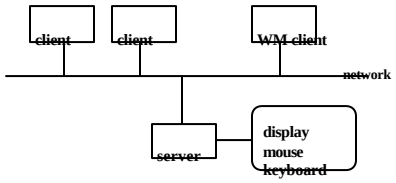
Graphical user interfaces

- **models**
  - X Window system
  - Java Swing
  - Visual Basic
  - Tcl/Tk (maybe)
- **ideas**
  - interface components: widgets, controls, objects, …
  - methods, properties
  - events: loops and callbacks
  - geometry and layout management
  - use of hierarchy, inheritance
- **the GUI is the biggest chunk of code in many applications**
  - libraries try to make it easier
  - development environments and wizards and builders try to make it easier
  - it's still hard

X Windows (Bob Scheifler, Jim Gettys, mid-1980's)

- **client-server over a network**
  - works on single machine too, with IPC

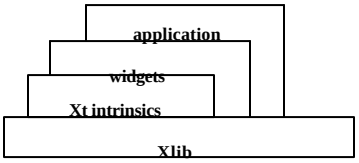


- **variants:**
  - X terminal (e.g., SunRay): server is standalone
  - workstation: server is on same processor as clients
  - remote clients, local server
  - Exceed: server on PC, clients on (usually) Unix
- **window manager is just another client, but with more properties**
  - clients have to let the window manager manage
  - InterClient Communications Conventions Manual

X Windows model (www.x.org)

- **server runs on the local machine**
  - accepts network (or local) client requests and acts on them
  - creates, maps and destroys windows
  - writes and draws in windows
  - manages keyboard, mouse and display
  - sends keyboard and mouse events back to proper clients
  - replies to information requests
  - reports errors
- **client application**
  - written with X libraries (i.e. Xlib, Xt)
  - uses the X protocol to
    send requests to the server
    receive replies, events, errors from server
- **protocol messages**
  - requests: clients make requests to the server
    e.g., Create Window, Draw, Iconify, ...
  - replies: server answers queries ("how big is this?")
  - events: server forwards events to client
    typically keyboard or mouse input
  - errors: server reports request errors to client

X Windows programming model



- **Xlib provides client-server communication**
- **intrinsics provide basic operations for building and combining widgets**
- **widgets implement user interface components**
  - buttons, labels, dialog boxes, menus, ...
  - multiple widget sets, e.g., Motif
- **application uses all of these layers**

Xlib: bottom level library

- **basic mechanisms for**
  - requests from client to server: "draw on window", "how big is this?"
  - replies from server to client: "this big"
  - events from server to client: "button 1 pushed", "window exposed"
  - error reports: "out of memory"
- **basic Xlib-level client program**
  - connect client to server: XOpenDisplay()
  - get info about screen, compute desired size for window;
    hints, not mandatory; the WM is in charge
  - create window: XCreateSimpleWindow()
  - set standard properties for window manager
    sizes, window name, icon name, ...
  - select events to be received and discarded
  - create "graphics context" for storing info on color, depth, ...
    things that don't change from request to request
    server caches this info to cut down traffic
  - display window: XMapWindow()
    causes it to appear; up to this point it hasn't
  - loop on events

Events

- **client registers for events it cares about**
- **events occur asynchronously**
- **queued for each client**
- **client has to be ready to handle events any time**
  - mouse buttons or motion
  - keyboard input
  - window moved or reshaped or exposed
  - 30-40 others
- **information comes back to client in a giant union XEvent**

```
Xevent myevent;
for (;;) {
        XNextEvent(mydisplay, &myevent);
        switch (myevent.type) {
        case ButtonPress: ...
        ...
```

Hello world in X toolkit / Motif widgets

```
#include <Xm/XmAll.h>

void main(int argc, char *argv[])
{
    Widget toplevel, main_w, button;
    XtAppContext app;
    XtSetLanguageProc(NULL, NULL, NULL);
    toplevel = XtVaAppInitialize(&app, "main", NULL, 0,
                                 &argc, argv, NULL, NULL);
    main_w = XtVaCreateManagedWidget("main_w",
        xmMainWindowWidgetClass,
        toplevel, XmNscrollingPolicy,
        XmAUTOMATIC, NULL);
    button = XtVaCreateWidget("Hello World",
        xmLabelWidgetClass, main_w, NULL);
    XtManageChild(button);
    XtRealizeWidget(toplevel);
    XtAppMainLoop(app);
}

/* cc x.c -lXm -lXt -lX11 */
```

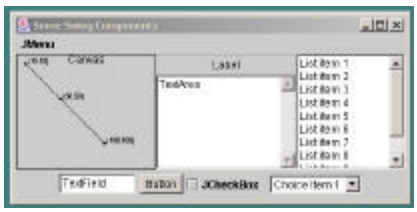
Hello world in GTk (plus ça change...)

```
#include <gtk/gtk.h>

static void hello( GtkWidget *widget, gpointer data ) {
    g_print ("Hello World\n");
}

static gboolean delete_event( GtkWidget *widget, GdkEvent  *event,
                              gpointer  data ) {
    g_print ("delete event occurred\n");
    return TRUE;
}

static void destroy( GtkWidget *widget, gpointer data ) {
    gtk_main_quit ();
}

int main( int argc, char *argv[] ) {
    GtkWidget *window;
    GtkWidget *button;
    gtk_init (&argc, &argv);
    window = gtk_window_new (GTK_WINDOW_TOPLEVEL);
    g_signal_connect (G_OBJECT (window), "delete_event",
                      G_CALLBACK (delete_event), NULL);
    g_signal_connect (G_OBJECT (window), "destroy",
                      G_CALLBACK (destroy), NULL);
    gtk_container_set_border_width (GTK_CONTAINER (window), 10);
    button = gtk_button_new_with_label ("Hello World");
    g_signal_connect (G_OBJECT (button), "clicked",
                      G_CALLBACK (hello), NULL);
    g_signal_connect_swapped (G_OBJECT (button), "clicked",
                              G_CALLBACK (gtk_widget_destroy),
                              G_OBJECT (window));
    gtk_container_add (GTK_CONTAINER (window), button);
    gtk_widget_show (button);
    gtk_widget_show (window);
    gtk_main ();

    return 0;
}
```

Graphical user interfaces in Java

- **interfaces built from components**
  - buttons, labels, text areas, lists, menus, dialogs, ...
  - canvas: graphics for drawing and image rendering
- **each component has**
  - properties: size, position, visibility, text, font, color, ...
  - methods: things it will do, e.g., change properties
  - events: external stimuli it responds to
- **containers: hold components and containers**
- **layout managers: control size, placement of objects within a container**

(Campione & Walrath *Java Tutorial*)



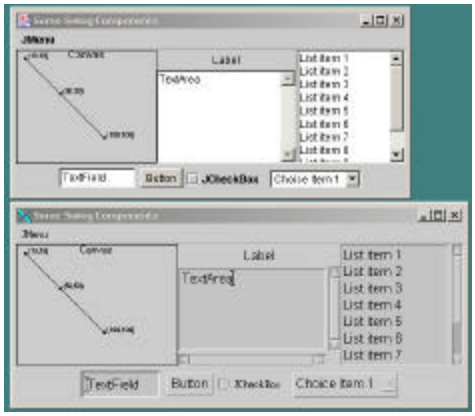
Which GUI package?

- **Java has two major GUI packages**

- **Abstract Window Toolkit (AWT)**
  - the original Java 1.0 version
  - very slow and weak, but simple
  - exists everywhere, though deprecated (correctly)
  - Java 1.1 has a newer event model
    slightly more complicated, somewhat faster

- **Swing**
  - for Java 1.2 and beyond
  - bigger, more complicated; many more components
  - "pluggable" look and feel
  - more powerful, faster
  - not as widespread, not in most browsers
    but available as a plug-in

- **we'll mostly use Swing**



Component object hierarchy

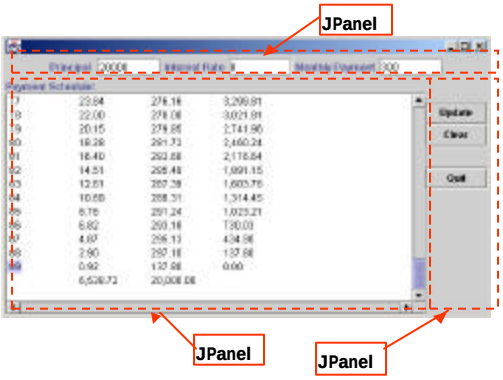
Object
- **-> Component**
  - **-> Container**
    - **-> Jcomponent**
      - **-> Jpanel**
      - **-> Jlabel**
      - **-> JButton**
      - **-> JTextComponent**
        - **-> JTextField**
          - **-> JPasswordField**
        - **-> JTextArea**
        - **-> …**

- **containers hold components and containers**
  - used to build up nested structures
  - JFrame top-level window
  - Jpanel: general container for components & containers
    put JPanels in a JFrame
  - JMenuBar for menubar across top of frame

- **individual components like Jbutton, Jtext…**
  - respond to events
  - have methods for other behaviors
  - have get and set methods for accessing properties
    like size, color, font

Layout hierarchy

- **JFrame holds one or more JPanels**
- **JPanel holds components and other Jpanels**
- **JPanel used for layout**
  - add() method adds components
  - uses a LayoutManager that lays out components
  - layout manager can be set to one of several



Events

- **stuff happens**
  - mouse motion, button push, button release, ...
  - scrollbar fiddled
  - keyboard keypress, release, shift key, etc.
  - component got or lost focus
  - window iconified, uniconified, hidden, exposed, moved, reshaped, killed
  - etc.
- **each such event is passed to event-handling mechanism in the program**
- **program can decide what to do with it**

Events (1.1 model)

- **components register to receive (listen for) events that they are interested in**
- **AWT runs a thread that watches for events like button push, mouse motion or click, keyboard, …**
- **each event is passed to the listener that registered for it**

- **obj.addActionListener(this)**
  - tells **obj** to notify **this** container when event happens
  - usually called by container that contains object that will get the event

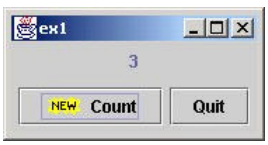
- **void actionPerformed(ActionEvent e) { … }**
  - called when event occurs
  - determine type or instance that caused event
  - handles it

- **different kinds of listeners for different sources**
  - keyboard, mouse, mouse motion, window, …

Example 1: Buttons and labels

- **after it starts:**

- **after Count button is pushed 3 times:**



- **after Quit button is pushed:**

Example 1 events, layout

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

public class ex1 extends JFrame
                implements ActionListener {
        int count;
        JLabel lab;
        JButton bcount, bquit;

public static void main(String[] args) {
        ex1 a = new ex1();
}

ex1() {
        setTitle("ex1");
        JPanel p1 = new JPanel();
        lab = new JLabel("Counter");
        p1.add(lab);
        bcount = new JButton("Count",
                                new ImageIcon("new.gif"));
        bcount.addActionListener(this);
        bquit = new JButton("Quit");
        bquit.addActionListener(this);
        JPanel p2 = new JPanel();
        p2.add(bcount);  p2.add(bquit);
        getContentPane().setLayout(new BorderLayout());
        getContentPane().add(p1, BorderLayout.NORTH);
        getContentPane().add(p2, BorderLayout.SOUTH);
        pack();
        show();
```

Example 1, continued

```
public void actionPerformed(ActionEvent ae) {
        System.out.println(ae.getActionCommand());
        if (ae.getActionCommand().equals("Count")) {
                                        // by content
                count++;
                lab.setText(Integer.toString(count));
        } else if (ae.getSource() == bquit) {
                                        // by object name
                System.exit(0);
        }
}
```

- **lots of steps to set up a control:**
  - declare an object, like Button
  - create it with new
  - add it to a container
  - add an ActionListener
  - test for the action in actionPerformed

Layout managers

- **control size, position, padding, stretching & shrinking, etc., for containers**
- **each container has a default layout manager**
  - change with setLayout method
    ```
    jp.setLayout(new BorderLayout())
    ```
  - or at creation
    ```
    JPanel jp = new JPanel(new BorderLayout());
    ```

- **FlowLayout**
  - fills area left to right in rows
  - each row can be centered, left or right adjusted
- **BorderLayout**
  - fills North, South, East, West, and Center
- **GridLayout**
  - regular array of rows and columns
  - specify number of each

- **CardLayout**
  - multiple windows that all occupy the same space
  - like tabs in Microsoft interfaces
- **GridBagLayout**
  - complicated grid layout
  - weighting factors on component areas, stretching, etc.

Flow Layout

- **default for Panels**


```
public class layout1 extends JFrame {

public static void main(String[] args) {
  layout1 a = new layout1();

  a.setTitle("layout1: flow");
  JPanel p = new JPanel();
  p.add(new Button("One"));
  p.add(new Button("Two "));
  p.add(new Button("Three"));
  p.add(new Button("Four"));
  p.add(new Button("Five"));
  a.getContentPane().add(p);
  a.pack();
  a.show();
}

}
```

Border Layout


```
public class layout2 extends JFrame {

public static void main(String[] args) {
  layout2 a = new layout2();

  a.setTitle("layout2: border");
  JPanel p = new JPanel();
  p.setLayout(new BorderLayout());
  p.add(new JButton("north button"),
                        BorderLayout.NORTH);
  p.add(new JButton("south button "),
                        BorderLayout.SOUTH);
  p.add(new JButton("east"), BorderLayout.EAST);
  p.add(new JButton("westernmost button"),
                        BorderLayout.WEST);
  p.add(new JButton("center button"),
                        BorderLayout.CENTER);
  a.getContentPane().add(p);
  a.pack();
  a.show();
}
```

Grid Layout


```
public class layout3 extends JFrame {

public static void main(String[] args) {
  layout3 a = new layout3();

  a.setTitle("layout3: grid");
  JPanel p = new JPanel();
  p.setLayout(new GridLayout(3,2));
        p.add(new Button("One"));
        p.add(new Button("Two "));
        p.add(new Button("Three"));
        p.add(new Button("Four"));
        p.add(new Button("Five"));
  a.getContentPane().add(p);
  a.pack();
  a.show();
}
```