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TOPOLOGY DRIVEN POWER SCHEDULING FOR WIRELESS SENSOR NETWORKS

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ABSTRACT

The main problem persists in day to day life is that the sensor nodes are deployed in remote areas. Due to the deployment of sensor nodes in remote areas, it is powered by a battery that decreases the lifetime of the sensor nodes. In wireless sensor networks (WSNs), extendingnetwork lifetime while covering multiple targets in a givenarea is a challenging problem. In order to overcome thischallenge, the authors address power management and sensorscheduling issues and propose an energy-efficient scheme formultiple target coverage (MTC) problems in WSNs.Major factors that affect the lifetime of sensor nodes are continuous monitoring, periodic control messages, and the frequency of events that takes place. This paper discuss about the literature review of the energy efficiency algorithms used in the existing papers to increase the lifetime of the wireless sensor network is been discussed.

1. INTRODUCTION

These days internet play an important role in most of the devices. In the modern world, most of the devices are connected to the internet. A tiny device or sensor which is connected to the internet is called an IoT device. IoT devices like sensor are connected to the base station through the internet and send the data frequently. IoT devices mainly consist of a microcontroller, power source, and a memory unit. However, nowadays the availability of low cost/power and high-performance transceivers, microcontroller for the modern wireless technologies and to the operational capability of wide area Wireless Sensor Networks (WSNs) is higher. The environmental physical parameters can be effectively collected and monitored. Thus, a mechanism is needed to sense the data and send the data to sink or gateway. The physical setup of sending the data from the sensor to sink or gateway through the internet already exists. But in most of the cases, the sensors used in IoT Devices are battery powered because of deployment of sensors in remote areas like plantation area, smart agriculture field, smart buildings, smart inventory system, smart city waste management system, noise detection and management for smart city, smart surveying device for resource optimization and street quality identification, where the sensors are used to sense the temperature, humidity, wind speed, quality check, level check, quantity check, and noise detection. Since wireless sensors are battery powered, it requires frequent maintenance to change the battery. If frequent maintenance for battery change is not performed on the wireless sensor, it will fail to send the data to the control station or server. So, in order to

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maximize or improve the lifetime of the sensor, this paper provides a literature review of the existing works.

In the target coverage problem, a goal is to monitor all thetargets by power-constrained sensors maintaining themaximization of the network lifetime. Cardei et al. [5]proposed a centralized scheduling scheme by forming matricesof sensors that can cover all targets and scheduling theactive/sleep time of the matrices to maximize he networklifetime. Dhawan and Prasad [6] proposed a distributed targetcoverage algorithm that enables sensors to schedule themselvesby using a lifetime dependency graph model. However, in themultiple target coverage problems, a sensor can recognizemultiple targets within its sensing range. Since the more targetsa sensor monitors, the more data it will collect. Thus, theenergy used to transmit the collected data will be in proportionto the number of targets that the sensor monitors. In addition,there exist overlapped targets that are monitored by more thantwo adjacent sensors at the same time. Obviously, thetransmission of the data collected from overlapped targets willresult in waste of energy and bandwidth of sensors. To reducethe wastage of energy while considering the transmission ofpower to extend the network lifetime of the system, a newenergy-efficient algorithm has been presented in this paper.

2. BACKGROUND

Nowadays, the wireless sensor networks are rapidly increasing because of the deployment of sensors in a remote area with a large quantity in number and also to communicate with microcontroller frequently. In order to communicate from sensor to microcontroller frequently, the wireless sensor network is used. The description of the wireless sensor network and its types are described in this section. As discussed in International Electrotechnical Commission (2017), sensor nodes offer a most powerful combination of distributed sensing, processing and communication. The capabilities of these sensor nodes are increasing day by day which includes sensing, processing, and communicating the data that enables the realization of Wireless Sensor Networks based on the overall effort of a number of other sensor nodes. The sensor nodes are usually deployed in a sensor field where each one of them has the capability to collect and send the data back to the sink or gateway and the end-users by a multi-hop functionality which involves less architecture through the sink. The sensor nodes use their processing capabilities in order to carry out the simplest process and transmit only the partial or fully processed data. Internet or any type of wireless sensor network (like Wi-Fi, mesh networks, cellular systems, etc.), is used to send the data from the sensor node to SINK and from the SINK node to a user indirectly by using a third-party software. But in many cases, the sink can be directly connected to users or consumers. As shown in figure 1, each sensor node consists of five main components namely; a microcontroller to process the information, a transceiver to receive and send the data, memory to store the data, power to energize the circuit to sense and send the data and sensor to sense the data.

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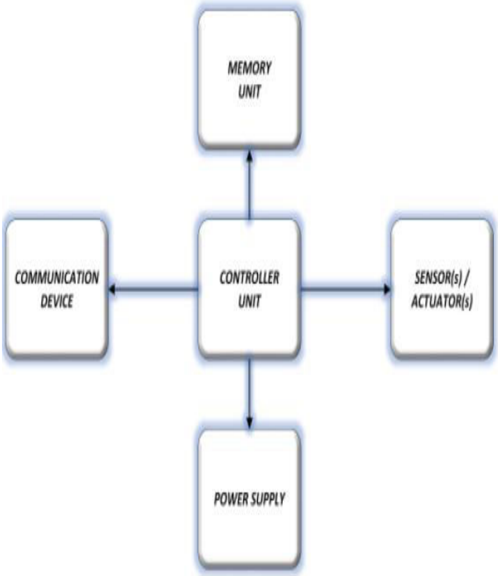

Figure 1 - Components of a sensor node in WSN

Each one of these components is required in designing a WSN to achieve better efficiency and accuracy. The microcontroller is the most important and main component that it processes the data and send it to the sink or nearest node. The controller consists of either onboard memory or small memory unit integrated into the embedded board. Through the transceiver, the sensor nodes communicate with other sensor nodes or with central nodes. The memory is a temporary storage of the sensed data and either it can be a RAM or a ROM. The power is the critical component and is used for node energy supply. The power mostly stored in batteries which could be either rechargeable or renewable source of energy. For a supplementary power supply, there are many sources like photovoltaic panels and cells which uses sunlight as a source, wind power which uses wind as a source to get charged, kinetic energy which uses the force of water when flowing from upper level to lower level, etc. Last is the sensor part, which is the main component that differentiates it from any other embedded system in terms of communication capabilities. It may generally include several sensor parts, which provide information on gathering or grouping capabilities from the physical world. The types of network are decided so that those can be deployed in underwater, underground, on land, etc., depending on the environment. As discussed by Pandey (2015) and Neha and Hitesh (2017), different types of WSN's are -

• Wireless Sensor Mesh Network
• Underground WSNs
• Terrestrial WSNs
• Underwater WSNs
• Multimedia WSNs
• Mobile WSNs

The above types of WSN have some existing mechanisms to reduce energy consumption. Hence, in the upcoming section, the types of existing mechanisms which are used to reduce the energy consumption is discussed. There are many mechanisms to reduce the energy consumption in WSN. The main types of mechanism which are discussed in existing papers are described below. The types are –

• Data Reduction Mechanism
• Radio Optimization Mechanism
• Sleep/Wakeup Mechanism
• Energy Efficient Routing Mechanism
• Charging Solution Mechanism

3. PROPOSED SYSTEM

In this paper, an energy-efficient algorithm for MTC hasbeen introduced. The summary of the conception of ourintroduced scheme is illustrated as follows. Firstly, proposedalgorithm makes

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groups of sensors where each sensor can be amember of multiple groups and each group consists of a leastnumber of sensors but completely covers all of the targets [5].As shown in Fig. 2, every group is defined as a joint matix andthese matrices D1, D2 and D3 can be formed based on thecoverage relationship.

Later, the algorithm removes the redundancy of overlappedtargets (OTs) from the formed joint matrices. In the multipletarget coverage, there exists a OT which is covered byadjacent sensors at the same time. The adjacent sensors thatmonitor the same target at the same time are defined asoverlapping sensors (OSs) for corresponding OT. The Ossgather overlapped data from the OT and transmit them to thesink node. Surely, multiple transmission of the same dataresults in the waste of energy. Through removing theredundancy of OTs, the wasted energy can be reduced whichincreases the network lifetime of the system.

3.1 MTC in WSN

MTC problem

In the multiple target coverage (MTC) problem such astracking and classifying of targets [7] and habitat-monitoring[8], a sensor can recognize multiple targets within its sensingrange. Therefore, each sensor can compute the coveragerelationship of itself and the same sensing time, a sensorcovers more targets which results in more collection of data.Thus, the sensor will consume the energy to transmit thecollected data to the link node in proportion to the number oftargets that the sensor covers. However, the energyconsumption model of sensor is totally different from that inthe conventional studies. Therefore, a new energyconsumption model for the MTCP is needed to be derived asfollows. Here, since one-hop transmission for the collecteddata is considered, sensing and transmission energies areoccupying the most portion of energy consumption of sensor.

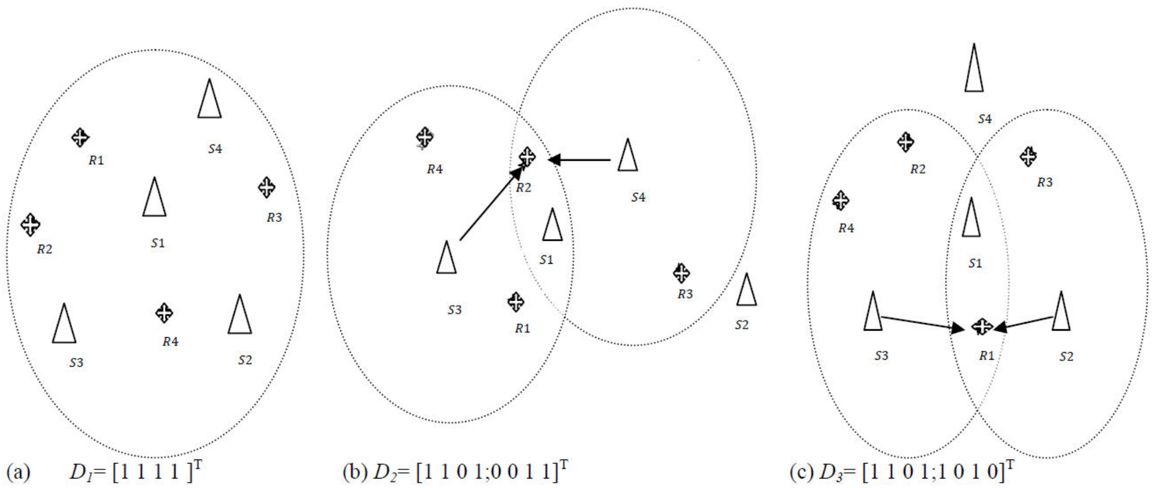

Fig. 2: Overlapped target and corresponding overlapping sensors (D1, D2 and D3 are three joint matrices)

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Next, the proposed scheme determines the active time ofeach joint matrix such that the network lifetime can be maximized while ensuring that all the targets are completelycovered. Once the active time of the joint matrices has beendetermined, each joint matrix is activated in order. Therefore,the network lifetime can be expressed as the sum of activetime of all the joint matrices. Only the sensors in the activatingjoint matrix go to active mode for the purpose of observing allthe targets and transmitting collected data to the sink node.The sensors not in the active joint matrix remain in sleep modeto conserve power. As a result, each sensor goes to active orsleep mode according to the joint matrices that the sensorbelongs to [9]. Finally, the proposed new algorithm does thecrossover operation which further prolongs the lifespan of thenetwork. Hence, this new scheme increases the networklifetime of the system effectively. In the algorithm authorshave used some variables. The variables which have beenconsidered in this paper are as follows:

U = Number of targets
V = Number of sensors
P_i = If input is $A^{U \times V}$, then the columns of the inputs are expressed as $P_1, P_2, \ldots, P_V$
L_{ss} = Lifetime matrix of sensors which are initially set as 1; then columns of the input life matrix can be expressed as S_i where $i = 1,2,3,\ldots,V$
D_j = A particular joint matrix, where $j = 1,2,\ldots,q$
T_i = Active lifetime of a particular joint matrix
W_j = Number of targets covered by a particular sensor
f = Target cover by each sensor after crossover
K = Power needed for covering each target

3.2 Proposed algorithm

Input matrix, $A^{U \times V}$
% Initialization
Set initial network lifetime = 0, $W_j := 0_{1 \times V}$,
    $L_{ss} := 1_{1 \times V}$, $j = 0$
Arrange sensors
% creation of joint matrix
for all sensors P_i where $i = 1,2,3,\ldots,V$
    $D_j := 0_{U \times V}$
    if two or more sensor's combination cover all targets
        $D_j :=$ take those sensors
        $j = j + 1$
% removal of overlapping
    for all joint matrix D_j where $j = 1,2,\ldots,q$
        Find the overlapped targets in D_j
    Select the responsible sensor, P_i where $i = 1,2,\ldots,q$
        $D_j :=$ Updated D_j
% updating of W_j
        for all sensors $P_i \in D_j$
    $N_i =$ Find the number of targets covered by $P_i \in D_j$
        $W_{1 \times j} = N_i$
        end for
% updating L_{ss}
        for all sensors $P_i \in D_j$
            $L_i = L_i - \alpha W_j T_i$
            If $L_i <= 0$
            $L_{ss} := L_{ss} - L_i$
            $A^{U \times V} = A^{U \times V} - P_i$
        end for
    end for
    Execution of crossover algorithm
end for
Return joint matrix $D_1, D_2, .., D_j$ and
    network's lifetime $j * T_i$

4. ENERGY EFFICIENT ROUTING MECHANISM

Energy Efficient Routing Mechanism – As discussed by Singh, Kumar, Singh, and Alryalat (2017) [43], Routing is another issue that can decrease the lifetime of the WSN very quickly. By using this routing mechanism, the energy efficiency can be increased more than charging solution mechanism. So, in order to increase the energy, the energy efficient routing algorithm is developed. There are many Energy Efficient Routing techniques are used in existing work that can increase the energy efficiency in WSN. In that some of the major methods are –

• Multi-hop clustering method
• Stable election protocol enhancement
• Energy aware neighbor-oriented clustering
• Grid based energy efficient routing algorithm
• Zigbee transceiver protocol technique

Multi-hop clustering method - As discussed by Singh, Kumar, Singh, and Alryalat (2017) [43], the energy of the sensor nodes which are near to the sink node gets depleted faster when compared to the sensor nodes which are far away from the sink node. The prime cause for this depletion of energy is because the nodes transmit its own data as well as data from its nearest nodes. Hence this node acts as an access point and also a sensor node. Because of this, the nodes which are nearer to the sink node die quickly and network disconnects even there is so much adequate energy in other sensor nodes. So this point is called a hot spot problem in WSN. To overcome this issue, the multi-hop clustering technique is developed in order to minimize this issue. Based on the number of hops or neighbors and residual energy of the sensors nodes in that network, the base station or central node elects the cluster head. This technique was found out to be that this increases the energy efficiency and also it reduces the hot spot problem when compared to other existing techniques.

Stable election protocol enhancement - As discussed by Rao (n.d.) [40], there are many existing protocols in WSN like datacentric, hierarchical and demand-based routing protocols which increase the energy efficiency of the WSN. Also, there are some clustering protocols like Deterministic energy efficient clustering, stable election protocol, and stable election protocol enhancement. So in this paper Rao (n.d.) [40], the performance is evaluated for all type of clustering protocols and discussed. The stable election protocol enhancement works as " The intermediate node is chosen as a fraction of energy between the limits of both the fractions of the energy of the advanced node as the upper bound and the normal node as the lower bound. The new heterogeneous setting with the three-tier node energy has no effect on the spatial density of the network, but the total initial energy of the system is increased by the introduction of intermediate nodes." Thus, the evaluation states that Stable Election Protocol Enhancement has more energy when compared to other existing routing protocols.

Energy aware neighbor-oriented clustering - As discussed by Sidy, Cisse, Ahmed, Sarr, and Gregory (2016) [42], clustering is a technique used to organize and structure the network to split into many sub-networks. The energy of the sensor nodes can be increased by involving the cluster head in the network and acts as a representative for that group. This Energy Aware Neighbor Oriented Clustering is an enhanced version of Hybrid Weight Based Clustering Algorithm and this enhanced one focuses on a new neighborhood discovery type. The receiver signal strength indication value, transmission range, and propagation model selection are having a greater impact on the rate of power consumption. This enhanced protocol has higher longer network lifetime when compared with dynamic load balancing clustering protocol.

Grid based energy efficient routing algorithm - As discussed by Paul and Chattopadhyay (2016) [38] and Paul and Chattopadhyay (2017) [39], "one cluster head is selected from each cluster for each round of the communication." There is a rectangular playground area which is divided into small equal squares. Here in each square, there are at least 25 to 50 nodes deployed. In this deployment, for the first round the center node in that square is elected as a cluster head and remaining nodes inside that square region will send the data to this cluster head. For the second round, the node near to the center node is elected as the cluster head. So same like this, the process continues in a cyclic manner. During this process, if the node's battery got finished then that node will not be considered in future and will be declared as a dead node. By using this routing algorithm, the energy efficiency is increased.

CONCLUSION

This paper has proposed an energy-efficient algorithm thatmaximizes the network lifetime in the multiple target coverageproblems. The performance gain of the proposed newalgorithm increases with the increasing number of sensors.Our algorithm does both the elimination of the redundancy ofthe overlapped target as well as crossover operation.Simulation result shows that this scheme is effective enough towork in an energy-efficient way.

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