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Efficient Routing Scheme for Mobile Wireless Sensor Networks using Hybrid multi-hop LEACH

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***Abstract*— *A Wireless Sensor Network (WSN) consists of spatially distributed autonomous sensors connected via a (wireless) communications infrastructure to cooperatively monitor, record and store physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants. This makes it more popular in emerging technologies that are used in our daily life. While WSNs have many benefits, there are also a few drawbacks. A big area of research into WSNs has concentrated on creating routing protocols that are energy efficient. It is a tremendous challenge to design routing protocols for applications of WSNs, which are mobility centric and energy efficient; because of network topology is often being changed. The concept of clustering offers more benefit than the other flat based routing protocols. A common side-effect of the many-to-one traffic pattern is the hot spot issue, which characterizes the majority of wireless sensor networks: nodes having the optimal path to the sink become overloaded with traffic from all other areas of the network which cause it to lose energy at a faster rate than the other nodes. This research work is aimed at evaluating and validating the proposed Mobile Data Collector-based routing protocol (MDC maximum residual energy LEACH) with A Novel Application Specific Network Protocol for Wireless Sensor Networks routing protocol (Hybrid multi-hop LEACH). A computer simulation was employed to obtain the results that have indicated an improvement in the overall energy efficiency of the network.*

***Keywords*—LEACH, Mobile Data Collector, Energy Efficient and Hierarchical routing protocol.**

I. INTRODUCTION

Because of the advances recently made in wireless communications and micro-electronics, wireless sensor networks (WSNs) are expected to become ever-present in the daily life of mankind [1]. Further, WSNs have already surfaced as a hot area of research, which consist of many sensor nodes that are low cost and have the ability to process and communicate. WSNs must be able to operate autonomously for extended lengths of time in the majority of their applications even though their sensors are tiny devices that possess power supplies which are limited. Appropriate solutions are necessary at each layer of the networking protocol stack so that the usage of energy can be better managed and the network lifetime as a whole can be increased. Most particularly, a tremendous amount of attention has been given to routing protocols that are energy aware at the network layer. This is because wireless communication has been well established to be the key cause of the consumption of power in WSNs.

The WSN's network layer has the responsibility of delivering packets and implementing an approach for addressing to take care of this task. It primarily creates routes for transmitting data throughout the network. Routing in WSNs is more challenging than in the common ad-hoc networks. This is because they possess resources that are limited in regards to the available power, processing ability and communication. These are considerable constraints to all applications in the sensor networks. Moreover, route maintenance is a difficult task because of frequent modifications to the topology resulting from these constraints [1, 2].

When considering the perspective of the network organization, there are roughly two main categories for the classification of routing protocols: hierarchical routing and flat routing. Hierarchical routing protocols have been seen as having greater scalability and being more energy-aware in the context of WSNs. Nodes play various roles in the network and are usually arranged into clusters in the hierarchical-based routing. The technique of sensor nodes in a network organizing themselves into groups in relation to particular prerequisites or metrics is known as clustering. Each cluster/group possesses a leader known as a cluster head (CH) and other member nodes (MNs) that are ordinary. The cluster heads can be arranged into further hierarchical levels. On the other hand, in a flat topology, all of the sensor nodes play the same role and have the same functionality as each other in the network. A flat routing protocol tries to locate a path to the sink, hop by hop, making some form of flooding whenever a node needs to transmit data. In networks that are relatively small, flat routing protocols are quite effective. On the other hand, they do not scale to large and dense networks very well as, usually, all of the nodes are alive and create greater processing and bandwidth usage [3, 4 and 5].

Single-sink data collection naturally results in a many-to-one traffic pattern from the sensing nodes to the sink. This single-sink data collection is the normal use in WSNs. It is usual for routing protocols to stay away from lossy links at any cost, because WSNs are very resource limited. Clustering approach provides a hierarchical architecture that is more easily scaled and has less power usage; therefore, it provides the entire network with a longer lifetime. Most of the sensing, processing of data and activities involved in communication can be carried out within the clusters. However, flat and cluster based routing protocols have own benefits but both created communication holes within the network.

Energy and routing holes are the major types of communication holes. The energy hole problem is a key factor in WSNs which disturbs the lifetime of network because sensor nodes normally perform as originator and router of data. The communication obeys a many-to-one and converge-cast pattern, where nodes transmit heavy communication load near the base station, causing increased energy dissipation rate. The primary and utmost objective in communication network is efficient routing. The efficient routing protocol in WSNs is to increase the quality of network services and prolong the network lifetime. Two types of "routing holes" can exist in real time sensor networks such as redeployable and non-redeployable holes [6, 7 and 8].

The MDC maximum residual energy LEACH was proposed for the validation of communication holes arguments. It is a protocol for multi-hop cluster-based routing for environmental applications in WSNs. It makes use of a mobility model with a pre-defined trajectory and transmits a beacon message at 5 sec intervals to the cluster heads (CHs) and the base station (BS). This beacon message has MDC location and the residual energy level of MDC. When the CHs received the beacon message from MDC, they choose the maximum residual MDC for the routing of sensed aggregated data towards the BS or some central location. The general network parameters are as follows: firstly, they possess a fixed BS that is situated far away from the area of the sensors; secondly, they are homogenous; thirdly, they are controlled by energy and finally, the communication process does not use any high energy sensor node. Data fusion is the optimal way to avoid the duplicate and overloaded data that is typically used in various existing hierarchical protocols of cluster-based routing.

This paper has been arranged as follows. Related work of energy efficient routing protocol is presented in Section 2. A description of the proposed MDC maximum residual energy LEACH protocol is given in Section 3. The performance evaluation of the proposed protocol is given in Section 4. Finally, the conclusions have been drawn in Section 5.

II. RELATED WORKS

The development of routing protocols in WSNs is experiencing a tremendous research effort presently. These protocols are being development on the basis of application specific needs and the particular architecture of the network. Nevertheless, when creating routing protocols for WSNs, several factors must be considered. As energy efficiency directly affects the network lifetime, it is the most important factor of all. In the literature, it has been found that there has been some effort to pursue WSNs energy efficiency.

A. A Modified SPIN for Wireless Sensor Network

When the data-centric method is used as the basis of the routing protocols it is appropriate to be used in applications performing in-network aggregation of data to produce data dissemination that saves energy. In [9], an altered SPIN protocol was proposed named M-SPIN, Its performance was compared with the commonly used SPIN protocol that makes use of broadcast communication.

The Modified-SPIN (M-SPIN) protocol sends data to a sink node only rather than throughout the entire network. A substantial amount of total energy can be saved as the total number of packets being transmitted is less in the proposed protocol. The proposed M-SPIN protocol makes use of the hop-count values of the sensor nodes for WSNs. In a typical SPIN protocol, negotiation is also performed before the actual data is transmitted; however, in M-SPIN, the nodes closer to the sink node transmit REQ packets as a reply to an ADV packet transmitted by the source node. As a result, the dissemination of the data is towards the sink or to the neighboring nodes on towards the sink node. The M-SPIN protocol gains energy savings by not transmitting packets to the direction that is opposite the sink node. The M-SPIN protocol is illustrated in Fig. 1.

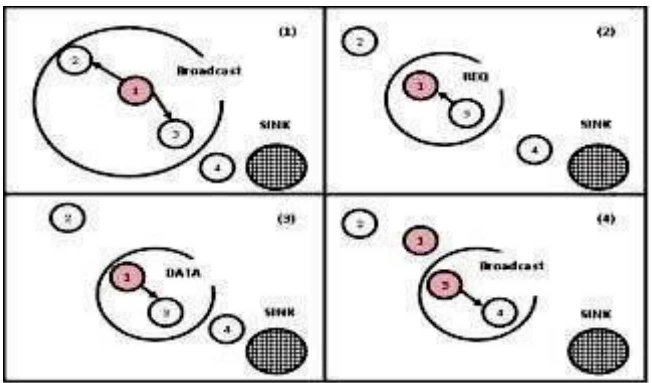

Fig.1: The M-SPIN Protocol

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B Threshold Sensitive Energy Efficient Sensor Network Protocol (TEEN)

Threshold sensitive Energy Efficient sensor Network protocol (TEEN) [10] proposes a reactive routing protocol specifically applicable to time sensitive applications. TEEN adopts the principle of hierarchical clustering. Sensor nodes are grouped together that is geographically close to each other with one common cluster head. For the purposes of this section, these cluster heads are seen as first layer cluster heads. The first layer of cluster heads collect data messages from the sensor nodes within its cluster, aggregate the data messages and forward the aggregated messages to a higher layer. The main disadvantage of TEEN is that if the hard threshold is never reached, no data messages will be forwarded towards the base station.

C. A Novel Application Specific Network Protocol for Wireless Sensor Networks

The newly developed self-organizing Hybrid Network Protocol for WSNs has been created on the basis of a cluster-based hierarchical architecture and multi-hop routing. This basis has been used so that energy efficiency can be improved and the lifetime of the network is extended. Multi-hop routing is employed in the hybrid protocol for inter-cluster communication between CHs and the BS rather than direct transmission. In this way, the transmission energy can be minimized and the energy load can be distributed throughout the entire network in an even manner. In addition, the same suppositions as created in the LEACH protocol are created in this protocol; the Carrier Sense Multiple Access (CSMA) MAC protocol, similar to the network model, is employed to reduce the potential of a collision taking place during the set-up phase. The node in the network knows of its own location. This is important to provide the multi-hop routing between CHs and is accomplished by using the Global Positioning System (GPS) technology. It makes use of a rotation of the local base stations (CHs) that is randomized so that the load of the energy can be allocated consistently among the sensors in the network [11].

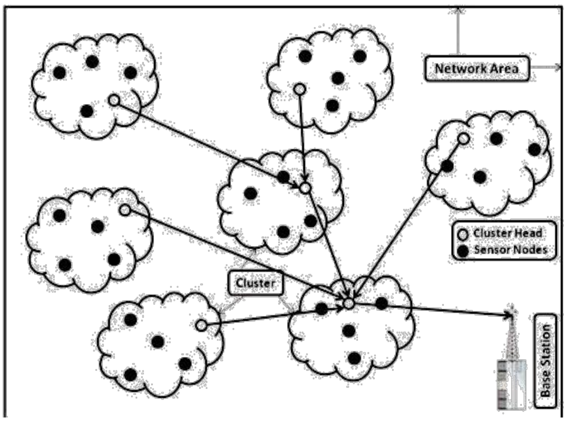


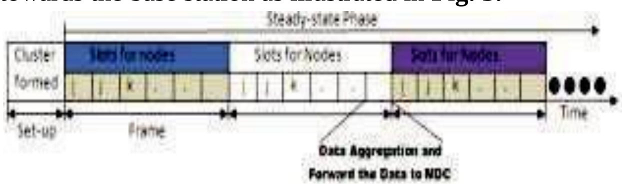
Fig.2: Architectural view of Hybrid multi-hop LEACH

Many frames make up the steady-state phase of the Hybrid multi-hop LEACH, same as LEACH routing protocol. Each member node stays in its own time slot to transmit its data to the CH. When a CH has any fused data to send to the BS, it attempts to locate a multi-hop route from among all of the CHs. Then it will send the data packet to the BS in accordance with the routing algorithm as illustrated in Fig. 2. This solution is one that is straightforward in the group of multi-hop routing algorithms. While a substantial advantage of this protocol is the decrease in the consumption of the transmission energy that directly enhances the overall network lifetime. The drawback of this Hybrid multi-hop LEACH routing protocol is facing energy and routing hole problems, since cluster head near the base station relaying heavy traffic load from another cluster heads in every round and relaying cluster head is died in current round because of energy depletion. According to energy hole concern in Hybrid multi-hop LEACH protocol which directly impacts in routing mechanism of the network. The routing path from cluster head to the base station is not available any more due to heavy traffic loads from another CH's and immediately drains the energy.

III. MOBILE DATA COLLECTOR MAXIMUM RESIDUAL ENERGY LEACH

In this section, a novel cluster based energy efficient routing protocol, named MDC maximum residual energy LEACH, is presented. This Protocol utilizes multi-hop communication and three-tier network architecture for data collection and communication from source to destination. It has been experiential that this type of architecture enhances the network scalability for large scale non-delay sensitive environmental applications; multi-hop communication is to reduce the channel disputation area and provide prospective energy savings by the help of long and multi-hop communication.

The MDC maximum residual energy LEACH protocol is divided into rounds and each round is followed by set-up phase for cluster formation and steady phase for data transmission from sensor nodes to the MDC and finally towards the base station as illustrated in **Fig. 3.**



A. Radio Model for Transmission of Data

There have been multiple studies carried out into low-energy propagation radio models over the last few years. The MDC maximum residual energy LEACH routing protocol possessing a maximum level of residual energy makes use of a basic First Order Radio Model. In this

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model, the receiver and transmitter dissipate E_{elec} 50 nj/bit and transmit the amplifier circuit $!_{amp}$ 100 pj/bit/m^2 to obtain an adequate E_b/N_o. The current state-of-the-art in radio design, the First Order Radio Model parameters are slightly better than the other models.

Consider that r^2 is the energy loss within the transmission of a channel when transmitting a *k*-bit message from a distance of *d* using a radio model; the calculations for the transmission end are seen in equations 1 and 2:

$$E_{Tx}(k,d) = E_{Tx-elec}(k) + E_{Tx-amp}(k,d)$$
$$E_{Tx}(k,d) = E_{elec} * k + \varepsilon_{amp} * k * d^2 \qquad (1)$$

And the calculations for the receiving end are:

$$E_{Rx}(k) = E_{Rx-elec}(k)$$
$$E_{Rx}(k) = E_{elec} * k \qquad (2)$$

B. Setup Phase or Cluster Formation

In the period of cluster formation, each node is autonomous and self-organized, and formed into clusters through short messages using the Carrier Sense Multiple Access (CSMA). MDC maximum residual energy LEACH creates clusters by the help of distributed algorithm where each node in the network must individually choose to become a cluster head or not using the probability of P_i [12]. The P_i node is computed utilizing the LEACH algorithm:

$$(3) \qquad P_i(t) = \begin{cases} \dfrac{k}{N-k \div \left(r \bmod \frac{N}{k}\right)} \\ 0 \end{cases}$$

While the set-up phase is initiated, each node employs this formula to compute the probability of *Pi*. The expected number of cluster heads for each round is guaranteed to be *k*. Because of this, the entire network is grouped into *k* clusters, the total number of nodes in the network is *N*. Each node has been chosen to be a cluster head once after *N/k* rounds on average and *r* represents the number of the round. Where *P* is the desired percentage of the total amount of nodes to function as a cluster heads at any given moment, the current round is denoted as *r* and the set of nodes participating in the selection of the cluster head that has not acted as a cluster head in the last $\frac{1}{P}$ rounds is denoted as *G*. Each node chosen to act as a cluster head in the current interval cannot be chosen to act as a cluster head in the following interval. A CSMA protocol applies for an announcement by each of the cluster heads in the network for all of the nodes. This message contains data like the position of the cluster head and the kind of message that it is; for example, it is a short message. Each of the nodes receives several announcement messages from various cluster heads after t_1 time. After receiving these all messages, the neighboring node determines which cluster head is nearest to it based on the strength of the signal from the packet announcement. It will then choose the cluster head that is the shortest distance away.

C. Steady Phase of MDC Maximum Residual Energy LEACH:

After the cluster formation, the cluster head sets up the TDMA schedule for every node to send data to the cluster head. This scheduling is to avoid collisions and reduce energy consumption between the data messages in the cluster and enables each member of the radio equipment to be off when not in use. To reduce inter cluster interference, every cluster uses a unique spreading code; when the node is selected as a cluster head, it selects that unique code and informs all of the member nodes within the cluster to transmit their data using this spreading code

Using Code Division Multiple Access (CDMA) codes, while not necessarily the most bandwidth efficient solution, does solve the problem of multiple-access in a distributed manner [13]. In data fusion mechanism towards the base station, all MDC's transmits a beacon message for all CH's which contained their current position and residual energy level. When CH received the beacon message from MDC, then CH selects the maximum residual energy MDC to route the data towards the base station (BS) in each round. Fig. 4 explains the detailed data fusion mechanism by the approach of maximum residual energy of MDC, in current round cluster head S_1 and S_2 received the residual energy level from MDC 1 and MDC 2 that is 25j and 23j respectively. Cluster head S_1 and S_2 select MDC 1 for transmitting the data because the RE level of MDC 1 is higher than MDC 2. In next round all cluster heads again received residual energy information along with MDC current location by beacon message from MDC's. At this round the RE level of MDC 2 is 23j and MDC 1 is 22j, all cluster heads selects MDC 2 as a relay node for data collection at the base station. Same procedure will follow for data collection within the network at the base station till the residual energy of sensor nodes and MDC's are accessible.

- *Route 1 at Round 1*: S1 and S2 – MDC 1 – BS
- *Route 2 at Round 2*: S1 and S2 – MDC 2 – BS
- *Route 3 at Round 3*: S1 and S2 – MDC 1 – BS

This approach clearly maintains the energy level of relay nodes that is MDC's throughout the network till the sensor nodes and MDC's are alive.

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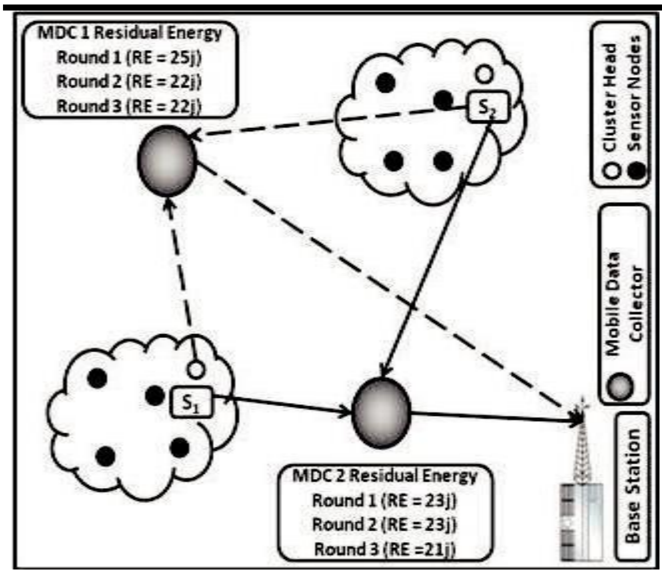


Fig. 4

IV. RESULT AND DISCUSSION

The simulation parameters of the MDC maximum residual energy LEACH routing protocol are based on environmental applications of WSNs. The main simulation parameters are summarized in Table 1 Shows simulation set up for different parameter used for different areas different nodes and cluster heads etc also it represent battery life number of nodes used and data rate handling, number of MDC is used velocity of MDC etc

Table.1: Simulation Setup

PARAMETERS	VALUES
Number of Nodes	Forty (40)
Simulation Area	1000 * 1000 (m)
Sensor Node Deployment	Random Deployment
Number of Cluster Head	Five (5)
Transmitter Electroics ($E_{TX-elec}$) Receiver Electronics ($E_{RX-elec}$)	50 nj/bit
Transmission Amplifier (E_{amp})	100 pj/bit/m^2
Battery	Initial capacity is assumed to be constant
Data Rate	250 kbps
Packet size	288 bits/packet or 36 Bytes
MDC Beacon Message Rate	5 sec/message
MDC Velocity	0.054 m/sec
Number of MDC's	2

A computer simulation was used to measure the following performance metrics. Since sensor nodes have a limited battery power source, the consumption of energy is the greatest metric in both static and mobile WSNs. A sensor node's energy usage is the same as the sum of the dissipation of the energy during the states of receiving, transmitting, sensing, overhearing, sleeping and idling. This research work put emphasis on addressing the depletion of energy during communication for not only the process of transmitting but also receiving. Furthermore, the amount of energy dissipation from the sensor nodes directly impacts on network lifetime. More energy dissipation means less network lifetime and a smaller amount of energy dissipation means longer network lifetime

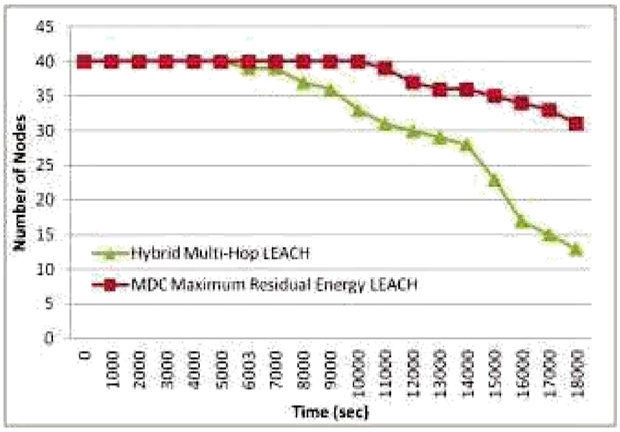


Fig.5: Energy Consumption of Node 14

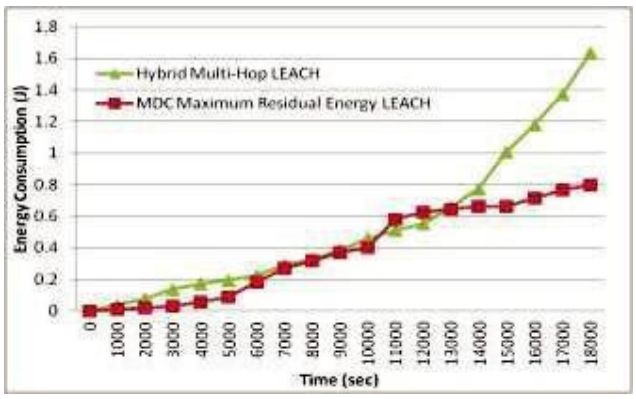


Fig.6: Energy Consumption of Node 21

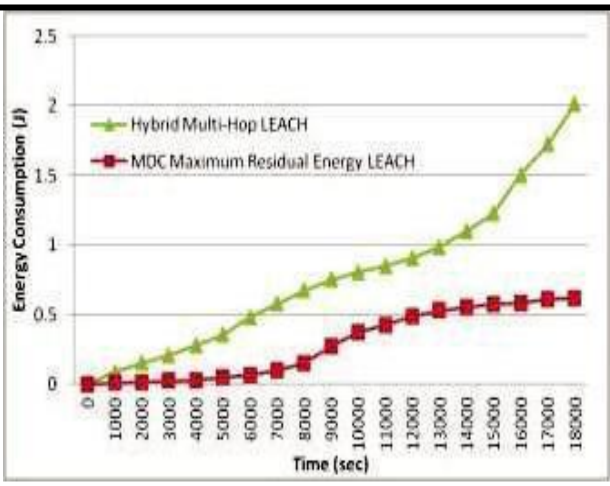
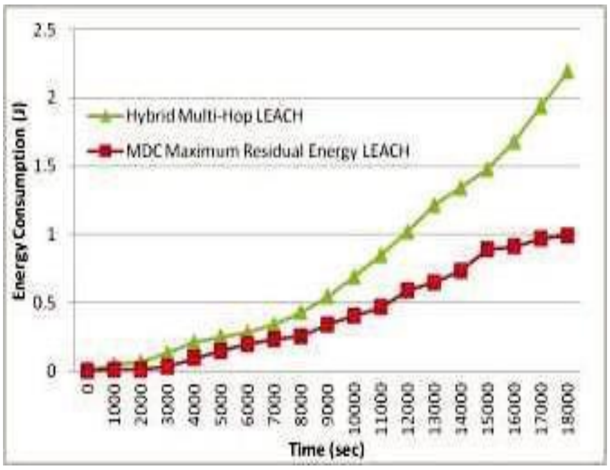
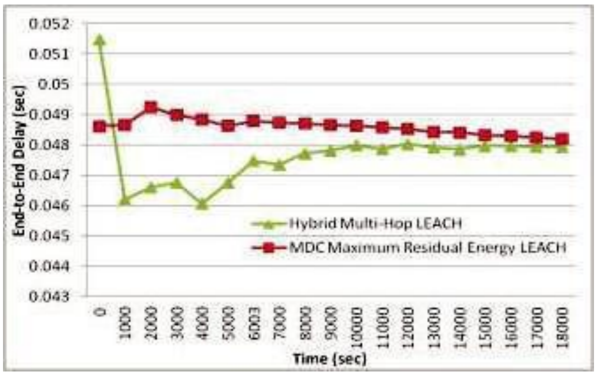


Fig.7: Energy Consumption of Node 37.



Energy Consumption of Sensor Nodes and Network Lifetime:

Fig.8: Network Lifetime



To provide communication towards the BS. A substantial variation in the level of the energy consumption of the sensor nodes is shown in the graphs. This variation had a direct impact on the performance of the network lifetime.

Variation in the network lifetime. Therefore, the MDC maximum residual energy LEACH routing protocol is betterthan the Hybrid multi-hop LEACH routing protocol in termsof network lifetime because it stayed active, on the whole,longer and falling slightly faster.reached by the receiver. Normally this delay is determinedby channel bandwidth, packet length and the coding scheme adopted.

The simulated result of Fig. 8 exposed the considerable variation in the network lifetime. Therefore, the MDC maximum residual energy LEACH routing protocol is better than the Hybrid multi-hop LEACH routing protocol in terms of network lifetime because it stayed active, on the whole,longer and falling slightly faster.reached by the receiver. Normally this delay is determined by channel bandwidth, packet length and the coding scheme

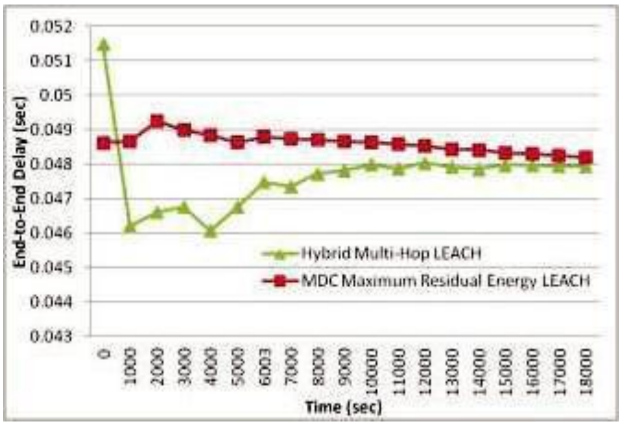


Fig.9: End-to-End Transmission Delay

Figures 5, 6 and 7 show the usage of power of the individual sensor nodes, 14, 21 and 37, respectively. These were the results obtained upon running the simulations several times using the MDC maximum residual energy LEACH and the Hybrid multi-hop LEACH routing protocols. There was a random distribution of the sensor nodes throughout the network with the farthest, average and nearest distances from the BS. In addition, the MDC (mobile agent) was employed to provide communication towards the BS. A substantial variation in the level of the energy consumption of the sensor nodes is shown in the graphs. This variation had a direct impact on the performance of the network lifetime.

The End-to-End delay is the primary metric of the network latency. It can be specified as the channel access delay, time latency of the data packet and other possible delays from the source to the destination. The graph illustrated in Fig. 9 is of the average End-to-End transmission delay over time when the MDC maximum residual energy LEACH routing protocol and the Hybrid multi-hop LEACH routing protocol were simulated. The End-to-End transmission delay of the MDC maximum residual energy LEACH routing protocol was found to be very similar to the Hybrid multi-hop LEACH routing protocol. This was because the aggregated data packets took multiple hops and used up a greater amount of processing time to get to the BS or control center.

V. CONCLUSION AND FUTURE WORK

The proposed algorithm is an improvement on the clustering

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routing protocol. This improvement was brought about by utilizing the MDC maximum residual energy
approach. A multi-hop communication between sensor nodes to MDC and then to the BS is provided by this mobile data collector. It reduces the consumption of the energy of all of the nodes in the network. Further, it can be employed in WSNs used in geographical areas that are large. The simulation studies reveals that the proposed MDC maximum residual energy routing protocol is better than the Hybrid multi-hop LEACH routing protocol in terms of energy consumption of sensor nodes and the extensive improvement of network lifetime. In future work, the authors will enhance and validate the multi-hop MDC based clustering routing protocol by a multi-channel concept at the base station to directly allocate the channel for the MDCs instead of a single channel.

REFERENCES

[1] Arshad, M.; Kamel, N.; Saad, N.M.; Armi, N.; , "Performance enhancement of wireless sensor nodes for environmental applications," Intelligent and Advanced Systems (ICIAS), 2010 International Conference on, vol., no., pp. 1-5, 15-17 June 2010.
[2] Muhammad Arshad, Nasrullah Armi, Nidal Kamel, N.M. Saad, "Mobile data collector based routing protocol for wireless sensor networks," Scientific Research and Essays Vol. 6(29), pp. 6162-6175, 30 November, 2011, ISSN 1992-2248 ©2011 Academic Journals.
[3] Arshad, M.; Saad, N.M.; Kamel, N.; Armi, N.; , "Routing strategies in hierarchical cluster based mobile wireless sensor networks," International Conference on Electrical, Control and Computer Engineering (INECCE), 2011, vol., no., pp.65-69, 21-22 June 2011.
[4] Muhammad Arshad, Mohamad Alsalem,Farhan A. Siddqui, N. M. Saad, Nasrullah Armi, Nidal Kamel; , "Data Fusion in Mobile Wireless Sensor Networks," International MultiConference of Engineers and Computer Scientists, 14 -16 March 2012, Hong Kong.
[5] Arshad, M.; Alsalem, M.; Siddqui, F.A.; Kamel, N.; Saad, N.M., "Efficient cluster head selection scheme in Mobile Data Collector based routing protoc ol," Intelligent and Advanced Systems (ICIAS), 2012 4th International Conference on , vol.1, no., pp.280,284, 12-14 June 2012
[6] Arshad, M.; Aalsalem, M.Y.; Siddqui, F.A., "Multi-hop routing protocol for Mobile Wireless Sensor Networks," Computer and Information Technology (WCCIT), 2013 World Congress on , vol., no., pp.1,6, 22-24 June 2013
[7] Akyildiz, I.F.; Weilian Su; Sankarasubramaniam, Y.; Cayirci, E.; , "A survey on sensor networks," Communications Magazine, IEEE , vol.40, no.8, pp. 102- 114, Aug 2002.
[8] Rehena, Z., Roy, S., Mukherjee, N., "A modified SPIN for wireless sensor networks," Communication Systems and Networks (COMSNETS), 2011 Third International Conference on , vol., no., pp.1-4, 4-8 Jan. 2011.
[9] Manjeshwar, A. and Agrawal, D.P., "TEEN: a routing protocol for enhanced efficiency in wireless sensor networks," Parallel and Distributed Processing Symposium., Proceedings 15th International, vol., no., pp.2009-2015, 23-27 April 2000.
[10] Zhao, J.; Erdogan, A.T.; , "A Novel Self-Organizing Hybrid Network Protocol for Wireless Sensor Networks," Adaptive Hardware and Systems, 2006. AHS 2006. First NASA/ESA Conference on, vol., no., pp.412-419, 15-18 June 2006.
[11] W. R. Heinzelman, A. Chandrakasan, and H. Balakrishnan, "Energy-Efficient Communication Protocol for WSNs," Proceedings of the 33th Hawaii International Conference on System Sciences, 2000.
[12] Gianluca Dini, Marco Pelagatti, Ida Maria Savino, " An algorithm for reconnecting wireless sensor network partitions," in Proceedings of the 5th European conference on Wireless sensor networks (EWSN'08), Roberto Verdone (Ed.). Springer-Verlag, Berlin, Heidelberg, 253-267.
[13] Gandham, S.R.; Dawande, M.; Prakash, R.; Venkatesan, S.; , "Energy efficient schemes for WSNs with multiple mobile base stations," Global Telecommunications Conference, 2003. GLOBECOM '03. IEEE , vol.1, no., pp. 377- 381.
[14] Munir, S.A.; Biao Ren; Weiwei Jiao; Bin Wang; Dongliang Xie; Man Ma; , "Mobile Wireless Sensor Network: Architecture and Enabling Technologies for Ubiquitous Computing," Advanced Information Networking and Applications Workshops, 2007, AINAW '07. 21st International Conference on , vol.2, no., pp.113-120, 21-23 May 2007.
[15] Jeong Hee-Jin; Nam Choon-Sung; Jeong Yi-Seok; Shin Dong-Ryeol; , "A Mobile Agent Based LEACH in Wireless Sensor Networks," Advanced Communication Technology, 2008. ICACT 2008. 10th International Conference on , vol.1, no., pp.75-78, 17-20 Feb. 2008
[16] Lotf, J.; Bonab, M.; Khorsandi, S. A Novel Cluster-based Routing Protocol with Extending Lifetime for Wireless Sensor Networks. In Proceedings of the 5th International Conference on Wireless and Optical Communications Networks, Surabaya, India, 2008; pp. 1–5.
[17] Allirani, A.; Suganthi, M. An Energy Efficient Cluster Formation Protocol with Low Latency In Wireless Sensor Networks. World Aca.