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Information Recuperation by Assigning Task in Wireless Sensor Network

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Abstract

Objective: The main objective of assigning tasks among sensor nodes in wireless sensor network environment is to recuperate the information loss due to network failures and to increase the network life time. **Methods**: The consummate way for downsizing energy consumption among nodes is to assign the task in an efficacious manner. The renovated version of Binary Particle Swarm Optimization (BPSO) is employed for assigning tasks in WSN. If any task assigned sensor node does not perform its operations, then those are considered as vulnerable nodes which can be pruned away from the network to avoid network failures. **Results:** In this paper, task assignment, information recuperation and topology permutation are proposed for improving the permanency of the sensor network. The task assignment problem for data recuperation was implemented in TCL language on NS2 running under windows environment. To gauge the adequacy and viability of this framework, results are compared with a technique that does not involve data recovery in its implementation. In the proposed system, the calculated execution time subtracts the execution time of the vulnerable sensor node. Subsequently, it minimizes the general execution time and improves the network performance and lifetime relies on upon fluctuating network size and tasks. Thus, the overall lifetime of the WSN and also fault tolerance level of the WSN is augmented. **Conclusion:** Task execution time, energy utilization and sensor network lifetime are considered in the fitness function to make a legitimate tradeoff among distinctive metrics and get the best overall executionin the fitness function to make a legitimate tradeoff among distinctive metrics and get the best overall execution.

Keywords: Failure Detection, Information Recuperation, Particle Swarm Optimization, Task Assignment, Wireless Sensor Network

1. Introduction

In order to examine physical or environmental happenings, a Wireless Sensor Network (WSN) is constructed with spatially scattered independent sensors. A WSN has canonical architecture as a parallel computing system, to reveal that it is necessary to assign each task to the proper group of nodes[1]. In a sensor network, nodes which are used for environmental sensing, are battery powered thus it have limited energy storage[2]. To prolong the network lifetime[3] among sensor nodes, tasks should be assigned with the consideration of energy conservation and balanced energy consumption.

A multi-objective constrained optimization problem includes task assignment problem[4] which results to be NP-hard. Therefore, to solve this problem in polynomial time, heuristic algorithms are formulated. In order to consider the success rate and solution quality, Particle Swarm Optimization (PSO) which outperforms other evolutionary based methods[5] is chosen. To achieve better performance, a different transfer function and a new position updating procedure with mutation operation[1,6] is proposed for the renovated version of PSO.

This paper aims to recuperate the data among vulnerable nodes with the help of tasks which is assigned to it to perform in an energy efficiency manner. By means of re-tasking WSNs, it is possible to permute topology of the network. Thus, the vulnerable sensor nodes in WSNs can be pruned and the sub-network performs the remaining operations.

The remaining section of this paper is sorted out as follows. Related work is surveyed in section 2. The system

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model is formulated in section 3. Problem formulation is examined in section 4. Simulations are performed in section 5. Conclusions are provided in section 6.

2. Related Work

In Wireless Sensor Networks (WSNs) there has been a far reaching research going ahead to augment the life time of the system. The greater part of the operations in WSN are event driven, which prompts to variations in, energy expended[2,7] by nodes. Therefore, it decreases the system lifetime, which is directly relative to energy utilization. In[3], the problem of Network Lifetime Maximization (NLM) can be defined as a mixed integer-convex optimization problem with selection of Time Division Multiple Access (TDMA) strategy.

An alternate technique based on a renovated version of BPSO is proposed in[1], tasks ought to be assigned to sensor nodes with respect to energy expended and balanced energy utilization to delay the network lifetime. In[5,6], the PSO technique was determined to perform better than different optimization algorithms regarding achievement rate and solution quality. In[13], to allocate resources efficiently, a technique called Position Balanced Parallel Particle Swarm Optimization (PB-PPSO) is proposed. Most past sensor network lifetime improvement methods concentrated on adjusting power dispersion, taking into account the presumption of uniform battery capability allocation among homogeneous nodes.

In[8], the data recuperation in case the nodes fail or if there is any network failures in the system is proposed. Failures are inexorable in wireless sensor networks because of unresponsive environment and unattended organization[9]. The data communication[10] and different network operations cause energy exhaustion in sensor nodes and subsequently, it is common for sensor nodes to fumes its energy totally and quit working. This may cause network and data loss. Accordingly, it is important that network failures are identified ahead of time[11,12] and proper measures are taken to maintain system operation.

3. System Model

In the proposed methodology, it is accepted that the expense of correspondence between tasks on the same sensor node is zero, and the task and nodes don't change until all tasks are executed.

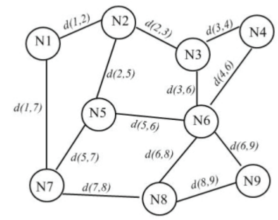

Figure 1. Sensor network architecture.

3.1 Sensor Network Architecture

The WSN is constructed with number of sensor nodes conveyed in the monitoring zone. The sensor nodes have diverse qualities, for example, processing speed, power utilization and transmission distance. The introductory energy and radio qualities are assumed to be indistinguishable. The WSN is graphically represented by a weighted undirected graph G = (N, L) as depicted in Figure 1. N = {N_i: i = 1, 2, . . . , n} is the set of vertices with respect to the sensor nodes. L is the set of edges with respect to the direct communication links between nodes. There is no direction for the links since all the nodes have the same greatest transmission range and the interchanges are bidirectional.

3.2 Task Model

The tasks and their relationship are indicated by a coordinated non-cyclic graph as delineated in Figure 2. The set of vertices M = {M_i : i = 1, 2, . . . , m} shows the tasks to be executed in the network. Every task is offered by its workload for processing and communication. The workload of every assignment is considered to be beyond the computational capacity of a solitary node. The direction of the links in the chart represents the priority and dependent relationship among distinctive tasks. The execution grouping of the assignments in Figure 2 is {M1, M2}, {M3, M4, M5} and {M6, M7}. {M1, M2} is tasked

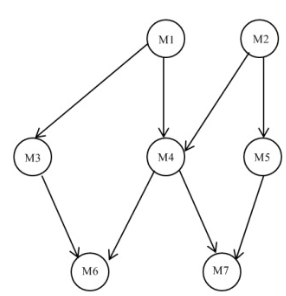

Figure 2. Coordinated non-cyclic graph for task model.

with the highest priority which must be executed firstly. {M3, M4, M5} are assignments with the auxiliary priority which must be executed after {M1, M2} have been finished. {M6, M7} are assignments with the least priority which must be executed after the various tasks have been done. Tasks with the same priority can be executed in an arbitrary request.

3.3 Binary Particle Swarm Optimization

Also, to attain better execution, most wise, optimal strategy ought to be explored for the task assignment problem of WSN. BPSO is the binary form of PSO and can possibly tackle numerous binary optimization issues of WSN. For example, BPSO was utilized for sensor selection scheme[6] of WSN and attained a better execution rate over GA. Thus, in this work, BPSO and its renovated version are utilized for task assignment issue of WSN and for the first time to recuperate data, which has a tendency to loss information because of node failure. Task assignment for WSN is a problem with 0−1 binary variables showing whether the node is chosen for a specific assignment. Thus, BPSO and its renovated version are used for the assignment of tasks among nodes in the network.

4. Problem Formulation

As shown in Figure 3, a user application obliges m computing task to be executed in the WSN. The set of tasks is formulated as $M = \{M_i: i = 1, 2, \ldots, m\}$. A WSN with n sensor nodes is represented by $N = \{N_j: j = 1, 2, \ldots, n\}$. For a task assignment M_i, a sensor node $N_i = \{N_i: i = 1, 2, \ldots, n\}$ is chosen.

4.1 Particle Encoding

Tasks in the coordinated non-cyclic graph have dependent associations with legitimate priorities; the binary position of a particle in a renovated version of BPSO is encoded as a complete guide of the coordinated non-cyclic graph to the graphical representation of sensor network architecture G, which remains for a complete solution for the task assignment problem. As represented in Figure 4, the particle position is encoded into an m×n binary matrix, where m is the aggregate number of tasks in the coordinated non-cyclic graph and n is the aggregate number of sensor nodes in the WSN.

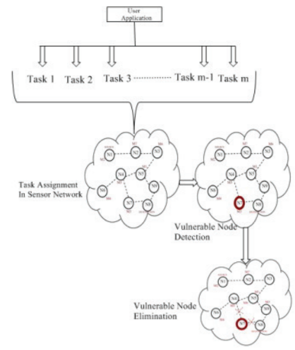

Figure 3. Data recuperation by pruning vulnerable sensor node.

Nodes / Tasks	1	2	....	n
1	0	1	....	0
2	1	0	....	1
⋮	⋮	⋮	⋮	⋮
m	0	1	....	1

Figure 4. The encoding for a particle.

4.2 The Constraints for Task Allocation

As per the particle encoding plan, each row of a particle position stands for an assignment plan of a particular task. The selected gathering of nodes must have enough assets to complete the workload of giving task. In addition, the node groups must be connected with one another to guarantee fundamental information trade among sensor nodes. When initializing and overhauling the swarm of particles, utilizing a renovated version of BPSO, the conditions on task workload and network connectivity should be fulfilled. For a particular task, the condition on task workload is exchanged to an issue on the restriction of the negligible number of selected sensors. The connectivity of the selected nodes must be guaranteed for vital information exchange. The selected nodes can be graphically represented by an undirected diagram GT = (NT, LT) where NT is the set of vertices indicating the selected sensor nodes, RT is the set of links indicating direct correspondence edges among nodes. GT is a subset of the entire WSN G = (N, L). The aggregate number of sensor nodes in GT is p. So, to check the network connectivity, each row of the particle ought to initially express by its adjacency framework. At that point the connectivity of the particle can be examined.

4.3 Failure Detection and Information Recuperation

In this segment, the strategy to recognize energy failures in the nodes and inform that to the neighbors of them is discussed. This discovery of failures is necessary to initiate the mechanism for the repair and recuperation of those failures in the network. A node is treated as a vulnerable node because either the task which is assigned to it is uncommitted or when its energy level drops beneath the threshold esteem. At the point when the node is fizzling, it sends the failure report message to its neighbors. The neighbors of each sensor node in the monitoring environment are determined by its transmission range. The threshold rate is the energy needed to transmit messages over a distance equivalent to the transmission range. This data of the failure report is a sign to begin the failure recuperation phase. A failure report message is sent by the vulnerable sensor node to its predefined neighbors. This helps the neighbors to understand that they have to scan for an alternate suitable node for further operations. If any sensor nodes, gets the failure report, it overlooks the failing sensor node for further information exchanges and thinks of it as a non-active part in a sensor network. Thus, the vulnerable sensor node is pruned from the network and the uncommitted task is re-assigned with respect to the renovated version of BPSO to the remaining nodes in the network which results in topology permutation.

4.4 Workflow

For a utilization of WSN, an ideal task assignment plan would be produced after the execution of task assignment algorithm. Every task would then be deteriorated into littler subtasks and allocated to a selected sensor node groups as per the ideal scheme. Figure 5 demonstrates the work flow of task allocation among sensor nodes incorporation with data recuperation from the vulnerable node, which may cause network failure.

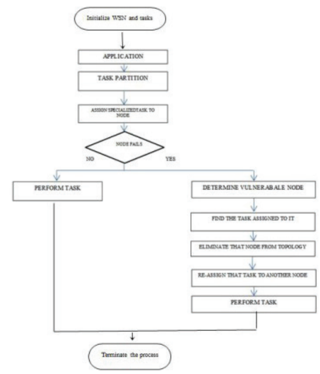

Figure 5. The workflow of data recuperation from vulnerable sensor nodes by task assignment.

5. Simulations

The proposed task assignment problem for data recuperation was implemented in TCL language on NS2 running under windows environment. To gauge the adequacy and viability of this framework, results are compared with a technique that does not involve data recovery in its implementation.

A WSN is actualized with a fluctuating number of sensor nodes haphazardly conveyed in a monitoring area of 500m × 500m. But formerly introduced, the nodes are assumed to be static. In Homogeneous setting, all the nodes are with indistinguishable Radio Frequency (RF) modular which runs at the 2.4GHz ISM band with a bandwidth of 250Kbps. The most extreme transmission range is assumed to be 100m. The energy storage is introduced to be 2 KJ. The computational load of every task is instated to be consistently conveyed in the range of [300, 600] KCC (Kilo Clock Cycles). The correspondence load for every task is instated to be consistently distributed in the range of [500, 800] bytes of information.

For entire simulations, the default number of tasks and sensor nodes are 10 and 30 respectively.

The number of tasks differed from 3 to 10 to monitor the performance of the algorithm with differing workload. Figure 6 demonstrates the averaged results.

For ordinary stream and under the proposed system, the execution time and energy utilization of tasks and sensor nodes contrasts. In the proposed system, the calculated execution time subtracts the execution time of the vulnerable sensor node. Subsequently, it minimizes the general execution time and improves the network performance and lifetime relies on upon fluctuating network size and tasks.

Table 1. Parameters Used in Simulation

Parameter	Value
Platform	Windows
Simulator	NS2
Area	500m × 500m
Network size	30 nodes
Simulation time	30 minutes

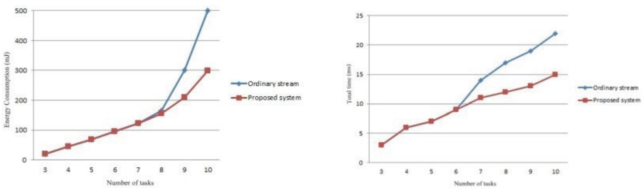

Figure 6. Performance analysis with varying number of tasks and its optimization metrics.

6. Conclusion

In this work, a task assignment methodology based on a renovated version of binary particle swarm optimization for data recuperation is proposed to enhance the lifetime of WSN. Task execution time, energy utilization and sensor network lifetime are considered in the fitness function to make a legitimate tradeoff among distinctive metrics and get the best overall execution. Simulation results demonstrate the feasibility of the proposed methodology for the task assignment problem in WSN. The proposed methodology for task assignments helps to recuperate the data which is lost during data transmission by re-assigning tasks to active sensor nodes in the network.

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