

A Honeypot Implementation as Part of the Brazilian Distributed Honeypots Project and Statistical Analysis of Attacks Against a University's Network

Claudia J. Barenco Abbas, Alessandra Lafetá, Giuliano Arruda

Universidade de Brasília – UnB – Laboratório de Redes de Comunicação – Campus
Universitário Darcy Ribeiro – FT CEP 70910-900 – Brasília/DF – Brazil

Luis Javier Garcia Villalba

Universidad Complutense de Madrid – Departamento de sistemas informáticos y programación
– Facultad de informática

Facultad de Informática, Despacho 431 – C/ Profesor José García Santesmases s/n
Ciudad Universitaria – 28040 - Madrid – Spain

Abstract. This paper intends to describe the deployment of a honeypot at University of Brasília (UnB), by configuring an unique machine as part of the Distributed Honeypots Project from the Brazilian Honeypots Alliance. This work initially presents all the tools needed to implement the honeypot environment, as well as the implementation itself. Afterwards, the collected data about the attacks and their analysis are presented. Finally, final statements are made and future works are suggested.

1 Introduction

Security is becoming an essential part of Information Technology, due to the increasing number of attacks, which threatens institutions and their assets. Consequently, these organizations invest in new tools developed by universities and research centers, especially directed to defend their interests by defeating hackers. Among the resulting technologies, we can find the honeypots, main subject of this work.

Basically, honeypots are lures, security resources, vulnerable by nature, designed to track the steps taken by hackers when they intend to attack a system. In a higher level, they can be connected to create a whole network, as has been made by the leaders in network security development, who founded the Honeynet Project [1]. In order to coordinate the researches around the world, they have set up the Honeynet Research Alliance, which takes in projects from many countries as part of the group, including Brazil.

With the objective of increasing the capacity of incident detection, event correlation and trend analysis in the Brazilian Internet space [2], the Honeynet.BR

Project [3] (Brazilian member of HoneyNet Research Alliance) team has created the Brazilian HoneyPots Alliance, which deploys a network of distributed honeypots, with the intention of analysing the traffic in Brazil, considered to be the biggest source of attacks. The Distributed HoneyPots Project is coordinated by NIC BR Security Office (NBSO), the Brazilian CERT, and by a research center called CenPRA (Renato Archer Research Center).

To achieve its goals, the Project's coordination is working to cover most of the Brazilian IP address space by setting up honeypots in a great number of Brazilian institutions, which contributes to the honeypots' maintenance with the allocation of resources and staff [4]. In order to make the deployment easier and to help with the procedures of updating, data collecting and management of several honeypots, these institutions must follow a configuration standard.

The collected data, besides being used locally for analysis of attacks against each institution, are also unloaded for a central server, where they are sanitized and stored in a database. A summary of the data of each institution is published daily, allowing all to follow the current activities in the honeypots of the distributed network. The Distributed HoneyPots Project also works to build a central data analysis' system to facilitate the study of attack trends and correlations, and to operate jointly with Computer Security Incident Response Teams (CSIRTs) with the purpose of disseminating the information acquired [3].

In this paper, we initially intend to show how we have implemented a honeypot at UnB following the procedures to become a member of the Brazilian HoneyPots Alliance. Then, we present a statistical analysis of the activities observed in our honeypot during a one-week period. This analysis has allowed us to identify some of the risks the university's network may be undergoing.

2 The HoneyPot Environment

For the future members, the Distributed HoneyPots Project's coordination offers a personalized version of HOACD, which contains all the tools needed to implement the honeypot, as well as all the needed configuration files, already in accordance with the Project's standard. HOACD was developed by the HoneyNet.BR Project team as a basic tool for implementing a low-interaction honeypot that runs directly from a CD, and stores its logs and configuration files on the machine's hard disk. A public version is available at their site [3].

HOACD uses the OpenBSD operating system, the low-interaction honeypot Honeyd and the user-space ARP daemon Arpd – HOACD means Honeyd, OpenBSD and Arpd in a CD.

2.1 Configuration of the Environment

UnB was invited by the Distributed HoneyPots Project to join the Brazilian HoneyPots Alliance. Therefore, a contact was established with CenPRA and NBSO in order to point the requisites needed to join the association. The requirements are:

- A machine with at least a 150 MHz processor, 64 MB RAM memory, IDE or SCSI hard disk with 512 MB capacity, NIC and CD-ROM drive;

- A CIDR IP range with at least 16 addresses with unrestricted access at the institution firewall.
- Definition of the participants of the Project's discussion list. All must have a PGP key to read summaries.

The next step was to set aside a machine with the following configuration:

- AMD Athlon XP 1900+ 1.6 GHz;
- 256 MB RAM memory;
- IDE hard disk with 40 GB;
- VIA VT86c100A Rhine-II PCI NIC;
- LG 52x CD-ROM drive.

Considering the access control to the hardware, it was defined that the machine would be installed in a UnB laboratory so that it would be under vigilance most of the time. The IP range was reserved, separated in a VLAN to avoid the excessive broadcast packages. One of the IP addresses would be used as the machine's real IP and the others would be configured as virtual honeypots. It was observed that the IP range wasn't being filtered by the laboratory's firewall.

For the institution to become part of the Alliance, it was necessary to define a designation to the honeypot, identifying it at the summaries sent to the discussion list. As the possibility of another honeypots to be installed in the same institution exists, this identification couldn't be too much generic.

With all the data and requisites in hand, a hyperlink to an ISO image from HOACD was given by the Distributed Honeypots Project's coordination. This file is personalized to each organization, differently from the one on the Internet [3], which is a public version for tests. Later, the installation of HOACD was done. All the steps described in the installation instructions were followed, including the suggested sizes for the hard disk partitions.

As the installation was concluded, the Honeyd configuration file was changed in order to have a more personalized and diversified environment. This configuration will be presented in the next section.

After the honeypot configuration was finished, tests and remote checks (from NBSO) could be done. The daily rotation of logs could be checked after some days – HOACD is configured to rotate the system's logs every day, generating new log files and compressing the old ones, so as to facilitate the process of collecting and to save space in the hard disk. Thereafter, the honeypot was subscribed at the central server and the remote monitoring and periodic remote status check were started.

We observed that there was another filter at the university network, which wasn't letting packages destined to some ports to pass. Hence, the total deliverance from external traffic was made available. Even with these changes, there was still a filter located at the National Research Network (RNP) backbone, of which UnB is part.

While the RNP's filter wasn't released, it was decided to collect and analyse the data available, even if it did not represent the whole universe of attack sources. From the data we had, the majority of the source addresses were from UnB and just a little bit from the rest of Brazil, what is explained by the existence of the RNP's filter. For that reason, it was decided that only logs from foreign activities would be used as the database for analysis.

When the filters were all set, the daily data collecting service and summary generation were set up within the Alliance, as well as the subscription of a responsible person for this honeypot in the discussion list. From this moment, the institution was

definitely considered as an Alliance's member and started to receive the several honeypots summaries.

2.2 Honeyd Configuration File

Because of the low risk offered to the institutions' networks, less surveillance needs, and higher maintenance and configuration facilities, the coordination of the Distributed Honeypots Project decided to use only low-interaction honeypots [5]. The solution chosen was Honeyd, an open source tool, which offers the highest number of functions. Some of them are unique, such as operating systems emulation at TCP/IP stack level and the ability of detecting any activity at any TCP and UDP port without the need of any special configuration.

Although the installation and configuration of the tools involved have to follow the standard established by the Project, the institutions are free to set up the Honeyd configuration file by their own way, defining which OS should be simulated and which service should be offered. Thus, we have configured the honeypot with:

- A Linux mail server, with scripts simulating POP3 (port 110/TCP) and SMTP (port 25/TCP) services. These scripts, which offer an interaction with the attacker and log their activity, were downloaded from the Honeyd site [6]. At first, the intruder faces a login prompt and, if his guess for the default password is successful, he believes to be connected to a true service and can try to run some commands. This will be mentioned in the analysis as honeypot 9.
- A FreeBSD ® file sharing server with a script simulating a FTP service (port 21/TCP). Additionally, the DNS (port 53/UDP) and HTTP (port 80/TCP) ports were left open. Honeypot 13.
- A Macintosh ® vulnerable workstation. There are no services being simulated but all TCP and UDP ports are open. Honeypot 14.
- A Microsoft Windows ® XP Home station (honeypot 15) and two Microsoft Windows ® 98 SE stations (honeypots 5 and 12) with a script simulating a command prompt with backdoors in six ports. This script was created by the Honeyd.BR Project [3] team and acts as a machine infected by many well-known worms such as: Blaster, Sasser, Dabber and Lovgate. It logs the commands typed by the intruder, as well as the non-printable characters in hexadecimal format.
- Three Microsoft Windows ® XP Professional stations with a script simulating a backdoor installed by the MyDoom virus in four ports. This script was also designed by the Honeyd.BR Project [3] team. It saves the files downloaded to the honeypot and logs all attempts of using the backdoor's proxy functions. Honeypots 2, 6 and 10.
- A CheckPoint Firewall-1 ® with all ports closed, except ports 23/TCP and 80/TCP, which were blocked. Honeypot 4.

The other hosts (honeypots 1, 3, 7, 8 and 11) were left with the default configuration from HOACD, which simulates a Microsoft Windows ® XP Professional station with some open ports. All these ports are greatly known as constant targets of attacks against Windows machines.

3 Results

The tool used to generate summaries and graphics from the Honeyd logs was Honeydsum v. 0.3, a script, written in Perl, developed by the Honeydnet.BR Project team. It is a free software and it is available for download at the Project's site [3].

Honeydsum organizes the data from the logs, sorting them by virtual honeypot (each honeypot corresponds to an IP address from the block of addresses monitored by Honeyd). For each honeypot, Honeydsum informs the number of connections per source IP and destination port. A connection is considered to be any access attempt to the port. Honeydsum also shows the top source and port access and the total number of connections (to all honeypots) per protocol (Connection Counter) and per hour.

Different parameters can be used as filters to produce the summaries, such as ports, protocols, IP addresses or networks. If no filter is specified, all possible information is generated. It is also possible to sanitize the IP addresses so as not to disclose the honeypots addressing. For this, Honeydsum allows to specify the private addresses that will have to substitute the public addresses.

The tool supports input from multiple Honeyd log files. If the Honeyd configuration file is also given as input, it displays the configuration of each honeypot in the summary. Honeydsum is able to generate summaries in simple text files or in valid HTML, for which it has the option to create graphics illustrating the information showed by the summary.

Table 1. Connection counter

Protocol	Connections	Percentage
TCP	7938	91,7%
UDP	418	4,85%
ICMP	297	3,45%
Total	8653	100%

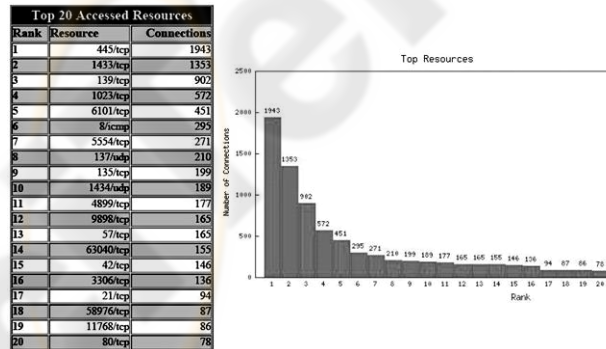


Fig. 1. Top resources

The first piece of information given in the summaries generated from the logs of the observation period was the number of access attempts logged by the honeypots in

one week: 8653, which represents an approximate average of 575 attacks suffered per honeypot. This is a considerable number, regarding that the access to the university's network was not completely released, since the filters from RNP were still blocking traffic from some sources.

By looking at Table 1, we observe that TCP was the protocol most used by the hackers. This can be explained by the fact that there are much more services that use TCP than other protocols. Although the total amount of ports is the same for TCP and UDP, for example, only two UDP ports appear among the 20 most accessed resources (considering all honeypots) in the period, as shown in Figure 1.

The next graphic (Figure 2) shows the number of connection attempts in each honeypot during the week. The eccentricity observed in honeypot 14 is due to the fact that all its ports were open. Most of the IP addresses that attacked it (Figure 3) have made much more access attempts than the average observed on the other honeypots. This indicates that possibly DoS attacks or vulnerability scans were launched against the ports that received more connection attempts in the supposed machine (Figure 4):

- Ports 445 and 139: Microsoft-ds and netbios-ns services, respectively, with vulnerabilities explored by Nimda and Blaster.
- Port 1433: MS-SQL service with vulnerability explored by SQL worms.

Another fact to point out is that all these ports are used by Microsoft® services.. According to [7], the systems of this company are the major targets of attacks, because they can resist for about 20 minutes when attacked, while Linux systems can resist up to three months. This does not prove that Windows® is more vulnerable than Linux; it only shows that it is the favorite target of the hackers.

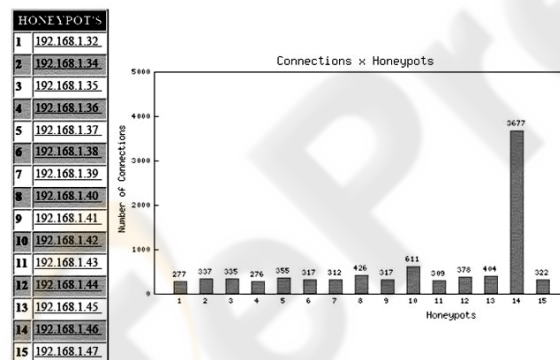


Fig. 2. Total number of connections per honeypot

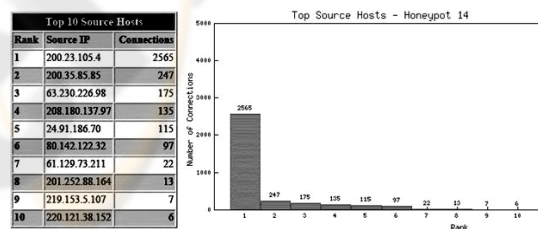


Fig. 3. Top source hosts at honeypot 14

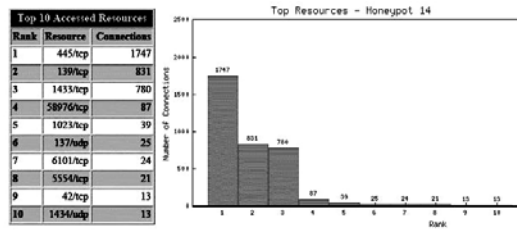


Fig. 4. Top resources at honeypot 14

The next graphic deals with the sources of the attacks. Only the 20 IP addresses that more attacked our honeypot were listed in a Top 20 graphic (Figure 5), together with the country they belong to, but the total number of sources logged during the observation period was 652 IP addresses, which gives an average of about 13 access attempts for hacker. The first source of the list is also the one that more attacked honeypot 14 (Figure 3). Probably, the difference between the number of total connections from this source and those recorded only in honeypot 14 represents the connections related to IP scans made by this source on the other honeypots. The two following sources of the list also had a number of connections above the average.

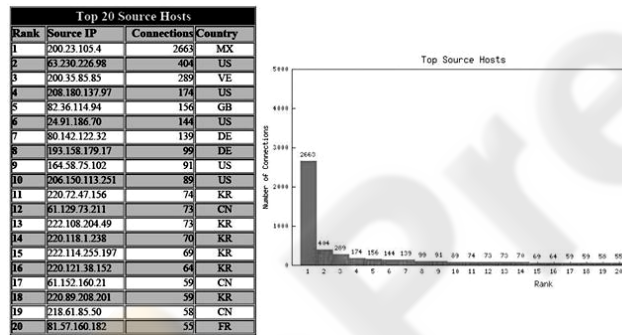


Fig. 5. Top source hosts

Table 2. Top source countries

Rank	Acronym	Country	Source IP addresses
1	CN	China	163
2	US	United States	114
3	KR	South Korea	67
4	NL	Netherlands	36
5	DE	Germany	31
6	JP	Japan	26
7	GB	Great Britain	23
8	TW	Taiwan	21
9	RU	Russia	17
10	IT	Italy	13

The acronyms of the countries corresponding to each IP address informed in Figure 5 were obtained by means of a query to WHOIS services. Table 2 shows a list of the countries that had the major number of distinct IP addresses which attacked the honeypot's environment. 51 countries were detected, but we decided to include only the top ten, because, after that, the difference between them starts to be very small.

As we can observe, the country that had more distinct sources of attacks was China, followed closely by the United States. The site [7] presents daily statistics of attacks against a honeynet that is part of the Honeynet Research Alliance. In each report, there is a ranking of the countries that had more sources of attacks on that day. China and the United States mostly appear in the first positions of the list. The site of NBSO [8] also presents statistical data that confirm that this analysis does not differ very much from reality, since the three countries subsequent to Brazil, which appear in the graphic of countries sources of attacks, are the same ones found in this analysis.

Figure 6 illustrates the number of attacks suffered on each day of the week. We could observe that the biggest amount of attacks happened in the middle of the week. The weekend seems to have had high traffic because of the data collected on Sunday; however, a detailed analysis of the logs of that day discloses that most of that high amount of attacks (66%) was launched by a single source. That source is the same one that appears on the top of the list of IP addresses that originated the greatest number of attacks.

According to [7], the amount of attacks tends to be lesser at the weekend. Considering the fact that at the weekend the offices are closed and, therefore, a great number of machines are off, we conclude that most of the attacks come from organizations that do not have good security mechanisms.

This analysis also showed that the top source concentrated its attacks on honeypot 14, more specifically on ports 139 and 445. Moreover, observing previous logs, it is verified the presence of IP scans carried out by this same source, initially with ICMP packages and later in TCP ports 1433 and 57. Superficially, we might conclude that the attacks to honeypot 14 were originated from the previous scans, because this honeypot was the only machine to which the source could establish a connection. Although normally the attacks are carried out in ports that have been scanned for vulnerabilities, there is also the practice of attacks that vary the ports during the footprint. Thus, there may be a link between the scans and the attacks.

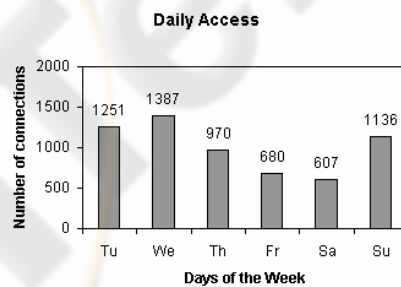


Fig. 6. Connections per day – Monday does not appear because the observation period covered only parts of that day

4 Final Statements

With the inclusion of UnB as a member of the Brazilian Honeypots Alliance, it will be possible to follow new research and technology development lines at the information security area. Thus, it can be said that this project is only the beginning of a great venture from UnB. From now on, since the university network administration has a closer contact with the presented technologies, new policies could be taken on to strengthen the security.

The installed tool will be of great value both nationally and locally. To the Alliance, it will be important for being another source of data. The more distributed the network is, i.e., the more members around the country it has, the more representative will be its results. The Alliance will also count on with another research team working together on the determination of new trends in intrusions.

For the university, it will be possible to identify problems such as the most searched vulnerabilities, from internal and external networks. The existent filter on the institution router revealed itself efficient for preventing the attacks to the most accessed resources, but a honeypot could help to verify if the organization security policies could be reinforced. With the honeypot, it is possible to identify new threats and rearrange the filtering rules in good time to avoid worse consequences. It will contribute also to detection of internal attack sources and infected workstations, because, during the collected data analysis, it was verified that there is a great volume of internal attacks, which shows that the biggest risk can be internal.

With the implementation of a honeypot, there is a huge volume of data to be analysed. In one week it was verified an enormous quantity of attacks even with some filtering on the source IP addresses in order to delimit the database to only foreign addresses. The time period of a week may seem short but this interval was chosen because of the amount of information acquired in a data analysis task.

The standardization of the ingress process, from the honeypot implementation until the effective entrance, when the official Alliance summaries start to be disposed, is decisive to the good flow of the project accomplishment. The determination of the procedures to be followed helps on the inclusion of new members, as was seen during the installation and configuration of the machine. Even though, a documentation of the problems found by other members and their solutions, after which a candidate could seek, would help the project integration even more.

The complete solution for the honeypot, with Honeyd running over OpenBSD, is adequate because the first is a strong and efficient tool from its category, whereas the latter is considered the most secure OS [9]. The configuration given by HOACD looks trustful too, so that it assures the protection of the machine in that it is installed, avoiding its compromising and its utilization as a starting place for new attacks.

Finally, it was observed that the analysis tools could get better in a way of interacting more with the user. The used programs do not have user friendly interface, probably for being open source. Furthermore, its configuration is too limited and the personalization of the results requires advanced knowledge of the technology.

4.1 Future Works

At this project, data from Brazil were not taken into consideration, being analysed only foreign attacks. A new deeper and more comprehensive analysis must be done in order to examine the network activities at all.

Another job is the study of the internal attacks. This examination ought to show the most important security problems which the university has and to propose solutions, so that it contributes to a greater protection of the internal assets. In addition, other filtering can be done, e.g., to choose some kind of attack and to select only the data logged by some related ports.

Some used tools are to a certain extent limited so that they need improvements or new ones to be developed, like the simulation scripts. A good firewall log analysis tool is also needed. With more tools and kinds of log to analyse, the data collected by this project, as the ones that need more intense work, could be studied further.

In relation to safeguarding, another measure to be taken is to improve the physical access control to the machine because of the risk of a reboot or even a shutdown by others. In the circumstances of other honeypots being installed at UnB as part of the Distributed Honeypots Project, it would be interesting to deploy a log host to concentrate all the information.

As a final point, it is necessary to write a documentation of the project with regard to maintenance: everything executed should be recorded to facilitate the future works and to function as a guide to upcoming members.

References

1. The Honeynet Project. Retrieved July, 2004, from <http://www.honeynet.org>
2. Brazilian Honeypots Alliance. Distributed Honeypots Project. Retrieved July, 2004, from <http://www.honeypots-alliance.org.br>
3. The Honeynet.BR Project. Retrieved July, 2004, from <http://www.honeynet.org.br>
4. Rocha, L.F.: Especialistas brasileiros lançam Consórcio Brasileiro de Honeypots. Módulo Security Magazine, São Paulo, n. 335, 05 abr. 2004. Retrieved November, 2004, from <http://www.modulo.com.br/index.jsp?page=3&catid=7&objid=2831&pagecounter=0>
5. Franco, L.H., Barbato, L.G.C., Montes, A.: Instalação e uso de honeypot de baixa interatividade: Tutorial. São Paulo, 18 abr. 2004. Retrieved October, 2004, from <http://www.honeynet.org.br/presentations/hnbr-gts2004-01-tutorial.pdf>
6. The Honeyd Project. Developments of the Honeyd Virtual Honeypot. Developed by Niels Provos, 1999-2004. Retrieved August, 2004, from <http://www.honeyd.org>
7. Security and Information Integrity: SIG² G-TEC Honeynet Project. Retrieved January, 2005, from <http://iwfc.security.org.sg>
8. NIC BR Security Office: *Estatísticas dos Incidentes Reportados ao NBSO*. Retrieved November, 2004, from <http://www.nbso.nic.br/stats/incidentes>
9. The OpenBSD Project. Developed by Theo de Raadt, 1996-2004. Retrieved August, 2004, from <http://www.openbsd.org>