# Ten Years of RIOT

## The Past, the Presence, the Future

Peter Schmerzl

September 18, 2023

# Alternative Facts

> **What could have been?**
>
> "We have to rethink the real in order to advance into the possible."[1]

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[1] Friedrich Dürrenmatt, Justiz

# Collaborating with a Big Player

# RIOT on Sale

# Specialization

# The Niche Product



Photo by Kate on Unsplash

# Academic Context

# The Fate of Research Projects

# Agenda

1. **What has been**
   - Lighthouse Projects
   - RIOT by the Numbers
   - Milestones
   - The Community

2. **How it all started**
   - RIOT's Roots
   - Anecdotes

3. **Pivotal Decisions**
   - The Good
   - The Bad
   - The Ugly

4. **Where are we going?**

# Agenda

# Academia, Industry, Makers



### Catering for many Needs

RIOT's vision from the start was to provide an OS that meets the needs of industrial, academic and private users alike.

Photo by Nathan Dumlao on Unsplash

# Lighthouse Projects

# Home Automation with KNX

## IoT is not always wireless



Author: Bas Stottelaar, @BasilFX

# Vehicle access & telematic unit for car sharing

## RIOT can open Doors for you



Author: Continental/OTAkeys

# CubeSATs

We are going to outer space ...



Author: ThingsSat, Grenoble university space centre, Didier Donsez

# Many amazing Projects

- Torque Wind Turbines
- Energy–Aware Urban Sensing
- A Decentralized Mesh Network as Fallback
- Leak Water Detection
- Dropwatcher: Measuring drip irrigation rate in heap leach for Mining
- Many more...: Check and share at
  *https://www.hackster.io/riot-os*

# RIOT by the Numbers

# Git Statistics

- $>$ 450 Contributors
- $\approx$ 30,000 Commits
- $\approx$ 16,500 merged Pull Requests
- $\approx$ 1,900 Forks on GitHub

# Code Statistics

- C Code: $\approx$ 2,100,000 Lines of Code
  - Kernel: $\approx$ 3,800
  - Network Stack: $\approx$ 47,000
  - Shell: $\approx$ 9,500
  - Drivers: $\approx$ 95,000
  - CPU: $\approx$ 1,600,000

- Assembly: 332 Lines of Code

- Makefiles: $\approx$ 13,000 Lines of Code

# Release Statistics

- 36 Releases
- 685 Commits per Release (Median)
- 46 Contributors per Release (Median)
- 1,800,000 Lines of Code per Release (Average)

# Feature Statistics

- 264 Supported Boards
- 8 CPU Families
- 11 Network Device Drivers
- 75 Sensor & Actuator Drivers
- 101 Packages
- 6 Network Stacks

# Milestones

# Core Features

- Lightweight and efficient Kernel
- Generic IP Network Stack: GNRC
- Package System for easy integration of Third Party Code
- Unified APIs for Hardware and User Applications
- Fully Integrated Build System

# IPv6 Networking

- From "Let's implement 6LoWPAN..." (2011)...
- ...to "The border router should be ready soon"...
- ...to "I can ping my Desktop PC" (2015).

**Today**

Connecting to the Internet is a matter of seconds

# Fairs, Exhibitions, and Demos

- Linux Tag
- CEBIT
- IETF Bit'n'Bytes
- Embedded World
- Lange Nacht der Wissenschaften
- ETSI Plugtests (6LoWPAN, CoAP, 6TiSCH)
- Scientific Conferences: Infocom, ICN, EWSN
- And more ...

# Industry Collaboration

- Phytec
- Cisco
- Loci Controls
- Eistec
- Continental (OTAKeys)
- Locha Mesh
- Zühlke

- SSV
- WolfSSL
- Mesotics SAS
- TriAgnoSys GmbH
- SODAQ
- ML!PA
- And more...

# The Community

# Interaction

- Chats (IRC, Matrix ...)
- Mailing Lists and Forum
- Regular Events (Hack'n'Ack, Sprint Day ...)
- GitHub

`devel` Mailing List Traffic
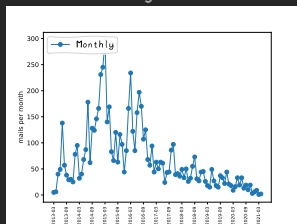


Forum Traffic
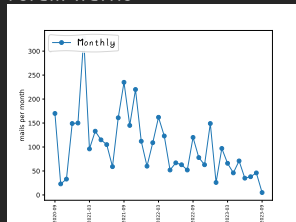
# The Summits

- First Summit in 2016
- Berlin, Amsterdam, Helsinki, Hamburg, Frankfurt, and online
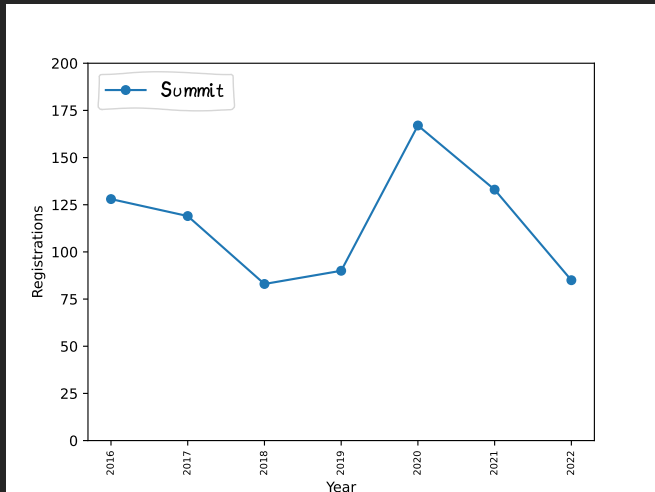
# Agenda

# RIOT's Roots

- The Limitations of WSN OS (TinyOS and Contiki)
- 2009: FeuerWare and Firekernel at FU Berlin[2]
- 2012: Reboot as µkleos
- 2013: First Release on GitHub

_____

[2]Will, Heiko, Kaspar Schleiser, and Jochen Schiller. "A real-time kernel for wireless sensor networks employed in rescue scenarios." 2009 IEEE 34th Conference on Local Computer Networks. IEEE, 2009.

[3]Levis, Philip. "Experiences from a Decade of TinyOS Development." 10th USENIX Symposium on Operating Systems Design and Implementation (OSDI 12). 2012.

- The Limitations of WSN OS (TinyOS and Contiki)
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### Lessons Learned from a Decade of TinyOS[3]

- Keep it simple
- Stick to the Standards
- Build a Community
- Bundle your Code

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# Anecdotes

# Finding a Name

- Fringe OS
- SchmerzlOS
- FOSSIT
- TicklOS
- FreeBearOS
- Wunix
- zeitlOS
- purpOS
- curiOS
- kronOS

- TeepitOS/TepitOS
- TOS/TTOS
- OSOT/OST/OS-T
- SOOS/SmOOS
- OSSO
- FU-BROS
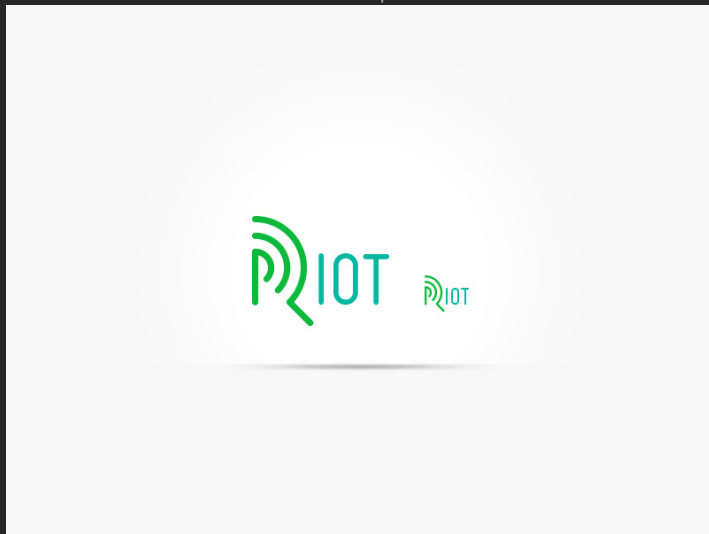- MyBROS
- FireKernel
- emix
- embrios

# ...and a Logo

## First Proposals

# ...and a Logo

First Proposals

## ...and a Logo

The Counter Proposal

...and a Logo

New Directions

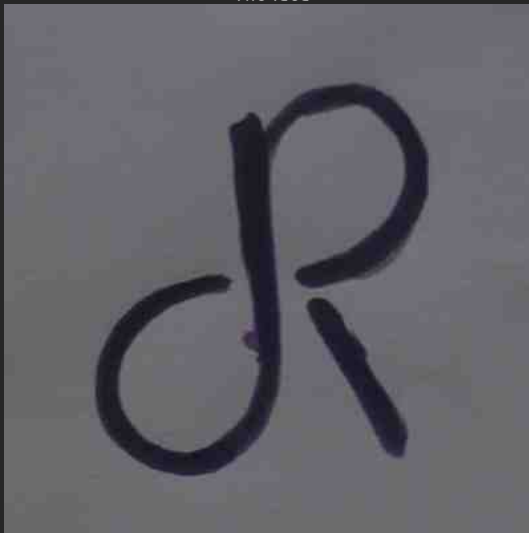...and a Logo

New Directions

## ...and a Logo

The Idea

## ...and a Logo

The Idea

## ...and a Logo

Finally

# When we almost sold RIOT



Photo by Jean-Luc Benazet Unsplash

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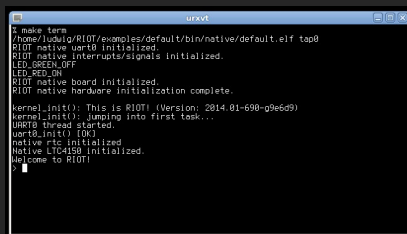   - The Good
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4. Where are we going?

# The Good

# Open Source and Open Standards



- Be Open
- Stick to the Standards
- Stand on the Shoulders of Giants

# RIOT Native



- Developing Software for Embedded Systems can be painful

- Having access to the right Hardware with you is challenging

- Debugging and Testing is limited

  $\implies$ Virtualization to the rescue

# The Shell

- Runtime Configuration instead of Reflashing

- Interactive Data Retrieval

- Easy Access for *NIX Users

```
> ifconfig
Iface   7    HWaddr: 1d:12    Channel: 26    Page: 0    NID: 0x23
             Long HWaddr: 36:32:48:33:46:d5:9d:12
             TX Power: 0dBm    State: IDLE    max. Retrans.: 3    CSMA Retries: 4
             ACK_REQ    CSMA    MTU:1280    HL:64    6LO    RTR    IPHC
             Source address length: 8
             Link type: wireless
             inet6 addr: fe80::3432:4833:46d5:9d12    scope: local VAL
             inet6 group: ff02::1
             inet6 group: ff02::1:ffd5:9d12
             inet6 group: ff02::1a

> ping6 fe80::3432:4833:46d8:7c2a
12 bytes from fe80::3432:4833:46d8:7c2a: id=83 seq=1 hop limit=64 time = 6.554 ms
12 bytes from fe80::3432:4833:46d8:7c2a: id=83 seq=2 hop limit=64 time = 8.473 ms
12 bytes from fe80::3432:4833:46d8:7c2a: id=83 seq=3 hop limit=64 time = 7.193 ms
    fe80::3432:4833:46d8:7c2a ping statistics
3 packets transmitted, 3 received, 0% packet loss, time 2.0628106 s
rtt min/avg/max = 6.554/7.406/8.473 ms
```

# The Bad

# Threatdful Networking



Photo by Stephane Gagnon Unsplash

- GNRC is super powerful and flexible – and super complex
- Threads introduce Runtime and Memory Overhead
- Difficult to trace a Packet through the Stack
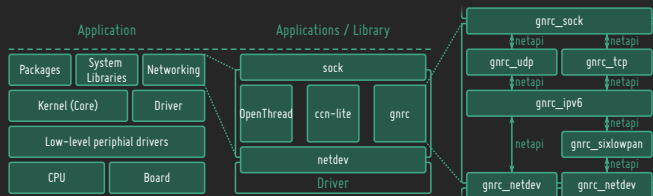
# The Build System

- Abusing Make
- Complexity became out of control
- The Transition to KConfig is a neverending Story
- What's next?

# The Ugly

# Licenses

- The Linux Way
- The Longest Discussion in RIOT's History
- Protection or Handicap?

# API Design



- General Purpose
- Heterogeneous Hardware
- Hard to get it right
  - Timers
  - Periph
  - Sockets
  - ...

# The Weird

# pyterm

Twisted not available, please install it if you want
to use pyterm's JSON capabilities

# pyterm

`Twisted not available, please install it if you want to use pyterm's JSON capabilities`

- "Nothing lasts longer than a provisional"
- Besides `make` probably the one most frequently called tool
- Yet, noone knows about all its features

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# The Roadmap

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Emmanuel Baccelli edited this page May 29, 2020

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Evergreen Topics:

- Security
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- Build and Configuration Management
- Testing
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Even more important:
Do we have a clear vision?

# Hostile Environments

- In terms of Money and Person Power RIOT cannot compete with ARM, AWS, or Intel
- The License and the Community makes RIOT distinctive, but what else?
    - Memory Footprint?
    - Rust Support?
    - Focus on Networking?
- Imagine an Internet without Linux – Do we want an IoT without FLOSS?

# Credits

# RIOT's League of Legends

RIOT has a hero

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RIOT has a hero

Its Community

# Unsung Heroes

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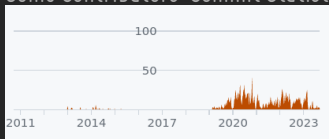- Executives: Emmanuel Baccelli, Thomas Schmidt, Matthias Wählisch

# Steady Contribution
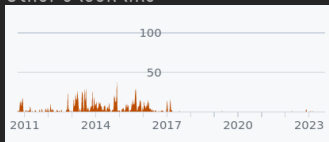
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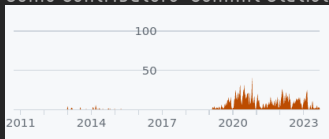
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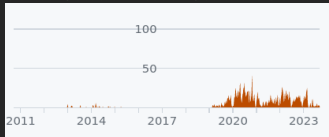Some Contributors' Commit Statistics look like
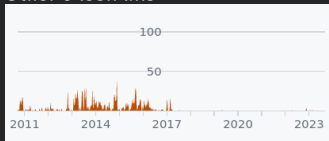


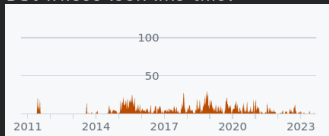Other's look like

# Steady Contribution

Some Contributors' Commit Statistics look like



Other's look like



But whose look like this?

# Unsung Heroine

RIOT's Unsung Heroine is actually a singing Heroine:



Martine Lenders aka @miri64

www.riot-os.org