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# Introduction

This report is a reflection on the realisation of a network, its development and the thought process which went into its making for a Graduate Scheme in Hypernet Ltd. The scenario requires the network to be able to span over Coventry and Birmingham in two different three-storey buildings, capable of managing 40-70 devices, whilst also considering scalability, redundancy and fault tolerance and to select the correct technologies and cables for long-distance connection considering both wired and wireless options.

The approach taken for this project, would be one considered popular as many well-known and mainstream strategies are used for network’s configuration and evaluation, these points and the network’s analysis will be more extensively developed in the following paragraphs.

# Network Analysis and Configuration

This network diagram checks a couple of requirements by, first and foremost, spanning over Coventry and Birmingham thus constituting a wide area network (WAN). A couple of routers around of the main router (in the centre) connecting several LAN’s, for the workspaces’ end devices which will be all linked and connected to every other device on the WAN and WLAN’s as well, as required with printers connected to each one of them to demonstrate that they are indeed functional. Many infrastructure resources such as switches, routers, access points and end devices can be seen, as required in the for the artefact, there are also servers in each subnet for DHCP configuration purposes (more in “2.1 Network Topologies and Protocols”). The main unit can be seen in Coventry.

However, the diagram below (see Appendix 1: IP Addressing Scheme; Top Level WAN; Schematic) is but a simplified version of the network to better represent its topology and constitution so, even if not represented, this diagram can support multiple devices on different floors of a building (see Artefact for better representation), slight mistakes such as servers and routers in Birmingham can also be found, which is obviously not the case in the artefact, as this representation was established to get an idea of how the main network would be constructed.

## Network Topology & Protocols

For this project, the design proposed, as briefly described in the previous section and seen in the image above, is an extended star topology; most used in networking practices its use would almost be a no-brainer, its speed and easy scalability is perfectly fitting for this scenario. Many other advantages come with using a star topology: easy scalability and great speed, as said previously, easily upgradable; its easy scalability allows to expand the workspace or add more redundant security measures (Bhardwaj, n.d.). It also has a “natural” security system as if one node goes down the whole system doesn’t stop working unless the issue comes from the central node making it also very easy to find the source of failure.

Furthermore, its performance can be assured, as it does not require unnecessary transmission of messages as compared to bus topologies, the message only being transferred by its source node through the central node to the destination node (Bhardwaj, n.d.).

This topology is especially, great for newbies to networking as it is very beginner friendly and widely used thus easy to find support for. It is easy to manipulate and requires less connections/configurations, great for trial and error as it is easily tweakable helping to better understand how to best utilise its model and when to use it (star topology).

Throughout the network, DHCP servers are configured for every end device, so DHCP protocol was used for their configuration whereas other devices such as routers and switches are manually configured using the TCP/IP protocol which ensures that every device is connected to the network and to be able to fetch that data from any device connected, temporarily or not, to the network.

The use of DHCP protocol has helped a lot make the task of configuration way easier as it becomes automated and thus less time consuming, especially with the amount of devices required in the assignment brief and also making the eventual expansion much easier and less of a hassle, not to forget that it is done pretty much flawlessly as well by automatically configuring the settings predetermined by the administrator connecting an end device to the network (University of Rochester, n.d.).

## IP Addressing Scheme

The detailed IP Addressing Scheme is available in Appendix 1.

The rationale behind the IP Addressing Scheme revolves around one main purpose, organisation within the network, as to make it easier to comprehend and configure each LAN has its own router with its own default gateway and its own subnets. There is also a separation between routers and switches by their subnet masks as routers have a 255.255.255.0 subnet mask whereas devices right below in the LAN (switches and end devices) have a subnet mask of 255.255.0.0, nevertheless every device has in common its host, here being 192.168.xxx.xxx thus allowing each device to communicate with each other in a full-duplex fashion. This rationale, which is pretty common in networking is required for TCP/IP protocol to function. (beingmerry. & Deland-Han. & EternalWill43. & MartineSmets. & MaryQiu1987. & Mehedi61. & simonxjx., 2023.)

The realisation of such a scheme helps to better understand how networks that surround us manage to communicate effectively and flawlessly, as many wouldn’t even realize how they’re able to communicate with one another, obviously not required to live but very interesting and nice to know and be able to do nevertheless, indeed being quite a worthwhile experience and great opening to the world of networking, computing and in general the science of technologies.

## Network Function

Simple networking devices such as routers, switches are used for their most basic uses, the most interesting devices are the servers used for DHCP configurations, firewall protection, DNS servers and custom websites. The vast range that servers are capable of covering through its “services” that are yet to be fully discovered are quite interesting as they are able of doing thing such as automated configurations through DHCP servers as previously said allowing one to save a lot of time on other networking tasks with one less thing to worry about. (BasuMallick, 2022)

Furthermore, another device used in majority are the multi-switches; in the artefact they serve as in-betweens between routers and switches and also between their LAN’s, DHCP server and the end devices before going through the switches with one on each floor. The use of multi-switches is to be sure the network is easily scalable, in addition to its beneficial topology the multi-switches grant plenty of room for expansion.

## Scalability, Security, Redundancy and Efficiency

### Scalability

As said many times previously, the capacity can be pretty much enlarged easily thanks to the easy to manipulate topology and the multi-servers for every floor. Thus; unless an absurd expansion of maybe 500 extra devices for example (hasn’t been tested obviously but seems like a pretty absurd amount) which would require the construction of more buildings; scalability should not be an issue for this network.

### Redundancy & Efficiency

The main protection provided by the network’s design would be the use of multiple switches (multi-switch – switch combination); before reaching the end devices, whilst also going through a firewall server. The use of extra switches might seem redundant but having a multi-switch, go through a regular switch which manages a limited number of end devices, adds an easy way of fault detection and ensures efficiency in its location and quick resolution.

### Security

The main risk and also weakness of a star topology would be the central hub, as if it were to go down, the whole system would be down (Singh, 2024). Thus to avoid the main hub from being at risk, everything going through the main hub goes through the firewall servers present in the multi-switch – switch connection.

# Network Evaluation

## Network Performance

The network’s performance is enhanced through the use of a star design over a bus design, despite it not being as performing as a partial or full mesh design. However, the use of a mesh topology would complicate the network by adding to much wiring, which would be a hassle if the network were to expand, thus as to improve scalability and management, performance has been ever so slightly reduced.

## Design Challenges

One of the main challenges in the making of the network would be the configuration of the servers (DHCP, DNS, HTTP). The approach taken to address these were to simply configure the settings necessary for the servers to function in the services tab. Using servers had been a bit of a challenge, nevertheless with the help of a couple of videos, their settings felt easier to manipulate and also a very good tool in the making of a network, especially one as big as this.

# Conclusion & Recommendations

In summary, this networking project has helped a lot in learning the basics of networking and the use of a networking simulation tool: how one would link up multiple devices, allowing them to communicate efficiently between each other, configure wireless connections, creating websites, making servers, installing protection services/firewalls, how to correctly wire certain devices,… etc.

The main achievement in this project is the network in itself as one can learn a lot in making a network, let it be functional or not one can also take a lesson from a project of that calibre; especially great for people seeking a career in networking or computing in general.

“Quality is not an act, it is a habit.” (Aristotle, 384 BC – 322 BC)

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# Appendix 1 - IP Addressing Scheme

## Top Level (WAN)

### Schematic

A computer diagram of a server

Description automatically generated

### IP Address Scheme

|  |  |  |  |
| --- | --- | --- | --- |
| Location | Network Address | Subnet Mask | Rationale |
| Central Router | 192.168.0.1  (GigabitEthernet)  192.168.XX.4 (Serial) | 255.255.255.0 | Private IP Address and first router |
| DNS Server | 192.168.0.200 | 255.255.255.0 | Range from 192.168.0.200 – 192.168.0.255 dedicated to DNS servers |
| HTTP Server | 192.168.0.100 | 255.255.255.0 | Range from 192.168.0.100 – 192.168.0.199 dedicated to HTTP servers |

## Intermediate Level (MAN)

### Schematic

A diagram of a network

Description automatically generatedA diagram of a network

Description automatically generated

Coventry

Birmingham

Central Unit\*

(Complete in WAN\*)

### IP Address Scheme

|  |  |  |  |
| --- | --- | --- | --- |
| Location | Network Address | Subnet Mask | Rationale |
| Cov. Router1 | 192.168.1.1  (GigabitEthernet)  192.168.11.1 (Serial) | 255.255.255.0 | First router |
| Cov. Router2 | 192.168.2.1  (GigabitEthernet)  192.168.12.1 (Serial) | 255.255.255.0 | Second router |
| Cov. Router3 | 192.168.3.1  (GigabitEthernet)  192.168.13.1 (Serial) | 255.255.255.0 | Third router |
| Brgham. Router1 | 192.168.4.1  (GigabitEthernet)  192.168.14.1 (Serial) | 255.255.255.0 | Fourth router |
| Brgham. Router2 | 192.168.5.1  (GigabitEthernet)  192.168.15.1 (Serial) | 255.255.255.0 | Fifth router |
| Brgham. Router3 | 192.168.6.1  (GigabitEthernet)  192.168.16.1 (Serial) | 255.255.255.0 | Sixth router |

## Building A (LAN)

### Schematic

A diagram of a computer network

Description automatically generated

### IP Address Scheme

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Device (x3) | Interface | IP Address[es] | Subnet | Gateway | Comment |
| Router | IPv4  IPv4  IPv4 | 192.168.1.1  192.168.2.1  192.168.3.1 | 255.255.255.0  255.255.255.0  255.255.255.0 | 192.168.1.1  192.168.2.1  192.168.3.1 | Interfaces, IP addresses, subnets and gateways of the 3 routers |
| Firewall | IPv4 | 192.168.1.50  192.168.2.50  192.168.3.50 | 255.255.255.0  255.255.255.0  255.255.255.0 | 192.168.1.1  192.168.2.1  192.168.3.1 | Interfaces, IP addresses, subnets and gateways of the 3 firewalls |
| Multi-switch | \ | \ | \ | \ | No need for these in the case of the switches (x5) and multi-switches |
| Switch (x5) | \ | \ | \ | \ | No need for these in the case of the switches (x5) and multi-switches |
| DHCP  Server | IPv4 | 192.168.1.2  192.168.2.2  192.168.3.2 | 255.255.255.0  255.255.255.0  255.255.255.0 | 192.168.1.1  192.168.2.1  192.168.3.1 | Interfaces, IP addresses, subnets and gateways of the 3 DHCP servers |
| PC (x60) | IPv4 | DHCP configured | DHCP configured  (255.255.0.0) | DHCP configured  (same as previous) | Configured automatically by DHCP Server |
| Access Point | IPv4 | \ | \ | \ | No need for these in the case of the access points |
| Printer | IPv4 | DHCP configured | DHCP configured  (255.255.0.0) | DHCP configured  (same as previous) | Configured automatically by DHCP Server |

## Building B (LAN)

### Schematic

A blue and black cubes

Description automatically generated with medium confidence

### IP Address Scheme

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Device | Interface | IP Address[es] | Subnet | Gateway | Comment |
| Multi-switch | \ | \ | \ | \ | No need for these in the case of the switches (x5) and multi-switches |
| Switch (x5) | \ | \ | \ | \ | No need for these in the case of the switches (x5) and multi-switches |
| DHCP  Server | IPv4 | 192.168.4.2  192.168.5.2  192.168.6.2 | 255.255.255.0  255.255.255.0  255.255.255.0 | 192.168.4.1  192.168.5.1  192.168.6.1 | Interfaces, IP addresses, subnets and gateways of the 3 DHCP servers |
| PC (x60) | IPv4 | DHCP configured | DHCP configured  (255.255.0.0) | DHCP configured  (same as previous) | Configured automatically by DHCP Server |
| Access Point | \ | \ | \ | \ | No need for these in the case of the access points |
| Printer | IPv4 | DHCP configured | DHCP configured  (255.255.0.0) | DHCP configured  (same as previous) | Configured automatically by DHCP Server |

# Appendix 2 – Device Purpose and Configuration

## Top Level (WAN)

|  |  |  |  |
| --- | --- | --- | --- |
| Device Type | Device Name | Configuration Information | Specific Purpose / Rationale |
| Router | Central Router | Hostname: Router0  SSH\*;  username: ROMAN  password:  cisco  (same for every router) | Serves as the main unit of the network connecting every LAN together, serving as a middle part and main trunk in the case of a branch expansion |
| Server | DNS Server | DNS service, resource records: google.com  (192.168.0.100)  surprise.com  (192.168.0.200)  And HTTP service of a custom website: google.com | Simple DNS server hosting a few websites and a HTTP server with a custom website |
| Server | HTTP Server | HTTP service of a custom website: surprise.com | HTTP server with a custom website |

## Intermediate Level (MAN)

|  |  |  |  |
| --- | --- | --- | --- |
| Device Type | Device Name | Configuration Information | Specific Purpose / Rationale |
| Router1 | Router1 | SSH\* | Assignment brief and requirement and necessary for proper network connections |
| Router2 | Router2 | SSH\* | Assignment brief and requirement and necessary for proper network connections |
| Router3 | Router3 | SSH\* | Assignment brief and requirement and necessary for proper network connections |
| Router4 | Router4 | SSH\* | Assignment brief and requirement and necessary for proper network connections |
| Router5 | Router5 | SSH\* | Assignment brief and requirement and necessary for proper network connections |
| Router6 | Router6 | SSH\* | Assignment brief and requirement and necessary for proper network connections |

## Building A (LAN)

|  |  |  |  |
| --- | --- | --- | --- |
| Device Type | Device Name | Configuration Information | Specific Purpose / Rationale |
| Router | Router(1-3) | SSH\* | Assignment brief and requirement and necessary for proper network connections |
| Firewall | ASA(1-3) | Username: ROMAN  Password: SECURITY\_PASS(1-6) | To protect end devices and only allow messages from the “INSIDE” to be sent or received |
| Multi-switch | Multi-switch(1-3) | \ | Connect the network |
| Switch (x5) | Switch(2-31) | \ | Connect the network and organise the end devices |
| DHCP  Server | Server(1-3) | DHCP Service configuration | To automatically configure end devices that would connect to the network |
| PC (x60) | PC(8-67) | DHCP activated | End devices for the requirement |
| Access Point | AccessPoint(0-2) | SSID: AP\_C(1-3)  WPA2-PSK; PSK Pass Phrase FloorC(1-3)\_Pass | To provide wireless connection |
| Printer | Printer(0-13) |  | To show that wireless connection works |

## Building B (LAN)

|  |  |  |  |
| --- | --- | --- | --- |
| Device Type | Device Name | Configuration Information | Specific Purpose / Rationale |
| Multi-switch | Multi-switch(4-6) | \ | Connect the network |
| Switch (x5) | Switch(2-31) | \ | Connect the network and organise the end devices |
| PC (x60) | PC(68-126) | DHCP activated | End devices for the requirement |
| Access Point | AccessPoint(3-5) | SSID: AP\_B(1-3)  WPA2-PSK; PSK Pass Phrase FloorB(1-3)\_Pass | To provide wireless connection |
| Printer | Printer(14-29) |  | To show that wireless connection works |

# Appendix 3 - Testing Documents

Connection Birmingham-Coventry

A map with many points on it

Description automatically generated

Connection between floors and main rack (bottom middle)

A computer screen shot of a diagram

Description automatically generated

Floor 3

Floor 2

Floor 1

Connection to end devices (PCs and printers)

A blueprint of a building

Description automatically generated

A computer server with many wires

Description automatically generated