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SINK REPOSITIONING OPTIMIZATION TECHNIQUE USING PARTICLE SWARM OPTIMIZATION IN WIRELESS SENSOR NETWORKS

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ABSTRACT

In today's wireless sensor networks mobile sinks plays an important role in data transmission and reception. Therefore it becomes very important to estimate the optimized position of the mobile sinks in order to improve the overall efficiency of the wireless sensor networks. In this paper, the particle swarm optimization technique has been used for the estimation of the position of the mobile sinks and its impact on the various performance factors of the wireless sensor network has been observed. The simulation result showed that finding the optimal location of the sink in the mobile environment improves the various performance parameters of the network thereby extending the overall lifetime of the network.

KEYWORDS: WSN, Particle Swarm Optimization , Mobile Sink.

INTRODUCTION

Wireless Sensor Network (WSN) is a wireless network that consists of spatially distributed autonomous devices using sensors to cooperatively investigate physical or environmental conditions. WSN has a hundreds or thousands of nodes that can communicate with each other and pass data from one node to another. Energy can be supplied to sensor nodes by batteries only and they are configured in a harsh environment in which the batteries cannot be charged or recharged simply. Sensor nodes can be randomly installed and they autonomously organize themselves into a communication network.

Multiple sink deployment and sink mobility can be considered to perform sink repositioning. Precise information of the area being monitored is needed to offer an ideal solution by the sink deployment method but this method is not a realistic often. To reallocate the sink, its odd pattern of energy must be considered. Since employing the sink requires the precise knowledge of the monitored area, they are not always possible even though the sink deployment can provide optimal solution.

In WSN, sinks are bounded with abundant resources and sensors that generate data are termed as sources. The sources can transmit data to one or multiple sinks for the purpose of analysis and processing.

In wireless sensor networks, sink relocation is preferred by all applications that involve real time traffic for even in the middle of multiple nodes it can balance the traffic load and thereby lessen the miss rate of real time packets. To carry out sink repositioning, multiple sink deployment and sink mobility can be considered. Precise information of the area being monitored is needed to offer an ideal solution by the sink deployment method but this method is not realistic often. To reallocate the sink, its odd pattern of energy must be considered [1].
Sink repositioning can be performed in the following ways.

Multiple Sink Deployment: Since the data will always be sent to the closest sink, deploying multiple sinks may decrease the average number of hops through which the message has to pass through.

Sink Mobility: WSNs may take the advantage of the mobile capacity, if a sink moves fast enough to deliver data with a tolerable delay. Hence, with the mechanical movements, the mobile sink picks up data from nodes and transports the data. Therefore, for the reduction of energy consumption of nodes, this approach trades data delivery latency.
Deploying Multiple Mobile Sinks: In this case, without delay and without causing buffer overflow, the multiple sinks are deployed so that the sensor data can be acquired.

LITERATURE REVIEW

Kemal Akkaya et al. [2] have investigated the performance advantage of relocating the sink node of WSN in response to changes in the network state and traffic pattern. Three main issues have been identified related to when the gateway should be relocated, where it would be best positioned and how the network operation would be managed during the gateway movement. Both the constrained and unconstrained network traffic is considered. For unconstrained data routing, energy metrics motivates and justifies the advantage of gateway's relocation. It checks the traffic density of the nodes that are one-hop away from the gateway and their proximity to the gateway.

Once the total transmission power for such nodes is guaranteed to be reduced more than a certain threshold and the overhead of moving the gateway is tolerable, the gateway starts to move to the new position. Simulation results have shown that such repositioning of the gateway increases the average lifetime of the nodes by decreasing the average energy consumed per packet. Moreover, the network throughput is positively impacted.

Zoltan Vincze et al. [3] have proposed a mathematical model that determines the locations of the sinks by reducing the sensor's average distance from the nearest sink. 1hop iterative algorithm carries out the sink deployment based only on the location information of the neighbouring nodes while the location of the distant nodes is being approximated. The algorithm shows that 1hop approaches the performance of global very closely. Based on the 1hop algorithm, the 1hop relocation algorithm is proposed for the coordinated relocation of multiple sinks. Simulation results show that the algorithm extends the network lifetime.

Mohamed Younis et al. [4] have proposed a repositioning approach for a gateway to enhance the overall performance of WSN in terms of energy, delay and throughput. This approach considers relocation of the gateway by checking the traffic density of the nodes that are one-hop away from the gateway and also their distance from the gateway. Once the total transmission power for such nodes is guaranteed to reduce more than a certain threshold and the overhead of moving the gateway is justified, the gateway starts to move to the new location. The gateway is moved in the routing phase so that the packet relaying will not be affected.

Simulation results have shown that such repositioning of the gateway increases the average lifetime of the nodes by decreasing the average energy consumed per packet and average delay per packet significantly. However, the transmission stops when the gateway goes out of the transmission range of the nodes.

Jesse English et al. [5] have proposed an efficient algorithm for Coordinated Relocation of gateways (CORE) that strives to maintain communication paths among gateways while repositioning individual gateways to better manage the sensors in their vicinity. CORE checks the impact of relocating one gateway on the inter-gateway connectivity possibly triggering adjustments of the position of other gateways in order to maintain a strongly connected inter-gateway topology.

CORE is validated in a simulated environment of target tracking application. Results show the effectiveness of CORE and its positive impact on contemporary metrics like network longevity and node coverage by allowing individual gateways more degree of freedom in optimizing their operation via relocation. However, the network overhead is more.

Jun Luo et al [6] have investigated the problem of maximum lifetime data collection in WSNs by jointly considering sink mobility and routing. They considered a type of continuously monitoring WSNs whose data generation rates of sensors can be estimated accurately. They also focused on the slow mobility approach and build a unified framework to cover most of the joint sink mobility and routing strategies. They developed an efficient interior point algorithm to resolve the sub-problem involving a single sink and then they applied this algorithm to a set of topological graphs. From the simulation results the benefits of sink mobility were proved.

PROBLEM IDENTIFICATION

During the regular network operation, relocating the sink becomes very challenging. During the sink's movement, the fundamental challenges are- when the sink should move, where the sink should go and how the data traffic would be handled when the sink is in motion. In a multi-hop network, finding an optimal location for the sink is even more difficult due to two factors. First, the sink can be moved to any potentially infinite possible positions. Second, in order to qualify the interim solution in comparison to the current or previously picked location in the search, a new multi-hop network topology needs to be established for every interim solution considered during the search for an optimal location [7].

Since employing the sink requires the precise knowledge of the monitored area, they are not always reasonable even though the sink deployment can provide optimal solution. When accurate position of sensor is available and when nodes have motion capabilities, controlled deployment or online deployment is possible. The developing graph may have different properties during the online deployment. The basic issue in the sensor deployment is controlling the dynamic graph of mobile sensor networks [8].The energy-unbalanced problem is another big challenge in sink deployment. Here the sensors that are closer to the sink are likely to consume their energy much faster than other nodes [9].When a network consists of multiple clusters, the relocation problem is significantly compounded. The sink cannot choose to stroll randomly around its cluster to enhance the intra-cluster network operation without considering the potential impact on inter sink connectivity that could impose on its capability to maintain communication with the sink nodes of other clusters [10].

Using the odd pattern of energy depletion or data route setup, first the relocation of the sink has to be motivated even if it is considered as the most efficient network operation for a given traffic distribution and network state at that time. The sink must make sure that no data is lost, when it is moves [11].Using mobile sinks for data gathering has the drawback of buffer overflow problem. In other words, the sink has to visit each sensor nodes before its buffer overflow which depends on the speed of the mobile sink. However, it will be difficult to set the optimum speed for the mobile sink to overcome the buffer overflow problem since each sensor node has different buffer sizes and data generation rate. Apart from this problem, the residual energy of the sensors should also be considered since sensors with low residual energy may deplete their energy before the mobile sink visits.

PROPOSED METHODOLOGY

In the proposed network model a single sink is deployed within the centre of the network and multiple mobile sinks are deployed for data gathering from the various sensors. For efficient network operation, a two tier hierarchy is considered where sensors form the lower tier and relays and sinks form the higher tier. Two tier hierarchy results into grouping wherein the network is divided into different cells or clusters. The grouping of the cells is done based on the location and data generation rate. The sensors are assigned to each group based upon their overflow time. One mobile sink is deployed for a particular cell and this mobile sink will move around in that particular cell for collecting the information from the various sensors in that particular cluster.

The various mobile sinks that are deployed in the clusters or cells will relocate at regular intervals in order to collect the data from the sensors. The data generation depends upon the buffer overflow of the sensors. In order to avoid the buffer overflow problem, which occurs due to the limited memory capacity of the sensors, the mobile sinks are used which will relocate at the regular intervals to collect the data from the sensors before their buffer overflows. A threshold value for the buffer overflow time is set. When the buffer overflow time is half then the mobile sink will relocate. The buffer overflow time of each sensor in the network is assigned as the ratio of the buffer capacity to the sampling rate. Each and every sensor in the network will have different data generation rate. In the proposed method the data generation rate is set as 250 Kbps.

Let, G_j denote a particular group in the network where j = 1, 2, 3, --------- N and N be the total number of groups in the network.Si be the sensors in the network where i = 1,2,3,--------------M where M is the total number of sensors in the network.T_B is the buffer overflow time .The sensors are assigned to a group based on the following equation.

2^{j-1} Tmin $\leq$ Tsi $\leq$ 2^{j} Tmin , j = 1,2,------- N-1
2^{j-1} Tmin $\leq$ Tsi $\leq$ 2^{j} Tmax , j = N

The groups are arranged in the increasing order of their buffer overflow time and using the above equations each and every sensor will be deployed in a particular group. By doing so this method has optimized the visit of a sink to collect the data from the sensors and the threshold value is set for each group in the network which is half of the maximum buffer overflow time and when this value is reached the sink will relocate.

For optimizing the data generation rate for transmission to the sink the particle swarm optimization is employed.PSO is used to find the optimum position of the sink. Firstly a set of K particles is created which is a set of random positions of the sink. For each particle the fitness value is calculated. The fitness value is given by the equation $x_k = \sum_{n=1}^{n\,j} d\ nk\ Tsi$ .This fitness value for k particles is the P best value. The minimum P_{best} value is considered to be the G_{best} value, i.e., min (x_k) = G_{best} .

The steps of the optimization method employed are as follows:

1. Randomly generate a set of k particles in the initial search.
2. At each optimization attempt, the particle will change its searching direction based on the two values, i.e., P_{best} and G_{best} values which are based on the fitness value.
3. The minimum P_{best} will be G_{best} values.
4. After this the iterative optimization process is moved on further to pursue the best solution.
5. The process repeats until the best solution is found.

SIMULATION RESULTS

The entire proposed technique has been simulated in the NS-2.32 environment. The figure below shows the NAM output of the simulation.

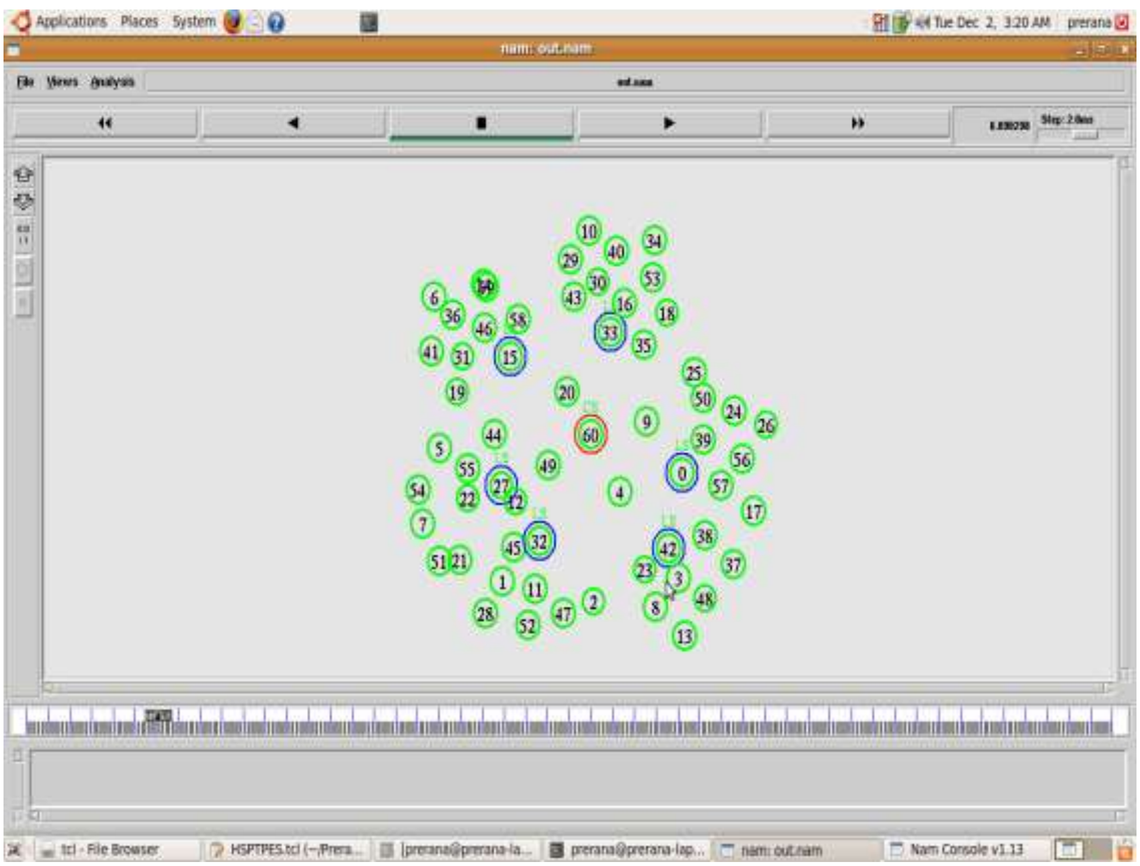

Figure 1 : NAM Output of the Simulation

As soon in the figure above the entire network is divided into different cells or groups or clusters and one mobile sink is deployed for each cell or group or cluster and the mobile sink will move inside this cluster in order to gather the information inside this particular cluster.

After running the simulation the observed output is shown in the figure below.

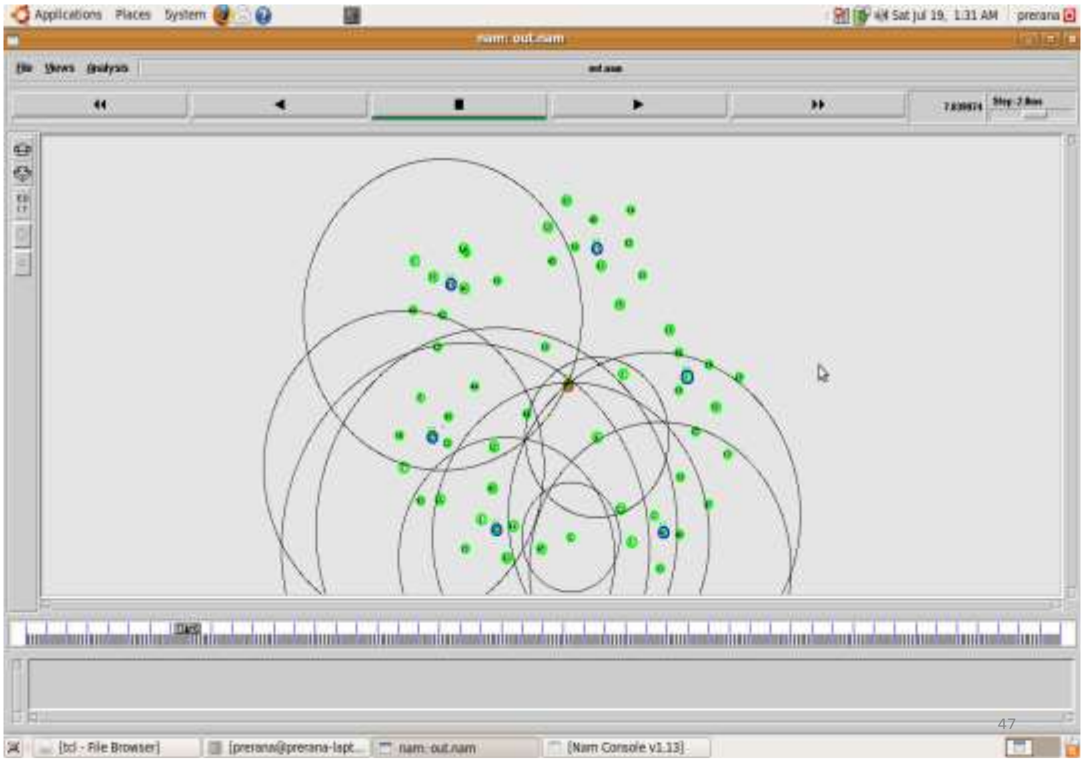

Figure 2 : NAM Output of the Simulation after mobile sink repositioning

The figure above shows that the mobile sink has relocated to an optimal new position. The impact of repositioning of the mobile sink after relocating to an optimal position is observed on the various performance parameters of the WSN.

No. Of Nodes	Delivery Ratio	Frames Generated	Frames Received	Queuing Delay	Routing Delay	Total Delay(ms)	Medium Access Time	Transmission Time	Throughput (Kbps)
20	100.0%	100	100	0	7.182	0.739	1.018	13.687	0.239
40	100.0%	250	250	0	0.739	6.213	1.733	12.727	0.208
60	98.9%	450	445	0	6.213	7.182	0.824	46.692	1.789
80	98.8%	800	790	0	7.915	7.915	1.151	17.353	0.811
100	98.6%	1020	1006	0.001	85.324	85.325	0.947	93.297	1.238

Table 1. Observation table for the various performance metrics

The simulation graphs observed for the various parameters of the network are shown below:

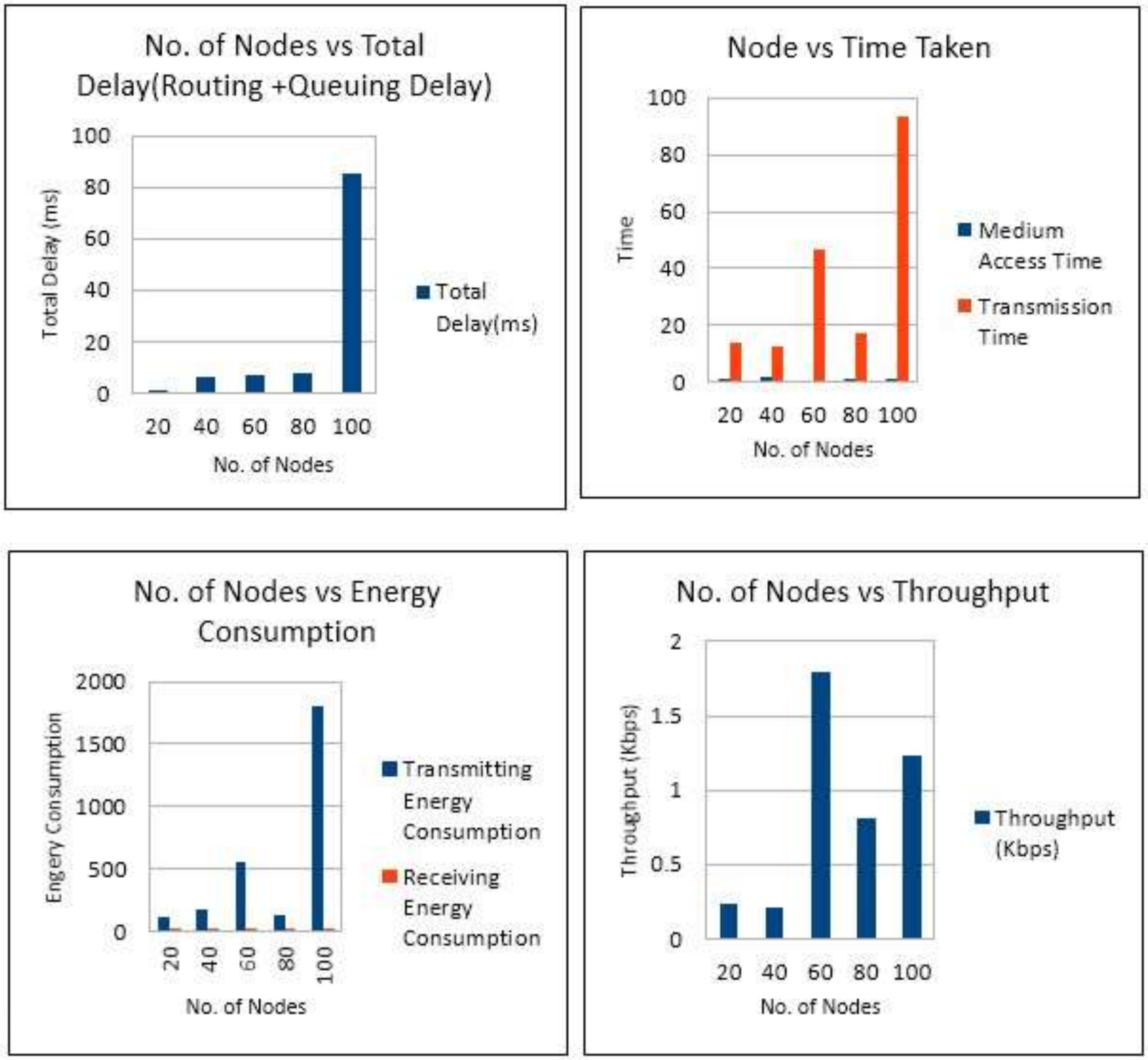

Figure 3 : Observations of the performance metrics of WSN

The results obtained proved that the proposed method shows significant amount of improvement in enhancing the various performance parameters of the WSN.

CONCLUSION

Optimization techniques play a vital role in extending the lifetime of the wireless sensor networks since sensors have limited battery resources. The proposed method helps in optimizing the position of the mobile sink thereby improving the overall efficiency. The optimization of data generation for transmission to the sink is achieved through Particle Swarm Optimization Algorithm. The simulation results show that after eight iterations the optimum value is attained. The important parameters like the total delay, throughput and the energy consumption are improved by deploying the proposed method.

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