Abstraction

Object:

an entity with specific attribute values (state), behavior, and identity

typically instantiated from a class

Class:

associated type of an object

defines attributes and methods

Java and UML Class

```
public class Frame { // version 0
    // represent a ‘window’
    /* body of class definition goes here */
}
```

UML class notation

Encapsulation

Class:

access control for attributes and methods

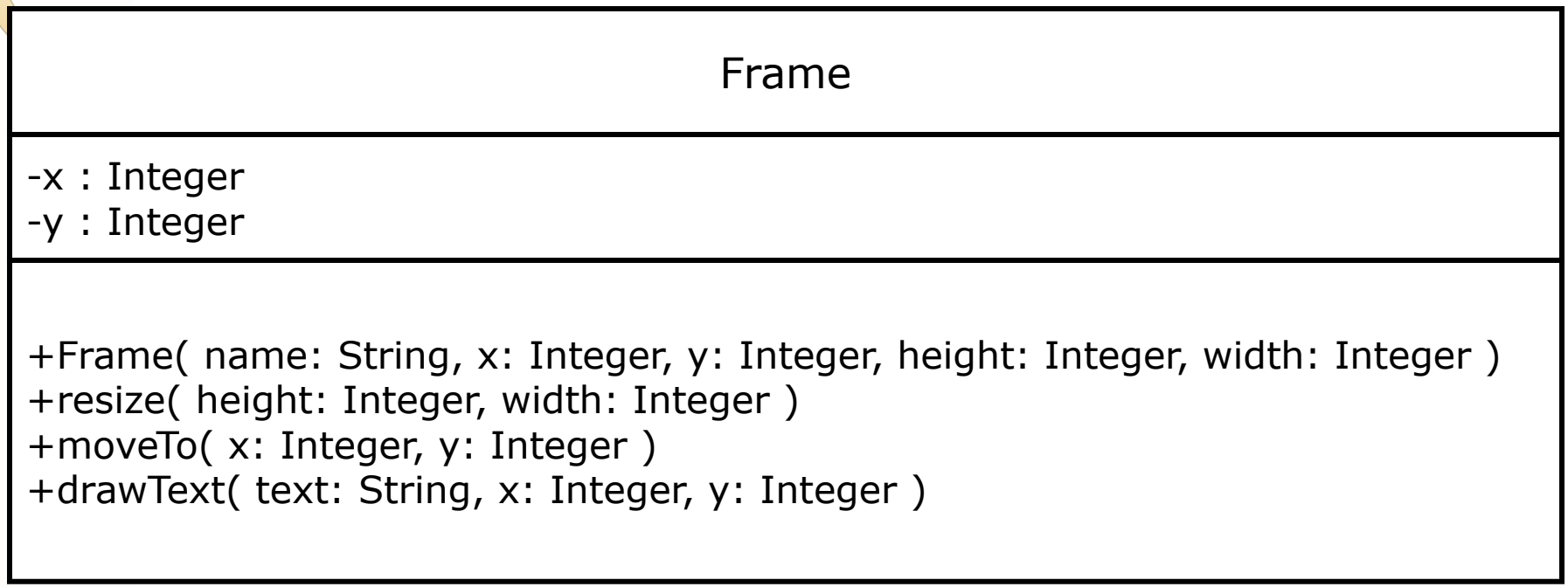
- e.g., public or private

access is not the same as visibility

“design by contract”

- public interface represents a contract between the developer who implements the class and the developer who uses the class

UML Class



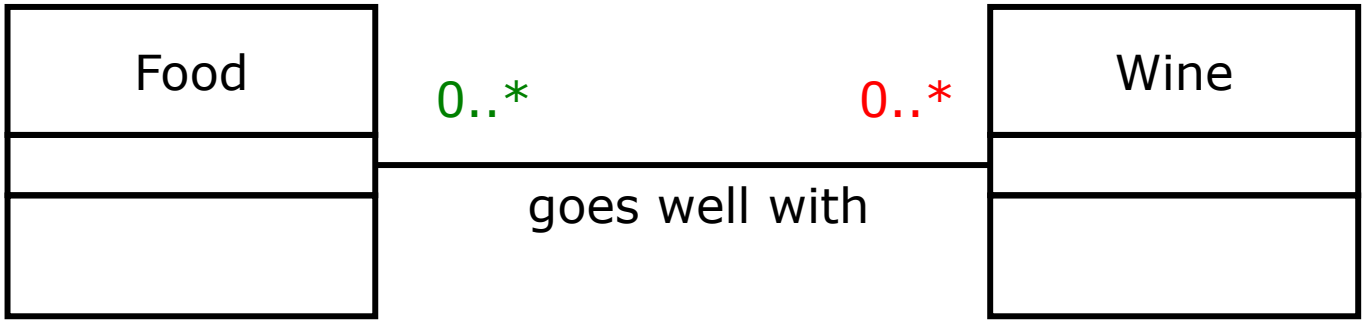
– private
+ public

Decomposition

Association relationship:
“some” relationship between classes

- e.g., between Book and Patron

UML Association



Read class diagram using “objects”

a Food *object* goes well with a Wine *object*

a Food *object* is associated with
0 or more Wine *objects*

a Wine *object* is associated with
0 or more Food *objects*

Decomposition

Aggregation relationship:

weak “has-a” relationship

whole “has-a” part

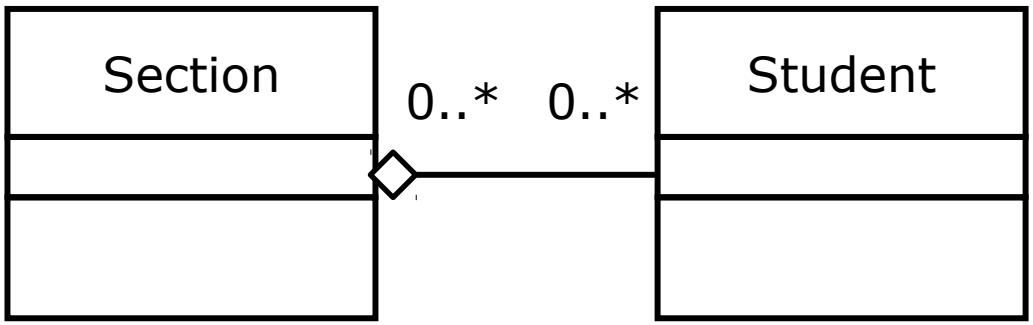
a part may belong to (be shared with) other wholes

e.g., a Section and a Student

Java and UML Aggregation

Dynamic number of aggregated objects:

```
public class Section {
    private ArrayList<Student> roster;
    …

    public Section() {
        roster = new ArrayList<Student>();
        …
    }
    public void add( Student s ) { … }
}
```



Java and UML Aggregation

Fixed number of aggregated objects:

```
public class Frame {

    private Location myLocation; // shared object
    private Size mySize; // shared object
    …
}
```

Decomposition

Composition relationship:

strong “has-a” relationship

exclusive containment of parts

related object life times

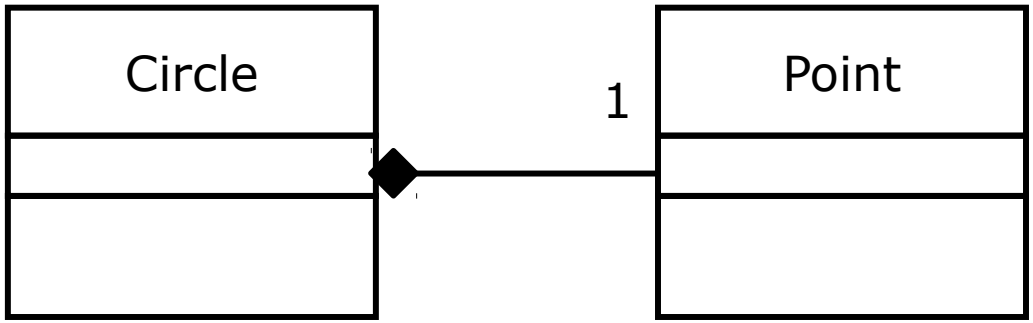
- the whole cannot exist without having the parts; if the whole is destroyed, the parts should also be destroyed

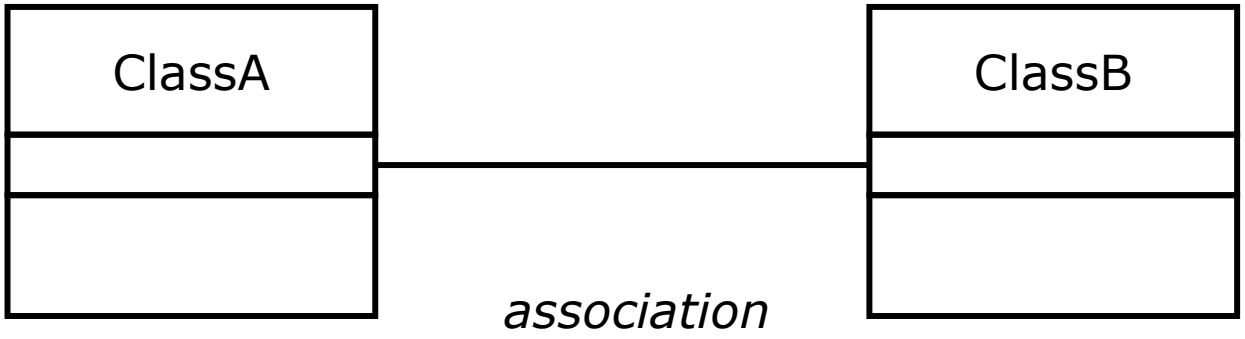
often access the parts through the whole

UML Composition

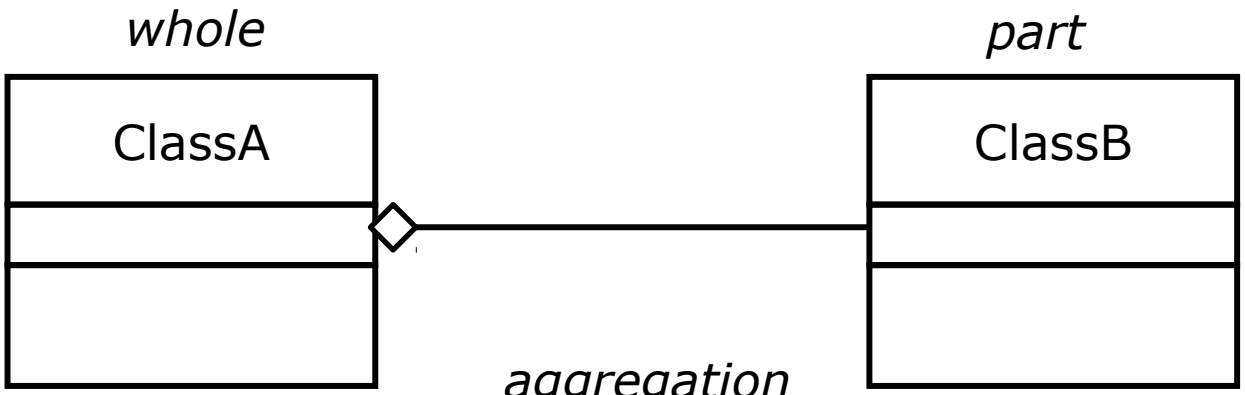
Contained *objects* are exclusive to the container

a Circle object has a Point object that is exclusive to it (however, other objects may contain Point objects, just not this one)

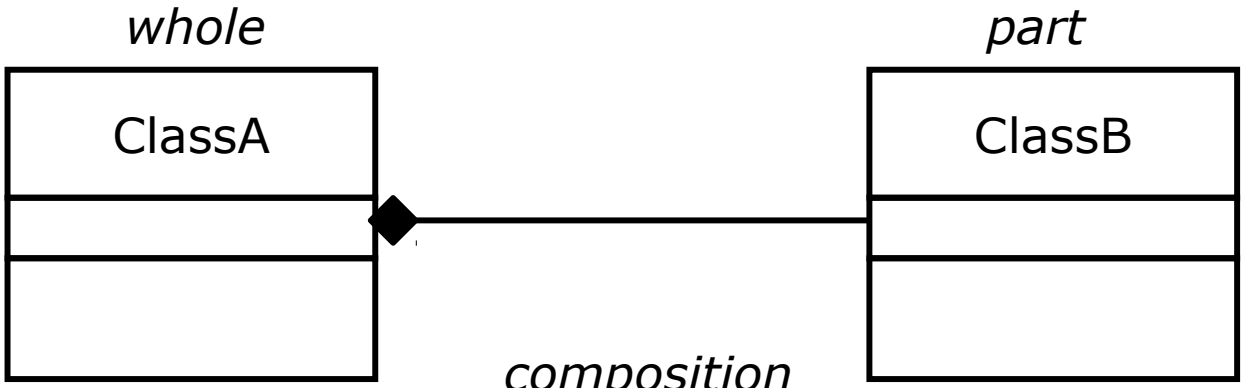




association



aggregation



composition

Exercise

Analyze a UML class model for a car rental company that keeps track of cars, renters, and renters renting cars.

Generalization

Look for commonalities:

common attributes

- e.g., all vehicles have ?

common methods (behavior)

- e.g., all vehicles can ?

Generalize:

find what is common, and factor it out into a more general "base" abstraction

Generalization

Implementation inheritance:

generalize about method signatures, method implementations, and/or attributes

- i.e., classes having these in common

Implementation Inheritance

General part:

a base class (or “superclass”) defines the attributes and methods to be shared

Specific part:

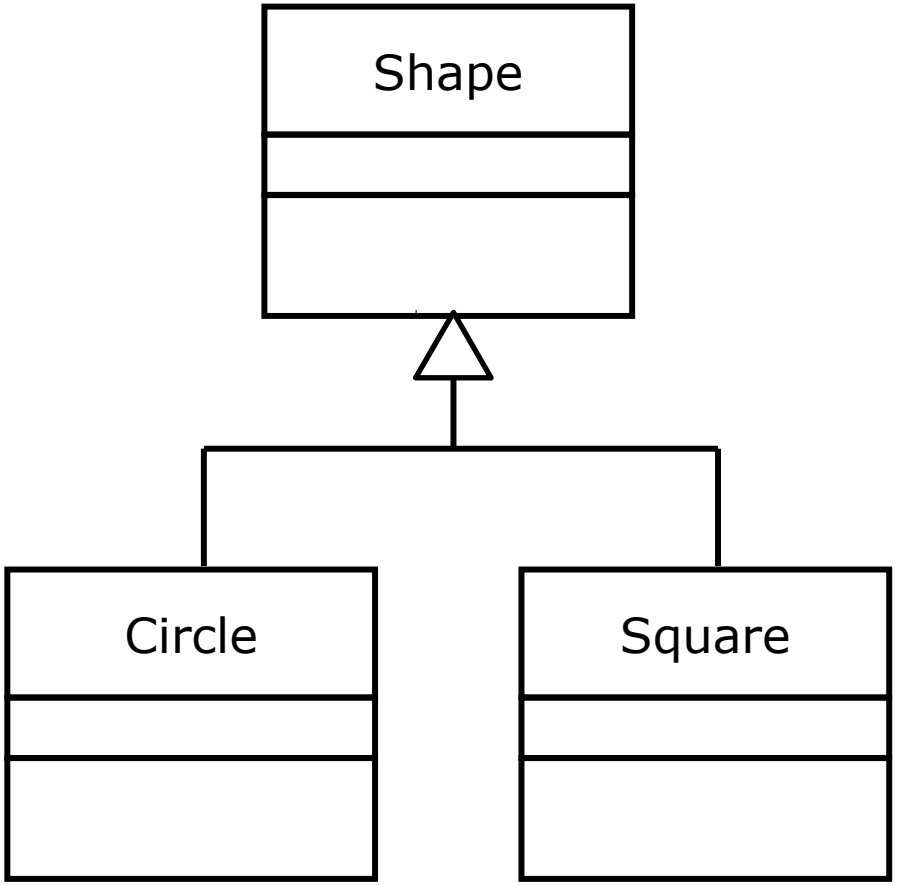
a derived class (or “subclass”) is endowed with the attributes and methods of its base class

a subclass may “extend” a superclass by adding attributes and methods, or overriding an existing method

UML Inheritance

Implementation inheritance relationship:

- "is-a" relationship between classes
- i.e., subclass "is-a" kind of superclass
- i.e., subclass "extends" superclass
- e.g., Circle "is-a" kind of Shape



Generalization Principles

Inappropriate inheritance:

subclass inherits from superclass but “is-a” (is a kind of) relationship *does not* exist

if “is-a” test fails

- likely not appropriate

if “is-a” test succeeds

- *may* or *may not* be appropriate

Generalization Principles

Liskov substitution principle:

an instance of the subclass should be substitutable anywhere a reference to a superclass object is used

```
Shape s;
s = new Circle(); // instance of subclass
…
Location l = s.getLocation(); // superclass method
```

Inheritance Example

Suppose:

class Dog

- provides bark(), fetch()

class Cat extends Dog

- “hides” bark(), “hides” fetch(), and adds purr()

Question:

Cat “is a” Dog?

Inheritance Example

Suppose:

class Window

- provides show(), move(), resize()

class FixedSizeWindow extends Window

- “hides” resize()

Question:

FixedSizeWindow “is a” Window?

Inheritance Example

Suppose:

class ArrayList

- provides add(), get(), remove(), …

class ProjectTeam extends ArrayList

Question:

ProjectTeam “is a” ArrayList?

Inheritance Issue

Problem:

superclass method is inherited, but it is not appropriate

what to do?

Inheritance Issue

```
public class Rectangle {
    public Rectangle( Size s ) { … }
    public void setLocation( Location p ) { … }
    public void setSize( Size s ) { … }
    public void draw() { … }
    public void clear() { … }
    public void rotate() { … }
}

public class Square extends Rectangle {

    // inherits setSize(), but want to “hide” it
}
// Square ‘is a’ Rectangle?
// Square specializes Rectangle?
```

Override the Method Approach

```
public class Square extends Rectangle {

    public void setSize( Size s ) {
        // should not implement
    }

}
```

Aggregation Approach

```
public class Square {
    private Rectangle rect;
    // Square 'has a' Rectangle,
    // not 'is a' Rectangle

    public Square( int side ) {
        rect = new Rectangle(
            new Size( side, side ) );
    }
    …
    public void setSide( int newSide ) {
        rect.setSize(
            new Size( newSide, newSide ) );
    }

    public void draw() {
        rect.draw();
    }
    …
}
```

Restructuring Approach

```
public class Quadrilateral {
    …
    public Quadrilateral() { … }
    public void setLocation( Location p ) { … }
    public void draw() { … }
    public void clear() { … }
    public void rotate() { … }
}

public class Rectangle extends Quadrilateral {
    public Rectangle( Size s ) { … }
    public void setSize( Size s ) { … }
}

public class Square extends Quadrilateral {
    public Square( int side ) { … }
    public void setSide( int side ) { … }
}
```

Inheritance

Java abstract class:

declares one or more abstract methods

cannot be instantiated; must be subclassed and have abstract methods overridden

```
public abstract class Shape {
    public abstract double area();
    public abstract double perimeter();
    // there may be other instance data and methods
}
class Circle extends Shape {
    public double area() { … }
    public double perimeter() { … }
}
```

Interface Inheritance

Java interface:

declares method signatures

classes implement the interface by providing all the method bodies

```
public interface Bordered {
    public double area();
    public double perimeter();
}
class Circle implements Bordered {
    public double area() { … }
    public double perimeter() { … }
}
```

Interface Inheritance

Java interface:

a “contract”, specifying a *capability* that an implementing classes must provide

gives method signatures, but no implementation

cannot be instantiated

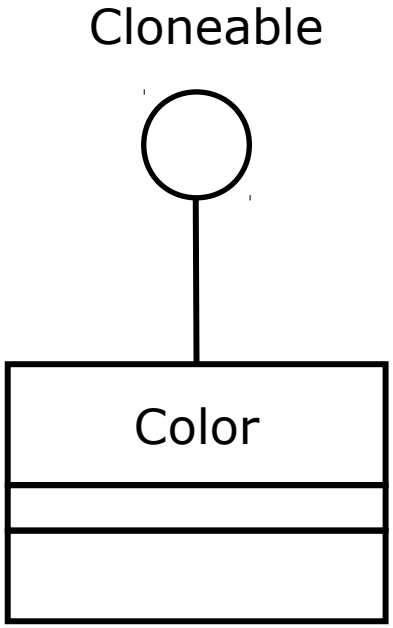
may extend other (sub)interfaces

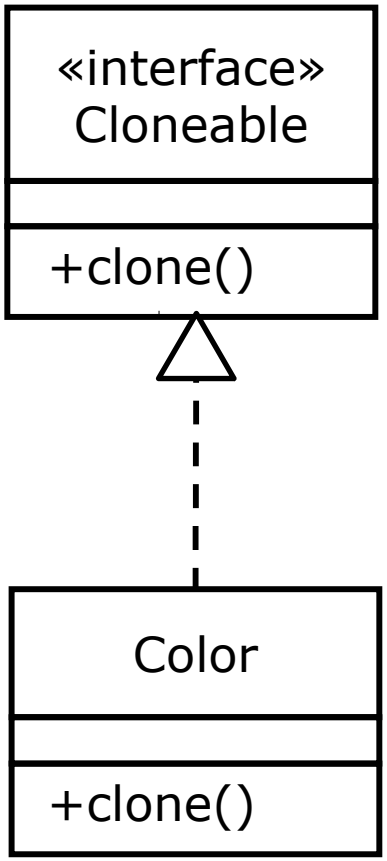
```
public interface Transformable extends Scalable,
Translatable, Rotatable {
    …
}
```

Java Interface

```
public interface Cloneable {
    public Cloneable clone();
}

public class Color implements Cloneable {
    private int red;
    private int green;
    private int blue;

    public Color( int r, int g, int b ) { … }

    public Cloneable clone() {
        return new Color( red, green, blue );
    }
}

Color red = new Color( 255, 0, 0 );
Color redClone = red.clone();
```

UML Interface





guillemets denote a stereotype

Abstract Class versus Interface

Differences:

- an abstract class may provide a partial implementation
- a class may implement any number of interfaces, but only extend one superclass
- adding a method to an interface will “break” any class that previously implemented it

Object-Oriented Analysis

Steps:

discover objects from problem domain

- nouns may lead to classes and attributes
- verbs may lead to relationships and methods

use CRC cards to note the analysis

evaluate

Problem Description

The library has books and magazines. Books may be borrowed by any patron for four weeks while magazines may only be borrowed for two days. Up to 6 items at a time may be borrowed. The system tracks when books and magazines are borrowed …

Nouns

The library has books and magazines. Books may be borrowed by any patron for four weeks while magazines may only be borrowed for two days. Up to 6 items at a time may be borrowed. The system tracks when books and magazines are borrowed …

Verbs

The library has books and magazines. Books may be borrowed by any patron for four weeks while magazines may only be borrowed for two days. Up to 6 items at a time may be borrowed. The system tracks when books and magazines are borrowed …

Discover Objects

Entity objects:
things that model the problem domain

Control objects:
things that respond to events and coordinate services

Boundary objects:
things that interact with the system

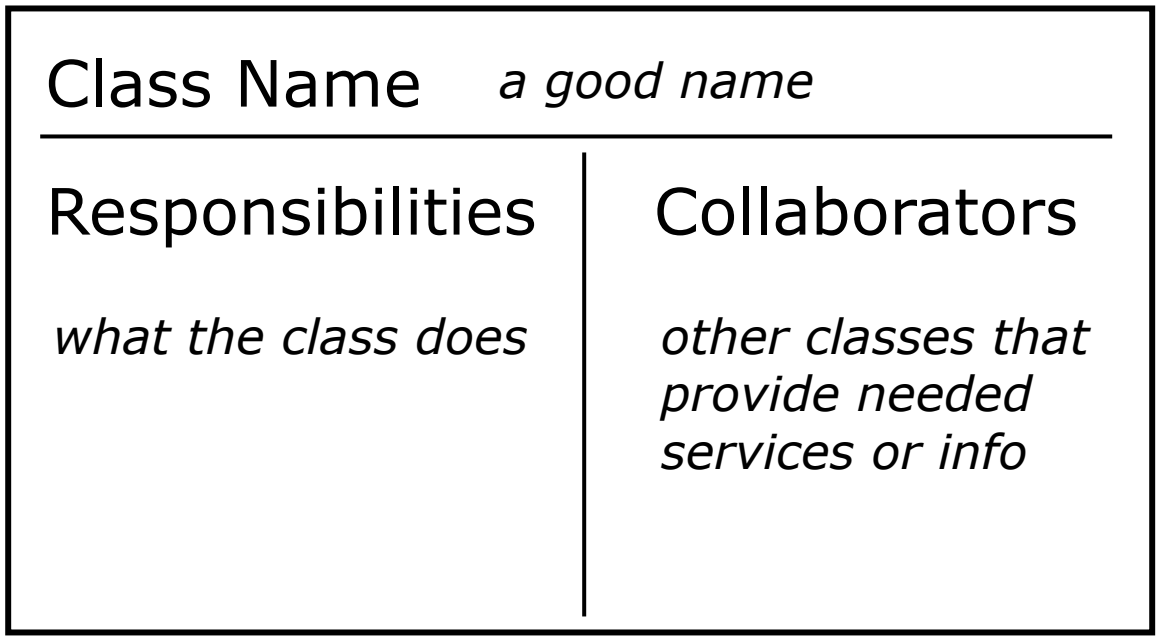
- e.g., other applications, devices, sensors, actors, roles, windows, forms

Use CRC Cards

Class-Responsibility-Collaborator

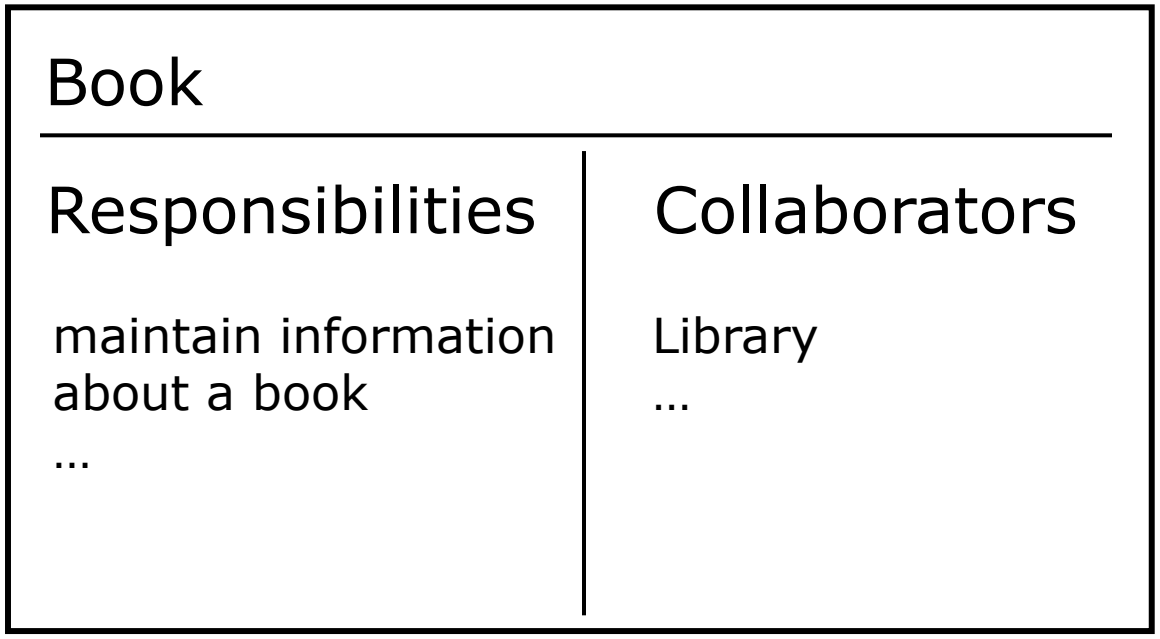
explore classes, their responsibilities, their interactions

organize index cards on a table



use the back for more details

Use CRC Cards



Use CRC Cards

Role playing:

refine the cards by acting out a particular scenario with the candidate objects

“become” the object

what do I do?

what do I need to remember?

with whom do I need to interact?

how do I respond?

Evaluate

Principles:

during analysis, objects should initially be technology independent

if an object has only one attribute, perhaps it should not be a separate object at all

if an object has several highly related attributes, perhaps these attributes should form a separate object

Override the Method Approach

```
public class Square extends Rectangle {

    public void setSize( Size s ) {
        // should not implement
    }

}
```

Guidelines

Modularity:

increase cohesion

- class has a clear specific responsibility

reduce coupling

- class is not connected to or knows too many others

separate the layers

- identify entity, control, and boundary objects
- allow replacing layers

Guidelines

Classes:

use good names

- should be meaningful and explanatory

avoid huge “blob” classes

- a single class can’t do everything

use information hiding

- hide changeable details, reveal assumptions

Guidelines

Generalization:

find superclasses

- look for and factor commonalities among classes

apply Liskov principle for proper inheritance

- or use is-a test

is-a test is not always enough

- class names can mislead, look at specific behavior

Guidelines

Adaptation:

hard to get it right the first time

- recognize problems and fix them

your software won’t go away

- make it easy to adapt to change

simplicity (as simple as possible)

- does not always mean using the first thing that comes to mind
- elegant designs may need effort