

1708174

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Table of Contents

1. Element 1	7
1.1 Introduction	7
1.2 Research.....	8
1.2.1 OSI 7 Layer Model	8
1.2.2 OSI 4 Layer Model	10
1.2.3 Encapsulation.....	11
1.2.4 De-encapsulation	11
1.2.5 Broadcasting	12
1.2.6 Port Allocation	13
1.3 Design Requirements	14
1.4 Implementation	16
1.4.1 Static Addressing and Routing	16
1.4.2 Dynamic Addressing and Routing	18
1.5 Testing and Analysis.....	24
1.6 Evaluation	27
2. Element 2	28
2.1 Introduction	28
2.2 Design Requirements	29
2.3 Implementation	32
2.3.1 CIDR/28 Subnetting.....	32
2.3.2 CIDR/27 and CIDR/30.....	35
2.3.3 VLANs	39
2.3.4 Access Control Lists.....	45
2.4 Testing and Analysis.....	46
2.5 Evaluation	49
3. Element 3	50
3.1 Introduction	50
3.2 Design Requirements	51
3.3 Implementation	54
3.4 Testing and Analysis.....	59
3.5 Evaluation	63
Works Cited.....	64

4. Appendix.....	65
4.1 Static Routes	65
4.2 Circuit Device Configuration	69
4.3 VLAN Test.....	80
4.4 VLAN Configuration.....	86
4.5 Web Page Program	89

Table of Figures

Figure 1 - 7 Layer Model	9
Figure 2 - Encapsulation Example	11
Figure 3 - De-encapsulation example.....	11
Figure 4 - LAN Circuit.....	14
Figure 5 - Class A Mask	16
Figure 6 - Static Addressing Test Results	16
Figure 7 - Router 1 Static Routing	17
Figure 8 - Static Routing Test Results	17
Figure 9 - Router 3 RIP Configuration	18
Figure 10 - Router 3 Routing Table	18
Figure 11 - Router 3 RIP Configuration	19
Figure 12 - RIP Testing Results	19
Figure 13 - Router 1 Net 1 Configuration	20
Figure 14 - Router 1 Net 2 Configuration	20
Figure 15 - Router 1 Net 3 Configuration	20
Figure 16 - PC1 DHCP Configuration.....	20
Figure 17 - Router 2 Helper Address.....	21
Figure 18 - Router 3 Helper Address.....	21
Figure 19 - PC2 Default Address	21
Figure 20 - PC2 DHCP Configuration.....	21
Figure 21 - PC3 DHCP Configuration.....	22
Figure 22 - Router 1 Exclusion Configuration.....	22
Figure 23 - PC1 Configuration with Exclusion	22
Figure 24 - PC2 Configuration with Exclusion	23
Figure 25 - PC3 Configuration with Exclusion	23
Figure 26 - Router 1 Running Configuration.....	25
Figure 27 - Router 2 Running Configuration.....	25
Figure 28 - Router 3 Running Configuration.....	25
Figure 29 - Circuit	29
Figure 30 - Circuit Static Routes	29
Figure 31 - CIDR/28 Milford	30
Figure 32 - CIDR/28 Tenby	30
Figure 33 - CIDR/28 Pembroke.....	30
Figure 34 - CIDR/28 Milford-Tenby	30
Figure 35 - CIDR/28 Tenby-Pembroke.....	30
Figure 36 - CIDR/28 Pembroke-Milford	30
Figure 37 - CIDR/27 Network Table	31
Figure 38 - CIDR/30 Network Table	31
Figure 39 - CIDR/27 VLAN Milford	31
Figure 40 - Milford CIDR/28 CLI	32
Figure 41 - Pembroke CIDR/28 CLI	32
Figure 42 - Tenby CIDR/28 CLI.....	32
Figure 43 - Milford Routing Table – CIDR/28	33
Figure 44 - Pembroke Routing Table – CIDR/28.....	33

Figure 45 - Tenby Routing Table – CIDR/28	34
Figure 46 – Milford CIDR/27 and CIDR/30 CLI	35
Figure 47 - Pembroke CIDR/27 and CIDR/30 CLI.....	35
Figure 48 - Tenby CIDR/27 and CIDR/30 CLI	35
Figure 49 - Milford Routing Table - CIDR/27 & CIDR/30	36
Figure 50 - Pembroke Routing Table - CIDR/27 & CIDR/30	36
Figure 51 - Tenby Routing Table - CIDR/27 & CIDR/30.....	36
Figure 52 - Milford IP Route	37
Figure 53 - Pembroke IP Route.....	37
Figure 54 - Tenby IP Route	38
Figure 55 - Milford Switch Configuration	39
Figure 56 - Milford Switchport Access	39
Figure 57 - Milford Show VLAN	40
Figure 58 - Milford Switchport Trunk	40
Figure 59 - Milford Router Sub-interfacing	41
Figure 60 - Milford Interface Brief	41
Figure 61 - Milford Switch Ports	42
Figure 62 - Milford Router Ports	42
Figure 63 - PC2 Ports.....	42
Figure 64 - PC3 Ports.....	42
Figure 65 - Tenby Routing Table - VLAN	43
Figure 66 - Pembroke Routing Table - VLAN.....	43
Figure 67 - Milford Routing Table - VLAN	44
Figure 68 - Pembroke Access List	45
Figure 69 - Pembroke Access Group.....	45
Figure 70 - CIDR/28 Testing	46
Figure 71 - CIDR/27 & CIDR/30 Testing	46
Figure 72 - VLAN Test Results.....	46
Figure 73 - PC4 to PC3 Ping.....	47
Figure 74 - PC4 to PC2 Ping.....	47
Figure 75 - PC5 to PC3 Ping.....	47
Figure 76 - PC5 to PC2	48
Figure 77 - PC5 to PC0 Ping.....	48
Figure 78 - Web Server VLAN.....	51
Figure 79 - Web Server Switch VLAN	51
Figure 80 - Web Server Switch VLAN With Connections	52
Figure 81 - VLAN Ping Test	52
Figure 82 - Hardware Block Diagram	53
Figure 83 - Web Server Hardware Set-up	53
Figure 84 - PLC Properties.....	54
Figure 85 - File Extensions.....	54
Figure 86 - PLC I/O	55
Figure 87 - Web Server Function Block.....	55
Figure 88 - HTML Index Page Download	55
Figure 89 - PLC Ethernet Addresses.....	56
Figure 90 - Web Server Files	56

Figure 91 - Web Page Program Heading	56
Figure 92 - Web Page Program Body	57
Figure 93 - Web Program PLC Output Forms	57
Figure 94 - Web Page Program Input Forms	58
Figure 95 - Siemens Diagnostics Page	59
Figure 96 - Web Control Test 1	59
Figure 97 - Web Control Test 2	60
Figure 98 - Web Control Test 3	60
Figure 99 - PLC Motor Input.....	60
Figure 100 - Motor Monitoring Webpage – 35%.....	61
Figure 101 - PLC Watch Table - 35%.....	61
Figure 102 - Motor Monitoring Webpage – 90%.....	62
Figure 103 - PLC Watch Table – 90%.....	62
Figure 104 - Class C Mask.....	65
Figure 105 - Class B Mask.....	65
Figure 106 - Router 2 Static Routing	66
Figure 107 - Router 3 Static Routing	66
Figure 108 - Router 1 Routing Table	67
Figure 109 - Router 2 Routing Table.....	67
Figure 110 - Router 1 RIP Configuration	68
Figure 111 - Router 2 RIP Configuration	68
Figure 112 - Milford Fast Ethernet.....	69
Figure 113 - Milford Serial 0/0	69
Figure 114 - Milford Serial 0/1	70
Figure 115 - Pembroke Fast Ethernet	70
Figure 116 - Pembroke Serial 0/0	71
Figure 117 - Pembroke Serial 0/1	71
Figure 118 - Tenby Fast Ethernet	72
Figure 119 - Tenby Serial 0/0	72
Figure 120 - Tenby Serial 0/1	73
Figure 121 - PC0 Fast Ethernet	73
Figure 122 - PC0 Settings.....	74
Figure 123 - PC1 Fast Ethernet	74
Figure 124 - PC1 Settings.....	75
Figure 125 - PC2 Fast Ethernet	75
Figure 126 - PC2 Settings.....	76
Figure 127 - PC3 Fast Ethernet	76
Figure 128 - PC3 Settings.....	77
Figure 129 - PC4 Fast Ethernet	77
Figure 130 - PC4 Settings.....	78
Figure 131 - PC5 Fast Ethernet	78
Figure 132 - PC5 Settings.....	79
Figure 133 - VLAN Test Circuit	80
Figure 134 - Test Switch Configuration	80
Figure 135 - Test Show VLAN.....	81
Figure 136 - Test Switchport Access.....	81

Figure 137 - Test Show VLAN (Continued)	82
Figure 138 - Test Switch Trunk	82
Figure 139 - Test Router Interface	82
Figure 140 - Test Interface Trunk.....	83
Figure 141 - Test Router IP Addresses	84
Figure 142 - Test Show Interface Brief.....	85

Extensive list of figures

Table 1 - Static Addressing	15
Table 2 - Static Addressing Testing Table.....	24
Table 3 - Static Routing Testing Table	24
Table 4 - RIP Testing Table	24

Good list of tables

1. Element 1

1.1 Introduction

Using the Cisco Packet Tracer software, a network consisting of three local area networks and two wide area networks will be designed and implemented. These networks will display the different classes of addressing that are available, showing that they can be implemented to work together. Each network will be made up of PCs, routers and switches because they are commonly used devices and connected via serial or ethernet connections.

Once the networks have been set up, testing will be completed on each to prove the functionality of the interconnections and addressing.

*Introduction is clear
and to the point*

1.2 Research

1.2.1 OSI 7 Layer Model

The Open System Interconnection, or OSI, model represents the 7 layers of a networking system. Each layer has its own function within the framework and gives a description of how a networking system is performing, allowing the user to isolate and identify any issues. The 7 layers of the OSI model are as follows.

7 – Application

This is the last layer of the model but is the first that users come into contact with. This would be an application that can be interacted with, such as a web browser.

6 – Presentation

This layer takes the data and presents it for the application to use by converting it from network format to application format. This could include encrypting data for transmission.

5 – Session

This layer creates a session, which allows interaction between two or more devices. This includes setting up the session, coordinating the session and terminating the session.

4 – Transport

The transport layer coordinates data transfer. This includes determining how much data is being sent and where it is being sent to.

3 – Network

The network layer determines the best possible route, from a choice of millions, for ensuring that any packet forwarding is completed as efficiently as possible.

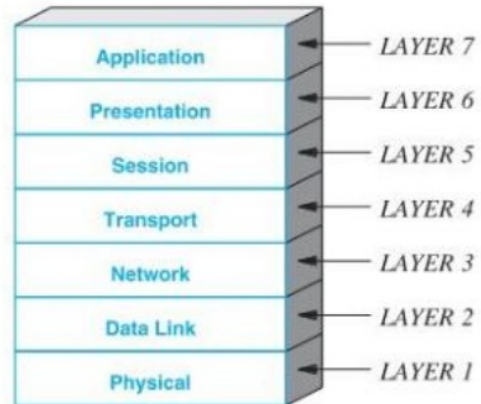
2 – Data Link

This layer, which is split into two sub-layers, allows transfer of data between two directly connected nodes. The two sub-layers present are the Media Access Control and Logic Link Control layers.

1 – Physical

This layer embodies any physical and electrical aspects of the network system, for example the cables used. This layer is typically the first part of the system checked when faults arise.

(Shaw, 2018)



Good diagram

Figure 1 - 7 Layer Model

1.2.2 OSI 4 Layer Model

The 4-layer model, also known as the Transmission Control Protocol model, is another type of networking system. This system is similar to the 7-layer model, but with fewer layers. The 4 layers are as follows.

4 – Application

The 4th layer of this model is also the application layer. However, this layer is the equivalent to the application, presentation and session layers in the 7-layer model. This layer includes higher level protocols, such as the Domain Naming System, or DNS, and the Hypertext Transfer Protocol, or HTTP.

3 – Transport

Like the 7-layer model, the 4 layer model's transport layer also determines how much data is being sent and where it is being sent to.

2 – Internet

The network layer is the equivalent of the 7-layer model's network layer and allows packets to be sent by hosts.

1 – Physical

This layer encompasses the Datalink and Physical layers of the 7-layer model and focuses on how data is physically sent using switches and cables.

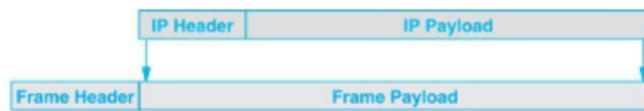
(Comer, 2015)

The 4-layer model is preferred because it is the basis for the internet. The internet was designed, built and expanded on the 4-layer model. Due to this, the 4-layer model has been gradually becoming widely used for industry network design standards. On the other hand, the 7-layer model is used as a reference model. It can be used for network architecture, but it becomes difficult to adapt and will not be used as widely as the 4-layer model. (TechDifferences, 2016)

You have identified the purpose of the 4 layer model and explained the differences from the 7 layer model

1.2.3 Encapsulation

Encapsulation is used to transmit a datagram over a network when the format is not understood. This is achieved by encapsulating the IP datagram within a payload area, adding IP and Frame Headers or Footers to the data. If travelling across multiple networks, different headers can be added individually. To ensure that the receiver is aware of the IP datagram, they must agree on the frame value used with the sender. The value prescribed to the frame is chosen by software. It must also have a media access controller address, or MAC address, which is supplied by the sender to the receiving computer. (Comer, 2015)



Explanation is correct

Figure 2 - Encapsulation Example
(Comer, 2015)

1.2.4 De-encapsulation

De-encapsulation is the process of reversing the encapsulation. During de-encapsulation, the receiving device removes the header or footer from the encapsulated data. Once the header or footer is removed from the information, the data can be freely processed for use by the receiving device. Typically, this device receives the encapsulated information from the lowest layer that it reaches, such as the physical layer.

Due to the datagram sometimes travelling across multiple networks, de-encapsulation can sometimes take place more than once due to the introduction of multiple headers or footers. (Comer, 2015)

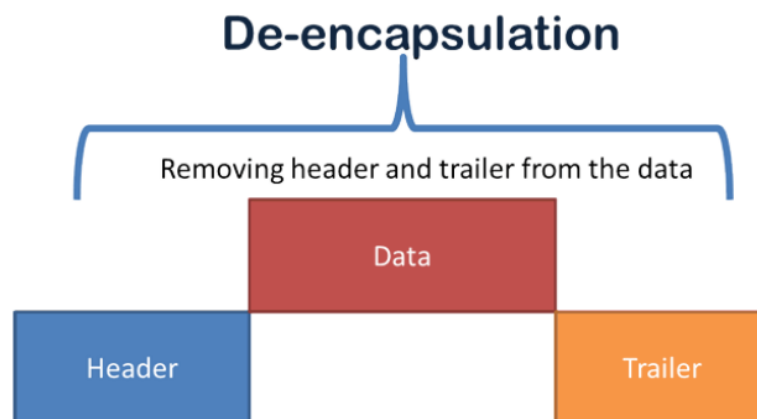


Figure 3 - De-encapsulation example
(ComputerNetworkingNotes, 2019)

This is correct. The headers are added during encapsulation and removed during decapsulation before the data is read. Each level in the model will have its own header.

1.2.5 Broadcasting

Broadcasting is the process of sending packets to computers on networks. In the case of broadcasting, the sending computer will transmit a copy of the packet to every computer on the same network, provided that they all share a broadcast address.

Along with broadcasting, unicasting and multicasting are also available. When using unicasting, the sending computer identifies a specific computer on the network and that computer becomes the designated receiver of the packet copy. Multicasting is a smaller version of broadcasting, in which the sending computer identifies a subnet of computers on the same network. This small group becomes the receiving party.

These methods are particularly advantageous when transmitting data amongst computers that all share a LAN because it is the most efficient form of delivery, given that the packet can be sent to every computer with the same broadcasting address. When received, the computer can then decide whether or not the packet should be processed. (Comer, 2015)

Good explanation

1.2.6 Port Allocation

There are two different types of ports available. These are.

- Transmission Control Protocol (TCP)
- User Datagram Protocol (UDP)

TCP ports are used when the sending device is directly connected to the receiving device. When this is used, there is a guarantee that the data will be transferred successfully. This makes this method of transferring data more reliable, but also causes the device, such as a computer, to work harder because it is also monitoring the transfer. Once complete, the connection is dropped.

UDP ports are used when there is not a direct connection between the sending and receiving devices. When this method is used, the sending device relies on other devices in the network to ensure that the data reaches its destination. This means that there is no guarantee of the data transmission being successful, but the devices do not work as hard and it can be used for information that has less importance.

Each IP address assigned to a device has ports. For TCP and UDP, there are 65,535 ports for each – depending on which is being used. When information is sent, it is sent to the IP address, but also to the port number. The sending device will send the information from a designated port, but the receiving device will collect the information on a random port. (Abrams, 2004)

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1.3 Design Requirements

To design and create a Local Area Network, or LAN, industrial layer devices are required. These devices include routers, switches and PCs. Shown below is a LAN circuit using the layer devices. In this circuit, the PCs and switches are connected to the routers via ethernet and the routers are connected together via serial link. By connecting the routers together via serial link, a Wide Area Network, or WAN, is formed.

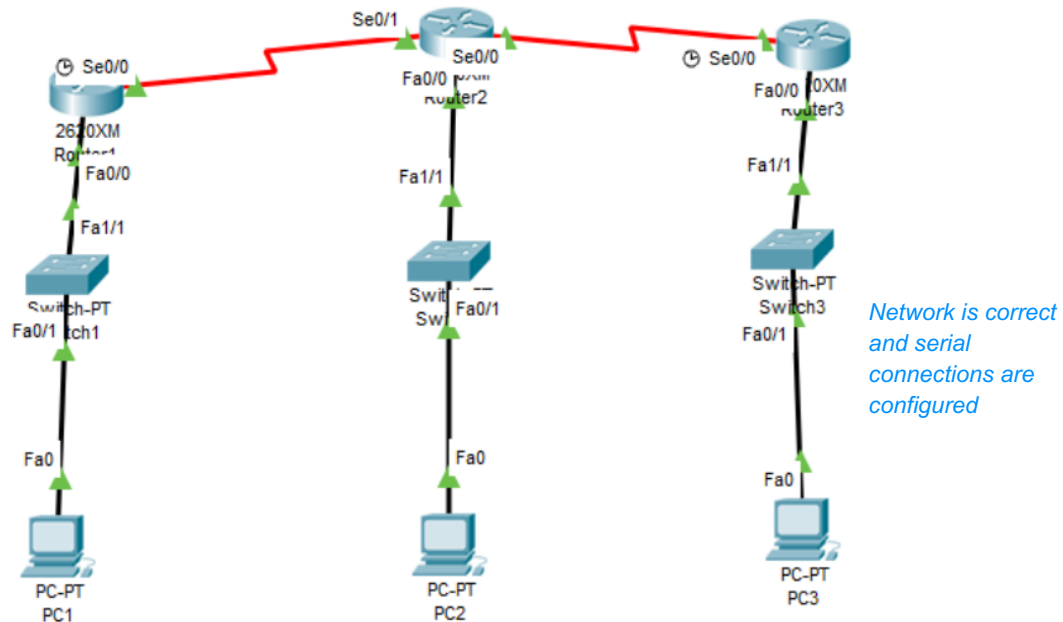


Figure 4 - LAN Circuit

To ensure that the devices can communicate with each other, static or dynamic addressing can be used. When addressing is used, the information is sent to an identified destination via a designated path. If static addressing is in use, the device will be assigned an IP address and it will not change under any circumstance. Dynamic addressing is assigned by the system and can change.

Static and dynamic routing can also be used to communicate between network devices. When static routing is used, the system uses a forwarding table which contains the same entries until they are manually changed. Dynamic routing uses route propagation software to update the forwarding table and provide the best route for each datagram. This means that dynamic routing is less susceptible to faults because the software can alter the forwarding table to accommodate for a failure on other devices.

Static routing is typically used on a host network to connect the devices to a router, which connects to the internet. Dynamic routing is used to connect a router to other routers.

There are three types of static addressing masks – Class A, Class B and Class C. The table shown below contains all of the different addresses that will be used for the LAN implementation and on which component they will be used on.

		Class C		Class A		Class B	
		PC1	Router1	PC2	Router2	PC3	Router3
Ethernet	Subnet Mask	255.255.255.0	255.255.255.0	255.0.0.0	255.0.0.0	255.255.0.0	255.255.0.0
	IP Address	192.168.4.1	192.168.4.254	100.0.0.1	100.0.0.254	170.25.0.1	170.25.0.254
	Gateway	192.168.4.254		100.0.0.254		170.25.0.254	
Serial 0/0	Subnet Mask		255.0.0.0		255.0.0.0		255.0.0.0
	IP Address		10.10.15.1		11.0.0.1		11.0.0.2
	Gateway						
Serial 0/1	Subnet Mask				255.0.0.0		
	IP Address				10.10.15.2		
	Gateway						

Table 1 - Static Addressing

A
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1.4 Implementation

1.4.1 Static Addressing and Routing

Using the table of addresses previously shown, the addresses can be applied to the routers and PCs.

This will allow data to be sent between the different devices on the LAN. Shown below is an example of a Class A mask, used on PC2.

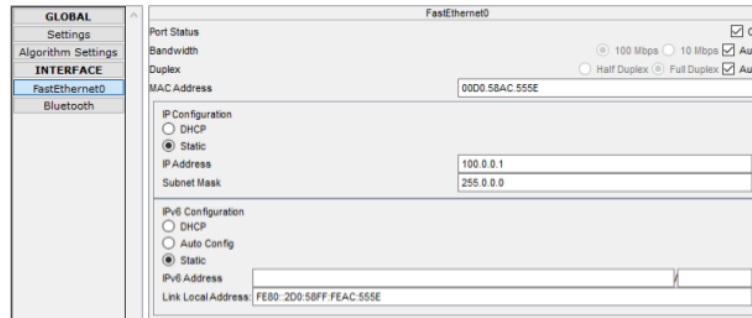


Image shows evidence of configuration

Figure 5 - Class A Mask

Further examples of the masks used can be found in the appendix. [Good reference to appendix](#)

If the static addressing is correctly set-up, information should be able to pass between the PCs, due to the addressing on the router serial ports. This can be tested by sending packets between each PC. The results from the test can be seen below.

PDU List Window										
Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC1	PC2	ICMP		0.000	N	0	(edit)	
	Successful	PC1	PC3	ICMP		0.000	N	1	(edit)	
	Successful	PC2	PC1	ICMP		0.000	N	2	(edit)	
	Successful	PC2	PC3	ICMP		0.000	N	3	(edit)	
	Successful	PC3	PC1	ICMP		0.000	N	4	(edit)	
	Successful	PC3	PC2	ICMP		0.000	N	5	(edit)	

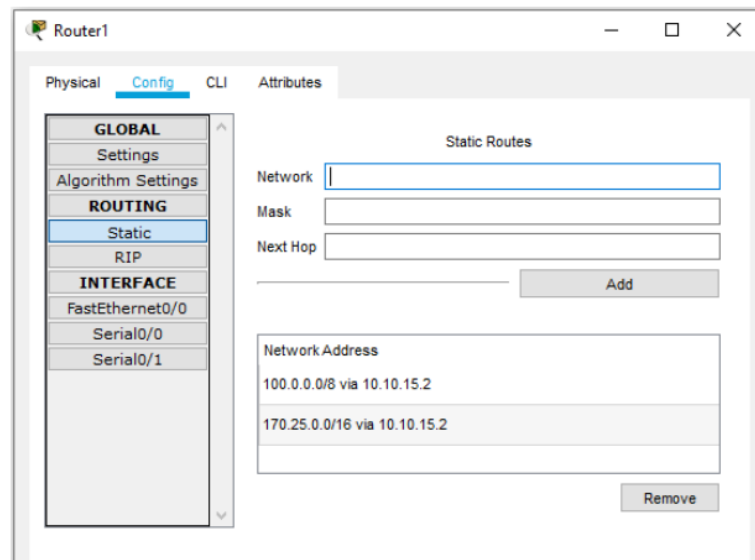
Ping tests are successful which

demonstrates that the routing tables are correct. The tests carried out perform a send and receive on each LAN

Figure 6 - Static Addressing Test Results

From these results it can be seen that the tests were carried out from between each PC, resulting in six successful tests. The success of the tests proves that both the ethernet and serial static addresses were set-up correctly.

Following the success of the static addressing, static routing can be applied. In the case of static routing, the device will be given destinations and routes that they must send data via. Due to the routing being static, the routes and addresses will remain constant. Shown below is the static routing configuration for Router 1.



Good illustration of static routing configuration

Figure 7 - Router 1 Static Routing

Again, the address values were taken from the addressing table that was displayed previously. From this example, Router 1 can send data to PC2 via Router 2 and to PC3 via Router 2. Router 2 is used for PC because it acts as the 'next hop' making it the designated optimum route.

Further examples of the static routing that was implemented can be found in the appendix.

The routing can be tested using the same method as the addressing – by sending packets between the PCs. Shown below are the results for the routing tests.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC1	PC2	ICMP		0.000	N	0	(edit)	
	Successful	PC1	PC3	ICMP		0.000	N	1	(edit)	
	Successful	PC2	PC1	ICMP		0.000	N	2	(edit)	
	Successful	PC2	PC3	ICMP		0.000	N	3	(edit)	
	Successful	PC3	PC1	ICMP		0.000	N	4	(edit)	
	Successful	PC3	PC2	ICMP		0.000	N	5	(edit)	

System tests for static configuration is successful

Figure 8 - Static Routing Test Results

The results shown are those of a successful test between the PCs. This, again, proves that the LAN's routing has been set up correctly and is functioning.

1.4.2 Dynamic Addressing and Routing

Dynamic addressing can also be applied to the devices. This is achieved by configuring the routers to use Routing Information Protocol, or RIP. An example of the RIP configuration can be seen below.

```
Router#Conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#router rip
Router(config-router)#ver 2
Router(config-router)#net 170.25.0.0
Router(config-router)#net 11.0.0.0
Router(config-router)#net 100.0.0.0
Router(config-router)#
```

Image shows evidence of RIP configuration for dynamic routing.

Figure 9 - Router 3 RIP Configuration

By displaying the routing table of a router, the routes to each network can be seen. An example of the routing table for Router 3.

Routing Table for Router3				
Type	Network	Port	Next Hop IP	Metric
R	10.0.0.0/8	Serial0/0	11.0.0.1	120/1
C	11.0.0.0/8	Serial0/0	---	0/0
R	100.0.0.0/8	Serial0/0	11.0.0.1	120/1
C	170.25.0.0/16	FastEthernet0/0	---	0/0
R	192.168.4.0/24	Serial0/0	11.0.0.1	120/2

Router configuration is demonstrated

Figure 10 - Router 3 Routing Table

In the routing table, all of the destinations assigned to Router 3 and the 'next hop' that the data will make can be seen.

By using the command '#show IP route', the RIP configuration will be displayed for a router. The routes for that router will be displayed with destinations and via points listed. It will also show the method of communication used between each device and how long it takes for data to travel if the devices are not directly connected.

```

Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

R    10.0.0.0/8 [120/1] via 11.0.0.1, 00:00:23, Serial0/0
C    11.0.0.0/8 is directly connected, Serial0/0
R    100.0.0.0/8 [120/1] via 11.0.0.1, 00:00:23, Serial0/0
C    170.25.0.0/16 is directly connected, FastEthernet0/0
R    192.168.4.0/24 is possibly down, routing via 11.0.0.1, Serial0/0

Router#

```

*Dynamic routing report
shows correct
configuration*

Figure 11 - Router 3 RIP Configuration

Further examples of the RIP routing configurations and tables can be found in the appendix.

*Good reference to
appendix*

Again, the RIP configuration can be tested by sending data packets between PCs. If set-up correctly, all of the tests should be successful.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC1	PC2	ICMP		0.000	N	0	(edit)	
	Successful	PC1	PC3	ICMP		0.000	N	1	(edit)	
	Successful	PC2	PC1	ICMP		0.000	N	2	(edit)	
	Successful	PC2	PC3	ICMP		0.000	N	3	(edit)	
	Successful	PC3	PC1	ICMP		0.000	N	4	(edit)	
	Successful	PC3	PC2	ICMP		0.000	N	5	(edit)	

Figure 12 - RIP Testing Results

*Dynamic routing tests are
successful which correct
configuration*

As seen in the table above, the tests carried out between each PC were successful. This, once again, proves that the RIP configurations were implemented correctly.

Dynamic Host Configuration Protocol, or DHCP, can also be used to assign dynamic addresses to routers. This is achieved by making one router the control router and the other routers as helpers. They will be assigned helper addresses to permit dynamic addressing. Shown below is the net configurations for Router 1, which will act as the control router.

```
Router#
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#ip dhcp pool net1
Router(dhcp-config)#net 192.168.4.0 255.255.255.0
Router(dhcp-config)#default-router 192.168.4.254
Router(dhcp-config)#dns-server 192.168.4.254
Router(dhcp-config)#exit
```

Figure 13 - Router 1 Net 1 Configuration

*Good clear explanation.
Remember that the dynamic
addresses will be default
addresses if DHCP helper
addresses are not configured*

```
Router(config-if)#ip dhcp pool net2
Router(dhcp-config)#net 100.0.0.0 255.0.0.0
Router(dhcp-config)#default-router 100.0.0.254
Router(dhcp-config)#dns-server 100.0.0.254
Router(dhcp-config)#exit
```

Figure 14 - Router 1 Net 2 Configuration

*Images show evidence of
DHCP configuration*

```
Router(config)#ip dhcp pool net3
Router(dhcp-config)#net 170.25.0.0 255.255.0.0
Router(dhcp-config)#default-router 170.25.0.254
Router(dhcp-config)#dns-server 170.25.0.254
Router(dhcp-config)#exit
```

Figure 15 - Router 1 Net 3 Configuration

Shown below is the DHCP configuration for PC1.

Display Name: PC1
Interfaces: FastEthernet0
Gateway/DNS IPv4:
☒ DHCP
☐ Static
Gateway: 192.168.4.254
DNS Server: 192.168.4.254
IP Configuration:
☒ DHCP
☐ Static
IP Address: 192.168.4.1
Subnet Mask: 255.255.255.0

Figure 16 - PC1 DHCP Configuration

*PC1 is clearly given the dynamic
address .4.1*

Following the configuration of the control router, the helper routers must be set up. Shown below are the configurations of the helper addresses for router 2 and router 3.

```

Router>en
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int f0/0
Router(config-if)#ip helper-address 10.10.15.1
Router(config-if)#
Router(config-if)#exit
Router(config)#

```

Helper address is identified and implemented

Figure 17 - Router 2 Helper Address

```

Router>en
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int f0/0
Router(config-if)#ip helper-address 10.10.15.1
Router(config-if)#exit
Router(config)#

```

Figure 18 - Router 3 Helper Address

If the helper addresses are not set-up correctly, the DHCP will assign default addresses to the PCs.

Below is an example of a default address applied to PC2.

☒ DHCP	☐ Static
IP Address	169.254.200.67
Subnet Mask	255.255.0.0
Default Gateway	0.0.0.0
DNS Server	0.0.0.0

Good demonstration of outcome when no helper address is configured.

Figure 19 - PC2 Default Address

However, when configured correctly, the PCs will be assigned the correct addresses. Shown below are the correct DHCP addresses.

Display Name: PC2	
Interfaces: FastEthernet0	
Gateway/DNS IPv4 ☒ DHCP ☐ Static	
Gateway	100.0.0.254
DNS Server	100.0.0.254
IP Configuration ☒ DHCP ☐ Static	
IP Address	100.0.0.1
Subnet Mask	255.0.0.0

This demonstrates that the dynamic address is the next available address

Figure 20 - PC2 DHCP Configuration

Display Name	PC3
Interfaces	FastEthernet0
Gateway/DNS IPv4 ☒ DHCP ☐ Static Gateway: 170.25.0.254 DNS Server: 170.25.0.254	
IP Configuration ☒ DHCP ☐ Static IP Address: 170.25.0.2 Subnet Mask: 255.255.0.0	

Figure 21 - PC3 DHCP Configuration

In some cases, it is possible to keep some aspects of the routing static and some dynamic. This can be achieved by using exclusions. The exclusions can be applied to limit the addresses that can be assigned to the devices by the control router. Shown below is the configuration of the control router to implement the exclusions.

```
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#ip dhcp excluded-address 192.168.4.10
Router(config)#ip dhcp excluded-address 100.0.0.1 100.0.0.10
Router(config)#ip dhcp excluded-address 192.168.4.1 192.168.4.10
Router(config)#ip dhcp excluded-address 170.25.0.1 170.25.0.10
Router(config)#
```

Good explanation. This is a common procedure in industry VLAN's

Figure 22 - Router 1 Exclusion Configuration

Now that the exclusions have been applied, the DHCP addresses assigned to the PCs should change to accommodate the new addresses.

GLOBAL Settings Algorithm Settings INTERFACE FastEthernet0 Bluetooth	FastEthernet0 Port Status: ☒ On Bandwidth: 100 Mbps Duplex: ☒ Full Duplex MAC Address: 00D0.D3B3.0E38 IP Configuration: ☒ DHCP ☐ Static IP Address: 192.168.4.11 Subnet Mask: 255.255.255.0
--	---

Figure 23 - PC1 Configuration with Exclusion

Image clearly demonstrates the DHCP excludes the addresses .1 to .10 and implements the next available which is .11



Figure 24 - PC2 Configuration with Exclusion

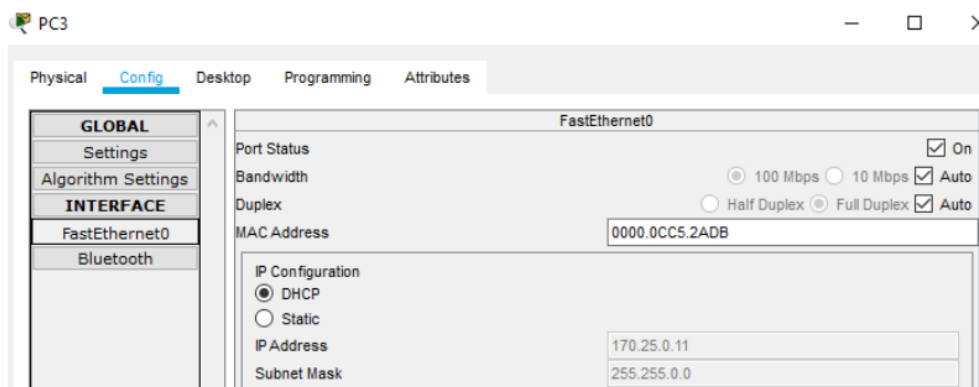


Figure 25 - PC3 Configuration with Exclusion

Tests are successful which proves configuration of excluded addresses

As seen in the above configurations, the addresses have all excluded between 1 and 10 and have gone to 11. This proves that the exclusions applied worked and, despite being set to DHCP, will behave as static devices.

1.5 Testing and Analysis

As seen previously, the conventional method of testing the network is to send packets between each PC. This ensures that the networks have been configured correctly. Shown below are results tables which display the results of each test carried out.

Static Addressing					
		Receive			
		PC1	PC2	PC3	
Send	PC1	N/A	✓	✓	Success = ✓
	PC2	✓	N/A	✓	
	PC3	✓	✓	N/A	Fail = X

Table 2 - Static Addressing Testing Table

Static Routing					
		Receive			
		PC1	PC2	PC3	
Send	PC1	N/A	✓	✓	Success = ✓
	PC2	✓	N/A	✓	
	PC3	✓	✓	N/A	Fail = X

Table 3 - Static Routing Testing Table

RIP					
		Receive			
		PC1	PC2	PC3	
Send	PC1	N/A	✓	✓	Success = ✓
	PC2	✓	N/A	✓	
	PC3	✓	✓	N/A	Fail = X

Table 4 - RIP Testing Table

Test tables are good

From these tables, it can be seen that the tests carried out were all successful. This proves that the addresses were set up correctly for each router and PC.

Another method of testing the network is to verify the configuration of each router, ensuring that they have been set up correctly as control and helper routers. This can be done by entering the command 'show running-config'. Shown below are the configurations of each router.

```

hostname Router
!
!
!
!
ip dhcp excluded-address 192.168.4.10
ip dhcp excluded-address 100.0.0.1 100.0.0.10
ip dhcp excluded-address 192.168.4.1 192.168.4.10
ip dhcp excluded-address 170.25.0.1 170.25.0.10
!
ip dhcp pool net1
network 192.168.4.0 255.255.255.0
default-router 192.168.4.254
dns-server 192.168.1.254
ip dhcp pool net1
network 192.168.4.0 255.255.255.0
default-router 192.168.4.254
dns-server 192.168.4.254
ip dhcp pool net2
network 100.0.0.0 255.0.0.0
default-router 100.0.0.254
dns-server 100.0.0.254
ip dhcp pool net3
network 170.25.0.0 255.255.0.0
default-router 170.25.0.254
dns-server 170.25.0.254

interface FastEthernet0/0
ip address 192.168.4.254 255.255.255.0
duplex auto
speed auto
!
interface Serial0/0
ip address 10.10.15.1 255.0.0.0
clock rate 64000
!
interface Serial0/1
no ip address
clock rate 2000000
shutdown
!
router rip
version 2
network 10.0.0.0
network 11.0.0.0
network 192.168.4.0

```

*Router configuration shows
all the configurations carried
out*

Figure 26 - Router 1 Running Configuration

```

interface FastEthernet0/0
ip address 100.0.0.254 255.0.0.0
ip helper-address 10.10.15.1
duplex auto
speed auto
!
interface Serial0/0
ip address 11.0.0.1 255.0.0.0
!
interface Serial0/1
ip address 10.10.15.2 255.0.0.0
!
router rip
version 2
network 10.0.0.0
network 11.0.0.0
network 100.0.0.0
network 170.25.0.0

```

Figure 27 - Router 2 Running Configuration

```

interface FastEthernet0/0
ip address 170.25.0.254 255.255.0.0
ip helper-address 10.10.15.1
duplex auto
speed auto
!
interface Serial0/0
ip address 11.0.0.2 255.0.0.0
clock rate 64000
!
interface Serial0/1
no ip address
clock rate 2000000
shutdown
!
router rip
version 2
network 11.0.0.0
network 100.0.0.0
network 170.25.0.0

```

Figure 28 - Router 3 Running Configuration

Very good point. It is the control router that will have the significant configuration

These configurations show all of the addresses that have been assigned to the routers and the devices – depending on whether it is a control router or helper router. In the case of the control router, more information is displayed, to accommodate the networks that have been set up on it. The helper routers, however, only display the helper address. The configurations also show the addresses of the devices, in this case PCs, connected to the routers via serial link or Ethernet. This information is displayed regardless of the router's use. To confirm the success of the router configurations, the running configurations can be cross-referenced to the table of addresses created previously. The addresses in the table are the same as those in the table, showing that the addresses have been assigned correctly.

Explanations and test analysis is very good and you have identified the key elements of the configuration of the system

1.6 Evaluation

The wide area network and local area networks were designed with the three different classes of addressing under consideration. This allowed all of the types to be demonstrated and tested on the same network, proving that they are interchangeable and can be used together if configured correctly. The routers were also configured for different types to provide depth to the network. These configurations include.

- Static Addressing
- Static Routing
- Dynamic Addressing
- Dynamic Routing

By compiling a table of the addresses used, the configuration of each device was completed with relative ease, due to the organisation introduced. This minimised the likelihood of failures during the testing of the configurations by sending packets between devices.

The testing of the networks were completed in two different ways – sending packets between PCs and by using the CLI command ‘#show running-config’. These tests were completed for all of the configuration types and on all of the classes of addressing. All of the packet tests carried out were successful, proving the configurations of each device functioned correctly. Using the CLI command further supported the packet testing by displaying the addresses that were configured to each device and how they were communicating with other devices – serial link or Ethernet.

Despite not having a major role in the design and implementation of the WAN, the research that was completed was relevant to networking and provided a deeper understanding into how networks function and the different aspects that is contained within them.

Evaluation is good and demonstrates your understanding of the key network characteristics which will be needed throughout the portfolio

2. Element 2

2.1 Introduction

The aim of element 2 is to further improve the network by implementing subnetting. This will be achieved using Classless Inter-domain Routing, or CIDR. There are three types of CIDR that will be used – 27, 28 and 30. These numbers represent the number of bits that make up the routing.

Virtual Local Area Networks, or VLANs, will also be implemented to allow the networks to work together as one LAN, or broadcast domain. However, an Access Control List will be used to limit access to one router.

2.2 Design Requirements

Shown below is the circuit which will be used to implement these changes.

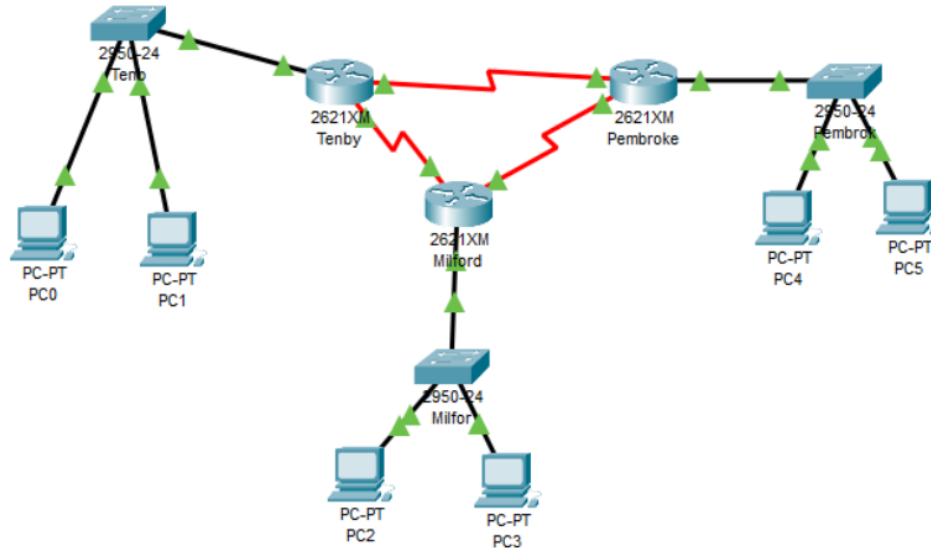


Figure 29 – Circuit

The static routes implemented on the circuit can be found below.

Static Routes					
Router				PC	
Ethernet		Serial		Ethernet	
Milford	192.168.45.30	M0/0	192.168.45.77	PC0	192.168.45.33
Tenby	192.168.45.46	M0/1	192.168.45.110	PC1	192.168.45.34
Pembroke	192.168.45.62	T0/0	192.168.45.94	PC2	192.168.45.17
		T0/1	192.168.45.78	PC3	192.168.45.18
		P0/0	192.168.45.93	PC4	192.168.45.49
		P0/1	192.168.45.109	PC5	192.168.45.50

Figure 30 - Circuit Static Routes

Good table of
addressing
scheme

The static configurations for the devices can be found in the appendix. To implement the CIDR/28 subnetting, the following tables will be used.

CIDR/28 Milford – Network 1									
Subnet mask	1	1	1	1	0	0	0	0	255.255.255.240
	0	0	0	0	0	0	0	0	Not used
Net addr 16	0	0	0	1	0	0	0	1	Lowest host addr 17
Net addr 16	0	0	0	1	0	0	1	0	Next host addr 18
Default gateway	0	0	0	1	1	1	1	0	FastEthernet 0/0 addr 30
	0	0	0	1	1	1	1	1	Broadcast 31

Figure 31 - CIDR/28 Milford

CIDR/28 Tenby – Network 2									
Subnet mask	1	1	1	1	0	0	0	0	255.255.255.240
	0	0	0	0	0	0	0	0	Not used
Net addr 32	0	0	1	0	0	0	0	1	Lowest host addr 33
Net addr 32	0	0	1	0	0	0	1	0	Next host addr 34
Default gateway	0	0	1	0	1	1	1	0	FastEthernet 0/0 addr 46
	0	0	1	0	1	1	1	1	Broadcast 47

Figure 32 - CIDR/28 Tenby

CIDR/28 Pembroke – Network 3									
Subnet mask	1	1	1	1	0	0	0	0	255.255.255.240
	0	0	0	0	0	0	0	0	Not used
Net addr 48	0	0	1	1	0	0	0	1	Lowest host addr 49
Net addr 48	0	0	1	1	0	0	1	0	Next host addr 50
Default gateway	0	0	1	1	1	1	1	0	FastEthernet 0/0 addr 62
	0	0	1	1	1	1	1	1	Broadcast 63

Figure 33 - CIDR/28 Pembroke

Milford – Tenby – Network 4									
Milford Router	0	1	0	0	1	1	0	1	FastEthernet 0/0 addr 77
Tenby Router	0	1	0	0	1	1	1	0	FastEthernet 0/1 addr 78

Figure 34 - CIDR/28 Milford-Tenby

Tenby – Pembroke – Network 5									
Pembroke Router	0	1	0	1	1	1	0	1	FastEthernet 0/0 addr 93
Tenby Router	0	1	0	1	1	1	1	0	FastEthernet 0/0 addr 94

Figure 35 - CIDR/28 Tenby-Pembroke

Pembroke – Milford – Network 6									
Pembroke Router	0	1	1	0	1	1	0	1	FastEthernet 0/1 addr 109
Milford Router	0	1	1	0	1	1	1	0	FastEthernet 0/1 addr 110

Figure 36 - CIDR/28 Pembroke-Milford

Tables show evidence of the configured address scheme using the sub net address method

These tables will provide the addresses required to use the CIDR/28 subnetting.

For CIDR/27 and CIDR/30, alternative tables are required.

CIDR/27 Networks 1, 2 and 3

Subnet mask	1	1	1	0	0	0	0	0	255.255.255.224
	0	0	0	0	0	0	0	0	Not used
Net addr 32	0	0	1	0	0	0	0	1	Lowest host addr 33 Tenby 1
Net addr 32	0	0	1	0	0	0	1	0	Next host addr 34 Tenby 2
Net addr 32	0	0	1	1	1	1	1	0	Highest Router addr 62 Tenby Router
Net addr 64	0	1	0	0	0	0	0	1	Lowest host addr 65 Milford 1
Net addr 64	0	1	0	0	0	0	1	0	Next host addr 66 Milford 2
Net addr 64	0	1	0	1	1	1	1	0	Highest Router addr 94 Milford Router
Net addr 80	0	1	1	0	0	0	0	1	Lowest host addr 97 Pembroke 1
Net addr 80	0	1	1	0	0	0	1	0	Next host addr 98 Pembroke 2
Net addr 80	0	1	1	1	1	1	1	0	Highest Router addr 126 Milford Router

Figure 37 – CIDR/27 Network Table

Table showing CIDR /27 configured for the LAN networks

CIDR/30 Networks 4, 5 and 6

Subnet mask	1	1	1	1	1	1	0	0	255.255.255.252
	0	0	0	0	0	0	0	0	Not used
Net addr 4	0	0	0	0	0	1	0	1	Lowest interface addr 5 Tenby serial 0/0
Net addr 4	0	0	0	0	0	1	1	0	Highest interface addr 6 Pembroke serial 0/0
Net addr 8	0	0	0	0	1	0	0	1	Lowest interface addr 9 Tenby serial 0/1
Net addr 8	0	0	0	0	1	0	1	0	Highest interface addr 10 Milford serial 0/0
Net addr 12	0	0	0	0	1	1	0	1	Lowest interface addr 13 Milford serial 0/1
Net addr 12	0	0	0	0	1	1	1	0	Highest interface addr 14 Pembroke serial 0/1

Figure 38 - CIDR/30 Network Table

Table showing CIDR /30 for the WAN networks

Again, these tables can provide the addresses required to implement the subnetting. Unlike the CIDR/28, the CIDR/27 and CIDR/30 subnetting will be implemented alongside each other on the circuit. The router will know which type of CIDR is implemented from the subnet mask. CIDR/28 is identified with the mask 255.255.255.240, 27 is identified with 255.255.255.224 and 30 is identified with 255.255.255.252. These masks can be seen as binary values in the tables above.

An additional table is required for the VLAN addresses.

VLAN Milford Router/Switch for CIDR/27 Sub Network

FastEthernet 0/0.1	0	1	0	1	1	1	1	0	Net addr 64 i/f addr 94
FastEthernet 0/0.2	1	0	0	1	1	1	1	0	Net addr 128 i/f addr 158
PC1 Milford	0	1	0	0	0	0	0	1	Net addr 64 host addr 65
PC2 Milford	1	0	0	0	0	0	0	1	Net addr 128 host addr 129

Figure 39 - CIDR/27 VLAN Milford

VLAN addressing is correct. An extra network address is used (128)

The VLAN will be implemented onto the 'Milford' network.

2.3 Implementation

2.3.1 CIDR/28 Subnetting

CIDR/28 is implemented using RIP version 2 configuration, which is entered through the router CLI.

Shown below is the application of the CIRD/28 routing to each router.

```
Milford>en
Milford#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#router rip
Milford(config-router)#ver 2
Milford(config-router)#net 192.168.45.16
Milford(config-router)#net 192.168.45.64
Milford(config-router)#net 192.168.45.96
Milford(config-router)#exit
Milford(config)#
Milford(config)#end
Milford#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 40 - Milford CIDR/28 CLI

```
Pembroke>en
Pembroke#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Pembroke(config)#router rip
Pembroke(config-router)#ver 2
Pembroke(config-router)#net 192.168.45.48
Pembroke(config-router)#net 192.168.45.96
Pembroke(config-router)#net 192.168.45.80
Pembroke(config-router)#exit
Pembroke(config)#
Pembroke(config)#end
Pembroke#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 41 - Pembroke CIDR/28 CLI

```
Tenby>en
Tenby#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Tenby(config)#router rip
Tenby(config-router)#ver 2
Tenby(config-router)#net 192.168.45.32
Tenby(config-router)#net 192.168.45.64
Tenby(config-router)#net 192.168.45.80
Tenby(config-router)#exit
Tenby(config)#
```

Figure 42 - Tenby CIDR/28 CLI

Configuration is now achieved using the CLI terminal. This is how the final practical implementation will be achieved

To ensure the routers accepted the CIDR/28, the routing tables can be checked. Here, all the routes should be visible.

Type	Network	Port	Next Hop IP	Metric
C	192.168.45.16/28	FastEthernet0/0	---	0/0
R	192.168.45.32/28	Serial0/0	192.168.45.78	120/1
R	192.168.45.48/28	Serial0/1	192.168.45.109	120/1
C	192.168.45.64/28	Serial0/0	---	0/0
R	192.168.45.80/28	Serial0/0	192.168.45.78	120/1
R	192.168.45.80/28	Serial0/1	192.168.45.109	120/1
C	192.168.45.96/28	Serial0/1	---	0/0

Figure 43 - Milford Routing Table – CIDR/28

Type	Network	Port	Next Hop IP	Metric
R	192.168.45.16/28	Serial0/1	192.168.45.110	120/1
R	192.168.45.32/28	Serial0/0	192.168.45.94	120/1
C	192.168.45.48/28	FastEthernet0/0	---	0/0
R	192.168.45.64/28	Serial0/0	192.168.45.94	120/1
R	192.168.45.64/28	Serial0/1	192.168.45.110	120/1
C	192.168.45.80/28	Serial0/0	---	0/0
C	192.168.45.96/28	Serial0/1	---	0/0

Figure 44 - Pembroke Routing Table – CIDR/28

Type	Network	Port	Next Hop IP	Metric
R	192.168.45.16/28	Serial0/1	192.168.45.77	120/1
C	192.168.45.32/28	FastEthernet0/0	---	0/0
R	192.168.45.48/28	Serial0/0	192.168.45.93	120/1
C	192.168.45.64/28	Serial0/1	---	0/0
C	192.168.45.80/28	Serial0/0	---	0/0
R	192.168.45.96/28	Serial0/1	192.168.45.77	120/1
R	192.168.45.96/28	Serial0/0	192.168.45.93	120/1

Tables show all the correct RIP configuration for all routers. The routed addresses are clearly shown

Figure 45 - Tenby Routing Table – CIDR/28

These tables show that each router has been configured for CIDR/28. Specifically, following the network address is a /28. This proves that the router has identified the CIDR type by the subnet. To ensure that the addresses configured function correctly, packets can be sent between PCs for testing.

2.3.2 CIDR/27 and CIDR/30

CIDR/27 and 30, also known as variable length subnet mask, are also implemented through CLI commands. Using the addresses in the CIDR tables, both 27 and 30 will be implemented on each router.

```
Milford>en
Milford#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#router rip
Milford(config-router)#ver 2
Milford(config-router)#net 192.168.45.64
Milford(config-router)#net 192.168.45.8
Milford(config-router)#net 192.168.45.12
Milford(config-router)#^Z
Milford#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 46 – Milford CIDR/27 and CIDR/30 CLI

```
Pembroke>en
Pembroke#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Pembroke(config)#router rip
Pembroke(config-router)#ver 2
Pembroke(config-router)#net 192.168.45.96
Pembroke(config-router)#net 192.168.45.4
Pembroke(config-router)#net 192.168.45.12
Pembroke(config-router)#^Z
Pembroke#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 47 - Pembroke CIDR/27 and CIDR/30 CLI

The images show clear evidence that the CIDR /27 and CIDR /30 have been configured according to the subnet addressing

```
Tenby>en
Tenby#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Tenby(config)#router rip
Tenby(config-router)#ver 2
Tenby(config-router)#net 192.168.45.32
Tenby(config-router)#net 192.168.45.4
Tenby(config-router)#
Tenby(config-router)#net 192.168.45.8
Tenby(config-router)#^Z
Tenby#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 48 - Tenby CIDR/27 and CIDR/30 CLI

Worth noting here that 'ver 2' RIP protocol is used because ver 1 does not support CIDR

Now, the routing tables should display both CIDR/27 and CIDR/30.

Type	Network	Port	Next Hop IP	Metric
R	192.168.45.4/30	Serial0/1	192.168.45.14	120/1
R	192.168.45.4/30	Serial0/0	192.168.45.9	120/1
C	192.168.45.8/30	Serial0/0	---	0/0
C	192.168.45.12/30	Serial0/1	---	0/0
R	192.168.45.32/27	Serial0/0	192.168.45.9	120/1
C	192.168.45.64/27	FastEthernet0/0	---	0/0
R	192.168.45.96/27	Serial0/1	192.168.45.14	120/1

Figure 49 - Milford Routing Table - CIDR/27 & CIDR/30

Type	Network	Port	Next Hop IP	Metric
C	192.168.45.4/30	Serial0/0	---	0/0
R	192.168.45.8/30	Serial0/0	192.168.45.5	120/1
R	192.168.45.8/30	Serial0/1	192.168.45.13	120/1
C	192.168.45.12/30	Serial0/1	---	0/0
R	192.168.45.32/27	Serial0/0	192.168.45.5	120/1
R	192.168.45.64/27	Serial0/1	192.168.45.13	120/1
C	192.168.45.96/27	FastEthernet0/0	---	0/0

Figure 50 - Pembroke Routing Table - CIDR/27 & CIDR/30

Type	Network	Port	Next Hop IP	Metric
C	192.168.45.4/30	Serial0/0	---	0/0
C	192.168.45.8/30	Serial0/1	---	0/0
R	192.168.45.12/30	Serial0/0	192.168.45.6	120/1
R	192.168.45.12/30	Serial0/1	192.168.45.10	120/1
C	192.168.45.32/27	FastEthernet0/0	---	0/0
R	192.168.45.64/27	Serial0/1	192.168.45.10	120/1
R	192.168.45.96/27	Serial0/0	192.168.45.6	120/1

Figure 51 - Tenby Routing Table - CIDR/27 & CIDR/30

Routing tables show the configuration is held in the routing tables as connections and routes

These routing tables show /27 and /30 at the end of the addresses. This shows that each router has detected a combination of both CIDR routing types. Another method of showing the routes is to use the #show ip route command.

```
Milford#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
      BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
      i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
      * - candidate default, U - per-user static route, o - ODR
      P - periodic downloaded static route

Gateway of last resort is not set

      192.168.45.0/24 is variably subnetted, 6 subnets, 2 masks
R       192.168.45.4/30 [120/1] via 192.168.45.14, 00:00:02,
Serial0/1
              [120/1] via 192.168.45.9, 00:00:01, Serial0/0
C       192.168.45.8/30 is directly connected, Serial0/0
C       192.168.45.12/30 is directly connected, Serial0/1
R       192.168.45.32/27 [120/1] via 192.168.45.9, 00:00:01,
Serial0/0
C       192.168.45.64/27 is directly connected, FastEthernet0/0
R       192.168.45.96/27 [120/1] via 192.168.45.14, 00:00:02,
Serial0/1
```

Figure 52 - Milford IP Route

```
Pembroke#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
      BGP
      D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
      N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
      E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
      i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
      * - candidate default, U - per-user static route, o - ODR
      P - periodic downloaded static route

Gateway of last resort is not set

      192.168.45.0/24 is variably subnetted, 6 subnets, 2 masks
C       192.168.45.4/30 is directly connected, Serial0/0
R       192.168.45.8/30 [120/1] via 192.168.45.5, 00:00:09, Serial0/0
              [120/1] via 192.168.45.13, 00:00:07,
Serial0/1
C       192.168.45.12/30 is directly connected, Serial0/1
R       192.168.45.32/27 [120/1] via 192.168.45.5, 00:00:09,
Serial0/0
R       192.168.45.64/27 [120/1] via 192.168.45.13, 00:00:07,
Serial0/1
C       192.168.45.96/27 is directly connected, FastEthernet0/0
```

Figure 53 - Pembroke IP Route

```

Tenby#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
       * - candidate default, U - per-user static route, o - ODR
       P - periodic downloaded static route

Gateway of last resort is not set

      192.168.45.0/24 is variably subnetted, 6 subnets, 2 masks
C       192.168.45.4/30 is directly connected, Serial0/0
C       192.168.45.8/30 is directly connected, Serial0/1
R       192.168.45.12/30 [120/1] via 192.168.45.6, 00:00:17,
Serial0/0
                               [120/1] via 192.168.45.10, 00:00:01,
Serial0/1
C       192.168.45.32/27 is directly connected, FastEthernet0/0
R       192.168.45.64/27 [120/1] via 192.168.45.10, 00:00:01,
Serial0/1
R       192.168.45.96/27 [120/1] via 192.168.45.6, 00:00:17,
Serial0/0

```

The routing configuration is evident in the report listed

Figure 54 - Tenby IP Route

2.3.3 VLANs

VLANs can be used to broadcast information across domains, so every device on the LAN will receive broadcasted information. This is useful because it reduce broadcast traffic but can also operate with security protocols which can restrict access to data on a VLAN. This is achieved by breaking up the broadcast domain into multiple domains, so each network has less traffic to deal with. Prior to implementing the VLAN onto the circuit, a test will be completed. The test circuit can be found in the appendix. The steps taken to set up the test VLAN can be applied to the original circuit to implement a VLAN on the Milford LAN. Again, the initial steps are to configure the switch. This time, the VLANs will be designated as VLAN 2 and VLAN 3. [Good reference to appendix](#)

```
Milford>en
Milford#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#vlan 2
Milford(config-vlan)#name vlan2
Milford(config-vlan)#exit
Milford(config)#vlan 3
Milford(config-vlan)#name vlan3
Milford(config-vlan)#exit
Milford(config)#^Z
Milford#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 55 - Milford Switch Configuration

```
Milford#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#int f0/1
Milford(config-if)#switchport mode access
Milford(config-if)#switchport access vlan 2
Milford(config-if)#exit
Milford(config)#int f0/2
Milford(config-if)#switchport mode access
Milford(config-if)#switchport access vlan 3
Milford(config-if)#exit
Milford(config)#^Z
```

Figure 56 - Milford Switchport Access

Now the switch should be configured and can be confirmed by showing the VLAN.

Milford#show VLAN

VLAN Name	Status	Ports
1 default	active	Fa0/3, Fa0/4, Fa0/5, Fa0/6, Fa0/7, Fa0/8, Fa0/9, Fa0/10, Fa0/11, Fa0/12, Fa0/13, Fa0/14, Fa0/15, Fa0/16, Fa0/17, Fa0/18, Fa0/19, Fa0/20, Fa0/21, Fa0/22, Fa0/23, Fa0/24
2 vlan2	active	Fa0/1
3 vlan3	active	Fa0/2
1002 fddi-default	active	
1003 token-ring-default	active	
1004 fddinet-default	active	
1005 trnet-default	active	

Figure 57 - Milford Show VLAN

This time, there are only two PCs in use on the VLAN, therefore only two fast ethernet ports are active – one per VLAN. Now, the trunk between the switch and router can be implemented.

```
Milford#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#int f0/10
Milford(config-if)#switchport mode trunk

Milford(config-if)#
%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/10,
changed state to down

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/10,
changed state to up

Milford(config-if)#^Z
Milford#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 58 - Milford Switchport Trunk

Now that the trunk is in place, the router can be configured for the sub-interfaces. For this circuit, the sub-interfaces will be f0/0.2 and f0/0.3.

```

Milford>en
Milford#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#int f0/0
Milford(config-if)#no shutdown
Milford(config-if)#no ip address
Milford(config-if)#exit
Milford(config)#int f0/0.2
Milford(config-subif)#
%LINK-5-CHANGED: Interface FastEthernet0/0.2, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0.2,
changed state to up

Milford(config-subif)#encapsulation dot1q 2
Milford(config-subif)#ip address 192.168.45.94 255.255.255.224
Milford(config-subif)#no shutdown
Milford(config-subif)#exit
Milford(config)#int f0/0.3
Milford(config-subif)#
%LINK-5-CHANGED: Interface FastEthernet0/0.3, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0.3,
changed state to up

Milford(config-subif)#encapsulation dot1q 3
Milford(config-subif)#ip address 192.168.45.158 255.255.255.224
Milford(config-subif)#no shutdown
Milford(config-subif)#exit

```

The images show evidence of the sub interfacing using the trunking protocol

Figure 59 - Milford Router Sub-interfacing

Now, the sub-interfaces will appear on the #show ip int brief command.

```

Milford#show ip interface brief
Interface          IP-Address      OK? Method Status
Protocol
FastEthernet0/0    unassigned      YES manual up
up
FastEthernet0/0.2  192.168.45.94   YES manual up
up
FastEthernet0/0.3  192.168.45.158  YES manual up
up
FastEthernet0/1    unassigned      YES unset  administratively
down down
Serial0/0          192.168.45.10   YES manual up
up
Serial0/1          192.168.45.13   YES manual up
up

```

The report printout shows the correct configuration

Figure 60 - Milford Interface Brief

Here, it shows the IP address for each PC and the sub-interfaces they are assigned to. Fast ethernet 0/0 is displayed as unassigned due to the # no ip address command. The switch and router ports that are being used can also be displayed.

Explanation is correct

Port	Link	VLAN	IP Address	MAC Address
FastEthernet0/1	Up	2	--	00D0.BC64.2A01
FastEthernet0/2	Up	3	--	00D0.BC64.2A02
FastEthernet0/3	Down	1	--	00D0.BC64.2A03
FastEthernet0/4	Down	1	--	00D0.BC64.2A04
FastEthernet0/5	Down	1	--	00D0.BC64.2A05
FastEthernet0/6	Down	1	--	00D0.BC64.2A06
FastEthernet0/7	Down	1	--	00D0.BC64.2A07
FastEthernet0/8	Down	1	--	00D0.BC64.2A08
FastEthernet0/9	Down	1	--	00D0.BC64.2A09
FastEthernet0/10	Up	--	--	00D0.BC64.2A0A
FastEthernet0/11	Down	1	--	00D0.BC64.2A0B
FastEthernet0/12	Down	1	--	00D0.BC64.2A0C
FastEthernet0/13	Down	1	--	00D0.BC64.2A0D
FastEthernet0/14	Down	1	--	00D0.BC64.2A0E
FastEthernet0/15	Down	1	--	00D0.BC64.2A0F
FastEthernet0/16	Down	1	--	00D0.BC64.2A10
FastEthernet0/17	Down	1	--	00D0.BC64.2A11
FastEthernet0/18	Down	1	--	00D0.BC64.2A12
FastEthernet0/19	Down	1	--	00D0.BC64.2A13
FastEthernet0/20	Down	1	--	00D0.BC64.2A14
FastEthernet0/21	Down	1	--	00D0.BC64.2A15
FastEthernet0/22	Down	1	--	00D0.BC64.2A16
FastEthernet0/23	Down	1	--	00D0.BC64.2A17
FastEthernet0/24	Down	1	--	00D0.BC64.2A18
Vlan1	Down	1	<not set>	0001.63B5.CC0B

Hostname: Milford

Switch configuration showing trunk channel active and VLAN's 2 and 3 active

Figure 61 - Milford Switch Ports

Port	Link	IP Address	IPv6 Address	MAC Address
FastEthernet0/0	Up	<not set>	<not set>	0001.432E.1101
FastEthernet0/0.2	Up	192.168.45.94/27	<not set>	0001.432E.1101
FastEthernet0/0.3	Up	192.168.45.158/27	<not set>	0001.432E.1101
FastEthernet0/1	Down	<not set>	<not set>	0001.432E.1102
Serial0/0	Up	192.168.45.10/30	<not set>	<not set>
Serial0/1	Up	192.168.45.13/30	<not set>	<not set>

Hostname: Milford

Figure 62 - Milford Router Ports

Milford router shows the two sub interface gateways for the VLANs

Form the sub-interfaces, the PCs should now display the IP addresses assigned as their gateways.

Port	Link	IP Address	IPv6 Address	MAC Address
FastEthernet0	Up	192.168.45.65/27	<not set>	00E0.B0E7.8D7B
Bluetooth	Down	<not set>	<not set>	0009.7CB7.D014

Gateway: 192.168.45.94
DNS Server: <not set>
Line Number: <not set>

Figure 63 - PC2 Ports

Port	Link	IP Address	IPv6 Address	MAC Address
FastEthernet0	Up	192.168.45.129/27	<not set>	0001.6305.7362
Bluetooth	Down	<not set>	<not set>	00E0.A335.4A61

Gateway: 192.168.45.158
DNS Server: <not set>
Line Number: <not set>

VLAN gateways shown in devices summary report

Figure 64 - PC3 Ports

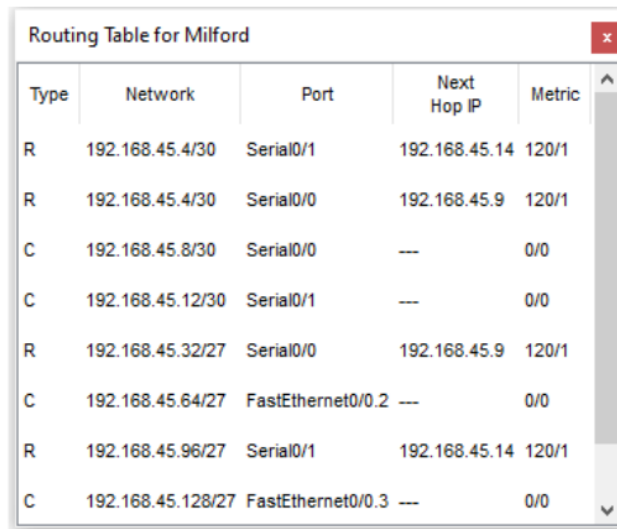
These tables above show that the gateways are assigned by the sub-interfaces correctly. Each routing table for the routers should also show the new address, which is 192.168.45.128 as declared by the VLAN table shown previously.

Type	Network	Port	Next Hop IP	Metric
C	192.168.45.4/30	Serial0/0	---	0/0
C	192.168.45.8/30	Serial0/1	---	0/0
R	192.168.45.12/30	Serial0/0	192.168.45.6	120/1
R	192.168.45.12/30	Serial0/1	192.168.45.10	120/1
C	192.168.45.32/27	FastEthernet0/0	---	0/0
R	192.168.45.64/27	Serial0/1	192.168.45.10	120/1
R	192.168.45.96/27	Serial0/0	192.168.45.6	120/1
R	192.168.45.128/27	Serial0/1	192.168.45.10	120/1

Figure 65 - Tenby Routing Table - VLAN

Type	Network	Port	Next Hop IP	Metric
C	192.168.45.4/30	Serial0/0	---	0/0
R	192.168.45.8/30	Serial0/0	192.168.45.5	120/1
R	192.168.45.8/30	Serial0/1	192.168.45.13	120/1
C	192.168.45.12/30	Serial0/1	---	0/0
R	192.168.45.32/27	Serial0/0	192.168.45.5	120/1
R	192.168.45.64/27	Serial0/1	192.168.45.13	120/1
C	192.168.45.96/27	FastEthernet0/0	---	0/0
R	192.168.45.128/27	Serial0/1	192.168.45.13	120/1

Figure 66 - Pembroke Routing Table - VLAN



The image shows a screenshot of a network device's routing table. The window title is 'Routing Table for Milford'. It contains a table with five columns: Type, Network, Port, Next Hop IP, and Metric. The table lists eight entries, including two routes for 192.168.45.4/30 and several connected networks. A vertical scrollbar is on the right side of the table.

Type	Network	Port	Next Hop IP	Metric
R	192.168.45.4/30	Serial0/1	192.168.45.14	120/1
R	192.168.45.4/30	Serial0/0	192.168.45.9	120/1
C	192.168.45.8/30	Serial0/0	---	0/0
C	192.168.45.12/30	Serial0/1	---	0/0
R	192.168.45.32/27	Serial0/0	192.168.45.9	120/1
C	192.168.45.64/27	FastEthernet0/0.2	---	0/0
R	192.168.45.96/27	Serial0/1	192.168.45.14	120/1
C	192.168.45.128/27	FastEthernet0/0.3	---	0/0

Images show good evidence of configuration

Figure 67 - Milford Routing Table - VLAN

Each routing table displays the new IP address for the VLAN.

2.3.4 Access Control Lists

Using an access control list allows a router to deny access to specific devices. These are used because they provide a local firewall which can easily be applied to a network. In this case, the Pembroke router will be used to restrict access from the Pembroke devices to a Milford PC.

```
Pembroke>en
Pembroke#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Pembroke(config)#hostname Pembroke
Pembroke(config)#access-list 1 deny 192.168.45.129 0.0.0.0
Pembroke(config)#access-list 1 permit any
Pembroke(config)#^Z
Pembroke#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 68 - Pembroke Access List

```
Pembroke>
Pembroke>en
Pembroke#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Pembroke(config)#int f0/0
Pembroke(config-if)#ip access-group 1 out
Pembroke(config-if)#^Z
Pembroke#
%SYS-5-CONFIG_I: Configured from console by console
```

Images show the ACL implementation

Figure 69 - Pembroke Access Group

With these controls in place, access from the Pembroke devices to PC3 on the Milford VLAN should be restricted. These ACLs demonstrate the security protocols that can be placed onto VLANs, as previously mentioned.

2.4 Testing and Analysis

Following the construction of each different protocol, tests were carried out. A combination of packet tests and pings were used to test the implemented protocols. The first protocol tested was the CIDR/28. A selection of PCs on each network were used for the testing. The selections reflected the use of PCs going to and from each network.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num
	Successful	PC0	PC2	ICMP		0.000	N	0
	Successful	PC3	PC0	ICMP		0.000	N	1
	Successful	PC3	PC4	ICMP		0.000	N	2
	Successful	PC5	PC2	ICMP		0.000	N	3
	Successful	PC1	PC4	ICMP		0.000	N	4
	Successful	PC5	PC0	ICMP		0.000	N	5

Figure 70 - CIDR/28 Testing

CIDR /28 tests are successful

This table shows that all the tests carried out were successful and thus proved that the CIDR/28 routing was implemented onto the system. Following the CIDR/27 implementation, CIDR/28 and CIDR/30 were added to the circuit. The same testing method was performed on the circuit, but with a different selection of PCs. Again, the tests carried out were completely successful.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	PC0	PC2	ICMP		0.000	N	0	(edit)	
	Successful	PC3	PC1	ICMP		0.000	N	1	(edit)	
	Successful	PC2	PC4	ICMP		0.000	N	2	(edit)	
	Successful	PC5	PC3	ICMP		0.000	N	3	(edit)	
	Successful	PC4	PC1	ICMP		0.000	N	4	(edit)	
	Successful	PC0	PC5	ICMP		0.000	N	5	(edit)	

Figure 71 - CIDR/27 & CIDR/30 Testing

VLSM tests are successful which proves the implementation of VLSM

The VLAN testing required more specific testing, due the devices involved. This led to more tests been carried out, as seen below.

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num
	Successful	PC2	PC3	ICMP		0.000	N	0
	Successful	PC2	PC1	ICMP		0.000	N	1
	Successful	PC0	PC2	ICMP		0.000	N	2
	Successful	PC3	PC1	ICMP		0.000	N	3
	Successful	PC0	PC3	ICMP		0.000	N	4
	Successful	PC3	PC4	ICMP		0.000	N	5
	Successful	PC5	PC3	ICMP		0.000	N	6
	Successful	PC2	PC4	ICMP		0.000	N	7
	Successful	PC4	PC2	ICMP		0.000	N	8

Figure 72 - VLAN Test Results

Tests show the VLAN must be implemented correctly for the send and receive ping tests to be successful. PC2 and PC3 are the devices on VLANs

Here, the tests are carried out from each LAN to the Milford VLAN PCs. No tests were required between the Tenby and Pembroke LANs as they were untouched and not involved in the VLAN process. Once completed, further modifications were made to the VLAN circuit, by implementing an access control list. To verify the ACL is in place, the addresses can be pinged from Pembroke to Milford.

```
Packet Tracer PC Command Line 1.0
C:\>ping 192.168.45.129

Pinging 192.168.45.129 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.45.129:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Screenshot shows the device address .129 is denies access

Figure 73 - PC4 to PC3 Ping

```
C:\>ping 192.168.45.65

Pinging 192.168.45.65 with 32 bytes of data:

Reply from 192.168.45.65: bytes=32 time=1ms TTL=126
Reply from 192.168.45.65: bytes=32 time=12ms TTL=126
Reply from 192.168.45.65: bytes=32 time=11ms TTL=126
Reply from 192.168.45.65: bytes=32 time=11ms TTL=126

Ping statistics for 192.168.45.65:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 12ms, Average = 8ms
```

Screenshot showing device .65 allowed access

Figure 74 - PC4 to PC2 Ping

```
C:\>ping 192.168.45.129

Pinging 192.168.45.129 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 192.168.45.129:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),
```

Same test from different device showing access denied

Figure 75 - PC5 to PC3 Ping

```

C:\>ping 192.168.45.65

Pinging 192.168.45.65 with 32 bytes of data:

Reply from 192.168.45.65: bytes=32 time=2ms TTL=126
Reply from 192.168.45.65: bytes=32 time=9ms TTL=126
Reply from 192.168.45.65: bytes=32 time=1ms TTL=126
Reply from 192.168.45.65: bytes=32 time=1ms TTL=126

Ping statistics for 192.168.45.65:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 9ms, Average = 3ms

```

Same tests from different source showing access allowed.

Figure 76 - PC5 to PC2

These ping tests show that the pings from Pembroke devices to PC3 are unsuccessful and time out every time. When pinging to PC2, the tests are successful because the router is not restricting access. To further confirm the operation, a ping test can be checked from PC5 to PC0.

```

C:\>ping 192.168.45.33

Pinging 192.168.45.33 with 32 bytes of data:

Reply from 192.168.45.33: bytes=32 time=9ms TTL=126
Reply from 192.168.45.33: bytes=32 time=1ms TTL=126
Reply from 192.168.45.33: bytes=32 time=2ms TTL=126
Reply from 192.168.45.33: bytes=32 time=11ms TTL=126

Ping statistics for 192.168.45.33:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 1ms, Maximum = 11ms, Average = 5ms

```

Figure 77 - PC5 to PC0 Ping

This test was also successful, proving that the access was only restricted to the desired device.

2.5 Evaluation

The aim was to apply Classless Inter-domain Routing and a Virtual Local Area Network to a circuit. To ensure they were applied successfully, tables were used dictating the addresses that were required – including the host and broadcast addresses. The CIDR/28 routes and CIDR/27 and CIDR/30 VLSM were applied via RIP routing version 2. This method detected the gateway being used to determine the CIDR in place.

- CIDR/28 – 255.255.255.240
- CIDR/27 – 255.255.255.224
- CIDR/30 – 255.255.255.252

All of the applied routes could be found using either the #show ip route command on the CLI or by accessing the routing table for the routers. The testing for the CIDR involved transferring packets between devices on different LANs.

The circuit containing CIDR/27 and CIDR/30 was further modified to accommodate the use of a VLAN for reduction of traffic on a broadcast domain. This was only applied to one network – Milford. The use of the test VLAN provided an understanding into VLAN implementation prior to creating a VLAN on the circuit. Further steps were required to complete the VLAN, including configuring the switch. Once again, the test method for the VLAN was to transfer packets between devices.

An access control list was implemented onto the Pembroke network to prevent PC4 and PC5 from communicating with PC3 on the Milford network. This was achieved by restricting access to the desired PC, while permitting access to the other devices in the circuit. An alternative testing method was used for the ACL, by using the ping function. Here, 4 packets are sent between devices. If a connection is made, there should be 0% loss. If a ping is sent to a device behind a firewall, the request will time out. Both of these were displayed through the testing employed.

All of the testing for these methods were carried out successfully. This proves that they were all implemented successfully on the circuit.

*Good evaluation
with focus on
the performance
of the VLAN
which will be
used in the
practical
element*

3. Element 3

3.1 Introduction

The aim of element 3 is to incorporate a web server into a VLAN. This will be a PLC web server, associated with a Siemens PLC and will be tested with the associated hardware. This is being completed to identify the impact that Industry 4.0 is having on PLCs and networking.

3.2 Design Requirements

To implement the web server, a VLAN is required. The VLAN that will be used can be seen below.

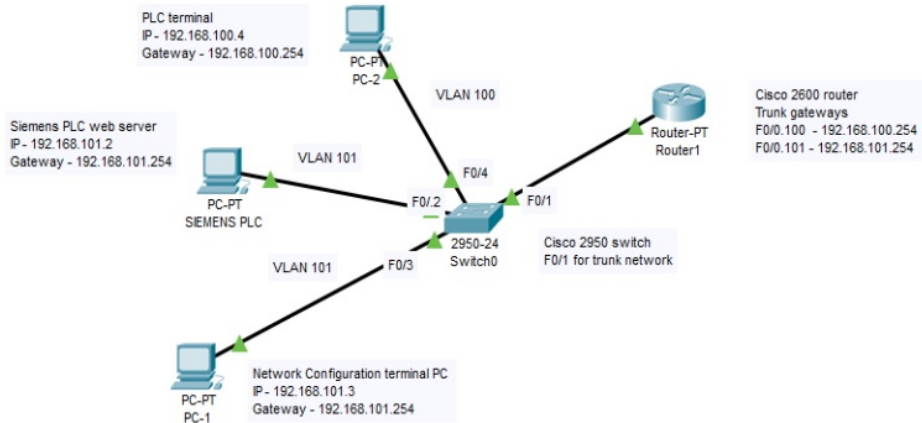


Figure 78 - Web Server VLAN

The configuration for the above VLAN can be found in the appendix. With the switch configured, the VLAN should show without any fast ethernet connections.

```
COM1 - PuTTY
Switch#show vlan

VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/2, Fa0/3, Fa0/4
                                           Fa0/5, Fa0/6, Fa0/7, Fa0/8
                                           Fa0/9, Fa0/10, Fa0/11, Fa0/12
100  vlan100                 active
101  vlan101                 active
1002 fddi-default           active
1003 token-ring-default     active
1004 fddinet-default        active
1005 trnet-default          active

VLAN Type  SAID      MTU    Parent RingNo BridgeNo Stp    BrgdMode Trans1 Trans2
-----
1    enet     1000001  1500   -       -       -       -       -       0       0
100  enet     100100  1500   -       -       -       -       -       0       0
101  enet     100101  1500   -       -       -       -       -       0       0
1002 fddi     101002  1500   -       -       -       -       -       0       0
1003 tr      101003  1500   -       -       -       -       -       0       0
1004 fdnet   101004  1500   -       -       -       ieee    -       0       0
1005 trnet   101005  1500   -       -       -       ibm     -       0       0
Switch#
```

Screenshot shows VLANs are active

Figure 79 - Web Server Switch VLAN

With the connections configured, the VLAN will show the fast ethernet.

```

COM1 - PuTTY
Switch#show vlan

VLAN Name                Status    Ports
-----
1    default                active    Fa0/1, Fa0/5, Fa0/6, Fa0/7
                                           Fa0/8, Fa0/9, Fa0/10, Fa0/11
                                           Fa0/12
100  vlan100                active    Fa0/4
101  vlan101                active    Fa0/2, Fa0/3
1002 fddi-default          active
1003 token-ring-default   active
1004 fddinet-default      active
1005 trnet-default       active

VLAN Type  SAID      MTU   Parent RingNo BridgeNo  Stp  BrdgMode Transl  Trans
-----
1    enet   1000001  1500  -      -      -      -    -        0      0
100  enet   100100  1500  -      -      -      -    -        0      0
101  enet   100101  1500  -      -      -      -    -        0      0
1002 fddi   101002  1500  -      -      -      -    -        0      0
1003 tr   101003  1500  -      -      -      -    -        0      0
1004 fdnet 101004  1500  -      -      -      ieee -        0      0
1005 trnet 101005  1500  -      -      -      ibm  -        0      0
Switch#conf t

```

Screenshot shows the VLANs are configured with interfaces

Figure 80 - Web Server Switch VLAN With Connections

To verify the configuration of the VLAN, a ping test can be completed.

```

C:\Users\Leils>ping 192.168.101.2

Pinging 192.168.101.2 with 32 bytes of data:
Reply from 192.168.101.2: bytes=32 time=6ms TTL=29
Reply from 192.168.101.2: bytes=32 time=1ms TTL=29
Reply from 192.168.101.2: bytes=32 time<1ms TTL=29
Reply from 192.168.101.2: bytes=32 time<1ms TTL=29

Ping statistics for 192.168.101.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 6ms, Average = 1ms

C:\Users\Leils>ping 192.168.101.3

Pinging 192.168.101.3 with 32 bytes of data:
Request timed out.
Reply from 192.168.101.3: bytes=32 time=1ms TTL=127
Reply from 192.168.101.3: bytes=32 time<1ms TTL=127
Reply from 192.168.101.3: bytes=32 time<1ms TTL=127

Ping statistics for 192.168.101.3:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 1ms, Average = 0ms

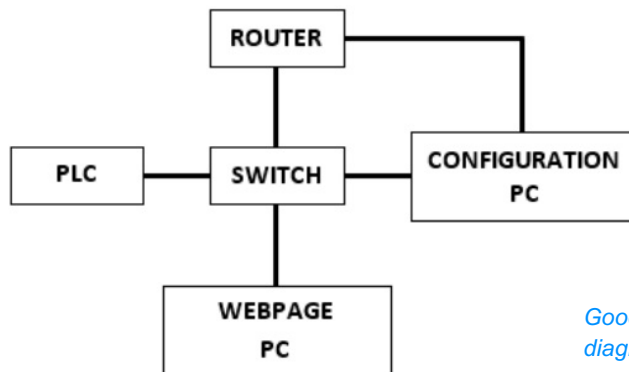
```

Ping tests carried out from the PLC configuration terminal to the other ip addresses.

Figure 81 - VLAN Ping Test

To test the web server, the following hardware is required.

- Laptops/PCs – Quantity: 2
- Siemens PLC – Quantity: 1
- Cisco 2600 Router – Quantity: 1
- Cisco 2950 Switch – Quantity: 1



Good use of block diagram

Figure 82 - Hardware Block Diagram

The hardware set-up of the system can be found below.

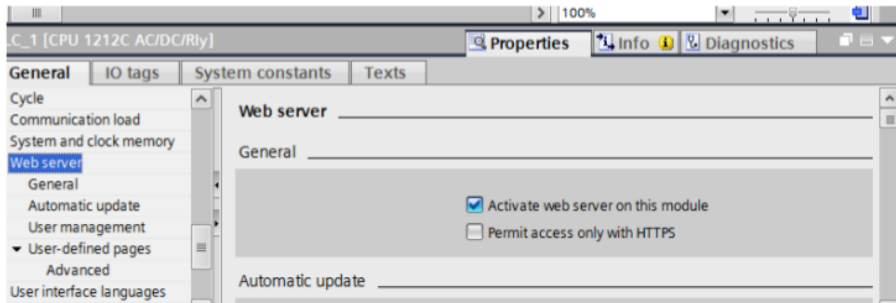


*Image shows evidence of
Cisco equipment connected to
devices*

Figure 83 - Web Server Hardware Set-up

3.3 Implementation

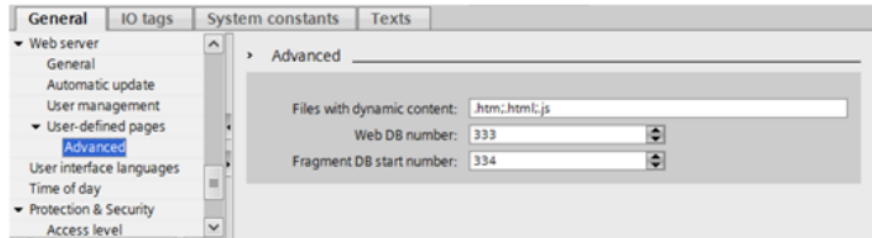
Within the PLC properties, the web server must be activated.



PLC web server activated

Figure 84 - PLC Properties

To use the web server, file extensions need to be added. The file extensions in use are HTM, HTML and .js.



The file types for the HTTP protocol are declared here along with the starting memory location of the web server

Figure 85 - File Extensions

Further file extensions can be used, if desired.

HTML	Hypertext Mark-up Language
HTM	Shortened HTML
.js	JavaScript
.json	JavaScript Extension
.png	Portable Network Graphics
.gif	Graphic Interchange Format

Approved file extensions for the web server are identified

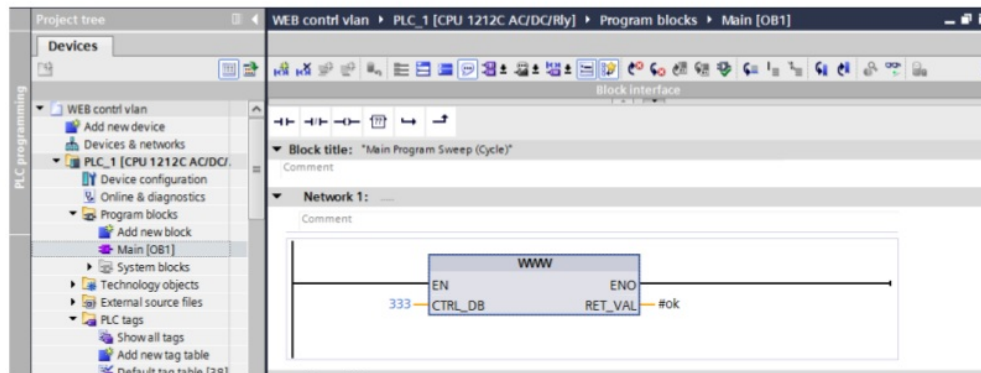
The .js file extension is not compatible with Siemens PLC Models less than 1500. However, it can be embedded into the HTML extension. With the web server enabled, the digital inputs and outputs on the PLC can be created. Here, there will be 8 inputs and 3 outputs.

	Name	Data type	Address	Retain	Access...	Write...	Visibl...	Comment
1	op	Bool	%Q0.0	☐	☒	☒	☒	
2	op2	Bool	%Q0.1	☐	☒	☒	☒	
3	op3	Bool	%Q0.2	☐	☒	☒	☒	
4	ip	Bool	%I0.0	☐	☒	☒	☒	
5	ip1	Bool	%I0.1	☐	☒	☒	☒	
6	ip2	Bool	%I0.2	☐	☒	☒	☒	
7	ip3	Bool	%I0.3	☐	☒	☒	☒	
8	ip4	Bool	%I0.4	☐	☒	☒	☒	
9	ip5	Bool	%I0.5	☐	☒	☒	☒	
10	ip6	Bool	%I0.6	☐	☒	☒	☒	
11	ip7	Bool	%I0.7	☐	☒	☒	☒	
12	<Add new>			☐	☒	☒	☒	

Screenshot shows the tags set up for io control

Figure 86 - PLC I/O

The web server can also be added to the main function block.



Web server block is implemented in the main program area

Figure 87 - Web Server Function Block

Now, with the function block in place, the web server is ready for the web pages to be downloaded.

The .html index page can be downloaded with the http:// source.

The developed web program is downloaded to the web server of the PLC

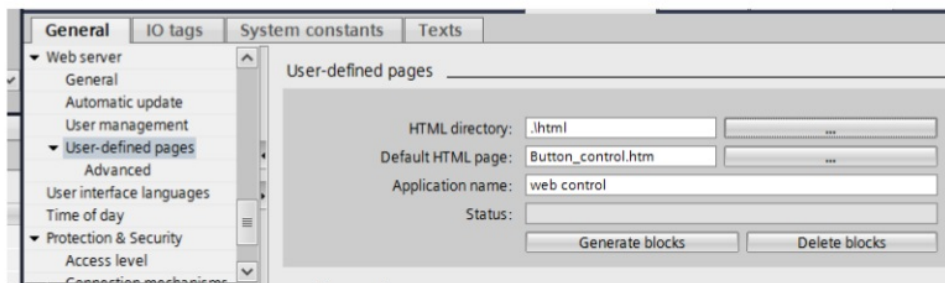
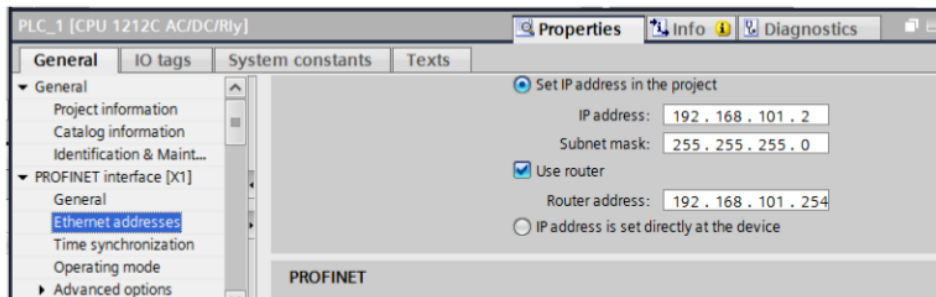


Figure 88 - HTML Index Page Download

With the index page ready, the web data blocks can be generated and the PLC's ethernet addresses can be configured.



The ip address of the PLC is now setup. The gateway address is active and is from a router

Figure 89 - PLC Ethernet Addresses

The web pages are saved in the 'UserFiles' folder within the PLC files. The three files generated include Button_control.htm, Status00.png and Status01.png.

c:\usb_white > USB Drive > NETWORKS > Element 3 portfolio 2019 > WEB contrl vlan_V15.1 > UserFiles				
Name	Date modified	Type	Size	
Button_control	02/05/2019 03:01	HTM File	3 KB	
Status00	16/06/2011 15:49	PNG File	17 KB	
Status01	16/06/2011 15:50	PNG File	18 KB	

The web program files are held in the userfiles in the TIA program for access

Figure 90 - Web Server Files

Shown below are the components of the HTML web page program. This program will monitor the inputs and activate the outputs. The heading of the program sets the design characteristics, such as background colour, and the refresh rate of the page.

```

1 <html>
2
3 <head>
4 <meta http-equiv="refresh" content="0.2">
5
6 <title>Web_control</title>
7 <meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1"><style type="text/css">
8 <!--
9 body,td,th {
10     color: #000033;
11 }
12 body {
13     background-color: #CCCCCC;
14 }
15 -->
16 </style></head>

```

Simple HTML program is demonstrated

Figure 91 - Web Page Program Heading

The body of the program contains the content that changes upon refresh. This includes the PLC I/O.

```

16 </style></head>
17
18 <body>
19
20 <!-- AWP_In_Variable Name="op" -->
21 <!-- AWP_In_Variable Name="op2" -->
22 <!-- AWP_In_Variable Name="op3" -->
23 <!-- AWP_In_Variable Name="ip" -->
24 <!-- AWP_In_Variable Name="ip1" -->
25 <!-- AWP_In_Variable Name="ip2" -->
26 <!-- AWP_In_Variable Name="ip3" -->
27 <!-- AWP_In_Variable Name="ip4" -->
28 <!-- AWP_In_Variable Name="ip5" -->
29 <!-- AWP_In_Variable Name="ip6" -->
30 <!-- AWP_In_Variable Name="ip7" -->

```

This is the method for declaring tags from the PLC that are to be accessed in the HTML program

Figure 92 - Web Page Program Body

The following forms are used to write to the outputs of the PLC.

```

31
32 <form>
33 <input type="submit" value="Set_Output_1_1">
34 <input type="hidden" name="op" value="1">
35 </form>
36
37 <form>
38 <input type="submit" value="Set_Output_1_0">
39 <input type="hidden" name="op" value="0">
40 </form>
41
42
43
44 <p>
45 <form>
46 <input type="submit" value="Set_Output_2_1">
47 <input type="hidden" name="op2" value="1">
48 </form>
49 <form>
50 <input type="submit" value="Set_Output_2_0">
51 <input type="hidden" name="op2" value="0">
52 </form>
53 <p>
54 <form>
55 <input type="submit" value="Set_Output_3_1">
56 <input type="hidden" name="op3" value="1">
57 </form>
58 <form>
59 <input type="submit" value="Set_Output_3_0">
60 <input type="hidden" name="op3" value="0">
61 </form>
62 </form>

```

HTML forms used to write data values to the output ports on PLC using tags declared

Figure 93 - Web Program PLC Output Forms

The PLC input forms below reads the values of the inputs and sets an LED .png, as per the Boolean condition.

Screenshot showing evidence of input monitoring function in web page

When an input is set to 0, the 0 is read and applied as the second identifier for deciding on which .png file is correct. A green LED .png file is known as "status00", with the second 0 being determined by the PLC inputs. A text write-up of the PLC program can be found in the appendix.

Explanations and images are good and clearly show how the program interacts with the PLC

3.4 Testing and Analysis

When accessing the webpage, the first screen displayed is a diagnostics page.

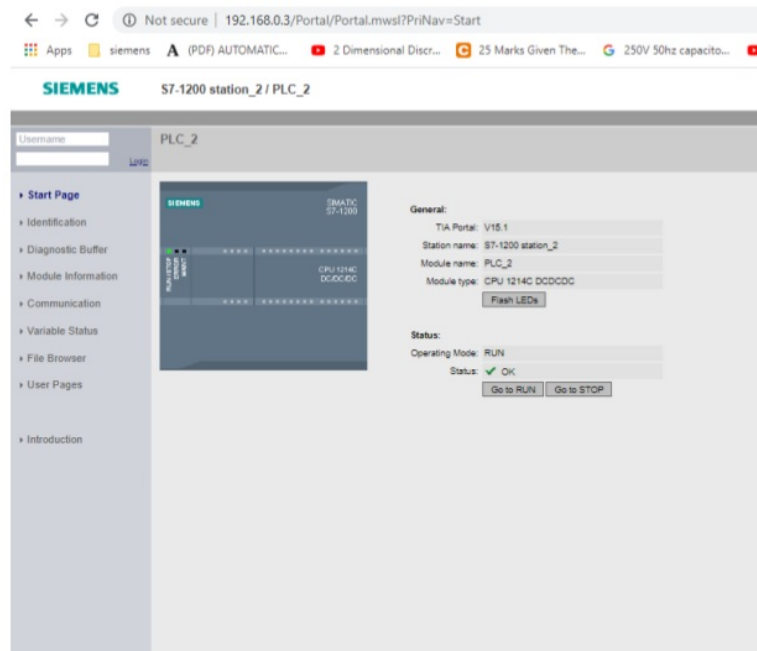


Image shows evidence of from web page generated from PLC web server

Figure 95 - Siemens Diagnostics Page

From this page, the dynamic user pages can be accessed – specifically, the control page. This page displays the PLC inputs and outputs as LEDs. Testing of the web control page can be seen below.

Input: 10011011

Output: 10100000



Figure 96 - Web Control Test 1

Input: 10010000

Output: 10000000



Figure 97 - Web Control Test 2

Input and output conditions are the same as indicated on the PLC showing the HTML program working with real time data

Input: 10010000

Output: 10000000



Figure 98 - Web Control Test 3

These testing images show that the PLC inputs are producing the desired outputs and they are being displayed correctly on the web page. This ultimately proves that a PLCs conditions can be represented with only a HTML extension and two different .png files.

These webpage systems can be further improved by using the JavaScript extensions, which will allow the PLC and webpage to utilise real-time monitoring of different systems. This would remove the need for a page refresh, meaning the graphic change will see an increase in quality the data will refresh much quicker. For example, using a webpage to monitor PWM control of a motor. Shown below is an image of a motor connected to a PLC.



Figure 99 - PLC Motor Input

The webpage below displays the motor power as a percentage.

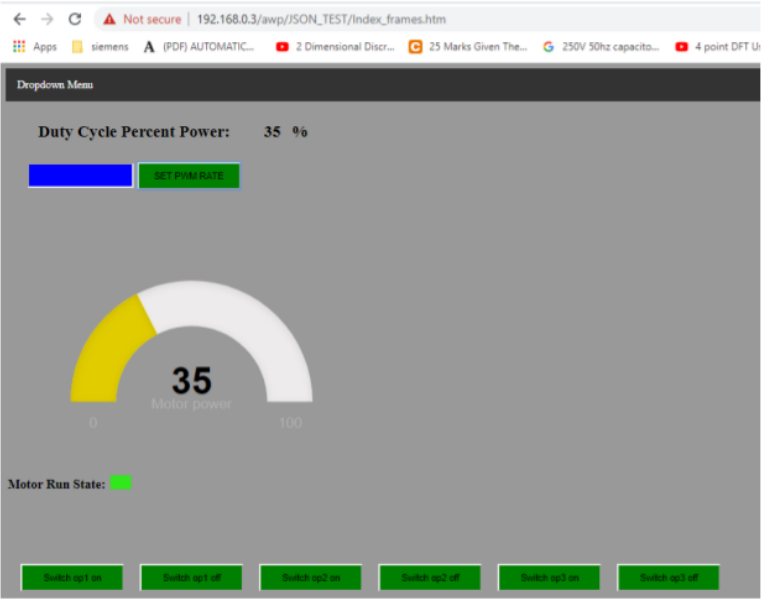


Figure 100 - Motor Monitoring Webpage – 35%

A screenshot of a PLC Watch Table interface. It features a toolbar with various icons at the top. Below the toolbar is a table with the following data:

Name	Address	Display format	Monitor value
"Motor Speed ..."	%QW1000	Hex	16#0023
"Motor RUN"	%I0.4	Bool	TRUE
"webdata".Motor...		DEC+/-	35

Figure 101 - PLC Watch Table - 35%

By increasing the motor power, the changes on the webpage screen can be seen, along with the changes in the PLC watch table.

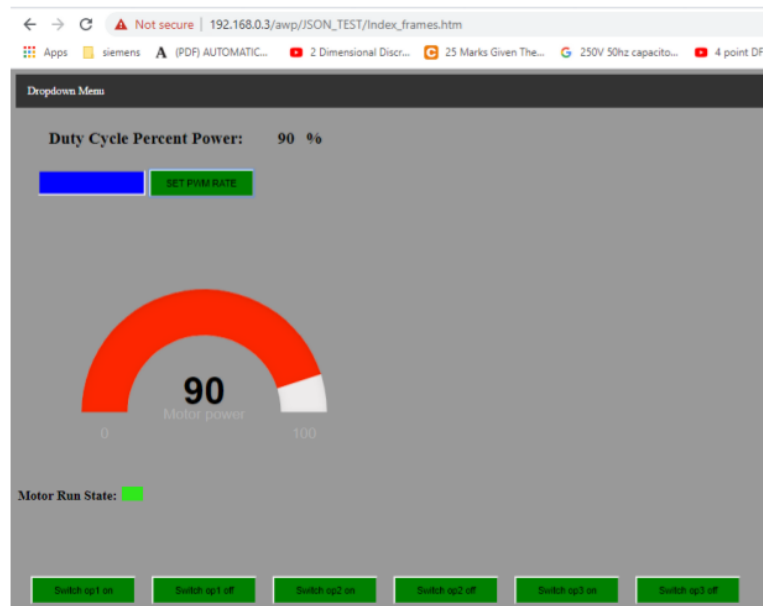


Figure 102 - Motor Monitoring Webpage – 90%

Name	Address	Display format	Monitor value	Mon
*Motor Speed ...	%QW1000	Hex	16#005A	
Motor RUN	%I0.4	Bool	TRUE	
*webdata".Motor...		DEC+/-	90	

Figure 103 - PLC Watch Table – 90%

This proves that the web server can be used for many different applications, including real time monitoring.

You are correct in your recommendation here that there can be vast improvements using other web technologies which are already compatible with the PLC web server. These functions of motor control is a good example of what can be achieved.

3.5 Evaluation

The objective of this element was to implement a web server onto the VLAN that worked with a Siemens PLC and could display inputs and outputs as desired. The web server was set-up on the PLC, which was configured with the network addresses that were found within the VLAN. The web server's program was entered into the PLC, giving the module a series of I/O that would be displayed on the control page. With the function block in place and the index pages downloaded, the web server was functional.

On the dynamic pages, the I/O in the program were displayed and the system could be tested. A series of input combinations were tested, with the desired outputs being produced correctly. As expressed previously, the system could be improved to focus on real-time monitoring, which is becoming more desirable in the world with Industry 4.0 being developed with PLCs in mind.

*This is a good point with IIOT
4.0*

Works Cited

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[Accessed 14 January 2020].

Shaw, K., 2018. *The OSI model explained: How to understand (and remember) the 7 layer network model*. [Online]
Available at: <https://www.networkworld.com/article/3239677/the-osi-model-explained-how-to-understand-and-remember-the-7-layer-network-model.html>
[Accessed 30 December 2019].

TechDifferences, 2016. *Difference Between TCP/IP and OSI Model*. [Online]
Available at: <https://techdifferences.com/difference-between-tcp-ip-and-osi-model.html>
[Accessed 18 December 2019].

Good
relevant
sources

4. Appendix

4.1 Static Routes

The screenshot shows a web-based configuration interface. On the left is a sidebar menu with 'GLOBAL' expanded, containing 'Settings' (highlighted), 'Algorithm Settings', and 'INTERFACE' (with sub-items 'FastEthernet0' and 'Bluetooth'). The main panel is titled 'Global Settings'. It contains a 'Display Name' field with 'PC1', an 'Interfaces' dropdown menu with 'FastEthernet0' selected, and a 'Gateway/DNS IPv4' section. In this section, the 'Static' radio button is selected, the 'Gateway' field contains '192.168.4.254', and the 'DNS Server' field is empty.

Figure 104 - Class C Mask

This screenshot is similar to the previous one, showing the 'Global Settings' interface. The 'Display Name' field now contains 'PC3'. The 'Interfaces' dropdown menu still shows 'FastEthernet0'. In the 'Gateway/DNS IPv4' section, the 'Static' radio button is selected, the 'Gateway' field contains '170.25.0.254', and the 'DNS Server' field is empty.

Figure 105 - Class B Mask

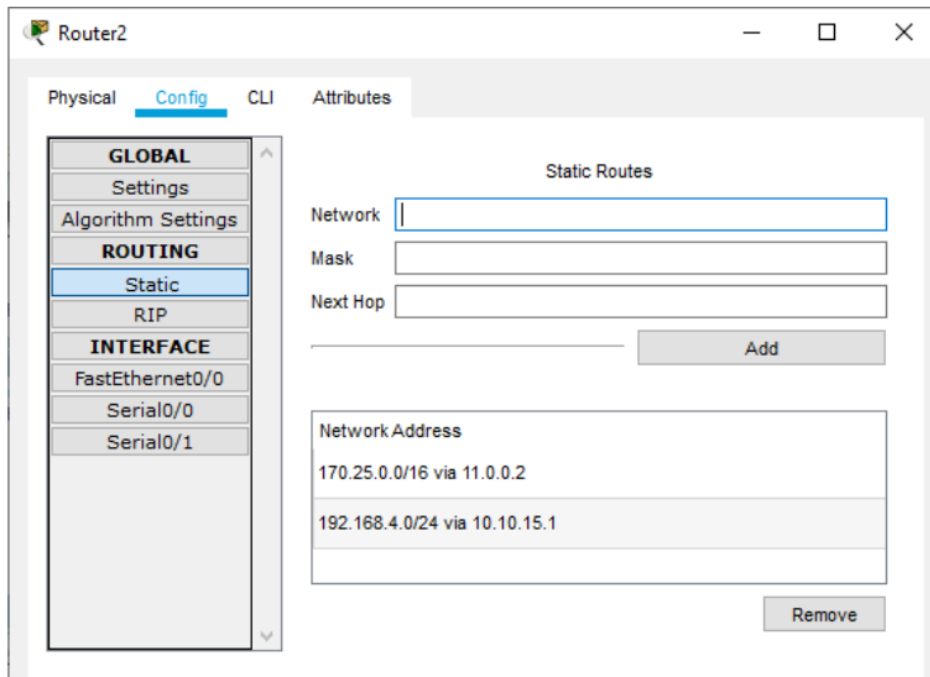


Figure 106 - Router 2 Static Routing

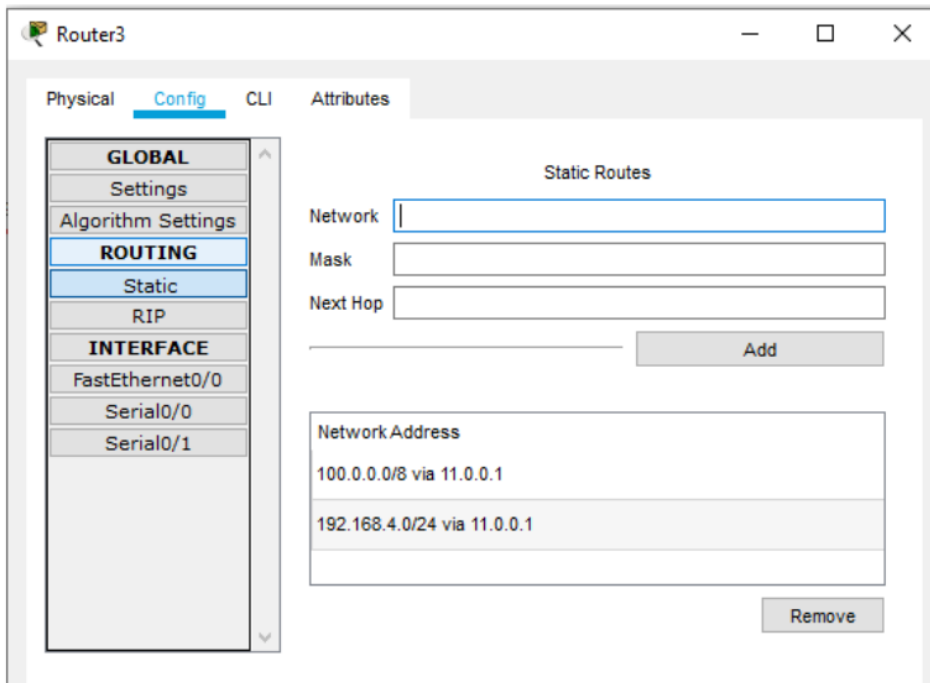


Figure 107 - Router 3 Static Routing

Routing Table for Router1

Type	Network	Port	Next Hop IP	Metric
C	10.0.0.0/8	Serial0/0	---	0/0
R	11.0.0.0/8	Serial0/0	10.10.15.2	120/1
R	100.0.0.0/8	Serial0/0	10.10.15.2	120/1
R	170.25.0.0/16	Serial0/0	10.10.15.2	120/2
C	192.168.4.0/24	FastEthernet0/0	---	0/0

Figure 108 - Router 1 Routing Table

Routing Table for Router2

Type	Network	Port	Next Hop IP	Metric
C	10.0.0.0/8	Serial0/1	---	0/0
C	11.0.0.0/8	Serial0/0	---	0/0
C	100.0.0.0/8	FastEthernet0/0	---	0/0
R	170.25.0.0/16	Serial0/0	11.0.0.2	120/1
R	192.168.4.0/24	Serial0/1	10.10.15.1	120/1

Figure 109 - Router 2 Routing Table

```

Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
        i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
        * - candidate default, U - per-user static route, o - ODR
        P - periodic downloaded static route

Gateway of last resort is not set

C    10.0.0.0/8 is directly connected, Serial0/0
R    11.0.0.0/8 [120/1] via 10.10.15.2, 00:00:04, Serial0/0
R    100.0.0.0/8 [120/1] via 10.10.15.2, 00:00:04, Serial0/0
R    170.25.0.0/16 [120/2] via 10.10.15.2, 00:00:04, Serial0/0
C    192.168.4.0/24 is directly connected, FastEthernet0/0

Router#

```

Figure 110 - Router 1 RIP Configuration

```

Router#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B -
BGP
        D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
        N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
        E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
        i - IS-IS, L1 - IS-IS level-1, L2 - IS-IS level-2, ia - IS-IS
inter area
        * - candidate default, U - per-user static route, o - ODR
        P - periodic downloaded static route

Gateway of last resort is not set

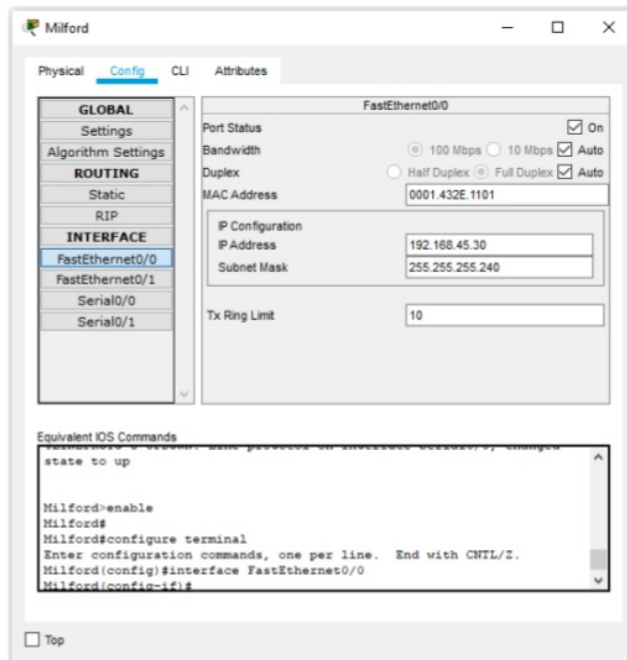
C    10.0.0.0/8 is directly connected, Serial0/1
C    11.0.0.0/8 is directly connected, Serial0/0
C    100.0.0.0/8 is directly connected, FastEthernet0/0
R    170.25.0.0/16 [120/1] via 11.0.0.2, 00:00:26, Serial0/0
R    192.168.4.0/24 is possibly down, routing via 10.10.15.1,
Serial0/1

Router#

```

Figure 111 - Router 2 RIP Configuration

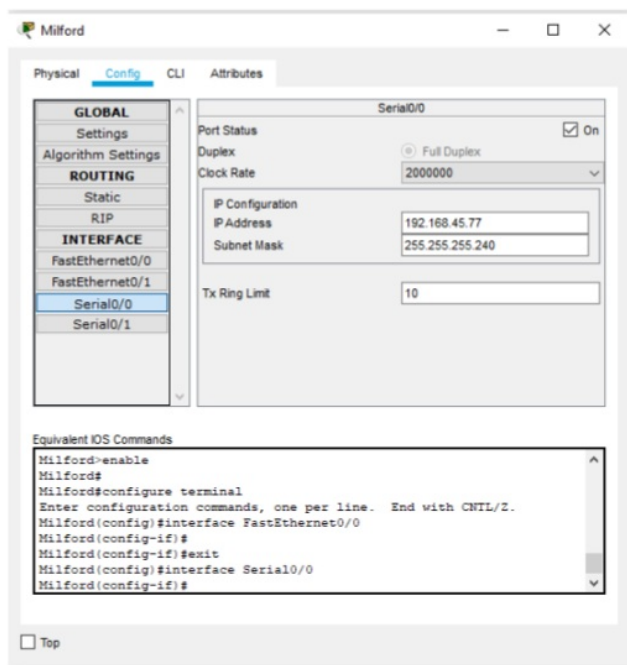
4.2 Circuit Device Configuration



The screenshot shows the 'Milford' configuration window with the 'Config' tab selected. The left sidebar has a tree view with 'INTERFACE' expanded and 'FastEthernet0/0' selected. The main area displays configuration for 'FastEthernet0/0'. The 'Port Status' is 'On'. 'Bandwidth' is set to '100 Mbps' and 'Duplex' is 'Full Duplex', both with 'Auto' checkboxes. The 'MAC Address' is '0001.432E.1101'. 'IP Configuration' shows 'IP Address' as '192.168.45.30' and 'Subnet Mask' as '255.255.255.240'. 'Tx Ring Limit' is '10'. The 'Equivalent IOS Commands' section shows the following commands:

```
Milford>enable
Milford#
Milford#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#interface FastEthernet0/0
Milford(config-if)#
```

Figure 112 - Milford Fast Ethernet



The screenshot shows the 'Milford' configuration window with the 'Config' tab selected. The left sidebar has a tree view with 'INTERFACE' expanded and 'Serial0/0' selected. The main area displays configuration for 'Serial0/0'. 'Port Status' is 'On'. 'Duplex' is 'Full Duplex' and 'Clock Rate' is '2000000'. 'IP Configuration' shows 'IP Address' as '192.168.45.77' and 'Subnet Mask' as '255.255.255.240'. 'Tx Ring Limit' is '10'. The 'Equivalent IOS Commands' section shows the following commands:

```
Milford>enable
Milford#
Milford#configure terminal
Enter configuration commands, one per line. End with CNTL/Z.
Milford(config)#interface FastEthernet0/0
Milford(config-if)#
Milford(config-if)#exit
Milford(config)#interface Serial0/0
Milford(config-if)#
```

Figure 113 - Milford Serial 0/0

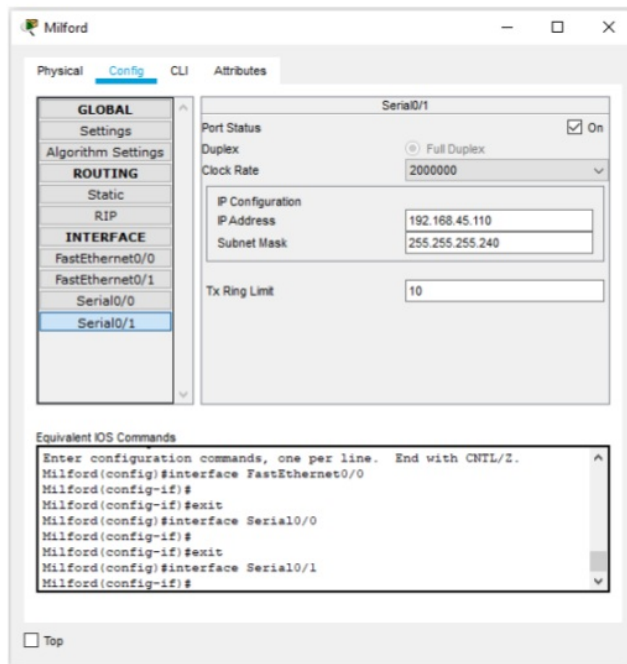


Figure 114 - Milford Serial 0/1

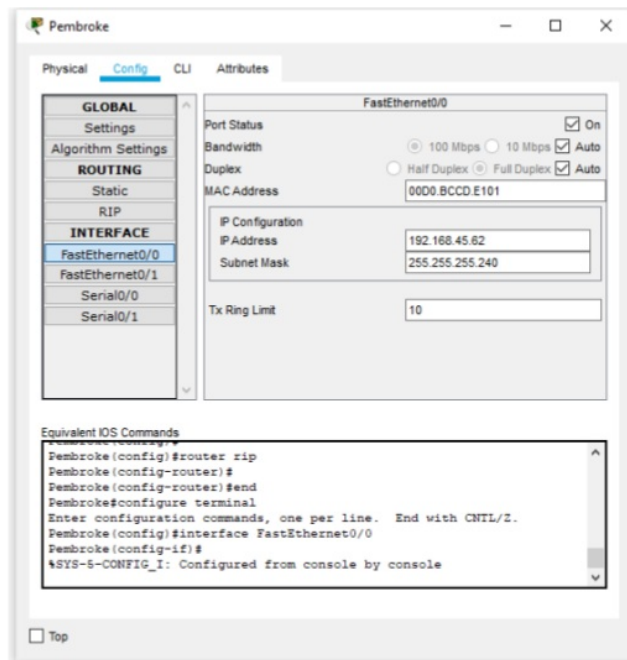


Figure 115 - Pembroke Fast Ethernet

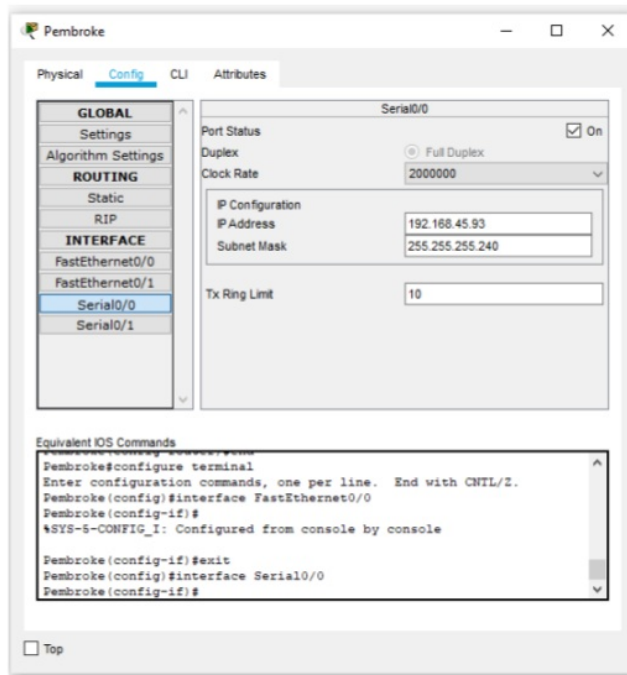


Figure 116 - Pembroke Serial 0/0

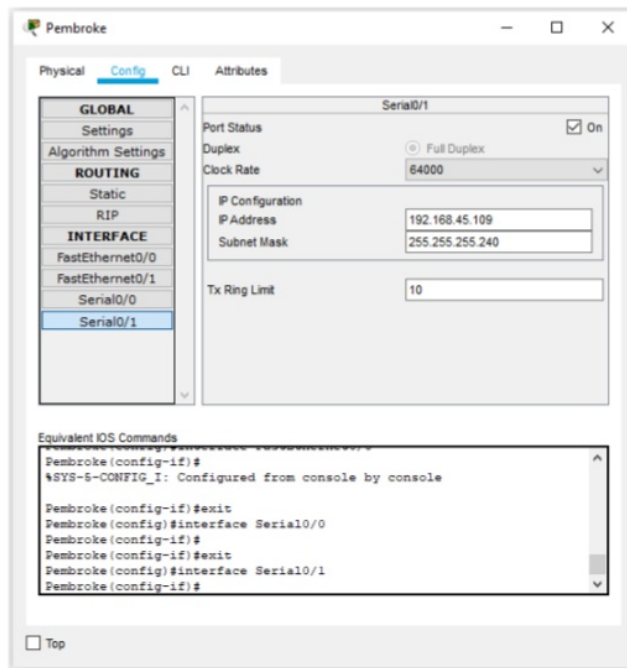


Figure 117 - Pembroke Serial 0/1

GLOBAL

- Settings
- Algorithm Settings

ROUTING

- Static
- RIP

INTERFACE

- FastEthernet0/0
- FastEthernet0/1
- Serial0/0
- Serial0/1

FastEthernet0/0

Port Status: ☒ On

Bandwidth: ☒ 100 Mbps ☐ 10 Mbps ☒ Auto

Duplex: ☐ Half Duplex ☒ Full Duplex ☒ Auto

MAC Address: 0060.2F91.8101

IP Configuration

IP Address: 192.168.45.46

Subnet Mask: 255.255.255.240

Tx Ring Limit: 10

Equivalent IOS Commands

```
Tenby(config-if)#exit
Tenby(config)#interface Serial0/1
Tenby(config-if)#
Tenby(config)#exit
Tenby(config)#interface FastEthernet0/1
Tenby(config-if)#
Tenby(config)#exit
Tenby(config)#interface FastEthernet0/0
Tenby(config-if)#
```

☐ Top

Figure 118 - Tenby Fast Ethernet

GLOBAL

- Settings
- Algorithm Settings

ROUTING

- Static
- RIP

INTERFACE

- FastEthernet0/0
- FastEthernet0/1
- Serial0/0
- Serial0/1

Serial0/0

Port Status: ☒ On

Duplex: ☒ Full Duplex

Clock Rate: 64000

IP Configuration

IP Address: 192.168.45.94

Subnet Mask: 255.255.255.240

Tx Ring Limit: 10

Equivalent IOS Commands

```
Tenby(config-if)#exit
Tenby(config)#interface Serial0/0
Tenby(config-if)#
Tenby(config)#exit
Tenby(config)#interface Serial0/1
Tenby(config-if)#
Tenby(config)#exit
Tenby(config)#interface Serial0/0
Tenby(config-if)#
```

☐ Top

Figure 119 - Tenby Serial 0/0

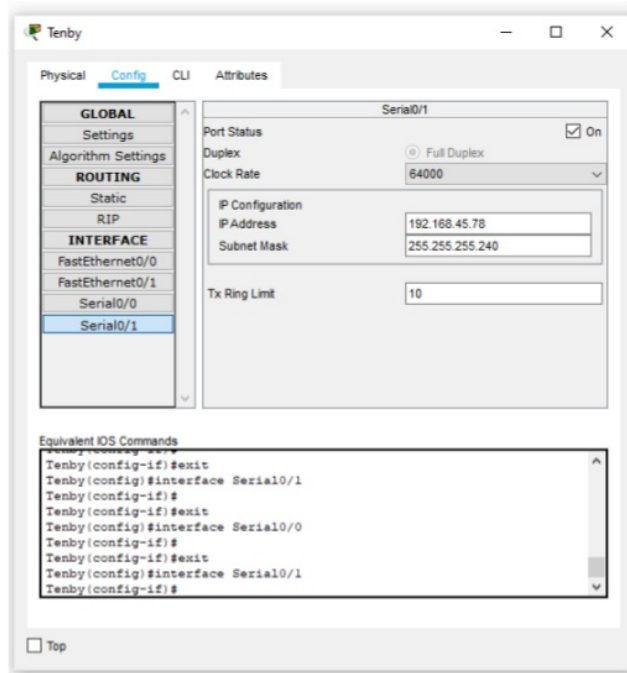


Figure 120 - Tenby Serial 0/1

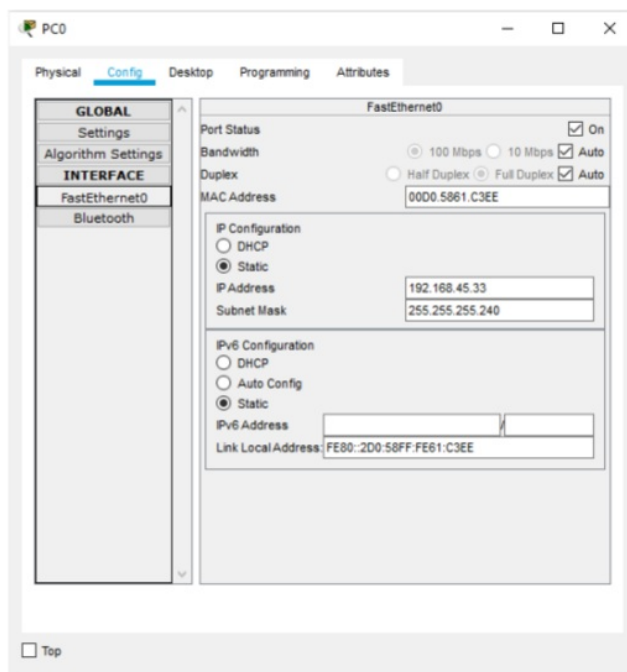


Figure 121 - PC0 Fast Ethernet

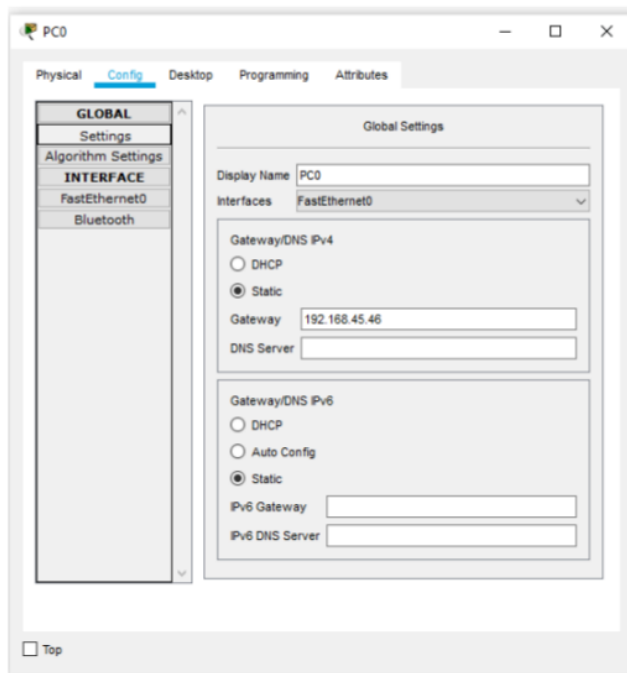


Figure 122 - PC0 Settings

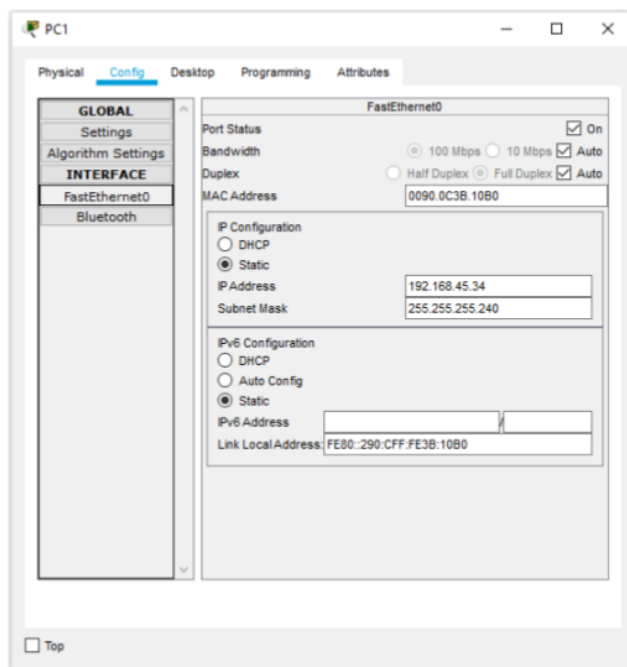


Figure 123 - PC1 Fast Ethernet

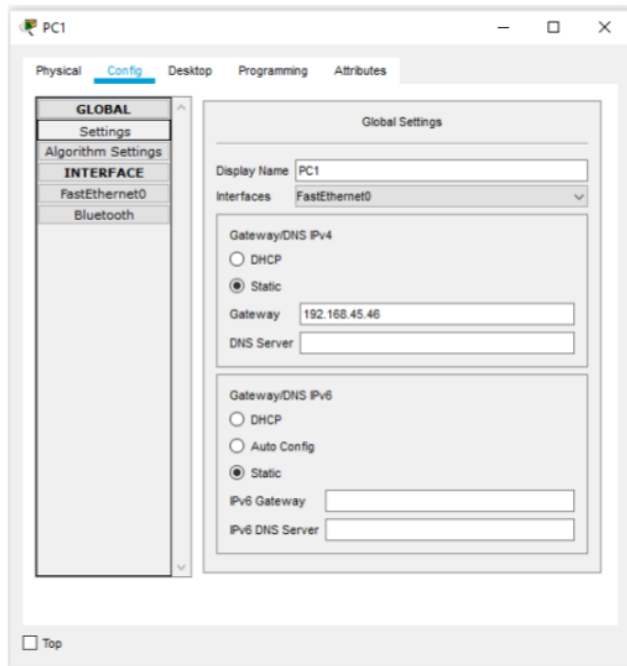


Figure 124 - PC1 Settings

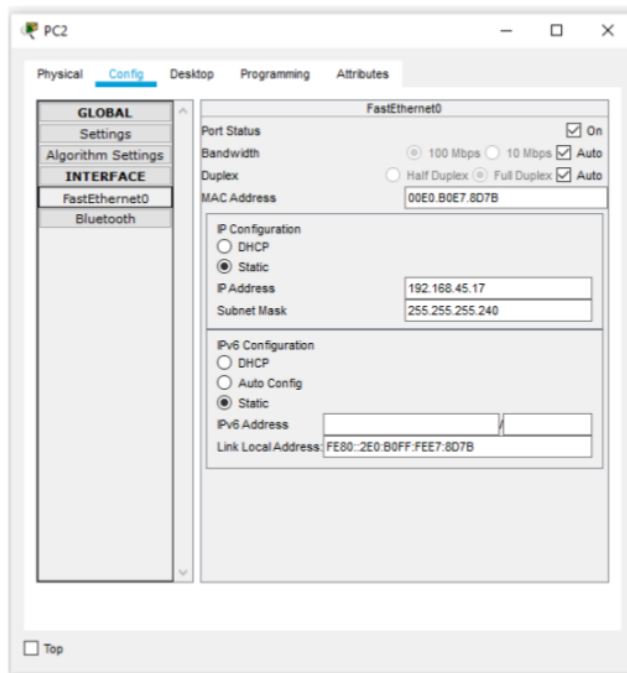


Figure 125 - PC2 Fast Ethernet

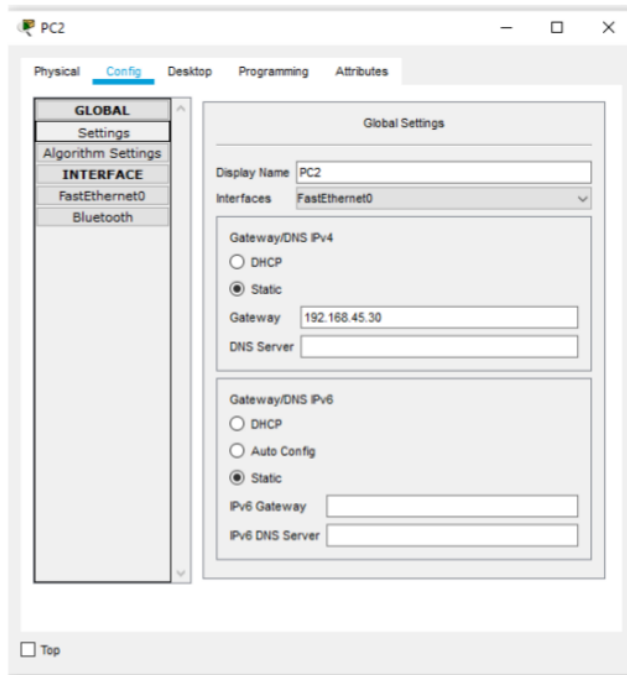


Figure 126 - PC2 Settings

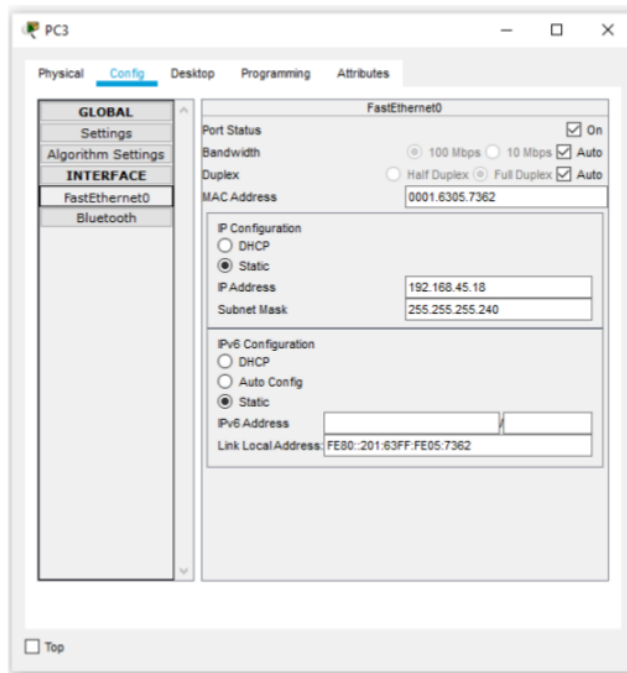


Figure 127 - PC3 Fast Ethernet

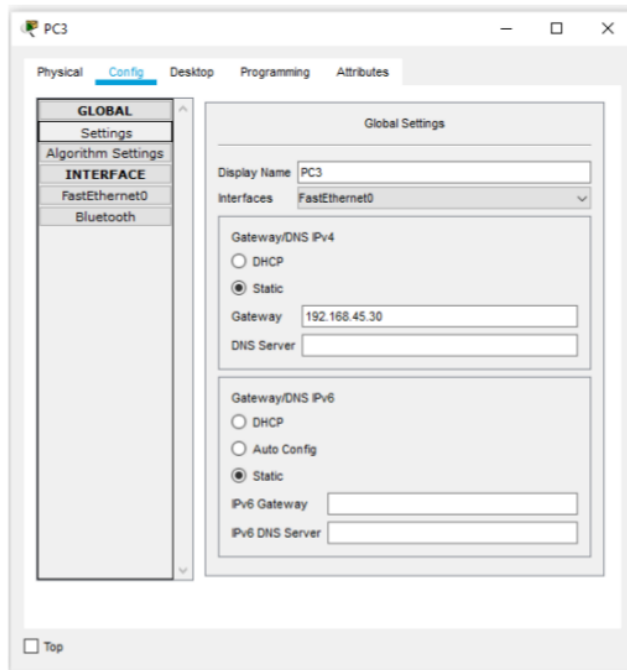


Figure 128 - PC3 Settings

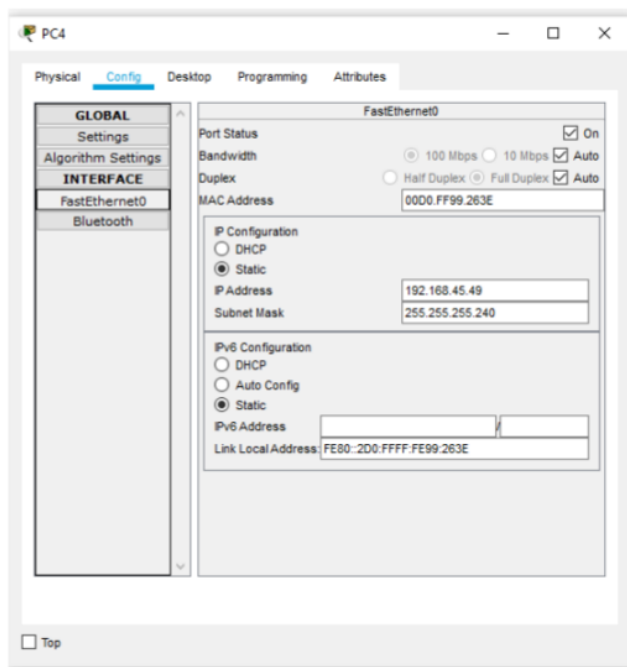


Figure 129 - PC4 Fast Ethernet

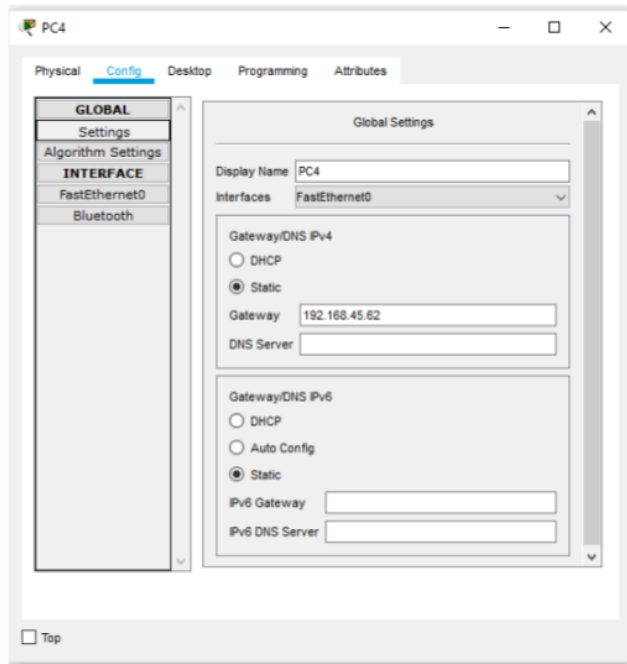


Figure 130 - PC4 Settings

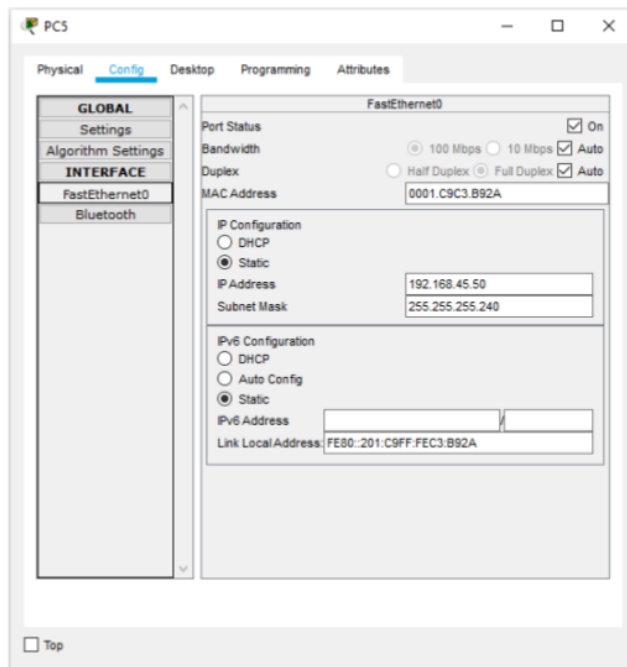


Figure 131 - PC5 Fast Ethernet

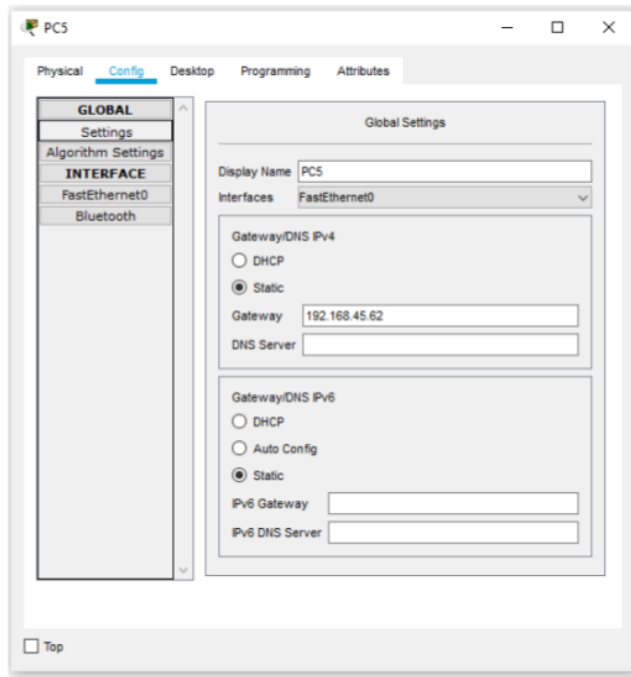


Figure 132 - PC5 Settings

4.3 VLAN Test

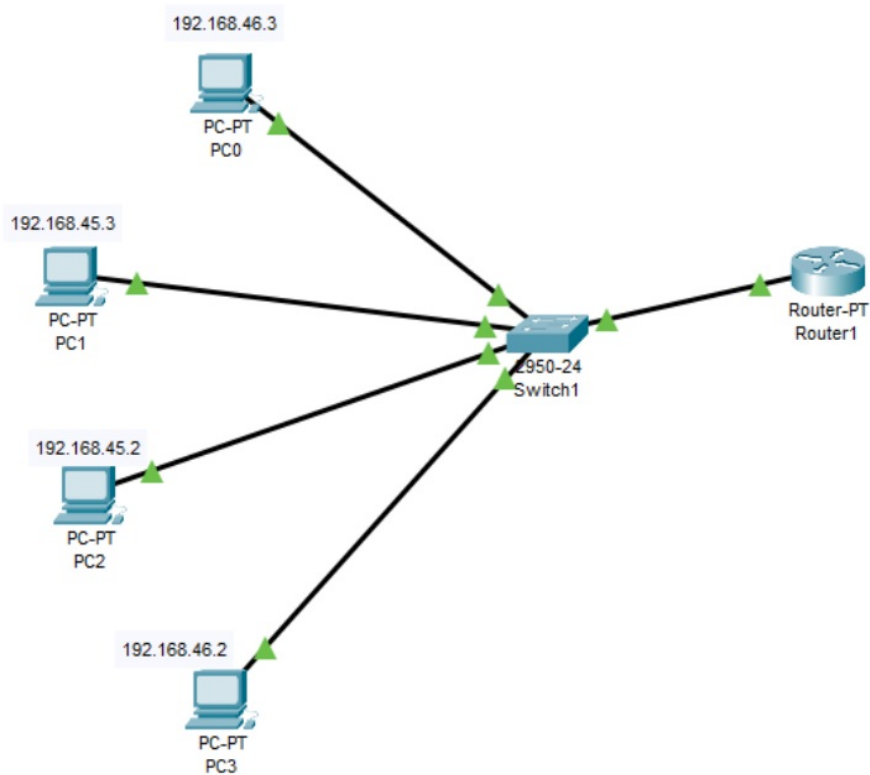


Figure 133 - VLAN Test Circuit

This circuit consists of four PCs, a switch and a router. To start setting up the VLANs, the switch must be configured. This circuit will use two VLANs.

```
Switch#en
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#vlan 45
Switch(config-vlan)#name vlan-45
Switch(config-vlan)#exit
Switch(config)#vlan 46
Switch(config-vlan)#name vlan-46
Switch(config-vlan)#exit
Switch(config)#^Z
Switch#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 134 - Test Switch Configuration

Here, the two VLANs have been set up as 45 and 46. By using the command `#show vlan`, the active VLANs will be displayed.

```
Switch#show vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/1, Fa0/2, Fa0/3, Fa0/4 Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24
45 vlan-45	active	
46 vlan-46	active	
1002 fddi-default	active	
1003 token-ring-default	active	
1004 fddinet-default	active	
1005 trnet-default	active	

Figure 135 - Test Show VLAN

This test shows the active VLANs as 45 and 46. Now, the switch's fast ethernet connections to the PCs must be assigned to the VLANs, as desired.

```
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#int f 0/2
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan-46
Switch(config-if)#exit
Switch(config)#int f 0/1
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 45
Switch(config-if)#exit
Switch(config)#int f 0/4
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 45
Switch(config-if)#exit
Switch(config)#int f 0/3
Switch(config-if)#switchport mode access
Switch(config-if)#switchport access vlan 46
Switch(config-if)#exit
Switch(config)#^Z
Switch#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 136 - Test Switchport Access

Once configured, these ports should appear when using the #show vlan command.

```
Switch#show vlan
```

VLAN Name	Status	Ports
1 default	active	Fa0/5, Fa0/6, Fa0/7, Fa0/8 Fa0/9, Fa0/10, Fa0/11, Fa0/12 Fa0/13, Fa0/14, Fa0/15, Fa0/16 Fa0/17, Fa0/18, Fa0/19, Fa0/20 Fa0/21, Fa0/22, Fa0/23, Fa0/24
45 vlan-45	active	Fa0/1, Fa0/4
46 vlan-46	active	Fa0/2, Fa0/3
1002 fddi-default	active	
1003 token-ring-default	active	
1004 fddinet-default	active	
1005 trnet-default	active	

Figure 137 - Test Show VLAN (Continued)

The switch must also be configured to create a VLAN with the router. This is done by creating an interface trunk on another fast ethernet port.

```
Switch#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Switch(config)#int f 0/10
Switch(config-if)#switchport mode trunk
Switch(config-if)#^Z
Switch#
%SYS-5-CONFIG_I: Configured from console by console
```

Figure 138 - Test Switch Trunk

The router must also be configured.

```
Router>en
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int f 0/0
Router(config-if)#no shutdown
```

Figure 139 - Test Router Interface

Now, the use of the command #show interface trunk will display the trunk between the switch and router, along with the VLANs.

```
Switch#show interface trunk

Switch#
%LINK-5-CHANGED: Interface FastEthernet0/10, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/10,
changed state to up

Switch#show interface trunk
Port      Mode          Encapsulation  Status      Native vlan
Fa0/10    on            802.1q         trunking    1

Port      Vlans allowed on trunk
Fa0/10    1-1005

Port      Vlans allowed and active in management domain
Fa0/10    1,45,46

Port      Vlans in spanning tree forwarding state and not pruned
Fa0/10    1,45,46
```

Figure 140 - Test Interface Trunk

Now, the router can be further configured for the interfaces and sub-interfaces. It will assign the protocols and IP addresses to the sub-interfaces.

```

Router>en
Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int f 0/0
Router(config-if)#no shutdown

Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed
state to up

Router(config-if)#^Z
Router#
%SYS-5-CONFIG_I: Configured from console by console

Router#conf t
Enter configuration commands, one per line. End with CNTL/Z.
Router(config)#int f 0/0
Router(config-if)#no ip address
Router(config-if)#exit

Router(config)#int f 0/0.45
Router(config-subif)#
%LINK-5-CHANGED: Interface FastEthernet0/0.45, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0.45, changed
state to up

Router(config-subif)#encapsulation dot1Q 45
Router(config-subif)#ip address 192.168.45.254 255.255.255.0
Router(config-subif)#no shutdown
Router(config-subif)#exit
Router(config)#int f 0/0.46
Router(config-subif)#
%LINK-5-CHANGED: Interface FastEthernet0/0.46, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0.46, changed
state to up

Router(config-subif)#encapsulation dot1Q 46
Router(config-subif)#ip address 192.168.46.254 255.255.255.0
Router(config-subif)#no shutdown
Router(config-subif)#^Z

```

Figure 141 - Test Router IP Addresses

Using the command #show ip int brief will display the active sub-interfaces and their ip addresses.

```

Router#show ip int brie
Interface          IP-Address      OK? Method Status
Protocol
FastEthernet0/0    unassigned      YES unset  up
FastEthernet0/0.45 192.168.45.254  YES manual up
FastEthernet0/0.46 192.168.46.254  YES manual up
FastEthernet1/0    unassigned      YES unset  administratively down
down
Serial2/0          unassigned      YES unset  administratively down
down
Serial3/0          unassigned      YES unset  administratively down
down
FastEthernet4/0    unassigned      YES unset  administratively down
down
FastEthernet5/0    unassigned      YES unset  administratively down
down

```

Figure 142 - Test Show Interface Brief

4.4 VLAN Configuration

Switch>enable

Switch#conf t

Switch(config)#vlan 100

Switch(config-vlan)#name vlan100

Switch(config-vlan)#exit

Switch(config)#vlan 101

Switch(config-vlan)#name vlan101

Switch(config-vlan)#exit

Switch(config)#^Z

Switch#conf t

Switch(config)#int f0/2

Switch(config-if)#switchport mode access

Switch(config-if)#switchport access vlan 101

Switch(config-if)#exit

Switch(config)#int f0/3

Switch(config-if)#switchport mode access

Switch(config-if)#switchport access vlan 101

Switch(config-if)#exit

Switch(config)#int f0/4

Switch(config-if)#switchport mode access

Switch(config-if)#switchport access vlan 100

Switch(config-if)#exit

Switch(config)#^Z

Switch#

End of VLAN configuration

Inter VLAN routing

Switch config:

```
Switch#conf t
Switch(config)#int f0/1
Switch(config-if)#switchport mode trunk
Switch(config-if)#^Z
Switch#
```

Router config:

```
Router>enable
Router#conf t
Router(config)#int f0/0
Router(config-if)#no shutdown
Router(config-if)#exit
Router(config)#int f0/0
Router(config-if)#no ip address
Router(config-if)#exit
```

```
Router(config)#int f0/0.100
Router(config-subif)#encapsulation dot1Q 100
Router(config-subif)#ip address 192.168.100.254 255.255.255.0
Router(config-subif)#no shutdown
Router(config-subif)#exit
```

```
Router(config)#int f0/0.101
Router(config-subif)#encapsulation dot1Q 101
Router(config-subif)#ip address 192.168.101.254 255.255.255.0
Router(config-subif)#no shutdown
Router(config-subif)#exit
```

Router(config)#^Z

4.5 Web Page Program

```
<html>

<head>

<meta http-equiv="refresh" content="0.2">

<title>Web_control</title>

<meta http-equiv="Content-Type" content="text/html; charset=iso-8859-1"><style type="text/css">

<!--
body,td,th {
    color: #000033;
}
body {
    background-color: #CCCCCC;
}
-->
</style></head>

<body>

<!-- AWP_In_Variable Name=""op"" -->
<!-- AWP_In_Variable Name=""op2"" -->
<!-- AWP_In_Variable Name=""op3"" -->
<!-- AWP_In_Variable Name=""ip"" -->
<!-- AWP_In_Variable Name=""ip1"" -->
<!-- AWP_In_Variable Name=""ip2"" -->
<!-- AWP_In_Variable Name=""ip3"" -->
<!-- AWP_In_Variable Name=""ip4"" -->
<!-- AWP_In_Variable Name=""ip5"" -->
<!-- AWP_In_Variable Name=""ip6"" -->
<!-- AWP_In_Variable Name=""ip7"" -->
```

```
<form>
<input type="submit" value="Set_Output_1_1">
<input type="hidden" name=""op"" value="1">
</form>
```

```
<form>
  <input type="submit" value="Set_Output_1_0">
<input type="hidden" name=""op"" value="0">
</form>
```

```
<p>
<form>
  <input type="submit" value="Set_Output_2_1">
<input type="hidden" name=""op2"" value="1">
</form>
```

```
<form>
  <input type="submit" value="Set_Output_2_0">
<input type="hidden" name=""op2"" value="0">
</form>
```

```
<p>
<form>
  <input type="submit" value="Set_Output_3_1">
<input type="hidden" name=""op3"" value="1">
</form>
```

```
<form>
  <input type="submit" value="Set_Output_3_0">
<input type="hidden" name=""op3"" value="0">
</form>
```

```

<form>

  <input type="submit" value="Set_Input_0_1">

  <input type="hidden" name="ip" value="1">

</form>


<p align="center">ip 0 : := "ip":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 1 : := "ip1":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 2 : := "ip2":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 3 : := "ip3":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 4 : := "ip4":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 5 : := "ip5":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 6 : := "ip6":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;ip 7 : := "ip7":&nbsp;&nbsp;&nbsp;

<p align="center">Output 0 : := "op":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;Output 2 : := "op2":&nbsp;&nbsp;&nbsp;

&nbsp;&nbsp;&nbsp;&nbsp;&nbsp;Output 3 : := "op3":&nbsp;&nbsp;&nbsp;


</body>
</html>

```

Very good use of the appendix

1708174

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

76/100

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

Text Comment. Extensive list of figures

Text Comment. Good list of tables

PAGE 8

Text Comment. Introduction is clear and to the point

PAGE 9

Text Comment. Good explanation and the 7 layers have been identified

PAGE 10

Text Comment. Good diagram

PAGE 11

Text Comment. You have identified the purpose of the 4 layer model and explained the

differences from the 7 layer model

PAGE 12

Text Comment. Explanation is correct

Text Comment. This is correct. The headers are added during encapsulation and removed during decapsulation before the data is read. Each level in the model will have its own header.

PAGE 13

Text Comment. Good explanation

PAGE 14

Text Comment. This is correct. There are also dedicated ports and dynamic ports. Well-known ports range from 0 through 1023.

PAGE 15

Text Comment. Network is correct and serial connections are configured

Text Comment. The explanation identifies the static and dynamic options for the system

PAGE 16

Text Comment. Addressing scheme has all three classes and you have set out your addressing for the serial connections

PAGE 17

Text Comment. Image shows evidence of configuration

Text Comment. Good reference to appendix

Text Comment. Ping tests are successful which demonstrates that the routing tables are correct. The tests carried out perform a send and receive on each LAN

PAGE 18

Text Comment. Good illustration of static routing configuration

Text Comment. System tests for static configuration is successful

Text Comment. Image shows evidence of RIP configuration for dynamic routing.

Text Comment. Router configuration is demonstrated

Text Comment. Dynamic routing report shows correct configuration

Text Comment. Good reference to appendix

Text Comment. Dynamic routing tests are successful which correct configuration

Text Comment. Good clear explanation. Remember that the dynamic addresses will be default addresses if DHCP helper addresses are not configured

Text Comment. Images show evidence of DHCP configuration

Text Comment. PC1 is clearly given the dynamic address .4.1

Text Comment. Helper address is identified and implemented

Text Comment. Good demonstration of outcome when no helper address is configured.

Text Comment. This demonstrates that the dynamic address is the next available address

Text Comment. Good explanation. This is a common procedure in industry VLAN's

Text Comment. Image clearly demonstrates the DHCP excludes the addresses .1 to .10 and implements the next available which is .11

Text Comment. Tests are successful which proves configuration of excluded addresses

Text Comment. Test tables are good

Text Comment. Router configuration shows all the configurations carried out

Text Comment. Very good point. It is the control router that will have the significant configuration

Text Comment. Explanations and test analysis is very good and you have identified the key elements of the configuration of the system

Text Comment. Evaluation is good and demonstrates your understanding of the key network characteristics which will be needed throughout the portfolio

Text Comment. Good table of addressing scheme

Text Comment. Tables show evidence of the configured address scheme using the sub net address method

Text Comment. Table showing CIDR /27 configured for the LAN networks

Text Comment. Table showing CIDR /30 for the WAN networks

Text Comment. VLAN addressing is correct. An extra network address is used (128)

Text Comment. Configuration is now achieved using the CLI terminal. This is how the final practical implementation will be achieved

Text Comment. Tables show all the correct RIP configuration for all routers. The routed addresses are clearly shown

Text Comment. The images show clear evidence that the CIDR /27 and CIDR /30 have been configured according to the subnet addressing

Text Comment. Worth noting here that 'ver 2' RIP protocol is used because ver 1 does not support CIDR

Text Comment. Routing tables show the configuration is held in the routing tables as connections and routes

Text Comment. The routing configuration is evident in the report listed

Text Comment. Good reference to appendix

Text Comment. Image shows the interfaces configured on VLAN's 2 and 3. Note that VLAN 1 is the default and any interface not configured is on VLAN 1.

Text Comment. Trunking channel is implemented here

Text Comment. The images show evidence of the sub interfacing using the trunking protocol

Text Comment. The report printout shows the correct configuration

Text Comment. Explanation is correct

Text Comment. Switch configuration showing trunk channel active and VLAN's 2 and 3 active

Text Comment. Milford router shows the two sub interface gateways for the VLANs

Text Comment. VLAN gateways shown in devices summary report

Text Comment. Images show good evidence of configuration

Text Comment. Images show the ACL implementation

Text Comment. CIDR /28 tests are successful

Text Comment. VLSM tests are successful which proves the implementation of VLSM

Text Comment. Tests show the VLAN must be implemented correctly for the send and receive ping tests to be successful. PC2 and PC3 are the devices on VLANs

Text Comment. Screenshot shows the device address .129 is denies access

Text Comment. Screenshot showing device .65 allowed access

Text Comment. Same test from different device showing access denied

Text Comment. Same tests from different source showing access allowed.

Text Comment. This is an important point. RIP ver 2 accepts the sub nets CIDR and VLSM subnetting.

Text Comment. Good evaluation with focus on the performance of the VLAN which will be used in the practical element

PAGE 51

PAGE 52

Text Comment. Screenshot shows VLANs are active

PAGE 53

Text Comment. Screenshot shows the VLANS are configured with interfaces

Text Comment. Ping tests carried out from the PLC configuration terminal to the other ip addresses.

PAGE 54

Text Comment. Good use of block diagram

Text Comment. Image shows evidence of Cisco equipment connected to devices

PAGE 55

Text Comment. PLC web server activated

Text Comment. The file types for the HTTP protocol are declared here along with the starting memory location of the web server

Text Comment. Approved file extensions for the web server are identified

PAGE 56

Text Comment. Screenshot shows the tags set up for io control

Text Comment. Web server block is implemented in the main program area

Text Comment. The developed web program is downloaded to the web server of the PLC

PAGE 57

Text Comment. The ip address of the PLC is now setup. The gateway address is active and is from a router

Text Comment. The web program files are held in the userfiles in the TIA program for access

Text Comment. Simple HTML program is demonstrated

PAGE 58

Text Comment. This is the method for declaring tags from the PLC that are to be accessed in the HTML program

Text Comment. HTML forms used to write data values to the output ports on PLC using tags declared

PAGE 59

Text Comment. Screenshot showing evidence of input monitoring function in web page

Text Comment. Explanations and images are good and clearly show how the program interacts with the PLC

PAGE 60

Text Comment. Image shows evidence of from web page generated from PLC web server

Text Comment. Good image showing input and output set under test

PAGE 61

Text Comment. Input and output conditions are the same as indicated on the PLC showing the HTML program working with real time data

PAGE 62

PAGE 63

Text Comment. You are correct in your recommendation here that there can be vast improvements using other web technologies which are already compatible with the PLC web server. These functions of motor control is a good example of what can be achieved.

PAGE 64

Text Comment. This is a good point with IIOT 4.0

PAGE 65

Text Comment. Good relevant sources

PAGE 66

PAGE 67

PAGE 68

PAGE 69

PAGE 70

PAGE 71

PAGE 72

PAGE 73

PAGE 74

PAGE 75

PAGE 76

PAGE 77

PAGE 78

PAGE 79

PAGE 80

PAGE 81

PAGE 82

PAGE 83

PAGE 84

PAGE 85

PAGE 86

PAGE 87

PAGE 88

PAGE 89

Text Comment. Very good use of the appendix

GRADING FORM: CSG-RUBIC

JORDAN
GOUGH

0

RESEARCH-INFORMED LITERATURE



Your research covers all what is required with good relevant sources used.

6/10

KNOWLEDGE AND UNDERSTANDING



Element 1: Good introduction to start the project. The design and implementation of the network is clearly explained with supporting images. There is sufficient evidence for correct implementation. 7.5/10 Element 2: Introduction explains the requirements clearly. The configuration is explained and documentation requirements for addressing schemes are good and good use of tables for this. 8/10 Element 3: The sections from the CAD designs in elements 1 and 2

23/30

are implemented using level 2, and 3 Cisco devices. The implementation of the VLAN and web server are clearly documented supported with good explanations and images. There is sufficient evidence of the ACL configuration. The web program implementation is achieved over the existing Cisco switch and router and explained clearly.7.5/10

ANALYSIS



Element 1: Testing and results are very well explained and supported with sufficient images. 3.5/5
Element 2: A good analysis of test results has been carried out with supporting images and a good method of testing used. Good use of tables in this section.7/10
Element 3: Good test results obtained and are clearly explained. All the requirements have been achieved with good evidence. 7.5/10

18/25

PRACTICAL APPLICATION AND DEP.



Element 1: Design and implementation from address scheme to class A, B and C and serial links are clearly implemented and tested. The procedures followed from design to implementation were efficient which simplified the testing stage. Test procedure used meant that redundant testing is eliminated. 3.5/5
Element 2: The configuration is more complex due to the subnetting required and the tables of addressing are very well ordered and follow a pattern. Implementation of the required network parameters has been carried out with significant points explained. This should have included the

18/25

reason for RIP ver 2 and not ver 1. The differences are important points. Test procedures and methods eliminate redundant tests while testing all components. 7.5/10 Element 3: The practical implementation was carried out using Cisco level 2 and 3 devices. The explanations are supported with good images. The testing carried out demonstrated the VLANs and ACL security used in industry networks. 7/10

SKILLS FOR PROFESSIONAL PRAC.



Quality of text and layout of the report is good in all elements. Good use of the appendix for repeated configurations and testing. 11/15

11/15