Beyond the Mouse – A Short Course on Programming

2. Fundamental Programming Principles I: Variables and Data Types

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"The Uncomfortable Truths Well", http://xkcd.com/568 (April 13, 2009)

Today's schedule ...

1. Solutions to Exercises
2. How does programming work?
3. Variables and Datatypes

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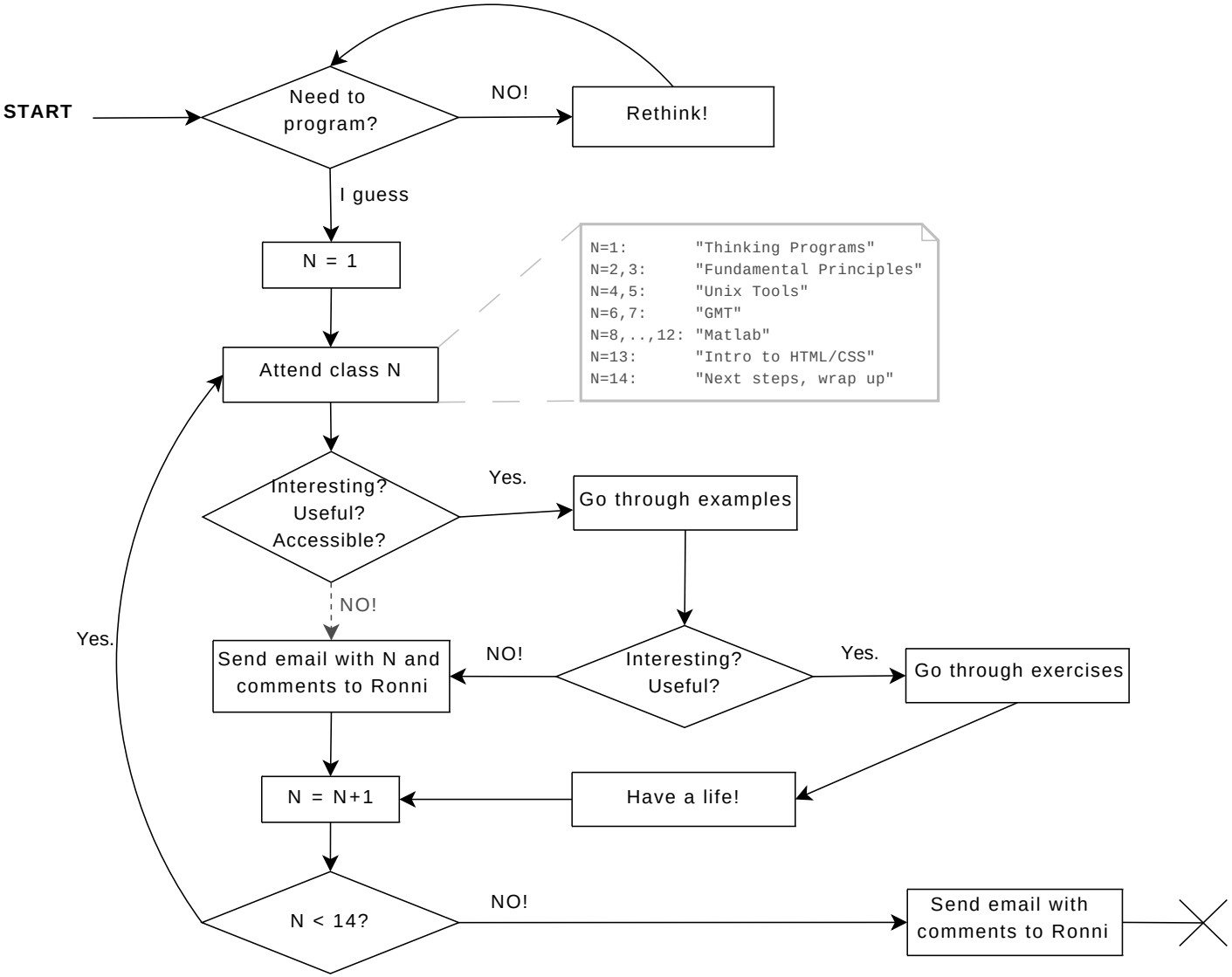
Exercise #0

. . .

thanks for the images :)

Exercise #1



Listing 1: Seminar flow (fixed)

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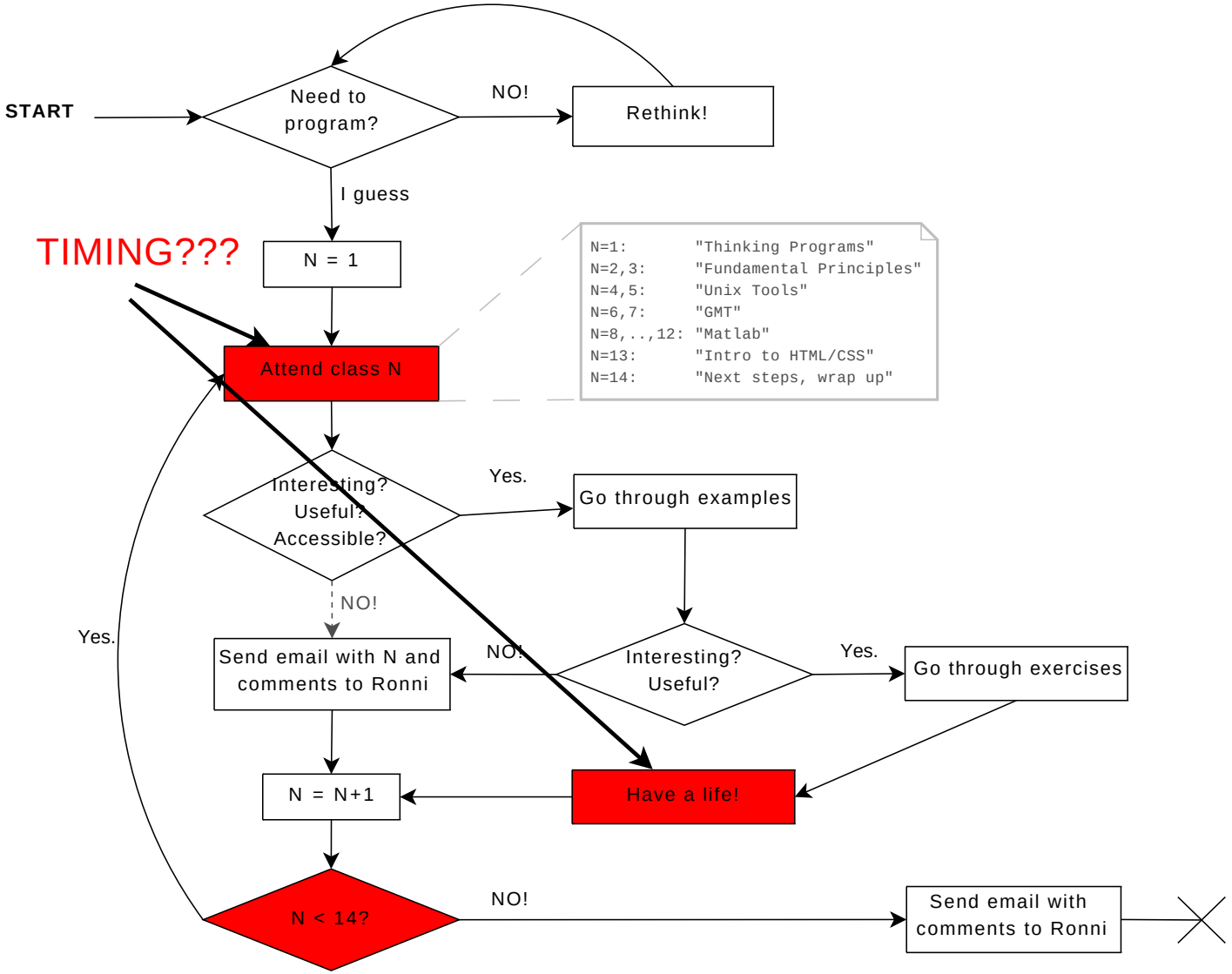

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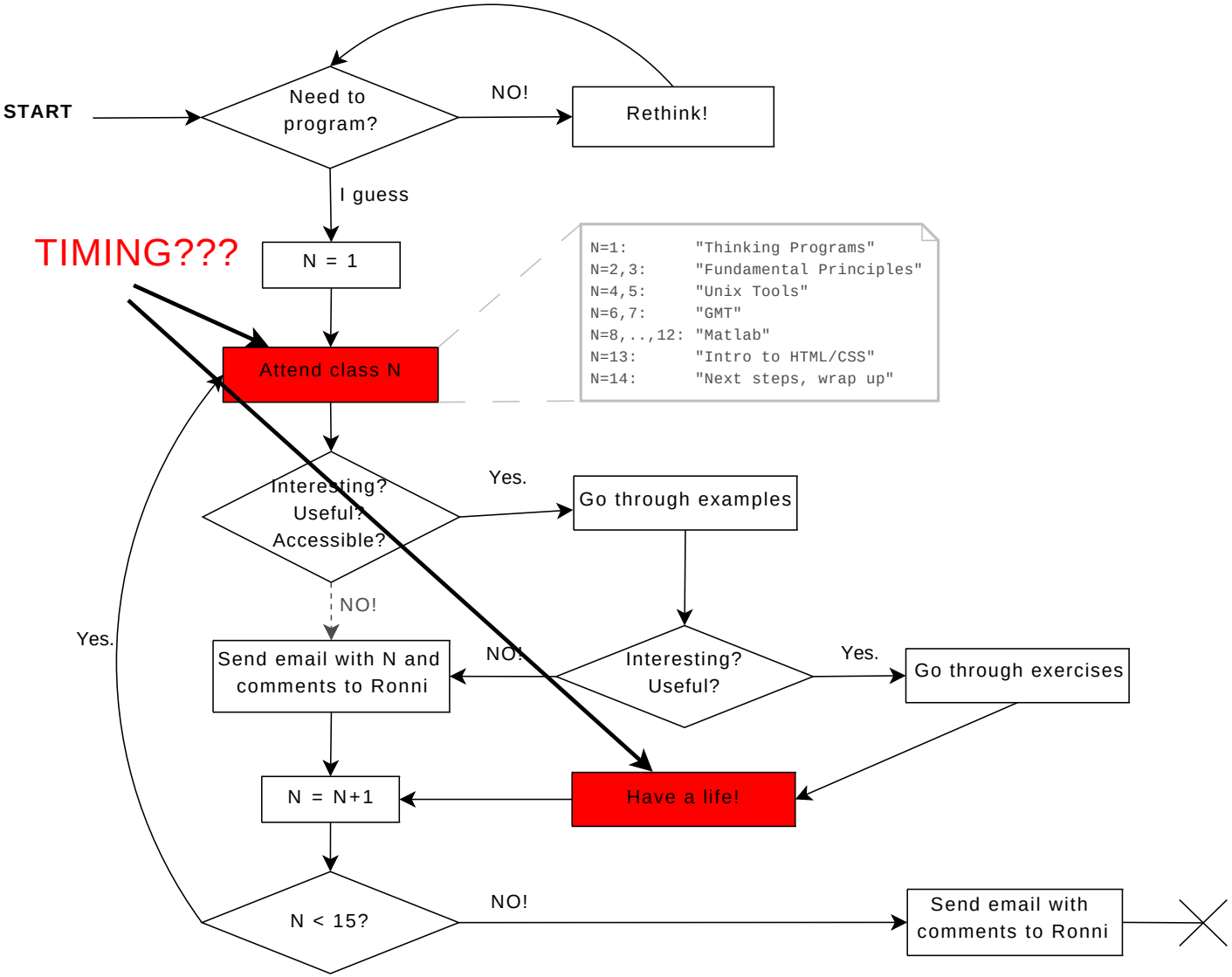

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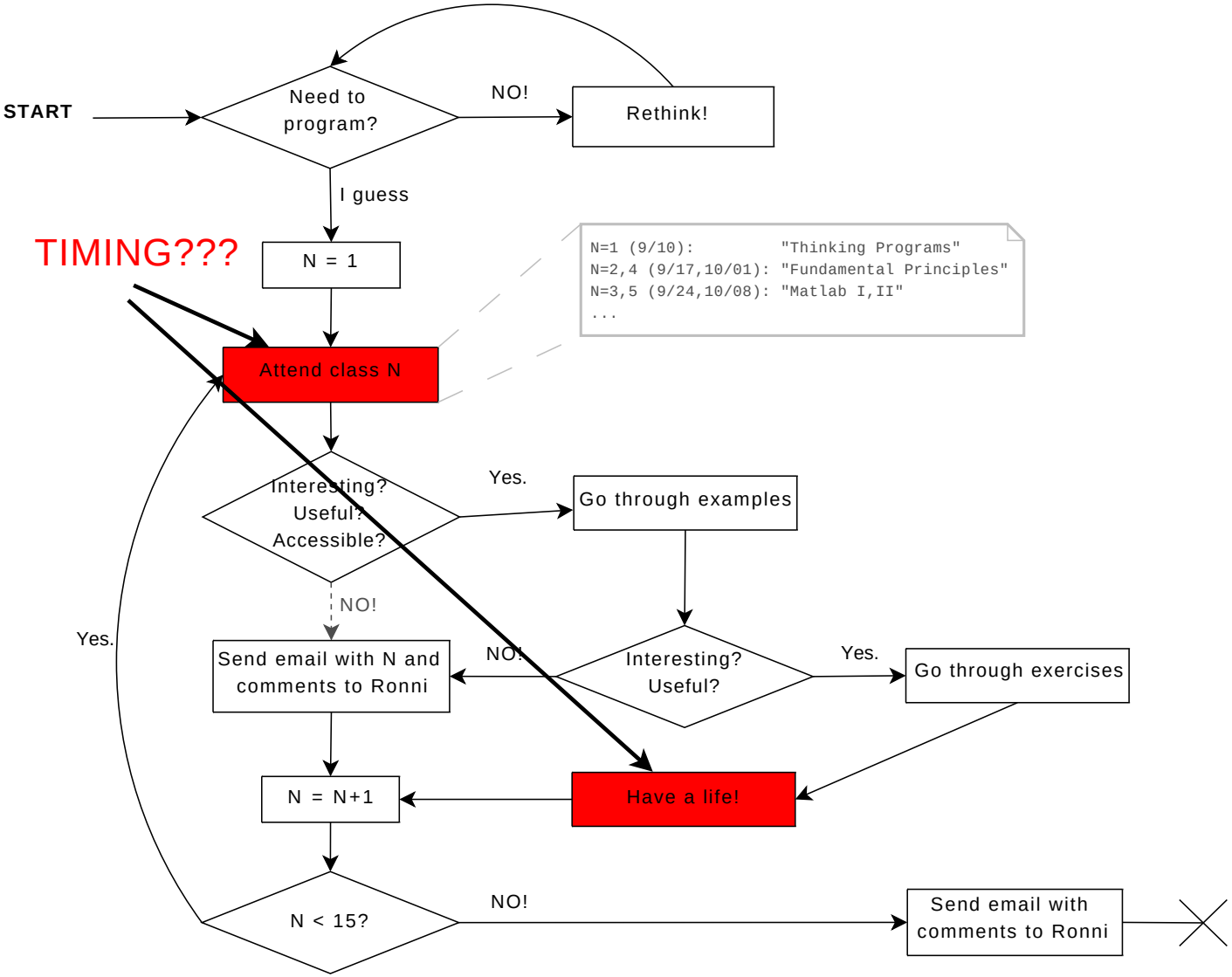

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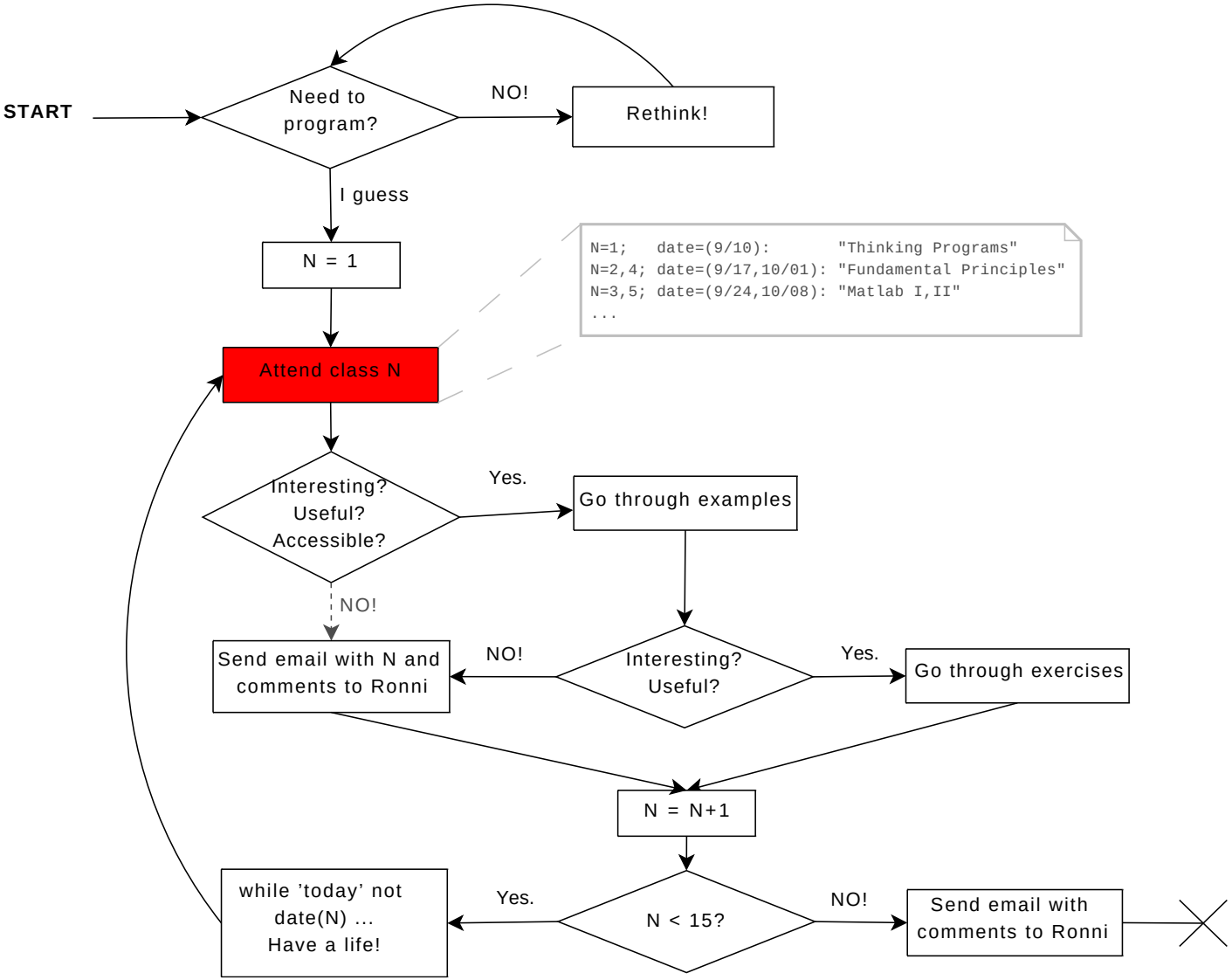

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Exercise in general

I'll come back to you with individual comments on project snapshots, flow charts etc.

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How does programming work?

Well, fist we should clearify terminology here!

What is a programming language?

What is a program?

Alright, what is it then?

Definitions (broad sense)

A **programming language** is an unambiguous artificial language that is made up of a set of symbols (vocabulary) and grammatical rules (syntax) to instruct a machine.

A **program** is a set of instructions in one or multiple programming languages that specifies the behavior of a machine.

Compilation or **interpretation** is the verification of a program and its translation into in the machine readable instructions of a specific platform.

Programming languages . . . continued

Two broad families can be identified:

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2. **Compiled languages**
   Programs are translated and saved in machine language. At runtime no additional program is necessary (e.g., C/C++).

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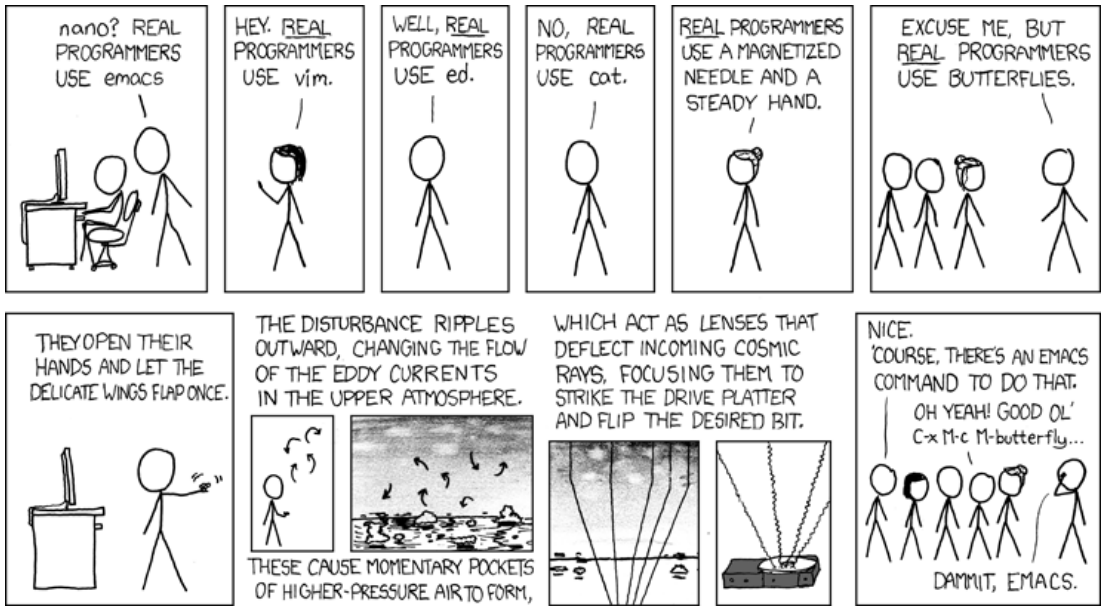
1. open **text** editor (vi, notepad, . . . , not MS Word!)



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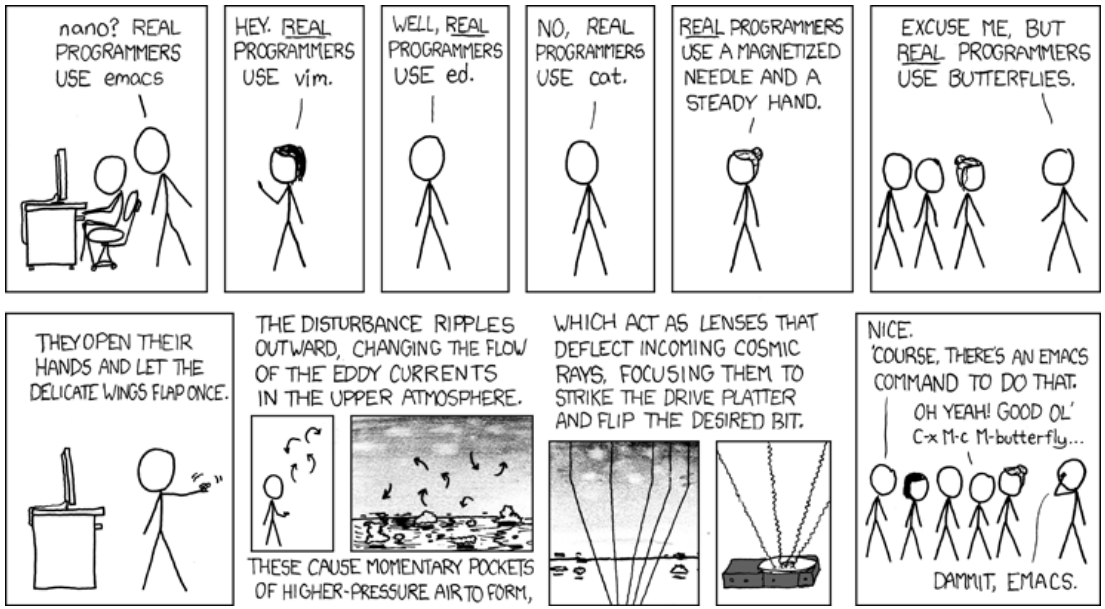

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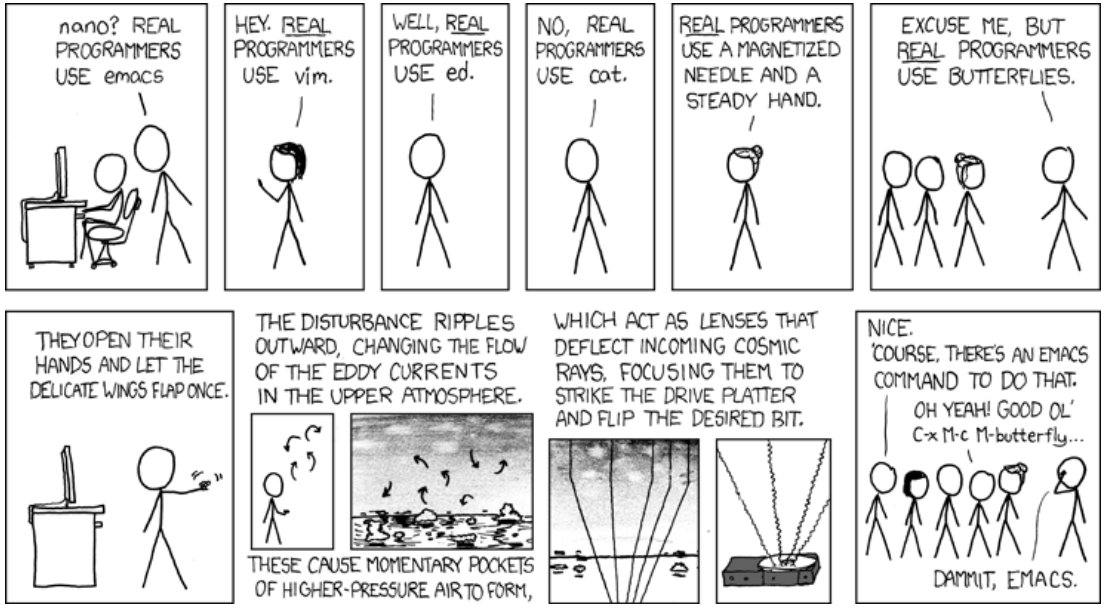

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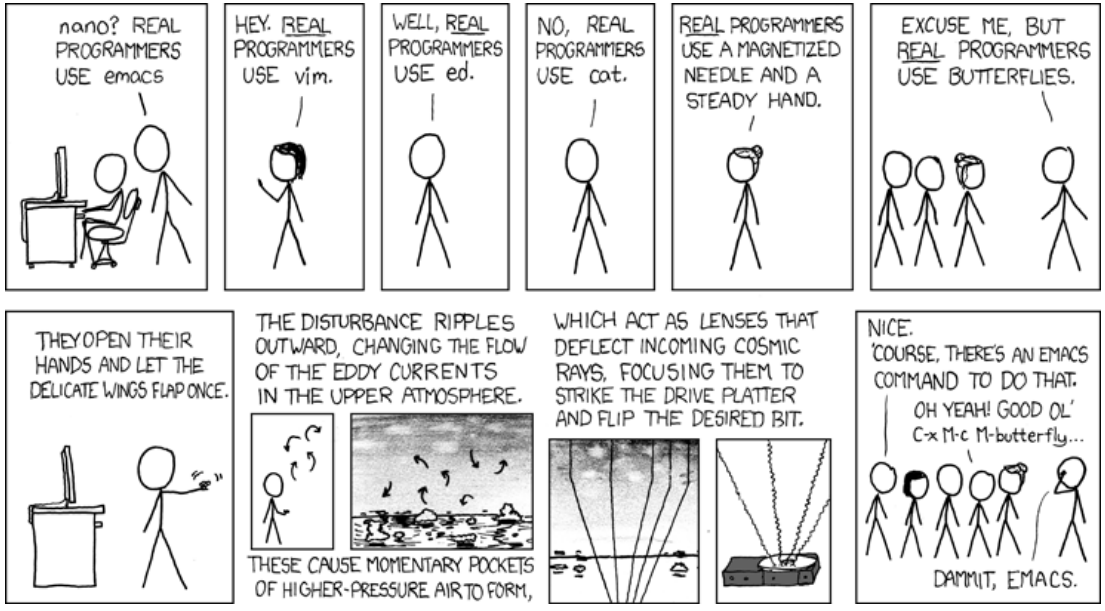

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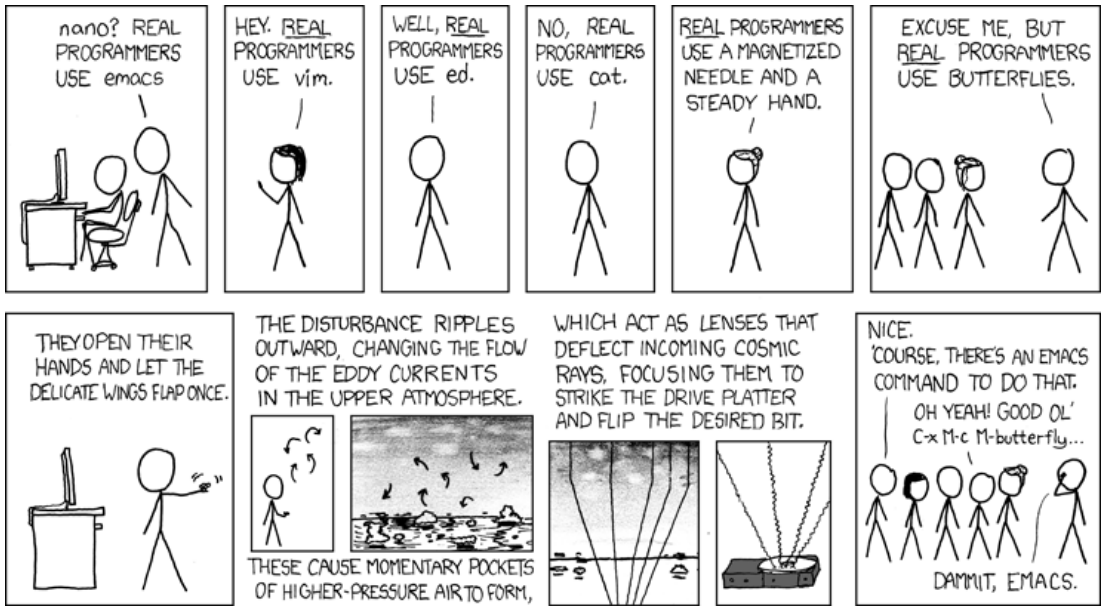

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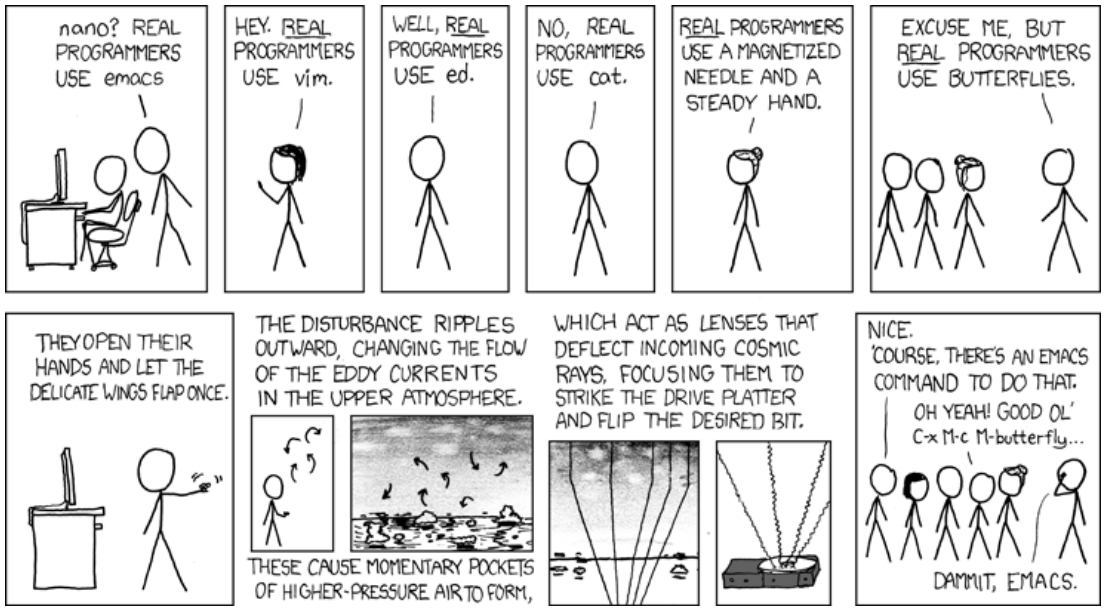

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5. test your program for semantical errors (the fun part!)
6. if errors, fix them and go back to (3)

Don’t even think that’s as simple as it sounds . . .

‘Hello World’ in Matlab

```
>> dsp(halo orld
??? dsp(halo orld
               |
Error: Unexpected MATLAB expression.

>> dsp('halo orld
??? dsp('halo orld
        |
Error: A MATLAB string constant is not terminated properly.

>> dsp('halo orld'
??? dsp('halo orld'
                   |
Error: Expression or statement is incorrect--possibly unbalanced (, {, or [.

>> dsp('halo orld')
??? Undefined function or method 'dsp' for input arguments of type 'char'.

>> disp('halo orld')
halo orld

% Sematically correct, if you want to say 'hi' to the world:
%
>> disp('hello world')
hello world
```

Listing 2.1: hello_world.log

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Variables (1)

Definitions – a selection

Donald Knuth: A quantity that may possess different values as a program is being executed.
Mehran Sahami: A box in which we stuff things – i.e. a box with variable content.
Wikipedia: User defined keyword that is linked to a value stored in computer's **memory** (runtime).

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- name
- type
- value

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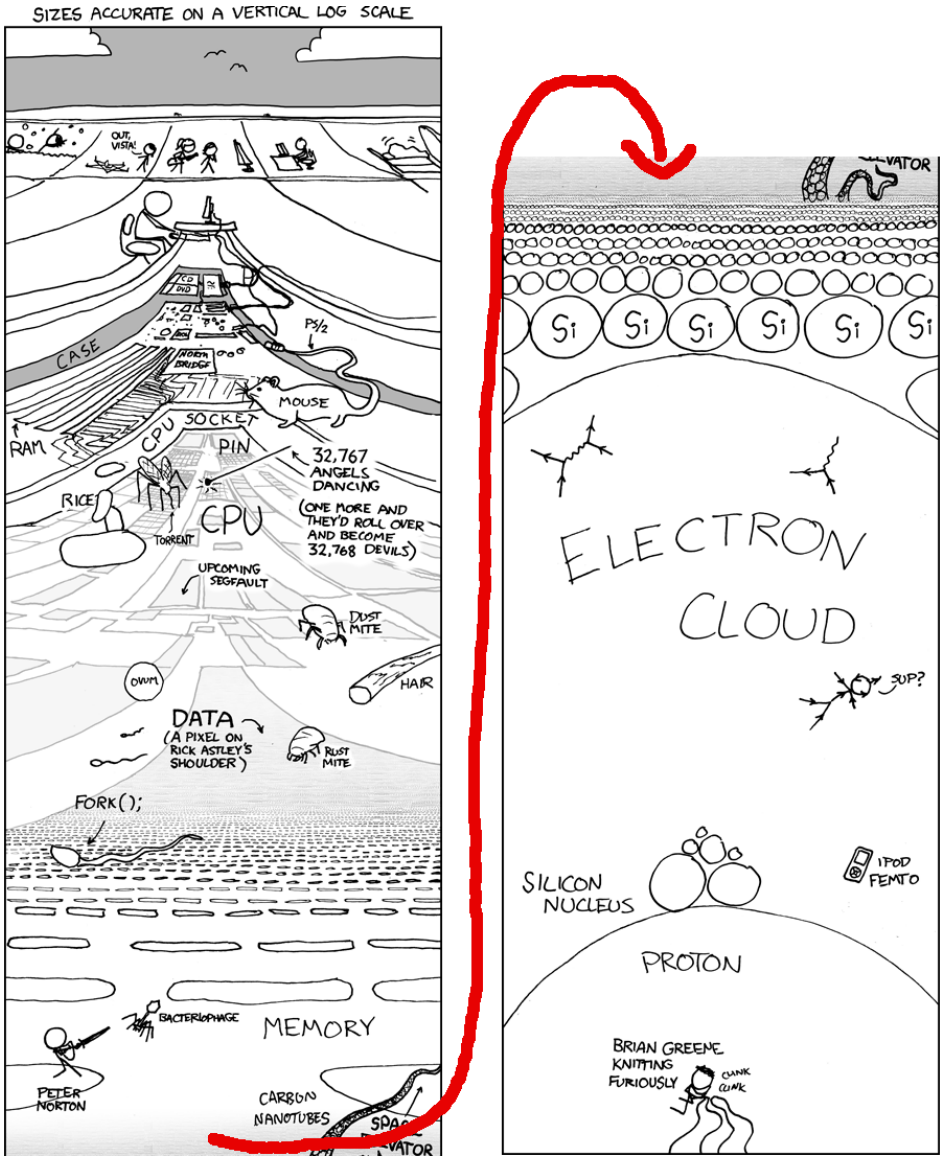

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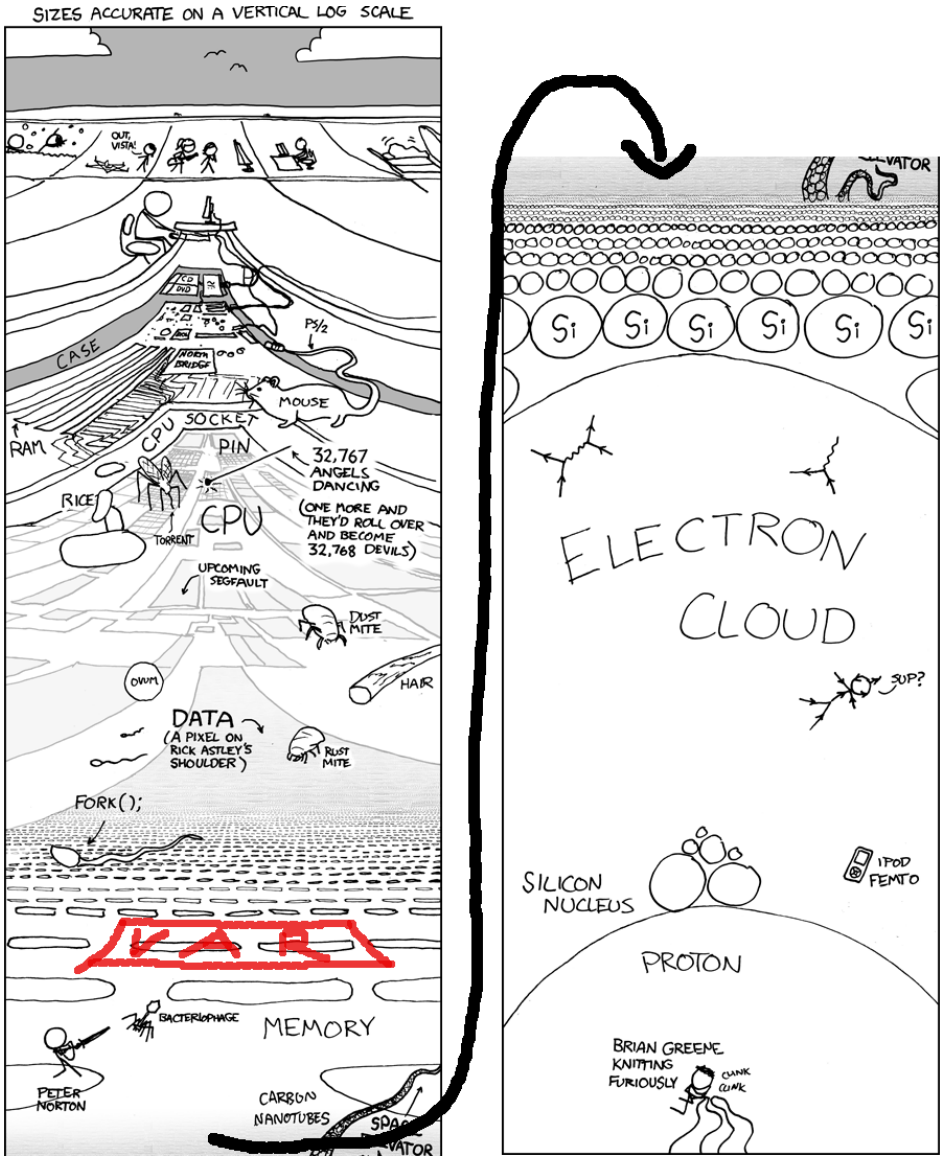

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- use consistent formatting, i.e.: ‘`my_cool_var`’ vs. ‘`myCoolVar`’ – supports reading
- a gazillion style guides exist – punchline: use meaningful names, be consistent (that’s hard enough)!

Variables (3) – type

What is a type? – Think of sets of numbers in math: $\mathbb{N}, \mathbb{R}, \mathbb{Z}, \ldots$ The type refers to how numbers are being represented in a computer's memory, i.e. which bit has which meaning.

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Two kinds of Types

- primitive, built in types – for MATLAB e.g.: '`int32`', '`double`', '`boolean`'
- complex, home made types – (arrays,) structs, cell arrays (Matlab), classes/objects

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Types in Programming Languages

- some languages, e.g. MATLAB, Shells, Perl are weakly typed: implicit type conversions (OR one type can be treated as another)
- this is nice at first, occasionally this leads to nasty/hard to fix problems (e.g. string interpreted as number, etc.)

Variables (4) – value

Value

- a value of the type of the variable: `23`, `3.1415926...`, `false`
- i.e., the thing we stuff in the box
- can/should change during the runtime of the program, otherwise use a constant (if possible)

Variables (4) – value

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Declaring a variable and Assigning a value:

In General: `(type) name = value;` or `(type) name = expression;`

Matlab: `myNewVar = 10;` **TC-Shell** (differs) `set myNewVar = 10;`
Access to the values (de-referencing):
Matlab: use `myNewVar;` **TC-Shell** (differs) use '`$`': `$myNewVar`

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What's that?

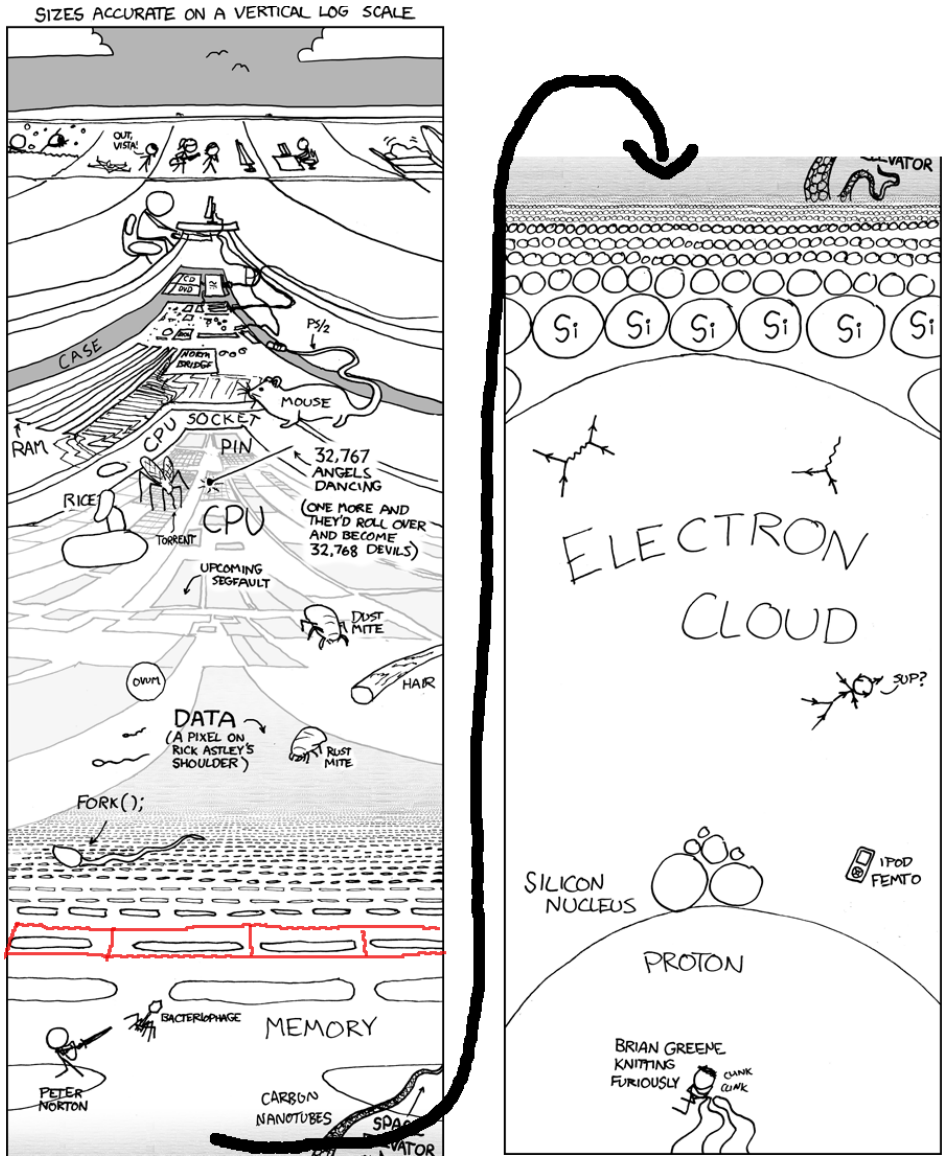
```
myNewVar = myNewVar + 1;
```

Advanced Variables: Vectors and Matrices (1)

Array variables

- are lists, vectors, matrices of data (1 to n dimensional – book keeping can become a hassle)
- therefore instead of one value they hold a **list of values**
- linked to a chunk of memory (a sequence of boxes)
- access by index number
- MATLAB treats everything as a matrix. Shells allow only vectors.

Memory interlude (2)



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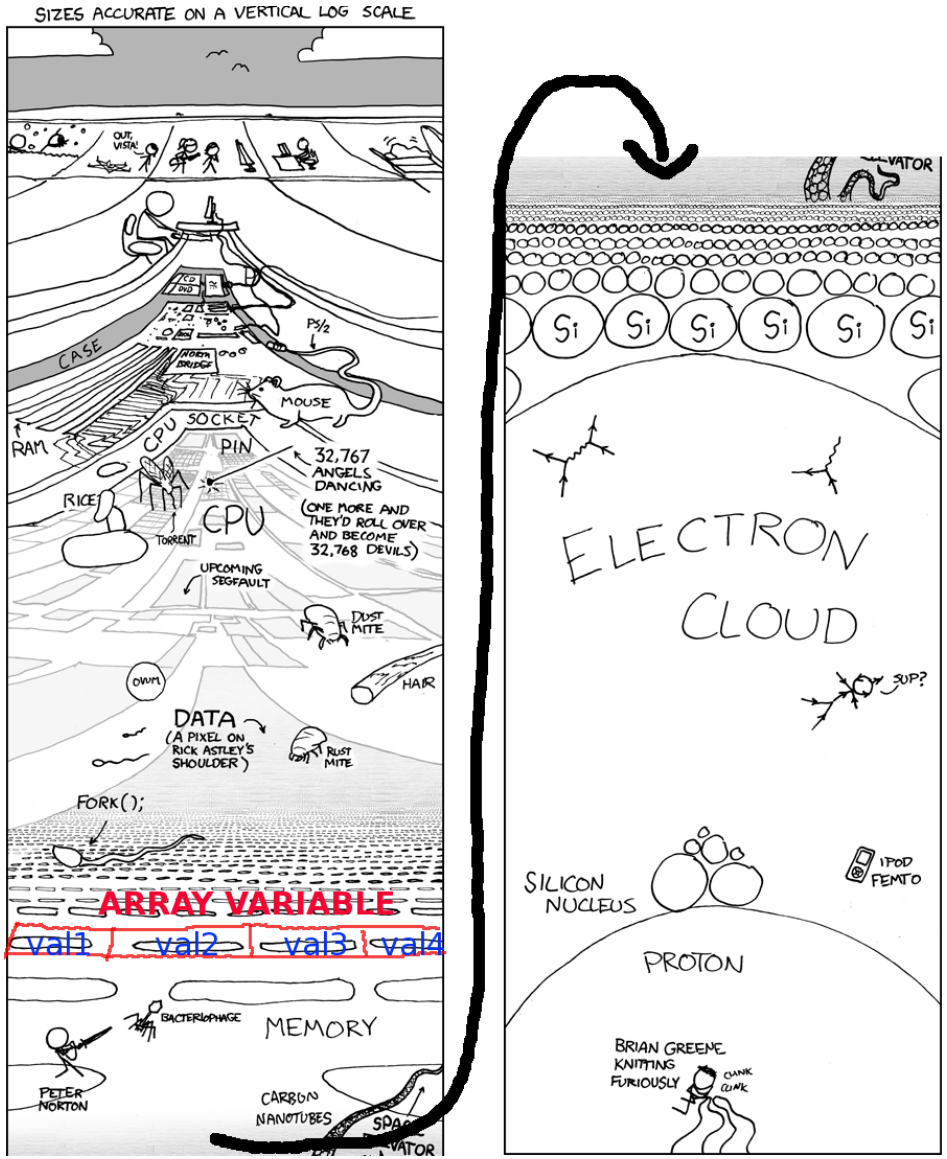

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Advanced Variables: Vectors and Matrices (2)

Example

index:	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
sting:	h	e	l	l	o		w	o	r	l	d	!	!	!	!
vector:	12	23.3	23.3	nan	nan	1	42	42.1	23	5	nan	nan	0	0	0

Advanced Advanced Variables: `struct` and Matlab `cell array` (1)

`structs, cells`

- organize and store data of different types in one variable
- these are containers you can put integers, doubles, strings, arrays of these, and other structs or cell arrays, etc ...

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`cell`

- MATLAB specific data type, created using braces '{...}'
- must be used for strings of various length!
- elements are a vector in the memory – access `myCell(1)`, or `myCell{1,1}`
- can contain any other data type

`myCell`	{:,1}	{:,2}
{1,:}	[1 5]	[2.4 3.6; 4.3 1]
{2,:}	{'MacGyver' 'Bart'}	true

Access: `myCell(1)`, `myCell{1,1}` or as given in table.

Advanced Advanced Variables: `struct` and Matlab `cell array` (2)

`struct`

- more organized array type: access to fields by a name
- can contain any other data type
- excellent for representing your tables of data

`student`	(1)	(2)	(3)
.name	'Jack'	'Jo'	'Jake'
.age	21	25	30

Access: `student(1)`, `student.age`, `student.name`