Implementation of LoRa WAN and its analysis for IoT Enabled Applications

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Abstract:
LoRa technology has revolutionized IoT by allowing for long range data communication, while using very little power which makes it an excellent candidate for use in times when conventional communication methods (cellular, Wi-Fi etc.) are not available. LoRa devices accommodate a wide range of IoT applications when connected to a non cellular LoRaWAN network by transmitting packets with important information. The paper introduces a LPWAN communication technology, LoRa to send the packet or data of individuals using LoRa nodes and send it via chirp spread spectrum modulation techniques to the gateways. The collected data from individual end nodes are forwarded to a network server via Wi-Fi. The gateway is a RAK 831 concentrator board used as the physical front-end and a Raspberry Pi acting as the physical back-end operating as the packet forwarder for the concentrator board. The data is forwarded to a network server from which the data can be viewed. Here, we used The Things Network servers as the network/application server connected to the packet forwarder via means of an Ethernet backhaul. Here the spreading factor which is known as the angle of chirp and it will determine how spread out the chirp would be and it will remains consistent throughout for the packet transmission. Here the LoRaWAN analysis shows increasing SF doubles the length of the chirp, and thus receiver will have more chances to analyse the signal power resulting in higher signal to noise ratio (SNR) and thus also increase sensitivity and transmission range.

Keywords: LoRa, LoRaWAN, IoT, Gateways, SNR.

1. INTRODUCTION

LoRa technology is a wireless technology which is capable of reaching a Long Range for communication [2]. It is a modulation method that provide more range than any other telecommunication providers are giving with reasonable and efficient power performance.

IoT stands for Internet of Things which simply means connecting different things internet. Internet of Things (IoT) services were implemented during olden days by using Wireless Sensor Networks (WSN) networks and Bluetooth which are used for short range communication technologies and is based on multi-hop routing protocols. But the major drawback is that the limited communication range since this mechanism must need high density network topologies which will affect the performance of the WSN network.

Hence, an alternative approach used is LPWANs (Low Power Wide Area Networks) communication protocols that employs long-range radio links. The data transfer is done by LoRaWAN which uses a one hop star network topology. LoRa is a type of spread spectrum modulation which are developed from chirp spread spectrum technology.

LoRa devices use wireless radio frequency technology for LoRa communication which is a long range (10-15 km), low power (<=25 mw) wireless platform that has become the most popular way for Internet of Things (IoT) networks used worldwide.

LoRa Technology allows development of smart IoT applications that helps resolve some of the problems facing right now like energy management, natural resource limitations, pollution reduction, infra efficiency and disaster management application and more.

LoRa uses the unlicensed free ISM band for communication. One of the main advantages of LoRa is that it allows very long range transmission ranges of more than 10 km in rural areas with low power consumption but at the cost of a reduced bandwidth (less than 50 kbps The technology consists of two parts/components LoRa, the physical layer which are dealing with actual transmission and reception of data and LoRaWAN (Long Range Wide Area Network), the upper layers that deal with the server side of the network. The modulation technique used in LoRa is chirp spread spectrum.

The speciality or feature of chirp spread spectrum modulation technique is that it will be in the use of chirp signal that changes constantly with the frequency.

One of the main advantages or usefulness of this method is that the difference in time and frequency to the sender and receiver is the same, thus considerably reducing the complexity.
II. OVERVIEW OF LoRa

LoRaWAN (Long Range Wide Area Network) is a LPWAN technology developed by semtech corporation. LoRaWAN mainly focused on star of star topology which consists of the end devices, gateways, network server and the application server. The physical layer, that provided by Semtech, uses a Chirp Spread Spectrum (CSS) radio modulation techniques and it can be used to establish a very long range communication link. [2]

Block Diagram
These structure is mainly divided into primarily back-end and the front-end part. The back-end part consist of the network server that stores the information received from the end node devices. The front-end of the system consist of end-node devices and gateway modules. The gateway devices act as bridging devices which are operating like base stations connecting end-node devices to the network servers. For uplink of data the flow is from device end to application end and the downlink of data is from application end to device end. The functionality of each of the entity is as follows:

a) End Nodes
The LoRa nodes or end nodes contain sensors, microcontroller, power source and other relevant electronic devices for the particular application or environment to be developed. These sensors and tracking devices form a very important of the embedded system being developed. The sensor used here is DHT 11 which is used to measure the temperature or humidity of the current environment. These sensors will senses the information and it will be passed to different gateways through LoRa modulation. The end devices support both uplink and downlink message to/from the gateways. So the endpoints are one of the main elements of the LoRa network where the sensing or control is undertaken.

b) Gateways
In Lora, the gateway acts as a bridge between the end device section and the network server section. Here RAK 831 is used as the gateway. The data send from the end devices will be collected by gateway and these gateway will forward these data to the network server part through backhaul network such as cellular, Wi-Fi, Ethernet or satellite. Raspberry Pi is used as the packet forwarder. The gateway is usually either a micro gateway or pico type gateway. Micro gateways are used in public network to give city or nationwide coverage while the use of Pico gateway is to be used in hard to reach dense areas to improve the quality of service and network capacity.

c) Network/Application Servers
The main functions of network server include duplicate and filtering the packets from different gateways, and it do the security checking and send the ACKs to the gateway. From the network server the packet is send to the specific application server. The need of handover or handoff can be eliminated here because in this type of network all the gateways can send the same packets to the network servers. This is useful for applications in which the subject or the asset to be tracked constantly moves from the region of coverage of one gateway to region of coverage of another gateway. The Application Server (AS) is responsible for end node key management and payloads sent or received by end nodes over the network.

d) TTN Server
The Things Network server is about allowing low-power devices to connect to an open-source network using long-range gateways to share data with applications. All gateways within a device's scope must receive the messages from the system and forward them to the Things Network so the Things Network serves as a cloud for data exchange.

Device Classes
LoRaWAN defines generally 3 different classes for communication.

(1) Class A:
Class A devices support bi-directional communication between the server and the gateway. It consist of Uplink messages (from the device to the server) can be sent at any time (randomly) followed by two downlink messages. That is one uplink slot followed by two downlink slot. The server can respond in any of these receive window, and the next opportunity will be only after the next uplink transmission form the end device. Class A devices provides the minimum transmission of the power for communication and is considered to be the most effective.

(2) Class B:
In addition to Class A devices here Class B devices is having a scheduled receive slot. For class b devices a synchronized beacon signal will be provided by the gateway providing a timing reference and based on this timing the end-devices open periodically the scheduled window. The network may also send downlink packets to class b at any of these receive slot. The downlink window is open only at the scheduled time. This helps the server to know whether the device is listening or not.

(3) Class C:
End devices with the Class C is having a continuously open window and it is closed only when it is in the transmitting mode. So the power consumed by the Class C devices will be high as compared with other classes. The latency will be also less for the Class C device.

LoRaWAN Features
A) Long Range: One of the main advantage of the LoRaWAN network is the ability to reach long range for communication. LoRa base station is having a deep penetration power in urban and sub urban area with clear line of sight and connect the rural areas up to 30 miles away.
B) Low power: The total power that consumed by the LoRa network is very less which result in the improvement of life of the end devices. The power consumed by the LoRa devices is very less and thus extend the life of the battery up to 20 years.

C) Range of frequency: LoRa generally uses unlicensed frequency band and as a result of these band the communication cost will be too less as compared with other networks.

D) High capacity: The capacity of LoRa network is very high which help for the public network operator where the number of customer is too high.

E) Low cost: The cost of the device is too low as compared with the others.

F) Security: The data send from the LoRa devices is secured with end-to-end encryption mechanism like AES128.

Although the bandwidth of LoRa is very low, Lora communication falls into a niche application range of IoT devices where range of the devices and ease of deployment matters a lot more than bandwidth. These niche applications include but not limited to remote access to sensor data where cellular technologies are not available, Extremely low power applications, disaster management applications where ease of deployment and scale of deployment matter over anything else.

III. DEVICE REGISTRATION

The devices that mainly used for the implementation of the LoRaWAN is TTGO LoRa32 as the end node, RAK831 as the gateway, Raspberry pi 3 as the packet forwarder and The Things network (TTN) as the cloud platform. The Things Network is a, open, decentralized and free internet of things network. The network allows different things to connect to the internet with little power and consumes less data. The Things network is mainly used to allowing low power devices to uses gateways to join to an open-source network to exchange data with other devices. For the proper functioning each of these devices should need to be registered correctly with the network. [7]

Gateway to TTN: To get the nodes to send data to the cloud The Things Network (TTN) provides a cloud service to parse and store the data sent by LoRa nodes via a LoRa gateway. so we need to register the gateway with the things network. Once gateway is correctly registered then the node can send the packet to the gateway. [7]

After registering the gateway with the TTN server, the devices need to be registered with an application to communicate with. Each of the LoRa node will be having a unique Device address, Device EUI and Application EUI. The end-nodes a were registered on the TTN console corresponding to an application and assigned device address, network keys and session keys for the transmission.[8]

Data from the Gateway

Once all the devices are registered with the TTN server, the data from the sensors is passed to gateways through the LoRa node and from the gateway these data is transferred to the network server for further applications.

HEX to ASCII Converter

The data received or the payload will be in Hexadecimal form. So we need to convert it to a known form. So here we uses an Hex to ASCII text converter and we can see the temperature value received at the TTN console in Fig 6.
IV. RESULT ANALYSIS

LoRa spreading factor relates to value that determines how the chirp will be spread out. Spreading factor known as the chirp angle which remains constant during the packet transmission [14]. Here an amount of spreading code is applied to the original data signal before transmission so that the signal will spread over a wide spectrum range. LoRa uses a spreading-range-based modulation that is (spread spectrum modulation technique) and a variant of the chirp spread spectrum. Generally LoRa spreading factor varies from SF7-SF12. Spreading factor of 7 means that each chirp represent 7 bits. Increasing SF doubles the length of the chirp, and thus receiver will have more chances to analyse the signal power resulting in higher signal-to noise ratio (SNR) and thus also increase sensitivity and transmission range.

V. CONCLUSION

LoRa is a wireless technology which is capable of reaching long range. LoRa uses modulation techniques that offers longer range than any other telecommunication providers. It has potential to reach massive number of IoT devices at low cost with reasonable efficient performance. LoRa uses star of star topology consisting of end devices, gateways and network servers. The range testing and connectivity of the end node (TTGO LoRa ESP32) was conducted in different geographical areas like the roads campus, on top of a building etc. It was seen that the sample data sent from the end device was received at an initial distance of 3 kms to 5 kms at the gateway (RAK831 concentrator module) which is configured with the TTN dashboard. As an analysis we can see that increasing SF doubles the length of the chirp, and thus receiver will have more chances to analyze the signal power resulting in higher signal-to noise ratio(SNR) and thus also increase sensitivity and transmission range

VI. REFERENCES


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