Java Applets

Applets

- An applet is a Panel that allows interaction with a Java program
- Typically embedded in a Web page and can be run from a browser
- You need special HTML in the Web page to tell the browser about the applet
- For security reasons applets run in a sandbox
  - Sandbox is a
    - Byte-code verifier
    - Class loader
    - Security manager
  - Only the correct classes are loaded
  - The classes are in the correct format
  - Un-trusted classes
    - Will not execute dangerous instructions
    - Are not allowed to access protected system resources

Applet Support

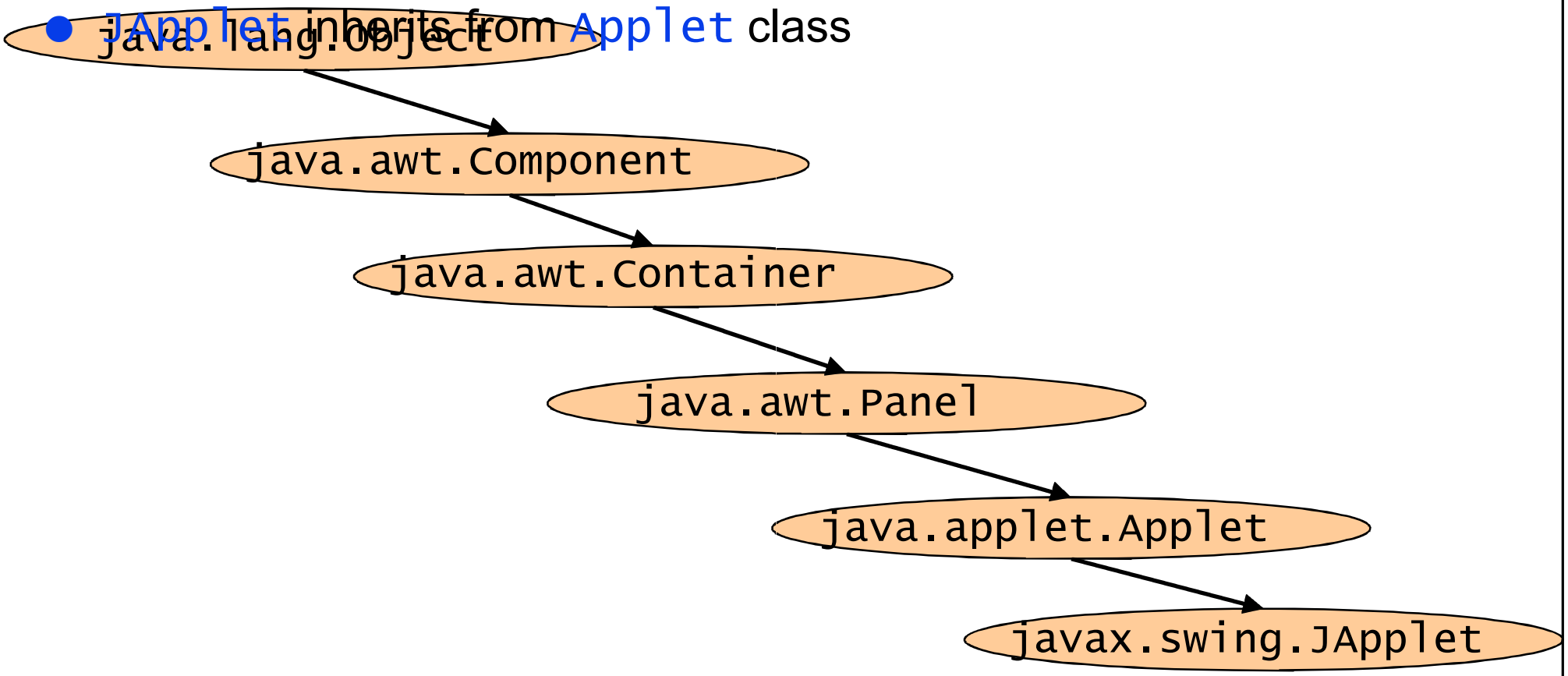
- Java 1.4 and above are supported from the most modern browsers if these browsers have the appropriate plug-in
- Basic browsers that support applets
  - Internet Explorer
  - Netscape Navigator (sometimes)
- However, the best support isn't a browser, but the standalone program `appletviewer`
- In general you should try to write applets that can be run with any browser

Notion of Applets in Java

- You can write an applet by extending the class `Applet`
- `Applet` class
  - Contains code that works with a browser to create a display window
  - Is just a class like any other
    - You can even use it in applications if you want
- When you write an applet you are only writing part of a program
- The browser supplies the `main` method
- NOTE: If you use Swing components in your applet you must use the `JApplet` class
  - `JApplet` extends the class `Applet`

The genealogy of the `Applet` class

- `Applet` inherits `awt Component` class and `awt Container` class
- `JApplet` inherits from `Applet` class



The Simplest Possible Applet

TrivialApplet.java

```
import java.applet.Applet;
public class TrivialApplet extends Applet { }
```

TrivialApplet.html

```
<applet
    code="TrivialApplet.class"
    width=150  height=100>
</applet>
```

The Simplest Reasonable Applet

```
import java.awt.*;
import java.applet.Applet;

public class HelloWorld extends Applet {
    public void paint( Graphics g ) {
        g.drawString( "Hello World!", 30, 30 );
    }
}
```

Applet methods

- Basic methods
  - `public void init ()`
  - `public void start ()`
  - `public void stop ()`
  - `public void destroy ()`
- Other Supplementary methods
  - `public void showStatus(String)`
  - `public String getParameter(String)`

How a Java Applet works?

- You write an applet by extending the class `Applet`
- `Applet` class defines methods as
  - `init( )`
  - `start( )`
  - `stop( )`
  - `destroy( )`
  - and some others…
- These methods do not do anything
  - They are stubs
- You make the applet do something by overriding these methods
- You don't need to override all these methods
  - Just the ones you care about

Method `init( )`

- This is the first of your methods to be executed
- It is automatically called by the system when the JVM launches the applet for the first time
- It is only executed once
- It is the best place to
  - Initialize variables
  - Define the GUI Components
    - E.g. buttons, text fields, scrollbars, etc.
  - Lay the components out
  - Add listeners to these components
  - Pick up any HTML parameters
- Almost every applet you ever write will have an `init( )` method

Method `start( )`

- Not usually needed
- It is automatically called after the JVM calls the `init( )` method
- Also called whenever a user returns to the HTML page containing the applet after having gone to other pages
  - i.e. each time the page is loaded and restarted
- Can be called repeatedly
  - Common place to restart a thread
    - E.g. resuming an animation
- Used mostly in conjunction with `stop( )`

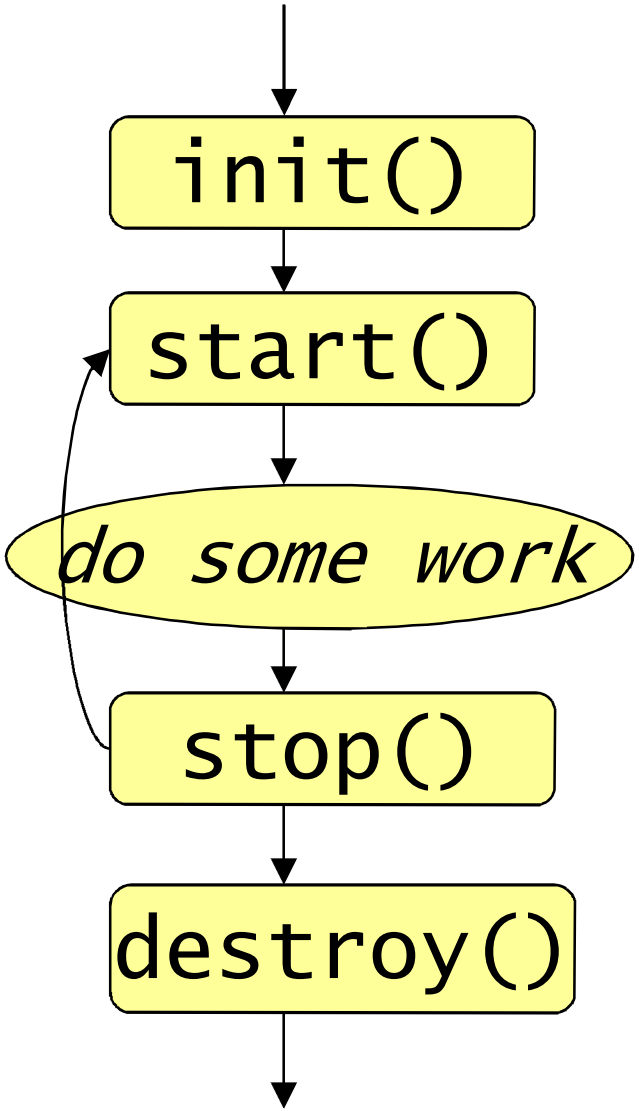
Method `stop( )`

- Not usually needed
- It is automatically called when the user moves off the page on which the applet sits
- Can be called repeatedly in the same applet
- Called just before `destroy( )`
- Gives a chance to stop time-consuming activity from slowing down the system when the user is not paying attention to the applet
- Should not be called directly
- Used mostly in conjunction with `start( )`

Method `destroy( )`

- Almost never needed
- Called after `stop( )`
- The JVM guarantees to call this method when the browser shuts down normally
- Use to explicitly release system resources
  - E.g. threads
- System resources are usually released automatically
- Commonly used for reclaiming non-memory-dependent resources

Order of Methods' Calls

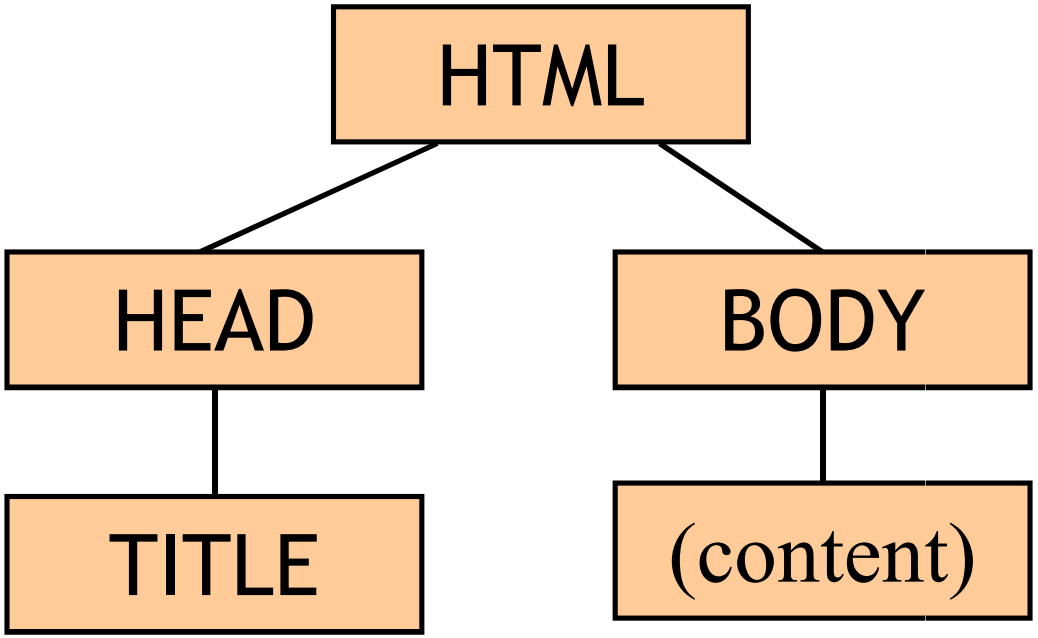


- `init( )` and `destroy( )` are only called once each
- `start( )` and `stop( )` are called whenever the browser enters and leaves the page
- do some work is code called by the listeners that may exist in the applet

Other Useful Applet Methods

- `System.out.println(String)`
  - Works from `appletviewer`, not from browsers
  - Automatically opens an output window
- `showStatus(String)`
  - Displays the String in the applet's status line
  - Each call overwrites the previous call
  - You have to allow time to read the line!

Structure of an HTML page



- Most HTML tags are containers
  - Not Java `Containers` !!!!
- A container is `<tag>` to `</tag>`

Invocation of Applets in HTML Code

```
<html>
  <head>
    <title> Hi World Applet </title>
  </head>

  <body>
    <applet code="HiWorld.class"
      width=300 height=200>
        <param name="arraysize" value="10">
    </applet>
  </body>
</html>
```

Not a container

Method getParameter(String)

- This method is called for the retrieval of the value of a parameter with specific name which is set inside the HTML code of the applet
  - This name is the only argument of the method

- E.g. let the HTML code for the applet

```
<applet code="HiWorld.class" width=300 height=200>
      <param name="arraysize" value="10">
</applet>
```

- A possible method call could be

```
String s = this.getParameter("arraysize");

try { size = Integer.parseInt (s) }
catch (NumberFormatException e) {…}
```

An Applet that adds two floating-point numbers

- Class and attributes' declarations

```
import java.awt.Graphics;   // import Graphics class
import javax.swing.*;  // import swing package

public class AdditionApplet extends JApplet {

// sum of the values entered by the user
double sum;
```

An Applet that adds two floating-point numbers

- Method `init( )`

```
public void init() {
      String firstNumber, secondNumber;
      double number1, number2;

      // read in first number from user
      firstNumber = JOptionPane.showInputDialog(
                  "Enter first floating-point value" );

      // read in second number from user
      secondNumber = JOptionPane.showInputDialog(
                  "Enter second floating-point value" );
```

An Applet that adds two floating-point numbers

- Method `init( )` cont.(1)

```
    // convert numbers from type String to type double
    number1 = Double.parseDouble( firstNumber );
    number2 = Double.parseDouble( secondNumber );

    // add the numbers
    sum = number1 + number2;
} //end of init
```

An Applet that adds two floating-point numbers

- Method `paint(Graphics)`

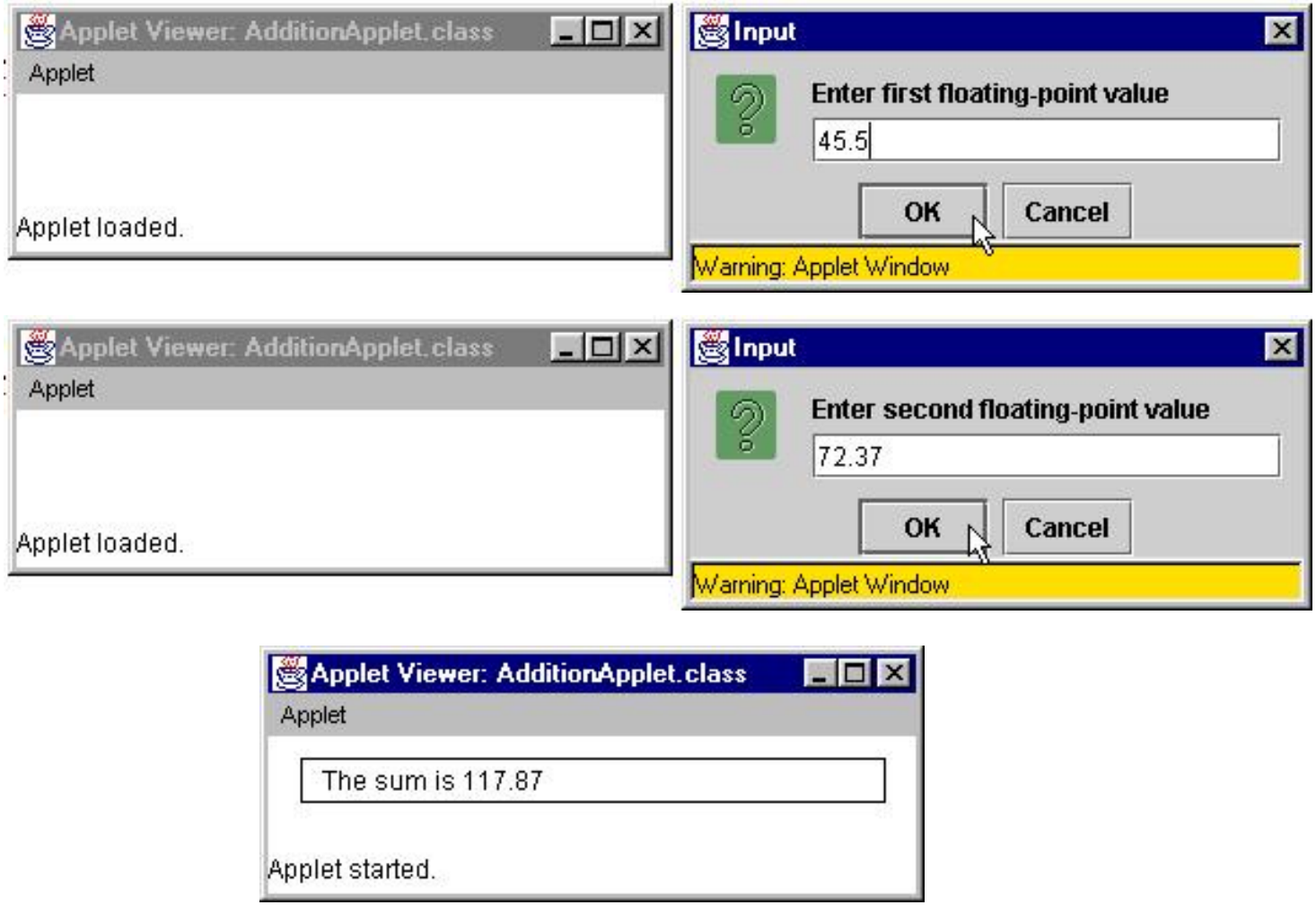
```
public void paint( Graphics g ){

      // draw the results with g.drawString
      g.drawRect( 15, 10, 270, 20 );
      g.drawString( "The sum is " + sum, 25, 25 );
} //end of paint
} //end of AdditionApplet class
```

- HTML source for the applet

```
<html>
<applet code=AdditionApplet.class width=300 height=50>
</applet>
</html>
```

An Applet that adds two floating-point numbers

- Output



A Digital Clock Applet

- Class and attributes' declarations

```
import java.awt.*;
import java.util.Calendar;
import java.applet.Applet;

public class DigitalClock extends Applet
                          implements Runnable {

protected Thread clockThread;
protected Font font;
protected Color color;
```

A Digital Clock Applet

- Initialization of fields in method `init( )`

```
public void init() {
        clockThread = null;
        font = new Font("Monospaced", Font.BOLD, 48);
        color = Color.green;
} //end of init
```

- Method `start( )`

```
public void start() {
     if (clockThread == null) {
          clockThread = new Thread(this);
          clockThread.start();
     }
} //end of start
```

calls the `run()` method

A Digital Clock Applet

- Method `stop( )`

```
public void stop() {
      clockThread = null;
} //end of stop
```

- Method `run( )` that runs the `clockThread`

```
public void run() {
      while (Thread.currentThread() == clockThread) {
            repaint();
            try {
                  Thread.currentThread().sleep(1000);
            } catch (InterruptedException e){}
      }
} //end of run
```

calls the `paint(Graphics)` method

`sleep()` must be invoked inside the try block

A Digital Clock Applet

- Method `paint(Graphics)`

```
public void paint(Graphics g) {
      Calendar calendar = Calendar.getInstance();
      int hour = calendar.get(Calendar.HOUR_OF_DAY);
      int minute = calendar.get(Calendar.MINUTE);
      int second = calendar.get(Calendar.SECOND);
      g.setFont(font);
      g.setColor(color);
      g.drawString(hour +
            ":" + minute / 10 + minute % 10 +
            ":" + second / 10 + second % 10,
            10, 60);
} //end of paint
} //end of DigitalClock class
```

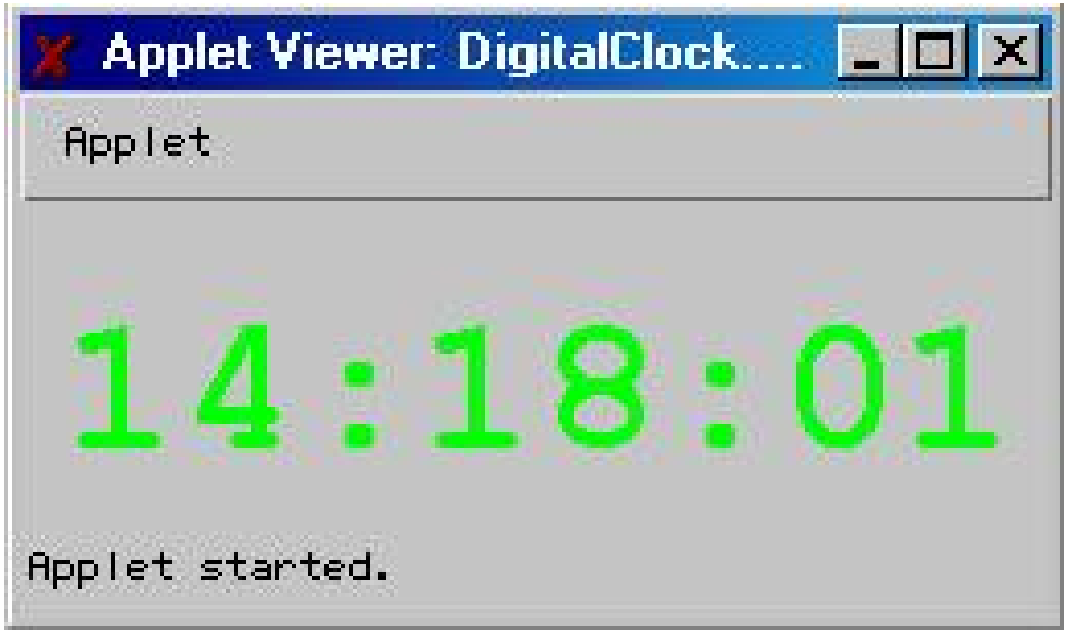
A Digital Clock Applet

- The HTML source for the applet

```
<html>
  <head>
    <title>Digital Clock Applet</title>
  </head>
<body bgcolor=white>
<h1>The Digital Clock Applet</h1><p>
<applet code=DigitalClock.class width=250 height=80>
</applet>
</body>
</html>
```

A Digital Clock Applet

- Output



A Scrolling Banner Applet

- Class and attributes' declarations

```
import java.awt.*;
import java.applet.Applet;

public class ScrollingBanner extends Applet
                               implements Runnable {


protected Thread bannerThread;
protected String text;
protected Font font;
protected int x, y;
protected int delay;
protected int offset;
protected Dimension d;
```

A Scrolling Banner Applet

- Initialization of fields in method `init( )`

```
public void init() {
        font = new Font("Sans-serif", Font.BOLD, 24);
        delay = 100;
        offset = 1;
        // get parameter "text"
        att = getParameter("text");
        if (att != null) {
                text = att;
        } else {
                text = "Scrolling banner.";
          }
        // set initial position of the text
        d = getSize();
        x = d.width;
        y = font.getSize();
} //end of init
```

A Scrolling Banner Applet

- Method `start( )`

```
public void start() {
  bannerThread = new Thread(this);
  bannerThread.start();
} //end of start
```

- Method `stop( )`

```
public void stop() {
  bannerThread = null;
} //end of stop
```

A Scrolling Banner Applet

- Method `run( )`

```
public void run() {
      while (Thread.currentThread() == bannerThread) {
            try {
                  Thread.currentThread().sleep(delay);
            }
            catch (InterruptedException e){}
            repaint();
      }
} //end of run
```

A Scrolling Banner Applet

```
public void paint(Graphics g) {
  // get the font metrics to determine the length of the text
  g.setFont(font);
  FontMetrics fm = g.getFontMetrics();
  int length = fm.stringWidth(text);
  // adjust the position of text from the previous frame
  x -= offset;
  // if the text is completely off to the left end
  // move the position back to the right end
  if (x < -length)
     x = d.width;
  // set the pen color and draw the background
  g.setColor(Color.black);
  g.fillRect(0,0,d.width,d.height);
  // set the pen color, then draw the text
  g.setColor(Color.green);
  g.drawString(text, x, y);
} //end of paint   } // end of ScrollingBanner class
```

A Scrolling Banner Applet

- The HTML source for the applet

```
<html>
  <head>
    <title>Scrolling Banner Applet</title>
  </head>
<body bgcolor=white>
<h1>The Scrolling Banner</h1><p>
<applet code=ScrollingBanner.class
        width=300 height=50>
  <param name="text" value="Java Rules!">
</applet>
</body>
</html>
```

A Scrolling Banner Applet

- Output

How to Avoid Flickering?

- In the previous applet the window flickers consecutively
- Flickering is caused by `repaint( )`
  - `repaint( )` calls the `update(Graphics)` method
  - The default `update(Graphics)` method does the following
    - Paints the whole area with the background color
    - Sets the foreground color
    - Calls the `paint(Graphics)` method.
  - The `update(Graphics)` method is also called by the system to update windows
- Solution
  - Override the `update(Graphics)` method
  - Use an off-screen image

An Extended Scrolling Banner (Flickering prevention)

- Class and attributes' declarations

```
import java.awt.*;

public class ScrollingBanner2 extends
                                    ScrollingBanner {

// The off-screen image
protected Image image;
// The off-screen graphics
protected Graphics offscreen;
```

An Extended Scrolling Banner (Flickering prevention)

- The overridden method `update(Graphics)`

```
public void update(Graphics g) {
    // create the offscreen image if it is the first time
    if (image == null) {
      image = createImage(d.width, d.height);
      offscreen = image.getGraphics();
    }
    // draw the current frame into the off-screen image
    //   using the paint method of the superclass
    super.paint(offscreen);
    // copy the off-screen image to the screen
    g.drawImage(image, 0, 0, this);
} //end of update
```

An Extended Scrolling Banner (Flickering prevention)

- The overridden method `paint(Graphics)`

```
public void paint(Graphics g) {
    update(g);
} // end of paint
} // end of ScrollingBanner2 class
```

A Bouncing Ball Applet

- Class and attributes' declarations

```
import java.awt.*;
import java.applet.Applet;
public class BouncingBall extends Applet
                          implements Runnable {
protected Color color;
protected int radius;
protected int x, y;
protected int dx, dy;
protected Image image;
protected Graphics offscreen;
protected Dimension d;
protected Thread bouncingThread;
protected int delay;
```

A Bouncing Ball Applet

- Initialization of fields in method `init( )`

```
public void init() {
    color = Color.green;
    radius = 20;
    dx = -2;
    dy = -4;
    delay = 100;
    d = getSize();
    x = d.width * 2 / 3 ;
    y = d.height - radius;
} //end of init
```

A Bouncing Ball Applet

- Method `start( )`

```
public void start() {
    bouncingThread = new Thread(this);
    bouncingThread.start();
} //end of start
```

- Method `stop( )`

```
public void stop() {
    bouncingThread = null;
} //end of stop
```

A Bouncing Ball Applet

- Method `run( )`

```
public void run() {
    while (Thread.currentThread() == bouncingThread) {
      try {
        Thread.currentThread().sleep(delay);
      } catch (InterruptedException e){}
      repaint();
    }
} //end of run
```

A Bouncing Ball Applet

- Method `update(Graphics)`

```
public void update(Graphics g) {
    // create the off-screen image buffer
    // if it is invoked the first time
    if (image == null) {
      image = createImage(d.width, d.height);
      offscreen = image.getGraphics();
    }
    // draw the background
    offscreen.setColor(Color.white);
    offscreen.fillRect(0,0,d.width,d.height);
```

A Bouncing Ball Applet cont.

- Method `update(Graphics)`

```
// adjust the position of the ball
// reverse the direction if it touches
// any of the four sides
if (x < radius || x > d.width - radius) {
  dx = -dx;
}
if (y < radius || y > d.height - radius) {
  dy = -dy;
}
x += dx;
y += dy;
```

A Bouncing Ball Applet cont.

- Method `update(Graphics)`

```
    // draw the ball
    offscreen.setColor(color);
    offscreen.fillOval(x - radius, y - radius,
                       radius * 2, radius * 2);
    // copy the off-screen image to the screen
    g.drawImage(image, 0, 0, this);
} //end of update
```

- Method `paint(Graphics)`

```
public void paint(Graphics g) {
    update(g);
} // end of paint
} // end of BouncingBall class
```

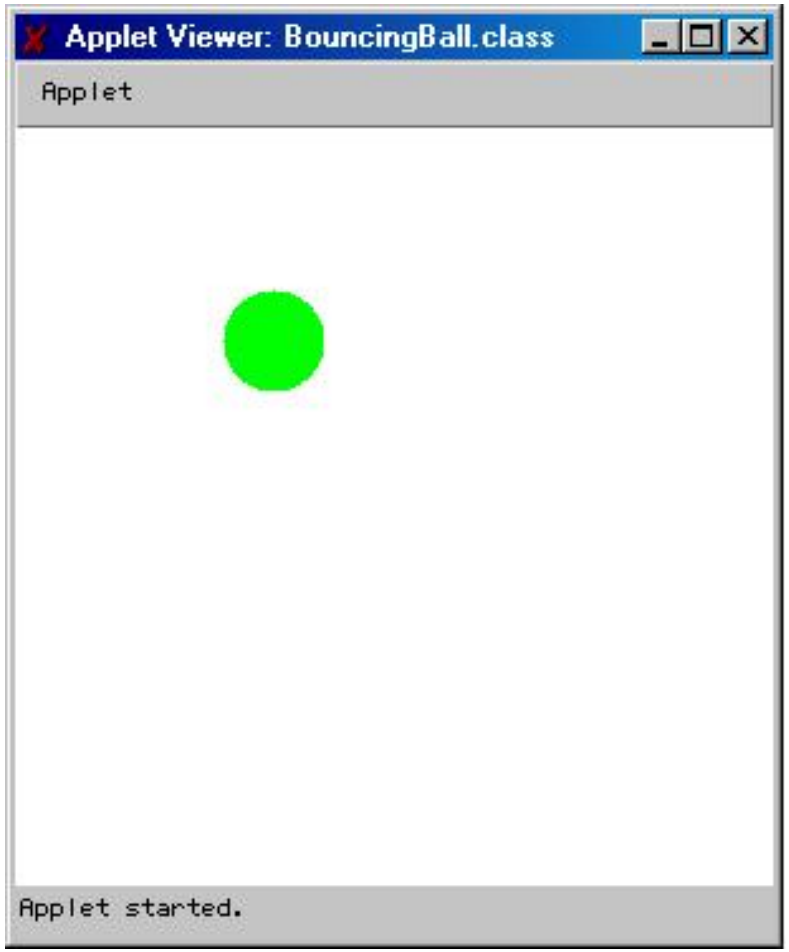
A Bouncing Ball Applet cont.

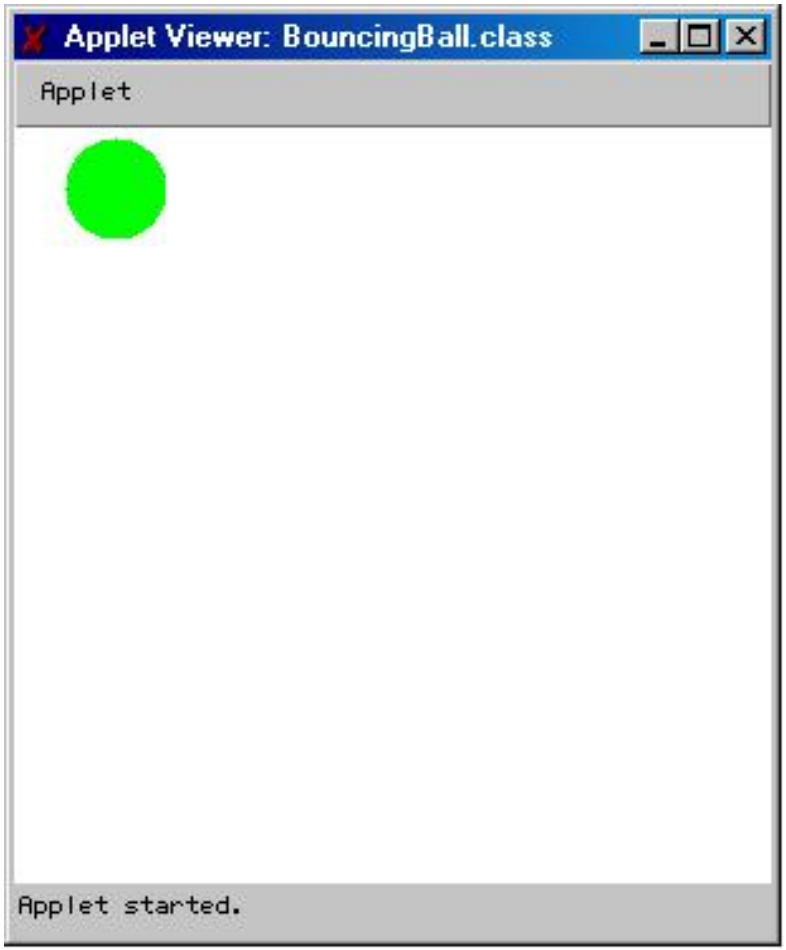
- The HTML source for the applet

```
<html>
  <head>
    <title>Bouncing Ball Applet</title>
  </head>
<body bgcolor=white>
<h1>The Bouncing Ball</h1><p>
<applet code=BouncingBall.class width=300 height=300>
</applet>
</body>
</html>
```

A Bouncing Ball Applet

- Output



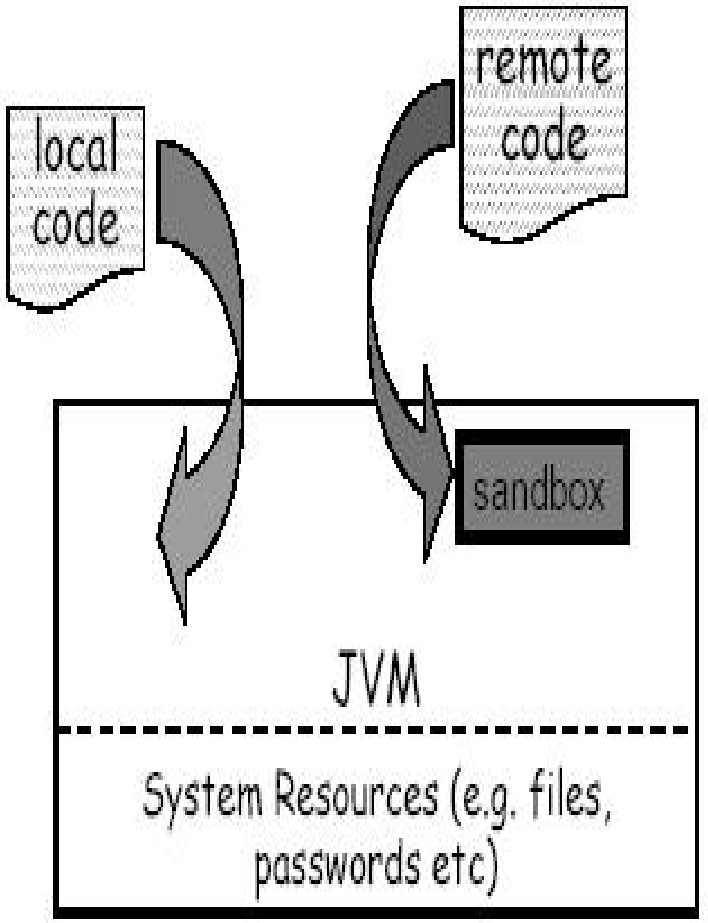


Java Security in Applets

- Remote applets may or may not be trusted
- Malicious applets can cause
  - Denial of Service
    - Deny platform use (busy threads, loop, exhaust GUI resources)
    - Kill other threads
  - Invasion of Privacy
  - Annoyance
    - E.g. constant sound
  - Flashing display
    - Causes seizures in some users
  - Steal CPU cycles
    - E.g. crack encryption

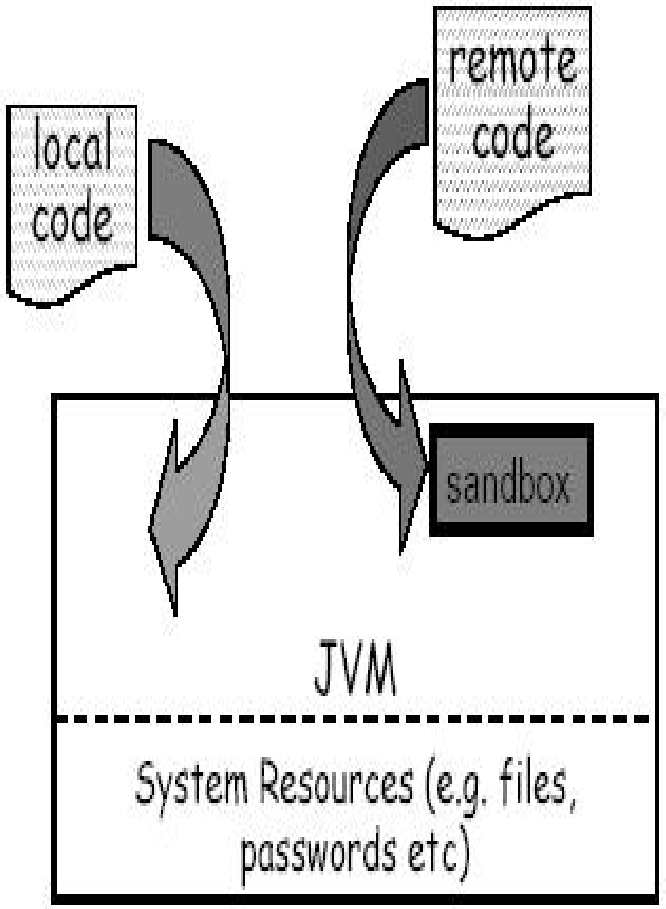
Java Security in Applets

- For that reason, applets always run with Java's security model
  - I.e. a sandbox model allocated by the web browser
- Inside this model applets cannot
  - Access (read/write/delete/create) to local file system
  - Modify other system resources
    - E.g. Configuration
  - Access the internals of web browser



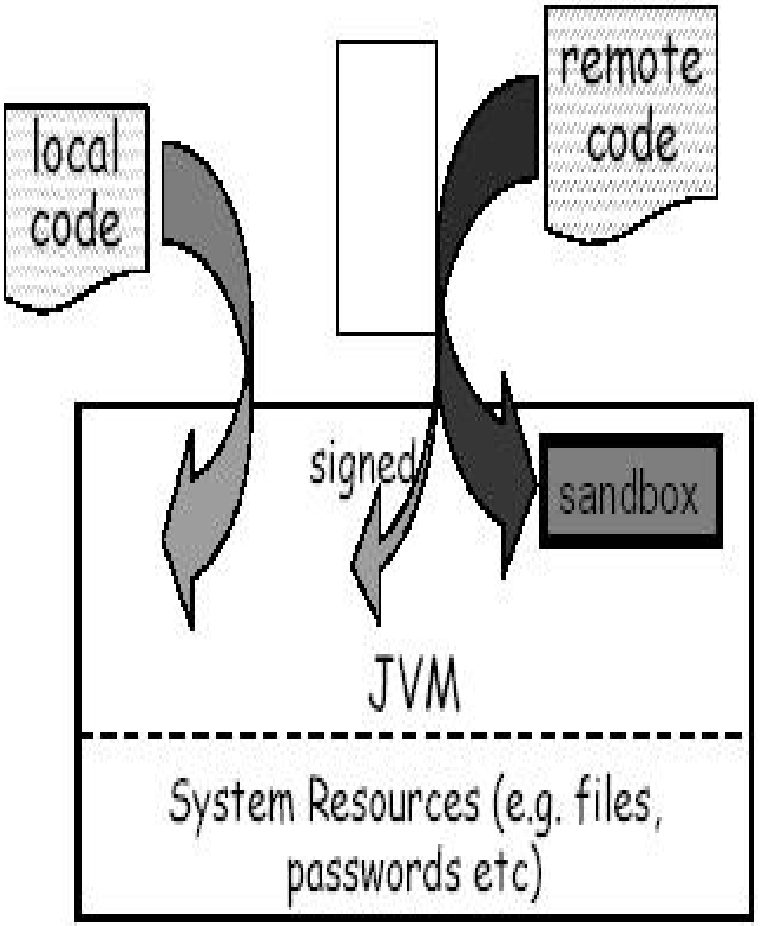
What is a Sandbox ?

- A byte-code verifier
  - Ensures that only legitimate Java bytecodes are executed
  - Together with the JVM, guarantees language safety at run time
- A class loader
  - Defines a local name space, which can be used to ensure that an untrusted applet cannot interfere with the running of other programs
- A security manager
  - Checks access to crucial system resources that is mediated by the JVM
  - Restricts the actions of a piece of untrusted code to the bare minimum

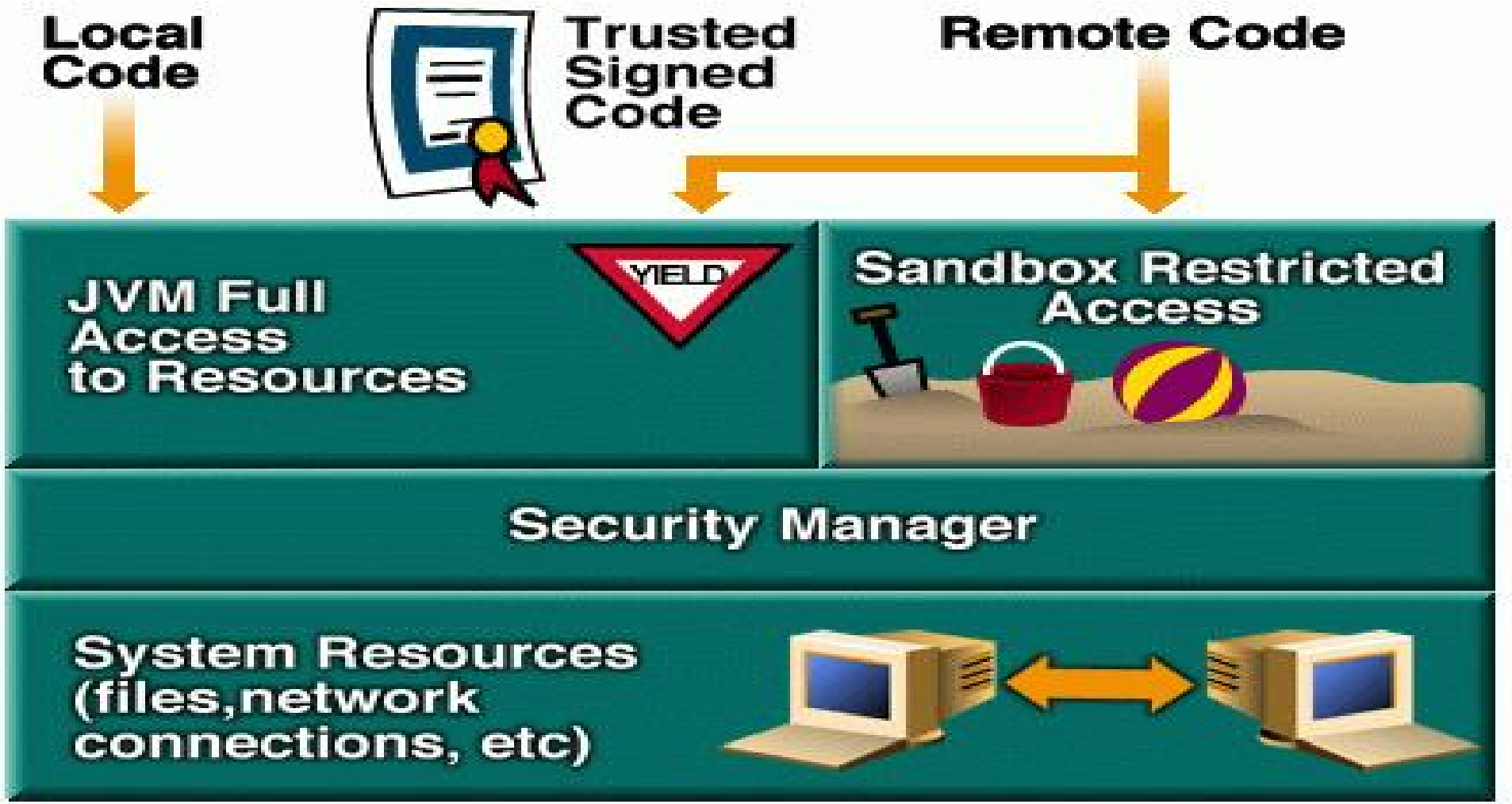


Java Security in Applets

- However, the sandbox model is too restricted
  - E.g. for LAN
- A solution for loosing this restriction is to use signed applets
  - An applet can be signed using digital signature
- A local site configuration can specify which signers are trusted
  - Applets signed by trusted parties are treated as trusted local codes and have full system access



JDK 1.2 Security



JDK 1.3 Security