NANYANG TECHNOLGICAL UNIVERSITY
School of Electrical and Electronic Engineering
IE4718 Enterprise Network Design

Project description of an Enterprise Network

1. Design requirements:
    a. The School of EEE has recently added two buildings, S2.1 and S2.2 to expand its research and lab facilities. The facilities are to be supported with an enterprise network to facilitate interworking, file sharing, printer access, and remote networking.
    b. The network interconnects local area networks (LANs) in various labs and staff/admin offices through a wide area network (WAN).
    c. The number of users in the various labs and offices are indicated in Figure 1, which shows the cross-sectional views of the lab and office layouts in the two buildings.
    d. The enterprise network supports four user groups; namely academic staff (Acad), administrative staff (Admin), research students (RS), and Lab PC users (Lab).
    e. Users belonging to the same group are interconnected, share network resources and interwork as a workgroup.
    f. Each workgroup shares a remote file server on the WAN, whereas each lab shares a file server on its LAN segment or on a local network.
    g. Users in each room should have access to shared printer(s) within its own room. Where different user groups are in the same room, separate printers should be dedicated to each workgroup.
    h. The number of shared printers and servers on the network are not reflected in Figure 1 and must be worked out in the design and for all users.
    i. All user PCs, servers and printers on the network must be assigned an IP address each.
    j. To minimize network address wastage, a LAN segment may form part of a larger LAN with an adjoining room, or it may be split into smaller LAN segments to optimize usage of address space.
    k. Whereas LAN segments of the same workgroup may be joined to form a larger LAN, LAN segment in a lab should not be joined with another of different lab.
    l. LAN segments must not extend beyond the operational limit of its maximum network diameter. For convenient, the distance between two adjoining labs/offices shall constitutes the maximum network diameter, and adjoining rooms shall mean neighboring rooms sharing a common wall or between floors. The full distance of an entire floor shall be deemed to exceed the maximum network distance.
    m. Access to campus wide services and the Internet by various workgroups is an integral function of the enterprise network. This includes access to HTTP service (Port 80), SQL service (Port 1433) and email server (Port 25).
    n. However, access to other services and networks are restricted in the following scenarios:
        i.) Laboratory users (Lab) are not permitted to access the enterprise SQL server, email server, and any of the other lab/office local networks.
        ii.) Only Acad and Admin workgroups can access a shared server on Port 138 for data sharing.
        iii.) Admin staff is not permitted to access file servers of Acad and RS workgroups, although Acad staff may access the Admin server for administrative services.
        iv.) Only Research students (RS) may establish FTP connections (Port 21) with Acad staff for file exchange.
        v.) All external access into the campus networks is not allowed, except access to the enterprise web server for HTTP service.
    o. The enterprise network should be designed using VLSM (variable length subnet mask) subnetting to optimize IP address space usage and subnets should be assigned in such a way that maximizes route aggregation.
    p. Other network services where necessary should be implemented to facilitate efficient and flexible implementation of the enterprise network, such as the use of DHCP and dynamic routing.
    q. The design is to be based on TCP/IP protocol.

2. Design work:
    a. The network design involves a top-down analysis of the requirements as described above.
    b. The design of the network is implemented bottom-up using five table templates, Table 1 to 5.
    c. The implementation should minimize network address wastage while also maximizing route aggregation for increased routing efficiency.
    d. The design should have a high degree of modularity and exhibit a layered hierarchy.
    e. Each layer of the network should maintain an appropriate level of robustness against node and link failures.
    f. All nodes on the distribution layer should have balanced (equal) router load distribution.
    g. Servers should be placed at appropriate layers of the network.
    h. You should use the table templates as worksheets to work out the design:
        i.) Table 1, work out the network addresses for all subnets and supernets in the network.
        ii.) Table 2, determine the host addresses for all PCs, router interfaces, printers and servers.
        iii.) Table 3, work out the IP addresses of all servers and their attached router interfaces.
        iv.) Table 4, identify the router and its interface for placing access control lists (ACLs).
        v.) Table 5, write the access-list statements for each ACL identified in Table 4.
    i. The network design should be implemented using the “Packet Tracer” program.
        i.) Label all hosts and network devices so that they can be similarly identified in the design report.
        ii.) For each LAN segment, assign the first useable host address to the router interface followed by the first PC host and consecutively the last PC host addresses, and any printer and server addresses that follow.
        iii.) Write the access-control lists using the CLI in Packet Tracer.
    j. Importance: ensure subnetting plan is fully configured and functional before proceeding to implement access control lists (ACLs) on the network. This ensures any issues with the implementation of ACLs will not be complicated by underlaying issues with the subnetting plan.

3. Project Submission:

    Project submission includes design report, design simulation, and power-point slides should be submitted on the course site. Label the filename using the format, “Fxx-Gyy_Title”; where Fxx is your tutorial group number, such as F53, and Gyy is the group number of the project team, such as G01. Title corresponds to ‘Report’, ‘Simulation’, and ‘Slides’.
    a. Design Report. A soft copy of the report in Microsoft Word is to be submitted to Turnitin on the course site.
        i.) The report should contain at least the following chapters:
            (1) Introduction and design objectives
            (2) Top-down analysis of network requirements
                - LAN segmentation of physical networks (T1)
            (3) Bottom-up network implementation of logical networks
                Host IP address assignment (T2)
            (4) Multilayered network design
                - Hierarchical layered design and servers placement (T3)
            (5) Network security requirements
                - Access control list filtering (T4)
            (6) Simulation and Testing
                - Scenarios for network interconnectivity and access control lists (T5)
            (7) Summary and conclusion
            (8) Members’ contribution to the contents in the above chapters.
        ii.) All good designs should be appropriately justified and substantiated.
        iii.) Reports are assessed for quality of presentation and readability, justification of network design with respect to modularity and functional layers, correctness and completeness of IP address assignments, access control lists, and simulation scenarios.
    b. Design Simulation. A soft copy of Packet Tracer simulation of the network design to be submitted on the course site.
        i.) Provide working simulations of the designed network.
        ii.) Provide simulation scenarios for packet routing and network access control.
        iii.) Provide a brief description for each simulation scenario created on the network.
        iv.) Simulation results will be assessed based on the scenarios created and those requirements described in Section 1.

c. Design Slides. A soft copy of the design slides in PPT format to be submitted on the course site.
   i.) Present an executive summary of the network design in the form of presentation slides; highlighting the design approach and key features in the design.
   ii.) Provide justifications to support a good network design.
   iii.) The slides will be assessed as part of the report. No oral presentation is required.

4. Submission Deadline:
   a. All submissions are due one week after the last day of the 3-week project design class.
   b. Penalty will be imposed for late submissions. Penalty marks of 30%, 50%, and 70% will be imposed on late submissions by 1 day, 2 days, and 3 days, respectively. No mark will be given for reports submitted later than 3 days.

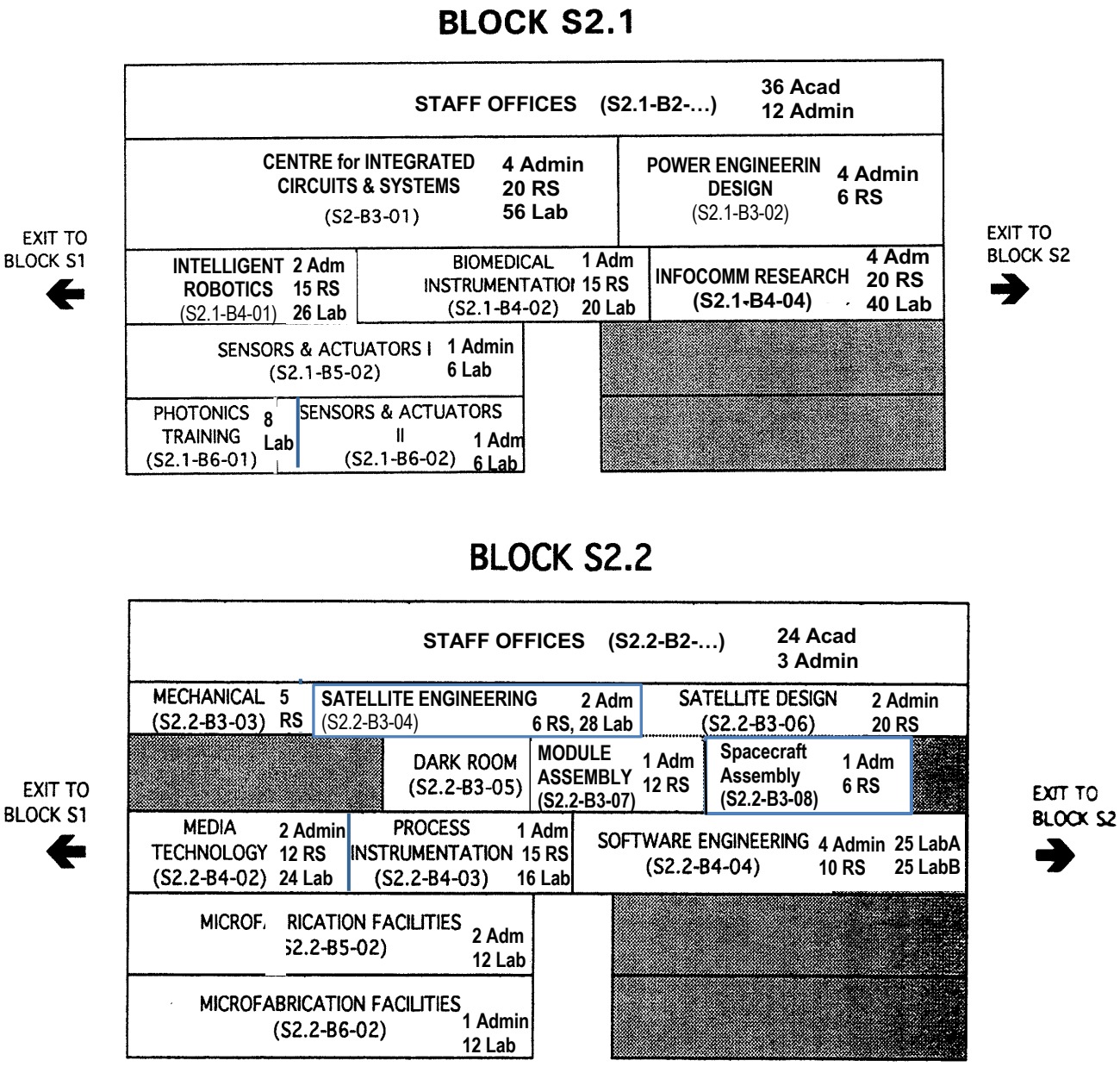

Figure 1. Distribution of PC hosts in labs and offices of S2.1 and S2.2 buildings.

Template for Network Address Assignments using VLSM Subnetting								
Location	Acad		Admin		RS		Lab	
Block S2.1	Hosts	Net#/Subnet Bits	Hosts	Net#/Subnet Bits	Hosts	Net#/Subnet Bits	Hosts	Net#/Subnet Bits
S2.1-b2	36	x.x.28.01/26	12					
s2.1-b3-01			4		20		56	x.x.30.01/26
s2.1-b3-02			4		6			
s2.1-b4-01			2		15		26	
s2.1-b4-02			1		15		20	
s2.1-b4-04			4		20		40	
s2.1-b5-02			1				6	x.x.30.0010/28
s2.1-b6-01							8	
s2.1-b6-02			1				6	x.x.30.0010/28
Total hosts*	**36+n**		**29**		**76**		**162**	
Block S2.2								
sS.2-b2	24	x.x.28.001/27	3					
s2.2-b3-03					5			
s2.2-b3-04			2		6		28	
s2.2-b3-06			2		20			
s2.2-b3-05								
s2.2-b3-07			1		12			
s2.2-b3-08			1		6			
s2.2-b4-02			2		12		24	
s2.2-b4-03			1		15		16	
s2.2-b4-04			4		10		2x25	
s2.2-b5-02			2				12	
s2.2-b6-02			2				12	
Total hosts*	**24+n**		**20**		**86**		**142**	
* to include additional n addresses for printers, servers, and router interfaces.								

Table 1a. Sample template for network address assignments (contents for illustration only)

Supernetting of Subnets for Network Address Summarization			
Network	Net#/Supernet Bits	Subnets	Description of logical group assignments
x.x.28.0	x.x.28.0/25	x.x.28.01/26 x.x.28.001/27	Supernet for aggregration of Acad groups in S2.1 and S2.2
			<Admin groups>
			<RS groups in S2.1>
			<RS groups in S2.2>
x.x.30.0			Network for all Lab groups in S2.1
x.x.30.32/28			Subnet for combined Lab groups in S2.1-b5-02 & S2.1-b6-02
			<All Lab groups in S2.2>
			<Combined Lab groups in S2.2>

Table 1b. Sample template for network address summarization

User Group	Locations	No of Hosts	No. of Printer/ Server	Sub Network Address	Sub-net Mask	Router Address	First Host Address	Last Host Address	Printer Address	Server Address	No. used / unused
Lab_2.1	VSLI	56	1 / 1	207.21.30.0	/26	x.x.x.65	x.x.x 66	x.y.z 121	x.x.x.122	x.x.x.123	59 / 3
	Intelligent Robots	26									
	Biomedical	20									
	Infocommunication Research	40									
	Sensors & Actuators i	6	1/1		/28						14 / 0
	Sensors & Actuators II	6	1/0								
	Photonics	8									

Table 2. Table template for host address assignments

Server Name	Server IP Address	Subnet Mask	Attached Router Name	Router Interface
Email server				
Web server				
Library server				
Data Server				
Printer Server				
Etc…				

Table3. Sample template for server address assignments

Network Name	Router Name	Router Interface	Network #	Subnet mask	IP Address	Access List Number
RS Network	RS S2.1	0/0				x
		1/0				x
		2/0				1 (OUT)
	RS S2.2	0/0				x
		1/0				x
		2/0				x
	RS	0/0				x
		1/0				123 (IN)
		2/0				
		3/0				

Table 4. Sample template for ACL assignments

Network	Router Name	Router Interface	IP Address	Type	Access-List
RS Network	RS S2.2	1/0		In/Out	Extended IP access list 101 **// permit FTP service from RS to Acad** permit tcp x.x.x.x filter y.y.y.y filter eq 21 **// deny FTP service from RS to others** deny tcp .. .. .. any eq 21 **// permit the rest access** permit ip any any
	RS	0/0		In/Out	Extended IP access list 102 **// permit FTP service from Acad to RS** … **// deny FTP service from others to RS** … **// permit the rest access** …

Table 5. Sample template for access-control list statements