LoRa Mesh Networking with RIOT

RIOT SUMMIT 2026

Nicolas ALBAREL, Didier DONSEZ













LIG / Drakkar activities

Laboratoire d'Informatique de Grenoble — Drakkar team

Wireless local area networks

802.11 / Wi-Fi

Traffic measurement and observation

Datasets · large-scale experimentation platforms (Slices FR)

Wireless sensor networks and the Internet of Things

Large-scale interconnection · 802.15.4 · LoRaWAN · 5G-MTC

Network security

Characterizing applications by the traffic they generate · anomaly detection · cyber-attacks · IoT security

Future architectures and protocols

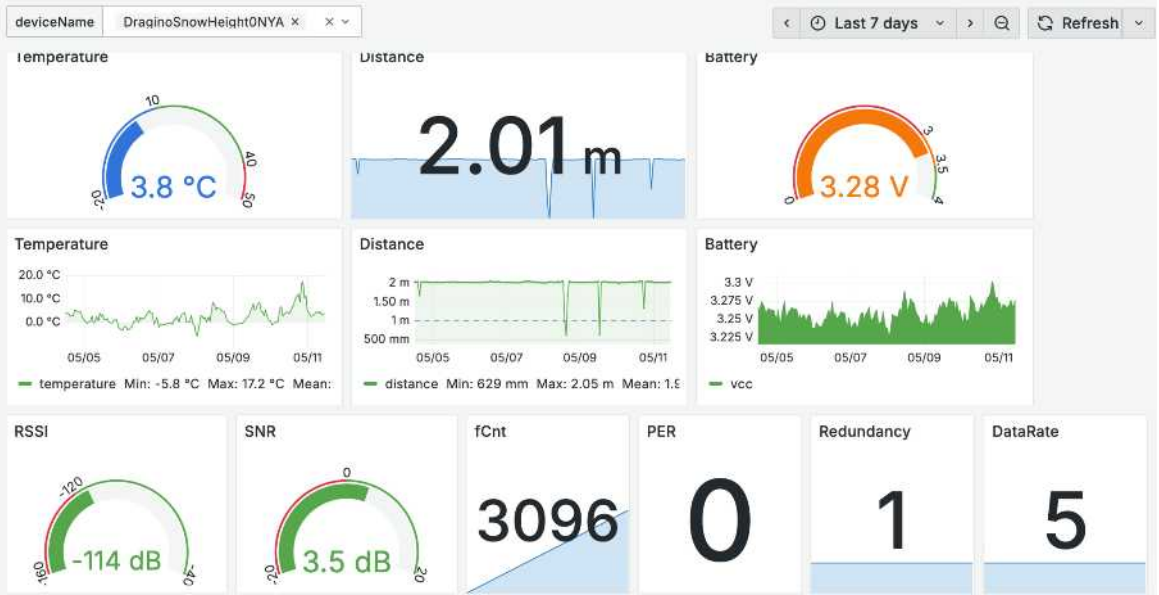
Advanced routing · mobility · self-organizing networks · new transport and congestion-control protocols

Inter-domain routing

and Extreme IoT



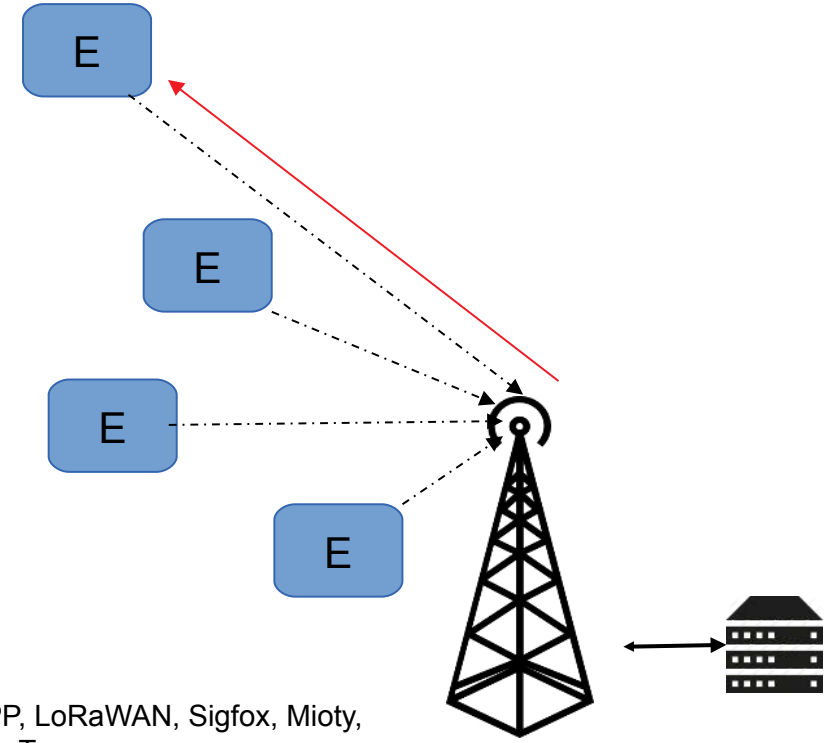
credit: JM Friedt



This talk

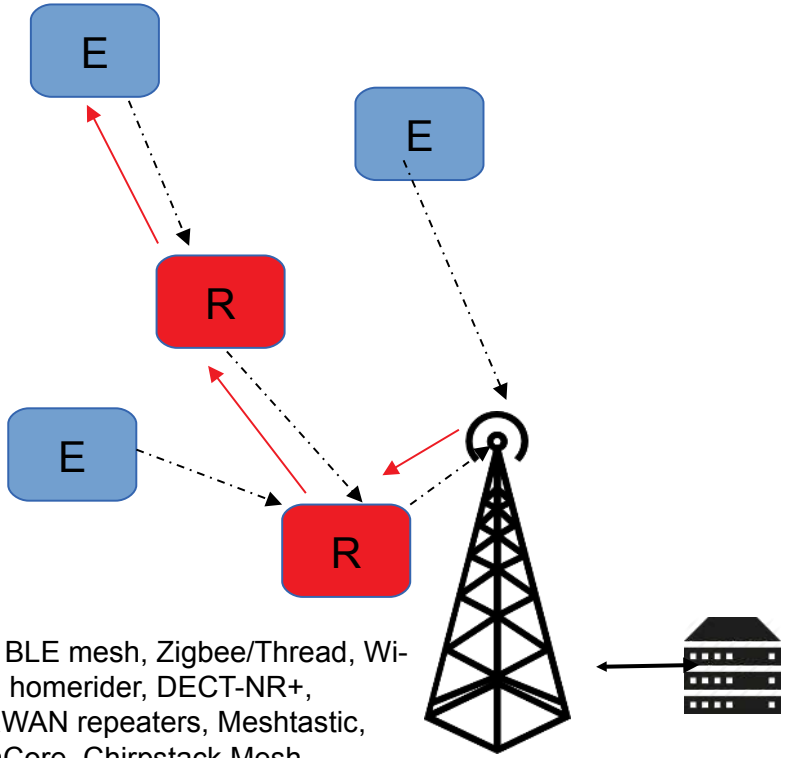
1. Wireless Mesh Network
2. LoRa Mesh Network
3. In natura
4. MeshCore and Meshtastic
5. LoRa Mesh Network in RIOT OS

Star vs Mesh topology



3GPP, LoRaWAN, Sigfox, Mioty, NB-IoT ...

Base station (BTS)

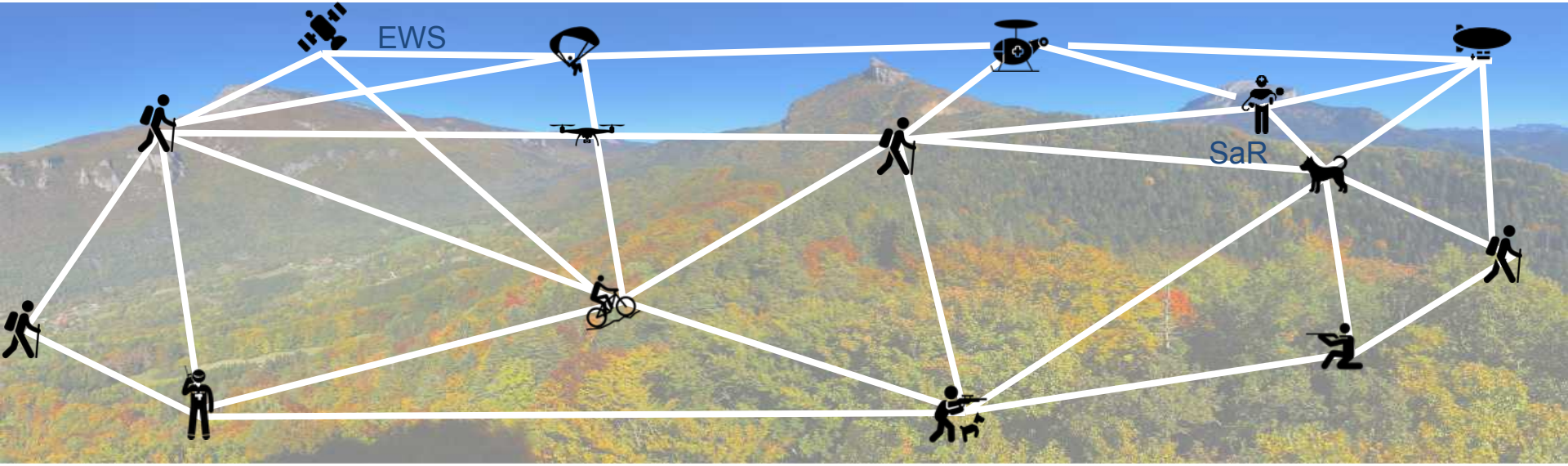


RPL, BLE mesh, Zigbee/Thread, Wi-SUN, homerider, DECT-NR+, LoRaWAN repeaters, Meshtastic, MeshCore, Chirpstack Mesh, …

Base station (BTS)

Offgrid Mesh Network

- No infrastructure, nodes communicate with one another to self-organize



icons from thenounproject.com

crédit photo: Didier Donsez

Two families of message forwarding

FLOODING

Every node — or a subset — rebroadcasts what it receives until the TTL (hop count) reaches zero.

Meshtastic · RadioHead · BLE mesh (Casambi, BitChat) · ChirpStack Mesh

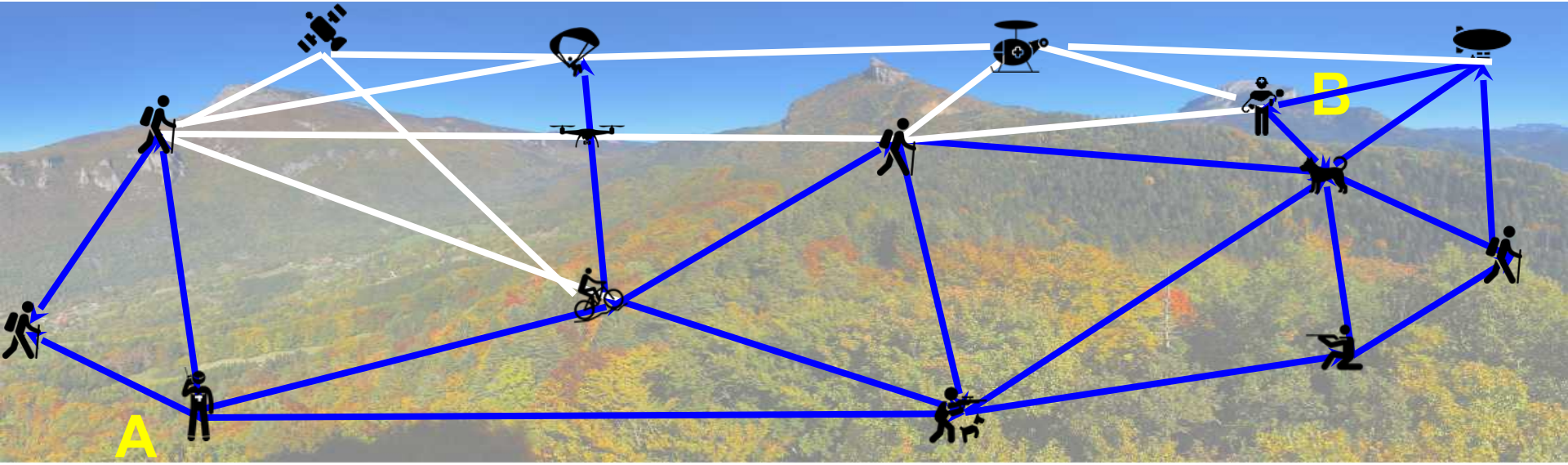
ROUTING

The packet travels only toward its destination, per routing tables.

IETF RPL (RFC 6553) · Thread · DECT-NR+ · Wi-SUN · Orama-net · NeoCortex

Flooding algorithms

Every node — or a subset — rebroadcasts what it receives until the TTL (hop count) reaches zero.

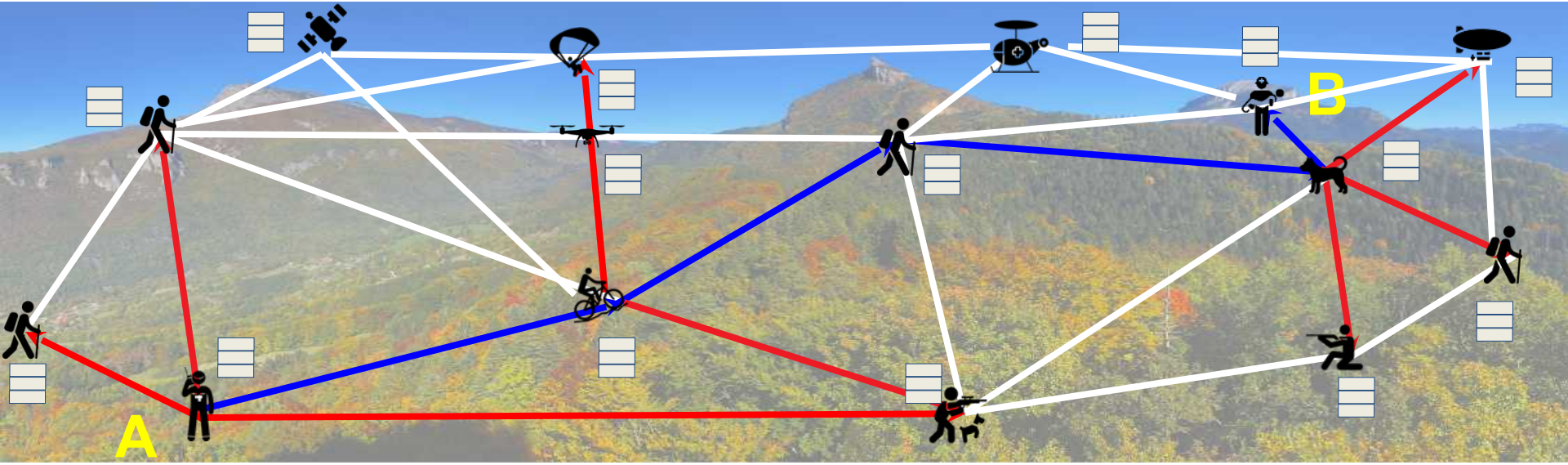


icons from thenounproject.com

crédit photo: Didier Donsez

Routing algorithms

The packet travels only toward its destination, per routing tables. The packet can also embeds its route, then it's called source-routing.



icons from thenounproject.com

crédit photo: Didier Donsez

Many applications

IoT sensor networks
White zones, rough terrain

Outdoor sports
Hiking, ski touring, paragliding

Festivals & large gatherings
Dense crowds, saturated cells

Early warning systems
EWS, alerting populations

Search and Rescue
No infrastructure to rely on

Blackout
Spain + Portugal, 2025-04-28

Disaster / humanitarian
Flood, storm, fire, nuclear — ATAK-CIV

Civic movements
Kill-switches, censorship, surveillance

Tactical networks
The origin — ATAK-MIL

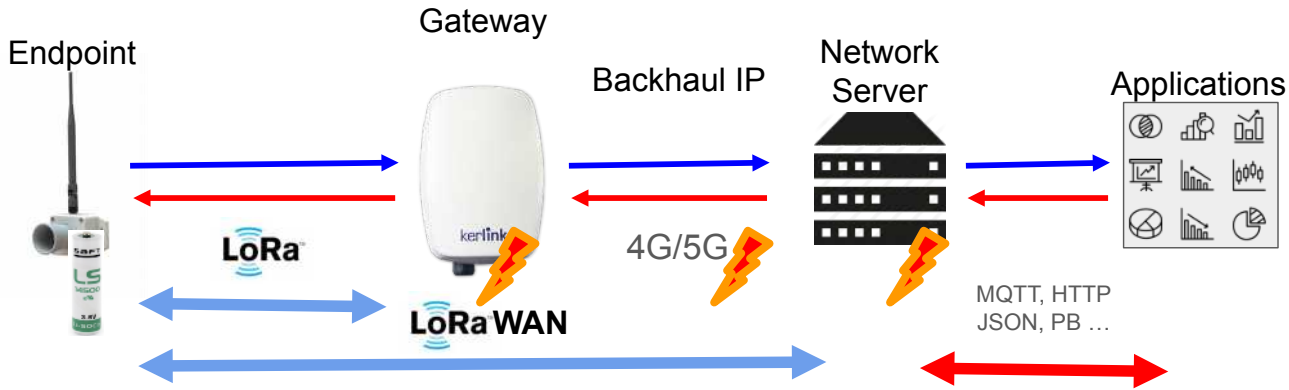
LoRa© vs LoRaWAN

LoRa© CSS

defines the Radio physical layer of a network

LoRaWAN

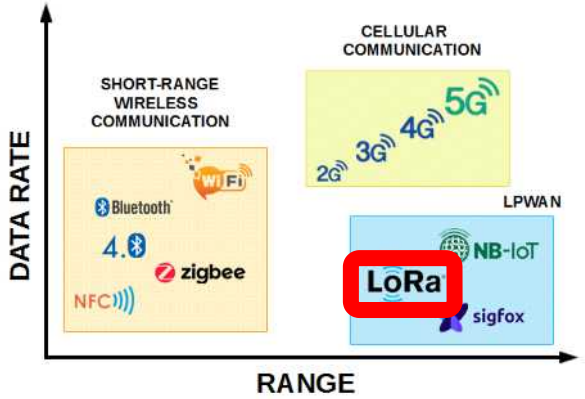
a STAR network protocol on top of it
— it defines the MAC layer



Why LoRa is a good choice for wireless mesh

Long range	km-scale hops.
Licence-free	Available in ISM bands.
Cheap	€40–100 per node
Tunable	SF / BW / CR settings are a per-deployment configuration

Bitrate: ~0.3–50 kbps. Long range needs low bitrate.



The landscape

OPEN SOURCE

- **Reticulum**
  A general networking stack; LoRa is one interface among many
- **ChirpStack Mesh**
  Relay / Border Gateway — keeps the LoRaWAN ecosystem
- **Meshtastic**
  Controlled flooding, mobility-oriented
- **MeshCore**
  Flooding and routing, fixed nodes

PROPRIETARY

- **ORAMA-Net**
- **NeoMesh (NeoCortec)**
- **Silvanet (Dryad)**
- **NM Mesh Connect (Northern Mechatronics)**

And many others, like 802.15.4 over LoRa...

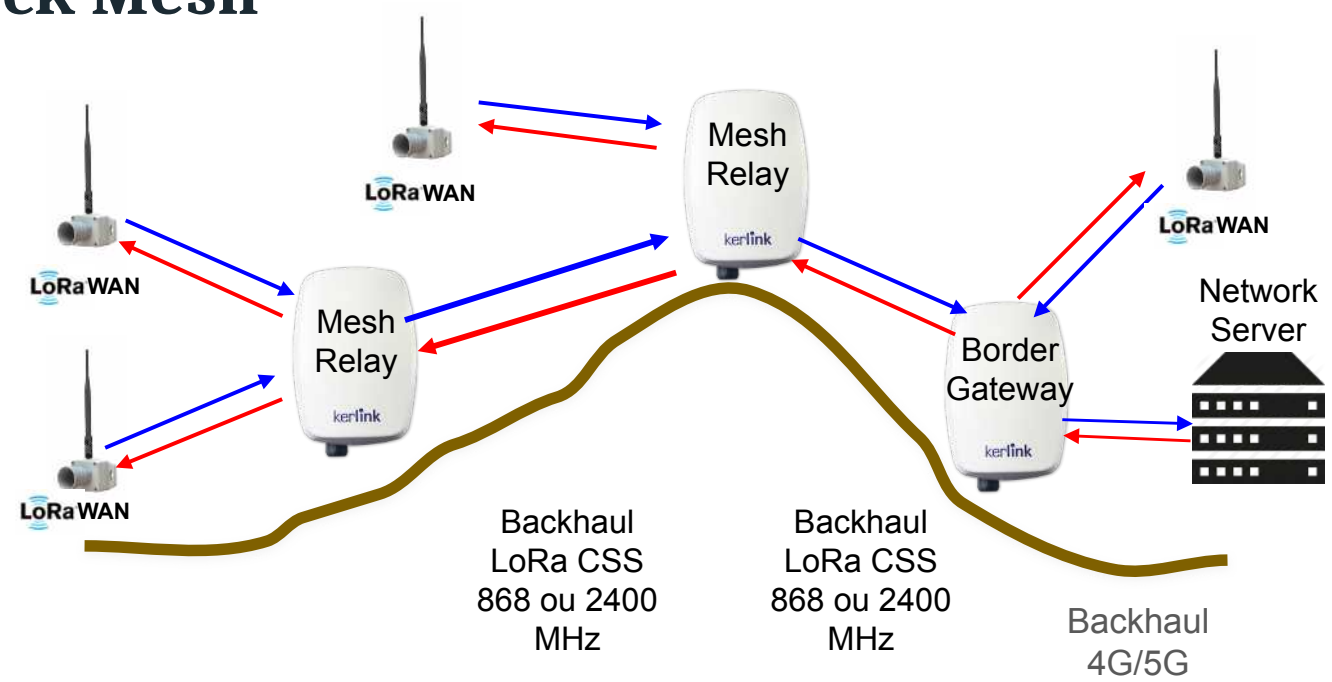
Reticulum

> *"A cryptography-based networking stack for building local and wide-area networks with readily available hardware."*

- Not a LoRa mesh stack — a network stack that can run over LoRa.
- Designed to keep working under very high latency and extremely low bandwidth
- But can do much more…

Used by many applications: LXMF (messaging) · NomadNet · Sideband · MeshChat · LXST

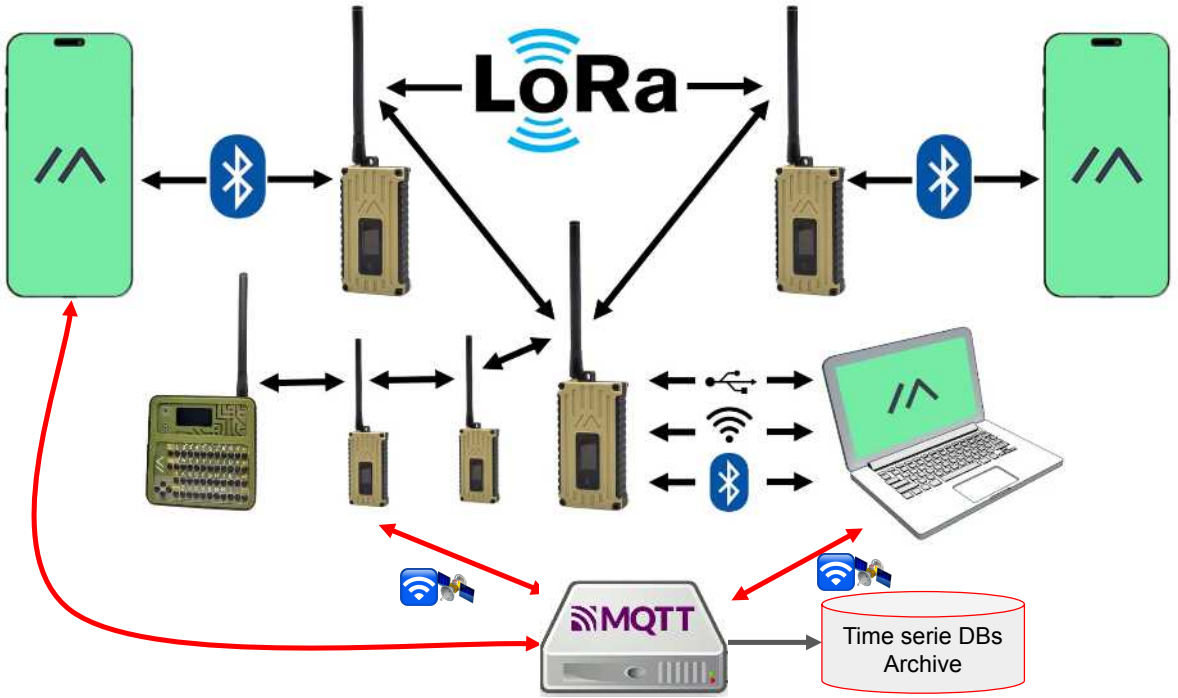
ChirpStack Mesh



- **Keeps the LoRaWAN ecosystem: existing endpoints and gateways are unchanged**
- 8 frequency channels × 125 kHz × 8 SF (SF5–SF12) — multi-frequency, multi-SF, unlike Meshtastic and MeshCore, which are single-frequency, single-SF
- Multi-hop, where LoRaWAN Relay (1.0.4) is single-hop

Meshtastic

Controlled flooding — moderated by roles, delay, signal quality, CAD, store & forward.

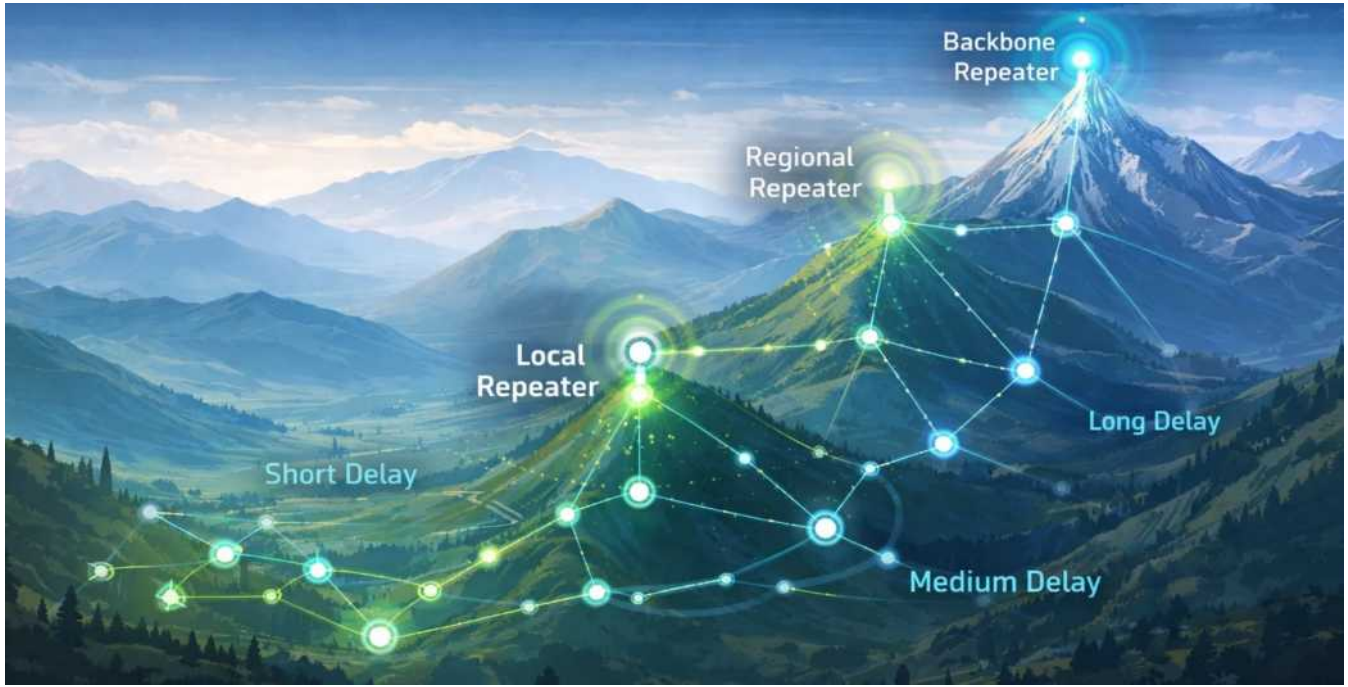


meshtastic.org/docs/introduction/

MeshCore

MESHCORE™

Flooding AND routing. Optimized for fixed nodes.



https://w6hs.net/meshcore-repeater-deployment-timing-considerations-for-wide-area-networks/

Field test from Grenoble: Fort du Murier



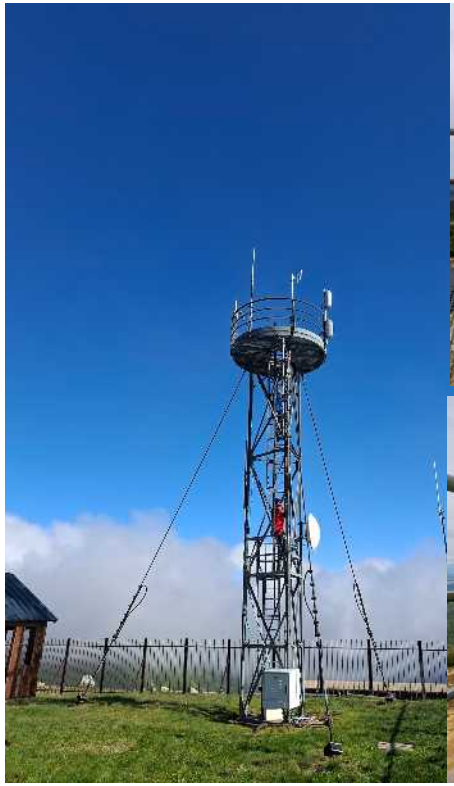


MeshCore

Meshtastic

R&D protocol

Field test from Mont Aigoual (Climatographe)









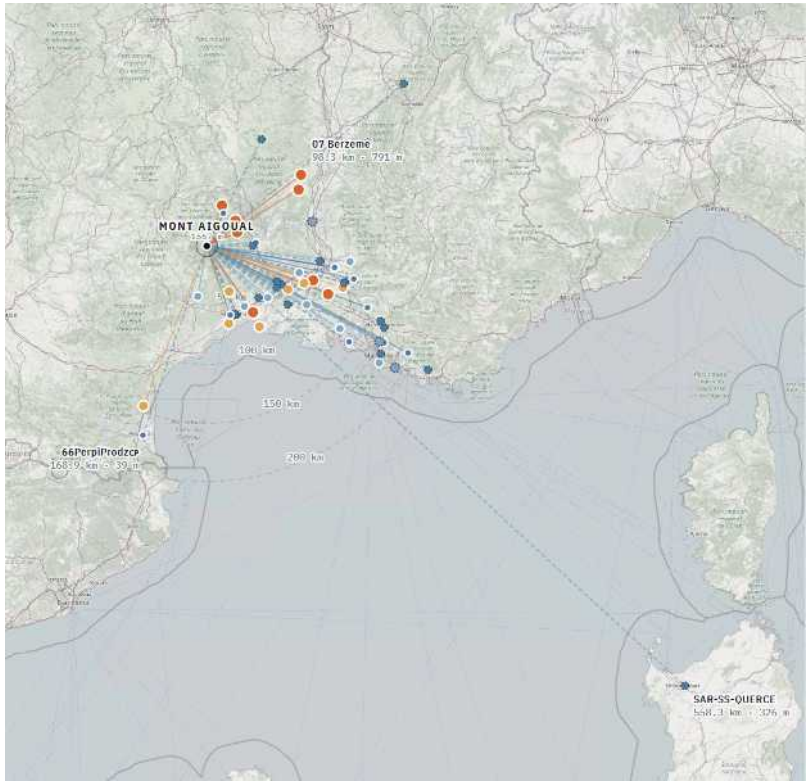
LoRaWAN

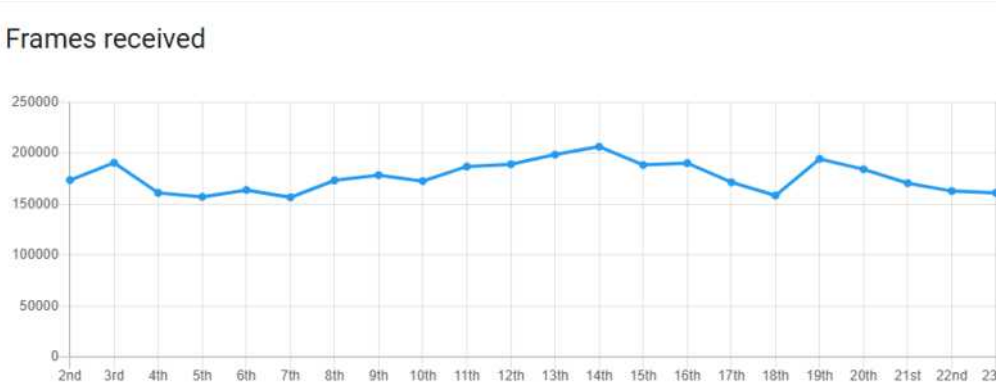
MeshCore

R&D protocol

Exceptional location, with weather exposure.

Field test from Mont Aigoual (Climatographe)

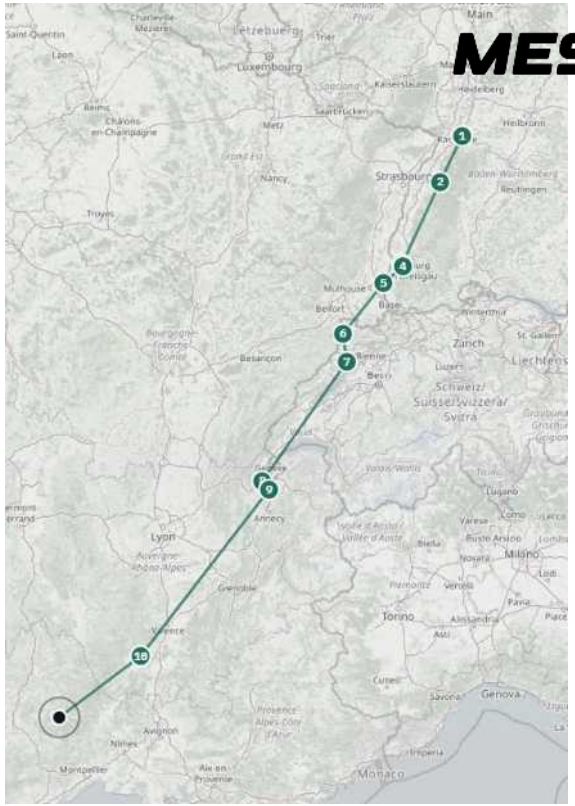




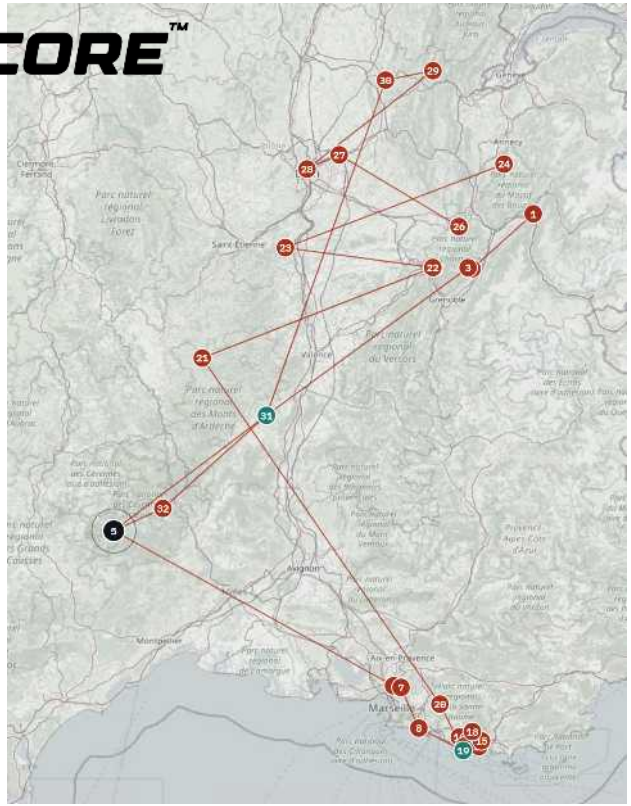
150-200K LoRaWAN messages per day
8K MeshCore messages per day

MeshCore observer can listen nodes > 200 kms away

Field test from Mont Aigoual (Climatographe)



MESHCORE™



Field test with Chirpstack Mesh

Jardin du Lautaret (2800 m alt) - July 2026
French Polynesia, Autumn 2026





GeoPred: the Saint-Eynard cliffs

Isterre & LIG, Carnot LSI



Climate warming is increasing rockfall

30–50 %

cut in road-infrastructure service life

× 6

damage costs by 2050

Volcanology: Etna, Piton des Neiges







Bocca Nuova crater

Photo credits: Julien Sudre, Luca Terray, Laurent Royer (2023)

Eruption precursors

- Radon
- Temperature
- Gas
- Seismology

Near space / new space

SatIoT +EWS, SaR, TXT or Direct 2 Cell

June 2026



October 2026



https://gricad-gitlab.univ-grenoble-alpes.fr/thingsat/public/-/blob/master/cubesat_mission_2/README.md

Disaster networks

Project VERCORS (Région AURA)

SDIS38 - OneTreck - LIG



crédit Dauphiné Libéré



crédit Seeedstudio https://www.seeedstudio.com/Mission-Pack.html

Why focus on MeshCore and Meshtastic?

1

Open source

Read it, fix it.

2

Node to node

no gateway, simple hardware.

3

Deployed at scale

Thousands of nodes on public maps today.

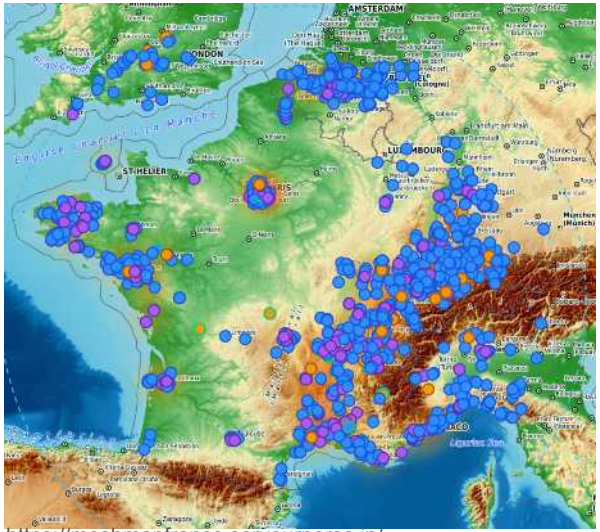
4

Simple enough to hack

You can test your ideas.

Many communities available, like Gaulix in France

Gaulix



https://meshmapfrance.serveurperso.in/

Hardware

MESHTASTIC MESHCORE™



Mesh repeater (solar powered)
100 euros





Companion/Tracker
BLE+LoRA 40 euros



“Observer” (PoE MQTT)
100 euros

Comparison

	Meshtastic	MeshCore
Best fit	mobile / nomadic repeaters	fixed nodes
Forwarding	managed flooding; next-hop routing for DMs (2.6+)	flooding, then source routing
Max hops	3 default — 7 hard cap	up to 64 (21 with 3-byte path hashes)
Address	32-bit — low bytes of the MAC	1 byte — first byte of the Ed25519 public key
Channels	8 max, AES-128/256	private channel / hashtag, AES-128
Roles	11	4+
Message types	14+	8+
Boards	~120	~70
Code	~64K LoC C++	~50K LoC C++
MQTT	native at the node (BLE/Wi-Fi)	via observers
Replay protection	admin sessions only (session ID, 300 s)	**frame counter, CMAC, digsig**
Firmware update	BLE / Wi-Fi via the app — not over LoRa	BLE / Wi-Fi via "start ota" — not over LoRa
Web of trust	**none**	**none**

Both: single frequency, single SF · Ed25519 + ECDH + PSK

What is missing

1. **No time synchronization**
   Absolute or relative. You cannot correlate two sensors.

2. **No real power management**
   No coordinated deep sleep, so no multi-year battery life.

3. **No FUOTA**
   Except if you use a drone to do BLE updates.

4. **No rate / link adaptation**
   No ADR equivalent.

5. **No web of trust**
   Identity is a favorite, not a proof.

Why doing LoRa Mesh Network in RIOT?

- The LoRa radio provides very long range links quite easily. The dev board in the picture can reliably exchange data with a board 146 kms away (Mont Aigoual).
- MeshCore and Meshtastic protocols are quite simple to understand.
  And country scale deployments are available.

- So working with these protocols using your favorite OS makes sense.



The mismatch with RIOT

Meshtastic and MeshCore are applications that contain a network stack.

- **Both are PlatformIO build.**
- **Portability by #ifdef:** NRF52_PLATFORM, ESP32, RP2040, STM32. **RadioLib is the radio abstraction**, Arduino core or Nordic SDK underneath.

```
void loop() {
  the_mesh.loop();           // routing
  interface_manager.loop();  // BLE / serial / MQTT
  sensors.loop();            // application
  ui_task.loop();            // display
  rtc_clock.tick();

  if (!the_mesh.hasPendingWork()) {
#if defined(NRF52_PLATFORM)
    board.sleep(0);   // idle only here, only on nRF52
#endif
  }
}
```

Already ported to RTOS

Both stacks are already ported to Zephyr.

ZephCore

MeshCore → Zephyr

Author: liquidraver (+ forks)

Approach: Port — full protocol compatibility

Maturity: ~625 commits, releases, DFU zips

Radios: SX126x, SX127x, LR1110, LR2021

SoCs: nRF52840, nRF54L15, ESP32, MG24, STM32WL, native Linux

meshtastic-zephyr

Meshtastic → Zephyr

Author: Benjamin Cabé (kartben) — independent, not endorsed by Meshtastic LLC

Approach: Mostly a rewrite from scratch

Maturity: Early / experimental

Radios: Any Zephyr board with LoRa

The Zephyr ports change the OS layer. They keep the network layer as-is.

ZephCore is a faithful port — protocol compatibility. Better firmware underneath, same mesh on top.

github.com/liquidraver/ZephCore · github.com/kartben/meshtastic-zephyr

Porting to RIOT

Upstreamed by Baptiste & Léandre Le Duc (LIG)

`pkg/radiolib (PR still open)`

RadioLib v7.6.0 in RIOT: one chip-agnostic radio API behind RiotHal, instead of a driver per transceiver. SX127x, LR11x0. Tested on b-l072z-lrwan1 via IoT-LAB.

`drivers/qma6100p`

New I2C driver for the QST QMA6100P accelerometer. ODR, range, power modes, data-ready interrupt, SAUL + Kconfig, hardware-verified test.

`boards/…-t1000e`

Full board bring-up for the SenseCAP T1000-E — unlocked by the two above. Pin/SPI config for RadioLib, on-board I2C for the QMA6100P.

TARGET HARDWARE **(both on RIOT's board-support wishlist, both popular in LoRa mesh communities)**

SenseCAP T1000-E

Mobile GNSS tracker — LR1110 (EU868), nRF52840, AG3335 GNSS, QMA6100P. IP65, credit-card sized, ~$40.



SenseCAP Solar Node P1 Pro

Solar endpoint / repeater — Wio-SX1262, XIAO nRF52840 Plus, XIAO L76K GNSS. Solar + battery, outdoor-rated.



Boards will be available for the Hackathon on friday !

Community Networks

The mesh you test on is production for somebody else.

1. **It is not your infrastructure**
   Repeaters are volunteer-owned — solar, on a roof or a summit. Their power budget can be limited.

2. **Airtime is shared and capped**
   Every test packet is airtime nobody else can use, on the one channel everyone shares.

3. **Flooding multiplies your mistakes**
   A chatty test node is not a local problem.

4. **You are visible**
   Community maps show your node, its role and its traffic. They show misbehaviour just as clearly.

BEFORE YOU DEPLOY

Try to contact the local community to tell what you are putting on the air.

LoRa Mesh Networking with RIOT

RIOT SUMMIT 2026

Nicolas ALBAREL, Didier DONSEZ











