Node Positioning
Application for Wireless Networks Industrial Plants

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Abstract: This article discusses the positioning of the nodes of a wireless network of an industrial plant for the network to meet the application requirements, particularly with respect to coverage characteristics and reliability. Issues involving these two parameters are investigated and it is intended to submit proposals using the concepts of computational intelligence to solve the problem.

1 INTRODUCTION

The possibility of using wireless network has been widely discussed in the areas of industrial automation, environmental monitoring, and location of road vehicles among others. The great advantage of not using cable for data transmission is the ease of network installation in all environments, including those where it is not possible to lay cables, be for the difficulty of access, or for being a dangerous area or not allowed access. Another advantage is the ease of maintenance of equipment. In the listed applications, it is of paramount importance the safety, reliability, availability, robustness, and network performance in carrying out the monitoring and process control. That is, the network cannot be sensitive to interference or stop its operation because of an equipment failure, nor can have high latency in data transmission and ensure that the information is not lost (Zheng and Myung, 2006), (Santos, 2007).

A network of wireless smart sensors is responsible for conducting the monitoring of a process or an environment, process the collected information and send it to other sensors or routers closer to the gateway. The sensors are powered by batteries and positioned according to the process to be monitored (Gomes, 2008).

Data transmission in a wireless network in today's industrial automation is faced with the problem of interference generated by other equipment and obstacles. In an attempt to minimize these effects, various methods of intermediate nodes positioning are used. The intermediate nodes or routers are responsible for making the routing of data, generated by sensors in the network to the gateway through hops, directly or indirectly. Such devices are responsible for meeting the safety, reliability and robustness criteria of the network and are of paramount importance in directing data transmission. However, they can leave all or a great part of the network dead, if they have any fault (Hoffert et al., 2005).

Most of the presented solutions to this problem use optimization algorithms to find the smallest number of routers needed to make the network meet the criteria related to the decrease of energy consumption of each node. Moreover, monitoring the total area, simplifying the network with the lowest cost, meeting the traffic demand not evenly distributed, reducing the latency of the data, the reduction of computational complexity, minimizing the burden placed on the nodes and maximizing the number of nodes that can communicate with the gateway are also key issues in the problem (Youssef and Younis, 2007), (Molina et al., 2008). These solutions typically face problems of scalability and changes of the network configuration the over the years. Thus, for each network configuration it would be necessary to develop a specific solution in accordance with new obstacles, positioning of the sensor nodes and, consequently, new positions for the routers.

This article is divided into four sections. This section is an introduction to the problem of positioning nodes in wireless networks. Section two discusses the importance of studying node

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positioning. In section three possible solutions to the problem using computational intelligence (CI) are discussed. The forth section closes the paper presenting research directions and preliminary conclusions.

2 NODE POSITIONING ISSUES

This section briefly discusses the positioning of nodes characteristics and its main constraints.

Why study the positioning of the nodes? For the network to meet the application requirements, especially regarding reliability and coverage issues. Positioning of the nodes can cause a dramatic impact on the efficient operation of networks.

The positioning of the nodes can be static, which is done before the network operation, or dynamic, where the repositioning of nodes continues on the network in operation.

Static positioning of the nodes depends on the method of nodes distribution, for instance controlled or randomized. It also varies with the optimization objective which may include the coverage area, connectivity, longevity or data fidelity. The role of node in the wireless network should also be taken into account in the positioning process e. g. the node can act as a sensor repeater, a base station or cluster-head node. Questions such as where and when to relocate nodes naturally arise and the characteristics of the network also play an important role in the whole process.

One has to define the network coverage or in other words the accessibility to the gateway. The critical nodes are those for which its load is overwhelming and the sensitivity of the network to a loss of such a node is high. Fault tolerance is also a key issue and it is of paramount importance to know what happens if a node fails. In such a case it is important to know if an alternative path exists for those paths having that faulty node. Determining the number and the positioning of repeater nodes is also an information one should have.

For industrial wireless networks every node must be able to communicate with the gateway, either directly or through other nodes, so that the targeted coverage should be equal to 100 %.

As far as the used criteria are concerned for each of such networks, every node must have a certain number of neighbors in order to increase the availability of alternative paths. That means also that a number of network nodes must be in direct connection with the gateway. The number of hops for which a message reaches a node to the gateway has to be closely monitored once the increase in the number of hops raises the message latency. Depending on the refresh rate of the measurements, in case of wireless sensor applications, this can be an important issue. Also the number of retransmissions from other nodes necessary for reaching the gateway should be carefully considered as increasing the number of retransmissions may shorten the battery life.

In terms of fault tolerance it is important to know what percentage of the network that is still working if a particular node fails. What is the most critical node on the network in relation to this criterion?

Those issues are to be considered in the building of the node positioning for industrial wireless networks.

3 CI BASED PROPOSALS

This section presents proposals for solving the problem of positioning nodes for wireless industrial networks employing computational intelligence techniques. Such techniques are very promising for application to the problem at hand because they allow consideration of heuristic optimization issues related to the theme.

The problem of positioning nodes is an NP-Hard (Molina, 2008) and in view of this, it is usual to use heuristics and stochastic optimization schemes. Thus potential techniques applicable to the solution of the problem involve those related to computational intelligence such as genetic algorithms, collective intelligence, such as ant colony optimization, artificial immune systems and others. Before proceeding it is necessary to emphasize an important feature of the problem of positioning nodes in wireless networks in industrial environments. Note that in this case, the nodes in the network are positioned at locations to be instrumented and connectivity with the central node, usually located in the control room, it is absolutely necessary otherwise the consequences can be devastating. This situation is distinct from a network of wireless computers only for INTERNET access in which connectivity can be lost and then resumed without major losses to the user, since the greatest interest is to achieve a high throughput.

3.1 Node Positioning using Artificial Immune Systems

The immune system is one of most important ones for the survival of humans and animals. It has the task of fighting the invaders, which cause diseases through complex mechanisms. Such mechanisms are complementary and fit to perform the recognition of pathogens (viruses, bacteria, foreign molecules etc.) and inhibit its action in the body of the individual and are divided into (Amaral, 2006) (Castro, 2001):

1. Recognition of pathogen - is accomplished by lymphocytes, i.e. B and T cells that have receptors for the purpose of joining the pathogen to subsequently eliminate it;
2. Affinity maturation of lymphocyte receptors and pathogen - there will be hypermutation receptors so that they are able to fit "perfectly" to the antigen;
3. Cloning of the antibody with higher affinity - cloning of lymphocytes that are better suited to the pathogen;
4. Distinction between self and non-self - this mechanism is of paramount importance for the individual able to survive without any autoimmune disease that destroys the cells and proteins of the organism itself. It will make the distinction between body proteins and the invaders;
5. Immunological memory - is a database stored in the memory immune receptors, which act more quickly and effectively against the next infection caused by the same pathogen.

The artificial immune systems exploit mechanisms found in natural immune systems to develop techniques for solving problems. The natural immune systems provide protection against numerous pathogens such as viruses, bacteria and others.

Some basic concepts of natural immune systems will be described so that we can develop the application in node positioning. Antigens are substances that are not recognized by the immune system as the body itself. There are two types of immune systems the innate and the adaptive. The first is the first line of defense of the living organism and reacts similarly to different pathogens such as the skin. Note that some pathogens cannot be fought by the innate immune system. The adaptive system fight against specific pathogens. Its main components are B cells which produce antibodies and T cells that attack the abnormal cells. The response of the innate immune system remains constant, the adaptive gives immunity against re-infection of the same infectious agent. Pathogens or molecules present antigens that are recognized by B cells. Note that the marriage is not always perfect. Since the antigen recognized, the B cell begins to produce antibodies. Each B cell produces only one type of antibody. For example, antibody to influenza virus is different from that for pneumonia. The more efficient antibodies are cloned.

Now an algorithm using artificial immune system techniques will be described.
The algorithm is as follows:

1 - Initialization: Original placement or pattern of antibodies.

2 - Training: Presentation of antigens for the iterative network of antibodies against antigens and antibodies.

3 - Competition: winners antibodies in accordance with an affinity function

4 - Cloning; reproducing the efficient antibodies.

5 - Convergence: each antibody is associated with an antigen and each antigen antibody should have a winner within a minimum defined distance.

6 - Pruning: After all training unrelated antibody with any antigen is removed.

Preliminary tests indicate that the above proposal is satisfactory.

4 CONCLUSIONS

The artificial immune systems are algorithms inspired by the functioning of the human immune system to solve optimization problems, pattern recognition and others. The most widely used algorithms in solving the problems mentioned above are the immune network algorithms, clonal selection and negative selection (Castro and Timmis, 2002). The artificial immune networks are algorithms that mimic the functioning of the immune network in combating human infectious diseases in slaughter. This network provides human immune B cells capable of recognizing and to recombine in the absence of the pathogenic agent, thereby forming a network capable of eliminating the invaders. They are formed in accordance with the degree of affinity between B cells. If the affinity between them is high, then the cell B is joined to the network, otherwise it will be repelled away from the network. This action of union or inhibition of B cells occur until the network stabilizes and so could fight off diseases. The purpose of this paper is to solve the problem of positioning nodes in wireless industrial networks using artificial immune, based on the human immune system. The algorithms based on immune networks have very desirable characteristics in solving this problem, among which we mention: scalability, self-organization, learning ability and continuous treatment of noisy data. It is intended to build positioning algorithms based on models of artificial immune networks (Castro 2001), aiming to get the best settings for a wireless network industry, positioning the router nodes in the network, so that all devices to communicate with gateway without loss of information.

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