

CMSC 132:

Object-Oriented Programming II



Threads in Java

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Daemon Threads

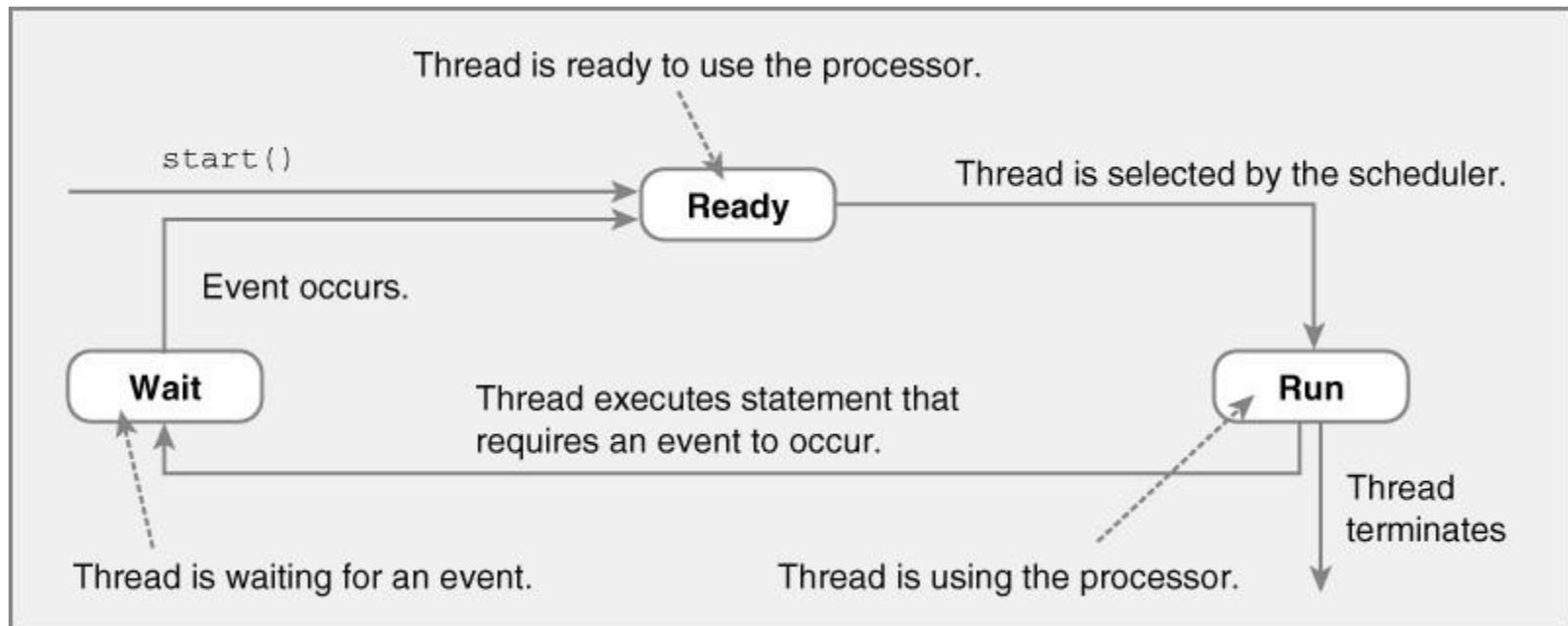
- Java threads types
 - User
 - Daemon
 - Provide general services
 - Typically never terminate
 - Call `setDaemon()` before `start()`
- Program termination
 - All user threads finish
 - Daemon threads are terminated by JVM

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

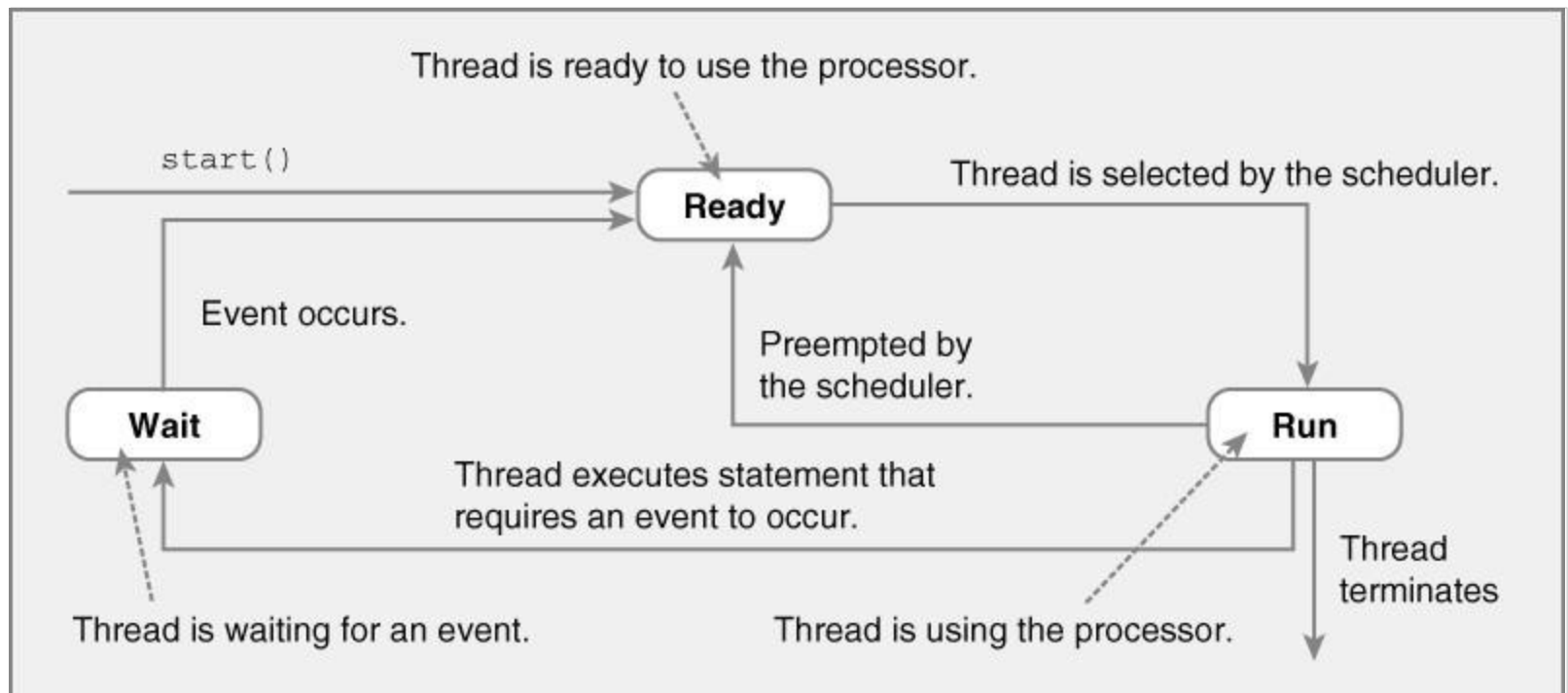
Threads – Non-preemptive Scheduling

- 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 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

```
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

main (): thread 1, thread 2, println Done

thread 1: println 0, println 1, println 2

thread 2: println 0, println 1, println 2

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)

```
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!
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