Performance Analysis Based On Battery Power Condition Over Wireless Sensor Network

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The thesis entitled "**Performance Analysis Based on Battery Power Condition over Wireless Sensor Network**", submitted by **Tantra Nath Jha** in partial fulfillment of the requirement for the award of the degree of "**Master of Science in Computer System and Knowledge Engineering**" has been accepted as a bona fide record of work independently carried out by him in the department.

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ABSTRACT

Wireless sensor network(WSN) is an emerging technology that has been popularized by its wide range of potential applications including military surveillance, habitat monitoring, object tracking, traffic monitoring, etc. The area that cannot be accessed easily are monitored by WSNs. The major problem or challenge of WSN is the life time of network or node due to depletion of battery energy. In many application of wireless sensor network there may be the need for the packets to be transmitted as soon as possible in such cases the slight delay can make large differences. Here, energy based routing protocol called Battery Condition Ad hoc on Demand Distance Vector (BCAODV) has used to improve the system performance of the WSN. The concept of priority of packet has been also used to handle the sensitive or delay tolerant packet. The system performance has been analyzed on the basis of packet delivery ratio, throughput and end to end delay. The packet delivery ratio and throughput has been found to be batter in case of the BCAODV than AODV protocol. However the end to end delay is better in the later one protocol. The time taken by the sensitive packet to reach its intended destination has improved when using priority. The algorithm development and simulation are carried out in Network Simulator (NS2).

Keywords: WSN; NS2; AODV; BCAODV

Table of Contents

List of Figure

List of Table

List of Abbreviations

AODV	Ad hoc on Demand Distance Vector
BCAODV	Battery Condition Ad hoc on Demand Distance Vector
CSMA/CA	Carrier Sense Multiple Access with Collision Avoidance
CTS	Clear-To-Send
CW	Contention Window
DCF	Distributed Coordination Function
LAN	Local Area Network
MAC	Medium Access Control
NAM	Network animator
NAV	Network allocation vector
NS2	Network Simulator 2xiii
QoS	Quality of Service
RF	Radio Frequency
RTS	Request to send
TCP	Transmission Control Protocol
TDMA	Time Division Multiple Access
TOS	Type of Service
TX	Transmission
UDP	User Datagram Protocol
WLAN	Wireless Local Area Network
WSN	Wireless Sensor Network

1 Introduction

1.1 Background

Wireless sensor network(WSN) is an emerging technology that has been popularized by its wide range of potential applications including military surveillance, habitat monitoring, object tracking, traffic monitoring, etc. Wireless Sensor Networks (WSNs) are extensively used whenever there is a need to monitor areas that cannot be accessed easily and to detect and alert hazardous conditions, such as fires, pollution or enemy approaching[1].It consists of sparsely distributed sensor nodes that are capable of collecting information from the environment and communicating with each other via wireless transceivers. These are often deployed in a few numbers to large quantities in remote locations and it is not feasible to replace the batteries of the devices. The data collected by each node is processed and delivered to the sink node through multi hop network [2].

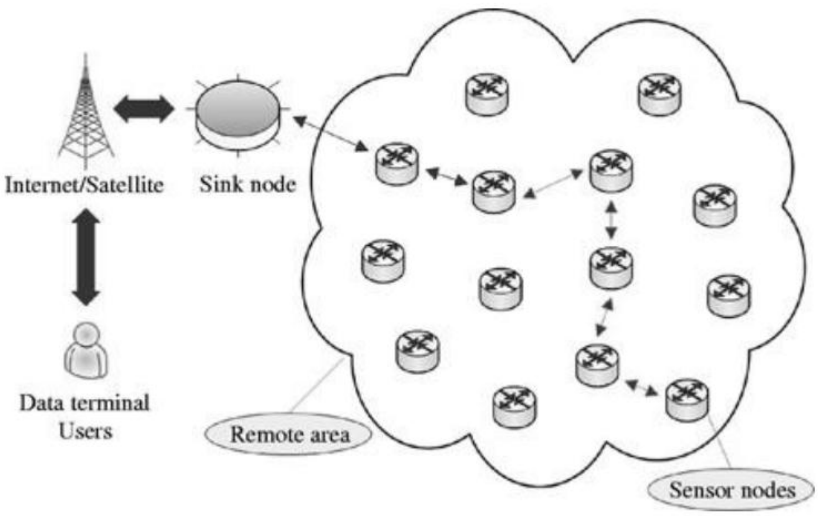

Figure 1.1 A typical wireless Sensor Network [3]

Nodes in the wireless sensor networks are deployed in an ad hoc fashion, with individual nodes remaining largely inactive for long periods of time, but then becoming suddenly active when something is detected. These characteristics of sensor networks have pointed the need for a MAC that is different from traditional wireless MACs such as IEEE 802.11 in energy consumption. Due to the use of battery powered nodes placed in remote location, energy efficiency becomes very important parameter to be considered in the wireless sensor network in comparison to the other parameters.

However, many methods deployed to make the system energy efficient in only MAC layer but not consider the residual battery power to take decision for route the packet . If the routing decision is made not only by the nearest neighbor but also take the metric as residual battery level to select the best path. Which increases the average remaining power and the lifetime of the network is increasing. The aim of this thesis is to analyze performance of sensor network considering with or without residual battery condition by using AODV and BCAODV (modify an existing ad hoc) routing algorithms in terms of residual battery power.

For sensor network, the MAC protocols like SMAC and T-MAC are used to improve the energy efficiency by applying sleep mode. However the scheduling when the sleep mode is applied is not interference free. For the scheduling to be interference free, TDMA approach can be applied. In this approach each communication link is provided with a different time slot and the links can be operated. However, a large number of time slots are required for this prompting the increase in the delay. The reason why I focus on the MAC layer is that, all other upper-layer components are dependent on the MAC layer and this makes it a primary decisive factor for the overall performance of the network[4].

Here Inbuilt 802_11 MAC is implemented. It is a low power MAC protocol with quality of service guaranteed for wireless sensor networks. There are many applications of wireless sensor network where it is needed to ensure the priority services for the critical data. So, the major advantage of this MAC protocol is that it is capable of provide priority services to the high priority data. Also MAC is implemented and the behavior of a network has been analyzed based upon the parameters like End to End delay and Packet Delivery Ratio incorporating with Battery Condition Ad hoc on Demand Distance Vector(BCAODV)and Ad hoc on Demand Distance Vector(AODV)[2].

1.2 Characteristics of Wireless Sensor Network:

The Characteristics of Wireless Sensor Networks are listed below:

- WSN consist of distributed node with each node having a battery to power it, radio device for communication and a minimal on board computing power.
- Use of battery powered device in distant location makes power consumption constrains for nodes.
- Nodes in WSN are connected to each other in ad-hoc fashion.
- Sensor nodes keep silent for most of the time, but they will become active suddenly when something is detected.
- The nodes may die or new nodes may be added over a course of time, the network should be capable of coping with it.
- The nodes used are heterogeneous, performing different sensing and working together in the large scale deployment.

1.3 Excess Power Consumption in Wireless Sensor Network:

The single most important consideration for a wireless sensor network is power consumption. While the concept of wireless sensor networks looks practical and exciting on paper, if batteries are going to have to be changed constantly, widespread adoption will not occur. Therefore, when the sensor node is designed power consumption must be minimized. There are several source of energy inefficiency. Some of them are listed below:

a. Idle listening
b. Collision
c. Overhearing

To improve the power consideration strict power management mechanisms has to be implemented. The most commonly used technique is introduction of sleep listen cycle to overcome the idle listening, transmission power control for overhearing and the collision can be overcome by proper collision avoidance multiple access technique.

1.4 Related Theory

1.4.1 IEEE 802.11 WLAN

CSMA/CA Technique:

The inbuilt MAC 802.11 is using CSMA/CA protocol. Distributed coordination function (DCF) is the fundamental MAC technique of the IEEE 802.11 based WLAN standard. DCF employs a CSMA/CA protocol. When a station sends an RTS frame, it includes the duration of time that it needs to occupy the channel. The stations that are affected by this transmission create a timer called a network allocation vector (NAV) that shows how much time must pass before these stations are allowed to check the channel for idleness. Each time a station accesses the system and sends an RTS frame, other stations start their NAV. In other words, each station, before sensing the physical medium to see if it is idle, first checks its NAV to see if it has expired.

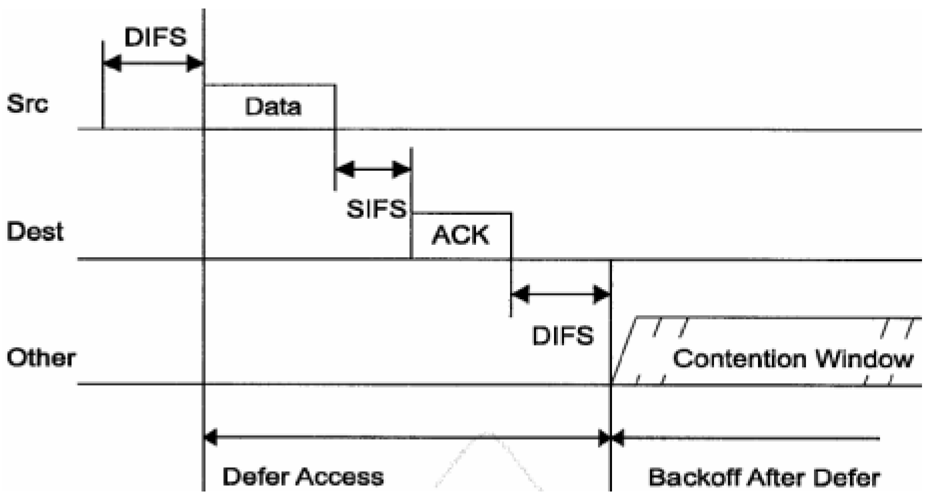

Figure 1.2 Standard Message Exchange in CSMA/CA [5]

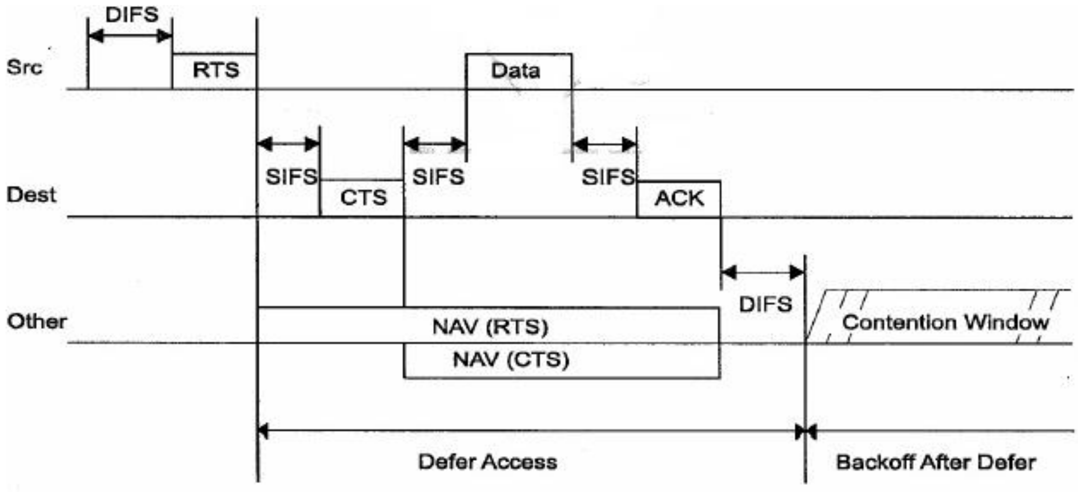

Figure 1.3 Timing Diagram CSMA/CA [5]

1.4.2 QoS Technique via 802.11

The major techniques used for ensuring QoS at the MAC layer include admission control and scheduling. In the IEEE 802.11 standard, the MAC layer provides the functionality of addressing, framing, reliability check, and access coordination to the wireless medium [6]. The MAC layer with QoS enhancements aims to provide the network with a much reduced overhead, segregating frames on the priority basis and keeping the collisions to the least possible level. That can be achieved by modifying the parameters that define how a station or node would access the wireless medium based on DCF. Although the contention-free service in the PCF is designed in 802.11 networks to provide QoS for real-time traffic but this service is for Infrastructure mode which is undesirable for WSN. Solutions using the Hybrid coordination function (HCF) that introduce priorities.

1.4.3 AODV ROUTING

The AODV is another simple and efficient routing protocol targeted for mobile ad hoc networks. It can quickly define routes between any sources to destination nodes. The notification of link failure and topology change will be provided in timely manner. The important messages behind AODV is Route Request (RREQ), Route Reply (RREP) and Route Error (RERR). A source node interested to send data packet to any destination node will first issue RREQ packet. The RREQ packet is forwarded to the destination node via intermediate nodes. When the destination node receives RREQ, it then replies to source node via RREP. When there is link failure, AODV will send link failure information via RERR message. AODV do not need to maintain the route if the destination are not involved in active communication. Another prime attribute of AODV is the implication of the destination sequence number. It provides more flexibility to the source node during the route selection process. Loop free nature is another key characteristic of AODV routing protocol.

1.4.4 Analytical calculation of consumption energy model

Here Energy=Power *Time. This is, when a node sends or receives a data packet, the energy which is consumed by the node is determined by the transmission power or the received power of the node and the time needed for handling the data packet. Among the time needed for handling a data packet is:

Time=8×Packetsize/Bandwidth

Therefore,

Etx = Ptx×8×Packetsize/Bandwidth.

Erx = Prx×8×Packetsize/Bandwidth. Here, Ptx is the transmission power, Prx is the receiving power. Etx and Erx indicate the amount of energy consumed by a node.

The total energy consumed by a node forwarding a data packet Efull by considering other neglects.

Efull=Etx+Erx+Eidle.

Assumption that the total Battery energy at node “a” is Eafull obeys uniform distribution on [0, Eafull].

1.5 Problem Statement

The use of wireless sensor network has been increasing extensively nowadays and a major breakthrough has been achieved in its application and advancement. However, due to the distributed remote location of the nodes, it cannot be accessed frequently and these battery powered devices are prone to exhausting their batteries and becoming dead, if proper care is not employed. In many application of wireless sensor network there may be the need for the packets to be transmitted as soon as possible in such cases the slight delay can make large differences. So, the concept of priority packet is implemented which uses the novel technique to achieve energy efficiency as well as minimization of delay and also increasing network life considering battery power level in wireless sensor network for routing.

1.6 Objective

To achieve optimum use of Wireless Sensor Network by

- Analyze the performance of network on the basis of parameter end-to-end delay and packet delivery ratio.
- To improve the life of the WSN node on the basis of its residual battery energy level.
- Handling the delay sensitive data.

1.7 Motivation

Wireless sensor Networks have been the recent research trend in the field of scientific community of late. The practicality of this sector and the future scope it carries with regards to its implementation and useful consequences motivated me to take this sector as part of my thesis topic. Most of the work has not taken account of battery energy and the delay sensitive packets both for the analysis of WSN. So this motivates me to take the opportunity of analyzing WSN on the above basis.

2 Literature Review

The concept of sensor network has been made viable by the advances in micro electro mechanical systems technology, wireless communications computer network and digital electronics. Sensor network consist of sensing, data processing and communication components. The sensor nodes form an ad hoc network and these are capable of working in various environment. From military application, environment monitoring, home appliances to health monitoring, they can be used anywhere with efficiency. The protocol stack used by the sensor node combines power and routing awareness, integrates data with networking protocols, communicates power efficiently through the wireless medium and promotes cooperative efforts of sensor nodes[4]. The protocol stack consists of application layer, transport layer, network layer, data link layer and the physical layer. The application layer gives proper user interface, transport layer helps to maintain the flow of data, network layer takes care of routing, and MAC protocol must be aware of power and minimize collision and physical layer addresses the needs for a robust modulation, transmission and receiving technique.

Sensor networks are the key to gathering the information needed from spatially distributed locations whether in buildings, utilities, industrial, home, shipboard, transportation systems automation and many more. The network topology is important parameter in any of the network. It is also important in wireless sensor network. Commonly used type is network in wireless sensor networks are mesh which may be used in conjuncture with other type of network. Another important thing in the wireless senor network is the multiple access protocols. Traditionally FDMA, TDMA and CDMA had been used. But due to the complexity involved in FDMA and CDMA, TDMA had been given preferences. But with new researches coming in different types of MAC protocol had been purposed for the specific requirements. In most of the cases, conservation of the energy is the primary focus.

In [2]there are several commonly used MAC protocols in wireless sensor network. TDMA being the most basic medium access technique helps to minimize the energy consumption due to the idle listening in wireless sensor network by allocating time slot to each nodes individually. Even though these MAC protocols provide energy efficiency, they have very high delay and no any priority could be assigned for any high priority data and all the incoming data are treated equally. These MAC protocol have been individually proposed either to improve the energy efficiency or improve delay suffered by critical packets by allocating priority.

In [4] However, In there is tradeoff between these two parameters and no MAC protocol mentioned above are capable of addressing the delay as well as energy efficiency need of wireless sensor network.

While in [6] the Internet and data networking models of the IEEE 802.11 WLAN technology, which are based on the datagram delivery model of IP, provide simple, adaptive and fault resilient network, they are ill-suited to QoS provisioning. The underlying datagram model of IP is a best-effort service—i.e., while the network tries to deliver packet to the destination correctly without any packet losses, it makes no guarantees. Multimedia applications, in particular, need stronger guarantees about the minimum throughput and maximum latency to work satisfactorily. An expensive solution for ensuring QoS is to overprovision. Most of the Internet QoS effort has focus down how to get a network with less capacity meet application but this service is for Infrastructure mode which is undesirable for WSN.

In[7] for routing some nodes become responsible for outing packets from many source destination pairs. After a short period of time, the energy resources of those nodes get depleted, which leads to node failure. It is therefore significant that the routing protocols designed for ad hoc networks take into account this problem. Indeed, a better choice of routes is one where packets get routed through paths that may be longer but that contain only nodes that have enough energy. For the last decade, many researches had been performed in mobile ad hoc networks (MANETs), especially in routing protocol of Ad hoc on demand Distance Vector (AODV) for the optimization or better performance.

3 Methodology

This thesis work is concerned with the battery power condition and the MAC layer condition. The figure 3.1 show the steps followed in this thesis work.

The inbuilt IEEE 802.11 MAC protocol is considered as for the Wireless Sensor Networks (WSNs) in term of energy consumption .Assign priority to the delay sensitive packet by contention size. The Performance of the network is analyzed in terms of 3 major parameter i.e. End to End delay, packet delivery ratio and throughput of priority packet versus normal packet. The effects of these three parameters with varying number of sensor nodes is analyzed and evaluated.

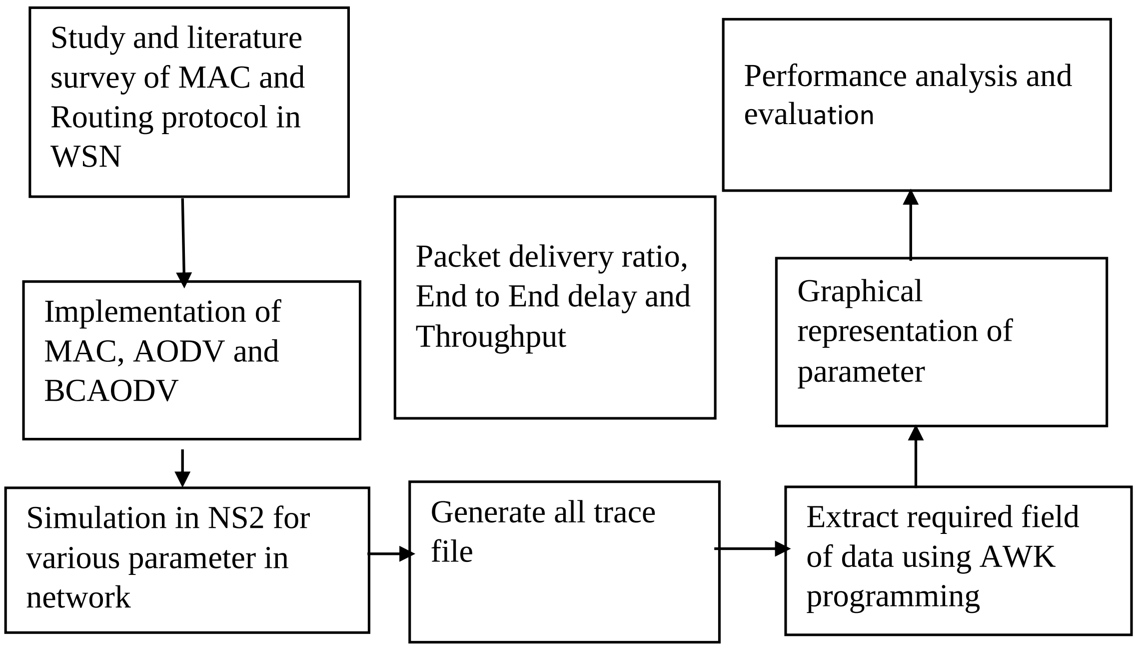

Figure 3.1 Different Stages of the system

The methodology has been divided into two parts.

3.1 Design of BCAODV

While searching a route, each node uses local information about its own battery to decide whether to take part or not in the route selection process. Thus, a node whose battery is exhausted can preserve its remaining energy by refusing to relay packets which are not intended to it. This is called a local approach, since the decision of a node is only based on its own state and does not require global information about the entire network, neither about its neighbors. We have chosen to adapt this approach to one of the most known routing protocol, AODV. The principle is to modify both of the route discovery and the route maintenance procedures, in the following way

1) Route Discovery

When a source node wants to reach a destination node, it starts the route discovery process and broadcasts the route request packets (RREQ), as in AODV. But when an intermediate node receives this request, there is an additional step that it has to do before sending the packet: it must compare its remaining energy with a certain threshold. If it finds that its energy level exceeds the threshold value, it rebroadcasts the request to all its neighbors. In the other case, the node concludes that its remaining energy is not enough anymore to route the others‟ packets. Therefore, the node rejects the RREQ packets and ignores the request. As soon as the destination receives the first RREQ packet, it transmits a RREP towards the source

2) Route Maintenance

Once the remaining energy below the threshold, the node must send a RRER packet to the source in order to launch a new route discovery process. The route is removed from the routing tables and update new table exclude the RRER sender node.

3.1.1 BCAODV routing algorithms implementation

If source wants to send data to destination then

{AODV ( )

{

For (each node between S and D)

{

Calculated energy of each node with the help of Energy Model

When any node receives a packet

{

If (Node Energy >Eth)

{

Receive RREQ packet and forward it to next Hop.

Route maintenance is done in which the next hop is selected based on remaining energy of a node.

}

Else

{No REPLY

It sends a RERR to the last node and source need to call AODV () again

}}}}

3.2 Priority Assignment to Sensitive Data and Back off time Assignment

3.2.1 Algorithms of Assigning Priority to Sensitive Packets

MAC classifies packets according to their importance (i.e. delay requirements) and stored the packets into the appropriate queue. The source node knows the degree of importance of the sensed data and accordingly the application layer sets the priority.

3.2.2 Back off Time Assignment

In DCF procedure, back off mechanism reduces the risk of collision but it does not remove this phenomenon completely and when a collision occurs again (no response of ACK packet), a new back off will be generated randomly. At each collision, window size increase in order to reduce the probability of such collisions to happen again. In the standard solution, CW values will change between given CWMin and CWMax values. When a packet is successfully transmitted, the CW is reset to CWMin Back off time for basic DCF is N * (Slot Time). Where Slot Time is function of physical layer parameters. When the value of attempt reaches an upper limit, the random range (CWMax) remains the same and when a packet is successfully transmitted, the CW is reset to CWMin. The back off time is given by Back off Time = Random() * Slot Time, where Random() is a pseudorandom integer drawn from a uniform distribution over the interval [0,CW]. CWMin and CWMax are respectively minimum and maximum value of CW. For the sensitive packet, the CWMin and CWMax are chosen such that the back off time generated will be always less than the normal packet. So the chance of getting channel access will be higher for the sensitive packet and it will reach the destination without too much delay.

3.3 Proposed System

Here, the figure 3.3 shows the flow chart of my proposed system. The work is started by initializing all the nodes, and then it will wait until they have data to send. When the node will have data to send then the nature of data will be checked. If the data will be sensitive then the node will be given priority to send its data without too much delay. After that the battery level of the node will be sensed and if the level will be below threshold value then it will be serviced with BCAODV routing protocol to enhanced its life in the network otherwise it will wait for a random back-off time and then the channel will be sensed, and if free then the data will be sent.

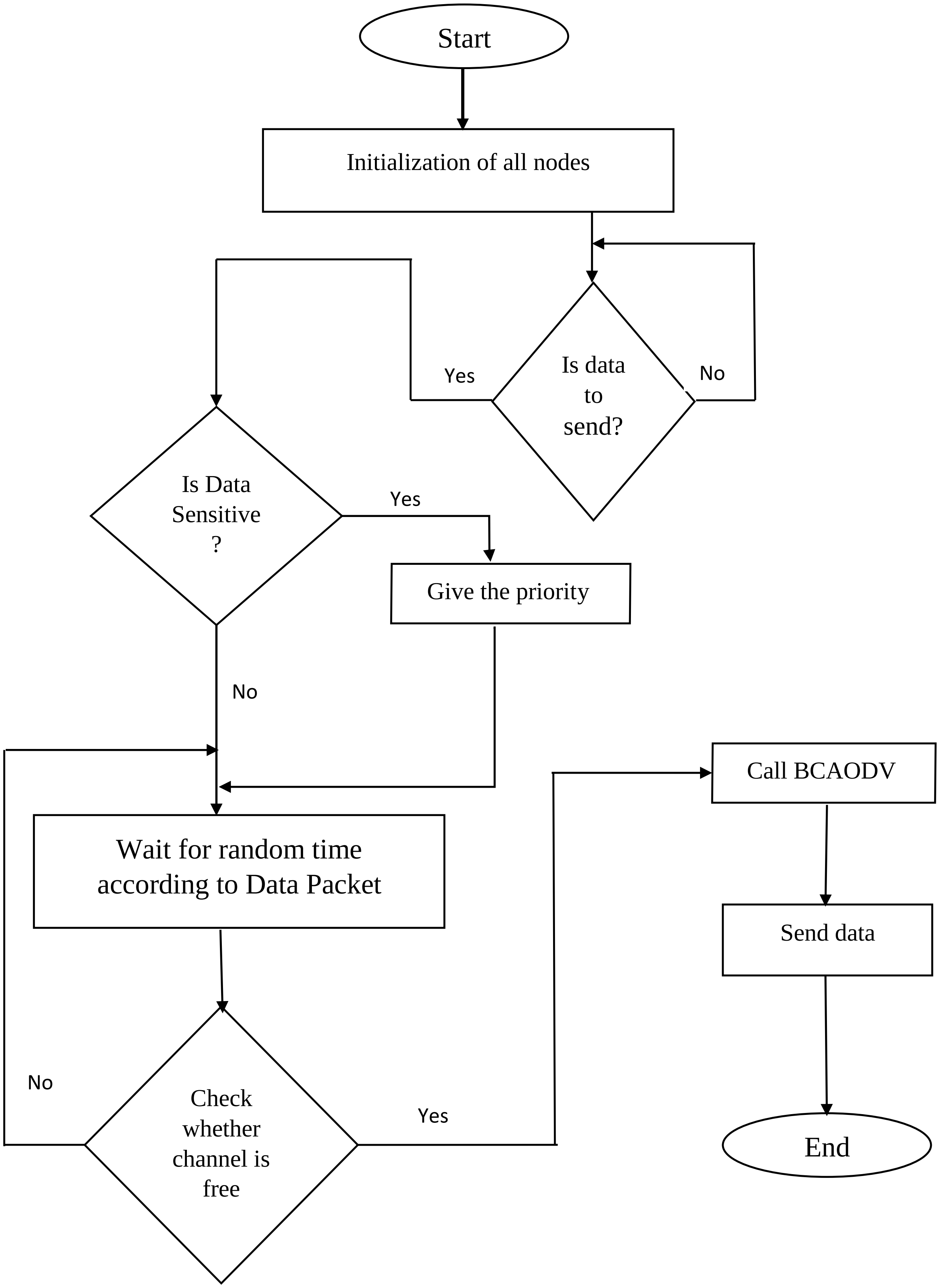

Figure 3.2 Flow chart of the system

4 Result Analysis and Comparison

4.1 Implementation

4.2 NS2 SIMULATION

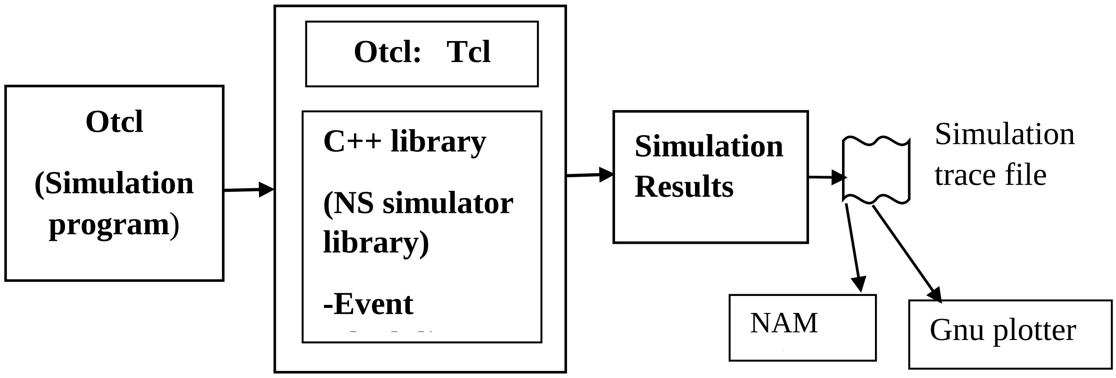

Figure 4.1 Basic Architecture for implement of NS2 [8]

The above figure in 4.1 shows the basic architecture of NS2. The NS2 by default provides, an executable command "ns" which takes an input argument to execute the required simulation. The input argument is actually the TCL simulation script file in which the basic simulation environment and parameters are defined. Once, the TCL file is executed by the NS2. It creates the trace file based on which we can get the animation in the NAM window or obtain data to plot in the convenient tool. The simulation script written in TCL is executed by the NS2 on the basis of the back end program which has been defined for the simulation.

Network Simulator mainly uses two languages namely Object Oriented Tool Command Language (OTCL) and C++. The C++ and OTCL is linked together by TclCL which is used to create the simulation and define basic parameters of the network to simulate.. Since TCL is a front end language, it is more useful in simulation of slightly varying parameters or configuration. TCL is commonly used for quickly exploring a number of scenarios; change the model and re run the simulation. C++ is more predominantly used for bye manipulation, packet processing, and algorithm implementation. Back end Programming language has comparatively slower turnaround time (i.e. run simulation, find bug, fix bug, recompile and re-run).

NS2 Simulation steps:

The Simulation in NS2 primarily consists of three main steps i.e. simulation design, configuring and running simulation and post simulation processing.

Simulation Design:

This very first step of simulation in NS2 involves the design of simulation environment. The users should be aware of and define the purpose of simulation, network configuration used in the simulation, the parameters based on which the performance is measured and the type of expected results. This usually involves getting all the parameters and protocols used in the simulation.

Configuration and Running Simulation:

Once the simulation is designed, it should be configured to run properly. The first phase is network configuration, which involves creation and configuration of network components like nodes and the various protocols used. Also, the events in the simulation such as the schedule time of data transfer to start and end is also mentioned. Once the network configuration is over, the simulation phase is started. It starts the simulation for the network configured in the network configuration phase. Events are executed in the chronological order. This phase runs until the clock reaches the threshold value defined in the network configuration phase. This involves running the simulation and obtaining the trace file.

Post Simulation Processing:

Once, the simulation is run, the integrity of the program run has to be verified which is called debugging and the performance of the simulated network is evaluated by collecting and compiling the simulation results. The final step involves, analyzing the trace file obtained from the simulation to get the required parameter to analyze the performance of the network.

TCL Script:

The TCL script is the front end language used in the simulation. The script has been used to define the topology i.e. create the nodes, set their
Distance of separation and create their overall topology by defining how they are placed in the network. Also it has been used to define link between nodes and the capacity of the link, data rate of transmission, packet size, transmitter and receiver threshold level, which protocol to access from back end, start and end of simulation, etc.

4.2.1 Communication Model

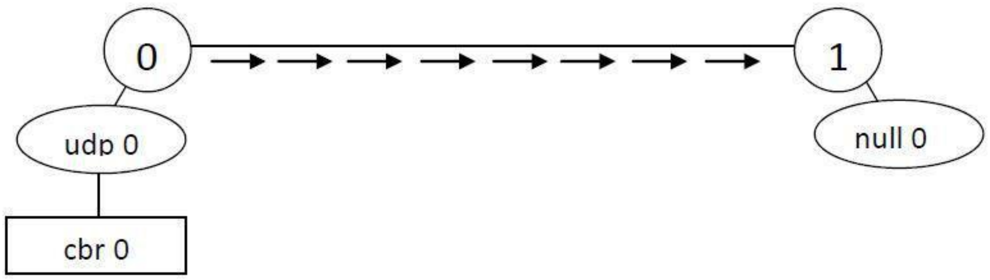

Figure 4.2 Communication Model between Two Nodes [8]

The above shown in figure 4.2 is the general communication model which can be achieved by using the TCL language in the NS2. Here Node 0 is the transmitter node and Node 1 is the receiver node. The communication is unidirectional between these two nodes. A UDP agent and CBR agent is required for the transmitter node and a null agent for the receiver node. "CBR 0" is agent for node 0 which is constant bit rate. It generates packet with the defined packet size at the defined rate. The simulation (i.e. transmission of packets, movement of nodes, etc.) can be visualized in GUI environment by the help of the Network Animator (NAM), which is a part of NS. To access this animator a NAM
Trace file has to be used. There are predefined codes for number of link, their paths, data rate, bandwidth, packet size and several other parameters. Hence, the network can be simulated under certain conditions, links, protocols, etc. as defined by the user.

C++ language:

The C++ language is the back end language used in the NS2 simulator. This is used to create the algorithm and protocols which is accessed by the front end language to simulate and see the result. Once, the protocol has been defined, it is compiled and accessed through the front end using proper variables to simulate and obtain the results. The major advantage of C++ in back end is its fast run time. However, if the input has to be regularly given, the back needs to be compiled every time resulting in the delay for running the simulation.

Linkage between and Otcl and C++:

NS2 has been written in two languages i.e. Otcl and C++. While Otcl is for the user interface, C++ actually runs the simulation from behind. The class hierarchies of both languages can be either standalone or linked together using an Otcl and C++ interface called TclCL. There are two types of class hierarchies called as the interpreted hierarchy and the compiled hierarchy in Otcl and C++ respectively. These include the Otcl and C++ classes which are linked together. But, there are also classes which are not at all linked together

.

Table 4.1 Simulation Parameter for node configuration

Channel	Wireless channel
Antenna	Omni directional
Queue	Drop Tail/Priority
Routing	AODV and BCAODV
Data Generated	CBR
Topology	Flat grid

Table 4.2 General Simulation Parameter for NS2

Initial Energy	30 joules
Number of node	11,15,20,25,30,35 and 40
Packet Size	1000 bytes*1000 packs/s
Simulation Time	50 seconds
Idle listening Power consumption	0.005 watts
Receive Power consumption	0.3 watts
Transmission Power consumption	0.6watts

Carrier Sense Threshold	8.10074e-10 watts(default for 200 m range [10]
Receiver Threshold	8.10074e-10 watts(default for 200 m range [10]
Maximum range of transmission	200 meters
Two node distance	150 meters
MAC	802.11/802.11Exth(2Mbps)
Contention Window Size (31, 91)	Delay sensitive data
Contention Window Size (91,1023)	Normal data
Time Slot for DSSS(Physical Parameter)	20 micro second

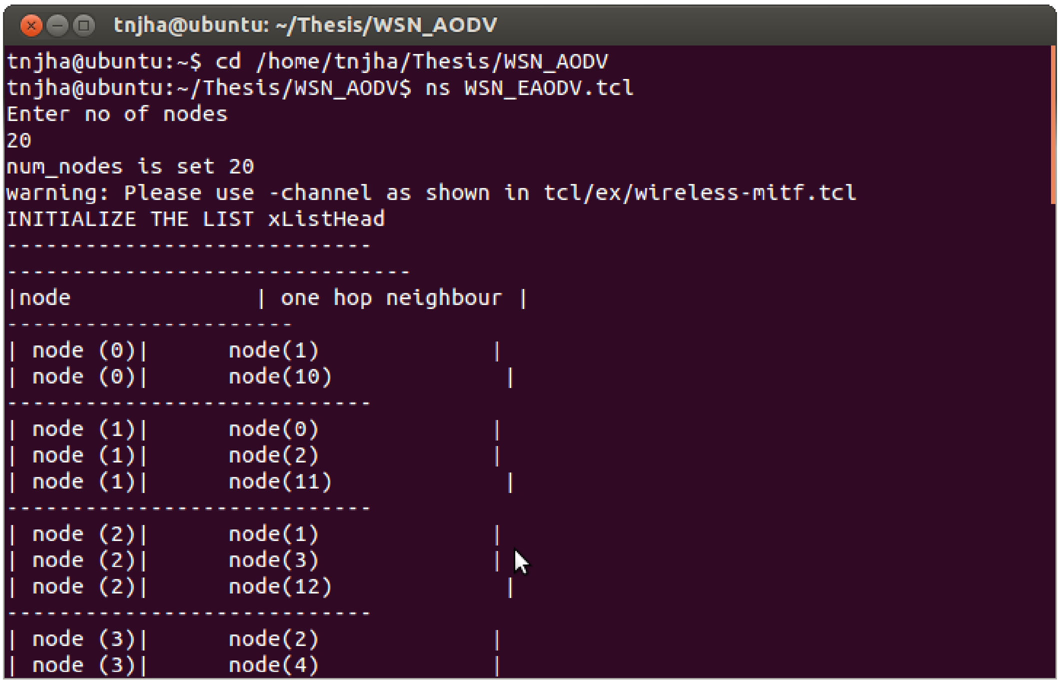

Figure 4.3 Routing table of neighbor discovery within range

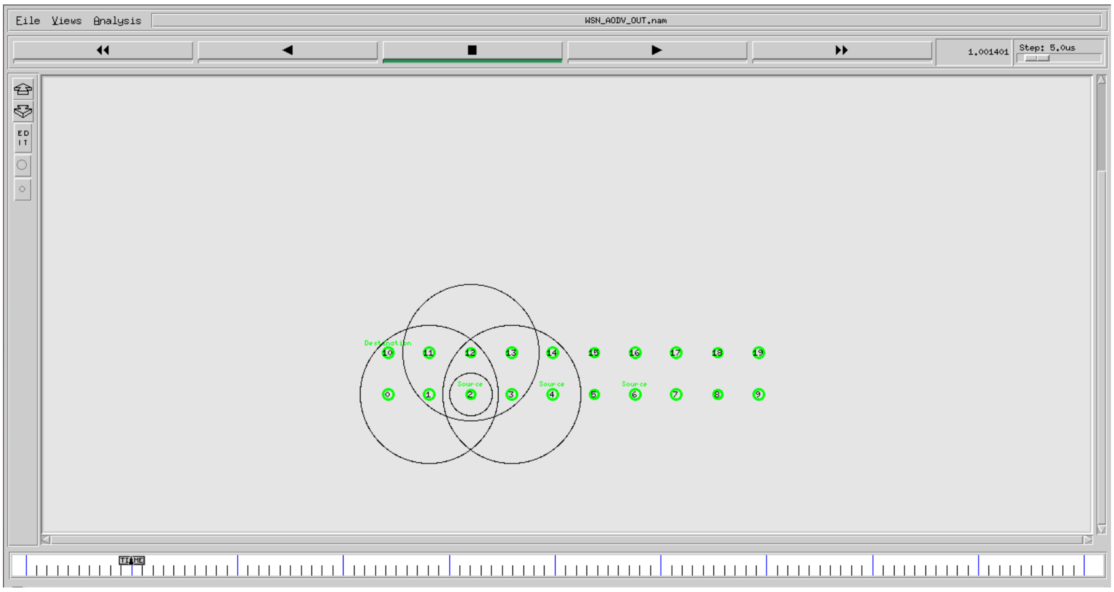

Figure 4.4 Hello packet transmission for route discovery

The figure 4.4 shows the snap of route discovery from source, which is at node (2). Here the circle shows the generation of HELLO packet and its radius shows the transmission and range.

Figure 4.5 Packet transmission

Here figure 4.5 shows the packet transmission from source to destination via multi hop communication.

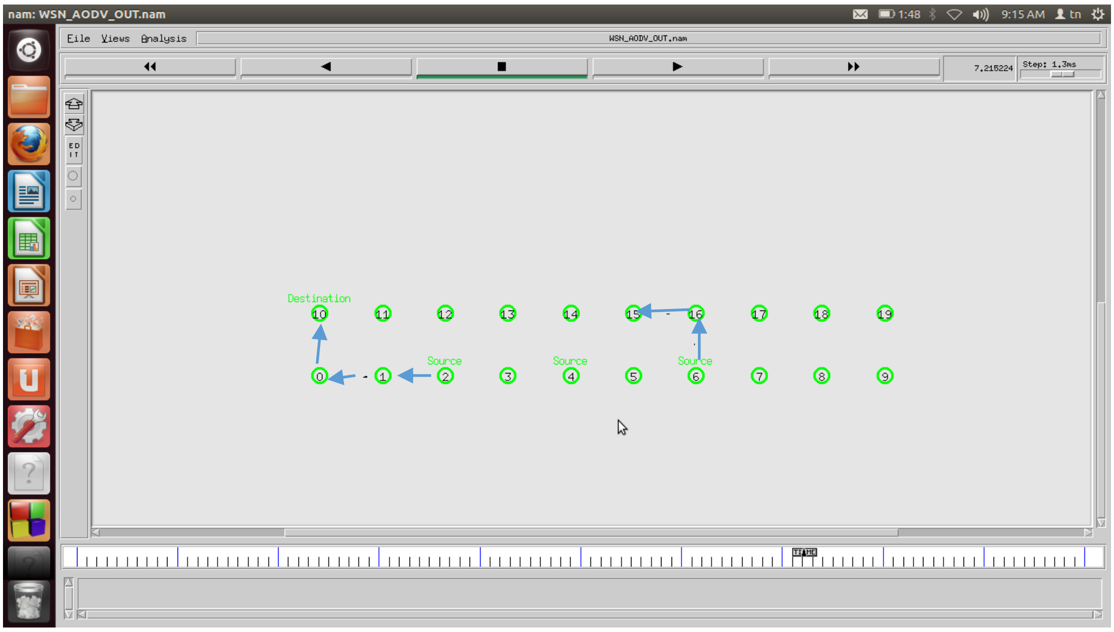

Figure 4.6 Packets forwarding from different source

Here in Figure 4.6 Packets are forwarding from different source to its destination. From source node (2) to destination node (10), from source node (6) to destination node (10) and from source node (4) to destination node (10).

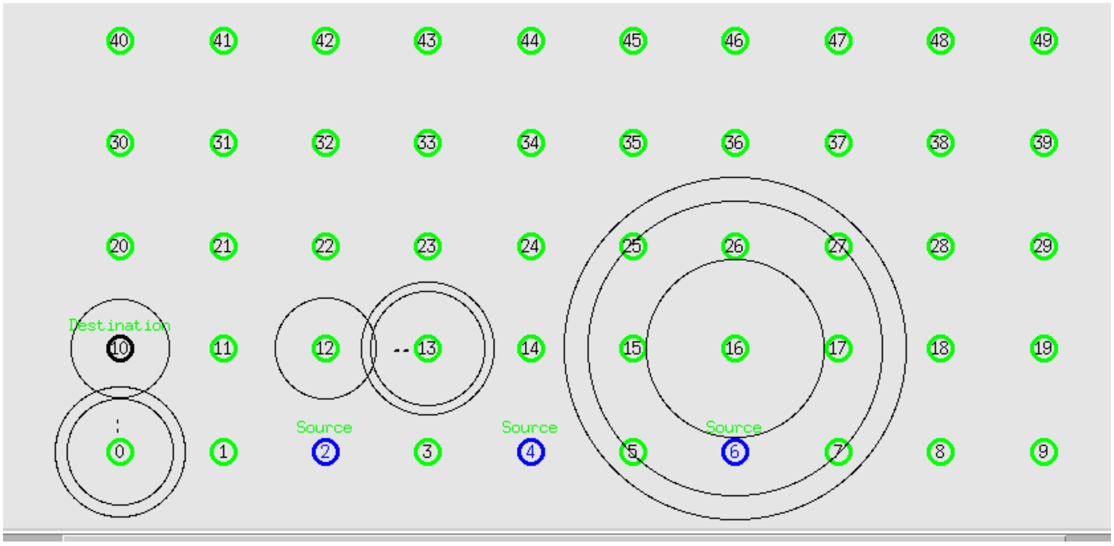

Figure 4.7 AODV Packet forwarding

Here in figure 4.7 less number of Intermediate node is participating to forward the packet from source to destination until node dead condition mean more battery energy is consuming for particular node, Residual battery level is more uneven.

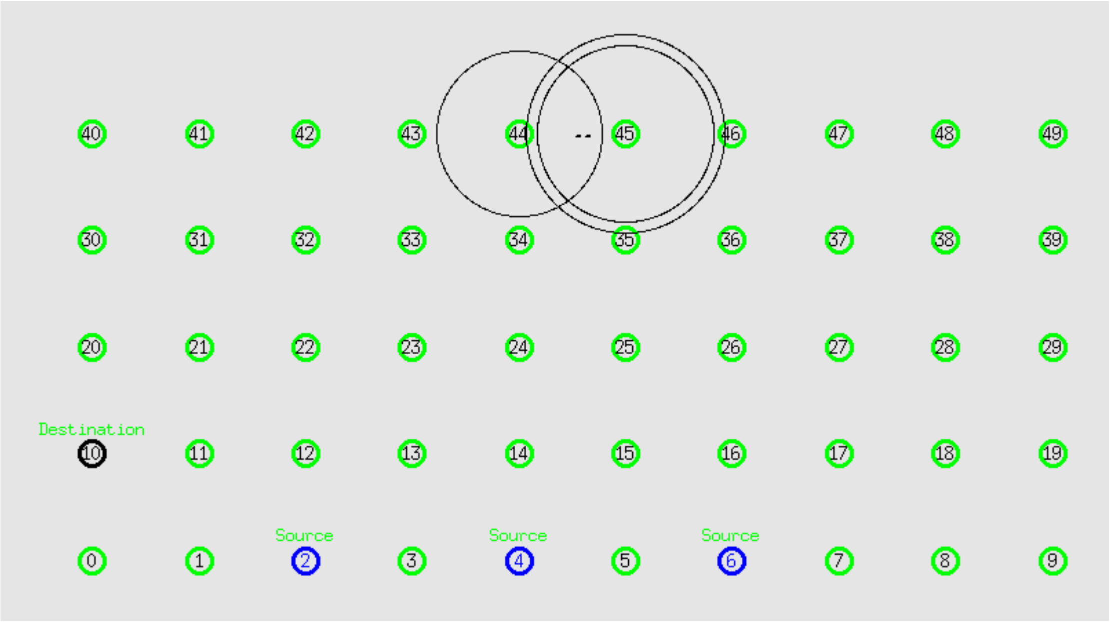

Figure 4.8 BCAODV packet forwarding

Here in figure 4.8 more number of Intermediate node is participating to forward the packet from source to destination until node threshold condition means less battery energy is consuming for any particular node.

Tracing:

Tracing is a necessary technique for each discrete-event simulator, because it tells us what had happened inside the system model during simulation. With proper understanding of trace file, we can extract suitable information, which has been lead us to the calculation of desired result. Normally for a simulation tool, trace data can be either displayed directly during execution of the simulation, or stored in a file to be post-processed and analyzed. NS2 supports the latter one better, though NAM (an animation tool designed for working with NS2) can implement the first one to a certain extent. NS2 is able to trace all packets that are received, dropped and sent by agents, routers, MAC layers or interface queues.

Type Identifier	Time	Source node	Destination node	Packet name	Packet size	Flags	Flow ID	S.A	D.A.	Sequence number	Packet Unique ID

Figure 4.9 Basic Trace File Format

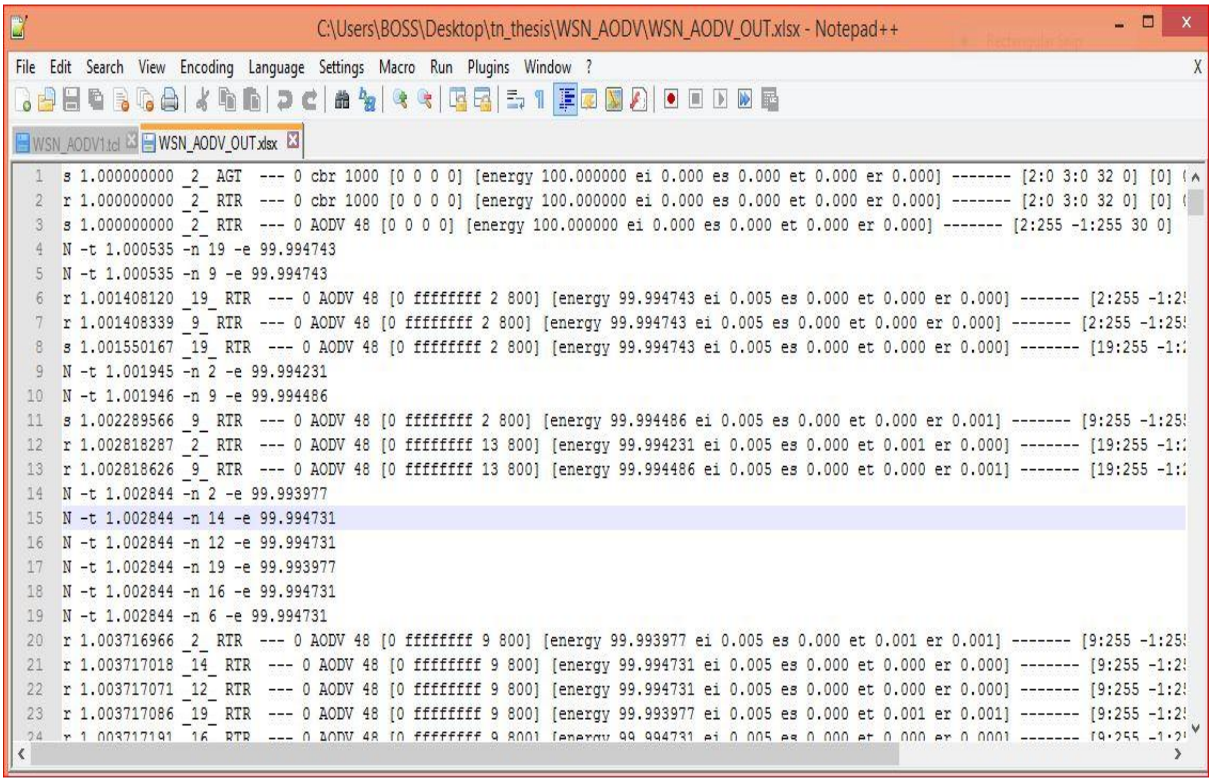

Figure 4.10 Generated trace file

Awk programming for trace file analysis

The trace file obtained from the simulation of the particular event has been analyzed to obtain the required parameter. So, certain algorithm has to be implemented for required parameters like end 2 end delay, energy consumption and packet delivery ratio.

4.3 System requirements and simulation

Hardware:

1. A Personal Computer with minimum of 1 GB RAM

Software:

1. Linux Operating System (Ubuntu 12.04)
2. Network Simulator 2(NS2) version 2.34
3. Gnu plot for plotting the graph

Languages:

1. TCL language.
2. C ++ language.
3. AWK for analyzing the trace file

4.4 Analysis

Here the analysis of wireless sensor network is done on the basis of packet delivery ratio, throughput and end-to-end delay. These parameters are the important for WSN to analyze. As the end-to-end delay plays a vital role in the performance of WSN and the Packet delivery ratio and throughput are the key parameters for quality of service.

The packet delivery ratio is given by

Packet delivery ratio = total received packets/ total sent packet

The end-to-end delay is the time elapsed between transmissions to reception of the packet.

Throughput is the total number of packets successfully received per second.

The figure 4.11shows the variation of packet delivery ratio vs number of nodes. As we can see from the figure 4.11 the packet delivery ratio is better in case of BCAODV then the AODV routing protocol. In the latter case there is chance of packet drop at the intermediate node due to its energy condition, which is not in the former case. As only the node having energy greater than the threshold value are taken as the intermediate node during the route discovery in former case whereas the energy is not accounted in later case, so the chance of packet drop is less in the former case.

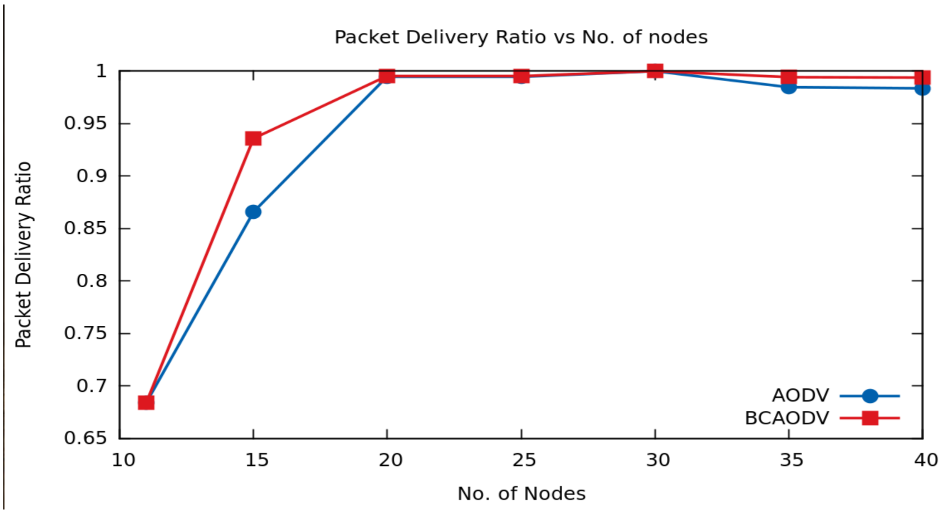

Figure 4.11 Packet delivery ratio vs. number of node

In both the cases the packet delivery ratio get increased as the number of nodes increase from 11 to 30 and after that it falls slightly and becomes less constant for the further increase in number of nodes. If the number of nodes get increase then there is number of chance of route formation due to availability of number of neighbor nodes, so PDR increases initially. However for the large number of nodes, here more than 30, the chance of packet drop increases slightly as the channel congestion increases and due to collision the packet get lost.

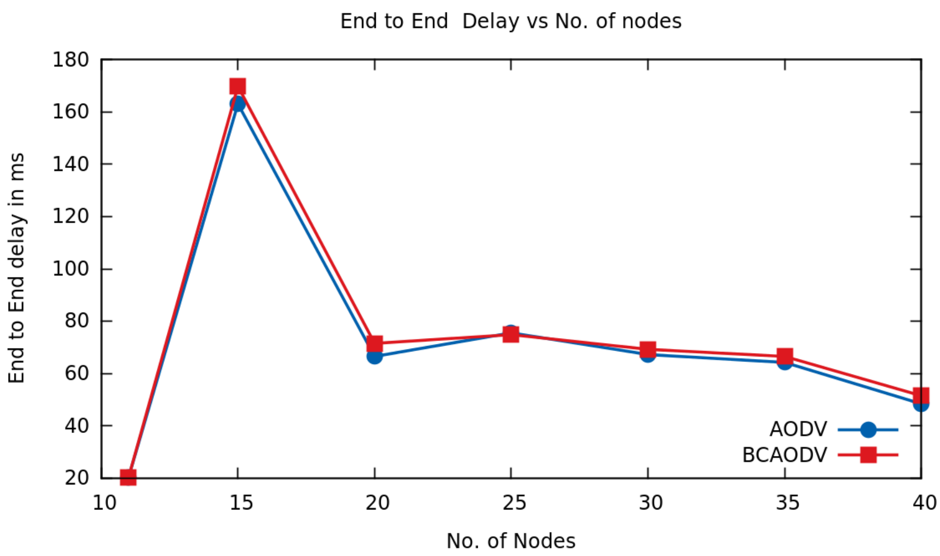

Figure 4.12 End to End delay

The figure 4.12 shows the variation of end-to-end delay vs. number of nodes. End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination. As from the figure 4.12 it is clear that the end-to-end delay is more in case of BCAODV than the AODV protocol. Since in case of BCAODV, there is chance of selection of long route due to energy condition as the energy threshold is checked during the route discovery, which does not happen in the case of AODV. In both the cases the end-to-end delays is minimum for 11 nodes here. And then it increases sharply after 11 nodes and goes maximum for 15 nodes. As the packet generation for the simulation starts at 1s and 5s. So for less number of nodes the packet generated does not get route for every packet as the nodes are busy for the nodes which stats at 1s, so the packet drop is maximum in this case. This is also clear from the figure 4.11. So for 11 number of nodes the end-to-end delay is minimum and packet drop is high. After 11 nodes the other node also gets route to destination so the end-to-end delay gets maximized. And after the 15 nodes the end-to-end delay decrease because due to large number of nodes there is chance of getting route every time and the generated packet does have to wait to get access to the channel so the, delay gets decrease.

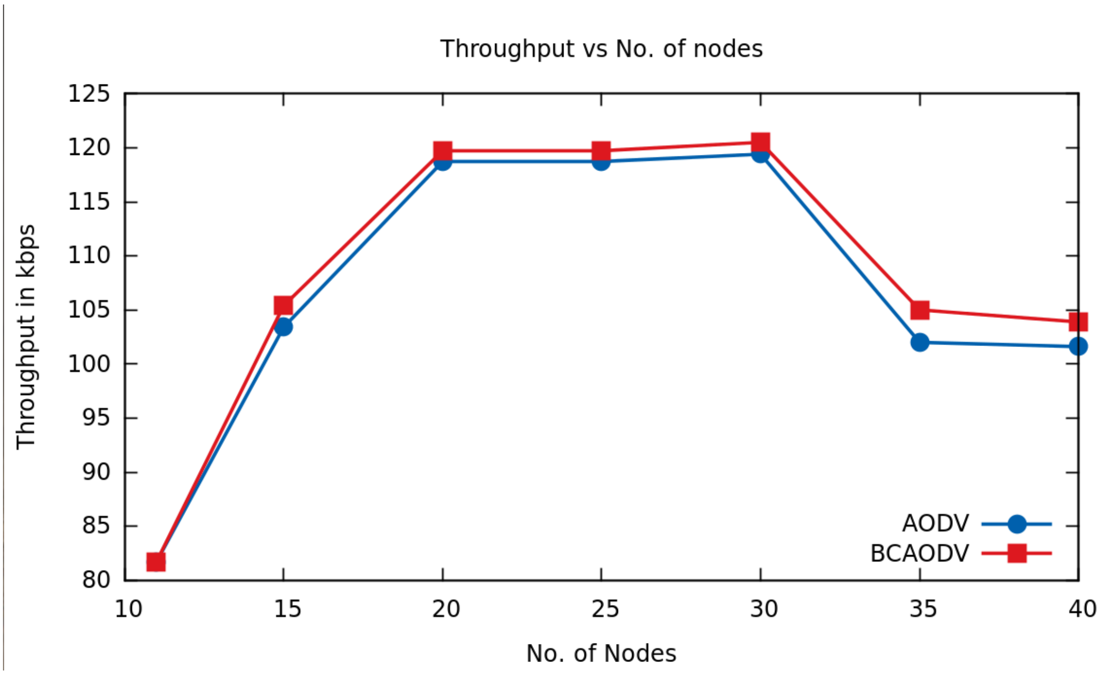

Figure 4.13 Throughput vs. No of nodes

The figure 4.13 shows the variation of throughput vs. number of nodes. Initially the throughput increases for increase in number of nodes from 11 to 30. And it is maximum for 30 nodes. The value is maximum in BCAODV case. As the number of nodes are small, the number of packets generated are less so its value is small. However as the number of nodes get increases, so does the throughput due to large number of packets generated and receive. But after the 30 number of nodes, the chance of packet loss gets increased because of the chance of packet drop due to collision of packets forwarded from different node. So the throughput gets decreases for rapidly beyond 30 nodes and after 35 nodes it decreases gradually or it is near about constant.

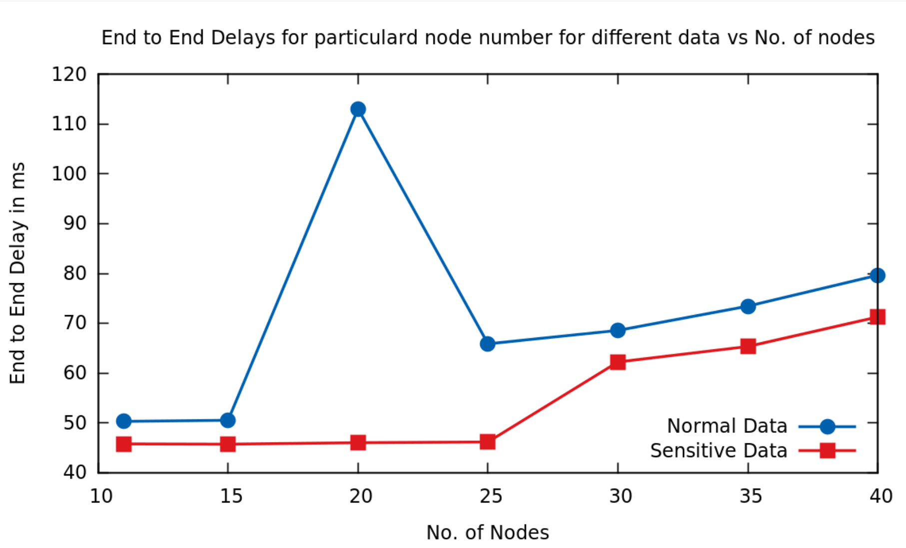

Figure 4.14 End to End Delay of normal and sensitive data

The figure 4.14 shows the variation of end to end delay vs. no. of node for sensitive as well as normal packets for particular node no. 4 , in all cases delay is less for sensitive packet than normal packets. According from figure 4.14 it has found that the delay is more less similar for small no. of node here up to 25. After that it gets increased for increase in number of nodes. In the case of 20 number of node the delay is maximum for normal packet, it may be due to BCAODV routing algorithms, which select the route on the basis of residual battery energy. So in this case, the path or route may get longer but for larger number of nodes, a multiple routes from source to destination so delay gets decreased.

5 Conclusion

This thesis analyzed the performance of WSN for battery energy condition and the sensitive data packets on the basis of packet delivery ratio, throughput and end to end delay.

The packet delivery ratio has found to be comparatively better in case of BCAODV than AODV based wireless sensor network. This is maximum for 30 number of nodes for both AODV and BCAODV cases. The PDR falls rapidly below 20 nodes and almost constant for 20 to 30 and then it falls gradually.

In case of BCAODV based WSN, the throughput has found to be better than AODV based wireless sensor network. This is maximum for 30 number of nodes for both AODV and BCAOD cases, however the values is greater for latter case.

The end to end delay has found to be maximum in case of BCAODV then the AODV and it is maximum for the 15 number of nodes. So it is very difficult to decide which is better. The choices has to be made on the basis of service required. Since the throughput and PDR are better in BCAODV, whereas the end to end delay is better in AODV based WSN.

The sensitive packet, which are delay sensitive, has to reach the destination on time otherwise, it will lose its importance. The sensitive packets sent with top priority reach its intended destination probably in less amount of time than they have sent without priority i.e. as normal packet. Hence the sensitive packet should be sent with priority.

The following things can be considered as future works:

- Priority assignment for packets of nodes having residual battery level below threshold based WSN
- Dynamically selective range for Back off Time for assignment according to the load condition to avoid from collision.

References

[1] A. K. Gurpreet Singh, "Energy-Efficient Dynamic Routing Protocol for Wireless Sensor Networks," *International Journal of Computer Trends and Technology (IJCTT)* , vol. volume 4 , no. issue 8, August 2013.

[2] M. M. Mohammad Arifuzzaman, "An Intelligent Hybrid MAC WithTraffic-Differentiation-Based QoS for Wireless Sensor Networks," *IEEE SENSORS JOURNAL,,* JUNE 2013.

[3] F. Lewis, "Wireless Sensor Networks," *University of Texas AT Arlington,,* 2004.

[4] I. Rhee, A. Warrier, M. Aia, and J. Min, "Z-MAC A hybrid MAC for wireless sensor networks," in *Proc. 3rd Int. Conf. Embedded Netw.Sensor Syst*, Nov. 2005, pp. 90–101.

[5] LAN MAN Standards Committee of the IEEE Computer Society, *LAN MAN Standards Committee of the IEEE Computer Society,,* 1997.

[6] Y. Li, C. S. Chen, Y.-Q. Song, Z. Wang et al., , "Real-time QoS support in wireless sensor networks: a survey," *International Conference on Fieldbuses & Networks in Industrial & Embedded Systems-FeT,* 2007.

[7] Chonggun Kim, Elmurod Talipov, and Byoungchul Ahn, "A Reverse AODV Routing Protocol in Ad Hoc Mobile Networks," *LNCS 4097,* p. pp. 522 , 2006.

[8] Mehdi Zarei, Karim Faez and Javad Moosavi Nya, "Modified Reverse AODV Routing Algorithm using Route Stability in Mobile Ad Hoc Networks," *Proceedings of the 12th IEEE International Multitopic Conference,* pp. 23-24, 2008.

[9] Saleh Ali K. Al Omari and Putra Sumari, "An overview of Mobile Ad Hoc Networks for the existing protocols and applications," *International Journal on applications of graph theory in wireless ad hoc networks and sensor network,* vol. 2, 2010.

[10] "http://www.isi.edu/nsnam/ns/The Network," [Online].

[11] W.Ye, J. Heidemann and D.Estrin., "Medium access control with coordinated adpative sleeping for wireless sensor networks," *ACM/IEEE,* pp. pp 493-506, June 2004.

[12] Z. Maria Wang, Stefano Basagni, Emanuel Melachrinoudis, "Exploiting Sink Mobility for Maximizing Sensor Networks Lifetime," in *IEEE Computer Society,* 2005.

[13] Abdusy Syarif and Riri Fitri Sari, "AODV-UI routing protocol with energy consumption improvement under mobility models in hybrid ad hoc network,"

International Journal on Computer Science and Engineering, vol. 3, no. 7, July 2011.