It can be rapidly deployed with user intervention

3- Need not to operate in a stand alone fashion but can be attached to the Internet or Cellular networks.

4- Devices are free to join or leave the network and they may randomly, possibly resulting in rapid and unpredictable changes.

6 MANET Applications

Typical applications include:

1) Military battlefield. Military equipment now routinelycontains some sort of computer equipment. Ad hocnetworking would allow the military to take advantage ofcommonplace network technology to maintain an informationnetwork between the soldiers, vehicles, and militaryinformationhead quarters. The basic techniques of ad hocnetwork came from this field.

2) Commercial sector. Ad hoc can be used inemergency/rescue operations for disaster relief efforts, e.g. infire, flood, or earthquake. Emergency rescue operations musttake place where non-existing or damaged communicationsinfrastructure and rapid deployment of a communicationnetwork is needed. Information is relayed from one rescueteam member to another over a small handheld. Othercommercial scenarios include e.g. ship-to-ship ad hoc mobilecommunication, law enforcement, etc.

3) Local level. Ad hoc networks can autonomously link aninstant and temporary multimedia network using notebookcomputers or palmtop computers to spread and shareinformation among participants at an e.g. conference orclassroom. Another appropriate local level application mightbe in home networks where devices can communicate directlyto exchange information. Similarly in other civilianenvironments

like taxicab, sports stadium, boat and smallaircraft, mobile ad hoc communications will have manyapplications.

2. Ad-hoc Routing Protocols

2.1 Routing Protocols Introduction

A routing protocol is needed to send data from one device to another. Whenever the packet is to travel to its destination via several intermediate nodes, routing protocol is needed. This chapter aims to review strategies widely used in routing protocols. Several well known routing protocols are discussed and analyzed. These routing protocols may generally be categorized as:

• Table-driven (Proactive) Routing Protocol

• On-Demand (Reactive) Routing Protocol

• Hybrid Routing Protocol

Despite being designed for the same type of underlying network, the characteristics of each of these protocols are quite distinct. In the Hybrid Routing Protocol**,** each node maintains the network topology information up to m hops, based on routing information update mechanism.The following sections describe the protocols and categorize them according to their characteristics.

2.2 The OSI Layer

An **open system interconnection (OSI) model** is a set of protocols that allows any two different systems to communicate regardless of their underlying architecture. The purpose of the OSI model is to show how to facilitate communication between different systems without requiring changes to the logic of the underlying hardware and software.

The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust and interoperable.

The OSI model is layered framework for the design of network systems that allows communication between all types of computer systems. If consists of seven separate but related layers, each of which defines a part of the process of moving information across a network (see figure 2.1). Understanding the fundamentals of the OSI model provides a solid basis for exploring data communications.

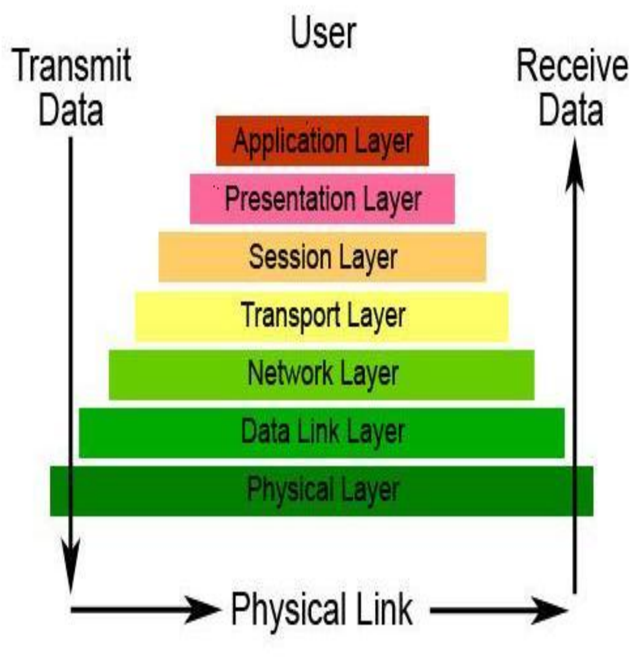


Figure 2.1 the seven layers of OSI

The OSI model is composed of seven ordered layers: physical (layer 1), data link (layer 2), network (layer 3), transport (layer 4), session (layer 5), presentation (layer 6), and application (layer 7). Within a single machine, each layer called upon the services of the layer just below it, For example layer 3 uses the services provided by layer 2 and provide services for layer 4. Between machines, layer x on one machine communicates with layer x on another machine. This communication is governed by an agreed-upon series of rules and conventions called protocols. The processes on each machine that communicate at a given layer are called (peer-to-peer processes). Communication between machines is therefore a peer-to-peer process using the protocols appropriate to a given layer. The passing of the data and network information down through the layers of the sending device and back up through the layers of the receiving device is made possible by an interface between each pair of adjacent layers

Transmission Control Protocol (TCP)

The TCP/IP protocol suite has specified two protocols for the transport layer: UDP and TCP, Figure 2.3 show the relationship of TCP to the other protocols in the TCP/IP protocol suite.

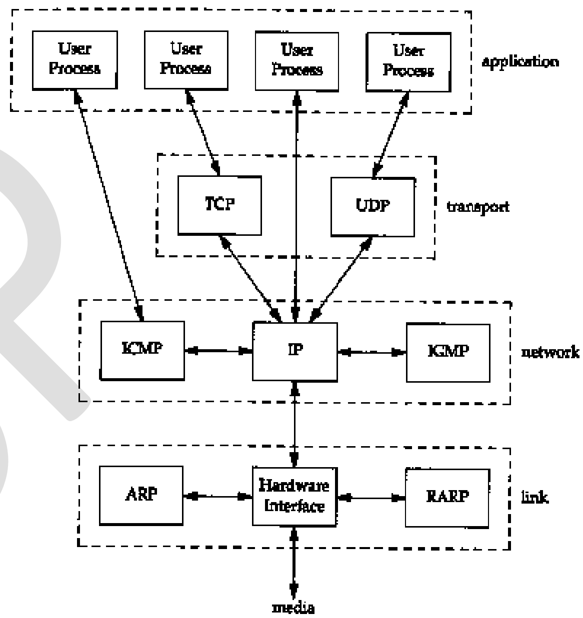


Figure 2.3 TCP/IP protocol suite

TCP lies between the application layer and the network layer and serves as the intermediary between the application programs and the network operations. TCP, unlike UDP, is a process-to-process (program-to-program) protocol. TCP, therefore, like UDP, uses port numbers. Unlike UDP, TCP is a connection-oriented protocol; it creates a virtual connection between two TCPs to send data. In addition, TCP uses flow-and error-control mechanisms at the transport level.

In brief, TCP is called a connection-oriented, reliable transport protocol. It adds connection-oriented and reliability features to the services of IP.

2.3.1 TCP Services

Let us explain the services offered by TCP to the processes at the application layer

- ***Process-to-process Communication:*** Like UDP, TCP provides process-to-process communication using port numbers.
- ***Stream Delivery Service:*** TCP, unlike UDP, is a stream-oriented protocol. It allows the receiving process to obtain data as a stream of bytes. TCP creates an environment in which the two processes seem to be connected by an imaginary "tube" that carries their data across the Internet.
- ***Sending and Receiving Process:*** because the sending and the receiving process may not write or read at the same speed, TCP needs buffers for storage. There are two buffers, the sending buffer and the receiving buffer, one for each direction.
- ***Full-Duplex Communication:*** TCP offers full-duplex services, where data can flow in both directions at the same time. Each TCP then has a sending and receiving buffer and segments move in both directions.
- ***Connection-Oriented Service:*** TCP, unlike UDP, is a connection-oriented protocol. When a process at site A wants to send a receive data from another process at site B, the following occurs:

  1- The two TCPs establish a connection between them.

  2- Data are exchange in both directions.

  3- The connection is terminated.

- ***Reliable service:*** TCP is a reliable transport protocol. It uses an acknowledgment mechanism to check the safe and sound arrival of data.

2.3.2 TCP Features

To provide the services mentioned in the previous section, TCP has several features that are briefly summarized in this section:

- ***Numbering system:*** although the TCP software keeps track of the segments being transmitted or received, there is no field for a segment number value in the segment header. Instead, there are two fields called the *sequence number* and the *acknowledgment number*. These two fields refer to the byte number and not the segment number.
- ***Flow control:*** TCP, unlike UDP, provides flow control. The receiver of the data controls how much data are to be sent by the sender. This is done to prevent the receiver from being overwhelmed with data. The numbering system allows TCP to use a byte-oriented flow control.
- ***Error control:*** to provide reliable service, TCP implements an error control mechanism. Although error control considers a segment as the unit of data for error detection (loss or corrupted segments), error control is byte-oriented.
- ***Congestion control:*** TCP, unlike UDP, takes into account congestion in the network. The amount of data sent by a sender is not only controlled by the receiver (flow control), but is also determined by the level of congestion in the network.

2.4 Routed and Routing Protocols

Before explaining the specificity of routing in an ad hoc network a definition of a routed and a routing protocol should be done.

• ***Routed protocols:*** Any network protocol that provides enough information in its network layer address to allow a packet to be forwarded from host to host based on the addressing scheme. Routed protocols are nothing more than data being transported across the networks. They define the format and use of the fields within a packet. Packets generally are conveyed from end system to end system. IP (Internet Protocol), Telnet, RPC (Remote Procedure Call), SNMP (Simple Network Management Protocol) are examples of routed protocols.

• ***Routing protocols****:* Facilitate the exchange of routing information between networks, allowing routers to build routing tables dynamically. Routing protocols are the routes which are available and which are the most efficient routes to a destination. RIP and RIP II (Routing Information Protocol), OSPF (Open Shortest Path First), BGP (Border Gateway Protocol) are examples of routing protocols.

1 Proactive Routing Protocol

These protocols are also referred to as Table Driven Routing Protocols. These protocols are extensions of the wired network routing protocols. They maintain the global topology information in the form of tables at every node. These tables are updated frequently in order to maintain consistent and accurate network state information.In proactive routing protocols, nodes continuously search for routing information with in a network, so that when a route is needed, the route is alreadyknown. Periodically floods the network to reconstruct the routing table E.g. DSDV (Destination Sequenced Distance Vector) routing protocol. The Destination Sequenced Distance- Vector (DSDV) routing protocol, is example for the protocols that belong to this category.

Their main characteristics are:

- Low route latency
- High overhead (periodic table updates)
- Route repair depends on update frequency.

3.1.1 Destination Sequenced Distance Vector (DSDV) Routing Protocol

The Destination Sequenced Distance Vector Routing protocol (DSDV) is a table-driven algorithm based on the classical Bellman-Ford routing mechanism. The improvements made to the Bellman-Ford algorithm include freedom from loops in routing tables.

Every mobile node in the network maintains a routing table in which all of the possible destinations within the network and the number of hops to each destination are recorded. Each entry is marked with a sequence number assigned by the destination node.

The sequence numbers enable the mobile nodes to distinguish stale routes from new ones, thereby avoiding the formation of routing loops. Routing table updates are periodically transmitted throughout the network in order to maintain table consistency. To help alleviate the potentially large amount of network traffic that such updates can generate, route updates can employ two possible types of packets. The first is known as a full dump. This type of packet carries all available routing information and can require multiple network protocol data units (NPDUs). During periods of occasional movement, these packets are transmitted infrequently. Smaller incremental packets are used to relay only that information which has changed since the last full dump. Each of these broadcasts should fit into a standard-size NPDU, thereby decreasing the amount of traffic generated. The mobile nodes maintain an additional table where they store the data sent in the incremental routing information packets.

New route broadcasts contain the address of the destination, the number of hops to reach the destination, the sequence number of the information received regarding the destination, as well as a new sequence number unique to the broadcast. The route labeled with the most recent sequence number is always used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize (shorten) the path. Mobiles also keep track of the settling time of routes, or the weighted average time that routes to a destination will fluctuate before the route with the best metric is received. By delaying the broadcast of a routing update by the length of the settling time, mobiles can reduce network traffic and optimize routes by eliminating those broadcasts that would occur if a better route was discovered in the very near future.

2 Reactive Routing Protocol

These protocols are also referred to as On Demand Driven or the source initiated routing protocol. It is the second category under ad hoc mobile routing protocols. For these types of protocols, it creates routes only when desired by source nodes. When a node requires a route to destination, it initiates route discovery process within the network. This process completes once one route is found or all possible route permutations are examined. Once a route is discovered and established, it is maintained by route maintenance procedure until either destination becomes inaccessible along every path from source or route is no longer desired.

Their main characteristics are:

- High route latency
- No overhead from periodic update
- Route changing can reduce latency.

3.2.1 Ad-hoc On-Demand Distance Vector (AODV) Routing Protocol

The Ad-hoc On-Demand Distance Vector (AODV) routing protocol builds on the DSDV algorithm previously described. AODV is an improvement on DSDV because it typically minimizes the number of required broadcasts by creating routes on a demand basis, as opposed to maintaining a complete list of routes as in the DSDV algorithm. The authors of AODV classify it as a pure on-demand route acquisition system, since nodes that are not on a selected path do not maintain routing information or participate in routing table exchanges.

When a source node desires to send a message to some destination node and does not already have a valid route to that destination, it initiates a path discovery process to locate the other node.

It broadcasts a route request (RREQ) packet to its neighbors, which then forward the request to their neighbors, and so on, until either the destination or an intermediate node with a "fresh enough" route to the destination is located. (Figure 3.1 a) illustrates the propagation of the broadcast RREQs across the network. AODV utilizes destination sequence numbers to ensure all routes are loop-free and contain the most recent route information. Each node maintains its own sequence number, as well as a broadcast ID. The broadcast ID is incremented for every RREQ the node initiates, and together with the node's IP address, uniquely identifies an RREQ. Along with its own sequence number and the broadcast ID, the source node includes in the RREQ the most recent sequence number it has for the destination. Intermediate nodes can reply to the RREQ only if they have a route to the destination whose corresponding destination sequence number is greater than or equal to that contained in the RREQ.

During the process of forwarding the RREQ, intermediate nodes record in their route tables the address of the neighbor from which the first copy of the broadcast packet is received, thereby establishing a reverse path. If additional copies of the same RREQ are later received, these packets are discarded. Once the RREQ reaches the destination or an intermediate node with a fresh enough route, the destination/intermediate node responds by unicasting a route reply (RREP) packet back to the neighbor from which it first received the RREQ (Fig. 3.1 b). As the RREP is routed back along the reverse path, nodes along this path set up forward route entries in their route tables which point to the node from which the RREP came. These forward route entries indicate the active forward route.

Associated with each route entry is a route timer which will cause the deletion of the entry if it is not used within the specified lifetime. Because the RREP is forwarded along the path established by the RREQ, AODV only supports the use of symmetric links.

Routes are maintained as follows. If a source node moves, it is able to reinitiate the route discovery protocol to find a new route to the destination. If a node along the route moves, its upstream neighbor notices the move and propagates a link failure notification message (an RREP with infinite metric) to each of its active upstream neighbors to inform them of the erasure of that part of the route.

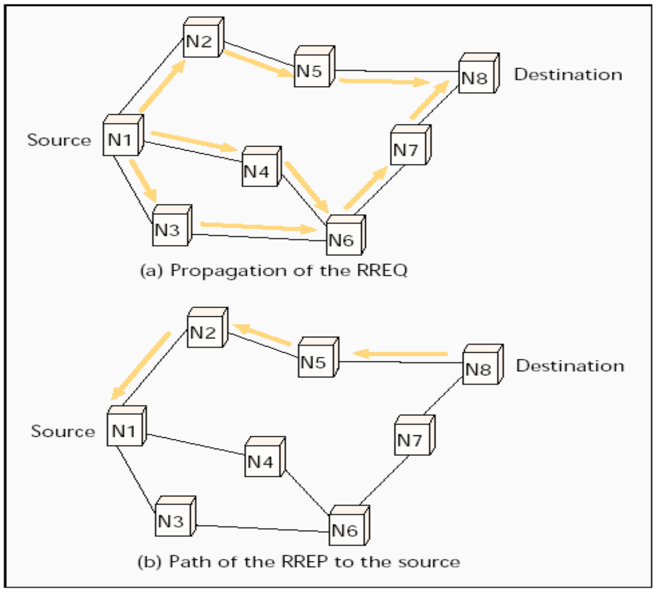


Figure 3.1 AODV route discoveries

These nodes in turn propagate the link failure notification to their upstream neighbors, and so on until the source node is reached. The source node may then choose to reinitiate route discovery for that destination if a route is still desired.

An additional aspect of the protocol is the use of hello messages, periodic local broadcasts by a node to inform each mobile node of other nodes in its neighborhood. Hello messages can be used to maintain the local connectivity of a node. However, the use of hello messages is not required. Nodes listen for retransmission of data packets to ensure that the next hop is still within reach. If such a retransmission is not heard, the node may use any one of a number of techniques, including the reception of hello messages, to determine whether the next hop is within communication range. The hello messages may list the other nodes from which a mobile has heard, thereby yielding greater knowledge of network connectivity.

Analysis of Simulation Results

When performing the simulation, we observe five phases of operation. In the first, the nodes are too far away and there is no connectivity between the source and the destination. During phase 2 the connection between nodes 0 and 5 use nodes 2, and 4 as a relay and the packets drop will start, whereas in the 3rd phase, there is a direct path between node 0 and 5, in the 4th phase the source and the destination nodes will use the node 3 as a rely, in the last phase the nodes 1 and 5 will use node 2 as a rely.

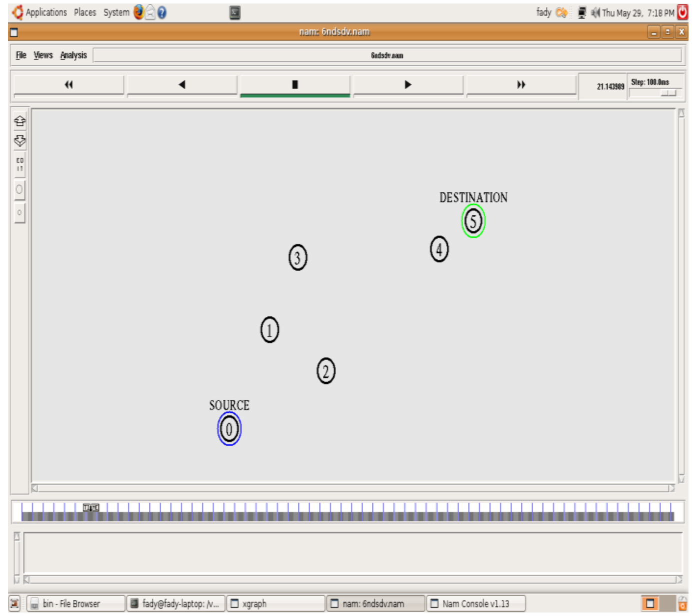


Figure 5.2 phase- 1 for DSDV routing protocol

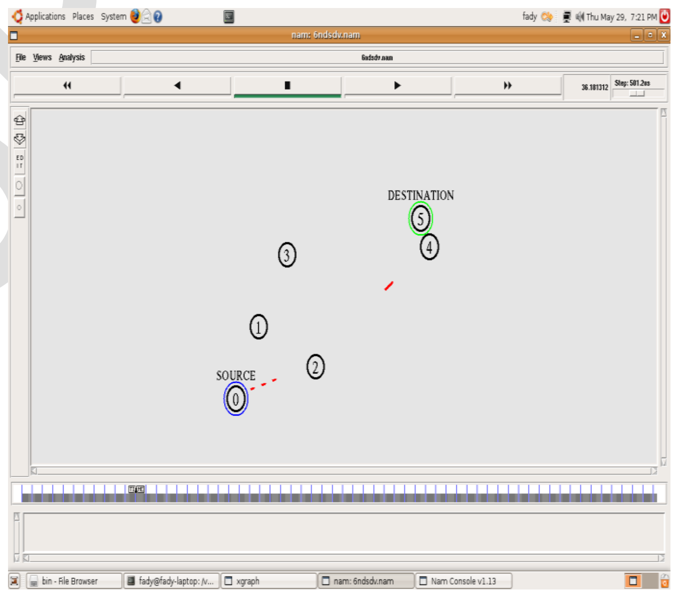


Figure 5.3 phase- 2 for DSDV routing protocol

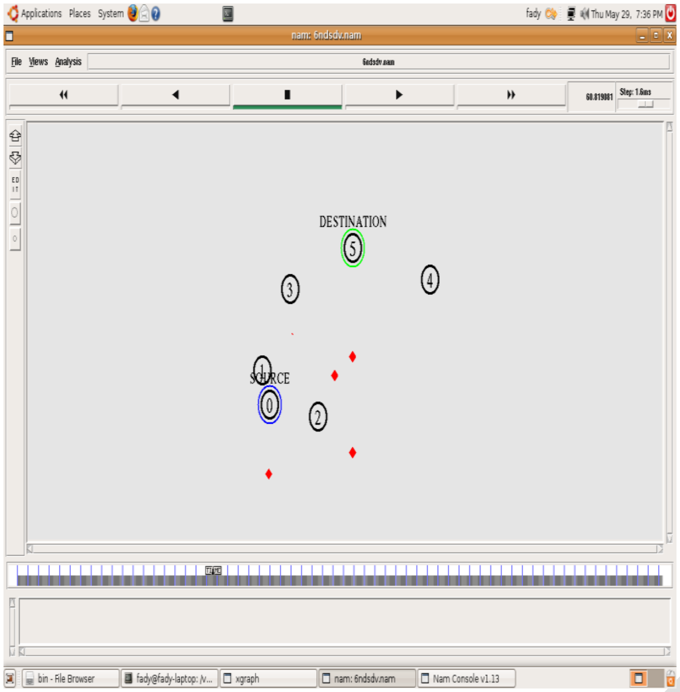


Figure 5.4 packets dropped in case of DSDV routing protocol

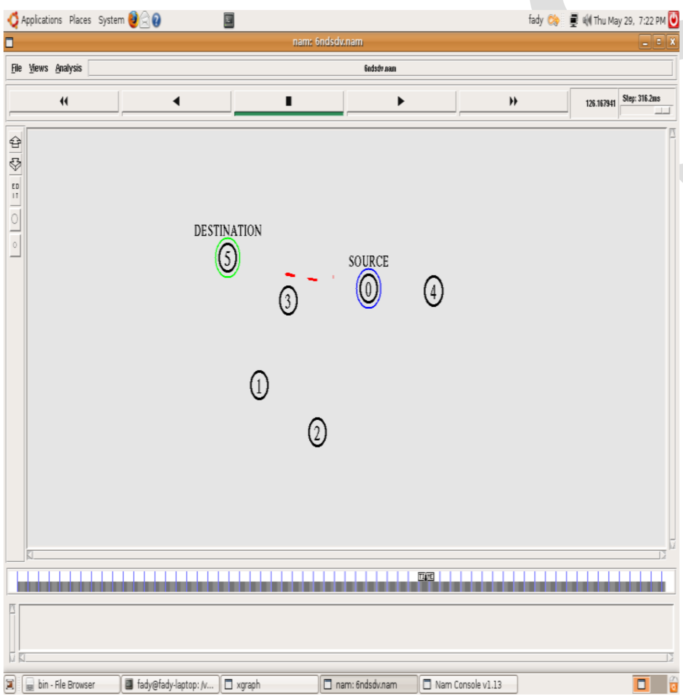


Figure 5.5 phase- 3 for DSDV routing protocol

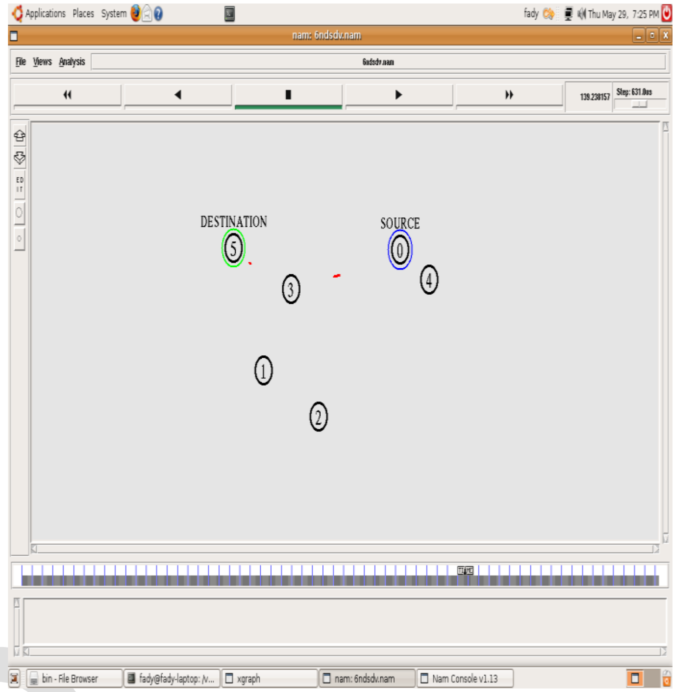


Figure 5.6 phase- 4 for DSDV routing protocol

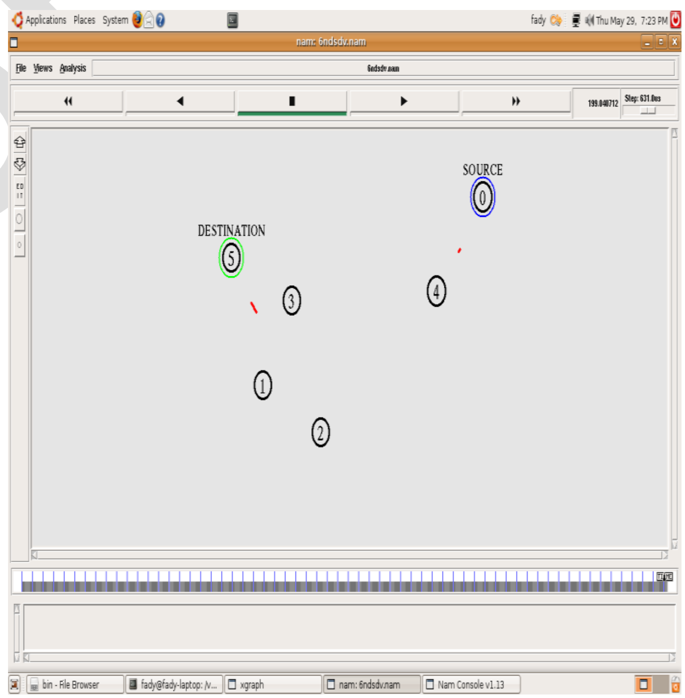


Figure 5.7 phase- 5 for DSDV routing protocol

At the beginning the nodes are too far away and a connection cannot be set. The first TCP signaling packet is transmitted at time 10 but the connection cannot be opened. After 20 seconds (time out) the connection between node 0 and node 5 will start and the packets will start passing between them. After 40 seconds node 0 will be closer to node 5, so the number of packets are increased between them. After 60 seconds, nodes 0 and 5 will be closer to each other so there is a direct connection established between them and the maximum value for packets received will be in this period (between 60-to-120 second). After that the distance between the source and the destination will increase and the mobiles get further apart till the direct link brakes and the packets drop will happen. The routing protocol is too slow to react and to create an alternative route. The window size evolution is given in figures 5.8 and 5.9 below.

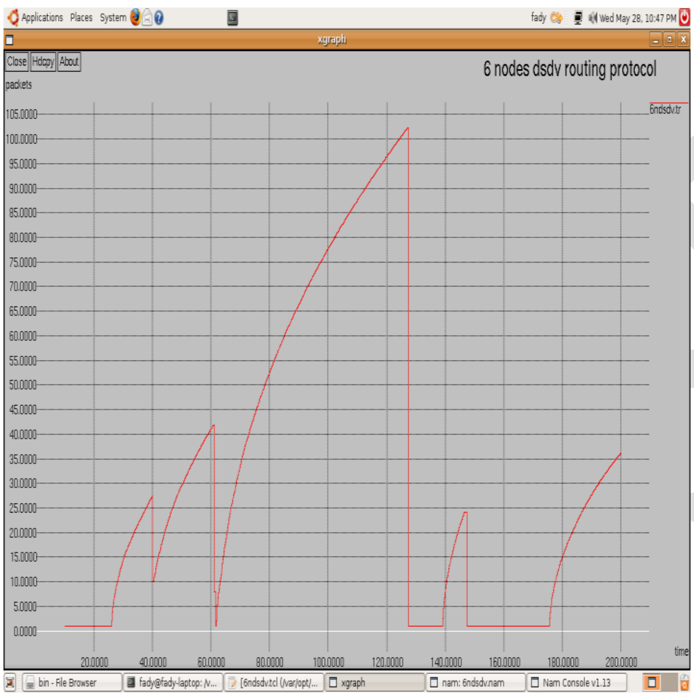


Figure 5.8 TCP window size in a six node scenario with DSDV routing protocol

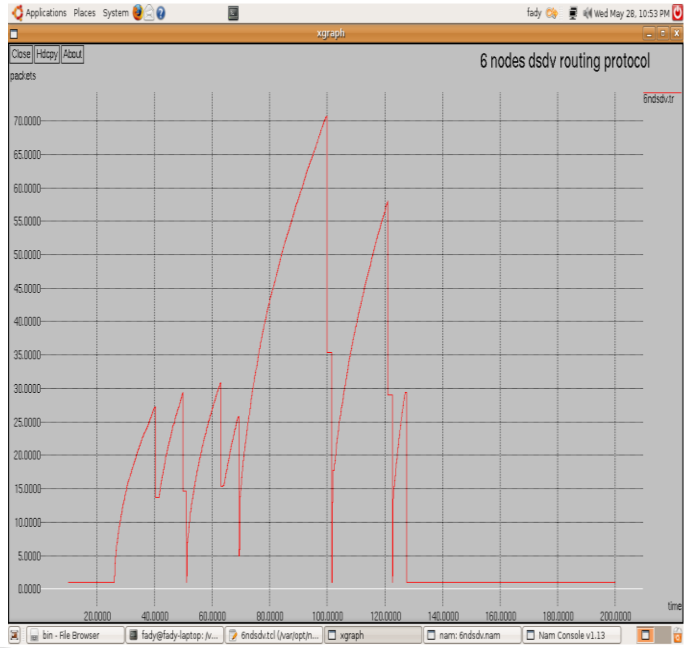


Figure 5.9 maximum windows of 2000 size evolutions for standard TCP

5.4 Simulation Scenario for AODV Routing Protocol

We start by presenting simple script that runs a single TCP connection over 6-nodes network over an area of a size of 500m over 400m depicted in fig 5.10.

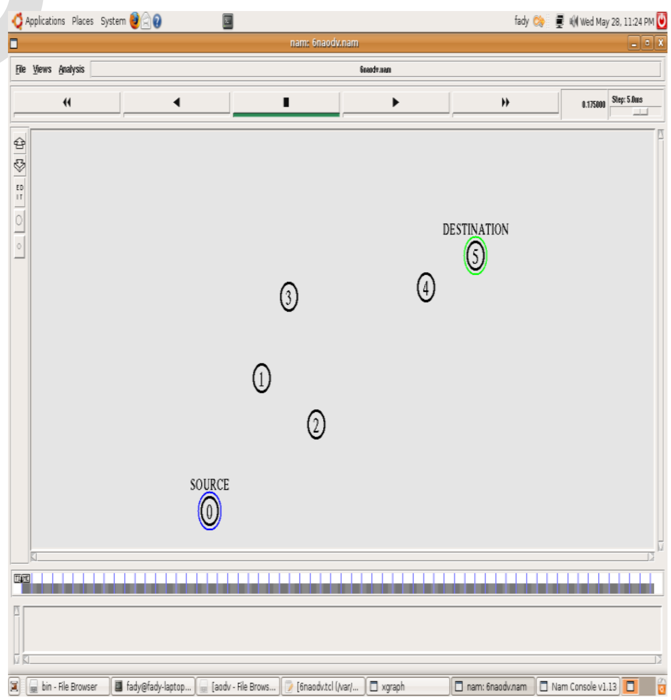


Figure 5.10 topology of a six nodes ad-hoc network

The initial location of nodes 0, 1, 2, 3, 4, 5 are respectively (5, 5), (100,150), (200,100), (150,240), (400,250), (490,285), the Z coordinate is assumed throughout to be 0.

The simulation lasts at 200 second, $ns at 200.0 "finish". At time 10, a TCP connection is initiated between node 0 and node 5, with using AODV routing protocol.

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