CMPSCI 220 Programming Methodology

10: Introduction to Functional Programming

Based on Head First Design Patterns

What is functional programming?

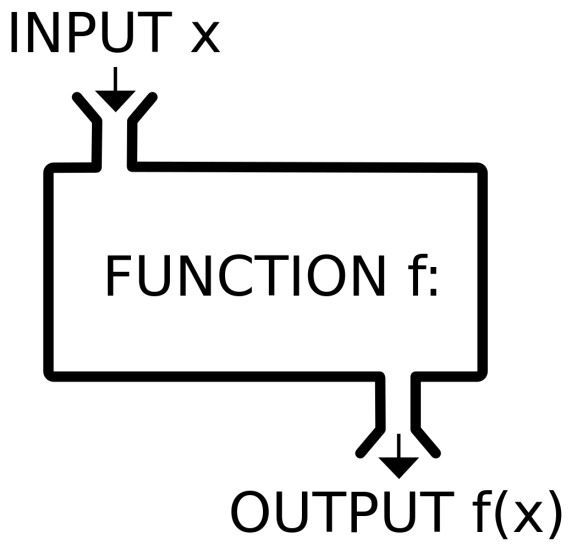
Functional Programming (FP)

The construction of programs using only
pure functions

What is a pure function?

What is a pure function?

A *pure function* is a function that…



has no side effects!

What is a side effect?

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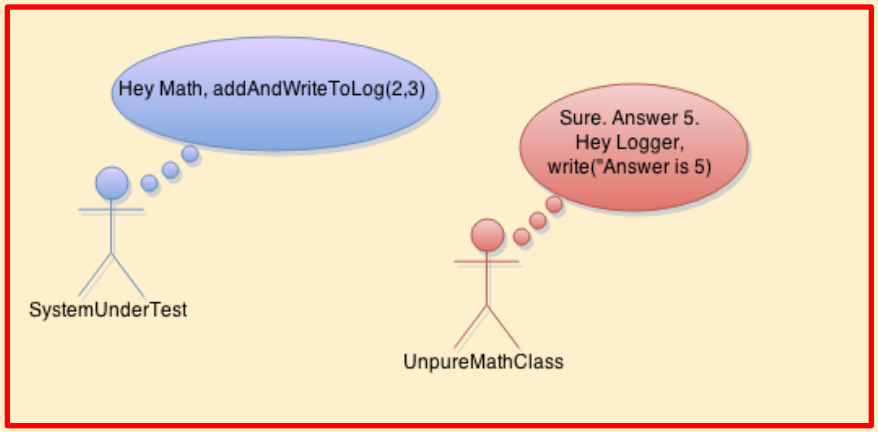
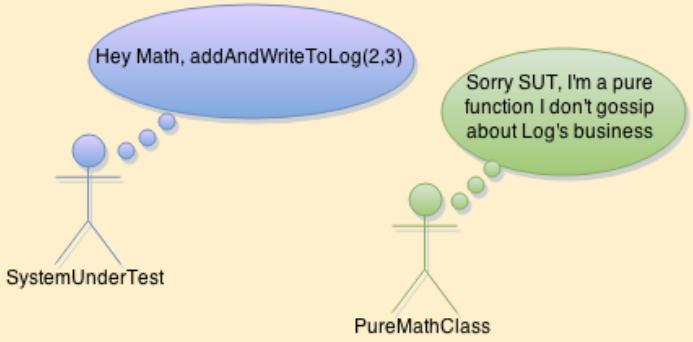
A function has a side effect if it does something other than simply returning a result.

- Modifying a variable
- Modifying a data structure in place
- Setting a field on an object
- Throwing an exception or halting with an error
- Printing to the console or reading user input
- Reading from or writing to a file
- Drawing on the screen

Pure Functions





We must respect the pure functions for not gossiping around the corners of the System.

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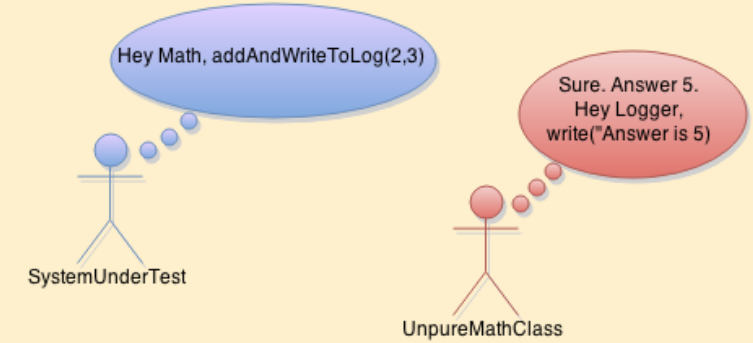
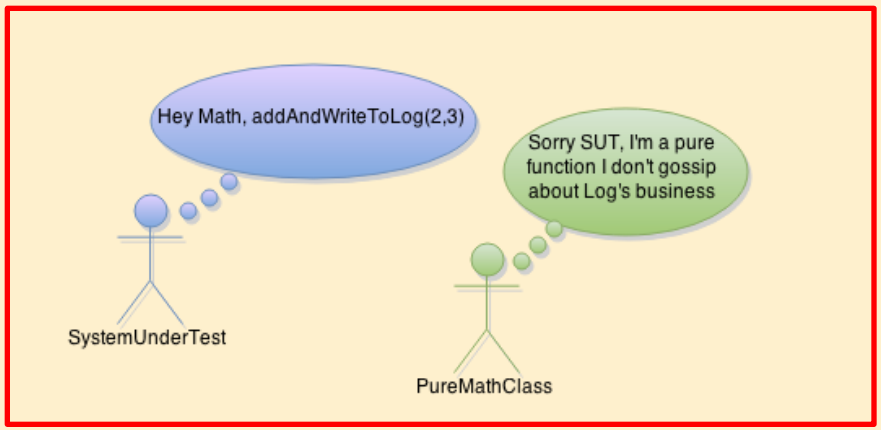
Pure Functions





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Programs without side effects?

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Or, with significant restrictions on when and how these actions can occur…

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Or, with significant restrictions on when and how these actions can occur…

Programs without side effects?

It may be difficult to

imagine…

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- Handle data that changes?

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How is it even possible to write useful programs at all?

If we can't reassign variables,

- How would write simple programs with loops?
- Handle data that changes?
- Handle errors/exceptions?
- Performing IO?

The answer…

Functional programming is a restriction on *how* we write programs…

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But, not on *what* programs we can express.

FP is a programming paradigm – a pattern in how you write programs without side effects.

What does FP give us?

FP is *tremendously* beneficial because of the increase in *modularity*.

Pure functions are easier to…

- Test
- Reuse
- Parallelize
- Generalize
- Reason About

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- Test
- Reuse
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- Reason About

} Much less prone to bugs!

A program with side effects

```
1 class Cafe {
2   def buyCoffee(cc: CreditCard): Coffee = {
3     val cup = new Coffee()
4     cc.charge(cup.price)
5     cup
6   }
7 }
```

Where is the side effect?

a) line 3
b) line 4
c) line 5
d) none of these

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Where is the side effect?

As a result of this side effect, the code is difficult to test.

Why?

A program that is better?

```
1 class Cafe {
2   def buyCoffee(cc: CreditCard, p: Payments): Coffee = {
3     val cup = new Coffee()
4     p.charge(cc, cup.price)
5     cup
6   }
7 }
```

This is a little better…Why?

But, we still have issues…

A program that is better?

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1 class Cafe {
2   def buyCoffee(cc: CreditCard, p: Payments): Coffee = {
3     val cup = new Coffee()
4     p.charge(cc, cup.price)
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6   }
7 }
```

We could create a “mock” implementation, but we are likely to modify some internal state. Additionally, creating an interface just so we can test a function is *overkill*.

A program that is better?

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2   def buyCoffee(cc: CreditCard, p: Payments): Coffee = {
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6   }
7 }
```

Furthermore, it is difficult to reuse **buyCoffee**.

Why?

Imagine a customer orders 12 cups of coffee.
How might we reuse buyCoffee?

A program that is better?

```
1 class Cafe {
2   def buyCoffee(cc: CreditCard, p: Payments): Coffee = {
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```
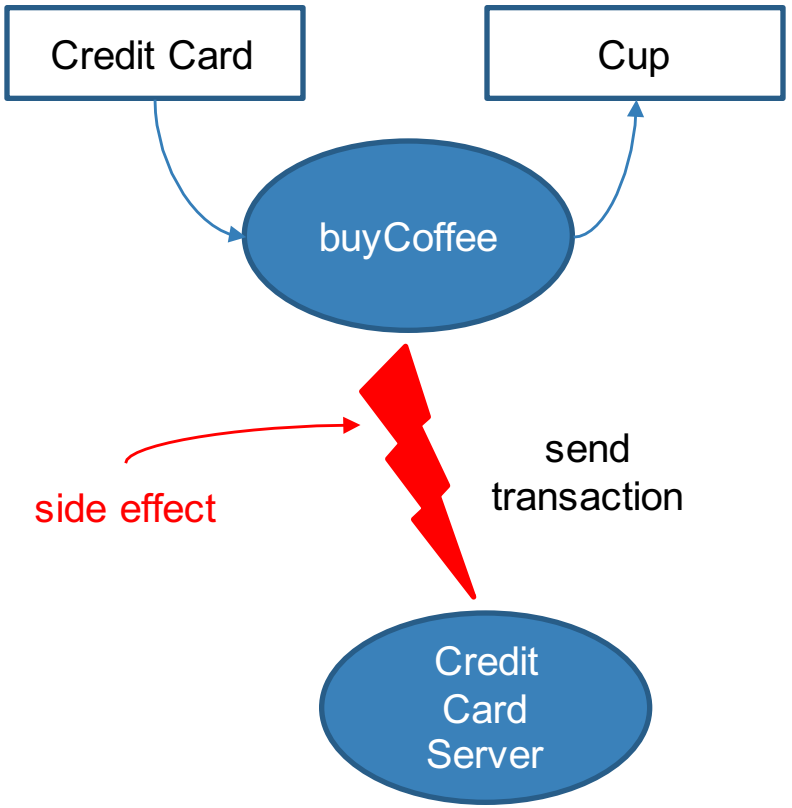

How can we fix this?

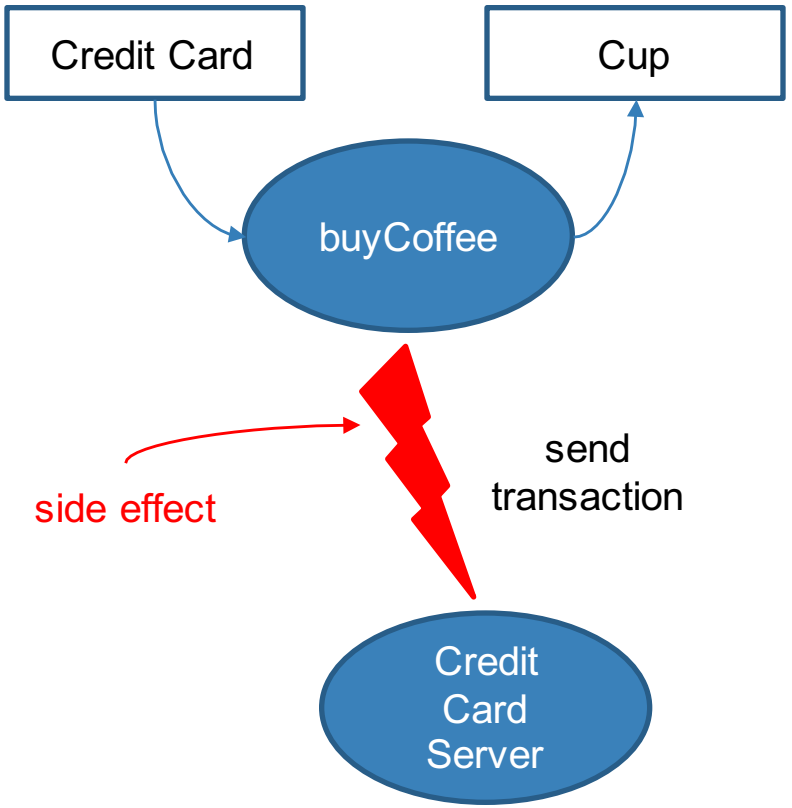
A program that is better?

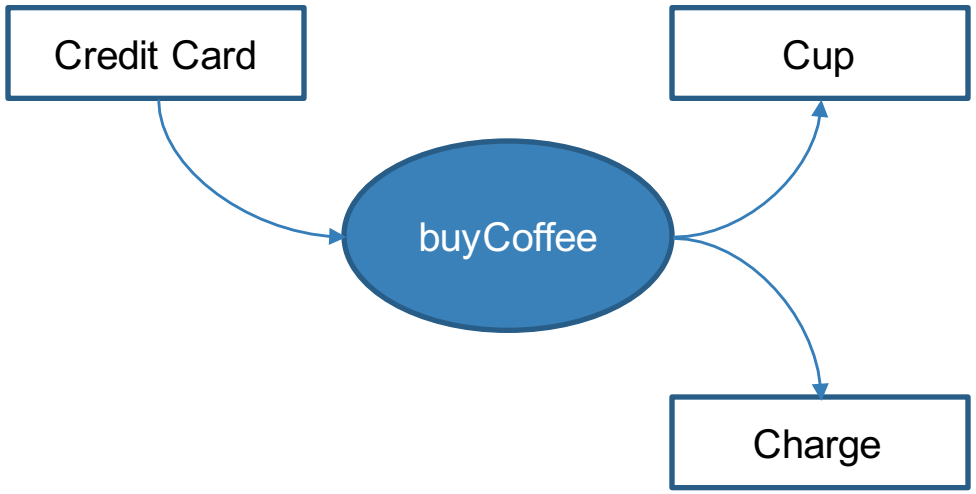


Can't test buyCoffee without credit card server.

Can't combine two transactions into one.

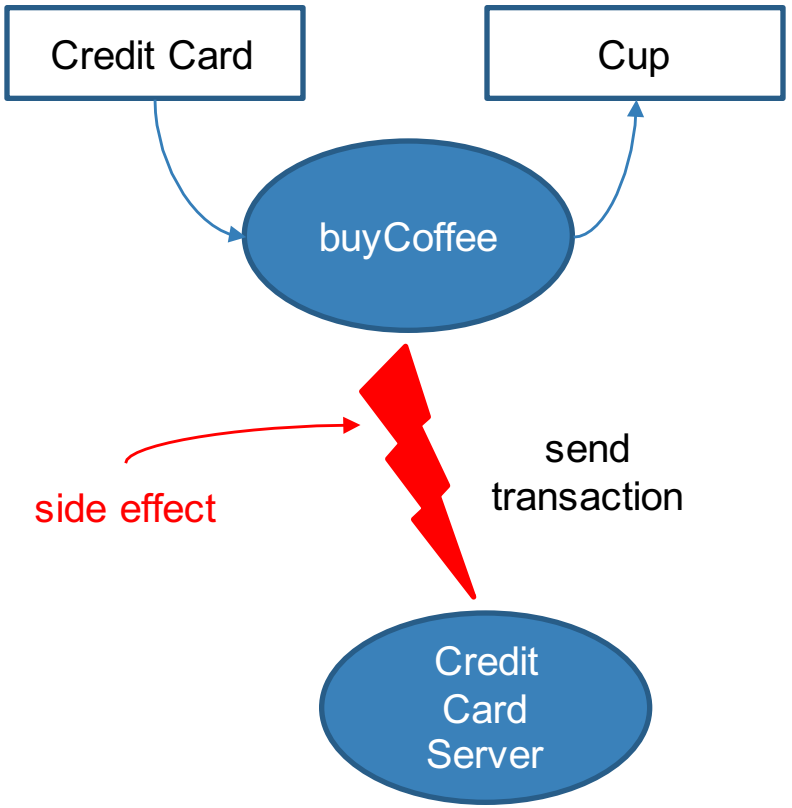
A program that is better?

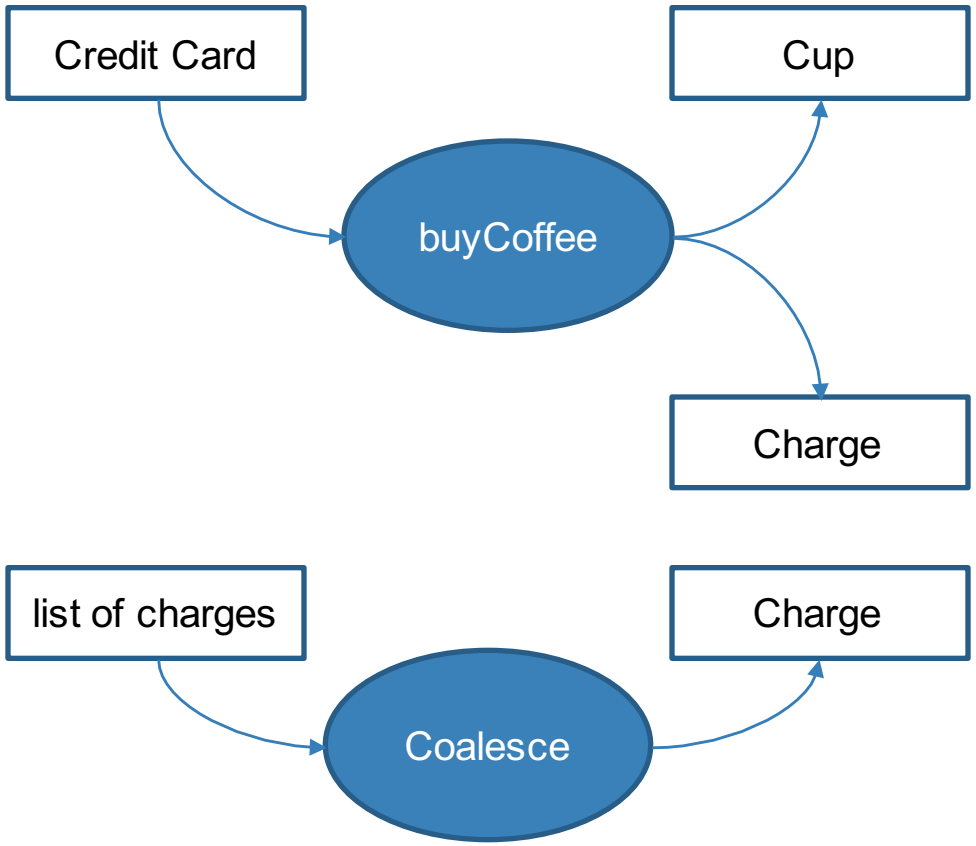




If buyCoffee returns a charge object instead of performing a side effect, then…

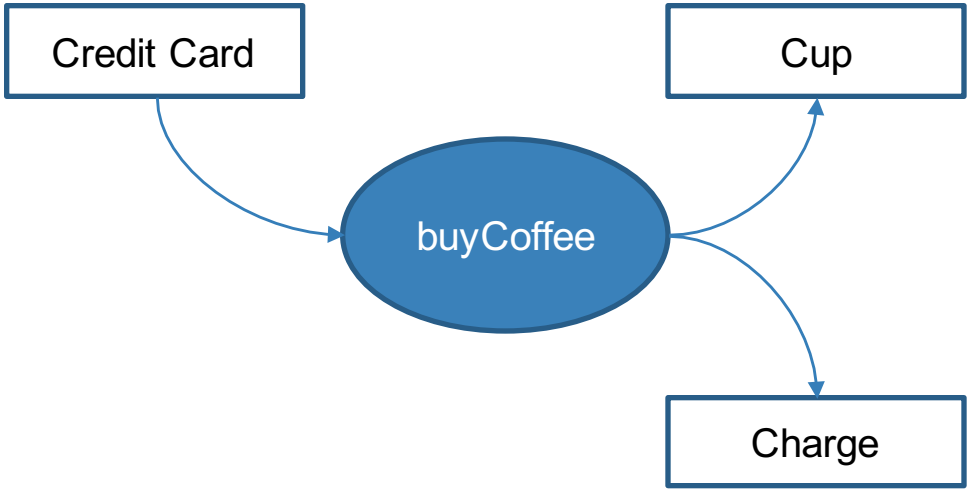
A program that is better?





The *functional* solution is to **eliminate** side effects

buyCoffee *returns the charge as a value* in addition to returning the Coffee.



A functional solution.

```
class Cafe {
  def buyCoffee(cc: CreditCard): (Coffee, Charge) = {
    val cup = new Coffee()
    (cup, Charge(cc, cup.price))
  }
}
```

buyCoffee now returns a pair of a Coffee and a Charge.

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Here we have separated the concern of creating a charge from the processing or interpretation of that charge. 0 side effects.

A functional solution.

```
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```

How can we reuse this version to easily purchase multiple coffees with a single transaction?

What is a Charge?

A Charge Class

```
case class Charge(cc: CreditCard, amount: Double) {
  def combine(other: Charge): Charge =
    if (cc == other.cc) Charge(cc, amount + other.amount)
  else
    throw new Exception("Can't combine different cards")
}
```

What is a **case** class?

A case class defines an algebraic data type.
It combines a class and a companion object into one.
Even better – it allows *pattern matching*.

Buying multiple cups…

```
class Cafe {
  def buyCoffee(cc: CreditCard): (Coffee, Charge) = …

  def buyCoffees(cc: CreditCard, n: Int): (List[Coffee], Charge) = {

    val purchases: List[(Coffee, Charge)] = List.fill(n)(buyCoffee(cc))

    val (coffees, charges) = purchases.unzip

    (coffees, charges.reduce((c1,c2) => c1.combine(c2)))
  }

}
```