61A Lecture 15

Monday, October 3

Terminology: Attributes, Functions, and Methods

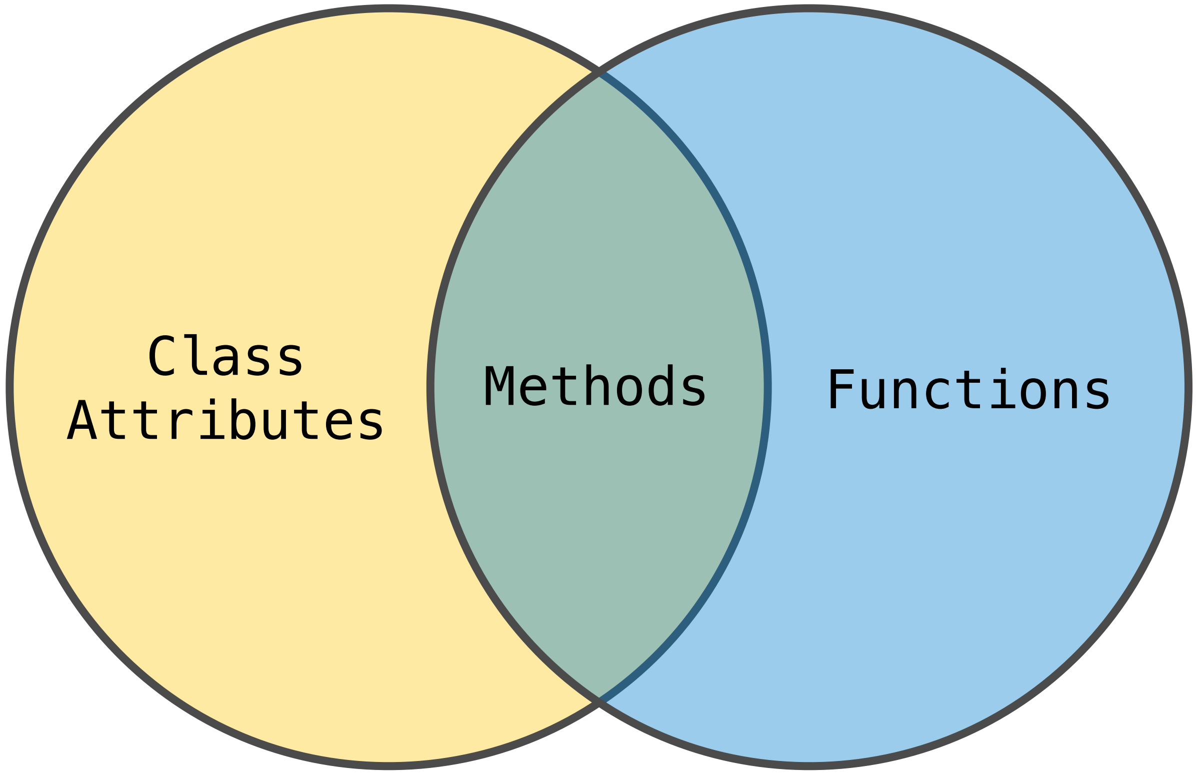
All objects have attributes, which are name-value pairs

Classes are objects too, so they have attributes

Instance attributes: attributes of instance objects

Class attributes: attributes of class objects

Terminology:



Python object system:

Functions are a type of object

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

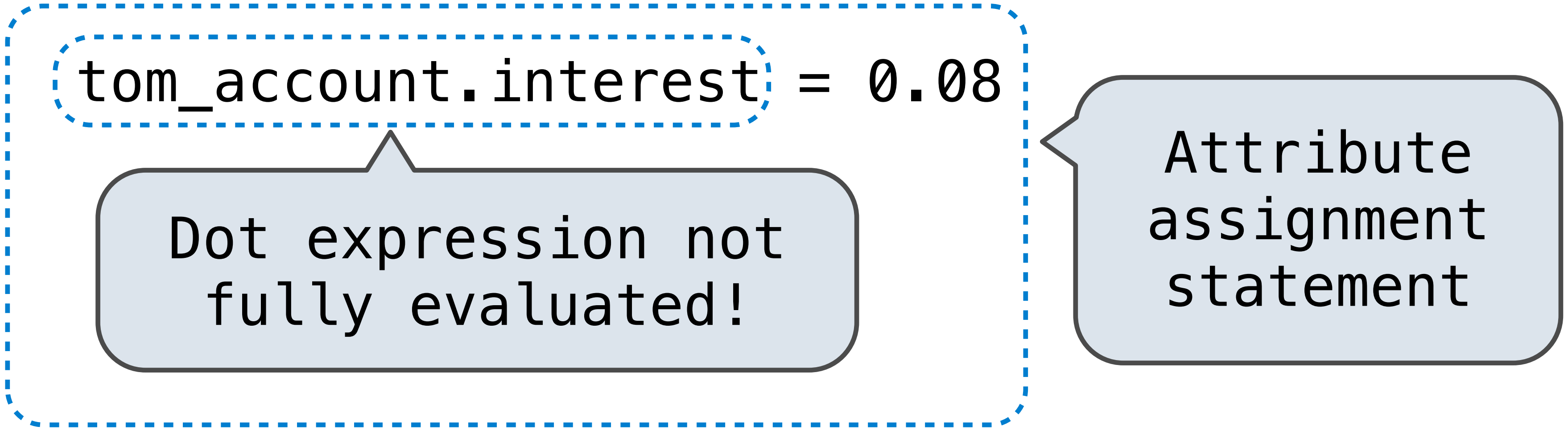
Dot expressions create bound methods from functions

Assignment Statements and 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

Instance Attribute Assignment :



```
tom_account.interest = 0.08
```

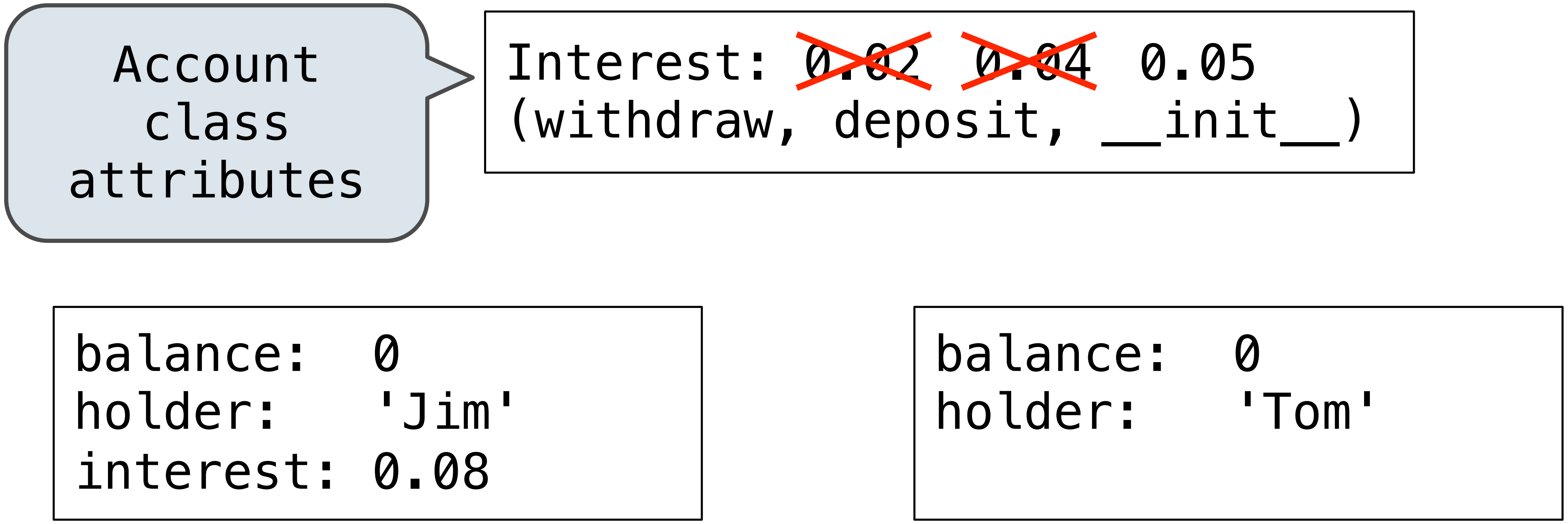
Dot expression not fully evaluated!

Attribute assignment statement

Class Attribute Assignment :

```
Account.interest = 0.04
```

Attribute Assignment Statements



Account class attributes

Interest: ~~0.02~~ ~~0.04~~ 0.05
(withdraw, deposit, __init__)

balance: 0
holder: 'Jim'
interest: 0.08

balance: 0
holder: 'Tom'

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

Looking Up Attributes by Name (Abbreviated)

`<expression> . <name>`

To evaluate a dot expression:

1. Evaluate the `<expression>`...

2. `<name>` is matched against the instance attributes...

3. If not found, `<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.

Inheritance

A technique for relating classes together

Common use: Similar classes differ in amount of specialization

Two classes have overlapping attribute sets, but one represents a special case of the other

```
class <name>(<base class>):
    <suite>
```

Conceptually, the new *subclass* "shares" attributes with its base class

The subclass may *override* certain inherited attributes

Using inheritance, we implement a subclass by specifying its difference 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)
```

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

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

Preferable to CheckingAccount.withdraw_fee

Base Class Generality

Base classes may contain logic that is meant for subclasses

Example: Same CheckingAccount behavior; different approach

Demo

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

∴ CheckingAccount inherits from Account

Composition is best for representing *has-a* relationships

E.g., a bank **has a** collection of bank accounts it manages

∴ A bank has a list of Account instances as an attribute

No local state at all? Just write a function!

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

Bank of America marketing executive wants:

- 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!
```

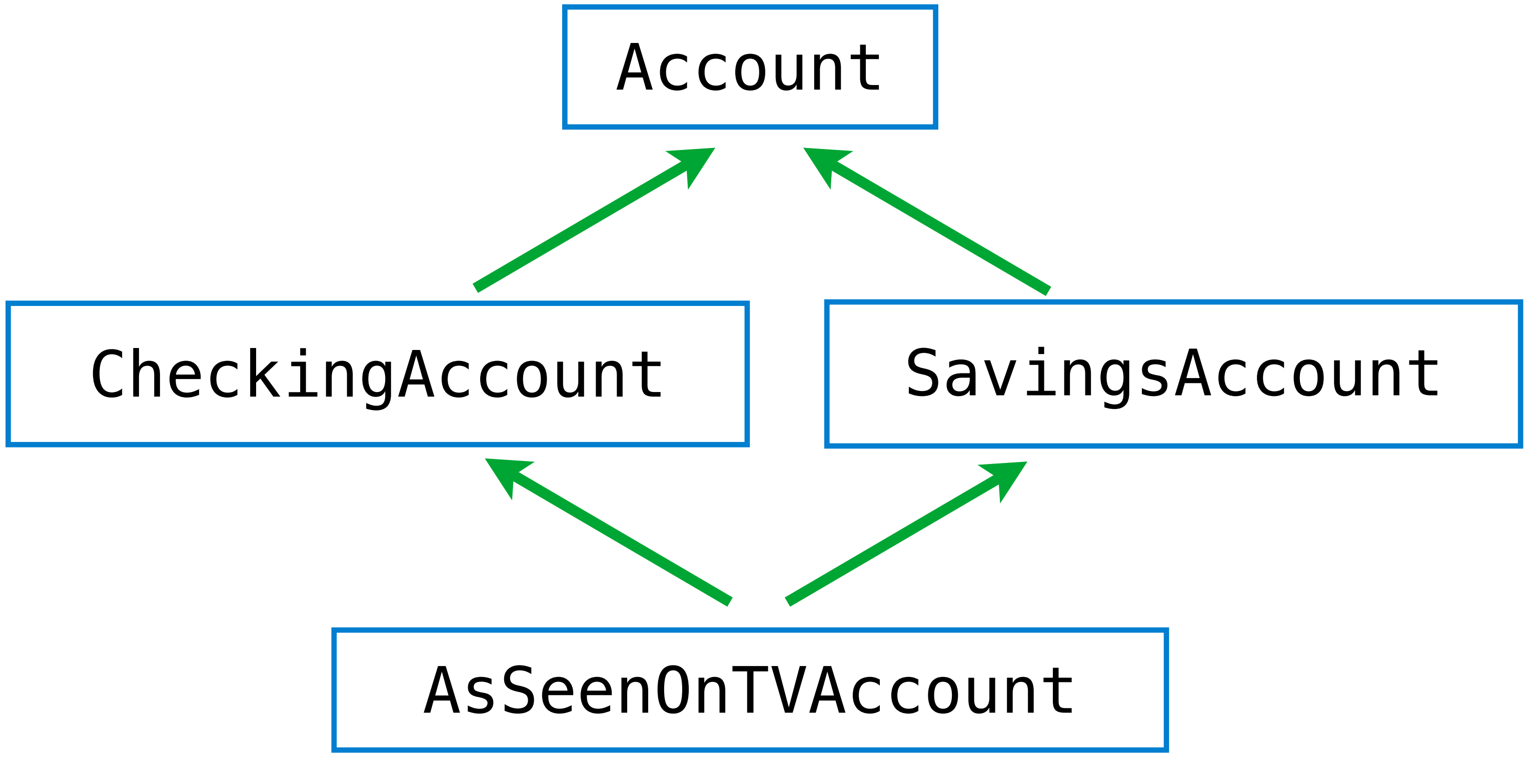
Instance attribute

SavingsAccount method

CheckingAccount method

```
>>> such_a_deal = AsSeenOnTVAccount("John")
>>> such_a_deal.balance
1
>>> such_a_deal.deposit(20)
19
>>> such_a_deal.withdraw(5)
13
```

Resolving Ambiguous Class Attribute Names



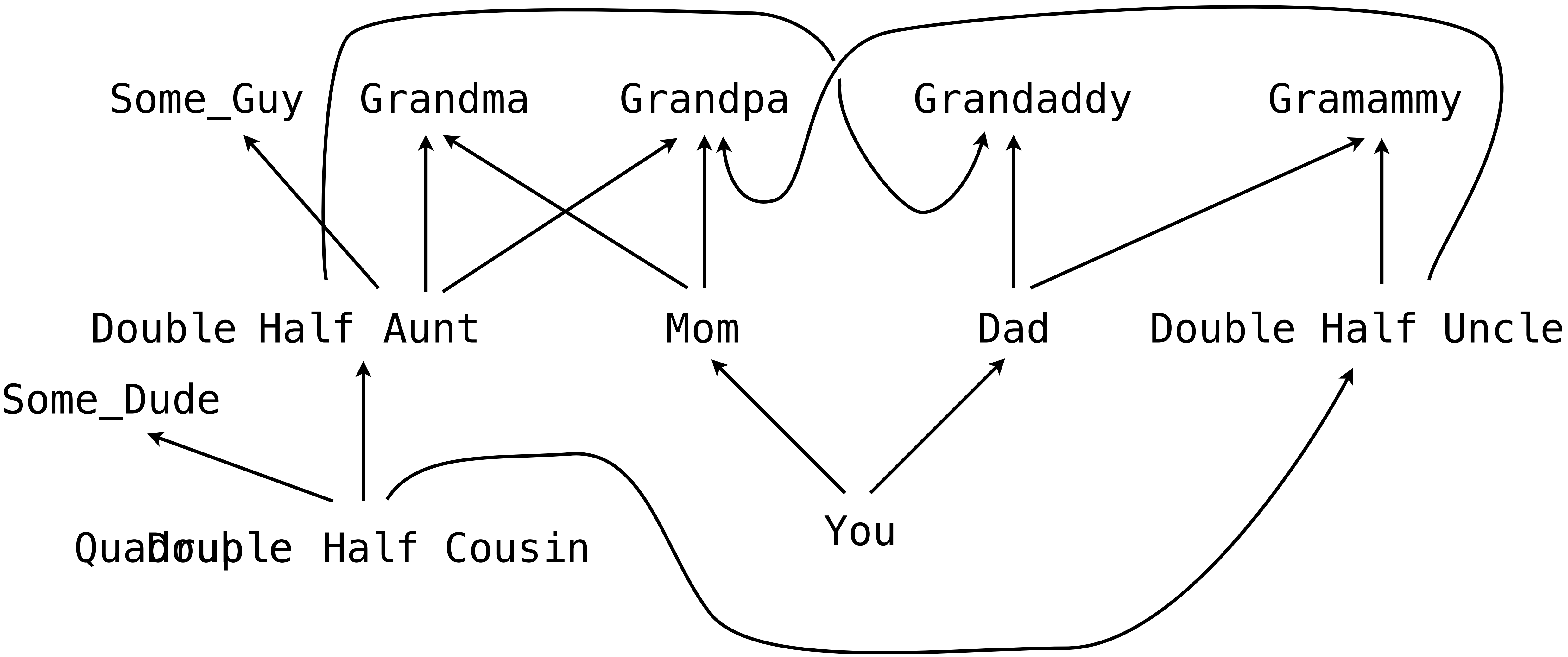
Instance attribute

SavingsAccount method

CheckingAccount method

```
>>> such_a_deal = AsSeenOnTVAccount("John")
>>> such_a_deal.balance
1
>>> such_a_deal.deposit(20)
19
>>> such_a_deal.withdraw(5)
13
```

Human Relationships



Some_Guy Grandma Grandpa Grandaddy Gramammy

Double Half Aunt Mom Dad Double Half Uncle

Some_Dude

Quadruple

Double Half Cousin

You