Java Thread Mode

- Thread: A *sequence* of execution in a program.
- Every java program contains at least one thread.
- The Java Virtual Machine allows an application to have multiple threads of execution running concurrently.

Single Thread Example

Control Flow:

1. JVM creates an initial thread of control
2. The thread enters main()
3. Executes the operations
4. Exit from main()
5. Terminate

Example:

```
Public class HelloWorld{
  Public static void main
      (String[] args){
  System.out.println("Hello
      World"); }
}
```

Threads in Java

- Thread Class
  - Every thread of control in a JVM is associated with a *Thread Object*.
- Thread Priority
  - Threads with higher priority are executed first.
  - Multi-level ready queue, Round Robin scheduling for each level.
  - New thread's priority is initially set to be the same priority of the creating thread.

Thread Creation

- Two ways to construct threads
  - Explicitly create a new class that is derived from the *Thread* class (java.lang.thread).
  - Implement the *Runnable* interface (java.lang.runnable).

Subclass of the Thread Class

- Override the *run()* method of the Thread class.

```
Class WorkerThread1 extends Thread{
  Public void run() {
     System.out.println("I am a worker thread.");
  }
}
```

Subclass of the Thread Class (Cont.)

- Create an object

```
WorkerThread1 w1 = new WorkerThread1();
```

- Call start() method for the new object to

1. allocate memory and initialize a new thread in JVM;
2. call the *run()* method (implicitly) making the thread eligible to be run by the JVM.

```
w1.start();
```

Subclass of the Thread Class (Cont.)

Main class (Thread) :

```
public class First {
    public static void main(String args[]) {
        WorkerThread1 w1 = new WorkerThread1();
        w1.start();
        System.out.println("I am the main Thread");
    }
}
```

Subclass of the Thread Class (Cont.)

- Results
  - Two threads are created by the JVM.
  - First: the thread that starts execution at the *main()* method;
  - Second: the *w1* thread begins execution in its *run()* method.

Implement Runnable Interface

- Define a class that implements the *Runnable* interface:

```
public interface Runnable {
    public abstract void run();
}
```

- The class must define a *run()* method.

```
Class WorkerThread2 implements Runnable {
    public void run() {
      System.out.println("I am a worker thread.");
    }
}
```

Implement Runnable Interface (Cont.)

- Thread creation

```
Public class Second {
    public static void main(String args[]){
      Runnable w2 = new WorkerThread2();
      Thread td = new Thread(w2);
      td.start();
      System.out.println("I am the main Thread.");
    }
}
```

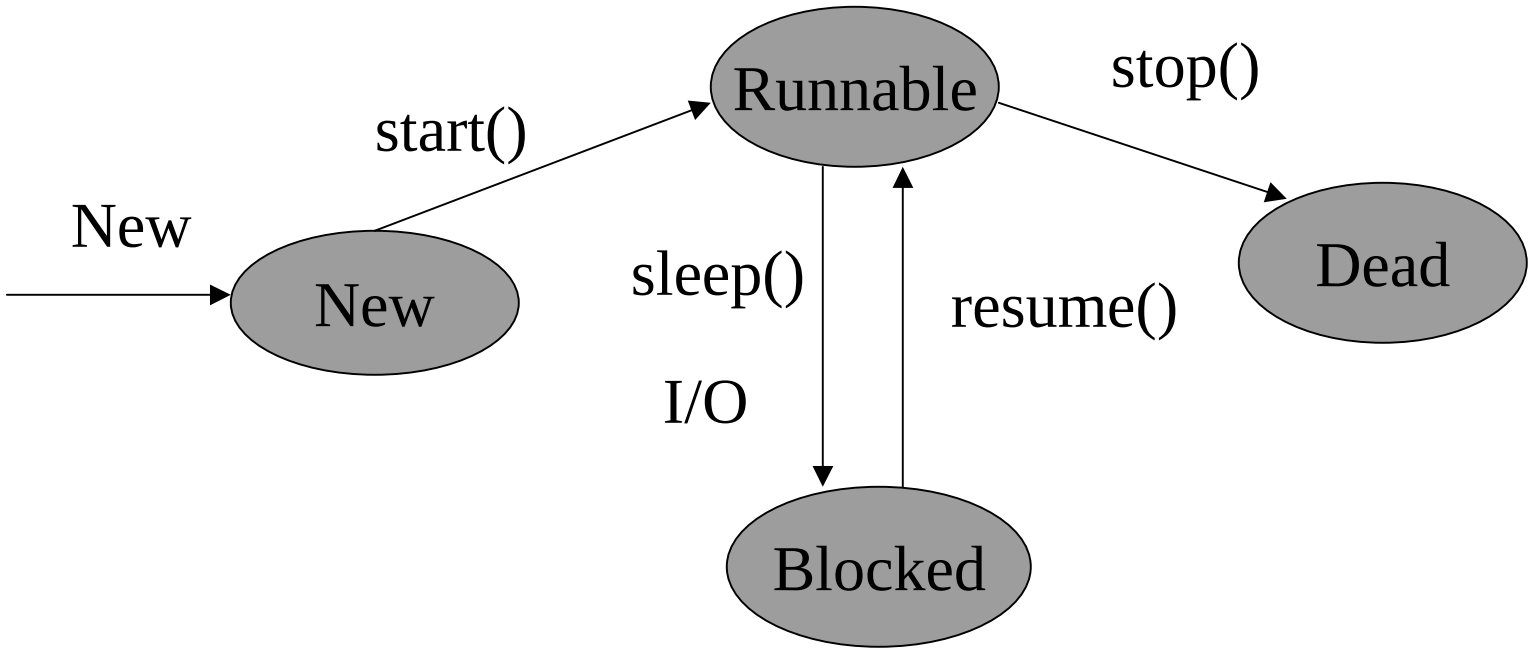
Java Thread States

- *New*: when an object for the thread is created.
- *Runnable*: when a thread's *run()* method is invoked, the thread moves from *New* to *Runnable*.
  - The thread in eligible to be run by the JVM.
  - A running thread is still in the *Runnable* state.

Java Thread States (Cont.)

- *Blocked* : when the thread performs a blocking statement, e.g., doing I/O; or if it invokes certain Java Thread methods, s.t., *sleep()*.
  - Thread in such state cannot be executed by the JVM scheduler.
- *Dead* : when the thread's *run()* method terminates.
  - Cannot be restart and is eligible for garbage collection.

Java Thread States (Cont.)



Java Thread Scheduling

- JVM schedules threads using preemptive, priority-based scheduling algorithm.
  - Always schedule the thread with the highest priority.
  - Using FIFO for the threads having the highest priority.

When to Schedule?

- One of the followings events occur:
  1. The currently running thread exists the *Runnable* state:
     - Blocking for I/O
     - Existing run() method
     - Having sleep(), yield() invoked (relinquishes control of CPU, allow another thread of equal priority to run)
  2. A thread with higher priority than the currently running thread enters the *Runnable* state.

Timing Slicing

- Implementation dependent (JVM).
- May yield to give up CPU if there is no time slicing…cooperative multitasking.

```
public void run(){
        while(true) {
                //perform a CPU-intensive task
                //now yield control of the CPU
                Thread.yield();
        }
}
```

Thread Priorities

- Threads are given a default priority when they are created and --- unless they are changed explicitly by the program.
- JVM does not dynamically alter priorities throughout the threads lifetime.

```
public class HighThread extends Thread{
        public void run(){
          this.setPriority(Thread.NORM_PRIORITY+1);
          //remainder of run() method
        }
}
```

Lab 2

- Purpose: multiple robots coordinate to eat goals.
  - Three colors for robots (red,green,blue) and four for goals(red,green,blue, black).
  - Each robot can eat goals with either its color or black color.
  - Run until all goals are eaten.

What robots do?

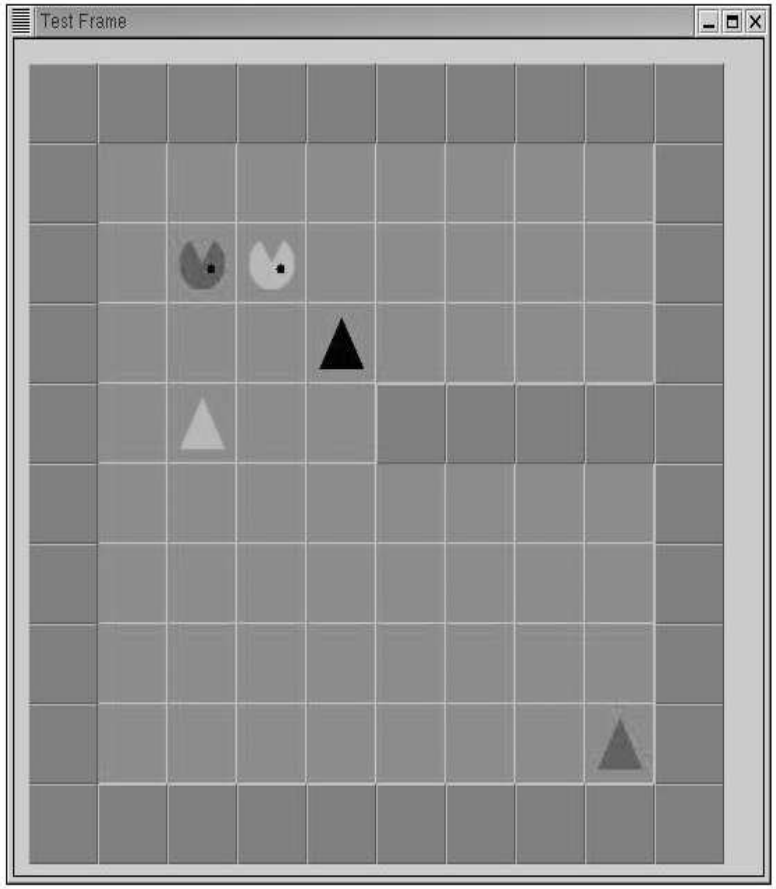
- Make decision to take a next step
  - Four directions to choose, choose the position with the minimum non-negative value from distance matrix.

    (∞ means it is an obstacle)
  - Move to that place. If there is a goal, eat it and signal that the goal has gone (need to reset the distance values).
  - If there is no goal to eat, the robots become dead and an obstacle for other color robots, also need to signal when robots die.

What need to be concerned about?

- Two robots cannot eat a same goal.
- Two robots cannot occupy the same cell(position) in the grid.
- Robots share the same map information.
- The group robots with the same color share one distance matrix to get/update the distance values for the goals.

Distance Function



∞	∞	∞	∞	∞	∞	∞	∞	∞	∞
∞	5	4	3	2	3	4	5	6	∞
∞	4	R	∞	1	2	3	4	5	∞
∞	3	2	1	0 (b)	1	2	3	4	∞
∞	4	∞	2	1	∞	∞	∞	∞	∞
∞	5	4	3	2	3	4	4	3	∞
∞	6	5	4	3	4	4	3	2	∞
∞	7	6	5	4	4	3	2	1	∞
∞	7	6	5	4	3	2	1	0 ®	∞
∞	∞	∞	∞	∞	∞	∞	∞	∞	∞

```
Map_Data{
Grid Info., int Grid[][];
Abstract_Robot Robots[];
Goal Goals;
Distance Dists[];
Semaphore sem;}
```

```
Distance{
char cColor; //group color
Map_Data myGrid; //referred map
int Dist[][]; //dis. Matrix
Grid size;
Semaphore sem;
void initDist(); //create the dis. Matrix
int fromNeighbor(int, int);
Void SetDist();}
```

```
Map{
  Map_Data md = new Map_Data;
  parse the map file;
  show the map;}
```

```
Robot extends Abstract_Robot{
  while{has eatable goals}
 { make decision for the next step;
    move;
    signal if eating a goal or becoming a dead robot
    (need to update distance matrix)}
```

```
Abstract_Robot{
  position;
  Map_Data myGrid;
  Distance my Dist;}
```