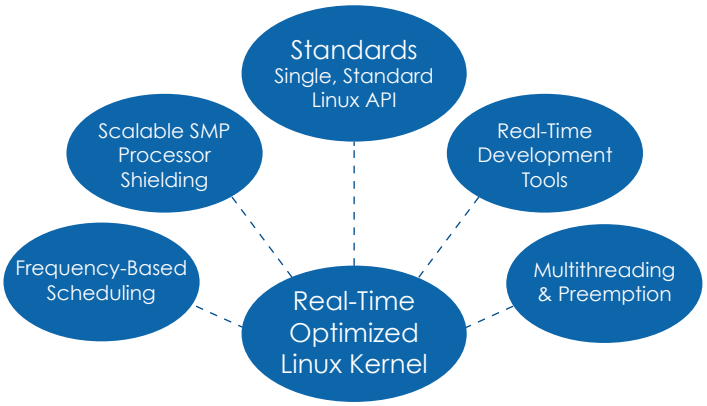
RedHawk Linux

Real-Time Linux Development Environment

- Field-proved value-add performance
- Guaranteed event response on certified platforms
- Advanced processor shielding features
- NightStar™ non-intrusive debugging and analysis tools
- Customized targed images



RedHawk Linux Overview

Concurrent Real-Time's RedHawk™ Linux® is an industry standard, real-time version of the open source Linux operating system for Intel x86 and ARM64 platforms. RedHawk Linux provides the guaranteed performance needed in time-critical and hard real-time environments. RedHawk is the ideal Linux solution for a broad range of server and embedded applications such as modeling, simulation, data acquisition, industrial control and medical imaging systems. RedHawk guarantees that a user-level application can respond to an external event in less than 5 microseconds on certified platforms.

Designed for developers who need to reduce cost, improve time to market, increase system reliability and overall quality of service of their applications, RedHawk offers field-proven, contemporary open source Linux technology, advanced GUI debugging and analysis tools, comprehensive multi-core support and award-winning customer service. RedHawk is widely used in aerospace, defense, automotive, manufacturing, medical and financial applications.

Complete Development Environment

RedHawk Linux offers a complete set of tools for effcient development of time-critical applications. Concurrent's powerful NightStar application development tool kit provides a robust graphic interface for non-intrusive control, monitoring, analysis and debugging of multi-threaded, multi-core applications. NightStar offers advanced debugging features such as lockless kernel trace. In addition to GNU C, C++ and Fortran, RedHawk also supports the popular Intel C/C++ and Fortran compilers.

Compatability with Red Hat®

RedHawk Linux user-level commands, utilities and system administration are fully compatible with Red Hat Enterprise Linux and CentOS. RedHawk achieves its superior real-time performance by providing the latest official long-term release from kernel.org with key open source patches and kernel enhancements developed by Concurrent. RedHawk user libraries provide access to value-add features that are not part of other Linux offerings. RedHawk is fully compatible with standard Linux user level APIs, thus Linux applications written for other Linux distributions will run on RedHawk without modification. RedHawk is also available with the Ubuntu user environment.

Scalable SMP and Processor Shielding

In tightly-coupled symmetric multiprocessing systems and multicore SBCs, RedHawk Linux allows individual CPUs and cores to be shielded from local timers, interrupts, daemons, bottom halves and other Linux tasks. RedHawk's comprehensive processor shielding features provide a highly deterministic execution environment where interrupt response is guaranteed. Unlike other distributions, RedHawk offers a field-proven, easy-to-use shielding API with both command-line and graphical-tool user interfaces. RedHawk also supports optional PREEMPT_RT scheduling for minimizing the latency of large numbers of threads without requiring processor shielding.

Multithreading and Preemption

RedHawk Linux allows multiple processes to execute in the kernel simultaneously. The kernel protects key data structures and critical sections of code with semaphores and spinlocks to preserve system integrity.

Processes executing in the RedHawk kernel can be preempted, i.e. forced to relinquish a CPU involuntarily. The RedHawk kernel can transfer control from a lower-priority process to a higher-priority process except when the lower priority process is executing in a critical kernel section. To provide deterministic response, many critical sections of the kernel have been tuned and optimized to dramatically shorten non-preemptable conditions. These changes are key to allowing a high-priority process to respond immediately to an external event, even when the CPU is currently in use.

Semaphores internal to RedHawk Linux also support priority inheritance to prevent priority inversion when multiple threads of an application are competing for operating system resources.

Single Kernel Environment

RedHawk is a complete Linux distribution designed to fully support time-critical applications. RedHawk provides a true single-kernel programming environment that directly controls all system operation. Complex time-critical applications often require that high-speed file I/O, networking and graphics be performed deterministically together with real-time task scheduling. Only RedHawk's single-kernel design ensures determinism and high-speed performance of all these features.

The U.S. Navy has selected RedHawk Linux as its Open Architecture Operating System for numerous programs including the Aegis Weapon System, Naval Undersea Warfare Center's next generation torpedo hardware-in-the-loop test bed, the Surface Electronic Warfare Improvement Program, and the U.S. Coast Guard Deep Water Program.

Frequency-Based Scheduler

RedHawk's Frequency-Based Scheduler (FBS) is a high-resolution task scheduler that enables the user to run processes in cyclical execution patterns. FBS controls the periodic execution of multiple, coordinated processes utilizing major and minor cycles with overrun detection. A performance monitor is also provided to view CPU utilization during each scheduled execution frame.

Real-Time Clock and Interrupt Module Support

On Concurrent iHawk™ real-time multiprocessors, RedHawk supports the Real-Time Clock & Interrupt Module (RCIM), a multifunction card designed for time-critical applications that require rapid response to external events. Eight programmable timers and twelve input and output external interrupt lines are available. Any interrupt source can be distributed to other iHawks for synchronizing multi-system applications. The RCIM includes a high-resolution synchronized clock to provide a common time base across multiple systems. On-the-wire time stamps allow RedHawk to provide for high-resolution NTP synchronization. RCIM options include a GPS module for synchronizing with GPS standard time and high-stability crystal oscillators to provide for accurate timekeeping without an external time source.

I/O Enhancements

RedHawk supports Linux user-level (UIO) device drivers. RedHawk's UIO facility provides a kernel driver stub that can be used with user code to develop a user-space driver for almost any type of hardware. RedHawk also includes the latest available NVIDIA® graphics and GPU drivers specially optimized for real-time performance by Concurrent. The enhanced drivers allow applications to achieve maximum determinism during image rendering and CUDA GPU computation.

Non-Uniform Memory Access (NUMA) Optimization

The standard Linux NUMA implementation does not offer a mechanism to ensure that pages of a real-time process are local to a given NUMA node and ensure that no other process' pages are using that same node. RedHawk's NUMA optimization features dramatically improve the determinism of real-time process memory access on NUMA architectures. RedHawk can automatically duplicate libraries and other modules as needed and hold them simultaneously in multiple nodes to maximize performance. RedHawk also improves real-time performance by replicating kernel code and read-only data in each NUMA node.

RedHawk Architect

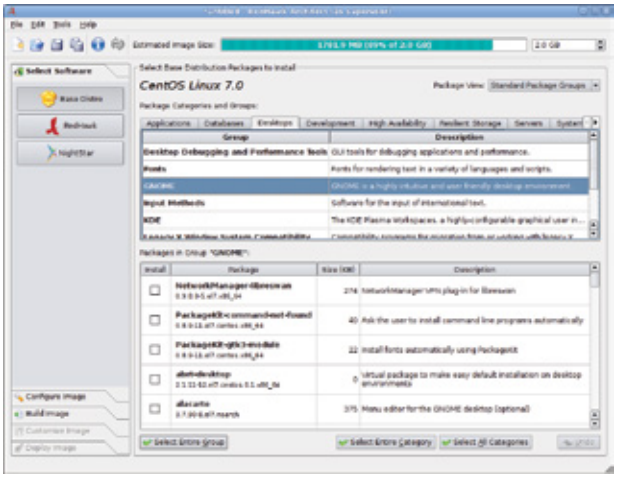
RedHawk Architect is a powerful tool with an easy-to-use GUI that lets a developer choose the Linux and application modules to be included in RedHawk target images. Designed especially for embedded applications, users can select as few or as many packages as desired from many different package groups. Architect allows the file system to be customized and minimized for diskless operation using flash size under 1 GB.

Architect's cluster manager software allows users to install and configure systems as highly-integrated, high-performance computing clusters. Architect includes mechanisms for network PXE installing and also for network PXE diskless booting of multiple nodes with the same version of RedHawk.

Architect creates and processes a configuration file defined by the user to perform actual RPM package installation. The tool prompts the user to insert the required RedHawk, NightStar, and Linux user land media depending upon the features selected. RedHawk Architect will allow customization of the RedHawk kernel itself and provides a flashing tool for burning RedHawk and the user's application image onto a CPU board's non-volatile memory, DVD or USB flash. Architect can also build virtual target images for use with QEMU/KVM. This allows embedded images to be tested without a physical target system.

RedHawk Features

- Real-time Linux operating system for x86 and ARM64 systems
- Field-proven value-add performance
  - Guaranteed <5 usec event response on certified platforms
  - Advanced shielding features
    - Processor, interrupt and local timer
    - Easy-to-use shielding API and GUI
  - NUMA performance optimization
  - User-level I/O
  - Frequency-based scheduling
  - Lockless kernel trace
  - Optimized graphics and CUDA® I/O
  - Support for Intel® Phi™ coprocessor MIC programming
  - Cluster management
  - Preemptive, multithreaded, reentrant kernel
  - Priority inheritance
  - User-level preemption control
  - Post/Wait services
  - Minimal dispatch latencies
  - Dynamic and static load balancing
  - SELinux Security
  - Virtual targets with QEMU/KVM
  - Optional PREEMPT_RT real-time Scheduling
- Industry Standards
  - Linux Standard Base (LSB)
  - POSIX 1003.13 Profile 54
  - POSIX 1003.1 real-time and threads
  - RHEL/CentOS® and Ubuntu compatibility
  - Eclipse IDE interoperable
- RedHawk Architect™ GUI configuration tool
  - Choose desired user packages and modules
  - Select a target-specific kernel
  - Build the complete root file system
  - Flash the file system image
  - Reconfigure images as needed
- Single-vendor Support for all Linux Needs
  - Software maintenance services
  - Telephone support, on-line updates, releases
  - Custom I/O driver development
  - Application rehosting
  - Consulting services



Build customized target images with RedHawk Architect

NightStar Application Development Tools

Concurrent's NightStar is a powerful, integrated tool set for developing time-critical CPU and GPU applications. NightStar tools run with minimal intrusion, thus preserving application execution behavior and determinism. Users can quickly and easily debug, monitor, schedule, analyze and tune applications in real-time. NightStar GUI-based tools reduce test time, increase productivity and lower development costs. Time-critical applications require debugging tools that can handle the complexities of multiple processors and cores, multitask interaction and multi-threading. NightStar's advanced features enable system builders to solve difficult problems quickly.

NightView™ is a source-level debugger that allows users to simultaneously debug multiple, time-critical processes. With NightView, a programmer can change program execution and modify or display data without stopping or interrupting the program. Eventpoint conditions, such as hit and ignore counts, are patched directly into an application and executed at full application speed. NightView includes an interactive memory debugger that helps find and eliminate heap memory leaks.

NightTrace™ is an event analyzer that displays and analyzes the dynamic behavior of applications, the RedHawk kernel and the interaction between them. NightTrace can log events from multiple processes executing simultaneously on multiple CPUs and GPUs. NightTrace can also combine user-defined application events with kernel events to present a synchronized view of the entire system. RedHawk's lockless kernel trace eliminates any contention when multiple cores log trace points simultaneously.

NightTrace allows users to zoom, search, filter and analyze events. Tracing analysis can be live or post execution. NightTrace's powerful application illumination GUI allows programmers to automatically trace CPU and GPU application function calls and examine the values of parameters passed and returned. Function call tracing is fully customizable and can provide a complete view of glibc activities.

NightSim™ is a tool for scheduling time-critical applications that require predictable, cyclic process execution. Ideal for simulation applications, NightSim allows developers to dynamically adjust the execution of multiple, coordinated processes, their priorities, scheduling policies and CPU assignments. Users can monitor the performance of applications by displaying period execution times, maximums and minimums, and optionally pause execution when a process overruns its allocated frame.

NightStar tools reduce test time and lower development costs

NightProbe™ is a tool for monitoring, modifying and recording data values from multiple, independent application resources including programs, shared memory segments, memory mapped files and PCI devices. NightProbe can be used in development for debugging, analysis, prototyping and fault injection, or in a production environment to create a GUI control panel for program input and output.

NightTune™ is a GUI for monitoring and tuning application and system performance. Users can monitor the priority, scheduling policy, CPU assignment and CPU and GPU usage of user applications. NightTune also monitors system CPU usage, context switches, interrupts, memory utilization, and disk and network activity. NightTune can be used to shield cores and adjust interrupt and process anity.

Customer Support

Technical support for your real-time Linux needs is provided directly by Concurrent Real-Time. Standard RedHawk services include telephone support, problem reporting and resolution, on-line software updates and new releases as available. Consulting services are also available for special hardware integration and software support needs.

Since the beginning of the millennium, Concurrent has deployed and supported thousands of proven Linux solutions in a range of technical industries. Concurrent Linux expertise and support has been a key factor in the success of many critical government and commercial applications.

About Concurrent Real-Time

Concurrent Real-Time is the industry's foremost provider of high-performance real-time computer systems, solutions and software for commercial and government markets. Its real-time Linux solutions deliver hard real-time performance in support of the world's most sophisticated hardware in-the-loop and man-in-the-loop simulation, high-speed data acquisition, process control and low-latency transaction processing applications. With over 50 years of experience in the real-time market, Concurrent provides sales and support from offices throughout North America, Europe and Asia.

For more information, please visit Concurrent Real-Time at www.concurrent-rt.com