Threads

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Overview

- Introduction to Threads
- Class Thread and Thread methods
  - Example of simple threads
- Thread Synchronization
  - Example of rendevous
- The Runnable interface
- Thread Groups

Threads

- A thread is an execution path in a program.
- We refer to the concurrent execution of more than one thread in a program as multi-threading.
- Java supports multithreading in the language constructs.
- Unique among many general purpose programming languages, including C and C++.

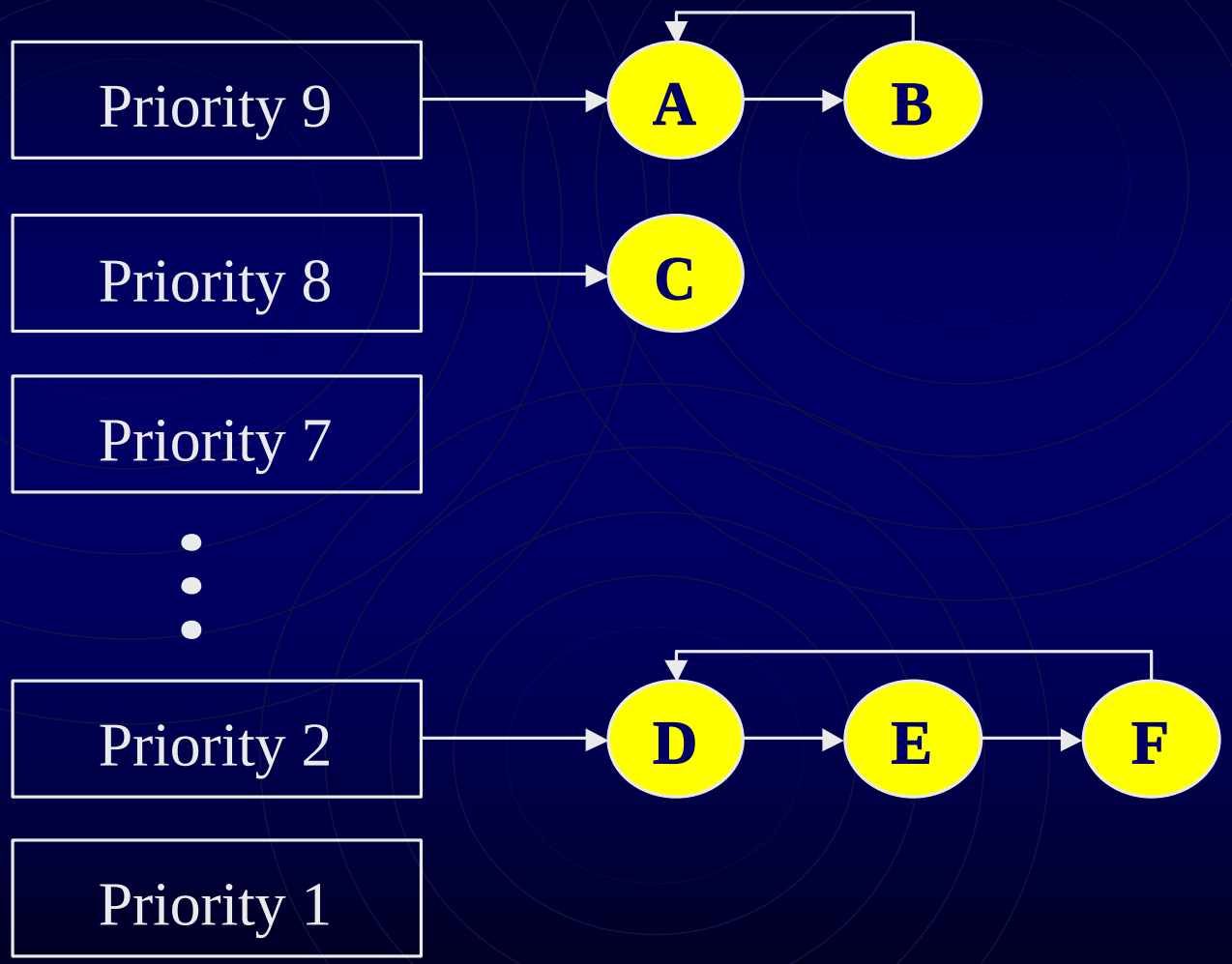
Priorities and Scheduling

- There is one CPU: which thread gets executed?
- Each thread is assigned a priority: higher priority gets execution before lower priority.
- The scheduling policy of the threads by their priorities is slightly different on different platforms: Solaris vs Win32.

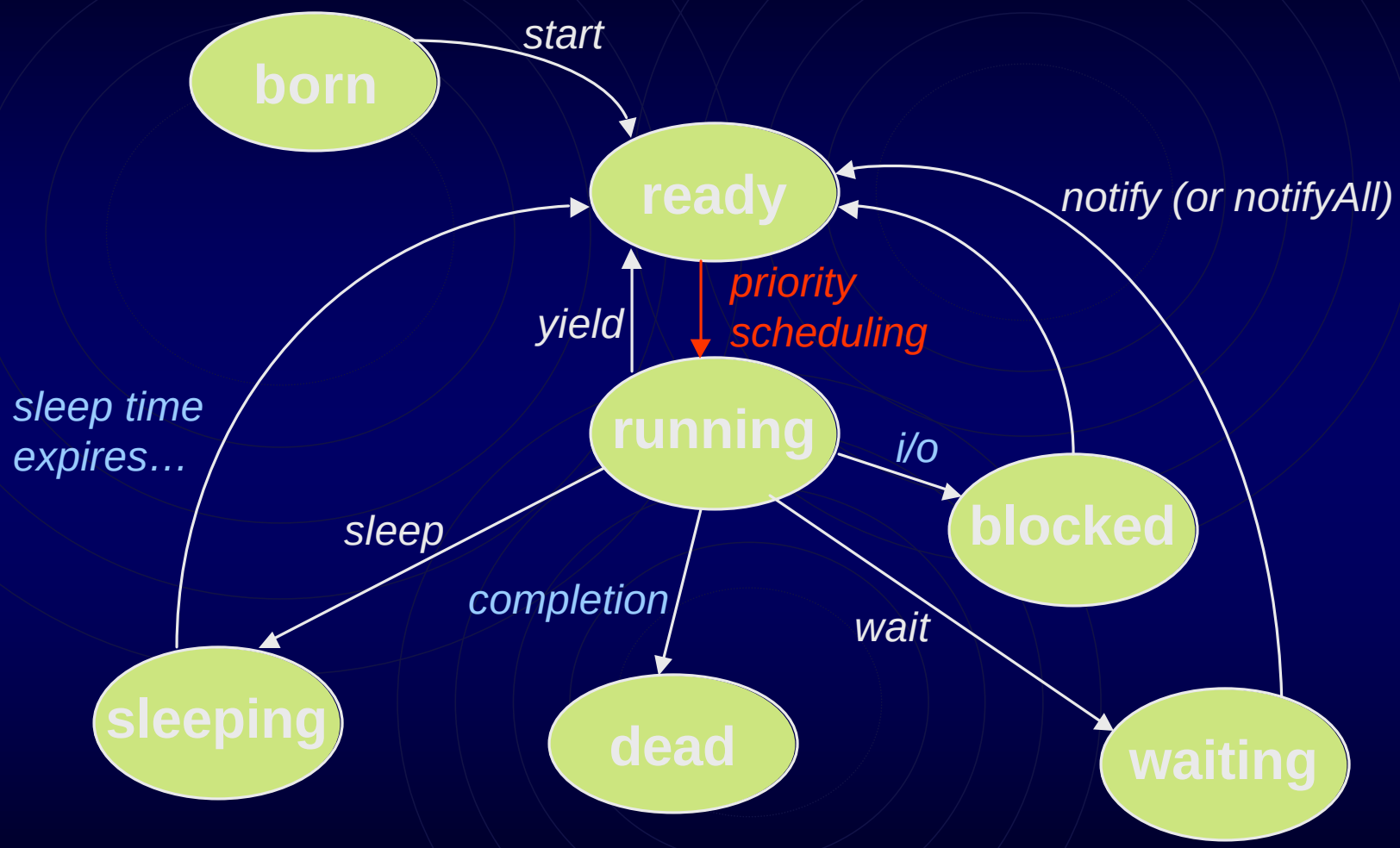
Priorities and Scheduling

- Solaris: non-preemptive multithreading
  - Higher priority thread gets execution first.
  - Same priority threads on a first come first serve basis.
  - Once a thread gets execution, it goes on until it is blocked or it voluntarily gives up.
- Win32: time-sliced multithreading
  - Higher priority thread gets execution first.
  - Same priority threads share in a round-robin basis, each getting a time-slice.
  - Once a thread gets execution, it goes on until it is blocked, it voluntarily gives up, or when its allotted time-slice expires.

Java Thread Priority Scheduling



Life Cycle of a Thread



Class Thread

- java.lang.Thread
- Class Thread encapsulates the primitive constructs for multi-threading in Java.
- Constructors…
- public Thread(String threadName);
- public Thread( ); // use default name.
- …
- …override the run method.
- public void run( );

Class Thread

```
class MyThread extends Thread
    {public void run( )
        {    System.err.println("I am running!");      }
    }
```

- To launch a new thread, use the start method…

```
public void start( );
MyThread mt = new MyThread( );
mt.start( );  // starts a new thread to call run( )…
…    // returns immediately after new thread
// is launched; to be running concurrently.
```

Class Thread

- static method sleep…

  public static void sleep(long millis);

  … to sleep for a number of milliseconds.

  … will not contend for CPU for a while.

- static method yield…

  public static void yield( );

  … to yield CPU to other running threads.

  … will not contend for CPU now.

Class Thread

- ***public final void setName(String name);***

  … specifies the name of this thread.
- ***public final String getName( );***

  … returns the name of this thread.
- ***public static Thread currentThread( );***

  … returns the thread currently running.
- ***public final void join( );***

  … waits for this thread to terminate.

Class Thread

- ***public int getPriority( );***

  …returns the priority of this thread.
- ***public void setPriority(int newPriority);***

  …sets the priority of this thread to newPriority.
- ***public static final int MAX_PRIORITY;***
- ***public static final int MIN_PRIORITY;***
- ***public static final int NORM_PRIORITY;***

  …for use in the system to get/set priorities.

Simple Thread – Driver

```
public class SimpleThreadExample extends JFrame
{   public Threads()
    {JTextArea printspace = new JTextArea();
    getContentPane().add(printspace);
    AThread[]  at = new AThread[10];
    for (int i=0;i<10;i++)
    {at[i]=new AThread(new String("Thread"+i), printspace);}
    for (int i=0;i<10;i++)
          {at[i].start();}
    }
    public static void main(String args[])
    {Threads f = new Threads();}
}
```

Simple Thread -- Proper

```
class AThread extends Thread
{private String name;
private JTextArea output;
public AThread (String inname, JTextArea ps)
    {this.name = inname;
    output = ps;
    output.append("starting"+getname()+”\n");}
public void run()
    {try  {Thread.sleep((int) (Math.random()*10000));}
    catch (InterruptedException e)
            {System.err.println(e.toString());}
    output.append("\t"+getname()+"exiting\n");}
}
```

Synchronization

- For threads to cooperate, sharing access to some common facilities… we need synchronization!
- Java uses *monitors* (CACM paper by Hoare, 1974) "Monitors: an operating system structuring concept."
- Synchronization is therefore NOT confined in the class Thread, but built into all Java objects.
- Any method can be declared ***synchronized***.
- Every object with synchronized methods is a monitor.
- It allows only ***ONE*** thread at a time to execute a synchronized method on the object.
- synchronized(Object) { … } // just a block of code…

synchronization: Object methods

- ***public final void wait( );***
- ***public final void wait(long millis);***
- ***public final void notify( );***
- ***public final void notifyAll( )***

Rendevous Example

- In order to manage a rendevous, we need four classes:
  - A driver class
  - One or more producer threads
  - One or more consumer threads
  - A synchronization monitor

Rendevous Driver

```
public class SynchThreads extends JFrame
{   public SynchThreads()
    { getContentPane().setLayout(new BorderLayout());
    JTextArea printspace = new JTextArea();
     getContentPane().add(printspace,BorderLayout.CENTER);
    SynchMsgMon smm = new SynchMsgMon(printspace);
    CThread reader = new CThread("Reader", printspace, smm);
    reader.start();
    PThread[]  at = new PThread[10];
    for (int i=0;i<10;i++)
          {at[i]=new PThread(new String("PT"+i), printspace, smm);
          at[i].start();}
    public static void main(String args[])
    {SynchThreads f = new SynchThreads();}}
```

Rendevous Synchornization

```
public class SynchMessageMonitor
{
private String ma[] = new String[10];
private boolean messages = false;
private boolean writeable =true;
private boolean readable = false;
private int nmsgs=0;
private int lastread = 0;
private int lastwritten =0;
private JTextArea output;

public SynchMessageMonitor(JTextArea o)
    {output=o;}
```

Rendevous Synchornization

```
public synchronized void writemessage(String name, String msg)
    {while (!writeable)
            {try{output.insert(name + " waiting to store msg\n",0);
                    wait();}
            catch(InterruptedException e)
                    {System.err.println(e.toString());}}
    readable = true;
    ma[lastwritten]=new String(msg);
    lastwritten = (lastwritten+1)%10;
    nmsgs++;
    output.insert( "There are " + nmsgs +" msgs \n",0);
    if (nmsgs==10)
            {writeable=false;
            output.insert("BUFFER IS FULL\n",0);}
    notify();}
```

Rendevous Synchornization

```
public synchronized String readmessage(String name)
    {while (!readable)
            {try{output.insert( name + " waiting to read message\n",0);
                    wait();}
            catch(InterruptedException e)
                    {System.err.println(e.toString());}}
    writeable = true;
    String msg=new String(ma[lastread]);
    lastread = (lastread+1)%10;
    nmsgs--;
    if (nmsgs==0)
            {readable=false;
            output.insert("BUFFER IS EMPTY\n",0);}
            notify();
    return msg;}}
```

Rendevous Consumer

```
class CThread extends Thread
{private SynchMsgMon smm;   private int coma_time;
private String name; private JTextArea output;
public CThread (String inname, JTextArea ps, SynchMsgMon sm)
    {name = inname;  output = ps;smm=sm;          }
public void run()
    {for (int attempts=0;attempts<100;attempts++)
            {String rmsg = smm.readmessage(name);
            try{Thread.sleep((int)(Math.random()*500));        }
            catch (InterruptedException e)
                        {System.err.println(e.toString());}            }
    output.insert(name+" exiting\n",0);
    }}
```

Rendevous Producer

```
class PThread extends Thread
{private SynchMsgMon smm;
private String name;   private JTextArea output;
public PThread (String inname, JTextArea ps, SynchMessageMonitor
    sm)
    {name = inname;   output = ps;  smm=sm;}
public void run()
    {for (int attempts=0;attempts<10;attempts++)
            {try{Thread.sleep((int) (Math.random()*2000););   }
            catch (InterruptedException e)
                        {System.err.println(e.toString());}
    smm.writemessage(name, "Msg "+attempts+ " from "+name);}
    }}
```

The Runnable Interface

- We extend class Thread to create a new class to support multi-threading. But if we have a class already, and it is not derived from class Thread, how can we support multi-threading in that class?
- We must implement ***Runnable*** interface in that class.

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

- We only need to implement the run method to implement the ***Runnable*** interface.

a thread in a Runnable object…

- We can then create a thread for the Runnable object, using these Thread constructors…

  public Thread(Runnable obj);

  public Thread(Runnable obj, String name);

- We then call the start method on the thread…

```
class X implements Runnable { … }
X obj = new X( );
Thread tx = new hread(obj,"MyThread");
tx.start( ); // to start the thread
```

Thread Groups

- When we have many many threads, it would be useful to organize threads into groups.
- In Java, the class ThreadGroup provides the facility: a ThreadGroup object is a group of Threads as well as ThreadGroups.
- A ThreadGroup is a group of Thread's, but can also be parent to other ThreadGroup's.
- ThreadGroup constructors…

  public ThreadGroup(String name);

  public ThreadGroup(ThreadGroup tg, String name);

associating a thread to a group…

- class Thread has these 3 constructors ...

  public Thread(ThreadGroup tg, String name);

  public Thread(ThreadGroup tg, Runnable obj);

  public Thread(ThreadGroup tg, Runnable obj, String name);

- The constructors allow us to create a thread associated to a particular thread group.
- The class ThreadGroup provides methods to manage groups of threads.

ThreadGroup methds

- ***public int activeCount*();**
- ***public int enumerate(Thread[] list);***
- ***public int enumerate(Thread[] list, boolean all);***
- ***public int enumerate(ThreadGroup[] list);***
- ***public int enumerate(ThreadGroup[] list, boolean all);***

ThreadGroup methdos

- ***public int getMaxPriority( );***
- ***public void setMaxPriority(int pri);***
- ***public String getName( );***
- ***public ThreadGroup getParent( );***
- ***public boolean parentOf(ThreadGroup tg);***