The Python Language (Part 5)

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Objectives

- We will cover:
  - A subset of Python...
  - That is appropriate for COS 333...
  - Through example programs

Agenda

- **Prelim: character and string encodings**
- Files
- The “with” statement
- Arrays
- Associative arrays

Character Encodings

- ***Unicode***
  - Maps each character to a number
- ***Character encoding***
  - Maps each such number to the byte(s) which represent it

Character Encodings

Common character encodings:

Encoding	Fixed/ Variable Width	Bytes
ASCII	Fixed	1 (7 bits)
Latin-1	Fixed	1
UCS-2	Fixed	2
UTF-32	Fixed	4
UTF-8	Variable	1, 2, 3, or 4

Character Encodings

Character	Unicode	ASCII	Latin-1	UCS-2	UTF-32	UTF-8
space	0020	20	20	0020	00000020	20
!	0021	21	21	0021	00000021	21
0	0030	30	30	0030	00000030	30
A	0041	41	41	0041	00000041	41
a	0061	61	61	0061	00000061	61
a with grave	00e0		e0	00e0	000000e0	e0
Greek small pi	03c0			03c0	000003c0	cf80
Double prime	2033			2033	00002033	e280b3
Aegean number 2000	10123				00010123	f09084a3

Character Encodings

- Python `str` class
  - An object of class `str` is a sequence of 0 or more characters
  - Internal encoding: Latin-1 | UCS-2 | UTF-32

Example	Python Literal	Internally
abc	`'abc'`	`61 62 63`
abπc	`'ab\u03c0c'`	`00 61 00 62 03 C0 00 63`

Aside: Python Bytes Class

- Python `bytes` class
  - An object of class `bytes` is a sequence of 0 or more **bytes**
  - Internal encoding: **None**

Example	Python Literal	Internally
61 62 63	`b'\x61\x62\x63'`	`61 62 63`
61 62 63	`b'abc'`	`61 62 63`

Agenda

- Prelim: character and string encodings
- **Files**
- The “with” statement
- Arrays
- Associative arrays

Files

- See **copybytes.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python copybytes.py file1 file2
$ cat file2
to be
or not to be
that is
the question
$
```

Files

- See **copystrings.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python copystrings.py file1 file2
$ cat file2
to be
or not to be
that is
the question
$
```

Agenda

- Prelim: character and string encodings
- Files
- **The “with” statement**
- Arrays
- Associative arrays

The “with” Statement

- Consider copystrings.py
- **Problem:**

```
in_file = open(…)
…
…
…
in_file.close()
```

Exception thrown => File never explicitly closed

The “with” Statement

- **Solution 1:**
  - `try…finally` statement

```
in_file = open(…)
try:
    …
    …
    …
finally:
   in_file.close()
```

If this is entered...

Then this certainly will be executed “on the way out”

The “with” Statement

- See **copystringsfinally.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python copystringsfinally.py file1 file2
$ cat file2
to be
or not to be
that is
the question
$
```

The “with” Statement

- **Solution 2:**
  - `with` statement

```
with open(…) as in_file:
    …
    …
    …
```

If this is entered, then in_file.close() certainly will be executed on the way out

The “with” Statement

- See **copystringswith.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python copystringswith.py file1 file2
$ cat file2
to be
or not to be
that is
the question
$
```

Agenda

- Prelim: character and string encodings
- Files
- The “with” statement
- **Arrays**
- Associative arrays

Arrays

- Generic term: **array**
- Python term: ***list***
  - A dynamically expanding (doubling) array of object references

Arrays

- List fundamentals:

```
$ python
>>> a = ['Ruth', 'Gehrig', 'Mantle']
>>> a[1]
'Gehrig'
>>> a.append('Jeter')
>>> a
['Ruth', 'Gehrig', 'Mantle', 'Jeter']
>>> 'Gehrig' in a
True
>>> 'Berra' in a
False
>>> quit()
$
```

Arrays

- Python term: ***tuple***
  - An immutable list

Arrays

- Tuple fundamentals:

```
$ python
>>> t = ('Ruth', 'Gehrig', 'Mantle')
>>> t[1]
'Gehrig'
>>> t.append('Jeter')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
AttributeError: 'tuple' object has no
attribute 'append'
>>> 'Gehrig' in t
True
>>> 'Berra' in t
False
>>> quit()
$
```

Arrays

- See **linesort.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python linesort.py < file1
or not to be
that is
the question
to be
$
```

```
$ cat pride8.txt
...
$ python linesort.py < pride8.txt
...
$
```

Elapsed wall clock time: **1.0 sec**

Arrays

- See **linesorttim.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python linesorttim.py < file1
or not to be
that is
the question
to be
$
```

```
$ cat pride8.txt
...
$ python linesorttim.py < pride8.txt
...
$
```

Elapsed wall clock time: **1.5 sec**

Agenda

- Prelim: character and string encodings
- Files
- The “with” statement
- Arrays
- **Associative arrays**

Associative Arrays

- Generic term: **associative array**
- Python term: ***dict***
  - An associative array implemented as a hash table

Associative Arrays

Dict fundamentals:

```
$ python
>>> aa = {'Ruth':3, 'Gehrig':4, 'Mantle':7}
>>> aa['Gehrig']
4
>>> aa.get('Gehrig')
4
>>> aa['Jeter']
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
KeyError: 'Jeter'
>>> aa.get('Jeter')
>>> aa.get('Jeter', 2)
2
>>> aa['Jeter'] = 2
>>> aa
{'Ruth': 3, 'Gehrig': 4, 'Mantle': 7, 'Jeter': 2}
>>> 'Gehrig' in aa
True
>>> 'Berra' in aa
False
>>> quit()
$
```

Associative Arrays

- See **concord.py**

```
$ cat file1
to be
or not to be
that is
the question
$ python concord.py < file1
to: 2
be: 2
or: 1
not: 1
that: 1
is: 1
the: 1
question: 1
$
```

```
$ cat pride8.txt
...
$ python concord.py < pride8.txt
chapter: 488
i: 16632
it: 12304
is: 6872
a: 15672
truth: 216
universally: 24
acknowledged: 160
...
whittingham: 8
co: 8
tooks: 8
chancery: 8
$
```

Associative Arrays

- See **concord.py** (cont.)

Arg to re.compile()	Meaning
`'[a-z]'`	Used to find a lower-case letter.
`'[a-z]+'`	Used to find a sequence of 1 or more lower-case letters.
`r'[a-z]+'`	A raw string literal. Backslash in string literal has no special meaning. Here unnecessary.

Associative Arrays

- See **concord.py** (cont.)

```
$ python concord.py < pride8.txt | sort -n -k 2 -r |
head -10
the: 34880
to: 33456
of: 29040
and: 28736
her: 17840
i: 16632
a: 15672
in: 15040
was: 14784
she: 13704
$
```

Elapsed wall clock time: 0.77 sec

For More Information

For more information:

```
$ python
>>> help(str)
>>> help(bytes)
>>> help(tuple)
>>> help(list)
>>> help(set)
>>> help(dict)
>>> quit()
$
```

Python Commentary

Date: Sun, 1 Jan 2006 13:18:08 -0800
From: Rob 'Commander' Pike <r@google.com>
To: Brian Kernighan <bwk@CS.Princeton.EDU>

python is a very easy language. i think it's actually a good choice for some things. awk is perfect for a line or two, python for a page or two. both break down badly when used on larger examples, although python users utterly refuse to admit its weaknesses for large-scale programming, both in syntax and efficiency.

-rob

Summary

- We have covered these aspects of Python:
  - Files
  - Arrays
  - Associative arrays

Summary

- We have covered:
  - Subset of Python...
  - That is appropriate for COS 333...
  - Through example programs
- See also:
  - **Appendix 1**: Iterable Classes
  - **Appendix 2:** Variadic Functions/Methods
  - **Appendix 3**: Duck Typing
  - **Appendix 4**: Regular Expressions
  - **Appendix 5**: The Python Debugger

Appendix 1:
Iterable Classes

Iterable Classes

- Python iterable classes

Class	Description of Object of that Class
`str`	An immutable sequence of characters
`bytes`	An immutable sequence of bytes
`list`	A sequence of object references
`tuple`	An immutable sequence of object references
`set`	A collection of object references that contains no duplicate references
`dict`	An associative array of object references implemented as a hash table
file	A persistent sequence of bytes

Iterable Classes

Creating iterable objects

```
str
   str1 = 'hi'
   str2 = "hi"
   str3 = r'hi'   # raw string

bytes
   bytes1 = b'hi'
   bytes2 = b"hi"
   bytes3 = rb'hi'

list
   list1 = [obj1, obj2, ...]

tuple
   tuple1 = (obj1, obj2, ...)
   tuple2 = (obj1, )                ← hack
```

Iterable Classes

Creating iterable objects (cont.)

```
set
   set1 = {obj1, obj2, ...}
   # tests for object ref equality

dict
   dict1 = {keyobj1:valueobj1, keyobj2:valueobj2, ...}

file
   fileobj = open('filename', mode='somemode')
      # somemode: r, rb, w, wb, ...
```

Iterable Classes

Some str Methods	
`str1 = str2.__add__(str3)`	`# str1 = str2 + str3`
`bool1 = str1.__eq__(str2)`	`# bool1 = str1 == str2`
`bool1 = str1.__ne__(str2)`	`# bool1 = str1 != str2`
`bool1 = str1.__lt__(str2)`	`# bool1 = str1 < str2`
`bool1 = str1.__gt__(str2)`	`# bool1 = str1 > str2`
`bool1 = str1.__le__(str2)`	`# bool1 = str1 <= str2`
`bool1 = str1.__ge__(str2)`	`# bool1 = str1 >= str2`
`int1 = str1.__len__()`	`# int1 = len(str1)`
`str1 = str2.__getitem__(int1)`	`# str1 = str2[int1]`
`bool1 = str1.__contains__(str2)`	`# bool1 = str2 in str1`

Iterable Classes

Some str Methods (cont.)
bool1 = str1.startswith(str2)
bool1 = str1.endswith(str2)
bool1 = str1.isspace()
bool1 = str1.isalnum()
bool1 = str1.isalpha()
bool1 = str1.isdecimal()
bool1 = str1.isdigit()
bool1 = str1.islower()
bool1 = str1.isnumeric()
bool1 = str1.isupper()
str1 = str2.upper()
str1 = str2.lower()

Iterable Classes

Some str Methods (cont.)
`list1 = str1.split(str2)`
`str1 = str2.replace(str3, str4)`
`str1 = str2.strip()`
`str1 = str2.lstrip()`
`str1 = str2.rstrip()`
`int1 = str1.find(str2)`
`int1 = str1.rfind(str2)`
`str1 = str2.join(list1)` (See note)
`bytes1 = str1.encode(encoding)`

Note:

```
'/'.join(['hello', 'there', 'world']) =>
'hello/there/world'
```

Iterable Classes

Some list Methods	
`list1 = list2.__add__(list3)`	`# list1 = list2 + list3`
`bool1 = list1.__contains__(obj1)`	`#` **`bool1 = obj1 in list1`**
`list1.__delitem__(int1)`	`# del(list1[int1])`
`obj1 = list1.__getitem__(int1)`	`#` **`obj1 = list1[int1]`**
`list1.__iadd__(list2)`	`# list1 += list2`
`int1 = list1.__len__()`	`#` **`int1 = len(list1)`**
`list1.__setitem__(int1, obj1)`	`#` **`list1[int1] = obj1`**

Iterable Classes

Some list Methods (cont.)
`list1.append(obj1)`
`list1.clear()`
`list1 = list2.copy()`
`int1 = list1.index(obj1)`
`list1.insert(obj1, int1)`
`obj1 = list1.pop()`
`list1.remove(obj1)`
`list1.reverse()`
`list1.sort()`

Iterable Classes

Some dict Methods	
`bool1 = dict1.__contains__(obj1)`	`#` **`bool1 = obj1 in dict1`**
`dict1.__delitem(obj1)`	`# del(dict1[obj1])`
`obj1 = dict1.__getitem__(obj2)`	`#` **`obj1 = dict1[obj2]`**
`int1 = dict1.__len__()`	`#` **`int1 = len(dict1)`**
`dict1.__setitem__(obj1, obj2)`	`#` **`dict1[obj1] = obj2`**
`dict1.clear()`	
`dict1 = dict2.copy()`	
`list1 = dict1.keys()`	
`list1 = dict1.items()`	
`list1 = dict1.values()`	

Iterable Classes

Some file Methods
file1.close()
file1.flush()
str1 = file1.read()
bool1 = file1.readable()
str1 = file1.readline()
list1 = file1.readlines()
fool1 = file1.writable()
file1.write(str1)
file1.writelines(list1)

Appendix 2:
Variadic Functions/Methods

Variadic Functions/Methods

- ***Variadic*** function/method:
  - A function/method that can be called with a variable number of arguments
  - Example: `printf()` in C
    - `printf("hello");`
    - `printf("The answer is %d", 5);`
    - `printf("The answers are %d and %d", 5, 10);`

Variadic Functions/Methods

- **Question**
  - How to define variadic functions/methods in Python?

Variadic Functions/Methods

- **Answer 1**
  - Default parameter values
    - Already described

```
def sub(minuend, subtrahend=0):
    return minuend - subtrahend

def main():
    difference = sub(5, 2)
    difference = sub(5)
    …
if __name__ == '__main__':
    main()
```

Variadic Functions/Methods

- **Answer 2**
  - `*args` and `**kwargs`...

Variadic Functions/Methods

- See **variadic.py**

```
$ python variadic.py
a
b
c
d
key1 e
key2 f
$
```

Variadic Functions/Methods

- See **variadic.py** (cont.)

Parameter	Referenced Object
`i`	`'a'`
`j`	`'b'`
`args`	`['c', 'd']`
`kwargs`	`{'key1':'e', 'key2':'f'}`

Appendix 3:
Duck Typing

Duck Typing

- See **euclid.py**
  - From a previous lecture
- See **euclidstrong.py**
  - Which is better, euclid.py or euclidstrong.py?

Duck Typing

- Observation:
  - Python uses ***duck typing***

> "When I see a bird that walks like a duck and swims like a duck and quacks like a duck, I call that bird a duck."
>
> -- James Whitcomb Riley

Duck Typing

- **Style 1**: Don't validate parameter types
  - Validating parameter types is constraining and slow
  - **So euclid.py is better**
- **Style 2**: Validate parameter types
  - Validating parameter types is safe
  - **So euclidstrong.py is better**
- We'll use Style 1

Duck Typing

- Commentary
  - **Small** projects:
    - Maybe need not validate parameter types
  - **Large** projects:
    - Maybe should validate parameter types

Duck Typing

- Commentary
  - But if you feel the need to validate parameter types, then why are you using Python???

Duck Typing

Language	Object references have types?	Objects have types?	Language classification
C	yes	no	**weakly** typed
Java	yes	yes	**strongly** typed
Python	no	yes	**dynamically** typed

Appendix 4:
Regular Expressions

Regular Expressions

- Used widely
  - Java (string manipulation)
  - Python (string manipulation)
  - Unix `grep` command (file searching)
  - Bash shell (filename wildcards)
  - SQL `like` clauses (querying databases)
    - See upcoming *Database Programming* lectures
  - …

Regular Expressions

RE	Matches
thing	thing anywhere in string
^thing	thing at beginning of string
thing$	thing at end of string
^thing$	string that contains only thing
^	any string, even empty
^$	empty string
.	non-empty, i.e. the first char in string
thing.$	thing plus any char at end of string
thing\.$	thing. at end of string
\\thing\\	\thing\ anywhere in string
[tT]hing	thing or Thing anywhere in string
thing[0-9]	thing followed by one digit
thing[^0-9]	thing followed by a non-digit
thing[0-9][^0-9]	thing followed by digit, then non-digit
thing1.*thing2	thing1 then any (or no) text then thing2
^thing1.*thing2$	thing1 at beginning and thing2 at end

Thanks to Prof. Brian Kernighan

Regular Expressions

- What do these match?
  - `a.*e.*i.*o.*u`
    - Try with `grep` command and /usr/share/dict/words file
  - `^[^aeiou]*a[^aeiou]*e[^aeiou]*i[^aeiou]*o[^aeiou]*u[^aeiou]*$`
    - Try with `grep` command and /usr/share/dict/words file

Thanks to Prof. Brian Kernighan

Regular Expressions

- Implementations vary
  - See *Mastering Regular Expressions* (Jeffrey Friedl) book
    - ~500 pages!
- In Python…

Regular Expressions

```
RE      Matches
X       the character X, except for metacharacters
\X      the character X, where X is a metacharacter
.       any character except \n
           (use DOTALL as argument to compile() to match \n too)
^       start of string
$       end of string
XY      X followed by Y
X*      zero or more cases of X (X*? is the same, but non-greedy)
X+      one or more cases of X (X+? is the same, but non-greedy)
X?      zero or one case of X (X?? is the same, but non-greedy)
[...]   any one of ...
[^...]  any character other than ...
[X-Y]   any character in the range X through Y
X|Y     X or Y
(...)   ..., and indicates a group
```

Precedence: * + ? higher than concatenation, which is higher than |

Regular Expressions

RE	Matches
\t	tab
\v	vertical tab
\n	newline
\r	return
\f	form feed
\a	alert
\e	escape
\\	backslash
\A	empty string at start of given string
\b	empty string, but only at start or end of a word
\B	empty string, but not at start or end of a word
\d	a digit
\D	a non-digit
\s	a white space character, that is, [\t\n\r\f\v]
\S	a non-white space character
\w	an alphanumeric character, that is, [a-zA-Z0-9_]
\W	a non-alphanumeric character
\Z	the empty string at the end of the given string

Regular Expressions

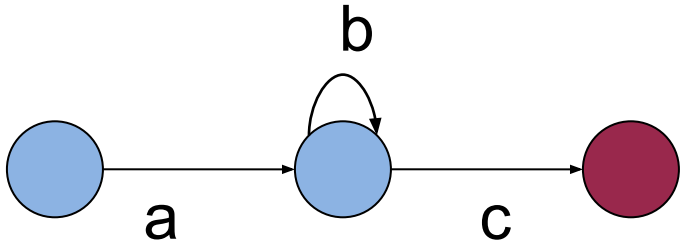
- What kinds of strings do these regular expressions match?
  - `[-+]?([0-9]+\.?[0-9]*|\.[0-9]+)([Ee][-+]?[0-9]+)?`
  - `/\*.*?\*/` (use with `DOTALL`)
    - Why the question mark?
    - Why `DOTALL`?
- Commentary: Regular expressions are write-only!!!

Regular Expressions

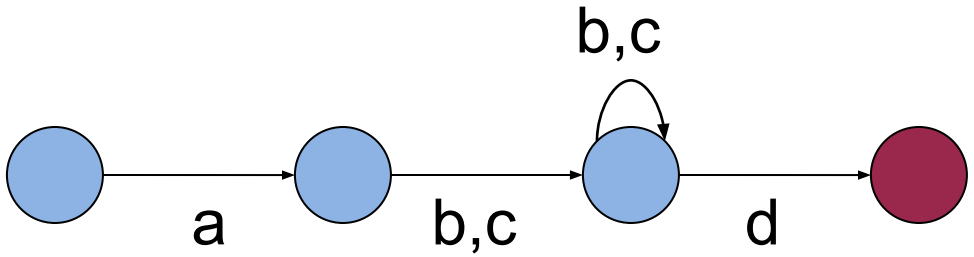
- Some theory:
  - Regular expressions have the same power as ***deterministic finite state automata*** (DFAs)
  - A regular expression defines a ***regular language***
  - A DFA also defines a regular language

Regular Expressions

ab*c



a[bc]+d



Appendix 5:
The Python Debugger

The Python Debugger

- `pdb` debugger is bundled with Python
- To use `pdb`:

```
$ python -m pdb somefile.py
```

The Python Debugger

Some `pdb` Commands

- `help`
- `break` *`functionOrMethod`*
- `break` *`filename`*`:`*`linenum`*
- `run`
- `list`
- `next`
- `step`
- `continue`
- `print` *`expr`*
- `where`
- `quit`

Note similarities with `gdb`

The Python Debugger

- Common commands have abbreviations:
  `h`, `b`, `r`, `l`, `n`, `s`, `c`, `p`, `w`, `q`
- Blank line means repeat the same command
- Beware: Cannot easily read from stdin