



**Embedded Linux  
Conference**  
Europe



**OpenIoT Summit**  
Europe

# **A Sockets API For LoRa**

**Andreas Färber,  
SUSE Labs  
afaerber@suse.com**

# About The Presenter

- Project Manager for arm64 architecture at SUSE Labs
- Involved in arm port of openSUSE Linux distribution
- Kernel maintainer for Realtek and Actions Semi arm SoCs
- Other kernel projects you might know:
  - Odroid-XU, Parallella, Spring Chromebook, GeekBox, ...
  - STM32F4, FM4, XMC4500; S905, IAP140, MB86S71, RDA8810PL
- Background in virtualization technologies – QEMU



# Why LoRa Technology?

- LoRa = **Long Range** – radio modulation by Semtech
  - [https://archive.fosdem.org/2018/schedule/event/sdr\\_lora\\_aes/](https://archive.fosdem.org/2018/schedule/event/sdr_lora_aes/)
- Low-Power Wide Area Network (**LPWAN**) with low throughput
- Unlicensed **sub-GHz** and 2.4 GHz ISM/SRD bands (U-LPWA)
- No dependency on network infrastructure providers
- Wide availability of HW – <https://en.opensuse.org/HCL:LoRa>
- ... and just because it's possible!



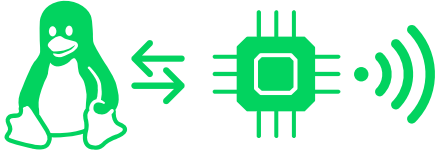
# Getting Started With LoRa Chipsets



... and down the rabbithole it goes!

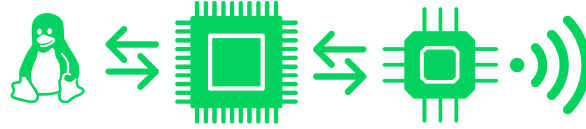


# Types Of LoRa Radio Modules



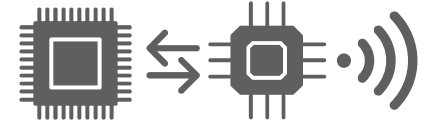
## Plain transceiver

- SPI / UART / USB
- Linux host needs software MAC



## MCU w/firmware + transceiver

- UART / USB
- Firmware determines features exposed
- Optional certified MAC

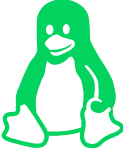
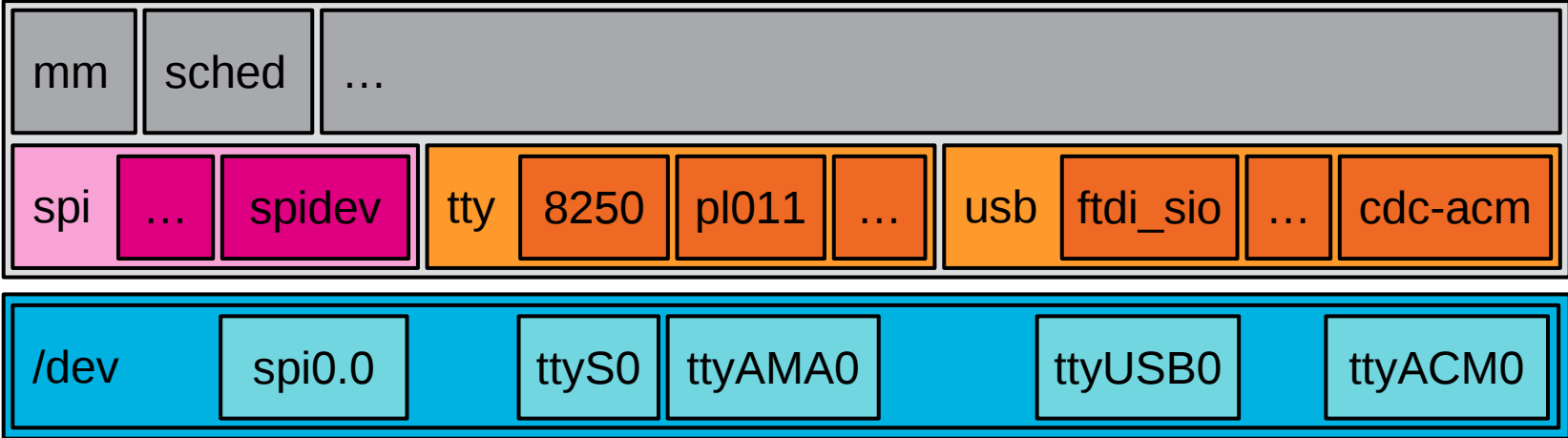


## Plain MCU + transceiver

- n/a – no fixed API
- Custom MCU code for sending / receiving
- Optional MAC



# Accessing LoRa Hardware Today



# Issues With LoRa Open Source Software Today

- No upstream community – per-vendor application forks
- Software license incompatibilities
- Use of spidev kernel module gets ugly in distros
- Hardware detection duplicated into applications



**Idea:** Move chipset drivers into mainline Linux kernel.

Encourage generic, community-maintained packet forwarders.



# Collecting Requirements

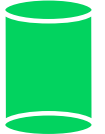
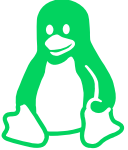
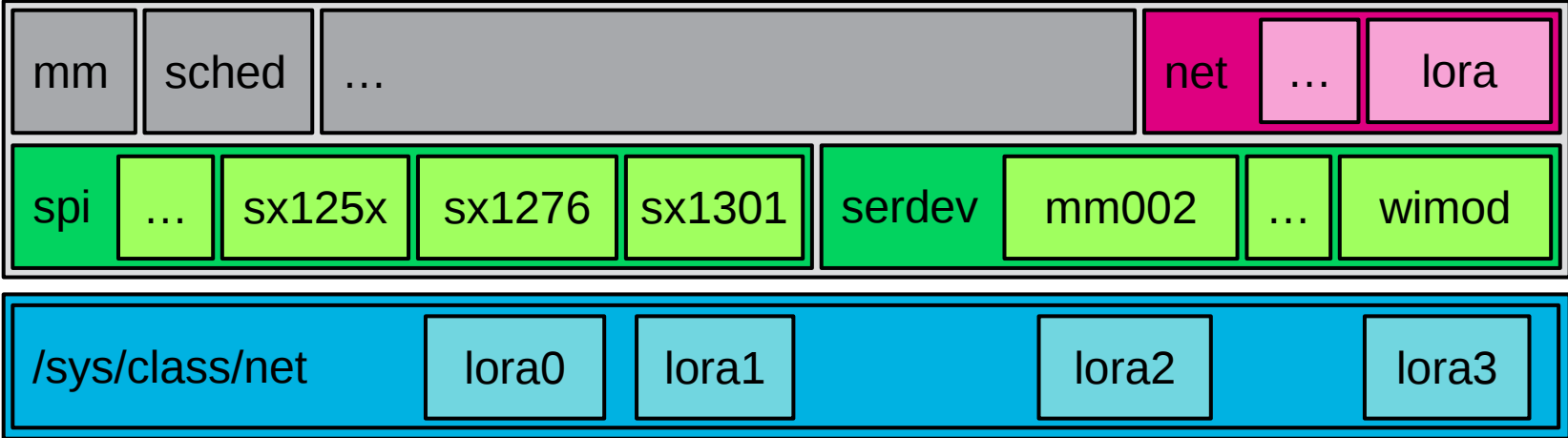
- Shall expose equivalent chipset features as before
- Shall allow implementation of proprietary protocols
- Shall allow reuse of protocols layered on top
- Shall fit all Semtech chipsets and many third-party modules

**Idea:** Sockets seem an intriguing approach for LoRaWAN. Similarities to Wifi and IEEE 802.15.4 may help users.





# Andreas In Wonderland – Sockets (Proposed)



# Semtech SX1272 f. / SX1276 ff. Transceivers

- Single channel
- Two modes: FSK/OOK and LoRa (switchable via Sleep mode)
- State machine for RX vs. TX (switchable via Standby)
- SPI register interface
- 256 byte RAM data buffer (LoRa) / 64 byte FIFO (FSK)



# Semtech SX1261 f. / SX1268 Transceivers

- Single channel
- Two modes: LoRa and FSK
- State machine for RX vs. TX (switchable via Standby RC/XOSC)
- SPI command interface, indirect register interface
- 256 byte RAM data buffer



# Semtech SX1280 f. Transceivers

- Single channel
- Multiple modes: LoRa, FLRC, FSK, BLE and Ranging
- State machine for RX vs. TX (switchable via Standby RC/XOSC)
- UART and SPI command interface, indirect register interface
- 256 byte RAM data buffer



# Semtech SX1301 / SX1308 Concentrators

- Multi-channel
- IF0-7 LoRa channels, IF8 LoRa uplink channel, IF9 FSK channel
- Two radio transceivers (SPI/ADC) – SX1255 / SX1257 f.
- SPI register interface – no documentation, only reference code
- 1024 byte data buffer
- Firmware blobs for calibration and operation



# Socket Addressing For Radios

- Transmission is broadcast
  - Addressing only at MAC layer
- Preamble may serve to recognize frame start, not “metadata”
- Optional filtering by Sync Word

**Idea:** Define address as radio properties that allow reception.  
(An alternative following later.)

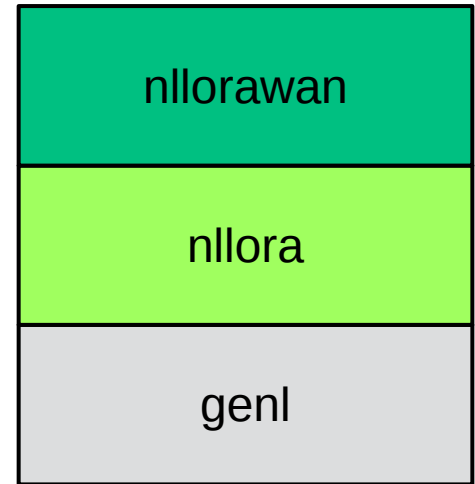
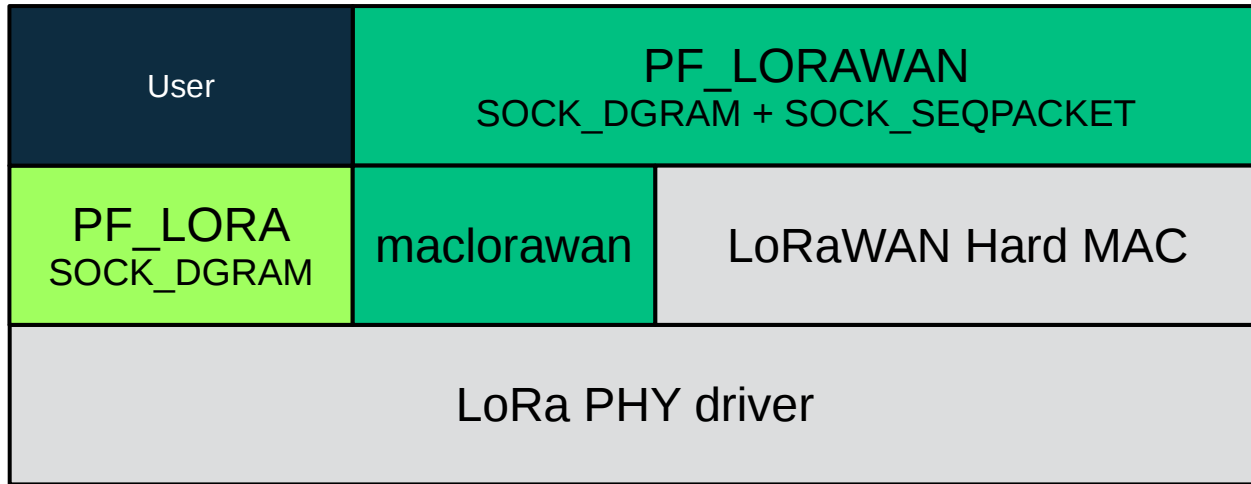


# LoRa Socket Address (Proposed)

- Network interface index
- Radio frequency
- Spreading Factor
- Bandwidth
- Sync Word (1 Byte)



# LoRa Socket Layers (Proposed)





# LoRaWAN Socket Address (Proposed)

- Network interface index
- Data Rate
  - LoRa: channel frequency, SF, bandwidth
  - FSK: channel frequency, bandwidth
- Port

Implies a fixed LoRa / FSK Sync Word respectively.

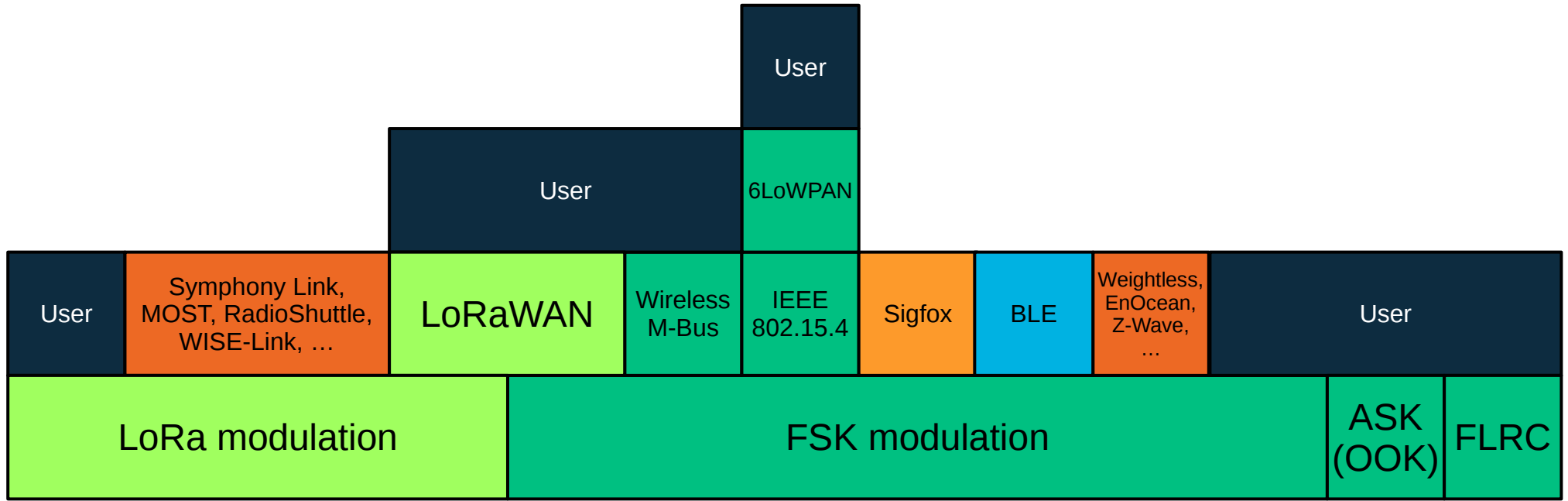


# Listening Can Be Hard

- Packets can be **transmitted** with different modes and settings
- Sockets require to **receive** whenever we're not transmitting
  - How to detect and handle conflicting settings for reception?
  - When socket is opened, all settings need to have been initialized
- There's no unified frame format field to **detect** MAC protocols
  - Need to try to parse incoming frames for each protocol



# Protocol Layers Around LoRa



# Frequency-Shift Keying (FSK)

- Address: frequency, sync word (multi-byte), Gauss ...
- Also found in: nRF24L01+, CC1120, MRF89XAM8A, SP1ML



# On/Off-Keying (Amplitude-Shift Keying)

- Address: frequency, ...
- Also found in: CC1120, MRF89XAM8A



# Fighting Pollution: Unified Radio Sockets?

- Can we avoid a socket address for each modulation?
- Use generic **PF\_PACKET** + SOCK\_DGRAM + htons(ETH\_P\_...)?
  - Would not allow radio configuration via socket address
  - Would still allow SOCK\_RAW for Software Defined Radio
  - How could we switch modes or detect conflicts? Socket options?



# Related: Bluetooth LE Support

- Semtech SX128x: alternative mode
- AppconWireless RF1276TS, Laird RM1xx: separate antenna
- Kernel appears to rely on **HCI** – what to do about raw PDUs?



# Test Setup For LoRa Kernel Drivers

- arm, arm64 and mips Single Board Computers
  - Using Device Tree Overlay where possible
- openSUSE Tumbleweed + Kernel:HEAD repo
  - Tricks for insmod: <https://github.com/afaerber/lora-modules>
- Relevant chipsets being tested before pushing to linux-lora.git
  - Limitations: 868 MHz and 433 MHz (EU), donated hardware
- Idea: interoperability testing, both locally and across radio link





# Action Plan

- Working towards RFC v2 – need to complete regmap adoption
  - Staging branch to be archived and squashed into series
- On top: LoRaWAN soft MAC patch series by Jian-Hong Pan
  - <https://www.slideshare.net/chienhungpan/lorawan-class-module-and-subsystem>
- Validate / evolve socket design – needs testing and feedback
- Merge into mainline kernel, enable in openSUSE Tumbleweed



# Credits

The background features abstract geometric shapes. A large teal shape occupies the left and top portions, while a green shape is on the right. A white diagonal line separates the teal and green areas, creating a sense of depth and movement.

# Industry Contributors – Code



# Industry Supporters – Hardware





# Competing LPWAN Technologies

# Other U-LPWAN: Sigfox

- Frequency: Unlicensed sub-GHz SRD/ISM bands
- MTU: 12 bytes uplink, 8 bytes downlink
- Why care? Found in Nemeus MM002-LS modules
  - How to expose? Device? PF\_SIGFOX? lora0 + sigfox0?
  - How to interact with LoRa sockets?



# Other LPWAN: NB-IoT

- Frequency: Licensed 3GPP bands
- MTU: 1500 bytes
- Two modes: UDP and non-IP
- SIM card needed

How to handle in Linux?



# Conclusions

The background features abstract geometric shapes in two shades of green. On the left, a large teal shape with a white border on its right side contains the word 'Conclusions'. To the right, a bright green shape is partially visible, separated from the teal shape by a white border. The overall design is clean and modern.



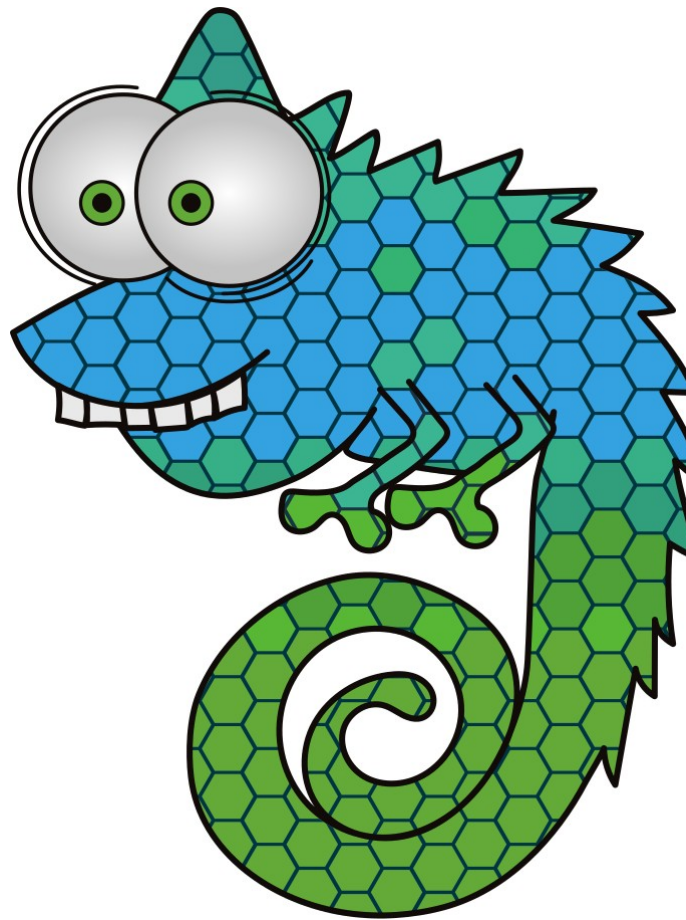
# Resources

- RFC patch series: <https://patchwork.ozlabs.org/cover/937545/>
- Testing hints: <https://github.com/afaerber/lora-modules>
- Staging tree with lora-next branch:  
<https://git.kernel.org/pub/scm/linux/kernel/git/afaerber/linux-lora.git/>
- Chipset overview and links to SBC expansion boards:  
<https://en.opensuse.org/HCL:LoRa>



The background features a teal-colored shape on the left and a green-colored shape on the right, separated by a white diagonal stripe. The text is centered in the teal area.

**Questions? Feedback?**



Join Us at [www.opensuse.org](http://www.opensuse.org)



The background features a large teal shape on the left and a green shape on the right, separated by a white diagonal line. The teal shape is a large, irregular polygon with a pointed top and a pointed bottom. The green shape is a large, irregular polygon with a pointed top and a pointed bottom, mirroring the teal shape's form. The white line runs diagonally from the top right to the bottom left, creating a sense of movement and division.

**Backup**

# Radio Modulation Types Of Other Technologies

- MIOTY: Lfour: BPSK; TS-UNB: GMSK; DD-UNB: BFSK
- Sigfox: D-BPSK and GFSK
- Weightless-P: GMSK  $BT=0.3$  or OQPSK
- Wireless M-Bus: 4GFSK
  
- Bluetooth LE: GFSK (2.4 GHz)



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### Template

Richard Brown  
[rbrown@opensuse.org](mailto:rbrown@opensuse.org)

### Design & Inspiration

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