

Computer Programming with Scala

Week 4: Sorting Bits

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Introduction

A comprehensive step-by-step guide

Programming in

Scala

Second Edition



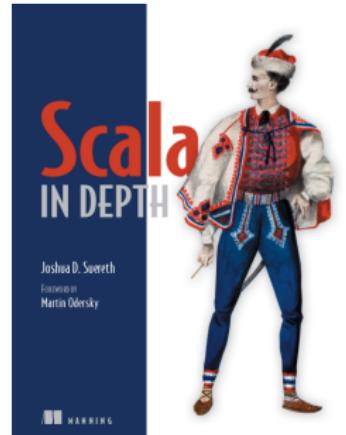
artima

Coming next

- ▶ How can you become a mature journalist? (poet)
- ▶ Train your programming skill
 - ▶ Experience comes from exercising
 - ▶ You don't learn swimming or skiing in the books
- ▶ Expertise can be (inefficiently) taught
 - ▶ Best practices can be presented, not sure if you get it
 - ▶ At least, get (exposed to) the vocabulary

What we saw so far

- ▶ We covered the base book (or almost)
- ▶ You received the language syntax and content
- ▶ Basics, OOP and FP syntax, some stylistic advices
- ▶ You know your letters, some know to read/write



Experience is what enables you to recognize a mistake when you make it again.

Design Patterns

What

- ▶ Classical patterns that you can find in large programs
 - ▶ Seminal work: common patterns from at least 3 large well organised projects
- ▶ Good programmer: someone that can detect patterns in someone else code
 - ▶ Mean of communication

Why

- ▶ Best Practice: Reuse the expertise of the ones before us
- ▶ Mean of communication: Put simple words on common concepts

I have this object with some important information and these objects over here need to know when its information changes. These other objects come and go. I'm thinking I should separate out the notification and client registration functionality from the functionality of the object and just let it focus on storing and manipulating its information. Do you agree?

I'm thinking of using the Observer pattern.
Do you agree?

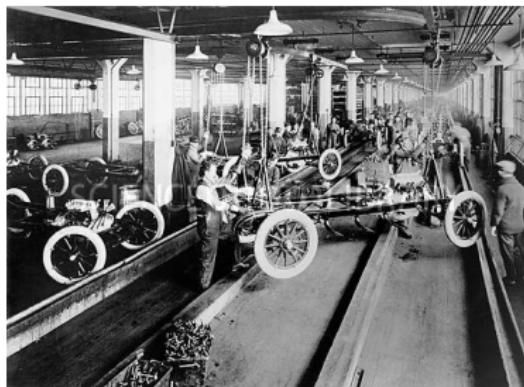
Why Not

- ▶ Sometimes boilerplates to circumvent language limitations. Bad idea.
- ▶ Lecturing on the 50 Design Patterns is too soporific, let's pick some.

Factory Pattern

What

- ▶ Provides an interface for creating an object, encapsulating class instantiation
- ▶ Lets subclasses decide which class to instantiate.



```
trait Animal
private class Dog extends Animal
private class Cat extends Animal
object Animal {
    def apply(kind: String): kind match {
        case "dog" => new Dog()
        case "cat" => new Cat()
    }
}
val d = Animal("dog")
```

Why? When?

- ▶ Extract complex object creation code
- ▶ Select which class to instantiate

Discussion

- 😊 Resembles constructor invocation
- 😢 Static factory

Singleton Pattern

What:

- ▶ Restrict the instantiation to one object
- ▶ Provide a global access point to this object



The Solitary Tree, Bobbi Jones Jones

```
object myApp extends App {  
    println("Hello World")  
}
```

Why? When?

- ▶ Have exactly one object of a class

Discussion

- ☺ Integrated into the language
- ☺ Java/C++ \sim boilerplate code

Adapter Pattern

What: Converts an interface into expected interface



Multiple jacks / adaptors, Mihai Andoni

```
trait Log {  
    def warning(message: String)  
    def error(message: String)  
}  
  
final class Logger {  
    def log(lvl: Level, msg: String) { /* ... */ }  
}  
  
implicit class Adapter(logger: Logger) extends Log {  
    def warning(msg: String) { logger.log(WARNING, msg) }  
    def error(msg: String) { logger.log(ERROR, msg) }  
}  
  
val log: Log = new Logger()
```

Why? When?

- ▶ Integrate incompatible classes
- ▶ Adapt existing components

Discussion

- 😊 Clear intent, Concise syntax
- 😢 Implicit behavior easily overseen

Decorator Pattern

What: Extends functionality of an object (alternative to subclassing)



Colour Pencils, George Hodan

```
trait OutputStream {  
    def write(b: Byte)  
    def write(b: Array[Byte])  
}  
class FileOutputStream(path: String) extends OutputStream {}  
trait Buffering extends OutputStream {  
    abstract override def write(b: Byte) {  
        // ...  
        super.write(buffer)  
    }  
}  
new FileOutputStream("foo.txt") with Buffering
```

Why? When?

- ▶ Extend final classes
- ▶ Arbitrarily graph of combination
- ▶ Multiple inheritance

Discussion

- 😊 Clear intent, Concise syntax
- 😊 Separation of concern
- 😢 Static binding
- 😢 No constructor parameter

Chain of Responsibility

What: Decouples the sender of a request from its receiver



Things in motion: Colored Domino,
Sigurd Decroos

```
case class Event(source: String)
type EventHandler = PartialFunction[Event, Unit]
val defaultHandler: EventHandler = PartialFunction(_ => ())
val keyboardHandler: EventHandler = {
  case Event("keyboard") => /* ... */
}
val mouseHandler(delay: Int) : EventHandler = {
  case Event("Mouse") => /* ... */
}
keyboardHandlerorElse mouseHandler(100)orElse defaultHandler
```

Why? When?

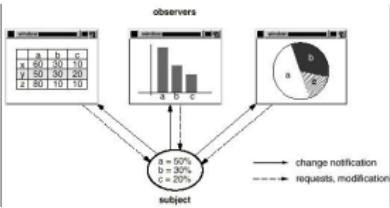
- ▶ Request proposed to the chain until handled
- ▶ Gives more than one object a chance

Discussion

- 😊 Concise syntax, Built-in logic
- 😊 General-purpose type

Observer Pattern

What: Broadcast object's state changes notifications to dependents



```
trait Observer {
    def notify(changed: Observable)
}

trait Observable {
    private var observers: List[Observer] = Nil
    def addObserver(o: Observer) = observers ::= o
    def fireChange = for (o <- observers) o.notify(this)
}
```

Why? When?

- ▶ Set of loosely coupled objects
- ▶ Decouple data Model from View

Discussion

- 😊 (rather) concise syntax
- 😢 Control flow complex to follow

The Pattern Bestiary (1/3)

Creational Patterns

- ▶ **Abstract Factory:** Factory for building related objects
- ▶ **Builder:** Factory for building complex objects incrementally
- ▶ **Factory Method:** Method in a derived class creates associates
- ▶ **Prototype:** Factory for cloning new instances from a prototype
- ▶ **Singleton:** Factory for a singular (sole) instance

Structural Patterns

- ▶ **Adapter:** Translator adapts a server interface for a client
- ▶ **Bridge:** Abstraction for binding one of many implementations
- ▶ **Composite:** Structure for building recursive aggregations
- ▶ **Decorator:** Extends an object transparently
- ▶ **Facade:** Simplifies the interface for a subsystem
- ▶ **Flyweight:** Many fine-grained objects shared efficiently.
- ▶ **Proxy:** One object approximates another

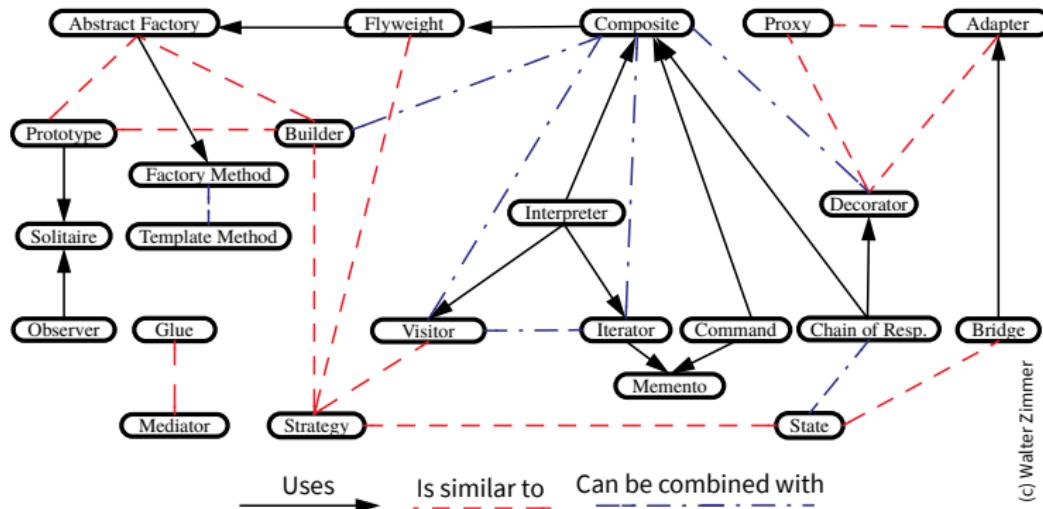
The Pattern Bestiary (2/3)

Behavioral Patterns

- ▶ **Chain of Responsibility:** Request delegated to the responsible service provider
- ▶ **Command:** Request or Action is first-class object, hence storable
- ▶ **Iterator:** Aggregate and access elements sequentially
- ▶ **Interpreter:** Language interpreter for a small grammar
- ▶ **Mediator:** Coordinates interactions between its associates
- ▶ **Memento:** Snapshot captures and restores object states privately
- ▶ **Observer:** Dependents update automatically when subject changes
- ▶ **State:** Object whose behavior depends on its state
- ▶ **Strategy:** Abstraction for selecting one of many algorithms
- ▶ **Template Method:** Algorithm with some steps supplied by a derived class
- ▶ **Visitor:** Operations applied to elements of a heterogeneous object structure

The Pattern Bestiary (3/3)

Patterns Interactions



Conclusion on Design Patterns

- ▶ These are only the 23 presented in seminal work. Maaaany more can be found
- ▶ Learning them is boring, Knowing them helps building on elder's experience

<https://speakerdeck.com/pavelfatin/design-patterns-in-scala>

Anti-Patterns

- ▶ Set of well known bad ideas to common problems
- ▶ **Bicycle shed:** Giving disproportionate weight to trivial issues
- ▶ **Bleeding edge:** Operating with cutting-edge technologies that are still unstable
- ▶ **Overengineering:** Spending time making a project more complex than needed
- ▶ **Big ball of mud:** A system with no recognizable structure
- ▶ **Interface bloat:** Making an interface so powerful that it is difficult to implement
- ▶ **God object:** Concentrating too many functions in a class
- ▶ **Object orgy:** Failed encapsulation permitting unrestricted access to internals
- ▶ **Sequential coupling:** Methods to be called in a particular order
- ▶ **Accidental complexity:** Unneeded complexity due to approach (\neq inherent)
- ▶ **Hard code:** Spread the constant values everywhere in the code
- ▶ **Repeating yourself:** copy paste considered harmful (DRY SPOT)
- ▶ **Action at a distance, Circular dependency, Premature optimization, Programming by permutation, Reinventing the square wheel, Shotgun surgery**

Experience is what enables you to recognize a mistake when you make it again

Code Smell

What

- ▶ When you have a bad feeling from reading the code
- ▶ Often surface symptoms of deeper issues
- ▶ Some problems can be automatically detected

Examples

- ▶ Duplicated code: identical or very similar code exists in more than one location
- ▶ Contrived complexity: forced usage of overly complicated design patterns
- ▶ God class: a class that has grown too large; Lazy class: does too little
- ▶ Cyclomatic complexity: too many branches or loops
- ▶ Spread literals: should be named constants
- ▶ Refused bequest: An overrided method that changes the contract (\neq Liskov)
- ▶ Excessively short/long identifiers
- ▶ Too many parameters: often denotes an ill-conceived function

https://en.wikipedia.org/wiki/Code_smell

<https://en.wikipedia.org/wiki/Anti-pattern>

Functional Patterns

OO Pattern

- ▶ Factory Pattern
- ▶ Strategy Pattern
- ▶ Decorator Pattern
- ▶ Visitor Pattern
- ▶ Interface Segregation Principle

FP Principle

- ▶ Functions
- ▶ Functions
- ▶ Functions
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- ▶ Yes, functions

Functional Patterns

OO Pattern

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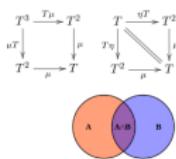
FP Principle

- ▶ Functions
- ▶ Functions
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- ▶ Functions
- ▶ Yes, functions

Design Patterns are OO boilerplate, FP is different

- ▶ (more on that troll: <http://c2.com/cgi/wiki?AreDesignPatternsMissingLanguageFeatures>)
- ▶ Now: quick tour of some FP recurring concepts

- ▶ Steal from Mathematics
- ▶ Types are not classes



- ▶ Functions are things 
- ▶ Composition everywhere 

FP Core Principle #1: Steal from Mathematics

In Mathematics we Trust

- ▶ Mathematical assertions: unusually precise, general (large class of instances)
- ▶ Mathematics: discipline of reasoning ↠ unusually high confidence level

Some quotes from E. W. Dijkstra

- ▶ *Programming is one of the most difficult branch of applied mathematics.*
- ▶ *OOP is an exceptionally bad idea which could only have originated in California.*
- ▶ *CS is not more related to Computers than Astronomy to Telescopes.*

Why are mathematical functions so cool?

FP Core Principle #1: Steal from Mathematics

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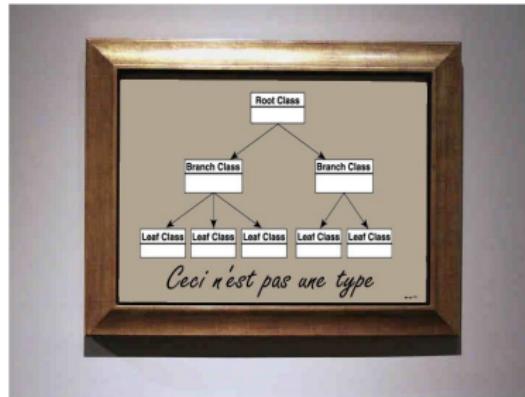
Why are mathematical functions so cool?

- ▶ They only map a value to another
- ▶ No calculation, just an immutable mapping (no side effect)

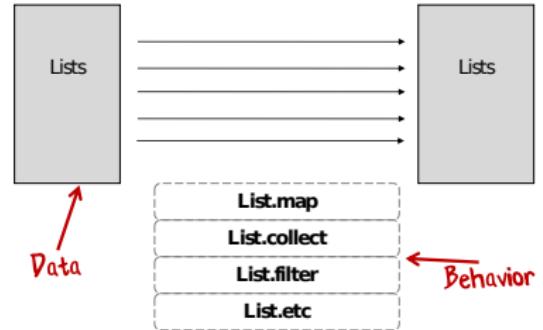
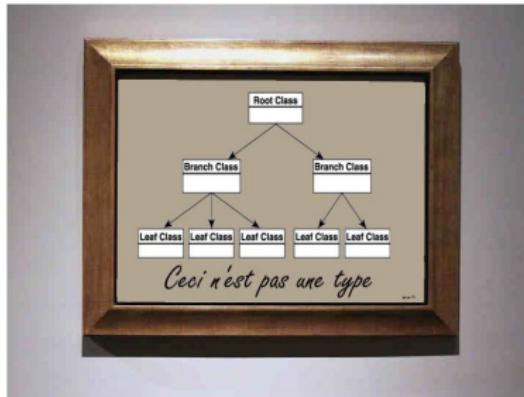
You should strive for Pure Functions

- ▶ Easy to understand, to reason about
- ▶ Lazily cachable results, Evaluation order does not matter

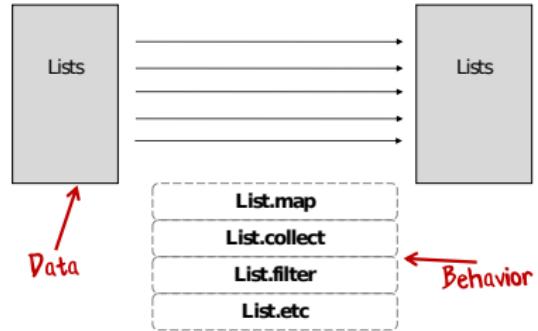
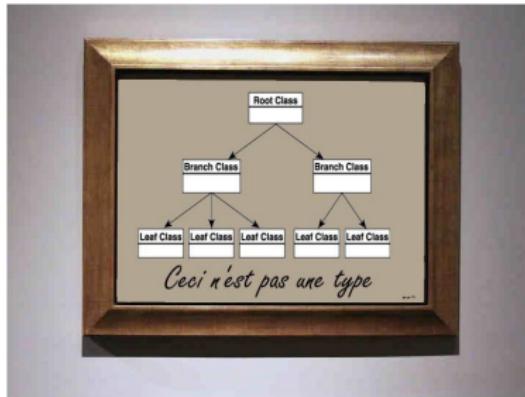
FP Core Principle #2: Types are not classes



FP Core Principle #2: Types are not classes



FP Core Principle #2: Types are not classes



Types are just Data (set of values) \neq Classes = Data + Behavior

Behavior is within the (pure) functions

FP Core Principle #3: Functions as things

A function is a standalone thing, not attached to a class

- ▶ You can manipulate functions as any other values
- ▶ Advice: Do as many pure functions as possible; **Avoid mutable objects**
- ▶ Advice: Parametrize all the things (Don't repeat yourself)

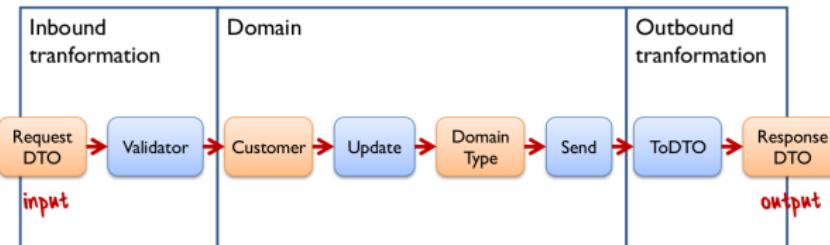
```
public static int Product(int n) {  
    int product = 1;  
    for (int i = 1; i <= n; i++) {  
        product *= i;  
    }  
    return product;  
}  
  
public static int Sum(int n) {  
    int sum = 0;  
    for (int i = 1; i <= n; i++) {  
        sum += i;  
    }  
    return sum;  
}
```

```
def product(n:Int) =  
    (1 to n).foldLeft(1)(_ * _)  
  
def product(n:Int) =  
    (1 /: (1 to n)) (_ * _)  
  
def sum(n:Int) =  
    (1 to n).foldLeft(0)(_ + _)  
  
def sum(n:Int)      =  
    (0 /: (1 to n)) (_ + _)
```

FP Core Principle #4: Composition everywhere

Functions can naturally be composed

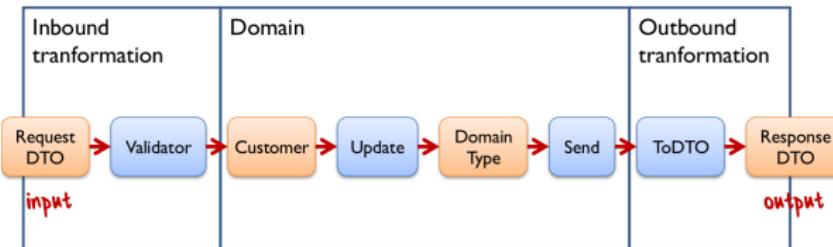
The FP flow is linear



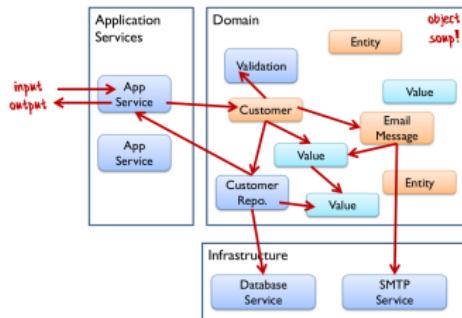
FP Core Principle #4: Composition everywhere

Functions can naturally be composed

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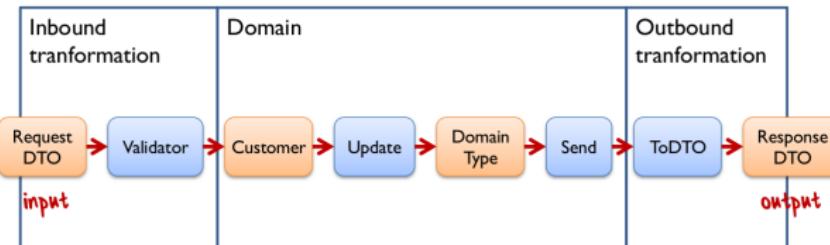
The OO flow soup



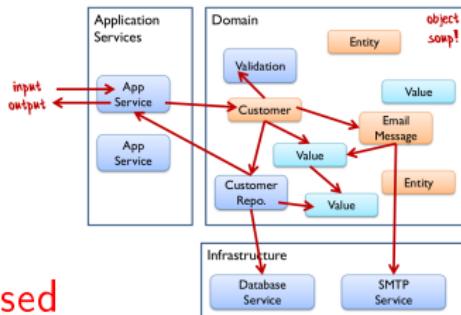
FP Core Principle #4: Composition everywhere

Functions can naturally be composed

The FP flow is linear



The OO flow soup



Types can also be composed

Product Type

- ▶ Tuple and type alias

```
val p = (1,2) // new Tuple2(1,2)
type Point = (Int, Int)
val p:Point = (1,2)
```

Sum Type

```
sealed trait Suit
case object Club    extends Suit
case object Diamond extends Suit
case object Spade    extends Suit
case object Heart    extends Suit
```

- ▶ Case class

sealed: no inheritance from other files

Painting Style



modernism



impressionism



abstract expressionism



realism



surrealism



cubism



photorealism

From: http://gotocon.com/dl/goto-aar-2013/slides/CristinaVideiraLopes_ExercisesInStyle.pdf

Writing Style



EXERCISES IN STYLE



RAYMOND QUENEAU

- ▶ Metaphor
- ▶ Surprises
- ▶ Dream
- ▶ Prognostication
- ▶ Hesitation
- ▶ Precision
- ▶ Negativities
- ▶ Asides
- ▶ Logical analysis
- ▶ Past
- ▶ Present
- ▶ ...
- ▶ (99)

What could be something like a programming style?

Exercises in Programming Style*



@cristalopes

github.com/crista/exercises-in-programming-style

Exercises in Programming Style

The story:

Term Frequency

given a text file,
output a list of the 25
most frequently-occurring
non stop, words, ordered by
decreasing frequency

Exercises in Programming Style

The story:

Pride and Prejudice

TF

Term Frequency

given a text file,
output a list of the 25
most frequently-occurring
words, ordered by decreasing
frequency

mr - 786
elizabeth - 635
very - 488
darcy - 418
such - 395
mrs - 343
much - 329
more - 327
bennet - 323
bingley - 306
jane - 295
miss - 283
one - 275
know - 239
before - 229
herself - 227
though - 226
well - 224
never - 220
...

[http://github.com/crista/
exercises-in-programming-style](http://github.com/crista/exercises-in-programming-style)

@cristalopes #style1 *name*

STYLE #1

```
1 import sys, string
2 # the global list of [word, frequency] pairs
3 word_freqs = []
4 # the list of stop words
5 with open('../stop_words.txt') as f:
6     stop_words = f.read().split(',')
7 stop_words.extend(list(string.ascii_lowercase))
8
9 # iterate through the file one line at a time
10 for line in open(sys.argv[1]):
11     start_char = None
12     i = 0
13     for c in line:
14         if start_char == None:
15             if c.isalnum():
16                 # We found the start of a word
17                 start_char = i
18             else:
19                 if not c.isalnum():
20                     # We found the end of a word. Process it
21                     found = False
22                     word = line[start_char:i].lower()
23                     # Ignore stop words
24                     if word not in stop_words:
25                         pair_index = 0
26                         # Let's see if it already exists
27                         for pair in word_freqs:
28                             if word == pair[0]:
29                                 pair[1] += 1
30                                 found = True
31                                 found_at = pair_index
32                                 break
33                         pair_index += 1
34                     if not found:
35                         word_freqs.append([word, 1])
36                     elif len(word_freqs) > 1:
37                         # We may need to reorder
38                         for n in reversed(range(pair_index)):
39                             if word_freqs[pair_index][1] >
40                                 word_freqs[n][1]:
41                                 # swap
42                                 word_freqs[n], word_freqs[
43                                     pair_index] = word_freqs[
44                                         pair_index], word_freqs[n]
45                                 pair_index = n
46                         # Let's reset
47                         start_char = None
48                         i += 1
49
50 for tf in word_freqs[0:25]:
51     print tf[0], ' - ', tf[1]
```

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Style #1 Main Characteristics

- ▷ No abstractions
- ▷ No use of libraries

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Monolith

Style #1 Main Characteristics

- ▷ No abstractions
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Brain-dump Style

@cristalopes #style2 *name*

STYLE #2

```
import re, string, sys

stops = set(open("../stop_words.txt").read().split(",") + list(string.ascii_lowercase))
words = [x.lower() for x in re.split("[^a-zA-Z]+", open(sys.argv[1]).read()) if len(x) > 0 and x.lower() not in stops]
unique_words = list(set(words))
unique_words.sort(lambda x, y: cmp(words.count(y), words.count(x)))
print "\n".join(["%s - %s" % (x, words.count(x)) for x in unique_words[:25]])
```

Credit: *Laurie Tratt*, Kings College London

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Style #2 Main Characteristics

- ▷ No [named] abstractions
- ▷ Very few [long] lines of code
- ▷ Advanced libraries / constructs

Style #2 Main Characteristics

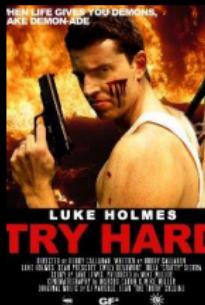
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Code Golf Style

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Try Hard Style

@cristalopes #style3 *name*

STYLE #3

```

1 import sys, string
2
3 # The shared mutable data
4 data = []
5 words = []
6 word_freqs = []
7
8 #
9 # The functions
10 #
11 def read_file(path_to_file):
12     """
13     Takes a path to a file and assigns the entire
14     contents of the file to the global variable data
15     """
16     global data
17     f = open(path_to_file)
18     data = data + list(f.read())
19     f.close()
20
21 def filter_chars_and_normalize():
22     """
23     Replaces all nonalphanumeric chars in data with white space
24     """
25     global data
26     for i in range(len(data)):
27         if not data[i].isalnum():
28             data[i] = ' '
29         else:
30             data[i] = data[i].lower()
31
32 def scan():
33     """
34     Scans data for words, filling the global variable words
35     """
36     global data
37     global words
38     data_str = ''.join(data)
39     words = words + data_str.split()
40
41 def remove_stop_words():
42     global words
43     f = open('../stop_words.txt')
44     stop_words = f.read().split(',')
45     f.close()
46     # add single-letter words
47     stop_words.extend(list(string.ascii_lowercase))
48     indeces = []
49     for i in range(len(words)):
50         if words[i] in stop_words:
51             indeces.append(i)
52     for i in reversed(indeces):
53         words.pop(i)
54

```

```

55 def frequencies():
56     """
57     Creates a list of pairs associating
58     words with frequencies
59     """
60     global words
61     global word_freqs
62     for w in words:
63         keys = [wd[0] for wd in word_freqs]
64         if w in keys:
65             word_freqs[keys.index(w)][1] += 1
66         else:
67             word_freqs.append([w, 1])
68
69 def sort():
70     """
71     Sorts word_freqs by frequency
72     """
73     global word_freqs
74     word_freqs.sort(lambda x, y: cmp(y[1], x[1]))
75
76
77 # The main function
78 #
79 #
80 read_file(sys.argv[1])
81 filter_chars_and_normalize()
82 scan()
83 remove_stop_words()
84 frequencies()
85 sort()
86
87 for tf in word_freqs[0:25]:
88     print tf[0], ' - ', tf[1]

```

```
1 data=[]
2
3 words=[]
4
5 freqs=[]
6
7
8
9
10
11
12
13     Takes a path to a file and assigns the entire
14     contents of the file to the global variable data
15     """
16
17     global data
18     f = open(path_to_file)
19     data = data + list(f.read())
20
21
22
23     Replaces all nonalphanumeric chars in data with white space
24     """
25
26     global data
27     for i in range(len(data)):
28         if not data[i].isalnum():
29             data[i] = ' '
30         else:
31             data[i] = data[i].lower()
32
33
34     Scans data for words, filling the global variable words
35     """
36
37     global data
38     global words
39     data_str = ''.join(data)
40     words = words + data_str.split()
41
42
43
44     f = open('../stop_words.txt')
45     stop_words = f.read().split(',')
46     f.close()
47     # add single-letter words
48     stop_words.extend(list(string.ascii_lowercase))
49     indeces = []
50     for i in range(len(words)):
51         if words[i] in stop_words:
52             indeces.append(i)
53     for i in reversed(indeces):
54         words.pop(i)
```

```
def frequencies():
    words with frequencies
    """
    global words
    global word_freqs
    for w in words:
        keys = [wd[0] for wd in word_freqs]
        if w in keys:
            word_freqs[keys.index(w)][1] += 1
        else:
            word_freqs.append([w, 1])

def sort():
    Sorts word_freqs by frequency
    """
    global word_freqs
    word_freqs.sort(lambda x, y: cmp(y[1], x[1]))

#
# Main
#
read_file(sys.argv[1])
filter_normalize()
scan()
rem_stop_words()
frequencies()
sort()

for tf in word_freqs[0:25]:
    print tf[0], ' - ', tf[1]
```

Style #3 Main Characteristics

- ▷ Procedural abstractions
 - maybe input, no output
- ▷ Shared state
- ▷ Commands

Style #3 Main Characteristics

- ▷ Procedural abstractions
 - maybe input, no output
- ▷ Shared state
- ▷ Commands



Cook Book Style

@cristalopes #style4 *name*

STYLE #4

```
1 import sys, re, operator, string
2
3 #
4 # The functions
5 #
6 def read_file(path_to_file):
7     """
8     Takes a path to a file and returns the entire
9     contents of the file as a string
10    """
11    f = open(path_to_file)
12    data = f.read()
13    f.close()
14    return data
15
16 def filter_chars(str_data):
17     """
18     Takes a string and returns a copy with all nonalphanumeric
19     chars replaced by white space
20     """
21    pattern = re.compile('[\W_]+')
22    return pattern.sub(' ', str_data)
23
24 def normalize(str_data):
25     """
26     Takes a string and returns a copy with all chars in lower case
27     """
28    return str_data.lower()
29
30 def scan(str_data):
31     """
32     Takes a string and scans for words, returning
33     a list of words.
34     """
35    return str_data.split()
36
37 def remove_stop_words(word_list):
38     """
39     Takes a list of words and returns a copy with all stop
40     words removed
41     """
42    f = open('../stop_words.txt')
43    stop_words = f.read().split(',')
44    f.close()
45    # add single-letter words
46    stop_words.extend(list(string.ascii_lowercase))
47    return [w for w in word_list if not w in stop_words]
48
49 def frequencies(word_list):
50     """
51     Takes a list of words and returns a dictionary associating
52     words with frequencies of occurrence
53     """
54    word_freqs = {}
```

```
55    for w in word_list:
56        if w in word_freqs:
57            word_freqs[w] += 1
58        else:
59            word_freqs[w] = 1
60    return word_freqs
61
62 def sort(word_freq):
63     """
64     Takes a dictionary of words and their frequencies
65     and returns a list of pairs where the entries are
66     sorted by frequency
67     """
68    return sorted(word_freq.iteritems(), key=operator.itemgetter
69                  (1), reverse=True)
70
71 #
72 # The main function
73 #
74 word_freqs = sort(frequencies(remove_stop_words(scan(normalize(
75         filter_chars(read_file(sys.argv[1]))))))
76
77 for tf in word_freqs[0:25]:
78     print tf[0], ' - ', tf[1]
```

```
1 import sys, re, operator, string
2
3 #
4 # The functions
5
6 def read_file(path):
7     """Takes a path to a file and returns the entire
8     contents of the file as a string
9     """
10    f = open(path_to_file)
11
12    return ...
13
14
15 def filter(str_data):
16     """Takes a string and returns a copy with all nonalphanumeric
17     chars replaced by white space
18     """
19    return ... .replace('[\W_]+', ' ', str_data)
20
21
22 def normalize(str_data):
23     """Returns a copy with all chars in lower case
24     """
25    return ... .lower()
26
27
28 def scan(str_data):
29     """Takes a string and scans for words, returning
30     """
31    return ...
32    .lower().split()
33
34
35 def rem_stop_words(wordl):
36     """Takes a list of words and returns a copy with all stop
37     words removed
38     """
39    f = open('../stop_words.txt')
40    stop_words = f.read().split(',')
41    f.close()
42
43    return ... [word for word
44               in string.ascii_lowercase
45               if not w in stop_words]
46
47
48 def frequencies(wordl):
49     """Takes a list of words and returns a dictionary associating
50     words with frequencies of occurrence
51     """
52
53    word_freqs = {}
```

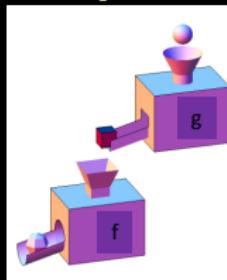
```
54    for w in word_list:
55        if w in word_freqs:
56            word_freqs[w] += 1
57
58    return ... - 1
59
60
61
62 def sort(word_freqs):
63     """Sorts the word frequency dictionary by frequency
64     and returns a list of pairs where the entries are
65     sorted by frequency
66     """
67
68    return ... .req.iteritems(), key=operator.itemgetter(1)
69
70
71
72 # Main
73 #
74 wfreqs=st(fq(r(sc(n(fc(rf(sys.argv[1]))))))))
75
76
77 for tf in wfreqs[0:25]:
78     print tf[0], ' - ', tf[1]
```

Style #4 Main Characteristics

- ▷ Function abstractions
 - $f: \text{Input} \rightarrow \text{Output}$
- ▷ No shared state
- ▷ Function composition $f \circ g$

Style #4 Main Characteristics

- ▷ Function abstractions
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Candy Factory Style

@cristalopes #style4 name

Image credit: Nykamp DQ, From *Math Insight*. http://mathinsight.org/image/function_machines_composed

@cristalopes #style5 *name*

STYLE #5

```
1 import sys, re, operator, string
2
3 #
4 # The functions
5 #
6 def read_file(path_to_file, func):
7     """
8         Takes a path to a file and returns the entire
9         contents of the file as a string
10    """
11    f = open(path_to_file)
12    data = f.read()
13    f.close()
14    return func(data, normalize)
15
16 def filter_chars(str_data, func):
17     """
18         Takes a string and returns a copy with all nonalphanumeric
19             chars
20             replaced by white space
21     """
22     pattern = re.compile('[\W_]+')
23     return func(pattern.sub(' ', str_data), scan)
24
25 def normalize(str_data, func):
26     """
27         Takes a string and returns a copy with all characters in lower
28             case
29     """
30     return func(str_data.lower(), remove_stop_words)
31
32 def scan(str_data, func):
33     """
34         Takes a string and scans for words, returning
35             a list of words.
36     """
37     return func(str_data.split(), frequencies)
38
39 def remove_stop_words(word_list, func):
40     """
41         Takes a list of words and returns a copy with all stop
42             words removed """
43     f = open('../stop_words.txt')
44     stop_words = f.read().split(',')
45     f.close()
46     # add single-letter words
47     stop_words.extend(list(string.ascii_lowercase))
48     return func([w for w in word_list if not w in stop_words],
49                 sort)
50
51 def frequencies(word_list, func):
52     """
53         Takes a list of words and returns a dictionary associating
54             words with frequencies of occurrence
55     """
56
```

```
56     word_freqs = {}
57     for w in word_list:
58         if w in word_freqs:
59             word_freqs[w] += 1
60         else:
61             word_freqs[w] = 1
62     return func(word_freqs, no_op)
63
64 def sort(word_freq, func):
65     """
66         Takes a dictionary of words and their frequencies
67         and returns a list of pairs where the entries are
68         sorted by frequency
69     """
70     return func(sorted(word_freq.iteritems(), key=operator.
71                     itemgetter(1), reverse=True), None)
72
73 def no_op(a, func):
74     return a
75
76 # The main function
77 #
78 word_freqs = read_file(sys.argv[1], filter_chars)
79
80 for tf in word_freqs[0:25]:
81     print tf[0], ' - ', tf[1]
```

```
1 import sys, re, operator, string
2
3 #
4 # The functions
5 #
6
7 def read_file(path, func):
8     ...
9     return func(..., normalize)
10
11
12 def filter_chars(data, func):
13     ...
14     return func(..., scan)
15
16
17 def normalize(data, func):
18     ...
19     return func(..., remove_stops)
20
21
22 def scan(data, func):
23     ...
24     return func(..., frequencies)
25
26
27 def remove_stops(data, func):
28     ...
29     return func(..., sort)
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46 def frequencies():
47     """
48         Takes a list
49         words with f
50     """
51
52     word_freqs = {}
53     for w in word_list:
54         if w in word_freqs:
55             word_freqs[w] += 1
56         else:
57             word_freqs[w] = 1
58     return func(word_freqs, no_op)
59
60
61 def sort(word_freq, func):
62     """
63         Takes a dictionary of words and their frequencies
64         and returns a list of pairs where the entries are
65         sorted by frequency
66     """
67     return func(sorted(word_freq.iteritems(), key=operator.
68                      itemgetter(1), reverse=True), None)
69
70
71 def no_op(a, func):
72     return a
```

```
# Main
w_freqs=read_file(sys.argv[1],
                  filter_chars)

for tf in w_freqs[0:25]:
    print tf[0], ' - ', tf[1]
```

Etc.

dictionary associating

Style #5 Main Characteristics

- ▶ Functions take one additional parameter, f
 - called at the end
 - given what would normally be the return value plus the next function

Style #5 Main Characteristics

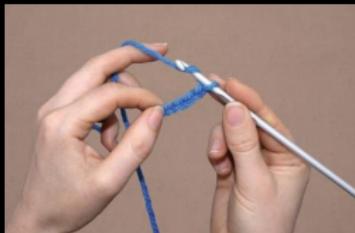
- ▶ Functions take one additional parameter, f
 - called at the end
 - given what would normally be the return value plus next function



Kick teammates
@cristalopes #style5 name

Style #5 Main Characteristics

- ▶ Functions take one additional parameter, f
 - called at the end
 - given what would normally be the return value plus the next function



Crochet Style
@cristalopes #style5 name

@cristalopes #style6 *name*

STYLE #6

```

1 import sys, re, operator, string
2 from abc import ABCMeta
3
4 #
5 # The classes
6 #
7 class TFEExercise(object):
8     __metaclass__ = ABCMeta
9
10    def info(self):
11        return self.__class__.__name__ + ": No major data
12            structure"
13
14 class DataStorageManager(TFEExercise):
15     """ Models the contents of the file """
16     _data = ''
17
18     def __init__(self, path_to_file):
19         f = open(path_to_file)
20         self._data = f.read()
21         f.close()
22         self.__filter_chars()
23         self.__normalize()
24
25     def __filter_chars(self):
26         """
27             Takes a string and returns a copy with all nonalphanumeric
28                 chars
29                 replaced by white space
30             """
31         pattern = re.compile('[\W_]+')
32         self._data = pattern.sub(' ', self._data)
33
34     def __normalize(self):
35         """
36             Takes a string and returns a copy with all characters in
37                 lower case
38             """
39             self._data = self._data.lower()
40
41     def words(self):
42         """
43             Returns the list words in storage
44             """
45             data_str = ''.join(self._data)
46             return data_str.split()
47
48     def info(self):
49         return self.__class__.__name__ + ": My major data
50             structure is a " + self._data.__class__.__name__
51
52 class StopWordManager(TFEExercise):
53     """ Models the stop word filter """
54     _stop_words = []
55
56     def __init__(self):

```

```

51         f = open('../stop_words.txt')
52         self._stop_words = f.read().split(',')
53         f.close()
54         # add single-letter words
55         self._stop_words.extend(list(string.ascii_lowercase))
56
57     def is_stop_word(self, word):
58         return word in self._stop_words
59
60     def info(self):
61         return self.__class__.__name__ + ": My major data
62             structure is a " + self._stop_words.__class__.__name__
63
64 class WordFrequencyManager(TFEExercise):
65     """ Keeps the word frequency data """
66     _word_freqs = {}
67
68     def increment_count(self, word):
69         if word in self._word_freqs:
70             self._word_freqs[word] += 1
71         else:
72             self._word_freqs[word] = 1
73
74     def sorted(self):
75         return sorted(self._word_freqs.iteritems(), key=operator.
76                         itemgetter(1), reverse=True)
77
78     def info(self):
79         return self.__class__.__name__ + ": My major data
80             structure is a " + self._word_freqs.__class__.__name__
81
82 class WordFrequencyController(TFEExercise):
83     def __init__(self, path_to_file):
84         self._storage_manager = DataStorageManager(path_to_file)
85         self._stop_word_manager = StopWordManager()
86         self._word_freq_manager = WordFrequencyManager()
87
88     def run(self):
89         for w in self._storage_manager.words():
90             if not self._stop_word_manager.is_stop_word(w):
91                 self._word_freq_manager.increment_count(w)
92
93         word_freqs = self._word_freq_manager.sorted()
94         for tf in word_freqs[0:25]:
95             print tf[0], ' - ', tf[1]
96
97     #
98     # The main function
99     #
100    WordFrequencyController(sys.argv[1]).run()

```

```

1 import sys, re, operator, string
2 from abc import ABCMeta
3
4 #
5 # The classes
6
7 class TFExercise():
8
9     def info(self):
10        + ": No major data
11        structure"
12
13 class DataStorageManager(TFExercise):
14
15     _data = ''
16
17     def __init__(self, path_to_file):
18         f = open(path_to_file)
19         self._data = f.read()
20         f.close()
21         self.__filter_chars()
22         self.__normalize()
23
24     def __filter_chars(self):
25         """
26             Takes a string and returns a copy with all nonalphanumeric
27             chars
28             replaced by white space
29         """
30         pattern = re.compile('[\W_]+')
31         self._data = pattern.sub(' ', self._data)
32
33     def __normalize(self):
34         """
35             Takes a string and returns a copy with all characters in
36             lower case
37         """
38         self._data = self._data.lower()
39
40     def words(self):
41         """
42             Returns the list words in storage
43         """
44         data_str = ''.join(self._data)
45
46     def info(self):
47
48         return self.__class__.__name__ + ": My major data
49
50 class StopWordManager(TFExercise):
51
52     """ Models the stop word filter """
53     _stop_words = []
54
55     def __init__(self):
56
57         f = open('../stop_words.txt')
58         self._stop_words = f.read().split(',')
59         f.close()
56         # add single-letter words
57
58     def is_stop_word(self, word):
59
60         return word in self._stop_words
61
62     def info(self):
63
64         + ": My major data
65         structure is a " + self._stop_words.__class__.__name__
66
67 class WordFreqManager(TFExercise):
68
69     word_freqs = []
70
71     def inc_count(self, word):
72
73         if word not in self._word_freqs:
74             self._word_freqs[word] += 1
75         else:
76             self._word_freqs[word] = 1
77
78     def sorted(self):
79
80         return sorted(self._word_freqs.items(), key=operator.
81                     itemgetter(1), reverse=True)
82
83     def info(self):
84
85         + ": My major data
86         structure is a " + self._word_freqs.__class__.__name__
87
88 class WordFreqController(TFExercise):
89
90     def __init__(self, path_to_file):
91         self._storage_manager = DataStorageManager(path_to_file)
92         self._stop_word_manager = StopWordManager()
93         self._word_freq_manager = WordFrequencyManager()
94
95     def run(self):
96
97         for word in self._storage_manager.words():
98             if not self._stop_word_manager.is_stop_word(word):
99                 self._word_freq_manager.increment_count(word)
100
101         word_freqs = self._word_freq_manager.sorted()
102         for tf in word_freqs[0:25]:
103             print tf[0], ' - ', tf[1]
104
105
106 # Main
107 WordFreqController(sys.argv[1]).run()

```

Style #6 Main Characteristics

- ▷ Things, things and more things!
- ▷ Capsules of data and procedures
- ▷ Data is never accessed directly
- ▷ Capsules say “I do the same things as that one, and more!”

Style #6 Main Characteristics

- ▷ Things, things and more things!
- ▷ Capsules of data and procedures
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Kingdom of Nouns Style
@cristalopes #style6 name

@cristalopes #style7 *name*

STYLE #7

```

1 import sys, re, operator, string
2
3 #
4 # Functions for map reduce
5 #
6 def partition(data_str, nlines):
7     """
8         Generator function that partitions the input data_str (a big
9             string)
10        into chunks of nlines.
11    """
12    lines = data_str.split('\n')
13    for i in xrange(0, len(lines), nlines):
14        yield '\n'.join(lines[i:i+nlines])
15
16 def split_words(data_str):
17     """
18         Takes a string, filters non alphanumeric characters,
19             normalizes to
20        lower case, scans for words, and filters the stop words.
21        It returns a list of pairs (word, 1), one for each word in the
22            input, so
23        [(w1, 1), (w2, 1), ..., (wn, 1)]
24    """
25
26 def _filter_chars(str_data):
27     """
28         Takes a string and returns a copy with all nonalphanumeric
29             chars
30        replaced by white space
31    """
32    pattern = re.compile('[\W_]+')
33    return pattern.sub(' ', str_data)
34
35 def _normalize(str_data):
36     """
37         Takes a string and returns a copy with all characters in
38             lower case
39    """
40    return str_data.lower()
41
42 def _scan(str_data):
43     """
44         Takes a string and scans for words, returning
45             a list of words.
46    """
47    return str_data.split()
48
49 def _remove_stop_words(word_list):
50    f = open('../stop_words.txt')
51    stop_words = f.read().split(',')
52    f.close()
53    # add single-letter words
54    stop_words.extend(list(string.ascii_lowercase))
55    return [w for w in word_list if not w in stop_words]

```

```

56
57 # The actual work of splitting the input into words
58 result = []
59 words = _remove_stop_words(_scan(_normalize(_filter_chars(
60     data_str))))
61 for w in words:
62     result.append((w, 1))
63
64 return result
65
66 def count_words(pairs_list_1, pairs_list_2):
67     """
68         Takes a two lists of pairs of the form
69        [(w1, 1), ...]
70        and returns a list of pairs [(w1, frequency), ...],
71        where frequency is the sum of all the reported occurrences
72    """
73    mapping = dict((k, v) for k, v in pairs_list_1)
74    for p in pairs_list_2:
75        if p[0] in mapping:
76            mapping[p[0]] += p[1]
77        else:
78            mapping[p[0]] = 1
79
80    return mapping.items()
81
82 #
83 # Auxiliary functions
84 #
85
86 def read_file(path_to_file):
87     """
88         Takes a path to a file and returns the entire
89        contents of the file as a string
90    """
91    f = open(path_to_file)
92    data = f.read()
93    f.close()
94    return data
95
96 def sort(word_freq):
97     """
98         Takes a collection of words and their frequencies
99        and returns a collection of pairs where the entries are
100       sorted by frequency
101    """
102    return sorted(word_freq, key=operator.itemgetter(1), reverse=
103        True)
104
105 #
106 # The main function
107 #
108 splits = map(split_words, partition(read_file(sys.argv[1]), 200))
109 splits.insert(0, []) # Normalize input to reduce
110 word_freqs = sort(reduce(count_words, splits))

```

```

1 import sys, re, operator, string
2
3 #
4 # Functions for map reduce
5 #
6 def partition(data_str, nlines):
7     """
8         Generator function that partitions the input data_str (a big
9             string)
10        into chunks of nlines.
11        """
12        lines = data_str.split('\n')
13        for i in xrange(0, len(lines), nlines):
14            yield '\n'.join(lines[i:i+nlines])
15
16 def split_words(data_str):
17     """
18         Takes a string, filters non alphanumeric characters,
19             normalizes to
20             lower case, scans for words, and filters the stop words.
21             It returns a list of pairs (word, 1), one for each word in the
22                 input, so
23                 [(w1, 1), (w2, 1), ..., (wn, 1)]
24
25 def _filter_chars(str_data):
26     """
27         Takes a string and returns a copy with all nonalphanumeric
28             chars
29             replaced by white space
30             """
31        pattern = re.compile('[\W_]+')
32        return pattern.sub(' ', str_data)
33
34 def _normalize(str_data):
35     """
36         Takes a string and returns a copy with all characters in
37             lower case
38             """
39        return str_data.lower()
40
41 def _scan(str_data):
42     """
43         Takes a string and scan
44             a list of words.
45             """
46        return str_data.split()
47
48 def _remove_stop_words(word):
49     f = open('../stop_words')
50     stop_words = f.read().split()
51     f.close()
52     # add single-letter words
53     stop_words.extend(list('aeiou'))
54     return [w for w in word if w not in stop_words]

```

```

50
51     # The actual work of splitting the input into words
52     result = []
53     words = _remove_stop_words(_scan(_normalize(_filter_chars(
54         data_str))))
55     for w in words:
56         result.append((w, 1))
57
58     return result
59
60 def count_words(pairs_list_1, pairs_list_2):
61     """
62         Takes a two lists of pairs of the form
63             [(w1, 1), ...]
64         and returns a list of pairs [(w1, frequency), ...],
65         where frequency is the sum of all the reported occurrences
66         """
67        mapping = dict((k, v) for k, v in pairs_list_1)
68        for p in pairs_list_2:
69            if p[0] in mapping:
70                mapping[p[0]] += p[1]
71            else:
72                mapping[p[0]] = 1
73
74    return mapping.items()
75
76 #
77 # Auxiliary functions
78 #
79 def read_file(path_to_file):
80     """
81         Takes a path to a file and returns the entire
82             contents of the file as a string
83             """
84        f = open(path_to_file)
85        data = f.read()
86        f.close()

```

```

# Main
splits = map(split_words,
              partition(read_file(sys.argv[1]), 200))
splits.insert(0, [])
word_freqs = sort(reduce(count_words, splits))

for tf in word_freqs[0:25]:
    print tf[0], ' - ', tf[1]

```

```

1 import sys, re, operator, string
2
3 #
4 # Functions for map reduce
5 #
6 def partition(data_str, nlines):
7     """
8     Generator function that partitions the input data_str (a big
9     string)
10    into chunks of nlines.
11    """
12    lines = data_str.split('\n')
13    for i in xrange(0, len(lines), nlines):
14        yield '\n'.join(lines[i:i+nlines])

def split_words(data_str)
    """
    Takes a string (many lines), filters, normalizes to
    lower case, scans for words, and filters the stop words.
    Returns a list of pairs (word, 1), so
    [(w1, 1), (w2, 1), ..., (wn, 1)]
    """
    ...
    result = []
    words = _rem_stop_words(_scan(_normalize(_filter(data_str))))
    for w in words:
        result.append((w, 1))
    return result

    A LIST OF WORDS.
    """
    return str_data.split()

def _remove_stop_words(word_list):
    f = open('../stop_words.txt')
    stop_words = f.read().split(',')
    f.close()
    # add single-letter words
    stop_words.extend(list(string.ascii_lowercase))
    return [w for w in word_list if not w in stop_words]

# The actual work of splitting the input into words
result = []
words = _remove_stop_words(_scan(_normalize(_filter_chars(
    data_str))))
for w in words:
    result.append((w, 1))

return result

def count_words(pairs_list_1, pairs_list_2):
    """
    Takes a two lists of pairs of the form
    [(w1, 1), ...]
    sorted by frequency
    """
    return sorted(word_freq, key=operator.itemgetter(1), reverse=True)

# The main function
#
splits = map(split_words, partition(read_file(sys.argv[1]), 200))
splits.insert(0, []) # Normalize input to reduce
word_freqs = sort(reduce(count_words, splits))

```

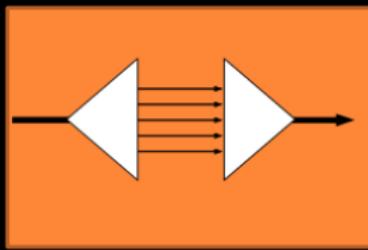
```
1 import sys, re, operator, string
2
3 #
4 # Functions for map reduce
5 #
6 def partition(data_str, nlines):
7     """
8     Generator function that partitions the input data_str (a big
9     string)
10    into chunks of size nlines
11    """
12    lines = data_str
13    for i in xrange(nlines):
14        yield '\r\n'.join(lines[i:i+nlines])
15
16 def split_words(data):
17     """
18     Takes a string and splits it into words, normalizing them to
19     lower case, and removing punctuation and numbers.
20     It returns a list of pairs [(w1, 1), (w2, 1), ...]
21     """
22    def _filter_chars(char):
23        """
24        Takes a character and replaces it with a space if it is not
25        a letter or digit, otherwise returns the character.
26        """
27        pattern = '[^a-zA-Z0-9]'
28        replaced = pattern.replace(char, ' ')
29        return replaced
30
31    def _normalize(string):
32        """
33        Takes a string and converts it to lower case.
34        """
35        lower = string.lower()
36        return lower
37
38    def _scan(string):
39        """
40        Takes a string and returns a list of words.
41        """
42        return string.split()
43
44    def _remove_stop_words(word_list):
45        f = open('../stop_words.txt')
46        stop_words = f.read().split(',')
47        f.close()
48        # add single-letter words
49        stop_words.extend(list(string.ascii_lowercase))
50        return [w for w in word_list if not w in stop_words]
51
52    # The actual work of splitting the input into words
53    result = []
54    words = _remove_stop_words(_scan(_normalize(_filter_chars(
55        data_str))))
56    for w in words:
57        result.append((w, 1))
58
59    return result
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Style #7 Main Characteristics

- ▷ Two key abstractions:
map(f, chunks) and
reduce(g, results)

Style #7 Main Characteristics

- ▶ Two key abstractions:
map(f, chunks) and
reduce(g, results)



iMux Style

@cristalopes #style7 *name*

Programming Style

There is always more than one way to express an idea

- ▶ Kiss! Getting things straight forward is very difficult
Simplicity does not precede complexity, but follows it
- ▶ One programmer's elegant solution is another one unpleasant beast

Improve your style now

- ▶ There is a huge literature on good programming style/methodology/buzzwords
- ▶ Reading code should be the way to learn, or at least write a lot of code

But don't search for your own style

- ▶ You are a journalist, not a poet: express ideas clearly with no stylistic trick
- ▶ Programming is a team game ↵ stick to some programming standards
- ▶ Programming tricks and Golf style should remain a game

Bad Style Coding as a Game

The International Obfuscated C Code Contest (www.ioccc.org)

- ▶ Yearly contest of intentionally obfuscated codes (in C; exist for other languages)

Example:

(arachnid, 2004 entry)

```
#include <curses.h>/*************  
    int          m[256] [ 256 ], a  
, b ;;; ;;; WINDOW*w; char*l="" "\176qx1" "q" "q" "k" "w\  
xm" "x" "t" "j" "v" "u" "n" ,Q[  
]= "Z" "pt!ftd" "qdc!eu" "dq!$c!nnwf"/* *** */"t\040\t";c(  
int u , int v){ v?m [u] [v-  
1] |=2,m[u][v-1] & 48?W[v-1] & 15]):0:0;u?m[u-1][v] |=1 ,m[  
u-1] [v]& 48? W-1 ] [v ] &  
15] ):0:0;v< 255 ?m [ u ][v+1] |=8,m [ u ][v+1] & 48? W [ v+1]&15]  
) :0 :0; u < 255 ?m [ u+1 ] [v ] |=  
4,m[u+1] [ v]&48?W+1 [ v ] &15]):0:0;W [ v ] & 15]);}cu(char*q){ return  
*q ?cu (q+ 1)& 17q [0] ++:  
q[0] -- :1; )d( int u , int/**/v, int/**/x, int y){ int  
Y=y -v, X=x -u; int S,s ;Y< 0?Y =-Y ,s,  
s=- i:( s=1);X<0?X=X ,S=- i :(S= 1); Y<= 1;X<<=i; if(X>Y){  
int f=Y -(X >>1 ); while(u!= x){  
f>= 0?v+=s,f-=X:0;u +=S ;f+= Y;m[u][v] |=32;mvwaddch(w,v ,u, m[u  
][ v ] & 16);c(u,v); ;;; return;}} lelse{int f=X -(Y>>1 ); while  
(v !=y ){f >=0 ?u +=S, f-= Y:0  
;v +=s ;f+=X;m[u][v] |= 32;mvwaddch(w,v ,u, m[u][v ] &64?60:46);if(m[u  
][ v ] & 16){c( u,v );};  
; return;}}})Z( int/**/a, int b){ l)e( int/**/y,int/**/ x){  
int i ; for (i= a;i <=a  
+S;i++)d(y,x,i,b),d(y,x,i,b+L);for(i=b;i<=b+L;i++)d(y,x,a,i),d(y,x,a+  
S,i  
); ;;; ;;; ;;; ;;; ;;; ;  
mvwaddch(w,x,y,64); ;;; ;;; ;;; refresh( w,b,a,0,0 ,L- 1,S-1  
);} main( int V , char *C[  
] ) {FILE*f= fopen(V==1?"arachnid.c":/* */ :C[ 1],"r");int/**/x,y,c,
```

Bad Style Coding as a Game

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Example: Full (interactive) Maze Escape Game (arachnid, 2004 entry)

```
#include <ncurses.h>/*************  
    int          m[256] [ 256 ],a  
,b ;;; ;;; WINDOW*w; char*l="" "\176qx1" "q" "q" "k" "w\  
xm" "x" "t" "j" "v" "u" "n" ,Q[  
]= "Z" "pt!ftd" "qdc!eu" "dq!$c!nnwf"/** *** /*"t\040\t";c(  
int u , int v){ v?m [u] [v-  
1] |=2,m[u][v-1] & 48?W[v-1] & 15]):0:0;u?m[u -1][v] |=1 ,m[  
u- 1] [ v]& 48? W-1 ] [v ] &  
15] ):0:0;v< 255 ?m [ u ] [v+1] |=8,m [ u ] [v+1] & 48? W [ v+1]&15]  
) :0 :0; u < 255 ?m [ u+1 ] [v ] |=  
4,m[u+1] [ v]&48?W+1] [v ] &15]):0:0;W [ v ] & 15]);}cu(char*q){ return  
*q ?cu (q+ 1)& 17q [0] ++:  
q[0] -- :1; }d( int u , int/**/v, int/**/x, int y){ int  
Y=y -v, X=x -u; int S,s ;Y< 0?Y =-Y ,s,  
s=- i:( s=1);X<0?X=-X,S =-i :(S= 1); Y<= 1;X<<=i; if(X>Y){  
int f=Y -(X >>1 ); while(u!= x){  
f>= 0?v+=s,f-=X:0;u +=S ;f+= Y;m[u][v] |=32;mvwaddch(w,v ,u, m[u  
][ v]&16){c(u,v); ;;; return;}} lelse{int f=X -(Y>>1 ); while  
(v !=y ){f >=0 ?u +=S , f-= Y:0  
;v +=s ;f+=X;m[u][v] |= 32;mvwaddch(w,v ,u,m[u][v]&64?60:46);if(m[u  
][ v]& 16){c( u, v );  
; return;}}}}Z( int/**/a, int b){ l)e( int/**/y,int/**/ x){  
int i ; for (i= a;i <=a  
+S;i++)d(y,x,i,b),d(y,x,i,b+L);for(i=b;i<=b+L;i++)d(y,x,a,i),d(y,x,a+  
S,i  
); ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;  
mvwaddch(w,x,y,64); ; ; ; ; ; ; ; ; ; ; ; ; ; ; ;  
);} main( int V , char *C[  
] ){FILE*f= fopen(V==1?"arachnid.c":/*"/ :C[ 1],"r");int/**/x,y,c,
```

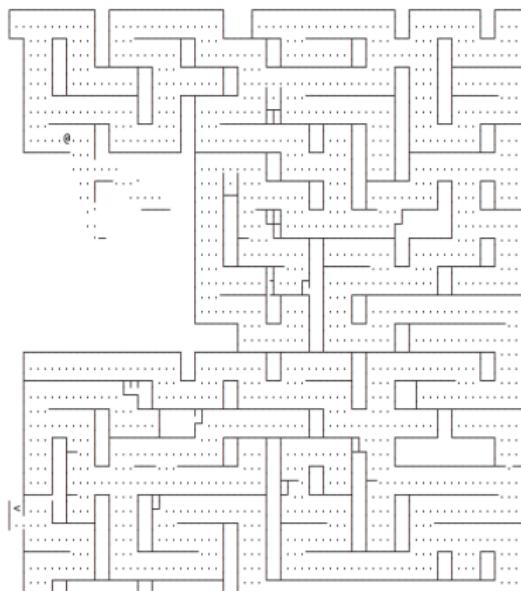
Bad Style Coding as a Game

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Example: Full (interactive) Maze Escape Game (arachnid, 2004 entry)
Screenshot

```
#include <ncurses.h>/*************  
    int          m[256]           ] [      256 ],a  
,b ;;; ;;; WINDOW*w; char*l="" "\176qx1" "q" "q" "k" "w\  
xm" "x" "t" "j" "v" "u" "n" ,Q[  
]= "Z" "pt!ftd" "qdc!eu" "dq!$c!nnwf"/** *** */"t\040\t";c(  
int u , int v){ v?m [u] [v-1] & [v-1] & [v-1] & [v-1] &  
[v-1] | 2,m[u][v-1] & 48?W[v-1] & 15]):0:0;u?m[u-1][v] |= 1,m[  
u-1] [v]& 48? W-1 ] [v] &  
15] ) :0:0;v< 255 ?m [u] [v+1] |= 8,m[u][v+1] & 48? W [v+1] & 15]  
) :0 :0; u < 255 ?m [u+1] |= 1,m[u+1] & 48? W [v] |= 1,v |= 1,  
4,m[u+1] [v]&48?W+1] [v] & 15]):0:0;W [v] & 15 ]);}cu(char*q){ return  
*q ?cu (q+ 1)& 17q [0] ++:  
q[0] -- :1; }d( int u , int/**/v, int/**/x, int y){ int  
Y=y -v, X=x -u; int S,s ;Y< 0?Y =-Y ,s,  
s=- i:( s=1);X<0?X=-X,S =-i :(S= 1); Y<= 1;X<<=i; if(X>Y){  
int f=Y-(X >>1 ); while(u!= x){  
f>= 0?v+=s,f-=X:0;u +=S ;f+= Y;m[u][v] |=32;mwaddch(w,v ,u, m[u]  
)[v]&64? 60: 46); if(m[u][v]&64){c(u,v); ;;; return;}} lelse{int f=X -(Y>>1 ); while  
(v !=y ){f >=0 ?u +=S , f-= Y:0  
;v +=s ;f+=X;m[u][v] |= 32;mwaddch(w,v ,u,m[u][v]&64?60:46);if(m[u]  
)[v]& 16){c( u,v );};  
; return;}}}}Z( int/**/a, int b){ lfe( int/**/y,int/**/ x){  
int i ; for (i= a;i<=a +S;i++)d(y,x,i,b),d(y,x,i,b+L);for(i=b;i<=b+L;i++)d(y,x,a+i),d(y,x,a+  
S,i );  
; mwaddch(w,x,y,64); ;;; ;;; ;prefresh( w,b,a,0,0 ,L- 1,S-1  
);}  
main( int V , char *C[  
] ) {FILE*f= fopen(V==1?"arachnid.c":/* */ :C[ 1], "r");int/**/x,y,c,
```



Recreational Obfuscation: Phillips entry of IOCCC'88

Program code

```
#include <stdio.h>
main(t,_,a){return!0<t?t<3?main(-79,-13,a+main(-87,1-_,
main(-86,0,a+1)+a)):1,t<_?main(t+1,_,a):3,main(-94,-27+t,a)&&t==2?_<13?
main(2,_+1,"%s %d %d\n":9:16:t<0?t<-72?main(_,_t,
"@n'++#'*{}w+/w#cdnr/+,{ }r/*de}++/*{**+,/w{ %+,/w#q#n+,/#{1,+,/n{n+,/+#n+,/#\
;#q#n+,/+k#;*+,/' r : 'd*'3,}{w+K w'K: '+'e#';dq#'\l \
q#'+d'K#!/+k#;q#r}eKK#}w'r)eKK{nl}'/#;#q#n'){})#}w'){}){nl]'/+#n';d}rw' i;# \
){nl]!/n{n#'; r{#w'r nc{nl]'/#{1,+ 'K {rw' iK{;[{nl]'/w#q#n'wk nw' \
iWk{KK{nl]!/w{ '%1##w# i; :{nl]'//*{q#l'd;r'}{nlwb!/*de}'c \
;:{nl'-{}rw]'/+,}##'*}#nc,' ,#nw]'/+kd'+e}+;#'rdq#w! nr' / ') }+}{rl#'{n' ' )# \
}'+}##(!!/")
:t<-50?_==*a?putchar(31[a]):main(-65,_,a+1):main((*a=='/')+t,_,a+1)
:0<t?main(2,2,"%s")*:a=='/'||main(0,main(-61,*a,
!"ek;dc i@bK'(q)-[w]*%n+r3#1,{}:\nuuwloca-0;m .vpbks,fxntdCeghiry"),a+1);}
```

Output

On the first day of Christmas my true love gave to me
a partridge in a pear tree.

On the second day of Christmas my true love gave to me
two turtle doves
and a partridge in a pear tree.

On the third day of Christmas my true love gave to me
three french hens, two turtle doves
and a partridge in a pear tree.

On the fourth day of Christmas my true love gave to me
four calling birds, three french hens, two turtle doves
and a partridge in a pear tree.

Output (cont)

On the eighth day of Christmas my true love gave to me
eight maids a-milking, seven swans a-swimming,
six geese a-laying, five gold rings;
four calling birds, three french hens, two turtle doves
and a partridge in a pear tree.

On the ninth day of Christmas my true love gave to me
nine ladies dancing, eight maids a-milking, seven swans a-swimming
six geese a-laying, five gold rings;
four calling birds, three french hens, two turtle doves
and a partridge in a pear tree.

On the tenth day of Christmas my true love gave to me
ten lords a-leaping,
nine ladies dancing, eight maids a-milking, seven swans a-swimming

Bad Coding Style as an Art

Another example

```
#include <stdio.h>
int l;int main(int o,char **o,
int I){char c,*D=o[1];if(o>0){
for(l=0;D[l]           ];D[l
++]-=10){D[l+=1]-=120;D[l]-=
110;while  (!main(0,0,l))D[l]
+= 20;  putchar((D[l]+1032)
/20    );putchar(10);}else{
c=o+   (D[I]+82)%10-(I>l/2)*
(D[I-l+I]+72)/10-9;D[I]+=I<0?0
:! (o==main(c/10,0,I-1))*((c+999
)%10-(D[I]+92)%10);}return o;}
```

Bad Coding Style as an Art

Another example: Computing Integer Square Roots

```
#include <stdio.h>
```

```
int l;int main(int o,char **o,  
int I){char c,*D=0[1];if(o>0){  
for(l=0;D[l] ] ;D[l  
++]-=10){D [l++]-=120;D[l] -=  
110;while (!main(0,0,l))D[l]  
+= 20; putchar((D[l]+1032)  
/20 ) ;}putchar(10);}else{  
c=o+ (D[I]+82)%10-(I>1/2)*  
(D[I-1+I]+72)/10-9;D[I]+=I<0?  
:(!(o=main(c/10,0,I-1))*((c+999  
)%10-(D[I]+92)%10);}return o;}
```

It actually works

```
$ ./cheong 1234  
35
```

$(35 \times 35 = 1225; 35 \times 36 = 1296)$

```
$ ./cheong 112233445566  
335012
```

$335012 \times 335012 = 112233040144$

$335013 \times 335013 =$
 112233710169

Bad Coding Style as an Art

Another example: Computing Integer Square Roots

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#include <stdio.h>
int l;int main(int o,char **o,
int I){char c,*D=0[1];if(o>0){
for(l=0;D[l] ] ;D[l
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110;while (!main(0,0,l))D[l]
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/20 ) ;putchar(10);}else{
c=o+ (D[I]+82)%10-(I>1/2)*
(D[I-1+I]+72)/10-9;D[I]+=I<0?0
:! (o==main(c/10,0,I-1))*((c+999
)%10-(D[I]+92)%10);}return o;}
```

It actually works

```
$ ./cheong 1234
35
(35 × 35 = 1225; 35 × 36 = 1296)
$ ./cheong 112233445566
335012
335012 × 335012 = 112233040144
335013 × 335013 = 112233710169
```

Author claim: code self-documented...

```
#include <stdio.h>
int l;int main(int o,char **o,
int I){char c,*D=0[1];if(o>0){
for(l=0;D[l] ] ;D[l
++]-=10){D [l++]-=120;D[l] ==
110;while (!main(0,0,l))D[l]
+= 20; putchar((D[l]+1032)
/20 ) ;putchar(10);}else{
c=o+
(D[I]+82)%10-(I>1/2)*
(D[I-1+I]+72)/10-9;D[I]+=I<0?0
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Bad Coding Style as an Art

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110;while (!main(0,0,1))D[l]
+= 20; putchar((D[l]+1032)
/20 ) ;}putchar(10);}else{
c=o+ (D[I]+82)%10-(I>1/2)*
(D[I-1+I]+72)/10-9;D[I]+=I<0?0
:! (o==main(c/10,0,I-1))*((c+999
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It actually works

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Author claim: code self-documented...

```
#include <stdio.h>
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for(l=0;D[l] ] ;D[l
++]-=10){D [l++]-=120;D[l] ==
110;while (!main(0,0,1))D[l]
+= 20; putchar((D[l]+1032)
/20 ) ;}putchar(10);}else{
c=o+ (D[I]+82)%10-(I>1/2)*
(D[I-1+I]+72)/10-9;D[I]+=I<0?0
:! (o==main(c/10,0,I-1))*((c+999
)%10-(D[I]+92)%10);}return o;}
```

It is an old observation that the best writers sometimes disregard the rules of rhetoric. When they do so, however, the reader will usually find in the sentence some compensating merit, attained at the cost of the violation. Unless he is certain of doing as well, he will probably do best to follow the rules.

– William Strunk, Jr. (1918)

Last one, just for fun: dhyang IOCCC'00

Saitou Hajime image

Source code

```
#define /*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*/*-----*/
```

Last one, just for fun: dhyang IOCCC'00

Saitou Hajime image that prints a prog

Source code

Output 1

Last one, just for fun: dhyang IOCCC'00

Saitou Hajime image that prints a prog that prints a prog

Source code

Output 1

Output 2

Last one, just for fun: dhyang IOCCC'00

Saitou Hajime image that prints a prog that prints a prog that prints a prog

Source code

Output 1

Output 2

Output 3

Last one, just for fun: dhyang IOCCC'00

Saitou Hajime image that prints a prog that prints a prog that prints a prog ...
Repeating endlessly "aku soku zan", Hajime's motto meaning *slay evil immediatly*.

Source code

Output 1

Output 3

Output 2

Output 4 (=1)

This is a Quine: [https://en.wikipedia.org/wiki/Quine_\(computing\)](https://en.wikipedia.org/wiki/Quine_(computing))

Conclusion

Computer Science is the Science of Abstraction

- ▶ Computer Scientists are engineers terraforming ideas and concepts
- ▶ Write code to communicate with humans, and accidentally to execute it
- ▶ Programming is not about technology for its own sake. It's about being able to express your ideas precisely and efficiently. <http://prog21.dadgum.com/>

FP vs. OOP: how you prefer to state your ideas?

- ▶ OOP is all about nouns, FP is all about verbs
- ▶ Please keep the troll level low: It's the mutable state that is evil, not the object

Don't hope to get it right on the first time

- ▶ To a great extent the act of coding is one of organization. Refactoring. Simplifying. Figuring out how to remove extraneous manipulations here and there.
- ▶ Write it. Rewrite it correct. Rewrite it efficient. Rewrite it modifiable / elegant.

This course is now over

- ▶ I really hope that you will like your long journey on the programmer path