Final Report : Design Credit Evaluation

Topic : Exploring LoRa communication for IoT

1. Aims and Objectives:

- To develop and put into use low power LoRa technology to create mid-range (2 km) transceivers capable of LoS communication.
- Create an interface circuit to transfer data from different analogue sensors, such as temperature, ultrasonic distance, and ECG sensors.
- Make an effort to transfer data without utilizing the Internet.

2. Introduction:

LoRa technology is a wireless communication technology that uses a radio modulation technique that allows long-range transmissions at low data-rates. The technology is designed to be used in Internet of Things (IoT) applications, and is particularly well suited to applications where power consumption is a key concern.

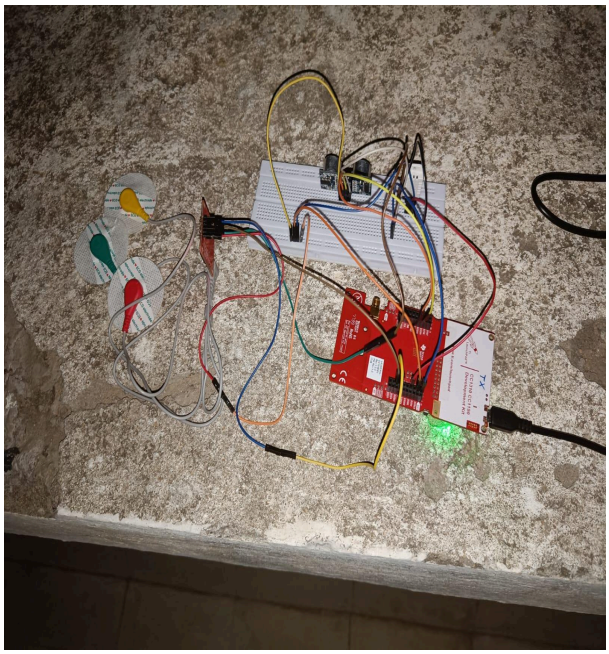
A LoRa module is a transceiver that is used for communication over a long range. It uses the LoRaWAN protocol to send and receive data. The module can be used to communicate with other LoRa modules or with a LoRa gateway.

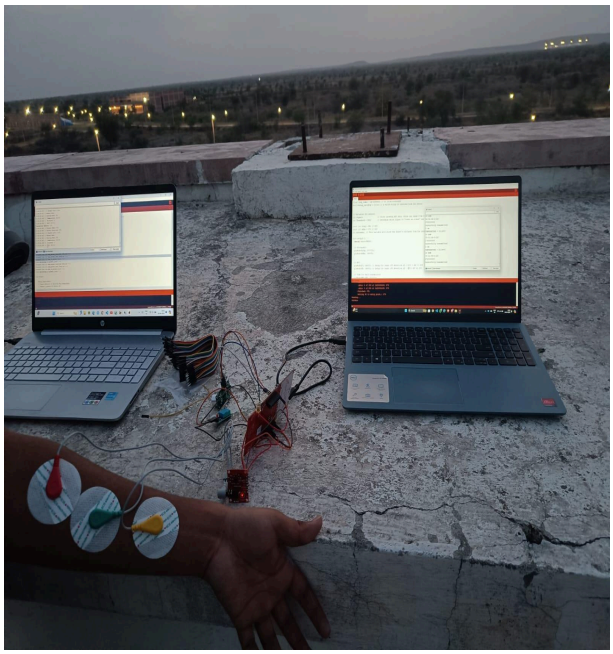
3. Apparatus Used:

- LoRa Module x 2
- ECG Sensor x 1
- Temperature Sensor(DHT11) x 1
- Ultrasonic Sensor x 1
- Breadboard x 1
- Jumper Wires
- CC1310 Board x 2

4. Experimental Setup :

Circuit diagram :- Actual Circuit of Transmitter Side :





5. Code with comments :

Source Code for Transmitter :

```
#include "EasyLink.h"

EasyLink_TxPacket txPacket;

EasyLink myLink;

#define HGM A5

#define LNA_EN A6

#define PA_EN A7


uint16_t value;

int analog_val;


// c_packet have 30 elements first 10 elements contains digits of number of packet

// transmitted successfully from transmitter

// in unsigned long int format

char c_packet[30] = {'0','0','0','0','0','0','0','0','0','0',';','S',';','0','0','0','0','0',';','0','0','0','0','0','0',' ','R','/','H','r'};

String s = ""; // string to contain sensor data

unsigned long int counter = 1; // number of packet sent successfully, range is [0, 4294967295] 10 digits beyond it max range counter will reset to 0

float t; // stores current time

float f = 1; // frequency of running the program

float dt = 1/f; // time period in seconds of running program i.e. void loop

float loop_timer = dt*1000000; // dt in microseconds

bool string_validity = false; // a valid string is received from the sensor

// Variables for sensors

int Signal;              // Store incoming ADC data. Value can range from 0-1024

int Threshold = 550;      // Determine which Signal to "count as a beat" and which to ignore.
```

```
const int trig = 38; // D20
const int echo = 37; // D19
int distance;  // This variable will store the object's distance from the sensor.

void setup() {
 Serial.begin(9600);

 // Ultrasonic
 pinMode(trig, OUTPUT);
 pinMode(echo, INPUT);

 // ECG
 pinMode(27, INPUT); // Setup for leads off detection LO + D19 -> A6 == D29
 pinMode(28, INPUT); // Setup for leads off detection LO - D20-> A7 == D30

 // Code for data transmission
 pinMode(RED_LED, OUTPUT);
 pinMode(GREEN_LED, OUTPUT);
 //Enable CC1190 Module ON
 pinMode(HGM, OUTPUT);
 pinMode(LNA_EN, OUTPUT);
 pinMode(PA_EN, OUTPUT);
 digitalWrite(HGM, HIGH);
 digitalWrite(LNA_EN, LOW);
 digitalWrite(PA_EN, HIGH);
 digitalWrite(RED_LED, LOW);

 digitalWrite(GREEN_LED, LOW);
 // begin defaults to EasyLink_Phy_50kbps2gfsk
```

```
 myLink.begin();
 // Set the destination address to 0xaa
 txPacket.dstAddr[0] = 0xaa;
 t = micros();
}
void loop() {
 //  int ecgdata = -1;
 // Heart Rate Sensor
 Signal = analogRead(A2); // Read the sensor value

 // Temperature Sensor
 float temp = analogRead(A3); //D26

 // Ultrasonic Sensor
 digitalWrite(trig, LOW);
 delayMicroseconds(2);
 digitalWrite(trig, HIGH);
 delayMicroseconds(10);
 digitalWrite(trig, LOW);

 // ECG Sensor
 //  if ((digitalRead(27) == 1) || (digitalRead(28) == 1)) {
 //    Serial.println('!');
 //  }
 //  else {
 // send the value of analog input 0:
 int ecgdata = analogRead(A0); //D23
//     Serial.println(ecgdata);
 //  }
```

```
 // Calculating the distance by multiplying the speed of sound by the time of echo
 distance = pulseIn(echo, HIGH) * 0.034 / 2;
 String ultrasonic = String(distance) + " cm";
 Serial.println(ultrasonic);

 // read analog volt from sensor and save to variable temp
//    temp = temp * 0.48828125;
//  temp = log(((10240000 / temp) - 10000));
//  temp = 1 / (0.001129148 + (0.000234125 + (0.0000000876741 * temp * temp )) * temp );
//  temp = temp - 273.15;
  temp = 60 - (((temp/204.8) - 0.5) * 10);
 // convert the analog volt to its temperature equivalent
 Serial.print("TEMPERATURE = ");
 Serial.print(temp); // display temperature value
 Serial.print("*C");
 Serial.println();
 Signal = 350;
 String heartRateData = String(ecgdata / 10) + " BPM";
 Serial.println(heartRateData);
      // Send the signal value to serial plotter
 // Collecting All Data
 String data = String(Signal / 10) + "-" + temp + "-" + String(distance) + "-" + String(ecgdata/10) + "!";
 Serial.println(data);
 // Code for transmission of data
 // Copy Counter Value to c_packet;
 String counter_str = String(counter);
 int n = counter_str.length();
 if(n>=10) {
```

```
  counter = 0;
  counter_str = "0";
 }
 int j=n-1;
//  Serial.println(counter_str);
 for(int i=9; i>=0 && j>=0; i--) {
  c_packet[i] = counter_str[j];
  j--;
 }
 String test = "";
 for(int i=9; i>=0; i--) {
  test+=c_packet[i];
 }
 Serial.println(test);
 for (int i = 0; i <= data.length(); i++) // element no 10 is ; so copy in element no 11 to last i.e 29 so maximum 19 characters can be sent
 {
  c_packet[i + 11] = data[i];
 }
 // copy data to be sent
 memcpy(&txPacket.payload, &c_packet, sizeof(c_packet));
 // Set the length of the packet
 txPacket.len = sizeof(c_packet);
 // Transmit immediately
 txPacket.absTime = EasyLink_ms_To_RadioTime(0);
 // read transmission status
 EasyLink_Status status = myLink.transmit(&txPacket);
 if (status == EasyLink_Status_Success) // if transmission is successful
 {
  counter++; // increase data sent counter by one
```

```
  // string correct and data transmission successful
  // green led blink & red led off
  digitalWrite(GREEN_LED, HIGH);
  delay(50);
  digitalWrite(GREEN_LED, LOW);
  delay(50);
  digitalWrite(RED_LED, LOW);
  Serial.println("Sucessfully transmitted");
 }
 else
 {
  // string correct but transmission failed
  // green led blink & red led on
  digitalWrite(GREEN_LED, HIGH);
  delay(50);
  digitalWrite(GREEN_LED, LOW);
  delay(50);
  digitalWrite(RED_LED, HIGH);
 } d
elay(1000);
}
```

Source Code for Receiver :

```
// program for Rx
////////////////////////////////////////////////////////////////////////////////////////////////////////////////////////
#include "EasyLink.h"
EasyLink_RxPacket rxPacket;
EasyLink myLink;
```

```
// char c_packet[19]; // number of packet sent by transmitter(5 digits); analog value(4 digits)
char c_packet[30];
#define HGM A5    //
#define LNA_EN A6 // low noise amplifier pin
#define PA_EN A7  // power amplifier enable pin
float t;         // stores current time in microseconds
unsigned long int num_packet_received_from_tx = 0;
unsigned long int num_packet_sent_from_tx = 0;
unsigned long int num_of_packet_loss = 0;
float percentage_of_packet_loss = 0;
unsigned long int num_packet_received_from_tx1 = 0;
unsigned long int num_packet_sent_from_tx1 = 0;
unsigned long int num_of_packet_loss1 = 0;
float percentage_of_packet_loss1 = 0;
unsigned long int num_packet_received_from_tx2 = 0;
unsigned long int num_packet_sent_from_tx2 = 0;
unsigned long int num_of_packet_loss2 = 0;
float percentage_of_packet_loss2 = 0;

void setup()
{
   Serial.begin(9600);
   // begin defaults to EasyLink_Phy_50kbps2gfsk
   // Enable c_packet1190 Module ON
   pinMode(HGM, OUTPUT);
   pinMode(LNA_EN, OUTPUT);
   pinMode(PA_EN, OUTPUT);
   digitalWrite(HGM, HIGH);
   digitalWrite(LNA_EN, HIGH);
   digitalWrite(PA_EN, LOW);
   myLink.begin();
   Serial.println(myLink.version());
   t = micros();
}

unsigned long long int getNumOfPacketSent(char data[]) {
 unsigned long long int num=0;
 int itr=0;
```

```
  for(int i=9; i>=0; i--) {
    num+=(data[i]-'0')*pow(10, itr);
    itr++;
  }
  return num;
}

void loop()
{
    for (int i = 0; i < 30; i++)
    {
        c_packet[i] = '-';
    }
    // rxTimeout is in Radio time and needs to be converted from miliseconds to RadioTime
    rxPacket.rxTimeout = EasyLink_ms_To_RadioTime(3000);
    // Turn the receiver on immediately
    rxPacket.absTime = EasyLink_ms_To_RadioTime(0);
    // check status of receiving and decoding the received packet
    EasyLink_Status status = myLink.receive(&rxPacket);
    if (status == EasyLink_Status_Success)
    {
        memcpy(&c_packet, &rxPacket.payload, sizeof(c_packet)); // copy receive payload to c_packet
        // if payload received is from device 170 (it is the id of device Tx (0Xaa))
        int tx_addr = rxPacket.dstAddr[0];
        Serial.print("Transmitter Address: ");
        Serial.print(tx_addr);
        Serial.println();

//        num_packet_sent_from_tx = 1 * (int(c_packet[9]) - 48) + 10 * (int(c_packet[8]) - 48) + 100 *
(int(c_packet[7]) - 48) + 1000 * (int(c_packet[6]) - 48) + 10000 * (int(c_packet[5]) - 48) + 100000 *
(int(c_packet[4]) - 48) + 1000000 * (int(c_packet[3]) - 48) + 10000000 * (int(c_packet[2]) - 48) +
100000000 * (int(c_packet[1]) - 48) + 1000000000 * (int(c_packet[0]) - 48);
        num_packet_sent_from_tx = getNumOfPacketSent(c_packet);
//Serial.print(c_packet[9]);
        Serial.print("Packets Sent: ");
        Serial.print(num_packet_sent_from_tx);
        Serial.println();
```

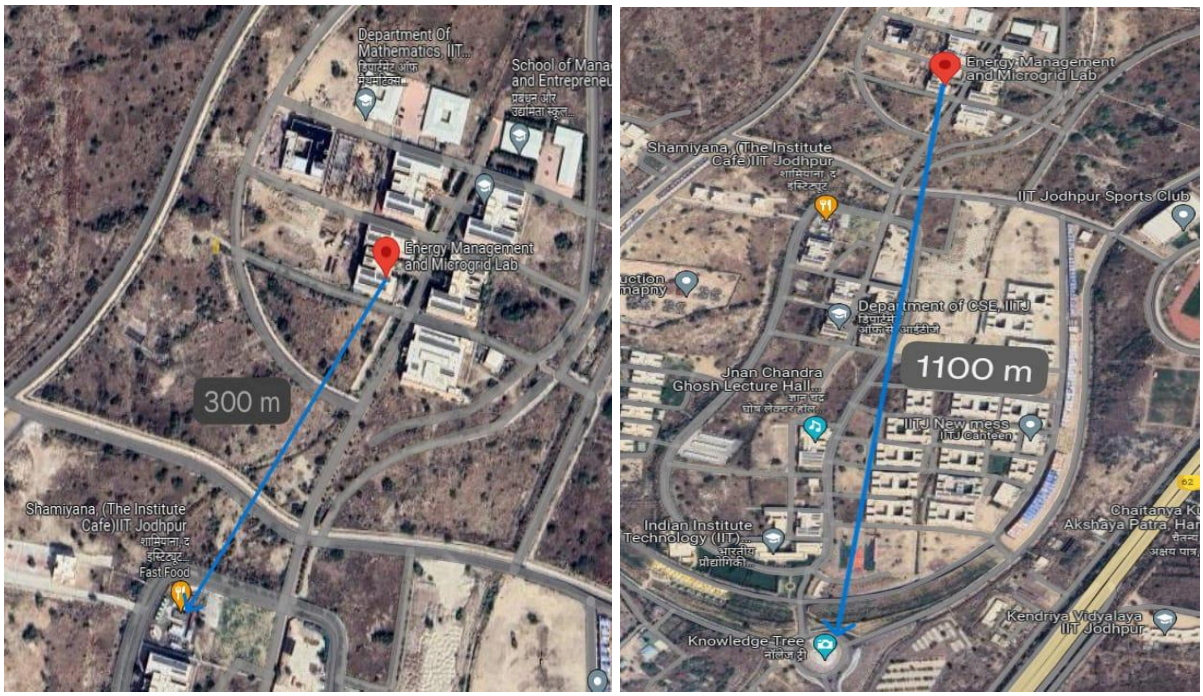
```
      num_packet_received_from_tx++;
      if (num_packet_received_from_tx > num_packet_sent_from_tx) // in case the tx0 is reset in
between the communication to avoid negative packet loss
      {
         num_packet_received_from_tx = num_packet_sent_from_tx;
      }

      Serial.print("Packets Received: ");
      Serial.print(num_packet_received_from_tx);
      Serial.println();

      num_of_packet_loss = num_packet_sent_from_tx -
                        num_packet_received_from_tx;
      float percentage_of_packet_loss = ((float)num_of_packet_loss /
(float)num_packet_sent_from_tx) * 100;

      Serial.print("% Packet Lost: ");
      Serial.print(percentage_of_packet_loss);
      Serial.println();

      // print sensor data
      Serial.println("Sensor Data:");
      Serial.print("Testing Data: ");
      int c=0;
      for (int i = 11; i <= 30; i++)
      {
       if(c_packet[i-1]=='-'){
         c++;
         if(c==1)
         Serial.print(" Temperature: ");
         if(c==2)
         Serial.print(" Distance: ");
         if(c==3)
         Serial.print(" ECG: ");
       }
       if(c_packet[i]!='-')
         Serial.print(c_packet[i]);
         if(c_packet[i]=='-')
```

```
        Serial.println();
      }
      Serial.println();
    }
    else {
      Serial.println("Error");
    }
}
```

6. Results and conclusions :

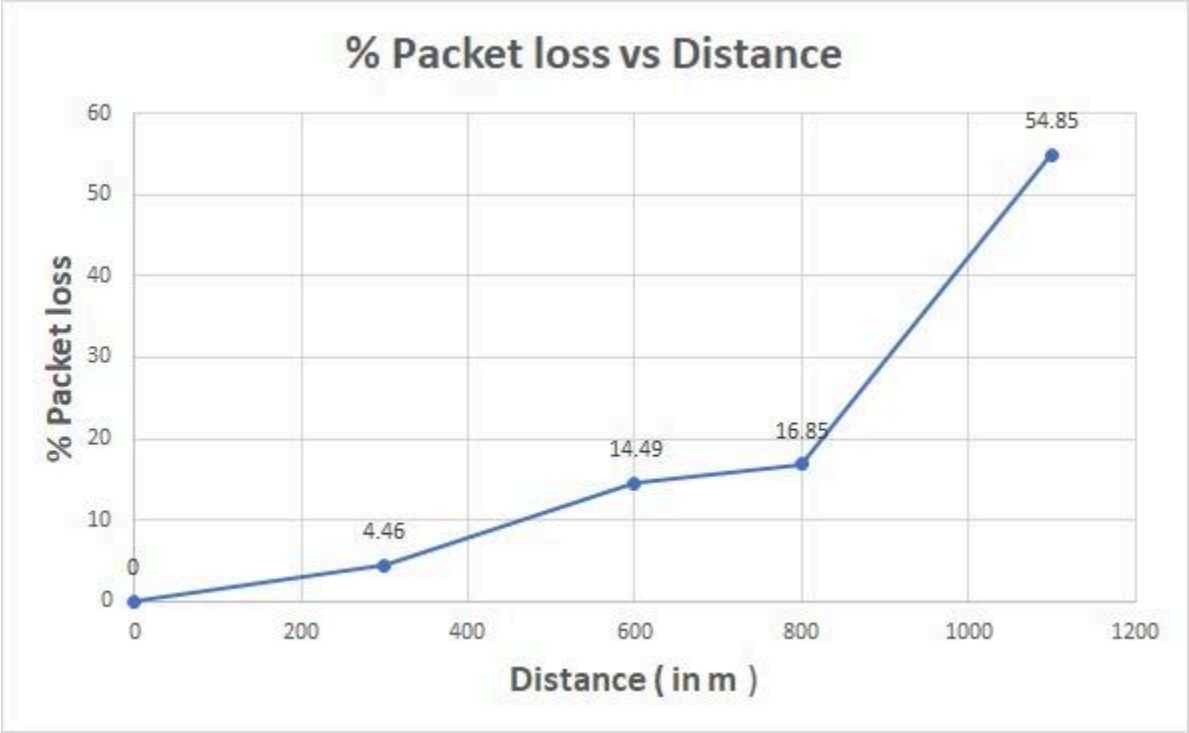
Our experiment was performed in which the transmitters were kept stationary on the top of the Department of Electrical Engineering building. While the receiver goes to different places . In this setup, a communication range of 1.1 km was obtained with the packet loss of 54.85% . Our experiment utilized LoRa (Long Range) technology to establish communication between various locations over mid-range distances (up to 2 km) without relying on the internet. The key objective completed included developing low-power LoRa transceivers, creating an interface circuit for data transfer from different analogue sensors, and assessing the feasibility of data transmission without internet connectivity.

From the table we can see a clear relationship between distance and packet loss, with an increase in packet loss observed as the distance between the transmitter and receiver increased. At shorter distances, such as 300 meters, the packet loss remained relatively low, but it escalated significantly at longer distances, reaching up to 54.85% at 1100 meters.



Knowledge Tree (1.1 km) & Shamiyana (300m)

Destination	Distance(in m)	% Packet loss
EE Department	0	0
Shamiyana Cafe	300	4.46
Jodhpur Club	600	14.49
Y-4 Hostel	800	16.85
Knowledge Tree	1100	54.85



END OF REPORT

THANKS

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