



MALAWI UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF COMPUTER SCIENCE AND INFORMATION TECHNOLOGY

Internship Report

Malawi Research and Education Networks (MAREN)

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Programme: BSc. Business Information Technology

Date: 10th May, 2024

1. Acknowledgement

First and foremost, I would like to express my deepest gratitude to the Almighty God for the grace of life and the opportunity to serve at MAREN.

Special thanks to MUST CSIT Head of Department, Dr. Bennet Kankuzi, and the whole CSIT team for their tireless efforts to find me a place for internship at MAREN. Their effort has really benefited me a lot.

I would like to extend my sincere thanks to my lecturers Mr. Ralph Tambala and Mrs. Priscilla Maliwichi for coming to my hosting organization and do the assessment on my internship performance.

Words cannot express my gratitude to Mr. Solomon Dindi, CEO at MAREN, Mr. Alexius Chipalamwazani, Network and Infrastructure manager, Trot Makasu, Assistant Network Engineer and the whole MAREN team for the knowledge I have learnt from them and their continues support.

Many thanks should also go to Mr. Jones Kumwenda, Systems Engineer at MAREN for introducing me to Vue and Laravel which has helped me a lot in my software development journey.

I am also grateful to my colleague Simeon Mataka for his continuous help and support over me.

Lastly, I extend my thanks to my parents, my relatives, my friends and everyone who contributed to my internship experience at MAREN. Your cooperation and encouragement have been instrumental in my growth and learning. May you all be abundantly blessed.

2. Executive Summary

At a certain point during the course of studying at Malawi University of Science and Technology, a student is sent to go for work integrated learning (WIL) for a minimum period of four month (one semester) at a certain organization based on the area of study.

As a student in Malawi Institute of Technology (MIT) studying Bachelors in Business Information Technology (BIT), I started my internship from 10th January, 2024 to 30th April, 2024 at Malawi Research and Education Networks (MAREN) in Network and Infrastructure department where my main duties were monitoring network, configuring network devices, engaging with clients, apart from my main duties, I was also working as a systems developer. I have learnt a lot during my internship period, such as understanding network devices (Routers, Switches, Servers), understanding operating systems (Alma Linux, Ubuntu Linux, windows, Kali Linux), hands on experience in configuring different network devices (Cisco, Juniper, Mikrotik, Huawei). Not only have learnt these hard skills, but also soft skills such as communication skills, team work, creative thinking as well as organizational behavior.

It is during my internship period that I have discovered and learnt that MAREN as a National Research and Education Networks (NREN) is the one which control and manage EDUROAM in Malawi.

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4. Overview of the host organization

a. Brief company history

The Malawi Research and Education Network (MAREN) stands as Malawi's National Research and Education Network (NREN), having garnered recognition from the Government of Malawi through the Ministry of Education. Established in 2005 by the University of Malawi and Mzuzu University, MAREN emerged from a pressing need to bridge the connectivity gap hindering access to electronic resources within academic institutions.

The precursor to MAREN was the VSAT network at four University campuses of Chancellor College, College of Medicine, Mzuzu University and Bunda College of Agriculture (a college under the University of Malawi, now under the Lilongwe University of Agriculture and Natural Resources) installed by the Malawi Libraries and Information Consortium. MAREN underwent extensive stakeholder consultations and international awareness campaigns prior to its official incorporation in 2009. Over the years, its operational framework expanded, encompassing additional stakeholders such as the National Commission for Science and Technology, Lilongwe University of Agriculture and Natural Resources, and the Malawi University of Science and Technology.

A pivotal moment in its evolution occurred in 2018 when MAREN secured a significant US\$4 million grant from the Malawi Government's Digital Malawi Project, bolstering its capacity and resources. This funding facilitated crucial advancements, including the employment of key personnel, procurement of necessary infrastructure, and capacity building initiatives. MAREN's mission is anchored in providing secure, reliable, high-speed, and affordable connectivity for research and education institutions, thereby fostering collaborative research, knowledge creation, and resource sharing. With a vision to emerge as a dynamic research and education network harnessing innovative technologies, MAREN envisions a future characterized by enhanced collaboration and seamless resource sharing among academic institutions nationwide.

b. Business size

MAREN is overseen by its Chief Executive Officer (CEO), currently Mr. Solomon Dindi. The organization comprises three key departments: Network and Infrastructure, Systems, and Financial and Administrative. Each department is led by a manager and supported by several subordinates. MAREN currently has more than ten employees, with each department having at least two employees. MAREN head office is located in Zomba, inside Chancellor College campus. Its Network Operation Center (NOC) is located in Blantyre at College of Medicine campus.

5. Plan of internship program

My internship period at MAREN ran from 10th January, 2024 to 30th April, 2024. I was allocated in Network and Infrastructure department under the supervision of Network and Infrastructure Manager, Mr. Alexius Chipalamwazani. In this department we were four of us in total, the manager of the department, Assistant Network Engineer and two of us whom were interns, myself and my colleague, Simeon Mataka both of us we were from MUST.

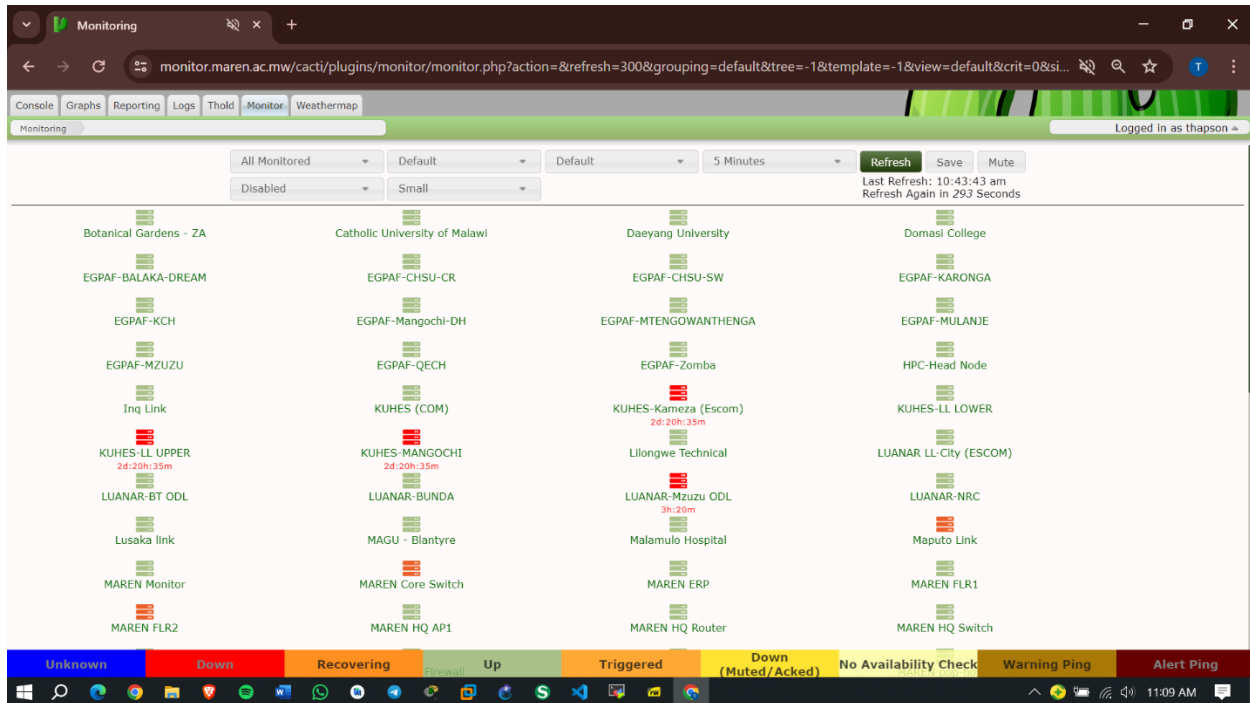
Apart from my department where I was allocated, I performed my duties as a systems developer in systems department, in a group of three, myself and my colleague whom we were both interns and a systems engineer who was a project leader. We embarked in the development of MAREN Customers Relationship Management System (CRM). I have been working on this project from 3rd April 2024 to 30th April 2024, which is a period nearly one month.

6. Training program

Below are my duties and responsibilities I performance during my internship period

i. Network monitoring

At MAREN since I was in the department of network and infrastructure which mostly concern making sure that performance of the network is sustained, so that clients should be able to get good network connectivity. Below is a figure for Cacti network monitoring tool which we were using. In this role my main daily tasks include:



Observing network performance such as bandwidth, latency, packet loss. MAREN network is bandwidth based, which means each client is given a specific bandwidth based on the subscription. For example a client can have 340mb/s which means the client can access internet not more than their allocated bandwidth. I was responsible for allocating client's bandwidth as well as monitoring bandwidth utilization for each client. I was also responsible for monitoring increase or decrease of latency in the network as well as checking packet losses in the network and take appropriate step to mitigate any issue in the network.

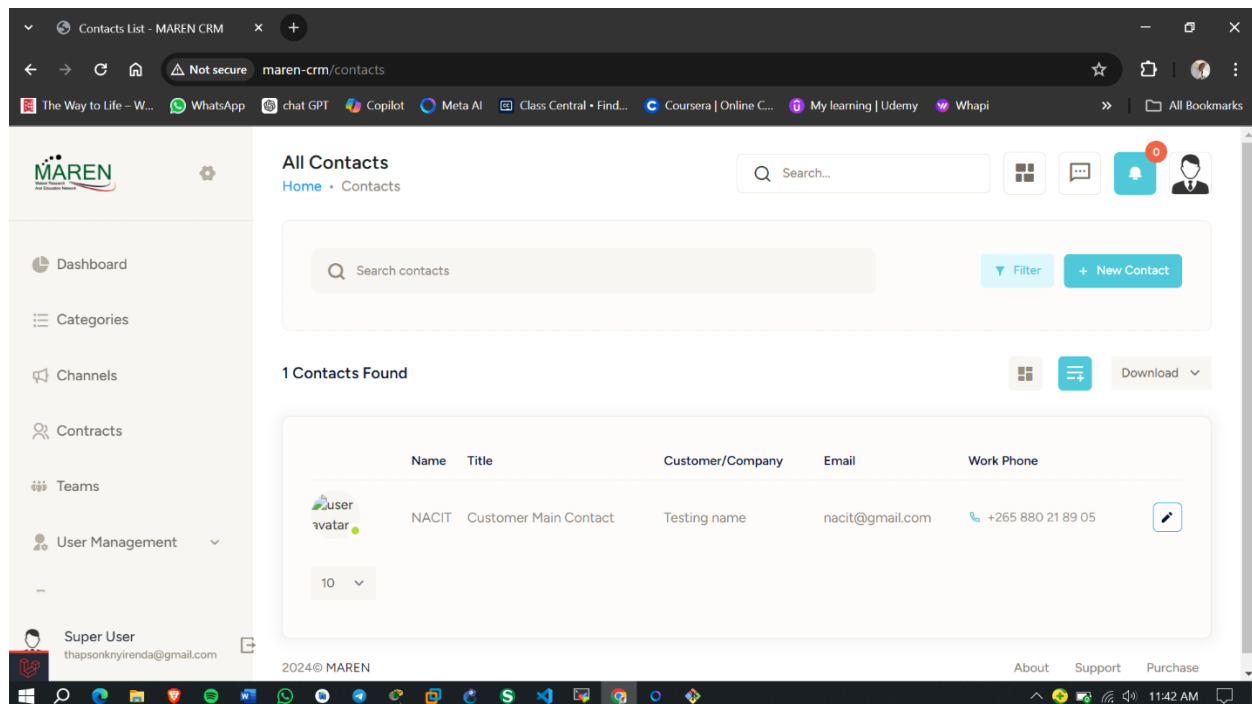
Monitoring network traffic and analyzing network data. In this task I was responsible in checking network usage, ports status, trends, anomalies and again routing protocols e.g. Open shortest path first (OSPF), Intermediate System (IS-IS), Border Gateway Protocol (BGP) and any related task.

Tracking network device status. I was also actively involved in monitoring and tracking the status of network devices, including routers, switches, and servers, to ensure they were functioning effectively and efficiently. Constantly checking the uninterrupted power supply for the network devices, so that they should always be on and connected.

I was also responsible for identifying potential network issues which includes bottlenecks and security threats. This was to ensure that network should be well optimized and again free from attacks.

ii. Systems development

During my internship period, despite being in the department of network and infrastructure, I was also working on developing MAREN Customer Management System (CRM). We were in a group of three developers, we started developing the system from scratch which we mainly used Vue (JavaScript frontend framework) with inertia for frontend development and Laravel (PHP backend framework) for the backend development and MySQL as our database. Below is MAREN CRM system user interface.

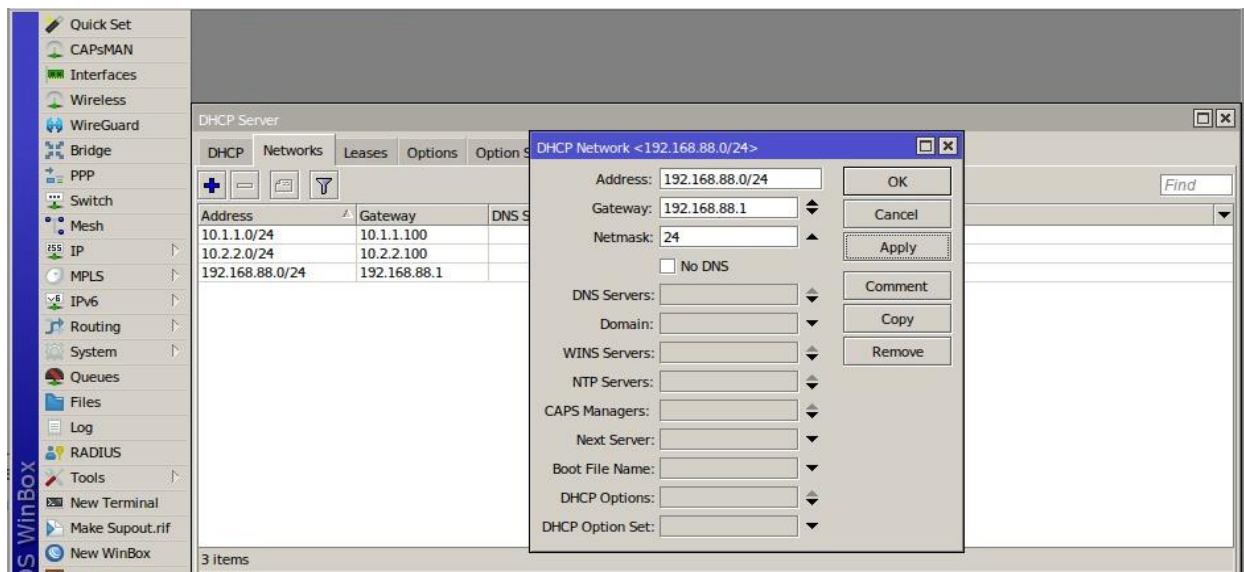


iii. Networking

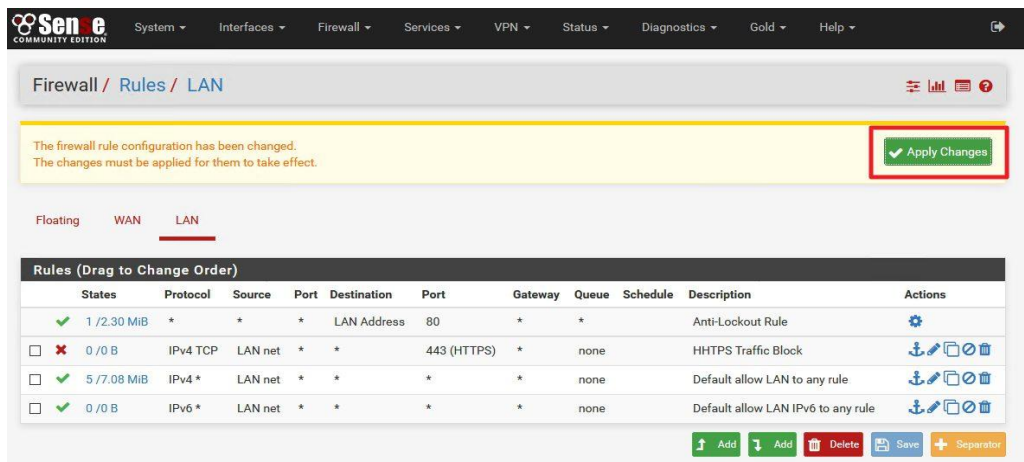
This role is similar to network monitoring but with differences because this role concerns more on actual technical aspect of network. Below are some of the roles I was performing concerning networking:

I was responsible for configuring network devices (routers, switches, firewalls). In this case I was configuring routing protocols to be using in the network, that is mostly in routers. I was also responsible in configuring virtual local area networks (VLANs), modern networking technology which utilizes the use of one physical link (cable) to carry two or more local area networks, which I was mostly configuring on layer three switches (Cisco, Huawei, juniper, Mikrotik).

Below is a picture for WinBox (Microtik configuration software)



Below is a PFSense firewall configuration interface:



Establishing network connections and setting up network protocols. During my internship period, I together with my colleagues have been establishing new network connections with new clients or within our clients. In this process we have been setting up Local Area Network (LAN), Wide Area Network (WAN) as well as Wireless Fidelity (Wi-Fi). After establishing the connection, then I and my colleague we could then setup a network

protocol, such as Transmission Control Protocol/Internet Protocol (TCP/IP), Domain Name System (DNS), Dynamic Host Configuration Protocol (DHCP).

iv. Preparing monthly reports

At the end of each month, I was responsible to generate and prepare a report on MAREN service level agreement with clients. I was responsible for MAREN clients from the north and central region, similarly my report only included these clients from north and central. MAREN uses internet service carriers like Electricity Corporation of Malawi (ESCOM), Open Connect Limited (OCL) and Airtel to distribute internet and other MAREN services to their clients. In a report I was including information concerning downtimes for a client over the month, the reason for the downtime which could be either from our carrier side or from the client side e.g. power issues from client side, duration for the downtime and actions performed on a specific downtime. Below is a sample report.

January, 2024						
Date/Time Fault Occurred	Date/Time Fault Restored	Fault Duration Hours	Status	Problem/Fault	Problem/Fault Details	Actions
9/1/2024 2:00	10/1/2024 2:00	24hr	Restored	Link down	Unknown	N/A
13/1/2024 2:00	18/1/2024 2:00	120h	Restored	link down	Dual fiber cut between Lilongwe-Kasungu and Salima-Dwangwa affecting links to Center and North	Fiber restored
19/1/2024 2:00	20/1/2024 2:00	24 hrs	Restored	link down	Unknown	N/A
22/1/2024 14:31	22/1/2024 16:40	2h 10m	Restored	link down	Power issues at client site	Power restored
24/1/2024 5:41	24/1/2024 10:34	4h 56m	Restored	link down	Dwangwa main power (ESCOM) down	Fiber restored
25/1/2024 19:56	25/1/2024 8:15	12h 21m	Restored	link down	Loose Ethernet cable at Ekwendeni exchange	Ethernet cable connection fixed
28/1/2024 2:00	29/1/2024 8:55	1d 6h 57m	Restored	link down	Mzimba-Kasungu backbone down, it was scheduled the next day due to heavy rains	Fiber restored
Feberuary, 2024						
1/2/2024 14:15	1/2/2024 16:00	1h 47m	Restored	link down	Power issues at client site	Power restored
2/2/2024 3:16	2/2/2024 9:00	5h 46m	Restored	link down	Unknown, suspect power issues	N/A
5/2/2024 0:20	5/2/2024 4:00	3h 42m	Restored	link down	Power issues at client site	Power restored
5/2/2024 14:12	5/2/2024 15:20	50m	Restored	link down	Power issues at client site	Power restored
9/2/2024 18:56	10/2/2024 12:20	5h 25m	Restored	link down	Power issues at client site	Power restored
16/2/2024 13:01	16/2/2024 14:15	1h 15m	Restored	link down	Power issues at client site	Power restored

v. Clients help desk support

As network and infrastructure personnel, I was also responsible for any client's complaint concerning network issue. At MAREN I and colleagues we were using phone calls and WhatsApp groups where we were communicating with client if there is any issue either to their end or to our end. In this way we were ensuring that any issue from the client should be addressed as fast as possible.

7. Learning Experiences

a. Knowledge acquired

During my internship in the Network and Infrastructure Department at MAREN, I gained extensive knowledge in network management and system administration, which directly complemented my academic studies. I had the opportunity to configure and maintain network devices such as routers and switches, utilizing network monitoring tools and troubleshooting network issues. This practical experience allowed me to apply and deepen my understanding of the theoretical concepts learned in my Computer Networks course, such as the OSI model, IP addressing, subnetting and routing algorithms. The combination of hands-on experience with network devices and server management provided me with a comprehensive understanding of how to optimize and maintain a robust network infrastructure, bridging the gap between classroom learning and real-world application.

b. Technical skills learned

I have acquired a wide range of technical skills during my internship period at MAREN, some of these include:

i. VLAN/LAN/WAN Configuration

Virtual Local Area Network (VLAN) is a modern way of connecting two or more Local Area Networks (LAN) using only single link which we call trunk link in terms of configurations. I have been configuring VLANs on different layer three switch for example Cisco, Mikrotik and Huawei. In this configuration it involves creating a VLAN for a client with a name and an ID, by assigning that VLAN a default gateway it means any device that is connected to that particular VLAN can have access to the internet which is Wide Area Network (WAN).

ii. EDUROAM Configuration

We had a three days EDUROAM training organized and lead by the MAREN CEO Mr. Solomon Dindi, where we learnt basic fundamentals of EDUROAM, how it works and how to set it up on Alma Linux from scratch. In this training we used Free radius server as our Radius server for authentication and authorization. And we used Open LDAP for storing user data to be used when logging into our EDUROAM which we setup.

iii. High Performance Computing (HPC) and big data Analytics

MAREN in collaboration with National Research and Academic Network of Armenia (ASNET-AM) lead by Dr. Astsatryan from ASNET-AM. organized a training workshop from 5th to 6th February which took place at Malawi University of Business and Applied

Sciences (MUBAS). This workshop covered a wide array of topics including High-Performance Computing (HPC), Big Data, Data Analytics, and NREN Communication and Marketing activities. Over 21 participants from MAREN's member institutions benefited from the insightful sessions. I obtained a hands-on experience in HPC where we were trying to experiment the computing power between using an ordinary computer and using HPC on a sample C# for-each loop code. It was a great experience since with HPC we can allocate as many available computing cores as possible to run a piece of code where by further reducing code process time, which is limited in an ordinary computer.

iv. Systems development using Vue JavaScript and Laravel frameworks

During my internship at MAREN, despite been allocated in network and infrastructure department. I was also in a team of developers where we were developing MAREN Customer Relationship Management (CRM) system. We were using Vue as a frontend JavaScript framework, Laravel as PHP backend framework, Apache as our development server and MySQL as our relational database.

c. Soft skills learned

During my internship in the Network and Infrastructure Department, I developed several important soft skills that will be valuable for my future career. I gained confidence by successfully handling complex tasks and making decisions, which helped me trust my abilities more. I learned empathy by working closely with colleagues and clients, understanding their needs, and helping them effectively. Teamwork was a big part of my experience, as I collaborated with others to achieve our goals. Finally creative thinking was essential for coming up with innovative solutions to problems we faced.

d. The most challenging task performed

The internship was full of interesting tasks as well as some challenging tasks. It was a time when we were setting up new Huawei equipments which MAREN bought in order to setup new Point of Presence (POP) in Mzuzu and Lilongwe in addition to the one which is currently located in Blantyre. I was given a task to configure VLAN for a client in Mzuzu in a Huawei Switch and Router for Mzuzu POP, since Huawei devices are not commonly used in most network setups, it was my first time to work with Huawei device configurations, since each company has its own different configurations commands for their network devices. I did more research on internet and documentations until I found a Huawei user manual which I followed and I managed to configure VLAN on both Huawei switch and router.

8. Problem Identification and Solution

a. Problem identification

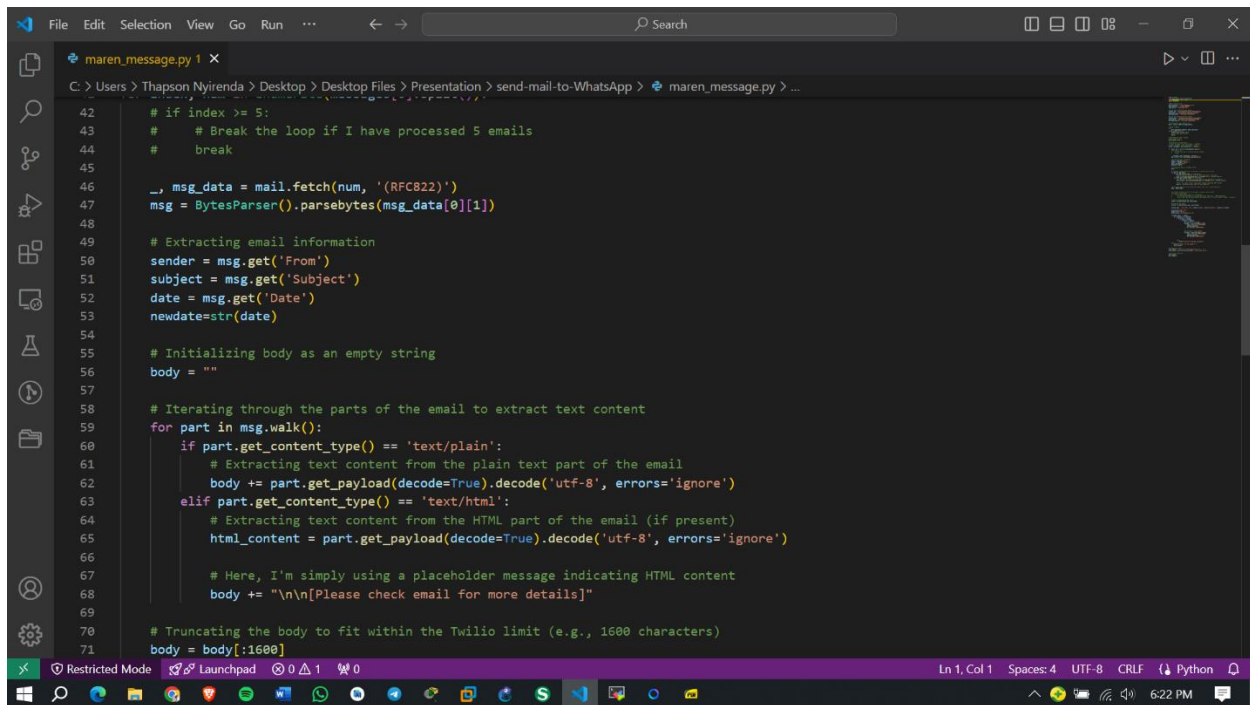
During my internship at MAREN, one of the big problem which I noticed was about delay in receiving notification alerts from network monitoring tools in which we were using Cacti and Zabbix. What was happening was that, the device can be monitored down by the monitoring system but it can send a notification alert sometimes after 10 to 15 minutes and alerts could only be sent through our emails, which was not effective and inefficiency as well.

b. Consequences of the current problem

The problem of delay in receiving notifications from network monitoring systems could cause a lot of problems mainly to our clients. The problem could come in because once we receive a notification about any link down or any anomalies, we were supposed to communicate with MAREN carriers which were Airtel, OCL, ESCOM to check on the issue. In this case, delay in receiving a notification alert about a client link down could lead to us from MAREN communicating late to carriers about client link down which could cause a client waiting longer than expected for the link to be fixed or checked by the carrier.

c. Suggested solution / Worked on solution

After doing some research closely for a week, I found out that I can integrate MAREN monitoring systems with WhatsApp Application Programming Interface (API) so that we can be receiving messages intime through WhatsApp application. I utilized a third party Twilio WhatsApp API, I developed an independent script using Python programing language so that MAREN network monitoring systems should be able to be sending notification alerts intime through WhatsApp. This solution worked and we were able to receive notifications alert through WhatsApp, which enhanced effectiveness and efficiency in our operation. Below is a code snippet and a sample notification alert received through WhatsApp.



```
42 # if index >= 5:
43 #     # Break the loop if I have processed 5 emails
44 #     break
45
46 msg_data = mail.fetch(num, '(RFC822)')
47 msg = BytesParser().parsebytes(msg_data[0][1])
48
49 # Extracting email information
50 sender = msg.get('From')
51 subject = msg.get('Subject')
52 date = msg.get('Date')
53 newdate=str(date)
54
55 # Initializing body as an empty string
56 body = ""
57
58 # Iterating through the parts of the email to extract text content
59 for part in msg.walk():
60     if part.get_content_type() == 'text/plain':
61         # Extracting text content from the plain text part of the email
62         body += part.get_payload(decode=True).decode('utf-8', errors='ignore')
63     elif part.get_content_type() == 'text/html':
64         # Extracting text content from the HTML part of the email (if present)
65         html_content = part.get_payload(decode=True).decode('utf-8', errors='ignore')
66
67         # Here, I'm simply using a placeholder message indicating HTML content
68         body += "\n\n[Please check email for more details]"
69
70 # Truncating the body to fit within the Twilio limit (e.g., 1600 characters)
71 body = body[:1600]
```

Figure: Code snippet

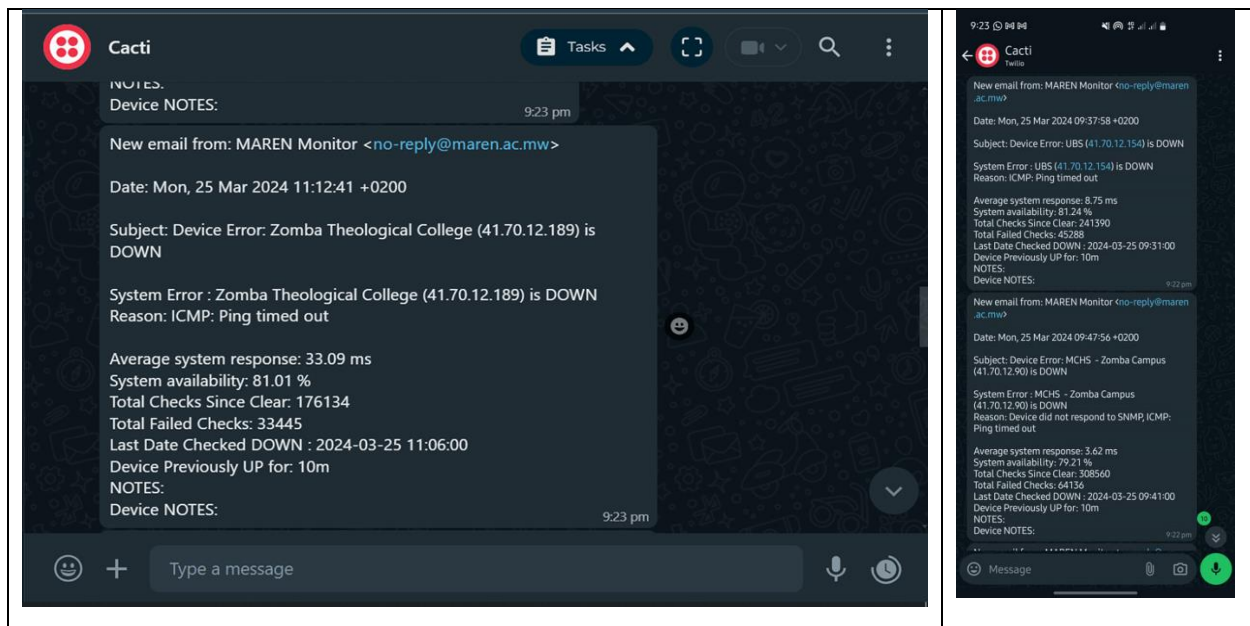


Figure: Notification alert sample, one for Windows and one for android WhatsApp

9. Conclusion

My internship at MAREN in Network and Infrastructure Department has been an invaluable learning experience. Throughout this period, I had the opportunity to apply theoretical knowledge in a practical setting, enhancing my understanding of network systems, infrastructure management, and the complexities involved in maintaining robust and secure network operations.

During my internship period, I worked on several projects that helped me improve my technical skills, like setting up networks, resolving network issues, and systems development. I also got to use new tools and technologies, which was very beneficial for my learning.

The experienced professionals in the department were very helpful and taught me a lot. Their guidance helped me handle challenges and complete my tasks successfully.

Overall, this internship has made me more interested in network and infrastructure field. It has also prepared me well for my future career. I am thankful for the opportunity to work at MAREN and look forward to using the skills and knowledge I gained in my future jobs.

10. References

MAREN background history retrieved from:

<https://maren.ac.mw/>

HPC and Bigdata workshop training retrieved from:

<https://ubuntunet.net/>

EDUROAM training organized and lead by:

Mr. Solomon Dindi (MAREN Chief Executive Officer)

Network Configurations (Cisco, Juniper, Mikrotik, Huawei) learnt from:

Mr. Trot Makasu (MAREN Assistant network Engineer)

Systems Development using Vue and Laravel learnt from:

Mr. Jones Kumwenda (MAREN systems Engineer)

Network Designing learnt from:

Mr. Alexius Chipalamwazani (MAREN Network and Infrastructure Manager)