Implementing LoRa, FSK & Further LPWAN Interfaces

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You, Me and IoT Microconference

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IoT Architecture and Properties
IoT Tiers With Low-Power WAN

Sensors

Gateways

Backends

Storage

Analysis

WPAN / LPWAN

LAN / WAN – Internet Protocol
LPWAN Characteristics (1/2)

**Low Power**

- up to 10 years

**Wide Area**

- up to 48 km (30 miles)
LPWAN Characteristics (2/2)

Asymmetric data volume

Uplink: e.g., sensor data, location

Downlink: e.g., actuator cmd, firmware OTA
LPWAN Classification

• **Unlicensed** (U-LPWA) – ISM/SRD
  - Sub-GHz (433 / 470 / 868 / 915 / 923 MHz)
  - 2.4 GHz
  - Regulatory restrictions: duty cycle, dwell time

• **Licensed**
  - LTE
Sigfox Network Architecture

Modules

Transceivers

Access Stations

Base Stations

Backend

Frontends

3D-UNB

GFSK

D-BPSK

Sigfox

IoT-Makers/sigfox-platform

backend.
sigfox.com

openSUSE
NB-IoT Network Architecture

Modems

Base Stations

Servers
Representing IoT in Linux
Protocol Layers Around LoRa

- **LoRa modulation**
  - FSK modulation
- **User**
- **LoRaWAN**
  - Wireless M-Bus
  - IEEE 802.15.4
  - Sigfox, EnOcean, ...
- **BLE**
- **MIOTY, Weightless, Z-Wave, ...**
- **User**
- **SCHC**
- **User**
- **6LoWPAN**
- **User**
- **Symphony Link, MOST, RadioShuttle, WISE-Link, ...**
- **User**

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- **Protocol Layers**
  - **LoRa modulation**
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**IEEE 802.15.4**

**Sigfox, EnOcean, ...**

**MIOTY, Weightless, Z-Wave, ...**

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**ASK (OOK)**

**FLRC**
Socket Address/Protocol Families

- AF_BLUETOOTH, AF_IEEE802154
- AF_LORA? \(\rightarrow\) PF_PACKET
- AF_LORAWAN
- AF_3DUNB?

- AF_MAX prohibits dynamic additions
Sockets: PF_PACKET Types

- ETH_P_IEEE802154 (0x00F6)
- ETH_P_LORA, ETH_P_FLRC
  - ETH_P_LORAWAN
- ETH_P_OOK(?), ETH_P_FSK
  - ERP2? ZWAVE? …
- ETH_P_3DUNB[_{DL,UL}]?
LoRa/FSK driver project
Getting Started With LoRa Chipsets
Types Of LoRa Radio Modules

- **Plain transceiver**
  - SPI / UART / USB
  - Volatile register settings
  - Software MAC needed

- **MCU w/firmware + transceiver**
  - UART / USB Serial
  - Firmware determines chip features exposed
  - Optional certified MAC

- **Plain MCU + transceiver**
  - n/a – no fixed API
  - Custom MCU code for sending / receiving
  - Optional MAC
LoRa Use Cases On Linux

• Prototyping of sensor/actuator node
  – Well-documented transceiver chips
  – Simple sending of raw LoRa packets
  – LoRaWAN client

• LoRaWAN gateway
  – Complex multi-channel “concentrator” chip
Accessing LoRa Hardware Today

```
mm  sched  ...  
spi ...  spidev  
tty  8250  pl011  ...  usb  ftdi_sio  ...  cdc-acm  
/dev  spi0.0  ttyS0  ttyAMA0  ttyUSB0  ttyACM0  
```

read/write
ioctl
Goals For LoRa On Linux

• Get vendor-independent interface
  – Hardware support via kernel, not via forks
  – Generic Open Source packages via distros
• Allow to containerize the userspace part
• Enable Kubernetes for gateway & backend
LoRa Sockets Concept

buffers
bind
read/write
Netlink Commands / Attributes

**NLLORA_CMD_SET_**
- U32 FREQ
- S32 TX_POWER
- u32 bandwidth
- u8 sf, cr, sync_word

**NLFSK_CMD_SET_**
- U32 FREQ
- U32 FREQ_DEV
- S32 TX_POWER
LoRa Socket Layers (Proposed)

- LoRa PHY driver
- PF_PACKET SOCK_DGRAM
- PF_LORAWAN SOCK_DGRAM + SOCK_SEQPACKET
- User
- LoRaWAN Hard MAC
- maclorawan
- nllorawan
- genl
- nllora
Userspace Code

- test.c
  - Trivial code sending a packet
- nltest.c
  - Evolving into a dual LoRa/FSK config tool
Regmap Workaround

• Writing to FIFOs is broken in 5.3 and 5.2
  – Breaks bringing sx130x interfaces up
• Patch in progress by Ben Whitten
• Workaround: bump .max_register = 0xffff
Netdev 0x13 Workshop Outcome

- Use module param for hard- vs. soft-MAC
- Expose two devices, use carrier up/down
- Not all modes (BLE) need to be exposed
- LoRaWAN soft-MAC like 802.15.4 6LoWPAN
Help Needed!

- Netlink operations need to be defined
- Complete/add driver implementations
- Prepare and document DT snippets
- Testing
- Design discussions
- Solve various unrelated problems
Resources

• linux-lpwan mailing list
• #lora on Freenode IRC

• ELCE 2018 video and slides
• Netdev 0x13 paper, slides and video
• oSC 2019 video
Kernel development on openSUSE
Kernel Development Options

- linux.git (cross-)compile → manual deploy
- kernel-source.git → OBS → package install
- kernel-{default,lpaes}-devel package
  → local module(s) or KMP package in OBS
My Interop Testing Setup

• Various Arm, MIPS boards (C-Sky TBD) with expansion boards or cables
  – No Intel or Arm ACPI yet – hardware needed
• GitHub afaerber/lora-modules.git
• kernel.org afaerber/linux-lora.git
• One sends; monitor others’ dmesg output
Credits – LoRa driver project
Industry Contributors – Code
Industry Supporters – Hardware

AppconWireless

DRAGINO

Embedded

Gimasi

HELTEC AUTOMATION

IMST

Laird

MIPOT

NEMEUS

nfuse