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Critical Monitoring Analysis Applying Sleep / Wakeup Scheduling Algorithms for Wireless Sensor Networks

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Abstract: Sleep/Wake up scheduling algorithm has been proposed for event-driven sensor networks for delay-sensitive applications where events occur rarely. The most efficient research efforts in Wireless Sensor Network are focused on energy problem since the nodes are usually battery-powered. To prolong the network lifetime, few sleep scheduling methods are always required in Wireless Sensor Networks, resulting in significant broadcasting delay, especially in large scale WSNs. In order to reduce the delay of alarm broadcasting from any sensor node in WSNs, many methods have been employed, and it is a research challenge in Wireless Sensor Networks because the Critical event monitoring has become essential through WSNs. In our research work, the performance of the different sleep/wakeup scheduling algorithms has been analyzed for minimizing the broadcast delay in WSNs and described their boon and bane of event management analysis and the issues addressed through them. Also, the Critical risk factors and the disputes of current various scheduling schemes that are employed have been briefed to maximize the utilization of Wireless sensor Networks.

Keywords: Wireless Sensor Networks, Sleep/wakeup scheduling, alarm broadcasting, critical event monitoring, broadcast delay.

I. INTRODUCTION

A wireless sensor network [1] consists of a large number of small, inexpensive sensor nodes which are distributed over a geographical area for monitoring physical phenomena like temperature, noise, light intensity and speed etc. Traditionally, the largest challenge of sensor network is the limited lifetime because of the battery-powered node [2]. Specially, applications like military operation, factory automation and so on, need a constraint time of a message transmission from source node to destination for guaranteeing validity of the message. For such kind of cases, the sensor network system can play a crucial role.

Wireless sensor network is a network of spatially distributed sensor nodes equipped with sensing, computing, power, and communication modules to monitor a certain phenomenon such as environmental data or object tracking [1,3]. The nodes in such networks are characterized by limited power, processing, and memory resources. As the sensor nodes are powered by batteries, it is difficult to replace or recharge these batteries because of cost (e.g., cost of batteries and labor) or geographic (e.g., difficult or unfriendly terrain) reasons. A sensor node consumes battery power in the following four operations: sensing data, receiving data, sending data, and processing data.

In this paper we have presented an introduction to Sleep/Wakeup Scheduling algorithms for Wireless Sensor Networks. It differs from traditional scheduling algorithms in many points, the parameters of them like time delay, energy, efficiency etc. All these characteristics make the traditional scheduling algorithms not suitable for WSN's.

This paper is organized as follows. A survey of the Sleep/Wakeup scheduling algorithms for Wireless Sensor Networks is presented in the Section 2. In Section 4, we discuss the challenges of the current Sleep/Wakeup Scheduling algorithms for sensor network and show the future work. In Section 5, we make a conclusion.

II. SLEEP/WAKEUP SCHEDULING ALGORITHMS FOR WIRELESS SENSOR NETWORKS

In this survey we collected recent Sleep/Wakeup scheduling algorithms proposed in the Literature. Several typical Sleep/Wakeup scheduling algorithms are included and discussed in this section.

We present the description of the collection of wireless sensor Networks sleep/wakeup scheduling algorithms and evaluate their advantages and disadvantages whenever possible.

Fig.1.Generic Periodic sleep and Listen Schedule for Network nodes.

Variety of sleep/wake scheduling algorithms has been proposed in this literature. Most of them use a period sleep/wake interval as shown in Figure 1, and provide effective energy conservation at the cost of delay and throughput.

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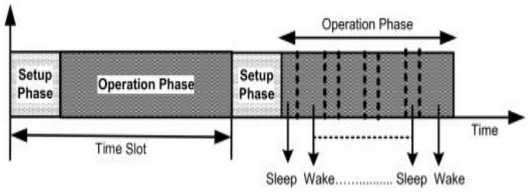

Figure 2. Life cycle of sensor network operations in SMED

Sleep scheduling algorithm is proposed for event-driven sensor networks for delay-sensitive applications where events occurs rarely. The protocol consists of two main phases: the setup phase and the operation phase, as shown in Figure 2. These phases are further divided into sub-phases, as shown in Figure 3. The flow chart and the interaction among different phases are detailed in Figure 4.

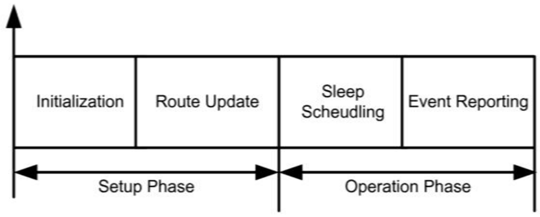

Figure 3. SMED operations.

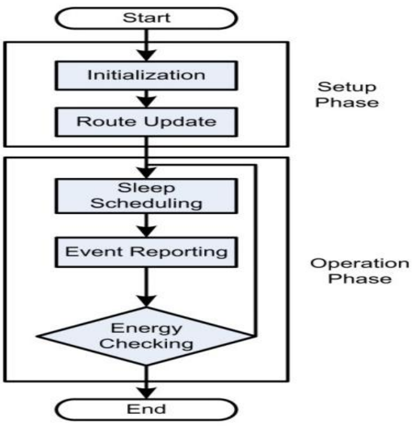

Figure 4. Flowchart of major phases and their interaction in SMED

2.1. Wakeup Scheduling in Wireless Sensor Networks.

2.1.1. Scheduled Wakeups

In this the nodes follow deterministic(or possibly random) wakeup patterns[4-14]. Time synchronization among the nodes in the network is generally assumed. Asynchronous methods are simpler to implement, they are not efficient as synchronous schemes, and in the worst case their guaranteed delay can be very long.

2.1.2 Wakeup On-demand

In this we assumed that the nodes can be signaled and awakened at any point of time and then a message is sent to the node. Here we present a class of wakeup methods called multi-parent schemes which assign multiple parents(forwarding nodes) with different wakeup schedules to each node in the network[21]. This method takes a cross-layer approach and exploits the existence of multiple paths between the nodes in the network to significantly improve the energy-efficiency of wakeup process and therefore increase the lifetime of the network while meeting the message delay constraints.

All the nodes in the network wakeup at the same time according to simple periodic pattern with a fixed period. The delay of a message that arrives at the base station and is forwarded to node in level 3. The distribution of delay in both forward and backward is the same.

2.2 Sleep/Wakeup Scheduling Scheme for Minimizing end-end delay(SMED) in Multi-hop Wireless Sensor Networks.

The Sleep/Wakeup scheduling patterns will be as shown below in Figure 1. This scheme is based on developing schedules based on traffic load requirements of nodes to reduce latency and enhance energy efficiency at the same time[22].

Delay Minimization:

This problem is discussed and use of variable sleep/Wakeup schedule for different nodes according to their traffic load requirement is advocated, in contrast to general sleep/wakeup approach.

SMED

This is introduced to reduce delay and to address the delay minimization problem. For minimizing the expected end-to-end delay is to identify different areas, where extra delay can be minimized. To achieve this, delay minimization at three levels is analyzed and addressed: The delay occurred because of traffic load at the nodes near the BS, The delay occurred due to traffic load at the connectivity critical node, and delay occurred while dealing with traffic burst when an event occurs.

This delay can be minimized by considering the fact that forwarding requirement of the nodes is different according to their distance from the sink node. Secondly, The delay can be minimized by allocating sleep/wake schedule to the nodes according to the traffic load determined by the node’s importance in connectivity. Giving a higher wake interval to heavily loaded nodes (connectivity critical nodes) to ensure their availability when they are needed and giving a lower wake interval to lightly loaded nodes (less connectivity critical nodes) to save their energy. Thirdly when an event occurs at any particular area in a WSN, generic sleep/wake cycles of the nodes remain the same regardless of the frequency of the event detection. It does not adapt itself based on frequency and location of events in terms of changing their sleep wake interval

2.3 Hops-based sleep Scheduling algorithm for Enhancing Lifetime Of Wireless Sensor Networks

In this the HSS divides the circular sensor network into several levels according to the average hop distance based on certain network parameters[24]. Hops-based sleep Scheduling(HSS) algorithm is used to alleviated the unevenly energy consumption rate problem. It will solve

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the following problems. Unbalanced energy consumption problem from randomly deployed sensor networks and also provides insights on the cluster formation and intra-cluster communication in heterogenous large-scale sensor networks. Where powerful sensors can be considered as the counterpart of the sink.

2.3.1 Hops-based Sleep Scheduling Scheme

The basic principle is to schedule a part of the sensors in the network to sleep in each round. the probability of putting a node to sleep is not purely random. It is related to the hop distance to the sink. This hop distance can be easily obtained by flooding during the initialization step [10], [11]. The energy expended by a sensor greatly depends on the level it is located. Since a sensor closer to sink loses more energy in relaying the received traffic from other farther-away sensors, then we wish to conserve the energy of these nodes by putting the farther-away sensors to sleep more often. In HSS the energy consumption rate of each level decreases more rapidly.

2.4. Sleep Scheduling for Critical Event Monitoring in Wireless Sensor Networks.

Sleep scheduling could cause transmission delay because sender nodes should wait until receiver nodes are active and ready to receive the message. The delay could be significant as the network scale increases. Therefore, a delay-efficient sleep scheduling method needs to be designed to ensure low broadcasting delay from any node in the WSN. Recently many sleep schedules for event monitoring have been designed, however most of them focus on minimizing the energy consumption.

It is still a challenge for us to apply the level-by-level offset to alarm broadcasting in the critical event monitoring. Two phases for the alarm broadcasting. First, when a node detects a critical event, it originates an alarm message and quickly transmits it to a center node along a predetermined path with a level-by-level offset way. Then the center node broadcasts the alarm message to the other nodes along another path also with a level-by-level offset way. When a critical event (e.g., gas leak or fire) occurs in the monitoring area and is detected by a sensor node, an alarm needs to be broadcast to the other nodes as soon as possible, which is shown in Fig. 5 as an example.

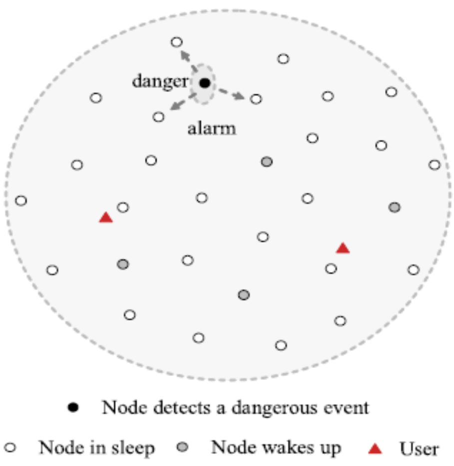

Figure 5. Critical event monitoring with WSN.

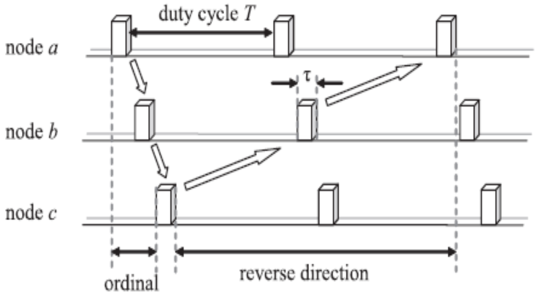

Figure 6. The level-by-level offset Schedule

As shown in Fig. 6, the packet can be delivered from node a to node c via node b with minimum delay. Hence, it is possible to achieve low transmission delay with the level-by-level offset schedule in multi-hop WSNs [10], [17], [18], [19].

2.4.1 Scheduling Method for critical event monitoring

The traffic path has been defined as follows. Fist from nodes to the center node as uplink and the traffic path from the center node to other nodes as downlink, respectively. To minimize the broadcast delay, established Breadth First search(BFS) tree for the uplink traffic and a Colored connected dominant set for the downlink traffic, respectively. To establish the second traffic path follows three steps as follows. First Constructs a Maximum independent Set(MIS).Secondly Select connector nodes to form a connected dominated set(CDS), and partition connector nodes and independent nodes in each layer into four disjoint sets with IMC algorithm proposed in [12]; thirdly color the CDS to be CCDS with no more than 12 channels.

Sleep/Wakeup schedule algorithm Summary

This is the summary of several sleep/wakeup scheduling algorithms which we presented in this section. To show the performance, Table 1 is created as a comparison of the sleep/wakeup scheduling algorithm and the power consumption, Broadcast delay and the Efficiency.

Table 1. Comparing performance of Sleep/Wakeup Schedule algorithm with Power, broadcast delay and Efficiency.

Sleep/Wakeup Schedule Algorithm	Power Consumption	Broadcast Delay	Efficiency
Sleep/Wakeup	Yes	Yes	Yes
HSS	Yes	Yes	Yes
SMED	Yes	Yes	Yes
Critical Event	Yes	Yes	Yes

III. OPEN ISSUES IN THIS RESEARCH FIELD

In the last section, we presented several Sleep/Wakeup Scheduling Algorithms proposed for Wireless sensor Networks. This section consists of open issues of current WSNs. The packets which are transmitted from source node should arrive at destination at stipulated time for

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guaranteeing the timeliness and validity of the alarm messages in the critical and dangerous environments. In order to avoid packets dropping or loss due to time constraint.

IV. CONCLUSION AND FUTURE SCOPE

Our work explains the analysis of the sleep/wakeup scheduling algorithms for Wireless Sensor Networks. The characteristics of the scheduling algorithms have been discussed and analyzed the Special schemes that involved in minimizing broadcast delay in Wireless Sensor Networks. And also discussed the advantages and disadvantages of the scheduling schemes. In addition, the open issues for current sensor networks are also briefed. In summary, most of the existing WSN scheduling schemes focus on decreasing broadcast delay. In future the key challenges which meets time delay can also be considered.

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