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MAXIMIZING THE LIFETIME OF WIRELESS SENSOR NETWORKS BY USING PETRINET BASED REAL-TIME SCHEDULING

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Abstract:-The impact of wireless sensor network is well known in various fields of communication, where the applications and solutions could be accessed through various devices. The bounded energy of sensor nodes makes difficult for the application designers and service providers in scheduling and utilizing the sensor nodes energy in efficient manner. Recent advanced scheduling methods have been studied for the improvement of the lifetime maximization of wireless sensor nodes. What happens while using STG based or virtual backbone scheduling is each node participate in 3 or 4 duty cycles and most of the nodes life-time becomes closure at the same time which shows the end of network services and compromise the lifetime maximization constraint of wireless sensor networks. We propose a new real time scheduling of sensor nodes which participate in duty cycles using Petrinet. Petrinet are the popular graph based technique used in scheduling of resources in operating system solutions. The resources are constructed as sensor node in the graph and there will be only one sink and we have the topology of the network. Based on the topology and the energy level , Petrinet Based Scheduling algorithm selects a transition path for the sink. The other sensor nodes are directed for sleep condition which saves the energy of those nodes on that particular transmission. Here we consider each sensor node as a resource and scheduled using the energy level of the sensor nodes. The proposed method has reduced the energy consumption of all sensor nodes in number of duty cycles and extends the life time of the network.

Index Terms:-Wireless Sensor Networks, Petrinet, Transmission Scheduling, Lifetime Maximization.

Introduction

Wireless sensor networks (WSN) is the most developed communication network and has huge impact on the technology development in various domains of applications like battle field, remote sensing, security surveillance and more. The only energy supplied to the WSN node is the battery which has bounded energy , so that utilizing energy of WSN node is the crucial factor which affects the life time of the WSN. Sometimes if the energy of sensor node has been utilized properly the sensor node could be operative up to few years also. WSN is a collection of sensor nodes, where each node could sense and transmit and has no fixed topology. There will be a sensor node called sink through which anything could be transmitted. Among the functional components of a sensor node, the radio consumes a major portion of the energy. Various techniques are proposed to minimize its energy consumption. In this

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paper, we focus on Petrinet based Real-time Scheduling (PBRS),which dynamically turns off the radio of the sensor nodes to save energy. BS lets a fraction of some of the sensor nodes in the network in a WSN turn on their radio to forward messages, which forms a backbone; the rest of the sensor nodes turn off their radio to save energy. This technique no way affects communication quality because WSNs have redundancy. By redundancy, we mean that turning off the radio of some sensor nodes in a WSN does not affect the connectivity of the network. This redundancy results in more than necessary wireless links. Thus, it is possible to construct communication backbones to save energy.

Petrinet is a graphical representation of resource used in operating system solutions where each process requires set of resource to complete its job. The Petrinet are the model used to schedule the resources where multiple jobs can be executed synchronously. In a multi user and multi task operating system, the computing device could operate multiple jobs synchronously where the resources necessary to execute multiple jobs has to be scheduled properly for the completion of jobs at minimum time. In that case the overall completion time is the key which has to be reduced. We adapt the same technique but to maximize the lifetime of the wireless sensor network. Here jobs are the data transmission or duty cycle and the resources are the sensor nodes. The challenge is how do we adapt the Petrinet scheduling with the lifetime maximization. We have only one instance for each resource but using the topology graph we compute the shortest and projective path to reach the sink which avoids and choose the exact sensor nodes to reach the sink with reduced energy consumption. Our ultimate aim is to maximize the lifetime of wireless sensor network and with providing minimum service for the prolong period of time.

Scheduling is the process of selection of sensor nodes whose radio has to be up for the particular duty cycle and whose radios has to be down at the cycle. Each sensor node has the radio which consumes more energy compare to other components of the sensor nodes. The life time of sensor networks hugely depend on the energy constraint of the sensor node and gauged with the time when a single sensor node drains with the energy. In order to maximize the lifetime of WSN the energy of sensor nodes has to be utilized in efficient manner.

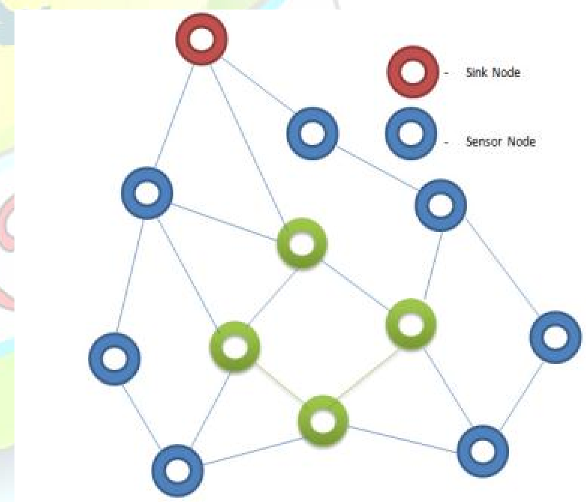

Figure1: Topology view of Network.

The figure 1 shows the topology of the wireless sensor network we considered and there is only one sink node and have other sensor nodes whose battery is having bounded charge whereas the battery of sink node is maximum to survive up to months and years.

We propose such a scheduling algorithm for the maximization of lifetime

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of wireless sensor networks in the following sections.

Background:

There are number of methods have been discussed earlier for the scheduling of sensor nodes to maximize the lifetime of the wireless sensor networks and here we discuss few of them before we discuss the proposed method.

Continuous Monitoring Using Event-Driven Reporting for Cluster-Based Wireless Sensor Networks [1], propose two new mechanisms that enable energy conservation in continuous-monitoring WSNs. The first mechanism can augment any existing protocol, whereas the second is conceived for cluster-based WSNs. With both mechanisms, sensor nodes only transmit information whenever they sense relevant data. To evaluate the efficiency of our proposals, the basic unscheduled transmission model and three well-known cluster-based protocols are used as baseline examples. Specifically, new analytical models for conventional cluster-based systems and for our approach-enabled systems are complemented by simulations in order to present a quantified perspective of the potential benefits of the proposed reporting technique.

In [2], the author propose a novel sleep scheduling method to reduce the delay of alarm broadcasting from any sensor node in WSNs. Specifically, we design two determined traffic paths for the transmission of alarm message, and level-by-level offset based wake-up pattern according to the paths, respectively. When a critical event occurs, an alarm is quickly transmitted along one of the traffic paths to a center node, and then it is immediately broadcast by the center node along another path without collision.

Towards Optimal Sleep Scheduling in Sensor Networks for Rare-Event Detection [4] discusses as each sensor node periodically produces data information and reports to one or several sink nodes. This typically implies that sensor nodes continuously transmit their information regardless of whether they have relevant data or not. By relevant data we refer to data that contains different information from the previous data information transmitted by the same sensor.

In access control in wireless sensor networks, Computer Networks [5], where each sensor node transmits periodically the sensed temperature to the sink node. In such application, it may happen that sensors have very similar reading during long periods of time and it would not be energy-efficient for sensors to continuously send the same value to the sink node. The network lifetime would be greatly increased by programming the sensors to transmit only when they have sensed a change in the temperature compared to the last transmitted information. In doing so, the end user would have a refresh value of the temperature in the supervised area even if the sensors are not transmitting continuously in a periodic fashion. The final user would have exactly the same information gathered by the WSN as with the classical continuous-monitoring applications, but while the sensors only transmit when there is relevant data.

An Ultra Low-Power MAC Protocol for Wireless Sensor Networks [7] , proposes combining these two schemes to obtain a further optimized low-power MAC protocol, called SyncWUF, for low-traffic wireless sensor network. Analytical and simulation results prove that our proposal achieves

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significant battery lifetime gain in different application cases without negatively affecting other important system parameters such as channel capacity and latency.

Towards Optimal Sleep Scheduling in Sensor Networks for Rare-Event Detection [8], propose a protocol for node sleep scheduling that guarantees a bounded-delay sensing coverage while maximizing network lifetime. Our sleep scheduling ensures that coverage rotates such that each point in the environment is sensed within some finite interval of time, called the detection delay. The framework is optimized for rare event detection and allows favorable compromises to be achieved between event detection delay and lifetime without sacrificing coverage for each point.

Wakeup Scheduling in Wireless Sensor Networks [9], consider the design of efficient wakeup scheduling schemes for energy constrained sensor nodes that adhere to the bidirectional end-to-end delay constraints posed by such applications. We evaluate several existing scheduling schemes and propose novel scheduling methods that outperform existing ones. We also present a new family of wakeup methods, called multi-parent schemes, which take a cross-layer approach where multiple routes for transfer of messages and wakeup schedules for various nodes are crafted in synergy to increase longevity while reducing message delivery latencies.

All the methods we have discussed have extends the lifetime of wireless sensor networks up to some level and has the problem of extending the lifetime of the network and extending the service provisioning time of the network. We propose a new petri net based real time scheduling of sensor nodes in wireless sensor network.

Proposed Method:

The proposed method consists of four stages namely Sensor Initialization, Graph Generation, PB Real-Time Scheduling, and Data Transmission. At the sensor initialization stage each sensor node gets loaded with unit of energy , at the graph generation process the sensor nodes with topology details are used to construct the graph, at the scheduling phase a shortest and efficient path will be identified for the transmission of data at the transmission phase.

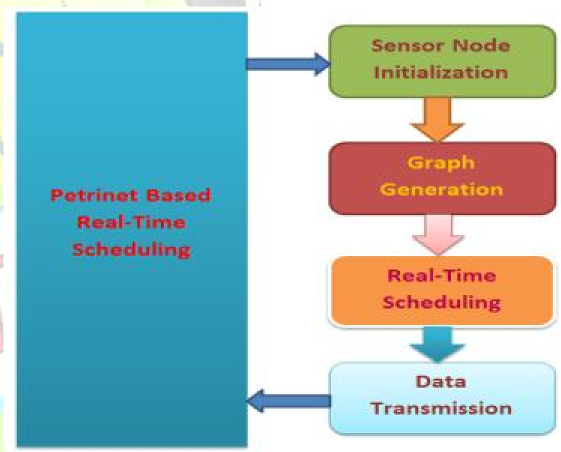

Figure. 2 Proposed System Architecture.

Sensor Node Setup Process:

At the initialization process each sensor is started with the components attached and the radio which is the most required component is started to receive the signals. Each sensor is attached with the battery which is the sole energy supplier for the sensor node and initialized with the duty cycle timer DCT and wait for the signal from the sink node. The sink node is the most powered sensor and co-ordinates the

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other sensor nodes in the network to provide service. The sink node schedules the transmission at each cycle and controls the mode of other sensor nodes whether they have to participate in the duty cycle or simply go in sleep mode. Once if the sensor node goes to the sleep mode it will wake up at the next duty cycle for the verification of the mode assigned in that cycle.

Algorithm:

Step1: start
Step2: initialize sensor node with Energy SE, Timer DCT.
Step3: Receive control message MC-mode control
Mc= {Sensor id, DC Number, Mode, TT}.
Step4: update timer DCT with TT
$DCT_{(T)}$=TT.
If (Mc.Mode==sense)
Wait for the transmission or forwarding.
Else
Go to sleep mode
end
Step5: wait for the timer to get closed.
Step6: wake up and go to step 3. Step
Step7: stop.

Graph Generation:

With the network topology set of sensor nodes are identified and for each sensor node identified we generate a vertex with the name of sensor node id. The sink is identified and a vertex is created as the root of the graph and the undirected graph is constructed. Each node in the graph is assigned with two values as sensor id and energy level in number of units. Generated graph is used for the scheduling the transmission duty cycle for the sensor nodes which participate in the transmission of data packets.

Algorithm:

Step1: start
Step2:initialize graph with the root G.
Step3: read network topology.
Step4: identify root node r.
Create a vertex v ={sink id, energy E}.
Assign v as the root of graph G.
Step5: for each node from graph g
Create a vertex v and assign sensor id as the id for vertex v.
V={sensor id, energy}.
Create initial connections as edges with other vertices.
End.
Step6: stop.

Petrinet Based Real-time Scheduling:

The scheduling of duty cycles for the sensor nodes are performed using the graph constructed in the previous stage of the proposed method. The graph consists of various sensor nodes and one sink node according to our configuration and each sensor node has fixed energy and assigned to a node in the graph G. The scheduling of the duty cycle is done whenever the timer DCT gets expired. Each sensor node and its corresponding vertex in the graph gets updated at each duty cycle and used for the scheduling at the next cycle. At each scheduling cycle the scheduler computes the available path by avoiding the first order nodes and the sensors participated in the previous cycle. The rest of nodes are selected for the computation of the path to reach the sensor node to complete the transmission. The same procedure will be repeated at each scheduling and the node status and energy level is updated at the

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vertex which represent the sensor nodes to support next scheduling cycle.

Algorithm:

Step1: start
Step2: read graph generated G.
Step3: initialize participating list Pl.
Step4: if pl.count <0
Compute the path to reach with least hop count.
$Tp= Ô(Ø(Tp×(G_{(n)}))$.
Add sensor id to the participating list pl.
Pl=pl+ΣTp.
Transmit control message Mc.
Transmit data Td.
Else
Nl = Identify list of nodes which are not participated in previous transmission.
Nl = $(Pl)×G.
Compute transmission path with less energy constraint and minimum hop.
Tp = Σ(Tp)×Nl.
If Tp.length>0
Transmit control message Mc.
Add sensor ids to the Pl.
Else
until (new route is true)
If all nodes has finished duty cycle
Pop the most earlier node and compute new path.
Compute transmission path with less energy constraint and minimum hop.
Tp = Σ(Tp)×Nl.

End
Do
Transmit control message Mc.
Add sensor ids to the Pl.

End
Step5: stop.

Data Transmission:

At the transmission stage the sensor nodes participating in the duty cycle will be sensing and forwarding to support the communication in wireless sensor networks. The sensor nodes will be sensing up to the data received with little delay and if the delay increases it goes to the sleep mode to wait for the next timer trigger. It will be wake only at the time when its timer triggers to receive the next control message.

Experimental Results:

We use simulations to evaluate the performance of PBRS and the proposed algorithms are implemented in a network simulator. The simulator implemented the Petri Net Graph construction algorithms that are used in this paper. We present the results of the network lifetime and the energy balance. The networks are modeled as unit disk graphs and sensor modes are randomly placed in a square area. The sink is placed at the center of the area. All sensor nodes have the same transmission range. The number of sensor nodes is varied to model different network densities and scales.

We assume that all the sensor nodes consume 1 unit of energy per round. we present the results of the network lifetime achieved by our proposed algorithms. Two configurations are used: identical initial energy and imbalanced initial energy. Sensor nodes are deployed in a 500 × 500 area. The transmission range is fixed to 250 so that all of the networks generated are fully connected. The number of nodes in the

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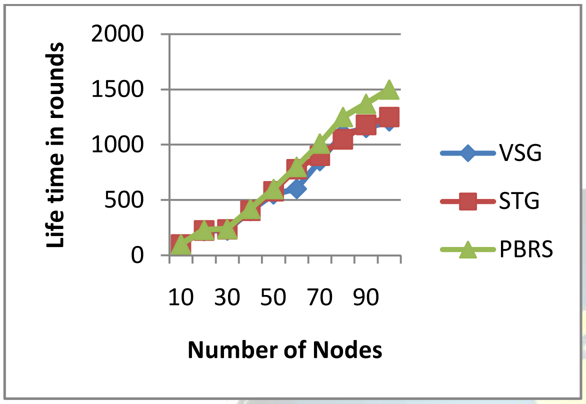
network ranges from 10 to 100 with a step of 10. Since the area of the network is fixed, these settings vary the density of the sensor nodes.



Graph1: shows the lifetime achieved by different algorithms.

The graph 1 shows the lifetime achieved by different algorithms and it shows clearly that the proposed petri net based real time scheduling maximize the overall network lifetime than the other algorithms.

Conclusion:

In this paper, we present a petri net based real time scheduling and duty cycling method by taking advantage of the redundancy in WSNs. The PBRS has produced efficient results in scheduling the sensor nodes in sensing and forwarding to maximize the network utility and increase the throughput of the wireless sensor networks. We formulate the MLBS problem to find the optimal schedule and prove its NP-hardness. We also conduct extensive theoretical analyses and simulation studies to verify the performance of PBRS.

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