Maximization of Lifetime and Reducing Power Consumption in Wireless Sensor Network Using Protocol

Lourthu Hepziba Mercy.M, Balamurugan.K, Vijayaraj.M

Abstract— This paper is to avoid duplicate transmission, node reconfiguration and power consumption in Wireless Sensor Networks (WSN). Wireless sensor network requires robust and energy efficient communication protocols to minimize the energy consumption as much as possible. However, the lifetime of sensor network reduces due to the adverse impacts caused by radio irregularity and fading in multi-hop WSN. The scheme extends High Energy First (HEF) clustering algorithm and enables multi-hop transmissions among the clusters by incorporating the selection of cooperative sending and receiving nodes. The work proposed focuses to develop any node to act as cluster head (CH) instead of affected CH because we need to get a data from CH continuously. To reduce energy consumption, proposed scheme extends with the help of S-MAC layer to get the efficient energy saving. The performance of the proposed system is evaluated in terms of energy efficiency and reliability. Simulation results show that tremendous energy savings can be achieved by adopting hard network lifetime scheme among the clusters. Many routing protocols are developed, but among those protocols cluster based routing protocols are energy efficient, scalable and prolong the network lifetime .The network simulator 2 (NS2) is used to verify the proposed network lifetime predictability model, and the results show that the derived bounds of the predictability provide accurate estimations of the energy saving and network lifetime.

Keywords- cluster head selection, network lifetime, schedulability, timing constraints, wireless sensor networks, AODV.

I. INTRODUCTION

A wireless sensor network (WSN) consists of sensor nodes capable of collecting information from the environment and communicating with each other via wireless transceivers. The collected data will be delivered to one or more sinks, generally via multi-hop communication. The sensor nodes are typically expected to operate with batteries and are often deployed to not-easily-accessible or hostile environment, sometimes in large quantities. It can be difficult or impossible to replace the batteries of the sensor nodes. On the other hand, the sink is typically rich in energy. Since the sensor energy is the most precious resource in the WSN, efficient utilization of the energy to prolong the network lifetime has been the focus of much of the research on the WSN. The communications in the WSN has the many-to-one property in that data from a large number of sensor nodes tend to be concentrated into a few sinks. Since multi-hop routing is generally needed for distant sensor nodes from the sinks to save energy, the nodes near a sink can be burdened with relaying a large amount of traffic from other nodes.

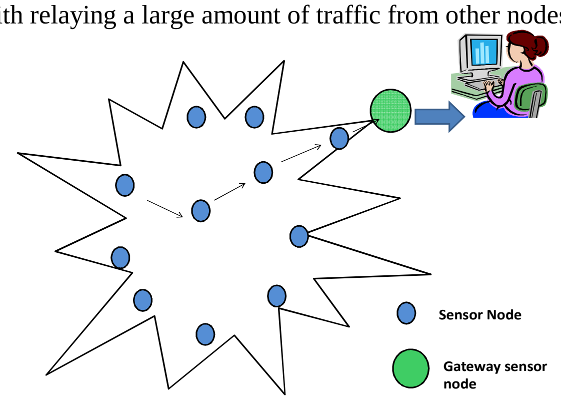

Fig 1: Typical Multi-Hop Wireless Sensor Network Architecture[2]

A. Timing Constraints

Often, when WSNs are used in safety-critical or highly-reliable applications, two timing constraints are considered: real-time constraints, and network life- time constraints (as shown in Fig. 1). Real-time computing is the study of systems that should operate correctly under time constraints [3],[4]. There are two types of real-time systems: hard real-time systems that do not allow any task to miss its deadline, and soft real-time systems that strive to satisfy deadline requirements statistically. With respect to WSNs, real-time computing has been mostly applied in the areas of sensing,data processing, aggregation, and communication with deadline constraint requirements [6],[7].

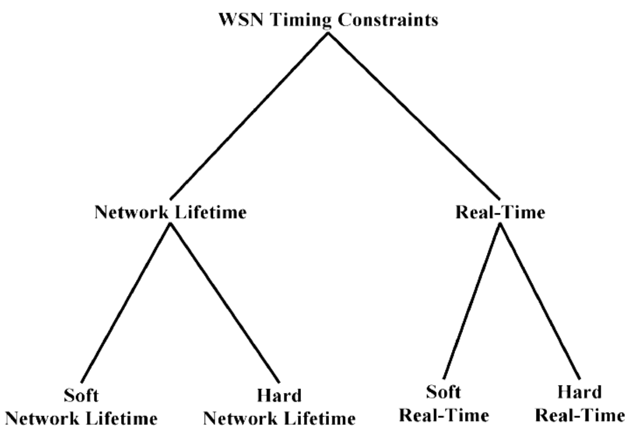

Figure 2.Two time constraints on WSN based safety critical systems.

The network lifetime is another form of deadline, where we need to investigate new solutions in the context and property of the network lifetime. With a mandatory network lifetime constraint, a WSN is characterized as a hard lifetime WSN in which every node must continue to function until the obligatory deadline. Depending on the mission requirements,

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Lourthu Hepziba Mercy.M Electronics and communication Engineering, ANNA university, Einstein College of Engineering, Tirunelveli, India.
Balamurugan.K, Electronics and communication Engineering, ANNA university, Einstein College of Engineering, Tirunelveli, India.
Vijayaraj.M, Associate Professor in the Department of Electronics and Communication Engineering at Government College of Engineering, Tirunelveli,Tamilnadu. India.

network lifetime is most widely defined as: 1) the time span from the deployment of the network to when the first node runs out of energy[10] (a.k.a. N-of-N lifetime), 2) the time duration from the deployment of the network to when a certain percentage of the nodes die due to energy resource exhaustion (a.k.a. K-of-N lifetime), or 3) the time taken from the deployment of the network to when the network is not able to fulfil designed requirements [10] (such as coverage, packet loss, and connectivity). A hard K-of-N lifetime requirement for a WSN means that the system must guarantee that at least K nodes are active at each round during the period from the start of operation to the end of the designated lifetime. Conversely, a soft network lifetime WSN makes a best effort, and has a certain level of acceptance of lifetime misses (as shown in Figure 2). Time-critical WSN systems are ubiquitous in many practical applications such as in an oil pollution monitoring system application[12], target tracking systems[11], health care application[13],[14] etc.

II. PROPOSING SYSTEM

Cluster heads are selected according to the probability of optimal cluster heads determined by the networks. After the selection of cluster heads, the clusters are constructed and the cluster heads communicate data with base station. Because LEACH is only depend on probability model, some cluster heads may be very close to each other and can be located in the edge of the WSN. These disorganized cluster heads could not maximize energy efficiency. To overcome the defects of LEACH methodology, a cluster head election method HEF algorithm has been introduced. This method proved that the network lifetime can be efficiently prolonged by using fuzzy variables (concentration, energy and density). Providing a trustworthy system behavior with a guaranteed hard network lifetime is a challenging task to safety-critical and highly-reliable WSN applications. For mission critical WSN applications, it is important to be aware of whether all sensors can meet their mandatory network lifetime requirements. The High Energy First (HEF) algorithm is proven to be an optimal cluster head selection algorithm that maximizes a hard N-of-N lifetime for HC-WSNs under the ICOH condition. Then, we provide theoretical bounds on the feasibility test for the hard network lifetime for the HEF algorithm. Our experiment results show that the HEF algorithm achieves significant performance improvement over LEACH, and HEF's lifetime can be bounded.

III.ARCHITECTURAL BLOCK DIAGRAM

Step 1 After starting the network, the wireless sensornodes will be divided into several clusters in the WSN.

Step 2 One node will be chosen as the cluster head in each cluster area. This cluster head will use a negotiation system to send joining messages to the nodes near the cluster head.

Step 3 After that, the cluster-heads will send invitations to the wireless sensor nodes in each cluster asking them to join the cluster-heads to form the clusters. The second phase includes the \transferring data process" and the \distributing the role of cluster head process" including the following three steps The AODV routing protocol is responsible for sending the data from the source to the destination nodes. The role of distribution is determined by regularly selecting a set of new cluster-heads based on the weight value.

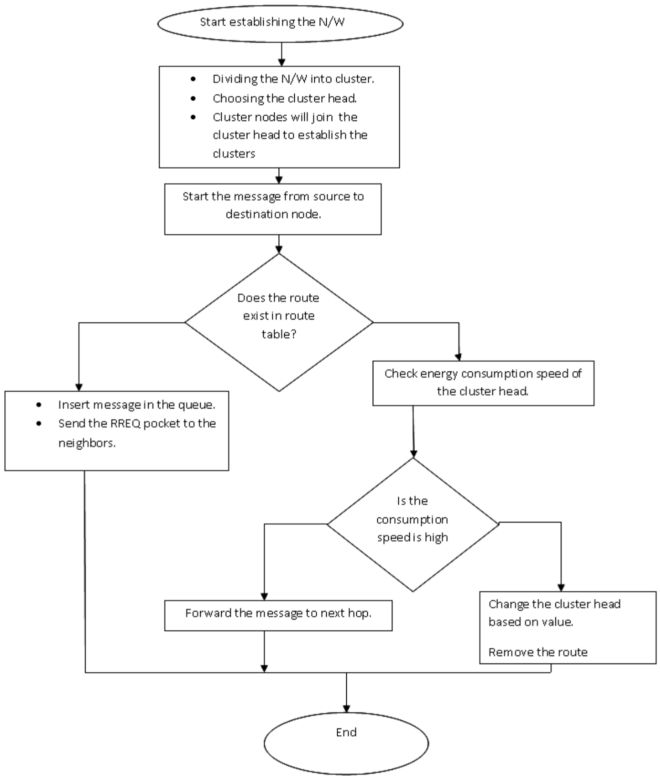

Figure 3.Architectural Block Diagram

Step 4 When any wireless sensor node needs to send a message, it has to check its routing table and look for a path to the destination node. Therefore, if the route is available in the routing table, it will forward the message to the next node. Otherwise, the message will be saved in a queue, and the source node will send the RREQ packet to its neighbors to commence the discovery process.

Step 5 During the forwarding of the message to the destination, the rate at which power is consumed by the cluster head will be calculated based on the energy model. If the energy consumption speed is high, then the procedure will choose another node to act as the cluster head based on the value.

Step 6 Then, the procedure will remove the route from the routing table of the source, which will lead the source node to initiate the discovery process in phase 2 again and a new path to the destination node through the new cluster head.

IV. MODULES

A. Cluster Head Selection

The cluster heads may be special nodes with higher energy or normal node depending on the algorithm and application. Here base station is a cluster head performs computational functions such as data aggregation and data compression in order to reduce the number of transmission to the base station (or sink) thereby saving energy. One of the basic advantages of clustering is that the latency is minimized compared to flat base routing and also in flat based routing nodes that are far from the base station lacks the power to reach it. Clustering based algorithms are believed to be the most efficient routing algorithm for the WSNs.

B. Energy Consumption

Transmission in WSNs is more energy consuming compared to sensing, therefore the cluster heads which performs the function of transmitting the data to the base station consume more energy compared to the rest of the nodes. Clustering schemes should ensure that energy dissipation across the network should be balanced and the cluster head should be rotated in order to balance the network energy consumption. Since energy consumption in wireless systems is directly proportional to the square of the distance, single hop communication is expensive in terms of energy consumption[20].

C. Network Lifetime

It is obvious from the simulation result that by exploiting the density property of the WSNs it is possible to enhance the network life time and also efficiently balance the energy consumption load across the network[17],[18]. Also the energy consumption of the network becomes uniform and it doesn't matter even if the cluster are balanced or unbalanced compared to LEACH.

V. SELECTION OF CANDIDATE CLUSTER HEAD

The selection of cluster head becomes highly challenging when there is an uneven distribution of sensor nodes in clusters. In order to make the cluster head (CH)[16] selection algorithm more accurate, we first identify the candidate sensor nodes for cluster head and then select the best among them. In order to select candidate cluster heads from each cluster, we use the K-theorem. The philosophy behind the K-theorem is to select a candidate CHs based on the bunch of sensor nodes.

The server node (SN) set the value for each cluster. The value is relative to the node density in a cluster and ratio of the cluster heads in a WSN. It is the product of the number of nodes in a cluster and ratio r. The value can vary from 0.01 to 0.99 but it should not be more than 0.50.

The server node (SN) maintains a table for each cluster, listing all the sensor nodes present in the cluster. It maintains nearest neighbors for each node and the frequency of occurrence of each node is maintained in the table. The ordered list of sensor nodes based on their frequency. The minimum frequency required in cluster i to be the CH is calculated based on weighted mean of frequencies and 1 is added for better result. Weighted mean is calculated by product of each frequency of occurrence into number of sensor nodes having that frequency. The value is rounded to the nearest integer if required. The sensor nodes having frequency or greater are identified as candidates for CH.

VI. ENERGY CONSUMPTION MODEL

HEF provides optimal cluster head selection with respect to network lifetime under the ICOH condition[1]. Now, we are ready to address the key characteristic and the deterministic predictability for a hard network lifetime of WSN. The amount of energy consumed by a sensor node depends on the role it serves, as well as the workload it handles. To analyze hard network lifetime for guaranteed schedulability, the worst-case energy consumption (WCEC) analysis is used and the minimum energy consumed for a cluster head, and a regular node in a round respectively.

In proposing HEF scheme, a total of nodes with the highest residual energy will be chosen to be cluster heads in each round. The rest of the nodes would serve as regular nodes. Each regular node joins the cluster formed by the cluster head closest to it. In each round, each sensor node sends the sensed data to its corresponding cluster, which forwards the information to the base station.

VII. CLUSTER-BASED SENSOR NETWORK

There are two different kinds of sensors in the network. Sensor acts as the cluster head and other sensors play the role of cluster members[21]. The message transmitted from the cluster members to the cluster head are constrained to the bits. Each cluster member quantizes its observation to bits and sends the quantized data to the cluster head. The cluster head performs source extraction based on its own observation and the received quantized data from the cluster members

VIII. CLUSTER FORMATION PHASE

In this phase, clusters are organized and cooperative MIMO nodes are selected according to the steps described below[15]

A. Cluster Head Advertisement

Initially, when clusters are being created, each node decides whether or not to become a cluster head for each round as specified by the original LEACH protocol. Each self-selected cluster head, broadcasts an advertisement (ADV) message using non-persistent carrier sense multiple access (CSMA) protocol. The message contains the header identifier (ID).

B. Cluster Setup

Each non-cluster head node chooses one of the strongest received signal strength (RSS) of the advertisement as its cluster head, and transmits a join-request (Join-REQ) message back to the chosen cluster head. The information about the node's capability of being a cooperative node, that is, its current energy status is added into the message. If a cluster head receives the advertisement message from another cluster head y, and if the received RSS exceeds a threshold, it will mark cluster head y as the neighboring cluster head and it record ID. If the sink receives the advertisement message, it will find the cluster head with the maximum RSS, and sends the sink-position message to that cluster head marking it as the target cluster head (TCH).

C. Schedule Creation

After all the cluster heads has received the join-REQ message, each cluster head creates a time division multiple access (TDMA) schedule and broadcasts the schedule to its cluster members as in original LEACH protocol. This prevents collision among data messages and allows the radio of each non-cluster head node to be turned off until its allocated transmission time to save energy.

D. Cooperative Node Selection

After the cluster formation, each cluster head will select J cooperative sending and receiving nodes for cooperative MIMO communication with each of its neighboring cluster head. Nodes with higher energy close to the cluster head will be elected as sending and receiving cooperative nodes for the cluster. At the end of the phase, the cluster head will broadcast a cooperative request (COOPERATE-REQ) message, which contains the ID of the cluster itself, the ID of the neighboring cluster head y, the ID of the transmitting and receiving cooperative nodes and the index of cooperative nodes in the cooperative node set of each cluster head to each cooperative node. The cooperative node on receiving the COOPERATE- REQ message, stores the cluster head ID and sends back a cooperate-acknowledgement (ACK) message to the cluster head.

IX. DATA TRANSMISSION PHASE

During this phase, the data sensed by sensor nodes are transmitted to the cluster head and forwarded to the sink using multi-hop MIMO scheme according to the routing table.

A. Inter Cluster Transmission

In this phase, the non-cluster head nodes send their data frames to the cluster head as in LEACH protocol during their allocated time slot. The duration and the number of frames are same for all clusters and depend on the number of non-cluster head nodes in the cluster.

After a cluster head receives data frames from its cluster members, it performs data aggregation and broadcasts the data to cooperative MIMO sending nodes. When each cooperative sending node receives the data packet, they encode the data using space time block code (STBC) and transmit the data cooperatively. The receiving cooperative nodes use channel state information to decode the space time coded data. The cooperative node relays the decoded data to the neighboring cluster head node and forwards the data packet to the TCH by multi-hop routing.

B. Inter Cluster Communication

After the formation of the clustered network, inter-cluster organization depends on the network application. A cluster head may directly communicate with a distant observer. Alternatively, current cluster heads can communicate with each other toaggregate their information via multiple hops. For multi-hop communication among cluster heads, the selected transmission range among cluster heads may vary to ensure a certain degree of connectivity and to control interference. Inter-cluster communication. The definition of connectivity depends on its multi-hop organization and the relationship between inter-cluster transmission rangesand the cluster transmission range.

X. SCHEDULABILITY ANALYSIS OF HEF

The most important property of the WSN network lifetime is not longevity, but predictability. Schedulability tests are essential for the time-critical system because it provides predictability to complement online scheduling. Cluster head selection algorithms produced by empirical techniques often result in highly unpredictable network lifetimes. Although an algorithm can work very well to prolong the network lifetime for a period of time, a possible failure can be catastrophic, resulting in the failure of a mission, or the loss of human life. A reliable guarantee of the system behaviors is hence a requirement for systems to be safe and reliable. However, there are currently no known analytical studies on the network lifetime predictability for cluster head selection algorithms. Apply the worst-case energy consumption analysis to derive the predictability of HEF.

The core idea of the HEF clustering algorithm is to choose the highest-ranking energy residue sensor as a cluster head.

A. HEF Algorithm

HEF selects the set of M highest ranking energy residue sensors for cluster heads τ at round where M denotes the required cluster numbers at round τ[1].

HEF is designed to select the cluster head based on the energy residue of each sensor to create a network-centric energy view. Intuitively, HEF is a centralized cluster selection algorithm.

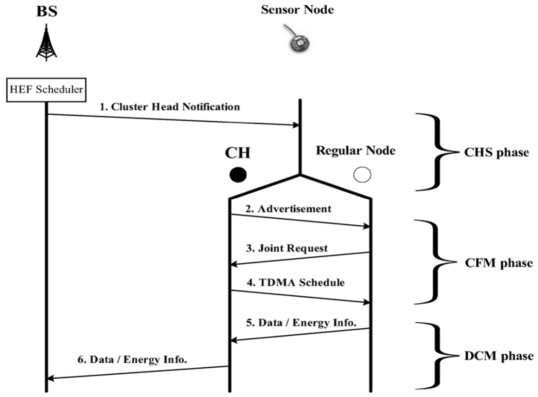

Figure 4.Information flow of the centralized HEF system

B. Operation of HEF

The interactions and detailed operations between components are discussed as follows.

- HEF selects cluster heads according to the energy remaining for each sensor node, and then the "setup" message (indicating cluster members, and the cluster head ID for each participated group) is sent to the cluster head of each cluster.
- The cluster head of each group broadcasts the "setup" message inviting the neighbor sensor nodes to join its group.
- After receiving the "setup" message at this round, the regular sensors send the "join" message to its corresponding cluster head to commit to associate with the group.
- Each cluster head acknowledges the commitment, and sends TDMA schedule to its cluster members.
- All sensors perform its sensing and processing and communication tasks cooperatively at this clock cycle (round). Each sensor sends its energy information to its cluster head at the end of this clock cycle.
- Upon collecting cluster members' information at a given period, the cluster head sends the summative report to the base station.

Ideal Conditions for Optimality of HEF (ICOH)

- All nodes must operate in a working-conserving mode. In other words, each node works as a clutter head, or a regular sensor in a round.

  The energy consumptions of ω_c and ω_r are constant during the entire operation, where $\omega_c \geq \omega_r$[1].

XI. SCHEDULABILITY TEST

The most important property of the WSN network lifetime is not longevity, but predictability. Schedulability tests are essential for the time-critical system because it provides predictability to complement online scheduling. Cluster head selection algorithms produced by empirical techniques often result in highly unpredictable network lifetimes. Although an algorithm can work very well to prolong the network lifetime for a period of time, a possible failure can be catastrophic, resulting in the failure of a mission, or the loss of human life. A reliable guarantee of the system behaviors is hence a requirement for systems to be safe and reliable.

Schedulability tests allow engineers to assess what actions (e.g. changing energy budget or lifetime, etc.) should be taken to improve the dependability and reliability of the systems. As shown in Fig. 5, the schedulability test flow chart consists of three major stages

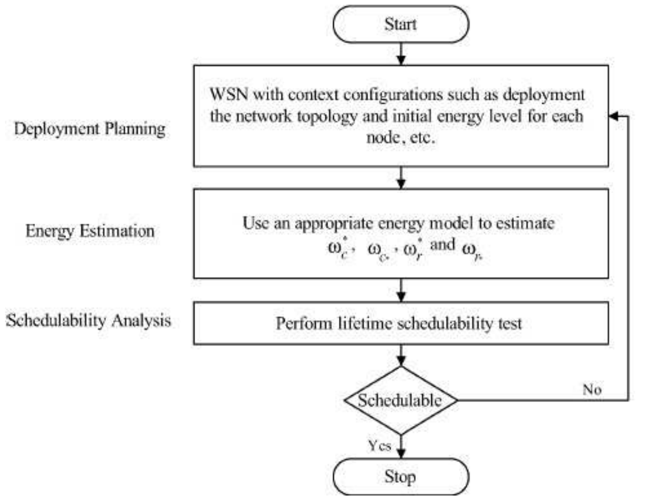

Figure 5.Flow chart of Schedulability test

- Deployment Planning
- Energy Estimation
- Schedulability Analysis

In the Deployment Planning stage, efforts are made to plan the shape of the network topology, the initial energy level of sensor nodes, and the necessary configurations to perform. Activities and measures for the minimum and maximum energy consumption of the cluster head and the regular node are conducted in the Energy Estimation stage. In the Schedulability Analysis stage, schedulability test results provide the necessary information to all running scenarios. If the running case is not schedulable, the feedback process can be used to alternate the WSN deployment plan or other configuration parameters (such as coverage range), which can be used to re-design the system.

XII. CLASSIFICATION OF THE ROUTING PROTOCOL

Several routing protocols have been proposed for ad hoc networks. Figure 7 shows the classification of the routing protocols for MANETs. At one end are the table-driven or proactive routing protocols such as the Destination Sequenced Distance Vector (DSDV) routing protocol, Wireless Routing Protocol (WRP), etc. At the other end, are the on-demand or reactive protocols such as Dynamic Source Routing (DSR) protocol and the Ad hoc On-demand Distance Vector (AODV) routing protocols.

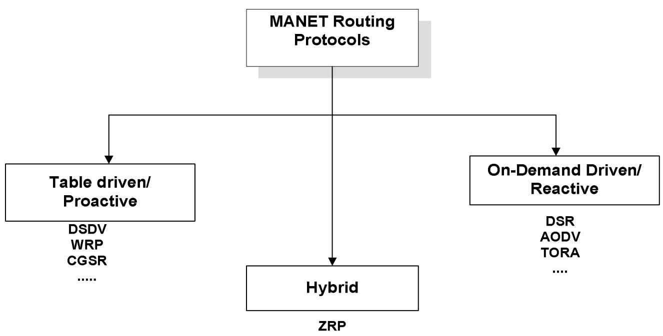

Figure 6.Classification of MANET routing protocols

A. Ad hoc On-demand Distance Vector (AODV)

The Ad hoc On-demand Distance Vector routing protocol [14] inherits the good features of both DSDV and DSR. The AODV routing protocol uses a reactive approach to finding routes and a proactive approach for identifying the most recent path. More specifically, it finds routes using the route discovery process similar to DSR and uses destination sequence numbers to compute fresh routes.

B. Route Discovery

During the route discovery process, the source node broadcasts RREQ packets similar to DSR. The RREQ packet contains the source identifier (SId), the destination identifier (DId), the source sequence number (SSeq), the destination sequence number (DSeq), the broadcast identifier (BId) and TTL fields. When an intermediate node receives a RREQ packet, it either forwards it or prepares a Route Reply (RREP) packet if it has a valid route to the destination in its cache. The (SId, BId) pair is used to determine if a particular RREQ has already been received in order to eliminate duplicates. Every intermediate node enters the previous node's address and its BId while forwarding a RREQ packet. The node also maintains a timer associated with every entry in order to delete a RREQ packet if the reply is not received before it expires.

Whenever a RREP packet is received by a node, it stores the information of the previous node in order to forward the packet to it as the next hop towards the destination. This acts as a "forward pointer" to the destination node. Thus each node maintains only the next hop information unlike source routing in which all the intermediate nodes on the route towards the destination are stored.

Figure 7 shows an example of route discovery mechanism in AODV. Let us suppose that node 1 wants to send a data packet to node 7 but it doesn't have a route in its cache. Then it initiates a route discovery process by broadcasting a RREQ packet to all its neighboring nodes.

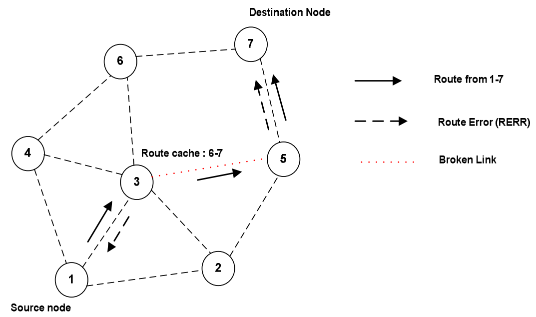

Figure 7.Route discovery in AODV

It inserts the SId, DId, SSeq, DSeq, BId, and TTL fields in the RREQ packet. When nodes 4, 3 and 2 receive this, they check their route caches to see if they already have a route. If they don't have a route, they forward it to their neighbors, else the destination sequence number DSeq in the RREQ packet is compared with the DSeq in its corresponding entry in route cache. If the DSeq in RREQ packet is greater, then it replies to the source node with a RREP packet containing the route to the destination. In figure 8, node 3 has a route to 7 in its cache and its DSeq is higher compared to that in RREQ packet. So, it sends a RREP back to the source node 1. Thus the path 1-3-6-7 is stored in node 1. The destination node also sends a RREP back to the source. For example, one possible route is 1-2-5-7. The intermediate nodes on the path from source to destination update their routing tables with the latest DSeq in the RREP packet.

C. Route Maintenance

The route maintenance mechanism works as follows – Whenever a node detects a link break by link layer acknowledgements or HELLO beacons, the source and end nodes are notified by propagating an RERR packet similar to DSR. This is shown in Figure 9. If the link between nodes 3 and 5 breaks on the path 1-3-5-7, then both 5 and 3 will send RERR packets to notify the source and destination nodes.

One optimization possible in AODV route maintenance is to use an expanding ring search to control the flood of RREQ and discover routes to unknown destinations [10]. The main advantage of AODV is that it avoids source routing thereby reducing the routing overload in large networks. Further, it also provides destination sequence numbers which allows the nodes to have more up-to-date routes. However, AODV requires bidirectional links and periodic link layer acknowledgements to detect broken links. Further, it has to maintain routing tables for route maintenance unlike DSR.

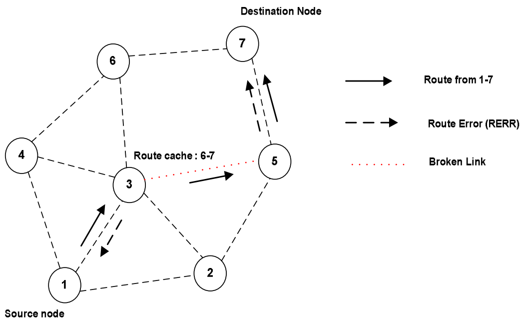

Figure 8. Route Maintenance in AODV

XIII. IMPLEMENTATION METHODOLOGY

In this phase I focus on the Clustering that is to form the group of vehicles. For that I need to the following steps,

- Fifty nodes created.
- In that fifty nodes,four base station nodes and 46 centre nodes mentioned.
- Communication provided between that nodes.
- Cluster Head with Communication.
- In next level I'm expecting with a use of S-MAC layer to get the efficient energy saving.

S-MAC Goals

The goals are Reduce energy consumption, Support good scalability, Each node goes into periodic sleep mode during which it switches the radio off and sets a timer to awake later, When the timer expires, it wakes up,Selection of sleep and listen duration is based on the application scenarios, Neighboring nodes are synchronized together.

XIV.RESULTS

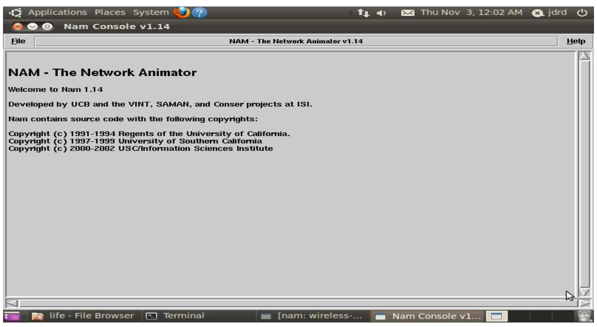

Figure 9. Output NAM Window

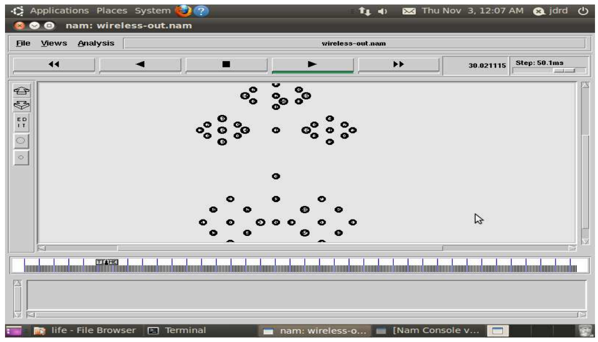

Figure 10. Output Window

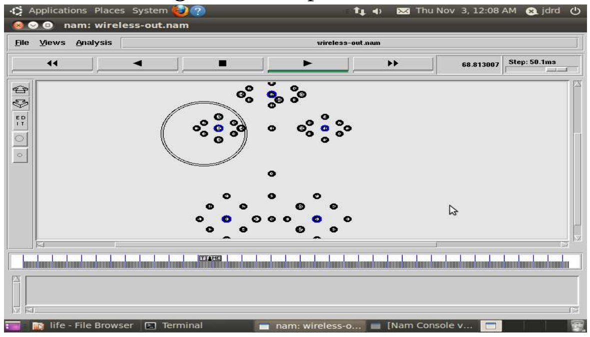

Figure 11. Cluster Head – Output

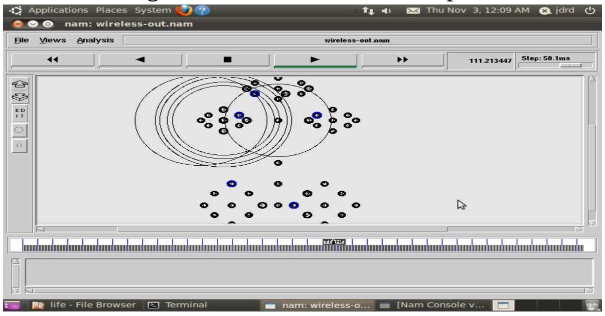

Figure 12. Cluster Head Changing - 1 Output

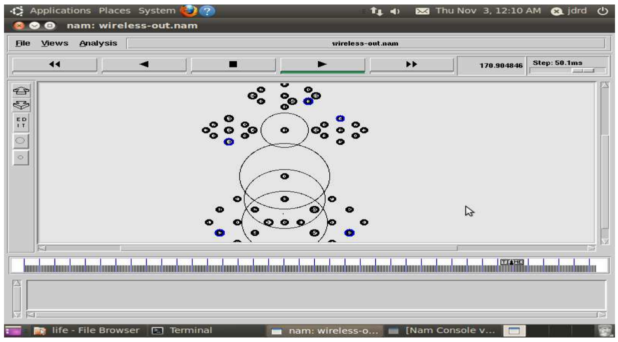

Figure 13. Cluster Head Changing – 2 Output

XV.CONCLUSION AND FUTURE WORK

Providing a trustworthy system behavior with a guaranteed hard network lifetime is a challenging task to safety-critical and highly-reliable WSN applications. For mission critical WSN, it is important to be aware of whether all sensors can meet their mandatory network lifetime requirements. First, the High Energy First (HEF) algorithm is proven to be an optimal cluster head selection algorithm that maximizes a hard N-of-N lifetime for HC-WSNs under the ICOH condition. Then, we provide theoretical bounds on the feasibility test for the hard network lifetime for the HEF algorithm. Our experiment results show that the HEF algorithm achieves significant performance improvement over LEACH, and HEF's lifetime can be bounded. The feasibility test analysis performed in this paper presented a solution that would guide the system administrator to ensure that the system lifetime is predictable.

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Lourthu Hepziba Mercy.M received her B.E degree from Francis Xavier College of Engineering, Tirunelveli, during 2011.Currently she is pursing M.E in Einstein College of Engineering, Tirunelveli, Tamilnadu.

Balamurugan.K received his B.E degree from Manonmanium Sundaranar University, Tirunelveli, Tamilnadu during 2002 and M.E degree from Anna University Chennai during 2005. Currently he is pursuing PhD programme in the area of Network-on-chip (NOC) at Anna University Chennai. He is working as Assistant professor in the Department of Electronics and Communication Engineering at Einstein College of Engineering ,Tirunelveli, Tamilnadu. He has published his research papers in various National and International Conferences and Journals in the field of VLSI Design.

Dr.Vijayaraj received his B.E degree from Madras University,Tamilnadu , M.E degree from Madurai Kamaraj University Madurai and Doctoral degree from Anna university Chennai.He has 25 years of teaching and research experience in the field of Wireless Communication. Currently he is working as Associate Professor in the Department of Electronics and Communication Engineering at Government College of Engineering, Tirunelveli, Tamilnadu. He has published his research papers in various National and International Conferences and Journals in the field of VLSI Design.