ARTIFICIAL IMMUNE SYSTEM AGENT MODEL

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ABSTRACT. The Artificial Immune Systems (AIS) is a biologically inspired techniques that emulates a natural system, in particular the vertebrate immune system, in order to develop computational tools for solving engineering problems. Immunity-based technique emerge as a new branch of artificial intelligence (AI). The human biological immune system has become the source of inspiration for developing intelligent problem-solving techniques. The powerful information processing capabilities of the human system, such as feature extraction, pattern extraction, learning, memory and its distributive nature provide rich metaphors for its artificial counterpart. Hence, the goal of this study is to develop an Artificial Immune System (AIS) model using agent approach for incremental learning. The main issue handled was how to integrate a multiagent system into an AIS application. This model proposed was simulated using cases for the performance measurement. The step by step activities performed in developing the agent based AIS model can be a guideline in developing an AIS application. Besides that, the simulation of the AIS model can be further enhanced to be used for teaching and learning purposes.

Keywords: Artificial Immune System (AIS), Agent Technology

INTRODUCTION

The immune system (IS) is a complex of cells, molecules and organs that represent an identification mechanism capable of perceiving and combating dysfunction from our own cells (*infectious self*) and the action of exogenous infectious microorganisms (*infectious nonself*). The interaction among the IS and several other systems and organs allows the regulation of the body, guaranteeing its stable functioning (Janeway Jr., 1992). Without the immune system, death from infection would be inevitable. Its cells and molecules maintain constant surveillance for infecting organisms. They recognize an almost limitless variety of infectious foreign cells and substances, known as *nonself* elements, distinguishing them from those native noninfectious cells, known as *self molecules* (Janeway Jr., 1992; Mannie, 1999). When a *pathogen* (infectious foreign element) enters the body, it is detected and mobilized for elimination. The system is capable of "remembering" each infection, so that a second exposure to the same pathogen is dealt with more efficiently.

The immune system, however is a system with high complexity and is under active research (from the biological point of view). The current Artificial Immune System (AIS) works adopted only a few immune mechanisms. Specifically, three immunological principles are primarily used in a piecemeal in AIS methods. These include the immune network theory, the mechanisms of negative selection and the clonal selection principles. The system uses learning, memory, and associative retrieval to solve recognition and classification tasks. In particular, it learns to recognize relevant patterns, remember patterns that have been seen

previously, and use combinatorics to construct pattern detectors efficiently. Artificial Immune Systems are used in pattern recognition, fault detection, computer security, and a variety of other applications in science and engineering.

Some of the first work in applying immune system metaphors was undertaken in the area of fault diagnosis (Ishida, 1990). Later work applied immune system metaphors to the field of computer security and virus detection (Forrest *et al*, 1994), which seemed to act as a catalyst for further investigation of the immune system as a metaphor in many areas.

Using the immune system as inspiration has proved very useful when trying to address many computational problems. The immune system is a remarkable learning system. Through the use of B-cells and T-cells the immune system can launch an attack against invading antigens and remove them from the system. This is achieved through a process of B-cell stimulation followed by cloning and mutation of new antibodies. This diversity that is generated allows the immune system to be adaptive to new, slightly different infections. The immune system is able to retain information about antigens; so that next time the body is infected a quicker, secondary immune response can be triggered to eliminate the infection. A number of theories exist about how the immune system retains this information, in a type of memory: the most popular being the clonal selection theory, and the idea of memory cells, and the alternative immune network theory, with the idiotypic interactions on antibodies. The immune system is composed of an enormous set of cells, molecules and organs, which can be viewed as immune agents distributed all over our bodies. (Forest *et al.,* 1997; Dasgupta, 1999; De Castro *et al*., 2000, Acklien *et al*. 2002)

LITERATURE REVIEW

The backbone of the study involves imitating the human immune system in terms of features and functions in multi agent systems. The motivation for this research comes from the fact that artificial immune system has found solutions for several applications.

Table 2: Comparison of rule based, cased based and artificial immune system.

Type	RB	CBR	AIS
Data	Rule base	Case base	Rule and case base
Incremental Learning	Yes	Yes	Yes
Redundancy	High	High	Medium
Storage of memory	High	High	Medium
Knowledge Acquisition	Difficult	Easy	Easy

Table 2 shows that the redundancy data, storage memory and knowledge acquisition by using AIS is better that the rule based and case based reasoning. From that viewpoint, this study will explore the AIS model capability in order to solve that kind of problem. Based on previous discussion, there are various related issues that need to be solved in this study. Artificial Immune System model will be used as a central theme to demonstrate the naturalistic decision making process in emergency situation. Thus, the aims of the study are to explore the learning, recognition process and memory mechanism in the human immune system on extracting the knowledge from the case and the expert. The human immune system has a capability to control the complex system.

In the same context agent based solutions have als been developed in different application domains. An agent is anything that can be viewed as perceiving its environment through sensors and acting upon that environment through effectors. The characteristics of the agents

are autonomous, sociable, cooperative, proactive and reactive entity. The reason for developing the Multi Agent System (MAS*)* is due to the similarities observed between the immune system architecture and the architecture of the agents. This study will concentrate on agent and their characteristics in order to develop the model of Artificial Immune System by adopting intelligent agent approach. The distinct similarities between the agents and the immune system are:

- Both are distributed or decentralized systems
- Both have multiple autonomous entities
- Both have individual and global goals
- Both systems learn from their experience
- Both are adaptable
- Both sense the changes in the environment and act accordingly
- Both systems communicate and coordinate
- Both possess knowledge with which they make intelligent decisions.

In a recent work, Dasgupta (1999) proposed an agent-based system for intrusion/anomaly detection and response in networked computers. In his approach, the immunity-based agents roamed around the nodes and routers monitoring the situation of the network. The most appealing properties of this system were: mobility, adaptability and collaboration. The immune agents were able to interact freely and dynamically with the environment and each other. Figure 1 depicts the types of agents employed and their hierarchical coordination. The decision/action agents could assume the forms of *helper*, *killer* or *suppressor* agents, like in the case of T-cells. The communicating agents corresponded to *lymphokines*, secreted by T-cells to regulate the immune response. Some of the monitoring agents worked in the complement space for monitoring changes (*non-self*), while others had the knowledge of known intrusions.

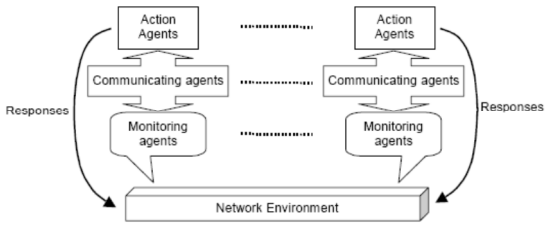

Figure 1. Conceptual view of the proposed multi-agent intrusion detection system.

Tung et al. (2004) proposed an Architecture Immune Dealing System (AIDS) as a system that uses the artificial immune algorithm that is implemented in the e-marketplace. It has similar architecture as the artificial immune system with agents acting to search for an appropriate match of buyer and seller. The AIDS represents the next generation of services in the e-marketplace, aiming to achieve an efficient and fair e-marketplace with less cost.. along with explosive growth rate. In this paper, Artificial Immune System is used as the E-marketplace's trading mechanism, which structure an Artificial Immune Dealing System(AIDS). The authors introduced a new Architecture of emarketplace, which uses artificial immune concept, named Artificial Immune Dealing System(AIDS). By the interaction of B lymphocytes, B memory lymphocytes and antigens provide all the functions of AIDS. The antigens act as a product's information catalog, which for antibodies to select. Antibodies act as a purchaser, which select product(antigen). The whole system works like a large intelligent multi-agent system. In this paper, it also introduced the algorithm that AIDS used and the advantage of AIDS.

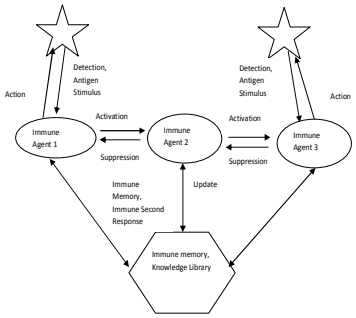

Figure 2. Multi-Immune Agent Schematic Network Model (Yunyuan & Wei, 2005)

Yunyuan and Wei (2005) propose an immune agent model combining the artificial immune system with the agent technology. In the model, a robot is regarded as an antibody and each environmental condition as an antigen respectively. Furthermore, based on the model, a new multi-robots cooperation algorithm is designed to build self-determination cooperation among robots even in a new environment. Inspired by pheromone from ants algorithm, a new pheromone as Inter- stimulus between robots in the model is introduced to the algorithm. By comparing the inter-stimulus value between antigen and antibody and among antibodies, the system will autonomously produce appropriate antibodies to kill the antigen. Finally, the model will be verified by simulation. This paper proposes an immune agent model by combining the artificial immune system and agent technology. Robots in this model perform self-determination cooperation in a new environment without awareness of the variety of the tasks. Simulation is performed to validate the effectiveness of the algorithm.

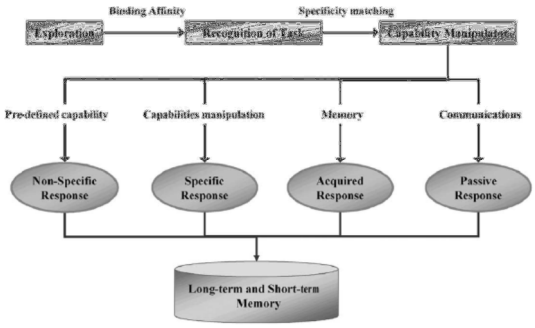

Figure 3. Architecture of the control framework for the individual AIS agent.

Hendry and Vicky (2006) present a formal mathematical model of an artificial immune system (AIS)-based control framework. The framework aims to provide an integrated solution to control and coordinate complex distributed systems with a large number of autonomous agents such as automated warehouses, distribution centers, and automated materialhandling systems. The control framework consists of a set of AIS agents working in response to the changing environment and the occurrence of tasks. The AIS agents manipulate their capabilities to derive appropriate responses to tackle different problems. A methodology describing the response-manipulation algorithm of the AIS agents and their ability to generate new capabilities is discussed in this paper. Through response manipulation and knowledge building, a self-organized and fully distributed system with agents that are able to adapt and

accommodate in a dynamic environment via distributed decision making and interagent communication is achieved. Figure 3 shows the architecture of the control framework proposed by the authors.

This study was conducted in four phases : study on current AIS framework; modeling AIS using agent approach; design the simulation for the AIS model and evaluate the system using selected test case.

CONCLUSION

This study will propose an AIS incremental learnirng model using intelligent agent approach. This model was simulated using real data for the performance measurement. The development activities involve can be used as a guideline for developing agent based AIS. .

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