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Energy Optimization Secure and Efficient Data Transmission for Mobile Wireless Sensor Networks

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Abstract **– Wireless sensor networks (WSNs) are resource constrained. Energy is one of the most important resources in such networks. Therefore, optimal use of energy is necessary. In this paper, we present a novel energy-efficient routing protocol for WSNs. The protocol is reliable in terms of data delivery at the base station (BS). We consider mobility in sensor nodes and in the BS. The proposed protocol is hierarchical and cluster based. Each cluster consists of one cluster head (CH) node, two deputy CH nodes, and some ordinary sensor nodes. The reclustering time and energy requirements have been minimized by introducing the concept of CH panel. At the initial stage of the protocol, the BS selects a set of probable CH nodes and forms the CH panel. Considering the reliability aspect of the protocol, it puts best effort to ensure a specified throughput level at the BS. Depending on the topology of the network, the data transmission from the CH node to the BS is carried out either directly or in multihop fashion. Moreover, alternate paths are used for data transmission between a CH node and the BS. Rigorous simulation results depict the energy efficiency, throughput, and prolonged lifetime of the nodes under the influence of the proposed protocol.**

Index Terms— Wireless Sensor Networks (WSN), Base Station (BS), Cluster Head (CH).

I. INTRODUCTION

WIRELESS Sensor Network (WSN) consists of several resource-constrained sensor nodes randomly deployed over a geographic region. These sensor nodes forward sensory data toward a resourceful base station (BS). Depending on the application type, the BS is located either far away from the sensor field or within the sensor field. Such networks have wide range of applications in military and civil domains. Some application areas of WSN are as follows: combat field surveillance, target tracking in battlefields, intrusion detection, post disaster rescue operations, smart home, monitoring and alarming systems for supermarkets, wildlife monitoring systems, and many safety and security related applications. In the aforementioned applications, the sensor nodes generate sensory data from the environment of interest. The sensed data are finally forwarded toward the BS for further processing and decision making with regard to the control for meeting the objectives of the system in place. Depending on the application type, the sensor nodes and the BS can be static or mobile. In a typical WSN, the sensor nodes are highly resource constrained. The sensor nodes are inexpensive, disposable, and expected to last until their energy drains out. Therefore, energy is a very limited resource for a WSN system, and it needs to be managed in an optimal fashion. Reliable and successful data delivery at the BS is desired. Energy efficiency is an important aspect of any application of WSN. Routing of data in WSN is a critical task, and significant amount of energy can be saved if routing can be carried out tactfully. Routing is an issue linked to the network layer of the protocol stack of WSN. In multihop communication, the major issue may be the selection of the intermediate nodes in the route. The intermediate nodes are to be selected in such a way that the energy requirement is minimized. At the same time, the data are to be delivered at the BS reliably and successfully.

II. RELATED WORK

In [2] O. Younis and S. Fahmy proposed a topology control in a sensor network balances load on sensor nodes and increases network scalability and lifetime. Clustering sensor nodes is an effective topology control approach. We propose a novel distributed clustering approach for long-lived ad hoc sensor networks. Our proposed approach does not make any assumptions about the presence of infrastructure or about node capabilities, other than the availability of multiple power levels in sensor nodes. We present a protocol, HEED (Hybrid Energy-Efficient Distributed clustering), that periodically selects cluster heads according to a hybrid of the node residual energy and a secondary parameter, such as node proximity to its neighbors or node degree. HEED terminates in O(1) iterations, incurs low message overhead, and achieves fairly uniform cluster head distribution across the network.

In [5] E. Felemban, Chang-Gun Lee and E. Ekici presented a novel packet delivery mechanism called Multi-Path and Multi-SPEED Routing Protocol (MMSPEED) for probabilistic QoS guarantee in wireless sensor networks. The QoS provisioning is performed in two quality domains, namely, timeliness and reliability. Multiple QoS levels are provided in the timeliness domain by guaranteeing multiple packet delivery speed options. In the reliability domain, various reliability requirements are supported by probabilistic multipath forwarding. These mechanisms for QoS provisioning are realized in a localized way without global network information by employing localized geographic packet forwarding augmented with dynamic compensation, which compensates for local decision inaccuracies as a packet travels towards its destination. This way, MMSPEED can guarantee end-to-end requirements in a localized way, which is desirable for scalability and adaptability to large scale dynamic sensor networks.

In [6] Shiwen Mao and Y. Thomas Hou presented a current expectations on sensor node in terms of size, cost, and energy efficiency have led to a severely limited design space on hardware and software. In this paper, we explore capabilities at the network edge for sensor networks, aiming to reduce the hardware and software complexity of a sensor node without sacrificing network performance. We present a novel edge-based routing protocol, nicknamed BeamStar, for wireless sensor networks. Under BeamStar, the base station exploits some nice properties associated with directional antenna and power control at the base station. We devise a simple protocol so that each sensor node can determine its location information passively with minimum control overhead. We also show how to design a robust routing protocol based on the location information at each sensor node. Under the proposed protocol, sensor nodes are relieved of the activities (or burdens) that are associated with control and routing, thus enabling much simpler hardware and software implementation at sensor nodes. Simulation results demonstrate that BeamStar achieves high reliability at comparable energy consumptions as compared with prior work.

Networking together hundreds or thousands of cheap micro-sensor nodes allows users to accurately monitor a remote environment by intelligently combining the data from the individual nodes. These networks require robust wireless communication protocols that are energy efficient and provide low latency. In [7] W.B. Heinzelman, A.P. Chandrakasan and H. Balakrishnan developed and analyzed a low-energy adaptive clustering hierarchy (LEACH), a protocol architecture for micro sensor networks that combines the ideas of energy-efficient cluster-based routing and media access together with application-specific data aggregation to achieve good performance in terms of system lifetime, latency, and application-perceived quality. LEACH includes a new, distributed cluster formation technique that enables self-organization of large numbers of nodes, algorithms for adapting clusters and rotating cluster head positions to evenly distribute the energy load among all the nodes, and techniques to enable distributed signal processing to save communication resources.

In [11] F. Ingelrest, D. Simplot-Ryl and I. Stojmenovic investigated the problem of minimum energy broadcasting in ad hoc networks where nodes have capability to adjust their transmission range. The minimal transmission energy needed for correct reception by neighbor at distance r is proportional to ralpha+ce , alpha and ce being two environment-dependent constants. We demonstrate the existence of an optimal transmission radius, computed with a hexagonal tiling of the network area that minimizes the total power consumption for a broadcasting task. This theoretically computed value is experimentally confirmed. The existing localized protocols are inferior to existing centralized protocols for dense networks. We present two localized broadcasting protocols, based on derived "target" radius, that remain competitive for all network densities. The first one, TR-LBOP, computes the minimal radius needed for connectivity and increases it up to the target one after having applied a neighbor elimination scheme on a reduced subset of direct neighbors. In the second one, TRDS, each node first considers only neighbors whose distance is no greater than the target radius (which depends on the power consumption model used), and neighbors in a localized connected topological structure such as RNG or LMST. Then, a connected dominating set is constructed using this sub graph. Nodes not selected for the set may be sent to sleep mode. Nodes in selected dominating set apply TR-LBOP. This protocol is the first one to consider both activity scheduling and minimum energy consumption as one combined problem. Finally, some experimental results for both protocols are given, as well as comparisons with other existing protocols.

III. PROPOSED FRAMEWORK

A novel routing protocol, which is called Energy-Efficient and Reliable Routing protocol for mobile wireless sensor network (E2R2), is proposed. The proposed protocol is a hierarchical one. Our major goal is to achieve energy efficiency and to provide connectivity to the nodes. The mobility of the nodes is considered while routing decisions are made. The main objective is to extend the lifetime of the sensor nodes in the network. The protocol offers some suitable alternate routes for packet forwarding in presence of node or link failure in the current route. This arrangement does not allow the throughput level at the BS, in terms of packet delivery, to degrade drastically. The protocol takes care of the energy efficiency and the reliability of the routes. The data packets are routed through multiple hops in order to minimize the transmission energy requirements at the sender nodes. In addition, some sensor nodes are intelligently scheduled for dormant state, which is a low-power state. Those nodes are scheduled for dormant state, whose services are not required at a particular instant in time. At a later stage, these nodes may perform state transition and again become active while needed. The state transition is dictated by the BS. This saves significant amount of energy at the nodes. Thus, the battery lives of the sensor nodes get prolonged.

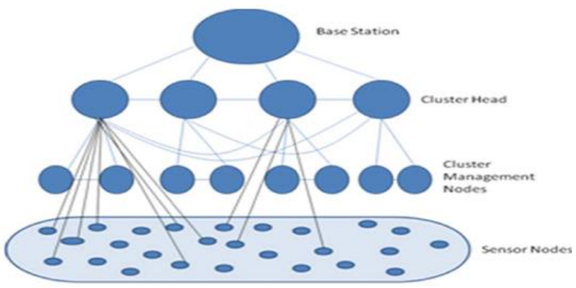


Fig.1: WSN system architecture.

After the deployment of the sensor nodes, the BS creates groups of different sensor nodes in order to form clusters. Each cluster contains a CH node and two DCH nodes. The BS selects a set of suitable sensor nodes from each cluster, which can act as CH or DCH at a later stage. This set of nodes is also called CH panel. The cluster members i.e., the sensor nodes, forward data to the respective CH node. The CH nodes do the data aggregation to remove redundancy and then forward the aggregated data toward the BS. The DCH nodes do several cluster management tasks that include mobility monitoring also. Other cluster management tasks are, for example, collecting location information of cluster members regularly and communicating this location information to the BS. They also remain ready to act as intermediate hop in presence of faults in some CH nodes. Therefore, the DCH nodes are also called cluster management nodes. The CH nodes do not transmit data directly to the BS, unless it is the nearest one to the BS. The communication pattern or the route for the CH nodes is determined by the BS and distributed to the respective CH nodes. Fig. 1 depicts the overall organization of the sensor network system. It is assumed that the BS has an idea about the expected number of data packets (i.e., the volume of data) to be arrived in it during a pecified time interval. Therefore, the BS keeps on monitoring the actual volume of data arrived from different clusters in the network. If the BS observes less arrival of data packets from some clusters in comparison with a pre-specified threshold level, then it informs the respective CH nodes to check their connectivity with their cluster members. The CH considers this as feedback from the BS and accordingly checks the current connectivity with its cluster members. If the connectivity status of the cluster members with the respective CH is very poor, the BS decides to shift the charge of cluster headship to another suitable member from within the CH panel. Depending on the connectivity scenario, the cluster headship may be transferred to one of the two DCH nodes also. The routing decisions are made at the BS and then communicated to the sensor nodes. Since the sensor nodes are resource constrained and, moreover, the nodes are also committed to data processing and communication apart from sensing activities, it is always advantageous to offload the routing decision making process from the sensor nodes. Therefore, this protocol exploits the resourcefulness of the BS by shifting routing and some cluster management activities to the BS. The overall protocol in terms of its different phases are describes as below

1. Self-Organization Phase
2. Scheduling and MAC Information Computing Phase
3. Operational Phase
4. SET Protocol
5. Exception Handling Phase

3.1 Self-Organization Phase

After random deployment of the sensor nodes in the sensor field, the self-organization phase starts. It is the first phase of the protocol. During this phase, the clusters are formed. The CH set, the current CH, and the two DCH nodes are selected by the BS. Initially, the BS collects the current location information from each of the sensor nodes and then forms a sensor field map.

After formation of the clusters, the BS identifies a set of suitable nodes, i.e., CH panel, from within each cluster. The nodes in the CH panel can take the role of CH node and DCH node. This selection is based on the cumulative credit point earned from the three parameters, namely, residual energy level of the node, degree of the node (i.e., the number of neighbors), and mobility level of the node (high, medium, low). At the initial stage of the self-organization phase, each node broadcasts its three attributes, namely, geographic location information, residual energy level, and mobility level or velocity. This broadcast is intended for the BS so that the BS can utilize those for cluster formation and CH panel selection. The designer can use a suitable normalization function to compute the cumulative credit point earned by a node considering these three non homogeneous parameters. Cluster setup validity period is equal to the next time interval.

A node earns cumulative credit point from three parameters, namely, residual energy level of the node, degree of the node (i.e., the number of neighbors), and mobility level of the node (high, medium, low). These three parameters are non homogenous, and therefore, a normalization method is required in order to compute the cumulative credit point. Ideally, a CH node should have higher residual energy, higher degree, and low mobility.

Selection of w1, w2, and w3: Three different criteria used at the time of selecting the CH and two DCH nodes are residual energy level of the node, number of neighbors, and mobility level of the node. Ideally, a CH node is expected to be equipped with maximum energy level, relative maximum number of neighbors, and minimum mobility level. Thus, one such parameter is not directly linked or correlated with the other parameters. All the three parameters are independent of each other.

Role of CH Node: The CH node is responsible for gathering sensed data from the cluster members, aggregate those and forward toward the BS either directly or in a multihop fashion. This part of data forwarding will take place according to the communication pattern or the route distributed by the BS.

Role of DCH Nodes: The DCH nodes keep monitoring the sensor nodes' mobility pattern. DCH nodes are also called cluster management nodes as they take a major responsibility of collecting current location information from the cluster members and communicating it to the BS. Based on this information, the BS computes the actual current topology. The initial state of the topology based on which the BS creates various clusters is an estimation only.

CH-BS Network Creation: Since the location information of each of the CH nodes is available with the BS, the BS computes different alternate multihop routes for each of the CH node. These routes are computed considering the CH nodes only, which are spread throughout the sensor network. Considering all the CH nodes in the field, a graph G showing the connectivity among the CH nodes can be constructed. The links in G are created based on the respective radio ranges and the geographic locations of the CH nodes.

Correlation Between Number of Cluster and Number of DCH: The number of clusters in the network is generally 5% of the total number of nodes in the network. Now, we have decided to have one CH node and two DCH nodes inside each cluster.

The total energy expenditure involved in a route due to communication is a function of two parameters, and those are as follows:

1) The number of transmissions considering the source node and all intermediate nodes;

2) The number of receptions considering the intermediate nodes and the destination node.

The physical distance separating two sensor nodes influences the overall energy consumption in transmitting data packets between the two nodes. The route is also called communication pattern, and it is valid only for a specific time duration t. These alternate routes are selected from the pool of multihop routes computed initially. The condition for selecting a multihop route is as follows: a multihop route must incur less energy expenditure than a direct route.

DCH-BS Network Creation: Similar to the CH-BS network creation process, the BS also creates the DCH-BS networks. In this situation, only the DCH nodes in the sensor field are considered. Alternate routes are also created for the DCH and switched intelligently by the BS.

Current Cluster Setup Cycle Length: An important and critical issue is how long a particular cluster setup will remain valid. Depending on the initial energy level of the sensor nodes and the kind of application, the optimal time duration is fixed. This optimal time duration is called as cycle length, and the current cluster setup remains valid until the end of the cycle length.

Use of the CH Panel: The CH panel is selected initially and remains valid until the end of the cycle length or until the reclustering process are initiated. If the current CH loses connectivity with most of its cluster members due to which throughput at the BS degrades, the CH may be asked to relinquish the charge of cluster headship. Even a CH node may drain out its energy below a threshold level and becomes useless; in this situation also, a new CH is necessary.

3.2 Scheduling and MAC Information Computing Phase

The sensor nodes can be in either of the two states active and dormant. Some sensor nodes are scheduled for dormant state, which is a low-power state. A node in dormant state does neither any sensing task nor any relaying task. This approach is opted based on the observation that if two senor nodes are in close proximity, then there is a very high probability that they sense similar and redundant data from the environment.

The BS distributes a time-division multiple access (TDMA)-based medium access time slot for each of the CH and DCH nodes in order to enable communication with the BS. It has been assumed that different CH nodes use different frequency bands so that they can communicate simultaneously.

3.3 Operational Phase

During this phase, actual sensory data transmissions take place. The sensor nodes forward data toward the CH node according to their respective medium access time slots. The CH nodes remove the redundancies in the data sent by the sensor nodes by the process of data aggregation and finally forward the aggregated data toward the BS as per the communication pattern distributed by the BS. DCH nodes do only cluster management tasks such as monitoring the mobility of the nodes and exception handling. Normally, they do not take part in data sensing and data forwarding tasks, but they do data forwarding under exceptional circumstances, which is described in the following. This phase, i.e., operational phase, has the longest time interval in comparison with the other aforementioned phases.

SET Protocol:

- We propose two Secure and Efficient data Transmission protocols, called SET-IBS and SET-IBOOS, by using the IBS scheme and the IBOOS scheme, respectively.

- The key idea of both SET-IBS and SET-IBOOS is to authenticate the encrypted sensed data, by applying digital signatures to message packets, which are efficient in communication and applying the key management for security.
- In the proposed protocols, secret keys and pairing parameters are distributed and preloaded in all sensor nodes by the BS initially.
- An SET-IBS scheme implemented consists of the following operations,
  - Setup. The BS (as a trust authority) generates a master key msk and public parameters param for the private key generator (PKG), and gives them to all sensor nodes.
  - Extraction. Given an ID string, a sensor node generates a private key sekID associated with the ID using msk.
  - Signature signing. Given a message M, time stamp t and a signing key, the sending node generates a signature SIG.
  - Verification. Given the ID, M, and SIG, the receiving node outputs "accept" if SIG is valid, and outputs "reject" otherwise.

3.4 Exception Handling Phase

This phase is an occasional one. Due to the node mobility and the sudden death of some sensor nodes, the CH node may lose enough links with its cluster members. This may significantly degrade the throughput level in terms of packet delivery at the BS. Under this situation, the BS may send feedback to the CH, and the CH then checks the current connectivity with its cluster members. If there is significant loss of connectivity with its cluster members, then the CH is asked to relinquish the charge of cluster headship, and a new one is selected either from the CH panel or one from within the two DCH nodes already selected. If a DCH node becomes the CH, another node from the CH panel is selected by the BS as the DCH. We consider this as the first exception condition. The second exception condition may be the link failure between the CH and the DCH. This link is not required all the time. However, if this link is not available at the time of need, either party, i.e., CH or DCH, informs the BS. Then, the BS checks and compares the geographic locations of both CH and DCH. The BS selects a new suitable DCH from within the CH panel if it finds that there is no chance of return of the current DCH node to the proximity of the CH node. The third exception condition is as follows: the CH may lose the link with the next hop in its communication pattern toward the BS. This is a critical situation, and the CH becomes unable to transmit data toward the BS. Then, the CH requests the DCH nodes to inform if it has a route available toward the BS. If such a route is available, then data packets follow the route through one of the two DCH nodes toward the BS. This process goes on until the next hop in the communication pattern of the CH becomes available or the BS distributes a new communication pattern to the CH for the next time duration (i.e., t). It is assumed that there is at least one such route always available toward the BS through either of the DCH nodes.

3.5 Protocol Operation

After the protocol initialization, SET-IBS operates in rounds during communication. Each round consists of a setup phase and a steady-state phase. We suppose that all sensor nodes know the starting and ending time of each round because of the time synchronization. The operation of SET-IBS is divided by rounds. Which is similar to other LEACH-

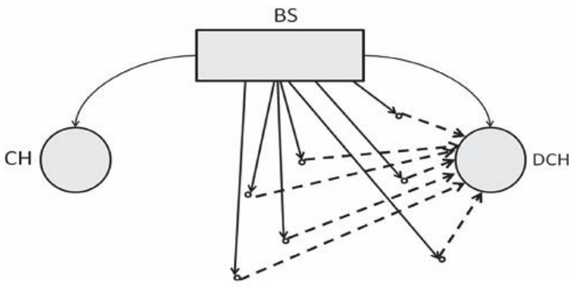


Fig. 2: Cluster headship gets shifted to DCH

like protocols. Each round includes a setup phase for constructing clusters from CHs, and a steady-state phase for transmitting data from sensor nodes to the BS. In each round, the timeline is divided into consecutive time slots by the TDMA control. Sensor nodes transmit the sensed data to the CHs in each frame of the steady-state phase. For fair energy consumption, nodes are randomly selected as CHs in each round, and other non-CH sensor nodes join clusters using one-hop transmission, depending on the highest received signal strength of CHs.

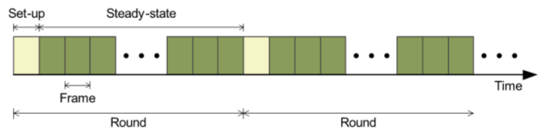


Fig. 3: Steady state diagram

To elect CHs in a new round, each sensor node determines a random number and compares it with a threshold. If the value is less than the threshold, the sensor node becomes a CH for the current round. In this way, the new CHs are self-elected based by the sensor nodes themselves only on their local decisions; therefore, SET-IBS functions without data transmission with each other in the CH rotations. Full steps in one round of SET-IBS. The setup phase consists of four steps, from Steps 1 to 4, and the steady-state phase consists of the latter two steps.

IV. SIMULATION RESULTS

Table-I

SIMULATION PARAMETERS

Parameter	Value
Simulator	NS2
Simulation time	10s
Area	1500X1500
Number of node	40
Physical Layer	IEEE 802.11
Routing protocol	AODV with WSN
Mobility model	Random way point
Radio type	802.11a/g
Transmission rate	10 packets/s
Packet Size	512/ 1024
Pause time	0s

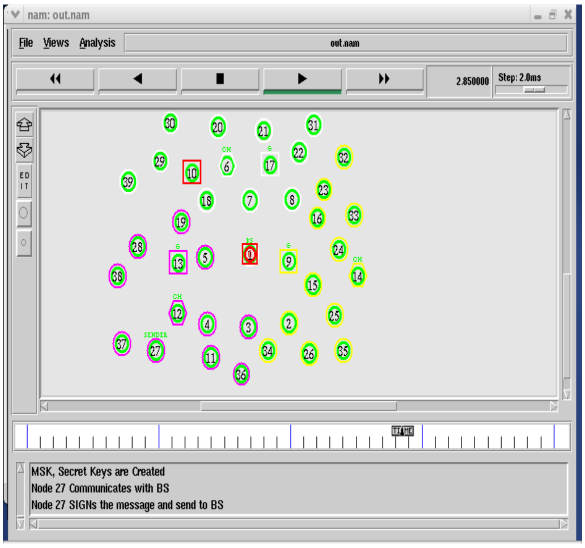
5.1 Experimental Result

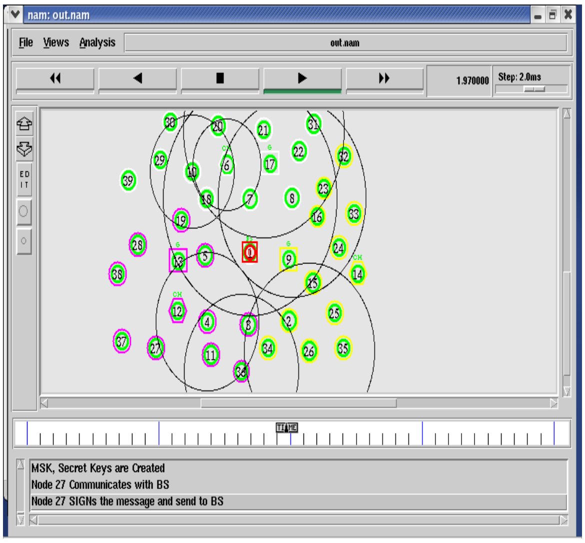
Here, we present some results obtained through simulation. We also provide an analysis of the results. The CH and two DCH nodes are selected by the BS based on the parameters such as geographic location information, residual energy level, and mobility level or velocity. Based on Algorithm (to compute cumulative credit point), which is given in proposed chapter, the BS selects the CH and two DCHs for each cluster. In our simulation, for a setup of 40 nodes the selected nodes as CH and DCHs are as presented in simulation.

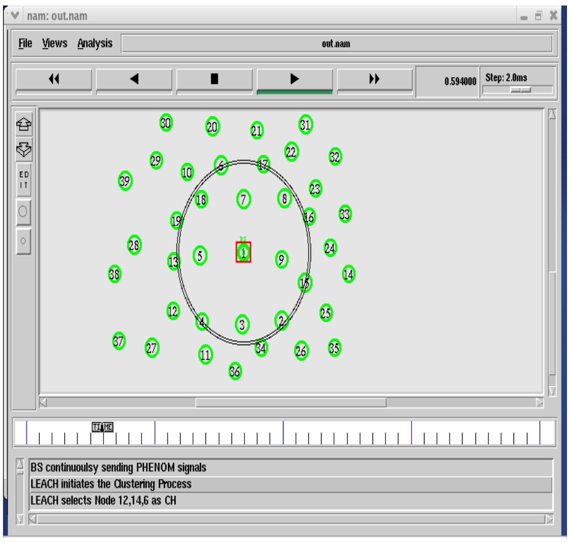
Table

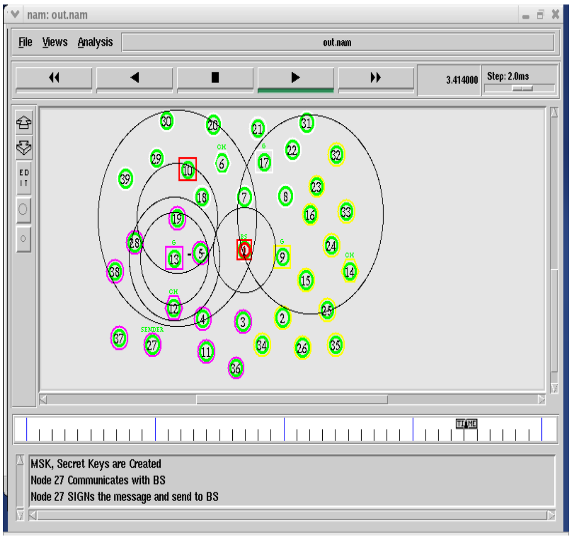
S. No	Parameter	Parameter static	E2r2 protocol
1	End To End Delay	1.26786 ms	0.79232 ms
2	Throughput	244732.00 bps	278700.00 bps
3	Energy Utilization	22.42%	24.51%

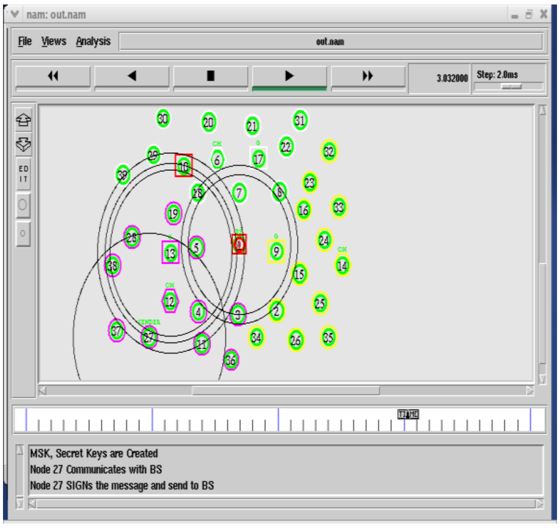
Screenshot











V.CONCLUSION

In this paper, we have proposed an energy-efficient and reliable routing protocol for mobile WSNs. The proposed protocol E2R2 is hierarchical and cluster based. Each cluster contains one CH node, and the CH node is assisted by two DCH nodes, which are also called cluster management nodes. We analyze the performance of the proposed protocol through simulations and compare with M-LEACH. The proposed protocol out per-forms M-LEACH in terms of lifetime and throughput. In the proposed protocol, the throughput improvement is 15% on average over M-LEACH. Such a routing protocol is useful when the sensor nodes and the BS are mobile. This work can be extended to improve the throughput even in the high-data-rate situation, where the sensor nodes generate data at a very high constant rate. The proposed protocol can be also tested under the influence of highly mobile sensor nodes.

REFERENCES

[1] I. F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," IEEE Commun. Mag., vol. 40, no. 8, pp. 102–114, Aug. 2002.

[2] O. Younis and S. Fahmy, "HEED: a hybrid, energy-efficient, distributed clustering approach for ad hoc sensor networks," IEEE Transactions on Mobile Computing Vol. 3, No. 4, pp. 366-379, Oct.-Dec. 2004

[3] W. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-efficient communication protocol for wireless microsensor networks," in Proc. 33rd Annu. HICSS, 2000, pp. 1–10.

[4] S. Lindsey and C. S. Raghavendra, "PEGASIS: Power-efficient gathering in sensor information systems," in Proc. IEEE Aerosp. Conf., 2002, pp. 1125–1130.

[5] E. Felemban, Chang-Gun Lee and E. Ekici, "MMSPEED: multipath Multi-SPEED protocol for QoS guarantee of reliability and. Timeliness in wireless sensor networks," IEEE Transactions on Mobile Computing Vol. 5, No. 6, pp. 738-754 June 2006

[6] Shiwen Mao and Y. Thomas Hou, "BeamStar: An Edge-Based Approach to Routing in Wireless Sensor Networks," IEEE Transactions on Mobile Computing Vol. 6, No. 11, Nov. 2007

[7] W.B. Heinzelman, A.P. Chandrakasan and H. Balakrishnan, "An application-specific protocol architecture for wireless microsensor networks," IEEE Transactions on Wireless Communications Vol. 1, No. 4, pp. 660-670 Oct. 2002

[8] A. Manjeshwar and D. P. Agarwal, "TEEN: A routing protocol for en-hanced efficiency in wireless sensor networks," in Proc. 15th IPDPS Workshops, 2000, pp. 2009–2015.

[9] A. Manjeshwar and D. P. Agarwal, "APTEEN: A hybrid protocol for ef-ficient routing and comprehensive information retrieval in wireless sensor networks," in Proc. IPDPS, 2002.

[10] D. B. Johnson, and D. A. Maltz, "Dynamic source routing in ad hoc wireless networks," in Mobile Computing. Norwell, MA, USA: Kluwer Publishers, 1996, pp. 153–181.

[11] F. Ingelrest, D. Simplot-Ryl and I. Stojmenovic, "Optimal transmission radius for energy efficient broadcasting protocols in ad hoc and sensor networks," IEEE Transactions on Parallel and Distributed Systems Vol. 17, No. 6, pp. 536-547, June 2006.

[12] C. Perkins and E. Royer, "Ad hoc on demand distance vector routing," in Proc. 2nd IEEE Workshop Mobile Comput. Syst. Appl., 1999, pp. 90–100.

[13] C. E. Perkins and P. Bhagwat, "Highly dynamic destination-sequenced distance-vector routing (DSDV) for mobile computers," in Proc. Conf. Commun. Archit., Protocols Appl., 1994, pp. P234–P244.