Feasibility of Long Range Wide Area Network (LoRaWAN) Technology for LEO Applications

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Abstract

Long Range (LoRa) is a widely used technology for terrestrial communications and is increasingly utilized for space related applications. On the ground, the LoRaWAN protocol allows gateways connected to the internet to serve as transceivers for any eligible end device in range of LoRa modulated signal. Certified gateways are produced by a variety of manufacturers with a range of capabilities, and publicly available networks contain thousands of gateways distributed around the world. Now, we propose to utilize the worldwide network of LoRaWAN gateways as a distributed ground station network capable of significantly reducing delays in link availability for a satellite in LEO. Using a COTS transceiver based on the LoRaWAN protocol, a module will be developed that functions as an end device in network architecture. As a half-duplex communication subsystem it will be capable of sending small packages of selective telemetry and receiving specific commands for essential functions, and will have worldwide compatibility in the range of 868 MHz to 915 MHz. Currently the module is planned to function as the secondary communication subsystem on the Cosmic X-Ray Background NanoSat-3 (CXBN-3) satellite, a 2U CubeSat mission under construction by students at Morehead State University to explore the diffuse emission of hard X-rays in the Cosmic X-Ray Background (CXB). This paper will describe the feasibility of LoRaWAN technology for LEO applications through the evaluation of a LoRaWAN space-based end device, its development based on a COTS transceiver, and validation testing to simulate LEO range by using LoRaWAN commercial gateways.

LoRa[1]

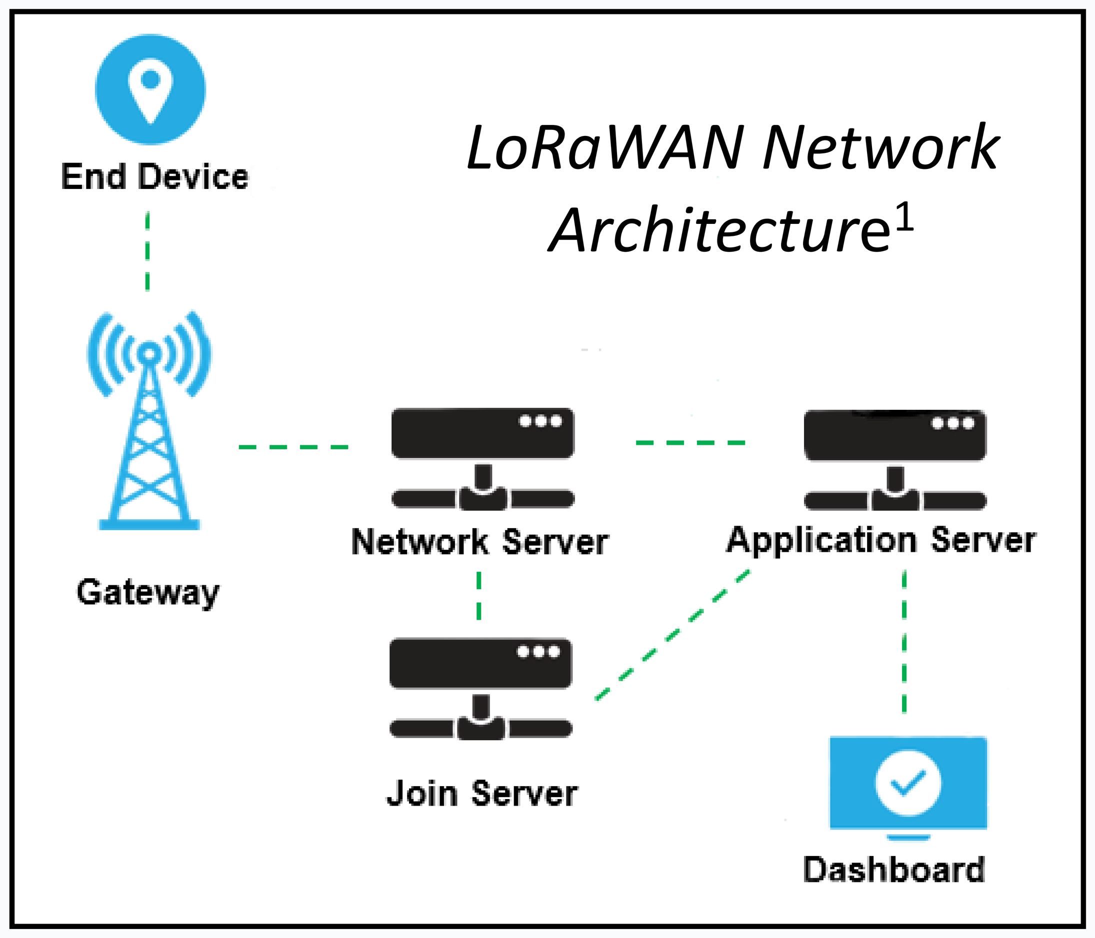
- **Lo**ng **Ra**nge (LoRa)
- Modulation protocol invented almost 15 years ago
- High immunity to noise, multipath, fading, and other LoRa signals.
- **R**adio **F**requency (RF) backbone for **L**ow **P**ower **W**ide **A**rea **N**etworks (LPWANs) and **I**nternet **o**f **T**hings (IoT) applications
- 125 kHz or 500 kHz uplink bandwidth
- 500 kHz downlink bandwidth.
- 6 predetermined orthogonal spreading factors (SF7-SF12).

LoRaWAN[1]

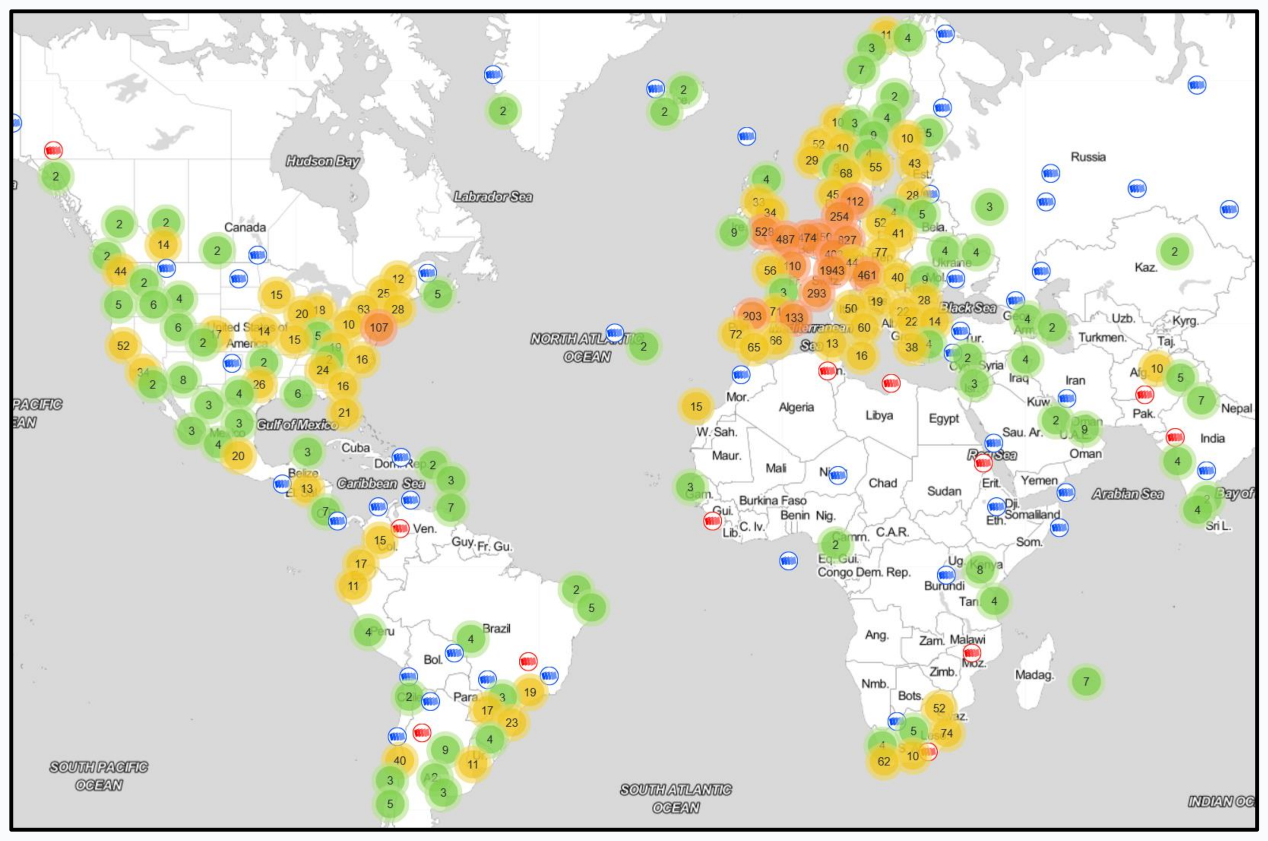
- **Lo**ng **Ra**nge **W**ide **A**rea **N**etwork (LoRaWAN)
- Utilizes physical layer of LoRa and the Internet
- Star topology

LoRaWAN Network Architecture[1]

- End Device – battery powered sensor
- Gateway – receives signals from any end device in range
- Network Server – receives messages from gateways, manages 128-bit Advanced Encryption Standard (AES)
- Join Server – manages join-request and join-accept including Over-The-Air-Activation process (OTAA)
- Application Server – decrypts data onto a dashboard for users



LoRaWAN Network Architecture[1]



Map of Available Gateways on The Things Network Community Edition[3]

The Things Network manages The Things Stack Community Edition, a LoRaWAN network of publicly set up and available gateways.

1 Sentence Summary

Utilizing a preexisting global network of thousands of LoRaWAN ground stations and implementing a satellite-based COTS transceiver module, it is feasible, with any Internet-connected device, to view selective packages of telemetry and send specific commands for an LEO CubeSat with reduced latency.

Proposal

Utilize the worldwide network of LoRaWAN gateways available on The Things Network as a distributed ground station for a satellite in LEO. The communication subsystem of the satellite will function as an end device in a LoRaWAN network using a COTS transceiver module.

- Eliminates requirement for line-of-sight with a single ground station
- Eliminates latency between the time a satellite needs to send information and how quickly a user can receive that information
- Thousands of gateways available for use around the world
- Selective packages of telemetry from the satellite available to anyone that can access the online dashboard on a computer or mobile device anywhere in the world
- The satellite will be able to receive specific commands from users

Mission

- Will function as the secondary communication subsystem aboard the **C**osmic **X**-Ray **B**ackground **N**anoSat-3 (CXBN-3)
- CXBN-3 is CubeSat being designed and built by students at the Morehead State University Space Science Center

Requirements Definitions[3-4]

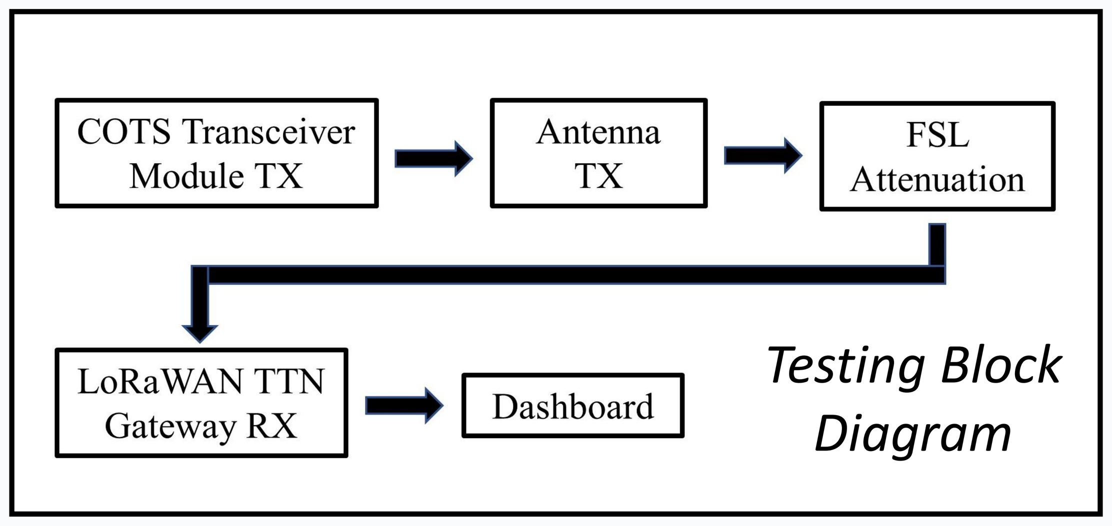
- The subsystem shall function as an end device in LoRaWAN network architecture.
- The subsystem shall be capable of functioning as a Class C end device.
- The subsystem shall comply with the LoRaWAN Regional Parameters for the US902-928MHz Industrial Scientific Medical (ISM) Band.
- The subsystem shall comply with the LoRaWAN Regional Parameters EU863-870MHz Band.
- The subsystem shall transmit according to The Things Network Fair Use Policy.

Technical Considerations[3-4]

- Class C End Device – always listening to gateways
- Over-The-Air-Activation (OTAA) procedure – activated by receiving a message from the network
- The Things Network Fair Use Policy – messages from end devices to 30 seconds or less per 24 hour period
- US915 Band has an **E**quivalent **I**sotropically **R**adiated **P**ower (EIRP) of +30 dBm.
- EU868 Band has an EIRP of +16 dBm.

Testing

- Simulating **F**ree **S**pace **L**oss (FSL) for LEO
- Testing different antenna configurations
- Comparing packets transmitted vs received vs dropped
- Measuring integrity of received packets



Testing Block Diagram

References

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*(accessed Jul. 7, 2023).