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CHANGE THE WORLD FROM HERE

Synchronization

CS 272 Software Development

Department of Computer Science
https://www.cs.usfca.edu/

Providing Consistency

- If **multithreading**…
    - If **sharing data** between threads…
        - If shared data not already **thread safe**…
            - must **synchronize** access to that data

Synchronization

- Using the **`synchronized`** keyword and intrinsic (or monitor) lock objects to protect blocks of code
- Using the **`volatile`** keyword to protect* variables
- Using **`wait()`** and **`notifyAll()`** to coordinate threads
- Using **conditional synchronization** via lock objects

Synchronization

- Using the **`synchronized`** keyword and intrinsic (or monitor) lock objects to protect blocks of code
- ~~Using the **`volatile`** keyword to protect* variables~~
- ~~Using **`wait()`** and **`notifyAll()`** to coordinate threads~~
- ~~Using **conditional synchronization** via lock objects~~

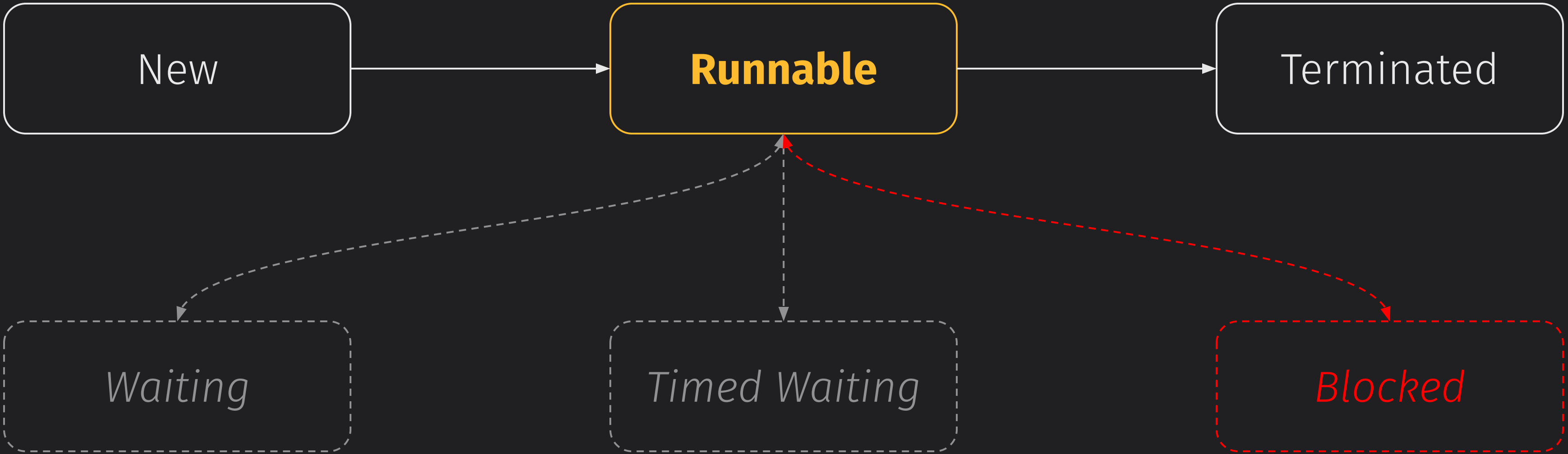
Synchronized Keyword

- Used to create **atomic** (uninterruptible) code
- Can be applied to blocks of code or an entire method
- If applied consistently everywhere shared data is accessed by multiple threads, provides **thread safety**
- Requires an **intrinsic lock** or monitor lock object to determine which threads to block

Synchronized Keyword

- An entering thread must attempt to **acquire** lock
    - Only one thread may hold lock object at once
    - Other code may use the same lock object
- The thread is **blocked** until able to obtain lock object
- The lock object is automatically **released** when a thread exits the synchronized code

Thread States



https://www.cs.usfca.edu/~cs272/javadoc/api/java.base/java/lang/Thread.State.html

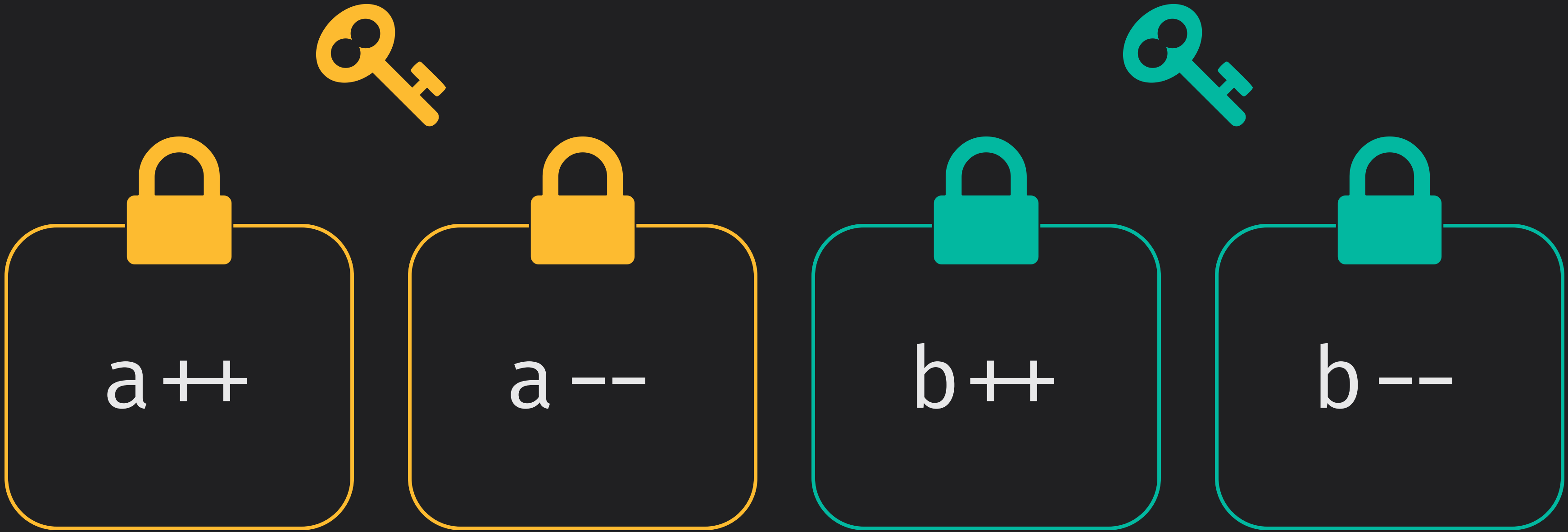
Synchronization Example

```
private Object lock;
private int a;
```

```
public void increment {
  synchronized (lock) {
    a++;
  }
}
```

```
public void decrement {
  synchronized (lock) {
    a--;
  }
}
```

Intrinsic Locks



Intrinsic Locks

- Must specify an object to use as the intrinsic lock
- Exact behavior depends on type of object used
  - e.g. class member versus an instance member
- Controls which threads are blocked and how many threads may access synchronized block

Synchronization Example

```
private Object lock;
private int a;
```

```
public void increment {
  synchronized (lock) {
    a++;
  }
}
```

```
public void decrement {
  synchronized (lock) {
    a--;
  }
}
```

Synchronization Example

```
private Object lock1;
private int a;

public void increment {
  synchronized (lock1) {
    a++;
  }
}
```

```
private Object lock2;

public void decrement {
  synchronized (lock2) {
    a--;
  }
}
```

**Assume lock1 and lock2 are different instances...*

Synchronization Example

```
// private Object lock;
private int a;

public void increment {
  synchronized (this) {
    a++;
  }
}
```

```
public void decrement {
  synchronized (this) {
    a--;
  }
}
```

Synchronization Example

```
private int a;

public synchronized void increment {
  a++;
}

public synchronized void decrement {
  a--;
}
```

Synchronized Methods

- Any method may be declared **synchronized**
  - `public synchronized void method()`
- Equivalent to placing all code within method in a **`synchronized (this)`** block
- All **synchronized** methods within a class use the same lock and may not run concurrently

** Using "this" to handle synchronization can cause security issues... ***

Synchronization Issues

- Protects code, **NOT** objects
    - Does not protect the lock or any objects within
- Must be used consistently to provide **thread safety**
    - Objects accessed within may still be accessed concurrently elsewhere in code
- Causes **blocking**, which slows down code

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