



RQF LEVEL 4



NITWO401

**NETWORKING
AND INTERNET
TECHNOLOGIES**

Wireless Network Outdoor

TRAINER'S MANUAL

October, 2024



WIRELESS NETWORK OUTDOOR

AUTHOR'S NOTE PAGE (COPYRIGHT)

The competent development body of this manual is Rwanda TVET Board ©, reproduce with permission.

All rights reserved.

- This work has been produced initially with the Rwanda TVET Board with the support from KOICA through TQUM Project
- This work has copyright, but permission is given to all the Administrative and Academic Staff of the RTB and TVET Schools to make copies by photocopying or other duplicating processes for use at their own workplaces.
- This permission does not extend to making of copies for use outside the immediate environment for which they are made, nor making copies for hire or resale to third parties.
- The views expressed in this version of the work do not necessarily represent the views of RTB. The competent body does not give warranty nor accept any liability
- RTB owns the copyright to the trainee and trainer's manuals. Training providers may reproduce these training manuals in part or in full for training purposes only. Acknowledgment of RTB copyright must be included on any reproductions. Any other use of the manuals must be referred to the RTB.

© **Rwanda TVET Board**

Copies available from:

- *HQs: Rwanda TVET Board-RTB*
- *Web: www.rtb.gov.rw*
- **KIGALI-RWANDA**

Original published version: October 2024

ACKNOWLEDGEMENTS

The publisher would like to thank the following for their assistance in the elaboration of this training manual:

Rwanda TVET Board (RTB) extends its appreciation to all parties who contributed to the development of the trainer's and trainee's manuals for the TVET Certificate IV in Networking and Internet Technologies, specifically for the module "**NITWO401: Wireless Network Outdoor**".

We extend our gratitude to KOICA Rwanda for its contribution to the development of these training manuals and for its ongoing support of the TVET system in Rwanda.

We extend our gratitude to the TQUM Project for its financial and technical support in the development of these training manuals.

We would also like to acknowledge the valuable contributions of all TVET trainers and industry practitioners in the development of this training manual.

The management of Rwanda TVET Board extends its appreciation to both its staff and the staff of the TQUM Project for their efforts in coordinating these activities.

This training manual was developed:

Under Rwanda TVET Board (RTB) guiding policies and directives



Under Financial and Technical support of



COORDINATION TEAM

RWAMASIRABO Aimable

MARIA Bernadette M. Ramos

MUTIJIMA Asher Emmanuel

Production Team

Authoring and Review

TUYISABE Annoncee

SHEMA Innocent

Validation

NSHIMIYIMANA Eugene

MUKANDAYISENGA Annualite

GATETE Patrick

Conception, Adaptation and Editorial works

HATEGEKIMANA Olivier

GANZA Jean Francois Regis

HARELIMANA Wilson

NZABIRINDA Aimable

DUKUZIMANA Therese

NIYONKURU Sylvestre

KWIZERA INGABIRE Diane

Formatting, Graphics, Illustrations, and infographics

YEONWOO Choe

SUA Lim

SAEM Lee

SOYEON Kim

WONYEONG Jeong

NDAYISABA Olivier

Financial and Technical support

KOICA through TQUM Project

TABLE OF CONTENT

AUTHOR'S NOTE PAGE (COPYRIGHT)-----	iii
ACKNOWLEDGEMENTS-----	iv
TABLE OF CONTENT -----	vii
ACRONYMS-----	viii
INTRODUCTION -----	1
MODULE CODE AND TITLE: NITWO401 WIRELESS NETWORK OUTDOOR -----	2
Learning Outcome 1: Plan wireless network outdoor installation-----	3
Key Competencies for Learning Outcome 1: Plan wireless network outdoor installation --	4
Indicative content 1.1: Identification of Network Requirements -----	7
Indicative content 1.2: Identification of Materials and Equipment -----	12
Indicative content 1.3: Design Wireless Network Topology -----	16
Learning outcome 1 end assessment -----	19
Further information to the trainer-----	24
Learning Outcome 2: Deploy wireless network outdoor -----	25
Key Competencies for Learning Outcome 2: Deploy wireless network outdoor -----	26
Indicative content 2.1 : Selection of Tools, Materials and Equipment-----	29
Indicative content 2.2: Installation of Wireless Network Devices -----	32
Indicative content 2.3: Configuration of Wireless Devices -----	37
Indicative content 2.4: Testing of Deployed Wireless Network Outdoor -----	40
Learning outcome 2 end assessment -----	43
Further information to the trainer-----	46
Learning Outcome 3: Maintain wireless network outdoor-----	47
Key Competencies for Learning Outcome 3: Maintain wireless network outdoor -----	48
Indicative content 3.1: Monitoring Wireless Network Outdoor.-----	52
Indicative content 3.2: Troubleshooting Wireless Network Outdoor . -----	56
Indicative content 3.3: Upgrading wireless Network Outdoor. -----	59
Indicative content 3.4: Document Wireless Network Outdoor.-----	62
Learning outcome 3 end assessment -----	65
Further information to the trainer-----	69

ACRONYMS

ACL :Access Control List

AP: Access Point

BoQ: Bill of Quantities

BSSID: Basic Service Set Identifier

CA: Coverage Area

CAT5e: Category 5 Enhanced

CAT6: Category 6

CAT6a: Category 6 Augmented

CBT/A: Competent Based Training/Assessment

CCNA/CCNP : Cisco Certified Network Associate / Cisco Certified Network Professional

CPE: Customer Premises Equipment

CR: Cognitive Radio

DHCP: Dynamic Host Configuration Protocol

DSSS: Direct Sequence Spread Spectrum

EIGRP: Enhanced Interior Gateway Routing Protocol

EMI/RFI :(Electromagnetic/Radio Frequency Interference)

GHz: Gigahertz

GNS3: Graphical Network Simulator

IEEE: Institute of Electrical and Electronics Engineers

IM: interference Management

IoT : Internet of Things

IP: Internet Protocol:

KOICA: Korea International Cooperation Agency

LAN: Local Area Network

LED: Light-Emitting Diode

MAC – Media Access Control:

MIMO: Multiple Input Multiple Output

MU-MIMO: Multi-User MIMO

NAT: Network Address Translation

NIC :Network Interface Card

OFDM: Orthogonal Frequency-Division Multiplexing

OFDMA: Orthogonal Frequency-Division Multiple Access

OSI: Open Systems Interconnection Model

OSPF: Open Shortest Path Firstk.

PoE: Power-Over-Ethernet

PSK – Pre-Shared Key:

PtMP: Point-to-Multipoint

PtP: Point-to-Point

QAM: Quadrature Amplitude Modulation

RF: Radio Frequency

RIP: Routing Information Protocol.

RJ45: Registered Jack 45

RTB: Rwanda TVET Board

SSID : Service Set Identifier

TPC: Transmit Power Control

TQUM Project: TVET Quality Management Project

TWT: Target Wake Time

UPS: Uninterruptible Power Supply

WPA – Wi-Fi Protected Access:

WPA2/WPA3: Wi-Fi Protected Access

INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled "**Wireless Network Outdoor.**" Trainees enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

The development of this training manual followed the Competency-Based Training and Assessment (CBT/A) approach, offering ample practical opportunities that mirror real-life situations.

The trainer's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainer, you will begin by asking questions related to the activities to encourage critical thinking and guide trainees toward real-world applications in the labor market. The manual also outlines essential information such as learning hours, didactic materials, and suggested methodologies.

This manual outlines the procedures and methodologies for guiding trainees through various activities as detailed in their respective trainee manuals. The activities included in this training manual are designed to offer students opportunities for both individual and group work. Upon completing all activities, you will assist trainees in conducting a formative assessment known as the end learning outcome assessment. Ensure that students review the key reading and the points to remember section.

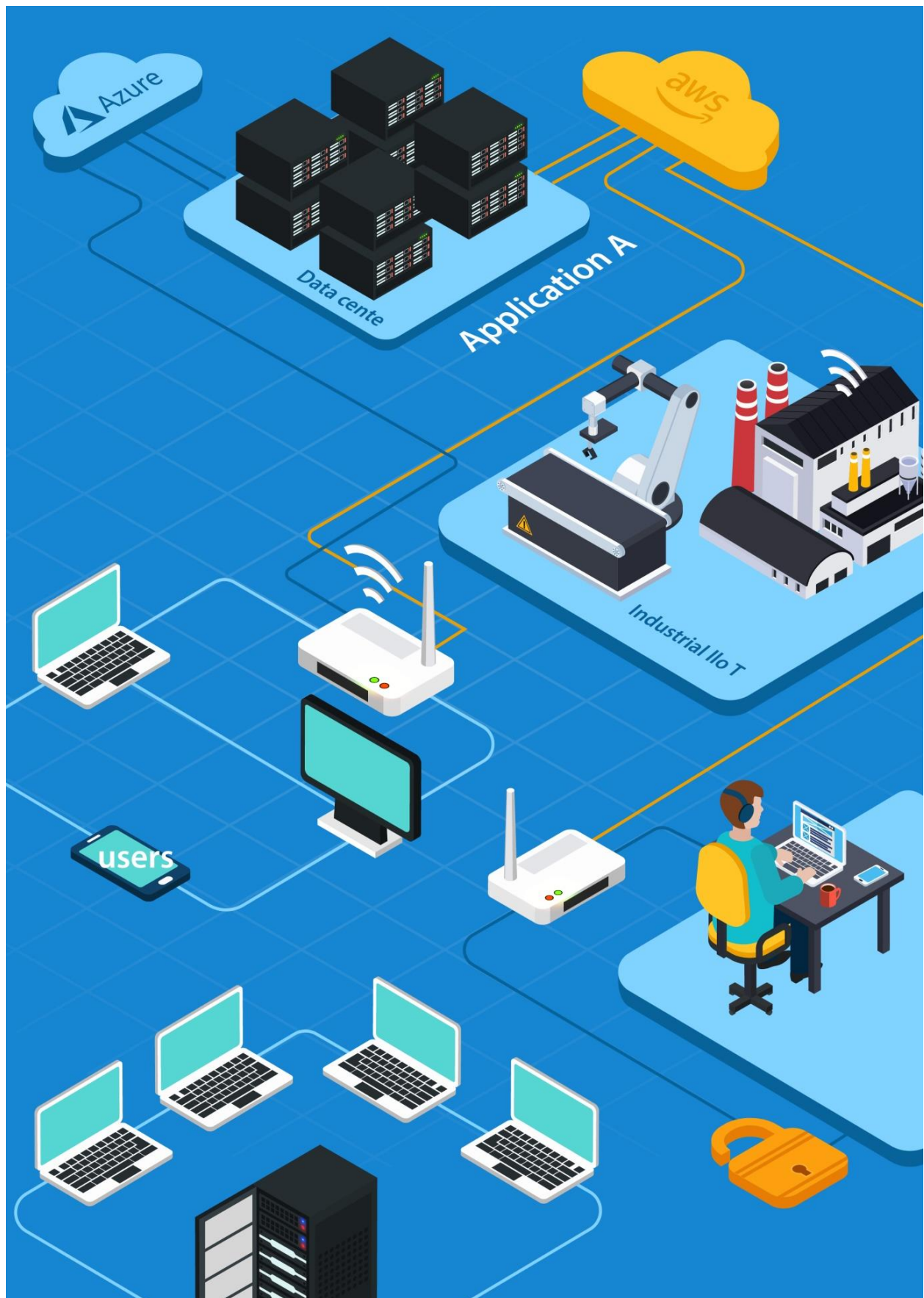
MODULE CODE AND TITLE: NITWO401 WIRELESS NETWORK OUTDOOR

Learning Outcome 1: Plan wireless network outdoor installation

Learning Outcome 2: Deploy wireless network outdoor

Learning Outcome 3: Maintain wireless network outdoor

Learning Outcome 1: Plan wireless network outdoor installation



Indicative contents

1.1 Identification of network requirements

1.2 Identification of Materials and Equipment

1.3 Design wireless network topology

Key Competencies for Learning Outcome 1: Plan wireless network outdoor installation

Knowledge	Skills	Attitudes
• Description of wireless network outdoor • Identification of wireless network outdoor areas of applications • Identification of Materials and Equipment used in wireless network outdoor installation • Description of radio frequency • Description of network topologies used to setup wireless network outdoor	• Conducting site survey for wireless network outdoor installation • Analysing site survey findings • Selecting tools, materials and equipment • Producing bill of quantity • Designing wireless network topology diagram	• Being attentive to details while recording site information • Being analytical thinker on analysing site survey • Having Accuracy on development of topology and producing bills of quantity. • Being Comprehensive by Including all relevant network components



Duration: 20hrs



Learning outcome 1 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe clearly wireless network outdoor concepts based on network standard
2. Conduct correctly site survey based on user requirements
3. Identify correctly tools, materials and equipment used in wireless network outdoor installation based on site survey findings.
4. Develop correctly bill of quantity based on network requirements
5. Design properly wireless network outdoor topology based on site survey findings



Resources

Equipment	Tools	Materials
● Computer ● Access points ● Router ● Repeater ● Wireless Extender ● Antennas ● Firewall ● PoE ● Switch ● Rack amount ● UPS ● Lightning Arrestor	● Edrawmax ● Draw.io ● Cisco packet tracer ● Lucidchart ● Site survey toolkit	● Connector ● Network Cables ● Cable ties ● Screws ● Internet Bundles ● Nails

**Advance Preparation:**

Before delivering this learning outcome, you are recommended to:

- Prepare site environment where site visit will be conducted
- Avail Site survey toolkit
- Prepare all required tools, materials and equipment



Indicative content 1.1: Identification of Network Requirements



Duration: 8hrs



Theoretical Activity 1.1.1: Description of wireless network outdoor concepts



Notes to the trainer:

- Trainer may use small groups for describing wireless network outdoor concepts.
- Trainer may use images and illustrations as didactic materials.



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to answer the following questions:

- What do you understand by wireless network outdoor?
- Describe these key terms related to wireless network outdoor:
 - Coverage area
 - Frequency spectrum
 - Antenna types and direction
 - Interference management
- Identify the application areas of wireless network outdoor

Step 2: Ask trainees to write their findings on papers or flipchart

Step 3: Ask trainees to present their findings in front of a whole class

Step 4: Provide an expert view on wireless network outdoor concepts.

Step 5: Ask trainees to read key readings 1.1.1 in trainee manual



Points to Remember

- A wireless network outdoor is a communication system designed to provide wireless internet and network connectivity across open spaces or outdoor environments
- The right type of antenna should be chosen based on the coverage area and specific application needs
- To avoid interference, Consider outdoor factors such as weather, physical obstacles, and the scale of deployment

- You need to identify potential sources of interference and Implement strategies to minimize interference, such as selecting appropriate channels and using advanced technologies like beamforming.
- The appropriate frequency bands is selected based on range, bandwidth requirements, and regulatory constraints.
- Network outdoor can be applied in many deferent area such as Public Wi-Fi hotspot, Smart City infrastructure, Wireless Surveillance and Security and Remote Connectivity



Theoretical Activity 1.1.2: Description of environment survey evaluation



Notes to the trainer:

- Trainer may use small groups for describing Environment survey evaluation
- Trainer may use images and illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions relating to the Environment survey evaluation.

- What do you understand by environment survey evaluation?
- Describe Physical Environment Survey?
- Describe Analysing Existing System?
- Describe Radio Frequency (RF) Site Survey
- Identify the main factors that should be analysed during a site survey for a wireless network to ensure optimal performance and reliability.

Step 2: Ask trainees to write their findings on paper or flipchart

Step 3: Ask trainees to present their findings in front of the whole class

Step 4: Provide expert view on Description of Environment survey evaluation.

Step 5: Ask trainees to read key readings 1.1.2 in trainee manual



Points to Remember

- An environment survey evaluation is a process of assessing the environmental conditions and their potential impact on a specific project or activity

- For clearly evaluate wireless outdoor environment you must survey the Physical Environment , Analyzing Existing System and Radio Frequency (RF) site survey
- A clearly Environment survey evaluation finds: bandwidth needs, network coverage area ,security measurement , network scalability option and weatherproof techniques



Practical Activity 1.1.3: Conducting site survey of wireless network outdoor.



Notes to the trainer

- Trainer may avail site survey toolkit
- Trainer may prepare site environment where the survey will be conducted



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask trainees to do the task described below:
WPX School want to deploy wireless network around sport field, you are requested to evaluating the environment, analysing the current system and measure RF signal strength to ensure efficient signal propagation and coverage area and then present the survey findings.
- Step 2:** Explain the task and provide clear work instruction
- Step 3:** Guide trainees in the process of environment survey evaluation
- Step 4:** Check whether trainees are able to perform survey evaluation and got the survey findings.
- Step 5:** Then after, ask trainees to present their survey findings to the class.
- Step 6:** Ask trainees to read key readings 1.1.3 in trainees manual and perform the application of learning 1.1



Points to Remember

- A site survey is a crucial step in planning and deploying a wireless network outdoors
- The key steps involved in conducting a site survey includes
 - ✓ Define the Scope

- ✓ Gathering Existing Information
- ✓ Conducting a Physical Site Visit
- ✓ Measuring RF Signal Strength
- ✓ Analyzing Environmental Factors
- ✓ Plan Antenna Placement
- ✓ Estimate Network Capacity
- ✓ Estimate Network Capacity
- ✓ Develop a Network Design
- ✓ Conduct a Pilot Deployment
- ✓ Conduct a Pilot Deployment
- ✓ Document the Site Survey



Practical Activity 1.1.4: Analysing site survey evaluation findings of wireless network outdoor.



Notes to the trainer

- Trainer may avail site survey toolkit, Ookla Speed test tool
- Trainer may avail site survey documentation



Key steps:

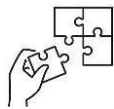
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask trainees to do the task described below:
Refer to the previous practical activity 1.1.3, validate the effectiveness of the wireless network outdoor in terms of the following aspects: Bandwidth, Network Coverage, Security, Scalability, and Weatherproofing and then elaborate the data validation report.
- Step 2:** Explain the task and provide clear work instruction
- Step 3:** Provide the site survey documentation to the trainees and guide them in the process of validating the effectiveness of the wireless network outdoor
- Step 4:** Evaluate whether all aspects were validated and if the data validation report is produced.
- Step 5:** Ask trainees to read key readings 1.1.4 in trainees manual and perform the application of learning 1.1



Points to Remember

- Ensure the appropriate bandwidth is proportional to the number of users.
- Ensure that the distance coverage is properly measured.
- Think of wireless network outdoor protection against theft, physical damage and unauthorized intruders.
- The better selection of appropriate wireless access points frequency band based on the nature of the medium.



Application of learning 1.1.

ABC school located in Kigali city want to deploy a network that interconnect both primary and secondary, the distance between primary and secondary is 1km. Secondary building is surrounded by trees and power transmission antenna. As network technician you are hired to conduct a site survey, plan the antenna placement based on description and measure the signal strength of current infrastructure

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Site survey is correctly conducted	1.1 Coverage areas are mentioned		
		1.2 Information of Existing infrastructure is described		
		1.3 Environment fact are analyzed		
		1.4 Network topology is created		
		1.5 Network Capacity is estimated		
		1.6 Antenna Placement is planed		
		1.7 Signal strength is measured		



Indicative content 1.2: Identification of Materials and Equipment



Duration: 6 hrs



Theoretical Activity 1.2.1: Description of wireless network outdoor materials and equipment



Notes to the trainer:

- Trainer may use small groups for describing wireless network outdoor Materials and Equipment.
- Trainer may use images and illustrations as didactic materials.



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions

- What do you understand by Materials and Equipment
- Describe the following Materials and Equipment of wireless outdoor network::
 - Connectors
 - Cable manager (Ties, clips, Sockets)
 - Ethernet Cable
 - Outdoor Access Points
 - Antennas
 - Wireless Extender
 - Power-Over-Ethernet
 - Lightning Arrestor
 - UPS
 - Network switch
 - Routers
 - Repeater
 - Firewall
 - Rack mount
- Describe bill of quantities

Step 2: Ask trainees to write their findings on paper or flipchart

- Step 3:** Ask trainees to present their findings in front of a whole class
- Step 4:** Provide expert view on network outdoor Materials and Equipment
- Step 5:** Ask trainees to read **key readings 1.2.1** in trainee manual



Points to Remember

- Materials are the physical components and substances used to construct and install the wireless infrastructure
- Equipment refers to the tools and devices used to install, test, and manage the wireless outdoor network
- While describing tools equipment and materials, identify the specifications of each based on functionality
- Some tools, materials and equipment differ from their type, manufacturer and the use case
- A Bill of Quantities (BoQ) is a detailed document that lists all the materials, labor, and equipment required for a project, along with their respective quantities and costs.



Practical Activity 1.2.2: Producing bill of quantity



Notes to the trainer

- Trainer may avail survey report that include the needed tools, materials and equipment.



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask the trainee to do the task bellow:
Referring to survey report that was produced in the previous practical activities (1.1.3).you are requested to produce bill of quantity of all requirement needed for deploying wireless network outdoor
- Step 2:** Explain the task and provide clear work instructions.

Step 3: Demonstrate the process of producing bills of quantity.

Step 4: Asks trainees to perform the activity of step 3 and monitor the procedures.

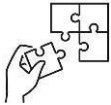
Step 5: Verify whether the tasks are clearly performed.

Step 6: Ask trainees to read the key readings 1.2.2 and perform the application of learning 1.2



Points to Remember

- The key steps involved in producing a bill of quantity
 - ✓ Create a List
 - ✓ Specify Quantities
 - ✓ Cost Estimation
 - ✓ Add Contingency
 - ✓ Compile the BoQ
 - ✓ Presentation
 - ✓ Feedback and Revision



Application of learning 1.2.

A non-profit organization plans to establish a community center in a remote rural area in Rwanda. They require a reliable and efficient wireless network to provide internet access to the community members. You are required to identify all required material, equipment and produce a bill of quantity.

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Materials needed are correctly identified	1.1 Connectors are identified		
		1.2 Cable manager (Ties, clips, Sockets) are considered		
		1.3 Ethernet Cables are identified		
2	Equipment needed are correctly identified	2.1 Outdoor Access Points are identified		
		2.2 Antennas are listed are identified		
		2.3 Wireless Extender are listed are identified		
		2.4 Power-Over-Ethernet are identified		
		2.5 Lightning Arrestor are identified		
		2.6 UPS are identified		
		2.7 Network switch are identified		
		2.8 Routers are identified		
		2.9 Repeater are identified		
		2.10 Firewall are identified		
		2.11 Rack mount are identified		
3	Bill of quantities is accurately produced	3.1 All material and equipment are mentioned with detail		
		3.2 The price are correctly calculated		
		3.3 contingency budget to handle unforeseen issues are considered		



Indicative content 1.3: Design Wireless Network Topology



Duration: 6 hrs



Theoretical Activity 1.3.1: Description of wireless network topology



Notes to the trainer:

- Trainer may use small groups for describing wireless network topology concepts.
- Trainer may use images and illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions related to wireless topology

- Define network topology
- Describe Network topology types
- Identify Advantages and disadvantages of wireless topology
- Identify network designing tools

Step 2: Ask trainees to write their findings on reserved space

Step 3: Ask trainees to present their findings in front of a whole class.

Step 4: Give clarification and expert view on wireless network outdoor concepts.

Step 5: Ask trainees to read key **readings 1.3.1** in trainee manual.



Points to Remember

- Network topology refers to the arrangement or layout of various elements (such as nodes, links, routers, and switches) in a computer or communication network.
- Wireless Topologies Include Infrastructure Mode, Ad-Hoc Mode, Mesh Topology, and Hybrid, each with unique advantages and challenges.
- Advantages of Wireless Networks is Mobility, ease of installation, scalability, convenience, and adaptability.
- Disadvantages of Wireless Networks is Limited range, interference, security concerns, slower speeds, and complexity.

- Network designing tools are software applications or platforms used by network engineers and architects to plan, design, and visualize network architectures
- Design Tools like Cisco Packet Tracer, GNS3, Microsoft Visio, and Solar Winds help in designing, simulating, and documenting network topologies.



Practical Activity 1.3.2: Designing wireless network topology



Notes to the trainer

- Trainer may avail the survey report that was produced in practical activity 1.1.3
- Trainer should avail computer installed designing tool (cisco packet trace)



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask the trainee to do the task bellow:

based on the survey report which is produced in practical activity 1.1.3, Design a topology of wireless network outdoor using any designing software that is available in the computer lab.

Step 2: Explain the task and provide clear work instruction

Step 3: Demonstrate how to produce wireless network topology

Step 4: Asks trainees to perform the activity of step 3 and monitor the procedures.

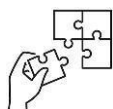
Step 5: Verify whether the tasks are clearly performed

Step 6: Ask trainee to Read key reading 1.3.2 and ask clarification where necessary



Points to Remember

- Wireless network topology determining how devices communicate with each other without physical connections.
- The key steps involved in designing Wireless network topology
 - ✓ Identify Key Components
 - ✓ Connected
 - ✓ Labeling
 - ✓ Document Configuration Details
 - ✓ Review and Validate
 - ✓ Maintain Documentation



Application of learning 1.3.

You are tasked by your school to Design a wireless outdoor network topology of your school that combine sport field area and staff department using one of the designing tools available in the computer lab.

Check list

SN	Criteria	Indicators	Observation	
			Yes	No
1	Network topology is correctly designed	1.1 All needed device and components are identified		
		1.2 All identified network devices are connected and labelled		
		1.3 Designed topology is reliable		



Learning outcome 1 end assessment

Written assessment

Section A: Read the following statement and answer by TRUE if it is correct otherwise by FALSE

1. A wireless network's coverage area is the total area that the network can serve effectively.

Answer: True

2. The frequency spectrum used in outdoor wireless networks is limited to 2.4 GHz only.

Answer: False

3. Directional antennas can focus signal strength in a specific direction, making them useful for long-distance communication.

Answer: True

4. Public Wi-Fi hotspots are typically designed for high-security applications.

Answer: False

5. A radio frequency site survey helps assess potential interference sources in a wireless network.

Answer: True

6. Bandwidth refers to the maximum data transfer rate of a network.

Answer: True

7. Outdoor access points require weatherproofing to ensure durability in harsh environmental conditions.

Answer: True

8. A repeater is used to amplify and extend the range of a wireless signal.

Answer: True

9. Analyzing site survey findings helps determine the best placement for antennas.

Answer: True

10. The firewall is used to enhance the physical security of a wireless network.

Answer: True

Section B: Multiple Choice Questions: Select the right answer

Circle the letter corresponding to the correct answer

1. Which of the following is NOT a type of outdoor antenna?
 - a) Omni-directional
 - b) Bi-directional

- c) Sub-directional
- d) Directional

Answer: c) Sub-directional

2. What is the main purpose of a lightning arrestor in an outdoor network?
- a) To increase signal strength
 - b) To protect equipment from lightning strikes
 - c) To extend the coverage area
 - d) To connect multiple devices

Answer: b) To protect equipment from lightning strikes

3. What type of network topology connects all devices to a central hub?
- a) Mesh
 - b) Star
 - c) Ring
 - d) Bus

Answer: b) Star

4. Which application would most likely utilize wireless surveillance?
- a) Smart home automation
 - b) Public Wi-Fi
 - c) Smart city infrastructure
 - d) Remote connectivity

Answer: c) Smart city infrastructure

5. When conducting a site survey, which factor is most important for determining network coverage?
- a) Number of users
 - b) Frequency interference
 - c) Type of devices
 - d) Bandwidth

Answer: b) Frequency interference

6. What does UPS stand for in networking equipment?
- a) Uninterruptible Power Supply
 - b) Universal Power System
 - c) United Power Supply
 - d) Unifying Power Source

Answer: a) Uninterruptible Power Supply

7. Which material is commonly used for outdoor network cables?

- a) PVC
- b) Fiber optic
- c) Teflon
- d) Polyethylene

Answer: d) Polyethylene

8. In a wireless network, which element manages the data traffic?

- a) Repeater
- b) Network switch
- c) Firewall
- d) Antenna

Answer: b) Network switch

9. What is the main disadvantage of a mesh topology?

- a) Complexity
- b) Cost
- c) Redundancy
- d) Scalability

Answer: a) Complexity

10. For which application is weatherproofing particularly important?

- a) Indoor networks
- b) Remote connectivity
- c) Smart city infrastructure
- d) Outdoor access points

Answer: d) Outdoor access points

Section C: Match the following terms with their descriptions by writing the letter corresponding to the correct description

Answer	TERM	DESCRIPTION
1....G....	1. Antenna Types	A. A document listing materials and costs for a project
2.....H....	2. Interference Management	B. Ability to expand a network as needed
3.....F....	3. Public Wi-Fi Hotspot	C. Device that directs data traffic between devices
4.....D....	4. Radio Frequency Site	D. Survey that identifies potential signal

	Survey	issues
5.....B....	5. Scalability	E. Provides security by monitoring incoming and outgoing traffic
6.....I....	6. Power-Over-Ethernet (PoE)	F. Outdoor location providing internet access to the public
7.....C....	7. Network Switch	G. Use antennas to focus or disperse signal
8.....J....	8. Remote Connectivity	H. System to manage and reduce signal interference
9.....E....	9. Firewall	I. Connects devices and provides power over Ethernet cables
10.....A....	10. Bill of Quantities	J. Enables users to access the network from different locations

Practical assessment

You have been hired by a city council to design an outdoor wireless network of public Wi-Fi hotspots. Your task is to assess the area then identify requirements, select appropriate materials and equipment, create a bill of quantity and create a topology diagram.

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Wireless outdoor site survey is well conduct	1.1 Coverage area is mentioned		
		1.2 Information of Existing infrastructure is described		
		1.3 Environment fact are analyzed		
		1.4 Network topology is created		
		1.5 Network Capacity is estimated		
		1.6 Antenna Placement is planed		
		1.7 Signal strength is measured		
2	Bill of quantity in well produced	2.1 All material and equipment are mentioned with detail		
		2.2 The price are correctly calculate		
		2.3 Contingency budget to handle unforeseen issues are considered		

3	Topology diagram is correctly designed	2.4 All needed device and components are identified		
		2.5 All identified network devices are connected and labelled		
		2.6 Designed topology is reliable		

END



Further information to the trainer

Adams, G. (2022, March 18). Effective Upgrading of Wireless Networks. Retrieved from IT Network Guides: www.itnetworkguides.com/upgrading-wireless

Brown, D. (2023, June 25). Troubleshooting Outdoor Wireless Networks. Retrieved from Network Troubleshooting: www.networktroubleshooting.com/outdoor

Brown, S. (2023, June 20). RF Site Survey Best Practices. Retrieved from Network World: www.networkworld.com/rf-site-survey

Doe, J. (2023, October 10). Outdoor Wireless Networks. Retrieved from Network Solutions: www.networksolutions.com/outdoor-wireless

Johnson, A. (2023, September 10). Monitoring Wireless Networks. Retrieved from Network Performance Solutions: www.networkperformancesolutions.com/monitoring

Johnson, E. (2022, August 15). Designing a Public Wi-Fi Network. Retrieved from Wi-Fi Alliance: www.wi-fi.org/public-network-design

Lee, B. (2023, August 5). Understanding Signal Strength and SNR. Retrieved from Wireless Tech Insights: www.wirelesstechinsights.com/signal-strength

Miller, F. (2023, April 30). Analyzing Packet Loss in Wireless Networks. Retrieved from Network Analysis Today: www.networkanalysistoday.com/packet-loss

Roberts, A. (2023, February 8). Weatherproofing Outdoor Equipment. Retrieved from Tech Innovations: www.techinnovations.com/weatherproofing

Smith, C. (2022, July 15). Tools for Monitoring Wi-Fi Performance. Retrieved from Tech Monitoring Hub: www.techmonitoringhub.com/wifi-tools

Smith, J. (2023, September 25). Understanding Wireless Technologies. Retrieved from TechRadar: www.techradar.com/wireless-tech

White, E. (2023, May 20). Firmware Management for Wi-Fi Devices. Retrieved from Cybersecurity Best Practices: www.cybersecuritybestpractices.com/firmware

White, L. (2022, April 18). Interference in Wireless Networks. Retrieved from TechSpot: www.techspot.com/interference

Wilson, J. (2023, December 1). Documenting Wireless Network Changes. Retrieved from IT Documentation Hub: www.itdocumentationhub.com/wireless

Wilson, T. (2023, May 30). Antenna Types Explained. Retrieved from Antenna World: www.antennaworld.com/types

Learning Outcome 2: Deploy wireless network outdoor



Indicative contents
2.1 Selection of tools, Materials and Equipment
2.2 Installation of wireless network devices
2.3 Configuration of wireless devices
2.4 Testing of deployed wireless network outdoor

Key Competencies for Learning Outcome 2: Deploy wireless network outdoor

Knowledge	Skills	Attitudes
● Identification of tools, materials and equipment used in deploying wireless network outdoor ● Description of wireless standards used in wireless network outdoor ● Description of Wireless Network Outdoor-Specific Features ● Description of wireless network devices configurations parameters	● Selecting tools, Materials and Equipment used in deploying wireless network outdoor ● Mounting network equipment ● Making and testing network cable ● Connecting network devices ● Configuring wireless network devices ● Testing deployed wireless network outdoor	● Being Attention to Detail when Selecting tools, Materials and Equipment and mounting them in proper space ● Being Patience and Perseverance while deploying and testing wireless outdoor network ● Having Problem-Solving Mindset during mounting network devices ● Being Analytical Thinker while reviewing configuration options such as SSID, channels, security protocols (e.g., WPA3), and bandwidth.



Duration: 40hrs



Learning outcome 2 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Identify correctly tools, materials and equipment used in deploying wireless network outdoor
2. Select appropriately tools, materials and equipment used in deploying wireless network outdoor
3. Mount correctly wireless network components based on the user requirements
4. Describe clearly Wireless Network Outdoor-Specific Features based on manufacturers standard
5. Describe clearly wireless network devices configurations parameters based on device specification
6. Perform correctly network cabling based on device placement
7. Configure correctly wireless network devices based on network standard
8. Test correctly the deployed outdoor wireless network



Resources

Equipment	Tools	Materials
• Access points • Router • Repeater • Wireless Extender • Antennas • Firewall • PoE • Switch • Rack amount	• Edrawmax • Draw.io • Cisco packet tracer • Lucidchart	• Connector • Network Cables • Cable ties • Screws • Internet Bundles • Nails

• Computer • UPS • Lightning Arrestor		
 Advance Preparation: Before delivering this learning outcome, you are recommended to: • Prepare work place where wireless network devices will be mounted • Avail all needed tools, materials and equipment used in mounting wireless network outdoor • Avail site survey report and topology of the network that need to be deployed		



Indicative content 2.1 : Selection of Tools, Materials and Equipment



Duration: 5hrs



Theoretical Activity 2.1.1: Description of tools, materials and equipment used in deploying wireless network outdoor



Notes to the trainer:

- Trainer may use small groups to describe tools, materials and equipment used in deploying wireless network outdoor
- Trainer may use images or illustration as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce activity and ask trainees to answer the following questions
- i. Differentiate these key terms: tools, materials and equipment
 - ii. Describe and classify these tools and mentions their role in wireless network outdoor deployment:
 - a. Cutting tools
 - b. Patching tools
 - c. Crimping tools
 - d. Drilling tools
 - e. Testing tools
 - f. Fixing tools
- Step 2:** Ask trainees to write their findings on reserved space
- Step 3:** Ask trainees to present their findings in front of a whole class
- Step 4:** Ask trainees to take notes for the clarifications given
- Step 5:** Ask trainees to read key readings 2.1.1 and address question if any.



Points to Remember

- While describing tools equipment and materials, identify the specifications of each based on manufacturer
- Tools are often handheld and assist in performing precise or manual tasks.

- Materials are the components or ingredients that are transformed or combined to create the final product
- Equipment typically involves more advanced technology and is used for tasks that cannot be done efficiently with hand tools alone.
- tools, materials and equipment differ from their type, manufacturer and the use case
- Some tools, materials and equipment are of the same types, you need to provide clear identifications and specifications to differentiate them.



Practical Activity 2.1.2: Selecting tools, materials and equipment



Notes to the trainer

- The trainer may avail all tools, materials and equipment that will be used in installing wireless network outdoor
- Avail survey document report and topology of the network that is going to be deployed



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to perform this task

Refer to the practical activity 1.1.2 and 1.3.2, select tools, materials and equipment that will be used to deploy the wireless network outdoor.

Step 2: Provide clear work instructions

Step 3: Guide trainees in selecting tools, materials and equipment

Step 4: Check whether all needed tools, materials and equipment are selected

Step 5: Ask trainees to read key readings 2.1.2

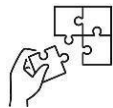
Step 6: Ask trainees to perform the application of learning 2.1



Points to Remember

- Before selecting tools, materials, and equipment, you need to review the survey report and network topology in detail.

- While selecting tools, materials and equipment, consider the Environmental Conditions, Coverage Area and Range, Frequency Bands and Spectrum Availability, Network Equipment Specifications to ensure reliable performance, coverage, and durability.
- When selecting tools consider the Durability and Weather Resistance, Portability, Precision and Versatility
- When selecting materials consider the Environmental Resilience, Durability and Strength, Shielding and Interference Protection
- When selecting equipment consider the Licensing and Support, Equipment Cost and Maintenance Costs
- Bad selections result in failed deployment, thus ensure that the tools, materials and equipment you select are the best for deployment



Application of learning 2.1.

LMT Cyber café located near of your school has recently conducted a site visit for the new a reliable and weather-resistant wireless outdoor deployment. The survey report and the network design were obtained. The manager of café need you to go in their store and select the necessary tools, materials, and equipment for deploying a reliable and weather-resistant outdoor wireless network.

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Tools, materials and equipment are correctly selected	1.1 Tools are selected		
		1.2 Materials are selected		
		1.3 Equipment are selected		



Indicative content 2.2: Installation of Wireless Network Devices



Duration : 15hrs



Theoretical Activity 2.2.1: Description of wireless standards



Notes to the trainer:

- Trainer may avail images , table of standard , illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to respond to these questions

- Describe these wireless network standard, their applications and their use case. Along with these details, give the advantage and disadvantages for each.
 - IEEE802.11a
 - IEEE802.11b
 - IEEE802.11n
 - IEEE802.11ac
 - IEEE802.11ax

Step 2: Ask trainees to write their answers on paper or flipchart

Step 3: Ask trainees to share their answers within their respective group

Step 4: Ask trainees to present their answers in front of a whole class

Step 5: Address questions or clarifications

Step 6: Ask trainees to read key readings 2.2.1



Points to Remember

- 802.11a and 802.11b were among the earliest standards, offering moderate speeds, with 802.11b providing wider adoption and range at the cost of slower speed.
- 802.11n improved both speed and range with MIMO technology and dual-band support.

- 802.11ac (Wi-Fi 5) brought much faster speeds and better performance on the 5 GHz band, while 802.11ax (Wi-Fi 6) focuses on efficiency, higher throughput, and handling many devices at once in dense environments, with improved performance in both the 2.4 GHz and 5 GHz bands. Wi-Fi 6E further extends this by adding the 6 GHz band for even higher performance and capacity.



Theoretical Activity 2.2.2: Description of Wireless Network Outdoor-Specific Features



Notes to the trainer:

- Trainer may avail images , illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce activity and ask trainees to provide answers to the following questions:

- i. Describe these Wireless Network Outdoor-Specific Features:
 - a. Point-to-Point (PtP) Bridging
 - b. Point-to-Multipoint (PtMP) Bridging
 - c. Wireless Mesh Networking
 - d. Outdoor Antenna Alignment
 - e. Long-Range Considerations
 - f. Quality of Service (QoS)

Step 2: Ask trainees to write their findings on the paper or flipchart

Step 3: Ask trainees to present their findings in front of a whole class

Step 4: After the presentations, give clarifications, address questions or concern.

Step 5: Ask trainees to read key reading 2.2.2



Points to Remember

- Point-to-Point (PtP) Bridging Requires clear line-of-sight (LOS) between two points to ensure optimal performance whereas point to multipoint can sometimes operate in near-line-of-sight (NLOS) conditions depending on the technology used.

- When aligning an outdoor antennas Take into account environmental factors (e.g., wind, rain) that might impact antenna stability and alignment over time.
- Ensure low-latency communication for applications like VoIP and video conferencing by setting appropriate QoS rules.



Theoretical Activity 2.2.3: Description of key considerations in Mounting network equipment and connecting devices



Notes to the trainer:

- Trainer may use small groups to describe the key considerations in mounting equipment and connecting network devices.
- Trainer may avail images, videos and illustrations as didactic materials.



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce activity and ask trainees to provide answers to the following questions:
- What do you understand by mounting network equipment?
 - Identify the Importance of Mounting Network Equipment
 - Describe the key factors to consider when connecting devices and mounting network equipment
 - Define the following terms:
 - Cable management
 - Cable Security
- Step 2:** Ask trainees to write their finding on paper or any other reserved space
- Step 3:** Ask trainees to present their findings in front of a whole class
- Step 4:** Address questions and clarification
- Step 5:** Ask trainees to read key readings and do the application of learning 2.2



Points to Remember

- Choosing the right mounting hardware requires careful consideration of the equipment's physical characteristics, the mounting environment, and security needs. Durability, ease of installation, and compatibility are key factors in

ensuring a safe, stable, and long-lasting installation, especially in demanding outdoor environments.

- When mounting network equipment and connecting devices, it is crucial to focus on physical stability, environmental protection, alignment, power supply, and security. Ensuring that equipment is properly mounted and connections are secure guarantees reliable network performance, ease of maintenance, and safety in both indoor and outdoor installations.



Practical Activity 2.2.4: Mounting network equipment, cabling and connecting devices

Notes to the trainer

- The trainer may avail tools, materials and equipment needed for Mounting network equipment and connecting devices
- Prepare environment where network equipment will be mounted
- Have personal protective equipment and ensure that every one is using them properly



Key steps:

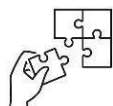
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activity and ask trainees to read and perform the stated activity
Refer to the practical activity **2.1.2**, go to the area where network equipment will be mounted and then mount network equipment in strategic locations. After mounting device, perform cabling based on device placement and ensure proper connectivity between devices.
- Step 2:** Explain the activity and give all needed tools, materials and equipment to Mount network equipment, cabling and connect devices
- Step 3:** Demonstrate the whole process of Mounting network equipment, cabling and connecting devices
- Step 4:** Ask trainees to repeat themselves the task of mounting network equipment and connecting devices
- Step 5:** Check whether if the equipment are properly mounted and connected then Give clarifications and address questions
- Step 6:** Ask trainees to read key readings 2.2.4 and do the application of Learning 2.2



Points to Remember

- Mount the network equipment in appropriate locations to avoid interferences.
- Properly connect network devices such as routers, access points, and switches.
- Ensure safe cable routing and management to enhance network connectivity



Application of learning 2.2.

You are hired for deploying a robust wireless network solution for a remote campus. The campus consists of multiple buildings, some of which are far apart, requiring both indoor and outdoor connectivity solutions. The project involves deploying access points based on different wireless standards, establishing outdoor connections between buildings, ensuring coverage in all areas, and setting up the necessary infrastructure (cabling, mounting equipment, etc.).

You must also ensure optimal performance with Quality of Service (QoS) for specific applications.

Checklist :

SN	Criteria	Indicators	Observation	
			Yes	No
1	Wireless network devices are correctly installed	1.1 Wireless standard are identified		
		1.2 Wireless Network Outdoor-Specific Features are applied		
		1.3 Network equipment are mounted		
		1.4 Cabling and connection of devices are done		



Indicative content 2.3: Configuration of Wireless Devices



Duration: 15hrs



Theoretical Activity 2.3.1: Description of wireless devices configurations



Notes to the trainer:

- Trainer may use small groups for describe the configurations wireless devices



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and ask trainees to respond to the following questions

- Describe these key terms:
 - DHCP
 - DNS
 - NAT
 - VPN
 - Wireless extender
 - Firewall
 - Proxy server
 - Content filtering
 - Quality of service
 - Logging and reporting
- Describe the access point settings

Step 2: Ask trainees to write their answers on a reserved space

Step 3: Ask trainees to present their answers to the whole class

Step 4: Address questions and clarifications

Step 5: Ask trainees to read key readings 2.3.1 and do the application of learning 2.3



Points to Remember

- While configuring a wireless network device choose a recognizable and unique SSID.
- Optionally, hide the SSID to prevent it from being visible to casual users (though this does not add significant security).
- Properly configuring access point settings ensures optimized performance, strong security, and reliable coverage for all users on the wireless network.



Practical Activity 2.3.2: Configuring wireless Network Devices



Notes to the trainer

- The trainer avail all needed tools, materials and equipment needed to configure and test wireless devices



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request trainees to read and perform this task accordingly

Refer to the previous practical activity 2.2.4, go where the wireless devices were installed and then configure those Wireless devices.

Step 2: Explain the scenario and give the clear work instructions. also give trainees all needed tools, materials and equipment

Step 3: Demonstrate the process of configuring wireless devices

Step 4: Ask trainees to Configure wireless network devices by yourself by following the demonstrated process

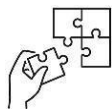
Step 5: Give clarifications and address questions

Step 6: Ask trainees to read key readings and do the application of Learning 2.2



Points to Remember

- Ensure the network is secure and protected from unauthorized access.
- Set strong password to enhance security
- Record key configurations for each access point, such as the SSID, security settings, IP addresses, and channels used
- Ensure that the selected channels are free from heavy interference from neighbouring networks.



Application of learning 2.3.

You are tasked with configuring a robust outdoor wireless network for a university campus. The network must provide consistent and reliable connectivity across various outdoor areas, including courtyards, walkways, and sports fields, ensuring that students, staff, and guests can access the internet and campus resources seamlessly.

Checklist

SN	Criteria	Indicators	Observation	
			Yes	No
1	Wireless network outdoor devices are correctly configured	1.1 Multiple access points SSIDs are specified		
		1.2 SSIDs are assigned to the access points		
		1.3 Channels are set		
		1.4 Transmit power settings are adjusted		
2	Network Security is correctly configured	2.1 WPA3 or WPA2 is chosen		
		2.2 MAC Address Filtering is added		
		2.3 Network Segmentation is applied		



Indicative content 2.4: Testing of Deployed Wireless Network Outdoor



Duration: 5hrs



Theoretical Activity 2.4.1: Description of the basic tests for the deployed wireless network



Notes to the trainer:

- Trainer may use small groups for describing the basic tests for the deployed wireless network
- Use image or illustrations as didactic material



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activity and ask trainees to respond to the following questions:
- Describe the following terms:
 - connectivity testing
 - security testing
 - performance testing
 - Identify the main tools used to test connectivity , security and performance
- Step 2:** Ask trainees to write their answers on a paper or flipchart
- Step 3:** Ask trainees to present their answers to the whole class
- Step 4:** Address questions and clarifications
- Step 5:** Ask trainees to read key readings 2.4.1 and do the application of learning 2.4



Points to Remember

- You have to check the coverage, signal strength, and stability of the wireless connection across different locations for verifying that devices can reliably connect to a network and communicate with each other.
- Ensure that the network is secure and resilient against potential threats by evaluating the safety measures of a network to protect it against unauthorized access, data breaches, and other security threats.

- Use properly the tools which corresponds to the testing type for getting accurate result.



Practical Activity 2.4.2: Testing the deployed wireless network outdoor



Notes to the trainer

- Trainer may avail all needed tools, materials and equipment needed to test the deployed wireless network outdoor



Key steps:

While delivering this activity, pass through the following steps:

- Step 1:** Introduce the activity and request trainees to read and perform this task accordingly
Referring to the practical activity 2.3.2, test the Deployed wireless network for connectivity, security, and performance to ensure that the network meets the required standards for reliable and secure wireless communication.
- Step 2:** Give the clear work instructions.
- Step 3:** Demonstrate the process of testing the deployed wireless network
- Step 4:** Ask trainees to repeat themselves the task of testing the deployed wireless network
- Step 5:** Give clarifications and address questions
- Step 6:** Ask trainees to read key readings and do the application of Learning 2.4



Points to Remember

- For connectivity testing, focus on coverage, signal strength, stability, and user experience.
- For security testing, assess vulnerabilities, conduct penetration testing, monitor for threats, and ensure compliance.
- For performance testing, measure throughput, latency, jitter, packet loss, and conduct load testing.
- Make sure that you use specialized tools for each testing type to ensure thorough and accurate assessments.



Application of learning 2.4.

XYZ School has recently deployed wireless network outdoor for their new building, they need you to test that network for connectivity, security, and performance to ensure that the network meets the required standards for reliable and secure wireless communication.

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Deployed wireless network outdoor is properly tested	1.1 Connectivity is tested		
		1.2 Performance is tested		
		1.3 Security is tested		



Learning outcome 2 end assessment

Theoretical assessment

Multiple choice questions

1. Circle the correct answer

I. Which of the following is a cutting tool?

- a) Ethernet Cable
- b) Wire Stripper
- c) Outdoor Antenna
- d) Nano Station

Answer: b) Wire Stripper

II. Which equipment is used to prevent power surges from damaging network devices?

- a) Firewall
- b) Lightning Arrestor
- c) Ethernet Cables
- d) Access Point

Answer: b) Lightning Arrestor

III. What does IEEE802.11ac refer to?

- a) Cable manager
- b) Wireless standard
- c) Testing tool
- d) Power-Over-Ethernet

Answer: b) Wireless standard

IV. Which device connects multiple network devices and forwards data based on MAC addresses?

- a) Router
- b) Network switch
- c) Wireless extender
- d) Nano Station

Answer: b) Network switch

2. Write true if the statement is correct and false if it is not correct

- I. Ethernet cables are materials used in network installation.

Answer: True

- II. A Point-to-Multipoint (PtMP) wireless bridge is used to connect a single device to a network.

Answer: False

- III. A crimping tool is used to terminate cables by attaching connectors.

Answer: True

- IV. IEEE802.11n is a wireless standard that supports only outdoor wireless networks.

Answer: False

- V. A UPS is used to ensure continuous power to network equipment during power outages.

Answer: True

3. Match the elements/ devices in the column A with their role in column B by writing the letter corresponding to the correct uses

Answer	Column A	Column B
1.....C.....	1. Wireless extender	A. Ensures uninterrupted power
2.....E.....	2. Patch tools	B. Used for cable management
3.....D.....	3. PoE (Power-Over-Ethernet)	C. Extends the wireless network
4.....A.....	4. Rack mount	D. Provides power through Ethernet cable
5.....B.....	5. Cable manager	E. Used for cable repairs

Practical assessment

You have been hired by a small business located in a multi-building campus environment to deploy an outdoor wireless network. The business requires seamless and reliable wireless connectivity across the entire campus to support day-to-day operations, including secure communication, video conferencing, and file sharing. You are tasked with selecting the appropriate tools, materials, and equipment, install and configure wireless devices, connect

three main buildings and an outdoor recreational area and then test the deployed network for connectivity, performance and security.

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Tools, materials and equipment are correctly selected	1.1 Tools are selected		
		1.2 Materials are selected		
		1.3 Equipment are selected		
2	Network devices are correctly installed and configured	2.1 Network standards and features are selected		
		2.2 Network devices are installed		
		2.3 Network devices are configured		
3	Network devices are correctly mounted and connected	3.1 Network devices are mounted		
		3.2 Network devices are connected		
4	Deployed wireless network is perfectly tested	4.1 Connectivity is tested		
		4.2 Performance is tested		
		4.3 Security is tested		

END



Further information to the trainer

Ciprian Adrian Rusen (Mars, 2020), How to choose a wireless router: 10 things to consider, URL: <https://www.digitalcitizen.life/things-consider-when-buying-wireless-router> Accessed on April 17 2023.

<https://www.akibia.com/what-factors-to-consider-when-selecting-network-cabling/>

Lee, B. (2023, August 5). Understanding Signal Strength and SNR. Retrieved from Wireless Tech Insights: www.wirelesstechinsights.com/signal-strength

Mark Kyrnin (June 2020), Installing a PCI Adapter Card, URL: <https://www.lifewire.com/pci-adaptcard-installation-833860>

Matthew S. Gast (2005). 802.11 Wireless Networks. The Definitive Guide, Second Edition. O'Reilly Media. Pp 187-317.

URL: <http://blog.dlink.com/how-to-extend-your-network-with-a-wireless-bridge/>

Learning Outcome 3: Maintain wireless network outdoor



Indicative contents

3.1 Monitoring wireless network Outdoor

3.2 Troubleshooting wireless network Outdoor

3.3 Upgrading wireless network Outdoor

3.4 Document wireless network Outdoor

Key Competencies for Learning Outcome 3: Maintain wireless network outdoor

Knowledge	Skills	Attitudes
• Description of wireless network outdoor Monitoring Metrics • Identification of tools used in network performance monitoring • Description of wireless controllers in managing multiple access points • Description of hardware components potential failure points. • Description of diagnostic commands for network troubleshooting • Description of wireless network outdoor upgrade	• Analysing wireless outdoor monitoring metric findings • Selecting monitoring metric tools used in wireless outdoor • Conducting physical inspections of wireless hardware • using diagnostic commands • Developing technical reports • Generating a technical journal for tracking wireless outdoor network changes	• Being Attentive to Detail while Analysing wireless outdoor monitoring metric and conduct physical inspections of wireless hardware • Being analytical thinker on Selecting monitoring metric tools • Being Proactive while monitoring and troubleshooting wireless network outdoor • Being Problem-Solver while troubleshooting

• Description of technical report and Technical Journals		wireless network outdoor • Being organized while Developing technical reports and maintaining a technical journal
--	--	--



Duration: 20 hrs



Learning outcome 3 objectives:

By the end of the learning outcome, the trainees will be able to:

1. Describe clearly Monitoring Metrics as used in wireless network outdoor
2. Describe clearly Monitoring Tools used in wireless network outdoor
3. Describe clearly Access Point Controllers based on monitoring metric
4. Conducting clearly physical inspections of wireless outdoor network hardware.
5. Describe clearly hardware components for potential failure points
6. Troubleshoot correctly wireless network Outdoor based environment fact
7. Use correctly troubleshooting Diagnosing commands of wireless network outdoor
8. Upgrade correctly wireless network Outdoor based on factor of wireless network outdoor
9. Generate properly technical reports and Technical journal of wireless network Outdoor



Resources

Equipment	Tools	Materials
● Router ● Wireless Extender ● Firewall ● PoE ● Switch ● UPS	● Ladder ● Drilling machine ● Tape Measure ● Hammer ● Networking tool Kit ● Cable tester ● Clipping tools ● Cisco packet tracer ● Edrawmax ● GSN3 ● Wireshark	● Connector (RJ45) ● Cable ties ● Screws ● Internet Bundles ● Nails ● Network cables

	• Solar Wind network performance • Wi-Fi Analyser(insider, NetSpot) • PRTG Network Monitor • Wi-Spy Spectrum Analyze • PingPlotter	
--	--	--



Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Prepare all tools, materials and equipment needed for Monitoring wireless network Outdoor



Indicative content 3.1: Monitoring Wireless Network Outdoor.



Duration: 4hrs



Theoretical Activity 3.1.1: Description of monitoring metrics and tools



Notes to the trainer:

- Trainer may use small groups for describing Monitoring metrics of wireless network outdoor.
- Trainer may use images and illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions

- Describe the following monitoring metrics :
 - Signal Strength (Bandwidth and Latency)
 - Signal to noise Ratio
 - Data throughput
 - Jitter
 - Packet Loss and Re-transmissions
- Describe the following monitoring tools
 - Monitoring Tools
 - Wireshark
 - Solar Winds Network Performance
 - Wi-Fi Analyser
- Describe clearly Access points controllers

Step 2: Ask trainees to present their findings in front of a whole class

Step 3: Give clarification and expert view on description of monitoring metrics and tools.

Step 4: Ask trainees to read key readings 3.1.1 in trainee manual



Points to Remember

- Network performance refers to the quality and effectiveness of a network system. It involves evaluating and reviewing the speed, connectivity, reliability, and efficiency of a network.
- Wireless network monitoring metrics are measurements used to assess the performance, reliability, and efficiency of a wireless network
- Key indicators of network performance include bandwidth, latency, throughput, jitter, and error rate. High-performing networks reliably transmit high volumes of data quickly and securely, with minimal delays or errors, improving productivity and user experience.
- Monitoring Tools are software applications or hardware devices used to track and analyze the performance, health, and security of a network or system
- Wireshark is a powerful open-source network protocol analyzer that allows you to capture and inspect data traffic on a network.
- Solar Winds Network Performance Monitor is a commercial, enterprise-grade tool designed to monitor and manage the performance of a network
- Wi-Fi Analyzer is a user-friendly tool that helps monitor and analyze wireless networks by visualizing the signal strength and channel usage of nearby Wi-Fi networks.
- Access Point Controllers are network devices or software solutions designed to manage and control multiple wireless access points (APs) within a network



Practical Activity 3.1.2: Measuring Signal Strength (RSSI) ,signal to noise Ratio(SRN), Data throughput, Jitter, Packet Loss and Re-transmissions using Acrylic Wi-Fi Analyzer network monitoring tool



Notes to the trainer

- The trainer avail tools Computer installed Acrylic Wi-Fi Analyzer as a network monitoring tool



Key steps:

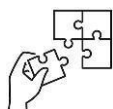
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask trainees to do the task described below:
Measure Signal Strength,signal to noise Ratio(SRN), Data throughput, Jitter, Packet Loss and Re-transmissions of your school wireless network in various locations using Acrylic Wi-Fi Analyzer network monitoring tool to identify areas of strong and weak coverage.
- Step 2:** Explain the task and provide clear work instruction
- Step 3:** Demonstrate the process of Measuring Signal Strength (RSSI) ,signal to noise Ratio(SRN), Data throughput, Jitter, Packet Loss and Re-transmissions
- Step 4:** Ask trainees to repeat themselves the task of Measuring Signal Strength (RSSI) ,signal to noise Ratio(SRN), Data throughput, Jitter, Packet Loss and Re-transmissions then monitoring the activity
- Step 5:** Give clarifications and address questions
- Step 6:** Ask trainees to read key 3.1.2 readings and do the application of Learning 3.1



Points to Remember

- When measuring network capacity, you firstly download Acrylic Wi-Fi Analyzer network monitoring tool on the trustfully website.
- Remember to walk around with your laptop and observe how the RSSI values change as you move closer or farther from the access point (AP).
- Record all collected data and identify patterns



Application of learning 3.1.

As a technician you are requested to measure a public smart city Wi-Fi to find the Signal Strength (Bandwidth and Latency), Signal to noise Ratio, Data throughput, Jitter, Packet Loss and Re-transmissions and write down the measurement

Checklist:

SN	Criteria	Indicators	Observation	
			YES	NO
1	Network signals are correctly measured	1.1 Signal Strength (Bandwidth and Latency) are measured		
		1.2 Signal to noise Ratio are measured		
		1.2 Data throughput are measured		
		1.3 Jitter are measured		
		1.4 Packet Loss and Re-transmissions are measured		



Indicative content 3.2: Troubleshooting Wireless Network Outdoor .



Duration: 8 hrs



Theoretical Activity 3.2.1: Description of Wireless outdoor troubleshooting



Notes to the trainer:

- Trainer may use small groups for describing troubleshooting Steps of wireless network outdoor.
- Trainer may use images and illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions

- Describe the key factors that can affect wireless network Outdoor performance
- Describe the following command :
 - Ping
 - Traceroute
 - netsh wlan show interfaces
 - IWconfig
 - Ifconfig

Step 2: Ask trainees to write their findings on paper or flipchart

Step 3: Ask trainees to present their findings in front of a whole class

Step 4: Give clarification and expert view on troubleshoot wireless network outdoor

Step 5: Ask trainees to read key readings 3.2.1 in trainee manual



Points to Remember

- Troubleshoot refers to the process of diagnosing and resolving problems or issues within a system, network, or device
- Key factors that can affect wireless network Outdoor performance should include obstructions, interference, weather Conditions, Terrain and Elevation



Practical Activity 3.2.2: Troubleshooting wireless network Outdoor



Notes to the trainer

- Trainer should prepare avail cisco access point
- Trainer may prepare working environment



Key steps:

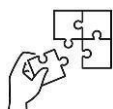
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask trainees to do the task described below:
Referring to the practical activity 2.3.2, you are requested to troubleshoot the deployed wireless network Outdoor
- Step 2:** Explain the task and provide clear work instruction
- Step 3:** Demonstrate process of You are requested to troubleshooting wireless network Outdoor
- Step 4:** Asks trainees to perform the activity of step 3 and monitor the procedures
- Step 5:** Ask trainees to read key readings 3.2.2 in trainee manual



Points to Remember

- Troubleshoot wireless network outdoor include Physical Inspection , Environment Factors, Check Software and Configuration Review
- Use Diagnosing Commands like ping and traceroute, ifconfig ,iwconfig or netsh wlan show interfaces to identifier network problem
- Regularly check for firmware updates from the manufacturer's website.
- Update the firmware either by group or device as long all the devices are of the same group or device type.
- Select the appropriate Firmware Version (for Base Firmware, Access Point Type) and Modem Slot (for Cellular Modem Firmware).
- Review the current configurations of each AP. Ensure settings such as SSID, encryption protocols (e.g., WPA3), channel assignments, and bandwidth limits are optimized for your network needs.



Application of learning 3.2.

A remote office is experiencing intermittent connectivity issues with their wireless outdoor access point. Users report slow speeds and frequent disconnections. Troubleshoot the problem, Diagnostic Commands that can be used then provide Possible Solutions Based on Findings

Check list:

SN	Criteria	Indicators	Observation	
			Yes	No
1	Troubleshoot process is properly proceeded	1.1 Step to identifier problem are well listed		
		1.2 Solution provide is based on problem finding		
		1.3 Possible solution is provided		
		1.4 Update firmware is noted in possible solution		
		1.5 Review of current configuration done		
2	Diagnosing Commands to use are indetify	2.1 Ping command are used		
		2.2 Traceroute command are use		
		2.3 Network Scanning are used		
		2.4 Signal Strength Measurement are used		



Indicative content 3.3: Upgrading wireless Network Outdoor.



Duration: 4 hrs



Theoretical Activity 3.3.1: Description of upgrade wireless network outdoor



Notes to the trainer:

- Trainer may use small groups for describing wireless network outdoor upgrading and step to upgrade.
- Trainer may use images and illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions

- Describe the contexts where to upgrade wireless network outdoor.
- Describe the important of the following Factors while Upgrading wireless outdoor
 - Coverage and Range
 - Bandwidth and Throughput
 - Interference and Noise
 - Security
 - Scalability
 - Durability and Weather Resistance
 - Power and Connectivity

Step 2: Ask trainees to write their findings on paper or flipchart

Step 3: Ask trainees to present their findings in front of a whole class

Step 4: Provide expert view on upgrade wireless network outdoor concept

Step 5: Ask trainees to read key readings 3.3.1



Points to Remember

- Upgrade refers to the process of improving or enhancing a system, software, hardware, or infrastructure to a newer, more advanced, or more efficient version
- Upgrading can be apply to various contexts :
 - ✓ Installing a new version of an application or operating system
 - ✓ Replacing or adding components to improve the performance or capabilities of a device
 - ✓ Enhancing systems like networks or facilities to meet increased demands or improve efficiency.
- Factors of upgrading wireless network outdoor include :
 - ✓ Coverage and Range
 - ✓ Bandwidth and Throughput
 - ✓ Interference and Noise
 - ✓ Security
 - ✓ Scalability
 - ✓ Durability and Weather Resistance
 - ✓ Power and Connectivity



Practical Activity 3.3.2: Upgrading wireless network outdoor



Notes to the trainer

- Trainer should avail cisco access point(AC)
- Trainer may prepare working environment



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask the trainee to do the task bellow:

Referring to the practical activity 3.2.2, you are requested to upgrade firmware of access point of deployed wireless network outdoor

Step 2: Explain the task and provide clear work instruction

Step 3: Demonstrate the process of upgrading wireless network outdoor

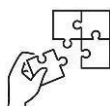
Step 4: Asks trainees to perform the activity of upgrading wireless network outdoor and monitor the procedures

Step 5: Ask trainee to Read key reading 3.3.2 and ask clarification where necessary



Points to Remember

- Firmware files can be downloaded through: Trivial File Transfer Protocol (TFTP) or Hypertext Transfer Protocol/with Secure Sockets (HTTP/HTTPS)
- Download last version of firmware of cisco website
- When you are upgrading the firmware, it is recommended to use wired Internet connection on your computer to avoid interruption during the upgrade process.



Application of learning 3.3.

SXV Community Park hosts events and recreational activities on area of 2 hectare. The existing Wi-Fi network is slow and has limited coverage, causing frustration for visitors who rely on connectivity. you are requested to upgrade wireless network outdoor in the park to Increase internet speed to support multiple users

Checklist:

SN	CRITERIA	INDICATORS	Observation	
			YES	NO
1	Upgrade of new wireless network is correctly performed	1.1 A new version of an application or operating system is installed		
		1.2 Components are added /replaced		
		1.3 Networks facilities to meet increased demands or improve efficiency is done		
		1.4 The cover the coverage and range are upgraded		
		1.5 Equipment supports are upgraded		



Indicative content 3.4: Document Wireless Network Outdoor.



Duration: 4 hrs



Theoretical Activity 3.4.1: Description of Technical Reporting and Journal Review



Notes to the trainer:

- Trainer may use small groups for describing wireless network outdoor concepts.
- Trainer may use images and illustrations as didactic materials



Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and request learners to respond to the following questions

- Describe Technical Reports part
- Describe a technical journal

Step 2: Ask trainees to write your findings on Paper or flipchart

Step 3: Ask trainee to Present their findings in front of a whole class

Step 4: Give clarification and expert view on wireless network outdoor concept

Step 5: Ask trainees to read key readings 3.4.1 in trainee manual



Points to Remember

- A report is a document that presents information in an organized format for a specific audience and purpose
- Types of reports include memos, minutes, lab reports, book reports, progress reports, justification reports, compliance reports, annual reports, and policies and procedures.
- Main sections of the standard report writing format is :
 - ✓ Title Section
 - ✓ Summary:
 - ✓ Introduction
 - ✓ Experimental details

- ✓ Results
 - ✓ Body
 - ✓ Conclusion
 - ✓ Recommendations
 - ✓ Appendices
- Remember that the information needs to be organized logically with the most important information coming first.
 - The document is generally clear and concise, but some sections could be further streamlined.
 - The summary effectively conveys the main points of the document, but it could be slightly more detailed.
 - The experimental details section is well-structured, providing a clear overview of the troubleshooting process.
 - The results section could be enhanced by providing more specific data and metrics to support the conclusions.



Practical Activity 3.4.2: Documenting wireless network Outdoor



Notes to the trainer

- Trainer may use small groups for describing wireless network outdoor Materials and Equipment.
- Trainer may use images and illustrations as didactic materials.



Key steps:

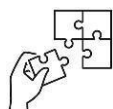
While delivering this activity, pass through the following steps:

- Step 1:** Introduce the topic and ask the trainee to do the task bellow:
You are requested to document troubleshoot procedure of wireless network outdoor
- Step 2:** Explain the task and provide clear work instruction
- Step 3:** Demonstrate the process of document wireless network Outdoor
- Step 4:** Asks trainees to make documentation of deployed wireless network outdoor and monitor the procedures
- Step 5:** Ask trainee to Read key reading 3.4.2 and ask clarification where necessary



Points to Remember

- A report is a document that presents information in an organized format for a specific audience and purpose
- Types of reports include memos, minutes, lab reports, book reports, progress reports, justification reports, compliance reports, annual reports, and policies and procedures.
- Main sections of the standard report writing format is :
 - ✓ Title Section
 - ✓ Summary:
 - ✓ Introduction
 - ✓ Experimental details
 - ✓ Results
 - ✓ Body
 - ✓ Conclusion
 - ✓ Recommendations
 - ✓ Appendices
- Remember that the information needs to be organized logically with the most important information coming first.



Application of learning 3.4.

As a network technician after installation of wireless network outdoor in XYZ Company, you are asked to create an official network documentation to ensure that the company retains all the knowledge that went into creating the network as well as how to maintain and upgrade it.

Checklist:

SN	Criteria	Indicators	Observation	
			Yes	No
1.	Wireless network outdoor is properly documented	1.1 All key sections of a documentation are available		
		1.2 Details with accurate quantity and descriptions are identified		
		1.3 All technical terms are described		



Learning outcome 3 end assessment

Theoretical assessment

Section A : True or False question

Read the following statement related to wireless network outdoor and answer True if the statement is correct or False if the statement is wrong

1. Signal strength is a critical metric for assessing the performance of an outdoor wireless network.

Answer: True

2. A higher signal-to-noise ratio typically indicates a better quality connection.

Answer: True

3. Data throughput refers to the total amount of data transmitted successfully over a network in a given time.

Answer: True

4. Jitter is the variation in packet delay in a network, which can affect real-time communications.

Answer: True

5. Wireshark is a hardware tool used for monitoring wireless networks.

Answer: False

6. Antenna alignment has no effect on the signal quality of a wireless network.

Answer: False

7. Firmware updates are unnecessary for maintaining optimal network performance.

Answer: False

8. Packet loss can lead to a significant decrease in the quality of service for applications like video streaming.

Answer: True

9. SolarWinds Network Performance is primarily used for analyzing wired networks only.

Answer: False

10. Technical reports should include detailed documentation of network performance metrics.

Answer: True

Section B: Multiple Choice Questions Select the right answer

Circle the letter corresponding the correct answer

1. Which metric indicates the quality of a wireless connection relative to background noise?

- a) Bandwidth
- b) Signal to Noise Ratio
- c) Jitter
- d) Packet Loss

Answer: b) Signal to Noise Ratio

2. What is the primary purpose of a Wi-Fi Analyzer?

- a) To configure routers
- b) To visualize network traffic
- c) To assess and optimize Wi-Fi performance
- d) To upgrade firmware

Answer: c) To assess and optimize Wi-Fi performance

3. Which of the following is NOT a factor to check when troubleshooting hardware issues in outdoor networks? a) Antenna alignment

- b) Cables integrity
- c) Signal strength
- d) Software configuration

Answer: d) Software configuration

4. Which of the following tools would you use to monitor data packets in a wireless network? a) SolarWinds

- b) Wireshark
- c) NetFlow
- d) PingPlotter

Answer: b) Wireshark

5. What does packet retransmission indicate?

- a) Efficient network performance
- b) High bandwidth usage
- c) Network congestion or errors
- d) Normal operation

Answer: c) Network congestion or errors

6. Which of the following is a common step in upgrading a wireless network? a) Disable all access points

- b) Review current configurations
- c) Change the frequency spectrum
- d) Disconnect all users

Answer b) Review current configurations

7. What environmental factor can impact outdoor wireless network performance? a) Temperature

- b) Rain and humidity
- c) Obstructions like trees and buildings
- d) All of the above

Answer: d) All of the above

8. Which command would you use to check connectivity to another device on the network? a) traceroute
b) ipconfig
c) ping
d) netstat

Answer: c) ping

9. What type of documentation is essential for maintaining a record of network changes and performance? a) User manuals
b) Technical reports
c) Installation guides
d) Marketing materials

Answer : b) Technical reports

10. Which tool can help in identifying and resolving network performance issues? a) Wireshark
b) Word Processor
c) Spreadsheet software
d) Photo editing software

Answer : a) Wireshark

Section C Match the following terms with their descriptions used in wireless network outdoor and write the letter corresponding to the correct description

Answer	TERM	DESCRIPTION
1.....J.....	1. Signal Strength	A. Variation in packet arrival times
2.....E.....	2. Packet Loss	B. The effectiveness of data transmission over time
3.....G.....	3. Firmware Updates	C. The process of identifying and resolving network issues
4.....D.....	4. Wi-Fi Analyzer	D. Tool used to assess wireless network performance
5.....F.....	5. Antenna Alignment	E. Loss of data packets during transmission
6.....I.....	6. Latency	F. Adjustment for optimal wireless signal reception
7.....B.....	7. Data Throughput	G. Regular updates to software controlling hardware
8.....A.....	8. Jitter	H. Documentation of ongoing network performance
9.....C.....	9. Troubleshooting	I. Time delay in data transmission
10.....H.....	10. Technical Journal	J. Measurement of signal quality
		K. Survey that identifies potential signal issues
		M. Review current configurations

Practical assessment

You are a part of a network management team responsible for maintaining an outdoor wireless network deployed in a public park. The network is used for public Wi-Fi access and smart city applications, including surveillance cameras and environmental sensors. Your task is to monitor the measure network performance, troubleshoot issues, upgrade the system as needed, and document all findings and actions taken.

Checklist:

SN	Criteria	Indicators	Observation	
			YES	NO
1	Network signals/ performance are correctly measured	1.1 Signal Strength (Bandwidth and Latency) are measured		
		1.2 Signal to noise Ratio are measured		
		1.3 Data throughput are measured		
		1.4 Jitter are measured		
		1.5 Packet Loss and Re-transmissions are measured		
2	Troubleshoot process is properly proceeded	2.1 Solution provide is based on problem finding		
		2.2 Update firmware is noted in possible solution		
		2.3 Review of current configuration is done		
3	Diagnosing Commands are properly used	3.1 Ping command are used		
		3.2 Traceroute command are use		
		3.3 Network Scanning are used		
		3.4 Signal Strength Measurement are used		
4	Upgrade of new wireless network is correctly performed	4.1 A new version of an application or operating system is installed		
		4.2 Networks facilities to meet increased demands or improve efficiency is done		
		4.3 The cover the coverage and range are upgraded		
		4.4 Equipment supports are upgraded		
1.	Wireless network outdoor is properly documented	5.1 All key sections of a documentation are available		
		5.2 Details with accurate quantity and descriptions are identified		
		All technical terms are described		

END



Further information to the trainer

Adams, G. (2022, March 18). Effective Upgrading of Wireless Networks. Retrieved from IT Network Guides: www.itnetworkguides.com/upgrading-wireless

Brown, D. (2023, June 25). Troubleshooting Outdoor Wireless Networks. Retrieved from Network Troubleshooting: www.networktroubleshooting.com/outdoor

Brown, S. (2023, June 20). RF Site Survey Best Practices. Retrieved from Network World: www.networkworld.com/rf-site-survey

Doe, J. (2023, October 10). Outdoor Wireless Networks. Retrieved from Network Solutions: www.networksolutions.com/outdoor-wireless

Johnson, A. (2023, September 10). Monitoring Wireless Networks. Retrieved from Network Performance Solutions: www.networkperformancesolutions.com/monitoring

Johnson, E. (2022, August 15). Designing a Public Wi-Fi Network. Retrieved from Wi-Fi Alliance: www.wi-fi.org/public-network-design

Lee, B. (2023, August 5). Understanding Signal Strength and SNR. Retrieved from Wireless Tech Insights: www.wirelesstechinsights.com/signal-strength

Miller, F. (2023, April 30). Analyzing Packet Loss in Wireless Networks. Retrieved from Network Analysis Today: www.networkanalysistoday.com/packet-loss

Roberts, A. (2023, February 8). Weatherproofing Outdoor Equipment. Retrieved from Tech Innovations: www.techinnovations.com/weatherproofing

Smith, C. (2022, July 15). Tools for Monitoring Wi-Fi Performance. Retrieved from Tech Monitoring Hub: www.techmonitoringhub.com/wifi-tools

Smith, J. (2023, September 25). Understanding Wireless Technologies. Retrieved from TechRadar: www.techradar.com/wireless-tech

White, E. (2023, May 20). Firmware Management for Wi-Fi Devices. Retrieved from Cybersecurity Best Practices: www.cybersecuritybestpractices.com/firmware

White, L. (2022, April 18). Interference in Wireless Networks. Retrieved from TechSpot: www.techspot.com/interference

Wilson, J. (2023, December 1). Documenting Wireless Network Changes. Retrieved from IT Documentation Hub: www.itdocumentationhub.com/wireless

Wilson, T. (2023, May 30). Antenna Types Explained. Retrieved from Antenna World: www.antennaworld.com/types



October 2024