Threads, SMP, and Microkernels

Chapter 4

1

Process

- Resource ownership - process is allocated a virtual address space to hold the process image
- Scheduling/execution- follows an execution path that may be interleaved with other processes
- These two characteristics are treated independently by the operating system

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Process

- Dispatching is referred to as a thread
- Resource ownership is referred to as a process or task

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Multithreading

- Operating system supports multiple threads of execution within a single process
- MS-DOS supports a single thread
- UNIX supports multiple user processes but only supports one thread per process
- Windows 2000, Solaris, Linux, Mach, and OS/2 support multiple threads

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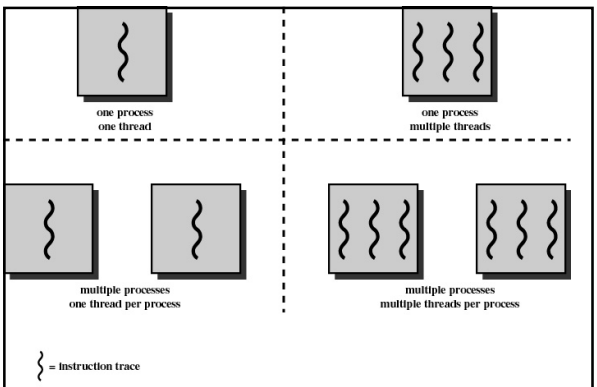

Figure 4.1 Threads and Processes [ANDE97]

Process

- Have a virtual address space which holds the process image
- Protected access to processors, other processes, files, and I/O resources

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Thread

- An execution state (running, ready, etc.)
- Saved thread context when not running
- Has an execution stack
- Some per-thread static storage for local variables
- Access to the memory and resources of its process
  - all threads of a process share this

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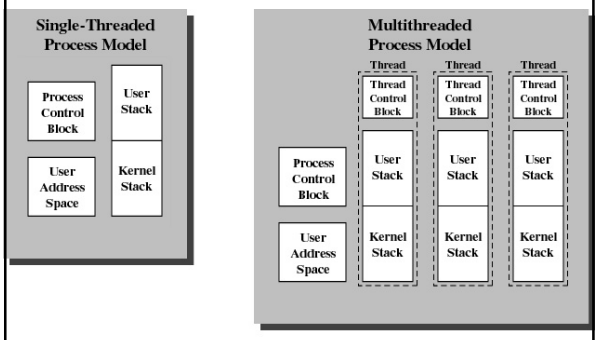

Figure 4.2 Single Threaded and Multithreaded Process Models

Benefits of Threads

- Takes less time to create a new thread than a process
- Less time to terminate a thread than a process
- Less time to switch between two threads within the same process
- Since threads within the same process share memory and files, they can communicate with each other without invoking the kernel

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Uses of Threads in a Single-User Multiprocessing System

- Foreground to background work
- Asynchronous processing
- Speed execution
- Modular program structure

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Threads

- Suspending a process involves suspending all threads of the process since all threads share the same address space
- Termination of a process, terminates all threads within the process

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Thread States

- States associated with a change in thread state
  - Spawn
    - Spawn another thread
  - Block
  - Unblock
  - Finish
    - Deallocate register context and stacks

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Remote Procedure Call Using Threads

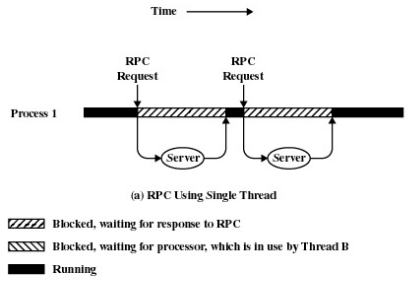

Figure 4.3 Remote Procedure Call (RPC) Using Threads

Remote Procedure Call Using Threads

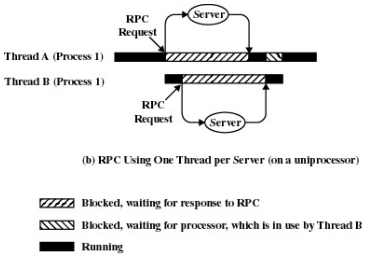

Figure 4.3 Remote Procedure Call (RPC) Using Threads

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User-Level Threads

- All thread management is done by the application
- The kernel is not aware of the existence of threads

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Kernel-Level Threads

- W2K, Linux, and OS/2 are examples of this approach
- Kernel maintains context information for the process and the threads
- Scheduling is done on a thread basis

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Combined Approaches

- Example is Solaris
- Thread creation done in the user space
- Bulk of scheduling and synchronization of threads done in the user space

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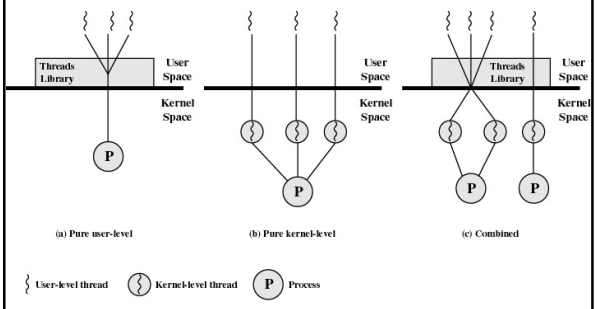

Figure 4.6 User-Level and Kernel-Level Threads

Relationship Between Threads and Processes

Threads:Process	Description	Example Systems
1:1	Each thread of execution is a unique process with its own address space and resources.	Traditional UNIX implementations
M:1	A process defines an address space and dynamic resource ownership. Multiple threads may be created and executed within that process.	Windows NT, Solaris, OS/2, OS/390, MACH

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Relationship Between Threads and Processes

Threads:Process	Description	Example Systems
1:M	A thread may migrate from one process environment to another. This allows a thread to be easily moved among distinct systems.	Ra (Clouds), Emerald
M:M	Combines attributes of M:1 and 1:M cases	TRIX

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Categories of Computer Systems

- Single Instruction Single Data (SISD)
  - single processor executes a single instruction stream to operate on data stored in a single memory
- Single Instruction Multiple Data (SIMD)
  - each instruction is executed on a different set of data by the different processors

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Categories of Computer Systems

- Multiple Instruction Single Data (MISD)
  - a sequence of data is transmitted to a set of processors, each of which executes a different instruction sequence. Never implemented
- Multiple Instruction Multiple Data (MIMD)
  - a set of processors simultaneously execute different instruction sequences on different data sets

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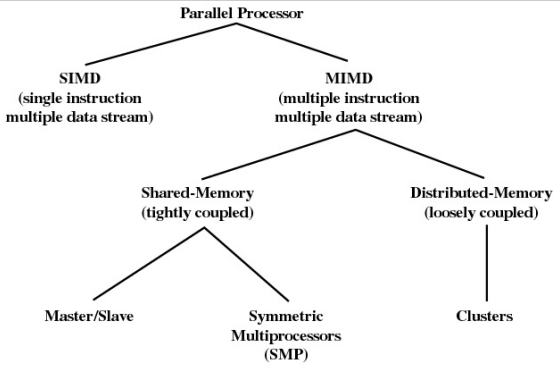

Figure 4.7 Parallel Processor Architectures

Symmetric Multiprocessing

- Kernel can execute on any processor
- Typically each processor does self-scheduling form the pool of available process or threads

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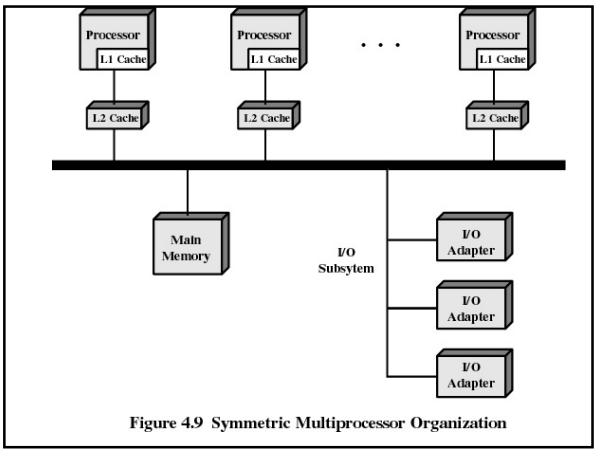

Figure 4.9 Symmetric Multiprocessor Organization

Multiprocessor Operating System Design Considerations

- Simultaneous concurrent processes or threads
- Scheduling
- Synchronization
- Memory Management
- Reliability and Fault Tolerance

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Microkernels

- Small operating system core
- Contains only essential operating systems functions
- Many services traditionally included in the operating system are now external subsystems
  - device drivers
  - file systems
  - virtual memory manager
  - windowing system
  - security services

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Benefits of a Microkernel Organization

- Uniform interface on request made by a process
  - All services are provided by means of message passing
- Extensibility
  - Allows the addition of new services
- Flexibility
  - New features added
  - Existing features can be subtracted

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Benefits of a Microkernel Organization

- Portability
  - Changes needed to port the system to a new processor is changed in the microkernel - not in the other services
- Reliability
  - Modular design
  - Small microkernel can be rigorously tested

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Benefits of Microkernel Organization

- Distributed system support
  - Messages are sent without knowing what the target machine is
- Object-oriented operating system
  - Components are objects with clearly defined interfaces that can be interconnected to form software

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Microkernel Design

- Low-level memory management
  - mapping each virtual page to a physical page frame
- Inter-process communication
- I/O and interrupt management

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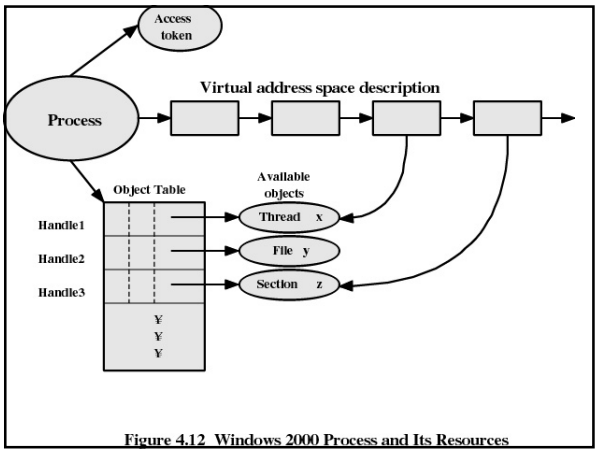
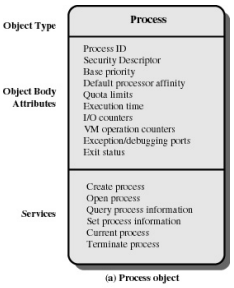


Figure 4.12 Windows 2000 Process and Its Resources

Windows 2000 Process Object



(a) Process object

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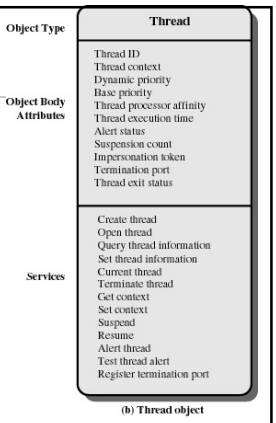
Windows 2000 Thread Object



(b) Thread object

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Windows 2000 Thread States

- Ready
- Standby
- Running
- Waiting
- Transition
- Terminated

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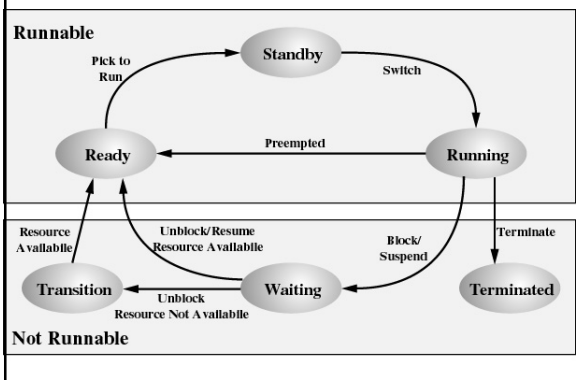

Figure 4.14 Windows 2000 Thread States

Solaris

- Process includes the user's address space, stack, and process control block
- User-level threads
- Lightweight processes
- Kernel threads

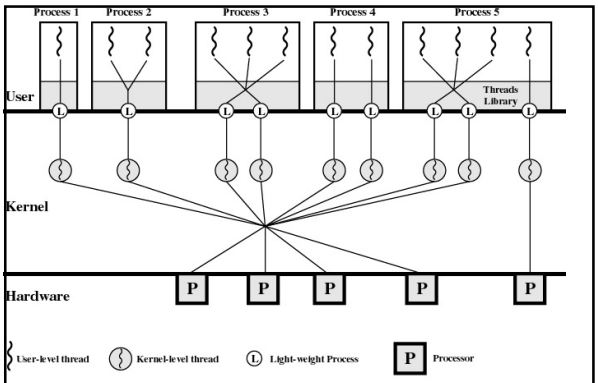

Figure 4.15 Solaris Multithreaded Architecture Example

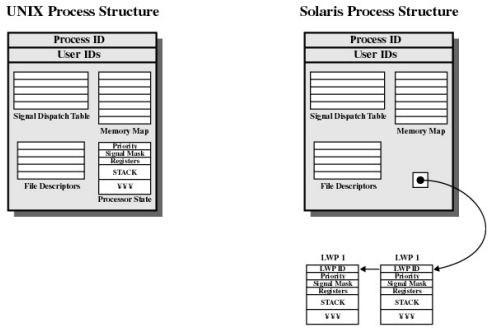

Figure 4.16 Process Structure in Traditional UNIX and Solaris [LEWI96]

Solaris Thread Execution

- Synchronization
- Suspension
- Preemption
- Yielding

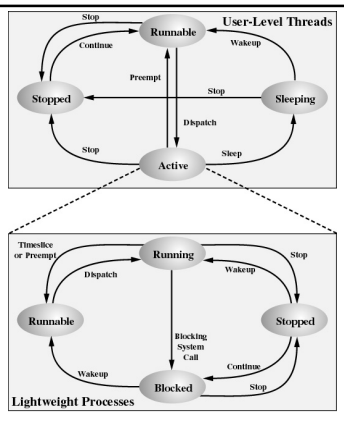

Figure 4.17 Solaris User-Level Thread and LWP States

Linux Process

- State
- Scheduling information
- Identifiers
- Interprocess communication
- Links
- Times and timers
- File system
- Virtual memory
- Processor-specific context

Linux States of a Process

- Running
- Interruptable
- Uninterruptable
- Stopped
- Zombie

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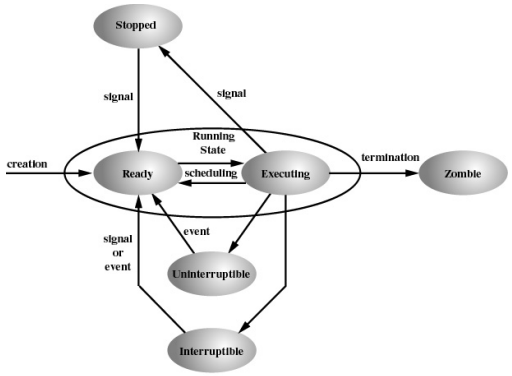

Figure 4.18 Linux Process/Thread Model