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توفير الطاقة في عمليات رصد الإشعاعات

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الخلاصة

إن عملية رصد الإشعاعات هي البحث عن وجود جسيمات مشعة في الهواء في مساحة محددة. يؤثر التأمين الإشعاعي على المواد الجينية (DNA) الموجودة في أجسادنا. هذا يسبب طفرات جينية ضارة تنتقل إلى الأجيال اللاحقة. في الكثير من الصناعات ومحطات الطاقة يتم وضع مجسمات إشعاعية لرصد والتحكم بمستوى الإشعاع ولكن يوجد بالتأكيد إشعاعات حول هذه الأماكن.

في هذه الورقة تم اقتراح شبكة لاسلكية للرصد WSN باستخدام عداد جيجر – ميولر وكذلك مجسمات الأشعة فوق البنفسجية من الموقع الأساسي يجب أن تصل المعلومات إلى المستخدمين المخولين. لاستخدام هذا المجس يجب تفعيل الاشتراكات في الشبكة العنكبوتية SWE .

عموما جميع تطبيقات الشبكات اللاسلكية للرصد WSN تحتاج مجسات صغيرة موزعة عشوائيا في المساحة المراد مراقبتها. وحيث أن هذه المجسات تستهلك طاقة كبيرة فإنه من الصعب المحافظة على مخزون الطاقة فيها لفترة طويلة.

تم نمذجة جدول ماك للطاقة الفعالة للمساحة المراد مراقبتها. لزيادة فعالية توفير الطاقة تم تطبيق (فتح/قفل) النظام بطريقة منتظمة للاستخدام الأمثل للمجسات الموزعة في المساحة وتقليل هدر الطاقة.

Energy conservation in radiation monitoring

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ABSTRACT

Radiation Monitoring is about monitoring a specific area for presence of radiation particles in the air. Ionizing radiations affect the genetic material (DeoxyriboNucleic Acid (DNA)) contained in our body. This will cause harmful genetic mutations that can be passed on to future generations. In the industries and power plants, radiation detectors are placed inside to continuously monitor and control the levels. But definitely there will be some radiation spread around those plants. A design of Wireless Sensor Networks with the Geiger-Muller Counter and Ultra Violet sensor is proposed in this paper. From the deployment site, the data has to reach the authorized users. For this Sensor Web Enablement (interfaces and services has to be enabled. In general all the Wireless Sensor Network applications need tiny sensor nodes to be randomly embedded in the target area. As the wireless Sensor Nodes are always energy hungry, it is a challenging process to retain their energy level for a long period. An energy efficient Medium Access Control schedule for the radio of the radiation monitoring sensor motes is also simulated. For efficiency in energy conservation, sleep / wake up scheduling is deployed which provides a systematic approach to adequate use of the nodes deployed and for minimizing replenishment of energy for the nodes.

Keywords: Cluster; energy efficiency; radiations; radio; schedule; sensors;

INTRODUCTION

Environmental monitoring is an important application of Wireless Sensor Networks. Acquisition of precise data and immediate transfer of the data to sink node in time is very important for environmental monitoring applications. From the survey of several WSN applications, it is clear that the energy consumption of any type of sensor network depends mostly on the data communication between the nodes. All the nodes from different types of available vendors are nowadays designed to have a sleep mode, so that, if they are not having anything to send or receive, the radio can go to sleep state. However, the nodes can communicate only if they are active. So, the nodes should follow a schedule, in-order to wake-up and sleep periodically. This sleep and wake-up states apply only to the radio. The sensors, which consume very minimal energy, always stay active.

Awareness about radiation is a must. Ionizing radiation can cause changes in the chemical balance of cells. Natural radiation comes from cosmic rays and naturally occurring radioactive elements found in the earth's crust. In addition to these natural sources, radiation can come from wide-ranging sources such as hospitals, research institutions, nuclear reactors and nuclear plants.

As the natural resources for power generation are slowly getting depleted, the major source for power generation is nuclear and it is un-avoidable. So there should be a constant monitoring of radiation around these places. If the safety and protective measures are completely given, this one will be the best resource for power generation in the future.

OBJECTIVES

For this Radiation Monitoring application (Figure1), acquisition of precise data and immediate transfer of the data to sink node in time, is very important. This application detects and measures the harmful radiations in the air, and sends the alarming message to the concerned people, if the radiation level exceeds the threshold level.

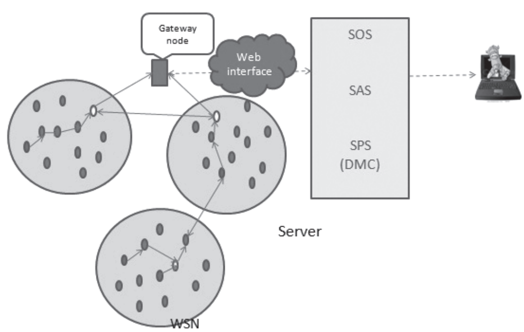

Fig. 1. Structure of the Radiation Monitoring System

This work is a part of the Environmental Dynamic Information System to alert the public. It is an Open Geospatial Consortium (OGC) standard based framework for the discovery, access, use and control of heterogeneous sensors, their meta data and their observations.

PROPOSED MIDDLEWARE

The proposed model is a three layer framework (Figure 2). The lower most layer is sensor specific. Two sensors namely Geiger-Muller Tube and SU 100 are used in this lowermost layer. The sensors are interfaced with TelosB mote. TelosB mote (TPR2400) is used as the sensor mote. It is having a zigbee radio which is enough for a short range communication. A fifty number of such motes interfaced with the above said two types of sensors are deployed in the site. All the motes (here we call them as nodes) are placed 30m - 50m apart.

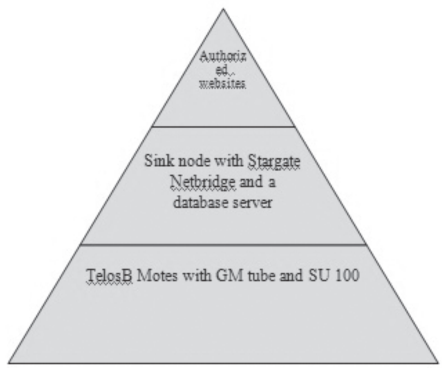

Fig. 2. Layer wise diagram of the Proposed Middleware

The middle layer is the important one as this is responsible for providing interface between the sensor network and sensor web. A sink node which in this case is Stargate Netbridge Gateway, is responsible for communicating with the application server. This gateway node is a special type of sensor node with some additional features like GPRS, an in-built Web server (Mote Explorer) and Sensor Network management tool (XServe). Using this, one can manage the sensors at the deployment site. Even if the nodes are not placed in frequently accessible positions, we can adjust and control their working conditions by using this sink node.

The uppermost layer is the application layer, where we can have the application running on normal machines. The Sensor Observation Service (SOS), Sensor Alert Service (SAS) and Sensor Planning Service (SPS) of Sensor Web Enablement (SWE) provided by the OGC standard are being used by the sensor web applications worldwide (Figure1).

In our work, the Sensor Observation Service (SOS) part of the SWE is being used. This code is available in 52 degrees North, a website. It is a trusted and well established entity in the field of Geoinformatics. They develop new concepts and technologies for managing real-time sensor data and integrating geoprocessing technologies with them. Using this SOS, we can monitor the sensors and their stored data range from the authorized websites. If the data range exceeds the safe limit, alert messages will be created and shown on those sites. This is our uppermost layer.

FRAMEWORK OF THE PROPOSED MODEL

In any country, radiation protection standards are set by government authorities, with recommendations by the International Commission on Radiological Protection (ICRP), along with the requirement to keep exposure levels As Low As Reasonably Achievable (ALARA), taking into account social and economic factors. The authority of the ICRP comes from the scientific standing of its members and the merit of its recommendations.

UVA may serve to initiate the most dangerous form of skin cancer known as malignant melanoma as a result of damaging DNA. Exposure to UVA actually causes a large fall in the body's immune cells, which in turn make it easier for malignant cells to grow. Medium-wavelength UVB is biologically very active, but cannot penetrate beyond the superficial skin layers. It is responsible for delayed tanning and burning; UVC has the highest frequency and the shortest wavelength and is recognized to be the most harmful of all. The ozone layer is currently absorbing the majority of UVC rays which prevent them from reaching the earth. However, due to the environmental state of the planet, this layer is being depleted and will eventually greatly increase the risk of suffering from skin cancer.

Each node will be having Geiger Counter sensing the ionizing radiation. It measures the number of counts per minute detected by the Geiger tube and sends this value using ZigBee and GPRS protocols to the control point. With this technology, radiation measurements can be made in real time, without compromising the life of humans, as they do not have to be inside the security perimeter in order to activate the Geiger counters.

Along with GM tube, a SU 100 is also interfaced. The SU 100 UV sensor mentioned here measures the ultraviolet radiation between 250 and 400 nanometres in µmol m-2 s-1 (micromoles of photons per square meter second). The SU-100 is a photodiode-based UV sensor sensitive to radiation from approximately 250-400 nm. This spans the UV-A, UV-B and UV-C wavelength ranges and provides a measurement of total UV radiation. The calibration is NIST-traceable. It is calibrated to measure total UV radiation.

All the above said details are about the lowermost layer which in the diagram (Fig.3), is on the left side. This layer is responsible for the real time physical data. Feature extraction module and Quality Assessment Module, which are programmed in the interface are responsible for capturing the correct data that actually exceed the safe limit. The motes are simply responsible for data sensing.

The Stargate Netbridge which is the sink node acts as a bridge between the application layer and the sensor nodes. GPRS facility present in the sink is the one which helps in transferring the required data to the authorized websites. This sink node will be in communication with a server for database management. Here only the threshold limit is set.

From the secured website, the data can be accessed by authorized users. The sensors can also be managed from here using the Sensor Observation Service (SOS). The real time dynamic data can be constantly monitored from this page. Since the threshold limit is set in the server, the alert process is completely automated.

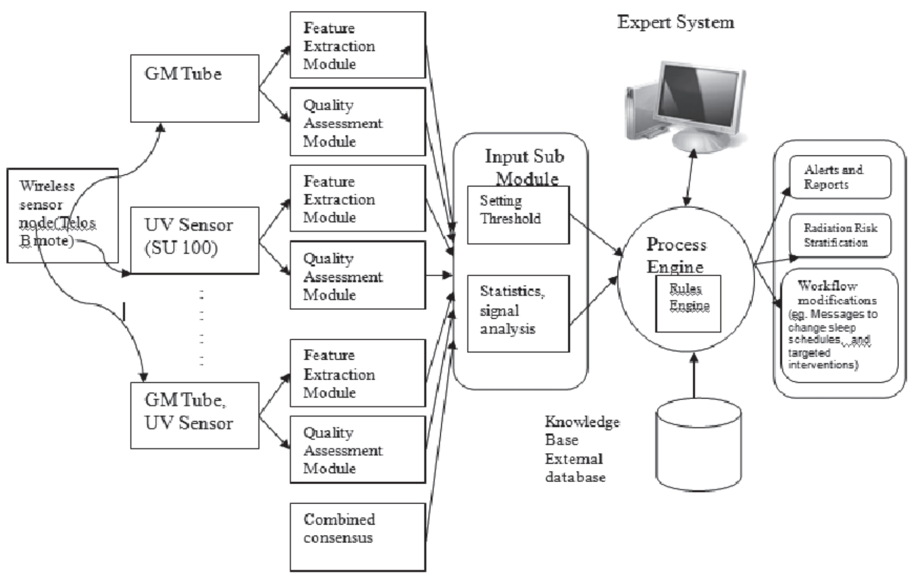

Fig. 3. Framework of the Proposed Model

RELATED WORKS

Environmental Monitoring Applications

Some applications on Environmental Monitoring are discussed in this section.

In wireless air-pollution monitoring system, Sonal *et al*. (2011) has stated, that this monitoring system gives alert messages to the concerned authorities, when there is a drastic change in the quality of air in the environment. They have used Air Quality

Index to find out the different levels of pollution. The entire area of Nagpur has been divided into several smaller sections. One of the nodes in each section gets the role of a cluster head. The cluster heads from all the sections send the data to the gateway node. This gateway node forwards the data to the database. Each sensor node sends the data packet, which is actually the sensed data together with a unique id. Here they have used the simple Distance Vector algorithm for the localization of the nodes. They did the simulation in NS.

A WSN of geophysical sensors to detect and prevent rainfall induced landslides (Maneesha *et al*., 2009) in a hilly area in Kerala was a major project in South India by deploying sensor network. Each node is having two layers. The lower layer collects the data from the sensor column, which is designed with different sensors namely strain gauge, pore pressure transducer, humidity sensor and geophone, at different levels under the soil. This lower layer sends the collected data to the upper layer, which in turn forwards the aggregated data to the sink node.

The consensus from all the homogeneous sensor columns placed in a locality is compared with each other. Some weightage is assigned to the sensors, based on the impact of landslide on that area. Using those weightage and the consensus, the aggregated data from that region is being sent as alerts. During rainy season there are more chances of landslides. So they developed two types of alert levels - lower alert level and higher alert level. During lower alert levels, the nodes work with less power, thus saving energy. Here they have used simple aggregation techniques for data communication.

In a recent work on Carbon Monoxide (CO) Monitoring (James *et al*., 2011), a network of CO monitoring sensors in cooking outlets of closely packed houses in a confined environment is described. All the sensors will be sending their collected data to an aggregator node which has been designed with a GSM/GPRS Modem. This node will send the consensus to a sink node, which by using satellite communication, stored and processed in a remote server. Later, through mobile phones the data about the presence of CO and its quantity can be viewed by a CO supervisor with proper authorization. Here the processing and estimation of the data is complex because the SWE interfaces are not used.

Multiresolution Compression and Query Framework (You-Chiun *et al*., 2009) is a new type of framework. Initially the nodes are arranged layer by layer. Each layer contains four blocks. Each block in layer i+1 contains α blocks in layer i. Each block is designed with a processing node (PN). It uses spatial compression algorithm for processing. In the lowest layer, the sensor nodes are placed in separate pixels. They are called as Leaf Nodes (LN). The aim is, while going deeper into the tree, finer resolution has to be obtained. So when a query arrives, it is passed through the resolutions to reach the correct pixel. Finally the value from the LN is disposed by the sink node. The

LN and the lowest layer PN use the temporal compression algorithm. The LN and the PN uses reverse exponential storage algorithm for storing historical data.

MAC SCHEDULES

Radiation monitoring requires precise data. Data processing and data transfer require more power. When the data has to be transferred and needs to be stored depends on the state of the radio in the node. To conserve energy, we can switch the radio to sleep state. This method of making the radio to be in sleep state and making it active only if any event is detected is called as on-demand scheme or event-based scheme.

There is another method of scheduling i.e. on regular time intervals, all the nodes will be either in sleep mode or active mode. This is called synchronous scheme. But the overheads for maintaining all the nodes in the synchronized state becomes complex. It is not necessary to keep all the nodes active at one time. WSN can follow a scheduling pattern accordingly and at any instant we can make only a limited number of nodes active. The work presented in this paper is based on the type of asynchronous mechanism. But the communicating nodes should be in synchronous state. In this work, the schedule preparation is described in detail, which clearly shows how less number of nodes alone is necessarily to be in synchronous state.

The complexity calculation for the cost of time consumption, energy consumption and message transfer (Xiang-Yang *et al*., 2011) was also done. The entire scenario is divided into three phases, namely Data collection, Data aggregation and Data Selection. Connected Dominating Set (CDS) has been reviewed. Methods for constructing a good CDS have been given under several Lemmas. Connected Dominating Set Tree can be constructed in many ways. CDS is constructed in a very simple way in this paper. First the nodes are constructed in a grid. In each cell, the node at square root of r divided by 2 will be the dominator. The nodes which are connected with a pair of dominator nodes which are at the least of three hops apart are the connector nodes. In this way CDS is constructed. Then the data collection for this type of tree starting from BFS is analysed. The data is collected from all the nodes, by scheduling only one time slot for each node in a dominating set to its dominator. Then the data aggregation is analysed. The dominator node aggregates the data from all the nodes in the set, and then forwards that along with its own data to its parent node. Then the data selection part which is for selecting the smallest data from all the nodes, is analysed. For all the three data operations, they analysed the methods for finding the lower bound on the cost complexity for time, message and energy.

In S-MAC (Sensor MAC) (Raja *et al*., 2010) the nodes will be either sleeping or active. The nodes are following the same schedule form a virtual cluster. Each node will be following a schedule of its own for sleep and wake-up. If it detects a neighbour, it sends its schedule to it through a sync frame. If that node has not yet started following a schedule, then it accepts this schedule. If it is following a schedule of its neighbour, then it wakes up also in the listen intervals of this new schedule along with the old schedule of its neighbour. If a new node arrives in between two already existing virtual clusters, then this node has to follow the schedule of both the clusters, hence following a new virtual cluster. If the nodes are following multiple schedules, then the energy will be depleted very soon (Ozlem *et al*., 2011). If a global sleep schedule is followed, the overall energy consumption would be reduced. The computation cost and time cost would also be reduced (Somnath *et al*., 2009)

The protocol-SMACL (Christophe & Wendi 2010), is a slight modification of the previous SMAC. According to this protocol, if a node is introduced between two different clusters, then the newly formed cluster will not be following multiple schedules. Instead, it will merge the two clusters into a single larger cluster and all the nodes inside this will be following one of the two schedules of the previous two clusters. For this they introduced schedule identifier, which is related to the node that actually created this particular schedule. So if a node receives new schedules from its neighbors, it checks the schedule identifier of the received schedules. It follows the schedule which is having the highest schedule identifier. They proved that their protocol consumes less energy than SMAC, by simulating this SMACL in NS-2 for different types of topologies.

Later the methods and steps required for preparing an energy efficient schedule was described (Yanwei *et al*., 2010). Four states of radio are considered. Scheduling is done on different clusters. Each cluster will be assigned chunk of time slots for preparing a schedule. This chunk depends on the number of nodes in each cluster. Inside the cluster, each node will be given one time slot for being active in this schedule. During this slot the node will send and receive data. The clusters are grouped in such a way, that they should not conflict with each other. The near-by clusters should follow different non-conflicting schedules. For this, both centralized and distributed approaches are discussed. The second part of this paper describes the construction of efficient Data Gathering tree. Tree construction based on BFS, SPT and CDS were reviewed.

The optimum energy consumption based on the above described scheduling and tree construction is calculated using simulation study. The cost of energy consumption is discussed in great detail. The cost factor for time delay is not discussed in detail.

ALGORITHM AND SIMULATION

The following sequence of events follows after some raw data is sensed by a node in a cluster.

1) If a node senses some data, it has to wait for its radio to become active. As per the current schedule, the radio comes to active state.

2) Till that time, if the same sensor senses some more data, they will be saved in the node's small memory, 'Flash' memory in this case.

3) When the allotted time comes, the radio of this node sends the data to the nearby active node.

4) Finally the cluster head gets the data and forwards it to one of the nodes in the other cluster which is in between the current cluster and the sink node in the tree.

If a new node is introduced, it has to fit into the nearby cluster and it should follow its schedule. If its location is in between two already existing clusters, then the two clusters should be combined. And all the nodes in the two clusters should follow a common schedule. If the number of clusters increases, the number of schedules will also increase. It creates overhead. Thereby, the energy consumption also increases.

SCHEDULING ALGORITHM

For environmental monitoring applications, the nodes will be in (1) remote harsh places. They should be (2) densely deployed. They should be small, powered by batteries and (3) should not be in need of frequent recharging. The protocols design so far studied and designed (though not fully) under our work are strictly based on the above said factors.

Scheduling is the first area. A TDMA based MAC protocol is the base for the scheduling. The MAC frame design for this schedule should carry the data, control data, source address, destination address, sync and error checking code (Yuwang *et al.*, 2008). This load will be of 127 bytes length, because the radio should be a zigbee compliant, as it is a radiation monitoring application. Periodically for route discovery, the route data from each node will be shared with the one hop neighbours. The schedule for the entire network should not contain more than N (total no. of nodes) time slots.

In-order to reduce the overall energy consumption, clustering technique is applied. Inside each cluster, based on the number of nodes the number of slots is allocated. The schedule should be the same for all the nodes inside a cluster. And at the same time the slots during which they have to be active, should be minimum. At a minimum rate of at least 2 times, each node has to be active. The clusters are formed in such a way that the nearby nodes in two different clusters should not be in the interference range. Inside the cluster, the nodes are placed 25m apart.

All the nearby nodes are grouped to form different clusters. The data from each cluster is collected by a cluster head and this one in turn sends the aggregated data to the active cluster head of the nearest cluster. While forming the clusters, the following rule should be followed - No two clusters should have one or more nodes in interference range.

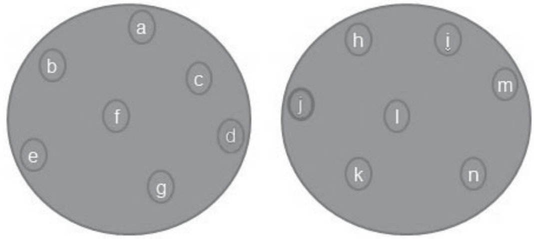

Fig. 4. Two clusters having two nodes in interference range

Interference range is that, the two nearest nodes in two different clusters should not be in either transmitting (r_t) or receiving state (r_r). This will cause interference and overhearing of packets and thereby wastage of energy. In the Figure 4, the nodes c and f are said to be in interference range. For the two neighbouring clusters this rule should be followed. If a node 'c' at time slot 't' in a cluster say C_i is in active state ($r_{c,t,a}$), then the node 'f' at the same time slot 't' in a neighbouring cluster say C_j should not be in active state.

The four states of radio considered here are sleep state, transmitting state, receiving state and listening state. The last three states are said to be active states. The cluster heads are selected based on the weight. This weight is calculated based on the active data from its child nodes and more importantly, the residual power of each node.

Inside each cluster, all the nodes follow a common schedule, which is not prepared in a single node. All the nodes inside a cluster (as they are synchronized) follow a common schedule, in a distributed manner.

1) Initially all the nodes in a cluster follow a random schedule.

2) Each schedule as previously said contain certain number of slots which corresponds with the total number of nodes in the tree.

3) After the completion of a schedule, in the second cycle, the nodes follow a new schedule. In this schedule, the nodes which are all having more data make use of the first slots. In addition to that, this schedule also follows a pattern in such a way, that all the nodes which are having less residual node power occupy the initial slots.

For a cluster head:

1) The one which contains the least weight will be the cluster head for that cycle.
2) The distance between the Cluster-head and any other node must be short.
3) The cluster head for a cycle will have the aggregated data.

From the cluster heads the data travels through the network and reaches the sink node.

If the entire network is taken as a single cluster, the cluster head will be the sink.

RESULTS AND DISCUSSION

The above said algorithm is simulated in Network Simulator NS-2.34 version in Fedora. The WSN is designed in simulation with 80 nodes and one sink node. The Initial energy is assigned to all the nodes. Details about the position of nodes and their residual energy are sent to all nodes in the cluster immediately after deciding on the number of nodes in each cluster. For the radiation monitoring applications, radiation will not be uniform across the environment. All the time maximum of the radiating environments follow inverse square law. Since being environmental monitoring, we cannot compromise with the detection and radiation of data. Hence there must be a test signal generation and accordingly the nodes are placed.

Finally after the placement of nodes, the clusters would automatically be rearranged according to the environment that it is defined for. After the rearrangement of clusters, a test signal would be passed on to test the efficiency of the detection and communicating capabilities of each and every node that is employed in the cluster as in Figure 5. The nodes that do not satisfy the criteria of threshold efficiency are just replaced with newer ones and then again the test signal is generated which does test the efficiency. This process is done iteratively, and hence the required setup is obtained.

The clusters as discussed in the above algorithms would need to set a cluster head (CH) based on the energy parameter. If there is no cluster head (CH), then the data transfer will involve lot of nodes to reach the sink node. According to our work for a network of 80 nodes, the number of active nodes is 20. There by, if we calculate the overall energy consumption, it will be very high because of many active nodes colored as yellow. The simulation of clusters without CH is depicted in the Figure 6 and Figure7. At any point of time, the energy of the cluster head should be more than or at least equal to the node with highest energy in the cluster. The CH formation according to the previously mentioned simple algorithm is shown in Figure 8. Therefore once the cluster head is nominated, the process carries as if it is on an automated system, where as the routing or the route followed by the data packet differs in order to help achieve minimum wastage, so as to protect the self-preserving nature of the nodes.

The simulation first shows the travel of the data packets to the sink node. But in this case the data packets do contain a bit more information about the radiation that has occurred at any point under the surveillance of the node, which is transmitting the energy. And continuous stream of data packets do signify that the amount of radiation being experienced is high or continuous and should be taken care of. The node with greater energy is set as sink node and according to algorithm the energy should come down to that of another node's energy or below that, only after which the assumption of cluster head (CH) can be changed (Figure 9). That is why it is important for the registers of all the nodes to store the information about all other nodes, so that choosing becomes easier with a condition

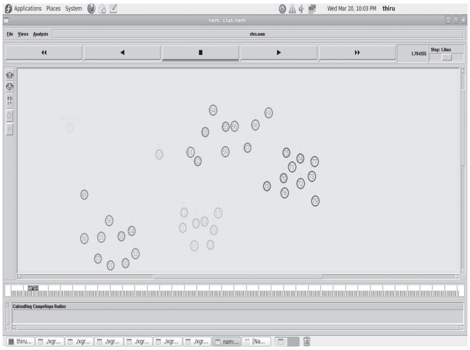

Fig. 5. Nodes arranged in random clusters

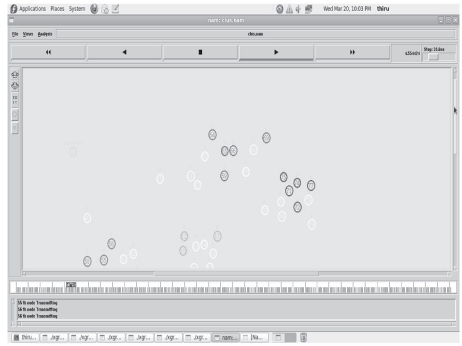

Fig. 6. Nodes made to sleep and wake up randomly

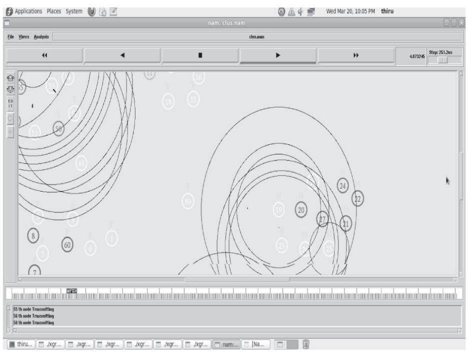

Fig. 7. Transfer of inter-cluster data packets

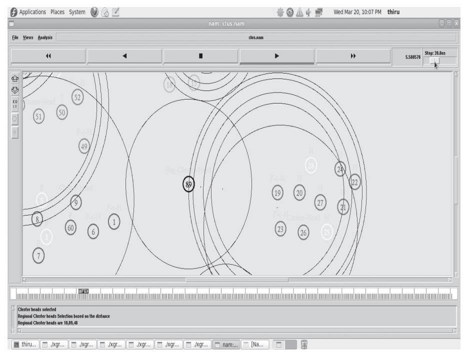

Fig. 8. Formation of cluster heads

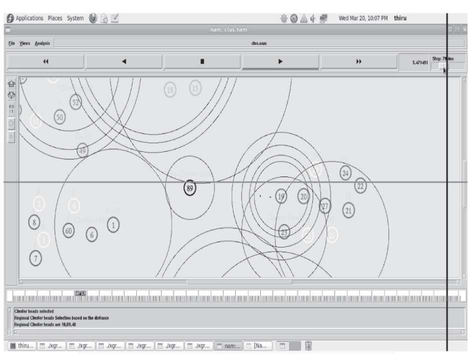

Fig. 9. Dynamic nature of cluster heads

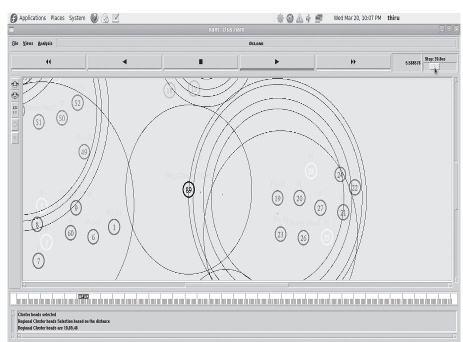

Fig. 10. Reduction of Active nodes

By continuing this algorithm for a period of 3 minutes, we can notice that the number of active nodes has been reduced to 6 in Figure 10 (the reduction in number of yellow colored nodes). Therefore, from the simulation study it has been observed that, initially without the proper scheduling algorithm the energy wastage was 25% and after the implementation of newly stated scheduling protocol, it has been reduced to 6%.

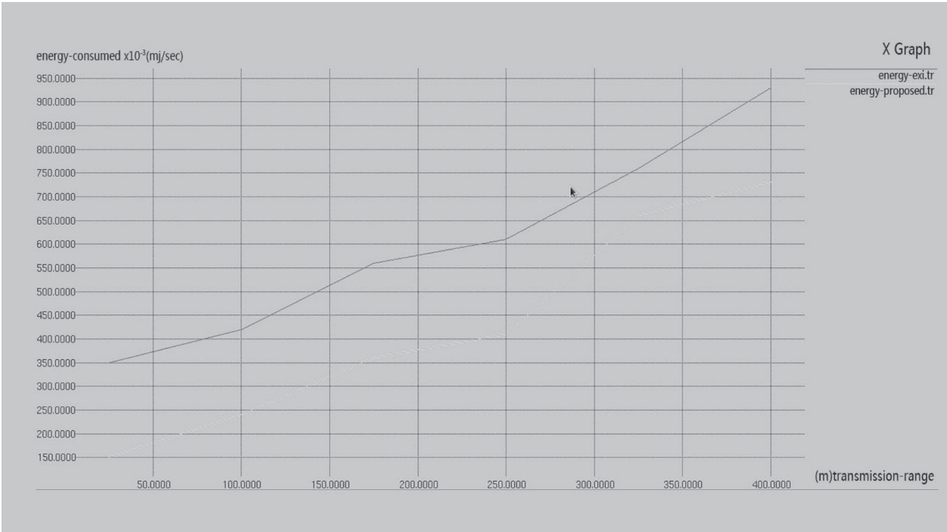

Fig. 11. Energy Consumed v/s Transmission Range graph

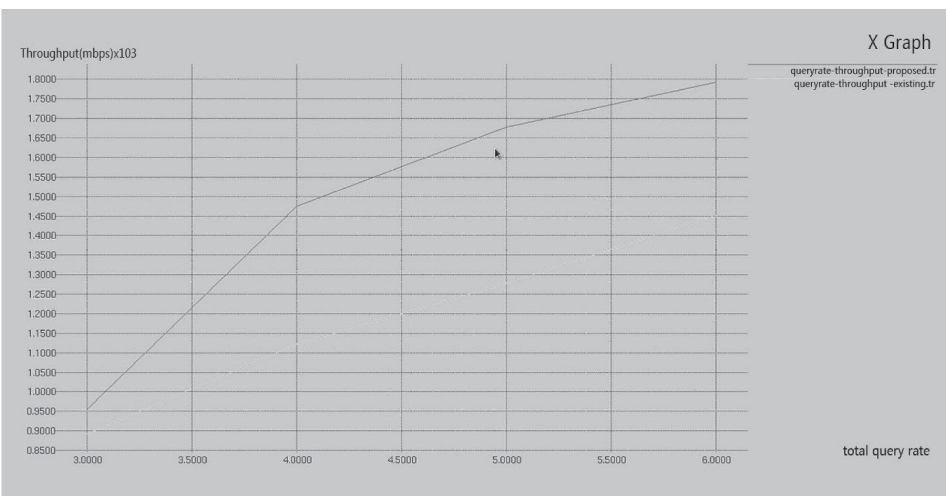

Fig. 12. Graph comparing throughput and total query rate

The graph in Figure 11 depicts the energy consumed by the nodes in a regular time basis. The y axis shows the energy consumption in millijoules/Seconds. The x axis shows the transmission range in meters. Also, the comparison is made with the theoretical calculations. The slope of the graph has been drastically reduced at an intermediate state. In the graph shown in Figure 12, throughput of the entire system is compared with the query rate. The query rate here refers to the number of data transfer between the nodes and the sink. Here the throughput parameter is on an increasing slope and hence the relation that "Throughput is inversely proportional to the energy consumed" is satisfied. Hence from the graphical output it can be clearly inferred that the main objective of saving the energy is achieved with utmost effectiveness.

CONCLUSION

The Wireless Sensor Network is an emerging area for research. Because of its constraints, particularly in 'energy consumption', it proves to be a major research topic. Whatever protocols and algorithms proposed in this research area can be validated only for a specific application, and they cannot be designed generic. The proposed algorithm for scheduling has proven to be moderately optimal for environmental monitoring applications at the simulator level. The work has taken all the problems one at a time and solved it efficiently, and in the end all the solutions are merged using the backtracking approach.

First considering the problem in interference domain, the whole network is broken down into clusters, so that the interference is straight away reduced to half the complexity and then a self-centric smallest area algorithm is designed and used such that it is overcome.

Next, the problem of energy consumption has also been checked in major level, assuming that the number of active nodes at any point of time should be as low as possible. It has also been proved.

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