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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 die 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

```
1. void transfer(Account to, Account from, int amount) {
2.   lock(a);
3.   lock(b);
4.
5.   withdraw(b, amount);
6.   deposit(a, amount);
7.
8.   unlock(b);
9.   unlock(a);
10. }
```

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

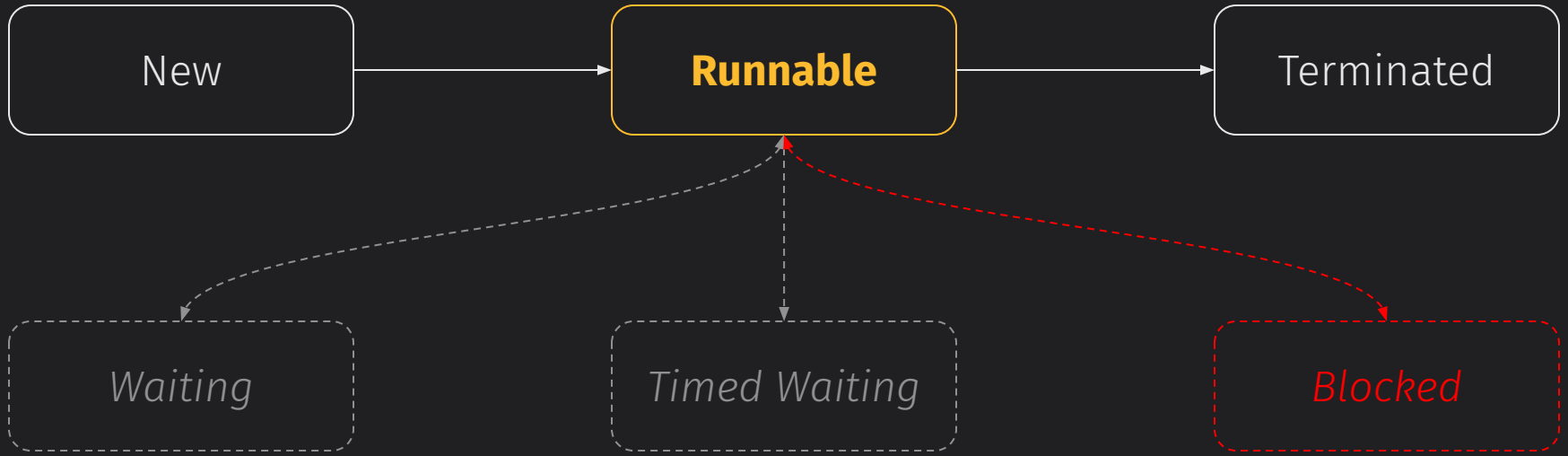
http://docs.oracle.com/javase/tutorial/essential/concurrency/starvelive.html

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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