Tornado II Development Platform
Improving developers’ time-to-productivity

Wind River’s Tornado® II development platform has dramatically improved embedded developer’s time-to-productivity, which is a key ingredient in achieving fast time to market. The integrated components of Tornado II include Tornado Tools, a comprehensive suite of core and optional cross-development tools and utilities; VxWorks® run-time system, a high-performance, scalable, real-time operating system that executes on the target processor; and a full range of communications options for the target connection to the host.
Embedded systems no longer occupy a niche category in the shadow of PC and enterprise computing. Instead, the embedded systems marketplace is rapidly becoming mainstream—and recognized as the driving force in the Internet era. Embedded computing products are found in the Internet infrastructure as well as in Internet “appliances.” Even traditional embedded products such as printers and copiers are becoming “Internet-enabled.” There’s also a wave of embedded systems-based consumer products, such as wireless communications devices, digital entertainment gear, and digital cameras.

As a result, the rules of embedded system product development are changing. Product development teams are just that: teams that compete to get attractively differentiated mass market products into distribution faster than their competitors.

Under these new rules, getting a product to market is not a goal, but a milestone in the long-term evolution of a product line.

**Successful manufacturers know that maintaining fast “time-to-productivity” in the development lab is a key ingredient in achieving fast time to market.**

Customers demand more and more features at lower prices. As a result, product development never stops. The hottest products on the market are fast and highly intelligent, and run far more code than ever before, so developers need to be able to start quickly and work fast. Successful manufacturers know that maintaining fast “time-to-productivity” in the development lab is a key ingredient in achieving fast time to market.

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**KEY FEATURES OF THE TORNADO ARCHITECTURE**

**All tools for all targets: target agent and target server**

*Target agent:* With Tornado, a scalable software agent can be inserted into the target processor. This target agent connects all Tornado host-resident tools to the target run-time system, giving the target an unprecedented level of independence from the host system. Both the agent and the agent’s driver interface are independent of the run-time system. As a result, the target agent can execute before the run-time kernel is running, thus simplifying the bring-up of the operating system on custom hardware. The agent can execute in either task-specific or system-wide breakpoints, which greatly simplifies debugging.

*Target server:* The host-based target server allows development tools to be independent of the target system. There is one server per target; all host tools access the target through this server, which functions to satisfy tool requests by breaking each request into the necessary transactions with the target agent. The target server includes features that improve the performance of the cross-development structure: a target memory cache, host-based target memory management, and a streamlined host-target protocol to reduce communication traffic. A target server need not reside on the same host as the Tornado Tools, as long as the server and tools hosts are connected. This provides great flexibility in setting up a development network.

**Dynamic linking and loading**

Tornado permits developers to incrementally load object modules into a target system. This ability to dynamically link and load object modules is central to the Tornado architecture: developers do not need to link the application to the kernel on the host, nor download the entire executable as one static environment. As a result, each edit-test-debug cycle is dramatically shortened. All application modules can be shared among development team members, but do not need to be re-linked on the host. This makes it possible for developers to add object modules to a “live” VxWorks target environment when debugging or reconfiguring applications.

**Integrated, open environment**

The Tornado architecture was specifically designed to provide an open platform for both the developer and third-party tool vendors. Several application program interfaces (APIs) are available and published for reference, from integrated development environment (IDE) interfaces down to the connection implementation.

At the IDE level, the API is based on Tool Command Language (Tcl), which provides front-end tool extensibility and customization. Many aspects of the user interface are under the user’s control, including menu items and extensions to the underlying Tcl code. The next level of API provides an interface to all the target information from the host. This allows third-party tool vendors to provide plugins to Tornado, since their tools can be easily incorporated. An API is available for backend plug-ins as well: a new connection strategy to the target can be written independently and dropped into the Tornado platform at any time. At the operating system level, there is an API to the VxWorks kernel itself, allowing new configurations of the run-time system and additional driver development to occur independently.

**Host, target availability**

Tornado II is available for both UNIX and Windows workstations. Supported target architectures include Motorola/IBM PowerPC; Motorola ColdFire; Motorola 68K; Motorola M-CORE; Intel® architecture family; Intel StrongARM and XScale™ microarchitectures; MIPS; ARM; and Hitachi SuperH.
Nonstop development also means that software and hardware engineering should proceed together without one group having to wait for the work of another to bear fruit. What’s more, companies that provide development tools and embedded operating systems must also have a solid track record of expertise, organizational depth, and financial stability to support customers at all phases: sales, consulting, training, and engineering assistance.

And manufacturers know that before work can start on an application, developers must be able to minimize their time-to-productivity—that is, the initial learning curve that all developers must go through in order to fully understand their development tools and the complexities of an embedded operating system. The less experience, the steeper the curve.

With the release of the Tornado II development platform, Wind River has dramatically improved developers’ time-to-productivity. The integrated components of Tornado II include Tornado Tools, a comprehensive suite of highly visual, automated cross-development tools and utilities; VxWorks run-time system, a high-performance, scalable, real-time operating system (RTOS) that executes on the target processor; and a full range of communications options for the target connection to the host.

Tornado II represents the second implementation of Wind River’s industry-leading Tornado embedded software development platform. The first-generation Tornado solution received the prestigious EDN Magazine “Product Innovation of the Year” award in 1995 and has attracted a worldwide user base of over 30,000 developers.

Tornado was originally designed to solve problems inherent in a cross-development environment, such as limited host-target communication, limited target resources, and poorly integrated tools. The result:

- An architecture that allows all tools to be used on all targets, regardless of target resources or communication mechanism, thereby unleashing the power of graphically oriented cross-development tools and utilities.

Key components of this architecture are the target server, which resides on the host workstation, and the target agent, which resides on the target CPU board.

- An open, extendible environment that makes it easy to integrate third-party hardware and software development tools. This creates, in effect, a “plug-and-play” framework that encourages the development of ever-more-powerful, high-level embedded tools.

- Faster development, whether for small, resource-constrained embedded targets or large-scale multiprocessing systems.

With Tornado II, Wind River built upon the Tornado framework, focusing on developer time-to-productivity. Key design elements include:

- Easy-to-use “autoscaling wizard” that even novice developers can use to speed configuration of the VxWorks OS and other components.

- A fully integrated, “ready-to-run” VxWorks simulator to help jump-start application development.

- Integrated visualization tools in order to improve developers’ ability to analyze application software.

Visual, automated Tornado Tools

As a result, Tornado II does more than respond to the changes caused by embedded computing’s movement from specialized niche to mainstream vehicle—it accelerates embedded product development. To start, Tornado Tools provide a more visual, automated environment that makes creating applications on VxWorks fast, easy, even fun for developers of all experience levels.

Recognizing that innovation is key to companies’ success in the Internet era, Wind River offers Tornado Tools under a business model that permits developers to purchase Tornado Tools “for life.” Developers can license Tornado Tools once, and use the tools across all projects and product lines. Wind River has also created
a variety of tools packages, each aimed at developers with differing levels of needs and experience. Each package includes the core tools from the Tornado development platform.

**Core tools enhance productivity**

Unique to Tornado is the fact that all development tools can be utilized at any stage of application development, with any level of target system resources. Moreover, the full suite of Tornado Tools is available to the developer regardless of target connection strategy — such as Ethernet, serial, or ICE — or target memory size. The following core development and debugging tools are available with each Tornado Tools package.

**Integrated simulator for jump-starting application development**

The VxSim-Lite simulator is fully integrated into the core Tornado Tools, permitting developers to start using Tornado II immediately — independent of BSP porting (if required), operating system configuration, and target hardware. Through the VxSim-Lite simulator, developers — even first-time users — can get acquainted with Tornado II and/or many optional WindPower™ or third-party tools and begin developing and debugging code even if target hardware is unavailable. The full VxSim™ prototyping and simulation tool is available as an option.

**WindView for the integrated simulator**

The WindView™ system-level diagnostic and analysis tool is included for use with VxSim-Lite. Embedded developers are often crippled by the inability to view system-level execution and timing characteristics of their software. This fully functional version of WindView provides detailed visibility into the dynamic behavior of embedded VxWorks applications running on the integrated simulator, graphically displaying the complex interactions between tasks, interrupts, and system objects. Additional seats of WindView to monitor system behavior in the target hardware are optionally available.

**Project facility and configuration tools to shorten development time**

These tools provide a powerful graphical interface that automates configuration of the VxWorks OS and other components. Automated dependency analysis, size calculations, and an autoscaling wizard minimize development cycles. The project interface simplifies organizing, configuring, and building VxWorks applications, and the project facility automates many aspects of managing a project and configuring VxWorks. This integrated graphical project management environment also augments the expertise of a development team: since individual components can be developed separately, then shared or reused by other members of the team. Links to existing, popular source-code control systems such as ClearCase, SCCS, RCS, PVCS, and MS Visual SourceSafe are built in, enabling teams to work in parallel without getting in each other’s way.

**Integrated debugger for high performance**

The high-performance debugger in Tornado II is equipped with productivity-enhancing graphical features such as a watch window that allows users to group-watch expressions on tabbed panes. Variables, register values, and locals can quickly be modified in the debugger’s graphical user interface (GUI), and radices can be specified for different groups of elements. Information is efficiently presented via a docking or floating palette layout. Advanced power users familiar with the GNU gdb debugging engine will appreciate the flexibility provided via the command-line interface mode, with its convenient command-completion and pulldown history window. Developers can spawn and debug tasks on the target runtime system. They can also attach the debugger to already-running tasks spawned from the application or from the debug environment for task-level debugging.

**Fully supported C and C++ compilation environment**

Tornado supports both the C language and updated C++ language with cross-compilers, the iostreams class library, and a variety of other tools. The cross-compilers contain several optimizations that allow developers to generate
functions and references to variables whose names are found in the system symbol table. Interpreted C statements give an easy-to-use interface to the target environment, plus valuable debug capabilities. Invocation of any subroutine loaded into memory, including VxWorks system and application modules, provides quick prototyping and incremental code development. Testing via dynamic function execution speeds development.

Launcher for easy setup
The Tornado launcher permits easy setup and configuration of a specific development environment. It also manages that environment and provides many administrative functions.

WindSh for interacting with target facilities
The interactive WindSh™ shell interface, which allows users to interact with all target facilities, is unique to Tornado. Unlike other “shells,” the Tornado shell can interpret and execute almost all C-language expressions, including calls to functions and references to variables whose names are found in the system symbol table. Very fast, efficient, compact code. Full run-time support for C++ includes exception handling, standard template library (STL) and run-time type identification (RTTI), loader support for static constructors and destructors, and C++ debugging features. The iostreams library supports formatted and typesafe I/O in C++, is extensible to user-defined data types, and is an industry standard for C++ application development.

Browser – graphical companion to the Tornado shell
The Tornado browser is a graphical companion to the Tornado shell. Like the shell, it presents information symbolically whenever possible. The browser’s main window gives a summary of the target system’s overall state, and allows the developer to launch dedicated displays that monitor the state of individual target operating-system objects, such as tasks, semaphores, message queues, memory partitions, and watchdog timers. These displays are updated either on demand or periodically, at the developer’s option.

WindNavigator for evaluating source code
The WindNavigator™ multilanguage browsing tool enables developers to dramatically reduce the time required to evaluate existing C and C++ source code, even if the code is incomplete or erroneous. With WindNavigator, developers can see the relationships between objects and functions and can easily build programs using existing, proven modules.

Optional WindPower and WindPower C++ tools
WindPower™, WindPower Java, and WindPower C++ tools are optionally available to Tornado II developers. Each WindPower tool addresses a particular aspect of application development, while WindPower C++ tools are specifically designed for developers who work in the C++ programming language. WindPower Java tools are designed for developers using Java technology in embedded systems.
programs as they run in a target system. It is available in two separate modules:

- CodeTEST/Coverage Module pinpoints untested areas of code and provides dynamic views of the system.
- CodeTEST/Memory Module permits developers to observe dynamic memory levels as they occur.

Visual SlickEdit – Tornado Edition: The full-featured editing capabilities of Visual SlickEdit are combined with special support for the Tornado development environment.

WindPower tools

- WindView: The WindView diagnostic and analysis tool provides detailed visibility into application software as it runs on the actual target hardware.
- VxSim: The VxSim prototyping and simulation tool enables developers to create prototype applications — including networking and multiprocessor-based designs — before the actual target hardware becomes available. VxSim also permits developers to test a large portion of application software early in the development cycle, when errors are less costly to correct.
- ScopePak: ScopePak includes StethoScope, a real-time data visualization, profiling, and debugging tool, as well as TraceScope, a real-time, function-level, software-based trace tool.
- PerformancePak: PerformancePak includes ScopeProfile, which provides detailed, function-by-function analysis of tasks running within an application, and MemScope, which helps developers control memory usage.
- CodeTEST for Tornado: This software-only version of CodeTEST is an easy-to-use, cost-effective tool for analyzing embedded programs as they run in a target system. It is available in two separate modules:
  - CodeTEST/Coverage Module pinpoints untested areas of code and provides dynamic views of the system.
  - CodeTEST/Memory Module permits developers to observe dynamic memory levels as they occur.
- Visual SlickEdit — Tornado Edition: The full-featured editing capabilities of Visual SlickEdit are combined with special support for the Tornado development environment.

WindPower C++ tools

- Wind Foundation Classes™: VxWorks Wrapper classes and Toolsh++ from Rogue Wave Software support object-oriented design and help accelerate application development.
- Look! for Tornado: This C++ visualization and debugging tool graphically explores a C++ program as it executes.

Flexible VxWorks RTOS

VxWorks, the run-time component of the Tornado II embedded development platform, is the most widely adopted RTOS in the embedded industry.

VxWorks is flexible, with more than 1,800 powerful application program interfaces; scalable, from the simplest to the most complex product designs; reliable, used in mission-critical applications ranging from antilock braking systems to interplanetary exploration; and available on all popular CPU platforms.

The VxWorks RTOS comprises the core capabilities of the wind® microkernel along with advanced networking support, powerful file system and I/O management, and C++ and other standard run-time support. These core capabilities can be combined with add-on components available from Wind River and its more than 600 WindLink™ for Tornado partner companies.

High-performance microkernel design

At the heart of the VxWorks run-time system is the highly efficient wind microkernel. This microkernel supports a full range of real-time features including fast multitasking, interrupt support, and both preemptive and round-robin scheduling. The microkernel design minimizes system overhead and enables fast, deterministic response to external events. The run-time environment also provides efficient intertask communication mechanisms, permitting independent tasks to coordinate their actions within a real-time system.
**Scalable run-time software**
VxWorks is designed for scalability, enabling developers to allocate scarce memory resources to their application, rather than to the operating system. From deeply embedded designs requiring a few kilobytes of memory, to complex, high-end real-time systems where more operating system functions are needed, the developer may choose from over 100 different options to create hundreds of configurations. Individual modules may be used in development and omitted in production systems. Furthermore, these individual modules are themselves scalable, allowing the developer to optimally configure VxWorks run-time software for the widest range of applications. Configuration options can be easily selected by means of the Tornado II project facility's graphical interface. Developers can also use Tornado II’s autoscaling feature, which automatically analyzes application code and incorporates the appropriate options.

**Comprehensive networking facilities**
VxWorks was the first real-time operating system to integrate industry-standard TCP/IP networking facilities optimized for real-time applications. This tradition of innovation continues with the VxWorks Network Stack, which supports Berkeley (BSD 4.4) networking features.

**Choice of platform**
Wind River offers off-the-shelf turnkey integration with an extensive set of commercial and evaluation boards. VxWorks’ open design is highly portable and complete across all supported processors, allowing application migration between architectures with minimal effort.

**Operating system accessories**
Accessory products are available to give developers access to an unprecedented range of features and to extend the capabilities of VxWorks. These include the BSP Developer’s Kit, support for flash file systems with TrueFFS for Tornado, support for graphics and embedded Internet applications, virtual memory management with VxVMI™, and multiprocessing with VxMP™ and VxFusion™.

**Widest selection of third-party products**
Wind River’s WindLink for Tornado Partner Program offers the industry’s widest and deepest selection of third-party enhancements to embedded software. The latest in third-party software offerings can be found in the TradeWinds™ directory, available in hardcopy or on the WindLink Partner pages on the Wind River Web site: http://www.windriver.com/corporate/html/partnerindex.html.
Wind River Services

Building embedded products not only requires sophisticated development tools and a reliable operating system, but also specialized engineering skills and skillful management. Wind River offers a comprehensive suite of professional services provided by experienced consultants who can guide a product from design and development through system integration and long-term maintenance. A Wind River manager oversees all projects, thereby guaranteeing the company’s direct involvement, as well as timely delivery of all services.

Wind River and its Services organization provides applications consulting, driver development, and custom enhancements to standard products for customers and partners.

Customer support

The Tornado II platform is backed by Wind River customer support services that help customers get the most from their investment. Services include a global network of Customer Support Response Centers staffed by knowledgeable and responsive Wind River engineers, a worldwide organization of field support engineers to provide on-site troubleshooting, and comprehensive round-the-clock online support provided via the WindSurf™ Web site.

Training

Comprehensive training courses on Tornado Tools and VxWorks are available at Wind River facilities in the United States and other locations throughout the world.

Tornado II enhances time-to-productivity

In the final analysis, the marketplace won’t wait for anyone or any product. Embedded product teams the world over are using the award-winning Tornado II platform to accelerate the development of a wide range of applications. Since Wind River’s founding, the company’s software and services have set the pace in embedded computing, with Tornado-based end-products exceeding expectations in environments as diverse as ink-jet printers and the surface of Mars.

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