A NOVEL APPROACH TO ELECTION ALGORITHM FOR COORDINATOR SELECTION IN WIRELESS SENSOR NETWORKS

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ABSTRACT

In a wireless sensor networks, coordinator election is a very important issue. An important challenge faced is the adoption of efficient algorithms for coordinator election. A coordinator is responsible of making sure the synchronization between different devices. In addition, a coordinator would assure the responsibility of dispatching IP, updating routing information and service list. Among all the algorithms reported in the literature, the Bully and Ring algorithms have gained more popularity. Their drawbacks are message passing cost and complexity. Many modified Bully and ring algorithms have been proposed to reduce the redundancy of the election process and the number of message passing. However, their modifications did not take available resources of a node into consideration. So our aim is to find out a new and improved algorithm for the election of the coordinator with reduced message passing and reduced message overhead along with maximum number of available resources. This paper will introduce a naïve algorithm for electing a coordinator based on the sensor node having the set of available resources.

Keyword: - *Election, Coordinator, Cluster Head, Wireless Sensor Networks*

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1. INTRODUCTION

Wireless Sensor Networks (WSN), are autonomous sensors that are distributed spatially to *monitor* physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. The WSN is built of several nodes, where each node is connected to one or several sensors. Each such sensor network node has several parts: a radio transceiver with an internal or external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. Many distributed algorithms require one process to act as coordinator, initiator, or otherwise perform some special role. The coordinating activities can be a directory search, balancing the load of the distributed system, etc. The major coordinating activity is to manage the use of a shared resource in an optimal manner. The goal of a coordinator election is to select one of the currently alive processes as a coordinator so as to manage the coordination activities of the other processes in the system. Such an election is done at the start of the sensor network and it is required every time when a current coordinator fails or crashes. Among many algorithms reported in the literature, the Bully and Ring algorithms have gained the utmost popularity. The communication between the sensors is held by message passing over the communication network [1]. As the nodes in the system need to interact with the coordinator node, they all must know who the current coordinator is. The important case to be dealt is when the coordinator fails, so there is a requirement for a temporary new coordinator to take the job of coordination. Hence an election is done to find out the next coordinator in the system. The election process is initiated when one or more processes discover that the coordinator has failed, and it terminates when the remaining processes know who the new coordinator after the result of election declared is.

2. EXISTING ELECTION ALGORITHMS

Much research has been carried out in the election area of distributed systems. Among the prominent algorithms in the literature, below are the two algorithms as listed:

(1) Hector Garcia -Molina,(1982; also known as Bully Algorithm).[3]
(2) Silberschatz and Galvin (1994; also called Ring algorithm).[4]

Both the above algorithms assume that all the processes have a unique priority and all the processes know the priority of every other process in the system. Also that the process with the highest priority among the currently alive processes will be the candidate for the new coordinator in case when the coordinator has failed due to some reason.

3. OVERVIEW OF PROPOSED ELECTION ALGORITHM

This paper presents an election strategy that is based on the resources currently available on the sensor node. The strategy is to find out a sensor node which is running on a machine with the richest set of resource characteristics available at the time of the election. The resource characteristics of a node may include the level of security provided by the node, number of processors in a multiprocessor system, speed of each processor, available RAM on the node, etc. Thus in addition to reducing the messaging overhead among the processes, the resource characteristics is an important criterion in electing a process as a coordinator.

The main goals of the proposed algorithm strategy are:

(1) To achieve a greater overall improvement in system performance at a reasonable cost.
(2) To utilize the available resources most efficiently.
(3) To have the ability to modify the system itself in accordance with any changes.
(4) To find an optimum coordinator who is enriched with the best resource characteristics.

3.1 Architecture of a Wireless Sensor Node

The core of the wireless sensor node is the processing unit, usually a microprocessor with a limited amount of memory. The processing unit is connected to the sensors via one or more Analog to Digital Converters (ADCs). The sensors and the ADCs form the sensing unit. The data received by the sensing unit are processed and eventually transmitted by the transceiver unit. The transceiver unit is usually capable of bidirectional communications. Specific nodes may integrate a location finding system that helps the node to discover its position, relative to its neighbors or global. This unit is often embedded on the transceiver module and requires the use of specific algorithms by the processing unit, depending on the adopted localization techniques. The power unit and the power generator are a key element in the sensor structure. The power unit is responsible to provide the electrical power needed by the other units in the system. Smart power units are also capable to provide information on the residual available energy, in order to apply energy aware decisions and consent the processing unit to complete the task at hand. Since the power generator usually consists of batteries, such devices have limited amount of energy available, thereby limiting the lifetime of the node.

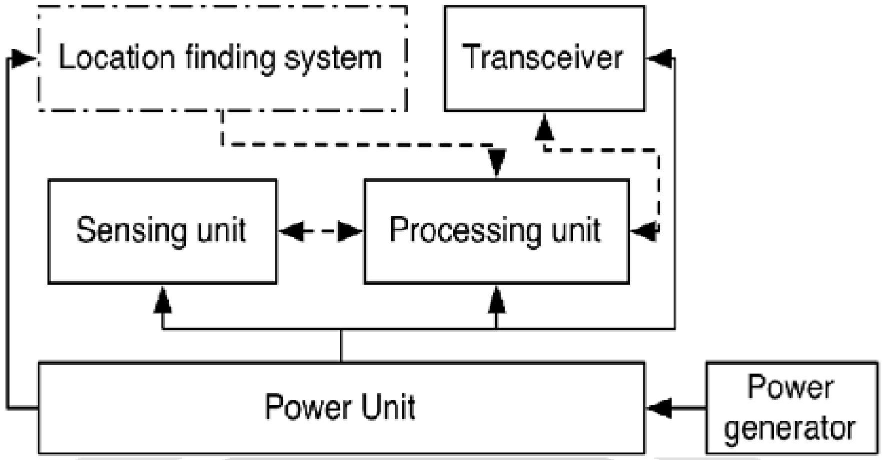

Fig -1: Wireless Sensor Node Architecture

3.2 Resource Factor of a Sensor Node

Let α0, α1,α2,……….αn be some weighted values given to the resource characteristics corresponding to the resources of a node and let r0,r1,r2,………..rn be the values of the available resources on that node such that,

α0 > α1 > α2 > ……….. αn …...………….(1.1)

ranked according to the priority of resource characteristics of each node and each αi, 0≤i≤n, for n characteristics, in the range [0-1] and

α0 + α1 + α2 + ………. + αn =1…………….(1.2)

Then resource factor of a sensor node is calculated as:

Resource factor (RF) = r0 * α0 + r1*α1 + …+rn* αn ….. ………(1.3)

Thus for every such j node out of m nodes of the system, the resource factor RF for each node j is:

for j=0 to m, i =0 to n,
RFj= Σi 〖(ri*αi〗 ………..………(1.4)

The node with the highest resource factor is a node with the highest resources. The resource characteristics of a node may include the level of security provided by the node, number of processors in a multiprocessor system, speed of each processor, available RAM on the node, battery life of the node, message queue etc. Thus in addition to reducing the messaging overhead among the processes, the resource characteristics is an important criterion in electing a process as a leader. In our proposed algorithm, we consider three important criteria from the above mentioned ones. We assign a weighted value for each resource characteristic. Hence assigning them as the weighted values and according to equation 1.1, we can assign them as follows:

Remaining Battery Life : 0.5 = α0
Message Queue : 0.35 = α1
Free RAM : 0.15 = α2

Hence, our formula of the resource factor of a node is calculated as:

Resource factor (RF) = r0 * α0 + r1*α1 + r2*α2 ….. ………(1.5)

The resource characteristic with the highest weighted value is considered to be of highest priority and then with the decreasing weighted values, decreases the priorities.

3.3 Steps of Proposed Algorithm

Step 1: Generate nodes. Generate a network of the newly generated nodes.

Step 2: Generate Clusters and Sub-Clusters of the nodes. The clusters will be made on the basis of Euclidean Distance. (Zoning and sub-zoning is done on the basis of Euclidean Distance).

Step 3: Create a Coordinator of Sub-Clusters on the basis of Resource Factor of a node. Initially, all the nodes are eligible to become the Coordinator of the Sub-Clusters. Hence, any random node is made the Coordinator.

Step 4: A Cluster Coordinator is elected from the set of Sub Cluster Coordinators. Since the cluster does not have a Sub Cluster Coordinator anymore, a new Sub Cluster Coordinator is elected. Hence Step 3 is repeated.

Step 5: When the Cluster Coordinator crashes, the election starts again and a new Cluster Coordinator is elected from the existing Sub Cluster Coordinators. Hence step 3 and 4 are repeated.

4. PERFORMANCE STUDY

The table given below shows the comparison between various coordinator election algorithms. It can be clearly seen that the proposed algorithm. Introducing hierarchy and also limiting the number of nodes running for the election of the coordinator reduces the amount of messages being passed in the system, both in the best and the worst case scenarios, hence improving system performance.

Table -1: Performance of Coordinator Election Algorithms

Method	**Total Memory Needed**	**Message Complexity**	**Min. Messages/ Best Case Scenario**	**Max. Messages/Worst Case Scenario**
Proposed Algorithm	2n	log n	n(c) -1	$[n(c)-1]+\frac{n}{n(c)}$
Max-Heap[3]	4n	log n	log n	log n+(n-1)
Ring[3]	n^2	n^2	N	n^2
Bully[2]	n^2	n^2	2n-2	n^2

5. CONCLUSIONS

Section [2] presents some techniques for election of a coordinator in distributed systems which can be applied to Wireless Sensor Networks. But they do not take the available resources of a node into consideration while electing the coordinator. This leads to inefficiency of work done by the coordinator. Introducing steps to deal with dynamic election of a coordinator will be a step towards improving the efficiency of the coordinator. A technique that utilizes the resources of the sensor nodes in its most efficient way is developed. Thus the sensor node that has the best resources available at the time of election will be designated as a new coordinator of the sub cluster. The main coordinator is then selected from a set of such sub-cluster coordinators which form a limited set. This node can then coordinate and manage the activities in the network with its rich set of resources.

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