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Department of CIVIL, CE, ETC, MECHNICAL, MECHNICAL SAND, IT Engg. Of Vishwabharati Academy's College of engineering, Ahmednagar, Maharastra, India

An Adaptive Fuzzy Logic Assisted Configuration Mechanism for WSN

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Abstract: 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. In this paper, we use fuzzy-logic mechanism for wireless sensor network in order to improve the design of network joining mechanism for ZigBee networks that can build large scale cluster-tree topology with maximum node connectivity. Similarly here we use the AODV routing protocol, in order to select the best nodes to be part of the routes. Here in this system we specially reduce the network set up time & no. of router (cluster head) node within the network in order to reduce power consumption.

Keywords: Wireless sensor network, scalability, fuzzy logic, routing protocol.

I. INTRODUCTION

We know wireless sensor network consist large number of sensor node communicating with each other through radio link. 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 technology 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-tree 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 overview of the ZigBee standard & ZigBee layer architecture. Section III describes the related work on different fuzzy logic assisted mechanism. Section IV describes the actual fuzzy logic mechanism. Section V; describe the details of the fuzzy logic applied to routing decision. The simulation set up & corresponding result discuss in section VI. Finally conclusion & future work are summarized in section VII.

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II. 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 1 shows ZigBee layer architecture.

IEEE 802.15.4 support star, tree, mesh & cluster tree topologies. In this work, we will be particularly interested in cluster tree topology. It is basically adopted for scalable wireless sensor network in many applications. Cluster tree topology consist number of clusters. Each cluster consist coordinator as a cluster head and multiple end devices as child nodes. In this case the PAN coordinator 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 the coordinator or 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 PAN coordinator. The figure 2 shows cluster tree topology.

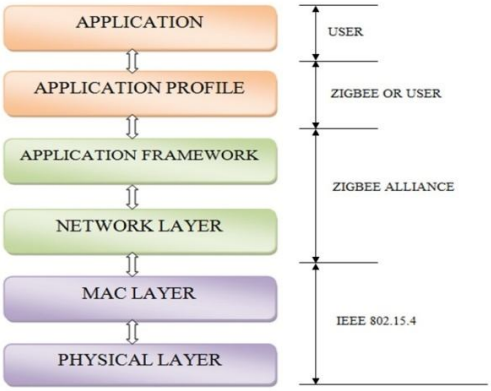

Fig. 1 ZigBee layer architecture

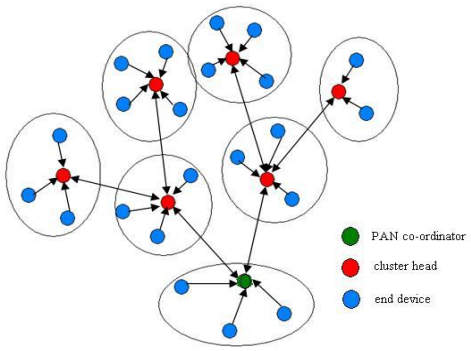

Fig. 2 cluster tree topology

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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.

III. 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 neighbour table detailed in ZigBee is proposed in [10] and [11], allowing the reduction of path length by creating new paths if possible, and adding neighbouring 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.

IV. 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

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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]. The essential characteristics of fuzzy logic are as follows.

- In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.
- In fuzzy logic everything is a matter of degree.
- Any logical system can be fuzzified
- In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently , fuzzy constraint on a collection of variables
- Inference is viewed as a process of propagation of elastic constraints [15].

In fuzzy logic based system, calculations are performed by an inference engine. In this case we studied literature of mamdani [16] approach in order to select the inference engine.

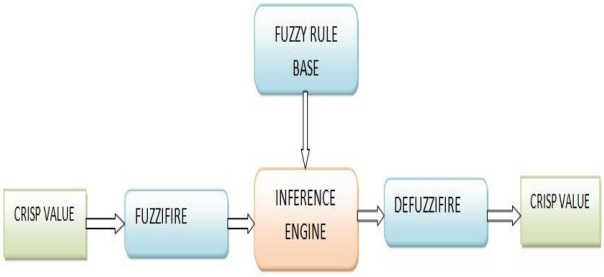

Fig. 3 mamdani fuzzy logic system

The mamdani approach for fuzzy logic based system contain four different blocks such as fuzzifire, inference engine, fuzzy rule base, defuzzifire. When we provide fuzzy sets as input to the fuzzifire, it converts those fuzzy sets into fuzzy values. Such fuzzy values are sending as input to the inference engine. We also define different fuzzy rules that are nothing but different possible probabilities of that fuzzy input sets. In this system all calculations are performed in inference engine. In inference engine all fuzzy values are compared with predefined fuzzy rules & according to that output is to be generated. The output generated by inference engine is also fuzzy values it needs to be converted into the fuzzy sets which is done by using defuzzifire.

The mechanism which is stated above according to that we define our proposal in detail. In this case the fuzzy logic is used for decision making process in order to improve the cluster tree based routing topology

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 as cluster 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 PAN coordinator, 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 cluster head (router) select as parents who have better operating condition in order to reduce the traffic & provide shortest path towards the coordinator.

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TABLE I
FUZZY RULE BASE

No of hope	Battery level	RSSI	Output
L	L	L	L
L	L	M	L
L	L	H	M
L	M	L	M
L	M	M	M
L	M	H	H
L	H	L	M
L	H	M	H
L	H	H	H
M	L	L	L
M	L	M	L
M	L	H	M
M	M	L	L
M	M	M	M
M	M	H	M
M	H	L	L
M	H	M	M
M	H	H	H
H	L	L	L
H	L	M	L
H	L	H	L
H	M	L	L
H	M	M	L
H	M	H	M
H	H	L	L
H	H	M	M
H	H	H	M

In our system we can define the node operating condition using three parameters such as no of hopes, remaining battery level, received signal strength indicator etc. Here we design fuzzy set to represent such parameter as input & according to that determine node condition at output. These fuzzy sets are shown in fig.4

Table I shows the fuzzy rule set to relate inputs & outputs this table includes rules which are structure as follows. If no of hope is L (low), remaining battery level is M (medium) & RSSI is H (high) then output is H (high). That means node operating condition is better. Here we can say that whenever operating condition of particular node is better such node will act as cluster head otherwise it will act as end device.

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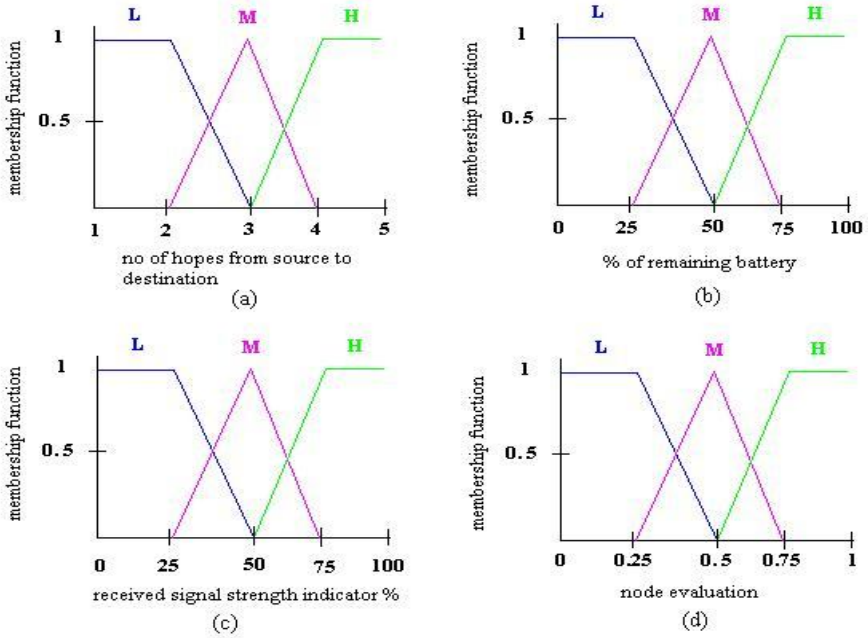

Fig. 4 (a), (b) & (c) are fuzzy input set & (d) is fuzzy output set

In this case the fuzzy input & output are represented triangular & trapezoidal function where the L(low), M(medium), & H(high) components represent the magnitude of participation for that input & corresponding output.

V. FUZZY LOGIC APPLIED TO ROUTING DECISION

In this system we are use the cluster tree based routing. In this case new network is initiated by the coordinator. 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 result of fuzzy evaluation of their variables. The node with highest evaluation 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 best reachable location 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.
- 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.

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VI. 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). Use of NS2 will be done to get packet related data detailing like shortest path, no of packet transferred per node, path length etc.

TABLE II
NO. OF NODES IN DIFFERENT REDIUS

Radius	Number Of Nodes
50m	20
100m	85
150m	170
200m	310
250m	480
300m	700
350m	950
400m	1240
450m	1570
500m	1950

Here we compare the traditional tree based routing (TR) with fuzzy logic based cluster tree routing (TR-FL). During the simulation we consider circular network area with radius from (50m) to (500m). In this case the nodes are deployed randomly & maintaining constant node density. The coordinator is placed at center. The table II shows no. of nodes which is present in particular radius including the coordinator.

In our system simulation is performed on the basis of following performance matrices:

A] Network set up time: it is the time takes the no. of nodes to decide device type & parent node as well as to be ready to start sending application data

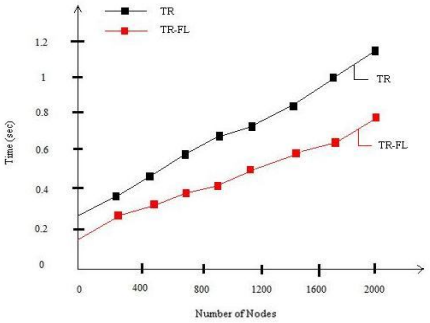

Fig. 5 Time Required To Set Up the Network

The figure 5 shows the fuzzy logic use in the device type & parent selection decision process is more efficient than that of traditional tree based routing. Network set up time required for fuzzy logic based tree routing is 25-30% lower than time taken by tree routing protocol defined by ZigBee.

B] no of the routers (cluster head) nodes within the network: we know to connect the maximum node within the network router (cluster head) nodes are necessary within the network. As the router node within the network are

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increases power consumption of the network also increases. So in order to reduce the power consumption there are necessary to reduce the no of router within the network.

The figure 6 shows that no. of the router nodes are reduce by using fuzzy logic based tree routing which reduce the power consumption of the network & extending the network lifetime.

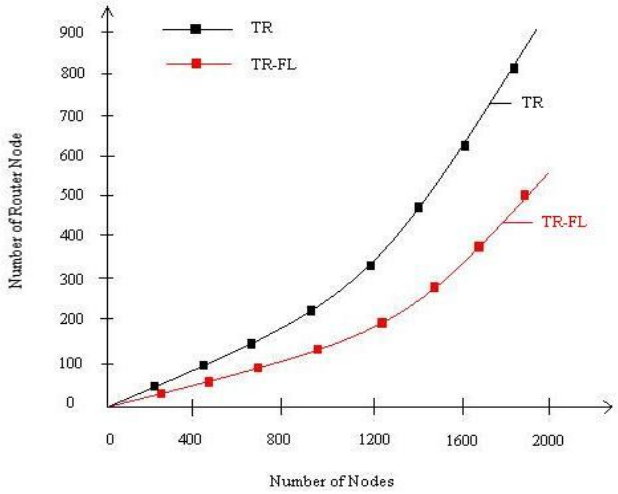

Fig. 6 Average Number of Router in the Node

VII.CONCLUSION & FUTURE SCOPE

In this case the fuzzy logic based system improves the performance of the routing protocol for tree 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 & 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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BIOGRAPHY

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