# ICT1013 Computer Networks

**AY2025/26 Trimester 2**

**Team Project: Designing and Implementing Enterprise Network with Redundancy**

Weightage: **35%**
Team size: **5-6 students** (within the same lab group)

**Due Dates**:

- **Week 4 Thu 29 Jan 6:00 pm** : self-enroll your team at ICT1013 course site, students left un-enrolled will be randomly formed into teams
- **Week 10 Tue 10 Mar 23:59 pm** : submit via dropbox at ICT1013 course site a report with logical topology diagram + config files (to be imported back for demo)
- **Week 10 Thu 12 Mar during lab class** : connect up network + import submitted config files for demo

## Learning Outcomes

Upon completion of this project, you should be able to:

- Design enterprise networks with redundancy based on hierarchical network model adopted in the industry;
- Configure switches and routers to implement enterprise networks;
- Troubleshoot and resolve network connectivity problems.

## Scenario

The UN 2030 Agenda for sustainable development and Goal 16.9 stipulating ID for all are in the midst of transforming our world towards digital economy and cashless future. An MNC has arrived in Singapore to promote and offer cashless payment and is inviting tenders to design and implement an enterprise network with redundancy for the company occupying 4 levels of a building, with each staff to be supported by 1 Ethernet port for Internet access distributed as follows:

- Level 4: Country Manager Office occupied by 1 x Country Manager, 1 x Dy Country Manager and 2 x Secretaries; HR office occupied by 1 HR Manager and 1 HR Executive; 1 x large meeting room with 28 Ethernet ports; cubicle for 1 x Network Engineer to provide closer network support to staff at Level 4;

- Level 3: Solution Developers Department occupied by 1 x Solution Manager, 2 x Senior Software Developers and 2 x Software Developers; Network Department occupied by 1 x Network Manager, 1 x Senior Network Engineers and 1 x Network Engineer; Server Room for housing servers and network devices; cubicle for 1 x HR executive to provide closer HR support to staff at Level 3;

- Level 2: Marketing and Sales Department occupied by 1 x Sales Manager, 1 x Dy Sales Manager and 8 Sales Executives; cubicles for 1 x HR Executive and 1 x Network Engineer for closer support to staff at Level 2;

- Level 1: Customer Service Department occupied by 1 x Service Manager, 1 x Dy Service Manager and 10 Service Executives; cubicles for 1 x HR Executive and 1 x Network Engineer for closer support to staff at Level 1; 3 x small meeting rooms each with 2 Ethernet ports for Internet access;

- host a Web server to offer cashless payment and promotion to attractive customers to sign up;
- host an authoritative DNS server so that the public may access its Web server via a domain name;
- host a caching DNS server to support users in the company to access the Internet instead of relying on public DNS servers like 8.8.8.8.

**IP Addressing and Internet Access**

The company has decided to use IP address block 172.16.1.0/24 for the enterprise network. VLSM is to be implemented to conserve IP addresses. No requirement to cater for future expansion.

To achieve better reliability to Internet access, the company has subscribed to 2 x ISPs. Please refer to Appendix A for connecting your network rack to the ISPs.

**Implementation Consideration**

A maximum of one network rack with 2 routers and 6 switches are available for your implementation and demo.

The computers do not need to be physically available. Nevertheless, the switch ports must be properly configured so that when a laptop is connected into the appropriate port, it will be able to access the network.

The implementation of the web page for the company is optional (which is the scope of INF1005 Web Systems and Technologies). Nevertheless, you are encouraged to distinguish your web page from the other teams, e.g. by re-using any of the existing web pages that you've developed in INF1005.

Each team is to propose a *hostname* to be concatenated with ICT domain name *sitict.net* to form the fully-qualified domain name *hostname.sitict.net* for the Web server of the company.

**Submissions and Assessments**

1. Zip up and name it according to your team number all your submissions comprising:

    - A logical topology diagram featuring the design of your enterprise network in original file format and also a good-quality pdf copy, showing clearly:

- network devices with given hostnames of your choice;
- connection links labeled with exact interface/port numbers of the devices;
- VLAN numbers, subnet address blocks and subnet masks; and
- IP addresses assigned to the network devices if applicable (excluding IP addresses assigned to user workstations).

Note: Using Cisco Packet Tracer for drawing network topology diagram is not recommended due to its low-quality which will affect your grade. Instead, use a suitable tool to draw high-quality and clearly annotated diagram, e.g. the free open source Dia Diagram Editor or Microsoft PowerPoint, etc. The widely recognized Cisco network device icons can be downloaded from:

https://www.cisco.com/c/en/us/about/brand-center/network-topology-icons.html

- running-conf of network devices : one file for each network device; name your files according to the device hostnames in your logical topology diagram (marks will be deducted if combining into one single file for all network devices, or in file format like pdf, etc. that cannot be imported into the network devices.)

- DNS configuration files and Wireshark captures on DNS servers

- A report containing the following:
  - front page : team number and names of all members
  - addressing table : documenting addressing scheme and device connection to complement your logical topology diagram (refer to lab exercises for examples)
  - rationale on design : your team may wish to highlight any consideration to demonstrate understanding
  - rationale on implementation: if one network rack of 2 routers and 6 switches are fully utilized and still insufficient to implement your design, justify why and which level is to be left out based on technical consideration, given that all requirements for a level must be met if implemented
  - DNS operation : referring to submitted Wireshark captures on your DNS servers, state clearly the exact line numbers of relevant network packets corresponding to the correct sequence of DNS operation to demonstrate understanding

- reflection on using/not using genAI tools : your team may use ChatGPT or other genAI tools if suitable, please elaborate:
  - if using : sample screenshots of queries and answers obtained, with your team's comments whether these were helpful;
  - if not using : comment why not.

2. demo with fault injections : various network faults will be introduced to test the resiliency of your network implementation during project demo.

## Appendix A: Connecting Edge Routers to ISPs for Internet Access

A.1 On the console panel of each network rack are 4 Ethernet ports labeled IDxxx, where xxx ranges from 001 onwards.

A.2 To access Internet via ***ISP1***, connect the interface of your edge router to the ***first left-most*** IDxxx port.

A.3 Configure IP address on the interface of your edge router connected to ***ISP1*** based on the IP address block allocated to your network rack as follows:

a. Each network rack is labeled with a digit representing row, and an alphabet representing column, e.g. Rack 7A represents row 7 column A.

b. Let ***r*** denote the row number to be **used** for calculation in the following formula, e.g. for Rack 7A, ***r*** = 7.

c. Convert the column alphabet into a numerical digit by considering A as 1, B as 2, and so on as shown:

| Rack Column Alphabet | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| Numerical Equivalent | 1 | 2 | 3 | 4 | 5 | 6 |

d. Let ***n*** denote the resultant rack number to be used for calculation in the following formula, e.g. for Rack 7A, ***n*** = 7A = 71.

e. Reduce the resultant rack number into a numerical value between 1 to 42 inclusive by applying the formula ***f*** = ***n*** - 4***r*** - 6, e.g. for Rack 7A, ***f*** = 71 - (4x7) - 6 = 37.

f. From above Step A.3.e, multiply ***f*** by 4 to derive the ***last octet*** of the IP address block allocated to your network rack; e.g. 37 x 4 = 148.

g. The IP address block allocated for your network rack between the interface of your edge router and ISP1 is 172.17.9.***i***/30 where ***i*** is derived in Step A.3.f above; e.g. Rack 7A will be 172.17.9.148/30.

h. The IP address for the interface of your edge router connecting to ISP1 is the first usable IP address within the allocated IP address block.

A.4 The public IP address block allocated by ***ISP1*** to your network rack is determined as follows:

a. From above Step A.3.e, multiply ***f*** by 8; e.g. 37 x 8 = 296.

b. Divide the result in Step A.4.a by 256 and determine the quotient ***q***; e.g. ***q*** = ⌊296/256⌋ = 1.

c. Divide the result in Step A.4.a by 256 and determine the remainder ***m***; e.g. ***m*** = 296 mod 256 = 40.

d. The public IP address block allocated to your network rack is 203.149.(210+***q***).***m***/29 where ***q*** and ***m*** are determined in Step A.4.b and A.4.c respectively; e.g. public IP address block for Rack 7A will be 203.149.211.40/29.

A.5 To access Internet via ***ISP2***, connect the interface of your edge router to the ***second left-most*** IDxxx port.

A.6 Configure IP address on the interface of your edge router connected to ***ISP2*** based on the IP address block allocated to your network rack as follows:

a. The IP address block allocated for your network rack between the interface of your edge router and ISP2 is 172.17.10.***i***/30 where ***i*** is determined in Step A.3.g above.

b. The IP address for the interface of your edge router connecting to ISP2 is the first usable IP address within the allocated IP address block.

A.7 The public IP address block allocated by ***ISP2*** to your network rack is 129.126.(142+***q***).***m***/29 where ***q*** and ***m*** are determined in Step A.4.b and A.4.c respectively.