

Unit 27: Transport Network Design

Unit code K/618/7439

Unit level 5

Credit value 15

Introduction

The exponential growth of the World Wide Web has put unprecedented demand on private and public networking infrastructures. The traffic generated by private and commercial networks has become dominated by Voice over Internet Protocol (VoIP) and video on demand. These developments require existing infrastructures to be adapted, that the design of new networks mitigates best-effort delivery issues, avoiding low bandwidths and high latency problems, and that they are based on traffic priority. For enterprise networks and internet infrastructures to meet expected demand, their design will have to take into consideration principles such as availability, scalability, resiliency, reliability and quality of service (QoS). As a result, network engineers designing and supporting enterprise or Internet Service Provider (ISP) networks will need the knowledge and skills to support diverse business needs, such as converged network traffics, centralised control and mission-critical applications.

This unit introduces students to enterprise network design principles, design models, scalable networks and their effectiveness in supporting business requirements. After evaluating the features of scalable networks, such as availability, reliability and hierarchy, students will apply network design principles to the design and implementation of redundant networks to provide Layer 2 and Layer 3 redundant solutions. Students are expected to evaluate Wide Area Network (WAN) technologies and make choices based on specific enterprise requirements. They will implement a range of WAN connections and protocols, such as Point-to-Point (PPP), Frame Relay and Virtual Private Network (VPN) with Internet Protocol Security (IPSec), using network simulators or network lab equipment. They will also solve network-related issues using network monitoring and troubleshooting methods and techniques.

Among the topics included in this unit are: network design principles, network design modules, features of enterprise IT networks, such as scalability, reliability, availability and hierarchy, Local Area Network (LAN) redundancy and related issues, spanning tree protocols, router redundancy protocols, link aggregation, in-band and out-of-band network device management, features and characteristics of WAN networks, WAN technologies and protocols, such as PPP, Frame Relay and VPN with IPSec, network monitoring tools, network security, network documentation, network troubleshooting methods and LAN and WAN connectivity issues.

On successful completion of this unit, students will be able to evaluate LAN design principles and their application in the network design process, implement a network using LAN design principles based on a predefined set of requirements, produce an appropriate WAN solution to a set of organisational requirements and solve a range of network-related problems using appropriate troubleshooting techniques and methods. As a result, students will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

Learning Outcomes

By the end of this unit students will be able to:

- LO1 Explore LAN design principles and their application in the network design process
- LO2 Implement a network using LAN design principles based on a predefined set of requirements
- LO3 Produce an appropriate WAN solution to a set of organisational requirements
- LO4 Solve a range of network-related problems using appropriate troubleshooting techniques and methods.

Essential Content

LO1 Explore LAN design principles and their application in the network design process

Discuss and evaluate LAN design principles based on business needs:

Analysing diverse business needs: support critical applications, support converged network traffic, centralised administrative control.

Network features: bandwidth, delay, load.

Evaluate LAN design models:

Review of OSI and TCP/IP models, three-layer design model, enterprise architecture design model, features of scalable networks (redundancy, hierarchy, scalability, availability, reliability and small failure domains).

Explore the characteristics and functions of routing protocols, e.g. OSPF (open shortest path first), RIPng (Routing Information Protocol next generation).

Analyse LAN redundancy:

Issues related to redundancy, Spanning Tree Concepts, Spanning Tree Protocols.

Solving bandwidth and load related issues:

Examine link aggregation concepts and operations, configure link aggregation using EtherChannel technology.

Evaluate the need for redundancy at router level:

Default gateway-related issues, router redundancy protocols.

LO2 Implement a network using LAN design principles based on a predefined set of requirements

Application of LAN design principles in network design and configuration:

Selecting network devices to implement a LAN design: use of modularity, stackability, port density, subnets, static and dynamic routes, switch forwarding, multi-layer switching and router requirements in the selection process.

Configuring LAN devices:

Comparison of out-of-band and in-band management, evaluate user interfaces, examine operating system management and licencing issues, basic device configuration.

Describe the concepts related to VLAN.

Implementing Layer 2 LAN redundancy:

Configuration of different Spanning Tree Protocols (STP and Rapid STP).

Implementing Layer 3 LAN redundancy for IPv4:

Configuring First Hop Redundancy Protocols (Hot Standby Routing Protocol, Virtual Router Redundancy Protocol and Gateway Load Balancing Protocol).

Implementing Layer 3 LAN redundancy for IPv6:

Configuring the 'new generation' of redundancy routing protocols, e.g. OSPFv3 (open shortest path first V3), RIPng (RIP New Generation), stateless address auto-configuration.

Configuring, managing and verifying interior routing protocols, e.g. OSPF, RIP.

LO3 Produce an appropriate WAN solution to a set of organisational requirements

WAN networks and protocols:

Analyse features and requirements of enterprise networks: analyse WAN enterprise architecture, uptime, bandwidth, ISPs, traffic flows, prioritisation, queuing algorithms, latency, QoS models, teleworking.

WAN technologies:

Examine WAN operations and services, analyse and compare private and public WAN technologies, select the appropriate WAN protocol and service for a specific network requirement.

Investigate the need for and methods of performing IOS upgrades to a router.

WAN serial connections:

Configuring point-to-point connections using Point-to-Point Protocol (PPP): explain point-to-point serial WAN serial communication, analyse and configure HDLC, analyse and configure PPP.

Configuring Frame Relay:

Analyse and compare Frame Relay and leased lines benefits and drawbacks, explain Frame Relay protocol Permanent Virtual Circuits (PVC), Link Management Interface (LMI) extensions, Data Link Connection Identifier (DLCI) mappings, configure static Frame Relay, implement advanced Frame Relay configurations.

VPN over a public infrastructure connection:

Explaining Virtual Private Network (VPN) features and benefits, compare VPN types, configure site-to-site secure tunnel connections, configure VPN with IP Security (IPSec) and compare IPSec and SSL VPNs (Secure Socket Layer).

LO4 Solve a range of network-related problems using appropriate troubleshooting techniques and methods

Network security considerations:

Network security issues, their impacts and solutions.

Network monitoring and troubleshooting methods:

Network monitoring tools including Syslog, Network Time Protocol (NTP), NetFlow and Simple Network Management Protocol (SNMP).

Network troubleshooting including establishing network baselines, optimising network performance troubleshooting methods with a systematic approach, e.g. root cause analysis, gathering information, questioning end users, preparing network documentation, comparing network troubleshooting tools.

Troubleshooting LAN and WAN connectivity issues:

Physical and Data Link layers networking issues and troubleshooting: examine cable faults, device failures, bottlenecks, congestions, attenuation, noise, power issues (redundant power supplies), encapsulation mismatches, STP related issues, etc.

Network layer issues and troubleshooting:

Evaluate divide and conquer method, importance of ipconfig, ping and traceroute commands, subnetting issues, troubleshooting routing protocols, PPP, Frame Relay and VPN configuration issues.

Transport and application layers networking issues and troubleshooting:

Examine the use of port numbers in Access Control Lists (ACL), denying and allowing errors, ACL misconfigurations, Network Address Translation (NAT), Domain Name System (DNS) and Dynamic Host Configuration Protocol (DHCP) related issues.

Learning Outcomes and Assessment Criteria

Pass	Merit	Distinction
LO1 Explore LAN design principles and their application in the network design process		LO1 and LO2 D1 Evaluate different implementations of link aggregation, using EtherChannel to solve bandwidth and load issues.
P1 Examine the network design models and features of scalable networks, based on a given set of business needs. P2 Discuss LAN redundancy, bandwidth and load related issues and possible solutions, with reference to Layer 2 and Layer 3 of the OSI Model.	M1 Analyse the switch and router redundancy protocols and their effectiveness in supporting scalable networks.	
LO2 Implement a network using LAN design principles based on a predefined set of requirements		
P3 Select LAN devices based on features and requirements and apply basic configuration commands for network connectivity. P4 Implement a LAN design with Layer 2 and Layer 3 redundancy, using switch and router redundancy protocols.	M2 Analyse different switch redundancy protocols and their effectiveness in solving redundancy issues. M3 Analyse Layer 3 redundancy implementations for IPv4 and IPv6.	

Pass	Merit	Distinction
LO3 Produce an appropriate WAN solution to a set of organisational requirements		LO3 and LO4 D2 Evaluate troubleshooting methods and their effectiveness in solving enterprise-wide networking issues.
P5 Examine WAN technologies and select the appropriate one for a set of enterprise requirements. P6 Configure WAN protocols as part of an enterprise network solution.	M4 Analyse the benefits and drawbacks of private and public WAN technologies. M5 Analyse features and benefits of different VPN types based on organisational needs.	
LO4 Solve a range of network-related problems using appropriate troubleshooting techniques and methods		
P7 Deploy network monitoring tools and troubleshooting methods to establish network baselines and produce network documentation. P8 Troubleshoot LAN and WAN connectivity issues at different networking layers.	M6 Develop effective documentation of troubleshooting methods and steps based on a given scenario.	

Recommended Resources

Textbooks

Meyers, M. (2015) *CompTIA Network+ Guide to Managing and Troubleshooting Networks*, 4th edn. London, UK: McGraw Hill Professional.

Subramanian, M. (2012) *Network Management: Principles and Practices*. USA: Prentice Hall.

Thomatis, M. (2015) *Network Design Cookbook: Architecting Cisco Networks*. USA: Lulu Press, Inc.

White, R. and Donohue, D. (2014) *The Art of Network Architecture: Business-Driven Design*. USA: Cisco Press.

Web

www.cisco.com	Cisco International networking company (General Reference)
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www.ncsc.gov.uk	National Cyber Security Centre (General Reference)
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www.sciencedirect.com	ScienceDirect online science journal Computer science section (General Reference)
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Links

This unit links to the following related units:

Unit 2: Networking

Unit 9: Computer Systems Architecture

Unit 29: Network Security

Unit 39: Network Management

Unit 40: Client/Server Computing Systems.