Improved Energy Efficiency in Wireless Sensor Networks using Shortest Reliable Routing and Ant Colony Optimization

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ABSTRACT
Wireless sensor networks have a wide range of potential applications to industry, science, transport, civil industry, and security. Energy efficiency and improving the network lifetime are the fundamental challenges in wireless sensor networks. Use of multiple sinks can improve the data collection resulting in improved network lifetime with reduced delay and congestion. In this paper a data collection scheme using ant colony optimization is used to address this issue which increases the network throughput and conserves energy resulting in maximum network lifetime. A typical zone based partition is applied to implement the shortest path using ant colony optimization. The residual energy of each node is assigned and the shortest path is selected using the ant colony optimization. This approach is validated through the simulations implemented in NS2.

General terms: The work deals with the improvement in energy efficiency of the wireless sensor network using shortest reliable route and thus improving the throughput, delay and packet loss of the network.

Keywords- Mobile sink, constrained path, residual energy, delay, throughput.

1. INTRODUCTION
Existing work shows the MULE architecture where the sensors transmit data only over a short range that requires less transmission power [1]. For example, in a city traffic monitoring application vehicles can act as mules, in a habitat monitoring scenario, the role can be served by animals, in a national park monitoring scenario and people can be MULES [6]. In the scenarios where the trajectories of the mobile sinks are often predetermined or constrained, efficient data collection problems are often concerned to improve the network lifetime [2] [3] [4]. The sink mobility can improve the performance of wireless sensor networks; where mobile sinks are mounted on some people or randomly moving creatures to collect information of interest sensed by the sensor nodes where the sink trajectories are randomly moving. The path constrained sink mobility is used to improve the energy efficiency of single hop sensor networks which may be in feasible due to the limits of the path location and communication power. This paper focuses on dense wireless sensor networks with path constrained mobile sinks that may exists in real world applications, such as ecological systems, environmental monitoring and health monitoring systems. The mobile sink collects data from the sensor nodes while moving closer to them. According to the range of communication the monitored region can be divided into two parts, the direct communication area (DCA) [1], and multihop communication area (MCA) for far off sensors. Sensor nodes with DCA, called sub sinks can directly transmit data to the mobile sink due to their closer proximity of the trajectory. Whereas the sensors with MCA[1], called members must first relay the data to the subsinks which then completes the final data transmission to the mobile sink. The throughput, delay and packet loss depends on the data collected and the number of members belonging to each sub sink.

2. RELATED WORK
The existing research on sink mobility can be classified into the following categories: random path, controllable path and constrained path.

2.1 Random path sink mobility
In random path the mobile sinks are placed randomly on moving creatures like animals, human beings . Due to this random mobility of the node it is difficult to bound the data transfer latency and the data delivery ratio. An analytical model based on queuing theory is presented for random path which incorporates many detailed aspects such as different mule mobility models, radio characteristics, energy models etc.

2.2Path constrained sink mobility:
Architecture of wireless sensor networks with mobile sinks (MSSN) is proposed for traffic surveillance application. However, it is also assumed that all sensor nodes in MSSN are located within the direct communication range of the mobile sink. A communication protocol and a speed controlling algorithm of the mobile sink are suggested to improve the energy performance and the amount of data collected by the sink. A routing protocol called Mobi route [11] [12] is suggested for WSNs with a path predictable mobile sink to prolong the network life time and improve the packet delivery ratio, here the the sink sojourns at some anchor points and the pause time is much longer than the movement time. Accordingly, the mobile sink has a longer time to collect data, which is different from the scenario defined by us. However, in Mobi route[11] all sensor nodes need to know the topological changes caused by the sink mobility.

2.3Path controllable sink mobility
Mobile element scheduling problem is studied and observed, where the path of the mobile sink is optimized and designed to visit each node and collect data before buffer overflow occurs. A partition based algorithm is presented to schedule the movements of the mobile element to avoid buffer overflow. The mobile sinks is required to visit all sensor nodes to collect data and the path optimization is based on the constraint of buffer and data generation rate of each node. The

path selection problem of a mobile sink is focused to achieve the smallest data delivery latency in the case of minimum energy consumption at each sensor. It has been assumed that each sensor node sends its data directly to the mobile sink. Single hop communication is not feasible due to the limitation of road infrastructure and requirement on delivery latency. A data collection approach is proposed to select the optimal reqiured path due to the delay limitation in WSNs with a mobile base station [11] [12].

3. PROBLEM FORMULATION

Let n sensor nodes be deployed randomly and let s nodes close to the trajectory of the mobile sink be chosen as subsinks. The other m nodes away from the mobile sink choose different subsinks as their destinations. The mobile sink moves along a fixed path with a constant speed to collect the data. Assuming that the mobile sink has unlimited energy, memory computing resources and has enough storage to buffer data. Each sensor node collects the data continuously and transmits them either directly to the mobile sinks or to one of the sub sinks which finally delivers the data to the constantly moving mobile sink. The members within the multihop communication area need to choose only one and only one subs ink as its destination. A highly dense sensor network is selected, in which all members can reach the subsinks through single-hop or multihop communication. Here the predictable mobile sink path is considered. The objective is to improve the energy efficiency and network lifetime for collecting the data, which improves the energy consumption of entire network and improves the lifetime of the network under the condition of maximizing the total amount of data collected by the mobile sink. Network life time can be improved by optimal subsink selection which depends on the residual energy of the nodes. The problem is solved as follows.

4. PROPOSED SYSTEM

A data collection scheme is proposed based on the multi-hop communication is designed to improve the amount of data and reduce energy consumption. Proposed protocol is a shortest reliable route is used to choose the cluster heads and data routing, which may cause imbalance in traffic and energy dissipation. To address this problem, the Maximum Amount Shortest Path (MASP) scheme proposed is designed to enhance data collection from the viewpoint of choosing cluster heads more efficiently. Moreover, if a mobile sink is mounted on public transportation, e.g., a bus or a public vehicle, the speed cannot be changed freely to the purpose of data collection. The mobile element visits the exact locations points, according to the predetermined schedule to collect data. These points buffer and aggregate data originated from the source nodes through multi hop relay and transfer to the mobile sink when it arrives.

5. PROBLEM SOLUTION

The proposed solution focuses on efficient data collection using improved ant colony optimization with improved AODV routing. Ant Colony Optimization with improved AODV routing which is a swarm intelligence optimization technique, which is widely used in network routing .It is a novel routing approach using Improved Ant Colony Optimization algorithm is proposed for Wireless Sensor Networks consisting path constrained mobile sink along with AODV routing. Ant colony optimization (ACO)[1] algorithms simulating the behavior of ant colony have been successfully applied in the proposed problem. Shortest Reliable Route (SRR) protocol is proposed to establish the shortest route that can satisfy the source node’s requirements including energy, trust, and route length.

5.1 Proposed Algorithm:

(1)A wireless sensor network with N number of nodes is considered, where N nodes denote all the nodes in the network.

(2)The communication among the nodes is based on a tree topology with sink as the root.

(3)The sink first broadcasts a message with a hop counter

(4) The nodes receiving the message will set the message sender as the parent node, increase the hop count by one and broadcast it to their neighbor.

(5) Shortest Reliable Route protocol is proposed to establish the shortest route that can satisfy the source nodes requirements, including energy, trust and route length.

(6) To establish thr route to destination node D, the source node S broadcast a RREQ packet and waits for RREP packet.

(7) The source node embeds its requirements in RREQ packet and the nodes that can satisfy these requirements broadcasts the packet.

(8)The destination node establishes the shortest route that can satisfy the source nodes requirements.

(9) The rationale of this SRR protocol is that the node that satisfies the source nodes requirements is trusted enough to act as a relay.

(10) The energy values of node are declared as numerical values such as 1,2,3,4 etc. and threshold of energy is assigned as 2, thus route is taken in such a way that node should have energy value of less than or equal to one.

5.1.1 Results and discussions

The performance of the proposed data collection scheme using shortest reliable routing using ant colony optimization is implemented in NS2. Initial energy of each node including the sink, subsink and sensor nodes are set and the mobile sink moves with a constant speed. Three zones are created each having 9 nodes where 1,2 and 3 are subsinks and 0 is the sink. From the energy file low value energy nodes are selected for routing path and one hop neighbours are identified. Source node 10 routing path is created i.e. 10-7-6-1-0 where 0 is the sink node and 1 is the subsink. For another flow the the path is 14-15-2-0.The sink moves towards the subsink to collect the data packets. Multiple sinks can gather more data efficiently. Here, the mapping between sensor nodes and subs inks is optimized to maximize the amount of data collected by mobile sinks and also balance the energy consumption. . The algorithm finds the shortest route which speeds up the packet delivery and provides energy efficient routing. The objective is to improve the energy efficiency for data gathering, which minimizes the energy consumption of entire network under the condition of maximizing the total amount of data collected by the mobile sink.

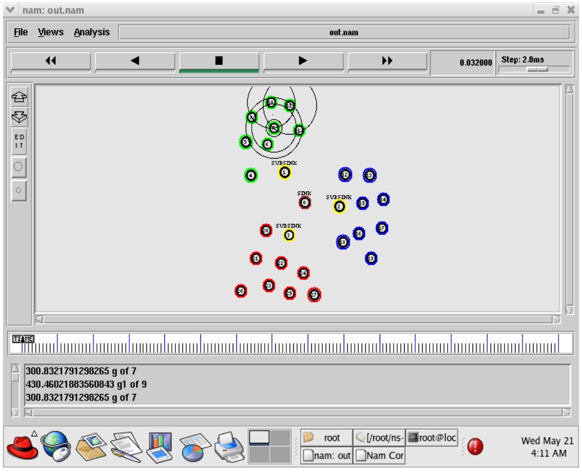

Figure 1. Trajectories of multiple sinks

SRR results for the delay, packetloss and throughput are shown below.

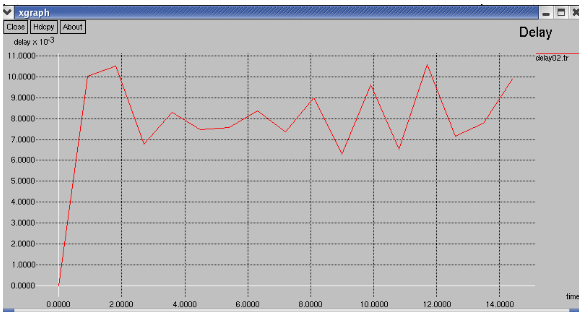

Figure 2. Graph for evaluation of delay

Figure 2 shows when the number of nodes sharing the network resources, the delay significantly increases.

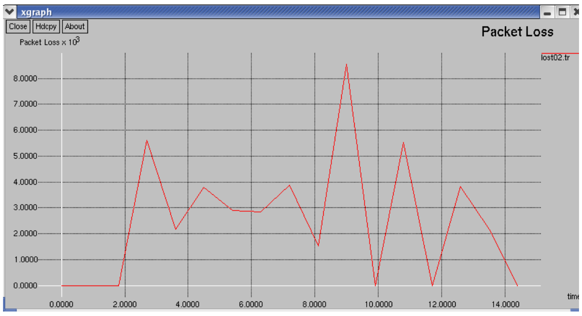

Figure. 3. Graph for evaluation of packetloss

The figure 3 shows a high packet drop rate whenever the number of nodes sharing a network increases. It can be seen that the packet loss rate in the interval 0 to 1.8 is zero. This can be easily justified since only one node is using the network during this time interval. However this high quality performance is deteriorated as the number of nodes sharing the network increases.

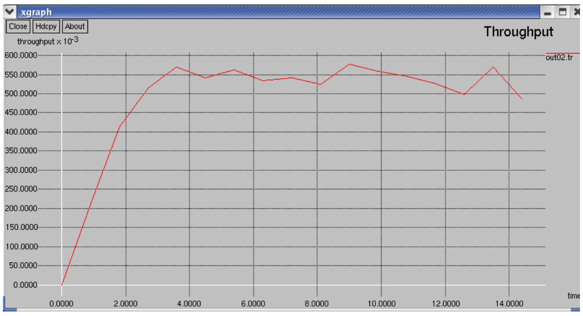

Figure.4. Graph for evaluation of throughput

Node 10 starts transmitting at time T =1 sec while Node 7 starts transmitting at time T=10 sec. During the period of time, Node 10 is the only transmitting node using the entire available bandwidth. This justifies the high performance of Node 10 during the specified interval of time. At time T=10 sec, Node 7 starts transmission hence sharing channel resources with Node 10. This explains the heavy reduction of bit rate. In addition, the bit rate plot shows multiple fluctuations and reduction as the number of transmitting nodes increases. Oscillations are reflected in heavy disorders in network performance. The SRR has stronger data collection ability than SPT with the same number of sinks.

6. CONCLUSION

This paper proposes an efficient data collection scheme using shortest reliable route (SRR) using ACO [1] for wireless sensor networks with path-constrained mobile sinks. Here, the mapping between sensor nodes and subs inks is optimized to maximize the amount of data collected by mobile sinks and also balance the energy consumption. An improved shortest reliable route algorithm, based on the basic ant colony algorithm is implemented where the subsinks receive the packets and deliver to the sink node.. The previous search probability of the path is introduced in every search to speed up the search. The algorithm finds the shortest route which speeds up the packet delivery and provides energy efficient routing. The objective is to improve the energy efficiency for data gathering, which minimizes the energy consumption of entire network under the condition of maximizing the total amount of data collected by the mobile sink. For future work we can validate the proposed scheme on different scenarios with various movement trajectories of mobile sinks and study the subsink selection problem.

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