

1. a) False
- b) True
- c) True
- d) True
- e) True
- f) False

Notes

• 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]

• Kernel Mode

- Is privileged (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]

• 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 Interrupts**

- * 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 previously requested

Examples

Transferring data between the hard drive and memory

2) **Software Interrupts**

- * Are generated by programs when a system call is requested

3) **Traps**

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

• **Context 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

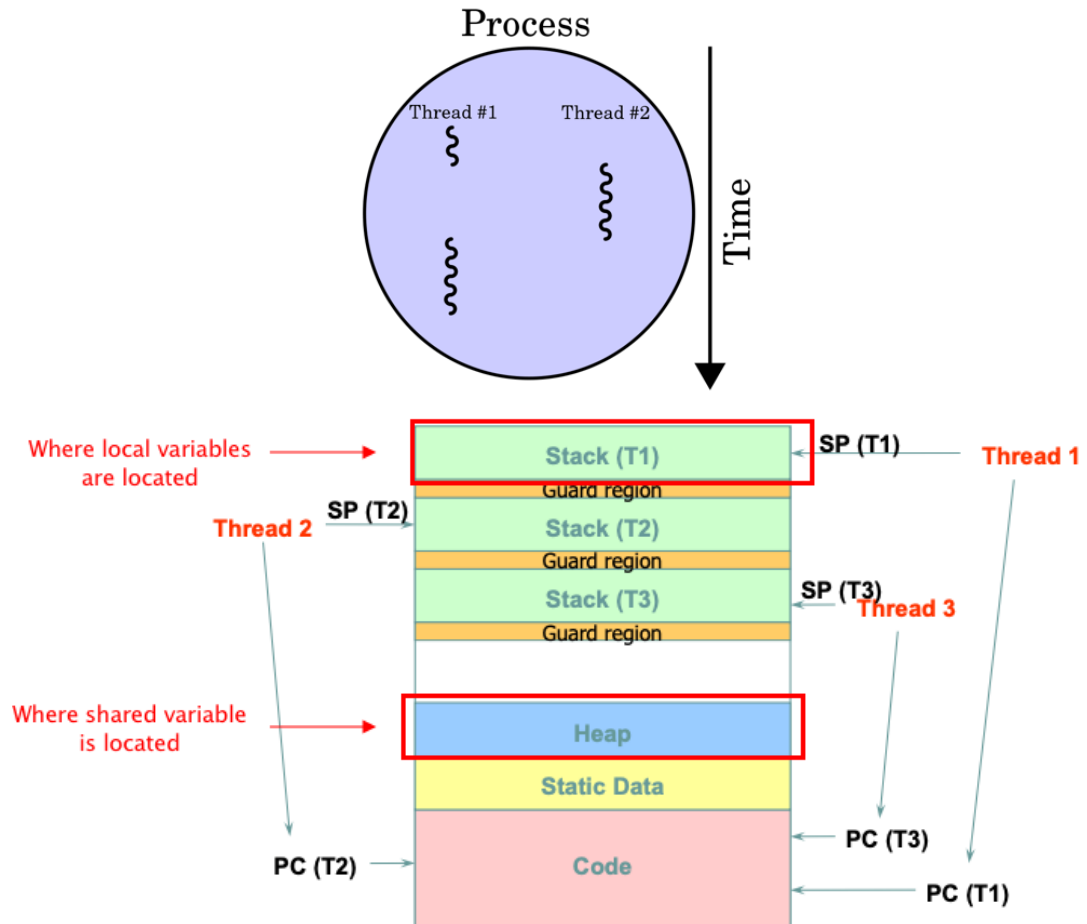
• **System Call**

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

• **Thread**

- Is a lightweight process that can be managed independently by a scheduler ^[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

- **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

- **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

- **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

- **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](#)

2. a)

Notes

- **System Call**

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