Inheritance

Slides adapted from Berkeley cs61a

- Attributes Assignments
- Inheritance
- Object-Oriented Design

  Inheritance vs. Composition vs. Mixin
- Multiple Inheritance
- Practice: *Attributes Lookup*

Attribute Assignment

Assignment to Attributes

Assignment statements with a dot expression on their left-hand side affect attributes for the object of that dot expression (a.f = x)

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class Account:
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        self.holder = holder
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    ...
tom_account = Account('Tom')
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Instance Attribute Assignment: tom_account.interest = 0.08

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0.02
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```

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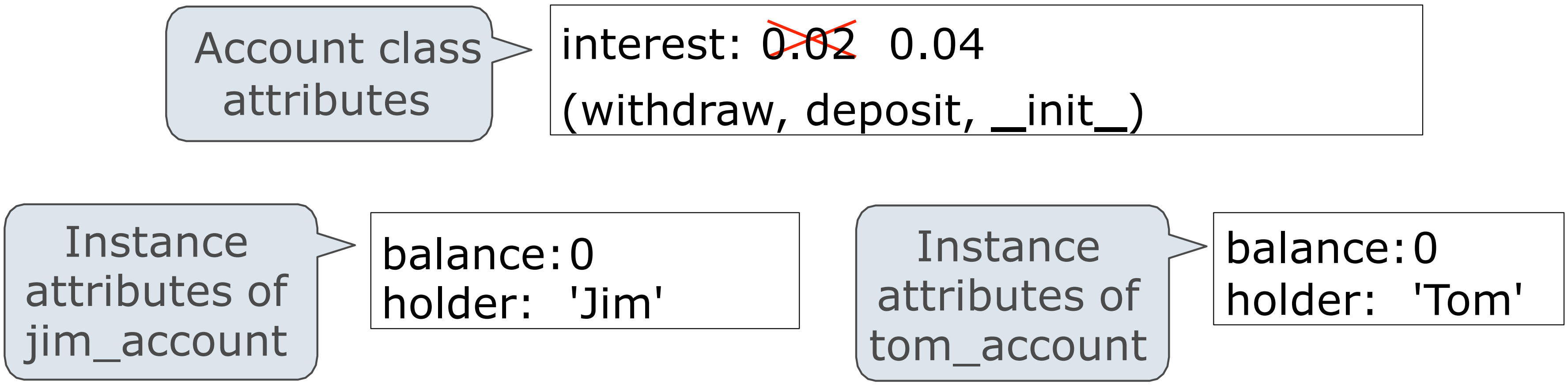


```
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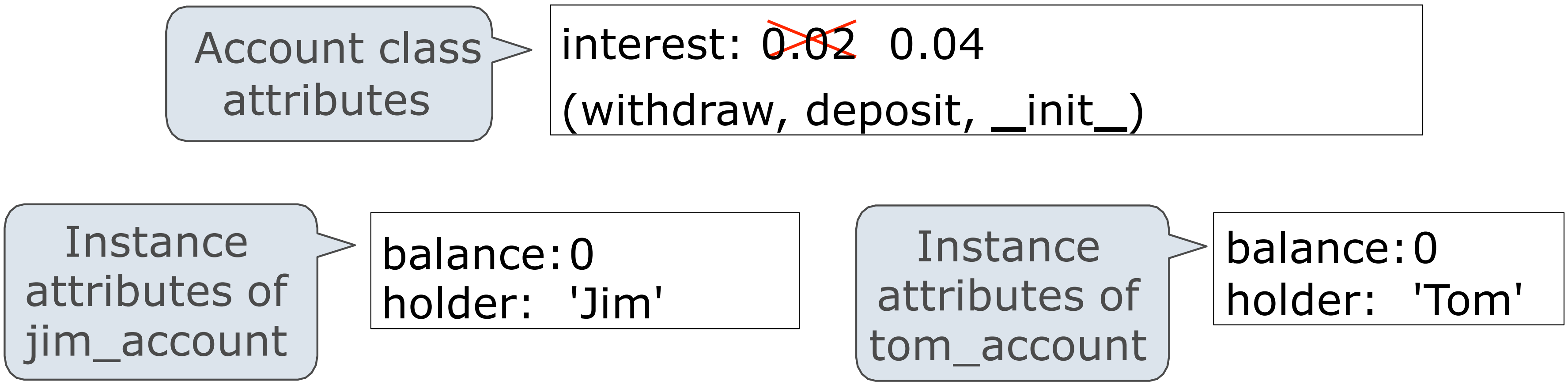


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Using inheritance, we implement a subclass by specifying its differences from the the base class

Inheritance Example

A CheckingAccount is a specialized type of Account

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```
>>> ch = CheckingAccount('Tom')
>>> ch.interest     # Lower interest rate for checking accounts
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>>> ch.deposit(20)  # Deposits are the same
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Most behavior is shared with the base class Account

```
class CheckingAccount(Account):
    """A bank account that charges for withdrawals."""
    withdraw_fee = 1
    interest = 0.01
    def withdraw(self, amount):
        return Account.withdraw(self, amount + self.withdraw_fee)
```

Looking Up Attribute Names on Classes

Base class attributes *aren't* copied into subclasses!

To look up a name in a class:

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demo_2: CheckingAccount

Object-Oriented Design

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Assume in the future, a subclass **GreenCheckingAccount** whose interest is 0.01 but withdraw_fee is only 0.23

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- Breaks encapsulation

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- Unnecessary cost for inheritance maintenance

  e.g., the cost of superclasses’ fields storage, constructors invocation, while only few behaviors of superclasses are needed

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“If you want to reuse some behavior, put that behavior in a class, create an object of that class, include it as an attribute, and call its methods when the behavior is needed”

- Composition does not break encapsulation, and does not affect the types (all public interfaces remain unchanged)
- No need to involve in possibly complex hierarchy, and easy to understand and implement

Inheritance vs. Composition

Guidance to choose inheritance or composition

- By conceptual difference

- By practical need

Inheritance vs. Composition

Guidance to choose inheritance or composition

- By conceptual difference

  Inheritance represents "is-a" relationship

  e.g., a checking account is a specific type of account

  Composition represents "has-a" relationship

  e.g., a bank has a collection of bank accounts it manages

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demo_3: Bank

Inheritance vs. Composition

Implementing composition means we need to wrap the delegation logic (delegated to the composed object) into certain methods, in which case inheritance's "direct reuse" seems more convenient.

Inheritance vs. Composition

Do we have some approach to somewhat take the advantages of both inheritance and composition?

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- Unlike Python, some languages such as Ruby and Scala, has language support to enforce the syntax/semantics of Mixin
    - E.g., Mixin is called module in Ruby, and trait in Scala
- Mixin is usually considered as a mean for multiple inheritance

Multiple Inheritance

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```
class SavingsAccount(Account):
    deposit_fee = 2
    def deposit(self, amount):
        return Account.deposit(self, amount - self.deposit_fee)
```

A class may inherit from multiple base classes in Python

CleverAccount marketing executive has an idea:

- Low interest rate of 1%
- A $1 fee for withdrawals
- A $2 fee for deposits
- A free dollar when you open your account

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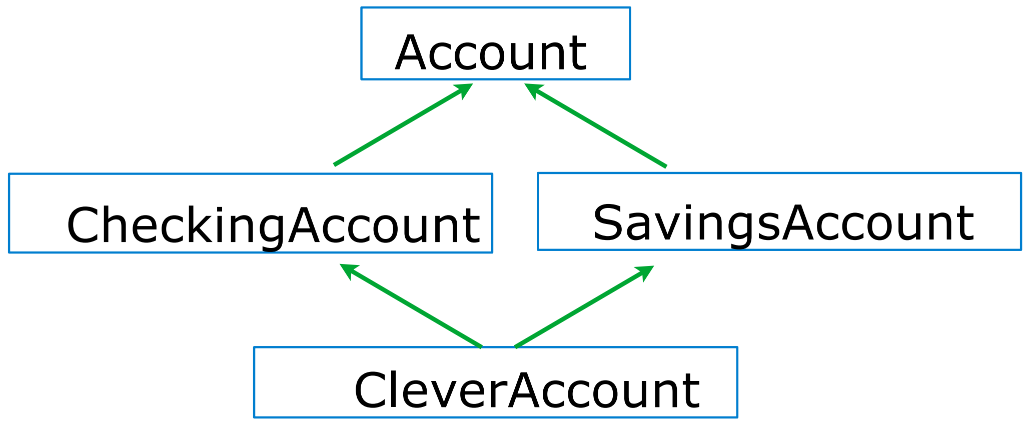
```
class CleverAccount(CheckingAccount, SavingsAccount):
    def __init__(self, account_holder):
        self.holder = account_holder
        self.balance = 1                # A free dollar!
```

Multiple Inheritance



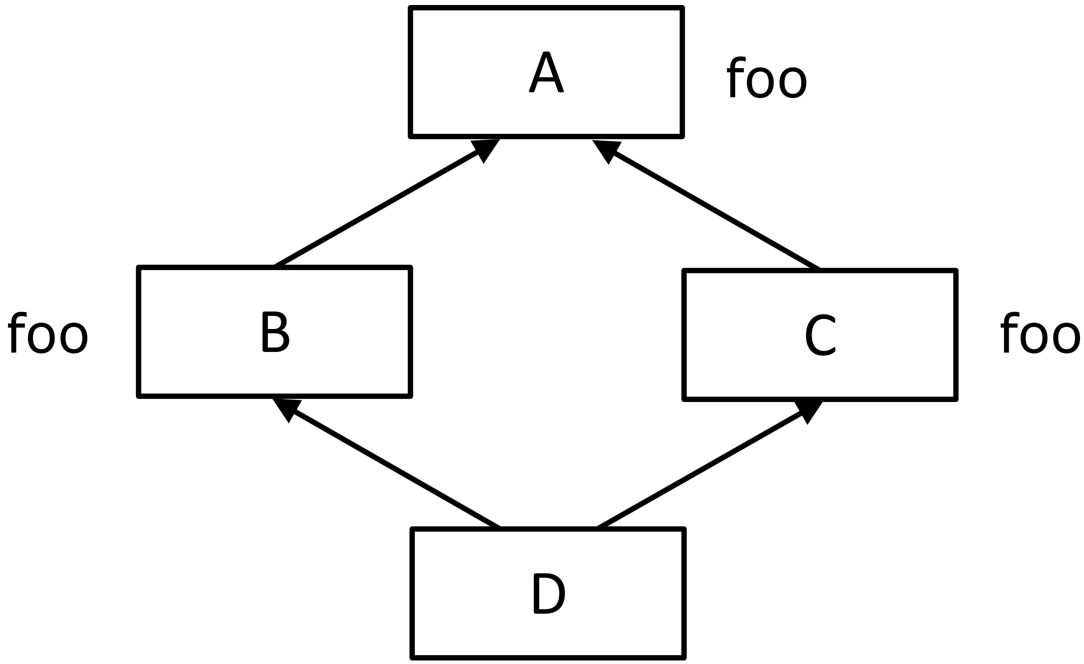

```
>>> tom= CleverAccount('Tom')
>>> tom.balance
1
>>> tom.deposit(20)
18
>>> tom.withdraw(5)
12
```

Instance attribute (tom.balance)

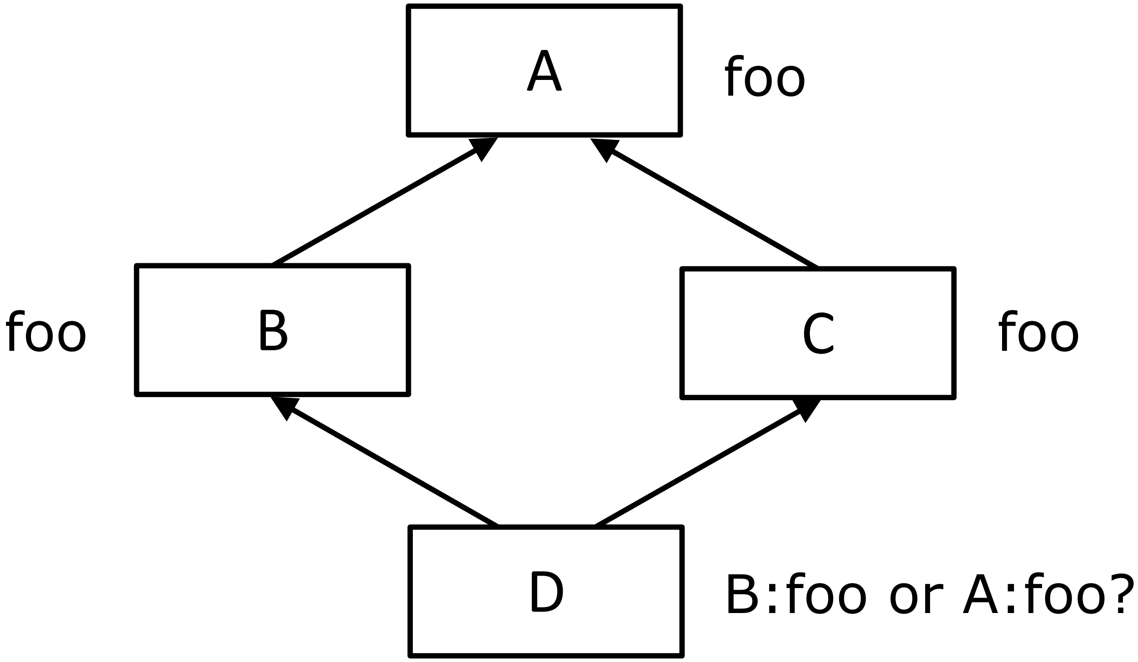
SavingsAccount method (tom.deposit)

CheckingAccount method (tom.withdraw)

Diamond Problem

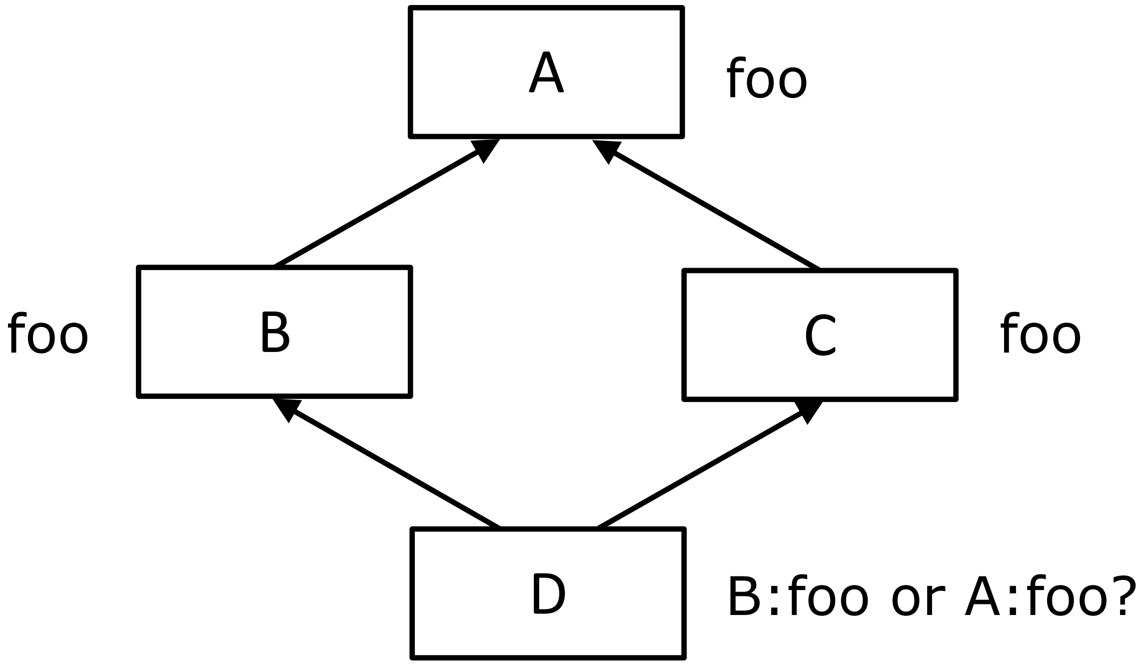


Diamond Problem



Method Resolution Order (MRO)

Diamond Problem



Method Resolution Order (MRO)

C3 Linearization algorithm for method resolution while doing multiple inheritance

Practice: Attributes Lookup

Inheritance and Attribute Lookup

```
class A:
    z = -1
    def f(self, x):
        return B(x-1)

class B(A):
    n = 4
    def __init__(self, y):
        if y:
            self.z = self.f(y)
        else:
            self.z = C(y+1)

class C(B):
    def f(self, x):
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a = A()
b = B(1)
b.n = 5
```

```
>>> C(2).n
```

```
>>> a.z == C.z
```

```
>>> a.z == b.z
```

Which evaluates to an integer?

- b.z
- b.z.z
- b.z.z.z
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- None of these

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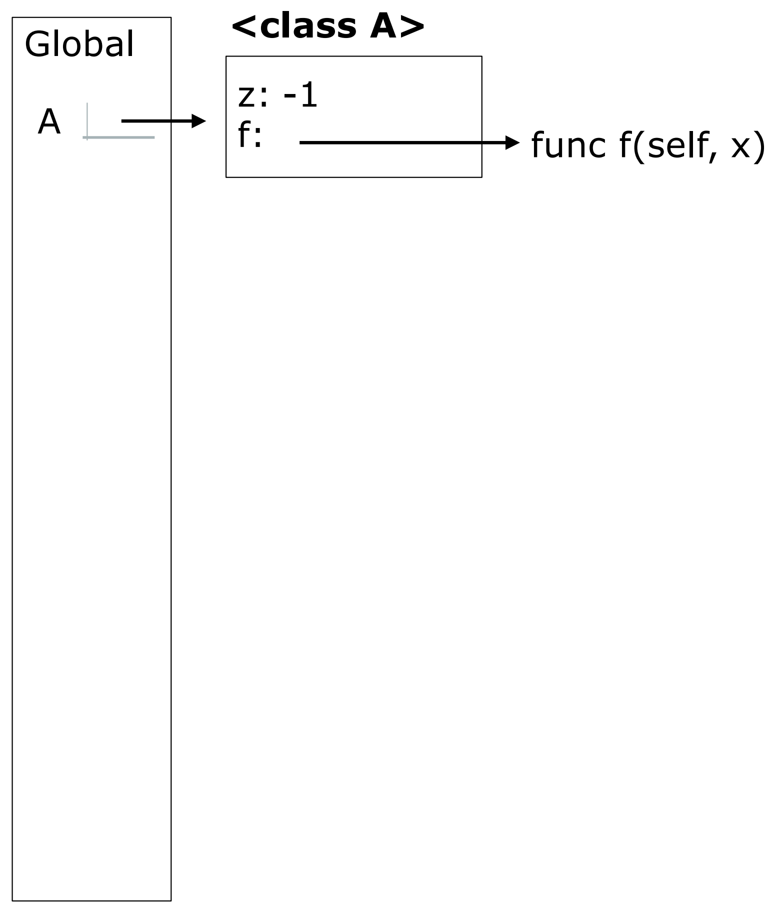

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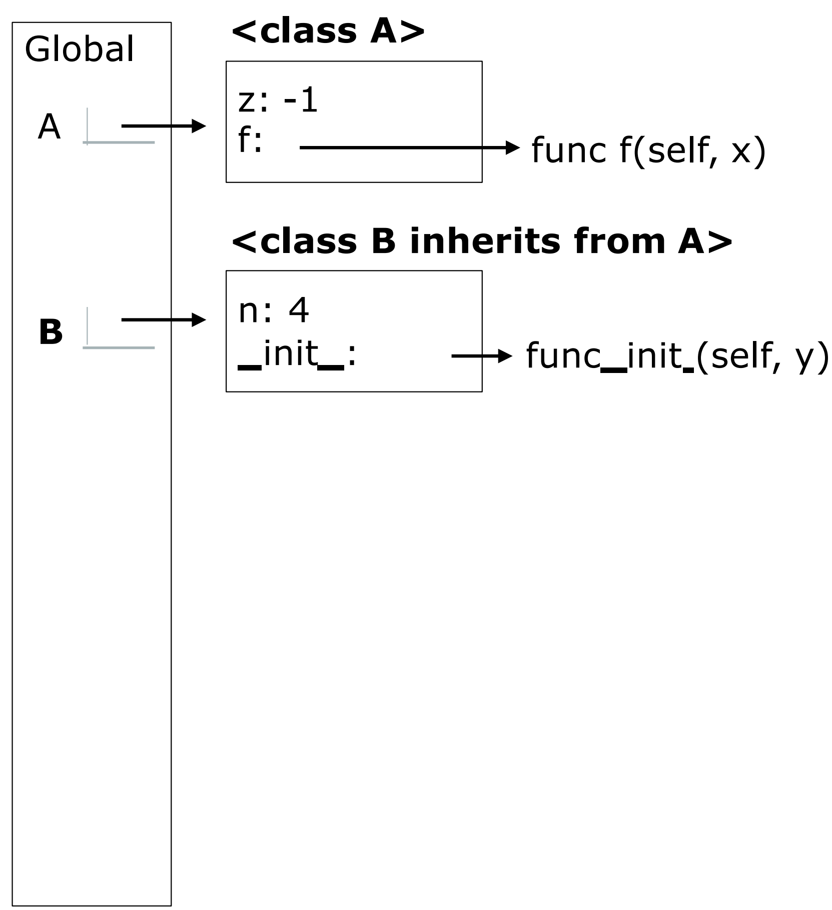

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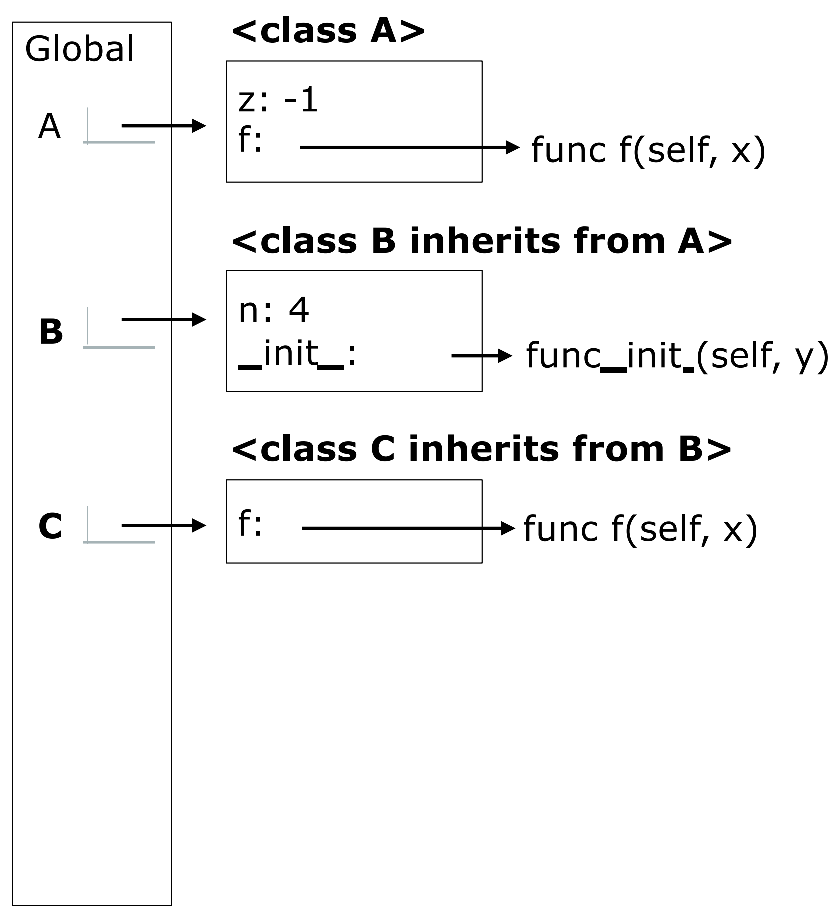

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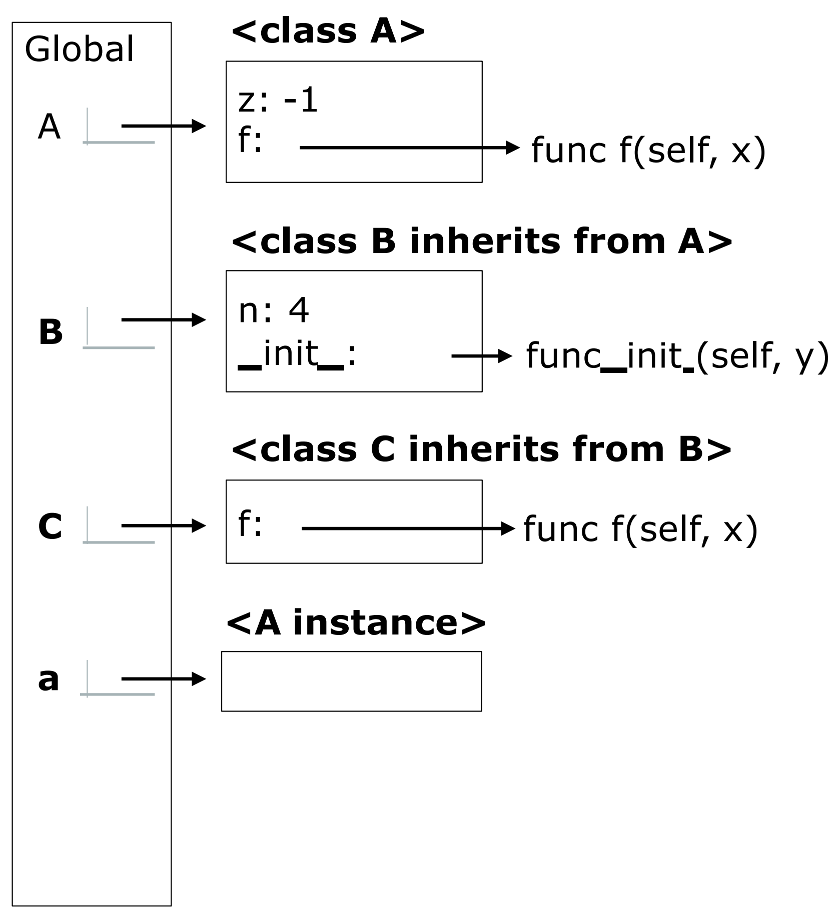

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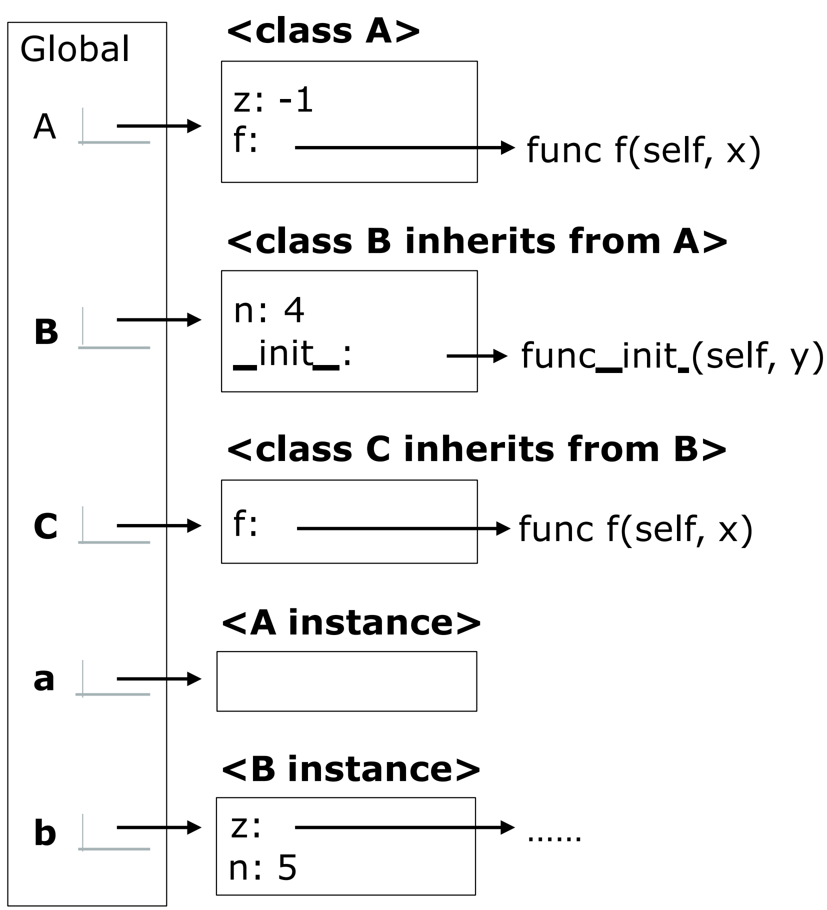

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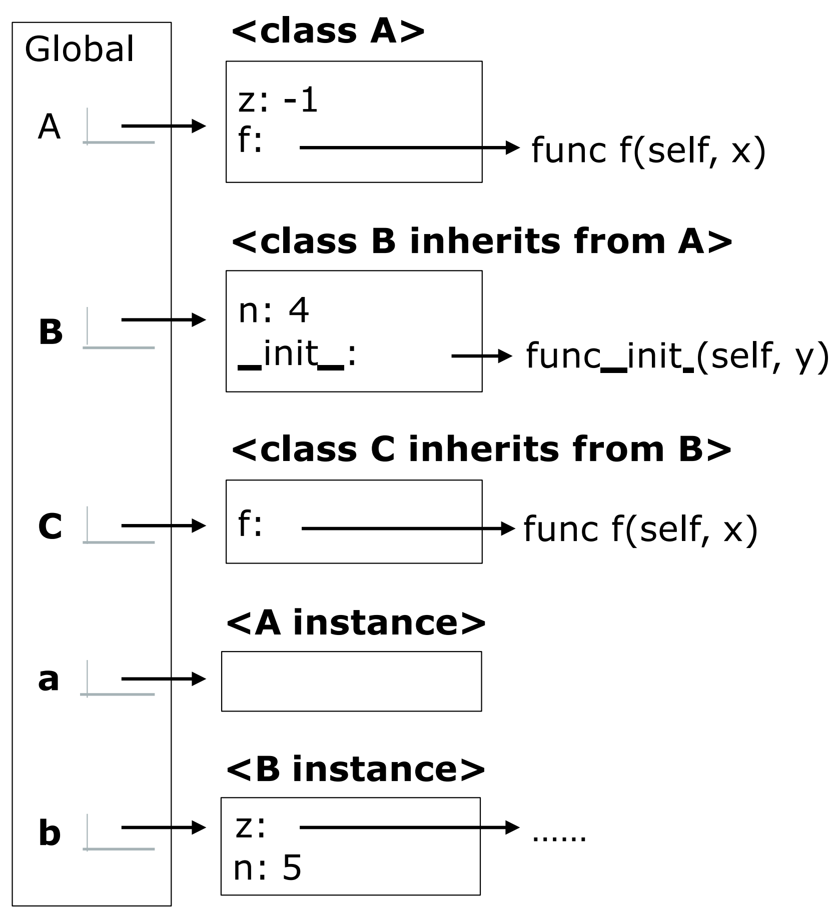

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>>> C(2).n
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>>> a.z == C.z
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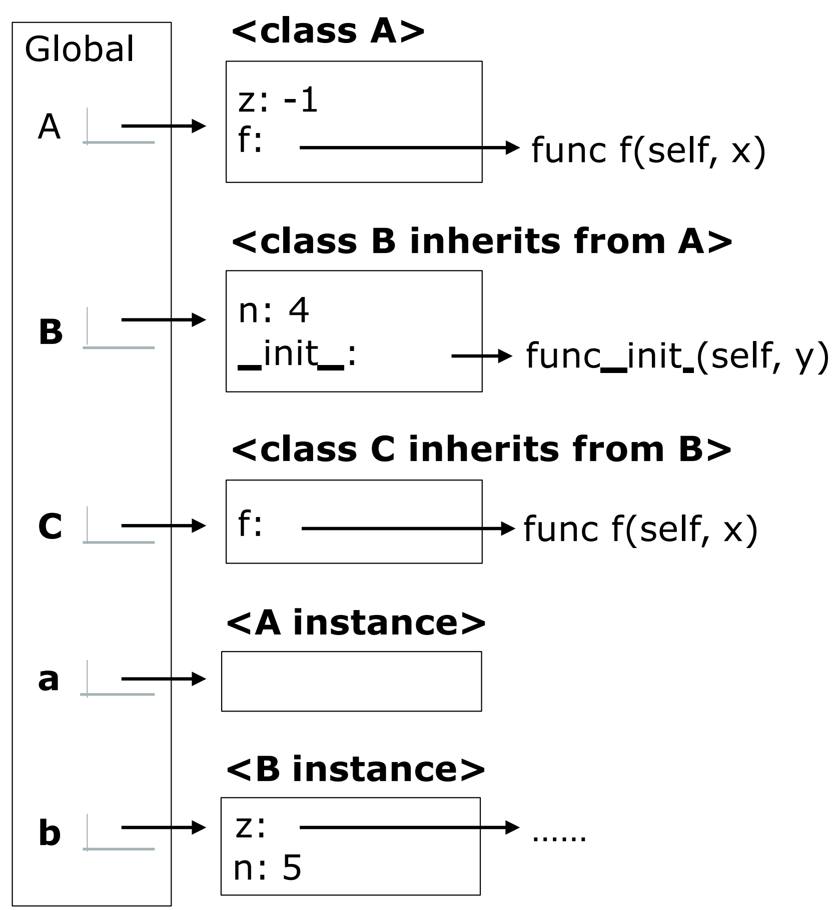

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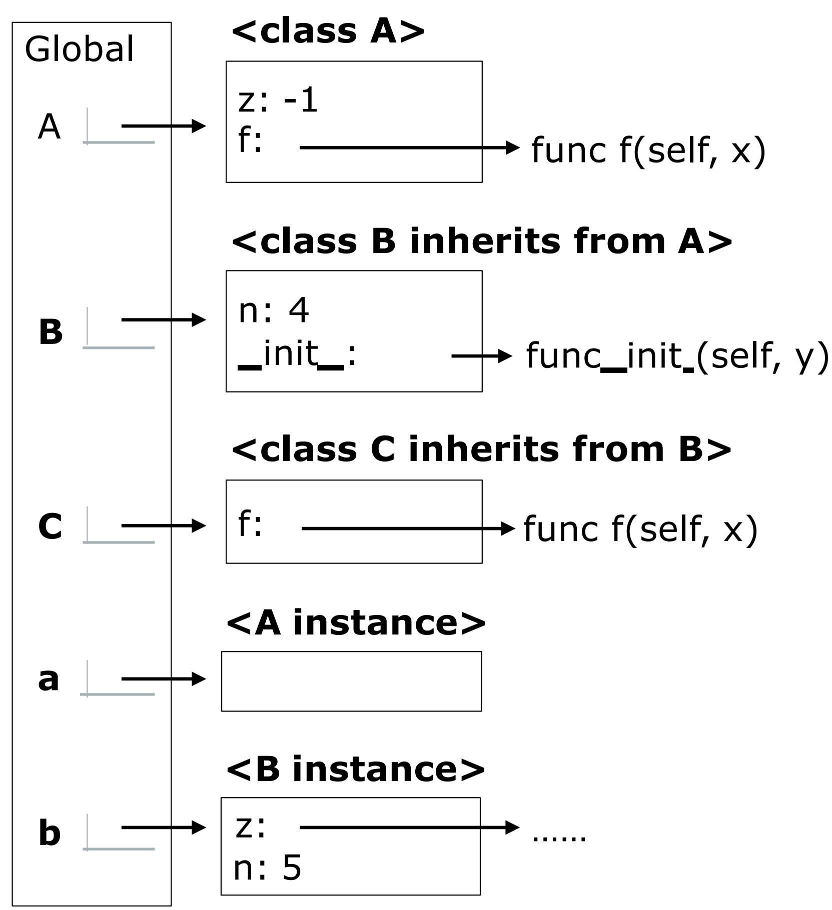

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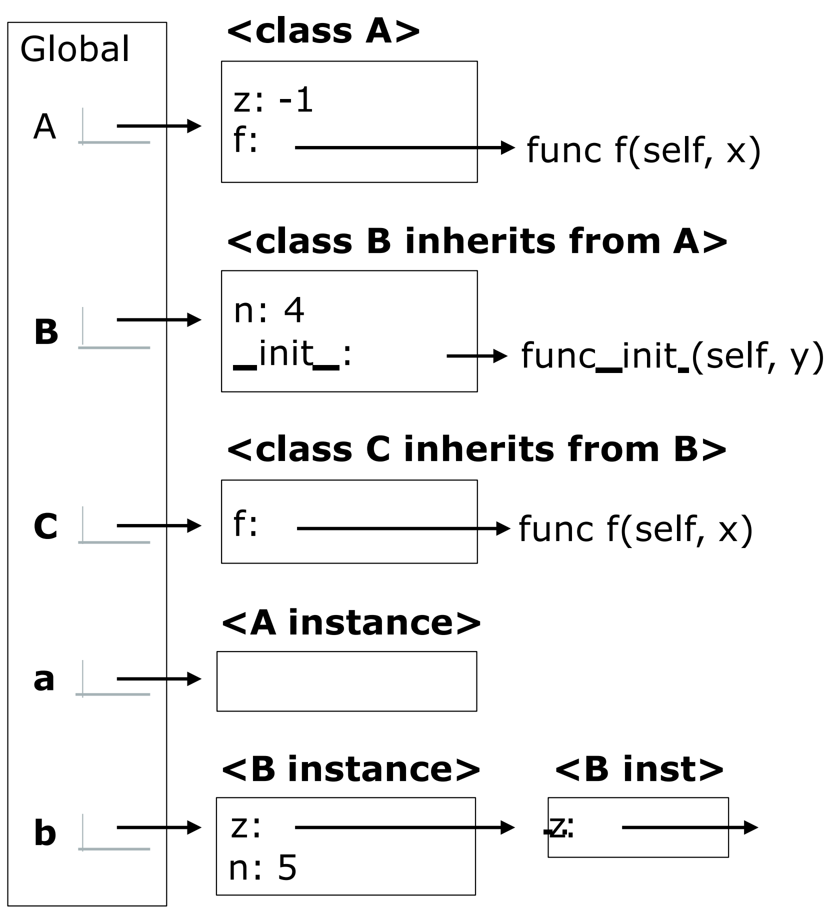

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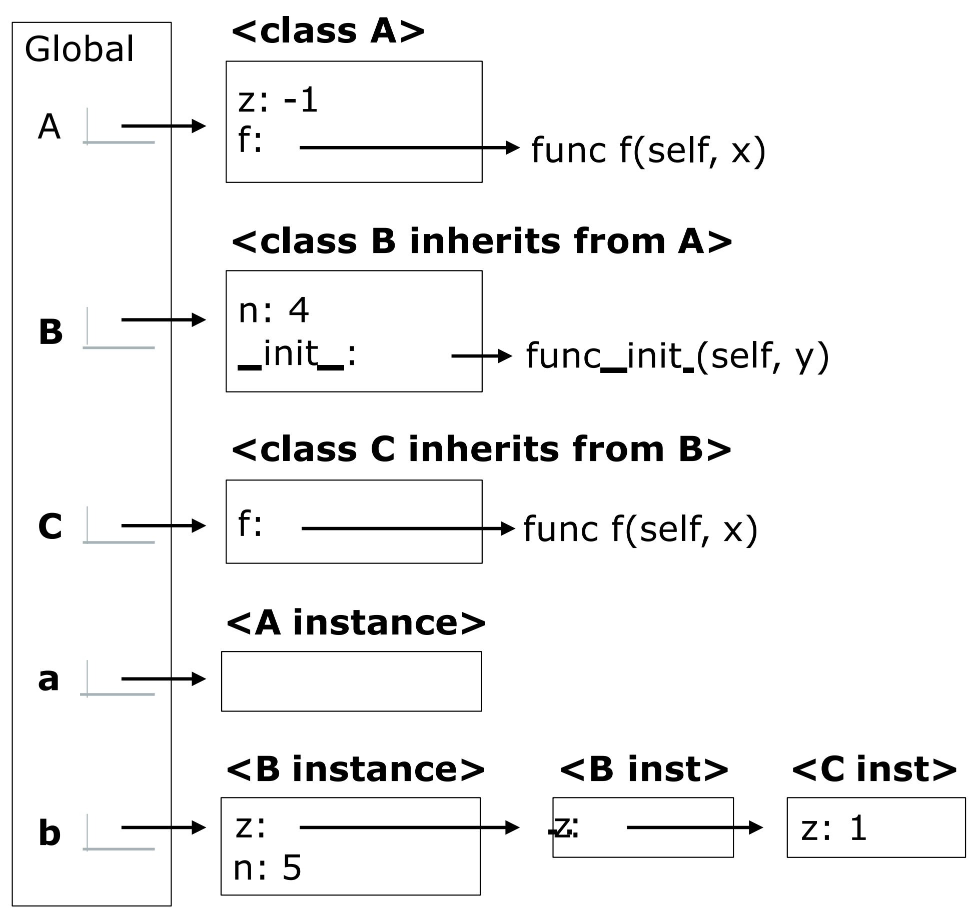

The X You Need To Understand In This Lecture

- Rules of attribute assignment
- Rules of inheritance
- Rules of attribute lookup on classes
- Difference between inheritance and composition