Review 2

Classes and Subclasses

Class Definition

class <*name*>(<superclass>):

    """Class specification"""

    definitions of fields

    definitions of properties

    constructor (__init__)

    definition of operators

    definition of methods

Class type to extend
(may need module name)

- Every class must extend *something*
- Mosts classes will extended object

Attribute Invariants

- What are the attribute invariants below?
- Why are they there?

```
class Time(object):
    """An instance is a time of day"""
    hr = 0    # hour of the day; int in range 0..23
    min = 0   # minute of the hour; int in range 0..59
    ...
```

Attribute Invariants

- Attribute invariants are important for programmer
  - Can look at them when writing methods
  - Any reader of the code will benefit as well

```
class Time(object):
    """An instance is a time of day"""
    hr = 0    # hour of the day; int in range 0..23
    min = 0   # minute of the hour; int in range 0..59
    ...
```

Enforcing Invariants

- Attribute invariants are the purpose of constructors
- They initialize the attributes to satisfy invariants

```
class Time(object):
    ...
    def __init__(self,t):
        """Constructor: an instance with time t,
        in minutes, in range 0..24*60-1"""
        self.hr  = t / 60
        self.min = t % 60
```

- Without seeing the invariants, might write self.min = t

Enforcing Invariants

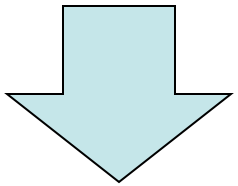
- Restrict access to fields
  - Make fields hidden
  - Force access through methods: getter & setter
- **Getter**: Read attribute
  - Just return the field
- **Setter**: Change attribute
  - Checks that new value satisfies the invariant
  - If so, changes field

```
class Time(object):
    _hr = 0     # int in range 0..23
    _min = 0  # int in range 0..59
...
def getHour(self):
    """Returns: hour of the day"""
    return self._hr

def setHour(self,value):
    """Sets hour to value"""
    assert type(value) == int
    assert value >= 0 and value <= 23
    self._hr = value
```

Properties: Getters and Setters

- Properties are preferred way to prevent access
  - Pair of getter and setter
  - Put invariant in getter
- Written as methods, but not called like methods

```
>>> t.hr = 2
```



Python converts to

```
>>> t.hr(2)
```

```
class Time(object):
    _hr = 0     # int in range 0..23
    ...
    @property
    def hr(self):
        """Hour of the day
        Invariant: int in range 0..23"""
        return self._hr

    @hr.setter
    def hr(self,value):
        assert type(value) == int
        assert value >= 0 and value <= 23
        self._hr= value
```

Specifies that next method is **getter**

Pairs **setter** with the getter

Special Methods

- Start/end with underscores
  - __init__ for constructor
  - __str__ for str()
  - __repr__ for backquotes
- Actually defined in object
  - You are overriding them
  - Many more of them
- For a complete list, see

  http://docs.python.org/reference/datamodel.html

```
class Point(object):
    """Instances are points in 3D space"""
    ...

    def __init__(self,x=0,y=0,z=0):
        """Constructor: makes new Point"""
        ...
    def __str__(self):
        """Returns: string with contents""”
        ...
    def __repr__(self):
        """Returns: unambiguous string""”
        ...
```

Modified Question from Fall 2010

- An object of class `Course` (next slide) maintains a course name, the instructors involved, and the list of registered students, sometimes called the roster.
  1. State the purpose of a constructor. Then complete the body of the constructor of `Course`, fulfilling this purpose.
  2. Complete the body of method `add` of `Course`
  3. Complete the body of method `__eq__` of `Course`. If you write a loop, you do not need to give a loop invariant.
  4. Complete the body of method `__ne__` of `Course`. Your implementation should be a single line.

Modified Question from Fall 2010

```
class Course(object):
    """An instance is a course at Cornell.
    Maintains the name of the course, the roster
    (list of netIDs of students registered for it),
    and a list of netIDs of instructors."""
    name = ''    # Course name. Must be a String.
    instructors = None   # Must be a list of netids
                         # Cannot be empty.
    roster = None        # Must be a list of netids
                         # Allowed to be empty.

    def __init__(self,name,b):
        """Instance w/ name, instructors b, no students.
        It must COPY b.  Do not assign b to instructors.
        Pre: name is a string, b is a nonemepty list"""
        # IMPLEMENT ME

    def add(self,n):
        """If student with netID n is not in roster, add
        student. Do nothing if student is already there.
        Precondition: n is a valid netID."""
        # IMPLEMENT ME

    def __eq__(self,ob):
        """Return True if ob is a Course with the same
        name and same set of instructors as this;
        otherwise return False"""
        # IMPLEMENT ME

    def __ne__(self,ob):
        """Return False if ob is a Course with the same
        name and same set of instructors as this;
        otherwise return True"""
        # IMPLEMENT ME IN ONE LINE
```

Modified Question from Fall 2010

1. State the purpose of a constructor. Complete the body of the constructor of `Course`, fulfilling this purpose.
   - The purpose is to initialize fields so that the attribute invariants in the class are all satisfied.

```
def __init__(self,name,b):
    """Instance w/ name, instructors b, no students.
    Pre: name is a string, b is a nonemepty list"""
    self.name = name
    self.instructors = b[:]  # Copies b
    self.roster = []         # Satisfy the invariant!
```

Modified Question from Fall 2010

2. Complete the body of method add of Course

```
def add(self,n):
    """If student with netID n is not in roster, add
    student. Do nothing if student is already there.
    Precondition: n is a valid netID."""
    if not n in self.roster:
        self.roster.append(n)
```

Modified Question from Fall 2010

3. Complete body of method __eq__ of Course.

```
def __eq__(self,ob):
    """Return True if ob is a Course with the same name and same
    set of instructors as this; otherwise return False"""
    if not (isinstance(ob,Course)):
        return False
    # Check if instructors in ob are in this
    for inst in ob.instructors:
        if not inst in self.instructors:
            return False
    # If instructors of ob are those in self, same if length is same
    return self.name==ob.name and len(self.instructors)==len(ob.instructors)
```

Modified Question from Fall 2010

4. Complete body of method __ne__ of Course. Your implementation should be a single line.

```
def __ne__(self,ob):
    """Return False if ob is a Course with the same  name and
    same set of instructors as this; otherwise return True"""
    # IMPLEMENT ME IN ONE LINE
    return not self == ob # Calls __eq__
```

Modified Question from Fall 2010

- An instance of Course always has a lecture, and it may have a set of recitation or lab sections, as does CS 1110. Students register in the lecture and in a section (if there are sections). For this we have two other classes: Lecture and Section. We show only components that are of interest for this question
- Do the following:
  - Complete the constructor in class Section
  - Complete the method add in Section
- Make sure invariants are enforced at all times

Modified Question from Fall 2010

```
class Lecture(Course):
    """Instance is a lecture, with list of sections"""
    # List of sections associated with lecture.
    seclist = None # Must be a list; can be empty

    def __init__(self, n, ls):
        """Instance w/ name, instructors ls, no students.
        It must COPY ls.  Do not assign ls to instructors.
        Pre: name is a string, ls is a nonemepty list"""
        super(Lecture,self).__init__(n,ls)
        self.seclist = []
```

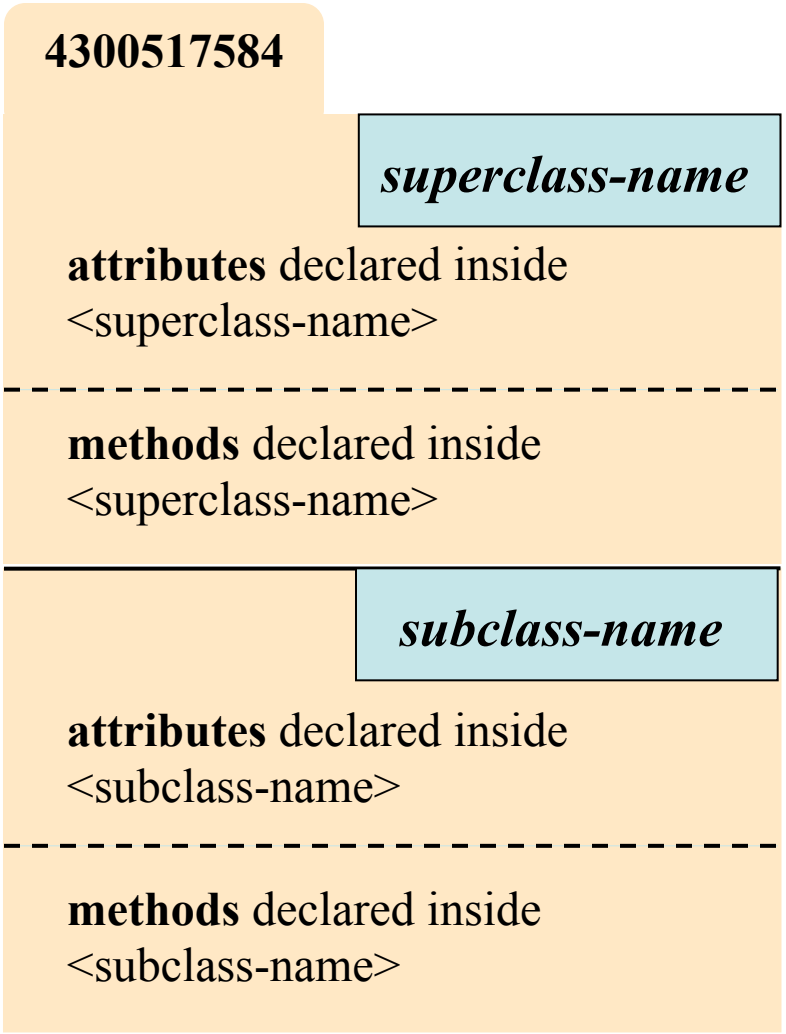
```
class Section(Course):
    """Instance is a section associated w/ a lecture"""
    # Lecture with which this section is associated.
    mainlecture = None # Should not be None.

    def __init__(self, n, ls, lec):
        """Instance w/ name, instructors ls, no
        students AND primary lecture lec.
        Pre: name a string, ls list, lec a Lecture"""
        # IMPLEMENT ME

    def add(self,n):
        """If student with netID n is not in roster of
        section,  add student to this section AND the
        main lecture.  Do nothing if already there.
        Precondition: n is a valid netID."""
        # IMPLEMENT ME
```

Modified Question from Fall 2010

```
def __init__(self, n, ls, lec):
    """Instance w/ name, instructors ls
    no students AND main lecture lec.
    Pre: name a string, ls list,
    lec a Lecture"""
    super(Section,self).__init__(n,ls)
    self.mainlecture = lec
```

```
def add(self,n):
    """If student with netID n is not in
    roster of section,  add student to
    this section AND the main lecture.
    Do nothing if already there.
    Precondition: n is a valid netID."""
    # Calls old version of add to
    # add to roster
    super(Section,self).add(n)
    # Add to lecture roster
    self.mainlecture.add(n)
```

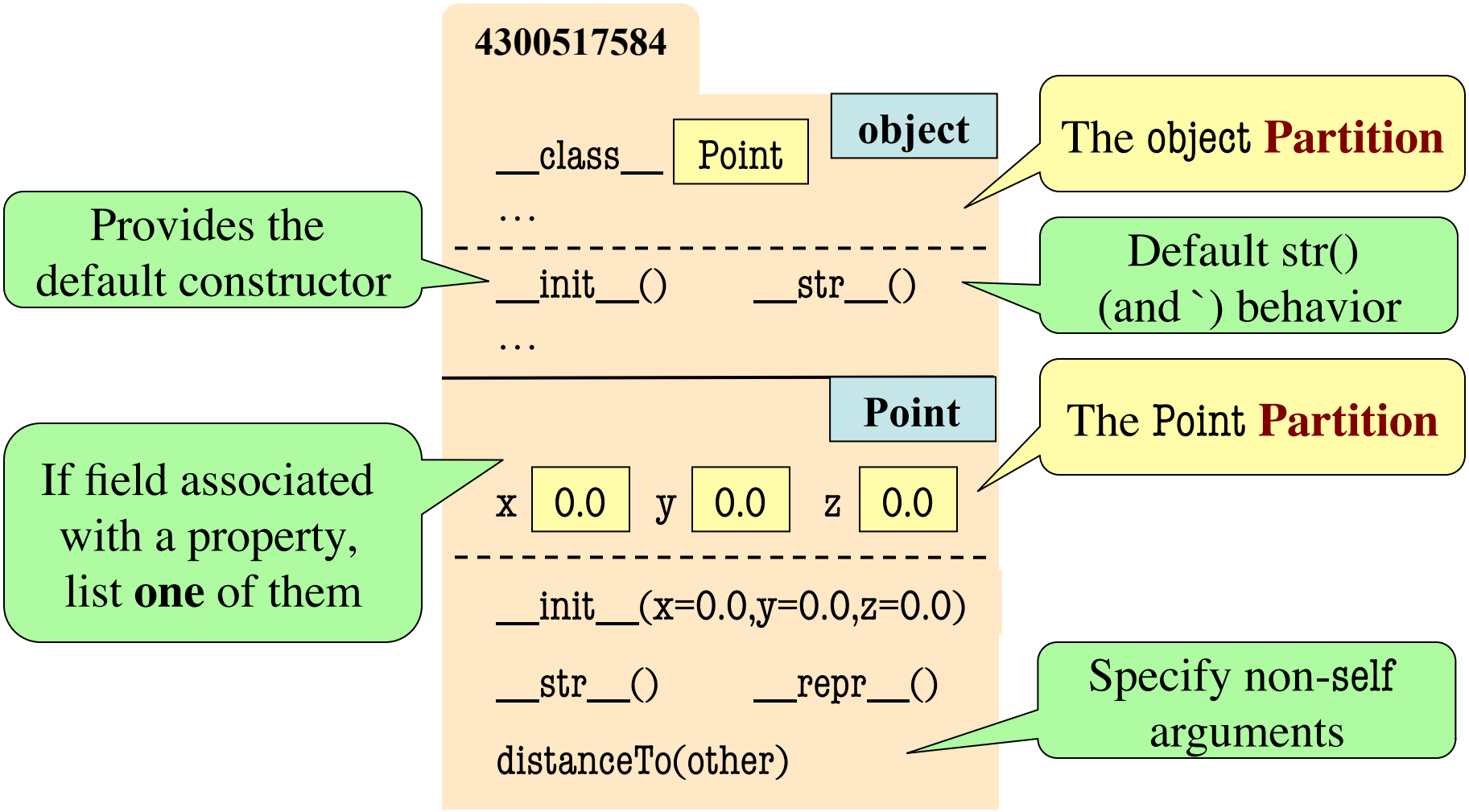
Diagramming Subclasses



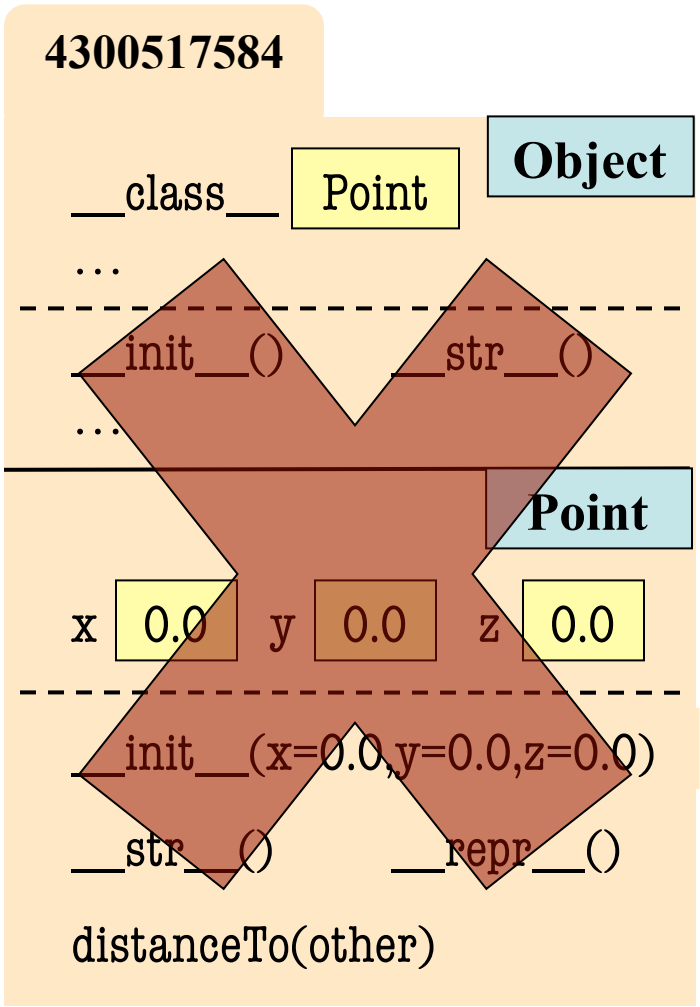
Important Details:

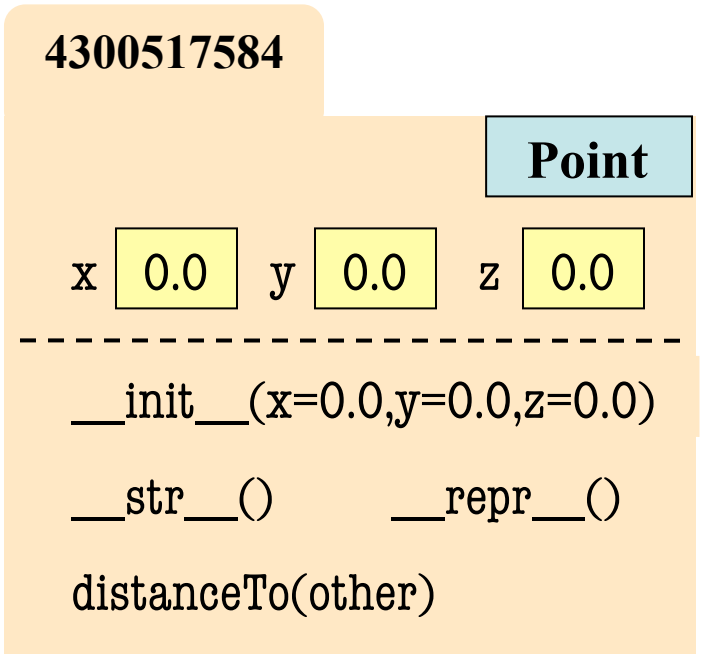
- Attributes should go in correct partition
- If property is overloaded, put in both partitions
- Do not need Object partition unless asked
- Methods must have parameter names
- Give parameter defaults

Example: Class Point



Example: Class Point





Because it is always there, typically omit the object partition

Two Classes

```
class CongressMember(object):
    _name = '' # Member's name

    @property
    def name(self):
        return self._name

    @name.setter
    def name(self,value):
        assert type(value) == str
        self._name = value

    def __init__(self,n):
        self.name = n  # Use the setter

    def __str__(self):
        return 'Honorable '+self.name
```

```
class Senator(CongressMember):
    _state = '' # Senator's state

    @property
    def state(self):
        return self._state

    @property
    def name(self):
        return self._name

    @name.setter
    def name(self,value):
        assert type(value) == str
        self._name = 'Senator '+value

    def __init__(self,n,s):
        assert type(s) == str and len(s) == 2
        super(Senator,self).__init__(n)
        self._state = s

    def __str__(self):
        return (super(Senator,self).__str__()+
                ' of '+self.state)
```

'Execute' the Following Code

```
>>> b = CongressMember('Jack')
>>> c = Senator('John', 'NY')
>>> d = c
>>> d.name = 'Clint'
```

Remember:
Commands outside of a function definition happen in global space

- Draw two columns:
  - **Global space**
  - **Heap space**
- Draw both the
  - Variables created
  - Objects (folders) created
- Put each in right space
- If a variable changes
  - Mark out the old value
  - Write in the new value

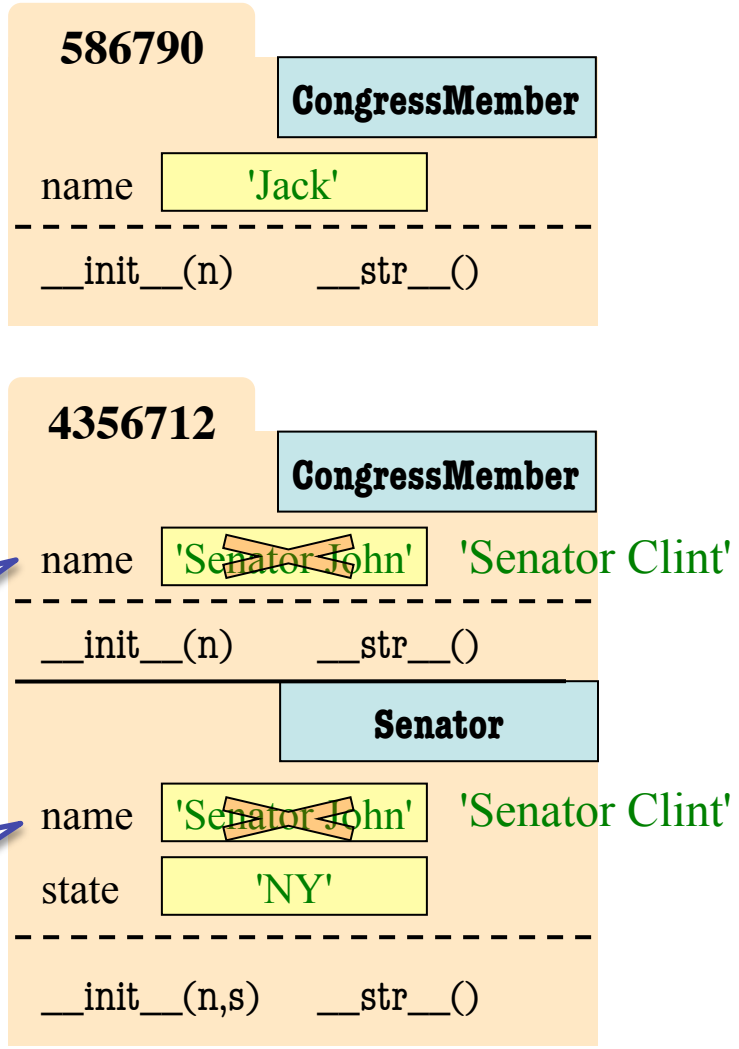
Global Space

b **586790**

c **4356712**

d **4356712**

Heap Space



If property overridden, same in both partitions

Note setter always puts string 'Senator' in front

```
class Senator(CongressMember):
    _state = '' # Senator's state

    @property
    def state(self):
        return self._state

    @property
    def name(self):
        return self._name

    @name.setter
    def name(self,value):
        assert type(value) == str
        self._name = 'Senator '+value

    def __init__(self,n,s):
        assert type(s) == str and len(s) == 2
        super(Senator,self).__init__(n)
        self._state = s

    def __str__(self):
        return (super(Senator,self).__str__()+
                ' of '+self.state)
```

Heap Space