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AN IMPROVED MULTIPATH ENERGY SAVING ROUTING PROCESS IN WIRELESS SENSOR NETWORK

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Abstract - Wireless sensor networks consist of sensor nodes connected wirelessly which constantly monitors a physical environment and a sink node or a centralized base station is present which collects the data gathered by the sensor nodes for processing and analyzing the data and detect changes in the environment and alerts the end user. As the sensor nodes communicate with each other through wireless links there is no definite topology in the network this result in interference and path loss periodically which in turn reduces efficiency and decrease the energy levels of the sensor nodes. To achieve efficiency and reduce energy consumption duty-cycled wireless sensor networks control the active and sleep state of the sensor nodes. But this mechanism leads to variation of routing link costs in the network constantly as they are time-dependent and it leads to transmission delay along with reduced efficiency and energy. Hence in this thesis a distributed algorithm for construction of shortest routing paths in a network is proposed called Fastest Time Shortest Path algorithm. In earlier methods, the routing paths in a network are computed in multiple executions, where as in the proposed algorithm it computes in a single execution. It provides loop free routing paths with maintenance of the shortest paths in the network. The performance of the proposed algorithm with defining network parameters is analyzed and validated through NS2 simulations.

Keywords –duty-cycle, time dependent, transmission latency, wireless sensor network

I. INTRODUCTION

Wireless sensor networks integrate sensing, computation, and communication into a single portable device called nodes. Hence Wireless Sensor Network can be defined as a network of a large number of spatially distributed, small, low cost and low power nodes, which can sense the environment and wirelessly communicate the information gathered to other nodes. In WSN the nodes deployed in the network are interconnected with each other and in turn all nodes are connected to a central base station by mesh topology. Hence the mesh networking connectivity is capable of hopping data from one node to another and reaches its destination by exploiting all the possible communication paths. It co-operatively passes there data through the network to a main location or sink where the data can be monitored and analyzed. A sink node or base station performs like a gate between users and the network. While the capabilities of a node in the network are minimalistic, deployment of numerous nodes in network provides a wide array of possible technologies

In general, a wireless sensor network may contain hundreds or thousands of sensor nodes. The sensor nodes can communicate among themselves using radio signals. After the deployment of sensor nodes in the monitored area, they are accountable for self organizing an acceptable network infrastructure often with multi-hop communication with each others. Then they start gathering information of interest. WSNs are normally comprised of scalar sensors capable of measuring physical phenomenon such as temperature, pressure, light intensity, and humidity.

Wireless sensor network contains sensor node connected wirelessly. The sensor nodes present in the network are portable in nature and can be placed strategically according to the needs of the user or specified applications. Hence when topology of the network changes, the routing path also changes as there is no pre-defined infrastructure as in a wired network. So the routing problem is prevalent in wireless network.

Routing process in wireless sensor network must address the issues of the dynamic or lossy nature of wireless communication. The major issue challenges with routing in wireless sensor network is that it must dynamically capture the link connectivity status at the node level and adaptively determine link estimates to take routing decisions and tabulate the same with information of link status and maintain it constantly to achieve reliability in the network statistics. A routing shortest path in a network is formed by the relative definition of a connectivity graph which represents the node that can communicate to the destination in a single hop. But in sensor network the nodes observe and share the communication events in the network and then generate a connectivity graph based on the data collection. Communication of nodes in the network is probably over a successful communication or not always due to interference, congestion and other loss factors. These factors change dynamically with respect to time due to the external environmental factors or assertions in the application behavior leading to strong or no connectivity between the sensor nodes. Usually routing protocols involved in wireless sensor or ad hoc networks discover paths with minimum hop count to the destination by assuming that link costs are static over wireless links. But this assumption is invalid in the case of duty-cycled wireless sensor networks.
Hence this paper proposes a dispersed calculation, which can effectively specify every single ideal route with slightest end-to- sink inactivity for infinite time interims in duty cycled networks which can powerfully and distributive keep up time-subordinate shortest routing paths.

II. LITERATURE SURVEY

A few of the protocols have been proposed for multi- hop routing, low power listening and to achieve low power communication over the recent years.

WSN exhibit time dependent features due to the shortest path in asynchronous duty-cycled wireless sensor network .Hence a WSN is modeled to evaluate the time-cost function that satisfies FIFO conditions and this provides a solution to solve the shortest path problem in polynomial time. This approach was proposed by S.Lai et al.,[1] and derived a fast distributed algorithm to build all-to-one shortest paths for all discrete times in a single execution using a β-synchronizer. This algorithm is loop-free with low-message complexity and low space complexity.

M.B. Srivastava et al., [2] stated that the wide utilization of Wireless Sensor Networks (WSNs) is obstructed by the severely limited energy constraints of the individual sensor nodes. This is the reason why a large part of the research in WSNs focuses on the development of energy efficient routing protocols. In this paper [2], a new protocol called Equalized Cluster Head Election Routing Protocol (ECHERP), which pursues energy conservation through balanced clustering, is proposed. ECHERP models the network as a linear system and, using the Gaussian elimination algorithm, calculates the combinations of nodes that can be chosen as cluster heads in order to extend the network lifetime. Threshold Sensitive Energy Efficient (TEEN) is a hierarchical protocol designed for sudden changes in the sensed environment. The response of the network in time-critical applications is extremely important, obliging the network to operate in a reactive mode. But the communication collision could be a very big problem for even moderate size networks and the disadvantage of this system is that it still does not completely and evenly distribute in the network.

T. Tong et al., [3] stated that dynamic and lossy nature of wireless communication poses major challenges to reliable, self-organizing multi-hop networks. These non-ideal characteristics are more problematic with the primitive, low-power radio transceivers found in sensor networks, and raise new issues that routing protocols must address. Link connectivity statistics should be captured dynamically through an efficient yet adaptive link estimator and routing decisions should exploit such connectivity statistics to achieve reliability. Link status and routing information must be maintained in a neighbourhood table with constant space regardless of cell density. But the drawbacks of this system was over head is very high and it is difficult to reconfigure the protocols after deployment.

D. Ganesan et al., [4] stated that increasingly many wireless sensor network deployments are using harvested environmental energy to extend system lifetime. Because the temporal profiles of such energy sources exhibit great variability due to dynamic weather patterns, an important problem is designing an adaptive duty-cycling mechanism that allows sensor nodes to maintain their power supply at sufficient levels (energy neutral operation) by adapting to changing environmental conditions. Existing techniques to address this problem are minimally adaptive and assume a priori knowledge of the energy profile. While such approaches are reasonable in environments that exhibit low variance, but it is highly inefficient in more variable scenarios. Hence in this paper [4] new techniques for solving this problem based on results from adaptive control theory is introduced and shows that it can achieve better performance than previous approaches on a broader class of energy source data sets. The drawback of this technique was it provided less throughput and it limited energy resources.

J. Polastre et al., [5] stated that in wireless sensor network deployments, reliably reporting data while consuming the least amount of power is the ultimate goal. One such application that drives the design of low power media access control (MAC) protocols is environmental monitoring. The UCLA Centre for Embedded Network Sensing have deployed wireless sensors for microclimate monitoring that operate at low duty cycles with multi-hop networking and reliable data reporting. They show that MAC mechanisms must support duty cycles of 1% while efficiently transferring various workloads and adapting to changing networking conditions. These workloads include periodic data reporting, bulk log transfer, and wirelessly reprogramming a node. In this paper we discuss the design of a MAC protocol motivated by monitoring applications. Nodes in a wireless sensor network do not exist in isolation; rather they are embedded in the environment, causing network links to be unpredictable. The disadvantage was high traffic and energy consumption.

J. Raja et al., [6] stated that in order to minimize unnecessary energy wastage, a preamble-based LPL node repeats preamble sensing for short active duration and sleeping for the rest of duration, within a listening cycle (LC). Preamble-based LPL can maximize energy conservation by lengthening sleep duration, but data response time might be significantly delayed, since a sender should transmit a long preamble to trigger a receiver which is performing periodic preamble sensing with long LC. On the other hand, if too short preamble is used, data response time can be reduced but energy might be wasted. That is, there exists a trade-off between energy and delay. Therefore, the key idea of the proposed LPL protocol, transmission rate-based adaptive low-power listening MAC (TRA-MAC), is to make it possible for LC to adapt dynamically to traffic variations. That is, devices in frequent communications shorten LC to improve data response time, but devices in infrequent communications lengthen LC to conserve energy. This might result in compensating trade-off between energy and delay. The disadvantage was it consumed more power and overhead is very high.

Many standard MAC protocols developed for duty-cycled Wireless sensor networks such as B-MAC, S-MAC etc employ an extended preamble and preamble sampling. In duty cycled Wireless sensor networks, MAC protocols exploit the concepts of extended preamble and preamble sampling. These MAC protocols are generally standard protocols in Wireless sensor networks with duty cycle. With this approach there is consumption of energy at non-designated receivers. Hence a MAC protocol called X-MAC is proposed by M .Buettner et al., [7] which is a lower power MAC protocol and employs a shortened preamble concept. Hence the short preamble packets contains the address of the designated receiver these short preamble packets combine to form a continuous preamble. The main use of shorter preamble packets is it permits the designated receiver to send a acknowledgement to the sender. Hence by this there is low power consumption, in the sensor nodes and simple decoupling sleep schedules of transmitter and receiver.

K.L. Cooke et al., [8] states that in congested transportation networks, arc travel times change over time due to time-of-day variations in traffic congestion. Even if one can account for these time-of-day variations, future travel times can at best be known a priori with uncertainty due to unforeseen events, such as poor roadway conditions, vehicle breakdowns, traffic accidents, and driver behaviour. In this work, we develop path search techniques that explicitly consider the inherent time-varying nature of future travel times. Recent studies have focused on time-dependent graphs. This type of generalization is useful for real word applications. A simple example is that of a computer communications network composed of dial up links each with its individual dialling schedules. Since delays depend on these predetermined schedules, finding the best route for a message from source to destination involves the computation of time-dependent functions. The aim was [8] to study the dynamic shortest path problem in a discrete time setting with positive transit times. It can be seen that from this that the problem is reduced to a classical shortest path problem on a so-called time-expanded network. But still eventually some packets were damaged and there was difficulty achieving equilibrium.

End to End communication in low duty cycle WSN cannot maintain the nodes to be in an always awake condition this makes the nature of wireless communication is dubious. Hence Y.Gu et al., [9] proposed the concept of dynamic switch based forwarding to achieve network efficiency, reliability by optimizing the data delivery ratio, communication delay, energy consumption. Dynamic switch based forwarding is mainly designed for unreliable network and nodes with predefined communication schedules. It also provides reduction in end-to-end delay by opportunistic looping.

I. Chabini et al., [10] the main objective of this paper is the study of the all-to-one dynamic shortest paths problem, one-to-all fastest paths problems are studied as well. Early results are revisited and new properties are established. Establishing the exact complexity of these problems and developing a solution algorithm optimally, in the run time sense. A new and simple solution algorithm is proposed for all-to-one all departure time intervals shortest path problems. It is proved, theoretically, that the new solution algorithm has an optimal run time complexity that equals the complexity of the problem. But the drawback was it limits the transmission efficiency and the network is unstable.

The time dependent shortest path problem is prevalent in Wireless sensor network for transportation applications where moving objects have physical limitations following certain paths as they are sizable physical entities. Observing that a system yields poly line instead of a line segment it is the real trajectory or path of an object in motion due to the interactions with moving object with that system. Hence H. Chon et al., [11] a distributed system which manages the information about moving objects called FATES- finding a time dependent shortest path .It is a two-dimensional space-time grid model used to provide time-dependent shortest path to moving objects. When there is an apparent congestion present in the network routes it reduces the average trip time with same inter arrival rate' λ' and skew rate' r'. Analysis of FATES shows that sometimes there may be extra trip time when the moving objects are re-routed to alternate routes from congested routes.

A. Orda et al., [12] this paper addresses algorithms for networks whose behaviour changes with time according to known functions. Because the computation depends on the same functions it attempts to compute, its execution must obey strict timing constraints. When distributed versions of such algorithms are considered, a key difficulty is how to transfer local timing functions among the participating nodes. To that end it is necessary to characterize the parameterization of the functions and accommodate this parameterization in the computation. In particular, consider the shortest-path problem in networks in which the delay of the edges changes with time according to continuous functions. Hence they proposed distributed protocols for finding the shortest and minimum delay path under various waiting constraints. The disadvantage was energy level is suitable for only limited sensor networks and it is difficult to reconfigure the protocols after deployment.

Classical Bellman-Ford algorithm computes the shortest paths to a destination node from a single source node to all the other nodes in a network. It offers exponential complexity in finding the shortest paths. The phenomenon of infinity counting and looping is predominant in Bellman-Ford algorithm. Even the concurrent node changes in a network. Hence G.D'Angelo et al., [13] proposed a fully dynamic algorithm called partially dynamic concurrent update of shortest paths which provides decremented algorithm complexity and it is able to update shortest paths concurrently in the network.

Scheduling strategies over wireless sensor network offer partial and target coverage scheduling which result in low density active nodes. Scheduling schemes should provide minimum packet delivery latency and prolong the battery life of sensor nodes. Hence L.Su et al., [14] implemented intermittent routing techniques in wireless sensor network that provides minimum latency in packet delivery by an on-demand minimum latency algorithm. They also derived two proactive routing algorithms that offer minimum latency by identifying routes between nodes with reduced routing overhead and delay with respect to route acquisition.
One of the major applications of wireless sensor network is data delivery to the concerned sink node or base station. It must be highly efficient in real-time scenarios application such as military surveillance, where the detection of an event must be reported immediately to the command centre in a specified time frame. For this the sensor nodes must be in constant sensing or active mode which results in loss of energy. To deliver data to the base station the node needs to be in active state. Hence for periodic delivery of data in such extremely low duty cycle sensor network management of sensor nodes is essential. The solution for management of sensor nodes in such low duty cycle networks in real-time was provided by Y.Gu et al., [15] for guaranteed communications delay in real-time sensor network they minimized the consumption of energy in nodes for bounding pair wise end-to-end delay and derived an optimal dynamic program based heuristic algorithm for communication between many to one and many to many nodes.

In wireless sensor network, preservation of energy in sensors is a critical task as they are mostly battery operated and has limited supply of energy. One of the techniques for saving energy is to turn off sensors when radio communication is not necessary. Existing wake-up schemes which allow sensors to turn off while idle increases end-to-end delay while preserving energy. Hence X.Yang et al., [16] proposed a wake-up scheme to attain the balance between energy saving and end-to-end delay called pipelined tone wake up(PTW0 scheme. It constructs an asynchronous wake up pipeline to overlap the wake up procedures with packet transmission with the use of wake up tones it enables a large duty cycle ratio without causing wake up delay in the next hop. Hence the pipeline helps in achieving less dissipation of energy during wake up with reducing the end-to-end delay in wireless sensor network.

Power saving and management is a critical factor required for efficient functioning of the sensors in the Wireless Sensor Network. Hence to address this factor, S.Lai et al., [17] proposed cyclic quorum pair (CQS-pair) which can guarantee that two asynchronous nodes adopt different cyclic quorum systems and they can hear each other at least once in there bounded time intervals. A fast construction scheme is designed [17] based on the multiplier theorem. Hence with this a wireless sensor network between two heterogeneous nodes can achieve different wireless sensor network between power saving ratios while maintaining connectivity. It also shows significant improvements in the performance with average delay quorum ratio and support for multicast and broadcast communication in wireless sensor network.

Synchronization of clocks accurately among various applications is a crucial part in wireless sensor network. Many of the existing synchronization techniques provide an average synchronization between arbitrary nodes. However, P. Sommer et al., [18] proposed gradient time synchronization protocol (GTSP) to provide accurately synchronized clocks between neighbors in a decentralized fashion. In this protocol the synchronization messages received from direct neighbors are used to calibrate the logical clock of the sensor node. It neither requires a reference node nor a topology which makes it robust against link free and node failures in the network.

A singular approach towards several distributed protocols in wireless sensor network with formal description and validation of the same was presented by A.Segall [19]. He introduced two basic protocols namely propagation of information and propagation of information with feedback (PIF) which is integrated with other existing protocols. Hence the distributed network protocols provide better connectivity, minimum hop paths and path updating in case of changes in the network topology.

A family of distributed algorithms for the dynamic computation of the shortest paths in a wireless sensor network maintain vector with distance to each and every node present in the network with the help of distance vectors the route update in the network are done with several entities such as destination, selected path for the query etc and even for changes in the network topology. Many other new algorithms also provided significant solutions in determining the shortest paths in the network but the looping problem is pre-dominant with combined messages and storage complexities. Hence a distributed shortest path routing called diffusing update algorithm or dual was proposed by J.J Garcia [20] which is a family of algorithm that provides loop free paths in the network regardless of its operational conditions. It uses hold down time which is proportional to the transmission delay that occurs between two routers before updating the routing information received from all the neighbor nodes in the network.

In wireless sensor network, the problem of idle nodes continuously sensing the network is prevalent leading to loss in energy for sensor nodes as they have limited supply of energy several MAC protocols are implemented to save energy in wireless sensor network but not in significant proportions. Hence a contention based MAC protocol for wireless sensor network called T-MAC is proposed by T.V Dam et al., [21] that reduces energy consumption by implementing an active/sleep duty cycle. It also introduces a novel approach towards adaptive duty cycle control by dynamic handling with this protocol the amount of energy wasted on idle listening is reduced and the wait is diverted towards potential incoming messages and at the same time maintenance of reasonable throughput in the network.

The sensors present in wireless sensor network when deployed in real-time environments offer a transitional region with unreliable links which does not support perfect reception within range among nodes in the network. M.Zuniga et al., [22] used mathematical techniques to analyze the low power wireless links from communication theory. They derived expressions for packet reception rate as a function of distance with these expressions the modulation and encoding of radio channels along with their paths exponents and shadowing variance is determined. The impact of these parameters on the channel behavior provides an accurate estimate on the quality of wireless links in the network.

Wireless sensor network operate as co-operative engagement of a collection of sensor nodes which interact with a centralized base station where as in mobile Ad-hoc network there is no centralized access required. C.E Perkins et al., [23] presented an innovative design DSDV to operate the mobile host stations as a specialized router and provide interconnection topology to other mobile hosts in the network and forward the packets with help of present routing protocols and some modifications. The poor looping properties and resolution of broken links with time dependent interconnection topology the links are connected between the mobile hosts. Actual routing is done by information present in the internal routing table but it is not advertised periodically or upon receipt. By this it automatically enables the use of network-layer routing capabilities for information sharing in the network.

Energy constraints of the individual sensor nodes, present in wireless sensor network limits the utilization of wireless sensor network in a range of application. Hence energy efficient routing among the sensors is required for conservation of energy in the nodes. Hence Stefanos A.Nikolidakis et al.,[24] proposed a new protocol called Equalized Cluster Head Election Routing [ECMERP] which ensures energy conservation by balanced clustering. The network is modeled as a linear system with Gaussian elimination algorithm and calculates the combination of nodes which can form as a cluster to extend network lifetime. Hence the overall network energy is minimized and it also adapts multi-hop routing for transfer of data to the sink node.

From the survey of the previous works mentioned, we can see that the techniques and algorithms proposed are targeted at efficient routing mechanisms and lower consumption of energy in wireless sensor networks.

2.1 Motivation

The primary inspiration of our work is to devise a dispersed calculation, which can effectively specify every single ideal route with slightest end-to- sink inactivity for infinite time interims. The second inspiration of our work is to propose calculations which can powerfully and distributive keep up time-subordinate shortest routing paths. The design of duty cycle in sensor nodes can be upgraded taking into account the remaining energy present or by number of nodes joining and leaving the system which changes the topology of the system. With this the routing paths and costs associated with also changes as the transmission links have to be updated or it results in multiple link failures. Efficient link update handling processes were proposed, but it resulted in execution of distributed multiple updates concurrently for a single node update and it consumes messages and memory in resource constrained WSN.

The third motivation is to concentrate on issues related to practical implementation. During initial deployment of nodes in the network scheduling awareness is needed between the neighboring nodes. This can be achieved by synchronization of the sensor nodes in the network and it aids in mutual exchange of duty-cycle information and differences in time intervals between the neighboring sensor nodes.

III. METHODOLOGY

A conveyed algorithm to process the time-dependent paths with slightest dormancy for all nodes in a duty cycled WSN is proposed. The algorithm has low message and space intricacy. The calculation is in view of inspecting the occasional examinations of the link expense work by which the distance function additionally changes occasionally for every last sensor node. Consequently the link expense capacity must fulfill the First-in-First-Out property. Additionally a circulated algorithm for maintaining the shortest paths is proposed. The routing paths are recomputed by the calculations proposed which are in light of previous path data. An imperfect usage, which obliges vectors with smaller sizes to link expense capacities and the distance function capacity, is executed.

The entire proposed system is divided into four modules. Each module concentrates on the part it is assigned and extensive background and related work is done. Finally all the modules are integrated into one and the experimentation is conducted for expected results and analysis. The modules are as follows:

Network Deployment and Configuration: To model the network, we first introduce the following parameters number of nodes, channel bandwidth, queue length of link, queue threshold of link and energy etc and it will deploy in Network Animator with some size into the topology. Based on the network model, we design a distributed duty cycle controller. We Control the duty cycle of each node by dynamically adjusting the sleep interval time under network condition changes.

Initial Route Construction: A algorithm is proposed where at first the distance are limitless from all nodes to the sink or centralized base station in duty cycled WSN's alluded to as Fast Time-Dependent Shortest Path calculation, which actualizes [2] and is fundamentally like the distributed Bellman-Ford algorithm. The distinction is that our algorithm is trading vectors and is fixed with a synchronizer.

Pick a synchronizer keeping in mind the end goal to evade exponential message intricacy. In FTSP, the shortest paths are registered in one execution for unbounded discrete time periods. There are basically two stages in our calculation for building routing paths. In the first step, we fabricate a spanning tree. In the second step, we compute the shortest paths and send back the affirmation to the sink for nodes in the system with a layer-by-layer methodology. In our calculation FTSP, we join the two stages and actualize them through iterations. Each of the cycle starts at node "n" by sending a control message to every one of its neighbors. The iterations is termed to be finished by node 'n', when all the neighboring nodes answer and it reaches the node 'n'.

Dynamic Route Maintenance: When contrasted with static systems, connection changes and node changes are more regular in duty cycled WSNs. In the event that a node changes its duty cycle setup, or powerfully joins or leaves the system, the connections associating with every one of its neighbors will be changed at various time interims. In such a circumstance, a single node redesign ordinarily causes different connection upgrades. We propose an answer in which a node just stores the course to the sink, which is more feasible in WSNs because of their memory imperatives the primary thought is first to distinguish which nodes should be redesigned. After that, the calculation redesigns the shortest path for these recognized nodes. The update procedure is like the course development.

Route Update: Initial spanning tree is developed slowly with all nodes. The motivation behind this is to let all nodes build their distances to the sink node, along the time-extended shortest path trees established is recognized. After the end all nodes never expand their distances again. In every cycle, every node sends a control message to all neighbors. Each and every other node will send control messages to every one of its neighbors in the event that it is in the spanning tree and gets a message from its parent.

In the event that the spanning tree in the present iteration, it weighs whether its parent in its shortest path in the wake of accepting a control message from its neighbor, which should be possible by checking whether. In the event that is genuine, will join the spanning tree and set some value. Thusly, the spanning tree will increment at most one level in every cycle. A control message will navigate from the root to all nodes. Different nodes in the spanning tree simply like that in FTSP-M. At the point when the source node gets a control message from the receiver, it just redesigns the component be too expanded in its distance vectors.

IV. IMPLEMENTATION

A fast distributed algorithm must be designed for routing over time-dependent WSN, which can productively identify all optimal paths with minimum end-to- sink latency for unbounded time interims and can also dynamically and distributive maintain time-dependent minimum latency paths.

Even the practical implementation issues must be addressed as it requires schedule-awareness in neighborhood. A suboptimal execution, which obliges vectors with smaller sizes to represent link expense functions and the distance function between the sensor nodes, is implemented.

4.1 System Requirements

To be used efficiently, all computer software needs certain hardware and software resources to be available on the computer. These prerequisites are known as system requirements. This includes the system level and functional requirements for the design and implementation of the algorithm:

- Pentium processor with dual core or higher architecture(core-2 duo, i3 etc)
- 2GB of RAM with 40GB available Hard disk space
- Inbuilt or an external graphics card.
- Operating system: LINUX, Ubuntu, Red Hat, Fedora, Windows (VMWARE or Cygwin). Most compatible is Ubuntu 13.04 edition.
- Software : Network Simulation Ver.2.35
- Pre-installed with Tool Command Language, AWK, C++ and necessary compilers for C/C++ executions and appropriate scripting compilers for compilation.

4.2 Data Flow Diagram

A Data Flow Diagram (DFD) describes the flow of data in a system graphically along with modeled process aspects. The origin and destination of the data in the system is represented with information regarding to input and output systems with transitions and storage of the data in the system. Information related to processing of data like sequential or parallel executions and timing constraints are not shown. The data flow diagram shown in figure 1 consists of the five modules namely network deployment, initial route construction, dynamic route maintenance, route updation and simulation results modules.

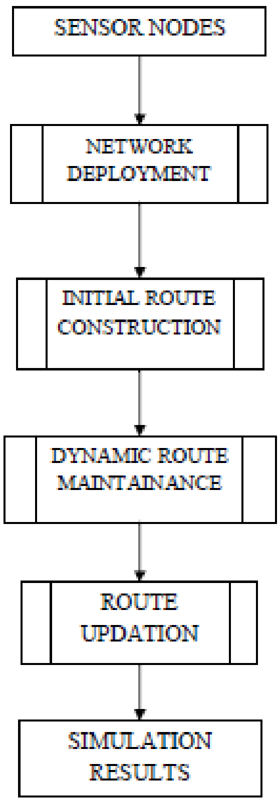

Figure 1. Data Flow Diagram for Multi Path Routing in WSN

Network Deployment and Configuration Module: In this module the sensor nodes are deployed into the network and are placed in their positions and respective configuration parameters are assigned to each and every node in the network. This module is defined by the data flow diagram in figure 2 and the following steps take place:

- Sensor nodes are deployed into the network.
- All the nodes are placed in the network in various positions defined for each node.
- After the placing of nodes in their positions they are in sleep state.
- When the nodes go into in active state, packets can be transmitted and received.
- Then the packets with control information are broadcasted to the neighboring nodes.

Initial Route Construction Module: This module handles the route construction and determines the shortest path between each of the nodes present in the network. These routes are calculated by an algorithm which is proposed where initially the distances are infinite from all nodes to the sink or centralized base station in duty-cycled WSN's. This module is defined in the data flow diagram in figure 3 with the following steps involved:

- From source node the distances of the neighboring nodes are calculated and tabulated.
- FTSP Algorithm is used for selecting the shortest paths between the source and destination nodes, where the nodes are primarily recruited on distances values obtained to the source. The distance values from the source node to the other nodes in the network is recorded and tabulated and the appropriate nodes with less distance values from the source nodes are selected.
- After determining the route packets are forwarded to the destination node.

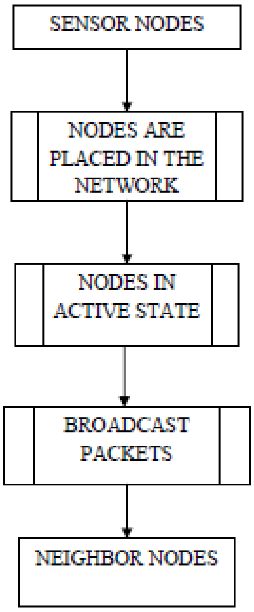

Figure 2. Data Flow Diagram of Network deployment module

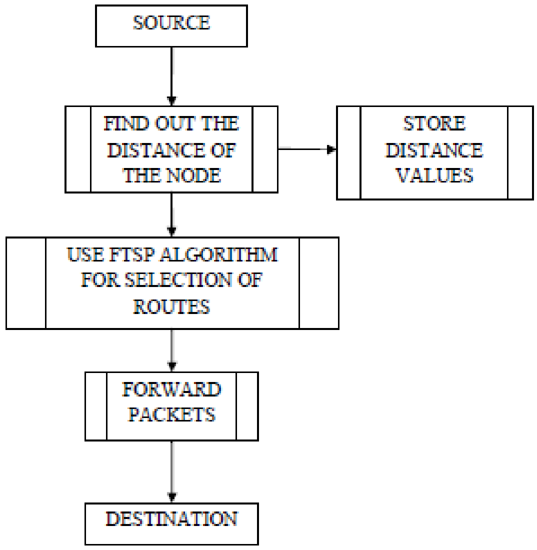

Figure 3. Data Flow Diagram of Initial Route Construction Module

Dynamic Route Maintenance Module: in this module the routes are maintained dynamically. Since in static systems connection changes and node changes are more regular in duty cycled WSNs. In the event that a node changes its duty cycle setup, or joins or leaves the system it causes various connection upgrades. Thus a node just stores the course to the sink which should be updated and the calculation updates the shortest path for the nodes to the recognized nodes. The module procedure is characterized in the data flow diagram in figure 4 and it includes the accompanying steps:

- From the source node we check the time interval of the nodes in the route to the destination
- Observing the duty cycle configuration of the nodes in the route, shortest path is selected and the packets are forwarded to the destination node.

Route updating module: In this module route updating is done between the nodes and the routing tables. This is done because initial spanning tree is built up gradually with all nodes. The purpose of this is to let all nodes increase their distances to the sink node, along the time-expanded shortest path trees rooted is identified. After the termination all nodes never increase their distance again. The differences in this route are updated among the nodes and the routing table. This module is defined by the data flow diagram in figure 5 and the following steps take place:

- The nodes are built by using spanning tree and the nearest nodes distances are calculated
- Control messages are forwarded to each and every node.
- The shortest path from the source to the destination is determined.
- Acknowledgement of packets received is sent to the source.

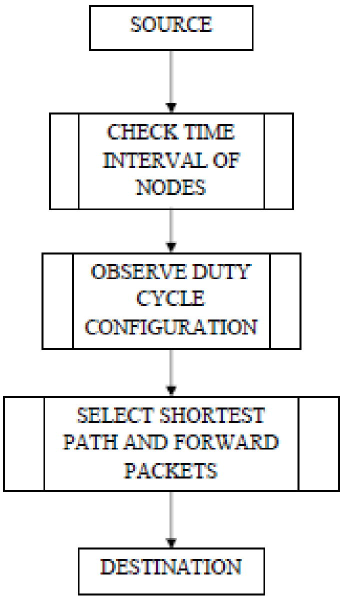

Figure 4. Data Flow Diagram of Dynamic Route Maintenance Module

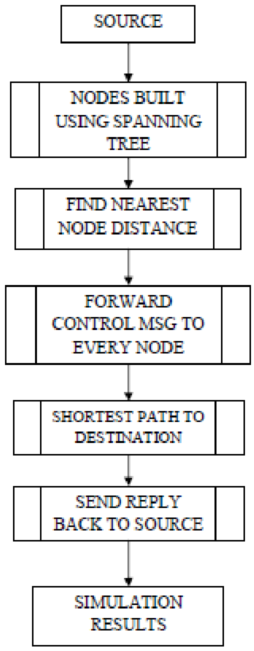

Figure 5. Data Flow Diagram of Route Updating modules

V. SIMULATION RESULTS

The realization of the technical specifications or algorithm specified for the proposed methodology as a program and deployment was extensively carried out in Network Simulator version 2.35.

For execution the users use the ns command along with the file name holding the simulation parameters known as Tcl Scripting file which is an input argument. The creation of simulation trace file is done by the programming languages mentioned and after compiling and execution of the same, graphical plots of the results generated during simulation is displayed. The configuration parameters for the simulations are defined in Table1.

Parameter	Values
Number of nodes	36
Network Area	1500m * 1000m
Interface Queue	CMUPriQueue
Interface Queue length	340 packets
Antenna	Omni- Antenna
Initial Energy	100 Joules

Traffic Type	CBR
Transmission Rate	256 bps

Table 1. Simulation Parameters

The performance evaluation of Fastest Time Shortest Path (FTSP) algorithm is done through extensive simulations using Network simulator 2, a discrete event simulator. Our algorithm is compared with distributed Bellman-Ford algorithm which is adapted to time dependent modeled networks.

The FTSP algorithm is a proactive protocol. The protocol is affordable for the initial route construction in the initial stages of wireless sensor networks. The feature low space complexity for route maintenance makes the algorithm scalable for large scale WSN's. The FTSP targets the Adaptive Low Power Listening (ALPL) mode with various checking intervals. Our work focuses on the scenario of a single sink node.

The following parameters are calculated and the performance of the proposed system is evaluated with the previous works mentioned along with necessary graphs are plotted.

- Throughput: It is the number of messages successfully delivered per unit time.
- Packet drops: The numbers of a packet that are lost or fail to successfully reach their destination in the network.
- Packet Delivery Ratio: The ratio of packets that are successfully delivered to a destination compared to the number of packets that have been sent out by the sender.
- Energy Consumption: It is the amount of energy consumed by the sensor nodes in the network during data transmission.

5.1 Graphical Representations of the Results

The values obtained during the simulation of the proposed system are obtained and necessary graphs are plotted to evaluate the performance the proposed system with the mentioned major parameters along with the existing system.

In figure 6 the graph represents the throughput comparison of the proposed and existing system. The graph is a system of time in seconds with respect to transfer of packets in the network in kilo bits per second. From the graph, we concur that greater throughput is obtained by using the proposed FTSP protocol rather than the existing system. The throughput increases with time and maintains a consistent stability rather than the existing system. Hence FTSP provides higher throughput efficiency.

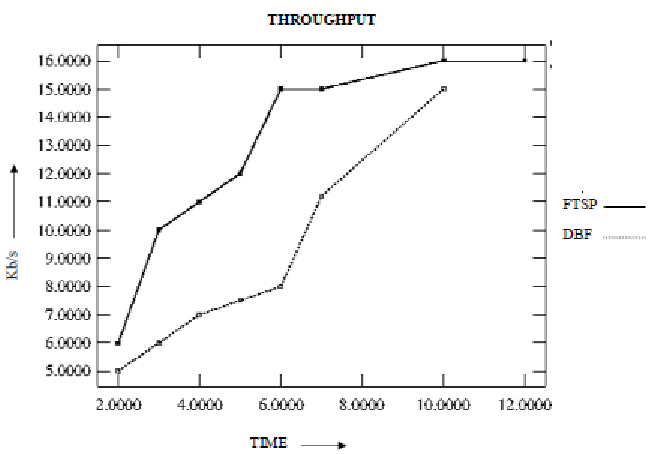

Figure 6. Graphical comparison of Throughput

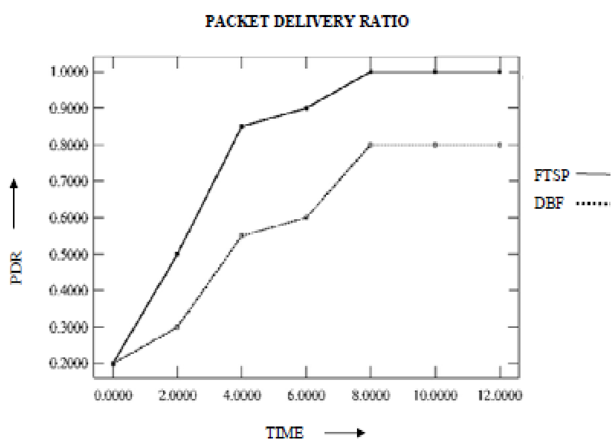

Figure 7. Graphical comparison of Packet delivery ratio

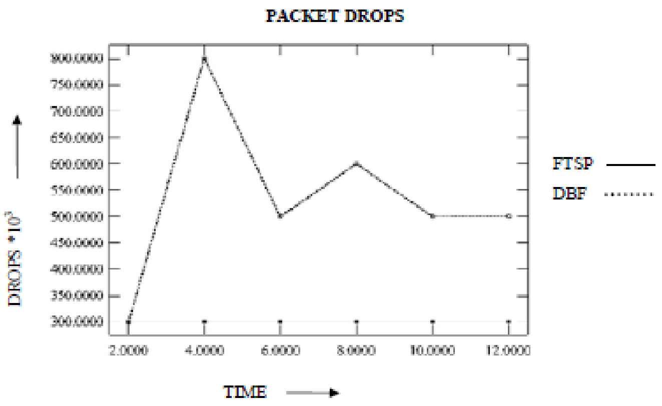

Figure 8. Graphical comparison of Packet drops

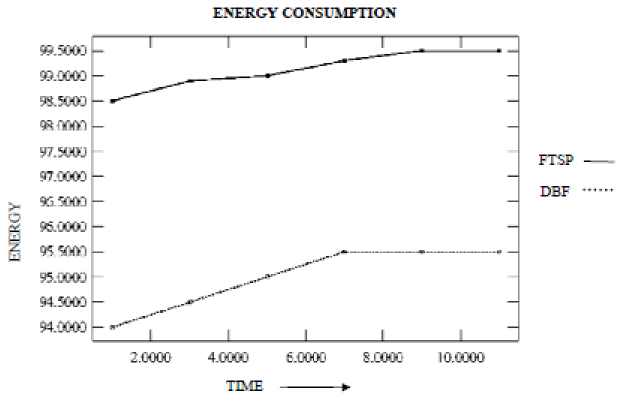

Figure 9. Graphical comparison of Energy Consumption

The graph in figure 7 represents the packet delivery ratio comparison of the proposed and existing system. The graph is a system of time in seconds with respect to the ratio of total number of packets received to the total number of packets transmitted. From the graph, we concur that greater packet delivery ratio is obtained by using the proposed FTSP protocol rather than the existing system.

The graph in figure 8 represents the packet drop comparison of the proposed and existing system. The graph is a system of time in seconds with respect to the total number of packets lost in the network during data transmission. From the graph, we concur that packet drops is less obtained by using the proposed FTSP protocol rather than the existing system.

The graph in figure 9 represents the energy consumption comparison of the proposed and existing system. The graph is a system of time in seconds with respect to energy in joules. From the graph, we concur that energy of the sensor nodes in the network is conserved in the by using the proposed FTSP protocol rather than the existing system during data transmission.

VI. CONCLUSIONS AND FUTURE WORK

Routing protocols development differ from applications and network architecture efficient routing protocol for Wireless sensor network is vitally needed to extend the lifetime of the sensor nodes relatively extending the network lifetime. Hence a single routing protocol for Wireless sensor network cannot be developed. The multi-hop routing, clustering and data aggregation techniques are used to preserve energy. Multi-hop data routing in sensor network normally generate a minimum hop path with the assumption of link cost is same in both wired and wireless links. But this assumption is invalid in duty-cycled Wireless sensor network. Sleep Wake up mechanisms is exploited in Wireless sensor network which violates static link routing costs. The intervals for sleep and wake can be varied according to applications but in heterogeneous low power listening mode is variation in neighbor discovery latency. From this optimal routing generation paths can be addressed as Time Dependent Short path.

In this thesis, a Time Dependent Shortest path is modeled as First-in-First-Out network. Fastest time shortest path algorithm is proposed for computing optimal routing paths between source and destination over duty-cycled Wireless sensor network. This algorithm provides low-message and low space intricacy nature. The proposed algorithm compute the routing paths based on latter path data and information of routes suboptimal implementation of vectors with distance values between the sensor nodes are generated and maintained. Our algorithm satisfies the FIFO condition and generate shortest path to the sink or destination node in a single execution for infinite time intervals, simultaneously after single path generation, we have enhanced it to discover multiple routing paths from the destination using the recruited node. Finally multiple paths for data transmission between source and destination is discovered resulting in increase in efficiency of the network with respect to throughput, packet delivery ratio, packet drops and energy consumption are compared to previous work.

Further the algorithm can be modified for the presence of mobility in sensor nodes and security algorithms can be implemented as the information is routed through multiple paths and the data is prone to errors, misuse and duplication if malicious nodes are present in the multipath routes.

REFERENCES

[1] S. Lai and B. Ravindran, "On Distributed Time-Dependent Shortest Paths over Duty-Cycled Wireless Sensor Networks," *Proc. IEEE INFOCOM*, 2010.

[2] C. Schurgers and M.B. Srivastava, "Energy Efficient Routing in Wireless Sensor Networks," *Proc. Military Comm. Conf. (MILCOM '01)*, vol. 1, pp. 357-361, 2001.

[3] A. Woo, T. Tong, and D. Culler, "Taming the Underlying Challenges of Reliable Multihop Routing in Sensor Networks," *Proc. First Int'l Conf. Embedded Networked Sensor Systems (Sensys)*, pp. 14-27, 2003.

[4] C.M. Vigorito, D. Ganesan, and A.G. Barto, "Adaptive Control of Duty Cycling in Energy-Harvesting Wireless Sensor Networks," *Proc. IEEE Comm. Soc. Conf. Sensor, Mesh and Ad Hoc Comm. And Networks (SECON)*, pp. 21-30, June 2007.

[5] J. Polastre, J. Hill, and D. Culler, "Versatile Low Power Media Access for Wireless Sensor Networks," *Proc. Int'l Conf. Embedded Networked Sensor Systems (Sensys '04)*, pp. 95-107, 2004.

[6] J. Raja, B. Pierre, and V. Cristina, "Adaptive Low Power Listening for Wireless Sensor Networks," *IEEE Trans. Mobile Computing*, vol. 6, no. 8, pp. 988-1004, Aug. 2007.

[7] M. Buettner, G.V. Yee, E. Anderson, and R. Han, "X-mac: A Short Preamble MAC Protocol for Duty-Cycled Wireless Sensor Networks," *Proc. ACM Fourth Int'l Conf. Embedded Networked Sensor Systems (Sensys)*, pp. 307-320, 2006.

[8] K.L. Cooke and E. Halsey, "The Shortest Route through a Network with Time- Dependent Internodal Transit Times," *J. Math. Analysis Application*, vol. 14, pp. 493-498, 1966.

[9] Y. Gu and T. He, "Data Forwarding in Extremely Low Duty-Cycle Sensor Networks with Unreliable Communication Links," *Proc. Sixth ACM Conf. Embedded Network Sensor Systems (Sensys)*, pp. 32- 38, 2007.

[10] I. Chabini, "Discrete Dynamic Shortest Path Problems in Transportation Applications: Complexity and Algorithms with Optimal Run Time," *Transportation Research Records*, vol. 1645, pp. 170-175, 1998.

[11] H. Chon, D. Agrawa, and A. Abbadi, "Fates: Finding a Time Dependent Shortest Path," *Mobile Data Management*, vol. 2574, pp. 165-180, 2003.

[12] A. Orda and R. Rom, "Distributed Shortest-Path Protocols for Time-Dependent Networks," *Distributed Computing*, vol. 10, no. 1, pp. 49-62, 1996.

[13] G. D'Angelo, S. Cicerone, G.D. Stefano, and D. Frigioni, "Partially Dynamic Concurrent Update of Distributed Shortest Paths," *Proc. Int'l Conf. Computing: Theory and Applications*, pp. 32-38, 2007.

[14] L. Su, C. Liu, H. Song, and G. Cao, "Routing in Intermittently Connected Sensor Networks," *Proc. IEEE Int'l Conf. Network Protocols*, pp. 278-287, 2008.

[15] Y. Gu, T. He, M. Lin, and J. Xu, "Spatiotemporal Delay Control for Low-Duty-Cycle Sensor Networks," Proc. *IEEE 30th Real-Time Systems Symp. (RTSS)*, pp. 127-137, 2009.

[16] X. Yang and N.H. Vaidya, "A Wakeup Scheme for Sensor Networks: Achieving Balance between Energy Saving and End to- End Delay," *Proc. IEEE 10th Real-Time and Embedded Technology and Applications Symp.*, 2004.

[17] S. Lai, B. Zhang, B. Ravindran, and H. Cho, "CQS-Pair: Cyclic Quorum System Pair for Wakeup Scheduling in Wireless Sensor Networks," *Proc. Int'l Conf. Principles of Distributed Systems (OPODIS)*. pp. 295-310, 2008.

[18] P. Sommer and R. Wattenhofer, "Gradient Clock Synchronization in Wireless Sensor Networks," *Proc. ACM Int'l Conf. Information Processing in Sensor Networks (IPSN)*, pp. 37-48, 2009.

[19] A. Segall, "Distributed Network Protocols," *IEEE Trans. Information Theory*, vol. 29, no. 1, pp. 23-35, Jan. 1983.

[20] J.J. Garcia-Lunes-Aceves, "Loop-Free Routing Using Diffusing Computations," *IEEE/ACM Trans. Networking*, no. 1, pp. 130-141, Feb. 1993.

[21] T.V. Dam and K. Langendoen, "An Adaptive Energy-Efficient Mac Protocol for Wireless Sensor Networks," *The First ACM Conf. Embedded Networked Sensor Systems (Sensys)*, 2003.

[22] M. Zuniga and B. Krishnamachari, "Analyzing the Transitional Region in Low Power Wireless Links," *Proc. IEEE Comm. Soc. Conf. Sensor, Mesh and Ad Hoc Comm. and Networks (SECON)*, pp. 517- 526, 2004.

[23] C.E. Perkins and P. Bhagwat, "Highly Dynamic Destination- Sequenced Distance-Vector Routing (DSDV) for Mobile Computers," *ACM SIGCOMM Computer Comm. Rev.*, vol. 24, no. 4, pp. 234-244, 1994.

[24] Stefanos A. Nikolidakis, Dionisis Kandris, Dimitrios D. Vergados and Christos Douligeris, "Energy Efficient Routing in Wireless Sensor Networks Through Balanced Clustering", *Algorithms Journal, pp. 29 – 42, 2013*