Advanced ICH-LEACH protocol for Wireless Sensor Network using Optimization Approach

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Abstract: Wireless Sensor Network (WSN) can be deployed in different applications like Medical analysis, Climate change observation, Military support applications, mechanical stress in bridges and building etc., and more energy efficient WSN is required for seamless performance of such tasks. Several research and implementation have been done towards the energy-efficient protocols for routing in WSN. LEACH is one of the well-known and popular energy-efficient hierarchical routing protocols that further amended into other protocols. Experimental results shows that comparative accuracy of the LEACH protocol is need to be improved for accurate CH selection. Here, will propose a new version of LEACH protocol named as OPT-RS-ICH LEACH (Optimized Route Selection for Intra Cluster Head Selection based LEACH Protocol) with a change in implementation, which would show that it's better than the ICH-LEACH. In order to improve the energy consumption in intra-cluster and inter cluster communication, we introduce ACO (Ant colony algorithm) for selecting the energy efficient route to transmit the data to their respective CH nodes. The simulation proves that our proposed protocol extends the network lifetime by reducing the energy consumption.

Keywords: WSN, Routing protocol, Energy efficiency, Cluster head selection, LEACH, ICH-LEACH, OPT-RS-ICH-LEACH.

I. Introduction

WSNs are generally known for economical and rapid deployment for applications that usually do not require much human supervision. The sensor nodes in WSNs are usually battery operated limited energy operated sensing devices. Therefore, efficiency of the energy is one of the most important considerations while modelling any protocols for routing in WSN as it decides the lifetime of any node. Practically, WSNs have been considered for applications that are suitable to work with constraints like limited power, short range communication and of course, economical along with an efficiency to provide reliable data transfer [1].

Wireless sensor network (WSN) is formed of multiple sensors which transfer the data that they gather to a special node called base station. In fact, there are multiple applications for WSN like industrial applications (Monitoring, control of machines), health care analysis, environment, traffic control, agriculture monitoring and home automation. However, routing process between nodes consumes a lot of energy which determines the network's lifetime. Furthermore, there are two categories of WSN routing protocol level routing and plane routing. In the last category, we have multiple protocols like DD [3], SPIN [4], SAR [5] etc. In the first category, there are numerous protocols like TEEN [6], LEACH [7] etc.

The wireless sensor network has the ability to interact with environment using scalar sensors. The extracted information could be used in many applications such as wireless communication, computer vision, etc. So, the collected data could be sent to different destinations via the sink. In fact .WSN has the following characteristics: Resource constraints, application-specification, High bandwidth demand. [2].

1.1 Routing Protocols

The routing protocols are classified according to various routing techniques used in WSN [8]. The routing techniques used in a WSN are classified according to network structures, protocols' operations and routing processes that decide the routing algorithms for routing protocols.

1.2 Routing Models

In WSN, a routing protocol generally coordinates activities of transmission of sensed data by the sensing nodes to the BS within. Thus, following three models have been categorized for the routing protocols in WSN [9]:

1.3 One-hop model

One-hop routing model [10] is the best known model to represent a direct communication since, the information transmission only and only happens from all sensor nodes to BS within a network. However, due to restricted range of transmission of sensor nodes, the direct communication may not be sensible for routing in WSN, therefore, it's not preferable for practical purposes.

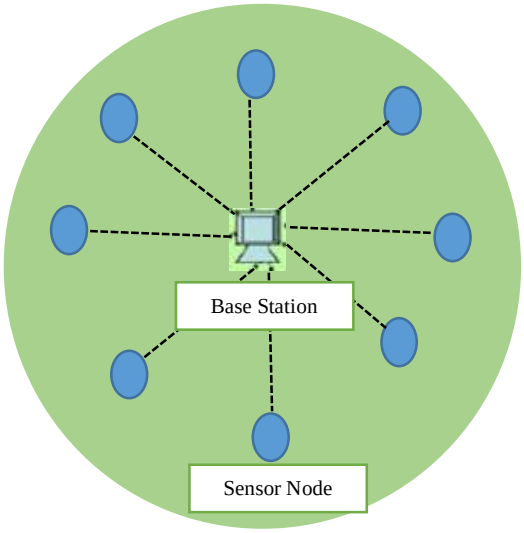

Figure 1: One-Hop Routing Model

1.4 Multi-hop Model

In multi-hop routing model [11], a sensor node sends the data to one of its neighbouring nodes which is closer enough to the BS and after multiple hoping the data finally reaches to the BS from a particular source sensor.

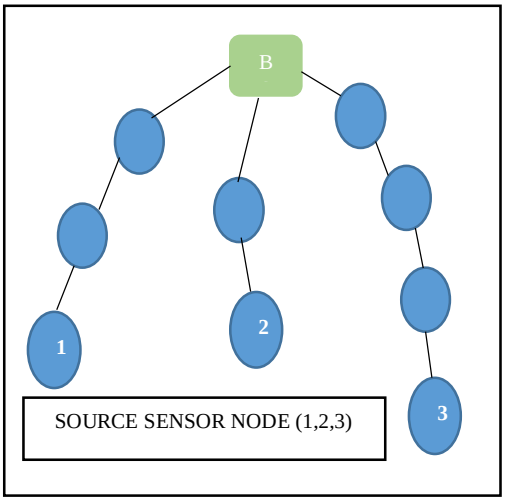

Figure 2: Multi-Hop Routing Model

1.5 Cluster-based hierarchical Model

Cluster-based hierarchical routing [12] is modelled for energy efficiency purpose in which sensor nodes are packed into a cluster with a single assigned CH to transmit data towards BS, thus, it's practically, suitable for the hierarchical routings in WSN. In this model, a node could be a CH for one cluster and also a member for other(s) which is nearer to the BS.

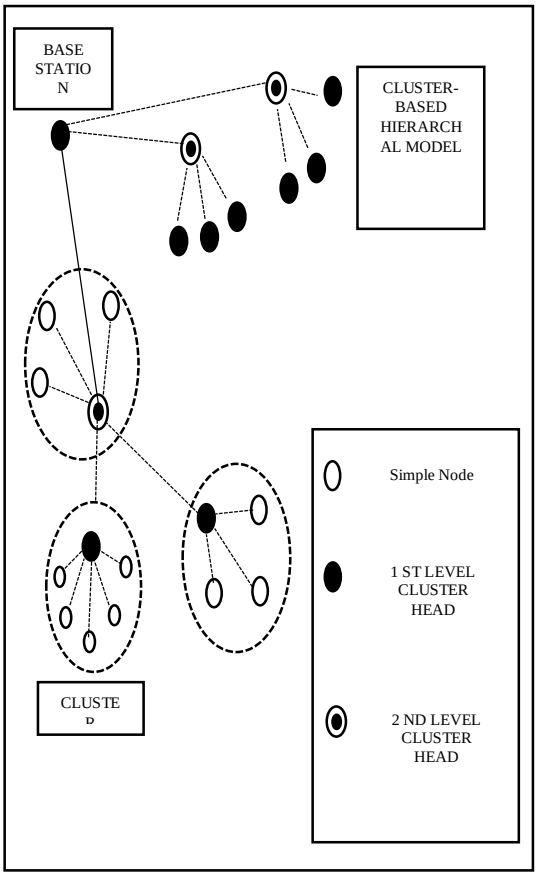

Figure 3: Cluster based Hierarchical Model

ICH-LEACH is one of the energy efficient hierarchical routing protocols. So, it's important to know the basic structure and function of hierarchical protocols along with basic LEACH with which a comprehensive comparison based research on ICH-LEACH has been done.

II. RELATED WORK

LEACH protocol [7] was propounded by Wendi B. Heinzelman. It divides the simulation time into equal period of time called round. A round is formed of two phases: cluster setup phase and steady phase. In the first phase, every node chooses to be a cluster head or not for the current round. This choice is made by using a random number between 0 and 1. Then, the chosen number is compared to the threshold T (n).

In [13], author deals the extension to LEACH protocol i.e. Modified LEACH protocol has been analytically and critically analyzed. It has been shown that the hard threshold value in Modified LEACH protocol has a direct impact on the network lifespan of a wireless sensor network. More the initial energy more will be the net lifetime of the network, as the number of alive nodes will be more. Simulation and analytical results reveal that the Modified LEACH protocol outperforms the traditional LEACH in every aspect.

In this author [14] said about compare our protocol in transferring images with other Leach protocol descendants.

By using the application layer, we applied the jpeg compression using the frequency domain on images before sending them to the network. In this paper, readers will find statistics concerning the lifetime of the network, the energy consumption and most importantly statistics about received images. Also, we used Castalia framework to simulate real conditions of transmission simulation results proved the efficiency of our protocol by prolonging the lifetime of the network and transmitting more images with better quality compared to other protocols.

In this author [15] propose a novel energy aware routing protocol, known as Energy Residue Aware (ERA) routing, to prolong the lifetime of a sensor network by balancing the energy consumption of the network. ERA enables each sensor to select a best route from possible candidate return paths. A path with a maximum sum of energy residues would be selected instead of that path with minimum power consumption.

In [16], ICH-LEACH is one of the energy efficient hierarchical routing protocols. So, it's important to know the basic structure and function of hierarchical protocols along with basic LEACH with which a comprehensive comparison based research on ICH-LEACH has been done.

III. Proposed Work

Here, will propose a new version of LEACH protocol named as OPT-RS-ICH LEACH with a change in implementation, which would show that it's better than the ICH-LEACH. In order to improve the energy consumption in intra-cluster and inter-cluster communication, we introduce ACO (Ant colony algorithm) for selecting the energy efficient route to transmit the data to their respective CH nodes. So that the CH nodes will search for SINK node and transmit the data to the sink in an energy efficient optimal path. In proposed method, pheromone computed to be placed on the path during return journey is not proper to reflect that path as the optimal during the simulation period. Strongest path should have largest amount of pheromone whereas weakest path should have least amount of zero. Among the competing stronger paths for selection, the variations in pheromone concentration should be such that always strongest path is selected.

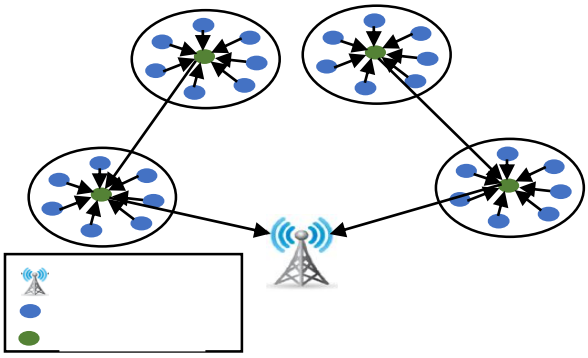

Figure 4: Structure of ICH-LEACH

The figure 2 shows that the ICH-LEACH structure. Here cluster head selection depends on parameters like distance, residual energy, and attenuation factor. In this protocol, some communications between cluster head and sink, based on intermediate cluster heads.

A. Initialization phase:

When the simulation starts, the sink broadcasts its coordinates to all the members of the network using a packet. Once a node receives the coordinates, it stores them along with the strength of signal of the packet. In fact, the coordinates of the sink will be used by the elected cluster-heads to decide whether to send data directly to the base station or not.

B. Cluster setup phase:

In the setup phase, each cluster head promotes itself to other non-cluster-heads in order to get members. Also, it sends its coordinates and its distance from the sink to other cluster head. When another cluster-head receives the coordinates and the strength of the signal, it stores them with the sink's information. Therefore, each cluster head has a complete routing table of all cluster members. This routing table is created once every round, and it's updated only when a cluster head received information of a neighbor cluster members.

C. Steady phase:

In this phase, every cluster-head is assigned to its members a frame window to send the collected data using TDMA. Once it's the turn of the cluster-head to send, it sorts the routing table that has been gathered. Here all cluster heads selection based distance, residual energy, and attenuation factor parameters. After selection of CH's, send the information to SINK. Here some cluster heads send the data to SINK by using intermediate cluster heads.

After ICH-LEACH routing process, ACO applied and followed in below steps:

1) Initialization of network process
2) Source node request for destination based on selection procedure for hop nodes
3) Randomly place nodes in network
4) Build the location of destination
5) Using ACO method and select the routes for knowing path for sending the data
6) Check the all neighbor nodes for select the best routing path
7) There are two working models for the ants: forward and backwards

8) The ant node memory allows them to retrace the path it has followed while searching for the destination node

9) Before moving backward on their memorized path, they eliminate any routes form it. While moving backwards, the ants leave pheromone on the arcs they traversed.

After selecting routing path, data transmission from source to destination.

Psedocode of Proposed system:

N= total number of nodes

D = distance between nodes; RE = Residual energy; AF = Attenuation Factor

R = Routes between the nodes

C [N] = Cluster node

CM [N] = Cluster member

CH [N] = Cluster head

PH [N] = Phenomena value

DT = Data transmission

NH = next hop

For I = 1: N

For each node CM [N]

Compute D

Compute RE

Compute AF

If { [D (CM [N]) <= D (CM [N+1])] || [RE (CM [N]) >= RE (CM [N+1])] || [AF (CM [N]) <=AF (CM [N+1])] }

CN = CH [N]

Else

NH = (CM [N])

End If

End For

///////ACO Process starts////////

For I = 1: N

Compute R

For each node R [N]

Compute PH

Compute D

If { [D (R [N]) <= D (R [N+1])] || [PH (R [N]) >= PH (R [N+1])] }

NH = R [N]

Else

NH = (R [N+1])

End If

End For

For [DT [N]]

Broadcast RREQ

IF [receive (RREP) == true]

Transmit the Data

End For

End

IV. Results and Discussion

Performance assessment and comparison of proposed scheme, OPT-RS-ICH-LEACH, against original ICH-LEACH and LEACH have been done using network simulator NS2. The metrics that have been used for performance assessment and comparison are Energy consumption (EC), Average End to End Delay (E-to-E Delay), and Throughput. Simulation parameters are illustrated in Table 1.

PARAMETER	VALUE
Application traffic	CBR
Transmission rate	512 bytes/ 0.5ms
Radio range	250m
Packet size	512 bytes
Clusters	8
Routing Protocol	AODV
Simulation time	10s
Number of nodes	21
Area	1000 x1000
Routing methods	OPT-RS-ICH-LEACH, ICH-LEACH, LEACH
Transmission Protocol	UDP

Table1: Simulation parameters

Network Simulator (NS2) version 2.35 is used to investigate and analyze proposed idea. Simulation context consists of 21 nodes in a region 1000 x 1000 m^2. Random Way Point (RWP) mobility is used and the transmission range is set to 250m for ideal unstructured. Two scripts are used, the first (code.tcl) for random generating traffic for constant Bit Rate (CBR) of 512 bytes according to UDP protocol. Simulation time is sets to 10 s for all tests. In our simulation, routing protocol (AODV) supports for routing information and it can be sharing with all the nodes in simulation of network environment.

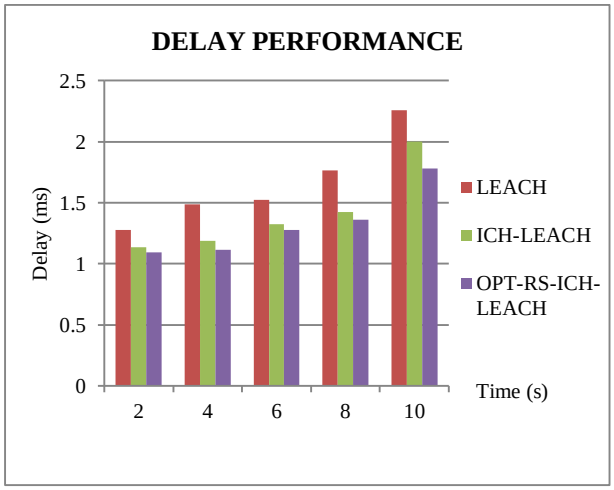

Figure 5: End-to-End Delay

In Figure 5 illustrates end-to-end delay (E2E delay) against simulation time. It is simple that, the OPT-RS-ICH-LEACH has a lower E2E delay than that one of the LEACH and ICH-LEACH. This is help to optimality of routing and decrease the transmission time between nodes early ACO based ICH-LEACH, resulting in minimization of E2E delay.

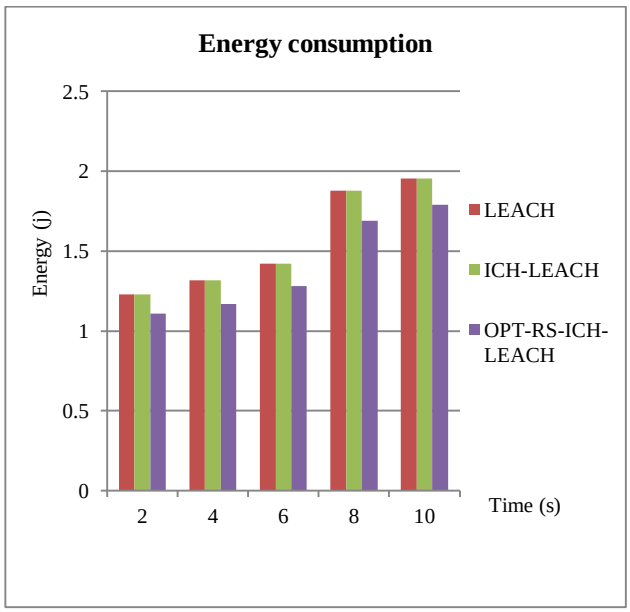

Figure 6: Energy Consumption

In Figure 6 Energy vs. Simulation time for LEACH, ICH-LEACH and OPT-RS-ICH-LEACH is presented. We note that the OPT-RS-ICH-LEACH has low energy consumption than that one of LEACH and ICH-LEACH. This is because route selection of OPT-RS-ICH-LEACH is based on the parameters as well as the proposed OPT-RS-ICH-LEACH method which predicts of the link failure in an earlier time before the energy loss for individual nodes. All of this resulting in efficient energy consumption of the proposed OPT-RS-ICH-LEACH.

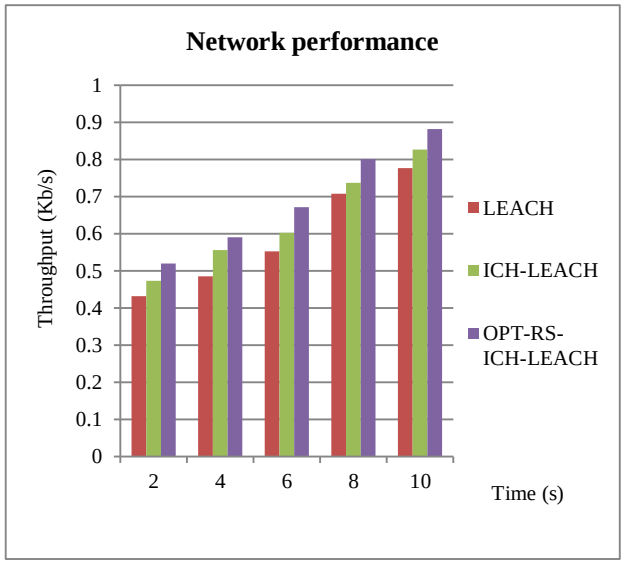

Figure 7: Throughput

In Figure 7 illustrates throughput against simulation time. It is obvious that the throughput of OPT-RS-ICH-LEACH is higher than other of the LEACH and ICH-LEACH. This due to, route selection of OPT-RS-ICH-LEACH is based on optimal route selection which result in prolonging route lifetime, as well as the proposed OPT-RS-ICH-LEACH method which predicts the link failure in an earlier time before dropping of data packets. All of this resulting in a high throughput of the proposed OPT-RS-ICH-LEACH.

V. Conclusion

A new framework ACO based ICH-LEACH for security is made during this project as security is major concern in WSN. From the approach and upon analyzing results it can be seen that the changed algorithmic rule for OPT-RS-ICH-LEACH offers best performance. The performance of Normal LEACH, ICH-LEACH and OPT-RS-ICH-LEACH was compared in the terms of energy consumption, detection time and OPT-RS-ICH-LEACH gave higher results as compared to these parameters, Network simulator-2 was used to simulate the scenario. The ACO was introduced for optimal route selection in intra and inter cluster communications. As a result a major performance of routing and network life time are increased.

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