Module-5:

GUI PROGRAMMING AND APPLETS

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Module-5: GUI PROGRAMMING AND APPLETS (6)

GUI Programming with Java: The AWT class hierarchy, introduction to swing, swings Vs AWT, hierarchy for swing components.

Containers: JFrame. JApplet, JDialog. Jpanel,

Overview of some swing components: JButton, JLabel, JTextField, JTextArea, simple applications.

Layout management: Layout manager types, border, grid and flow.

Applets: Inheritance hierarchy for applets, differences between applets and applications, life cycle of an applet, passing parameters to applets.

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What is GUI?

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AWT and Swing

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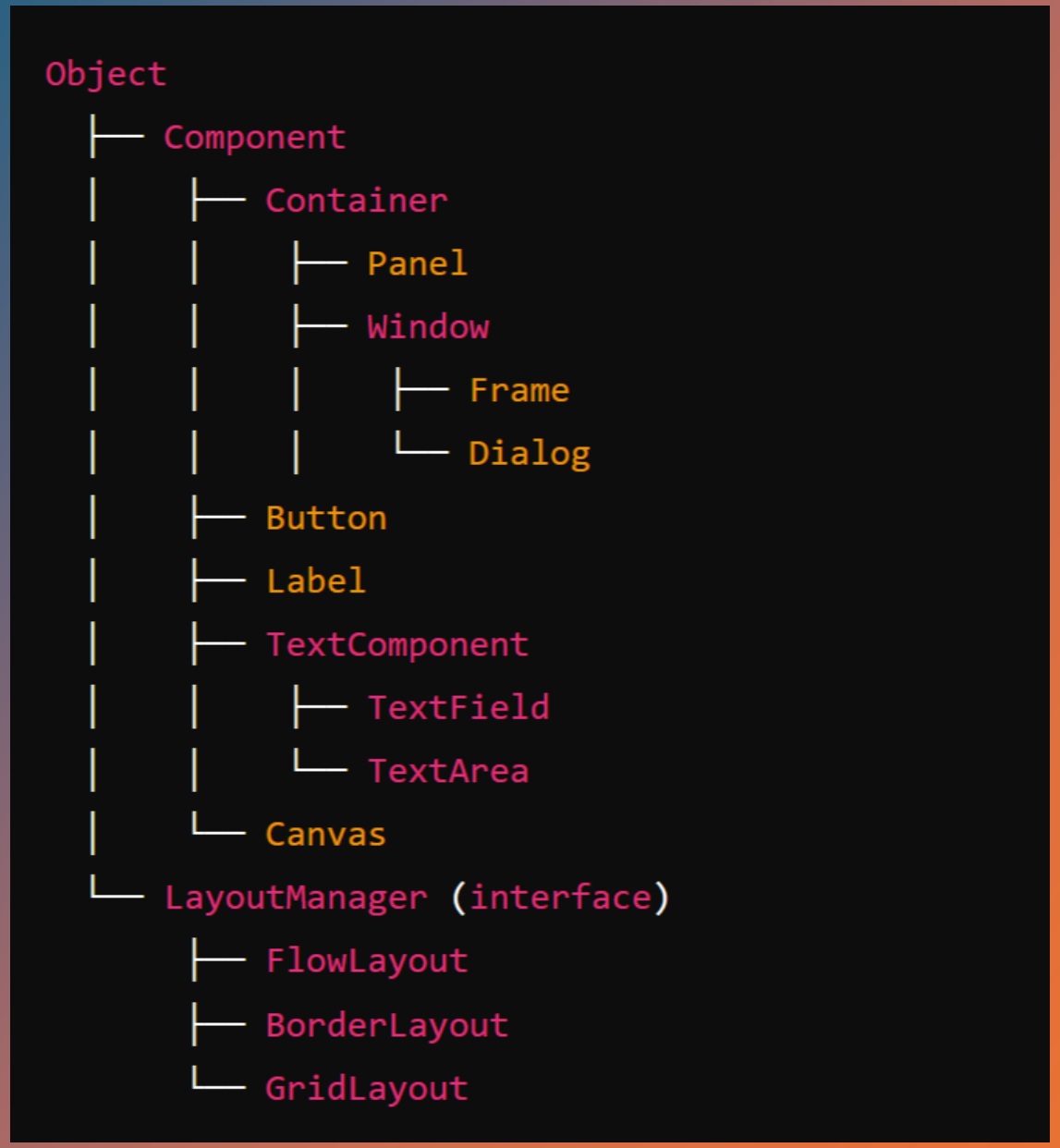
AWT class:

The **AWT (Abstract Window Toolkit)** is a key part of Java's **original graphical user interface** (GUI) **framework**. It provides a set of classes for building user interfaces (UI) like **windows**, **buttons**, **text fields**, and **menus**.

Java **AWT** (**Abstract Window Toolkit**) is an API to develop Graphical User Interface (GUI) or windows-based applications in Java.

The java.awt package provides classes for AWT API such as **TextField**, **Label**, **TextArea**, **RadioButton**, **CheckBox**, **Choice**, **List** etc.

AWT Class Hierarchy



1. Object

The root of the class hierarchy in Java. All classes inherit from Object, including those in AWT.

2. Component (extends Object)

The **base class** for all AWT components. It represents the common attributes and behaviors of UI elements, such as buttons, labels, text fields, etc.

Key subclasses of Component:

- **Container**: Can contain other components.
- **Button**: Represents a clickable button.
- **Label**: Displays a text string.
- **TextComponent**: Base class for TextField and TextArea.
- **Scrollbar**: Adds a scrollbar to a component.
- **Canvas**: Provides a blank area on which custom drawing can be done.

3. Container (extends Component):

A specialized component that can **hold** **other components** (like panels, frames).

Subclasses of Container:

1. **Window**: Represents a **top-level window** with **no borders** or **menus** (typically used for creating dialogs or windows).

Subclasses of Windows:

- **Dialog:** A pop-up window often used to interact with the user.
- **Frame:** A **fully functional window** with **title**, **borders**, and **buttons** like minimize, maximize, and close.

2. Panel (extends Container):

A generic container used for **grouping other components**.

A container for organizing components in a specific layout. Frequently used for grouping elements.

4. TextComponent (extends Component):

The base class for text-related components.

Subclasses:

- **TextField:** A single-line text input field.
- **TextArea:** A multi-line text input area.

5. LayoutManager

An interface used to define how components are arranged in a container.

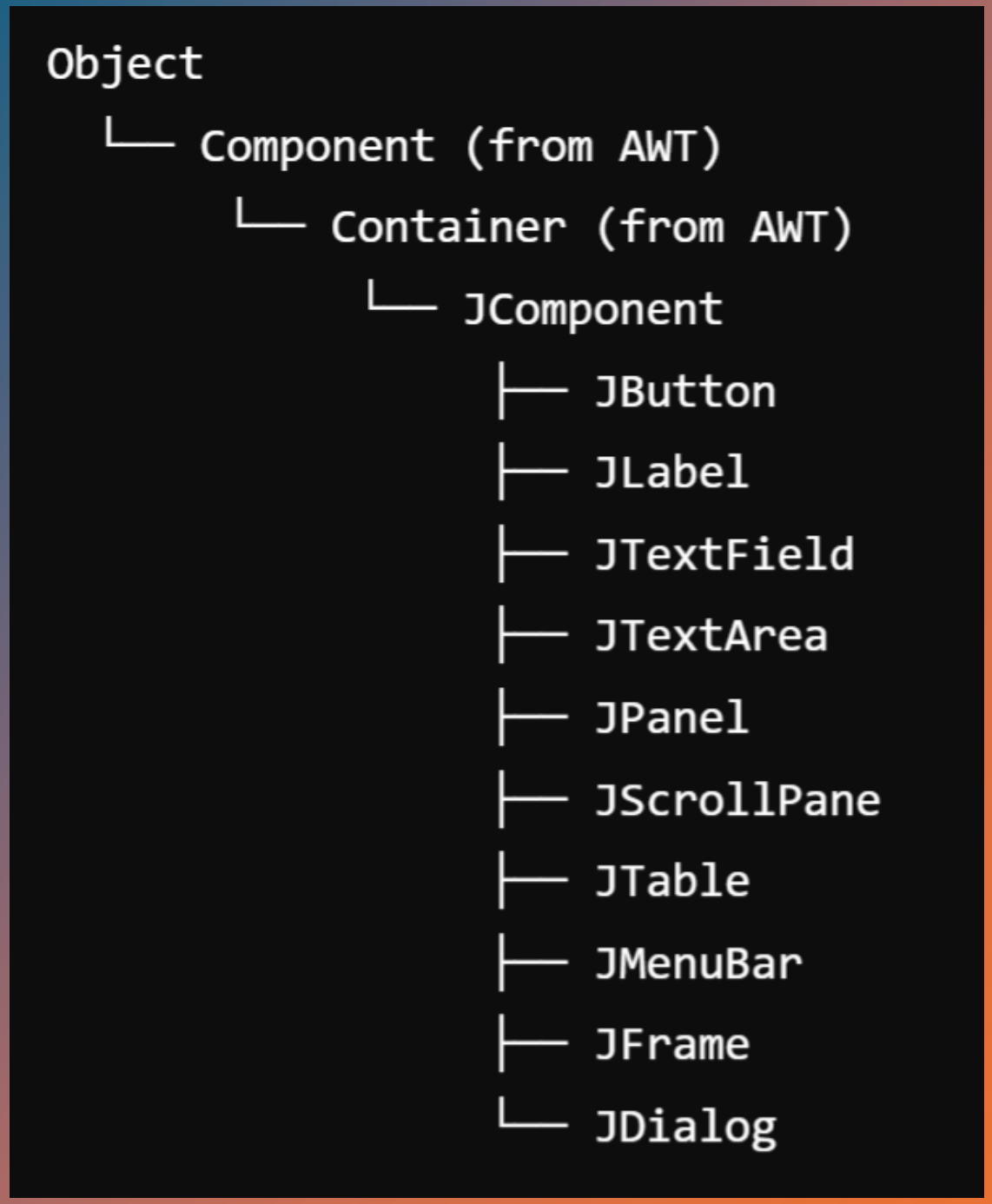
Key implementations:

- **FlowLayout:** Lays out components in a row.
- **BorderLayout:** Arranges components in five areas (North, South, East, West, and Center).
- **GridLayout:** Arranges components in a grid of rows and columns.

Swing:

Swing is a part of Java's **JFC (Java Foundation Classes)** and is a more **advanced** and **flexible** GUI toolkit compared to AWT (Abstract Window Toolkit).

While AWT provides **basic components** and is **platform-dependent** (uses native GUI components), Swing is built on top of AWT and is **platform-independent** because it renders its components **using Java code** rather than relying on the **underlying operating system's** native components. This allows for a more consistent look and feel across different platforms.



Hierarchy for Swing components:

The Swing component hierarchy in Java follows a **well-defined structure based on the AWT hierarchy** but adds its **own** set of components for creating **rich user interfaces**.

1. Object

The root class of all Java classes.

2. Component (from AWT)

The base class for all graphical components that can be added to a GUI.

3. Container (from AWT)

A subclass of Component that can hold other components (like panels or frames).

4. JComponent (extends Container)

The **base class** **for all Swing components**. It provides additional functionality such as double buffering, **borders**, and **tooltips**.

Core Swing Components (Subclasses of JComponent):

Component	Description
JButton	Represents a clickable button.
JLabel	Displays static text or an image.
JTextField	A single-line text input field.
JTextArea	A multi-line text area for text input or output.
JPanel	A generic lightweight container used for **organizing components**.
JScrollPane	Provides a scrollable view of another component, like a text area or table.
JTable	A component that displays tabular data in rows and columns.
JList	Displays a list of items.
JComboBox	A drop-down list that allows the user to select one item from a list of choices.
JCheckBox	A component that represents a check box (on/off state).
JRadioButton	Represents a radio button (allows selection of one option within a group).
JMenuBar	Components for creating a menu bar.
JMenu	Represents a menu within a menu bar.
JMenuItem	Represents an item within a menu.

Top-Level Containers

1. JFrame (extends Frame):

A top-level window that **contains** the main application window.

2. JDialog (extends Dialog):

A pop-up window for user interaction (e.g., confirmation dialogs).

3. JWindow (extends Window)

A window **without any borders** or **title bar**.

4. JApplet (extends Applet):

A container for applets, used in embedding GUI components in web browsers.

5. JToolBar:

Provides a set of actions or controls, often used for creating toolbars.

Specialized Components:

1. JTabbedPane

Manages **multiple components with tabs**, allowing the user to **switch between them**.

2. **JSpinner:**

Allows the user to select a value from a sequence of values (like a number spinner).

3. JProgressBar:

Displays the progress of a task.

4. JTree

Displays a hierarchical tree of data (e.g., a file directory structure).

Swing v/s AWT

Feature	AWT (Abstract Window Toolkit)	Swing (Java Foundation Classes)
Component Model	Uses native OS components, making it **platform-dependent**.	**Built entirely in Java**, providing a consistent look and feel across platforms.
Lightweight vs. Heavyweight	**Heavyweight components** (each AWT component is a wrapper around a native system component).	**Lightweight components** (not tied to native components, allowing more flexibility and customization).
Look and Feel	**Limited** to the platform's **native look and feel**.	Supports **pluggable look and feel**, allowing for greater customization and different styles.
Event Handling	Uses a **simpler event handling** model based on listener interfaces.	Provides **a more advanced event handling** model with more event types and capabilities.
Graphics	**Basic graphics capabilities**, primarily for drawing shapes and text.	**Richer graphics capabilities**, including advanced rendering and painting options.
Containers	**Limited** container options (e.g., Frame, Panel).	**More flexible** container hierarchy (e.g., JFrame, JPanel, JLayeredPane).
Performance	Generally **faster for simple applications** due to native components.	Slightly **slower** **due to the overhead of additional features** and abstraction.
Threading Model	**Not as robust**, leading to potential issues with performance and responsiveness.	Supports the SwingWorker class for better concurrency management in UI updates.
Availability	Part of the original Java AWT library.	Introduced later as part of Java 2 (JFC) and is now standard in Java applications.
Development Complexity	**Easier for simple GUIs**, but can become complex for larger applications.	**More complex to learn** due to its rich feature set but offers better support for larger applications.

Jframe:

A JFrame is one of the most **important** classes in the Java Swing library. It is a **top-level container** that represents a **window** in a graphical user interface (GUI) application.

JFrame provides a window with all the standard window features, such as a **title bar**, **minimize/maximize buttons**, and a **close button**.

Example:

```java
import javax.swing.*;

public class JFrameExample {
    public static void main(String[] args) {
        // Create a JFrame instance
        JFrame frame = new JFrame("My JFrame Example");

        // Set the size of the frame
        frame.setSize(400, 300);

        // Specify what happens when the close button is clicked
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Add a button to the frame
        JButton button = new JButton("Click Me");
        frame.add(button);

        // Make the frame visible
        frame.setVisible(true);
    }
}
```

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JApplet :

JApplet is a class in the Java Swing library that **extends** the **Applet class** and provides a framework for **building applets** with a Swing-based graphical user interface (GUI).

Applets are small Java programs that are typically **embedded within a web page** and run in a web browser. JApplet was designed to use the rich, lightweight components from Swing, as opposed to the heavyweight AWT components used in Applet.

JDialog:

JDialog is a part of the Java Swing library and is used to create **dialog windows**, which are smaller windows that appear on top of the main application window (JFrame).

Unlike **JFrame**, which represents a full-fledged window, JDialog is typically used for **temporary, pop-up windows** that require user interaction, such as **alerts**, **confirmations**, or **input forms**.

Jpanel:

JPanel is one of the most commonly used components in the Java Swing library. It is a **lightweight container** that can hold and organize a group of components, such as **buttons**, **labels**, **text fields**, or other panels. It serves as a flexible, invisible container to help structure the layout of GUI.

Example:

1. JDialog
2. Jpanel
3. Jlabel
4. JTextField
5. JButton

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```java
import javax.swing.*;

public class JDialogDemo {
    public static void main(String[] args) {
        // Create the main application window (JFrame)
        JFrame frame = new JFrame("Main Window");
        frame.setSize(400, 200);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Create a button that opens the dialog
        JButton openDialogButton = new JButton("Enter Name");
        frame.add(openDialogButton); // Add the button to the JFrame

        // Create a dialog (JDialog)
        JDialog dialog = new JDialog(frame, "Name Input", true); // Modal dialog
        dialog.setSize(300, 150);

        // Add components to the dialog
        JLabel nameLabel = new JLabel("Enter your name:");
        JTextField nameField = new JTextField(15);
        JButton okButton = new JButton("OK");

        JPanel panel = new JPanel();
        panel.add(nameLabel);  // Add label to the panel
        panel.add(nameField);  // Add text field to the panel
        panel.add(okButton);   // Add OK button to the panel
        dialog.add(panel);     // Add the panel to the dialog

        // Action listener for the "Enter Name" button
        openDialogButton.addActionListener(e -> dialog.setVisible(true));

        // Action listener for the "OK" button in the dialog
        okButton.addActionListener(e -> {
            String name = nameField.getText(); // Get the input from the text field
            if (!name.isEmpty()) {
                JOptionPane.showMessageDialog(frame, "Hello, " + name + "!");
                dialog.setVisible(false); // Close the dialog after OK is clicked
            } else {
                JOptionPane.showMessageDialog(dialog, "Please enter your name.");
            }
        });

        // Show the main window
        frame.setVisible(true);
    }
}
```

Layout management:

Layout Manager controls the **positioning** and **sizing** of **components within a container**. Different layout managers provide different ways to arrange components, making GUI design more **flexible** and **dynamic**.

Layout manager types:

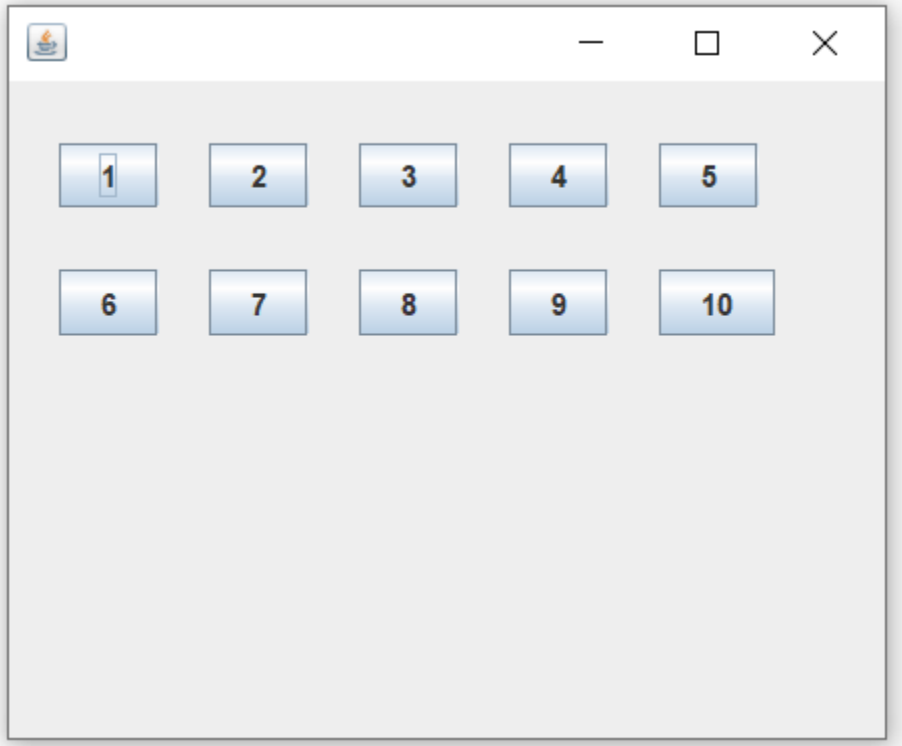
Java Swing provides several layout managers that allow you to organize components in different ways within containers like JFrame, JPanel, and JDialog.

1. FlowLayout
2. BorderLayout
3. GridLayout

FlowLayout :

FlowLayout arranges components **in a line** (left to right) and **wraps to the next line** if there isn't enough space. Components are aligned to the **left**, **center**, or **right** (default is centered).

Use Case: Common for toolbar-like layouts or for smaller components that don't require precise.



Example:

```java
import javax.swing.*;
import java.awt.*;

public class FlowLayoutExample {
    public static void main(String[] args) {
        JFrame frame = new JFrame("FlowLayout Example");
        frame.setSize(400, 200);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Set FlowLayout with centered alignment
        frame.setLayout(new FlowLayout(FlowLayout.CENTER));

        for (int i = 1; i <= 5; i++) {
            frame.add(new JButton("Button " + i));
        }

        frame.setVisible(true);
    }
}
```

BorderLayout:

BorderLayout **divides the container** into **five regions**: **NORTH**, **SOUTH**, **EAST**, **WEST**, and **CENTER**. Each region can hold only one component. The CENTER region expands to fill any remaining space.

Use Case: Suitable for applications with a main central area and surrounding sections (like a header, footer, or sidebars).

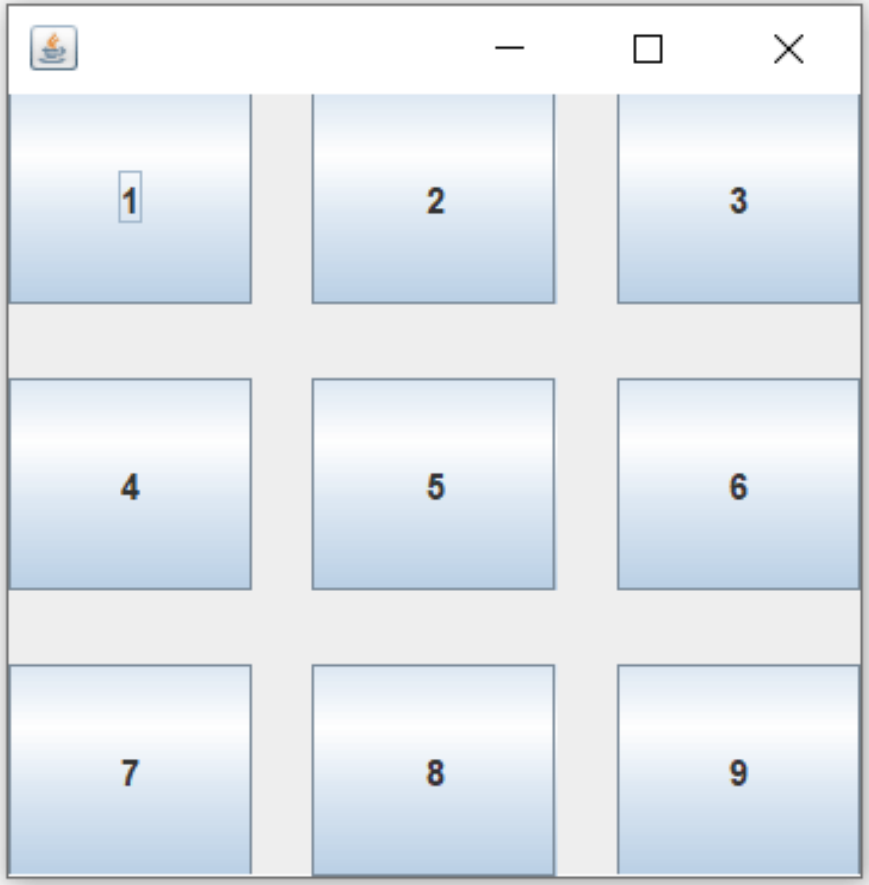
Example:

```java
import javax.swing.*;
import java.awt.*;

public class BorderLayoutExample {
    public static void main(String[] args) {
        JFrame frame = new JFrame("BorderLayout Example");
        frame.setSize(400, 300);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Set BorderLayout as the layout manager
        frame.setLayout(new BorderLayout());

        frame.add(new JButton("North"), BorderLayout.NORTH);
        frame.add(new JButton("South"), BorderLayout.SOUTH);
        frame.add(new JButton("East"), BorderLayout.EAST);
        frame.add(new JButton("West"), BorderLayout.WEST);
        frame.add(new JButton("Center"), BorderLayout.CENTER);

        frame.setVisible(true);
    }
}
```

GridLayout:

GridLayout arranges components in a **rectangular grid** of **rows** and **columns**. Each cell the grid is of **equal size**, and all components are resized to fit within their assigned cell.

Use Case: Useful for creating uniform, grid-like layouts, such as calculator buttons or a game board.



Example:

```java
import javax.swing.*;
import java.awt.*;

public class GridLayoutExample {
    public static void main(String[] args) {
        JFrame frame = new JFrame("GridLayout Example");
        frame.setSize(400, 300);
        frame.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);

        // Set GridLayout with 2 rows and 3 columns
        frame.setLayout(new GridLayout(2, 3));

        for (int i = 1; i <= 6; i++) {
            frame.add(new JButton("Button " + i));
        }

        frame.setVisible(true);
    }
}
```

Applets

Applet:

An **applet** in Java is a **small application that can run** in a **web browser** or **applet viewer**. To create a Interactive or dynamic Web Page.

Applets were primarily designed to provide **interactive features** in **web pages**, but over time **their usage has decreased**, especially with the shift towards modern web technologies like **HTML5**, **JavaScript**, and **CSS**.

What is an Applet?

An applet is a **subclass** of **java.applet.Applet** or **javax.swing.JApplet**.

It is a Java program **embedded into web pages** and can be executed using a **Java-enabled browser** or an **applet viewer tool**.

Applets are different from standalone applications because they **don't have a main() method**. Instead, they rely on **lifecycle methods** for execution.

Types of Applets:

- **AWT Applet (java.applet.Applet):** Uses Abstract Window Toolkit (AWT) components like Button, Label, TextField.
- **Swing Applet (javax.swing.JApplet):** Uses Swing components like JButton, JLabel, JTextField. It offers more advanced GUI components compared to AWT.

Inheritance hierarchy for applets:

In Java, applets are part of the class hierarchy that ultimately inherits from the base class **java.lang.Object**. Applets can be written using either the Abstract Window Toolkit (AWT) or Swing.

1. AWT Applet Inheritance Hierarchy:

AWT-based applets inherit from the **java.applet.Applet** class, which in turn inherits from other standard Java classes. Here is the detailed inheritance hierarchy:

```
java.lang.Object
    ↳ java.awt.Component
        ↳ java.awt.Container
            ↳ java.awt.Panel
                ↳ java.applet.Applet
```

2. Swing Applet Inheritance Hierarchy:

Swing-based applets inherit from **javax.swing.JApplet**, which adds more advanced GUI capabilities by utilizing the Swing toolkit.

Hierarchy:

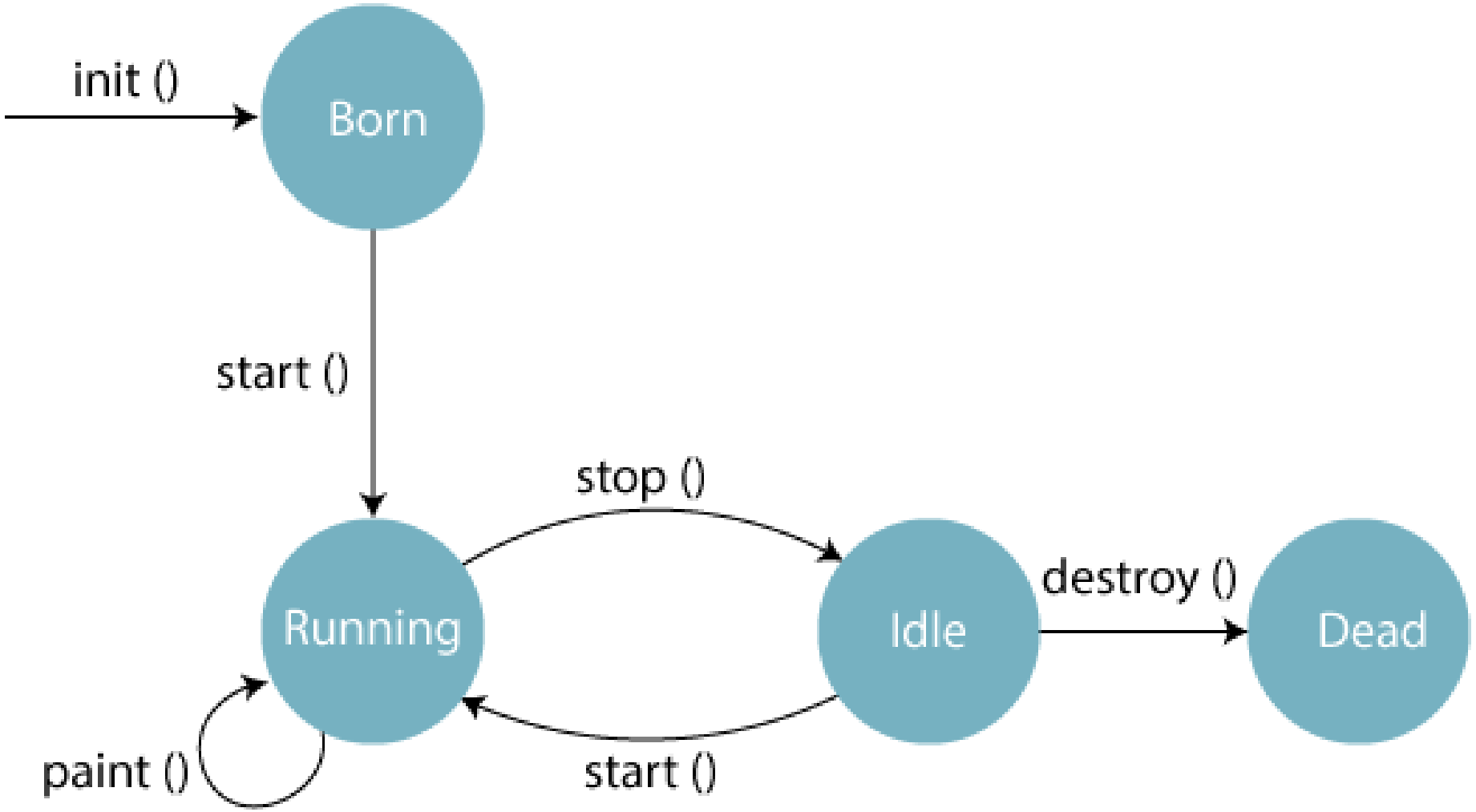
```
java.lang.Object
    ↳ java.awt.Component
        ↳ java.awt.Container
            ↳ java.awt.Panel
                ↳ java.applet.Applet
                    ↳ javax.swing.JApplet
```

Differences between Applets and Applications:

Feature	Java Applet	Java Application
Definition	A **small program** that **runs within a web browser** or **applet viewer**.	A **standalone program** that runs directly on the **JVM**.
Execution Environment	Runs in a web browser or applet viewer (like appletviewer).	Runs in the Java Virtual Machine (JVM).
Main Method	**No main()** method; uses **init**(), **start**(), **stop**(), and **destroy**() methods.	Entry point is **public static void main(String[] args).**
Security Restrictions	Restricted by a **security sandbox** (can't access local file system by default).	Has **full access** to the system resources (based on permissions).
User Interaction	Limited due to **browser restrictions**.	**Full control** over user interaction and system resources.
GUI Creation	Typically **uses AWT** (Abstract Window Toolkit) for user interface components.	Can use **Swing**, **AWT**, **JavaFX**, or other libraries for GUI creation.
Deployment	**Embedded** within a web page as an applet tag or called in an HTML page.	Run directly from a **Java archive (JAR)** or **class file** on the desktop or server.
Network Access	Limited to the server from which it was downloaded, unless explicitly signed.	No restrictions on network access (depends on application configuration).
Performance	Generally **slower** due to browser overhead and security checks.	Generally **faster** as it runs directly on the local JVM.
Modern Usage	**Rarely used**, as browsers no longer support applets due to security concerns.	**Widely used** in a variety of desktop and server applications.

Life Cycle of an Applet:

- In Java, an applet is a special type of program **embedded** in the web page to generate **dynamic content**. Applet is a class in Java.
- The applet life cycle can be defined as the process of how the **object is created**, **started**, **stopped**, and **destroyed** during the entire execution of its application. It basically has **five core methods** namely **init**(), **start**(), **stop**(), **paint**() and **destroy**().These methods are invoked by the browser to execute.
- In Java, the life cycle of an applet consists of a sequence of methods that manage the different stages of an applet's existence. These methods ensure that the applet is **initialized**, **starts running**, **stops** when needed, and finally, is **destroyed** when no longer required.


init ()
Born
start ()
stop ()
Running
Idle
destroy ()
Dead
paint ()
start ()

1. Initialization (init()):

- Called when the applet is first loaded.
- This method is used to **initialize the applet**, such as **setting up the initial state**, **loading resources**, or **setting up the user interface**.
- **Executed only once** when the **applet starts**.

2. Starting (start()):

- **Called each time** the applet becomes active (e.g., when the user visits or revisits the page containing the applet).
- Typically used **to start animations** or any activity that needs to continue as long as the applet is active.
- **Can be called multiple times** if the applet is paused and resumed.

3. Painting (**paint(Graphics g)**):

- Called **whenever the applet's display needs to be redrawn**.
- Used to **render graphics** and text on the applet's display area.
- **Automatically called after init() and start(),** and can be invoked by calling **repaint**().

4. Stopping (stop()):

- Called when the **applet is no longer active**, like when the user navigates away from the page.
- Used to **pause animations** or **other ongoing activities**.
- Can be called multiple times when the applet is paused and resumed.

5. Destruction (destroy()):

- Called when the **applet is being removed from memory** (usually when the **browser is closed**).
- Used to **release resources** and **perform cleanup tasks**.
- **Executed only once** in the applet's lifecycle, **after stop().**

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

public class LifeCycleApplet extends Applet {

    // Called once when the applet is first loaded
    @Override
    public void init() {
        System.out.println("init() method called: Applet initialized.");
    }

    // Called each time the applet is started or restarted
    @Override
    public void start() {
        System.out.println("start() method called: Applet started.");
    }

    // Called whenever the applet needs to repaint its contents
    @Override
    public void paint(Graphics g) {
        System.out.println("paint() method called: Applet repainting.");
        g.drawString("Hello, Applet Lifecycle!", 20, 20);
    }

    // Called each time the applet is stopped
    @Override
    public void stop() {
        System.out.println("stop() method called: Applet stopped.");
    }

    // Called once when the applet is being destroyed
    @Override
    public void destroy() {
        System.out.println("destroy() method called: Applet destroyed.");
    }
}
```

Example:

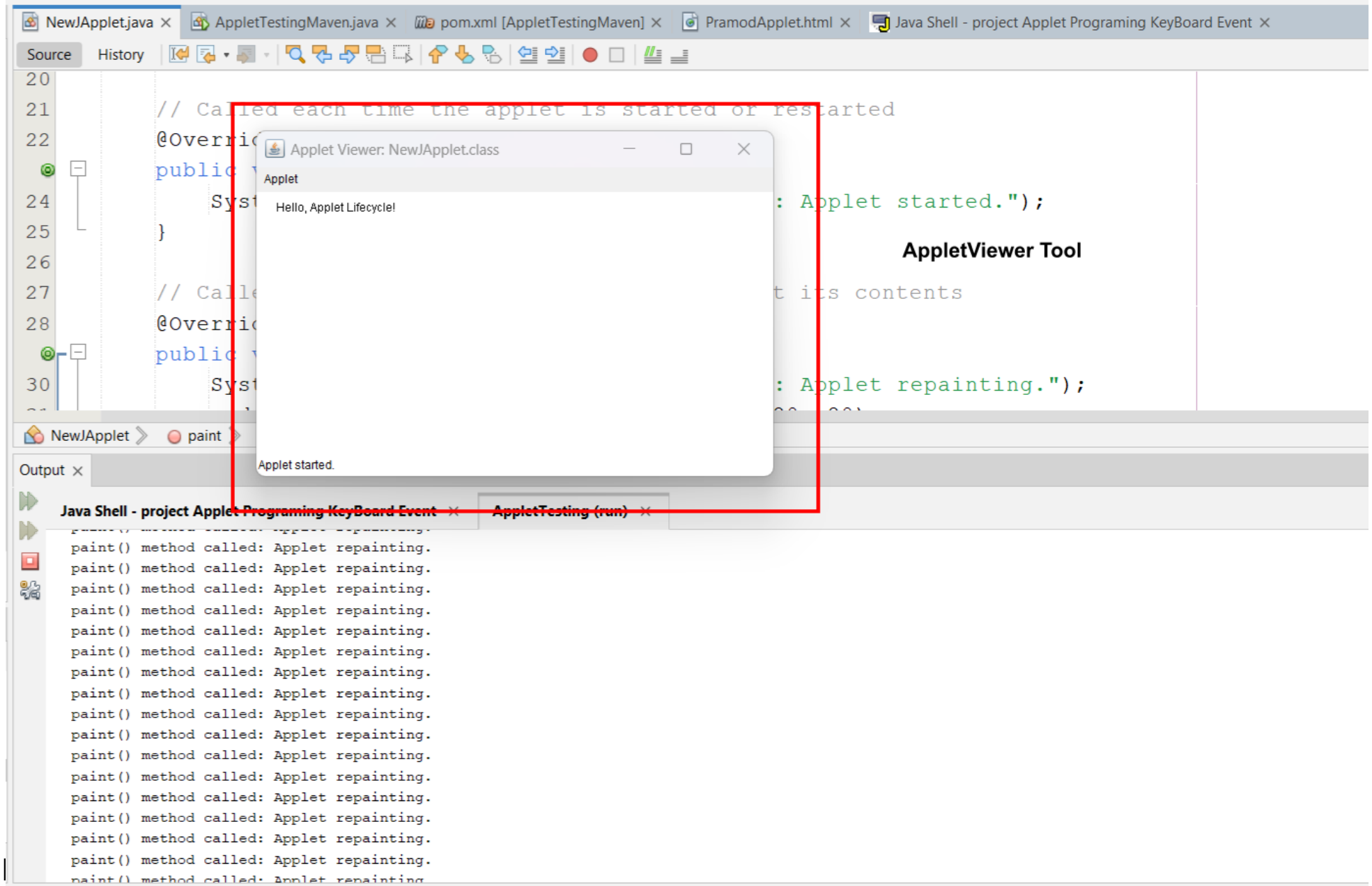
2 Ways to Run this Applet Program:

1. Using **AppletViewer Tool**
2. By **Embedding** the .class file in **HTML**.

Embedding the .class file in HTML:

```
<!DOCTYPE html>
<html>
<head>
    <title>LifeCycleApplet Example</title>
</head>
<body>
    <h1>Applet Lifecycle Example</h1>
    <applet code="LifeCycleApplet.class" width="300" height="200">
        Your browser does not support Java Applets.
    </applet>
</body>
</html>
```

Output:



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Passing Parameters to Applets:

- In Java, an applet can **receive parameters from** an **HTML** file using the **<param> tag**.
- These parameters are passed to the applet via the **getParameter()** method, which retrieves the value of a parameter specified in the HTML code.
- The parameters can then be used inside the applet to **control behavior**, **display messages**, etc.

Steps to Pass the Parameter from HTML to Applet file:

1. HTML Code:

Parameters are passed from an HTML page where the **applet is embedded.** The **<param> tag** inside the **<applet> tag** specifies the parameter **names** and their **values**.

2. Applet Code:

In the applet's code, the **getParameter(String name)** method is used to **retrieve** the parameter values by specifying the **parameter name.**

3. Key Methods:

getParameter(String paramName): Used to get the value of a parameter passed to the applet.

Example:

1. HTML File:

```
<html>
    <body>
        <h2>Passing Parameters to Applet</h2>
        <applet code="MyApplet.class" width="300" height="100">
            <param name="msg" value="Welcome to Java Applets!" />
        </applet>
    </body>
</html>
```

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2. Applet Code: MyApplet.java

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

public class MyApplet extends Applet {
    String message;

    // Initialization of the applet
    public void init() {
        // Retrieve the parameter named 'msg' from the HTML
        message = getParameter("msg");

        // If no message is passed, use a default message
        if (message == null) {
            message = "Hello, World!";
        }
    }

    // Paint method to display the message
    public void paint(Graphics g) {
        g.drawString(message, 20, 20);
    }
}
```