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An Approach for Node Reconfiguration in Wireless Sensor Networks using Genetic Algorithm

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***Abstract*— Reconfiguration of sensor nodes is a significant concern in networks where the dynamic functional transformation is recurrent. Automatic assignment of functions to sensor nodes is performed so that the nodes can cope up with the needs of the owed function. Traditional network configuration applications are occasional, so need not be optimized, and these applications may spend half their active time in reconfiguration every time when they wake up. It is extremely difficult for such a network to attain serenity since it is much costly and unfeasible. Also the achievement of reconfiguration actions cannot be dogged with assurance. This paper introduces a new approach to achieve successful network reconfiguration with the aid of genetic algorithm. The approach is exceedingly adaptive and can easily be adopted by practical WSN deployments since it reduces the resource usage significantly at a very low run-time overhead cost.**

***Keywords*— Reconfiguration, Wireless sensor networks, genetic algorithm, function assignment, deployment.**

I. Introduction

Wireless Sensor networks consist of spatially disseminated autonomous devices using sensors to considerately monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. Sensor networks gather data from places where it is difficult for humans to reach and once they are deployed, they work on their own and serve the data for which they are deployed. In wireless sensor networks, each sensor node transmits the sensing data by itself and plays the role of router to relay the data of other sensor nodes to a sink node. To accomplish these requirements, sensor nodes usually adopt the queue mechanism to treat the input data packets. Large and dense networks of these devices can be deployed inconspicuously in the physical environment in order to monitor a wide variety of real world phenomena with unprecedented quality and scale while only marginally disturbing the observed physical processes.

Most of the sensor-network applications require some form of self configuration, where sensor nodes take on specific functions in the network. Configuration of a sensor network is particularly challenging, as the anticipated large number of sensor nodes participating in a network typically precludes manual configuration of individual nodes. Additionally, pre-deployment configuration is often infeasible because some configuration parameters such as node location and network neighbourhood are typically unknown prior to deployment. Also, node parameters may change over time, necessitating dynamic re-configuration. When sensor nodes join the network, they are in an initial, homogeneous software state.

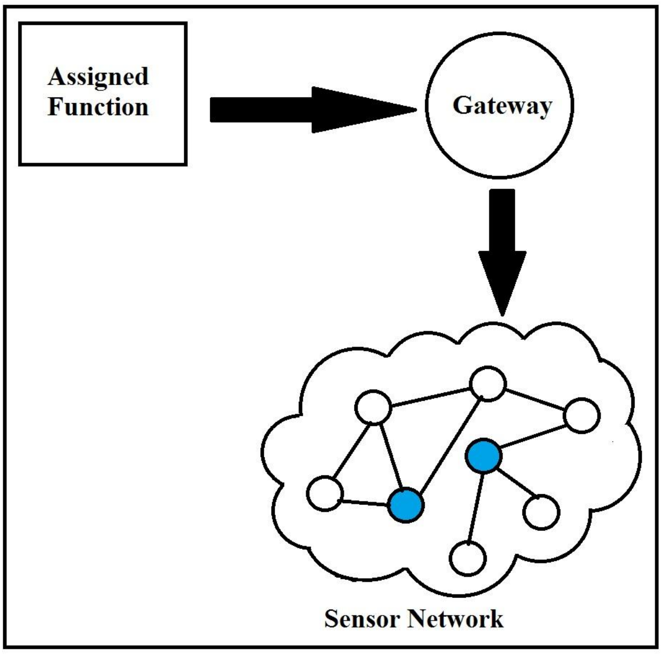

Fig 1: Function Assignment to network nodes

However, nodes may differ in their hardware capabilities and parameters such as their location or their network neighbourhood. The goal of configuration is to break the initial symmetry and assign specific functions to individual sensor nodes based on their properties. As the network and node properties change over time, function assignments must be updated to reflect these changes. Based on the assigned functions, sensor nodes may adapt their behaviour accordingly; establish cooperation with other nodes [1].

Establishing a large Wireless Sensor Network (WSN) with modern technology is significantly expense and the employment effort is very high. WSNs are thus viewed as long-term infrastructure and are increasingly expected to support multiple applications. In addition, applications are increasingly making use of resources disseminated across multiple WSNs. Reconfigurable component-based approaches clutch significant promise for this application as they allow for self-motivated deployment of new functionality along with the modification of existing functionality to meet changing application requirements and environmental conditions. A typical function assignment strategy is shown if fig 1.

The approach introduced in this paper has an architecture designed to provide support for the efficient execution of reconfiguration in WSN environments. The proposed model is inspired by the scientific workflows in the network and node reconfiguration is performed successfully using the genetic algorithm. The Scalability is ensured through decentralized and hierarchical execution of the iterative steps of genetic algorithm and reconfiguration and dynamicity is managed through adaptive execution of the workflow.

The rest of the paper is organized as follows. In the section II we review and investigate some of the recent works on reconfiguration of sensor networks. Section III gives the detailed explanation of proposed approach and finally in section IV we conclude the paper.

II. Related Work

Most of the existing approaches in the area of WSN are autonomous applications and respond to the effects caused by changes in dynamic behaviour instead. These reactive run-time reconfiguration approaches can be classified as either distributed [4] or centralized [6]. In a centralized approach a central location, such as the sink, collects in- formation from all nodes in the network in order to make decisions on how to reconfigure the network. Centralized approaches do not allow for adaptation of parameters in response to frequent changes, due to the over head involved in taking the decision and communicating it. Purely centralized approaches are therefore not suitable for most practical deployments. In a distributed approach, all nodes decide locally on how to adapt their configuration, based only on locally observed quality aspects.

Heidemann et al. demonstrated numerous schedules that are common in real-world networks with programmed MAC protocols [3]. This paper also shows how to wander all schedules in a network to a single common schedule, dipping the cost of multiple schedules. Schedule-based MAC protocols can potentially influence the low-power listening with flooding protocol proposed in the paper for exchanging schedule harmonization information during flooding. Still there is a chance that multiple schedules will happen after flooding. All these different schedules can be further converged with the global schedule algorithm [3] after reconfiguration.

Hongsheng et.al [5] pointed out the advantages of using genetic algorithm in the ground of node power management in two ways for energy preservation in wireless sensor networks. Keeping nodes at very low power states as long as possible and using the lowest possible emission power for the nodes. Nevertheless, both of ways have a bang on the whole wireless sensor networks. Genetic algorithm primarily uses three operators, selection, crossover and mutation. The operational strategy of genetic algorithm is shown in the Fig 2. Crossover is the main operator since it has global search potential. While mutation is an auxiliary operation which has local search capabilities. Genetic algorithm make itself having the balance of both global and local search capabilities through these cooperating and challenging operations between crossover and mutation. The coordinates is resources when a group fall into a hyper-plane of the search space in the evolution and cannot get rid of it by crossover alone, mutation operation can help to escape. The mutual competition is means that when crossover has formed into the desired product logs, mutation would break these product logs significantly.

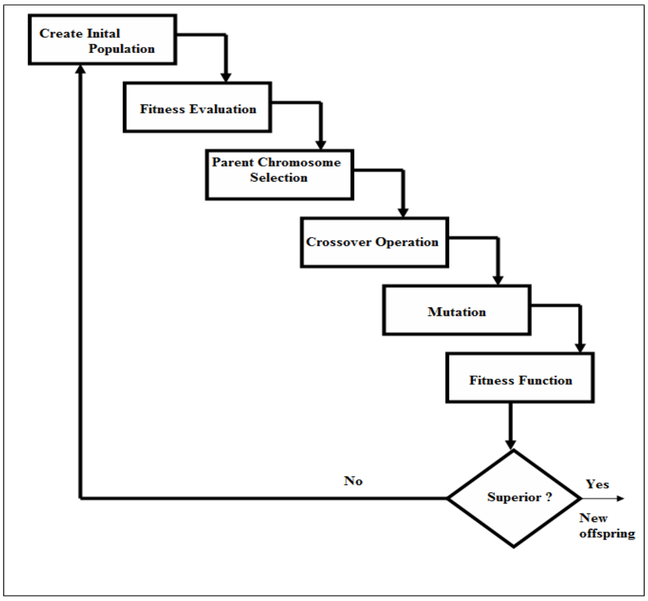

Fig 2: Operational strategy of Genetic Algorithm

Yuan Li et.al [2] developed a new protocol for efficient network reconfiguration after a long network sleep. The main challenges discussed are the things that change over time. The most significant of these is clock drift the fact that typical clocks will drift from true time and each other. As a result, not only must tightly synchronized operations such as scheduled MAC protocols, recover after sleep, but the network must be careful even to ensure all nodes are active. The paper focuses first on the need for all nodes to conclude when the entire network is awake, since it is common to all networks before traffic can be sent. The exact set of services that need to be reconfigured after sleep vary depending on the application and protocols in use, ranging from determining that all nodes are up, setting a MAC schedule, finding MAC-level neighbours, re-establishing forwarding paths, resetting time synchronization.

Christian Frank et.al [7] demonstrates and evaluates tangible instances of a configuration language, a dispersed role-assignment algorithm, and a role compiler. The paper present a simulation-based tool that implements all these functions, allowing for large-scale planning and evaluation of role-assignment errands in sensible network setups. The concept supports the idea that generic role assignment is virtually viable both in terms of effectiveness and sturdiness.

This paper proposes an approach through which the reconfiguration and function assignment can be done extensively which ensures the triumphant synchronization of the nodes with abridged utilization of node power. The aid of genetic algorithm enables the selection of efficient nodes to which the function assignment can be performed. This approach ensures the suitability towards the assorted reconfiguration events. Also the technique focuses on the impending benefits of processing to enacting reconfiguration in WSNs. The work can be extended to take in context-awareness strategies to optimize the reconfiguration events automatically.

III. PROPOSED APPROACH

In this section, the proposed reconfiguration approach is elucidated which can cope up with most of the challenges in dynamic function assignment to the network nodes. In the scenario discussed in this paper, it is assumed that large number sensor nodes are scattered over a large area which are able to sense some contextual data. Every node in the network is calibrated to perform a uniform set of functions. But in some situations, it is necessary to assign some specific tasks or functions to some nodes in the network even after setting up the entire network. There comes the relevance of reconfiguration of nodes in the network. The proposed approach is eminent for such a situation. The aid of genetic algorithm in the approach can make out the finest node to which the function can be assigned.

NPw	**NFt**	**NNs**	**NNId**	**NDFr**

Fig 3. Initial Population Chromosome

For solving very compound tribulations, genetic algorithm can be used. The algorithm can be used to various streams like learning machinery, various optimal solution problems in robotics etc. The operational steps of the algorithm are shown in Fig. 2. Initial step is to create the basic population of chromosomes to denote the solution of the problem. In the next step the algorithm evaluates the fitness of the original chromosomes and selects a parent chromosome to pertain genetic functions. Then in the next stage the algorithm goes through genetic operations named as crossover and mutation. Finally the fitness of newly created individuals is checked and points out the superior ones in the next generation. The algorithm is repeated if any superior individual does not exist.

A. Overview

Complex optimal solution problems can be handled by genetic algorithm with easiness. That is why so called algorithm is adopted for the most significant fraction of network reconfiguration. The function assignment has to be done to the most efficient node in the network so that the execution of the specified function can be ensured with least

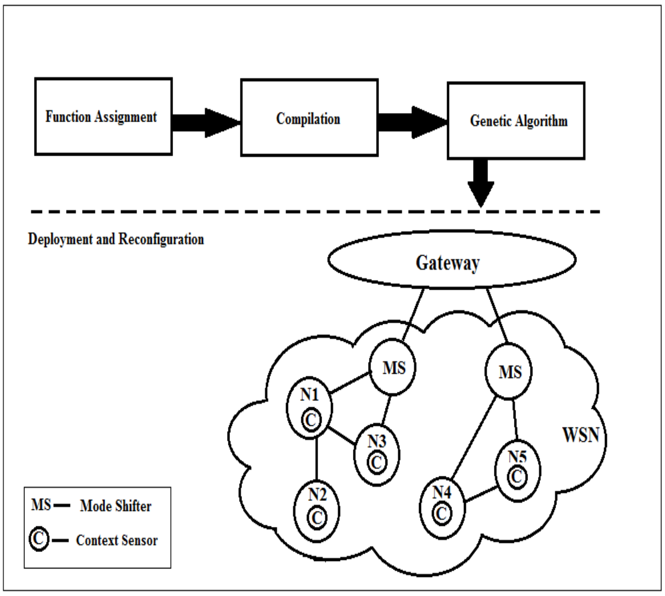

Fig 4. System Architecture

resource utilization. Also the changes that can happen to the network should be managed and configured accordingly. Initial population is created by including all the nodes in the network with its specific properties like battery power, fitness, neighbour node ID, data forwarding rate etc. A typical example of initial chromosomes is shown in the fig 3.

B. System Architecture

The node to which role assignment has to be done is selected with the aid of genetic algorithm. The operational steps for this procedure are given below.

- Initial population of chromosomes, i.e. the collection of network nodes which has the properties as shown in fig 3. are obtained.
- Calculates the fitness of nodes by checking the battery power, efficiency in data transfer etc.
- Select the most efficient nodes from each cluster of nodes to which the role assignment has to be done.
- Evaluate each selected node for its fitness and other properties, and ensure its consistency in data transfer rate and energy backup.
- Finalize the selection if it is promising and go on with the next procedures.

- Otherwise, repeat the selection process iteratively until the desired optimal solution is obtained.

The procedure in reconfiguration of network nodes is shown in the fig 4. The specified task or role is assigned to the node which is being selected from the network via genetic algorithm. The fitness testing stage in the algorithm ensures the capability of selected node for role execution and reconfiguration. The nodes selected for the so called function assignment is termed as Mode Shifters (MS). Mode Shifters which reside at the edges of each cluster of nodes receives the role assigned. These extraordinary nodes have the responsibility for enacting all the changes that happens to the sensor networks. The Mode Shifters works on the approach introduced in [8], scrutinizing the states of sensor network with the help of context-sensors which are software components that can provide the status information of each node in the network. These context sensors can be used to notify the adaptive behaviour of Mode Shifters. The most imperative properties of the Mode Shifters are explained below in detail.

1) Target Node Selection

The Mode Shifters, situated at the outer section of the network selects the target nodes to which the function assignment should be done. Multiple numbers of physical nodes should be enacted for this. In this case, contextual information about the nodes such as remaining battery power may be used to opt for the most apposite node.

2) Fault tolerance

Fault tolerance plays a significant role in reconfiguration of sensor network. Since the introduction of new functions to nodes change the entire configuration of network, selection and deployment of new function should reduce the failure rate and make certain the successful reconfiguration of network. This can be competently supervised by the Mode shifters and there by ensures the triumphant management of the network.

3) Disused action elimination

Some times the locations where nodes are positioned will be deployed with components where an equivalent component is previously deployed. The mode Shifters will scrutinize the existing network configuration and if disused functions are perceived, they will not be enacted.

4) Implementing Reconfiguration Strategies

A number of reconfiguration strategies are obtainable depending up on the nature and organization of sensor nodes in the network. Even though, the Mode Shifters in the network will confine the reconfigurations that other components may carry out in their wireless sensor network infrastructure. The selection and implementation of reconfiguration strategy is incredibly susceptible since it is highly reliant on the network node properties and their deployment. The context sensors that are attached to every node help the Mode Shifters to access the node properties like number of neighbour nodes, neighbour node data transfer rate etc. Hence the reconfiguration of network can be performed resourcefully.

IV. CONCLUSION

This paper contemplates on reconfiguration of dynamic wireless sensor environments. The paper introduced a new approach for function assignment and reconfiguration of network nodes with the aid of genetic algorithm. This approach ensures the suitability towards the assorted reconfiguration events. Also the technique focuses on the impending benefits of processing to enacting reconfiguration in WSNs. The work can be extended to take in context-awareness strategies to optimize the reconfiguration events automatically. Along with this, the techniques ensures that the burden of application developers for optimizing the reconfiguration events will be trimmed down eventually, since the nodes opted for role allocation posses all the potential behaviours needed for significant management of the network.

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