BSc (Hons) in Computing
Level C/I/H

GROUP ASSIGNMENT

Module Code & Title: COMP4002 Networking Concepts and Cyber Security-1

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Date of Submission: 08 July 2022

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Word Count: 2730

Placed a ☑ to indicate where each member has completed the respective

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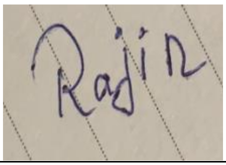
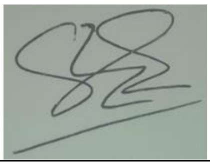
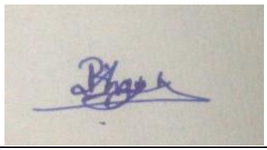
Network design and justification (including hardware)	✓	✓	✓
Layer 2 technology discussion and justification	✓	✓	✓
Layer 3 technology discussion and justification	✓	✓	✓

WAN technology discussion and justification	✓	✓	✓
Network Configuration **Building A**		✓	
Network Configuration **Building B**	✓		
Network Configuration **Building C**			✓
Report, Research & Referencing	✓	✓	✓
Signature			

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Acknowledgements

This report's final output was the result of a lot of hard effort, and we are grateful to
Mr. Vidura Perera for all his help when we needed advice or feedback on our project.
As the team leader I RAJIN SANDIRA DIVYAGAHAGE (CB009455) am grateful for the help of my teammates POLPAGODA GAMAGE BHAGYA BHAVANI SUMANAWEERA (CB010220) & SACHINTHA LAKMIN KAHINGALAGE (CB010454) for all
the help in creating a successful final report and the configurations for the assignment.

Abstract

Our assignment includes documentation and network configurations for a packet tracer file with the technologies. The version of Packet Tracer we used was 8.1.1.0022.

Introduction

The network infrastructure for all three of E-Gaming Unlimited locations will be entirely redone considering the company's recent expansion into a new facility.
The Games Design, Engine Development, and AI Teams, as well as the majority of the support development services and data centres, are located in Building A, which also houses the HQ.
The marketing and events management teams are housed in Building B, which is a little smaller, while the newly formed Esports team is housed in Building C, which is the newest and smallest addition.

Location	Network	Number of Hosts
A	ICT	16
	Server/Data Center	8
	Games Design	48
	Engine Development	12
	AI	8
	Support Services	40

Figure 1:Building A requerments

B	ICT	10
	Marketing	16
	Events	32
	Support Services	8
C	E-Sports	50
	ICT	6
	Support Services	5

Figure 2: Building B & C requiremnts

Network Design for E-Gaming Unlimited.

*/

<u>Note</u>

This network design was created with in the limitations of the packet tracer, with the use of packet tracer 8.1.1.0022. Limitations have been listed.

The command "**switchport block multicast**" which would stop multicast packets from flooding building networks is **not available in Packet Tracer**.

Therefore, in order to **minimize the effects of multicast HSRP storms**, cross links between distribution switches and core switches were **<u>manually shutdown</u>**. In a physical implementation these switchports can be turned on.

Due performance issues and limitations in packet tracer the number of switches and links have been reduced in the diagrams. Refer the Throughput calculation table for the actual switch number.

/*

Full Network Diagram

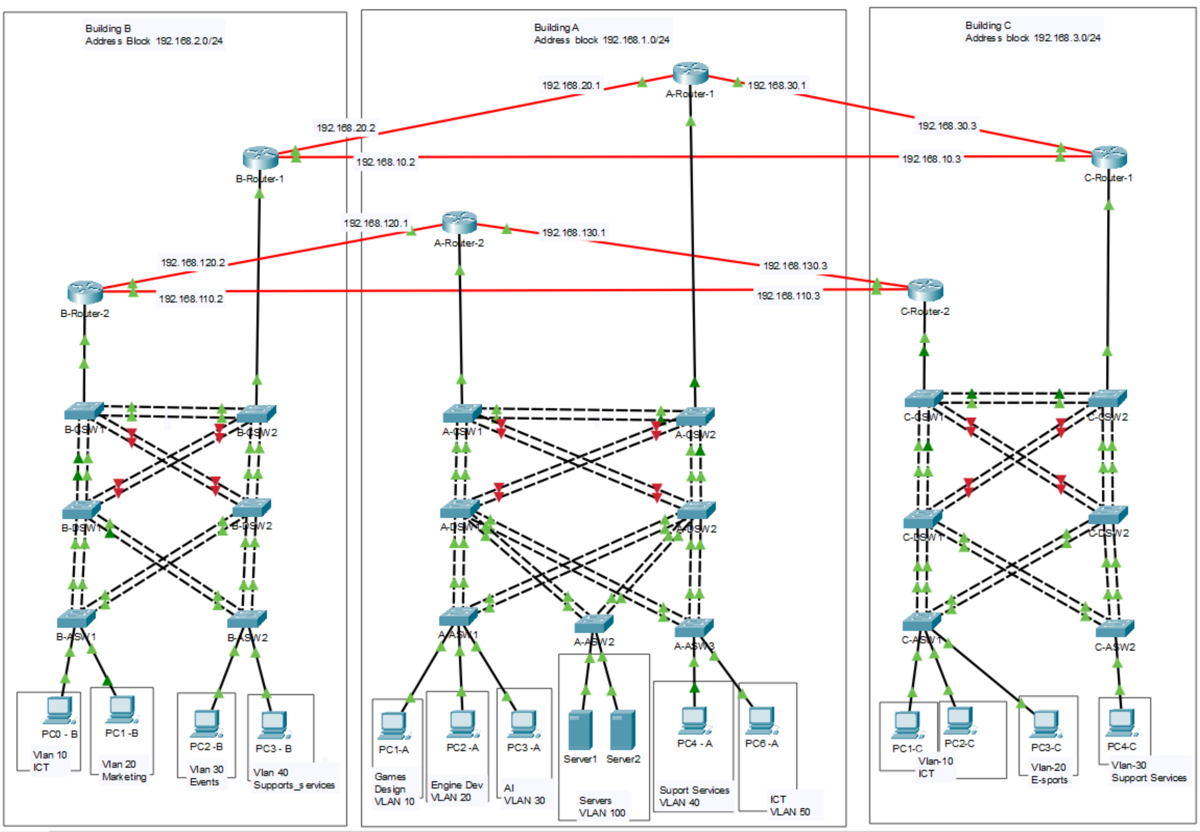

Figure 3:Full network diagram.

Building A Diagram

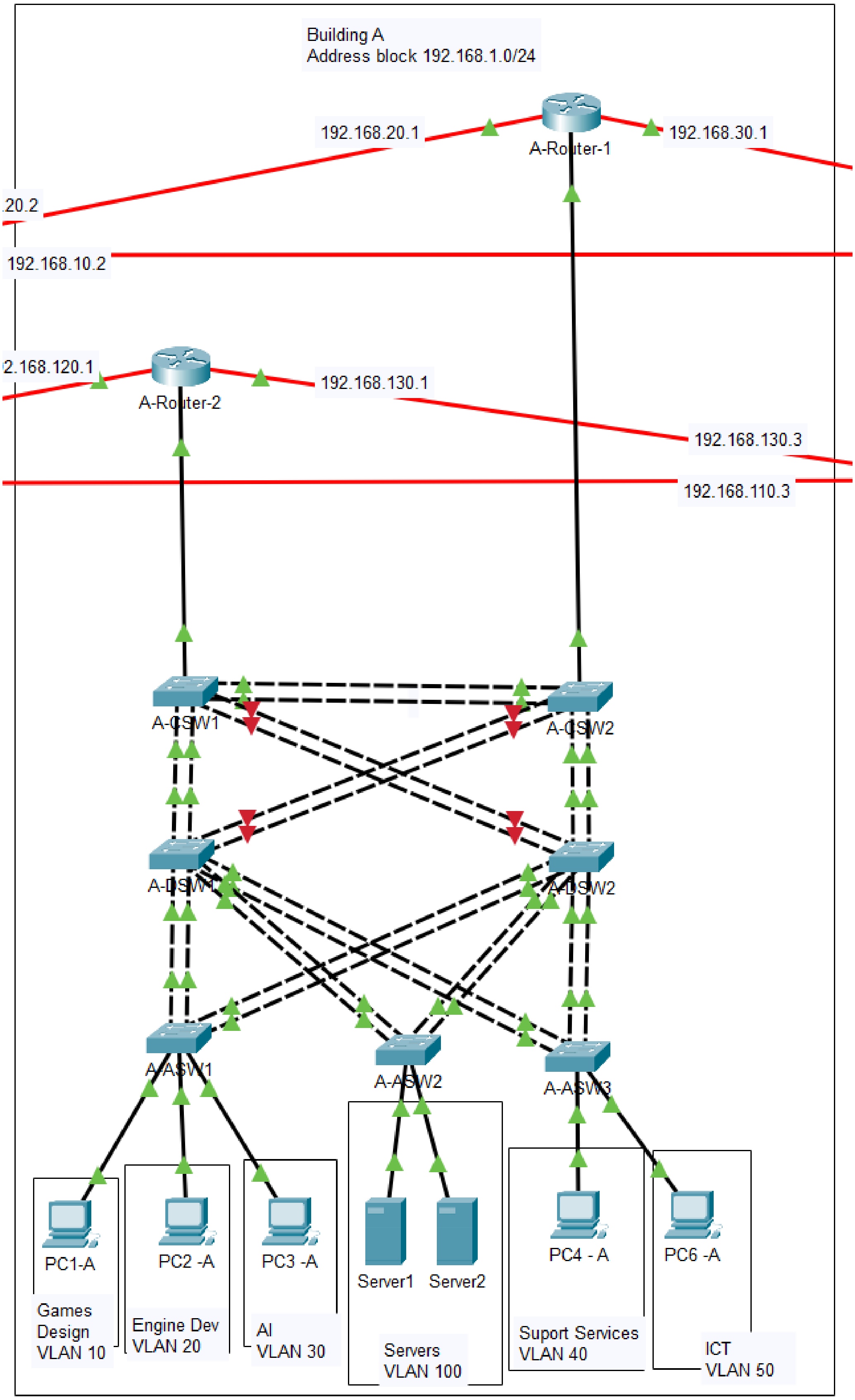

Figure 4:Building A Network diagram

Building B Diagram

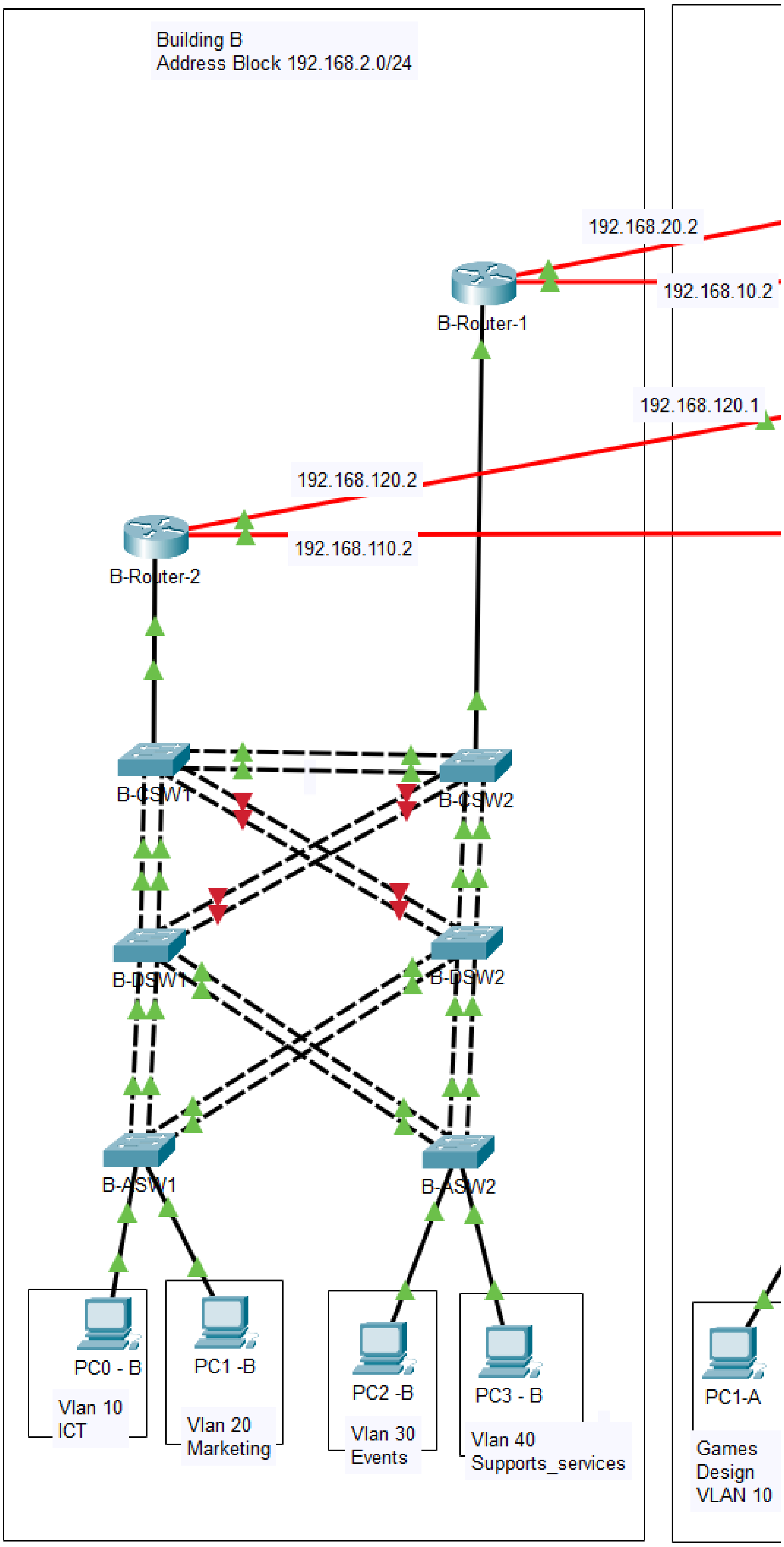

Figure 5:Building B Network diagram

Building C Diagram

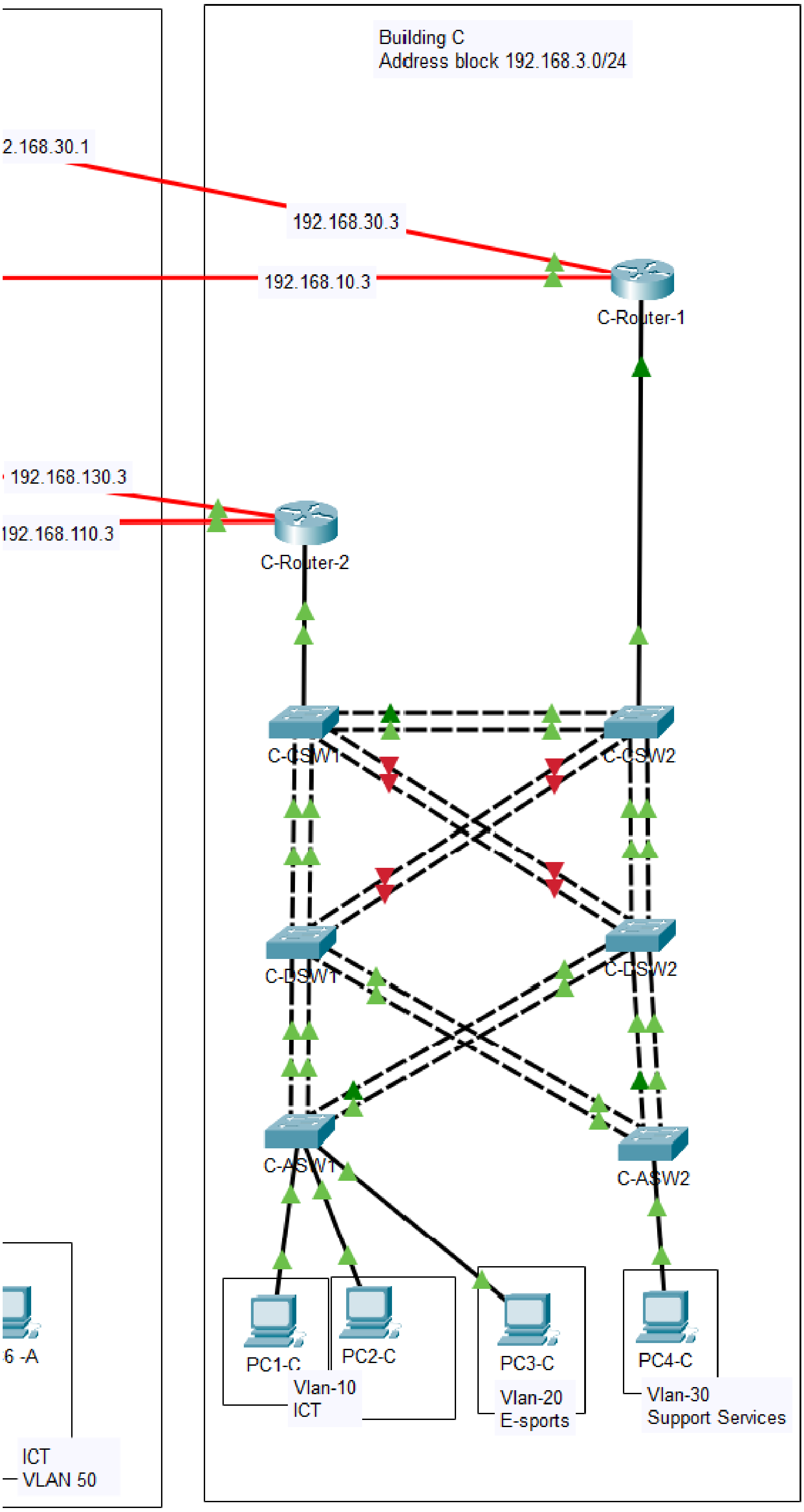

Figure 6:Building C Network diagram

IP Addressing plan (VLSM Table)
IPs needed for expansion was considered when allocation IPs

Subnet Name	Needed Size	Allocated Size	Address	Mask	Dec Mask	Assignable Range	Broadcast
A - Games	48	62	192.168.1.0	/26	255.255.255.192	192.168.1.1 - 192.168.1.62	192.168.1.63
A - Support	40	62	192.168.1.64	/26	255.255.255.192	192.168.1.65 - 192.168.1.126	192.168.1.127
A - AI	8	30	192.168.1.128	/27	255.255.255.224	192.168.1.129 - 192.168.1.158	192.168.1.159
A - EngineDev	12	30	192.168.1.160	/27	255.255.255.224	192.168.1.161 - 192.168.1.190	192.168.1.191
A- ICT	16	30	192.168.1.192	/27	255.255.255.224	192.168.1.193 - 192.168.1.222	192.168.1.223
A- Servers	8	14	192.168.1.224	/28	255.255.255.240	192.168.1.225 - 192.168.1.238	192.168.1.239
B-Events	32	62	192.168.2.0	/26	255.255.255.192	192.168.2.1 - 192.168.2.62	192.168.2.63
B-Marketing	16	30	192.168.2.64	/27	255.255.255.224	192.168.2.65 - 192.168.2.94	192.168.2.95
B-ICT	10	30	192.168.2.96	/27	255.255.255.224	192.168.2.97 - 192.168.2.126	192.168.2.127
B-Support	8	14	192.168.2.128	/28	255.255.255.240	192.168.2.129 - 192.168.2.142	192.168.2.143
C - E-Sports	50	126	192.168.3.0	/25	255.255.255.128	192.168.3.1 - 192.168.3.126	192.168.3.127
C - ICT	6	14	192.168.3.128	/28	255.255.255.240	192.168.3.129 - 192.168.3.142	192.168.3.143
C - Support	5	14	192.168.3.144	/28	255.255.255.240	192.168.3.145 - 192.168.3.158	192.168.3.159
B - C Link 1	2	6	192.168.10.0	/29	255.255.255.248	192.168.10.1 - 192.168.10.6	192.168.10.7
A - B Link 1	2	6	192.168.20.0	/29	255.255.255.248	192.168.20.1 - 192.168.20.6	192.168.20.7
A - C Link 1	2	6	192.168.30.0	/29	255.255.255.248	192.168.30.1 - 192.168.30.6	192.168.30.7
B - C Link 2	2	6	192.168.110.0	/29	255.255.255.248	192.168.110.1 - 192.168.110.6	192.168.110.7
A - B Link 2	2	6	192.168.120.0	/29	255.255.255.248	192.168.120.1 - 192.168.120.6	192.168.120.7
A - C Link 2	2	6	192.168.130.0	/29	255.255.255.248	192.168.130.1 - 192.168.130.6	192.168.130.7

Figure 7: Ip addressing plan (VLAM Table)

Subnet calculation using vlsmcalc.net

Cisco three-layer hierarchical model

This is a model developed by Cisco for designing networks with reliability, redundancy and scalability in mind. The network is designed with redundant links in-between layers. Multiple switches are implemented in the distribution and core layer. This ensures that connectivity will be maintained when equipment fails as there are no single points of failure.

Access Layer

Access layer is the layer end-hosts connect to the network. End hosts can be placed in VLANs by configuring access switches

Distribution Layer

Distribution layer is the layer providing communication between core and access. This layer can be used for inter-VLAN routing and filtering.

Core Layer

Core layer's main purpose is rapidly forwarding high volume of traffic.

(Study CCNA, 2021)

Throughput calculation table

Note: Hosts for future expansions have been taken into account.

<table>
<tr><th colspan="5">Access Layer</th></tr>
<tr><th>Network</th><td>A - Hosts</td><td>A-Data Centre</td><td>B</td><td>C</td></tr>
<tr><th>Hosts</th><td>199</td><td>11</td><td>124</td><td>145</td></tr>
<tr><th>Number of access switches</th><td>5</td><td>1</td><td>3</td><td>4</td></tr>
<tr><th>Throughput from hosts</th><td>199Gbps</td><td>110Gbps</td><td>124Gbps</td><td>145Gbps</td></tr>
<tr><th>Uplink throughput per switch</th><td>~40Gbps</td><td>110Gbps</td><td>~42Gbps</td><td>~37Gbps</td></tr>
<tr><th colspan="5">Distribution Layer</th></tr>
<tr><th>Throughput to distribution layer</th><td colspan="2">~310Gbps</td><td>124Gbps</td><td>145Gbps</td></tr>
<tr><th>Number of distribution switches</th><td colspan="2">3</td><td>2</td><td>2</td></tr>
</table>

Avg. Throughput per switch	~104Gbps	62Gbps	~73Gbps
Core Layer			
Number of core switches	2	2	2
Throughput per switch	~155Gbps	62Gbps	~73Gbps

Hardware

Hardware Selection is based on the throughput calculations.

Access switches

Cisco Catalyst 9300 series with 48*1Gig ports and 4*25Gig uplinks. (C9300LM-48T-4Y)
https://www.cisco.com/c/en/us/products/collateral/switches/catalyst-9300-series-switches/nb-06-cat9300-ser-data-sheet-cte-en.html

Datacentre access switch

Cisco Catalyst 9500 series with 24*25Gig and 4*100Gig uplinks
(C9500-32QC) https://www.cisco.com/c/en/us/products/collateral/switches/catalyst-9500-series-switches/nb-06-cat9500-ser-data-sheet-cte-en.html

Distribution and core switches

Cisco Catalyst 9500 series 32*100Gig ports
(C9500-32C)
https://www.cisco.com/c/en/us/products/collateral/switches/catalyst-9500-series-switches/nb-06-cat9500-ser-data-sheet-cte-en.html

Routers

Cisco Catalyst 8500 series with max 240GE throughput per router, is ideal for max throughput but it is expensive.

https://www.cisco.com/c/en/us/products/collateral/routers/catalyst-8500-series-edge-platforms/datasheet-c78-744089.html

At a lower throughput and price we can use Cisco catalyst 8300 series router.

https://www.cisco.com/c/en/us/products/collateral/routers/catalyst-8300-series-edge-platforms/datasheet-c78-744088.html

SD-WAN is supported.

Layer Two Technologies.

EtherChannel.

EtherChannel is a port/link aggregation technology that operates in the data-link layer (layer 2). Port/link aggregation is the practice of combining a group of multiple physical ports/links into one logical port/link. (GeeksforGeeks, 2018)

The following protocols can be used to create EtherChannels. Both protocols are similar in functionality

1. Port Aggregation Protocol (PAgP): - Cisco proprietary protocol
2. Link Aggregation Control Protocol (LACP): - IEEE open standard protocol

Why use multiple links?

In networking having many links from one device to another device brings many advantages; the two main ones are,

- Redundancy: - If one link fails traffic flow through the network will not be completely cut off because other links are still up and functioning.
- Increased speeds: - The combined throughput of multiple links will be higher than the throughput of one single link. This is especially useful when providing uplinks that are needed to handle high traffic.

Issues that would arise when multiple links are connected without using EtherChannel.

When multiple links are connected between two devices without using EtherChannel, the network devices see them as two independent links. This will create a loop. The STP protocol will act to prevent the loop formation by blocking links and the speed will be now limited.

How EtherChannel solves this issue.

When an EtherChannel is created, multiple links would form **one logical link**. Now they won't be seen as many independent links thus no loops will form between them. Thus, both redundancy and combined throughput will be available.
(Study CCNA, 2021)

Justification of EtherChannel

EtherChanelling allows for redundant links with combined bandwidth. The proposed network will use LACP Etherchannels instead of PAgP, because the open standard LACP is supported by most vendors.

Virtual Local Area Network (VLAN).

Virtual Local Area Network or VLAN is a layer 2 network segmentation technology. A VLAN is created by logically grouping interfaces that should belong in the same broadcast domain. In simple terms, a VLAN acts like a virtual switch. Since, they are virtual, they can span across many physical switches. This allows devices connected to separate physical switches to be in one VLAN. (N-able, 2019)

Minimizing the sizes of broadcast domain

By default, switches forward all layer 2 broadcast traffic that it receives to all connected interfaces except the interface that it received the broadcast. Even if the network is segmented using subnetting, the switch being a Layer 2 device will not recognize the IP subnetting done in layer 3. So even layer 3 broadcasts will be flooded by the switch.

When VLANs are configured the broadcast domain is reduced in size. Thus, the **broadcast traffic is contained within the VLAN** reducing unnecessary network traffic and improving the security of the network. (NetworkLessons, 2016)

VLAN justification

VLANs allows us to reduce the number of switches that are needed in the network reducing cost & operational costs as well.
The designed network, end hosts are grouped according to the department using VLANs. IP assignment is done with DHCP pools per VLAN.

Spanning-tree Protocol.

STP is a Layer 2 technology that prevent loop formation in a network.
Loops can bring the network to a halt. When redundant links are given between devices, paths will be blocked by STP if it creates a loop. We can configure the root bridge manually.

Per-VLAN Spanning Tree (PVST).

PVST allows the switch to have spanning trees for each VLAN. This flexibility in STP configuration allows fine tuning of the network making sure traffic from different VLANs take different paths, so that all links will be utilized and none of them are fully blocked by STP.

Advantages of STP

- It is enabled by default on switches.
- Allows to configure functionality of STP (change priority, root, etc).
- Supported by switches and bridges of many different vendors.
- Will provide backup paths if the current path fails.

Disadvantages of STP

- STP is not effective in networks with high traffic.
- Lower network capacity because STP blocks some paths.
- May add latency

(Eye On Tech, 2020)

Justification for STP.

STP prevents looping in networks. Looping is when a packet like ARP is sent across the network to find a device which will cause a back & forth of the packets being sent between the switches. Looping is very bad for the network as it will cause other packets to be dropped infinitely there is no way to stop looping other than restarting all the network devices.

STP mode on all switches are set to Rapid-PVST. The distribution layer switches are configured manually such that one switch function as primary root for one group of VLANs while the other switch functions as primary root for the other group. PVST blocks links per VLAN, so links are not fully blocked so all links are used while maintaining redundancy.

Layer Three Technologies.

IP (Internet Protocol)

IP is a layer 3 protocol that handles packet transmission using the IP address of the source and destination device. IP addresses is a unique identifier that is used to identify a device on a local network or on the internet. Theses addresses are managed by the non-profit organization IANA (Internet Assigned Numbers Authority).
There are two main versions of IP in use today: IPv4 and IPv6 (GeeksforGeeks, 2020)

- IPv4 addresses are normally expressed in the decimal format e.g.: 192.168.1.0.
- IPv6 addresses are expressed in hexadecimal format e.g.: fdac:3456:f424:23c3:260c:a57b:3c4b:3c01

Types of IP addresses.

There are four main types of IP addresses. They are,

- Private IP addresses.
- Public IP addresses.
- Static IP addresses.
- Dynamic IP addresses.

(Glenn, 2018)

IP address justification

In the company network, hosts should be given an IP as an identifier for network communication. In this network end hosts are placed into subnets according to the department they are in and are given the IP addresses by using DHCP.

Routing Information Protocol (RIP)

In networking, routing is the technique of forwarding packets across networks to their destination. There are two types of routing. (Cloudflare, no date)

1. Static Routing: The routes are manually configured.
2. Dynamic Routing: The routes are learnt by the router and the best path is selected. The routing tables get updated automatically when there is any change in the network.

Routing Information Protocol (RIP) is a **dynamic routing protocol**. In RIP the hop count is used as the routing metric in best route selection. Hop count is the number of devices a packet will go through in its journey to the destination. The maximum hop count that is supported by RIP is 15. If there are multiple paths with equal hops, the protocol will load balance the traffic through all of them. Routers configured with RIP will share the details of its routing table with its neighbour routers ensuring that the paths will be updated quickly if there is any network change. (metaswitch, 2019)

Types of RIP. (360training, no date)

1. **RIP version 1**

   In RIPv1 the request for routing tables is sent as a broadcast message. It only supports classful networks.

2. **RIP version 2**

   The request for routing tables is sent using the multicast address. It supports classless networks and provides more features such as authentication when updates are sent.

3. **RIPng**

   RIP Next Generation (RIPng) works with **IPv6** while RIPv1 and RIPv2 works with IPv4.

Justification for RIPv2

In the designed network, RIPv2 was chosen to implement routing between buildings. Apart from the features discussed above, one other reason for that selection is RIPv2 configuration being very straight forward and easy.

HSRP

Hot Standby Routing Protocol (HSRP) is a FHRP protocol used to provide redundant routers by having two routers have the same Virtual IP Address (VIA) acting as the active or standby according to an election based on the priority configured. Only the active router will serve the end hosts using the "VIA" and it periodically sends "hello" messages to the standby router. If the standby router does not receive the message, it will take over the role of active router. So, if a router in the network fails, the end-users will still have connectivity through the other router. (Study CCNA, 2021)

Justification for HSRP

"E-gaming Unlimited" is a business operating in the digital world of games. If any part of the business loses connectivity, the financial loss can be very high, therefore all three buildings have two routers with HSRP enabled. HRSP priorities for different sub-interfaces configured differently on the routers in a way that would balance the traffic through both routers. If one fails, the other router will become active for all sub-interfaces/VLANs.

WAN Technologies.

There are many WAN technologies that can be used. Three of the alternatives that can be used are SD-WAN, MPLS & VPN.

VPN stands for Virtual Private Network, it establishes a connection between your computer and the network, providing a private tunnel for your data communications. (Avast, no date)

Multiprotocol Label Switching (MPLS) is a WAN technology that uses “labels” placed in between datalink and network layers when routing traffic through networks. MPLS packet forwarding time is lower than IP forwarding because the packet header is not analysed and processed at each router in the MPLS network. (Cisco, 2018) (Huawei, no date)

Software Defined WAN is a WAN technology is a virtual WAN architecture that allows corporations to combine multiple transport services (e.g.: MPLS, VPN & the cloud) while other conventional types of WAN technology were not designed for handling cloud traffic, they move the traffic from the branches to the network hub or headquarters for the traffic to be sent to the cloud resulting in backhauling of traffic. SD WAN prevents this by sending cloud traffic straight to the could from the branch office. (Cisco, no date)

WAN Justification.

We have chosen **SD-WAN** as is easy to set up cheap and secure, it also allows “E-Gaming Unlimited” to expand to the cloud in the future very quickly and cost effectively.

Configurations.

VLAN configurations.

```
VLAN Name                             Status    Ports
---- -------------------------------- ---------
-------------------------------
1    default                          active    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, Gig0/1,
Gig0/2
10   GamesDesign                      active
20   EngineDevelopment                active
30   AI                               active
40   SupportServices                  active    Fa0/5
50   ICT                              active    Fa0/6
100  Servers                          active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

Figure 8: Building A 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
10   ict                              active
20   marketing                        active
30   Events                           active    Fa0/1
40   Support_services                 active    Fa0/2
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

Figure 9: Building B Vlan

```
VLAN Name                             Status    Ports
---- -------------------------------- ---------
-------------------------------
1    default                          active    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
                                                Gig0/1, Gig0/2
10   ICT                              active    Fa0/1, Fa0/7, Fa0/8
20   E-sports                         active    Fa0/2
30   support                          active
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active
```

Figure 10: Building C Vlan

RIP configurations.

```
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    192.168.1.0/24 [120/1] via 192.168.30.1, 00:00:04, GigabitEthernet2/0
R    192.168.2.0/24 [120/1] via 192.168.10.2, 00:00:14, GigabitEthernet3/0
     192.168.3.0/24 is variably subnetted, 3 subnets, 2 masks
C       192.168.3.0/25 is directly connected, GigabitEthernet4/0.2
C       192.168.3.128/28 is directly connected, GigabitEthernet4/0.1
C       192.168.3.144/28 is directly connected, GigabitEthernet4/0.3
     192.168.10.0/29 is subnetted, 1 subnets
C       192.168.10.0 is directly connected, GigabitEthernet3/0
R    192.168.20.0/24 [120/1] via 192.168.30.1, 00:00:04, GigabitEthernet2/0
                     [120/1] via 192.168.10.2, 00:00:14, GigabitEthernet3/0
     192.168.30.0/29 is subnetted, 1 subnets
C       192.168.30.0 is directly connected, GigabitEthernet2/0
```

Figure 11: RIP Configurations.

Spanning-tree configurations.

```
spanning-tree mode rapid-pvst
spanning-tree extend system-id
spanning-tree vlan 10,30 priority 24576
spanning-tree vlan 20 priority 28672
```

Figure 12: Spanning-tree Configurations.

DHCP configurations.

Building A

```
ip dhcp excluded-address 192.168.1.1 192.168.1.3
ip dhcp excluded-address 192.168.1.161 192.168.1.163
ip dhcp excluded-address 192.168.1.129 192.168.1.131
ip dhcp excluded-address 192.168.1.65 192.168.1.67
ip dhcp excluded-address 192.168.1.193 192.168.1.195
!
ip dhcp pool GamesDesign-10
 network 192.168.1.0 255.255.255.192
 default-router 192.168.1.1
 dns-server 8.8.8.8
ip dhcp pool EngineDev-20
 network 192.168.1.160 255.255.255.224
 default-router 192.168.1.161
 dns-server 8.8.8.8
ip dhcp pool AI-30
 network 192.168.1.128 255.255.255.224
 default-router 192.168.1.129
 dns-server 8.8.8.8
ip dhcp pool Support-40
 network 192.168.1.64 255.255.255.192
 default-router 192.168.1.65
 dns-server 8.8.8.8
ip dhcp pool ICT-50
 network 192.168.1.192 255.255.255.224
 default-router 192.168.1.193
 dns-server 8.8.8.8
```

Figure 13: Building A DHCP Configurations.

Building B

```
ip dhcp excluded-address 192.168.2.1 192.168.2.3
ip dhcp excluded-address 192.168.2.97 192.168.2.99
ip dhcp excluded-address 192.168.2.129 192.168.2.131
ip dhcp excluded-address 192.168.2.65 192.168.2.67
!
ip dhcp pool ICT
 network 192.168.2.96 255.255.255.224
 default-router 192.168.2.97
 dns-server 8.8.8.8
ip dhcp pool Events
 network 192.168.2.0 255.255.255.192
 default-router 192.168.2.1
 dns-server 8.8.8.8
ip dhcp pool Marketing
 network 192.168.2.64 255.255.255.224
 default-router 192.168.2.65
 dns-server 8.8.8.8
ip dhcp pool Support_Service
 network 192.168.2.128 255.255.255.240
 default-router 192.168.2.129
 dns-server 8.8.8.8
```

Figure 14: Building B DHCP Configurations.

Building C

```
ip dhcp excluded-address 192.168.3.1 192.168.3.3
ip dhcp excluded-address 192.168.3.129 192.168.3.131
ip dhcp excluded-address 192.168.3.145 192.168.3.147
!
ip dhcp pool ICT
 network 192.168.3.128 255.255.255.240
 default-router 192.168.3.129
 dns-server 8.8.8.8
ip dhcp pool Esports
 network 192.168.3.0 255.255.255.128
 default-router 192.168.3.1
 dns-server 8.8.8.8
ip dhcp pool Support
 network 192.168.3.144 255.255.255.240
 default-router 192.168.3.145
 dns-server 8.8.8.8
```

Figure 15: Building C DHCP Configurations.

PC DHCP

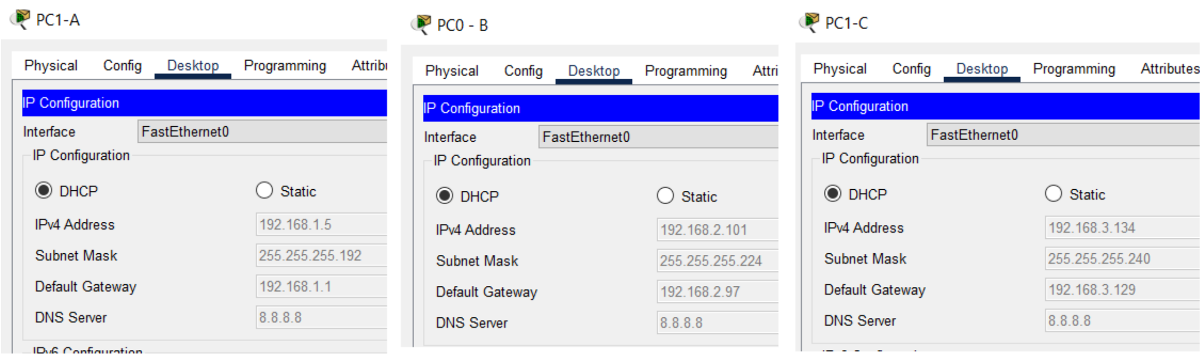

Figure 16: PC DHCP

EtherChannel configurations.

```
Flags:  D - down        P - in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      f - failed to allocate aggregator
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port


Number of channel-groups in use: 2
Number of aggregators:           2

Group  Port-channel  Protocol    Ports
------+-------------+-----------
+-----------------------------------------------

1      Po1(SU)           LACP   Fa0/1(P) Fa0/2(P)
2      Po2(SU)           LACP   Fa0/3(P) Fa0/4(P)
```

Figure 17: EtherChannel Configurations.

Trunk ports.

```
Port        Mode         Encapsulation  Status        Native vlan
Po1         on           802.1q         trunking      1
Po3         on           802.1q         trunking      1
Gig4/1      on           802.1q         trunking      1

Port        Vlans allowed on trunk
Po1         1-1005
Po3         1-1005
Gig4/1      1-1005

Port        Vlans allowed and active in management domain
Po1         1,10,20,30
Po3         1,10,20,30
Gig4/1      1,10,20,30

Port        Vlans in spanning tree forwarding state and not pruned
Po1         1,10,20,30
Po3         1,10,20,30
Gig4/1      1,10,20,30
```

Figure 18: Trunk ports Configurations.

Sub-Interface configurations.

Building A

```
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     unassigned      YES NVRAM  up                    up
GigabitEthernet0/0.10  192.168.1.3     YES NVRAM  up                    up
GigabitEthernet0/0.20  192.168.1.163   YES NVRAM  up                    up
GigabitEthernet0/0.30  192.168.1.131   YES NVRAM  up                    up
GigabitEthernet0/0.40  192.168.1.67    YES NVRAM  up                    up
GigabitEthernet0/0.50  192.168.1.195   YES NVRAM  up                    up
GigabitEthernet0/0.100 192.168.1.227   YES NVRAM  up                    up
GigabitEthernet1/0     unassigned      YES NVRAM  up                    down
GigabitEthernet2/0     192.168.30.1    YES NVRAM  up                    up
GigabitEthernet3/0     192.168.20.1    YES NVRAM  up                    up
GigabitEthernet4/0     unassigned      YES NVRAM  down                  down
```

Figure 19:Building A Sub-Interface Configurations.

Building B

```
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     unassigned      YES NVRAM  down                  down
GigabitEthernet1/0     192.168.20.2    YES NVRAM  up                    up
GigabitEthernet2/0     192.168.10.2    YES NVRAM  up                    up
GigabitEthernet3/0     unassigned      YES NVRAM  up                    up
GigabitEthernet3/0.1   192.168.2.99    YES manual up                    up
GigabitEthernet3/0.2   192.168.2.67    YES manual up                    up
GigabitEthernet3/0.3   192.168.2.3     YES manual up                    up
GigabitEthernet3/0.4   192.168.2.131   YES manual up                    up
GigabitEthernet4/0     unassigned      YES NVRAM  administratively down down
```

Figure 20:Building B Sub-interface Configurations.

Building C

```
C-Router-1#sh ip in br
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     unassigned      YES NVRAM  down                  down
GigabitEthernet1/0     unassigned      YES NVRAM  administratively down down
GigabitEthernet2/0     192.168.30.3    YES NVRAM  up                    up
GigabitEthernet3/0     192.168.10.3    YES NVRAM  up                    up
GigabitEthernet4/0     unassigned      YES NVRAM  up                    up
GigabitEthernet4/0.1   192.168.3.131   YES NVRAM  up                    up
GigabitEthernet4/0.2   192.168.3.3     YES NVRAM  up                    up
GigabitEthernet4/0.3   192.168.3.147   YES NVRAM  up                    up
GigabitEthernet5/0     unassigned      YES NVRAM  administratively down down
```

Figure 21:Building C Sub-interface Configurations.

HSRP

```
interface GigabitEthernet0/0.10
 encapsulation dot1Q 10
 ip address 192.168.1.3 255.255.255.192
 standby 0 ip 192.168.1.1
 standby preempt
!
interface GigabitEthernet0/0.20
 encapsulation dot1Q 20
 ip address 192.168.1.163 255.255.255.224
 standby 0 ip 192.168.1.161
 standby priority 110
 standby preempt
!
interface GigabitEthernet0/0.30
 encapsulation dot1Q 30
 ip address 192.168.1.131 255.255.255.224
 standby 0 ip 192.168.1.129
 standby preempt
!
interface GigabitEthernet0/0.40
 encapsulation dot1Q 40
 ip address 192.168.1.67 255.255.255.192
 standby 0 ip 192.168.1.65
 standby priority 110
 standby preempt
!
interface GigabitEthernet0/0.50
 encapsulation dot1Q 50
 ip address 192.168.1.195 255.255.255.224
 standby 0 ip 192.168.1.193
 standby preempt
```

Figure 22:Building A HSRP

```
interface GigabitEthernet3/0.1
 encapsulation dot1Q 10
 ip address 192.168.2.99 255.255.255.224
 standby 0 ip 192.168.2.97
 standby preempt
!
interface GigabitEthernet3/0.2
 encapsulation dot1Q 20
 ip address 192.168.2.67 255.255.255.224
 standby 0 ip 192.168.2.65
 standby priority 110
 standby preempt
!
interface GigabitEthernet3/0.3
 encapsulation dot1Q 30
 ip address 192.168.2.3 255.255.255.192
 standby 0 ip 192.168.2.1
 standby preempt
!
interface GigabitEthernet3/0.4
 encapsulation dot1Q 40
 ip address 192.168.2.131 255.255.255.240
 standby 0 ip 192.168.2.129
 standby priority 110
 standby preempt
```

Figure 23:Building B HSRP

```
interface GigabitEthernet4/0.1
 encapsulation dot1Q 10
 ip address 192.168.3.131 255.255.255.240
 standby 0 ip 192.168.3.129
 standby priority 110
 standby preempt
!
interface GigabitEthernet4/0.2
 encapsulation dot1Q 20
 ip address 192.168.3.3 255.255.255.128
 standby 0 ip 192.168.3.1
 standby preempt
!
interface GigabitEthernet4/0.3
 encapsulation dot1Q 30
 ip address 192.168.3.147 255.255.255.240
 standby 0 ip 192.168.3.145
 standby priority 110
 standby preempt
!
```

Figure 24: Building C HSRP Configurations.

Pings

	Successful	PC4 - A	PC1-C	ICMP		0.000	N	0
	Successful	PC2 -B	PC2-C	ICMP		0.000	N	1
	Successful	PC0 - B	Server1	ICMP		0.000	N	2
	Successful	PC1 -B	PC4 - A	ICMP		0.000	N	3

Figure 25: pings

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