DATA GATHERING WITH MULTIPLE MOBILE SINK IN SECURE WIRELESS SENSOR NETWORK USING RSA

A PROJECT REPORT

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BONAFIDE CERTIFICATE

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INTERNAL EXAMINER **EXTERNAL EXAMINER**

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ABSTRACT

The emerging wireless energy transfer technology enables charging sensor batteries in a wireless sensor network (WSN) and maintaining perpetual operation of the network. Recent breakthrough in this area has opened up a new dimension to the design of sensor network protocols. In the meanwhile, secure mobile data gathering has been considered as an efficient alternative to data relaying in WSNs. To achieve a secure system, security must be integrated into every component, since components designed without security can become a point of attack. Consequently, security must pervade every aspect of system design.

In this proposed work a new secure data gathering mechanism for large-scale wireless sensor networks by introducing mobility into the network along with secure data collection by RSA algorithm. We propose a framework of joint Wireless Energy Replenishment and anchor-point based Mobile Data Gathering (WerMDG) in WSNs by considering various sources of energy consumption and time-varying nature of energy replenishment. Data aggregation, as a typical operation in data gathering applications, can cause more energy wastage since sensor nodes, when it is not receiving data may keep in the listen state during the data collection process. To that end, we first determine the anchor point selection strategy and the sequence to visit the anchor points by multiple mobile sink. Secure Mobile data gathering using multiple mobile sink along with RSA algorithms has been considered as an efficient alternative to data relaying in WSNs.

TABLE OF CONTENTS

LIST OF FIGURES

List of abbreviations

WSN	Wireless Sensor Network
TSP	Travelling Sensor Network
DCF	Distributed Coordination Function
AODV	Ad-hoc on Demand Distance Vector routing
PTS	Packet Transmission Scheduling
JMERDG	Join Mobile Energy replenishment and data gathering
WERMDG	Wireless energy replenishment and data gathering

CHAPTER I

INTRODUCTION

Currently, wireless sensor networks (WSNs) are mainly powered by batteries. Due to limited energy storage capacity of a sensor battery, WSNs can usually remain operational only for a limited amount of time. However, in many applications, such as earthquake, soil monitoring and glacial movement monitoring, due to the harshness of the environment, a long period of unattended operability is required. Although there has been a flourish of research efforts on prolonging the lifetime of WSNs, network lifetime remains a performance bottleneck of WSNs and one of the key factors that hinder their large scale deployment. On the other hand, it has been shown that energy harvesting from natural sources, such as solar, wind, thermal and vibration can effectively improve network performance and prolong network lifetime. However, the success of extracting energy from the environment remains limited in practice. This is because that the outcome of energy-harvesting highly depends on the environment. For example, in a solar harvesting system, the amount of harvested energy is determined by the time and strength of solar radiation.

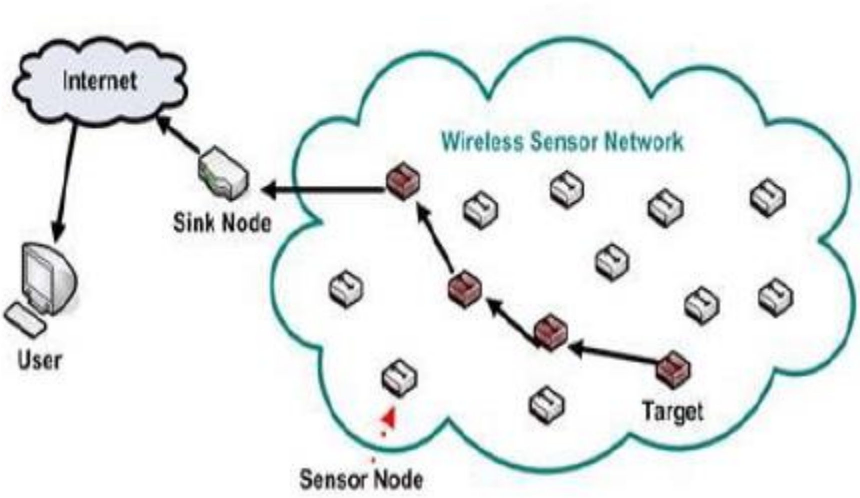

Figure 1.1 WSN Architecture

Energy harvesting from natural sources such as solar, wind, thermal, and vibration, have been shown to be effective in addressing the above problem. The amount and source of energy that can be leveraged depends on the environment and the application. For example, in a deployment for monitoring vibration of industrial machines, vibration energy could be readily available. Similarly, for a deployment for monitoring the air-quality in the AC-ducts, thermal energy can be harvested when hot air is blowing. For outdoor deployments, solar energy is readily available for a wide range of application scenarios.

A Wireless Sensor Network (WSN) is a self-configuring network of small sensor nodes communicating among themselves using radio signals, and deployed in quantity to sense, monitor and understand the physical world. It consists of spatially distributed autonomous sensors to *monitor* physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bidirectional enabling also to *control* the activity of the sensors. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring and so on. Multiple sensors (often hundreds or thousands) form a network to cooperatively monitor large or complex physical environments.

Every sensor communicates directly with the base station. It may require large transmit powers and may be infeasible in large geographic areas. This is called as single hop transmission. A sensor, which serve as relay for other sensor nodes to transmit the data is called Multi-hop transmission. It may reduce power consumption and allows for larger coverage. It introduces the problem of routing.

1.1.1 Mobile Sink Wireless Sensor Networks

In Mobile Sink Wireless Sensor Networks all the sensors are statically deployed to sense the environment and mobile sink traverse the networks. In the sink neighbourhood problem is neighbour nodes of sink participate more in the data transmission. The result is the faster energy deplete compared to other nodes in the network. If we look over the energy conservation model sensor deplete some amount of energy during the data receiving and the data transmission. As the sensor those are close to the sink, participate more data transmission i.e. for them and for those sensors away from the sink in the same direction.

In MSWSN all nodes are static other than the sink in the network. Mobile sink traverse randomly to collect the sensor data. It may be collect with one hop or multi hop communication and our proposed model is the one hop data collection. As sink traversing throughout the network for data collection so the neighbour of the sink is not fix, so neighbourhood problem will not arises. Here we use LR-WPAN IEEE 802.15.4 low cost wireless link. IEEE 802.15.4 intends the lower network layers of a type of wireless personal area network (WPAN) which focuses on low cost, low speed global communication between the sensors. IEEE 802.15.4 security consists of four kinds of security services such as access control, message integrity, message confidentiality, and replay protection. The access control feature should prevent illegal users to participate in the process. In other word, only authorized users can able join in a legitimated network. Message integrity means the validity of transferred data and message authentication implies message sender's verification using cryptographic function.

Considering the superiority and promising applications of mobile data gathering, we present distributed algorithms to achieve its optimal performance. We consider anchor-based mobile data gathering, where a mobile collector periodically starts a data gathering tour, and in each tour it visits some predefined positions called anchor points in the field and stays at each anchor point for a period of sojourn time to collect data from nearby sensors via multi-hop transmissions. In general, a good data gathering scheme should ensure an expected network lifetime and have abounded data gathering latency as well. Therefore, our overall objective is to maximize the network utility under the constraints of guaranteed network lifetime and data gathering latency to achieve this objective, we will address following three issues that critically affect the data gathering performance. First, from a sensor's point of view, since the Sencar may stay at different anchor points to collect data, how much data should be sent from the sensor to the Sencar at a particular anchor point? Second, in terms of communication efficiency.

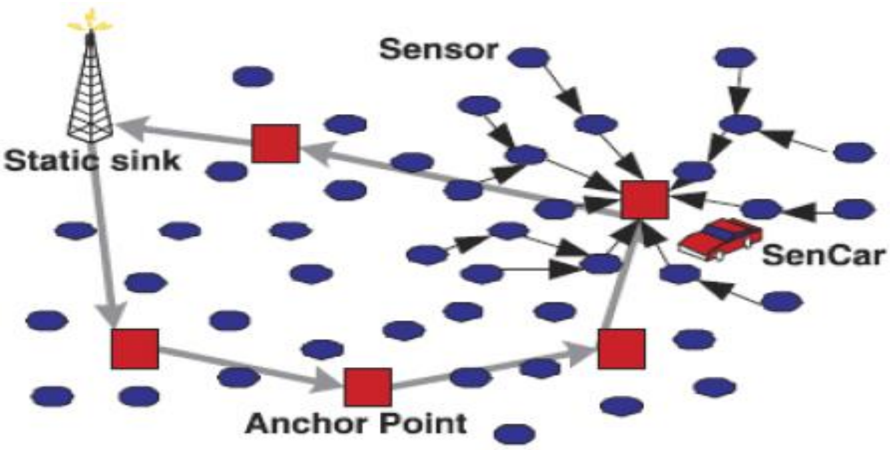

Fig 1.2 Anchor-based mobile data gathering

Third, from the SenCar's point of view, to bound the data gathering latency is actually to constrain the total sojourn time at all anchor points under a threshold.

1.2 ENERGY REPLENISHMENT

In order to provide steady and high recharging rate for the power supplies of sensors, and meanwhile effectively alleviate energy expenditure on data gathering, in this paper we alternatively propose a joint design of energy replenishment and data gathering by exploiting mobility, which is referred to as J-MERDG. In particular, a multi-functional mobile entity, called *SenCar* in this paper, is employed, which is equipped with a powerful transceiver and high capacity battery. The SenCar will periodically choose a subset of sensors to visit. While migrating among these sensors, it delivers energy to the visited sensors by utilizing wireless energy transmissions and meanwhile it collects data from nearby sensors via short-range multi-hop communication. This way, the SenCar, serving as both an energy transporter and a mobile data collector, performs the tasks of energy replenishment and data gathering simultaneously.

In contrast to the conventional energy harvesting networks, the mobility brings us many benefits. First, since sensors receive energy supplement directly from the SenCar, the replenishment will no longer suffer from environmental variations. Second, as long as the SenCar moves close enough to sensors, high charging efficiency can be achieved to ensure high rate data services. Third, as the SenCar takes the responsibility of energy delivery, it is commercially appealing that no complex energy harvesting devices are needed at each sensor, which significantly reduces the cost of sensors. Finally, by exploiting controlled mobility, the SenCar can efficiently perform energy delivery and data gathering simultaneously. This is extremely desirable as such combination makes a double contribution to the energy management of the network. On one hand, the Sencar infuses steady and abundant renewable energy into the network almost at no additional cost. On the other hand, mobility alleviates the routing burden at sensors for data uploading so that great energy can be saved to further leverage the refilled energy.

In recent years, energy harvesting technologies have been effectively integrated into sensor systems. A variety of ambient energy, such as mechanical, thermal, photovoltaic and electromagnetic energy can be converted into electrical energy to drive sensors or recharge sensor batteries, such that prolonged network lifetime or perpetual operations can be achieved. However, as all these energy sources are from the external environment and their spatial-temporal profiles exhibit great variations, the strength of harvested energy is typically low, and especially sensitive to the environment dynamics. For example, in a solar harvesting system, the output power of a sensor is determined by the solar radiation that arrives at the equipped solar panel, which drastically varies with time and weather. Statistics show that the difference can be up to three orders of magnitude among the available solar power in shadowy, cloudy and sunny environments. As there is generally a lack of a priori knowledge of energy profile, such dynamics imposes much difficulty on the design of protocols that must keep sensors from running out of energy.

1.3 DATA AGGREGATION IN WIRELESS SENSOR NETWORKS

An example of data aggregation is obtaining AVERAGE, MAX, MIN, or SUM of readings from all sensors. For example, if the sink wants to collect the average temperature of the area monitored by a sensor network, the naive approach would be to let each sensor node send its temperature reading back to the sink, and the sink can then compute the average temperature from collected readings.

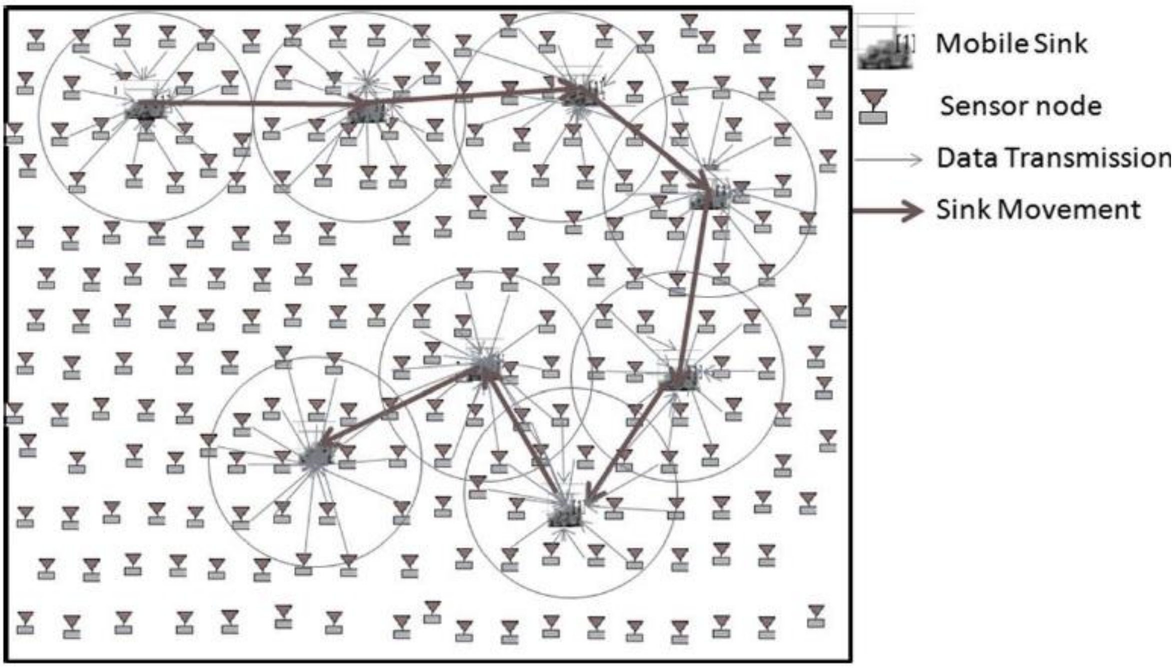

Figure 1.3 Wireless Sensor Networks with Mobile Sink

However, instead of sending individual readings back to the sink, intermediate sensor nodes can combine their temperature readings with the received readings, and send only the average temperature of all readings it has, together with the number of readings contributing to the average temperature, to the sink. The average temperature can be updated while being forwarded toward the sink, and eventually the sink can still compute the average temperature of all sensor readings. In this way, each node only sends the number of readings and the average temperature, which is significantly less data than forwarding all readings for others.

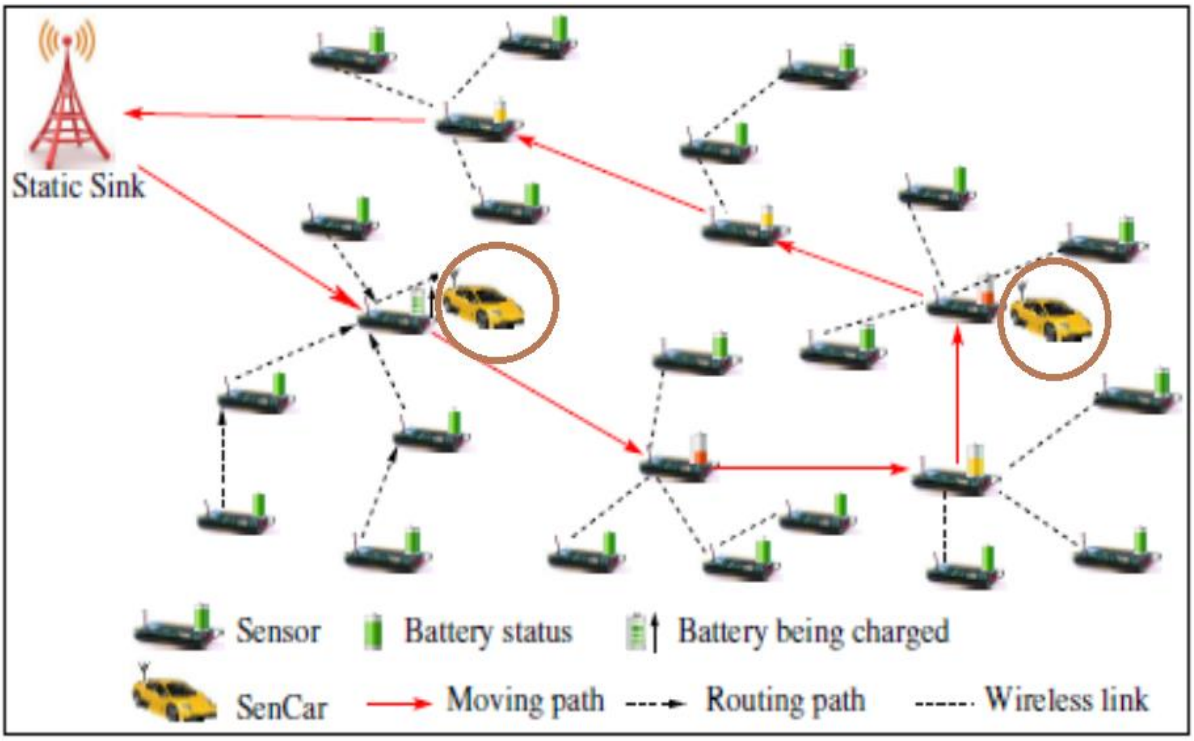

Figure 1.4 Network Model with Multiple Mobile Sink

CHAPTER II

LITERATURE SURVEY

Prolonging sensor lifetime in energy harvesting/rechargeable networks has recently attracted considerable attention in the wireless networking research community. In the authors' current solutions for fair and high throughput data extraction in the presence of renewable energy sources, which aims to compute the lexicographically maximum data collection rate for each node? Chenetill-considered the problem of maximizing throughput over a finite-horizon time period for a sensor network with energy replenishment. Liu et al. studied the problem of joint energy management and resource allocation in rechargeable it is defined as the total number of packets delivered over the total simulation time. The throughput comparison shows that the three algorithms performance margins are very close under traffic load of 50 and 100 nodes in WSN scenario and have large margins when number of nodes increases to 200. Mathematically, it can be defined as: Throughput= N/1000 Where *N* is the number of bits received successfully by all destinations. Above graphs shows the variation of the delay. AODV consistently shows the highest delay. DSDV has the lowest delay as compared to the DSR and DSDV. One factor can be that it have less throughput (Number of packets delivered per unit time) so it is having the less delay

sensor networks to maximize network utility while maintaining perpetual operation. In addition, energy harvesting techniques have been considered along with the traditional data collection with a static data sink. In the meanwhile, utility maximization problem for mobile data gathering in WSN has been considered Zhao et al. formalized the mobile data gathering problems as network utility maximization problems under the constraints of guaranteed network lifetime and data gathering latency.

In data collection performance was further improved by equipping the vehicle with multiple antennas to allow concurrent uploading. The network utility maximization was studied for MANETs with loss links such that the rate-outage probability is within some arbitrarily small target tolerance. In, a transmission scheduling algorithm was studied for wireless sensor networks with high node densities, where a mobile sink is responsible for gathering the data packets from the sensor nodes with similar observations. However, these works do not consider the current battery energy of sensor node in energy balance constraint and the energy consumptions in receiving and sensing data.

2.1 WIRELESS ENERGY TRANSFER

Recently, there have been great research efforts in the area of wireless energy transfer. It was shown that wireless energy residing in the radio frequencies can be effectively captured to power small devices such as sensors. In order to achieve timely and efficient charging, Erol-Kantarci and Mouftah proposed a sustainable wireless rechargeable sensor network which employs mobile chargers that charge multiple sensors from several landmark locations. In Chiu et al. studied mobility-aware charger deployment for wireless rechargeable sensor networks with an objective of maximizing the survival rate of end-devices. In He et al. considered reader (energy provider) deployment, point provisioning and path provisioning in a wireless rechargeable sensor network to ensure the WISP tags (energy receivers) can harvest sufficient energy for continuous operation. In Wang et al. studied real time recharge policy for wireless rechargeable sensor networks. In addition to wireless energy transfer via radio frequencies, energy transfer through magnetic coupling can usually support higher amount of energy transfer in short time with high efficiency.

Its application in WSNs was envisioned. Shi et al. considered the scenario of a mobile charging vehicle periodically traveling inside a sensor network with static data collection and recharging each sensor node's battery wirelessly. Zhao et al. combined wireless energy transfer with mobile data collection and formulated the problem into a utility Maximization problem. However, mobile data collection was not considered, while the energy consumptions in receiving data and the time-varying nature of recharging process were not reflected in the analysis. Moreover, the works overlook the fact that the recharge process brings the energy gradually to the level of battery capacity. In wireless charging and mobile data collection in WSNs were jointly studied and distributed algorithms on how to select data rates, adjust link flow and recharge sojourn time were proposed. However, only results on individual nodes were provided.

2.2 EFFICIENT RESOURCE ALLOCATION

Jointly compute data collection rates for each node, find routes and schedule transmissions. Similar to our work, Zhao et al. gave a solution in which the locations of a subset of sensors are periodically selected as anchor points and proposed a distributed algorithm to adjust data rates, link scheduling and flow routing. However, these works do not consider the current battery energy of sensor node and the time varying nature of recharging process in their distributed algorithm. Zhang et al. proposed a harvesting aware utility- based sensing rate allocation algorithm whereas they focused on the environmental energy harvesting instead of wireless charging, and did not deal with the problem of how to select sensor nodes to be recharged.

In a joint opportunistic power scheduling and end-to- end rate control scheme was presented for wireless ad hoc networks by modelling the time-varying wireless channel as a stochastic process. In the authors modelled an efficient spatial-TDMA based adaptive power and rate cross-layer scheduling problem as a mixed integer linear program .

2.3 LITERATURE SURVEY

1. M. Ma and Y. Yang, "**SenCar: An Energy Efficient Data Gathering Mechanism for Large Scale Multihop Sensor Networks**, Proposed a hearing-range-based localization scheme that also exploits the network topology changes caused by jamming attacks. In particular, to quantify the network topology changes, we introduced the concept of a node's hearing range, an area from which a node can successfully receive and decode the packet. We have discovered that a jammer may reduce the size of a node's hearing range, and the level of changes is determined by the relative location of the jammer and its jamming intensity. Therefore, instead of searching for the jammer's position iteratively, we can utilize the hearing range to localize the jammer in one round, which significantly reduces the computational cost yet achieves better localization performance than prior work.

2. R.-S. Liu, K.-W. Fan, Z. Zheng, and P. Sinha, "**Perpetual and Fair Data Collection for Environmental Energy Harvesting Sensor Networks**," Renewable energy enables sensor networks with the capability to recharge and provide perpetual data services. Due to low recharging rates and the dynamics of renewable energy such as solar and wind power, providing services without interruptions caused by battery run outs is nontrivial. Most environment monitoring applications require data collection from all nodes at a steady rate. The objective of this paper is to design a solution for fair and high throughput data extraction from all nodes in the presence of renewable energy sources. Specifically, we seek to compute

the lexicographically maximum data collection rate and routing paths for each node such that no node will ever run out of energy.

We propose a centralized algorithm and two distributed algorithms. The centralized algorithm jointly computes the optimal data collection rate for all nodes along with the flows on each link, the first distributed algorithm computes the optimal rate when the routing structure is a given tree, and the second distributed algorithm, although heuristic, jointly computes a routing structure and a high lexicographic rate assignment that is nearly optimum. We prove the optimality for the centralized and the first distributed algorithm, and use real test-bed experiments and extensive simulations to evaluate both of the distributed algorithms.

3. M. Ma, Y. Yang, and M. Zhao, "**Tour Planning for Mobile Data Gathering Mechanisms in Wireless Sensor Networks**," in this paper, we propose a new data-gathering mechanism for large-scale wireless sensor networks by introducing mobility into the network. A mobile data collector, for convenience called an M-collector in this paper, could be a mobile robot or a vehicle equipped with a powerful transceiver and battery, working like a mobile base station and gathering data while moving through the field. An M-collector starts the data-gathering tour periodically from the static data sink, polls each sensor while traversing its transmission range, then directly collects data from the sensor in single-hop communications, and finally transports the data to the static sink. Since data packets are directly gathered without relays and collisions, the lifetime of sensors is expected to be prolonged. In this paper, we mainly focus on the problem of minimizing the length of each data-gathering tour and refer to this as the single-hop data-gathering problem (SHDGP). We first formalize the SHDGP into a mixed-integer program and then present a heuristic tour-planning algorithm for the case where a single M-collector is employed.

For the applications with strict distance/time constraints, we consider utilizing multiple M-collectors and propose a data-gathering algorithm where multiple M-collectors traverse through several shorter sub tours concurrently to satisfy the distance/time constraints. Our single-hop mobile data-gathering scheme can improve the scalability and balance the energy consumption among sensors. It can be used in both connected and disconnected networks. Simulation results demonstrate that the proposed data-gathering algorithm can greatly shorten the moving distance of the collectors compared with the covering line approximation algorithm and is close to the optimal algorithm for small networks. In addition, the proposed data-gathering scheme can significantly prolong the network lifetime compared with a network with static data sink or a network in which the mobile collector c- n only move along straight lines.

4. M. Zhao and Y. Yang, "**Optimization Based Distributed Algorithms for Mobile Data Gathering in Wireless Sensor Networks**," Recent advances have shown a great potential of mobile data gathering in wireless sensor networks, where one or more mobile collectors are employed to collect data from sensors via short-range communications. Among a variety of data gathering approaches, one typical scheme is called anchor-based mobile data gathering. In such a scheme, during each periodic data gathering tour, the mobile collector stays at each anchor point for a period of sojourn time, and in the meanwhile the nearby sensors transmit data to the collector in a multihop fashion. In this paper, we focus on such a data gathering scheme and provide distributed algorithms to achieve its optimal performance. We consider two different cases depending on whether the mobile collector has fixed or variable sojourn time at each anchor point. We adopt network utility, which is a properly defined function, to characterize the data gathering performance, and formalize the problems as network utility maximization problems under the constraints of guaranteed network lifetime and data gathering latency. To efficiently solve these problems, we decompose each of them into several sub problems and solve them in a distributed manner, which facilitates the scalable implementation of the optimization algorithms. Finally, we provide extensive numerical results to demonstrate the usage and efficiency of the proposed algorithms and complement our theoretical analysis.

5. R.-S. Liu, P. Sinha, and C. Koksal, "**Joint Energy Management and Resource Allocation in Rechargeable Sensor Networks**," Energy harvesting sensor platforms have opened up a new dimension to the design of network protocols. In order to sustain the network operation, the energy consumption rate cannot be higher than the energy harvesting rate, otherwise, sensor nodes will eventually deplete their batteries. In contrast to traditional network resource allocation problems where the resources are static, the time-varying recharging rate presents a new challenge. In this paper, we first explore the performance of an efficient dual decomposition and sub gradient method based algorithm, called Quick Fix, for computing the data sampling rate and routes.

However, fluctuations in recharging can happen at a faster time-scale than the convergence time of the traditional approach. This leads to battery outage and overflow scenarios, that are both undesirable due to missed samples and lost energy harvesting opportunities respectively. To address such dynamics, a local algorithm, called Snap It, is designed to adapt the sampling rate with the objective of maintaining the battery at a target level. Our evaluations using the TOSSIM simulator show that Quick Fix and Snap It working in tandem can track the instantaneous optimum network utility while maintaining the battery at a target level. When compared with IFRC, a backpressure-based approach, our solution improves the total data rate by 42% on the average while significantly improving the network utility.

6. M. Zhao, J. Li, and Y. Yang, "**Joint Mobile Energy Replenishment and Data Gathering in Wireless Rechargeable Sensor Networks**," Recent studies have shown that energy harvesting wireless sensor networks have the potential to provide perpetual network operations by capturing renewable energy from the external environment. However, the spatial-temporal profiles of such ambient energy sources typically exhibit great variations, and can only provide intermittent recharging opportunities to support low-rate data services. In order to provide steady and high recharging rates, and achieve energy-efficient data gathering from sensors, in this paper, we propose to utilize mobility for the joint design of energy replenishment and data gathering.

In particular, a multifunctional mobile entity, called *SenCar* in this paper, is employed, which serves not only as a data collector that roams over the field to gather data via short-range communication but also as an energy transporter that charges static sensors on its migration tour via wireless energy transmissions. Taking advantages of the SenCar's controlled mobility; we give a two-stage approach for the joint design. In the first stage, the locations of a subset of sensors are periodically selected as *anchor points*, where the SenCar will sequentially visit to charge the sensors at these locations and gather data from nearby sensors in a multi-hop fashion. In order to achieve a desirable balance between the energy replenishment amount and data gathering latency, we provide a selection algorithm to search for a maximum number of anchor points where sensors hold the least battery energy, and meanwhile by visiting them the tour length of the SenCar is no more than a threshold value. In the second stage, we consider data gathering performance when the SenCar migrates among these anchor points. We formulate the problem into a network utility maximization problem and propose a distributed algorithm to adjust data rates, link scheduling and flow routing so as to adapt to the up-to-date energy replenishing status of sensors. The effectiveness of our approach is validated by extensive numerical results. Comparing with solar harvesting networks, our solution can improve the network utility by 48% on average.

7. M. Zhao, M. Ma, and Y. Yang, "**Efficient Data Gathering with Mobile Collectors and Space-Division Multiple Access Technique in Wireless Sensor Networks**," Recent years have witnessed a surge of interest in efficient data gathering schemes in wireless sensor networks (WSNs). In this paper, we address this issue by adopting mobility and space-division multiple access (SDMA) technique. Specifically, mobile collectors, called SenCars in this paper, work like mobile base stations and collect data from associated sensors via single-hop transmissions so as to achieve uniform energy consumption. We also apply SDMA technique to data gathering by equipping each SenCar with multiple antennas such that distinct compatible sensors may successfully make concurrent data uploading to a SenCar. To investigate the utility of the joint design of controlled mobility and SDMA technique, we consider two cases, where a single SenCar and multiple SenCars are deployed in a WSN, respectively. For the single SenCar case, we aim to minimize the total data gathering time, which consists of the moving time of the SenCar and the data uploading time of sensors, by exploring the trade-off between the shortest moving tour and the full utilization of SDMA. We refer to this problem as mobile data gathering with SDMA, or MDG-SDMA for short. We formalize it into an integer linear program (ILP) and propose three heuristic algorithms for it. In the multi-SenCar case, the sensing field is divided into several regions, each having a SenCar. We focus on minimizing the maximum data gathering time among different regions and refer to it as mobile data gathering with multiple Sencar and SDMA (MDG-MS) problem. Accordingly, we propose a region-division and tour-planning (RDTP) algorithm in which data gathering time is balanced among different regions. We carry out extensive simulations and the results demonstrate that our proposed algorithms significantly outperform single SenCar and non-SDMA schemes.

8. M. Zhao and Y. Yang, "**Bounded Relay Hop Mobile Data Gathering in Wireless Sensor Networks**," Recent study reveals that great benefit can be achieved for data gathering

in wireless sensor networks by employing mobile collectors that gather the data via short-range communications. To pursue maximum energy saving at sensor nodes, intuitively, a mobile collector should traverse the transmission range of each sensor in the field such that the transmission of each packet can be constrained to a single hop. However, this approach may lead to significantly increased data collection latency due to the low moving velocity of the mobile collector. On the other hand, data collection latency can be effectively shortened by performing local aggregation via multi-hop transmissions and then uploading the packets from relay sensors to the mobile collector. However, local transmission hops should not be arbitrarily increased since it may incur too much energy consumption on packet relays, which would adversely affect the overall efficiency of mobile data collection. Based on these observations, in this paper, we study the trade-off between energy saving and data collection latency in mobile data gathering by exploring a balance between the relay hop count of local data aggregation and the moving tour length of the mobile collector. We first propose a polling-based mobile collection approach and formulate it into an optimization problem, named bounded relay hop mobile data collection (BRH-MDC). Specifically, a subset of sensors will be selected as polling points that buffer locally aggregated data and upload the data to the mobile collector when it arrives. In the meanwhile, when sensors are affiliated with these polling points, it is guaranteed that any packet relay is bounded within a given number of hops. We then give two efficient algorithms to select polling points among sensors. The effectiveness of our approach is validated through extensive simulations.

9. A.Sharifkhani and N.C. Beaulieu, "**A Mobile-Sink-Based Packet Transmission Scheduling Algorithm for Dense Wireless Sensor Networks**," A transmission scheduling algorithm is proposed for wireless sensor networks with high node densities, where a mobile sink is responsible for gathering the data packets from the sensor nodes with similar observations. The proposed algorithm is based on the well-known trade-off between the energy consumption and the probability of successful packet arrival at the sink, when the sensor nodes need to share a single transmission channel at each time slot. An optimal algorithm along with two reduced-complexity algorithms is introduced, where the new data packets generated by the sensor nodes are incorporated in the model. The simulation results indicate that, when the algorithm is used for transmission scheduling, it is advantageous in

terms of power consumption and successful packet transmission rate for networks with higher node densities.

10. T.-C. Chiu, Y.-Y. Shih, A.-C. Pang, J.-Y. Jeng, and P.-C. Hsiu, "**Mobility-Aware Charger Deployment for Wireless Rechargeable Sensor Networks**," Wireless charging technology is considered as one of the promising solutions to solve the energy limitation problem for large-scale wireless sensor networks. Obviously, charger deployment is a critical issue since the number of chargers would be limited by the network construction budget, which makes the full-coverage deployment of chargers infeasible. In many of the applications targeted by large-scale wireless sensor networks, end-devices are usually equipped by the human and their movement follows some degree of regularity. Therefore in this paper, we utilize this property to deploy chargers with partial coverage, with an objective to maximize the survival rate of end-devices. We prove this problem is NP-hard, and propose an algorithm to tackle it. The simulation results show that our proposed algorithm can significantly increase the survival rate of end-devices. To our knowledge, this is one of very first works that consider charger deployment with partial coverage in wireless rechargeable sensor networks.

11. S. He, J. Chen, F. Jiang, D.K.Y. Yau, G. Xing, and Y. Sun, "**Energy Provisioning in Wireless Rechargeable Sensor Networks**," Wireless rechargeable sensor networks (WRSNs) have emerged as an alternative to solving the challenges of size and operation time posed by traditional battery-powered systems. In this paper, we study a WRSN built from the industrial wireless identification and sensing platform (WISP) and commercial off-the-shelf RFID readers. The paper-thin WISP tags serve as sensors and can harvest energy from RF signals transmitted by the readers. This kind of WRSNs is highly desirable for indoor sensing and activity recognition and is gaining attention in the research community. One fundamental question in WRSN design is how to deploy readers in a network to ensure that the WISP tags can harvest sufficient energy for continuous operation. We refer to this issue as the energy provisioning problem. Based on a practical wireless recharge model supported by experimental data, we investigate two forms of the problem: point provisioning and path provisioning. Point provisioning uses the least number of readers to ensure that a static tag placed in any position of the network will receive a sufficient recharge rate for sustained

operation. Path provisioning exploits the potential mobility of tags (e.g., those carried by human users) to further reduce the number of readers necessary: mobile tags can harvest excess energy in power-rich regions and store it for later use in power-deficient regions. Our analysis shows that our deployment methods, by exploiting the physical characteristics of wireless recharging, can greatly reduce the number of readers compared with those assuming traditional coverage models.

12. S. Guo, C. Wang, and Y. Yang, "**Mobile Data Gathering with Wireless Energy Replenishment in Rechargeable Sensor Networks**," The emerging wireless energy transfer technology enables charging sensor batteries in a wireless sensor network (WSN) and maintaining perpetual operation of the network. Recent breakthrough in this area has opened up a new dimension to the design of sensor network protocols. In the meanwhile, mobile data gathering has been considered as an efficient alternative to data relaying in WSNs. However, time variation of recharging rates in wireless rechargeable sensor networks imposes a great challenge in obtaining an optimal data gathering strategy. In this paper, we propose a framework of joint Wireless Energy Replenishment and anchor-point based Mobile Data Gathering (WerMDG) in WSNs by considering various sources of energy consumption and time-varying nature of energy replenishment. To that end, we first determine the anchor point selection and the sequence to visit the anchor points. We then formulate the WerMDG problem into a network utility maximization problem which is constrained by flow conversation, energy balance, link and battery capacity and the bounded sojourn time of the mobile collector. Furthermore, we present a distributed algorithm composed of cross-layer data control, scheduling and routing sub algorithms for each sensor node, and sojourn time allocation sub algorithm for the mobile collector at different anchor points. Finally, we give extensive numerical results to verify the convergence of the proposed algorithm and the impact of utility weight on network performance.

13. B. Zhang, R. Simon, and H. Aydin, "**Maximum Utility Rate Allocation for Energy Harvesting Wireless Sensor Networks**," There is currently tremendous interest in deploying energy harvesting wireless sensor networks. Engineering such systems requires striking a careful balance between sensing performance and energy management. Our work addresses this problem through the design and analysis of a harvesting aware utility-based sensing rate

allocation algorithm. Based on a network utility formulation, we show that our algorithm is optimal in terms of assigning rates to individual nodes to maximize overall utility, while ensuring energy-neutral operation. To our knowledge, our work is the first optimal solution that maximizes network utility through rate assignments for tree-structured energy harvesting sensor networks. Our algorithm is fast and efficient with running time O(N3), where N is the number of nodes. We evaluate the performance, scalability, and overhead of our algorithm for various utility functions and network sizes, underlining its significant advantages.

14. W.R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "**Energy-Efficient Communication Protocol for Wireless Micro sensor Networks**," Wireless distributed micro sensor systems will enable the reliable monitoring of a variety of environments for both civil and military applications. In this paper, we look at communication protocols, which can have significant impact on the overall energy dissipation of these networks. Based on our findings that the conventional protocols of direct transmission, minimum-transmission-energy, multi-hop routing, and static clustering may not be optimal for sensor networks, we propose LEACH (Low-Energy Adaptive Clustering Hierarchy), a clustering-based protocol that utilizes randomized rotation of local cluster based station (cluster-heads) to evenly distribute the energy load among the sensors in the network. LEACH uses localized coordination to enable scalability and robustness for dynamic networks, and incorporates data fusion into the routing protocol to reduce the amount of information that must be transmitted to the base station. Simulations show the LEACH can achieve as much as a factor of 8 reductions in energy dissipation compared with conventional outing protocols.

CHAPTER III
SYSTEM ANALYSIS

3.1 EXISTING SYSTEM

- Generally a lack of a priori knowledge of energy profile, such dynamics imposes much difficulty on the design of protocols that must keep sensors from running out of energy.
- Multi-hop radio networks in the presence of energy replenishment and designed an energy-aware routing algorithm that is asymptotically optimal with respect to network size.
- Optimal sampling rates based on average energy replenishment rate and then designed a local algorithm for each sensor to adjust data rate according to instantaneous battery state.
- Sensors close to the static data sink deplete energy much faster than others due to the fact that they forward much more data than other sensors.
- Mobile collectors move along parallel straight lines for data collections.
- Mobile relays to help relieve sensors that are heavily burdened by a high volume of network traffic.
- Rendezvous design, which aims to find a set of rendezvous points (RPs) to be visited by the mobile collector within a required delay bound, while the network cost incurred in transmitting data from sources to RPs is minimized.
- Coupled magnetic resonance, it is feasible to transfer energy wirelessly between two coils.
- Joint design of energy replenishment and mobile data gathering (JMERDG) by establishing a flow-level network utility maximization model to characterize the data gathering performance.
- Existing schemes can greatly save energy by utilizing mobile collectors compared to the relay routing in static networks, none of them has considered renewable energy for sensors.
- In existing system energy consumption only in data transmission but not in data receiving and sensing, and regards recharging rates as constant instead of time-varying.

3.1.1 Disadvantages of Existing System

- The existing considers energy consumption only in data transmission but not in data receiving and sensing, and regards recharging rates as constant instead of time-varying.
- Network lifetime and data gathering latency.
- Minimum wireless energy transfer via radio frequencies.
- The energy consumptions in receiving data and the time-varying nature of recharging process were not reflected in the analysis.
- The environmental energy harvesting instead of wireless charging, and did not deal with the problem of how to select sensor nodes to be recharged.
- The Exiting works do not adopt mobile data gathering and do not consider the impact from wireless energy replenishment on link scheduling and data routing, whereas we combine these two aspects in our formulations.
- If nodes are not visited by the SenCar, their data packets would be buffered until these nodes are selected as anchor points. It would result in longer average data collection latency and is not scalable for large networks.

3.2 PROPOSED SYSTEM

The proposed solution, the SenCar only visits a subset of selected sensor nodes (anchor points) and collects data through multi-hop transmissions, which can enhance data collection fairness, reduce data collection latency, and avoid stopping at unnecessary sensor locations for battery recharge. We also assume the energy replenished into sensor's battery is much larger than the energy consumed due to transmission, sensing activities and the amount of energy consumed at the anchor points would be compensated by wireless recharge.

- The proposed traffic aware anchor point selection scheme is specifically designed for wireless Rechargeable sensor networks which have periodic traffic with different sampling rates.

- An develop an algorithm for the SenCar to determine the anchor points in each time period, which achieves a desirable balance between the energy replenishing range and data gathering latency.
- The proposed system builds a flow-level network utility maximization model to characterize the data gathering performance when the SenCar moves over different anchor points.
- Traffic aware routing protocol to schedule the routing in wireless networks.
- Traffic aware scheme can effectively collect data and save energy by utilizing mobile collectors.
- The routing protocol is sensitive to the battery status of routing nodes and can save a significant amount of energy compared to existing routing protocols.
- Coupled magnetic resonance, it is feasible to transfer energy wirelessly between two coils.
- The mobile collector directly provides electric energy to sensors by wireless energy transfer; energy delivery will no longer suffer from environmental variations such as weather or seasonal effects.

3.2.1 Advantages of Proposed System

- The non-uniformity of energy consumption among sensor nodes and alleviate the heavy traffic load of sensor nodes closer to the data sink.
- The proposed can provide reliable energy without being affected by the dynamics of environments
- This algorithm eliminates wires or plugs between the charger and receiver
- This Proposed does not interfere with the normal operations of sensors such as sensing, packets delivering and receiving.
- Energy balance constraint and the energy consumptions in receiving and sensing data.
- The Energy transfer through magnetic coupling can usually support higher amount of energy transfer in short time with high efficiency.
- To adjust data rates, link scheduling and flow routing.

3.3 FEASIBILITY STUDY

Generally system study/analysis and design refers to the process of examining a business solution with the intent of improving it through better procedures and methods. System study and the two major components of system development. Analysis specifies what the system to do. When developing a system, it is necessary to evaluate the feasibility of a project at the earliest possible time. Unexpected technical problems can occur when poor problem definition is obtained. It is advisable to conduct discussions regarding the analysis and design of the project before starting it. Feasibility analysis is carried out for this project.

3.3.1 Economic Feasibility

Traffic aware data collection. While computationally expensive, the results are far more accurate than **conventional** ***data aggregation***. Hence, there exists a trade-off between accuracy and computational cost. This trade off decreases as more efficient algorithms is utilized and increased computational power becomes inexpensive.

3.3.2 Technical Feasibility

This project is developed using C++ with NS2 Simulator. It is executed in the minimum hardware of Intel Pentium III,RAM of 1 GB ,hard disk capacity of 80GB,15 inches monitor, 104 keys and mouse, the software java, the fedora 8 operating system and that has been used in this project are found to be technically feasible.

3.3.3 Social Feasibility

The system operation is the longest phase in the development life cycle of a system. So, operational feasibility should be given much importance. The users of the system don't need thorough training on the system. All they are expected to know to operate the system is the basic net surfing knowledge. It has a user-friendly interface.

3.4 APPLICATIONS

Wireless sensor network has a wide range of applications such as

1. Military applications

- Monitoring friendly forces and equipment
- Battle field surveillance
- Nuclear, biological and chemical attack detection

2. Environmental applications

- Forest fire detection
- Bio complexity mapping of the environment
- Flood detection

CHAPTER IV

MODULE DESCRIPTION

4.1 PROBLEM DEFINITION

However, existing works do not adopt mobile data gathering and do not consider the impact from wireless energy replenishment on link scheduling and data routing, whereas we combine these two aspects in our formulations.

- However, these works do not consider the current battery energy of sensor node in energy balance constraint and the energy consumptions in receiving and sensing data.
- The existing algorithm did not deal with the problem of how to select sensor nodes to be recharged.
- WERMDG algorithm works do not adopt mobile data gathering and do not consider the impact from wireless energy replenishment on link scheduling and data routing.

- Mobile collectors move along parallel straight lines for data collections.

4.2 OVERVIEW OF FRAMEWORK

- Traffic aware routing protocol to schedule the routing in wireless networks.
- Traffic aware scheme can effectively collect data and save energy by utilizing mobile collectors.
- The routing protocol is sensitive to the battery status of routing nodes and can save a significant amount of energy compared to existing routing protocols.
- Coupled magnetic resonance, it is feasible to transfer energy wirelessly between two coils.
- The mobile collector directly provides electric energy to sensors by wireless energy transfer; energy delivery will no longer suffer from environmental variations such as weather or seasonal effects.

4.3 MODULE DESCRIPTION

4.3.1 Network Model

Network model consider a network consisting of stationary rechargeable sensor nodes and a static sink. We deploy a multi-functional mobile collector, called SenCar, which could be a mobile robot or vehicle equipped with a powerful transceiver to gather data. The SenCar is also equipped with a resonant coil as energy transmitter as well as a high capacity battery to store sufficient energy. The SenCar periodically visits some predefined sensor positions called anchor points in the field and stays at each anchor point for a period of sojourn time.

4.3.2 Anchor Points Selection

- Since R-tours and D-tours are treated separately, the criteria for these tours are different. For R-tours, the selection of anchor points falls into the following two aspects. First, the sensors selected as anchor points should be those with the most urgent needs of energy supplement.

- We develop an algorithm for the SenCar to determine the anchor points in each time period, which achieves a desirable balance between the energy replenishing range and data gathering latency.
- The SenCar moves over the anchor points back and forth for data gatherings during a time interval, the length of each migration tour is expected to be short so that the SenCar can spend more time on data collection.
- When the SenCar arrives at an anchor point, it will also act as a data collector to gather the data from nearby sensors.

4.3.3 Traffic Aware Data Gathering

- The data collection traffic by partitioning the network into multiple cluster and then assigns different channels to different cluster.
- Traffic aware aggregation technique in which the data gathering technique can be changed into structured and structure-free adaptively, depending on the load status of the traffic.
- In our model, we use utility function $U_i(f)$ to characterize the impact of the data from a sensor on the overall data gathering performance.
- It also designed a technique that effectively reduces the computation and communication costs involved in the compressive data gathering process.
    - The optimal data rate of a sensor for the SenCar sojourning at a particular anchor point.
    - It also designed a technique that effectively reduces the computation and communication costs involved in the compressive data gathering process.
    - To route the data to the SenCar at each anchor point taking into account of energy and link capacity constraints

4.3.4 Multi-hop Routing

The routing setup phase when a multi-hop data-routing tree rooted a cluster-head is constructed. The terms a parent node and a child node along a multi-hop data-routing tree. The next hop recipient to which a sender transfers a packet destined for the cluster-head is called its (sender) parent sensor, while to the parent sensor (recipient); this sensor (sender) is its (recipient) child sensor. Each sensor becomes a source and router with the ability of data aggregation over the multi-hop data-routing tree.

4.4. RSA Algorithm

4.4.1 Introduction

This algorithm is based on the difficulty of factorizing large numbers that have 2 and only 2 factors (Prime numbers). The system works on a public and private key system. The public key is made available to everyone. With this key a user can encrypt data but cannot decrypt it, the only person who can decrypt it is the one who possesses the private key. It is theoretically but extremely difficult to generate the private key from the public key, this makes the RSA algorithm a very popular choice in data encryption.

4.4.2 Algorithm

First of all, two large distinct prime numbers p and q must be generated. The product of these, we call n is a component of the public key. It must be large enough such that the numbers p and q cannot be extracted from it - 512 bits at least i.e. numbers greater than 10154. We then generate the encryption key e which must be co-prime to the number $m = \phi(n) = (p - 1)(q - 1)$. We then create the decryption key d such that de mod m = 1. We now have both the public and private keys.

4.4.3 Encryption

We let y = E(x) be the encryption function where x is an integer and y is

The encrypted form of x

y = x e mod n

4.4.4 Decryption

We let X = D(y) be the decryption function where y is an encrypted integer

And X is the decrypted form of y

X = y d mod n

4.4.5 Simple Example

1. We start by selecting primes p = 3 and q = 11.

2. n = pq = 33

m = (p − 1)(q − 1) = (2)(10) = 20.

3. Try e = 3

gcd(3, 20) = 1

⇒ e is co-prime to n

4. Find d such that 1 ≡ de mod m

⇒ 1 = Km + de

Using the extended Euclid Algorithm we see that 1 = −1(20) + 7(3)

⇒ d = 7

5. Now let’s say that we want to encrypt the number x = 9:

We use the Encryption function y = x e mod n

y = 93 mod 33

y = 729 mod 33 ≡ 3

⇒ y = 3

6. To decrypt y we use the function X = y d mod n

X = 37 mod 33

X = 2187 mod 33 ≡ 9

$\Rightarrow X = 9 = x$

⇒ Desired results are obtained.

CHAPTER V

SYSTEM DESIGN

5.1 Dataflow Diagram

Level 0

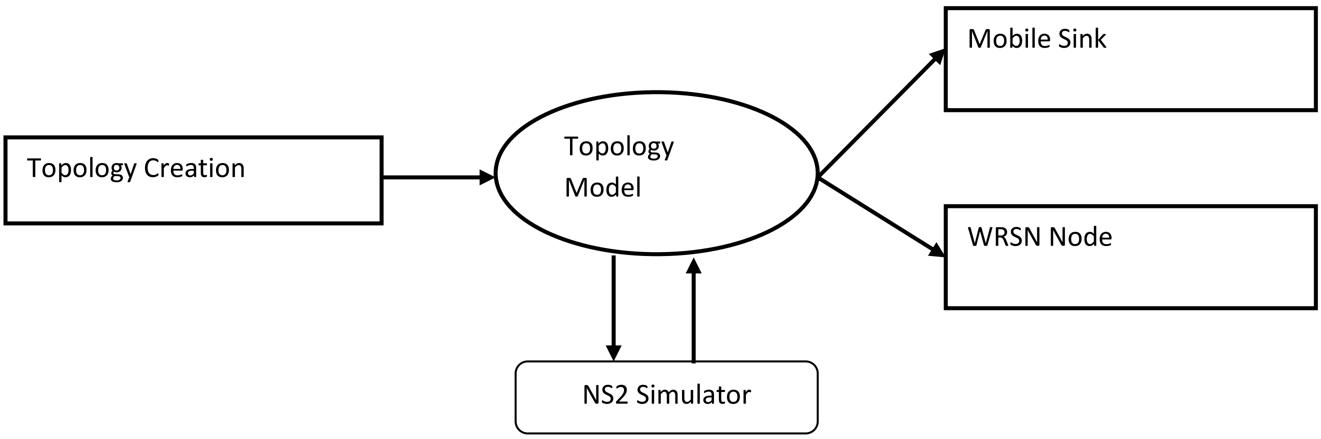

Figure 5.1.1 LEVEL 0

Level 1

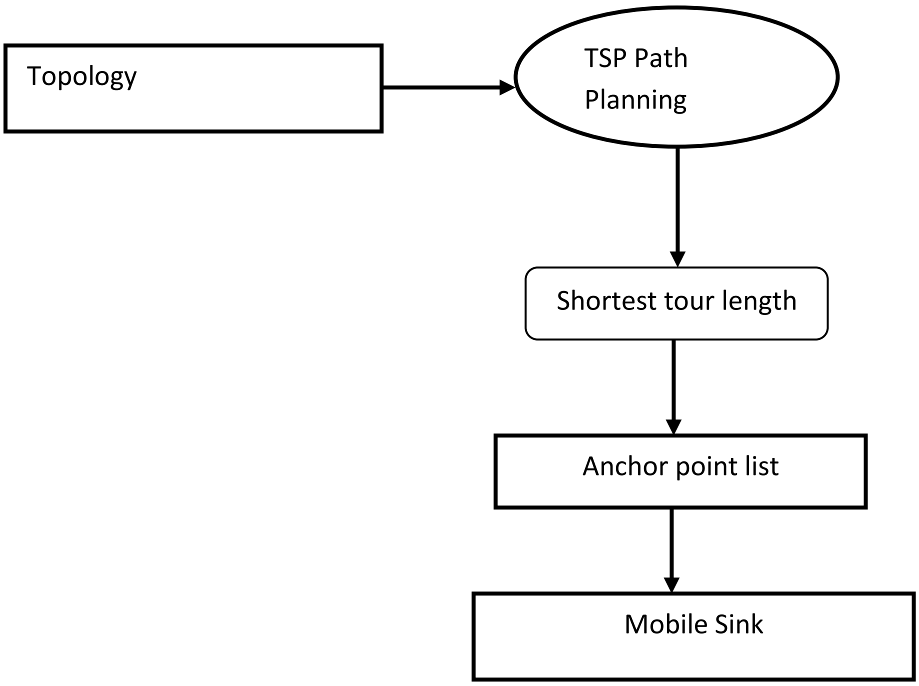

Figure 5.1.2 LEVEL 1

Level 2

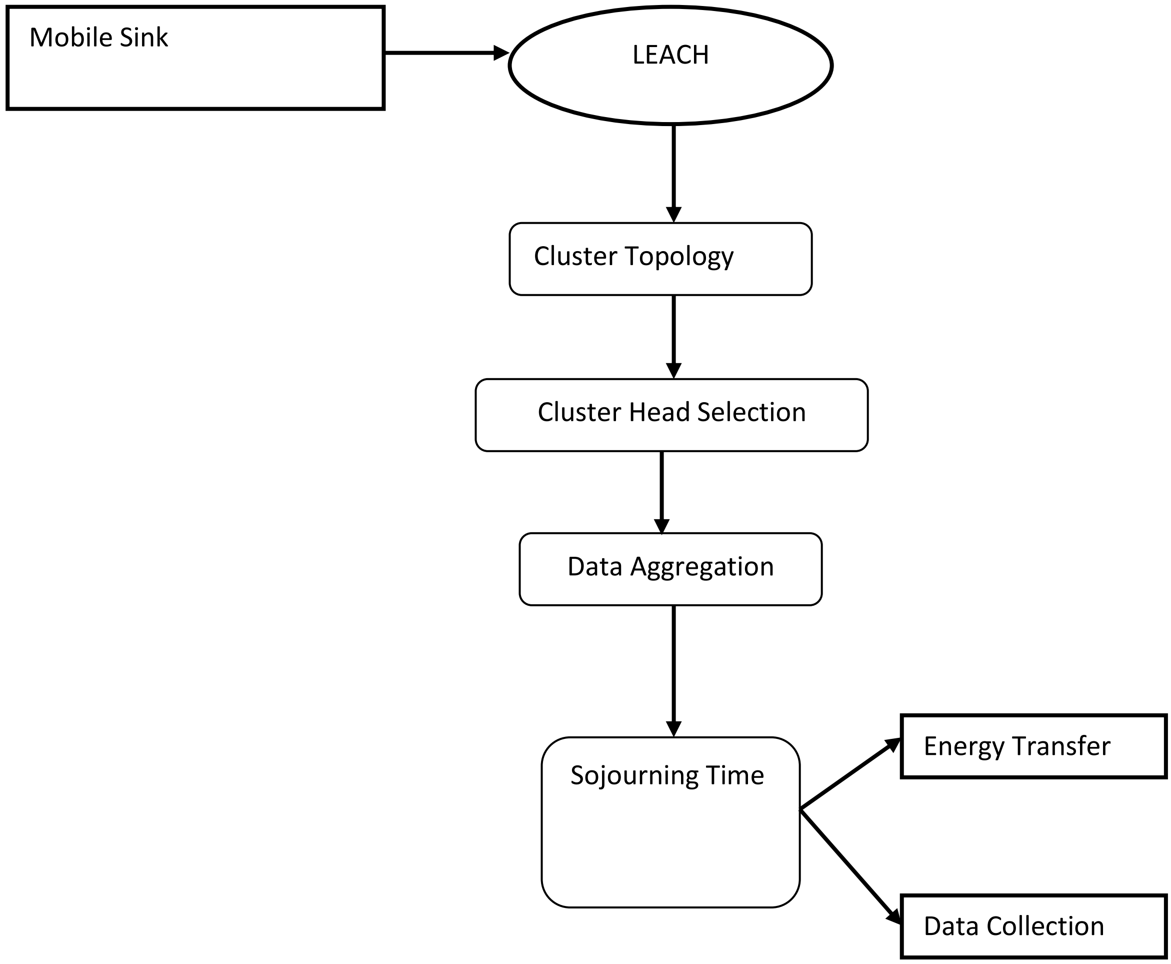

Figure 5.1.3 LEVEL 2

Level 3

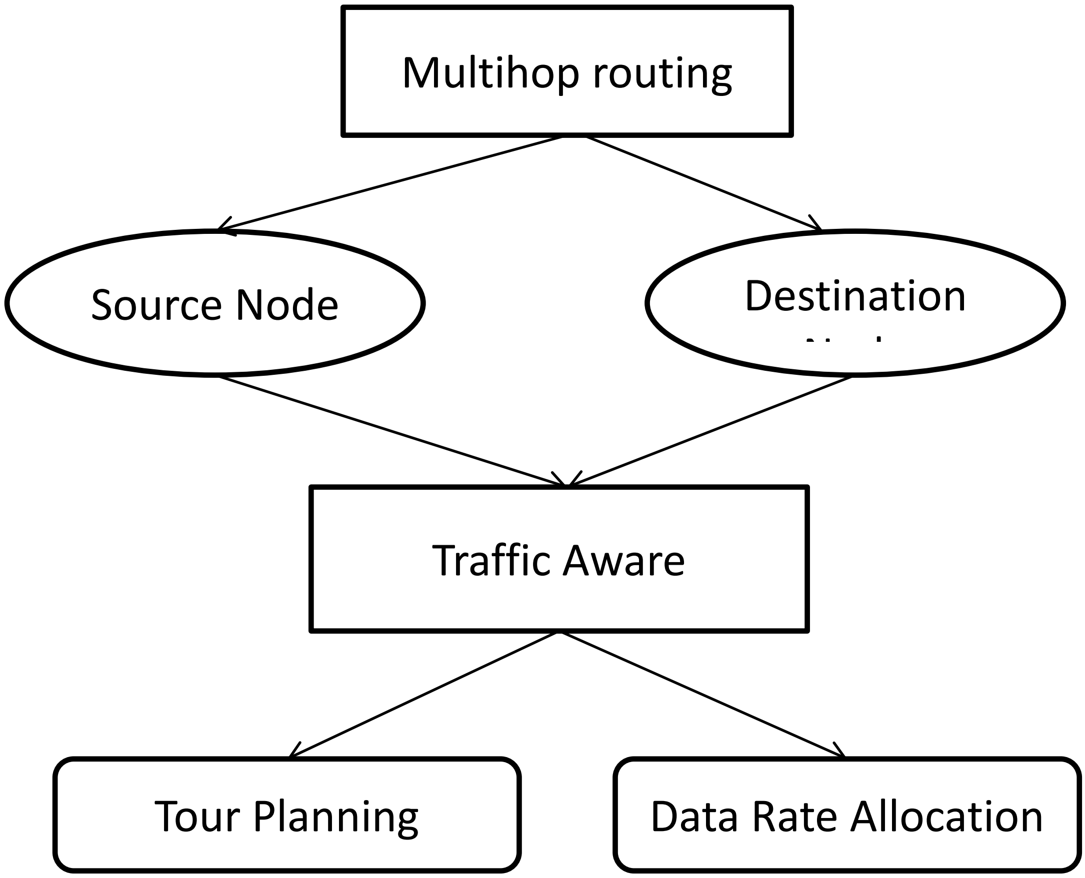

Figure 5.1.4 LEVEL 3

5.2 Input Design

The input design of this project is being done with the following considerations

The following forms are designed to provide input to the system.

- Ns 2 Topology Parameters

5.3 Output Design

The output design of this project is being done with the following considerations

The following forms are designed to provide input to the system.

- Average success rate. A node's success rate is the ratio of the number of received files to the number of initiated file queries. This metric represents the performance of successful data querying.
- Average path length. A query's path length is the number of hops for routing the query to the metadata holder. This metric represents routing protocol efficiency.
- Overhead. This is the total number of all traversed hops in metadata responding, mapping updating, and location updating. This metric shows the overhead and reflects the energy-efficiency of a data search system. Cluster form based on correlation degree calculation.

CHAPTER VI

SYSTEM DESCRIPTION

6.1 SYSTEM REQUIREMENT

6.1.1 Hardware Requirement

Processor	: Pentium IV
Processor speed	: 1.5 GHZ
Memory (RAM)	: 256MB
Hard disk	: 40GB
Monitor	: 15"color monitor
Keyboard	: Logitech 104 keys
Mouse	: Logitech scroll mouse

6.1.2 Software Requirement

Operating System	: Fedora 8.0
Language	: C++ & TCL Scripting
Protocol	: DSR

6.2 SOFTWARE DESCRIPTION

Network Simulator (NS2) is a discrete event driven simulator developed at UC Berkeley. It is part of the VINT project. The goal of NS2 is to support networking research and education. It is suitable for designing new protocols, comparing different protocols and traffic evaluations. NS2 is developed as a collaborative environment. It is distributed freely and open source. A large amount of institutes and people in development and research use, maintain and develop NS2. This increases the confidence in it. Versions are available for FreeBSD, Linux, Solaris, Windows and Mac OS X.

6.2.1 STRUCTURE OF NS2

NS2 is built using object oriented methods in C++ and OTcl (object oriented variant of Tcl.

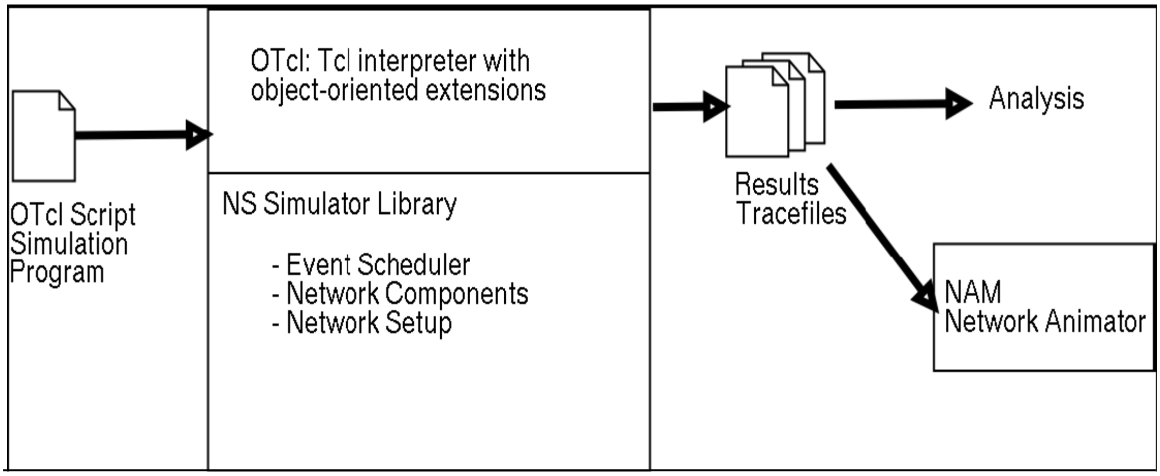

Fig 6.1 Simplified User's View of Ns

can see in Fig 6.1, NS2 interprets the simulation scripts written in OTcl. A user has to set the different components (e.g. event scheduler objects, network components libraries and setup module libraries) up in the simulation environment. The user writes his simulation as a OTcl script, plumbs the network components together to the complete simulation. If he needs new network components, he is free to implement them and to set them up in his simulation as well. The event scheduler as the other major component besides network components triggers the events of the simulation (e.g. sends packets, starts and stops tracing). Some parts of NS2 are written in C++ for efficiency reasons. The data path (written in C++) is separated from the control path (written in OTcl). Data path object are compiled and then made available to the OTcl interpreter through an OTcl linkage (tclcl) which maps methods and member variables of the C++ object to methods and variables of the linked OTcl object. The C++ objects are controlled by OTcl objects. It is possible to add methods and member variables to a C++ linked OTcl object.

6.2.2 FUNCTIONALITIES OF NS2.33

Functionalities for wired, wireless networks, tracing, and visualization are available in NS2.

• Support for the wired world include

– Routing DV, LS, and PIM-SM.

– Transport protocols: TCP and UDP for unicast and SRM for multicast.

– Traffic sources: web, ftp, telnet, cbr (constant bit rate), stochastic, real audio.

– Different types of Queues: drop-tail, RED, FQ, SFQ, DRR.

– Quality of Service: Integrated Services and Differentiated Services.

– Emulation.

• Support for the wireless world include

– Ad hoc routing with different protocols, e.g. AODV, DSR, DSDV, TORA

– Wired-cum-wireless networks

– Mobile IP

– Directed diffusion

– Satellite

– Sensor-MAC

– Multiple propagation models (Free space, two-ray ground, shadowing)

– Energy models

• Tracing

• Visualization

– Network Animator (NAM)

– Trace Graph

• Utilities

– Mobile Movement Generator

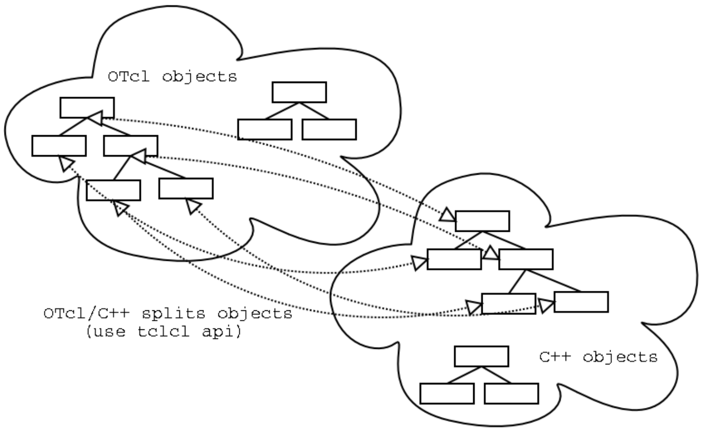

Fig 6.2 OTcl and C++: the duality

6.2.3 Mobile Networking In Ns2.33

This section describes the wireless model that was originally ported as CMU's Monarch group's mobility extension to NS2. The first section covers the original mobility model ported from CMU/Monarch group. In this section, we cover the internals of a mobile node, routing mechanisms and network components that are used to construct the network stack for a mobile node. The components that are covered briefly are Channel, Network interface, Radio propagation model, MAC protocols, Interface Queue, Link layer and Address resolution protocol model (ARP). CMU trace support and Generation of node movement and traffic scenario files are also covered in this section. The original CMU model allows simulation of pure wireless LANs or multihop ad-hoc networks. Further extensions were made to this model to allow combined simulation of wired and wireless networks. Mobile was also extended to the wireless model.

6.2.4 The Basic Wireless Model in Ns

The wireless model essentially consists of the Mobile Node at the core, with additional supporting features that allows simulations of multi-hop ad-hoc networks, wireless LANs etc. The Mobile Node object is a split object. The C++ class Mobile Node is derived from parent class Node. A Mobile Node thus is the basic Node object with added functionalities of a wireless and mobile node like ability to move within a given topology, ability to receive and transmit signals to and from a wireless channel etc. A major difference between them, though, is that a Mobile Node is not connected by means of Links to other nodes or mobile nodes. In this section we shall describe the internals of Mobile Node, its routing mechanisms, the routing protocols dsdv, aodv, tora and dsr, creation of network stack allowing channel access in Mobile Node, brief description of each stack component, trace support and movement/traffic scenario generation for wireless simulations.

6.2.5 Mobile Node: Creating Wireless Topology

Mobile Node is the basic *ns* Node object with added functionalities like movement, ability to transmit and receive on a channel that allows it to be used to create mobile, wireless simulation environments. The class Mobile Node is derived from the base class Node. Mobile Node is a split object. The mobility features including node movement, periodic position updates, maintaining topology boundary etc. are implemented in C++ while plumbing of network components within Mobile Node itself (like classifiers, dmux , LL, Mac, Channel etc.) have been implemented in Otcl.

Table 6.1: Available Options for Node Configuration

Option	**Available Values**	**Default**
General		
Address type	Flat, Hierarchical	Flat
MPLS	ON,OFF	OFF
Both Satellite and Wireless Oriented		
Wired Routing	ON,OFF	OFF
II Type	LL,LL/sat	OFF
Mac Type	Mac/802_11,Mac/Csma/Ca, Mac/Sat/Unslotted/Aloha,Mac/Tdma	OFF

Option	**Available Values**	**Default**
Satellite Oriented		
satNodeType	Polar,Geo,Terminal,Geo-repeater	OFF
downlinkBW	<bandwidth value, e.g "2MB">	OFF
Wireless Oriented		
Adhoc Routing	DIFFUSION/RATE,DIFFUSION/PROB, DSDV,FLOODING,OMNICAST,AODV,TORA	OFF
propType	Propagation/2RayGround,Propagation Shadowing	OFF
propInstance	Propagation/2RayGround,Propagation Shadowing	OFF
antType	Antenna/Omni Antenna	OFF
Channel	Channel/Wireless Channel,Channel/sat	OFF
topoInstance	<toplogy file>	OFF
MobileIP	ON,OFF	OFF
Energy model	Energy model	OFF
Initial Energy	<value in joules>	OFF
rxPower	<value in W>	OFF
txPower	<value in W>	OFF
Idle Power	<value in W>	OFF
AgentTrace	ON,OFF	OFF
routerTrace	ON,OFF	OFF
macTrace	ON,OFF	OFF

movementTrace	ON,OFF	OFF
Errproc	UniformErrorProc	OFF
toraDebug	ON,OFF	OFF

6.2.6 Implementation Environment

Network simulator 2 is used as the simulation tool in this project. NS was chosen as the simulator partly because of the range of features it provides and partly because it has an open source code that can be modified and extended. There are different versions of NS and the latest version is ns-2.1b9a while ns-2.1b10 is under development

6.2.7 Network Simulator (Ns)

Network simulator (NS) is an object–oriented, discrete event simulator for networking research. NS provides substantial support for simulation of TCP, routing and multicast protocols over wired and wireless networks. The simulator is a result of an on-going effort of research and developed. Even though there is a considerable confidence in NS, it is not a polished product yet and bugs are being discovered and corrected continuously.

NS is written in C++, with an OTcl1 interpreter as a command and configuration interface. The C++ part, which is fast to run but slower to change, is used for detailed protocol implementation. The OTcl part, on the other hand, which runs much slower but can be changed very fast quickly, is used for simulation configuration. One of the advantages of this split-language program approach is that it allows for fast generation of large scenarios. To simply use the simulator, it is sufficient to know OTcl. On the other hand, one disadvantage is that modifying and extending the simulator requires programming and debugging in both languages.

NS can simulate the following:

1. Topology: Wired, wireless

2. Scheduling Algorithms: RED, Drop Tail,

3. Transport Protocols: TCP, UDP

4. Routing: Static and dynamic routing

5. Application: FTP, HTTP, Telnet, Traffic generators

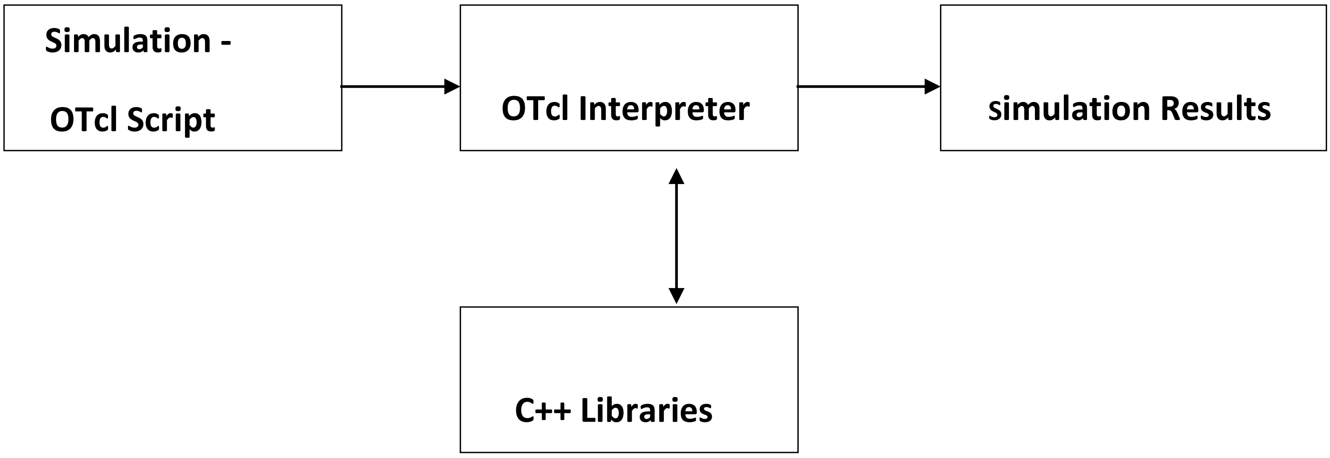

Figure 6.3 Block diagram of Architecture of NS-2

6.2.8 Network Components

This section talks about the NS components, mostly compound network components. Figure 6.4 shows a partial OTcl class hierarchy of NS, which will help understanding the basic network components.

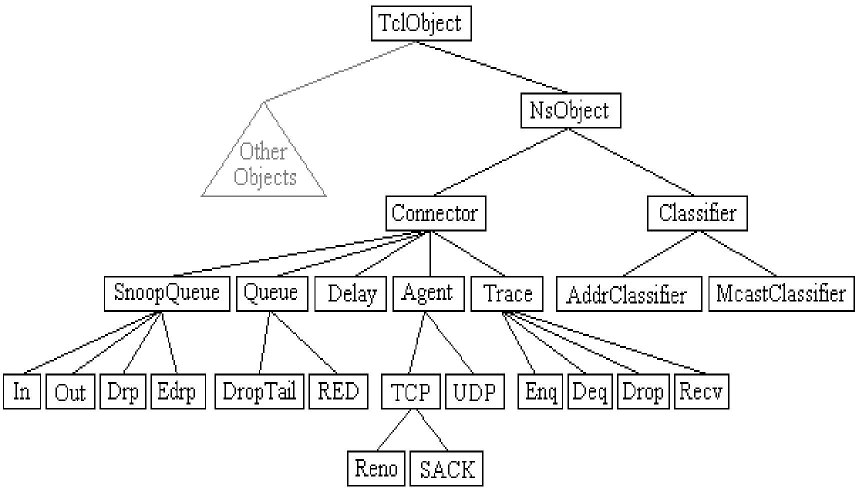

Figure 6.4 OTcl Class Hierarchies

The root of the hierarchy is the TclObject class that is the super class of all OTcl library objects (scheduler, network components, timers and the other objects including NAM related ones). As an ancestor class of TclObject, NsObject class is the super class of all basic network component objects that handle packets, which may compose compound network objects such as nodes and links. The basic network components are further divided into two subclasses, Connector and Classifier, based on the number of the possible output DATA paths. The basic network and objects that have only one output DATA path are under the Connector class, and switching objects that have possible multiple output DATA paths are under the Classifier class.

6.2.9 Class Tcl

The class Tcl encapsulates the actual instance of the OTcl interpreter and provides the methods to access and communicate with that interpreter, code. The class provides methods for the following operations:

1. Obtain a reference to the Tel instance
2. Invoke OTcl procedures through the interpreter
3. Retrieve, or pass back results to the interpreter
4. Report error situations and exit in an uniform manner
5. Store and lookup "TclObjects"
6. Acquire direct access to the interpreter.

6.2.10 Command Methods: Definition And Invocation

For every TclObject that is created, ns establishes the instance procedure, cmd{}, as a hook to executing methods through the compiled shadow object. The procedure cmd {} invokes the method command () of the shadow object automatically, passing the arguments to cmd {} as an argument vector to the command () method. The user can invoke the cmd {} method in one of two ways, by explicitly invoking the procedure, specifying the desired operation as the first argument, or implicitly, as if there were an instance procedure of the same name as the desired operation. Most simulation scripts will use the latter form.

Consider the distance computation in SRM is done by the compiled object. It is often used by the interpreted object. It is usually invoked as $srmObject distance? (Agent

Address)If there is no instance procedure called distance? The interpreter will invoke the instance procedure unknown {}, defined in the base class TclObject. The unknown procedure then invokes

$srmObject cmd distance? (Agent Address)

To execute the operation through the compiled object's command() procedure. The user could explicitly invoke the operation directly. One reason for this might be to overload the operation by using an instance procedure of the same name.

For example,

```
Agent/SRM/Adaptive instproc distance? Addr {
$self instvar distanceCache_($addr)
If![info exists distanceCache_($addr)] {
Set distance Cache_($addr) [$self cmd distance? $addr]
}
Set distance Cache_($addr)
}
```

The following shows how the command () method using SRMAgent::command()

```
Int ASRMAgent::command(int argc, const char*const*argv) {
Tcl& tcl = Tcl::instance();
if (argc == 3) {
If (strcmp(argv[1], "distance?") == 0) {
int sender = atoi(argv[2]);
SRMinfo* sp = get_state(sender);
tcl.tesultf("%f", sp->distance_);
return TCL_OK;    '
```

```
}

}

return (SRMAgent::command(argc, argv));
```

The following observations are made from this piece of code:

The function is called with two arguments. The first argument (argc) indicates the number of arguments specified in the command line to the interpreter. The command line arguments vector (argv) consists of argv [0] contains the name of the method, "cmd" and argv[1] specifies the desired operation. If the user specified any arguments, then they are placed in argv [2...(argc - 1)]. The arguments are passed as strings. They must be converted to the appropriate data type. If the operation is successfully matched, the match should return the result of the operation, command () itself must return either TCL_OK or TCL_ERROR to indicate success or failure as its return code. If matched in this method, it must invoke its parent's command method, and return the corresponding result. This permits the user to conceive of operations as having the same inheritance properties as instance procedures or compiled methods.

CHAPTER VII

RESULTS AND DISCUSSIONS

7.1 PERFORMANCE METRICS

Various metrics are calculated in order to evaluate the performance of total wireless sensor networks. This graph is plotted for many parameters and comparative analysis is done

Here various parameters are used for comparative analysis they are

- Energy consumption
- Throughput
- Packet drop

7.1.1 Topology Deployment

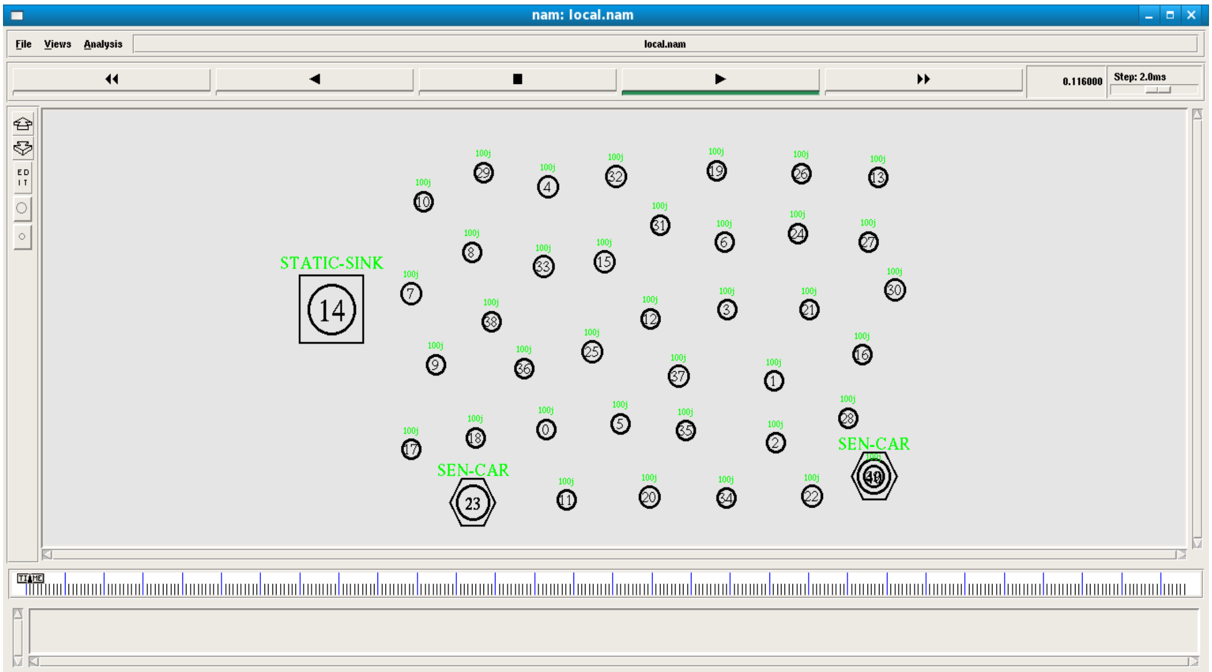

Figure 7.1.1 Topology deployment

Topology deployment is the initial setup that is done where a mobile Sencar is used to collect the data. Sencar is represented here with the hexagon shape.it is a multifunctional device.

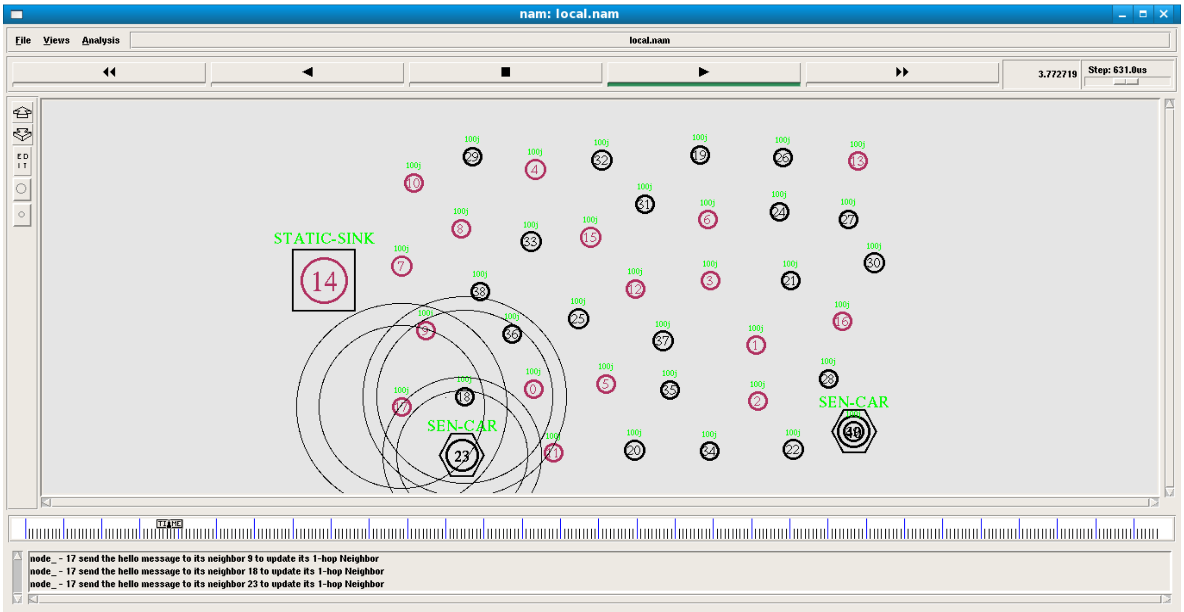

Figure 7.1.2 Collect sensed data

7.1.2 Anchor Point Selection

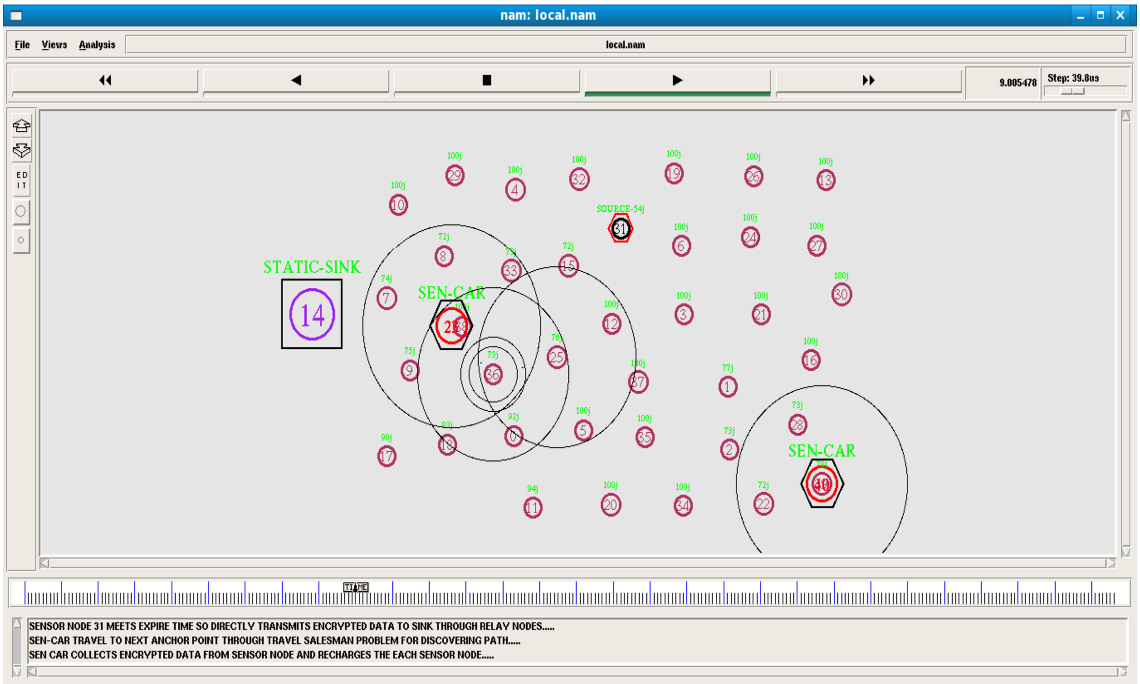

Figure 7.1.3 Anchor point selection

The anchor point selection is based on anchor point selection algorithm were TSP is used. Initially the nodes are listed in ascending order with their corresponding distance. The nodes are visited by Sencar respectively.

7.1.3 Anchor point Data Collection by SenCar

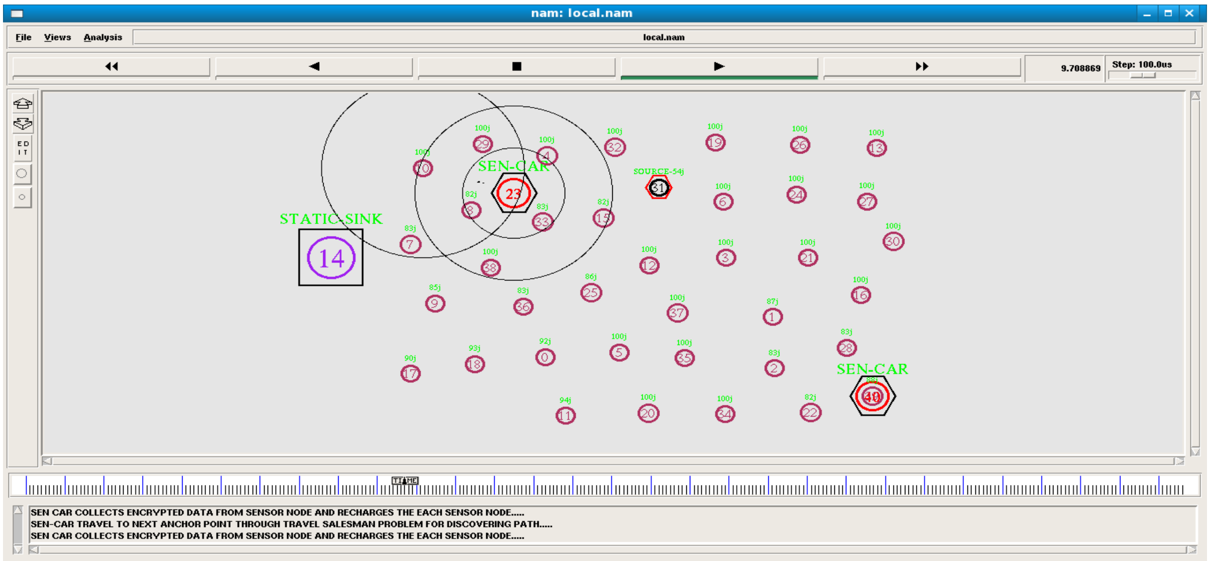

Figure 7.1.4 Anchor point Data Collection by SenCar

The Sencar visits each anchor point in the respective order and collects data where initial authentication of mobile sink is done using RSA algorithm,

7.1.4 Sencar Send the collected data to Static Sink(Base Station)

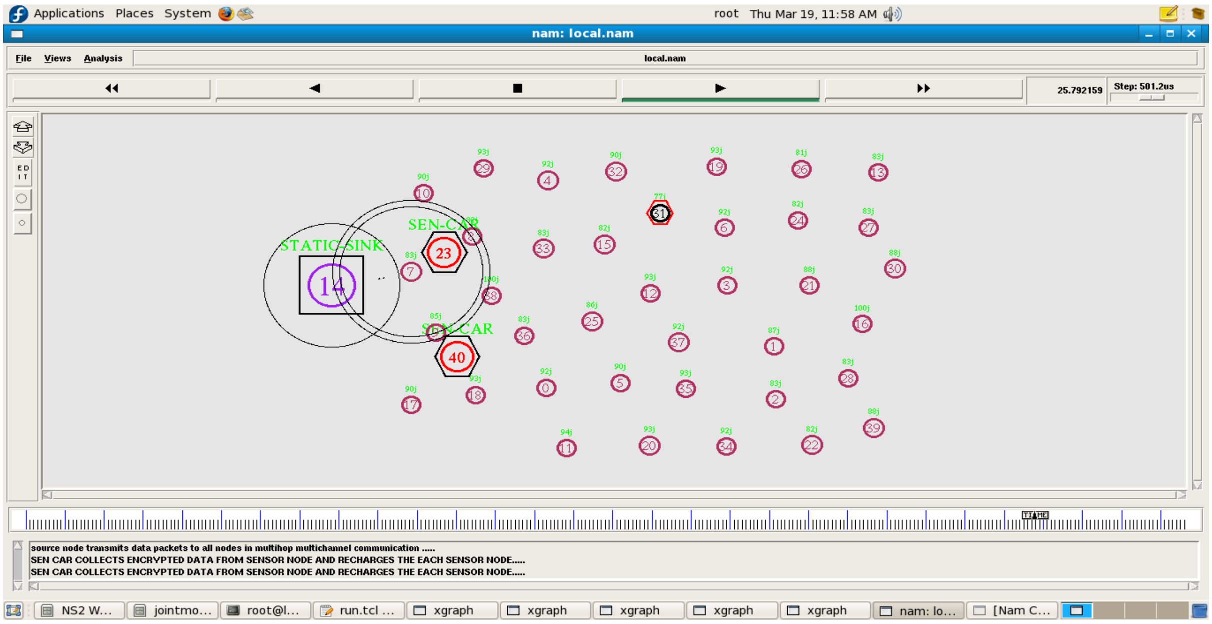

Figure 7.1.5 SenCar Send the collected data to Static Sink (Base Station)

The Sencar collects the data in a pre-determined fashion and then sends it to the static sink using long range communication.

7.1.5 Throughput comparison existing and Proposed System

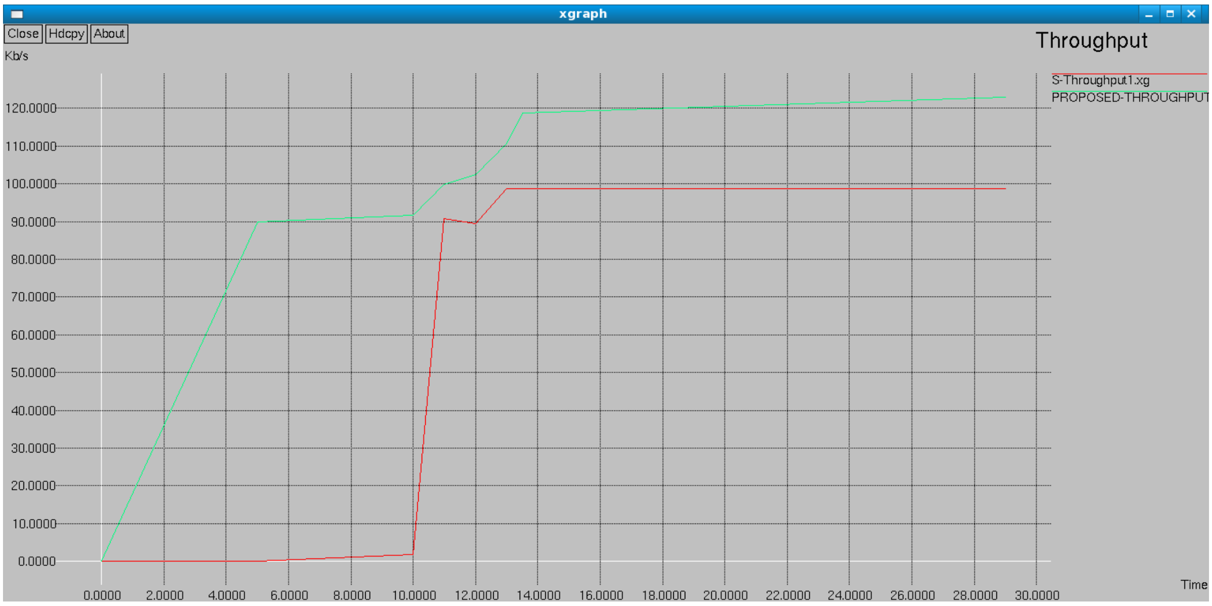

Figure 7.1.6 Throughput comparison existing and Proposed System

It is defined as the total number of packets delivered over the total simulation time. The throughput comparison shows that the three algorithms performance margins are very close under traffic load of 50 and 100 nodes in WSN scenario and have large margins when number of nodes increases to 200. Mathematically, it can be defined as: Throughput= N/1000 Where *N* is the number of bits received successfully by all destinations. Above graphs shows the variation of the delay. AODV consistently shows the highest delay. DSDV has the lowest delay as compared to the DSR and DSDV. One factor can be that it have less throughput (Number of packets delivered per unit time) so it is having the less delay.

The throughput of the network is increased considerably with multiple mobile sink since the delay is less and data collection speed is increased.

7.1.6 Energy consumption Proposed System

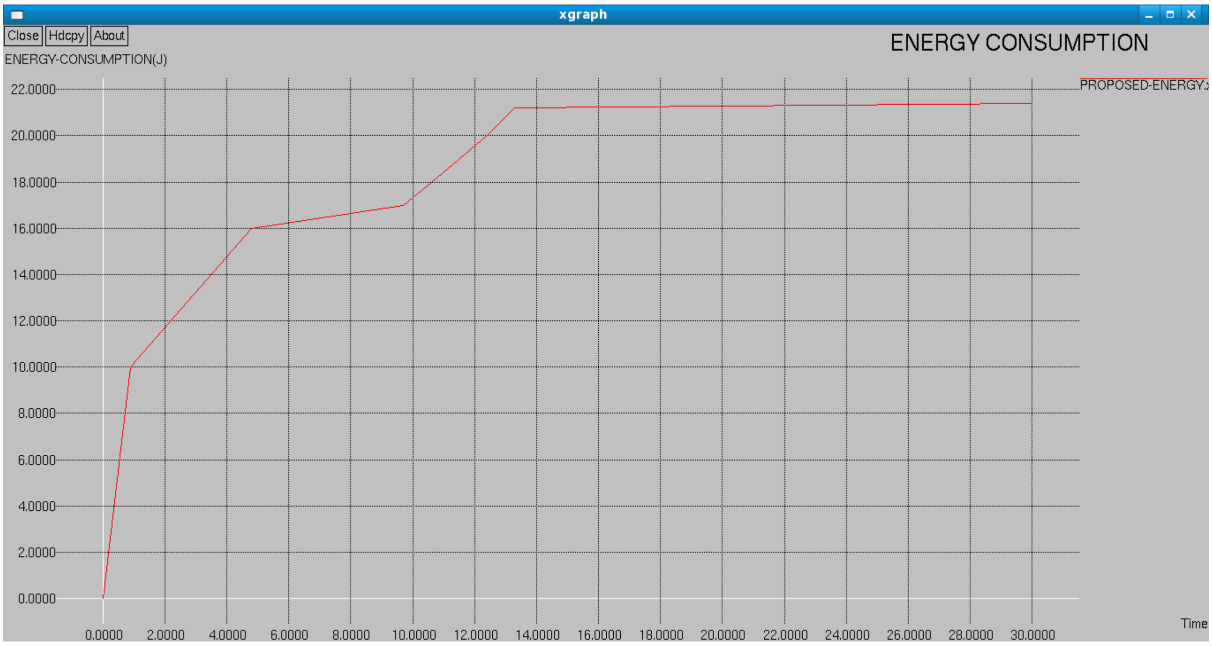

Figure 7.1.7 Energy consumption Proposed System

7.1.7 Packet Drop comparison existing and Proposed System

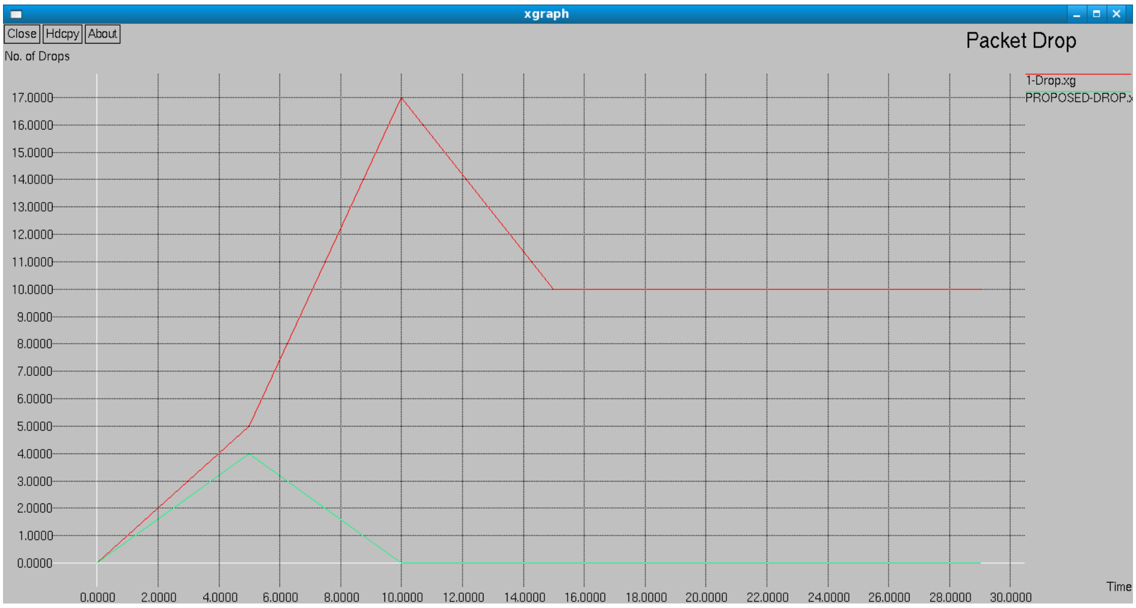

Figure 7.1.8 Packet Drop comparison existing and Proposed System

Packet Lost: the total number of packets dropped during the simulation. Packet lost = Number of packet send – Number of packet received .The Proposed system have small no of packet loss achieved.

7.1.8 PDR comparison existing and Proposed System

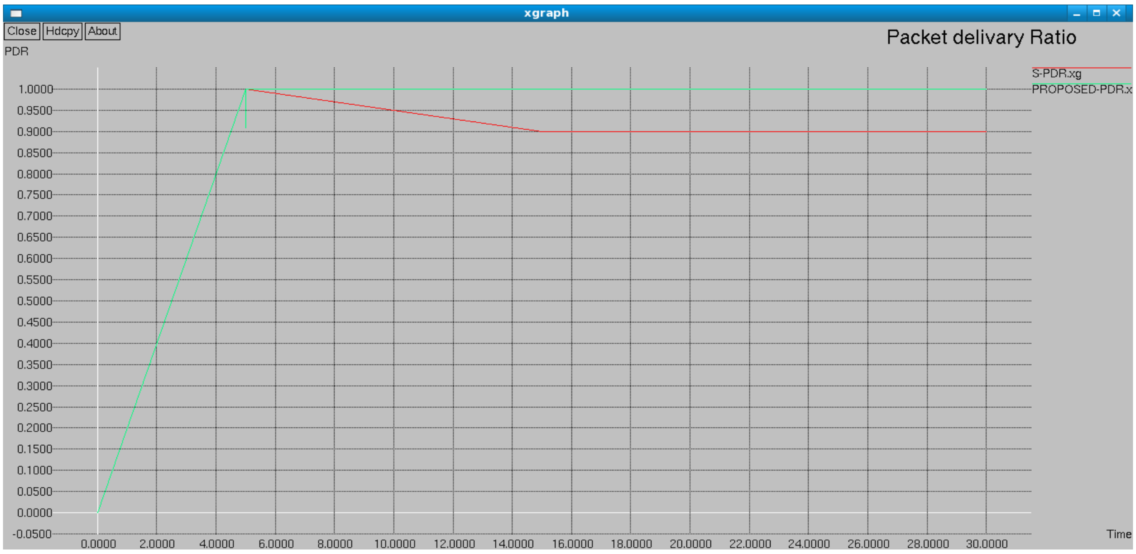

Figure 7.1.9 PDR comparison existing and Proposed System

We can see that the trend of network utility in one data gathering tour and sojourn time decrease with the increase of the recharging rate. This is because a higher recharging rate will result in the sensor battery to be refilled in shorter time and once the battery has been refilled at an anchor point and data collection is completed, the SenCar can move to the next anchor point. Thus, the SenCar is able to make more recharge tours during a fixed interval when the sojourn time at each sensor node has been shortened. Therefore, exploiting a higher recharge rate is beneficial to the performance of the network in terms of utility, lifetime and scalability

CHAPTER VIII

CONCLUSION AND FUTURE WORK

9.1 CONCLUSION

The proposed TSP method determines clusters and set of anchor points for mobile sink to collect a data in effective manner. It minimizes energy depletion throughout the network and prevents formation of energy holes. The highest weighted node reduces the number of multihop transmissions in the data collection of the mobile sink. The result of algorithm is obtained from the NS2 simulation which indicates Network energy consumption and Maximum lifetime. RSA algorithm has been implemented so that secure data gathering is achieved in the network.

9.2 FUTURE WORK

We have studied the problem of joint wireless energy replenishment and mobile data gathering (WerMDG) for rechargeable sensor networks. In particular, a multi-functional SenCar is deployed in the sensing field to charge the visited sensors via wireless energy transfer and simultaneously collect data from nearby sensors via multi-hop transmissions. We first present an anchor point selection algorithm to determine the sensors that should get recharged in priority and the sequence of the anchor points that the SenCar visits. We then formulate the WerMDG problem into a network utility maximization problem by taking into account the overall energy consumption and the time-varying recharging rate.

Last, we provide extensive numerical results to demonstrate that the proposed WerMDG algorithm converges, and verify the impact of utility weight and recharging rate on network performance in terms of the amount of data gathered, network utility, link flow rate and sojourn time allocation. Finally, we would like to point out that there are some interesting issues that may be studied in our future work. First, a hybrid scheme combining static data transmission to the sink with mobile data gathering may be considered for high density and connected sensor networks since it may reduce the traveling time of the SenCar thus data collection latency. It poses some new challenges such as determining whether it is beneficial for a sensor node to forward data to the sink or to the SenCar since the anchor points may change from time to time.

CHAPTER IX

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LIST OF PUBLICATIONS

Conferences

- Presented a paper titled ” Data gathering with multiple mobile sink in secure wireless sensor network using RSA” in 2nd IEEE International Conference on Innovations in Information, Embedded and Communication systems (ICIIECS’15) on 19 th & 20th March 2015,organized by Karpagam College of Engineering, Coimbatore.

- Presented a paper titled “Mobile Data gathering and energy replenishment in wireless sensor network ” in Fourth national Conference on Emerging trends in computer communication and informatics (ETCCI’15) on 23rd March, 2015, organized by Tamilnadu college of engineering, Coimbatore.

Journal

- Paper titled, ” Data gathering with multiple mobile sink in secure wireless sensor network using RSA” has been selected for the journal International Journal of Applied Engineering Research (IJAER).