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RESEARCH ARTICLE

Lifetime Maximization in Sensor Networks for Rare-Event Detection using Optimal Sleep Scheduling

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Abstract— Recent advancements in technology have made low-cost, low power wireless sensors a reality. A network of such nodes can coordinate among themselves for distributed sensing and processing of certain phenomena. In this project a protocol to provide a stateless solution in sensor networks for lifetime maximization is proposed. The protocol proposes a unique way to maximize the life time. Lifetime maximization is one key element in the design of sensor- network-based surveillance applications. A protocol for node sleep scheduling that guarantees a bounded-delay sensing coverage while maximizing network lifetime is proposed. The detection of rare events, where the network is normally silent, except when an event occurs is focused. 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 delay and lifetime without sacrificing coverage for each point. The goal of this system to develop a localized distributed protocol for solving the aforementioned constrained optimization problem while ensuring upper bounds on the worst-case detection delay. The resulting sleep schedule achieves the lowest overall target surveillance delay given constraints on energy consumption.

Keywords: - Detection Delay; OSP, Rare Event Detection; WSN

I. Introduction

Sensor networks comprise a large number of low-cost miniaturized computers each acting autonomously and equipped with short-range wireless communication, limited processing and memory, and a physical sensing capability. Decisions in daily life are based on the accuracy and availability of information. Sensor networks can significantly improve the quality of the information as well as the ways of gathering it. For example sensor networks can help to get higher fidelity information, get information in real time, get hard-to-obtain information and reduce the cost of getting information. Therefore it is assumed that sensor networks will be applied in many different areas in the future. Application areas might be production surveillance, traffic management, environmental supervision, medical care or military applications.

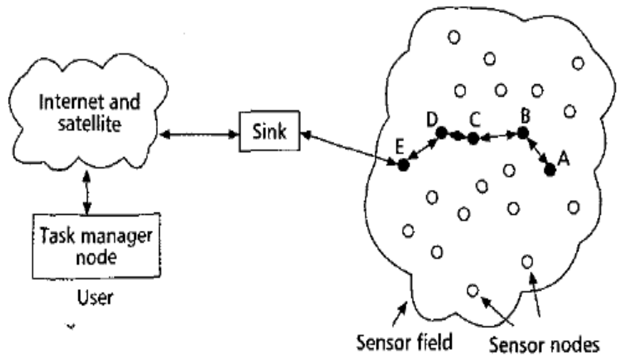


Fig 1Example Sensor Network

One of the important parts of a wireless sensor networks is the communication between the nodes. The character of the communication used in a wireless sensor networks has a huge impact on the usability of a sensor network. For example, the lifetime of a sensor networks in which single nodes are battery-powered is essentially influenced by the used communication patterns.

Therefore a lot of research in wireless sensor networks is currently focused on the communication aspect. To be able to optimize communication in wireless sensor networks it is important to consider all communication layers. The goal of this special session is to present and discuss current problems on the various communication layers.

The advances in science and technology are deeply intertwined. The telescope enables a deeper understanding of astronomy, the microscope brings bacteria into view, and satellites survey the Earth's surface, expanding what I can perceive and measure.

Now, I can use computers to visualize, through numerical simulation. This trend has advanced with the prolonged exponential growth in the underlying semiconductor technology. The number of transistors on a cost-effective chip and, therefore, the processing or storage capacity of that chip, double every year or two, following Moore's law. While it has provided ever more computing power, researchers are now applying this technology in ways that enable a new role for compute in science.

A given computing capacity becomes exponentially compute smaller and cheaper with each passing year. Researchers can use the semiconductor manufacturing technique that underlie this miniaturization to build radios and exceptionally small mechanical structures that sense fields and forces in the physical world. These inexpensive low-power communication devices can be deployed throughout a physical space, providing dense sensing close to physical phenomena, processing and communicating this information and coordinating actions with other nodes. Combining these capabilities with the system software technology that forms the internet makes it possible to instrument the world with increasing fidelity.

To realize this opportunity, information technology must address a new collection of challenges. The individual devices in a wireless sensor (WSN) are inherently resource constrained. They have limited processing speed, storage capacity, and communication bandwidth.

These devices have substantial processing capability in the aggregate, but not individually, so I must combine their many vantage points on the physical phenomena within the network itself. In most settings, the network must operate for long periods of time and the nodes are wireless, so the available energy resources-whether batteries, energy harvesting, or both- limit their all operation.

To minimize energy consumption, moist of the devices components, including the radio, will likely be turned off most of the time. Because they are so closely coupled to a changing physical world, the nodes forming the network will experience wide variations in connectivity and will be subject to potentially harsh environment conditions.

Their dense deployment generally means that there will be a high degree of interaction between nodes, both positive and negative. Each of these factors further complicates the networking protocols. Despite these operational factors, deploying and maintaining the nodes must remain inexpensive.

Because manually configuring large networks of small devices is impractical, the nodes must organize themselves and provide a means of programming and managing the network as an assembler, rather than administering individual devices. Overcoming these challenges will let computer technology fill a new role in the progress of science.

II. RELATED WORK

A sensor network provides surveillance of large areas with possibly unprecedented accuracy. Currently, energy supply is one of the fundamental bottlenecks. It is very expensive to replace sensor node batteries once they are deployed, both because of the large number of sensing nodes and because of the typically hazardous or unfriendly environment in which these nodes are deployed. Hence, prolonging battery life is a prime consideration in network design. The existing system advocates employing redundancy to allow some nodes to go to sleep without jeopardizing sensory coverage by using sleep scheduling. These approaches imply that a minimum number of nodes must remain awake for the right degree of coverage to remain satisfied. It is likely that sensor nodes that are awake at any given time do not form a connected graph unless their wakeup times are appropriately synchronized.

The main disadvantage in this system is when a node is in sleep mode and when it is necessary for the node to sense within that time, the data will be blocked till the particular node wakes and it will result in delivery latency and energy loss. So there will be a delay in detecting an event and it will affect the whole network performance.

A. Rare-Event Detection using Optimal Sleep Scheduling

The proposed system addresses sleep scheduling schemes for minimizing packet delivery latency to a common base-station. The proposed protocol is optimized for detection of rare (but urgent) events. In such applications, network longevity is especially important, since mission lifetime must be appropriately large. Nodes operate at very low duty cycles and do not communicate when an event is detected. Therefore, sensing power as the predominant energy drain over the system lifetime is considered. Once detection occurs, a prompt reaction may be needed.

A sleep scheduling protocol outperforms both random and synchronized scheduling in terms of average detection delay. The protocol is distributed, and has the favorable feature that it guarantees local optimality in that every node ends up with a wakeup point. The proposed protocol will optimize end-to-end delivery latency and is explored to reduce overall surveillance delay and to detect the rare event nodes easily. The protocol will also extend the life time of the sensor network by reducing the energy utilization and increases the information transmission ratio to avoid delay.

III. PROPOSED OPTIMAL SCHEDULING

The proposed protocol outperforms both random and synchronized scheduling in terms of average detection delay. The protocol is distributed, and has the favorable feature that it guarantees local optimality in that every node ends up with a wakeup point. The Optimal Scheduling protocol (OSP) will optimize end-to-end delivery latency and is explored to reduce overall surveillance delay and to detect the rare event nodes easily. The protocol will also extend the life time of the sensor network by reducing the energy utilization and increases the information transmission ratio to avoid delay.

A. Optimal Sleep Scheduling Techniques

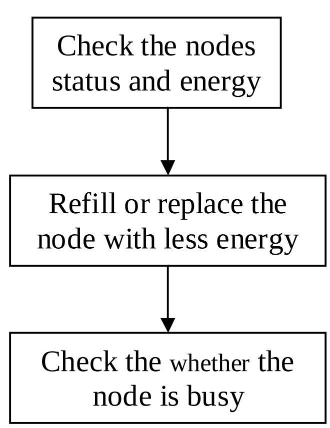


Fig 3.1 (a) Example Sensor Monitoring

In Fig 3.1 (a) each node should contain minimum energy to receive or forward information. For every transaction, we have to Refill the energy. Forwarding nodes should not be in busy state for smooth transaction.

The following fig. 3.2 (b) required information should be typed and source and destination node has to be decided and transmitted. Based on the energy level and status of the node information will be forwarded.

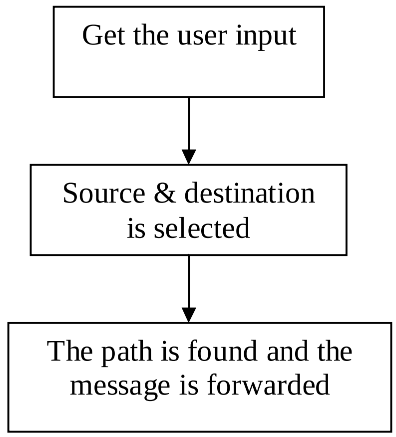


Fig. 3.2 (b) Example Data Dissemination

B. Rare Event Detection

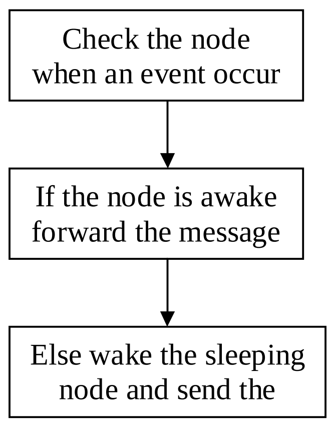


Fig 3.2 (c) Example Rare Event Detection

Rare Event Detection (Fig. 3.2. (c)) techniques is the important factor is event detection which leads to delivery latency. We set the wake up time of every node. Based on this time node decides to forward information.

C. Recalculation

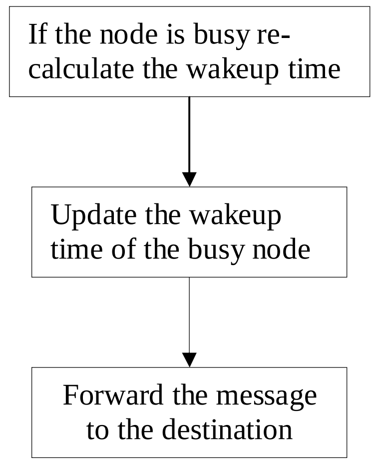


Fig. 3.3(d) Example Recalculation

Each and every iteration Recalculation [Fig. 3.3 (d)] is updating their wake time up regarding to the neighbor node which is control the delivery latency. We set the proper wake up time for all nodes which overcomes the energy consumption and the delivery latency.

IV. ANALYSIS AND SIMULATION

A. Node Creation

Node Creation is used to construct the nodes for communication purpose. Initially, give how many nodes need to plot on the screen. Node plotting starts from o to how many nodes we have given to plot. Based on our input we can draw the nodes on the screen at the specified location. X and Y position of every plotting which the location is already selected will be stored into the database. By using this X and Y position we will plot the node on the screen.

B. Sensor Node Monitoring

Each node should contain minimum energy to receive or forward information. For every transaction, we have to Refill the energy if the required energy less. Forwarding nodes should not be in busy state for smooth transaction. Before start the transmission, busy states should be removed and the energy for each node also the important factor. The energy should not less than or equal to 20. If it is less than 20, the transaction is not possible through intermediate nodes. After done these preliminary steps we can start the message transmission.

The power consumed by the sensor nodes can be reduced by developing design methodologies and architectures which help in energy aware design of sensor networks. The lifetime of a sensor network can be increased significantly if the operating system, the application layer and the network protocols are designed to be energy aware. Power management in radios is very important because radio communication consumes a lot of energy during operation of the system. Another aspect of sensor nodes is that a sensor node also acts a router and a majority of the packets which the sensor receives are meant to be forwarded.

Traffic can also be distributed in such a way as to maximize the life of the network. A path should not be used continuously to forward packets regardless of how much energy is saved because this depletes the energy of the nodes on this path and there is a breach in the connectivity of the network. It is better that the load of the traffic be distributed more uniformly throughout the network.

C. Data dissemination

The required information should be typed and source and destination node has to be decided and transmitted. Based on the energy level and status of the node information will be forwarded. If the busy status is selected at intermediate node, the sending node cannot be used for data transmission. So we have to remove the busy state. The energy reduces for every transaction so we have to refill if energy reduced below 20. Delay time also the important factor to transmit data.

Developers use this basic communication capacity to implement protocols that let the collection of nodes transport and process information and coordinate their activities. A basic capability in such networks involves disseminating information over many nodes. This can be achieved by a flooding protocol in which a root node broadcasts a packet with some identifying information. Receiving nodes retransmit the packet so that more distant nodes can receive it. However, a node can receive different versions of the same message from several neighboring nodes, so the network uses the identifying information to detect and suppress duplicates.

Flooding use various techniques to avoid contention and minimize redundant transmissions. The network uses dissemination to issue commands, convey alarms, and configure and task the network. But it also uses dissemination to establish routes. Each packet identifies the transmitter and its distance from the root. To form a distributed tree, nodes record the identity of a node closer to the root. The network can use this reverse communication tree for data collection by routing data back to the root or for data aggregation by processing data at each level of the tree. The root can be a gateway to a more powerful network or an aggregation point within the sensor network, as determined by some higher-level task.

D. Rare Event Detection

The important factor is event detection which leads to delivery latency. We set the wake up time of every node. Based on this time node decides to forward information.

The protocol is optimized for detection of rare (but urgent) events. In such applications, network longevity is especially important, since mission lifetime must be appropriately large. Nodes operate at very low duty cycles and do not communicate unless an event is detected. Therefore, we consider sensing power as the predominant energy drain over the system lifetime. Once detection occurs, a prompt reaction may be needed (e.g., activating a camera or reporting an emergency).

Consider, for example, the detection of forest fires. There are two natural concerns with this application: first, how long will the networks last once deployed? Second, how responsive will it be in reacting to rare events? The design translates these two questions into two related design parameters; namely, the energy consumption rate (i.e., the duty cycle which determines lifetime) and the surveillance delay. The protocol offers a design space in which the designers can trade-off these parameters in a near-optimal fashion.

Current literature advocates employing redundancy to allow some nodes to go to sleep without jeopardizing sensory coverage. These approaches imply that a minimum number of nodes must remain awake for the right degree of coverage to remain satisfied. A trade-off exists between energy savings and coverage. For example. The partial coverage schemes are investigated to increase energy saving gains. In these efforts, both random and synchronized sleep schedules are proposed and studied for certain scenarios. The former refers to the case where each node independently chooses random sleep and wakeup times.

The latter refers to the case where all nodes go to sleep and wake up together in a synchronized fashion In contrast; we develop a near-optimal deterministically rotating sensory coverage. In this scheme, the area is only partially covered at any point in time. However, any point is eventually sensed within a finite delay bound. The energy/coverage trade-off is thus more meaningfully expressed as one between energy savings and the average detection delay, defined as the average time elapsed between event occurrence at a point and its detection by a nearby sensor.

It is desired to minimize average detection delay subject to a constraint on energy consumption (expressed as a duty-cycle constraint). The goal of this paper is to develop a localized distributed protocol for (near-optimally) solving the aforementioned constrained optimization problem while ensuring upper bounds on the worst-case detection delay. The paper also addresses sleep scheduling schemes for minimizing packet delivery latency to a common base-station. Observe that at very low duty cycles, it is likely that sensor nodes that are awake at any given time do not form a connected graph unless their wakeup times are appropriately synchronized. Such synchronization, however, may deviate from the optimal sleep schedule from the perspective of minimizing average detection delay. We develop a heuristic that provides partial synchronization to reduce delivery latency without significantly impacting the average detection delay.

Sleep scheduling

We consider an area covered by sensing nodes. Let some event (e.g., a fire) occur at one point in the area. The maximal detection delay for an event occurring at this point is defined as the longest time that may elapse before the event is detected by a nearby node. The average detection delay for this point is defined as the average time elapsed until the event is detected. The maximal detection delay for the entire area is the largest value of all maximal detection delays at points in the area. Similarly, the average detection delay for the area, denoted γ, is the average value for all detection delays of all points. Trivially, when the area is sensing covered both the maximal detection delay and the average detection delay for the areas are 0, since all events are detected immediately.

Sensors in the area are duty-cycled. Most sensors have a finite .warm-up time Tw upon startup before reliable readings can be reported. Following the warm-up time, a sensor takes a sample of the environment, which itself takes time .This may be followed by other necessary processing which takes time Ts. Hence, from the instant a node is powered on, a minimum time interval Ton= Tw + Ts+Tp, must elapse before the node can go to sleep again. Given a duty cycle constraint β which defines the maximum percentage of time a node can be awake, the node must sleep for at least a duration Td, where Ton/(Ton+Td)=β. Hence, any event is detected in at most time units. It is desired to minimize the average event detection time. We are especially interested in very low duty-cycle operation where Ton<<Td.

Two-level sleep scheduling frameworks are proposed. The first level selects a minimal subset of all deployed nodes, called the primary subset, such that sensing coverage is maintained using the fewest primary nodes. We assume that there are enough nodes in the network for sensory coverage to be achieved. The remaining nodes are turned off. This process is repeated periodically at a fairly large period (e.g., of the order of tens of hours) to change the set of primary nodes so that their energy is not depleted. Algorithms for such rotation have been proposed in prior literature and are not considered in this paper. The second level focuses on the current primary nodes. It contributes further energy savings by duty-cycling these nodes at a higher frequency (e.g., seconds or minutes). That is to say, each node in the primary subset sleeps for Td then wakes up for Ton, where Ton/(Ton+Td)=β, the desired duty cycle . Our purpose, in this paper, is to coordinate the duty cycles of primary nodes such that the average detection delay in the area is minimized.

One interesting remark is that although the maximum energy savings by first level scheduling are bounded by the need to maintain sensory coverage, the second level savings can be made arbitrarily large by decreasing the duty cycle of primary nodes. In principle, there is no lower bound on energy consumption after the second level scheduling. The only consideration is that lowering the duty cycle increases average detection delay.

E. Recalculation

For every iteration, we have to update their wake time up regarding to the neighbor node which is control the delivery latency. We set the proper wake up time for all nodes which overcomes the energy consumption and the delivery latency.

Sleep schedule optimization:

The protocol is distributed, and has the favorable feature that it guarantees local optimality in that every node ends up with a wakeup point that cannot be further improved in terms of the average detection delay within its sensing range. We also present a protocol for optimizing end-to-end delivery latency. The combination of these two protocols is explored to reduce overall surveillance delay.

Our overall algorithm for minimizing detection delay is a three stage transition process, shown in Figure 4.1

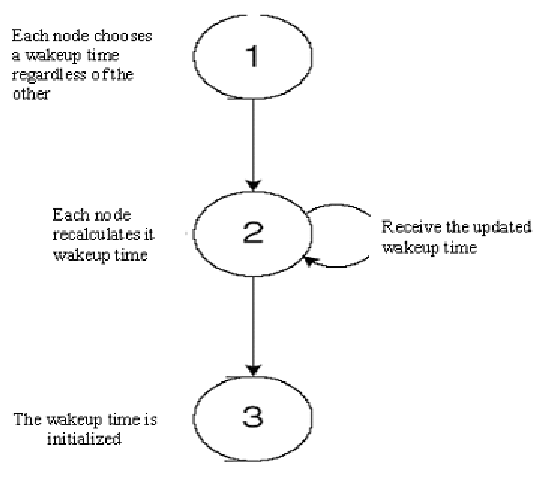


Fig. State Transmission of Optimization

The system assumes that neighboring nodes have approximately synchronized clocks. Protocols for clock synchronization in sensor networks can be found .Each node starts at Stage 1, where it randomly picks an initial wakeup time, ti[0] for itself on a common timeline in the cyclic interval [0,Td+Ton]. For the purposes of this analysis, the wakeup time denotes the instant at which the node's wakeup interval Ton starts.

The initial selection of the wakeup times of different nodes is completely uncoordinated. Each node communicates its randomly chosen wakeup time to its neighbors, sets up an iteration timer to fire at a period Tc, and enters Stage 2. Observe that in this stage all primary nodes are still awake (i.e., have not yet started their duty cycling). The period Tc is called the schedule iteration period, which is different from the period Ton+Td of the would-be duty cycles.

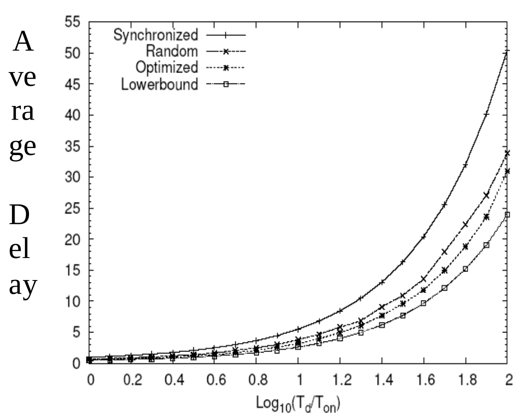
In Stage 2, each node undergoes multiple schedule iterations. Within a single iteration, a node makes at most one adjustment to its wakeup time to reduce the average detection delay. Ultimately, a local minimum is reached where no more reductions can be obtained. More specifically, when the iteration timer of node i fires, denoting the beginning of a new schedule iteration, k , the node considers adjusting its wakeup time from ti[k-1](the value chosen in the previous iteration) to a new value ti[k], This new value should minimize the average detection delay in the area within nodes i's sensing range, denoted γi[k], given the updated wakeup times received from i's neighbors in the last iteration. Note that by neighbors, we are only referring to those nodes that have overlapping sensing ranges with the current node, since for the current node, only the waking times of these sensing neighbors are relevant.

If the difference between the old and new detection delays (γi[k]-γi [k-1]) is larger than a preset threshold, the new wakeup time, is adopted and the node reports this new wakeup time to all its neighbors. Otherwise, the old wakeup time, ti [k-1], remains in place and no updates are sent. The node then waits for the next invocation of the iteration timer Tc to start a new iteration.

If the node does not receive any updates within iteration and has not changed its own wakeup time, it enters Stage 3 in which it starts duty-cycling, phased in accordance with its computed wakeup time. Once all nodes reach Stage 3, we consider the detection delay optimization complete. Note that, since clocks drift over time, the duty cycle period Td+Ton must be large enough to accommodate a fair amount of phase drift without the need for clock re-synchronization. This constraint is met naturally, since we are interested in very low duty cycles (Td>>Ton) in which Td must be reasonably large.

F. COMPARISON CHART

Delay Ratio



Average Delay

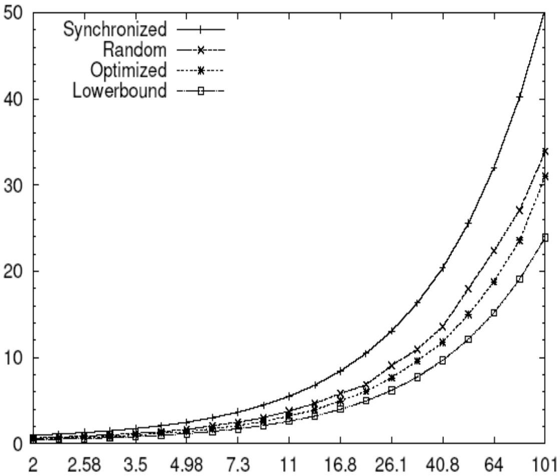
From the above figure we can say that packet delivery ratio is high for both the sleep scheduling techniques. The proposed protocol optimizes the delay when compared to the existing system.

Life Time Ratio

From the above figure we can say that the life time is high for both the sleep scheduling techniques. The proposed protocol maximizes the expected life time of the system when compared to the existing system.

Delay Vs Life Time

Expected Lifetime



Average Delay

Expected Lifetime

In the above figure we are comparing the life time and delay for both the sleep scheduling techniques. The proposed protocol maximizes the expected life time and minimizes delay when compared to the existing system.

V. CONCLUSION

The delay is considered to be composed of detection delay and delivery delay, and propose optimizations for both. The protocol is distributed, and has the favorable feature that it guarantees local optimality in that every node ends up with a wakeup point. The proposed protocol optimized end-to-end delivery latency and is explored to rare event nodes easily. The protocol will also extend the life time of the sensor network by reducing the energy utilization increases the information transmission ratio to avoid delay. The final outcome is a flexible framework in which application designers can trade-off energy versus latency of event detection.

This is in contrast to data collection networks that continuously stream periodic data to a collection center. The study reported in this work is a step towards more general models that optimize performance in the presence of communication as well. A general study of optimizing detection delay for moving targets is another worthy extension. This issue is to be considered as the future work.

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