NETBOX AS THE CENTRAL NETWORK MANAGEMENT SYSTEM

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Abstract

It is crucial to describe the basic properties of a network operations center. Here we describe three basic aspects of the Network Operations Center (NOC). After the analysis, we focus on the NOC documentation processes using NetBox. NetBox is a tool specializing in documenting networks and IT equipment. In this paper, we describe how we import data to NetBox and how we extend NetBox functions using its plugin system. Ultimately, we explain how NetBox should be utilized in the NOC as the primary source of information for network automation, leveraging a powerful, lightweight automation platform, Semaphore UI. Here we use Ansible to collect configurations from network devices and save them to GIT server.

Keywords: *script, NetBox, network operations center, automation, REST API, documentation, plugin*

1 INTRODUCTION

In recent years, the number of students at the Faculty of Management and Informatics has been increasing. Their number also increases the demands on the faculty's IT infrastructure. Within the faculty's IT infrastructure, we have various systems that are crucial for the faculty's functioning and teaching processes. An increase in the number of students will increase the load on IT systems, and thus, their outages may occur more often. Administrator teams handle recovering these systems. The increased load and occurrence of outages increases the load on admin teams. Therefore, we attempted to alleviate the burden on administrators and involve students in IT management. An academic network operations center (NOC) appears to be a viable solution. By introducing NOC, we can streamline and enhance processes in IT management. However, this solution is complex, and its implementation is difficult. Given its complexity, which we will introduce below, we focused on improving the practical aspects of the company's documentation processes. For network documentation, we propose using the NetBox tool, which has gained popularity in recent years. In the following chapters, we will describe why documentation is important, how

we utilize NetBox to document the department network on which we test the desired benefits of the NetBox system, and how we utilize NetBox for other network processes. Finally, we will describe how we can integrate NetBox with other systems and thus enrich other network processes.

2 NETWORK OPERATIONS CENTER

2.1 What is the Network Operations Center?

A network operations center is a centralized location where organizations manage their network infrastructure, including network devices, servers, and other equipment. NOC is a critical part of effective IT support and network management. NOC monitors the network in real time to quickly detect errors in the infrastructure and then eliminate the error in the shortest possible time. A properly built NOC will detect the error before the end user notices it and fix it in accordance with the established processes [1].

2.2 Three aspects of NOC

NOC has three basic aspects that define the structure of an NOC center. These aspects are personnel, processes, and platform. All aspects are equal, and insufficient investment in one aspect will affect the quality of the others [1].

2.2.1 Processes

Processes are dedicated to the effective setup of processes in the NOC center, concerning the organization. This means that how the processes are set up depends on the needs and specifics of the organization. Process frameworks can help us with this. The Information Technology Infrastructure Library (ITIL) framework is among the most widely used and describes the five basic processes necessary for an effectively designed NOC [2]:

- event management and monitoring – setting the monitoring scope,
- incident management – identification, management and elimination of errorsn IT organizations,
- problem management – identification, management, and elimination of sources of errors,
- capacity management – management of data storage capacity, lines, performance, and other infrastructure parameters,
- change management – management of planned changes in infrastructure.

The ITIL operational framework is used to document processes, functions, and roles. This library of recommendations establishes a more effective organizational structure for processes and provides a comprehensive guide to the most common processes [2].

Runbook

The process book is a collection of documents needed by the NOC worker during the performance of his work. The process book contains documents of several types,

references, and outputs intended to standardize processes and tasks in the NOC center. This documentation should be easily accessible to all NOC workers. A quality process book reduces the time needed to perform a documented task. This creates space for other tasks [3].

Basic Processes

Above, we have defined the basic processes in the NOC in accordance with ITIL guidelines (Figure 1). These represent rather a managerial view of the processes. As best practices for the department, we have identified and defined six basic processes to address when managing the IT infrastructure. We must address these processes for IT management, but not everything has to be provided by the NOC center. Since the NOC is a center built according to the requirements of the organization, it is up to us how we implement the individual processes.

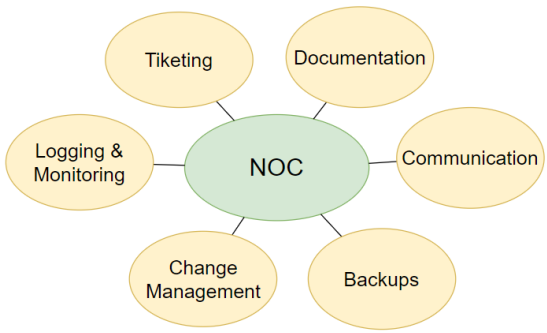


Figure 1 Basic Processes

2.2.2 People

People include all the people working in the NOC. Here we define all necessary employee roles, what level of responsibility these roles have or even the work shift schedule (Figure 2)[4].

The first step we need to take is to create an organizational structure. The organizational structure describes how the NOC staff will work. One of the basic organizational structures is the tiered structure. This structure features a Tier 1 (T1) team at its center, which utilizes monitoring tools, writes and escalates tickets, analyzes incidents, communicates with customers, and more. There can be more than one tier, and they are set up to resolve incidents in the infrastructure appropriately. Each tier has its responsibilities in resolving the incident. Suppose the first tier does not have sufficient resources to resolve the incident within the expected timeframe. In that case, the incident ticket is escalated to the next team by the escalation policy. The next team has more experienced workers and should therefore resolve the incident in the required time [4].

The second organizational structure model that we will mention is the intelligent swarm organizational structure. This organizational structure works in such a way that a worker or a group of workers is given a complex ticket to solve. They either manage to solve the ticket or the team breaks it down into smaller incidents. The aim is to skip the

unnecessary waiting by escalating the ticket to the level that can solve the ticket, but to immediately assign the ticket to the person who is most likely to solve the problem. This way, we can solve a large number of simple tickets quickly, while more complicated tickets may have to wait a while for the right person to take them over. [5].

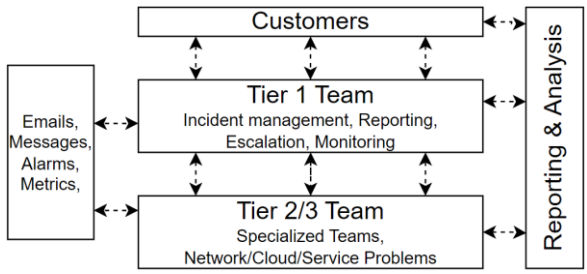


Figure 2 Example of tiered organizational structure

Other processes include [4]:

- Defining roles and responsibilities – We create job positions and their current and future responsibilities. We then add a level of involvement in the processes using the Responsible, Accountable, Consulted and Informed Matrix (RACI).
- Staff selection – We select new employees based on role specifications and expected skills. It is also important that the employee is interested in learning and enjoys working in IT.
- Staff training – We create staff training plans. They will undergo this training upon joining the position and regularly during their work. It is recommended that there be 1-3 months between regular training sessions.
- Work schedule planning – This involves designing work shifts. The plans are influenced by a range of factors such as the number of employees, the working hours at the NOC center, or the experience of the employees.
- NOC Quality Control – Focuses on quality control of processes, services, staff training, average ticket resolution time, and other metrics. These metrics point to inefficient parts of the NOC center that we can then fix.

2.2.3 Platform

We see the platform as a technological tool in the NOC center. The platform assists staff in all processes within the NOC center. These systems are used in incident resolution, infrastructure troubleshooting, documentation, and communications. They also help with staff training, infrastructure analysis, and network processes. As technology and infrastructure continue to evolve rapidly, we must select tools that provide the necessary functionality [6].

The basic categories of systems include [6]:

- Network Management Systems – These are systems for collecting data and metrics about an organization's network and infrastructure. These systems typically collect logs, metrics, and other data to help detect incidents.

- Ticketing Systems – Ticketing systems are tools that organize requests for troubleshooting. Each ticket is assigned a priority based on set criteria, which helps sort tickets.
- Communication Systems – These systems are used for rapid information exchange and efficient process resolution. Communication can take the form of video calls, messages, or emails.
- Documentation Tools – This is one of the main pillars of the NOC center. The three main parts of documentation are: network documentation, infrastructure documentation, and user documentation. Documentation must always be up-to-date and specific so that the reader does not have to guess the necessary facts.

Control panel

A control panel is used to monitor the status of the infrastructure or a range of factors that may affect the functioning of the infrastructure. It is basically a group of screens mounted in a place where every involved NOC worker can see them. When an alarm or error notification appears on the screen, a technician or team of technicians opens the given problem and starts to solve the identified problem [7].

2.3 Benefits of NOC for the organization

By implementing an NOC center into IT management for the organization, we can create countless benefits. Below is a list of some of the benefits that the faculty needs to ensure.

- Backup management – The NOC center can take responsibility for managing and creating backups. Thus, one department (NOC) handles backups.
- Software update – It is a planned process when it may happen that the systems will not be operational. The NOC must be aware of any planned outage and prepare itself and customers for a potential system outage.
- Incident management – When errors occur in the IT infrastructure, we have precisely defined processes for eliminating and documenting the error. Incident management strives not only for quick error elimination but also for detection in the shortest possible time from the error occurrence.
- Problem management – We have set processes for eliminating the source of errors in the infrastructure and thus preventing repeated occurrences of the same error.
- Customer support – Although customer support is more the domain of the Helpdesk center, the NOC can communicate with customers/users. Communication can be aimed at resolving the incident, but also at informing about possible outages or changes in the infrastructure. Support also includes creating reports that are used to communicate changes and system optimizations.

- Infrastructure Status Monitoring Center – Infrastructure monitoring and management of existing components will be under the umbrella of a single IT department. This will increase the efficiency of infrastructure management.
- More efficient IT departments – Network management is usually done by multiple teams. This could be a team of administrators implementing new systems or a team of cyber specialists securing the infrastructure against cyber threats. By implementing NOC, some of the responsibilities from other departments will be transferred to NOC, which will increase the efficiency of the work of other departments.

2.4 Recommendations for the NOC

The NOC center must be integrated with the organization's infrastructure. Since we have no experience in building a NOC center, we will use the KIS infrastructure as a test environment. If the approach proves successful, we can expand NOC to manage faculty systems. The software must be open source, as our resources are limited. The NOC center should be integrated into existing processes. The goal is to enhance existing processes and establish new ones that benefit the organization. Preferred technological solutions are those that are easy to manage and maintain. The goal is for administrators to avoid wasting time managing support systems. Students should be involved in the NOC center. The expected number of students who would work in the NOC center at one time is a maximum of 2, because there are only two places in the classroom reserved for the NOC center. The network operations center should operate only five days a week for eight hours of support.

3 NETBOX

3.1 What is NetBox?

NetBox is a network modeling and documentation tool. Its advantage over other configuration management systems (CMDB) is that it provides a large number of objects that try to model the network as accurately as possible [7].

3.2 Primary functions of NetBox

NetBox has a data model that models real infrastructure as closely as possible to reality. This tool combines the features of IP address management (IPAM) and data center management (DCIM).

A significant advantage of NetBox is its "Representational State Transfer Application Programming Interface" (REST API) and support for webhooks. Thanks to them, NetBox can also be used as a source of network information for other systems. After setting up integration with other systems, NetBox can send data to various automation scripts, monitoring systems and other systems [8].

3.3 NetBox and other alternatives

NetBox is not the only tool of its kind. We compared NetBox with other DCIM tools to see if NetBox is the best fit for our department. We compared NetBox with four

tools: RackTables, openDCIM Ralph, and iTop. Each tool has slightly distinctive features. RackTables and openDCIM focus on simple and clear documentation of hardware equipment. The basic objects of these tools include physical devices, physical lines, and switchboards. They also have limited IP Address Management (IPAM) features. Compared to NetBox, they are easier to manage and easier to use. However, they do not support the same level of documentation detail as NetBox, which can cause the tool to become just a simple wiki. [9], [10].

The other two tools are Ralph and iTop. These tools provide other features besides the documentation of physical parts of the infrastructure. Ralph has support for license documentation and a REST API for programmatic access to data. Therefore, we can also use Ralph for infrastructure automation [9]. Documentation of contracts, licenses, and other objects can be achieved in NetBox using plugins. The iTop tool is unique compared to the others. We would classify this tool in the Configuration Management Database (CMDB) group. CMDB tools focus on streamlining IT processes. They can provide ticketing, integration, and documentation of IT devices and their relationships. The iTop tool cannot model physical IT devices as detailed as NetBox, and its purpose is to help with inventorying end devices and servers. iTop provides a large number of plugins that extend its data model and usage options [9], [11].

4 DESIGN OF DOCUMENTATION OF THE DEPARTMENT NETWORK USING NETBOX

4.1 The role of the NetBox in managing the department network

The main use of NetBox at the KIS department is as a documentation tool for network infrastructure. This is because the department currently has less up-to-date documentation in the DokuWiki tool, which shows its limitations in maintaining network documentation. Another reason we need to strengthen network documentation is that I need to have up-to-date information about the network infrastructure at hand for every planning. We also focused on automating network processes. Here NetBox plays a key role. When automating network processes, we use NetBox as a database of network data. The script finds this data before it starts running.

NetBox can also be used to validate configurations, generate configurations, or as a source of information for other systems we use.

4.2 Building up NetBox documentation

We use NetBox for precise modeling of the organization's IT infrastructure. NetBox supports various objects with which we document the organization's components and their relationships. These objects are logically grouped according to their type. Documentation in NetBox requires preliminary planning and an overview of the organization. Documentation has a recommended procedure. First, we will propose the use of objects in the Organization category. We use these to document the physical spaces of the organization. These are branches, rooms or regions. We created a branch of the Faculty of Engineering and Informatics, in which we created rooms. Then we

documented physical devices, data distribution boards and physical lines. Finally, we documented VPN tunnels and IP addressing on network devices. We did not use power and virtualization objects.

Data entry into NetBox can be solved in many ways. The first is manual data entry into NetBox. This involves writing forms where we specify the properties of new objects. This method is very demanding and is not recommended for major changes. The second method is uploading files where we have defined objects and their properties. This way we can change multiple objects at the same time. Other approaches that we have not used are creating objects with our own scripts and using the REST API interface. For specifics of individual methods of inserting data into NetBox, we recommend referring to the official documentation [12].

4.3 Integration of NetBox plugins

NetBox provides various plugins that we can use to add functions to NetBox. We focused on three plugins. The first plugin is called netbox-topology-views. The plugin provides the function of drawing network topologies. The plugin looks into the database according to the set filters and draws the allowed parts of the topology. Thanks to it, we can always have high-quality documentation of the network topology. We use another plugin to move devices in the distribution rack. The netbox-reorder-rack plugin provides the ability to move devices in distribution racks using a "drag and drop" method. Without this plugin, we have to move devices by editing the position data on the devices. The last plugin that we integrated into the department's NetBox is netbox-attachments. This plugin allows users to store important files and documents on objects in NetBox. These can be, for example, contracts, documentation or images.

4.4 Configuration Templates and scripts

While working on, we also explored the creation of configuration templates and custom scripts. These are advanced features native to NetBox. Using configuration templates, we can generate appropriate configurations that we can then apply to devices. Templates generate configurations by inserting device, interface, and other object data into selected locations when generating the configuration. The Jinja2 language is used to write configuration templates. Custom scripts use NetBox's internal code and are used to assess documentation, generate new objects, ensure compliance with documentation rules, or generate reports. We created several scripts to assess basic documentation policies.

5 AUTOMATION OF NETWORK PROCESSES

As part of our work, we also implemented the Semaphore UI automation platform. This platform supports several scripting technologies. We used automation using Ansible technology. The advantage of this tool is low hardware requirements, support for Lightweight Directory Access Protocol (LDAP), or automation of script execution at a specific time.

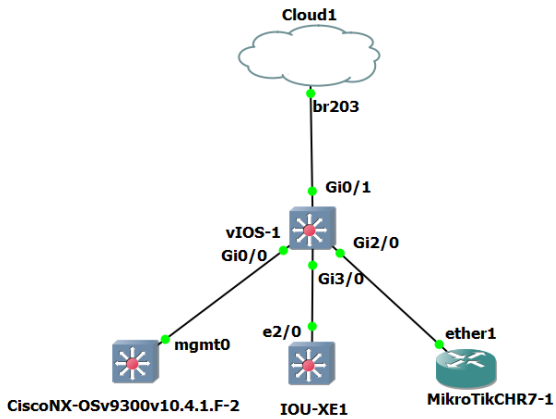


Figure 3 Test Topology

5.1 Configuration Backup

The script we created downloads configurations from devices and stores them on a GIT server. We tested this script in a GNS3 environment on various platforms that are in the department topology. In the picture **Figure 3**3 we can see the test topology in GNS3.

Topology includes platforms: - Cisco IOS, - Cisco IOS XE, - Cisco NXOS, - RouterOS. We need to ensure that the devices are accessible from the Semaphore UI service. All devices have a minimum configuration. This includes an account that we will use for Secure Shell (SSH) access in the script. We also need to have secure access to the department NetBox and GIT server, where we have the script stored in one repository and the network configurations in the other.

The script works in several phases. In the first phase, the task fetches the GIT repository with the necessary files. These files contain a list of tasks and a list of devices. We use a Bitbucket access token to access the repository.

Once we download and load these files, the first phase begins. In it, we query NetBox for a list of devices from which we should get the configuration. When accessing NetBox, we use the access API token generated in NetBox. Ansible has a plugin called netbox, which we use to get data. Therefore, we only define the conditions that the devices must meet. The main condition is that we only need those devices that have both a backup and a primary IP address. Once we have all the devices and Ansible knows the list of devices, we can start running the script.

The script has three phases. In the first phase, we delete the old configuration repository folder that was left over from the previous script run. Then we download the repository again to avoid potential problems when uploading a new version of the configurations. Then we download the new versions of the configurations from all the devices that the script knows. This part is divided into several tasks since each network

device platform requires a different Ansible module. Then we push the configurations to the GIT server.

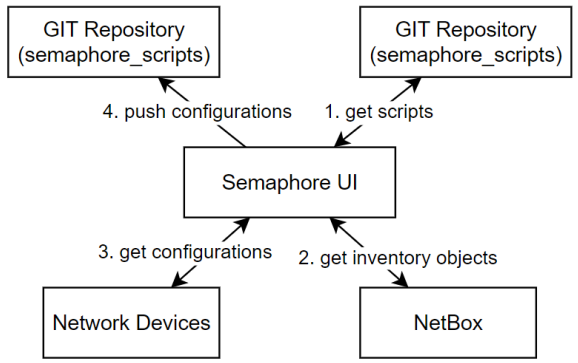


Figure 4 Backup Diagram

6 CONCLUSION

The article tries to introduce ways to improve IT infrastructure management. At the beginning, we describe the characteristics of specialized centers focused on IT management in organizations. Here we describe their basic aspects that we need to address. Then we focused on documentation processes. After taking into account current documentation processes and technical equipment, we found that the DokuWiki tool cannot cover all documentation requirements. Therefore, we used the modern NetBox tool. NetBox serves as a database of IT data. This data is used for troubleshooting, IT decision-making, and integration with other systems. We expanded NetBox with several plugins according to the department's requirements. Finally, we integrated NetBox with the Semaphore UI automation platform. Here, we created and tested a script for downloading configurations from network devices. Thus, we used a modern solution for automating configuration backups. We believe that integration and automation are two concepts that have a future in IT management.

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