International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622
National Conference on Advances in Engineering and Technology
(AET- 29th March 2014)

RESEARCH ARTICLE OPEN ACCESS

Fuzzy Logic Based Energy Efficient Data Aggregation For Wireless Sensor Network (Fleda)

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ABSTRACT
A sensor network is a network with large number of sensors. Each node in the network is defined with some energy parameters. With each communication over the network some amount of energy is consumed. The proposed work is related to improve the network life by using the concept of prioritization along with the mobile base station over circular path in a clustered network in such a way that maximum connectivity will be there. Prioritization will be done to each communicating node and is performed under parametric factors such as residual energy, distance and connectivity. The first prioritization will be based on residual energy. High energy is considered as one parameter in cluster head selection. In the same way, short distance and maximum connectivity will also be assigned higher priority. All the decision regarding prioritization will be taken by using the fuzzy logic approach. As the base station is defined with specific communication range, each time base station update its location the nodes in its sensing range will activate and perform direct communication with it. The activated area is called hot spot area. Simulation results obtained from this work are satisfactory as it has improved network life as well as reduce the energy consumption in the network.
Keywords –Clustering, Data Aggregation, Energy Efficiency, Fuzzy Logic, Mobile Base Station, WSNs.

I. INTRODUCTION

Wireless Sensor Networks (WSN) is self-organized wireless ad hoc networks comprising of a large number of resource constrained sensor nodes. One of the most important tasks of these sensor nodes is systematic aggregation of data (for reducing the number of data transmissions by eliminating redundant information) and then transmits gathered data to a base station (BS). Optimizing energy consumption for extending the lifetime in wireless sensor networks is of dominant importance. Bandwidth, memory, signal strength, time, battery power etc. have also been utilized to examine the performance of a sensor network. Wireless Sensor Networks have a wide range of applications such as environment monitoring, agricultural monitoring, habitat monitoring, fire detection, wildlife protection, military applications etc.

As this paper is based on clustered network architectures, all nodes firstly sends data to cluster head and then all cluster heads after aggregating the data sends it to base station. Here electing a node as cluster head is based on the prioritization and all the decision regarding prioritization will be taken by using the fuzzy logic approach.

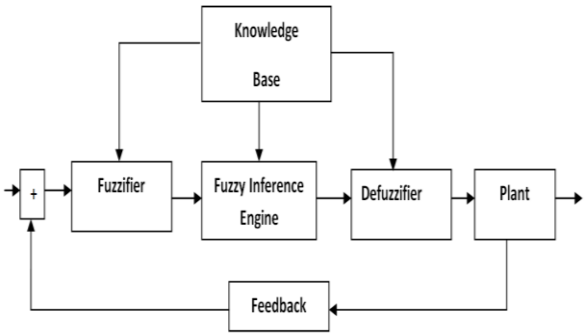

Fig 1: Fuzzy Logic

1.1 INTRODUCTION TO FUZZY LOGIC

Fuzzy Logic (FL) is a problem-solving control system methodology that lends itself to implementation in the system ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or workstation-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. Working of fuzzy logic is shown in Figure 1.

II. RELATED WORK

Research work in [1] proposed a power-efficient gathering for sensor information systems

(PEGASIS) to transmit the collected data from sensor nodes to the sink node. It is based on the assumption of a relatively static network topology in which each node knows the location of other nodes in the network. The node which was selected as a leader was within the transmission range to the sink node in one hope. A chain is constructed from the utmost nodes to the sink before the data is transmitted. When leader transmit the message to the sink then the message will pass from one node to the next node.

In [2], authors proposed an energy efficient hierarchical clustering scheme to enable nodes transmission within long distance. The sensors are organized into groups and communicate information only to cluster heads and then the cluster heads communicate the accumulated information to the processing center. The processing center determines the final estimates of the parameters in question using the information transmitted by the cluster heads. Since the sensors are now transmitting data over smaller distances in the accumulated environment, the energy spent in the network will be much lesser as compare to the energy.

Local Closest First (LCF) and Global Closest First (GCF) solution given in [3] describes the usage of mobile agent for data fusion in WSNs. In their computing model, data stay at the local site, while the fusion process (code) is moved to the data sites. By transmitting the computation engine instead of data, network bandwidth requirement is largely reduced and the performance of the fusion process is more stable. They presented a method to develop an optimal itinerary for mobile agent to fulfill the integration task while consuming minimum amount of resources, including time and power. For the algorithm Local Closest First (LCF), the MA starts its itinerary from a node and searches for the next destination with the shortest distance to its location. As far as the Global Closest First (GCF) algorithm is concerned, the MA starts its itinerary from a node and selects the next destination with the closest to the center of the surveillance zone.

Mechanism given in [4] is used to generate randomized multipath routes. Under this design, the paths taken by the shares of different packets changes over time. So even if the routing algorithm becomes known to the opponent, the opponent still cannot point out the routes cross over by each packet. Besides irregularities, the generated paths are also highly distributive and energy efficient, making them quite capable of mislead black holes. They tentatively check out the security and energy performance of the proposed schemes. They also formulate an optimization problem to decrease the end-to-end energy consumption under given security compulsions. Wide simulations are conducted to verify the validity of our mechanisms. They propose arbitrary multipath routing algorithm that can overcome the above problems. In their approach, multiple paths are computed in arbitrary way each time an information packet needs to be sent, such that the set of routes taken by various shares of different packets keep changing over time. As a result, a large number of routes can be conceivably generated for each source and destination. To interrupt different packets, the opponent has to accord or jam all possible paths from the source to the destination, which is practically not possible.

Author in [5] proposed the efficient mechanism of energy efficient techniques for data aggregation in WSN using principles like global weight calculation of nodes, data collection for cluster head and data aggregation techniques using data cube aggregation. It is a multidimensional approach for data aggregation. The values are stored in separate cell of a data cube, each phase of cube is divided into separate rows & columns and each value & node such as consumption, bandwidth, MRIC, RSSI etc are represented at the beginning of rows. It provides an accurate usage of battery and low power consumption so that the user can send multiple messages in limited resources. The parameters that are used manage the cluster head generation, and the node selection methods so that the message can be easily transferred under such circumstances with right decision using principles like global weight calculation of nodes, data collection for cluster head and data aggregation techniques using data cube aggregation.

Research in [6] presented an agent migration protocol based on reinforcement learning method to reduce the query delay and improve the total performance. They worked on the subject of access to WSNs over the Internet, in order to integrate WSNs by using mobile agents which are sent over the Internet through a gateway node. The solution at hand provides advantage in energy consumption, by connecting to the Internet only via gateway nodes through which the MA's were sent.

III. SYSTEM MODEL

A sensor network is defined with limited resource because of energy constraint. Each node gives some energy loss with each communication. Because of this it is required to reduce the communication over the network. Clustering is such a technique that is used to save the energy of the network. In sensor network, there are number of available cluster based routing protocols. One of such common protocol is ‘LEACH’. The ‘LEACH’ gives the energy effective communication in a clustered environment. It can perform the communication on a

hierarchical as well as non hierarchical network. The network reduces the energy with each communication over the network. Clustering Process has two phases: the set-up phase and steady-state phase. In the set-up phase, the cluster-heads are chosen "stochastically", which is randomly based on an algorithm. In steady-state phase data is collected.

The proposed research work is the improvement over the existing clustering architecture to increase the network communication and the network life. Fuzzy Logic Based Energy Efficient Data Aggregation in Wireless Sensor Network (FLEDA) is about to reduce the network traffic by inclusion of mobile base station.

As the cluster head is responsible to handle the communication within cluster as well will communicate with base station. The cluster head accepts the information from the cluster nodes and will send it to the base station with direct or with cooperative communication. The proposed research work suggested three important parameters for deciding the cluster head management. These parameters include the connectivity, distance and residual energy based cluster head selection and the management of mobile base station over the network to provide effective communication. The first prioritization will be based on residual energy. High energy is considered as one parameter in cluster head selection. In same way, the short distance node will also be assigned by the higher priority. The proposed work also includes the concept direct communication to the base station. The proposed work is the improvement over the existing clustering architecture to increase the network communication and the network life.

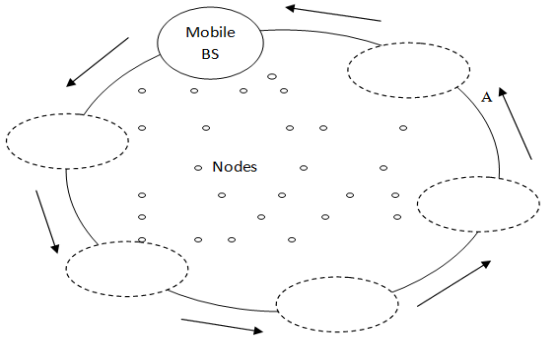

Fig. 2: Movement of Base Station around circumference

In this research work, base station is not stationary. Figure 2 shows the movement of mobile base station around its circumference. The movement of mobile base station helps in efficient utilization of energy as only those nodes which come in range of mobile base station communicate with it and passes data either by direct communication or by multi-hop communication; other nodes are not communicated at this time.

IV. RESEARCH DESIGN

The presented work includes two main phases. In first phase, a mobile base station over circular path is defined in such a way that maximum connectivity will be there. The center to the circular path will be selected along with the radius specification to that path (Fig. 3). In second phase, prioritization will be done to each communicating node.

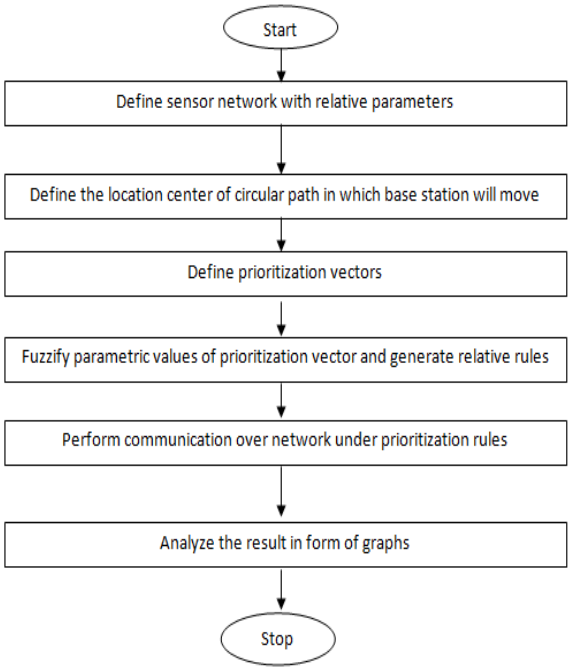

Fig 3: Working of FLEDA

The proposed research work is the improvement over the existing clustering architecture to increase the network communication and the network life. The improvement is defined under two main factors:

a. The base station is moving in a radial path.
b. Selection of the cluster head over the network.

The algorithm defined for the proposed work is given as under

4.1 Algo_FLEDA (Nodes, N)

(i) Distribute N Nodes called node1, node2…..nodeN randomly over the area mxn.
(ii) Set CenterX= m/2 , CenterY=n/2 and Set Radius R for Base station radial path.

(iii) Set BaseStation with parameters (CenterX,CenterY,R,ConstantSpeed,SensingRange)
(iv) Set probability of becoming a clusterhead is p; hence, on average, n/p sensors will become cluster heads
(v) For i = 1 to N
(vi) Neighbor (i , :) = FindNodes (Nodes, SensingRange)
(vii) For inter = 1 to MAXITERATIONS
(viii) For i = 1 to n
(ix) If (Distance(Node(i),bs)<=SensingRange)
a. Perform Direct Communication between the base station and sensor node i
b. Energy(Node(i)) = Energy(Node(i)) - TransmissionEnergy
Else
a. Find the multihop path between basestation and node I with nodes m nodes
End if (ix)
(x) For j=2 to m
(xi) Energy(Node(j))=Energy(Node(j))-ForwardingEnergy;
(xii) Energy(Node(i))=Energy(Node(i))-TransmissionEnergy;
(xiii) Set status=0;
(xiv) For i=1 to n
(xv) ProbabilityVector (Node(i)) = Energy(Node(i)) * ProbabilityVector (Node(i)) + (1-ProbabilityVector(Node(i))) * EnergyConsumed (Node (i))
(xvi) If (ProbabilityVector(Node(i))>.5)
a. If (FuzzyHighDecision (Energy (Node(i))) > Threshold And ResponseTime (Node (i)) < MinResponseTime And ConnectivityVector (Node(i)) > MaxConnectivity)
- Set MaxEnergy=Energy(Node(i))
- Set MinResponseTime = ResponseTime (Node(i)
- Set MaxConnectivity = ConnectivityVector (Node(i))
- Set Status = 1;

Endif (xvi-a)
b. Elseif (FuzzyMediumDecision (Energy (Node (i))) > Threshold and ConnectivityVector (Node (i)) > MaxConnectivity)
- Set MaxEnergy = Energy (Node(i))
- Set MinResponseTime = ResponseTime (Node(i))
- Set MaxConnectivity = ConnectivityVector (Node (i))
- Set Status=1;

Endif (xvi)
(xvii) If (status=0)
a. Set all Alive Nodes as Cluster head so that communication can be performed with base station directly.
b. If (Energy (Node(i) < = 0)
- Dead=Dead+1;

Endif (xvii-b)
Endif (xvii)

V. SIMULATION RESULTS

Simulation result shows comparative analysis of existing and proposed approach.

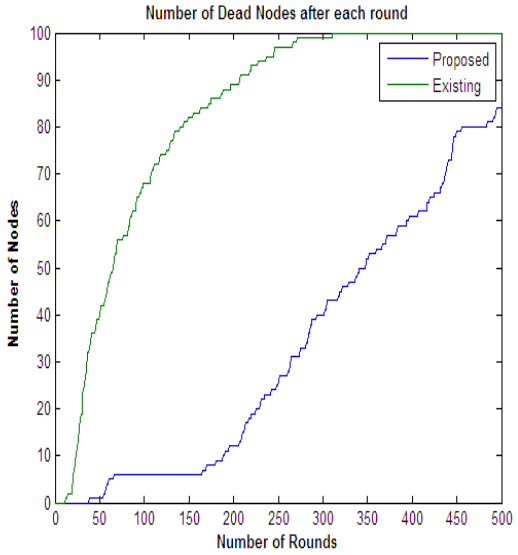

Fig 4: Dead Node after each round

Figure 4 shows in existing approach the nodes starting dead in the starting rounds whereas in proposed approach nodes starting dead after 30 rounds. The complete network dies in existing approach in 380 rounds whereas in proposed work, the network stays after 500 rounds.

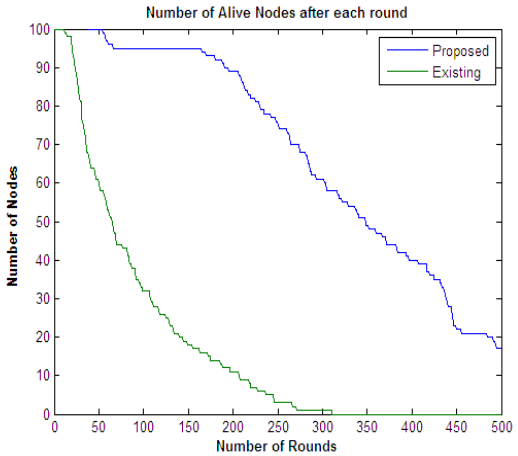

Fig 5: Alive Node after each round

Figure 5 shows in the existing approach the nodes stay alive upto 380 rounds but in proposed approach, the network is alive even after the completion of 500 rounds. This shows the presented approach is far better than existing approach.

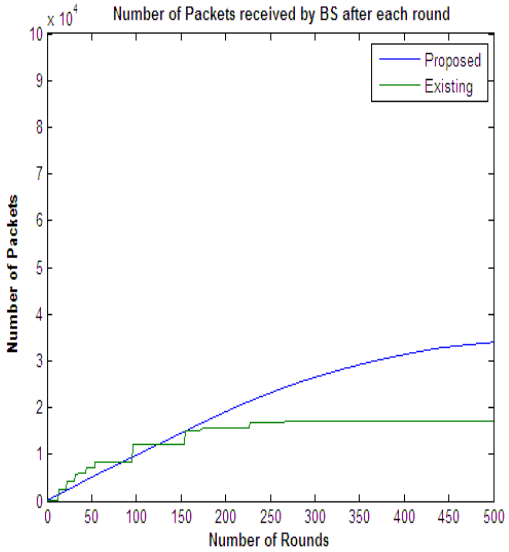

Fig 6: Packet received by BS after each round

Figure 6 shows that packet transmission to the base station is high in proposed approach as compared to existing approach, so network throughput increases.

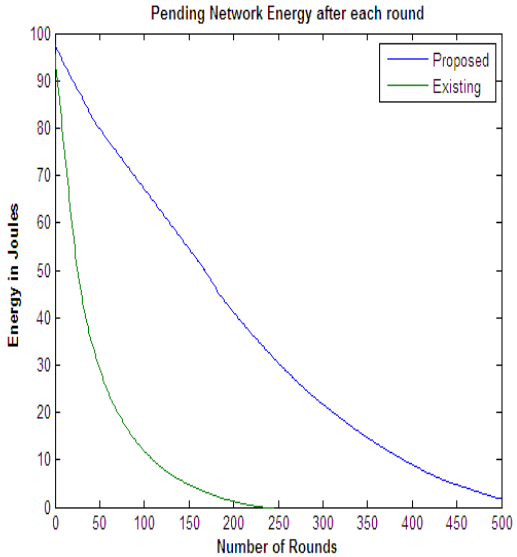

Fig. 7: Pending network Energy after each round

Figure 7 is showing remaining energy in proposed approach is more because of this the energy is still balanced over the network after the completion of 500 rounds.

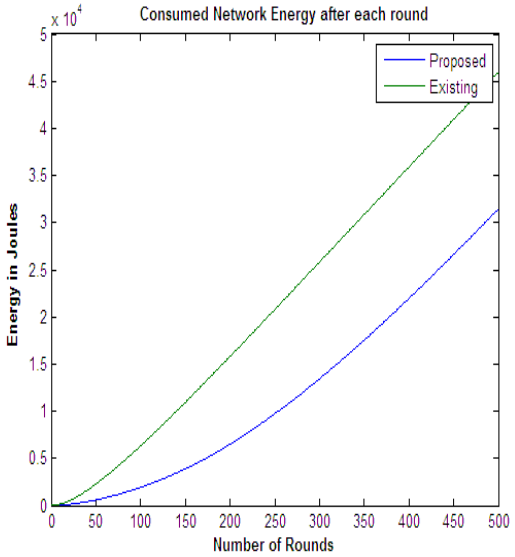

Fig 8: Energy consumed in WSN after each round

Figure 8 shows the energy consumption in the proposed approach is less as compared to energy consumption in existing approach.

VI. CONCLUSION AND FUTURE SCOPE

Energy is one of the critical issues in sensor networks. The main problem with static base station is the multihop communication performed by distance nodes. In proposed approach, base station is non stationary and is defined with specific sensing range. Clusters comes in sensing range can directly communicate with it, whereas other perform a multihop communication. It provides equal chances to all clusters to perform direct communication with base station. Base station will move on a redial surface, for some time instance, a specific group of clusters can directly communicate with base station. The obtained results show that the presented work has improved network life as well as network communication by reducing energy consumption over existing protocols.

The proposed work is focused on a homogenous network in which all sensors are of same type, in future the work can also be improved by considering some heterogeneous network. The proposed work is been performed on a standard wireless network that can be improved with some other sensor network such as underwater sensor network, body area network, personal area network etc. In this work, only one problem of sensor network is considered called the energy consumption or the network life improvement. But there are many other issues along with energy consumption such as security etc. In future the work can also be done in direction to

improve the security aspects in sensor network. The proposed work is implemented on a clustered architecture. In future the same work can be performed on some aggregative communication.

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