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Adaptive Recommendation Routing for node efficiency for Wireless Sensor Network

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ABSTRACT: Wireless sensor networks have become a hub for research and attracted many due to its cost efficiency, reliable monitoring of the environment that finds application in various fields like battlefield, etc. Routing is a major challenge in WSN. A dynamic route needs to be created during any node failure. In this work, a novel algorithm called Adaptive Recommendation Routing (ARR) is proposed that can be applied to wireless sensor network to overcome its energy constraints and will assist in increasing the network and data efficiency. This algorithm is intended to be data centric and provides a robust and reliable route even at adverse situations. Machine learning algorithms are implemented specifically for calculating the next hop and helps in clustering of faulty sensors from the working ones. This helps in creating the dynamic and efficient route. This design is an elaborated justification for providing energy efficient systems that will perform better than the standard protocols by transmitted lesser data for creating the routing logic, thus delivering network and data efficiency. This prescribed work describes in detail about incorporating swarm intelligence with bio-inspired computation for determination of the cluster head and making the routing efficient and simple.

Keywords: Adaptive Recommendation Routing (ARR), clustering, data efficiency, node failure scalability, weight assignment, Wireless Sensor Network (WSN)**.**

I. INTRODUCTION

A well-organized group of dedicated sensors that are dispersed spatially using certain protocols is known as a Wireless Sensor Network (WSN). The architecture is widely used for monitoring and assessing the physical conditions of the environment, like temperature, sound or pollution levels, humidity, etc. of a certain location. The sensors used for measuring these attributes are equipped with programming capabilities and wireless communication capability, in addition to sensing. The cost of implementing a Wireless Sensor Network is also considerably low as it involves only few cheap sensors and hardware programming knowledge.

In this paper, a node-efficient geographic wireless routing protocol known as ARR is proposed. The algorithm mainly puts constraints on data that has been collected by the sensors and assigns the best possible way for the data to be sent in the next hop based on fitness value. The main advantage is that, even if the sensors values are scaled too high, the best possible route obtained does not change. The algorithm also uses machine learning techniques to aid the calculation of the next possible hop as well as clustering of working sensors and faulty sensors.

Networking these kinds of sensors that track the geographical conditions of an area can assist in rescue operations for locating any survivors in case of any disaster or identify the areas which are risky to work in and thus warning the crew to stay cautious. Computing the routing paths by electing random cluster is major work done by LEACH [9]. However, the major research gap in LEACH is to compute the optimal cluster head. SPIN [9] uses broadcasting technique where all the nodes are considered to be potential base station. The major challenge here is heavy energy consumption due to broadcast. This proposed work has been designed to consume less energy and provide a better performance than the classical routing protocols.

II. BACKGROUND

The concern of this paper is data, topology and hierarchy. It examines the different types of wireless routing protocols, research done in this field as well as classifies the various methods that are said. Other benefits include knowing the node mobility, where the node is deployed etc [1]. In this paper, wireless sensor networks are classified based on their network type that is either proactive or reactive. Also, a protocol called TEEN (Threshold sensitive Energy Efficient sensor Network protocol) is reviewed and used primarily for energy efficiency and applications with time constraints and performance is measured. It outruns the conventional sensor network protocols [2].

The scrutiny of all major routing protocols is studied. Apart from investigation, model design and counteractions are also discussed [3]. In another analysis, the authors propose a cluster model called the LEACH (Low energy adaptive clustering hierarchy) protocol that works in a distributive environment. This is vital for reducing the energy usage by distributing the energy evenly to all the sensors. This provides large scale usability as well as toughness. There is also evidence of decrease in communication energy and lifespan [4].

There was a dire need to find the location of the sensors. A few researchers proposed a routing method which primarily focusses on energy efficiency of untended sensors or actuators.

An algorithm, termed as GEAR also known as geographic and energy aware routing was proposed. Routing is decided based on the neighbour's selection. This also avoids the typical flooding scenario. Simulation is done to measure the performance. In terms of packet, it outperforms GPSR by 70 to 80% and also packets delivered are 25 to 30% more than a GPSR. A few researchers came out with a updated version of GEAR [5]. The main objective was to create a hybrid protocol called APTEEN which primarily focusses on retrieval of information, reacting to periodic as well as time critical events. It enables a user to get the historical data in the form of queries and analyse it. This model works better in terms of energy efficiency as well as the lifetime of senor networks whose nodes are evenly distributed and could be extended to unevenly distributed nodes in the future [6].

More emphases was needed to solve the energy constraints in WSN. Thus there was proposed method on need for energy efficient wireless sensors because there is battery oriented and it's hard to track and replace them. Routing protocol called the Base-Station Controlled Dynamic Clustering Protocol (BCDCP) was proposed that aims in even distribution of energy among the sensor nodes and compares it to LEACH-C and PEGASIS. BCDCP provide a means of balancing the clusters as well as outperforming the computational tasks that demands more energy and provides a wide range of applicability for sensors [7]. Another research paper was focused on the study of energy efficient routing for wireless sensors. It investigates the energy histogram and draws various methods to enhance routing. Packet streams are joined together in the first approach, next arguments on various energy efficient routing of sensors is done. Finally, conclusions are drawn that energy efficient routing is impossible in practical life. This paper stresses more on the need of practical implementations of energy efficient routing models [8].

III. METHODOLOGY

To deploy the proposed method, a case study of water pollution detection was considered where various sensors have been deployed to collect the sensor readings / pollutants from various remote water source. So, the detection of failure is the more important to make the system robust. Various chemical sensors have been deployed to get the pollutant concentrations and data aggregation methods such as boundary value analysis to reduce the data over the network and make the system more efficient over longer run.

Here, gateway is the Cluster Head (CH) which has multiple sensor nodes, the data are aggregated over the cluster head and low-level analysis are being carried out. Node density can vary among Cluster Head (CH), these data from the various node and different clusters are formatted and stored in Data Repository. In control center most of the server analysis such as Clustering, Decision making takes place to derive various patterns.

Functional modules of simulated environment:

– Sensors data Aggregation
– Network failure optimization
– Server analysis (Clustering, Decision making)
– Next Hop Analysis

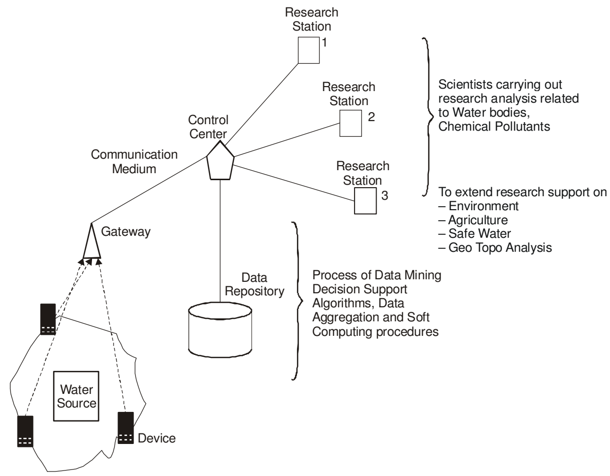

Fig. 1. WSN deployment for water pollution detection.

A. Algorithm

1. Assign equal weight values to all the sensor nodes. Initialize all the weights to zero (w=0).
2. Increment the weight value when a sensor node transmits data. (Trans ~ w++).
3. Calculate a fitness value (V) based on higher weights of nodes. These nodes form the active node cluster.
4. The cluster head (CH) is selected for the node with the highest weight value (W). CH = Node (W).
5. The next hop (h) can be calculated based on highest weight (W) of neighbor mode which is decided by CH.

This algorithm allows intelligent dynamic route selection based on fitness values as well as the neighbor weight value.

B. Properties of the proposed system

– Node failure detection
– Cluster node anomaly detection
– Data aggregation and data reduction

Node Failure Detection:

– The adaptive recommendation routing algorithm, which is implemented on lower level of the system, i.e. from nodes to Cluster Head (CH). Here the data from various chemical sensors is aggregated to the Cluster Head CH.

- The weights have been assigned equal values to all the sensor nodes initially. (w=0)

– For each transaction from the sensor nodes the weights increased over the timestamp, timestamp is the delta between each transmission.

– The fitness values are calculated according to the timestamp and independent of the values on the sensors. (t ~ fitness value)

– The failed node is detected by the minimum average of the fitness values (fv) among all the sensors nodes. (min avg (fv)).

Working sensor: Case study of sensors with cluster head with timestamps in x axis and pollutant concentration in y axis (Fig. 2)

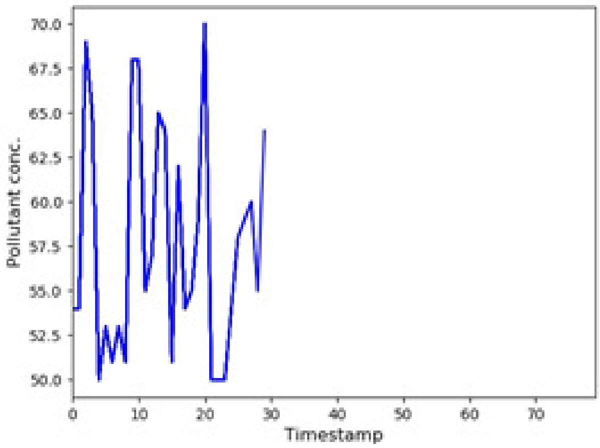

Fig. 2. Working sensor data transmission graph.

Data aggregation over Cluster Head (CH): Pollutant concentration captured with respect to timestamp and corresponding fitness values for a particular sensor in cluster (Table 1).

Table 1: Data aggregation over Cluster Head (CH).

Timestamp (sec)	Pollutant Concentration	Fitness Value
0.5	54	1
1	54	3
1.5	69	6
2.0	65	10
2.5	50	15
3.0	53	21
3.5	51	28
4.0	68	36
4.5	68	45

Faulty Sensor: In the below graph (Fig. 3), it is observed some of sensors record no value which we can infer that there is a node failure.

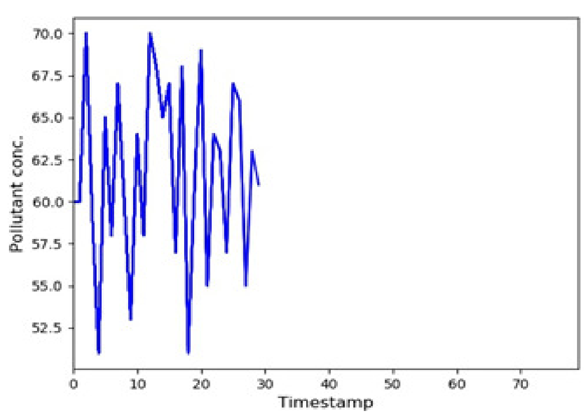

Fig. 3. Faulty Sensor data transmission graph.

Data aggregation over Cluster Head (CH): Pollutant concentration captured with respect to timestamp and corresponding fitness values for a particular sensor in cluster with node failure (some of the fitness value are 0 in Table 2).

Table 2: Data aggregation over Cluster Head (CH) with failed nodes.

Timestamp (sec)	Pollutant Concentration	Fitness Value
0.5	0	0
1	95	2
1.5	0	0
2.0	0	0
2.5	88	5
3.0	95	11
3.5	0	0
4.0	93	0
4.5	0	8

This data is finally taken to analyse for other knowledge extraction, various patterns such as faulty node clusters, anomalies on clusters as well as on sensor nodes, selecting the next hop (h), etc.

Cluster node anomaly detection: On the cluster various high computational analysis are done to make the system robust and reliable on optimal usage. Using cluster fitness values, the node are clustered and the cluster head is chosen according to their behaviors.

IV. RESULTS AND DISCUSSIONS

Here, a comparison is done based on the efficiency of similar wireless sensor routing algorithms such as LEACH and SPIN. This comparison of the algorithm is done based on the metrics network efficiency, Data efficiency and scalability**.**

A. Network Efficiency

Here, with ARR algorithm, the data transfer size varies very less with the increase in the cluster heads, because the fitness values are generated over the control center, the data over the network is much lesser than leach and spin (Fig. 4).

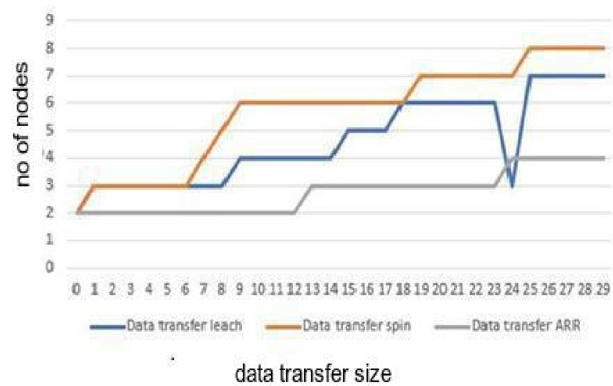

Fig. 4. Data transfer vs number of Cluster heads (CH) graph.

B. Data efficiency

Here, the data accumulation over the cluster head is directly proportional to the number of nodes, since the only parameter used to calculate fitness values, is sensor data only. Very less data used for routing and processing than spin and leach (Fig. 5).

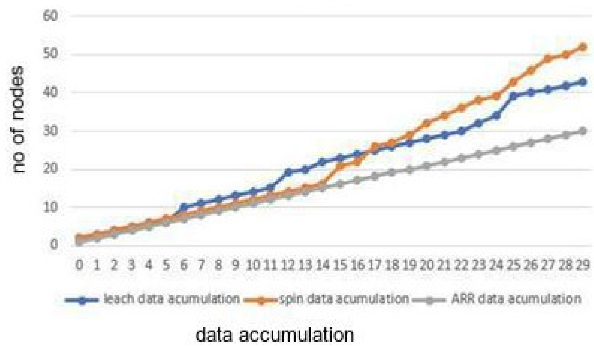

Fig. 5. Data accumulation vs number of nodes.

C. Scalability

Here, the performance of various routing algorithms are compared in increasing cluster environment, since ARR have no additional dependencies or querying process it is highly scalable than spin and leach algorithms (Fig. 6).

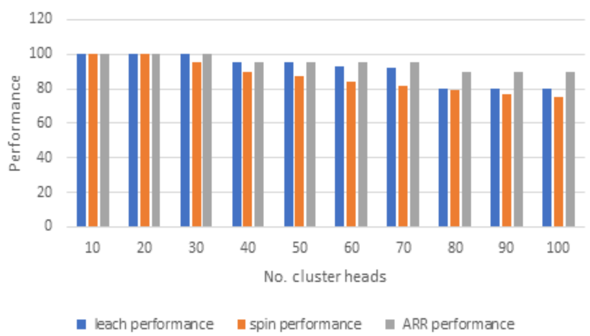

Fig. 6. Performance vs number of cluster head (CH).

V. CONCLUSION

In this work, the proposed Adaptive Recommendation Routing (ARR) was deployed to overcome the WSN energy constraints and to maximize network efficiency and scalability. The result analysis shows that the proposed method ARR performs better than LEACH and SPIN. The energy efficiency of WSN is a big challenge. There is need to develop a framework which makes sure that nodes would transmit data only if required. This research would also be applied to various real time systems such as health care where as extension of WSN can be deployed for the wearable sensors. Extension of this research would be possible in smart city projects by Govt. of India, by implementing ARR scheme into the IoT network

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