Subclassing vs. Subtyping

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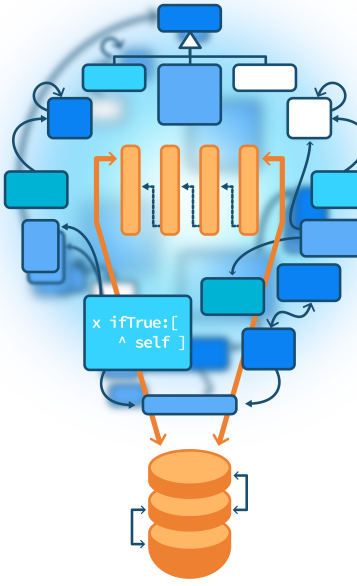


Goals

- Discuss the relation between the **API** of a class and its **subclasses**
- Discuss the relation between the **API** of a class and its **clients**
- Compare **subtyping** & **subclassing**
- Impact on design
- Subtyping is good even in dynamically-typed languages

Example 1

```
class Poem extends LinkedList
{
  ...
}
```

What do you think about it?

- Yes, we can write this code
- What do you think of it? Does it make sense?

A poem API

- is addWord(word), isAlexandrin(), isHaiku(), ...
- should not contain addBeforeLink(aLinkOrObject, otherLink) (that is part of LinkedList)

Another example

```
class Stack extends LinkedList
{
  ...
}
```

What do you think about it?

- Yes, we can write this code.
- What do you think of it? Does it make sense?

A Stack API

- is pop(),push(el), top(), isEmpty()
- should not contain LinkedList methods.

Subclassing

The two previous examples are examples of subclassing, e.g., a subclass does not have an API in relation with its superclass.
It reuses the superclass code.

Subtyping/subclassing and type systems

Did you notice previous code snippets were in Java tiny syntax... because:

- You **can** use subtyping and subclassing in **dynamically-typed** languages
- You **can** use subtyping and subclassing in **statically-typed** languages

The compiler's type checker does not check such a point

- It just checks that we can put **squares** into **squares**

Let us study a simple example

Basic Stack:

```
>>> s push: 12.
>>> s push: 24.
>>> s top
>>> s pop
24
>>> s isEmpty
false
```

Stack as subclass of OrderedCollection

```
OrderedCollection << Stack
```

```
Stack >> pop
  ^ self removeFirst

Stack >> push: anObject
  self addFirst: anObject

Stack >> top
  ^ self first
```

We get size, includes:, do:, collect: for free.

Wait!

- What do we do with the **rest** of the OrderedCollection **API?**
- Our Stack also understands: add:beforeIndex:, addAllFirstUnlessAlreadyPresent:, join:...
- A Stack **is not** an OrderedCollection!
- In a client program we cannot replace an OrderedCollection **by a** Stack

Wait!

Some messages that make sense on the class OrderedCollection do not make sense on the class Stack

```
OrderedCollection new add: newObject beforeIndex: index
```

```
OrderedCollection new add: newObject ; removeFirst
```

We could cancel some operations

```
Stack >> removeFirst
  self error
```

And get a convoluted pop?

Remember:

```
Stack >> pop
  ^ self removeFirst
```

Jumping over cancelled operation :(

```
Stack >> pop
  ^ super removeFirst
```

- Ugly
- Complexify the solution
- Complexify the evolution

Stepping back

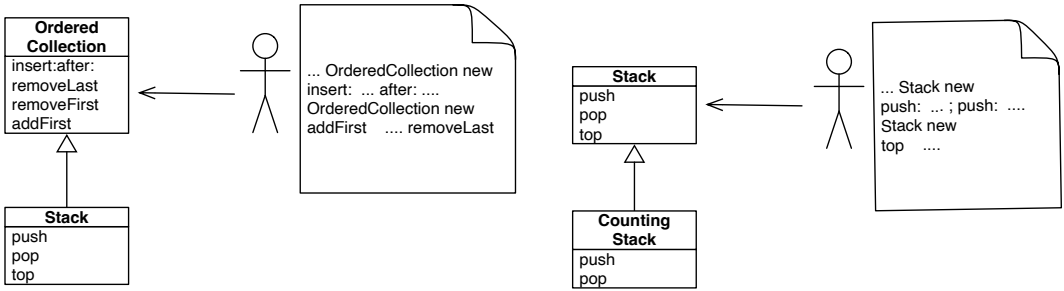
- There is not a **simple relationship** between Stack and OrderedCollection APIs.
- Stack interface is not an **extension** nor a **subset** of OrderedCollection interface.

Imagine CountingStack

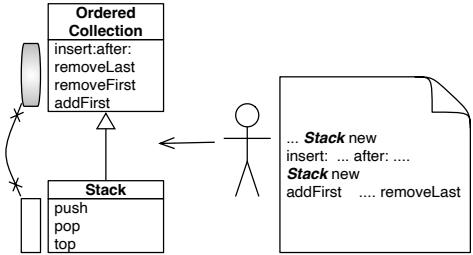
```
CountingStack >> pop
  operations := operations + 1.
  ^ super pop
```

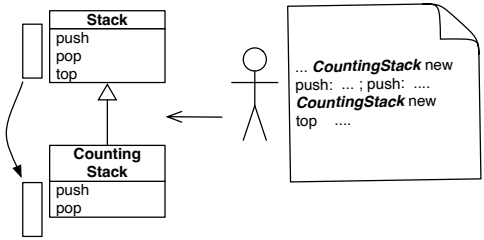
```
CountingStack >> push: anElement
  operations := operations + 1.
  ^ super push: anElement
```

Compare the two uses



Compare the two replacements





Back to Stack

Better use composition! A Stack holds a collection of elements

```
Object << Stack
  slots: {#elements}
```

```
Stack >> push: anElement
  elements addFirst: anElement
```

```
Stack >> pop
  ^ element ifNotEmpty: [ element removeFirst ]
```

Subclassing inheritance

- Inheritance for code reuse
- Subclass reuses code from superclass, but as a **different** specification
- It cannot be used everywhere its superclass is used. Usually overrides of code

Cons:

- **Lowers** understanding
- **Hampers** future evolution
- **Forces** strange code

Subtyping inheritance

- **Reuse** of specifications: interface inheritance
- A subclass **refines** superclass specifications
- A program that works with Numbers should ’work’ with Fractions
- A program that works with Collections should ’work’ with Arrays

Subclasses must not cancel methods

```
Stack >> removeFirst
  self error
```

This is a sign of a bad design decision

- Cheap
- But you will pay later

RestrictedStack

Imagine that we have a stack where we can only push elements smaller than the top elements

```
push: anElement
  self top < anElement
    ifTrue: [^ self ]
  super push: anElement
```

What is the good superclass?

- Stack Probably.
- It would be better if the client handles this behavior, but maybe it is not mandatory or possible.
- A subclass does not have to make sure that the client program works (this is behavioral subtyping)

About Liskov Substitution Principle (LSP)

'if for each object o1 of type S there is another object o2 of type T such that for all programs P defined in terms of T, the behavior of P is unchanged when o1 is substituted for o2, then S is a subtype of T.' Barbara Liskov, "Data Abstraction and Hierarchy," SIGPLAN Notices, 23,5 (May 1988)

- LSP is about behavioral typing (about the same behavior)
- Most of the time when you define subclass to change behavior
- By definition, a subclass often exhibits a slightly different behavior than its superclass
- Therefore LSP looks useless in such a context.

Inheritance and polymorphism

- Polymorphism works best with **conforming**/**substituable** interfaces
- Subtyping inheritance creates **families** of classes with **similar interfaces**
  - An abstract class describes an interface fulfilled by its subclasses
- Subtyping inheritance helps software reuse by creating **polymorphic objects**
- Now classes in different hierarchies implementing the same interface can also **be substituable**

'extend' one term for two concepts

- We only have one `extend` or `subclass:` construct in programming language
- Still you can express a **subtype** or **subclass** relationship between a class and its subclass.
- Subclassing/subtyping is not related to static typing

Conclusion

- Subclassing is about program specification **reuse**
- Subtyping is about creating **family of classes sharing common API**
- **Avoid** subclassing: it is a bad idea when you want subtyping

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