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A NOVAL METHOD FOR OPTIMIZING MAXIMAL LIFETIME COVERAGE (OMLC) SCHEDULING OF NODES IN WIRELESS SENSOR NETWORKS

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ABSTRACT

Aims: *Wireless Sensor Network (WSN) lifetime depends on nodes lifespan. In remote target coverage applications, random deployment provides high density. Many scheduling algorithms are proposed to improve the performance of network lifetime.* ***Materials and methods:*** *Among all, the Greedy algorithm addresses the optimization problems. In Greedy Activity Selection Algorithm the items are sorted in the decreasing order of values based on the finishing time, then scan the sorted list is scanned and the data is collected. Maximal Lifetime Coverage Scheduling (MLCS) trying to cover the target with maximum number of nodes in a schedule based approach. Both the approaches tried to maximize the lifetime but failed in reduction of unwanted data transmission. The proposed work Optimized Maximal Lifetime Coverage Scheduling (OMLCS) addresses the above mentioned problem by two methods. First one, Improved Sleep Scheduling algorithm is employed in which very limited number of nodes covers the target, while others in sleep state.* ***Results:*** *This idea reduces the energy consumption of nodes and reduces the redundant information about the target. Second idea depicts the periodic exchange of locally sensed information with neighboring sensors. This idea is utilized mainly for the purpose of sending the information only when the change occurs. The network lifetime is increased significantly.* ***Conclusion:*** *The simulation results show that 15% improvement in packet delivery ratio and throughput and 30% of reduction in end-to-end*

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KEY WORDS

Wireless Sensor Networks, Lifespan, Maximal Lifetime Coverage Scheduling, Sleep Scheduling, Packet delivery ratio, throughput, End-to-end delay.

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INTRODUCTION

The Wireless Sensor Network (WSN) comprises of a collection of active sensor nodes which are deployed in a well-defined area to collect the information about the physical or environmental weather parameters such as pressure, temperature, humidity, etc., and to transmit the sensed data to a centralized node or server cooperatively. In many cases, a group of targets need to be monitored in the defined geographical area. To achieve the assigned Quality of Service, every target should be covered by at least by one sensor node.

The Coverage plays vital role in a WSN, which determines how fine an area of interest can be monitored or followed by sensors [1]. The coverage is classified in to three types based on what is to be sheltered, namely discrete point coverage, area coverage and barrier coverage. The *Connectivity* is another parameter in WSNs which deals with delivering the sensed data from a source sensor to the sink node (destination node) through radio link. In the transceiver part of a sensor is equipped with different transmission power levels to attain different communication ranges. The maximum permissible power level ensures the maximum communication range. Two sensors are said to be connected whenever both of them are within each other's maximum allowable communication range. Multi-hop communications support a sensor to connect another if they cannot reach the sink node directly. In this way sensors in a WSN acts as repeaters to increase their coverage by relaying the data to other sensors to the remote destination. Therefore, both transmission and reception of data swallow a certain amount of energy. The time stamp between the periods from the time when the sensor network was set up to the time when the WSN cannot confirm the *coverage/ connectivity* requirements is defined by the term *network Lifetime* of WSN. i.e It specifies the time period of WSN which function well without any connectivity or coverage issues. It can be prolonged by scheduling merely a subset of sensors necessary to be active and scheduling remaining subset of sensors to be inactive. Hence the improved lifetime is guaranteed due to condensed idle listening, traffic load and collisions of *Media Access Control* (MAC).

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EXISTING METHOD

Greedy Activity Selection Algorithm

Greedy is most suitable on optimization problems with the following uniqueness [2]:

1. Greedy-choice property: A global optimum can be achieved by picking a local optimum.
2. Optimal substructure: An optimal elucidation to the problem includes an optimal solution to sub problems.

The property 2 may make greedy algorithms look like dynamic programming. However, the two methods are quite different.

An Activity-Selection Problem

Let S = {1, 2, . . . , n} be the set of actions that compete for a resource S.

Every action k has its starting time S_k and ending time F_k with $S_k \le F_k$, if selected, k takes place during time (S_k).

The resource cannot be shared by two actions simultaneously at any period of time.

The actions k and l are compatible if their time periods are disjoint. The activity-selection problem is the setback of selecting the largest set of mutually compatible activities [**Figure- 1**].

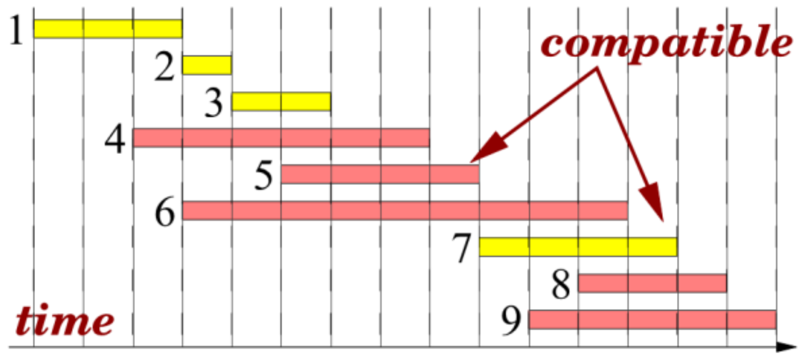

Fig.1 Activity-Selection

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Greedy Activity Selection Algorithm

In this algorithm, based on the finishing time, the activities are first sorted, from the most primitive to the most modern, where a tie can be broken arbitrarily. Then the activities are greedily preferred by referring the list and by selecting.[3]
The running time of this method depends on the type of sorting algorithm used. The sorting part can be as small as O(n log n) and the other part is O(n), so the total is O(n log n).

Greedy-Activity-Selector get to the bottom of the activity-selection issues.

Proof

The proof is by initiation on n. Initially,
let n = 1.The statement trivially holds.
For the induction step, let $n \ge 2$, It is assumed that the claim holds for all values of n less than the current one.
Let us assume that the action are previously sorted based on their finishing time.
Let p be the number of activities in each optimal solution for [1, . . . , n − 1] and let q be the number for [1, . . . , n].
Here $p \le q$ holds. It's because every optimal result for [1, . . . , n − 1] is a elucidation for [1, . . . , n].

PROPOSED METHOD

The above said methods are trying to prolong the lifetime of WSNs. During this process they failed in reduction of redundant data transmission. The lifetime of sensors are wasted in transmitting the repeated information which are collected from the neighboring sensor nodes.

Maximal Lifetime Coverage Scheduling (MLCS)

All the sensors are powered by built-in batteries. The sensing of a target leads in the reduction of battery lifetime. In this scenario, there is a necessity of considering the reduction of power consumption. In this scenario, there is a necessity of considering the reduction of power consumption by turning OFF the power of the sensors, when they are inactive [4, 5]. Due to the critical issue of

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power limitation, a novel method should be devised to prolong the life time of WSN to assume the Quality of Service. Thus the detailed study has been explored in the literature survey.

In target coverage problem in WSNs, the network lifetime is described as the time duration that each and every target point is examined. As depicted out in [1], the lifetime of the network can be extended by alternatively switch ON and OFF the different group of sensors. Actually the entire sensor nodes are organized into various sub set of groups. The scheduling is initiated in such a way that alternatively switch ON and OFF at given span of time. This scheduling is repeated with number of turns to cover all the targets. [**Figure- 2]** depicts an example. Four target points which are covered with four sensors are taken into consideration. The sensors *SN*1, *SN*2, *SN*3 and SN4 can monitor target points (*T1, T4*), (*T1,T2*), (*T2,T3*) and (T3,T4) respectively. It is indicated in Table 1.

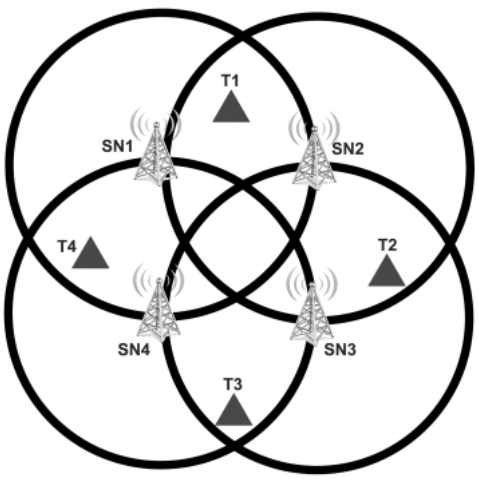

Fig.2 Target coverage in WSNs

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Table.1 Coverage of sensors and targets

Sensor	Target Points covered
SN1	T1,T4
SN2	T1,T2
SN3	T2,T3
SN4	T3,T4

If all the sensors are working three time units, then by alternatively switching "on" and "off", all the target points will be covered in four time units. The suitable schedule would be:

Table.2. Scheduling sensors by incorporating Sleep scheduling

Time units	Sensor Nodes ON	Sensor Nodes OFF	Target Points Covered
1st Time unit	SN1,SN2,SN3	SN4	T1,T2,T3,T4
2nd Time unit	SN1,SN2,SN4	SN3	T1,T2,T3,T4
3rd Time unit	SN1,SN3,SN4	SN2	T1,T2,T3,T4
4th Time unit	SN2,SN3,SN4	SN1	T1,T2,T3,T4

During the first time unit, the nodes (SN1,SN2,SN3) are turned on and the node SN4 is turned off; in the second time unit, the node (SN1,SN2,SN4) are turned on and the node SN3 is turned off; in the third time unit, the node (SN1,SN3,SN4) are turned on and the node SN2 is turned off; in the fourth time unit, the node (SN2,SN3,SN4) are turned on and the node SN1 is turned off; As per this schedule, all the target points are covered in four time units by running all targets only in three time units.. If the sensor

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nodes are not switched, then three time units are sufficient to monitor any target point.(Table.2) Therefore, to prolong the network lifetime, it is mandatory to build up efficient algorithms to schedule the sensors to perform the monitoring tasks [6, 7].

The proposed work Optimized Maximal Lifetime Coverage Scheduling (OMLCS) addresses the above mentioned problem by two methods. First one, Improved Sleep Scheduling algorithm is employed in which very limited number of nodes covers the target, while others in sleep state [1, 3, 8].

The area covered by a sensor is decided by
Area of coverage

$$\pi r^2(N) = \frac{(\ln N + \sqrt{N})}{N} \qquad (1)$$

Where r – Radius of the sensing field
N – Number of Nodes deployed in the network.

In the deployment of new nodes some analogy should be followed to ensure the unceasing detection of all nodes in that networks. Random deployment of sensors may desecrate the performance of the entire network.
The distance between two nodes (i & j) are confirmed by

$$d_{i,j} = \sqrt{(x_j - x_i)^2 + (y_j - y_i)^2} \qquad (2)$$

where, x & y are coordinates.

With this equation we can find second nodes coordinates(x_j, y_j), if we know the distance (may be fixed by us, as critical distance) and first node location. This idea reduces the energy consumption of nodes and reduces the redundant information about the target. Second idea depicts the periodic exchange of locally sensed information with neighboring sensors. This idea is utilized mainly for the purpose of sending the information only when the change occurs.

Simulation

The Simulation is carried out with a network scenario of a fixed number of targets and sensors randomly deployed around the targets. In this simulation the sensor are considered as equal initial energy without any loss.

Various iterations are carried out on the simulation of Greedy Algorithm, Maximal Lifetime Coverage Scheduling and the proposed Optimized Maximal Lifetime Coverage Scheduling. The observations are recorded and analysis have been carried out. The network parameters average delay [**Figure- 3**], Packet loss [**Figure- 4**], Packet delivery ratio [**Figure- 5**], Control overhead [**Figure- 6**] and throughput [**Figure- 7**] are taken into account for analysis.

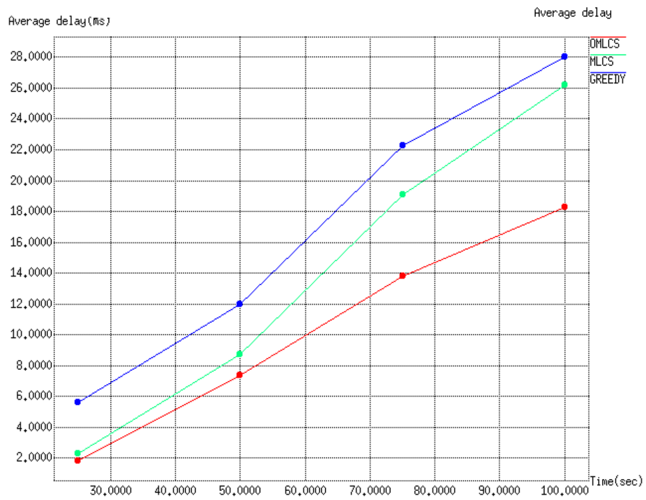

Fig. 3: Analysis of average delay

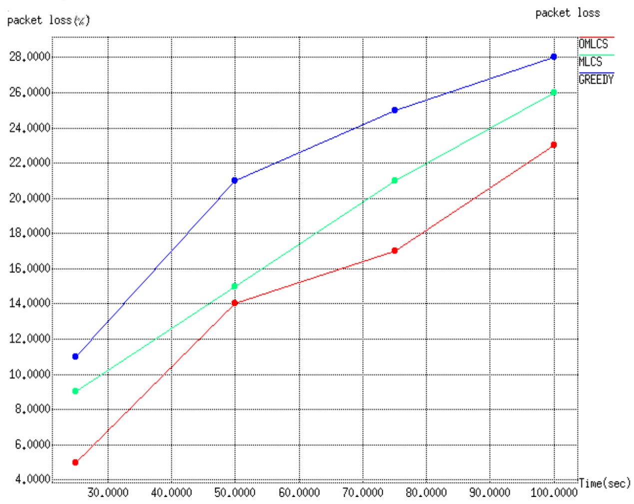

Fig.4: Analysis of Packet loss

RESULTS

The major objective is to witness the increase in network lifetime as the Maximal Lifetime Coverage Scheduling is done along with optimization. In the optimization process, the periodic exchange of locally sensed information with neighboring sensors. This idea is utilized mainly for the purpose of sending the information only when the change occurs. It reduces redundant data transmission.

From **Table-3**, It is observed that the average delay encountered in the transmission of data under Optimized Maximal Lifetime Coverage Scheduling has been reduced considerably. The delay plays a vital role in pulling down the life time of sensors.

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Table.3 Average Delay in GA, MCLS, OMCLS

Time (Sec)	15	50	75	100
Average Delay (ms)				
Greedy Algorithm	5.8	12	22.2	28
MCLS	2.2	9	19	26.2
OMCLS	1.8	7.5	13.8	18.2

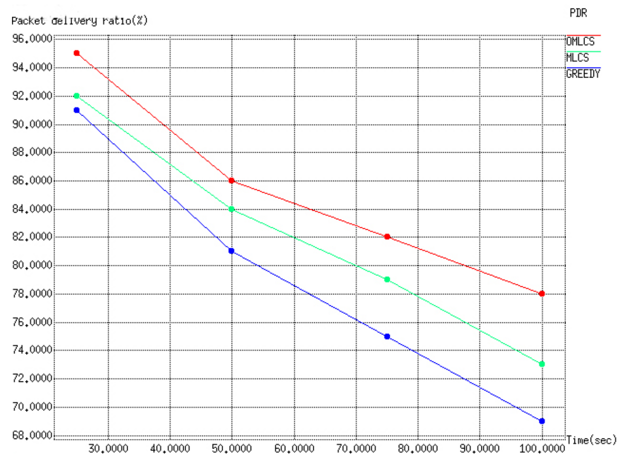

Fig.5: Analysis of Packet Delivery ratio (PDR)

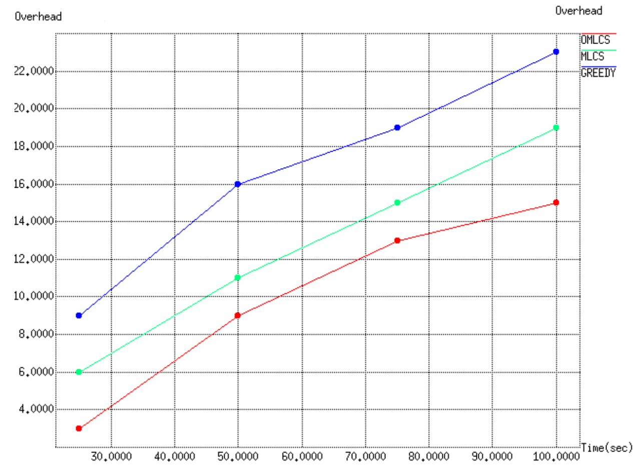

Fig.6: Analysis of Overhead

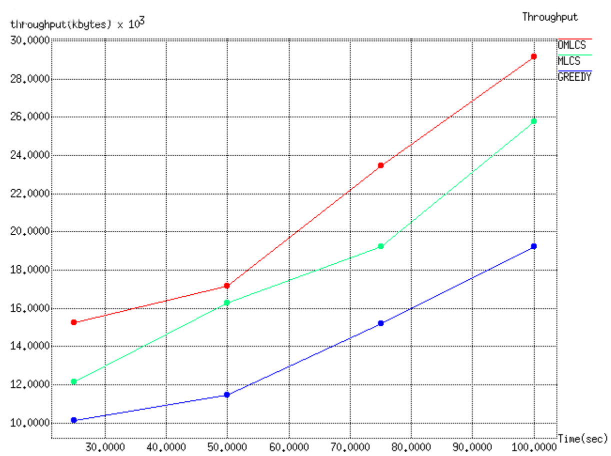

Fig.7: Analysis of Throughput

Table.4 Packet Delivery ratio in GA, MCLS, OMCLS

Time (Sec)	15	50	75	100
Packet Delivery Ratio (%)				
Greedy Algorithm	91	81	75	69
MCLS	92	84	79	73
OMCLS	95	86	82	78

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The **Table-4** shows the progress the packet delivery ratio in OMCLS compare to the other schemes like Greedy Algorithm and MCLS.

Table.5 Packet loss in GA, MCLS, OMCLS

Time (Sec)	15	50	75	100
Packet Loss (%)				
Greedy Algorithm	11	19	25	28
MCLS	9	15	21	26
OMCLS	5	14	17	21

The **Table-5** is the evidence for the reduction in packet loss drastically in contrast to the other schemes. It ensures the effective packet transmission with minimum loss which in turn indirectly increases the life time of sensors.

Table.6 Packet loss in GA, MCLS, OMCLS

Time (Sec)	15	50	75	100
Overhead				
Greedy Algorithm	9	16	19	23
MCLS	6	11	15	19
OMCLS	2	9	13	13

The observation from **Table-6** indicates the diminution of overhead in OMCLS scheme.

Table.7 Packet loss in GA, MCLS, OMCLS

Time (Sec)	15	50	75	100
Throughput (Kbytes) X 10^3				
Greedy Algorithm	10.2	11.5	15	19
MCLS	12.2	16.5	19	25.8
OMCLS	15.2	17	23.5	29.2

Table.7 witnesses the augmentation in the throughput of Optimized Maximal Lifetime Coverage Scheduling which will escalate the connectivity of I/O devices to the sensors. Within given time span, more amount of data can be shared among the neighboring sensors which will increase the life time of sensors noticeably.

CONCLUSION

The simulation results show that 15% improvement in packet delivery ratio and throughput and 30% of reduction in end-to-end delay.

CONFLICT OF INTEREST

The authors declare no conflict of interests.

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None

FINANCIAL DISCLOSURE

None.

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