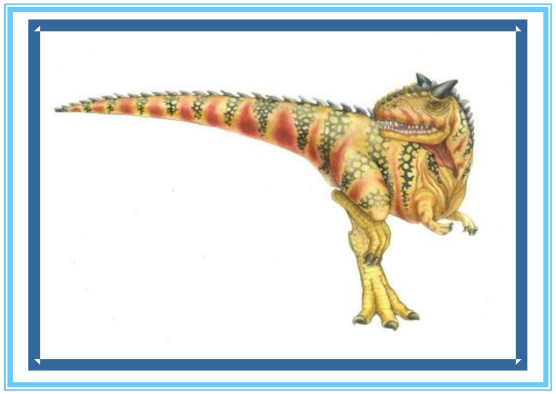
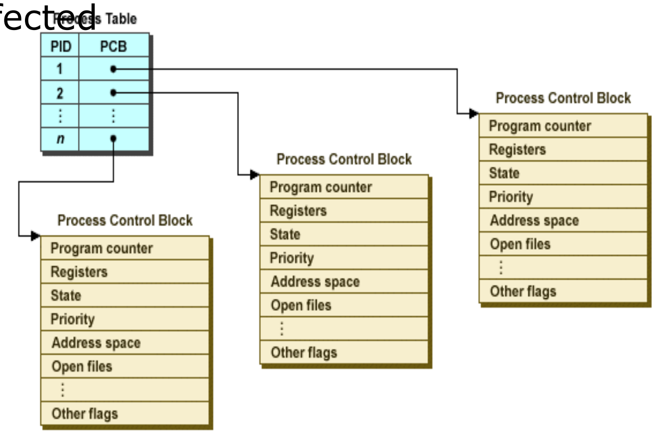
# Lecture 6,7 : Thread

## From Processes to Threads



# The Soul of a Process

Shared data, has IPC, execution been affected




What is similar in cooperating processes?

- They all share the same code and data (address space)
- They all share the same privileges
- They all share the same resources (files, sockets, etc.)

What don't they share?

- Each has its own execution state: PC, SP, and registers
- Key idea: Why don't we separate the concept of a process from its execution state?
  - Process: address space, privileges, resources, etc.
  - Execution state: PC, SP, registers
- Exec state also called thread of control, or thread

# Processes and Threads

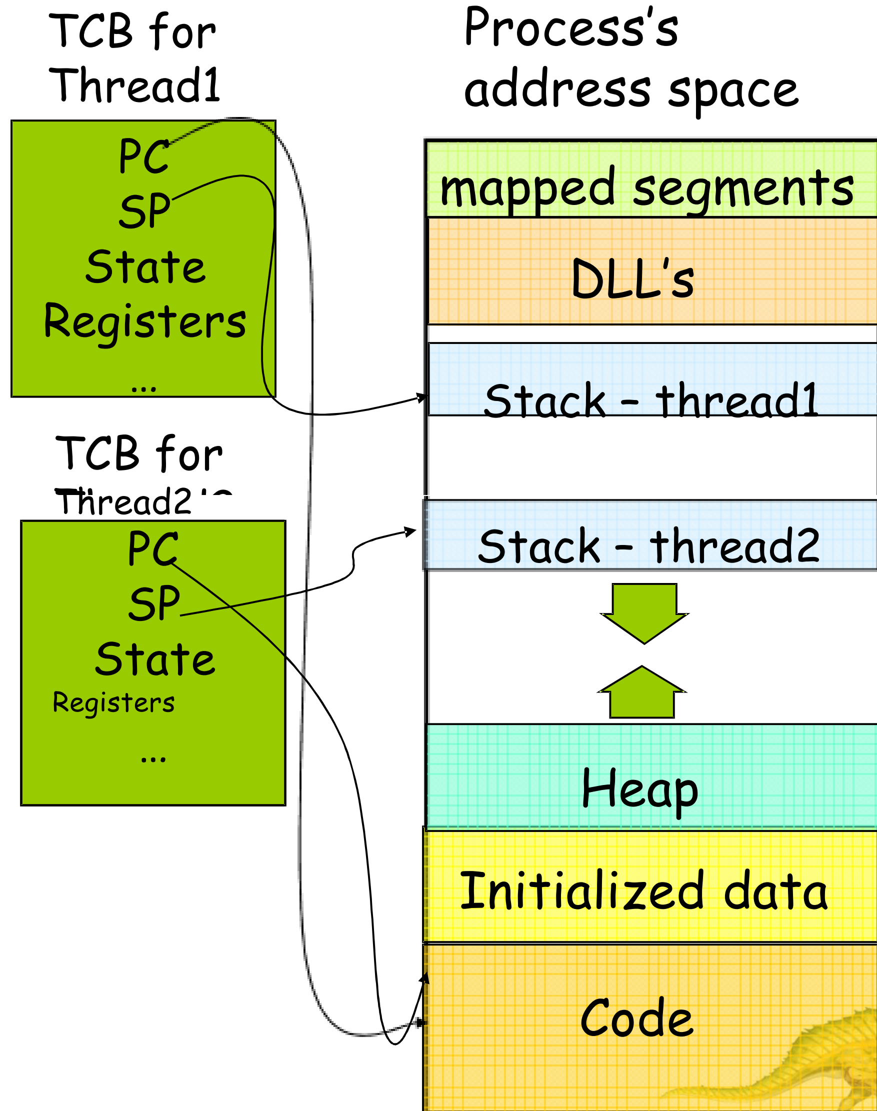
Processes define an address space; threads share the address space

Process Control Block (PCB) contains process-specific information

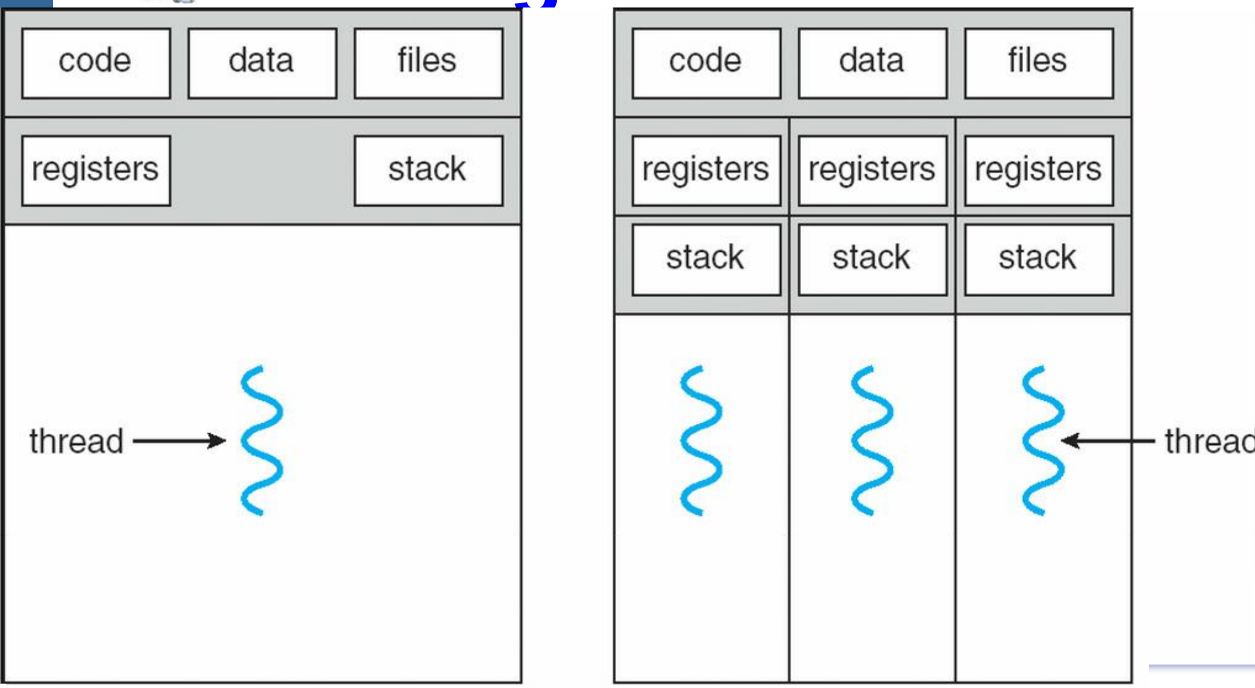
- Owner, PID, heap pointer, priority, active thread, and pointers to thread information

Thread Control Block (TCB) contains thread-specific information

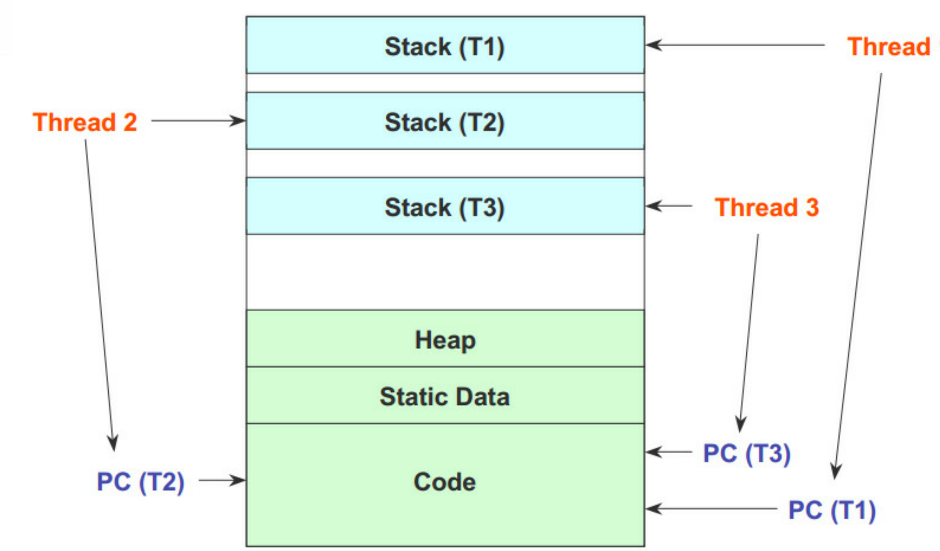
- Stack pointer, PC, thread state (running, …), register values, a pointer to PCB, …



# Single and Multithreaded Processes




single-threaded process multithreaded process



# Threads Benefits

- A thread represents an abstract entity that executes a sequence of instructions
  - It has its own set of CPU registers
  - It has its own stack
  - There is no thread-specific heap or data segment (unlike process)
- Threads are lightweight
  - Creating a thread more efficient than creating a process.
  - Communication between threads easier than processes.
  - Context switching between threads requires fewer CPU cycles and memory references than switching processes.
  - Threads only track a subset of process state (share list of open files, pid, …)
- Examples:
  - OS-supported: Windows' threads, Sun's LWP, POSIX threads

# Context switch time for which entity is greater?

1. Process
2. Thread

# Multithreads vs processor

| | | | | |
|---|---|---|---|---|
| | T1 | C1+I1 | TT=C1+I1+C2 | Case1: Simple |
| P1 | | | TT=C1+ Max (I1, C2) | Case2: Multithreaded process@uniprocessor |
| | T2 | C2 | TT=Max(C1+I1, C2) | Case2: Multithreaded process@multiprocessors [Not work for Many to one Model] |

# How Can it Help?

Consider a Web server

Create a number of threads, and for each thread do

get network message from client

get URL data from disk

send data over network

What did we gain?

# Overlapping Requests (Concurrency)

| Request 1<br>Thread 1 | Request 2<br>Thread 2 |
|---|---|
| get network message (URL) from client | |
| get URL data from disk | get network message (URL) from client |
| (disk access latency) | get URL data from disk |
| | (disk access latency) |
| | send data over network |
| send data over network | |

Time

- Total time is less than request 1 + request 2

# Threads vs. Processes

## Threads

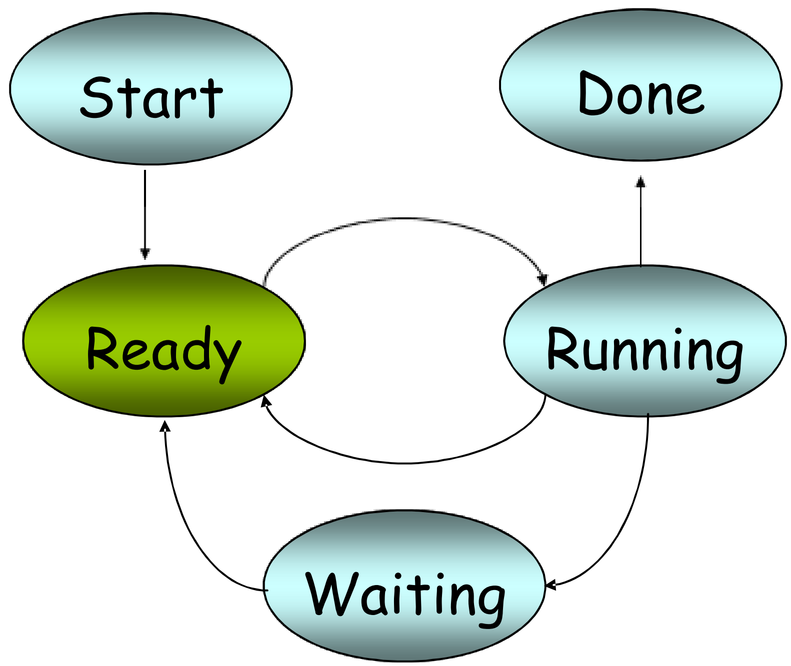
- A thread has no separate data segment or heap
- A thread cannot live on its own, it must live within a process
- There can be more than one threads in a process, the first thread calls main & has the process's stack
- If a thread dies, its stack is reclaimed
- Inter-thread communication via memory.
- Inexpensive creation and context switch

## Processes

- A process has code/data/heap & other segments
- There must be at least one thread in a process
- Threads **within a process share** code/data/heap, share I/O, but each has its own stack & registers
- If a process dies, its resources are reclaimed & all threads die
- Inter-process communication via OS /data copying/message passing.
- Expensive creation and context switch

# Threads' Life Cycle

Threads (just like processes) go through a sequence of *start*, *ready*, *running*, *waiting*, and *done* states



# Threads have the same scheduling states as processes

1. True
2. False

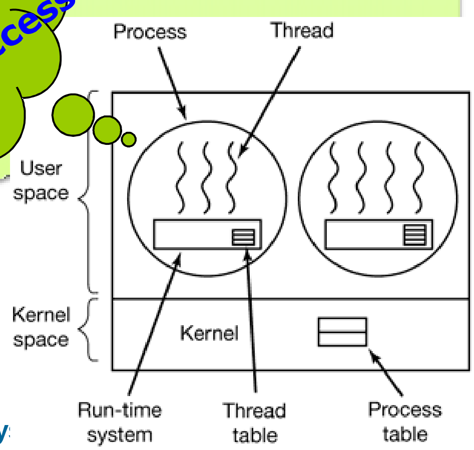
# Implementing Threads

**POSIX Pthreads**

## User Level

- Threads package entirely in user space
- Kernel knows nothing about threads
- Fast to create and switch-scheduler as local procedure

**· Blocking System Call**
**· CPU access**



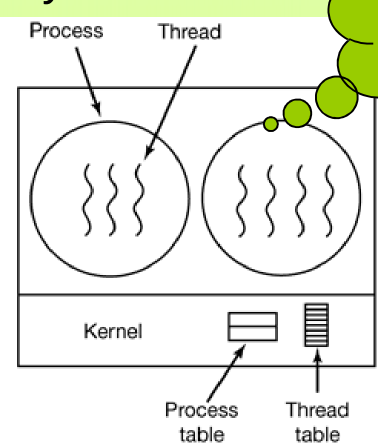

**Windows NT**
**Windows 2000**

## Kernel Level

- No runtime system
- Global Thread table, updated by kernel call
- Do not block process for systemcall
- Thread switching: same or another process
- Not so fast as runti[me] system

**Thread Recycling**
**Thread pool**

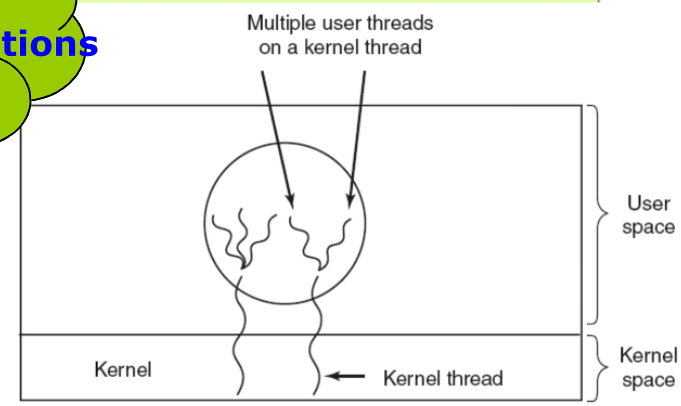
**Frequent thread operations**
**Need many System calls**




**Solaris**

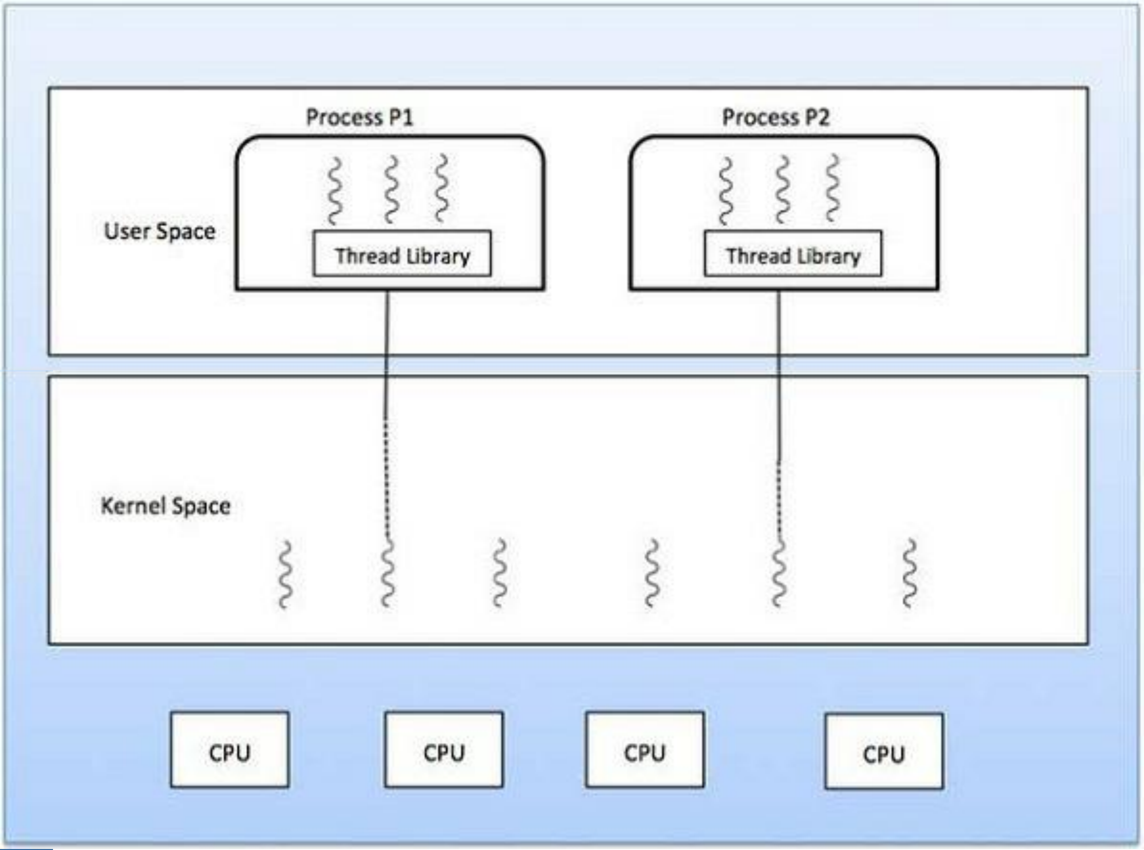
## Hybrid

- Use kernel-level threads and then multiplex user-level threads onto same or all kernel threads.



# Multithreading Models

Many to one Model

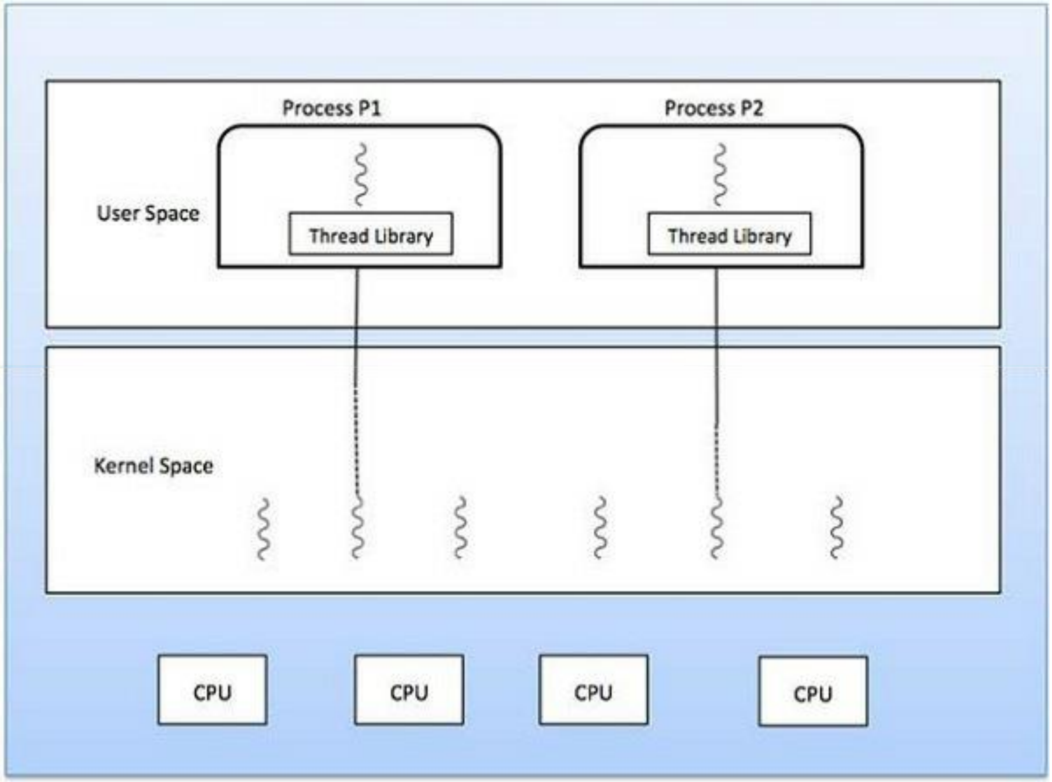



https://www.tutorialspoint.com/operating_system/os_multi_threading.htm

- Thread management is done in user space.
- Entire process is block if a thread makes blocking system call.
- No used in multi processors system. No concurrency.
- Green threads – Solaris thread library.

# Multithreading Models

One to one Model

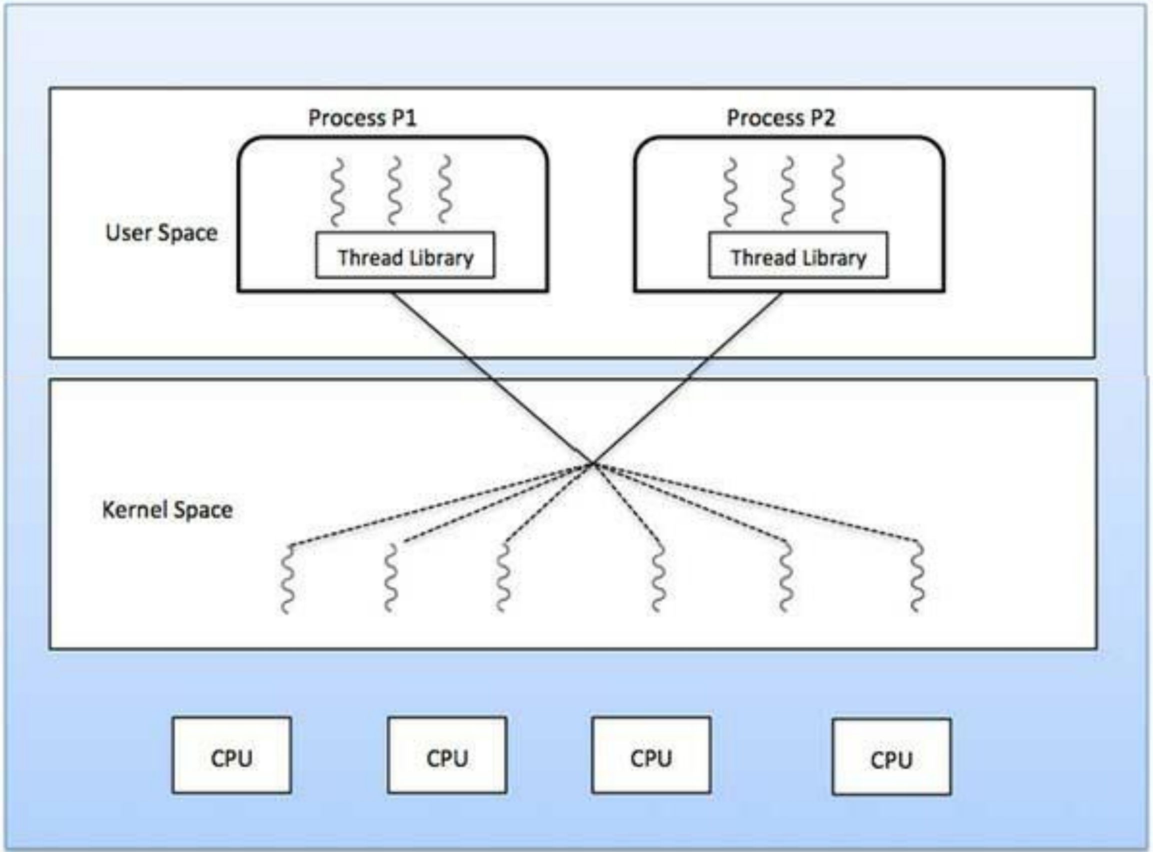



https://www.tutorialspoint.com/operating_system/os_multi_threading.htm

- Provide more concurrency than many to one.
  - another thread will run when a thread makes a blocking system call.
- Multiple threads to run in parallel on microprocessors.
- Drawback: creating a user thread, requires to create a kernel thread.
- Restriction has # User (or kernel) threads are supported by the system.
- Windows NT, Windows 2000

# Multithreading Models

Many to Many Model

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- Many users level threads to a Greater or equal number of kernel threads.
- Solve one-to-one, Many-to-one Model's restrictions.
- Users can create as many user threads as need
  - corresponding kernel threads can run parallel @ multiprocessor
- Solaris 2, IRIX, HP-UX

**Course materials:**
**Galvin book 5.1-5.2,5.3.1**

# End of Lecture 6,7