MCOMD2NOS

Networks and Operating Systems

Assignment 2

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# Task 1: Network Re-Design *CASE STUDY*:

## Step 1: Hierarchical Network Diagram

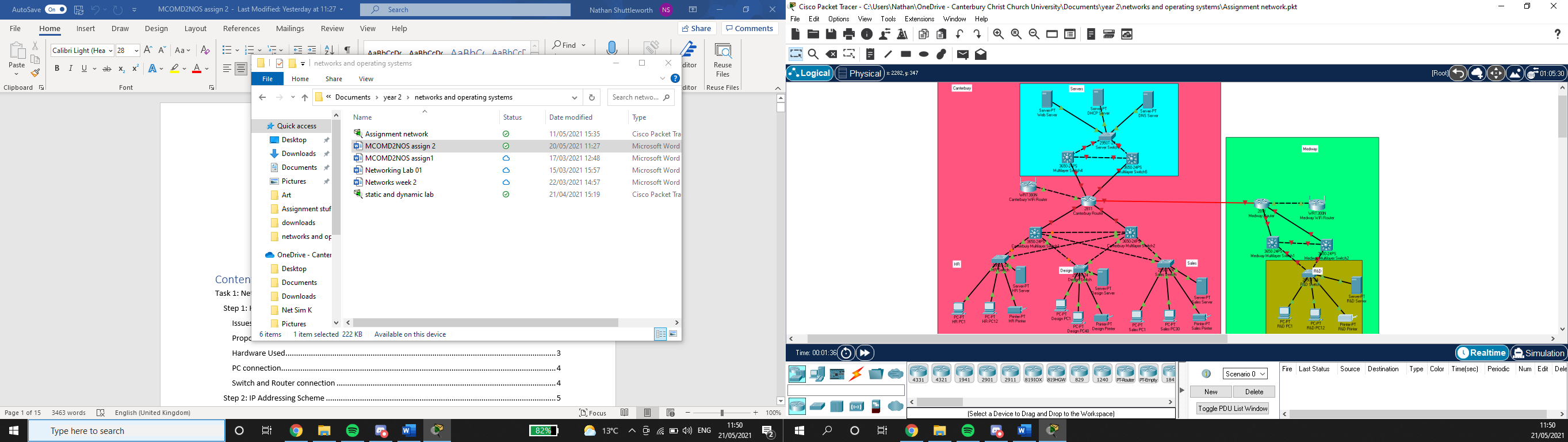
### Issues with Previous Network

The original network for the animation company has issues in many areas. This primarily stems from its topology design, and the choice of components. A main issue that users were experiencing because of the network was a lack of speed, particularly in sending data between the offices. Another important problem is that one network cable being faulty caused the entire network to go down.

One key reason for the lack of speed in the network was the use of CAT-5 cables. These are a very outdated medium to use, when both CAT 5e and CAT 6 cables are now available. CAT 5e cables have a theoretical top speed of 1000 Mbps, 10x faster than that of CAT 5 (Wilson,M.), and CAT 6 can go even higher. Also, the only types of cable being used are these twisted pair cables, even though Fibre Optic cables, which are faster could be used to connect routers to switches.

The reason the entire network went down with only one cable being faulty is because this network is reliant on a single cable going from the router to each of the offices switches, as well as the servers and databases. It is not a hierarchical network.

### Proposed Solution



I tried to design this network so that it would have a clear hierarchy and trying to make it modular. The reason for the hierarchy is it means that there are more connections between devices, this will deal with the issue of the entire network being taken down by only one device or cable failing. For each of Canterbury offices, they each have their own switches which then link into multilayer switches to keep them separate and make it easier to add both more devices into the offices and to add a new offices as well. The servers are separate from the offices, so that if either location needs to access them, there are less devices that have to be used for the transport of data. As a result, by keeping them separate, if an office were to go down then the servers would still be accessible to other offices.

In this model, there are only 2 PCs in each office however the real network will have the required amount.

The Medway location currently only has one office, however I have still implemented a hierarchy so that new offices and corresponding switches can be easily added. This also once again lowers the reliance on single pieces of hardware or cables.

Each location also has a Wi-Fi router to allow users to connect to the network at either location with their mobile devices.

Since this location covers a large area (Canterbury and Medway are approximately 20 kilometres away from each other), it can be considered a WAN (Wide Area Network). There is no official definition of how large a Network can be to be labelled as a WAN, but I believe it covering two separate towns is sufficient. The network parts for each location can be considered LANs (Local Area Network), and since there are Wi-Fi routers installed, it has elements of WLANs (Wireless LAN). The network parts for each location can be considered LANs (Local Area Network), and since there are Wi-Fi routers installed, it has elements of WLANs (Wireless LAN).

The solution was designed using the software Cisco Packet Tracer. This program was developed by Cisco, who are an international technology company, meaning that this is a professional level tool.

### Hardware Used

|  |  |
| --- | --- |
| **Hardware** | **Use in network** |
| Router | Had additional modules attached to increase number of ports and allow more fibre cables to be used. |
| Switch | Connects all of the end devices in an office together, goes into the multilayer switches |
| Multilayer switch | Used to connect switches together and link them to routers. |
| Wi-Fi router | Allows users to connect mobile devices such as laptops and phones to the network. |
| PC | End user device |
| Printer | End user device specialised for making physical copies of documents |
| Server | Used to store large quantities of data for all to access. |
| Fibre optic cable | Faster cable that uses light, primarily for connecting routers. |
| Copper straight-through cable | CAT 6 cables to be used in this network, both ends are T568B connectors |
| Copper cross-over cable | CAT 6 cables to be used in this network, one end is T568A, the other T568B. |

### PC connection

In this network, the PCs are physically connected using CAT 6 straight through ethernet cables to switches.

### Switch and Router connection

#### Switches

The Switches are connected to PCs using straight through ethernet cables. They’re connected to other switches with crossover cables, and to multilayer switches also with crossovers. The multilayer switches connect to routers using straight through cables. All ethernet cables used are CAT 6, as opposed to CAT 5 or CAT 5e.

#### Routers

The routers connect to one another using Fibre optic cables. The Wi-Fi routers are connected using CAT 6 crossover cables, since the routers did not have available enough ports to use Fibre cabling. Modules have been added to the routers to increase the number of ports available.

## Step 2: IP Addressing Scheme

For this network, IPv4 is being used. This network features numerous offices and locations, so the most efficient thing to do to make the network easier to maintain would be to split them into separate subnets.

|  |  |
| --- | --- |
| **Subnet needed** | **Number of hosts** |
| HR Office | 14 (12 PCs + printer + server) |
| Design office | 42 (40 PCs + printer + server) |
| Sales Office | 32 (30 PCs + printer + server) |
| R&D Office | 14 (12 PCs + printer + server) |
| Servers | 3 (3 servers) |
| **Total number of hosts** | 105 |
| **Total number of subnets** | 5 |

Since there are 5 subnets needed on the network of different size requirements, I will use Variable Length Subnet Masks (VLSM). If I were to use the /26 scheme, whilst it would create equal sized subnets which are large enough and give space for expansion, I would only be able to have 4 subnets which is not enough. However, if I am to use /27, which gives 8 subnets, then the maximum number of usable hosts that can be on each subnet is only 30. I will get around this by using VLSM.

|  |  |  |
| --- | --- | --- |
| **Subnet Mask** | **Slash notation** | **Hosts/Subnet** |
| 255.255.255.0 | /24 | 254 |
| 255.255.255.128 | /25 | 126 |
| 255.255.255.192 | /26 | 62 |
| 255.255.255.224 | /27 | 30 |
| 255.255.255.240 | /28 | 14 |
| 255.255.255.248 | /29 | 6 |
| 255.255.255.252 | /30 | 2 |

The subnets sorted by number of IP addresses needed is:

* Design – 42
* Sales – 32
* HR – 14
* R&D – 14
* Servers – 3

*My planning for the subnets is based on work by Mohammad Sobur, Sunny Classroom and Tutorialspoint respectively.*

VLSM requires that the highest IP available has to be assigned to the highest requirement.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Subnet Name** | **Network ID** | **Subnet mask** | **Host ID range** | **# of usable hosts** | **# of hosts being used** | **Broadcast ID** |
| Design | 192.168.1.0 | /25 | 192.168.1.1 – 192.168.1.126 | 126 | 42 | 192.168.1.127 |
| Sales | 192.168.1.128 | /26 | 192.168.1.129 – 192.168.1.190 | 62 | 32 | 192.168.1.191 |
| HR | 192.158.1.192 | /27 | 192.168.1.193 – 192.168.1.222 | 30 | 14 | 192.168.1.223 |
| R&D | 192.168.1.224 | /28 | 192.168.1.225 – 192.168.1.238 | 14 | 14 | 192.168.1.239 |
| Servers | 192.168.1.240 | /29 | 192.168.1.241 – 192.168.1.246 | 6 | 3 | 192.168.1.247 |

**Design Office**

|  |  |
| --- | --- |
| **Specification** |  |
| Default Subnet Mask (binary) | 11111111.11111111.11111111.00000000 |
| Custom Subnet Mask (binary) | 11111111.11111111.11111111.10000000 |
| Custom subnet mask (decimal) | 255.255.255.128 |
| Total number of subnets | 2 |
| Total number of host addresses | 42 |
| Number of usable addresses | 126 |
| Number of bits borrowed | 1 |
| First IP Host address | 192.1.168.1 |
| Last IP Host address | 192.168.1.126 |

**Sales**

|  |  |
| --- | --- |
| **Specification** |  |
| Default Subnet Mask (binary) | 11111111.11111111.11111111.00000000 |
| Custom subnet mask (binary) | 11111111.11111111.11111111.11000000 |
| Custom subnet mask (decimal) | 255.255.255.192 |
| Total number of subnets | 4 |
| Total number of host addresses | 32 |
| Number of usable addresses | 62 |
| Number of bits borrowed | 2 |
| First IP Host address | 192.168.1.97 |
| Last IP Host address | 192.168.1.126 |

**HR Office**

|  |  |
| --- | --- |
| **Specification** |  |
| Default Subnet Mask (binary) | 11111111.11111111.11111111.00000000 |
| Custom subnet mask (binary) | 11111111.11111111.11111111.11100000 |
| Custom subnet mask (decimal) | 255.255.255.224 |
| Total number of subnets | 8 |
| Total number of host addresses | 14 |
| Number of usable addresses | 30 |
| Number of bits borrowed | 3 |
| First IP Host address | 192.168.1.161 |
| Last IP Host address | 192.168.1.190 |

**R&D Office**

|  |  |
| --- | --- |
| **Specification** |  |
| Default Subnet Mask (binary) | 11111111.11111111.11111111.00000000 |
| Custom subnet mask (binary) | 11111111.11111111.11111111.11110000 |
| Custom subnet mask (decimal) | 255.255.255.240 |
| Total number of subnets | 16 |
| Total number of host addresses | 14 |
| Number of usable addresses | 14 |
| Number of bits borrowed | 4 |
| First IP Host address | 192.168.1.161 |
| Last IP Host address | 192.168.1.190 |

**Servers**

|  |  |
| --- | --- |
| **Specification** |  |
| Default Subnet Mask (binary) | 11111111.11111111.11111111.00000000 |
| Custom subnet mask (binary) | 11111111.11111111.11111111.11111000 |
| Custom subnet mask (decimal) | 255.255.255.248 |
| Total number of subnets | 32 |
| Total number of host addresses | 3 |
| Number of usable addresses | 6 |
| Number of bits borrowed | 5 |
| First IP Host address | 192.168.1.193 |
| Last IP Host address | 192.168.1.222 |

With this system using VLSM, it lowers the amount of IP wastage, particularly with the subnets that have fewer hosts. One downside is that (particularly with the R&D office) there is no space to add more hosts, instead a new subnet would have to be created or the subnets size have to be changed.

## Step 3: Routing Protocol

The routing protocol I have chosen to use for this network is EIGRP. This is an Internal Gateway Protocol (IGP) that stands for Enhanced Interior Gateway Routing Protocol. It was designed by Cisco, and is a distance vector and a classless protocol. It is a newer version of the RIP (Routing Information Protocol) and works in a similar way except for sending smaller incremental updates more frequently rather than large ones less often. Because of this, it scales better to large networks. This is beneficial for the network, because if the network where to grow (for instance if a new office were to be added) there would not be a large hit in performance.

As a dynamic routing protocol, the route used for routing changes automatically if the topology or traffic changes. Routing is the process used by a router to forward packets to the destination network (Mohammad Sobur).

An example is if one PC in the Sales office wanted to send something to the printer in the R&D office to be printed, the file would first go to the Canterbury router via the switches, and it would then be routed to the Medway router. The protocol ensures that it is sent to this router, and not for example the Wi-Fi router. Once it has got here, the packets that make up the file are then routed down through the switches to the printer. The use of EIGRP is important, it means that if there was a lot of data being sent between 2 switches, it would avoid this and go around to use a faster route. Also, because of the EIGRP protocol it does not matter if devices are leaving and joining the network, the fastest route will always be used.

## Step 4: Verification Commands

|  |  |  |
| --- | --- | --- |
| **Command** | **Examples to Command Usage to test function** | **What should be expected outcome should be seen if the function is working?** |
| ***ping*** | ping google.com | There should be a log for each packet that has been sent to the address, saying how long the reply took to be received and how many bytes there were. It will display the address (in this case the IP for google.com) and will say how many packets were sent and lost, and the % loss. It will also display the average round trip times for a packet to be sent to the address and then sent back. |
| ***tracert*** | tracert google.com | Works similarly to ping, except it shows each hop taken to reach the address, the time taken for each hop and the address of each hop, up to a maximum of 30 hops. Used by Windows Operation Systems. |
| ***traceroute*** | traceroute google.com | Performs the same as tracert, but the version used on Linux, MacOS and other Unix based Operating systems |
| ***Ipconfig*** | Ipconfig /all | Displays TCP/IP network values, for example the type of adapter used to connect to the network, the IP address, subnet mask and default gateway.  It can also be run with the suffix /all, which shows details for all adapters. /release ends and active TCP/IP connections and /renew re-starts those connections. |
| ***show run*** | show running config | This is a Cisco command for Cisco routers and switches, it shows the current basic information for the device such as its firmware version and also its host name. |
| ***show IP route*** | show ip route | A command run on routers; it is used to display the current state of the routing table. It includes a key to the abbreviations used, and then shows the IP and information about the gateway of the last resort. After this, the routing table is displayed, and the means by which entry in the table is determined. This command is used by the OS of Cisco routers. |

Used work by Seb Blair, Gareth Ward & Allan Callaghan for *ping, tracert* and *ipconfig*, as well as RouterSwitchTech for *show IP route*.

## Step 5: Set up HTTP and DNS Server

### DHCP server

#### Function

A DHCP server is a network server that is used in the assigning of IP addresses. DHCP stands for Dynamic Host Configuration Protocol. When a new device connects to the network, it automatically sends the required parameters. This is so that the person in charge of the network does not have to do it manually each time. They assign each client with their unique IP, and all of this data is stored on the server.

#### Configuration

A DHCP server is set up by first creating the DHCP pool. This is the selection of all the available IPs that can be used. Next, the subnets, default gateway/router and other servers need to be specified, so that their IPs are not used in the selection of IPs that will be used dynamically. After this, when a device joins the network, it will be given an available IP.

### DNS server

#### Function

A Domain Name System (DNS) server is used to maintain the name of a domain associated with an IP, for when those IP’s are for the internet. Otherwise, every time you want to look up a web page, you would have to type in its IP address. The DNS server is forwarded the web address by the router, it then converts it into the IP and returns this to the user, again via the router. The user can then access the website.

#### Configuration

Firstly, the DNS server and domain lookup need to be enabled. Next, the IP addresses need to be mapped to host names, this can be got from the DHCP server. A default domain name can be stated, and up to six hosts can be assigned as name servers to supply name information for DNS.

### HTTP server

#### Function

Otherwise known as a web server, this is used to host web pages. When a web page is created, it has to be stored somewhere for people to access. It would be very inefficient to host it on a user’s end device, and so dedicated servers are used instead. Alongside this, the SSL (Secure Socket Layer) protocols are used to make websites secure. These use certificates that ensure the data passed between the server and host are private. TLS (Transport Layer Security) is a more modern version of SSL.

#### Configuration

Once the server is enabled, there are various characteristics that can be configured. These include: how long the HTTP server should remain open, specifying the port to be used, the URL for the HTML files and the maximum number of connections that can happen at once. It also needs to be specified whether it is using HTTP or HTTPS (secure) by using SSL.

## Step 6: Report and Documentation

Causes of complaints in the Canterbury office

Issues with Previous Network

Proposed solution for the Canterbury and Medway office

Proposed Solution

List of the Hardware and software Used in Your Design Diagram

Hardware Used

IP address of your design

Step 2: IP Addressing Scheme

## List of Protocols used

|  |  |
| --- | --- |
| Protocol | Where used |
| TCP/IP | IP addressing |
| EIGRP | Routing |
| DHCP | IP addressing |
| DNS | Web domain |
| SSL | Web server |
| TLS | Web server |

(I did this assignment in the ‘written’ way, so I had already covered these sections before, as it more sense to include them in these areas)

# Task 2: IP Packets

## Components

|  |  |  |
| --- | --- | --- |
| **Component** | **Type** | **Associated OSI level** |
| Web browser | Software | Application |
| Router | Device | Network |
| Multilayer switch | Device | Data link and network |
| Switch | Device | Data link |
| Cable (Fibre, Copper etc.) | Device | Physical |
| EIGRP | Protocol | Network |
| TCP | Protocol | Transport |
| IP (v4 and v6) | Protocol | Network |
| Email client | Software | Application |
| DNS | Protocol | Application |
| HTTP | Protocol | Application |
| DHCP | Protocol | Data link |
| SSL | Protocol | Presentation |
| TLS | Protocol | Presentation |

## Network Data Transfer Breakdown

|  |  |  |
| --- | --- | --- |
| **Layer #** | **OSI Layer** | **Packet Data Unit** |
| 7 | Application | Message |
| 6 | Presentation | Message |
| 5 | Session | Message |
| 4 | Transport | Segment |
| 3 | Network | Packet |
| 2 | Data link | Frame |
| 1 | Physical | Bit |

A common example of data that travels through multiple networks is an email. If I sent an email to a friend, the first layer of the OSI reference model the data would have to pass through is the application layer. In this case, I would be using an email client in a web browser. The only thing this layer deals with is displaying the sent/received data to the user. The next layer is the presentation layer. This is where the data is encrypted or compressed. For instance, if the email I was sending contained sensitive data, this is where it would be encrypted so that only my friend would be able to read it. The message would also be compressed, so that the amount of data that has to be sent is not as large, making the transfer more efficient. After this the data is passed to the session layer, where ethe connection between the origin and destination hosts is established. It also checks that the data is being sent to the correct place.

The data is next passed to the transport layer where the data is broken up into segments, since a full email is too large to send at once. Next, the network layer breaks the segments into packets and assigns them with headers and other data that represents the origin and destination. Routing protocols such as EIGRP also calculate the best path for the data to travel along, taking into account traffic and the shortest route (the one that goes through the least devices). The data link layer now makes the data into frames and uses MAC addresses to determine where to send the data. Finally, the physical layer sends the data down the physical cables of the network to the destination, for example fibre cables. The data is sent as bits as either flashes of light or electrical pulses depending on the cable.

The email has now arrived at my friend’s device. This data is received at the other end in the data link layer, the bits are then consolidated back into frames. My friends network layer then determines where this new data needs to be sent and puts the frames back into packets. The email is now sent up to the transport layer, where the origin host is communicated to notify whether all of the data has been received, this data is reassembled back into segments. Now that all the data has been received, the session layer closes the communication between the origin and destination hosts. The remaining data is simply the formatted email (with the encryption and compression). The presentation layer de-compresses and unencrypts the data. Now, the data that remains is the same email that I originally sent, and the application layer displays it to my friend in their email client.

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