COMP10001 Foundations of Computing
The Basics of Types

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Chris Leckie & Nic Geard

THE UNIVERSITY OF MELBOURNE

Lecture Agenda

- Last lecture:
  - Basics of Python
  - Grok
- This lecture:
  - Design of algorithms
  - Types
  - Strings
  - Literals and variables

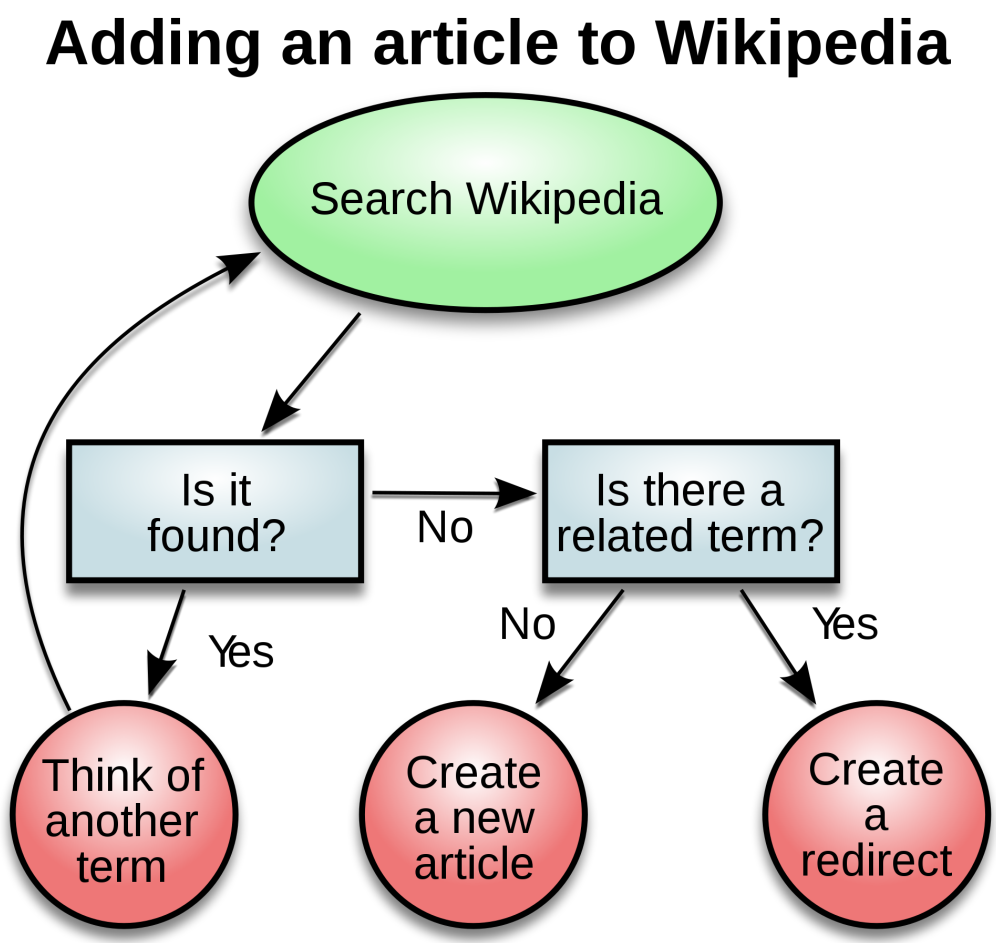
Programming

- Computer programs are simply sets of steps to complete some task
- Determining what the steps should be requires learning how computers "think"...
- ...and how a particular programming language expresses the way a computer thinks.
- Communicating with humans in different languages can be tricky, but achievable. Computers are not so forgiving.

Program Design

- Many modern computing languages express similar concepts
- They allow "conditioning" on particular values, "looping" over sub-sets of steps, and "nesting" of loops
- Common ways to abstractly represent programs are:
  - flowcharts
  - pseudo-code (i.e. a computer program in an abstract language, without the "bookkeeping" that individual languages require) `http://www.bestrecipes.com.au/recipe/choc-chip-cookies-L4351.html`

Example Flowchart

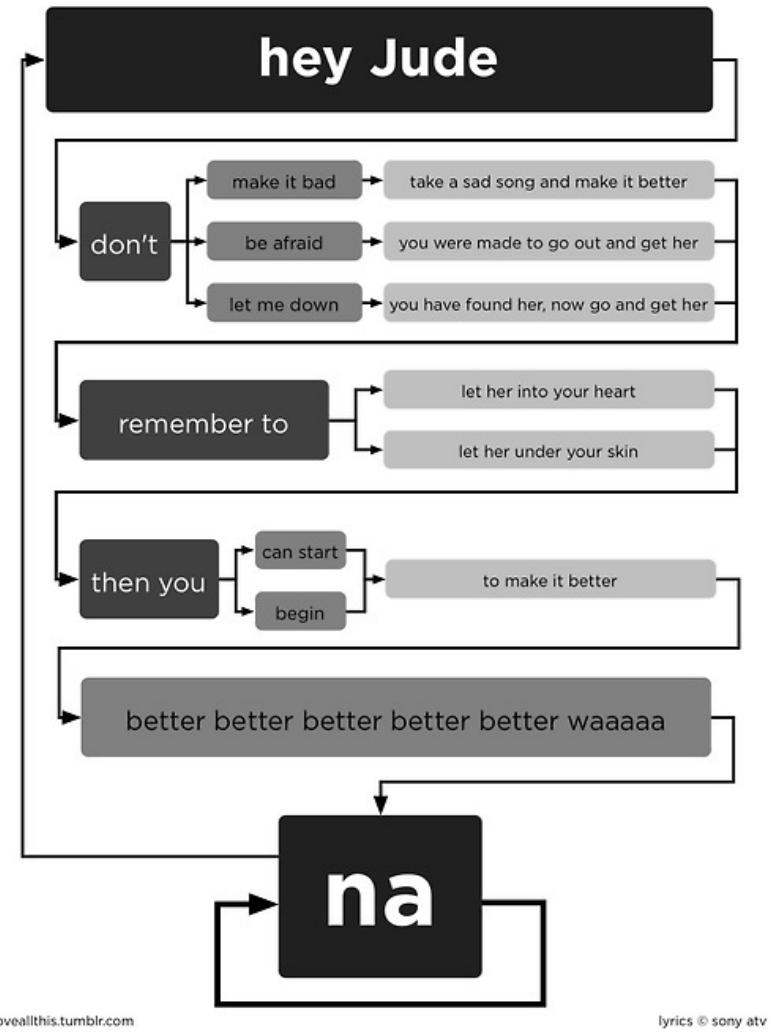


Source(s): `http://commons.wikimedia.org/wiki/File:Wikipedia_article-creation-2.svg`

Equivalent Psuedocode

repeat
    search Wikipedia for the candidate article
    if article found **then**
        think of another term
    else if article found for related term **then**
        create a redirect
    else
        create a new article
    end if
until article created **or** redirect created

More Interesting Flowchart



Source(s): `http://laughingsquid.com/hey-jude-flow-chart/`

Types (1)

- In Python, every object has a "type", which defines: (a) what operators, "functions" and "methods" can be applied to it, and (b) the semantics of each; consider:
- The two number types we will see most of are:
  - `int` (integer)
  - `float` (real number)

  also `complex` for complex numbers
- So how does Python work out the type for a given (real) number? If it contains a decimal place (.), it's a `float`, otherwise it's an `int`

Types (2)

- Use the "function" `type()` to determine the type of an object:

```
>>> print(type(1))
<type 'int'>
>>> print(type(1.0))
<type 'float'>
```

- The semantics of operators and functions is determined by the types of the operands:

```
>>> print(type(1 + 2))
<type 'int'>
>>> print(type(1/2))
<type 'float'>
```

Jargon alert

Syntax: "the arrangement of words and phrases to create well-formed sentences in a language"

- `print hello''()` Incorrect syntax
- `print('hello')` Correct syntax

Semantics: "the meaning of a word, phrase, or text"

- `print(1 + 2)` '+' adds two numbers
- `print('h'+ 'a')` '+' concatenate two strings

A New Type: Strings

- A string (`str`) is a "chunk" of text, standardly enclosed within either single or double quotes:
  - `"Hello world"`
  - `'How much wood could a woodchuck chuck'`
- To include quotation marks (and slashes) in a string, "escape" them (prefix them with `\`):
  - `\"`, `\'` and `\\`
- Also special characters for formatting:
  - `\t` (tab), `\n` (newline)
- Use triple quotes (`'` or `"`) to avoid escaping/special characters:
  - `"""Ow," he said/yelled."""`

String Operators

- The main binary operators which can be applied to strings are:
  - + (concatenation)

```
>>> print("a" + "b")
ab
```

  - * (repeat string *N* times)

```
>>> print('z' * 20)
zzzzzzzzzzzzzzzzzzzz
```

  - in (subset)

```
>>> print('z' in 'zizzer zazzer zuzz')
True
```

Overloading

- But but but ... didn't + and * mean different things for `int` and `float`?
  - Answer: yes; the operator is "overloaded" and functions differently depending on the type of the operands:

```
>>> print(1 + 1)
2
>>> print(1 + 1.0)
2.0
>>> print("a" + "b")
ab
>>> print(1 + 'a')
Traceback (most recent call last):
  File "<web session>", line 1, in <module>
TypeError: unsupported operand type(s) for +: 'int' and 'str'
```

Literals and Variables

- To date, all of the values have taken the form of "literals", i.e. the value is fixed and has invariant semantics
- It is also possible to store values in "variables" of arbitrary name via "assignment" (=)
  - N.B. = is the assignment operator and NOT used to test mathematical equality (we'll get to that later ...)
- We use variables to name cells in the computers memory so we don't need to know their addresses

The Ins and Outs of Assignment I

- The way assignment works is the right-hand side is first "evaluated", and the value is then assigned to the left-hand side ... making it possible to assign a valuable to a variable using the original value of that same variable:

```
>>> a=1
>>> print(a+1)
2
>>> print(a+a+1)
3
>>> a=a+a+1
>>> print(a)
3
```

The Ins and Outs of Assignment II

- Note that assignment can only be to a single object (on the left-hand side):

```
>>> a=1
>>> a=a+a+1
>>> a+1=2
Traceback (most recent call last):
  File "<web session>", line 1
SyntaxError: can't assign to operator
```

... although we will later see that it is possible for an object to have complex structure, and that it is possible to assign to the "parts" of an object ...

The Ins and Outs of Assignment III

- It is also possible to assign the same evaluated result to multiple variables by "stacking" assignment variables:

```
>>> a = b = c = 1
>>> a = b = c = a + b + c
>>> print(a)
3
>>> print(b)
3
>>> print(c)
3
```

Variable Naming Conventions

- Variable names must start with a character (`a-zA-Z`) or underscore (_), and consist of only alphanumeric (`0-9a-zA-Z`) characters and underscores (_)
- Casing is significant (i.e. `apple` and `Apple` are different variables)
- "Reserved words" (operators, literals and built-in functions) cannot be used for variable names (e.g. `in`, `print`, `not`, ...)
  - valid variable names: `a`, `dude123`, `_CamelCasing`
  - invalid variable names: `1`, `a-z`, `13CABS`, `in`

Class Exercise (1)

- Calculate the *i*th Fibonacci number using only three variables

Assignment and State

- Python is an "imperative" language, meaning that it has "program state" and the values of variables are changed only through (re-)assignment:

```
>>> a = 1
>>> b = 2
>>> c = a + b
>>> a = 2
>>> print(c)
3
>>> c = a + b
>>> print(c)
4
```

Type Conversion

- Python implicitly determines the type of each literal and variable, based on its syntax (literals) or the type of the assigned value (variables)
- To "cast" a literal/variable to a different type, we use functions of the same name as the type: `int()`, `float()`, `str()`, `complex()`

```
>>> print(float(1))
1.0
>>> print(int(1.0))
1
>>> print(int(1.5))
1
>>> int('a')
Traceback (most recent call last):
  File "<web session>", line 1, in <module>
ValueError: invalid literal for int() with base 10: 'a'
```

A Couple of Other Useful Functions

- `abs()`: return the absolute value of the operand
- `len()`: return the length of the iterable operand (i.e. a `str` for now)

```
>>> print(len('apple'))
5
>>> print(len(1))
Traceback (most recent call last):
  File "<web session>", line 1, in <module>
TypeError: object of type 'int' has no len()
```

Class Exercise (2)

- Given `num` containing an `int`, calculate the number of digits in it

Looking Towards Next Week

- Commencement of workshops (work out when your workshop is and where your room is located)
- Make sure you can log in to Grok

Lecture Summary

- Types: what are they, what basic types have we learned, and how do you determine the type of a literal/variable?
- Strings: how are they specified, and what basic operators apply to them?
- Literals and variables: what's the difference, and what are the constraints on variable names?