

MultiThreading

CHAPTER 23 OF JAVA HOW TO PROGRAM

Processes and threads

- process: A program running on the computer.
 - Processes have memory isolation (don't share data with each other).
- thread: A "lightweight process"; a single sequential flow of execution or isolated sub-task within one program.
 - A means to implement programs that seem to perform multiple tasks simultaneously (a.k.a. concurrency).
 - Threads within the same process do share data with each other.
 - i.e., Variables created in one thread can be seen by others.
 - "shared-memory concurrency"
 - sometimes called a lightweight process

Places threads are used

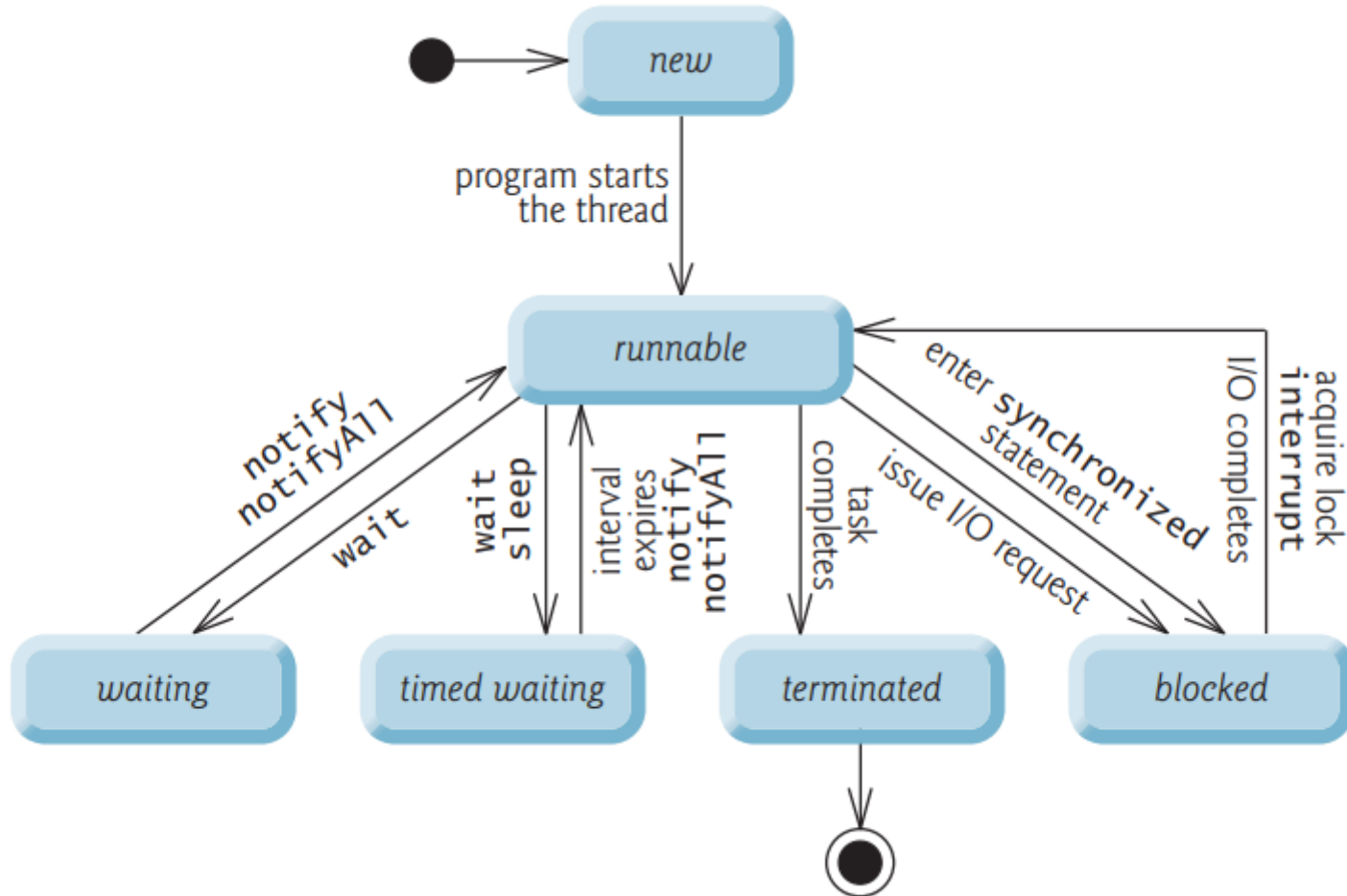
- I/O:
 - loading a file in the background
- Networking:
 - example: thread that waits for another machine to connect
- Parallelized algorithms
 - example: multithreaded merge sort
- Event-handling loops
 - largely handled for us by Java

A multithreaded program

- 1 thread:
 - program executes sequentially
 - every program has a "main thread" for its *main* method
- 2 or more threads:
 - runs each thread sequentially, but interleaves them
 - overall program is concurrent
- Scheduling: OS lets each thread/process run for a short time slice then switches to another.
 - High priority threads run first.



Thread life-cycle



Example: Extending from Thread Class

- See Thread Example Code.

Example:

Implementing Runnable Interface

- If we need multithreading support in a class that already extends a class other than **Thread**, we must implement the ***Runnable** interface* in that class, because Java does not allow a class to extend more than one class at a time.
- See Runnable Example Code.

Example:

Thread Pool and ExecutorService

- An ***Executor*** object executes `Runnable`s.
- It does this by creating and managing a group of threads called a ***thread pool***.
- Using an ***Executor*** has many advantages over creating threads yourself. Executors can ***reuse existing threads to eliminate the overhead of creating a new thread*** for each task and can improve performance by ***optimizing the number of threads to ensure that the processor stays busy***, without creating so many threads that the application runs out of resources.

Example:

Thread Pool and ExecutorService

- See Executor Example Code.

```
// create ExecutorService to manage threads  
ExecutorService executorService = Executors.newCachedThreadPool();
```

Thread Synchronization

- See Section 23.4
- Threads working on shared objects.
- Multiple threads are updating the shared objects.
- One thread read and one thread update.
- Problem solved by thread synchronization.
- This solution ensures mutual exclusion on working threads.

Thread Synchronization

- A common way to perform synchronization is to use Java's built-in **monitors**. Every object has a monitor and **a monitor lock** (or intrinsic lock).

```
synchronized (object)  
{  
    statements  
}
```

```
public synchronized String toString()  
{  
    return Arrays.toString(array);  
}
```

Unsynchronized Data Sharing Example

- See `UnsynchronizedExample` code.

Synchronized Data Sharing Example

- See SynchronizedExample code.
- Be careful with add and toString methods' signature in SimpleArray class.

Producer/Consumer Relationship

- See ProdConsumExample code.
- See Section 23.6
- In a *producer/consumer* relationship, the *producer* portion of an application generates data and stores it in a shared object, and the *consumer* portion of the application reads data from the shared object.

Producer/Consumer Relationship

Wait/Notify

- See WaitNotifyExample code.
- See Section 23.7
- We need a way to allow our threads to *wait*, depending on whether certain conditions are true.

Concurrent Collections

Collection	Description
<code>ArrayBlockingQueue</code>	A fixed-size queue that supports the producer/consumer relationship—possibly with many producers and consumers.
<code>ConcurrentHashMap</code>	A hash-based map (similar to the <code>HashMap</code> introduced in Chapter 16) that allows an arbitrary number of reader threads and a limited number of writer threads. This and the <code>LinkedBlockingQueue</code> are by far the most frequently used concurrent collections.
<code>ConcurrentLinkedDeque</code>	A concurrent linked-list implementation of a double-ended queue.
<code>ConcurrentLinkedQueue</code>	A concurrent linked-list implementation of a queue that can grow dynamically.
<code>ConcurrentSkipListMap</code>	A concurrent map that is sorted by its keys.
<code>ConcurrentSkipListSet</code>	A sorted concurrent set.
<code>CopyOnWriteArrayList</code>	A thread-safe <code>ArrayList</code> . Each operation that modifies the collection first creates a new copy of the contents. Used when the collection is traversed much more frequently than the collection's contents are modified.
<code>CopyOnWriteArraySet</code>	A set that's implemented using <code>CopyOnWriteArrayList</code> .
<code>DelayQueue</code>	A variable-size queue containing <code>Delayed</code> objects. An object can be removed only after its delay has expired.

Concurrent Collections

<code>LinkedBlockingDeque</code>	A double-ended blocking queue implemented as a linked list that can optionally be fixed in size.
<code>LinkedBlockingQueue</code>	A blocking queue implemented as a linked list that can optionally be fixed in size. This and the <code>ConcurrentHashMap</code> are by far the most frequently used concurrent collections.
<code>LinkedTransferQueue</code>	A linked-list implementation of interface <code>TransferQueue</code> . Each producer has the option of waiting for a consumer to take an element being inserted (via method <code>transfer</code>) or simply placing the element into the queue (via method <code>put</code>). Also provides overloaded method <code>tryTransfer</code> to immediately transfer an element to a waiting consumer or to do so within a specified timeout period. If the transfer cannot be completed, the element is not placed in the queue. Typically used in applications that pass messages between threads.
<code>PriorityBlockingQueue</code>	A variable-length priority-based blocking queue (like a <code>PriorityQueue</code>).
<code>SynchronousQueue</code>	[For experts.] A blocking queue implementation that does not have an internal capacity. Each insert operation by one thread must wait for a remove operation from another thread and vice versa.

Multithreading with GUI: SwingWorker

- See `SwingWorkerExample` code.
- See Section 23.11

Method	Description
<code>doInBackground</code>	Defines a long computation and is called in a worker thread.
<code>done</code>	Executes on the event dispatch thread when <code>doInBackground</code> returns.
<code>execute</code>	Schedules the <code>SwingWorker</code> object to be executed in a worker thread.
<code>get</code>	Waits for the computation to complete, then returns the result of the computation (i.e., the return value of <code>doInBackground</code>).
<code>publish</code>	Sends intermediate results from the <code>doInBackground</code> method to the <code>process</code> method for processing on the event dispatch thread.

Multithreading with GUI: SwingWorker

- See `SwingWorkerExample` code.
- See Section 23.11

Method	Description
<code>process</code>	Receives intermediate results from the <code>publish</code> method and processes these results on the event dispatch thread.
<code>setProgress</code>	Sets the progress property to notify any property change listeners on the event dispatch thread of progress bar updates.