ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume: 02 Issue: 04, April 2017, pp. 24 – 29

A Survey on Techniques for Selection of Forwarding Node in Wireless Sensor Networks

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Abstract: *Wireless Sensor Networks (WSNs) consist of nodes with sensing, calculation, and wireless communications competences. There are many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy consciousness is an important intend issue. In this paper, we present an investigation on the various methods that are used to discover the next best forwarding node. The selection of the nodes is based on the different techniques such as fuzzy logic, neuro fuzzy and the mobility of the nodes.*

Keyword: *Wireless Sensor Networks; fuzzy logic; neuro fuzzy;*

1. INTRODUCTION

A wireless sensor network (WSN) consists of distributed self-directed devices that utilize sensors to sense the substantial and environmental conditions. A WSN system consists of a gateway that provides wireless connectivity between the wired world and disseminated nodes [1, 2].

The networks used in nowadays are bi-directional and it also enables organize of antenna activity. The development of these networks was initiated by military applications mainly due to surveillance. Today these wireless sensor networks are used for many purpose, such as industrial process monitoring and direct, health monitoring, and so on.

The WSN is built of nodes ranging from a small amount of sensors to several hundreds or even thousands of nodes. Every node is associated to a sensor. Each sensor network node has numerous parts: a two-way radio transceiver with a transmitter to broadcast and obtain the indication, a microcontroller, an electronic circuit to edge the sensors and a power resource. The power resource, usually a sequence or the power is gained from the heat radiations. A sensor node may diverge in size from small to the size of a granule. The cost of sensor nodes may range from a few to hundreds of dollars, depending on the personality sensor nodes.

1.1 Characteristics of WSN

The main characteristics of a WSN are as follows:

- Power expenditure constraints for nodes using batteries or energy gathering
- Ability to contract with node failures (resilience)
- Some mobility of nodes
- Heterogeneity of nodes
- Scalability in consumption
- Ability to withstand all type of ecological conditions
- Easy to use
- Cross-layer design

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1.2 Applications of WSN

The wireless sensor technologies has become more advance in the recent years and so they are used in various purposes. Based on the purpose, the various application of the sensor network are in the field of agriculture, health care, area monitoring, disaster relief and so on.

1.2.1 Area Monitoring

Area monitoring is a widespread purpose of WSNs. In area monitoring, the WSN is deployed over a province where some event has to be monitored. In military the sensors are used to detect enemy infringement; a civilian example is the geo-fencing of gas or oil pipelines.

1.2.2 Health Care Monitoring

The medical submission is of two types: wearable and implanted. Wearable devices are used on the body exterior of a human or just at close to the user. The implantable medical devices are those that are inserted within human cadaver. There are also numerous other applications e.g. body arrangement measurement and location of the person, overall monitoring of ill patients in hospitals and also at homes. Body-area networks can gather information about the person's health, fitness, and energy expenditure.

1.2.3 Air Pollution Monitoring

The sensor networks have been deployed in several cities to monitor the attentiveness of dangerous gases in air. These sensors can take advantage of the ad hoc wireless links than wired mechanisms, which also make them more mobile to test readings in dissimilar areas.

1.2.4 Forest Fire Detection

A large number of Sensor nodes can be installed in a forest to detect when a fire has started. The nodes are equipped with sensors to find temperature, humidity and gases which are produced by fire in the trees or in environment. The early detection is important for a successful action of the fire-fighters. The Section 2 describes the identification of the forwarding node based on the fuzzy logic method. The Section 3 describes the identification of the forwarding node based on the neuro fuzzy method and the Section 4 describes the role of mobility in selecting the next forwarding node.

2. FUZZY LOGIC BASED SELECTION OF BEST FORWARDING NODE

In the Fuzzy logic, the system works based on the IF-THEN rules. Fuzzy logic deals with the reasoning on high level using information acquired from the users. But they lack the ability to learn and adjust themselves to the changing environment. In this technique, the next forwarding node can be selected based on the information from the users.

Gopinath et. Al. [3] proposed a method to find a best route that can able to broadcast data through the energy competence transmit. The paramount node from the neighbouring node is selected using the fuzzy logic. Fuzzy Logic system is taken for indicating the environment variables for selecting the best neighbouring node to transmit the data to the destination. Fuzzy rules will be created in admiration of the attributes and the linguistic variables which are used to reveal the values of those attributes. By using antecedents, the energy efficiency is calculated for each and every node within the environment. The node with the highest energy efficiency has been considered as the best neighbouring node to broadcast the data to objective. By this, every node in the network will be analysed and the best node will be found out from all amongst the nodes presented in that surroundings. In the best node selection there will be less container transaction with high energy expenditure.

A modified method [4] is proposed for energy optimisation in the wireless sensor networks. This method mainly focuses on the routing of the generated data in the network. This generalized approach is soft and tuneable and hence it can accommodate sensor networks comprising of different types of sensor nodes having different energy metrics. The nodes are grouped to form clusters. The shortest path from each cluster to the destination is found by an algorithm with minimal energy of the path [5]. The routing table is periodically refreshed to find the current state of the network. The method uses the fuzzy routine to determine the value of cost for a link between two sensor nodes such that the life of a sensor network is maximized [6].

A novel fault tolerant fuzzy logic based routing protocol [7] is proposed for the wireless sensor networks. The problem of routing is divided into two sections. The first section deals with the creation of the routing algorithm and the second section deals with the fault tolerant mechanism in order that the mechanism is tolerant against the routing faults. The packets that are generated are prioritized into three levels such as Level 0,1 and 2. The network lifetime, consumed energy and delivery ratio are used as the parameters for the fuzzy logic to select the forwarding node in the network. The multi-path routing method is used to avoid the node failures in the network thereby increasing the delivery ratio of the packet in the network [8].

A method for energy optimisation [9] is proposed to enlarge the lifetime of the nodes in the network by focusing on the remaining energy of the nodes. The proposed optimal routing protocol is inspired by the behaviour of the ants. The ants are used to find the existing path from the source to destination node. Then the best path with optimal energy is found by

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International Journal of Advances in Computer and Electronics Engineering
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combining the behaviour of ant and the fuzzy logic to make the best decision. In this, fuzzy ant colony optimization routing each node in the network can receive, transmit or idle. When two or more nodes want to send a packet at the same time over the same transmission medium or channel, collision will occur. When a node wants to transfer data, it makes a request that is broadcasted to all of its neighbours. Two ants are used such as the Forwarding ants used to find the route from source to destination and the backward ants tries to avoid the usage of the same node [10].

Mohammad Samadi Gharajeh et. al. [11] proposed a new inferential routing protocol called SFRRP (Static Three-Dimensional Fuzzy Routing based on the Receiving Probability). The data packets are transmitted by hop-to-hop delivery to the base station. It uses a fuzzy procedure to transmit the sensed data or the buffered data packets to one of the neighbours called selected node. In the proposed fuzzy system, the distance and number of neighbours are input variables, while the receiving probability is the output variable. SFRRP just uses the local neighbourhood information to forward the packets and is not needed by any redundant packet for route discovery. The proposed protocol has some advantages such as a high delivery ratio, less delay time, high network life, and less network traffic. In this way, the traffic load of the network is reduced, the energy consumption of the nodes decreased, the network life and data delivery ratio considerably enhanced, and the data packets delivered to the base station in an acceptable time [12].

Iman M et. al. [13] designed a protocol named Fuzzy Energy Aware tree based Routing (FEAR) that aims to improve performance the of existing tree based routing protocol and improve the lifetime of the network by considering the energy of the nodes. This is a cross layer protocol and uses information from all the layers to achieve the aim. This protocol constructs a logical tree using the neighbouring nodes and assigns a logical id to each node. Then it constructs a neighbour table to route the packet generated. During transmission both the energy and depth of the node are considered to increase the lifetime of the node. The constructed tree can be reconstructed when a node or link failure occurs. This may also happen when a new node enters the current network. During the construction and reconstruction of the tree the fuzzy inference based ranking system is used to rank the neighbouring nodes [14].

Ge Ran et. al., (2010) proposed a method that can improve the performance of the LEACH protocol in combination with the fuzzy logic. In this approach, the parameters considered are energy, distance, node density and the nodes can get its location. Each input function has different membership functions and each of the membership function has a degree. The defuzzification method is used to get the crisp value using the centroid, which returns the centre of the area by aggregating the results [15].

Barani S et. al., [16] designed an algorithm for routing that mainly focuses on the energy of the nodes. The source node has the sensing range of 50 meters. It selects its neighbour node from the first level. Then that neighbouring node selects its first level neighbouring node and so on until this reaches the destination node. The details of the neighbours are updated into the neighbour table. Then the fuzzy rules are applied by considering the parameters such as residual energy, queue length between the links and the distance between the nodes. The best nodes are selected and all possible routes to the sink node from the source node are constructed. The best route is selected by the parameters and the packet is routed through that path.

3. NEURO FUZZY BASED SELECTION OF BEST FORWARDING NODE

Neuro fuzzy is the combination of neural network and fuzzy logic. The neuro fuzzy systems can be trained to make human like decision making and be used to solve the problems that cannot be solved mathematically. The system can be able to handle some critical conditions and thus improves the performance of the system.

Pon Rohini et. al., [17] proposed a method that finds the multiple paths from the source node to the destination node. The neuro fuzzy method is used to find the void node in the network. This is also used to find the path without any connectivity holes. All the possible paths from the source to the destination are identified and the best path is selected to route the data that is created. The paths that are found can be overlapped, edge disorganised or node disorganised with one another. This avoids the route that contains the holes in the connectivity. The data that is created are encrypted to provide security with a dynamic secret key. The final path through which the data is routed be shortest and energy efficient path. This reduces the end-to-end delay.

Sasikala K et. al., [18] proposed a routing protocol for wireless mesh networks that uses the shortest path to the destination. The node that wants to send the data to the destination broadcasts a request message. The nodes that receive the request send the acknowledgement message to the sender and transmit the request towards the destination. The source node receives the reply with the hop count from the particular node towards the destination. Each node that is sending the reply message is included as the forwarding nodes. Here the neuro fuzzy method is used to find the available neighbours for the particular node.

A new protocol [19] is constructed a method that uses the Adaptive Neuro-Fuzzy Inference System (ANFIS) to construct multiple paths by using the data set that is generated by the Factorial Experimental

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
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Design Model (FEDM). The data set is collected as a survey from the users and the users rank the possible paths with a score. From all the possible set of the data a total of 162 data's were used. Fuzzification of sub-network transforms the real inputs into fuzzified inputs in term of "high" and "low" ranges. The output layer has only one neuron for representing membership function of compliance/delay threshold rate. The ANFIS generates a system for route utility from the training and checking data set. Within the range of the input parameters, the membership functions and rule bases were calibrated by the system. The ANFIS already contains a fuzzy inference system. Error between the data set and the fuzzy inference system was reduced by the back propagation algorithm by selecting suitable number of epochs and error tolerance.

TABLE 1 A COMPARATIVE STUDY OF SURVEY

Reference	Technique	Parameter Used
Gopinath et. al., (2014)	Fuzzy Logic	Packet Loss Ratio, Mobility, Distance
Tarique Haider et. al., (2009)	Fuzzy Logic	Energy, Queue Size, Distance
Mostafa Fard et al. (2013)	Fuzzy Logic	Traffic, Hops, Packet Priority
Ehsan Amiri et. al. (2014)	Fuzzy Logic	Energy, Distance, Connectivity Degree
Mohammad Gharajeh et. al. (2013)	Fuzzy Logic	Distance, Number of neighbours
Iman M et. al. (2011)	Fuzzy Logic	Node Depth, Energy
Ge Ran et. al., (2010)	Fuzzy Logic	Distance, Node Density, Battery
Barani S et. al., 2011	Fuzzy Logic	Energy, Queue Size, Distance
Pon Rohini et. al., (2015)	Neuro Fuzzy	Traffic load, Distance
Sasikala K et. al., (2014)	Neuro Fuzzy	Energy, Distance
Suji R et. al., (2013)	Neuro Fuzzy	Travel and queue time, Speed, Utility

Table 1A shows the overall comparative study of the survey using the neuro fuzzy and the fuzzy logic techniques with the parameters that are used for the selection of the next forwarding node.

4. MOBILITY BASED SELECTION OF BEST FORWARDING NODE

The selection of a forwarding node from the dynamic network is a crucial task because it involves the speed, energy and the direction of the nodes in the network.

Jun Luo et. al., [20] proposed a method that can conserve the energy of the nodes that are near to the source node because the nodes that are near to the destination has to relay the packets from other parts of the network. The solution proposed was a network with the sink as mobile. Here the destination node moves with the same speed in all the direction. The networks with the static destination and a network with the mobile destination are compared to analyse the performance of the networks. Due to the mobile destination the traffic load of the network gets reduced rapidly and reduces the congestion in the network.

Stefano Basagini et. al., [21] suggested a method that show the advantages of the controlled mobility to increase the lifetime of the network. The sink node moves in the network to collect the data from the other nodes in the network. To determine the movement of the sink node a Mixed Integer Linear Programming (MILP) analytical model whose solution determines those sink routes that maximize network lifetime. Greedy Maximum Residual Energy (GMRE) method moves the sink from its current location to a new location where the nodes around it have the highest residual energy.

Ioannis et. al., [22] suggested four characteristics mobility patterns for the sink along with different data collection analysis strategies. This reduces the transfer of the packets from the intermediate node to the sink. In the first method, the sink performs the random walk and the data is collected in a passive manner. The sink node sends a beacon message periodically. Each node receives the message and acquires the channel to transmit the sensed data. This causes the collision in the network. In the second method, the sink performs the partial random walk with limited multi hop propagation. The network area is partitioned into equal sized square regions and the centre of the region is considered as a vertex. The centres of all the regions are connected and the sink moves along the centre point. So that all nodes in a particular region can transmit the data to the sink. In the third method, biased random walk with the passive data collection is used by the sink node. In the fourth method, Deterministic walk with Multi-hop data propagation is used.

Erman et. al., [23] proposed a method to enable mobility in wireless sensor nodes in the unmanned aerial vehicle. The nodes that are present in the network are homogeneous and moves with constant mobility. This changes the topology of the network. It is capable of detecting events that occurs in the critical regions.

Deng S et. al., [24] proposed a mobility based clustering protocol for mobile wireless sensor networks. In this the sensor node elects itself as the cluster head based on its remaining energy and mobility. A non-cluster-head node aims at its link stability with a cluster head during clustering according to the estimated connection time. Each non-cluster-head node is allocated a timeslot for data transmission in ascending order in a time division multiple address (TDMA) schedule based on the estimated connection

ISSN: 2456 - 3935
International Journal of Advances in Computer and Electronics Engineering
Volume: 02 Issue: 04, April 2017, pp. 24 – 29

time. In the steady state, the node transmits its sensed data in its timeslot and also broadcasts a join request message to join in a new cluster. This avoids more packet loss in the network when the node joins with the new cluster. The random way point model is used as the mobility type of the nodes.

A rendezvous-based data collection approach [25] is proposed in which a subset of nodes serve as the rendezvous points that buffer and aggregate data originated from sources and transfer to the base station when it arrives. This method uses the advantages of controlled mobility and in-network data caching and can achieve a desirable balance between network energy saving and data collection delay. Two efficient rendezvous design algorithms with provable performance bounds for mobile base stations with variable and fixed tracks are used. It is assumed that data from different sources can be aggregated at a node before being relayed. This reduces the energy consumption of the nodes.

A novel method [26] proposed that can adaptively move the sink node inside the covered region, according to the evolution of current events, so as to minimize the energy consumption incurred by the multi-hop transmission of the event related data.

Kim et. al., [27] proposed an improved protocol called "LEACH-Mobile" for mobile nodes to declare the membership of a cluster as they move, and to confirm whether a mobile sensor node is able to communicate with a specific cluster head within a time slot allocated in TDMA schedule. The operation of LEACH is broken up into rounds, where each round begins with a set-up phase when the clusters are organized, followed by a steady-state phase when data transfers to the base station occur. The basic idea in LEACH-Mobile is that the nodes in the network should belong to a specific cluster at the steady-state phase as head of the cluster in Tree Based Data model [28]. The cluster with the minimum energy can be identified by sending the messages to the non-cluster head node according to TDMA time schedule [29].

Xing et. al., [30] proposed a method that exploits mobile nodes present in the sensor field as forwarding agents. As a mobile node moves in close proximity to sensors, data is transferred to the mobile node for later depositing at the destination. The parameters used are sensor buffer size, data generation rate, radio characteristics, and mobility patterns of mobile nodes.

The MULE (Mobile Ubiquitous LAN Extensions) architecture is used which provides connectivity by adding an intermediate layer of mobile nodes to the existing relationship between sensors and access-points used in typical sensor network designs [31]. The data routing using this architecture is very simple and extremely light weight for the sensor nodes [32].

5. CONCLUSION

The selection of next node to forward in sensor networks is a new area of research. The lifetime of the node is crucial for a network to function. However, most work fails to consider some features of the node when evaluating the routing techniques. Most of these routing algorithms are location-based and therefore they are subject to related problems like local minimum, position inaccuracy. The researchers tried to resolve these issues using diverse methods and they produce acceptable solutions. However, improvements have to be carried out energy-efficiency field since energy resource of sensor is scarce.

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