

### Lecture 24: Graphical User Interfaces

CS 2110, Matt Eichhorn and Leah Perlmutter November 18, 2025

### Roadmap

#### Java, Complexity, OOP

start–9/30

#### **ADTs I**

- List, Stack, Queue, Iteration
  - 10/2 10/16

#### **ADTs II**

- Trees, Set, Map, Hash Table, Graph
  - Tues 10/21-11/13

### **Beyond ADTs**

- Graphical User Interfaces & Event-Driven Programming
  - 11/18, 11/20
- Parallel Programming
  - 11/25, 12/2
- Data Structures and Social Implications
  - 12/4

### Overview of today

#### Introduction

- Motivation
- Ingredients of Graphical User Interfaces

### TicTacToe (Tuesday)

- Review code for game logic
- Visual components

### TicTacToe (Thursday)

Interactive components



# Motivation

### History: How do we interact with computers?

#### Phase 1: Batch applications

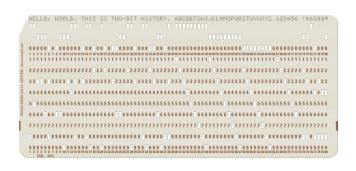
- Computers ran one program to completion
  - Input: Punchcards, files, program arguments
  - Output: Punchcards, files

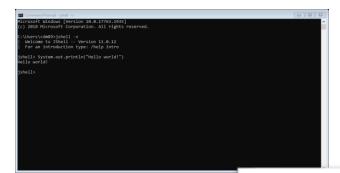
#### Phase 2: Command-line interface (CLI) 1960s+

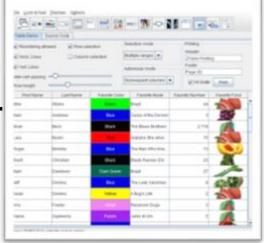
- Interactive command-line application
  - Input: User typing (System.in)
  - Output: Console (System.out)

### Phase 3: Graphical user interface (GUI) mainstream in 1980s+

- Rich, visual interactions with users
  - Input: mouse, keyboard, gamepad, ...
  - Output: formatted text, images, animations, ...







### "The Mother of all Demos"

Douglas Engelbart, 1968

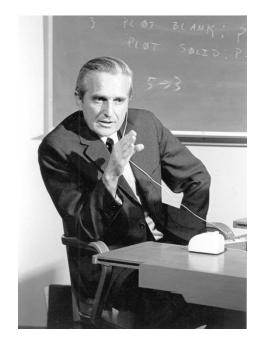
90-minute demo at ACM/IEEE Joint Computer Conference

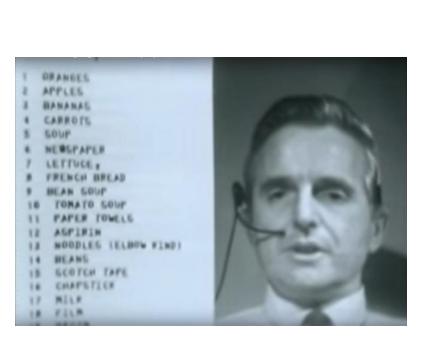


Computers can augment the capabilities of the human mind

- Computer mice
- Application windows
- Hyperlinks
- Word processors

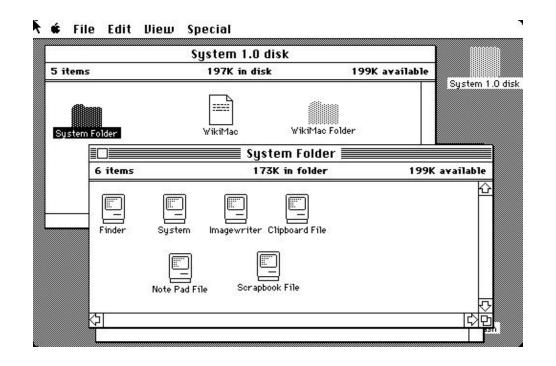
- File menus
- Copy-paste
- Teleconferencing
- Document sharing





### **GUI Paradigm:**

WIMP: Windows, Icons, Menus, Pointer



Macintosh System 1





# Ingredients for Graphical Applications

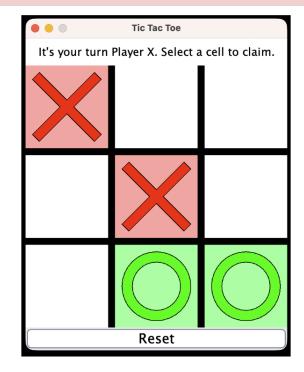
## Ingredients for Graphical Applications

#### What's in a GUI?

- Accept user input, interaction -Controller
- Reset the game Controller
- Display images in color View
- Backend that stores state of game, connected to visual component - Model

**Lecture 24: Graphical User Interfaces** 

Display text - View



Model - objects & methods underlying application state

View - visuals

**Controller –** logic that responds to user input

## Model View Controller (MVC)

#### Model (backend)

 objects underlying application state, including methods that access and modify state

#### View (frontend)

stuff shown on the screen for the application

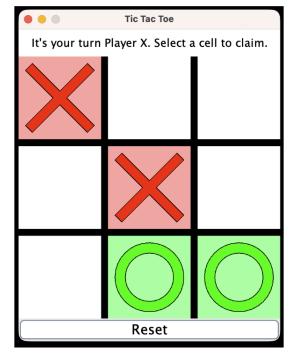
#### Controller

 logic that responds to user inputs (aka events) by updating model and view The model, view, and controller must connect to each other for the application to work, but the more we can minimize coupling, making each component as self-contained as possible, the easier it is to maintain our program.

## Ingredients for Graphical Applications

#### What's in a GUI?

- •
- ..



**Model –** objects & methods underlying application state

**View** – visuals

**Controller –** logic that responds to user input

### **GUI Frameworks**

**Framework –** large software library that includes base implementations of many view components and utility classes for layout, rendering, and handling user input

Framework	Programming Language	Kind of application
Angular	TypeScript	web
Flutter	Dart	web, mobile, desktop
ReactNative	JavaScript	primarily mobile
Kotlin	Kotlin	mobile, web, desktop
Electron	any web programming language	desktop
Swing	Java	desktop

The concepts and principles of GUI programming that you will learn here are more important than the specifics of the library

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Interactive components



# Tic Tac Toe Game

### Demo

#### Tic Tac Toe console game (lecture 8)

TicTacToe.java – model

TicTacToeConsole.java – view & controller

### TicTacToe graphical game (new)

TicTacToeGraphical.java

## **Swing Components: JFrame**

widget - A graphical element of a graphical application

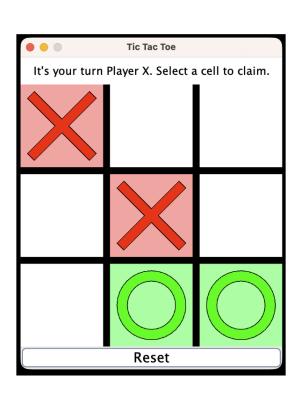
Widgets are typically used to

- a) display information about the state of the program or
- b) provide an interface for user interaction

Component – the Java Swing term for a widget

#### **JFrame**

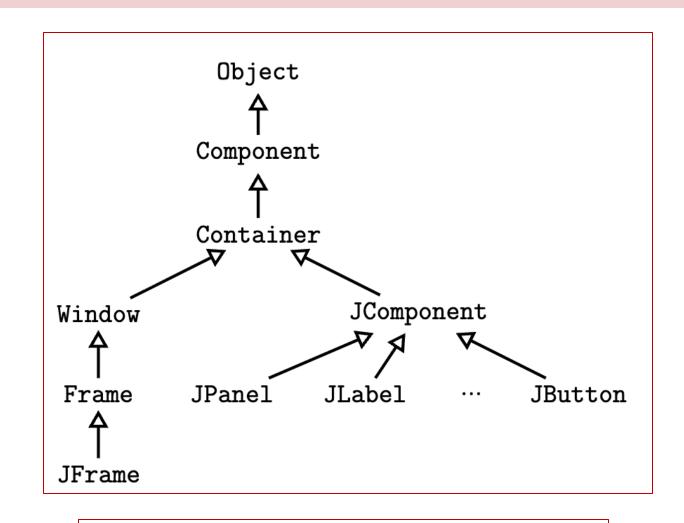
- an application window
- parent class of our Tic Tac Toe graphical interface
- can have title and window control buttons



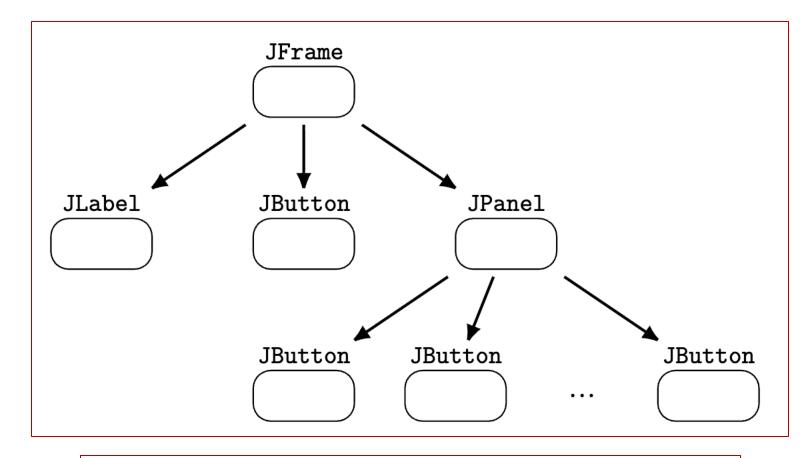
## Demo: TicTacToeGraphical constructor

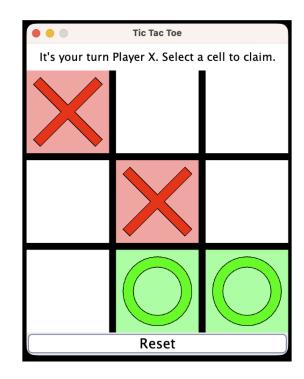
## **Swing Widget Types**

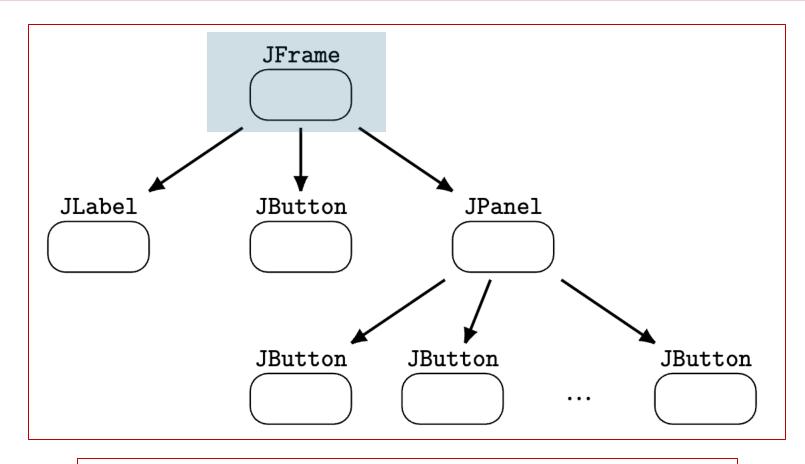
- JPanel
  - container that supports arrangement of other components inside it
- JLabel
  - for text
- JButton
  - can be clicked to invoke behavior
- Demo
  - the rest of the constructor

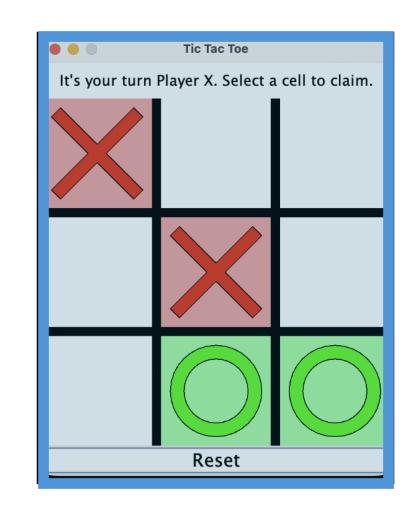


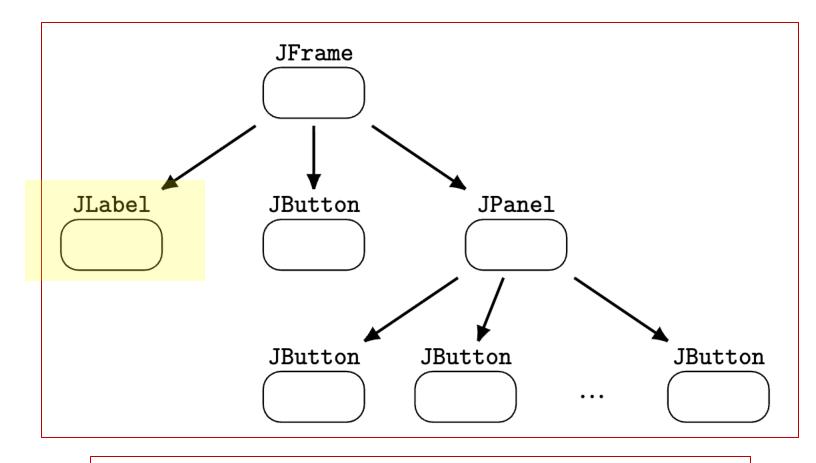
Inheritance diagram of Java Swing classes

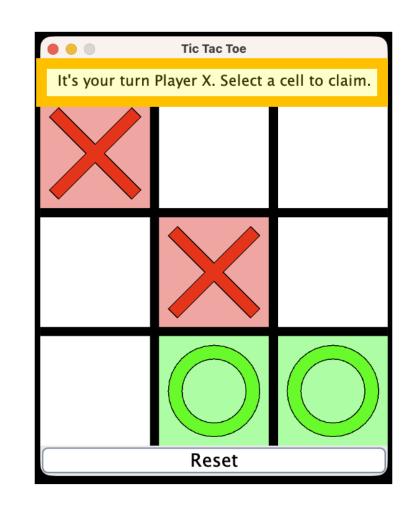












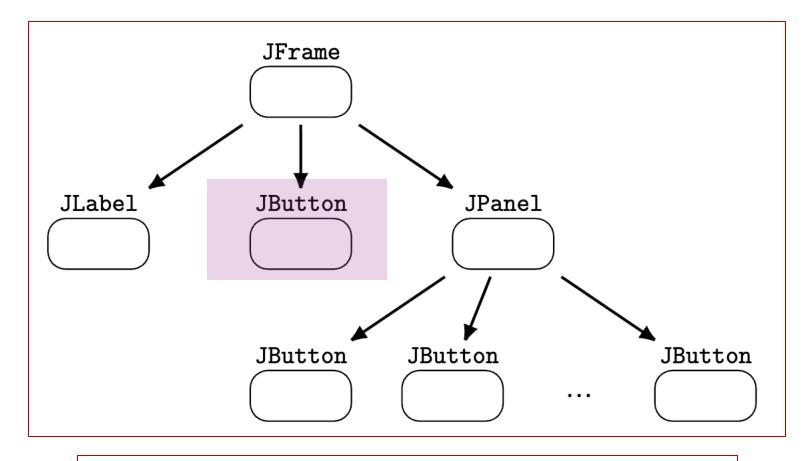
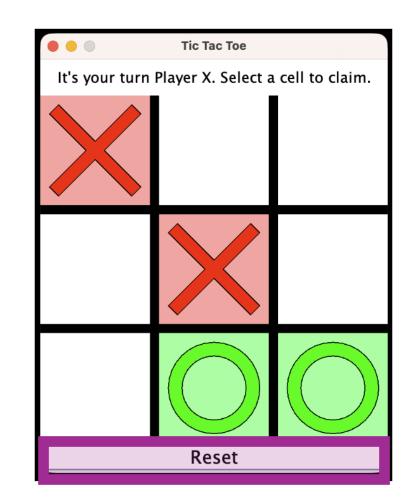
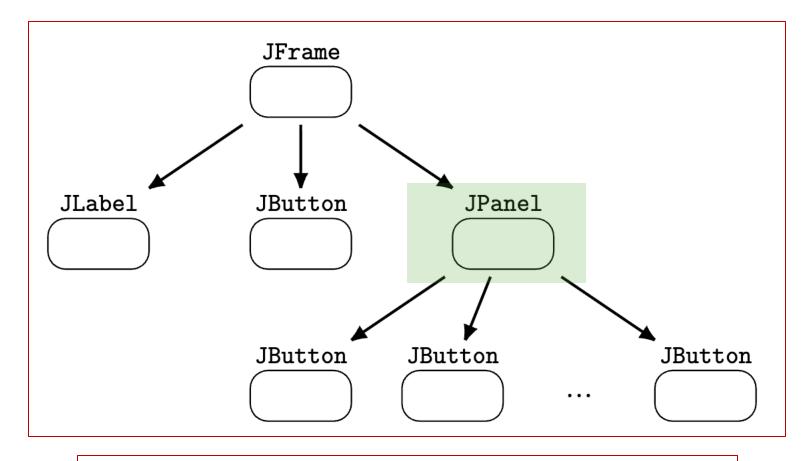
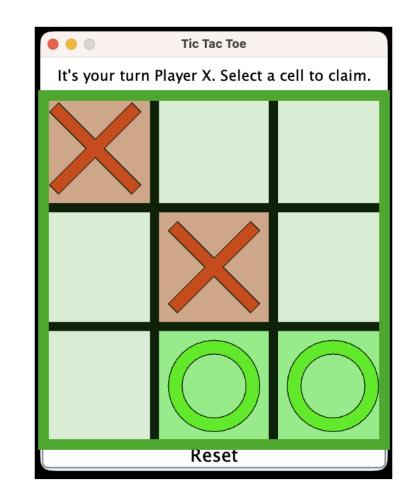


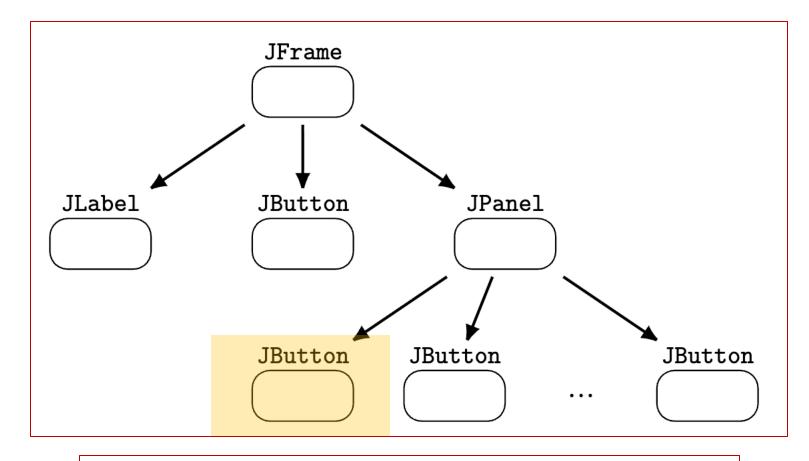
Illustration of how components are hierarchicially nested in our TicTacToe application. (This is not an inheritance diagram.)

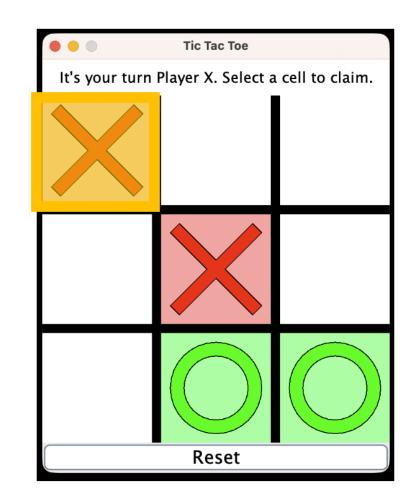
**Lecture 24: Graphical User Interfaces** 

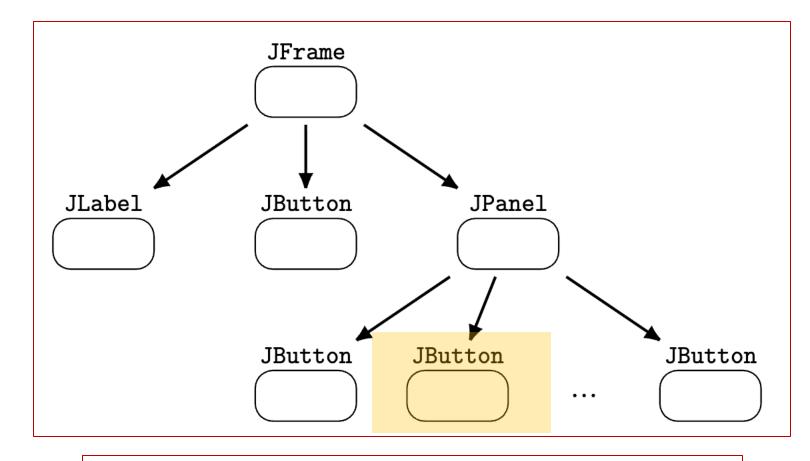


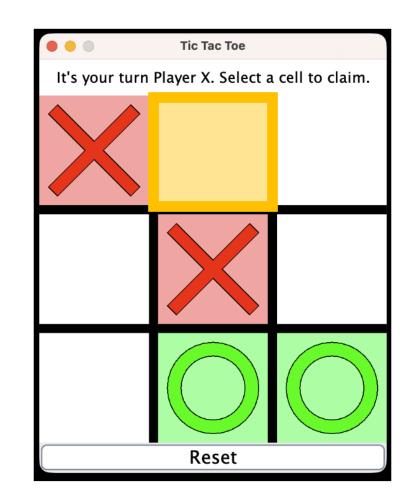


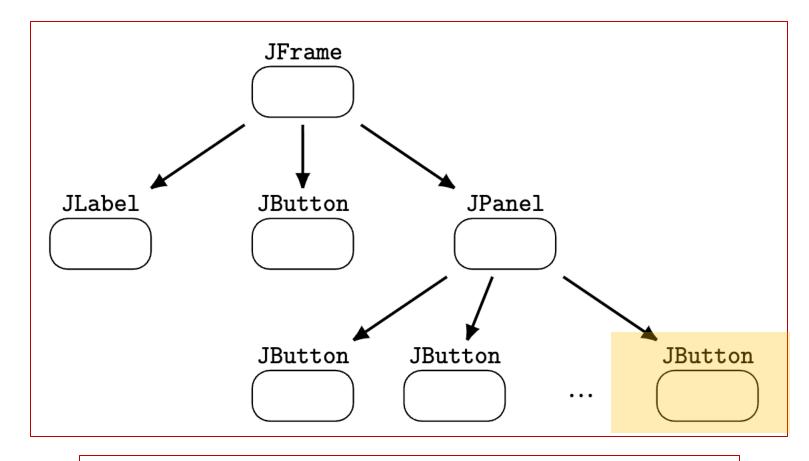


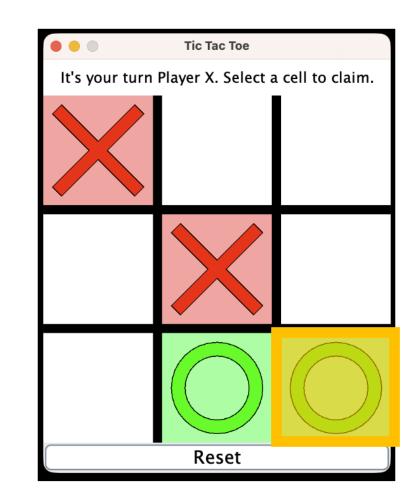




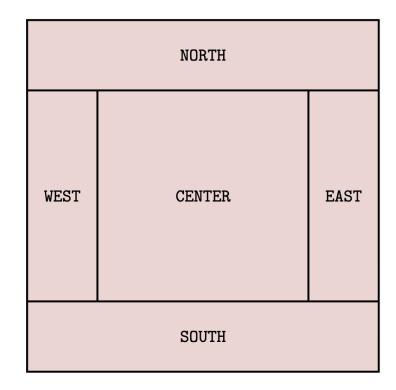


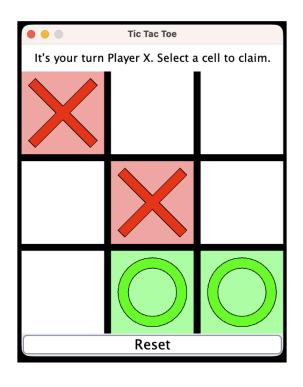


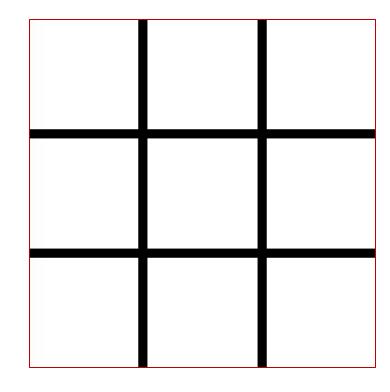




## **Layout Managers**







Border Layout Default location is Center

Grid layout (can have any dimensions) Items are added in row-major order

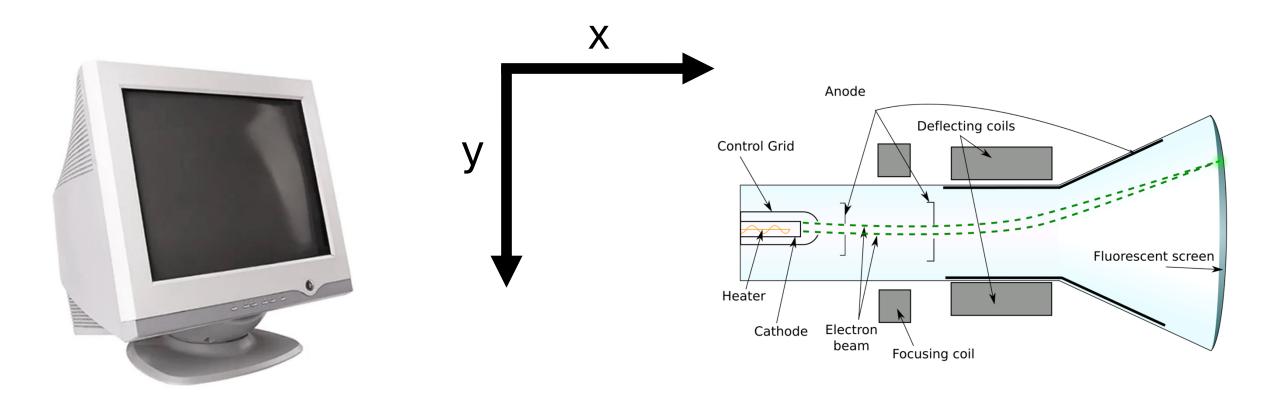
## Demo: looking at layouts

TicTacToeGraphical – border layout TicTacToeGrid – grid layout

### Demo: Model & Controller

TicTacToeGrid – has a field for the model (to be continued...)
TicTacToeCell – addSymbol and reset methods

## Computer graphics coordinates

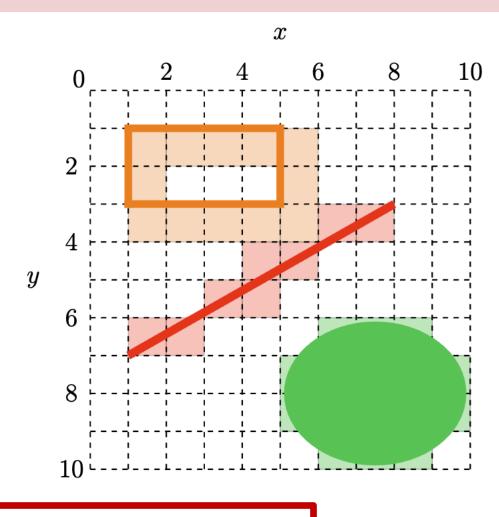


For historical reasons, the coordinate system we use for computer graphics has the origin in the upper left. The x axis points right and y axis points down.

Image: Photo of CRT monitor. https://www.sbcrecycle.com/business-recycling/computer-monitor/
Image: Diagram of a CRT Tube. Vector: Interiot, Raster: Theresa Knott. Creative Commons Attribution-Share Alike 3.0 Unported license.

## java.awt. Graphics and paint Component()

```
@Override
public void paintComponent(Graphics g) {
  super.paintComponent(g);
  g.setColor(Color.ORANGE);
  g.drawRect(1,1,4,2);
  g.setColor(Color.RED);
  g.drawLine(1,7,8,3);
  g.setColor(Color.GREEN);
  g.fillOval(5,6,5,4);
```



[Demo: paint component code in Tic Tac Toe]

Do not call paintComponent() yourself, you can only request that swing call it using setVisible() and repaint()

## Computer graphics & color choices

Poll: Do you have color blindness or color vision deficiency?

- A) Yes
- B)No
- C)Not sure or would rather not say

About 10% of the class responded "yes". If your app's colors did not have sufficient contrast, and you did not mitigate the issue in any way, then up to 1 in 10 users might find it hard to use! That's a significant portion of the user base.



PollEv.com/leahp text leahp to 22333

### Demo: Accessible colors

#### Color Blind Simulator

In our app, the shapes (X and O) make it usable to colorblind users even if the color contrast is low. However, to achieve the visual satisfaction of contrasting colors for more users, it is meaningful to adjust our color palette!

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### Metacognition

 Take 1 minute to write down a brief summary of what you have learned today

Thanks and have a great day!