Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

SPEAN402

ADVANCED NETWORKING

PERFORM ADVANCED NETWORKING

Competence

RQF Level: 4

Learning Hours: 80

Credits: 8

Sector: ICT and Multimedia

Trade: Software Programming and Embedded Systems

Module Type: Specific Module

Curriculum: ICTSES4002 TVET Certificate IV in Software Programming and Embedded System

Copyright: © Rwanda TVET Board, 2023

1200

Issue Date: August 2023

<table>
<tr><td>Purpose statement</td><td colspan="6">This module aims to equip learners with the knowledge and skills necessary to perform advanced configuration for both wired and wireless networks. By the end of this module, learners will be able to configure routing protocols, configure VLANs, VTP, and STP, implement Inter-VLAN routing, and configure WAN and wireless networks. The learners will be able to carry out the above tasks with minimum supervision.</td></tr>
<tr><td>Learning assumed to be in place</td><td colspan="6">Apply network fundamentals</td></tr>
<tr><td rowspan="6">Delivery modality</td><td colspan="2">Training delivery</td><td>100 %</td><td colspan="2">Assessment</td><td>Total 100%</td></tr>
<tr><td colspan="2">Theoretical content</td><td>30%</td><td rowspan="3">Formative assessment</td><td>30%</td><td rowspan="3">50%</td></tr>
<tr><td colspan="2">Practical work:</td><td rowspan="3">70%</td><td rowspan="3">70%</td></tr>
<tr><td>Group project and presentation</td><td>30%</td></tr>
<tr><td>Individual project /Work</td><td>40%</td></tr>
<tr><td colspan="3"></td><td colspan="2">Summative Assessment</td><td>50%</td></tr>
</table>

Elements of Competence and Performance Criteria

Elements of Competence	Performance Criteria
1. Configure routing protocols	1.1 Classful and classless routing protocols are efficiently applied based on routing configuration principles
	1.2 Routes are properly configured based on the routing configuration principles
	1.3 HSRP (Hot standby router protocol) is properly applied based on the network's high availability principles
2. Configure VLANs, VTP, STP, and switch security	2.1 VLANS are properly configured based on network requirement
	2.2 VTP is properly configured based on network requirement
	2.3 STP is properly configured based on network requirement

	2.4 Switch security is adequately configured based on network requirement
3. Implement Inter-VLAN routing	3.1 Traditional inter-VLAN routing is properly configured based on the network requirement
	3.2 Router-on-a–stick inter-VLAN routing is properly configured based on network requirement
	3.3 Layer 3 switching inter-VLAN routing is properly implemented based on network requirement
	3.4 Access control lists (ACLs) are properly configured based on network security measures
	3.5 Router security is precisely implemented based on network security measures
4. Configure wireless and WAN networks	4.1 SOHO and Enterprise wireless networks are systematically implemented based on user requirements
	4.2 WLAN security attacks are properly described based on the network security requirement
	4.3 Wireless connectivity and security arrangements are efficiently tested based on wireless security standards
	4.4 WAN is efficiently configured based on network topology

Intended Knowledge, Skills and Attitude

Knowledge	**Skills**	**Attitude**
✓ Distinguish classful and classless routing protocols ✓ Classify dynamic routing protocols ✓ Describe HSRP ✓ Describe network security ✓ Identify security attacks ✓ Explain VLANS,, VTP and STP concepts. ✓ Explain wireless technologies	✓ Apply classful and classless routing protocols ✓ Configure static and default routes ✓ Apply HSRP (Hot standby router protocol ✓ Configure VLANS, VTP, STP ✓ Configure switch security. ✓ Implement Inter-VLAN routing ✓ Implement routing security ✓ Configure wireless Networks	✓ Use creativity and innovation in network configuration ✓ Demonstrate the interest in securing the network ✓ Manage network resources

	✓ Configure WAN networks	

Course content

Learning outcomes	At the end of the module the learner will be able to: **1. Configure routing protocols** **2. Configure VLANs, VTP, and STP** **3. Implement Inter-VLAN routing** **4. Configure the wireless and WAN networks**
Learning outcome 1: Configure routing protocols	Learning hours: 12 Hours

Indicative content

- **Configuration of class-full and classless routing protocols**
  - ✓ Class full IP addressing
    - IP addressing scheme
  - ✓ VLSM and IP addressing (Review)
    - Basic VLSM calculation and addressing design activity
    - Challenges of VLSM calculation and addressing design activity
  - ✓ Classless Inter-domain routing (CIDR)
    - Description of CIDR
    - Calculating route summarization
    - Configuration of summarized static routes
  - ✓ Classification of dynamic routing protocols
  - ✓ Configuration of RIPv2
    - RIPv2 operations
    - RIPv2 configuration and summarization
    - RIPv2 verification and troubleshooting
  - ✓ Configuration of EIGRP
    - EIGRP Operation
    - EIGRP ASN, router ID, and passive interface

- Configuring EIGRP for IPV4

✓ Configuration OSPFv2 (Single area)

- OSPF Operations and network topology
- OSPF ASN, router ID, and passive interface
- Configuration of OSPF for IPV4
- Verifying and troubleshooting the OSPF issues

● Configuration of static and default routes

✓ Description, functions, and features of the router

- Router hardware components
- Packet forwarding methods
- Default Gateways
- Loopback interface configuration
- Path determination
- Routing table

✓ Static and default routing

- Configuration of DHCP
- Configuration of static routes
- Configuration of default route
- Troubleshooting static and default routes

● Application of Hot Standby Router Protocol (HSRP)

✓ Description of HSRP

- HSRP versions and features
- HSRP advantages and applications

✓ Configuration of HSRP

- HSRP configuration guidelines
- Default HSRP configuration
- Authentication and timers
- HSRP verification and troubleshooting

Resources required for the learning outcome

Equipment	Projector, Routers, switches, and Computers
Materials	Console cable and RJ45 cables, HDMI cables, crimping machines, RJ45 connectors
Tools	Packet tracer or GNS3, Putty
Facilitation techniques	➢ Brainstorming on static and default routes, class-full and classless routing protocols, access control lists, Hot Standby routing protocol, and router security ➢ Group discussion on fundamental concepts of static and default routes, class-full and classless routing protocols, access control lists, Hot Standby routing protocol, and router security ➢ Demonstration on how to configure static and default routes, class-full and classless routing protocols, access control lists, Hot Standby routing protocol, and router security ➢ Practical exercise on configuring static and default routes, class-full and classless routing protocols, access control lists, Hot Standby routing protocol, and router security

Formative assessment methods /(CAT)	✓ Oral assessment ✓ Written assessment ✓ Practical assessment

Learning Outcome 2: Configure VLANs, VTP and STP	Learning hours: 18 Hours

Indicative content

- **Configuration of VLANs**
  - ✓ **Switching as a general concept**
    - Ingress port
    - MAC address table
    - Switching domains
    - Differentiating between unicast, broadcast, and multicast traffic
  - ✓ **The key elements of Ethernet / 802.3 networks**
    - Media Access Control in ethernet
    - Ethernet communications
    - Preamble and start frame delimiter fields
    - Duplex setting
  - ✓ **Design consideration for ethernet/802.3 network**
    - Bandwidth and throughput
    - Collusion domains
    - Broadcast domains
    - Network latency
    - Network congestion
    - LAN segmentation
  - ✓ **VLAN concepts**
    - Purpose of VLAN
    - Comparison of physical LANs and VLANs.
    - Types of VLANs: Default VLAN, Data VLAN, Voice VLAN, Management VLAN, and Native VLAN
    - VLAN Membership: Tagged, Untagged, and Native VLANs
  - ✓ **Configuration of VLANs**
    - Creation of VLANs
    - Assigning switch port to VLANs
    - Verification of VLAN configuration
  - ✓ **Trunk configuration**
    - Configuration Trunking on the inter-switch connections
    - Verification of trunk configuration
- **Configuration of VTP**
  - ✓ VTP components

- VTP domain
- VTP advertisement
- VTP modes

✓ Description of VTP operations

- VTP version
- Configuration revision number
- VTP domain name
- VTP Pruning mode
- VTP traps generation

✓ VTP frame structure

✓ VTP configuration

- VTP configuration guidelines
- Managing VLAN on VTP server
- Enabling VTP version
- Enabling VTP pruning
- Troubleshooting VTP configurations

● STP configuration

✓ Introduction to spanning tree protocol (STP)

- Examine redundant design
- Issues with redundancy
- Real-world redundancy issues

✓ STP Basics and Terminology

- Bridge, bridge ID, and Root bridge
- STP BPDU
- Port roles
- Port states
- Main types of Spanning Tree Protocol

✓ STP Convergence process (STP algorithm)

✓ Configuration of STP and RSTP

- Enabling and disabling STP/RSTP
- Verifying STP/RSTP status and root bridge information
- Modifying STP/RSTP priority values to influence root bridge election
- Configuring specific ports as root or designated ports
- Troubleshooting STP Issues

● Configuration of switch security

✓ Switch security access Configuration

- Configuration of EXE Mode password
- Encrypted password and password recovery
- Configuring login banner
- Configuration of console access
- Configuring Telnet and SSH

➢ Port security ✓ Common switch security Attacks and countermeasures ➢ MAC address attack ➢ VLAN hopping ➢ ARP attacks ➢ DHCP attacks ➢ Spoofing attacks ➢ Preventing switch security attacks	
Equipment	Projector, Switch and computer
Materials	Console cable, RJ45 cables, HDMI cable
Tools	Packet tracer/ GNS3 and putty
Facilitation techniques	● Brainstorming on VLAN concepts, VTP, STP and switch security ● Group discussion on VLAN concepts, the role of VTP in a network, STP topology change and switch security ● Demonstration on VLAN configuration, VTP configuration, STP configuration and switch security configuration. ● Practical exercise on VLAN, VTP, and STP configurations
Formative assessment methods /(CAT)	● Oral assessment ● Written assessment ● Practical assessment

Learning outcome 3: Implement Inter-VLAN routing	**Learning hours: 30 Hours**
Indicative content	

- **Introduction to inter-VLAN routing**
  - ✓ Defining the inter-VLAN routing
  - ✓ Purpose of the inter-VLAN routing
  - ✓ Differentiating inter-VLAN routing types
- **Configuration of traditional inter-VLAN routing**
  - ✓ Enabling interfaces on the router
  - ✓ Assignment of IP address to the physical interfaces
  - ✓ Assignment of VLANs to the interfaces
  - ✓ Troubleshooting the configured inter-VLAN routing
- **Configuration of router-on-a-stick inter-VLAN routing**
  - ✓ Configuration of IP address on the router's sub-interfaces
  - ✓ Assignment of encapsulations (dot1q or ISL)
  - ✓ Configuration of Management VLANs
  - ✓ Troubleshooting the configured inter-VLAN routing
- **Implementation of Layer-3 switch inter-VLAN routing**
  - ✓ Creation of VLANs
  - ✓ Switch port
    - Access port
    - Trunk port
  - ✓ Creation of SVI
  - ✓ Configuration of DHCP for different VLANs
- **Configuration of access control list**
  - ✓ Standard access control list
    - Describing the Standard access control list
    - Configuration of Standard access control list
    - Troubleshooting the standard access control list
  - ✓ Extended access control list
    - Describing the extended access control list
    - Configuration of extended access control list
    - Troubleshooting the extended access control list
  - ✓ Named access control list
    - Describing the named access control list
    - Configuration of Named Standard access control list
    - Troubleshooting the Named Extended access control list
- **Implementation of router security**
  - ✓ Router access security
    - Physical security

- Securing the router's local and remote access
- Disabling unnecessary services or unused ports

✓ Standards ports and protocols

✓ Backup and Recovery

- Performing backup of configuration files and other critical files
- Recovery plan in place in case of a security breach or failure

Resources required for the Learning outcome

Equipment	Projector, Router, Switch and computer
Materials	HDMI, Console cable and RJ45 cables
Tools	Packet tracer/ GNS3 and putty
Facilitation techniques	• Brainstorming on Inter-VLAN routing concepts • Group discussion on different types of inter-VLAN routing • Demonstration of inter-VLAN routing configurations • Practical exercise on inter-VLAN routing configurations
Formative assessment methods /(CAT)	• Oral assessment • Written assessment • Practical assessment

Learning outcome 4: Configure wireless network	Learning hours: 20 Hours

Indicative content

- **Implementation of SOHO and Enterprise wireless network**
  - ✓ **Description of SOHO and enterprise network**
    - Definition and characteristics of a SOHO network.
    - Importance of network connectivity for small businesses and home offices.
  - ✓ **WLAN Topologies and Components**
    - Network topologies (star, bus, mesh) applicable to SOHO environments
    - Key network components: routers, switches, access points, and modems
  - ✓ Wireless technologies
  - ✓ Wireless network operations
    - 802.11 frame structure
    - 802.11 WLAN technologies
    - CSMA/CA
    - Discovering APs
  - ✓ Installation and configuration of WLAN devices
    - Access points
    - WLAN bridges
    - Controllers
- **Description of WLAN security attack**
  - ✓ **Identification of WLAN security attacks**
    - Eavesdropping
    - Hijacking
    - Man-in-the-middle
    - Denial of service (DoS)
    - Encryption cracking
    - MAC spoofing
    - Rogue Access points
    - Evel twins attacks
  - ✓ WLAN security attack prevention
- **Testing Wireless connectivity and security**
  - ✓ Wireless LAN testing considerations
    - Signal coverage testing
    - Performance testing
    - Interference and Co-Channel Interference
    - Security vulnerability testing
  - ✓ **Troubleshooting wireless station connection to AP**

- Tools for Troubleshooting like Wi-Fi analyzers, command-line utilities, and network monitoring software.
- SSID and Network visibility (network's SSID is not visible to devices)
- Authentication Failures
- Compatibility issues, driver updates, and device-specific settings

✓ Troubleshooting AP connection to Wired LAN

- Verifying physical connectivity
- DHCP and IP Addressing Troubleshooting
- Check for power issues with the AP
- Checking if the AP is broadcasting the SSID
- Checking the AP radio settings

✓ **Configuration of WAN**

- Security Measures (firewalls, intrusion detection systems,Encryption of sensitive data using protocols like IPsec to protect it during transmission)
- Quality of Service (QoS)
- WAN Optimization
- Redundancy and Failover
- Monitoring & Management
- Configure Frame Relay
- Configure PPP
- Configure HDLC
- Configure VPN
- Configure DNS

Resources required for the Learning outcome

Equipment	Projector, Access points, WIFI-routers, Routers, Switches and computer
Materials	HDMI cable, Console cable and RJ45 cables
Tools	Packet tracer/ GNS3 and putty
Facilitation techniques	• Brainstorming on SOHO network and different wireless technologies • Group discussion on the SOHO network and different wireless technologies • Demonstration of WLAN configurations • Practical exercise on WLAN configurations
Formative assessment methods /(CAT)	• Oral assessment • Written assessment • Practical assessment

Integrated/Summative assessment (For specific module)

Integrated situation

XYZ Company Ltd is a medical supply company located in Kigali, Rwanda. It has 4 different departments: Administration, Sales, IT and Support department. The company is initiating a fresh network installation to the new premises to support its diverse departments and ensure a modern, efficient, and secure network environment. The company envisions a network that facilitates seamless communication, optimizes resource sharing, and provides robust wireless connectivity.

Key responsibilities:

As a network administrator of that company, you are responsible for designing and implementing a brand-new network infrastructure for XYZ Company.

In order to meet the company's connectivity requirements, your tasks involve:

- configuring routing protocols,
- establishing VLANs,
- enabling inter-VLAN routing, and
- setting up wireless networks
- ensuring data security

The provided network is 192.168.10.0/24. Each department should have at least 60 hosts IP addresses.

Project tasks:

1. Identification of needed equipment
2. Network design
3. Routing protocol configuration
4. Configure the ACL to allow people to access only the server through SSH and HTTPs only
5. VLAN creation and configuration based on department
6. Inter-VLAN routing setup
7. Wireless network deployment
8. Implement Router and Switch access security
9. Testing and verification
10. Documentation

	Resources
Tools	Crimping tools, network cable testers, screwdrivers, labeling tools, documentation tools

Equipment	Routers, Switches, Access points, Network racks or cabinets, patch panels, router and switch modules (SFP), computers, server and UPS
Materials/ Consumables	Ethernet cables, ethernet connectors, cable management accessories, labeling materials, power cords, and surge protectors

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
Learning Outcome 1: Configure routing protocols (30%)	1.1 Static and default routes are properly configured based on the routing configuration principles	Static route is configured for establishing the connection to the ISP router			5 marks
		The default route is configured			5 marks
	1.2 Classful and classless routing protocols are efficiently applied based on routing configuration principles	The network is segmented into 4 subnets			5 marks
	1.3 HSRP (Hot standby router protocol) is properly applied based on the network's high availability principles				
	1.4 Access control lists (ACLs) are properly configured based on network security measures	The access control list is configured			5 marks
	1.5 Router security is precisely implemented based on network security measures	Protecting the privilege exe mode with encrypted password			3 marks
		Console and Virtual terminal access is protected by			5 marks

		strong authentication			
		The banner message is configured			2 marks
Learning Outcome 2: Configure VLANs, VTP, STP and switch security (30%)	2.1 VLANS are properly configured based on network requirement	VLANs are configured			8 marks
		Trunk ports are configured on the router			4 marks
		VLANs are assigned to the switch ports			8 marks
	2.2 VTP is properly configured based on network requirement				
	2.3. STP is properly configured based on network requirement				
	2.4 Switch security is adequately configured based on network requirement	Console security is well-implemented			2.5 marks
		Virtual terminal security is well-implemented			2.5 marks
		Privilege mode is protected with the encrypted password			2.5 marks
		The banner message is configured to all			2.5 marks
Learning Outcome 3: Implement Inter-VLAN routing (20%)	3.1 Traditional inter-VLAN routing is properly configured based on the network requirement				
	3.2 Router-on-a–stick inter-VLAN routing is properly configured based on network requirement	Sub-interfaces are configured			4 marks
		Encapsulation dot1q is applied			4 marks
		IP addresses are applied on sub-interfaces			4 marks

		DHCP is properly configured on the router based on department subnet			8 marks
	3.3 Layer 3 switching inter-VLAN routing is properly implemented based on network requirement				
Learning Outcome 4: Configure wireless network (20%)	4.1 SOHO and Enterprise wireless networks are systematically implemented based on user requirements	The network diagram is elaborated			4 marks
		All required network equipment and tools are selected			4 marks
		Proper network cables are used for interconnecting network devices			4 marks
	4.2 WLAN security attacks are properly described based on the network security requirement	SSID is properly configured on each wireless access point			2 marks
		WPA2 encryption protocol is used			2 marks
		SSID is broadcasted			2 marks
	4.3 Wireless connectivity and security arrangements are efficiently tested based on wireless security standards	The entire network is tested			2 marks
Total marks					
Percentage Weightage					100%
Minimum Passing line % (Aggregate): 70%					

References:

Here is the list of references formatted in APA style:

1. Meyers, M. (Year of Publication). *CompTIA Network+ Certification All-in-One Exam Guide, Seventh Edition (Exam N10-007)*. Publisher.

2. Angelescu, S. (Year of Publication). CCNA Certification All-In-One For Dummies.

3. Seifert, R., & Edwards, J. (Year of Publication). The All-New Switch Book: The Complete Guide to LAN Switching Technology, Second Edition*

4. Lammle, T. (Year of Publication). *CCNA Routing and Switching Complete Study Guide*. Publisher.

5. Donahue, G. A. (Year of Publication). *Network Warrior: Everything You Need to Know That Wasn't on the CCNA Exam, Second Edition. Online

6. CISCO. (2023). Advanced Routing ENARSI 300-410. Online

7. Computer Networking Notes. (2023). VLAN Configuration Commands Step by Step Explained
. Retrieved from https://www.computernetworkingnotes.com/ccna-study-guide/vlan-configuration-commands-step-by-step-explained.html

8. CISCO. (2023). Configure IP Addresses and Unique Subnets for New Users
. Retrieved from https://www.cisco.com/c/en/us/support/docs/ip/routing-information-protocol-rip/13788-3.html