



OLLSCOIL NA GAILLIMHE
UNIVERSITY OF GALWAY

Semester 1 Examinations 2022-2023

CT3531 Marking Scheme

Question 1

- a) Assume that you are working for a large corporation that uses the private IPv4 address range 10.0.0.0/8 for its internal network. The company management wants to be able to provision up to 16 separate sites in Ireland with a subnet for each site, with at least 4000 host IPv4 addresses available per subnet. Ireland has been allocated the range 10.16.0.0/16 for the company's operations in Ireland. You are requested to design the network layout. Answer the following questions and fully explain the logic behind each answer:

- (i) What subnet mask will need to be used for the individual subnets in Ireland? Fully explain the logic behind your answer. 5 MARKS

Need to use a /20 subnet mask i.e. have 4 bits for subnetting.

- (ii) What are the valid host addresses and the broadcast addresses for the first and second subnets in Ireland? 5 MARKS

First subnet 10.16.0.0/20 with host addresses 10.16.0.1 – 10.16.15.254

Second subnet 10.16.16.0/20 with host addresses 10.16.16.1 – 10.16.31.254

- (iii) The company has operations in 8 other European countries and each country has been allocated a /16 address range. These individual /16 address ranges are contiguous and Ireland has been allocated the first of these ranges. What route summary or supernet could be used to define a single routing entry for all of the European address ranges?

3 MARKS

Need to use a 10.16.0.0/13 as the route summary in this case

- b) Write a short essay, approximately 300 words, on one of the following topics. The essay should include a full description of the topic and also discuss its advantages, disadvantages and competitor technologies (if applicable):

- (i) The Domain Name System (DNS)
(ii) The GNS3 Network Simulator
(iii) Internet Exchange Points

12 MARKS

Essay should take about 15 minutes and be about 300 words (about 1 written page).

Question 2

A company has an office building that has been fitted out with the Local Area Network topology shown in Figure 1 below:

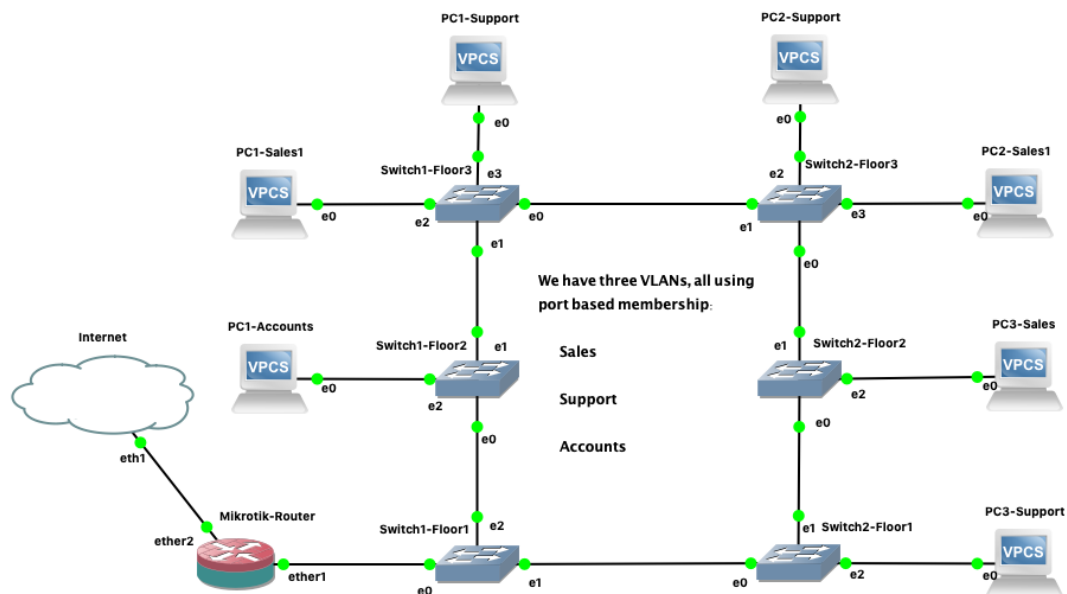


Figure 1 - Local Area Network Topology

The office building has three floors and each floor has two network switches that are used to interconnect with other switches and to connect end user devices e.g. PCs. The company is organised into three departments i.e. Sales, Support and Accounts, each department has its own VLAN. There is also a Mikrotik router connected to one of the switches on the ground floor, this router also provides internet access via an ethernet connection provided by an ISP. Answer the following questions in relation to the design and configuration of this network.

- a) What are the advantages of using a VLAN for each Department? Suggest a suitable VLAN id and IP subnet for each VLAN. 5 MARKS

The main advantage is that each VLAN is a separate broadcast domain and traffic between VLANs is routed. This helps limit the broadcast traffic and keep traffic that is related in the same VLAN. Each VLAN needs a separate VLAN id as per the 802.1q standard, a separate /24 IP subnet, using RFC1918 private IP address ranges, for each VLAN would also make sense.

- b) What port configuration would be required for Switch2-Floor1? In this context explain the purpose of the 802.1q protocol. 5 MARKS

The switch will need to configure port 0 and port 1 as trunk ports i.e. ethernet frames on these ports will contain VLAN tags, as per the 802.1q standard. Port 2 will need to be defined as an access port in the Support VLAN. Answer should also include an explanation of the 802.1q protocol.

- c) What configuration is required on the Mikrotik router to allow it to act as a DHCP server for the various VLANS and to ensure that NAT is used for outgoing internet traffic? The full list of RouterOS commands is not required, just provide a description of the various items that need to be configured. 5 MARKS

The answer should mention that the router will need to have VLAN interfaces configured on ether1 and have an IP address e.g. 192.168.1.0/24 assigned to each VLAN interface. A separate DHCP server will also be configured then on each VLAN interface. A NAT firewall rule will need to be configured for outgoing traffic routed via ether1 to the internet.

- d) What steps and additional configuration would be needed, on the router and the switches, to add another new VLAN to the existing setup? 5 MARKS

A new VLAN interface would need to be added to the router on the physical interface ether1. A new IP address range then be needed on the new VLAN interface. A DHCP server would also need to be added on the new VLAN interface on the router. Finally, any switch ports connecting device to the new VLAN would need to be configured as access ports for the new VLAN.

- e) What is meant by the term broadcast storm and could this be possible in the topology shown? What mechanism or protocol could be used to ensure that a broadcast storm could not occur? Explain the basic operation of this mechanism. 5 MARKS

The Spanning Tree Protocol (STP) is a network protocol that builds a loop-free logical topology for Ethernet networks. The basic function of STP is to prevent bridge loops and the broadcast radiation that results from them. Answer should also describe the operation of STP.

Question 3

- a) Explain how traceroute works and what it shows. 5 MARKS

When an IP Datagram is sent, its TTL is set, which is the number of routers (hops) it can pass through before the packet is discarded. As the packet passes through a router the TTL is decremented until, when the TTL reaches zero, the packet is destroyed and an ICMP "time exceeded" message is returned to the sender. Trace Route works by setting the TTL for a packet to 1, sending it towards the requested destination host, and listening for the reply. When the initiating machine receives a "time exceeded" response, it examines the packet to determine where the packet came from - this identifies the machine one hop away. Then the tracing machine generates a new packet with TTL 2, and uses the response to determine the machine 2 hops away, and so on.

- b) State and differentiate the three main means of interconnecting an Autonomous System with another Autonomous System. 3 MARKS

Answer should mention and describe briefly the following options: 1: A private dedicated link between the two AS (most expensive). 2: Using an IP transit provider (less expensive). 3: Using an Internet Exchange Point (least expensive).

- c) Describe briefly each of the following: Autonomous System, Border Gateway Protocol, Internet Exchange Point 6 MARKS

An Internet exchange point (IX or IXP) is the physical infrastructure through which Internet service providers (ISPs) and content delivery networks (CDNs) exchange Internet traffic between their networks (autonomous systems). Border Gateway Protocol (BGP) is a standardized exterior gateway protocol designed to exchange routing and reachability information among autonomous systems (AS) on the Internet. The protocol is classified as a path vector protocol.

- d) Describe in your own words what a Route Server is, what function it performs and why it is necessary. 5 MARKS

A BGP route server is the external BGP (EBGP) equivalent of an internal IBGP (IBGP) route reflector that simplifies the number of direct point-to-point EBGP sessions required in a network. EBGP route servers are transparent in terms of BGP attribute propagation so that a route received from a route server carries the set of BGP attributes as if the route is from a directly connected EBGP peer.

- e) The result of running the command /ip route print on a Mikrotik router at the edge of an Autonomous System is shown below. The router has a BGP peering session with a router in a different Autonomous System and it is also running OSPF with other routers in the same Autonomous System:

```
[admin@10.10.10.1] > ip route print
Flags: X - disabled, A - active, D - dynamic,
C - connect, S - static, r - rip, b - bgp, o - ospf, m - mme,
B - blackhole, U - unreachable, P - prohibit
#      DST-ADDRESS      PREF-SRC      GATEWAY      DISTANCE
0 AD0  0.0.0.0/0            10.1.1.2      110
```

1	ADC	10.1.1.0/24	10.1.1.1	ether1	0
2	ADo	10.1.4.0/24		10.1.1.2	110
3	ADC	10.10.10.1/32	10.10.10.1	loopback	0
4	ADo	10.10.10.2/32		10.1.1.2	110
5	ADo	10.10.10.4/32		10.1.1.2	110
6	ADb	10.10.10.5/32		172.21.1.1	20
7	ADb	10.10.10.6/32		172.21.1.1	20
8	ADb	172.16.1.0/24		172.21.1.1	20
9	ADb	172.17.1.0/24		172.21.1.1	20
10	ADC	172.21.1.0/30	172.21.1.2	ether2	0
11	ADC	192.168.10.0/24	192.168.10.1	ether3	0
12	ADo	192.168.11.0/24		10.1.1.2	110
13	ADo	192.168.12.0/24		10.1.1.2	110
14	ADo	192.168.81.0/24		10.1.1.2	110
15	ADC	192.168.182.0/24	192.168.182.138	ether4	0

Answer the following questions in relation to this routing table.

- i. What does the route entry for destination 0.0.0.0/0 mean and why is this route entry particularly important? 2 MARKS

This is the default route and it will be used if no shorter matching prefix is found in the routing table. It is important for internet access if the upstream transit provider does not provide you with the full Default Free Zone of all possible prefixes.

- ii. Is the destination IP range 172.16.1.0/24 in the same Autonomous System or in a different Autonomous System? How can you tell? 2 MARKS

It is in a different AS, as the route was received via BGP. It is marked as ADb (Active / Dynamic / BGP) in the route flags.

- iii. What is the meaning of the GATEWAY value shown and how might this affect a routing decision? 2 MARKS

This is the IP address or the interface used for the next hop or the final deliver of the packet if it is a local network.

Question 4

Assume that an Internet Service Provider has built a routed network in Co Galway as shown in Figure 2 below:

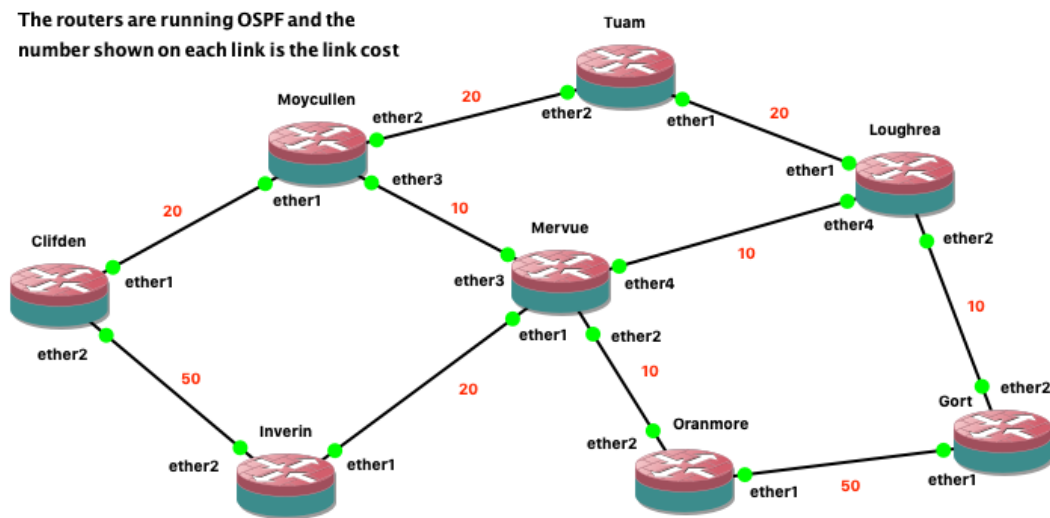


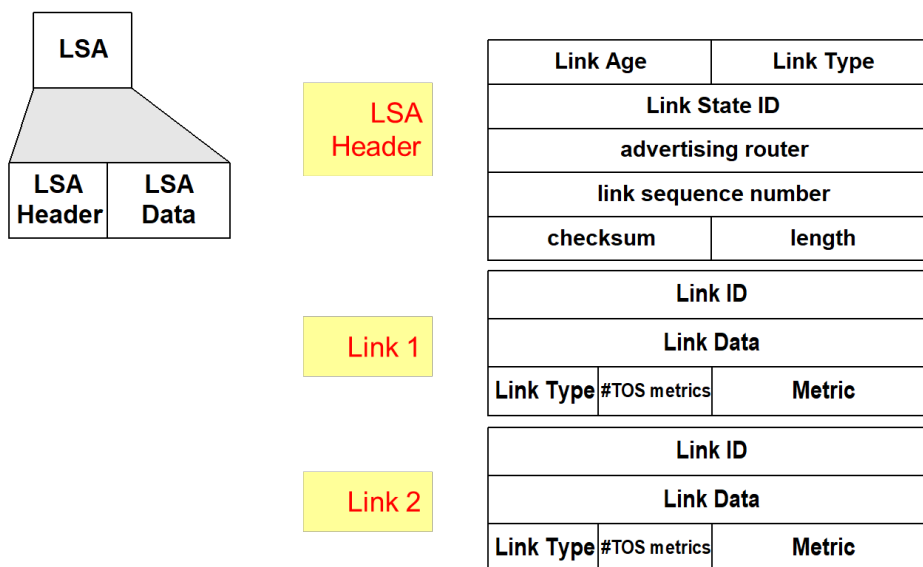
Figure 2 - ISP Regional Network

The routers are all Mikrotik routers running the RouterOS operating system. Answer the following questions in relation to the operation and configuration of this network. Please note that you do not need to build the network shown in the GNS3 simulator to answer these questions.

- a) Describe the operation and purpose of the OSPF protocol in the network shown. How is Dijkstra's Algorithm used by OSPF in this context and what would the sink tree look like from the Mervue router? 5 MARKS

Using OSPF each router must discover their neighbours and learn their net addresses. The router then measures the delay or cost to each of their neighbours. The router constructs a packet telling all it has just learned and sends this packet to all other routers in the network. Each router can then compute the shortest path to every other router. Each router establishes a relationship ("adjacency") with its neighbors. Each router generates link state advertisements (LSAs) which are distributed to all routers LSA = (link id, state of the link, cost, neighbors of the link). Each router maintains a database of all received LSAs (topological database or link state database), which describes the network has a graph with weighted edges Each router uses its link state database to run a shortest path algorithm (Dijkstra's algorithm) to produce the shortest path to each network. Using Dijkstra's Algorithm, each node in the network is labeled with its distance from the source node along the best known path. The sink tree for the Mervue router should be a graph, with the Mervue router at the root, showing the shortest paths to all possible destinations.

- b) Describe the format of an OSPF Link State Announcement. Explain how a Link State Announcement from the Loughrea router would be disseminated throughout the network and how can this be done reliably. 5 MARKS



A router sends and refloods LSA-Updates, whenever the topology or link cost changes. (If a received LSA does not contain new information, the router will not flood the packet). This is done using a mechanism called Reliable Flooding where each LSA update is acknowledged by each neighbour and then propagated further.

- c) Suggest suitable IP subnets for the links connected to the Clifden router. What RouterOS commands are required to assign appropriate IP addresses and to also fully enable OSPF on the Clifden router? **5 MARKS**

The following command would enable OSPF on one of the links, assuming that the link was using the IP subnet 10.1.1.0/24

```
/routing ospf network
add area=backbone network=10.1.1.0/24
```

- d) What route would a PC attached to the Clifden router normally take to get to the Gort router? What exactly would happen with OSPF if the link between Mervue and Loughrea became unavailable for some reason? **5 MARKS**

A PC attached to the Clifden router will normally take the path via the Moycullen, Mervue and Loughrea routers, as this path has the lowest cost. If the link went down then the traffic would reroute via Tuam and Loughrea. The answer should provide details on how exactly this would happen.

- e) Assume that the Tuam router needs to have an additional local area network, attached to ether3, for some end user devices e.g. PCs. Suggest a suitable IP subnet for this new local area network. What RouterOS commands would be required on the Tuam router to assign an appropriate IP address for this additional local area network and to ensure that the new IP range is reachable from the other routers in the network? **5 MARKS**

```
/ip address add address=192.168.10.1/24 interface=ether3
/routing ospf instance
set [ find default=yes ] redistribute-connected=as-type-1
```


- 5.a: What types of Sockets are supported in the Java networking package and which type of Socket would you recommend for a VOIP type application and a File Transfer type application? 5 MARKS

Answer should mention both Stream (TCP) and Datagram (UDP) type sockets. A VOIP type application would typically use Datagram type sockets to ensure timely delivery of packets and to minimise the mouth to ear delay. File transfer type applications would use Stream type sockets for reliability.

- b: Write a network Server program in Java where the Server waits for incoming client connections using stream type sockets. Once a Client connects it sends a String object to the server with a simple query – the server then responds with a text based response. The connection is then terminated. The server should use a separate thread of execution for each new client connection and all interaction between the Server and the Client should be done within this thread. The answer only needs to include source code for the server side application.

10 MARKS

```
import java.io.*;
import java.net.*;

public class server {
    public static void main(String a[]) throws
        IOException {
        int timeoutsecs = 600;
        int port = 4444;
        Socket sock;

        ServerSocket servsock = new ServerSocket(port, timeoutsecs);

        while (true) {
            // wait for the next client connection
            sock=servsock.accept();
            ClientHandler ch = new ClientHandler(sock);
            ch.start();
        }
    }

    public class ClientHandler extends Thread {

        private Socket sock;

        public ClientHandler(Socket s) {
            sock = s;
        }

        public void run() {

            ObjectOutputStream out = new ObjectOutputStream(sock.getOutputStream() );
            ObjectInputStream in = new ObjectInputStream(sock.getInputStream() );

            Integer fromclient1 = (Integer) in.readObject();
            String fromclient2 = (String) in.readObject();
            System.out.println(fromclient1, fromclient2);

            out.writeObject("Hello from server...");
            out.flush();
            sock.close();
        }
    }
}
```

```
}
}
```

- c: Write another Java application with the same functionality as outlined above, in part a of this question, but this time using Datagram type sockets. Hint: you can use `ByteArrayOutputStream` and `ByteArrayInputStream` to populate and read the array associated with the `DatagramPacket` object. This application does not need to implement a reliable data transfer protocol or use multiple threads at the server for each new client. The answer only needs to include source code for the server side application. 10 MARKS

```
// Code for sending a string object using a Datagram type socket
ByteArrayOutputStream baos = new ByteArrayOutputStream();
ObjectOutputStream oos = new ObjectOutputStream(baos);
oos.writeObject("Hello from server...");
oos.flush();
byte[] Buf= baos.toByteArray();
packet = new DatagramPacket(Buf, Buf.length, client, port);
socket.send(packet);

// Using a ByteArrayInputStream to receive an object
DatagramSocket socket = new DatagramSocket(1234);

byte[] data = new byte[4];
DatagramPacket packet = new DatagramPacket(data, data.length );
socket.receive(packet);

int len = 0;
// byte[] -> int
for (int i = 0; i < 4; ++i) {
    len |= (data[3-i] & 0xff) << (i << 3);
}

// now we know the length of the payload
byte[] buffer = new byte[len];
packet = new DatagramPacket(buffer, buffer.length );
socket.receive(packet);

ByteArrayInputStream baos = new ByteArrayInputStream(buffer);
ObjectInputStream oos = new ObjectInputStream(baos);
String fromClient = (String) oos.readObject();
System.out.println(fromClient);
```