Amirkabir University of Technology
(Tehran Polytechnic)
Computer Engineering Department

Java Threading

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Outline

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Threading in Java

How to create threads in Java?

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Java Virtual Machine

How JVM executes threads?

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Low-level Mechanisms

Low-level thread communication

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High-level Mechanisms

More advanced features…

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Threading in Java

- Thread Creation in Java
- Approach 1: Extending Thread Class
- Approach 2: Implementing Runnable Interface

Thread Creation in Java

There are two ways to create a thread:

- The new class is a subclass of java.lang.Thread.
- The new class implements java.lang.Runnable interface.

run() method must be implemented in the new class.

This method describes the new thread's task.

1 Approach 1: Extending Thread Class

```
class MyThread extends Thread {
      @Override
      public void run() {
         System.out.println("Hello");
         System.out.println("Bye");
      }
}
public class ThreadExample{
    public static void main(String[] args) {
        System.out.println("Hi");
        MyThread t = new MyThread();
        t.start();
        System.out.println("Good luck");
    }
}
```

- An object should be instanced from MyThread class.
- start() method should be called on it.

Approach 2: Implementing Runnable Interface

```
Class MyRunnable implements Runnable{
      @Override
      public void run() {
         System.out.println("Hello");
         System.out.println("Bye");
      }
}

Thread t = new Thread(new MyRunnable());
t.start();
```

- An object should be instanced from MyRunnable class.
- The MyRunnable instance should be passed to Thread class's constructor.
- Calling the start method on created Thread object will start thread execution.

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Java Virtual Machine

- Green Threads
- Threading Implementation in JVM

Green Threads

- Green Threads refers to the name of the original thread library for the programming language Java.
- Green threads or virtual threads are threads that are scheduled by a runtime library or virtual machine.
- Green threads emulate multithreaded environments without relying on any native OS abilities.
- They are managed in user space instead of kernel space.

Threading Implementation in JVM

- In Java 1.1, green threads were the only threading model used by the Java Virtual Machine.
- Java versions dropped green threads in favor of native threads.
- Squawk virtual machine uses green threads to minimize the use of native code, and to support migrating.
- Virtual threads is a lightweight user-mode scheduled alternative to standard OS managed threads.

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Low-level Mechanisms

- Synchronized Blocks
- Inter-Thread Communication

Synchronized blocks

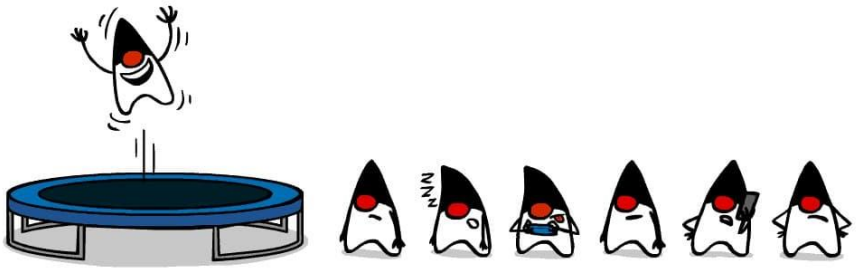
- The synchronized keyword specifies the critical sections.
- There is one lock for each object.
- If an object's synchronized method is called, object's lock should be acquired before entering the method.

```
public class BankAccount{
     private float balance;
     public synchronized void deposit(float amount) {
         balance+= amount;
     }
     public synchronized void withdraw(float amount) {
        balance-= amount;
     }
}
```

3 Synchronized blocks

- It is possible to use other locks to protect critical sections.
- If a static method is defined as synchronized:
  - Each thread should acquire the class's lock instead of object's lock.
  - Therefore no two threads can execute the static method at the same time.

```
List<String> names;
...
synchronized(names){
    names.add("ali");
}
```



Inter-Thread Communication

- Sometimes a thread needs to wait until another thread notifies it.
- These methods are defined in the Object class.
- A thread should have the object's lock to call notify() and wait() methods on that object.
- Thus wait() and notify() of object X should only be called inside synchronized(X) block.
- Each object has a list of waited threads.

```
synchronized (obj) {
  obj.notify();
}
```

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High-level Mechanisms

- Synchronizer Objects
- Semaphore, CountDownLatch, Exchanger, and CyclicBarrier

High-level Threading Mechanisms

- So far, we saw low-level threading mechanisms, which are painful to work with.
- As of Java 5, high-level APIs were added to Java (java.util.concurrent package).
- Easier to use, better performance, and higher utilization on multicore CPUs

Synchronizer Objects

- A shared object is used to synchronize threads.
- Plenty of different classes:
  - Semaphore
  - CountDownLatch
  - Exchanger
  - CyclicBarrier

Semaphore

- Controls access to shared resources.
- Has an internal state to keep the number of allowed threads.
- Primary methods: acquire() and release()
  - acquire() blocks if internal state of semaphore reaches zero.

4 Semaphore: Example

- Two concerns:
  - Threads should not access the list at the same time → `synchronized`
  - Consumer must be blocked if the list is empty → `semaphore`

```
Semaphore sem = new Semaphore(0);
```

```
sem.acquire();
synchronized (list) {
  obj = list.remove(0);
}
```

Consumer

```
synchronized(list){
  list.add(obj);
}
sem.release();
```

Producer

4 CountDownLatch

- Allows multiple threads to wait until certain amount of work is done.
- Major methods:
  - await(): blocks the calling thread until the countdown reaches zero.
  - countdown(): decreases the countdown by one.

```
CountDownLatch latch = new CountDownLatch(2);
```

Thread#1

```
latch.await();
System.out.println("Finished!");
```

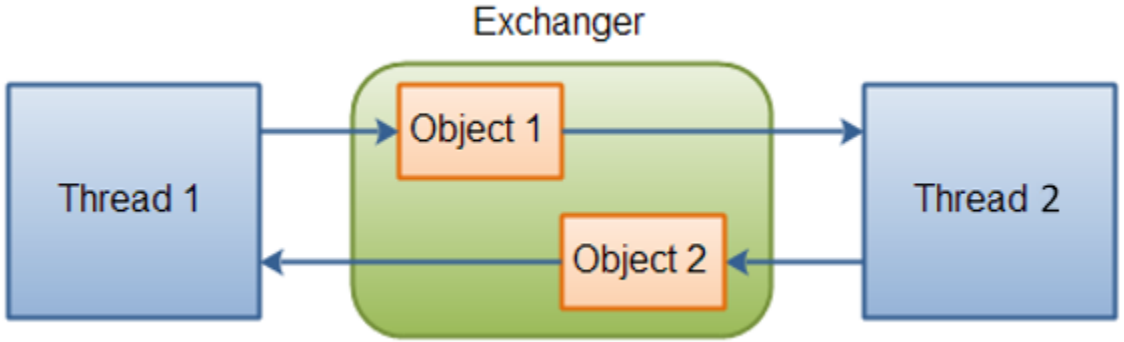
```
latch.countDown();
```

Thread#2

```
latch.countDown();
```

Thread#3

4 More synchronizers



- Exchanger
  - For synchronization and message passing between two threads.

4 More synchronizers

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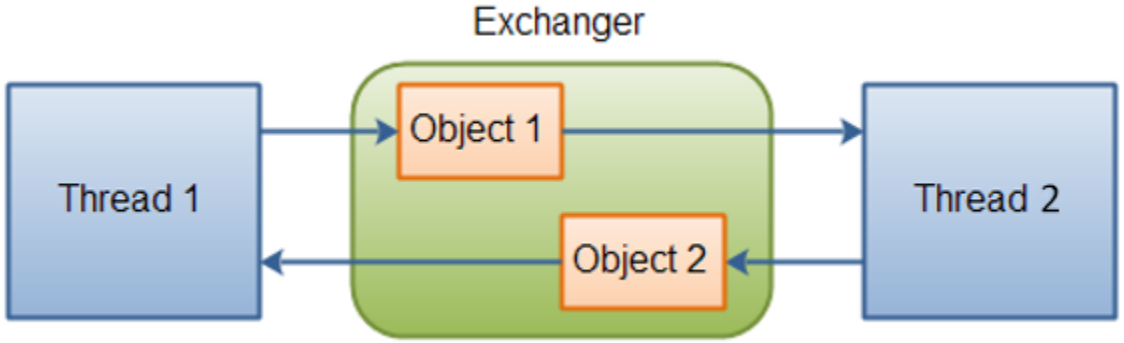
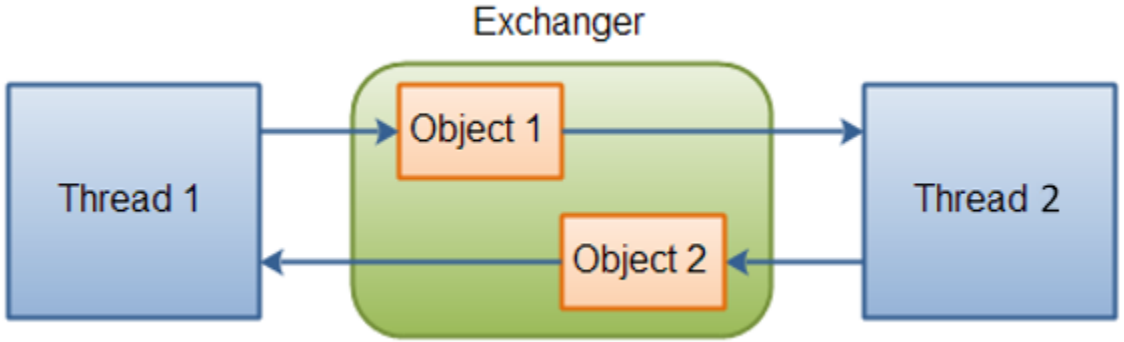



```
Exchanger<String> e = new Exchanger<>();
```

```
e.exchange("x=2");
```
Thread#1

```
e.exchange("y=3");
```
Thread#2

4 More synchronizers



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- CyclicBarrier
  - Barrier for specific number of threads

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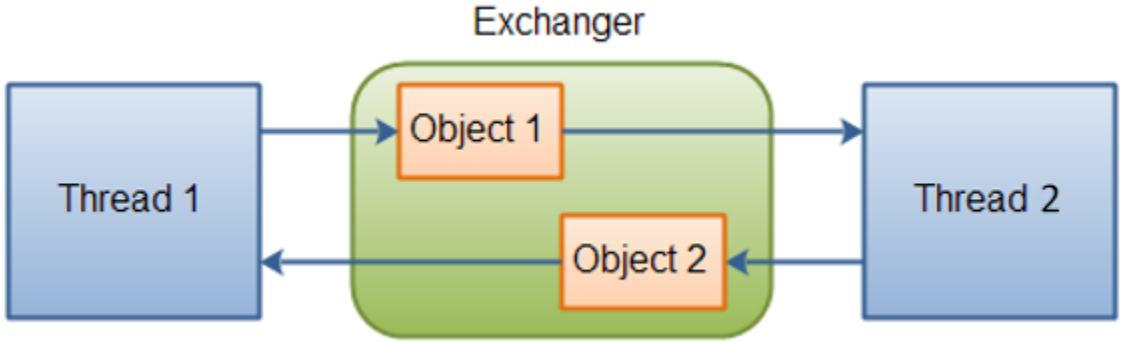

- Exchanger
  - For synchronization and message passing between two threads.

```
Exchanger<String> e = new Exchanger<>();
```

```
e.exchange("x=2");
```
Thread#1

```
e.exchange("y=3");
```
Thread#2

- CyclicBarrier
  - Barrier for specific number of threads

```
CyclicBarrier barrier
      = new CyclicBarrier(3);
```

```
barrier.await();
barrier.await();
barrier.await();
```

Thank You!

Any questions?

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