ALTIS
INVESTMENT MANAGEMENT

Developing financial software

Numerical reliability, lazy initialization, digital signatures

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Pycon Italia 3
Firenze, May 8th-10th
http://www.pycon.it/

A Tuscan invention

Fibonacci
Liber Abaci
1202

Filippo Calandri
De arimetricha opusculum
Firenze 1491

Fast fwd to today

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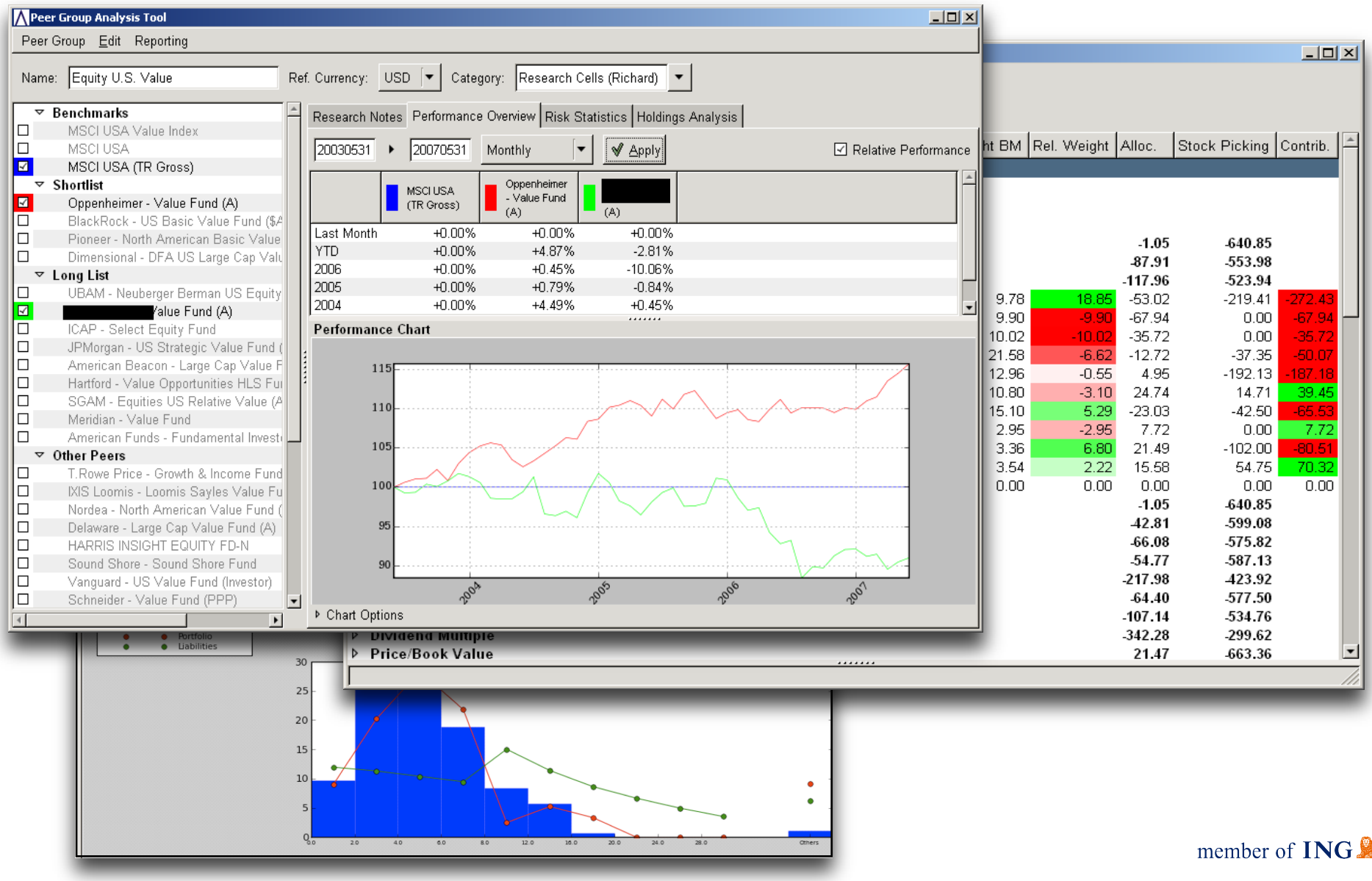

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The company

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A specialist 'Boutique' which is part of ING Investment Management

- Track record since 1999, when team was formed at Morgan Stanley
- The first to develop 'Holdings-Based Analysis' driven by 'Aggregated Risk Management'
- 2004: Independent Specialist, acquired by ING in 2008 as its specialist multi-manager resource
- Manages in excess of €5bn, advises on in excess of €11bn

Offices in Switzerland (9 staff) and the Netherlands (4 staff)

- 12 out of 13 staff are full-time professionals – no marketing or other distractions

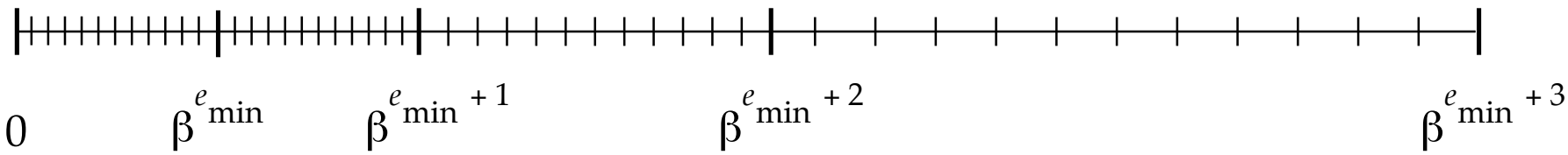
An integrated part of ING's fiduciary offering as part of 'Implemented Client Solutions'

- But operates at arm's length without conflicts of interest as manager selection boutique

Floating-Point numbers

```
>>> 1 + 1.1
2.1000000000000001
```

$$\mathbb{F} = \{-\infty, +\infty\} \cup \{x \in \mathbb{R} \,|\, x = m\beta^e\}$$



Do you really mean it?

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```
>>> 1 + 1.1
2.1000000000000001

>>> 100 + 110
210

>>> def format(x):
...     import re
...     return re.sub('\d\d$', '.\g<0>', repr(x))
>>> format(100 + 110)
'2.10'
```

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Decimal FP

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```
>>> from decimal import Decimal as D
>>> D('1') + D('1.10')
Decimal('2.10')

>>> from decimal import localcontext
>>> with localcontext() as ctx:
...     ctx.prec = 16
...     D(2 ** 53).log10()
Decimal('15.954589770191100')

>>> import math
>>> math.log10(2 ** 53)
15.954589770191003
```

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An example

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$$f(x,y) = (333.75 - x^2)y^6 + x^2(11x^2y^2 - 121y^4 - 2) + 5.5y^8 + x/(2y)$$

```
>>> def f(x,y):
...     return (
...         (333.75 - x**2)* y**6 + x**2 *
...             (11* x**2 * y**2 - 121 * y**4 - 2)
...         + 5.5 * y**8 + x/(2*y))

>>> f(77617.0, 33096.0)
1.172603940053178 7
```

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With decimal FP

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```
>>> def fd(x,y):
...     return (
...         (D('333.75')-x**2)* y**6 + x**2 *
...             (11* x**2 * y**2 - 121*y**4 - 2)
...         + D('5.5') * y**8 + x/(2*y))

>>> fd(D(77617), D(33096))
Decimal('-999999998.827396059946821368 1')

>>> with localcontext() as ctx:
...     for p in [29, 30, 31]:
...         ctx.prec = p
...         print fd(D(77617), D(33096))
100000001.17260394005317863186
20000001.172603940053178631858 8
-999998.827396059946821368141165 1
```

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Using GMPy

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```
>>> from gmpy import mpf
>>> f(mpf(77617), mpf(33096))
mpf('3.285436508427236398 77e26')

>>> pprint([f(mpf(77617, n), mpf(33096, n)) for n in (53, 100, 150)])
[mpf('3.285436508427236398 77e26'),
 mpf('1.172603940053178631823874167326495690282e0',100),
 mpf('1.172603940053178631823874167326495690281887942030 2e0',150)]
```

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Rationals

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```
>>> from fractions import Fraction as F
>>> def ff(x,y):
...     return (
...         (F(33375, 100)-x**2)* y**6 + x**2 *
...             (11* x**2 * y**2 - 121*y**4 - 2)
...         + F(55, 10) * y**8 + x/(2*y))
```

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Rationals

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```
>>> from fractions import Fraction as F
>>> def ff(x,y):
...     return (
...         (F(33375, 100)-x**2)* y**6 + x**2 *
...             (11* x**2 * y**2 - 121*y**4 - 2)
...         + F(55, 10) * y**8 + x/(2*y))

>>> ff(F(77617), F(33096))
Fraction(-54767, 66192)

>>> float(_)
-0.8273960599468214
```

$$f(77617, 33096) = -\frac{54767}{66192} = -0.827396\ldots$$

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Intervals

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```
>>> from interval import interval
>>> k = interval([0, 1], [2, 3], [10, 15])
```

$$k = [0, 1] \cup [2, 3] \cup [10, 15]$$

```
>>> interval[1, 2]
interval([1.0, 2.0])

>>> interval(1, 2)
interval([1.0], [2.0])

>>> interval(1), interval[1]
(interval([1.0]), interval([1.0]))
```

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Rounding errors

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```
>>> interval[10] / interval[3]
interval([3.3333333333333, 3.3333333333333339])

>>> from interval import imath
>>> imath.exp(1)
interval([2.7182818284590451, 2.7182818284590455])

>>> print f(interval(77617.0), interval(33096.0))
interval([-3.54177486215e+21, 3.54177486215e+21])
```

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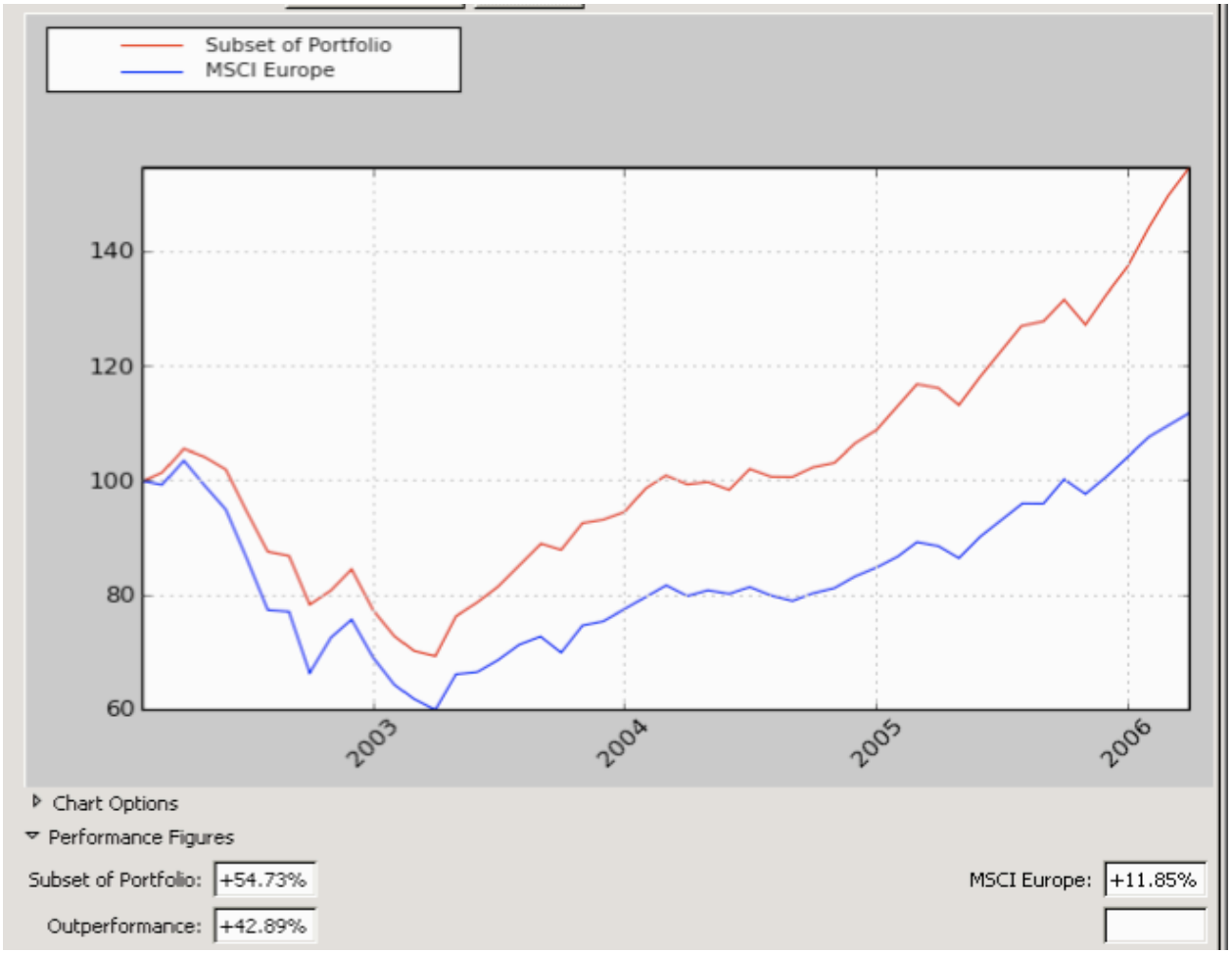
References

- http://pypi.python.org/pypi/pyinterval/
- http://conference.scipy.org/slides/
- http://gmpy.googlecode.com/
- D. Goldberg, "What every computer scientist should know about floating-point arithmetic", *ACM Computing Surveys*, vol. 23 (1991), pp. 5–48
  - Republished many times and available on the web.

Before & After



Before & After

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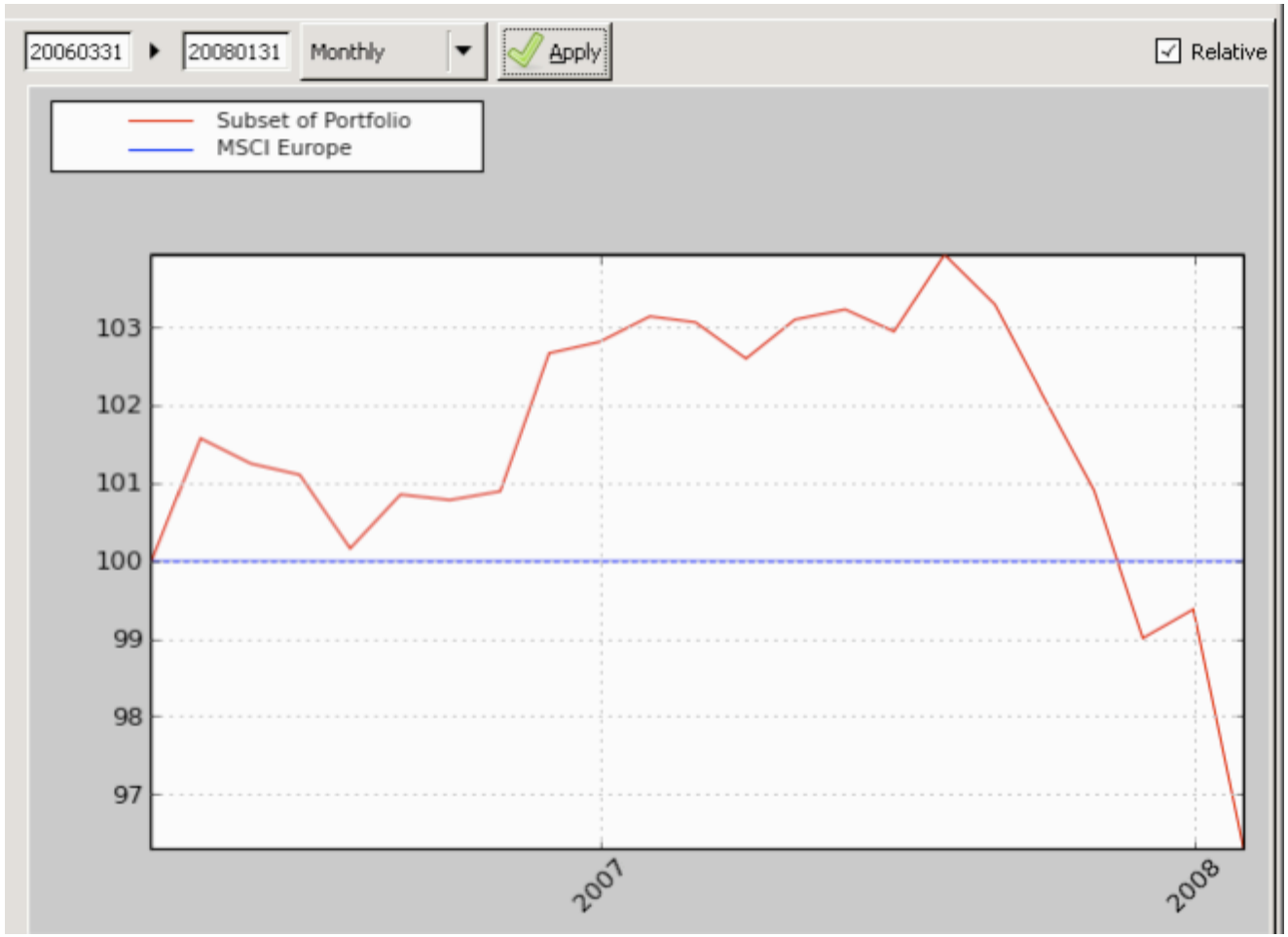
Before & After



Lazy Initialization

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- Complexity management
  - 60k sloc in Python
- Lazy Evaluation
  - Evaluate an expression only when it’s needed
- Functional-style programming
  - Immutable state
  - A variable is set only at initialization
- Lazy initialization
  - State is still mutable
  - A variable is initialized only when it’s needed
  - Traversal of dependency DAG.

Goal

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```
>>> class A(object):
...     "A fantastic class"
...     @initializer
...     def x(self):
...         "A very delicate property."
...         return 1

>>> a = A()
>>> a.x
1

>>> a.x = 2
>>> a.x
2

>>> del a.x
>>> a.x
1
```

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Implementation

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```
>>> class initializer(object):
...     def __init__(self, f):
...         self.f = f
...         self.__doc__ = f.__doc__
...     def __get__(self, obj, type=None):
...         if obj is None:
...             return self
...         v = self.f(obj)
...         setattr(obj, self.f.__name__, v)
...         return v
...     def __repr__(self):
...         return self.__doc__ or 'Undocumented'
```

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Added bonus

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```
>>> help(A)
Help on class A in module __builtin__:
<BLANKLINE>
class A(object)
 |  A fantastic class
 |
 |  Methods defined here:
 |
 |  x = A very delicate property.
 |  ----------------------------------------------------------------------
 |  Data descriptors defined here:
 |
 |  __dict__
 |      dictionary for instance variables (if defined)
 |
 |  __weakref__
 |      list of weak references to the object (if defined)
<BLANKLINE>
```

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Deploying a Python Application

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- Components
  - Python interpreter stub + bootstrapping script
  - Python packages and modules
  - Dynamically-linked binary libraries (DLLs)
    - Including Python extensions
  - Data resources (XMLs, pickles, icons...)
- Code signing
  - Guaranteeing the source of the application
  - “Authenticity”, no forgery
  - Requirement of some deployment environments
- MS Windows support for .EXE and .DLL files
  - PE (Portable Executable) file format
  - `#include <winnt.h>`

Solution

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- One-file packaging:
  - Py2exe's `bundle_files` option
  - No unpackaging to temporary directories:
    - Else, almost as effective as signing just the installer.
  - The four component can then be signed all-together:
    - i.e. you guarantee that they belong all together. (CVS vs SVN)

- Loading from one file:
  - Python interpreter stub + bootstrapping script:
    - Taken care by the OS shell + API
  - Python packages and modules
    - zipimporter (stdlib)
  - Dynamically-linked binary libraries (DLLs)
    - Joachim Bauch's MemoryModule
    - Used in py2exe's interpreter stub and zipextimporter
  - Data resources (XMLs, pickles, icons...)
    - Converted to code resources (à la PyQT)
    - Or, embedded into the PE

Conclusions

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- Beware of the numbers you produce
  - FP are leaky abstractions
  - Try either *a priori* reliability assessments or *a posteriori* or both
- Beware of system complexity
  - Adopting and adapting functional techniques
  - Lazy initialization as an interesting tool
- Use real one-file approach when signing code

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