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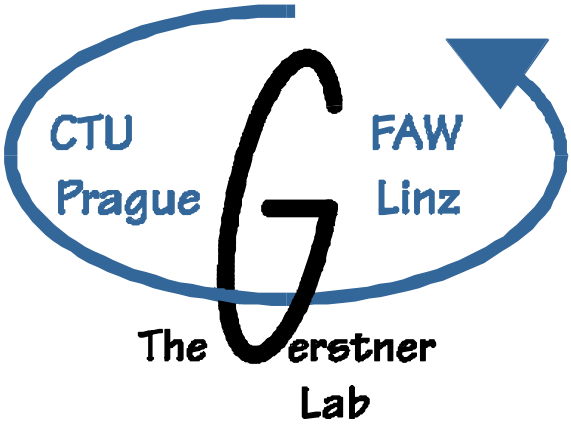

Joint Research Center of CTU Prague and FAW J. Kepler Linz

Immune System Methods for Information Security Systems

Jirí Hodík

xhodik@fel.cvut.cz

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Gerstner Laboratory
Czech Technical University in Prague
Faculty of Electrical Engineering
Technická 2, 166 27 Prague 6,
Czech Republic

http://gerstner.felk.cvut.cz

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Jiri Hodik,
Gerstner Laboratory for Intelligent Decision Making and Control
Czech Technical University in Prague
Technická 2, 166 27 Prague 6, Czech Republic
email: xhodik@fel.cvut.cz

Abstract

Immune system as model for development of information security system (ISS) is discussed in this paper. This research is part of project BASIS [Skormin], and is oriented to defense of computer nets against Denial of Service (DoS) attacks provided by malicious data packets. For some kinds of DoS attacks the defense of particular computers is ineffective and requires distributed solution. Immune systems of vertebrates contain distributed defense against intruder microorganisms and viruses. Their systems and methods have been developed by evolution for millions of years and only kinds having successful systems have survived to present days. The survived systems are self-protected and able of adaptability. But these systems have been developed for biological organisms not for computers neither these systems are perfect. We describe basic organs, cells and lower chemical structure related to immune system as well as their limitations for biological systems, and limitations of ability of defense too.

Introduction

Information security systems (ISS) are necessary for connecting computers to global computer net which is been developed from today's Internet. Due to novel communication technologies, information can be shared by not only thousands but by millions of users. While the information revolution is greatly beneficial for mankind, it does come without a drawback: it makes individuals and organizations dependent on readily available information, thus creating the conditions for information terrorism and even information warfare. Even so-called hackers, who mostly do not have any special agenda besides exercising control over legitimate institutions and individuals and gaining visibility, can cause dramatic financial losses, loss of human lives and ecological catastrophes. In the era when global computer nets became a crucial component of our civilization, our survival depends on our ability to develop successful information security systems (ISS).

ISS must be able to detect and deny attack against protected net, trace and analyze the attack and find and, if it is possible, deny attacker. ISS must be able to use information about contemporary attacks to defense against attack in the future. There are many methods how to do it. Some of them are good others are little worse. There is new branch of Artificial Intelligence (AI) called Artificial Immune Systems (AIS) [Dasgupta], which investigates and use methods developed by nature during billions of years as defense systems of organisms. These systems are very effective in detecting, analyzing and destroying intruders inside organism. In BASIS project [Skormin] they use these well-developed methods to design highly effective and self-learning distributed information security system. Whole research can be divided into lot of steps. Some of them are smaller others are bigger but all of them are important.

The best defense weapon against intruders, which we have found in biology, is immune system of vertebrates. In this paper that is one of the steps of our research we try to find analogy of DoS attacks and ISS in immune system, describe similarities and differences, and suggest the level of analogy of computational systems and immune systems of vertebrates.

Computational net is group of connected computers exchanging data. The net can be divided from other, bigger, net. Some nets are more specialized for process data (groups of end-users) others more for transport of data (providers of internet). Net could be viewed as organism divided into particular tissues, i.e. computers, which are formed by cells, i.e. programs. Others components of the organisms are chemical structures flowing round cells and used by these cells as messages and source of energy. The chemical structures represent packets sent between programs.

DoS Attacks

Definition of DoS Attack is fuzzy because everything that denies any service is DoS Attack. In this paper we assume only attacks provided by malicious packets sent between programs running on computers connected to net. We consider attackers, which are sources of malicious packet, operating outside the net that we are protecting such as attacker operating inside the net and attacking both of inner and outer side of our net. Malicious packet can cause consummation of most resources of computers that regular users are not able to use them, or crash the system. No other attacks are assumed but this paper might offer way how to find the defense against them too.

Non-conventional attributes of packets - e.g. the length of packet is big, or it is impossible to complete fragmented packet because of missing fragments or wrong description of fragments (their size and position in big packet), or the same address of source and destination.

Well-structured packets misusing some services - e.g. Broadcast and Echo services, if they are provided, can decrease computation power of net and deny the communication with rest of the world.

Well-structured packets but in big amount - Packets that each of them has right structure and looks like regular one. If they are in big amount, they flood the ability of computer to receive the packets of the same right structure but from regular users. The packets might contain IP address of computer that they are sent from or different IP address generated by attacking computer.

Filtering of and defense against the first two attacks is not very difficult. Incoming packets of first attack don't match the standards for right packets, and packets of second attack ask for services that could be easy misused. Setting standards allowing only right packets and denying all services, which are not necessary to provide, is defense good enough against most of attacks from the first and second group. Defense against attacks from third group is not so easy because each of packets match standards for right packet and is using usually provided service. These packets contain address of source but we don't know which of them are real addresses of sending computers and which of them are not. If the attacking packets contain source addresses from limited group, we don't know if this group is really attacking or attacker wants to deny our services for this (e.g. other our computers) group of IP addresses. If the attacking packets contain different source addresses, we don't know that somebody is attacking us, or whether it is too big interest of regular users. We suppose this attack the worst one since of difficult recognition of attacking packets, and the solution of problem caused by this kind of attack requires advanced solution and cooperation of distributed components.

Introduction to biology

There are many attacks that animal can meet during its life such as other animals hunting and eating it. Defense against this kind of attack is to be stronger, faster, or not to be seen. There are another attackers too. They are so small that we cannot see them and they are slower then we are. They are microorganisms and viruses. This front of fight to survive it is not out of the body it is inside. The best weapon, which one has for this fight, is the immune system.

The part of nature that is described in this paper involves biological organisms consisting of one or more cells, and viruses. Both of organisms and viruses have just one goal, to spread their genes [Dawkins]. Both of them attain it by begetting new individuals. Organisms can do it by their self, viruses needs for doing it some cell. For the making new individuals one usually abuse resources of others. This use sometimes means the damage or death for abused one but we have to know that no organism neither virus has as a primary goal to destroy another organisms. Dissolution of hosts as well predecessors is just a side effect of keeping genes for the future.

After the spending all of resources to born new generation, individual dies because it has fulfilled its sense of life. Thus every organism is only for one use. When it is run down new one replaces it. Immune system is for one use too. The organism has some resources and organism use them. Some of resources are limited and after their exhausting organism ends with its work.

Immune system has been developed during evolution and is the optimal system, maybe not for particular bodies, but for maintenance of genes of animal kinds. Therefore during construction of computation systems inspired by biological systems we have to assume here described limitations and limitations that will be discussed later. We can use principles and methods but we have to assume the area, for which they have been developed. We have not to repeat methods in parts of our computation systems, which are too different from biological systems.

Biological attacks

There are many kinds of attack against which the organism has to defense [Janeway]. Immune system fights with viruses, mycobacteria, bacteria, fungi, and protozoa. The next problem that system has to solve is cancer, which is mistake of organism.

Virus penetrates into body through one of mucous membranes. It inserts its content into cell and this infected cell stop doing right work. Virus replicates in the cell and after the filling all cytoplasm virus destroy cell membrane and release new viruses to neighborhood of infected cell. Destroying of cell membrane leads to death of cell. Attacked cells are cells forming mucous membrane, cells of liver, neurons and lymphocytes. Virus cannot move in other way than the flow of liquid in which the virus is.

Mycobacterium gets into body through lung or skin. It induces chronic inflammation and this chronic inflammation damages and changes tissue of attacked body. Attacked tissues are lungs, skin, bones, joints and any tissue where macrophages can migrate (Macrophage is cell of immune system, it will be discussed later). Mycobacterium can migrate through body only inside macrophage, which is moved in lymph or blood stream.

Bacterium - There are two ways how bacterium penetrates in the body. Mucous membrane and any damaged tissue. Bacterium produce toxins and these toxins destroy tissue and bacterium eats material of destroyed tissues. It destroys any tissue.

Fungus gets inside body via mucous membrane or skin. Fungus usually colonizes a part of tissue; consumes proteins, liquids, and salt from tissue fluids. The colonization leads to bad supplement of host tissues and their death. Fungus may use dead cells as source of energy. Damaged tissues are mainly mucous membrane, skin, sometimes lung, connective tissues and muscles.

Protozoa has two strategies, to penetrate into cells and do like viruses, or to act under discrimination of immune system and do like fungi. Protozoa can move actively and attack any tissue except bones and cartilages.

Toxins are chemical structures produced by attackers penetrating inside the organism. Toxins are trash made during the life of foreign structures, or their chemical weapons inhibiting defense reaction of immune system.

Cancer is not incoming attacker but mistake of organism. It is caused by tumor cells, which are formed from epithelial cells. Tumor cells are not attackers they are non-properly working cells of body. They stop any supporting of nearest tissues and such stop their function. Tumor cells are moved via lymph or blood flow and the cancer can be spread in any tissue in the body.

Lines of defense

Defense against intruders consist of few sophisticated systems. These systems are not dedicated just for defense; they are bounded with other organism system to form the body. This thesis doesn't describe all their functions but some of the must important functions for defense system.

First line of defense system is passive and actually is not part of immune system. Its work is to embarrass access into organism for all potential attackers. First line involves skin, mucous membranes and inside of stomach. They retard entry of microbes, as much is possible. Temperature, acidic pH of skin surface and stomach, and chemicals on mucous membrane inhibit growth and kill most of pathogens, but not all of

them. There are some pathogens, which can pass through this barrier or which use damage of this surface of organism. To deny them the body has other system, mainly dedicated to the fight with enemies present inside organism. It is immune system. This immune system use specialized organs, cells and macromolecules to recognize attack, and find and destroy attacker.

The immune system has limited ability of adaptability. When the system is "turned on", it is after the birth, system is able to recognize all enemies, which the organism can meet during its life. The number of kind of enemies is 10^9 and the immune system is able to recognize 10^{11} different possible enemy structures. Knowledge that system doesn't contain is the probability of meeting with particular enemies. System learns this knowledge during whole life of the body. At the beginning the probability of meeting with any pathogen is set to the lowest level and is increased for each of pathogen structure when the body meets it. The higher level means faster and stronger response to attack and elimination of intruders.

To set up the level to the highest one for all enemies is at first too resources consuming and organism is not able to use all energy just for the defense. How it was mentioned above, defense of particular body is not main function of animal kind. The immune system can consume maximum 2% of body energy in normal state, and maximum 4% of energy during hard attack. If it took more it would mean damage of some other system (e.g. brain damaged by high temperature). At second to set up the level to the highest one is impossible because surface of defense cells contains chemical structures that are necessary for recognition of attackers, and which can start reaction of others defense cells. In fact the reaction of other cells is necessary for ending of reaction when the attackers are destroyed, and for setting up the memory of immune system.

Immune system is not able to defense against all kinds or combinations of attacks. When the attacker is very similar to the structure of body cells, immune system can damage these self-cells. Some of attackers destroy parts of immune system and therefore system has no weapons to destroy this intruder, neither any other ones too. As was mentioned, destruction of host organism is never primary goal of intruders. The host organism is sometimes destroyed but it is just side effect of effort intruder to spread its genes.

Tissues and structures of immune system

The intruders can be present on the surface of defending organism, they can form their own cell structures in tissues and they can attack particular cells of the organism. Each kind of enemy uses its type of attack and immune system is prepared to defense against all of these types. Immune system contains centralized organs used as source and place of education of defenders, and lot of peripheral organs in the body, where the defense is organized. The peripheral organs are centers of defense for particular tissues and components of the organism. The armament of immune system include antibodies (easy chemical structures, which can bind just to some structures on the surface of microorganisms and viruses), cells hunting and presenting every no-properly working (both self and non-self) structure to other components of immune system, cells killing every cell, which is not right self, and cells helping with organization of response. Immune system is like a big machine containing lot of small wheels. Some of them are more important then others, some of them could be easy replaced, but all of them are important for good work of machine of immune system.

Central organs

Central organs of immune system are thymus and bone marrow; peripheral organs are divided into capsulated and noncapsulated. Capsulated are lymph nodes and spleen; noncapsulated are GALT (Gut-Associated Lymphoid Tissue), BALT (Bronchi-Associated Lymphoid Tissue), and MALT (Mucosa-Associated Lymphoid Tissue). Other tissues used for defense are liver and skin.

Thymus is located in chest. It is the place of T-cells formation and development, and includes T-cells in different steps of development (thymocytes: 65% CD4+Th0 and 35% CD8+), dentritic cells and macrophages. During immune reaction no cells are produced and all of unfinished are destroyed because they could be spoiled (trained to recognize enemy as self).

Bone marrow is located in tubular bones. Main function is the formation and development of all blood cells except T lymphocytes, and developing of B-cells. In bone marrow there are present progenitors for all blood cell (included T-cells).

Lymph nodes are distributed in the body and they are about 2000 of lymph nodes of different sizes. They work as filters for lymph, place of immune response inc. antigen presentation, place of antibody production (about 1/5 of antibody), and T and B cells proliferation. The functions are provided by cells present in the nodes (B-cells, T-cells, macrophages and dentritic cells).

Spleen is located at left side of stomach. The function of spleen is to be similar filter like lymphatic nodes are but for blood. There is about 1/4 of antibody produced in the spleen.

Function of **gut, bronchi, and mucosa-associated lymphoid tissues** is mucosal immune response, mucosal barrier, antibody production, and T and B cells proliferation (especially B cells). GALT are organized in Peyer's patches in thin-gut wall and they control microbic flora in gut too. BALT are placed in the walls of big and middle bronchi.

Functions in immune system of **liver** are filter for blood, especially flowing from gut, and secretion of nonspecific defense factors (e.g. opsonins – specific for some of sure non-self cell surface molecules, so no selection is necessary). There are macrophages and NK-cells present in the liver.

Functions important for immune system of **skin** are to be barrier and place of many phagocytic and cytotoxic reactions. Skin includes macrophages, neutrophils and special sets of T lymphocytes. These T lymphocytes are developed before the born of organism and are T cytotoxic mainly. Number of specificities of these lymphocytes is very small (10^9 - 10^20).

Main cells of immune systems

Immune system uses some kinds of specialized cells. The groups of them are immunocompetent cells; non-immunocompetent cells specialized for defense reaction, and other non-immunocompetent cells. Cells of first group form the core of defense army. When they are activated they recognize attackers, organize defense and destroy most of enemies. The second group is distributed in the blood and tissues. These cells inform that something is wrong and defense could by mobilized. The third group contains cells their main function is not to fight in the war but their functions are effectively used during the defense.

Immunocompetent cells are monocytes, macrophages and dentritic cells, T lymphocytes and B lymphocytes, and Natural killer cells.

Monocytes, macrophages and dentritic cells are mainly produced in bone marrow. Main function of them is to find enemy cell structure by non-self MHC-I or by bounded IgG or IgA. After finding the cell is phagocyted and in most of cases destroyed and remains of destroyed cell are present on the surface of phagocyting cell (i.e. antigen presenting cell). Monocytes are mainly present in blood, macrophages in tissues, and dentritic cells in lymph organs. Macrophages can connect into multinuclear giant cells that are able to isolate enemies not able to be destroyed.

There are two sorts of **T lymphocytes**: T-cytotoxic (CD8+) and T-helper (CD4+). T lymphocytes are mainly produced in thymus and in peripheral lymph organs by cloning from T memory cells. They are highly specific for chemical structures present on surface of other cells. The specification is given randomly and after it the selection and destruction of cells specific to self-structure, and irresponsive to anything, is done (more than 90% of them). Both of them are forming memory cells that mediate faster and stronger response to this kind of enemy in the future. This is learning of system about the possibility to meet this attacker because one met attacker is expected to be met in future again. Both of them are present in lymphatic organs, and migrate in blood and lymph streams (i.e. finding suitable cooperators, and distribution of knowledge inside organism). Tcytotoxic cell destroy virus-infected cells. Thelper cells are responsible for immunoregulation (via producing of immunomediators). They are produced in thymus and after activation changed to C4+Th0, C4+Th1 or C4+Th2. (Mechanism of changing is not well known yet.) C4+Th1 regulates chronic inflammation and C4+Th2 regulate humoral immune response.

B lymphocytes are produced in bone marrow and in peripheral lymphatic organs by cloning from B memory cell. Like T lymphocytes are, B ones are highly specific and after the developing only some of them are used by immune system. They produce memory cells too. The functions of B cells are immunoglobulin production and antigen presentation. Immunoglibulin (will be discussed later) is chemical structure bounding to specific chemical structures on the surface of cells and viruses.

Natural killer cells (NK cells) are born in bone marrow and are present in blood stream, liver and lymphatic organs. Their function is to destroy all cells having low density of MHC-I on their surface. Cells with low density of MHC-I are infected or tumor or too old cells. All of them are potentially danger for the organism and they must be eliminated.

For defense reaction specialized non-immunocompetent cells are mast cells and basophils, eosinophils, and neutrophils.

Mast cells and basophils are produced in bone marrow. Mast cells are present in tissues and basophils in blood. They look for IgE (one of immunoglobulins) bounded to foreign structure and after founding it they start inflammation reaction by secreting granules with histamine.

Eosinophils are produced in bone marrow and they are present in blood. Eosinophils negatively reduce mast cells' and basophiles' activity (and sometimes kill worms in gut) by their phagocytosis and production of enzyme destroying histamine (and surface of microbes and worms).

Neutrophils are produced in bone marrow and they are present in blood and sometimes in tissues. They highly effectively look for and destroy by phagocytosis most of bacteria marked by opsonins (opsonin is chemical structure produced in liver and specific for some surface chemicals – will be discussed later).

Other non-immunocompetent cells are endothelial cells, fibroblasts, mucosal epithelium cells, and Skin epithelium cells.

Endothelial cells are ones of cells forming vessel wall. They regulate migration of immunocompetent cells in tissues, display the site of inflation, and sometimes they are antigen-presenting cells. During defense reaction they receive mediators from non-immunocompetent cells specialized for defense reaction, and display special molecules on their surface.

Fibroblasts build intracellular matrix of connective tissue and can (vary rarely) phagocytosis cells marked by opsonins. They are sometimes antigen-presenting cells.

Mucous epithelium cells form surface of mucous tissues. Their functions are to be the barrier, production of mucus and mediators of inflammation, and antigen and antibody transportation.

Skin epithelium cells form surface of skin. Their functions are to be the barrier and production of mediators of inflammation.

Lower chemical structures of immune system

There are chemical structures, molecules, in immune system that are used for communication between particular cells, and as weapons against intruders. Immunomediators are produced and received by all cells interconnected to immune system and these chemical structures are mainly used as messages. Immunoglobulins are highly specific structures produced by plasma cells (activated B cells) and their functions are to catch, sign and inhibit abilities of intruders. The functions of opsonins are similar to immunoglobulins but opsonins are produced in liver and they are not so specific like immunoglobulins are.

Immunomediators

Immunomediators are chemical messages released and received by immunocompetent cells. Some of them are messages for tissues and structures playing role in immune reaction. There are more than 40 of imunomediators, only some of most important for immune system are presented here. They are divided into interleukins (IL), tumor necrosis factors (TNF), and interterferons (INF). The most important of them are described in tab.1 and in following text.

Immunomediator	Senders	Receivers
IL-1	Dentritic cells, macrophages, B-cells and other cells	T-cells, B-cells, dentritic cells, macrophages and many other cells
IL-2	T cells (CD8+, CD4+Th1), NK cells	T cells (CD8+, CD4+Th1), NK cells
IL-4	T cells (CD4+Th2)	T cells, B cells
IL-5	T cells (CD4+Th2)	B-cells
IL-6	Macrophages, dentritic cells, endothelial cells	Liver
IL-8	Macrophages, dentritic cells, endothelial cells	Neutrophils
IL-10	T cells (CD4+Th2)	T cells (CD4+Th1, CD8+)
IL-18	Dentritic cells, macrophages	T cells (CD4+Th0)
TNF α	T, MF, DC, endothelial cells	Macrophages, dentritic cells, neutrophils, endotherial cells
TNF β	T cells (CD8+, CD4+Th1), NK cells	Cells having low density of cell membrane (virus infected, tumor and old cells)
IFN γ	T cells (CD8+, CD4+Th1), NK-cells	Macrophages, dentritic cells, T cells (CD4+Th2, CD4+Th0), B-cells

Tab.1: List of immunomediators, and their senders and receivers

IL-1 co-stimulate T cells and antigen presentation of other receivers. It is spread in whole body to find the location of penetration.

IL-2 is broadcasted only in lymph nodes or small parts of spleen. It stimulates proliferation of all receivers (for cellular immune response).

IL-4 is produced by activated CD4+Th2 to stimulate proliferation of other CD4+Th2 and B-cells acting in humoral response. In the same time this immunomediator switches CD4+Th0 to change to CD4+Th2 and stops cellular immune response provided by CD8+ and CD4+Th1. IL-4 is used only in lymph nodes or small parts of spleen.

IL-5 stimulates antibody production of plasma cells and changes the produced immunoglobulin classes (from IgM to others). It operates in shall area.

IL-6 switches ON the liver on inflammatory response. During the receiving it liver synthesize opsonins.

IL-8 attracts of neutrophiles in inflammatory site, stimulates them to phagocytosis and their capacity to kill bacteria. IL-8 is broadcasted to whole body to involve neutrophiles into reaction.

IL-10 is released in small area of inflammation to cancel all activities of IFN γ.

IL-18 is used in peripheral lymphatic organs to switch CD4+ from Th0 to Th1.

TNF a stimulates macrophages and dentritic cells to phagocytosis and killing microbes. It is a trigger of inflamantory changes in endothelial cells that after receiving this immunomediator shows it on their surface and release information about inflammation. TNF α is spread in whole body to find the location of penetration and start defense actions.

TNF b is bounding and destroying cells with low density of cell membrane (virus infected, tumor and old cells).

IFN g positive stimulates functions of MF and DC, stops humoral response and changes CD4+Th0 to CD4+Th1. The distance of use is short.

Immunoglobulins and opsonins

Immunoglobulins are produced by plasma cells (form of B-cell). They are highly specific and bind to viruses on mucosal surface, bacteria in gut or bronchi, fungi in tissues and not-properly working self-cells (infected or tumor cells). Immunoglobulins are part of specific immune system. Main of them are IgM, IgG, IgE and IgA.

IgM is produced as first reaction during first contact to this enemy. It can touch to 10 antigen molecules and is used as scavenger picking trash in body fluids. The concentration of IgM is low (because of low population of defenders specific for this enemy).

IgG is the core of immune reaction provided by B cells. It catches 2 antigens and then binds to macrophage that destroys them.

IgE speeds reaction at second time.

IgA is placed on mucous surface where neutralizes viruses and bacteria (inhibits attachment to the cells). One IgA can bind to 4 antigens.

When the reaction against not met yet attacker is started only IgM and no other immunoglobulins are present. In few days after the first contact, and during every other one, IgM is not produced more but the production of others is started. There are about 5 times more units of IgG than IgA, and about 10^3 times more units of IgA than IgE.

Opsonin is protein molecule produced in liver. Opsonins are specific for some of surface molecules, which are presented on surfaces of bacteria, fungi and protozoa. These surface molecules could be presented on old self-cells too, actually on cells, which have to be destroyed and repleased. Surface molecules, looked for by opsonins, are never presented on properly working self-cells. Therefore liver produce opsonins without "out-going" test and opsonins are part of nonspecific immune system. They serve as flags labeling intruders and help phagocytes to find and destroy these labeled enemies.

Defense methods

The best defense system is one, which help to provide the spreading of genes and birth of new generation. It means not to be destroyed and not to have denied resources for surviving. It is valid for both defender and attacker. There are different kinds of intruders and each of these ones uses its method to penetrate in and misuse sources of host. Presence of foreign structure in the organism and its consuming of organism resources could weaken the body and therefore decrease the possibility to survive of this body. It is why the body contains immune system.

Vertebrates use immune system as a defense against enemy structures penetrating inside their organisms. System consists of few centralized structures used as sources of defense power, hundreds of checkpoints, where stuff circulating inside body is checked, and great number of defending units that are produced and organized in previous structures. The immune system has ability of adaptability, and level its capacity is proved during the lifetime of the organism. Different kinds of attacker, defense structures and units were

described in previous section. This part describes the ideas and methods used by immune system to organize elimination of anything strange.

Inner part of organism is divided from the rest of the world by skin and mucous (inner parts of lung, stomach or gut are inside body but outside organism). Some foreign structures are tolerated on skin and mucous surface but they are out of organism. Everything foreign that penetrate inside organism must be destroyed. For example some microflora on mucous surface is friend but the same one penetrating in or behind mucous is foe. Reaction to penetrating one induces reaction suppressing this microorganism both on and behind mucous surface.

Immune system is organized in network of lymph nodes and spleen. Lymph nodes are places where all intracellular fluid is filtered and then returned to blood. Any antigen is moved to node by itself or by some antigen-presenting cell and then the reaction is started. From lymph nodes there are antibody and cells organizing defense released in whole body. Defense organizing cells stop at the area where antigen is intrusion is present, and attract cells suppressing intruders.

Most of defense units (cells) are developed in bone marrow some of them (T-cells) in thymus. After the releasing, immunocompetent cells circulate through the body in blood and lymph until the inflammatory response is started. They make about 20 rounds in the body every day. Reaction of immune system consists of two parts: nonspecific and specific. Nonspecific system contains monocytes, macrophages, dentritic cells and NK-cells. These cells recognize the foreign cell by non-self MHC-I (unique finger-print of body) or by tagged opsonins or immunoglobulins (mainly IgG). Some immunoglobulins are present in the organism, mainly on mucous surfaces during all time, i.e. before the attack too. Especially NK-cells recognize and destroy cells having low density of self MHC-I. Monocytes, macrophages and detritic cells phagocyte recognized enemy structure and try to destroy it inside themselves. After phagocytosis the enemy structure is destroyed, or it infects the cell. In both cases the antigen is presented on the cell surface and this cell is named Antigen Presenting Cell (APC). Another APC is B-cell after the first contact to antigen. All these cells that could be APC contain on their surfaces MHC-II structures. MHC-II is used for cell recognition by T cells.

Scenarios of defense

When the antigen is presented at lymph node to lymphocytes (T cells and B cells), specific immune response is started. At the beginning all components recognizing foreign structure are activated but only some of them are effective in their actions. The meeting to antigen causes proliferation of successful cells and this positive feedback rapidly increases level of effective defense. In addition to proliferation activated cells produces immunomediators coordinating defense. Besides these function immunomediators inhibit activation and therefore proliferation of other, in this battle not so effective, cells. This negative feedback guarantees only effective defense. There are three main scenarios of defense. There are Hummoral Immune Response (HIR), Cellular Immune Response (CIR) - chronic inflammation, and CIR antiviral response.

HIR is used to eliminate enemy structures present out of the cells. In this case APC is mainly provided by B-cell. This cell, after the contact to antigen of its specification, stays at lymph node (or spleen) and waits for CD4+Th2 having right specification. If the contact is not done until approximately 100 hours, B-cell switches itself to anergy state and it cannot be used by immune system again. If this APC B-cell has a contact to right CD4+Th2, this T-cell produces immunomediators, which activate all APC B-cells in its neighborhood and proliferate. Activated B-cells divide into new generation of B-cells and main part of these cells become plasma cells others are memory cells. Plasma cell produces immunoglobulins (IgM at the beginning, others after the switch by mediators). Production of immunoglobulins is very exhausting therefore plasma cell dies within two days after the activation. Memory cell is pre-prepared reaction for the contact to this antigen in the future. Antibodies bind to specific enemy structure; IgG tagged structure is destroyed by macrophage invited to this area, and IgA tagged structure is denied to bind to any other structure. Phagocyting cells move in this area because of they look for local maximum of some immunomediators released by T-cells. After the antigen presentation some CD4+Th1 are activated too. Their immunomediators are turning off the reaction of CD4+Th2 but during the presence of antigen their influence is low to be important. When the antigen is destroyed no new T-cells are produced, and present CD4+Th2 are turned off by immunomediators from CD4+Th1. CD4+Th1 are turned off by

immunomediators from CD4+Th2. Plasma cells die in short time, and other B-cells are suppressed by another B-cells reacting to parts of their antigen receptors. This negative feedback inhibits the number of new B-cells to the level that doesn't cause false reaction but provides quick response to attackers present next time. After the end trash is cleaned by macrophages and organism contain new T and B memory cells that provide faster reaction again this kind of enemy in the future.

CIR-chronic inflammation is used to eliminate enemy captured by macrophages mainly. APC is recognized by CD4+Th1 and reaction is provided by invited and stimulated macrophages. CD4+Th1 proliferates and forms new CD4+Th1 and memory cells. All of them have the same specification. In special case, when macrophage is not able to destroy phagocyted enemy structure, CD4+Th1 produces immunomediators that tell macrophages to form Multinucleated Giant Cell (MGC). MGC consists of more macrophages and has bigger capacity to destroy phagocyted enemy. If the power of MGC is not big enough (after weeks and moths of fight), CD4+Th1 order MGC and other close macrophages to mineralize. The area is lost but the enemy is isolated and denied to hurt the rest o organism. The end of this CIR is similar to the end of HIR. After antigen presenting some CD4+Th2 is activated and when enemies are destroyed these T-cells help to finish reaction.

CIR-antiviral response is used to destroy viruses and some protozoa infected cells. APC (mainly dentritic cell) is recognized by CD8+, which proliferate and produce new CD8+ and memory cells (with the same specification), and destroys infected cell.

Imperfections of immune system

Immune system has some weaknesses and intruders take this opportunity. In this part we describe only some of them that we assume being the most interesting for ISS development.

B-cells are not so specific like T-cells are, and immunoglobulins from one B-cell can bind to less similar structures than T-cell activating this B-cell is able to recognize. When enemy structure is similar to self-structure, activated B-cell produce immunoglobulins binding to the self-structure too and this tagged structure is destroyed by macrophages. Immune reaction is suppressed by other B-cells and intruder can continue in the attack. Other attack is based on suppressing of ineffective defense. Attackers, or infected cells, produce immunomediators that inhibit immune reaction of, for attackers danger, defense systems. Another attack destroys T cells because immune reaction is organized and in some cases provided by T-cells too. If the attacker destroys this part of defense, organism is not able to eliminate any foreign structure. It means surviving inside body for any, not only defense destroying, intruders. For the body it means damage and death by exploiting of all resources. Another problem, which the defense system is not able to solve quick and effective, is deadlock of T-cells during simultaneous viral and bacterial attack. Both CD4+Th1 and CD4+Th2 are activated and both of them produce immunomediator inhibiting work of other T-cells. Response to attack is slow and intruders are able to made worse damage than in case of separate attacks.

Immune system is able to fight with attackers, their first attack is survived and attackers are destroyed. Attacker, which is not destroyed, is not knocked down. This attacker is only temporary denied to spread in the organism. The temporary sometimes means until the end of life (some kind of hepatitis), sometimes the denying is temporary decreased and attacker has a while for its action (herpes simplex virus), or immune system is not able to destroy attacker and this destroy the organism later (HIV). The immune system is not able to inhibit these attacks and the organism is stigmatized until the end of its function, or destroyed. Otherwise, most of these attacks damage only particular bodies and doesn't inhibit spreading genes of kind, so the evolution-developed defense is adequate. Other these kinds of attack look to be very dangerous for the future of kinds. Our organism developed the organ that is by the way able, as we hope, to develop defense against them. It is brain.

Information security system against DoS denies all packets, their structure match to some of known patterns of known bad-boy packet. The security program (neither immune system) is not able to recognize that some action is attack until the system knows the conditions of attack (structures that are not known as self or are recognized as danger, or definition of denied service). Computer programs and packets don't have MHC. So if we have list of results of attack (or something magic saying that there is some problem)

we know there is some problem. But until we have something that says what causes the problem, we are not able to find and destroy it. In computer systems the most of attack is deadly during the first attack (computer could be restarted but the data may be lost, stolen or changed - it is deadly for people). The defense is done by security systems, their abilities are increased by vaccines. After receiving pre-prepared vaccine the software add new information to its database, like immune system prepare itself for the future fight to this attacker. Until the vaccine is prepared computer is not able to defense this attack. After the receiving the vaccine the response is fast and attack is destroyed immediately.

Conclusion

We suppose big system containing great deal of computers and lot of processes running o every computer. We supp78f -0.2243 T
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