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A Survey of Architectural Optimization Algorithms & Techniques in WSNs for Energy Conservation & Maximization of Life Time

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***Abstract*— A Wireless Sensor Network(WSN) consist of spatially dispersed ,dedicated sensing nodes for monitoring and recording various physical conditions of the environment, which later organize the collected data to a central location.WSN technology is gaining much important for its growing need for data collection & transmission in various day to day applications. A node is basically a sensor ,operated by battery, low cost device with limited computing, communication & storage capabilities which is deployed in hostile or inaccessible location in which node replacement or repair is impractical For deployment of network efficiently ,various key parameters are to be considered for evaluation in an application specific way. For the special structured network architecture deployment, efficient placement of nodes, QoS, life time maximization, delay tolerance are some important parameters to be taken care. This paper briefly gives an idea about different optimization algorithms used for the deployment of sensor nodes inconsideration with different factors and aspects, which provides a reliable WSN to conserve energy and life time of sensors.**

***Index Terms*—Wireless Sensor Network (WSN) , Quality Of Service (QoS), Sensor**

1. INTRODUCTION

A Wireless Sensor Network (WSN) is generally a distributed network and it comprises a large number of distributed, wirelessly interconnected devices (each being able to compute, control and communicate with each other) which are self-directed, tiny, low powered devices called sensor nodes. A wireless sensor can interact with their environment by controlling and sensing ‘‘physical’’ parameters. WSNs have fueled a enormous number of applications, such as disaster relief, target tracking in battlefields, environment control and biodiversity mapping, machine surveillance, intelligent building, precision agriculture, pervasive health applications, and so on. WSN structured naturally includes a large number of spatially dispersed, battery operated, petite, embedded devices that are networked with any of suitable networking to supportively collect, process, and convey collected information to the user ends, and it is also restricted with the computing and processing capabilities. In WSNs depending upon the application sensors may be deployed either randomly or deterministically. The below figures gives us an idea of how a Wireless sensor networks looks like.

In modern day’s scenario because of technical advancement and enhancement in processor, communication, and usage of low power embedded computing devices ,wireless network is the most popularly utilized in industrial and commercial application. Mainly the sensor nodes are the one which are used to monitor environmental general conditions like temperature, pressure, humidity, sound, vibration, position etc. In many real time applications the sensor nodes are performing different tasks like neighbour node discovery, smart sensing, data storage and processing, data aggregation, target tracking, control and monitoring, node localization, synchronization and efficient routing between nodes and base station. Most of the currently adopted technologies for WSNs are based on low cost processors, restricted memory space and resulting in limited energy budget.

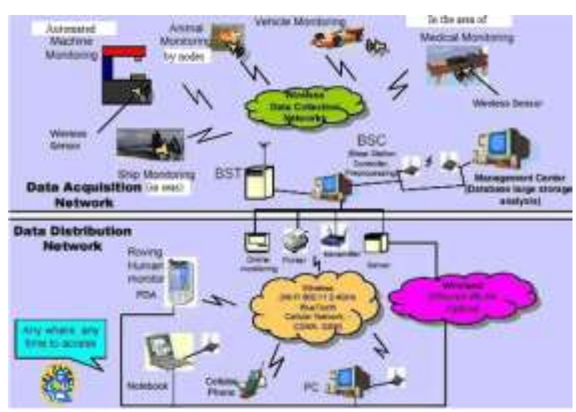

Figure: Wireless Sensor Networks [1]

An energy efficient Wireless Sensor Network (WSN) with maximum coverage can be achieved through a cost effective deployment mechanism. This can be done by utilizing an effective planning mechanism in arranging the limited number of sensor nodes.

In many applications, it is expected that the sensor node last for a long time because in most of the cases these networks are used in remote areas and recharging and/or replacing power supply units is considered difficult or prohibitive due to hazardous and inaccessible places where they are supposed to operate. Further, due to the availability of cheap hardware and various possibilities for the radio communication frequency, numerous topologies for WSN can be adopted.

The major characteristics of WSN is call for optimization. Other important parameters like network lifetime, network connectivity which depends upon the communication protocol are some another WSN design issue. The above mentioned issues call for simultaneous optimization of more than one nonlinear design criteria and is the one to optimize as energy resources in a WSN are limited due to operation on battery. Replacing or recharging of battery in the network may be infeasible. Though the overall function of the network may not be hampered due to failure one or few nodes of the network as neighboring nodes may take over, but for optimum performance the network density must be high enough.[1]

The below figures gives us an idea of various WSN applications.

Figure: Applications of Wireless Sensor Networks

2. TECHNIQUES FOR OPTIMIZATION

A: Adaptive design optimization of wireless sensor networks using genetic algorithms

Genetic Algorithm (GA) is one of the most powerful heuristics for solving optimization problems that is based on natural selection and an appropriate fitness function is developed to incorporate many aspects of network performance. The optimal sensor network designs constructed by the genetic algorithm system fulfill the existent connectivity constraints satisfy all application-specific requirements and incorporate energy-conservation characteristics. It is a multi-objective optimization methodology for self-organizing, adaptive wireless sensor networks design and energy management, taking into consideration application-specific requirements, communication constraints and energy-conservation characteristicsThe GA repeatedly modifies a population of individual solutions. At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generations, the population "evolves" towards an optimal solution. The fundamental aspect of using Genetic Algorithm for sensor networks is the identification of the nodes which will implement the aspects of the cooperation concerning the caching decisions.

The design characteristics are optimized by the genetic algorithm system which include network clustering with the choice of appropriate cluster heads ,the status of sensor nodes (whether they are active or inactive) and finally the choice between two signal ranges for the simple sensor nodes. Energy management is the main consideration that are required by the specific application , which should be optimized to guarantee maximum life span of the network without lack of the network characteristics.

GAs tries to imitate the natural evolution processes by assigning a fitness value to each candidate in the family and can find solution of the problem by applying the principle of survival of the fittest. Their basic components are the representation of candidate solutions to the problem in a ‘‘genetic’’ form (called as genotype), the creation of an initial, usually random population of solutions, the establishment of a fitness function that rates each solution in the population, the application of genetic operators of crossover and mutation to produce new individuals from existing ones and finally the tuning of the algorithm parameters like population size and probabilities of performing the pre-mentioned genetic operators. The successful application of GAs in a sensor network design in [10] led to the development of several other GA-based application-specific approaches. In most of these approaches, either very limited network characteristics are considered, or we can restrict the several requirements of the application cases into the performance measure of the algorithm.

B: Algorithms with Correlation Optimization

The sensing data of nodes is generally correlated in dense wireless sensor networks, and the active node selection problem aims at selecting a minimum number of nodes to provide required data services within error threshold so as to efficiently extend the network lifetime. First step is to propose a new Cover Sets Balance (CSB) algorithm to choose a set of active nodes with the partially ordered tuple (data coverage range, residual energy). Then, can be introduced to a new Correlated Node Set Computing (CNSC) algorithm to find the correlated node set for a given node. Finally a High Residual Energy First (HREF) node selection algorithm to further reduce the number of active nodes. Extensive experiments demonstrate that HREF significantly reduces the number of active nodes, and CSB and HREF effectively increase the lifetime of wireless sensor networks compared with related works.

C: Radio Sleep Mode Optimization in Wireless Sensor Networks

The radio is a major contributor to overall energy node consumption. MAC protocols which are Current energy efficient for sensor networks use a fixed low power radio mode for putting the radio to sleep [2] process . Energy-efficiency is one of the central challenge in sensor networks. Fixed low power modes involve with an inherent tradeoffs. The light sleep modes have quick and inexpensive switching to active mode with a higher current draw while the deep sleep modes have low current draw and high energy cost and latency for switching the radio to active mode. This technique proposes adaptive radio low power sleep modes based on current traffic conditions in the network.

Its procedures first step introduces a comprehensive node energy model, which includes energy components for radio switching, transmission, reception, listening, and sleeping, as well as the often disregarded micro-controller energy component for determining the optimal sleep mode and MAC protocol is used for given traffic scenarios. The model is later used for evaluating the energy-related performance of our recently proposed RFID Impulse protocol enhanced with adaptive low power modes, and comparing it against BMAC and IEEE 802.15.4, for both MicaZ and TelosB platforms under varying data rates.

In low traffic scenario the comparative analysis confirms that RFID Impulse with adaptive low power modes provides up to 20 times lower energy consumption than IEEE 802.15.4. On the basis of data rates for each node platform the evaluation also yields the optimal settings of low power modes. It provides guidelines and a simple algorithm for the selection of appropriate MAC protocol, low power mode, and node platform for a given set of traffic requirements of a sensor network application.

E: for large-scale wireless sensor network Simulation-based optimization of communication protocols

In this technique an optimization method is proposed that can be used to tune parameters of the middleware services and applications to provide optimal performance [5]. The optimization method is based on simulation, and is well capable of handling 'noisy' error surfaces. This proposed optimization algorithm is illustrated by a new spanning-tree formation algorithm, which can effectively operate even if links between nodes are asymmetrical. These sensor networks often use distributed operating system-like services (called middleware) over wireless communication protocols, which must be fault tolerant and adaptive because of the dynamic network topology and changing mission objectives. In the near future large-scale sensor networks will be the key elements of embedded systems used in space and aviation related challenges. Since the sensors have limited resources, and thus the used protocols are usually very simple compared to ones used in wired communication schemes The design of such middleware services is not straightforward.

F: Particle Swarm Optimization in Wireless Sensor Networks

Particle swarm optimization (PSO) is a simple, effective and computationally multidimensional efficient optimization algorithm based on artificial life and evolutionary computing. It even performs better and Its behavior is different from pure evolutionary computing methods such as genetic algorithms (GA) and Evolutionary Simulated Annealing (ESA) .In swarm intelligence (SI) [26, 28], the strategy changed from being based on competition as in GA and the focus became on a social model of optimization. The particle tries to imitate its neighbor If a particle's (individual's) neighbor has a better performance for a problem [25]. Basically, the individuals create a working social network where they collaborate together to get to a better result. Wireless sensor networks (WSNs) are networks of autonomous nodes used for monitoring an environment. . It has been applied to address WSN issues such as optimal deployment, node localization, clustering and data-aggregation. Bio-inspired optimization methods are computationally efficient alternatives to analytical methods.

Developers of WSNs are facing the challenges such that arise from communication link failures, memory and computational constraints, and limited energy [3]. Many issues in WSNs are formulated as multidimensional optimization problems, and approached through bio-inspired techniques. PSO falls under the topological planning area where a certain number of sinks is added to the network for the purpose of making the network more manageable and prolonging its lifetime by reducing the energy dissipated at each sensor node. This problem is referred to as: multiple sink placement problem. Unfortunately, finding the appropriate number of sinks and their best locations is an NP-Hard problem, so no exact solution can be found for large WSNs. A good approximation algorithm can still produce good results leading to (1) better load balancing, (2) fewer number of intermediate hops needed to reach the closest sink, (3) less delay incurred by a message from a sensor to the corresponding sink, and (4) reduced amount of utilized resources. All these advantages translate to increased network lifetime. PSO algorithm

PSO models social behaviour of a flock of birds. It consists of a swarm of *s* candidate solutions called particles, which explore an *n*-dimensional hyperspace in search of the global solution (*n* represents the number of optimal parameters to be determined). The cost (fitness) of a particle close to the global solution is lower (higher) than that of a particle that is farther. PSO thrives to minimize (maximize) the cost (fitness) function.

G: Network Lifetime Optimization in Wireless Sensor Networks

In the design of energy-constrained wireless sensor networks (WSNs) Network lifetime (NL) is a one of the critical metric [4]. In this technique, a joint optimisation design of the physical, MAC and routing layers to maximize NL of a multiple-sources and single-sink (MSSS) WSN with energy constraints is investigated. The problem of NL maximization (NLM) can be formulated in many ways and one of the efficient is as a mixed integer-convex optimization problem with adoption of time division multiple access (TDMA) technique. An iterative algorithm is proposed using the D&C approach to handle larger scale planar networks.Numerical results can be extended to the large planar case and its performance is close to globally optimal performance.

E:Territorial Predator Scent Marking Algorithm (TPSMA)

A sensor node placement scheme that utilizes a new biologically inspired optimization technique known as Territorial Predator Scent Marking Algorithm (TPSMA) ,it imitates the behavior of territorial predators in marking their territories with their odors.Positions of sensor nodes in a Wireless Sensor Network (WSN) must be able to provide maximum coverage with a longer lifetime.

With this scheme would be able to reduce the energy usage without jeopardizing the required coverage level. TPSMA imitates the behaviour of territorial predators in marking its territories with their odors and the sensor nodes placement scheme would mark the area that the sensor nodes would give the maximum coverage ratio. Sensor nodes will then can be placed according to the marked area. For designing the sensor node placement technique where the territory of a sensor node can be scent marked based on the design objectives such as maximum coverage, minimum uniformity, minimum energy consumption and maximum connectivity ,Territorial predator scent marking behaviour can be adopted. This is done based on the scent marking behaviour where normally predator will scent mark the area due to certain factors such as food resources. Based on their marked territories that imitates the scent matching behaviour ,Sensor node will identify its monitored location.

G: Coverage and Lifetime Optimization of Wireless Sensor Networks with Gaussian Distribution

A desirable sensing coverage of wireless sensor network (WSN) has to maintain and periodically report sensed data to the administrative center (i.e., base station), and the reporting period may range from months to years. Due to constraint of associated battery power, Coverage and lifetime are two paramount problems in a WSN. In this technique, an analytical framework for the coverage and lifetime of a WSN that follows a 2D Gaussian distribution can be used.

H: Dynamic Deployment Optimization in Wireless Sensor Networks

This technique proposes a self-organizing technique for enhancing the coverage of WSNs which consists of mobile and stationary nodes [7]. The mobile nodes will relocate themselves to find the best deployment under various kinds of situations for covering largest area. For solving multi-dimension function optimization in continuous space the new locations of mobile nodes are determined by parallel particle swarm optimization (PPSO) . Especially, the mobile nodes deployment with PPSO is useful in situations while some area need cooperative measuring with multiple nodes, and can be adjusted dynamically according to the requirement of environment. The experimental results verify that mobile nodes deployment with PPSO has good performance in quickness, coverage and connectivity. The proposed PPSO based dynamic deployment optimization algorithm is useful in deployment of cooperative measurement with the effective coverage performance taken as criterion while precision and speed of optimization is satisfied.

CONCLUSION

In the field of Wireless Sensor Networks ,various optimization techniques are available. This paper briefly surveys various techniques . By the proper analysis of each, looking at the merits and demerits of individual techniques can help the researchers get more insight into optimization of Wireless sensor networks ,the ways of optimizing performance and overcoming the hurdles during. Each technique has its own way of improving the lifetime of sensors and there by optimizing the functioning of Wireless sensor networks.

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