1 User Mode

- Is restricted
- Executing code has no ability to *directly* access hardware or reference memory [1]
- Crashes are always recoverable [1]
- Is where most of the code on our computer / applications are executed [3]

2 Kernel Mode

- Is previleged (non-restricted)
- Executing code has complete and unrestricted access to the underlying hardware [3]
- Is generally reserved for the lowest-level, most trusted functions of the operating system [1]
- Is fatal to crash; it will halt the entire PC (i.e the blue screen of death) [3]

3 Interrupt

- Are signals sent to the CPU by external devices, normally I/O devices. [2]
- Tells the CPU to stop its current activities and execute the appropriate part of the operating system (**Interrupt Handler**). [2]
- Has three different types [2]

  1) **Hardware Interupts**
     - Are generated by hardware devices to signal that they need some attention from the OS.
     - May be due to receiving some data

       Examples

       * Keystrokes on the keyboard
       * Receiving data on the ethernet card

     - May be due to completing a task which the operating system previous requested

       Examples

       Transfering data between the hard drive and memory

2) **Software Interupts**

   - Are generated by programs when a system call is requested

3) **Traps**

   - Are generated by the CPU itself
   - Indicate that some error or condition occured for which assistance from the operating system is needed

4 Content Switch

- Is switching from running a user level process to the OS kernel and often to other user processes before the current process is resumed
- Happens during a timer interrupt or system call
- Saves the following states for a process during a context switch
  - Stack Pointer
  - Program Counter
  - User Registers
  - Kernel State
- May hinder performance

5 System Call

- Is the programmatic way in which a computer program requests a previleged service from the kernel of the operating system
- i.e. Reading from disk
- Steps

  1) Setup **trap tables** on boot
  2) Execute system call
  3) Save *Program Counter*, *CPU registers*, *kernal stack* (so process can resume after **return-from-trap** or **context switch**)
  4) Switch from **user mode** to **kernel mode**
  5) Perform previleged operations

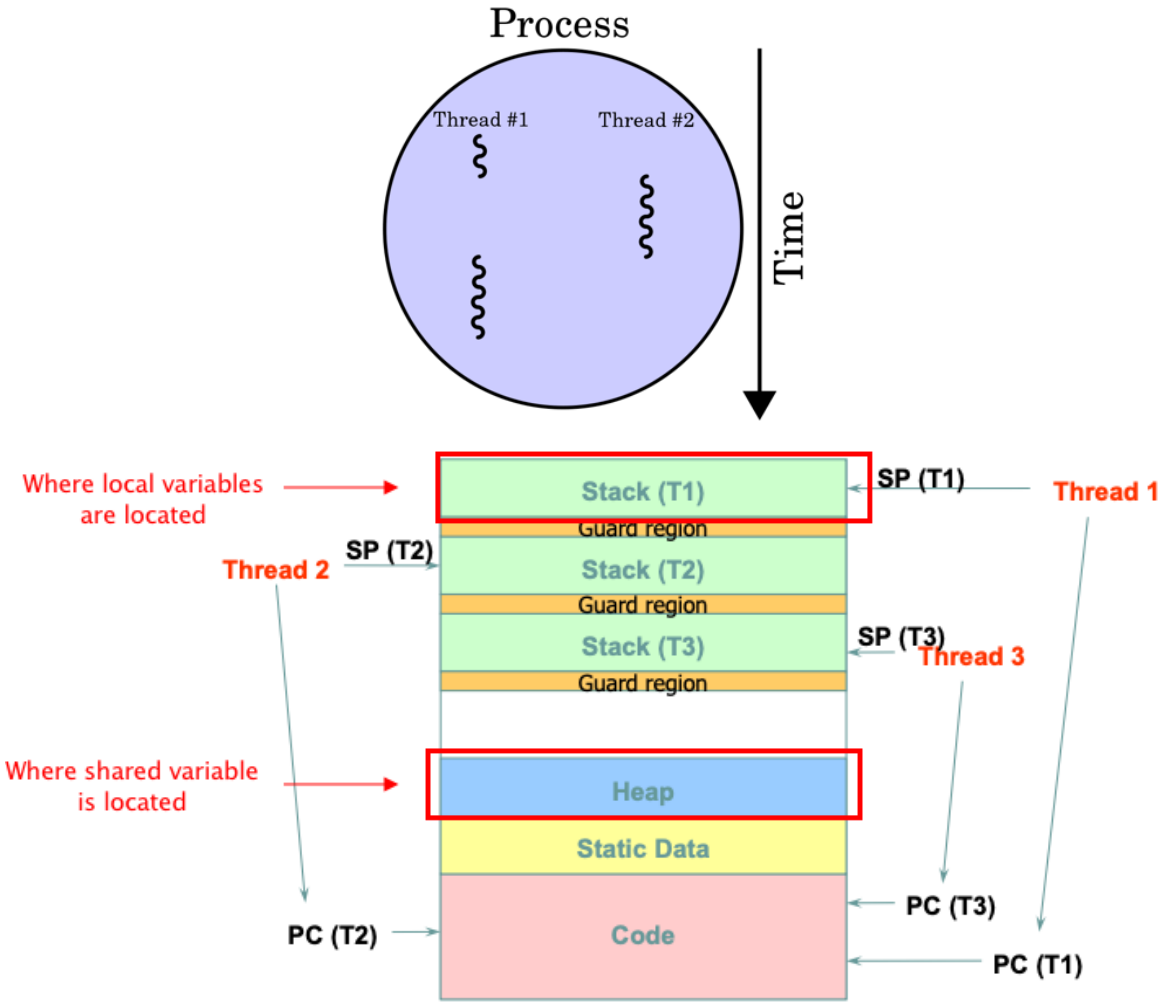
6) Finish and execute **return-from-trap** instruction
7) Return from **kernel mode** to **user mode** and resume user program

Example

- `yield()`
  - Is a system call
  - Causes the calling thread to relinquish the CPU
  - Places the current thread at the end of the run queue
  - Schedules another thread to run

6 Thread

- Is a lightweight process that can be managed independently by a schdeduler [4]
- Improves the application performance using parallelism. (e.g peach)



- A thread is bound to a single process
- A process can have multiple threads
- Has two types
  - **User-level Threads:**
    - Are implemented by users and kernel is not aware of the existence of these threads
    - Are represented by a program counter(PC), stack, registers and a small process control block
    - Are small and much faster than kernel level threads
  - **Kernel-level Threads:**
    - Are handled by the operating system directly
    - Thread management is done by the kernel
    - Are slower than user-level threads

7 Process

- Is a program in execution
- Is named by it's process ID or PID
- Can be described by the following states at any point in time
  - Address Space
  - CPU Registers
  - Program Counter
  - Stack Pointer
  - I/O Information

  (wait. this is PCB)
- Exists in one of many different **process states**, including
  1. Running
  2. Ready to Run
  3. Blocked

  - Different events (Getting Scheduled, descheduled, or waiting for I/O) transitions one of these states to the other

8 Signals

- Provides a way to communicate with the process
- Can cause job to stop, continue, or terminate
- Can be delivered to an application
  - Stops the application from whatever its doing
  - Runs Signal handler (some code in application to handle the signal)
  - When finished, the process resumes previous behavior

9 Spinlock

- Is the simplest lock to build
- Uses a lock variable
  - 0 - (available/unlock/free)
  - 1 - (acquired/locked/held)
- Has two operations
  1. `acquire()`

```
boolean test_and_set(boolean *lock)
{
      boolean old = *lock;
      *lock = True;
      return old;
}
boolean lock;

void acquire(boolean *lock) {
       while(test_and_set(lock));
}
```

  2. `release()`

```
void release(boolean *lock) {
        *lock = false;
}
```

- Allows a single thread to enter critical section at a time
- Spins using CPU cycles until the lock becomes available.
- May spin forever

10 Response Time

- **Formula** $T_{response} = T_{firstrun} - T_{arrival}$
- measures the interactive performance between users and the system

11 Turnaround Time

- **Formula** $T_{turnaround} = T_{completion} - T_{arrival}$
- measures the amount of time taken to complete a process

12 Scheduling policies

- Are algorithms for allocating CPU resources to concurrent tasks deployed on (i.e., allocated to) a processor (i.e., computing resource) or a shared pool of processors [5]
- Are sometimes called **Discipline**
- Covers the following algorithms in textbook
  - **First In First Out**
  - **Shortest Job First**
  - **Shortest Time-to-completion First**
  - **Round Robin**
    - Runs job for a **time slice** or **quantum**
    - Each job gets equal share of CPU time
    - Is clock-driven [6]
    - Is starvation-free [7]

* Must have the length of a time slice (**quantum**) as multiple of timer-interrupt period

```
void release(boolean *lock) {
        *lock = false;
}
```

– **Multi-level Feedback Queue**

References

1) Coding Horror, Understanding User and Kernel Mode, link

2) Kansas State University, Basics of How Operating Systems Work, link

3) Kansas State University, Glossary, link

4) Tutorials Point, User-level threads and Kernel-level threads, link

5) Science Direct, Scheduling Policy, link

6) Guru 99: What is CPU Scheduling?, link

7) Wikipedia: Round-robin Scheduling, link