

# Join Python

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Join-calculus for Python

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# 1 Overview

Join Python is a Python 3 library that implements join-calculus. Join Python can be used by importing the module `join` in any Python 3 program, provided that Join Python is installed.

Join Python provides the ability to write more concise code using almost any published concurrency pattern with explicit monitor calls.

## 2 Signals

A signal is a function that runs asynchronously. It is put in its own thread. To declare a signal, add the `@signal` decorator to a function definition or pass function to the constructor of the class `signal`.

```
>>> from join import *
>>> import time
>>>
>>> @signal
>>> def sig(delay, value):
>>>     time.sleep(delay)
>>>     print(value)
>>>
>>> sig(0.25, 'first')
>>> print('last')
last
first
```

```
>>> from join import *
>>> import time
>>>
>>> def f(delay, value):
>>>     time.sleep(delay)
>>>     print(value)
>>>
>>> signal(f)(0.25, 'first')
>>> print('last')
last
first
```

As an extension to join-calculus, signals in Join Java can be joined with the returned value of the function can be fetched when joined.

```
>>> from join import *
>>> import time
>>>
>>> def f(delay, value):
>>>     time.sleep(delay)
>>>     return value ** 2
>>>
>>> sig = signal(f)(0.25, 4)
>>> print('between')
>>> print(sig.join())
between
16
```

In the next chapter fragments will be introduced. If you want a signal without a fragment capability use `@puresignal` or `puresignal` instead of `@signal` or `signal`.

## 3 Fragments

A fragment is a partial function. What this means is that you can make functions that block until all its fragments have returned. Signals return immediately. Waiting for a fragment is called joining,<sup>1</sup> when joining when a fragment you receive the arguments in was invoked with and the value it returned, the latter being an extension to join-calculus. Remember that a signal returns an object with an argumentless method name `join` that joins with the signal and returns that value the signal function returned.

```
>>> from join import *
>>>
>>> @fragment
>>> def frag(value):
>>>     return value ** 2
>>>
>>> def f(value):
>>>     (frag_value,), _kwargs, rc = join(frag)
>>>     return rc + frag_value + value
>>>
>>> frag(2)
>>> print(f(3))
9
```

The function `join` returns a tuple of the positional arguments, the named arguments and the returned value. But you can also join with multiple fragments, in which case `join` returns a list of these tuples, one tuple for each fragment, in the same order as they appear as arguments for the `join` call.

```
>>> from join import *
>>>
>>> @fragment
>>> def f1(value):
>>>     return value ** 2
>>>
>>> @fragment
>>> def f2(value):
>>>     return value ** 3
>>>
>>> def f(value):
>>>     (_args1, _kwargs1, rc1), (_args2, _kwargs2, rc2) = join(f1, f2)
>>>     return value + rc1 + rc2
>>>
>>> f1(2)
>>> f2(2)
>>> print(f(2))
14
```

As with `@signals`, you can use constructor of `fragment` instead of a the `@fragment` decorator.

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<sup>1</sup> Yes, it is a bit inconvenient that waiting for a thread or signal is also called joining.

## 4 Join-switches

Join-switches is an advanced joining technique. It lets join join with whatever fragment group that is joined first. There are two versions of this: ordered joining and unordered joining. Ordered joining and unordered joining behaves the same if none of the fragment group have already joined when the joining is requested. But if there are more than one fragment group that have already joined that will behave differently: unordered joining will select a fragment group at random, whereas ordered joining will select the fragment group with highest precedence, that is, the fragment group specified first in the joining request. Ordered joining is done with the function `ordered_join` and unordered joining is done with the function `unordered_join`. They work similarly to `join`, except each group is specified as a tuple of fragments and the returned value is a tuple of the index of the selected join case (fragment group) and what `join` returned for that fragment group.

```
>>> from join import *
>>>
>>> @fragment
>>> def f1():
>>>     pass
>>>
>>> @fragment
>>> def f2():
>>>     pass
>>>
>>> @fragment
>>> def f3():
>>>     pass
>>>
>>> def ordered():
>>>     case, (_args, _kwargs, _rc) = ordered_join((f1,), (f2,), (f3,))
>>>     return case
>>>
>>> def unordered():
>>>     case, (_args, _kwargs, _rc) = unordered_join((f1,), (f2,), (f3,))
>>>     return case
>>>
>>> def switch(f):
>>>     f1()
>>>     f2()
>>>     f3()
>>>     return f()
>>>
>>> print([switch(ordered) for _ in range(10)])
>>> print([switch(unordered) for _ in range(10)])
[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]
[2, 2, 1, 0, 1, 2, 0, 1, 1, 2] # uniformly random
```

## 5 Fork-merge

As an extension to join-calculus Join Python offers a blocking function that runs multiple functions in parallel. `concurrently` takes any number of functions and executes them in parallel and waits for all of them to return. Functions that are signals (`@signal` or `@puresignal`) will have their return value returned by `concurrently`.

```
>>> from join import *
>>>
>>> @signal
>>> def sig(value = 4):
>>>     print('In parallel')
>>>     return value ** 2
>>>
>>> def fun(value):
>>>     print('In parallel')
>>>     return value ** 3
>>>
>>> print(concurrently(signal(lambda : sig(2).join()), lambda : fun(3)))
In parallel
In parallel
[4, None] # it is actually undefined where we get 'None' here
>>> print(concurrently(sig, signal(lambda : fun(3))))
In parallel
In parallel
[16, 27]
```



## 6 Working with Classes

If a signal or fragment is a part of a class, it is automatically made into a static function. To make a function into an instance function or instance method, you need to decorate it with `@joinmethod`.

```
>>> from join import *
>>>
>>> class Class:
>>>     def __init__(self, value):
>>>         self.value = value
>>>
>>>     @joinmethod
>>>     @fragment
>>>     def fi(self):
>>>         return self.value ** 3
>>>
>>>     @fragment
>>>     def fs(value):
>>>         return value ** 3
>>>
>>> Class.fs(2)
8
>>> Class(2).fi()
8
```

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