

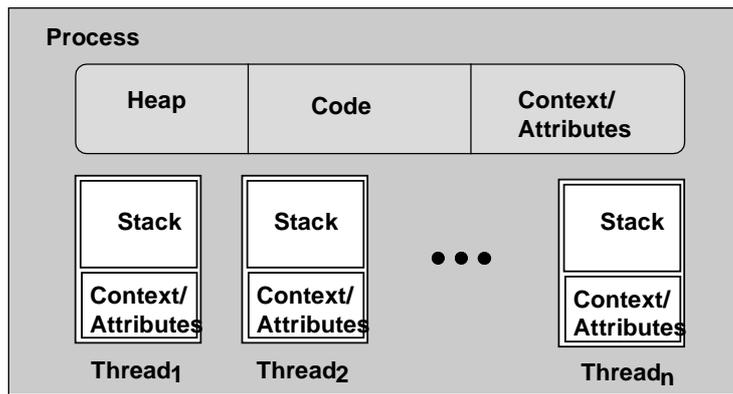


C340 Concurrency: Concurrency in Java

Wolfgang Emmerich



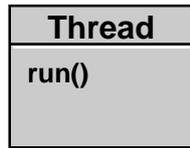
Threads and OS Processes



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



Threads using Inheritance



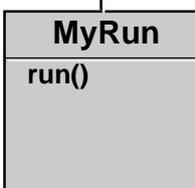
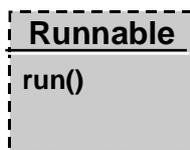
```
class MyThread extends Thread {
    public void run() {
        ...
    }
}
```

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**

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FSP Model of Java Thread Lifecycle

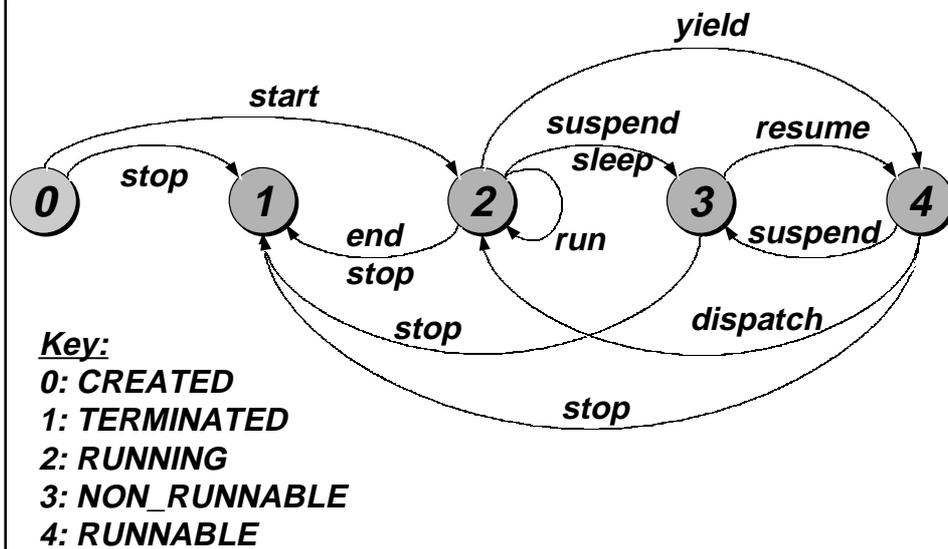
```
THREAD = CREATED,  
CREATED = ( start -> RUNNING  
            | stop -> TERMINATED),  
RUNNING = ( {suspend, sleep}-> NON_RUNNABLE  
            | yield -> RUNNABLE  
            | {stop, end} ->TERMINATED  
            | run -> RUNNING),  
RUNNABLE= ( suspend -> NON_RUNNABLE  
            | dispatch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

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LTS of Java Thread Lifecycle



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=10) = COUNTDOWN[N],

COUNTDOWN[i:0..N] =

(when(i>0) tick->COUNTDOWN[i-1]

| when(i==0) beep->STOP

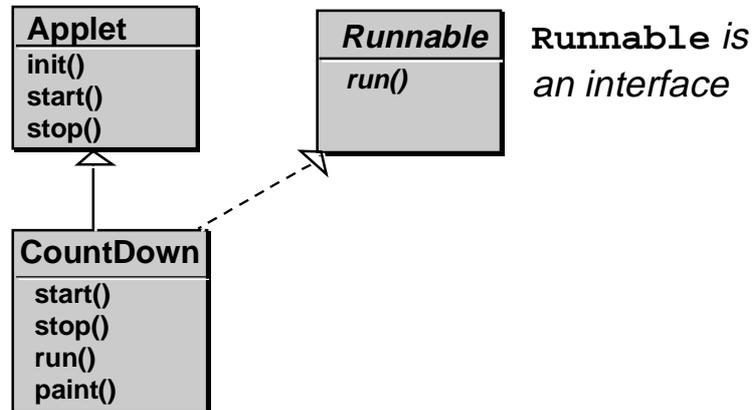
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CountDown Timer - Class diagram



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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);
    }
}
```

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Concurrent Threads

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

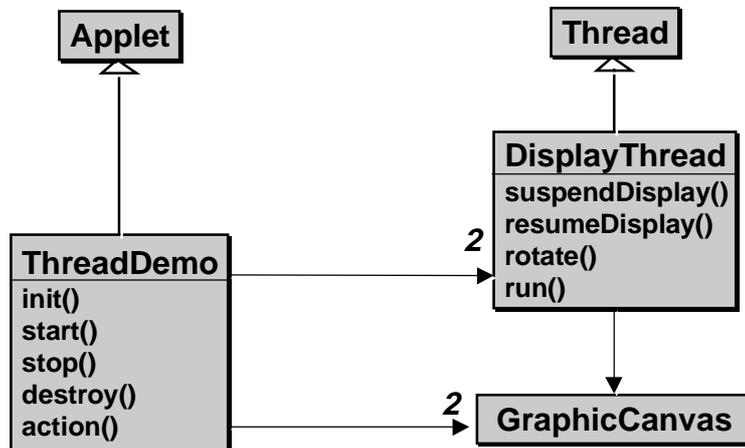


FSP Spec of Thread Demo

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



Class Diagram of ThreadDemo



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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**

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