CLUSTER HEAD LOAD BALANCE AND ACHIEVEMENT OF MAXIMUM LIFETIME BY ENERGY AWARENESS OF WSNs

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ABSTRACT-Wireless sensor networks consist of hundreds to thousands of low power multi functioning sensor nodes. It operates in an unattended environment with limited computational and sensing capabilities. A wireless sensor network is constructed based on a cluster tree. Isolated node with the maximum number of neighbor isolated nodes that launch the cluster generation process. Therefore, the total amount of cluster heads is minimizing. In the cluster tree creation algorithm, the cluster tree architecture is projected and it minimizes the entire number of nodes included in a cluster tree hence, the routing cost is reduced. In the cluster tree repair algorithm, while a cluster head or a cluster associate node fails or move out of communication range of router, a new cluster head or cluster associate node is elected to maintain the cluster tree topology. The cluster tree repair algorithm doesn't consider the non uniform node distribution. In order to elect cluster heads with higher energy, the parameter of cluster head competition in EADC and EADUC is based on the ratio between the average residual energy of neighbor nodes and the residual energy of the node itself. The aim is to improve load balance among cluster heads, energy consumption and improve the network life time significantly among uniform and non uniform node distribution.

Key terms: Wireless, Cluster, Cluster Head, Load Balance, Life time, Energy, etc.

1. INTRODUCTION

A wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion pollutant at different location. In addition to one or more sensors, every node in a sensor network is usually prepared with a radio transceiver or other wireless communications device, a tiny microcontroller and an energy source, usually a battery. These low-cost and power efficient sensor nodes works together to form a network for monitoring the target region. The development of wireless sensor networks was originally motivated by military.

1.1. CLUSTERING

Clustering can be defined as a notional arrangement of the dynamic nodes into various groups. These virtual collections of nodes are grouped together regarding their relative transmission range proximity to each other that allows them to establish a bidirectional link. The diameter size of the clusters determines the control architectures as single-hop clustering and multi-hop (K-hop) clustering. In single-hop clustering every member node is never more than 1-hopfrom a central coordinator and the cluster head.

Thus all the member nodes remain at most two hops distance away from each other within a logical cluster. In multi-hop clustering, the limitation or restriction of an immediate proximity to member nodes from the head is removed, allowing them to be present in serial k-hop distance to form a cluster.

1.2. DESIGN GOALS OF CLUSTERING

Implementing clustering algorithms are critical to the design if the aim to create an invisible global infrastructure is ever to be realized where mobile devices can communicate with each other effectively, efficiently, reliably and wirelessly without loss of connectivity, data or vast amounts of energy.

- Cost of Clustering
- Load Balancing
- Clustering Formation
- Real-Time Operation
- Maximizing Network Longevity
- Maintenance Mechanisms
- Connectivity and Reduced Delay

2. LITERATURE REVIEW

Wireless networks consist of a amount of nodes which communicate with each other over a wireless channel which have various types of networks: sensor network, ad hoc mobile networks, cellular networks and satellite networks. Wireless sensor networks consist of small nodes with sensing, computation and wireless communications capabilities.

Xiaonan Wang and Huanyan Qian (2012) proposed cluster generation algorithm, a cluster tree is always an out-of-the-way node with the maximum number of neighbor isolated nodes that launch the cluster generation process; therefore, the totality number of cluster heads is minimized. In the cluster-tree creation algorithm, the cluster-tree architecture, the cluster-tree construction algorithm minimizes the total number of nodes included in a cluster tree; therefore, the routing cost is cheap.

In the cluster-tree repair algorithm, while a cluster head or a cluster associate node fails or move, a new cluster head or cluster associate node is selected to maintain the cluster-tree topology. The performance parameters of Least Cluster Change algorithm with Lowest-ID, Root-based Lowest-ID cluster construct mechanism, the cluster-tree topology strength, the routing memory cost, and the routing update rate.

Alzoubi.K and Hong.X (2003), compared with a WSN with flat network architecture, a WSN with hierarchical network architecture had better performance and scalability. Iwata.A, Chiang.C.C*et al* (1999), the performance of WSNs with different topologies was analyzed, and the fact that the performance of WSNs with the tree topology was better was demonstrated.

Jiguo Yu, Yingying Qi*et al* (2012) proposed non-uniform node distributions, the energy consumption among nodes are more imbalanced in cluster-based wireless sensor networks. A cluster-based routing protocol for wireless sensor networks with non uniform node allocation is proposed, which includes an energy-aware clustering algorithm EADC and a cluster-based routing algorithm. EADC uses contest range to construct clusters of even sizes.

Gupta.A *et al* (2007), adaption of the association process in IEEE 802.15.4 to construct the network was proposed, but it discussed neither the corresponding cluster generation algorithm nor the cluster-tree repair algorithm when the cluster-tree topology failed.

The scheme proposed Mainak Chatterjee*et al* (2002), an on-demand distributed clustering algorithm for multi-hop packet radio networks. These types of networks, also recognized as ad hoc networks, are active in nature due to the mobility of nodes. The connection and dissociation of nodes to and from clusters perturb the stability of the network topology, and therefore a reconfiguration of the system is often unavoidable. However, it is essential to keep the topology stable as long as possible.

Because the sink nodes periodically broadcast the control packets in the whole network, a lot of network resources were consumed. The scheme proposed Yu.C.W, Chang.C.C *et al* (2009), the cluster tree was made up of the cluster heads and the cluster gateway nodes, and the communication between two cluster heads was performed through the cluster gateway nodes. The routing algorithm modified cluster head gateway switch routing (MCGSR), and the performance of the algorithm was analyzed.

Did not discuss the cluster tree repair algorithm when the cluster tree topology failed. Ossama Younis*et al* (2006) proposed large-scale deployment of wireless sensor networks (WSNs) and the need for data aggregation necessitate efficient organization of the network topology for the purpose of balancing the load and prolonging the network duration. Clustering has proven to be an effective approach for organizing the network into a connected hierarchy.

Chen.Y.S and Lin.T.H (2005) proposed node weight clustering algorithm, the lowest ID clustering algorithm, and the least cluster change (LCC) algorithm were studied, and their performances be compared.

Chiang.C.C *et al* (1997) the flat network routing protocol destination-sequenced distance vector routing (DSDV) and the hierarchical routing protocol cluster head gateway switch routing (CGSR) were studied, and their performances be compared.

Tao Liu*et al* (2012) proposed an Energy-Balancing unequal Clustering Approach for Gradient-based routing (EBCAG) in wireless sensor networks. The nodes into clusters of unequal size, and each sensor node maintain a slope value, which is defined as its minimum hop count to the sink.

The scheme proposedGee Keng Ee*et al* (2009) different ways of routing header encapsulation in 6LoWPAN protocol stack is discussed. The simplified version Ad-Hoc On-Demand Distance Vector (AODV) such as On-Demand Distance Vector (LOAD) and Dynamic MANET On-demand for 6LoWPAN (DYMO-low) have currently been proposed in 6LoWPAN routing. Hierarchical routing (HiLow) is another routing protocol that is used in 6LoWPAN to increase the network scalability.

Abdel Rahman H.Hussein*et al* (2007) proposed mobile ad-hoc network indicated to use of clustering algorithm because it simplifies routing and can improve the performance of flexibility and scalability in the network.

3. PROPOSED SYSTEM

In the cluster creation algorithm, a cluster tree is always an isolated node with the maximum number of neighbor isolated nodes that launches the cluster creation process. Therefore, the total number of cluster heads is minimized. In the cluster-tree repair algorithm, when a cluster head or a cluster correlate node fail or moves, a new cluster head or cluster associate node is selected to maintain the cluster-tree topology. The states of the nodes transform, the cluster-tree repair algorithm is adopted to elect a new cluster head/new cluster relate node. Because all the control frames in the repair algorithm are transmitted within the cluster, the routing cost is lower. As a result, the cluster-tree topology is more stable. The uniformly distributed cluster heads enable the clusters have the uniform cluster sizes (EADC), so that the energy consumption among cluster members can be balanced.

However, the imbalanced energy consumption still exists among cluster heads due to the non uniform node distribution. An energy-aware distributed unequal clustering protocol (EADUC) in multi-hop heterogeneous wireless sensor networks to “energy hole” trouble. Protocols can symmetry the energy consumption among non uniform nodes and increase the network lifetime significantly.

3.1. SYSTEM ARCHITECTURE

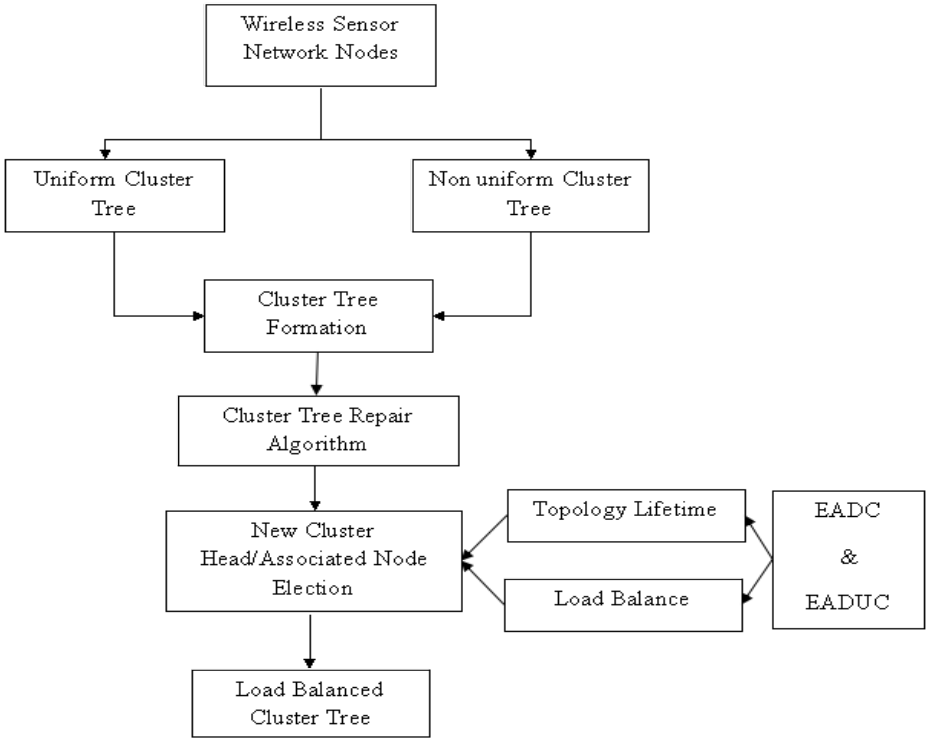

Figure 1: System Architecture

Cluster generation process with an equal shape and ordered or random numbers and unequal shape and random numbers. After a cluster tree formation a new parent node or a new child node, it broadcasts the ID of the new parent or child node within its cluster. Balance the energy consumption among cluster heads by adjusting the intra-cluster and inter-cluster energy consumption of cluster heads.

3.2. MODULE DESCRIPTION

In the cluster creation algorithm, a cluster tree is forever an isolated node with the maximum number of neighbor isolated nodes that launches the cluster creation process. Therefore, the total number of cluster heads is minimizing. In the cluster-tree repair algorithm, when a cluster head or a cluster relate node fail or moves, a new cluster head or cluster associate node is elected to maintain the cluster-tree topology.

The uniformly distributed cluster heads enable the clusters have the uniform cluster sizes (EADC), so that the energy consumption among cluster members can be balanced. An energy-aware distributed unequal clustering protocol (EADUC) in multi-hop heterogeneous wireless sensor networks to “energy hole” problem. Protocol can balance the energy consumption among non uniform nodes and increase the network lifetime significantly.

3.2.1. Cluster Tree Formation

Cluster generation process with an equal shape and ordered or random numbers and unequal shape and random numbers. A cluster member or a cluster associate node receives a beacon frame from its neighbor cluster head or cluster associate node, then it forwards to its cluster head the beacon frame with the maximum number of neighbor cluster heads and cluster associate nodes.

3.2.2 Cluster Tree Repair Algorithm

After a cluster tree formation a new parent node or a new child node, it broadcasts the ID of the new parent or child node within its cluster. Because the failure or movement of a cluster head or a cluster associate node can cause the failure of the corresponding cluster tree, the cluster-tree repair algorithm is discussed in the following two situations: Failure/movement of a cluster member. Failure/movement of a cluster head (a cluster associate node).

After a cluster head h (a cluster associate node m) fails or moves, the cluster members in the same cluster will elect a new cluster head or cluster associate node based on the weight algorithm.

3.2.3 EADC and EADUC (Load Balance, Topology Lifetime)

This protocol contains an energy-aware clustering algorithm EADC, EADUC and a cluster-based routing algorithm. In order to elect cluster heads with higher energy, the parameter of cluster head competition in EADC is based on the ratio between the average residual energy of neighbor nodes and the residual energy of the node itself. Moreover, cluster heads broadcast head messages using the same competition range to construct clusters of even sizes. Thus, the energy consumption among cluster members can be balanced well and prolong the network lifetime. An energy-aware distributed unequal clustering protocol (EADUC) in multi-hop heterogeneous wireless sensor networks to "energy hole" problem.

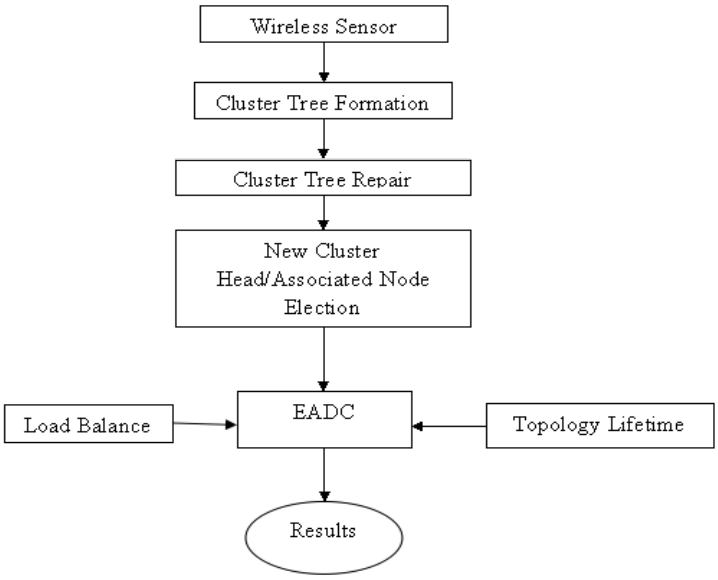

Figure 2: EADC

3.3. ALGORITHM

Case1: Cluster Tree Formation

Step1: An isolated node *x* sends a Join_C control frame to all the isolated nodes in its neighbor node table.

Step2: If a neighbor isolated node receives multiple Join_C control frames sent by the isolated nodes within the specified time.

Step3: Then it compares the source IDs of the received Join_C control frames and returns a Res_C control frame to the isolated node with the smallest ID.

Step4: In the specified time, if the total number of Res_C control frames received by node *x* is equivalent to the total number of isolated nodes in node *x*'s neighbor node table.

Step5: Node *x* marks itself as a cluster head and returns an Ack_C control frame to its neighbor isolated nodes. Otherwise, node *x* remains in the isolated state.

Step6: Within the specified time, if the neighbor isolated node receives the Ack_C control frame returned by node *x*.

Step7: Then it marks itself as a cluster member and records the ID of its cluster head *x*. Otherwise, the neighbor isolated node remains in the isolated state.

Step8: The cluster-tree construction process is discussed in the following situations.

Step8.1: A cluster head *h* receives multiple beacon frames that were sent by its neighbor cluster associate nodes.

Step8.2: A cluster head *h* receives no beacon frames that were sent by its neighbor cluster associate nodes, but it receives beacon frames that were forwarded by its cluster members.

Step8.3: A cluster head *h* receives no beacon frames that were sent by its neighbor cluster associate nodes or its cluster members

Step9: The cluster generation process ends.

Case2: Cluster Tree Repair Algorithm

Step10: A cluster member x calculates its weight value, and if its weight value is not equivalent to 0, then it broadcasts a weight frame within the cluster.

Step11: After a cluster member in the same cluster receives the weight frame, if the cluster member's weight value is more than the weight value in the weight frame, then it broadcasts a weight frame within the cluster.

Step12: If the weight value of node x is the largest among the cluster members in the same cluster, then it marks itself as a cluster head (a cluster associate node) and broadcasts a New_head control frame (New_associate control frame).

Step13: After the cluster member or cluster associate node (the cluster head) in the same cluster receives the New_head control frame (New_associate control frame), it updatesthe entry for cluster head h (cluster associate node m) with the ID of node x.

Step14: After the original parent or childnode of node h (node m) receives the New_head control frame (New_associate control frame), it updates the entry for node h (node m) with the ID of node x.

Step15: A new cluster head (a new cluster associate node) is successfully elected.

Case3: EADC & EADUC.

Step16: The whole process is divided into three phases: information collection phase, cluster head competition phase, cluster formation phase.

4. RESULTS AND DISCUSSION

Cluster generation process with an equal shape and ordered or random numbers and unequal shape and random numbers. A cluster member or a cluster associate node receives a beacon frame from its neighbor cluster head or cluster associate node, then it forwards to its cluster head the beacon frame with the maximum number of neighbor cluster heads and cluster associate nodes.

CLUSTER FORMATION

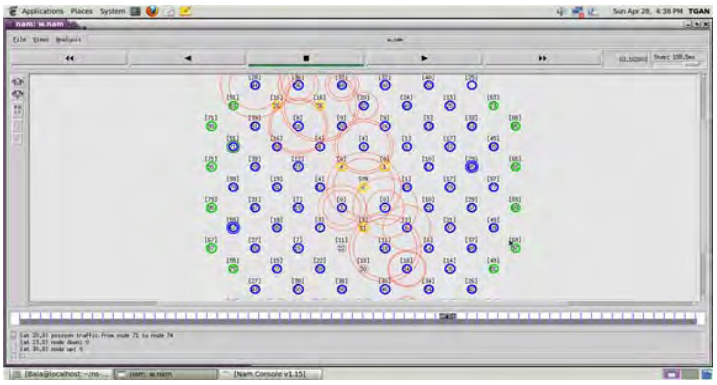

Figure 3: Cluster Formation

Cluster tree is always an isolated node with the maximum number of neighbor isolated nodes that launches the cluster creation process. Therefore, the total number of cluster heads is minimized.

EADC AND EADUC OUTPUT

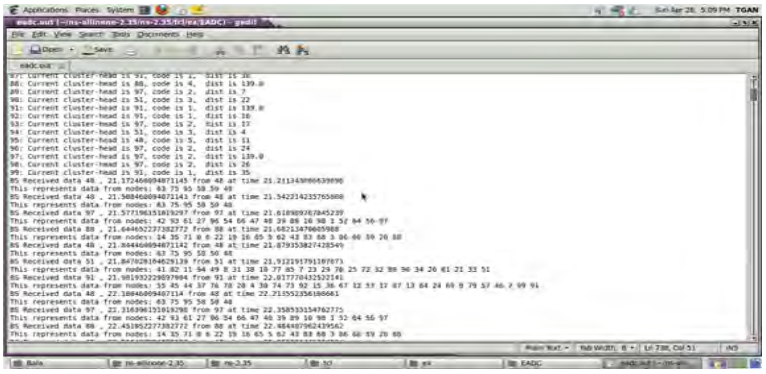

Figure 4: EADC and EADUC Output

The clustering algorithm balances the energy consumption among cluster members by constructing equal clusters and unequal clusters. In addition an algorithm for border node detection proposed which used to prevent boundary node become cluster head. Performance evaluation showed that our algorithm provides a better network lifetime.

CLUSTER HEADS

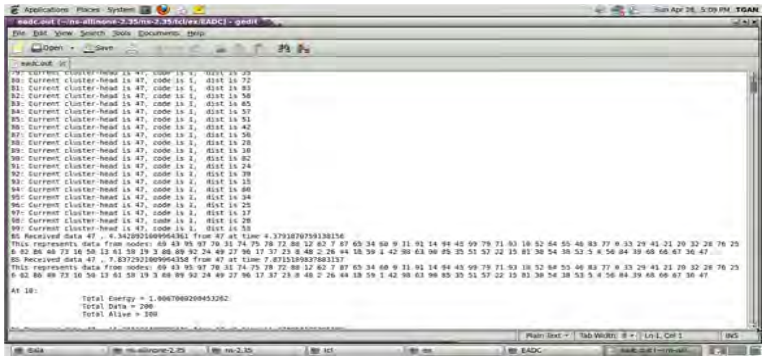

Figure 5: Cluster Heads

The method of clustering which prolongs network topology by using energy, group and centrality factors and also the distances between nodes for formulating clusters. Assume the supervisor node for every cluster head which is to be its alternate when the cluster head fails. This property causes an boost in network lifetime.

TRACE FILE

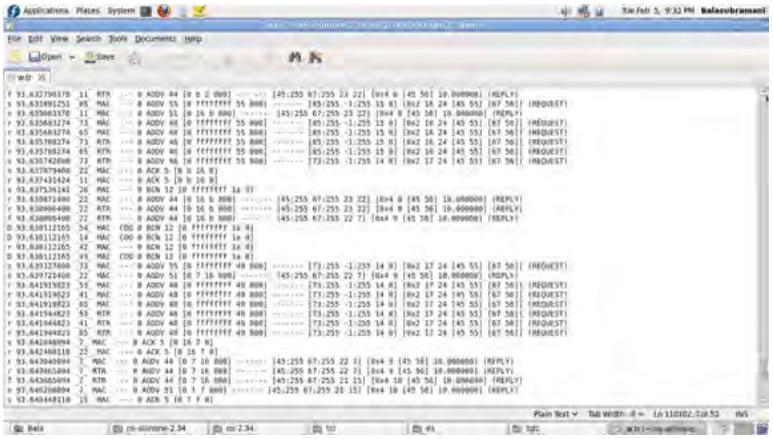

Figure 6: Trace File

NUMBER OF CYCLES Vs REMAINING ENERGY

No. of. Cycles	Remaining Energy (% / Cycles)	
	EADC	LEACH
5	87.34	62.13
10	70.56	40.45
15	66.76	32.15
20	50.42	12.67
25	42.56	3.5

Table 1: Number of Cycles Vs Remaining Energy

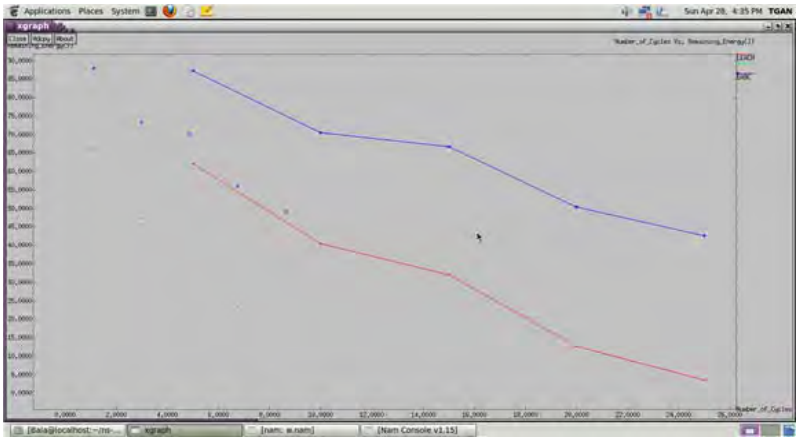

Figure 7: Number of Cycles Vs Remaining Energy

Residual energy is crucial to cluster heads because cluster heads suffer heavier burden than general cluster members. The energy will drain quickly as cluster head needs to not only collect data from its cluster members but also process, data aggregation and then transmit message to the sink. To ensure that the cluster heads perform their task without interrupt, the nodes are more eligible than the others nodes in terms of residual energy that have the maximum remaining energy.

NUMBER OF NODES Vs NETWORK LIFETIME

No. of. Nodes	Network Lifetime (%)	
	EADC	LEACH
20	91	72
40	80	49
60	71	31
80	67	12
100	58	5

Table 2: Number of Nodes Vs Network Lifetime

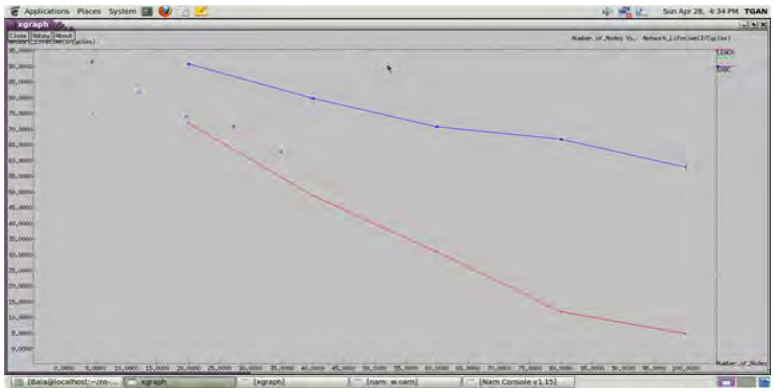

Figure 8: Number of Nodes Vs Network Lifetime

The cluster lifetime indicates how often the nodes change their cluster memberships, the inter-cluster link lifetime assesses how long neighbor clusters remain connected, and the path lifetime evaluates how stable an end-to-end communication path can be. It is obvious that long lifetime implies stable architecture and good communication performance.

CONCLUSION

The cluster and the cluster-tree repair algorithms analyzed the performances of the existing schemes based on the lifetime. Proposed a cluster-based routing protocol for wireless sensor networks, it contains an energy-aware of maximum lifetime for cluster. The proposed work achieved the uniform and non uniform node distribution, load balance among cluster heads, energy consumption and improved the network lifetime significantly. Our continuing work is to improve the cluster tree construction algorithm to reduce time complexity. However the energy hole problem is a constraint in non uniform node distribution. In future the energy hole problem can be minimized and lifetime of non uniform nodes can be increased.

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