Distributed Node Connectivity Improving & Monitoring Mechanism for WSN

Paresh V. Pawale and V. G. Puranik

Abstract--- The wireless sensor network is the latest emerged technology trends in the coming decade. As the use of the WSN technology rapidly growing the researchers faces the number of networking challenges to develop the system which work efficiently in all environment condition. As we know the recent wireless communication network used different type of protocols for efficient routing of sensor node information from source to destination. Such protocol are used when large number of sensor nodes are deployed everywhere in different environment connected to each other within the same network with different topologies. We have to design a highly versatile connectivity improving and monitoring system to facilitate a real time monitoring in adverse condition. This system is equipped with wireless radio frequency networking, global positioning system to monitor the location of the node and the host of the sensor to collect the data from distributed node which is on the field and store it on the database. Database is used to select the nodes which have better operating condition using fuzzy logic.

Index Terms--- Wireless Sensor Network, Scalability, Fuzzy Logic, Routing Protocol

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I. INTRODUCTION

We know wireless sensor network is a wireless network consist large number of tiny autonomous sensor node communicating with each other through radio link. Due to radio link many node are communicating with each other from certain distance instead of potentially wiring up locations. Now a day's WSN use for wide range of application such as agricultural field, environmental field, medical field, home automation, target tracking, transportation etc. Real time monitoring in environmental disaster is very important issue. WSN is one of the promising technologies that use for real time monitoring.

In many different application large no of sensor nodes deployed everywhere randomly on the field which are battery operated. After discharging the battery it must be either recharged or replaced. In some cases nodes are discarded from the network once there battery level depleted. If such nodes are use in the harsh environment then frequently replacing or charging the battery is not possible. In such application there is need to long battery life & which is achieved reducing the power consumption of the network during operation.

In past WSN is used for small area but now recently in many applications demand for the construction of the large scale WSNs increasing rapidly. If the number of nodes are increasing within the network complexity also increases. To solve such network scalability problem we required efficient network joining mechanism that connect all the nodes in large scale WSN.

Main purpose of this study is to detect the problem & find efficient solution on that problem which is occurred number of time during real time monitoring. In this paper we design different operating states of the node using fuzzy-logic & using that we can improve the connectivity & performance of large scale cluster-star routing protocol used by ZigBee in the network layer. Similarly we improve the operation of the application layer in order to reduce the energy consumption of the nodes which are already deployed on the field.

The rest of this paper is organized as follows. Section II describes basic WSN system. Section III describes overview of ZigBee methodology. Section IV describes the related work. Section V describes fuzzy logic mechanism. Section VI describes the fuzzy logic applied to routing decision. The simulation set up & corresponding result discuss in section VII. Finally conclusion & future work are summarized in section VIII.

II. BASIC WSN SYSTEM

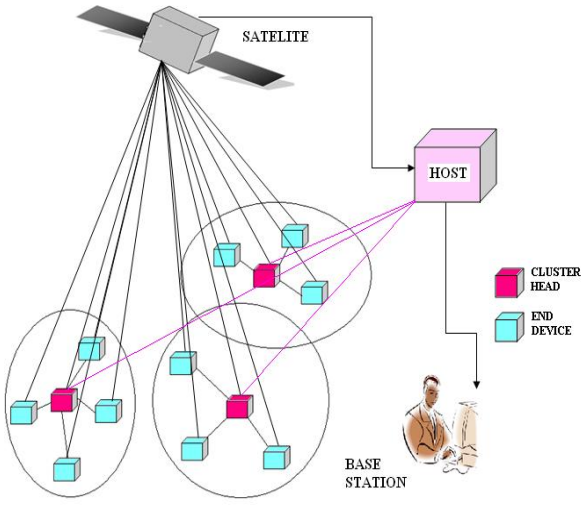

Fig. 1: Typical Wireless Sensor Network

Figure 1 shows in above consist number of nodes which are actually deployed on the field. Circular part presents the cluster so in above diagram there are three clusters. Each cluster contains different number of nodes in which particular node act as cluster head and other act as end device. Cluster head of each cluster continuously communicated with base station through host and send all real time information towards the base station. Each node are configure with GPS (Global positioning system). Satellite continuously captures the location of the node and Sends it towards the base station via host. The main use of the GPS when nodes are movable and distance of each nodes from each other is more than 100 meter. If the distance in between clusters and host less than 100 meter then we can use the ZigBee to transmit and receive the data otherwise we can use GSM to transmit and receive the data.

In this work, we will be particularly interested in cluster star topology. It is basically adopted for scalable wireless sensor network in many applications. Cluster star topology consist number of clusters. Each cluster consist a cluster head and multiple end devices as child nodes. In this case the coordinator or host initiates the network& act as the root of the network. The network consist parent-child relationships. New nodes join within the network as children with cluster head. A new node join in the network may be FFD (full function device) or RFD (reduced function device). If node is act as FFD then it is act as either end device or cluster head of the new cluster after instructed by a coordinator or host.

III. OVERVIEW OF ZIGBEE METHODOLOGY

The ZigBee protocol architecture can be described as a stack of different protocol layers. The PHY and MAC layers are defined in the IEEE 802.15.4 standard [1] while the network and application layers are defined in the ZigBee specification (ZigBee Alliance) [2].

In 1999 IEEE established IEEE 802 LAN/MAN standards committee work group as a part of IEEE computer society's. Main function of the committee is to develop standards for wireless networks. The ZigBee uses IEEE 802.15.4 standard protocol for low data rates WPAN (wireless personal area network). IEEE 802.15.4 standard

offers no of features such as flexibility, low cost, very less power consumption; low data rates etc. figure 2 shows ZigBee layer architecture.

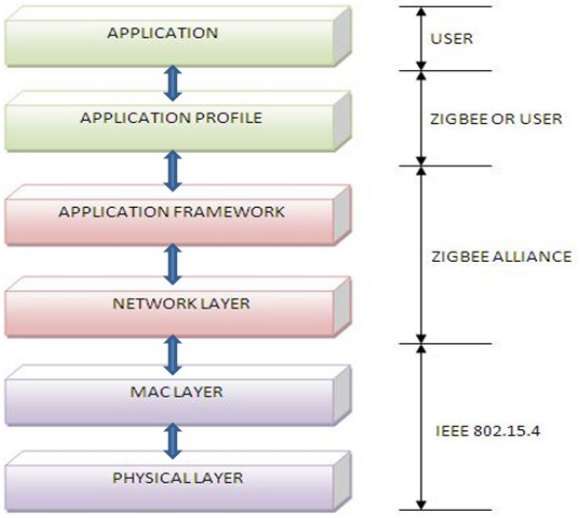

Fig. 2: ZigBee Layer Architecture

We know nodes within the wireless network designed in such a way that they required less energy & other computational resources. In such cases use of fuzzy logic with low computational resources is natural & effective way towards the deployment of such mechanism in different environment.

IV. RELATED WORK

As defined earlier, now days, ZigBee uses IEEE 802.15.4 standard protocol for development of low data rates WPAN (wireless personal area networks).

Several recent studies on the network configuration mechanisms of the IEEE 802.15.4 have been appeared in the literature. In [3], the author introduces a scheme aiming to reduce the number of nodes that may potentially become disconnected from the network. The work in [4], undertakes an in-depth study of the network configuration mechanisms of the IEEE 802.15.4. The author particularly interested in assessing the constraints set by the standards, such as the number of routers and depth of the network. Their main goal has been to provide guidelines to set up real-life ZigBee networks.

In [5], the authors provide a mechanism to select the coordinator node assuming emergency scenarios. They focus, similar to our study herein, on a tree topology. The main purpose is to reduce the number of nodes having to act as routers as well as the depth of the network. These two parameters are particularly relevant in scenario where the response time -the time to deliver a packet- is of prime importance.

Closely related to the network configuration schemes, the literature is rich on the analysis of the ZigBee routing mechanisms. The distance vector approach proposed by the standard for mesh networks has been enhanced in [6] by updating paths when a shorter path is found. The addition of a metric based on energy and delay restrictions has been evaluated in [7] and compared to AODV (Ad Hoc on demand Distance Vector routing).

Ad-hoc On Demand Distance Vector (AODV) is one of the routing protocol specific in the ZigBee network [8]. It determines unicast routes to destinations within the multi-hop wireless network. If source node wants to transmit data, it will broadcast Route Request (RREQ) messages to the whole network. When intermediate node receives this routing request and does not have any routing toward the destination, it will rebroadcast the RREQ. If the intermediate node has a routing path to destination node or it is the destination node it will send back a Route Reply (RREP) message which will create a route toward the destination. If the source node received many RREPs it will compare all the routes and choose one of them with minimum number of hops.

In [9] a shortcut tree routing is proposed to enhance tree-routing in ZigBee network by using neighbor-table. In this protocol source nodes compare all neighbor nodes within transmission range to find a node which has a smallest tree level for transmitting data packets. The use of the neighbor table detailed in ZigBee is proposed in [10] and [11], allowing the reduction of path length by creating

new paths if possible, and adding neighboring communication besides of parent-child communication.

The use of different mechanisms to make routing decisions is a common topic in the literature of wireless sensor networks.

Artificial Intelligence (AI) is one of these mechanisms and different techniques have been proposed to improve the decision making process of routing protocols. A suitable AI technique to be implemented in sensor nodes is fuzzy logic, which has been proposed to improve the performance of diverse aspects of wireless sensor networks. In [12], fuzzy logic is used to select cluster-head nodes and improve the network lifetime in cluster-head-based networks. The use of fuzzy logic is also proposed in [13] to be the basis of a data fusion algorithm to reduce traffic and enhance the performance of the network.

In this proposed system, we use the artificial intelligence, specifically fuzzy logic, is proposed in order to improve the performance of the cluster tree Routing (CTR) protocol used by ZigBee.

V. FUZZY LOGIC MECHANISM

Basically, fuzzy logic is a precise logic of imprecision and approximate reasoning. More specifically, fuzzy logic may be viewed as an attempt at formalization /mechanization of two remarkable human capabilities. First, the capability to converse, reason & make rational decisions in an environment of imprecision, uncertainty, incompleteness of information, conflicting information, partiality of truth and partiality of possibility in short in an environment of imperfect information. And second, the capability to perform a wide variety of physical and mental tasks without any measurements and any computations. Fuzzy logic has emerged as a powerful technique for the controlling industrial processes, household and entertainment electronics, diagnosis systems and other expert systems [14].

First, role in decision process is carried on each & every node during the network joining time. It decides whether the nodes joining in the network is act as cluster heads or remains as an end device. The new node join in the network act ascluster head or as an end device is depend on the operating condition of that node. In our system operating condition is measure in terms of no of hopes (distance) from coordinator or host, battery conditions & received signal strength indicator (RSSI). In such case the nodes which have better operating condition act as cluster head otherwise it act as end device.

Second, role in decision process is parent selection. This step is based on the location (latitude & longitude) & neighboring feature. In such way, only those nodes select as parents who have better operating condition in order to avoid disturb the network.

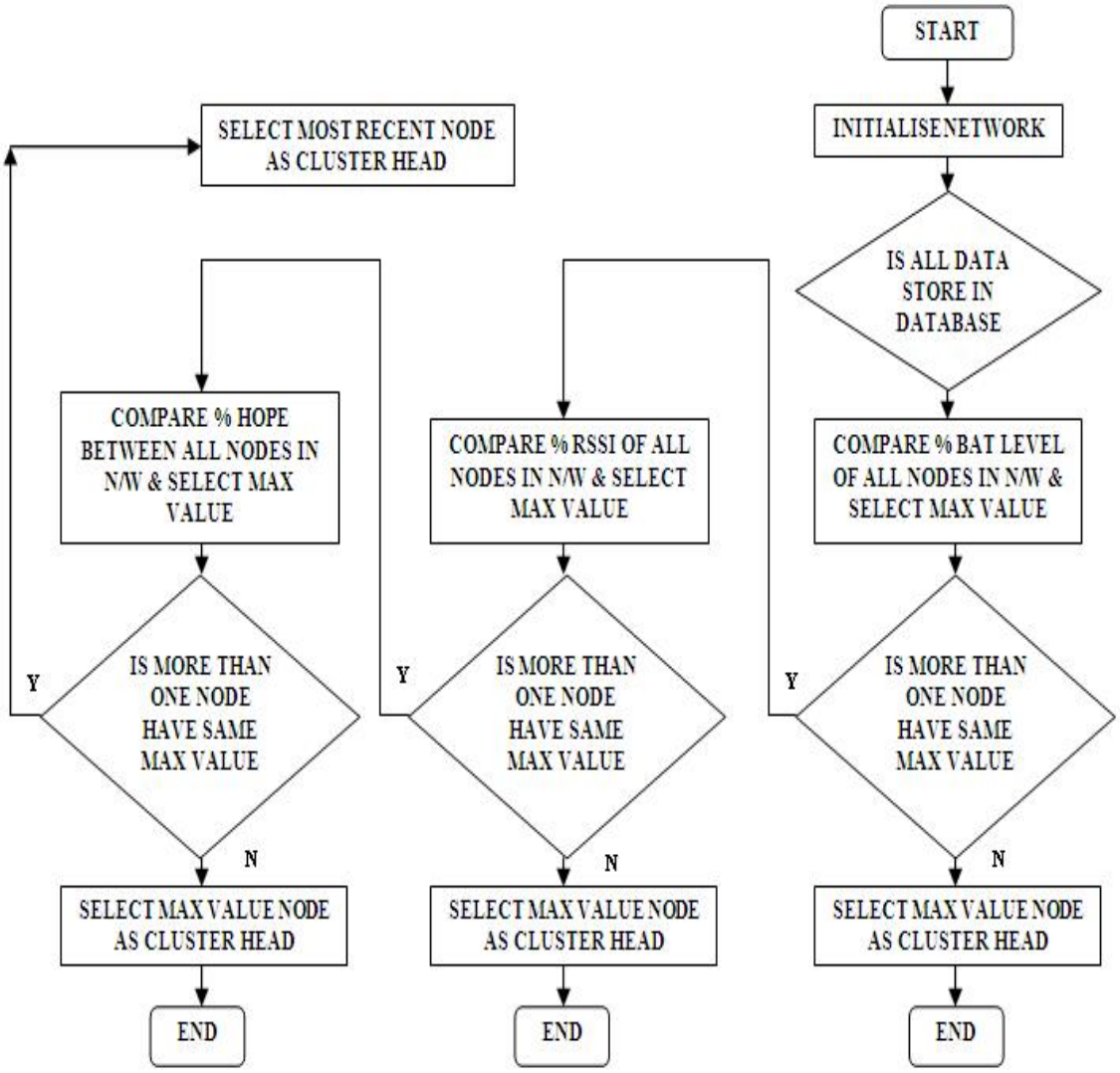

Fig. 3: Flowchart of Fuzzy Logic Used in System

In the system the figure 3 shows the flowchart which is used to select the cluster head selection. In this system first user first initiates the network. In this case base station sends the acknowledgement signal to all cluster head of the clusters. After that cluster head send the wake up signal to the entire node within the network & whole network is initiated. Cluster head of each cluster send the information about the operating condition of its all child node along with itself to the base station. The information which is received at the base station is stored in the database. This database is continuously updated within 10 minutes. After that system presented at the base station continuously compare operating condition of the each node & detect the maximum value. The node which have maximum value selected as the cluster head of that particular cluster. If more than one node has same maximum value then compares the second operating condition of those nodes only. At the end more priority or value found same then select the most recent node as cluster head.

Table I: Node Evaluation Technique

Node	Bat level	RSSI	No of hopes
N11	85	82	62
N21	75	83	86
N31	52	71	87
N12	51	77	41
N22	65	51	64
N32	55	72	31
N42	65	77	84
N13	61	65	64
N23	74	87	74
N33	74	87	25
N43	50	76	84
N53	74	87	76

Above table I show the one example of node evaluation technique. In this technique the first column shows the nodes which is deployed on the field. Node N11 means the node 1 in cluster1 and N43 means node 4 in cluster 3. So from above table we can say that there are total 3 clusters are presented on the field. Cluster 1 contains 3 nodes, cluster 2 contains 4 nodes & cluster 3 contains 5 nodes. Here we use the comparison logic in order to select best node within the clusters for that we use the three operating condition like battery level, RSSI, no of hopes.

To find the best node in cluster 1 we compare the battery level of all three nodes from cluster 1. So we can say that node 1 in cluster 1 have maximum battery level i.e. 85% which is maximum in table. So we can select node 1 as cluster head of the cluster 1. Similarly to find best node in cluster 2 we compare the battery level of all four nodes from cluster 2. In cluster 2 there are two nodes which have same maximum value i.e. 65%. In that case we compare the next operating condition of those two nodes i.e. RSSI. In that case we can say that node 4 in cluster 2 has 77% RSSI & which is maximum. So node 4 is act as cluster head in cluster 2. Similarly node 5 in cluster 3 acts as cluster head.

VI. FUZZY LOGIC APPLIED TO ROUTING DECISION

In this system we are use the cluster star based routing. In this case new network is initiated by the coordinator or host. The new nodes want to join the network have to connect with the coordinator or with a cluster head (router).

In our system, the fuzzy logic is used in decision process, device type. In order to decide device type node compare the all parameters & select the maximum value. The node with maximum value become act as cluster head otherwise node becomes end device.

During the parent selection process, the node which is want to join in the network able to reach the coordinator, it will selected as parent; otherwise it will select the as parent the cluster head which having better operating condition among all reachable cluster head

In order to manage such mechanism there are different situations arises such as node failure, new node join in the network, low resource cluster head (router) etc. For such cases following mechanism are included

- Low resourced cluster head: in case of cluster head failure & network separation due to remaining battery level drop below the threshold, cluster head node send device type change request & its child node select another cluster head according to its fuzzy logic mechanism to maintain the network connectivity.
- Cluster head failure: we know during node communication cluster head nodes send acknowledgement (ACK) message when data is receiving from other node. If a node does not receive ACK message from cluster head node during two consecutive time, it select the another cluster head as parent which having better operating condition.

- New node joining the network: suppose network is in working condition & new node want to join the network it send ACK message to the coordinator. If the message from coordinator or cluster head is detected, the node selects it as parent. If no message from coordinator & cluster head is received, the new node will send the device type change request to select it as end device. When node is act as end device it select best reachable cluster head as parent according to its location.

Table II: Database of the Node

Cluster Id	Node Id	Bat	RSSI	Hopes	Latitude
C1	N1	23	95	45	18.4855555555556,73.8019444444444
C1	N2	3	4	6	18.5529880611772,73.8988139823005
C1	N2	3	4	6	18.5439561722222,73.8948178629342
C1	N2	12	41	100	18.5427177282236,73.8665312765657
C1	N2	68	57	73	18.5375730253407,73.8769840242865
C1	N2	67	31	80	18.4855555555556,73.8019444444444
C1	N3	13	93	48	18.5976451969648,73.8833086857237
C1	N3	78	19	43	18.5525666640798,73.8870737398467
C2	N4	24	67	67	18.4876802765957,73.815936144086
C2	N4	35	10	85	18.5735402443166,73.8230777515652
C2	N4	35	80	77	18.4947388481616,73.8037411729138
C2	N5	1	10	85	18.5910646476881,73.8683518237173
C2	N5	13	27	51	18.5057517084611,73.8604264547433
C2	N6	34	34	35	18.5117817646077,73.8321276002409
C2	N6	68	79	64	18.5118408329071,73.8449301986983
C2	N6	79	23	38	18.5876829531533,73.880230537086
C3	N7	24	7	7	18.5124975377274,73.9002505091677
C3	N7	79	6	75	18.499065880885,73.9141383386181
C3	N8	23	60	16	18.4856396840969,73.8441208146922
C3	N8	63	33	91	18.5714445511667,73.9085283023588
C3	N9	57	64	39	18.5318943111239,73.8613907597713

VII. SIMULATION SET UP & RESULT

In the process of development we will take inputs from each node by passing the parameter values for operating conditions with the help of GUI format/excel sheet input. Add on nodes with various process conditions to evaluate role by each node as parent, child, and cluster head (router). Here we use the visual studio 2008 software as a platform & programming is done in c sharp language.

Table II shows the database which contains different operating conditions of the node which is deployed on the field. In this case the each & every node sends its operating condition to its base station. Base station receive that data store it in the database. The values stored in database are fetching to the fuzzy logic mechanism to improve the network by selecting the strongest node.

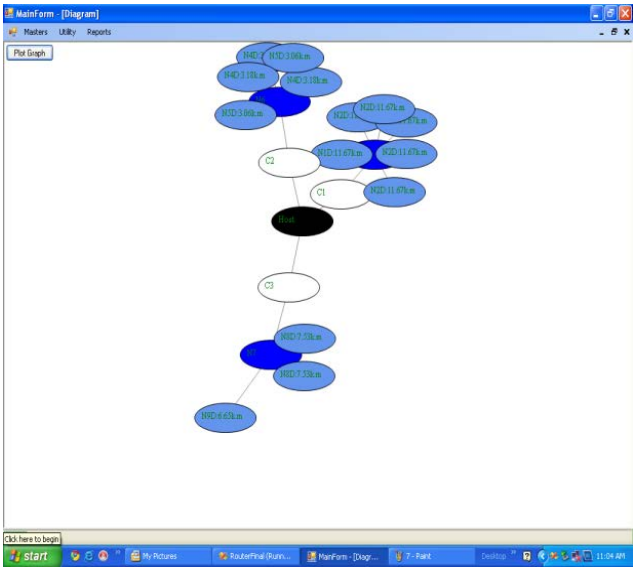

Fig. 4: Graph On a Screen

After selecting the proper database we enter the plot graph button which is present on the screen so we get following connectivity diagram which is shown in figure 4. In which black circle represent the host, white circle represent the cluster ID, dark blue circle represent the cluster head & sky blue circle represent the end device.

If operating condition of any node suddenly drop below threshold our fuzzy logic mechanism change the connectivity without disturb the network.

VIII. CONCLUSION & FUTURE SCOPE

In this case the fuzzy logic based system improves the performance of the routing protocol for star based networks specified by ZigBee. Using this scheme we can reduce the network set up time & number of router (cluster head) nodes within the network.

The three parameters such as remaining battery level, RSSI, no. Of hopes to the coordinator or host& there evaluation using fuzzy logic has been proposed.

We know the Clustering algorithms have been a hot research area in the last few years. The Clustering routing protocols organize sensor nodes in such a way that propagation of message to the sink is achieved with minimal energy. Hierarchical (cluster-based) routing protocols hold a great potential toward energy efficiency in WSN. In future we can proposed the system in which node operating condition is defined by No of hops to the router, Received signal strength, No of child nodes per router, Remaining bat level, Longitude and Latitude of node, Delaying, Best reachable node, Nodes per unit area, No of nodes travelled by packets, No of packets transmitted etc. parameters in order to improve the performance of the WSN.

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