# C340 Concurrency: Concurrency in Java

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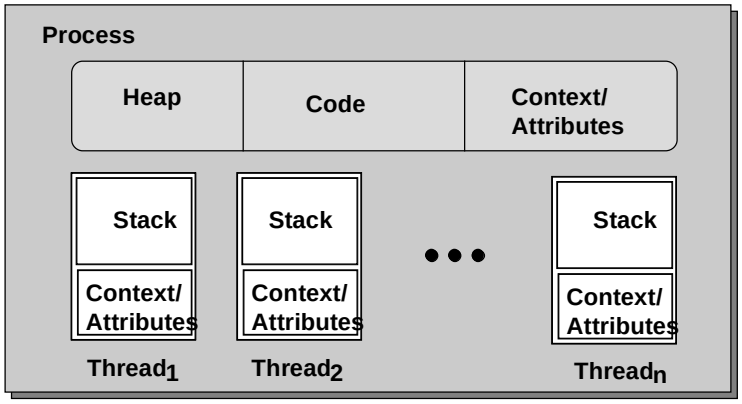
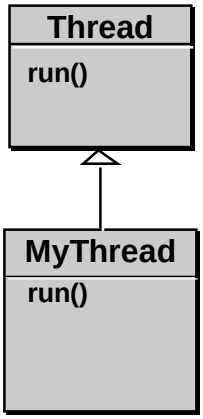
## Threads and OS Processes




- *OS process provides protected address space.*
- *Many threads may execute within space.*
- *Each thread: stack & context (saved registers).*

## Threads using Inheritance




```
class MyThread extends Thread {
  public void run() {
    ...
}
```

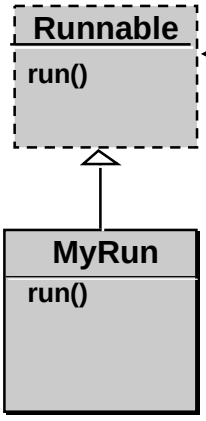
***Creation of thread:***

```
MyThread t=new MyThread();
```





## Threads implementing Interfaces




```
class MyRun implements Runnable {
  public void run() {
    ...
}
```

***Creation of thread:***

```
Thread t=new Thread(new MyRun);
```

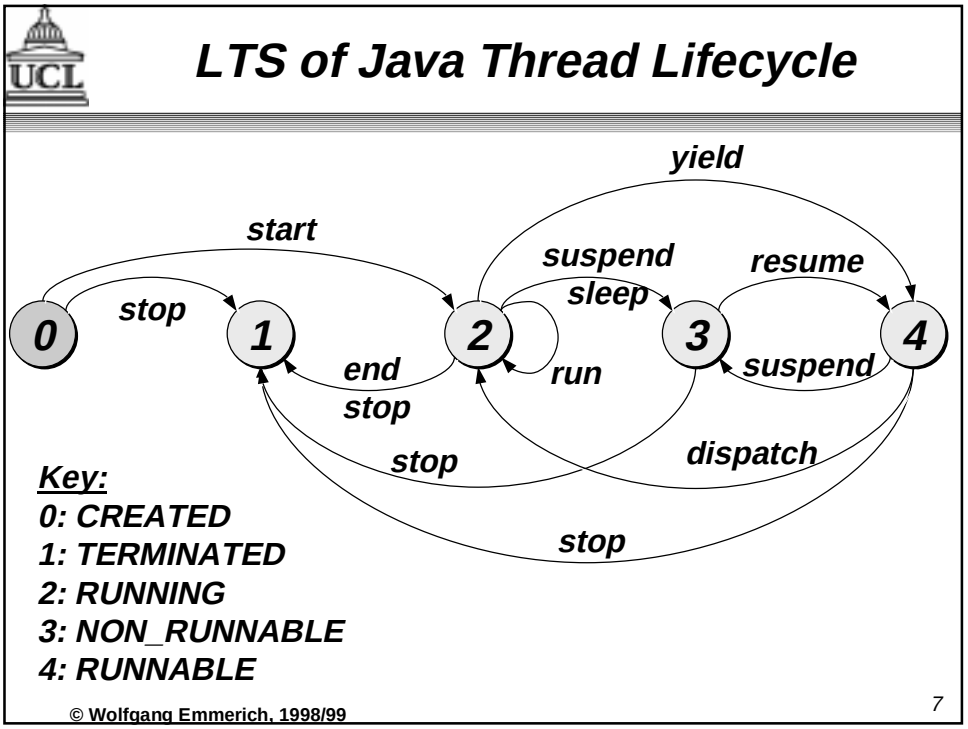
## Thread Lifecycle

- Started by start() which invokes run()
- Terminated when
  - run() returns or
  - explicitly terminated by stop().
- A started thread may be
  - running or
  - runnable (waiting to be scheduled)
- Thread gives up processor using yield().
- A thread may be suspended by suspend()
- If Suspended gets runnable by resume().
- sleep() suspends for a given time and then resumes




## FSP Model of Java Thread Lifecycle

```
THREAD = CREATED,
CREATED = ( start -> RUNNING
          | stop -> TERMINATED),
RUNNING = ( {suspend,sleep}-> NON_RUNNABLE
          | yield -> RUNNABLE
          |{stop, end} ->TERMINATED
          | run -> RUNNING),
RUNNABLE= ( suspend -> NON_RUNNABLE
          | dispatch -> RUNNING
          | stop -> TERMINATED),
NON_RUNNABLE = ( resume ->RUNNABLE
               | stop ->  TERMINATED),
TERMINATED = STOP.
```


LTS of Java Thread Lifecycle
yield
start
suspend
resume
sleep
stop
0
1
2
3
4
end
stop
run
suspend
stop
dispatch
stop
Key:
0: CREATED
1: TERMINATED
2: RUNNING
3: NON_RUNNABLE
4: RUNNABLE
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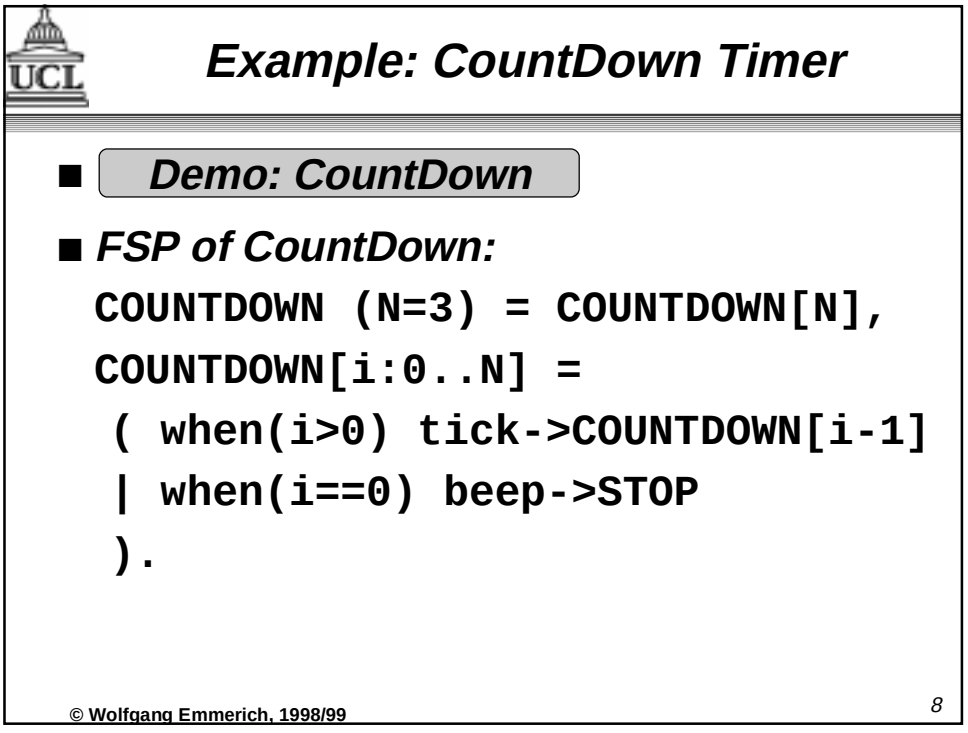
Example: CountDown Timer
Demo: CountDown
FSP of CountDown:
COUNTDOWN (N=3) = COUNTDOWN[N],
COUNTDOWN[i:0..N] =
( when(i>0) tick->COUNTDOWN[i-1]
| when(i==0) beep->STOP
).
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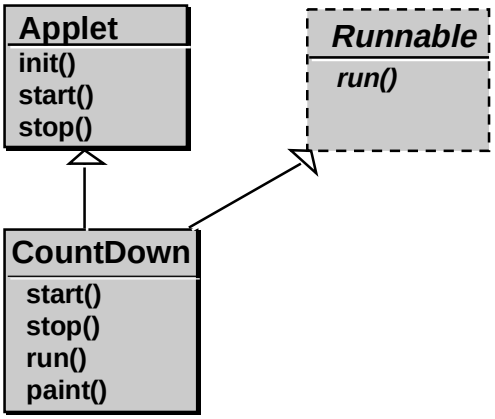
# CountDown Timer - Class diagram




**Runnable** *is an interface*





# CountDown Timer - Java class

```
import java.awt.*;            //windows toolkit
import java.applet.*;         //applet support
public class CountDown extends Applet implements Runnable{
  int counter; Thread cd;
  public void start() {     // create thread
   counter = 60;  cd = new Thread(this); cd.start();
  }
  public void stop() { cd = null;}
  public void run() {      // executed by Thread
   while (counter>0 && cd!=null) {
    try{Thread.sleep(1000);}
    catch (InterruptedException e){}
    --counter;  repaint(); //update screen
   }
  }
  public void paint(Graphics g) {
    if (counter>0)
      g.drawString(String.valueOf(counter),25,75);
    else g.drawstring("Bang", 10, 50);
  }
}
```

## Concurrent Threads

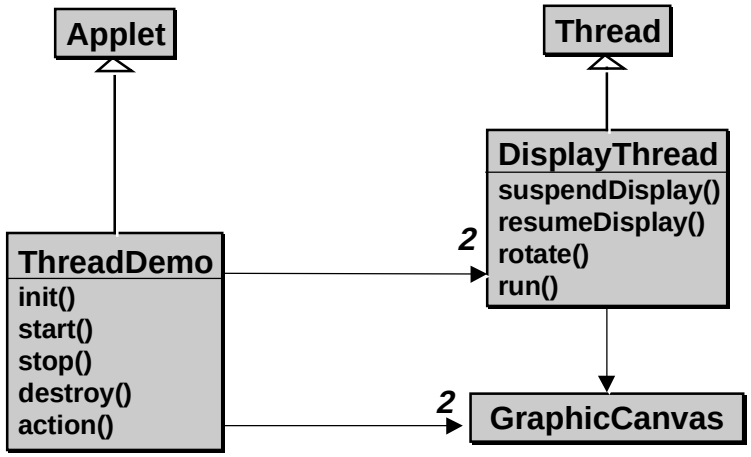
- *Parallel composition operator ||*
- *Implemented by creation of several new thread objects*
- *Example: ThreadDemo*
- *Creates two thread objects that execute concurrently*




## FSP Spec of Thread Demo

```
DISPLAY_THREAD = SUSPENDED,
SUSPENDED = ( resume->RUNNING ),
RUNNING =   ( rotate->RUNNING
            | suspend->SUSPENDED
            ).
||THREAD_DEMO =
   (a:DISPLAY_THREAD||b:DISPLAY_THREAD).
```

## Class Diagram of ThreadDemo








## Summary

- *Threads vs. operating system processes*
- *Threads through class inheritance / interface implementation*
- *Thread lifecycle*
- *Concurrent threads by creating new thread objects*
- *Class diagrams*
- *Next: Java Thread Programming Lab*