Managing the Java Thread Lifecycle: Java Thread Interrupts vs. Hardware/OS Interrupts

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Learning Objectives in this Part of the Lesson

• Know various ways to stop Java threads
  • Stopping a thread with a volatile flag
  • Stopping a thread with an interrupt request

• Learn the patterns of interrupting Java threads

• Understand differences between a Java thread interrupt & a hardware/OS interrupt
Java Thread Interrupts vs. Hardware/OS Interrupts
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- **Asynchronous**
  - Can occur essentially anytime & are independent of the instruction currently running
  - A program needn’t test for them explicitly since they occur “out-of-band”
Interrupts at the hardware or OS layers have several properties:

- Asynchronous
- Preemptive
  - Pause (& then later resume) the execution of currently running code without its cooperation

See [en.wikipedia.org/wiki/Preemption_(computing)](en.wikipedia.org/wiki/Preemption_(computing))
This example shows how to catch the UNIX SIGINT signal.

```c
void sig_handler(int signo) {
    if (signo == SIGINT)
        printf("received SIGINT\n");
}

int main(void) {
    if (signal(SIGINT, sig_handler)
        == SIG_ERR)
        printf("can't catch SIGINT\n");

    for (;;)  
        sleep(10);

    return 0;
}
```

See [www.thegeekstuff.com/2012/03/catch-signals-sample-c-code](http://www.thegeekstuff.com/2012/03/catch-signals-sample-c-code)
Java Thread Interrupts vs Hardware/OS Interrupts

- This example shows how to catch the UNIX SIGINT signal
- It occurs asynchronously

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    for (;;)
        sleep(10);
    return 0;
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```

The SIGINT interrupt is typically generated by typing ^C in a UNIX shell.
This example shows how to catch the UNIX SIGINT signal.

- It occurs asynchronously.
- It preempts the current instruction.

```java
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    for (; ;)
        sleep(10);

    return 0;
}
```
Java Thread Interrupts vs Hardware/OS Interrupts

- This example shows how to catch the UNIX SIGINT signal
  - It occurs asynchronously
  - It preempts the current instruction
  - It needn’t be tested for explicitly

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Java Thread Interrupts vs Hardware/OS Interrupts

• Asynchronous & preemptive interrupt handling make it hard to reason about programs

See [en.wikipedia.org/wiki/Unix_signal#Risks](en.wikipedia.org/wiki/Unix_signal#Risks)
Java Thread Interrupts vs Hardware/OS Interrupts

- Asynchronous & preemptive interrupt handling make it hard to reason about programs, e.g.
  - Race conditions

Race conditions occur when a program depends on the sequence or timing of threads for it to operate properly

See [en.wikipedia.org/wiki/Race_condition#Software](en.wikipedia.org/wiki/Race_condition#Software)
Java Thread Interrupts vs Hardware/OS Interrupts

• Asynchronous & preemptive interrupt handling make it hard to reason about programs, e.g.
  • Race conditions
  • Re-entrancy problems

A non-entrant function cannot be interrupted in the middle of its execution & then safely called again before its previous invocations complete execution

See en.wikipedia.org/wiki/Reentrancy_(computing)
Java Thread Interrupts vs Hardware/OS Interrupts

- Asynchronous & preemptive interrupt handling make it hard to reason about programs, e.g.
  - Race conditions
  - Re-entrancy problems
  - Non-transparent restarts

E.g., an I/O operation returns the # of bytes transferred & it is up to the application to check this & manage its own resumption of the operation until all the bytes have been transferred

See [en.wikipedia.org/wiki/PCLSRing#Unix-solution:_restart_on_request](en.wikipedia.org/wiki/PCLSRing#Unix-solution:_restart_on_request)
Java Thread Interrupts vs Hardware/OS Interrupts

- Java thread interrupts differ from hardware or operating system interrupts

See docs.oracle.com/javase/tutorial/essential/concurrency/interrupt.html
Java Thread Interrupts vs Hardware/OS Interrupts

- Java thread interrupts differ from hardware or operating system interrupts, e.g.
  - Delivery is *synchronous* & *non-preemptive* rather than *asynchronous* & *preemptive*
  - i.e., they don’t occur at an arbitrary point & don’t pause (& later resume) running code
Java Thread Interrupts vs Hardware/OS Interrupts

- Java thread interrupts differ from hardware or operating system interrupts, e.g.
  - Delivery is *synchronous* & *non-preemptive* rather than *asynchronous* & *preemptive*
- A program must test for them explicitly

```java
void processNonBlocking()
{
    ...
    while (true) {
        ... // Do some long-running
        // computation
        if (Thread.interrupted())
            throw new
                InterruptedIOException();
    ...
}
```
Java Thread Interrupts vs Hardware/OS Interrupts

- Java thread interrupts differ from hardware or operating system interrupts, e.g.
  - Delivery is *synchronous* & *non-preemptive* rather than *asynchronous* & *preemptive*
- A program must test for them explicitly
  - i.e., InterruptedException is (usually) thrown synchronously & is handled synchronously

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void processNonBlocking()
{
  ...
  while (true) {
    ... // Do some long-running
    // computation
    if (Thread.interrupted())
      throw new
        InterruptedException();
  }
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Java Thread Interrupts vs Hardware/OS Interrupts

- Java thread interrupts differ from hardware or operating system interrupts, e.g.
  - Delivery is *synchronous* & *non-preemptive* rather than *asynchronous* & *preemptive*
- A program must test for them explicitly
- Certain operations cannot be interrupted
  - e.g., blocking I/O calls that aren’t “interruptable channels”

```java
static class SleeperThread
    extends Thread {
    public void run() {
        int c;
        try {
            c = System.in.read();
        }
        ...
    }
}
```

End of Managing the Java Thread Lifecycle: Java Thread Interrupts vs. Hardware/OS Interrupts