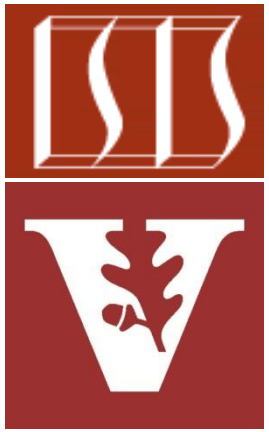
Managing the Java Thread Lifecycle: Java Thread Interrupts vs. Hardware/OS Interrupts



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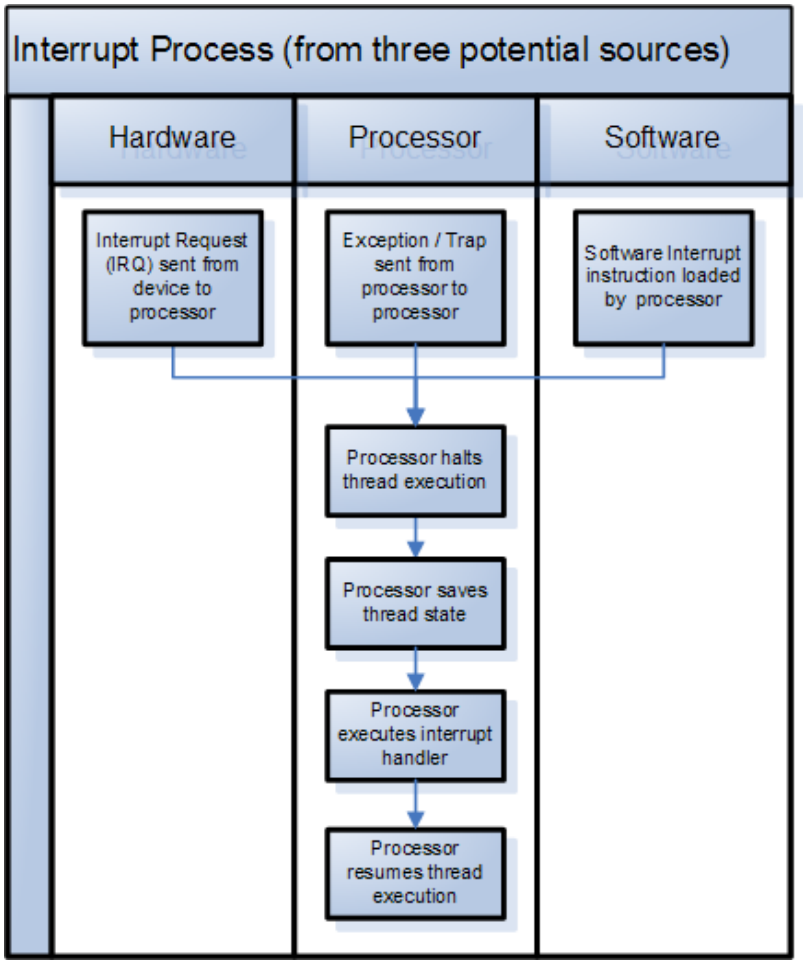
Learning Objectives in this Part of the Lesson

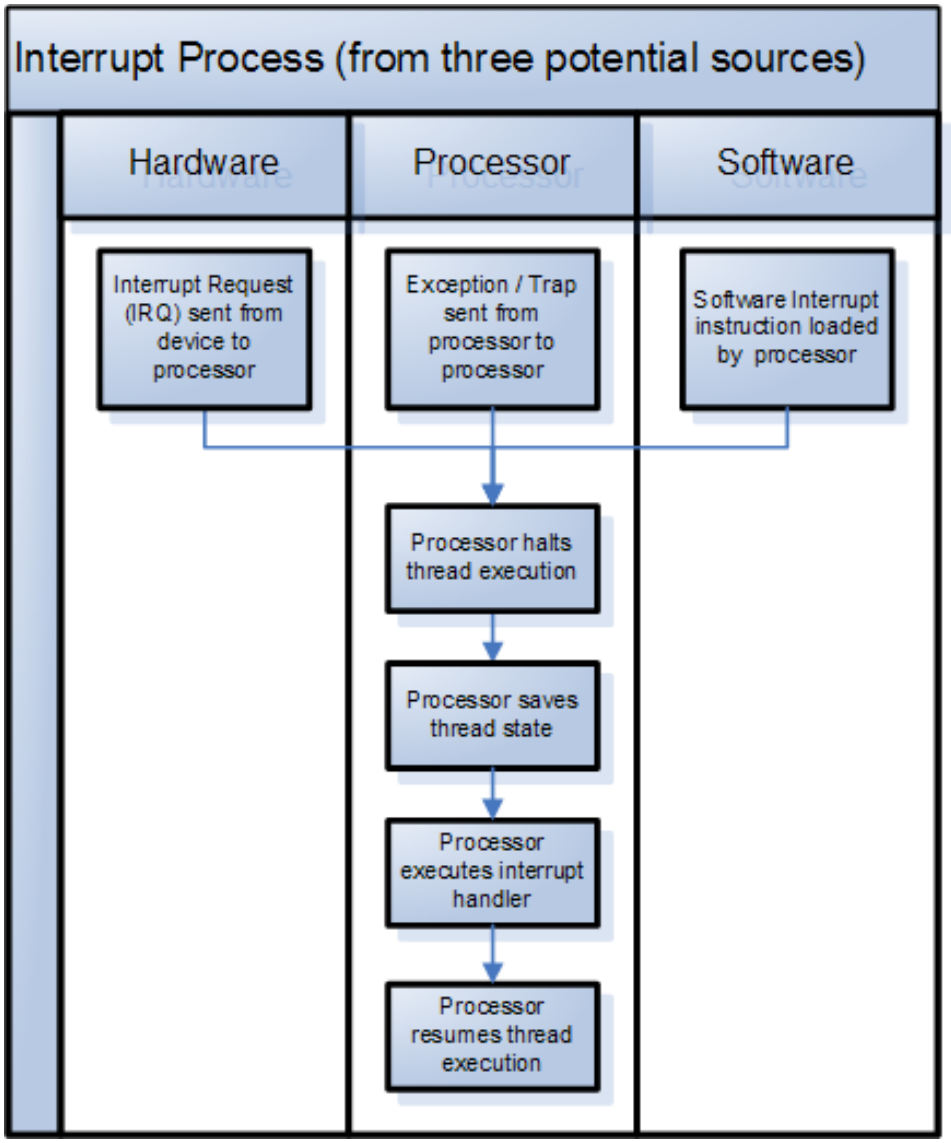
- Know various ways to stop Java threads
  - Stopping a thread with a volatile flag
  - Stopping a thread with an interrupt request
    - Learn the patterns of interrupting Java threads
    - Understand differences between a Java thread interrupt & a hardware/OS interrupt



Java Thread Interrupts vs. Hardware/OS Interrupts

Java Thread Interrupts vs Hardware/OS Interrupts

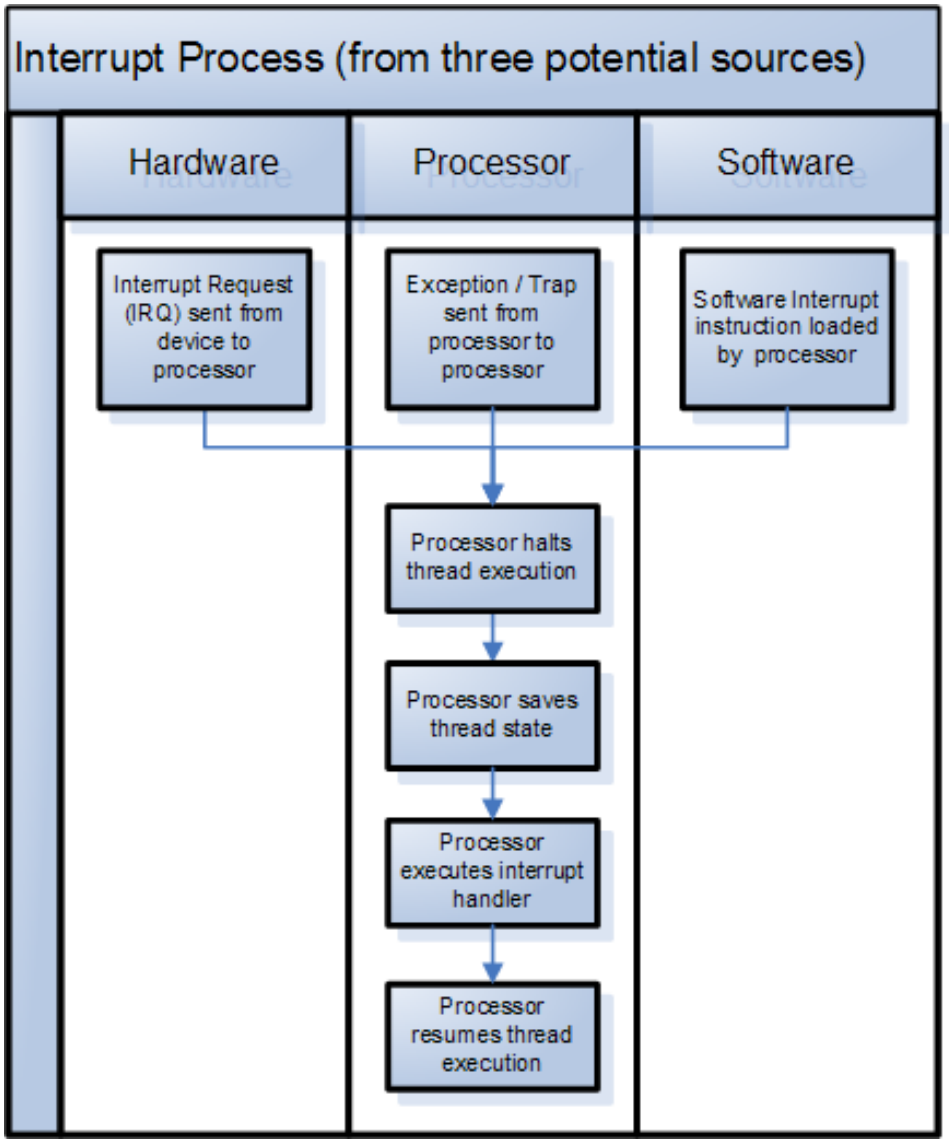
- Interrupts at the hardware or OS layers have several properties



See en.wikipedia.org/wiki/Interrupt & en.wikipedia.org/wiki/Unix_signal

Java Thread Interrupts vs Hardware/OS Interrupts

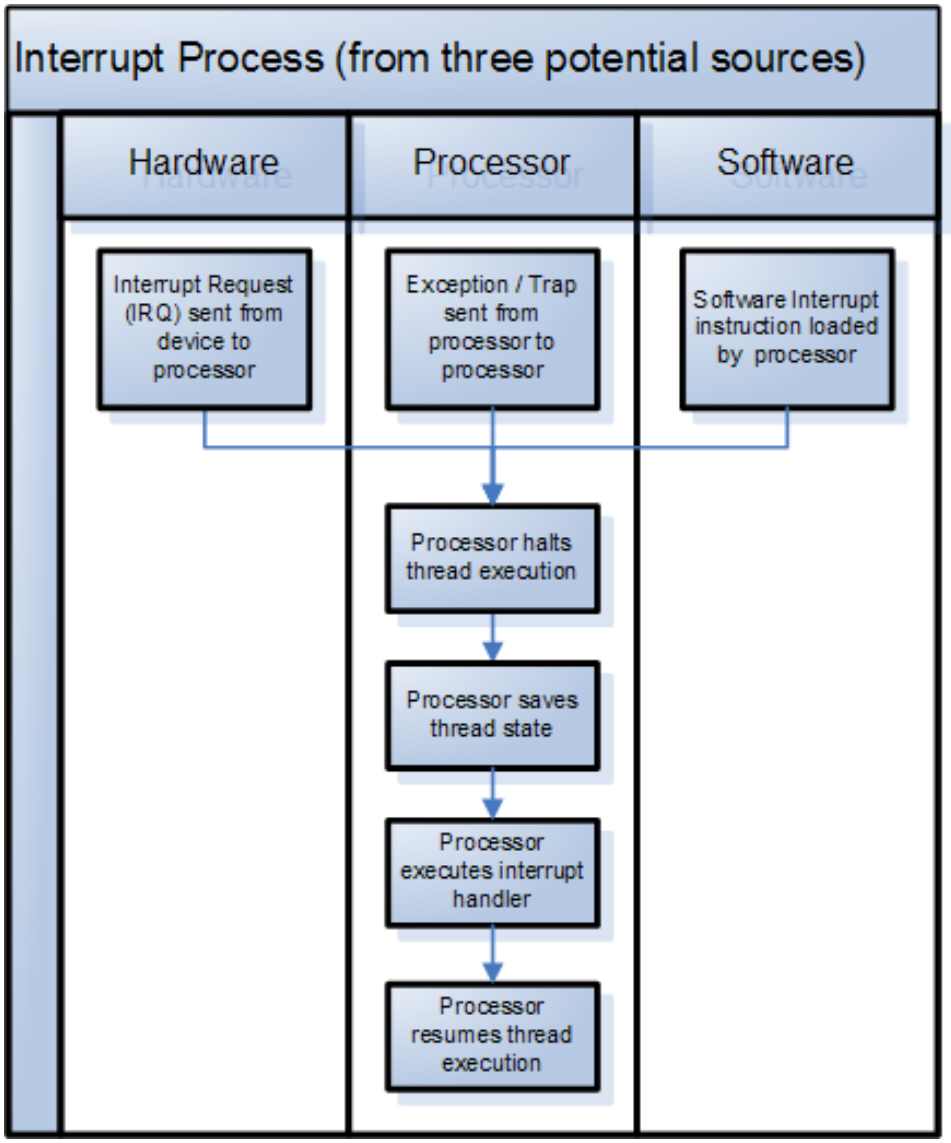
- Interrupts at the hardware or OS layers have several properties
  - **Asynchronous**
    - Can occur essentially anytime & are independent of the instruction currently running



See vujungle.blogspot.com/2010/12/differentiate-synchronous-and.html

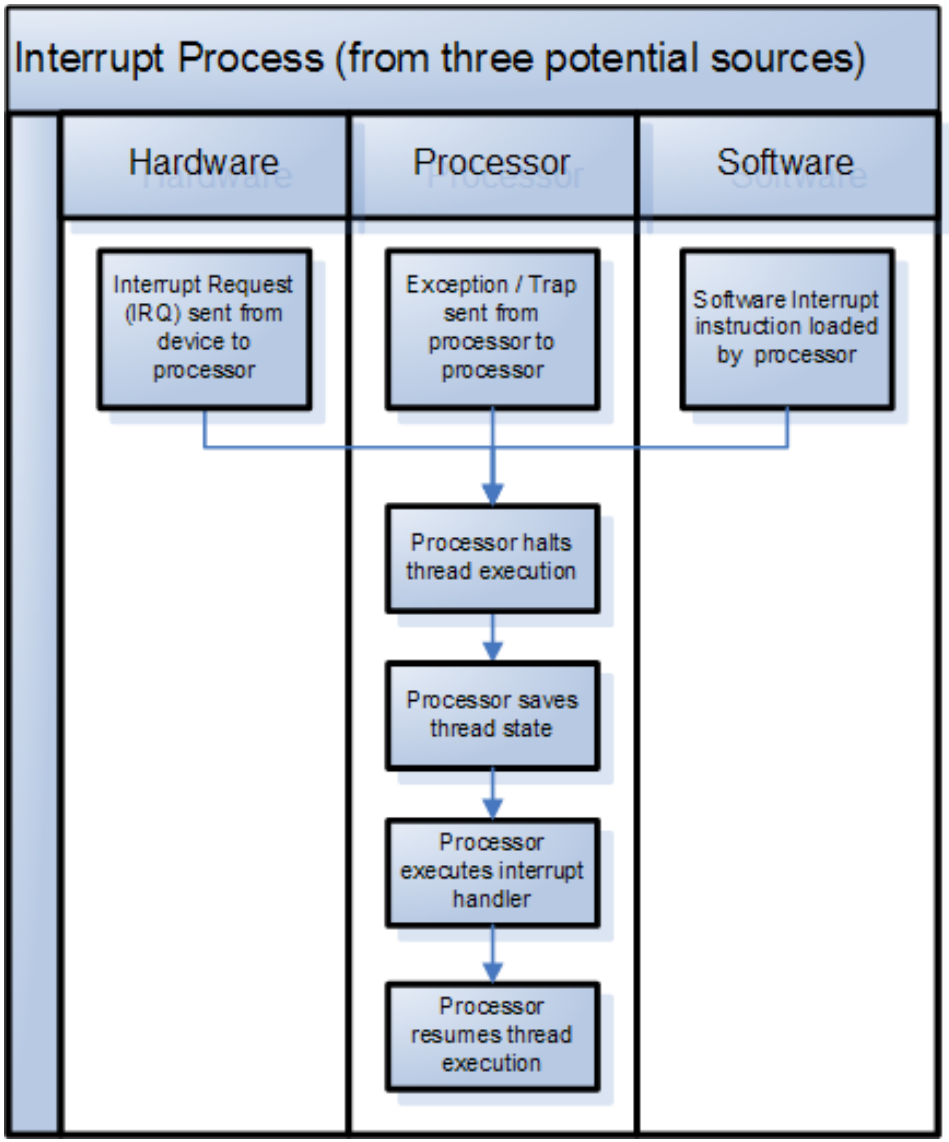
Java Thread Interrupts vs Hardware/OS Interrupts

- Interrupts at the hardware or OS layers have several properties
  - **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"



Java Thread Interrupts vs Hardware/OS Interrupts

- 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)

Java Thread Interrupts vs Hardware/OS Interrupts

- This example shows how to catch the UNIX SIGINT signal

```
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

Java Thread Interrupts vs Hardware/OS Interrupts

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

The SIGINT interrupt is typically generated by typing ^C in a UNIX shell

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Java Thread Interrupts vs Hardware/OS Interrupts

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  - It preempts the current instruction
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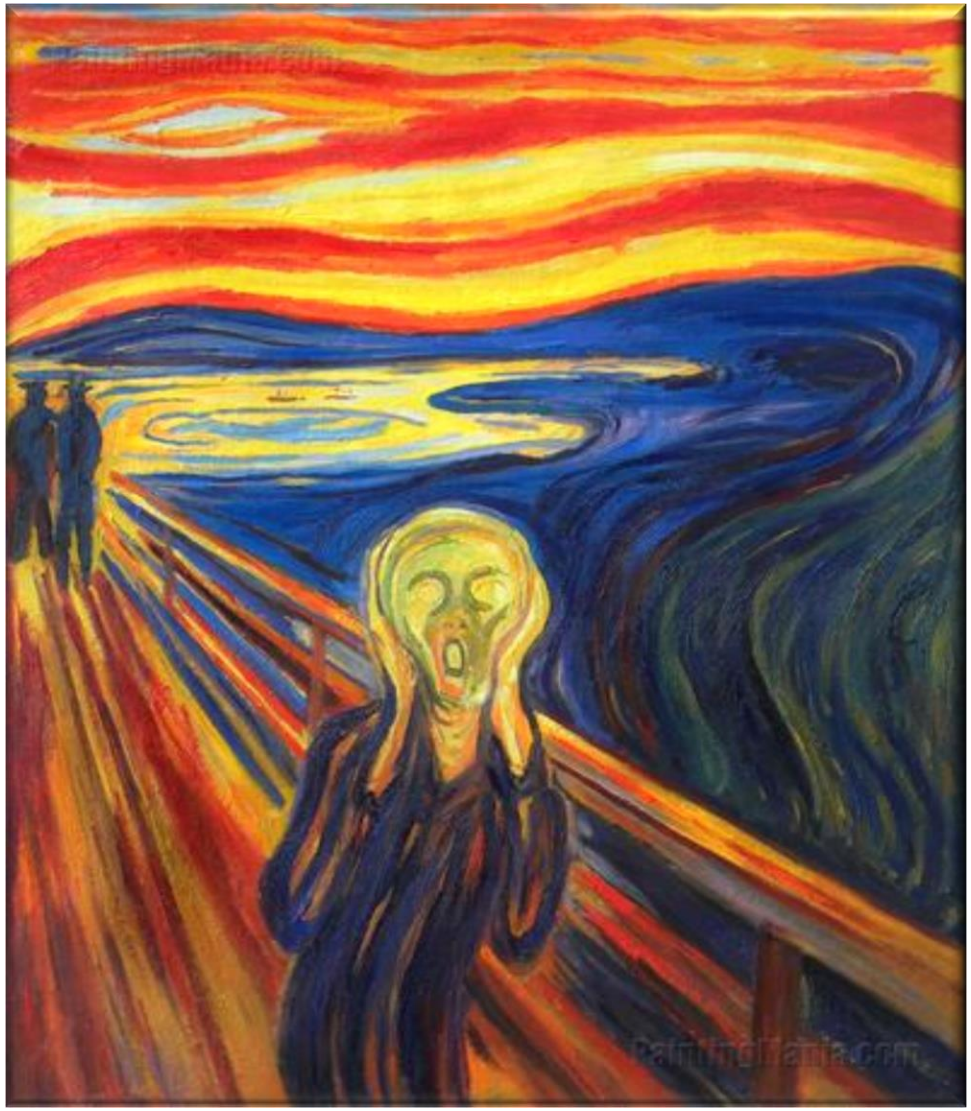
Java Thread Interrupts vs Hardware/OS Interrupts

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

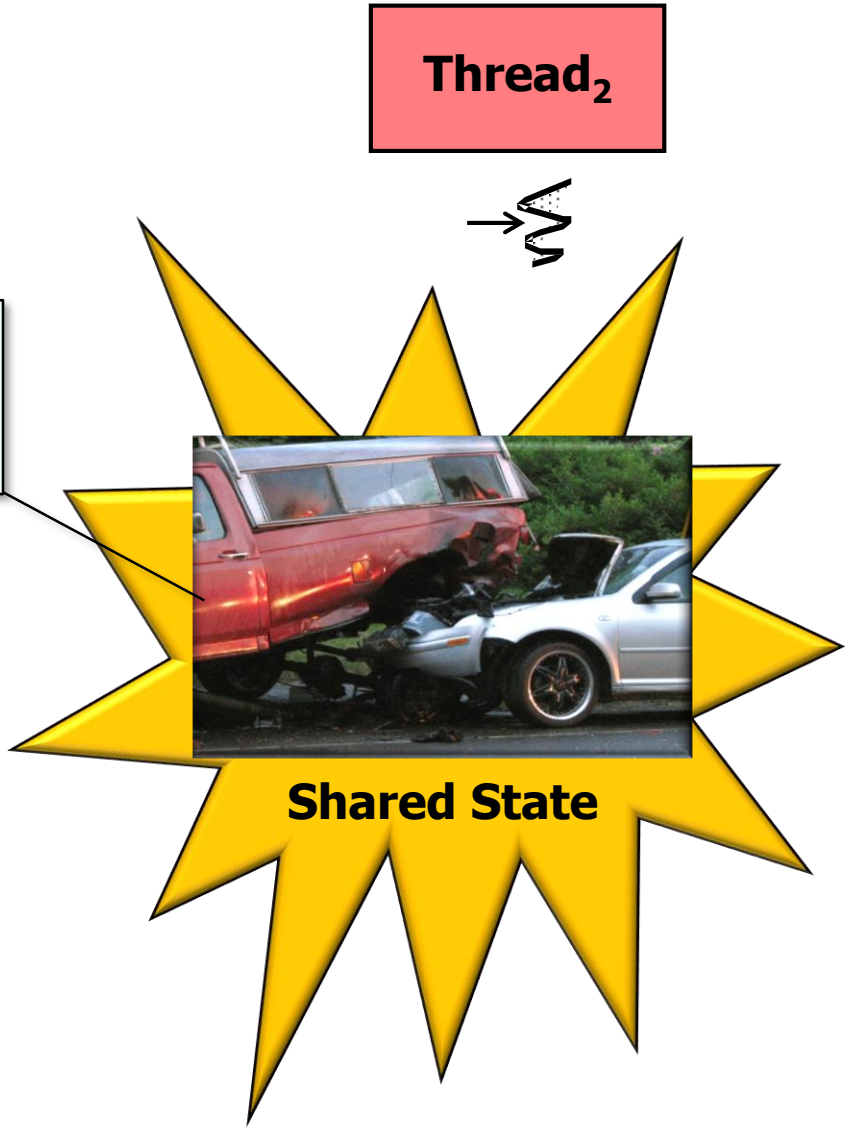


See en.wikipedia.org/wiki/Unix_signal#Risks

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

Java Thread Interrupts vs Hardware/OS Interrupts

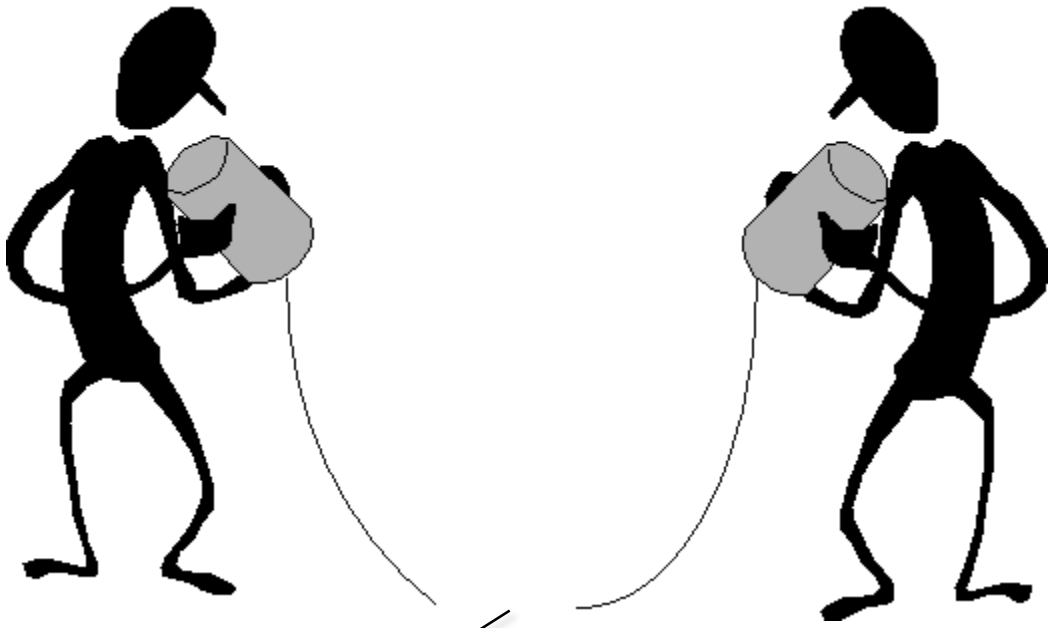
- Asynchronous & preemptive interrupt handling make it hard to reason about programs, e.g.
  - Race conditions
  - Re-entrancy problems

A non-reentrant 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

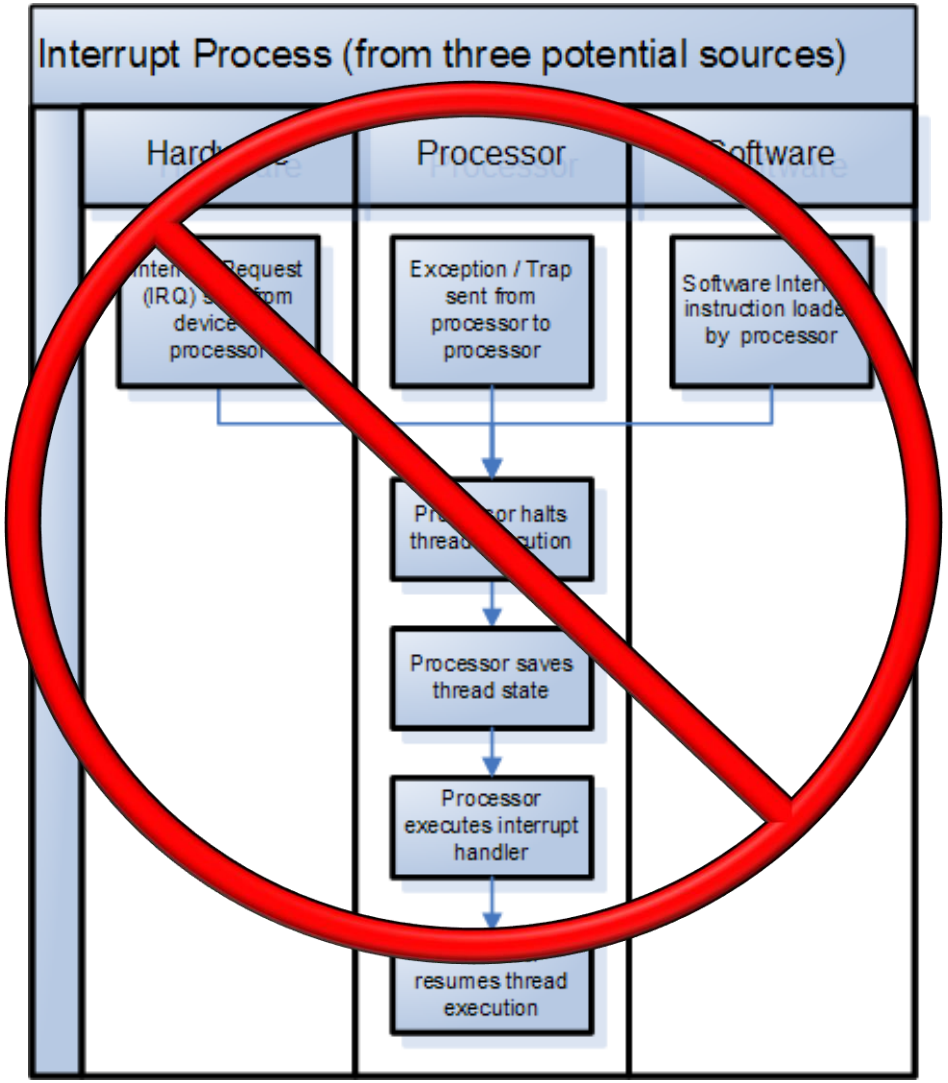


e.g., an I/O operation returns the # of bytes transferred & it is up to the application to check this & manage its own resumption of the operation until all the bytes have been transferred

See en.wikipedia.org/wiki/PCLSRing#Unix-solution:_restart_on_request

Java Thread Interrupts vs Hardware/OS Interrupts

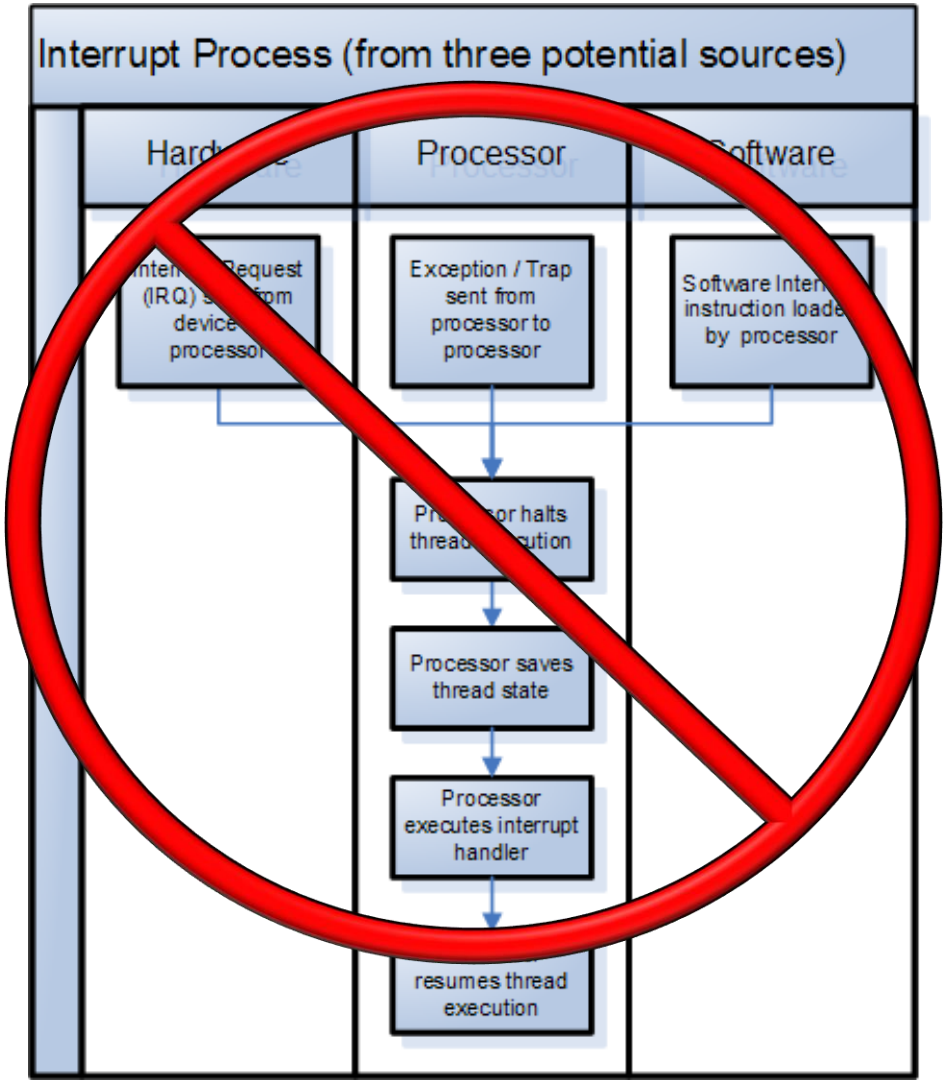
- Java thread interrupts differ from hardware or operating system interrupts



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 r*ather than *asynchronous* & *preemptive*
    - i.e., they don't occur at an arbitrary point & don't pause (& later resume) running code



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  - A program must test for them explicitly

```
void processNonBlocking()
{
   ...
   while (true) {
      ... // Do some long-running
          // computation
     if (Thread.interrupted())
       throw new
         InterruptedException();
     ...
```

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  - 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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  - 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"

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

See bugs.java.com/bugdatabase/view_bug.do?bug_id=4514257

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