LoRaWAN-Based Energy-Efficient Surveillance for Intelligent Transportation Systems

July 2018

Agenda

- Introduction
- Low Power WAN (LPWAN) Technologies
- LoRa and LoRaWAN
- LoRaWAN PoC
- Moving Forward

כמה מילים עלי.....

- בוגר טכניון – הנדסת מחשבים
- עד 2015 - מנהל התכנה בחברת Telco Systems
- כיום – מהנדס מעבדת רשתות תקשורת בפקולטה למדעי המחשב בטכניון

מעבדת רשתות תקשורת LCCN

Laboratory of Computer Communications & Networking

צוות המעבדה

- פרופ' ראובן כהן – ראש מעבדה ומנחה אקדמי
- פרופ' דני רז – ראש מעבדה ומנחה אקדמי
- איציק אשכנזי – מהנדס המעבדה ומנחה פרויקטים

תחומי הפעילות במעבדה

מחקר

ביצוע

מה תחומי המחקר במעבדה?

- אלגוריתמים פורצי דרך לשיפור ביצועי הרשתות
- ניתוח ביצועי פרוטוקולים : TCP Cubic vs BBR, QUIC
- טכנולוגיות העתיד בתחום הרשתות: SDN, NFV, P4, IoT

מה מבצעים במעבדה?

פרויקטים עם חברות מובילות מהתעשייה

- פרויקטים של מחקר והיתכנות עם חברות תקשורת מהמובילות בארץ ובעולם
  - ✓ החברות מציעות פרויקטים במסגרת המעבדה
  - ✓ נציגים מהחברה משתתפים בהנחיית הפרויקטים

פרויקטים עם גופי תקינה ומאגדים

- פרויקטים עם גופי תקינה מובילים שמגדירים את הרשת העתידית
- משתתפים במאגד אקדמיה-תעשייה לחקירת תחום רשתות מתוכנתות
- שת"פ מחקרי ב NATO

פרויקטים של קוד פתוח

- משתתפים בפרויקטי קוד פתוח (Open Source) ותורמים לקהיליית המפתחים

MININET

Low Power WAN (LPWAN)

- Group of wireless telecommunication WAN Technologies
- Basic Technology Characteristics:
  - Inter-connect battery-powered devices over long ranges
  - The devices must operate
    - At low power
    - With low bit rate
  - Data rate :0.3 kbit/s to 200 kbit/s per Frequency Channel
  - Uses Licensed or un-Licensed frequencies
  - Runs proprietary or open standard protocols

Low Power WAN (LPWAN) Technologies

- Sigfox
- LoRaWAN
- NB-IOT (Narrowband IOT)
- LTE-M

Low Power WAN (LPWAN) Technologies

What's the Target of these technologies?

Mobile network operators will adopt their technology for IoT deployments over both city and nationwide LPWANs

- Narrowband (or ultra-narrowband) technology
- uses a standard radio transmission method called

Binary Phase-Shift Keying (BPSK)

- Requires an inexpensive endpoint radio, but expensive HW at the Gateway
- Uplink – good, Downlink -Limited
- Good for Europe and not for US
- Business model - royalties from network operator resales
- Has presence in more than 36 countries (end 2017)

- Spread-Spectrum technology
- Wide band (125Khz or more)
- Based on frequency-modulated chirp
- Looks at a wider amount of spectrum than SigFox
- Can get more Interference
- The larger receiver bandwidth is mitigated by the coding gains

LoRa Business Model

- More open than SigFox
- Anyone can join the LoRa Alliance
- LoRa Gateway spec is open
- Both the Endpoint and the Gateway are relatively inexpensive
- Currently – Semtech is the only company that does the LoRa radio

- MAC Protocol
- LoRaWAN is an open standard developed by committee.
- Network management spec is open

LoRaWAN Technical Spec

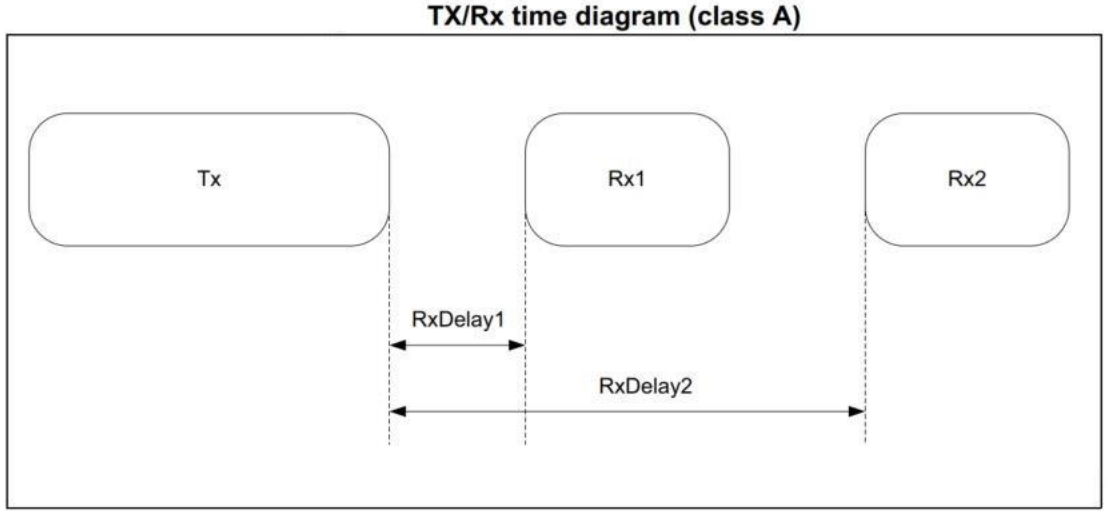
LoRaWAN

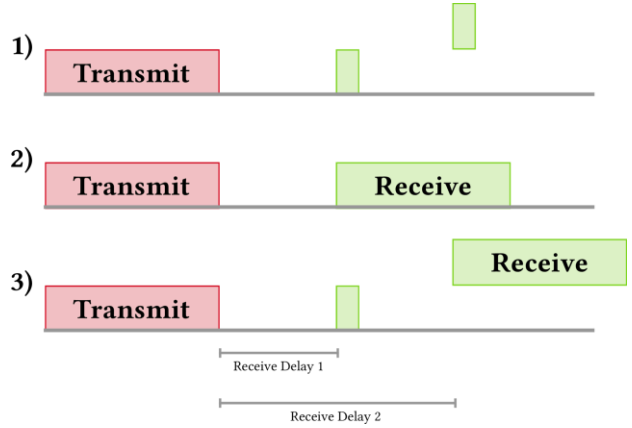
- ISM Band : 868MHz - 900MHz (EU) , 902MHz - 928MHz (US)
- Ranges: 5 km (Urban) - 15 km (Rural) *
- Security: Authentication and Encryption AES-128
- Data Rates: 0.3Kbps – 50Kbps

* Range record – 340Km!!

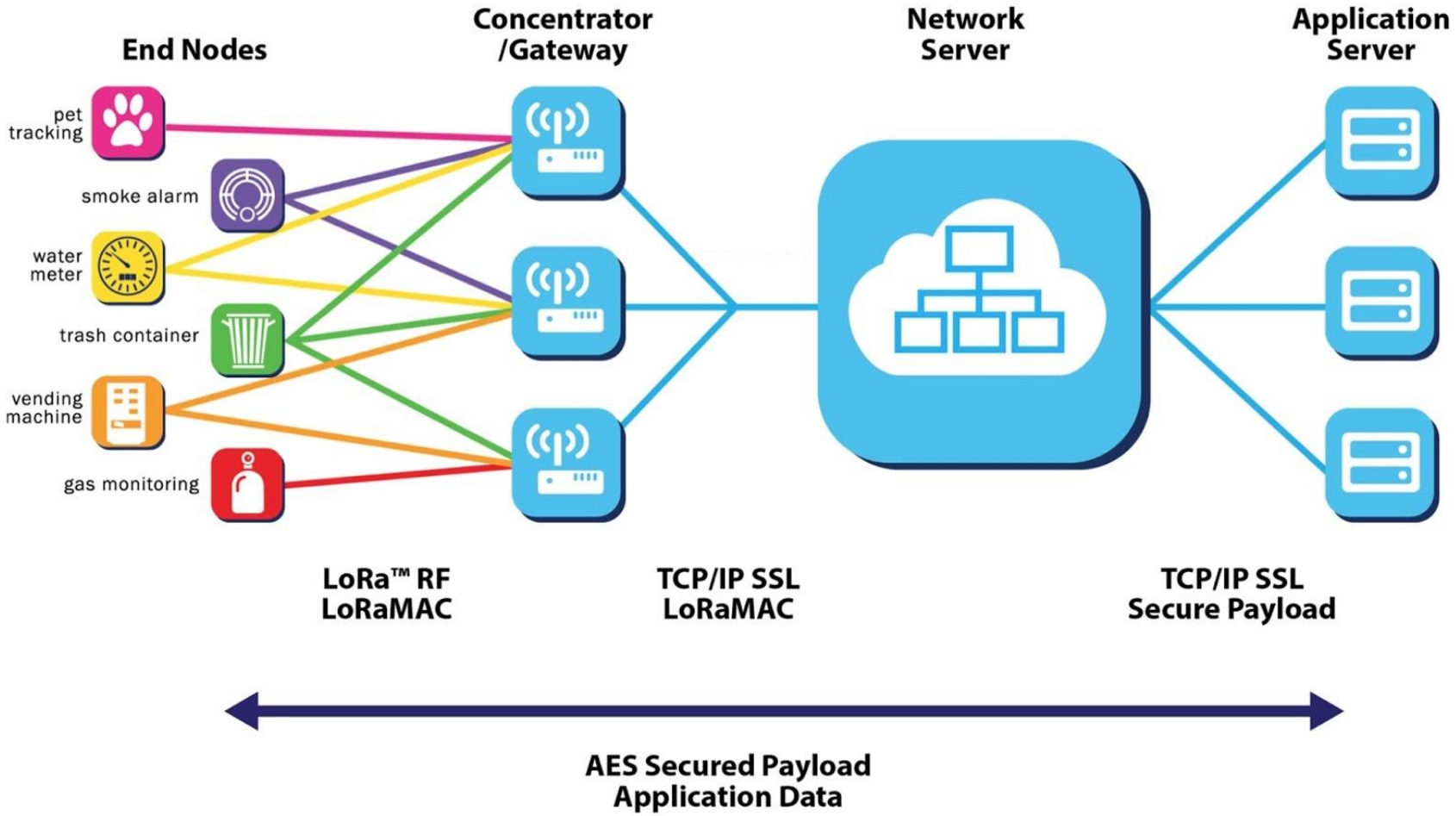
LoRaWAN Device Classes

- **Class A** devices have lowest power consumption, by opening two short receive windows after transmission.
- **Class B** devices extend Class A by adding slotted communication.
- **Class C** devices extend Class A by keeping the receive windows open unless they are transmitting.

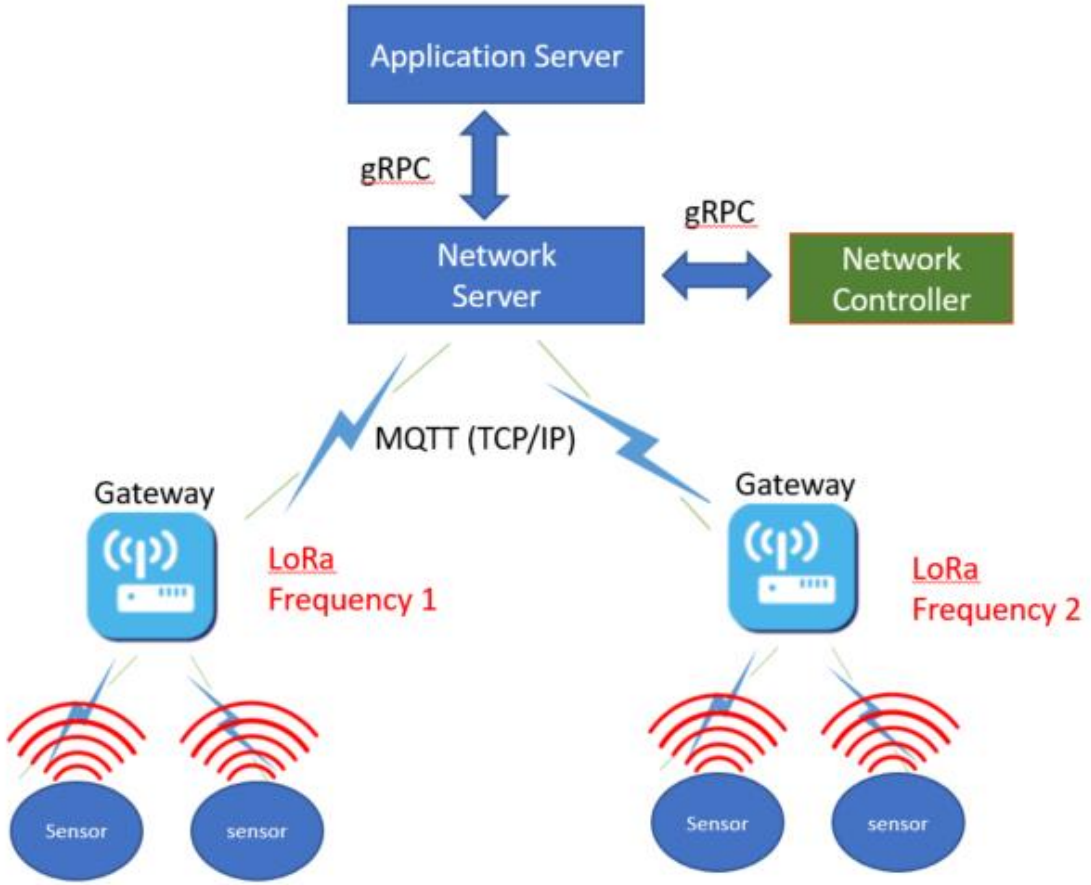




LoRaWAN Network



LoRaWAN PoC



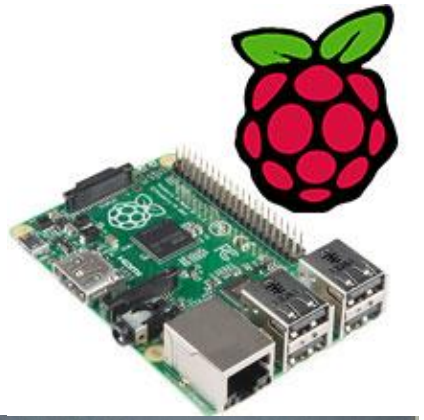
Done By:
Saar Eliad, Guy Shwigman

LoRaWAN Sensor

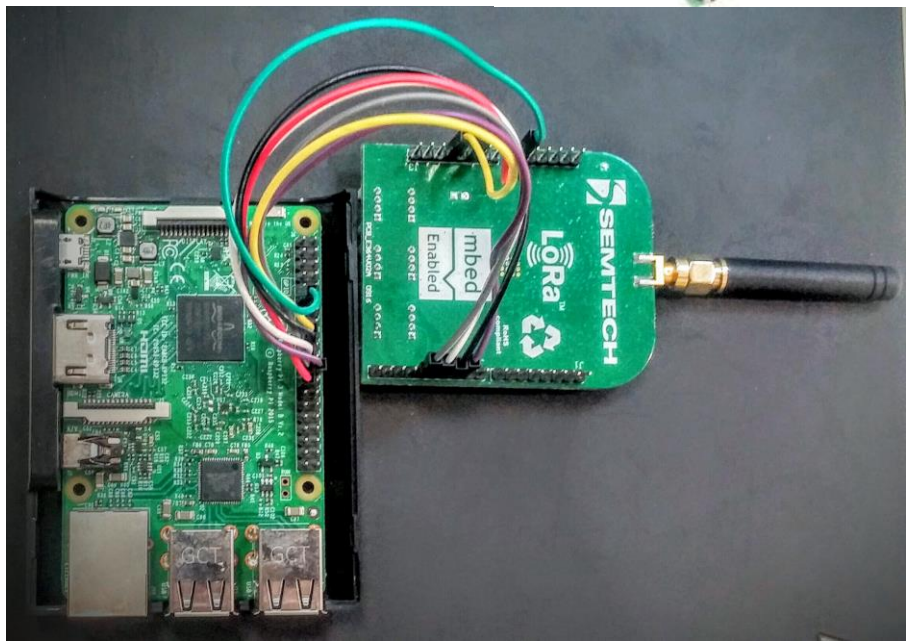
- HW: STM Nucleo board with Semtech sx1272 LoRa transceiver
- SW: open-source LoRaWAN end node implementations called

  Lora-Mac (from: Semtech)
- Class A support
  - Optimized the RX parameters (Delay, window)

LoRaWAN Gateway

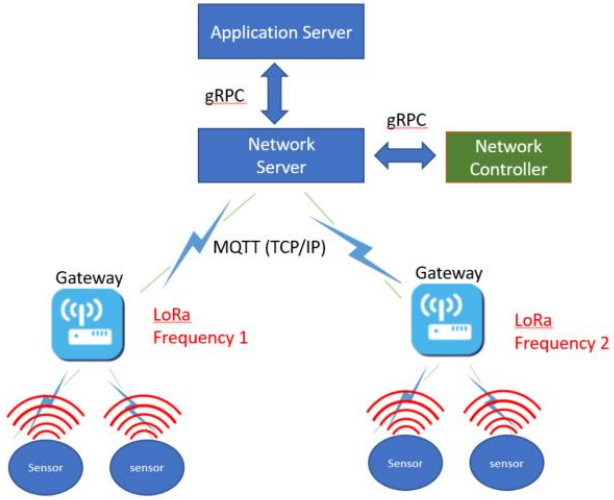


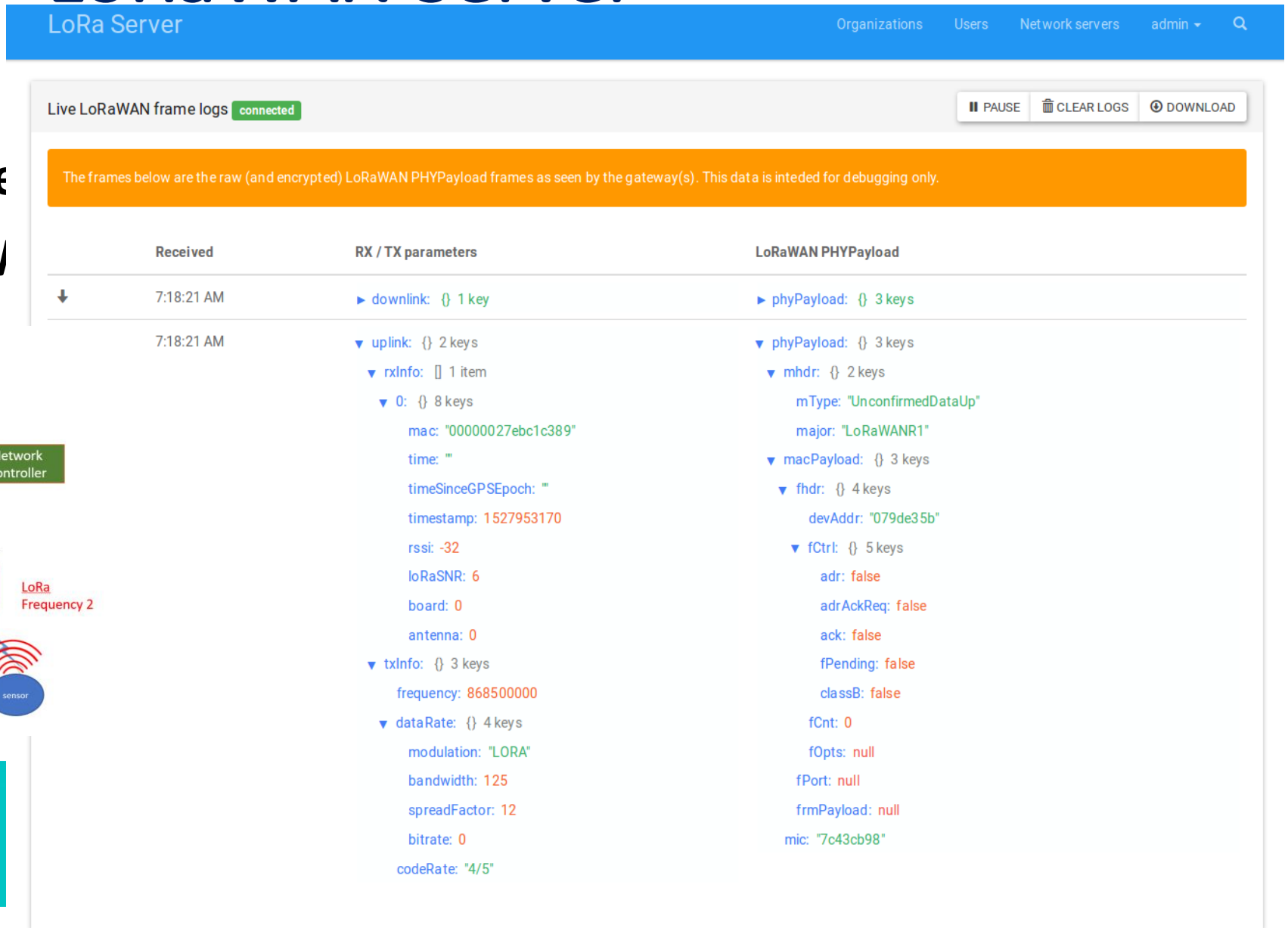
- HW: Raspberry Pi-3 with Semtech sx1272 LoRa transceiver
- Single Channel GW
- SW:
  - Open source single channel gateway from WAZIUP project.
  - Modified it to be LoRaWAN compatible.



LoRaWAN Server

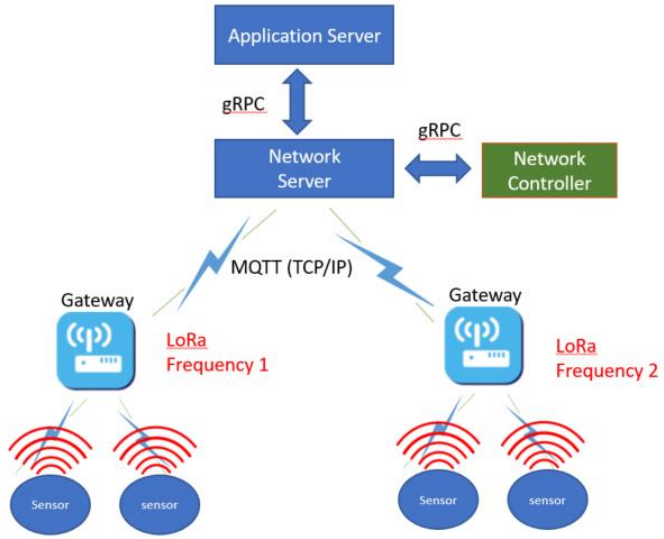
- **Used the ope**
- **Modified SW**





LoRaWAN Network Controller

- Controls the network with LoRaWAN MAC commands.
- The server updates the controller on every RX.
- The controller holds databases of all the sensors and decides which mac commands to schedule in the server.
- Implemented:
  - **Load balancing for single channel gateways.**
  - **Track sensor battery status.**
  - **Sensor Duty-Cycle**

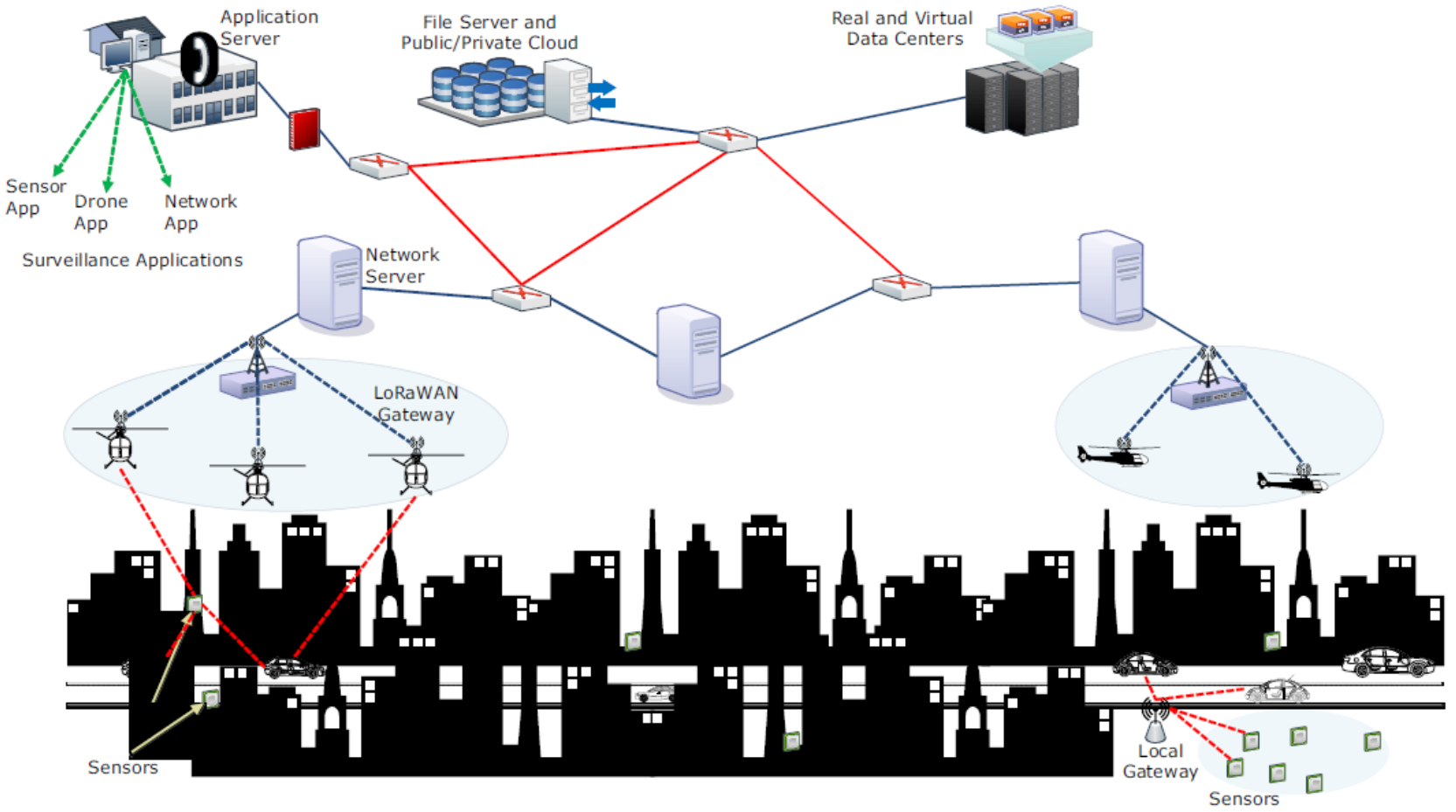


LoRaWAN PoC Achievements

- Single channel gateway
- Gateway statistics
- OTTA (Over The Air Activation) vs ABP (Activation by Personalization)
- Demo duty cycle functionality in sensor
- Optimized RX parameters with the smallest receive windows possible
- Demo Proprietary mac commands
- Demo GW Load Balancing

Moving Forward…

LoRaWAN GW on Drones



Firmware over-the-air

- Enable Sensor Firmware upgrade for:
  - Security patches
  - New feature
  - Bug fix

LoRaWAN Integration

- Integrate LoRa Server with GCP (Google Cloud Platform) and Kubernetes

Google Cloud Platform

- Analyze needed LoRaWAN GW modifications– to integrate it into 4G/5G Network

Take Away

- LPWANs are gaining momentum
- LoRaWAN openness can help to adopt it to ITS

thank you!