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A Survey on applications of Genetic Algorithm in Wireless Sensor Networks

Sandeep Kaur[1], Er. Vikas Goyal[2], Er. Pawan Luthra[3]
CSE Department, Shaheed Bhagat Singh State Technical Campus
Ferozepur, Punjab, India

Abstract: ***Wireless sensor networks (WSN) are becoming extremely attractive for both tele-communication and network industry. It is the promising technology to solve a large number of problems with its wide range of present and future applications possibilities. In this paper, we propose an efficient method based on Genetic Algorithms (GAs) to solve a sensor network optimization problem. Long communication distances between sensors and a sink (or destination) in a sensor network can greatly drain the energy of sensors and reduce the lifetime of a network. GA can be used to minimize the total communication distance, thus prolonging the network lifetime.***

Keywords: Wireless Sensor Networks (WSN), Micro Electronics Mechanic System (MEMS), Genetic Algorithm (GA), applications, Energy Efficiency.

I. INTRODUCTION

Wireless Sensor Networks have gained much more attention in recent years with the introduction of Micro Electro Mechanic System (MEMS) technology. It gives rise to the development of smart sensor nodes. These sensor nodes are small in size with limited computing resources and inexpensive as compared to the traditional sensors. These sensor nodes sense, measure, and collect the information from the environment and send it to the user. A Smart sensor node can equipped of one or more sensors that sense the data, a processor capable of doing small computation, memory, a low power unit, a radio, and an actuator. The sensor node deployment is shown in fig. 1.

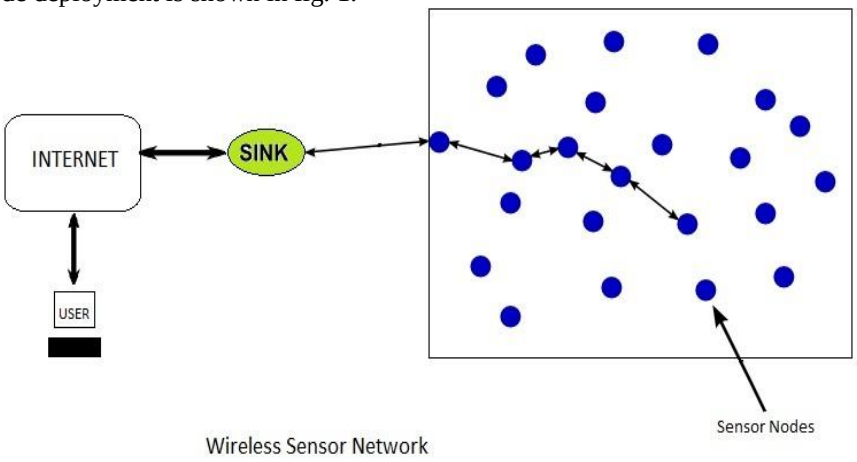

Fig. 1

Since the sensor nodes have limited memory and are typically deployed in difficult-to-access locations, a radio is implemented for wireless communication to transfer the data to a base station. Battery is the main power source in a sensor node. Secondary power supply that harvests power from the environment such as solar panels may be added to the node depending on the appropriateness of the environment where the sensor will be deployed. Depending on the application and the type of sensors used, actuators may be built-in in the sensors. This paper is organized with different applications and to find nearly optimal solution for nonlinear function with the help of Genetic Algorithm in Wireless Sensor Network (WSN). There are a number of applications for such devices and networks such as; military, health monitoring, indoor and outdoor fire fighting applications, security applications, and environmental, agricultural, climate changes and studying animal behavior.

II. RELATED WORK

When the principles, characteristics and requirements of application-specific WSNs factors are considered, then the problem of optimal design and management of WSNs becomes much more complex. A WSN designer who takes into account all these design issues has to deal with multi-objective nonlinear functions that should be optimized simultaneously(this problem is discussed in [14]). Thus, the focus of the problem is how to find many near-optimal solutions in a short, computational time. From the possible set of approaches to tackling such problems, Genetic Algorithms (GAs) [15] is one of the most powerful heuristics, which is also appropriate to apply in our multi-objective optimization problem.

GAs work on the basis of natural evolution by assigning a fitness value to each candidate solution of the problem and by on the principle of survival of the fittest[16]. The genetic algorithm starts with the initial population of chromosomes from the search space. The population "evolves" towards the better chromosomes by applying genetic operators modeling the genetic processes occurring in the nature—selection, crossover and mutation. In Selection the pair of individual chromosomes from the population is chosen as parent chromosomes, which will take part in the reproduction process. The selection occurs with a given probability on the base of fitness functions. The fitness function plays a role of the environment to distinguish between good and bad solutions. Then recombination is carried out after selection process. It combines, with predefined probability, the features of two selected parent chromosomes resulting in formation of child chromosomes. Then the child chromosomes undergo the mutation process. Generally, the mutation refers to the creation of a new chromosome from one and only one individual with predefined probability. After all these operators are carried the offspring is inserted into the population, replacing the parent chromosomes in which they were derived from, producing a new generation. This cycle is performed until the required optimization criterion is met.

In [17], the IEEE 802.15.4 MAC protocol is discussed to address the need for low rate, low power, low cost wireless networking.

Genetic Algorithm (GA) [18] can be useful in enhancing the performance of clustering algorithm. The long distance between the sink node and sensor can greatly drain energy of sensors thus reduce the lifetime of network.

There are several applications known for wireless sensor networks (WSN), and such variety demands improvement of the currently available protocols and the specific parameters. Some notable parameters are lifetime of network and energy consumption for routing which play very important role in every application. Genetic algorithm [19] is one of the nonlinear optimization methods and efficient for large scale applications. The various surveys tries to use a comprehensive improvement in all operational stages of a WSN including node placement, network coverage, clustering, and data aggregation and achieve an ideal set of parameters of routing and application based WSN. Using genetic algorithm and based on the results of simulations in NS, a specific fitness function was achieved, optimized, and customized for all the operational stages of WSNs

III. APPLICATIONS

We categorize the applications into military, environment, health, home and other commercial areas. It is possible to expand this classification with more categories such as space exploration, chemical processing and disaster relief.

(A) Military:

The concept of Wireless Sensor Network plays a very important role in military applications. Wireless sensor networks can be used for a number of purposes by the military such as monitoring militant activity in remote areas and protection of forces. [1] These networks can enable detection of enemy movement, identification of enemy force and analysis of their movement and progress with the use of appropriate sensors. [2] With the formation of DARPA, sensor networks are applied very successfully in the military applications [3]. In battlefield context, the sensor nodes should provide the following services:

i) Monitoring friendly forces, equipments: The sensor nodes can monitor the movement of troops and tanks and provide the relative information to senior officers.

ii) Intrusion detection: The sensor nodes can detect the presence of the intruder and put alert alarm accordingly to the report as it is safe to replace the civilian by thousands of dispersed sensor nodes. Then, the prevention of intrusion will be the responsibility of the defense system as given in [4].

iii) Battlefield surveillance: The sensor node focuses on gathering the information from battlefield, border or other critical areas about any enemy activity in that area. For example in

Evaders Detection with the Help of WSN [5] researchers of the University of California at Berkeley proposed to deploy WSN to help pursuers detect and track evaders. The basic concept is based on a Pursuer-Evaders Game (PEG).There are two teams competing with one another, Pursuers and Evaders. The other part WSN is used to help pursuer team via locating evaders and help to catch them. The use of a deployed WSN greatly improved the overall performance of a PEG.

iv) Targeting: Sensors being embedded in weapons Wireless Sensor Networks can provide the exact information about the target like distance, angle, moving direction etc can be collected and sent to the shooter. So the collaboration of different number of sensors with the weapons is useful for better target assessment.

v) Battle damage assessment: Sensor nodes can be deployed to collect the information about the damage assessment of the battle affected area.

vi) Nuclear, Biological and chemical attack detection: Sensor networks can be used as Nuclear, Biological and Chemical warning system. On detecting the presence of any nuclear, biological or chemical agent within the critical area, the embedded alert system will send a warning message to the central commander. So early detection of the presence of these hazardous objects provides military the time to check the situation and prevent the possible attacks.

(B) Environmental Applications

Another important category of Wireless Sensor Networks is Environment monitoring. [6] Automated Local Evaluation in Real-Time (ALERT [2]) is probably the first well-known wireless sensor network being deployed in real world. It was developed by the National Weather Service in the 1970's. ALERT provides important real-time rainfall and water level information to evaluate the possibility of potential flooding. ALERT sensor sites are usually equipped with meteorological/hydrological sensors, such as water level sensors, temperature sensors, and wind sensors, data are transmitted via light-of-sight radio communication from the sensor site to the base station, a Flood Forecast Model is adopted to process those data and issue automatic warning, web-based query is available.

i) Habitat monitoring: Environmental sensors tells how the vegetation reacts according to the changes in environment and imaging sensors can identify, track, and measure the population of birds and other species. One of the most representative examples is the deployment of a sensor network in Great Duck Island (GDI), Maine in [7]. The network deployed was used for habitat monitoring. Total numbers of thirty-two nodes were deployed on the island. The nodes use sensors that were able to sense temperature, pressure, and humidity. In addition, passive infrared sensors and photo resistors were used. The aim was to monitor the natural environment of a bird (storm petrel) and its behavior according to climatic changes. Therefore, some nodes were installed inside birds' burrows, to detect their presence, while the rest were deployed in the outside environment. Data collected by different sensor nodes is aggregated and are passed through to a gateway that transmits data to a local base station. The database is accessible through the internet and is replicated to another remote location for safety [8].

ii) Pollution monitoring: WSNs can be deployed for monitoring the level of pollution and generate warning at when a certain level is reached. Air Pollution Monitoring Systems are deployed in cities like London and Brisbane to monitor the level of pollutants. These sensor networks monitor the amount of toxic gases and these statistics helps to evaluate if pollution has increased and take actions to control pollution [9].

iii) Forest fire detection: The sensor nodes can be deployed in the Forests to detect the fire.

An integral network of nodes equipped with sensors to measure temperature, humidity and gases, wind speed and direction which will help the determination of fire risk level and its probable direction. The detection of the origin of the fire via the collaborative data from different nodes is crucial for a successful action of the firefighters; fire-brigades to control the fire before it become uncontrollable.

(C) Health Monitoring

Health science and health care system takes the advantage of wireless sensor networks. Consider a personal health monitor application running on PDA receives data from various sensors for example ECG, EEG, Blood Pressure etc. The monitored data is recorded in the database and report is generated for future referential.

In some modern hospital sensor networks are constructed to monitor patient physiological data, to control the drug administration track and monitor patients and doctors and inside a hospital. A significant concern is the care of the elderly, especially if they are affected by cognitive disorder, sensor nodes could monitor them and even support them in their daily routine. Sensors can be used to capture vital signs from patients in real-time and relay the data to handheld computers and sensor nodes can store patient data such as identification, history, and treatments.

With these ideas in mind, Harvard University and School of Medicine at Boston University cooperatively developing CodeBlue, an infrastructure supporting wireless medical sensors, PDA, PC, and some extra devices that may be used to monitor and treat patients in different medical scenarios [10].

(D) Industrial Monitoring:

Commercial industry has long been interested in sensing as a means of lowering the cost and improving machine performance and maintainability. The initial focus of sensor nodes in industrial applications are based on process monitoring then moving to process control, as Wireless sensors are used for environmental condition monitoring in industries like monitoring the level of water in overflow tanks Nuclear Power plant, pressure and temperature inside refrigerators. Machine Health Monitoring is another important application of sensor networks in the field of industry [3]. The monitoring is done by examining the inaccessible parts of the machine, any wear or vibrations and lubrication leakages through the insertion of sensors in the inaccessible parts and restricted area etc.

[5]Another example of industrial monitoring is Intel and Rockwell Automation has interest in deployment of sensor network in Semiconductor fabrication. The goal of this application was to detect the faulty parts of the equipments that needs to be repaired or replacement by sensed vibrations of sensors.

i) Inventory Control: is another big problem in big companies. As these companies are expanded all over the world therefore the management of the large pieces of equipment, machinery, and different types of products can be achieved

through the use of wireless sensor networks or asset tracking via RF ID tags. The sensor nodes can be attached to warehouse items. The sensors can tell the user about the exact location or the number of items of that category in the warehouse.

ii) Interactive museums: In the near future, places like museums will become interactive with the help of sensor networks. Interaction of the children will make them learn about the objects in the museums more quickly and efficiently. Moreover the objects will be able to respond to their queries and touch with the help of sensors [1].

(E) Agriculture Monitoring:

Agriculture research community is becoming increasingly interested in wireless sensor networks for agriculture monitoring. The sensor nodes measure the temperature, humidity, soil moisture and transfer the data back to the sink. Proposals have also been developed to deploy nodes in the environment, to enhance the efficiency and growth of cultivations, efficient water usage. An example of agricultural monitoring is proposed Intel's Wireless Vineyard [12]. The sensors deployed in the environment collects, process about the presence of parasites and take decisions about the usage of right kind of insecticides. Data collection relies on *data mules*, small devices carried by people (or dogs) that communicate with the nodes and collect data.[13]

Another example of crop monitoring is shown in the LOFAR _Agro project [14], a wireless sensor network was deployed in a potato field. The sensor nodes are used to collect the information regarding the relative environment like the temperature and humidity to be able to find parts of the field where the conditions were favorable for the potato disease phytophthora. Based on the acquired information, the use of pesticides can be decreased by spraying only in the areas where there are chances of spreading, rather than spreading around the whole field aimlessly.

(F) Automobile Applications of WSN:

Sensors being embedded in vehicles that are ultimately connected to WSN can be used for vehicle tracking mechanism and tracking for theft vehicle theft as well. The vehicle tracking application is used to locate a specific vehicle and monitor its movement. Modern vehicle tracking systems commonly use GPS Vehicle information can be viewed on electronic maps via the Internet.

i) Traffic Control

Sensor networks have been used for vehicle traffic monitoring and control for quite a while. Most traffic intersections have either overhead or buried sensors to detect vehicles load and control traffic lights accordingly.[3] Furthermore, video cameras are used to monitor heavy traffic road segments and the video sent to human operators at central locations. Low cost sensors with can be deployed at every road intersection to detect and count vehicle traffic and estimate its speed. These sensors will communicate with neighboring nodes to develop a "global traffic picture" that will help human operators or automatic controllers to generate control signals.

ii) Car park management

Finding an empty spot in an almost fully filled car park can be a frustrating experience. Sensors could be used to allow the smart signs to direct the visitor along the free parking space nearby. This technology also helps to locate the exact location of the vehicle in case it is staying more than car park management allows, or otherwise use the car park inappropriately.

(G) Public Safety

Threats to public safety are abundant - they include natural disasters, terrorist attacks and accidents in plants. Wireless Sensor Networks has also been used in public safety. Fire rescue is one of the most important public safety activities. When any department of the building gets fire, the sensors constructed within the building puts the alarm as the smoke reaches there. As the fire department gets the alarm call it will send the fire rescue team to the fire field.

IV. CONCLUSION

The above described features ensure a wide range of applications for sensor networks. Some of the application areas are health, military, and security. For example, sensor networks can also be used to detect foreign chemical agents in the air and the water. They can help to identify the type, concentration, and location of pollutants. In real meaning, sensor networks will provide the end user with intelligence and a better understanding of the environment. We can say that in near future, wireless sensor networks will be an integral part of our lives.

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