Towards a Cloud-Based Cyber War Simulator

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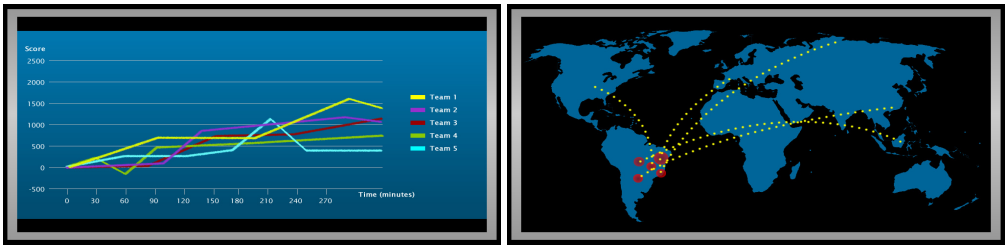

Figure 1: *Report Screen*

Abstract

Everyday more confidential data are brought to computers. Leak of those data is a critical concern to nowadays organizations. Fuel level, water and power distribution, location of supply, armament and specialists, tactical operations, control power plants and stations and war plans are just part of a growing list of targets. Due to the outstanding need of control the technology of cyber war simulations to train professionals, civilian or military, we have developed this work. Exercises with simulated attacks have been teaching people about the attacks and vulnerabilities and how to deal with them in a theoretical way. Our proposal uses the idea of an isolated simulated environment with real world threats to instruct the participating teams even more effectively. It is important to emphasize the requirement of an implementation that facilitates the scalability and the ease to access the system from anywhere, thus the players can attend the training from different centers, and the cloud computing approach satisfies these requisites. The cloud-based cyber war simulator uses intelligent agents to manage the interaction between the attacker machines and the player machines.

Keywords:: cyberwar simulation, cloud computing, real-time attacks, multi-agent-based system

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1 Introduction

The internet is a constantly growing process. With Softwares updating, new languages being used and different techniques being applied, each part of that organism evolves separately to compose a symbiotic complex network. But this sprawl has drawbacks. And in a world so dependent to the world wide web, cyber threats can materialize in the worst ways possible. Hence malwares, DDoS, phishing, trapdoors, logic bombs and others, bring concerns from the public and private organizations to ordinary users.

Globally, cyber crime has affected about 556 million people each year, causing losses to reach US$ 110 billion, 8 billion in Brazil alone. In the face of threats, many countries have organized and prepared for an imminent cyber war. China has recently formulated a framework of cyberattacks implemented to train officers and conduct drills and military exercises. In the United States, the Pentagon reported interest in investment in developing tools for cyber warfare. In 2007, Syria had its air defense network compromised then could not react against bombs from the Israeli Air Force. Estonia had hit by a collapsing DDoS that makes their online banking, newspaper's website and government's electronic services practically inaccessible. Georgia also suffered with this type of cyber attack, simple and, sometimes, fulminant.[Clarke 2010]

Aiming a training for a possible cyber war, is presented in this paper a cyberwar simulation system model. The simulator is based on cloud computing due to its various advantages such as availability and scalability in addition to the cost of the infrastructure be vastly reduced. The paper is organized as follows: section 2 presents the work related to simulation of cyber attacks. In session 3, it showed details about the model of the system architecture. Session 4 provides details about the model of the system design. The section 5 presents the conclusion of this article and shows the objectives and benefits of the proposed model, and suggest future work.

2 Related Work

The use of simulators for training on cyber warfare is not a new proposal. Several research about simulations are being carried out. We can quote Ariel Futoransk et al. [2009], which proposes the "Insight", a framework that is centered on the point of view of the attacker and is based on a probabilistic model of attacks and using this model of attacks the simulator does not become so realistic. Our model however, attempt to focus on the two sides of the simulation, both the side of the attacker and the defense, it also makes use of a multi-agents based system, using intelligent agents to simulate the attackers, so it creates a real system, since agents can learn on each simulation, making it different and more challenging than the last.

There are also commercial applications that are being developed especially for armies governments to prepare for potential attacks. Although there are not many details in the literature on these types of simulators is possible to see that Isarel's is among the greatest simulators, maintained by Elbit Systems [Elb] that is used by the Brazilian armies nowdays, [CDC]and there is no Brazilian literature on the subject.

3 Architecture Model

While developing this work, one of our main concern were that the simulator could be accessed from anywhere, allowing different centers to participate on the same exercise, making it more realistic. Having this in mind we built all the virtual machines on a private cloud server. The architecture is specified in Figure 2

The main subsystem is the SysAdmin. It is used to manage all the exercise, choosing the training scenarios, numbers of players and attackers, time and etc. This machine is also responsible for generating and show the live reports (explained in details later) using the logs received from SysConfig.

SysAttacker machine will simulate an attacker and the numbers of machines will be choosen by the Administrator on the configuration section. This system will act like a real attacker, simulating all the steps for a successful penetration, since the reconnaissance until the real exploitation, using real vulnerabilities. This subsystem connects directly to the database where the exploits are.

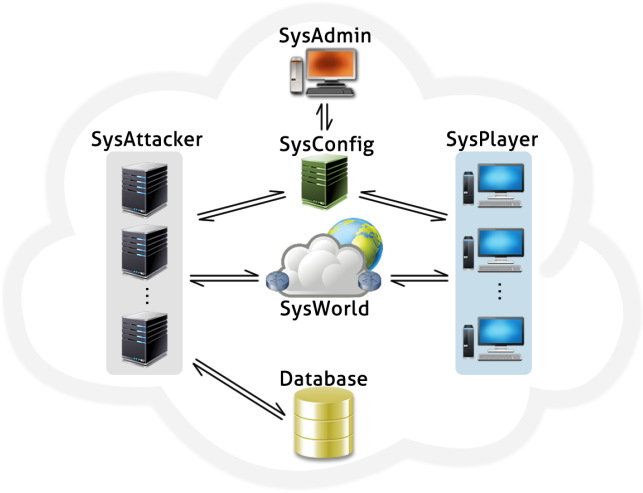

Figure 2: *Cloud Achitecture*

The SysWorld is a virtual machine responsible for simulating all the communications, i.e., real world routes, email, telephony, etcetera. It can be configured for different kinds of exercises, since attackers on the same network as the players, until attackers on the other side of the world, simulating the use of proxies, tunnels passing through internet providers, firewalls and all the sort of network devices. This part of the simulation is useful when training how to protect from internal threats or how to trace the origin of the attacks.

The SysPlayer are vulnerable operational systems controlled by the teams. The vulnerabilities are dynamic, choosen by the Administrator through the SysAdmin. The players must fix the vulnerabilities before the Attackers exploit them. As the simulator is built on the cloud, teams can access it from different trainning centers around the country through the internet.

SysConfig machine handle the configuration files generated by the SysAdmin and do all the communication between both SysAttacker and SysPlayer, setting the configurations and also querying for new information for state updates.

4 Design Model

4.1 Agents

A Multi-agent system is used to control the exercise, setting up the configuration on each virtual machine. This task is accomplished using a multi-agent system (MAS), in formal definition, it is a system composed of multiple interacting intelligent agents within an environment [WEISS 1999]. An agent is a computer system that is situated in an environment and is capable of autonomous actions in this environment in order to accomplish its design objectives [Wooldridge 2002].

The synchronization of the agents is fundamental for the simulator itself and for a better learning of the agents. Each machine has many intelligent agents, in particular one that controls the other agents and its own machine. Among others functions, the agents must control and monitor.

4.1.1 Control and Action

The Control Agents set up the machines that are involved in the simulation.

On the Administrator's machine, these agents have the function to send beginning or ending signals of the simulation, besides the function of managing the initial set up configurations. In fact, these settings can be changed at any time, thus the Administrator can set the difficulty level of the training.

On configuration machine, Control Agents delegates the actions that the agents on another machines conduct since the beginning of the simulation until the end of that, but the initial set up of the exercise is dictated only by the Administrator, while during the simulation, besides the Administrator interference in the actions, the agents analizes the state, i.e., signals sent by other agents, and delegate the tasks to be performed.

In defense machines, the agents configure which vulnerabilities are enabled and which are disabled, and also monitor if the integrity of the defense machines is mantained, i.e., if the enabled services by the agents are still working and vulnerable, whether they are disabled, etc., thereby sending signals of the machine state where it is situated to the configuration machine that delegates what action should be taken.

On each attacker machine, this agents configure which attacks are made, for how long and at what intensity they occur, which exploits are used, which others attacks machines is assisting during an attack, originating, thus, a distributed attack.This machine also have Attacker Actions Agent who will be responsible for making the attack on the stipulated targets using the information collected by the monitoring agents, these intelligent agents adapt to the environment and thus, they can choose the best strategy to efficiently dominate the target, if succesful, its implements these backdoors or logic bombs; and contain Defense Actions Agent that are able to prevent attacks on the Attackers machine to succeed, making decisions on how to proceed in case an attack against them is occurring.

4.1.2 Monitoring

The Monitoring Agents will make the analysis of the activities, such as network traffic, which occur on each machine during simulation to generate reports and logs, and populate the memory of all agents.

On SysAttacker machines such agents monitor attacks indicating the final result, whether the attack was successful or failure. In case of success, how long it took to reach the goal, how much computational effort was required to make the attack and if the attacker machine had been compromised. In case of faillure, a simple report about what had been done.

In the SysPlayer machine, the agents will monitor the activity of the machine player, i.e., how much time was required to detect a current attack, how many vulnerable services were exploited, which services are active and secured and how long it took to fix them, which tools were used to block the attack and which were these.

In the SysConfig machine, these agents will gather and organize all the information passed by the Monitoring Agent of the other machines to build the graphics and pictures of the activities that will be displayed on the monitor of the Administrator.

The Monitoring Agents are sentries that are active throughout simulation, analyzing each step and activity occurred on the machine where it resides. All this information will be available for the Administrator to visit at any time of the simulation and to be used by the agents on the SysConfig machine.

4.1.3 Report/Logs

The main simulation's goal is training people cyber defense and, in order to get the best of this learning experience, is required beyond good simulations, a post-simulation analysis that can be studied to fix the mistakes made on the training. A close look into the participants during the training is important to improve the capabilities. Hence, a variety of graphics and reports are generated during and after the simulations.

Live reports show what is happening during the exercises and is used by the Administrators so they can evaluate how the teams are handling the attacks and doing their defenses.

Among the informations available on this reports is possible to verify the network traffic, which teams were attacked, which services are still vulnerable. For this will be used an evaluation system, explained later. With this informations the Administrator can verify which team were more active during the simulation, which strategy they are using, can also identify network traffic peaks, protocols usage and more.

The post-simulation reports, is used for the Administrators so they can statistically evaluate what happened during the simulation. Informations about what kind of attacks were the most efficients, possible damage caused, what threats were easily defended and a parallel with the previous exercises to see if the teams are going better. The Administrator can also see traffic patterns and which actions were taken to solve a problem. Thus the weaknesses can be improved.

4.2 Database

The attacks that will be made by the simulator will vary in each scenario. New kind of attacks may be included or excluded according to the need of the Administrator. This is possible with the use of a database of vulnerabilities. It contains two important types of information, what vulnerabilities exist and what their exploits. The first piece is important because it is from the Administrator chooses which kinds of vulnerabilities the teams have to defend, and the second contains the necessary information on how attackers exploit them.

4.2.1 Vulnerabilities

This database holds all the information necessary to create vulnerable environments. With this, Administrators can choose which type of attack the teams will have to protect from. The information about each vulnerability are: type (i.e., stack exploits, format string exploits, xss, phishing, etc.) and difficulty. The agents explained will be responsible for executing the appropriate attack.

4.2.2 Exploit

The exploits database will store the information necessary to perform the attacks. Based on intelligent analysis, the AttackerVM will discover the flaws in the players systems and use the correct exploit for that. The main information in this database is: which exploits work with a specific vulnerability.

4.3 Evaluation System

For a better analysis on the performance of teams during the exercises, the intelligent agents queries for different types of states on the SysPlayer machine. Depending on their states, a team scores or gets a penalty.

4.3.1 Services are active and vulnerable

The exercise starts with all choosen services active and vulnerable. This is the worst case, since the begining, the teams must work on fixing all they can without compromised the services.

4.3.2 Services are active and not vulnerable

The best situation is when services are active but not vulnerable. It is considered ideal because the services are protected and available.

4.3.3 Services are not active

Disabling the attacked services is not the best way to protect the machine, because in this way the teams can avoid being attacked, on the other hand it fails to provide the services. A strategy must be used to analyse what causes the worst consequences.

5 Conclusion and Future Work

We take this as biggest incentive to study the need for the country has to dominate this type of technology. Most articles related to the subject, consulted for this research is about developing simulators, some already in operation, originating from other countries.

As mentioned in the introduction of this paper, one of the requirements is that the simulator could add in one battle simulation, people across different training centers. The choice of implementation on a private cloud server was the best option among surveyed, as was shown in the architecture model session.

The use of a multi-agent system in based came naturally during development of the work, when the team realized it would be more real if the battles become more hard over time. The implementation model can be seen in descriptions of the Control Agents, Monitoring Agents and Action Agents, on the fourth session.

For the reason we have not found descriptions of other simulations involving cloud computing and multi-agent based systems, we can say that these are important contributions made by our research.

The Administration and maintenance of networks in a situation of cyber attack depends not only on IT professionals, but also the top decision makers of the institution. With that in mind, we have as future work the suitability of this simulator training to include this type of exercise. In this type, do not interest them how the attack occur, but what consequences it brings, i.e., what should they do in case of a global communication attack or take down of the electric company. Thus, the top decision maker could measure the consequences of a resolution before it happens in real world.

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