Smart Linux Solutions for the Intelligent Edge

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Linux and the Intelligent Edge

Almost everything we interact with in today's world is an embedded device that includes its own processor and operating system. Each increasingly communicates with others, computing data on or near location at the intelligent edge.

To operate effectively, these devices all require varying degrees of security, safety, and reliability. Whether your system requirements are mission critical, high security, long lasting, cost sensitive, customized, or off the shelf, your embedded devices need to keep up with rigid constraints.

A device designer faces many choices when determining how to architect an embedded solution. The Linux operating system offers faster innovation with artificial intelligence (AI) and machine learning, high levels of security, standards that are common across all industries, flexibility and adaptability for many use cases, and cloud-native and DevOps support. But it doesn't come without challenges.

When creating an embedded device, developers must consider the need for longterm support, high levels of performance and reliability, keeping up with the latest industry-specific features and standards, compliance and export audits, and staying ahead of security breaches. All of these pose significant business risks. Organizations also often have to choose whether to create their own embedded Linux operating system (OS) or choose one that is supported and available on a variety of hardware platforms.

If you face this decision, you should first consider the best use of your engineering resources. Is it worth it to invest in supporting Linux for several years? To take one example, what about the number of common vulnerabilities and exposures (CVEs) that come up constantly throughout the product lifecycle?



The embedded systems market is projected to grow at a rate of 6.1% through **2025**.¹

1 "Embedded System Market — Global Forecast to 2025," MarketsandMarkets, March 2020

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The open source Linux OS leverages more than 7,000 person-years of development. However, it can still be a large and complicated solution with many unknowns. Learning, using, building, and running Linux on an embedded platform (unlike a commonly distributed package for desktop or server applications) takes time, ongoing support, patches, and security vulnerability management that all add cost and considerable effort to maintain over several years after launch. When entrusting the base platform development and maintenance to commercial Linux providers, customers can achieve an improved total cost of ownership.

Performance and Cost Comparisons with Wind River

Wind River® offers Linux packages tailored to specific applications, ranging from small, lightweight systems to heavier, server-class and real-time configurations. The "tiny" kernel is the absolute minimum, single task-oriented kernel meant for unconnected, unintelligent devices. The standard kernel is server class, with medium to small configurations for low-latency and real-time virtualization use cases.

Table 1 shows a comparison of response times for three standard kernels, including Wind River Linux.

Table 1. Response-Time Comparison Between Wind River Linux and CentOS Kernel

	Wind River Linux RT-Kernel	CentOS 7.6 RT-Kernel	CentOS 7.6 Std Kernel	
Bare Metal Workload	9 µs	16 µs	93 µs	
Container Workload	9 µs	26 µs	405 µs	
VM Workload	22 µs	550 µs	2287 µs	

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Performance and Cost Considerations



Table 2 shows some of the Wind River Linux typical characteristics for RAM, storage, and file system management.

Table 2. Wind River Linux Configurations and Characteristics

			Kernel Profile		DAM		
		Standard	Preempt-RT	Tiny	 Std kernel up to 1.2 GB Tiny kernel 5–6 MB of RAM At least 8–16 MB for user space 		
File System Type	Wind River Linux	Yes	Yes	No	 More RAM helps with performance 		
	Linux Tiny	No	No	Yes	Storage2-4 MB of space for a tiny kernel		
	Wind River OVP	No	Yes	No	 For a not-too-complex user space; 8–16 MB of storage can be sufficient 		

Designers face a real challenge in terms of open source compliance — and so do companies that are considering the costs of roll-your-own vs. commercial Linux. The device runtime may have more than 100 different licenses, and disclosures and export requirements must be managed by its creators. What's more, each device shipped requires several compliance artifacts, such as source code, legal notices, open source bill of materials (BOMs), SPDX data, and licensing analysis reports. There are good reasons: These all help meet the requirements set forth in a 2021 executive order to help "improve the nation's cybersecurity" by providing a higher level of transparency in the software supply chain.

The costs of maintaining this kind of security can be hidden and unpredictable, however. With increased security alerts each year, the total number of CVEs increases annually, and the defect rate can increase by up to eight times or more over the lifecycle of a device. Table 3 shows an example of how the CVEs relevant to Wind River have increased with each year.

Table 3. Annual Increases in CVEs

	2017	2018	2019	2020	2021*
Monitored	14619	16406	17788	18551	20276
Assessed as non-vulnerable	14307	15961	17356	18002	19328
Investigated and notified	1851	1222	1139	929	1288
Delivered fixes	1613	948	805	576	722

^{*}As of end of 2021, data source: Wind River CVE Database



The purpose of Wind River Linux is to enable embedded solutions and allow designers to build and scale. It solves key business problems with a comprehensive suite of products, tools, and support services to help you create and manage your Linux platform.

Figure 1 demonstrates how Wind River balances time-to-market, competitiveness, and risk management with an open source solution.



Figure 1. Open source solutions can help balance competing requirements

Adherence to Industry Standards

Applications running embedded Linux span a wide variety of industries, including aerospace and defense, automotive, energy, medical, and telecommunications. Cryptography, Security Technical Implementation Guides (STIGs), and standards for military-grade solutions are some examples of defense; secure gateways, intelligent communications, and advanced driver assist systems (ADAS) fall under automotive applications.

Wind River is prepared to meet industry standards such as IEC 61850 for energy, Class II medical device and over-the-air (OTA) update standards, and carrier grade requirements for telecommunications.

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Wind River Key Advantages and Support Structure

Wind River can help accelerate your time-to-market while enabling you to focus on product differentiation and device optimization. With streamlined development and premium support, Wind River provides tested and validated code every three weeks, with faster response times for troubleshooting.

Wind River continuous delivery service provides the latest tested and validated code that can be easily integrated into a designer's development environment. And for features that are not in the standard roadmap, Wind River offers services for accelerated feature development.

In terms of security, Wind River continuously monitors CVEs while performing assessments and remediations, with many common security packages as part of distribution. Regular updates include security fixes, and hardening options are offered for cybersecurity. The 250 security packages included offer a range of features, such as access-control lists, openSSL and openSSH for networking security, encryption packages, and more.

Additional support consists of modern, cloud-native development as well as an extensive range of board support packages. Wind River offers pre-built container solutions, Docker and Kubernetes support, and container-based continuous integration. This translates to faster development and cloud-native standards that, in turn, ensure compatibility and commonality in deployment, scalability, and a more familiar development environment. Hardware support spans a wide range of boards and chipsets, including Intel[®], NXP, Marvell, Xilinx, Texas Instruments, AMD, Renesas, Raspberry Pi, and Arm[®] devices.

Professional services and customer support are also available to help simplify development efforts, assist with customizations for specific use cases, and provide tailored support for unique demands. On-demand learning and 24/7 global support are also available, as well as dedicated premium support for those who desire it.

The following is a high-level summary of Wind River Linux advantages:

- No royalties
- Fully customized Linux
 deployment
- Enhanced security with CVE response
- Faster time-to-market
- Modern, cloud-native environment
- Robust hardware support
- Flexible delivery and support models
- Quality, compliance, and certification
- Product lifecycle and distribution management
- World-class service and support

Wind River Offers a Purpose-Built Linux Solution

Working on the intelligent edge requires more than good support and a cost-effective structure; it also requires certifications, standards, best practices, and quality.

Wind River complies with open source development, cloud native and DevOps, cybersecurity, and ISO 9001 quality standards for development and release processes. Wind River uses OpenChain conformance for license disclosure artifacts.

Wind River helps designers create their own embedded Linux and provides the tools to build a supported, purpose-built system. A user can start either from source code or from pre-built binary images, then decide what exactly will be included (kernel options and drivers, space packages, etc.). This results in a customized Linux OS image that includes only what is needed for your embedded solution.

For years Wind River has been among the top three contributors to the Yocto Project, a collaborative, open source project meant to enable Linux distributions for embedded applications and IoT software, independent of target hardware. Figure 2 displays a visual of the relative level of code contribution to the Yocto Project and the open source community as a whole.



Figure 2. Commits percentage to the Yocto Project, by organization

Benefits include:

- Tuned Linux OS
- Minimized memory/ storage requirements
- Limited attack surfaces
- CVE and vulnerability response/mitigation
- Project-based pricing with no royalties
- Fully documented source code origins/ licensing
- 10+ year support with possible extension



Figure 3 shows the project lifecycle as it relates to the Yocto Project.



Figure 3. Wind River Linux lifecycle and alignment with kernel.org and the Yocto Project

A Quantified Look

Let's shift and take a quantitative look at some of the quality metrics. With 3,000 builds that run daily (100% of which use Docker containers with Mesos orchestration), 100% of quality tests that are run weekly, 100% of user-space packaged code changes that are verified on demand, and 99.85% of test areas that are automated, Wind River covers design, development, integration, verification, validation, and maintenance that is certified to ISO 9001:2015. On top of that, the client receives a product that is secure from design and build to maintenance after deployment. Security assessments and consulting can help the designer build a secure framework with added cybersecurity (apps, data, access, and boot), as well as monitor and manage CVEs after launch.

All together, these factors — when coupled with an open source platform — keep your system at its best at the intelligent edge.



Long-Term Support

LTS21 is designed for long-term support deployments but also introduces a binary distribution (Wind River Linux Distro), which simplifies the overall developer workflow with fast deployment of the operating system on popular embedded hardware targets.

Key features of LTS 21 include:

- Linux LTS 5.10 kernel and Yocto Project 3.3 as the base
- Linux Assembly Tool, which can be used to perform tasks that help manage images, build and publish RPM packages, generate images from feeds for specific hardware, and generate updated SDKs
- Support for Qt 5 tool kit version 5.15.2
- TensorFlow machine learning
- OpenVINO, which enables convolutional neural networks (CNNs) for Intel hardware
- Docker upgraded to 19.03
- Enhanced OSTree support allowing image upgrades on deployed devices
- Hardware support for a variety of chipsets including Intel, Marvell, NXP, TI, Xilinx, and Raspberry Pi

Wind River Linux provides many key advantages for designers working at the intelligent edge, including extreme customizability for the most demanding embedded applications, full support that removes the burden of managing CVEs and bug fixes, and a Yocto Project–based open source environment or pre-built binary images. The security, reliability, performance, sustainability, and compliance of Wind River Linux is helping drive innovation in sophisticated devices at today's intelligent edge.

Wind River is a global leader of software for the intelligent edge. Its technology has been powering the safest, most secure devices since 1981 and is in billions of products. Wind River is accelerating the intelligent transformation of mission-critical edge systems that demand the highest levels of security, safety, and reliability.

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