Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

NITWN401

WIDE AREA NETWORK

Setup Wide Area Network

Competence

RQF Level: 4

Learning Hours 100

Credits: 10

Sector: ICT & MULTIMEDIA

Trade: Networking and Internet Technologies

Module Type: Specific

Curriculum: ICTNIT4001 - TVET Certificate IV in Networking and Internet Technologies

1200

Issue Date: September 2023

<table>
<tr><td>Purpose statement</td><td colspan="6">This module describes the skills, knowledge and attitude required to Setup WAN. This module intended to prepare students pursuing TVET Level 4 in Networking and Internet Technologies. At the end of this module, the students will be able To Install WAN equipment, Apply VLAN Configurations, Apply Router configurations, Maintain WAN.</td></tr>
<tr><td>Learning assumed to be in place</td><td colspan="6">N/A</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>20%</td><td rowspan="4">Formative assessment</td><td>20%</td><td rowspan="4">50%</td></tr>
<tr><td colspan="2">Practical work:</td><td rowspan="3">80%</td><td rowspan="3">80%</td></tr>
<tr><td>Group project and presentation</td><td>30%</td></tr>
<tr><td>Individual project /Work</td><td>50%</td></tr>
<tr><td colspan="3"></td><td colspan="2">Summative Assessment</td><td>50%</td></tr>
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Elements of Competence and Performance Criteria

Elements of competence	Performance criteria
1. Install WAN equipment	1.1 WAN environment is properly prepared based on organization's infrastructure requirements
	1.2 WAN Technology is appropriately identified based on WAN types
	1.3 Materials and equipment are properly identified based on the WAN technologies.
	1.4. WAN infrastructure equipment is properly interconnected based on connection types
2. Apply VLAN Configurations	2.1 VLANs are properly created based on organization's structure
	2.2 VTP is appropriately configured based on created VLANs
	2.2 Switchport interfaces are properly configured based on modes.
	2.3 Inter-VLAN is effectively implemented based on created VLANs
	2.5. Spanning Tree Protocol (STP) is properly applied based on IEEE 802.1Q standards
	2.6. Aggregation modes are efficiently applied based on IEEE 802.1Q
3. Apply Router configurations	3.1 Communication among devices is properly configured based on WAN requirements
	3.2. Network Address Translation (NAT) is appropriately applied based on the design
	3.3. Routing protocols are well configured properly based on the design
	3.4. WAN security is properly configured in line with the access control list and organization's measures.
4. Maintain WAN	4.1. Monitoring tools are properly installed according to WAN design

	4.2. Monitoring tools are effectively customized based on configured WAN design.
	4.3. Updated report is regularly documented based on monitoring tools' insights.
	4.4. Vulnerabilities are properly assessed based on generated monitoring reports.
	4.5. Vulnerabilities are efficiently troubleshot according to identified WAN threats.
	4.6. Troubleshooting report is properly generated based on the work done.

Intended Knowledge,Skills, and Attitude

Knowledge	Skills	Attitude
✓ Describe WAN concepts ✓ Describe inter-VLAN routing ✓ Describe Spanning Tree Protocol ✓ Describe IP addressing ✓ Identify routing protocols ✓ Describe modulation & demodulation techniques ✓ Define Multiplexing & De-multiplexing techniques.	✓ Identify WAN Installation requirements ✓ Create and configure VLANS ✓ Perform routing and switching ✓ Router configurations	✓ ✓ Attention to detail ✓ Patience ✓ Environmental Awareness ✓ Effective communication ✓ Self confidence ✓ Adaptability ✓ Safety Awareness

Course content

Learning outcomes	At the end of the module the learner will be able to: 1. Install WAN equipment 2. Apply VLAN Configurations 3. Apply Router configurations 4. Maintain WAN

Learning outcome 1: Install WAN equipment	Learning hours: 20

Indicative content

- **Conduct Site Visit**
  - ✓ Preparation of site visit
    - Understand the purpose
    - Define The objectives
    - Prepare a checklist
  - ✓ Site Assessment
    - Surroundings
    - safety hazards
  - ✓ Infrastructure Evaluation
    - Existing infrastructure
    - Cabling and network layout
  - ✓ Document findings
- **Identification of WAN Installation requirements**
  - ✓ Definition of Key terms
    - WAN
    - LAN
    - MAN
    - VLAN

- ✓ Types of WAN
  - Switched WAN
  - Point-to-point WAN
  - Cloud Based (SD WAN)
- ✓ Evaluation of Network Infrastructure design
  - Hardware infrastructure
  - Software infrastructure
- ✓ Materials
- ✓ Tools
- ✓ Equipment

- **Performing WAN Connections**
  - ✓ Description of WAN Technologies
    - Point to point
    - Hub and Spoke
    - Full Mesh
    - Virtual Private Network (VPN)
    - Multiprotocol Label Switching (MPLS)
    - Ethernet
    - Wireless
    - Cloud Based (SD WAN)
  - ✓ Wired Connections
    - Leased line
    - T1/E1 Lines
    - T3/E3 Lines
    - Metro Ethernet
    - MPLS (Multiprotocol Label Switching)
  - ✓ Wireless Connections
    - Wi-Fi/WLAN
    - Cellular Networks (2G,3G, 4G, and 5G)

- Satellite

✓ Hybrid Connections

- VPN
- MPLS-VPN

✓ Dial-up Connections

- Traditional Dial-up
- ISDN (Integrated Services Digital Network)

✓ Broadband Connections

- DSL (Digital Subscriber Line)
- Cable Internet
- Fiber Optic

- **Apply modulation & demodulation techniques**

✓ Types of modulation

- Amplitude Modulation (AM)
- Frequency Modulation (FM)
- Phase Modulation (PM)

✓ Digital modulation

- Amplitude Shift Keying (ASK)
- Frequency Shift Keying (FSK)
- Phase Shift Keying (PSK)

✓ Optical modulation

- Unguided
- Guided

- **Apply Multiplexing & De-multiplexing techniques.**

✓ Frequency division multiplexing (FDM)

✓ Time division multiplexing (TDM)

- Synchronous
- Statistical

✓ Wavelength division multiplexing (WDM)

✓ Code division multiplexing (CDM)	
Resources required for the learning outcome	
Equipment	▪ Routers ▪ Switches ▪ Hubs ▪ Repeaters ▪ Gateways ▪ Bridges ▪ Modems ▪ Rack Mount
Materials	▪ CAT5 ▪ CAT6 ▪ Fiber optic cables ▪ Coaxial Cables ▪ BNC ▪ RJ45 ▪ RJ11
Tools	▪ Cable tester ▪ Crimping tool ▪ Wire cutter ▪ Striping tool ▪ Putty ▪ Terr term ▪ CISCO Packet racer ▪ EdrawMax
Facilitation techniques	▪ Demonstration and simulation ▪ Individual and group work ▪ Trainer guided

	▪ Group discussion
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation

Learning outcome 2: Apply VLAN Configurations	**Learning hours: 30**
Indicative content	

- **Creation of VLANs**
  - ✓ VLAN overview
  - ✓ Benefit of VLANs
  - ✓ VLAN ID range
    - Normal range
    - Extended range
  - ✓ VLAN characteristics
  - ✓ VLANs Types
  - ✓ Network traffic types
  - ✓ Controlling broadcast Domains
    - Network without VLANs
    - Network with VLANs
  - ✓ Configuration of VLANs
  - ✓ Verification of VLAN configuration
- **Configuration of VTP**
  - ✓ VTP BENEFITS
  - ✓ VTP components
    - VTP Domain
    - VTP Advertisement
    - VTP Modes
    - VTP Pruning
  - ✓ VTP Operations

- VTP version
- Configuration revisions
- VTP Domain name
- VTP Operating Mode
- VTP Pruning Mode
- VTP Modes
- VTP traps generation

✓ Configure the VTP

- VTP server switches
- VTP client switches

✓ Managing VLAN on VTP Server and Client

✓ Enabling VTP version

✓ Enabling VTP pruning

✓ Adding a VTP client switch to a VTP Domain

✓ Verify VTP Configurations

- **Configuration of Switch port Interface**

✓ Access Mode

✓ Trunk Mode

✓ Verifying Switchport interfaces

- **Configure inter VLAN routing**

✓ Introduction of inter-VLAN routing

- Definition of Inter-VLAN routing
- Router–on–a stick inter-VLAN routing
- Traditional inter-VLAN Routing
- Router sub-interfaces
- Router interface and sub-interface comparison

✓ Configure traditional inter VLAN Routing

✓ Configure router on-a-stick inter-VLAN routing.

✓ Legacy Inter-VLAN routing

- ✓ Layer 3 switch inter-VLAN Routing (SVI)
- ✓ Verifying inter-VLAN Routing

- **Configure Spanning Tree Protocol**
  - ✓ Introduction to STP
  - ✓ Redundancy
    - Examine a redundant design
    - Real word redundancy issues
  - ✓ Spanning Tree Algorithm
  - ✓ STP BPDU
  - ✓ Bridge ID
  - ✓ Port roles
  - ✓ STP port states and BPDU Timers
  - ✓ Configuration of STP bridges IDs
- **Apply Converge STP**
  - ✓ Electing roots bridge
  - ✓ Elect roots port
  - ✓ Electing designated ports and non-designated ports
  - ✓ STP topology change
- **Configure PVST+, RSTP and rapid PVST+**
  - ✓ STP Variants
  - ✓ PVST+ Bridge ID
  - ✓ Per-VLAN Spanning Tree
    - Primary and Secondary root Bridges
    - PVST+ switch priority
  - ✓ Rapid Spanning Tree Protocol
    - RSTP characteristics
    - RSTP BPDU
    - Edge ports
    - Link types

- RSTP Ports states and port roles

- **Apply Aggregation modes**
  - ✓ Configure Port Aggregation Protocol (PAgP)
  - ✓ Configure Link Aggregation Control Protocol (LACP)
  - ✓ Configure Static Link Aggregation / Manual EtherChannel
  - ✓ Configure Virtual Router Redundancy Protocol (VRRP)

Resources required for the learning outcome	
Equipment	▪ Routers ▪ Switches ▪ Hubs ▪ Repeaters ▪ Gateways ▪ Bridges ▪ Modems
Materials	▪ CAT5 ▪ CAT6 ▪ Fiber optic cables ▪ Coaxial Cables ▪ BNC ▪ RJ45 ▪ RJ11
Tools	▪ Cable tester ▪ Crimping tool ▪ Wire cutter ▪ Striping tool ▪ Putty ▪ Terraterm ▪ CISCO Packet racer

	▪ EdrawMax
Facilitation techniques	▪ Demonstration and simulation ▪ Individual and group work ▪ Trainer guided ▪ Group discussion
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation

Learning outcome 3. Apply Router configurations	**Learning hours: 25**
Indicative content	

- **Perform IP addressing**
  - ✓ Class full IP addressing
  - ✓ Classless Ip addressing
  - ✓ IP address scheme
  - ✓ VLSM and IP Addressing
    - Basic VLSM Calculation
    - Troubleshooting a VLSM
  - ✓ Configure DHCP server
  - ✓ Classless Inter-Domain Routing (CIDR)
    - Describe CIDR
    - Route Summarization
- **Configuration of NAT**
  - ✓ Purpose
  - ✓ Advantages and disadvantages
  - ✓ Types of NAT
    - Static NAT

- Dynamic NAT
- Port Address Translation (PAT)
- NAT64

✓ NAT configuration

- Inside and Outside Interfaces
- Configure IP Addresses
- Create Access List
- Apply NAT to Inside and outside Interface
- Optional (Static NAT)

- **Configure routing protocols**

✓ Static route

✓ Default Routes

✓ Dynamic Routing

✓ RIPv1

- RIPv1 Operation
- RIPv1 Configuration
- RIPv1 Summarizations
- RIPv1 Verification
- RIPv1 Troubleshooting

✓ Processing RIP Updates

✓ IGRP

- IGRP Operation
- IGRP Configuration
- IGRP Summarizations
- IGRP Verification
- IGRP Troubleshooting

✓ Processing IGRP Updates

✓ Configure BGP

- **Configuration of EIGRP IPv4 & IPv6**

- ✓ EIGRP Network Topology
- ✓ Autonomous System numbers
- ✓ Router EIGRP Commands
- ✓ EIGRP Router ID
- ✓ Passive interface
- ✓ Verifying EIGRP
- ✓ Troubleshooting of EIGRP Issues

- **Configuration of OSPF for IPv4 & IPv6**
  - ✓ OSPFv2 (Single OSPF)
  - ✓ OSPFv3 (Multi Area OSPF)
- **Configuration of router security**
  - ✓ Access Control List Types
    - Standard Access Lists
    - Extended Access Lists
  - ✓ Access List Configuration
  - ✓ Configure Filtering Devices
    - Firewalls
    - Intrusion Prevention/Detection Systems (IPS/IDS)
    - Proxy Servers
    - content Filtering Appliances
    - Load Balancers
  - ✓ Test router security

Resources required for the learning outcome	
Equipment	▪ Uninterruptible Power Supply (UPS), ▪ Routers ▪ Switches ▪ Hubs ▪ Repeaters

	▪ Gateways ▪ Bridges ▪ Modems ▪ Access Point
Materials	▪ CAT5 ▪ CAT6 ▪ Fiber optic cables ▪ Coaxial Cables ▪ BNC ▪ RJ45 ▪ RJ11
Tools	▪ Network Cable Testers ▪ Solar Winds Network Performance Monitor (NPM) ▪ Paessler PRTG Network Monitor ▪ Wireshark ▪ Cisco Thousand Eyes
Facilitation techniques	▪ Demonstration and simulation ▪ Individual and group work ▪ Trainer guided ▪ Group discussion
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation

Learning outcome 4: Maintain WAN	Learning hours: 25

Indicative content

- **Installation of WAN monitoring tools**
  - ✓ Identify Monitoring Objectives
    - Bandwidth
    - Latency
    - Packet loss
    - Security threats
  - ✓ Perform installation of suitable tools
    - Placement of Monitoring Probes
    - SPAN (Switched Port Analyzer)
    - Bandwidth Monitoring
    - Latency and Packet Loss Analysis
    - Verify Quality of Service
  - ✓ Customisation of tools.
    - Key Performance Indicators (KPIs) Selection
    - Customize dashboard.
    - Customize User Access and Roles
  - ✓ Application of WAN security monitoring
    - Identification of suspicious traffic patterns
    - DDoS attacks
    - Brute force
    - Man in the middle
  - ✓ Generation of WAN monitoring report
- **Performing hardware and software Preventive maintenance**
  - ✓ Setting of preventive measures
  - ✓ Regular Firmware and Software Updates

- ✓ Backup and Disaster Recovery

- **Performing Corrective maintenance**
  - ✓ Hardware
    - Identification of common problems and their causes
    - Repair/Replace damaged devices.
  - ✓ Software
    - Troubleshoot network configurations.
    - Update network configurations
- **Checking hardware and software functionalities**
  - ✓ Hardware
    - Connectivity
    - Status
  - ✓ Software
    - Performance
    - Status
    - Updates
    - Services of features
- **Elaboration of maintenance report**
  - ✓ Introduction to Maintenance report
  - ✓ Elements of Maintenance report
    - Client information
    - Status before maintenance
    - Implementation of solution
    - Used Tools, materials, and Equipment.
    - Status after maintenance
    - Recommendation

Resources required for the learning outcome	
Equipment	▪ Uninterruptible Power Supply (Ups)

	▪ Routers ▪ Switches ▪ Hubs ▪ Repeaters ▪ Gateways ▪ Bridges ▪ Modems
Materials	▪ CAT5 ▪ CAT6 ▪ Fiber optic cables ▪ Coaxial Cables ▪ BNC ▪ RJ45 ▪ RJ11
Tools	▪ Network Cable Testers ▪ SolarWinds Network Performance Monitor (NPM) ▪ Paessler PRTG Network Monitor ▪ Wireshark ▪ Cisco ThousandEyes
Facilitation techniques	▪ Demonstration and simulation ▪ Individual and group work ▪ Trainer guided ▪ Group discussion
Formative assessment methods /(CAT)	▪ Written assessment ▪ Oral presentation ▪ Performance assessment

Integrated/Summative assessment

HH Media Ltd is a private company operating in Kigali city, Gasabo district, Gisozi sector, has been operating with a local area network (LAN) for their office communication and data sharing needs. However, as the company grows and expands its operations, and currently operates in 3 districts (Gasabo, Rubavu, and Nyagatare) and this LAN is no longer serving them as it can't connect all these new bran ches. There is a need to establish a wide area network (WAN) to connect multiple branches and remote employees. HH Media Ltd bought a public IP from their ISP (197.243.71.70).

HH Media Ltd needs internal network to handle the problems stated above at the headquarter and at all branches.

Its usable hosts are divided in 3 departments in each district (Administration, Marketing and Production).

As a Network Transmission Technician, you are requested to setup WAN and make required configurations so that all users from different offices across each district will have ability to share information over a secured WAN and implement a way of monitoring the whole network at the headquarter and set measures to prevent issues future.

The above work is intended to be done in 6 hours.

Resources	
Tools	▪ Cutting Tools ▪ Crimping tools ▪ Drilling Tools ▪ Fixing Tool ▪ Patching Tools ▪ Network toolkit

	▪ Glue gun
Equipment	▪ Router ▪ Switch ▪ Computer ▪ Firewall ▪ Console cables ▪ Serial cables ▪ Ladder ▪ Packet Tracer ▪ EdrawMax ▪ NIC
Materials/ Consumables	▪ Internet bundles ▪ Network cables ▪ Connectors ▪ Flexible PIPE Cables ▪ Cable Trunks ▪ Cables Ties ▪ Cables clips ▪ Elbow, tee ▪ Cable Sockets ▪ Wall plugs ▪ Keystone Jacks ▪ Junction boxes ▪ Nails ▪ Insulating tape

Assessable outcomes	Assessment criteria (Based on performance criteria)	Indicator	Observation		Marks allocation
			Yes	No	
Install WAN equipment **(21%)**	WAN environment is properly prepared based on organization's infrastructure requirements	Infrastructure is evaluated			2
		Site is well prepared			4
	WAN Technology is appropriately identified based on WAN types	WAN Technologies is selected			3

	Materials and equipment are properly identified based on the WAN technologies.	Materials are selected			3
		Equipment are selected			3
		Tools are selected			3
	WAN infrastructure equipment is properly interconnected based on connection types	WAN Equipment are connected			3
Apply VLAN Configurations (42%)	VLANs are properly created based on organization's structure	VLANs are created			3
		VLANs are Verified			3
	Switchport interfaces are properly configured based on modes.	Switch port access mode is configured			3
		Switch port Trunk mode is configured			3
		Switch port interfaces are Verified			3
	VTP is appropriately configured based on created VLANs	VTP Server switch is configured			3
		VTP Client switch is configured			3
		VTP Client is added to VTP Domain			3
		VTP Configurations are Verified			3
	Inter-VLAN is effectively implemented based on created VLANs	Legacy Inter-VLAN is configured			3
		Legacy Inter-VLAN is Tested			3
	Spanning Tree Protocol (STP) is properly applied	Per-VLAN Spanning Tree is configured			3

	based on IEEE 802.1Q standards	Rapid Spanning tree Protocol is configured			3
		STP configurations are Tested			3
Apply Router configurations (27%)	Communication among devices is properly configured based on WAN requirements	IP Address are subneted.			3
		IP Address are configured.			3
	Network Address Translation (NAT) is appropriately applied based on the design	NAT is configured			3
		NAT is tested			3
	Routing protocols are well configured properly based on the design	Routing protocol are configured			3
		Routing protocols are tested			3
	WAN security is properly configured in line with the access control list and organization's measures.	Access control list are configured.			3
		Filtering devices are configured			3
		Router security is tested			3
Maintain WAN (10%)	Monitoring tools are properly installed according to WAN design	Monitoring tool are Installed			2
		Monitoring tools are customised			2
	Monitoring tools are effectively customized based on configured WAN design.	Monitoring tool are Configured			3
	Vulnerabilities are properly assessed based on generated monitoring reports.	Vulnerabilities are assessed			3

Total marks	100
Percentage Weightage	100%
Minimum Passing line % (Aggregate): 70%	

References

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