Subtyping and Inheritance

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ADAP C03

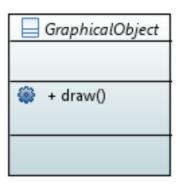
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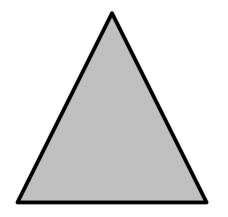
Agenda

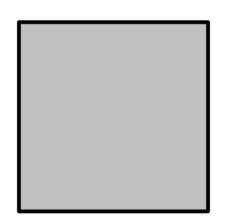
- 1. Forms of subtyping
- 2. Liskov Substitutability Principle (LSP)
- 3. Applied to class hierarchies
- 4. Co- and contravariance
- 5. Multiple inheritance
- 6. Abstract Superclass Rule (ASR)
- 7. Class hierarchy evolution
- 8. Cascading superclass calls

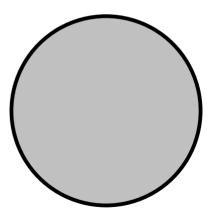
1. Forms of Subtyping

Subtyping Examples 1/3

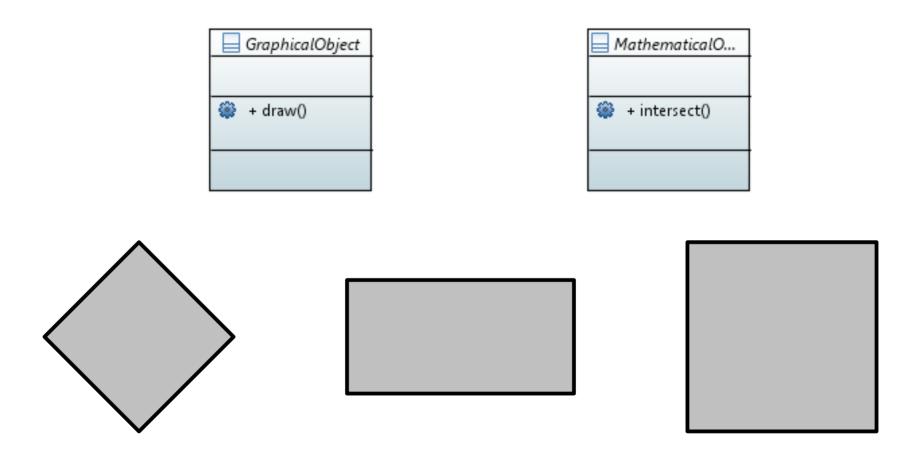




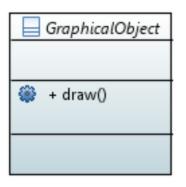


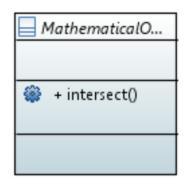


Subtyping Examples 2/3

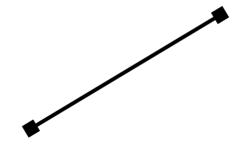


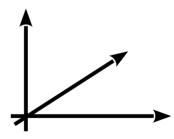
Subtyping Examples 3/3



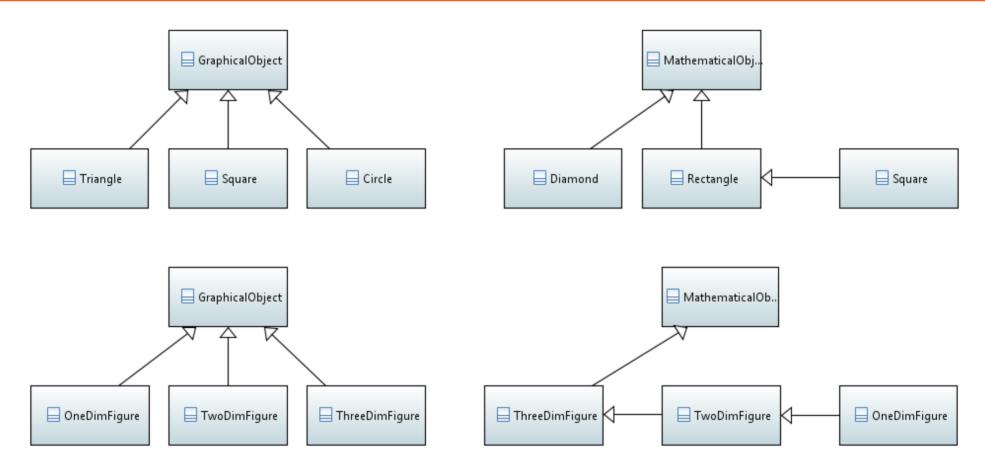








Subtyping Examples Discussion Continued



2. Liskov Substituability Principle

The Subtype Requirement [LW94] [1]

Let $\varphi(x)$ be a property provable about objects x of type T. Then $\varphi(y)$ should be provable for objects y of type S, where S is a subtype of T.

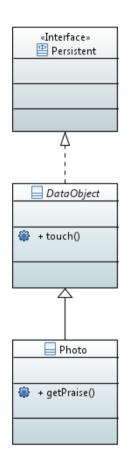
In Simpler Words

All properties that hold for instances of a supertype should also hold for instances of a subtype.

No surprises for a use-client

3. Applied to Class Hierarchies

Subclasses as Extended Subtypes



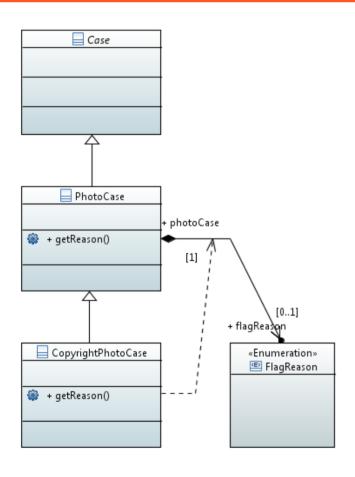
Subclass

- Adds methods and state
- Does not constrain superclass

Example

- public void DataObject#touch()
- public float Photo#getPraise()

Subclasses as Constrained Subtypes



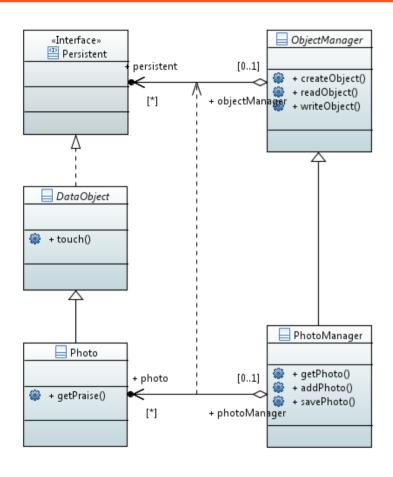
Constrained subtypes

- Superclass defines possibility space
- Subclass constrains behavior or return results

Example

- FlagReason PhotoCase#getReason()
 - Returns any of enum FlagReason
- FlagReason CopyrightPhotoCase#getReason()
 - Returns only FlagReason.COPYRIGHT

Dual Class Hierarchies



- Constrained subtypes
 - ObjectManager
 - PhotoManager
- Extended subtypes
 - ObjectManager and DataObject
 - PhotoManager and Photo
- Association refinement

4. Co- and Contravariance

Covariance and Contravariance

Covariant redefinition

• A method has been **covariantly** redefined in its result or argument types if those result or argument types are of a subclass of the original result or argument types

Contravariant redefinition

• A method of a has been **contravariantly** redefined in its result or argument types if those result or argument types are of a superclass of the original result or argument types

Quiz: Co- and Contravariance

- 1. Which form of redefinition of result types violates the Liskov Substituability Principle, if any?
 - a. Contravariant redefinition
 - b. Covariant redefinition
 - c. None
 - d. Both
- 2. Which form of redefinition of method argument types violates the Liskov Substituability Principle, if any?
 - a. Contravariant redefinition
 - b. Covariant redefinition
 - c. None
 - d. Both

Covariance of Method Result Types

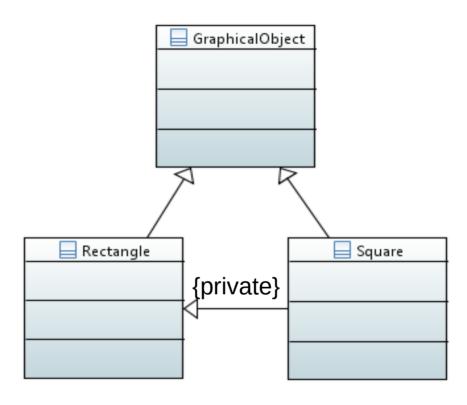
- General Java examples
 - Object Object#clone()
 - MyClass MyClass#clone()
- Wahlzeit examples
 - Persistent ObjectManager#createObject(...)
 - Photo PhotoManager#createObject(...)
- Covariant redefinition of method result types satisfies the LSP
 - Case of the constrained subtypes

Contravariance of Method Argument Types

- Not a language feature in Java (but in other languages)
 - Hence no examples at hand
- Contravariant redefinition of method arguments satisfies the LSP
 - Case of the extended subtypes

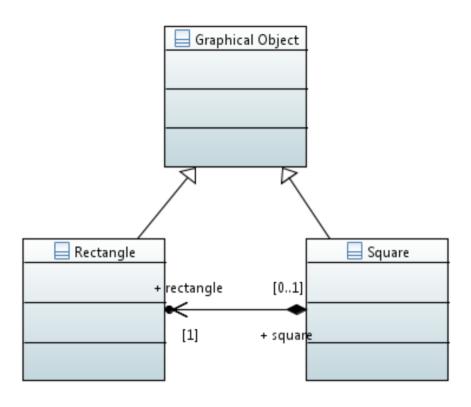
5. Multiple Inheritance

Multiple Inheritance



Not possible in Java (not a language feature)

Implementation Delegation



Well possible in Java (and other languages)

Interface vs. Implementation Inheritance

Interface inheritance

- Follows the LSP
- Can be realized in Java
 - Using Java interfaces
 - Using regular classes

Implementation inheritance

- Breaks the LSP
- Can be realized in Java
 - But is generally a bad idea
 - Rather use delegation

6. Abstract Superclass Rule

Inheritance and Abstractness

- Inheritance
 - Relationship between two classes, a superclass and a subclass
- Abstract(ness)
 - Relationship between a class and its instances (none if abstract)

Abstract Superclass Rule (ASR) [H94]

All superclasses must be abstract (in design).

Abstract Superclass Rule as a Guideline

A superclass should be abstract in implementation.

How to Make a Class Abstract (in Java)

- By declaration
 - of the class, e.g. "abstract class Counter { ... }"
 - of at least one method, e.g. "public abstract void count(...)"
- By hiding constructors
 - by declaring them protected or private
 - by making sure no implicit public empty constructor exists
- By inheritance
 - by inheriting from an abstract class and
 - not completing it
- The best way is to explicitly declare one's intention

Corollaries to Abstract Superclass Rule

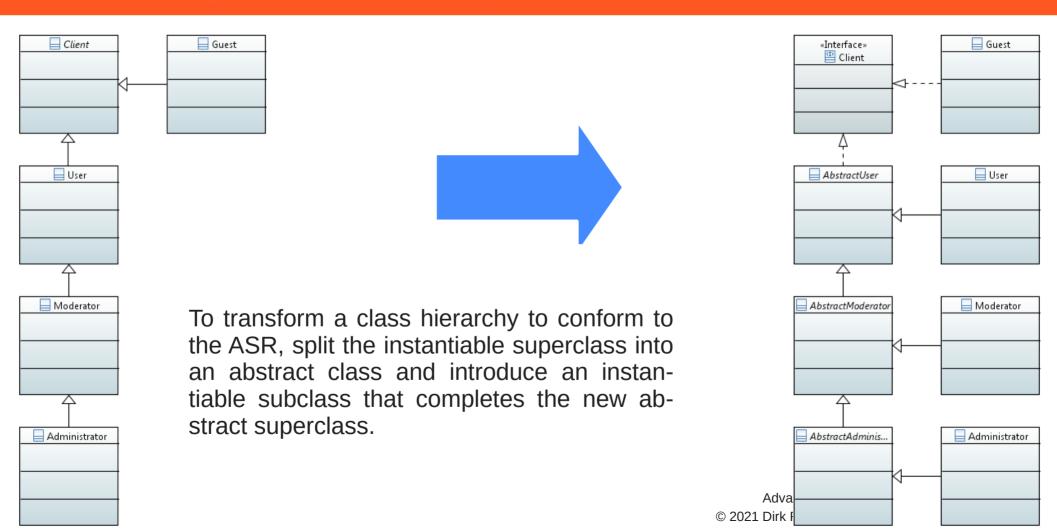
- Hard corollaries (rules)
 - No abstract class should subclass a concrete class
 - All subclasses should first be abstract, then concrete
- Soft corollaries (guidelines)
 - The root of a class hierarchy should be an abstract class
 - (Most) leaf classes in an application should be concrete
- In a framework, leaf classes may be abstract
 - Because they are expecting subclasses in applications

But Why? LSP applied to ASR

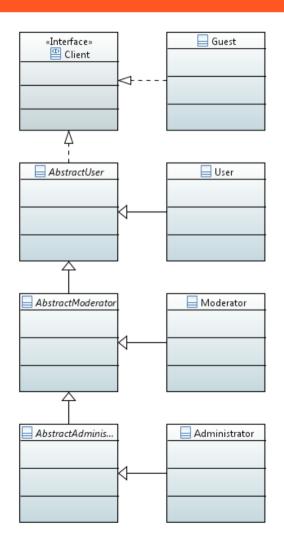
- The ASR helps comply with the LSP
 - The ASR automatically casts subclasses as constrained subtypes
 - Applying the ASR, developers have to think about subclasses
 - Subclasses fill in the holes defined by the abstract superclass
 - Thus, concrete subclasses constrain the abstract superclass
 - With this, the abstract superclass becomes better (re)usable

7. Class Hierarchy Evolution

Transforming a Class Hierarchy

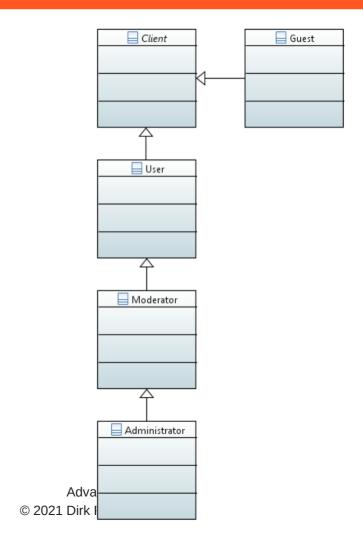


Simplifying a Class Hierarchy





To simplify a class hierarchy, merge a default implementation with its abstract superclass.

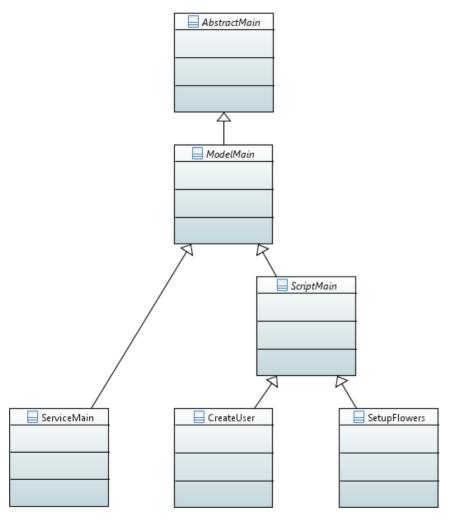


What to Use When?

- Transform to conform in preparation for
 - Increasingly complex default implementation class
 - Other implementation classes as alternatives
- Simplify (and not conform) to
 - Reduce number of overall classes
 - Assuming implementation class is basically empty

8. Cascading Superclass Class

Cascading Inheritance Interfaces



- ServiceMain#startUp() →
 - ModelMain#startUp() →
 - AbstractMain#startUp()
- ServiceMain#shutDown() →
 - Modelmain#shutDown() →
 - AbstractMain#shutDown()
- CreateUser#execute() →
- ScriptMain#execute()

Cascading Superclass Calls

```
public void ServiceMain#startUp(boolean ip, String rd) ... {
 super.startUp(ip, rd);
  log.info("ModelMain#startUp() completed");
  log.config(LogBuilder.createSystemMessage()...);
 initWebPartTemplateService();
  . . .
protected void ModelMain#startUp(boolean ip, String rd) ... {
 super.startUp(ip);
  log.info("AbstractMain#startUp() completed");
  log.config(LogBuilder.createSystemMessage()...);
 initImageStore();
  . . .
protected void AbstractMain#startUp(boolean ip) throws Exception {
 isInProduction = ip;
```

Traditional Run vs. ServletContext

```
public static main(String[] argv) { new FlowersMain.run() }
void FlowersMain#run() {
  startUp();
  execute();
  shutDown();
public void contextInitialized(ServletContextEvent sce) {
  serviceMain.startUp(true, rootDir);
public void contextDestroyed(ServletContextEvent sce) {
  serviceMain.shutDown();
```

Summary

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- 5. Multiple inheritance
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Thank you! Questions?

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