


# Tutorial: **Towards Ubiquitous RFID Infrastructure**

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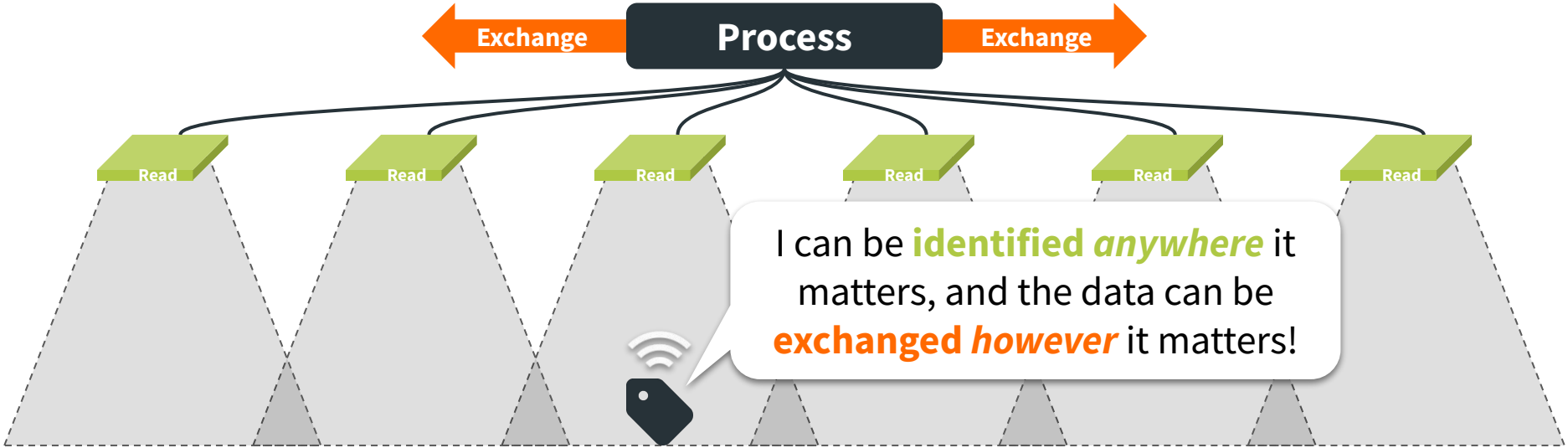
# Towards Ubiquitous RFID Infrastructure

**Abstract:** Tags, tags, tags! **44.8 Billion** RAIN RFID tag ICs and **5.4 Billion** Bluetooth devices shipped in 2023 alone. That's 50 Billion "things" that can be identified, using radio-frequencies, **at a range of several metres**. So, do we have reader/gateway infrastructure deployed every few metres throughout the physical spaces in which potential RFID applications abound (i.e. everywhere)? *Not yet.* Do we have, in those same physical spaces, edge processing infrastructure and middleware ensuring **interoperability** and facilitating **data exchange** within an ever-evolving **ecosystem** of software applications? *Not yet.* However, we may be closer than you think! This tutorial will provide an overview of the current state of RFID infrastructure, and present a path towards ubiquitous RFID infrastructure, including live demos and audience interaction.

# Can we achieve this?




For *any* standard active/passive RFID technology?

# Standard passive & active RFID

**44.8 Billion**

IC Shipments in 2023

RAIN RFID

Source: RAIN Alliance

**5.4 Billion**

Device Shipments in 2023

Bluetooth®

*Specifically Bluetooth Low Energy

Source: Bluetooth SIG

With RAIN RFID and Bluetooth Low Energy alone,

that's **50 Billion "things"** per year

that can be **identified**, using radio-frequencies

at a **range of several metres**.

*Cumulative* RAIN RFID & Bluetooth Low Energy shipments to date are likely on the order of **250 Billion**!

# The challenge…

Hundreds of billions, and counting…


**Radio-identifiable "things"**

**Radio-identification infrastructure**

PART 1

# A **reader/gateway** every few metres?

I may not be **RFID**…


…but I'm ubiquitous.

Heads up *(literally)*! **WiFi access points** (APs) are deployed throughout buildings and across campuses, often every 10-20m.

I already support **2.4GHz**, so why not support Bluetooth Low Energy?



*Specifically Bluetooth Low Energy

**Tens of millions**, if not more, deployed WiFi APs include a Bluetooth Low Energy radio—*that's active RFID!*

# Fun Fact!

At reelyActive, we're currently working with hospitals, schools, museums, airports and even nuclear power plants where the **existing WiFi infrastructure** serves as Bluetooth Low Energy infrastructure for applications such as asset tracking and environmental sensing.

Aren’t your frequencies too low,
and your antennas too big?


?


Can UHF Passive RFID piggyback on existing WiFi infrastructure?

🤔

Some of us WiFi APs have a spare **PoE** PSE port…

…I can accept your **power** *and* **connectivity**!

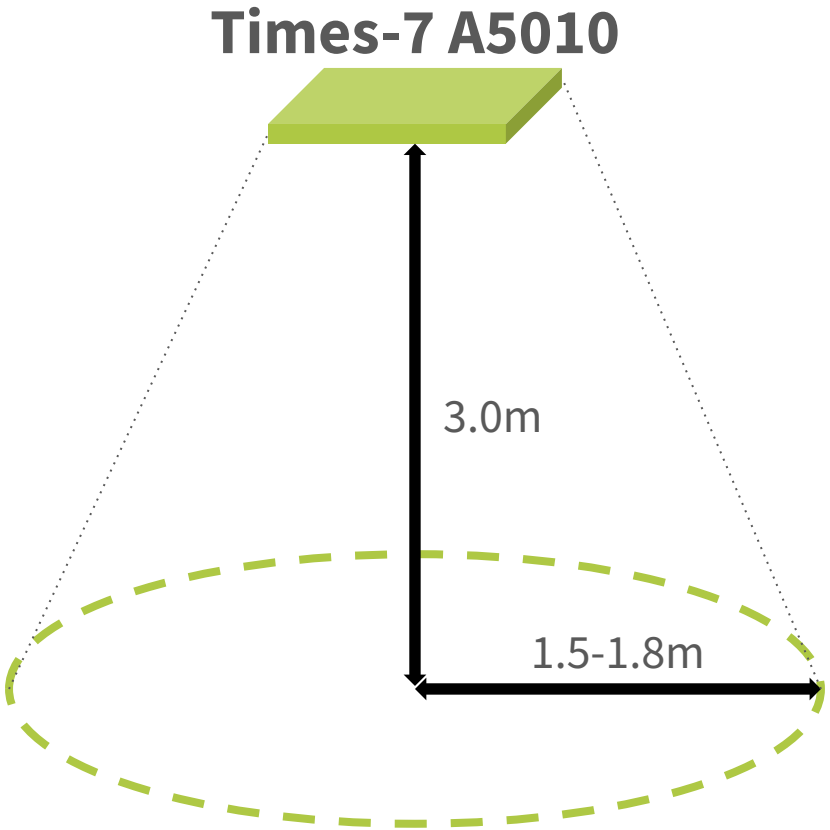

Power over Ethernet

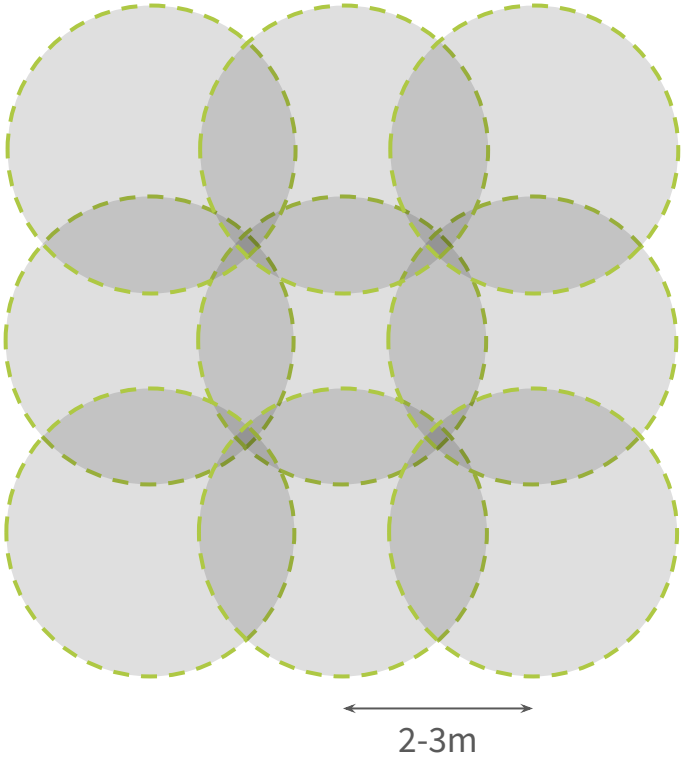
WiFi APs can power and connect common RAIN RFID readers using a single cable, if they can act as **PoE** Power Sourcing Equipment (PSE).


Yes, those are **32 antennas** piggybacked on a single WiFi AP!

# What **coverage** can be expected of a ceiling-mounted RAIN RFID antenna?

Source: Times-7






Ceiling-mounted UHF passive RFID antennas might be spaced every **2-3m**, resulting in an average coverage of about **5-10m²** each.

# Coverage per reader?

32

x 5m²

**160m²**

to

32

x 10m²

**320m²**

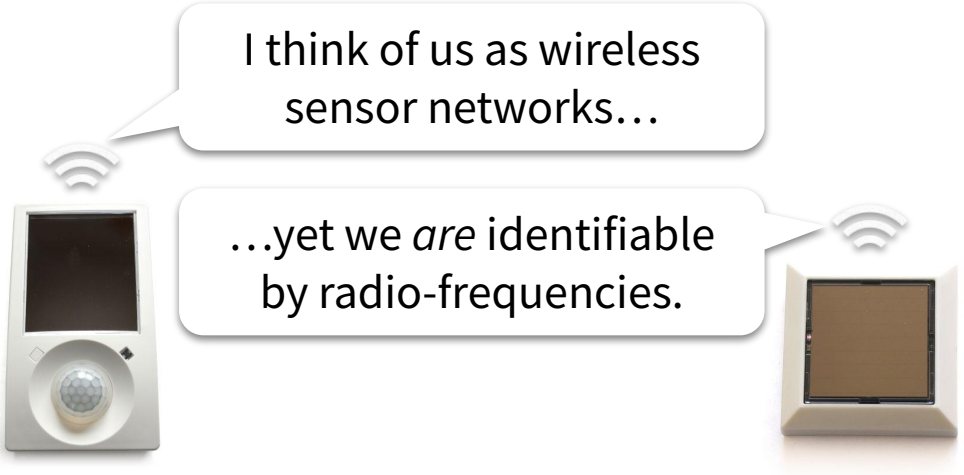
A WiFi AP will often cover 2500ft² (**240m²**). ✓

# Beyond RAIN & BLE?

Us WiFi APs with a spare **USB** port can accept…


…dongles!

# Example: EnOcean Alliance

# Summary: PART 1

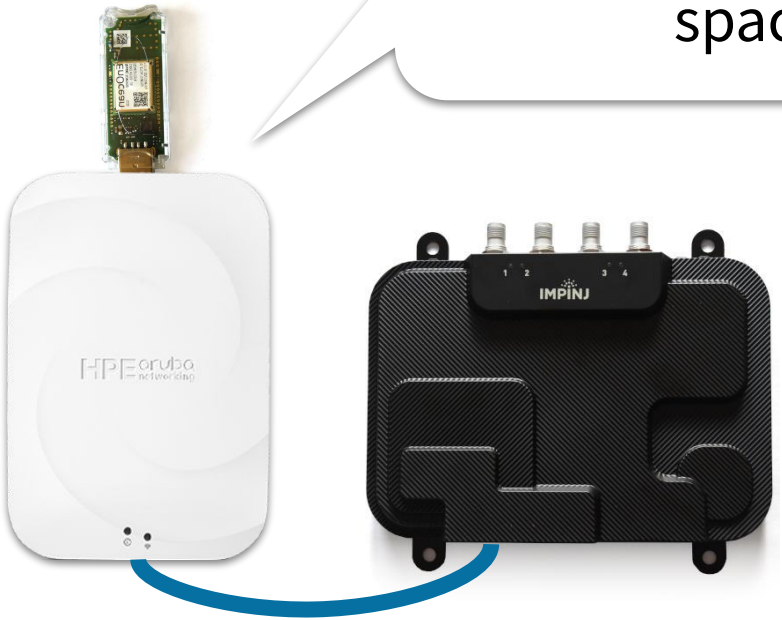
Ubiquitous **WiFi** can also serve as **Bluetooth Low Energy** infrastructure, often affording power and connectivity for **RAIN RFID** as well as other technologies—*all of which provide similar range/coverage.*

~~Parallel~~ Piggyback infrastructure. ✓

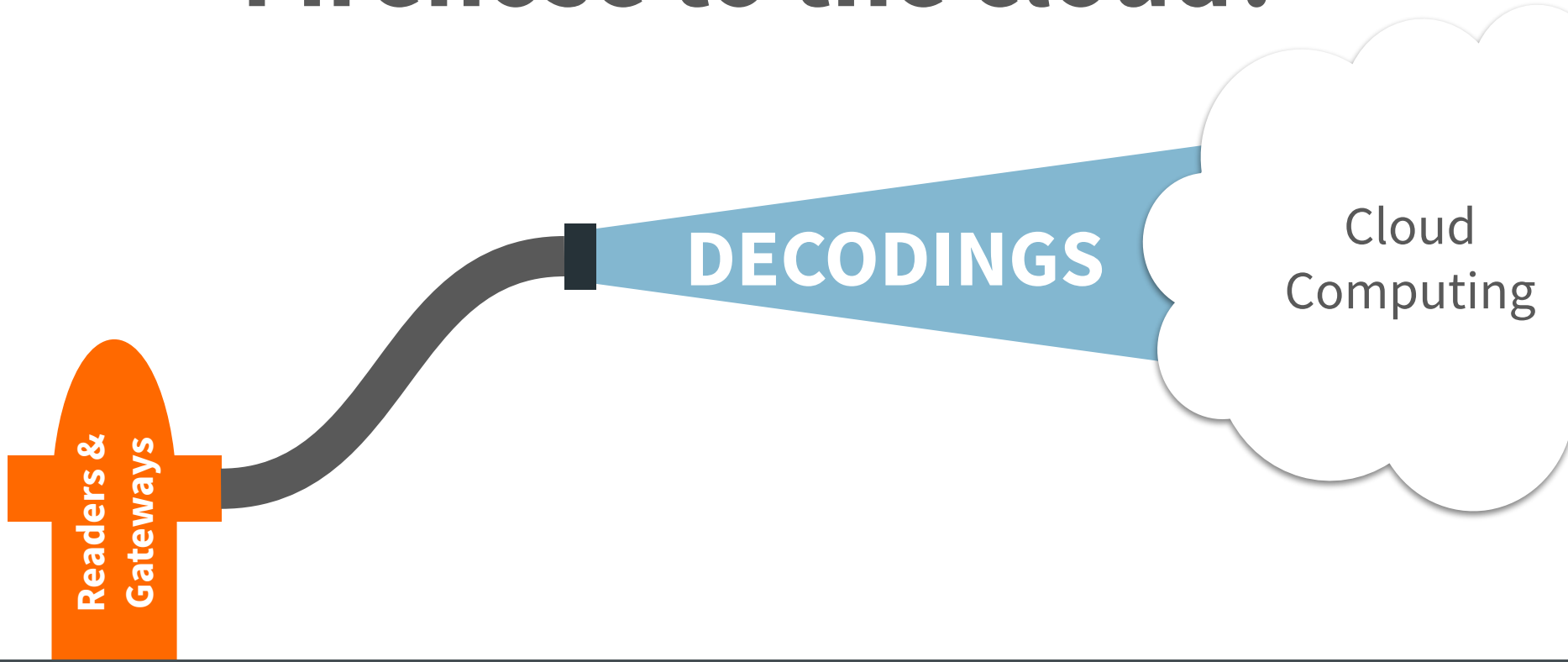
PART 2

# Edge **processing** infrastructure?

Okay, we're decoding radio packets and reading tags throughout physical spaces, **now what?**



# Firehose to the cloud?



# RFID breaks the Internets?

**100 Gigathings**
x **1kbps** decoding
**100Tbps**

Current total
Internet bandwidth*
**>1000Tbps**

*Source: AI summary of Web search

Reading & forwarding every “thing” every second could consume **~10%** of Internet capacity.

# IoT cloud isn't *every*thing

Currently, it's really just for IP-connected "things"

## AWS IoT Core

Easily and securely connect devices to the cloud

Get started with AWS IoT Core

**2.25 million connection minutes and 500,000 messages per month**

for 12 months with the AWS Free Tier

## Azure IoT Hub

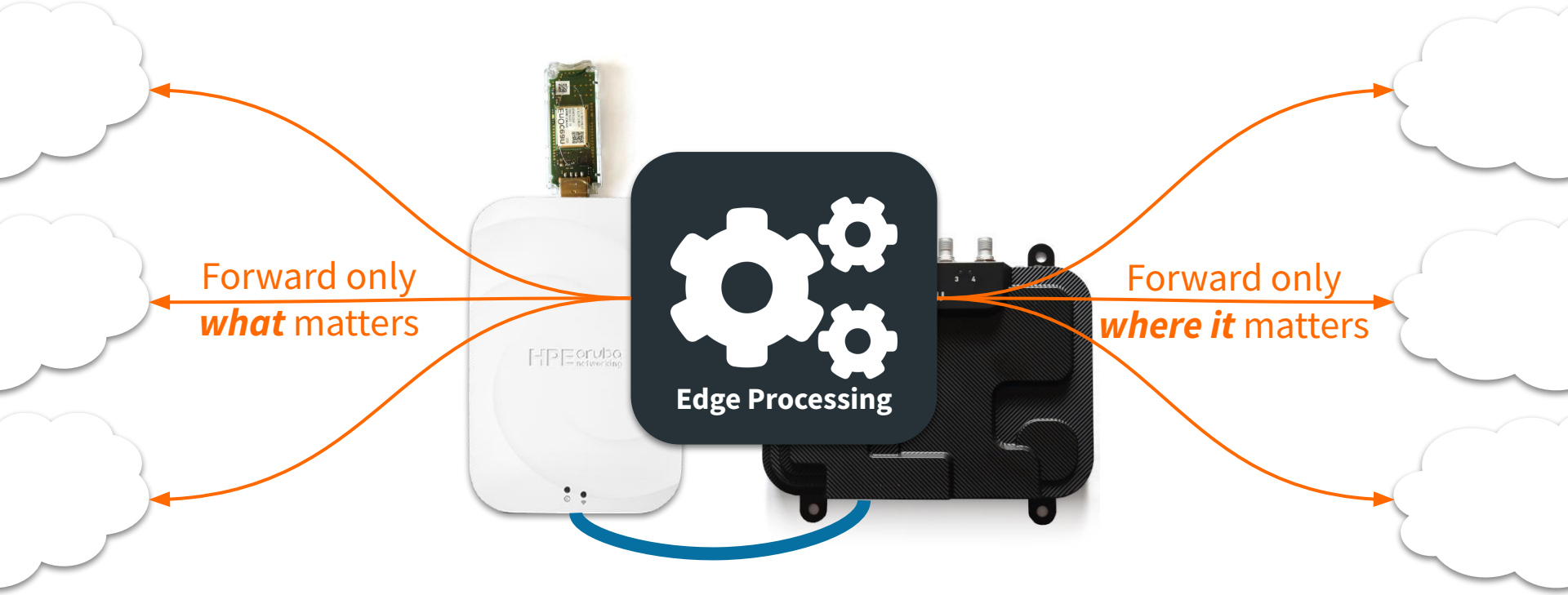
Connect, monitor, and manage billions of IoT assets.

Try Azure IoT Hub free

Create a pay-as-you-go account

Free tier: **8,000** daily messages

# A little edge wouldn't hurt



# Middleware at the Edge

**Pareto Anywhere** is reelyActive's **open source** IoT **middleware**

I'm written in **Node.js**!

And MIT-Licensed, open source on GitHub.


I can run ***anywhere***, including at the edge!

See www.reelyactive.com/pareto/anywhere/
and github.com/reelyactive/pareto-anywhere/

# Edge-embracing hardware

I can run containerised code!
(Aruba AOS 10)


I can run embedded applications!

# Mo Protocols Mo Problems

I represent data *my* own way.

I represent data *my* own way.


I represent data *my* own way.

No standard, protocol-agnostic way to represent a radio decoding?

# raddec: protocol-agnostic

```
{
    "transmitterId": "...",
    "transmitterIdType": 0,
    "rssiSignature": [{
        "receiverId": "...",
        "receiverIdType: 0,
        "rssi": -99,
        "numberOfDecodings": 1,
        "receiverAntenna": 3,
        "aoa": [ 0, 0 ]
    }],
    "timestamp": 1645568542222,
    "packets": [ '...' ],
    "events": [ 0, 2 ],
    "position": [ 0, 0, 0 ]
}
```

**Interoperability** between:

- ➔ Bluetooth Low Energy
- ➔ RAIN RFID
- ➔ EnOcean Alliance
- ➔ WiFi
- ➔ Proprietary RFID
- ➔ …

See reelyactive.github.io/diy/cheatsheet/ and github.com/reelyactive/raddec/

# Publication pending…

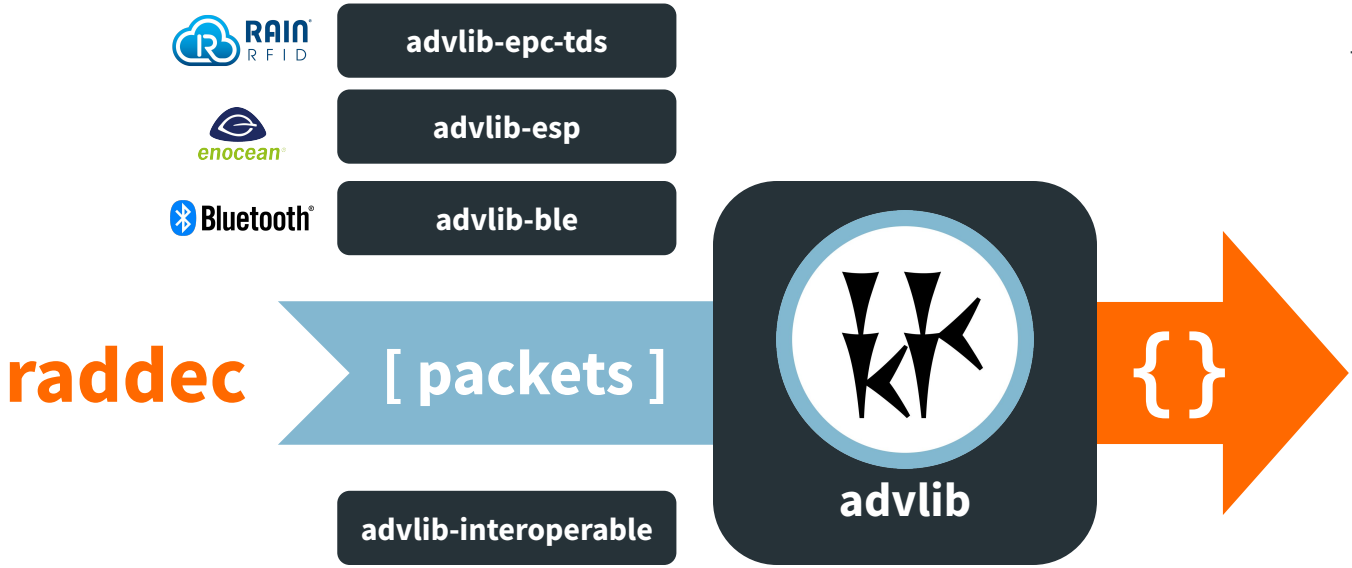

IEEE 10th World Forum on Internet of Things
10–13 November 2024 // Ottawa, Canada

## raddec: Elevating IoT Interoperability Through a Common Radio Decoding Data Format

Jeffrey Dungen
*reelyActive*
Montréal, Québec, Canada
jeff@reelyactive.com

# A single data structure

# *Another* single data structure




```
{
  acceleration: [ 0.2, 0.9, 0.3 ],
  batteryPercentage: 50,
  deviceIds: [ '...', '...' ],
  heartRate: 60,
  illuminance: 333,
  isButtonPressed: [ false ],
  isContactDetected: [ true ],
  isMotionDetected: [ false ],
  magneticField: [ 0.7, 0, 0.1 ],
  name: "advlib by reelyActive",
  position: [ -73.5, 45.5, 88 ],
  relativeHumidity: 69,
  temperature: 21.0,
  txCount: 123456789,
  unicodeCodePoints:[ 0x1f989 ],
  uptime: 60000,
  uri: "https://...",
  uuids: [ '...', '...' ],
  version: "1.2.0"
}
```

See github.com/reelyactive/advlib/

# Makes sense at the edge

You can represent **who/what** is **where/how** as web-standard JSON, what we call **hyperlocal context***, in a *vendor*-agnostic, *technology*-agnostic and *application*-agnostic way.

And it's all open source, real-time, running at the edge.

See www.reelyactive.com/context/
and our IEEE RFID 2022 tutorial

# Summary: PART 2

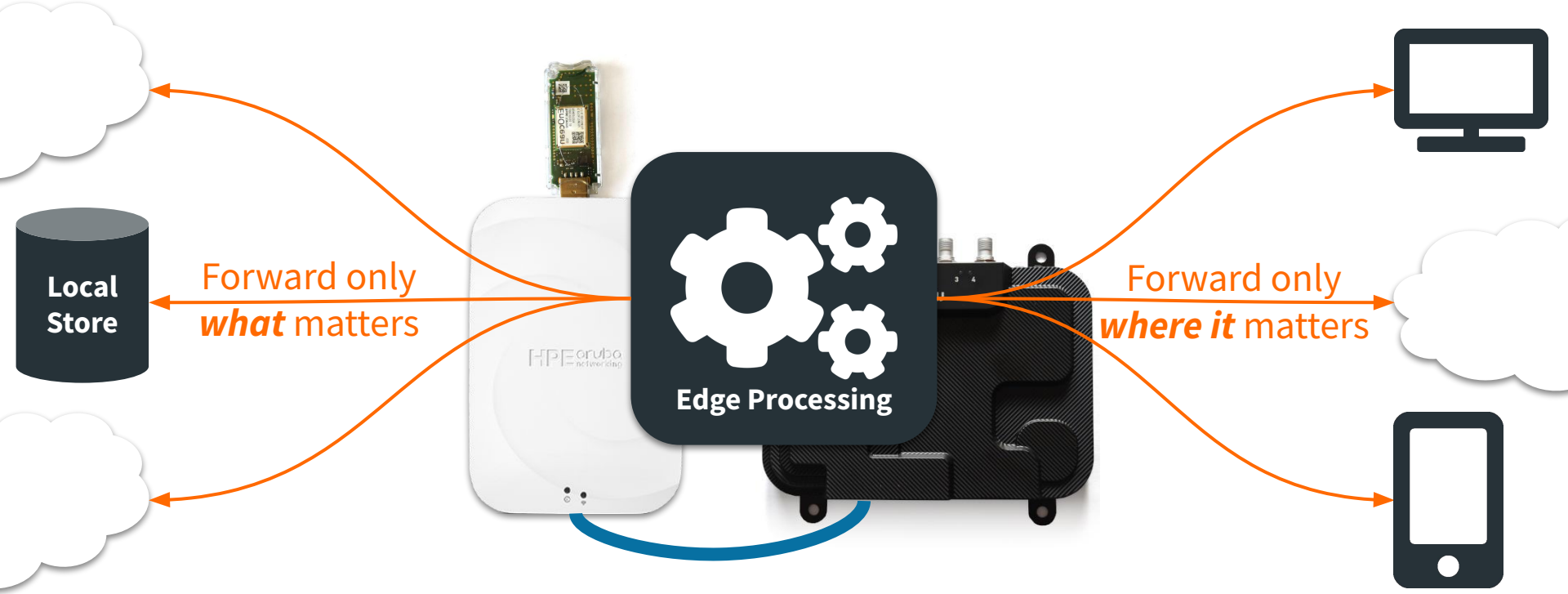
Ubiquitous **WiFi** and **reader** hardware affords edge processing capabilities for lightweight **middleware**, which can make sense of the data in a vendor-and-technology-agnostic way.

Infrastructure with an edge. ✓

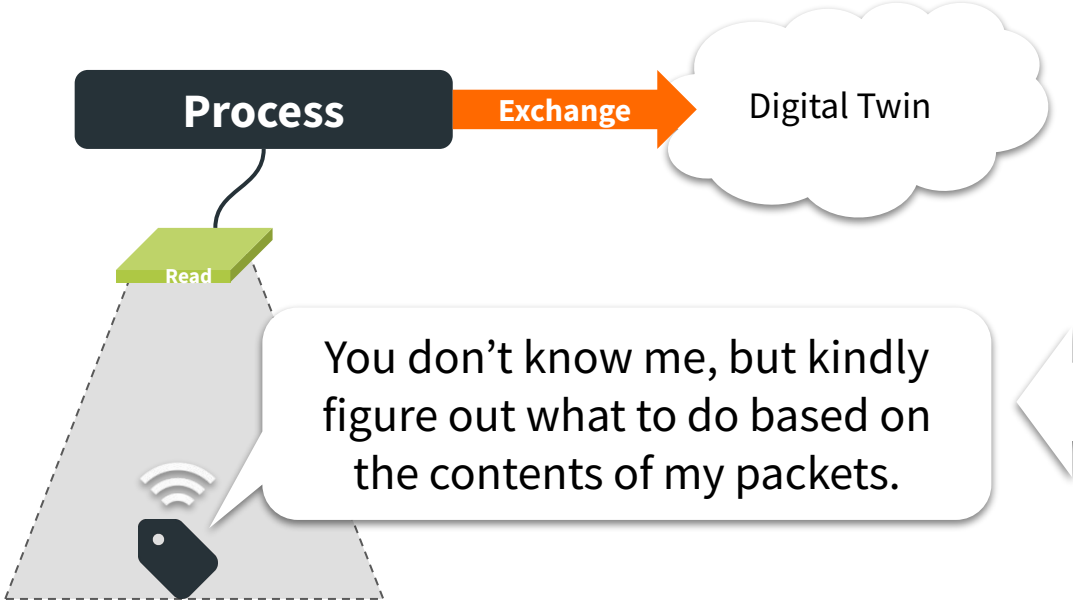
PART 3

# Data **exchange** infrastructure?

# Exchange what, where?



# We need to “resolve” this




## ISO/IEC DIS 18975

This standard will define an approach for using HTTP URIs as identifiers in AIDC systems.

**IEEE CRFID and RAIN Alliance Challenge**

Design a web resolver that connects physical things to their digital twins in the cloud, enabling people to securely access their twins.

## Bluetooth (GAP) URI

Short URIs only!

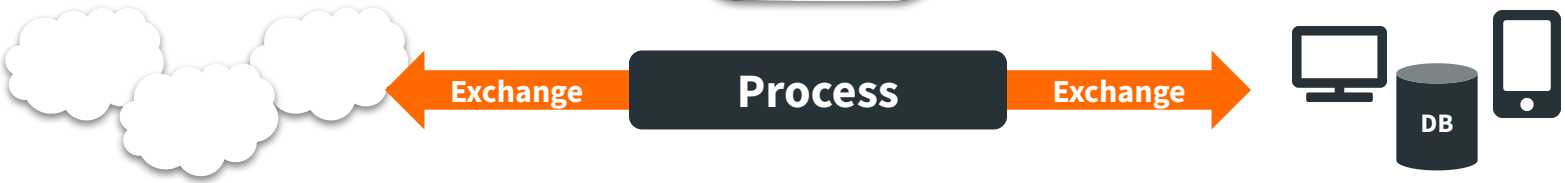
# More than WAN option

I give you **the Internet**.

I can also give you a **local** wireless network...

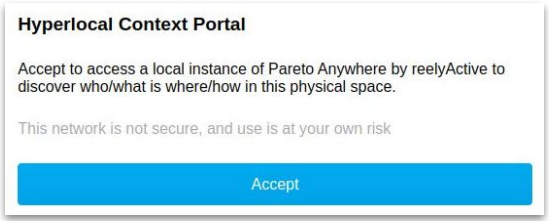

**WAN** ✓

**LAN** ✓



# Free WiFi with an IoT twist!

**SSID**: Hyperlocal Context

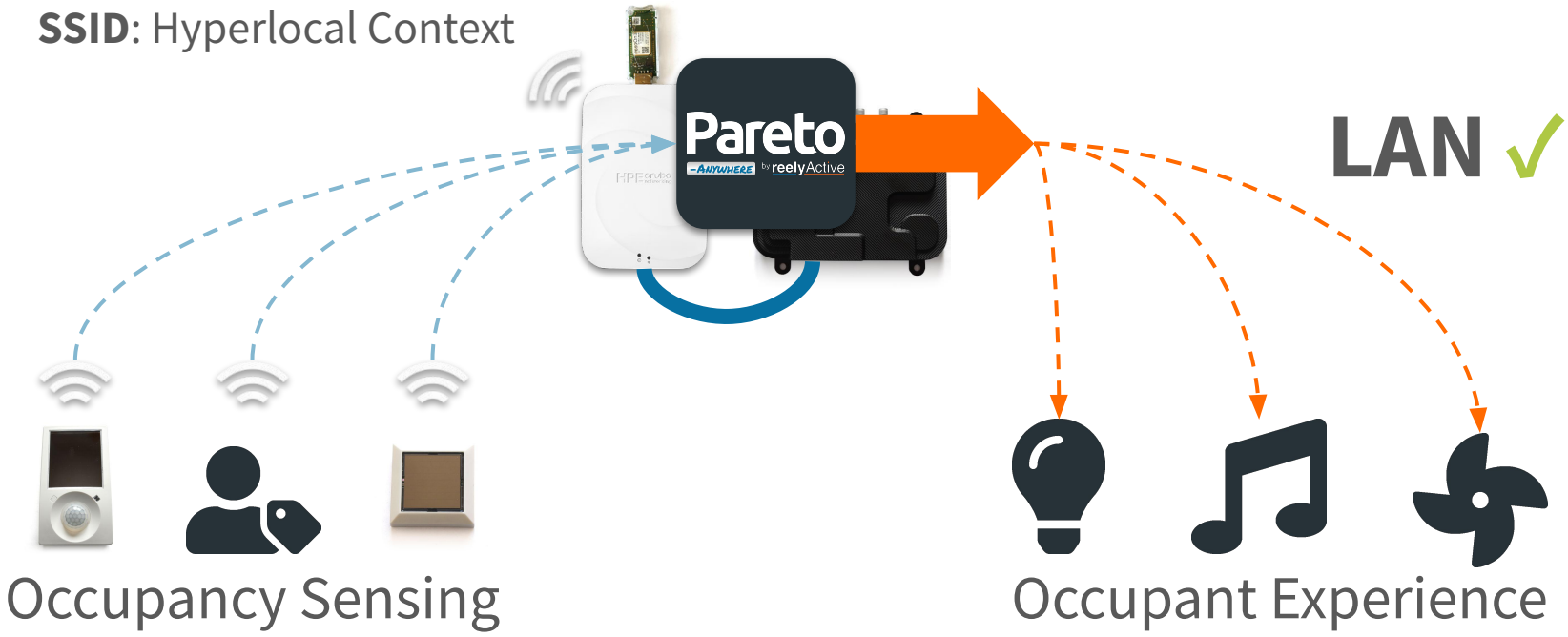




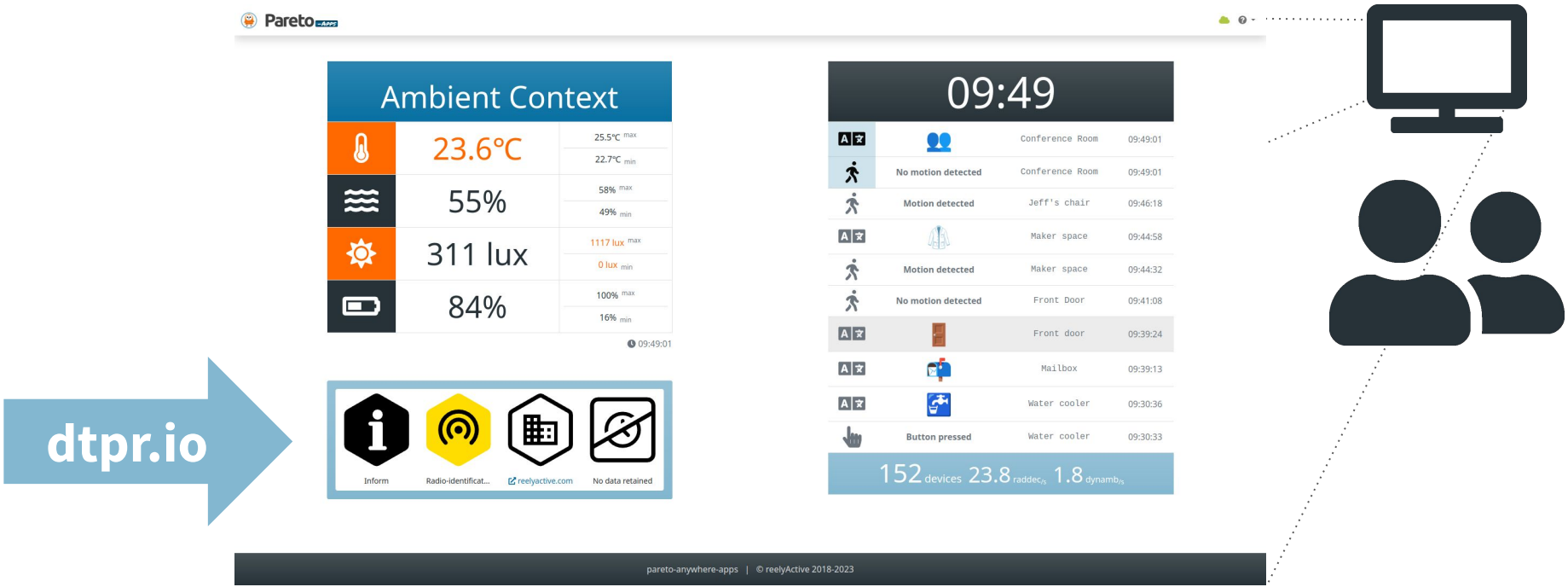

1 Connect to WiFi through **captive portal**

2 GET /context

# Look ma, no clouds!



# Humans may be present too!



# Fits in a carry-on

Pareto
-ANYWHERE by reelyActive
on an industrial
Raspberry Pi 4

enocean

Bluetooth

RAIN RFID

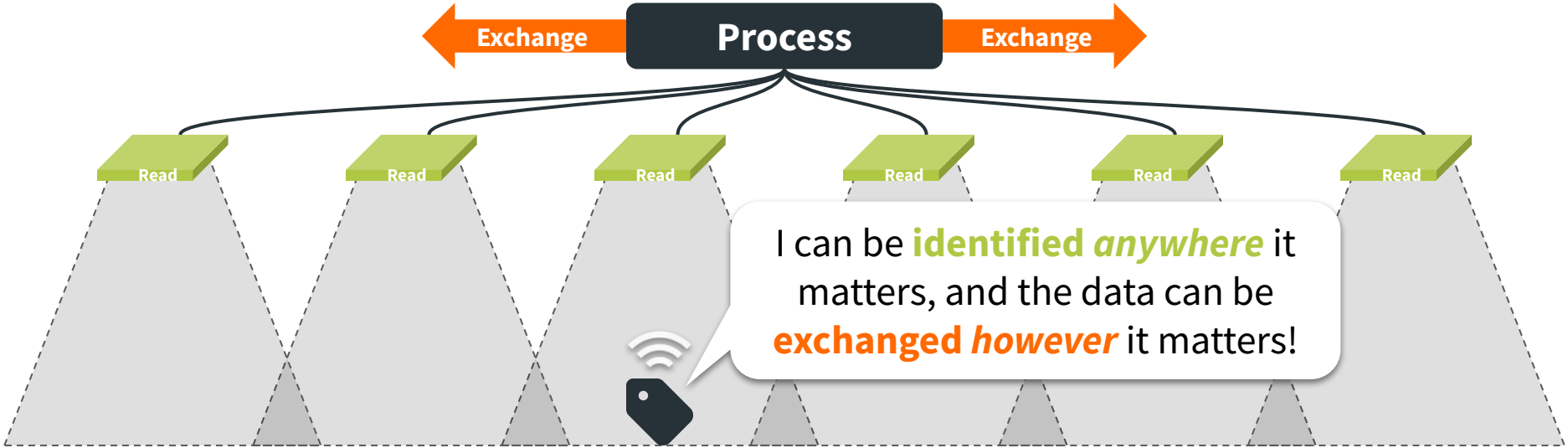
reelyactive.com/the-briefcase-kit/

# Summary: PART 3

Data exchange can be facilitated by the **WiFi network infrastructure** already in place, both locally (**LAN**) and across the Internet (**WAN**). Looking up digital twins to facilitate exchange could be better resolved.

Emerging exchange infrastructure. ✓

# Mission Accomplished?




For *any* standard active/passive RFID technology?

# Towards Ubiquitous RFID Infrastructure

1. Piggyback on *existing* ubiquitous infrastructure.
2. Process into *useful* data at the edge.
3. Promote exchange using *emerging* standards.

# Towards Ubiquitous RFID Infrastructure

Presented by Jeffrey Dungen
Co-founder & CEO of reelyActive
at IEEE RFID 2024 in Cambridge, MA

www.reelyactive.com | reelyactive.github.io