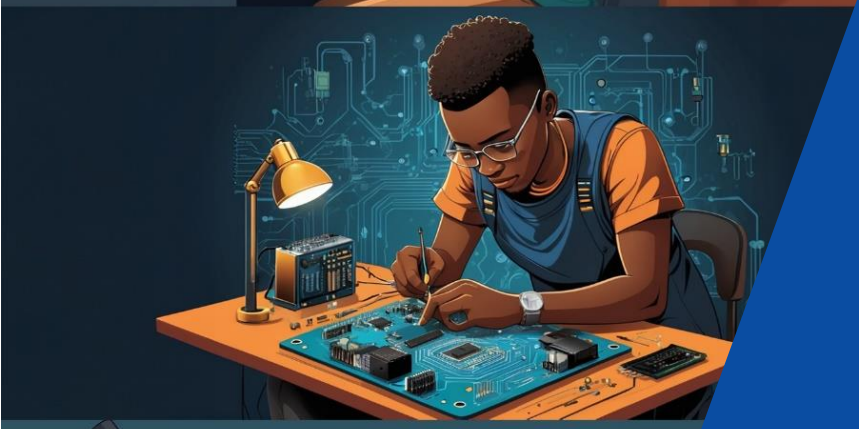
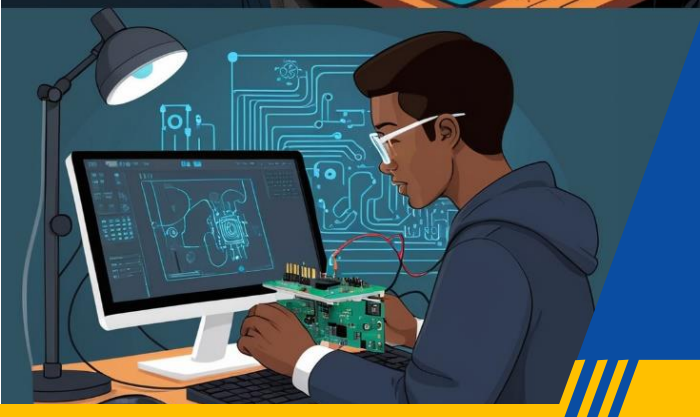
RQF LEVEL 4





NITID401

NETWORKING AND INTERNET TECHNOLOGIES

IoT System Development

TRAINER'S MANUAL

October, 2024

IoT SYSTEM DEVELOPMENT

KOICA Korea International Cooperation Agency

TQUM TVET Quality Management Project

2024

AUTHOR'S NOTE PAGE (COPYRIGHT)

Copies available from:

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

Original published version: October 2024

ACKNOWLEDGEMENTS

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

Rwanda TVET Board (RTB) extends its appreciation to all parties who contributed to the development of the trainer's and trainee's manuals for the TVET Certificate IV in Networking and internet technologies, specifically for the module "NITID401: IoT system development".

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

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

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

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

This training manual was developed:

Under Rwanda TVET Board (RTB) guiding policies and directives

Under Financial and Technical support of

COORDINATION TEAM

RWAMASIRABO Aimable

MARIA Bernadette M. Ramos

MUTIJIMA Asher Emmanuel

Production Team

Authoring and Review

BUGIRIMFURA Jean Baptiste

HABUKUBAHO Gad

Validation

NDIZEYE Aime Joseph
MANISHIMWE Yves
BAYISENGE Jean Bosco

Conception, Adaptation and Editorial works

HATEGEKIMANA Olivier

GANZA Jean Francois Regis

HARELIMANA Wilson

NZABIRINDA Aimable

DUKUZIMANA Therese

NIYONKURU Sylvestre

BIZIMANA Eric

Formatting, Graphics, Illustrations, and infographics

YEONWOO Choe
SUA Lim
SAEM Lee
SOYEON Kim
WONYEONG Jeong
NIYONZIMA Augustin

Financial and Technical support

KOICA through TQUM Project

TABLE OF CONTENT

ACRONYMS

3D: Three Dimensions

API: Application Programming Interface

BLE: Bluetooth Low Energy

BNC: Bayonet Neill–Concelman

CNC: Computer Numerical Control

DC: Direct Current

ESD: Electrostatic Discharge

ESP-IDF: Espressif IoT Development Framework

GPS: Global Positioning System

HEX/BIN: Hexadecimal/ Binary

HiL: Hardware-in-Loop

HMI: Human Machine Interface

ICSP: In- Circuit serial Programming

IDE: Integrated Development Environment

IoT: Internet of Things

IPC: Inter- Process Communication

IR: infrared

JST: Japan Solderless Terminal

JTAG: Joint Test Action Group

KOICA: Korean International Cooperation Agency

LCD: Liquid Crystal Display

LED: light emitting diode

LTE: Long Term Evolution

MATLAB: Matrix Laboratory

MQ: Metal Oxide

NPN: Negative-Positive-Negative

OLED: Organic Light Emitting Diode

PC: Personal Computer

PCB: Printed Circuit Board

PIC: Peripheral Interface Controller

PIR: Passive Infrared

QEMU: Quick Emulator

RF: Radio Frequency

RJ45: Registered Jack 45

RTB: Rwanda TVET Board

RTOS: Real-Time Operating System

SD cards: Secure Digital Card

SRD: System Requirements Document

SWD: Serial Wire Debug

TCP/IP: Transmission Control Protocol/Internet Protocol

TQUM Project: TVET Quality Management Project

UART: Universal Asynchronous Receiver-Transmitter

USB: Universal Serial Bus

Wi-Fi: Wireless- Fidelity

INTRODUCTION

This trainer's manual includes all the methodologies required to effectively deliver the module titled **"IoT System Development."** Students enrolled in this module will engage in practical activities designed to develop and enhance their competencies.

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

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

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

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

MODULE CODE AND TITLE: NITID401 IoT SYSTEM DEVELOPMENT

Learning Outcome 1: Plan IoT system development.
Learning Outcome 2: Build IoT system.
Learning Outcome 3: Deploy IoT system.

Learning Outcome 1: Plan IoT System Development.

Indicative contents

1.1 Identification of IoT system requirements
1.2 Selection of Tools, materials, and equipment
1.3 Design IoT System Diagrams

Key Competencies for Learning Outcome 1: Plan IoT System Development

Knowledge	Skills	Attitudes
• Description of the customer requirements • Identification of IoT system usage • Identification of IoT system designs and diagrams • Description of system Feasibility • Description of tools, materials, and equipment • Description of data flow diagram • Identification of use case diagram	• Documenting system requirements • Selecting tools, materials, and equipment • Designing system block diagrams	• Having Attention to Details while documenting system requirement • Having good communication and collaboration to others. • Having critical thinking while selecting tools, materials, and equipment to be used • Being rapid during work execution

Duration: 30 hrs

Learning outcome 1 objectives:

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

1. Identify properly the IoT system requirements based on user needs
2. Describe properly the data flow diagrams according to the user needs
3. Select correctly Tools, materials, and equipment used for IoT system development according to the entire system requirements
4. Design correctly IoT system Diagrams based on IoT system requirements
5. Identify Cleary the IoT system feasibility according the gathered data.
6. Document and Analyse Cleary the IoT system requirements according to the data being collected.

Resources

Equipment	Tools	Materials
• IoT Development Boards • Sensors and Actuators • Communication Modules • Microcontrollers and Processors • Power Supplies • Soldering Equipment • PCB Design Software and Equipment • Computer	• IDEs • Edraw Max • Easyeda • Lucid Chart • Draw.io • Smart draw • Proteus • Glue gun	• Connectors and Cables • Internet • Electricity • Cables • PCB • Copper clad • Soldering wire(Tin) • Glue Stick

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Avail prepared workshop

Indicative content 1.1: Identification of IoT system Requirements

Duration: 10hrs

Theoretical Activity 1.1.1: identificationof IoT system requirements

Notes to the trainer:

- Trainer may use small group for identifying of IoT system requirements.
- Have video to be used as didactic material

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the activity and Ask Trainees to answer the following questions

i. What do you understand by the terms?
   - Data
   - Data collection

ii. Describe Data Collection Methods

iii. Differentiate Functional requirements and non-functional requirements

iv. Explain the System feasibility component

Step 2: Ask any trainee to write answers provided on flipchart.

Step 3: Ask trainees to discuss the provided answer and choose correct answers.

Step 4: Provide expert view and address ideas by using didactic materials.

Step 5: Address any questions or concerns about the Activity.

Step 6: Ask Trainees to read the key readings 1.1.1

Points to Remember

- There are methods of data collection while planning the development of IoT system like: surveys, Interviews, observations, Questionnaires, Experiments here the designer he/she can select the suitable method that can use to gather information from customer.
- There is different between functional requirements and non-functional requirements, where functional requirements is a description of the functions that the user requires from the system while non-functional requirements is a statement of what a system is or how it will be constructed, or a constraint on how the product will be designed or will behave.

Practical Activity 1.1.2: Documenting IoT system Requirements

Notes to the trainer

- This activity should take place in computer lab where the trainees will document IoT system requirements
- Avail sample of collected data of any IoT existing system.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the Activity and ask trainees to do the task described below:

A tech company, Smart Life Solutions, is developing a Smart Home Automation System that allows homeowners to control and monitor household devices remotely, such as lights, thermostats, security cameras, and appliances. The system will include a mobile app, cloud integration, and several IoT devices (sensors, actuators, and controllers). As the system analyst, your role is to document the requirements for the system, ensuring all stakeholder needs are captured and translated into clear specifications for the development team.

Step 2: Explain the task and provide clear work instruction

Step 3: Demonstrate how to document IoT system requirements, while demonstrating explain the procedures.

Step 4: Ask trainees to document IoT system requirements and monitor the activity

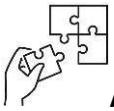
Step 5: Verify whether the IoT system is properly documented.

Points to Remember

- **Procedures/steps on how to document IoT system requirements:**

1. Identify Stakeholders
2. Define the System's Purpose
3. Gather Functional Requirements
4. Gather Non-Functional Requirements

5. Use a Requirements Management Tool
6. Document in a Clear and Concise Manner



Application of learning 1.1.

A and B are all Companies that use IoT irrigation system to help the farmers to irrigate their farms in different benefits like when is summer seasons. When the farmers access those systems, they prefer to use some of them rather than others. So as IoT system Developer, you are requested to do the data validation of collected data and document the system requirement.

Checklist:

Criteria	Indicators	Yes	No
System requirements is properly documented	Stakeholders are identified		
	System's purpose is defined		
	Functional requirements are gathered		
	Non-functional requirements are gathered		
	User cases are created		
	System is documented		

Indicative content 1.2: Selection of Tools, Materials, and Equipment

Duration: 5 hrs

Theoretical Activity 1.2.1: Description of IoT Tools, Materials, and Equipment

Notes to the trainer:

- While delivering this content, a small group can be used for describing the tools, material and equipment used for developing the IoT system
- Use of Images, videos and illustration as didactic Materials.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Engage trainee's in groups formation.

Step 2: Introduce the activity and request trainees to respond to the following questions:

i. What is meant by the following terms?
   - Git
   - IDE
   - Debugging

ii. List any 5 IoT system testing tools

iii. Differentiate Microcontroller from Processor

iv. Name any three (3) testing and measurement instruments used in IoT system development

Step 3: Engage trainees in presentation of their findings

Step 4: Provides expert view and clarifies ideas by using didactic materials.

Step 5: Address any questions or concerns.

Points to Remember

- Integrated Development Environment (IDE) in the context of IoT (Internet of Things) system development is a comprehensive software suite that provides developers with the necessary tools to write, test, debug, and deploy IoT applications.

- **Git** is a distributed version control system that tracks changes in any set of computer files, usually used for coordinating work among programmers who are collaboratively developing source code during software development. Its goals include speed, data integrity, and support for distributed, non-linear workflows (thousands of parallel branches running on different computers).
- **Debugging** is the process of identifying and resolving errors, or bugs, in a software system.

Practical Activity 1.2.2: Selecting the IoT tools, Material and Equipment

Notes to the trainer

- This activity should take place in computer lab where trainees should select IoT tool, equipment.
- Avail of video to be used as didactic material

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask trainees do the task described below:

As an IoT system developer, you are asked to go to the computer lab to select the tools, material and equipment that can help you to develop the any IoT system.

Step 2: Explain the task and provide clear work instruction.

Step 3: Demonstrate how to select the IoT Tools and equipment. While demonstrating, explain the steps to follow.

Step 4: Asks trainees to select IoT tools, equipment and monitor the procedures.

Step 5: Verify whether the tools and equipment are correctly selected.

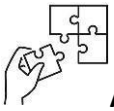
Step 6: Ask trainees to read key reading 1.2.2.

Points to Remember

- The steps and procedure of selecting IoT tools and Equipment while developing IoT system

  - Define your IoT project's goals and requirements

- Identify the Key components
- Evaluate the tools, equipment and material.
- Consider cost and scalability
- Evaluate vendor support and community
- Prototype and test
- Deployment and Monitoring



Application of learning 1.2.

A large agricultural company, WH Solutions, plans to implement an IoT-based smart agriculture system across its farms. The goal is to use connected sensors and devices to monitor soil health, manage irrigation, track weather patterns, and automate various farming processes. You are requested to select the appropriate IoT tools and equipment for this IoT system in order to be developed.

Checklist

Criteria	Indicators	Yes	No
Tools, material and equipment are properly selected based on system development standard	Tools are correctly selected		
	Material are clearly selected		
	Equipment are perfectly used		

Indicative content 1.3: Design IoT system Diagrams

Duration: 15 hrs

Theoretical Activity 1.3.1: Description of IoT System Diagrams.

Notes to the trainer:

- While delivering this content, a small group can be used for Description of IoT system Diagrams.
- The use of videos as didactic materials is required.

Key steps:

While delivering this activity, pass through the following steps:

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

i. What do you understand about High-level Architecture Diagram?

ii. Provide the description of:

- Block diagram
- Data Flow Diagram
- Flowchart Diagram
- Use case Diagram

iii. What are the Factors to consider when designing IoT diagrams?

Step 2: Ask trainees to present their findings to the whole class.

Step 3: Provides expert view and clarifies ideas by using didactic materials

Step 4: Address any questions or concerns.

Step 5: Ask trainee to read the key readings on activity 1.3.1

Points to Remember

- An IoT (Internet of Things) high-level architecture diagram provides an overview of the key components, interactions, and data flows within an IoT system.
- Data flow diagram is one of the tools used in the analysis phase. Data flow diagram is a graphical tool used to analyse the movement of data through a system-manual or automatedincluding the processes, stores of data, and delay in the system.

- A flowchart is a type of diagram that represents an algorithm, workflow or process.

- In IoT development, there are important factors you consider while Designing the Diagrams which are: Components representation, Data flow, Scalability and Flexibility, Security consideration, User interface

Practical Activity 1.3.2: Designing the IoT System Diagram

Notes to the trainer

- This activity should be carried out in the workshop where the trainees should design IoT system diagram
- Avail computer installed with EDrawMax

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask trainees do the task described below:

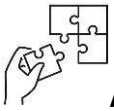
As an IoT system developer, you are asked to go to the Computer lab to design IoT system Diagrams.

Step 2: Explain the task and provide clear work instructions.
Step 3: Demonstrate how to Design the IoT system Diagrams. While demonstrating, explain the steps to follow.
Step 4: Ask trainees to design IoT system diagram and monitor the activity.
Step 5: Verify whether architecture diagram, block diagram, flow diagram, dataflow diagram, flowchart, user case diagram is correctly designed.
Step 6: Ask trainees to read key reading 1.3.2.

Points to Remember

- While designing an effective IoT (Internet of Things) system diagram pass through to the following steps:
  1. Define the Purpose
  2. Identify Components
  3. Establish Relationships
  4. Choose a Diagram Type

5. Sketch the Diagram
6. Label Components
7. Review and Refine
8. Finalize the Diagram



Application of learning 1.3.

XYZ Company wants to establish the project of smart agriculture system. The system will use IoT technology to monitor environment conditions and automate irrigation for optimizing crop growth, you are requested to design IoT diagram such as High-level architecture diagram, Block diagram, Data flow diagram, Flowchart diagram, Use case diagram for that company**.**

Checklist:

Assessment criteria (Based on performance criteria)	**Indicators**	**observation**	
		Yes	**No**
IoT diagrams are properly designed	High level architecture diagram is designed		
	Block diagram is designed		
	Data flow diagram is designed		
	Flowchart diagram is designed		
	Use case diagram is designed		

Written assessment

1. **Cycle the letter corresponding to the best answer:**

A) Which of the following is NOT a common data collection method for understanding customer requirements for an IoT system?

i) Surveys

ii) Experiments

iii) Interviews

iv) User manuals

Answer: iv

B) What is the process of examining the quality and accuracy of the collected data before processing and analysing it?

i) Data validation

ii) Data transformation

iii) Data exploration

iv) Data visualization

Answer: i

C) Functional requirements define what the system must do**. They are:**

i) Optional

ii) Based on user preferences

iii) Dependent on external factors

iv) Mandatory

Answer: iv

D) Which of the following is NOT an example of a non-functional requirement?

i) System performance and scalability

ii) User interface design

iii) Security

iv) Cost of development

Answer: ii

E) Technical feasibility analysis evaluates the:

i) Availability of necessary skills and equipment

ii) Projected costs and benefits of the project

iii) Legal compliance

iv) Operational efficiency of the system

Answer: i

F) What type of feasibility study examines how well a product will satisfy needs and how simply it will be used and maintained?

i) Technical feasibility

ii) Economic feasibility

iii) Legal feasibility

iv) Operational feasibility

Answer: vi

G) The System Requirements Document (SRD) should include:

i) A list of functional and non-functional requirements

ii) The purpose of the system and its stakeholders

iii) An outline of the development process

iv) All of the above

Answer: vi

H) Which of the following is NOT a common debugging tool used for IoT development?

i) Wireshark (packet capture tool)

ii) J-Link debugger

iii) Microsoft Word

Answer: iii

MATCHING QUESTIONS:

Term	Description
1. Data Collection Methods	a) A tool used for measuring electrical properties such as voltage and resistance.
2. Functional Requirements	b) Evaluates whether the resources, equipment, and technical expertise are available
3. Technical Feasibility	c). A representation of user interactions with the system, showing relationships between actors
4. Use Case Diagram	d). A description of the functions required from the system in response to inputs.
5. Multimeter	e) Ensures the accuracy and completeness of data before processing

ANSWERS:

1. e

2. d

3. b

4. c

5. a

ANSWER BY TRUE OR FALSE :

1. Data validation ensures the accuracy and completeness of data before it is processed and analyzed.
   True
2. Non-functional requirements describe the specific actions or capabilities that the system must perform.
   False
3. Technical feasibility evaluates whether the project complies with legal regulations and ethical guidelines.
   False
4. Node-RED is a visual programming tool built on Node.js, used for connecting devices and services in IoT development.
   True
5. A multimeter is used to measure voltage, current, and resistance in IoT devices.
   True

Practical assessment

XYZ Company wants to implement the IoT system that will improve crop yield and optimize water usage for large farm. The system will use sensors to monitor soil moisture, temperature and humidity level. You are requested to plan an IoT system.

Criteria	**Indicators**	**observation**	
		Yes	**No**
IoT system development is planned correctly?	IoT system requirements are Identified		
	Tools, materials, and equipment are selected		
	IoT system Diagrams are designed		

END

Further information to the trainer

Alice James, A. S. (2022). *IoT System Design: Project Based Approach.* Academia, Amazon.

Brian Russell, D. V. (2018). *Practical Internet of Things Security.* Amazon.

Fattahi, A. (2022). *IoT Product Design and Development: Best Practices.* Amazon.

Kranz, M. (2016). *Building the Internet of Things.* Amazon.

Lea, P. (2018). *Internet of Things for Architects.* Amazon.

https://www.conceptdraw.com/helpdesk/internet-of-things-diagram
https://www.velvetech.com/blog/iot-hardware-development/
https://www.arm.com/glossary/iot-devices.

https://www.amazon.com/Object-Oriented-Design-Martin-Fowler/s?rh=n%3A4013%2Cp_lbr_one_browse-bin%3AMartin+Fowler

Indicative contents
2.1 Design IOT circuit board **2.2 Mount IoT components on the circuit board** **2.3 Develop IoT Firmware** **2.4 Upload Firmware into micro-controller** **2.5 Develop Human Machine Interface (HMI)** **2.6 Test the IoT system**

Key Competencies for Learning Outcome 2: Build IoT System

Knowledge	Skills	Attitudes
• Description of IoT circuit board • Identification of safety measurements • Description of communication protocols • Description of IoT system firmware • Identification firmware upload procedures • Description of Human Machine Interface (HMI)	• Designing of IoT circuit board • Mounting IoT components on the circuit board • Developing IoT firmware • Uploading firmware into micro-controller • Documenting and maintaining IoT firmware • Connecting micro-controller to the PC • Compiling and debugging of IoT firmware • Uploading firmware into micro-controller. • Developing human machine interface • Testing the IoT system • Documenting the IoT system testing process	• Having Attention to Details while designing IoT circuit board • Having critical thinking • Being rapid during work execution • Being Quick when creating an enclosure • Having teamwork skills

Duration: 85 hrs

Learning outcome 2 objectives:

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

1. Describe clearly IoT circuit board based on system requirements
2. Identify properly the safety measurements according to the IoT system
3. Describe clearly communication protocols based on developed firmware
4. Describe clearly IoT system firmware according to the IoT system
5. Describe clearly Human Machine Interface (HMI) according to the IoT system
6. Design neatly IoT circuit board based on system requirements
7. Mount correctly IoT components to the circuit board according to the IoT system circuit diagram
8. Develop appropriately an IoT firmware according to hardware design
9. Upload successfully firmware into the micro-controller on its flashing process
10. Develop properly human machine interface based on system accessibility
11. Test systematically IoT system based on the intended use

Resources

Equipment	Tools	Materials
● Computer ● Sensors ● Bread Board ● Prototyping Board ● Communication modules ● Microcontrollers ● Power supply ● Power regulator ● ▪ Personal Protective Equipment (PPE)	● Arduino IDE ● VS code ● Nextion Editor ● Stone Designer ● Simulation software ● Digital Multimeter ● Oscilloscope ● ESD Toolkit	● Internet ● Wires ● Screw ● Labelling tags

Advance Preparation:

Before delivering this learning outcome, you are recommended to:

- Have didactic materials and equipment
- Prepare the required tools

Indicative content 2.1: Design IOT Circuit Board

Duration: 10 hrs

Theoretical Activity 2.1.1: Description of IoT Circuit Board

Notes to the trainer:

- May use small groups for describing IoT circuit board.
- Have sample of image of PPEs to be used as didactic material.

Key steps:

While delivering this activity, pass through the following steps:

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

i. What do you understand by schematic diagram?

ii. List out the key components of an IoT circuit board.

iii. Identify the applications of IoT circuit board.

iv. What are the purposes of design rule(DRC) check in IoT circuit board design?

Step 2: Ask trainees to write the answers on provided flipchart/paper.

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

Step 4: Provide expert view for more clarification

Step 5: Address any questions or concerns.

Step 6: Ask trainees to read the **Key readings 2.1.1** in their manuals.

Points to Remember

- Schematic design refers to the initial phase of the design process in various fields such asarchitecture, engineering, electronics, and other creative disciplines.
- Here are the key components of IoT circuit board: Microcontroller/Microprocessor

Connectivity Modules, Sensors, Actuators, Power Supply Circuitry, Input/Output Interfaces. Communication Interfaces, PCB Layout, Antennas

- IoT circuit boards are used in a wide range of applications, including: Smart Home Devices, Wearable Technology, Industrial Automation and Smart Agriculture.
- The purposes of design rule check in IoT circuit board design are: Error Detection, Manufacturability, Performance Assurance

Practical Activity 2.1.2: Designing an IoT Circuit Board

Notes to the trainer

- This activity should take place in a workshop or computer laboratory, where Trainer should perform IoT circuit board design.
- Avail computer lab and software needed to perform IoT circuit board design for the given task.
- Have sample of real PPEs to be used as didactic material.

Key steps:

While delivering this activity, pass through the following steps:

Step1: Introduce the Activity and ask trainees to do the task described below:

As IoT system Developer, you are requested to design circuit board that contains a microcontroller (Arduino uno), a dc motor, NPN transistor, PIR sensor, and other circuitry element.

Step 2: Explain the task and provide clear work instruction.

Step 3: Demonstrate how to design an IoT circuit board. While demonstrating, explain the step to follow.

Step 4: ask trainees to design IoT circuit board and Monitor the activity.

Step 5: Verify whether schematic diagram, PCB layout, trace routing, power and ground planes, design rule check, and PCB prototyping are clearly designed.

Points to Remember

- Here are some steps to consider when designing an IoT circuit board:
  1. Define Requirements
  2. Select Components
  3. Create Schematic Diagram
  4. Design PCB Layout
  5. Design Rule Check (DRC):
  6. Prototype and Testing
  7. Iteration and Improvement
  8. Finalize Design for Production

Application of learning 2.1.

XY is a Company which use IoT system for gate automation using GSM based system. When the system users access this system, they prefer to use their mobile phone instead of mechanical systems. You are requested to design an IoT circuit board for this gate automated system

Checklist:

SN	Criteria	Indicators	Yes	No
1	Circuit board is properly designed	Schematic diagram is created		
		PCB layout is defined		
		PCB is routed		
		Power and ground planes are added		
		Design rules check are implemented		
		PCB is prototyped and tested		
Decision				

Indicative content 2.2: Mounting IoT Components on the Circuit Board

Duration: 15 hrs

Theoretical Activity 2.2.1: Identification of safety measurements

Notes to the trainer:

- May use small groups for identifying the safety measures of mounting IoT components on the circuit board.
- Have sample of real/image of safety equipment and signs to be used as didactic material.

Key steps:

While delivering this activity, pass through the following steps:

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

i. Identify the use of applying safety measures during IoT components mounting on the circuit board.

ii. What is meant by the following terms?

- Power Isolation
- Grounding
- Voltage Testing

iii. What are the essential safety measures for mounting IoT components on the circuit board?

Step 2: Ask trainees to write the answers on provided flipchart/paper.

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

Step 4: Provide expert view for more clarification

Step 5: Address any questions or concerns.

Step 6: Ask trainees to read the **Key readings 2.2.1** in their manuals.

Points to Remember

- When mounting IoT components on the circuit board, there are some essential safety measures are: Component Selection and Handling; Circuit Board Preparation; Mounting Techniques; Soldering Practices and Electrical Safety.

Practical Activity 2.2.2: Mounting IoT Components on Circuit Board

Notes to the trainer

- This activity should take place in workshop, where the trainees should mount IoT components on circuit board.
- Avail all predetermined conditions required.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the Activity and ask trainees to do the task described below:

As IoT system Developer, you are requested to mount IoT components on a circuit board that contains a microcontroller (Arduino uno), a dc motor, NPN transistor, PIR sensor, and another circuitry element.

Step 2: Demonstrate how to mount an IoT circuit board, while demonstrating explain the steps to follow.

Step 3: Ask trainees to mount IoT components on circuit board and monitor the activity

Step4: Verify whether application of safety measures, interpretation of circuit board design, build circuit board, Housing are clearly performed.

Step 5: Ask Trainees to read the key readings 2.4.1

Points to Remember

- **While mounting IoT components on the circuit board pass through the following steps:**
    - ✓ Selection of component
    - ✓ Component placement:
    - ✓ Soldering
    - ✓ Signal integrity
    - ✓ Heat dissipation
    - ✓ Housing (Enclosure):

Application of learning 2.2.

XYZ company wants to assemble a smart home sensor device that will monitor temperature, humidity and light levels in various room. this IoT device must communicate wirelessly with a central hub. you are requested to mount all required components on the circuit board to make this device.

Checklist:

SN	Criteria	Indicators	Yes	No
1	IoT components are properly mounted on the circuit board	Safety measures are applied		
		Circuit board design is interpreted		
2		Circuit board are built		
		Circuit board is well covered		
Decision				

Indicative content 2.3: Develop IoT Firmware

Duration: 15 hrs

Theoretical Activity 2.3.1: Description of Communications Protocols

Notes to the trainer:

- May use small groups for describing IoT firmware used in IoT system development.
- Use of Images, videos and illustrations as didactic Materials.

Key steps:

While delivering this activity, pass through the following steps:

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

i. What is the purpose of IoT firmware in IoT system?
ii. List down the functions of IoT firmware in IoT system.
iii. Identify the components of IoT firmware.
iv. Provide the programming languages used in IoT firmware development
v. What are the communication protocals in IoT development?

Step 2: Ask trainees to write the answers on provided flipchart/paper.

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

Step 4: Provide expert view for more clarification

Step 5: Address any questions or concerns.

Points to Remember

- In IoT devices, firmware is responsible for managing hardware components, processing data from sensors, enabling communication with other devices or networks, and executing application-level logic.

- Here are some key Functions of IoT Firmware: Hardware Control; Data Acquisition; Communication; Device Management; Power Management and Security
- An IoT Firmware is made of the following main components: Bootloader; Real-Time Operating System (RTOS; Application Layer; Communication Stack and Drivers
- For developing and deploying an IoT firmware, these are the required components: Programming Languages; Development Tools; Testing and Validation and Over-the-Air (OTA) Updates

Practical Activity 2.3.2: Developing IoT firmware

Notes to the trainer

- This activity should take place in school computer lab, where trainee should develop IoT firmware.
- Avail the computer lab.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the Activity and ask trainees to do the task described below:

As IoT system Developer, you are requested to develop a firmware that will be uploaded in circuit board of PIR based DC motor control that contains a microcontroller (Arduino uno), a dc motor, NPN transistor, PIR sensor, and other circuitry elements.

Step 2: Demonstrate how to develop IoT firmware, while demonstrating explain the steps to follow.

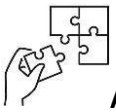
Step 3: Ask trainees to develop IoT firmware and Monitor the activity.

Step 4: Verify whether firmware preparation, implementation, data transfer from/to external platform, security and efficiency, documentation and maintenance are effectively developed.

Points to Remember

- While developing IoT firmware, here are the steps to help you through the process:

1. Define Requirements
2. Select Hardware Platform
3. Choose Development Tools and Environment
4. Design the Firmware Architecture
5. Develop the Firmware
6. Testing and Debugging
7. Implement Security Measures
8. Prepare for Deployment
9. Monitor and Maintain



Application of learning 2.3.

Home owners want a reliable security solution that provides real-time monitoring, alerts, and remote control of security devices (cameras, alarms, and locks). Develop an IoT firmware based smart home security system that allows homeowners to monitor their property remotely, receive alerts for unusual activities, and control security devices via a mobile app.

Checklist:

SN	Criteria	Indicators	Yes	No
1	Firmware is correctly developed	The computer is available		
		The language is selected according to system		
2	Firmware is well tested	All sensors are correctly integrated		
		Setting of Development environment is well done		
Decision				

Indicative content 2.4: Upload Firmware into Microcontroller

Duration: 20 hrs

Practical Activity 2.4.1: Upload Firmware into micro-controller

Notes to the trainer

- This activity should take place in school computer laboratory, where Trainer may use small group or individuals for performing uploading in microcontroller.
- Avail the microcontroller
- Avail computer, micro-controller and communication media

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the Activity and ask trainees to do the task described below:

YZ compony needs to develop system that reads temperature data from a sensor and sends it to a cloud service for monitoring. as an IoT system developer, You are requested to upload the firmware in that IoT system.

Step 2: Explain the task and provide clear work instruction.

Step 3: Demonstrate how to upload a firmware While demonstrating, explain the step to follow.

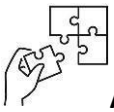
Step 4: Ask the trainees to upload a firmware and monitor the activity.

Step 5: Verify whether the uploading procedures, debugging and security are effectively performed.

Step 6: Ask trainees to read key reading 2.4.1.

Points to Remember

- While uploading firmware into microcontroller, these are the general Steps to follow:
  - ✓ Set Up Your Development Environment
  - ✓ Prepare the Hardware
  - ✓ Write or Modify the Firmware
  - ✓ Compile the Firmware
  - ✓ Select the Target Microcontroller
  - ✓ Upload the Firmware
  - ✓ Verify the Upload
  - ✓ Make adjustment



Application of learning 2.4.

NB is people who live in one of the cities located in Rwanda, he wants to make his home smart by securing the entrance of his home. He wants to use a smart door lock code system that will be controlled via mobile phone application. As firmware developer, you are requested to upload a firmware in a microcontroller used in that system.

Checklist:

SN	Criteria	Indicators	Yes	No
1	Firmware uploading procedures are well applied	Firmware procedures are respected		
		The firmware is completely compiled and debugged		
2	Firmware is uploaded correctly in a microcontroller	The microcontroller is well connected to the PC		
		The firmware is well uploaded		
Decision				

Indicative content 2.5: Develop Human Machine Interface (HMI)

Duration: 15hrs

Theoretical Activity 2.5.1: Description of Human Machine Interface

Notes to the trainer:

- May use small group for describing of Human Machine Interface.
- Use of Images, videos and illustration as didactic Materials.

Key steps:

While delivering this activity, pass through the following steps:

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

i. What are the components of Human Machine Interface?
ii. Identify the functions of Human Machine Interface?
iii. List out the examples of human machine interface applications.
iv. Explain the benefits of Human Machine Interface in IoT system

Step 2: Ask trainees to write the answers on provided flipchart/paper.
Step 3: Ask trainees to present their findings to the whole class
Step 4: Provide expert view for more clarification
Step 5: Address any questions or concerns.
Step 6: Ask trainees to read the **Key readings 2.5.1** in their manuals.

Points to Remember

- A Human-Machine Interface (HMI) is a system that allows interaction between humans and machines.
- The components of human machine interface are:
  - ✓ User Interface
  - ✓ Input Devices
  - ✓ Output Displays
  - ✓ Communication Interfaces
- Here are the functions of human machine interface:
  - ✓ Monitoring
  - ✓ Control

- ✓ Data Visualization
- ✓ User Feedback
- ✓ Configuration and Settings

- The benefits of human machine interface are:
  - ✓ Improved Usability
  - ✓ Increased Efficiency
  - ✓ Enhanced Safety
  - ✓ Remote Access
- Human machine interface is generally applied in different sectors like:
  - ✓ Industrial Automation
  - ✓ Transportation
  - ✓ Healthcare
  - ✓ Consumer Electronics

Practical Activity 2.5.2: Develop Human Machine Interface (HMI)

Notes to the trainer

- This activity should take place in school computer laboratory, where Trainer may use small group or individuals for developing Human Machine Interface.
- Avail computer, designing software

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the Activity and ask trainees to do the task described below:

With an `IoT security system made up with IP cameras and smartphone. As an IoT system developer, you are requested to developer a Human Machine Interface this IoT system security based made up with IP cameras and a smartphone as monitoring device.

Step 2: Explain the task and provide clear work instruction.

Step 3: Demonstrate how to develop a Human Machine Interface. While demonstrating, explain the steps to follow.

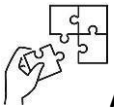
Step 4: Asks trainees to develop a Human Machine Interface and monitor the procedures.

Step 5: Verify whether design, sensor modalities, integration of IoT circuit board with HMI, user testing and improvement are well developed.

Step 6: Ask trainees to read **key reading 2.5.2.**

Points to Remember

- Steps for developing a Human Machine interface:
  - ✓ User Research and Analysis
  - ✓ Define User Requirements
  - ✓ Design the User Interface
  - ✓ Prototype and Test
  - ✓ Develop and Implement
  - ✓ Continuous Evaluation and Improvement



Application of learning 2.5.

CMC Company would like to commission the design and development of a user-friendly Human-Machine Interface (HMI) for a smart car parking system with different sensor. You are requested to design an HMI that should allow the system user to monitor the number of cars in parking.

Checklist:

SN	Criteria	Indicators	Yes	No
1	HMI is efficiently designed	Navigations are highly provided		
		Colors and contrast are correctly designed		
2	Interface is well designed	Power connections are correctly developed		
		Data ports are correctly developed		
Decision				

Indicative content 2.6: Test the IoT system

Duration: 10hrs

Theoretical Activity 2.6.1: identification of IoT system testing categories

Notes to the trainer:

- While delivering this content, a small group can be used for identifying of IoT system testing categories.
- Use of Images, videos and illustration as didactic Materials.
- Avail flipchart
- Trainer may avail tools, materials and equipment related to this activity

Key steps:

While delivering this activity, pass through the following steps:

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

i. Identify different types of functional testing in IoT system.
ii. What are the IoT system testing types?

Step 2: Ask trainees to write the answers on provided flipchart/paper.

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

Step 4: Provide expert view for more clarification

Step 5: Address any questions or concerns.

Step 6: Ask trainees to read the **Key readings 2.6.1** in their manuals.

Points to Remember

Types of testing to consider when identifying testing for an IoT system: Functional Testing; Performance Testing; Security Testing; Interoperability Testing; Usability Testing; Reliability Testing; Compliance Testing; Field Testing and End-to-End Testing.

Practical Activity 2.6.2: Test the IoT system

Notes to the trainer

- This activity should take place in workshop, where Trainer may use small group or individuals for testing an IoT system.
- Avail the practical task as activity and own required materials to be used for each group created.
- Avail the Equipment needed to perform firmware development for the given practical task.
- Avail all predetermined conditions required.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the Activity and ask trainees to do the task described below:

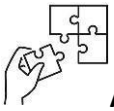
With a system designed for monitoring the room temperature using different sensors (temperature sensors). As an IoT system developer, you are requested to perform a testing of that system.

Step 2: Demonstrate how to perform IoT system testing.
Step 3: Monitor the procedures
Step 4: Ask trainees to read key reading 2.2.6

Points to Remember

- Here are steps guiding on how to test an IoT system, including various testing types and methodologies.
  - ✓ Define Testing Objectives
  - ✓ Develop a Test Plan
  - ✓ Set Up the Testing Environment
  - ✓ Perform Functional Testing
  - ✓ Conduct Performance Testing
  - ✓ Execute Security Testing
  - ✓ Perform Interoperability Testing

- ✓ Conduct Usability Testing
- ✓ Execute Reliability Testing
- ✓ Perform Compliance Testing



Application of learning 2.6.

CMC Company would maintain the security system. As an IoT developer, you are requested to perform different testing techniques in order to check its functionality, performance, security and compatibility. Develop the testing report of the performed activity.

Checklist:

SN	Criteria	Indicators	Yes	No
1	Testing methods are applied correctly	Testing is well performed		
		Testing system is well identified		
2	Documentation is correctly performed	Report is well generated		
		Testing is well documented		
Decision				

Learning Outcome 2 End Assessment

Written assessment

1. Which of the following is the first step in designing the schematic circuit for an IoT device?

a) Selecting key components
b) Defining requirements and specifications
c) Laying out the PCB
d) Choosing a microcontroller

Answer: **(d)**

2. What does DRC stand for in the context of PCB design?

a) Data Routing Check
b) Direct Routing Control
c) Design Rule Check
d) Data Readout Code

Answer: **(c)**

3. What is the primary function of a power plane in a PCB?

a) To route data signals between components
b) To provide a stable voltage reference for components
c) To connect different layers of the PCB
d) To dissipate heat generated by components

Answer: **(b)**

4. When selecting components for mounting on an IoT circuit board, what is a crucial safety consideration?

a) Using the correct color-coded resistors
b) Ensuring compatibility with voltage and current ratings
c) Matching the component footprint with the PCB design
d) Choosing components with the highest operating temperature

Answer: **(b)**

5. What type of communication protocol is commonly used for low-bandwidth, machine-to-machine communication in IoT applications?

a) HTTP
b) Bluetooth
c) LoRaWAN
d) Ethernet

Answer: (d)

6. What is the main purpose of a sensor driver in IoT firmware?

a) To define the layout of the PCB
b) To abstract the communication with sensors
c) To convert sensor data into a visual format
d) To encrypt data transmitted to the cloud

Answer: **(b)**

7. What is a key step in data processing for IoT firmware that helps remove noise from sensor readings?

a) Data encryption
b) Data normalization
c) Data filtering
d) Data transmission

Answer: **(c)**

8. When designing decision-making logic for IoT firmware, what approach involves pre-defined rules for triggering actions?

a) Machine learning
b) Rule-based logic
c) Edge analytics
d) Real-time analysis

Answer: **(b)**

9. Which security measure is essential for protecting data transmitted between an IoT device and the cloud?

a) Data redundancy
b) Data compression
c) Data encryption
d) Data validation

Answer: **(c)**

10. What is the primary goal of power optimization in IoT firmware development?

a) To improve the processing speed of the device

b) To enhance the visual clarity of sensor data displays

c) To extend the battery life of the device

d) To increase the storage capacity of the device

Answer: **(c)**

Practical assessment

A homeowner wants to enhance the security of their residence by implementing an IoT-based system that can remotely monitor and control various aspects of their home's security. As an IoT designer you are requested to design and build an IoT-enabled smart home security system that incorporates cameras, sensors, window sensors, door locks, smartphone, and other notification devices.

Checklist:

Criteria	Indicators	Yes	No
IoT system is built appropriately	IOT circuit board is designed		
	IoT components on the circuit board are mounted		
	IoT Firmware is developed		
	Firmware into micro-controller is uploaded		
	Human Machine Interface (HMI) is developed		
	IoT system is tested		

END

Further information to the trainer

Alice James, A. S. (2022). *IoT System Design: Project Based Approach.* Academia, Amazon.

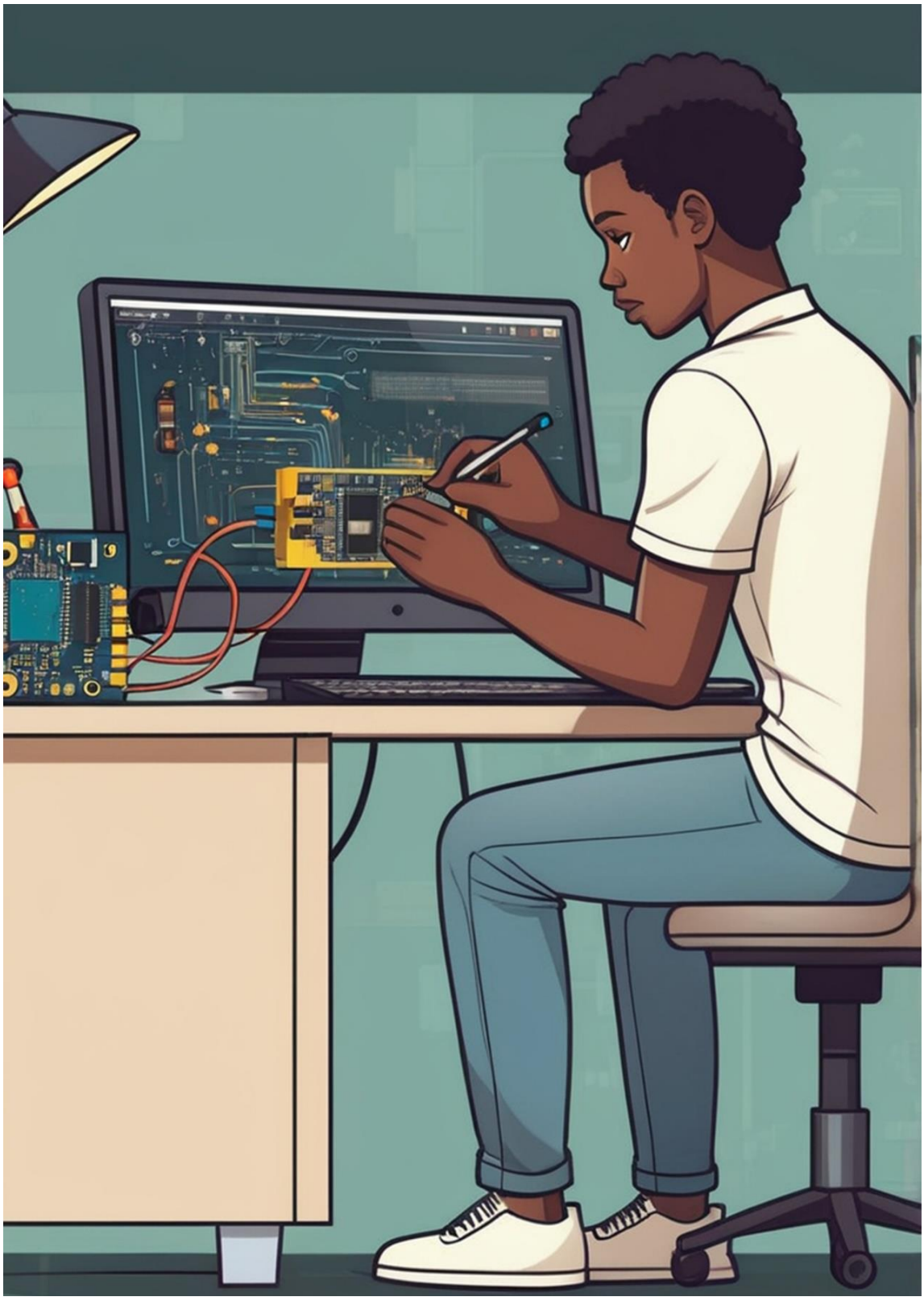
Brian Russell, D. V. (2018). *Practical Internet of Things Security.* Amazon.

Fattahi, A. (2022). *IoT Product Design and Development: Best Practices.* Amazon.

Kranz, M. (2016). *Building the Internet of Things.* Amazon.

Lea, P. (2018). *Internet of Things for Architects.* Amazon.

https://www.cirexx.com/pcb-design-steps/
https://www.barbara.tech/blog/iot-communication-protocols-you-should-know-about
https://lembergsolutions.com/blog/firmware-development-key-points-you-should-know
https://yalantis.com/blog/iot-testing-guide/



Indicative contents
3.1 Install IoT System **3.2 Test the IoT system** **3.3 Document IoT system**

Key Competencies for Learning Outcome 3: Deploy the IoT system

Knowledge	Skills	Attitudes
• Description of IoT system • Description of hardware and network setup	• Installing IoT System • Setting up the network infrastructure • Setting up the IoT devices and sensors. • Installing the gateway • Choosing a cloud platform. • Testing the IoT system • Documenting the IoT System	• Being Practical oriented • Have Communication Skills • Have critical thinking • Have Team work spirit • Being Problem solver

Duration: 25hrs

Learning outcome 3 objectives:

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

1. Identify properly the installation of IoT system requirements based on user needs
2. Describe properly the Hardware and network Infrastructure according to the user needs
3. Install and Configure clearly the Gateway
4. Test correctly the IoT system based on designed system
5. Identify Cleary the IoT system testing type according the usability of system
6. Document and Analyse Cleary the IoT system requirements based on user manual, testing report and bill of quantity

Resources

Equipment	Tools	Materials
● Microcontroller ● Digital Multimeter ● Power Supply (e.g., batteries or solar panels) ● Enclosure ● Prototyping Materials ● Oscilloscope ● Computer ● Screwdrivers ● Bread Board	● Arduino IDE ● IoT Web Application API ● Soldering Iron ● Calibration Tools ● Manuals ● Mounting Tool ● Cutting tools ● Glue Gun	● Internet ● Sensors ● USB Cable ● Soldering Tin ● Electricity ● Glue sticks ● Connector ● wires

Advance Preparation:

Before delivering this learning outcome, you are recommended to: :

- Have didactic materials and equipment
- Avail the computer lab to find the computer connected to the internet.
- Have software tool for writing codes and debugging the IoT system
- Prepare the required tools
- Have some videos or pictures related to the topic.

Indicative content 3.1: Install IoT System

Duration: 12 hrs

Theoretical Activity 3.1.1: Description of IoT system

Notes to the trainer:

- While delivering this content, a small group can be used for the description of IoT system

Key steps:

While delivering this activity, pass through the following steps:

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

i. Describe the key component of IoT system
ii. Define the following term:
   - Sensor
   - Cloud services
iii. Explain the functionality of an IoT system.

Step 2: Monitor the tasks

Step 3: Ask trainees to present their findings to the whole class.

Step 4: Provides expert view and clarifies ideas by using didactic materials.

Step 5: Ask the trainees ready the key readings 3.1.1 in trainee manual

Points to Remember

There are key components of an IoT system which are: Devices and Sensors, Data Processing, Connectivity, Cloud Services, User Interfaces, Data Security and Privacy

Functionality of an IoT System are: Data Collection, Automation and Control, Remote Monitoring, Predictive Analytics, Integration with Other Systems

Practical Activity 3.1.2: Installing IoT system

Notes to the trainer

- This activity should take place in a computer lab where trainees should perform the Installation of IoT system.
- While delivering this content, you are required to:
- Avail computer connected to the internet.
- Avail computer installed with ARDUINO IDE

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask trainees do the task described below:

As IoT system developer, you are asked to go to the computer lab to perform Hardware and network setup and the Configuration of setup.

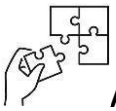
Step 2: Explain the task and provide clear work instruction.
Step 3: Demonstrate how to install the IoT system, while demonstrating, explain the steps to follow.
Step 4: Ask trainees to Install IoT system and monitor the activity
Step 5: Verify whether hardware and Network setup, configuration and set up are properly performed
Step 6: Ask trainees to read key reading 3.1.2.

Points to Remember

- **Steps to install the IoT system**

1. Define Objectives and Requirements
2. Select Hardware Components
3. Plan the Network Architecture
4. Set Up Hardware
5. Configure Communication
6. Install and Configure Software
7. Implement Data Management

8. Create User Interfaces
9. Testing and Validation
10. Deployment
11. Maintenance and Updates



Application of learning 3.1.

XYZ Company wants to establish the system will use sensors to gather real-time data and actuators to control devices all connected to central cloud platform for monitoring and management, you are requested to install an IoT system that automates environment controls in an office including lighting, heating, ventilation, air conditioning(HVAC) of the company.

Checklist:

Criteria	**Indicators**	**observation**	
		Yes	**No**
IoT system is adequately installed in line with operational environment	The Hardware and network setup are performed		
	The configuration and setup are performed		

Indicative content 3.2: Test the IoT System

Duration: 8hrs

Theoretical Activity 3.2.1: Description of IoT System Testing

Notes to the trainer:

- While delivering this content, a small group can be used for describing IoT System Testing.

Key steps:

While delivering this activity, pass through the following steps:

Step1: Introduce the activity and request trainees to respond to the following questions:

i. What do you understand by the term testing?
ii. Provide a description:
    a) Functional testing
    b) Performance testing
    c) Security testing

Step 2: Asks any learner to write answers provided on paper.

Step 3: Asks trainees to discuss the provided answer and choose correct answers.

Step 4: Provides expert view and clarifies ideas by using didactic materials.

Step 5: Address any questions or concerns.

Step 6: Ask trainees to read the key readings 3.2.1 in the trainee manual.

Points to Remember

- Testing is a crucial aspect of ensuring the reliability, performance, security, and usability of anIoT system.
- There is the different types of Testing: functional testing, performance testing, security testing, and Reliability testing and user acceptance testing.

Practical Activity 3.2.2. Testing the IoT system

Notes to the trainer

- While delivering this content, individual groups can be used for to test IoT System.

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask trainees to do the task described below:

As a software IoT system developer, you are asked to go to the installed IoT system to apply the testing Techniques.

Step 2: Explain the task and provide clear work instructions.

Step 3: Demonstrate how to test the IoT system. While demonstrating, explain the steps to follow.

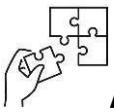
Step4: Ask trainees to test IoT system and monitor the activity

Step5: Asks trainees to read key readings in activity 3.2.2

Points to Remember

The steps to pass through wile testing the IoT system

1. Define Testing Objectives
2. Create a Testing Plan
3. Set Up the Testing Environment
4. Conduct Functional Testing
5. Perform Performance Testing
6. Execute Security Testing
7. Conduct Reliability and Stability Testing
8. Perform User Acceptance Testing (UAT)
9. Conduct Usability Testing
10. Perform Interoperability Testing
11. Document Testing Results
12. Review and Analyze Results
13. Deploy the System



Application of learning 3.2.

A farmer has installed a smart agriculture irrigation system to monitor and control various crop conditions, including temperature, humidity, soil moisture, and irrigation. The system is designed to provide real-time data and alerts to optimize crop management. The farmer now needs an IoT system developer to assist with testing the installed system on the farm. You are requested to perform the above activity of IoT testing.

Checklist:

Criteria	**Indicators**	**Observation**	
		Yes	**No**
IoT system is systematically is well tested correctly?	The functional testing is done		
	Performance testing is done		
	Security testing is Done		
	Reliability testing is performed		
	Reliability and user Acceptance testing is perfomed.		

Indicative content 3.3: Document IoT System

Duration: 5hrs

Theoretical Activity 3.3.1: Description of IoT system Document

Notes to the trainer:

- While delivering this content, a small group can be used for describing IoT system document

Key steps:

While delivering this activity, pass through the following steps:

Step1: Introduce the activity and request trainees to respond to the following questions:

Discuss on the user manual document, testing report document, bill of quantity document

Step2: Monitor the task

Step3: Ask trainees to present their findings to the whole class.

Step4: Provide expert view and clarify ideas by using didactic materials.

Step5: Ask trainees to read the key reading 3.3.1. in trainee manual

Points to Remember

- The purpose of an IoT system document is to provide a comprehensive and structured overview of an IoT (Internet of Things) project. It serves as a blueprint for the entire system, outlining its components, functionality, and how they interact

Practical Activity 3.3.2: Documenting the IoT system

Notes to the trainer

- Engages trainees to use the text editing and word processing for creating detailed documents, including system architectures, requirements, and procedures.
- While delivering this content, you are required to:
- Avail computer connected to the internet
- Avail computer installed the Microsoft word and other text editing tools
- Avail IoT Platform Documentation (e.g., AWS IoT, Azure IoT) provide their own documentation tools or templates.

Key steps:

While delivering this activity, pass through the following steps:

Step 1: Introduce the topic and ask trainees do the task described below:

As an IoT system developer, you are asked to go to the computer lab to document the installed IoT System

Step 2: Explain the task and provide the work instructions

Step 3: Demonstrate how to document IoT system while demonstrating, explain the steps to follow.

Step 5: Verify whether User manual, testing report and bill of quantity are clearly performed.

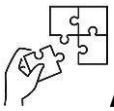
Step 6: Ask trainees to read key reading 3.3.2.

Step 7: Ask trainees to perform the task provided in application of learning 3.3

Points to Remember

The key steps to effectively document an IoT system:

1. Define Documentation Objectives
2. Identify Target Audience
3. Gather Information
4. Create System Architecture Documentation
5. Document Functional Specifications
6. Develop User Documentation
7. Create Technical Documentation
8. Outline Security Documentation
9. Include Testing Documentation
10. Version Control and Change Management
11. Review and Edit Documentation
12. Publish and Distribute Documentation
13. Maintain Documentation



Application of learning 3.3.

A small-scale farmer in Rwanda is struggling to maintain crop yields due to unpredictable weather conditions and pests. The farmer implement an IoT-based system to monitor crop health, soil moisture, and weather patterns, as IoT system developer Implement documentation on farmer IoT system.

Checklist:

Criteria	**Indicators**	**observation**	
		Yes	**No**
IoT system is properly documented.	IoT system User manual is documented		
	IoT system Testing report is documented		

	IoT system Bill of quantities is documented		

Learning Outcome 3 End Assessment

Written assessment

1. Which of the following is NOT a crucial component of IoT system hardware and network setup?

   A) IoT devices and sensors

   B) Cloud servers

   C) Network infrastructure

   D) UPS devices

   Answer: D

2. When choosing a cloud platform for an IoT system, which factor should be considered the most important?

   A) Cost

   B) Scalability

   C) Location

   D) Security

   Answer: D

3. Functional testing of an IoT system primarily focuses on:

   A) Evaluating system performance under heavy loads

   B) Assessing system security vulnerabilities

   C) Verifying that the system meets specified requirements

   D) Ensuring system reliability over time

   Answer: C

4. The purpose of a Bill of Quantities in an IoT project is to:

A) Document the testing results

B) Provide a detailed list of materials and costs

C) Create a user manual

D) Configure IoT devices

Answer: B

Answer by True or False:

Questions	Answer
1. The first step in deploying an IoT system is interpreting the system requirements document.	**True**
2. Network infrastructure setup is optional when deploying an IoT system.	**False**
3. IoT devices and sensors must be set up after the network infrastructure is configured.	**True**
4. An uninterruptable power source ensures continuous operation during power failures.	**True**
5. Hardware installation includes connecting devices to the power source and network.	**True**
6. IoT deployment does not require specialized hardware or sensors.	**False**
7. Understanding the system requirements document helps ensure proper IoT deployment.	**True**
8. Setting up the network infrastructure involves configuring IP addresses and routers.	**True**
9. Sensors in an IoT system do not require calibration during setup.	**False**
10. An uninterruptable power source is only necessary in industrial IoT deployments.	**False**

Matching Questions

Question	Answer
1. Choosing suitable communication protocols for devices.	**b. Set Up Network Infrastructure**
2. Installing devices in specific locations.	**c. Setup IoT Devices and Sensors**

3. Ensuring continuous power supply for critical devices.	**d. Setup Uninterruptable Power Source**
4. Analyzing the system objectives and requirements.	**a. Interpret System Requirements Document**
5. Selecting routers, switches, and access points.	**e. Hardware and Network Setup**

Practical assessment

A local agricultural farm is looking to improve its crop monitoring and management system through IoT technology. The goal is to deploy a **Smart Farming IoT System** that helps in real-time monitoring of soil moisture levels, temperature, humidity, and crop health. This system will enable the farm to automate irrigation, reduce water waste, and optimize crop yield. The system should also provide analytics and reporting, allowing farm managers to access data remotely via a cloud platform.

You have been hired as an IoT systems integrator to install, test and document this Smart Farming IoT solution. The project includes setting up IoT sensors, network infrastructure, cloud integration, and data storage solutions.

Criteria	**Indicators**	**observation**	
		Yes	**No**
IoT system is properly deployed	IoT system is installed		
	IoT system is tested		
	IoT system is documented		

END

Further information to the trainer

Alice James, A. S. (2022). *IoT System Design: Project Based Approach.* Academia, Amazon.

Brian Russell, D. V. (2018). *Practical Internet of Things Security.* Amazon.

Fattahi, A. (2022). *IoT Product Design and Development: Best Practices.* Amazon.

Kranz, M. (2016). *Building the Internet of Things.* Amazon.

Lea, P. (2018). *Internet of Things for Architects.* Amazon.

https://www.coursera.org/courses?query=iot&product-Type-Description
https://www.udemy.com/topic/internet-of-things/
https://www.testingmind.com/what-is-iot-device-testing-how-to-perform-it/
https://developer.ibm.com/technologies/iot/patterns/smart-agriculture-iot/
https://www.researchgate.net/figure/Illustration-of-the-Internet-of-Things-IoT-system-architecture-and-node-design

RTB | RWANDA TVET BOARD

October 2024