Java Programming Language SE – 6

Module 15: Threads

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ORACLE®

Certified Professional

Java SE 6 Programmer

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Objectives

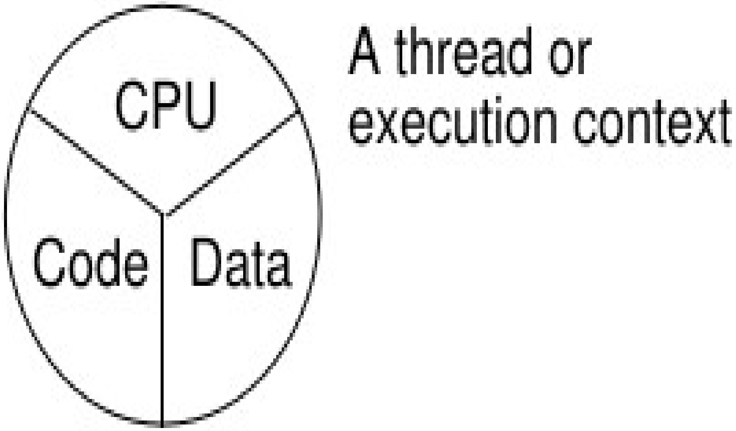
- Define a thread
- Create separate threads in a Java technology program, controlling the code and data that are used by that thread
- Control the execution of a thread and write platform- independent code with threads
- Describe the difficulties that might arise when multiple threads share data
- Use wait and notify to communicate between threads
- Use synchronized to protect data from corruption

Relevance

- How do you get programs to perform multiple tasks concurrently?

Threads

- What are threads?
  - Threads are a virtual CPU.
- The three parts of at thread are:
  - CPU
  - Code
  - Data



A thread or execution context

Creating the Thread

```
public class ThreadTester {
public static void main(String args[]) {
HelloRunner r = new HelloRunner();
Thread t = new Thread(r);
t.start();
}}
class HelloRunner implements Runnable {
int i;
public void run() {
i = 0;
while (true) {
System.out.println("Hello " + i++);
if ( i == 50 ) {
break;
}}}}
```

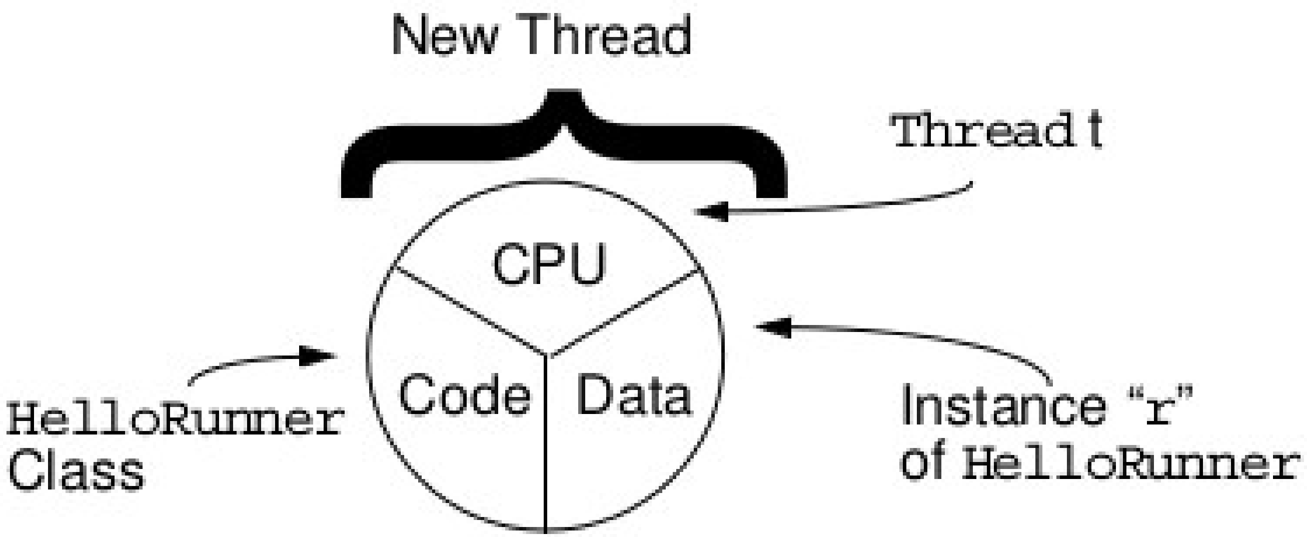
Creating the Thread

- Multithreaded programming has these characteristics:
- Multiple threads are from one Runnable instance.
- Threads share the same data and code.
- For example:

```
Thread t1 = new Thread(r);

Thread t2 = new Thread(r);
```

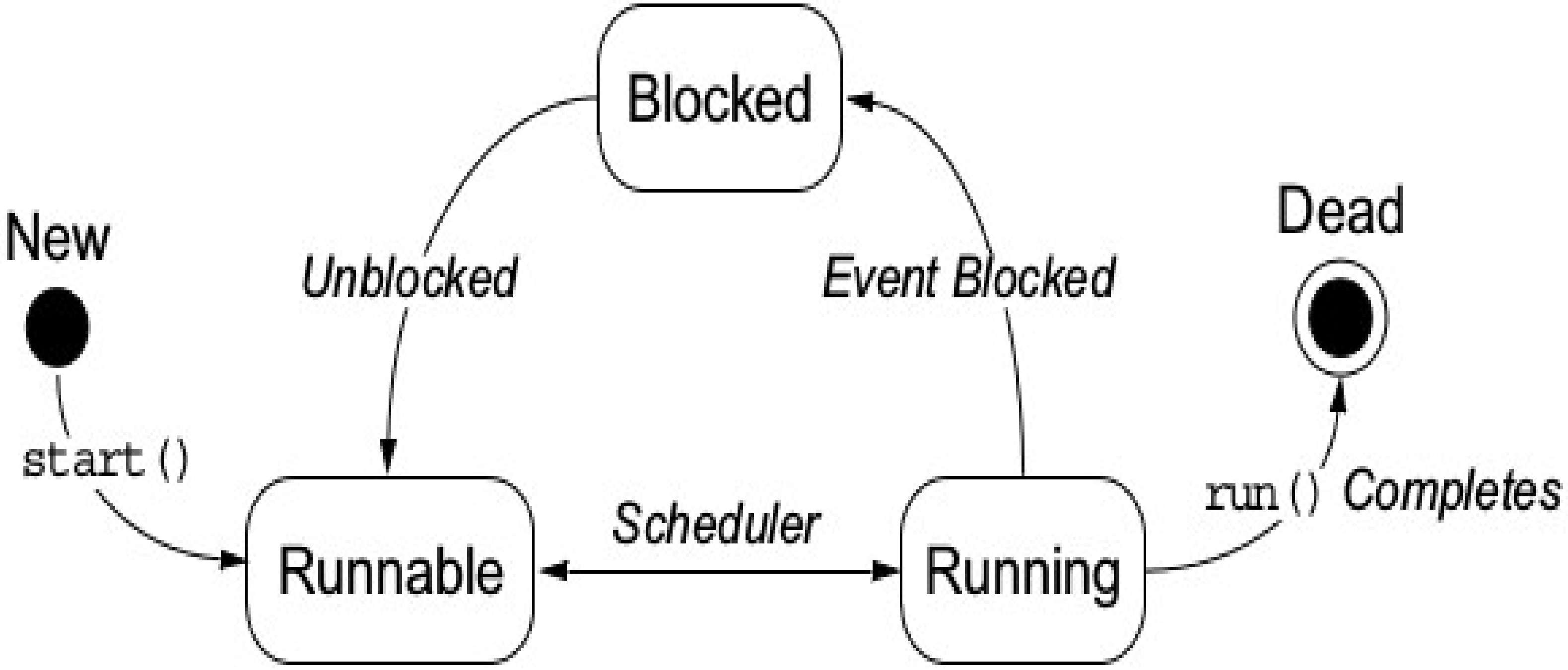
Creating the Thread



Starting the Thread

- Use the start method.
- Place the thread in a runnable state.

Thread Scheduling



Thread Scheduling Example

```
public class Runner implements Runnable {
public void run() {
while (true) {
// do lots of interesting stuff
// ...
// Give other threads a chance
try {
Thread.sleep(10);
} catch (InterruptedException e) {
// This thread’s sleep was interrupted
// by another thread
}}}}
```

Terminating a Thread

```
public class Runner implements Runnable {
private boolean timeToQuit=false;
public void run() {
while ( ! timeToQuit ) {
// continue doing work
}
// clean up before run() ends
}
public void stopRunning() {
timeToQuit=true;
}}
```

Terminating a Thread

```
public class ThreadController {
private Runner r = new Runner();
private Thread t = new Thread(r);
public void startThread() {
t.start();
}
public void stopThread() {
// use specific instance of Runner
r.stopRunning();
}}
```

Basic Control of Threads

- Test threads:
  - isAlive()
- Access thread priority:
  - getPriority()
  - setPriority()
- Put threads on hold:
  - Thread.sleep()// static method
  - join()
  - Thread.yield()// static method

The join Method

```
public static void main(String[] args) {
Thread t = new Thread(new Runner());
t.start();
...
// Do stuff in parallel with the other thread for a while
...
// Wait here for the other thread to finish
try {
t.join();
} catch (InterruptedException e) {
// the other thread came back early
}
...
// Now continue in this thread
...}
```

Other Ways to Create Threads

```
public class MyThread extends Thread {
public void run() {
while ( true ) {
// do lots of interesting stuff
try {
Thread.sleep(100);
} catch (InterruptedException e) {
// sleep interrupted
}}}
public static void main(String args[]) {
Thread t = new MyThread();
t.start();
}}
```

Selecting a Way to Create Threads

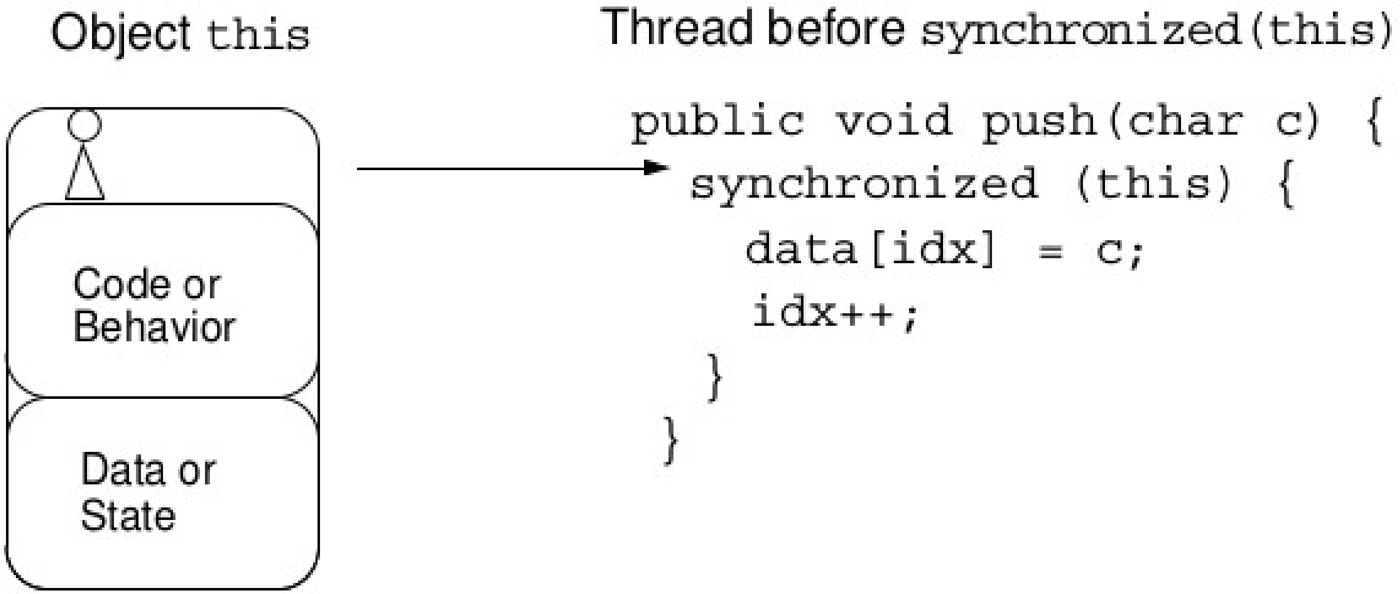
- Implement Runnable:
  - Better object-oriented design
  - Single inheritance
  - Consistency
- Extend Thread:
  - Simpler code

Using the synchronized Keyword

```
public class MyStack {
int idx = 0;
char [] data = new char[6];
public void push(char c) {
data[idx] = c;
idx++;
}
public char pop() {
idx--;
return data[idx];
}
```

The Object Lock Flag

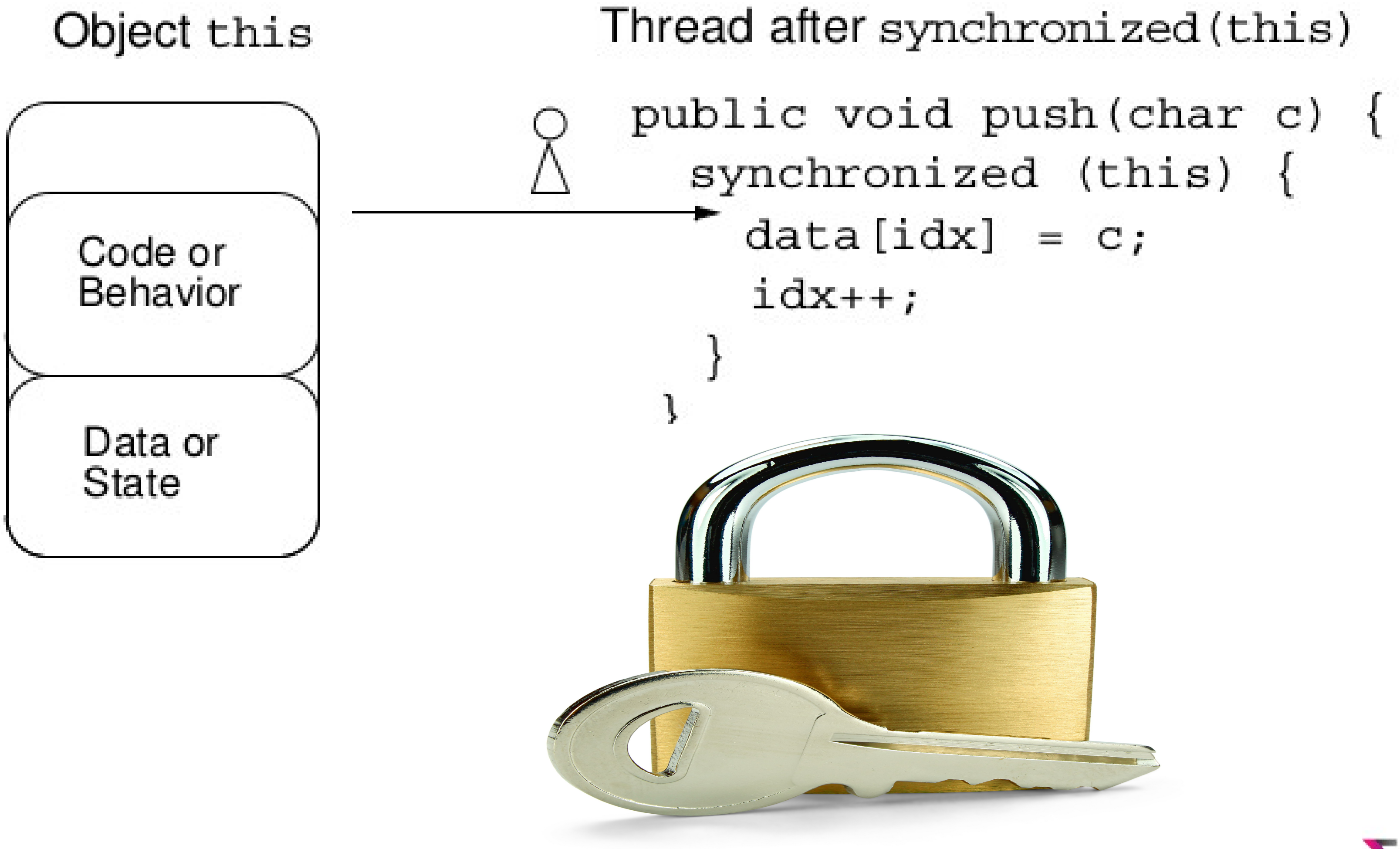
- Every object has a flag that is a type of lock flag.
- The synchronized enables interaction with the lock flag.



Thread before synchronized(this)

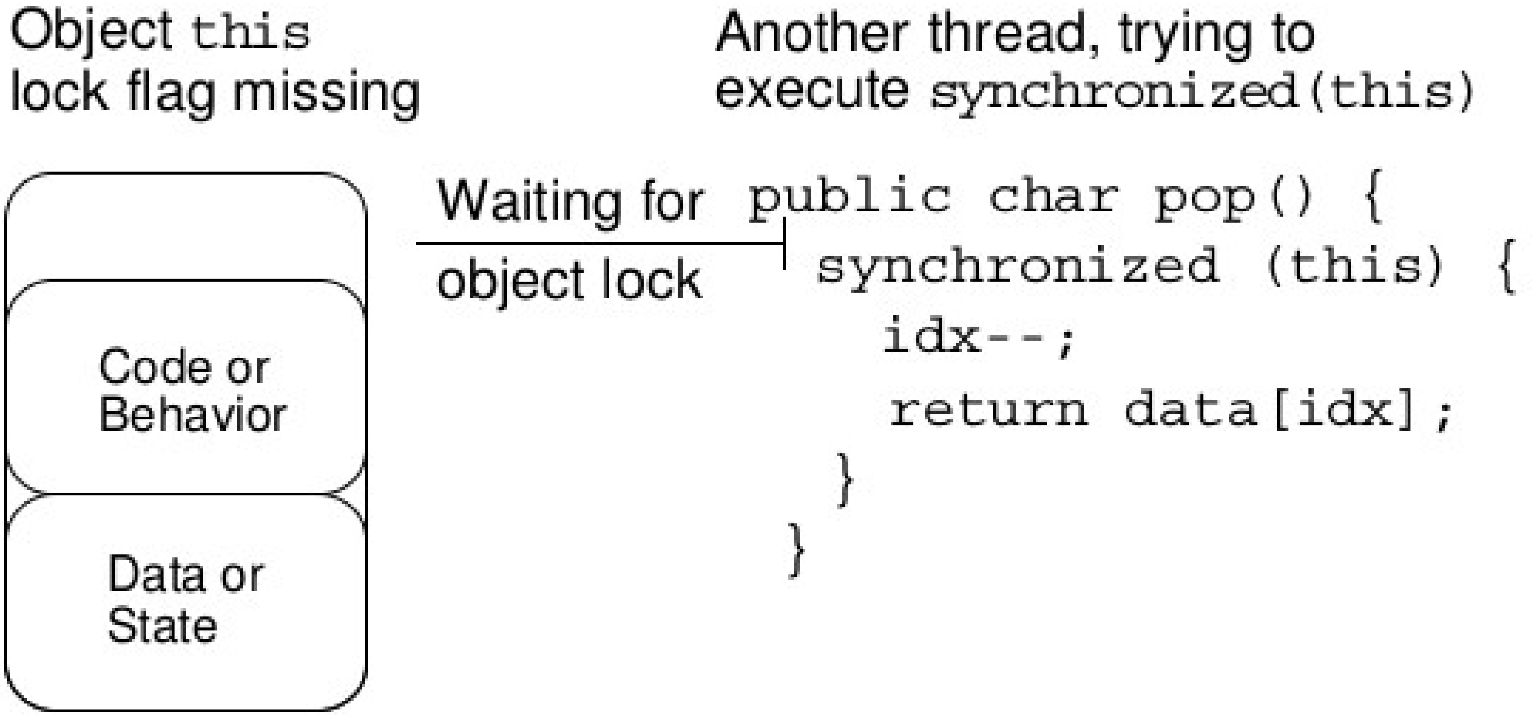
```
public void push(char c) {
  synchronized (this) {
    data[idx] = c;
    idx++;
  }
}
```

The Object Lock Flag



```
public void push(char c) {
  synchronized (this) {
    data[idx] = c;
    idx++;
  }
}
```

The Object Lock Flag



Object `this` lock flag missing

Another thread, trying to execute `synchronized(this)`

```
public char pop() {
  synchronized (this) {
    idx--;
    return data[idx];
  }
}
```

Releasing the Lock Flag

The lock flag is released in the following events:

- Released when the thread passes the end of the synchronized code block
- Released automatically when a break, return, or exception is thrown by the synchronized code block

Using synchronized – Putting It Together

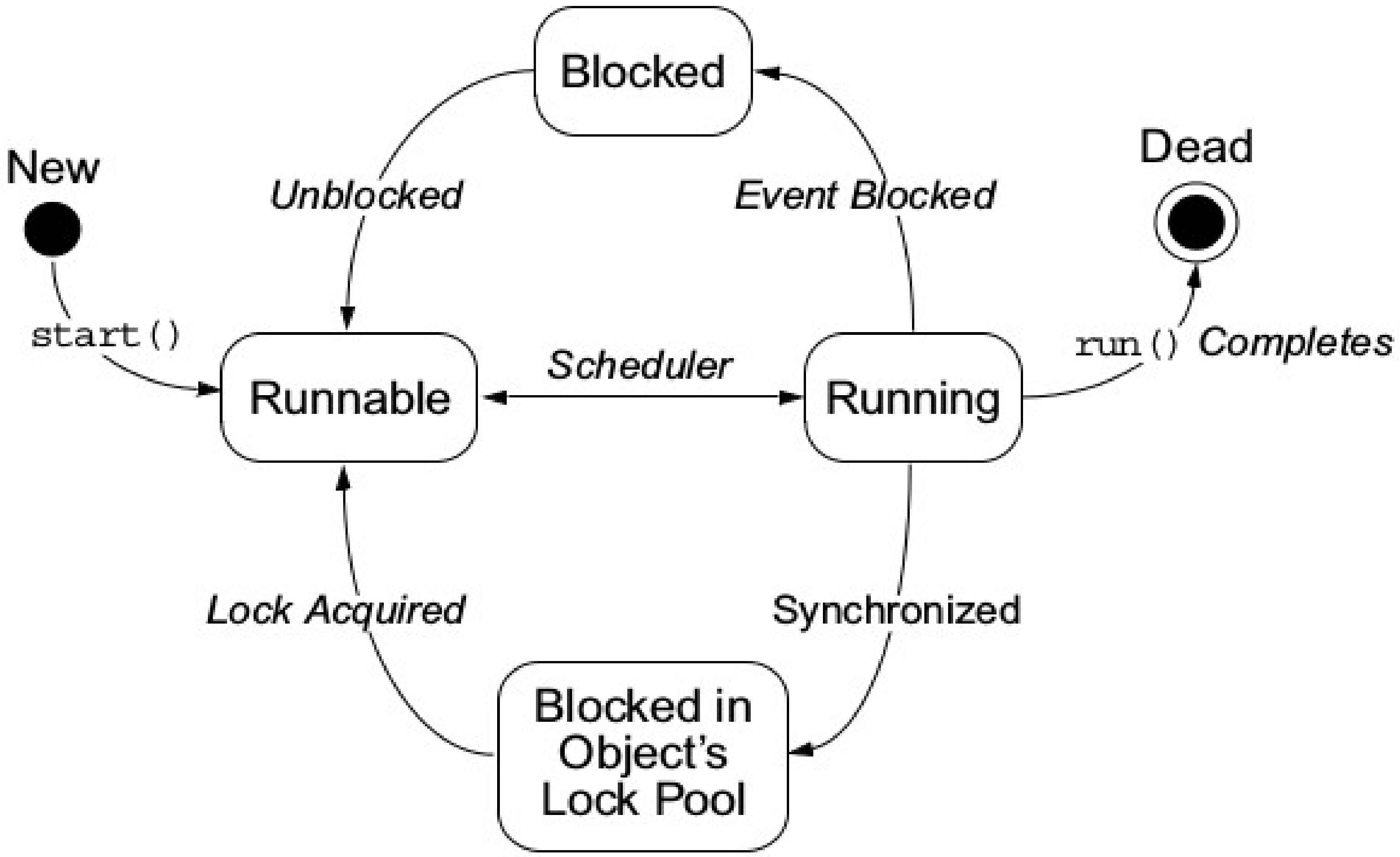
- All access to delicate data should be synchronized.
- Delicate data protected by synchronized should be private.

Using synchronized – Putting It Together

The following two code segments are equivalent:

```
public void push(char c) {
synchronized(this) {
// The push method code
}
}
public synchronized void push(char c) {
// The push method code
}
```

Thread State Diagram With Synchronization



Deadlock

A deadlock has the following characteristics:

- It is two threads, each waiting for a lock from the other.
- It is not detected or avoided.
- Deadlock can be avoided by:
  - Deciding on the order to obtain locks
  - Adhering to this order throughout
  - Releasing locks in reverse order

Thread Interaction – wait and notify

- Scenario:
  - Consider yourself and a cab driver as two threads.
- The problem:

  How do you determine when you are at your destination?
- The solution:
  - You notify the cab driver of your destination and relax.
  - The driver drives and notifies you upon arrival at your destination.

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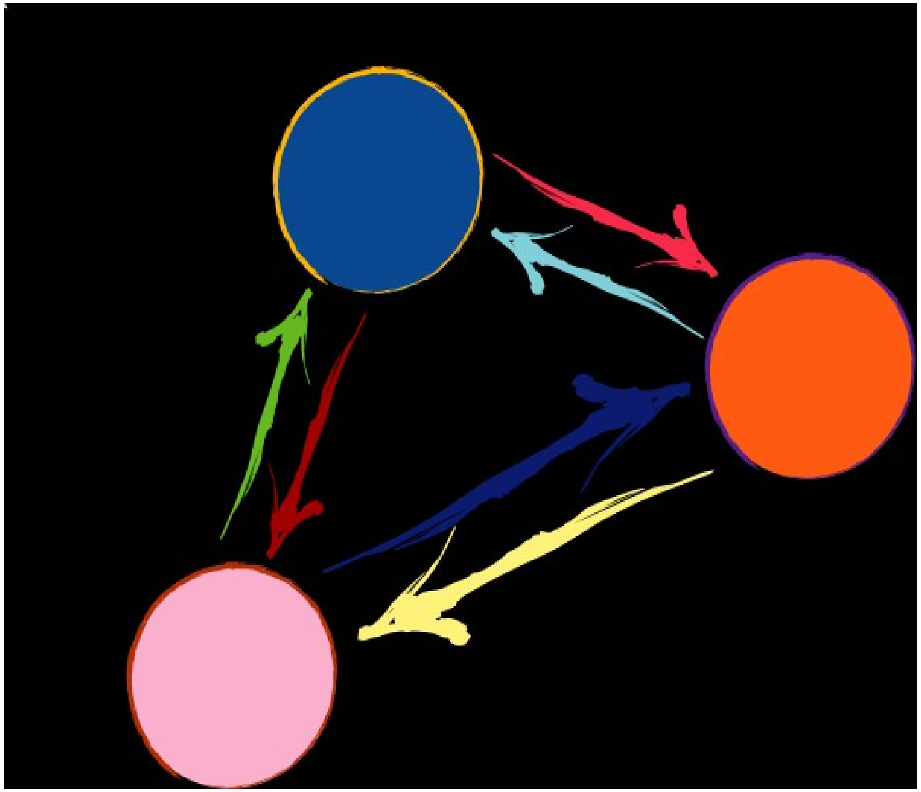
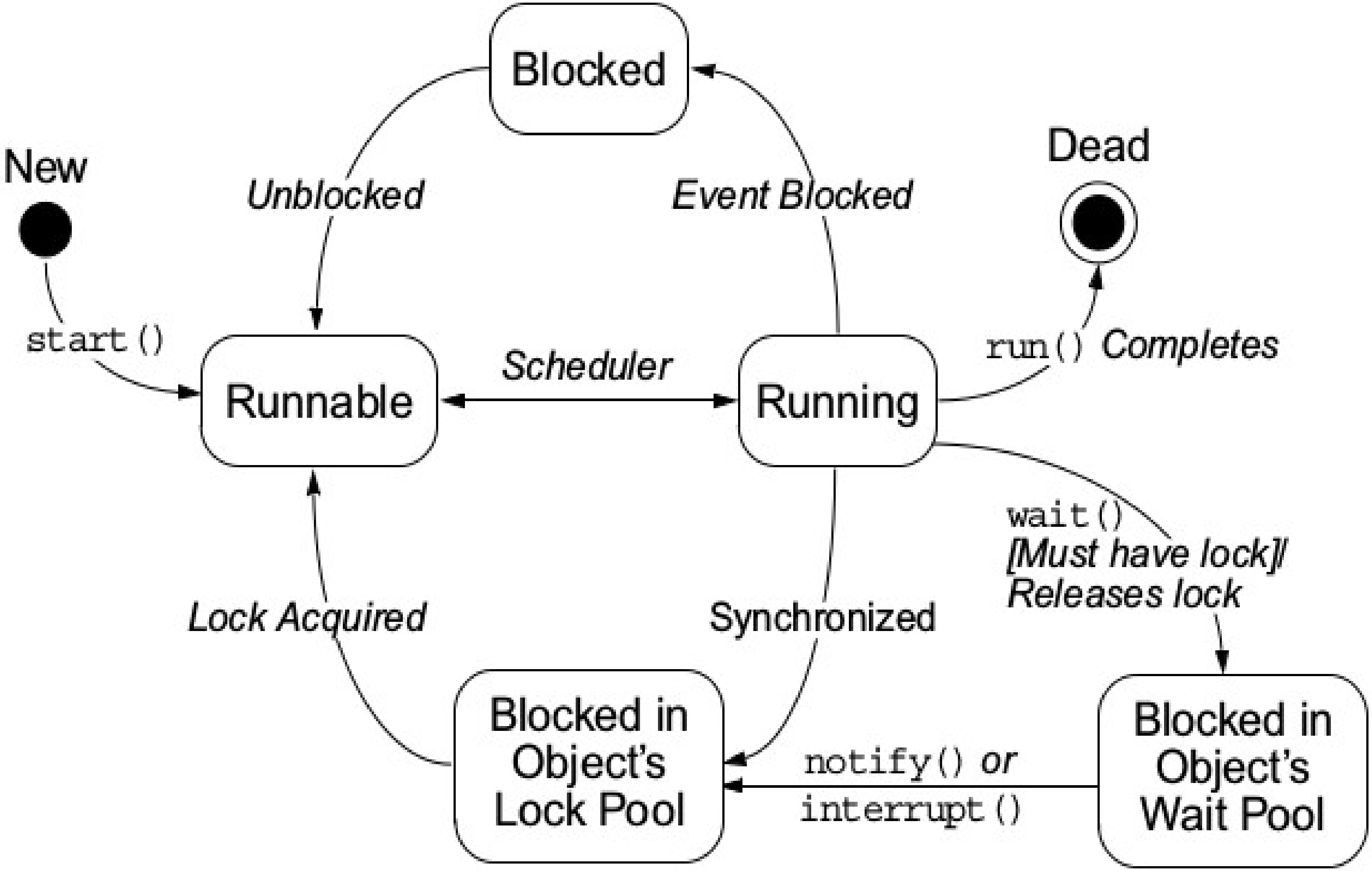
Thread Interaction

Thread interactions include:

- The wait and notify methods
- The pools:
  - Wait pool
  - Lock pool



Thread State Diagram With wait and notify



Monitor Model for Synchronization

- Leave shared data in a consistent state.
- Ensure programs cannot deadlock.
- Do not put threads expecting different notifications in the same wait pool.

The Producer Class

```
package mod13;
public class Producer implements Runnable {
private SyncStack theStack;
private int num;
private static int counter = 1;
public Producer (SyncStack s) {
theStack = s;
num = counter++;
}
```

The Producer Class

```
public void run() {
char c;
for (int i = 0; i < 200; i++) {
c = (char)(Math.random() * 26 +’A’);
theStack.push(c);
System.out.println(“Producer” + num + “: “ + c);
try {
Thread.sleep((int)(Math.random() * 300));
} catch (InterruptedException e) {
// ignore it
}}}}
```

The Consumer Class

```
package mod13;
public class Consumer implements Runnable {
private SyncStack theStack;
private int num;
private static int counter = 1;
public Consumer (SyncStack s) {
theStack = s;
num = counter++;
}
```

The Consumer Class

```
public void run() {
char c;
for (int i = 0; i < 200; i++) {
c = theStack.pop();
System.out.println(“Consumer” + num + “: “ + c);
try {
Thread.sleep((int)(Math.random() * 300));
} catch (InterruptedException e) {
// ignore it
}
}
} // END run method
```

The SyncStack Class

This is a sketch of the SyncStack class:

```
public class SyncStack {
private List<Character> buffer = new ArrayList<Character>(400);
public synchronized char pop() {
// pop code here
}
public synchronized void push(char c) {
// push code here
}
}
```

The pop Method

```
public synchronized char pop() {
char c;
while (buffer.size() == 0) {
try {
this.wait();
} catch (InterruptedException e) {
// ignore it...
}
}
c = buffer.remove(buffer.size()-1);
return c;
}
```

The push Method

```
public synchronized void push(char c) {
this.notify();
buffer.add(c);
```

The SyncTest Class

```
package mod13;

public class SyncTest {


}
```

The SyncTest Class

```
public static void main(String[] args) {
SyncStack stack = new SyncStack();
Producer p1 = new Producer(stack);
Thread prodT1 = new Thread (p1);
prodT1.start();
Producer p2 = new Producer(stack);
Thread prodT2 = new Thread (p2);
prodT2.start();
Consumer c1 = new Consumer(stack);
Thread consT1 = new Thread (c1);
consT1.start();
Consumer c2 = new Consumer(stack);
Thread consT2 = new Thread (c2);
consT2.start();
}
```

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