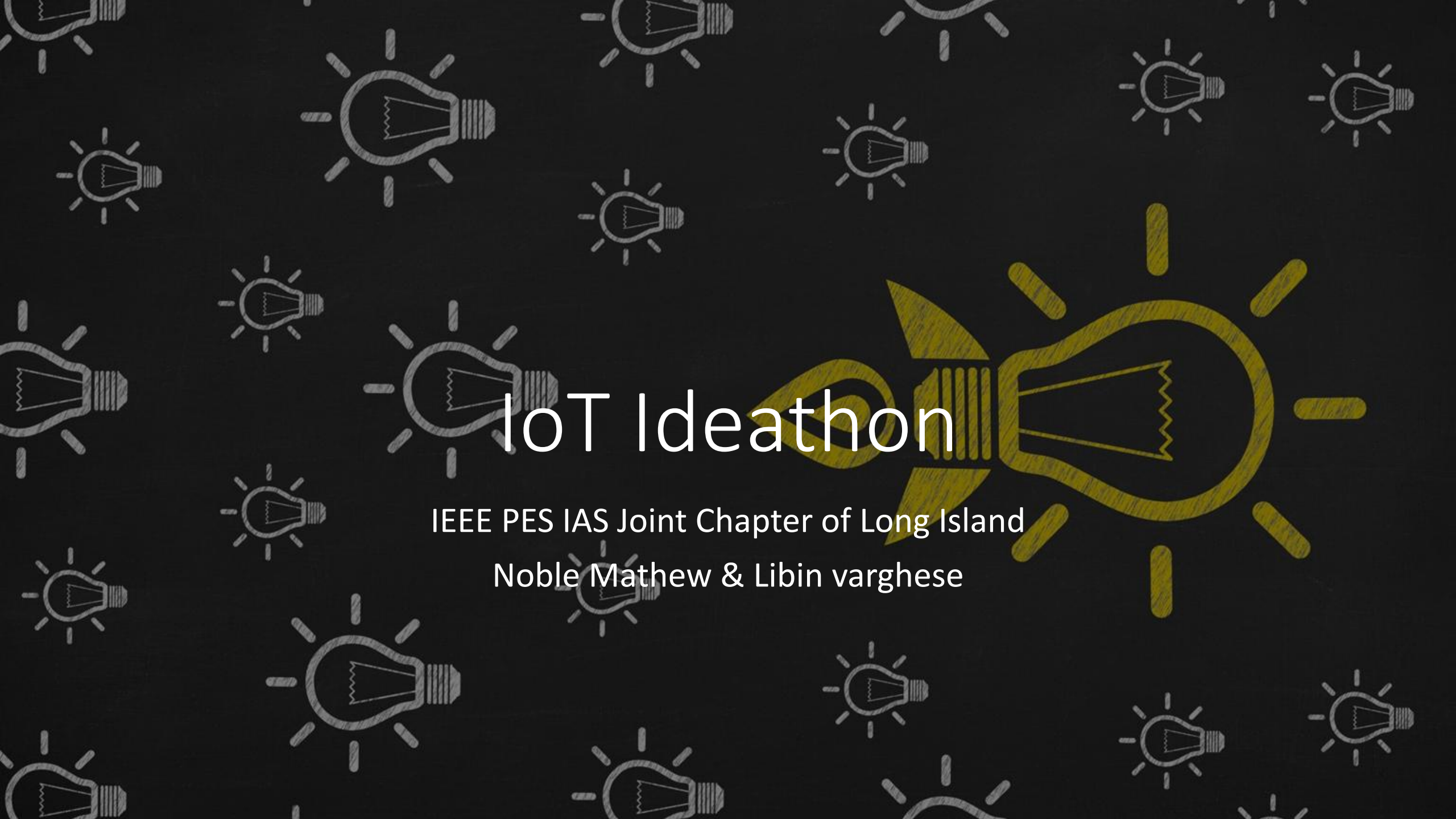


IoT Ideathon

IEEE PES IAS Joint Chapter of Long Island

Noble Mathew & Libin varghese

Welcome and Introduction

- IEEE PES IAS Joint Chapter of Long Island
- **Mission of PES :**
  - To be the leading provider of scientific and engineering information on electric power and energy for the betterment of society, and the preferred professional development source for our members.
- Benefits of Joining
- Connect with professionals, academics, and fellow students.
- Access to job boards, career fairs, and workshops

IEEE PES Power & Energy Society™

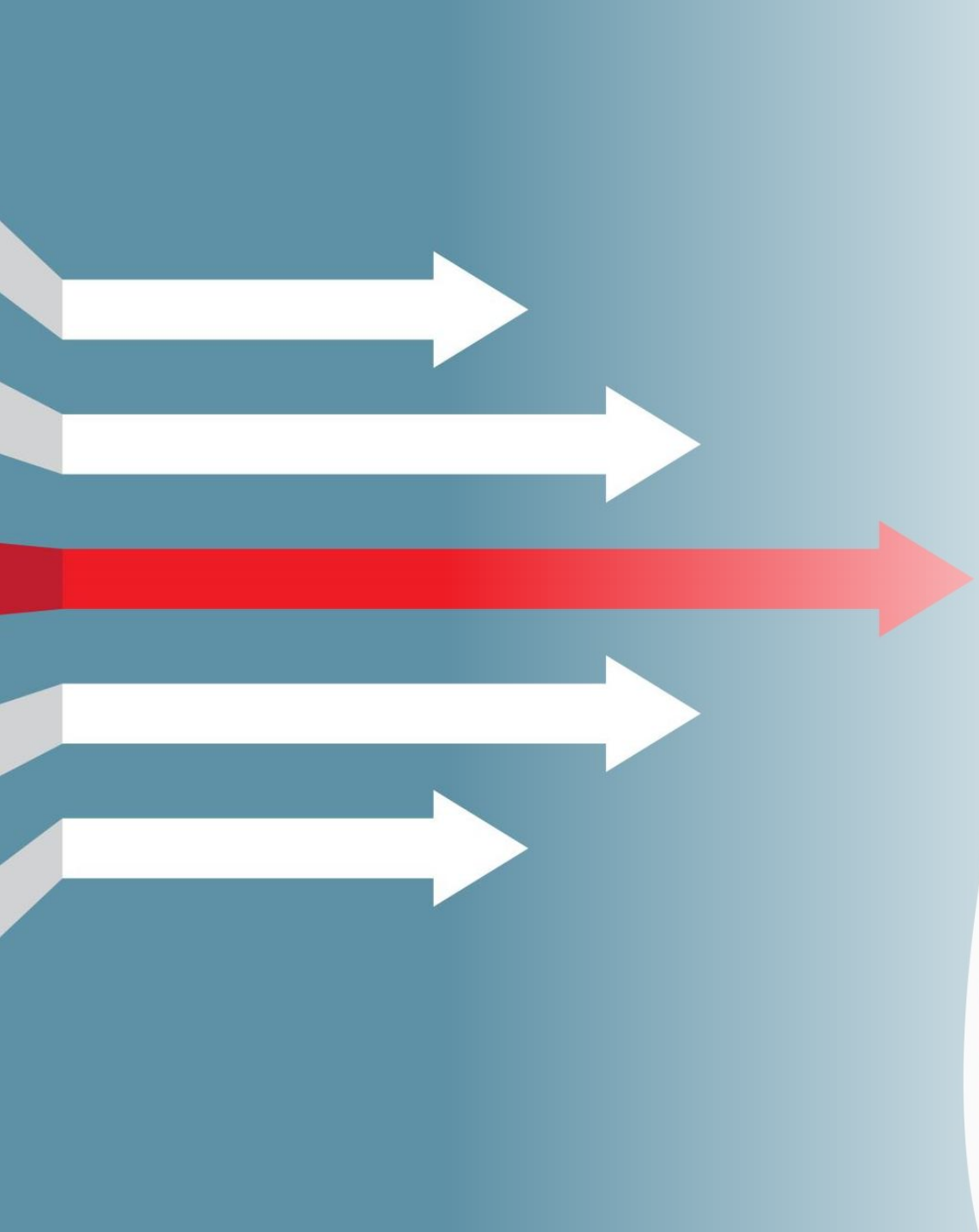
IAS IEEE INDUSTRY APPLICATIONS SOCIETY Linking Research to Practice

Problem Statement

Traditional electricity meters are outdated, requiring manual readings and lacking real-time data integration. In remote or rural areas, connectivity issues and high maintenance costs further complicate energy monitoring.

Challenge:
Develop a **Smart Electricity Metering System** using **LoRaWAN** and **IoT** to:

- Enable real-time remote monitoring of electricity usage.
- Optimize energy efficiency and provide detailed usage analytics.
- Reduce operational costs by eliminating manual readings and improving infrastructure.
- Ensure scalability, reliability, and security for widespread deployment.



Goal

- Create a cost-effective, scalable solution that enhances accuracy, supports energy management, and enables better decision-making for both utilities and consumers.

Why is it Important?

Smart electricity meters are used to track and measure energy usage.

Traditional meters often rely on more power-hungry technologies, but LoRaWAN® offers a new, low-energy alternative.

This technology is particularly well-suited for IoT (Internet of Things) networks and smart grids because:

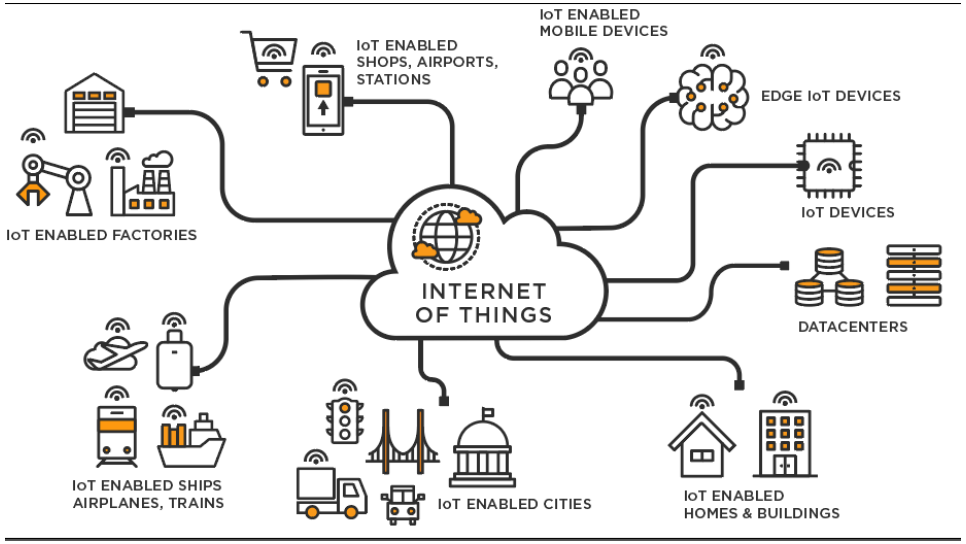
Long Range: LoRaWAN® can connect devices over vast distances, even in rural or hard-to-reach areas.

Low Power Consumption

Cost-Effective

Reliability and Scalability: LoRaWAN® networks can easily handle a large number of devices

LoRaWAN ,IOT and Metering



LoRa Vs LoRaWAN

What Is LoRa?

- Originally developed for adding wireless communication capabilities for the utility metering industry, the LoRa protocol operates in an unlicensed radio spectrum with data rates up to 253 kB/s and is prized for its ability to send tiny amounts of data over long distances while requiring extraordinarily little power.

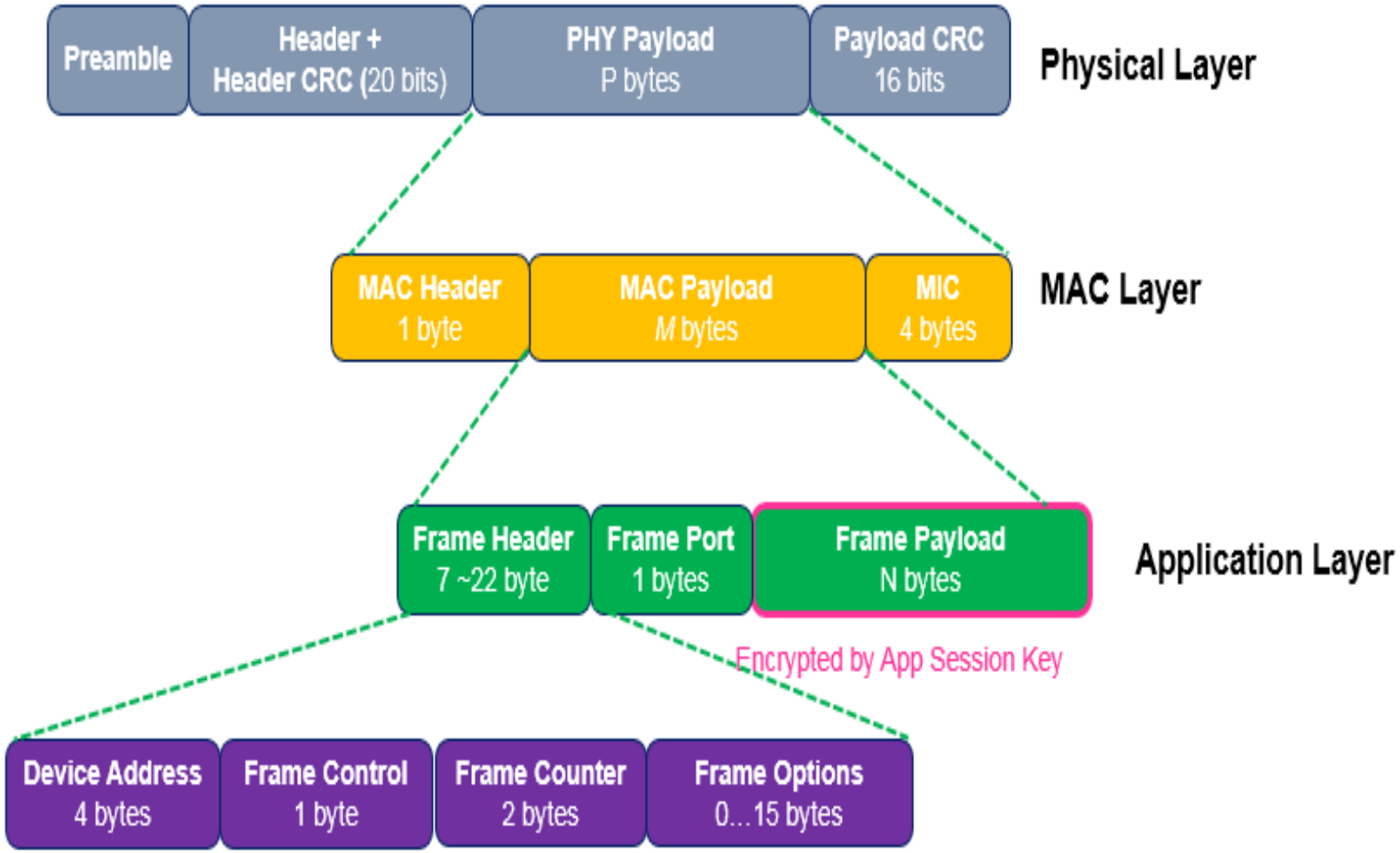
What Is LoRaWAN?

- LoRaWAN technology consists of a low-power, wide-area network protocol built onto LoRa modulation useful for securing dependable bi-directional IoT communications. The LoRaWAN protocol provides end-to-end encryption to deliver advanced security features at scale.

Radio Frequencies based on Different Countries

- **Europe (EU868):** Operates in the 863-870 MHz band.
- **North America (US915):** Operates in the 902-928 MHz band.
- **Australia (AU915):** Operates in the 915-928 MHz band.
- **Asia (AS923):** Operates in the 915-928 MHz band
- **Asia (AS923-1):** Operates in the 915-928 MHz band
- **Asia (433 MHz):** Operates in the 433 MHz band.
- **India (IN865):** Operates in the 865-867 MHz band

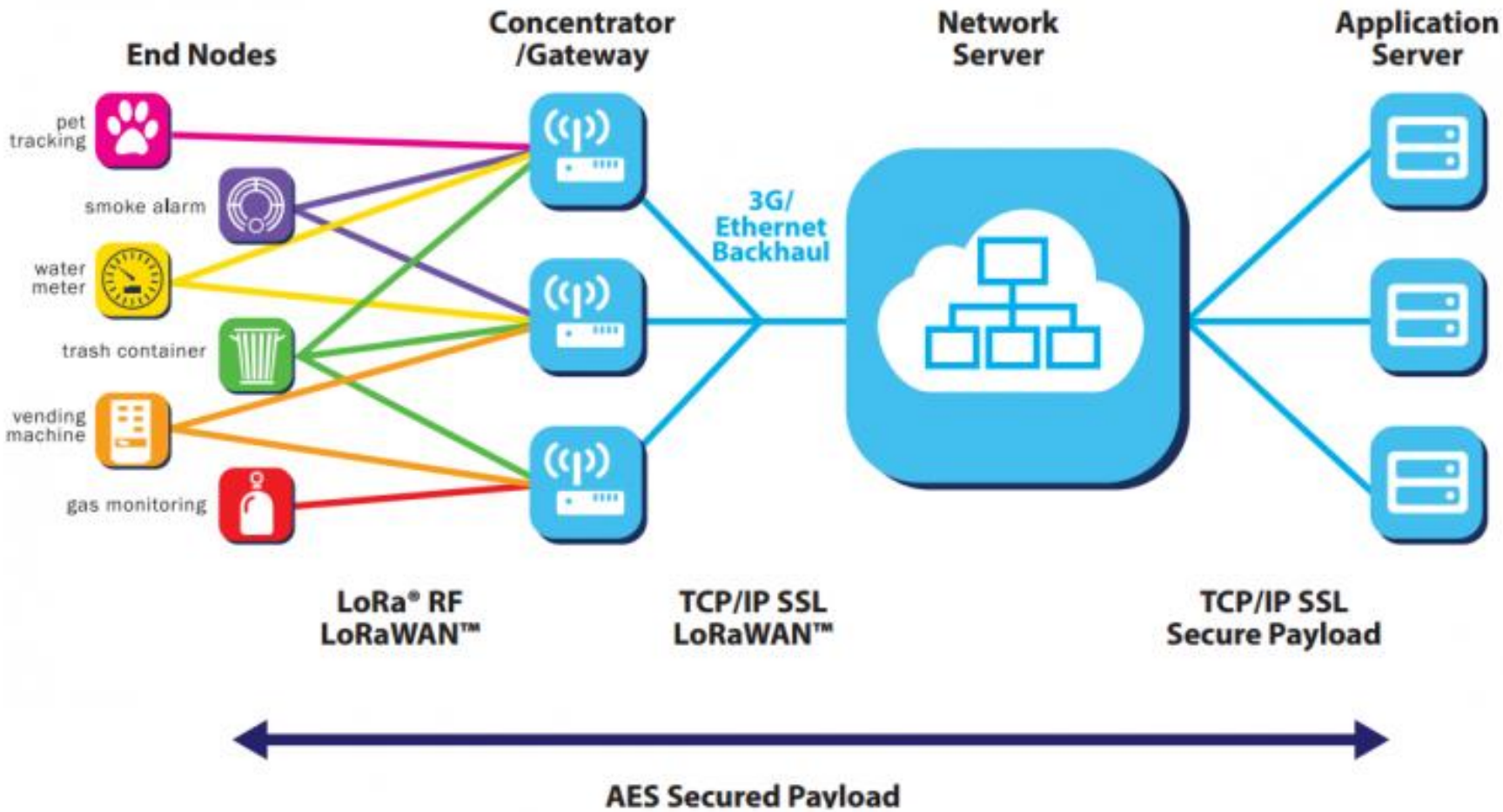
LoRa Frame Format

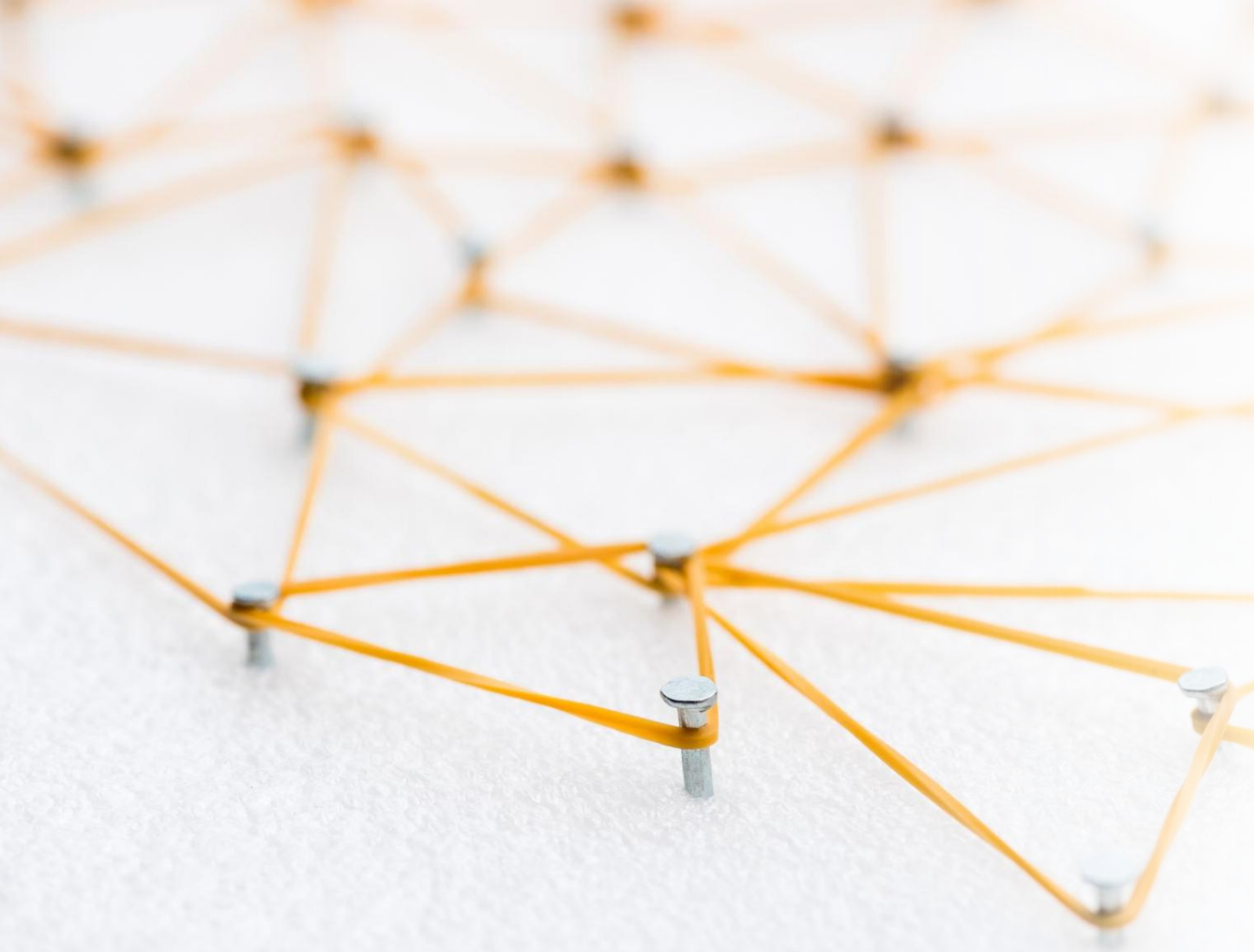


LoRaWAN Packet

- 1. Physical Layer (LoRa):
- 2. MAC Layer (LoRaWAN):
- 3.FPort (Frame Port):
- FRMPayload (Frame Payload)
- MIC (Message Integrity Code)
- Uplink
- Downlink

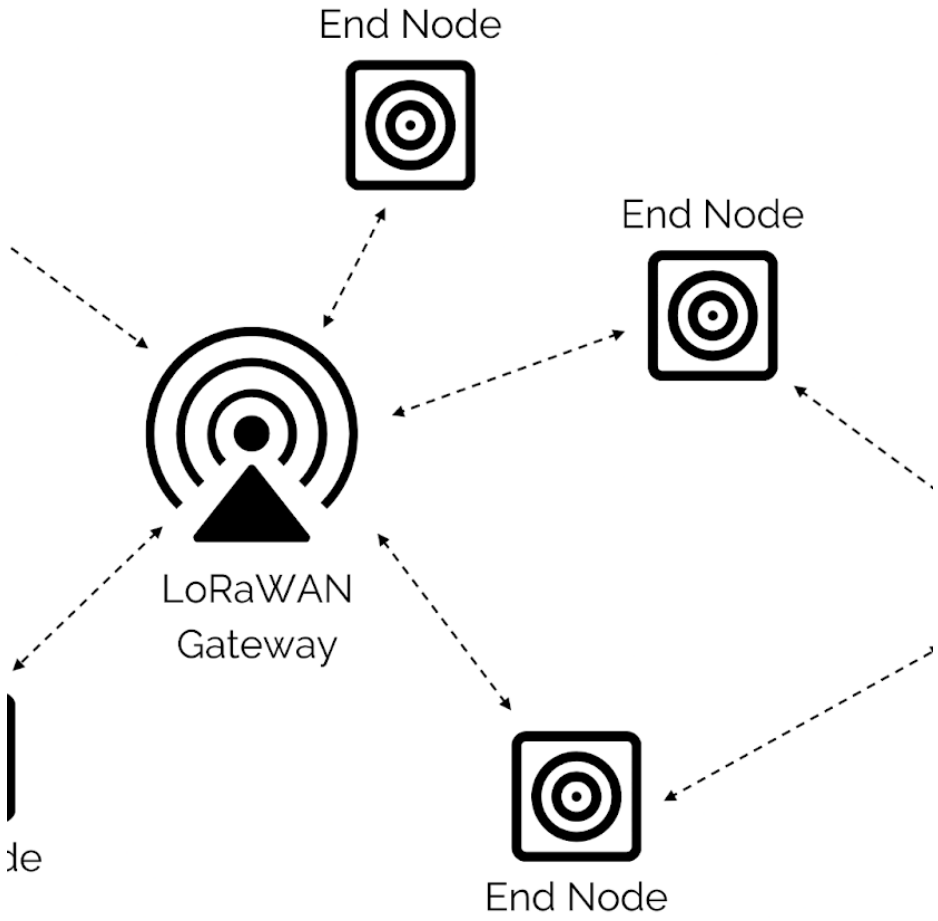
Key Components





Connection Topologies

1. **End Nodes** – Represents edge devices or sensors
2. **Gateway** – Collects or concentrates data from several end nodes
3. **Network Server** – Consolidates data from gateways for upload to the application server
4. **Application Server** – Processes or displays consolidated data



- **LoRaWAN End Nodes**

  They usually come in the form of low-power microcontrollers that can be deployed for years without any requirement for maintenance and are equipped with a LoRa transmitter to send data packets to the Gateways

LORA Gateway

- **Function**
  - *Data Collection:* LoRaWAN gateways receive data transmitted by LoRa-enabled end devices (sensors, actuators, etc.) within their range.
  - *Forwarding:* The gateway then forwards this data to a network server via backhaul connections like Ethernet, Wi-Fi, or cellular.
  - *Bridging:* It acts as a bridge between the low-power, long-range LoRa radio communication and the IP network used by the network server.
- **Key Features**
  - *Range:* LoRaWAN gateways are designed for long-range communication, typically covering several kilometers in rural areas and up to a few kilometers in urban areas.
  - *Capacity:* A single gateway can support thousands of end devices.

LORAWAN SERVER AND APPLICATION SERVER

1 LoRaWAN Network Server (LNS):

•Core Network Management: The LNS is the heart of the LoRaWAN network, responsible for managing the overall infrastructure, including gateways and end-devices.

•Data Routing and Security: It receives data packets from gateways, decrypts them, performs authentication and integrity checks, and routes them to the appropriate Application Server.

•Network Operations: Handles deduplication of uplink messages, selects the best gateway for downlinks, manages adaptive data rates (ADR), and ensures network efficiency and reliability.

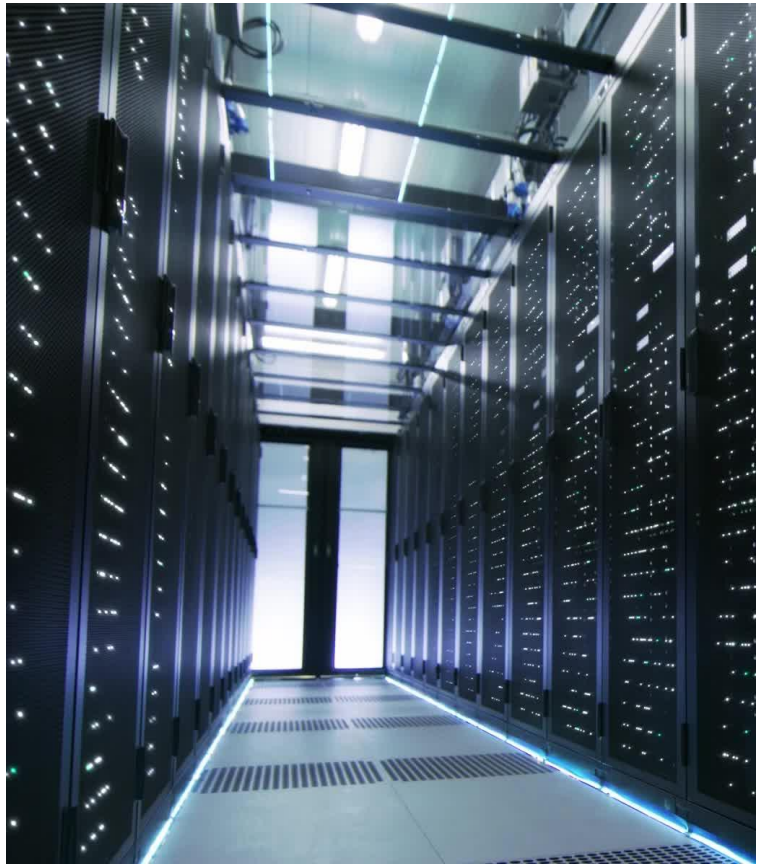
2. LoRaWAN Application Server (AS):

•Application Data Processing: The AS receives decrypted data from the LNS and processes it based on the specific application requirements.

•Data Analysis and Storage: It is responsible for analyzing the sensor data, triggering actions, and storing the data for further use.

•Application-Specific Logic: It implements the business logic for the specific application, like smart agriculture, asset tracking, or environmental monitoring.

•User Interface: The AS provides a user-friendly interface for end-users to visualize and interact with the data.

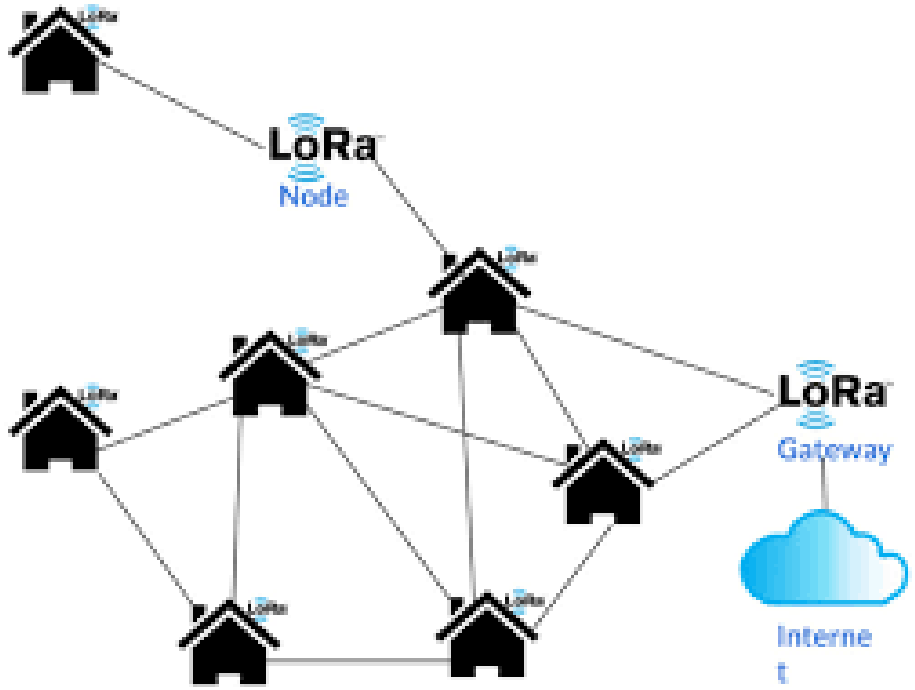


Connection Topology

- **LoRa Mesh** refers to a network topology using LoRa (Long Range) technology where devices communicate with each other in a mesh-like structure, relaying data across multiple devices to reach their destination

- Key Features:
- Decentralized Communication: Unlike the star topology of LoRaWAN, where devices communicate directly with a central gateway, LoRa Mesh allows devices to communicate directly with each other.
- Multi-hop Communication: Data packets can be forwarded through multiple nodes to reach the destination, effectively extending the network range and coverage area.
- Self-Organizing Network: The network can automatically establish and maintain its topology, adapting to changes as devices join or leave.
- Increased Reliability: The presence of multiple communication paths provides redundancy and improves network resilience. If one route fails, data can be rerouted through another path.

- **Mesh,**
- **peer to peer,**
- **Lora wan.**

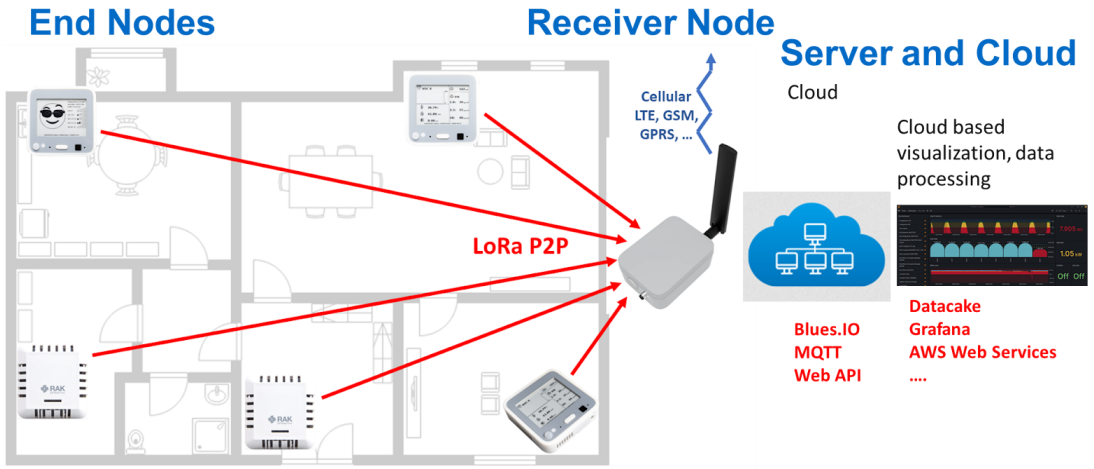


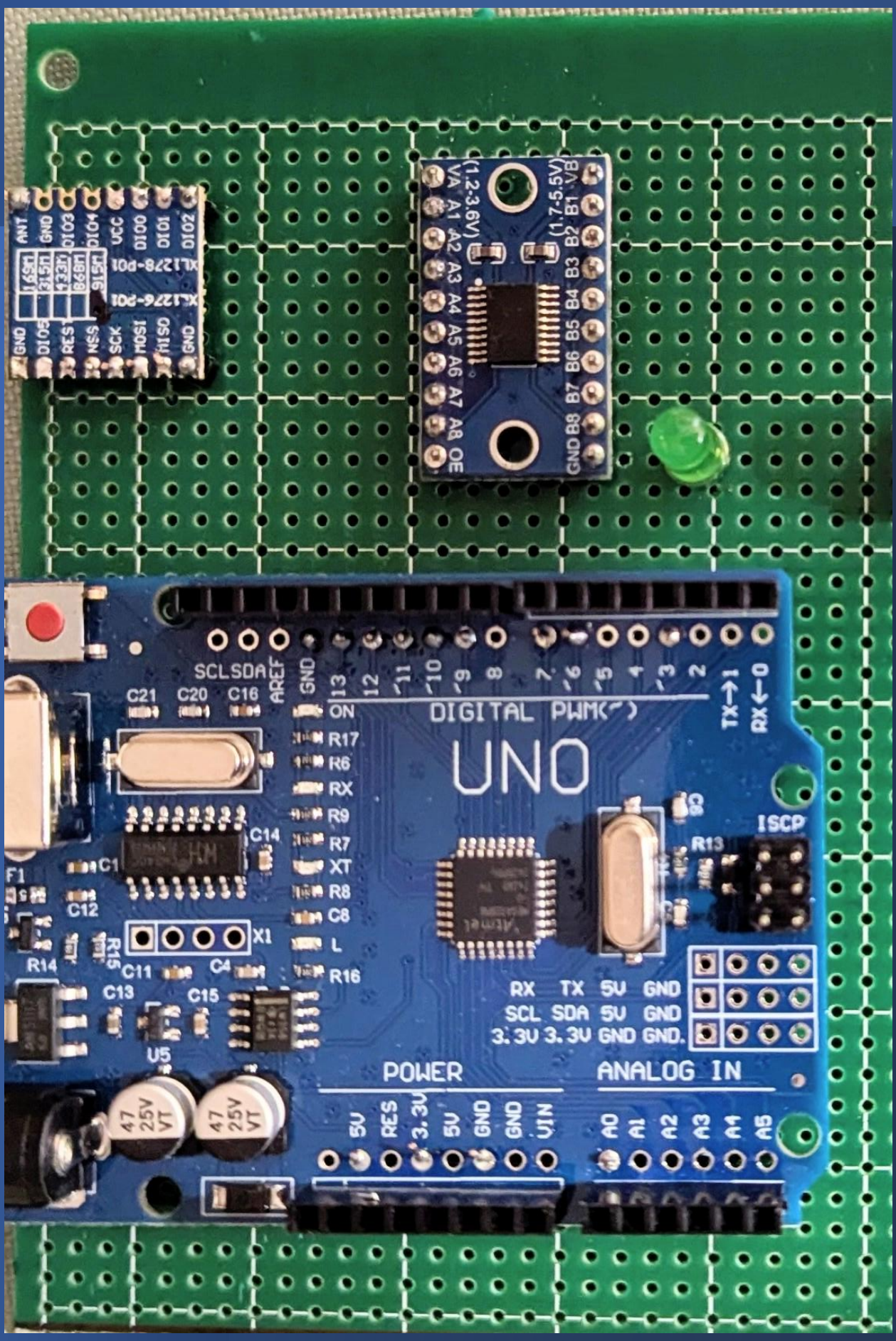
LORA MESH

- A LoRa mesh network, in simple terms, is a network of LoRa-enabled devices that can communicate with each other, extending the range and coverage of the network. .
- Key Features of a LoRa Mesh Network:
- Extended Range: LoRa's already impressive range can be further extended by hopping data between nodes.
- Increased Reliability: Multiple paths offer redundancy, making the network more resilient to node failures.
- Coverage in Challenging Environments: LoRa's ability to penetrate obstacles, combined with mesh networking, allows for broader coverage, even in complex environments.
- Decentralized: No need for a central coordinator, making the network simpler to deploy and more flexible.

Peer to Peer LORA

- LoRa Peer-to-Peer (P2P) communication allows two LoRa-enabled devices to directly communicate with each other without relying on a central network infrastructure, like gateways in a LoRaWAN network.
- Direct Communication: Devices send and receive data directly between each other.
- Simplified Setup: It doesn't require a complex network infrastructure like LoRaWAN, making it simpler and potentially more cost-effective for small-scale applications.
- Lower Latency: Direct communication between devices can reduce latency compared to LoRaWAN where data needs to pass through gateways and servers.
- Unlicensed Frequencies: LoRa P2P, like LoRaWAN, utilizes the license-free sub-GHz bands, making it cost-effective and accessible.

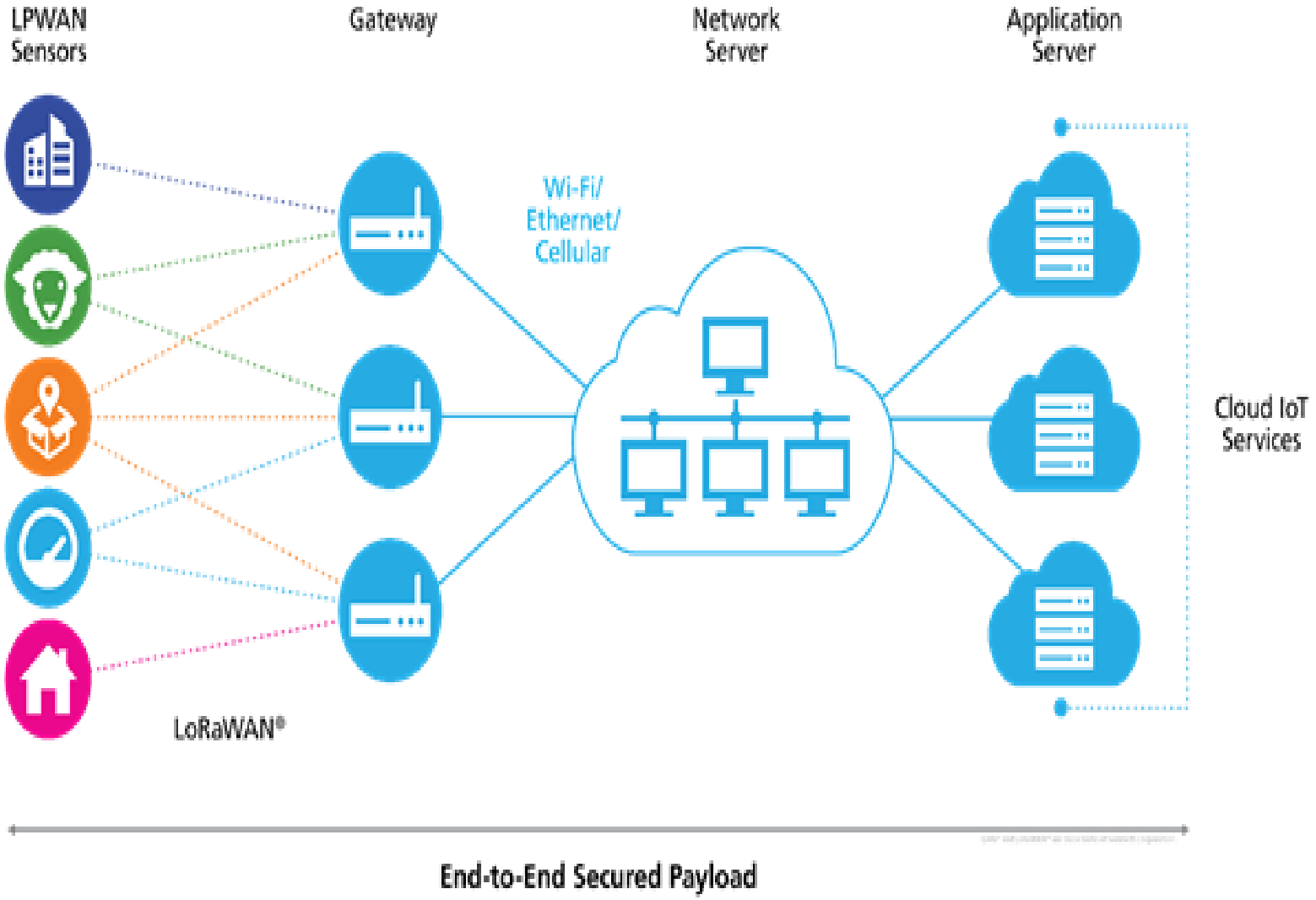



ANT
GND
DIO3
DIO4
VCC
DIO0
DIO1
DIO2
XL1278-P01
XL1276-P01
GND
DIO5
RES
NSS
SCK
MOSI
MISO
GND
(1.2-3.6V)
VA A1 A2 A3 A4 A5 A6 A7 A8 OE
(1.7-5.5V)
VB B1 B2 B3 B4 B5 B6 B7 B8 GND
SCL SDA AREF GND
13 12 ~11 ~10 ~9 8 7 ~6 ~5 4 ~3 2 TX→1 RX←0
DIGITAL PWM(~)
UNO
ON
R17
R6
RX
R9
R7
XT
R8
C8
L
R16
C21 C20 C16
C14
C1
F1
C12
X1
R14
R15
C11
C4
C13
C15
U5
47 25V VT
47 25V VT
ISCP
R13
RX TX 5V GND
SCL SDA 5V GND
3.3V 3.3V GND GND
POWER
5V RES 3.3V 5V GND GND VIN
ANALOG IN
A0 A1 A2 A3 A4 A5

LoRaWAN

LoRaWAN stands for Long Range Wide Area Network. It's a low-power, wide-area networking (LPWAN) protocol designed specifically for connecting battery-operated "things" to the internet wirelessly, especially over long distances.

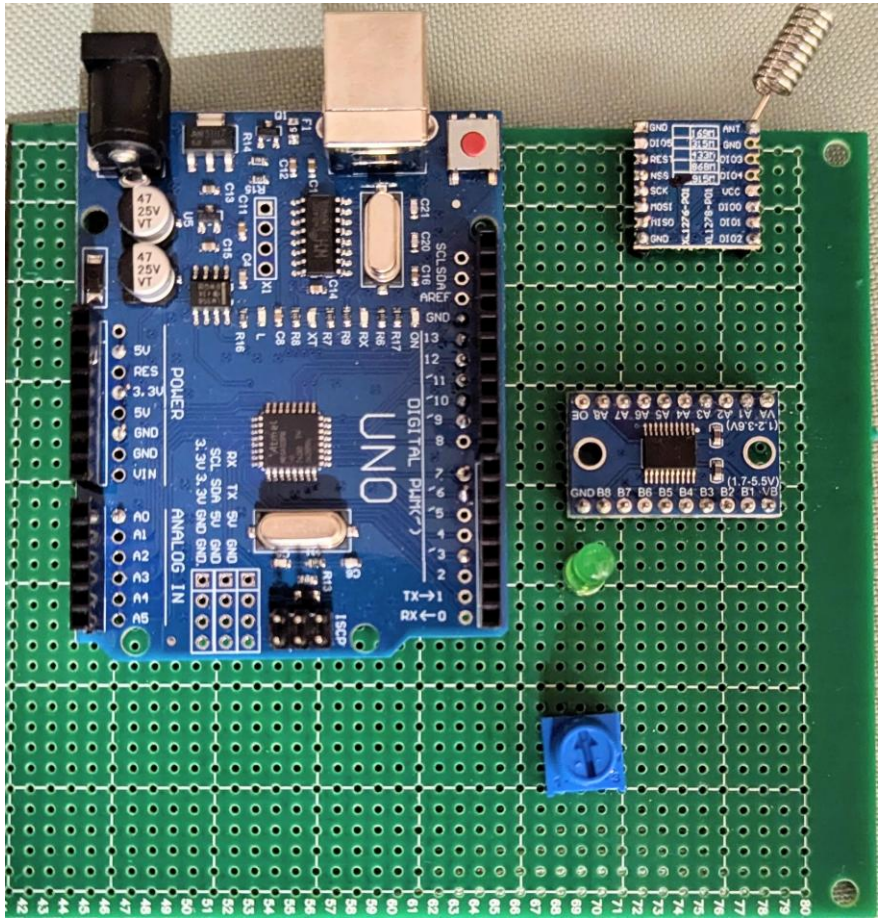
LoRaWAN networks typically have a star-of-stars topology, with end-devices (sensors) connecting to gateways via LoRa, and gateways relaying data to a central network server.

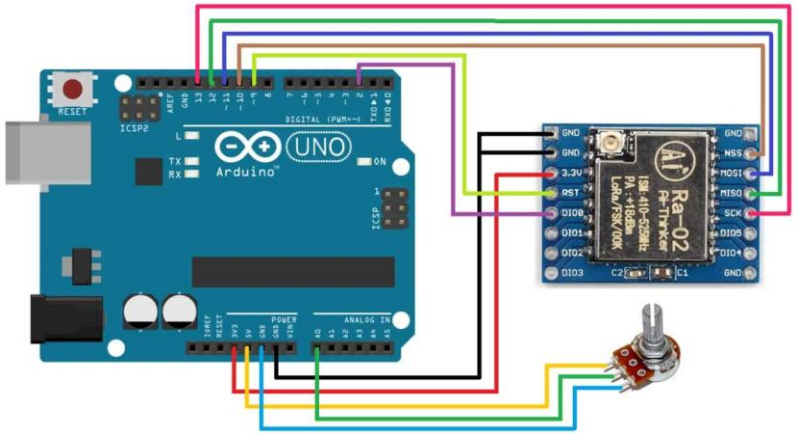


LORA WAN vs LORA Peer to Peer

Feature	LoRa Peer-to-Peer	LoRaWAN
Network Structure	Direct device-to-device	Star-of-stars (devices -> gateways -> network server)
Scalability	Small to medium-scale	Large-scale, wide-area
Complexity	Simpler, less infrastructure	More complex, requires gateway infrastructure
Security	Requires implementation in the application layer	End-to-end encryption via LoRaWAN protocol
Data Handling	Simpler data transmission	More robust data handling with Adaptive Data Rate (ADR)
Management	Decentralized	Centralized network management

Experimental Set up

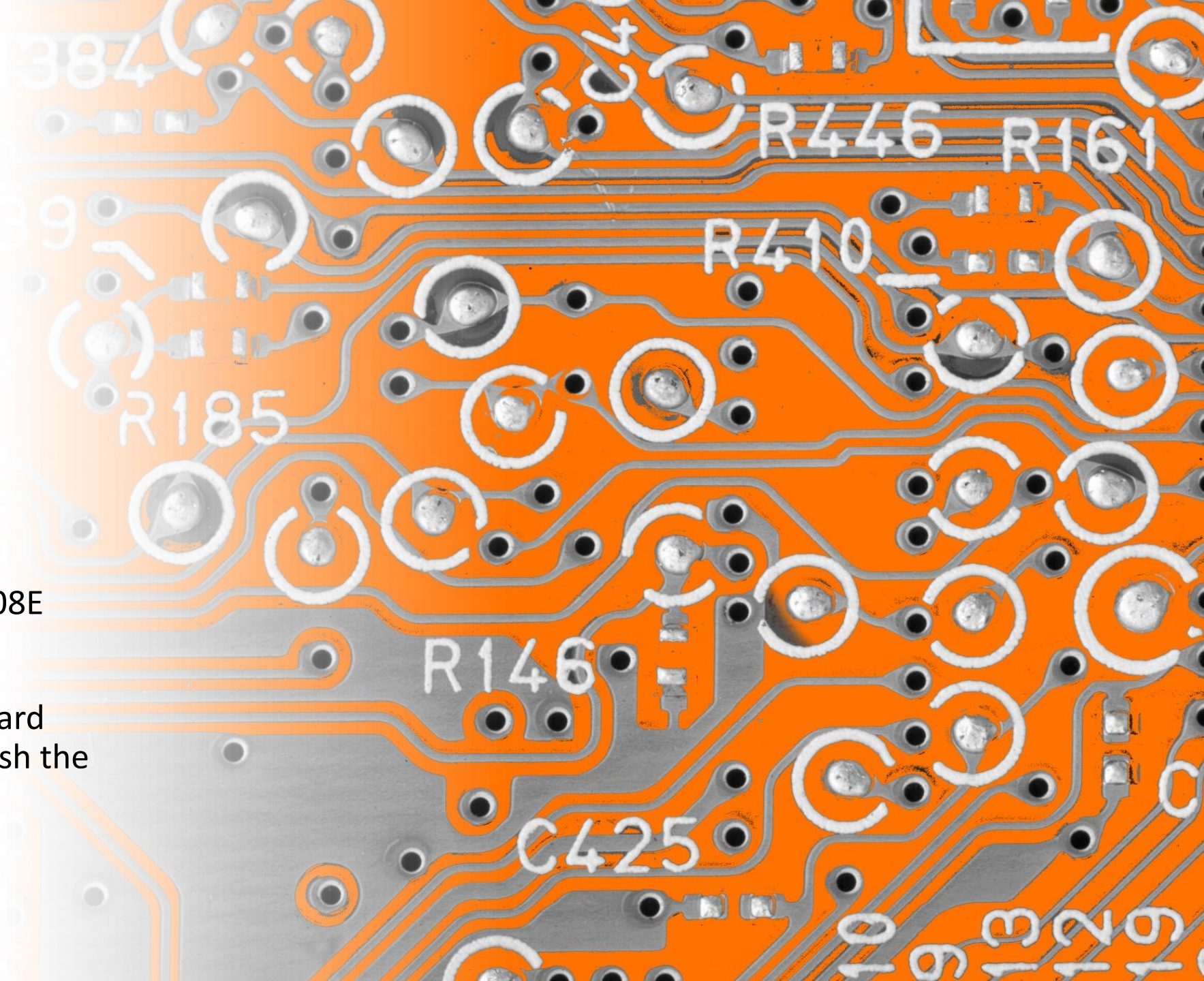




Arduino and the setup

- Arduino UNO
- Lora Module SX1276
- Led For Indication
- 10K Potentiometer
- Logic Level Shifter TXS0108E

- These Components are Hard Wired Together to Establish the Lora Wan Setup



Arduino


Reset Switch
USB Connector
USB Interface Chip
Crystal Oscillator
Voltage Regulator
Power Port
Digital Pins
TX RX LEDs
Microcontroller
Analog Input Pins
UNO
ARDUINO
DIGITAL (PWM~)
POWER
ANALOG IN

Illustration of Peer to Peer Lora End Node Communications

Connecting End devices together in a Transmitter and Receiver Mode where a Transmitter can send Data to Multiple or single Node directly without any gateway or server.

Illustration of LoRaWan GATEWAY With Things Network (LoRaWan Server)

- In which the End nodes are connected to a Gateway and the collected datas are forwarded to a cloud-based “Things Network” an IOT Lora Server
- Further It can be connected to Application server Based on the Processing

THANK YOU!