Zephyr Project: Unlocking IoT Innovation with an Open Source RTOS

Kate Stewart, The Linux Foundation
kstewart@linuxfoundation.org
Phantom’s ELDA system uses two devices employing Nordic’s nRF52832 SoC for mesh networking between wall switch and LED drivers.

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“Because we required multi-tasking, the Nordic SoC’s Zephyr RTOS [real-time operating system] support was also important.” - Wu Tianji, CTO at Phantom

Source: https://www.nordicsemi.com/News/2019/06/Phantom-ELDA-system-uses-two-devices-employing-nRF52832-SoC-for-mesh-networking
Products Running Zephyr Today

- Intellinium Safety Shoes
- Rigado IoT Gateway
- ProGlove Scanning Gloves
- Adero tracking devices
- RUUVI node
- GEPS
- Point Home Alarm
- Anicare reindeer tracker
- HereO Core Box
- Grush Gaming Toothbrush
- hereO Smartwatch
- Blocks Modular Smartwatch
- Intellinium Safety Shoes
1 year of traffic to zephyr.org website
2 weeks of traffic to github.com/zephyr code repository
Zephyr Project:

- Open source real time operating system
- Vibrant Community participation
- Built with safety and security in mind
- Cross-architecture with growing developer tool support
- Vendor Neutral governance
- Permissively licensed - Apache 2.0
- Complete, fully integrated, highly configurable, modular for flexibility, better than roll-your-own
- Product development ready using LTS includes security updates
- Certification ready with Auditable

Open Source, RTOS, Connected, Embedded
Fits where Linux is too big

Zephyr OS

3rd Party Libraries
Application Services
OS Services
Kernel
HAL
Zephyr Supported Hardware Architectures

- ARC
- Synopsys
- ARM
- Intel
- Nios II
- Processor
- RISC-V
- Tensilica
Native execution on a POSIX-compliant OS

- Build Zephyr as native Linux application
- Enable large scale simulation of network or BLE tests without involving HW
- Improve test coverage of application layers
- Use any native tools available for debugging and profiling
- Develop GUI applications entirely on the desktop
- Optionally connect to real devices with TCP/IP and BLE
- Reduce requirements for HW test platforms during development
Sample of Board Support

SiFive HiFive1  Arduino Due  Nucleo 103RB  NRF51  Nucleo64 L476RG  Nucleo F411RE  NRF52 pca10040  Nucleo F334RB  Synopsys EMSK

Arduino 101  Minnowboard  Altera MAX10  Nucleo 401RE  Hexiwear  ARM V2M MPS2  STM3210c  Atmel SAM E70  Adafruit Feather

Galileo  NXP FRDM K64F  NRF52  Seeed Carbon  TI Launchpad Wifi  BBC Microbit  STM32373c  Redbear BLE Nano  96b Neon Key

Quark D2000  STM32 Olimexino  STM Mini A15  Seeed Nitrogen  ARM V2M Beetle  Zedboard Pulpino  NXP FRDM-KW41Z  tinyTILE  NXP LMX RT1050

170 BOARDS TODAY WITH MORE ON WAY...

http://docs.zephyrproject.org/boards/boards.html
Boards Shipping with Zephyr Today

Antmicro Badge

Phytec Reel Board

Electronuts Papyr
Highly Configurable, Highly Modular

Cooperative and Pre-emptive Threading

Memory and Resources are typically statically allocated

Integrated device driver interface

Memory Protection: Stack overflow protection, Kernel object and device driver permission tracking, Thread isolation

Bluetooth® Low Energy (BLE 4.2, 5.0) with both controller and host, BLE Mesh

Native, fully featured and optimized networking stack
Growing a Diverse Community!

**Lifetime project participation**

- **Authors**
  - 2016/2: 80
  - 2019/6: 499

- **Commits**
  - 2016/2: 2,806
  - 2019/6: 31,274

- **Boards**
  - 2016/2: 4
  - 2019/6: 167 in progress

**1.14 (LTS) release participation**

- Intel
- Nordic Semiconductor
- (Unknown)
- Linaro
- NXP
- Oticon
- Foundries.io
- STMicroelectronics
- Synopsys
- PHYTEC Messtechnik...
- emix GmbH
- Microchip Technolog...
- Zilogic Systems
- Prevas
- Cisco
- ARM
- Endian Technologies
- Google, Inc.
- Western Digital
Open Source OS/RTOS Options Today
Operating System Contributors

Source: Data as of 2019-4-25 from github (* from openhub.net)
Total Commits by Operating System

Source: Data extracted on 2019-4-25 from github (* from openhub.net)
<table>
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<th>Operating System</th>
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Data extracted on 2019-6-23 from github (* from openhub.net)
Zephyr in RTOS Landscape 2019/6/23

## Total Contributors

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## Commits to Master (last 30 days)

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<tr>
<td>3</td>
<td>mbed OS</td>
<td>207</td>
</tr>
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Zephyr Ecosystem

Zephyr OS
- The kernel and HAL
- OS Services such as IPC, Logging, file systems, crypto

Zephyr Project
- SDK, tools and development environment
- Additional middleware and features
- Device Management and Bootloader

Zephyr Community
- 3rd Party modules and libraries
- Support for Zephyr in 3rd party projects, for example: Jerryscript, Micropython, Iotivity

Zephyr “Community”

Zephyr Project
- Kernel / HAL
- OS Services
- Application Services

Kernel / HAL
- Scheduler
- Kernel objects and services
- low-level architecture and board support
- power management hooks and low level interfaces to hardware

OS Services and Low level APIs
- Platform specific drivers
- Generic implementation of I/O APIs
- File systems, Logging, Debugging and IPC
- Cryptography Services
- Networking and Connectivity
- Device Management

Application Services
- High Level APIs
- Access to standardized data models
- High Level networking protocols
Developer Tools...

MCUXpresso Software and Tools
COMMON TOOLKIT FOR THOUSANDS
OF KINETIS & LPC MCUs
NXP
LEARN MORE

RENO
by:

Synopsys DesignWare ARC Development Tools

SEGGER

Lauterbach Development Tools
Zephyr Supported Hardware Architectures

- ARC Synopsys
- ARM
- Intel
- Nios II Processor
- RISC-V
- Tensilica
Native execution on a POSIX-compliant OS

- Build Zephyr as native Linux application
- Enable large scale simulation of network or BLE tests without involving HW
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What is next for Zephyr?
Security & Safety Certifications!
Zephyr OS: Development

- Quality is a **mandatory expectation** for software across the industry.

- Assumptions:
  - Software Quality is enforced across Zephyr project members
  - Compliance to internal quality processes is expected.

- Software Quality is not an additional requirement caused by functional safety standards.

- Functional safety considers Quality as an existing pre-condition.
Zephyr OS: Long Term Support (LTS - 1.14)

It is:

• Product Focused
• Current with latest Security Updates
• Compatible with New Hardware: We will make point releases throughout the development cycle to provide functional support for new hardware.
• More Tested: Shorten the development window and extend the Beta cycle to allow for more testing and bug fixing

It is not:

• A Feature-Based Release: focus on hardening functionality of existing features, versus introducing new ones.
• Cutting Edge
Building in Security for LTS & Auditable

- Established **Security Committee**, meets bi-weekly.
- Secure Coding Practices have been **documented** for project.
- Zephyr Project **registered as a CVE Numbering Authority** with MITRE.
- Security Working Group has vulnerability response criteria publicly documented
  - addressed weaknesses and vulnerabilities already
- Passing Best Practices for projects as defined by CII
  - [https://bestpractices.coreinfrastructure.org/projects/74](https://bestpractices.coreinfrastructure.org/projects/74)
- Leveraging Automation to prevent regressions:
  - Weekly Coverity Scans to detect bad practices in imported code
  - MISRA scans being incorporated, to evolve to conformance and address issues.
Zephyr OS: Auditable Considered Standards

Coding for Safety, Security, Portability and Reliability in Embedded Systems:

- MISRA C:2012, with Amendment 1, following MISRA C Compliance:2016 guidance

Safety:

- IEC 61508: 2010 (SIL 3 initially, eventually though like to get to SIL 4)
  - broadest for robotics and autonomous vehicle engineering companies. Reference for other standards in Robotics domain.

- Sampled Certifications derived from IEC 61508: Medical: IEC 62304; Auto: ISO 26262; Railway: EN 50128

Security:

- PSA (Level 1+), Common Criteria (EAL4+), FIPS(140-2)

Others:

- Medical: FDA 510(K), ISO 14971, IEC 60601; Industrial: UL 1998, ??
Zephyr OS: Auditable

- Initial target was decided by Governing Board to be 61508 (it is a common basis for others standards that the members care about)
- An auditable code base will be established from a subset of the Zephyr OS LTS.
  - Code bases will be kept in sync.
  - More rigorous processes (necessary for certification) will be applied to the auditable code base.

Processes to achieve selected certification to be determined by Safety Committee and Security Committee and coordinated with Technical Steering Committee.
Options for Safety Certification?

Explicit Path

Proprietary

LTS

Auditable

?
2019 Auditable Scope (in orange)

Not in scope:

- Platform drivers or BSPs
- No platform specific power management implementation, only device and kernel part of power-management
- No filesystem or sensor driver implementation, only interface and infrastructure to support those on top of existing APIs

Zephyr Use Cases

- **Single Core MCU**
  - Unicore SoC
  - Core 1
  - RTOS
  - App
  - App

- **AMP**
  - Multicore SoC
  - Core 1
  - Core 2
  - Linux*
  - RTOS
  - App
  - App
  - App
  - App

- **SMP**
  - SoC
  - Core 1
  - Core 2
  - RTOS
  - App
  - App

- **Hypervisor Guest**
  - Hypervisor
  - Zephyr
  - Linux
  - Core 1
  - Core 2

Safety and security requirements grow with complexity of use cases
Zephyr Project Roadmap

2019

- User-space and Memory Protection Support
- Logging and Shell infrastructure
- Timer and Tick-less overhaul
- BSD Socket based networking

2020

- MISRA-C Compliance
- Commercial Compiler Support and IDE Integration
- Multi Core / SMP
- Bluetooth® Split Layer
- Advanced Power Management

2021

- E2E Cloud Integration
- Sound/Audio Capabilities
- Next Gen Bluetooth Technologies
- Quality Standards Compliance
- Certifiable Code Base

Accelerated Path

- Functional Safety Certification
- Quality Standards Compliance

LTS 1

- Security Certification

LTS 2
Zephyr Participation Information

Orientation:
- [https://www.zephyrproject.org/community/how-to-contribute](https://www.zephyrproject.org/community/how-to-contribute)

Github:
- [https://github.com/zephyrproject-rtos/zephyr](https://github.com/zephyrproject-rtos/zephyr)

Mail Lists:
- [https://lists.zephyrproject.org/g/main](https://lists.zephyrproject.org/g/main)

Slack:
- [https://zephyrproject.slack.com](https://zephyrproject.slack.com) (get invite from github page)
www.zephyrproject.org