Lesson 2

Keep things decoupled

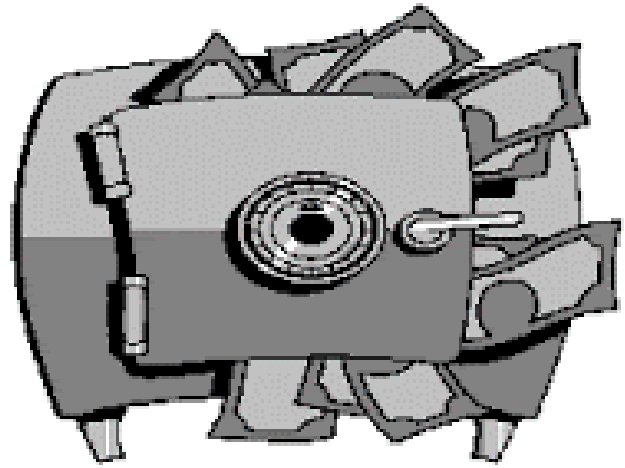
Spaghetti code

Development AntiPattern:

Spaghetti Code

spa·ghet·ti code [Slang] an undocumented piece of software source code that cannot be extended or modified without extreme difficulty due to its convoluted structure.

Un-structured code
is a liability



Well structured code
is an investment.

MITRE

Do you know when your code smells?

- Maybe your code is written in a way where you're doing a little bit of everything all at once
- e.g. `wave_clus`
  - very useful software to sort spikes
  - has a GUI in Matlab GUIDE
  - GUIDE makes it exceptionally hard to write good code
  - Picked it because it's real code

Sample code

Code here.

What's going here?

This is a callback for a function in a GUI for spike sorting.

- Does many things at once
  - Manipulates the GUI
  - Modifies data
  - Reads a jpg file?
- Uses magic numbers and magic columns
- Uses various string formatting functions and `exec`
- Big function
- Not complex, but it's complicated

Tightly coupled

- When code is tightly coupled (does a lot of unrelated things at once) it becomes very hard to reason about.
- Let's say your results are weird, are they weird because...
  - the data is bad
  - you're loading the data wrong
  - your model is incorrectly implemented
  - your model is inappropriate for the data
  - you statistical tests are inappropriate for the data distribution
- Let's say you want to describe to someone what the bug is in your code

Uncouple and simplify

- Keep each of the boxes separate with minimal interface
  - Separation of concerns:
    - example: your data loading function should just load data
    - Your computation functions shouldn't load data, they should just compute
- Make each of the boxes small
  - don't make giant monolithic functions
  - Make functions which are small
    - a screen's worth, 80 columns, 50 lines
- Avoid side effects, prefer pure functions

What's a side effect?

In computer science, an operation, function or expression is said to have a side effect if it modifies some state variable value(s) outside its local environment, that is to say has an observable effect besides returning a value (the main effect) to the invoker of the operation. State data updated "outside" of the operation may be maintained "inside" a stateful object or a wider stateful system within which the operation is performed. Example side effects include modifying a non-local variable, modifying a static local variable, modifying a mutable argument passed by reference, performing I/O or calling other side-effect functions. (Wikipedia)

Side effects

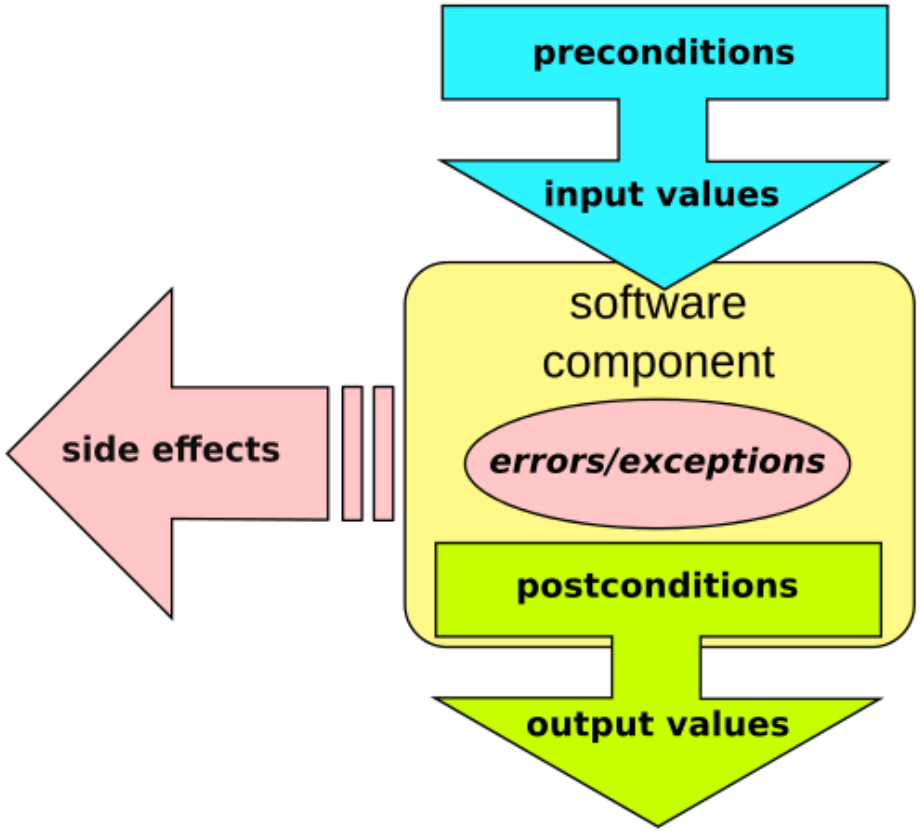


Figure 2: From Wikipedia

A function with side effects

```
def reversi(arr):
    """Reverses a list."""
    for i in range(len(arr) // 2):
        arr[-i - 1] = arr[i]
    return arr
```

Side effects

- Modifying arguments
- Printing
- Making API calls
- Changing globals

Side effects are not the best

- Stuff happens outside of the normal flow from arguments $\rightarrow$ return value
- Need to know state of function to understand it
- Hard to test
- Let's box them

Demo

- `fib.py`
- Fibonacci sequence, $F(n) = F(n-1) + F(n-2)$
- Memoization

Learn more about your language

- Sometimes (but not always!), code smells come from lack of knowledge
  - E.g. using magic column numbers in a raw numpy array rather than named columns in pandas because you don't know pandas
  - Using unnamed dimensions in numpy rather than xarray
  - Using + and bespoke casting for string formatting rather than the one true solution, the f-string
- Take time to learn more about the language you use

Enough theory!

Let's de-couple CKA!

Centered kernel alignment

- Let's compare the responses of two systems, e.g. a brain and a deep neural net
- Same number of stimuli n, potentially different numbers of features
- Let's collect the responses of each system into matrices $\mathbf{X}, \mathbf{Y}$, each n high.
- Center $\mathbf{X}, \mathbf{Y}$ so each column has 0 mean, then:

$$CKA(\mathbf{X}, \mathbf{Y}) = \frac{||\mathbf{X}^T\mathbf{Y}||_2^2}{||\mathbf{X}^T\mathbf{X}||_2||\mathbf{Y}^T\mathbf{Y}||_2}$$

- Min 0, max 1
- Check: if $\mathbf{X}$ and $\mathbf{Y}$ are one-dimensional, then $CKA = \rho(\mathbf{X}, \mathbf{Y})^2$.

Live coding!

Lesson 2

- Keep things decoupled
- By keeping things decoupled, you can think about one part of your program at a time
- Save your WM slots
- Your 5-minute exercise: take existing piece of code and wrap it in main