Threads, SMP, and Microkernels

Chapter 4

Processes

- Resource ownership - process is allocated a virtual address space to hold the process image
- Dispatched - process is an execution path through one or more programs
  - execution may be interleaved with other processes

- *These two characteristics are treated independently by the operating system*

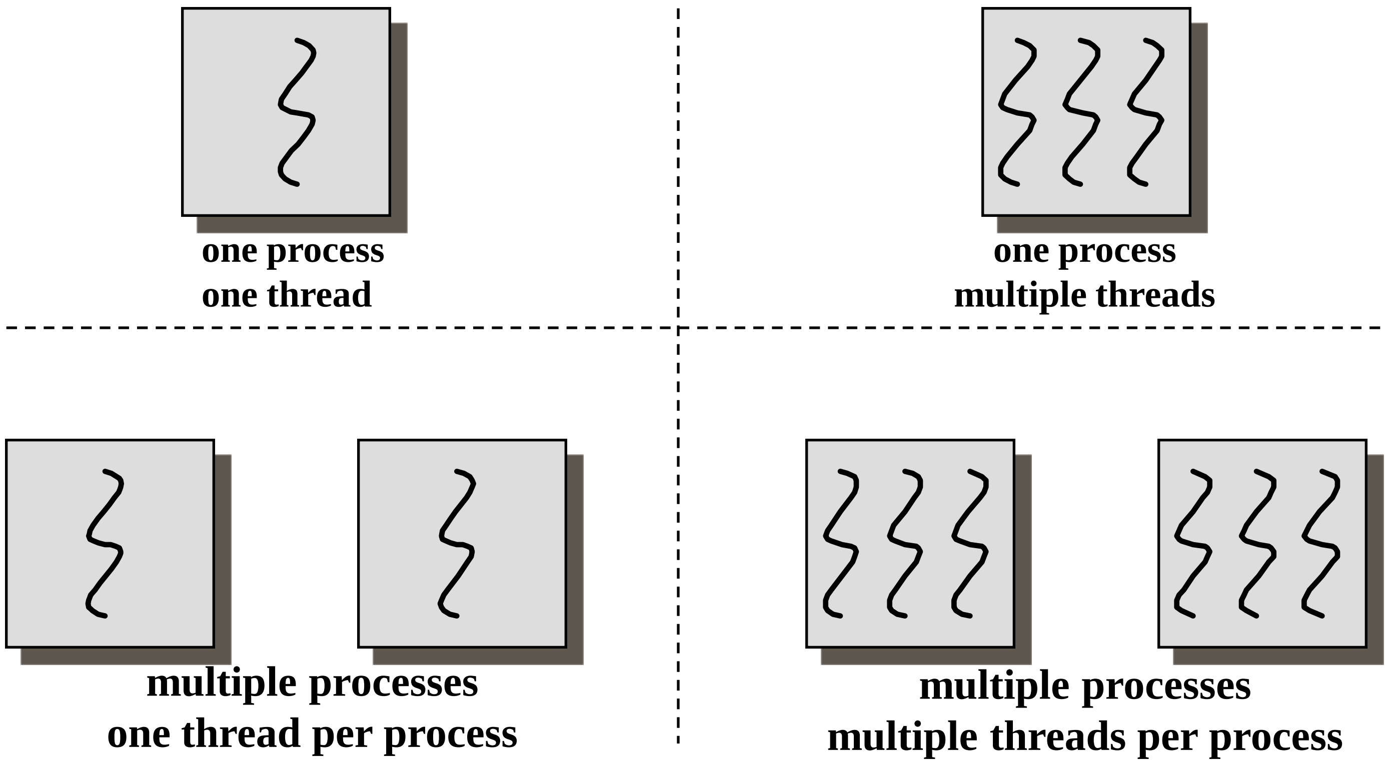
Processes

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

Multithreading

- Operating system supports multiple threads of execution within a single process
- *MS-DOS* supports just one process and a single thread
- *Traditional UNIX* supports multiple user processes but only one thread per process
- *Modern Unix* (Solaris,Linux,AIX) and *Windows* (2000/XP) support multiple threads per process

Threads and Processes



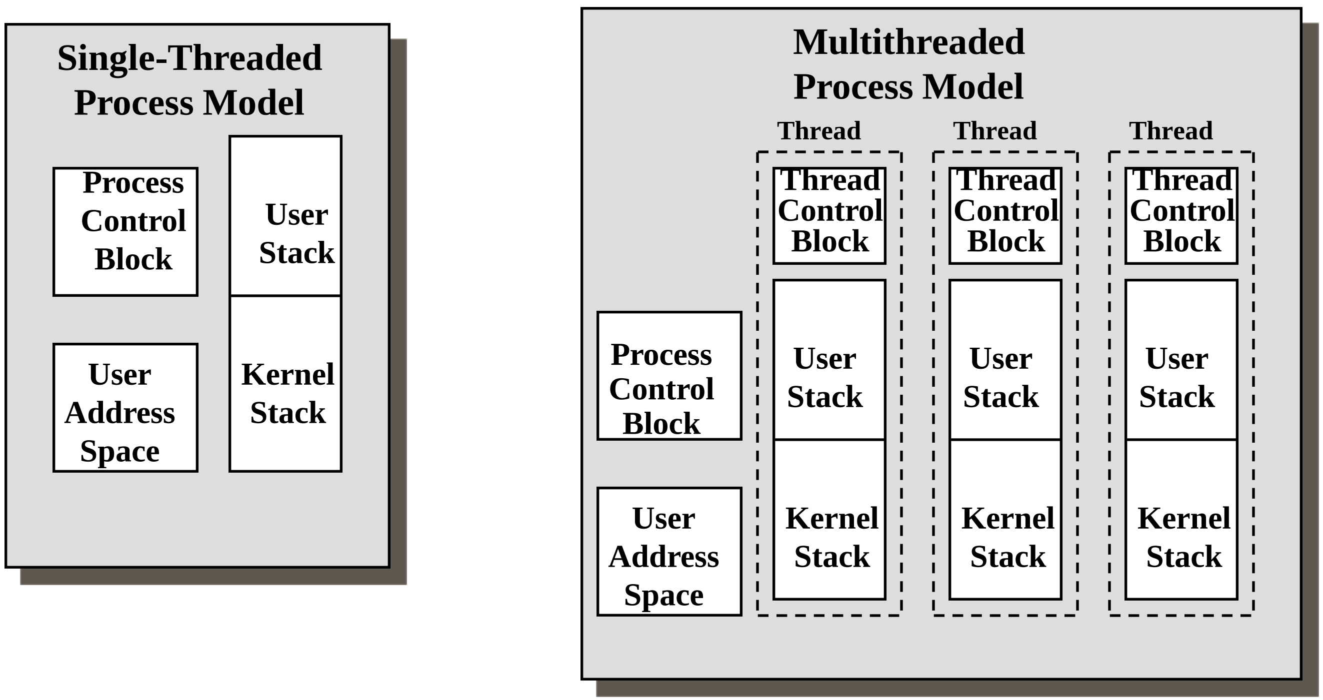
Process Resources

- ✓ Have a virtual address space which holds the process image
- ✓ Protected access to process*ors*, communication lines to other processes, files, and I/O resources (devices, channels)

Thread Resources

- ✓ An execution state (running, ready, etc.)
- ✓ Saved thread context when not running
- ✓ An execution stack
- ✓ Per-thread static storage for local variables
- ✓ Access to the memory and other resources of the owner-process
  - all <u>threads</u> of a process <u>share</u> the resources/memory of the owner-process

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

Suspension and Termination of 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

User-Level Threads

- ✓ All thread management is done by the application
- ✓ The kernel is not aware of the existence of threads
- ✓ Thread switching does not require kernel mode privileges
- ✓ Scheduling is application specific

Kernel-Level Threads

- ✓ Windows 2000/XP, Modern UNIXes are examples of this approach
- ✓ Kernel maintains context information for the process and the threads
- ✓ Switching between threads requires the kernel

Combined Approaches for Threads

- ✓ Example is Solaris (Sun’s Unix)
- ✓ Thread creation is done in the user space
- ✓ Bulk of scheduling and synchronization of threads is done in the user space

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.	Linux, Windows XP, Solaris, OS/2, OS/390, MACH

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

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)
  - one instruction is executed on different sets of data by the different processors

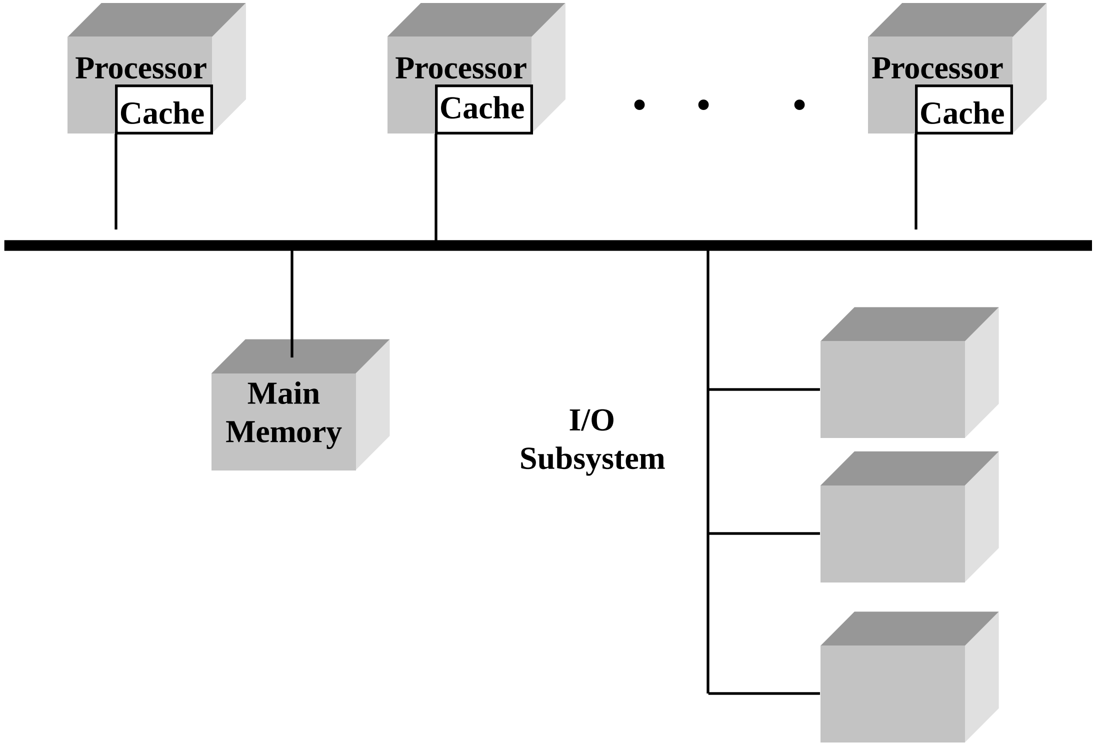
Categories of Computer Systems

- 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

Symmetric Multiprocessing

- ✓ Kernel can execute on any processor
- ✓ Typically each processor does self-scheduling from the pool of available processes or threads

Symmetric Multiprocessor Organization



Microkernel

- 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 and security services

Benefits of a Microkernel Organization

- ✓ Uniform interface to requests made by a process
  - all services are provided by means of message passing
- ✓ Extensibility
  - allows the addition of new services
- ✓ Flexibility
  - existing features can be subtracted

Benefits of a Microkernel Organization

- ✓ Portability
  - changes needed to port the system to a new processor can be limited to the microkernel - not to the other services
- ✓ Reliability
  - modular design
  - small microkernel can be rigorously tested

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

Microkernel Design

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

MS Windows Processes

- ✓ Implemented as objects
- ✓ An executable process may contain one or more threads
- ✓ Both process and thread objects have built-in synchronization capabilities

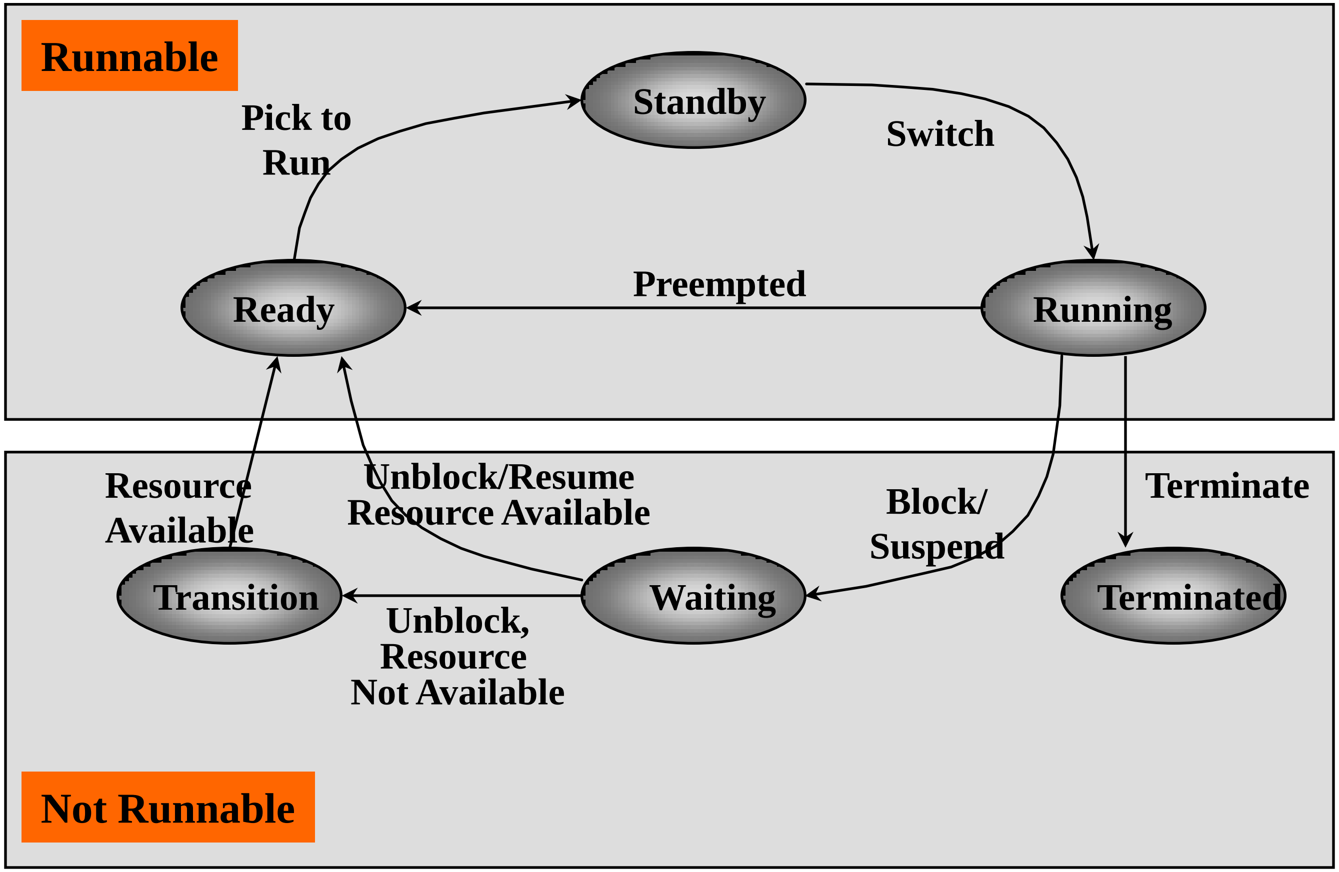
Windows Process Object Attributes

Process ID
Security Descriptor
Base priority
Default processor affinity
Quota limits
Execution time
I/O counters
VM operation counters
Exception/debugging ports
Exit status

Windows Thread Object Attributes

Thread ID
Thread context
Dynamic priority
Base priority
Thread processor affinity
Thread execution time
Alert status
Suspension count
Impersonation token
Termination port
Thread exit status

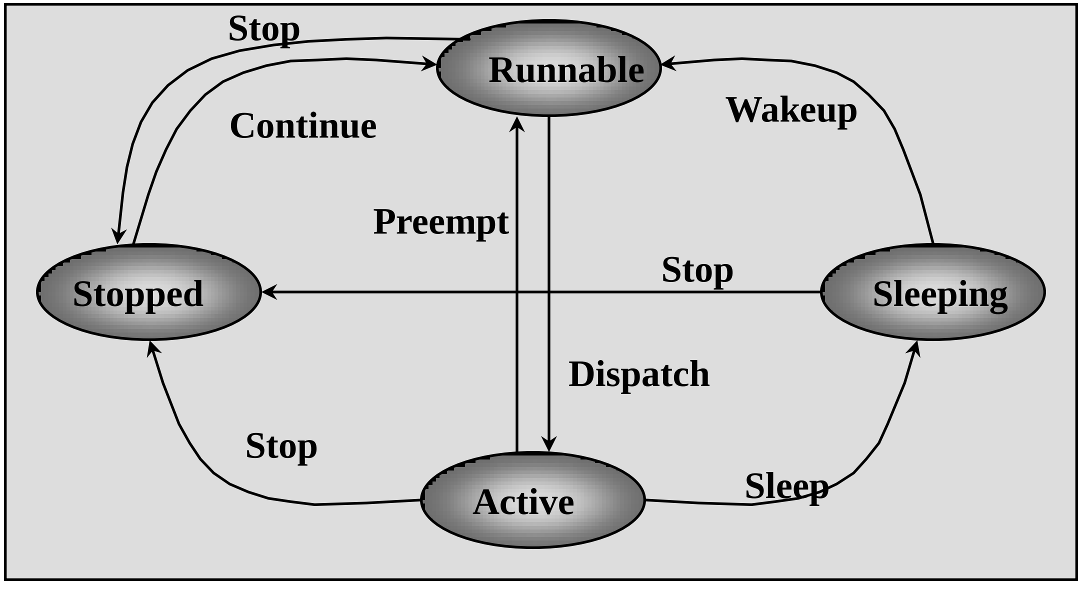
Windows Thread States



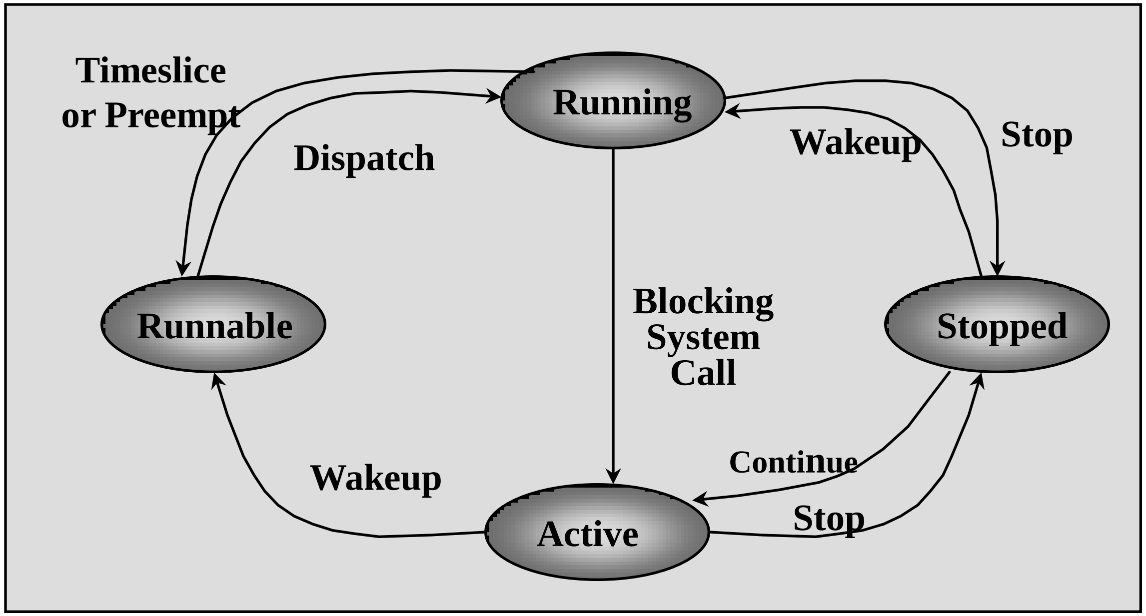
Solaris

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

Solaris User Level Threads



Solaris Lightweight Processes



Linux Threads

- Linux threads appear as processes to the kernel: it doesn’t distinguish that much among them
- But processes can share the same process group ID
  - Processes with the same group ID share resources
    - Memory
    - files