

Inheritance

Announcements

Attributes

Terminology: Attributes, Functions, and Methods

All objects have attributes, which are name–value pairs

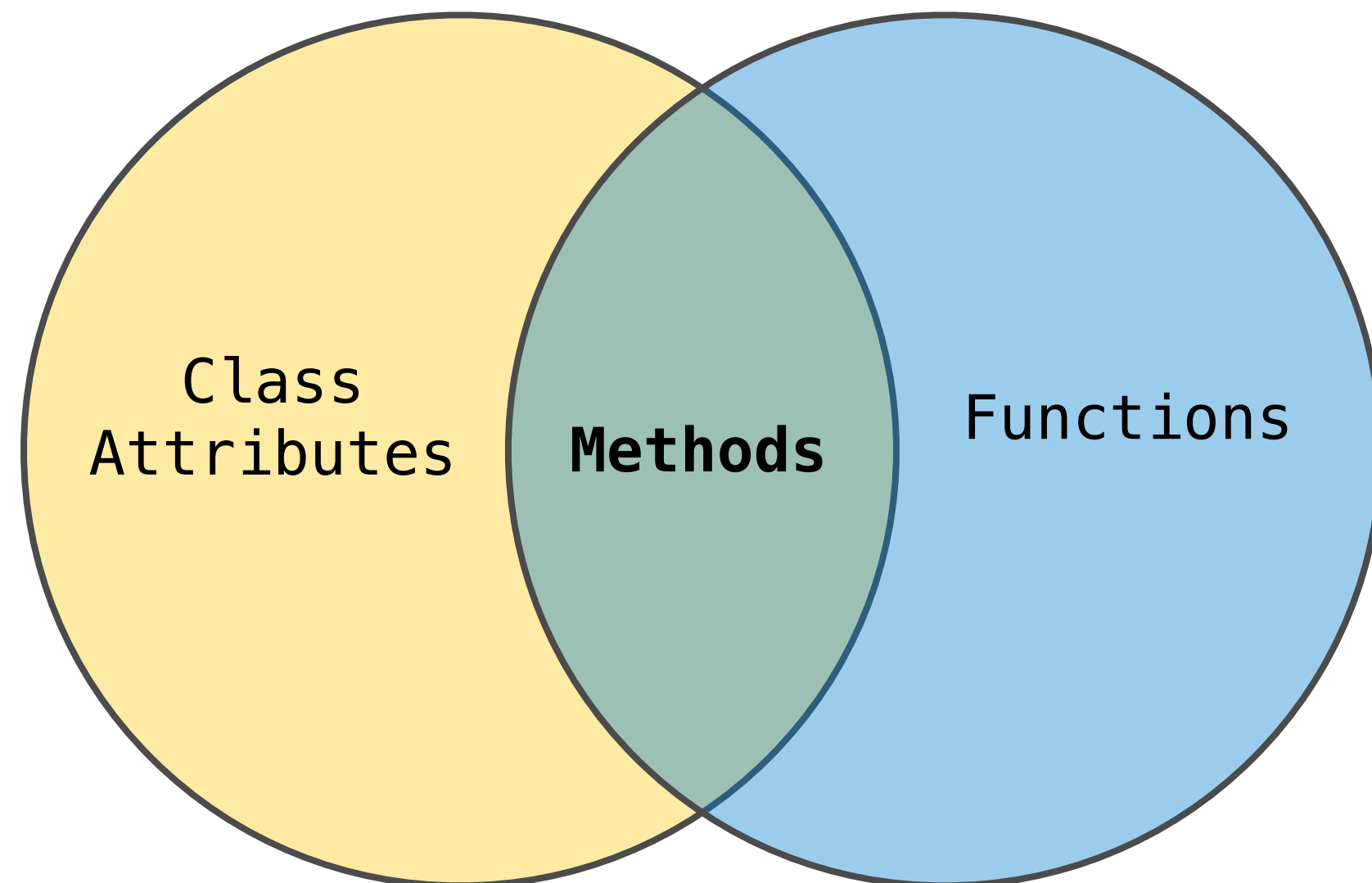
A class is a type (or category) of objects

Classes are objects too, so they have attributes

Instance attribute: attribute of an instance

Class attribute: attribute of the class of an instance

Terminology:



Python object system:

Functions are objects

Bound methods are also objects: a function that has its first parameter "self" already bound to an instance

Dot expressions evaluate to bound methods for class attributes that are functions

`<instance>.<method_name>`

Looking Up Attributes by Name

`<expression> . <name>`

To evaluate a dot expression:

1. Evaluate the `<expression>` to the left of the dot, which yields the object of the dot expression
2. `<name>` is matched against the instance attributes of that object; if an attribute with that name exists, its value is returned
3. If not, `<name>` is looked up in the class, which yields a class attribute value
4. That value is returned unless it is a function, in which case a bound method is returned instead

Class Attributes

Class attributes are "shared" across all instances of a class because they are attributes of the class, not the instance

```
class Account:
    interest = 0.02    # A class attribute

    def __init__(self, account_holder):
        self.balance = 0
        self.holder = account_holder

# Additional methods would be defined here
```

```
>>> tom_account = Account('Tom')
>>> jim_account = Account('Jim')
>>> tom_account.interest
0.02
>>> jim_account.interest
0.02
```

The **interest** attribute is *not* part of the instance; it's part of the class!

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

- If the object is an instance, then assignment sets an instance attribute
- If the object is a class, then assignment sets a class attribute

```
class Account:  
    interest = 0.02  
    def __init__(self, holder):  
        self.holder = holder  
        self.balance = 0  
    ...  
tom_account = Account('Tom')
```

Instance
Attribute
Assignment

tom_account.interest = 0.08

This expression
evaluates to an
object

But the name ("interest")
is not looked up

Attribute
assignment
statement adds
or modifies the
attribute named
"interest" of
tom_account

Class
Attribute
Assignment

Account.interest = 0.04

Attribute Assignment Statements

Account class
attributes

```
interest: 0.02 0.04 0.05  
(withdraw, deposit, __init__)
```

Instance
attributes of
jim_account

```
balance: 0  
holder: 'Jim'  
interest: 0.08
```

Instance
attributes of
tom_account

```
balance: 0  
holder: 'Tom'
```

```
>>> jim_account = Account('Jim')  
>>> tom_account = Account('Tom')  
>>> tom_account.interest  
0.02  
>>> jim_account.interest  
0.02  
>>> Account.interest = 0.04  
>>> tom_account.interest  
0.04  
>>> jim_account.interest  
0.04
```

```
>>> jim_account.interest = 0.08  
>>> jim_account.interest  
0.08  
>>> tom_account.interest  
0.04  
>>> Account.interest = 0.05  
>>> tom_account.interest  
0.05  
>>> jim_account.interest  
0.08
```

Inheritance

Inheritance

Inheritance is a technique for relating classes together

A common use: Two similar classes differ in their degree of specialization

The specialized class may have the same attributes as the general class, along with some special-case behavior

```
class <Name>(<Base Class>):  
    <suite>
```

Conceptually, the new subclass inherits attributes of its base class

The subclass may override certain inherited attributes

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`

```
>>> ch = CheckingAccount('Tom')
>>> ch.interest      # Lower interest rate for checking accounts
0.01
>>> ch.deposit(20)   # Deposits are the same
20
>>> ch.withdraw(5)   # Withdrawals incur a $1 fee
14
```

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)
        or
        return super().withdraw(        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:

1. If it names an attribute in the class, return the attribute value.
2. Otherwise, look up the name in the base class, if there is one.

```
>>> ch = CheckingAccount('Tom') # Calls Account.__init__
>>> ch.interest # Found in CheckingAccount
0.01
>>> ch.deposit(20) # Found in Account
20
>>> ch.withdraw(5) # Found in CheckingAccount
14
```

(Demo)

Object-Oriented Design

Designing for Inheritance

Don't repeat yourself; use existing implementations

Attributes that have been overridden are still accessible via class objects

Look up attributes on instances whenever possible

```
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)
```

Attribute look-up
on base class

Preferred to `CheckingAccount.withdraw_fee`
to allow for specialized accounts

Inheritance and Composition

Object-oriented programming shines when we adopt the metaphor

Inheritance is best for representing is-a relationships

- E.g., a checking account is a specific type of account
- So, `CheckingAccount` inherits from `Account`

Composition is best for representing has-a relationships

- E.g., a bank has a collection of bank accounts it manages
- So, A bank has a list of accounts as an attribute

(Demo)

Review: Attributes Lookup, Methods, & Inheritance

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):
        return x

a = A()
b = B(1)
    
```

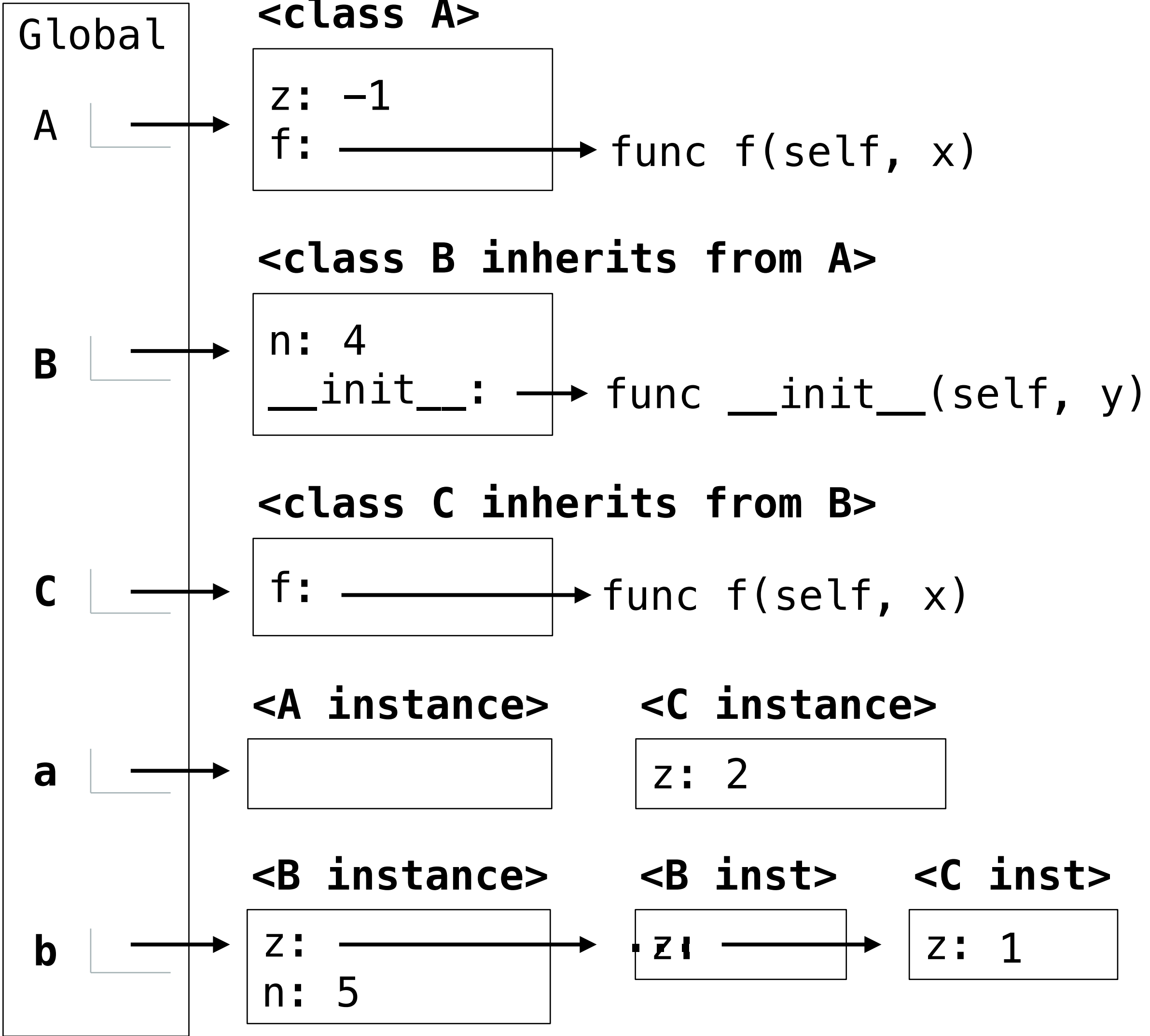
```

>>> C(2).n
4

>>> a.z == C.z
True

>>> a.z == b.z
False

Which evaluates
to an integer?
b.z
b.z.z
▶ b.z.z.z
b.z.z.z.z
None of these
    
```



Environment diagrams for objects aren't required, but can be very helpful!

Multiple Inheritance

Multiple Inheritance

```
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

CleverBank 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

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

Multiple Inheritance

A class may inherit from multiple base classes in Python.

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

Instance attribute

```
>>> such_a_deal = AsSeenOnTVAccount('John')
```

```
>>> such_a_deal.balance
```

```
1
```

SavingsAccount method

```
>>> such_a_deal.deposit(20)
```

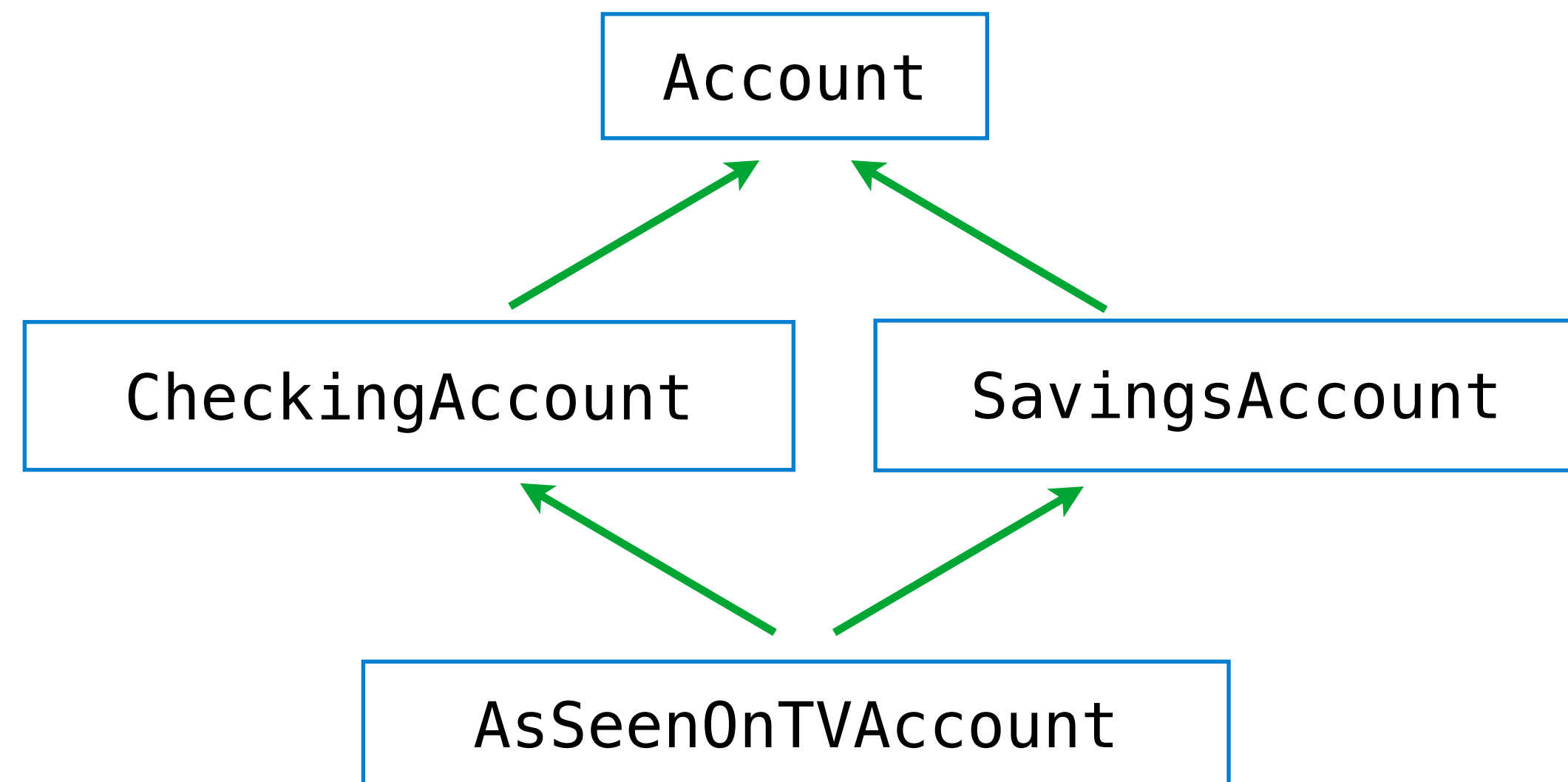
```
19
```

CheckingAccount method

```
>>> such_a_deal.withdraw(5)
```

```
13
```

Resolving Ambiguous Class Attribute Names



Instance attribute

```
>>> such_a_deal = AsSeenOnTVAccount('John')
```

```
>>> such_a_deal.balance
```

```
1
```

SavingsAccount method

```
>>> such_a_deal.deposit(20)
```

```
19
```

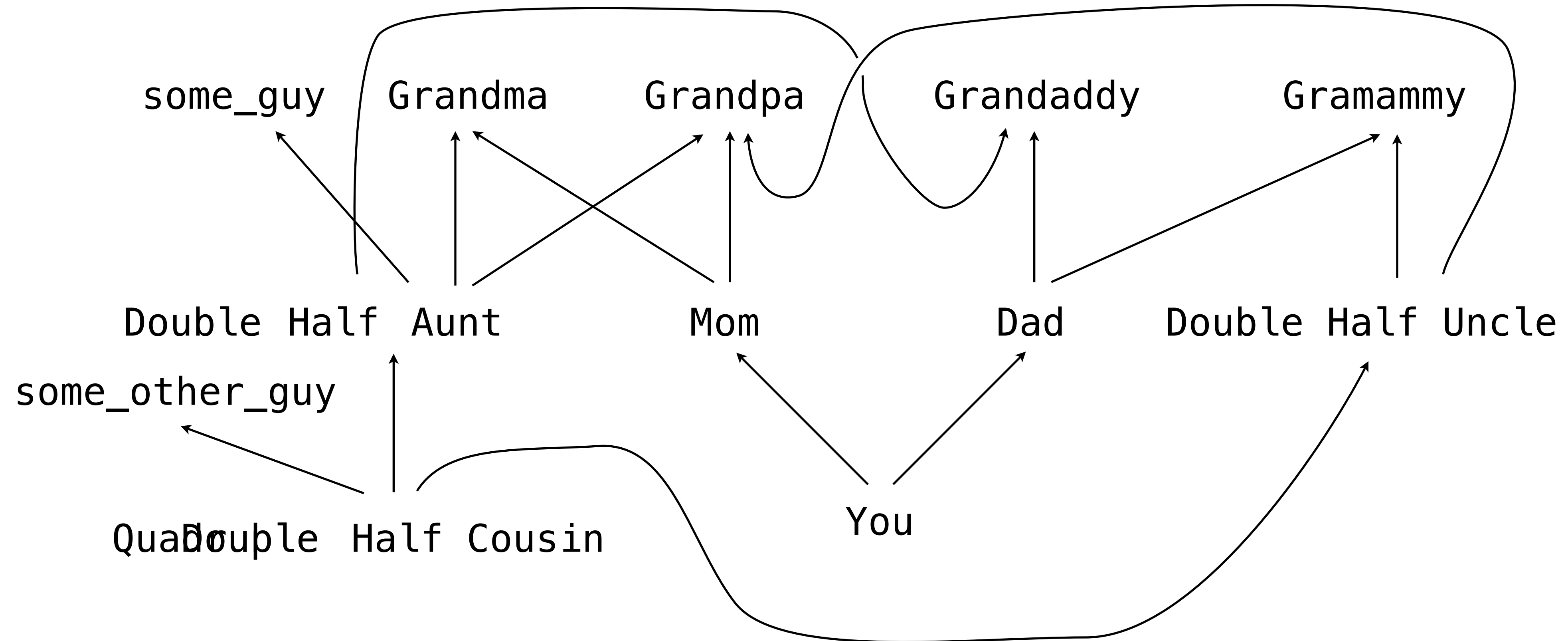
CheckingAccount method

```
>>> such_a_deal.withdraw(5)
```

```
13
```

Complicated Inheritance

Biological Inheritance



Moral of the story: multiple inheritance can be complicated, so don't overuse it!