Immune-based Middleware for Large Scale Network

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Abstract

Very large scale networks such as the Internet require a new operational model to use resources efficiently and reduce the need for the administration necessary in client-server networks. In this paper, we present an autonomous decentralised system based on mobile agent paradigm and inspired by the immune system as an alternative to the traditional client-server paradigm. The immune system has a useful set of organising principles that guide the design of scale, adapt and efficient enough networking model to bring answers to some large scale networking challenges. This research is the part of an effort to develop a mobile agent-based middleware that can monitor the resources distributed over a large scale networks.

1. Introduction

The rule today is large scale networking where billions of users should access to variety and increasing number of resources distributed over the network. The resources can be nomadic mobile, partially connected and more widely distributed. The ability to maintain and allocate all of these resources is an important and challenging issue.

In this paper, we present an autonomous decentralised model based on mobile agents and inspired by the immune system as an alternative to the traditional client-server paradigm. Unlike the classical C/S approach, in our immune-based approach, each user request is considered as an attack launched against the global network. The immune-based middleware reacts like an immune system against pathogens that have entered the body. It detects the infection (i.e., user request) and deliver an appropriate response to eliminate it (i.e., satisfy the user request). This immune approach can be considered as the opposed approach to the client-server one.

Recently, mobile agents have been advocated as an useful mechanism to design and implement large scale network based services [1,2,3,4,5]. Mobile agent possesses the following proprieties: *Autonomy* (agents operates without the direct intervention of humans); *Social ability* (agents communicates with other agents); *Reactivity* (agents perceives their environment and respond in a timely fashion to changes that occur in it); *Proactivity* (agents do not simply act in response to their environment, they are able to exhibit behaviour by taking the initiatives); *Mobility* (agents are able to travel through computer networks).

The rest of the paper is organised as follows. In section 2 we present an overview of the natural immune system. Section 3 presents the mapping between the functionalities and characteristics that the immune system exhibits and our Immune-Networking based middleware. Conclusion is given in section 4.

2- Immune system: An overview

The immune system defends the body against harmful diseases and infections [6,7,8,9]. Once pathogens have been entered the body, they are handled by the innate and the adaptive immune system. The innate and adaptive immune system are produced primarily by leukocyte cells. Among the several different types of leukocytes, there are phagocyte and lymphocyte cells. The phagocyte cells are the first lines of defense for innate immune system. They engulfs the antigen and destroy or presents them to adaptive immune system. The adaptive immune system consists primarily of lymphocytes that circulate through the body in the blood and lymph system. There are two categories of lymphocytes, the T-cells and B-cells. The T-cells are divided into two major categories: the T-helper cells and the T-killer/suppressor cells. The principle function of T-helper cells is to potentiate immune response by the secretion of specialised factors that activate other cells to fight off infection. The T-killer/suppressor are important

in directly killing an antigen. The major function of B-cell is the production of antibodies in response to foreign antigen. If the antibodies bind to antigens it acts a signal for phagocyte or T-killer cells to engulf and kill them.

3. The immune based middleware

The middleware is an Immune-Net architecture that provides Immune-Net platform and software agents. Immune-Net platform provides execution and support services for the software agents. Software agents are autonomous, reactive and mobile. They correspond to cells in immune system and can roam around the server sites in order to allocate and/or recognize resources distributed across the network. These agents can mutually recognize each user request, work on behalf of the user and can take appropriate actions to localize the required resource.

Generally, the middleware will be designed to fulfil several important proprieties summarised as follow:

- *Distributability:* the immune system are able to determine locally the presence of an infection. No central coordination takes place. The middleware is open and evolving; No global administrator agent. The mobile agents are dispatched from various remote server sites and acts on behalf of user without central control.
- *Multi-layered:* the immune system is composed of different layers of defense: physical, physiological, innate and adaptive. The middleware is composed of interchangeable modules, each providing some of the required functionalities. However, the middleware should allow new components, such as new agents and new archives to be easily integrated.
- *Autonomy:* the immune system does not require outside management; It autonomously classifies and eliminates pathogens. The middleware is autonomously classifies and satisfies all user requests. It not requires outside control.
- *Adaptability:* the immune system learns to detect new pathogens, and retains the ability to recognise previously seen pathogens through immune memory. The middleware able to recognise new resources and remembering the signatures to previous allocation.
- *Self-regulatory:* the human immune system replicates detectors to deal with replicate pathogens. Our agents-based system are subject to a similar numbers game of immune system, by replicating the agents into clones in order to propagate the resource information and allocate it quickly.
- *Dynamically changing coverage:* the immune system makes a space/time tradeoff in its detector set : it cannot maintain a set of lymphocytes large enough to cover the space of all pathogens. The middleware able to maintain a set of mobile agents to cover the wide area in order to satisfay/manage a wider variety of user requests.

4. Conclusion

The increased network connectivity and the requirement to access to resource through large scale network such as Internet makes the resource management one of the most important factors in today's computing. In this paper, an autonomous decentralised system based on mobile agents and inspired by the immune system is presented as an alternative to the traditional client-server paradigm. The proposed immune based middleware integrates several functionalities of the natural immune system. The middleware exhibits self-organisation with support for mobility, scalability, and adaptability to user and network conditions changes. Our further studies is the performance and simulation issues of our middleware with Network Simulator 2 (NS2) and Aglets.

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