CS 61A/CS 98-52

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Credits: Mostly a direct Python adaptation of "Wizards and Warriors", a series by **Eric Lippert**, a principal developer of the C# compiler.

Object-Oriented Design

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OOP is **far more** than mere encapsulation + polymorphism + . . .

If you've never really struggled with OOP, you haven't really seen OOP. ;)

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Let's see some toy examples.

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A **player** has a **weapon**.

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A **player** has a **weapon**.

$\Longrightarrow$ *How do we model this problem?*

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class Player(object):
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class Wizard(Player):
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class Warrior(Player):
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Let's incorporate these requirements. **What do we do?**

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class Player(object):
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Is this good? *(Hint: no...)*

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Is this good? *(Hint: no...)* **What is the problem?**

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players = [Wizard(), Warrior()]
for player in players:
    player.set_weapon(weapon)
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Oops: `AssertionError:  weapon is not a Staff`

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No, it isn't the programmer's fault. **Raise an error instead.**

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```
class Wizard(Player):
    def get_weapon(self):
        return self.w
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        if not isinstance(w, Staff):
            raise ValueError("weapon is not a Staff")
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But we declared every `Player` has a `set_weapon()`!

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`ValueError:  weapon is not a Staff`

But we declared every `Player` has a `set_weapon()`!

⟹ **`Player.set_weapon()`** ***is a lie.*** It does **not** accept a mere `Weapon`.

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In fact, for `set_weapon` to guarantee anything to the caller, the caller must already know the type of `self`.

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- We've planted a ticking time bomb
- We've only shifted the problem around

Object-Oriented Design

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We'll get back to this. First, **let's consider other problems too.**

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New rule!

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How do we represent this?

- Classes represent nouns (things); methods represent verbs (behavior)
- We're describing a behavior
- Clearly we need something like a `Player.attack()` method

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Do you see a problem?

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- Why put mutual interaction logic in `Warrior` instead of `Werewolf`?

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- Again: **arbitrary symmetry breakage is a *code smell***—indicating a *potentially deeper problem*.

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- Can lead to *code fragmentation*: later logic might just as easily end up in `Werewolf`, suddenly multiplying the number of places such logic is maintained, making maintainance difficult and error-prone.

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- Can cause other unforeseen problems—code smells often bite back!

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Fundamentally, we want *double dispatch*

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With classes, we get *single dispatch*: dispatching based on a *single* argument (`self`).

Fundamentally, we want *double dispatch*: deciding what method to call based on the `Player` *and* `Monster` arguments.

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"Visitor pattern"—simulate double dispatch via single dispatch:

```
class Warrior(Player):  # visitor
    def attack(self, monster):
        return monster.warrior_defend(self)  # request visit
class Wizard (Player):  # visitor
    def attack(self, monster):
        return monster. wizard_defend(self)  # request visit
```

Object-Oriented Design

Solving problem 2(a) (avoiding `isinstance`):
"Visitor pattern"—simulate double dispatch via single dispatch:

```
class Warrior(Player):  # visitor
    def attack(self, monster):
        return monster.warrior_defend(self)  # request visit
class Wizard (Player):  # visitor
    def attack(self, monster):
        return monster. wizard_defend(self)  # request visit

class Werewolf(Monster):  # visitee
    def warrior_defend(self, warrior): ...  # accept visit
    def  wizard_defend(self,  wizard): ...  # accept visit
class Vampire (Monster):  # visitee
    def warrior_defend(self, warrior): ...  # accept visit
    def  wizard_defend(self,  wizard): ...  # accept visit
```

Object-Oriented Design

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$\Longrightarrow$ **Is there a *fundamentally different, superior* solution?**

Object-Oriented Design

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$\sim$ Words of Wisdom #1 $\sim$

Object-Oriented Design

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Then stop doing it.
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Elegant solutions often solve multiple problems at once.

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Let's take a step back and ***re-examine our assumptions & goals****.*

Object-Oriented Design

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Maybe we made poor assumptions?

Object-Oriented Design

Solution:

Object-Oriented Design

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Object-Oriented Design

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Object-Oriented Design

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- **Users** provide sequences of **commands**...
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- ...to produce **effects**.

Object-Oriented Design

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Object-Oriented Design

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- Make a `Command` called **`Wield`** that holds a `Player` and a `Weapon`. Evaluate `Commands` in the context of `Rules`, producing `Effects`.
- Make `Rules` for evaluating different `Commands`, like `Wield`. These would modify any produced `Effects` as desired.

Object-Oriented Design

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- We can put rules into a database and pass them around if needed
- We can write engines to test rules in different orders, for validation
- We can write rules in a simpler *domain-specific language* (DSL)
  No more need to know codebase—***or to even be a programmer!***

Object-Oriented Design

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Object-Oriented Design

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How did we achieve this?

Object-Oriented Design

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How did we achieve this? By **not coding blindly**.

Object-Oriented Design

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- Software engineering can require genuine **thinking** and **insight**. Take it seriously. Don't naively assume it's "beneath" you as a theorist or systems programmer (or whatever).

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- Constantly watch out for **code smells** and unnecessary oddities.
- Software engineering can require genuine **thinking** and **insight**. Take it seriously. Don't naively assume it's "beneath" you as a theorist or systems programmer (or whatever).
- Fundamentally poor decisions **may not make themselves obvious**. If you don't actively re-evaluate your design decisions, you may never notice problems.

Object-Oriented Design

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```
def breadth_first_search(v):
    i = 0
    queue = [v]
    while i < len(queue):
        v = queue[i]
        i += 1
        queue.extend(v.children)
        yield v
```

Object-Oriented Design

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Object-Oriented Design

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```
class BreadthFirstSearcher(object):
    def __init__(self, v):
        (self.i, self.queue) = (0, [v])
    def next(self):
        while self.i < len(self.queue):
            v = self.queue[self.i]
            self.i += 1
            self.queue.extend(v.children)
            return v
```

Object-Oriented Design

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Object-Oriented Design

Let's make it a class instead!

Why make a whole class for BFS?? Does anybody do this?!

Well, maybe because we can now very easily:

- **Inspect** the queue while iterating
- **Modify** the queue if desired
- **Save and restore** the iterator state
- **Copy/fork** the iterator mid-way and continue it on multiple graphs

Note that making `BreadthFirstSearcher` a class is **not obvious!**

Realizing this solution takes some thinking... and pays dividends.