Comp 401 Graphics

Instructor: Prasun Dewan

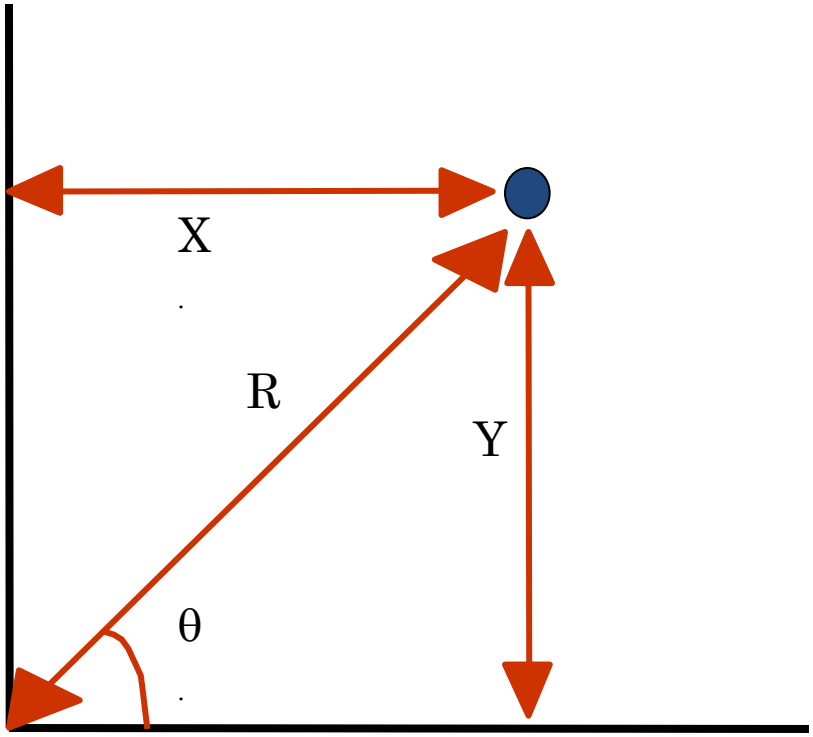
Prerequisite

- Interfaces

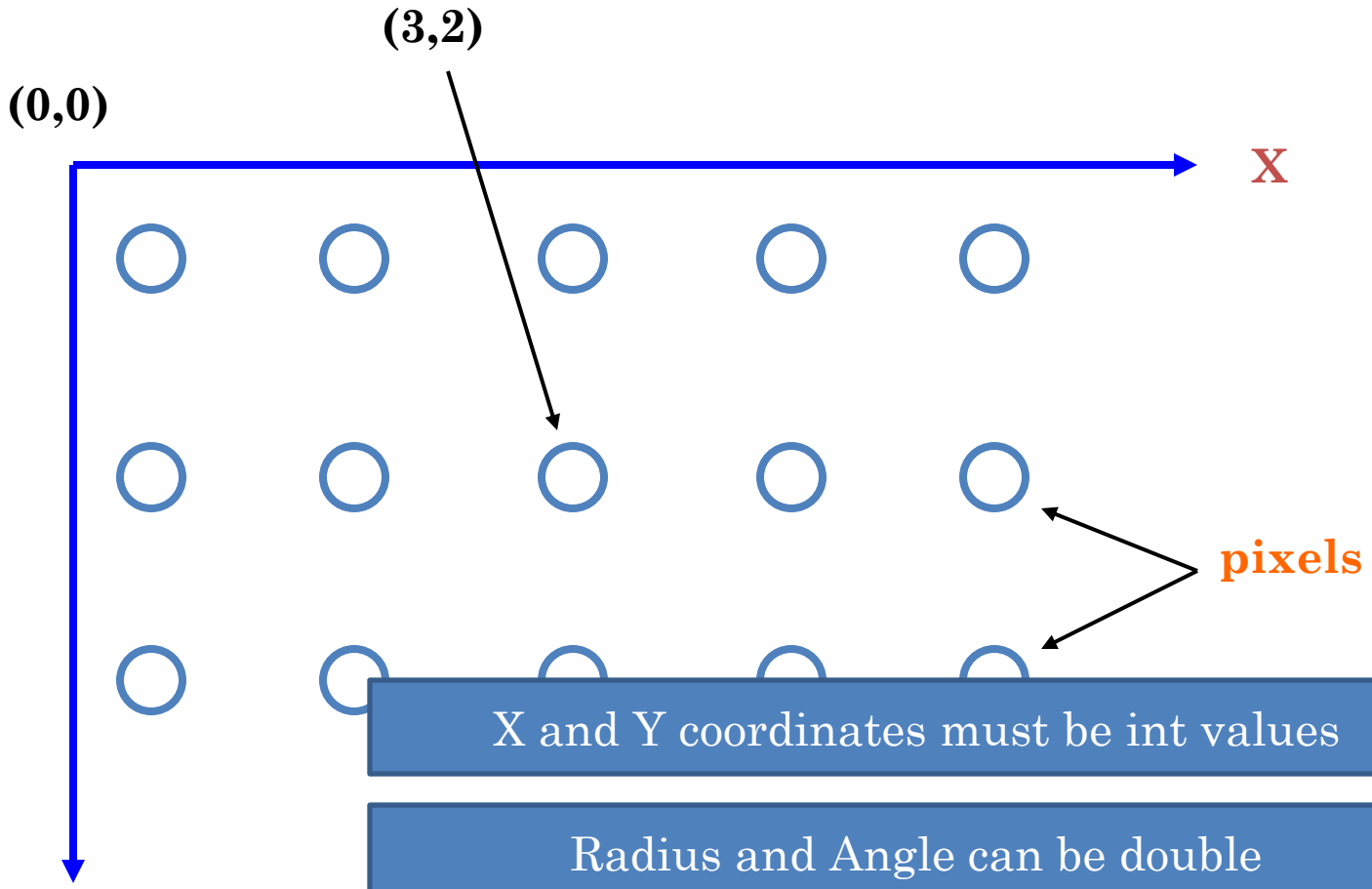
More on Objects

- Graphics types
- Test-first approach
- Stubs
- Physical vs. logical representation
- Representations with errors

Mathematical Point

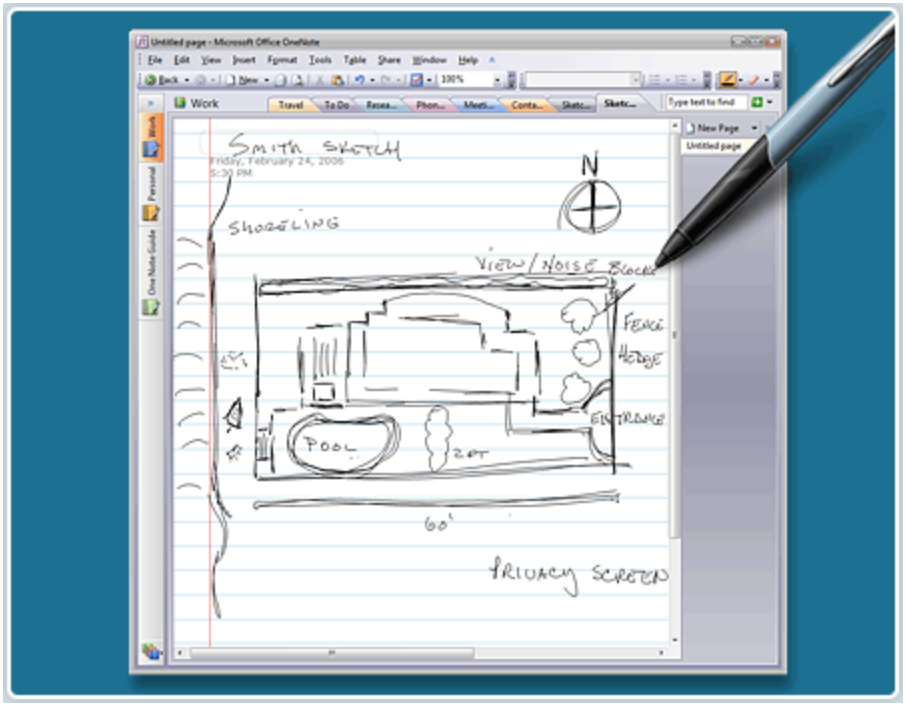


Java Coordinate System



- X and Y coordinates must be int values
- Radius and Angle can be double
- Angle is a decimal value between 0 and 2π
- Each window has its own coordinate system

Why not Mathematical Coordinate System



Computer coordinate system modeled after paper documents

In LTR (left to write languages) coordinate origing top left, and x, goes left to right, and y top to bottom

A window typically shows an underlying electronic document

Point Interface

```
public interface Point {
        public int getX();
        public int getY();
        public double getAngle();
        public double getRadius();
}
```

Read-only properties defining immutable object!

Top-down, test-first?

Stubs?

Point Interface (Review)

```
public interface Point {
        public int getX();
        public int getY();
        public double getAngle();
        public double getRadius();
}
```

Read-only properties defining immutable object!

Top-down, test-first?

Stubs?

ACartesianPoint Tester

```
public class ACartesianPointTester {
        public void test () {
                test (10, 0, 10.0, 0); // 0 degree angle
                test (0, 10, 10.0, Math.PI / 2); // 90 degree angle
                .. //more tests
        }
        public void test (int theX, int theY,
                        double theCorrectRadius, double theCorrectAngle) {
                Point point= new ACartesianPoint (theX, theY);
                double computedRadius = point.getRadius();
                double computedAngle = point.getAngle();
                System.out.println("-----------");
                System.out.println("X:" + theX);
                System.out.println("Y:" + theY);
                System.out.println("Expected Radius:" + theCorrectRadius);
                System.out.println("Computed Radius:" + computedRadius);
                System.out.println("Radius Error:"
                        + (theCorrectRadius - computedRadius));
                System.out.println("Expected Angle:" + theCorrectAngle);
                System.out.println("Computed Angle:" + computedAngle);
                System.out.println("Angle Error:" +
                        (theCorrectAngle - computedAngle));
                System.out.println("-----------");
        }

        }
```

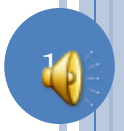
Stubs for ACartesianPoint

```
public class ACartesianPoint implements Point {
        public ACartesianPoint(int theX, int theY) {
        }
        public ACartesianPoint(double theRaidus,
                                        double theAngle) {
        }
        public int getX() {
                return 0;
        }
        public int getY() {
                return 0;
        }
        public double getAngle() {
                return 0;
        }
        public double getRadius() {
                return  0;
        }
}
```

Test-First Approach

1. Write the interface
2. Create a class with stubs for each interface method and constructor
    1. If method is procedure method does nothing
    2. If method is function, it returns 0 or null value
    3. No variables need be declared as this point!
3. Write a tester for it
4. Write/rewrite in one or more stub methods
5. Use tester
6. If tester results not correct, go back to 4

Steps may be combined for simple classes!

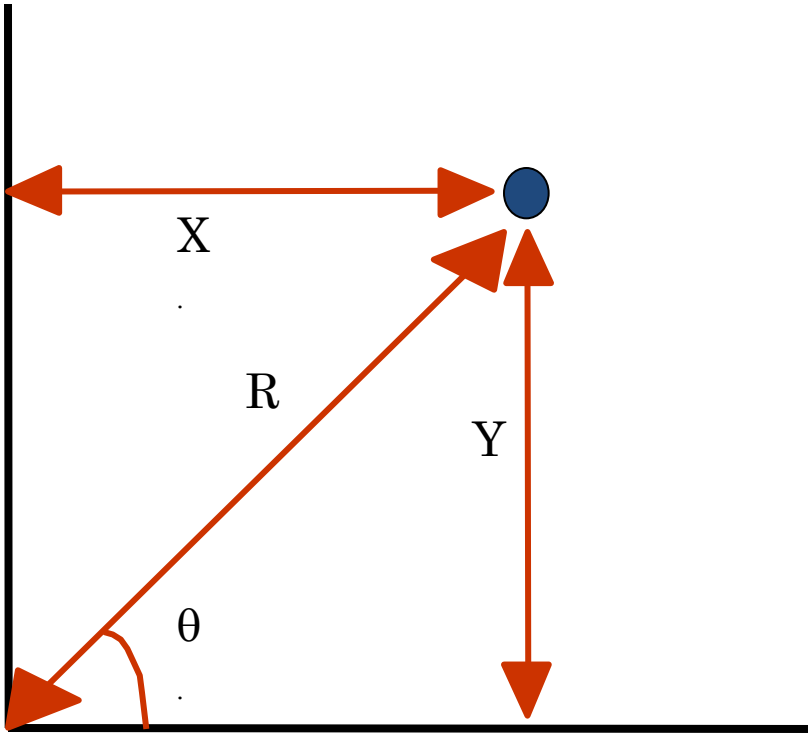


Point Variable Representations

- X, Y (Cartesian Representation)
- Radius, Angle (Polar Representation)
- X, Radius 
- X, Y, Radius, Angle
- …

Does not completely specify the point

Algorithms



Cartesian Representation

$R = \text{sqrt}\ (X^2 * Y^2)$

$\theta = \arctan\ (Y/X)$

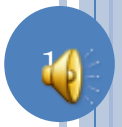
Polar Representation

$X = R*\cos(\theta)$

$Y = R*\sin(\theta)$

Class: ACartesianPoint

```
public class ACartesianPoint implements Point {
  int x, y;
  public ACartesianPoint(int theX, int theY) {
    x = theX;
    y = theY;
  }
  public ACartesianPoint(double theRadius, double theAngle) {
     x =  (int) (theRadius*Math.cos(theAngle));
     y = (int) (theRadius*Math.sin(theAngle));
  }
  public int getX() { return x; }
  public int getY() { return y; }
  public double getAngle() { return Math.atan2(y, x); }
  public double getRadius() { return Math.sqrt(x*x + y*y); }
}
```



Class: APolarPoint

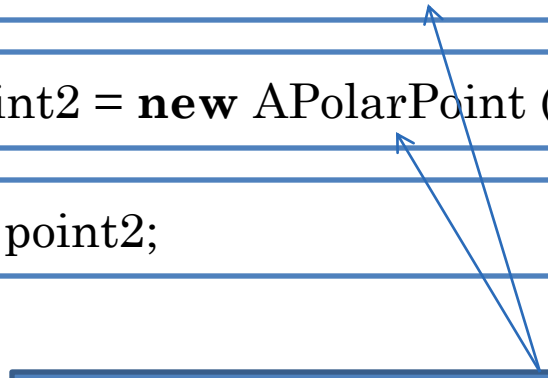
```
public class APolarPoint implements Point {
  double radius, angle;
  public APolarPoint(double theRadius, double theAngle) {
    radius = theRadius;
    angle = theAngle;
  }
  public APolarPoint(int theX, int theY) {
    radius = Math.sqrt(theX*theX + theY*theY);
    angle = Math.atan((double) theY/theX);
  }
  public int getX() { return (int) (radius*Math.cos(angle)); }
  public int getY() { return (int) (radius*Math.sin(angle)); }
  public double getAngle() { return angle; }
  public double getRadius() { return radius; }
}
```

Using the Interface and Its Implementations

```
Point point1 = new ACartesianPoint (50, 50);
```

```
Point point2 = new APolarPoint (70.5, Math.pi()/4);
```

```
point1 = point2;
```



Constructor chooses implementation

Constructor cannot be in interface

Representing Geometric Objects

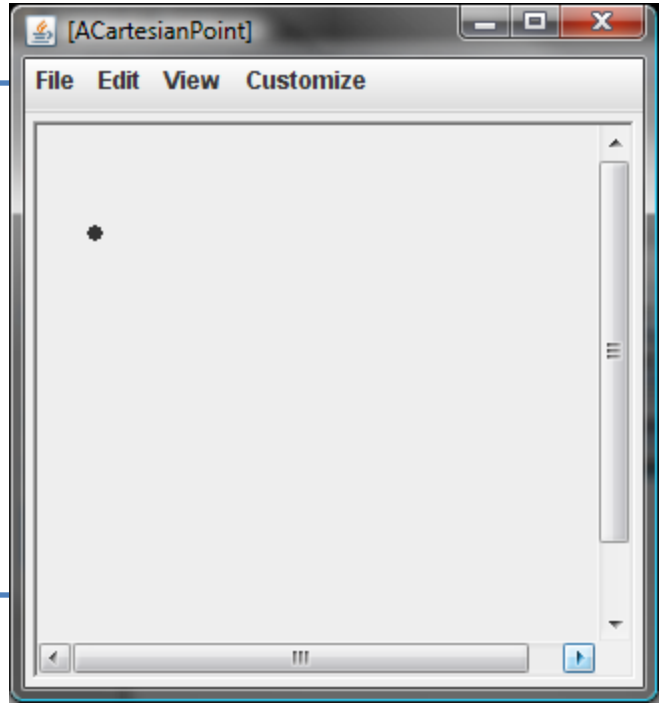
- Geometric example to show multiple useful implementations of an interface
- Most geometric objects have multiple representations

What is a Representation

- Logical representation
  - Defined by its interface
  - Specifies properties
- Physical representation
  - Defined by its instance variables
- ACartesianPoint and APolarPoint have the same logical reperesentation but different physical representation

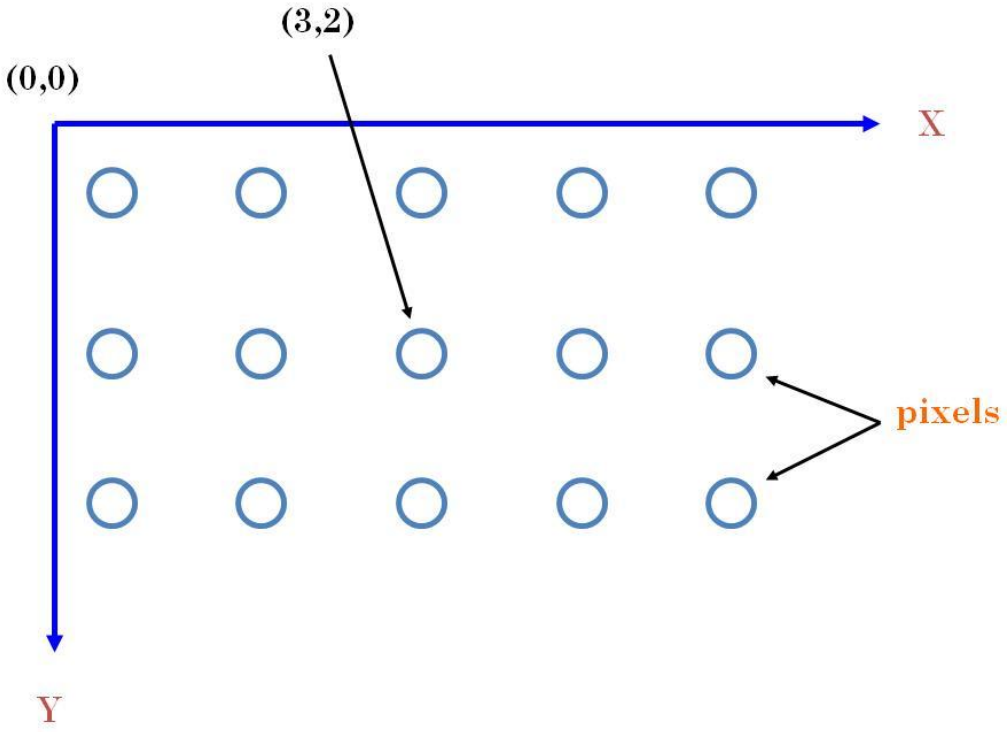
Using ObjectEditor

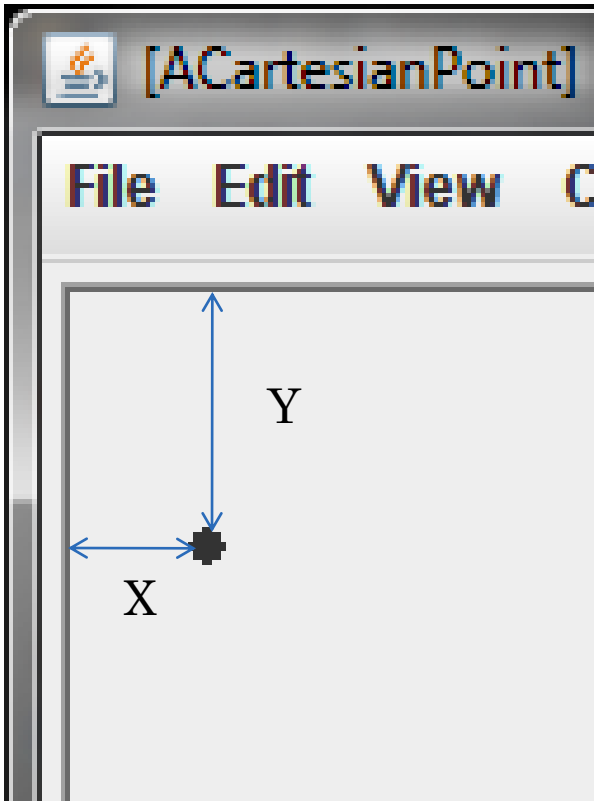
```
public interface Point {
        public int getX();
        public int getY();
        public double getAngle();
        public double getRadius();
}
```




```
ObjectEditor.edit(new ACartesianPoint (25, 50));
```

Java Graphics





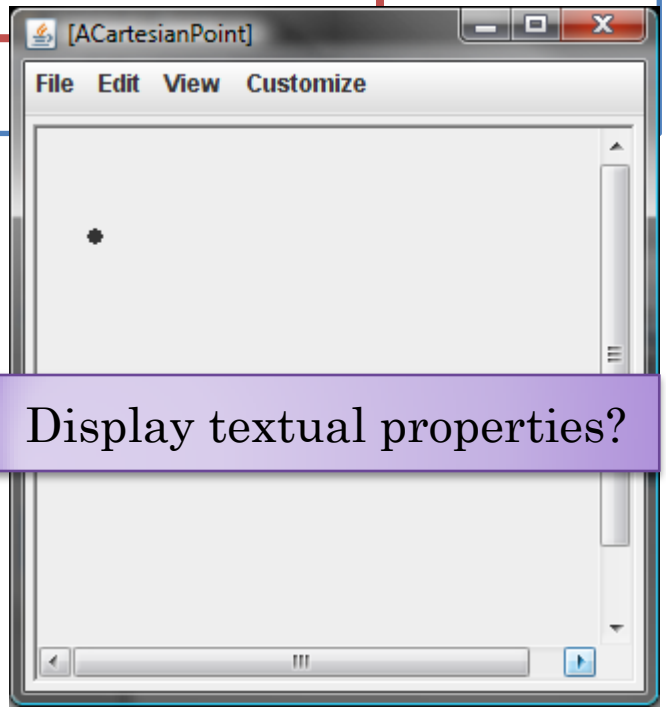
ObjectEditor Point Rules

- An object is recognized as a point representation if:
  - Its interface or class has the string "Point" in its name or has a Point annotation
  - It has (read-only) int properties, X and Y, representing Cartesian window coordinates
  - Can have additional properties

```
@StructurePattern(StructurePatternNames.POINT_PATTERN)
public interface Point {
        public int getX();
        public int getY();
        public double getAngle();
        public double getRadius();
}
```

Point Annotation

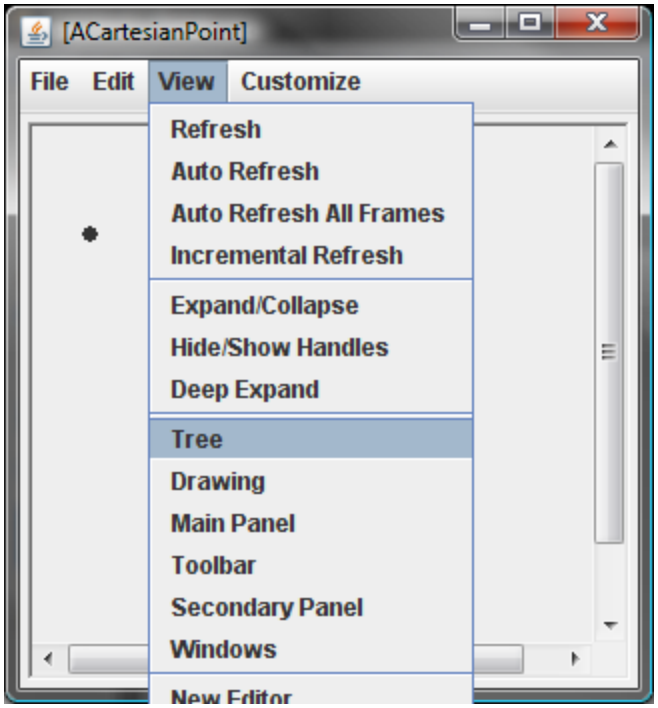
```
import util.annotations.StructurePattern;
import util.annotations.StructurePatternNames;
@StructurePattern(StructurePatternNames.POINT_PATTERN)
public interface Point{
    …
}
```



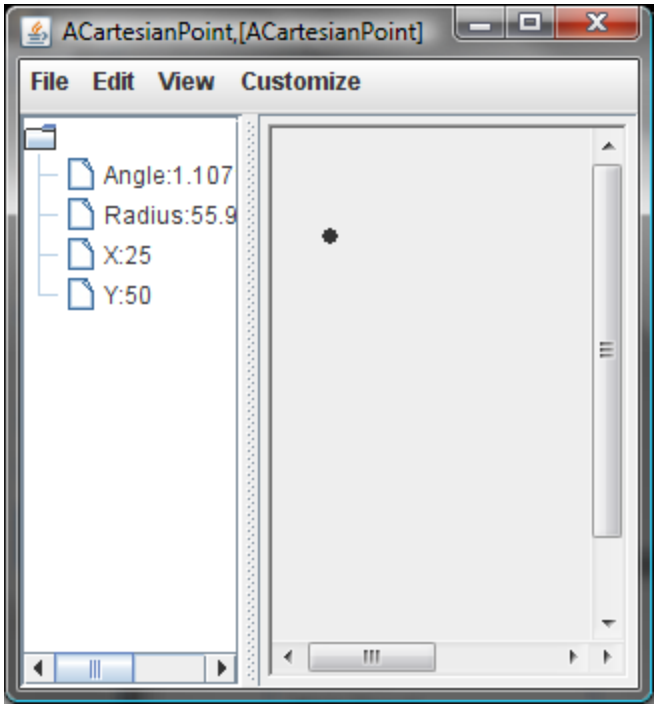
Display textual properties?

Structure(<PatternName>) before class or interface asserts that the type is following the pattern. ObjectEditor ignores class/interface name and gives warnings if methods do not follow the pattern

Adding Tree View

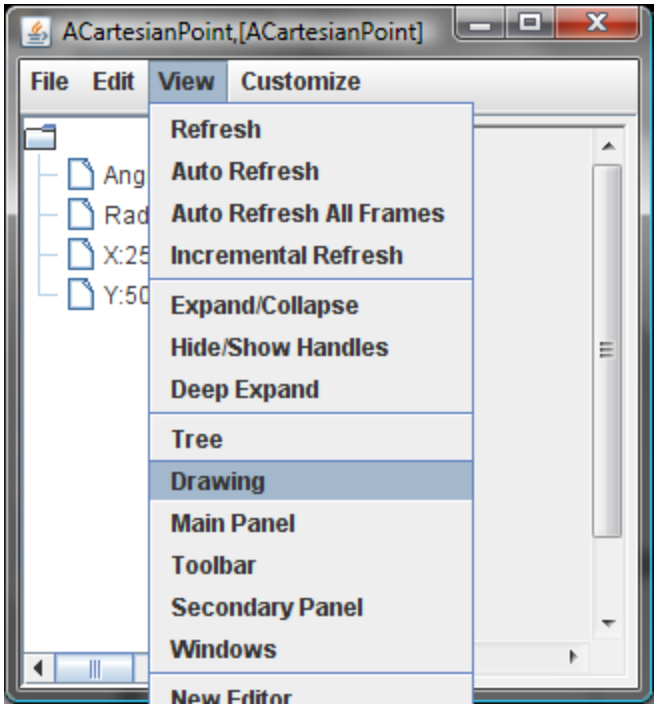


Tree View

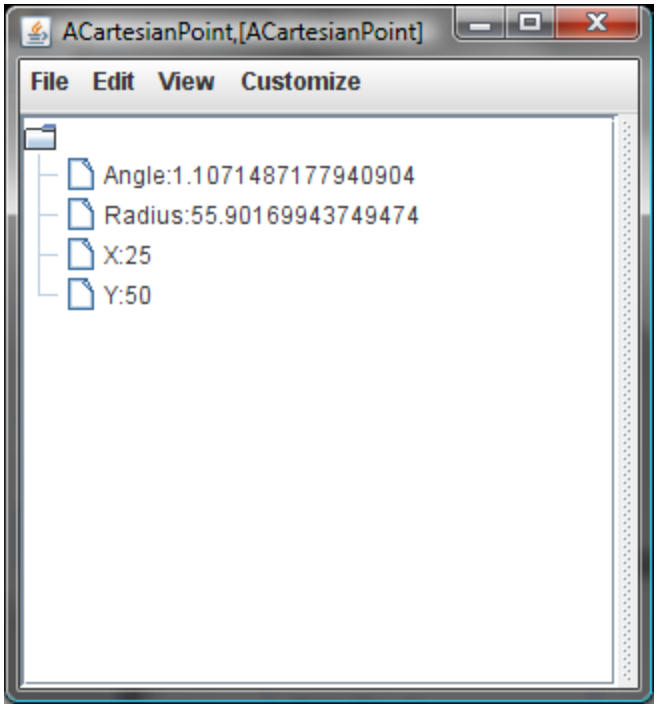



```
OEFrame frame = ObjectEditor.edit(new ACartesianPoint (25,
50));
frame.showTreePanel();
```

Removing Graphics View

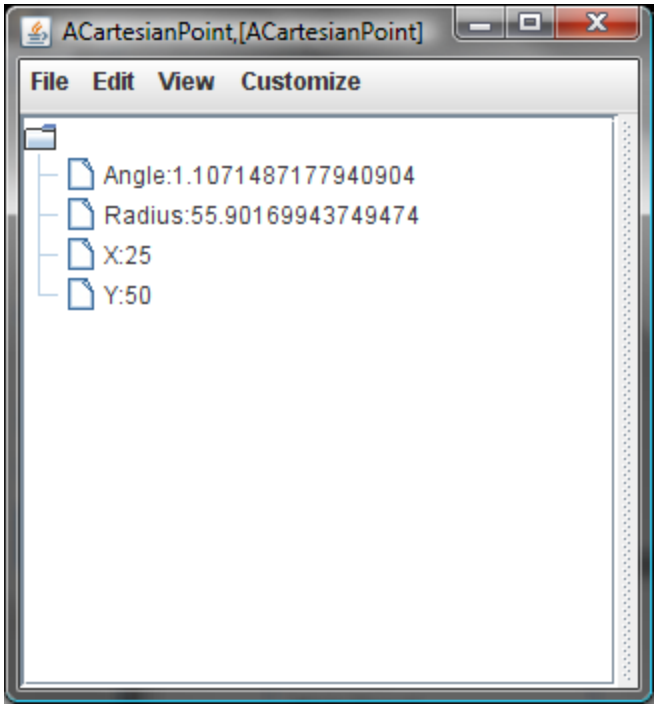


Tree-only View



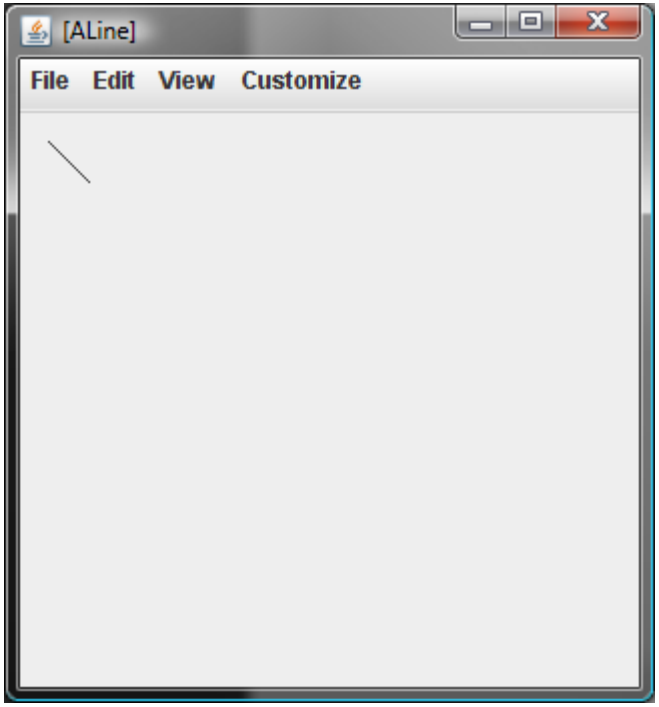

```
OEFrame frame = ObjectEditor.edit(ObjectEditor.edit(new
ACartesianPoint (25, 50);
frame.hideDrawingPanel(); //to be added
frame.showTreePanel();
```

Customizing the Size of the Window




```
OEFrame frame = ObjectEditor.edit(ObjectEditor.edit(new
ACartesianPoint (25, 50);
frame.setSize(400, 300); // width and height
Frame.setLocation(500, 400);// x and y
```

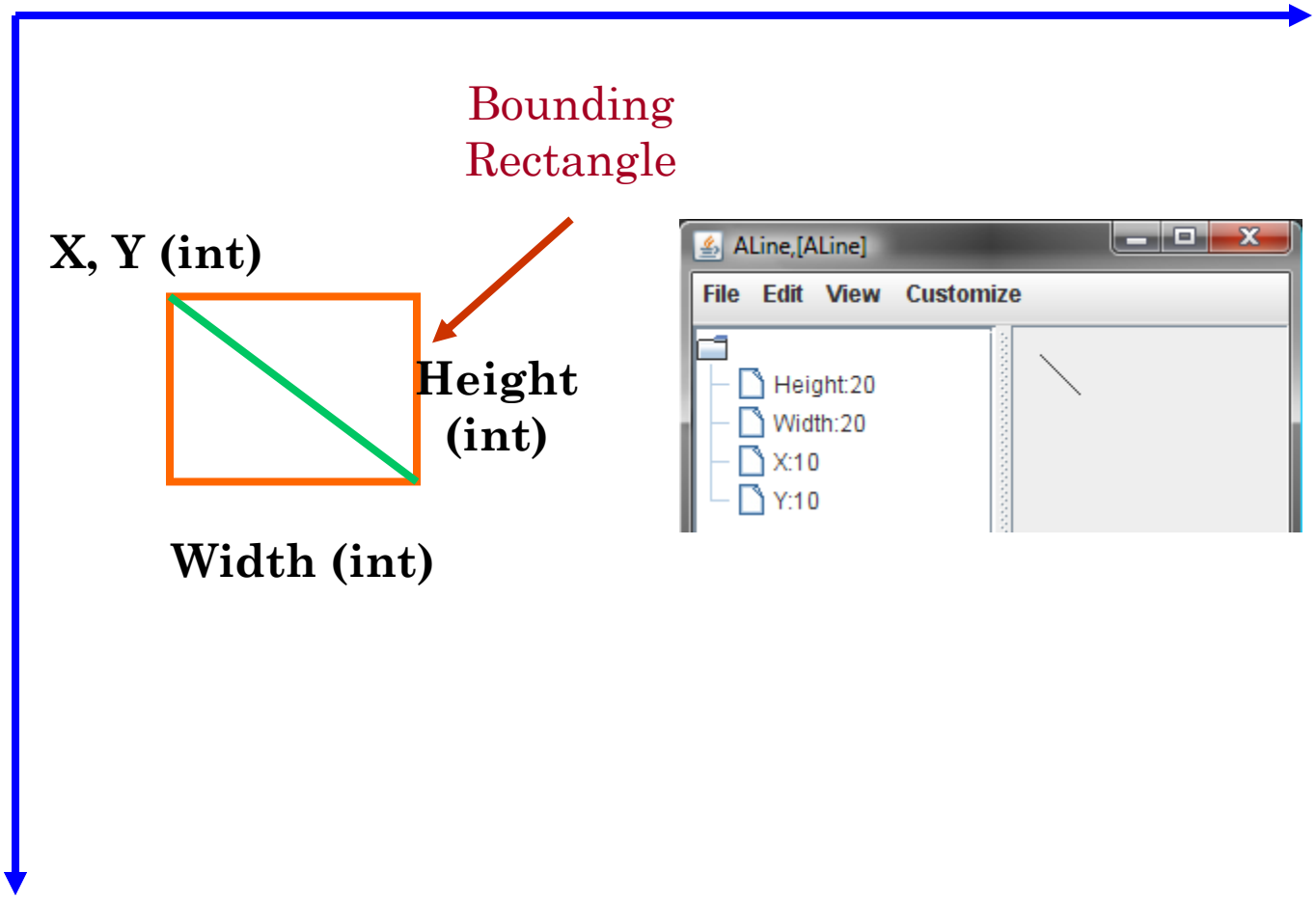
Line?



What is a Representation

- Logical representation
  - Defined by its interface
  - Specifies properties
- Physical representation
  - Defined by its instance variables

Line Logical Representation (Properties)



Line Implementation

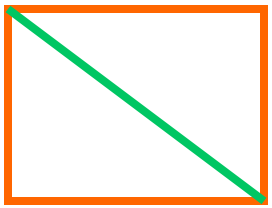
```
@StructurePattern(StructurePatternNames.LINE_PATTERN)
public class ALine  implements Line{
        int x, y, width, height;
        public ALine (int initX, int initY, int initWidth, int initHeight) {
                x = initX;
                y = initY;
                width = initWidth;
                height = initHeight;
        }
        public int getX() {return x;}
        public void setX(int newX) {x = newX;}
        public int getY() {return y;}
        public void setY(int newY) {y = newY;}
        public int getWidth() {return width;}
        public void setWidth(int newVal) {width = newVal;}
        public int getHeight() {return height;}
        public void setHeight(int newHeight) {height = newHeight;}
}
```

Logical representation == physical repersentation

ObjectEditor Shape Rules

Line

X, Y



Height

Width

Rectangle

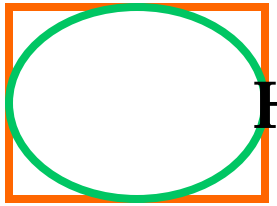
X, Y

Height

Width

Oval

X, Y



Height

Width

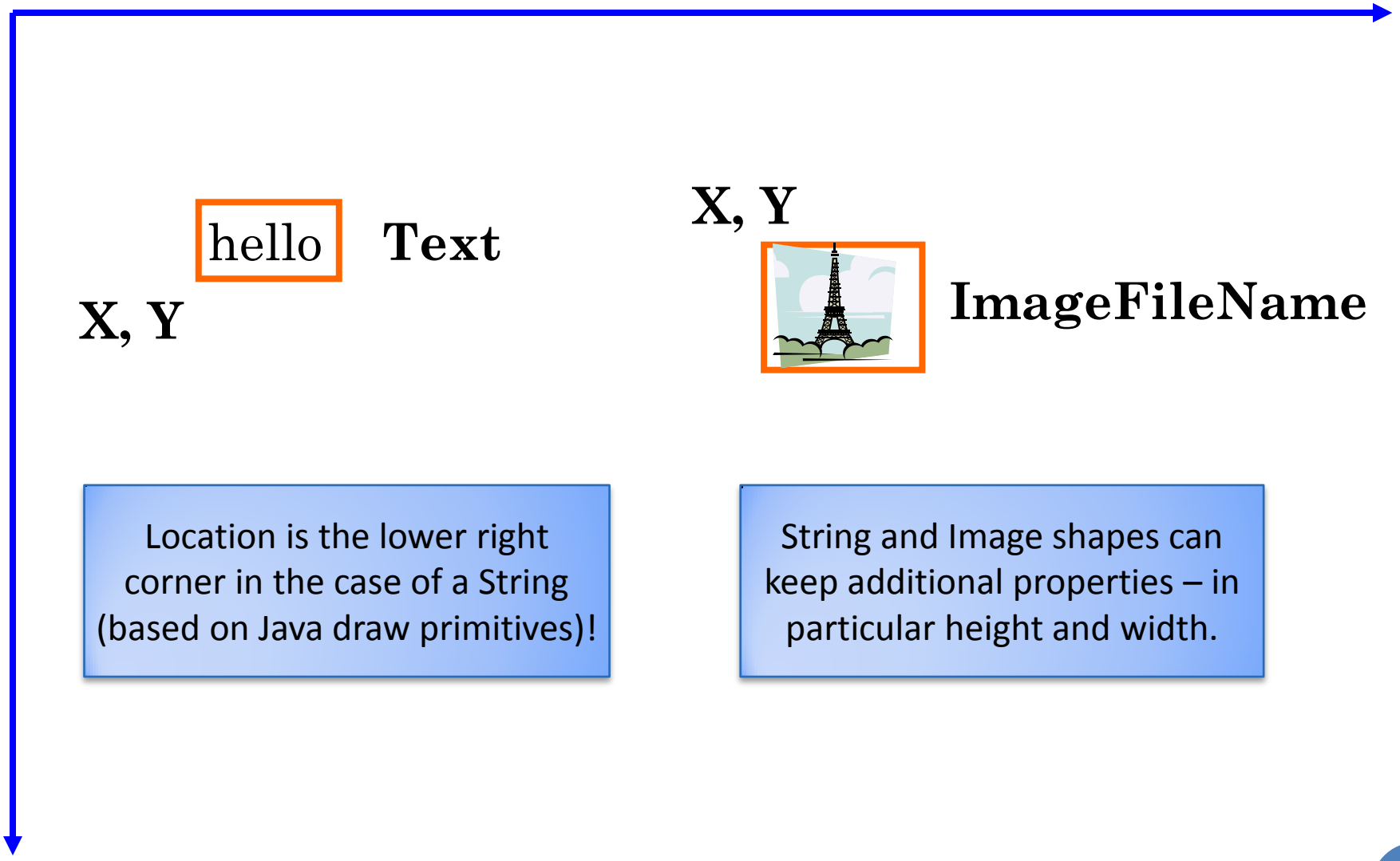
XY-Based Line/Oval/Rectangle Interface

```
public interface Rectangle
        public int getX();
        public void setX(int newX);
        public int getY();
        public void setY(int newY);
        public int getWidth();
        public void setWidth(int newVal);
        public int getHeight();
        public void setHeight(int newHeight);
}
```

Oval/Rectangle logical representation?

Other shapes needed in project?

XY-based String and Image Rules

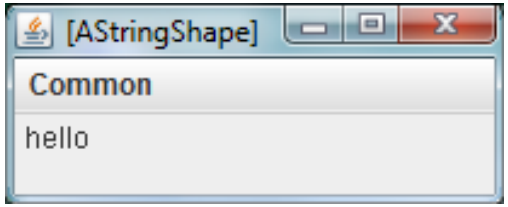


Location is the lower right corner in the case of a String (based on Java draw primitives)!

String and Image shapes can keep additional properties – in particular height and width.

AString Shape

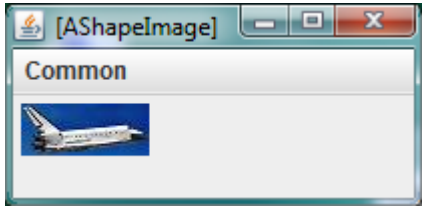
```
@StructurePattern(StructurePatternNames.STRING_PATTERN)
public class AStringShape implements StringShape {
  String text;
  int x, y;
  public AStringShape(String initText, int initX, int initY) {
    text = initText;
    x = initX;
    y = initY;
  }
  public int getX() {return x;}
  public void setX(int newX) {x = newX;}
  public int getY() { return y;}
  public void setY(int newY) {y = newY;}
  public String getText() {return text;}
  public void setText(String newVal) {text = newVal;}
}
```




```
public static void main(String args[]) {
  StringShape hello= new AStringShape("hello", 0, 10);
  ObjectEditor.edit(hello);
}
```

Image Implementation

```
@StructurePattern(StructurePatternNames.IMAGE_PATTERN)
public class AShapeImage implements ImageShape {
  String imageFileName;
  int x, y;
  public AShapeImage (String initImageFileName, int initX, int initY) {
    imageFileName = initImageFileName;
    x = initX;
    y = initY;
  }
  public int getX() {return x;}
  public void setX(int newX) {x = newX;}
  public int getY() { return y; }
  public void setY(int newY) {y = newY;}
  public String getImageFileName() {return imageFileName;}
  public void setImageFileName(String newVal) {imageFileName = newVal ;}
}
```




```
public static void main (String args[]) {
      ImageShape shuttle = new AShapeImage("shuttle2.jpg", 0, 0);
      ObjectEditor.edit(shuttle);
}
```

Short file name (without "/") implies file in the project folder, the one containing src and bin

ObjectEditor vs. Java Graphics

```
public class ALine  implements Line{
        int x, y, width, height;
        public ALine (int initX, int initY, int in
                x = initX;
                y = initY;
                width = initWidth;
                height = initHeight;
        }
        public int getX() {return x;}
        public void setX(int newX) {x = newX;}
        public int getY() {return y;}
        public void setY(int newY) {y = newY;}
        public int getWidth() {return width;}
        public void setWidth(int newVal) {widt
        public int getHeight() {return height;}
        public void setHeight(int newHeight) {height = newHeight;}
}
```

Encapsulates state of line in one object

Object and view are independent (can show object in tree view or graphics view)

If external state of object changes, the display is updated

```
ObjectEditor.edit(new ALine(x, y, w, h));
```

```
graphics.drawLine(x1, y1, x2, y2)
```

Requires knowledge of panel, paint events, inheritance

Graphics Types

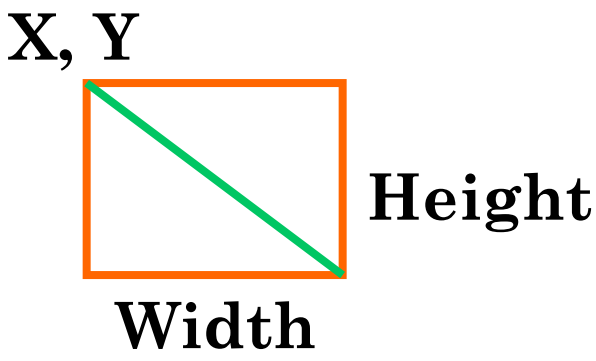
- Point
  - No shape
  - Just a location
- Line/Rectangle/Oval
  - A shape
  - A location plus an area on the screen determined by object

ObjectEditor Graphics

- Can automatically display objects representing points, rectangles, ovals, and lines as corresponding graphics
  - Java provides libraries to manually display graphics
- Has rules for recognizing these objects
- Rules based on Java graphics standards
  - Inverted coordinate system
  - Cartesian coordinates for points
  - Bounding rectangles for lines, rectangles, ovals
- Plus naming conventions and annotations

ObjectEditor Bounding Box Rules

- A shape object describes its bounding box if it:
  - represents the size of the bounding box using int (read-only or editable) properties, “Height”, and “Width”
  - describes the location of the upper left corner of the bounding box using “X”, “Y” properties of type int



ObjectEditor Line/Shape/Oval Rules

- An object is recognized as a rectangle/line/oval if:
  - Its interface or class has the string "Rectangle"/"Oval"/"Line" in its name or has a Point/Oval/Line annotation
  - It has (readonly or editable) properties describing the bounding box of the shape
  - Can have additional properties

```
import util.annotations.StructurePattern;
import util.annotations.StructurePatternNames;
@StructurePattern(StructurePatternNames.LINE_PATTERN)
public interface Line{
    …
}
```

ObjectEditor String Shape Rules

- An object is recognized as a string shape if:
  - Its interface or class has the string "String" in its name or a String annotation
  - It has a (readonly/editable) "Text" of type String describing the string to be displayed
  - It has (readonly or editable) int "X", "Y" properties describing the location of the lower left corner of the bounding box of the shape
  - Can have additional properties

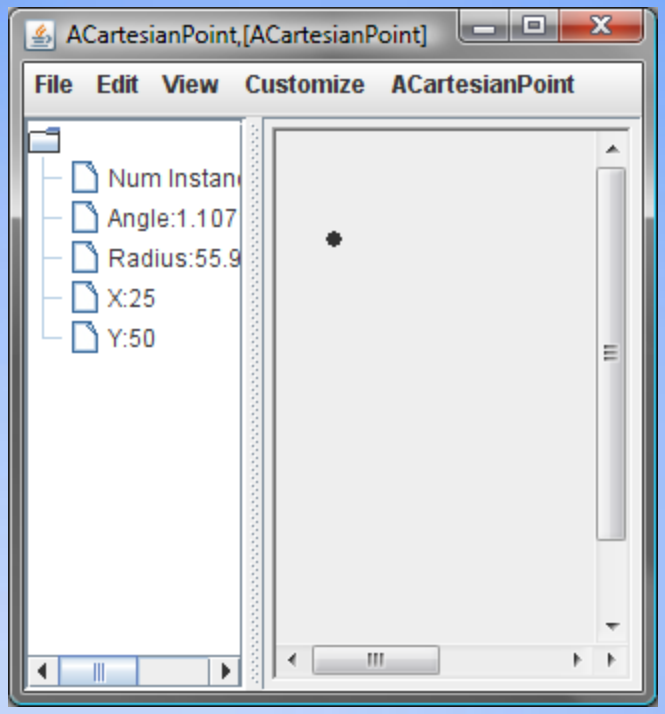
```
public interface StringShape {
  public int getX();
  public void setX(int newX);
  public int getY();
  public void setY(int newY);
  public String getText() ;
  public void setText(String newVal);
}
```

ObjectEditor Image Shape Rules

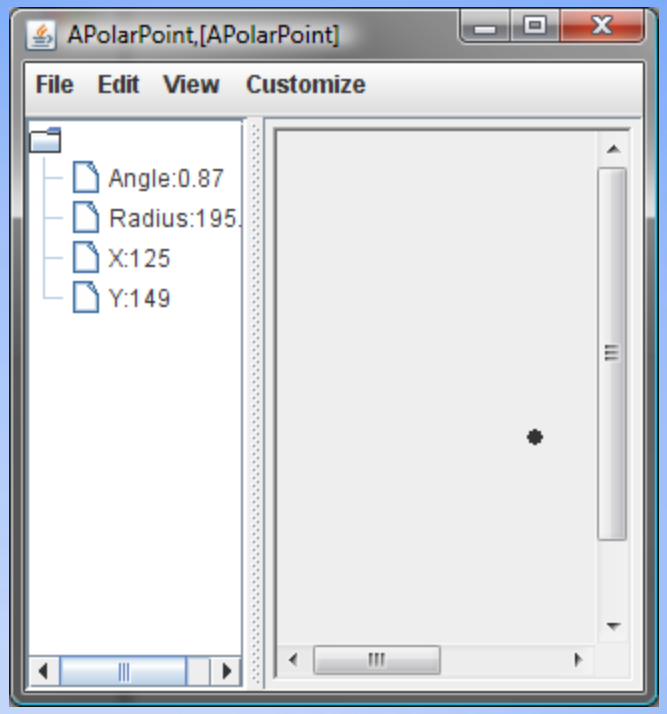
- An object is recognized as an image shape if:
  - Its interface or class has the string "Image" in its name
  - It has a (readonly/editable) String "ImageFileName" property describing the name of the image file to be displayed
  - It has (readonly or editable) int X, Y properties describing the location of the upper left corner of the bounding box of the shape
  - Can have additional properties

```
public interface ImageShape {
public int getX();
 public void setX(int newX);
 public int getY();
 public void setY(int newY);
 public String getImageFileName() ;
 public void setImageFileName(String newVal);
}
```

Typing Point Objects



ACartesianPoint



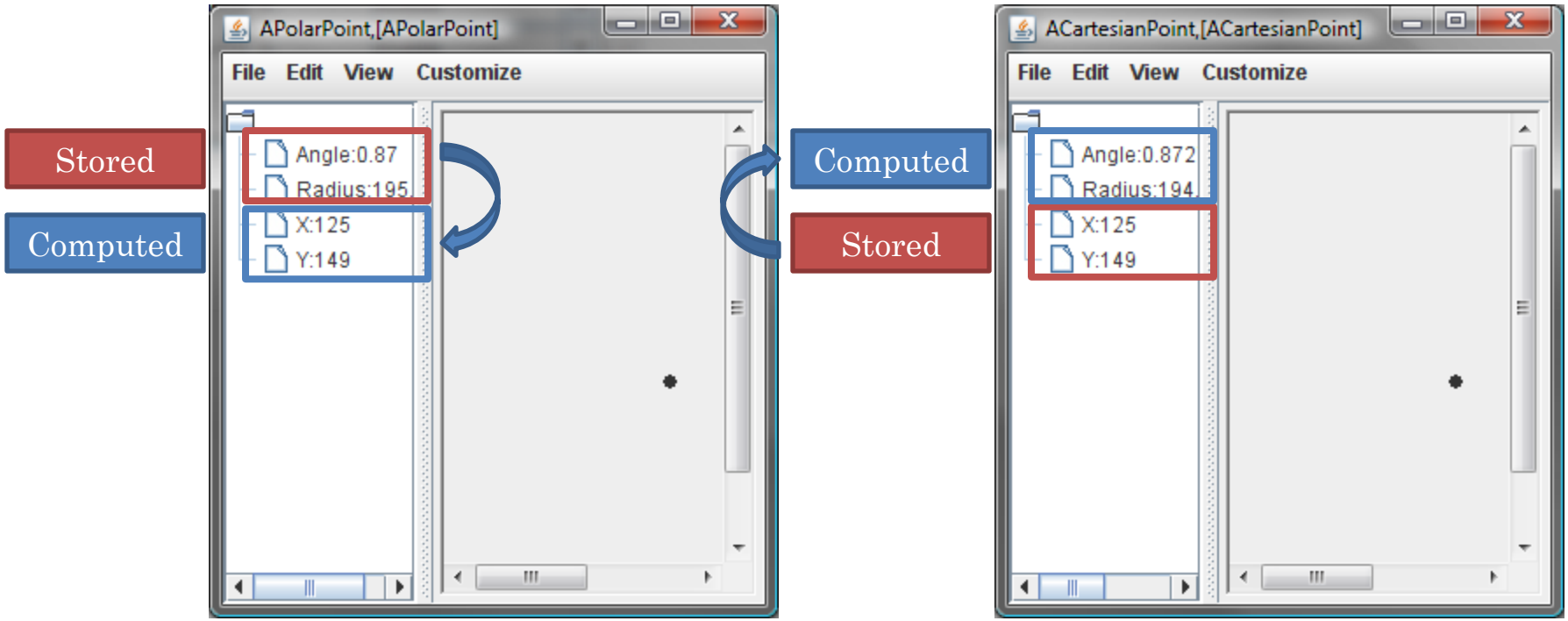
APolarPoint

Point

Equivalent Representations

```
ObjectEditor.edit(new APolarPoint (195.05, 0.87));
```

```
ObjectEditor.edit(new ACartesianPoint (125, 149));
```



Cartesian coordinates the same but not the polar coordinates!

Reason for Error

```
public int getX() {
        return (int) (radius*Math.cos(angle));
}
```

- Calculated X and Y values are truncated when converted to int

Consequence of Physical Representation Choice?

- Physical representation determines
  - Space efficiency
  - Time efficiency
  - Precision of various properties

EXTRA SLIDES

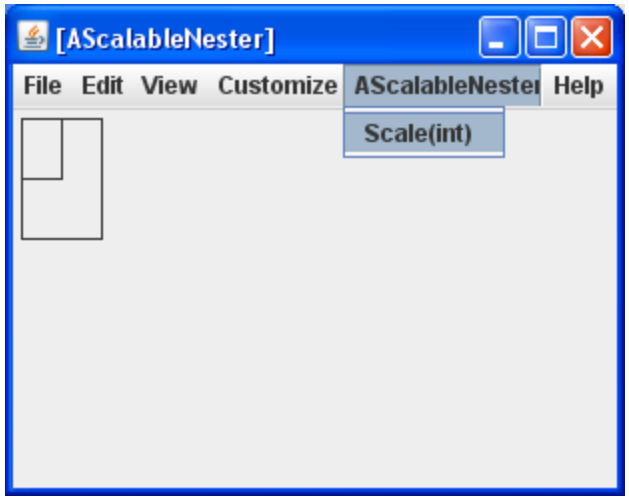
ObjectEditor Shape Rules

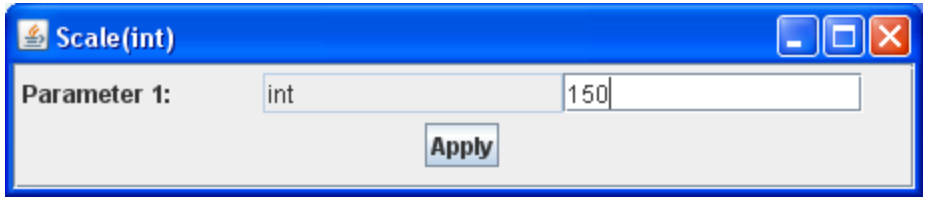
- An object is recognized as a rectangle/line/oval if:
  - Its interface or class has the string "Rectangle"/"Oval"/"Line" in its name
  - It has properties describing the bounding box of the shape
  - Can have additional properties

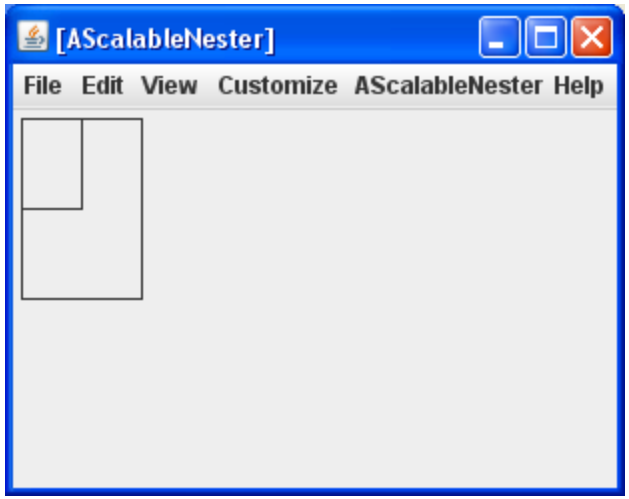
```
public interface Line {
    public int getX();
    public void setX(int newVal);
    public int getY();
    public void setY(int newVal);
    public int getWidth();
    public void setWidth(int newVal);
    public int getHeight() ;
    public void setHeight(
        int newVal);
}
```

```
public interface AnotherLine {
    public Point getLocation();
    public void setLocation(
        Point newVal);
    public int getWidth();
    public void setWidth(int newVal);
    public int getHeight() ;
    public void setHeight(int newVal);
}
```

AScalableNester







Properties
NestedRectangle (Rectangle)
EnclosingRectangle (Rectangle)

Methods (non getter/setter)
public void scale (**int** percentage)

ACartesianPlane Stubs

```
public class ACartesianPlane implements CartesianPlane {
    int axesLength ;
    Line xAxis;
    Line yAxis;
    Label xLabel;
    Label yLabel;
    final int LABEL_BOUNDS_SIDE_LENGTH = 10;
    public ACartesianPlane (int theAxesLength,
            int theOriginX, int theOriginY ) {

    }
    public Line getXAxis() {return xAxis;}
    public Line getYAxis() {return yAxis;}
    public int getAxesLength() {return axesLength;}
    public void setAxesLength(int newVal) {

    }
    public Label getXLabel() {return xLabel;}
    public Label getYLabel() {return yLabel;}

}
```

ObjectEditor vs. Java Graphics

```
public class ALine  implements Line{
        int x, y, width, height;
        public ALine (int initX, int initY, int in
                x = initX;
                y = initY;
                width = initWidth;
                height = initHeight;
        }
        public int getX() {return x;}
        public void setX(int newX) {x = newX;}
        public int getY() {return y;}
        public void setY(int newY) {y = newY;}
        public int getWidth() {return width;}
        public void setWidth(int newVal) {widt
        public int getHeight() {return height;}
        public void setHeight(int newHeight) {height = newHeight;}
}
```

Encapsulates state of line in one object

Object and view are independent (can show object in tree view or graphics view)

If external state of object changes, the display is updated

```
ObjectEditor.edit(new ALine(x, y, w, h));
```

```
graphics.drawLine(x1, y1, x2, y2)
```

Requires knowledge of panel, paint events, inheritance

Graphics Types Seen So Far

- Point
  - No shape
  - Just a location
- Line
  - A shape
  - A location plus an area on the screen determined by object
- Other shapes and rules?
  - Line rules with slight adaptations

Line, Rectangle Oval, Label Patterns

Oval

```
public interface
        public
        public void setX(int newX);
        public int getY();
        public void setY(int newY);
        public int getWidth();
        public void setWidth(int newVal);
        public int getHeight();
                                (int newHeight);
```

```
public interface Label {
    public int getX();
    public void setX(int newX);
    public int getY();
    public void setY(int newY);
    public int getWidth();
    public void setWidth(int newVal);
    public int getHeight() ;
    public void setHeight(int newHeight);
    public String getText();
    public void setText(String newString);
    public String getImageFileName();
    public void setImageFileName(
        String newVal);

}
```

```
public interface ImmutableIcon {
    public int getX();
    public int getY();
    public int getWidth();
    public int getHeight() ;
    public String getText();
    public String getImageFileName();
}
```

XY-based ObjectEditor Shape Rules

Rectangle

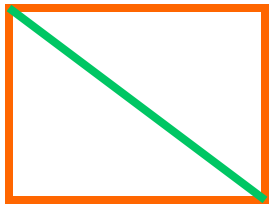
X, Y

Height

Width

Line

X, Y

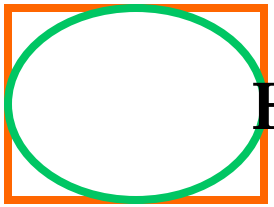


Height

Width

Oval

X, Y



Height

Width

TextBox

X, Y

hello **Height**

Width

X, Y Label

Eiffel **Height**

Width

ObjectEditor Bounding Box Rules

- A shape object describes its bounding box if it:
  - represents the size of the bounding box using int (read-only or editable) properties, Height, and Width
  - describes the location of the upper left corner of the bounding box using X, Y properties of type int

ObjectEditor Shape Rules

- An object is recognized as a rectangle/line/oval if:
  - Its interface or class has the string "Rectangle"/"Oval"/"Line" in its name
  - It has properties describing the bounding box of the shape
  - Can have additional properties

Oval

```
public interface
    public int getX();
    public void setX(int newVal);
    public int getY();
    public void setY(int newVal);
    public int getWidth();
    public void setWidth(int newVal);
    public int getHeight() ;
    public void setHeight(
        int newVal);
}
```

ObjectEditor TextBox Rules

- An object is recognized as a textbox if:
  - Its interface or class has the string "Text" in its name
  - It has properties described the bounding box of the text-box
  - It has String property Text representing contents of the text-box
  - Can have additional properties

```
public interface TextBox {
    public int getX();
    public void setX(int newVal);
    public int getY();
    public void setY(int newVal);
    public int getWidth();
    public void setWidth(int newVal);
    public int getHeight() ;
    public void setHeight(int newVal);
    public String getText();
    public void setText(String newVal);
}
```

ObjectEditor Label Rules

- An object is recognized as a label if:
  - Its interface or class has the string "Label" or "Icon" in its name
  - It has properties described the bounding box of the label.
  - It either has String property
    - Text giving the label text.
    - ImageFileName describing the name of a graphics file describing the label icon.
  - Can have additional properties

```
public interface SimpleLabel {
    public int getX();
    public int getY();
    public int getWidth();
    public int getHeight() ;
    public String getImageFileName();
}
```

Example Label Implementation

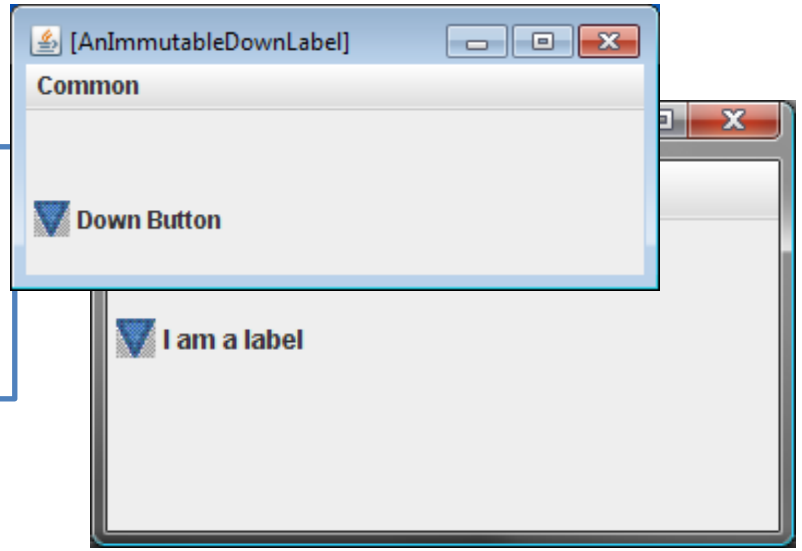
```
public class AnImmutableDownLabel  implements ImmutableLabel {
int x, y;
int width = 100;
int height = 100;
String imageFileName = "dn.gif";
String text = "Down Button";
public AnImmutableDownLabel(int theX, int theY) {
x = theX;
y = theY;
}
public int getX() {return x;}
public int getY() {return y;}
public int getWidth() {return width;}
public int getHeight() {return height;}
public String getText() {return text;} public String
getImageFileName() {return imageFileName;}
}
}
```

Generic Label Implementation

```
public class ALabel implements Label {
    int width, height;
    String text, imageFile;
    Point location;
    public ALabel (
            int initX, int initY, int initWidth, int initHeight,
            String initText, String theImageFile) {
        location = new ACartesianPoint(initX, initY);
        width = initWidth;    height = initHeight;
        text = initText;          imageFile = theImageFile;
    }
    public Point getLocation() {return location;}
    public void setLocation(Point newVal) {location = newVal;}
    public int getWidth() { return width;}
    public void setWidth(int newVal) {width = newVal;}
    public int getHeight() {return height;}
    public void setHeight(int newHeight) {height = newHeight;}
    public String getText() {return text;}
    public void setText(String newVal) {text = newVal;}
    public String getImageFileName() {return imageFile;}
    public void setImageFileName(String newVal) {imageFile = newVal;}
}
```

Using ALabel

```
ObjectEditor.edit(
   new AnImmutableDownLabel(
                                  0, 0);
}
```



The label icon and image are offset 0, height/2 from upper left corner

Text follows the label in a left-to-right order.

File should be in the project folder (directory) containing bin and src