Topology Control for energy saving in Wireless Ad Hoc Networks

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Topology Control for energy saving in Wireless Ad Hoc Networks

Major Project

Submitted in partial fulfillment of the requirements

For the degree of

Master of Technology in Computer Science and Engineering

b By

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DECLARATION

I, **Ashish Gajjar**, 10MCEC24, give undertaking that the Major Project entitled **Topology Control for energy saving in Wireless Ad Hoc Networks"** submitted by me, towards the partial fulfillment of the requirements for the degree of Master of Technology in Institute of Technology of Nirma University, Ahmedabad, is the original work carried out by me and I give assurance that no attempt of plagiarism has been made. I understand that in the event of any similarity found subsequently with any published work or any dissertation work elsewhere; it will result in severe disciplinary action.

Ashish Gajjar

Certificate

This is to certify that the Major Project entitled "Topology Control for energy saving in Wireless Ad Hoc Networks" submitted by Ashish Gajjar (10MCEC024), towards the partial fulfillment of the requirements for the degree of Master of Technology in Computer Science and Engineering of Nirma University, Ahmedabad is the record of work carried out by him under my supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

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Abstract

In a wireless ad hoc network, end to end connectivity among nodes is established using intermediate forwarding nodes. A node chose one of its neoghbors for forwarding its packets to a particular destination. Having more nodes in neighborhood (dense network) increases probability of end to end connectivity but consumes more energy (due to unnecessary reception of packets by all nodes in communication range and higher transmit power); on the other hand having a few nodes in neighborhood may reduce energy consumption but reduce the probability of end to end connectivity. We study K-neighbourhood topology control protocol and analyze effect of value of K on energy consumption and packet delivery ratio for different network scenarios using simulations.

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- Ashish Gajjar
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Abbreviation

Abbreviation	Meaning
MANET	Mobile Ad-hoc Network
CTR	Critical Transmission Range
CTS	Clear to Send
RTS	Request to Send
PAMAS	Power Aware Multi-Access Protocol with Signalling
LILT	Local information Linkstage Topology
NDDS	Non-Ordered Discrete Data Spaces
CDS	Continuous Data Space
HDS	Hybrid Data Spaces
RSSI	Received signal strength indication
DCF	Distributed coordination function
MAC	Medium Access Control
MACA	Multiple Access with Collision Avoidance
MACAW	Multiple Access with Collision Avoidance for Wireless

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Chapter 1

Introduction

An ad hoc network is a group of nodes which are capable of movement and are connected dynamically. These nodes exchange information in the wireless medium and are decentralized in arbitrary manner. The network topology is dynamic and nodes can enter or leave the network at any time. The communication takes place among the nodes within some specific transmission range. To communicate with the nodes which are outside the transmission range. a node takes the help of other intermediate nodes to send and receive the messages. So, a node in this kind of network acts as a terminal and a router.

Ad hoc Network has it's own challenging properties like limited battery power, dynamic topology, fast topology changes. Wireless devices also change their locations periodically. So dynamic topology exists in ad hoc network. There is a need to save energy in devices for long time connectivity.

This report contains a general overview of wireless ad hoc network technology. survey of different topology control techniques for ad hoc network, advantages and disadvantages of these techniques, proposed algorithm and description of the simulator used to gather the results.

The art of coordinating nodes decisions regarding their transmitting ranges,in order to generate a network with the desired properties Topology control: Topology control is a technique used mainly in wireless ad hoc and sensor networks to reduce the initial topology of the network in order to save energy, cut down interference and extend the lifetime of the network. The main goal is to reduce the number of active nodes and active links,preserving

the saved resources for future maintenance.[7]
Power control: a wireless channel perspective optimize the choice of the transmit power level for a single wireless transmission, possibly along several hops. topology control Adjust network topology according to some given criteria as environment changes to achieve certain properties.[8]

1.1 Problem Statement

A wireless ad hoc network is a temporary infrastructure less network, formed by a set of mobile hosts that dynamically establish their own network on the fly without relying on any central administration. wireless adhoc network to ensured by the powerful fixed infrastructure in traditional networks, such as packet forwarding, route update, route request, neighbor discovery. The resource limitation of nodes used in adhoc network, particular in energy supply, along with the multi-hop nature of this network may cause a new phenomenon which does not exist in traditional networks. To save its energy node may behave k-nearest neighbor and uses the services of the nodes without correctly participate in system.

1.2 Objective of the Work

Our aim is to analyze performance of K-neighbor topology control mechanism in ad hoc network for different values of K in different network scenarios.

1.3 Scope of the Work

The scope of this work is:

- To study topology control protocols.
- To device topology control protocol for energy efficient and its implementation in ns-2 simulator.
- Analyzing the results for deriving effectiveness of the model.

1.4 Motivation of the Work

Both energy and capacity are limited resources in ad hoc networks In case of Wireless Sensor Networks (WSN), energy consumption is especially critical. The ad hoc network designer should strive for reducing node energy consumption and providing sufficient network capacity. Topology Control maintain a topology with certain properties (e.g. transmission range, connectivity) while reducing energy consumption and increasing network capacity and network stability.

1.5 Thesis Organization

The rest of the thesis is organized as follows.

Chapter 2, *Literature Survey*, describes texonomy of topology control and related work.

Chapter 3, *Proposed Algorithm and Tools* , describe Network Simulator and gives information about other tools which are used during the work.

Chapter 4, *Implementation*,describe the behaviors which are simulated in this report. It also mention the algorithm used for simulation.

Chapter 5, *Simulation Parameter and Results*, describe simulation parameter and results.

Chapter 6,*Conclusion and Future work*, concluding remarks and scope for future work is described.

Chapter 2

Literature Survey

Ad-hoc mode is a method for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows all wireless devices within range of each other to discover and communicate in peer-to-peer fashion without involving central access points.

As the wireless network technology exploded, it has opened a new view to users and expanded the information and application sharing very conveniently and fast. Mobile ad hoc networks (MANETs) use wireless technology without a pre-existing infrastructure (access points). As the name states, MANETs consists of mobile nodes, which can vary from notebooks, PDAs to any electronic device that has the wireless RF transceiver and message handling capability. Mobility and no-infrastructure forms the basis of this network type.

Mobility gives maximum freedom to users, as they can be connected to the network, whether they are fixed or moving, unless they are in the range of the network. Also, it is highly dynamic, as the new nodes come, they can be connected to the network very easily.

Unlike the fixed networks or traditional wireless networks, MANETs don't need any infrastructure to create and maintain communication between nodes. This property provides the ability to create a network in very unexpected and urgent situations very quickly, also without any extra cost.[7]

Two nodes that want to communicate with each other can send and receive messages directly, if they are both in their transmission range. Otherwise, every node is also capable to be a router, and the messages between nodes are relayed by the intermediate nodes, from the originator of the message to the destination. Since the nodes are mobile and the members of the network changes without any notice, the network structure is very dynamic. So, the route the messages are sent by, are dynamic also.

2.1 Taxonomy of topology control

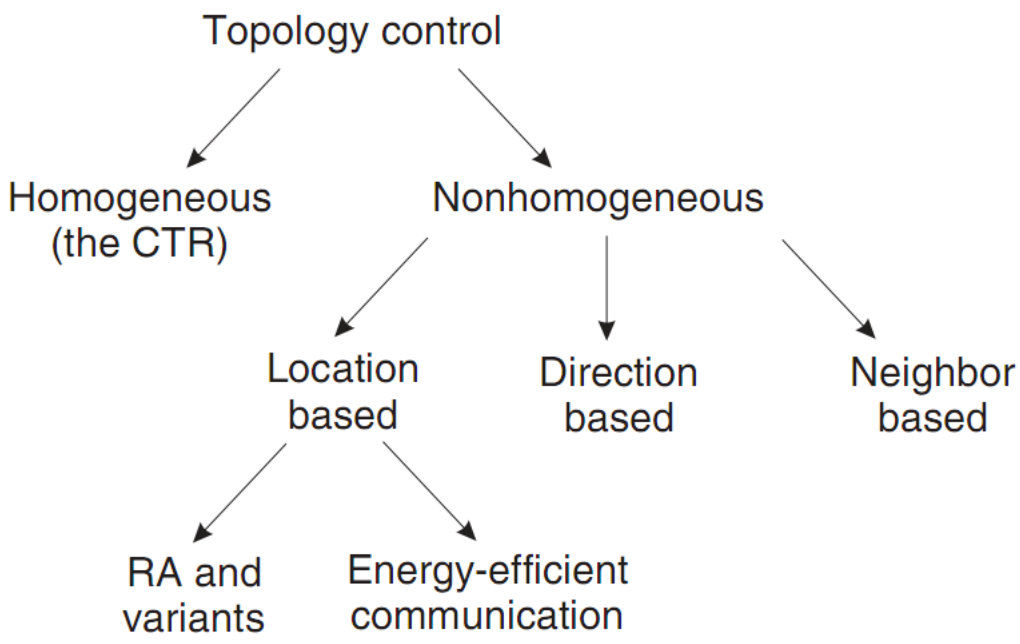

Figure 2.1: Taxonomy of topology control.[8]

2.1.1 Homogenous Topology Control

Homogeneous CTR all the network nodes must use the same transmitting range r , and the topology control problem reduces to the simpler problem of determining the minimum value of r such that a certain network wide property is satisfied. This value of r is known as the critical transmitting range (CTR),since using a range smaller than r would compromise the desired network wide goal.[8] The homogeneous case is by far the simplest formulation of the topology control problem. Nevertheless, it has attracted the interest of many researchers in the field, probably because, owing to its simplicity, deriving clean theoretical results in this context is a challenging but feasible task.

Critical transmission range (CTR)

The simplest form of topology control considered is the characterization of the critical transmission range(CTR). In this topology control, all the network nodes are assumed to have the same transmitting range r. The most-studied version of the CTR problem in ad hoc networks is the characterization of the CTR for connectivity, that is identifying the minimum value of r such that the resulting communication graph is connected. The interest in characterizing the minimal conditions for connectivity lies in the fact that this is the most important network topological property. More formally, the problem can be stated as follows:[3]

Definition (CTR for connectivity) Suppose n nodes are placed in a certain region R = [0, l]d , with d = 1, 2, or 3.Which is the minimum value of r such that the r-homogeneous range assignment is connecting?[1]

In the definition above, the deployment region is the d-dimensional cube with side l. This is only because most of the results presented in this obtained for this shape of the deployment region. The definition of CTR for connectivity can be extended in a straightforward manner to deployment regions with arbitrary shape and size. The assumption that all the nodes use the same transmitting range reflects all those situations in which transceivers use the same technology and no transmit power control.[8]

- **Fixed deployment region:** In this problem, the side l of the deployment region R is fixed (e.g. R is the unit square), and the asymptotic value of the CTR as n $\rightarrow \infty$ is investigated. In principle, results obtained for this version of the problem can be applied only to dense networks. In fact, the value of the CTR is characterized as the node density n/ ld grows to infinity, since l is an arbitrary constant.

- **Deployment region of increasing side:** In this problem, the side l of the deployment region is a further model parameter, and the asymptotic value of the CTR as l $\rightarrow \infty$ is investigated. In this model, l can be seen as the independent variable, and both r and n are expressed as a function of l (and of the distribution F). Since in this version of the problem the node density n(l,F) ld can either converge to a constant $c >= 0$ or diverge as l $\rightarrow \infty$, the theoretical results obtained using this model can be applied to networks with arbitrary density.[8]

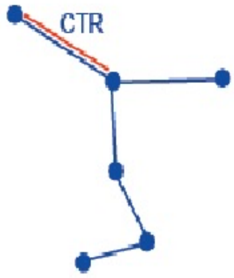

Figure 2.2: The CTR for k-connectivity[8]

The k-connectivity graph property is an immediate extension of the concept of graph connectivity.Formally, k-connectivity is defined as follows:[1]

Definition (Connectivity): A graph G is said to be k-connected, where $1 <= k < n$, if for any pair of nodes u, v there exist at least k node disjoint paths connecting them. The connectivity of G, denoted as k(G), is the maximum value of k such that G is k-connected. A 1-connected graph is also called simply connected. A similar definition of connectivity can be given by considering edge, instead of node, disjoint paths between nodes. Denoting with $\sum$ (G) the edge-connectivity of G, it is seen immediately that k(G)<= $\sum$(G). Figure illustrates the concepts of k-connectivity and k-edge connectivity.

2.1.2 Non-homogeneous topology control:

In Non-homogeneous topology control[3], nodes are allowed to choose different transmitting ranges. Non-homogeneous topology control is classified into three categories, depending on the type of information that is used to compute the topology.[18]

Location-based topology control:

In location-based approaches[4], it is assumed that the most accurate information about node positions is known. This information is either used by a centralized authority to compute a set of transmitting range assignments that optimizes a certain measure or it is exchanged between nodes and used to compute an 'almost optimal' topology in a fully distributed manner (this is the case of protocols for building energy-efficient topologies for unicast or broadcast communication). we present two location-based topology control protocols. the CBTC protocol and the DistRNG protocol.

a. The CBTC Protocol: The CBTC (Cone-based Topology Control) protocol is based on the following idea: Distance and angle information between nodes is available. CBTC Protocol is a two-phase algorithm.

- Phase 1:
  - Every node starts with a small transmission power
  - Increase it until a node has sufficiently many neighbors
  - What is "sufficient"? - When there is at least one neighbor in each cone of angle
- Phase 2:
  - Remove redundant edges: Drop a neighbor w of u if there is a node v of w and u such that sending from u to w directly is less efficient than sending from u via v to w
  - Essentially, a local Gabriel graph construction

b. **The DistRNG Protocol**: The DistRN[3]G is a distributed implementation of the computation of the Relative Neighborhood Graph (RNG).

Definition: (Relative neighborhood graph) Let N be a set of points in the Euclidean two- dimensional space. The Relative Neighborhood Graph of N, denoted by RNG(N), has an edge between two nodes u and v if there is no node w N such that max$\{\delta$(u,w), δ(v,w)$\} \leq \delta$(u, v).

RA Problems : we have investigated various network design problems under the assumption that all the nodes have the same transmitting range, which reflects all those situations in which nodes cannot change the transmit power level. However, nodes can change the transmit power level. So, the problem of choosing the nodes transmit power levels in network topology satisfies certain properties becomes relevant. we consider the problem of

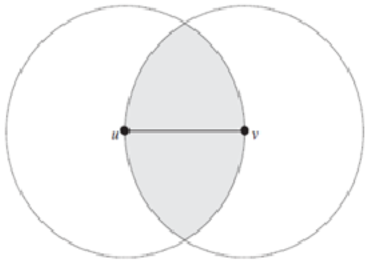

Figure 2.3: The DistRNG Protocol

determining a set of power level assignments that generates a connected communication graph while at the same time minimizing the energy consumption. This problem is known as the Range Assignment problem.

RA problem Let N be a set of nodes in the d-dimensional region R, denoting the node position and determining a connecting range assignment RA of minimum energy cost.

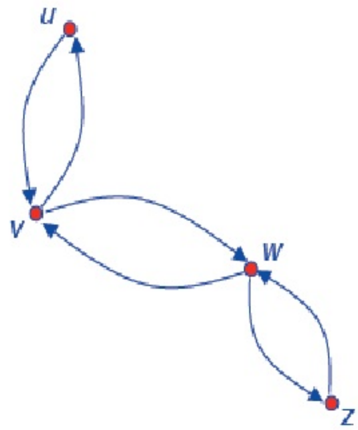

Figure 2.4: Range Assignment Problem

Direction-based approaches

We consider the topology control protocols that rely on the ability of the nodes to estimate the relative direction of their neighbors. This is relatively less accurate information than knowing exact node locations,

Direction-based topology control protocols can produce almost as good topologies as in the case of location-based topology control. In particular, fully distributed, localized protocols that preserve worst-case connectivity can be designed.

Neighbor-based approaches

we consider topology control protocols that rely on the nodes ability to determine the number and identity of neighbors within the maximum transmitting range and to build an order on this neighbor set.this is the minimum amount of information needed by the nodes to build the network topology. if a node is not able to identify its neighbors, it has no clue on how to set its transmit power level. The only possible way of setting the transmit power level.

a. The KNeigh Protocol[1] : The KNeigh protocol maintains the number of neighbors of every node equal to or slightly below a specific value k. it is assumed that when a node u receives a message from node v, u is able to estimate the distance to node v.

This can be accomplished by using one of the many distance estimation techniques following:

Radio signal strength indicator : Distance is estimated by comparing the transmitted power at the sender with the received power at the receiver of the message.- **Time of arrival** : Distance is estimated by comparing the time of arrival of different types of signals.

Distributed Topology control [4] : Topology control is its potential to reduce interference between concurrent transmissions. A typical measure used to quantify the expected interference is the node degree of the communication graph: if the transmitting node u has small degree, relatively few nodes will experience interference during u's transmission.

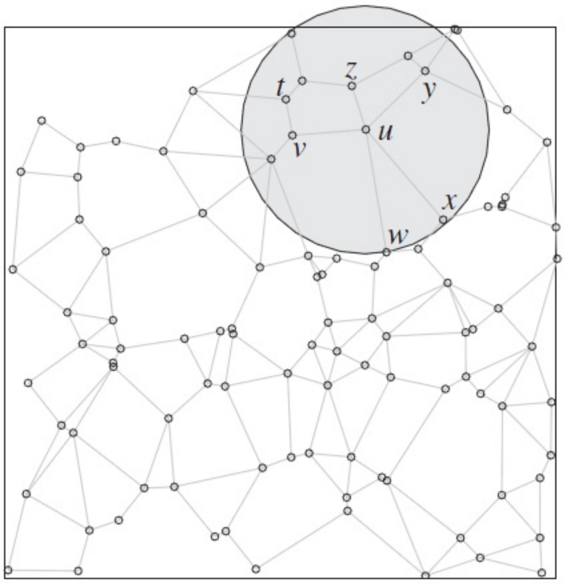

Figure 2.5: Logical And Physical node degrees in distributed topology control

2.2 Related Works

Power Management Based Protocols.

- In PAMAS [15] energy efficiency goal is achieved by using two separate channels, one for control and other for data. RTS/CTS signals are transmitted over the control channel while data are transmitted over data channel. Nodes with packet to transmit sends a RTS over the control channel, and waits for CTS, if no CTS they receives within a specific time then node enters to a backoff state. However, if CTS is received, then the node transmits the data packet over the data channel. The receiving node transmits a busy tone over the control channel for its neighbors indicating that its data channel is busy. The use of control channel allows nodes to determine when and how long to power off. The length of power off time is determined by different condition. After waking up, a node access the channel over the data channel and found multiple transmission going on. The node uses a probe protocol in this case to find how much time it will power off. Simulation results shows that good range of power saving is achieved in PAMAS.

Power Control Based Protocol.

- Power control MAC (PCM) [12] achieves energy saving without causing throughput degradation by implementing different type of transmission power. DATA and ACK packets are transmitted using minimum power while RTS/CTS packets are transmitted using maximum power. Receiver calculates the minimum power required by the sender to send data, depending upon the surrounding noise and interference. When the transmission takes place the neighboring node defers their transmission. During data transmission same procedure are used for finding minimum required power level that should be enough for the transmission of DATA as well as ACK. PCM require an accurate estimation signal strength based upon which its power control works. Also factors like multipath propagation, fading and shadowing effects may degrade its performance.

- Sahoo et al. [9] propose a distributed transmission power control protocol for wireless network to achieve energy conservation in the node level. The protocol uses distributed algorithm to build the power saving tree topologies without taking the local information of the nodes and provide a simple way to maintain network by changing the transmission power. The study on impact of power control performance on IEEE 802.11 wireless networks describes about optimization of spectral reuse in large scale networks. This protocol shows that network with power control, avoiding hidden nodes can achieve higher overall network capacity as compared with minimum-transmit power approach. The proposed distributed algorithm tries to achieve high spectral reuse by reducing expose node while entirely avoiding hidden node. The pros and cons of common-range and variable-range transmission power control on the physical and network layer connectivity. The simulation result shown that variable-range transmission power control out-performs common-range transmission power control in term of energy saving and network capacity.

Topology Control Based Protocol.

- SPAN [13] is a distributed power saving protocol adaptively elects coordinator from all nodes in the network. Coordinator nodes stay awake continuously and perform multi-hop packet routing. Other nodes remain in power save mode to conserve energy. SPAN achieves four goals such as, it elects enough coordinator nodes, rotates the coordinator nodes to balance residual energy, attempts to minimize the numbers of coordinator and elects the coordinator using local information in a decentralize manner. SPAN gives guarantee of network connectivity by ensuring that every node has at least one active node in its radio range. Fairness among the nodes is based on the amount of residual energy and the additional neighbor pairs that a node can connect. It balances both fairness and network connectivity. The entire active node in SPAN form a connected backbone, each node periodically broadcast hello message which includes different information. From this, node constructs a table containing information like current state of the node, current state of the neighbor, residual energy of the neighbor, etc. When any inactive node found that its two of the neighbors cannot reach directly or through one or two active node then that node became an active node. On other hand any coordinator node can step down, if every pair of its neighbors can reach each other either directly or via other coordinators.

- Ramanathan et al. proposes two centralized topology control algorithm [14] for ad hoc network. They have proposed two centralized algorithms called CONNECT and BICONN for use in static network. Algorithm CONNECT is a greedy algorithm similar to minimum spanning tree (MST). The BICONN-AUGMENT is also a greedy based algorithm whose objective is to identify the biconnected components in the network. For mobile network they have proposed two distributed heuristic, namely local information no topology (LINT) and local information link-state topology (LILT).

- Sheu et al. proposes a location free topology control algorithm [4] for faster access. The algorithm has two phases, link determination phase to determine the power required to send data packet while interference announcement phase to handle the hidden terminal problem.

- Douglas,[1] propose an approach to topology control based on the principle of maintaining the number of neighbors of every node equal to or slightly below a specific value k. The approach enforces symmetry on the resulting communication graph, thereby easing the operation of higher layer protocols.To evaluate the performance of our approach, we estimate the value of k that guarantees connectivity of the communication graph with high probability. We then define k-Neigh, a fully distributed, asynchronous, and localized protocol that follows the above approach and uses distance estimation. We prove that k-Neigh terminates at every node after a total of 2n messages have been exchanged (with n nodes in the network) and within strictly bounded time.

Chapter 3

Proposed Algorithm

3.1 Neighbor-based approaches

We consider topology control protocols that rely on the nodes ability to determine the number and identity of neighbors within the maximum transmitting range and to build an order on this neighbor set. this is the minimum amount of information needed by the nodes to build the network topology. if a node is not able to identify its nearest neighbors, it has no clue on how to set its transmit power level. The only possible way of setting the transmit power level.

Most similarity searching algorithms may be distilled to a simple formula applicable to CDS, NDDS, or HDS index structures. Further, range queries may be viewed as a special case of nearest neighbor queries where the final search radius is known at the start of the search. As such, this thesis focuses upon nearest neighbor search algorithms. The following algorithms perform similarity searches for the nearest neighbor to a query based on an index structure of fixed dimensionality. Generally, the search for a single nearest neighbor may be expanded to find k nearest neighbours by maintaining a list of neighbors found and using the distance between the neighbor that occupies the kth distance related slot and the query point as a search range/radius value to search within. Each of the index structures described in the following sections may generally be used in conjuncture with one of the following search methods. However, developers will typically modify the algorithm to better suit the applicable structure.[1]

3.1.1 Exact Searching Methods

The most basic method to perform a k-NN similarity search involves using a range search algorithm. Begin with radius r = $\alpha : (\alpha > 0)$ centrad at query point q.Increase α until at least k elements lie within the radius. The cost, in terms of page accesses, of this algorithm is similar to that of performing a range search. This cost however is greatly affected by the amount the value α is adjusted by every time the desired number of elements is not yet found. Too small, the performance cost will quickly grow; too large, the number of points returned will far exceed the desired number thus decreasing the usefulness of the solution. The most common application of this idea is to order potential search paths by either their MINDIST or MINMAXDIST values to q. The MINDIST ordering gives the optimistic approach that a lower MINDIST value is caused by a relatively closer object in the index structure. This may not always prove true in spatial index structures. Commonly, some point of a search path only exists at the top most layers. At higher levels within an index structure, points may actually be the result of the intersection of lines drawn from several points lower in the index structure. When this technique appears to suffer from this problem, the pessimistic approach using MINMAXDIST may be used instead. Here, search paths are ordered by the increasing value of their furthest point. Thus a search may correctly assume that it will at least not encounter any points further away than the MINMAXDIST.

3.1.2 Approximate Searching Methods

Relaxing the precision of the query results may lead to even further reductions in time complexity. This is a reasonable procedure for many applications due to some approximation in the moralization of feature vectors for both general metric and CDS indexes. In addition to the query itself, a user specifies some query parameter ϵ to control how far away from the query point the search may progress.

3.1.3 Unique Searching Methods

The techniques described thus far cover universal proposals for performing k-NN similarity searches. There are however examples of k-NN search algorithms developed for specific indexes that are inapplicable in a generic sense. Such algorithms depend upon the structure developed to support them and are unable to be incorporated with common indexing techniques.Clarkson [19] proposes a method that alleviates the need to perform extensive backtracking by creating data structure where points are inserted into multiple subtrees. The tree is constructed by first selecting representatives for the root(s) and then inserting each element u into not only the sub tree of its closest representative p, but also into the subtree of any other representative p' such that D(u, p') $\leq$ 3*D(u, p). During a query on object α_q the search enters all subtrees such that D(α_q, p') $\leq$ 3*D (α_q ,p). As shown by Clarkson, this is enough to guarantee the retrieval of the nearest neighbor and could be extended to determine the set of k-NN.

3.2 The KNeigh Protocol

The KNeigh protocol introduced in is a distributed implementation of the computation of Gk-based on distance estimation. it is assumed that when a node u receives a message from node v, u is able to estimate the distance to node v. This can be accomplished by using one of the many distance estimation techniques. k-NN is a type of instance-based learning, or lazy learning where the function is only approximated locally and all computation is deferred until classification. The k-nearest neighbor algorithm is amongst the simplest of all machine learning algorithms: an object is classified by a majority vote of its neighbors, with the object being assigned to the class most common amongst its k nearest neighbors (k is a positive integer, typically small). If k = 1, then the object is simply assigned to the class of its nearest neighbor.

The test sample (green circle) should be classified either to the first class of blue squares or to the second class of red triangles. If k = 3 it is assigned to the second class because there are 2 triangles and only 1 square inside the inner circle. If k = 5 it is assigned to the first class (3 squares vs. 2 triangles inside the outer circle).

The KNeigh protocol maintains the number of neighbors of every node equal to or slightly below a specific value k. it is assumed that when a node u receives a message from node v, u is able to estimate the distance to node v. This can be accomplished by using one of the many distance estimation techniques following:

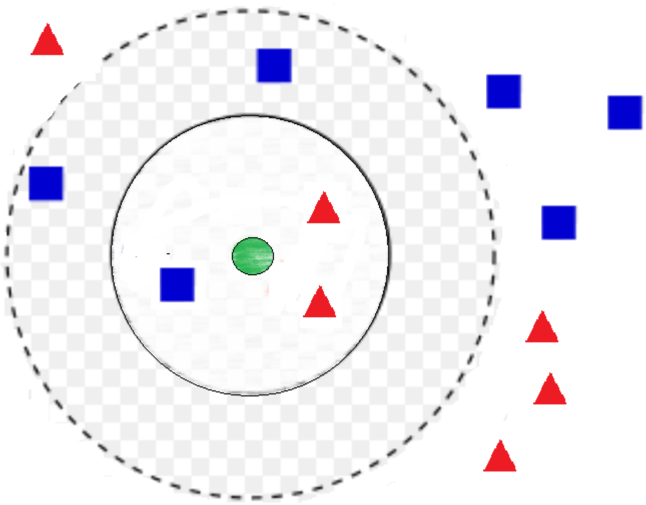

Figure 3.1: Example of K-Nearest neighbor

Proposed Algorithm

Algo: K-Neighbor

1. Node i wakes up at time ti,ti ϵ [0,Δ]. At random time ti chosen in the interval [ti + Δ,ti + Δ + d] node i announces its ID at maximum power.

2. For every message received from other nodes, i stores the identity and the estimated distance of the sender.

3. At time ti +2Δ+d, i orders the list of its neighbors (i.e.of the nodes from which it has received the announcement message) based on the estimated distance; let Li be the list of the k nearest neighbors of node i (if i has less than k neighbors, Li is the list of all its neighbors).

4. At random time ti^2 chosen in the interval [ti + 2Δ+d+τ, ti + 2Δ+d+τ](is an upper bound on the duration of step 3), node i announces its ID and the list Li at maximum power.

5. At time ti + 3Δ+d+τ node i, based on the lists Lj received from its neighbors, calculates the set of symmetric neighbors in Li, Let Li be the list of symmetric neighbors of node i, and let j be the farthest node in Li.

6. Node i sets its transmitting power Pi to the power needed to transmit at distance δij, where δij is the estimated distance between nodes i and j.

7. end if

Chapter 4

Implementation

4.1 Node Structure

Mobile node is implemented as an object with functionalities such as movement and the ability to transmit and receive on a channel that allows it to be used to create mobile, wireless simulation environments. The mobile node is designed to move on a height always equal to zero. Thus the mobile node has X, Y, Z co-ordinates that are continually adjusted as the node moves. When creating a mobility scenario, the starting position of the node and its future destinations may be set explicitly. These directives are normally included in a separate movement scenario file. Other than this, the topography for mobile nodes always needs to be defined.

The network stack for a mobile node consists of a link layer, an ARP module connected to the link layer, an interface priority queue, a MAC layer and a network interface, all connected to the channel. Each component is briey described here.

Link Layer: The link-layer object is responsible for simulating the data link protocols. Many protocols can be implemented within this layer such as packet fragmentation and reassembly, and reliable link protocol.

Another important function of the link layer is setting the MAC destination address in the MAC header of the packet. Normally for all outgoing (into the channel) packets, the packets are handed down to the link layer by the Routing Agent. Then the link layer hands down packets to the interface queue. For all incoming packets (out of the channel), the

MAC layer hands up packets to the link layer.

Interface Queue: For the purposes of ad hoc routing, the interface queue is implemented as a priority queue which gives priority to routing protocol packets by inserting them at the head of the queue.

Radio Signal Strength: distance is estimated comparing the transmitted power at the sender (which is piggy backed in the message) and the received power at the receiver of the message. This technique can be implemented at virtually no cost (RSSI registers are a standard feature in many wireless network cards [20]), but provides poor accuracy. In [20], it is shown that RSSI-based distance estimation is feasible only in a quite idealized setting (football field with all the nodes positioned at the ground level).

The IEEE 802.11 distributed coordination function (DCF) MAC protocol has been implemented by CMU. DCF is similar to MACA and MACAW and is designed to use both physical carrier sense and virtual carrier sense mechanisms to reduce the probability of collisions due to hidden terminals. The details of this implementation result will be covered in the next section along with the network interface implementation which is used by mobile nodes to access the channel. We will modify energy efficient techniques for wireless ad hoc network in Mac layer. In this technique we choose an environment where, nodes are deployed randomly in a multi dimensional area. It is assumed that each node has at least two power levels such as Pmax and Pmin. Former is the power required to reaches farthest node while latter is the power required to reach the nearest node. The power control here is to minimize the power consumption of a node. It is assumes that there may exist some intermediate power level between Pmax and Pmin.

It is a common technique of the distance estimation for its case. It has no additional hardware requirements and a distance computation is based on the simple Friis equation[28]

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2} \tag{4.1}$$

where $Pr_(d)$ is the received power in dependence on the distance between transmitter and receiver, Pt is the transmitted power, Gt, Gr are transmitters resp. receivers antenna gain and is the wavelength of the transmitted signal in meters.

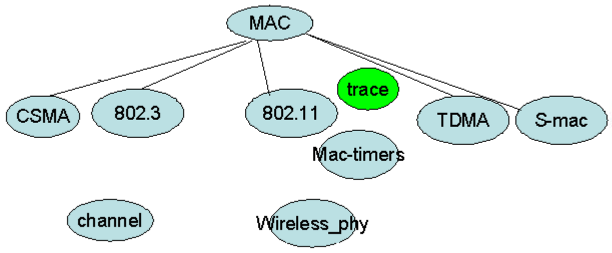

Figure 4.1: MAC in ns-2

4.1.1 Basic functions of General MAC class.

- **recv (packet, handler)**, This is the entry from upper target to send a packet to MAC. After the MAC transmit this packet successfully, it will use this callback handler to inform the upper target that MAC is idle and give another packet if there are packets buffered.

- **SendUp**, The MAC here is supposed to be full-duplex and receive can be happened simultaneously. it does not care about collisions.

- **SendDown**,Used to sending packet down. Called by recv().init a timer for tx, and the timer handler is defined to call resume().

- **Resume()**, When tx timer out, reset MAC as idle state and callback..

- **Discard**, When a packet has to be drop, the drop class has to be called to handle this, In cmu-trace.h. three-character string is defined to describe those reasons in the trace file.

4.2 Neighbor Discovery

Neighbor Discovery Protocol modifying some parameters to adjust it to Wireless Network.

a. Every node broadcasts, with periodicity HELLO INTERVAL, a message to all neighbors indicating that is available to forward packets.

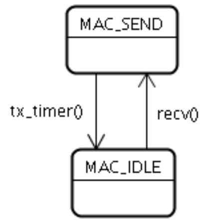

Figure 4.2: General MAC class

b. Also with periodicity HELLO INTERVAL, every node checks if its neighbors are still available. That is done by means of a timeout. Each neighbor has an associated expire time. If the node k has not received any HELLO message from neighbor n and current time is greater than the expire time, neighbor n is deleted from the list. Furthermore, all entries in the routing table related to this neighbor are also erased.

c. Nodes are constantly listening. When a node k receive a HELLO message from node n, it first checks if that neighbor n is already in the list. If not, the new neighbor n is added to the list, and the routing table T_k is updated, adding an entry for every destination d with an associated probability find that is initialized to a minimum value. If the neighbor is reliable, its probability will increase by the behavior of the routing agents. In addition, and in all cases, the expire time is updated.

To implement the algorithm some steps should be required to carry out in the simulator coding.

a. Identify node Position.

b. The maximum transmission power P is the same for all the nodes.

c. Given n, P is chosen in such a way that the communication graph that results when all the nodes transmit at power P is connected w.h.p.

d. A distance estimation mechanism, possibly error prone, is available to every node.

e. The nodes initiate the k-Neigh protocol at different times. However, the difference between node wake up times is upper bounded by a known constant δ.

4.3 Tools

4.3.1 Network Simulator

Network simulator is tool used to stimulate different network scenarios. We can build ns either from the the various packages (Tcl/Tk, otcl, etc.), or We can download an 'all-in-one' package. Start with the all-in-one package, especially if we're not entirely sure which packages are installed on your system, and where exactly they are installed. The disadvantage of the all-in-one distribution is the size, since it contains some components that we don't need anymore after we compiled ns and nam. It's still good for first tests, and we can always switch to the single-package distribution later.[23]

- Run the ./install to install ns.
- Set the environment variable as per the ns directory.
- Run ./configure to configure various parameters.

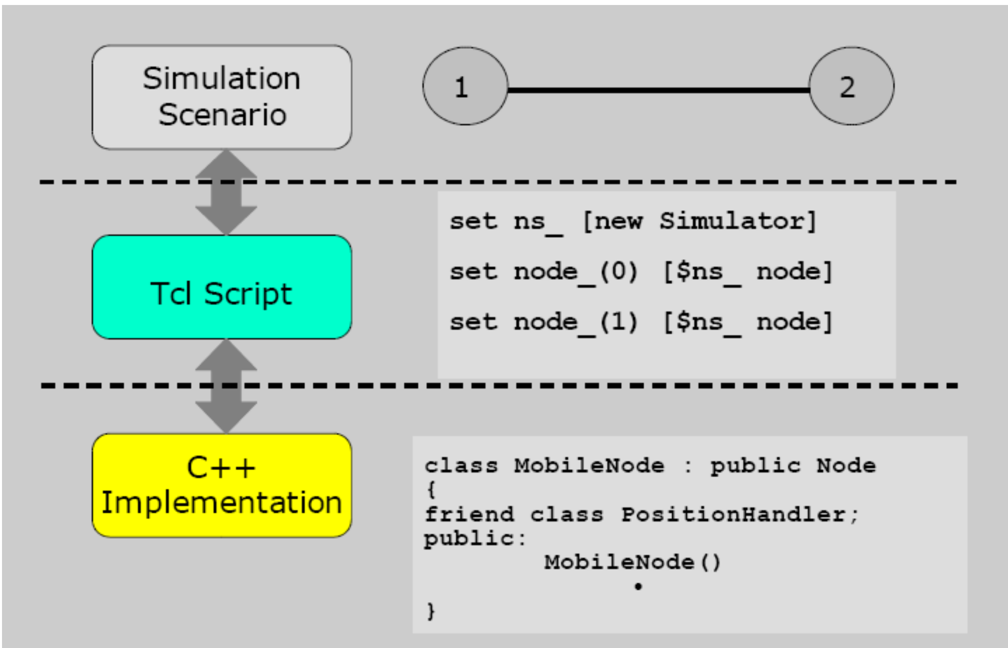

Figure 4.3: Architectural View of NS

4.3.2 GNUPlot

Gnuplot is a command-driven interactive function plotting program. It can be used to plot functions and data points in both two- and three-dimensional plots in many different formats. It is designed primarily for the visual display of scientific data. gnuplot is copy righted, but freely distributable; you don't have to pay for it. GNUPlot provides following functionalities.

a. Plotting two-dimensional functions and data points in many different styles

b. Plotting three-dimensional data points and surfaces in many different styles

c. Algebraic computation in integer,float and complex arithmetic

d. Support for a large number of operating systems, graphics file formats and output devices

e. TEX-like text formatting for labels, titles, axes, data points

f. Extensive on-line help

4.3.3 Awk

Awk has two faces: it is a utility for performing simple text-processing tasks, and it is a programming language for performing complex text-processing tasks.The two faces are really the same, however. Awk uses the same mechanisms for handling any text-processing task, but these mechanisms are flexible enough to allow useful Awk programs to be entered on the command line, or to implement complicated programs containing dozens of lines of Awk statements. The Awk text-processing language is useful for such tasks as:

- Tallying information from text files and creating reports from the results.
- Adding additional functions to text editors like "vi".
- Translating files from one format to another.
- Creating small databases.
- Performing mathematical operations on files of numeric data.

Awk statements comprise a programming language. In fact, Awk is useful for simple,quick-and-dirty computational programming. Anybody who can write a BASIC program can use Awk, although Awk's syntax is different from that of BASIC. Anybody who can write a C program can use Awk with little difficulty, and those who would like to learn C may find Awk a useful stepping stone. Awk is not really well suited for extremely large, complicated tasks. It is also an "interpreted" language that is, an Awk program cannot run on its own, it must be executed by the Awk utility itself. That means that it is relatively slow, though it is efficient as interpretive languages go, and that the program can only be used on systems that have Awk. There are translators available that can convert Awk programs into C code for compilation as stand-alone programs, but such translators have to be purchased separately

Chapter 5

Simulation Parameter and Results

5.1 Simulation Parameter

The experiments were carried out using the network simulator (ns-2). The scenarios developed to carry out the tests use as parameters the mobility of the nodes and the number of active connections in the network. The module explained above was tested with the previously developed attacks. The choices of the simulator parameters that are presented in table I consider both the accuracy and the efficiency of the simulation.

The number of nodes (network size N) is 50. The mobility model chosen is the Random Way Point Model, which is general in nature and provides the node distributions. Unless otherwise indicated, the speed is uniformly distributed between 0 and 20 ms. We used Random Way Point model because we were not targeting particular application. Constant Bit Rate (CBR) is chosen for generating data packet. In each traffic pattern, 50 sessions are constantly maintained to keep every node involved in networking. We modify energy

Type	**Value**
Transmit Power	0.60 W
Receiving Power	0.30 W
Traffic Model	CBR
Packet Size	512 Bytes
Maximum Packet	10000
Initial Energy	100,1000
Simulation Time	200 Sec

Table I: Simulation Parameter

saving mac protocols in ns2 simulator. The version of ns2 that we used is ns 2.34. We set the experiment space to be a 670 m x 670 m square and place nodes at random in the space. In these simulations we consider mobility.

An instance of the NS simulator is created, network topology is defined using the provided scenario file and also trace files2 are prepared to write on them. Mobile nodes are configured with the settings provided in tables I and II.

Type	**Value**
X dimension of topography	670,1000,1250
Y dimension of topography	670,1000, 1250
Number of mobile nodes	50
Ad-hoc routing protocol	DSR
Scenario file	$Scen670x670 - 50$
Connection pattern file	$CBR - 50$
Trace output file	tc.tr

Table II: Example of user defined options of NS-2 simulations.

We generate traces for dynamic topology with CBR. Each result is average of 10 traces. Following table summarize the detail of k-nearest neighbor

Topology	**Traffic Model**	**Num of Nodes**	**Num of K-NN**
Dynamic	CBR	50	3,5,7,9,11,13,15,17,19

Table III: Trace Details.

5.2 Result

We plotted Energy Consumption and Packet Delivery Ratio of K- Nearest Neighbor node. Figure 5.1,5.2 and 5.3 shows the graph of relationship between Energy Consumption and K-Node Degree.

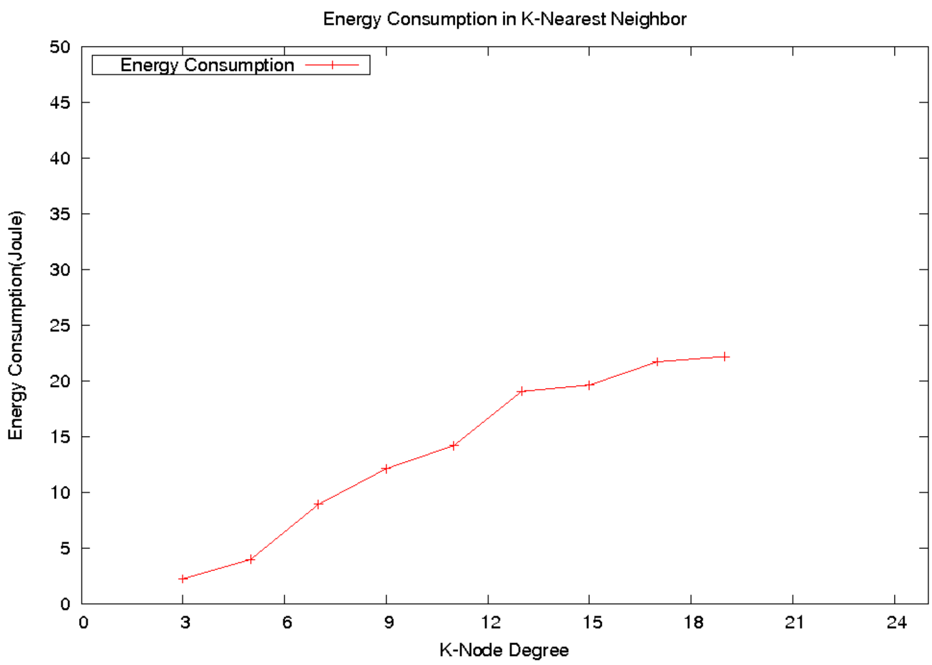

Figure 5.1: Energy Consumption Vs. K-Node Degree(670 x 670).

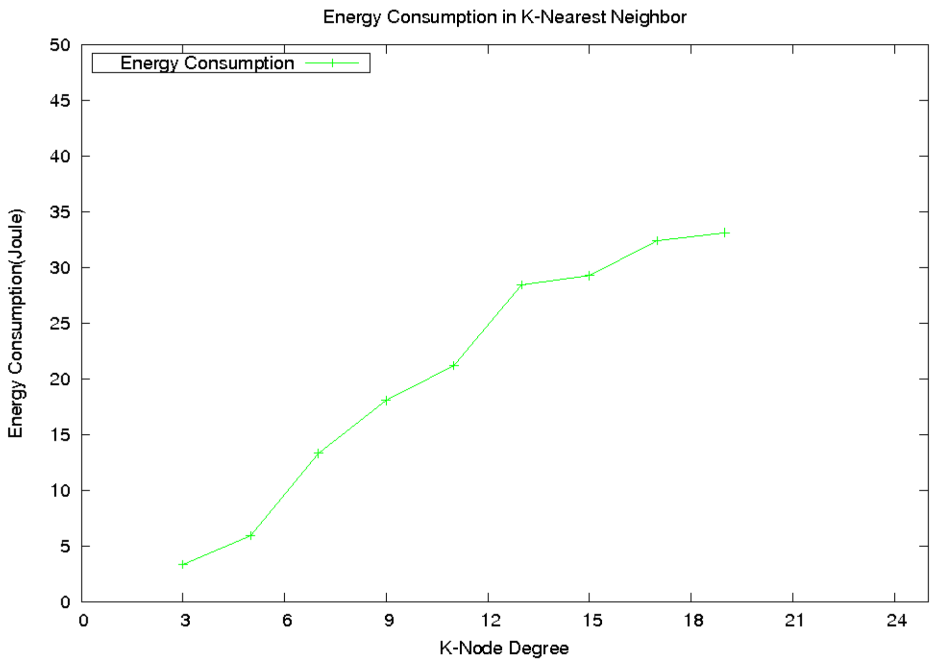

Figure 5.2: Energy Consumption Vs. Node Degree(1000 x 1000).

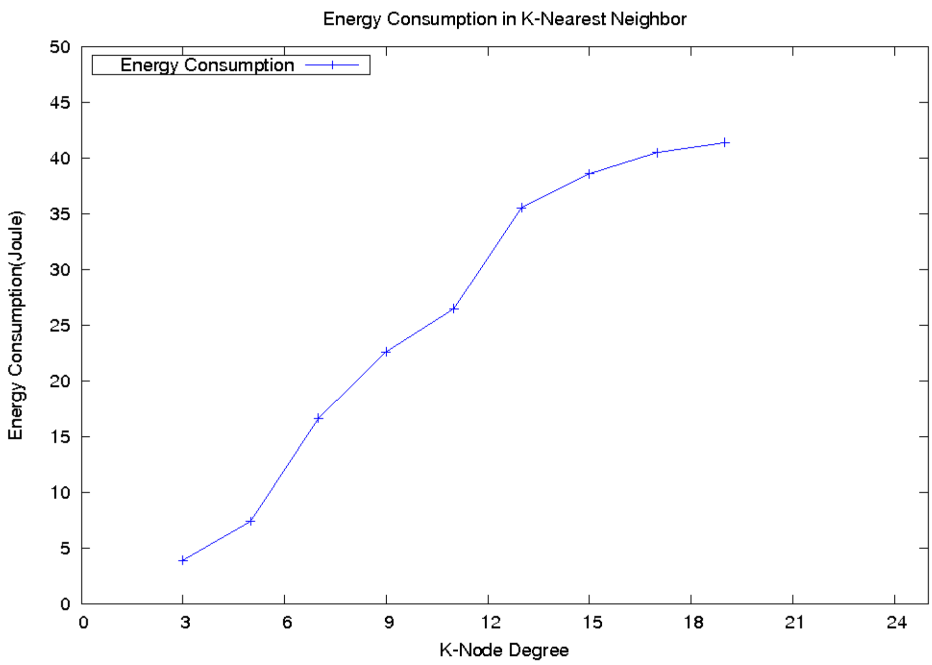

Figure 5.3: Energy Consumption Vs. Node Degree(1250 x 1250).

From the graphs in figure 5.1,5.2 and 5.3 we can say that with increasing value of K, energy consumption increases.

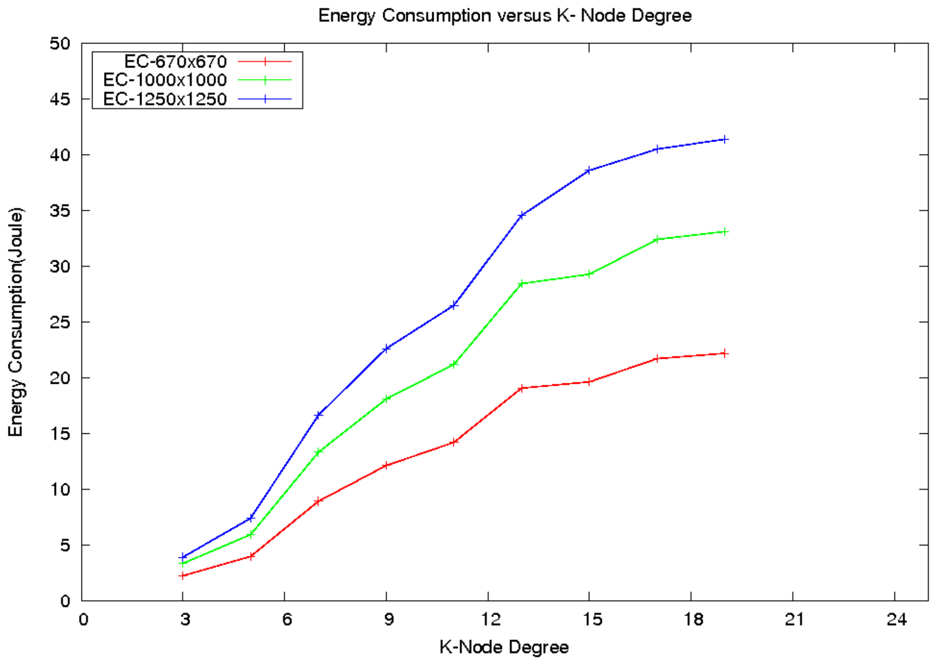

Figure 5.4: Comparison of Energy Consumption Vs. K-Node Degree in Different Scenario

From the graph in figure 5.4 we can say that with the increase of area, energy consumption increases.

Figure 5.5,5.6 and 5.7 shows the relationship between PDR (Packet Delivery Ratio) and K-Node degree.

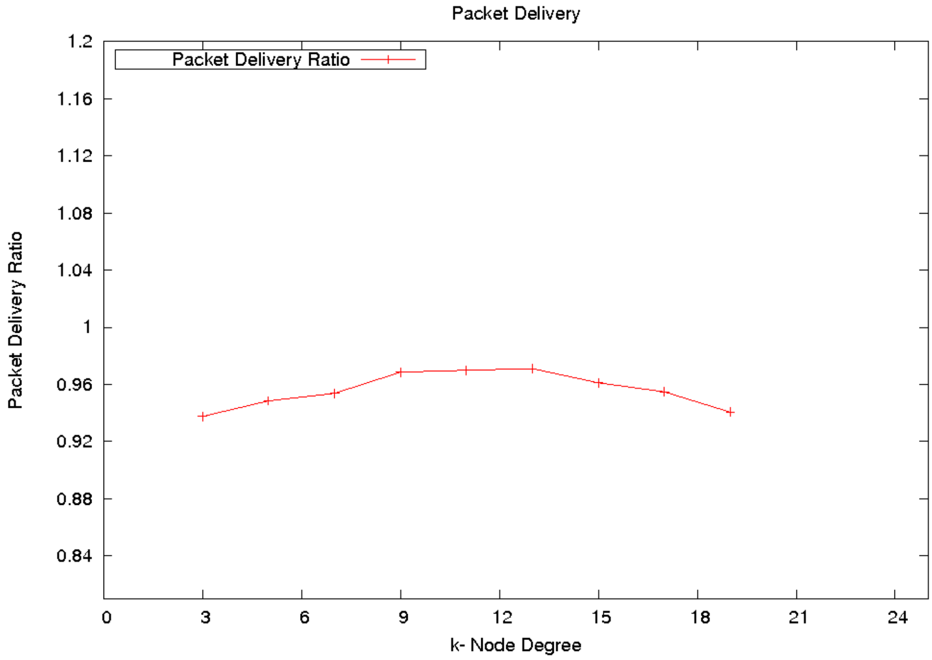

Figure 5.5: PDR Vs. K-Node Degree(670 x 670).

From the graphs in figure 5.5,5.6 and 5.7 we can say that PDR increases up to some value of K(e.g. k=10,11,13). But after some value of K if we increase the value K, PDR will decrease.

Figure 5.6: PDR Vs. K-Node Degree(1000 x 1000).

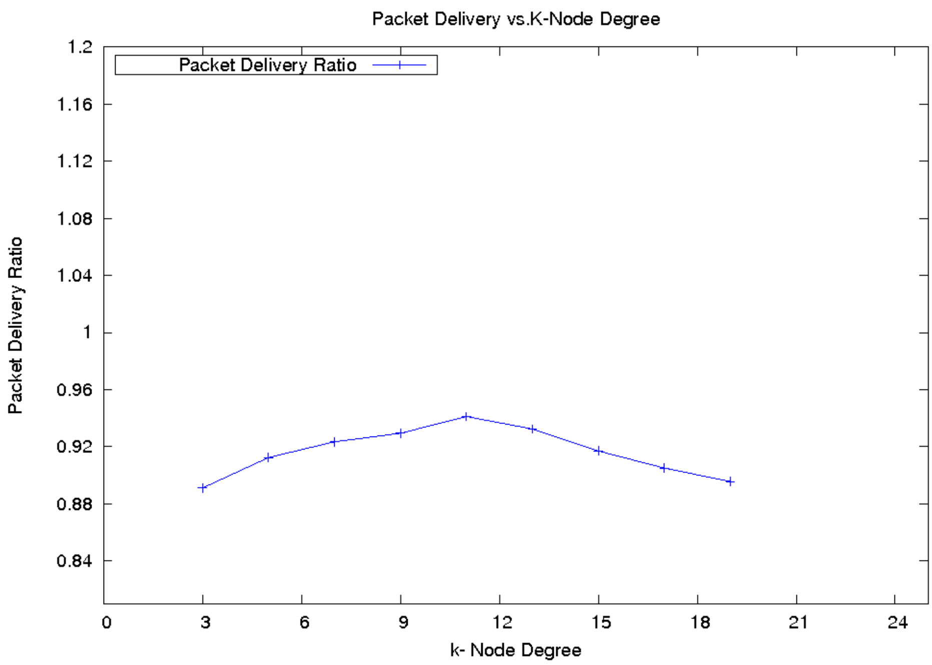

Figure 5.7: PDR Vs. K-Node Degree(1250 x 1250).

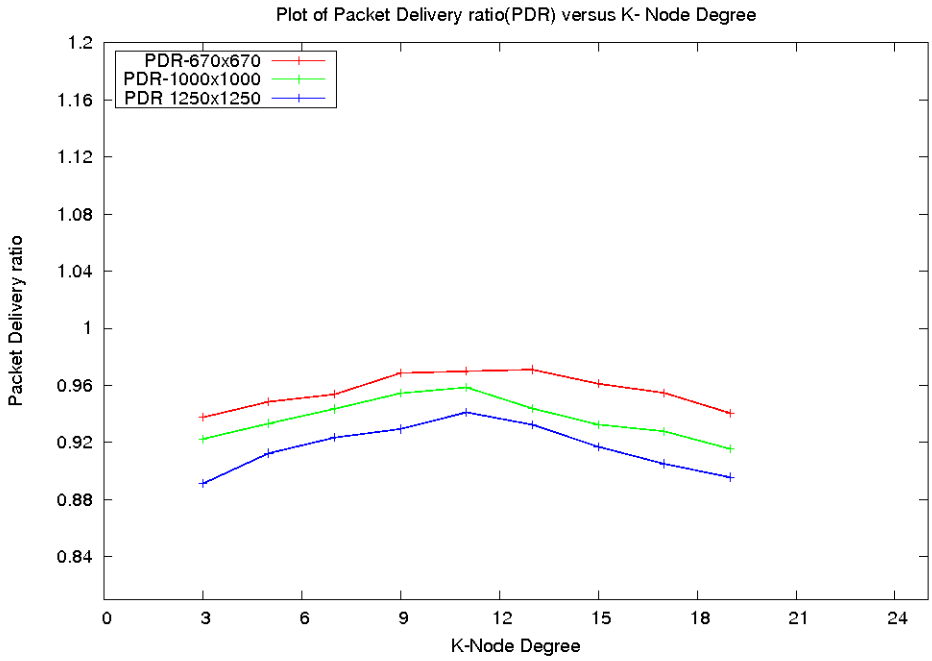

Figure 5.8: Comparison of PDR Vs. K- Node Degree in Different Scenario.

Chapter 6

Conclusion and Future work

6.1 Conclusion

In this thesis, we analyze performance of K-neighbor topology control mechanism in ad hoc network for different values of K in different network scenarios. We have plotted and analyzed several graphs of energy consumption vs K-Node degree and PDR vs K-Node degree for different areas. From the analysis of those graphs we can say that energy consumption increases with increasing value of K and PDR increases for some value of K but after that value PDR decreases.

6.2 Future Work

Literature survey is carried out topology control protocol for energy saving in wireless adhoc network. we identify certain limitation of various topology protocol and aim is to compare performance of various topology control protocol using simulation with respect to energy saving in major parameter.

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