29.6. contextlib — Utilities for with-statement contexts

Source code: Lib/contextlib.py

This module provides utilities for common tasks involving the `with` statement. For more information see also Context Manager Types and With Statement Context Managers.

29.6.1. Utilities

Functions and classes provided:

class `contextlib.`**`AbstractContextManager`**

An abstract base class for classes that implement `object.__enter__()` and `object.__exit__()`. A default implementation for `object.__enter__()` is provided which returns `self` while `object.__exit__()` is an abstract method which by default returns `None`. See also the definition of Context Manager Types.

New in version 3.6.

`@contextlib.`**`contextmanager`**

This function is a decorator that can be used to define a factory function for `with` statement context managers, without needing to create a class or separate `__enter__()` and `__exit__()` methods.

A simple example (this is not recommended as a real way of generating HTML!):

```
from contextlib import contextmanager

@contextmanager
def tag(name):
    print("<%s>" % name)
    yield
    print("</%s>" % name)

>>> with tag("h1"):
...     print("foo")
...
<h1>
```

```
foo
</h1>
```

The function being decorated must return a generator-iterator when called. This iterator must yield exactly one value, which will be bound to the targets in the `with` statement's `as` clause, if any.

At the point where the generator yields, the block nested in the `with` statement is executed. The generator is then resumed after the block is exited. If an unhandled exception occurs in the block, it is reraised inside the generator at the point where the yield occurred. Thus, you can use a `try`…`except`…`finally` statement to trap the error (if any), or ensure that some cleanup takes place. If an exception is trapped merely in order to log it or to perform some action (rather than to suppress it entirely), the generator must reraise that exception. Otherwise the generator context manager will indicate to the `with` statement that the exception has been handled, and execution will resume with the statement immediately following the `with` statement.

`contextmanager()` uses `ContextDecorator` so the context managers it creates can be used as decorators as well as in `with` statements. When used as a decorator, a new generator instance is implicitly created on each function call (this allows the otherwise "one-shot" context managers created by `contextmanager()` to meet the requirement that context managers support multiple invocations in order to be used as decorators).

Changed in version 3.2: Use of `ContextDecorator`.

`contextlib.`**`closing`**(*thing*)

Return a context manager that closes *thing* upon completion of the block. This is basically equivalent to:

```
from contextlib import contextmanager

@contextmanager
def closing(thing):
    try:
        yield thing
    finally:
        thing.close()
```

And lets you write code like this:

```
from contextlib import closing
from urllib.request import urlopen

with closing(urlopen('http://www.python.org')) as page:
    for line in page:
        print(line)
```

without needing to explicitly close `page`. Even if an error occurs, `page.close()` will be called when the `with` block is exited.

contextlib.**suppress**(**exceptions*)

Return a context manager that suppresses any of the specified exceptions if they occur in the body of a with statement and then resumes execution with the first statement following the end of the with statement.

As with any other mechanism that completely suppresses exceptions, this context manager should be used only to cover very specific errors where silently continuing with program execution is known to be the right thing to do.

For example:

```
from contextlib import suppress

with suppress(FileNotFoundError):
    os.remove('somefile.tmp')

with suppress(FileNotFoundError):
    os.remove('someotherfile.tmp')
```

This code is equivalent to:

```
try:
    os.remove('somefile.tmp')
except FileNotFoundError:
    pass

try:
    os.remove('someotherfile.tmp')
except FileNotFoundError:
    pass
```

This context manager is reentrant.

New in version 3.4.

contextlib.**redirect_stdout**(*new_target*)

Context manager for temporarily redirecting `sys.stdout` to another file or file-like object.

This tool adds flexibility to existing functions or classes whose output is hardwired to stdout.

For example, the output of `help()` normally is sent to *sys.stdout*. You can capture that output in a string by redirecting the output to an `io.StringIO` object:

```
f = io.StringIO()
with redirect_stdout(f):
    help(pow)
s = f.getvalue()
```

To send the output of `help()` to a file on disk, redirect the output to a regular file:

```
with open('help.txt', 'w') as f:
    with redirect_stdout(f):
        help(pow)
```

To send the output of `help()` to *sys.stderr*:

```
with redirect_stdout(sys.stderr):
    help(pow)
```

Note that the global side effect on `sys.stdout` means that this context manager is not suitable for use in library code and most threaded applications. It also has no effect on the output of subprocesses. However, it is still a useful approach for many utility scripts.

This context manager is reentrant.

New in version 3.4.

`contextlib.`**`redirect_stderr`**(*new_target*)

Similar to `redirect_stdout()` but redirecting `sys.stderr` to another file or file-like object.

This context manager is reentrant.

New in version 3.5.

class `contextlib.`**`ContextDecorator`**

A base class that enables a context manager to also be used as a decorator.

Context managers inheriting from `ContextDecorator` have to implement `__enter__` and `__exit__` as normal. `__exit__` retains its optional exception handling even when used as a decorator.

`ContextDecorator` is used by `contextmanager()`, so you get this functionality automatically.

Example of `ContextDecorator`:

```
from contextlib import ContextDecorator

class mycontext(ContextDecorator):
    def __enter__(self):
        print('Starting')
        return self

    def __exit__(self, *exc):
        print('Finishing')
        return False

>>> @mycontext()
... def function():
...     print('The bit in the middle')
...
>>> function()
Starting
The bit in the middle
Finishing

>>> with mycontext():
...     print('The bit in the middle')
...
Starting
The bit in the middle
Finishing
```

This change is just syntactic sugar for any construct of the following form:

```
def f():
    with cm():
        # Do stuff
```

`ContextDecorator` lets you instead write:

```
@cm()
def f():
    # Do stuff
```

It makes it clear that the `cm` applies to the whole function, rather than just a piece of it (and saving an indentation level is nice, too).

Existing context managers that already have a base class can be extended by using `ContextDecorator` as a mixin class:

```
from contextlib import ContextDecorator
```

```
class mycontext(ContextBaseClass, ContextDecorator):
    def __enter__(self):
        return self

    def __exit__(self, *exc):
        return False
```

Note: As the decorated function must be able to be called multiple times, the underlying context manager must support use in multiple `with` statements. If this is not the case, then the original construct with the explicit `with` statement inside the function should be used.

New in version 3.2.

class `contextlib.`**`ExitStack`**

A context manager that is designed to make it easy to programmatically combine other context managers and cleanup functions, especially those that are optional or otherwise driven by input data.

For example, a set of files may easily be handled in a single with statement as follows:

```
with ExitStack() as stack:
    files = [stack.enter_context(open(fname)) for fname in filenam
    # All opened files will automatically be closed at the end of
    # the with statement, even if attempts to open files later
    # in the list raise an exception
```

Each instance maintains a stack of registered callbacks that are called in reverse order when the instance is closed (either explicitly or implicitly at the end of a `with` statement). Note that callbacks are *not* invoked implicitly when the context stack instance is garbage collected.

This stack model is used so that context managers that acquire their resources in their `__init__` method (such as file objects) can be handled correctly.

Since registered callbacks are invoked in the reverse order of registration, this ends up behaving as if multiple nested `with` statements had been used with the registered set of callbacks. This even extends to exception handling - if an inner callback suppresses or replaces an exception, then outer callbacks will be passed arguments based on that updated state.

This is a relatively low level API that takes care of the details of correctly unwinding the stack of exit callbacks. It provides a suitable foundation for higher level context managers that manipulate the exit stack in application specific ways.

New in version 3.3.

`enter_context`(*cm*)

Enters a new context manager and adds its `__exit__()` method to the callback stack. The return value is the result of the context manager's own `__enter__()` method.

These context managers may suppress exceptions just as they normally would if used directly as part of a `with` statement.

`push`(*exit*)

Adds a context manager's `__exit__()` method to the callback stack.

As `__enter__` is *not* invoked, this method can be used to cover part of an `__enter__()` implementation with a context manager's own `__exit__()` method.

If passed an object that is not a context manager, this method assumes it is a callback with the same signature as a context manager's `__exit__()` method and adds it directly to the callback stack.

By returning true values, these callbacks can suppress exceptions the same way context manager `__exit__()` methods can.

The passed in object is returned from the function, allowing this method to be used as a function decorator.

`callback`(*callback*, **args*, ***kwds*)

Accepts an arbitrary callback function and arguments and adds it to the callback stack.

Unlike the other methods, callbacks added this way cannot suppress exceptions (as they are never passed the exception details).

The passed in callback is returned from the function, allowing this method to be used as a function decorator.

`pop_all`()

Transfers the callback stack to a fresh `ExitStack` instance and returns it. No callbacks are invoked by this operation - instead, they will now be invoked when the new stack is closed (either explicitly or implicitly at the end of a `with` statement).

For example, a group of files can be opened as an “all or nothing” operation as follows:

```
with ExitStack() as stack:
    files = [stack.enter_context(open(fname)) for fname in file
    # Hold onto the close method, but don't call it yet.
    close_files = stack.pop_all().close
    # If opening any file fails, all previously opened files wi
    # closed automatically. If all files are opened successfull
    # they will remain open even after the with statement ends.
    # close_files() can then be invoked explicitly to close the
```

close()

Immediately unwinds the callback stack, invoking callbacks in the reverse order of registration. For any context managers and exit callbacks registered, the arguments passed in will indicate that no exception occurred.

29.6.2. Examples and Recipes

This section describes some examples and recipes for making effective use of the tools provided by `contextlib`.

29.6.2.1. Supporting a variable number of context managers

The primary use case for `ExitStack` is the one given in the class documentation: supporting a variable number of context managers and other cleanup operations in a single `with` statement. The variability may come from the number of context managers needed being driven by user input (such as opening a user specified collection of files), or from some of the context managers being optional:

```
with ExitStack() as stack:
    for resource in resources:
        stack.enter_context(resource)
    if need_special_resource():
        special = acquire_special_resource()
        stack.callback(release_special_resource, special)
    # Perform operations that use the acquired resources
```

As shown, `ExitStack` also makes it quite easy to use `with` statements to manage arbitrary resources that don’t natively support the context management protocol.

29.6.2.2. Simplifying support for single optional context managers

In the specific case of a single optional context manager, `ExitStack` instances can be used as a "do nothing" context manager, allowing a context manager to easily be omitted without affecting the overall structure of the source code:

```
def debug_trace(details):
    if __debug__:
        return TraceContext(details)
    # Don't do anything special with the context in release mode
    return ExitStack()

with debug_trace():
    # Suite is traced in debug mode, but runs normally otherwise
```

29.6.2.3. Catching exceptions from `__enter__` methods

It is occasionally desirable to catch exceptions from an `__enter__` method implementation, *without* inadvertently catching exceptions from the `with` statement body or the context manager's `__exit__` method. By using `ExitStack` the steps in the context management protocol can be separated slightly in order to allow this:

```
stack = ExitStack()
try:
    x = stack.enter_context(cm)
except Exception:
    # handle __enter__ exception
else:
    with stack:
        # Handle normal case
```

Actually needing to do this is likely to indicate that the underlying API should be providing a direct resource management interface for use with `try`/`except`/`finally` statements, but not all APIs are well designed in that regard. When a context manager is the only resource management API provided, then `ExitStack` can make it easier to handle various situations that can't be handled directly in a `with` statement.

29.6.2.4. Cleaning up in an `__enter__` implementation

As noted in the documentation of `ExitStack.push()`, this method can be useful in cleaning up an already allocated resource if later steps in the `__enter__()` implementation fail.

Here's an example of doing this for a context manager that accepts resource acquisition and release functions, along with an optional validation function, and maps them to the context management protocol:

```
from contextlib import contextmanager, AbstractContextManager, ExitSta

class ResourceManager(AbstractContextManager):

    def __init__(self, acquire_resource, release_resource, check_resou
        self.acquire_resource = acquire_resource
        self.release_resource = release_resource
        if check_resource_ok is None:
            def check_resource_ok(resource):
                return True
        self.check_resource_ok = check_resource_ok

    @contextmanager
    def _cleanup_on_error(self):
        with ExitStack() as stack:
            stack.push(self)
            yield
            # The validation check passed and didn't raise an exceptio
            # Accordingly, we want to keep the resource, and pass it
            # back to our caller
            stack.pop_all()

    def __enter__(self):
        resource = self.acquire_resource()
        with self._cleanup_on_error():
            if not self.check_resource_ok(resource):
                msg = "Failed validation for {!r}"
                raise RuntimeError(msg.format(resource))
        return resource

    def __exit__(self, *exc_details):
        # We don't need to duplicate any of our resource release logic
        self.release_resource()
```

29.6.2.5. Replacing any use of `try-finally` and flag variables

A pattern you will sometimes see is a `try-finally` statement with a flag variable to indicate whether or not the body of the `finally` clause should be executed. In its simplest form (that can't already be handled just by using an `except` clause instead), it looks something like this:

```
cleanup_needed = True
try:
    result = perform_operation()
    if result:
        cleanup_needed = False
finally:
    if cleanup_needed:
        cleanup_resources()
```

As with any `try` statement based code, this can cause problems for development and review, because the setup code and the cleanup code can end up being separated by arbitrarily long sections of code.

`ExitStack` makes it possible to instead register a callback for execution at the end of a `with` statement, and then later decide to skip executing that callback:

```
from contextlib import ExitStack

with ExitStack() as stack:
    stack.callback(cleanup_resources)
    result = perform_operation()
    if result:
        stack.pop_all()
```

This allows the intended cleanup up behaviour to be made explicit up front, rather than requiring a separate flag variable.

If a particular application uses this pattern a lot, it can be simplified even further by means of a small helper class:

```
from contextlib import ExitStack

class Callback(ExitStack):
    def __init__(self, callback, *args, **kwds):
        super(Callback, self).__init__()
        self.callback(callback, *args, **kwds)

    def cancel(self):
        self.pop_all()

with Callback(cleanup_resources) as cb:
    result = perform_operation()
    if result:
        cb.cancel()
```

If the resource cleanup isn't already neatly bundled into a standalone function, then it is still possible to use the decorator form of `ExitStack.callback()` to declare the resource cleanup in advance:

```
from contextlib import ExitStack

with ExitStack() as stack:
    @stack.callback
    def cleanup_resources():
        ...
    result = perform_operation()
    if result:
        stack.pop_all()
```

Due to the way the decorator protocol works, a callback function declared this way cannot take any parameters. Instead, any resources to be released must be accessed as closure variables.

29.6.2.6. Using a context manager as a function decorator

`ContextDecorator` makes it possible to use a context manager in both an ordinary `with` statement and also as a function decorator.

For example, it is sometimes useful to wrap functions or groups of statements with a logger that can track the time of entry and time of exit. Rather than writing both a function decorator and a context manager for the task, inheriting from `ContextDecorator` provides both capabilities in a single definition:

```
from contextlib import ContextDecorator
import logging

logging.basicConfig(level=logging.INFO)

class track_entry_and_exit(ContextDecorator):
    def __init__(self, name):
        self.name = name

    def __enter__(self):
        logging.info('Entering: %s', self.name)

    def __exit__(self, exc_type, exc, exc_tb):
        logging.info('Exiting: %s', self.name)
```

Instances of this class can be used as both a context manager:

```
with track_entry_and_exit('widget loader'):
    print('Some time consuming activity goes here')
    load_widget()
```

And also as a function decorator:

```
@track_entry_and_exit('widget loader')
def activity():
    print('Some time consuming activity goes here')
    load_widget()
```

Note that there is one additional limitation when using context managers as function decorators: there's no way to access the return value of `__enter__()`. If that value is needed, then it is still necessary to use an explicit `with` statement.

See also:

PEP 343 - The "with" statement
The specification, background, and examples for the Python `with` statement.

29.6.3. Single use, reusable and reentrant context managers

Most context managers are written in a way that means they can only be used effectively in a `with` statement once. These single use context managers must be created afresh each time they're used - attempting to use them a second time will trigger an exception or otherwise not work correctly.

This common limitation means that it is generally advisable to create context managers directly in the header of the `with` statement where they are used (as shown in all of the usage examples above).

Files are an example of effectively single use context managers, since the first `with` statement will close the file, preventing any further IO operations using that file object.

Context managers created using `contextmanager()` are also single use context managers, and will complain about the underlying generator failing to yield if an attempt is made to use them a second time:

```
>>> from contextlib import contextmanager
>>> @contextmanager
... def singleuse():
...     print("Before")
...     yield
...     print("After")
...
>>> cm = singleuse()
>>> with cm:
...     pass
...
```

```
Before
After
>>> with cm:
...     pass
...
Traceback (most recent call last):
    ...
RuntimeError: generator didn't yield
```

29.6.3.1. Reentrant context managers

More sophisticated context managers may be “reentrant”. These context managers can not only be used in multiple `with` statements, but may also be used *inside* a `with` statement that is already using the same context manager.

`threading.RLock` is an example of a reentrant context manager, as are `suppress()` and `redirect_stdout()`. Here’s a very simple example of reentrant use:

```
>>> from contextlib import redirect_stdout
>>> from io import StringIO
>>> stream = StringIO()
>>> write_to_stream = redirect_stdout(stream)
>>> with write_to_stream:
...     print("This is written to the stream rather than stdout")
...     with write_to_stream:
...         print("This is also written to the stream")
...
>>> print("This is written directly to stdout")
This is written directly to stdout
>>> print(stream.getvalue())
This is written to the stream rather than stdout
This is also written to the stream
```

Real world examples of reentrancy are more likely to involve multiple functions calling each other and hence be far more complicated than this example.

Note also that being reentrant is *not* the same thing as being thread safe. `redirect_stdout()`, for example, is definitely not thread safe, as it makes a global modification to the system state by binding `sys.stdout` to a different stream.

29.6.3.2. Reusable context managers

Distinct from both single use and reentrant context managers are “reusable” context managers (or, to be completely explicit, “reusable, but not reentrant” context managers, since reentrant context managers are also reusable). These context managers support being used multiple times, but will fail (or otherwise not work correctly) if the specific context manager instance has already been used in a containing with statement.

`threading.Lock` is an example of a reusable, but not reentrant, context manager (for a reentrant lock, it is necessary to use `threading.RLock` instead).

Another example of a reusable, but not reentrant, context manager is `ExitStack`, as it invokes *all* currently registered callbacks when leaving any with statement, regardless of where those callbacks were added:

```
>>> from contextlib import ExitStack
>>> stack = ExitStack()
>>> with stack:
...     stack.callback(print, "Callback: from first context")
...     print("Leaving first context")
...
Leaving first context
Callback: from first context
>>> with stack:
...     stack.callback(print, "Callback: from second context")
...     print("Leaving second context")
...
Leaving second context
Callback: from second context
>>> with stack:
...     stack.callback(print, "Callback: from outer context")
...     with stack:
...         stack.callback(print, "Callback: from inner context")
...         print("Leaving inner context")
...     print("Leaving outer context")
...
Leaving inner context
Callback: from inner context
Callback: from outer context
Leaving outer context
```

As the output from the example shows, reusing a single stack object across multiple with statements works correctly, but attempting to nest them will cause the stack to be cleared at the end of the innermost with statement, which is unlikely to be desirable behaviour.

Using separate `ExitStack` instances instead of reusing a single instance avoids that problem:

```
>>> from contextlib import ExitStack
>>> with ExitStack() as outer_stack:
...     outer_stack.callback(print, "Callback: from outer context")
...     with ExitStack() as inner_stack:
...         inner_stack.callback(print, "Callback: from inner context"
...         print("Leaving inner context")
...     print("Leaving outer context")
...
Leaving inner context
Callback: from inner context
Leaving outer context
Callback: from outer context
```