Multiple Dispatch Documentation

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CHAPTER 1

Design

1.1 Types

```
signature  :: [type]
              a list of types

Dispatcher :: {signature: function}
              A mapping of type signatures to function implementations

namespace  :: {str: Dispatcher}
              A mapping from function names, like 'add', to Dispatchers
```

1.2 Dispatchers

A `Dispatcher` object stores and selects between different implementations of the same abstract operation. It selects the appropriate implementation based on a signature, or list of types. We build one dispatcher per abstract operation.

```
f = Dispatcher('f')
```

At the lowest level we build normal Python functions and then add them to the `Dispatcher`.

```
>>> def inc(x):
...     return x + 1

>>> def dec(x):
...     return x - 1

>>> f.add((int,), inc)     # f increments integers
>>> f.add((float,), dec)   # f decrements floats

>>> f(1)
2

>>> f(1.0)
0.0
```

Internally `Dispatcher.resolve` selects the function implementation.

```
>>> f.resolve((int,))
<function __main__.inc>
```

```
>>> f.resolve((float,))
<function __main__.dec>
```

For notational convenience dispatchers leverage Python's decorator syntax to register functions as we define them.

```
f = Dispatcher('f')

@f.register(int)
def inc(x):
    return x + 1

@f.register(float)
def dec(x):
    return x - 1
```

This is equivalent to the form above. It also adheres to the standard implemented by `functools.singledispatch` in Python 3.4.

1.3 Namespaces and `dispatch`

The `dispatch` decorator hides the creation and manipulation of `Dispatcher` objects from the user.

```
# f = Dispatcher('f')  # no need to create Dispatcher ahead of time

@dispatch(int)
def f(x):
    return x + 1

@dispatch(float)
def f(x):
    return x - 1
```

The `dispatch` decorator uses the name of the function to select the appropriate `Dispatcher` object to which it adds the new signature/function. When it encounters a new function name it creates a new `Dispatcher` object and stores name/Dispatcher pair in a namespace for future reference.

```
# This creates and stores a new Dispatcher('g')
# namespace['g'] = Dispatcher('g')
# namespace['g'].add((int,), g)
@dispatch(int)
def g(x):
    return x ** 2
```

We store this new `Dispatcher` in a *namespace*. A namespace is simply a dictionary that maps function names like `'g'` to dispatcher objects like `Dispatcher('g')`.

By default `dispatch` uses the global namespace in `multipledispatch.core.global_namespace`. If several projects use this global namespace unwisely then conflicts may arise, causing difficult to track down bugs. Users who desire additional security may establish their own namespaces simply by creating a dictionary.

```
my_namespace = dict()

@dispatch(int, namespace=my_namespace)
def f(x):
    return x + 1
```

To establish a namespace for an entire project we suggest the use of `functools.partial` to bind the new namespace to the `dispatch` decorator.

```
from multipledispatch import dispatch
from functools import partial

my_namespace = dict()
dispatch = partial(dispatch, namespace=my_namespace)

@dispatch(int)  # Uses my_namespace rather than the global namespace
def f(x):
    return x + 1
```

CHAPTER 2

Method Resolution

Multiple dispatch selects the function from the types of the inputs.

```
@dispatch(int)
def f(x):            # increment integers
    return x + 1

@dispatch(float)
def f(x):            # decrement floats
    return x - 1

>>> f(1)             # 1 is an int, so increment
2
>>> f(1.0)           # 1.0 is a float, so decrement
0.0
```

2.1 Union Types

Similarly to the builtin `isinstance` operation you specify multiple valid types with a tuple.

```
@dispatch((list, tuple))
def f(x):
    """ Apply ``f`` to each element in a list or tuple """
    return [f(y) for y in x]

>>> f([1, 2, 3])
[2, 3, 4]

>>> f((1, 2, 3))
[2, 3, 4]
```

2.2 Abstract Types

You can also use abstract classes like `Iterable` and `Number` in place of union types like `(list, tuple)` or `(int, float)`.

```
from collections import Iterable

# @dispatch((list, tuple))
```

```
@dispatch(Iterable)
def f(x):
    """ Apply ``f`` to each element in an Iterable """
    return [f(y) for y in x]
```

2.3 Selecting Specific Implementations

If multiple valid implementations exist then we use the most specific one. In the following example we build a function to flatten nested iterables.

```
@dispatch(Iterable)
def flatten(L):
    return sum([flatten(x) for x in L], [])

@dispatch(object)
def flatten(x):
    return [x]

>>> flatten([1, 2, 3])
[1, 2, 3]

>>> flatten([1, [2], 3])
[1, 2, 3]

>>> flatten([1, 2, (3, 4), [[5]], [(6, 7), (8, 9)]])
[1, 2, 3, 4, 5, 6, 7, 8, 9]
```

Because strings are iterable they too will be flattened

```
>>> flatten([1, 'hello', 3])
[1, 'h', 'e', 'l', 'l', 'o', 3]
```

We avoid this by specializing `flatten` to `str`. Because `str` is more specific than `Iterable` this function takes precedence for strings.

```
@dispatch(str)
def flatten(s):
    return s

>>> flatten([1, 'hello', 3])
[1, 'hello', 3]
```

The `multipledispatch` project depends on Python's `issubclass` mechanism to determine which types are more specific than others.

2.4 Multiple Inputs

All of these rules apply when we introduce multiple inputs.

```
@dispatch(object, object)
def f(x, y):
    return x + y

@dispatch(object, float)
```

```
def f(x, y):
    """ Square the right hand side if it is a float """
    return x + y**2

>>> f(1, 10)
11

>>> f(1.0, 10.0)
101.0
```

2.5 Ambiguities

However ambiguities arise when different implementations of a function are equally valid

```
@dispatch(float, object)
def f(x, y):
    """ Square left hand side if it is a float """
    return x**2 + y

>>> f(2.0, 10.0)
?
```

Which result do we expect, `2.0**2 + 10.0` or `2.0 + 10.0**2`? The types of the inputs satisfy three different implementations, two of which have equal validity

```
input types:    float, float
Option 1:       object, object
Option 2:       object, float
Option 3:       float, object
```

Option 1 is strictly less specific than either options 2 or 3 so we discard it. Options 2 and 3 however are equally specific and so it is unclear which to use.

To resolve issues like this `multipledispatch` inspects the type signatures given to it and searches for ambiguities. It then raises a warning like the following:

```
multipledispatch/dispatcher.py:74: AmbiguityWarning:
Ambiguities exist in dispatched function f

The following signatures may result in ambiguous behavior:
    [object, float], [float, object]


Consider making the following additions:

@dispatch(float, float)
def f(...)
```

This warning occurs when you write the function and guides you to create an implementation to break the ambiguity. In this case, a function with signature `(float, float)` is more specific than either options 2 or 3 and so resolves the issue. To avoid this warning you should implement this new function *before* the others.

```
@dispatch(float, float)
def f(x, y):
    ...

@dispatch(float, object)
```

```
def f(x, y):
    ...

@dispatch(object, float)
def f(x, y):
    ...
```

If you do not resolve ambiguities by creating more specific functions then one of the competing functions will be selected pseudo-randomly.