A Bio-Inspired Concept for Information Security Modelling

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ABSTRACT

Bio-inspired models for information security were designed to demonstrate the performances by which biology achieves security. Existing research focuses on borrowing partial ideas from biological systems to resolve some facet of information security in a network environment, such as intrusion detection and fault tolerance. This work uses the bio-inspired concept of the body system to demonstrate an information security model that makes use of the immune system. The white blood cells (leucocytes) produce the antibodies (lymphocyte) that fight against all antigens (foreign materials) and kill them. The skin layer of the body contains keratin that prevents microorganisms from penetrating the body. The authors relate the processes in biological systems to information security using mechanisms of the immune system in molecular biology as the key paradigm. Theory of set and algebra were used to describe the relationship between the immune system and the information security model. A simple simulator was developed to demonstrate the operation of the designed bio-inspired model. Although the simulator was tested with assumed data, the work offered insight into how the immune system of biology can be adapted to design and implement a more secure information security system.

Keywords: Bio-Inspired Concepts, Biological Systems, Immune System, Information Security, Information Security Models

1. INTRODUCTION

The evolution of computing and communication capabilities has been accompanied with an evolution in security requirements and increasing demands on security mechanisms. In early computing systems, physical controls were an effective means of protecting data and software from unauthorized access because these systems were physically isolated. Multiuser-programming and the connection of computers to networks created a need for mechanisms to control the sharing of data and programs amongst a community of users. The move to distributed systems exacerbated these problems, providing remote access not only for users, but also for attackers from anywhere in the world (Dieter & Raul, 2000).

Biological and social systems of comparable and greater complexity have self-healing processes which are crucial to their survival. It will be necessary to mimic such systems if...
our future computer systems are to prosper in a complex and hostile environment (Mark, 1998).

Computers and the information they contain are often considered confidential systems because their use is typically restricted to a limited number of users. This confidentiality can be compromised in a variety of ways. For example, computers and computer data can be harmed by people who spread computer viruses and worms. Hackers also violate confidentiality by observing computer monitor screens and by impersonating authorized users of computers in order to gain access to the users’ computers. Security in computer comes in different way: Backup, Encryption, Approved users, passwords, Firewalls, Intrusion detection, Application safeguard, etc. Network security starts from authenticating any user, most likely a username and a password. Once authenticated, a stateful firewall enforces access policies such as what services are allowed to be accessed by the network users. Though effective to prevent unauthorized access, this component fails to check potentially harmful contents such as computer worms being transmitted over the network. An intrusion prevention system (IPS) helps detect and prevent such malware. IPS also monitors for suspicious network traffic for contents, volume and anomalies to protect the network from attacks such as denial of service. Communication between two hosts using the network could be encrypted to maintain privacy. Individual events occurring on the network could be tracked for audit purposes and for a later high level analysis (Wikipedia, 2007).

The biological immune system has been successful at protecting the human body against a vast variety of foreign pathogens. A growing number of computer scientists have carefully studied the success of this competent natural mechanism and proposed computer immune models for solving various problems including fault diagnosis, virus detection, and mortgage fraud detection (Jungwon & Bentley, 1999).

1.1 Biology Security

Cell (biology), is the basic unit of life. Cells are the smallest structures capable of basic life processes, such as taking in nutrients, expelling waste, and for reproduction. All living things are composed of cells. Some microscopic organisms, such as bacteria and protozoa, are unicellular, meaning they consist of a single cell. Plants, animals, and fungi are multicellular; that is, they are composed of many cells working in concert. But whether it makes up an entire bacterium or is just one of trillions in a human being, the cell is a marvel of design and efficiency. Cells carry out thousands of biochemical reactions each minute and reproduce new cells that perpetuate life.

1.2 Immune System

In human body there is a surprising protection mechanism called the immune system. An immune system is a collection of mechanisms within an organism that protects against disease by identifying and killing pathogens and tumor cells. It detects a wide variety of agents, from viruses to parasitic worms, and needs to distinguish them from the organism’s own healthy cells and tissues in order to function properly. Detection is complicated as pathogens adapt and evolve new ways to successfully infect the host organism (Beck & Habicht, 1996). To survive this challenge, several mechanisms evolved that recognize and neutralize pathogens. Even simple unicellular organisms such as bacteria possess enzyme systems that protect against viral infections. Other basic immune mechanisms evolved in ancient eukaryotes and remain in their modern descendants, such as plants, fish, reptiles, and insects. These mechanisms include antimicrobial peptides called defensins, phagocytosis, and the complement system. More sophisticated mechanisms, however, developed relatively recently, with the evolution of vertebrates (Beck & Habicht, 1996). The immune systems of vertebrates such as humans consist of many types of proteins,
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