Implementation of MPLS Routing in Traditional LEACH

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***Abstract*- Wireless Sensor networks composed of enormous number of micro-sensors are capable of fetching and transporting different types of data to sink. The deployment of sensor nodes need a battery back-up necessary for its normal functioning but practically it becomes impossible for any network to exchange the batteries at regular intervals of time. Therefore, routing protocols having higher energy efficiency are being used primarily to enhance the life expectancy of network. Traditional LEACH (Low Energy Adaptive Clustering Hierarchy) incorporated in Wireless Sensor Networks employs Time Division Multiplexing Access intended for transmission of data from multiple number of nodes to cluster heads and finally from cluster head to base station. In our proposed work, we apply "labels" to each data packet in order to fix the priority bits and then route these priority set packets to the cluster head and then fused data-cells are routed to the base station using multi-protocol label switching tunneling algorithm. Using the MPLS (Multi-Protocol Label Switching) routing in LEACH will transform it into multi-hop which will reduce the average energy dissipation of cluster head in each cluster and results incrementing the life-time of network. Relay Nodes that are higher power nodes are used to collect and send the data from cluster head to sink in order to decrement the energy loss in each cluster head.**

Keywords- Tunneling; Label; Relay nodes; Clustering; Label switching.

I. INTRODUCTION

Recent advancements in Wireless sensor network (WSN)[1] are intensively motivated by various industrial as well as consumer applications such as battle surveillance applications, region monitoring, medical applications and so on. It provides massive amount of benefits by inculcating remote sensing points without any cost of running wires which includes energy as well as material savings, labour savings which results in improvements in processing and productivity.

Internet Protocol was the very first defined routing protocol intended for various commercial applications, lately replaced by Asynchronous Transfer Machine (ATM) that applies the concept of Packet Switching but due to the limitations of large header length, it's not widely adopted. Hence, Multi-protocol Label Switching (MPLS) technology has been introduced that inculcates and combines the concept of circuit and packet switching networks.

II. RELATED WORK

LEACH [2] implies for Low Energy Adaptive Clustering Based Hierarchy and basically a clustering based protocol [3] having self configurable capability. In this protocol, sensor nodes appoint themselves to be local cluster heads prone to randomized rotation depending on a certain probability in given time interval. This randomized rotation is employed to keep node energy more balanced. Here, cluster head is responsible for collecting data from other sensor nodes in their respective clusters as well as for data fusion [2-5] to reduce the data size to be sent to the sink which minimizes the energy consumption and enhance the life expectancy of network.

The cluster heads are never elected a priori and do not remain stationary throughout the life period of the system because it will result in decrementing shelf life [6] of unlucky sensors that are chosen out to be cluster heads. Thus, the LEACH protocol will imbibe randomized assignment of high energy cluster head position in order to increase the lifetime of WSN.

The entire operation of LEACH is divided into rounds named as the set up phase and the steady state phase. Setup phase is the phase during which the clusters are organized. During the next phase, transmission takes place between different cluster heads and the base station. Initially to determine the cluster head for any network, the decision is made by node choosing a random number 'k' between the numbers 0 and 1. If the number is less than a threshold value T (m), node will become a cluster head for the respective current round and the threshold function is defined as:

$$T(m) = \begin{cases} \frac{P}{1-P*(r \bmod (\frac{1}{P})} & if\ m \in G \\ 0 & Otherwise \end{cases}$$

Where, P = the desired percentage of nodes (cluster heads), r = number of current rounds and G = set of nodes that have not become cluster heads in the last (1/p) rounds.

A. First order radio model[8]-[10]

In our work, we assume a simple first order radio model [7] where the considered radio characteristics are as follows:
Energy Dissipation at

Transmitter (E_{Tx}) = *50 nJ/ bit*
Receiver (E_{Rx}) = *50nJ/ bit*
Amplifier (E_{amp}) = *100pJ/bit/ m^2*

Let ($E_{Tx} = E_{Rx}$ = E) and
Energy loss due to channel transmission: l^2
If we transmit N-bit message a distance 'l'. Applying this model as shown in Fig 1 ; it gives:
To Transmit,

$$E_{Tx}(N, l) = E_{Tx}(N) + E_{amp}(N, l) \quad (1)$$

$$E_{Tx}(N, l) = E * N + E_{amp} * N * l^2 \quad (2)$$

To Receive,

$$E_{Rx}(N) = E * N \quad (3)$$

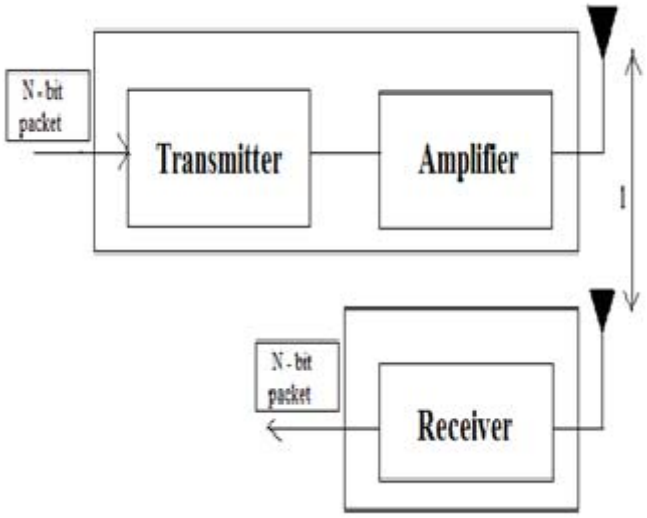

Figure 1: Block diagram of radio model

In our work, we have assumed a symmetric radio channel where each sensor nodes are sensing the surroundings at a constant rate and thus always have information to transmit to the end-user.

Diverse qualities of service (QoS) [9] parameters are being offered by the internet protocol for an increasing number of users and for a wide variety of networking services. Internet protocol is the best substitute considered for traditional circuit- switched networks as it provides certain degree of QoS guarantees.[10] Certain technologies like differentiated services (DiffServ) and MPLS are therefore incorporated to enhance the QoS capability of internet protocol networks, thus paving the way for future services portfolio.

In DiffServ, when the traffic enters the network, it is classified, policied and modeled in such a way that it can be conditioned at the edges of the network. DiffServ is a simple model that assigns different behavior aggregates to each traffic point. Thus, each behavior aggregate is identified by a single DS Code Point (DSCP). DSCP always associates the Per-Hop behavior (PHB) to the fast forwarded packets at the core of the network. The DiffServ is associated with different forwarding treatments and varied QoS levels as it assigns different classes to the traffic of DSCPs.

MPLS is an up gradation to DiffServ that integrates the label swapping forwarding paradigm with network layer routing mechanism. Label Switched Paths (LSP) [11] are explicit ways that are created by using a signaling protocol. A label is used in the packet header instead of using an IP source – destination address for forwarding the packets in the MPLS domain. Label Switched Routers (LSRs) are the main routers used in this domain. To designate routes of different granularity ranging from coarse to fine, the myriad technology of MPLS & DiffServ merged with Bandwidth constrained routing results in QoS provisioning. The LSPs must be aggregated.in order to decrease the label-state sizes in MPLS domain. LSMP (Label Switched Multi-Path) are used for imbibing deterministic QoS in internet protocol network using a purely connectionless approach. MPLS is implemented by route planning in internet networks. The packets are assigned with labels using specific meaning under the label switching scheme. The constrained based routing and traffic engineering methods are employed to increase QoSR (Quality of Source routing) [11] from one ingress router to the egress router through Label Switched Paths (LSPs). Multipoint-to-point aggregation is based on the rule that if two packets received by a router follow the same path starting from router to destination then they must possess the same label. To compute the routes between different routers, constraint based routing is used. The constraint based routing consists of Bandwidth constrained routing comprising of explicit routes and QoS constraints. The two factors that are responsible for QoS degradation of flows include network congestion and route flapping. Dynamic routing is used that will decrease blocking probability and increases resource utilization and availability.

Resource Reservation Protocol with Traffic Engineering Extension (RSVP-TE) also named as Constrained based Routing Label Distribution Protocol (CR-LDP) is used for establishment of resource reservoir. The packets are always forwarded with Forwarded Equivalence Class (FEC) [12] in

MPLS domain. The packets having the same FEC will follow the same route in the MPLS domain. Network service providers traditionally use a variety of methods to provide quality of service to the customers. Service guarantee or Service Level Agreement (SLA) is defined as the service contract that consists of specific criteria that defines certain aspects of service guarantee and quality metrics in order to evaluate performance bound values such as average packet loss and delay bounds for customer traffic.

Internet service provider using the MPLS technology has the advantages of:

1. It provides a flexible support for a wide variety of sources and service models for delivering high quality internet protocol based services.
2. SLAs can be used to predict the network performance.
3. To build reliable and survivable mission-critical services in order to provide access to public and private services.

The main fundamental building blocks of MPLS are:

A. Label swapping forwarding algorithm.[11-12]
B. Different control and forwarding components.

MPLS is a multilayer switching solution consisting of two distinct functional components:

A. Control component.
B. Forwarding component.

Standard routing protocols such as Open Shortest Path First (OSPF), Border Gateway Protocol (BGP) and Intermediate Systems to Intermediate Systems (IS-IS) are used to exchange the entire information with other routers to build in order to maintain a forwarding table. During the arrival of packets, the forwarding component will search for the forwarding table to create a routing decision for each packet. The forwarding component looks for the information contained in the packet's header then searches the forwarding table and forwards the packet via system switching fabric. In MPLS networks, labels are embedded in packets as label is considered as the short fixed length value carried in packets header to classify and identify a FEC. A label is analogous to a connection identifier.

Labels are not meant to encode information from a network layer. An FEC is defined as the set of packets that are intended to get forwarded over the same path through a network even if their ultimate decisions are different.

Using a label swapping algorithm, label switches ignore the packets network layer header. When a labeled packet is reached at a switch, forwarding component uses the input port number and label to perform an exact match search [12]. The role of forwarding component is to change the incoming label with the outgoing label and the packet is then directed for transmission to the next hop in LSP. When labeled packet is arrived at the egress label switch, the forwarding table is searched by the forwarding component. If the next hop is not a label switch, the egress switch will discard the label and the packet is forwarded using conventional longest match.

III. PROPOSED WORK

The basic self organizing adaptive clustering protocol that distributes the energy load among the sensors in the network uses randomization of cluster heads is LEACH. In this protocol, usually Time Division Multiple Access (TDMA) [7] scheduling has been done to transmit the data from different nodes to the cluster head.

In our proposed work, the formations of local clusters are followed by the selection of cluster- heads that finally connects to the base-station via different high energy relay nodes. MPLS labeling is being employed in each packet stream belonging to each node to transmit the data to the cluster head and then to the base station. The labels will comprise ToS (Trade of Service) bits as in IP header so that packets with high priority will get routed first to the cluster head. Then, the cluster head will perform the data fusion and data aggregation according to the priority of packets to get finally routed to the base station.

Usually, the data packets contain "beacons" that will contain the source and destination address. Here, implementing MPLS labeling in WSN will use QoS routing (QoSR) to ensure certain parameters as delay, delay jitter, bandwidth, packet loss, cost etc.

In QoSR, high priority means there will be a direct mapping of 3 bits carried in internet protocol precedence of incoming internet protocol header to a label field. From Cluster head to Base station, we propose the MPLS routing algorithm consisting of Bandwidth differentiated routing algorithm.

The fused data will reach the sink or destination through min-cut link path, that possess the highest capacity that means the fused data cell from each cluster head will choose the link with minimum weight of links over the path. The weight of each link is always determined by the number of hops from source to destination and the amount of congestion in the network.

In the proposed algorithm, the links or LSPs occurring between cluster heads and sink in bandwidth differentiated algorithm is based on residual bandwidth value. The forwarding of packets will be done on ToS value [12-16] of the fused data cell. Bandwidth differentiation algorithm will

be used to perform the classification of links on the basis of the upper bounds of bandwidth value on every links. Hence, min-cut links L_{mc} [13] should be used and they are differentiated into four categories based on the values of bandwidth.

If bandwidth of link "i" <= link threshold bandwidth (T_{high}), it will be classified as CATEGORY 1.If bandwidth of link "I"<= another threshold bandwidth (T_{low}), it will be classified as CATEGORY 2. The set of links that are neither included in CATEGORY 1 nor CATEGORY 2 will be included in CATEGORY 3. And, set of non min-cut links……..$L_{mc(non)}$...are included in CATEGORY 4.

A. CALCULATION OF CRITICAL LINKS(L(j))

To reduce congestion in the links and for the weight calculation, the concept of critical links can be used along with the differentiation of links.

$$L(j) = \frac{Total\ demands\ per\ link}{Length\ of\ all\ possible\ connections} \quad (3)$$

Since, calculation of critical links depends upon the future demands and requests, the higher values of critical links should be avoided in order to reduce congestion.

Calculation of link weight:

Here, weight of link "i" could be determined by:

$$W(j) = \frac{L(j)}{Residual\ bandwidth\ of\ each\ link} \quad (4)$$

Since, weight of the link is directly proportional to the value of critical links and therefore critical links should be less. So, weight of each should be less to balance the loads through under-utilized paths so that residual bandwidth of each link should be more thus having more bandwidth utilization.

Weight of paths (W(S, D)) :

$$W(S,D) = \sum W(j) \quad (5)$$

Where, W(S, D) [15] is the net path weight from Source S to destination D.

Path weight is used to route the packets from ingress path to egress path through LSP (Label Switching Path). Priority constrained routing also states that higher path should be avoided. If several paths exist having minimum path weights, this algorithm would put a shortest path to reserve network bandwidth.

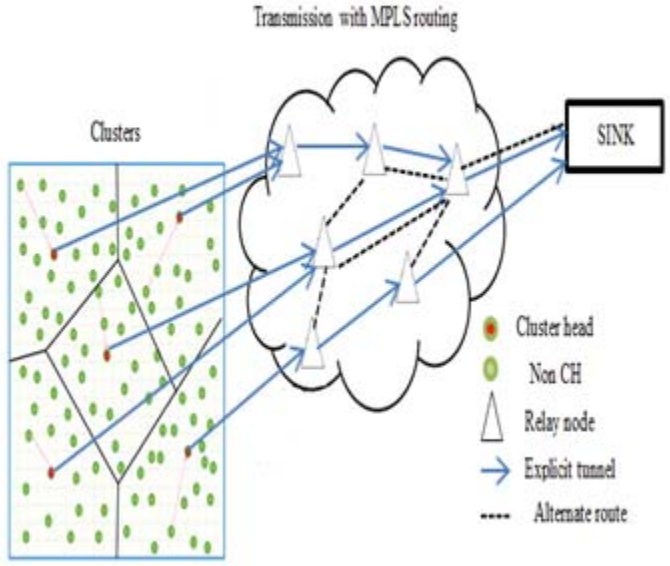

Figure 2: Illustration of MPLS based LEACH protocol

Figure 2 shows that packets from nodes to respective cluster head will be transmitted according to its precedence bit, mapped into EXP Field [14-17] of MPLS label. Then at the cluster heads, the entire packets with ordered priority will be aggregated and fused and finally transmitted to the sink. The prioritized data cell from Cluster head to sink can follow the LSPs or tunnels having highest residual bandwidth. If such multiple paths are existing then the routing will follow the critical link algorithm to compute min-weight of the links.

IV. RESULTS

In order to trace the efficiency of our proposed algorithm, we have implemented MPLS- based LEACH in MATLAB 7.6 and compared the results of average energy of cluster-head versus traditional LEACH and verified that dying rate of cluster head in MPLS based LEACH is comparatively less.

Simulation Parameters are as follows:

We have considered a 100 node network randomly deployed in an area of 100m x100 m field where base station is located at (50, 300), 10 relay high power nodes are being used and all the other parameters are taken as per the first order radio model and data packet length is 2000 bits.

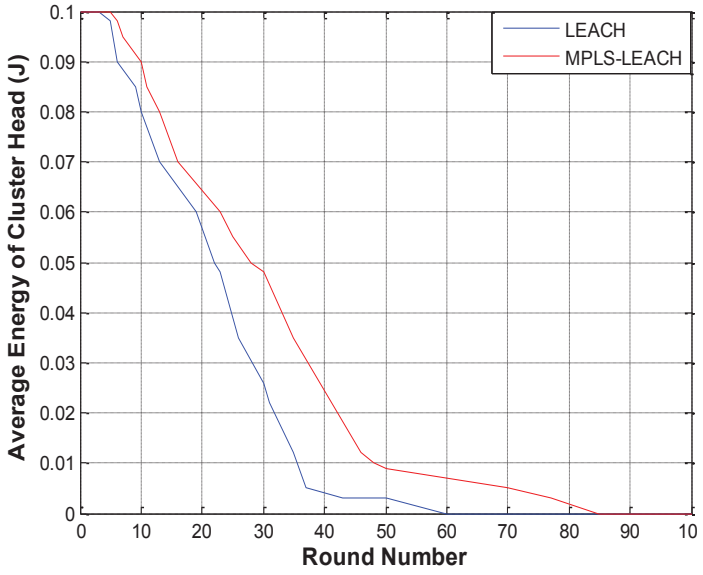

Figure 3: Traditional LEACH versus MPLS based LEACH.

Figure 3 shows that the average energy of each cluster head is saved and the average time for dying out of cluster head for MPLS leach will increase substantially as compared to traditional LEACH.

V. CONCLUSION

The proposed algorithm gives better results in terms of Average energy dissipation of cluster heads as the prioritized data cells are transmitted to the relay nodes first and then will select the high bandwidth residual paths. If there are number of paths, then they will follow the shortest path algorithm or min hop algorithm to get routed to the base station. Thus, leading to a decrease in packet – drop at the destination. This algorithm making use of relay nodes will modify traditional leach into multi-hop leach with prioritized packets transfer.

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