Objectives

- Design Patterns
  - Strategy
  - MVC
  - Factory

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Review

1. What is common to how we address code smells?
2. What is the design-by-contract/Liskov Substitution Principle?
   - How does it relate to the Roulette code base?
3. What are design patterns? How are they used?
   a) What is an example of a design pattern?
4. What was the solution to the Audobon Society's bird modeling problem?
   a) Why is composition preferred over inheritance?

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Review: Summary of LSP

- Liskov Substitution Principle (a.k.a. design by contract) is an important feature of programs that conform to the Open-Closed Principle
- Derived types must be completely substitutable for their base types
- Derived types can then be switched out without consequence

Review: Design Pattern

General reusable solution to a commonly occurring problem in software design

- Not a finished design that can be transformed directly into code
- Description or *template* for how to solve a problem that can be used in many different situations
  - "Experience reuse" rather than code reuse

Design Principle: Favor Composition Over Inheritance

- Design Pattern: Composition
  - Using other objects in your class
  - "Delegate" responsibilities to this object

Why is composition preferred over inheritance?

- Inheritance → dependence on parent class
  - Only want to depend on things you know won't change (higher stability)
- Composition: Provide different behaviors for your class by plugging in new object

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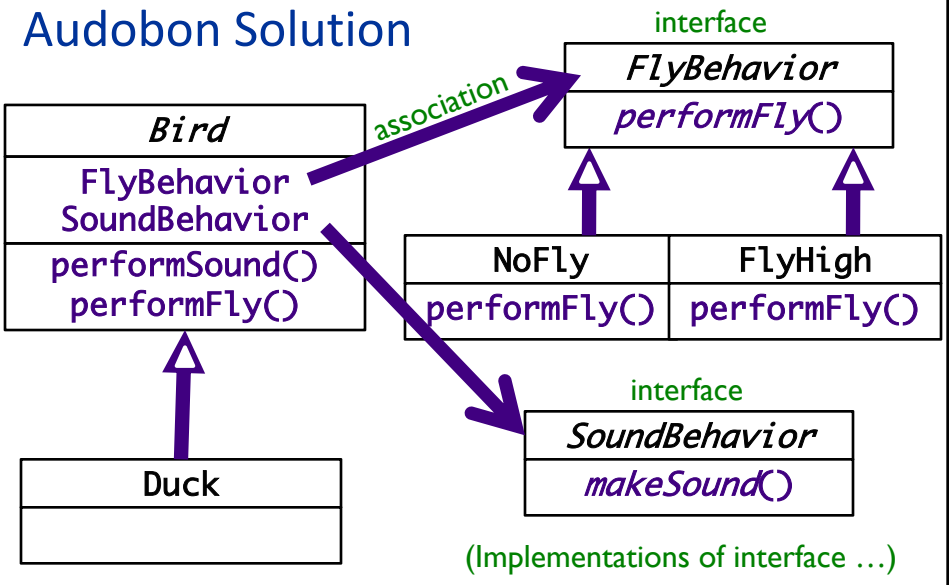
Audobon Solution



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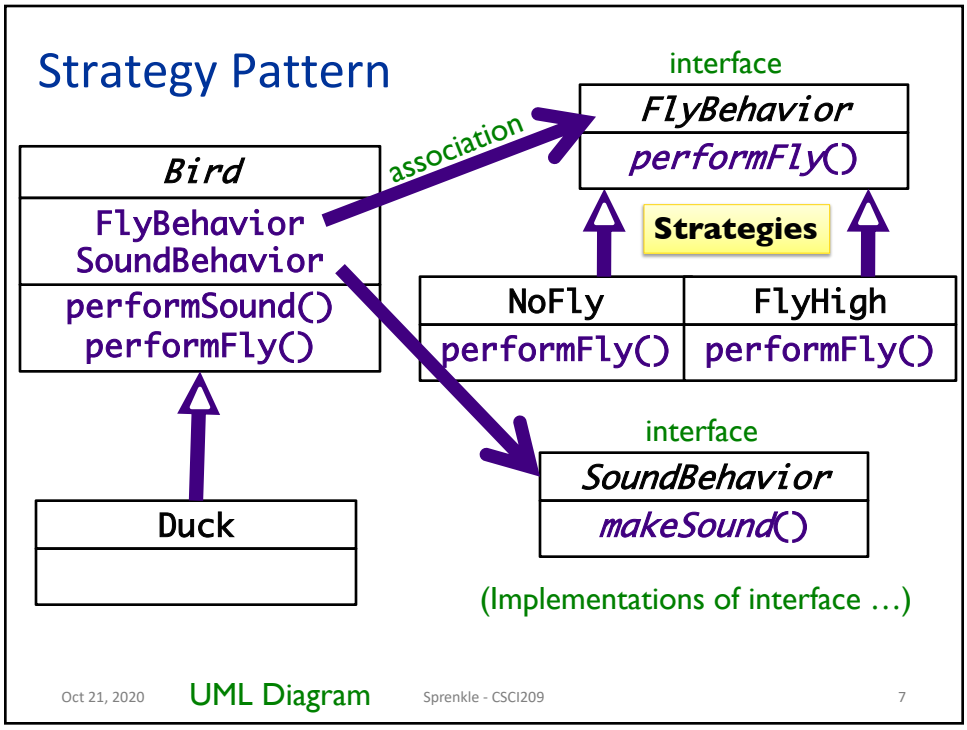
Strategy Pattern
interface
FlyBehavior
performFly()
association
Bird
FlyBehavior
SoundBehavior
performSound()
performFly()
Strategies
NoFly
performFly()
FlyHigh
performFly()
interface
SoundBehavior
makeSound()
Duck
(Implementations of interface …)
Oct 21, 2020
UML Diagram
Sprenkle - CSCI209
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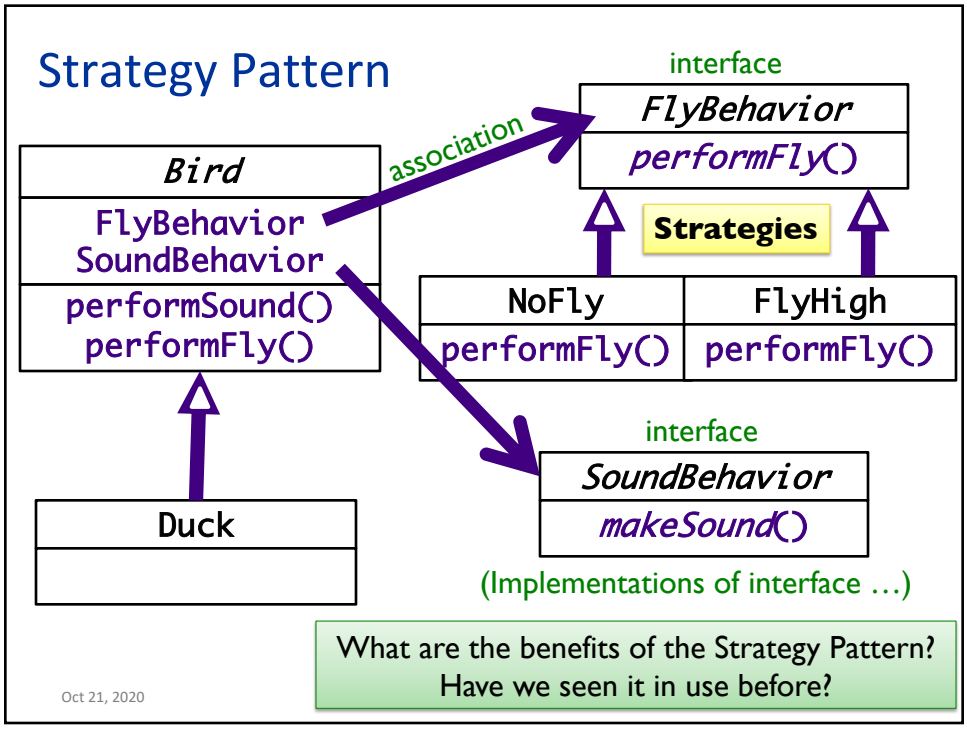
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(Implementations of interface …)
What are the benefits of the Strategy Pattern?
Have we seen it in use before?
Oct 21, 2020

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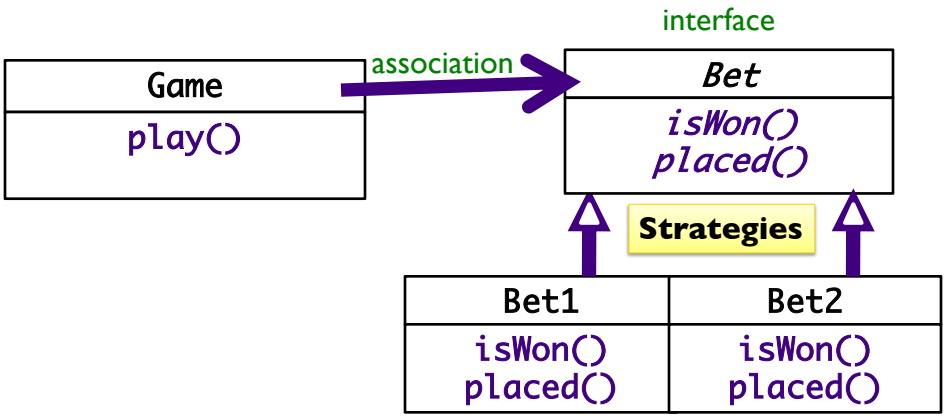
Design Pattern: **Strategy**

- Defines a family of algorithms, encapsulates each one, and makes them interchangeable
- Allows algorithm/behavior to vary independently of clients that use it
  - Allows behavior changes at runtime
- Design Principle:

Favor ***composition*** over inheritance

Roulette



Benefits of Audobon Solution

- Uses ***delegation***
  - Reduces Bird's responsibilities
  - ***Delegate*** some responsibilities to `SoundBehavior` and `FlyBehavior`
  - Reduces Bird's code
- Easy swap of different ***strategy***
  - Can easily plug in different behavior/implementation
    - Others using Bird class are coding to interface, not implementation
- Adheres to open-closed principle

Summary: Audobon Solution

- Applies ***composition*** pattern
  - Uses-a or Has-a behavior rather than using inheritance
- Applies ***delegation*** pattern
  - Reduces Bird's responsibilities
  - ***Delegate*** some responsibilities to `SoundBehavior` and `FlyBehavior`
  - Reduces Bird's code
- Applies ***strategy*** pattern
  - Can easily plug in different behavior/implementation
    - Others using Bird class are coding to interface, not implementation

Discussion: Applying Design Patterns

- When should we apply the **delegation** pattern?
  - Example, if X, then we should apply the pattern.
- When should we apply the **strategy** pattern?
- When will we know we've gone too far (overapplying)?
  - What are some symptoms to look for?

Discussion: Applying Design Patterns

- When should we apply the **delegation** pattern?
  - When we know that the requirements or implementations for a **responsibility** are likely to *change*
    - Change: Number/types of birds; types of behaviors; or lower-level implementation details
- When should we apply the **strategy** pattern?
  - When there are lots of desired behaviors for one responsibility and they could change
- When will we know we've gone too far (overapplying)? What are some symptoms to look for?
  - "Too small" classes → don't do anything
  - Have many more strategies than necessary
  - "Speculative generality"

Design Principle: **Loose Coupling**

Goal: loosely coupled designs between objects that interact

- Loosely coupled objects can interact but have very little knowledge of each other
  - Minimize dependency between objects
  - More flexible systems
  - Handle change

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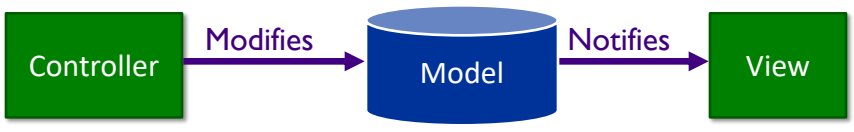
Model - Viewer - Controller (MVC)

- A common **design pattern** for GUIs
- Separate
  - Model: application data
  - View: graphical representation
  - Controller: input processing



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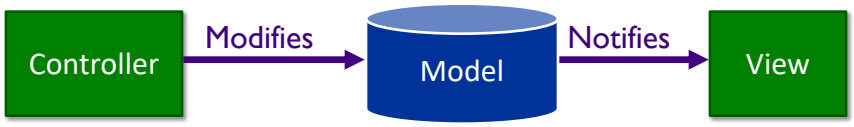
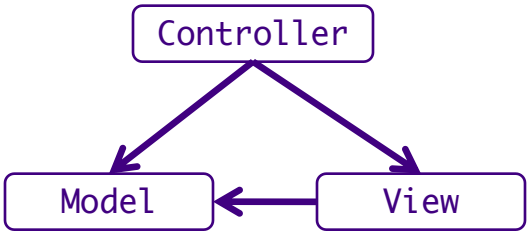
Model-Viewer-Controller



- Can have multiple viewers and controllers
- Goal: modify one component without affecting others

Direct associations



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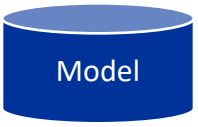
Model



- Represents application state
- Responsible for managing application state
- Purely **functional**
  - Nothing about how view presented to user

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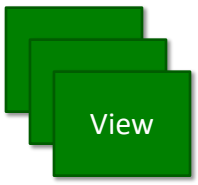
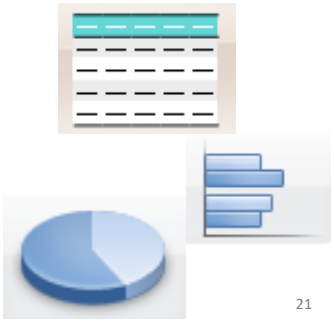
Multiple Views



- Provides graphical components for model
  - Look & Feel of the application
- User manipulates view
  - Informs **controller** of change
- Example of multiple views: spreadsheet data
  - Rows/columns in spreadsheet
  - Pie chart, bar chart, …



Controller(s)

- Handles user input
- Update **model** as user interacts with **view**
  - Call model's methods (often mutators)
  - Makes decisions about behavior of model based on UI
- Views are associated with controllers

Example: Goblin Game

- Model: GamePiece and child classes
- View-Controller: Game
  - View: displaying locations of model
  - Implemented KeyListener
    - Key strokes made changes to (controlled) the Human

```
public void keyPressed(KeyEvent e) {
        int key = e.getKeyCode(); // key pressed
        if (key == KeyEvent.VK_UP)
                professor.setDirection(0, -1); // move up
        if (key == KeyEvent.VK_DOWN)
                professor.setDirection(0, 1);
        if (key == KeyEvent.VK_LEFT)
                professor.setDirection(-1, 0);
        …
```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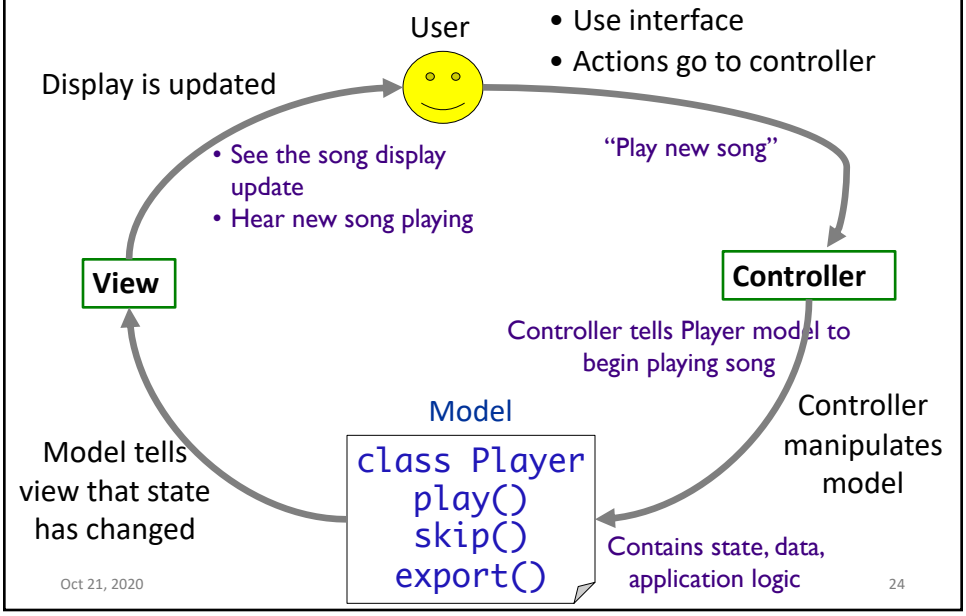
Example: Music Player



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MVC: Combination of Design Patterns

- Observer
  - Views, Controller notified of Model's state changes
- Strategy
  - View can plug in different controllers
  - Different views of the same model
- Composite
  - View is a composite of GUI components
    - Top-level component learns about model update, updates components
    - A container computes its preferred size by combining all the preferred sizes of its components

Summary: Model View Controller (MVC)

- Common design pattern
  - Used in GUIs, Web Applications
  - Helpful to understand how GUIs are designed
- Combination of design patterns
- Design principles applied
  - Loosely coupled
    - Components are aware of each other but not *too* integrated
  - Depend on abstractions

Dependency Inversion Principle

Depend upon abstractions

"Inversion" from the way you think

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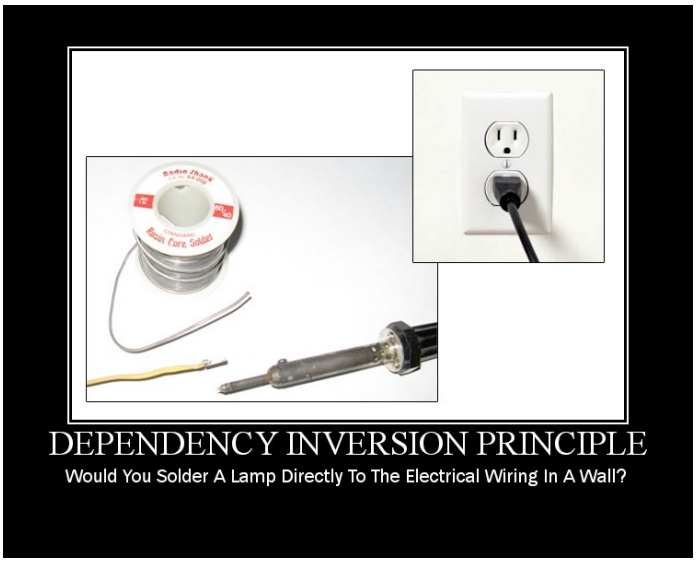

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Dependency Inversion Principle

Depend upon abstractions.
Do not depend upon concrete classes.

- High-level components should not depend on low-level components
  - Both should depend on abstractions
  - High-level: more user-facing
  - Low-level: work horses – doing the work/processing
- Abstractions should not depend upon details. Details should depend upon abstractions
- "Inversion" from the way you think

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FACTORY DESIGN PATTERN

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Design Pattern: **Factory Methods**

- Allows creating objects without specifying exact (concrete) class of created object
- Often used to refer to any method whose main purpose is creating objects

- How it works:
  1. Define a method for creating objects
  2. Child classes override method to specify the derived type of product that will be created

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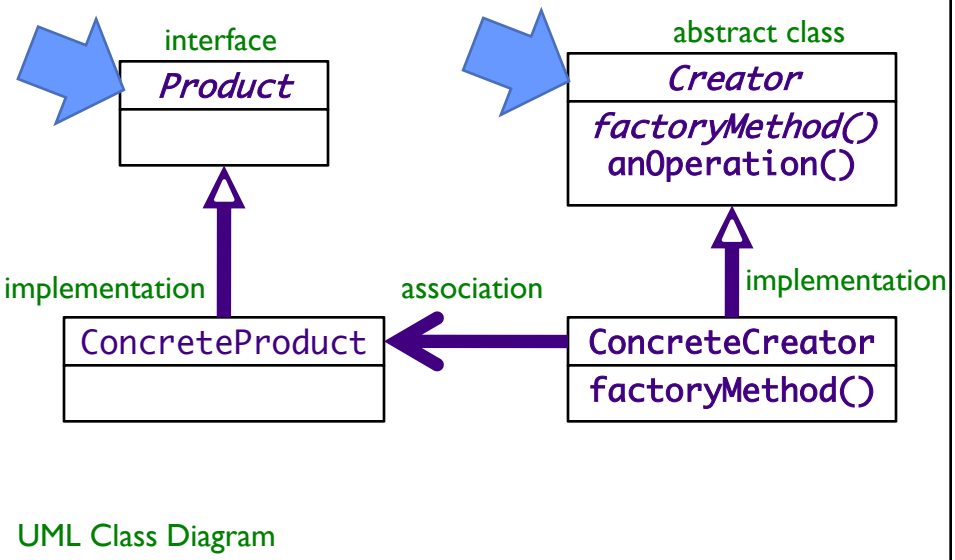
Factory Method Pattern



UML Class Diagram

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Guidelines to Follow DIP

- No variable should hold a reference to a concrete class
  - Using new → holding reference to concrete class
  - Use factory instead
- No class should derive from a concrete class
  - Why? Depends on a concrete class
  - Derive from an interface or abstract class instead
- No method should override an implemented method of its base class
  - Base class wasn't an abstraction
  - Those methods are meant to be shared by child classes

What's a problem with following all of these guidelines?

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Dependency Inversion Principle

Depend upon abstractions

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Discussion of Abstraction

- What does abstraction allow?
- Are there any limitations to abstraction?

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Abstraction Discussion

- Making code abstract makes code easier/more resilient to change
- Examples:
  - Magic number → Constant
    - Change constant (once) → changes value everywhere it is used
  - Long method → Extract method(s)
    - Method call is an abstraction of the concrete statements
      - Can change the implementation of the method without breaking the calling code
  - Large class→Extract class(es)
    - Class encapsulates state/functionality
    - Can change implementation of class and not break the code that uses the class

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Abstract Discussion

- Abstraction makes it (a little) harder to understand code
  - Examples:
    - Need to look up the value of the defined constant
    - Need to read a called method's API or go to its source to understand what it does
- However, those are relatively low costs and will get cheaper as you get better at coding

Summary of Designing for Change

Use ***abstraction*** for code that is *likely to change*

- Can depend on code that is *stable* and unlikely to change
  - Example of stable code: `System.out`

Design patterns in practice

SCREENSAVERS

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Understanding ScreenSavers Code

- How do you run the code?
- What represents an object in the screen saver?
- How are screen saver objects generated?
- How is animation handled?
- How are events handled?

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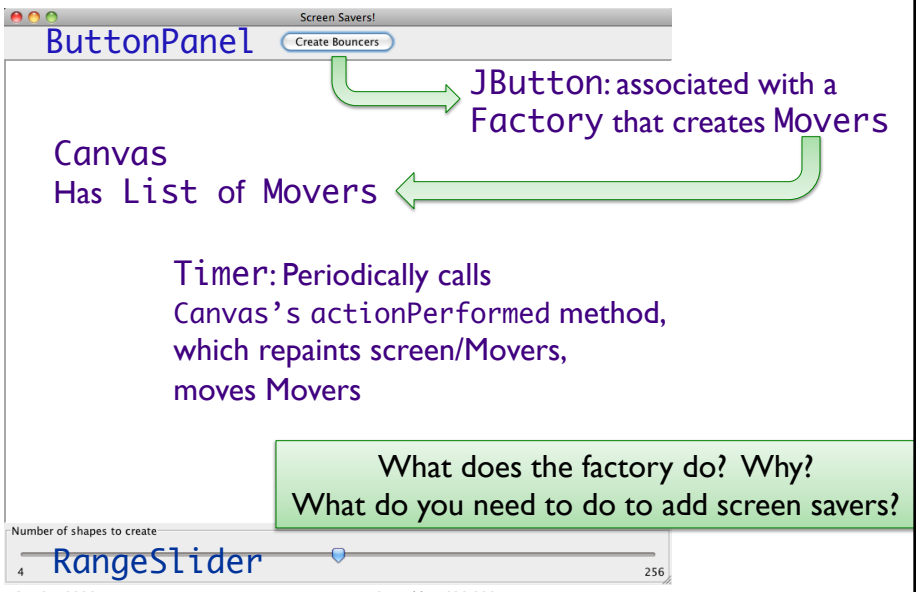
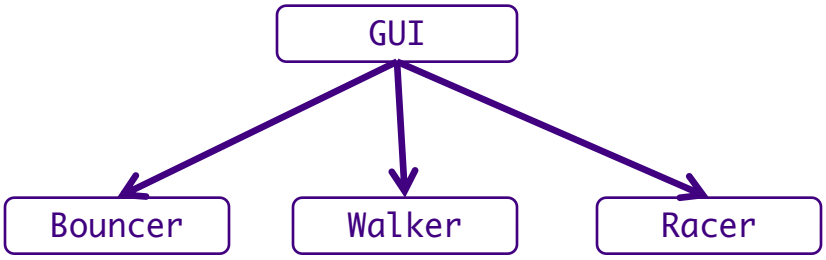
Screensavers GUI/Architecture



Dependency Inversion Principle

- How would you typically build/design the screen saver application?
  - Know we need to view/display a screen saver
    - Buttons, slider, objects that move
    - Top-down
  - Know we need to create a bunch of types of screen savers
    - Abstraction
    - Bottom-up

One Option for Screen Saver Design



Violates Dependency Inversion Principle:
High-level component is dependent on concrete classes.
If implementations change, GUI may have to change

Mapping Factory Design Pattern to Screen Savers

- How does the screen saver application use factory methods?
- What would be the alternative solution?
- What problems are the factories addressing?

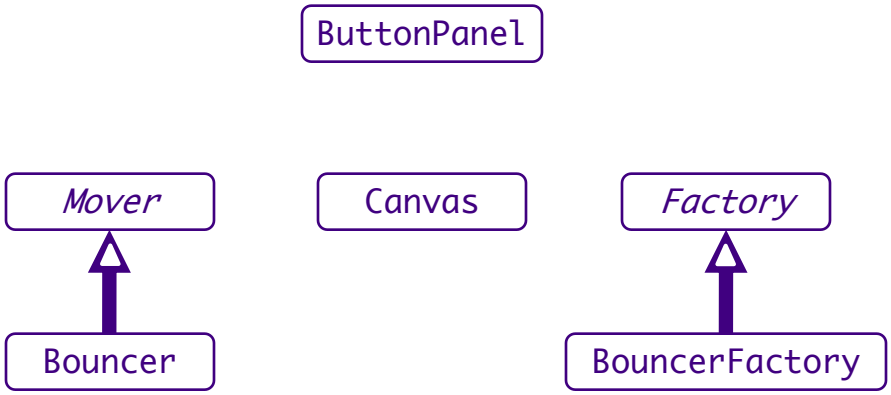
Mapping Factory Design Pattern to Screen Savers

- What problems are the factories addressing?
  - Delegate creation of concrete `Movers`
    - Likely to change
    - Encapsulate change in factory
  - Using abstraction instead of specifying concrete classes
    - Reduces dependencies to concrete classes

Thoughts

- Didn't need to know design pattern to understand code
  - Helps to know the **terminology** to understand the naming
- Design principles all come down to **where there is change, use abstraction**

Our Screen Saver Dependencies



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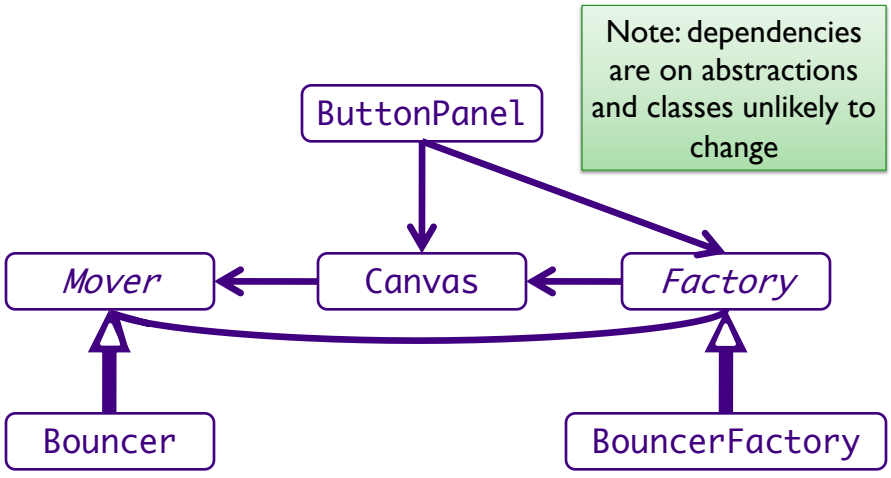
Our Screen Saver Dependencies



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Exam 2 Discussion

- Similar format to Exam 1
  - Timed (70 minutes), online
  - Open book/notes/slides **NOT** internet
  - 3 "sections" – very short answer, short answer, applied
  - Open Friday at 9:30 a.m. through Sunday at 11:59 p.m.
- Content covers through Wednesday's class
- I will hold office hours during Friday class time

Looking Ahead

- Assignment 8
  - Deadline extended to Thursday at 11:59 p.m.
- Exam: Fri - Sun