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A Novel Energy Saving Scheme using Potential Based Dynamic Routing in Wireless Sensor Networks

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***Abstract*— Wireless sensor networks (WSN) refers to a group of autonomous sensors that are spatially distributed. It consists of sensor nodes with limited battery power. Data aggregation is an effective method to reduce energy consumption in wireless sensor networks by eliminating the redundancy and reduces the number of transmission. The data sampled by the same kind of sensors have much redundancy since the sensor nodes are usually quite dense in sensor networks. In order to make Data aggregation much more efficient, here proposed attribute aware data aggregation consisting of packet driven timing algorithm and a dynamic routing protocol. Based on concept of potential in physics and pheromone in ant colony, Here uses potential based dynamic routing scheme to transfer data into sink. To make packets more timely convergent, a packet driven timing control scheme is proposed. Here also proposed a scheme that detects congestion efficiently by using queue occupancy parameter of a node and it also overcomes the congestion problem by selecting alternate path using PBDR routing scheme.**

Index Terms*— Wireless Sensor Network, attribute-aware Data aggregation, dynamic routing, potential field, congestion detection

I. INTRODUCTION

Wireless sensor networks consists of large number of sensor nodes for monitoring and recording the environmental applications, such as temperature, humidity and to co-operatively pass their data through the network to main locatino. Normally Sensor node consists of four supply units. Sensing unit which is composed of collection of sensor that produces the electric signal by sensing physical environment. Processing Unit consists of memory (RAM), microcontroller, operating system and timer which are responsible for storing, processing and executing the events respectively. Third component is communication unit that provides communication channel. Fourth component power supply unit consists of power battery to supply energy to the node.

In WSN community, most investigations on data aggregation schemes focus on designing proper strategies to drive the packets carrying redundant and correlated data converge spatially and temporally, which will provide sufficient conditions for data aggregation operations. The data aggregation schemes classified into two categories. i.e., temporal solutions and spatial solutions. The resources in wireless sensor networks, especially energy in sensor networks are quite limited. Since the sensor nodes are usually much dense, data sampled by the homogeneous sensor nodes have much redundancy. Here Data aggregation used as an efficient method to eliminate redundancy. Thereby reduces the number of data transmissions, and also save energy in SNs. Most phenomena or events are spatially and temporally correlated, means the data from adjacent sensors are often redundant and highly correlated. To bring both spatial and temporal correlations, the data aggregation, which can be considered as simple data fusion is performed. Then the abstracted data will transmit to the sink, and also save energy consumption by avoiding redundant transmission. Obviously, the underlying data collection routing protocol is crucial to drive packets converge spatially. In many of the real time environment applications of WSN's, data is generated continuously and it should reach the destination node without delay and loss.

Congestion is the one of the main issue in Wireless sensor networks. Congestion detection and Avoidance in WSNs is a critical issue. It will affect transmission reliability and also causes transmission delay. The way of handling the data against the congestion is very difficult task. Queue occupancy parameter is an accurate indicator of congestion. In this work we propose the scheme that detects congestion by using queue occupancy parameter of a node. If queue length of a node has reached peak threshold then sensed data should not be transmitted through that node for certain time period to avoid congestion. It removes congestion by selecting another neighbouring node based on PBDR routing protocol, which previously used. This node does not causes congestion and transmit the data to the destination node very rapidly and reliably without delay and loss.

II. RELATED WORK

The nodes in WSNs have limited energy and hence, lifetime maximization is the difficult task during protocol designing. Low Energy Adaptive Clustering Hierarchy (LEACH) protocol is a benchmark Clustering Protocol. In Assisted LEACH (A-LEACH) [1], achieves uniform distribution of dissipated energy of nodes by separating the Routing and Data Aggregation operations. It introduces the concept of Helper Nodes which assists Cluster Heads for Multi-hop Routing. A new algorithm has been developed to facilitate energy efficient Multi-hop Route Setup for helper nodes to reach base station. Here proposed work enhances the lifetime of the network.

S.R. Madden, M.J. Franklin, J.M. Hellerstein, and W. Hong proposed TAG(Tiny Aggregation Algorithm)[2].Here proposed a simple SQL-like declarative language for expressing aggregation queries over data sensed by the sensor nodes and also identifies the properties of aggregation functions.

W. Zhang and G. Cao proposed a dynamic convoy tree-based collaboration (DCTC) [3] to reduce the overhead of tree reconstruction in event-based applications in wireless sensor networks. DCTC assumes that each node knows the distance to the events that are generated and the node near the center of events acts as the root to build and maintain the aggregation tree dynamically.

To make data aggregation more efficient in the case of heterogeneous sensors, In [4] introduce the concept of packet attribute, which is defined as the identifier of the data sampled by different kinds of sensors, and then propose an attribute-aware data aggregation (ADA) scheme consisting of a packet-driven timing algorithm and a special dynamic routing protocol.Here uses the concept of potential in physics and pheromone in ant colony. ADA scheme can make the packets with the same attribute spatially convergent as much as possible and thereby improve the efficiency of data aggregation.

In[5] combined the shortest path tree with the cluster method and also developed a hybrid routing protocol to support data aggregation efficiently. Here node in each minimum dominating set performs data aggregation and all head nodes are connected by constructing a global shortest path tree.

Fengyuan Ren, Tao He, Sajal .K. Das and Chuang Lin introduced traffic-aware dynamic routing (TADR) algorithm in [6]. In this work, present a solution that improves the overall throughput of WSNs by alleviating congestion issues in WSNs. To achieve this goal, a traffic-aware dynamic routing (TADR) algorithm is proposed to route packets around the congestion areas and scatter the excessive packets along multiple paths that does not causes the congestion. Using the concept of potential in physics, our TADR algorithm is designed through constructing a hybrid virtual potential field using depth and normalized queue length to force the packets to steer clear of obstacles created by congestion and eventually move toward the sink.

A new minimum spanning tree based protocol called PEDAP (Power Efficient Data gathering and Aggregation Protocol)[7] is proposed. This scheme prolongs the lifetime of the last node in the system while providing a good lifetime for the first node. Where as its power-aware version provides optimal lifetime for the first node and also slightly decreasing the lifetime of the last node. Another merit of this protocol is they improve the lifetime of the system even if the base station is inside the field.

Ant Colony Algorithm is proposed for optimal data aggregation in Wireless Sensor Networks[8]. The algorithm consists of two passes. In forward of this algorithm route is constructed by one of the ants in which other ants search the nearest point of discovered route that previously found. The points where multiple ants join are considered as an aggregation nodes. In the backward pass nodes of the discovered path will generate weight in form of node potential. Which represents heuristics for reaching to destination point or nearest aggregation point. Ants follow the path having more pheromone contents. Finally we get optimal route. Non-optimal route pheromone gets evaporated with time.

A simple centralized feedback timing control algorithm is proposed for tree-based aggregation in [9] and sink node determines the maximal interval for one data aggregation operation with the knowledge of the information quality in the previous aggregation operation. Fan et al. proposed a random waiting timing scheme in [10].Here, each node aggregates and forwards incoming packets after waiting a randomized interval.

Congestion is the one of the main issue in Wireless sensor networks. In [11] proposed scheme that detects congestion efficiently by using queue occupancy parameter of the node. If queue length of any node has reached maximum threshold then data should not be transmitted through that node for certain period of time for avoiding congestion. It overcomes the congestion by selecting alternative neighboring node which does not cause congestion problem and transmit the data reliably and rapidly to the sink node without delay and loss.

III. SYSTEM MODEL

A. Design Models of PBDR Routing Protocol

Here, we are discussing some design models such as Depth Potential Field, Pheromone Potential Field, and Hybrid Potential Fields.

1. Depth Potential Field

To provide the routing function such as how to move packets toward the sink, we have to find the depth potential field V_d of each node. The depth potential D(u) is defined as:

$$V_d(u)=D(u)$$

Where, D(u) is the depth of the node.It means the number of hop that it away from the sink node. The force from node u to one of its neighbors v∈ Ω(u) in the depth potential field is defined as:

$$F^d_{u\to v}=D(u)-D(v)$$

The depth differences between the neighbors are 1, 0, or 1.since the nodes that are two hops away from a node cannot become its neighbors. The depth potential field will drive packets move to the destination along the shortest path without any loops. Finally we get best route.

2. Pheromone Potential Field

To gather the packets with the same attribute together we have to construct Pheromone potential field. Here uses the ant colony concept. According to this, the packets in WSN are treated as the ants leaving volatile pheromone at each passed node. The path selected by more packets will have more pheromone and can attract more packets with the same attribute (i, δ)as the amount of pheromone where i is the ID of node and δ is the attribute of data packet. τ(i,δ) is initialized to 0. Each packet will leave constant pheromone τ when passing a node. In ant colony, the pheromone will increase after ants passing and also continuously evaporate with the time. When a packet with attribute δ reaches node v or after an aggregation operation at node v, τ (v,δ)will be updated as follows:

$$\tau(v,\delta) = \rho * \tau(v,\delta) + I * \Delta\tau$$

Where ρϵ(0,1) represents the pheromone evaporation , and I represents indicative function. When a new packet with attribute reaches node v, I = 1, otherwise I = 0. The packets will be forwarded to the sink in the steepest gradient direction, so the nodes with more intense pheromone should have lower pheromone potential value. Therefore, the pheromone potential field force V_P(u,δ) of node u is defined as:

$$V_P(u,\delta) = 1 - \tau(u,\delta)$$

We calculate the pheromone potential field force from node u to one of its neighbor vϵΩ(u) is,

$$F^{p}_{u\to v} = V_P(u,\delta) - V_P(v,\delta)$$

We define $\Delta\tau = \frac{1}{S}$, where S is the buffer size of nodes.

3. Hybrid Potential Field

By combining the depth potential field and the pheromone potential field ,we get hybrid potential field as follows:

$$V_h(u,\delta) = (1-\alpha)V_d(u) + \alpha V_p(u,\delta)$$

V_h(u,δ)is the potential value of the hybrid field at node u with attribute δ.The parameter αϵ[0,1) is a weight. The force from nodes u to v in the hybrid potential field with attribute δ is,

$$F^{h}_{u\to v}(\delta) = (1-\alpha)F^{d}_{u\to v} + \alpha\, F^{p}_{u\to v}(\delta)$$

The PBDR selects the next hop for node u according to force given by node vϵΩ(u) in the hybrid potential field. A packet p with attribute δ at node u will be transmitted to the neighbor node in which the hybrid potential force from node u with attribute δ, $F^{h}_{u\to x}(\delta)$ is maximum.

B. Packet Driven Timing Scheme

Here, the node will not start up the timer until receiving the first packet and will update the timer after receiving other packets. When the packets at the node increases, the time set by the timer will also decreases. When it reaches 0, then the packets will be aggregated and forwarded immediately to next node. After receiving the first packet, node *u* will start the timer which sets the wait time as:

$$T_u(t) = T_F * \left[1 - \frac{N_u(t)}{S*\emptyset}\right]$$

where $N_u(t)$ is the number of packets in the queue of the node u, and the parameter ∅(0<∅<1)is ratio factor T_F is a time constant and s is the buffer size.

C. Congestion Detection and Avoidance

Buffer occupancy is an accurate indicator of congestion in most of the congestion detection mechanism. This mechanism will gives the faster detection and feedback action in right time. Here, proposes a technique, which will gives us the detection of congestion earlier and avoid this problem by routing the data through alternative neighboring node which may not affect congestion.

In this work consider the buffer as 100% queue size. Here, define two threshold levels. Low Level Threshold (LLT) and High Level Threshold (HL).We consider the HL is at 80% of the full buffer size and LL is at 60% of full buffer size.

Algorithm: Congestion Detection and Avoidance with priority bit (P)

1: Check buffer occupancy consistently.
2: If buffer is filled due to the incoming flow of packets, Lr is the current buffer occupancy.
3: If Lr>=HLT, then set CN bit as high and also set priority bit P as high.
4: Send this choke packet to the previous nodes that detect the congestion in current congested node.
5: previous node should send the packets to the next node using PBDR Routing and also check the congestion. ie, Lr<=LLT.
6: When Lr<=LLT, Then reset CN bit low and also set priority bit P as low.

Finally, the number of packet loss will be reduced and at the same time the data is transmitted to the sink node without delay and action will takes place within the specified time

IV. PERFORMANCE EVALUATION

The proposed scheme provides a better dynamic routing and congestion management technique for wireless sensor network. This scheme improves data aggregation more efficiently and reduces the end to end delay.

The variation of end to end delay is shown in Fig 1. Proposed scheme reduces the loss of packets and also improves the reliability. Addition of congestion management algorithm reduces end to end delay.

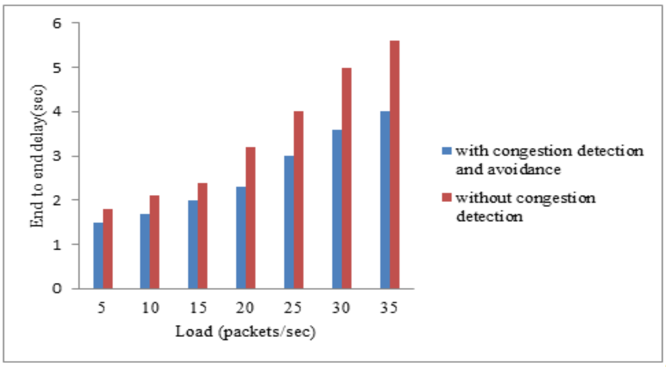

Fig. 1. End to end delay versus Load

V. CONCLUSION

An efficient dynamic routing scheme has been proposed.It consists of PBDR routing protocol and packet driven timing scheme.This scheme enhances the efficient routing of aggregated data packets to the sink node.Here,also reduced the end to end delay problem due to the congestion in sensor nodes by using early congestion detection avoidance algorithm.

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