Integration of LoRa

ICNRG Interim Meeting

Macau, 27.09.2019

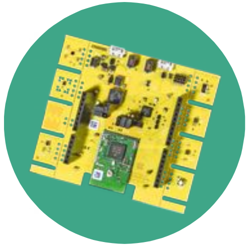
Peter Kietzmann

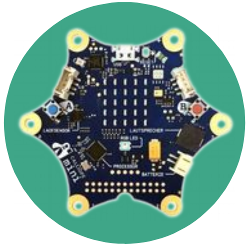
✉ peter.kietzmann@haw-hamburg.de

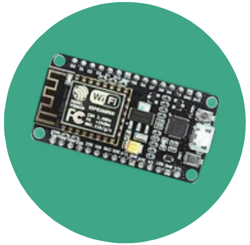
iNET AG, Dept. Informatik, HAW Hamburg

What is RIOT?

- Free and Open Source operation system – “Linux for the IoT”
- Supports Class 0 – 2 devices
  - Kilobytes memory
  - Megahertz CPU frequency
  - Milliwatt energy consumption
- Implements expandable network stacks
  - IPv6/6LoWPAN
  - OpenThread
  - BLE
  - NDN
  - **LoRaWAN**
  - …







IoT Technology Overview

Smart HOME

- Bluetooth LE
- ZigBee
- Thread (6LoWPAN)
- Z-Wave
- ANT+
- WirelessHART
- ISA100.11a (6loWPAN)
- EnOcean
- Plus more

SMARTOFFICE

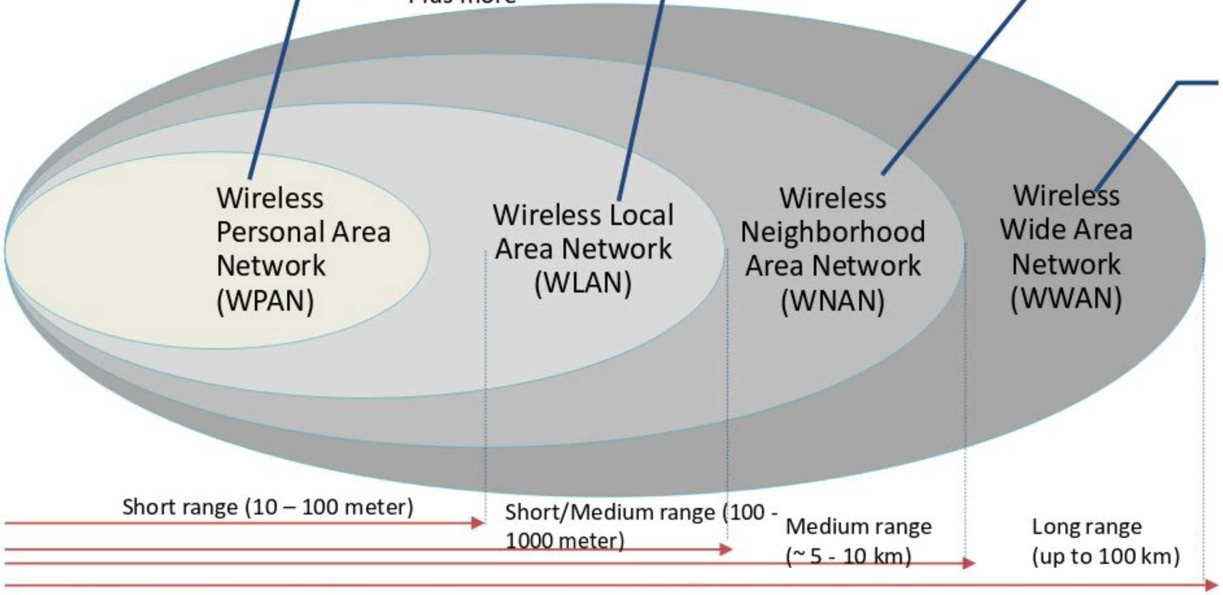
- 802.11a/b/g/n/ac
- 802.11af (white space)
- 802.11ah & 802.11p

SMART INDUSTRY

- Wi-SUN (6LoWPAN)
- ZigBee-NAN (6LoWPAN)

SmartCity

- Cellular
  - 2G/3G/4G
  - LTE-MTC
  - 5G in the future
- Low Power Wide Area (LPWAN)
  - SIGFOX
  - LoRa
  - Telensa
  - PTC
  - *Plus more*



Wireless Personal Area Network (WPAN)

Wireless Local Area Network (WLAN)

Wireless Neighborhood Area Network (WNAN)

Wireless Wide Area Network (WWAN)

Short range (10 – 100 meter)

Short/Medium range (100 - 1000 meter)

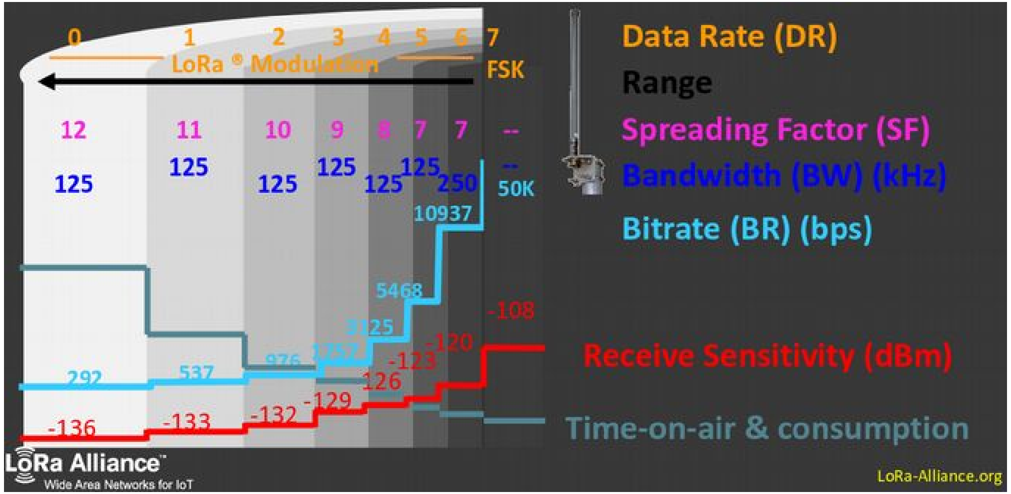
Medium range (~ 5 - 10 km)

Long range (up to 100 km)

https://riot-os.github.io/riot-course/slides

What is LoRa – Physical Layer

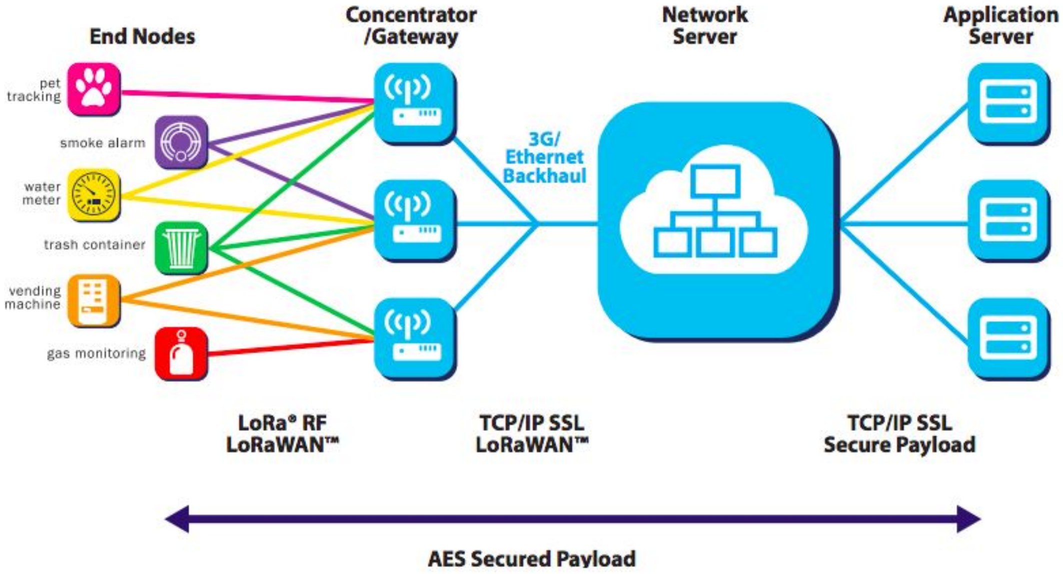
- Long range radio communication technology
- Modulation is robust
  - Noise, multipath fading, doppler, ...
- Configurable modulation adjusts
  - Range
  - Time-on-air
  - Energy consumption
- Frequency (ISM) band depends on region
- Duty cycle of 1% / channel



LoRa and LoRaWAN

- LoRaWAN defines protocol on top of LoRa
- End Nodes connect in a start topology
- Gateway relays over an IP-based network
- Network Server de-duplicates packets and routes to applications (TTN, LoRIOT, AWS …)

- 2-layer security based on AES encryption
  - Network Session Key
  - Application Session Key



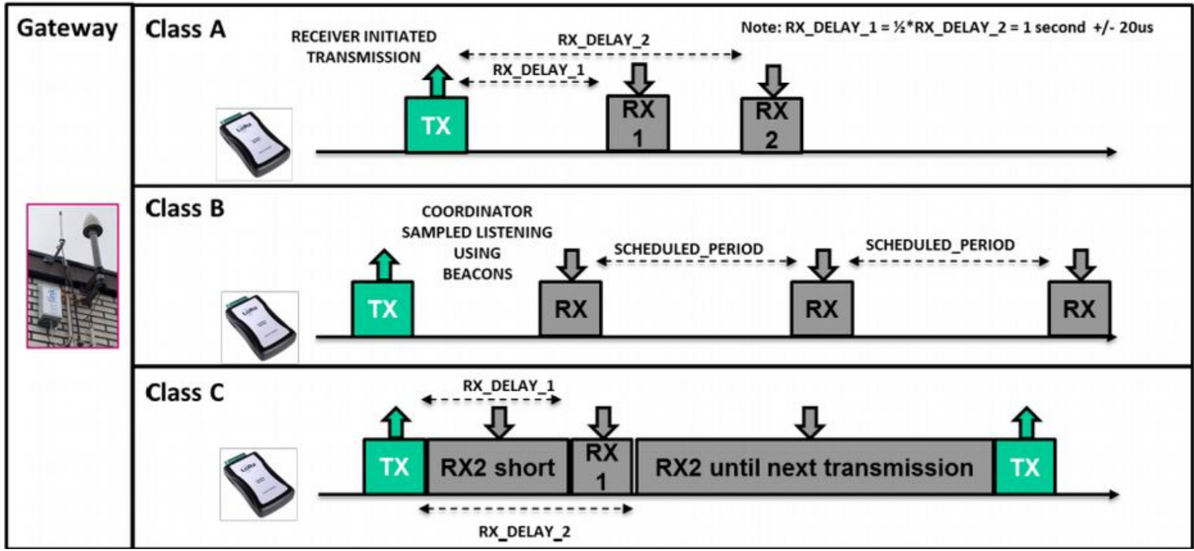
https://medium.com/coinmonks/lpwan-lora-lorawan-and-the-internet-of-things-aed7d5975d5d

Join Procedures

- Over-the-Air-Activation (w/ handshake, derives session keys)
  - “Preferred” way to connect to Network Server
  - Devices perform join procedure (handshake)
  - Keys and dynamic `DevAddr` are derived
- Activation by Personalization
  - “Hardcoded” `DevAddr` and keys already available
  - No activation handshake required
  - We use this to save energy ...

3 Device Classes

- Class A
  - Only receive after send
  - Very low power consumption
- Class B
  - Receive windows scheduled
- Class C
  - Always listen
  - “High” power consumption



Gateway
Class A
RECEIVER INITIATED TRANSMISSION
RX_DELAY_2
Note: RX_DELAY_1 = ½*RX_DELAY_2 = 1 second +/- 20us
RX_DELAY_1
TX
RX 1
RX 2
Class B
COORDINATOR SAMPLED LISTENING USING BEACONS
SCHEDULED_PERIOD
SCHEDULED_PERIOD
TX
RX
RX
RX
Class C
RX_DELAY_1
TX
RX2 short
RX 1
RX2 until next transmission
TX
RX_DELAY_2

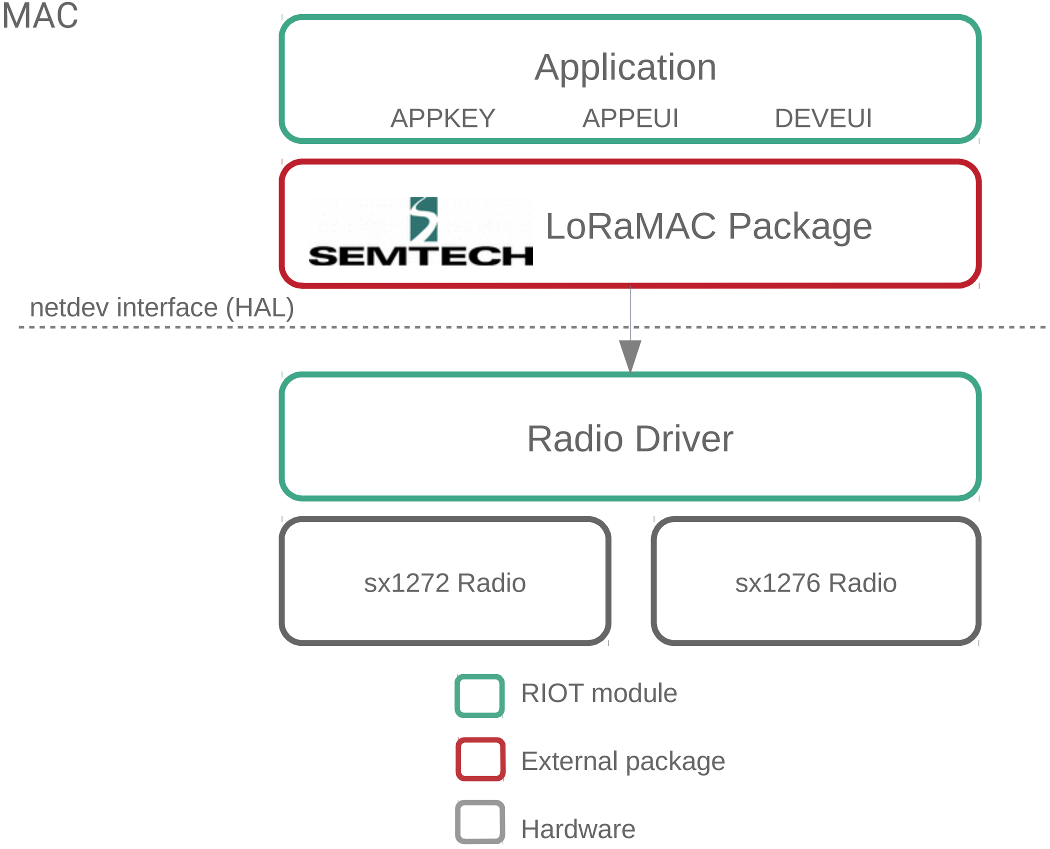
https://link.springer.com/article/10.1007/s11277-017-4419-5

Semtech Package in RIOT (since 2017.10)

- Reference implementation by vendor provides MAC
  - Class A – C
  - OTAA & ABP join procedures
  - EUI storage (EEPROM)
- Directly uses RIOT radio driver (sx127x)
- Asynchronous MCPS/MLME API (IEEE-like)
- Optimization potential for OS integration

w/o LoRaMAC

- *netdev* as a generic network device API
- Access pure radio



Application

APPKEY APPEUI DEVEUI

SEMTECH LoRaMAC Package

netdev interface (HAL)

Radio Driver

sx1272 Radio

sx1276 Radio

🟩 RIOT module

🟥 External package

⬜ Hardware

gnrc_lorawan in RIOT (WIP)

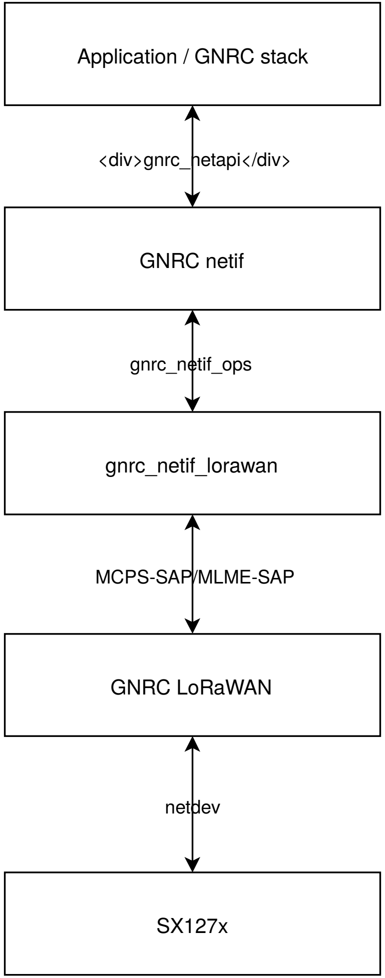
- Integrated into GNRC network infrastructure

  → Allows transparent re-utilization of existing modules: *netif, ifconfig, netreg, …*

- **Asynchronous** send/receive with notifications from MAC (was not always the case with Semtech ...)

- MCPS/MLME API (IEEE-like)
  - Request-confirmation based
  - Handling data & management (set key, link check, …)
  - Bidirect. communication between MAC and upper layer

- Requires 4,5kB less ROM, 1,5kB less RAM than Semtech



Application / GNRC stack

<div>gnrc_netapi</div>

GNRC netif

gnrc_netif_ops

gnrc_netif_lorawan

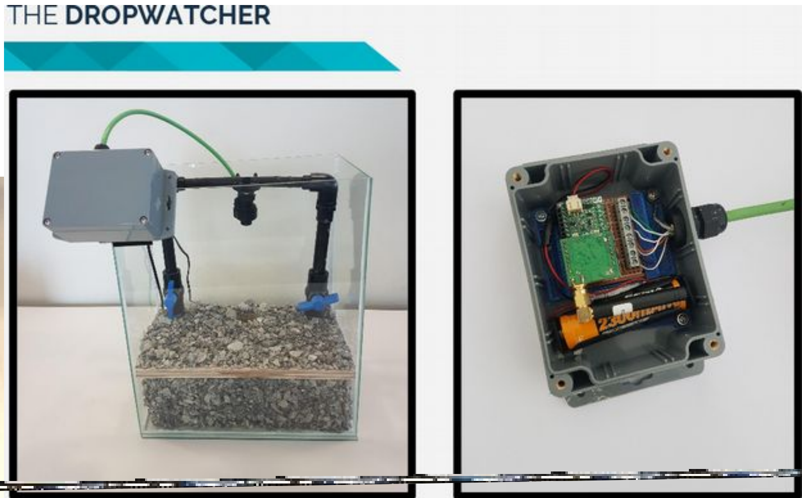
MCPS-SAP/MLME-SAP

GNRC LoRaWAN

netdev

SX127x

Deployments



References

Info

- https://github.com/RIOT-OS/RIOT
- https://www.iot-lab.info
- https://github.com/Lora-net/LoRaMac-node
- https://github.com/RIOT-OS/RIOT/pull/11022

Tutorials

- https://riot-os.github.io/riot-course
- https://github.com/RIOT-OS/Tutorials
- https://www.iot-lab.info/tutorials/