LoRaWAN Gateway Mesh: Experimental Evaluation and Protocol Analysis

جامعة الملك عبدالله للعلوم والتقنية
King Abdullah University of Science and Technology

Communication Theory Lab

Thevindu Kalubowila, Salah Abdeljabar, Hasan Albensaid

Introduction and Problem Overview

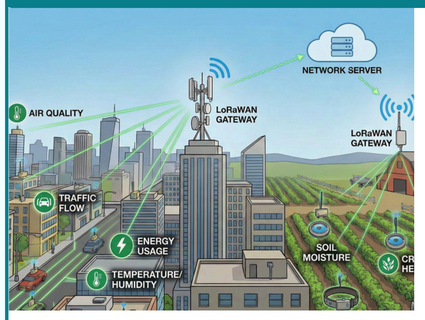
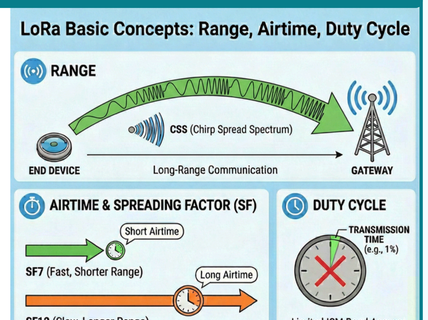


Fig 1: LoRaWAN in Large Scale IoT



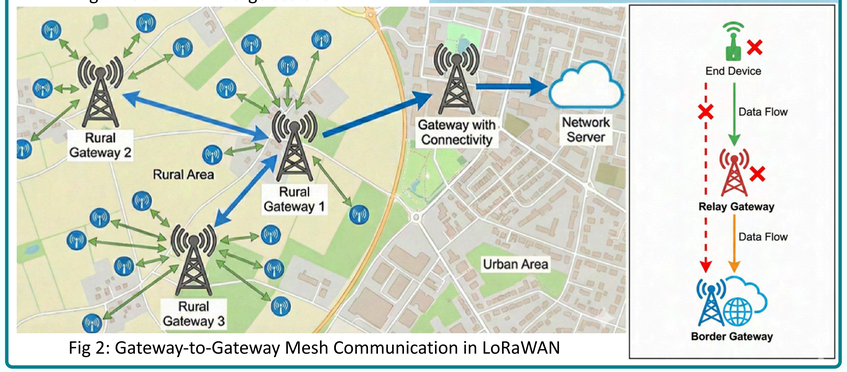


Fig 2: Gateway-to-Gateway Mesh Communication in LoRaWAN

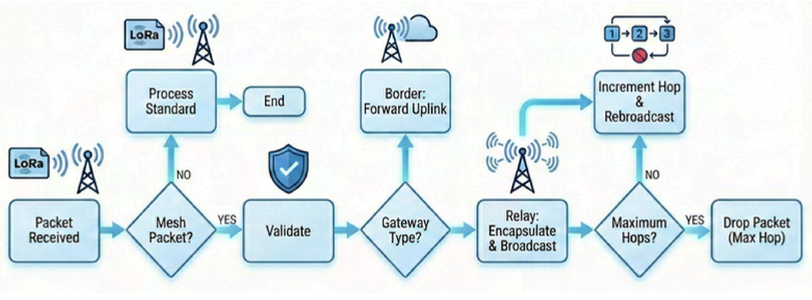
Motivation

ChirpStack

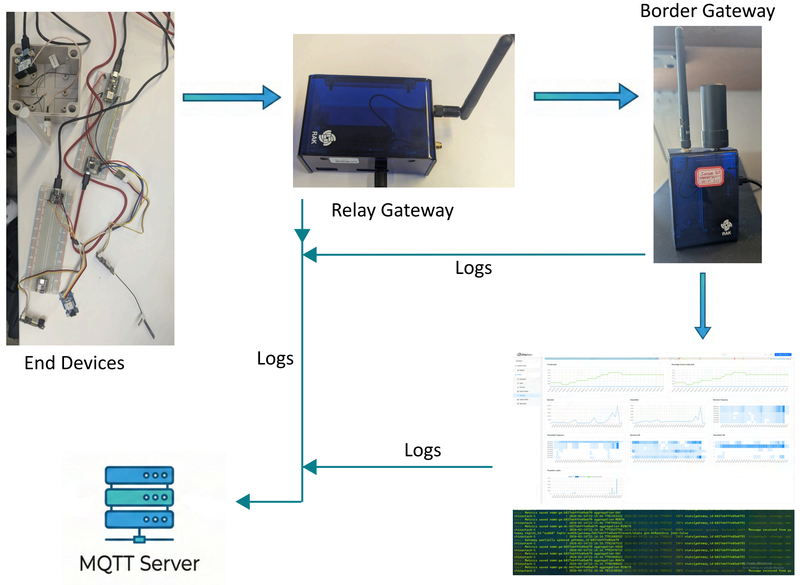
- Open-Source G2G Mesh
- RAK® Smart Parks — Collaborative Dev
- Limited Public Data
- Our Analysis: Protocol, Reliability, Performance

Methodology

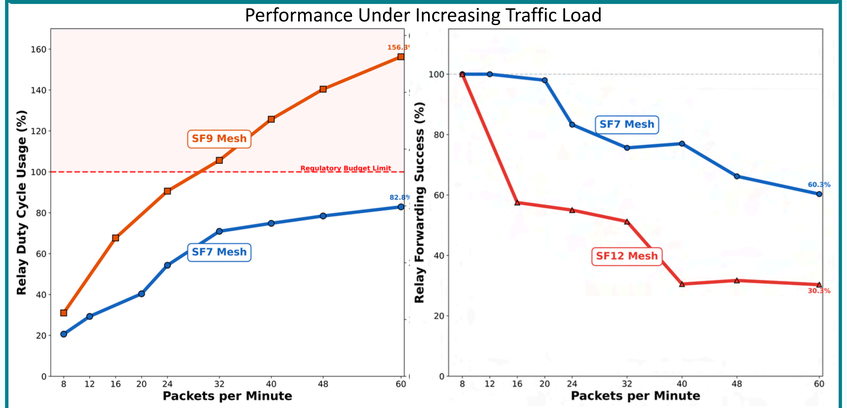
1. Protocol-Level Behavioral Analysis of ChirpStack Gateway Mesh



2.Experimental Setup



Results



- SF9 mesh exceeds the duty-cycle limit, while SF7 remains compliant.
- Forwarding efficiency drops for higher mesh spreading factors

Conclusions

1.Regulatory Limitation
- High SF for Increased Range
- High Duty Cycle Usage (Under Load)
- Regulatory Breaches

2.Protocol Limitation
- High Traffic Load at Higher SF (Long Airtime)
- Network Collisions & Gateway Saturation
- PDR Decreases (Failed Packets)

Future Work

- Adaptive SF
- Duty-Cycle-Aware Scheduling
- Load Balancing
- Large-Scale Evaluation