WIND RIVER

Backgrounder: Powering Innovation Since 1981

To the casual observer of technology, the world of computing is comprised of PCs, game consoles, and servers that power the Internet. However, behind the scenes, out of sight, there exists another world. A world of embedded computing products that control infrastructure and systems that impact the quality of our lives every minute of the day. This lesser known computing domain dwarfs the traditional computer market in scale. For three decades, Wind River has been a pioneer and leader in this world of embedded computing, delivering software that has been at the heart of more than a billion embedded computing devices deployed around the globe. Wind River has had the honor of collaborating with visionary companies to bring some of the most innovative new technologies from the back of a napkin to market—in aerospace and defense, communications, industrial control, medical, automotive, and mobile.

Recognizing the Future of Computing

Wind River was founded as a consultancy in 1981 by Jerry Fiddler in his Berkeley, California, garage. Later that year, Fiddler invited David Wilner to join him in the business. The two had previously worked together as computer scientists at the U.S. Department of Energy's Lawrence Berkeley National Laboratory, an experience that would bring great value and technical discipline to Wind River. The company name was derived from Fiddler's cherished memories of vacationing at Wyoming's Wind River mountain range.

The partnership flourished and Fiddler and Wilner incorporated Wind River Systems in 1983. After a flip of a coin, Fiddler assumed the chief executive title and Wilner the role of technical lead. Early Wind River projects were quite notable, including a film-editing system for Francis Ford Coppola and a system that the National Football League used to annotate game films with a searchable database.

While much of Wind River's earliest work was based on minicomputers, Fiddler and Wilner had long realized the potential of the microprocessor and how it would lead to millions of smart embedded systems. As Red Herring would later write, Wind River recognized that "future computing would take place not on a desktop PC but inside the myriad appliances of everyday life."

With this vision in mind, Fiddler transformed Wind River from a consultancy to a product company. The first breakthrough for the company was the introduction of VxWorks in 1987. The expanding Wind River team required a real-time operating system (RTOS) for their microprocessor work and used a ROM-based kernel called VRTX from a company called Hunter & Ready. However, Wind River was underwhelmed by its lack of basic operating system facilities, such as a file system, so the team developed the accompaniments that would enhance VRTX. The VxWorks product name was playfully derived from the fact that the team made VRTX work.

It was through Wind River's development of accompaniments to VRTX that the first incarnation of VxWorks was created. Initially developed as an integrated development environment (IDE), VxWorks revolutionized the productivity equation for software development in embedded applications. With the introduction of the VxWorks IDE, the Wind River team filled a void in the market at a time when Moore's Law was driving rapid performance advances in microprocessors but the corresponding development tools greatly lagged in speed of evolution and sophistication. Today VxWorks has evolved into the de facto RTOS standard for embedded development.

What no one could have predicted was the impact the software would eventually have in incredibly complex and important systems. Wind River software would later enable NASA's Mars Pathfinder and Mars Exploration Rovers, the Boeing 787 Dreamliner, and many other systems, including devices we use in our personal lives on a daily basis.

'Matrix of Pain'

The company would expand its product line and propagate its technology across multiple microprocessor families and development platforms. The success was driven by a rigorous adherence to coding conventions and peer review, uncanny insight into emerging technologies, and perseverance to wade through complexities and realize simple, elegant solutions.

An embodiment of Wind River's perseverance was a document, and ultimately a methodology, affectionately dubbed the "Matrix of Pain." This methodology charted Wind River's support for various development host devices on one axis and different processors on the other. This ever expanding chart was a constant reminder of new engineering challenges and guided the team through a methodical approach when making decisions to undertake new projects. Regardless of the challenge at hand, the Wind River team was compelled to attack complex problems and deliver simple and elegant solutions. Fiddler pointed out that most problems look simple at first. But as you work through a problem, complexities emerge that typically lead to highly, and often unnecessarily, complex solutions. The real genius is persevering until you find unifying factors that lead back to a simple result.

The company followed the rigorous standards set by Wilner in every development project. Wilner had created a coding-convention document as one of his first tasks at Wind River. Adhering closely to those guidelines, the engineering team was required to document its work concurrently with the development process and undergo rigorous peer reviews. And the coding conventions yielded modular reusable code long before object-oriented programming tools were introduced.

The rigorous approach would prove incredibly important as Wind River developed its first kernel, which ultimately replaced the VRTX kernel. The task of developing what was then called the Wind kernel fell to John Fogelin, who joined the company at age 17 while at the University of California, Berkeley, and who quickly rose to top engineering positions in his early 20s, ultimately becoming chief technology officer in 2001.

Wilner had insisted from the start that Wind River would develop predominantly in a high-level language, with C being the obvious choice. Most developers working with microprocessors back in the 1980s were using assembly language. Wilner insisted on sparing use of assembly language optimization, insightfully arguing that faster microprocessors would soon eliminate the performance advantage that assembly language might offer.

Working with mentor Wilner, Fogelin delivered a kernel with superior real-time performance measured by the time it took to handle interrupts in embedded systems. The C-based kernel simplified the operating system interface for developers who could implement their code in standard C libraries. Wind River brought its kernel to market in 1989 in what had become the VxWorks real-time operating system.

The bet on C paid dividends by allowing Wind River to support more processors and offer its software on more development hosts. Following a rigorous approach, the team encapsulated processor-specific code in modules, simplifying the porting process. To this day, porting and optimizing code remains an incredible Wind River strength.

Wind River created another game changer with the introduction of Tornado in 1995, the first fully integrated GUI-based IDE for embedded. This new product category radically improved the productivity of software development. Tornado would win trade magazine *EDN*'s Embedded Development Software Innovation of the Year award in 1995.

Only Scratching the Surface

In a 1999 *EE Times* column, Fiddler wrote, "Until now, we have only scratched the surface of products and appliances that will be connected to the Internet for a wide variety of yet untold reasons." Before this vision could come to life, the company required capital to fuel growth. The company took its first venture funding in 1990, and in 1993 the company became the first embedded computing company to go public. The company utilized the cash infusions to fund incremental R&D, grow sales and marketing and its international footprint, expand into emerging growth markets, and make key acquisitions.

Many of Wind River's acquisitions came in the late 1990s. Perhaps the most significant came in 1999 when the company bought its largest competitor, Integrated Systems Inc. (ISI). With ISI came the pSOS operating system and Diab compiler.

Probably the biggest paradigm shift for the company occurred when it decided to transition to a dual operating system model after recognizing the opportunity and value of open source. In the early years of the new millennia Linux became a big disruptive force in the operating system market. IT products such as servers were the first to

aggressively adopt Linux, but it soon began to attract broader attention.

Wind River formally embraced Linux in 2004 with the introduction of an embedded Linux platform specifically designed for the telecommunications market. In four years after establishing its Linux business from merely a concept, Wind River achieved the market share lead with greater than 30 percent of total market revenue.

The move to adopt Linux offered a strategic advantage to Wind River's customers. VxWorks is optimized for characteristics such as memory footprint, performance, and real-time capabilities. Linux offers the advantage of industry-standard user interface technology and robust support of IT capabilities.

In fact, dual operating systems are regularly being deployed together. For example, a multifunction printer requires an RTOS to control the precise firing of the nozzles that place ink on paper. Linux, meanwhile, offers a perfect platform upon which developers can build a robust user interface and add features such as network connectivity. A key enabler to make implementing dual operating systems is through embedded virtualization, which Wind River introduced in 2008 via a product called Wind River Hypervisor.

Wind River's success in embracing open source propelled it into its next growth opportunity: mobile computing. Wind River joined Google's Open Handset Alliance as an original Linux commercialization partner in 2007, and after amassing expertise in what would later be dubbed Android, the company launched its commercialized Android platform in 2009. This Android offering, combined with global services and support organizations, vast mobile expertise, and the creation of a testing framework, allowed Wind River to make a successful entry into the mobile business. By 2011, Wind River had set up more than 20 development centers covering not only mobile but a wide range of technology specialties.

The biggest newsmaker in the company's history also occurred in 2009. Intel sent reverberations through the market when it acquired Wind River for approximately $884 million. Wind River now operates as a wholly owned subsidiary of Intel and is part of its Software and Services Group. Wind River continues its mission of enabling embedded, and more recently, mobile developers.

The microprocessor and Moore's Law have provided embedded design teams a miniature programmable platform that is capable of replacing incredibly complex hardware-centric systems. It is Wind River technology that enables teams to realize the complex systems in software, adding functionality, flexibility, and extensibility.

In 2003, Fiddler shared his thoughts in an internal memo, saying, "The building of the Connected World, with hundreds of billions of connected smart devices—sensors, processors, appliances, vehicles, buildings, telephones, and yet-to-be-named devices—has hardly begun. It's a spectacular opportunity, and Wind River will lead that world. So work hard, have fun, make some really cool stuff, and continue making the world a better place."

This credo lives on today.