Execution Units

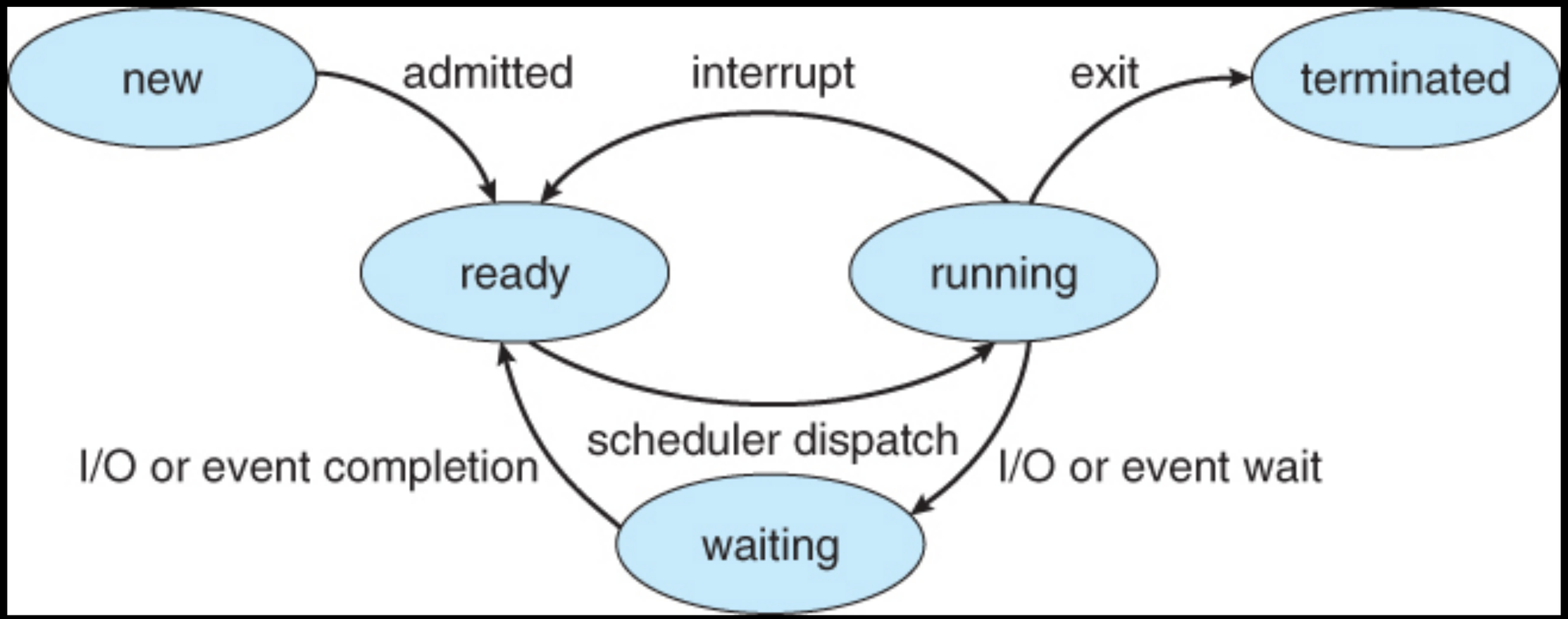
Execution Units

1. Process
2. Thread

Process

1. Self-contained environment:
    - Virtual address space
    - Executable code
    - Privileges
    - Resources (files, sockets)
2. Most of applications are single process
3. Multiple processes application: Chrome

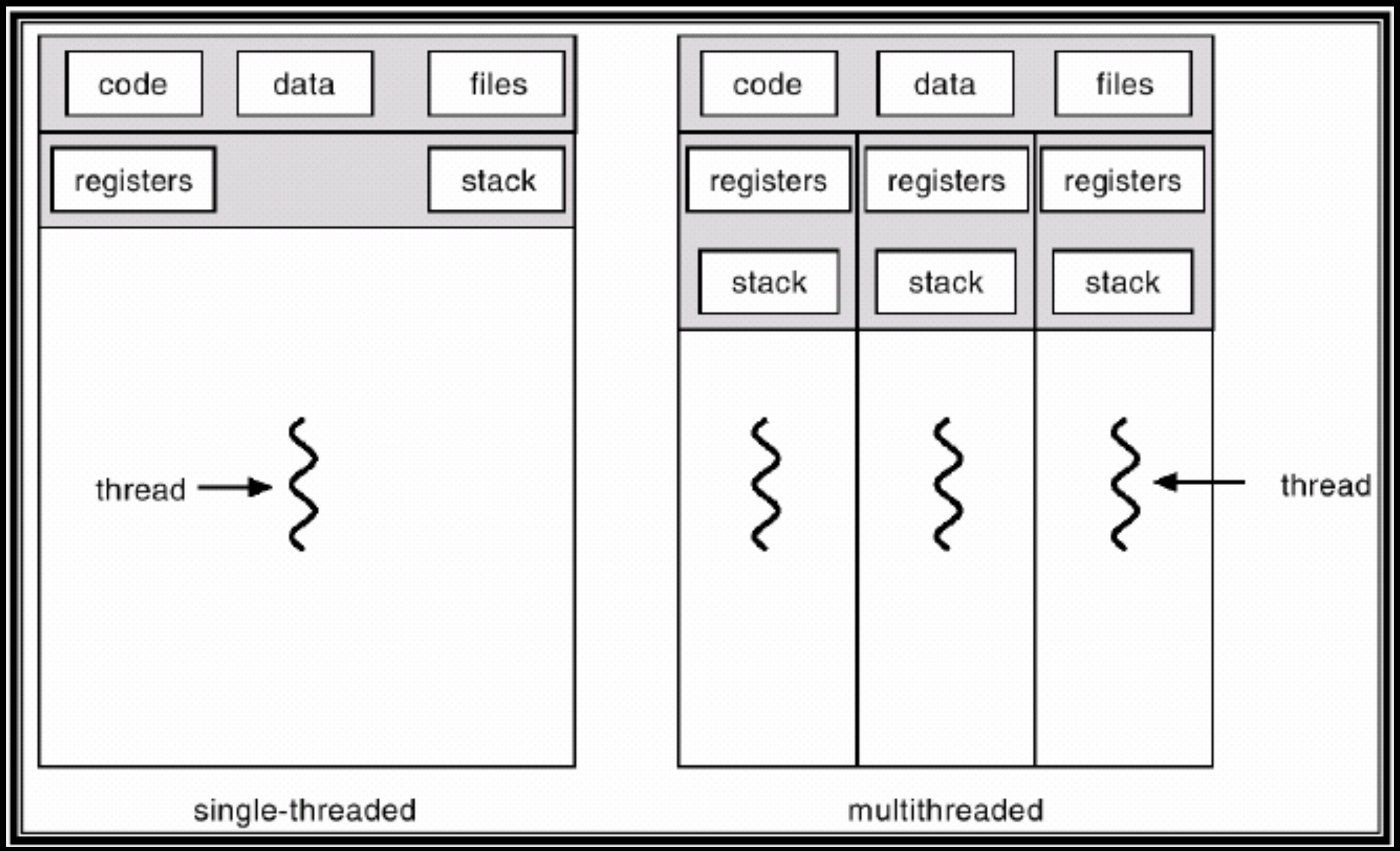
Process States



Inter Process Communication

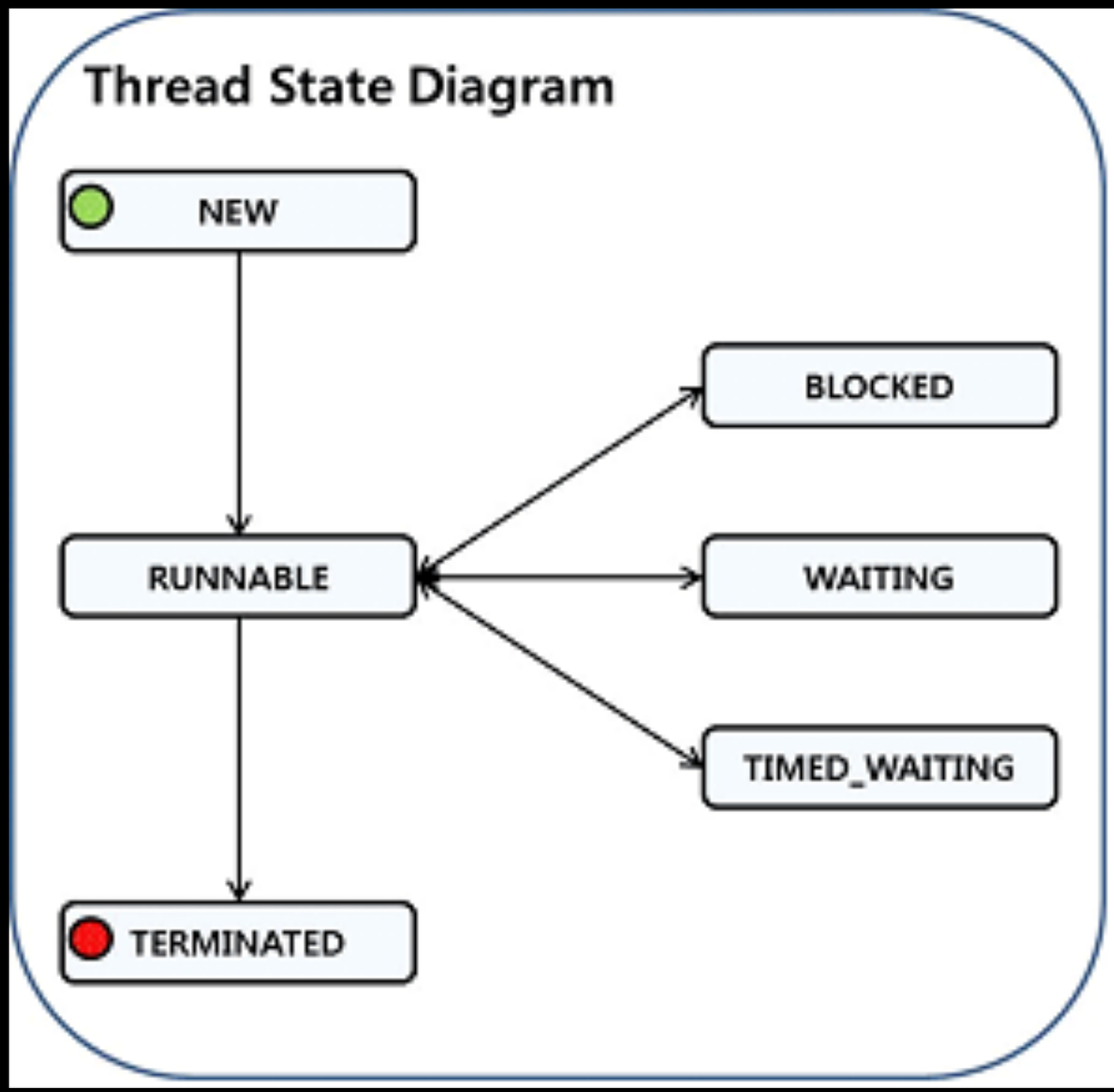
- Socket
- Shared Memory
- Pipe

Multithreaded Process



Thread State

WAITING is TIMED_WAITING with infinite timeout (0 means INFINITE)



Steps to create threads

1. Extends `Thread class` and override `run method`
2. Or implements `Runnable Interface` and implements `run method`
3. Create new execution as a regular object
4. Call `start` to start a thread

Extends Thread class

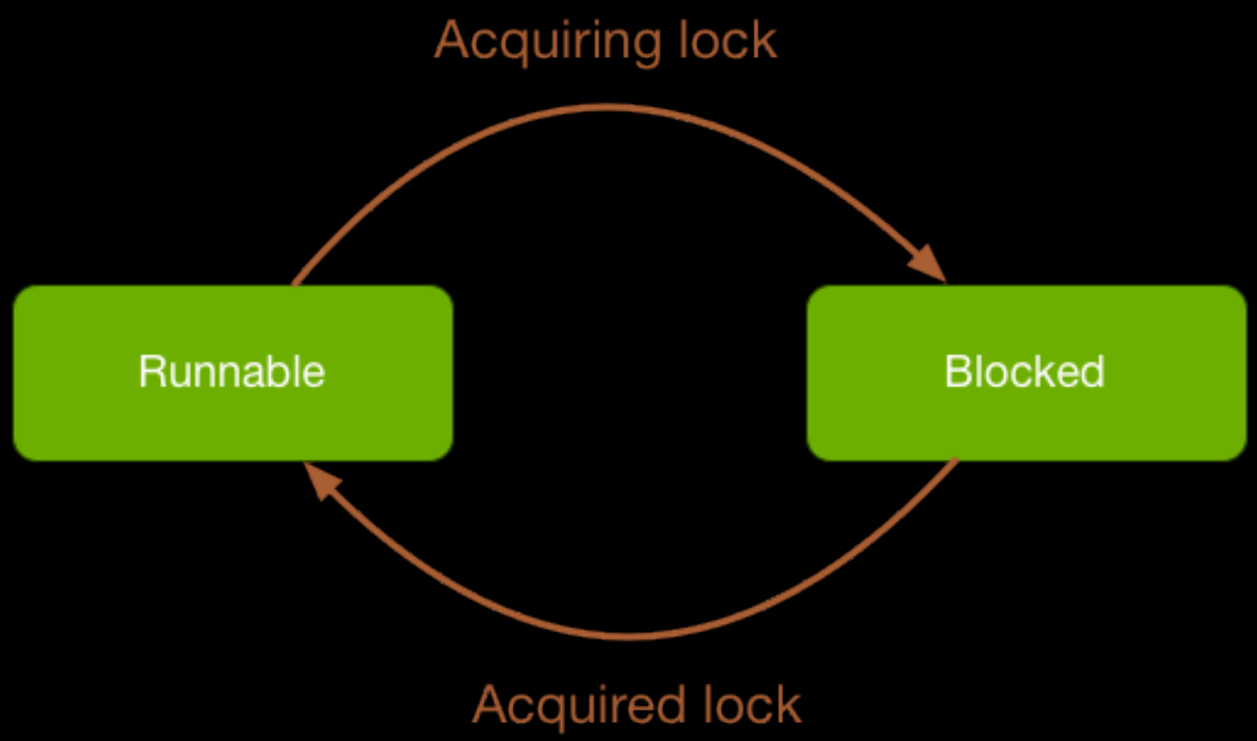
```
class PrimeCalculation extends Thread {
    long minPrime;

    PrimeThread(long minPrime) {
        this.minPrime = minPrime;
    }

    public void run() {
    // compute primes larger than minPrime
    }
}

PrimeCalculation p = new PrimeCalculation(143);
p.start();
```

Implements Runnable

```
class PrimeCalculation implements Runnable {
    long minPrime;

    PrimeThread(long minPrime) {
        this.minPrime = minPrime;
    }

    public void run() {
    // compute primes larger than minPrime
    }
}

PrimeCalculation p = new PrimeCalculation(143);
p.start();
```

Blocked State

Calling `synchronized` method/block is to acquire an intrinsic lock.



Timed Wait

- `sleep` until timeout
- `wait(timeout)` until other threads call `notify` or `notifyAll`
- `join` wait until that thread die

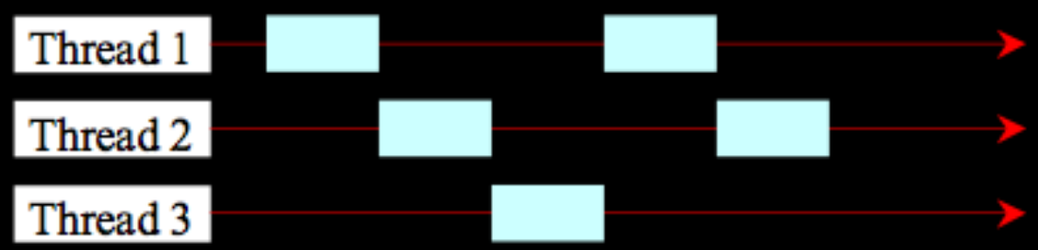
Important Methods

- `Thread.start` to start a thread
- `Object.wait` to wait until timeout or other thread wakes up
- `Object.notify` to wake up one of waiting threads
- `Object.notifyAll` to wake up all waiting threads
- `Thread.sleep` to sleep until timeout

CPU Cycles

How to schedule threads?

Multiple processer (Parallel)



Single processor (Concurrent)

Scheduling

Time-slicing: interrupts the running thread periodically to give other threads a chance to run.

Other schedulers consider thread priority

Context Switch

Context: CPU Registers + Program Counter

Yield

`Thread.yield` to temporarily pause executing thread and allow other threads to execute

Executor

- Manage thread is still an expensive operation.
- Thread pool or executor contains lightweight exection.

Executor Example

```
ExecutorService executor = Executors.newFixedThreadPool(poolSize);
class PrimeCalculation implements Runnable {
    long minPrime;

    PrimeThread(long minPrime) {
        this.minPrime = minPrime;
    }

    public void run() {
    // compute primes larger than minPrime
    }
}
excutor.execute(new PrimeCalculation(100));
```