CS215

DATA COMMUNICATIONS AND MANAGEMENT

ASSIGNMENT 1

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"Don't worry, it's not rocket science. It's subnetting, which is way more complicated!"

-Someone smart

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Introduction

Brief Overview

The HealthPlus pharmacy is looking forward to establishing 8 outlets in different parts of the country. Therefore, with the establishment of the 8 outlets, it would provide healthcare products and services to more people. However, it is also essential to design a LAN/WAN infrastructure that would allow these different outlets to communicate and manage their operations efficiently.

This assignment aims to design a LAN/WAN infrastructure considering all requirements presented by the pharmacy for the 8 outlets that is being established.

Objective of the design

The HealthPlus pharmacy requires a design of a WAN infrastructure which consist of 7 LAN connections, each LAN belonging to one of the 8 outlets. The sites chosen are Suva, Nausori, Sigatoka, Nadi, Lautoka, Labasa and Savusavu. While designing the infrastructure based on the requirements It is important to note :

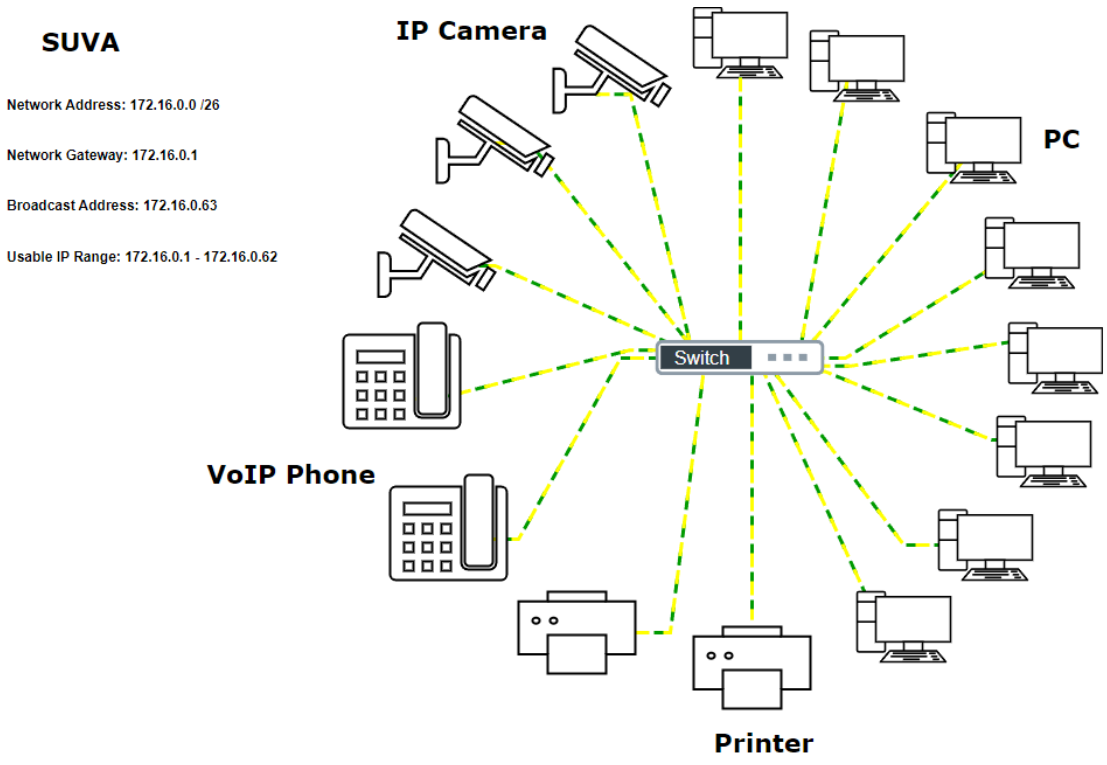
- Each site should be able to cater for the current host requirements and for future expansions
- The servers should be in a separate subnet to ensure security
- Correct choice of routing protocol
- End to end connectivity

Importance of the project

This project is important as it will allow efficiency in the operations carried out by the outlets as there will be real-time communication and data sharing. This will allow the pharmacies to improve the overall workflow, thus, saving time. The pharmacies main priority is to provide healthcare services to people, therefore having a concise workflow and access to information in real time would complement its services.

Design For the Proposed Network

Network Diagram:



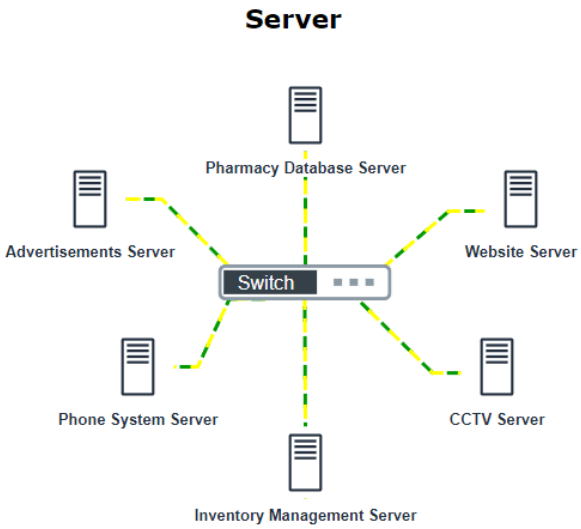
SUVA- SERVERS

Network Address: 172.16.1.96 /28

Network Gateway: 172.16.1.97

Broadcast Address: 172.16.1.111

Usable IP Range: 172.16.0.97 - 172.16.0.110



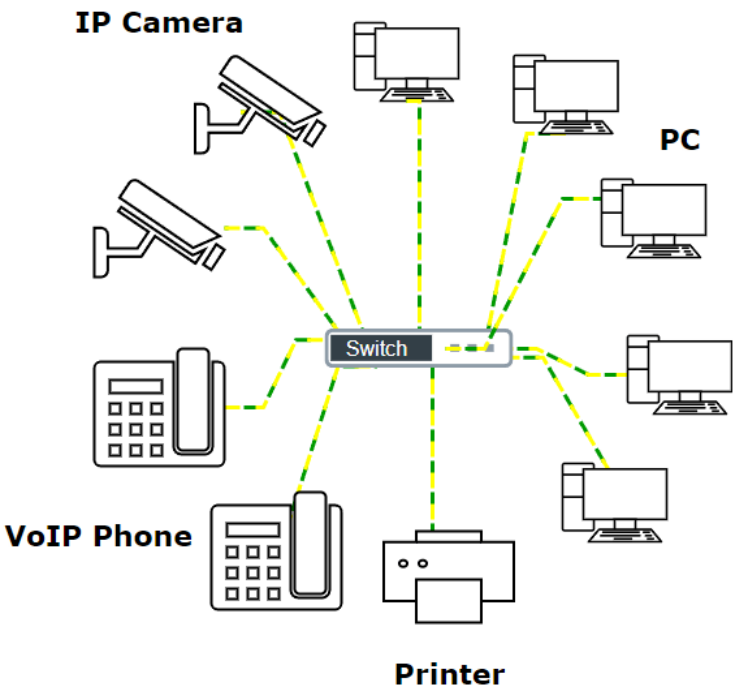
LAUTOKA

Network Address: 172.16.0.64 /26

Network Gateway: 172.16.0.65

Broadcast Address: 172.16.0.127

Usable IP Range: 172.16.0.65 -172.16.0.126



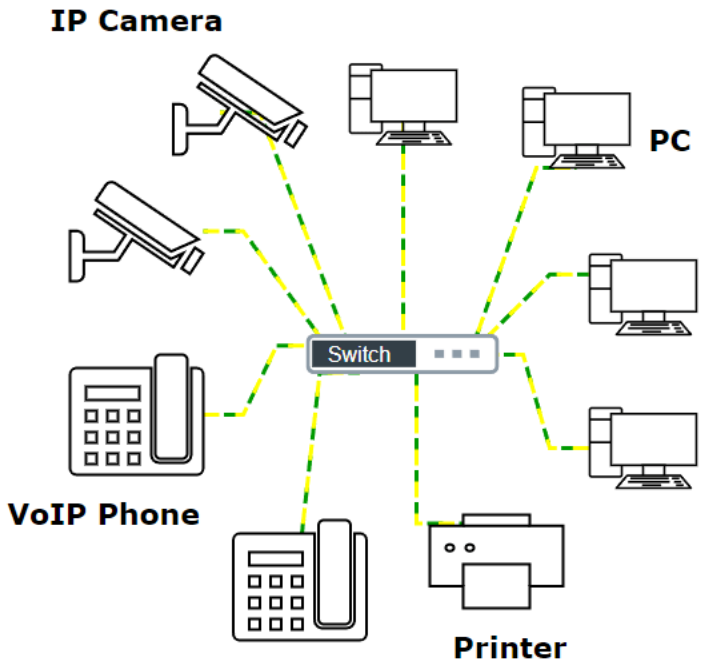
NAUSORI

Network Address: 172.16.0.128 /26

Network Gateway: 172.16.0.129

Broadcast Address: 172.16.0.191

Usable IP Range: 172.16.0.129 -172.16.0.190



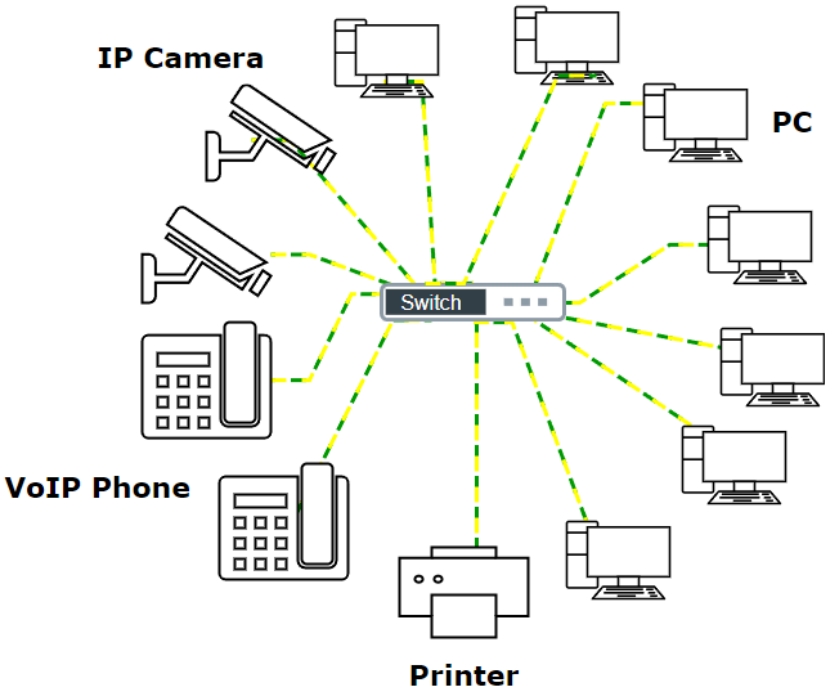
SIGATOKA

Network Address: 172.16.0.192 /26

Network Gateway: 172.16.0.193

Broadcast Address: 172.16.0.255

Usable IP Range: 172.16.0.193 -172.16.0.254



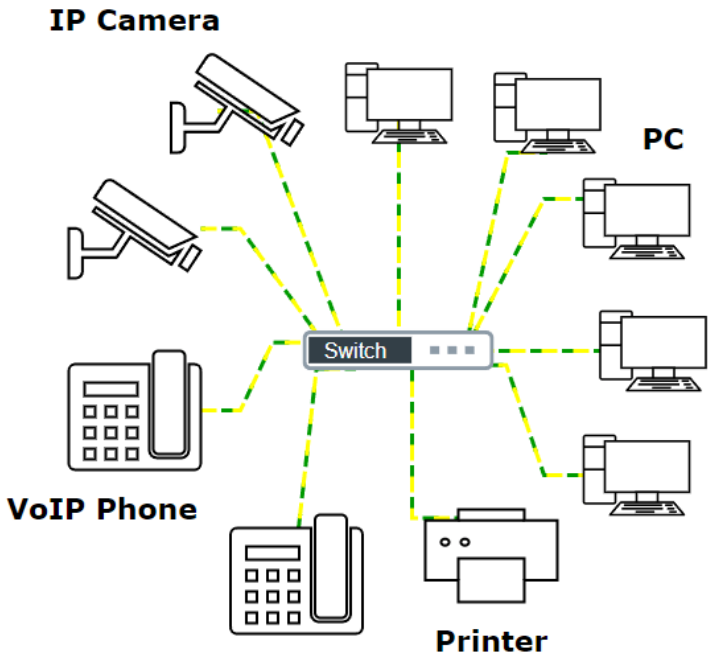
NADI

Network Address: 172.16.1.0 /27

Network Gateway: 172.16.1.1

Broadcast Address: 172.16.1.31

Usable IP Range: 172.16.1.1 -172.16.1.30



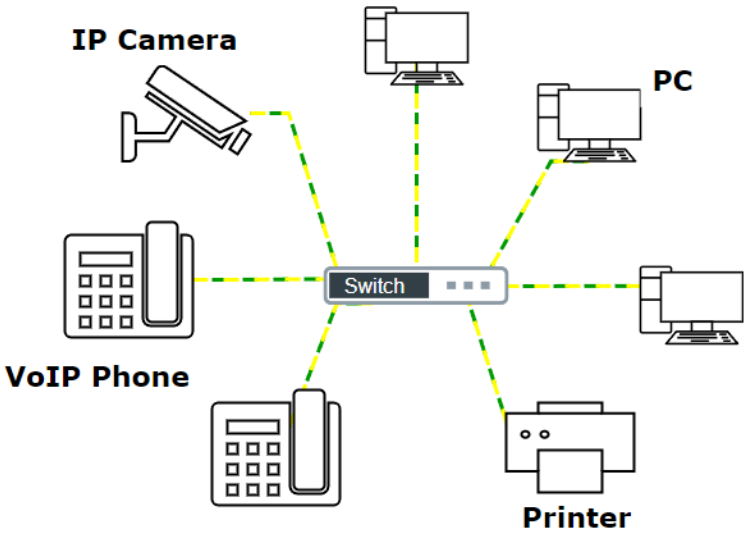
LABASA

Network Address: 172.16.1.32 /27

Network Gateway: 172.16.1.33

Broadcast Address: 172.16.1.63

Usable IP Range: 172.16.1.33 - 172.16.1.62



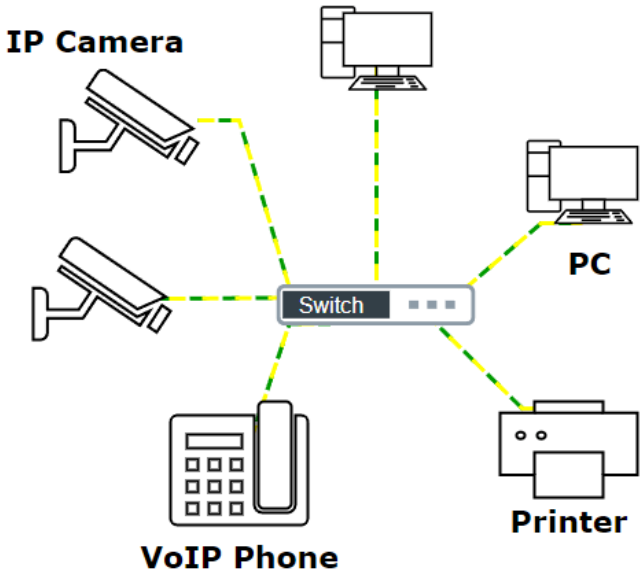
SAVUSAVU

Network Address: 172.16.1.64 /27

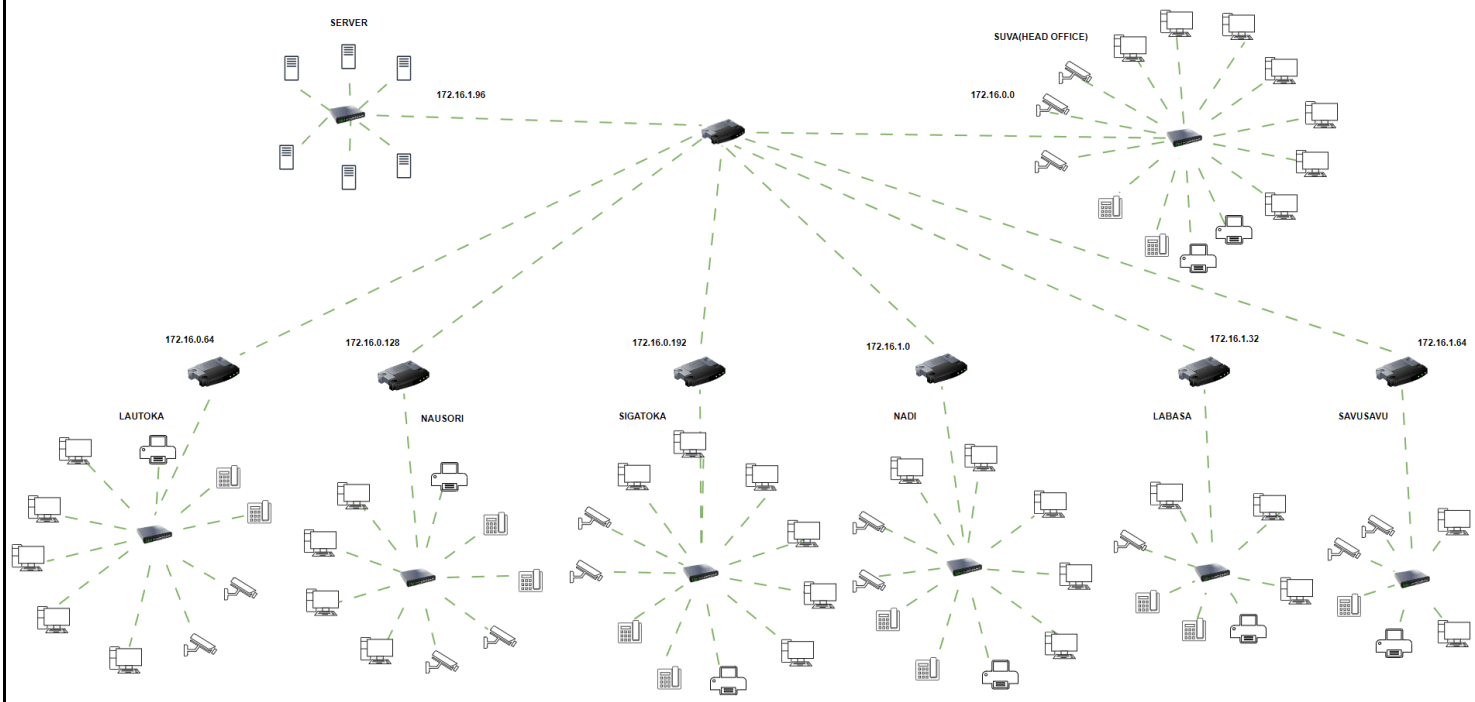
Network Gateway: 172.16.1.65

Broadcast Address: 172.16.1.95

Usable IP Range: 172.16.1.65 - 172.16.1.94



HealthPlus Pharmacy Network Design



IP Addressing Scheme:

Site/Branch	Network Address	Broadcast Address	IP Address Range(Usable)	Network Gateway
Suva	172.16.0.0/26	172.16.0.63	172.16.0.1 - 172.16.0.62	172.16.0.1
Lautoka	172.16.0.64/26	172.16.0.127	172.16.0.65 - 172.16.0.126	172.16.0.65
Nausori	172.16.0.128/26	172.16.0.191	172.16.0.129 - 172.16.0.190	172.16.0.129
Sigatoka	172.16.0.192/26	172.16.0.255	172.16.0.193 - 172.16.0.254	172.16.0.193
Nadi	172.16.1.0/27	172.16.1.31	172.16.1.1 - 172.16.1.30	172.16.1.1
Labasa	172.16.1.32/27	172.16.1.63	172.16.1.33 - 172.16.1.62	172.16.1.33
Savusavu	172.16.1.64/27	172.16.1.95	172.16.1.65 - 172.16.1.94	172.16.1.65
Server	172.16.1.96/28	172.16.1.111	172.16.1.97 - 172.16.1.110	172.16.1.97

Branch	Device	Serial Interface	Serial IP Address
Suva	Router	Se0/0/0	172.16.2.1/30
Suva	Router	Se0/0/1	172.16.3.1/30
Suva	Router	Se0/1/0	172.16.4.1/30
Suva	Router	Se0/1/1	172.16.5.1/30
Suva	Router	Se0/2/0	172.16.6.1/30
Suva	Router	Se0/2/1	172.16.7.1/30
Lautoka	Router	Se0/0/0	172.16.2.2/30
Nausori	Router	Se0/0/0	172.16.3.2/30
Sigatoka	Router	Se0/0/0	172.16.4.2/30
Nadi	Router	Se0/0/0	172.16.5.2/30
Labasa	Router	Se0/0/0	172.16.6.2/30
Savusavu	Router	Se0/0/0	172.16.7.2/30

The table above shows the use of **class B** network addresses due to multiple locations and various hosts, therefore the network address and subnet mask used initially was **172.16.0.0/16**. This network was further divided into 8 sub-networks. Each branch has their host requirements so it is important to create sub-networks that would be able to accommodate the requirements of the branch.

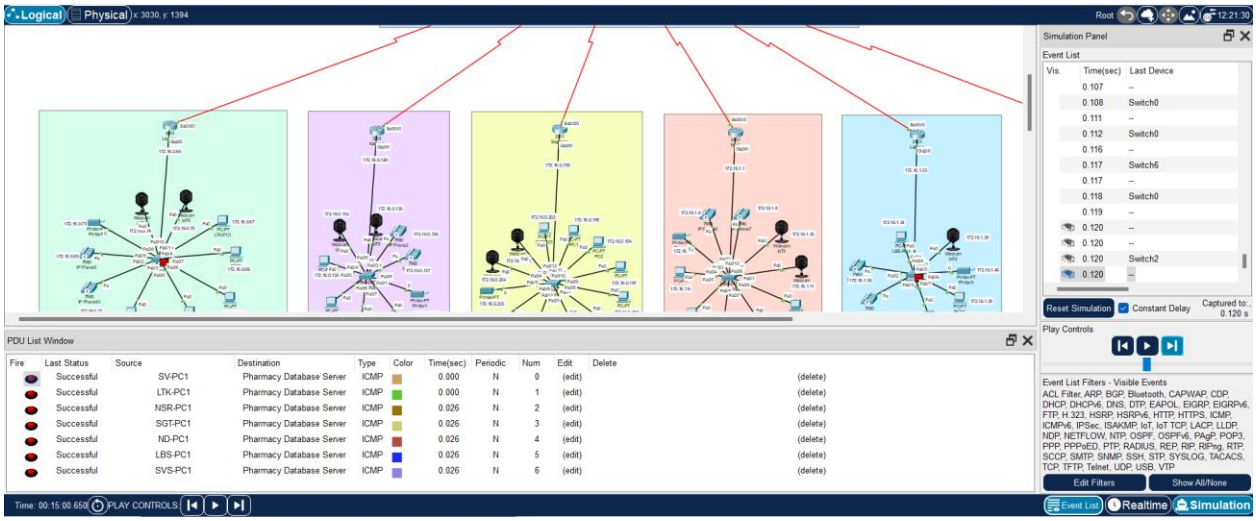
Below is a table that shows the total IP addresses assigned to a particular branch:

Site/Branch	Subnet	Subnet Mask	Total IP Addresses	Usable IP Addresses	Hosts Required
Suva	172.16.0.0/26	255.255.255.192	64	62	40
Lautoka	172.16.0.64/26	255.255.255.192	64	62	40
Nausori	172.16.0.128/26	255.255.255.192	64	62	35
Sigatoka	172.16.0.192/26	255.255.255.192	64	62	32

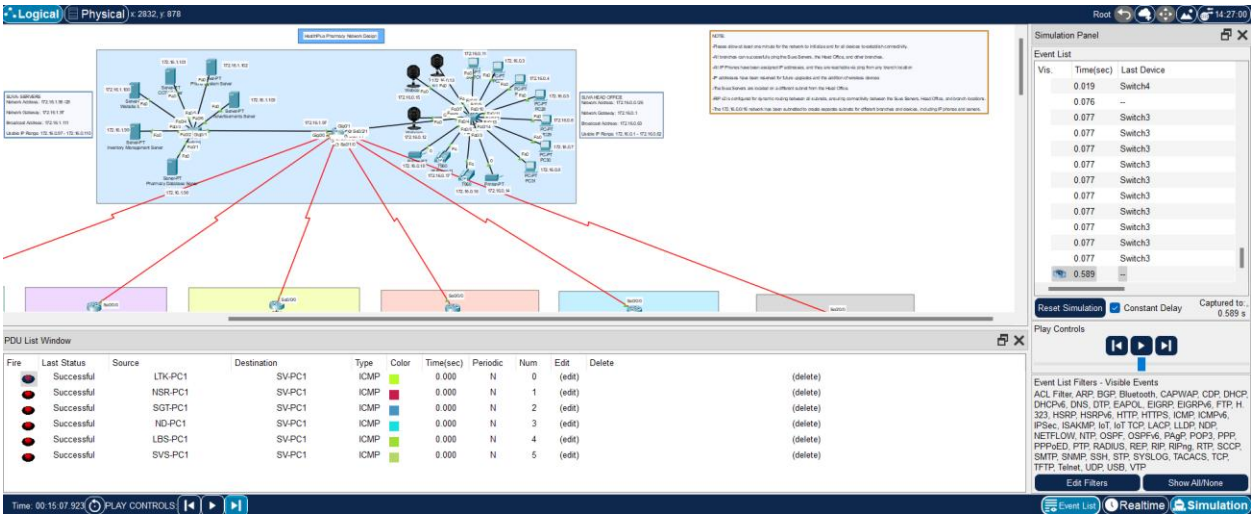
Nadi	172.16.1.0/27	255.255.255.224	32	30	28
Labasa	172.16.1.32/27	255.255.255.224	32	30	27
Savusavu	172.16.1.64/27	255.255.255.224	32	30	15
Server	172.16.1.96/28	255.255.255.240	16	14	11

Screenshots of PDU Ping Scenarios:

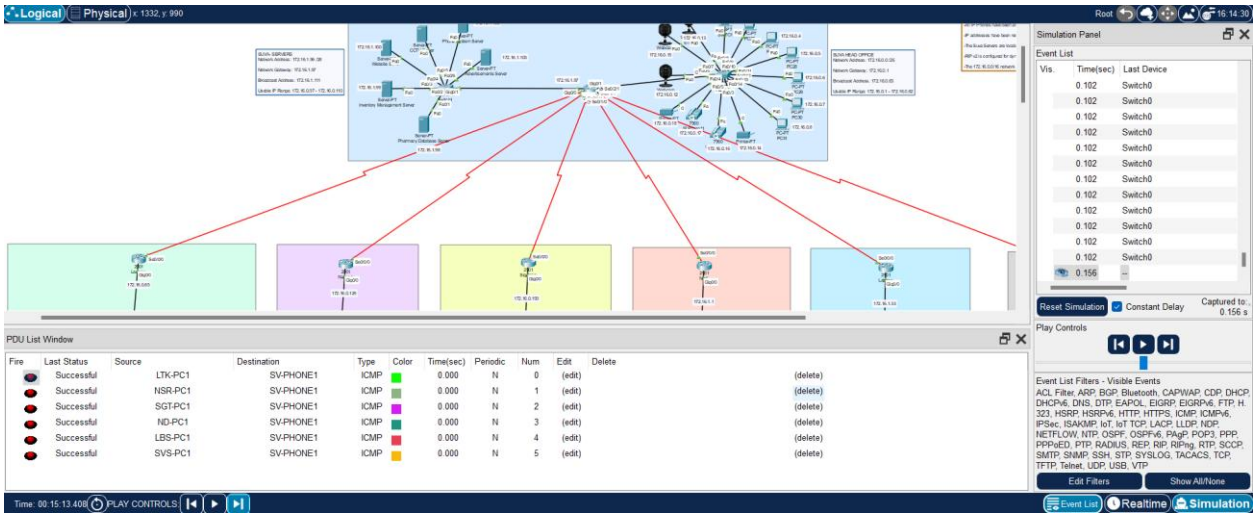
- The screenshot below shows a successful PDU transmission between the branch PCs and Suva Servers.



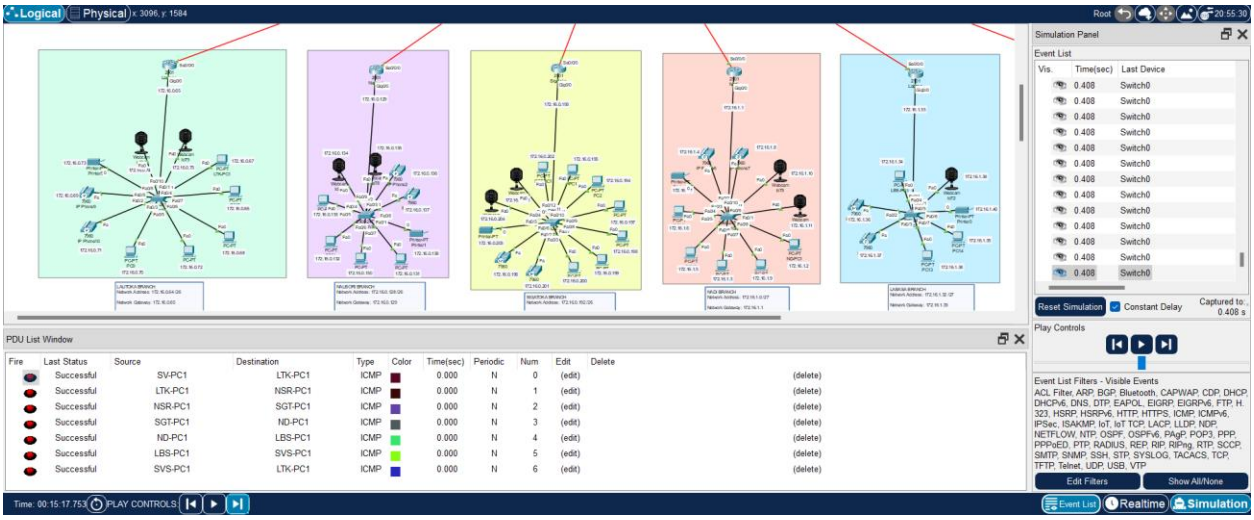
- The screenshot below shows a successful PDU transmission between the branch PCs and Suva(Head Office) PCs.



- The screenshot below shows a successful PDU transmission between the branch PCs and Suva(Head Office) IP phone.



- The screenshot below shows a successful PDU transmission between the different branch PCs



Justification for the Choice of Design

IP Usage Calculation:

The method used to calculate the different subnets for each branch was **VLSM(Variable Length Subnet Mask).** This method was used because it is more efficient as it reduces IP address being wasted.

<u>Steps for VLSM:</u>

- Identify the host requirements for each network.
- Arrange the networks from largest to smallest based on their host requirements.
- Find the host bits for the first (largest) network.
- Create your new subnet.
- Find the increment(last network bit).
- Calculate your network range using the increment.
- Repeat the steps for the next network.

Below is a diagram that shows the calculation of the subnets using VLSM, the first network created was for Suva consisting of 40 hosts. This includes the current and future requirements, however when creating the subnet for Suva, we have to consider the network address and the broadcast address. Therefore, 42 hosts will be considered.

Furthermore, to accommodate for 42 hosts, we will need to have 6 host bits because 2^6=64 IP addresses(62 usable IP addresses) which is sufficient for Suva branch. Similarly, Lautoka, Nausori and Sigatoka require the same number of host bits to accommodate for their network.

Using the network address 172.16.0.0/16
Subnet calculation for Suva, Lautoka, Nausori and Sigatoka

2^6=64 IP addresses
therefore, 62 usable IP addresses

+2 for the network and broadcast address therefore 42

128 (64) 32 16 8 4 2 1

-40 hosts ⟶ 6 bits needed for 40 hosts

-Original Subnet

Save 6 bits for the hosts ←

/16=11111111 11111111 00000000 00000000

The rest becomes network bits

-New Subnet

64

/26=11111111 11111111 11111111 (1)1000000

255.255.255.192

-Find the increment(last network bit) = 64

-Calculate Network Range

172.16.0.0 - 172.16.0.63 /26

172.16.0.64 - 172.16.0.128/26

Since Lautoka also has 40 hosts requirement, we can use the same increment

172.16.0.128 - 172.16.0.191/26

172.16.0.192 - 172.16.0.255/26

We can use the same increment for Nausori(35 hosts) and Sigatoka(32 hosts)

*They require the same number of host bits to accomodate for the IP addresses required by the hosts

Using the network address 172.16.0.0/16
Subnet calculation for Nadi, Labasa and Savusavu

For Nadi:

2^5=32 IP addresses
therefore, 30 usable IP addresses

+2 for the network and broadcast address therefore 30

128 64 **32** 16 8 4 2 1

-28 hosts ⟶ 5 bits needed for 28 hosts

-Original Subnet

Save 5 bits for the hosts

/16=11111111 11111111 00000000 00000000

The rest becomes network bits

-New Subnet

32

/27=11111111 11111111 11111111 11100000
255.255.255.224

-Find the increment(last network bit) = 32

-Calculate Network Range

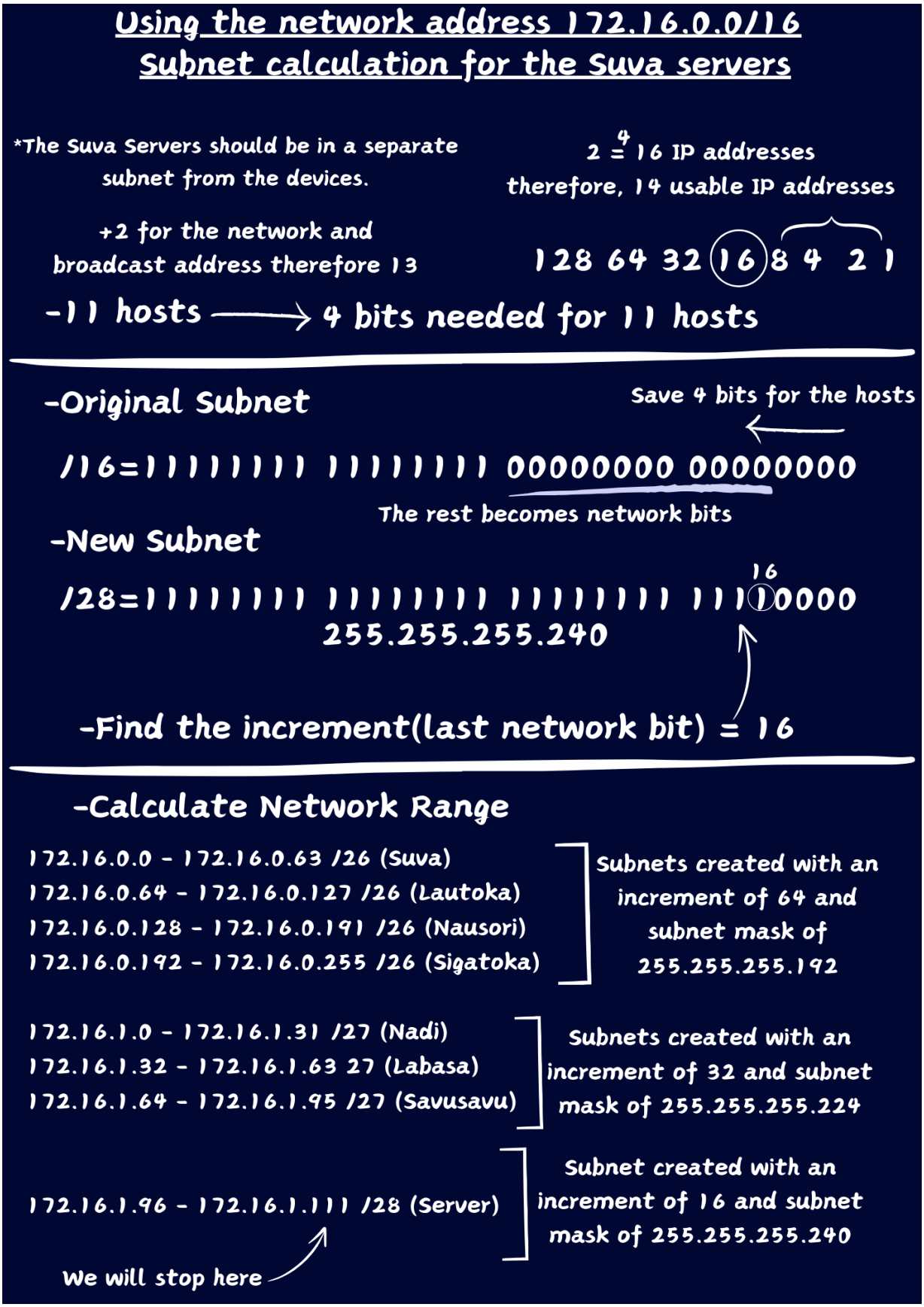
172.16.1.0 - 172.16.1.31 /27

172.16.1.32 - 172.16.1.63/27

Labasa has 27+2 hosts, therefore needs 5 host bits to get 32 IP addresses to accommodate for host requirements in the network

172.16.0.64 - 172.16.0.95/27

Savusavu (15+2) hosts, therefore, same increment can be used to calculate for this subnet


Using the network address 172.16.0.0/16
Subnet calculation for the Suva servers
*The Suva Servers should be in a separate subnet from the devices.
+2 for the network and broadcast address therefore 13
2^4 = 16 IP addresses
therefore, 14 usable IP addresses
128 64 32 16 8 4 2 1
-11 hosts ⟶ 4 bits needed for 11 hosts
-Original Subnet
Save 4 bits for the hosts
/16=11111111 11111111 00000000 00000000
The rest becomes network bits
-New Subnet
16
/28=11111111 11111111 11111111 11110000
255.255.255.240
-Find the increment(last network bit) = 16
-Calculate Network Range
172.16.0.0 - 172.16.0.63 /26 (Suva)
172.16.0.64 - 172.16.0.127 /26 (Lautoka)
172.16.0.128 - 172.16.0.191 /26 (Nausori)
172.16.0.192 - 172.16.0.255 /26 (Sigatoka)
Subnets created with an increment of 64 and subnet mask of 255.255.255.192
172.16.1.0 - 172.16.1.31 /27 (Nadi)
172.16.1.32 - 172.16.1.63 27 (Labasa)
172.16.1.64 - 172.16.1.95 /27 (Savusavu)
Subnets created with an increment of 32 and subnet mask of 255.255.255.224
172.16.1.96 - 172.16.1.111 /28 (Server)
Subnet created with an increment of 16 and subnet mask of 255.255.255.240
We will stop here

Justification for the Choice of Interconnecting Devices

Interconnecting devices are hardware used to allow communication between networks such as routers, switches and repeaters. Such hardware devices are needed to allow communication between different LANs such as in our network design.

Therefore, to allow communication between devices in a LAN network, the CISCO Catalyst 2960 is used for this purpose.

For Switch:

Capacity

- The C2960 has 48 ethernet ports which will be sufficient for the LAN requirements.
- Each port in the switch support speeds of 100Mbps
- PoE(Power over Ethernet) support, which is needed for IP phones and Cameras
- Handles a total of 16Gbs of network traffic across its ports.

Reliability

- CISCO is a reputable brand when it comes to networking hardware's, and it has been in business for almost 40 years.
- There is PoE reliability for IP phone and IP cameras on the network.
- The C2960 receives firmware update and there are forums online for help in troubleshooting.
- The CS290 has been used by businesses around the world and it has shown its reliability and consistent performance.

Cost

- The C2960 can be ordered brand new from the Amazon website at a total cost of $4615.48 FJD.
- Based on local businesses that offer setting up and installing the switch in a LAN network, the exact pricing details needs to be negotiated by the service providers.

For Router:

Capacity

- The C2901 has 2 integrated ethernet port.
- Each port supports speeds of 100 or 1000Mbps.
- The router also has 4 Enhanced High-Speed WAN Interface Cards which allows connections such as serial.

- Along with that, the router also has 2 USB 2.0 port that allows for additional connectivity or storage.

Reliability

- The C2901 has been designed to perform in work environments and under traffic loads, there this router would be a suitable choice based on its reliability and longevity
- It is a product of a reputable brand CISCO
- The router also supports security features such as firewall and intrusion detection system.

Cost

- The C2901 can be ordered brand new from the eBay website at a total cost of $747.61 FJD
- Based on local businesses that offer setting up and installing the router in a LAN network, the exact pricing details needs to be negotiated by the service providers.

Below is a table that summarizes the justification for the Choice of Interconnecting Devices including their model names, Capacity, reliability and overall cost.

Interconnecting Device	Capacity	Reliability	Cost(Per Unit)
Cisco Catalyst 2960  Switch Model: Cisco WS-C2960-48PST-S (*Amazon, n.d.*)	-48 x Ethernet 10/100 PoE ports. -Bandwidth - 16Gbps -PoE Ports- 24 ports up to 15.4W	-Reputable Manufacturer -PoE reliability -Robust firmware -Positive feedback in real world scenarios	Price: $4615.48 Shipping: $243.92 Import Charges: $857.56 Total: $5716.96 (All Prices are in FJD)
CISCO 2901  Router Model: CISCO2901/K9	-2 x Integrated 10/100/1000 Ethernet Ports -4 x EHWIC Slots(For WAN NIC) -2 x USB 2.0 Ports	- Durable hardware design -Reputable Manufacturer -Advanced security	Price: $433.20 Import Charges: - Shipping: $314.40 Total: $747.61

(*eBay, n.d.*)		-Modular design	(All Prices are in FJD)

Justification for the Choice of Transmission Media

Transmission Media	Capacity	Reliability	Cost per Unit
Ethernet Cable (Cat 6)  (*Bondwell, n.d.*)	-Supports transfer speeds of 1Gbs over 100m distance -10Gbs over short distances (55m)	STP (shielded twisted pair) protects against EMI which is suitable against electronic noise. It is used by many business therefore, it is designed to meet the standard of the industries.	$35.00 per 10m from Bondwell (Local Vendor)

Discussion on Branch Requirements

Services for Each Branch:

The Suva branch is the head office for the HealthPlus Pharmacy Group and provided services via its servers. The current requirement has 6 servers, and each server has managed specific operations such as a pharmacy database server, inventory management server, website server, CCTV server, phone system server and advertisement server. The branches including Lautoka, Nausori, Sigatoka, Nadi, Labasa and Savusavu are able to access these servers' data in real time. They provide medical services while also having services such as VoIP, computer systems, printers and IP cameras. All devices have been assigned IP addresses respective of their network via subnetting. The subnetting method used is VLSM(Variable Length Subnet Mask) which allows minimum IP wastage. Also, to allow for successful ping across different devices and branches RIP v2 routing protocol has been implemented.

Furthermore, to cater for the bandwidth requirements of the various branches, Telecom Fiji Limited was considered as the WAN provider for HealthPlus Pharmacy. It provides services such as data and network solutions for local businesses. It has multiple high speed bandwidth options that will be able to cater for the data needs of the branches without any issues.

Current Network Design:

The subnets have been created to meet the needs of each network based on their hosts requirements. Each network consists of end devices such as computers, printers, VoIP devices and cameras. These end devices need to be able to communicate throughout the LAN network of the particular sit therefore, interconnecting device such a switch which is a layer 2 device(forwards data using MAC addresses). However, this communication is not only limited to one LAN network but with other LAN networks within the WAN infrastructure, to allow communication in a WAN network therefore, a router being a layer 3 device (allows communication to different IP networks) is implemented. Lastly, for the transmission of data, gigabit ethernet connections have been used only from the routers to the switch due to its high transmission speed which will help in overcoming network traffic during peak hours.

Future Wireless Networking Plans:

The HealthPlus Pharmacy Group Chairman has advised that in the current network design, there will be no wireless devices, however, it is recommended that in the future there will be wireless devices.

Future Employee Wireless Devices:

Wireless Access Points can be setup in offices which will allow employees to connect their mobile devices and laptops to the organization's networks. The AP needs to have a SSID(service set identifier) which is simply the name of the wireless network. Also, the AP needs to be assigned a password which will be needed by the employees when connecting to this wireless network.

Customer Wi-Fi Implementation:

In order to allow customers to have access to the wireless network, a separate guest network needs to be created to isolate traffic with a different SSID such as "Guest_WiFi". A password

isn't really recommended as it is a guest network, and it would be more convenient to connect to it without authentication. However, access limit needs to be enforced which will allow guests to use the Wi-Fi for a limited time(15mins). This is done mainly to optimize cost and avoid security risk due to an open network being exposed for a long period of time.

Conclusion

To sum up, the host requirements for the individual branches was taking into consideration and subnetting was done using VLSM (Variable Length Subnet Mask). Each subnet will also be able to accommodate for future devices as there are IP addresses in reserve. The routing protocol used between different LAN networks was dynamic routing (RIP V2). Also, connectivity was tested through PING, all devices were able to access the servers and the head office(Suva) with no issues.

Potential improvements can be made such as the implementation of firewalls. This will help against security risks that can disrupt the network. Using wireless APs can benefit the network along with the use of performance monitoring tools which will help manage and troubleshoot network in real time. Lastly, VLAN (Virtual LAN) implementation will help segregate the network traffic; for example, putting all IOT devices(Printers, Computers, Cameras) in VLAN 20 named as IOT and all IP phones in VLAN 30 named as VOICE. This will reduce unnecessary traffic as there will not be direct communication between the two separate VLANs unless it is allowed by the network administrator allowed.

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