QNX SOFTWARE SYSTEMS LTD.

SYMMETRIC MULTIPROCESSING (SMP) AT A GLANCE

The bandwidth explosion, combined with many new network services, is putting extreme demands on the control-plane processor, to the point where the fastest CPU struggles to keep pace. In response, many software designers are distributing the workload across multiple CPUs, using symmetric multiprocessing (SMP). The commercial advantages are many: greater system density, lower development costs, compressed time to market, and the scalability to handle growing network topologies and new network services on demand.

What is SMP?

SMP is a specific implementation of multiprocessing in which multiple CPUs share the same board, memory, peripherals, resources and operating system (OS), physically connected via a common high-speed bus.

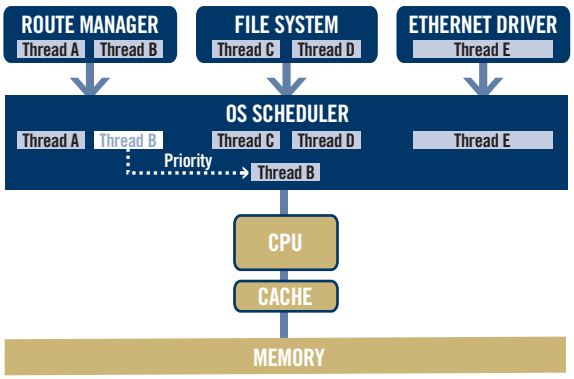
Different Processing Environments

Consider three different environments and how multiprocessing can be implemented: uniprocessing, simple distributed multiprocessing, and SMP.

Uniprocessing Environment

A single CPU handles all system processing activity and is directly connected to the main memory.

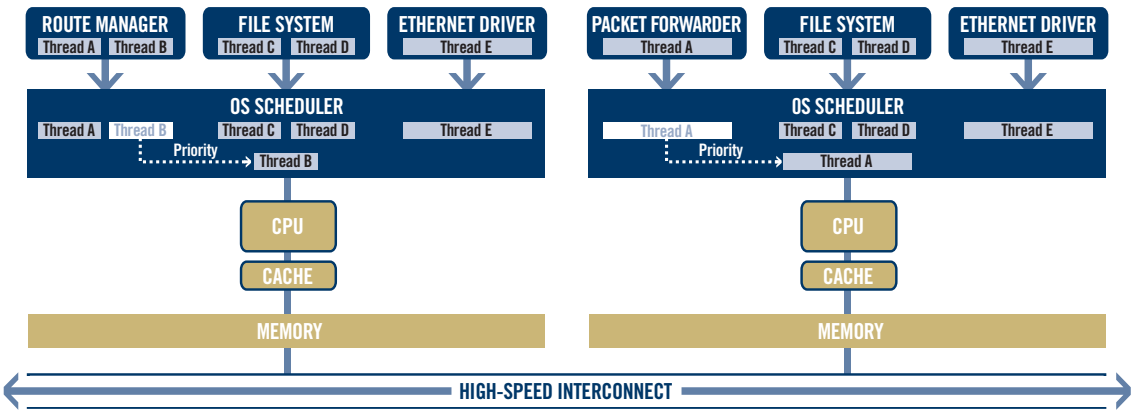
- **For improved processing, the CPU can be replaced with a higher-speed alternative, which can result in heat dissipation problems.**
- **Increasing CPU speed will increase performance, but not in a linear fashion, due to existing peripheral and component limitations.**
- **Concurrency is simulated by switching among different tasks.**



Simple Distributed Multiprocessing Environment

Individual CPUs function as separate nodes, each utilizing its own OS, peripherals, and memory. These nodes are joined together by some form of network or high-speed interconnect.

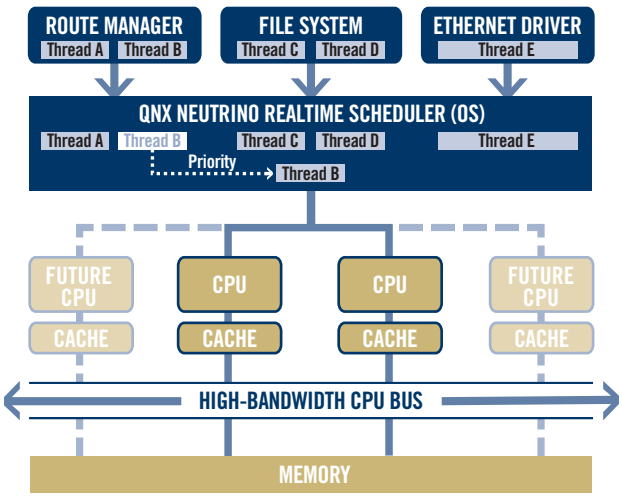
- **Requires replication of OS, peripherals, and resources for each CPU contributing to incremental costs, space and power requirements, but this approach can also provide greater fault tolerance and system availability.**
- **Works best when processes distributed across the multiple nodes share relatively small amounts of data.**
- **Application software may require modifications to support inter-node communication, unless the OS provides built-in distributed processing (QNX® Neutrino® RTOS, for example).**



SMP Environment

Processor cores lie in close proximity to one another and are physically connected by a common high-speed bus. Common resources are shared by all CPUs, including memory, peripherals, resources, and the operating system (OS), which coordinates simultaneous tasks or threads among the CPUs.

- Each CPU runs tasks independently as scheduled by the OS, providing true concurrency by allowing multiple applications and system services to execute at the same time.
- Tasks are distributed transparently across several CPUs to maximize performance or can be bound to a specific processor to segment realtime and non-realtime system components.
- There are no incremental hardware requirements, other than for the additional CPUs.
- Applications and system services require little or no changes if OS is based on a microkernel architecture.
- Software doesn't incur any overhead to maintain a coherent view of the data distributed among the several processors; this coherency is handled transparently by the SMP hardware.



Applying SMP

Who Needs It

- System-level architects
- Application designers
- System designers

Benefits

- Scalability to support new network services, without the need for forklift upgrades
- Improved system density
- Significantly boosts processing power without incremental costs of support chips, chassis slots, upgraded peripherals
- Provides true concurrency by allowing multiple applications and system services to execute at the same time

Sample Applications

- Systems comprising many different processes, that need to operate in parallel without source code modifications
- Multithreaded applications
- Compute-intensive applications
- Systems requiring additional processing power, but without incurring cost and time of software rewrites

Examples

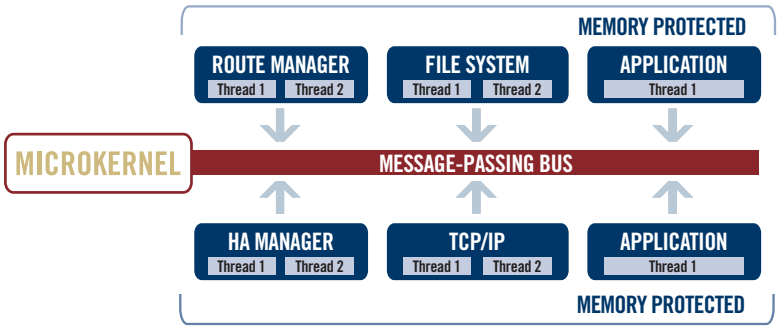
- Packet forwarding
- Routing table adjustments
- Encryption and decryption
- Voice and data compression and encoding
- Voice recognition
- Speech synthesis
- High-end medical imaging
- Simulators for aircraft and high-speed trains
- Multithreaded server systems such as storage area networking devices and online transaction processing systems

Architecture Matters

Not all operating systems can take full advantage of the concurrency offered by SMP hardware.

A highly componentized operating system, based on a microkernel architecture, is naturally suited to SMP environments. Because such systems inherently have a high degree of parallelism, different components can run concurrently. The overall system benefits from all available processors. Moreover, the kernel modifications required for SMP are small: only the microkernel is modified, incurring negligible overhead. Other services can gain the performance advantages of SMP without code changes, thereby avoiding costly and time-consuming software rewriting. This inherently distributed architecture offers another key benefit: the ability to take advantage of both simple distributed multiprocessing and SMP, offering choice to the software or application designer.

QNX Neutrino Microkernel Architecture



Operating systems that contain a number of cooperating components, such as the QNX Neutrino microkernel RTOS, use separate processes to run system services. Performance can increase due to the number of independent components that can operate concurrently in multiprocessor CPU configurations.

In comparison, systems based on a monolithic architecture can't take full advantage of the real concurrency offered by SMP systems. Monolithic kernels provide many services, such as file-system and networking requests, within the locked kernel region. As a result, significant precautions must be taken at the kernel level to ensure the monolithic kernel does not become a bottleneck when used in an SMP configuration.

The Best of Both Worlds

When it comes to improving performance and scalability, SMP and other multiprocessing options have their advantages and tradeoffs. For the system designer, the real issue is being able to choose the best model for the job. Microkernel OS architectures gain the full benefits of the concurrency offered by SMP hardware, allowing designers to add processing power and scalability to network elements without increasing software development or compromising system density. Moreover, they provide inherent support for distributed multiprocessing, allowing developers to create fault-tolerant clusters that contain a mix of uniprocessor and SMP systems.

QNX Neutrino Support for SMP

QNX Neutrino is the only commercial RTOS to support true symmetric multiprocessing: any thread in any process can be scheduled to run on any processor of an SMP board. With QNX Neutrino, you don't have to hardcode SMP awareness into your applications, drivers, or protocol stacks. If a process is multithreaded, its threads will be transparently scheduled onto the SMP board's multiple CPUs.

With QNX Neutrino, you can:

> **Use your SMP board of choice —** choose from a rich variety of off-the-shelf SMP boards based on MIPS, PowerPC, and x86 processors.

> **Fine-tune performance using processor affinity —** To optimize processor cache usage, QNX Neutrino will always attempt to dispatch a thread to the processor where it last ran, when appropriate. To help optimize cache usage even further, QNX Neutrino provides a processor affinity mask, which lets you "lock" a thread to one or more specified processors.

> **Make the most of every processor —** Because QNX Neutrino can schedule any thread on any processor, all processors can be utilized as fully as possible, ensuring the greatest possible performance boost. And, unlike conventional OS kernels, the QNX Neutrino microkernel doesn't need large numbers of performance-robbing code modifications to support SMP. The SMP microkernel is, in fact, just a few kilobytes larger than the standard microkernel.

> **Build fault-tolerant clusters of immense processing power —** By combining these SMP capabilities with the distributed processing provided by QNX Neutrino, you can easily construct massive, fault-tolerant clusters that integrate hundreds of uniprocessor and SMP systems. In fact, with QNX Neutrino, you have the unique ability to target uniprocessor, SMP, and cluster systems using just one set of application binaries.

> **Improve performance** — Improve performance on SMP-based systems with a suite of development tools, including QNX system profiler and CPU-specific performance counters.

Built for Embedded Developers

The QNX Neutrino RTOS has everything you need to develop reliable, scalable, high-performance embedded systems: a fault-resilient microkernel architecture... dynamic upgradability... distributed processing... symmetric multiprocessing... a feature-rich GUI... proven realtime response... POSIX-based portability... support for a wide range of processors and hardware... a comprehensive, yet easy-to-use IDE – all delivered by one of the most service-conscious, customer-responsive companies in the business. Contact us today to find out how QNX Neutrino can bring unprecedented reliability, scalability, and performance to your next project.

QNX NEUTRINO AT A GLANCE

MICROKERNEL ARCHITECTURE
> Dynamically upgradable services and applications
> Fine-grained fault isolation and recovery
> Message-passing design for modular, well-formed systems

DISTRIBUTED PROCESSING
> Transparent access to remote resources
> Simplified design of fault-tolerant clusters

SMP MICROKERNEL
> True SMP on MIPS, PowerPC, and x86
> Automatic scaling of multithreaded applications

INSTRUMENTED MICROKERNEL
> System-wide performance analysis and optimization
> Fast detection of timing conflicts, hidden faults, etc.

QNX PHOTON MICROGUI®
> Customizable look-and-feel
> Sophisticated multilayer displays
> Extensible multimedia framework

PROTOCOL STACKS
> NetBSD (IPsec, IPv6) and tiny TCP/IP stacks

FILE SYSTEMS
> Image, RAM, Flash, QNX, Linux, DOS, CD-ROM, DVD, NFS, CIFS, Compression, Package

DEVICE DRIVERS
> Audio, character, disk, graphics, input, networking, parallel, printer, serial, USB

HIGH AVAILABILITY MANAGER
> Heartbeating for early fault detection
> Intelligent restart of faulty components

JAVA
> Certified Java powered runtime environment
> Java applications have full access to OS services

PREDICTABLE REALTIME PERFORMANCE
> Preemptive scheduler with choice of scheduling methods
> Distributed priority inheritance

POSIX SUPPORT
> POSIX 1003.1-2001, with threads and realtime extensions

PROCESSOR SUPPORT
> ARM, MIPS, PowerPC, SH-4, StrongARM, XScale, x86

QNX MOMENTICS DEVELOPMENT SUITE
> Graphical IDE, BSPs, DDKs, and GNU tools
> Multi-host, multi-language, multi-target development

About QNX Software Systems

Founded in 1980, QNX Software Systems is the industry leader in realtime, microkernel OS technology. The inherent reliability, scalable architecture, and proven performance of the QNX Neutrino RTOS make it the most trusted foundation for future-ready applications in the networking, automotive, medical, and industrial automation markets. Companies worldwide like Cisco, Ford, Johnson Controls, Siemens, and Texaco depend on the QNX technology for their mission- and life-critical applications. Headquartered in Ottawa, Canada, QNX Software Systems maintains offices in North America, Europe, and Asia, and distributes its products in more than 100 countries worldwide.

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