Real-Time Operating Systems: Software Profiles

Summary

Profiled products are from selected RTOS vendors with more than 20 years of experience in real time, as well as newer visible players, such as Microsoft, Sun Microsystems and some Linux suppliers.

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Enea OSE Systems/OSE Systems, Inc.
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OSE Real-Time Operating System (RTOS)

Markets: Concentration on the telecommunications and data communications arenas, but supports applications ranging from small, handheld devices to high-availability telecommunications systems. OSE Systems also specializes in safety-critical systems for industrial process control, medical and petrochemical applications.

Enea OSE Systems is a subsidiary of Enea Data, a Swedish company founded in 1968. In 1988 Enea Data designed the OSE operating system for the Motorola 68K processor. OSE is marketed as a highly scalable, off-the-shelf solution for a variety of real-time applications. The RTOS has a message-based architecture and supports fault-tolerant systems. The operating system comprises a number of key components: Real-time Kernel, network support, Internet support, Link Handler, Program Handler and File System. Added to these components on the host side are source and application debugging tools and the OSE Soft Kernel, which allows OSE programs to run on the host system.

Enea OSE received an IEC1508 certification for its performance in safety-critical applications. It also received an IEC 61508 safety certification, the first RTOS product to be granted this certification. OSE also specializes in signal handling, which produces high throughput rates, making it appropriate for high-performance communications systems. Enea OSE runs on HP-UX, Sun Solaris and SunOS and Windows NT/2000 systems. It supports Amtel, Analog Devices, Intel StrongArm, MIPS, Mitsubishi, Motorola (ColdFire, 6800, PowerPC and M-Core) and NEC processors.

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Markets: Embedded Java Virtual Machine (JVM) for Internet devices, pagers, personal digital assistants (PDAs) and wireless phones markets.

Jbed
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Esmertec, based in Switzerland, offers a line of Java-oriented, RTOS and development products. The Jbed line, which is based on Sun Microsystems’ Java 2 Platform, Micro Edition (J2ME) technology, consists of the following: the Jbed RTOS, an RTOS for embedded JVM applications; Jbed Light, a lightweight version of the Jbed RTOS for fast and precompiled applications; and Jbed Micro Edition Connected Limited Device Configuration (CLDC), a fast JVM for memory-restrictive devices, including PDAs, mobile phones and Internet appliances. Because it based on Java, Jbed is small and fast and is suitable for high-volume applications like cellular phones and PDAs.

Green Hills Software

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Integrity and ThreadX

Markets: Aerospace, consumer products, defense, education/research, financial analysis, industrial automation, manufacturing, medical and telecommunications.

Green Hills Software is an RTOS development supplier for 32- and 64-bit, embedded systems. Integrity is Green Hills Software’s protected memory, royalty-free RTOS that is geared for mission-critical response. The operating system includes a small, fast, multitasking kernel. Integrity 4.0, released in March 2002, offers full memory protection and supports sub-200-ns interrupt response and sub-microsecond context switching (on a 233MHz processor).

Integrity’s kernel handles communications circuits, context switching, message queue management, semaphores and shared memory control. It offers an unlimited number of process priority levels. Integrity offers a real-time scheduler with support for multiple priority levels with guaranteed CPU percentage allocation within a level. It provides networking support, including TCP, User Datagram Protocol (UDP), Sockets and Web server technologies. Integrity runs on HP Alpha AXP, HP-UX, IBM AIX, Sun Solaris and SunOS and Windows NT/2000 computers. It supports ARM, MIPS, PowerPC and XScale processors. Green Hills also offers its MULTI Integrated Development Environment (IDE), which is designed to automate all facets of embedded software development and optimization.

The company also offers ThreadX, a deterministic RTOS with a speed-oriented picokernel architecture, originally developed by Express Logic. It uses high-priority thread structures and offers the capability to divide an application into easily managed portions. It runs on a wide variety of processors, including ARM7, ARM/Thumb, ColdFire, MIPS, i960, PowerPC, SH, StrongARM and v8xx.

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LynxOS, BlueCat Linux and BlueCatRT

Markets: A family of embedded operating systems focused at diverse embedded systems requirements and embedded applications, including avionics, automotive, communications, office automation, process control and telecommunications systems.

LynuxWorks, formerly Lynx Realtime Systems, offers three embedded OSs: LynxOS, a Unix- and Posix-compliant RTOS; BlueCat Linux, a Linux-based, embedded OS; and BlueCatRT, a Linux-based, embedded RTOS. LynxOS, introduced in 1988, is a popular multiprocessor and multithreaded operating system designed for complex real-time applications that require fast, deterministic response. It runs on x86, PowerPC, MIPS, microSPARC, microSPARC II, 68k, Precision Architecture Reduced Instruction Set Computer (PA-RISC) and other processors. LynxOS 4, released in March 2002, provides new IPsec, IPv6 and integrated firewall features. It is also the first commercially available RTOS to provide true application binary interface (ABI) compatibility to Linux, enabling users to run Linux applications unmodified under LynxOS.

First released in February 2000, BlueCat Linux is LynuxWorks’ version of Linux for high-availability and highly reliable embedded applications. Based on the Linux 2.4 kernel, the product can scale from small consumer-type devices to large-scale, multiprocessor configurations. BlueCatRT is an integration of BlueCat Linux, with the RTLinux/Pro technology that provides hard real-time performance for embedded devices with Linux. All three of LynuxWorks’ embedded OSs share source code compatibility. The LynxOS and BlueCat Linux products share application programming interfaces (APIs), a compatible application development toolset and a support infrastructure. With a commitment to the Linux market, LynuxWorks provides a range of products and services for embedded software development under the Linux, Windows and Solaris operating systems. In support of its embedded efforts, Intel and Motorola have made minority investments in LynuxWorks.

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Mentor Graphics, a supplier of electronic hardware and software design products, acquired Accelerated Technology in March 2002. Accelerated Technology Inc. (ATI) was founded in 1990 and offers the royalty-free Nucleus Plus real-time, multitasking kernel. The company also offers the code|lab Developer Suite. Mentor Graphics provides VRTX, a real-time operating system for System-on-Chip (SoC).
Mentor Graphics pursued ATI because of synergy between the two embedded product lines and to give its customers a wide range of embedded choices. ATI is part of Mentor Graphics’ Embedded Systems Division and retains its headquarters in Mobile, Alabama.

**Mentor Graphics VRTX**

**Markets:** Designed for SoC applications.

VRTX is composed of API-compatible kernels that permit developers to select appropriate levels of RTOS support for SoC applications. It is available in two editions: VRTXmc is a compact real-time product with critical kernel services for applications that require minimal ROM and RAM consumption; VRTXsa is a full-featured RTOS with a broad range of configuration and scalability options. It supports ARM, MIPS, PowerPC and other embedded RISC processors.

**ATI Nucleus Plus**

**Markets:** Embedded systems that range from small devices like cellular telephones to complex factory automation systems.

The royalty-free Nucleus Plus is written nearly completely in ANSI C for portability. It offers standard task control, intertask communication, intertask synchronization, memory management, timer management and interrupt management facilities. The ATI product line is available for Windows 95/98, Windows NT/2000, Sun Solaris and SunOS environments. Nucleus Plus runs on a broad variety of processors, including ARM, Hitachi, Infineon, MIPS, Motorola (ColdFire, 680x0, 683xx), PowerPC and x86 processors.

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**Windows CE.Net**

**Markets:** Small-footprint smart devices, including cellular phones, handheld computers, retail point-of-sale (POS) devices, set-top boxes and Web-enabled devices.

Microsoft released Windows CE.Net as the successor to Windows CE 3.0 in January 2002. It is a platform for creating smart mobile devices and is capable of operating in footprints as small as 200KB. Windows CE.Net offers interrupt management techniques and support for 256 thread priority levels. It supports a wide range of processor families, including Intel x86, Xscale, ARM, MIPS and the SH 3/4 Series.

Windows CE.Net was designed to get developers up and running fast. It comes with pre-configured design templates for embedded devices like handhelds, smart phones, retail POS devices, set-top boxes and Web pads. Developers have access to a range of third-party and Microsoft technologies to build sophisticated devices. These technologies include Bluetooth and 802.11 for wireless support and multimedia tools like Microsoft Internet Explorer 5.5, Windows Media 8 and DirectX 8. Windows CE.Net also supports Lightweight Directory Access Protocol (LDAP) 3.0, Remote Access Service (RAS) Server, TCP/IP and other open networking standards.
QNX RTOS and QNX/Neutrino

Markets: The QNX RTOS is geared for automotive computing, industrial automation, medical instrumentation, POS and telecommunications markets. QNX/Neutrino is designed for deeply embedded applications such as consumer electronics, office equipment, industrial controllers and telecommunications data communications devices.

QNX RTOS is QNX's full-featured, RTOS with a small microkernel and optional processes. The QNX RTOS microkernel is small enough to be used in ROM-based, embedded applications, yet is capable of spanning to distributed networks running hundreds of processors. The QNX microkernel (Neutrino) handles process creation, memory management and timer control. Transparent distributed processing allows processes to be launched across the QNX network, allowing for full inheritance of the environment, including open files, current directory, file descriptors and user ID. Multiple file systems can be run at the same time, including the Posix Fsys, embedded Efsys, SMB, network, DOS and block. The microkernel also includes Posix.1 (certified) and many Posix.1b real-time services, as well as high-speed diagnostic event tracing. The QNX RTOS runs on AMD, MIPS, PowerPC, SH and StrongARM processor families.

Introduced in 1996, QNX/Neutrino is a Posix-based, real-time kernel for deeply embedded systems. It can be scaled to a stand-alone system as small as 32KB or as large as 4GB. A subset of the modules available for the full QNX RTOS is available for QNX/Neutrino. It supports SMP, allowing the same code base used in tiny embedded devices to be scaled up to large, distributed networks of SMP clusters.

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OS-9

Markets: Avionics, automotive control, consumer (cell phones, digital television), deeply embedded, industrial automation, Internet and wireless communications, office automation and telecommunications markets.

RadiSys Corp. acquired Microware Systems, a longtime RTOS specialist and creator of OS-9, in August 2001. RadiSys manufactures and markets communications and Internet technologies for telecommunications systems. OS-9 features a modular design with dynamic memory management, communications facilities and interrupt and exception-handling services. OS-9 includes kernel, device
drivers, descriptors and file manager modules. This architecture allows individual modules to be added or deleted when Microware OS-9 is configured for a specific application.

OS-9’s bundled middleware includes a multiprotocol networking stack, a lightweight multimedia subsystem (mwMAUI), communication subsystem (mwSoftStax), RAM disk support, broad application and I/O support and user-installable system calls. OS-9 runs on ARM, Intel x86, IXP 1200, Motorola 68K, PowerPC and SH3/SH4 processors. Microware is a totally owned subsidiary of RadiSys.

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eCos
Markets: Can be used for a wide range of applications, including aerospace, automotive, consumer electronics, Internet, office automation, networking and telecommunications.

eCos, the embedded configurable operating system, is an open-source, real-time operating system for deeply embedded applications. It provides the basic runtime infrastructure necessary to support devices with memory footprints as low as 10KB. In January 2000 Red Hat Software, the leading Linux distributor, acquired Cygnus Solutions and its Embedded Cygnus Operating System (eCos). It is a royalty-free, runtime solution that is available under open-source licensing terms.

The core of eCos is a configurable real-time kernel, providing multithreading, a choice of schedulers, a full set of synchronization primitives, memory allocation primitives and thread-manipulation functions. eCos supports EL/IX Level I, a Linux compatibility interface, for embedded applications in devices that are too small for even stripped-down versions of Linux or that require real-time capabilities. eCos 1.3 includes a new Component Description Language, which is designed to recognize and resolve conflicts between software applications. It supports a variety of processor types, including ARM9 and ARM Thumb, Cirrus Logic EP-7209 and EP-7212, Hitachi SH and Intel x86 and StrongARM.

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ChorusOS
Markets: Embedded operating system for cellular telephones and base stations, public switches and PBXs, cross-connect switches, voice mail systems and Web phones.

ChorusOS has been used in mission-critical applications for more than 15 years. It includes a development environment for creators of high-end telecommunications equipment for cellular, data communications and switching networks. Its component architecture enables the ChorusOS operating
environment to scale from very small, embedded systems (10KB) to high-functionality, transparently distributed platforms.

The Sun Embedded Workshop, an integrated development environment, ships with ChorusOS. It contains the tools and all the components needed to build the ChorusOS runtimes. ChorusOS runs on Intel x86 and UltraSPARC processors.

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**Markets:** Digital imaging, consumer appliances, mission-critical aerospace and defense systems, medical products and industrial measurement and control systems.

Founded in 1983, Wind River Systems is the leading supplier of embedded systems software. In 2000 the company acquired one of its longtime competitors, Integrated Systems Inc. (ISI), an embedded systems specialist with more than 20 years of experience. Determined to keep its market lead in the face of increasing competition, Wind River purchased ISI and its pSOS RTOS—for approximately US$1 billion—to fortify its product line and technical resources. Wind River extended itself again in April 2001, with its purchase of Eonic Systems, an RTOS vendor based in Belgium. With that acquisition, Wind River gained the rights to Virtuoso, an RTOS specially designed for application-specific integrated circuit (ASIC) and digital signal processing (DSP) applications.

**VxWorks**

VxWorks is one of the most popular RTOSs in the embedded industry. It provides a microkernel that supports such real-time features as dynamic memory management, interrupt handling, multitasking, an unlimited number of tasks, 256 priority levels and preemptive and round-robin scheduling. VxWorks 5.0 offers more than 1,800 APIs, advanced networking (TCP, UDP, sockets and standard Berkeley Software Distribution [BSD] network services), flexible file system and I/O management and C++ and other standard runtime support.

VxWorks’ basic capabilities can be supplemented with third-party add-on products from Wind River and more than 600 WindLink partner companies. The software can be targeted to ARM; Hitachi SuperH; Motorola/IBM PowerPC and ColdFire; Intel x86, StrongARM and XScale; and MIPS processor architectures.

**pSOS+3**

pSOS supports embedded applications that range from simple, stand-alone devices to complex, networked systems. pSOS+3 is the multitasking kernel and the core of pSOS. Modular software components and libraries can be plugged into the kernel as needed. A board support package (BSP) containing chip initialization and device drivers isolates pSOSSystem components and applications from the underlying hardware. The pRISM+3 IDE provides tools needed to bring up hardware, develop firmware, develop and debug applications, profile and optimize system performance, manage team-based development and enable mixed-platform development for pSOSSystem 3-based applications.
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**Virtuoso**

Virtuoso provides an RTOS and development environment for hard real-time embedded applications that use high-performance DSPs, ASIC cores and microprocessors. The Virtuoso development environment consists of the RTOS, a project manager, multithreaded asynchronous network host server and a suite of graphical analysis and debugging tools. It supports ADSP-2106x, ADSP-2116x, TMS32OC6x, ARM and other types of processors.