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Liveness

CS 272 Software Development

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Motivation

- We want *healthy* threads (i.e. **thread liveness**)
  - Thread should execute in a timely manner
- Several situations to avoid (i.e. **liveness problems**)
  - Threads can *stop* prematurely (deadlock)
  - Threads can *starve* and take a long time (starvation)
  - Threads can be too *distracted* (livelock)

http://docs.oracle.com/javase/tutorial/essential/concurrency/liveness.html

Deadlock

Deadlock

- Occurs when two or more threads must wait for each other to finish work
- Threads are indefinitely blocked and never complete
    - The threads are effectively dead (hence deadlock)
    - Similar effect as an infinite loop

http://docs.oracle.com/javase/tutorial/essential/concurrency/deadlock.html

Deadlock Example

```
void transfer(Account to, Account from, int amount) {
  lock(to);
  lock(from);

  withdraw(from, amount);
  deposit(to, amount);

  unlock(from);
  unlock(to);
}
```

Deadlock Example

#	transfer(ann, bev, amount)	transfer(bev, ann, amount)
1	`lock(ann);`	`lock(bev);`
2	`lock(bev);`	`lock(ann);`
3	`withdraw(bev, amount);`	`withdraw(ann, amount);`
4	`deposit(ann, amount);`	`deposit(bev, amount);`
5	`unlock(bev);`	`unlock(ann);`
6	`unlock(ann);`	`unlock(bev);`
7	*Will this finish?*	

Deadlock Example

#	transfer(ann, bev, amount)	transfer(bev, ann, amount)
1	`lock(ann);`	`lock(bev);`
2	`lock(bev); // must wait`	`lock(ann); // must wait`
3	~~`withdraw(bev, amount);`~~	~~`withdraw(ann, amount);`~~
4	~~`deposit(ann, amount);`~~	~~`deposit(bev, amount);`~~
5	~~`unlock(bev);`~~	~~`unlock(ann);`~~
6	~~`unlock(ann);`~~	~~`unlock(bev);`~~
7	*DEADLOCK on line 2!*	

Deadlock Avoidance

- Deadlock **detection** and **prevention** difficult
  - Must turn to heuristics for **avoidance**
- Avoid obtaining multiple locks if possible
- Try to obtain locks in same order
- Avoid dependencies and cycles

Starvation and Livelock

Starvation

- Occurs when a higher priority thread prevents a lower priority thread from accessing a resource
  - Resource may be CPU time or something else
  - Often caused by overzealous synchronization
- Lower priority threads are starved of the resource, and take too long (or never) complete

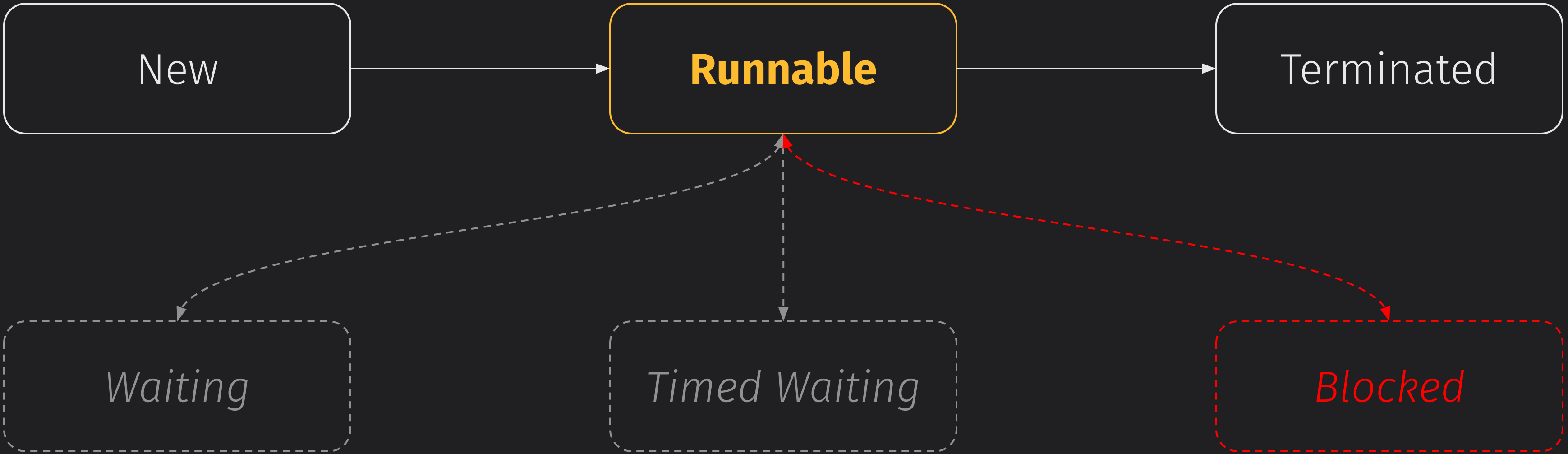
http://docs.oracle.com/javase/tutorial/essential/concurrency/starvelive.html

Livelock

- Occurs when a thread triggers another thread, which triggers the previous thread, and so on
- Threads spend all effort on responding to each other
  - Threads are not blocking each other, so still "lively" but locked in a loop preventing progress
  - *Sometimes caused by deadlock prevention!*

http://docs.oracle.com/javase/tutorial/essential/concurrency/starvelive.html

Thread States



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

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