Everything Open 2024

Dante®

Transitioning from FreeRTOS to Zephyr RTOS: A Product Refresh Journey

Elton Shih

About us

Elton Shih

- Research engineer @Audinate
- Embedded systems & systems software

Audinate

- Maker of Dante (pro AV networking)

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Product Refresh Story

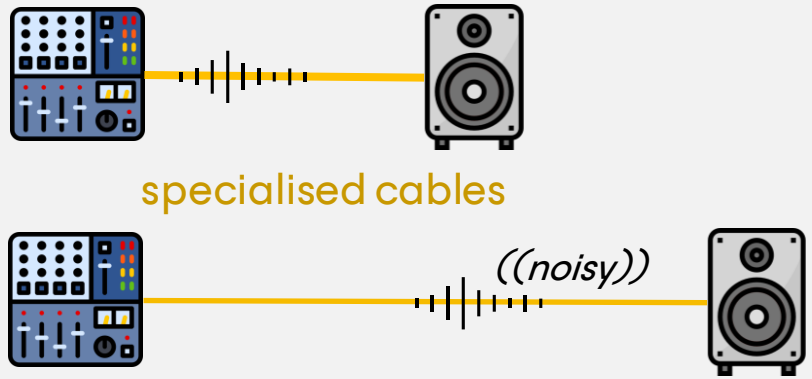
Dante Intro

Dante replaces complex audio cabling with computer networks

How does it work?

Traditionally..

Point-to-point physical connections.

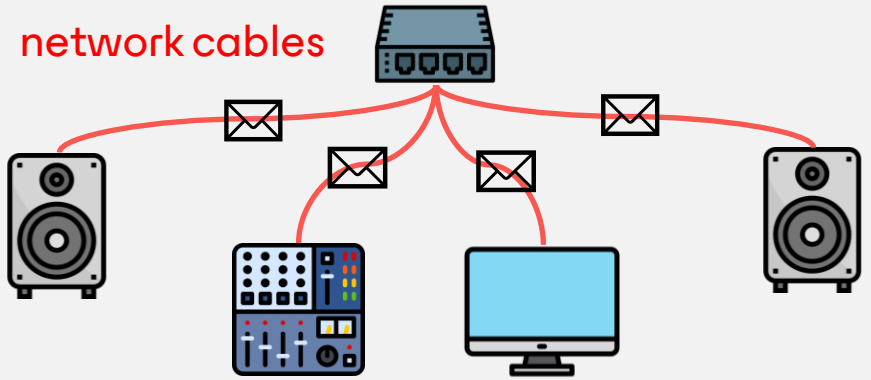


Single-purpose, specialised cables..

Labor intensive, expensive
distance ↑ noise & signal degradation

With Dante

Devices are connected to the network
Connections managed through software



Low latency, synchronize

Dante replaces complex audio cabling with computer networks

Where is Dante used?

4000+ products from manufacturers

600+ Dante manufacturers

Sydney Opera House

Sydney Trains

Recording Studios

Universities, Conference Rooms, Broadcast Studios, Corporate Campuses, Houses of Worship, Arenas & Stadiums, Conference Centres, Amusement Parks, Zoos, Theatres

Dante products

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Consumers

System Software
for system setup, management, and troubleshooting

AVIO Network Adaptors
{Bluetooth, USB, Analog} ↔ Dante

PC / Mac / Cloud Software
E.g. Virtual Soundcard and more

Manufacturers (OEMs)

Embedded Audio

Hardware

Brooklyn
Broadway
Ultimo

(Chips, Cards & Modules)

Software

Dante Embedded Platform
(Linux)

Dante IP Core
(FPGA IP)

Embedded Video

Hardware

Software

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Embedded Audio

Chips, Cards & Modules

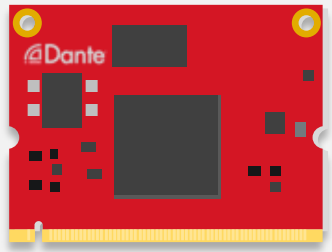
64x64 ch

Brooklyn

Broadway

4x4 ch

Ultimo



Brooklyn

FPGA-based

Suitable for mixing consoles & DSPs

Yamaha DM7 Mixer

Ultimo

MCU-based

Suitable for networked speakers & mics

Fostex Dante Speakers

Audio-Technica Dante Mic

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Product Refresh Story

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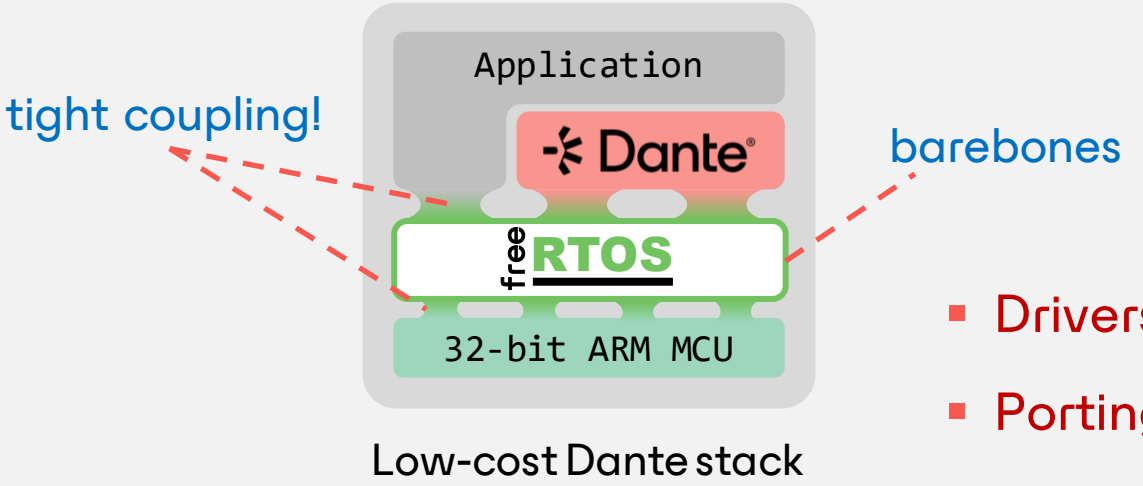
Low-cost Dante based on FreeRTOS + MCU



Low-cost Dante stack

- Drivers and implementation customised over the years
- Porting effort significant!

⚠ **Hitting resource limits**

audio encryption | cloud connectivity | new audio formats | | |

fitting more features and taking up more resources →

→ **Product refresh needed!**

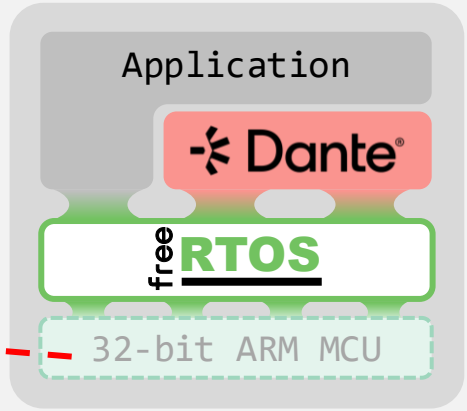
running out of space for future features

"We have plenty of time!" - 2020

2020

Ultimo Low-cost Dante based on FreeRTOS + MCU

Chip supply shortage 2021 - 2023



MCU chip shortage!

Low-cost Dante stack

Supply chain uncertainties..

- MCU vendor allocation was *VERY* dynamic
- *If...* porting overhead was minimal

→ **We can spin variant of different MCUs**

However..

- Tight coupling between RTOS & MCU makes porting hard

→ **Need to reduce reliance on single hardware portfolio**

2021

"We don't have plenty of time!" - 2021

Ultimo Product Refresh

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(Initial) MCU selection
Technical Flash, RAM, Ethernet MAC, I²S, crypto, clock speed
Non-technical BSP completeness Vendor support activities
Commercial Price & Availability

next-gen
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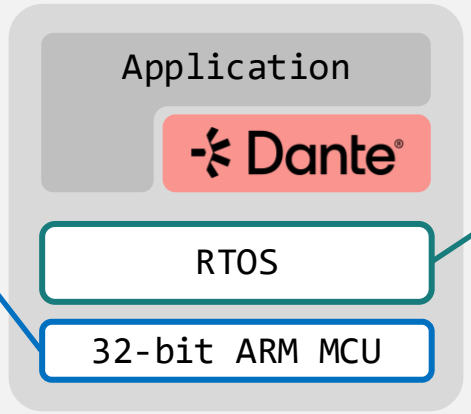
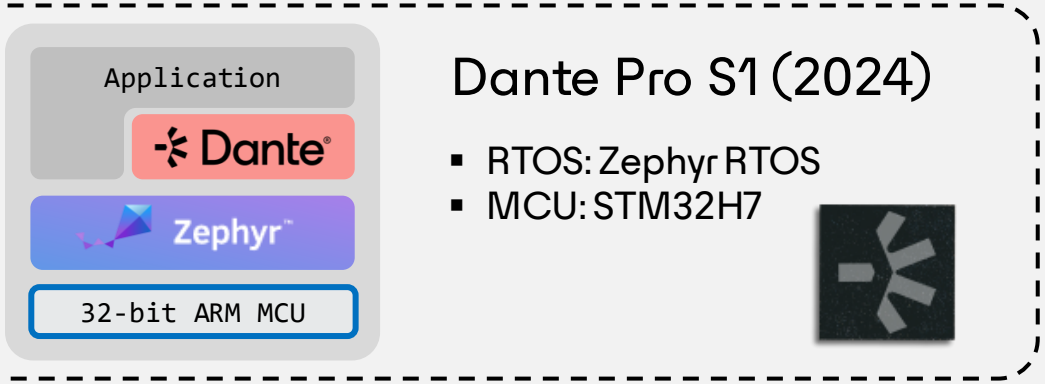


RTOS selection
Technical Modularity & Portability Network & Connectivity Security Subsystems and features
Non-technical Steering committee Cross-vendor support BSP Project Roadmaps



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Zephyr Dev Experience

Positives

RTOS Selection
Technical Modularity & Portability Network & Connectivity Security Subsystems and features
Non-technical Steering committee Cross-vendor support BSP Project Roadmaps

Zephyr RTOS

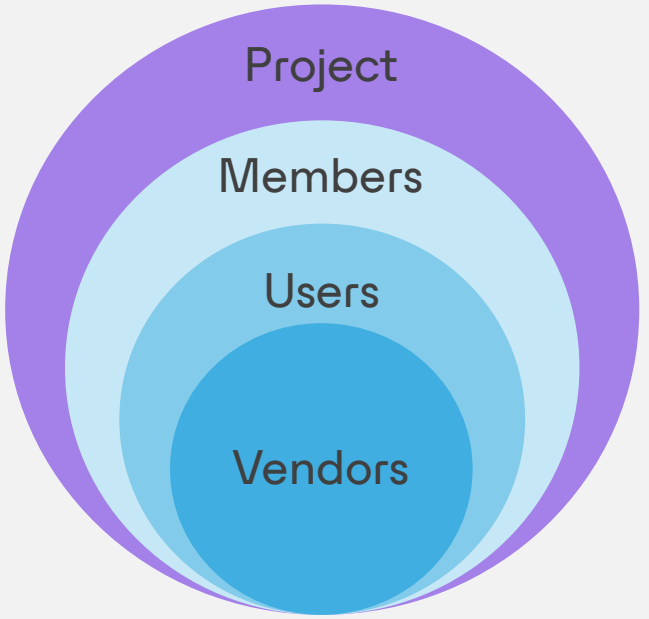
→ Vendor neutral

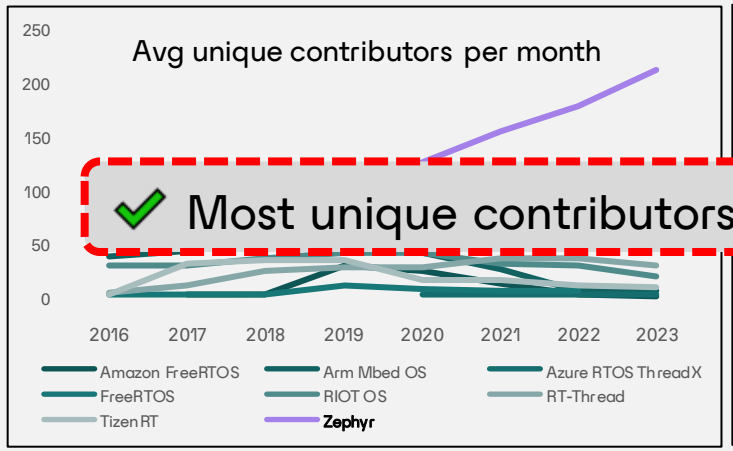
→ Vibrant community

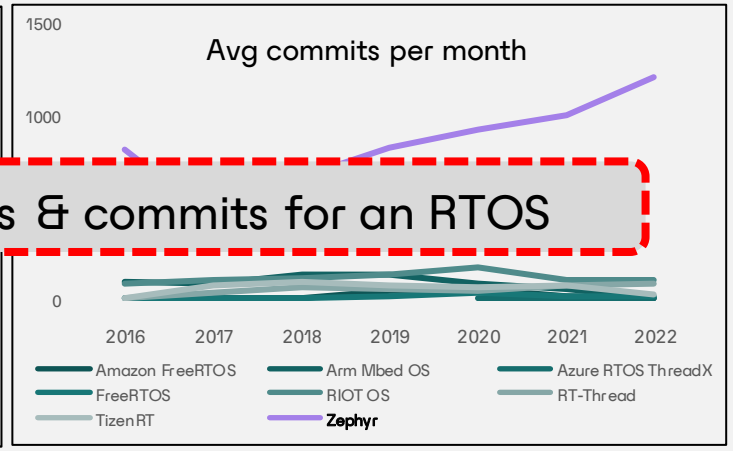
Technical Steering Committee

[Maintainer, Collaborator, Contributor]

[hobbyists, industry reps, vendors]







✔ Most unique contributors & commits for an RTOS

Cloud vendors purchasing RTOS

https://zephyrproject.org/wp-content/uploads/sites/38/2024/01/Zephyr-Overview-20240110.pdf
https://www.intel.com/content/www/us/en/developer/articles/community/zephyr-story-how-became-self-sustaining-ecosystem.html

RTOS Selection
Technical Modularity & Portability Network & Connectivity Security **Subsystems and features**
Non-technical ~~Steering committee~~ **Cross-vendor support** **BSP** Project Roadmaps

Cross-vendor support

Zephyr™ THE LINUX FOUNDATION

→ Cross-architecture

ARC	ARM	Intel x86	MIPS
NIOS II	RISC-V	SPARC	Xtensa

→ 100+ supported vendors

→ 600+ supported boards

Feature-rich

- Plenty of sample applications
- Working drivers out-of-the-box

✔ Fast prototyping & feature evaluation

Ultimo Product Refresh - **Why Zephyr RTOS?**

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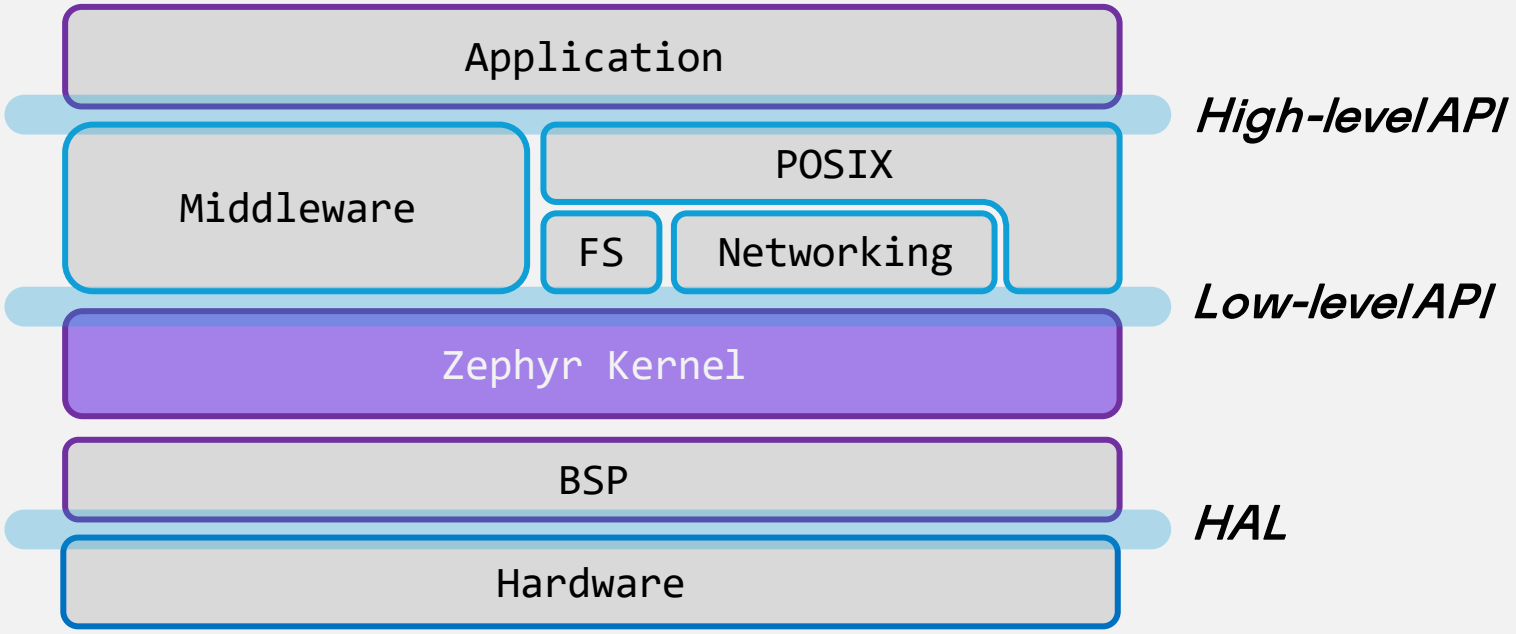
RTOS Selection
Technical Modularity & Portability Network & Connectivity Security ~~Subsystems and features~~
Non-technical ~~Steering committee~~ Cross-vendor support BSP Project Roadmaps



Ultimo Product Refresh - **Why Zephyr RTOS?**

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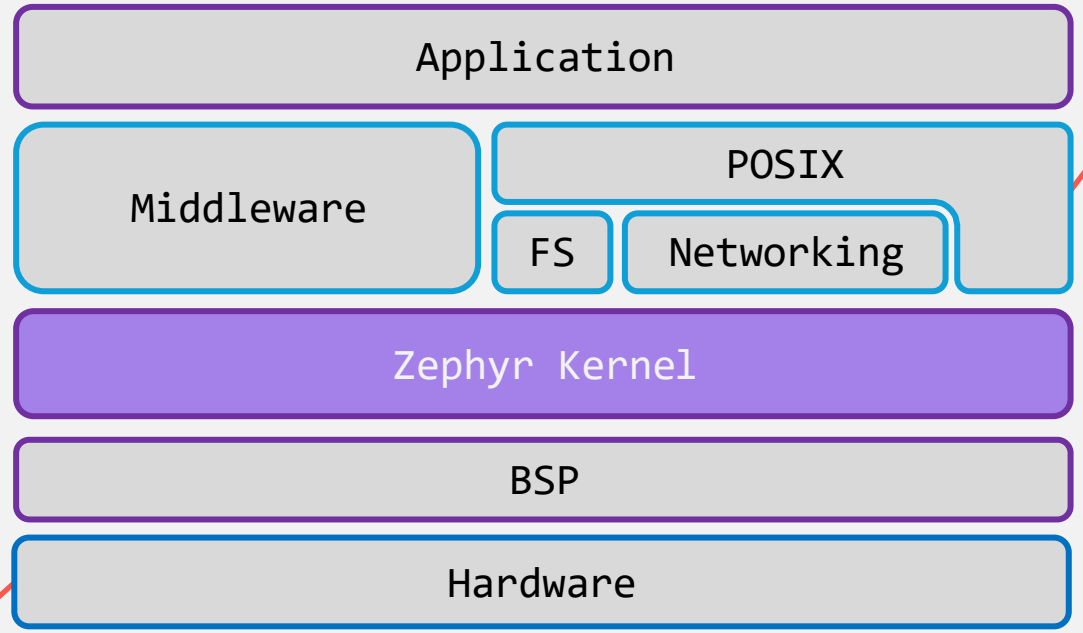
RTOS Selection
Technical **Modularity & Portability** Network & Connectivity Security ~~Subsystems and features~~
Non-technical ~~Steering committee~~ **Cross-vendor support** **BSP** Project Roadmaps

CMake Zephyr Modules

Third-party libs, HAL, FS, IPC libs etc included as Zephyr modules (modularity)

Reuse Dante codebase for Linux based systems



KConfig configuration

(cleanly turn on/off features)

Device-tree configurations

→ generates C headers rather than dtb

Clear abstractions, configurability, wide range of hw-support → **more hardware agnostic (portability)**

✅ All leveraging standard & widely used tools/frameworks

Ultimo Product Refresh - Why Zephyr RTOS?

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RTOS Selection
Technical ~~Modularity & Portability~~ Network & Connectivity Security ~~Subsystems and features~~
Non-technical ~~Steering committee~~ ~~Cross-vendor support~~ ~~BSP~~ Project Roadmaps

RTOS	MPU support	Open source
FreeRTOS	Optional	Open-source
ARM Mbed	Mandatory	Open-source
Nucleus 3.X	Mandatory	Proprietary
Keil RTX	None	Proprietary
Contiki	None	Open-source
ThreadX	None	Proprietary
TinyOS	None	Open-source
TI-RTOS	None	Open-source
uC/OS-II	Optional	Proprietary
VxWorks	Optional	Proprietary

Native Connectivity Stacks

- **Network stack**
- Bluetooth
- USB stack

Security

- **MPU/MMU support (x86, ARM, ARC)**
- Stack overflow protection
- Kernel object & device driver permissions tracking
- Thread isolation

- Separation between Application, Dante, and Zephyr
- Limit vulnerability attack surface

Zhou, Wei, et al. "Good motive but bad design: Why ARM MPU has become an outcast in embedded systems." *arXiv preprint arXiv:1908.03638* (2019).

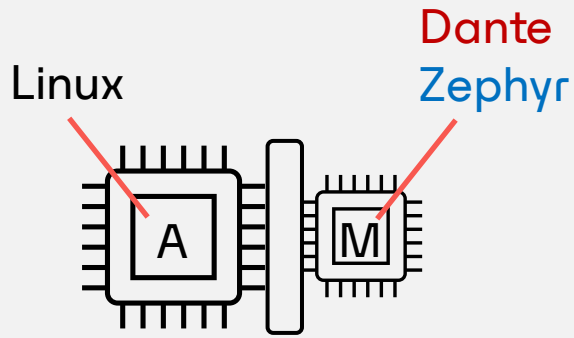
RTOS Selection
Technical ~~Modularity & Portability~~ ~~Network & Connectivity~~ ~~Security~~ ~~Subsystems and features~~
Non-technical ~~Steering committee~~ ~~Cross-vendor support~~ ~~BSP~~ Project Roadmaps

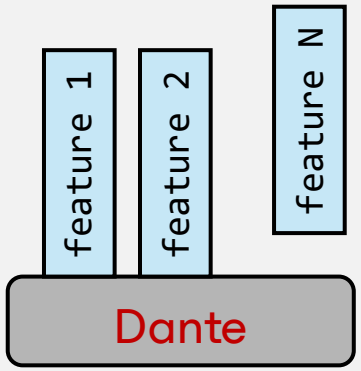
Project roadmap

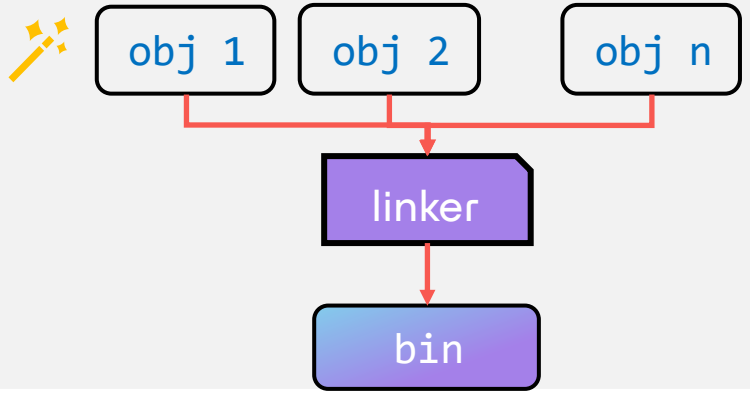
- Transparent
- Gaining development inspiration from the Zephyr roadmap
- Aligning timeline with the Zephyr roadmap

Some ideas:

- IoT endpoints – Dante on X
- Partitioned Dante on Cortex M of an MPSoC + Linux on Cortex A
- Linkable Loadable Extensions (LLEXT)
- Link Time Optimisations (LTO)







Risks with choosing Zephyr RTOS

- ⚠ Relatively new RTOS
- ⚠ Vendor's official support for Zephyr (at the time)
- ⚠ Talent pool and Zephyr familiarity within the company

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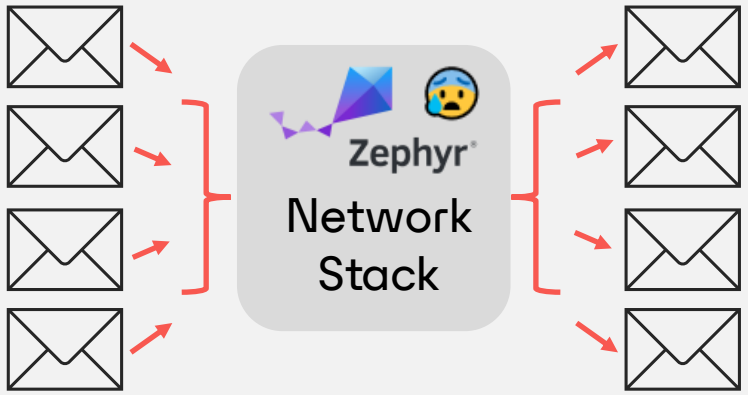
Zephyr Dev Experience

Challenges

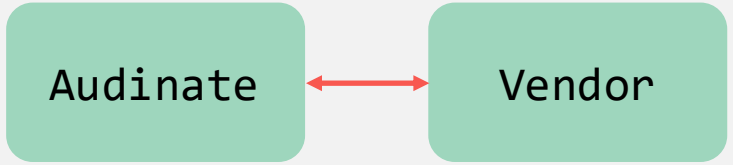
Zephyr's Network stack



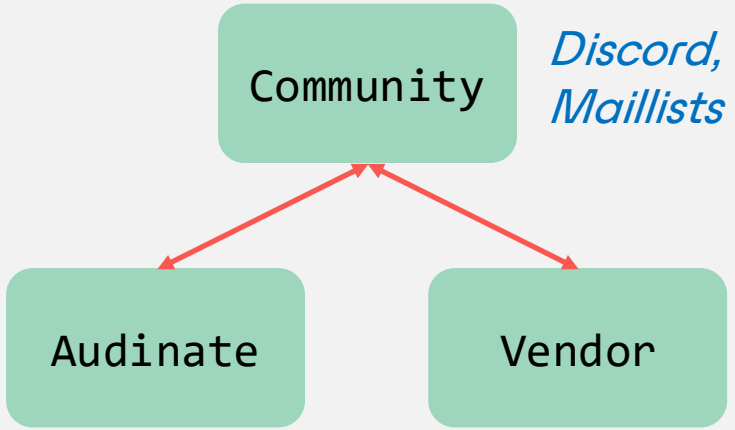
Still maturing..

- Dante relies heavily on the network stack!
- Stress tests the Zephyr TCP/IP stack
- Issues emerged during the project

→ Engaging with the community!



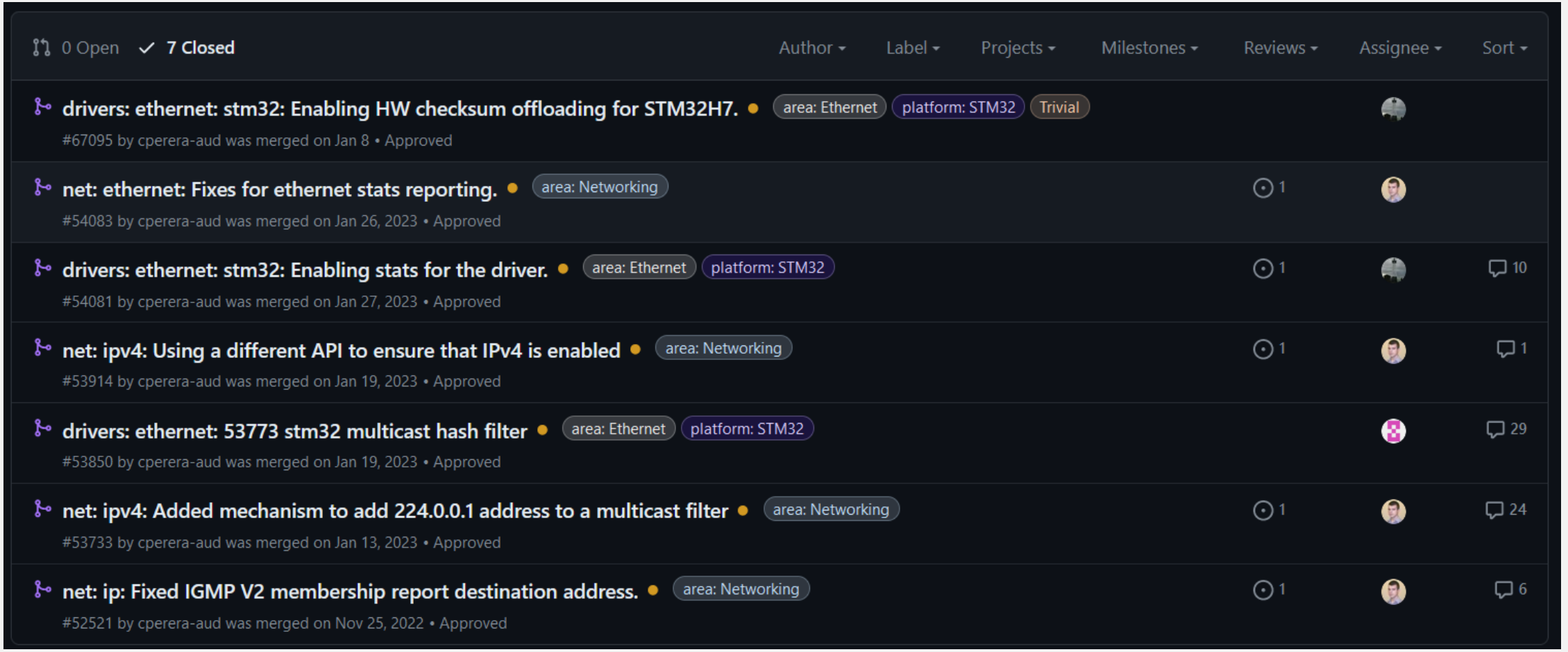
Then



Discord, Github
Maillists

Now

Network stack issues we've upstreamed



Not always perfect!

We faced network performance bottlenecks

- Challenging for the community to reproduce (without Dante tools)
- We were the only ones facing this issue

- Developed our own solutions that addresses our need
  - Implementation + testing
  - Challenging to upstream

Regardless, Zephyr Community is awesome!

- Open to first time contributions
- Responsive
- *Discord chats / friendly PR process ;)*

Project Maturity

Zephyr®

Commercially, Zephyr is relatively new!

- Supporting industries / ecosystem still developing

Talent pool with Zephyr expertise still building up

- Fewer embedded engineers with Zephyr experience
- Small-ish freelance sites have less talent-pool for Zephyr

Things are changing! The future looks promising!

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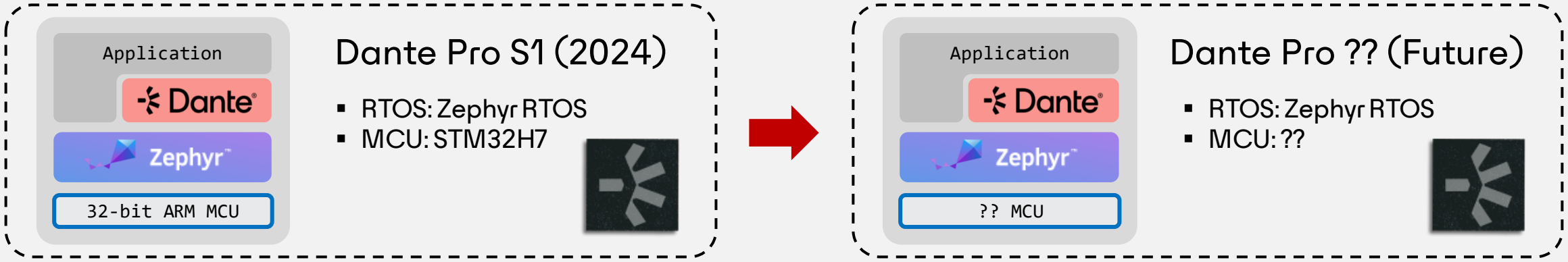
Zephyr Dev Experience

The future

Low-cost Dante The future



1. **Portability of code** → variations of Dante on various platforms
2. **Community** → fast turnover & joint effort of the whole Zephyr community
3. **Features** → help define next generation Dante

We had more participation in upstreaming than previous projects!
→ and we expect this to only increase
- Upstreaming fixes
- Design discussions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Thank you
Gladstone!
AUDINATE
EverythingOpen24, Gladstone