Advanced Programming

Concurrency — Multithreading in Java

Instructor: Ali Najimi

Author: Hossein Masihi

Department of Computer Engineering

Sharif University of Technology

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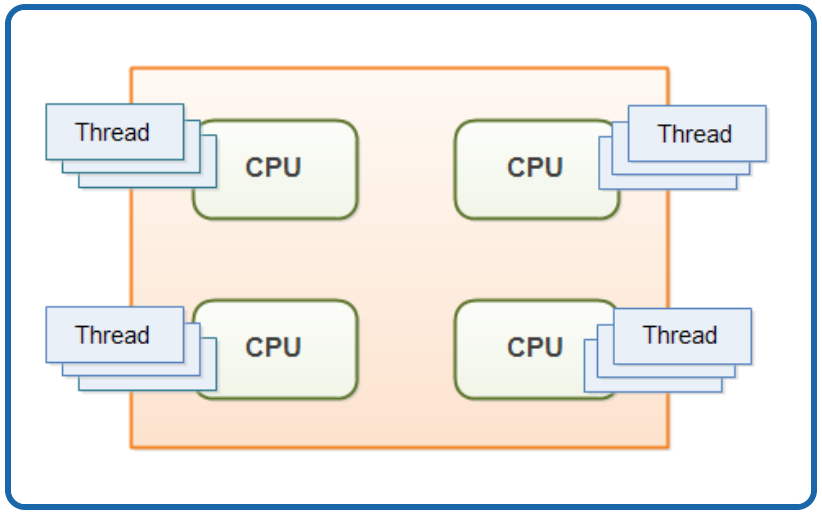
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Concurrency — Concept

- **Concurrency** allows multiple tasks to progress **overlapping in time**.
- In Java, concurrency is primarily achieved using **Threads**.
- Useful for:
  - Parallel computation
  - Responsive UI
  - Server handling multiple clients

```
class MyThread extends Thread {
    public void run() {System.out.println("Running in parallel!"); }
    }
```

> Concurrency ≠ Parallelism
>
> (parallelism requires multiple CPU cores)

Creating Threads

Extending `Thread`

```
class Worker extends Thread {
    public void run() {
        System.out.println("Thread running");
    }
}
new Worker().start();
```

Implementing `Runnable`

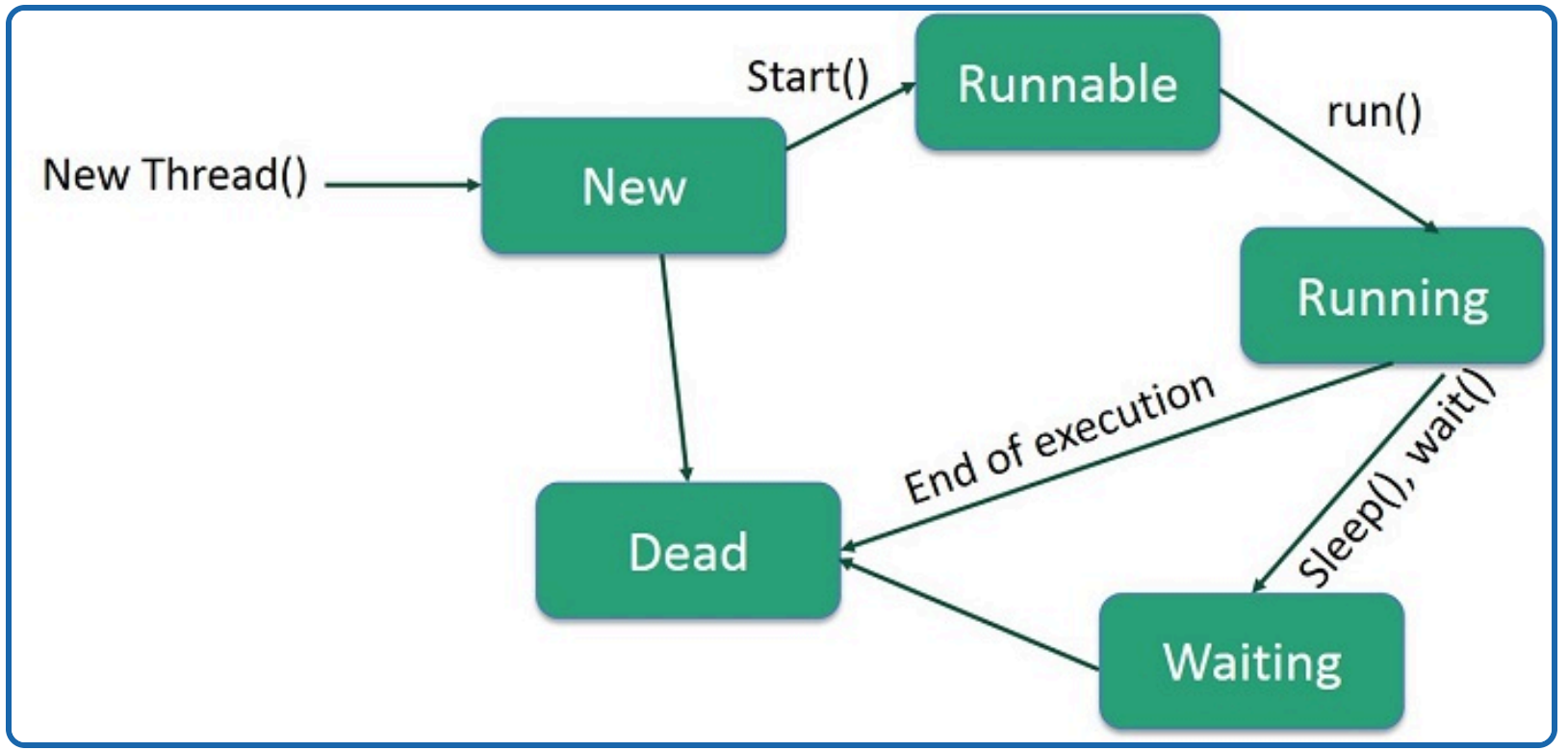
```
class Worker implements Runnable {
    public void run() {
        System.out.println("Running");
    }
}
new Thread(new Worker()).start();
```

> Always use `start()`, never call `run()` directly.

Thread Life Cycle

State	Meaning
New	Thread created but not started
Runnable	Ready to run or running
Blocked / Waiting	Waiting for a resource / event
Timed Waiting	Waiting for a specified time
Terminated	Execution finished

Thread Lifecycle



Synchronization — Why?

Multiple threads accessing shared data simultaneously can cause **race conditions**.

Example of incorrect behavior:

```
class Counter {
    int value = 0;
    void increment() { value++; }
}
```

Two threads running increment() may **overwrite each other** → wrong results.

Synchronization — Solution

```
class Counter {
    private int value = 0;

    synchronized void increment() {
        value++;
    }

    synchronized int getValue() {
        return value;
    }
}
```

- `synchronized` ensures **mutual exclusion**.
- Only one thread can run the synchronized method at a time.

> Synchronization prevents **race conditions** but reduces performance.

Critical Section

- A **Critical Section** is code that accesses **shared data**.
- It must be executed **atomically** (one thread at a time).

Identifying critical section:

```
balance = balance – amount;
```

If not synchronized → corrupted financial transactions.

Errors that occur here:

Error	Cause
Race Condition	Two threads update shared data at same time
Data Corruption	Intermediate state becomes visible
Lost Update	One write overwrites the other

Locks — More Control

```
import java.util.concurrent.locks.*;

class Account {
    private Lock lock = new ReentrantLock();
    private int balance;

    void withdraw(int amount){
        lock.lock();
        try { balance -= amount; } finally { lock.unlock(); }
    }
}
```

`Lock` provides:

- `tryLock()` → avoid deadlock
- More flexibility than `synchronized`

Deadlock — When Threads Block Each Other

Occurs when two threads wait forever for resources held by each other.

```
Thread A waits for resource X → held by Thread B
Thread B waits for resource Y → held by Thread A
```

> Avoid holding multiple locks at the same time when possible.

Summary

Concept	Key Idea
Concurrency	Overlapping execution of tasks
Thread Life Cycle	States from creation → termination
Synchronization	Prevents race conditions
Critical Section	Code accessing shared data
Locks	Give more granular control
Goal	Safe and efficient multi-threaded programs

Thank You!

Concurrency — Safe Multithreading

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