Threads in Java

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Daemon Threads

• Java threads types
  • User
  • Daemon
    • Provide general services
    • Typically never terminate
    • Call setDaemon() before start() 

• Program termination
  • All user threads finish
  • Daemon threads are terminated by JVM
Threads – Scheduling

- **Scheduler**
  - Determines which runnable threads to run
    - When *context switching* takes place
  - Can be based on thread *priority*
  - Part of OS or Java Virtual Machine (JVM)

- **Scheduling policy**
  - Non-preemptive (cooperative) scheduling
  - Preemptive scheduling
Threads – Non-preemptive Scheduling

- Threads continue execution until
  - Thread terminates
  - Executes instruction causing wait (e.g., IO)
  - Thread volunteering to stop (invoking yield or sleep)
Threads – Preemptive Scheduling

- Threads continue execution until
  - Same reasons as non-preemptive scheduling
  - Preempted by scheduler

![Thread State Diagram](image.png)
Thread Scheduling Observations

• Order thread is selected is indeterminate
  • Depends on scheduler
• Scheduling may not be fair
  • Some threads may execute more often
• Thread can block indefinitely (starvation)
  • If other threads always execute first
• Your code should work correctly regardless the scheduling policy in place
Java Thread Example

```java
public class ThreadNoJoin extends Thread {
    public void run() {
        for (int i = 0; i < 3; i++) {
            try {
                sleep((int)(Math.random() * 5000)); // 5 secs
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
            System.out.println(i);
        }
    }
    public static void main(String[] args) {
        Thread t1 = new ThreadNoJoin();
        Thread t2 = new ThreadNoJoin();
        t1.start();
        t2.start();
        System.out.println("Done");
    }
}
```

To understand this example better, let’s assume we want to make a sandwich
Java Thread Example – Output

• Possible outputs
  • 0,1,2,0,1,2,Done // thread 1, thread 2, main()
  • 0,1,2,Done,0,1,2 // thread 1, main(), thread 2
  • Done,0,1,2,0,1,2 // main(), thread 1, thread 2
  • 0,0,1,1,2,Done,2 // main() & threads interleaved
Thread Class – join( ) Method

- Can wait for thread to terminate with join( )
- Method prototype
  - public final void join( )
    - Returns when thread is done
    - Throws InterruptedException if interrupted
Java Thread Example (Join)

```java
public class ThreadJoin extends Thread {
    public void run() {
        for (int i = 0; i < 3; i++) {
            try {
                sleep((int)(Math.random() * 5000)); // 5 secs
            } catch (InterruptedException e) {
                e.printStackTrace();
            }
            System.out.println(i);
        }
    }

    public static void main(String[] args) {
        Thread t1 = new ThreadJoin();
        Thread t2 = new ThreadJoin();
        t1.start();
        t2.start();
        try {
            t1.join();
            t2.join();
        } catch (InterruptedException e) {
            e.printStackTrace();
        }
        System.out.println("Done");
    }
}
```
About Join

• Important: You will limit the concurrency level if you do not start/join correctly

• Suppose you want to run many threads concurrently. **Start them all and then execute the join for each one. Do not start one thread, then join on that thread, start the second one, join on that thread, etc.**

• The following is WRONG!

```java
t1.start()
t1.join()
t2.start()
t2.join()
```

• Feel free to use arrays, sets, etc., to keep track of your threads
About Threads

• **Common mistake** → calling the run() method. If you want to run a thread you must execute start() and not call the run() method; the run() method is called for you

• **Thread.sleep** → Suppose you have a thread object reference (t1) and invoke t1.sleep(2000). Which thread will be sleeping for 2 seconds? It will not be t1
Terminating Threads

- A thread ends when the run() method ends
- Sometimes we may need to stop a thread before it ends
  - For example, you may have created several threads to find a problem solution and once one thread finds it, there is no need for the rest
- How to stop thread?
  - **Using stop() method** → WRONG! This is a deprecated method. Using it can lead to problems when data is shared
  - **Using interrupt() method**
    - This method does not stop the thread. Instead, it notifies the thread that it should terminate. The method sets a boolean variable in the thread and that value can be checked by the thread (by using the method interrupted())
    - It is up to the thread to terminate or not
  - public void run() {
      while(!Thread.interrupted()) {
          // work
      }
      // release resource, cleaning tasks
  }
Thread Example

• Swing uses a single-threaded model
• Long computations in the EDT freezes the GUI
• Example: Progress Bar Example