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Power Management and connectivity efficiency for mobile sensor nodes by 3 tier Operating mode

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Abstract— These Wireless sensor nodes are a versatile, general-purpose technology capable of measuring, monitoring and controlling their environment. Even though sensor nodes are becoming ever smaller and more power efficient, there is one area that is not yet fully addressed; efficient switching of nodes. Standard solutions that are efficient enough for electronic devices with higher power consumption than sensor nodes, such as mobile phones or PDAs, may prove to be ill suited for the extreme low-power and size requirements often found on wireless sensor nodes. So to provide the low power wireless nodes efficient switching we introduce a 3tier switching mechanism. This also improves the connectivity between nodes.

Index Terms— Sensor node, Grid Deployment ,coverage, Asynchronous Power Management, mobile nodes, sleeping nodes, base station.

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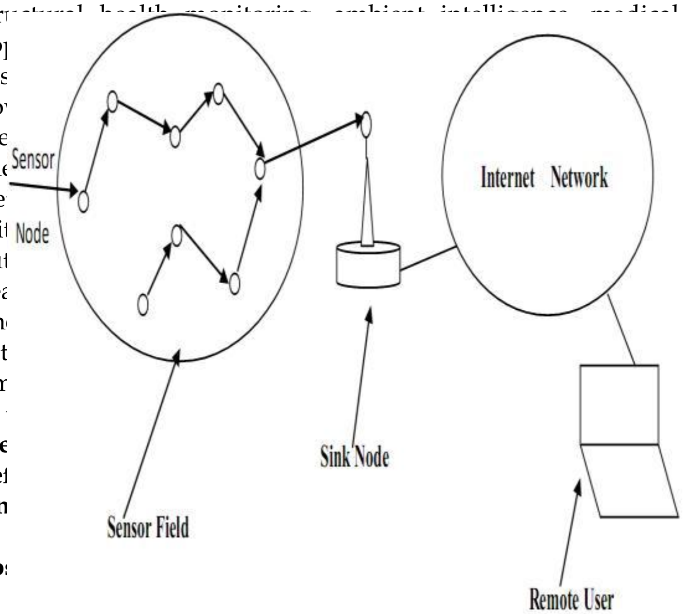
1 Introduction

A Wireless Sensor Network (WSN) consists of small devices with very limited capabilities, called wireless sensor nodes, that collect information from the environment by sensors, process the information, locally make decisions and wirelessly communicate with other nodes in the network. A scheme of a WSN connected to the Internet is presented in Figure 1. WSNs are implemented in a wide range of distributed, remote and wireless sensing applications in environmental monitoring, agriculture, production and delivery, military, structural health monitoring, ambient intelligence, medical



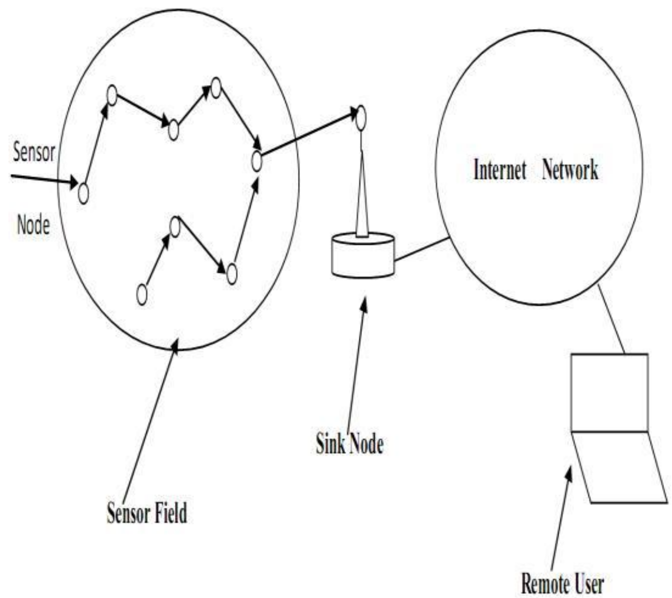


Figure 1 Wireless Sensor Network

2 Related Works

Wireless sensor network is an emerging technology of great interest to many academic units and research centers worldwide. A sensor network is composed of multiple sensor nodes that communicate with each other via a wireless network, and the data of each node are integrated. Motion- less design is a common design because long-term motion will consume a lot of energy. From a different perspective, a mobile sensor node is useful to deploy sensor nodes based on the requirement, which makes the system more flexible. Recently, some studies have been devoted to the design of mobile nodes [1], [2] and tried to achieve the best usage of their mobility.

Assigning nodes' location is an important topic on sensor networks, and lots of researchers investigate different efficient deployment methods for various purposes. In terms of communication quality, Corke et al. [3] present a sensor network deployment method that determines gaps in connectivity of the deployed network and generates a plan for repair, which completes the connectivity. In the field of target tracking, Chakrabarty et al. [4] propose the first systematic theory that leads to novel sensor deployment strategies for effective surveillance and target location.

A distributed energy-efficient deployment algorithm is proposed by Heo and Varshney [5]. The goal is the formation of an energy-efficient node topology for a longer system lifetime.In order to achieve this goal, they employ a syner- gistic combination of cluster structuring and a peer-to-peer deployment scheme. Moreover, an energy-efficient deployment algorithm based on Voronoi diagrams is also proposed here. Rahimi et al. [6] show another deployment method that extends the lifetime of a wireless sensor network. In their system, some nodes are autonomously mobile, allowing them to move in search of energy, recharge, and deliver energy to static energy- depleted nodes.

Coverage is the most considered factor in nodes' distribution, and there are three main deployment methods. The first method discusses the variety of regular deployment topologies, including circular and star deployments, as well as triangular, square, and grid deployments, and analyzes each topology's performance [7], [8]. The second method utilizes the virtual forces to determine the placement of all sensor nodes [9]–[12]. The third protocol is based on the principle of moving sensors from a heavily deployed region to a dispersedly deployed area. For example, Wang et al. [13] use Voronoi diagrams to discover the coverage vacancies and design three movement-assisted sensor deployment protocols, including VEC (vector based), VOR (Voronoi based), and minimax.In [14], the author proposes an event-based power manage- ment policy, where the node can update the probability of event generation. It is a useful method on a single node, but it has some shortcomings in a large sensor networking system.

3.SYSTEM ANALYSIS AND DESIGNING

The increasing interest in wireless sensor networks can be promptly understood simply by thinking about what they essentially are: a large number of small sensing self-powered nodes which gather information or detect special events and communicate in a wireless fashion, with the end goal of handing their processed data to a base station. Sensing, processing and communication are three key elements whose combination in one tiny device gives rise to a vast number of applications. Sensor networks provide endless opportunities,

but at the same time pose formidable chal lenges, such as the fact that energy is a scarce and usually non-renewable resource. However, recent advances in low power VLSI, embedded computing, communication hardware, and in general, the convergence of computing and communications, are making this emerging technology a reality

Mobile wireless sensor [1,2]networks are an area of rapid development. Areas like power management of sensor node, efficient deployment for connectivity etc still have an infinite possibility of research and development. Wireless LANs (WLANs) are becoming increasingly popular and are being widely deployed in academic institutions, corporate campuses, and residences. WLAN hotspots are now a common sight at airports, hotels, and shopping malls in many parts of the world. Despite this growth, the WLAN market is still young and immature.

Issues such as user behavior, security, business models, and the types of applications that WLAN can support remain unclear. This leads to a constantly evolving mix of applications and performance demands on WLANs. Measurement studies of WLANs are important for understanding the characteristics of a WLAN. Information about user session behavior, mobility pattern, network traffic, and the load on the access point can often help engineers identify bottlenecks and improve performance.

3.1 SENSOR NETWORK AND NODE ARCHITECTURE

With wireless sensors rapidly evolving in multiple engineering disciplines, there currently exist a large number of different academic and commercial wireless sensor platforms. The majority of the wireless sensors described herein are passive wireless sensors. Similar to traditional cabled sensors, these passive wireless sensors only measure structural responses due to static and dynamic loadings. A sensor network architecture is shown below(Figure 2).

This is in contrast to active sensors that can interact with or excite a structure when desired. As costs continue to decline and field deployments of wireless sensors are defined by ever higher nodal densities, local based damage detection is becoming increasingly attractive. Active sensors, such as piezoelectric pads, are proving to be a powerful sensing technology that is ideally suited for localized SHM (Park et al., 2000, 2003; Wu and Chang, 2001). To take full advantage of the benefits of active sensing, some wireless sensors are now being designed with actuation.

Interfaces to which active sensors can be attached. Wireless sensor prototypes that are capable of achieving active sensing are also described in detail in this review paper. Recognizing power consumption to be major limitations of wireless sensors operating on batteries, some researchers are exploring the development of power-free wireless sensors known as radio-frequency identification (RFID)[3,4] sensors. RFID sensors are a passive radio technology, which capture radio energy emanated from a remote reader so that it can communicate its measurement back. RFID sensors explicitly developed for structural monitoring are also included as part of the paper's scope. With wireless sensors offering impressive computational resources for processing data, hardware only represents onehalf of the complete wireless sensing unit design; software embedded in the wireless sensor represent the second half.

With computational power coupled with the sensor, wireless sensors are capable of autonomous operation. Without a physical link existing between individual wireless sensors and the remainder of the wireless sensor network, wireless sensors must know when to act autonomously or collaboratively. Software embedded in the wireless sensor's computational core is responsible for its autonomous operation including the collection and storage of data, interrogation of measurement data, and deciding when and what to communicate to other wireless sensors in the wireless sensor network. Embedded software can be classified as one of two types: the operating system (OS) and engineering analysis software.

The OS takes control of the operation of the unit and is intended to serve as an abstraction layer that hides the implementation details of hardware from upper engineering analysis layers. The second layer is where algorithms designed to autonomously interrogate structural response data are stored. In this paper, the var-Lynch and Lohious software options for wireless sensors are described. An emphasis is placed on embedded engineering analyses, including damage detection algorithms, which have already been embedded in the computational cores of wireless sensors.

A true test of a new emerging sensing technology is its performance in the field. The research community has installed wireless structural monitoring systems upon a diverse set of structures to assess the performance of wireless sensors within the complex and challenging field environment. In the literature, a large number of validation tests have been performed on laboratory structures as well as upon bridges, buildings, aircraft, offshore oil platforms, naval ships, among many others. In this paper we provide a detailed description of the current state of experimentation with wireless sensors in the laboratory and the field

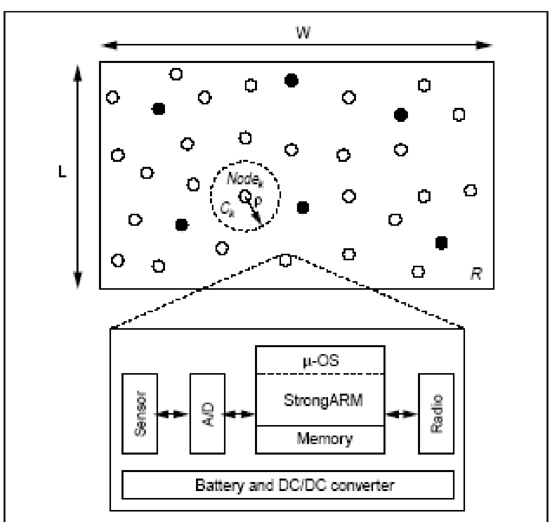


Figure 2 Node Architecture

4 PROPOSED SYSTEM

In the section, we discuss the novel approach to the base system we tried to adapt the features of the base system in to a brand new application. While doing this we add some enhancements to the base system which in the end of the day help in achieving the goal of our application. In this project we mainly concentrate on the power management and internodes communication. In networking communication, an asynchronous paging scheme that each node is free to switch on or off its components based on observed event statistics is proposed. We also make a tradeoff between communication and power consumption, which will influence the transmission rate slightly. Finally, we adjust the deepest sleeping interval by taking account of the battery status. By combing these methods, the power consumption of the sensor node can be reduced. Here we propose an innovative algorithm for efferent power management of the sensor nodes in the network. We modify the algorithm proposed in base system by considering more factors such as battery status, coverage of the whole sensor system, and communication situation.

Sensor nodes are deployed over a targeted area in a fashion that ensures connectivity. This is done by considering cost efficiency, obstacles, event probabilities etc. mobile nodes roam inside the network. Here we introduce our power management algorithm. Keeping whole sensors all time will be a power consuming task so we develop an independent switching algorithm.

The following section describes the coverage algorithm. The notations used here are

Fcover is the coverage
Fobstacle is the obstacles in the coverage area
Fdegree is the weightage value of nodes
K is the total number of nodes

1. Start

2. while (Main Node moving)

Get neighbor nodes of current node;

3. For each neighbor node do

get *Fcover & Fobstacle;*
end

4. If number of of neighbor node < = *K* then

5. For each neighbor node do

get *Fdegree*;
end
end

6. Calculate next location;

7. If next location is contained in obstacle or outside of target area then

next location sets current location;
end
end

8. Stop

4.1 GRID DEPLOYMENT METHOD

The map of the network area is divided into multiple grids. Each grid is a square with the same edge and its size its adaptive. The nodes are deployed in these grid regions. Each grid is having a weight age. Based on these weight age values the nodes are deployed for coverage. The smaller resolution of grids will reduce computational complexities. A grid will be marked when a static node is placed within its coverage. The values of the grids next to boundary and obstacles are weighted as 1 to avoid the boundary effect and obstacle effect.

A grid will be marked when a static node is placed within its range. Other grids calculate their weighting values and form the weighting field of this node at the same time. The length of the grid edge is defined as one unit, and we compute the difference of (x, y) and find the square between the marked grid and the evaluated one. The weighting value of the grid can be obtained by taking the inverse of the evaluated value.

The coverage of nodes is the most important factor to evaluate the deployment performance. It shows the extent that one can monitor in the environment. The better the coverage, the higher the probability, that the events can be detected in this area. Covering more regions with less sensor nodes means that this policy is more powerful. So the grids are deployed in a manner so as to avoid this problem. An over tight distribution will cause an "overlap" situation and make the system inefficient; looser deployment results in "coverage vacancy" namely, the area that cannot be monitored by any node) and influences the quality of surveillance. Here, the coverage is defined as the ratio of areas located in some node's sensing region to the whole monitored environment.

Boundary Effect : The coverage of the sensor node next to the boundary will be composed, and the mobile node might hit against the wall due to the inaccuracy of mobility. To avoid these situations, the values of grids next to the boundary are set to one.

Obstacle Effect : The grids covered by obstacles also need to be considered. This can prevent the mobile node from being deployed inside the obstacle. For the same reason above, the values of grids next to the obstacle are set as one

4.2 power management

An efficient power saving algorithm is proposed so as to overcome the problem of energy saving, coverage and over density. The sensor nodes are having three stages:

Shallow sleep deep sleep on state

The sleeping state of the sensor node is the condition that the node is fully or partially inactive. The condition is designed for the purpose of power saving. ON state is the condition that the sensor node is active and it will receive data from the device. That node is in fully working condition. If the whole nodes are in the ON state the unnecessary nodes also consume power and that will cause maximum power consumption of the network. We need to have some nodes that are active when the device is reaching at its range. So the nodes near the device must be active for the data transfer. But it is not practical. So we proposed such an algorithm for the purpose of avoiding this problem.

The shallow sleep state is the condition where nodes are in semi sleep. The semi sleeping nodes can receive some signals and based on this signal they can come to ON state or OFF state. In our system the nodes just far from the mobile device will go to the semi sleeping or shallow sleeping stage. If the node needs send data, or when the mobile node come into the range of semi sleeping node, the node will get into the ON state and the data transferring will happen. So this will reduce the power consumption of the network by a limit. The nodes far from the mobile node and the nodes which the mobile node visited sometimes before will go to the semi sleeping mode so as to reduce the power consumption.

DEEP sleep state is the condition that the node is in OFF state. That is the node is in inactive mode. During the deployment of nodes, the system will check whether a region is having more coverage area and some nodes are unnecessary, that is the coverage will not affect without that node. Such nodes will be sending to DEEP sleep state. Also some other nodes also send to OFF state and they will be awaken by some timers or by some other awaken processes. By combining these three conditions the power management of the system is maintained.

4.2.1 Awaken Methods : The nodes need to be awakening from its sleep state. The strategy is done by the following three methods.

- Event driven.
- Message driven.
- Timer driven.

Event Driven: This method is designed to awaken a node from its shallow sleep mode. When an event such as an abrupt change in temperature or a signal generated by a moving object occurs, the sensor produces an interrupt and awakens the CPU. The CPU processes the signals with data fusion algorithms or transmits them to the other nodes, and then, it goes to sleep again.

Data fusion techniques combine data from different sources together. The main objective of employing fusion is to produce a fused result that provides the most detailed and reliable information possible. Fusing multiple information sources together also produces a more efficient representation of the data. AUG Signals has been involved in research and development in the area of data fusion for over a decade. The company has developed techniques in all three categories of data fusion.

- Pixel / Data level fusion

- Feature level fusion
- Decision level fusion

Pixel level fusion is the combination of the raw data from multiple source images into a single image. Feature level fusion requires the extraction of different features from the source data – before features are merged together. Decision level fusion combines the results from multiple algorithms to yield a final fused decision. AUG Signals' fusion algorithms have been applied to various types of data including:

- Multi-sensor data
- Multi-temporal data
- Multi-resolution data
- Multi-parameter data

The two main application areas are Image Fusion and Algorithm Fusion. Image Fusion techniques use different fusion techniques to combine multiple images into a single fused image. Algorithm Fusion techniques fuse the decision results from multiple algorithms to yield a more accurate decision.

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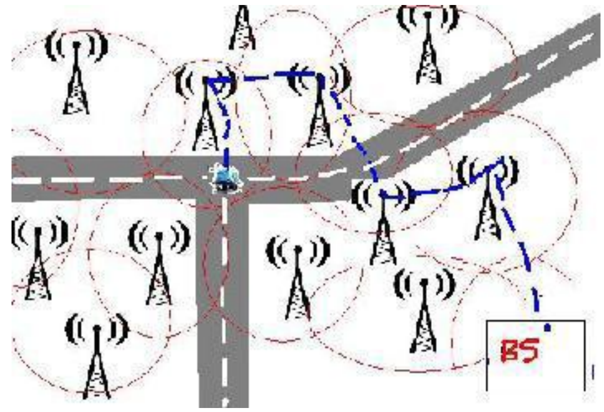
Message driven : If our device i needs to send data packet to a node j in sleep state, then it sends a message to the node to awaken it. After receiving the awakening message, node j will check if the sleeping time is longer than Tth(k). If it is true, the node wakes up instantly; otherwise, it will awaken the node until the sleep time t is more than Tth(k). Then, the active node j will send an acknowledgment to node i. If node i receives the acknowledgment in Tth(2), it will send the packets to node j; if not, it will send an awakening message to another node. Such method can avoid the huge energy consumption caused by failed packet transmission.

Timer driven:In this third policy we will set a timer to sleep the sensor node. After the time period the node will send to active mode. Then for a particular time period it is in active mode and after that, it will send to the sleeping state.

5. SIMULATION RESULT OF GRID DEPLOYMENT METHOD

The 50-m-by-50-m square monitored area is divided into 2500 small uniform square grids. Each grid has the same length of 1 m, each node is equipped with identical sensor, and the sensing radius is equal to 5 m. The weighting values of the grids within three units from the boundary are all set to one. If there are no pre-deployed static nodes. The result shows good uniformity, particularly after distributing a certain number of nodes. More nodes make uniformity better according to our algorithm. It helps a lot to increase the system efficiency, improve energy conservation, and decrease the probability of missing an event. The coverage of nodes is the most important factor to evaluate the deployment performance. It shows the extent that one can monitor in the environment. The better the coverage, the higher the probability that the events can be detected in this area. Covering more regions with less sensor nodes means that this policy is more powerful.

$$Coverage = \frac{\bigcup_{i=1,\ldots,N} A_i}{A}$$



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6. CONCLUSIONS

In this work, fundamental problem of deployment in mobile sensor network is discussed. Following deployment problem has considered: Given a target area and number of sensor node, how the given approach should self-deploy the sensor into a connected ad-ho network that has the maximum coverage. The issues of mobile sensor network deployment are investigated in detail. It further discusses the types of algorithm and different ways of deployment like deterministic, random and incremental deployment along with self deployment. Different approaches for mobile sensor network deployment are discussed in detail with their comparisons. The approaches are virtual force based, movement assisted, computational geometry and pattern based approach. Modeling of deployment problem with other real world problem is also discussed. For future study, more real world problem formulation for deployment could be addressed. Again the soft computing approaches and bio inspired algorithm could be studied in future work.

All previously deployed nodes do not need to change their status, and we just assign a mobile sensor node to the destination. The results show that grid deployment can achieve good coverage and uniformity performances. Asynchronous power management is efficient to reduce power depletion on a sensor network. We design an "nduplicate- covered" algorithm to guarantee the maximum sensing region. It is similar to the coverage-based off duty eligibility rule, but we can easily avoid the situation that there are more than two nodes making off-duty decisions simultaneously.Items will be set outside of the paragraphs.

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