The effectiveness of *Automatic Network Administration* (ANA) in network automation simulation at Universitas Pendidikan Ganesha

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Abstract. Network administration activities pose scalability challenges. Challenges arise when the devices handled are very numerous. Instead of using traditional methods, IT organizations need to implement automation methods. It is very inefficient to administer a large number of network devices by logging into them one by one. Human error is very susceptible to occur, which will cause configuration inconsistencies, to configuration errors, which will have an impact on poor network services provided. The automation method on the network is known as Network Automation (NA). NA uses an algorithmic approach in arranging steps in problem solving. NA is executed in the form of an application program that has the main function of automating routine, complex, repetitive, and comprehensive activities. Network administration activities that can be automated include routing automation, virtual administration and backup or restore. The simulation of NA implemented by ANA. ANA is the test which was carried out using the Python programming language by utilizing Paramiko and Netmiko Library in a virtual environment using GNS3 and Virtual Box. The purpose of developing ANA was to make network administration activities run more efficiently. The results of applying the ANA can be taken into consideration in network administration activities. The result showed ANA was effective to prove the NA purpose.

1. Introduction

Challenges for IT organizations arise when increasing network devices are managed. These tools need to be maintained in a way to ensure that their configuration works as intended as the organization grows. This is solely to ensure that all functions run well so that the organization’s business processes are not hampered. Supposedly, a network administrator can manage their network devices efficiently. Efficient means "doing things right" [1]. Efficient means that you can do your job properly so the time and effort is not wasted. The impact of this is the increase of productivity. The choice of network administration method is very important. The old manual method should be abandoned. Network administrators must be able to create network orchestrations. If there are changes to components in the data center, such as server or storage configurations, changes will also be required on the network. Network changes should happen quickly, and automatically. Network automation also enables it to recognize the device as they are added and automated with their settings [2]. The problem that arises when automating was not yet implemented needs to be solved for many IT organizations. IT organizations should gradually adopt automation methods.

The Technical Implementation Unit in the field of Information and Communication Technology (UPT-TIK) is an example of an IT organization. UPT-TIK is under the Ganessa University of Education.
(Undiksha). Network infrastructure management is one of the jobs this unit does. UPT-TIK serves 4 campus locations with 8 faculties. This organization also has many information systems that are managed by themselves. Thus, it can be estimated that the managed network devices are not small, starting from routers, switches, access points, and servers. Network administrators traditionally perform network administration. Traditionally means the network administrator enters the network device and performs administration one by one. This method is very inefficient when the number of managed devices is in the hundreds. The worst thing that can happen is human error. Human error delivers 40% to 80% of the causes of failure in the network implementation [3]. Other possibilities are inconsistent configuration between related devices, difficulty in analyzing network performance, and outdated network topology. These possibilities if not addressed will have an impact on increasing network maintenance costs. The problem will be bigger due to the accumulation of problems. It will also decrease organizational performance so that the service is also reduced which ultimately disappoint the users.

Automating all work related to network administration is a solution to the problem above. Automated jobs are tasks that are complex, routine, repetitive, and comprehensive such as initial configuration, updating configuration, connectivity testing, backup/restore of configuration. The approach using the network automation method can accommodate these jobs so that it can substitute the traditional methods. This approach results in applications that can be the center of all network administration activities such as routing configuration, VLANs, backup, and restore to all managed network devices. Network Automation is an automation method for network administration. NA is a way to configure network devices more quickly. The principles of NA automation are the same as for other types of automation in applications, systems, storage and telephony. NA is needed because it will have an impact on the management of a simplified architecture, oriented towards definite results (deterministic outcomes), and can make business processes faster (business agility) [4]. NA can reduce the time when doing development, configuration changes, and backup/restore network configurations.

The solution using NA has been proven by many other researchers. The architecture in application distribution used Amazon as IAAS and Ansible as the orchestration engine. This research uncovered how application provisioning is done in the cloud using an architectural overview and found out more about how the industry practices automation. The results in this study represented a new way to distribute applications in the cloud using automatic provisioning. There is the use of Ansible, a 4th generation configuration management tool for automated provisioning using the AWS infrastructure. This research proved that since 2015, the industry has started to implement automation methods. Automation can be done with the help of applications such as Ansible. The weakness of this study was that it has not shown the specifics of the configured network equipment and whether Ansible can do that or not. NA-based Ansible application can make work more flexible, easy, and fully automated in all application deployment procedures. The result was a well-tested functionality web-based application for network automation [5][6].

GNS3 can be an extension for network configuration in virtual environments. The extension, aimed at generating automation mechanisms, against valid configurations, for all network equipment in the created GNS3 scenario. This extension feature can save network administrators time in configuring and testing networks using JSON for file parsing and object-oriented programming language Perl in the implementation of its Automatic configuration generator application. This application was used to generate the configuration files needed. There are 2 scenarios, first, using 2 Cisco routers configured for RIPv2 dynamic routing automatically. The application has successfully generated 2 configuration files which will then be loaded into the router. As a result, both routers can function properly. The second scenario used 16 routers. The application has successfully generated 16 configuration files. This research proved that when the configuration file was successfully created using the application, it can be more efficient in terms of initial configuration. This proved that simulations carried out in a virtual environment using GNS3 can be used as a starting point before further application in the field. A very significant difference occurred when using more routers. The weakness of this research was that the configuration load was still carried out one by one to the device. Automation only runs on generating configuration files and not in the final configuration [7].
The lab formed using virtualization can simulate all the problems that exist in the field. Apart from providing an inexpensive solution, virtual labs provided easy access to test configuration results. The result found that virtual labs allowed users to emulate real-life network topologies without significant resource costs. What was adopted from this research was the use of GNS3-based virtual labs and virtual machines in network automation simulations [8].

Automation has also been shown to increase network security by identifying and fixing security vulnerabilities and improving network stability. These methods represented the future of networking, enabling the management of an increasing number of devices as a whole. This research also showed the importance of automation in previous networks, which are not yet based on the OpenFlow SDN protocol. What was adopted in this research was the use of the Python programming language in the implementation of network automation. The use of Python means that network administrators do not need to configure each device themselves, they only need to create the right infrastructure by implementing automation scripts. Organizations will benefit from an automation strategy with benefits in change control, architecture, security and operational management. The weakness of this research was that the concept of abstraction offered has not been implemented yet. This research was only in the form of concept and literature study so that there was no testing related to the functionality of the system [9].

2. Method
The literature study is the stage of searching for various written sources, whether in the form of books, archives, magazines, articles and journals, or documents that are relevant to the problem being studied. So that, the information obtained from this literature study was used as a reference to strengthen existing arguments. This literature study was carried out after determining the research topic and determining the formulation of the problem, before going to the field to collect the necessary data. Literature study is a series of activities relating to methods of collecting library data, reading and taking notes, and managing research materials. The output of this literature study was the collection of references relevant to problem formulation. The studies carried out were within the scope of Network Automation in network administration, virtualization, and network simulation activities.

Analysis of functional requirements includes an analysis of the functions of applications made in order to implement Network Automation theories. The application has one type of user which is administrator. The functionality in this application, among others.

1. Administrators can CRUD the device and categorize it by vendor
2. Administrators can automate VLAN configuration, backup, and restore of 5 Cisco Layer 3 Management Switches
3. Administrators can automate VLAN configuration, backup, and restore for 5 Microtic routers
4. Administrators can configure simultaneously to all devices at the same time

Software analysis includes analysis of software used in implementing Network Automation. The applications used were as follows.

1. Python programming language version 3
2. pyCharm for coding the Python programming language
3. Paramiko and Netmiko libraries for SSH connection and configuration penetration to multiple network devices
4. Django Framework to create a web-based interface
5. GNS3 to perform network simulation
6. Oracle VirtualBox to virtualize server network devices

The design stage is the stage in designing the network topology used. Besides, there were scenarios in the implementation of Network Automation. This simulation scenario used 10 layer 3 manageable Cisco switches, 3 Linux servers, and 8 proxy routers. The configurations performed on 10 cisco layer 3 manageable switches included VLAN configuration, backup, and restore. Configuration performed on 3 servers included web server configuration, backup, and restore. The configuration performed on the
proxy router included dynamic routing, backup, and restore. The topology used was similar to the topology used in the UPT-TIK Undiksha as shown in Figure 1.

![Network Topology](image)

**Figure 1.** Network topology.

The implementation stage is a description of the stages of configuring using an application that has been made in order to see whether the application can perform its function properly. The correctness of all these functions was evaluated using instruments carried out at the testing stage.

The evaluation and testing phase is a continuation of the implementation stage. There were two test parameters, namely functionality testing and configuration time testing. The functionality testing carried out was black box testing to ensure the application can automate the entire simulation scenario. The black box testing instrument could be seen in Table 1. Table 1 is a snapshot of the instrument. The entire instrument has 63 assessment items.

| No. | Items Tested                          | Results |
|-----|--------------------------------------|---------|
| 1   | Application can configure VLAN on FTK Switch | Success | Failed |
| 2   | Application are able to do backups on FTK Switch |         |        |
| 3   | Application can perform restore on FTK Switch |         |        |
| 4   | Application can configure VLAN on FOK Switch |         |        |
| 5   | Application are able to do backups on FOK Switch |         |        |

3. Results and Discussion
The research was initiated by designing a simulation design according to Figure 1. This was done using the VirtualBox and GNS3 applications. Figure 2 is the simulation design using Cisco virtual switches and virtual proxy routers as devices that represented switches and routers in field conditions.
The next step was to develop an application based on web apps. The web application was used to configure simultaneously to all registered devices. Application web was named ANAv1.0 (here in after ANA). ANA is an abbreviation of Automatic Network Administration. ANA was built using Python programming language. The framework used was Django. Netmiko and Paramiko were the libraries for SSH purposes. Figure 3 is an initial view of the ANA application. The display is a dashboard that shows the number of devices being managed, the number of devices per vendor, and the configuration that has been done.

In general, the functionality of this application is as follows.
1. Can perform CRUD devices and categorize them into vendor types
2. Can perform ssh commands and remote to the destination device
3. Can perform simultaneous automatic configuration
Specifically, ANA’s functionality is as follows.
1. Administrators can automate VLAN configuration, backup, and restore of 5 Cisco Layer 3 Management Switches
2. Administrators can automate VLAN configuration, backup, and restore for 5 microtic routers

![Admin page](image1)

**Figure 4. Admin page.**

On the admin page, there is a menu for logging in, a page for adding devices and categorizing them based on the type of vendor, whether Cisco or Mikrotik, and a page for managing devices whether to modify or delete as shown in Figure 4.

![Configuration page](image2)

**Figure 5. Configuration page.**

Figure 5 is a page for configuration. The admin can choose which devices will be configured at the same time by checking them. Then, type the command in the appropriate area.

![Configuration results page](image3)

**Figure 6. Configuration results page.**
Figure 6 is a page to display the configuration results and a log page. The log page contains the status of the configuration whether it was executed successfully or not.

Tests were carried out using instruments as in the results in Table 2. Table 2 shows that all tasks can be performed by ANA. These results showed that ANA was very effective in accommodating network automation.

Table 2. Tasks which was performed by ANA.

| No. | Items Tested                                      | Results |
|-----|---------------------------------------------------|---------|
| 1   | Application can configure VLAN on FTK Switch      | ✓       |
| 2   | Application are able to do backups on FTK Switch  | ✓       |
| 3   | Application can perform restore on FTK Switch     | ✓       |
| 4   | Application can configure VLAN on FOK Switch      | ✓       |
| 5   | Application are able to do backups on FOK Switch  | ✓       |

The goal of network automation is to increase the efficiency of network operations including network administration [4]. This was the next step that will be carried out by using ANA. Thus, ANA can contribute to network automation related to proving these goals.

The next discussion for the topic of network automation is related to simplified architecture. Network automation promises a simplified architecture [4]. There are several questions that can be asked such as, can ANA prove that managed devices can be cross-platform and cross-vendor? Of course this involves several extensions, APIs, and library availability. If later ANA can provide these features, it will prove that network administration work will be simpler, repeatable, and easier to maintain also automate.

4. Conclusion
ANA is an application resulting from the implementation of the Network Automation (NA) concept which was built using the Python programming language, the Django framework, and the Netmiko and Paramiko Libraries. NA is a way of administering the network efficiently. ANA worked effectively and efficiently. The effectiveness was seen from the success of testing its functionality while the efficiency was seen from the success of doing work simultaneously. The next step in this study was to calculate the time difference between using ANA and conventional methods, namely configuring each device.

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