Online Simulation of LoRaWAN™ Devices

Jan Jongboom Principal Developer Evangelist, Arm

LoRaWAN™

Creating Valuable IoT Connections

Who am I

Jan Jongboom

Principal Developer Evangelist, Arm

Doing LoRaWAN for the last 4 years

Arm

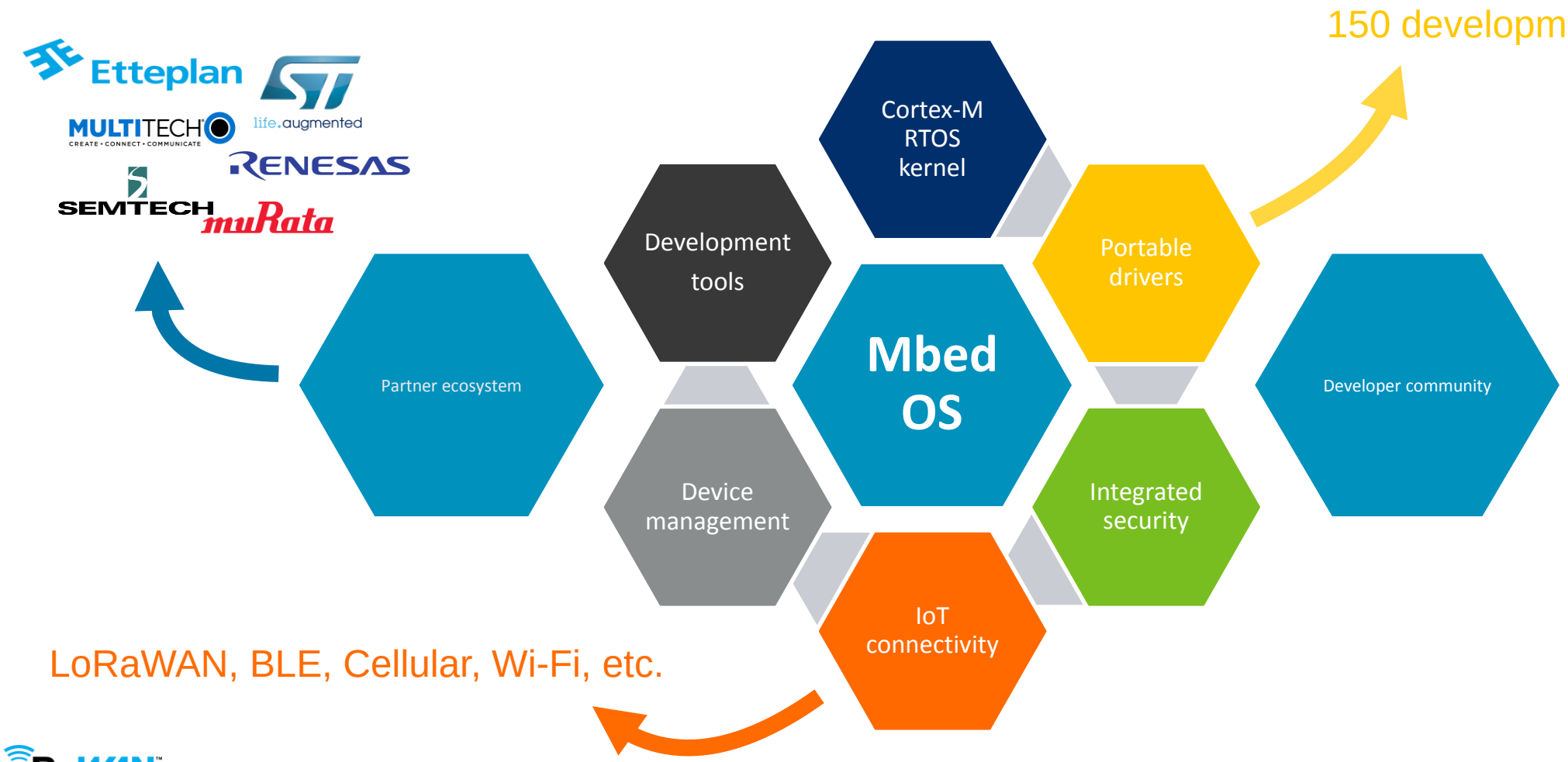
Semi-conductor company

21 billion processors sold last year

LoRa Alliance Contributor member

arm MBED

A free, open source Platform OS targeting IoT end node devices



LoRaWAN is great, but...

Testing Hard Connections

Device connected to multiple gateways with varying backhaul performance

Adaptive Data Rating

Rapidly moving devices

Uncalibrated crystals

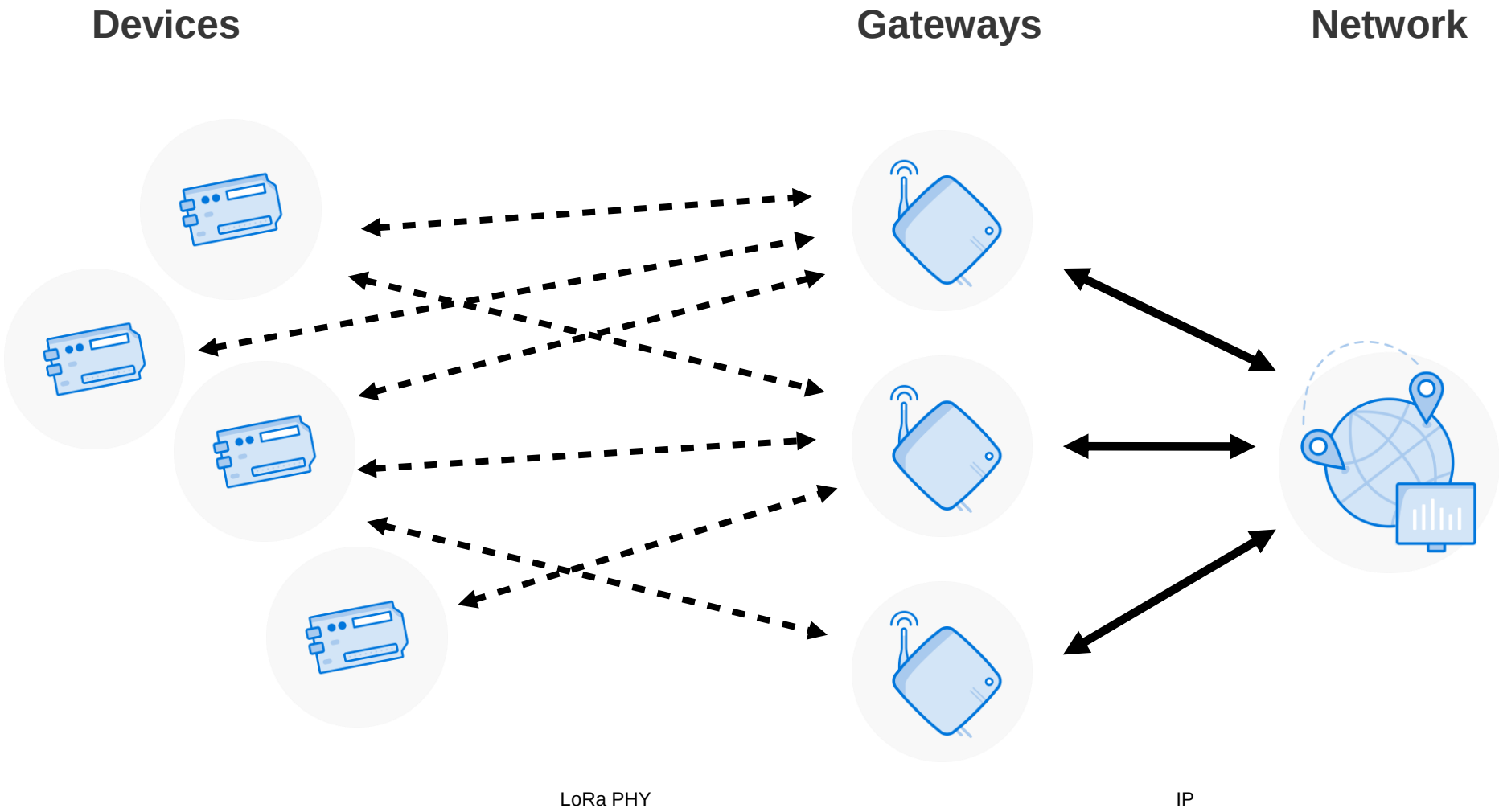
http://www.redwoodcomm.com/product/01.php

Can we do better?

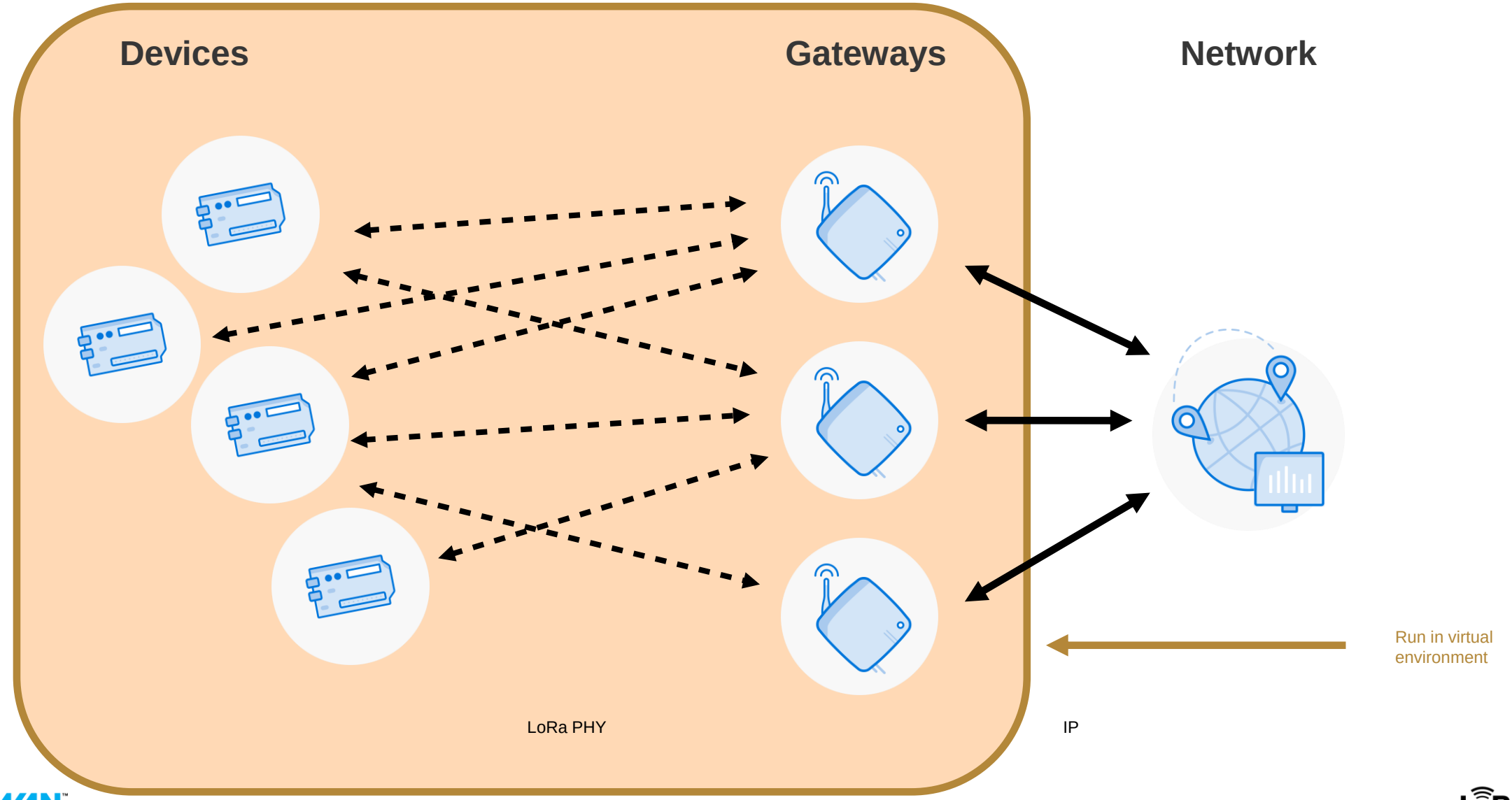
Removing **LoRa** from

LoRaWAN

Device to network



Device to network



Benefits

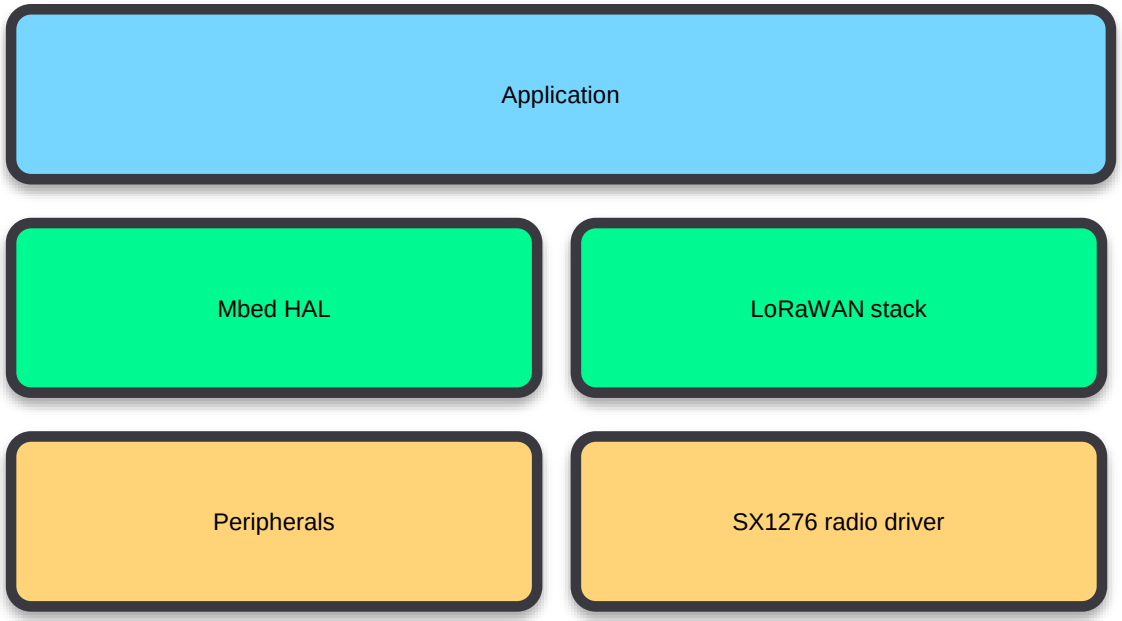
Run application in seconds

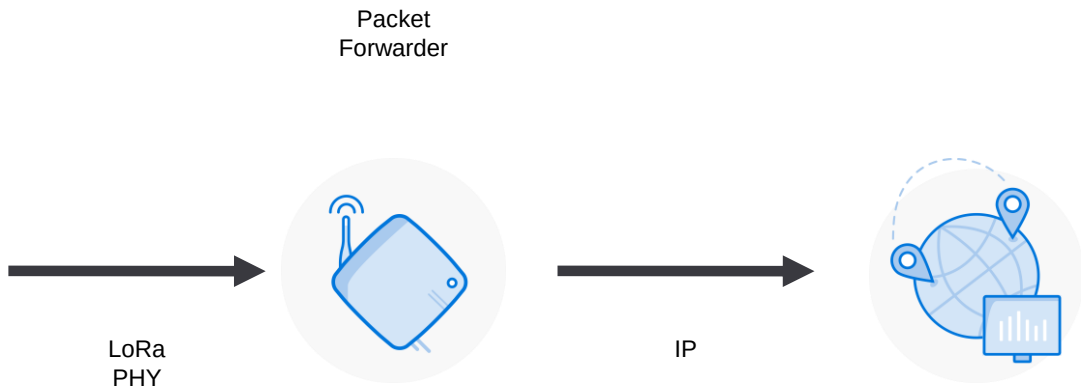
Full control over gateway parameters (RSSI, gateways within reach)

Still LoRaWAN: end-to-end encryption, spreading factors, channel hopping

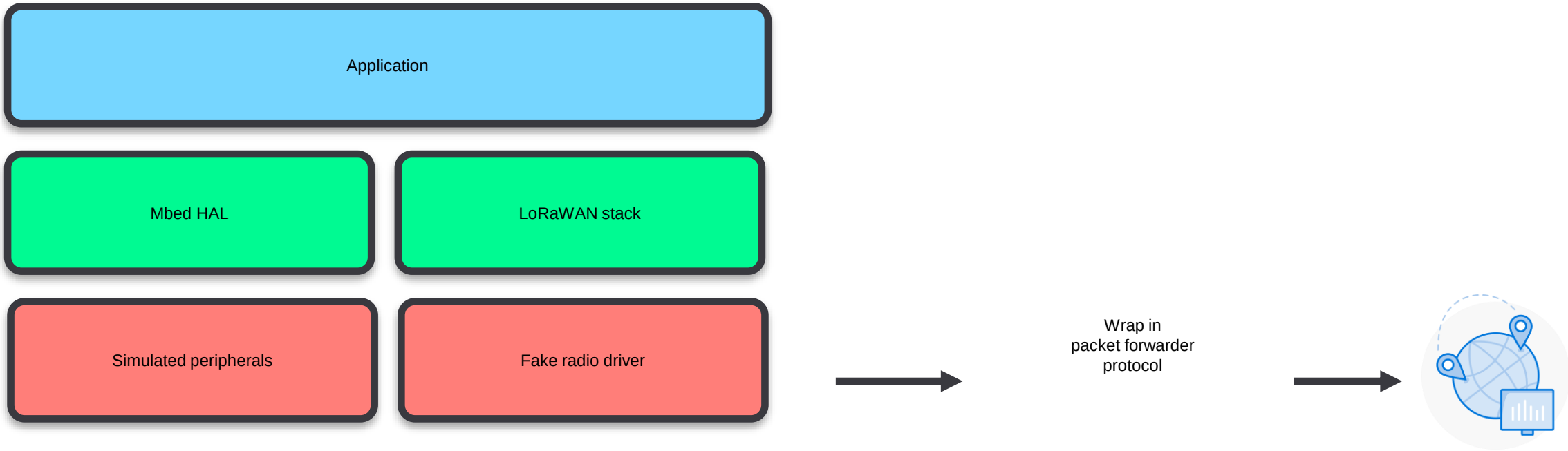
No changes required on network side

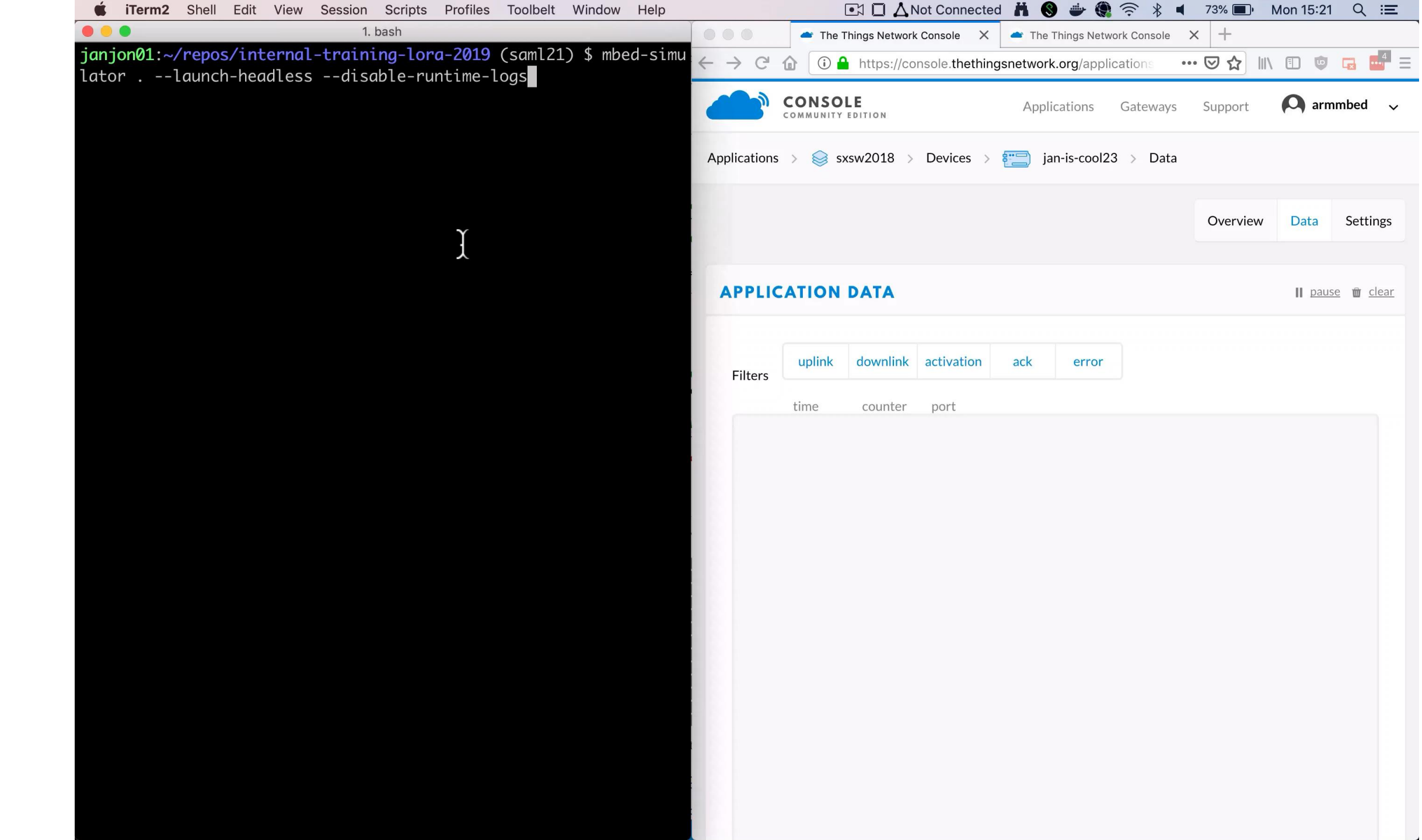
Device


Application
Mbed HAL
LoRaWAN stack
Peripherals
SX1276 radio driver


Packet
Forwarder
LoRa
PHY
IP

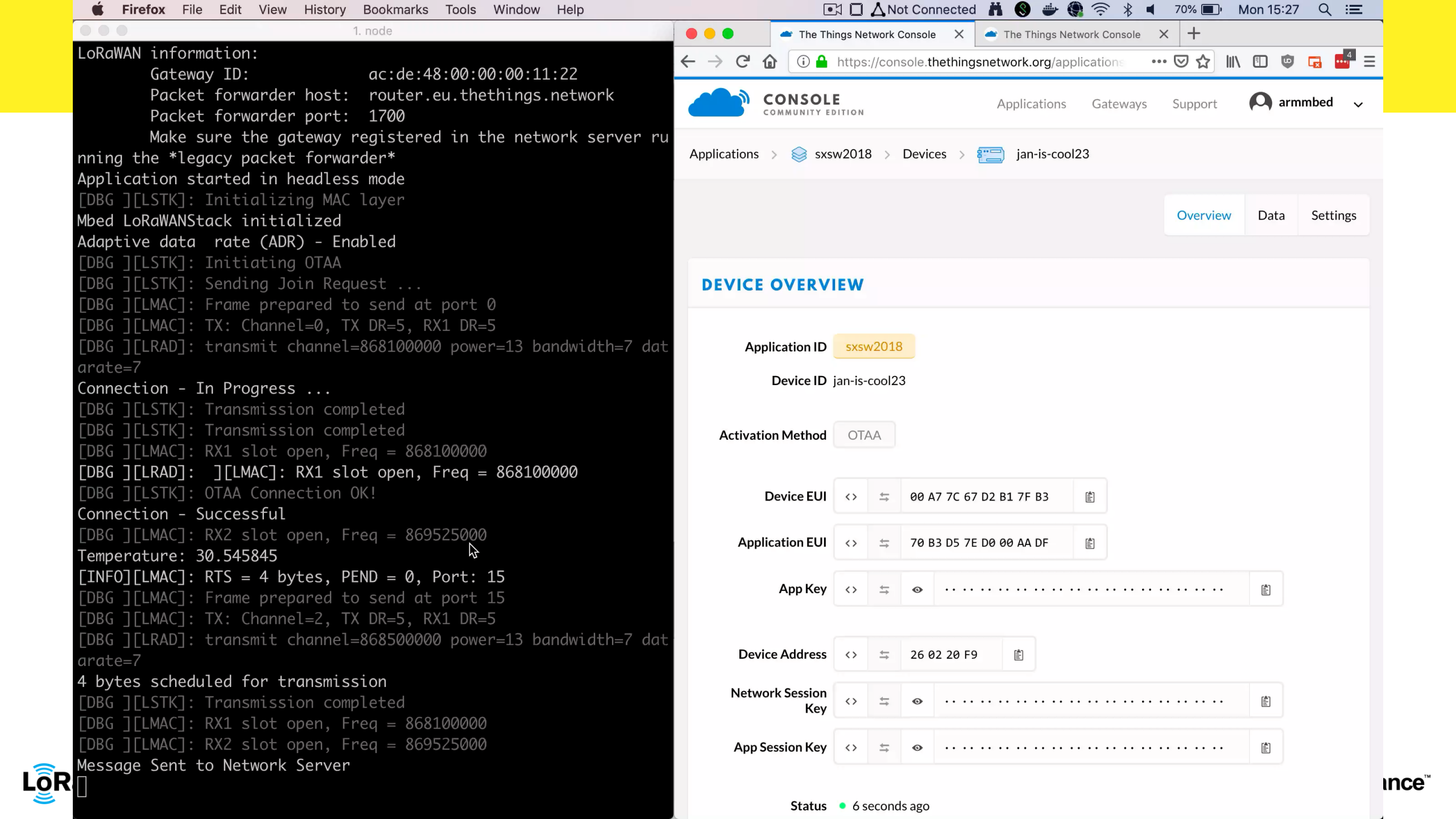
Device

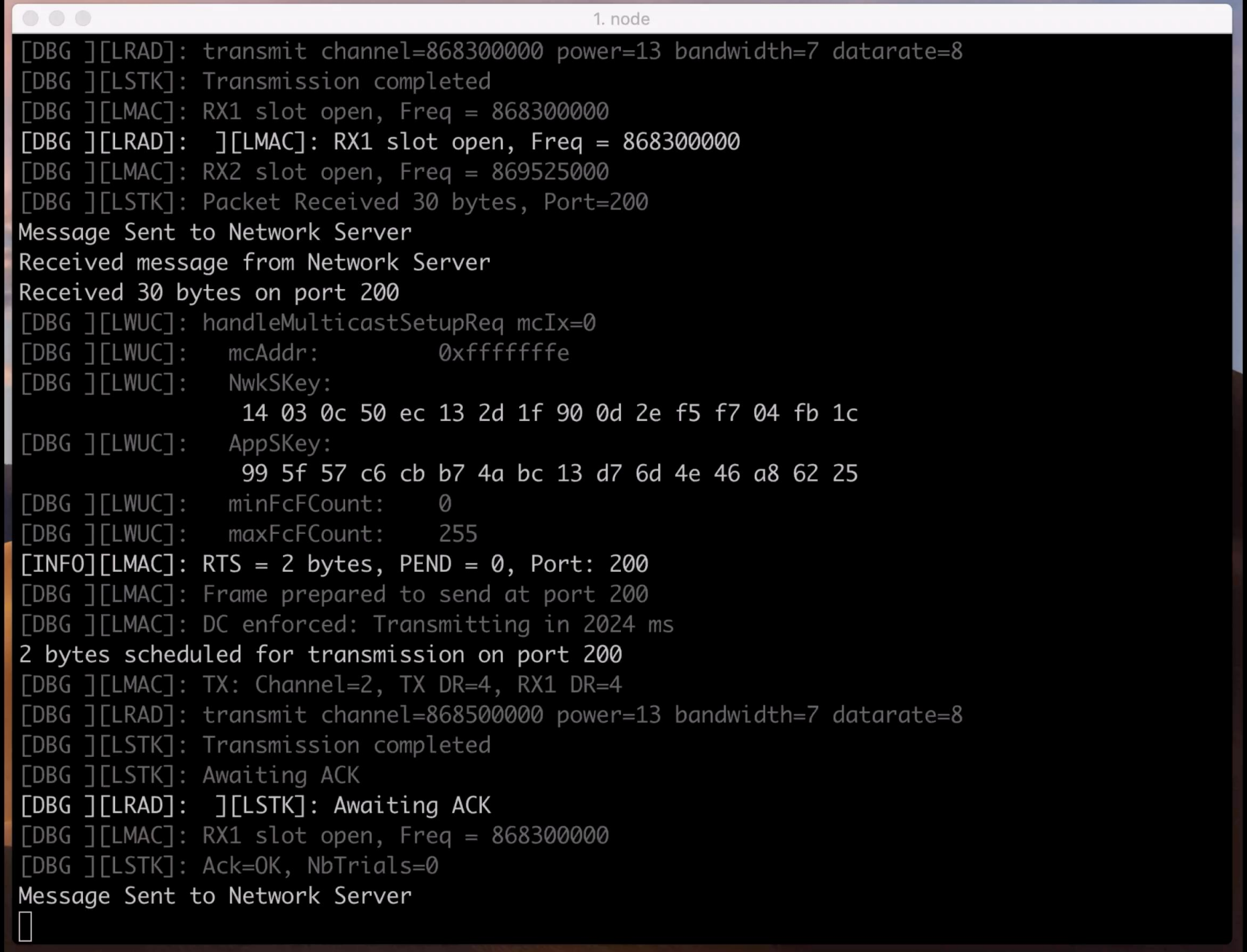

Application
Mbed HAL
LoRaWAN stack
Simulated peripherals
Fake radio driver
Wrap in
packet forwarder
protocol


iTerm2 Shell Edit View Session Scripts Profiles Toolbelt Window Help
Not Connected
73%
Mon 15:21
1. bash
janjon01:~/repos/internal-training-lora-2019 (saml21) $ mbed-simu
lator . --launch-headless --disable-runtime-logs
The Things Network Console
The Things Network Console
https://console.thethingsnetwork.org/applications
CONSOLE
COMMUNITY EDITION
Applications
Gateways
Support
armmbed
Applications
sxsw2018
Devices
jan-is-cool23
Data
Overview
Data
Settings
APPLICATION DATA
pause
clear
Filters
uplink
downlink
activation
ack
error
time
counter
port

Frequency hopping

time	frequency	mod.	CR	data rate	airtime (ms)	cnt				
▲ 15:26:08	868.1	lora	4/6	SF 8 BW 125	102.9	12	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:25:58	867.5	lora	4/6	SF 8 BW 125	102.9	11	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:25:48	867.9	lora	4/6	SF 8 BW 125	102.9	10	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:25:38	867.1	lora	4/6	SF 8 BW 125	102.9	9	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:25:28	868.1	lora	4/6	SF 8 BW 125	102.9	8	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:25:17	867.5	lora	4/6	SF 8 BW 125	102.9	7	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:25:07	867.5	lora	4/6	SF 8 BW 125	102.9	6	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:24:57	868.3	lora	4/6	SF 8 BW 125	102.9	5	dev addr:	26 02 29 B0	payload size:	17 bytes
▲ 15:24:47	868.3	lora	4/6	SF 8 BW 125	102.9	4	dev addr:	26 02 29 B0	payload size:	17 bytes


Firefox File Edit View History Bookmarks Tools Window Help
Not Connected
70%
Mon 15:27
1. node
LoRaWAN information:
Gateway ID: ac:de:48:00:00:00:11:22
Packet forwarder host: router.eu.thethings.network
Packet forwarder port: 1700
Make sure the gateway registered in the network server ru
nning the *legacy packet forwarder*
Application started in headless mode
[DBG][LSTK]: Initializing MAC layer
Mbed LoRaWANStack initialized
Adaptive data rate (ADR) - Enabled
[DBG][LSTK]: Initiating OTAA
[DBG][LSTK]: Sending Join Request ...
[DBG][LMAC]: Frame prepared to send at port 0
[DBG][LMAC]: TX: Channel=0, TX DR=5, RX1 DR=5
[DBG][LRAD]: transmit channel=868100000 power=13 bandwidth=7 dat
arate=7
Connection - In Progress ...
[DBG][LSTK]: Transmission completed
[DBG][LSTK]: Transmission completed
[DBG][LMAC]: RX1 slot open, Freq = 868100000
[DBG][LRAD]:][LMAC]: RX1 slot open, Freq = 868100000
[DBG][LSTK]: OTAA Connection OK!
Connection - Successful
[DBG][LMAC]: RX2 slot open, Freq = 869525000
Temperature: 30.545845
[INFO][LMAC]: RTS = 4 bytes, PEND = 0, Port: 15
[DBG][LMAC]: Frame prepared to send at port 15
[DBG][LMAC]: TX: Channel=2, TX DR=5, RX1 DR=5
[DBG][LRAD]: transmit channel=868500000 power=13 bandwidth=7 dat
arate=7
4 bytes scheduled for transmission
[DBG][LSTK]: Transmission completed
[DBG][LMAC]: RX1 slot open, Freq = 868100000
[DBG][LMAC]: RX2 slot open, Freq = 869525000
Message Sent to Network Server
The Things Network Console
The Things Network Console
https://console.thethingsnetwork.org/applications
CONSOLE
COMMUNITY EDITION
Applications
Gateways
Support
armmbed
Applications
sxsw2018
Devices
jan-is-cool23
Overview
Data
Settings
DEVICE OVERVIEW
Application ID
sxsw2018
Device ID
jan-is-cool23
Activation Method
OTAA
Device EUI
00 A7 7C 67 D2 B1 7F B3
Application EUI
70 B3 D5 7E D0 00 AA DF
App Key
Device Address
26 02 20 F9
Network Session Key
App Session Key
Status
6 seconds ago

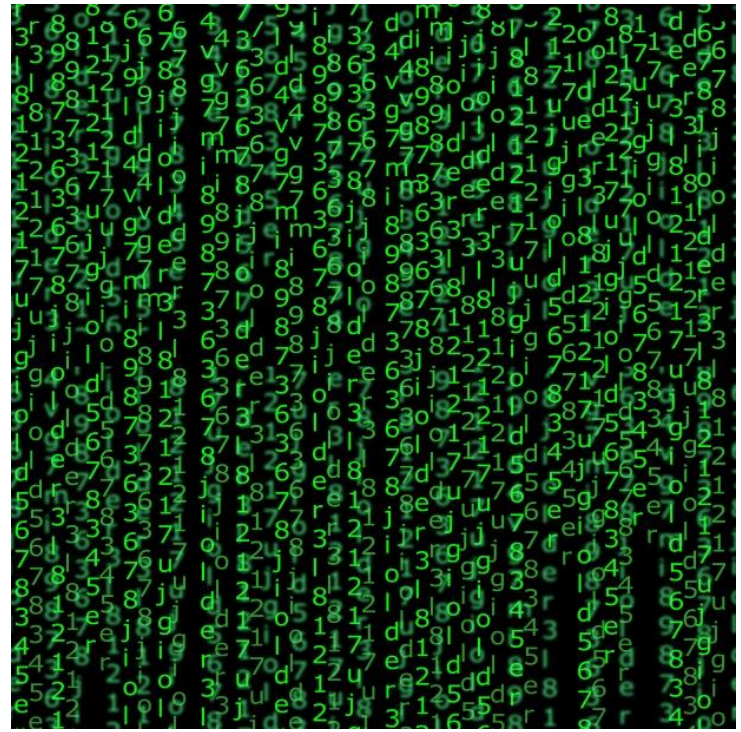

1. node
[DBG][LRAD]: transmit channel=868300000 power=13 bandwidth=7 datarate=8
[DBG][LSTK]: Transmission completed
[DBG][LMAC]: RX1 slot open, Freq = 868300000
[DBG][LRAD]:][LMAC]: RX1 slot open, Freq = 868300000
[DBG][LMAC]: RX2 slot open, Freq = 869525000
[DBG][LSTK]: Packet Received 30 bytes, Port=200
Message Sent to Network Server
Received message from Network Server
Received 30 bytes on port 200
[DBG][LWUC]: handleMulticastSetupReq mcIx=0
[DBG][LWUC]: mcAddr: 0xfffffffe
[DBG][LWUC]: NwkSKey:
14 03 0c 50 ec 13 2d 1f 90 0d 2e f5 f7 04 fb 1c
[DBG][LWUC]: AppSKey:
99 5f 57 c6 cb b7 4a bc 13 d7 6d 4e 46 a8 62 25
[DBG][LWUC]: minFcFCount: 0
[DBG][LWUC]: maxFcFCount: 255
[INFO][LMAC]: RTS = 2 bytes, PEND = 0, Port: 200
[DBG][LMAC]: Frame prepared to send at port 200
[DBG][LMAC]: DC enforced: Transmitting in 2024 ms
2 bytes scheduled for transmission on port 200
[DBG][LMAC]: TX: Channel=2, TX DR=4, RX1 DR=4
[DBG][LRAD]: transmit channel=868500000 power=13 bandwidth=7 datarate=8
[DBG][LSTK]: Transmission completed
[DBG][LSTK]: Awaiting ACK
[DBG][LRAD]:][LSTK]: Awaiting ACK
[DBG][LMAC]: RX1 slot open, Freq = 868300000
[DBG][LSTK]: Ack=OK, NbTrials=0
Message Sent to Network Server

Recap

Radio is hard!

Feedback loop on embedded is long

Simulation is here to save us



https://github.com/janjongboom/mbed-simulator

Thank you

Getting started with Mbed OS

https://github.com/ArmMbed/mbed-os-example-lorawan

Simulator

https://labs.mbed.com

Contact and slides

jan.jongboom@arm.com

http://janjongboom.com

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@LoRaAlliance

linkedin.com/company/loraalliance/

marcom@lora-alliance.com

lora-alliance.org

LoRa Alliance™