



Building Hard Real-Time Systems with Xenomai

Jan Kiszka | LinuxCon Japan, December 5, 2023

Agenda

Why still Xenomai?

Some Examples from the field

A look under the hood

How to set it up

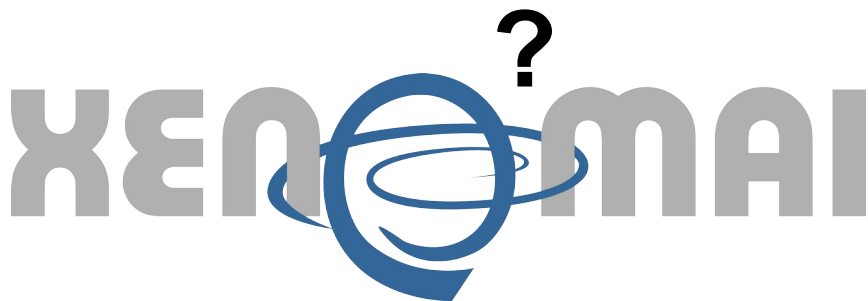
Strengthening the community

Summary

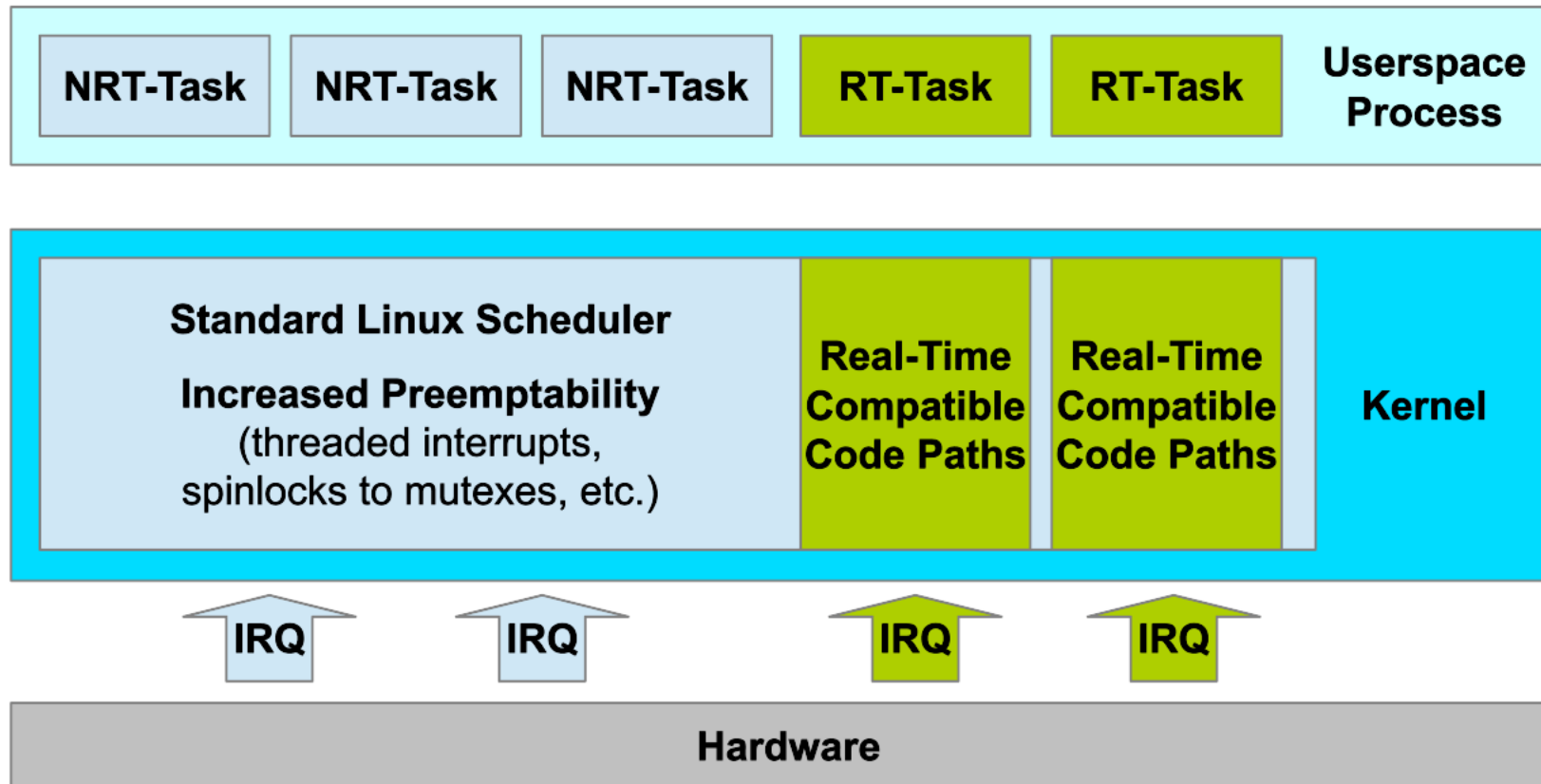
What Would You Associate with Real-Time Linux?



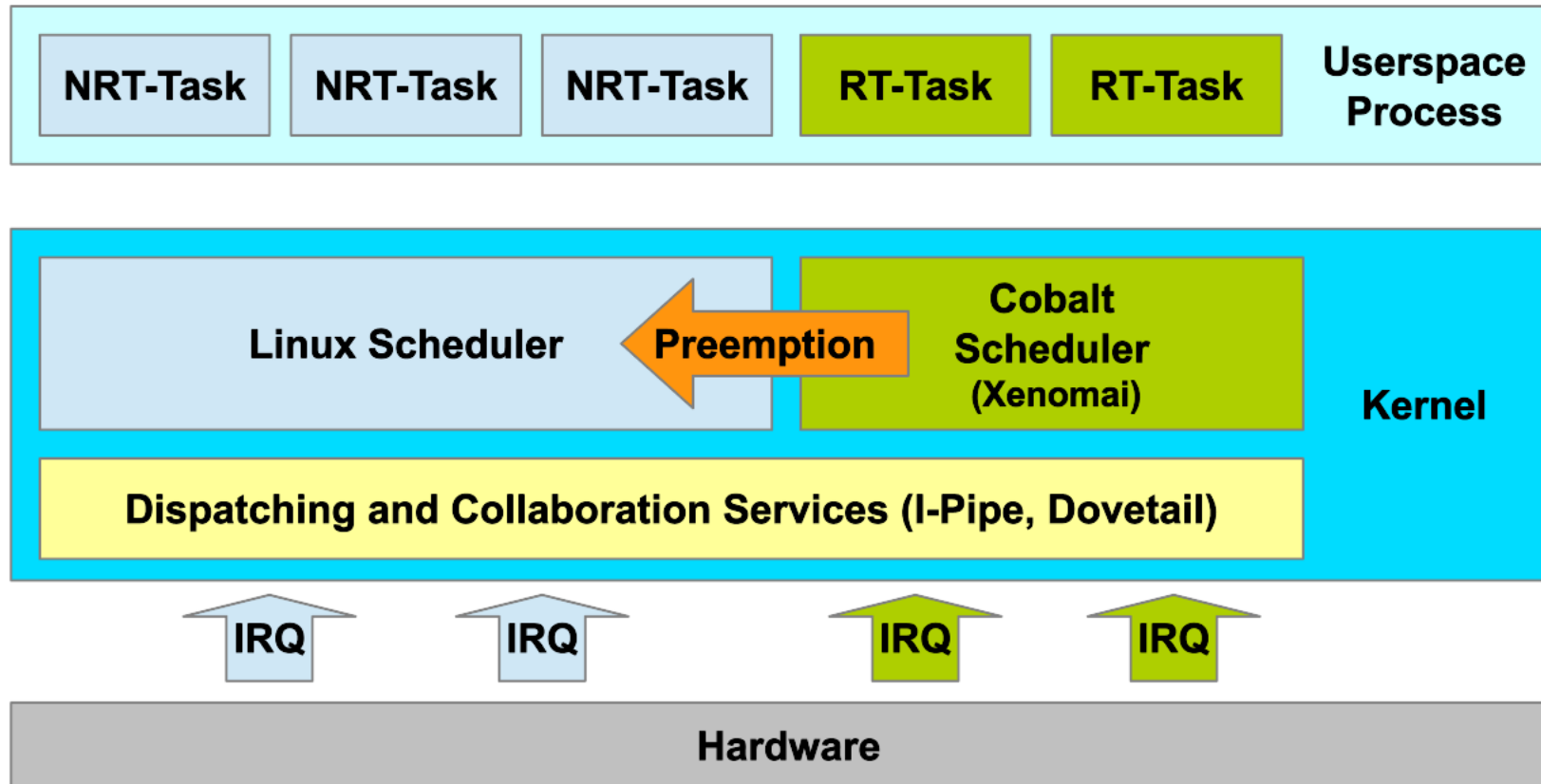
Mixabest, CC BY-SA 3.0



Native Real-Time For Linux – PREEMPT-RT



The Co-Kernel Concept of Xenomai



Why Still Using a Co-Kernel?

Allows to port complex RT application stacks to Linux

- Different scheduling mechanisms
- Scheduler tunings
- Additional APIs
- Accurate modeling of legacy RTOS behavior

Architectural separation of RT and non-RT

- Often simpler system configuration
- Application gets early feedback when leaving RT path
- Even libraries cannot disturb RT silently

Can provide better latencies

- Lower overhead on low-end platforms
- Better latencies with RT and non-RT on same core
- Can decouple from scalability issues (~8+ cores)

Xenomai Applications at Siemens



- Hard real-time requirements with minimal latencies
- API-extensions to serve needs of existing (large) code base
- Long-term support

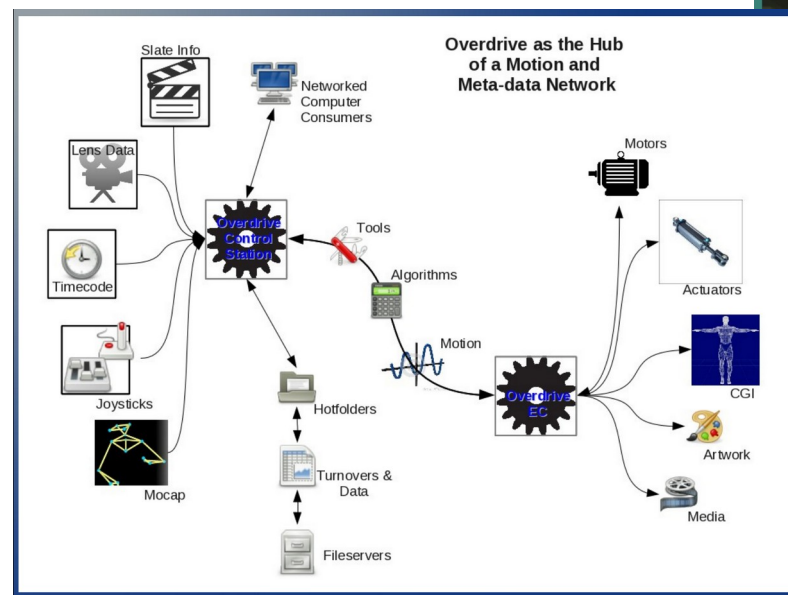


- Maintain separation of RT and non-RT architecturally
- High through-put demands aside RT workload

Xenomai in Your Cinema?

Concept Overdrive

- Provides motion control solutions for movies, entertainment events etc.
- In several regards similar to industrial motion control – but can also do real-time rendering for virtual cameras
- Previously used RTcore, now migrated to Xenomai 3
- See more in Steve Rosenbluth's talk @ Xenomai Meetup 2022
- Recently received an Emmy



<https://intel.csdn.net/2022GlobalXenomaiCommunityMeetup/en>

Some Xenomai-backed examples:

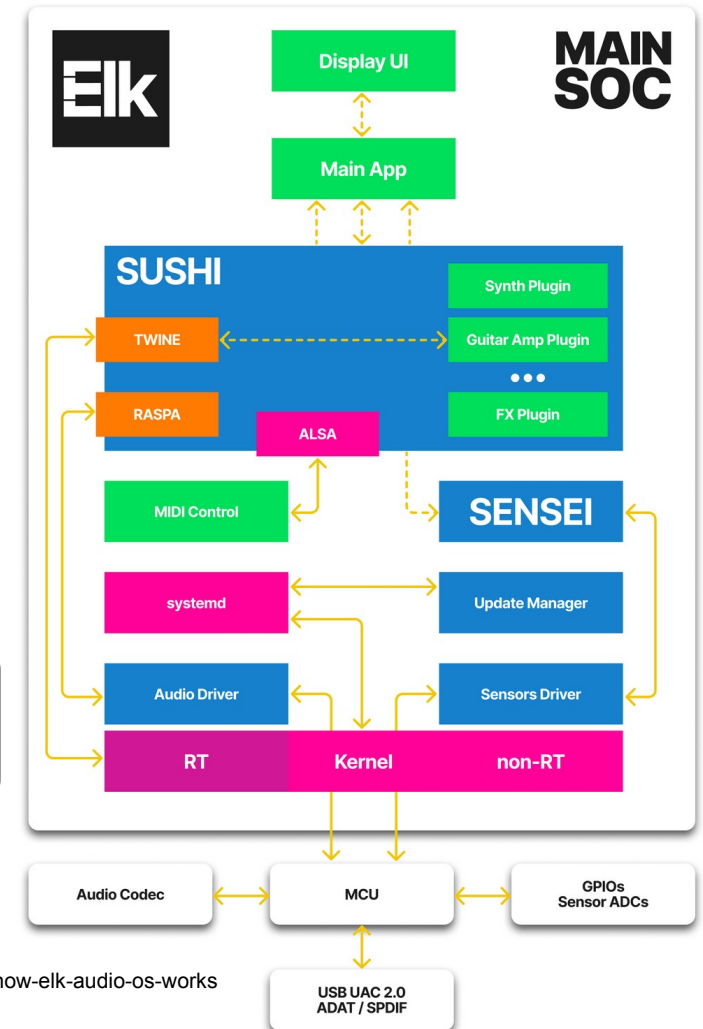
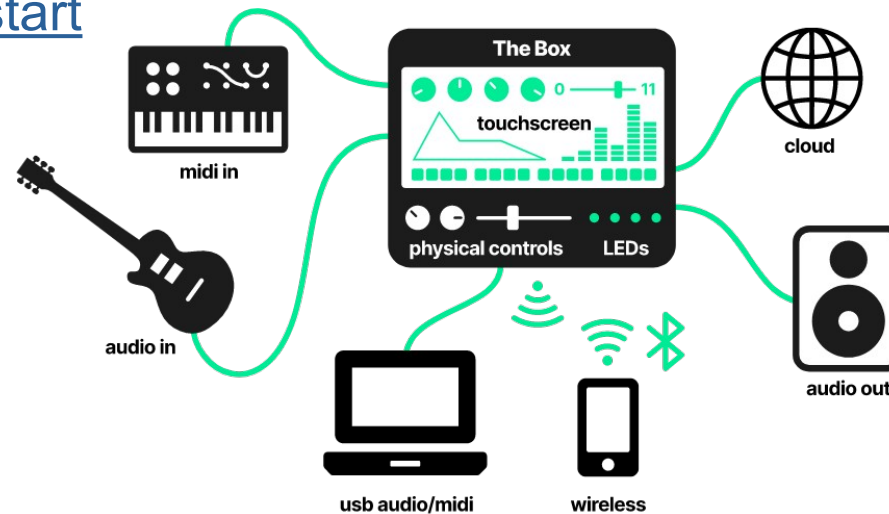
National Gallery of Australia, Jordan Wolfson Robot artwork
Dungeons and Dragons film
The School for Good and Evil TV film
Oscars 2023 E! TV fashion review AR
Met Gala 2023 E! TV fashion review AR
Ahsoka (Star Wars) TV series

Kenobi (Star Wars) TV series
Boba Fett (Star Wars) TV series
Blue Beetle film
Percy Jackson TV series
Halo TV series
Gladiator 2 film
Chucky TV series

Sounds Like Xenomai

Elk Audio OS

- Embedded Linux optimized for low-latency audio
- Supports a number of common embedded boards
- Uses Xenomai (formerly 3, now 4) to “to achieve extremely low hard real-time performances”
- <https://www.elk.audio/start>



<https://www.elk.audio/how-elk-audio-os-works>

Let's Look Under the Hood...



Andy / Andrew Fogg, CC BY-SA 2.0 Deed

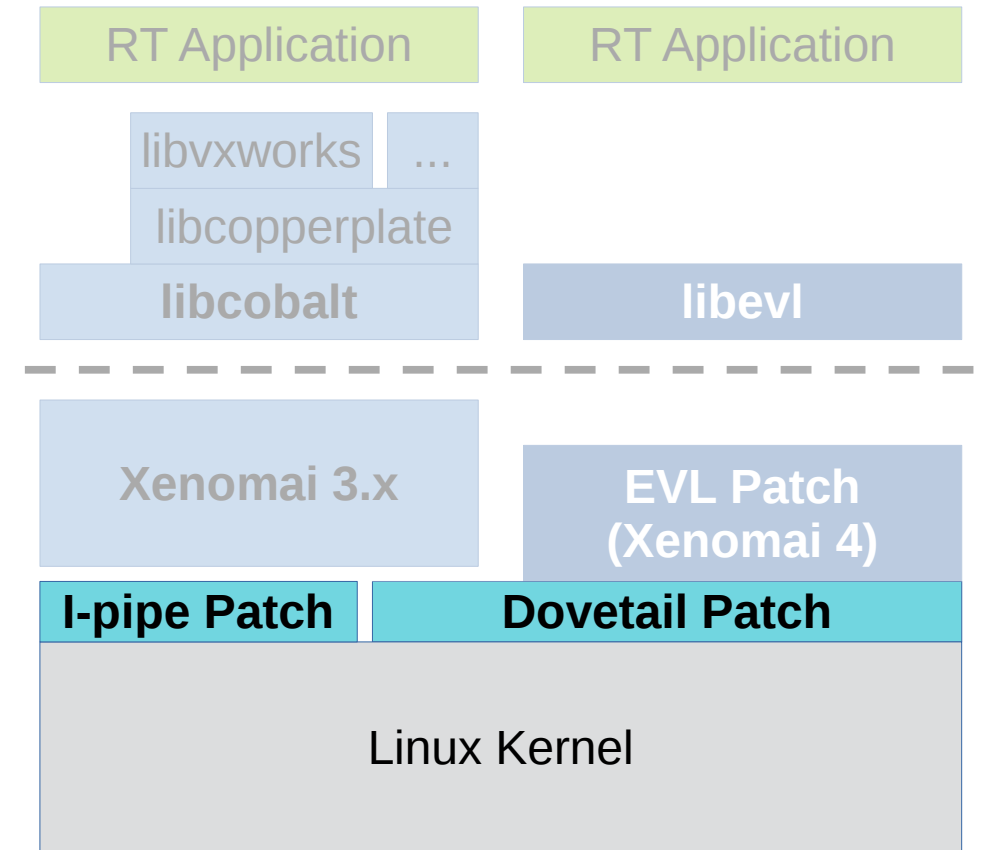
Foundational Kernel Patches

Dovetail is the modern patch

- Supports LTS kernels 5.10, 5.15, 6.1, 6.6, and head (currently 6.7-rcX)
- Architectures: ARM, ARM64, x86
- Same for Xenomai 3.2+ and Xenomai 4
- Provided as rebased queue (vendor kernels...) and as merging branch

I-pipe is the historic patch

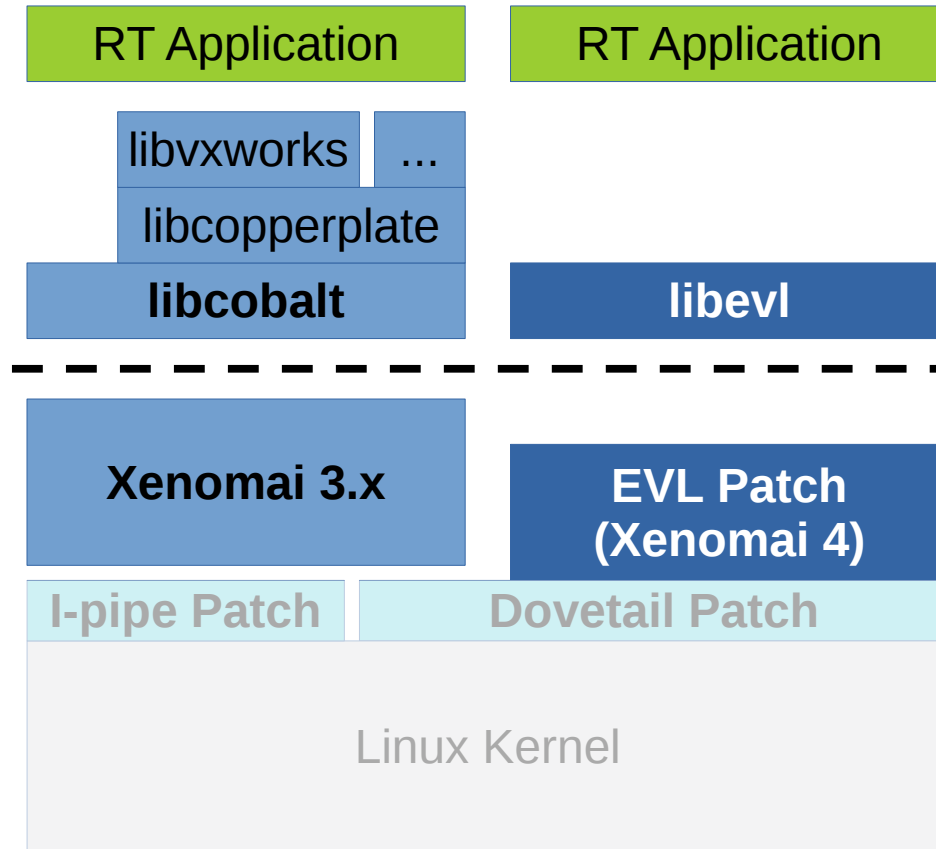
- Ends with 5.4 and Xenomai 3.2.x
- 4.19-cip and 4.4-cip also still maintained



Xenomai 3 vs. Xenomai 4

Xenomai 3

- Out-of-source-tree Cobalt core + libraries
- Supports POSIX natively
- Emulates VxWorks, PSOS and “Native” APIs
- Drivers are forks/rewrites against the Real-Time Driver Model (RTDM)
- Currently 3 stable release series
- Maintained by Jan Kiszka



Xenomai 4

- EVL (EVen Less) Core comes as kernel patch
- Supports a new ABI
- No POSIX, no legacy RTOS emulation
- Drivers are kernel drivers with patched-in “Out-of-Band” support
- Aims at supporting 2 LTS kernel series + head
- Maintained by Philippe Gerum

Xenomai From Scratch

Xenomai 3

- Fetch Xenomai from <https://source.denx.de/Xenomai/xenomai>
- Pick up kernel from <https://source.denx.de/Xenomai/linux-dovetail>
- Run `.../xenomai/scripts/prepare-kernel.sh` in kernel repo, then configure and compile kernel
- `cd .../xenomai; scripts/bootstrap.sh; ./configure; make [install]`

Xenomai 4

- Pick up kernel from <https://source.denx.de/Xenomai/xenomai4/linux-evl>, configure and compile it
- Fetch and compile <https://source.denx.de/Xenomai/xenomai4/libevl>
- Or use its Rust binding: <https://source.denx.de/Xenomai/xenomai4/revl>



Build Your Own Xenomai Debian Image

Provide quick-start images

- Just takes privileged docker or podman to build
- All architectures supported
- Currently Xenomai 3, EVL support on the way
- QEMU images + generic x86 + BeagleBone Black (ARM) + HiKey (ARM64)
- Debian-based, easy to extend during runtime
- Can be a base for product images (ISAR build tool)
- Also used to generate our LAVA test images

<https://source.denx.de/xenomai/xenomai-images>



Building and Strengthening the Community

Challenges

- Many non-visible users
vs. few providing feedback
- Tricky kernel development tasks
vs. few key contributors
- Increasing interest in China
vs. originally Europe-centric community

Measures taken so far

- Improve transparency of development workflows
- Try to distribute tasks between more developers
- Bi-weekly community call (open for everyone!)
- Virtual Xenomai meetup in 2022 (>90% from China!)
- Physical meetup in Wuxi last week



Xenomai Workshop, Wuxi, China, November 30, 2023

Summary

The Co-kernel is here to stay

- Used in production for >20 years
- Valid use cases aside PREEMPT-RT
- Default RT choice will remain PREEMPT-RT

Xenomai 3, Xenomai 4 – project keeps on evolving

- Pace is not fast but steady
- We are committed to not drop broadly used support

The Xenomai project happy about active users

- Stand up and provide feedback, publicly!
- We would welcome more core hackers...
- ...but there are also many other ways to contribute



Any Questions?

Thank you!

<https://xenomai.org>

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