AN ENERGY EFFICIENT MULTIPATH ROUTING PROTOCOL FOR WIRELESS SENSOR NETWORKS USING IPV6

[1]Subhrendu Guha Neogi, [2]Anand A. Bhaskar
[1,2]Assistant Professor,
[1]Department of Computer Science and Engineering,
[1]Sir Padampat Singhania University, Udaipur, India

Abstract: Wireless Sensor Networks (WSNs) plays an important and challenging role and characterized by having specific requirements for the design purposes. Wireless Sensor Networks consist of nodes with limited power are deployed to gather useful information from the field and send the gathered data to the users. In WSNs, it is critical to collect the information in an energy efficient manner. So, in this paper we propose an energy efficient multipath routing protocol. Such an approach can maximize the network lifetime and reduce the energy consumption. An important attribute of WSNs is their limited power supply, and therefore some metrics (such as energy consumption of communication among nodes, residual energy, path length) were considered as very important criteria while designing routing in the paper. Firstly, a cluster head (CH) is selected among nodes located in the event area according to some parameters, such as residual energy. Secondly, an improved ACO algorithm is applied in the search for multiple paths between the CH and sink node. Finally, the CH dynamically chooses a route to transmit data with a probability that depends on many path metrics, such as energy consumption. The technique uses two routing levels. In the first level (intra-cluster), cluster members send data directly to their cluster head. In the second level (inter-cluster), the cluster heads use election algorithm to find a route to the base station. As only cluster heads participate in the inter-cluster routing operation, the method can provide a smooth operation more effectively. To assess the efficiency of the proposed algorithm, we compare the method with some previous routing algorithms. The results show that the algorithm is more effective in routing in terms of cost of the path and energy dissipation. The transmission of information, for the cluster heads node away from the base station (Sink), along the best path was achieved and the energy consuming of cluster heads node was decreased. Meanwhile, not only the node residual energy, but also the distance between the cluster heads was considered for the selection of cluster heads. The simulation results show that this method can prolong the network lifetime, as well as balance of energy consumption among nodes and reduce the average energy consumption effectively. It resulted in the more even distribution of cluster heads. Simulation result indicates that the new algorithm helped to increase in extension of network life compared with other existing routing protocols.

***Index Terms* - WSN, energy efficiency, network life-time, node mobility, scalability, cluster head, clustering algorithm, multipath Routing.**

I. INTRODUCTION

Wireless communication and networking are becoming very predominant due to their flexibility and ease of deployment. Particularly, sensor networks that involve large numbers of small-sized sensor nodes equipped with sensors and radio for wireless operation have found applications in several commercial and industrial areas [1]. The wireless sensor networks (WSNs) technology have been widely applied in military, industry, agriculture and many other areas [1-2]. In the architecture of WSNs, a lot of nodes operate on limited batteries, making energy resources the major bottleneck. Therefore, an economical and frugal management of energy is essential for improving energy efficiency. Because energy consumption due to communication is the major part of the energy consumption in WSNs [3], a high performance routing protocol is often a key requirement in WSNs systems. But there are many defects in sensors in WSN, such as the limited energy power, capability of calculating and resource-consuming. So the algorithm of planning the optimal routing and the related field in WSN need to be studied and applied. The design of routing protocols in WSNs is very challenging due to their inherent characteristics of large scale, no global identification, dynamic topology, and very limited power, memory, and computational capacities for each sensor. Currently, many energy-efficient routing algorithms have been studied with the aim of saving energy [4–6]. In recent years, multi-path routing has been applied to WSN. Research shows that the multi-path routing is effective significantly in the utility of transmission bandwidth, which increases the reliability and fault tolerance of transmission [7]. But its fault tolerance and robustness are poor. That will make a big influence on transmission delay, energy-consuming of node and reliability of data transmission. For the shortage of single path routing, multi-path routing algorithm can reduce the frequency of requests and data delay, so improve the reliability of data transmission and realize the load balance [8]. The multi-path routing scheme is discussed in [9] that helps the source node to establish the multiple routing paths reaching to the destination node and then ranks the multiple routing paths according to the link cost. The routing path with the minimum link cost is considered as the primary path. If the primary path fails, then the source node chooses another optimal routing path as the primary path to continue routing the data. In the scheme of IPv6 Routing, maximum number of the child nodes are defined [10]. When the number of child nodes in the multi-way tree is saturated, some nodes are unable to join the multi-way tree due to the lack of the address resources. The source node establishes the routing path reaching the destination node through building the multi-way tree but the scheme is unable to perform the routing path repair. In addition, maintaining the multi-way tree topology consumes a lot of network resources. In this approach, the cumulative routing costs are adopted as the weights of establishing the best routing path. Moreover, the routing discovery is performed by broadcasting Route Request (RREQ) packets. Thus, a lot of network resources are consumed. The routing scheme based on location information is introduced in [11]. The network is divided into multiple grids based on location coordinates. Each node's address includes its location coordinate. When one node wants to communicate with another node, it launches the routing establishment process according to the location coordinate of the destination node. The solution for integrating networks and fixed IP networks is introduced in [12]. The solution handles the mobility of vehicles based on street layout as well as the distance between vehicles and fixed base stations. The routing scheme based on clusters is proposed that adopts the hierarchical address structure to achieve the hierarchical routing [13]. Improved multipath routing was put forward based on path optimization methods in the WSN. And it can achieve path optimization in WSN, and this method is effective and feasible, which is showed by simulation experiment results in different parameters. This paper is organized as: section 2 is concentrated on the discussion of related methods where section 3 describes the mechanism of energy efficient multipath routing protocol for cluster-based wireless sensor networks, section 4 gives the algorithm for the proposed techniques, section 5 with result and discussion and section 6 concludes the paper.

II. RELATED WORK

A number of routing protocols for WSN have recently being developed to establish different performance metrics like energy efficiency, scalability with the optimization of routing mechanism. Al-Karaki, et al. [14] has classified protocols according to network structure and protocol operation (routing criteria), which is illustrated in Fig. 1. Routing in WSNs is generally divided in two ways: according to the network structure as flat-based, hierarchy-based, and location-based routing, and according to the protocol operation as multipath-based, query-based, and negotiation-based, QoS-based, or coherent-based. This section focuses on hierarchical routing protocols, because hierarchical routing efficiently way to lowers energy consumption within a cluster, performing data aggregation and fusion to reduce the number of messages sent to the BS.

Heinzelman, et al. [15] introduced a hierarchical clustering algorithm for sensor networks, known as Low-Energy Adaptive Clustering Hierarchy (LEACH). LEACH is a cluster-based protocol that applies randomized rotation of the cluster heads to distribute the energy load evenly among the sensor nodes in the network. The operation of LEACH is organized in rounds, each consisting of a set-up phase and a steady-state phase. During the set-up phase, the network is separated into clusters, each with a randomly selected cluster head from nodes in a cluster. During the steady-state phase, the cluster heads gather data from nodes within their clusters respectively, and fuse the data before forwarding them directly to the sink. LEACH provides sensor networks with many good features, such as clustering-based, localized coordination and randomized rotation of cluster-heads, but expends much energy in cluster heads when directly forwarding data packets to the sink.

Lindsey et al. [16] presented an enhanced LEACH protocol. The protocol, Power Efficient Gathering in Sensor Information Systems (PEGASIS), assumes that all nodes have location information about all other nodes, and that each can send data directly to the base station. Hence, the chain of PEGASIS is constructed easily using a greedy algorithm based on LEACH. Each node transmits to and receives from only one of its neighbors. In each round, nodes take turns to be the leader on the chain path to send the aggregated data to the sink. To locate the closest neighbor node in PEGASIS, each node adopts the signal strength to measure the distance of all neighbor nodes. However, the global information of the network known by each sensor node does not scale well and is not easy to obtain. Since a sensor network generates too much data for the end-user to process, it has to aggregate the data.

Energy consumption is one of the most important criterions for the development of autonomous sensor network nodes. To improve efficiency all the sensor network mote designs used duty cycling techniques which means unused motes go to sleep mode with periodic wake up to save power. Battery replacement is not an option for networks with thousands of physically embedded nodes used in technologies to save power such as power-aware computing, energy-aware software or power management radios [17]. The research in WSN has become more and more active and its applications are also extending. However, many of the IPv6 routing lookup algorithms used nowadays cannot adapt to the new requirements of IPv6 and impact the performance of WSN. Hong et al. [18] proposed an improved longest prefix matching routing algorithm based on IPv6. The network prefixes and the destination addresses are transformed into the decimal system and the network prefixes are stored using Scalable Bloom Filter and the destination addresses are stored segmentally to reduce the number of filters. Fast lookup speed is achieved by equitable distribution of the address prefixes. Power Efficient Data Gathering and Aggregation in Wireless Sensor Networks (PEDAP) [19] is based on a minimum spanning tree. PEDAP assumes that the sink knows the locations of all nodes, and that the routing information is calculated by Prim's algorithm with the sink as the root. PEDAP prolongs the lifetime of the last node in the system while providing a good lifetime for the first node. Additionally, sensor nodes transmit the sensed data to the sink via the previously constructed routing path to produce a minimum energy consuming system. Nevertheless, the intermediate nodes consume energy quickly. In the Hierarchy-Based Anycast Routing (HAR) Protocol for Wireless Sensor Networks [20], the sink constructs a hierarchical tree by sending packets (such as CREQ, CREP, CACP, PREQ) to discover each node's own child nodes in turn. HAR avoids both flooding and periodic updating of routing information, but needs to reconstruct the tree when nodes fail or new nodes are added. The drawback of HAR is that it sends and receives too many packets in the network, expending much energy. Camilo, et al. [21] presented a new WSNs routing algorithm based on ACO which can minimize communication load and save energy. Ren, et al. [22] proposed a multipath routing based on ant colony system, which extends the network lifetime.

III. PROPOSED ARCHITECTURE

The energy efficient cluster-based multipath routing protocol (CBMRP) is designed in such a way that it used to search for multiple paths after the cluster is formed. The process of ants moving will result in forming multiple paths between cluster head (CH) and sink. After multiple paths are formed, data will be transferred along the multiple paths. The model of data transmission in CBMRP is shown in Fig. 1.

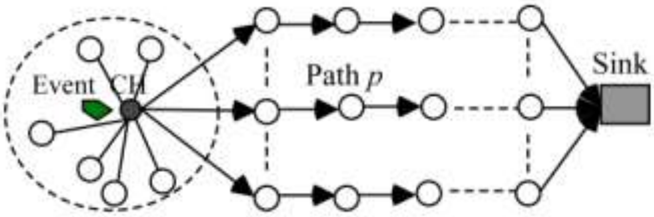

Fig. 1: Data Transmission Model

From Fig. 1, we know that CBMRP can maximize the network lifetime by reducing transmitted data where in clustering data aggregation can reduce energy consumption or by using multiple paths to achieve load balancing which can avoid frequently used paths by locating minimum energy nodes. The network in WSN consists of large number of sensors and modeled as undirected graph G (V, E, W) where V = {v_1, v_2, v_3, v_4, …, v_n} is set of all the node where each v_n has its maximum communication range with radius R and E is the set of all bi-directional wireless links (i,j) where (i,j ∈ V) & e(i, j) ∈ E exists between v_i and v_j if $d(v_i,v_j) \leq R$ [19,24]. It indicates that node v_i and node v_j can directly communicate to each other with distance $d(v_i,v_j)$ where W is the weight of all directed wireless links (i,j) and the weight e_{ij} of link (i,j) is the energy consumption of communication between node *i* and *j*. Let S_e = {v_1, v_2, v_3, v_4, …, v_l} be the set of all nodes in the area where nodes perform the event where S_e is the subset of V ($S_e \subseteq$ V). Nodes can estimate distance based on the signal strength between them and control the radio power. If N nodes are uniformly distributed and communication is symmetric then the formation of cluster head is uniform and nodes are distributed uniformly in each cluster. Let N_i denote the set of neighbors of node i and $N_i = \{j \mid d_{ij} \leq R, j \in V\}$. The energy costs of transmitting and receiving *k* bit data packet between node *i* and node *j* with distance *d* are denoted by E_T(i,j) and E_R(i,j) computed as:

$$E_T(\mathrm{i,j}) = E_{elec} * k + E_{amp} * k * d^{Y} . \qquad E_R(\mathrm{i,j}) = E_{elec} * k \quad . \tag{1}$$

$$E_{trans}(n,d) = \begin{cases} n * \left(E_{elec} + \xi_{fmp} * d^2\right), & d < d_0 \\ n * \left(E_{elec} + \xi_{amp} * d^4\right), & d \geq d_0 \end{cases} \tag{2}$$

$$k = \sqrt{\frac{\mathrm{N} * \xi_{amp} * H^2}{2\Pi * \xi_{fmp} * d^2}} \tag{3}$$

Where $E_{elec}$and $E_{amp}$are the per bit energy dissipation for transmission and reception with γ ∈{2, 4} computed as pass loss exponent. Based on this CBMRP is used to maximize network lifetime (T_{net}) while minimizing the energy consumption between cluster head (CH) and sink can be calculated from MAX(T_{net}), MIN($\sum_{[i,j \in V,(i,j)\in E]} e_{ij}$) where network lifetime is associated with residual energy node with energy consumption and number of hops in path p. ξ_{amp} is the amplified circuit power coefficient for multipath fading model, ξ_{fmp} is the the amplified circuit power coefficient for free space model, n is the number of bits, k is number of clusters, N is total number of sensor nodes distributed in HxH area.

CBMRP is divided into three phases: cluster formation, constructing multipath routing topology and data transmission strategy. The first phase is executed when an event happens to realize dynamic clustering. In the second phase, the CH use election algorithm, to search for multipath routing environment and in the last phase a path is dynamically chosen to transmit data according to evaluation function [23]. The proposed multipath routing protocol is designed to improve the lifetime, latency and reliability through discovering multiple paths from the source node to the sink. Discovery of multiple paths from different portions of a network helps in distributing the network traffic evenly. This will increase network lifetime but at the cost of extra route establishment time. Moreover, in multipath routing the traffic increases significantly due to transmission of the same data from different discovered routes. Therefore, a tradeoff must be made between the reliability, security and energy efficiency when considering the number of paths in the multipath routing protocol. Discovery of multiple paths from different portions of a network helps in distributing the network traffic evenly. This will increase network lifetime but at the cost of extra route establishment time. Moreover, in multipath routing the traffic increases significantly due to transmission of the same data from different discovered routes. Therefore, a tradeoff must be made between the reliability, security and energy efficiency when considering the number of paths in the multipath routing protocol. The nodes in the WSN act as data sender as well as data router. Once the data packet has arrived at an intermediate routing node, it must select the next node having the capability of passing the data packet in the direction of the sink. The selection of the next node is based on gradient information including signal strength, residual energy and others.

Multipath routing is an efficient technique to route data in wireless sensor networks because it can provide reliability, security and load balance, which are especially critical in the resource constrained system such as WSNs. Multipath routing protocols for WSNs are classified into three categories, infrastructure based, non-infrastructure based and coding based, based on the special techniques used in building multiple paths and delivering sensing data. For each category, we study the design of protocols, analyze the tradeoff of each design, summary of design goals, challenges, and evaluation metrics for multipath routing. Multi-path routing protocols in resource constrained systems in general. Multipath routing is an alternative routing technique, which selects multiple paths to deliver data from source to destination. Because of the nature of multipath routing that uses redundant paths, multipath routing can largely address the reliability, security and load balancing issues of single path routing protocols. Thus, multipath routing plays an important role in WSNs and many multipath routing protocols have been proposed in the literary of WSNs research. In this paper, we take an initial step to summarize all multipath routing techniques proposed in the WSN research literary. On the basis of the protocol feature and its specification we classify existing multipath routing techniques into three categories: A) Infrastructure Based, B) Non-Infrastructure based, and C) Coding Based. The major concern of the protocols within category A is to construct and maintain specific multipath infrastructure by considering location and resource capabilities. Protocols which do not build any specific infrastructure and decide the next hop on the basis of its local knowledge are classified into category B. The category C protocols use variant kinds of coding schemes to fragment the data packet at the source node and then send the chunks through discovered multiple paths. In a wireless sensor network, the sensor nodes are resource constrained. Effective and efficient usage of the available resources is a big challenge in sensor networks. Several routing protocols have been proposed for WSN, many of which adopt single path routing techniques and suffer from many problems as we discussed in the previous section. With the help of multipath routing we can use the available resources at each node more efficiently. Multipath routing can overcome significant drawbacks of a single path routing scheme because it can provide reliable data transmission, even distribution of network traffic and data security. Multipath routing can improve security because of the nature of multiple paths. When data is sent from multiple paths, even in the presence of malicious paths, we can get the original data to the receiving end by using reliable paths. With the help of multipath routing, the malicious attacks can be counter measured by increasing the confidentiality and robustness of transmitted data. Moreover, by incorporating the coding technique with multipath routing, the data can be transmitted in an encoded form and only decoded at the destination node, which prevents eavesdrop on the sensing data during transmission. This approach is efficient and is an ideal mechanism in a resource constrained environment because it requires much less energy in encoding and decoding than in communications. Wireless sensor nodes have limited energy supply, therefore efficient use of energy is necessary to maximize the network lifetime. In the single path routing protocol the usage of the same optimal path over and over again may cause certain nodes to deplete their energy at a faster pace, which may cause network partition. Load distribution using multipath routing helps to improve the network lifetime by delaying the appearance of network partition, although more data could be transmitted than that using single path routing. To control the duplicated transmission of the same data via multiple paths, various coding techniques can be used. Using coding techniques, the original data will be fragmented into pieces and those fragments, instead of the whole data, are transmitted through different paths. Thus, load can be distributed to multiple paths and each path transmits much less data compared with an optimal single path. In this way, coding techniques control the increased volume of the total transmitted data and extend the lifetime of WSNs. When considering the same level of reliability, multipath routing can be more energy-efficient.

IV. CBMRP: CLUSTER-BASED MULTIPATH ROUTING PROTOCOL

The algorithm is explained in the following steps:

Step 1: Initialization

Set number of CREP = 0 and status of parent node, CREP send and received, CREQ send and receive as NULL.

Choose BS as parent (node), BS broadcasts CREQ packets, Sensor broadcasts PREQ packets, call election algorithm to select cluster-head (CH).

Step 2: Formation of tree

Select cluster-head (CH) near the sink (BS) and if node elected as CH connect to BS and send request to nodes else node will join CH as leaf in the tree as source node

Step 3: Topology model

- All sensor nodes are started with same initial energy with transmission distance
- Transmission distance calculated between CH and nodes
- Each sensor node can compute the distance d of the source based on the received location information
- Transmitting power of a sensor node is controllable, i.e., transmitting power of a sensor node can be modulated according to the transmitting distance
- Change the flag values accordingly as per transmission and buffer the packets for transmission
- Transmission distance d is the distance between CH and BS

Election of Cluster Head (CH): One time Query for calculating residual energy of each node

CHi = max (R(i) && cost (i))

and CHi = max (Ed (i))

where R is residual energy, cost is the metric of node i and Ed is energy density of node i.

All node elect the CH which has better energy capacity and less energy dissipation

Sleep and Wake-up Algorithm: One time Query for calculating residual energy of each node and when any node initiate or involve in Routing process Wake-up state is activated or else it goes to sleep mode, but most of the time CH is in active state for communication with other nodes. Node will be in standby mode using sleep function when node is not involve in Routing

Step 4: Update Energy of each sensor node

The transmission depends on the residual energy of each node and All nodes need to transmit only to their immediate CH to save energy. If cost of CH goes low then election process will start depending on the threshold value which is the minimum energy among all nodes

Step 5: Each node transmit data during their allocated time slot t and finally data will be transmitted to BS via CH

Each time after selection of cluster-heads (CH) the information will broadcast in the cluster so that each node can send PREQ to establish connection with CH but in case of unicast the broadcast process will be once to minimize the overhead and utilize less energy.

The Energy dissipation during transmission and reception. In case of Unicast Routing there is only one source and one destination of packet. In case of Anycast Routing there are many destination but the CH will deliver the packet to the destination near to the source and accordingly path will be determined. In anycast group the destination cluster head is initiating the routing process. In case of Multicast Routing there are many source and many destination and each packet will be delivered to all possible destination node by using Multicast Group

Step 6: Update energy factor of each sensor node and rebuild the tree

Step 7: After completion of one round repeat step 3 to 5

In case of anycast routing the process is initiated by receiving CH and it will be destination sequenced. The proposed method is using hybrid approach. The routing table formation is dynamic based on different parameter so the proposed method is basically reactive source initiated destination sequenced approaches. In case of multipath routing load balancing between paths is on average weighted basis depending on cost of path.

In the initial state, IPv6 ingress nodes in WSN are preset and their IPv6 addresses are preconfigured. All sensor nodes except IPv6 ingress nodes are in the isolated state and all fixed isolated nodes have a connectivity parameter with the same initial value, which defines the threshold connectivity with which a fixed isolated sensor node can be marked as a cluster head. In the scheme, an isolated sensor node periodically broadcasts an Adv packet within one-hop scope. A fixed isolated sensor node becomes a cluster head or an isolated sensor node joins a cluster to become a cluster member through the following steps:

(1) A sensor node Y within one-hop communication area of an isolated node X receives an Adv packet sent by X. If Y is marked as a cluster member or it is a mobile isolated node then it abandons to process the packet and goes to step (6); otherwise, Y adds X into its neighbor node list. If Y is a fixed isolated node then it decreases its connectivity parameter by 1; otherwise, if Y is marked as a cluster head and has address resources for allocation then it sends a Join_C packet to X and goes to step (3);

(2) If Y is a fixed isolated node and its connectivity parameter is equivalent to zero then it sends a Join_C packet to the isolated nodes in its neighbor node list; otherwise, Y still keeps the isolated state and goes to step (6);

(3) After X (or an isolated node Z in Y's neighbor node list) receives the Join_C packet, if it is in the isolated state and does not return a Res_C packet to other nodes, then it returns to Y a Res_C packet;

(4) If Y is a cluster head and receives a Res_C packet returned by X, then it adds X into its neighbor list and its cluster member list, and at the same time sends an Ack_C packet to X. If Y is a fixed isolated node, then in the predetermined time (the value of the predetermined time is generally set to the total response time of a packet across WSN), Y checks if the total number of the received Res_C packets is equivalent to the threshold connectivity. If it is, then Y marks itself as a cluster head, sets its cluster member list to its neighbor node list, and sends an Ack_C packet to each cluster member in the cluster member list. Otherwise, Y deletes from its neighbor node list the nodes that do not return one Res_C packet, sets its connectivity parameter to the total number of the isolated nodes returning a Res_C packet, still keeps the isolated state and goes to step (6). If a fixed isolated node receives the Res_C packet sent by an isolated node that is in its neighbor node list, then it deletes the isolated node from its neighbor node list and at the same time increases its connectivity parameter by 1;

(5) After X (or Z) receives an Ack_C packet sent by Y, it marks itself as a cluster member;

(6) A cluster's generation process ends, as shown in Figure 3.

In Figure 3, WSN includes 15 fixed isolated nodes and 45 mobile isolated nodes. The initial value of a fixed isolated sensor node's connectivity parameter is set to 6. According to the cluster generation algorithm, six clusters are generated.

From the above process, it can be inferred that only the fixed isolated node whose connectivity is not less than the threshold connectivity can be marked as a cluster head. The goal of the generation algorithm of a cluster is to control the total number of cluster heads and to ensure that the total number of cluster members in one cluster is not less than the threshold connectivity in order to shorten the delay time of IPv6 address configuration and to reduce the cost of IPv6 address configuration.

In the algorithm, the generation of a cluster is associated with the density of sensor nodes. In general, the density of sensor nodes in WSN is high enough to collect enough data for monitoring even if the sensor nodes are unevenly distributed. Therefore, the algorithm can work well even in unevenly distributed networks.

IPv6 address configuration for cluster heads

After a fixed isolated node becomes a cluster head, it needs to join a cluster tree to acquire an IPv6 address. The process of a cluster head X acquiring an IPv6 address is as follows:

(1) X broadcasts a Join_T packet to join a cluster tree;

(2) A cluster head A with an IPv6 address within the coverage area of the Join_T packet receives the packet. If A's address resources for assignment are available, then it returns to X a Res_T packet whose payload is the assigned IPv6 address;

(3) In the predetermined time, X may receive multiple Res_T packets. According to the assigned IPv6 addresses encapsulated in the Res_T packets, X calculates the distance (4 bits are for one hop) from the cluster head, which returns a Res_T packet, to the root node of the cluster tree where the cluster head locates. Then X selects the node F with the minimum distance as its parent node and returns to F an Ack_T packet. At the same time, X records its IPv6 address assigned by F;

(4) After F receives the Ack_T packet, it marks the assigned IPv6 address as Occupied to avoid reassignment;

(5) X successfully joins a cluster tree and acquires its IPv6 address.

From the process of a cluster head joining a cluster tree, it can be inferred that in a cluster tree a father node and its child nodes are within each other's one-hop communication scope. According to Narten et al. [9], the source address of a Res_T packet is the unspecified address and the destination address of a Res_T packet is the all-nodes multicast address. A Res_T packet is broadcasted only within a one-hop communication area, so when a senor node receives a Res_T packet it can determine if it is the packet's destination node by checking the packet's destination link address, which is preset when a sensor node is manufactured.

To generate IPv6 addresses that are globally unique but have low overhead for intra-subnetwork communication, DAS uses both link local addresses created from the 16-bit short address and global unicast addresses from EUI-64. Combining both the addressing schemes, the overhead can be reduced in the sensor network, intra/inter-subnetwork mobility can be supported in the WSN, and each sensor node can be accessed and managed.

V. RESULT AND DISCUSSION

The proposed work is simulated in Network Simulator NS-3 and Contiki based Cooja Simulator to show the nodes deployed in the different types of WSN Topologies. The parameters defined are initial energy, transmission energy, receiving energy, packet size and number of nodes utilized in the simulators for the analysis of the proposed work.

The performance of different protocols compared with proposed model and the performance evaluated on the basis of

- System Life Time
- Energy Consumption and Energy Dissipation
- Node and Sink Life Cycle
- Delay and Latency
- Packet Delivery Ratio
- Packet Overhead
- Routing Overhead
- End-to-End Delay
- Throughput

Simulation parameters required to setup the experiments and these values are set to perform experiments on the basis of the properties of WSN. The performances of the protocols are compared on the basis of the simulation parameters during experimental setup. The initial energy set to 1 J or 2 J as per requirements. The network area is varied from 100X100 m^2 to 500X500 m^2. The number of motes varies from 100 to 500 depends on the scenarios. The MAC protocol can be TMAC or IEEE802.15.4 as per the Routing Protocols used in the experiment. Initial radio energies are default values of WSN. Time interval may vary during experiment and number of rounds may vary as per the type routing protocol and types of communications between nodes. The intensive set of simulation is performed using the values given in the table below. Table 1 shows the parameters applied during simulation throughout all the scenarios.

Table 1: Simulation Parameters

Parameter Name	**Value**
Network Area (maximum)	500 X 500 m^2
Number of Sensor Nodes	100 to 500
Data packet size	512 bytes or 4096 bits
Control packet size	32 bytes or 256 bits
Initial Energy	1 *J*
δ	5 *s*
Sink Speed	Interval of 5 *m/s*
Mobility Mode	Random
E_{elec}	50 *nJ/bit*
ξ_{fs}	10 $pJ/bit/m^2$
ξ_{mp}	0.0013 $pJ/bit/ m^4$
d_0	87 *meters*
E_{low}	0.2 *nJ/s*
Simulation Time	400 to 600 *s*
MAC Protocol	TMAC or IEEE 802.15.4
IP Protocol	IPv6
Energy Model	MICAz energy model

Multipath routing are used to find the alternative routing path with same destination address and it is helpful to reduce routing overhead. Multipath routing is the routing technique of using multiple alternative paths through a network, which can yield a variety of benefits such as fault tolerance, increased bandwidth, or improved security. We have modified exiting multipath routing with IPv6 addressing and the proposed model compared with multipath routing of RPL, LEACH, HRP. The experiment is done using Contiki/Cooja simulators with implementing existing protocols using the simulator.

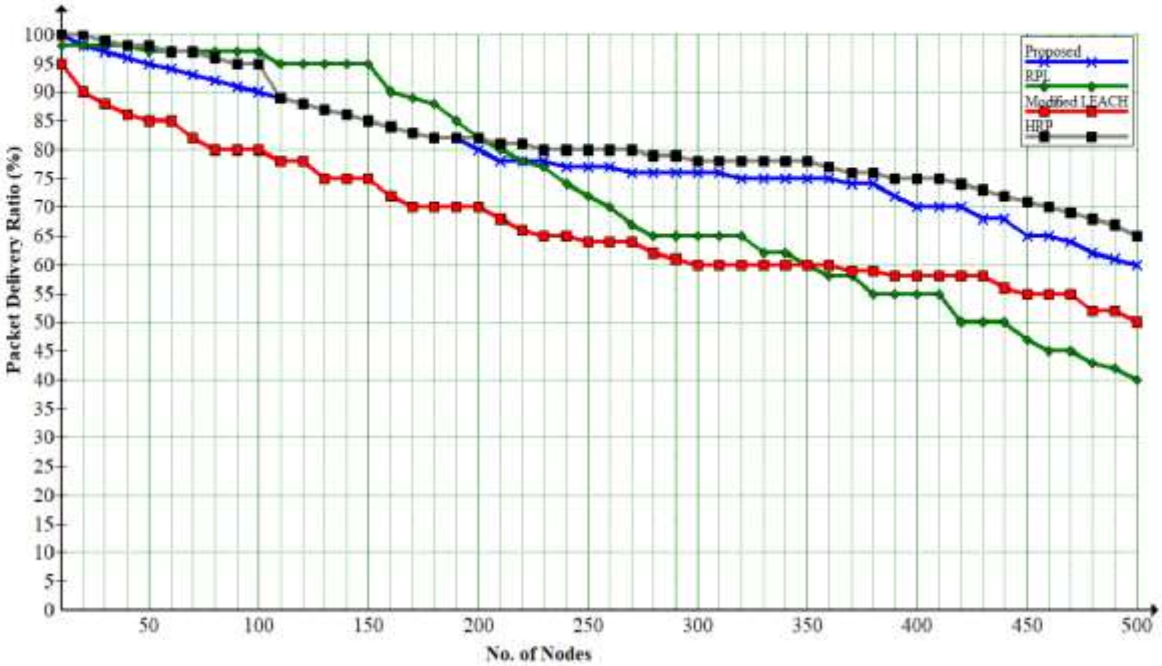

Fig. 2: Performance comparison for packet delivery ratio with varying number of nodes

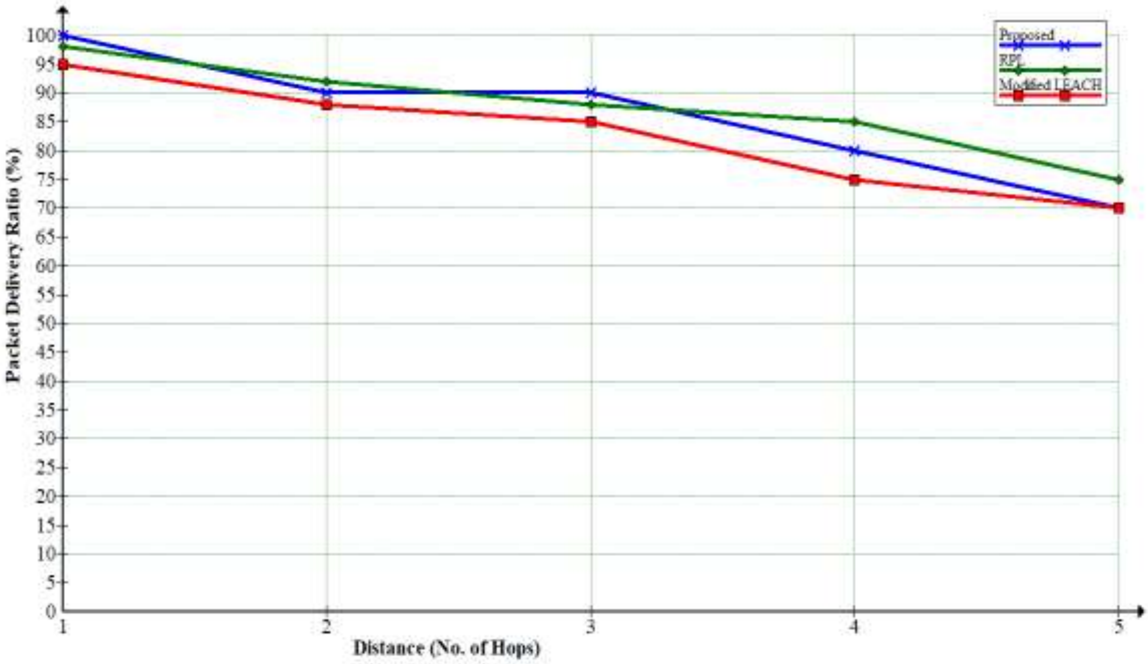

Fig. 3: Performance comparison for packet delivery ratio with varying number of hops

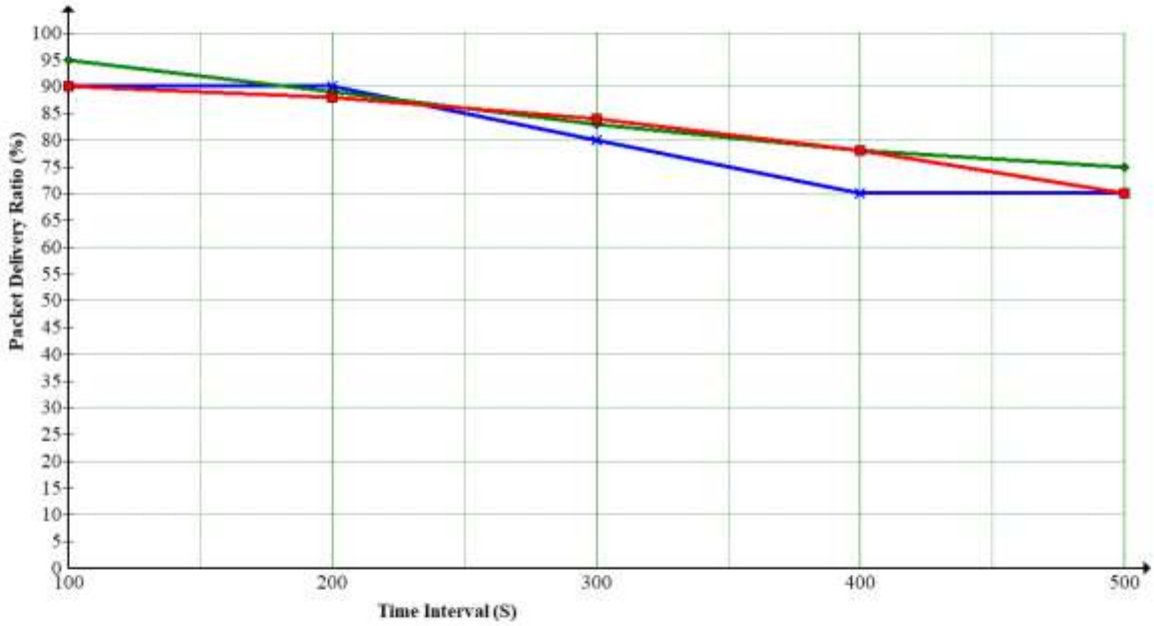

Fig. 4: Performance comparison for packet delivery ratio with varying time interval

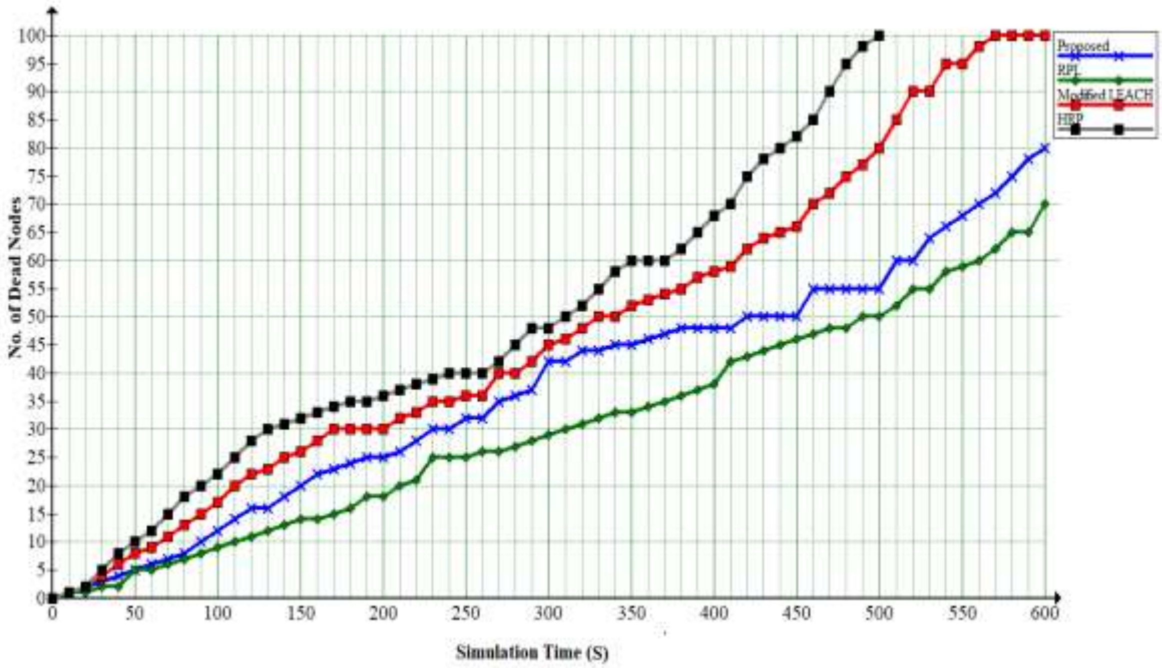

Fig. 5: Performance comparison for System Life Time

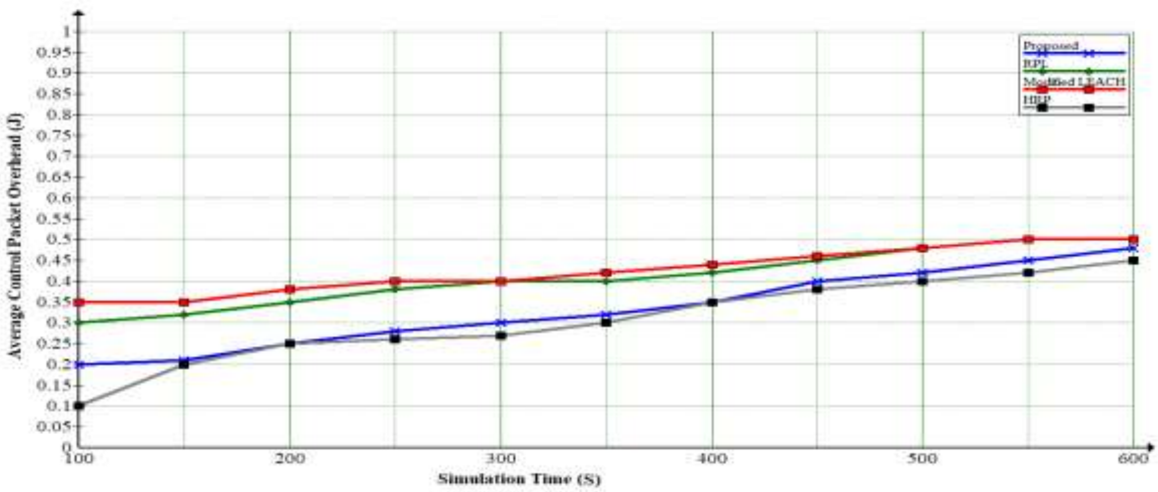

Fig. 6: Performance comparison for Average Control Packet Overhead

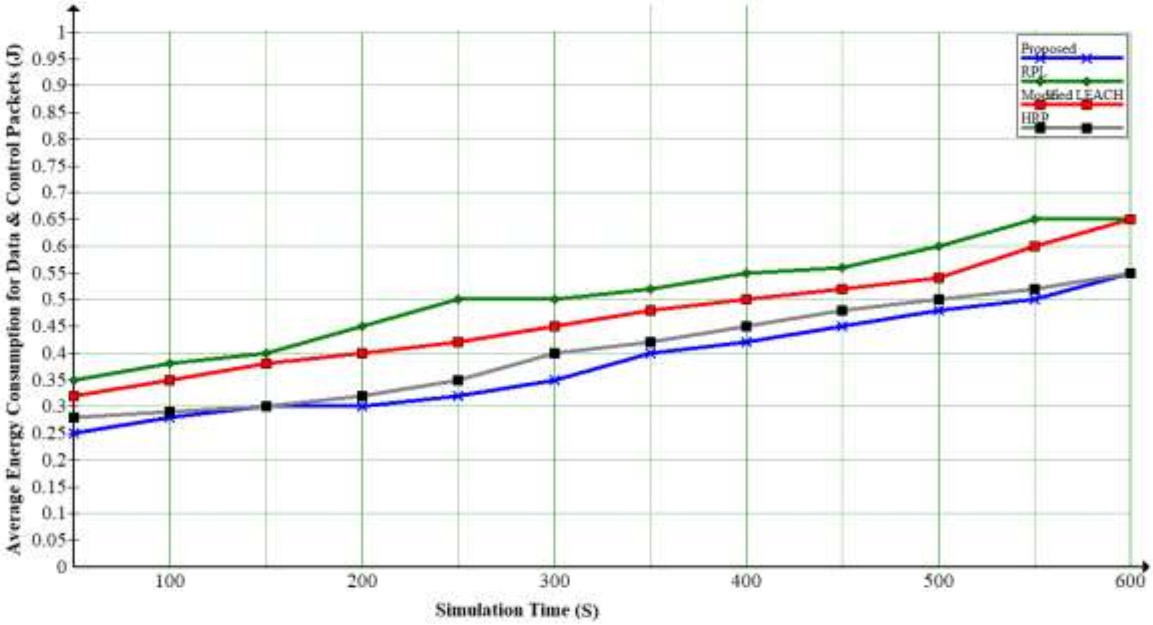

Fig. 7: Performance comparison for average energy consumption

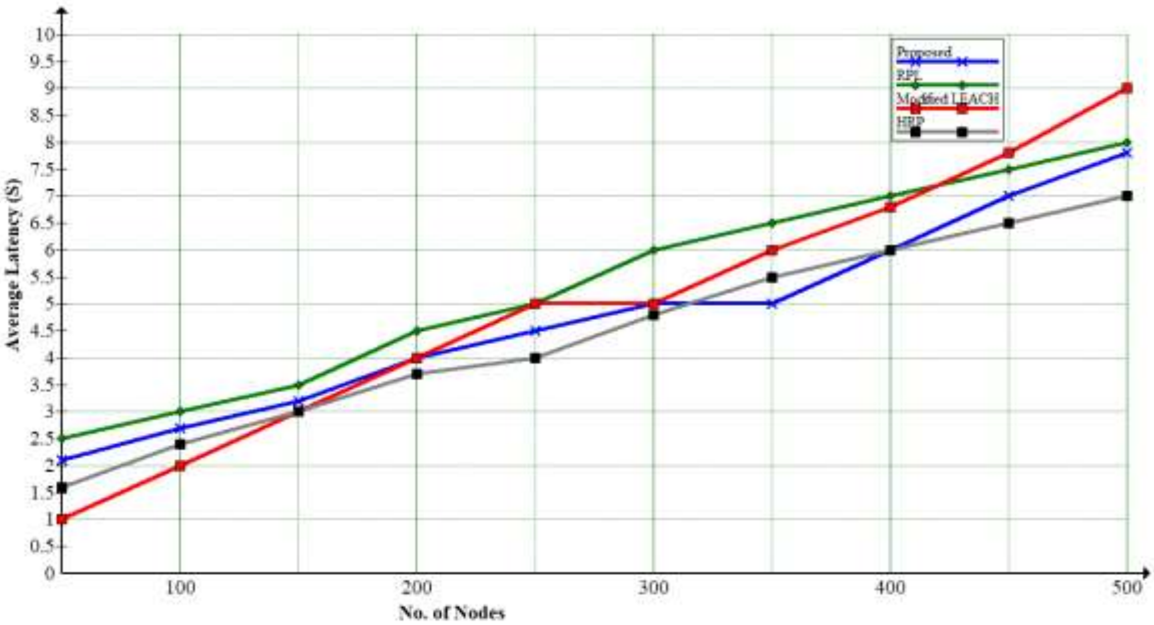

Fig. 8: Performance comparison for Average Latency

Table 4.2 illustrates the performance comparison with higher number of nodes involved in clustering and in such cases network formation is one of the major issues due to energy constraints but the routing protocols can still perform better.

Table 2: Performance Comparison of different Routing Protocols

Protocols	**Performance Comparison**			
	No. of Cluster Heads formed	**Packets to CH from Nodes**	**Packets to Sink**	**Performance**
LEACH	6092	153849	128890	48%
RPL	7441	177590	157950	65%
Proposed	5568	192840	128400	56%
HRP	6160	158000	120800	60%

DACH	7849	358050	250834	78%

VI. CONCLUSION AND FUTURE WORK

The proposed clustered tree based routing protocol with mobile sink has been designed to reduce the data traffic in the network and efficiently manage the mobile sink. The traffic has been reduced by the cluster head, which used aggregation technique. The number of cluster heads is restricted to the number of grids presented in the network. The tree is constructed in the network using the cluster heads as vertices. The data has been transmitted to the sink through the tree structure. The protocol is effective in terms of energy-efficiency, network lifetime, end-to-end latency and data delivery ratio. The proposed energy efficient hierarchy based clustering routing protocol with mobile sink has been designed for the time-sensitive applications, which efficiently transmit the data to the mobile sink. Each sensor node can communicate with the scalable region. Whereas, energy consumption and network lifetime have been improved using IPv6 over WSN. It explored new possibilities for WSN. The research proposals made out of this thesis have opened several challenging research directions, which can be further investigated. The proposed schemes mostly deal with energy efficiency in routing protocol can be further extended to improving energy efficiency in MAC layer. In the design issues of Routing Protocols of WSN, some more important areas and their issues which require more attention by the researchers are mention here. Coverage and connectivity are important open issues for all researchers in related protocols. Random deployment of sensor nodes in harsh environments and limited resources are the main challenges for network coverage. Limited work has been done in this area, so it requires more awareness. One more challenging area is its variants of localization which requires more study by the researchers. From this survey it is clear that most variants of Routing Protocols are distributed in nature and location information is very important for them.

VII. ACKNOWLEDGMENT

We would like to thank Dr. P. Chakrabarti, Dr. Amrit Ghosh and our anonymous reviewers for their very helpful comments on earlier drafts of this paper.

REFERENCES

[1] Razaque, A. and Elleithy, K., 2014, “Energy-Efficient Boarder Node Medium Access Control Protocol for Wireless Sensor Networks”, J. of Sensors, **14**(3), 5074-5117.
[2] Razaque, A.; Elleithy, M.K., “Pheromone Termite (PT) Model to provide Robust Routing over WSNs”, In Proceedings of the IEEE International Conference for American Society for Engineering Education (ASEE), Bridgeport, CT, USA, 3–5, 2014.
[3] Razaque, A. and Elleithy, M.K., “Mobility-Aware Hybrid Medium Access Control Protocol for Wireless Sensor Network (WSN)”, In Proceedings of the 2014 IEEE Sensors Applications Symposium, Rydges Lakeland Resort, Queenstown, New Zealand, 18–20, 2014.
[4] Razaque, A. and Elleithy, M.K., “Low Duty Cycle, Energy-Efficient and Mobility-Based Boarder Node—MAC Hybrid Protocol for Wireless Sensor Networks”, Springer Journal of Signal Processing Systems, 2014.
[5] Kim, E., Kaspar, D., Gomez, C., Bormann, C., “Problem Statement and Requirements for IPv6 over Low-Power Wireless Personal Area Network (6LoWPAN) Routing”, IET FRFC6606, 2012.
[6] Shelby, Z., Chakrabarti, S., Nordmark, E., Bormann C., “Neighbor Discovery Optimization for IPv6 over Low-Power Wireless Personal Area Networks (6LoWPANs)”, IET FRFC6775, 2012
[7] Montenegro, G., Yoo, S. and Kushalnagar, N., “6LoWPAN Ad Hoc on-demand distance vector routing (LOAD)”, IETF, draftdaniel-6lowpanload-adhoc-routing-03, 2005.
[8] Peng, Y., Chang, J.M., “A novel mobility management scheme for integration of vehicular ad hoc networks and fixed IP networks”, Springer’s Mobile Networks and Applications Journal, 15 (1):112– 125, 2010.
[9] Wang, X., Zhong, S., “An hierarchical scheme on achieving all-IP communication between WSN and IPv6 networks”, International Journal of Electronics and Communications,10.1016/j.aeue.2012.10.012, 2012.
[10] Jiang-Ming Chang, Hsin Yun Yang, Han Chieh Chao., “Multipath design for 6LoWPAN ad hoc on demand distance vector routing”, Int. J. Information Technology, Communications and Convergence, **1**(1), 24-40, 2010.
[11] Wang, W., Li, X. and Frieder, O., “k-Anycast game in selfish networks”, Proc. ICCCN, 289-294, 2004.
[12] Wu, B. and Wu, J., “K-Anycast Routing Schemes for Mobile Ad Hoc Networks”. IEEE Proc. IPDPS, 2006.
[13] Xiaonan, W., “Analysis and design of a k-Anycast communication model in IPv6”, Computer Communications, 2008(31):2071–2077.
[14] Al-Karaki J. N., Kamal A. E., “Routing techniques in wireless sensor networks: a survey,” IEEE Wireless Comm., **11**(6), 6 (2004).
[15] Heinzelman W. R., Chandrakasan A., “Energy-Efficient Communication protocol for Wireless Microsensor Networks,” Proc. 33rd Hawaii International Conference on System Sciences (2000).
[16] Lindsey S., Raghavendra C. S., “PEGASIS: Power-efficient gathering in sensor information systems,” Proc. IEEE Aerospace Conference, **3**, 1125 (2002).
[17] Shao, Jie, Ye, Ning, “An estimate cost based algorithm for data aggregation routing in wireless sensor networks, Journal of Computational Information Systems, 2009(5): 1351-1356.
[18] Hong J., Qing-song Y., Xiao-lei Y., “An improved IPv6 routing lookup algorithm of WSN,” Proc. Eighth Int’l Conf. Fuzzy Systems and Knowledge Discovery, **4**, 2234 (2011).

[19] Hüseyin Özgür Tan and Ibrahim Körpeoglu, "Power Efficient Data Gathering and Aggregation in Wireless Sensor Networks, Proc. ACM Conf. on SIGMOD, San Diego, CA, **32**, 66-71 (2003).
[20] Thepvilojanapong N., Tobe Y., Sezaki K., "HAR: hierarchy-based anycast routing protocol for wireless sensor networks," Proc. the 2005 Symp. on Applications and the Internet, 204 (2005).
[21] T. Camilo, C. Carreto, J. S. Silva, and F. Boavida., "An energy-efficient ant-based routing algorithm for wireless sensor networks," in Proc. 5th Int. Workshop Ant Colony Optim. Swarm Intell. (ANTS), **4150**, 49-59, 2006.
[22] F. Ren, J. Zhang, Y. Wu, T. He, C. Chen, C. Lin, "Attribute-Aware Data Aggregation Using Potential-Based Dynamic Routing in Wireless Sensor Networks", IEEE Transactions on Parallel and Distributed Systems, 24 (5) 881-892, 2013.
[23] N.R. Wankhade, D.N. Choudhari, Novel Energy Efficient Election Based Routing Algorithm for Wireless Sensor Network, Procedia Computer Science, **79**, 772-780,2016, ISSN 1877-0509.