Outline

MCS 260 Lecture 28
Introduction to Computer Science
Jan Verschelde, 16 March 2016

what is an exception?

Goal: make code **robust**, capable to handle errors.

An *exception* is an unexpected event that happens during the execution of a program, interrupting the normal flow.

Examples: division by zero in a calculation, wrong user input, or raised by assert statement.

Two phases:

1. the exception is *triggered* (or thrown) by an error, or *raised* explicitly by code in the program;
2. code is executed to *handle* the exception.

Python's exception mechanism allows programs to handle abnormal situations in a structured way.

Closing Elevator Doors

a real world example

We all use elevators:

- exception: many people are not afraid to risk body parts impeding closing doors in order to catch a ride
- if-else: attendant with manual closing of doors, doubled up: exterior and interior door

For safety, an elevator without monitoring obstacles between closing doors would be unacceptable.

However, exceptions are for exceptional situations.

Frequent use of exceptions is more expensive than the usual if-else construction.

exceptions: defining, raising and handling

1. Exception Handling
   - the try-except statement
   - the try-finally statement
2. Python's Exception Hierarchy
   - exceptions are classes
   - raising exceptions
   - defining exceptions
3. Anytime Algorithms
   - estimating π using Monte Carlo
   - handling the KeyboardInterrupt
4. Summary + Assignments

the `try-except` statement

The syntax of the `try-except` statement is

```
try:
    < code where errors may happen >
except < sequence of exceptions > :
    < code to handle the exception >
```

Three parts in a `try-except` statement:

1. The code following the `try:` defines the scope of the associated exception handlers.
2. After `except` we specify which exceptions to catch.
   If the sequence is empty, all exceptions are caught.
3. The code to be executed when the exception occurs, follows the `:` of the `except`.

Multiple `except` statements may follow one `try` to handle different exceptions differently.

allow for spelling mistakes when prompting for a file

```
"""
Prompts the user for a file name and displays
an error message if the name given by the user
does not correspond to a file.
"""
NAME = input('Give the name of a file : ')
try:
    INFILE = open(NAME, 'r')
    print('opened \"' + NAME + '\" for reading')
    INFILE.close()
except IOError:
    print('file \"' + NAME + '\" does not exist?')
```

keep on trying, `while True`

```
"""
Prompts the user for a file name and displays
an error message if the name given by the user
does not correspond to a file.  Asks to retry.
"""
while True:
    NAME = input('Give the name of a file : ')
    try:
        INFILE = open(NAME, 'r')
        print('opened \"' + NAME + '\" for reading')
        INFILE.close()
        break
    except IOError:
        print('file \"' + NAME + '\" does not exist?')
        RETRY = input('Try again ? (y/n) ')
        if RETRY != 'y':
            break
```

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the `try-finally` statement

The syntax of the `try-finally` statement is

```
try:
    < code where errors may happen >
finally:
    < statements before raising exception >
```

Three parts in a `try-finally` statement:

1. The code following the `try:` defines the scope of the associated exception handlers.
2. Statements after `finally:` will be executed even if an exception happens.
3. After executing the statements after `finally:` the exception will be raised.

always confirm user input

Consider the following code:

```
NAME = input('Give file name : ')
INFILE = open(NAME, 'r')
print('opened \"' + NAME + '\" for reading...')
```

If the file with given name does not exist,
then the last `print` will not be executed.

If we always want to confirm the given name:

```
NAME = input('Give file name : ')
try:
    INFILE = open(NAME, 'r')
finally:
    print('opened \"' + NAME + '\" for reading...')
```

Even if the file with given name does not exist,
`print` will happen before raising `IOError`.

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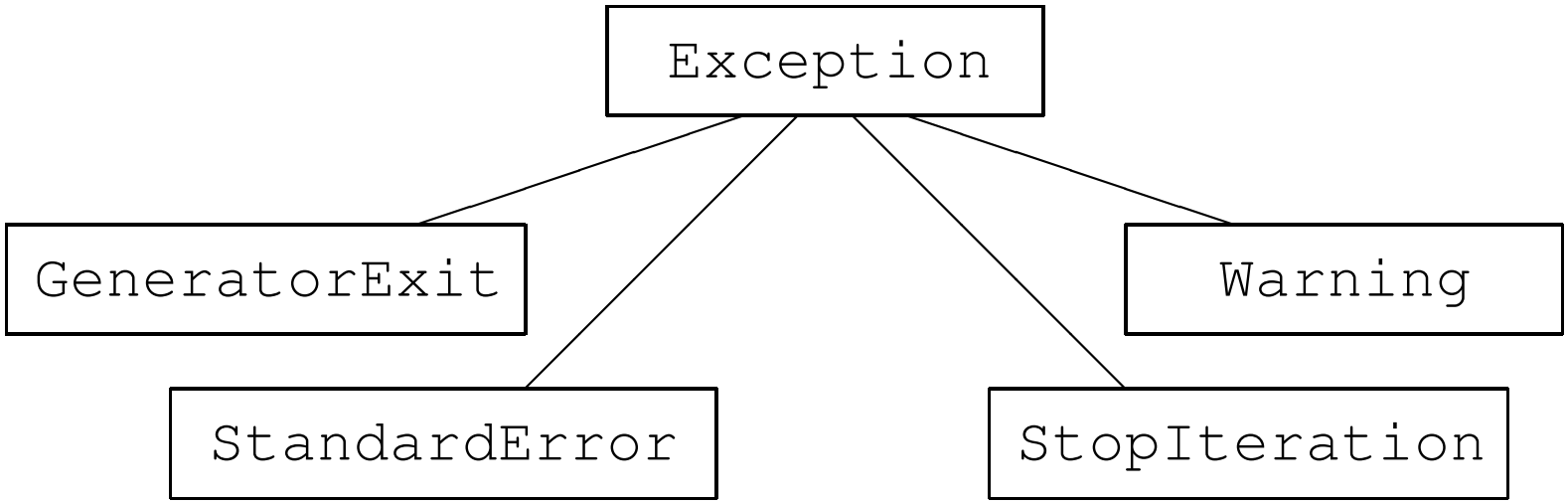
Python's Exception Hierarchy – in Python2 ...

exceptions are classes

Object-oriented design is good at expressing hierarchies.
Exceptions in Python are classified as below:



`Exception` is the base class from which
the other four exceptions are derived.
`StandardError` and `Warning` have many subclasses.

the exception hierarchy

```
>>> from builtins import BaseException
>>> print(BaseException.__doc__)
Common base class for all exceptions
>>> help(BaseException)
```

Typing `help(ValueError)` shows:

```
Help on class ValueError in module builtins:

class ValueError(Exception)
 |  Inappropriate argument value (of correct type).
 |
 |  Method resolution order:
 |      ValueError
 |      Exception
 |      BaseException
 |      object
```

an example of an exception: `ValueError`

```
>>> ValueError.__bases__
(<type 'exceptions.StandardError'>,)
>>> issubclass(ValueError,StandardError)
True
```

When does a `ValueError` happen?

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

NameError, TypeError, and IndexError

```
>>> int(a)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
NameError: name 'a' is not defined

>>> 'a'/3
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) \
    for /: 'str' and 'int'

>>> 'a'[3]
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: string index out of range
```

KeyboardInterrupt

```
"""
The following program shows the handling
of the keyboard interrupt: cntrl+c.
"""

COUNT = 0
print('hold ctrl and c to stop...')
try:
    while True:
        COUNT = COUNT + 1
except KeyboardInterrupt:
    print('counted ' , COUNT)
```

Running at the command prompt `$`:

```
$ python cntrlc.py
hold ctrl and c to stop...
^Ccounted  1749022
```

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raising exceptions: the raise statement

```
"""
Reads numerator and denominator, raises
ZeroDivisionError when denominator == 0.
"""
try:
    ARAW = input('Give numerator : ')
    BRAW = input('Give denominator : ')
    (A, B) = (int(ARAW), int(BRAW))
    try:
        if B == 0:
            raise ZeroDivisionError
    finally:
        print('read %d/%d' % (A, B))
except ZeroDivisionError:
    print('raised ZeroDivisionError')
```

Observe the use of `finally` to show the result, even in case an exception is raised.

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defining exceptions: exceptions with arguments

We can define our own exceptions.
For example, when a file does not exist:

```
class FileNotThere(IOError):
    """
    The exception FileNotThere is raised when a
    file does not exist.  The argument of the
    exception is the file name.
    """
    def __init__(self, name=''):
        "stores the name of the file"
        IOError.__init__(self)
        self.name = name
```

`FileNotThere` inherits from `IOError`:
if not handled explicitly, then it can still be handled via `IOError`.

The name given by the user is the object data attribute,
when handling the exception, we may use the name.

raising exceptions with arguments

An example of raising `FileNotThere`:

```
NAME = input('Give the name of a file : ')
try:
    try:
        INFILE = open(NAME, 'r')
    except IOError:
        raise FileNotThere(NAME)
except FileNotThere as err:
    print('file \"' + err.name + '\" does not exist')
```

When raising `FileNotThere`, we provide the file name.
The variable `err` is an instance of `FileNotThere`.

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Anytime Algorithms

An anytime algorithm is an algorithm that given some more resources will improve the accuracy of the estimate.

Recall the Monte Carlo method to estimate π...

Instead of fixing #samples in advance:

1. use of a `while True` loop
2. monitor the progress of the computations via handling of cntrl+c interrupt
3. the handler of `KeyboardInterrupt` shows current approximation and asks user to continue or not

running anytimepi.py

```
$ python anytimepi.py
approximating pi = 3.14159265358979
hold ctrl and c to check...
^C#samples : 1193168, estimate : 3.14061389510949
continue ? (y/n) y
^C#samples : 3733763, estimate : 3.14069746794320
continue ? (y/n) y
^C#samples : 6486987, estimate : 3.14059948015928
continue ? (y/n) y
^C#samples : 11327766, estimate : 3.14173898013077
continue ? (y/n) y
^C#samples : 16384015, estimate : 3.14114434099334
continue ? (y/n) n
```

Monte Carlo Method

```
"""
Recall the Monte Carlo method to estimate Pi.
"""

from math import pi
from random import uniform as u

print('approximating pi = %.14f' % pi)
(COUNT, TOTAL) = (0, 0)
N = int(input('give number of samples : '))
for i in range(0, N):
    TOTAL += 1
    (X, Y) = (u(0, 1), u(0, 1))
    if X**2 + Y**2 <= 1:
        COUNT += 1
APPROX = (4.0*COUNT)/TOTAL
print('#samples : %d, estimate : %.14f' % (TOTAL, APPROX))
```

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Pseudo Code

Anytime algorithm with user controlling the stop criterion:

```
< initialize >
while True:
    try:
        while True:
            < compute estimate >
    except KeyboardInterrupt:
        < show estimate >
        ans = raw_input('continue ? (y/n) ')
        if ans != 'y':
            break
```

The `try-except` stays inside the outer `while True` loop.

We leave the outer loop with `break`.

an anytime Python script to estimate π

```
from math import pi
from random import uniform as u

print('approximating pi = %.14f' % pi)
print('hold ctrl and c to check...')
(COUNT, TOTAL) = (0, 0)
while True:
    try:
        while True:
            TOTAL += 1
            (X, Y) = (u(0, 1), u(0, 1))
            if X**2 + Y**2 <= 1:
                COUNT += 1
    except KeyboardInterrupt:
        APPROX = (4.0*COUNT)/TOTAL
        print('#samples : %d, estimate : %.14f' \
            % (TOTAL, APPROX))
        ANS = input('continue ? (y/n) ')
        if ANS != 'y':
            break
```

Summary + Assignments

Assignments:

1. Write a function that prompts the user for an age.
   Raise `Exception` when the age is negative.
2. Define an exception `InvalidAge` that has the age
   as object data attribute.
3. Give an illustration of how to raise the exception defined in
   previous exercise.