RESEARCH

Python tool for behavioral studies of the IP Pools in the BRAS

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Abstract

The deployment of postpaid services at interoperable hotel Wi-Fi sites nationwide—allowing up to three devices per account—alongside expanded coverage and higher occupancy, has increased IP address utilization. Consequently, the Telecommunications Company of Cuba S. A., ETECSA has experienced an increase in terms of requests for IP address ranges at these sites, currently allocated via empirical calculations based on estimated guest numbers and service usage. The absence of tools providing accurate IP address usage statistics hinders behavioral studies to determine optimal pool sizing. This may cause service disruption and dissatisfaction for both customers experience address exhaustion, while ETECSA faces inefficient network resource allocation. To address this, a Python-based utility was developed to collect data for behavioral analysis. This tool was developed so as to solve the this problem. This paper describes the work performed and the results obtained with this tool, contributing to our Company enhancing tourism-sector service delivery and optimizing network resource efficiency.

Keywords: Python, Netmiko, Network Automation, WiFi.

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Introduction

The service known as Wi-Fi Interoperability constitutes one of the possible forms of Internet access provided by ETECSA, as a service provider for hotels, campsites, restaurants, hospitals, universities, public transport hubs, and many other places. This service's network architecture, which uses an IPoE solution with Web authentication (Figure 1), customer traffic is transported by layer from the Wi-Fi network Access Points (AP) deployed at each location, to the ME60 devices, operating as Broadband Remote Access Servers (BRAS) in the IP/MPLS network. To accomplish this, service VLANs are appropriately routed through the access switches and transit equipment of the transport/aggregation networks, which terminate at the corresponding BAS sub-interfaces on such BRAS. User control is guaranteed in these latter devices through interaction with the other system elements, such as: Session Control, Captive Portal, AAA, and DNS. The BRAS also function as the DHCP servers towards the customers, dynamically assigning IP addresses to their Stations (STA) or terminal equipment. For this, it is necessary to configure a private IP address pool, exclusive to each particular site. ETECSA, as the service provider, manages and controls these ranges, and their dimensioning is performed based on information provided by the personnel where the service is installed, which includes the estimated number of concurrent customers, calculated from the number of installed APs and the expected occupancy of the facilities, elements which can vary from time to time.

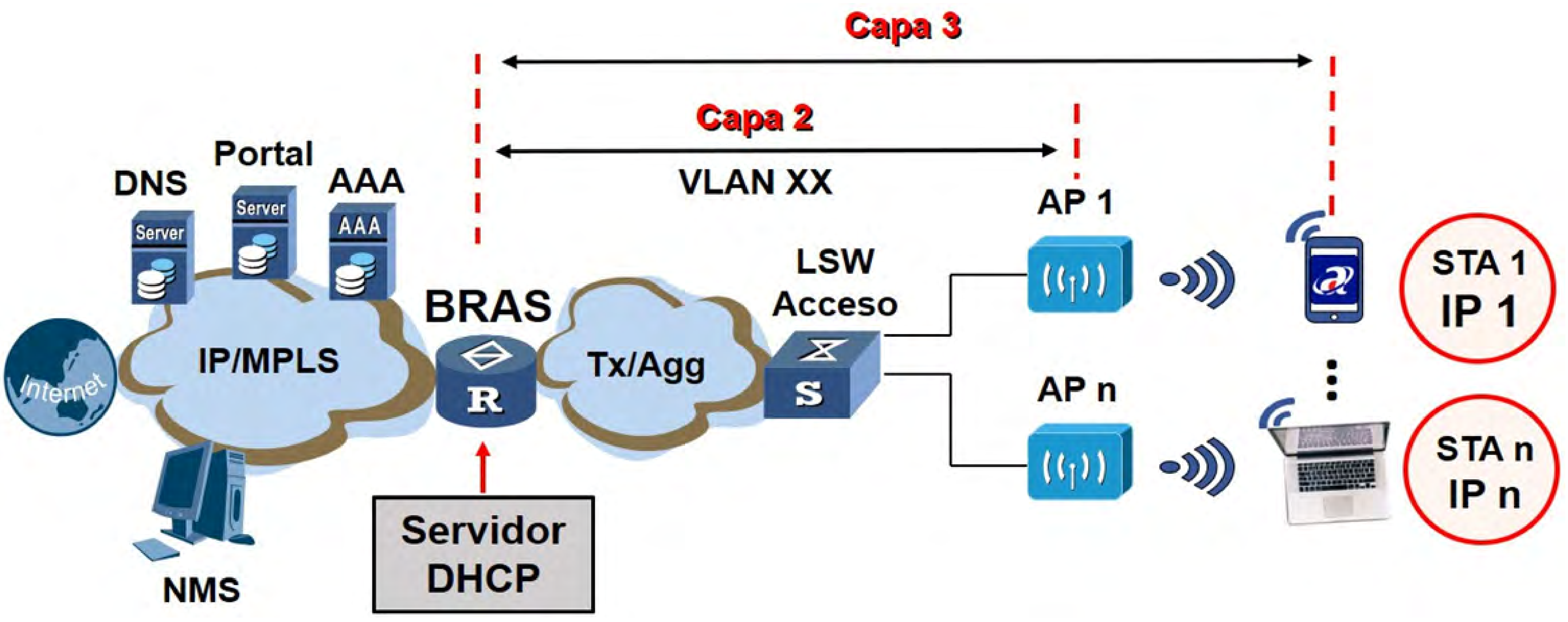


Figure 1. Summarized diagram of the Wi-Fi Interoperability service

In the designation of the above-mentioned Pool IPs may occur the following cases:

1. Under-dimensioned pool: It is below actual needs. It may happen that a number of customer devices request IPs and there are no available addresses left to assign to them (the range configured on the server is exhausted). This causes service impairment in those customers who fail to get IP addresses.

2. Over-dimensioned pool: It exceeds the actual needs. It leads to an inefficient use of network resources (IPs) to the detriment of the provider, which, in an extreme case, may be left without free ranges for its operation.

3. Correctly dimensioned pool: It matches the actual needs. There is no negative impact for either the customers or the provider.

As part of the Company's prioritized attention to the tourism sector, we are continuously working on improving the Wi-Fi service in hotels and solving their demands. As a result, the Wi-Fi Interoperability modality called Postpaid Wallet, which has been applied with good results since 2022; started in Havana and has spread throughout the country. Here are some new features of this service:

1.- Billing based on total traffic processed and not on the credit consumed from active accounts.

2.- Creation of customer accounts from the hotel itself, with access to GESNAUTA platform.

3.- Possibility to connect up to 3 devices per account.

4.- Need for accounts to remain connected

as long as possible once authenticated. In order to achieve this, the disconnection for low traffic and inactivity was disabled in the BRAS. In the particular case of hotels on the Gaviota chain, this last option was set for disconnection at 15 minutes.

In this postpaid modality, customers' accounts can remain active until logout, disconnection that the AAA sends at 12 hours of being authenticated. This, together with the expansion of WiFi service in hotel facilities, with coverage in practically all areas and increased levels of occupation, has brought with it greater use of IP addresses, and thus the need to expand the Pool in those places where it is required. In this context, there has been an increase in demands for the expansion of the IP Pools by the hotels' technical and administrative staff, who make an estimate based on the number of guests according to housing capacities, multiplied by the 3 possible devices to connect per account, resulting in a high number of requested IP addresses (mostly /22 and /21 ranges).

On the other hand, the provider's NCE management system provides indications of IP address exhaustion in the Pools, by generating usage alarms above 80% of IP addresses (a configurable value, it comes with a default value), but it does not provide in a timeline the specific values it reaches, but only when they exceed the configured threshold value. Therefore, in the cases under analysis, the required information was obtained on a case-by-case basis, by manually probing the BRAS where the specific service was set up.

This is an inconvenience for precise monitoring use of IP addresses, which makes it difficult to carry out behavioral studies, that allow to choose the optimal Pool and serve as evidence to show in response to customer demand. This can lead to service impairments and dissatisfaction, both for customers and our Company, a fact which constituted the problem to be solved in our case and which motivated the development of a scheduled utility on Python, with which it was possible to collect the information needed to conduct the relevant studies and analyses related to IP Pools.

Python is a trend in the world of data network automation. (Damien, 2020), given by its simplicity, versatility, modularity, database processing, file management and graphical interfaces for viewing information, as well as by the multiple and powerful libraries available for connection to equipment from various manufacturers, as is the case with Netmiko (Byers, 2024), used in this work. Furthermore, it has a large international community of developers, which is active, participatory and collaborative. These elements, as well as having previous experience of its use, were crucial when choosing the programming language used. This paper describes the work done and the results obtained with the developed computer tool.

Materials and methods

This research was developed under an applied engineering and research approach for development (R+D). The methodology was structured in three sequential phases to address the core problem of the lack of accurate data on the use of IP addresses in the Wi-Fi Interoperability service. Phase I consisted of the analysis of possible commands to be used on the BRAS ME60, which would allow gathering the necessary information. Phase II focused on analyzing the tools available for network automation that would allow remote management of the BRAS via the SSH protocol. Phase III consisted of the development and implementation of a utility for automated data collection, processing and presentation. These phases are described below.

Study of possible commands to obtain the required information

As a first task, a survey of technical information was carried out, to know the available commands and to choose the one suitable for defined purposes. Among them was chosen the command disp ip-pool pool-usage pool-name (pool name), the output of which simply and explicitly provides the required information, which is: Pool address range, IPs in use (including those allocated, conflicting and blocked) and the percentage of use they represent.

Network automation with Netmiko Python library

As a second step, the possible tools for collecting the required information were studied and the Netmiko library of Python was chosen for this purpose. This library was developed by Kirk Byers as an improved version of Paramiko and is designed to facilitate automated interaction with multi-manufacturers' network devices, such as: Cisco, Juniper, Arista, and many others (Byers, 2024). Netmiko uses several communication technologies, the most important being the SSH (Secure Shell) protocol, which encrypts the management information transmitted thus achieving safer communication. SSH is available on most telecommunication devices for their remote access, this being the most used method when applying automation to the field of telecommunications networks (Damien, 2020). This library helps network operators to send commands to equipment such as switches, routers, firewalls, among others, in a scheduled and repeatable way, and offers a simple and consistent way to automate network device management tasks (Figure 2). This minimizes the manual intervention by operators and reduces the margin of human error. This fact, combined with Python's multi-area capabilities, were the reasons for deciding on this tool when choosing an effective network automation method.

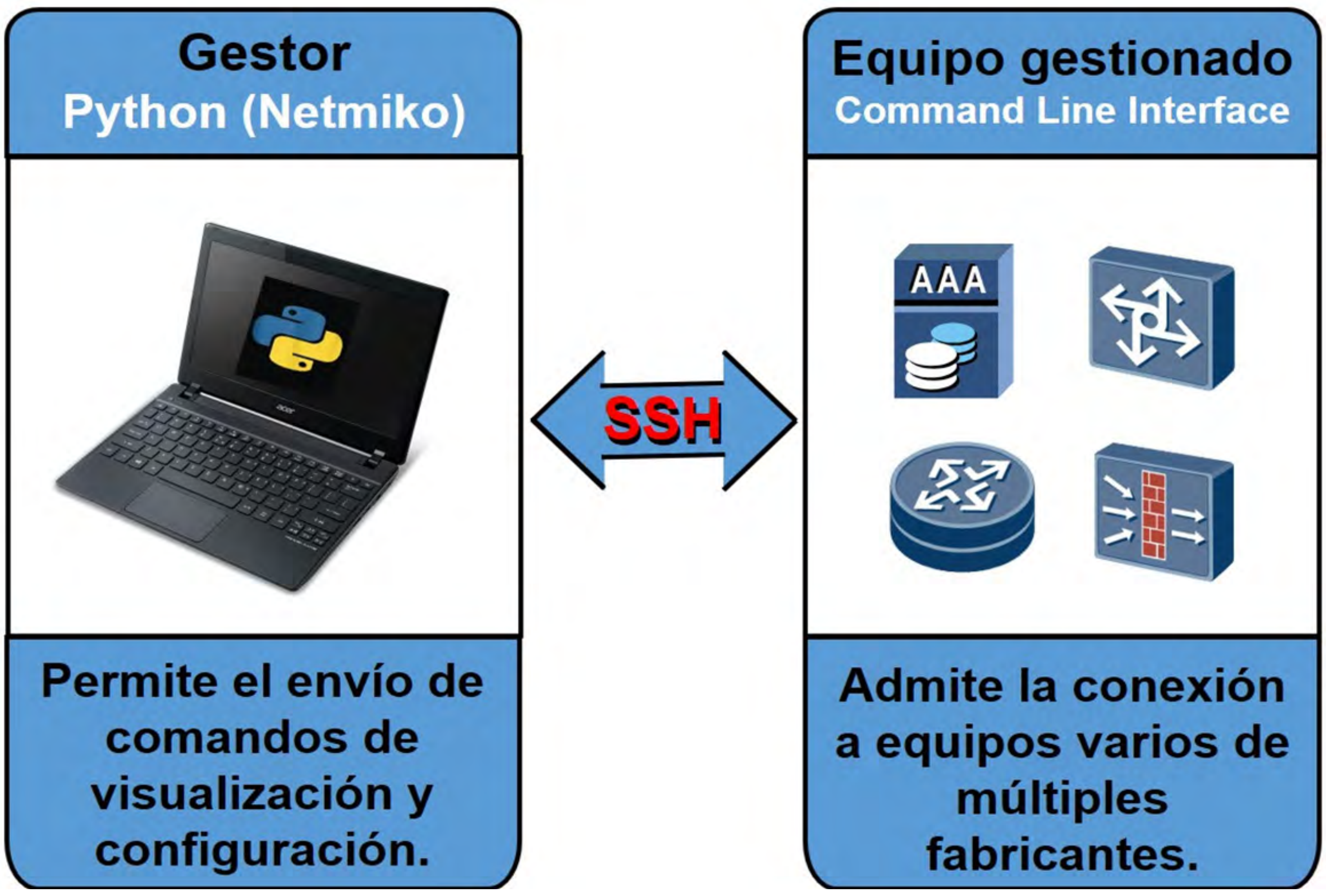


Figure 2. Network automation using Netmiko

Structure of the Python-based program

Subsequently, a program on Python was developed, consisting of two modules (Figure 3); the first one (left) shows a Graphical User Interface (GUI), which allows to enter the necessary parameters for its execution. In its development, it was used primarily in the Tkinter library. The second one (right) has in turn two parts: one for the periodic connection to the equipment via SSH (using the Netmiko and Schedule libraries), where the chosen command, described above, is sent to the BRAS. This allows to query one or several selected IP Pools and properly process the information it returns. The other part, after finishing the

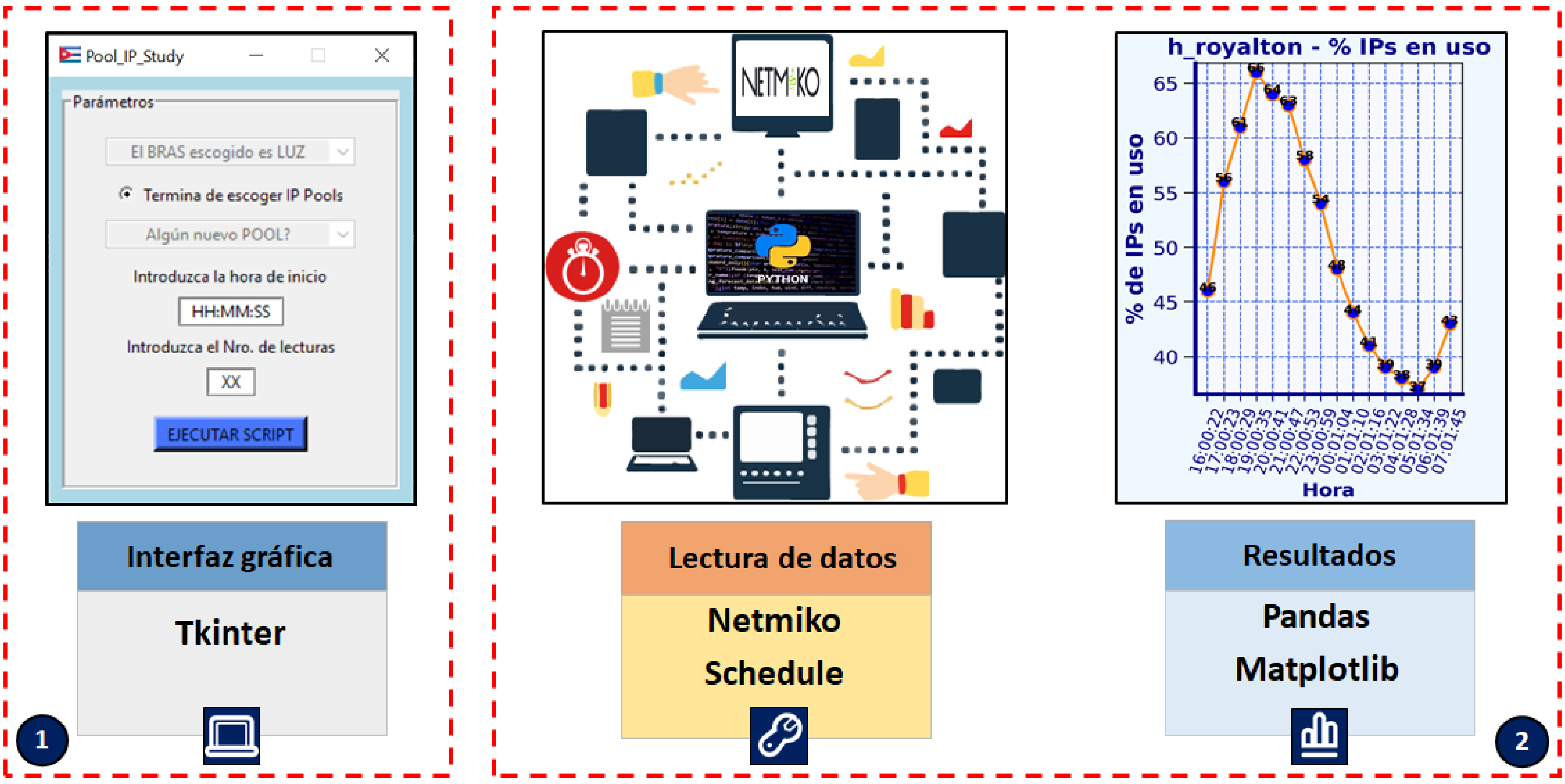


Figure 3. Structure of the Python-based program

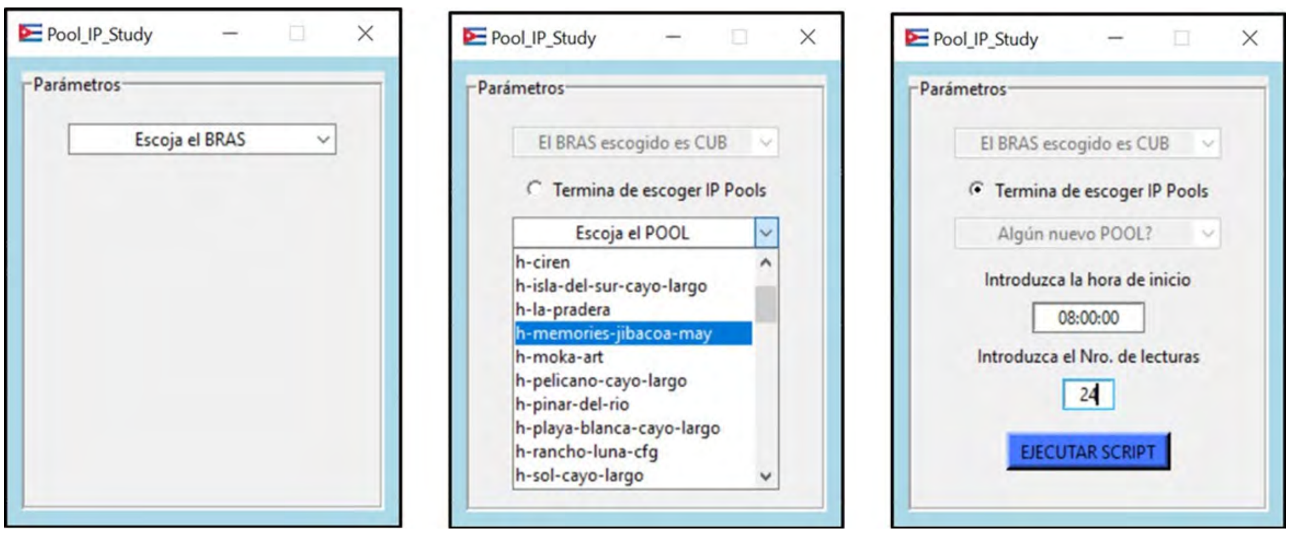
number of defined readings, stores the data obtained in files with .csv, .txt and .pdf extensions, in the latter case shows them graphically. The Pandas and Matplotlib libraries were used for this part.

Program execution steps

The program execution consists of four steps (Figure 4):

1. Choosing the desired BRAS from a drop-down list (Figure 4a).
2. Choosing the IP Pool(s) to be analyzed from a drop-down list (it automatically obtains them by connecting to the selected BRAS) (Figure 4b).
3. Entering the start time to take readings and the number of readings to be performed (Figure 4c).
4. Clicking on the 'Execute Script' button (Figure 4c).

Once the above is done, module 2 starts running at the time entered; it takes the number of desired readings and processes the obtained information.

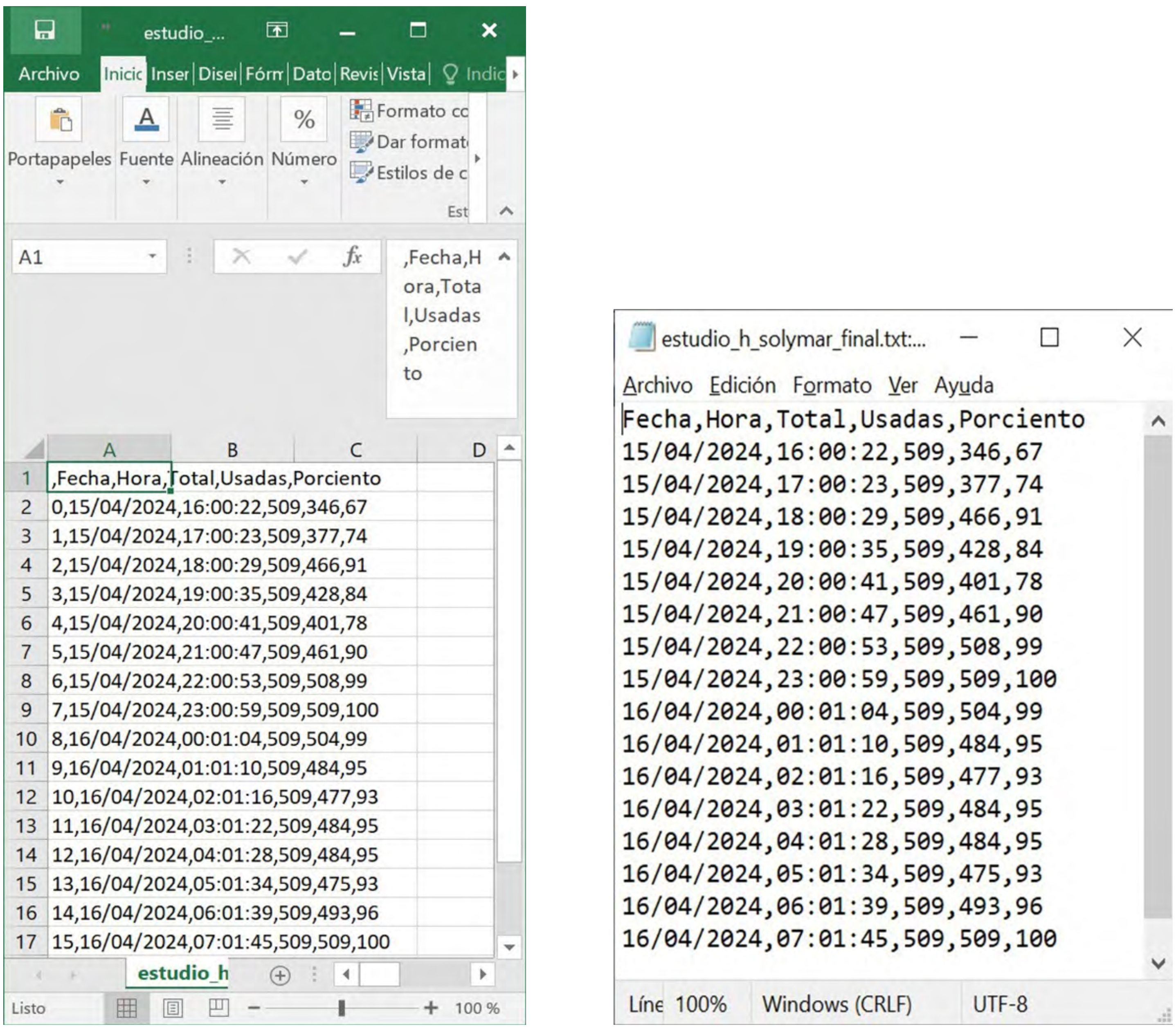


a) b) c)

Figure 4. Program execution steps

Results and discussion

Once the execution cycle of the program as shown in the previous section is finished, the information obtained is stored in Excel and text files, with .csv and .txt extensions (an example of this is shown in Figures 5 a and b, respectively), as well as graphs with a .pdf extension.



a) b)

Figure 5. Example of Excel and text information files

The case in Figure 6 is one of those that was monitored based on the alarms generated in the NCE management system. According to the information obtained with the Python utility, it was verified that IP address exhaustion was occurring (in the red circles, moments when it reaches 100% use) and thereby affecting customers.

Figure 6. Under-dimensioned IP Pool Behavior

Figure 7 shows a case where the IP pool was increased to /21, in respond to a hotel demand. It can be seen in the obtained graphs that does not exceed 20% of the use of IP addresses, being an example of over-dimensioning, with implications for our Company.

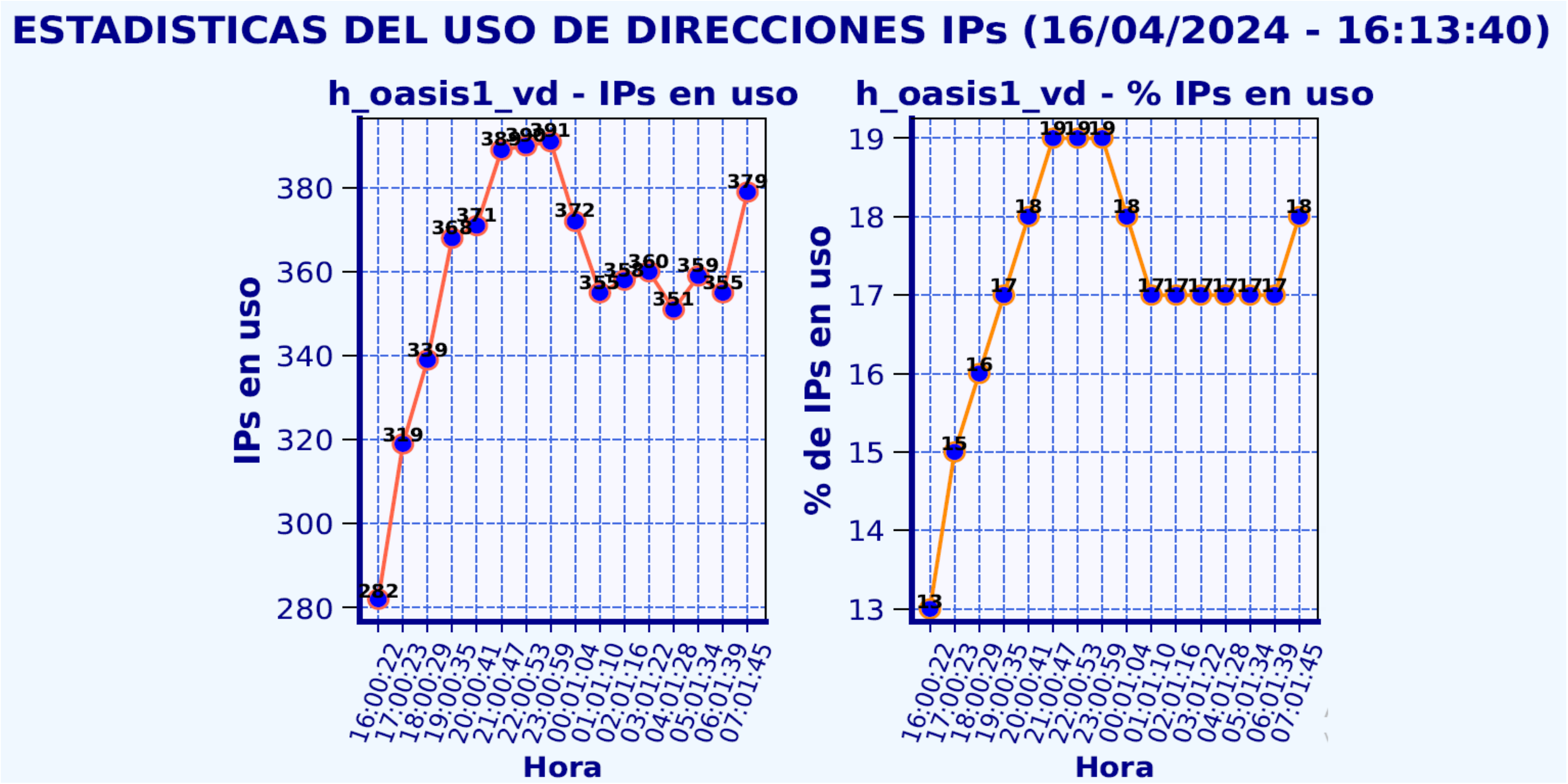


Figure 7. Over-dimensioned IP Pool Behaivor

Figure 8 shows a correctly sized case. This particular one requested to expand its IP address range, which was not necessary to do at that time, based on the statistics obtained and shared with the hotel staff.

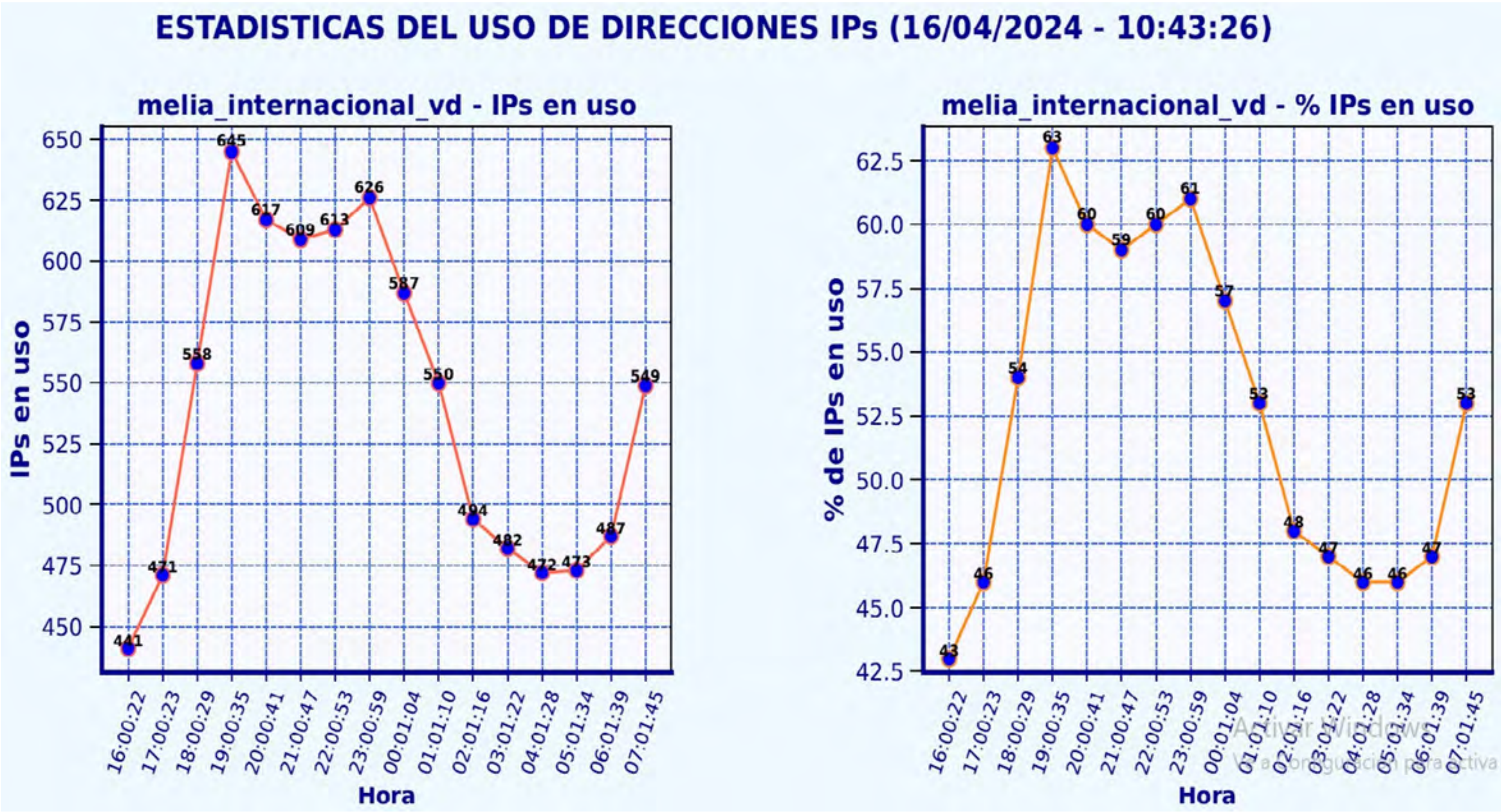


Figure 8. Correctly-dimensioned IP Pool Behaivor

It should be mentioned that in all the examples shown, there was a high level of occupancy in the hotels, which in turn suggests high percentages of IP address use.

Conclusions

The conclusions of this research reflect the positive impact of implementation of a computer tool developed in Python to analyze and manage the IP Pools within ETECSA's network. First of all, it is shown that this tool is an effective solution to overcome the lack of accurate information, allowing for automated collection and processing of behavior of IP Pools, especially in environments where BRAs act as DHCP servers. This facilitated early detection of issues, such as exhaustion of IP addresses in hotels, and allowed timely corrective actions to be taken, such as expanding the address range, avoiding service interruptions. In addition, it was found that a correct dimensioning of the Pools avoids unnecessary costs in the acquisition of new IP addresses, contributing to a more efficient use of resources. The statistics generated not only improve service quality Wi-Fi for users, but also provide valuable evidence for technical and administrative staff, increasing customer satisfaction. Finally, although the tool was initially designed for the hotel sector, its application potential is extended to other network IP Pool services, demonstrating its flexibility and usefulness in different ETECSA's network resource management contexts.

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