Environment for Threat Intelligence Analysis and Generation using Open Sources

J. V. C. Júnior[1] and J. J. C. Gondim

***Abstract*— Analyzing attacks on computer networks is complex given the volume of data considered and the large number of machines, even in small networks. The volume of data is large and the time to process and analyze it is short. The goal is to extract and analyze information about network attacks that has been obtained from open sources. Using a robust, elastic and scalable architecture that makes use of processing techniques with the use of Hadoop so that the information is available in a timely manner. With the proposed architecture implemented all the desired characteristics were obtained allowing the processing of the data in near real time. The system provides intelligence information about large-scale attacks with agility and efficiency.**

***Keywords*— Attack detection, K-means Clustering, Threat Intelligence, Big data**

I. INTRODUCTION

The mastery of information is a fundamental point for the evolution of humanity since its inception. Being able to analyze data on threats to systems is essential for structuring protection and recovery plans. Big Data applies information that cannot be processed or analyzed using traditional processes or tools, with the focus of the systems on obtaining the greatest amount of data on transactions and their users.

According to [7], three characteristics are inherent to Big Data: volume, variety and velocity. The volume refers to what has already been addressed about the large amount of data that are and will be generated in the future, making centralized systems unable to process the entire data set. The variety refers to the diversity of sources from which the data originates, low-level access records, location information, accelerometers, writing patterns, among others, form the origin of the information. Finally, the speed at which this data cannot be processed in the background, in an increasingly dynamic environment a few seconds can mean the loss of brand value and consequently a financial loss.

However, the processing of large volumes of data is hampered by a number of problems that need to be considered, such as shortening the access time and recording of information, consulting all the data in a large database and realizing interactive data analysis. The solution found was to divide and distribute the data across multiple disks and parallelize access to them, to reduce space wastage, access to all disks would be shared between processes and users ensuring that on average the use of this additional space is always optimized.

The main contribution presented here is to build a low-cost environment for organizing, understanding, and better viewing threats on open-source switch networks. As a long-term goal, this architecture seeks to generate threat intelligence using open sources with the capacity for abstract difficulties listed so far. Additionally, it demonstrates how the environment can be used to build profiles of attackers and targets.

This work is organized as follows: Section 2 discusses some of the works present in the literature as well as the differences between the approaches to this work. Section 3 describes the proposed architecture and its components, and Section 4 deals with the data sources used to develop this work. The results of the experiments are detailed in Section 5, and finally Section 6 presents conclusions and some final observations.

II. RELATED WORK

In the literature, there are several works that use Hadoop-based architectures, both for extraction and for analysis of large masses of data with objectives related to information security.

In Bachupally et al. [2], for example, a HDFS- and Hive-based architecture is used to process network captures for threat identification and network attacks. The main improvement pointed out by the author was the possibility of processing a large amount of data in a short period of time.

Janeja et al. [8] proposed a distributed in-trusion detection system, basing its development on the HAMRframework [12] that operates with a real-time data flow with an in-memory computing mechanism. The architecture seeks to detect multifaceted intrusions that can be distributed over time and also over the network.

In the same line Jia [9] explains about an architecture based on Big Data for the detection of Advanced Persistent Threats, decomposing its examination layer by layer and using various security techniques.

Similarly, the objective of this work is to propose an architecture for Big Data processing, based on the Hadoop suite for capturing and analyzing data related to information security. Among the differences for the related works is the simplifying factor of the analysis, allowing that without great knowledge about the architecture and processing of the data it is possible to extract information.

III. METHODS AND MATERIALS

Environment Architecture

In order to allow the insertion and processing of the mass of data obtained through the open sources, a robust architecture was necessary. Thinking about it, four general characteristics were defined that guided the development of this approach,

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are they:1. Scalability 2. Elasticity 3. High availability 4. Adaptability

Following these concepts, the system will meet the growing increase in the number of fingerprints and allow several types of analysis and an agile extraction of data in the face of the vertiginous increase in information about attacks generated daily, thus allowing the application of various techniques of analysis on the data.

The artifact chosen to compose the solution proposed in this work is the Hadoop suite that already has a distributed file system the Hadoop Distributed FileSystem(HDFS) [3], a tool for processing large amounts of data the MapReduce [5] and the Yet Another Resource Negotiator(YARN) [11] that controls the tasks executed without a Hadoop cluster. This choice aimed to simplify the management and installation of the components that make up the Hadoop cluster and centralize the control and monitoring of all services and equipment present. From this, it is possible to add and remove computers from the cluster, and also add and remove services on all computers belonging. These features allow the execution of programs in this environment to be elastic, scalable and adaptable. To ensure high availability, the cluster has been configured in a public cloud that ensures uninterrupted system operation.

Figure 1 illustrates the configuration of the complete architecture for implementing the capture system. Attack data is captured by the catcher who acts as a proxy simulating a real connection to the site providing the information, such as the LookingGlassCyber NorseCorp site. This program receives the data from open sources and creates a HTTP GET type request, then sends a message to Flume via an HTTP source.

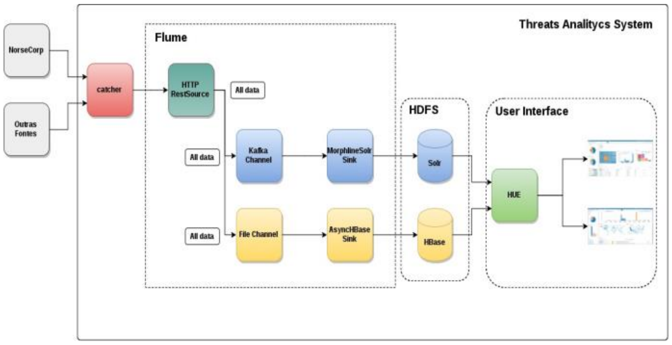


Figure 1. System architecture

This source is connected and replicating the data to two channels, Kafka Channel and File Channel. After the data is sent to these two channels, by a Flume feature, it will only be removed from the channel after it has been delivered to its respective sink. In this case there are two sinks, MorphlineSolr Sink and AsyncHBase Sink. The first one processes the data to insert them into the Solr program, the second one processes them to store the HBase program.

With all data already entered and persisted, the HUE tool is responsible for displaying this data in a clear, objective and simple way. There are countless options for displaying and filtering the data, with the user being able to extract information in real time and build up prior knowledge on a number of aspects of the captured attack data.

Data Capture

The data capture protocol seeks to simulate a legitimate connection from a browser to the data source website. Using the websocket-client library, the program creates a websocket-type connection directly to the source server. The use of this protocol as a basis for the capture program is due to the fact that most of the data sources use this protocol for communication between the client application and the server.

Many other sources of attack data can be found on the Internet, such as: 1.ThreatMap CheckPoint- [4] 2.Digital Attack Map - [1]. One of the data sources chosen was the NorseCorp website. A Cybersecurity company specializes in delivering intelligence against network attacks, security breaches, and various threats. It offers continuous network state updates through various sensors around the world.

To disseminate the technology used, NorseCorp provides part of this information through an online tool in the form of an interactive map. The site can be accessed at http://map.norsecorp.com/, being possible to visualize in real time the attacks occurring against the company's clients.

The data received by this data source is preprocessed by the company and limited.. Table 1 provides a summary of the data that is stored in the database followed by examples of values. As there was no description of the data available, it remained the observation of the data where it was possible to obtain some initial information such as the existence of redundant data such as dport and svc that always have the same value. The vector_id and type only have meaning when used inside the company page because they are used during the map design functions. Even so, all data is stored in the database for completeness.

TABLE I
DESCRIPTION OF THE DATA CAPTURED FROM THE COMPANY NORSECORP

Data name	Description	Example
_id	Unique identifier of the object in the database	ObjectId("58d1bbbf e2e558522a")
city	City of origin of the attack	Washington
city2	City where the target of the attack resides	De Kalb Junction
dport	Door on which the attack was carried out	25
countrycode	Code of the country of origin of the attack	US
countrycode2	Target country code	US
country	Identification of the country of origin of the attack	US
country2	Identification of the target country	US
latitude	Approximate latitude of the source of the attack	38.95
longitude	Approximate longitude of attack source	-77.02
latitude2	Approximate latitude of target	-44.48
longitude2	Approximate longitude of target	-75.3
svc	Service exploited by the	25

	attack	
timestamp	Date and time at time of data capture	2017-03-21 23:48:15.161973
vector_id	Information forwarded by the server for drawing on animation screen	NumberLong("3032 41862584")
org	Organization that holds the IP address block that originated the attack	Microsoft Corporation
type	Information about the company's tool that captured the attack information	ipviking.honey
md5	IP number of the machine that sent the attack	65.55.169.250

IV. Results and Discussion

After implementing the architecture defined in Section 3, data capture and ingestion began. Between the months of August and December 2017, about 14 million records of attacks were internalized.

Even with this large number of entries, the queries in the tool did not vary in their response time, displaying the result almost immediately after the filters were selected. This behavior is related to the fact that the indexing of the data is carried out at the moment of their insertion. Thus, the processing required during the queries is reduced considerably.

Google Cloud Platform was the solution chosen to host the cluster. In this environment two machines were created, a so-called Master with 2 virtual CPU's, 14GB of RAM and 100GB of secondary memory. And another so-called Slave with 1 virtual CPU, 4GB of RAM and 100GB of secondary memory.

After internalizing the data and processing them, it was observed that TCP ports with 50864 and 53413 values were frequent. Thus, two filter options were defined for a more accurate analysis: attacks that target port 50864 and attacks that use port 53413 for the same purpose. The choice of ports was based on all the previous information about vulnerabilities in these ports and because of the concentration of their source. After making this selection again, all data in the tool pane displays only the selected data.

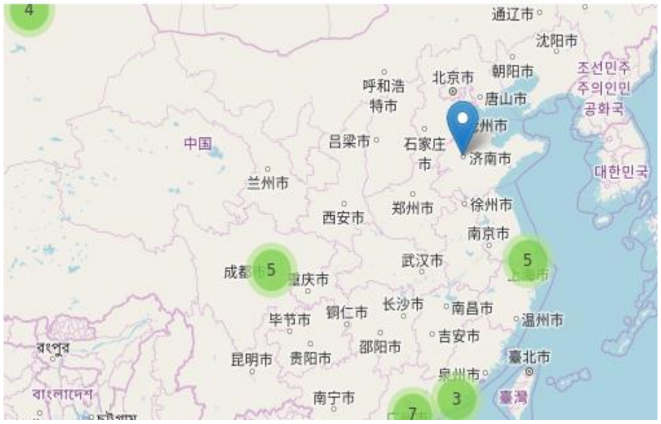


Figure 2. Region of origin of the attacks port 50864

The Figures 2 to 5 illustrates the regions from which the attacks that exploited possible vulnerabilities on these ports originated. In Figure 2, only the eastern region of China is shown where the green markers represent the grouping of cities from which we started attacks, while in Figure 5, in addition to this, the region of South Korea also appears as one of the main origins.

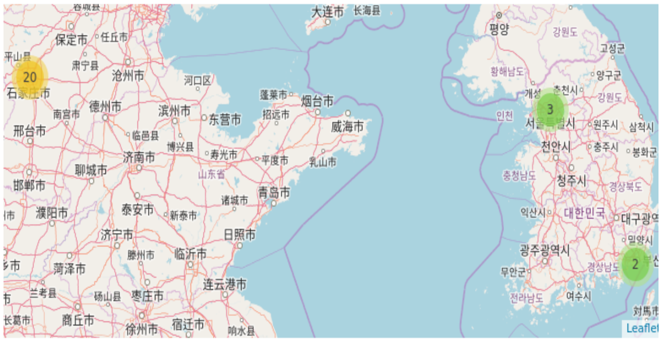


Figure 3. Region of origin of the attacks port 53413

However, the map represented in Figure 5 at the time of image capture was centered in a specific region, so it does not fully display all the countries that use this port. The Figures 2 and 3, which shows the attacking countries and their respective cities.

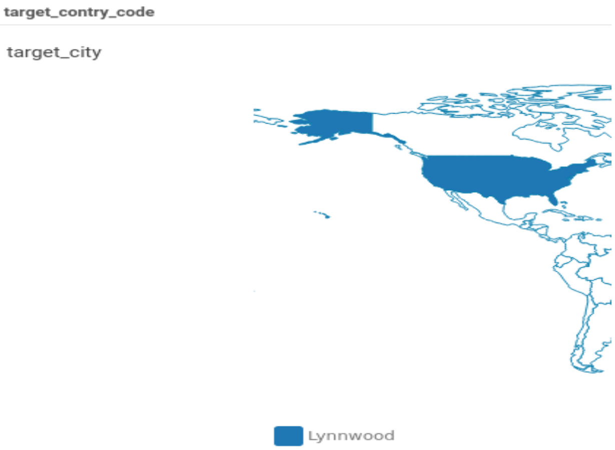


Figure 4. Country and city of destination of the attacks at port 50864

The Figures 4 and 5 below illustrates the maps that contain the information about the target cities. On the left map only the city of Lynnwood(US) appears as an attack target that has gate 50864 as its target, on the right however more cities appear as a target when gate 53413 is defined: the city of Nama(Japan), Aix-En-provence(France), Dubai(United Arab Emirates) and San Francisco(US).

The attacking cities are represented in Figure 4, where the attacks are concentrated in three nations: China, South Korea and Pakistan. In China it is worth noting that at the two gates chosen for the analysis there is a different city represented, at gate 50864 the city of Guanzhoue to gate 53413 the city of Shijiazhuang that appears as originating from the attacks.

As a complement to the information of attacking regions and cities and targets, there is also the alternative of studying the number and origin of attacks through the filter tools: attacker_country_code and target_country_code. Sometimes it is more readable to access information by looking at these fields than other tool options.

Performing a quick search, several forums and websites have emerged reporting the interest of Chinese attackers in ports with values above 40,000 with emphasis on ports 50,866, 50,864 and 54,413 [10]. Another information that emerged during the surveys was a possible backdoor in Netis routers made in China from the company Netcore Group[6], where using port 54,413[10] attackers could take full control of the device without any knowledge of its owner.

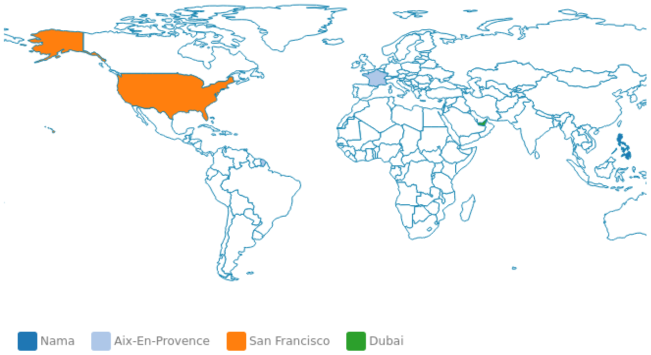


Figure 5. Country and city of destination of the attacks at port 53413

These references corroborate the results obtained by observing the data captured, and also provide new information on which countries are using these vulnerabilities. In addition to the filters for countries that appear as targets for attacks, there is also the option of filtering the countries from which the attacks originate. This option is motivated by the fact that two different countries play a role as sources of attacks. To illustrate the difference, the two largest attacking countries registered in the database were chosen, the United States (US) and China (CN).

Each filter was selected independently, and the results of the visualization tools can be seen in Figures 8 and 9. The first two tools show the ports that received the most attacks, Figure 8 refer to information about the most attacked ports by machines located in China. Figure 9 illustrate the same information only as in the United States.

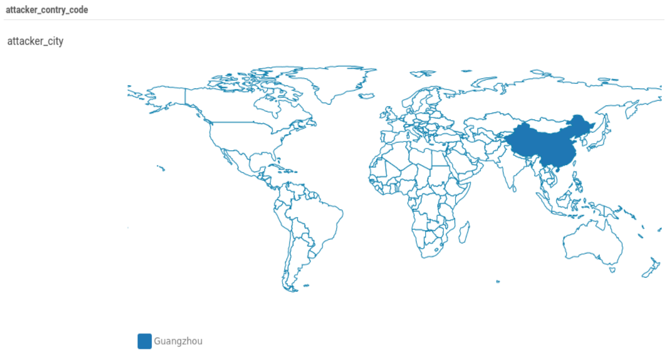


Figure 6. Country and city of origin of the attacks at port 50864

While the circle tool shown in Figures 8 and 9 is intended to show the proportion of attacks on each door by means of a circular graph, the list has an additional objective. They can be used to apply a new filter to the information already displayed in this way further restricting the application of the filter and generating new sub-sequential information.

At first glance it is evident that there are several differences between the two results, observing the circular graph it is possible to immediately extract clear information about the desired point. While attacks departing from China have multiple ports with significant amounts of attacks, the United States concentrates the attacks on one specific port, while the others only represent less than 25 percent of total attacks.

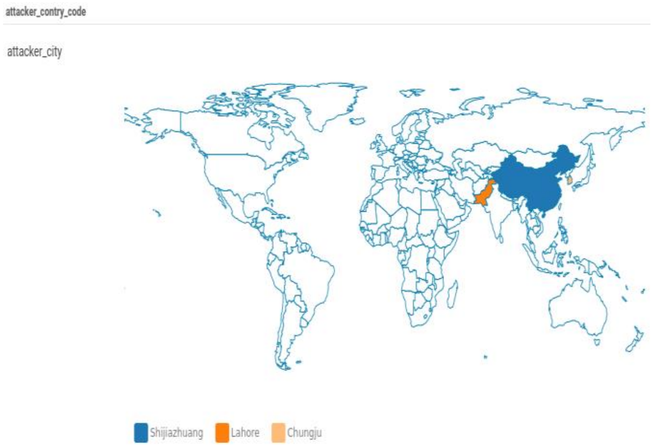
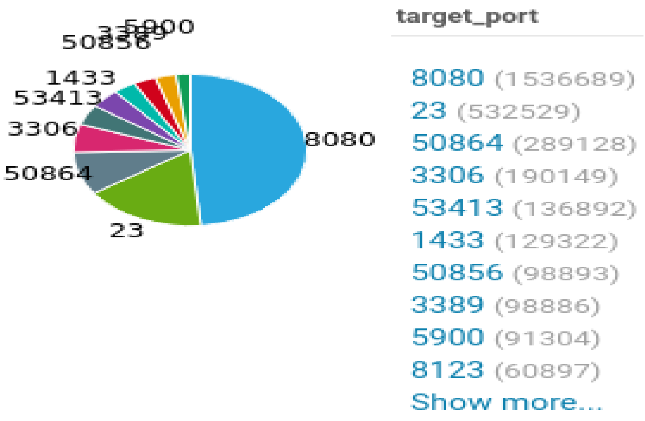


Figure 7 Country and city of origin of the attacks at port 53413

Observing the list of ports in Figures 8 and 9 the user is able to see that the port most attacked by China is port 8080 while from the United States the most used port is port 25.

Port 23 ranks second in both countries, due to the fact that this port belongs to the Telnet protocol, which in addition to being highly insecure and a constant target for attacks. It also draws attention to the fact that among the ports most attacked by the Americans, there are none that exceed the value of 40,000. But looking at the target ports for attacks from China, there are at least three ports with higher values.

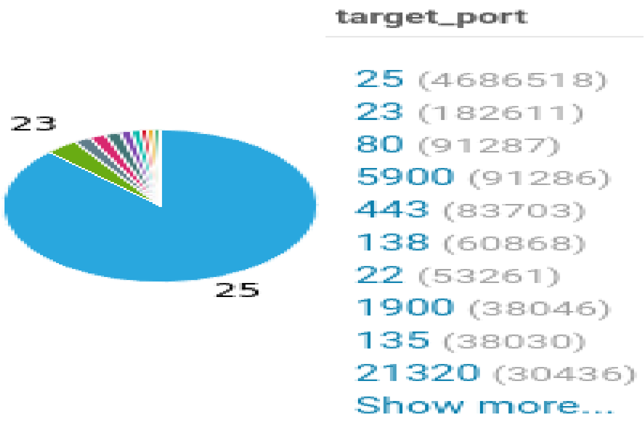


target_port

8080 (1536689)
23 (532529)
50864 (289128)
3306 (190149)
53413 (136892)
1433 (129322)
50856 (98893)
3389 (98886)
5900 (91304)
8123 (60897)
Show more...

Figure 8 Distribution and table of attacked ports from China

Continuing to scroll through the tools panel, two options for observing static maps are shown, one to represent the countries and cities that receive the most attacks and another for the cities that are the source of these attacks. With the filter properly selected, Figures 10 and 11 shows the maps that contain the most attacked cities by China and the United States, respectively. The correspondence between the cities and the countries is represented by the colors of the rectangles.



target_port

25 (4686518)
23 (182611)
80 (91287)
5900 (91286)
443 (83703)
138 (60868)
22 (53261)
1900 (38046)
135 (38030)
21320 (30436)
Show more...

Figure 9. Distribution and table of attacked ports from United States

There are several similarities between the group of countries attacked from the United States and China, such as: Norway, United States, Russia, France, Italy. With the United States, a fact similar to what happened with France, the country itself appears as one of its main attackers. In the case of the Americans, the explanation seems simpler since most of the data centers that provide Cloud Computing services are located in that country, a fact that is even more confirmed when we observe the organizations from which the largest number of attacks originate.

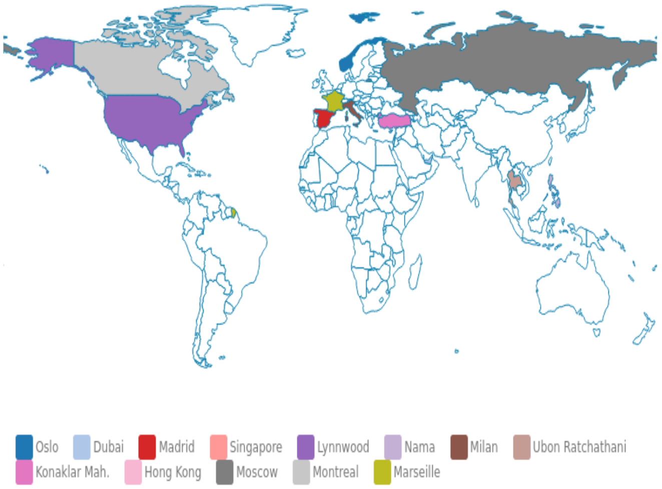


Figure 10. Most attacked cities from China

In Figure 13, the Microsoft Corporation organization holds almost all of the attackers hosted in the country. It is important to point out that, even though the company's focus is not to provide Internet access services, Microsoft has several IP ranges under its control, which are used within its Cloud services. For this reason, it is included in the list of organizations.

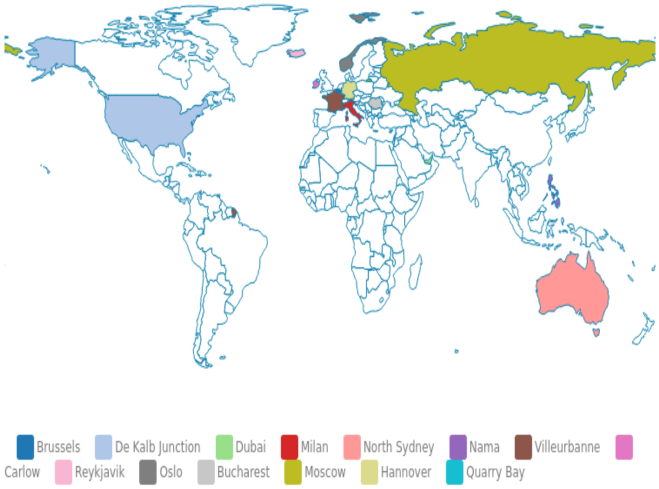


Figure 11. Most attacked cities from the United States

Finally, the last graph presented for this data selection is represented in Figures 12 and 13. It shows the ten organizations that are Internet Service Providers (ISPs) of the machines that originated the attacks captured by the tool. The names of each organization are in order below the chart and are sometimes shifted to the right.

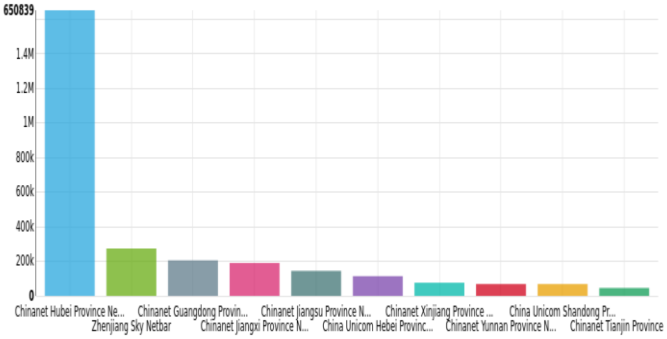


Figure 12. Top 10 organizations responsible for IPs – China

The clearest information when looking at the graph is the concentration of the attackers in a single organization for each country, with the others remaining with very low participation at this point.

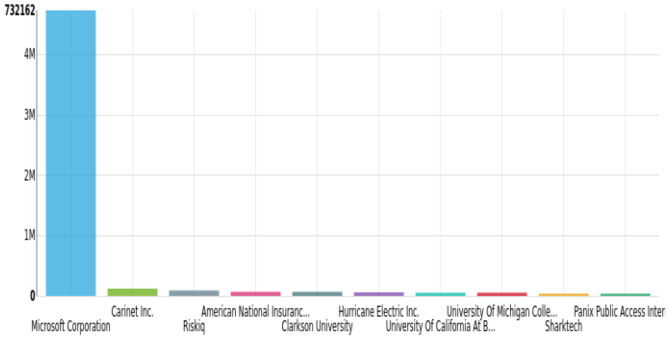


Figure 13 Top 10 organizations responsible for IPs - United States

IV. CONCLUSION

The approach adopted offers a range of possibilities that have not been fully explored given the time available for the development of the architecture and its correct functioning, but it is possible to evaluate the perspectives of its use.

The presentation of information in a visual way with simplicity and illustrations of easy understanding allow a user, even if devoid of information about how that data is being processed, can understand and interact with it. This allows patterns to be observed and that the user with his previous knowledge or through other sources can enrich the data generating information and validating it. Thus, the mass of data containing scarce information can be converted, through various processing techniques, into information that aggregates various concepts and that generate a completely new view of what was thought to have full knowledge.

In the environment it was possible to represent the changes over time. The general behavior of the analyzed information can be compared to define a trend or several of them. Thus, the implemented environment allows the production of threat intelligence with the profiling of attacks, attackers and targets. A possible improvement to the environment would be the incorporation of machine learning facilities.

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