RQF LEVEL 4

NITFO401

NETWORKING AND INTERNET TECHNOLOGIES

Fiber Optic Network Deployment

TRAINEE'S MANUAL

October, 2024

FIBER OPTIC NETWORK DEPLOYMENT

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

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COORDINATION TEAM

RWAMASIRABO Aimable
MARIA Bernadette M. Ramos
MUTIJIMA Asher Emmanuel

Production Team

Authoring and Review

AMINA Adele

NSHIMIYIMANA Eugene

Validation

MPATSWENUMUGABO Vedaste

TUYISABE Annoncee

MANIRAGUHA Denys

Conception, Adaptation and Editorial works

HATEGEKIMANA Olivier

GANZA Jean Francois Regis

HARELIMANA Wilson

NZABIRINDA Aimable

DUKUZIMANA Therese

NIYONKURU Sylvestre

UMEREWENEZA Naasson

Formatting, Graphics, Illustrations, and infographics

YEONWOO Choe
SUA Lim
SAEM Lee
SOYEON Kim
WONYEONG Jeong
HAKIZAYEZU Adrien

Financial and Technical support

KOICA through TQUM Project

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ACRONYMS

BER: Bit Error Rate
EMI: Electromagnetic Interference
FC: Ferrule Connector
LAN: Local Area Network
LAN: Local Area Network
LC: Lucent Connector
LSPM: Light Source and Power Meter
MT: Multi-Fiber
MT: Multimode Trunk
NMS: Network Management System
ODF: Fiber Optic Distribution Frame
ONT: Optical Network Terminal
OPM: Optical Power Meter
OTDR: Optical Time-Domain Reflectometer
PDUs: Install Power Distribution Units
PPE: Personal Protective Equipment
QoS: Quality of Service (QoS) and Security
ROW: Right-of-Way
RTB: Rwanda TVET Board
SAN: Storage Area Network
SC: Straight Connector
SC: Subscriber Connector
SFP: Small Form Factor Pluggable
ST: Straight Tip
TQUM Project: TVET Quality Management Project
VFL: Visual Fault Locator
VLANs: Virtual Local Area Networks
WDMs: Wavelength Division Multiplexers

INTRODUCTION

This trainee's manual includes all the knowledge and skills required in **Networking and Internet Technologies**, specifically for the module of **" Fiber Optic Network Deployment".** 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.

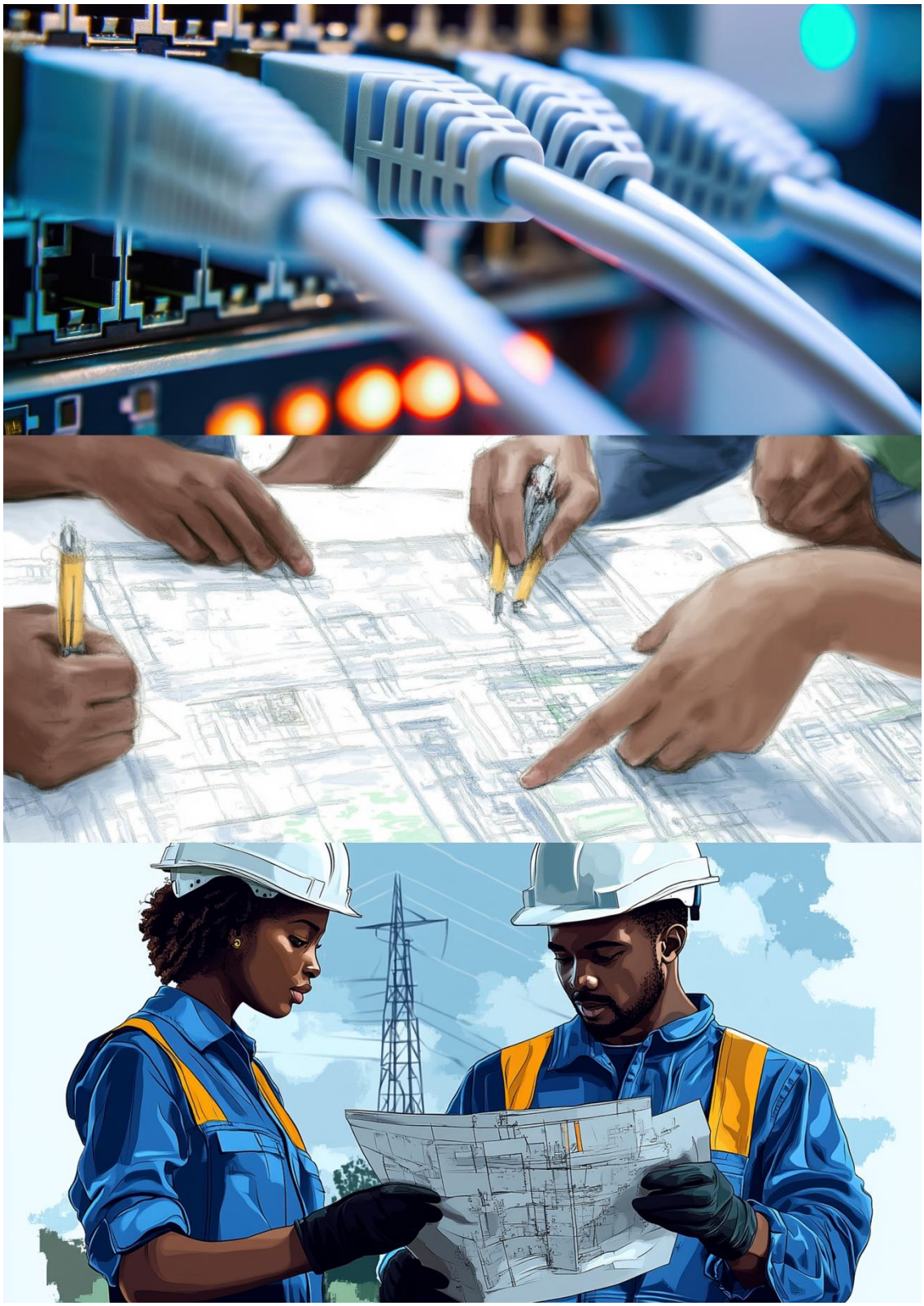
The trainee's manual is organized into Learning Outcomes, which is broken down into indicative content that includes both theoretical and practical activities. It provides detailed information on the key competencies required for each learning outcome, along with the objectives to be achieved.

As a trainee, you will start by addressing questions related to the activities, which are designed to foster critical thinking and guide you towards practical applications in the labor market. The manual also provides essential information, including learning hours, required materials, and key tasks to complete throughout the learning process.

All activities included in this training manual are designed to facilitate both individual and group work. After completing the activities, you will conduct a formative assessment, referred to as the end learning outcome assessment. Ensure that you thoroughly review the key readings and the 'Points to Remember' section.

MODULE CODE AND TITLE: NITFO410 FIBER OPTIC NETWORK DEPLOYMENT

Learning Outcome 1: Plan fiber network
Learning Outcome 2: Implement fiber optic network
Learning Outcome 3: Maintain fiber optic network



Indicative contents
1.1 Conducting site survey **1.2 Identification of materials and equipment** **1.3 Design Fiber optic network**

Key Competencies for Learning Outcome 1: Plan Fiber Optic Network

Knowledge	Skills	Attitudes
• Description of fiber optic and network connection • Interpretation of fiber optic network topology • Identification of materials and equipment used in fiber optics network • Identification of components of fiber optic network	• Applying data collection and preparing bill of quantities • Selecting transmission equipment • Calculating link loss budget • Selecting fiber optic route • Scheduling the installation • Producing route map	• Having critical thinking while planning for fiber optic network • Having self-confidence while planning fiber optic network • Being hard worker in planning fiber optic network

Duration:15 hrs

Learning outcome 1 objectives:

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

1. Describe properly fiber optic and network connection according to fiber optic site environment
2. Interpret properly fiber optic network topology according to the site survey findings
3. Identify correctly components used in fiber optic network based on Fiber optic network design
4. Identify correctly different characteristic of fiber optic cables based on the design.
5. Identify correctly Materials and equipment used in planning fiber optic network.
6. Conduct properly site survey according to fiber optic environment.
7. Design properly fiber optic network according to the site survey findings.

Resources

Equipment	Tools	Materials
● Router ● switch ● Media converter ● Small form factor pluggable (SFP) ● Fiber optic light source tester ● Optical Fiber optic closure ● Optical Fiber Distribution Frame (ODF)	● Pooling machine ● Blowing machine ● Splicing machine ● Optical timer ● Domain ● Reflectometer ● Tubing cutter ● Buffer tube cuter ● Pliers ● read light ● Jacket stripper ● Kevlar scissor ● Tweezers	● Fiber optic cable ● Optical fiber jumper cords (OJC) ● Optical Connectors ● Fusion splice sleeves ● Mechanical splice connectors ● Fiber optic cable ducts and conduits ● Fiber optic cable trays and supports

Indicative content 1.1: Conducting Site Survey

Duration: 5 hrs

Theoretical Activity 1.1.1: Description of fiber optic

Tasks:

1. 1: Answer the following questions:
   i. What do you understand by the following terms?
      a. Fiber optic cable
      b. Fiber optic network
      c. Loop ring
   ii. What are the types of fiber optic cables?
   iii. Identify different parts of fiber optic cables.
   iv. List out fiber color codes.
   v. Describe the characteristics of fiber optic cables.
2. Write your findings on papers, flipchart, blackboard or white board.
3. Present your findings to the trainer and/or classmates.
4. Ask questions for clarifications where necessary.
5. Read the key readings 1.1.1

Key readings 1.1.1: Description of fiber optic

- **Definition of key terms**

✓ **Fiber optics**

It is the science of transmitting data, voice, and images by the passage of light through thin, transparent fibers. In telecommunications, fiber optic technology is used to link computers within local area networks. Fiber optics is also the basis of the fiberscopes used in examining internal parts of the body.

✓ **Fiber optic cable**

Fiber optic cable is a high-speed data transmission medium. It contains tiny glass or plastic filaments that carry light beams.

✓ **Fiber optic network**

A fiber optic network is a system that uses fiber optic cables to transmit data and information over long distances using light signals.

✓ **Loop ring**

Loop ring typically refers to a specific network topology used to improve reliability and ensure continuous service.

- **Types of fiber optic cables**

Fiber optic cables are essential for high-speed data transmission, offering significantly higher bandwidth and longer distances compared to traditional copper cables. There are two primary types:

✓ **Single-Mode Fiber (SMF)**

Core size: Extremely small (8-9 microns).
Light paths: Carries only one mode of light.
Applications: Ideal for long-distance transmission, such as intercity networks and backbone networks.
Advantages: Minimal signal distortion, low attenuation, and high data rates.

Fig2.1 ingle mode fiber

✓ **Multimode Fiber (MMF)**

Core size: Larger (50 or 62.5 microns).
Light paths: Can carry multiple modes of light simultaneously.
Applications: Suitable for shorter distances within buildings or campuses.
Advantages: Lower cost, easier installation, and can be used with LED light sources.

Fig :multimode fiber.

➢ ***Within Multimode Fiber, there are different categories based on their bandwidth capabilities:***

OM1: Oldest type, supports 100 Mbps.
OM2: Supports 1 Gbps.
OM3: Supports 10 Gbps.
OM4: Supports 100 Gbps.
OM5: Supports 400 Gbps and beyond.
Parts of a Fiber Optic Cable

- **Parts of fiber optic cable**

✓ ***A fiber optic cable consists of the following parts:***

Core: The central part of the cable made of glass or plastic. This is where the light travels.

Cladding: A layer surrounding the core with a lower refractive index. This helps confine the light within the core.

Buffer Coating: A protective layer that shields the core and cladding from environmental factors like moisture, temperature fluctuations, and mechanical stress.

Strength Member: A high-strength material, often steel or aramid fiber, that provides structural support to the cable.

Jacket: The outer covering of the cable that protects the inner components and provides mechanical protection

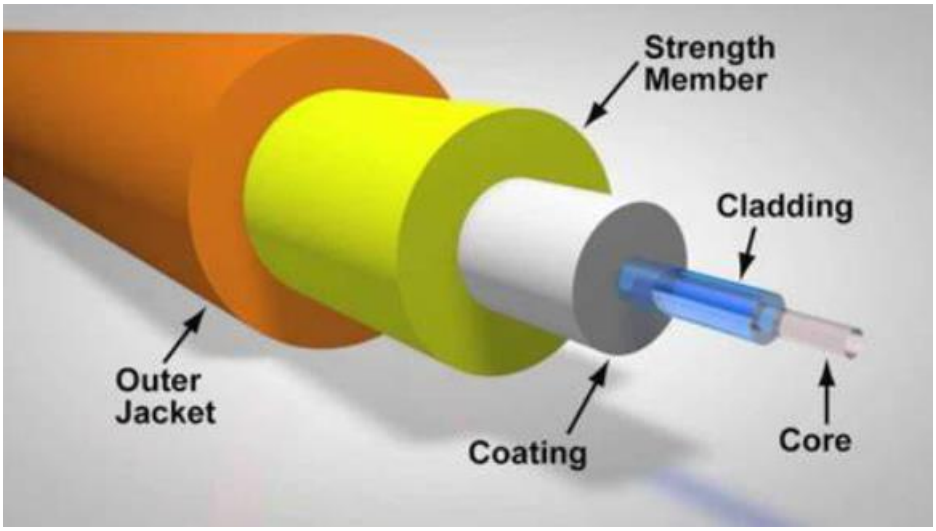


Fig: Picture illustrating main parts of fober optic cable.

- **Fiber Optic color code cables:**

Fiber optic cables have color codes for the individual fibers inside them. A common standard is the TIA-598-C color code, which includes the following:

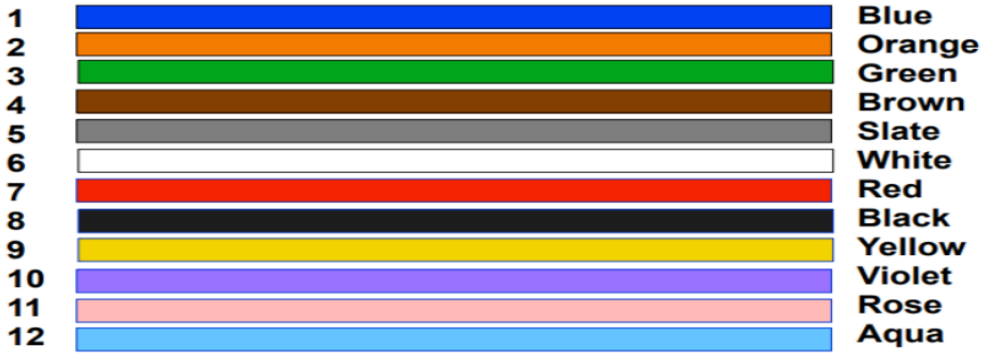


Fig: Picture illustrating Fiber Optic color code cables

- **Characteristics of fiber optic cable**

Fiber optic cables have several characteristics that make them highly effective for various applications:

- ✓ **High Bandwidth**: Fiber optics can carry a significantly larger amount of data compared to traditional copper cables. This makes them ideal for high-speed internet and telecommunications.

- ✓ **Low Signal Loss**: Fiber optic cables experience minimal signal loss over long distances, allowing for longer cable runs without the need for signal boosters
- ✓ **Immunity to Electromagnetic Interference (EMI)**: Unlike copper cables, fiber optics are not affected by electromagnetic interference, making them suitable for environments with high electrical noise.
- ✓ **Electrical Isolation**: Since fiber optics use light to transmit data, they do not conduct electricity. This eliminates the risk of electrical shocks and ground loops.
- ✓ **Lightweight and Small Size**: Fiber optic cables are much lighter and thinner than copper cables, which makes them easier to install and requires less physical space.
- ✓ **Security**: Fiber optics are more secure than copper cables because they are difficult to tap into without being detected.
- ✓ **Durability**: Fiber optic cables are resistant to harsh environmental conditions, including temperature fluctuations and moisture.

Theoretical Activity 1.1.2: Identification of fiber optic connection types

Task:

1: Answer the following question:

i. Describe the types of fiber optic network connection.

2: Write your findings on paper, flipcharts, blackboard or white board.

3: Present your findings to the trainer or classmates.

4: Ask questions for clarification where necessary.

5: Read the key readings 1.1.2

Key readings 1.1.2: Identification of types of fiber optic connection

- **Types of fiber optic network connections**
- ✓ **Dedicated connection**

A dedicated fiber optic connection provides a direct, private link between two points. This means that the entire bandwidth of the fiber is exclusively allocated to the specific users or devices connected at each end.

- ➢ **Key characteristics of dedicated connection:**

High bandwidth: Offers high data transmission speeds.

Low latency: Ensures minimal delay in data transmission.

Security: Provides a secure and private connection, reducing the risk of data interception.
Reliability: Offers high reliability and uptime, making it suitable for critical applications.
Scalability: Can be easily scaled to meet increasing bandwidth demands.

- **Common use of dedicated connection**

Enterprise networks: Connecting multiple locations within a company.
Data centres: Providing high-speed connectivity between servers and storage devices.
Telecommunications networks: Transporting large volumes of data over long distances.

- ✓ **Point-to-multipoint connection**

A point-to-multipoint fiber optic connection is a network topology where a single fiber optic cable connects a central hub to multiple remote locations. This allows for efficient sharing of bandwidth among multiple users.

- **Key characteristics:**

Shared bandwidth: The available bandwidth is divided among the connected devices.
Cost-effective: Can be more cost-effective than dedicated connections for multiple users.
Flexibility: Allows for easy addition or removal of remote locations.
Potential for congestion: Can experience congestion during peak usage times.

- **Common use of point-to-multipoint connection**

Access networks: Connecting residential or business customers to a central network.
Wireless backhauls: Providing connectivity between base stations in wireless networks.
Video distribution: Distributing video content to multiple locations.

Theoretical Activity 1.1.3: Identification of fiber optic network topology

Task:

1: Answer the following questions:

i. Define the term fiber optic network topology.
ii. Identify different types of fiber optic network topologies.

2: Write your findings on papers, flipcharts, blackboard or white board.
3: Present your findings /answer to the trainer or classmates.
4: Pay attention to the trainer's clarifications and ask questions where necessary.
5: Read the key readings 1.1.3

Key readings 1.1.3: Identification of fiber optic network topology

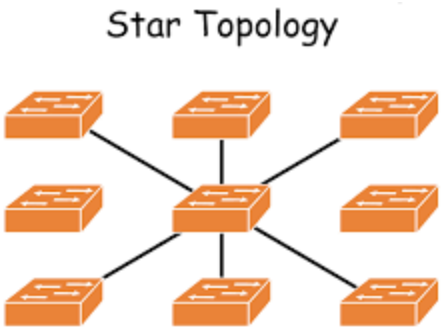
- **Definition**

Fiber optic network topologies refer to the arrangement of nodes (devices) and links (connections) within a fiber optic network. The choice of topology depends on factors such as the size of the network, scalability requirements, and desired performance characteristics.

- **Common fiber optic network topologies**

✓ **Star topology**

- Central hub: A central switch or router connects all other devices
- Point-to-point connections: Each device has a dedicated connection to the central hub
- Advantages: Easy to manage, high reliability, and good scalability.
- Disadvantages: Single point of failure, high cabli.



✓ **Ring topology**

- Circular arrangement: Devices are connected in a circular loop.
- Data transmission: Data flows in a single direction around the ring.
- Advantages: High fault tolerance, easy to add or remove devices.
- Disadvantages: Complex installation, potential for congestion.

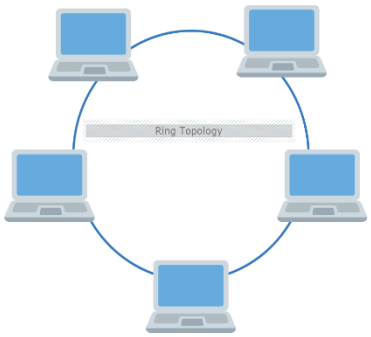


Fig: *Ring topology fiber optic network*

✓ **Mesh Topology**

- Multiple connections: Each device is connected to multiple other devices.
- Redundancy: Provides high fault tolerance and redundancy.
- Advantages: Scalable, robust, and suitable for large networks.
- Disadvantages: Complex installation and management, high cabling costs.

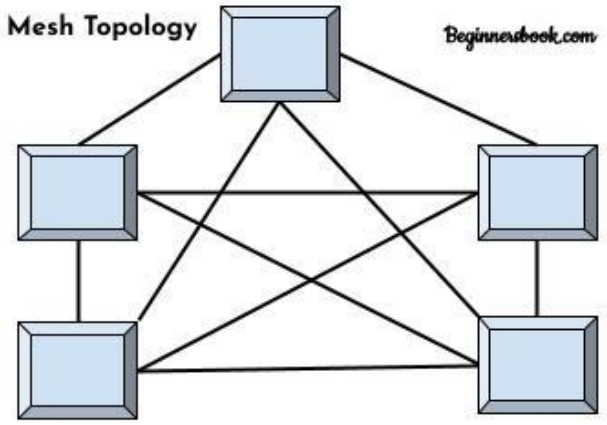


Fig: Mesh topology fiber optic network

- ✓ **Tree Topology**
  - Hierarchical structure: Devices are arranged in a hierarchical structure, resembling a tree.
  - Central node: A central node connects to multiple subordinate nodes.
  - Advantages: Easy to manage, scalable, and suitable for large networks.

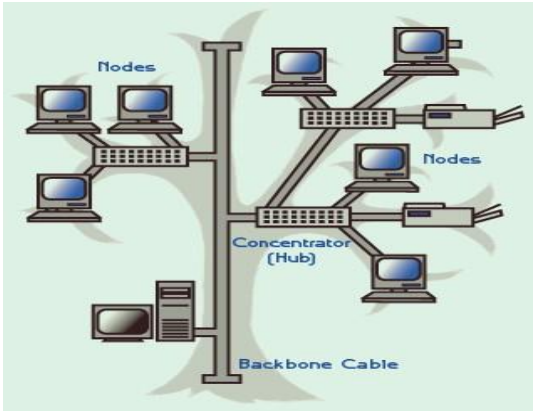


Fig: Tree topology

Disadvantages: Single point of failure at the central tree topology fiber optic network

- ✓ **Hybrid Topology**
  - Combination: Combines elements of multiple topologies.

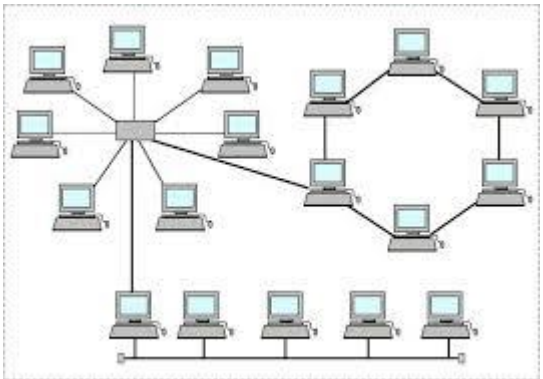


Fig: Hybrid topology fiber optic network

- ✓ **Factors to consider when choosing a topology:**

- Network size: Larger networks may benefit from mesh or hybrid topologies.
- Scalability: Scalable topologies like mesh or hybrid are suitable for growth.
- Reliability: Redundant topologies like mesh offer higher reliability.
- Cost: Cabling costs and complexity can vary between topologies.

Practical Activity 1.1.4: Collecting data

Task:

1. You are requested to go in the workshop/workplace and collect data required for fiber optic network
2. Apply safety precautions (wear the PPE)
3. Present the steps to collect data about fiber optic network.
4. Collect the data about fiber optic network.
4. Present your data to the trainer and /or classmates.
5. Ask questions for clarifications where necessary.
6. Read the key readings 1.1.4

Key readings 1.1.4: Collecting data

- **Introduction**

Data collection is a crucial step in the planning and deployment of fiber optic networks. It helps ensure efficient network design, minimize costs, and avoid potential issues during installation.

- **Key considerations for data collection**

✓ **Surveying:**

Conduct thorough surveys to gather detailed information about both terrain details and obstacles.

This can include using GPS, aerial imagery, and ground-penetrating radar.

✓ **Mapping:**

Create detailed maps that incorporate both terrain and obstacles to aid in planning the most efficient and cost-effective fiber optic routes.

✓ **Impact analysis:**

Assess how terrain details and obstacles might impact installation, maintenance, and long-term network performance.

In summary, both terrain details and terrain obstacles are crucial for effective fiber optic network planning and deployment. Proper data collection and analysis of these factors ensure that the network is installed efficiently and operates reliably over its lifetime.
Steps for Collecting Data in Fiber Optic Network Planning
1. **Define Project Scope and Objectives:**

Clearly outline the purpose of the fiber optic network.
Determine the coverage area and target customer base.
Identify the services to be offered (e.g., internet, TV, phone).
Set performance targets (e.g., bandwidth, latency, reliability).
2. Conduct Market Research:

Analyze existing infrastructure and competition.
Assess customer demand and willingness to pay.
Identify potential partners and stakeholders.
Understand regulatory requirements and permits.
3. Gather Geographic Data:

Obtain detailed maps of the coverage area.
Identify potential infrastructure constraints (e.g., rivers, mountains, buildings).
Use GIS (Geographic Information Systems) software for analysis and visualization.
4. Conduct Site Surveys:

Physically inspect potential routes and locations for infrastructure.
Collect data on existing infrastructure, access points, and potential obstacles.
Document findings with photos, videos, and sketches.
5. Collect Customer Data:

Conduct surveys or interviews to understand customer needs and preferences.
Gather data on demographics, usage patterns, and willingness to pay.
Analyze existing customer data from other services (if available).
6. Assess Economic Feasibility:

Estimate the cost of building and operating the network.
Project revenue streams and potential profitability.
Conduct a cost-benefit analysis to justify the investment.
7. Develop a Network Design:

Based on the collected data, design the network topology.
Select appropriate equipment and technologies.
Optimize the network for performance, cost, and scalability.

8. Obtain Necessary Permits and Approvals:

Navigate regulatory hurdles and obtain required permits.
Coordinate with local authorities and stakeholders.
Ensure compliance with environmental and safety regulations.

- **Types of data frequently collected:**

✓ **Terrain Details**

Definition:
This refers to the general characteristics and features of the land over which the fiber optic cable will be laid. This includes elevation changes, land use, vegetation, and soil types.
Purpose:
Understanding the physical characteristics of the area where the fiber optic cables will be laid.
Importance:
Routing and Planning: Terrain details help in planning the most efficient route for the fiber optic cables, considering factors such as elevation changes and land types that might affect installation methods.
Cost Estimation: Different terrain types can affect installation costs. For example, rocky terrain may require more expensive trenching or boring techniques compared to flat, open land.
Environmental Impact: Understanding the terrain helps in assessing the environmental impact of the installation and in complying with environmental regulations.
Data points:
Elevation: The height above sea level.
Slope: The steepness of the terrain.
Landform: The shape or features of the land (e.g., mountains, valleys, plains).
Soil conditions: The type of soil (e.g., rocky, sandy, clay) and its properties.
Benefits:
Helps determine the optimal cable routing to avoid obstacles and minimize construction costs.
Provides insights into potential areas of erosion or instability.

✓ **Terrain Obstacles**

Definition:
These are physical objects or features in the landscape that can obstruct the installation or affect the performance of the fiber optic network. Examples include buildings, roads, rivers, and utility lines.
Purpose:
Identifying potential obstructions that could affect the installation or performance of the fiber optic network.
Importance:

Installation Challenges: Obstacles can create challenges in installation, requiring special techniques or equipment. For instance, crossing a river might need specialized trenchless technology.
Network Performance: Some obstacles can affect the network's performance indirectly. For example, proximity to other utility lines might cause interference or require additional shielding.
Permits and Approvals: Certain obstacles may require additional permits or approvals from local authorities, especially if they involve crossing public land or roads.
Data points:
Existing infrastructure: Roads, buildings, power lines, pipelines.
Natural features: Rivers, lakes, forests, cliffs.
Underground utilities: Water, sewer, gas lines.
Benefits:
Helps avoid damage to existing infrastructure during installation.
Ensures the network's reliability and long-term performance.

- ***Data collection methods for fiber optic network planning often include:***

Field surveys: Physical inspections of the terrain to gather information.
Aerial imagery: Using drones or airplanes to capture high-resolution images.
GIS (Geographic Information Systems): Analysing existing digital maps and data to identify potential obstacles.
LiDAR (Light Detection and Ranging): Using laser technology to create detailed 3D models of the terrain.
By collecting accurate and comprehensive data on terrain details and obstacles, network planners can make informed decisions about cable routing, infrastructure requirements, and potential risks. This ultimately leads to a more efficient, reliable, and cost-effective fiber optic network.

Practical Activity 1.1.5 Preparing bills of quantity

Task:

1. You are requested to go in the workshop/workplace and prepare the bill of quantity for fiber optic network
2. Apply safety precautions (wear the PPE).
3. Prepare the bill of quantity for fiber optic network.
4. Present your findings to the trainer and/or the whole class.
5. Read the key readings 1.1.5 and ask questions for clarifications where necessary.
6. Perfom the task provided in application of learning 1.1.

Key readings 1.1.5: Preparing bills of quantity

- **Definition of a Bill of Quantities (BoQ)**

It is a detailed list of materials, labor, and equipment required to complete a construction project. It serves as a blueprint for contractors to estimate costs and bid on the project.

- **Key components of a BoQ include Itemization, Quantities:** Determining the exact number of materials, labor, and equipment needed for each task.

Measurements: Specifying units of measurement (e.g., square meters, cubic meters, hours).

Rates: Estimating the cost per unit of each item.

Total costs: Calculating the overall estimated cost for the project.

- **Steps to be followed while preparing bills of quantity for fiber optic network**

✓ **Define Project Scope**:

Clearly outline the project's objectives, including the geographic area to be covered, the number of subscribers, and the required network capacity.

Identify the specific components and infrastructure needed, such as fiber optic cables, ducts, manholes, and equipment.

✓ **Gather Design Data:**

Obtain detailed design drawings, plans, and specifications from the engineering team. These documents will provide information on the route, cable lengths, and the types of materials and equipment required.

✓ **Identify Work Items:**

Break down the project into smaller, manageable work items, such as cable laying, jointing, equipment installation, and testing.

✓ **Determine Quantities:**

Calculate the quantities of materials, labor, and equipment needed for each work item.

Consider factors such as cable lengths, jointing distances, and equipment requirements.

✓ **Develop a Bill of Quantities:**

Create a structured document listing each work item, the quantities required, and the units of measurement.

Include detailed descriptions of materials, equipment, and labor.

✓ **Consider Contingencies:**

Allocate a contingency factor to account for unforeseen circumstances or changes in the project scope.

This can help to ensure that the project budget is sufficient to cover unexpected costs.

✓ **Obtain Pricing:**

Obtain price quotes from suppliers for materials and equipment.
Negotiate favorable pricing terms to ensure cost-effectiveness.

- ✓ **Calculate Costs:**

Multiply the quantities of each item by their respective prices to determine the total cost.
Consider labor costs, transportation, and other overhead expenses.

- ✓ **Review and Verify:**

Carefully review the BOQ to ensure accuracy and completeness.
Have it reviewed by relevant stakeholders, such as engineers, project managers, and procurement specialists.

- ✓ **Update as Needed:**

Be prepared to update the BOQ throughout the project as changes occur or additional information becomes available.

- **Examples of Bill of Quantities (BOQ) for Fiber Optic Network Deployment**

Project: Fiber Optic Network Expansion in Kigali, Rwanda
Note: This is a simplified example. Actual BOQs may be more detailed and include additional items based on specific project requirements.

Section 1: Civil Works

Item No.	Description	Quantity	Unit	Unit Price	Total
1.1	Trench excavation for fiber optic cable (depth: 0.6m, width: 0.3m)	1000	Meters	$10	$10,000
1.2	Backfilling and compaction of trenches	1000	Meters	$5	$5,000
1.3	Duct installation (HDPE, 4-core)	1000	Meters	$20	$20,000

Section 2: Fiber Optic Cable Installation

Item No.	Description	Quantity	Unit	Unit Price	Total
2.1	Fiber optic cable (single-mode, 24-core)	1000	meters	$50	$50,000
2.2	Cable splicing (fusion splicing)	100	splices	$50	$5,000

2.3	Cable termination (FC connectors)	200	terminations	$20	$4,000

Section 3: Equipment and Materials

Item No.	Description	Quantity	Unit	Unit Price	Total
3.1	Optical fiber splicing machine	1	unit	$5,000	$5,000
3.2	Optical power meter	1	unit	$1,000	$1,000
3.3	Optical time domain reflectometer (OTDR)	1	unit	$3,000	$3,000

Section 4: Testing and Commissioning

Item No.	Description	Quantity	Unit	Unit Price	Total
4.1	Fiber optic network testing	1000	project	$10,000	$10,000
4.2	Certification and documentation	1	project	$5,000	$5,000

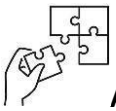
Total Project Cost: $118,000

Note: This is a simplified example. Actual BOQs may include additional items such as manholes, handholes, joint closures, cable markers, and other accessories. The unit prices may vary depending on the specific location, market conditions, and supplier. It's essential to conduct a detailed site survey and obtain accurate quantities before finalizing the BOQ

Points to Remember

- Core is the central parts of the fiber, made of glass or plastic and it is where light signal travels.
- The specific composition of each layer can vary depending on the cable's intended use.
- Multimode and single mode are the main types of fiber optic cables.
- It is important to memorize the sequence of fiber Color code standard.
- Dedicated Connection provides a direct or privet link between two points.
- Point-to-multipoint connection allows for sharing bandwidth among multiple users.
- Fiber optic network topology is the arrangements of nodes and links within a fiber network.

- Terrain details refer to physical characteristic of the area where the fiber optic cables are laid.
- Terrain obstacles deal with analyzing of existing digital maps and data identification
- While preparing bills of quantity, ensure clear description of items, quantities and unit.
- Cost estimation provides a detailed breakdown of project costs.
- Tendering serves as a basis for contractors to submit bids.



Application of learning 1.1.

Conduct a study visit in one of the institutions or companies that owns a fiber optic network. Observe their fiber optic network and by then collect data and make a bill of quantity about what you observed.

Indicative content 1.2: Identification of Materials and Equipment

Duration: 5hrs

Theoretical Activity 1.2.1: Description of materials and equipment used in fibre optic network deployment

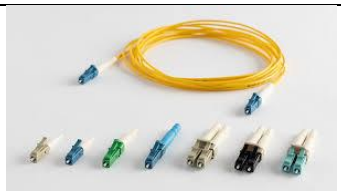
Tasks:

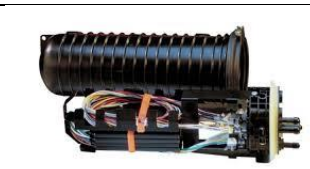
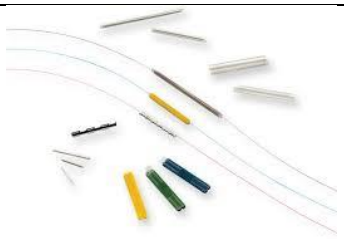
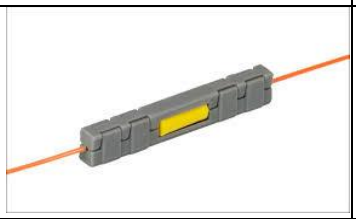
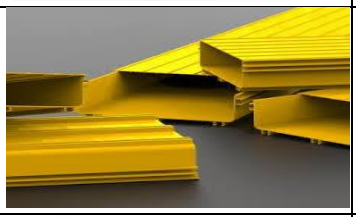
1. Answer the following question:
   i. Describe different types of materials and equipment used in fiber optic network deployment
2: Write your findings on paper, flipchart, blackboard or white board.
3: Present your findings to the trainer or classmates.
4: Pay attention to the trainer's clarifications and ask questions for clarification where necessary.
5: Read the key readings 1.2.1

Key readings 1.2.1: Description of materials and equipment used in fibre optic network deployment

- **Identification of materials and equipment**
  - ✓ **Materials**

Fiber Optic Cables: Single-mode or multimode, depending on distance and data rate requirements.
Fiber Optic Connectors and Adapters: LC, SC, ST, FC, and others, used to connect cables to devices.

SN	Name of material	Image	Description
1	Fiber Optic Cables		Single-mode or multimode, depending on distance and data rate requirements
2	Fiber Optic Connectors and Adapters		LC, SC, ST, FC, and others, used to connect cables to devices.

3	Fiber Optic Closure		A sealed enclosure for splicing or terminating cables.
4	Fusion Splice Sleeves		Used with fusion splicers to create a permanent bond between fibers.
5	Mechanical Splice Connectors		Used to connect fibers without requiring fusion.
6	Fiber Optic Cable Ducts and Conduits:		Provide protection and routing for cables.
7	Fiber Optic Cable Trays and Supports		Support cables in aerial or underground installations.
8	Fiber Optic Patch Cords and Pigtails:		Short lengths of cable used for connections.
9	Fiber Optic Distribution Frames (ODF)		Centralized termination points for cables.

✓ **Equipment**

SN	**Name of equipment**	**Image**	**Description**
1	Router		Directs data packets between networks.

2	Switch		Connects devices within a local area network.
3	Media Converter		Converts between different media types (e.g., copper and fiber).
4	Small Form Factor Pluggable (SFP)		Modular transceivers used in various network devices.
5	Fiber Optic Light Source Tester:		Generates optical signals for testing and troubleshooting.

Points to Remember

- Consider factors such as performance, scalability, features, and compatibility when selecting routers.
- Choose switches based on port density, switching capacity, features, and scalability.
- Use reliable and accurate light source testers for network testing and troubleshooting.
- Select compatible connectors and adapters that match the cable type and network devices.
- Use the correct type of splice sleeves for fusion or mechanical splicing.

Application of learning 1.2.

Visit one of the fiber optic companies in your area and observe their fiber optic network. By referring to the key readings 1.2.1, You are requested to identify the fiber optic materials and equipment available in those companies and then make bills of quantity.

Indicative content 1.3: Design Fiber Optic Network

Duration: 5 hrs

Theoretical Activity 1.3.1: Identification of fiber optic network design

Tasks:

1: Answer the following questions:

i. Identify at least five (5) components used in fiber optic design?
ii. Define the term link loss budget used in fiber optic equipment.
iii. State all the types of types of reserve restoration cables?

2: Write your findings on papers, flipchart, blackboard or white board.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 1.3.1

Key readings 1.3.1: Identification of fiber optic network design

When identifying components in a fiber optic network, several key elements must be considered. These components play a crucial role in determining the performance and reliability of the system.

- **Primary components used in fiber optic design**
  - ✓ **Fiber Cable:**

Description: The core medium through which light signals travel. It consists of a core (transmits light), cladding (reflects light back into the core), and protective coatings.
Types of fiber optic cable are mode fiber (SMF): Used for long-distance communication, has a smaller core (8-10 microns) and multi-mode fiber (MMF): Suitable for shorter distances, with a larger core (50-62.5 microns).

- ✓ **Transmitters (Light Sources):**

Description: Devices that convert electrical signals into light signals.
Types: Laser diodes (LD): Provide high-intensity light, used for long distances and high data rates and Light-emitting diodes (LED): Used for shorter distances and lower data rates.

- ✓ **Receivers (Detectors):**

Description: Devices that convert the light signal back into electrical signals.
Types: Photodiodes (PIN): Commonly used in single-mode and multi-mode systems and Avalanche photodiodes (APD): Provide higher sensitivity and are used in long-distance communication.

- ✓ **Splices:**

Description: Permanent or semi-permanent connections between two fiber ends.

Types: Fusion splicing: melts the fiber ends together to form a low-loss connection and mechanical splicing: aligns the fiber ends using a mechanical device but may result in slightly higher loss.

- ✓ **Connectors:**

Description: Temporary or removable connections between fiber cables and other equipment.

Types: SC (Subscriber Connector): Commonly used in patch panels, LC (Lucent Connector): Smaller form factor, often used in high-density networks and ST (Straight Tip): Older type, used in multi-mode systems.

- ✓ **Optical Splitters:**

Description: Devices that divide a single optical signal into multiple paths.

Types: Passive splitters: Split the light without requiring power, often used in passive optical networks (PON) and Active splitters: Require external power and amplify the signal, used in some active networks.

- **Calculation of link loss budget**

Link loss budget. is a critical factor in fiber optic systems. It determines the maximum allowable signal attenuation over a given distance. This budget is calculated by considering various components that contribute to signal loss.

- ✓ **Key components and their losses:**

Fiber Loss: This is the primary factor and is directly proportional to the fiber length and the attenuation coefficient of the fiber.

Formula: Fiber Loss (dB) = Fiber Length (km) * Attenuation Coefficient (dB/km)

Splicing Loss: Occurs when two fiber ends are joined together. The quality of the splice determines the loss.

Formula: Total Splice Loss (dB) = Number of Splices * Average Splice Loss (dB)

Connector Loss: Occurs at the interface between the fiber and other components like transmitters, receivers, or patch panels.

Formula: Total Connector Loss (dB) = Number of Connectors * Average Connector Loss (dB)

Splitter Loss: Occurs when a signal is divided into multiple paths, as in optical splitters.

Formula: Total Splitter Loss (dB) = Number of Splitters * Average Splitter Loss (dB)

Calculating the Total Link Loss Budget

The total link loss budget is the sum of all these individual losses, plus a safety margin to account for uncertainties and future changes.

Formula: Total Link Loss Budget (dB) = Fiber Loss + Splice Loss + Connector Loss + Splitter Loss + Safety Margin

- ***Example Calculation:***

Consider a fiber optic link with the following parameters:

Fiber Length: 5 km
Attenuation Coefficient: 0.2 dB/km
Number of Splices: 3
Average Splice Loss: 0.3 dB
Number of Connectors: 4
Average Connector Loss: 0.5 dB
Number of Splitters: 2
Average Splitter Loss: 1 dB
Safety Margin: 3 dB

Calculation:

Fiber Loss: 5 km * 0.2 dB/km = 1 dB
Splice Loss: 3 * 0.3 dB = 0.9 dB
Connector Loss: 4 * 0.5 dB = 2 dB
Splitter Loss: 2 * 1 dB = 2 dB
Total Link Loss Budget: 1 dB + 0.9 dB + 2 dB + 2 dB + 3 dB = 9.9 dB

Interpretation: This link can tolerate a maximum total signal loss of 9.9 dB. If the actual losses exceed this budget, the signal quality will degrade.

- **Reserve restoration cable**

Reserve restoration cables are spare fiber optic cables that are installed in a network to provide redundancy and ensure uninterrupted service in case of failures. These cables can be activated to bypass damaged sections or provide alternative paths for data transmission.

- ✓ **Types of reserve restoration cables**

Dark Fiber: These are unused fibers within an existing cable plant. They can be activated quickly in case of a failure, minimizing service disruption.

Spare Cables: These are additional cables laid alongside the primary cables, specifically for backup purposes. They may require more time to activate due to the need for splicing and testing.

Automatic Restoration Switches (ARS): These devices can automatically reroute traffic to backup paths when a failure is detected, providing rapid restoration.

- ✓ **Factors to Consider When Planning Reserve Restoration Cables**

Failure Probability: The likelihood of failures in different sections of the network should be assessed to determine the optimal placement of reserve cables.

Restoration Time: The time required to activate a reserve cable should be considered, especially for critical services.

Cost: The cost of installing and maintaining reserve cables should be balanced against the potential benefits of improved reliability.

Regulatory Requirements: Some jurisdictions may have specific regulations regarding the use of reserve cables, especially for critical infrastructure.

- ✓ **Benefits of Reserve Restoration Cables**

Improved Reliability: Redundancy provided by reserve cables ensures continuous service even in the event of failures.

Faster Restoration: Automatic restoration switches can quickly reroute traffic, minimizing service disruptions.

Cost-Effective: Reserve cables can be a cost-effective way to improve network reliability compared to rebuilding damaged sections.Scheduling Fiber Optic Installation

Scheduling fiber optic installation is a critical step in ensuring a successful project. Careful planning and coordination are essential to minimize disruptions and optimize resource allocation.

Practical Activity 1.3.2: Designing fiber optic network

Task:

1. You are requested to go in the workplace and perform the following tasks:

i. You are requested to go in the workplace and select transmission equipment, schedule fiber optic route and produce route map.

2. Apply safety precaution (wear the PPE)

3. Present the key considerations for selecting transmission equipment, scheduling optic fiber optic route and producing the route map

4. Select transmission equipment, schedule fiber optic route and produce the route map

5. Read the key readings 1.3.2 and ask questions for clarification where necessary.

6. Perform the task provided in application of learning 1.3.

Key readings 1.3.2: Designing fiber optic network

- **Selection of transmission equipment**

Transmission equipment is crucial for the effective and reliable transmission of data over fiber optic networks.

✓ **Key Steps for Selecting Transmission Equipment in Fiber Optic Planning**

Step1. Define Requirements:

Bandwidth: Determine the required data transfer rate for current and future needs.

Distance: Calculate the distance the signal needs to travel.

Wavelength: Select the appropriate wavelength for the fiber optic cable.

Loss Budget: Account for signal attenuation due to cable length and connectors.

Reliability: Ensure equipment has high reliability and availability.

Step2. Evaluate Equipment Options:

Optical Transceivers: Consider factors like data rate, wavelength, reach, and power consumption. EX

Equipment Types

Transceivers: These devices convert electrical signals to optical signals and vice versa. They are available in various form factors, including SFP, SFP+, and QSFP.

Fig: Transceivers equipments

Optical Amplifiers: Used to boost the optical signal over long distances, especially in point-to-point links.

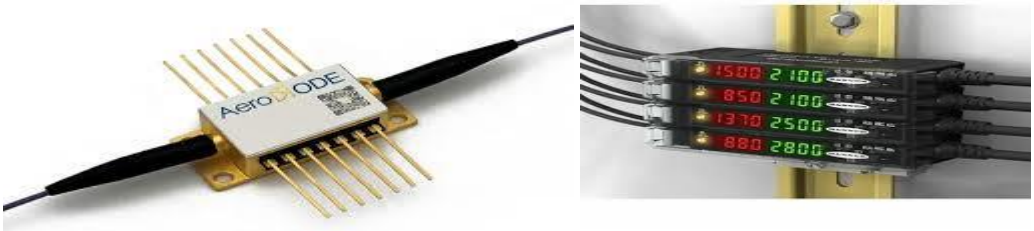


Fig: Optical amplifier

Wavelength Division Multiplexers (WDMs): Allow multiple optical signals to be transmitted simultaneously over a single fiber, increasing capacity.

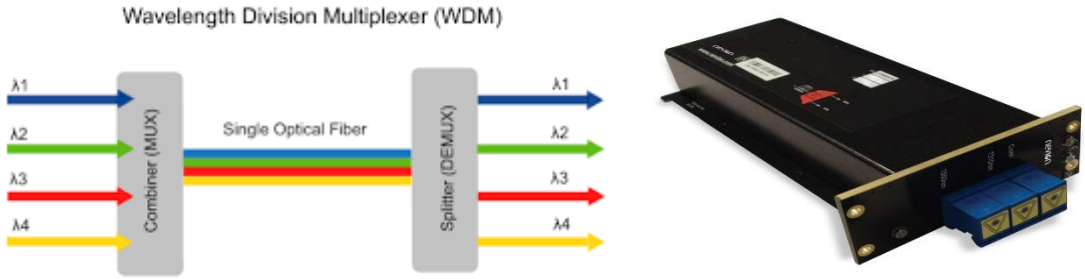


Fig: Wavelength division Multiplexers(WDMS)

Optical Switches: Used to route optical signals between different paths or networks.

Fig: Optical switches

Step3. Perform Network Simulation:

Optical Link Budget Calculation: Model the entire network and calculate signal loss and power margins.
System Margin Analysis: Ensure sufficient margin to accommodate future upgrades and environmental factors.
Step4. Consider Future Upgrades:

Scalability: Select equipment that can accommodate future bandwidth increases and new services.
Modulation Formats: Choose equipment compatible with advanced modulation formats for higher data rates.
Step5. Evaluate Vendors and Products:

Technical Specifications: Compare specifications from different vendors.
Reliability and Support: Consider vendor reputation and after-sales support.
Cost: Evaluate the total cost of ownership, including equipment, installation, and maintenance.
step6. Make Informed Decisions:
Balance Performance and Cost: Select equipment that meets requirements while optimizing cost.
.

- ✓ **Key Considerations while selecting transmision equipment**

Compatibility: Ensure that the equipment is compatible with the network's existing components and standards.

Performance: Consider factors such as bit error rate (BER), sensitivity, and power consumption.

Cost: Evaluate the cost of the equipment, including initial purchase, maintenance, and ongoing operating expenses.

Reliability: Choose equipment with a proven track record of reliability and durability.

Future Scalability: Select equipment that can accommodate future network growth and changes.

Accurate identification of fiber optic components is essential for effective network management, maintenance, and troubleshooting.

- **Scheduling Fiber Optic Routes**

The selection of fiber optic routes is a critical decision that impacts the performance, reliability, and cost-effectiveness of a network.

- ✓ **Steps of scheduling route installation**

Step 1: Planning and requirements gathering.

Step 2: Site surveys and feasibility studies.

Step 3: Network topology design.

Step 4: Fiber optic cable routing.

Step 5: Equipment selection.

Step 6: Capacity and bandwidth planning.

Step 7: Power and infrastructure planning.

Step 8: Network documentation and standards.

Step 9: Implementation and testing.

Step 10: Ongoing maintenance and optimization.

- **Producing a Route Map for Fiber Optic Network Deployments**

When planning fiber optic network deployments, creating a route map is essential to ensure efficient, reliable, and cost-effective implementation. The route map provides a clear visualization of the planned network path, connecting various nodes, hubs, or data centers.

- ✓ **Key steps for producing a route Map**

Surveying the Terrain: Identify optimal paths, avoiding natural obstacles like rivers, mountains, and urban congestion.

Infrastructure Assessment: Assess existing infrastructure such as utility poles or underground ducts that can support fiber deployment.

Right-of-Way (ROW) Acquisition: Secure legal access to land or public spaces for fiber installation.

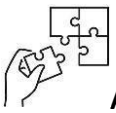
Cost Estimation: Factor in trenching, cable installation, and regulatory approvals for budget accuracy.

Network Design: Ensure redundancy and scalability by mapping diverse routes to prevent single points of failure.

A well-designed route map enhances operational efficiency, minimizes disruptions, and lays the groundwork for future expansions

Points to Remember

- Fiber optic components are: fiber optic cable, transmitters (light source), receivers (detectors), splicer and connector.
- Link loss budget is a critical factor in fiber optic systems, it determines the maximum allowable signal attenuation over a given distance.
- Types of reserve restoration cables are: dark fiber and spare cables
- It is essential to consult the manufacturer's specifications for accurate calculations.
- The specific values for attenuation coefficients, splice losses, connector losses, and splitter losses will vary depending on the types of fiber, splicing techniques, connectors, and splitters used.
- Key Steps for Selecting Transmission Equipment in Fiber Optic Planning are: Define Requirements, Evaluate Equipment Options, Perform Network Simulation, Consider Future Upgrades, Evaluate Vendors and Products and Make Informed Decisions
- Steps of schedule fiber optic route encloud: Surveying the Terrain: Infrastructure Assessment, Right-of-Way (ROW) Acquisition, Cost Estimation and Network Design.



Application of learning 1.3.

Visit any fiber optic company that deals with deployment of fiber optic networks. Then, help the company to design a fiber optic deployment by selecting transmission equipment, scheduling fiber optic route, and producing route map required

Learning outcome 1 end assessment

Theoretical assessment

Q1. Answer the following questions by TRUE if the statement is correct or by FALSE if the statement is incorrect.

- Splitter loss is a significant factor in the link loss budget calculation.

- The route map for a fiber optic network should only include the main cable paths and ignore any potential obstacles.
- Identifying components accurately is crucial for the efficient design and maintenance of a fiber optic network.

Q2. Circle the letter corresponding with the correct answer

i. Which of the following is NOT a factor in calculating the link loss budget?
   a) Fiber loss
   b) Splicing loss
   c) Connector loss
   d) Signal modulation

ii. **What is the primary purpose of a reserve restoration cable?**
   a) To increase data transmission speed
   b) To provide a backup in case of cable failure
   c) To reduce splicing loss
   d) To enhance signal strength

iii. **Which type of transmission equipment is typically used for long-distance fiber optic communication?**
   a) Optical amplifiers
   b) Ethernet switches
   c) Coaxial cables
   d) Wireless routers

Q3. Read and answer the following questions:

i. Describe the process of selecting the optimal fiber optic route for a new network installation. What factors must be considered?
ii. What are the environmental factors (e.g., temperature, humidity, electromagnetic interference) to consider when selecting fiber optic Route?
iii. How will the route map be used and maintained?
iv. What is the type of fiber optic cable for the reserve restoration?
v. What are the potential delays or challenges that could affect the installation timeline?
vi. What is the estimated connector loss per connector?
vii. What types of optical switches or multiplexers will be needed?

viii. Explain how you would calculate the total link loss budget for a fiber optic network. Include all relevant components and their respective losses.
ix. What are the key steps involved in scheduling the installation of a fiber optic network?
x. What is the required data transmission rate for the network?

Practical assessment

Suppose that ABC university campus wishes to upgrade its network infrastructure to support high-bandwidth applications, including video conferencing, online courses, and research activities. The goal is to design a fiber optic network that can provide reliable and high-speed connectivity to all buildings on campus. You are tasked to deliver the fiber optic network by planning all it requires to deploy a fiber optic network.

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Indicative contents
2.1. Selection of fiber optic deployment route
2.2. Deployment of fiber optic equipment
2.3. Perform fiber optic splicing
2.4. Testing fiber optic link
2.5. Perform Fiber optic patching
2.6. Generate technical documentation

Key Competencies for Learning Outcome 2: Implement fiber optic network

Knowledge	Skills	Attitudes
• Identification of routes and installations • Identification of fiber optic equipment • Description of splicing process • Identification of fiber optic connectors • Description of general technical documentation	• Selecting fiber optic deployment route • Setting up equipment and deployment • Splicing fiber optic cableS • Testing fiber optic link • Performing fiber optic patching • Generating technical documentation	• Being hardworking in the deployment of fiber optic • Being collaborative in setting and deploying fiber optic network • Being careful while • splicing fiber optic cable

Duration: 25hrs

Learning outcome 2 objectives:

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

1. Describe properly splicing process based on fiber optic network design and standard
2. Identify clearly fiber optic patching according to fiber optic network design
3. Identify clearly fiber optic equipment based on network design
4. Describe correctly fiber link testing process according to fiber network design
5. Describe clearly general technical documentation based on the implementation
6. Select properly fiber optic deployment route based on network design
7. Splice properly fiber optic based on fiber optic network design and standards
8. Select properly fiber optic deployment route based on network design
9. Patch correctly fiber optic cable according to the network design
10. Deploy properly fiber optic equipment based on fiber optic network design
11. Test correctly link continuity according to Fiber optic network design
12. Generate properly technical documentation based on the implementation

Resources

Equipment	Tools	Materials
● Router ● Switch ● Media converter ● Small form factor pluggable ● Fiber optic light source tester ● Optical fiber optic closure ● Optical Fiber Distribution Frame (ODF)	● Pooling machine ● Splicing machine ● Optical timer domain Reflectometer ● Tubing cutter ● Buffer tube cuter ● Pliers ● Read light	● Fiber optic cable ● Optical Fiber jumper cords (OJC) ● Optical connectors ● Fusion splice sleeves ● Mechanical splice connectors ● Fiber optic cable ducts and conduits ● Fiber optic cable trays and supports

Indicative content 2.1: Selection of Fiber Optic Deployment Route

Duration: 4 hrs

Theoretical Activity 2.1.1. Identification of fiber optic deployment route

Tasks:

1: Answer the following questions:

i. What are the tools used in deployments of fiber optic route?
ii. Describe the two main types of fiber optic route installation
iii. What are the key considerations when choosing a fiber optic route installation?

2: Write your findings on papers or flipcharts.

3: Present your findings to the trainer or classmates.

4: Ask questions for clarifications where necessary.

5: Read the key readings 2.1.1

Key readings 2.1.1.: Identification of fiber optic route installation

- **Fiber optic tools**

Fiber optic networks require specialized tools for installation, maintenance, and troubleshooting. Here are some key tools:

✓ **Splicer machine (Mechanical and Fusion)**

Splicer machines are essential tools for connecting fiber optic cables. They ensure a precise and reliable joint between the two ends of the fiber, minimizing signal loss and maintaining network integrity. There are two primary types of splicer machines: mechanical and fusion.

Mechanical Splicers machine

Operation: Mechanical splicers use a mechanical alignment process to align the cores of the two fibers. A mechanical sleeve is then inserted over the joint and secured with a clamp.

Advantages: Generally, less expensive and easier to use than fusion splicers.

Disadvantages: Can have higher insertion loss compared to fusion splicers, especially for *multimode fibers.*

Fig: Picture indicating mechanical splicer

- **Fision splicer**

Operation: Fusion splicers use an electric arc to melt the ends of the fibers together, creating a permanent bond. A precise alignment process is used to ensure the cores of the two fibers are perfectly aligned before the fusion.

Advantages: Typically have lower insertion loss than mechanical splicers, especially for single-mode fibers. Provide a more reliable and durable joint.

Disadvantages: More expensive and require specialized training to operate effectively.

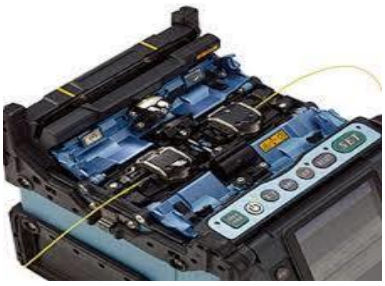


Fig: Fusion Splicers

- **Fiber optic testing equipment**

Fiber optic testing equipment is essential for ensuring the proper functioning and performance of fiber optic networks. Here are some key tools used for testing and troubleshooting:

- ✓ **Optical Power Meter (OPM)**

Purpose: Measures the optical signal power at the output of a transmitter or the input of a receiver.

Applications: Used to verify signal levels, detect faults, and assess overall network performance.

Fig: Picture indicating Optical Power Meter

- ✓ **Optical Time-Domain Reflectometer (OTDR)**

An Optical Time-Domain Reflectometer (OTDR) is a specialized piece of test equipment used to measure the attenuation and length of optical fibers. It works by sending a high-power pulse of light into the fiber and measuring the time it takes for reflected light to return.

Purpose: Locates faults, breaks, or other anomalies in the fiber optic cable.

Applications: Used to identify the location of splices, connectors, and other components along the cable.

Fig: Picture indicating time - domen reflectometer (OTDR)

- ✓ **Visual Fault Locator (VFL)**

A Visual Fault Locator (VFL) is a handheld optical test instrument used to visually identify faults or breaks in optical fibers. It works by emitting a visible red laser light into the fiber, which is then reflected back from any discontinuities or breaks.

How a VFL Works:

Laser Emission: The VFL emits a red laser light into the fiber.

Fiber Propagation: The laser light travels through the fiber.

Reflection at Faults: If there is a break or other fault in the fiber, the laser light will be reflected back.

Visualization: The VFL has a built-in detector that can detect the reflected light and indicate its presence visually, often by emitting a bright red light or a loud audible tone.

- ✓ **Fiber Optic Identifier**

Purpose: Determines the polarity of a fiber optic connection.

Applications: Used to ensure proper connectivity between devices and prevent signal inversion.

- ✓ **Fiber Optic Connector Cleaner**

Fiber Optic Identifier is a specialized tool used to quickly and accurately identify individual fibers within a bundle or cable. It emits a visible or infrared laser light into the fiber, and the light can be detected and identified using a handheld receiver.

How a Fiber Optic Identifier Works:

Laser Emission: The identifier emits a laser light into the fiber being tested.

Fiber Propagation: The laser light travels through the fiber.

Receiver Detection: A handheld receiver is used to detect the transmitted light.

Identification: The receiver can identify the specific fiber based on the unique wavelength or modulation pattern of the laser light.

- ✓ **Fiber Optic Patch Cables**

Fiber Optic Patch Cables are pre-terminated, single-mode or multimode optical cables used to connect fiber optic devices, such as routers, switches, and servers. They are typically terminated with connectors on both ends, such as LC, SC, ST, or FC.

- **Types of Fiber Optic Patch Cables:**

Single-Mode Patch Cables: Designed for long-distance transmission and high data rates. They have a smaller core diameter than multimode cables, which allows for less signal dispersion and higher bandwidth.

Multimode Patch Cables: Suitable for shorter distances and lower data rates. They have a larger core diameter, which allows for more light to be transmitted but also results in more signal dispersion.

Hybrid Patch Cables: Combine single-mode and multimode fibers in a single cable, providing flexibility for various applications.

- ✓ **Fiber Optic Pigtails**

Purpose: Short lengths of fiber used to connect equipment to the main cable.

Applications: Used for connecting devices to the network.

- ✓ **Fiber Optic Cable Blowing and Pulling**

Fiber optic cable blowing and pulling are two common methods for installing fiber optic cables in underground ducts or conduits. Each method has its own advantages and disadvantages depending on the specific circumstances of the installation.

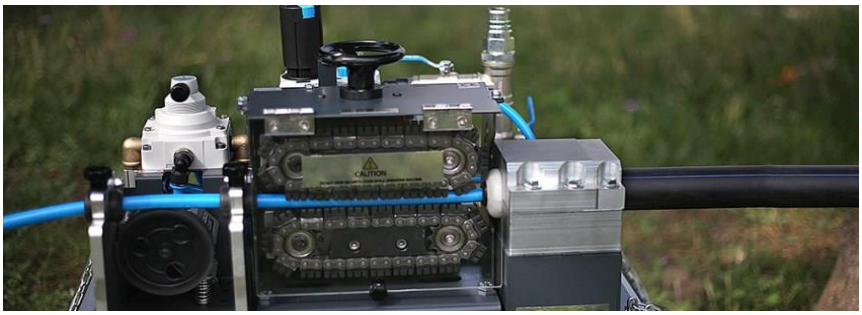


Fig: Picture indicating Fiber Optic Cable Blowing and Pulling

- **Hand tools**

Fiber optic networks require a variety of hand tools for installation, maintenance, and troubleshooting. Here are some essential tools:

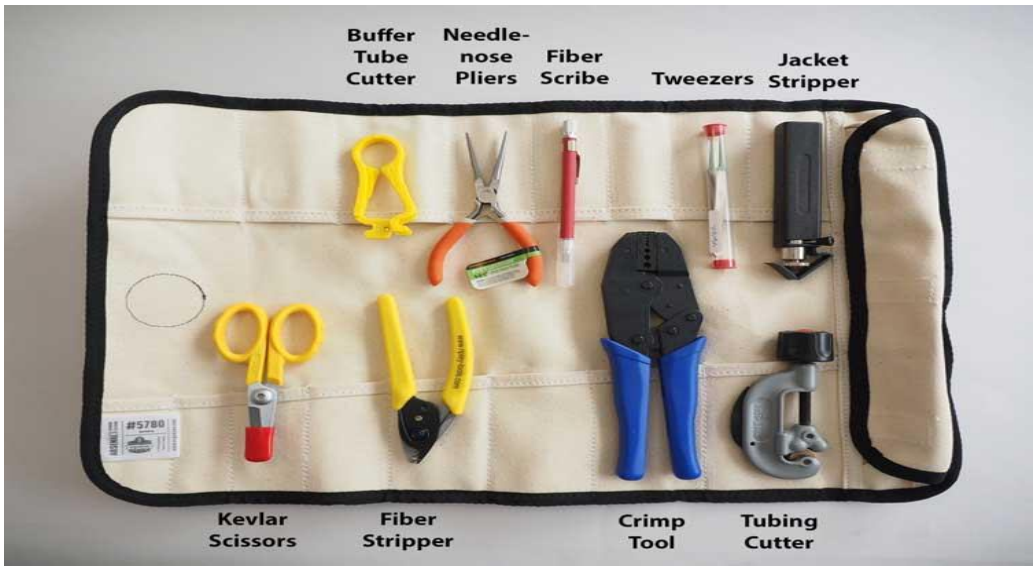
✓ **Cable Preparation Tools:**

Fiber Optic Stripper: Used to remove the outer jacket and buffer coating from fiber optic cables.

Fiber Optic Cleaver: Creates a precise, angled cut on the fiber end for proper connection.

Fiber Optic Connector Cleaner: Removes contaminants from fiber optic connectors to ensure proper contact.

✓ **Fiber Optic Cable Cutter**



A fiber optic cable cutter is a specialized tool designed to cleanly and accurately cut fiber optic cables without damaging the core or introducing excessive loss. It is an essential tool for fiber optic network installation and maintenance.

Fig: Picture indicating fiber optic cable cutter

visible red laser light into the fiber, allowing technicians to visually locate the problem area.

Fig: Picture indicating visual fault locator tool

- ✓ **Cable Tracing and Labelling Tools**

Cable tracing and labeling tools are essential for managing and identifying fiber optic cables within a network. They help ensure proper connectivity, facilitate maintenance, and prevent errors during troubleshooting.

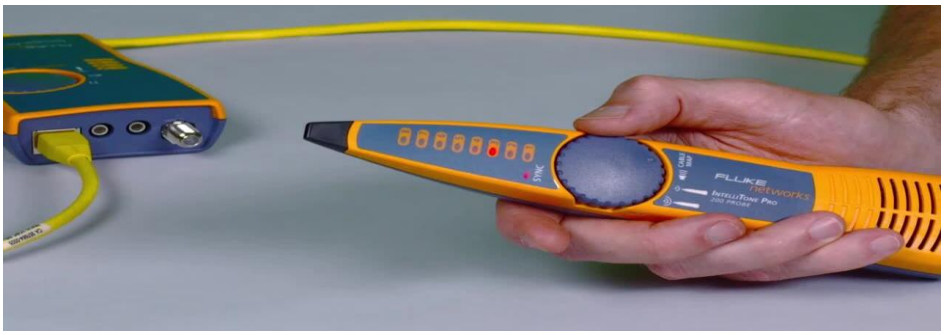


Fig: Picture indicating Fiber Optic Cleaning Tools

- ✓ **Fiber Optic Cleaning Tools**

Fiber optic cleaning tools are essential for maintaining the integrity and performance of fiber optic connections. Contaminants such as dust, dirt, and oil can degrade signal quality and cause transmission errors.

Fig: Picture indicating Fiber Optic Cleaning Tools

- ✓ **Cable Pulling and Installation Tools**

Cable pulling and installation tools are essential for deploying fiber optic networks. These tools help to efficiently and safely lay and connect cables, ensuring optimal performance and reliability.

- **Here are some key tools used in cable pulling and installation:**

- ✓ **Cable Pulling Equipment:**

Cable Pulling Grips: These specialized devices are attached to the cable to provide a secure grip for pulling. They come in various sizes and styles to accommodate different cable types and diameters.

Cable Pulling Winches: These motorized winches are used to exert force and pull cables through conduits or ducts. They can be either manual or electric, and they often have features like speed control and tension indicators.

Cable Pulling Lubricants: These lubricants are applied to the cable to reduce friction and make it easier to pull through conduits. They can also help protect the cable from damage during installation.

Cable Pulling Jacks: These devices are used to create a pulling eye on the cable, allowing it to be attached to a winch or other pulling equipment

fig: Picture indicating Cable Pulling and Installation Tools

- **Fiber Optic safety tools**

Fiber Optic Safety Tools are specialized equipment designed to protect technicians from potential hazards during the installation, maintenance, and troubleshooting of fiber optic networks.

Fig: Picture indicating Fiber Optic safety tools

- **Types of Fiber Optic Route Installation**

Fiber optic cables can be installed in various ways, depending on factors like terrain, land use, and cost. Here are some common methods:

- ✓ **Underground Installation**

Trenching: Cables are laid in trenches dug along the desired route. This is a common method for both urban and rural areas.

Boring: A tunnel is bored beneath the surface to accommodate the cables, minimizing disruption to existing infrastructure.

Micro trenching: A narrow trench is created using specialized equipment, reducing the impact on the environment and minimizing disruption to traffic.

Fig: picture indicating underground fiber optic installation

- ✓ **Aerial Installation**

Overhead Lines: Cables are suspended from poles or towers, often along existing utility lines. This method is suitable for areas with limited underground access or where overhead infrastructure is already in place.

Cable Trays: Cables are installed in cable trays mounted on poles or buildings, providing a protected and organized route.

Fig: Picture indicating Aerial installation of fiber optic network

- **Key considerations of choosing Fiber optic route installation**

When selecting a fiber optic route installation method, several factors should be carefully considered:

- **Location and visibility:** Location and visibility are critical factors in fiber optic networks, affecting network performance, maintenance, and troubleshooting.
- **Environment consideration:** Fiber optic technology offers several environmental benefits compared to traditional copper-based communication systems.
- **Reliability and resilience:** are critical factors in fiber optic networks, ensuring uninterrupted service and minimizing downtime.
- **Cost:** The cost of a fiber optic network is influenced by several factors, including:
- **Cable Purchase:** The cost of the fiber optic cable itself, which depends on the type, length, and specifications.

- **Installation:** The cost of labor, equipment, and permits required for installation, which can vary significantly depending on the terrain, existing infrastructure, and the complexity of the project.
- **Infrastructure Components:** The cost of splicing cabinets, manholes, distribution points, and other necessary equipment.

Practical Activity 2.1.2: Selecting fiber optic deployment tools and equipment

Task:

1. You are requested to go in the workshop/workplace to select fiber optic deployment routes.
2. Apply safety precautions (wear the PPE)
3. Select fiber optic deployment tools and equipment according to the specification and their application or use.
4. Present your selected fiber optic deployment tools and equipment to the trainer and the whole class.
5. Read the key readings 2.1.2 and ask questions for clarifications where necessary.
6.Perform the task provided in application of learning 2,1.

Key readings 2.1.2: Selecting fiber optic deployment route Equipment

Fiber optic networks rely on various equipment to transmit, receive, and manage data. Here is same example of equipment:

- ✓ **Routers**

They are essential components in fiber optic networks, responsible for directing data packets between different networks or subnets. They play a crucial role in ensuring efficient and reliable communication.

- **Functions of Routers in Fiber Optic Networks**

Routing: Routers determine the best path for data packets to reach their destination based on network topology, traffic conditions, and routing protocols.

Internetworking: They enable communication between different networks, allowing data to be exchanged across various network technologies and protocols.

Fig: Picture of fiber optic router

- ✓ **Switches**

They are essential components in fiber optic networks, responsible for connecting devices within a local area network (LAN). They play a crucial role in managing data traffic and ensuring efficient communication between devices.

- **Functions of Switches**

Data Forwarding: Switches examine the destination address of incoming data packets and forward them to the appropriate port.

Collision Avoidance: In half-duplex mode, switches prevent collisions between multiple devices transmitting data simultaneously on the same segment.

Broadcast Control: Switches limit the propagation of broadcast traffic to only the necessary devices, reducing network congestion.

VLAN Segmentation: Switches can be configured to create virtual local area networks (VLANs), allowing multiple logical networks to coexist on a single physical infrastructure.

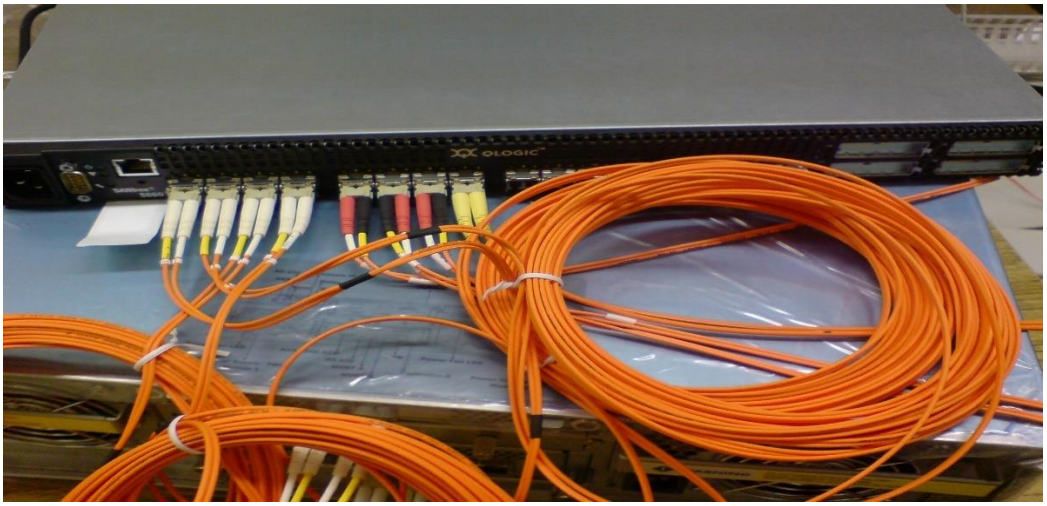


Fig: Fiber optic switch

- ✓ **Media converter**:

Media converters are devices that bridge the gap between different types of transmission media, such as copper (Ethernet) and fiber optic. They allow for seamless integration of various network components and technologies.

Functions of Media Converters

Protocol Conversion: Media converters can convert between different network protocols, such as Ethernet and Fiber Channel.

Media Conversion: They convert electrical signals (copper) to optical signals (fiber) and vice versa.

Distance Extension: Media converters can extend the reach of a network by converting signals to fiber optic, which can travel longer distances with less attenuation.

Fiber-to-Copper Bridging: They allow for the connection of fiber optic cables to copper-based devices, such as Ethernet switches or computers.

Types of Media Converters

Ethernet-to-Fiber Converters: Convert Ethernet signals to fiber optic signals and vice versa.

Fiber Channel-to-Ethernet Converters: Convert Fiber Channel signals to Ethernet signals and vice versa, enabling interoperability between different storage area network (SAN) technologies.

Small Form Factor Pluggable (SFP) Converters: These modular devices can be inserted into various network devices, providing flexibility and ease of installation.

✓ **Small form factor pluggable (SFP)**

SFP (Small Form Factor Pluggable) is a type of modular transceiver used in fiber optic networks. It provides a standardized interface for connecting optical transmitters and receivers to network devices.

Key Features of SFP

Compact Size: SFP modules are small and lightweight, making them ideal for high-density applications.

Hot-Swappable: SFP modules can be inserted or removed from network devices without powering down the system, allowing for easy maintenance and upgrades.

Versatility: SFP modules are available in various configurations, supporting different data rates, wavelengths, and distances.

Cost-Effective: SFP modules offer a cost-effective solution for connecting fiber optic cables to network devices.

✓ **Fiber optic light source tester:**

A fiber optic light source tester is a valuable tool for testing and troubleshooting fiber optic networks. It consists of several essential components:

Light Source: Generates a stable and reliable optical signal at a specific wavelength. This signal is used to test the transmission path of the fiber optic cable.

Optical Attenuator: Allows for precise control of the output power of the light source, simulating different attenuation levels that may be encountered in the network.

Wavelength Selection: Provides options to select different wavelengths of light, which are crucial for testing various types of fiber optic cables and components.

Output Connector: A connector that matches the type of fiber optic connector used in the network (e.g., LC, SC, ST).

- **Tools**

Fiber optic networks require specialized tools for installation, maintenance, and troubleshooting. Here are some key tools:

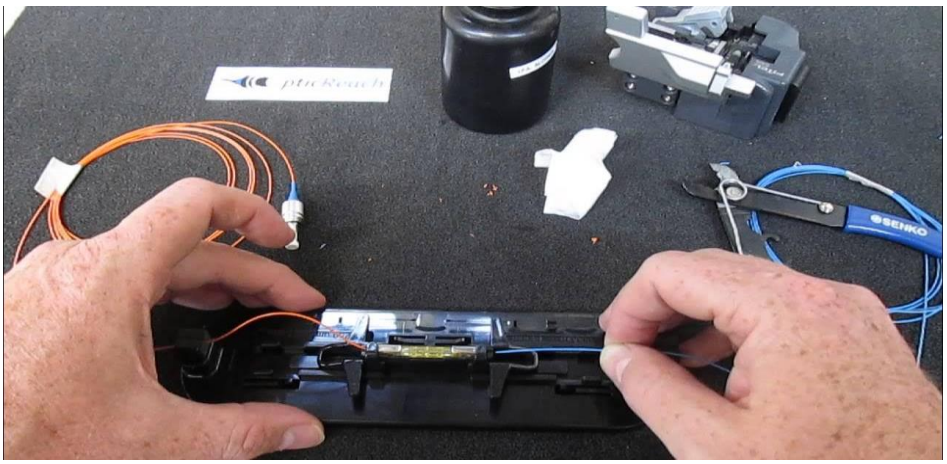
✓ **Splicer machine (Mechanical and Fusion)**

Splicer machines are essential tools for connecting fiber optic cables. They ensure a precise and reliable joint between the two ends of the fiber, minimizing signal loss and maintaining network integrity. There are two primary types of splicer machines: mechanical and fusion.

Mechanical Splicers

Operation: Mechanical splicers use a mechanical alignment process to align the cores of the two fibers. A mechanical sleeve is then inserted over the joint and secured with a clamp.

Advantages: Generally, less expensive and easier to use than fusion splicers.
Disadvantages: Can have higher insertion loss compared to fusion splicers, especially for multimode fibers.



- **Fusion Splicers**

Operation: Fusion splicers use an electric arc to melt the ends of the fibers together, creating a permanent bond. A precise alignment process is used to ensure the cores of the two fibers are perfectly aligned before the fusion.
Advantages: Typically have lower insertion loss than mechanical splicers, especially for single-mode fibers. Provide a more reliable and durable joint.
Disadvantages: More expensive and require specialized training to operate effectively.

- **Fiber Optic Testing Equipment**

Fiber optic testing equipment is essential for ensuring the proper functioning and performance of fiber optic networks. Here are some key tools used for testing and troubleshooting:

- ✓ **Optical Power Meter (OPM)**

Purpose: Measures the optical signal power at the output of a transmitter or the input of a receiver.

Applications: Used to verify signal levels, detect faults, and assess overall network performance.

- ✓ **Optical Time-Domain Reflectometer (OTDR)**

Purpose: Locates faults, breaks, or other anomalies in the fiber optic cable.

Applications: Used to identify the location of splices, connectors, and other components along the cable.

- ✓ **Visual Fault Locator (VFL)**

Purpose: Emits a visible red laser light into the fiber to identify faults or breaks.

Applications: Used for quick and easy fault localization in the field.

- ✓ **Fiber Optic Identifier**

Purpose: Determines the polarity of a fiber optic connection.

Applications: Used to ensure proper connectivity between devices and prevent signal inversion.

- ✓ **Fiber Optic Connector Cleaner**

Purpose: Removes contaminants from fiber optic connectors to ensure proper contact.

Applications: Used to maintain the cleanliness and performance of connectors.

- ✓ **Fiber Optic Patch Cables**

Purpose: Used to connect fiber optic devices.

Applications: Used for temporary connections or for testing purposes.

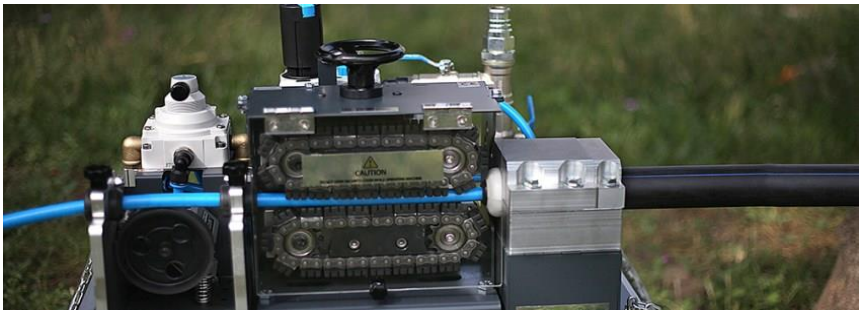
- ✓ **Fiber Optic Pigtails**

Purpose: Short lengths of fiber used to connect equipment to the main cable.

Applications: Used for connecting devices to the network.

- **Fiber Optic Cable Blowing and Pulling**

Fiber optic cable blowing and pulling are two common methods for installing fiber optic cables in underground ducts or conduits. Each method has its own advantages and disadvantages depending on the specific circumstances of the installation.



- **Hand tools**

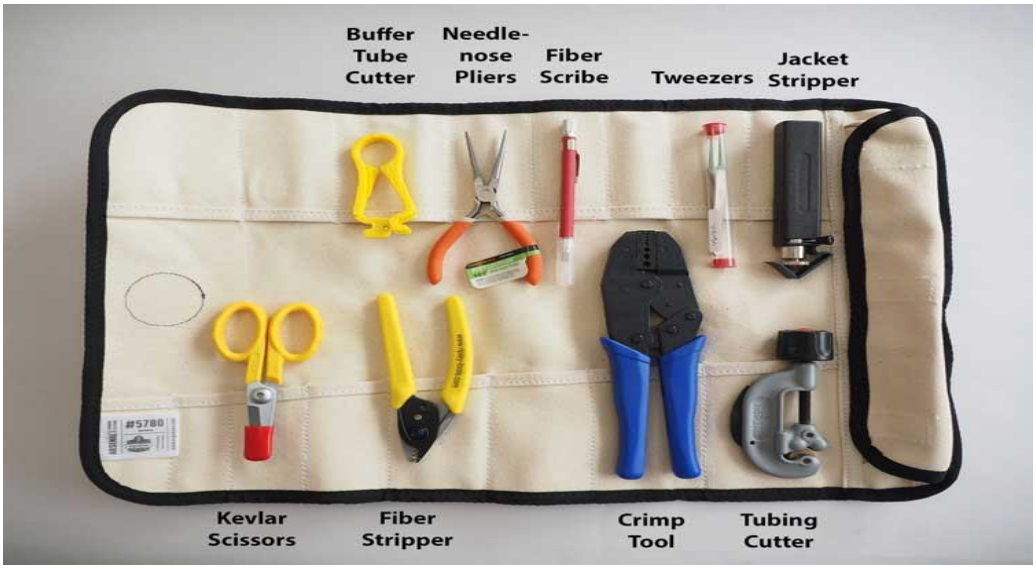
Fiber optic networks require a variety of hand tools for installation, maintenance, and troubleshooting. Here are some essential tools:

✓ **Cable Preparation Tools**

Fiber Optic Stripper: Used to remove the outer jacket and buffer coating from fiber optic cables.

Fiber Optic Cleaver: Creates a precise, angled cut on the fiber end for proper connection.

Fiber Optic Connector Cleaner: Removes contaminants from fiber optic connectors to ensure proper contact.



✓ **Fiber Optic Cable Cutter**

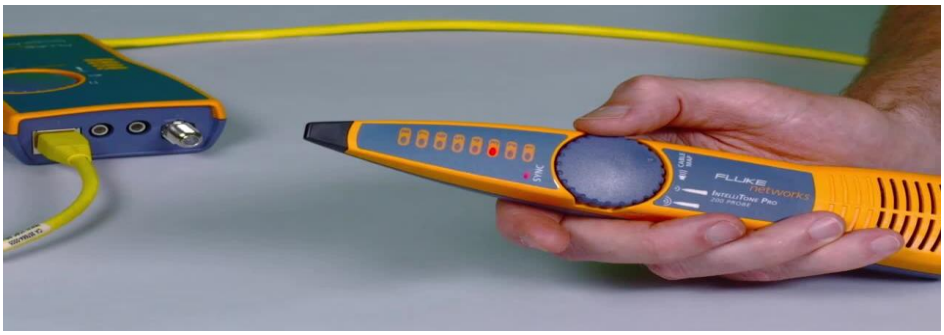
A fiber optic cable cutter is a specialized tool designed to cleanly and accurately cut fiber optic cables without damaging the core or introducing excessive loss. It is an essential tool for fiber optic network installation and maintenance.

✓ **Visual Fault Locator (VFL)**

A Visual Fault Locator (VFL) is a handheld device used to identify faults, breaks, or bends in fiber optic cables. It emits a visible red laser light into the fiber, allowing technicians to visually locate the problem area.

- **Cable Tracing and Labelling Tools**

Cable tracing and labeling tools are essential for managing and identifying fiber optic cables within a network. They help ensure proper connectivity, facilitate maintenance, and prevent errors during troubleshooting.



- **Fiber Optic Cleaning Tools**

Fiber optic cleaning tools are essential for maintaining the integrity and performance of fiber optic connections. Contaminants such as dust, dirt, and oil can degrade signal quality and cause transmission errors.

- **Cable Pulling and Installation Tools**

Fiber optic cable pulling and installation require specialized tools to ensure efficient and safe deployment.

- **Fiber Optic safety tools**

Fiber optic safety tools are specialized equipment designed to protect technicians from potential hazards during the installation, maintenance, and troubleshooting of fiber optic networks.

Points to Remember

- There are two main type of fiber optic route installation which are underground and overhead
- Key considerations when choosing a fiber optic route installation are: location and visibility, environment consideration, reliability and resilience and cost.
- The tools used in deployment of fiber optic route are**:** splicer machine (mechanical and fusion), hand tools, fiber optic cable cutter, fiber optic cable cutter
- While installing fiber optic route, there are key considerations which include location and visibility, environment consideration, reliability and resilience and cost.
- To implement fiber optic network, we use the following tools: pooling machine, splicing machine, optical timer domain reflectometer, tubing cutter, buffer tube cuter, pliers, read light.
- Consider the physical characteristics of the route and the impact of installation on the environment.
- Evaluate the costs associated with each installation method, including materials, labor, and permits

Application of learning 2.1.

Conduct a study visit to any fiber optic company that wishes to install a high-speed network to support its growing digital infrastructure, including online learning platforms, administrative systems, and security cameras. Referring to the key readings 2.1.2, you are tasked to select tools and equipments used in fiber optic deployment route .

Indicative content 2.2: Deployment of Fiber Optic Equipment

Duration: 5 hrs

Practical Activity 2.2.1: Deploying fiber optic closure, fiber optic distribution flame and cabinet rack

Task:

1.You are requested to go in the workshop/workplace and deploy fiber optic closure, fiber optic distribution flame and fix the cabinet rack.
2. Apply safety precautions (Wear PPE)
3. Present the steps to deploy fiber optic closure, fiber optic distribution flame and fix cabinet rack.
4. Referring to the steps presented in task 2, deploy fiber optic closure, fiber optic distribution flame and fix cabinet rack
5. Present the results of your work to the trainer and/or classmates
6. Read the key readings 2.2.1 and ask questions for clarifications where necessary.
7. Perform the task provided in application of learning 2.2.

Key readings Providing 2.2.1: Deploying fiber optic closure, distribution flame and cabinet rack

- **Fiber optic closure**

A fiber optic closure is a protective device used in fiber optic cable systems. It secures and safeguards the spliced fiber optic connections from environmental and mechanical damage. This closure ensures that the fibers remain protected from water, dust, and other contaminants, enabling the system to function without interruption.

- ✓ **Steps used to deploy fiber optic closure**

The process of deploying a fiber optic network closure involves several key steps:

Step1. Choose the appropriate location

Step2. Fiber Optic Cable Installation:

Lay the cables: Carefully place the fiber optic cables into the prepared trenches or conduits.

Splice the cables: Connect the fiber optic cables together using specialized splicing equipment, ensuring proper alignment and continuity.

Test the cables: Conduct tests to verify the integrity of the fiber optic connections and ensure they meet the required specifications.

Step3. Closure Preparation and Installation:

Select the appropriate closure: Choose a closure that is suitable for the specific application and environment, considering factors such as capacity, protection level, and ease of access.

Prepare the closure: Install any necessary components, such as termination blocks or splice trays, within the closure.

Mount the closure: Securely attach the closure to the prepared site, ensuring it is stable and protected from environmental factors.

Step4. Cable Termination and Splicing:

Strip and clean the cables: Prepare the fiber optic cables for termination by removing the outer jacket and buffer layers, and cleaning the fiber ends.

Terminate the cables: Connect the fiber optic cables to the termination blocks or splice trays within the closure, using appropriate termination methods.

Splice the cables (if necessary): If required, splice the fiber optic cables together within the closure, ensuring proper alignment and continuity.

Step5. Closure Sealing and Testing:

Seal the closure: Close and seal the closure to protect the fiber optic connections from environmental factors and contaminants.

Test the connections: Conduct final tests to verify the integrity of the fiber optic connections and ensure the network is functioning properly.

Step6. Documentation and Maintenance:

Document the installation: Record relevant information, such as the closure location, cable numbers, and termination details, for future reference and maintenance.

Implement a maintenance plan: Establish a routine maintenance schedule to inspect the closure, test the connections, and address any issues that may arise

- **Fiber Optic Distribution Frame (ODF)**

A Fiber Optic Distribution Frame (ODF) is a key component of the fiber optic infrastructure. It provides a centralized point to terminate and connect fiber optic cables, making cable management easier. ODFs help organize the network, offering a means to patch and splice the fibers for network scalability and troubleshooting.

✓ **Importance of deploying Cabinet Rack Fiber Optic Distribution Frame (ODF)**

- Used for fiber termination, splicing, and interconnection.
- Provides a structured layout for connecting optical cables.
- Enhances ease of maintenance and troubleshooting.
- Protects fiber connections from physical stress or damage.
- Available in wall-mounted or rack-mounted versions.

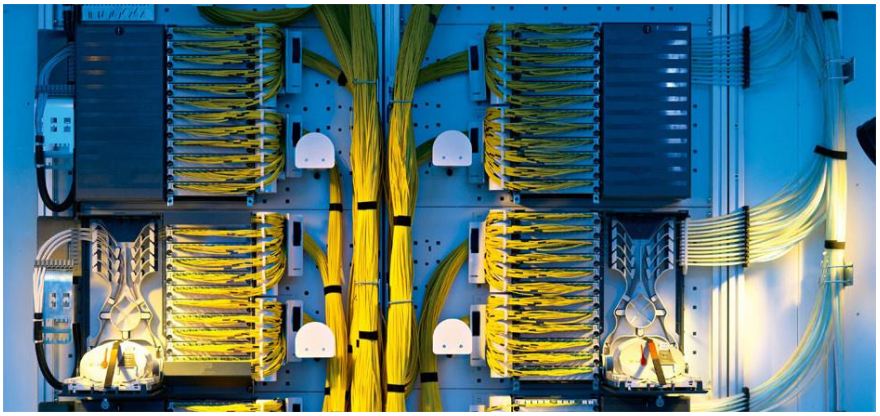


Fig: Picture illustrating fiber optic Distribution frame

- **Cabinet Rack**

It is a physical enclosure designed to house network equipment, including fiber optic components like switches, routers, patch panels, and ODFs. It provides a structured way to organize and secure devices in a data center, telecommunications room, or other network environments.

✓ **Importance of using Cabinet Rack**

- Encloses and organizes networking equipment.
- Provides protection from dust, debris, and unauthorized access.
- Supports cable management, ensuring proper airflow and cooling.
- Comes in different sizes (e.g. Cabinet Rack 19-inch rack standard) to fit diverse equipment.
- Offers space-saving, scalable infrastructure solutions in data centers.
- These components play critical roles in ensuring efficient and reliable fiber optic network deployment.

✓ **Steps used to deploy Cabinet Rack**

Step1. Planning and Design: Measure the room dimensions and check the available space where the cabinet rack will be installed. Ensure proper room for future expansion.

Step2. Select the Right Cabinet: Rack by considering size, weight capacity, cable management, cooling features, security.

Step3. Prepare the Installation Site: Ensure the floor can support the weight of the fully loaded rack. For raised floors, ensure proper cable routing underneath.

Step4. Position the Cabinet Rack: Move the rack into the designated location, ensuring enough space for airflow, maintenance access, and equipment installation.

Step5. Install Power Distribution Units (PDUs): Install vertical or horizontal PDUs inside the cabinet rack to distribute power to the devices.

Step6. Install Equipment: Begin with the heaviest equipment, such as servers, at the bottom of the rack to maintain stability.

Use rail kits or shelves to secure the equipment. Ensure it is properly aligned and securely fastened.

Leave sufficient space between equipment for airflow and cooling.

Step7. Cable Management

Use cable management accessories like vertical cable managers, horizontal lacing bars, and cable ties to organize cables neatly.

Route power cables separately from network cables to avoid interference.

Label cables on both ends for easy identification and future troubleshooting.

Ensure cables are not bent at sharp angles and are of appropriate length to avoid signal loss or power issues.

Step8. Cooling and Ventilation Setup

Ensure all equipment is positioned in a way that promotes proper airflow from front to back. Use blanking panels to cover any unused rack spaces to prevent hot air recirculation.

Consider installing fans or additional cooling units if the equipment generates significant heat.

Ste9. Grounding and Power Check

Connect all equipment to the grounding system for safety.

Verify that the power supply is properly distributed and that all devices are receiving sufficient and stable power.

Check the UPS and PDUs to ensure they are functioning properly.

Ste10. Testing and Final Inspection

Power on all equipment and verify it functions correctly.

Check that the equipment is properly cooled and airflow is not obstructed.

Perform network and server tests to ensure connectivity and performance are as expected.

Review cable management and make any adjustments if necessary to maintain neatness and accessibility.

Fig: Picture illustrating fiber optic Cabinet Rack

Points to Remember

- A fiber optic closure is a protective enclosure designed to house and terminate fiber optic cables.
- Cabinet racks serve several important roles in fiber optic network deployment like: housing and organization cables, protection, cable management and accessibility
- Optical fiber distribution frames (ODFs) are essential for organizing, terminating, and distributing fiber optic cables within a network
- Retain that there are three main types of fiber optic installations which are aerial, underground, and indoor.
- Components of a fiber optic closure include closure body, fiber management trays, splice trays, termination blocks, sealing glands
- Distributes fiber optic cables between network components.
- All the components work together to provide a secure, organized, and efficient environment for fiber optic networks.

Application of learning 2.2.

Visit any fiber optic company that wishes to install a high-speed network to support its growing digital infrastructure, including online learning platforms, administrative systems, and security cameras. Referring to the key readings 2.2.1, you are tasked to provide and fix fiber optic closure, distribution flame and cabinet rack required in fiber network implementation.

Indicative content 2.3: Perform Fiber Optic Splicing

Duration: 4 hrs

Theoretical Activity 2.3.1: Description of splicing process and their types

Tasks:

1: Answer the following questions:

i. Define the term splicing used in implementation of fiber optic network?

ii. Differentiate the two main types of splicing?

2: Write your finding on papers or flipchart.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 2.3.1

Key readings 2.3.1: Description of splicing process and their types

- **Definition**

Fiber optic splicing is a critical process in fiber optic network installation and maintenance. It involves joining two fiber optic cables together to create a continuous transmission path. There are two primary types of splicing: mechanical and fusion.

- **Types of splicing**

We have two main types of splicing**:** Mechanical Splicing and Fusion Splicing are two common types/methods used to join optical fibers in telecommunications and data transmission. Here's a breakdown of each types/method:

✓ **Mechanical Splicing:**

Description: Mechanical splicing involves aligning the ends of two optical fibers using a special mechanical fixture. The fibers are held in place with an index-matching gel or glue, which minimizes reflection and losses.

Advantages:

Quick and easy: Faster than fusion splicing as no special machinery (like arc fusion) is required.

No heat involved: Useful in environments where heat sources are restricted or impractical.

Reversible: The splice can be undone if needed, allowing for flexibility in installations.

Disadvantages:

Higher loss: Typically results in higher signal loss (0.2-0.75 dB) compared to fusion splicing.

Less durable: Mechanical splices are generally less reliable over the long term.
Expensive consumables: The use of index-matching gel or glue can add to the cost.

- ✓ **Fusion Splicing:**
- **Description**: Fusion splicing involves welding or "fusing" two fiber ends together using an electric arc. This creates a continuous connection between the fibers, which results in lower signal loss and better long-term performance.
- **Advantages**:

Low loss: Fusion splices typically have minimal signal loss (around 0.1 dB or less).
High durability: Once fused, the splice is permanent and highly reliable in terms of long-term stability.
Ideal for high-performance networks: Particularly suitable for high-speed, high-bandwidth applications.

- **Disadvantages**:

More time-consuming: Requires specialized equipment (fusion splicer) and more time to perform compared to mechanical splicing.
Not reversible: Once the fibers are fused, they cannot be separated again.
Higher initial cost: The equipment for fusion splicing is expensive, though it is a long-term investment.

- **Comparison:**

Signal Loss: Fusion splicing has lower signal loss compared to mechanical splicing.
Equipment: Mechanical splicing is simpler and requires fewer tools, while fusion splicing requires a specialized fusion splicer.
Durability: Fusion splices are more durable and provide a more permanent solution, while mechanical splices are more flexible but less reliable over time.

Practical Activity 2.3.2: Performing fiber splicing and core arrangements

Task:

1.You are requested to go in the workshop/workplace to make splicing and core arrangements of fiber optic network cables
2. Apply safety precautions (wear the PPE)
3. Present the steps to perform splicing and core arrangement of fiber optic network cables.
4. Referring to the steps presented in task 2, splice cables and perform core arrangement of fiber optic network cables
5. Read the key readings 2.3.2 and ask questions for clarifications where necessary.
7. Perform the task provided in application of learning 2.3.

Key readings 2.3.2: Performing fiber splicing and core arrangements

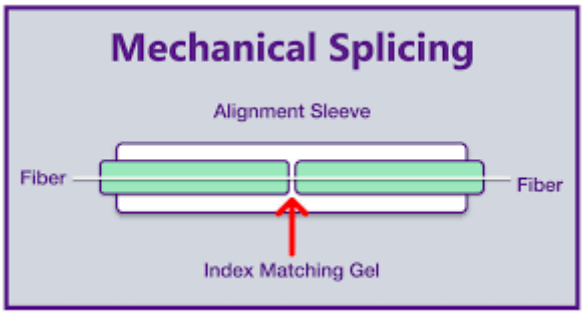
Steps of performing fiber splicing

- **Key steps of performing Mechanical Splicing**

Step1:Prepare the Fibers: Strip the outer jacket and buffer coating from the fiber ends using a fiber stripper.

Step2:Clean the Fibers: Clean the fiber ends with a fiber optic cleaner to remove any contaminants that could affect the splice quality.

Step3:Align the Fibers: Carefully align the cores of the two fibers using a mechanical alignment tool.



Step4:Insert the Sleeve: Insert the prepared fiber ends into a pre-cut mechanical sleeve.

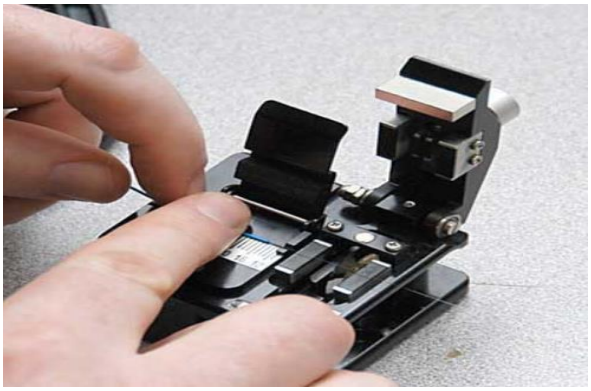
Step5:Secure the Sleeve: Apply pressure to the sleeve using a crimping tool or clamp to secure the fibers in place.

- **Key steps for perming Fusion Splicing**

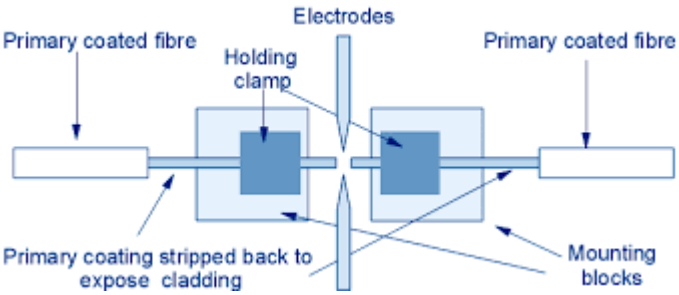
Step1:Prepare the Fibers: Strip the outer jacket and buffer coating from the fiber ends using a fiber stripper.

Step2:Clean the Fibers: Clean the fiber ends with a fiber optic cleaner to remove any contaminants.

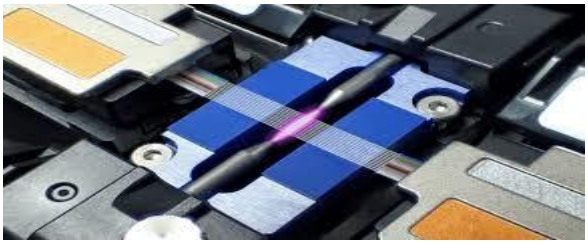
Step3:Cleave the Fibers: Use a fiber cleaver to create a clean, perpendicular cut on the fiber ends.



Step4:Align the Fibers: Carefully align the cores of the two fibers using a fusion splicer's alignment mechanism.



Step5:Fuse the Fibers: Apply an electric arc to the fiber ends, melting them together to form a permanent bond.



Step6:Inspect the Splice: Use a microscope to inspect the splice for any defects or imperfections.

- **Core Arrangements**

Core arrangement refers to the physical configuration of the fibers within a cable. There are two common core arrangements:

Ribbon: Fibers are arranged in parallel ribbons, which can be easily spliced and terminated.

Loose Tube: Fibers are individually encased in tubes, which can provide better protection against bending and microbending loss.

- ✓ **Core Arrangement in Fiber Optic Implementation: A Step-by-Step Guide**

  Core arrangement is a critical step in fiber optic implementation, ensuring efficient utilization of the available fibers and minimizing future network upgrades. Here's a breakdown of the key steps involved:

Step1. Network Design and Planning:

Define Service Requirements: Determine the bandwidth needs for each service (e.g., internet, voice, video) and the number of subscribers.

Capacity Planning: Forecast future growth and potential bandwidth demands to avoid premature network congestion.

Fiber Optic Cable Selection: Choose the appropriate fiber optic cable type (single-mode or multi-mode) and core count based on distance, bandwidth requirements, and future scalability.

Step2. Core Assignment:

Logical Core Mapping: Assign specific fibers to particular services or subscriber groups. This may involve color-coding or labeling fibers for easy identification.

Redundancy Planning: Incorporate redundant fibers to ensure network resilience in case of fiber cuts or equipment failures.

Growth Considerations: Reserve a portion of the core count for future expansion to accommodate new services or increased subscriber demand.

Step3. Splicing and Termination:

Fiber Splicing: Carefully splice fibers together using fusion splicing or mechanical splicing techniques, ensuring minimal signal loss.

Connectorization: Install connectors on the ends of the fibers for easy connection to equipment.

Step4. Testing and Verification:

Optical Time-Domain Reflectometer (OTDR) Testing: Use an OTDR to measure signal attenuation and identify any faults or breaks in the fiber.

Loss and Return Loss Measurements: Verify that signal loss and return loss are within acceptable limits.

End-to-End Testing: Conduct comprehensive testing of the entire network to ensure proper functionality and performance.

Step5. Documentation:

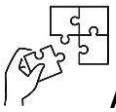
Core Assignment Records: Maintain detailed records of core assignments, including fiber numbers, services, and subscriber connections.

Splice Point Documentation: Document the location and details of each splice point for future reference and maintenance.

Points to Remember

- Fiber optic splicing It is the process of joining two fiber optic cables together to create a continuous transmission path.
- There are two primary methods of splicing: (a) mechanical splicing which is generally less expensive but may have higher loss, and (b) fusion splicing which provides a more reliable joint but requires specialized equipment and training.
- Fiber optic splicing requires these key steps: prepare fibers, clean fibers, align fibers, splice fibers, inspect splice.
- Ribbon and loose tube are common arrangements in fiber optic splicing
- Choose core arrangement based on application, cable type, and splicing/termination methods.

- Key consideration in fiber optic splicing is fiber type, cable length, and environmental factors.
- Successful fiber splicing and core arrangements are essential for reliable fiber optic networks.
- Successful fiber splicing and core arrangements are essential for reliable fiber optic networks.



Application of learning 2.3.

Visit any fiber optic company that wishes to deploy a fiber optic network in its buildings. Then, help the company implement fiber optic network by splicing a fiber optic cable and make the arrangement of the core.

Indicative content 2.4: Testing Fiber Optic Link

Duration: 4 hrs

Theoretical Activity 2.4.1: Description of fiber optic link testing

Tasks:

1: Answer the following questions:

i. What is the primary purpose of fiber link testing?
ii. How does a continuity tester work in verifying fiber link connectivity?
iii. What is the purpose of measuring the optical power level at the receiving end of the fiber link?
iv. Why is it important to test the actual distance of a fiber link?
v. How does an OTDR detect faults or breaks in a fiber link?

2: Write your findings on papers or flipcharts

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 2.4.1

Key readings 2.4.1.: Description of fiber optic link testing

Fiber link testing process

Fiber link testing is a crucial step in ensuring the integrity and performance of fiber optic networks. It involves various techniques to assess the quality of the fiber, connections, and overall transmission path.

- **Common fiber link testing techniques:**

Optical Power Meter (OPM): Measures the optical signal power at different points in the link to assess attenuation and signal loss.

Optical Time-Domain Reflectometer (OTDR): Provides a visual representation of the fiber link, allowing for the identification of faults, breaks, and other anomalies.

Continuity Tester: Checks for continuity between the two ends of the fiber link to verify connectivity.

Loss Budget Analysis: Calculates the maximum allowable loss for the link based on the distance, fiber type, and equipment specifications.

- **General fiber link testing procedure:**

Prepare Equipment: Gather necessary equipment, including an OPM, OTDR, continuity tester, and any other relevant tools.
Establish Reference Points: Identify reference points along the fiber link, such as splices, connectors, and end points.
Perform OPM Measurements: Measure the optical power at the transmitter, receiver, and any intermediate points.
Conduct OTDR Testing: Connect the OTDR to the fiber link and acquire a trace.
Check Continuity: Use a continuity tester to verify connectivity between the two ends of the link.
Analyze Results: Compare the measured values with the link's specifications and identify any anomalies or issues.

- **Test Continuity**

Purpose: Ensure a physical connection exists between the two ends of the fiber link.
Method:
Use a continuity tester or an optical power meter (OPM) in the continuity mode.
Connect the tester to both ends of the fiber link.
If a connection exists, the tester will indicate continuity.

- **Test Power Link**

Purpose: Measure the optical power level at the receiving end of the fiber link.
Method:
Use an OPM to measure the received optical power.
Compare the measured power to the expected power level for the specific fiber type and distance.
If the power level is significantly lower than expected, it may indicate a problem such as attenuation or a faulty connection.

- **Test Link Distance**

Purpose: Determine the actual length of the fiber link.
Method:
Use an OPM with a distance measurement function.
Connect the OPM to one end of the fiber link and generate a pulse.
The OPM will measure the time it takes for the pulse to travel to the other end and return.
Using the speed of light in the fiber, calculate the link distance

- **Analyse Optical Time Domain Reflectometer (OTDR) Report**

Purpose: Identify faults, breaks, or other issues within the fiber link.
Method:

Use an OTDR to generate a visual representation of the fiber link.
The OTDR sends a pulse of light into the fiber and measures the reflected light to identify any discontinuities or losses.
Analyze the OTDR report for:
Event markers indicating faults or breaks.
Attenuation profiles to assess fiber quality and identify potential problems.
Reflections caused by connectors, splices, or other irregularities.

- **Additional Considerations:**

Fiber Type: Ensure that the testing equipment is compatible with the fiber type (single-mode or multimode).
Wavelength: Select the appropriate wavelength for the testing equipment and the fiber link.
Reference Levels: Use reference levels provided by the fiber manufacturer or network standards to compare measured values.
Documentation: Record the test results for future reference and troubleshooting.

By following these steps and carefully analyzing the test results, you can effectively assess the integrity and performance of a fiber optic link.

Practical Activity 2.4.2: Testing Fiber optic link

Task:

1. You are requested to go in fiber optic network control room and test the continuity, test power link and test link distance of the fiber network.
2. Apply safety precautions (wear the PPE)
3. Present the procedures of testing the continuity, power link and link distance of a fiber optic network.
4. Referring to the procedures presented in task 2, test the continuity, power link and link distance
5. Present your testing results to the trainer or classmates.
6. Read the key readings 2.4.2: and ask questions for clarifications where necessary.
7. Perform the task provided in application of learning 2.4.

Key readings 2.4.2: Testing fiber optic link

- **Continuity Testing**

Equipment: Continuity tester or tone generator

Procedure:

Connect the continuity tester or tone generator to one end of the fiber optic link.

Connect the other end of the tester or generator to the other end of the link.

Activate the tester or generator and listen for a tone or indication of continuity.

If a tone or indication is heard, the link is continuous. If not, there may be a break or disconnection.

- **Power Link Testing**

Equipment: Optical power meter (OPM)

Procedure:

Connect the OPM to the transmitter end of the fiber optic link.

Measure the output power of the transmitter.

Connect the OPM to the receiver end of the link.

Measure the received power.

Calculate the link loss by subtracting the received power from the transmitted power.

Compare the calculated link loss to the allowed loss budget for the link.

- **Link Distance Testing**

Equipment: Optical Time-Domain Reflectometer (OTDR)

Procedure:

Connect the OTDR to the transmitter end of the fiber optic link.

Activate the OTDR and acquire a trace.

Identify the event markers on the trace that correspond to the ends of the link.

Measure the distance between the event markers to determine the link length.

Compare the measured link length to the expected length based on the installation documentation.

Additional Considerations:

Reference Points: Establish reference points along the fiber link to correlate measurements with specific locations.

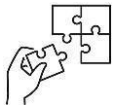
Baseline Measurements: Take baseline measurements to monitor changes in link performance over time.

Troubleshooting: Use the test results to troubleshoot issues and identify the root cause of problems.

Documentation: Document all test results and findings for future reference.

Points to Remember

- The primary purpose of fiber link testing is to ensure the integrity, performance, and reliability of a fiber optic network by detecting faults, breaks, signal loss, or connectivity issues along the fiber link.
- A continuity tester works by sending a signal from one end of the fiber to the other
- The purpose of measuring the optical power level at the receiving end is to verify that the transmitted signal is strong enough for proper data transmission.
- Testing the actual distance of a fiber link is important to confirm that the cable length matches design expectations.
- An OTDR detects faults or breaks by sending a pulse of light into the fiber and measuring the reflected light.
- Follow these procedures while testing fiber optic network: connect equipment, measure values, analyze results
- Ensure that you are using this equipment while testing fiber optic network: continuity tester, optical power meter, and OTDR



Application of learning 2.4.

Suppose that XYZ Company wishes to install a high-speed network to support its growing digital infrastructure including online learning platforms, administrative systems, and security cameras. Referring to the key readings 2.4.2, you are tasked to implement a fiber network by testing continuity, power link and link distance.

Indicative content 2.5: Perform Fiber Optic Patching

Duration: 4hrs

Theoretical Activity 2.5.1: Identification of fiber optic connector and jumper cord

Tasks:

1: Answer the following question:

i. What are the five common types of fiber optic connectors?

ii. What are the key points to remember while identifying jumper card?

2: Write your finding on papers or flipcharts.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 2.5.1

Key readings 2.5.1.: Identification of fiber optic connector and jumper cord

- **Definition of terms**

Fiber optic connectors are the physical interface points where fiber optic cables are terminated and connected to network equipment.

Jumper cords are short lengths of fiber optic cable with connectors on both ends, used to connect equipment within a network.

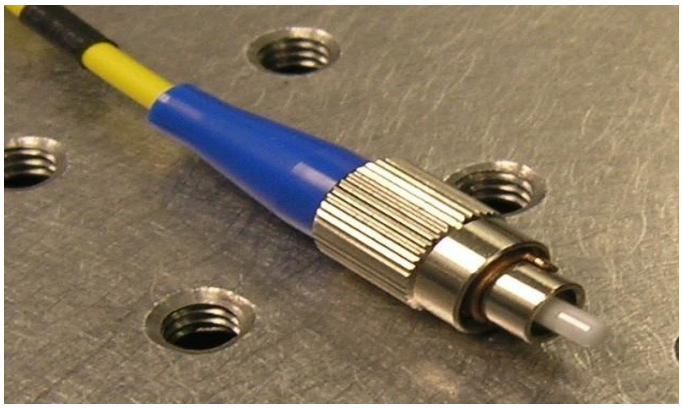
- **Common Fiber Optic Connectors**

LC (Lucent Connector): A small, push-pull connector that is widely used in high-density applications.

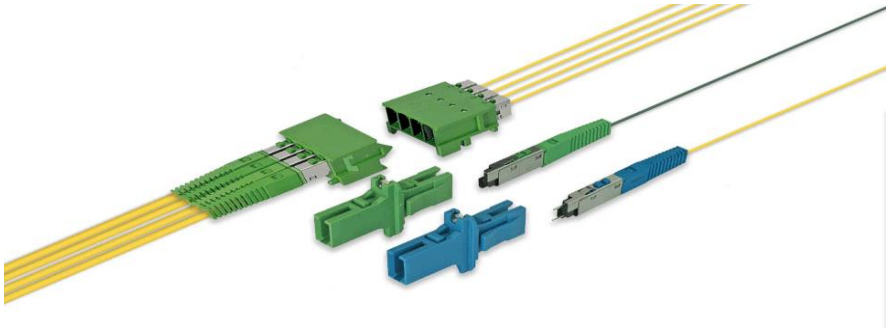
SC (Straight Connector): A larger, push-pull connector that is commonly used in various network environments.

ST (Straight Tip): A bayonet-style connector that is still used in some older installations but is less common today.

FC (Ferrule Connector): A precision connector with a bayonet-style locking mechanism, often used in high-performance applications.



MT (Multi-Fiber): A connector designed to terminate multiple fibers in a single unit, typically used in high-density applications.



- **Identifying Connectors**

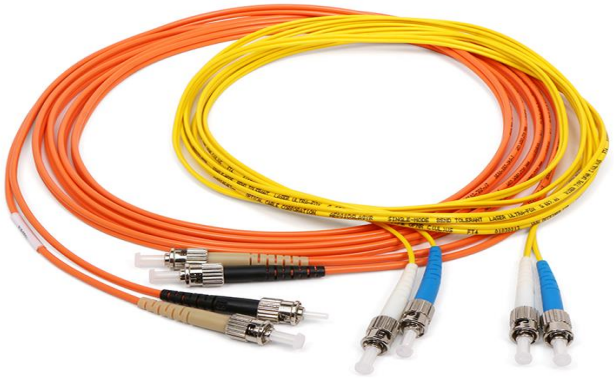
To identify a fiber optic connector, examine its physical characteristics, including:

Size and Shape: The connector's overall dimensions and the shape of the keying mechanism.

Locking Mechanism: Whether it's push-pull, bayonet-style, or another type.
Ferrule Type: The type of ferrule used within the connector (e.g., ceramic, plastic).
Polarity: Some connectors have polarity markings to indicate the correct orientation for connection.
Jumper Cords: Jumper cords are typically labeled with the connector types on each end and the fiber type (single-mode or multimode). They may also be labeled with the length of the cable and other specifications.

- **Key Points to Remember while identifying jumper card.**

Connector Compatibility: Ensure that connectors are compatible with the equipment they are being used with.
Polarity: Pay attention to connector polarity to avoid signal inversion.
Fiber Type: Use jumper cords with the appropriate fiber type for your network.
Labeling: Proper labeling of jumper cords can help with identification and management.



Fiber optic jumper cord labels typically include the following information:
Connector Types: The types of connectors on both ends of the cord (e.g., SC-SC, LC-LC).
Fiber Type: The type of fiber used in the cord (e.g., single-mode, multimode).
Core Diameter: The diameter of the fiber core.
Cable Length: The overall length of the jumper cord.
Wavelength: The wavelength range supported by the cord.
Manufacturer and Product Number: Information for identifying the manufacturer and specific product.

Theoretical Activity 2.5.2: Identification of fiber optic pigtail

Tasks:

1: Answer the following questions:

i. What is the primary purpose of a fiber optic pigtail?
ii. How does the connector type on a fiber optic pigtail typically relates to the main cable and network equipment?

2: Write your findings on papers or flipchart.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 2.5.2

Key readings 2.5.2: Identification of fiber optic pigtail

- **Definition of fiber optic pigtail**

Fiber optic pigtail is a short length of fiber optic cable with a connector on one end. It is used to connect network equipment to the main fiber optic cable. Pigtails are typically terminated with the same type of connector as the main cable, allowing for a seamless connection.

- **Key Points to Remember while during identification of fiber optic pigtail**

Length: Pigtails are typically shorter than jumper cords, often around 1 meter or less.

Connector Type: The connector type on a pigtail should match the connector type on the main cable and the network equipment.

Fiber Type: Pigtails should be the same fiber type as the main cable (single-mode or multimode).

Labeling: Pigtails may be labeled with the fiber type, connector type, and other specifications.

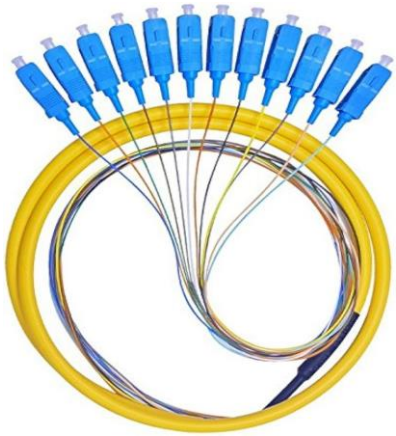


Fig. fiber optic pigtail

- **Primary Purpose of a Fiber Optic Pigtail**

A fiber optic pigtail is a short, pre-terminated fiber optic cable that connects a main fiber optic cable to a network device or termination point. Its primary purpose is to provide a flexible and reliable link between the main cable and the equipment, allowing for easier installation, maintenance, and testing.

- **Connector Type and Compatibility**

The connector type on a fiber optic pigtail is crucial for ensuring compatibility with the main cable and network equipment. Common connector types include:

FC (Ferrule Connector): Often used in older installations and laboratory equipment.

ST (Straight Tip): A popular choice for indoor and outdoor applications due to its simplicity and reliability.

SC (Subscriber Connector): Widely used in various networking environments, including data centers and telecommunications networks.

LC (Lucent Connector): Known for its small size and high density, making it ideal for high-density applications.

MT (Multimode Trunk): Designed for high-density applications, especially in data centers and central offices.

The connector type on the pigtail must match the connector type on both the main cable and the network device to establish a proper connection.

Practical Activity 2.5.3: Performing fiber patching process and connect IP equipment

Task:

1.You are requested to go in the workshop/workplace and patch fiber cable and connect IP equipment

2. Apply safety precautions (wear the PPE)

3. Present the steps for patching fiber cable and connecting IP equipmemt

4. Referring to the steps presented in task 2, patch the fiber cable and connect the IP equipment

5. Present the results of your work to the trainer or classmates

5. Read the key readings 2.5.3 and ask questions for clarifications where necessary.

6. Perform the task provided in application of learning 2.5.

Key readings 2.5.3: Perfoming fiber patching process and connect IP Equipment

- **Fiber Patching Process**

Fiber patching involves connecting fiber optic cables together using jumper cords. This process is essential for creating the physical connections between network devices and the main fiber optic infrastructure.

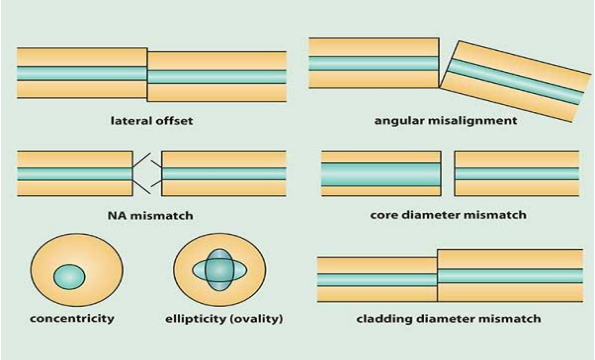
➢ **Key Steps to be followed while performing Fiber Patching:**

- **Prepare the Equipment:** Ensure that the fiber optic cables and equipment are properly prepared and powered off.

- **Identify Connectors:** Identify the correct connectors on the cables and equipment.

- **Clean Connectors:** Clean the connectors to remove any contaminants that could interfere with the connection.

- **Align Connectors:** Align the connectors carefully to ensure proper contact.



- **Insert Connectors:** Insert the connectors into the appropriate ports on the equipment or patch panel.
- **Secure Connectors:** Secure the connectors using the appropriate locking mechanism (e.g., push-pull, bayonet-style).
- **Verify Connection:** Use a continuity tester or other appropriate tools to verify that the connection is successful.

➢ **Key Considerations while patching fiber optic cable**

Connector Compatibility: Ensure that the connectors on the cables and equipment are compatible.

Polarity: Pay attention to connector polarity to avoid signal inversion.

Fiber Type: Use jumper cords with the appropriate fiber type for your network.

Labeling: Properly label the connections for easy identification and management.

- **Connecting IP Equipment**

IP (Internet Protocol) equipment is essential for networking and communication. It includes devices such as routers, switches, firewalls, and servers. Proper connection of IP equipment is crucial for a functional network.

- **Basic Steps for Connecting IP Equipment**

Step1. Physical Connection:

Connect the power cables to the devices.

Connect the network cables (Ethernet or fiber optic) to the appropriate ports on the devices.

Ensure secure connections and proper cable management.

Step2. Configuration:

Assign IP addresses to each device.

Configure network settings, such as subnet masks, default gateways, and DNS servers.

Set up security measures like firewalls and access control lists (ACLs).

Step3. Testing:

Ping devices to verify connectivity.

Test network performance using tools like Wireshark or network analyzers.

Troubleshoot any issues that arise.

- **Common IP Equipment and Their Connections**

Routers: Connect multiple networks together. They typically have multiple Ethernet ports and may also have WAN (Wide Area Network) ports for connecting to external networks.

Switches: Connect devices within a local area network (LAN). They have multiple Ethernet ports and are often used to create VLANs (Virtual Local Area Networks).

Firewalls: Protect networks from unauthorized access. They typically have multiple Ethernet ports and are configured with security rules.

Servers: Provide services to other devices on the network, such as file storage, web hosting, or email. They may have multiple Ethernet ports and additional connections for storage devices or peripherals.

- **Additional Considerations**

Cable Types: Use the appropriate cable type (e.g., Ethernet, fiber optic) based on the distance and network requirements.

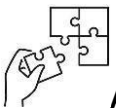
Hubs: While less common today, hubs can be used to connect multiple devices on a network. However, they broadcast all traffic to all devices, which can reduce performance.

Wireless Access Points: Can be used to create wireless networks. They typically have Ethernet ports for connecting to the wired network.

Network Topology: Consider the network topology (e.g., star, ring, mesh) when connecting devices.

Points to Remember

- Primary purpose of pigtail is to provide a flexible and reliable link between the main cable and the equipment.
- The connector type on the pigtail must match the connector type on both the main cable and the network device to establish a proper connection. Ensure connectors are compatible with equipment and fiber types.
- Ensure the pigtail connector matches the main cable and equipment.
- Common types of fiber optic connectors are: FC (ferrule connector), ST (straight tip), SC (subscriber connector), LC (lucent connector), MT (multimode trunk)
- Characteristics that can be used to identify a fiber optic connector are: connector style, ferrule shape and size, keying mechanism, housing material and polarity
- Connector types**,** fiber type**,** core diameter**,** cable length**,** wavelength**,** manufacturer and product number are the information labelled on jumper cord
- The key steps involved in the fiber patching process are: prepare the fiber optic connectors, align the connectors, insert and latch, verify the connection



Application of learning 2.5.

Suppose that ABC fiber Optics is a company that is seeking to install a high-speed network to support its growing digital infrastructure. Referring to the key readings 2.5.3, you are tasked to help the company implement its fiber optic by patching fiber optic network cable and connecting IP equipment.

Indicative content 2.6: Generate Technical Documentation

Duration: 4hrs

Practical Activity 2.6.1: Performing core allocation, fiber allocation and equipment location

Task:

1. You are requested to go in the workshop to perform (i) core allocation, (ii) fiber allocation, and (iii) equipment location for fiber optic network.
2. Apply safety precautions (wear the PPE)
3. Present the steps to perform core allocation, fiber allocation and equipment location of fiber optic network.
4. Referring to the steps provided in task 2, perform core allocation, fiber allocation and equipment location of fiber optic network.
5. Present the results of your work to the trainer and/or classmates
6. Read the key readings 2.6.1 and ask questions for clarifications where necessary.
7. Perform the task provided in application of learning 2.6.

Key readings 2.6.1.: Performing core allocation, fiber allocation and equipment location.

- **Core Allocation**

Core allocation refers to the process of assigning specific functions or services to different network cores. This involves dividing the network into logical layers or segments, each responsible for handling different types of traffic or providing specific services.

✓ **Common Core Layers:**

Access Core: The outermost layer of the network, responsible for connecting end-user devices to the network.

Aggregation Core: The middle layer of the network, responsible for aggregating traffic from multiple access cores and distributing it to the distribution core.

Distribution Core: The innermost layer of the network, responsible for routing traffic between different parts of the network and providing services such as quality of service (QoS) and security.

✓ **Steps of performing Core Allocation of fiber optic**

Identify Network Requirements: Determine the number of fibers needed to meet the network's bandwidth capacity and future growth requirements.

Analyze Network Topology: Study the network's physical layout and identify potential bottlenecks or areas where additional fibers may be needed.
Allocate Cores: Assign specific cores within each fiber to different services or connections based on their bandwidth requirements and priorities.
Consider Future Expansion: Allocate extra cores to accommodate future growth or changes in network traffic.

- **Fiber Allocation**

Fiber allocation involves determining the optimal routing of fiber optic cables within the network. This involves considering factors such as distance, cost, and network topology.

- ✓ **Key Considerations for Fiber Allocation:**

Fiber Type: The type of fiber optic cable (single-mode or multimode) to be used.
Cable Routing: The physical path that the fiber optic cables will follow.
Splicing and Termination: The locations of splices and terminations within the network.
Redundancy: The need for backup paths to ensure network reliability.

- ✓ **Steps to be followed while performing fiber allocation**

Determine Fiber Paths: Plan the routes for the fiber optic cables, considering factors like distance, terrain, and infrastructure availability.
Allocate Fibers: Assign specific fibers to different routes or sections of the network based on their connectivity requirements and capacity needs.
Redundancy Planning: Implement redundancy by allocating multiple fibers for critical connections to ensure network reliability in case of failures.
Labeling and Documentation: Clearly label and document the fiber paths and their assigned purposes for future reference.

- **Equipment Location**

Equipment locations refer to the physical placement of network devices, such as routers, switches, and servers. Proper equipment placement is essential for network performance, scalability, and manageability.

- ✓ **Factors to Consider for Equipment Locations:**

Network Topology: The physical structure of the network.
Traffic Patterns: The expected volume and type of traffic that will flow through the equipment.
Environmental Factors: Temperature, humidity, and other environmental conditions.
Security: The need for physical security measures to protect network equipment.
Accessibility: The ease of access for maintenance and troubleshooting.

- ✓ **Steps to Perform Equipment Location in a Fiber Optic Network**

Identify Equipment Needs: Determine the types and quantities of equipment required for the network, such as optical switches, routers, and amplifiers.
Select Equipment Locations: Choose suitable locations for the equipment based on factors like accessibility, power availability, and environmental conditions.

Consider Network Topology: Ensure that the equipment locations are compatible with the overall network topology and support the desired connectivity.
Rack Mounting and Cabling: Install the equipment in racks and connect it to the fiber optic cables using appropriate connectors and patch cords.

Practical Activity 2.6.2: Performing OTDR report

Task:

1: You are requested to go in the workshop to perform OTDR for fiber optic network
2: Apply safety precautions (wear the PPE)
3: Present the steps to perform OTDR report for fiber optic network.
4: Referring to the steps provided in task 2, perform OTDR report.
5: Present the results of your work to the trainer and/or classmates
6: Read the key readings 2.6.2 and ask questions for clarifications where necessary.
7: Perform the task provided in application of learning 2.6.

Key readings 2.6.2: Performing OTDR report

- **Definition**

OTDR (Optical Time-Domain Reflectometer) reports provide valuable insights into the performance and integrity of fiber optic networks. By analysing OTDR traces, you can identify faults, measure attenuation, and assess the overall health of your fiber optic links.

- **OTDR Testing Procedure**

Prepare Equipment: Ensure that the OTDR is properly calibrated and connected to the fiber optic link.

Set Parameters: Configure the OTDR settings, such as the launch power, wavelength, and acquisition time, based on the specific requirements of your network.

Acquire Trace: Initiate the OTDR measurement and capture the trace.

Analyse Trace: Examine the OTDR trace for any anomalies or events, such as reflections, attenuation, or breaks.

Interpret Results: Use the OTDR report to identify the location and nature of any issues.

- **Key Components of an OTDR Report**

Trace: A graphical representation of the fiber link, showing the signal attenuation over

distance.

Events: Anomalies or discontinuities in the fiber link, such as splices, connectors, or faults.

Measurements: Numerical data related to the link's length, attenuation, and other parameters.

Event Analysis: Identify the cause of events (e.g., splices, connectors, bends) and take corrective action.

- **Steps to Perform an OTDR Report**

✓ **Equipment Setup:**

Connect OTDR: Connect the OTDR to the fiber under test using appropriate connectors (e.g., FC, LC, ST).

Configure Parameters: Set the OTDR's parameters, such as pulse width, wavelength, sampling rate, and acquisition time, based on the fiber length and desired resolution.

✓ **Perform Measurement:**

Trigger OTDR: Initiate the OTDR measurement by triggering the launch of a light pulse into the fiber.

Capture Backscatter: The OTDR captures the backscattered light as it travels back through the fiber.

Analyze Data: The OTDR analyzes the captured data to determine attenuation and other fiber characteristics.

✓ **Interpret OTDR Trace:**

Identify Events: Examine the OTDR trace for events such as fiber breaks, splices, connectors, and bends.

Measure Attenuation: Calculate the attenuation of the fiber between events by analyzing the amplitude of the backscattered light.

Evaluate Fiber Quality: Assess the overall quality of the fiber based on the presence of events, attenuation levels, and other parameters.

✓ **Analyse Event Data:**

Identify Event Type: Determine the type of event (e.g., splice, connector, bend) based on its signature on the OTDR trace.

Measure Event Loss: Calculate the loss associated with each event.

Evaluate Event Impact: Assess the impact of the event on the fiber's performance.

✓ **Generate OTDR Report:**

Create Report: Generate an OTDR report summarizing the key findings, including:

Fiber length

Attenuation profile

Event locations and types

Event losses

Overall fiber quality assessment

Include Trace: Include a copy of the OTDR trace to provide visual evidence of the measurements.

- **Analyse Report:**

Review Findings: Carefully review the OTDR report to identify any potential issues or anomalies.

Compare to Specifications: Compare the measured attenuation and event losses to the fiber's specifications.

Take Corrective Action: If necessary, take corrective action, such as repairing damaged sections of the fiber or replacing faulty components.

Points to Remember

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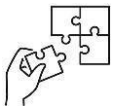
- Core assignment is the allocation of cores based on service priorities and bandwidth demands.
- Fiber paths are to plan routes for fiber cables considering factors like distance, terrain, and infrastructure.
- Implement redundancy for critical connections is to ensure reliability.
- Labeling and documentation clearly label and document fiber paths for future reference.
- Rack mounting and cabling is to install the equipment in racks and connect it to fiber cables
- Regular monitoring is to conduct periodic OTDR measurements to monitor fiber health and identify potential problems early.
- Consider the following factor while making OTDR report of fiber: type, cable routing, splicing/termination, redundancy, network topology, traffic patterns, environmental factors, security, accessibility.
- TDR is a specialized instrument for measuring fiber link performance.
- Testing procedure**:** prepare equipment, set parameters, acquire trace, analyze trace.



Application of learning 2.6.

Conduct a study visit to any fiber optic network company and then help the company to do the following task:

a) Perform core and fiber allocation after implementation of fiber optic network.
b) Locate fiber optic network equipment
c) Write OTDR report

Learning outcome 2 end assessment

Theoretical assessment

Q1. Answer the following questions by TRUE if the statement is correct or by FALSE if the statement is incorrect:

i. Aerial installation is preferred in urban areas to avoid underground obstacles.
ii. Small Form Factor Pluggable (SFP) modules are used to provide flexible and high-speed network connections.
iii. Mechanical splicing is generally more reliable than fusion splicing.
iv. An Optical Time-Domain Reflectometer (OTDR) can identify faults and measure signal loss in a fiber optic cable.
v. Proper labeling of fiber optic cables is essential during patching to ensure easy identification and troubleshooting.
vi. Detailed technical documentation helps in future troubleshooting and maintenance of the fiber optic network.

Q2. Read and answer the following questions:

i. Describe the steps involved in performing fiber optic patching.
ii. What are the differences between mechanical and fusion splicing?
iii. Explain the process of testing a fiber optic link.

Q3. Circle the letter corresponding with the correct answer

i. Which of the following tools is primarily used for fusion splicing of fiber optic cables?
   a) Fiber Optic Cleaver
   b) Fusion Splicer
   c) Visual Fault Locator
   d) OTDR
ii. Which equipment is used to test the integrity and performance of a fiber optic link?
   a) Fiber optic cleaver
   b) OTDR
   c) Media converter
   d) Router
iii. Which of the following components is used to organize and terminate fiber optic cables in a network?
   a) Router
   b) Switch
   c) Patch Panel
   d) Media Converter
iv. Which of the following is NOT typically included in technical documentation for a fiber optic network?
   a) Cable routes

b) Test results
c) Personal opinions
d) Equipment inventory

v. Which device is used to convert electrical signals to optical signals in a fiber optic network?
a) Router
b) Switch
c) Media Converter
d) Patch Panel

vi. Which factor is NOT typically considered when selecting a fiber optic deployment route?
a) Distance
b) Environmental conditions
c) Cable color
d) Existing infrastructure

vii. Which of the following is NOT typically included in technical documentation for a fiber optic network?
a) Cable routes
b) Test results
c) Personal opinions
d) Equipment inventory

Practical assessment

Suppose that a certain area located in Rwandan community requires a reliable and high-speed internet connection. The goal is to implement a fiber optic network to provide internet access to schools, healthcare facilities, government offices, and residents. You are requested to perform the following task:

a) Select fiber optic deployment tools and equipment required in the project.
b) Select fiber optic deployment route according to the fiber optic design
c) Deploy fiber optic equipment based on fiber optic network design.
d) Perform fiber splicing and core arrangements of fiber network cable.
e) Perform fiber optic patching and connect and connect IP equipment.
f) Perform continuity, power link and link distance test for your installed fibe optic network.
g) Perform OTDR report your fiber network deployed.

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Indicative contents
3.1. Fiber optic network preventive maintenance **3.2. Perform corrective maintenance** **3.3. Elaboration of troubleshooting process** **3.4 Troubleshooting report**

Key Competencies for Learning Outcome 3: Maintain Fiber Optic Network

Knowledge	Skills	Attitudes
● Preparation of hardware preventive maintenance ● Preparation of software preventive maintenance ● Description of corrective maintenance	● Preforming fiber optic network preventive maintenance ● Performing troubleshooting report.	● Having critical thinking on preventive maintenance ● Being hard worker on corrective maintenance

Duration: 20 hrs

Learning outcome 3 objectives:

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

1. Prepare clearly hardware preventive maintenance according to the network standards
2. Prepare clearly software preventive maintenance according to the network standards
3. Preform properly fiber optic network preventive maintenance according to the network standards
4. Conduct properly corrective hardware and software maintenance according to the network standards
5. Elaborate correctly troubleshooting process according to the work done
6. Troubleshoot clearly report generated according to monitoring report

Resources

Equipment	Tools	Materials
● Computer	● Pooling machine ● Blowing machine ● Splicing machine ● Optical timer ● Domain reflectometer ● Tubing cutter ● Buffer tube cuter ● Pliers ● Read light ● Jacket stripper ● Kevlar scissor ● Tweezers ● Fiber scribe ● Cleaver ● Fiber stripper ● Fiber optic power meter ● Knife ● Cleaning tool ● Screwdriver	● Internet bundles

Indicative content 3.1: Fiber Optic Network Preventive Maintenance

Duration: 5 hrs

Theoretical Activity 3.1.1: Preparation of hardware maintenance

Tasks:

1: Answer following questions:

i. What is the importance of doing scheduled regular cleaning for fiber optic networks?
ii. Why are preventive measures important for fiber optic networks?
iii. Why do we need checking physical equipment condition for fiber optic network?
iv. What are some environmental factors that can affect the performance of fiber optic networks?

2: Write your findings on papers or flipchart.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 3.1.1

Key readings 3.1.1.: Preparation of hardware maintenance

- **Definition of terms**

Hardware maintenance is a critical component of ensuring the reliability and performance of fiber optic networks. It involves a combination of preventive measures and corrective actions to maintain the physical integrity and functionality of network equipment.

Preventive maintenance is crucial for ensuring the optimal performance and longevity of fiber optic networks. It involves proactive measures to identify and address potential issues before they lead to failures or disruptions.

Fiber optic networks require regular maintenance to ensure optimal performance and longevity.

- **Four key aspects of hardware maintenance:**

✓ **Scheduled Regular Cleaning**

Scheduled regular cleaning is a crucial aspect of maintaining the optimal performance and longevity of fiber optic networks. By removing dust, dirt, and other contaminants from network components, you can prevent signal degradation, reduce errors, and minimize downtime.

- **Key point to consider while Scheduled Regular Cleaning**

Frequency: Establish a cleaning schedule based on environmental factors, network usage, and specific equipment recommendations.

Components: Clean connectors, patch panels, and other hardware components to remove dust, dirt, and contaminants that can degrade signal quality.

Tools: Use specialized cleaning tools and solutions designed for fiber optics to avoid damaging the delicate components.

- ✓ **Setting of Preventive Measures**

Preventive measures are crucial for ensuring the long-term reliability and performance of fiber optic networks. By taking proactive steps to protect your network from potential hazards, you can minimize downtime, reduce maintenance costs, and enhance overall network resilience.

- **Key point to consider while setting preventive measures**

Cable Routing: Ensure cables are routed properly to prevent excessive bending, kinking, or tension that can cause damage.

Environmental Protection: Take measures to protect cables from harsh environmental conditions such as extreme temperatures, moisture, and corrosive substances.

Physical Protection: Use protective sleeves, conduit, or enclosures to shield cables from physical damage.

- ✓ **Checking Physical Equipment Condition**

Regular inspections of fiber optic equipment are essential to identify and address potential issues before they lead to network failures or performance degradation. By monitoring the physical condition of your equipment, you can prevent downtime, reduce maintenance costs, and ensure the long-term reliability of your network.

- **Key Components to Inspect**

Cables: Check for signs of damage, such as cuts, abrasions, or excessive bending. Ensure that cables are properly routed and secured to prevent strain.

Connectors: Inspect connectors for dirt, debris, or corrosion. Ensure that they are properly mated and have no loose or damaged pins.

Patch panels: Check for loose or damaged patch cords, as well as any signs of physical damage to the patch panel itself.

Optical transceivers: Inspect transceivers for any visible damage, such as cracks or burns. Ensure that they are properly seated in their respective slots.

Other hardware: Depending on your network configuration, you may also need to inspect other components such as switches, routers, and amplifiers.

- ✓ **Checking Environment Condition**

Environmental factors can have a significant impact on the performance and reliability of fiber optic networks. Monitoring and controlling environmental conditions are essential to prevent network failures and ensure optimal operation.

- **Key Environmental Factors to Monitor**

- **Temperature:**

Acceptable range: Most fiber optic cables and equipment have specific temperature operating ranges. Exceeding these limits can cause degradation of the fiber and connectors.

Monitoring: Use temperature sensors to monitor the temperature in areas where fiber optic equipment is located.

Temperature control: Implement cooling or heating systems to maintain the temperature within the recommended range.

- **Humidity:**

Acceptable range: High humidity can lead to corrosion and condensation on fiber optic components.

Monitoring: Use humidity sensors to monitor humidity levels.

Humidity control: Install dehumidifiers or ventilation systems to maintain humidity levels within the recommended range.

- **Power Supply:**

Stability: Ensure a stable and reliable power supply for fiber optic equipment. Power fluctuations can cause equipment failures and data loss.

Surge protection: Use surge protectors to protect equipment from power surges and spikes.

Redundancy: Consider implementing redundant power supplies to provide backup power in case of outages.

- **Environmental Hazards:**

Construction activities: Be aware of nearby construction activities that may pose risks to fiber optic cables, such as excavation or heavy machinery.

Natural disasters: Prepare for natural disasters such as storms, earthquakes, or floods that could damage fiber optic infrastructure.

Security threats: Protect fiber optic cables and equipment from vandalism, theft, or other security threats.

Theoretical Activity 3.1.2: Preparation of software maintenance

Tasks.

1: Answer the following questions:

i. What is the importance of changing network credentials?
ii. What is network monitoring software licensing in fiber optic maintenance?
iii. What are the benefits of staying updated for network monitoring software and device firmware?

2: Write your findings on paper, flipchart, blackboard or white board.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.
5: Read the key readings 3.1.2

Key readings 3.1.2: Preparation of software maintenance

Effective software maintenance requires careful planning and preparation to ensure successful outcomes. Here are some key areas to focus on:

- **Regular Change of Network Credentials:**

Regularly changing network credentials is a critical security best practice that helps protect your network and data from unauthorized access. By updating passwords, access keys, and other credentials on a consistent basis, you can reduce the risk of breaches and data theft.

✓ **Importance of regular changes network credentials**

Reduces the risk of unauthorized access: Outdated credentials can be compromised through various means, such as phishing attacks, password guessing, or data breaches. Regularly changing credentials makes it more difficult for unauthorized individuals to gain access to your network.

Protects against credential stuffing: Credential stuffing attacks involve using stolen credentials to gain access to multiple accounts. By regularly changing credentials, you can make it more difficult for attackers to exploit stolen credentials.

Complies with security standards: Many security standards and regulations require organizations to implement regular password change policies.

✓ **Best Practices for Credential Changes**

Strong and unique passwords: Ensure that passwords are strong and unique for each account. Avoid using easily guessable information, such as personal details or common phrases.

Password complexity: Require passwords to meet specific complexity requirements, such as including a combination of uppercase and lowercase letters, numbers, and symbols.

Password expiration: Set a reasonable password expiration policy to force users to change their passwords regularly.

Multi-factor authentication (MFA): Implement MFA to add an extra layer of security by requiring users to provide multiple forms of identification, such as a password and a code generated by a security token.

Password management tools: Consider using password management tools to securely store and manage credentials.

Educate users: Provide users with training on password security best practices, including the importance of strong, unique passwords and avoiding sharing credentials.

- **Network Monitoring Software Licensing:**

Network monitoring software licensing refers to the terms and conditions governing the use of network monitoring tools. Licenses typically define the rights and restrictions associated with using the software, including the number of devices or users that can be monitored, the features that are included, and the support and maintenance services provided.

- ✓ **Common Licensing Models:**

Per-device licensing: This model charges based on the number of devices or network interfaces being monitored.

Per-user licensing: This model charges based on the number of users who have access to the monitoring software.

Unlimited licensing: This model allows for unlimited monitoring of devices or users within a specific organization.

Subscription-based licensing: This model involves a recurring fee for access to the software, often with additional features or support included.

- ✓ **Key Considerations When Choosing a License:**

Scalability: Ensure that the license model can accommodate your future growth and expansion needs.

Features: Evaluate whether the license includes the specific features and functionality that you require for your network monitoring needs.

Support and maintenance: Consider the level of support and maintenance services provided with the license.

Cost: Compare the costs of different licensing models and vendors to find the most affordable option that meets your requirements.

- **Updating and Upgrading network monitoring software and device firmware**

Regular updates and upgrades of software and firmware are essential for maintaining the security, performance, and functionality of your network devices. Updates often include bug fixes, security patches, and new features, while upgrades may involve significant changes to the software or firmware.

- ✓ **Key Consideration while Updating and Upgrading network monitoring software and device firmware**

Importance of updates: Stay up-to-date with the latest software and firmware versions to benefit from security patches, bug fixes, and new features.

Scheduling updates: Develop a schedule for regular updates and upgrades to minimize downtime and disruptions.

Testing and validation: Before deploying updates or upgrades, thoroughly test them in a controlled environment to ensure compatibility and functionality.

Backup and recovery: Create backups of your network configuration and data before applying updates or upgrades to have a fallback option in case of issues.

Documentation: Maintain detailed documentation of all updates and upgrades, including the version numbers, changes made, and any known issues.

Vendor support: Consult with the vendor's documentation and support resources for guidance on updates and upgrades.

- ✓ **Benefits of Staying Updated:**

Improved security: Updates often patch vulnerabilities exploited by attackers.

Enhanced functionality: Upgrades can introduce new features and improve software performance.

Practical Activity 3.1.3: Preforming fiber optic network preventive maintenance.

Task:

1.You are requested to go in the server room of your computer lab and perform fiber optic network preventive maintenance.

2. Apply safety precautions (wear the PPE)

3. Present the steps to perform fiber optic network preventive maintenance.

4. Referring to the steps provided in task2 perform fiber optic network preventive maintenance.

5. Present the results of your work to the trainer or classmates.

6. Read the key readings 3.1.3.

7. Perform the task provided in application of learning 3.2.

Key readings 3.1.3: Preforming Fiber optic network preventive maintenance.

Preventive maintenance is crucial for ensuring the optimal performance and longevity of fiber optic networks. By proactively addressing potential issues before they lead to failures or disruptions, you can minimize downtime, reduce maintenance costs, and enhance network reliability.

- **Key steps to be followed while performing hardware preventive maintenance**

Hardware preventive maintenance is essential for ensuring the optimal performance and longevity of your equipment. By following these key steps, you can identify and address potential issues before they lead to failures or disruptions.

Step1. Develop a Hardware Preventive Maintenance Plan:

Identify critical components: Determine which hardware components are most critical to your operations.

Schedule inspections: Establish a regular schedule for inspections and maintenance tasks.

Assign responsibilities: Assign specific responsibilities to individuals or teams for

different maintenance tasks.

Step 2. Gather Necessary Tools and Resources:

Equipment: Ensure you have the necessary tools, such as screwdrivers, wrenches, and cleaning supplies.

Documentation: Gather relevant documentation, including user manuals, technical specifications, and maintenance guidelines.

Step 3. **Conduct Visual Inspections:**

Inspect for damage: Look for signs of physical damage, such as cracks, scratches, or corrosion.

Check for cleanliness: Ensure that equipment is clean and free from dust and debris.

Monitor temperature and humidity: Verify that environmental conditions are within acceptable ranges.

Step 4. **Test Functionality**:

Perform diagnostic tests: Use diagnostic tools or software to test the equipment's functionality.

Check for errors: Look for any error messages or unusual behavior.

Step 5. Clean and Lubricate:

Remove contaminants: Clean components to remove dust, dirt, and other contaminants.

Apply lubricant: Apply lubricant to moving parts according to manufacturer's recommendations.

Step 6. Check Connections:

Inspect cables: Ensure that cables are properly connected and secure.

Tighten connections: Tighten any loose connections.

Step 7. Replace Faulty Components:

Identify faulty parts: If you identify any faulty components, replace them according to manufacturer's instructions.

Proper installation: Ensure that replacement components are installed correctly and securely.

Step 8. **Document Maintenance Activities:**
Record findings: Document the results of your inspections, tests, and maintenance

activities.

Update records: Keep your maintenance records up-to-date.

- **Key steps to be followed while performing software preventive maintenance.**

Software preventive maintenance is essential for ensuring the reliability, security, and optimal performance of your applications. By following these key steps, you can identify and address potential issues before they lead to failures or disruptions.

Step 1. Develop a software preventive Maintenance Plan:

Prioritize applications: Identify critical applications that require frequent maintenance.

Schedule updates: Establish a regular schedule for updates, patches, and security fixes.

Assign responsibilities: Assign specific responsibilities to individuals or teams for different maintenance tasks.

Step 2. Conduct Regular Backups:

Full backups: Create regular full backups of your software and data to protect against data loss or corruption.

Incremental backups: Perform incremental backups to capture only the changes made since the last full backup.

Step 3. Monitor System Performance:

Performance metrics: Track key performance indicators (KPIs) such as response times, resource utilization, and error rates.

Identify bottlenecks: Identify any performance bottlenecks that may be affecting the software's efficiency.

Step 4. Apply system Updates

Stay up-to-date: Install the latest updates and patches to address security vulnerabilities, bug fixes, and new features.

Test before deployment: Test updates and patches in a controlled environment to ensure compatibility and functionality.

Step 5. Conduct Regular Testing:

Functional testing: Verify that the software is functioning as expected.

Regression testing: Ensure that recent changes have not introduced new bugs or affected existing functionality.

Security testing: Conduct security testing to identify and address potential vulnerabilities.

Step 6. Optimize Performance:

Identify performance bottlenecks: Use profiling tools to identify areas where the

software can be optimized.

Optimize code: Make necessary code changes to improve performance and resource utilization.

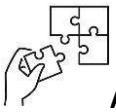
Step 7. Document Maintenance Activities:
Record changes: Document all maintenance activities, including updates, patches, and configuration changes.

Track issues: Keep track of any issues or problems that arise during maintenance.

Points to Remember

- The importance of doing scheduled regular cleaning for fiber optic networks is to prevent signal degradation, reduce errors and minimize downtime.
- Setting preventive measure is important for fiber optic networks because it protect your network from potential hazards.
- We need checking of physical equipment condition for fiber optic network because it reduces maintenance costs, and ensure the long-term reliability of your network
- Environmental factors that can affect the performance of fiber optic networks are: temperature, humidity, power supply and other environmental hazards.
- Reduces the risk of unauthorized access, protects against credential stuffing and complies with security standards are the importance of changing regularly network credentials.
- Network monitoring software licensing refers to the terms and conditions governing the use of network monitoring tools.
- Improved security and enhanced functionality of the fiber optic network are the benefits of staying updated with monitoring software and device firmware.
- Key steps to be followed while performing hardware preventive maintenance:
  - ✓ Develop a hardware preventive maintenance plan
  - ✓ Gather necessary tools and resources
  - ✓ Conduct visual inspections
  - ✓ Test functionality
  - ✓ Clean and lubricate
  - ✓ Check connections
  - ✓ Replace faulty components
  - ✓ Document maintenance activities
- Key steps to be followed while performing software preventive maintenance:
  - ✓ Develop a software preventive maintenance plan
  - ✓ Conduct regular backups
  - ✓ Monitor system performance

- ✓ Apply system updates
- ✓ Conduct regular testing
- ✓ Document maintenance activities



Application of learning 3.1.

Suppose that there is an institution located in your area that have experienced poor fiber optic network connection (the network is interrupted). Referring to the key readings 3.1.1 and 3.1.2, you are tasked to prepare hardware and software preventive maintenance of fiber optic network by identifying issues that caused the failure of that network

Indicative content 3.2: Perform Corrective Maintenance

Duration: 8 hrs

Theoretical Activity 3.2.1: Description corrective maintenance

Tasks:

1: Answer the following questions:

i. What are the common hardware problems we can identify during corrective mainten ance?
ii. Why do we need to repair/replace damaged equipment during corrective maintenan ce?
iii. How do we check network settings of fiber optic network?
iv. How can we check network status of fiber optic network during corrective maintenan ce?
v. Why do we need to update network configuration during corrective maintenance?

2: Present your findings to the trainer or classmates.

3: Pay attention to the trainer's clarifications and ask questions where necessary.

4: Read the key readings 3.2.1

Key readings 3.2.1.: Description corrective maintenance.

- **Introduction**

Corrective maintenance involves addressing hardware or software issues that have already occurred. It typically involves troubleshooting, repairing, or replacing faulty components to restore normal network operations.

Description of hardware corrective maintenance Hardware corrective maintenance involves addressing and resolving issues that have already occurred in network equipment. It typically involves troubleshooting, repairing, or replacing faulty components to restore normal network operations.

- **Description hardware corrective maintenance**

➢ **Identification of common problems and their causes**

Identifying common problems and their underlying causes is a crucial step in effective network maintenance. By understanding the root causes of issues, you can take targeted

corrective actions and implement preventive measures to prevent similar problems from occurring in the future.

✓ **Common network problems and their potential causes**

No	Common fiber problems	Couse	Solution
1	Signal Loss (Attenuation)	• Excessive cable length • Bends, kinks, or improper routing • Dirty or damaged connectors • Fiber aging or poor splicing	Regular testing, proper cable management, cleaning connectors, and ensuring correct splicing techniques.
2	Back Reflection (Optical Return Loss - ORL)	• Dirty or damaged fiber end faces • Poor-quality or mismatched connectors • Bad splices	Clean connectors, use appropriate connectors, and ensure smooth splicing. Fiber Breaks
3	Fiber Breaks	• Physical damage from bending, crushing, or cutting • Environmental factors (extreme temperatures, moisture, etc.) • Rodent or mechanical damage	Inspect connectors, secure cable connections, and stabilize environmental conditions.

4	Poor or Intermittent Connectivity	• Loose or worn connectors • Improper cable installation • Environmental factors like vibration or temperature shifts	Inspect connectors, secure cable connections, and stabilize environmental conditions.
5	Cross-talk and Interference	• Improper shielding or insufficient spacing between cables • External electrical interference	Use shielded cables, maintain proper cable separation, and avoid placing cables near electrical noise sources.
6	Increased Signal Noise	• Loose or worn connectors • Improper cable installation • Environmental factors like vibration or temperature shifts	Inspect connectors, secure cable connections, and stabilize environmental conditions.

- **Repair/Replace Damaged Equipment**

Repair or replacement of damaged equipment is a critical aspect of network maintenance. When hardware components fail or are damaged, it can disrupt network operations and lead to data loss or service outages.

- ✓ **Identifying Damaged Equipment**

Visual inspections: Regularly inspect equipment for signs of wear, damage, or corrosion.
Functionality tests: Test equipment periodically to ensure it is operating correctly.
Error messages: Monitor system logs and error messages for indications of hardware problems.

- ✓ **Repairing Damaged Equipment**

Attempt repairs: If the damage is minor, consider repairing the equipment. However, repairs may not always be feasible or cost-effective.

Consult with vendor: Consult with the equipment vendor for guidance on repairs and potential replacement options.

- ✓ **Replacing Damaged Equipment**

Choose a compatible replacement: Select a replacement component that is compatible with your existing network infrastructure.

Proper installation: Ensure that the replacement component is installed correctly and securely.

Test functionality: Test the replaced component to verify that it is functioning properly and does not cause any issues.

- **Description Software corrective maintenance.**

Software corrective maintenance involves addressing and resolving issues that have already occurred in software applications. It typically involves troubleshooting, debugging, and applying patches or updates to fix errors, bugs, or performance problems.

- ✓ **Troubleshoot Network Configuration**

Check network settings: Verify that IP addresses, subnet masks, and default gateways are configured correctly for all devices on the network.

Review firewall rules: Ensure that firewall rules are not blocking necessary traffic.

Test connectivity: Use ping and traceroute commands to test connectivity between devices on the network.

Check routing tables: Verify that routing tables are configured correctly to ensure that traffic can reach its destination.

- ✓ **Check Network Status**

Monitor network performance: Use monitoring tools to track network traffic, bandwidth utilization, and response times.

Identify anomalies: Look for any unusual patterns or spikes in network traffic.

Check for errors: Look for error messages in system logs or network monitoring tools.

- ✓ **Update Network Configuration**

Review configuration changes: Document any changes made to the network configuration.

Test changes: Test the changes carefully to ensure that they do not introduce new problems.

Implement changes: If the changes are successful, implement them permanently.

- **Updating network configuration during corrective maintenance**

Reflect Changes in Network Setup: When hardware components (such as cables, switches, or routers) are repaired or replaced, the network configuration needs to be updated to reflect these changes. This ensures that the new equipment is properly recognized and integrated into the network.

Optimize Performance: After correcting a network issue, configuration updates may be required to optimize performance. For example, adjustments may be made to routing tables, bandwidth allocation, or Quality of Service (QoS) settings to improve data flow.
Address Security Vulnerabilities: Corrective maintenance may reveal outdated configurations that pose security risks. Updating network settings, such as access controls or firewall rules, helps to close vulnerabilities and enhance security.
Prevent Recurrence of Issues: Some network issues are caused by misconfigurations. During corrective maintenance, updating configurations ensures that the same problem does not recur due to outdated or incorrect settings.
Ensure Compatibility with New Equipment: If new hardware or software components are installed during corrective maintenance, the network configuration must be updated to ensure compatibility. This includes updating firmware versions, IP addresses, or interface settings.
Documentation and Compliance: Updating the configuration ensures that network documentation is current. Accurate documentation is important for future troubleshooting and for meeting regulatory or compliance standards.

Practical Activity 3.2.2: Performing corrective maintenance

Task:

1.You are requested to go in the server room of your computer lab and perform corrective maintenance of fiber optic network deployment
2. Apply safety precautions (wear the PPE)
3. Present the steps to perform software maintenance
4. Referring to the steps provided in task 2, perform software maintenance
5. Present the results of your work to the trainer or classmates
6. Read the key readings 3.2.2
7. Perform the task provided in application of learning 3.2.

Key readings 3.2.2. Performing corrective maintenance

Corrective maintenance involves addressing hardware or software issues that have already occurred. It typically involves troubleshooting, repairing, or replacing faulty components to restore normal network operations.

- **Key steps for performing corrective maintenance:**

Step1. Identify the problem: Use diagnostic tools, error messages, or user reports to pinpoint the root cause of the issue.

Step2. Isolate the problem: If possible, isolate the affected component or system to prevent the problem from spreading.

Step3. Troubleshoot: Use troubleshooting techniques to identify the specific cause of the problem.

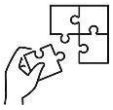
Step4. Repair or replace: If the problem is caused by a faulty component, repair or replace it as needed.

Step5. Test and verify: Test the network to ensure that the issue has been resolved and that the network is functioning normally.

Step6. Document the incident: Document the incident, including the cause, resolution, and any lessons learned.

Points to Remember

- Signal loss (attenuation), back reflection (optical return loss) are the common fiber optic problem that can be identified.
- We can check network settings of fiber optic network by verifying: IP addresses, subne t masks, and default gateways for all devices on network.
- We need to update network configuration because it helps us to optimize performance .
- Check configuration changes to Verify if recent configuration updates have caused issues.
- Ensure that software updates are compatible with your network hardware and configuration.
- Software troubleshooting employ tools to automate configuration management and reduce errors.
- Troubleshooting methodology Consult documentation: Refer to network documentation, user manuals, and vendor support resources.



Application of learning 3.2.

XNBK company has experienced issues in its fiber optic network connection (the network is interrupted). Help the company to perform both hardware and software maintenance by providing preventive measures such as improved cable management and regular software updates.

Indicative content 3.3: Elaboration of Troubleshooting Process

Duration: 4 hrs

Theoretical Activity 3.3.1: Identification of elements for troubleshooting

Tasks:

1: Answer the following questions:

i. What the term troubleshoot mean in fiber optic networks?

ii. Identify different elements of troubleshooting?

2: Write your findings on papers or flipcharts.

3: Present your findings to the trainer or classmates.

4: Pay attention to the trainer's clarifications and ask questions where necessary.

5: Read the key readings 3.3.1

Key readings 3.3.1.: Identification of elements for troubleshooting

- **Introduction to troubleshoot**

Troubleshooting is a systematic process of identifying, isolating, and resolving problems in a system or network. It involves a combination of technical knowledge, logical thinking, and problem-solving skills. Effective troubleshooting can help minimize downtime, improve system performance, and reduce costs.

- **Elements of troubleshooting**

✓ **Client/System Information:**

Gather details: Collect information about the affected client, system, or network component. This includes hardware specifications, software versions, and recent changes.

Understand the environment: Familiarize yourself with the system's configuration, dependencies, and interactions with other components.

✓ **Status Before Troubleshooting:**

Document the issue: Clearly describe the problem, including symptoms, frequency, and severity.

Gather evidence: Collect any relevant logs, error messages, or performance data.

✓ **Identification of Common Problems:**

Knowledge base: Refer to troubleshooting guides, documentation, or knowledge bases for common issues and their solutions.

Pattern recognition: Look for patterns or recurring issues that might indicate a systemic problem.

Ask questions: Gather more information from users or other stakeholders to understand the problem better.

- ✓ **Implementation of Solution:**

Test changes: Implement potential solutions in a controlled environment or on a test system before applying them to the production system.

Verify results: Monitor the system after implementing changes to ensure the problem is resolved and no new issues are introduced.

Document the solution: Record the steps taken, the solution implemented, and the outcome for future reference.

- ➢ **Additional Considerations:**

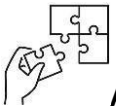
Isolation: Isolate the affected component or system to prevent the problem from spreading to other parts of the network.

Escalation: If the problem cannot be resolved in-house, escalate it to higher-level support or vendors.

Root Cause Analysis: After resolving the immediate issue, conduct a root cause analysis to identify the underlying cause and prevent similar problems in the future.

Points to Remember

- Troubleshooting is a systematic process of identifying, isolating, and resolving problems in a system or network.
- Elements of troubleshooting are client/system information, status before troubleshooting, identification of common problems and implementation of solution.



Application of learning 3.3.

Suppose that ABC company has recently experienced intermittent network outages and signal degradation in their fiber optic network. You are tasked to help the company to (a) elaborate on troubleshooting and resolve the issue.

Indicative content 3.4: Troubleshooting Report

Duration : 3 hrs

Practical Activity 3.4.1. Performing troubleshooting report

Task:

1. You are requested to go in the server room of your computer lab and do the task described below:
i. Make fiber optic deployment troubleshooting report on a fiber network internet
2. Apply safety precautions (wear the PPE)
3. Present the tools used while troubleshooting on a fiber network internet
4. Referring to the presentation in task 2, make fiber optic deployment troubleshooting report
5. Present the results of your work to the trainer or classmates
6. Read the key readings 3.4.1
7. Perform the task provided in application of learning 3.4.

Key readings 3.4.1. Performing troubleshooting report

- ✓ **Tools, materials, and equipment used while troubleshooting**

Visual Fault Locator (VFL): Identifies visible defects in the fiber cable, such as breaks or bends.

Visual Fault Locator (VFL)

- **Light Source and Power Meter (LSPM):** Measures the amount of light transmitted through the fiber cable, helping to identify attenuation or loss.

Light Source and Power Meter (LSPM)

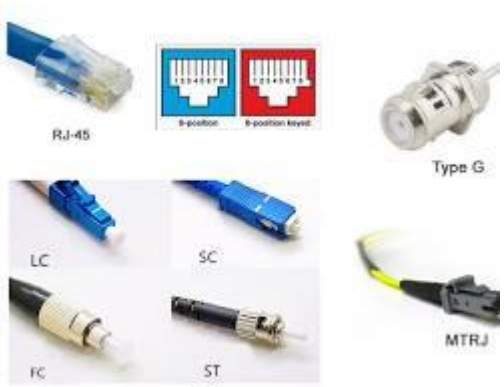
- **Optical Time Domain Reflectometer (OTDR):** Measures the distance and location of faults in the fiber cable, such as breaks, splices, and connectors.

Optical Time Domain Reflectometer (OTDR)

- **Fiber Optic Cleaver:** Used to cleanly cut the fiber cable to ensure proper connection

Fig: Fiber Optic Cleaver

- **Fiber Optic Connectors:** Used to terminate the fiber cable and connect it to other devices.



Fiber Optic Connectors

- **Splicing Kit:** Used to fuse two fiber cables together to create a seamless connection.

Splicing Kit

✓ **Status after Maintenance:**

Fault resolved: The specific issue that caused the network outage or performance problem was identified and corrected.

System restored to full functionality: The fiber optic network is now operating as intended, with all services and connections restored.

Preventive maintenance performed: Any routine maintenance or upgrades were completed, such as cleaning connectors or replacing faulty components.

✓ **Updated Built Design:**

Network layout updated: The network diagram was updated to reflect any changes made during the troubleshooting process, such as the addition or removal of equipment.

Documentation revised: Any relevant documentation, such as troubleshooting procedures or network maps, was updated to reflect the latest findings and changes.

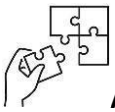
✓ **Recommendations:**

Regular maintenance: To prevent future issues, it is recommended to perform regular maintenance on the fiber optic network, including cleaning connectors, inspecting splices, and testing for attenuation.

Proper cable management: Ensure that the fiber cables are properly routed and secured to prevent damage or strain.
Use high-quality components: Use only high-quality fiber optic cables, connectors, and other equipment to minimize the risk of faults.
Regular training: Provide training to network administrators and technicians on proper troubleshooting and maintenance procedures.

Points to Remember

- Steps for fiber troubleshooting report are: introduction, network overview troubleshooting steps analysis of findings, recommendations, conclusion and appendices



Application of learning 3.4.

Suppose that XYZ is a fiber optic company that has recently experienced intermittent network outages and signal degradation in their fiber optic network. You are tasked to help the company make fiber optic deployment troubleshooting report

Learning outcome 3 end assessment

Theoretical assessment

Q1. Circle the letter corresponding with the correct answer:

i. **The first step in troubleshooting a fiber optic network issue is:**

a) Replace the fiber optic cable
b) Perform an OTDR test
c) Gather client/system information
d) Clean all connectors

ii. **Which of the following is a common cause of signal loss in fiber optic networks?**

a) High humidity
b) Dirty connectors
c) Low temperature
d) Excessive bandwidth

iii. **What is the purpose of adding redundancy in a fiber optic network design?**

a) Reduce installation costs
b) Increase network speed
c) Enhance reliability and minimize downtime
d) Simplify network management

iv. **Why is it important to keep updated network diagrams and records?**

a) To comply with legal requirements
b) To ensure accurate and efficient troubleshooting and maintenance
c) To reduce the need for skilled technicians
d) To increase the resale value of the network

v. **What is a best practice for cable management in fiber optic networks?**

a) Using zip ties to bundle cables tightly
b) Labeling cables and maintaining proper bend radius
c) Running cables parallel to power lines
d) Minimizing the use of cable trays

vi. **What is a key benefit of regular preventive maintenance for fiber optic networks?**

a) Reduces the need for skilled technicians
b) Prevents potential issues before they cause significant disruptions
c) Increases the cost of network operation
d) Decreases network performance

vii. **How can network monitoring tools be used effectively in fiber optic networks?**

a) To increase the network's physical security
b) To proactively detect and address anomalies
c) To reduce the need for physical inspections
d) To simplify the installation process

Q2. Match the items (in Column B) with their corresponding descriptions (in Column C). write the letter of the correct answer in the provided blank space (in column A)

Column A	Column B	Column C
Answers	**Items**	**Descriptions**
1. …….	1. OTDR	**A**. A tool used to measure the power level of an optical signal.
2**. ……**	2. Single-mode Fiber	**B**. A practice that involves regular inspections and cleaning to prevent issues..
3. ……	3. Preventive Maintenance	**C.** A device that helps locate faults in fiber optic cables by emitting visible light.
4. ……	4. Splicing Machine	**D**. The outer optical material surrounding the core of a fiber optic cable.
5. **……**	5. Network Redundancy	**E**. A machine used to join two fiber optic cables together.
6. **……**	6. Power Meter	**F.** A type of fiber optic cable with a small core, used for long-distance transmission.
7…….	7. Cladding	**G.** The process of keeping cables organized and labeled to prevent damage and ensure easy access.
8. **……**	8. Visual Fault Locator	**H**. A tool that uses light reflections to identify faults and measure the length of fiber optic cables.
9. **…..**	9. Cable Management	**I.** The practice of adding backup paths to enhance network reliability.
10. **…..**	10. Documentation	**J.** The practice of keeping updated records and diagrams of the network configuration

Q3. Read and answer the following questions:

i. Identify the essential tools used in fiber optic network maintenance.
ii. Explain the importance of regular maintenance for fiber optic networks.
iii. Discuss the role of documentation in maintaining a fiber optic network.
iv. What measures can be taken to protect fiber optic cables from physical damage?

Practical assessment

Imagine that there is a fiber optic company located in a remote area with limited IT support. The company has been experiencing intermittent network connectivity problems, affecting productivity and communication. You are tasked to help that company perform the following tasks: (a) Provide maintenance services. (b) Troubleshoot the fiber network. (c) Document the work done, and (d) Report the work done

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