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MULTIOBJECTIVE CLUSTERING BASED PACKET ROUTING IN WIRELESS SENSOR NETWORK

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ABSTRACT

Particle Swarm Optimization based effective clustering in Wireless Sensor Networks is proposed. In the existing OEERP, during cluster formation some of the nodes are left out without being a member of any of the cluster which results in residual node formation. Such residual or individual nodes forward the sensed data either directly to the Base Station or by finding the next best hop by sending many control messages hence reduces the network lifetime. The proposed E-OEERP reduces/eliminates such individual node formation and improves the overall network lifetime when compared to the existing protocols. It can be achieved by applying the concepts of Particle Swarm Optimization (PSO) and Gravitational Search Algorithm (GSA)for cluster formation and routing respectively. For each Cluster Head, a supportive node called Cluster Assistant (CA) node is elected to reduce the overhead of the Cluster Head. With the help of PSO, clustering is performed until all the nodes become a member of any of the cluster. This eliminates the individual node formation which results in comparatively better network lifetime. With the concept of GSA, the term force between the cluster heads is considered for finding then ex t best hop during route construction phase. The performance of the proposed work in terms of Energy Consumption, Throughput, Packet Delivery Ratio and Network Life time are evaluated and compared with the existing OEERP, LEACH, DRINA, BCDCP protocols. The work is simulated using MATLAB simulator. The results prove that, the proposed E-OEERP shows better performance in term of lifetime.

1. INTRODUCTION

A Wireless Sensor Network(WSN) or wireless sensor and actor network are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on.

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, although functioning "motes" of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth.

Wireless Sensor Network was been designed as a military warning system for monitoring borders. WSN are always in the stage of development, there are practical applications for experimental and demonstration purposes. WSN are widely used for professional applications. Communications in WSN are ad hoc networks. Ad hoc networks are meshed networks in which network nodes are connected one or more neighbours. This results in a multi – hop communication ,which pass the messages from node to node until they reach their destination. The battery power of a wireless sensor node must therefore be as efficient as possible , while all other parts must have a very low power consumption

2. Related Work

Most QoS provisioning protocols proposed for traditional ad hoc networks have large overhead caused by end-to-end path discovery and resource reservation [5], [6]. Thus, they are not suitable for resource-constrained WSNs. Some mechanisms have been designed to provide QoS services specifically for WSNs. Here we mainly focus on the metrics of delay and reliability.

2.1. Providing Real-Time Service

RAP exploits the notion of velocity and proposes a velocitymonotonic scheduling policy to minimize the ratio of missed deadlines [7]. The global information of network topology is required. Implicit Earliest Deadline First (EDF) mainly utilizes a medium access control protocol to provide real-time service [8]. The implicit prioritization is used instead of relying on control packets as most other protocols do. SPEED maintains a desired delivery speed across the network through a novel combination of feedback control and non-deterministic QoS-aware geographic forwarding [9]. In [10], a two-hop neighbor information based gradient routing mechanism is proposed to enhance realtime performance. The routing decision is made based on the number of hops from a source to the sink and the twohop information.

2.2 Providing Reliability Service

Adaptive Forwarding Scheme (AFS) employs the packet priority to determine the forwarding behavior to control the reliability. ReInforM uses the concept of dynamic packet states to control the number of paths required for the desired reliability [1]. Both of AFS and ReInforM require to know the global network topology. LIEMRO [2] utilizes a dynamic path maintenance mechanism to monitor the quality of the active paths during network operation and regulates the injected traffic rate of the paths according to the latest perceived paths quality. It does not consider the effects of buffer capacity and service rate of the active nodes to estimate and adjust the traffic rate of the active paths.

2.3. Providing Real-Time and Reliability Services

MMSPEED extends SPEED for service differentiation and probabilistic QoS guarantee [6]. It uses the same mechanism as SPEED to satisfy the delay requirements for different types

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of traffic, and uses redundant paths to ensure reliability. The MAC layer function is modified to provide prioritized access and reliable multicast delivery of packets to multiple neighbors. When the network is congested, all the source nodes still continuously transmit packets to the sink along multipaths without taking some other mechanisms, such as caching packets for some time. This not only deteriorates reliability but also retards the delay-sensitive packets. Energy-Efficient and QoSbased Multipath Routing Protocol (EQSR) improves reliability through using a lightweight XOR-based Forward Error Correction (FEC) mechanism, which introduces data redundancy in the data transmission process.

Furthermore, in order to meet the delay requirements o various applications, EQSR employs a queuing model to manage real-time and non-real-time traffic. DARA considers reliability, delay and residual energy. But it only differentiates the applications into two classes: critical and non-critical. The neighbor sets of a node for the two kinds of applications are different and all the packets belonging to the same category will be forwarded to the next hop computed by the same function. Obviously, two classifications of the applications in WSNs are not enough. D. Djenouri and Balasingham proposed LOCALMOR, which considers latency, reliability and energy [3]. It puts the incoming packets into three queues according to their requirements. LOCALMOR satisfies the requirement of reliability-sensitive applications by transmitting the data to both the primary sink and the secondary sink, which incurs much overhead. What's more, it combines the queue management mechanism and routing to provide differentiated services.

How to design a routing protocol that provides data integrity and delay differentiated services over the same WSN simultaneously without incurring much overhead is an extremely challenging problem. The main contribution of this paper is to borrow the concept of the potential field from physics and design a novel potential-based dynamic routing algorithm, IDDR, which can provide high integrity and delay-differentiated services using only local information.

3. Multiobjective Clustering Based Packet Routing Scheme

Particle Swarm Optimization in order to reduce the individual/ residual node formation. Clustering in the existing Optimized Energy Efficient Routing Protocol results in individual node formation. For eliminating such individual nodes, the concepts of Particle Swarm Optimization (PSO) are used for cluster formation. Constructing the optimal routing path to transmit the sensed data is another challenging task in WSN. In the proposed system, Gravitational Search Algorithm (GSA) is also used for constructing an optimal routing path to transmit the sensed data to the base station.

3.1 Particle Swarm Optimization

PSO is generally initialized with a random particles' group and in turn explores for optimal solution by means of updating generations Raghavendra V. Kulkarni, and Ganesh Kumar Venayagamoorthy. In the context of iterations, every particle is being updated by the maximum values. In which the first maximum value can be referred to as the fitness i.e. the best solution accomplished so far and is known as p best. The second "best" value could be tracked by means of the particle swarm optimizer and is the best value found so far in the whole swarm population and it could be referred to as g best i.e. global best. Likewise, when a particle assumes in the population of swarm as its topological neighbours, it could be known as l best i.e.

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local best X. Wang, S. Wang, and J. J. Ma. Let *(X,Y)* be the sensing region and *r* be the coverage of any sensor node. sample sensor network. It is divided into smaller portions called cluster with radius r. Let *(x,y)* be the coordinates of a cluster in a sensing region.

The total Number of Clusters formed *NC* can be calculated based on the whole network area and size of a cluster.

$$NC= XY/xy$$

where,

XY be the network area and xy be the area of the cluster.

Let the value of *x=y=t*, can be written as

$$NC = XY/t^2$$

The value of r can be written as, $r=t/\sqrt{2}$

So the total number of clusters formed can be given as,

$$NC=XY/2r^2$$

This is for the lower bound. The same value is calculated for the upper bound region also. Above equation is used for calculating the number of clusters formed in upper bound as,

$$NC= \{(XY/xy) + (X/x) + (Y/y)$$

If x=y=t, &X=Y, t=r√2, the above equation becomes, $NC = \{(X + 2 \sqrt{2}x*r) / 2r \}$

The average number of clusters formed in a network can be calculated using the lower bound and the upper bound values respectively as,

$$NC_{Avg} = \{(X^2 + 2\sqrt{2}x*r) / 2r^2 \}$$

3.2. Clustering using PSO

The fitness value Jun Yang, Hesheng Zhang, Yang Ling (Mar 2014) , Yang G. Kim and Myung J. Lee (Jan 2014) ,of each particle can be calculated using as,

$$fitness = \alpha1x1+ \alpha2x2+ \alpha3x3$$

where,

α1 and α2 be any constant value between 0 and 1 and

α3=1- α1- α2

$$x1 =\{ \_ (dN - dP)\} / Cn$$

where,

$d_N - d_P$ is the distance between the particle and the Nth node,

N= 1,2,3…m} & Cn is the number of cluster nodes reachable from the particle p. $x_2 =$

$$EAvg (C_n) / E (p)$$

$$x_3 = 1 / C_n$$

where, *n* is the number of nodes reachable to a particular particle

ω - weight of node velocity

ω1 & ω2 - weights of node location

vt-1 - previous velocity of the node pt-1 - previous position of the node and pt - current position of the node.

$$^{P}update = {}^{P}t\text{-}1 {}^{+V}update$$

Fitness threshold may be computed as,

$$F_T = f_{max} /2$$

Gravitational Search Algorithm is an optimization algorithm used in the proposed

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method for constructing an optimal path for transmitting the sensed data to the base station [4]. The node which has the data to transmit is called source node. Such node checks for the next best hop to transmit the sensed data towards the forward the same request to its available neighbors by replacing the received position, velocity and energy value by its own value. The same process is repeated until it

This can be given as, $F \varepsilon G.M_1M_2 / R$ Where,

F - force of a particle

G - Gravitational constant ($G = 6.8x10^{-11}\ m^3\ kg^{-1}s^{-2}$) M1 and

M2 - mass of particle 1 & 2 respectively

R - distance between particle 1 and 2.

Once cluster formation and cluster head election take place using Particle Swarm Optimization technique, all the cluster nodes start sensing the data and redundancies. Before transmitting the sensed data to the Base Station, each cluster head has to predict the shortest available path with high reliability to transmit the aggregated data. So each cluster head start constructing the routing path by finding the best next hop. The term force is considered between the cluster heads while choosing the best next hop. The node with minimal distance is considered to choose the next hop. Route construction takes place by considering the next best hop with minimum distance and high force if attraction.

4. Performance Analysis

In addition to the reduced number of residual nodes, different network parameter analysis is being done for the proposed and existing protocols. Parameters like Total Energy Consumption, Load Variance , Packet Delivery Ratio, Overall Network lifetime, are compared for the proposed and the existing protocols. The energy consumption of a node is based on sensing, computing and communication. The energy consumption for a node can be calculated as

$$Ec = E_i - E_r$$

where,

Ec - Energy consumed

Ei - Initial energy of the sensor node

Er - Remaining energy available of the node after sensing and communication operation.

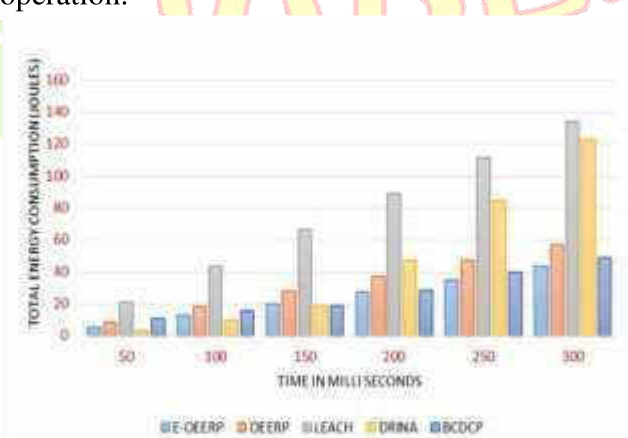

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Figure 4.1 Total Energy Consumption at different time slots

The total energy consumed for all the nodes in the network can be calculated as,

consumed $^{=}$ initial – ^{E}remaining$^{)}$

The Packet Delivery Ratio (PDR) can be calculated

^{PDR} $\bar{=}$ ^{RX} packets $^{/ TX}$ packets

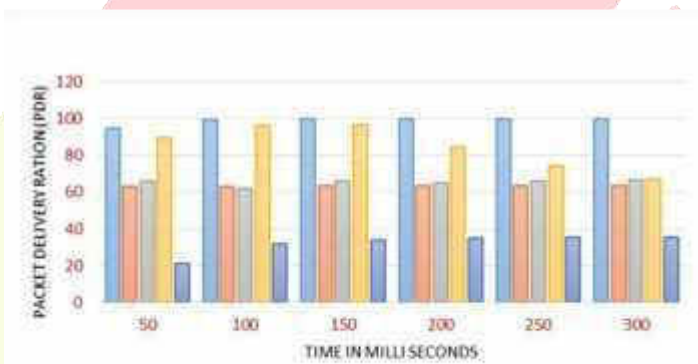

Figure 4.2 Packet Delivery Ratio at different timeslots

The network lifetime can be improved by avoiding the sensor ode to transmit raw data. This can be achieved by

- Aggregating the sensed data to eliminate the data Redundancies
- Eliminating the control overheads messages
- Avoiding the long distance transmission

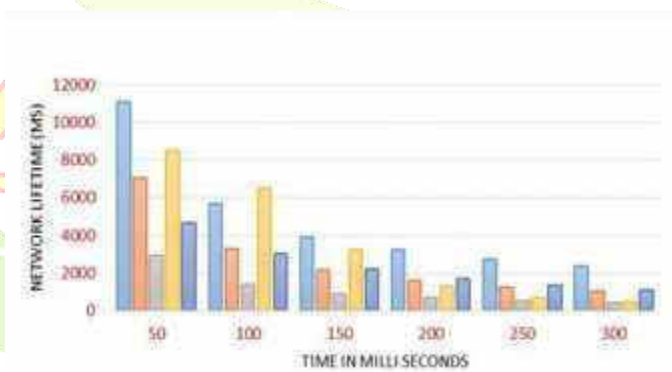

Figure 4.3 Overall Network Lifetime at different time slots

5. Conclusion and Future Work

An Enhanced Optimized Energy Efficient Routing Protocol (E-OEERP) is proposed. In the existing OEERP, the individual node formation takes place during cluster formation. And such individual nodes can become a member of any cluster during next cluster formation and some other node may become as an individual node. Though the percentage of individual nodes varies from one time slot to other, it is a major drawback while considering the network lifetime. Such nodes may die earlier as it has to transmit the sensed data either directly to the Base station or after finding the best next hop. These individual nodes in WSN are eliminated by using Particle Swarm Optimization in the proposed work. This can be done by finding the fitness value of each and every node in the network. A new node called Cluster Assistant is introduced with Cluster Head in the proposed method. It act as a coordinator node for the corresponding Cluster Head. Using Gravitational Search Algorithm, the parameters like distance and force between the sensors nodes are taken into consideration for finding the next best hop. The proposed work provides better performance than the existing routing protocols. For mobile WSN, the same work can be used for eliminating individual node formation during clustering.

In future, Network lifetime, Total energy consumption, Packet Delivery Ratio, Load variance be further improved by Symbiotic Organism Search algorithm.

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