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# Hypothesis Documentation

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**David R. MacIver**

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[Hypothesis](#) is a Python library for creating unit tests which are simpler to write and more powerful when run, finding edge cases in your code you wouldn't have thought to look for. It is stable, powerful and easy to add to any existing test suite.

It works by letting you write tests that assert that something should be true for every case, not just the ones you happen to think of.

Think of a normal unit test as being something like the following:

1. Set up some data.
2. Perform some operations on the data.
3. Assert something about the result.

Hypothesis lets you write tests which instead look like this:

1. For all data matching some specification.
2. Perform some operations on the data.
3. Assert something about the result.

This is often called property based testing, and was popularised by the Haskell library [Quickcheck](#).

It works by generating arbitrary data matching your specification and checking that your guarantee still holds in that case. If it finds an example where it doesn't, it takes that example and cuts it down to size, simplifying it until it finds a much smaller example that still causes the problem. It then saves that example for later, so that once it has found a problem with your code it will not forget it in the future.

Writing tests of this form usually consists of deciding on guarantees that your code should make - properties that should always hold true, regardless of what the world throws at you. Examples of such guarantees might be:

- Your code shouldn't throw an exception, or should only throw a particular type of exception (this works particularly well if you have a lot of internal assertions).
- If you delete an object, it is no longer visible.
- If you serialize and then deserialize a value, then you get the same value back.

Now you know the basics of what Hypothesis does, the rest of this documentation will take you through how and why. It's divided into a number of sections, which you can see in the sidebar (or the menu at the top if you're on mobile), but you probably want to begin with the [Quick start guide](#), which will give you a worked example of how to use Hypothesis and a detailed outline of the things you need to know to begin testing your code with it, or check out some of the [introductory articles](#).



This document should talk you through everything you need to get started with Hypothesis.

### 1.1 An example

Suppose we've written a [run length encoding](#) system and we want to test it out.

We have the following code which I took straight from the [Rosetta Code](#) wiki (OK, I removed some commented out code and fixed the formatting, but there are no functional modifications):

```
def encode(input_string):
    count = 1
    prev = ''
    lst = []
    for character in input_string:
        if character != prev:
            if prev:
                entry = (prev, count)
                lst.append(entry)
            count = 1
            prev = character
        else:
            count += 1
    entry = (character, count)
    lst.append(entry)
    return lst

def decode(lst):
    q = ''
    for character, count in lst:
        q += character * count
    return q
```

We want to write a test for this that will check some invariant of these functions.

The invariant one tends to try when you've got this sort of encoding / decoding is that if you encode something and then decode it then you get the same value back.

Lets see how you'd do that with Hypothesis:

```
from hypothesis import given
from hypothesis.strategies import text

@given(text())
def test_decode_inverts_encode(s):
    assert decode(encode(s)) == s
```

(For this example we'll just let pytest discover and run the test. We'll cover other ways you could have run it later).

The text function returns what Hypothesis calls a search strategy. An object with methods that describe how to generate and simplify certain kinds of values. The `@given` decorator then takes our test function and turns it into a parametrized one which, when called, will run the test function over a wide range of matching data from that strategy.

Anyway, this test immediately finds a bug in the code:

```
Falsifying example: test_decode_inverts_encode(s='')
UnboundLocalError: local variable 'character' referenced before assignment
```

Hypothesis correctly points out that this code is simply wrong if called on an empty string.

If we fix that by just adding the following code to the beginning of the function then Hypothesis tells us the code is correct (by doing nothing as you'd expect a passing test to).

```
if not input_string:
    return []
```

If we wanted to make sure this example was always checked we could add it in explicitly by using the `@example` decorator:

```
from hypothesis import given, example
from hypothesis.strategies import text

@given(text())
@example('')
def test_decode_inverts_encode(s):
    assert decode(encode(s)) == s
```

This can be useful to show other developers (or your future self) what kinds of data are valid inputs, or to ensure that particular edge cases such as "" are tested every time. It's also great for regression tests because although Hypothesis will *remember failing examples*, we don't recommend distributing that database.

It's also worth noting that both example and given support keyword arguments as well as positional. The following would have worked just as well:

```
@given(s=text())
@example(s='')
def test_decode_inverts_encode(s):
    assert decode(encode(s)) == s
```

Suppose we had a more interesting bug and forgot to reset the count each time. Say we missed a line in our encode method:



```
def encode(input_string):
    count = 1
    prev = ''
    lst = []
    for character in input_string:
        if character != prev:
            if prev:
                entry = (prev, count)
                lst.append(entry)
                # count = 1 # Missing reset operation
            prev = character
        else:
            count += 1
    entry = (character, count)
    lst.append(entry)
    return lst
```

Hypothesis quickly informs us of the following example:

```
Falsifying example: test_decode_inverts_encode(s='001')
```

Note that the example provided is really quite simple. Hypothesis doesn't just find *any* counter-example to your tests, it knows how to simplify the examples it finds to produce small easy to understand ones. In this case, two identical values are enough to set the count to a number different from one, followed by another distinct value which should have reset the count but in this case didn't.

The examples Hypothesis provides are valid Python code you can run. Any arguments that you explicitly provide when calling the function are not generated by Hypothesis, and if you explicitly provide *all* the arguments Hypothesis will just call the underlying function once rather than running it multiple times.

## 1.2 Installing

Hypothesis is available on PyPI as “hypothesis”. You can install it with:

```
pip install hypothesis
```

You can install the dependencies for *optional extensions* with e.g. `pip install hypothesis[pandas, django]`.

If you want to install directly from the source code (e.g. because you want to make changes and install the changed version), check out the instructions in [CONTRIBUTING.rst](#).

## 1.3 Running tests

In our example above we just let pytest discover and run our tests, but we could also have run it explicitly ourselves:

```
if __name__ == '__main__':
    test_decode_inverts_encode()
```

We could also have done this as a `unittest.TestCase`:

```
import unittest

class TestEncoding(unittest.TestCase):
    @given(text())
    def test_decode_inverts_encode(self, s):
        self.assertEqual(decode(encode(s)), s)

if __name__ == '__main__':
    unittest.main()
```

A detail: This works because Hypothesis ignores any arguments it hasn't been told to provide (positional arguments start from the right), so the self argument to the test is simply ignored and works as normal. This also means that Hypothesis will play nicely with other ways of parameterizing tests. e.g it works fine if you use pytest fixtures for some arguments and Hypothesis for others.

## 1.4 Writing tests

A test in Hypothesis consists of two parts: A function that looks like a normal test in your test framework of choice but with some additional arguments, and a *@given* decorator that specifies how to provide those arguments.

Here are some other examples of how you could use that:

```
from hypothesis import given
import hypothesis.strategies as st

@given(st.integers(), st.integers())
def test_ints_are_commutative(x, y):
    assert x + y == y + x

@given(x=st.integers(), y=st.integers())
def test_ints_cancel(x, y):
    assert (x + y) - y == x

@given(st.lists(st.integers()))
def test_reversing_twice_gives_same_list(xs):
    # This will generate lists of arbitrary length (usually between 0 and
    # 100 elements) whose elements are integers.
    ys = list(xs)
    ys.reverse()
    ys.reverse()
    assert xs == ys

@given(st.tuples(st.booleans(), st.text()))
def test_look_tuples_work_too(t):
    # A tuple is generated as the one you provided, with the corresponding
    # types in those positions.
    assert len(t) == 2
    assert isinstance(t[0], bool)
    assert isinstance(t[1], str)
```

Note that as we saw in the above example you can pass arguments to *@given* either as positional or as keywords.

## 1.5 Where to start

You should now know enough of the basics to write some tests for your code using Hypothesis. The best way to learn is by doing, so go have a try.

If you're stuck for ideas for how to use this sort of test for your code, here are some good starting points:

1. Try just calling functions with appropriate arbitrary data and see if they crash. You may be surprised how often this works. e.g. note that the first bug we found in the encoding example didn't even get as far as our assertion: It crashed because it couldn't handle the data we gave it, not because it did the wrong thing.
2. Look for duplication in your tests. Are there any cases where you're testing the same thing with multiple different examples? Can you generalise that to a single test using Hypothesis?
3. [This piece is designed for an F# implementation](#), but is still very good advice which you may find helps give you good ideas for using Hypothesis.

If you have any trouble getting started, don't feel shy about *asking for help*.



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## Details and advanced features

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This is an account of slightly less common Hypothesis features that you don't need to get started but will nevertheless make your life easier.

### 2.1 Additional test output

Normally the output of a failing test will look something like:

```
Falsifying example: test_a_thing(x=1, y="foo")
```

With the `repr` of each keyword argument being printed.

Sometimes this isn't enough, either because you have values with a `repr` that isn't very descriptive or because you need to see the output of some intermediate steps of your test. That's where the `note` function comes in:

`hypothesis.note(value)`

Report this value in the final execution.

```
>>> from hypothesis import given, note, strategies as st
>>> @given(st.lists(st.integers()), st.randoms())
... def test_shuffle_is_noop(ls, r):
...     ls2 = list(ls)
...     r.shuffle(ls2)
...     note("Shuffle: %r" % (ls2))
...     assert ls == ls2
...
>>> try:
...     test_shuffle_is_noop()
... except AssertionError:
...     print('ls != ls2')
Falsifying example: test_shuffle_is_noop(ls=[0, 1], r=RandomWithSeed(1))
Shuffle: [1, 0]
ls != ls2
```

The note is printed in the final run of the test in order to include any additional information you might need in your test.

## 2.2 Test Statistics

If you are using `pytest` you can see a number of statistics about the executed tests by passing the command line argument `--hypothesis-show-statistics`. This will include some general statistics about the test:

For example if you ran the following with `--hypothesis-show-statistics`:

```
from hypothesis import given, strategies as st

@given(st.integers())
def test_integers(i):
    pass
```

You would see:

```
test_integers:
- 100 passing examples, 0 failing examples, 0 invalid examples
- Typical runtimes: ~ 1ms
- Fraction of time spent in data generation: ~ 12%
- Stopped because settings.max_examples=100
```

The final “Stopped because” line is particularly important to note: It tells you the setting value that determined when the test should stop trying new examples. This can be useful for understanding the behaviour of your tests. Ideally you’d always want this to be `max_examples`.

In some cases (such as filtered and recursive strategies) you will see events mentioned which describe some aspect of the data generation:

```
from hypothesis import given, strategies as st

@given(st.integers().filter(lambda x: x % 2 == 0))
def test_even_integers(i):
    pass
```

You would see something like:

```
test_even_integers:
- 100 passing examples, 0 failing examples, 36 invalid examples
- Typical runtimes: 0-1 ms
- Fraction of time spent in data generation: ~ 16%
- Stopped because settings.max_examples=100
- Events:
  * 80.88%, Retried draw from integers().filter(lambda x: <unknown>) to satisfy_
↳filter
  * 26.47%, Aborted test because unable to satisfy integers().filter(lambda x:
↳<unknown>)
```

You can also mark custom events in a test using the `event` function:

`hypothesis.event` (*value*)

Record an event that occurred this test. Statistics on number of test runs with each event will be reported at the end if you run Hypothesis in statistics reporting mode.

Events should be strings or convertible to them.

```
from hypothesis import given, event, strategies as st

@given(st.integers().filter(lambda x: x % 2 == 0))
def test_even_integers(i):
    event("i mod 3 = %d" % (i % 3,))
```

You will then see output like:

```
test_even_integers:
- 100 passing examples, 0 failing examples, 38 invalid examples
- Typical runtimes: 0-1 ms
- Fraction of time spent in data generation: ~ 16%
- Stopped because settings.max_examples=100
- Events:
  * 80.43%, Retried draw from integers().filter(lambda x: <unknown>) to satisfy_
↳filter
  * 31.88%, i mod 3 = 0
  * 27.54%, Aborted test because unable to satisfy integers().filter(lambda x:
↳<unknown>)
  * 21.74%, i mod 3 = 1
  * 18.84%, i mod 3 = 2
```

Arguments to `event` can be any hashable type, but two events will be considered the same if they are the same when converted to a string with `str`.

## 2.3 Making assumptions

Sometimes Hypothesis doesn't give you exactly the right sort of data you want - it's mostly of the right shape, but some examples won't work and you don't want to care about them. You *can* just ignore these by aborting the test early, but this runs the risk of accidentally testing a lot less than you think you are. Also it would be nice to spend less time on bad examples - if you're running 100 examples per test (the default) and it turns out 70 of those examples don't match your needs, that's a lot of wasted time.

`hypothesis.assume` (*condition*)

Calling `assume` is like an `assert` that marks the example as bad, rather than failing the test.

This allows you to specify properties that you *assume* will be true, and let Hypothesis try to avoid similar examples in future.

For example suppose you had the following test:

```
@given(floats())
def test_negation_is_self_inverse(x):
    assert x == -(-x)
```

Running this gives us:

```
Falsifying example: test_negation_is_self_inverse(x=float('nan'))
AssertionError
```

This is annoying. We know about NaN and don't really care about it, but as soon as Hypothesis finds a NaN example it will get distracted by that and tell us about it. Also the test will fail and we want it to pass.

So lets block off this particular example:

```
from math import isnan

@given(floats())
def test_negation_is_self_inverse_for_non_nan(x):
    assume(not isnan(x))
    assert x == -(-x)
```

And this passes without a problem.

In order to avoid the easy trap where you assume a lot more than you intended, Hypothesis will fail a test when it can't find enough examples passing the assumption.

If we'd written:

```
@given(floats())
def test_negation_is_self_inverse_for_non_nan(x):
    assume(False)
    assert x == -(-x)
```

Then on running we'd have got the exception:

```
Unsatisfiable: Unable to satisfy assumptions of hypothesis test_negation_is_self_
↪inverse_for_non_nan. Only 0 examples considered satisfied assumptions
```

### 2.3.1 How good is assume?

Hypothesis has an adaptive exploration strategy to try to avoid things which falsify assumptions, which should generally result in it still being able to find examples in hard to find situations.

Suppose we had the following:

```
@given(lists(integers()))
def test_sum_is_positive(xs):
    assert sum(xs) > 0
```

Unsurprisingly this fails and gives the falsifying example `[]`.

Adding `assume(xs)` to this removes the trivial empty example and gives us `[0]`.

Adding `assume(all(x > 0 for x in xs))` and it passes: the sum of a list of positive integers is positive.

The reason that this should be surprising is not that it doesn't find a counter-example, but that it finds enough examples at all.

In order to make sure something interesting is happening, suppose we wanted to try this for long lists. e.g. suppose we added an `assume(len(xs) > 10)` to it. This should basically never find an example: a naive strategy would find fewer than one in a thousand examples, because if each element of the list is negative with probability one-half, you'd have to have ten of these go the right way by chance. In the default configuration Hypothesis gives up long before it's tried 1000 examples (by default it tries 200).

Here's what happens if we try to run this:

```
@given(lists(integers()))
def test_sum_is_positive(xs):
    assume(len(xs) > 10)
    assume(all(x > 0 for x in xs))
    print(xs)
    assert sum(xs) > 0
```

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```
In: test_sum_is_positive()
[17, 12, 7, 13, 11, 3, 6, 9, 8, 11, 47, 27, 1, 31, 1]
[6, 2, 29, 30, 25, 34, 19, 15, 50, 16, 10, 3, 16]
[25, 17, 9, 19, 15, 2, 2, 4, 22, 10, 10, 27, 3, 1, 14, 17, 13, 8, 16, 9, 2...
[17, 65, 78, 1, 8, 29, 2, 79, 28, 18, 39]
[13, 26, 8, 3, 4, 76, 6, 14, 20, 27, 21, 32, 14, 42, 9, 24, 33, 9, 5, 15, ...
[2, 1, 2, 2, 3, 10, 12, 11, 21, 11, 1, 16]
```

As you can see, Hypothesis doesn't find *many* examples here, but it finds some - enough to keep it happy.

In general if you *can* shape your strategies better to your tests you should - for example `integers(1, 1000)` is a lot better than `assume(1 <= x <= 1000)`, but `assume` will take you a long way if you can't.

## 2.4 Defining strategies

The type of object that is used to explore the examples given to your test function is called a `SearchStrategy`. These are created using the functions exposed in the `hypothesis.strategies` module.

Many of these strategies expose a variety of arguments you can use to customize generation. For example for integers you can specify `min` and `max` values of integers you want. If you want to see exactly what a strategy produces you can ask for an example:

```
>>> integers(min_value=0, max_value=10).example()
1
```

Many strategies are built out of other strategies. For example, if you want to define a tuple you need to say what goes in each element:

```
>>> from hypothesis.strategies import tuples
>>> tuples(integers(), integers()).example()
(-24597, 12566)
```

Further details are *available in a separate document*.

## 2.5 The gory details of given parameters

`hypothesis.given(*given_arguments, **given_kwargs)`

A decorator for turning a test function that accepts arguments into a randomized test.

This is the main entry point to Hypothesis.

The `@given` decorator may be used to specify which arguments of a function should be parametrized over. You can use either positional or keyword arguments, but not a mixture of both.

For example all of the following are valid uses:

```
@given(integers(), integers())
def a(x, y):
    pass

@given(integers())
def b(x, y):
```

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```
    pass

@given(y=integers())
def c(x, y):
    pass

@given(x=integers())
def d(x, y):
    pass

@given(x=integers(), y=integers())
def e(x, **kwargs):
    pass

@given(x=integers(), y=integers())
def f(x, *args, **kwargs):
    pass

class SomeTest(TestCase):
    @given(integers())
    def test_a_thing(self, x):
        pass
```

The following are not:

```
@given(integers(), integers(), integers())
def g(x, y):
    pass

@given(integers())
def h(x, *args):
    pass

@given(integers(), x=integers())
def i(x, y):
    pass

@given()
def j(x, y):
    pass
```

The rules for determining what are valid uses of `given` are as follows:

1. You may pass any keyword argument to `given`.
2. Positional arguments to `given` are equivalent to the rightmost named arguments for the test function.
3. Positional arguments may not be used if the underlying test function has varargs, arbitrary keywords, or keyword-only arguments.
4. Functions tested with `given` may not have any defaults.

The reason for the “rightmost named arguments” behaviour is so that using `@given` with instance methods works: `self` will be passed to the function as normal and not be parametrized over.

The function returned by `given` has all the same arguments as the original test, minus those that are filled in by `@given`. Check [the notes on framework compatibility](#) to see how this affects other testing libraries you may be using.

## 2.6 Custom function execution

Hypothesis provides you with a hook that lets you control how it runs examples.

This lets you do things like set up and tear down around each example, run examples in a subprocess, transform coroutine tests into normal tests, etc. For example, `TransactionTestCase` in the Django extra runs each example in a separate database transaction.

The way this works is by introducing the concept of an executor. An executor is essentially a function that takes a block of code and run it. The default executor is:

```
def default_executor(function):
    return function()
```

You define executors by defining a method `execute_example` on a class. Any test methods on that class with `@given` used on them will use `self.execute_example` as an executor with which to run tests. For example, the following executor runs all its code twice:

```
from unittest import TestCase

class TestTryReallyHard(TestCase):
    @given(integers())
    def test_something(self, i):
        perform_some_unreliable_operation(i)

    def execute_example(self, f):
        f()
        return f()
```

Note: The functions you use in `map`, etc. will run *inside* the executor. i.e. they will not be called until you invoke the function passed to `execute_example`.

An executor must be able to handle being passed a function which returns `None`, otherwise it won't be able to run normal test cases. So for example the following executor is invalid:

```
from unittest import TestCase

class TestRunTwice(TestCase):
    def execute_example(self, f):
        return f()()
```

and should be rewritten as:

```
from unittest import TestCase

class TestRunTwice(TestCase):
    def execute_example(self, f):
        result = f()
        if callable(result):
            result = result()
        return result
```

An alternative hook is provided for use by test runner extensions such as `pytest-trio`, which cannot use the `execute_example` method. This is **not** recommended for end-users - it is better to write a complete test function directly, perhaps by using a decorator to perform the same transformation before applying `@given`.

```
@given(x=integers())
@pytest.mark.trio
async def test(x):
    ...
# Illustrative code, inside the pytest-trio plugin
test.hypothesis.inner_test = lambda x: trio.run(test, x)
```

For authors of test runners however, assigning to the `inner_test` attribute of the `hypothesis` attribute of the test will replace the interior test.

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**Note:** The new `inner_test` must accept and pass through all the `*args` and `**kwargs` expected by the original test.

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If the end user has also specified a custom executor using the `execute_example` method, it - and all other execution-time logic - will be applied to the *new* inner test assigned by the test runner.

## 2.7 Making random code deterministic

While Hypothesis' example generation can be used for nondeterministic tests, debugging anything nondeterministic is usually a very frustrating exercise. To make things worse, our example *shrinking* relies on the same input causing the same failure each time - though we show the un-shrunk failure and a decent error message if it doesn't.

By default, Hypothesis will handle the global `random` and `numpy.random` random number generators for you, and you can register others:

```
hypothesis.register_random(r)
```

Register the given `Random` instance for management by Hypothesis.

You can pass `random.Random` instances (or other objects with `seed`, `getstate`, and `setstate` methods) to `register_random(r)` to have their states seeded and restored in the same way as the global PRNGs from the `random` and `numpy.random` modules.

All global PRNGs, from e.g. simulation or scheduling frameworks, should be registered to prevent flaky tests. Hypothesis will ensure that the PRNG state is consistent for all test runs, or reproducibly varied if you choose to use the `random_module()` strategy.

## 2.8 Using Hypothesis to find values

You can use Hypothesis's data exploration features to find values satisfying some predicate. This is generally useful for exploring custom strategies defined with `@composite`, or experimenting with conditions for filtering data.

```
hypothesis.find(specifier, condition, settings=None, random=None, database_key=None)
```

Returns the minimal example from the given strategy `specifier` that matches the predicate function `condition`.

```
>>> from hypothesis import find
>>> from hypothesis.strategies import sets, lists, integers
>>> find(lists(integers()), lambda x: sum(x) >= 10)
[10]
>>> find(lists(integers()), lambda x: sum(x) >= 10 and len(x) >= 3)
[0, 0, 10]
```

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```
>>> find(sets(integers()), lambda x: sum(x) >= 10 and len(x) >= 3)
{0, 1, 9}
```

The first argument to `find()` describes data in the usual way for an argument to `given()`, and supports *all the same data types*. The second is a predicate it must satisfy.

Of course not all conditions are satisfiable. If you ask Hypothesis for an example to a condition that is always false it will raise an error:

```
>>> find(integers(), lambda x: False)
Traceback (most recent call last):
...
hypothesis.errors.NoSuchExample: No examples of condition lambda x: <unknown>
```

(The `lambda x: unknown` is because Hypothesis can't retrieve the source code of lambdas from the interactive python console. It gives a better error message most of the time which contains the actual condition)

## 2.9 Inferred Strategies

In some cases, Hypothesis can work out what to do when you omit arguments. This is based on introspection, *not* magic, and therefore has well-defined limits.

`builds()` will check the signature of the `target` (using `getfullargspec()`). If there are required arguments with type annotations and no strategy was passed to `builds()`, `from_type()` is used to fill them in. You can also pass the special value `hypothesis.infer` as a keyword argument, to force this inference for arguments with a default value.

```
>>> def func(a: int, b: str):
...     return [a, b]
>>> builds(func).example()
[-6993, '']
```

`hypothesis.infer`

`@given` does not perform any implicit inference for required arguments, as this would break compatibility with pytest fixtures. `infer` can be used as a keyword argument to explicitly fill in an argument from its type annotation.

```
@given(a=infer)
def test(a: int): pass
# is equivalent to
@given(a=integers())
def test(a): pass
```

### 2.9.1 Limitations

**PEP 3107** type annotations are not supported on Python 2, and Hypothesis does not inspect **PEP 484** type comments at runtime. While `from_type()` will work as usual, inference in `builds()` and `@given` will only work if you manually create the `__annotations__` attribute (e.g. by using `@annotations(...)` and `@returns(...)` decorators). The `typing` module is fully supported on Python 2 if you have the backport installed.

The `typing` module is provisional and has a number of internal changes between Python 3.5.0 and 3.6.1, including at minor versions. These are all supported on a best-effort basis, but you may encounter problems with an old version of the module. Please report them to us, and consider updating to a newer version of Python as a workaround.

## 2.10 Type Annotations in Hypothesis

If you install Hypothesis and use `mypy` 0.590+, or another [PEP 561](#)-compatible tool, the type checker should automatically pick up our type hints.

---

**Note:** Hypothesis' type hints may make breaking changes between minor releases.

Upstream tools and conventions about type hints remain in flux - for example the `typing` module itself is provisional, and Mypy has not yet reached version 1.0 - and we plan to support the latest version of this ecosystem, as well as older versions where practical.

We may also find more precise ways to describe the type of various interfaces, or change their type and runtime behaviour together in a way which is otherwise backwards-compatible. We often omit type hints for deprecated features or arguments, as an additional form of warning.

---

There are known issues inferring the type of examples generated by `deferred()`, `recursive()`, `one_of()`, `dictionaries()`, and `fixed_dictionaries()`. We will fix these, and require correspondingly newer versions of Mypy for type hinting, as the ecosystem improves.

### 2.10.1 Writing downstream type hints

Projects that *provide Hypothesis strategies* and use type hints may wish to annotate their strategies too. This is a supported use-case, again on a best-effort provisional basis. For example:

```
def foo_strategy() -> SearchStrategy[Foo]: ...
```

**class** `hypothesis.strategies.SearchStrategy`

`SearchStrategy` is the type of all strategy objects. It is a generic type, and covariant in the type of the examples it creates. For example:

- `integers()` is of type `SearchStrategy[int]`.
- `lists(integers())` is of type `SearchStrategy[List[int]]`.
- `SearchStrategy[Dog]` is a subtype of `SearchStrategy[Animal]` if `Dog` is a subtype of `Animal` (as seems likely).

**Warning:** `SearchStrategy` should only be used in type hints. Please do not inherit from, compare to, or otherwise use it in any way outside of type hints. The only supported way to construct objects of this type is to use the functions provided by the `hypothesis.strategies` module!

## 2.11 The Hypothesis pytest Plugin

Hypothesis includes a tiny plugin to improve integration with `pytest`, which is activated by default (but does not affect other test runners). It aims to improve the integration between Hypothesis and Pytest by providing extra information and convenient access to config options.

- `pytest --hypothesis-show-statistics` can be used to *display test and data generation statistics*.
- `pytest --hypothesis-profile=<profile name>` can be used to *load a settings profile*. `pytest --hypothesis-verbosity=<level name>` can be used to *override the current verbosity level*.

- `pytest --hypothesis-seed=<an int>` can be used to *reproduce a failure with a particular seed*.

Finally, all tests that are defined with Hypothesis automatically have `@pytest.mark.hypothesis` applied to them. See [here](#) for information on working with markers.

---

**Note:** Pytest will load the plugin automatically if Hypothesis is installed. You don't need to do anything at all to use it.

---





Hypothesis tries to have good defaults for its behaviour, but sometimes that's not enough and you need to tweak it.

The mechanism for doing this is the `settings` object. You can set up a `@given` based test to use this using a settings decorator:

`@given` invocation is as follows:

```
from hypothesis import given, settings

@given(integers())
@settings(max_examples=500)
def test_this_thoroughly(x):
    pass
```

This uses a `settings` object which causes the test to receive a much larger set of examples than normal.

This may be applied either before or after the given and the results are the same. The following is exactly equivalent:

```
from hypothesis import given, settings

@settings(max_examples=500)
@given(integers())
def test_this_thoroughly(x):
    pass
```

### 3.1 Available settings

**class** `hypothesis.settings` (*parent=None, \*\*kwargs*)

A settings object controls a variety of parameters that are used in falsification. These may control both the falsification strategy and the details of the data that is generated.

Default values are picked up from the `settings.default` object and changes made there will be picked up in newly created settings.

### **buffer\_size**

The size of the underlying data used to generate examples. If you need to generate really large examples you may want to increase this, but it will make your tests slower.

default value: (dynamically calculated)

### **database**

An instance of `hypothesis.database.ExampleDatabase` that will be used to save examples to and load previous examples from. May be `None` in which case no storage will be used, `:memory:` for an in-memory database, or any path for a directory-based example database.

default value: (dynamically calculated)

### **deadline**

If set, a time in milliseconds (which may be a float to express smaller units of time) that each individual example (i.e. each time your test function is called, not the whole decorated test) within a test is not allowed to exceed. Tests which take longer than that may be converted into errors (but will not necessarily be if close to the deadline, to allow some variability in test run time).

Set this to `None` to disable this behaviour entirely.

default value: 200

### **derandomize**

If this is `True` then hypothesis will run in deterministic mode where each falsification uses a random number generator that is seeded based on the hypothesis to falsify, which will be consistent across multiple runs. This has the advantage that it will eliminate any randomness from your tests, which may be preferable for some situations. It does have the disadvantage of making your tests less likely to find novel breakages.

default value: `False`

### **max\_examples**

Once this many satisfying examples have been considered without finding any counter-example, falsification will terminate.

The default value is chosen to suit a workflow where the test will be part of a suite that is regularly executed locally or on a CI server, balancing total running time against the chance of missing a bug.

If you are writing one-off tests, running tens of thousands of examples is quite reasonable as Hypothesis may miss uncommon bugs with default settings. For very complex code, we have observed Hypothesis finding novel bugs after *several million* examples while testing `SymPy`.

default value: 100

### **phases**

Control which phases should be run. See [the full documentation for more details](#)

default value: (<Phase.explicit: 0>, <Phase.reuse: 1>, <Phase.generate: 2>, <Phase.shrink: 3>)

### **print\_blob**

Determines whether to print blobs after tests that can be used to reproduce failures.

See [the documentation on @reproduce\\_failure](#) for more details of this behaviour.

default value: `PrintSettings.INFER`

### **report\_multiple\_bugs**

Because Hypothesis runs the test many times, it can sometimes find multiple bugs in a single run. Reporting all of them at once is usually very useful, but replacing the exceptions can occasionally clash with debuggers. If disabled, only the exception with the smallest minimal example is raised.

default value: `True`

**stateful\_step\_count**

Number of steps to run a stateful program for before giving up on it breaking.

default value: 50

**suppress\_health\_check**

A list of health checks to disable.

default value: ()

**timeout**

The timeout setting has been deprecated and no longer does anything.

default value: not\_set

The timeout setting can safely be removed with no effect.

**verbosity**

Control the verbosity level of Hypothesis messages

default value: Verbosity.normal

### 3.1.1 Controlling What Runs

Hypothesis divides tests into four logically distinct phases:

1. Running explicit examples *provided with the `@example decorator`*.
2. Rerunning a selection of previously failing examples to reproduce a previously seen error
3. Generating new examples.
4. Attempting to shrink an example found in phases 2 or 3 to a more manageable one (explicit examples cannot be shrunk).

The `phases` setting provides you with fine grained control over which of these run, with each phase corresponding to a value on the `Phase` enum:

**class hypothesis.Phase**

1. `Phase.explicit` controls whether explicit examples are run.
2. `Phase.reuse` controls whether previous examples will be reused.
3. `Phase.generate` controls whether new examples will be generated.
4. `Phase.shrink` controls whether examples will be shrunk.

The `phases` argument accepts a collection with any subset of these. e.g. `settings(phases=[Phase.generate, Phase.shrink])` will generate new examples and shrink them, but will not run explicit examples or reuse previous failures, while `settings(phases=[Phase.explicit])` will only run the explicit examples.

### 3.1.2 Seeing intermediate result

To see what's going on while Hypothesis runs your tests, you can turn up the verbosity setting. This works with both `find()` and `@given`.

```
>>> from hypothesis import find, settings, Verbosity
>>> from hypothesis.strategies import lists, integers
>>> find(lists(integers()), any, settings=settings(verbosity=Verbosity.verbose))
Tried non-satisfying example []
```

(continues on next page)

(continued from previous page)

```
Found satisfying example [-1198601713, -67, 116, -29578]
Shrunk example to [-1198601713]
Shrunk example to [-1198601600]
Shrunk example to [-1191228800]
Shrunk example to [-8421504]
Shrunk example to [-32896]
Shrunk example to [-128]
Shrunk example to [64]
Shrunk example to [32]
Shrunk example to [16]
Shrunk example to [8]
Shrunk example to [4]
Shrunk example to [3]
Shrunk example to [2]
Shrunk example to [1]
[1]
```

The four levels are quiet, normal, verbose and debug. normal is the default, while in quiet mode Hypothesis will not print anything out, not even the final falsifying example. debug is basically verbose but a bit more so. You probably don't want it.

If you are using `pytest`, you may also need to [disable output capturing for passing tests](#).

## 3.2 Building settings objects

Settings can be created by calling `settings` with any of the available settings values. Any absent ones will be set to defaults:

```
>>> from hypothesis import settings
>>> settings().max_examples
100
>>> settings(max_examples=10).max_examples
10
```

You can also pass a 'parent' settings object as the first argument, and any settings you do not specify as keyword arguments will be copied from the parent settings:

```
>>> parent = settings(max_examples=10)
>>> child = settings(parent, deadline=None)
>>> parent.max_examples == child.max_examples == 10
True
>>> parent.deadline
200
>>> child.deadline is None
True
```

## 3.3 Default settings

At any given point in your program there is a current default settings, available as `settings.default`. As well as being a settings object in its own right, all newly created settings objects which are not explicitly based off another settings are based off the default, so will inherit any values that are not explicitly set from it.

You can change the defaults by using profiles.

### 3.3.1 settings Profiles

Depending on your environment you may want different default settings. For example: during development you may want to lower the number of examples to speed up the tests. However, in a CI environment you may want more examples so you are more likely to find bugs.

Hypothesis allows you to define different settings profiles. These profiles can be loaded at any time.

**class** `hypothesis.settings` (*parent=None, \*\*kwargs*)

A settings object controls a variety of parameters that are used in falsification. These may control both the falsification strategy and the details of the data that is generated.

Default values are picked up from the `settings.default` object and changes made there will be picked up in newly created settings.

**static** `register_profile` (*name, parent=None, \*\*kwargs*)

Registers a collection of values to be used as a settings profile.

Settings profiles can be loaded by name - for example, you might create a 'fast' profile which runs fewer examples, keep the 'default' profile, and create a 'ci' profile that increases the number of examples and uses a different database to store failures.

The arguments to this method are exactly as for `settings`: optional `parent` settings, and keyword arguments for each setting that will be set differently to parent (or `settings.default`, if parent is None).

**static** `get_profile` (*name*)

Return the profile with the given name.

**static** `load_profile` (*name*)

Loads in the settings defined in the profile provided.

If the profile does not exist, `InvalidArgument` will be raised. Any setting not defined in the profile will be the library defined default for that setting.

Loading a profile changes the default settings but will not change the behavior of tests that explicitly change the settings.

```
>>> from hypothesis import settings
>>> settings.register_profile("ci", max_examples=1000)
>>> settings().max_examples
100
>>> settings.load_profile("ci")
>>> settings().max_examples
1000
```

Instead of loading the profile and overriding the defaults you can retrieve profiles for specific tests.

```
>>> settings.get_profile("ci").max_examples
1000
```

Optionally, you may define the environment variable to load a profile for you. This is the suggested pattern for running your tests on CI. The code below should run in a `confest.py` or any setup/initialization section of your test suite. If this variable is not defined the Hypothesis defined defaults will be loaded.

```
>>> import os
>>> from hypothesis import settings, Verbosity
>>> settings.register_profile("ci", max_examples=1000)
>>> settings.register_profile("dev", max_examples=10)
>>> settings.register_profile("debug", max_examples=10, verbosity=Verbosity.verbose)
>>> settings.load_profile(os.getenv('HYPOTHESIS_PROFILE', 'default'))
```

If you are using the hypothesis pytest plugin and your profiles are registered by your confest you can load one with the command line option `--hypothesis-profile`.

```
$ pytest tests --hypothesis-profile <profile-name>
```

---

## What you can generate and how

---

*Most things should be easy to generate and everything should be possible.*

To support this principle Hypothesis provides strategies for most built-in types with arguments to constrain or adjust the output, as well as higher-order strategies that can be composed to generate more complex types.

This document is a guide to what strategies are available for generating data and how to build them. Strategies have a variety of other important internal features, such as how they simplify, but the data they can generate is the only public part of their API.

Functions for building strategies are all available in the `hypothesis.strategies` module. The salient functions from it are as follows:

`hypothesis.strategies.binary` (*min\_size=0, max\_size=None*)  
Generates the appropriate binary type (str in python 2, bytes in python 3).

`min_size` and `max_size` have the usual interpretations.

Examples from this strategy shrink towards smaller strings and lower byte values.

`hypothesis.strategies.booleans` ()  
Returns a strategy which generates instances of `bool`.

Examples from this strategy will shrink towards `False` (i.e. shrinking will try to replace `True` with `False` where possible).

`hypothesis.strategies.builds` (*\*callable\_and\_args, \*\*kwargs*)  
Generates values by drawing from `args` and `kwargs` and passing them to the callable (provided as the first positional argument) in the appropriate argument position.

e.g. `builds(target, integers(), flag=booleans())` would draw an integer `i` and a boolean `b` and call `target(i, flag=b)`.

If the callable has type annotations, they will be used to infer a strategy for required arguments that were not passed to `builds`. You can also tell `builds` to infer a strategy for an optional argument by passing the special value `hypothesis.infer` as a keyword argument to `builds`, instead of a strategy for that argument to the callable.

If the callable is a class defined with `attrs`, missing required arguments will be inferred from the attribute on a best-effort basis, e.g. by checking `attrs` standard validators. Dataclasses are handled natively by the inference

from type hints.

Examples from this strategy shrink by shrinking the argument values to the callable.

```
hypothesis.strategies.characters(whitelist_categories=None,    blacklist_categories=None,
                                blacklist_characters=None,    min_codepoint=None,
                                max_codepoint=None, whitelist_characters=None)
```

Generates unicode text type (unicode on python 2, str on python 3) characters following specified filtering rules.

- When no filtering rules are specified, any character can be produced.
- If `min_codepoint` or `max_codepoint` is specified, then only characters having a codepoint in that range will be produced.
- If `whitelist_categories` is specified, then only characters from those Unicode categories will be produced. This is a further restriction, characters must also satisfy `min_codepoint` and `max_codepoint`.
- If `blacklist_categories` is specified, then any character from those categories will not be produced. Any overlap between `whitelist_categories` and `blacklist_categories` will raise an exception, as each character can only belong to a single class.
- If `whitelist_characters` is specified, then any additional characters in that list will also be produced.
- If `blacklist_characters` is specified, then any characters in that list will be not be produced. Any overlap between `whitelist_characters` and `blacklist_characters` will raise an exception.

The `_codepoint` arguments must be integers between zero and `sys.maxunicode`. The `_characters` arguments must be collections of length-one unicode strings, such as a unicode string.

The `_categories` arguments must be used to specify either the one-letter Unicode major category or the two-letter Unicode [general category](#). For example, `('Nd', 'Lu')` signifies “Number, decimal digit” and “Letter, uppercase”. A single letter (‘major category’) can be given to match all corresponding categories, for example `'P'` for characters in any punctuation category.

Examples from this strategy shrink towards the codepoint for `'0'`, or the first allowable codepoint after it if `'0'` is excluded.

```
hypothesis.strategies.complex_numbers(min_magnitude=0,    max_magnitude=None,    al-
                                      low_infinity=None, allow_nan=None)
```

Returns a strategy that generates complex numbers.

This strategy draws complex numbers with constrained magnitudes. The `min_magnitude` and `max_magnitude` parameters should be non-negative [Real](#) numbers; values of `None` correspond to zero and infinite values respectively.

If `min_magnitude` is positive or `max_magnitude` is finite, it is an error to enable `allow_nan`. If `max_magnitude` is finite, it is an error to enable `allow_infinity`.

The magnitude constraints are respected up to a relative error of (around) floating-point epsilon, due to implementation via the system `sqrt` function.

Examples from this strategy shrink by shrinking their real and imaginary parts, as `floats()`.

If you need to generate complex numbers with particular real and imaginary parts or relationships between parts, consider using `builds(complex, ...)` or `@composite` respectively.

```
hypothesis.strategies.composite(f)
```

Defines a strategy that is built out of potentially arbitrarily many other strategies.

This is intended to be used as a decorator. See [the full documentation for more details](#) about how to use this function.



Examples from this strategy shrink by shrinking the output of each draw call.

```
hypothesis.strategies.data()
```

This isn't really a normal strategy, but instead gives you an object which can be used to draw data interactively from other strategies.

It can only be used within `@given`, not `find()`. This is because the lifetime of the object cannot outlast the test body.

See [the rest of the documentation](#) for more complete information.

Examples from this strategy do not shrink (because there is only one), but the result of calls to each `draw()` call shrink as they normally would.

```
hypothesis.strategies.dates(min_value=datetime.date(1, 1, 1), max_value=datetime.date(9999,
12, 31))
```

A strategy for dates between `min_value` and `max_value`.

Examples from this strategy shrink towards January 1st 2000.

```
hypothesis.strategies.datetimes(min_value=datetime.datetime(1, 1, 1, 0, 0),
max_value=datetime.datetime(9999, 12, 31, 23, 59, 59,
999999), timezones=None())
```

A strategy for generating datetimes, which may be timezone-aware.

This strategy works by drawing a naive datetime between `min_value` and `max_value`, which must both be naive (have no timezone).

`timezones` must be a strategy that generates `tzinfo` objects (or `None`, which is valid for naive datetimes). A value drawn from this strategy will be added to a naive datetime, and the resulting tz-aware datetime returned.

---

**Note:** tz-aware datetimes from this strategy may be ambiguous or non-existent due to daylight savings, leap seconds, timezone and calendar adjustments, etc. This is intentional, as malformed timestamps are a common source of bugs.

---

`hypothesis.extra.pytz.timezones()` requires the `pytz` package, but provides all timezones in the Olsen database. If you want to allow naive datetimes, combine strategies like `none() | timezones()`.

`hypothesis.extra.dateutil.timezones()` requires the `python-dateutil` package, and similarly provides all timezones there.

Alternatively, you can create a list of the timezones you wish to allow (e.g. from the standard library, `dateutil`, or `pytz`) and use `sampled_from()`. Ensure that simple values such as `None` or `UTC` are at the beginning of the list for proper minimisation.

Examples from this strategy shrink towards midnight on January 1st 2000.

```
hypothesis.strategies.decimals(min_value=None, max_value=None, allow_nan=None, al-
low_infinity=None, places=None)
```

Generates instances of `decimal.Decimal`, which may be:

- A finite rational number, between `min_value` and `max_value`.
- Not a Number, if `allow_nan` is `True`. `None` means “allow NaN, unless `min_value` and `max_value` are not `None`”.
- Positive or negative infinity, if `max_value` and `min_value` respectively are `None`, and `allow_infinity` is not `False`. `None` means “allow infinity, unless excluded by the min and max values”.

Note that where floats have one NaN value, Decimals have four: signed, and either *quiet* or *signalling*. See the [decimal module docs](#) for more information on special values.

If `places` is not `None`, all finite values drawn from the strategy will have that number of digits after the decimal place.

Examples from this strategy do not have a well defined shrink order but try to maximize human readability when shrinking.

`hypothesis.strategies.deferred` (*definition*)

A deferred strategy allows you to write a strategy that references other strategies that have not yet been defined. This allows for the easy definition of recursive and mutually recursive strategies.

The definition argument should be a zero-argument function that returns a strategy. It will be evaluated the first time the strategy is used to produce an example.

Example usage:

```
>>> import hypothesis.strategies as st
>>> x = st.deferred(lambda: st.booleans() | st.tuples(x, x))
>>> x.example()
((False, (True, True)), (False, True)), (True, True))
>>> x.example()
True
```

Mutual recursion also works fine:

```
>>> a = st.deferred(lambda: st.booleans() | b)
>>> b = st.deferred(lambda: st.tuples(a, a))
>>> a.example()
True
>>> b.example()
(False, (False, ((False, True), False)))
```

Examples from this strategy shrink as they normally would from the strategy returned by the definition.

`hypothesis.strategies.dictionaries` (*keys*, *values*, *dict\_class*=<type 'dict'>, *min\_size*=0, *max\_size*=None)

Generates dictionaries of type `dict_class` with keys drawn from the `keys` argument and values drawn from the `values` argument.

The size parameters have the same interpretation as for lists.

Examples from this strategy shrink by trying to remove keys from the generated dictionary, and by shrinking each generated key and value.

`hypothesis.strategies.emails` ()

A strategy for generating email addresses as unicode strings. The address format is specified in [RFC 5322#section-3.4.1](#). Values shrink towards shorter local-parts and host domains.

This strategy is useful for generating “user data” for tests, as mishandling of email addresses is a common source of bugs.

`hypothesis.strategies.fixed_dictionaries` (*mapping*)

Generates a dictionary of the same type as `mapping` with a fixed set of keys mapping to strategies. `mapping` must be a dict subclass.

Generated values have all keys present in `mapping`, with the corresponding values drawn from `mapping[key]`. If `mapping` is an instance of `OrderedDict` the keys will also be in the same order, otherwise the order is arbitrary.

Examples from this strategy shrink by shrinking each individual value in the generated dictionary.

```
hypothesis.strategies.floats (min_value=None, max_value=None, allow_nan=None,
                              low_infinity=None, width=64, exclude_min=False,
                              exclude_max=False)
```

Returns a strategy which generates floats.

- If `min_value` is not `None`, all values will be `>= min_value`.
- If `max_value` is not `None`, all values will be `<= max_value`.
- If `min_value` or `max_value` is not `None`, it is an error to enable `allow_nan`.
- If both `min_value` and `max_value` are not `None`, it is an error to enable `allow_infinity`.

Where not explicitly ruled out by the bounds, all of infinity, -infinity and NaN are possible values generated by this strategy.

The `width` argument specifies the maximum number of bits of precision required to represent the generated float. Valid values are 16, 32, or 64. Passing `width=32` will still use the builtin 64-bit `float` class, but always for values which can be exactly represented as a 32-bit float. Half-precision floats (`width=16`) are only supported on Python 3.6, or if `Numpy` is installed.

The `exclude_min` and `exclude_max` argument can be used to generate numbers from open or half-open intervals, by excluding the respective endpoints. Attempting to exclude an endpoint which is `None` will raise an error; use `allow_infinity=False` to generate finite floats. You can however use e.g. `min_value=float("-inf"), exclude_min=True` to exclude only one infinite endpoint.

Examples from this strategy have a complicated and hard to explain shrinking behaviour, but it tries to improve “human readability”. Finite numbers will be preferred to infinity and infinity will be preferred to NaN.

```
hypothesis.strategies.fractions (min_value=None, max_value=None,
                                 max_denominator=None)
```

Returns a strategy which generates Fractions.

If `min_value` is not `None` then all generated values are no less than `min_value`. If `max_value` is not `None` then all generated values are no greater than `max_value`. `min_value` and `max_value` may be anything accepted by the `Fraction` constructor.

If `max_denominator` is not `None` then the denominator of any generated values is no greater than `max_denominator`. Note that `max_denominator` must be `None` or a positive integer.

Examples from this strategy shrink towards smaller denominators, then closer to zero.

```
hypothesis.strategies.from_regex (regex, fullmatch=False)
```

Generates strings that contain a match for the given regex (i.e. ones for which `re.search()` will return a non-`None` result).

`regex` may be a pattern or `compiled regex`. Both byte-strings and unicode strings are supported, and will generate examples of the same type.

You can use regex flags such as `re.IGNORECASE` or `re.DOTALL` to control generation. Flags can be passed either in compiled regex or inside the pattern with a `(?iLmsux)` group.

Some regular expressions are only partly supported - the underlying strategy checks local matching and relies on filtering to resolve context-dependent expressions. Using too many of these constructs may cause health-check errors as too many examples are filtered out. This mainly includes (positive or negative) lookahead and lookbehind groups.

If you want the generated string to match the whole regex you should use boundary markers. So e.g. `r"\A.\Z"` will return a single character string, while `"."` will return any string, and `r"\A.$"` will return a single character optionally followed by a `"\n"`. Alternatively, passing `fullmatch=True` will ensure that the whole string is a match, as if you had used the `\A` and `\Z` markers.

Examples from this strategy shrink towards shorter strings and lower character values, with exact behaviour that may depend on the pattern.

`hypothesis.strategies.from_type(thing)`

Looks up the appropriate search strategy for the given type.

`from_type` is used internally to fill in missing arguments to `builds()` and can be used interactively to explore what strategies are available or to debug type resolution.

You can use `register_type_strategy()` to handle your custom types, or to globally redefine certain strategies - for example excluding NaN from floats, or use timezone-aware instead of naive time and datetime strategies.

The resolution logic may be changed in a future version, but currently tries these four options:

1. If `thing` is in the default lookup mapping or user-registered lookup, return the corresponding strategy. The default lookup covers all types with Hypothesis strategies, including extras where possible.
2. If `thing` is from the `typing` module, return the corresponding strategy (special logic).
3. If `thing` has one or more subtypes in the merged lookup, return the union of the strategies for those types that are not subtypes of other elements in the lookup.
4. Finally, if `thing` has type annotations for all required arguments, it is resolved via `builds()`.

`hypothesis.strategies.frozensets(elements, min_size=0, max_size=None)`

This is identical to the `sets` function but instead returns frozensets.

`hypothesis.strategies.integers(min_value=None, max_value=None)`

Returns a strategy which generates integers; in Python 2 these may be ints or longs.

If `min_value` is not `None` then all values will be  $\geq$  `min_value`. If `max_value` is not `None` then all values will be  $\leq$  `max_value`.

Examples from this strategy will shrink towards zero, and negative values will also shrink towards positive (i.e. `-n` may be replaced by `+n`).

`hypothesis.strategies.iterables(elements, min_size=0, max_size=None, unique_by=None, unique=False)`

This has the same behaviour as lists, but returns iterables instead.

Some iterables cannot be indexed (e.g. sets) and some do not have a fixed length (e.g. generators). This strategy produces iterators, which cannot be indexed and do not have a fixed length. This ensures that you do not accidentally depend on sequence behaviour.

`hypothesis.strategies.just(value)`

Return a strategy which only generates `value`.

Note: `value` is not copied. Be wary of using mutable values.

If `value` is the result of a callable, you can use `builds(callable)` instead of `just(callable())` to get a fresh value each time.

Examples from this strategy do not shrink (because there is only one).

`hypothesis.strategies.lists(elements, min_size=0, max_size=None, unique_by=None, unique=False)`

Returns a list containing values drawn from `elements` with length in the interval `[min_size, max_size]` (no bounds in that direction if these are `None`). If `max_size` is 0 then elements may be `None` and only the empty list will be drawn.

If `unique` is `True` (or something that evaluates to `True`), we compare direct object equality, as if `unique_by` was `lambda x: x`. This comparison only works for hashable types.

if `unique_by` is not `None` it must be a function returning a hashable type when given a value drawn from elements. The resulting list will satisfy the condition that for  $i \neq j$ , `unique_by(result[i]) != unique_by(result[j])`.

Examples from this strategy shrink by trying to remove elements from the list, and by shrinking each individual element of the list.

`hypothesis.strategies.none()`

Return a strategy which only generates `None`.

Examples from this strategy do not shrink (because there is only one).

`hypothesis.strategies.nothing()`

This strategy never successfully draws a value and will always reject on an attempt to draw.

Examples from this strategy do not shrink (because there are none).

`hypothesis.strategies.one_of(*args)`

Return a strategy which generates values from any of the argument strategies.

This may be called with one iterable argument instead of multiple strategy arguments, in which case `one_of(x)` and `one_of(*x)` are equivalent.

Examples from this strategy will generally shrink to ones that come from strategies earlier in the list, then shrink according to behaviour of the strategy that produced them. In order to get good shrinking behaviour, try to put simpler strategies first. e.g. `one_of(none(), text())` is better than `one_of(text(), none())`.

This is especially important when using recursive strategies. e.g. `x = st.deferred(lambda: st.none() | st.tuples(x, x))` will shrink well, but `x = st.deferred(lambda: st.tuples(x, x) | st.none())` will shrink very badly indeed.

`hypothesis.strategies.permutations(values)`

Return a strategy which returns permutations of the ordered collection `values`.

Examples from this strategy shrink by trying to become closer to the original order of values.

`hypothesis.strategies.random_module()`

The Hypothesis engine handles PRNG state for the `stdlib` and `Numpy` random modules internally, always seeding them to zero and restoring the previous state after the test.

If having a fixed seed would unacceptably weaken your tests, and you cannot use a `random.Random` instance provided by `randoms()`, this strategy calls `random.seed()` with an arbitrary integer and passes you an opaque object whose `repr` displays the seed value for debugging. If `numpy.random` is available, that state is also managed.

Examples from these strategy shrink to seeds closer to zero.

`hypothesis.strategies.randoms()`

Generates instances of `random.Random`, tweaked to show the seed value in the `repr` for reproducibility.

Examples from this strategy shrink to seeds closer to zero.

`hypothesis.strategies.recursive(base, extend, max_leaves=100)`

`base`: A strategy to start from.

`extend`: A function which takes a strategy and returns a new strategy.

`max_leaves`: The maximum number of elements to be drawn from `base` on a given run.

This returns a strategy `S` such that `S = extend(base | S)`. That is, values may be drawn from `base`, or from any strategy reachable by mixing applications of `|` and `extend`.

An example may clarify: `recursive(booleans(), lists)` would return a strategy that may return arbitrarily nested and mixed lists of booleans. So e.g. `False`, `[True]`, `[False, []]`, and `[[[True]]]` are all valid values to be drawn from that strategy.

Examples from this strategy shrink by trying to reduce the amount of recursion and by shrinking according to the shrinking behaviour of base and the result of extend.

`hypothesis.strategies.register_type_strategy(custom_type, strategy)`

Add an entry to the global type-to-strategy lookup.

This lookup is used in `builds()` and `@given`.

`builds()` will be used automatically for classes with type annotations on `__init__`, so you only need to register a strategy if one or more arguments need to be more tightly defined than their type-based default, or if you want to supply a strategy for an argument with a default value.

`strategy` may be a search strategy, or a function that takes a type and returns a strategy (useful for generic types).

`hypothesis.strategies.runner(default=not_set)`

A strategy for getting “the current test runner”, whatever that may be. The exact meaning depends on the entry point, but it will usually be the associated ‘self’ value for it.

If there is no current test runner and a default is provided, return that default. If no default is provided, raises `InvalidArgument`.

Examples from this strategy do not shrink (because there is only one).

`hypothesis.strategies.sampled_from(elements)`

Returns a strategy which generates any value present in `elements`.

Note that as with `just()`, values will not be copied and thus you should be careful of using mutable data.

`sampled_from` supports ordered collections, as well as `Enum` objects. `Flag` objects may also generate any combination of their members.

Examples from this strategy shrink by replacing them with values earlier in the list. So e.g. `sampled_from((10, 1))` will shrink by trying to replace 1 values with 10, and `sampled_from((1, 10))` will shrink by trying to replace 10 values with 1.

`hypothesis.strategies.sets(elements, min_size=0, max_size=None)`

This has the same behaviour as lists, but returns sets instead.

Note that Hypothesis cannot tell if values are drawn from elements are hashable until running the test, so you can define a strategy for sets of an unhashable type but it will fail at test time.

Examples from this strategy shrink by trying to remove elements from the set, and by shrinking each individual element of the set.

`hypothesis.strategies.shared(base, key=None)`

Returns a strategy that draws a single shared value per run, drawn from `base`. Any two shared instances with the same `key` will share the same value, otherwise the identity of this strategy will be used. That is:

```
>>> s = integers() # or any other strategy
>>> x = shared(s)
>>> y = shared(s)
```

In the above `x` and `y` may draw different (or potentially the same) values. In the following they will always draw the same:

```
>>> x = shared(s, key="hi")
>>> y = shared(s, key="hi")
```

Examples from this strategy shrink as per their base strategy.

```
hypothesis.strategies.text (alphabet=characters(blacklist_categories=('Cs', )), min_size=0,
                             max_size=None)
```

Generates values of a unicode text type (unicode on python 2, str on python 3) with values drawn from alphabet, which should be an iterable of length one strings or a strategy generating such strings.

The default alphabet strategy can generate the full unicode range but excludes surrogate characters because they are invalid in the UTF-8 encoding. You can use `characters()` without arguments to find surrogate-related bugs such as [bpo-34454](#).

`min_size` and `max_size` have the usual interpretations. Note that Python measures string length by counting codepoints: U+00C5 Å is a single character, while U+0041 U+030A A is two - the A, and a combining ring above.

Examples from this strategy shrink towards shorter strings, and with the characters in the text shrinking as per the alphabet strategy. This strategy does not `normalize()` examples, so generated strings may be in any or none of the ‘normal forms’.

```
hypothesis.strategies.timedeltas (min_value=datetime.timedelta(-999999999),
                                   max_value=datetime.timedelta(999999999, 86399, 999999))
```

A strategy for timedeltas between `min_value` and `max_value`.

Examples from this strategy shrink towards zero.

```
hypothesis.strategies.times (min_value=datetime.time(0, 0), max_value=datetime.time(23, 59,
                                         59, 999999), timezones=None())
```

A strategy for times between `min_value` and `max_value`.

The `timezones` argument is handled as for `datetimes()`.

Examples from this strategy shrink towards midnight, with the timezone component shrinking as for the strategy that provided it.

```
hypothesis.strategies.tuples (*args)
```

Return a strategy which generates a tuple of the same length as `args` by generating the value at index `i` from `args[i]`.

e.g. `tuples(integers(), integers())` would generate a tuple of length two with both values an integer.

Examples from this strategy shrink by shrinking their component parts.

```
hypothesis.strategies.uuids (version=None)
```

Returns a strategy that generates `UUIDs`.

If the optional `version` argument is given, value is passed through to `UUID` and only `UUIDs` of that version will be generated.

All returned values from this will be unique, so e.g. if you do `lists(uuids())` the resulting list will never contain duplicates.

Examples from this strategy don’t have any meaningful shrink order.

## 4.1 Shrinking

When using strategies it is worth thinking about how the data *shrinks*. Shrinking is the process by which Hypothesis tries to produce human readable examples when it finds a failure - it takes a complex example and turns it into a simpler one.

Each strategy defines an order in which it shrinks - you won’t usually need to care about this much, but it can be worth being aware of as it can affect what the best way to write your own strategies is.

The exact shrinking behaviour is not a guaranteed part of the API, but it doesn't change that often and when it does it's usually because we think the new way produces nicer examples.

Possibly the most important one to be aware of is `one_of()`, which has a preference for values produced by strategies earlier in its argument list. Most of the others should largely “do the right thing” without you having to think about it.

## 4.2 Adapting strategies

Often it is the case that a strategy doesn't produce exactly what you want it to and you need to adapt it. Sometimes you can do this in the test, but this hurts reuse because you then have to repeat the adaption in every test.

Hypothesis gives you ways to build strategies from other strategies given functions for transforming the data.

### 4.2.1 Mapping

`map` is probably the easiest and most useful of these to use. If you have a strategy `s` and a function `f`, then an example `s.map(f).example()` is `f(s.example())`, i.e. we draw an example from `s` and then apply `f` to it.

e.g.:

```
>>> lists(integers()).map(sorted).example()
[-25527, -24245, -23118, -93, -70, -7, 0, 39, 40, 65, 88, 112, 6189, 9480, 19469,
 ↪27256, 32526, 1566924430]
```

Note that many things that you might use mapping for can also be done with `builds()`.

### 4.2.2 Filtering

`filter` lets you reject some examples. `s.filter(f).example()` is some example of `s` such that `f(example)` is truthy.

```
>>> integers().filter(lambda x: x > 11).example()
26126
>>> integers().filter(lambda x: x > 11).example()
23324
```

It's important to note that `filter` isn't magic and if your condition is too hard to satisfy then this can fail:

```
>>> integers().filter(lambda x: False).example()
Traceback (most recent call last):
...
hypothesis.errors.NoExamples: Could not find any valid examples in 20 tries
```

In general you should try to use `filter` only to avoid corner cases that you don't want rather than attempting to cut out a large chunk of the search space.

A technique that often works well here is to use `map` to first transform the data and then use `filter` to remove things that didn't work out. So for example if you wanted pairs of integers  $(x,y)$  such that  $x < y$  you could do the following:

```
>>> tuples(integers(), integers()).map(sorted).filter(lambda x: x[0] < x[1]).example()
[-8543729478746591815, 3760495307320535691]
```



### 4.2.3 Chaining strategies together

Finally there is `flatmap`. `flatmap` draws an example, then turns that example into a strategy, then draws an example from *that* strategy.

It may not be obvious why you want this at first, but it turns out to be quite useful because it lets you generate different types of data with relationships to each other.

For example suppose we wanted to generate a list of lists of the same length:

```
>>> rectangle_lists = integers(min_value=0, max_value=10).flatmap(
... lambda n: lists(lists(integers(), min_size=n, max_size=n)))
>>> find(rectangle_lists, lambda x: True)
[]
>>> find(rectangle_lists, lambda x: len(x) >= 10)
[[], [], [], [], [], [], [], [], [], []]
>>> find(rectangle_lists, lambda t: len(t) >= 3 and len(t[0]) >= 3)
[[0, 0, 0], [0, 0, 0], [0, 0, 0]]
>>> find(rectangle_lists, lambda t: sum(len(s) for s in t) >= 10)
[[0], [0], [0], [0], [0], [0], [0], [0], [0], [0]]
```

In this example we first choose a length for our tuples, then we build a strategy which generates lists containing lists precisely of that length. The finds show what simple examples for this look like.

Most of the time you probably don't want `flatmap`, but unlike `filter` and `map` which are just conveniences for things you could just do in your tests, `flatmap` allows genuinely new data generation that you wouldn't otherwise be able to easily do.

(If you know Haskell: Yes, this is more or less a monadic bind. If you don't know Haskell, ignore everything in these parentheses. You do not need to understand anything about monads to use this, or anything else in Hypothesis).

### 4.2.4 Recursive data

Sometimes the data you want to generate has a recursive definition. e.g. if you wanted to generate JSON data, valid JSON is:

1. Any float, any boolean, any unicode string.
2. Any list of valid JSON data
3. Any dictionary mapping unicode strings to valid JSON data.

The problem is that you cannot call a strategy recursively and expect it to not just blow up and eat all your memory. The other problem here is that not all unicode strings display consistently on different machines, so we'll restrict them in our doctest.

The way Hypothesis handles this is with the `recursive()` function which you pass in a base case and a function that, given a strategy for your data type, returns a new strategy for it. So for example:

```
>>> from string import printable; from pprint import pprint
>>> json = recursive(none() | booleans() | floats() | text(printable),
... lambda children: lists(children, 1) | dictionaries(text(printable), children, min_
↳ size=1))
>>> pprint(json.example())
[[1.175494351e-38, ''], 1.9, True, False, '.M}Xl', ''], True]
>>> pprint(json.example())
{'de{l': None,
 'nK': {'(Rt)': None,
        '+hoZh1YU]gy8': True,
```

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```
'8z]EIFA06^l`i^': 'LFE{Q',
'9,': 'l{cA=/'}}
```

That is, we start with our leaf data and then we augment it by allowing lists and dictionaries of anything we can generate as JSON data.

The size control of this works by limiting the maximum number of values that can be drawn from the base strategy. So for example if we wanted to only generate really small JSON we could do this as:

```
>>> small_lists = recursive(booleans(), lists, max_leaves=5)
>>> small_lists.example()
True
>>> small_lists.example()
[False]
```

### 4.3 Composite strategies

The `@composite` decorator lets you combine other strategies in more or less arbitrary ways. It's probably the main thing you'll want to use for complicated custom strategies.

The composite decorator works by converting a function that returns one example into a function that returns a strategy that produces such examples - which you can pass to `@given`, modify with `.map` or `.filter`, and generally use like any other strategy.

It does this by giving you a special function `draw` as the first argument, which can be used just like the corresponding method of the `data()` strategy within a test. In fact, the implementation is almost the same - but defining a strategy with `@composite` makes code reuse easier, and usually improves the display of failing examples.

For example, the following gives you a list and an index into it:

```
>>> @composite
... def list_and_index(draw, elements=integers()):
...     xs = draw(lists(elements, min_size=1))
...     i = draw(integers(min_value=0, max_value=len(xs) - 1))
...     return (xs, i)
```

`draw(s)` is a function that should be thought of as returning `s.example()`, except that the result is reproducible and will minimize correctly. The decorated function has the initial argument removed from the list, but will accept all the others in the expected order. Defaults are preserved.

```
>>> list_and_index()
list_and_index()
>>> list_and_index().example()
([15949, -35, 21764, 8167, 1607867656, -41, 104, 19, -90, 520116744169390387,
↪7107438879249457973], 0)

>>> list_and_index(booleans())
list_and_index(elements=booleans())
>>> list_and_index(booleans()).example()
([True, False], 0)
```

Note that the repr will work exactly like it does for all the built-in strategies: it will be a function that you can call to get the strategy in question, with values provided only if they do not match the defaults.

You can use `assume` inside composite functions:

```
@composite
def distinct_strings_with_common_characters(draw):
    x = draw(text(), min_size=1)
    y = draw(text(alphabet=x))
    assume(x != y)
    return (x, y)
```

This works as *assume* normally would, filtering out any examples for which the passed in argument is falsey.

## 4.4 Drawing interactively in tests

There is also the *data()* strategy, which gives you a means of using strategies interactively. Rather than having to specify everything up front in *@given* you can draw from strategies in the body of your test.

This is similar to *@composite*, but even more powerful as it allows you to mix test code with example generation. The downside of this power is that *data()* is incompatible with explicit *@example(...)*s - and the mixed code is often harder to debug when something goes wrong.

If you need values that are affected by previous draws but which *don't* depend on the execution of your test, stick to the simpler *@composite*.

```
@given(data())
def test_draw_sequentially(data):
    x = data.draw(integers())
    y = data.draw(integers(min_value=x))
    assert x < y
```

If the test fails, each draw will be printed with the falsifying example. e.g. the above is wrong (it has a boundary condition error), so will print:

```
Falsifying example: test_draw_sequentially(data=data(...))
Draw 1: 0
Draw 2: 0
```

As you can see, data drawn this way is simplified as usual.

Optionally, you can provide a label to identify values generated by each call to `data.draw()`. These labels can be used to identify values in the output of a falsifying example.

For instance:

```
@given(data())
def test_draw_sequentially(data):
    x = data.draw(integers(), label='First number')
    y = data.draw(integers(min_value=x), label='Second number')
    assert x < y
```

will produce the output:

```
Falsifying example: test_draw_sequentially(data=data(...))
Draw 1 (First number): 0
Draw 2 (Second number): 0
```



---

## First-party extensions

---

Hypothesis has minimal dependencies (just `attrs`), to maximise compatibility and make installing Hypothesis as easy as possible.

Our integrations with specific packages are therefore provided by `extra` modules that need their individual dependencies installed in order to work. You can install these dependencies using the `setuptools extra` feature as e.g. `pip install hypothesis[django]`. This will check installation of compatible versions.

You can also just install `hypothesis` into a project using them, ignore the version constraints, and hope for the best.

In general “Which version is Hypothesis compatible with?” is a hard question to answer and even harder to regularly test. Hypothesis is always tested against the latest compatible version and each package will note the expected compatibility range. If you run into a bug with any of these please specify the dependency version.

There are separate pages for *Hypothesis for Django users* and *Hypothesis for the Scientific Stack*.

### 5.1 hypothesis[dpcontracts]

This module provides tools for working with the `dpcontracts` library, because `combining contracts and property-based testing works really well`.

It requires `dpcontracts >= 0.4`.

`hypothesis.extra.dpcontracts.fulfill` (*contract\_func*)

Decorate `contract_func` to reject calls which violate preconditions, and retry them with different arguments.

This is a convenience function for testing internal code that uses `:py:dpcontracts`, to automatically filter out arguments that would be rejected by the public interface before triggering a contract error.

This can be used as `builds(fulfill(func), ...)` or in the body of the test e.g. `assert fulfill(func)(*args)`.

## 5.2 hypothesis[lark]

This extra can be used to generate strings matching any context-free grammar, using the [Lark parser library](#).

It currently only supports Lark's native EBNF syntax, but we plan to extend this to support other common syntaxes such as ANTLR and [RFC 5234](#) ABNF. Lark already [supports loading grammars](#) from [nearley.js](#), so you may not have to write your own at all.

Note that as Lark is at version 0.x, this module *may* break API compatibility in minor releases if supporting the latest version of Lark would otherwise be infeasible. We may also be quite aggressive in bumping the minimum version of Lark, unless someone volunteers to either fund or do the maintenance.

`hypothesis.extra.lark.from_lark(grammar, start=None)`

A strategy for strings accepted by the given context-free grammar.

`grammar` must be a Lark object, which wraps an EBNF specification. The Lark EBNF grammar reference can be found [here](#).

`from_lark` will automatically generate strings matching the nonterminal `start` symbol in the grammar, which was supplied as an argument to the Lark class. To generate strings matching a different symbol, including terminals, you can override this by passing the `start` argument to `from_lark`.

Currently `from_lark` does not support grammars that need custom lexing. Any lexers will be ignored, and any undefined terminals from the use of `%declare` will result in generation errors. We hope to support more of these features in future.

## 5.3 hypothesis[pytz]

This module provides `pytz` timezones.

You can use this strategy to make `hypothesis.strategies.datetimes()` and `hypothesis.strategies.times()` produce timezone-aware values.

`hypothesis.extra.pytz.timezones()`

Any timezone in the Olsen database, as a `pytz.tzinfo` object.

This strategy minimises to UTC, or the smallest possible fixed offset, and is designed for use with `hypothesis.strategies.datetimes()`.

## 5.4 hypothesis[dateutil]

This module provides `dateutil` timezones.

You can use this strategy to make `hypothesis.strategies.datetimes()` and `hypothesis.strategies.times()` produce timezone-aware values.

`hypothesis.extra.dateutil.timezones()`

Any timezone in `dateutil`.

This strategy minimises to UTC, or the timezone with the smallest offset from UTC as of 2000-01-01, and is designed for use with `datetimes()`.

Note that the timezones generated by the strategy may vary depending on the configuration of your machine. See the `dateutil` documentation for more information.

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## Hypothesis for Django users

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Hypothesis offers a number of features specific for Django testing, available in the `hypothesis[django]` *extra*. This is tested against each supported series with mainstream or extended support - if you're still getting security patches, you can test with Hypothesis.

**class** `hypothesis.extra.django.TestCase`

Using it is quite straightforward: All you need to do is subclass `hypothesis.extra.django.TestCase` or `hypothesis.extra.django.TransactionTestCase` and you can use `@given` as normal, and the transactions will be per example rather than per test function as they would be if you used `@given` with a normal django test suite (this is important because your test function will be called multiple times and you don't want them to interfere with each other). Test cases on these classes that do not use `@given` will be run as normal.

**class** `hypothesis.extra.django.TransactionTestCase`

We recommend avoiding `TransactionTestCase` unless you really have to run each test case in a database transaction. Because Hypothesis runs this in a loop, the performance problems it normally has are significantly exacerbated and your tests will be really slow. If you are using `TransactionTestCase`, you may need to use `@settings(suppress_health_check=[HealthCheck.too_slow])` to avoid *errors due to slow example generation*.

Having set up a test class, you can now pass `@given` a strategy for Django models:

```
hypothesis.extra.django.from_model(model, **field_strategies)
```

Return a strategy for examples of `model`.

**Warning:** Hypothesis creates saved models. This will run inside your testing transaction when using the test runner, but if you use the dev console this will leave debris in your database.

`model` must be an subclass of `Model`. Strategies for fields may be passed as keyword arguments, for example `is_staff=st.just(False)`.

Hypothesis can often infer a strategy based the field type and validators, and will attempt to do so for any required fields. No strategy will be inferred for an `AutoField`, nullable field, foreign key, or field for which

a keyword argument is passed to `from_model()`. For example, a `Shop` type with a foreign key to `Company` could be generated with:

```
shop_strategy = from_model(Shop, company=from_model(Company))
```

Like for `builds()`, you can pass `infer` as a keyword argument to infer a strategy for a field which has a default value instead of using the default.

For example, using the trivial django project we have for testing:

```
>>> from hypothesis.extra.django import from_model
>>> from toystore.models import Customer
>>> c = from_model(Customer).example()
>>> c
<Customer: Customer object>
>>> c.email
'jaime.urbina@gmail.com'
>>> c.name
↳ '\U00109d3d\U000e07be\U000165f8\U0003fabf\U000c12cd\U000f1910\U00059f12\U000519b0\U0003fabf\U000f1
↳ '
>>> c.age
-873375803
```

Hypothesis has just created this with whatever the relevant type of data is.

Obviously the customer's age is implausible, which is only possible because we have not used (eg) `MinValueValidator` to set the valid range for this field (or used a `PositiveSmallIntegerField`, which would only need a maximum value validator).

If you *do* have validators attached, Hypothesis will only generate examples that pass validation. Sometimes that will mean that we fail a `HealthCheck` because of the filtering, so let's explicitly pass a strategy to skip validation at the strategy level:

---

**Note:** Inference from validators will be much more powerful when [issue #1116](#) is implemented, but there will always be some edge cases that require you to pass an explicit strategy.

---

```
>>> from hypothesis.strategies import integers
>>> c = from_model(Customer, age=integers(min_value=0, max_value=120)).example()
>>> c
<Customer: Customer object>
>>> c.age
5
```

`hypothesis.extra.django.from_form(form, form_kwargs=None, **field_strategies)`

Return a strategy for examples of `form`.

`form` must be an subclass of `Form`. Strategies for fields may be passed as keyword arguments, for example `is_staff=st.just(False)`.

Hypothesis can often infer a strategy based the field type and validators, and will attempt to do so for any required fields. No strategy will be inferred for a disabled field or field for which a keyword argument is passed to `from_form()`.

This function uses the fields of an unbound `form` instance to determine field strategies, any keyword arguments needed to instantiate the unbound `form` instance can be passed into `from_form()` as a dict with the keyword `form_kwargs`. E.g.:



```
shop_strategy = from_form(Shop, form_kwargs={"company_id": 5})
```

Like for `builds()`, you can pass `infer` as a keyword argument to infer a strategy for a field which has a default value instead of using the default.

## 6.1 Tips and tricks

### 6.1.1 Custom field types

If you have a custom Django field type you can register it with Hypothesis's model deriving functionality by registering a default strategy for it:

```
>>> from toystore.models import CustomishField, Customish
>>> from_model(Customish).example()
hypothesis.errors.InvalidArgument: Missing arguments for mandatory field
  customish for model Customish
>>> from hypothesis.extra.django import register_field_strategy
>>> from hypothesis.strategies import just
>>> register_field_strategy(CustomishField, just("hi"))
>>> x = from_model(Customish).example()
>>> x.customish
'hi'
```

Note that this mapping is on exact type. Subtypes will not inherit it.

`hypothesis.extra.django.register_field_strategy` (*field\_type*, *strategy*)  
Add an entry to the global field-to-strategy lookup used by `from_field`.

*field\_type* must be a subtype of `django.db.models.Field`, which must not already be registered. *strategy* must be a `SearchStrategy`.

### 6.1.2 Generating child models

For the moment there's no explicit support in `hypothesis-django` for generating dependent models. i.e. a `Company` model will generate no `Shops`. However if you want to generate some dependent models as well, you can emulate this by using the `flatmap` function as follows:

```
from hypothesis.strategies import lists, just

def generate_with_shops(company):
    return lists(from_model(Shop, company=just(company))).map(lambda _: company)

company_with_shops_strategy = from_model(Company).flatmap(generate_with_shops)
```

Lets unpack what this is doing:

The way `flatmap` works is that we draw a value from the original strategy, then apply a function to it which gives us a new strategy. We then draw a value from *that* strategy. So in this case we're first drawing a `company`, and then we're drawing a list of shops belonging to that company: The `just` strategy is a strategy such that drawing it always produces the individual value, so `from_model(Shop, company=just(company))` is a strategy that generates a `Shop` belonging to the original `company`.

So the following code would give us a list of shops all belonging to the same company:

```
from_model(Company).flatmap(lambda c: lists(from_model(Shop, company=just(c))))
```

The only difference from this and the above is that we want the company, not the shops. This is where the inner map comes in. We build the list of shops and then throw it away, instead returning the company we started for. This works because the models that Hypothesis generates are saved in the database, so we're essentially running the inner strategy purely for the side effect of creating those children in the database.

### 6.1.3 Generating primary key values

If your model includes a custom primary key that you want to generate using a strategy (rather than a default auto-increment primary key) then Hypothesis has to deal with the possibility of a duplicate primary key.

If a model strategy generates a value for the primary key field, Hypothesis will create the model instance with `update_or_create()`, overwriting any existing instance in the database for this test case with the same primary key.

### 6.1.4 On the subject of `MultiValueField`

Django forms feature the `MultiValueField` which allows for several fields to be combined under a single named field, the default example of this is the `SplitDateTimeField`.

```
class CustomerForm(forms.Form):
    name = forms.CharField()
    birth_date_time = forms.SplitDateTimeField()
```

`from_form` supports `MultiValueField` subclasses directly, however if you want to define your own strategy be forewarned that Django binds data for a `MultiValueField` in a peculiar way. Specifically each sub-field is expected to have its own entry in data addressed by the field name (e.g. `birth_date_time`) and the index of the sub-field within the `MultiValueField`, so form data for the example above might look like this:

```
{
  'name': 'Samuel John',
  'birth_date_time_0': '2018-05-19', # the date, as the first sub-field
  'birth_date_time_1': '15:18:00'   # the time, as the second sub-field
}
```

Thus, if you want to define your own strategies for such a field you must address your sub-fields appropriately:

```
from_form(CustomerForm, birth_date_time_0=just('2018-05-19'))
```

---

## Hypothesis for the Scientific Stack

---

### 7.1 numpy

Hypothesis offers a number of strategies for NumPy testing, available in the `hypothesis[numpy]` *extra*. It lives in the `hypothesis.extra.numpy` package.

The centerpiece is the `arrays()` strategy, which generates arrays with any dtype, shape, and contents you can specify or give a strategy for. To make this as useful as possible, strategies are provided to generate array shapes and generate all kinds of fixed-size or compound dtypes.

`hypothesis.extra.numpy.from_dtype(dtype)`

Creates a strategy which can generate any value of the given dtype.

`hypothesis.extra.numpy.arrays(dtype, shape, elements=None, fill=None, unique=False)`

Returns a strategy for generating `numpy.ndarrays`.

- `dtype` may be any valid input to `dtype` (this includes `dtype` objects), or a strategy that generates such values.
- `shape` may be an integer  $\geq 0$ , a tuple of such integers, or a strategy that generates such values.
- `elements` is a strategy for generating values to put in the array. If it is `None` a suitable value will be inferred based on the dtype, which may give any legal value (including eg `NaN` for floats). If you have more specific requirements, you should supply your own elements strategy.
- `fill` is a strategy that may be used to generate a single background value for the array. If `None`, a suitable default will be inferred based on the other arguments. If set to `nothing()` then filling behaviour will be disabled entirely and every element will be generated independently.
- `unique` specifies if the elements of the array should all be distinct from one another. Note that in this case multiple `NaN` values may still be allowed. If `fill` is also set, the only valid values for it to return are `NaN` values (anything for which `numpy.isnan` returns `True`. So e.g. for complex numbers `(nan+1j)` is also a valid fill). Note that if `unique` is set to `True` the generated values must be hashable.

Arrays of specified dtype and shape are generated for example like this:

```
>>> import numpy as np
>>> arrays(np.int8, (2, 3)).example()
array([[ -8,  6,  3],
       [-6,  4,  6]], dtype=int8)
```

- See *What you can generate and how*.

```
>>> import numpy as np
>>> from hypothesis.strategies import floats
>>> arrays(np.float, 3, elements=floats(0, 1)).example()
array([ 0.88974794,  0.77387938,  0.1977879 ])
```

Array values are generated in two parts:

1. Some subset of the coordinates of the array are populated with a value drawn from the elements strategy (or its inferred form).
2. If any coordinates were not assigned in the previous step, a single value is drawn from the fill strategy and is assigned to all remaining places.

You can set fill to `nothing()` if you want to disable this behaviour and draw a value for every element.

If fill is set to None then it will attempt to infer the correct behaviour automatically: If unique is True, no filling will occur by default. Otherwise, if it looks safe to reuse the values of elements across multiple coordinates (this will be the case for any inferred strategy, and for most of the builtins, but is not the case for mutable values or strategies built with flatmap, map, composite, etc) then it will use the elements strategy as the fill, else it will default to having no fill.

Having a fill helps Hypothesis craft high quality examples, but its main importance is when the array generated is large: Hypothesis is primarily designed around testing small examples. If you have arrays with hundreds or more elements, having a fill value is essential if you want your tests to run in reasonable time.

`hypothesis.extra.numpy.array_shapes` (*min\_dims=1, max\_dims=3, min\_side=1, max\_side=10*)

Return a strategy for array shapes (tuples of int >= 1).

`hypothesis.extra.numpy.scalar_dtypes` ()

Return a strategy that can return any non-flexible scalar dtype.

`hypothesis.extra.numpy.unsigned_integer_dtypes` (*endianness='??', sizes=(8, 16, 32, 64)*)

Return a strategy for unsigned integer dtypes.

*endianness* may be < for little-endian, > for big-endian, = for native byte order, or ? to allow either byte order. This argument only applies to dtypes of more than one byte.

*sizes* must be a collection of integer sizes in bits. The default (8, 16, 32, 64) covers the full range of sizes.

`hypothesis.extra.numpy.integer_dtypes` (*endianness='??', sizes=(8, 16, 32, 64)*)

Return a strategy for signed integer dtypes.

*endianness* and *sizes* are treated as for `unsigned_integer_dtypes()`.

`hypothesis.extra.numpy.floating_dtypes` (*endianness='??', sizes=(16, 32, 64)*)

Return a strategy for floating-point dtypes.

*sizes* is the size in bits of floating-point number. Some machines support 96- or 128-bit floats, but these are not generated by default.

Larger floats (96 and 128 bit real parts) are not supported on all platforms and therefore disabled by default. To generate these dtypes, include these values in the *sizes* argument.

`hypothesis.extra.numpy.complex_number_dtypes` (*endianness='?', sizes=(64, 128)*)

Return a strategy for complex-number dtypes.

*sizes* is the total size in bits of a complex number, which consists of two floats. Complex halves (a 16-bit real part) are not supported by numpy and will not be generated by this strategy.

`hypothesis.extra.numpy.datetime64_dtypes` (*max\_period='Y', min\_period='ns', endianness='?'*)

Return a strategy for datetime64 dtypes, with various precisions from year to attosecond.

`hypothesis.extra.numpy.timedelta64_dtypes` (*max\_period='Y', min\_period='ns', endianness='?'*)

Return a strategy for timedelta64 dtypes, with various precisions from year to attosecond.

`hypothesis.extra.numpy.byte_string_dtypes` (*endianness='?', min\_len=0, max\_len=16*)

Return a strategy for generating bytestring dtypes, of various lengths and byteorder.

`hypothesis.extra.numpy.unicode_string_dtypes` (*endianness='?', min\_len=0, max\_len=16*)

Return a strategy for generating unicode string dtypes, of various lengths and byteorder.

`hypothesis.extra.numpy.array_dtypes` (*subtype\_strategy=scalar\_dtypes(), min\_size=1, max\_size=5, allow\_subarrays=False*)

Return a strategy for generating array (compound) dtypes, with members drawn from the given subtype strategy.

`hypothesis.extra.numpy.nested_dtypes` (*subtype\_strategy=scalar\_dtypes(), max\_leaves=10, max\_itemsize=None*)

Return the most-general dtype strategy.

Elements drawn from this strategy may be simple (from the *subtype\_strategy*), or several such values drawn from `array_dtypes()` with *allow\_subarrays=True*. Subtypes in an array dtype may be nested to any depth, subject to the *max\_leaves* argument.

`hypothesis.extra.numpy.valid_tuple_axes` (*ndim, min\_size=0, max\_size=None*)

Return a strategy for generating permissible tuple-values for the *axis* argument for a numpy sequential function (e.g. `:func: numpy.numpy.sum`), given an array of the specified dimensionality.

All tuples will have a length  $\geq$  *min\_size* and  $\leq$  *max\_size*. The default value for *max\_len* is *ndim*.

Examples from this strategy shrink towards an empty tuple, which render most sequential functions as no-ops.

The following are some examples drawn from this strategy.

```
>>> [valid_tuple_axes(3).example() for i in range(4)]
[(-3, 1), (0, 1, -1), (0, 2), (0, -2, 2)]
```

`valid_tuple_axes` can be joined with other strategies to generate any type of valid axis object, i.e. integers, tuples, and None:

```
any_axis_strategy = none() | integers(-ndim, ndim - 1) | valid_tuple_axes(ndim)
```

## 7.2 pandas

Hypothesis provides strategies for several of the core pandas data types: `pandas.Index`, `pandas.Series` and `pandas.DataFrame`.

The general approach taken by the pandas module is that there are multiple strategies for generating indexes, and all of the other strategies take the number of entries they contain from their index strategy (with sensible defaults). So e.g. a `Series` is specified by specifying its `numpy.dtype` (and/or a strategy for generating elements for it).

`hypothesis.extra.pandas.indexes` (*elements=None, dtype=None, min\_size=0, max\_size=None, unique=True*)

Provides a strategy for producing a `pandas.Index`.

Arguments:

- `elements` is a strategy which will be used to generate the individual values of the index. If `None`, it will be inferred from the `dtype`. Note: even if the `elements` strategy produces tuples, the generated value will not be a `MultiIndex`, but instead be a normal index whose elements are tuples.
- `dtype` is the `dtype` of the resulting index. If `None`, it will be inferred from the `elements` strategy. At least one of `dtype` or `elements` must be provided.
- `min_size` is the minimum number of elements in the index.
- `max_size` is the maximum number of elements in the index. If `None` then it will default to a suitable small size. If you want larger indexes you should pass a `max_size` explicitly.
- `unique` specifies whether all of the elements in the resulting index should be distinct.

`hypothesis.extra.pandas.range_indexes` (*min\_size=0, max\_size=None*)

Provides a strategy which generates an `Index` whose values are `0, 1, ..., n` for some `n`.

Arguments:

- `min_size` is the smallest number of elements the index can have.
- `max_size` is the largest number of elements the index can have. If `None` it will default to some suitable value based on `min_size`.

`hypothesis.extra.pandas.series` (*elements=None, dtype=None, index=None, fill=None, unique=False*)

Provides a strategy for producing a `pandas.Series`.

Arguments:

- `elements`: a strategy that will be used to generate the individual values in the series. If `None`, we will attempt to infer a suitable default from the `dtype`.
- `dtype`: the `dtype` of the resulting series and may be any value that can be passed to `numpy.dtype`. If `None`, will use pandas's standard behaviour to infer it from the type of the elements values. Note that if the type of values that comes out of your `elements` strategy varies, then so will the resulting `dtype` of the series.
- `index`: If not `None`, a strategy for generating indexes for the resulting `Series`. This can generate either `pandas.Index` objects or any sequence of values (which will be passed to the `Index` constructor).

You will probably find it most convenient to use the `indexes()` or `range_indexes()` function to produce values for this argument.

Usage:

```
>>> series(dtype=int).example()
0    -2001747478
1     1153062837
```

`class hypothesis.extra.pandas.column` (*name=None, elements=None, dtype=None, fill=None, unique=False*)

Data object for describing a column in a `DataFrame`.

Arguments:

- `name`: the column name, or `None` to default to the column position. Must be hashable, but can otherwise be any value supported as a pandas column name.

- `elements`: the strategy for generating values in this column, or `None` to infer it from the dtype.
- `dtype`: the dtype of the column, or `None` to infer it from the element strategy. At least one of `dtype` or `elements` must be provided.
- `fill`: A default value for elements of the column. See `arrays()` for a full explanation.
- `unique`: If all values in this column should be distinct.

`hypothesis.extra.pandas.columns` (*names\_or\_number*, *dtype=None*, *elements=None*, *fill=None*, *unique=False*)

A convenience function for producing a list of `column` objects of the same general shape.

The `names_or_number` argument is either a sequence of values, the elements of which will be used as the name for individual column objects, or a number, in which case that many unnamed columns will be created. All other arguments are passed through verbatim to create the columns.

`hypothesis.extra.pandas.data_frames` (*columns=None*, *rows=None*, *index=None*)

Provides a strategy for producing a `pandas.DataFrame`.

Arguments:

- `columns`: An iterable of `column` objects describing the shape of the generated DataFrame.
- `rows`: A strategy for generating a row object. Should generate either dicts mapping column names to values or a sequence mapping column position to the value in that position (note that unlike the `pandas.DataFrame` constructor, single values are not allowed here. Passing e.g. an integer is an error, even if there is only one column).

At least one of `rows` and `columns` must be provided. If both are provided then the generated rows will be validated against the columns and an error will be raised if they don't match.

Caveats on using rows:

- In general you should prefer using columns to rows, and only use rows if the columns interface is insufficiently flexible to describe what you need - you will get better performance and example quality that way.
- If you provide rows and not columns, then the shape and dtype of the resulting DataFrame may vary. e.g. if you have a mix of int and float in the values for one column in your row entries, the column will sometimes have an integral dtype and sometimes a float.
- `index`: If not `None`, a strategy for generating indexes for the resulting DataFrame. This can generate either `pandas.Index` objects or any sequence of values (which will be passed to the Index constructor).

You will probably find it most convenient to use the `indexes()` or `range_indexes()` function to produce values for this argument.

Usage:

The expected usage pattern is that you use `column` and `columns()` to specify a fixed shape of the DataFrame you want as follows. For example the following gives a two column data frame:

```
>>> from hypothesis.extra.pandas import column, data_frames
>>> data_frames([
...   column('A', dtype=int), column('B', dtype=float)])
...   A          B
0  2021915903  1.793898e+232
1  1146643993           inf
2 -2096165693  1.000000e+07
```

If you want the values in different columns to interact in some way you can use the `rows` argument. For example the following gives a two column DataFrame where the value in the first column is always at most the value in the second:

```
>>> from hypothesis.extra.pandas import column, data_frames
>>> import hypothesis.strategies as st
>>> data_frames(
...     rows=st.tuples(st.floats(allow_nan=False),
...                    st.floats(allow_nan=False)).map(sorted)
... ).example()
      0          1
0 -3.402823e+38  9.007199e+15
1 -1.562796e-298 5.000000e-01
```

You can also combine the two:

```
>>> from hypothesis.extra.pandas import columns, data_frames
>>> import hypothesis.strategies as st
>>> data_frames(
...     columns=columns(["lo", "hi"], dtype=float),
...     rows=st.tuples(st.floats(allow_nan=False),
...                    st.floats(allow_nan=False)).map(sorted)
... ).example()
      lo          hi
0  9.314723e-49  4.353037e+45
1 -9.999900e-01  1.000000e+07
2 -2.152861e+134 -1.069317e-73
```

(Note that the column dtype must still be specified and will not be inferred from the rows. This restriction may be lifted in future).

Combining rows and columns has the following behaviour:

- The column names and dtypes will be used.
- If the column is required to be unique, this will be enforced.
- Any values missing from the generated rows will be provided using the column's fill.
- Any values in the row not present in the column specification (if dicts are passed, if there are keys with no corresponding column name, if sequences are passed if there are too many items) will result in `InvalidArgument` being raised.

### 7.2.1 Supported Versions

There is quite a lot of variation between pandas versions. We only commit to supporting the latest version of pandas, but older minor versions are supported on a “best effort” basis. Hypothesis is currently tested against and confirmed working with Pandas 0.19, 0.20, 0.21, 0.22, and 0.23.

Releases that are not the latest patch release of their minor version are not tested or officially supported, but will probably also work unless you hit a pandas bug.



Hypothesis tries to detect common mistakes and things that will cause difficulty at run time in the form of a number of ‘health checks’.

These include detecting and warning about:

- Strategies with very slow data generation
- Strategies which filter out too much
- Recursive strategies which branch too much
- Tests that are unlikely to complete in a reasonable amount of time.

If any of these scenarios are detected, Hypothesis will emit a warning about them.

The general goal of these health checks is to warn you about things that you are doing that might appear to work but will either cause Hypothesis to not work correctly or to perform badly.

To selectively disable health checks, use the `suppress_health_check` setting. The argument for this parameter is a list with elements drawn from any of the class-level attributes of the `HealthCheck` class. Using a value of `HealthCheck.all()` will disable all health checks.

**class** `hypothesis.HealthCheck`

Arguments for `suppress_health_check`.

Each member of this enum is a type of health check to suppress.

**data\_too\_large = 1**

Check for when the typical size of the examples you are generating exceeds the maximum allowed size too often.

**filter\_too\_much = 2**

Check for when the test is filtering out too many examples, either through use of `assume()` or `filter()`, or occasionally for Hypothesis internal reasons.

**too\_slow = 3**

Check for when your data generation is extremely slow and likely to hurt testing.

**return\_value = 5**

Checks if your tests return a non-None value (which will be ignored and is unlikely to do what you want).

**hung\_test = 6**

This health check is deprecated and no longer has any effect. You can use the `max_examples` and `deadline` settings together to cap the total runtime of your tests, rather than the previous fixed limit.

**large\_base\_example = 7**

Checks if the natural example to shrink towards is very large.

**not\_a\_test\_method = 8**

Checks if `@given` has been applied to a method of `unittest.TestCase`.

## 8.1 Deprecations

We also use a range of custom exception and warning types, so you can see exactly where an error came from - or turn only our warnings into errors.

**class** `hypothesis.errors.HypothesisDeprecationWarning`

A deprecation warning issued by Hypothesis.

Actually inherits from `FutureWarning`, because `DeprecationWarning` is hidden by the default warnings filter.

You can configure the Python `warnings` to handle these warnings differently to others, either turning them into errors or suppressing them entirely. Obviously we would prefer the former!

Deprecated features will be continue to emit warnings for at least six months, and then be removed in the following major release. Note however that not all warnings are subject to this grace period; sometimes we strengthen validation by adding a warning and these may become errors immediately at a major release.

---

## The Hypothesis Example Database

---

When Hypothesis finds a bug it stores enough information in its database to reproduce it. This enables you to have a classic testing workflow of find a bug, fix a bug, and be confident that this is actually doing the right thing because Hypothesis will start by retrying the examples that broke things last time.

### 9.1 Limitations

The database is best thought of as a cache that you never need to invalidate: Information may be lost when you upgrade a Hypothesis version or change your test, so you shouldn't rely on it for correctness - if there's an example you want to ensure occurs each time then *there's a feature for including them in your source code* - but it helps the development workflow considerably by making sure that the examples you've just found are reproduced.

The database also records examples that exercise less-used parts of your code, so the database may update even when no failing examples were found.

### 9.2 File locations

The default storage format is as a fairly opaque directory structure. Each test corresponds to a directory, and each example to a file within that directory. The standard location for it is `.hypothesis/examples` in your current working directory. You can override this by setting the `database` setting.

If you have not configured a database and the default location is unusable (e.g. because you do not have read/write permission), Hypothesis will issue a warning and then fall back to an in-memory database.

### 9.3 Upgrading Hypothesis and changing your tests

The design of the Hypothesis database is such that you can put arbitrary data in the database and not get wrong behaviour. When you upgrade Hypothesis, old data *might* be invalidated, but this should happen transparently. It can never be the case that e.g. changing the strategy that generates an argument gives you data from the old strategy.

## 9.4 Sharing your example database

---

**Note:** If specific examples are important for correctness you should use the `@example` decorator, as the example database may discard entries due to changes in your code or dependencies. For most users, we therefore recommend using the example database locally and possibly persisting it between CI builds, but not tracking it under version control.

---

The examples database can be shared simply by checking the directory into version control, for example with the following `.gitignore`:

```
# Ignore files cached by Hypothesis...
.hypothesis/*
# except for the examples directory
!.hypothesis/examples/
```

Like everything under `.hypothesis/`, the examples directory will be transparently created on demand. Unlike the other subdirectories, `examples/` is designed to handle merges, deletes, etc if you just add the directory into git, mercurial, or any similar version control system.

---

## Stateful testing

---

With `@given`, your tests are still something that you mostly write yourself, with Hypothesis providing some data. With Hypothesis's *stateful testing*, Hypothesis instead tries to generate not just data but entire tests. You specify a number of primitive actions that can be combined together, and then Hypothesis will try to find sequences of those actions that result in a failure.

---

**Note:** This style of testing is often called *model-based testing*, but in Hypothesis is called *stateful testing* (mostly for historical reasons - the original implementation of this idea in Hypothesis was more closely based on `ScalaCheck`'s *stateful testing* where the name is more apt). Both of these names are somewhat misleading: You don't really need any sort of formal model of your code to use this, and it can be just as useful for pure APIs that don't involve any state as it is for stateful ones.

It's perhaps best to not take the name of this sort of testing too seriously. Regardless of what you call it, it is a powerful form of testing which is useful for most non-trivial APIs.

---

Hypothesis has two stateful testing APIs: A high level one, providing what we call *rule based state machines*, and a low level one, providing what we call *generic state machines*.

You probably want to use the rule based state machines - they provide a high level API for describing the sort of actions you want to perform, based on a structured representation of actions. However the generic state machines are more flexible, and are particularly useful if you want the set of currently possible actions to depend primarily on external state.

### 10.1 You may not need state machines

The basic idea of stateful testing is to make Hypothesis choose actions as well as values for your test, and state machines are a great declarative way to do just that.

For simpler cases though, you might not need them at all - a standard test with `@given` might be enough, since you can use `data()` in branches or loops. In fact, that's how the state machine explorer works internally. For more complex workloads though, where a higher level API comes into it's own, keep reading!

## 10.2 Rule based state machines

Rule based state machines are the ones you're most likely to want to use. They're significantly more user friendly and should be good enough for most things you'd want to do.

### `class hypothesis.stateful.RuleBasedStateMachine`

A `RuleBasedStateMachine` gives you a more structured way to define state machines.

The idea is that a state machine carries a bunch of types of data divided into Bundles, and has a set of rules which may read data from bundles (or just from normal strategies) and push data onto bundles. At any given point a random applicable rule will be executed.

A rule is very similar to a normal `@given` based test in that it takes values drawn from strategies and passes them to a user defined test function. The key difference is that where `@given` based tests must be independent, rules can be chained together - a single test run may involve multiple rule invocations, which may interact in various ways.

Rules can take normal strategies as arguments, or a specific kind of strategy called a Bundle. A Bundle is a named collection of generated values that can be reused by other operations in the test. They are populated with the results of rules, and may be used as arguments to rules, allowing data to flow from one rule to another, and rules to work on the results of previous computations or actions.

You can think of each value that gets added to any Bundle as being assigned to a new variable. Drawing a value from the bundle strategy means choosing one of the corresponding variables and using that value, and `consumes()` as a `del` statement for that variable. If you can replace use of Bundles with instance attributes of the class that is often simpler, but often Bundles are strictly more powerful.

The following rule based state machine example is a simplified version of a test for Hypothesis's example database implementation. An example database maps keys to sets of values, and in this test we compare one implementation of it to a simplified in memory model of its behaviour, which just stores the same values in a Python `dict`. The test then runs operations against both the real database and the in-memory representation of it and looks for discrepancies in their behaviour.

```
import shutil
import tempfile

from collections import defaultdict
import hypothesis.strategies as st
from hypothesis.database import DirectoryBasedExampleDatabase
from hypothesis.stateful import Bundle, RuleBasedStateMachine, rule

class DatabaseComparison(RuleBasedStateMachine):
    def __init__(self):
        super(DatabaseComparison, self).__init__()
        self.tempd = tempfile.mkdtemp()
        self.database = DirectoryBasedExampleDatabase(self.tempd)
        self.model = defaultdict(set)

    keys = Bundle('keys')
    values = Bundle('values')

    @rule(target=keys, k=st.binary())
    def add_key(self, k):
        return k

    @rule(target=values, v=st.binary())
    def add_value(self, v):
        return v
```

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```

@rule(k=keys, v=values)
def save(self, k, v):
    self.model[k].add(v)
    self.database.save(k, v)

@rule(k=keys, v=values)
def delete(self, k, v):
    self.model[k].discard(v)
    self.database.delete(k, v)

@rule(k=keys)
def values_agree(self, k):
    assert set(self.database.fetch(k)) == self.model[k]

def teardown(self):
    shutil.rmtree(self.tmpd)

TestDBComparison = DatabaseComparison.TestCase

```

In this we declare two bundles - one for keys, and one for values. We have two trivial rules which just populate them with data (`k` and `v`), and three non-trivial rules: `save` saves a value under a key and `delete` removes a value from a key, in both cases also updating the model of what *should* be in the database. `values_agree` then checks that the contents of the database agrees with the model for a particular key.

We can then integrate this into our test suite by getting a unittest `TestCase` from it:

```

TestTrees = DatabaseComparison.TestCase

# Or just run with pytest's unittest support
if __name__ == '__main__':
    unittest.main()

```

This test currently passes, but if we comment out the line where we call `self.model[k].discard(v)`, we would see the following output when run under `pytest`:

```

AssertionError: assert set() == {b''}

----- Hypothesis -----

state = DatabaseComparison()
var1 = state.add_key(k=b'')
var2 = state.add_value(v=var1)
state.save(k=var1, v=var2)
state.delete(k=var1, v=var2)
state.values_agree(k=var1)
state.teardown()

```

Note how it's printed out a very short program that will demonstrate the problem. The output from a rule based state machine should generally be pretty close to Python code - if you have custom `repr` implementations that don't return valid Python then it might not be, but most of the time you should just be able to copy and paste the code into a test to reproduce it.

You can control the detailed behaviour with a settings object on the `TestCase` (this is a normal hypothesis settings object using the defaults at the time the `TestCase` class was first referenced). For example if you wanted to run fewer examples with larger programs you could change the settings to:

```
DatabaseComparison.TestCase.settings = settings(max_examples=50, stateful_step_
↳count=100)
```

Which doubles the number of steps each program runs and halves the number of test cases that will be run.

### 10.3 Rules

As said earlier, rules are the most common feature used in `RuleBasedStateMachine`. They are defined by applying the `rule()` decorator on a function. Note that `RuleBasedStateMachine` must have at least one rule defined and that a single function cannot be used to define multiple rules (this to avoid having multiple rules doing the same things). Due to the stateful execution method, rules generally cannot take arguments from other sources such as fixtures or `pytest.mark.parametrize` - consider providing them via a strategy such as `sampled_from()` instead.

`hypothesis.stateful.rule` (*targets=()*, *target=None*, *\*\*kwargs*)

Decorator for `RuleBasedStateMachine`. Any name present in `target` or `targets` will define where the end result of this function should go. If both are empty then the end result will be discarded.

`target` must be a `Bundle`, or if the result should go to multiple bundles you can pass a tuple of them as the `targets` argument. It is invalid to use both arguments for a single rule. If the result should go to exactly one of several bundles, define a separate rule for each case.

`kwargs` then define the arguments that will be passed to the function invocation. If their value is a `Bundle`, or if it is `consumes(b)` where `b` is a `Bundle`, then values that have previously been produced for that bundle will be provided. If `consumes` is used, the value will also be removed from the bundle.

Any other `kwargs` should be strategies and values from them will be provided.

`hypothesis.stateful.consumes` (*bundle*)

When introducing a rule in a `RuleBasedStateMachine`, this function can be used to mark bundles from which each value used in a step with the given rule should be removed. This function returns a strategy object that can be manipulated and combined like any other.

For example, a rule declared with

```
@rule(value1=b1, value2=consumes(b2), value3=lists(consumes(b3)))
```

will consume a value from `Bundle b2` and several values from `Bundle b3` to populate `value2` and `value3` each time it is executed.

`hypothesis.stateful.multiple` (*\*args*)

This function can be used to pass multiple results to the `target(s)` of a rule. Just use `return multiple(result1, result2, ...)` in your rule.

It is also possible to use `return multiple()` with no arguments in order to end a rule without passing any result.

### 10.4 Initializes

Initializes are a special case of rules that are guaranteed to be run at most once at the beginning of a run (i.e. before any normal rule is called). Note if multiple initialize rules are defined, they may be called in any order, and that order will vary from run to run.

Initializes are typically useful to populate bundles:

`hypothesis.stateful.initialize` (*targets=()*, *target=None*, *\*\*kwargs*)

Decorator for `RuleBasedStateMachine`.



An initialize decorator behaves like a rule, but the decorated method is called at most once in a run. All initialize decorated methods will be called before any rule decorated methods, in an arbitrary order.

```
import hypothesis.strategies as st
from hypothesis.stateful import RuleBasedStateMachine, Bundle, rule, initialize

name_strategy = st.text(min_size=1).filter(lambda x: "/" not in x)

class NumberModifier(RuleBasedStateMachine):

    folders = Bundle('folders')
    files = Bundle('files')

    @initialize(target=folders)
    def init_folders(self):
        return '/'

    @rule(target=folders, name=name_strategy)
    def create_folder(self, parent, name):
        return '%s/%s' % (parent, name)

    @rule(target=files, name=name_strategy)
    def create_file(self, parent, name):
        return '%s/%s' % (parent, name)
```

## 10.5 Preconditions

While it's possible to use `assume()` in `RuleBasedStateMachine` rules, if you use it in only a few rules you can quickly run into a situation where few or none of your rules pass their assumptions. Thus, Hypothesis provides a `precondition()` decorator to avoid this problem. The `precondition()` decorator is used on rule-decorated functions, and must be given a function that returns True or False based on the `RuleBasedStateMachine` instance.

`hypothesis.stateful.precondition` (*precond*)

Decorator to apply a precondition for rules in a `RuleBasedStateMachine`. Specifies a precondition for a rule to be considered as a valid step in the state machine. The given function will be called with the instance of `RuleBasedStateMachine` and should return True or False. Usually it will need to look at attributes on that instance.

For example:

```
class MyTestMachine(RuleBasedStateMachine):
    state = 1

    @precondition(lambda self: self.state != 0)
    @rule(numerator=integers())
    def divide_with(self, numerator):
        self.state = numerator / self.state
```

This is better than using `assume` in your rule since more valid rules should be able to be run.

```
from hypothesis.stateful import RuleBasedStateMachine, rule, precondition

class NumberModifier(RuleBasedStateMachine):

    num = 0
```

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```

@rule()
def add_one(self):
    self.num += 1

@precondition(lambda self: self.num != 0)
@rule()
def divide_with_one(self):
    self.num = 1 / self.num

```

By using `precondition()` here instead of `assume()`, Hypothesis can filter the inapplicable rules before running them. This makes it much more likely that a useful sequence of steps will be generated.

Note that currently preconditions can't access bundles; if you need to use preconditions, you should store relevant data on the instance instead.

## 10.6 Invariants

Often there are invariants that you want to ensure are met after every step in a process. It would be possible to add these as rules that are run, but they would be run zero or multiple times between other rules. Hypothesis provides a decorator that marks a function to be run after every step.

`hypothesis.stateful.invariant()`

Decorator to apply an invariant for rules in a `RuleBasedStateMachine`. The decorated function will be run after every rule and can raise an exception to indicate failed invariants.

For example:

```

class MyTestMachine(RuleBasedStateMachine):
    state = 1

    @invariant()
    def is_nonzero(self):
        assert self.state != 0

```

```

from hypothesis.stateful import RuleBasedStateMachine, rule, invariant

```

```

class NumberModifier(RuleBasedStateMachine):

```

```

    num = 0

    @rule()
    def add_two(self):
        self.num += 2
        if self.num > 50:
            self.num += 1

    @invariant()
    def divide_with_one(self):
        assert self.num % 2 == 0

```

```

NumberTest = NumberModifier.TestCase

```

Invariants can also have `precondition()`s applied to them, in which case they will only be run if the precondition function returns true.

Note that currently invariants can't access bundles; if you need to use invariants, you should store relevant data on the instance instead.

## 10.7 Generic state machines

The class `GenericStateMachine` is the underlying machinery of stateful testing in Hypothesis. Chances are you will want to use the rule based stateful testing for most things, but the generic state machine functionality can be useful e.g. if you want to test things where the set of actions to be taken is more closely tied to the state of the system you are testing.

**Note:** `GenericStateMachine` is a *very* thin wrapper around `@given` and `data()`. Consider using those primitives directly, as the resulting tests are usually easier to write, understand, and debug. `GenericStateMachine` only exists because it predates `data()`, and will be deprecated and removed in a future version ([issue #1693](#)).

### `class hypothesis.stateful.GenericStateMachine`

A `GenericStateMachine` is the basic entry point into Hypothesis's approach to stateful testing.

The intent is for it to be subclassed to provide state machine descriptions

The way this is used is that Hypothesis will repeatedly execute something that looks something like:

```
x = MyStateMachineSubclass()
x.check_invariants()
try:
    for _ in range(n_steps):
        x.execute_step(x.steps().example())
        x.check_invariants()
finally:
    x.teardown()
```

And if this ever produces an error it will shrink it down to a small sequence of example choices demonstrating that.

#### `steps()`

Return a `SearchStrategy` instance that defines the available next steps.

#### `execute_step(step)`

Execute a step that has been previously drawn from `self.steps()`

#### `teardown()`

Called after a run has finished executing to clean up any necessary state.

Does nothing by default.

#### `check_invariants()`

Called after initializing and after executing each step.

For example, here we use stateful testing as a sort of link checker, to test `hypothesis.works` for broken links or links that use HTTP instead of HTTPS.

```
from hypothesis.stateful import GenericStateMachine
import hypothesis.strategies as st
from requests_html import HTMLSession

class LinkChecker(GenericStateMachine):
```

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```

def __init__(self):
    super(LinkChecker, self).__init__()
    self.session = HTMLSession()
    self.result = None

def steps(self):
    if self.result is None:
        # Always start on the home page
        return st.just("https://hypothesis.works/")
    else:
        return st.sampled_from([
            1
            for l in self.result.html.absolute_links
            # Don't try to crawl to other people's sites
            if l.startswith("https://hypothesis.works") and
            # Avoid Cloudflare's bot protection. We are a bot but we don't
            # care about the info it's hiding.
            '/cdn-cgi/' not in l
        ])

def execute_step(self, step):
    self.result = self.session.get(step)

    assert self.result.status_code == 200

    for l in self.result.html.absolute_links:
        # All links should be HTTPS
        assert "https://hypothesis.works/" not in l

TestLinks = LinkChecker.TestCase

```

Running this (at the time of writing this documentation) produced the following output:

```

AssertionError: assert 'https://hypothesis.works/' not in 'http://hypoth...test-
↳ fixtures/'
'https://hypothesis.works/' is contained here:
  https://hypothesis.works/articles/hypothesis-pytest-fixtures/
? ++++++

----- Hypothesis -----

Step #1: 'https://hypothesis.works/'
Step #2: 'https://hypothesis.works/articles/'

```

## 10.8 More fine grained control

If you want to bypass the `TestCase` infrastructure you can invoke these manually. The stateful module exposes the function `run_state_machine_as_test`, which takes an arbitrary function returning a `GenericStateMachine` and an optional settings parameter and does the same as the class based `runTest` provided.

This is not recommended as it bypasses some important internal functions, including reporting of statistics such as runtimes and `event()` calls. It was originally added to support custom `__init__` methods, but you can now use `initialize()` rules instead.

Hypothesis does its level best to be compatible with everything you could possibly need it to be compatible with. Generally you should just try it and expect it to work. If it doesn't, you can be surprised and check this document for the details.

### 11.1 Python versions

Hypothesis is supported and tested on CPython 2.7 and CPython 3.4+, i.e. [all versions of CPython with upstream support](#),

Hypothesis also supports the latest PyPy for both Python 2 (until 2020) and Python 3. Hypothesis does not currently work on Jython, though it probably could ([issue #174](#)). IronPython might work but hasn't been tested. 32-bit and narrow builds should work, though this is currently only tested on Windows.

In general Hypothesis does not officially support anything except the latest patch release of any version of Python it supports. Earlier releases should work and bugs in them will get fixed if reported, but they're not tested in CI and no guarantees are made.

### 11.2 Operating systems

In theory Hypothesis should work anywhere that Python does. In practice it is only known to work and regularly tested on OS X, Windows and Linux, and you may experience issues running it elsewhere.

If you're using something else and it doesn't work, do get in touch and I'll try to help, but unless you can come up with a way for me to run a CI server on that operating system it probably won't stay fixed due to the inevitable march of time.

## 11.3 Testing frameworks

In general Hypothesis goes to quite a lot of effort to generate things that look like normal Python test functions that behave as closely to the originals as possible, so it should work sensibly out of the box with every test framework.

If your testing relies on doing something other than calling a function and seeing if it raises an exception then it probably *won't* work out of the box. In particular things like tests which return generators and expect you to do something with them (e.g. nose's yield based tests) will not work. Use a decorator or similar to wrap the test to take this form, or ask the framework maintainer to support our *hooks for inserting such a wrapper later*.

In terms of what's actually *known* to work:

- Hypothesis integrates as smoothly with pytest and unittest as we can make it, and this is verified as part of the CI.
- `pytest` fixtures work in the usual way for tests that have been decorated with `@given` - just avoid passing a strategy for each argument that will be supplied by a fixture. However, each fixture will run once for the whole function, not once per example. Decorating a fixture function with `@given` is meaningless.
- The `unittest.mock.patch()` decorator works with `@given`, but we recommend using it as a context manager within the decorated test to ensure that the mock is per-test-case and avoid poor interactions with Pytest fixtures.
- Nose works fine with Hypothesis, and this is tested as part of the CI. `yield` based tests simply won't work.
- Integration with Django's testing requires use of the *Hypothesis for Django users* package. The issue is that in Django's tests' normal mode of execution it will reset the database once per test rather than once per example, which is not what you want.
- `Coverage` works out of the box with Hypothesis; our own test suite has 100% branch coverage.

## 11.4 Optional Packages

The supported versions of optional packages, for strategies in `hypothesis.extra`, are listed in the documentation for that extra. Our general goal is to support all versions that are supported upstream.

## 11.5 Regularly verifying this

Everything mentioned above as explicitly supported is checked on every commit with `Travis`, `Appveyor`, and `CircleCI`. Our continuous delivery pipeline runs all of these checks before publishing each release, so when we say they're supported we really mean it.

## 11.6 Hypothesis versions

Backwards compatibility is better than backporting fixes, so we use *semantic versioning* and only support the most recent version of Hypothesis. See *Help and Support* for more information.

---

## Some more examples

---

This is a collection of examples of how to use Hypothesis in interesting ways. It's small for now but will grow over time.

All of these examples are designed to be run under `pytest`, and `nose` should work too.

### 12.1 How not to sort by a partial order

The following is an example that's been extracted and simplified from a real bug that occurred in an earlier version of Hypothesis. The real bug was a lot harder to find.

Suppose we've got the following type:

```
class Node(object):
    def __init__(self, label, value):
        self.label = label
        self.value = tuple(value)

    def __repr__(self):
        return "Node(%r, %r)" % (self.label, self.value)

    def sorts_before(self, other):
        if len(self.value) >= len(other.value):
            return False
        return other.value[:len(self.value)] == self.value
```

Each node is a label and a sequence of some data, and we have the relationship `sorts_before` meaning the data of the left is an initial segment of the right. So e.g. a node with value `[1, 2]` will sort before a node with value `[1, 2, 3]`, but neither of `[1, 2]` nor `[1, 3]` will sort before the other.

We have a list of nodes, and we want to topologically sort them with respect to this ordering. That is, we want to arrange the list so that if `x.sorts_before(y)` then `x` appears earlier in the list than `y`. We naively think that the easiest way to do this is to extend the partial order defined here to a total order by breaking ties arbitrarily and then using a normal sorting algorithm. So we define the following code:

```

from functools import total_ordering

@total_ordering
class TopoKey(object):
    def __init__(self, node):
        self.value = node

    def __lt__(self, other):
        if self.value.sorts_before(other.value):
            return True
        if other.value.sorts_before(self.value):
            return False

        return self.value.label < other.value.label

def sort_nodes(xs):
    xs.sort(key=TopoKey)

```

This takes the order defined by `sorts_before` and extends it by breaking ties by comparing the node labels.

But now we want to test that it works.

First we write a function to verify that our desired outcome holds:

```

def is_prefix_sorted(xs):
    for i in range(len(xs)):
        for j in range(i+1, len(xs)):
            if xs[j].sorts_before(xs[i]):
                return False
    return True

```

This will return false if it ever finds a pair in the wrong order and return true otherwise.

Given this function, what we want to do with Hypothesis is assert that for all sequences of nodes, the result of calling `sort_nodes` on it is sorted.

First we need to define a strategy for Node:

```

from hypothesis import settings, strategies
import hypothesis.strategies as s

NodeStrategy = s.builds(
    Node,
    s.integers(),
    s.lists(s.booleans(), max_size=10))

```

We want to generate *short* lists of values so that there's a decent chance of one being a prefix of the other (this is also why the choice of bool as the elements). We then define a strategy which builds a node out of an integer and one of those short lists of booleans.

We can now write a test:

```

from hypothesis import given

@given(s.lists(NodeStrategy))
def test_sorting_nodes_is_prefix_sorted(xs):

```

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```
sort_nodes(xs)
assert is_prefix_sorted(xs)
```

this immediately fails with the following example:

```
[Node(0, (False, True)), Node(0, (True,)), Node(0, (False,))]
```

The reason for this is that because `False` is not a prefix of `(True, True)` nor vice versa, sorting things the first two nodes are equal because they have equal labels. This makes the whole order non-transitive and produces basically nonsense results.

But this is pretty unsatisfying. It only works because they have the same label. Perhaps we actually wanted our labels to be unique. Lets change the test to do that.

```
def deduplicate_nodes_by_label(nodes):
    table = {node.label: node for node in nodes}
    return list(table.values())
```

We define a function to deduplicate nodes by labels, and can now map that over a strategy for lists of nodes to give us a strategy for lists of nodes with unique labels:

```
@given(s.lists(NodeStrategy).map(deduplicate_nodes_by_label))
def test_sorting_nodes_is_prefix_sorted(xs):
    sort_nodes(xs)
    assert is_prefix_sorted(xs)
```

Hypothesis quickly gives us an example of this *still* being wrong:

```
[Node(0, (False,)), Node(-1, (True,)), Node(-2, (False, False))]
```

Now this is a more interesting example. None of the nodes will sort equal. What is happening here is that the first node is strictly less than the last node because `(False,)` is a prefix of `(False, False)`. This is in turn strictly less than the middle node because neither is a prefix of the other and  $-2 < -1$ . The middle node is then less than the first node because  $-1 < 0$ .

So, convinced that our implementation is broken, we write a better one:

```
def sort_nodes(xs):
    for i in xrange(1, len(xs)):
        j = i - 1
        while j >= 0:
            if xs[j].sorts_before(xs[j+1]):
                break
            xs[j], xs[j+1] = xs[j+1], xs[j]
            j -= 1
```

This is just insertion sort slightly modified - we swap a node backwards until swapping it further would violate the order constraints. The reason this works is because our order is a partial order already (this wouldn't produce a valid result for a general topological sorting - you need the transitivity).

We now run our test again and it passes, telling us that this time we've successfully managed to sort some nodes without getting it completely wrong. Go us.

## 12.2 Time zone arithmetic

This is an example of some tests for `pytz` which check that various timezone conversions behave as you would expect them to. These tests should all pass, and are mostly a demonstration of some useful sorts of thing to test with Hypothesis, and how the `datetimes()` strategy works.

```
>>> from datetime import timedelta
>>> from hypothesis.extra.pytz import timezones
>>> from hypothesis.strategies import datetimes

>>> # The datetimes strategy is naive by default, so tell it to use timezones
>>> aware_datetimes = datetimes(timezones=timezones())

>>> @given(aware_datetimes, timezones(), timezones())
... def test_convert_via_intermediary(dt, tz1, tz2):
...     """Test that converting between timezones is not affected
...     by a detour via another timezone.
...     """
...     assert dt.astimezone(tz1).astimezone(tz2) == dt.astimezone(tz2)

>>> @given(aware_datetimes, timezones())
... def test_convert_to_and_fro(dt, tz2):
...     """If we convert to a new timezone and back to the old one
...     this should leave the result unchanged.
...     """
...     tz1 = dt.tzinfo
...     assert dt == dt.astimezone(tz2).astimezone(tz1)

>>> @given(aware_datetimes, timezones())
... def test_adding_an_hour_commutates(dt, tz):
...     """When converting between timezones it shouldn't matter
...     if we add an hour here or add an hour there.
...     """
...     an_hour = timedelta(hours=1)
...     assert (dt + an_hour).astimezone(tz) == dt.astimezone(tz) + an_hour

>>> @given(aware_datetimes, timezones())
... def test_adding_a_day_commutates(dt, tz):
...     """When converting between timezones it shouldn't matter
...     if we add a day here or add a day there.
...     """
...     a_day = timedelta(days=1)
...     assert (dt + a_day).astimezone(tz) == dt.astimezone(tz) + a_day

>>> # And we can check that our tests pass
>>> test_convert_via_intermediary()
>>> test_convert_to_and_fro()
>>> test_adding_an_hour_commutates()
>>> test_adding_a_day_commutates()
```

## 12.3 Condorcet's Paradox

A classic paradox in voting theory, called Condorcet's paradox, is that majority preferences are not transitive. That is, there is a population and a set of three candidates A, B and C such that the majority of the population prefer A to B, B to C and C to A.

Wouldn't it be neat if we could use Hypothesis to provide an example of this?

Well as you can probably guess from the presence of this section, we can! The main trick is to decide how we want to represent the result of an election - for this example, we'll use a list of "votes", where each vote is a list of candidates in the voters preferred order. Without further ado, here is the code:

```
from hypothesis import given, assume
from hypothesis.strategies import lists, permutations
from collections import Counter

# We need at least three candidates and at least three voters to have a
# paradox; anything less can only lead to victories or at worst ties.
@given(lists(permutations(['A', 'B', 'C']), min_size=3))
def test_elections_are_transitive(election):
    all_candidates = {"A", "B", "C"}

    # First calculate the pairwise counts of how many prefer each candidate
    # to the other
    counts = Counter()
    for vote in election:
        for i in range(len(vote)):
            for j in range(i+1, len(vote)):
                counts[(vote[i], vote[j])] += 1

    # Now look at which pairs of candidates one has a majority over the
    # other and store that.
    graph = {}
    for i in all_candidates:
        for j in all_candidates:
            if counts[(i, j)] > counts[(j, i)]:
                graph.setdefault(i, set()).add(j)

    # Now for each triple assert that it is transitive.
    for x in all_candidates:
        for y in graph.get(x, ()):
            for z in graph.get(y, ()):
                assert x not in graph.get(z, ())
```

The example Hypothesis gives me on my first run (your mileage may of course vary) is:

```
[['A', 'B', 'C'], ['B', 'C', 'A'], ['C', 'A', 'B']]
```

Which does indeed do the job: The majority (votes 0 and 1) prefer B to C, the majority (votes 0 and 2) prefer A to B and the majority (votes 1 and 2) prefer C to A. This is in fact basically the canonical example of the voting paradox.

## 12.4 Fuzzing an HTTP API

Hypothesis's support for testing HTTP services is somewhat nascent. There are plans for some fully featured things around this, but right now they're probably quite far down the line.

But you can do a lot yourself without any explicit support! Here's a script I wrote to throw arbitrary data against the API for an entirely fictitious service called Waspfinder (this is only lightly obfuscated and you can easily figure out who I'm actually talking about, but I don't want you to run this code and hammer their API without their permission).

All this does is use Hypothesis to generate arbitrary JSON data matching the format their API asks for and check for 500 errors. More advanced tests which then use the result and go on to do other things are definitely also possible. The [swagger-conformance](#) package provides an excellent example of this!

```
import unittest
from hypothesis import given, assume, settings, strategies as st
from collections import namedtuple
import requests
import os
import random
import time
import math

Goal = namedtuple("Goal", ("slug",))

# We just pass in our API credentials via environment variables.
waspfinder_token = os.getenv('WASPFINDER_TOKEN')
waspfinder_user = os.getenv('WASPFINDER_USER')
assert waspfinder_token is not None
assert waspfinder_user is not None

GoalData = st.fixed_dictionaries({
    'title': st.text(),
    'goal_type': st.sampled_from([
        "hustler", "biker", "gainer", "fatloser", "inboxer",
        "drinker", "custom"]),
    'goaldate': st.one_of(st.none(), st.floats()),
    'goalval': st.one_of(st.none(), st.floats()),
    'rate': st.one_of(st.none(), st.floats()),
    'initval': st.floats(),
    'panic': st.floats(),
    'secret': st.booleans(),
    'datapublic': st.booleans(),
})

needs2 = ['goaldate', 'goalval', 'rate']

class WaspfinderTest(unittest.TestCase):

    @given(GoalData)
    def test_create_goal_dry_run(self, data):
        # We want slug to be unique for each run so that multiple test runs
        # don't interfere with each other. If for some reason some slugs trigger
        # an error and others don't we'll get a Flaky error, but that's OK.
        slug = hex(random.getrandbits(32))[2:]

        # Use assume to guide us through validation we know about, otherwise
        # we'll spend a lot of time generating boring examples.

        # Title must not be empty
        assume(data["title"])

        # Exactly two of these values should be not None. The other will be
        # inferred by the API.

        assume(len([1 for k in needs2 if data[k] is not None]) == 2)
        for v in data.values():
```

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```
    if isinstance(v, float):
        assume(not math.isnan(v))
data["slug"] = slug

# The API nicely supports a dry run option, which means we don't have
# to worry about the user account being spammed with lots of fake goals
# Otherwise we would have to make sure we cleaned up after ourselves
# in this test.
data["dryrun"] = True
data["auth_token"] = waspfinder_token
for d, v in data.items():
    if v is None:
        data[d] = "null"
    else:
        data[d] = str(v)
result = requests.post(
    "https://waspfinder.example.com/api/v1/users/"
    "%s/goals.json" % (waspfinder_user,), data=data)

# Lets not hammer the API too badly. This will of course make the
# tests even slower than they otherwise would have been, but that's
# life.
time.sleep(1.0)

# For the moment all we're testing is that this doesn't generate an
# internal error. If we didn't use the dry run option we could have
# then tried doing more with the result, but this is a good start.
self.assertNotEqual(result.status_code, 500)

if __name__ == '__main__':
    unittest.main()
```



# CHAPTER 13

---

## Community

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The Hypothesis community is small for the moment but is full of excellent people who can answer your questions and help you out. Please do join us. The two major places for community discussion are:

- [The mailing list](#).
- An IRC channel, [#hypothesis](#) on freenode, which is more active than the mailing list.

Feel free to use these to ask for help, provide feedback, or discuss anything remotely Hypothesis related at all. If you post a question on StackOverflow, please use the [python-hypothesis](#) tag!

Please note that [the Hypothesis code of conduct](#) applies in all Hypothesis community spaces.

If you would like to cite Hypothesis, please consider [our suggested citation](#).

If you like repo badges, we suggest the following badge, which you can add with reStructuredText or Markdown, respectively:

```
.. image:: https://img.shields.io/badge/hypothesis-tested-brightgreen.svg
   :alt: Tested with Hypothesis
   :target: https://hypothesis.readthedocs.io
```

```
[![Tested with Hypothesis](https://img.shields.io/badge/hypothesis-tested-brightgreen.
→svg)](https://hypothesis.readthedocs.io/)
```

Finally, we have a beautiful logo which appears online, and often on stickers:

As well as being beautiful, dragonflies actively hunt down bugs for a living! You can find the images and a usage guide in the [brand](#) directory on GitHub, or find us at conferences where we often have stickers and sometimes other swag.





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## The Purpose of Hypothesis

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What is Hypothesis for?

From the perspective of a user, the purpose of Hypothesis is to make it easier for you to write better tests.

From my perspective as the author, that is of course also a purpose of Hypothesis, but (if you will permit me to indulge in a touch of megalomania for a moment), the larger purpose of Hypothesis is to drag the world kicking and screaming into a new and terrifying age of high quality software.

Software is, as they say, eating the world. Software is also *terrible*. It's buggy, insecure and generally poorly thought out. This combination is clearly a recipe for disaster.

And the state of software testing is even worse. Although it's fairly uncontroversial at this point that you *should* be testing your code, can you really say with a straight face that most projects you've worked on are adequately tested?

A lot of the problem here is that it's too hard to write good tests. Your tests encode exactly the same assumptions and fallacies that you had when you wrote the code, so they miss exactly the same bugs that you missed when you wrote the code.

Meanwhile, there are all sorts of tools for making testing better that are basically unused. The original Quickcheck is from 1999 and the majority of developers have not even heard of it, let alone used it. There are a bunch of half-baked implementations for most languages, but very few of them are worth using.

The goal of Hypothesis is to bring advanced testing techniques to the masses, and to provide an implementation that is so high quality that it is easier to use them than it is not to use them. Where I can, I will beg, borrow and steal every good idea I can find that someone has had to make software testing better. Where I can't, I will invent new ones.

Quickcheck is the start, but I also plan to integrate ideas from fuzz testing (a planned future feature is to use coverage information to drive example selection, and the example saving database is already inspired by the workflows people use for fuzz testing), and am open to and actively seeking out other suggestions and ideas.

The plan is to treat the social problem of people not using these ideas as a bug to which there is a technical solution: Does property-based testing not match your workflow? That's a bug, let's fix it by figuring out how to integrate Hypothesis into it. Too hard to generate custom data for your application? That's a bug. Let's fix it by figuring out how to make it easier, or how to take something you're already using to specify your data and derive a generator from that automatically. Find the explanations of these advanced ideas hopelessly obtuse and hard to follow? That's a bug. Let's provide you with an easy API that lets you test your code better without a PhD in software verification.

Grand ambitions, I know, and I expect ultimately the reality will be somewhat less grand, but so far in about three months of development, Hypothesis has become the most solid implementation of Quickcheck ever seen in a mainstream language (as long as we don't count Scala as mainstream yet), and at the same time managed to significantly push forward the state of the art, so I think there's reason to be optimistic.

This is a page for listing people who are using Hypothesis and how excited they are about that. If that's you and your name is not on the list, [this file is in Git](#) and I'd love it if you sent me a pull request to fix that.

### 15.1 Stripe

At Stripe we use Hypothesis to test every piece of our machine learning model training pipeline (powered by scikit). Before we migrated, our tests were filled with hand-crafted pandas Dataframes that weren't representative at all of our actual very complex data. Because we needed to craft examples for each test, we took the easy way out and lived with extremely low test coverage.

Hypothesis changed all that. Once we had our strategies for generating Dataframes of features it became trivial to slightly customize each strategy for new tests. Our coverage is now close to 90%.

Full-stop, property-based testing is profoundly more powerful - and has caught or prevented far more bugs - than our old style of example-based testing.

### 15.2 Kristian Glass - Director of Technology at LaterPay GmbH

Hypothesis has been brilliant for expanding the coverage of our test cases, and also for making them much easier to read and understand, so we're sure we're testing the things we want in the way we want.

### 15.3 Seth Morton

When I first heard about Hypothesis, I knew I had to include it in my two open-source Python libraries, [natsort](#) and [fastnumbers](#). Quite frankly, I was a little appalled at the number of bugs and "holes" I found in the code. I can now say with confidence that my libraries are more robust to "the wild." In addition, Hypothesis gave me the confidence to expand these libraries to fully support Unicode input, which I never would have had the stomach for without such thorough testing capabilities. Thanks!

## 15.4 Sixty North

At Sixty North we use Hypothesis for testing [Segpy](#) an open source Python library for shifting data between Python data structures and SEG Y files which contain geophysical data from the seismic reflection surveys used in oil and gas exploration.

This is our first experience of property-based testing – as opposed to example-based testing. Not only are our tests more powerful, they are also much better explanations of what we expect of the production code. In fact, the tests are much closer to being specifications. Hypothesis has located real defects in our code which went undetected by traditional test cases, simply because Hypothesis is more relentlessly devious about test case generation than us mere humans! We found Hypothesis particularly beneficial for Segpy because SEG Y is an antiquated format that uses legacy text encodings (EBCDIC) and even a legacy floating point format we implemented from scratch in Python.

Hypothesis is sure to find a place in most of our future Python codebases and many existing ones too.

## 15.5 mulkieran

Just found out about this excellent QuickCheck for Python implementation and ran up a few tests for my [bytesize](#) package last night. Refuted a few hypotheses in the process.

Looking forward to using it with a bunch of other projects as well.

## 15.6 Adam Johnson

I have written a small library to serialize `dicts` to MariaDB's dynamic columns binary format, [mariadb-dyncol](#). When I first developed it, I thought I had tested it really well - there were hundreds of test cases, some of them even taken from MariaDB's test suite itself. I was ready to release.

Lucky for me, I tried Hypothesis with David at the PyCon UK sprints. Wow! It found bug after bug after bug. Even after a first release, I thought of a way to make the tests do more validation, which revealed a further round of bugs! Most impressively, Hypothesis found a complicated off-by-one error in a condition with 4095 versus 4096 bytes of data - something that I would never have found.

Long live Hypothesis! (Or at least, property-based testing).

## 15.7 Josh Bronson

Adopting Hypothesis improved [bidict](#)'s test coverage and significantly increased our ability to make changes to the code with confidence that correct behavior would be preserved. Thank you, David, for the great testing tool.

## 15.8 Cory Benfield

Hypothesis is the single most powerful tool in my toolbox for working with algorithmic code, or any software that produces predictable output from a wide range of sources. When using it with [Priority](#), Hypothesis consistently found errors in my assumptions and extremely subtle bugs that would have taken months of real-world use to locate. In some cases, Hypothesis found subtle deviations from the correct output of the algorithm that may never have been noticed at all.

When it comes to validating the correctness of your tools, nothing comes close to the thoroughness and power of Hypothesis.

## 15.9 Jon Moore

One extremely satisfied user here. Hypothesis is a really solid implementation of property-based testing, adapted well to Python, and with good features such as failure-case shrinkers. I first used it on a project where we needed to verify that a vendor's Python and non-Python implementations of an algorithm matched, and it found about a dozen cases that previous example-based testing and code inspections had not. Since then I've been evangelizing for it at our firm.

## 15.10 Russel Winder

I am using Hypothesis as an integral part of my Python workshops. Testing is an integral part of Python programming and whilst unittest and, better, pytest can handle example-based testing, property-based testing is increasingly far more important than example-base testing, and Hypothesis fits the bill.

## 15.11 Wellfire Interactive

We've been using Hypothesis in a variety of client projects, from testing Django-related functionality to domain-specific calculations. It both speeds up and simplifies the testing process since there's so much less tedious and error-prone work to do in identifying edge cases. Test coverage is nice but test depth is even nicer, and it's much easier to get meaningful test depth using Hypothesis.

## 15.12 Cody Kochmann

Hypothesis is being used as the engine for random object generation with my open source function fuzzer `battle_tested` which maps all behaviors of a function allowing you to minimize the chance of unexpected crashes when running code in production.

With how efficient Hypothesis is at generating the edge cases that cause unexpected behavior occur, `battle_tested` is able to map out the entire behavior of most functions in less than a few seconds.

Hypothesis truly is a masterpiece. I can't thank you enough for building it.

## 15.13 Merchise Autrement

Just minutes after our first use of hypothesis we uncovered a subtle bug in one of our most used library. Since then, we have increasingly used hypothesis to improve the quality of our testing in libraries and applications as well.

## 15.14 Florian Kromer

At `Roboception GmbH` I use Hypothesis to implement fully automated stateless and stateful reliability tests for the 3D sensor `rc_visard` and robotic software components .

Thank you very much for creating the (probably) most powerful property-based testing framework.

## 15.15 Reposit Power

With a micro-service architecture, testing between services is made easy using Hypothesis in integration testing. Ensuring everything is running smoothly is vital to help maintain a secure network of Virtual Power Plants.

It allows us to find potential bugs and edge cases with relative ease and minimal overhead. As our architecture relies on services communicating effectively, Hypothesis allows us to strictly test for the kind of data which moves around our services, particularly our backend Python applications.

## 15.16 Your name goes here

I know there are many more, because I keep finding out about new people I'd never even heard of using Hypothesis. If you're looking to way to give back to a tool you love, adding your name here only takes a moment and would really help a lot. As per instructions at the top, just send me a pull request and I'll add you to the list.

---

## Open Source Projects using Hypothesis

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The following is a non-exhaustive list of open source projects I know are using Hypothesis. If you're aware of any others please add them to the list! The only inclusion criterion right now is that if it's a Python library then it should be available on PyPI.

You can find hundreds more from [the Hypothesis page at libraries.io](#), and over a thousand on [GitHub](#).

- [aur](#)
- [argon2\\_cffi](#)
- [attrs](#)
- [axelrod](#)
- [bidict](#)
- [binaryornot](#)
- [brotlipy](#)
- [chardet](#)
- [cmph-cffi](#)
- [cryptography](#)
- [dbus-signature-pyparsing](#)
- [fastnumbers](#)
- [flocker](#)
- [flownetpy](#)
- [funsize](#)
- [fusion-index](#)
- [hyper-h2](#)
- [into-dbus-python](#)

- [justbases](#)
- [justbytes](#)
- [loris](#)
- [mariadb-dyncol](#)
- [mercurial](#)
- [natsort](#)
- [pretext](#)
- [priority](#)
- [PyCEbox](#)
- [PyPy](#)
- [pyrsistent](#)
- [python-humble-utils](#)
- [pyudev](#)
- [qutebrowser](#)
- [RubyMarshal](#)
- [Segpy](#)
- [simoa](#)
- [srt](#)
- [tchannel](#)
- [vdirsyncer](#)
- [wcag-contrast-ratio](#)
- [yacluster](#)
- [yturl](#)



---

## Projects extending Hypothesis

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Hypothesis has been eagerly used and extended by the open source community. This page lists extensions and applications; you can find more or newer packages by searching PyPI by [keyword](#) or [filter by classifier](#), or search [libraries.io](#). If there's something missing which you think should be here, let us know!

---

**Note:** Being listed on this page does not imply that the Hypothesis maintainers endorse a package.

---

### 17.1 External Strategies

Some packages provide strategies directly:

- [hypothesis-fspaths](#) - strategy to generate filesystem paths.
- [hypothesis-geojson](#) - strategy to generate GeoJSON.
- [hs-dbus-signature](#) - strategy to generate arbitrary D-Bus signatures.
- [hypothesis\\_sqlalchemy](#) - strategies to generate SQLAlchemy objects.
- [hypothesis-ros](#) - strategies to generate messages and parameters for the Robot Operating System.
- [hypothesis-csv](#) - strategy to generate CSV files.

Others provide a function to infer a strategy from some other schema:

- [hypothesis-jsonschema](#) - infer strategies from JSON schemas.
- [lollipop-hypothesis](#) - infer strategies from lollipop schemas.
- [hypothesis-drf](#) - infer strategies from a `djangorestframework` serialiser.
- [hypothesis-mongoengine](#) - infer strategies from a `mongoengine` model.
- [hypothesis-pb](#) - infer strategies from Protocol Buffer schemas.

## 17.2 Other Cool Things

`swagger-conformance` is powered by Hypothesis and `pyswagger`. Based on a [Swagger specification](#), it can build and run an entire test suite to check that the implementation matches the spec. The command-line version can test apps written in any language, simply by passing the file or URL path to the schema to check!

`Trio` is an async framework with “an obsessive focus on usability and correctness”, so naturally it works with Hypothesis! `pytest-trio` includes *a custom hook* that allows `@given(...)` to work with Trio-style async test functions, and `hypothesis-trio` includes stateful testing extensions to support concurrent programs.

`libarchimedes` makes it easy to use Hypothesis in the `Hy` language, a Lisp embedded in Python.

`battle_tested` is a fuzzing tool that will show you how your code can fail - by trying all kinds of inputs and reporting whatever happens.

`pytest-subtesthack` functions as a workaround for [issue #377](#).

## 17.3 Writing an Extension

See `CONTRIBUTING.rst` for more information.

New strategies can be added to Hypothesis, or published as an external package on PyPI - either is fine for most strategies. If in doubt, ask!

It’s generally much easier to get things working outside, because there’s more freedom to experiment and fewer requirements in stability and API style. We’re happy to review and help with external packages as well as pull requests!

If you’re thinking about writing an extension, please name it `hypothesis-{something}` - a standard prefix makes the community more visible and searching for extensions easier. And make sure you use the `Framework :: Hypothesis` trove classifier!

On the other hand, being inside gets you access to some deeper implementation features (if you need them) and better long-term guarantees about maintenance. We particularly encourage pull requests for new composable primitives that make implementing other strategies easier, or for widely used types in the standard library. Strategies for other things are also welcome; anything with external dependencies just goes in `hypothesis.extra`.

# CHAPTER 18

---

## Changelog

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This is a record of all past Hypothesis releases and what went into them, in reverse chronological order. All previous releases should still be available on pip.

Hypothesis APIs come in three flavours:

- **Public:** Hypothesis releases since 1.0 are *semantically versioned* with respect to these parts of the API. These will not break except between major version bumps. All APIs mentioned in this documentation are public unless explicitly noted otherwise.
- **Semi-public:** These are APIs that are considered ready to use but are not wholly nailed down yet. They will not break in patch releases and will *usually* not break in minor releases, but when necessary minor releases may break semi-public APIs.
- **Internal:** These may break at any time and you really should not use them at all.

You should generally assume that an API is internal unless you have specific information to the contrary.

### 18.1 4.12.0 - 2019-03-18

This update adds the `report_multiple_bugs` setting, which you can use to disable multi-bug reporting and only raise whichever bug had the smallest minimal example. This is occasionally useful when using a debugger or tools that annotate tracebacks via introspection.

### 18.2 4.11.7 - 2019-03-18

This change makes a tiny improvement to the core engine's bookkeeping. There is no user-visible change.

### 18.3 4.11.6 - 2019-03-15

This release changes some of Hypothesis's internal shrinking behaviour in order to reduce memory usage and hopefully improve performance.

### 18.4 4.11.5 - 2019-03-13

This release adds a micro-optimisation to how Hypothesis handles debug reporting internally. Hard to shrink test may see a slight performance improvement, but in most common scenarios it is unlikely to be noticeable.

### 18.5 4.11.4 - 2019-03-13

This release removes some redundant code that was no longer needed but was still running a significant amount of computation and allocation on the hot path. This should result in a modest speed improvement for most tests, especially those with large test cases.

### 18.6 4.11.3 - 2019-03-13

This release adds a micro-optimisation to how Hypothesis caches test cases. This will cause a small improvement in speed and memory usage for large test cases, but in most common scenarios it is unlikely to be noticeable.

### 18.7 4.11.2 - 2019-03-13

This release removes some internal code that populates a field that is no longer used anywhere. This should result in some modest performance and speed improvements and no other user visible effects.

### 18.8 4.11.1 - 2019-03-13

This is a formatting-only patch, enabled by a new version of `isort`.

### 18.9 4.11.0 - 2019-03-12

This release deprecates `sampled_from()` with empty sequences. This returns `nothing()`, which gives a clear error if used directly... but simply vanishes if combined with another strategy.

Tests that silently generate less than expected are a serious problem for anyone relying on them to find bugs, and we think reliability more important than convenience in this case.

## 18.10 4.10.0 - 2019-03-11

This release improves Hypothesis's to detect flaky tests, by noticing when the behaviour of the test changes between runs. In particular this will notice many new cases where data generation depends on external state (e.g. external sources of randomness) and flag those as flaky sooner and more reliably.

The basis of this feature is a considerable reengineering of how Hypothesis stores its history of test cases, so on top of this its memory usage should be considerably reduced.

## 18.11 4.9.0 - 2019-03-09

This release adds the strategy `valid_tuple_axes()`, which generates tuples of axis-indices that can be passed to the `axis` argument in NumPy's sequential functions (e.g. `numpy.sum()`).

Thanks to Ryan Soklaski for this strategy.

## 18.12 4.8.0 - 2019-03-06

This release significantly tightens validation in `hypothesis.settings`. `max_examples`, `buffer_size`, and `stateful_step_count` must be positive integers; `deadline` must be a positive number or `None`; and `derandomize` must be either `True` or `False`.

As usual, this replaces existing errors with a more helpful error and starts new validation checks as deprecation warnings.

## 18.13 4.7.19 - 2019-03-04

This release makes some micro-optimisations to certain calculations performed in the shrinker. These should particularly speed up large test cases where the shrinker makes many small changes. It will also reduce the amount allocated, but most of this is garbage that would have been immediately thrown away, so you probably won't see much effect specifically from that.

## 18.14 4.7.18 - 2019-03-03

This patch removes some overhead from `arrays()` with a constant shape and dtype. The resulting performance improvement is modest, but worthwhile for small arrays.

## 18.15 4.7.17 - 2019-03-01

This release makes some micro-optimisations within Hypothesis's internal representation of test cases. This should cause heavily nested test cases to allocate less during generation and shrinking, which should speed things up slightly.

## 18.16 4.7.16 - 2019-02-28

This changes the order in which Hypothesis runs certain operations during shrinking. This should significantly decrease memory usage and speed up shrinking of large examples.

## 18.17 4.7.15 - 2019-02-28

This release allows Hypothesis to calculate a number of attributes of generated test cases lazily. This should significantly reduce memory usage and modestly improve performance, especially for large test cases.

## 18.18 4.7.14 - 2019-02-28

This release reduces the number of operations the shrinker will try when reordering parts of a test case. This should in some circumstances significantly speed up shrinking. It *may* result in different final test cases, and if so usually slightly worse ones, but it should not generally have much impact on the end result as the operations removed were typically useless.

## 18.19 4.7.13 - 2019-02-27

This release changes how Hypothesis reorders examples within a test case during shrinking. This should make shrinking considerably faster.

## 18.20 4.7.12 - 2019-02-27

This release slightly improves the shrinker's ability to replace parts of a test case with their minimal version, by allowing it to do so in bulk rather than one at a time. Where this is effective, shrinker performance should be modestly improved.

## 18.21 4.7.11 - 2019-02-25

This release makes some micro-optimisations to common operations performed during shrinking. Shrinking should now be slightly faster, especially for large examples with relatively fast test functions.

## 18.22 4.7.10 - 2019-02-25

This release is a purely internal refactoring of Hypothesis's API for representing test cases. There should be no user visible effect.

## 18.23 4.7.9 - 2019-02-24

This release changes certain shrink passes to make them more efficient when they aren't making progress.

## 18.24 4.7.8 - 2019-02-23

This patch removes some unused code, which makes the internals a bit easier to understand. There is no user-visible impact.

## 18.25 4.7.7 - 2019-02-23

This release reduces the number of operations the shrinker will try when reordering parts of a test case. This should in some circumstances significantly speed up shrinking. It *may* result in different final test cases, and if so usually slightly worse ones, but it should not generally have much impact on the end result as the operations removed were typically useless.

## 18.26 4.7.6 - 2019-02-23

This patch removes some unused code from the shrinker. There is no user-visible change.

## 18.27 4.7.5 - 2019-02-23

This release changes certain shrink passes to make them *adaptive* - that is, in cases where they are successfully making progress they may now do so significantly faster.

## 18.28 4.7.4 - 2019-02-22

This is a docs-only patch, noting that because the `lark-parser` is under active development at version 0.x, `hypothesis[lark]` APIs may break in minor releases if necessary to keep up with the upstream package.

## 18.29 4.7.3 - 2019-02-22

This changes Hypothesis to no longer import various test frameworks by default (if they are installed), which will speed up the initial `import hypothesis` call.

## 18.30 4.7.2 - 2019-02-22

This release changes Hypothesis's internal representation of a test case to calculate some expensive structural information on demand rather than eagerly. This should reduce memory usage a fair bit, and may make generation somewhat faster.

## 18.31 4.7.1 - 2019-02-21

This release refactors the internal representation of previously run test cases. The main thing you should see as a result is that Hypothesis becomes somewhat less memory hungry.

## 18.32 4.7.0 - 2019-02-21

This patch allows `array_shapes()` to generate shapes with side-length or even dimension zero, though the minimum still defaults to one. These shapes are rare and have some odd behavior, but are particularly important to test for just that reason!

In a related bigfix, `arrays()` now supports generating zero-dimensional arrays with `dtype=object` and a strategy for iterable elements. Previously, the array element would incorrectly be set to the first item in the generated iterable.

Thanks to Ryan Turner for continuing to improve our Numpy support.

## 18.33 4.6.1 - 2019-02-19

This release is a trivial micro-optimisation inside Hypothesis which should result in it using significantly less memory.

## 18.34 4.6.0 - 2019-02-18

This release changes some inconsistent behavior of `arrays()` from the Numpy extra when asked for an array of `shape=()`. `arrays()` will now always return a Numpy `ndarray`, and the array will always be of the requested `dtype`.

Thanks to Ryan Turner for this change.

## 18.35 4.5.12 - 2019-02-18

This release fixes a minor typo in an internal comment. There is no user-visible change.

## 18.36 4.5.11 - 2019-02-15

This release fixes [issue #1813](#), a bug introduced in `3.59.1`, which caused `random_module()` to no longer affect the body of the test: Although Hypothesis would claim to be seeding the random module in fact tests would always run with a seed of zero.

## 18.37 4.5.10 - 2019-02-14

This patch fixes an off-by-one error in the maximum length of `emails()`. Thanks to Krzysztof Jurewicz for [pull request #1812](#).

## 18.38 4.5.9 - 2019-02-14

This patch removes some unused code from the shrinker. There is no user-visible change.



## 18.39 4.5.8 - 2019-02-12

This release fixes an internal `IndexError` in Hypothesis that could sometimes be triggered during shrinking.

## 18.40 4.5.7 - 2019-02-11

This release modifies the shrinker to interleave different types of reduction operations, e.g. switching between deleting data and lowering scalar values rather than trying entirely deletions then entirely lowering.

This may slow things down somewhat in the typical case, but has the major advantage that many previously difficult to shrink examples should become much faster, because the shrinker will no longer tend to stall when trying some ineffective changes to the shrink target but will instead interleave it with other more effective operations.

## 18.41 4.5.6 - 2019-02-11

This release makes a number of internal changes to the implementation of `hypothesis.extra.lark.from_lark()`. These are primarily intended as a refactoring, but you may see some minor improvements to performance when generating large strings, and possibly to shrink quality.

## 18.42 4.5.5 - 2019-02-10

This patch prints an explanatory note when [issue #1798](#) is triggered, because the error message from Numpy is too terse to locate the problem.

## 18.43 4.5.4 - 2019-02-08

In Python 2, `long` integers are not allowed in the shape argument to `arrays()`. Thanks to Ryan Turner for fixing this.

## 18.44 4.5.3 - 2019-02-08

This release makes a small internal refactoring to clarify how Hypothesis instructs tests to stop running when appropriate. There is no user-visible change.

## 18.45 4.5.2 - 2019-02-06

This release standardises all of the shrinker's internal operations on running in a random order.

The main effect you will see from this that it should now be much less common for the shrinker to stall for a long time before making further progress. In some cases this will correspond to shrinking more slowly, but on average it should result in faster shrinking.

## 18.46 4.5.1 - 2019-02-05

This patch updates some docstrings, but has no runtime changes.

## 18.47 4.5.0 - 2019-02-03

This release adds `exclude_min` and `exclude_max` arguments to `floats()`, so that you can easily generate values from open or half-open intervals (issue #1622).

## 18.48 4.4.6 - 2019-02-03

This patch fixes a bug where `from_regex()` could throw an internal error if the `re.IGNORECASE` flag was used (issue #1786).

## 18.49 4.4.5 - 2019-02-02

This release removes two shrink passes that Hypothesis runs late in the process. These were very expensive when the test function was slow and often didn't do anything useful.

Shrinking should get faster for most failing tests. If you see any regression in example quality as a result of this release, please let us know.

## 18.50 4.4.4 - 2019-02-02

This release modifies the way that Hypothesis deletes data during shrinking. It will primarily be noticeable for very large examples, which should now shrink faster.

The shrinker is now also able to perform some deletions that it could not previously, but this is unlikely to be very noticeable.

## 18.51 4.4.3 - 2019-01-25

This release fixes an open file leak that used to cause `ResourceWarnings`.

## 18.52 4.4.2 - 2019-01-24

This release changes Hypothesis's internal approach to caching the results of executing test cases. The result should be that it is now significantly less memory hungry, especially when shrinking large test cases.

Some tests may get slower or faster depending on whether the new or old caching strategy was well suited to them, but any change in speed in either direction should be minor.

## 18.53 4.4.1 - 2019-01-24

This patch tightens up some of our internal heuristics to deal with shrinking floating point numbers, which will now run in fewer circumstances.

You are fairly unlikely to see much difference from this, but if you do you are likely to see shrinking become slightly faster and/or producing slightly worse results.

## 18.54 4.4.0 - 2019-01-24

This release adds the `from_form()` function, which allows automatic testing against Django forms. (issue #35)

Thanks to Paul Stiverson for this feature, which resolves our oldest open issue!

## 18.55 4.3.0 - 2019-01-24

This release deprecates `HealthCheck.hung_test` and disables the associated runtime check for tests that ran for more than five minutes. Such a check is redundant now that we enforce the `deadline` and `max_examples` setting, which can be adjusted independently.

## 18.56 4.2.0 - 2019-01-23

This release adds a new module, `hypothesis.extra.lark`, which you can use to generate strings matching a context-free grammar.

In this initial version, only `lark-parser` EBNF grammars are supported, by the new `hypothesis.extra.lark.from_lark()` function.

## 18.57 4.1.2 - 2019-01-23

This patch fixes a very rare overflow bug (issue #1748) which could raise an `InvalidArgument` error in `complex_numbers()` even though the arguments were valid.

## 18.58 4.1.1 - 2019-01-23

This release makes some improvements to internal code organisation and documentation and has no impact on behaviour.

## 18.59 4.1.0 - 2019-01-22

This release adds `register_random()`, which registers `random.Random` instances or compatible objects to be seeded and reset by Hypothesis to ensure that test cases are deterministic.

We still recommend explicitly passing a `random.Random` instance from `randoms()` if possible, but registering a framework-global state for Hypothesis to manage is better than flaky tests!

## 18.60 4.0.2 - 2019-01-22

This patch fixes [issue #1387](#), where bounded `integers()` with a very large range would almost always generate very large numbers. Now, we usually use the same tuned distribution as unbounded `integers()`.

## 18.61 4.0.1 - 2019-01-16

This release randomizes the order in which the shrinker tries some of its initial normalization operations. You are unlikely to see much difference as a result unless your generated examples are very large. In this case you may see some performance improvements in shrinking.

## 18.62 4.0.0 - 2019-01-14

Welcome to the next major version of Hypothesis!

There are no new features here, as we release those in minor versions. Instead, 4.0 is a chance for us to remove deprecated features (many already converted into no-ops), and turn a variety of warnings into errors.

If you were running on the last version of Hypothesis 3.x *without any Hypothesis deprecation warnings* (or using private APIs), this will be a very boring upgrade. **In fact, nothing will change for you at all.** Per [our deprecation policy](#), warnings added in the last six months (after 2018-07-05) have not been converted to errors.

### 18.62.1 Removals

- `hypothesis.extra.datetime` has been removed, replaced by the core date and time strategies.
- `hypothesis.extra.fakefactory` has been removed, replaced by general expansion of Hypothesis' strategies and the third-party ecosystem.
- The SQLite example database backend has been removed.

### 18.62.2 Settings

- The `deadline` is now enforced by default, rather than just emitting a warning when the default (200 milliseconds per test case) deadline is exceeded.
- The `database_file` setting has been removed; use `database`.
- The `perform_health_check` setting has been removed; use `suppress_health_check`.
- The `max_shrinks` setting has been removed; use `phases` to disable shrinking.
- The `min_satisfying_examples`, `max_iterations`, `strict`, `timeout`, and `use_coverage` settings have been removed without user-configurable replacements.

### 18.62.3 Strategies

- The `elements` argument is now required for collection strategies.
- The `average_size` argument was a no-op and has been removed.
- Date and time strategies now only accept `min_value` and `max_value` for bounds.

- `builds()` now requires that the thing to build is passed as the first positional argument.
- Alphabet validation for `text()` raises errors, not warnings, as does category validation for `characters()`.
- The `choices()` strategy has been removed. Instead, you can use `data()` with `sampled_from()`, so `choice(elements)` becomes `data.draw(sampled_from(elements))`.
- The `streaming()` strategy has been removed. Instead, you can use `data()` and replace iterating over the stream with `data.draw()` calls.
- `sampled_from()` and `permutations()` raise errors instead of warnings if passed a collection that is not a sequence.

### 18.62.4 Miscellaneous

- Applying `@given` to a test function multiple times was really inefficient, and now it's also an error.
- Using the `.example()` method of a strategy (intended for interactive exploration) within another strategy or a test function always weakened data generation and broke shrinking, and now it's an error too.
- The `HYPOTHESIS_DATABASE_FILE` environment variable is no longer supported, as the `database_file` setting has been removed.
- The `HYPOTHESIS_VERBOSITY_LEVEL` environment variable is no longer supported. You can use the `--hypothesis-verbosity` pytest argument instead, or write your own setup code using the settings profile system to replace it.
- Using `@seed` or `derandomize=True` now forces `database=None` to ensure results are in fact reproducible. If `database` is *not* `None`, doing so also emits a `HypothesisWarning`.
- Unused exception types have been removed from `hypothesis.errors`; namely `AbnormalExit`, `BadData`, `BadTemplateDraw`, `DefinitelyNoSuchExample`, `Timeout`, and `WrongFormat`.

## 18.63 3.88.3 - 2019-01-11

This changes the order that the shrinker tries certain operations in its “emergency” phase which runs late in the process. The new order should be better at avoiding long stalls where the shrinker is failing to make progress, which may be helpful if you have difficult to shrink test cases. However this will not be noticeable in the vast majority of use cases.

## 18.64 3.88.2 - 2019-01-11

This is a pure refactoring release that extracts some logic from the core Hypothesis engine into its own class and file. It should have no user visible impact.

## 18.65 3.88.1 - 2019-01-11

This patch fixes some markup in our documentation.

## 18.66 3.88.0 - 2019-01-10

Introduces `hypothesis.stateful.multiple()`, which allows rules in rule based state machines to send multiple results at once to their target `Bundle`, or none at all.

## 18.67 3.87.0 - 2019-01-10

This release contains a massive cleanup of the Hypothesis for Django extra:

- `hypothesis.extra.django.models.models()` is deprecated in favor of `hypothesis.extra.django.from_model()`.
- `hypothesis.extra.django.models.add_default_field_mapping()` is deprecated in favor of `hypothesis.extra.django.register_field_strategy()`.
- `from_model()` does not infer a strategy for nullable fields or fields with a default unless passed `infer`, like `builds()`. `models.models()` would usually but not always infer, and a special `default_value` marker object was required to disable inference.

## 18.68 3.86.9 - 2019-01-09

This release improves some internal logic about when a test case in Hypothesis's internal representation could lead to a valid test case. In some circumstances this can lead to a significant speed up during shrinking. It may have some minor negative impact on the quality of the final result due to certain shrink passes now having access to less information about test cases in some circumstances, but this should rarely matter.

## 18.69 3.86.8 - 2019-01-09

This release has no user visible changes but updates our URLs to use HTTPS.

## 18.70 3.86.7 - 2019-01-08

Hypothesis can now automatically generate values for Django models with a `URLfield`, thanks to a new provisional strategy for URLs (issue #1388).

## 18.71 3.86.6 - 2019-01-07

This release is a pure refactoring that extracts some internal code into its own file. It should have no user visible effect.

## 18.72 3.86.5 - 2019-01-06

This is a docs-only patch, which fixes some typos and removes a few hyperlinks for deprecated features.

## 18.73 3.86.4 - 2019-01-04

This release changes the order in which the shrinker tries to delete data. For large and slow tests this may significantly improve the performance of shrinking.

## 18.74 3.86.3 - 2019-01-04

This release fixes a bug where certain places Hypothesis internal errors could be raised during shrinking when a user exception occurred that suppressed an exception Hypothesis uses internally in its generation.

The two known ways to trigger this problem were:

- Errors raised in stateful tests' teardown function.
- Errors raised in finally blocks that wrapped a call to `data.draw`.

These cases will now be handled correctly.

## 18.75 3.86.2 - 2019-01-04

This patch is a docs-only change to fix a broken hyperlink.

## 18.76 3.86.1 - 2019-01-04

This patch fixes [issue #1732](#), where `integers()` would always return long values on Python 2.

## 18.77 3.86.0 - 2019-01-03

This release ensures that infinite numbers are never generated by `floats()` with `allow_infinity=False`, which could previously happen in some cases where one bound was also provided.

The trivially inconsistent `min_value=inf, allow_infinity=False` now raises an `InvalidArgumentError`, as does the inverse with `max_value`. You can still use `just(inf)` to generate `inf` without violating other constraints.

## 18.78 3.85.3 - 2019-01-02

Happy new year everyone! This release has no user visible changes but updates our copyright headers to include 2019.

## 18.79 3.85.2 - 2018-12-31

This release makes a small change to the way the shrinker works. You may see some improvements to speed of shrinking on especially large and hard to shrink examples, but most users are unlikely to see much difference.

## 18.80 3.85.1 - 2018-12-30

This patch fixes [issue #1700](#), where a line that contained a Unicode character before a lambda definition would cause an internal exception.

## 18.81 3.85.0 - 2018-12-29

Introduces the `hypothesis.stateful.consumes()` function. When defining a rule in stateful testing, it can be used to mark bundles from which values should be consumed, i. e. removed after use in the rule. This has been proposed in [issue #136](#).

Thanks to Jochen Müller for this long-awaited feature.

## 18.82 3.84.6 - 2018-12-28

This patch makes a small internal change to fix an issue in Hypothesis's own coverage tests ([issue #1718](#)).

There is no user-visible change.

## 18.83 3.84.5 - 2018-12-21

This patch refactors the `hypothesis.strategies` module, so that private names should no longer appear in tab-completion lists. We previously relied on `__all__` for this, but not all editors respect it.

## 18.84 3.84.4 - 2018-12-21

This is a follow-up patch to ensure that the deprecation date is automatically recorded for any new deprecations. There is no user-visible effect.

## 18.85 3.84.3 - 2018-12-20

This patch updates the Hypothesis pytest plugin to avoid a recently deprecated hook interface. There is no user-visible change.

## 18.86 3.84.2 - 2018-12-19

This patch fixes the internals for `integers()` with one bound. Values from this strategy now always shrink towards zero instead of towards the bound, and should shrink much more efficiently too. On Python 2, providing a bound incorrectly excluded long integers, which can now be generated.



## 18.87 3.84.1 - 2018-12-18

This patch adds information about when features were deprecated, but this is only recorded internally and has no user-visible effect.

## 18.88 3.84.0 - 2018-12-18

This release changes the stateful testing backend from `find()` to use `@given` (issue #1300). This doesn't change how you create stateful tests, but does make them run more like other Hypothesis tests.

`@reproduce_failure` and `@seed` now work for stateful tests.

Stateful tests now respect the `deadline` and `suppress_health_check` settings, though they are disabled by default. You can enable them by using `@settings(...)` as a class decorator with whatever arguments you prefer.

## 18.89 3.83.2 - 2018-12-17

Hypothesis has adopted `Black` as our code formatter (issue #1686). There are no functional changes to the source, but it's prettier!

## 18.90 3.83.1 - 2018-12-13

This patch increases the variety of examples generated by `from_type()`.

## 18.91 3.83.0 - 2018-12-12

Our pytest plugin now warns you when strategy functions have been collected as tests, which may happen when e.g. using the `@composite` decorator when you should be using `@given(st.data())` for inline draws. Such functions *always* pass when treated as tests, because the lazy creation of strategies mean that the function body is never actually executed!

## 18.92 3.82.6 - 2018-12-11

Hypothesis can now `show statistics` when running under `pytest-xdist`. Previously, statistics were only reported when all tests were run in a single process (issue #700).

## 18.93 3.82.5 - 2018-12-08

This patch fixes issue #1667, where passing bounds of Numpy dtype `int64` to `integers()` could cause errors on Python 3 due to internal rounding.

## 18.94 3.82.4 - 2018-12-08

Hypothesis now seeds and resets the global state of `np.random` for each test case, to ensure that tests are reproducible.

This matches and complements the existing handling of the `random` module - Numpy simply maintains an independent PRNG for performance reasons.

## 18.95 3.82.3 - 2018-12-08

This is a no-op release to add the new Framework `:: Hypothesis trove classifier` to `hypothesis` on PyPI.

You can use it as a filter to find Hypothesis-related packages such as extensions as they add the tag over the coming weeks, or simply visit *our curated list*.

## 18.96 3.82.2 - 2018-12-08

The *Hypothesis for Pandas extension* is now listed in `setup.py`, so you can `pip install hypothesis[pandas]`. Thanks to `jmshi` for this contribution.

## 18.97 3.82.1 - 2018-10-29

This patch fixes `from_type()` on Python 2 for classes where `cls.__init__` is `object.__init__`. Thanks to `ccxcz` for reporting [issue #1656](#).

## 18.98 3.82.0 - 2018-10-29

The `alphabet` argument for `text()` now uses its default value of `characters(blacklist_categories=('Cs',))` directly, instead of hiding that behind `alphabet=None` and replacing it within the function. Passing `None` is therefore deprecated.

## 18.99 3.81.0 - 2018-10-27

`GenericStateMachine` and `RuleBasedStateMachine` now raise an explicit error when instances of `settings` are assigned to the classes' `settings` attribute, which is a no-op ([issue #1643](#)). Instead assign to `SomeStateMachine.TestCase.settings`, or use `@settings(...)` as a class decorator to handle this automatically.

## 18.100 3.80.0 - 2018-10-25

Since *version 3.68.0*, `arrays()` checks that values drawn from the `elements` and `fill` strategies can be safely cast to the dtype of the array, and emits a warning otherwise.

This release expands the checks to cover overflow for finite `complex64` elements and string truncation caused by too-long elements or trailing null characters ([issue #1591](#)).

## 18.101 3.79.4 - 2018-10-25

Tests using `@given` now shrink errors raised from `pytest` helper functions, instead of reporting the first example found.

This was previously fixed in *version 3.56.0*, but only for stateful testing.

## 18.102 3.79.3 - 2018-10-23

Traceback elision is now disabled on Python 2, to avoid an import-time `SyntaxError` under Python < 2.7.9 (Python: [bpo-21591](#), *Hypothesis 3.79.2*: [issue #1648](#)).

We encourage all users to [upgrade to Python 3 before the end of 2019](#).

## 18.103 3.79.2 - 2018-10-23

This patch shortens tracebacks from Hypothesis, so you can see exactly happened in your code without having to skip over irrelevant details about our internals ([issue #848](#)).

In the example test (see [pull request #1582](#)), this reduces tracebacks from nine frames to just three - and for a test with multiple errors, from seven frames per error to just one!

If you *do* want to see the internal details, you can disable frame elision by setting `verbosity` to `debug`.

## 18.104 3.79.1 - 2018-10-22

The abstract number classes `Number`, `Complex`, `Real`, `Rational`, and `Integral` are now supported by the `from_type()` strategy. Previously, you would have to use `register_type_strategy()` before they could be resolved ([issue #1636](#)).

## 18.105 3.79.0 - 2018-10-18

This release adds a CLI flag for verbosity `--hypothesis-verbosity` to the Hypothesis `pytest` plugin, applied after loading the profile specified by `--hypothesis-profile`. Valid options are the names of verbosity settings, `quiet`, `normal`, `verbose` or `debug`.

Thanks to Bex Dunn for writing this patch at the PyCon Australia sprints!

The `pytest` header now correctly reports the current profile if `--hypothesis-profile` has been used.

Thanks to Mathieu Paturel for the contribution at the Canberra Python Hacktoberfest.

## 18.106 3.78.0 - 2018-10-16

This release has deprecated the generation of integers, floats and fractions when the conversion of the upper and/ or lower bound is not 100% exact, e.g. when an integer gets passed a bound that is not a whole number. ([issue #1625](#))

Thanks to Felix Grünewald for this patch during Hacktoberfest 2018.

## 18.107 3.77.0 - 2018-10-16

This minor release adds functionality to `settings` allowing it to be used as a decorator on `RuleBasedStateMachine` and `GenericStateMachine`.

Thanks to Tyler Nickerson for this feature in #hacktoberfest!

## 18.108 3.76.1 - 2018-10-16

This patch fixes some warnings added by recent releases of `pydocstyle` and `mypy`.

## 18.109 3.76.0 - 2018-10-11

This release deprecates using floats for `min_size` and `max_size`.

The type hint for `average_size` arguments has been changed from `Optional[int]` to `None`, because non-`None` values are always ignored and deprecated.

## 18.110 3.75.4 - 2018-10-10

This patch adds more internal comments to the core engine's sequence-length shrinker. There should be no user-visible change.

## 18.111 3.75.3 - 2018-10-09

This patch adds additional comments to some of the core engine's internal data structures. There is no user-visible change.

## 18.112 3.75.2 - 2018-10-09

This patch avoids caching a trivial case, fixing [issue #493](#).

## 18.113 3.75.1 - 2018-10-09

This patch fixes a broken link in a docstring. Thanks to Benjamin Lee for this contribution!

## 18.114 3.75.0 - 2018-10-08

This release deprecates the use of `min_size=None`, setting the default `min_size` to 0 ([issue #1618](#)).

## 18.115 3.74.3 - 2018-10-08

This patch makes some small internal changes to comply with a new lint setting in the build. There should be no user-visible change.

## 18.116 3.74.2 - 2018-10-03

This patch fixes [issue #1153](#), where time spent reifying a strategy was also counted in the time spent generating the first example. Strategies are now fully constructed and validated before the timer is started.

## 18.117 3.74.1 - 2018-10-03

This patch fixes some broken formatting and links in the documentation.

## 18.118 3.74.0 - 2018-10-01

This release checks that the value of the `print_blob` setting is a `PrintSettings` instance.

Being able to specify a boolean value was not intended, and is now deprecated. In addition, specifying `True` will now cause the blob to always be printed, instead of causing it to be suppressed.

Specifying any value that is not a `PrintSettings` or a boolean is now an error.

## 18.119 3.73.5 - 2018-10-01

Changes the documentation for `hypothesis.strategies.datetimes`, `hypothesis.strategies.dates`, `hypothesis.strategies.times` to use the new parameter names `min_value` and `max_value` instead of the deprecated names

## 18.120 3.73.4 - 2018-09-30

This patch ensures that Hypothesis deprecation warnings display the code that emitted them when you're not running in `-Werror` mode ([issue #652](#)).

## 18.121 3.73.3 - 2018-09-27

Tracebacks involving `@composite` are now slightly shorter due to some internal refactoring.

## 18.122 3.73.2 - 2018-09-26

This patch fixes errors in the internal comments for one of the shrinker passes. There is no user-visible change.

### 18.123 3.73.1 - 2018-09-25

This patch substantially improves the distribution of data generated with `recursive()`, and fixes a rare internal error (issue #1502).

### 18.124 3.73.0 - 2018-09-24

This release adds the `fulfill()` function, which is designed for testing code that uses `dpcontracts` 0.4 or later for input validation. This provides some syntactic sugar around use of `assume()`, to automatically filter out and retry calls that cause a precondition check to fail (issue #1474).

### 18.125 3.72.0 - 2018-09-24

This release makes setting attributes of the `hypothesis.settings` class an explicit error. This has never had any effect, but could mislead users who confused it with the current settings `instance` `hypothesis.settings.default` (which is also immutable). You can change the global settings with `settings profiles`.

### 18.126 3.71.11 - 2018-09-24

This patch factors out some common code in the shrinker for iterating over pairs of data blocks. There should be no user-visible change.

### 18.127 3.71.10 - 2018-09-18

This patch allows `from_type()` to handle the empty tuple type, `typing.Tuple[()]`.

### 18.128 3.71.9 - 2018-09-17

This patch updates some internal comments for `mypy`. There is no user-visible effect, even for `Mypy` users.

### 18.129 3.71.8 - 2018-09-17

This patch fixes a rare bug that would cause a particular shrinker pass to raise an `IndexError`, if a shrink improvement changed the underlying data in an unexpected way.

### 18.130 3.71.7 - 2018-09-17

This release fixes the broken cross-references in our docs, and adds a CI check so we don't add new ones.

## 18.131 3.71.6 - 2018-09-16

This patch fixes two bugs (issue #944 and issue #1521), where messages about `@seed` did not check the current verbosity setting, and the wrong settings were active while executing *explicit examples*.

## 18.132 3.71.5 - 2018-09-15

This patch fixes a `DeprecationWarning` added in Python 3.8 (issue #1576).

Thanks to tirkarathi for this contribution!

## 18.133 3.71.4 - 2018-09-14

This is a no-op release, which implements automatic DOI minting and code archival of Hypothesis via [Zenodo](#). Thanks to CERN and the EU *Horizon 2020* programme for providing this service!

Check our [CITATION](#) file for details, or head right on over to [doi.org/10.5281/zenodo.1412597](https://doi.org/10.5281/zenodo.1412597)

## 18.134 3.71.3 - 2018-09-10

This release adds the test name to some deprecation warnings, for easier debugging.

Thanks to Sanyam Khurana for the patch!

## 18.135 3.71.2 - 2018-09-10

This release makes Hypothesis's memory usage substantially smaller for tests with many examples, by bounding the number of past examples it keeps around.

You will not see much difference unless you are running tests with `max_examples` set to well over 1000, but if you do have such tests then you should see memory usage mostly plateau where previously it would have grown linearly with time.

## 18.136 3.71.1 - 2018-09-09

This patch adds internal comments to some tree traversals in the core engine. There is no user-visible change.

## 18.137 3.71.0 - 2018-09-08

This release deprecates the coverage-guided testing functionality, as it has proven brittle and does not really pull its weight.

We intend to replace it with something more useful in the future, but the feature in its current form does not seem to be worth the cost of using, and whatever replaces it will likely look very different.

### 18.138 3.70.4 - 2018-09-08

This patch changes the behaviour of `reproduce_failure()` so that blobs are only printed in quiet mode when the `print_blob` setting is set to ALWAYS.

Thanks to Cameron McGill for writing this patch at the PyCon Australia sprints!

### 18.139 3.70.3 - 2018-09-03

This patch removes some unnecessary code from the internals. There is no user-visible change.

### 18.140 3.70.2 - 2018-09-03

This patch fixes an internal bug where a corrupted argument to `@reproduce_failure` could raise the wrong type of error. Thanks again to Paweł T. Jochym, who maintains Hypothesis on `conda-forge` and consistently provides excellent bug reports including [issue #1558](#).

### 18.141 3.70.1 - 2018-09-03

This patch updates hypothesis to report its version and settings when run with pytest. ([issue #1223](#)).

Thanks to Jack Massey for this feature.

### 18.142 3.70.0 - 2018-09-01

This release adds a `fullmatch` argument to `from_regex()`. When `fullmatch=True`, the whole example will match the regex pattern as for `re.fullmatch()`.

Thanks to Jakub Nabaglo for writing this patch at the PyCon Australia sprints!

### 18.143 3.69.12 - 2018-08-30

This release reverts the changes to logging handling in 3.69.11, which broke test that use the `pytest caplog` fixture internally because all logging was disabled ([issue #1546](#)).

### 18.144 3.69.11 - 2018-08-29

This patch will hide all logging messages produced by test cases before the final, minimal, failing test case ([issue #356](#)).

Thanks to Gary Donovan for writing this patch at the PyCon Australia sprints!



## 18.145 3.69.10 - 2018-08-29

This patch fixes a bug that prevents coverage from reporting unexecuted Python files ([issue #1085](#)).

Thanks to Gary Donovan for writing this patch at the PyCon Australia sprints!

## 18.146 3.69.9 - 2018-08-28

This patch improves the packaging of the Python package by adding `LICENSE.txt` to the sdist ([issue #1311](#)), clarifying the minimum supported versions of `pytz` and `dateutil` ([issue #1383](#)), and adds keywords to the metadata ([issue #1520](#)).

Thanks to Graham Williamson for writing this patch at the PyCon Australia sprints!

## 18.147 3.69.8 - 2018-08-28

This is an internal change which replaces `pickle` with `json` to prevent possible security issues.

Thanks to Vidya Rani D G for writing this patch at the PyCon Australia sprints!

## 18.148 3.69.7 - 2018-08-28

This patch ensures that `note()` prints the note for every test case when the `verbosity` setting is `Verbosity.verbose`. At normal verbosity it only prints from the final test case.

Thanks to Tom McDermott for writing this patch at the PyCon Australia sprints!

## 18.149 3.69.6 - 2018-08-27

This patch improves the testing of some internal caching. It should have no user-visible effect.

## 18.150 3.69.5 - 2018-08-27

This change performs a small rename and refactoring in the core engine. There is no user-visible change.

## 18.151 3.69.4 - 2018-08-27

This change improves the core engine's ability to avoid unnecessary work, by consulting its cache of previously-tried inputs in more cases.

## 18.152 3.69.3 - 2018-08-27

This patch handles passing an empty `enum.Enum` to `from_type()` by returning `nothing()`, instead of raising an internal `AssertionError`.

Thanks to Paul Amazona for writing this patch at the PyCon Australia sprints!

## 18.153 3.69.2 - 2018-08-23

This patch fixes a small mistake in an internal comment. There is no user-visible change.

## 18.154 3.69.1 - 2018-08-21

This change fixes a small bug in how the core engine consults its cache of previously-tried inputs. There is unlikely to be any user-visible change.

## 18.155 3.69.0 - 2018-08-20

This release improves argument validation for stateful testing.

- If the target or targets of a `rule()` are invalid, we now raise a useful validation error rather than an internal exception.
- Passing both the `target` and `targets` arguments is deprecated - append the `target bundle` to the `targets` tuple of bundles instead.
- Passing the name of a `Bundle` rather than the `Bundle` itself is also deprecated.

## 18.156 3.68.3 - 2018-08-20

This is a docs-only patch, fixing some typos and formatting issues.

## 18.157 3.68.2 - 2018-08-19

This change fixes a small bug in how the core engine caches the results of previously-tried inputs. The effect is unlikely to be noticeable, but it might avoid unnecessary work in some cases.

## 18.158 3.68.1 - 2018-08-18

This patch documents the `from_dtype()` function, which infers a strategy for `numpy.dtypes`. This is used in `arrays()`, but can also be used directly when creating e.g. Pandas objects.

## 18.159 3.68.0 - 2018-08-15

`arrays()` now checks that integer and float values drawn from `elements` and `fill` strategies can be safely cast to the dtype of the array, and emits a warning otherwise (issue #1385).

Elements in the resulting array could previously violate constraints on the `elements` strategy due to floating-point overflow or truncation of integers to fit smaller types.

## 18.160 3.67.1 - 2018-08-14

This release contains a tiny refactoring of the internals. There is no user-visible change.

## 18.161 3.67.0 - 2018-08-10

This release adds a `width` argument to `floats()`, to generate lower-precision floating point numbers for e.g. Numpy arrays.

The generated examples are always instances of Python's native `float` type, which is 64bit, but passing `width=32` will ensure that all values can be exactly represented as 32bit floats. This can be useful to avoid overflow (to +/- infinity), and for efficiency of generation and shrinking.

Half-precision floats (`width=16`) are also supported, but require Numpy if you are running Python 3.5 or earlier.

## 18.162 3.66.33 - 2018-08-10

This release fixes a bug in `floats()`, where setting `allow_infinity=False` and exactly one of `min_value` and `max_value` would allow infinite values to be generated.

## 18.163 3.66.32 - 2018-08-09

This release adds type hints to the `example()` and `seed()` decorators, and fixes the type hint on `register_type_strategy()`. The second argument to `register_type_strategy()` must either be a `SearchStrategy`, or a callable which takes a `type` and returns a `SearchStrategy`.

## 18.164 3.66.31 - 2018-08-08

Another set of changes designed to improve the performance of shrinking on large examples. In particular the shrinker should now spend considerably less time running useless shrinks.

## 18.165 3.66.30 - 2018-08-06

“Bug fixes and performance improvements”.

This release is a fairly major overhaul of the shrinker designed to improve its behaviour on large examples, especially around stateful testing. You should hopefully see shrinking become much faster, with little to no quality degradation (in some cases quality may even improve).

## 18.166 3.66.29 - 2018-08-05

This release fixes two very minor bugs in the core engine:

- it fixes a corner case that was missing in [3.66.28](#), which should cause shrinking to work slightly better.
- it fixes some logic for how shrinking interacts with the database that was causing Hypothesis to be insufficiently aggressive about clearing out old keys.

## 18.167 3.66.28 - 2018-08-05

This release improves how Hypothesis handles reducing the size of integers' representation. This change should mostly be invisible as it's purely about the underlying representation and not the generated value, but it may result in some improvements to shrink performance.

## 18.168 3.66.27 - 2018-08-05

This release changes the order in which Hypothesis chooses parts of the test case to shrink. For typical usage this should be a significant performance improvement on large examples. It is unlikely to have a major impact on example quality, but where it does change the result it should usually be an improvement.

## 18.169 3.66.26 - 2018-08-05

This release improves the debugging information that the shrinker emits about the operations it performs, giving better summary statistics about which passes resulted in test executions and whether they were successful.

## 18.170 3.66.25 - 2018-08-05

This release fixes several bugs that were introduced to the shrinker in [3.66.24](#) which would have caused it to behave significantly less well than advertised. With any luck you should *actually* see the promised benefits now.

## 18.171 3.66.24 - 2018-08-03

This release changes how Hypothesis deletes data when shrinking in order to better handle deletion of large numbers of contiguous sequences. Most tests should see little change, but this will hopefully provide a significant speed up for *stateful testing*.

## 18.172 3.66.23 - 2018-08-02

This release makes some internal changes to enable further improvements to the shrinker. You may see some changes in the final shrunk examples, but they are unlikely to be significant.

### 18.173 3.66.22 - 2018-08-01

This release adds some more internal caching to the shrinker. This should cause a significant speed up for shrinking, especially for stateful testing and large example sizes.

### 18.174 3.66.21 - 2018-08-01

This patch is for downstream packagers - our tests now pass under `pytest 3.7.0` (released 2018-07-30). There are no changes to the source of Hypothesis itself.

### 18.175 3.66.20 - 2018-08-01

This release removes some functionality from the shrinker that was taking a considerable amount of time and does not appear to be useful any more due to a number of quality improvements in the shrinker.

You may see some degradation in shrink quality as a result of this, but mostly shrinking should just get much faster.

### 18.176 3.66.19 - 2018-08-01

This release slightly changes the format of some debugging information emitted during shrinking, and refactors some of the internal interfaces around that.

### 18.177 3.66.18 - 2018-07-31

This release is a very small internal refactoring which should have no user visible impact.

### 18.178 3.66.17 - 2018-07-31

This release fixes a bug that could cause an `IndexError` to be raised from inside Hypothesis during shrinking. It is likely that it was impossible to trigger this bug in practice - it was only made visible by some currently unreleased work.

### 18.179 3.66.16 - 2018-07-31

This release is a very small internal refactoring which should have no user visible impact.

### 18.180 3.66.15 - 2018-07-31

This release makes Hypothesis's shrinking faster by removing some redundant work that it does when minimizing values in its internal representation.

## 18.181 3.66.14 - 2018-07-30

This release expands the deprecation of `timeout` from *3.16.0* to also emit the deprecation warning in `find` or *stateful testing*.

## 18.182 3.66.13 - 2018-07-30

This release adds an additional shrink pass that is able to reduce the size of examples in some cases where the transformation is non-obvious. In particular this will improve the quality of some examples which would have regressed in *3.66.12*.

## 18.183 3.66.12 - 2018-07-28

This release changes how we group data together for shrinking. It should result in improved shrinker performance, especially in *stateful testing*.

## 18.184 3.66.11 - 2018-07-28

This patch modifies how which rule to run is selected during *rule based stateful testing*. This should result in a slight performance increase during generation and a significant performance and quality improvement when shrinking.

As a result of this change, some state machines which would previously have thrown an `InvalidDefinition` are no longer detected as invalid.

## 18.185 3.66.10 - 2018-07-28

This release weakens some minor functionality in the shrinker that had only modest benefit and made its behaviour much harder to reason about.

This is unlikely to have much user visible effect, but it is possible that in some cases shrinking may get slightly slower. It is primarily to make it easier to work on the shrinker and pave the way for future work.

## 18.186 3.66.9 - 2018-07-26

This release improves the information that Hypothesis emits about its shrinking when *verbosity* is set to `debug`.

## 18.187 3.66.8 - 2018-07-24

This patch includes some minor fixes in the documentation, and updates the minimum version of `pytest` to 3.0 (released August 2016).

## 18.188 3.66.7 - 2018-07-24

This release fixes a bug where difficult to shrink tests could sometimes trigger an internal assertion error inside the shrinker.

## 18.189 3.66.6 - 2018-07-23

This patch ensures that Hypothesis fully supports Python 3.7, by upgrading `from_type()` (issue #1264) and fixing some minor issues in our test suite (issue #1148).

## 18.190 3.66.5 - 2018-07-22

This patch fixes the online docs for various extras, by ensuring that their dependencies are installed on readthedocs.io (issue #1326).

## 18.191 3.66.4 - 2018-07-20

This release improves the shrinker's ability to reorder examples.

For example, consider the following test:

```
import hypothesis.strategies as st
from hypothesis import given

@given(st.text(), st.text())
def test_non_equal(x, y):
    assert x != y
```

Previously this could have failed with either of `x="", y="0"` or `x="0", y=""`. Now it should always fail with `x="", y="0"`.

This will allow the shrinker to produce more consistent results, especially in cases where test cases contain some ordered collection whose actual order does not matter.

## 18.192 3.66.3 - 2018-07-20

This patch fixes inference in the `builds()` strategy with subtypes of `typing.NamedTuple`, where the `__init__` method is not useful for introspection. We now use the field types instead - thanks to James Uther for identifying this bug.

## 18.193 3.66.2 - 2018-07-19

This release improves the shrinker's ability to handle situations where there is an additive constraint between two values.

For example, consider the following test:

```
import hypothesis.strategies as st
from hypothesis import given

@given(st.integers(), st.integers())
def test_does_not_exceed_100(m, n):
    assert m + n < 100
```

Previously this could have failed with almost any pair  $(m, n)$  with  $0 \leq m \leq n$  and  $m + n == 100$ . Now it should almost always fail with  $m=0, n=100$ .

This is a relatively niche specialisation, but can be useful in situations where e.g. a bug is triggered by an integer overflow.

### 18.194 3.66.1 - 2018-07-09

This patch fixes a rare bug where an incorrect percentage drawtime could be displayed for a test, when the system clock was changed during a test running under Python 2 (we use `time.monotonic()` where it is available to avoid such problems). It also fixes a possible zero-division error that can occur when the underlying C library double-rounds an intermediate value in `math.fsum()` and gets the least significant bit wrong.

### 18.195 3.66.0 - 2018-07-05

This release improves validation of the `alphabet` argument to the `text()` strategy. The following misuses are now deprecated, and will be an error in a future version:

- passing an unordered collection (such as `set('abc')`), which violates invariants about shrinking and reproducibility
- passing an alphabet sequence with elements that are not strings
- passing an alphabet sequence with elements that are not of length one, which violates any size constraints that may apply

Thanks to Sushobhit for adding these warnings ([issue #1329](#)).

### 18.196 3.65.3 - 2018-07-04

This release fixes a mostly theoretical bug where certain usage of the internal API could trigger an assertion error inside Hypothesis. It is unlikely that this problem is even possible to trigger through the public API.

### 18.197 3.65.2 - 2018-07-04

This release fixes dependency information for coverage. Previously Hypothesis would allow installing `coverage` with any version, but it only works with coverage 4.0 or later.

We now specify the correct metadata in our `setup.py`, so Hypothesis will only allow installation with compatible versions of coverage.



## 18.198 3.65.1 - 2018-07-03

This patch ensures that *stateful tests* which raise an error from a `pytest` helper still print the sequence of steps taken to reach that point (issue #1372). This reporting was previously broken because the helpers inherit directly from `BaseException`, and therefore require special handling to catch without breaking e.g. the use of ctrl-C to quit the test.

## 18.199 3.65.0 - 2018-06-30

This release deprecates the `max_shrinks` setting in favor of an internal heuristic. If you need to avoid shrinking examples, use the `phases` setting instead. (issue #1235)

## 18.200 3.64.2 - 2018-06-27

This release fixes a bug where an internal assertion error could sometimes be triggered while shrinking a failing test.

## 18.201 3.64.1 - 2018-06-27

This patch fixes type-checking errors in our vendored pretty-printer, which were ignored by our `mypy` config but visible for anyone else (whoops). Thanks to Pi Delpont for reporting issue #1359 so promptly.

## 18.202 3.64.0 - 2018-06-26

This release adds *an interface* which can be used to insert a wrapper between the original test function and `@given` (issue #1257). This will be particularly useful for test runner extensions such as `pytest-trio`, but is not recommended for direct use by other users of Hypothesis.

## 18.203 3.63.0 - 2018-06-26

This release adds a new mechanism to infer strategies for classes defined using `attrs`, based on the the type, converter, or validator of each attribute. This inference is now built in to `builds()` and `from_type()`.

On Python 2, `from_type()` no longer generates instances of `int` when passed `long`, or vice-versa.

## 18.204 3.62.0 - 2018-06-26

This release adds **PEP 484** type hints to Hypothesis on a provisional basis, using the comment-based syntax for Python 2 compatibility. You can *read more about our type hints here*.

It *also* adds the `py.typed` marker specified in **PEP 561**. After you `pip install hypothesis`, `mypy 0.590` or later will therefore type-check your use of our public interface!

## 18.205 3.61.0 - 2018-06-24

This release deprecates the use of `settings` as a context manager, the use of which is somewhat ambiguous.

Users should define settings with global state or with the `@settings(...)` decorator.

## 18.206 3.60.1 - 2018-06-20

Fixed a bug in generating an instance of a Django model from a strategy where the primary key is generated as part of the strategy. See [details here](#).

Thanks to Tim Martin for this contribution.

## 18.207 3.60.0 - 2018-06-20

This release adds the `@initialize` decorator for stateful testing (originally discussed in [issue #1216](#)). All `@initialize` rules will be called once each in an arbitrary order before any normal rule is called.

## 18.208 3.59.3 - 2018-06-19

This is a no-op release to take into account some changes to the release process. It should have no user visible effect.

## 18.209 3.59.2 - 2018-06-18

This adds support for partially sorting examples which cannot be fully sorted. For example, `[5, 4, 3, 2, 1, 0]` with a constraint that the first element needs to be larger than the last becomes `[1, 2, 3, 4, 5, 0]`.

Thanks to Luke for contributing.

## 18.210 3.59.1 - 2018-06-16

This patch uses `random.getstate()` and `random.setstate()` to restore the PRNG state after `@given` runs deterministic tests. Without restoring state, you might have noticed problems such as [issue #1266](#). The fix also applies to stateful testing ([issue #702](#)).

## 18.211 3.59.0 - 2018-06-14

This release adds the `emails()` strategy, which generates unicode strings representing an email address.

Thanks to Sushobhit for moving this to the public API ([issue #162](#)).

## 18.212 3.58.1 - 2018-06-13

This improves the shrinker. It can now reorder examples: 3 1 2 becomes 1 2 3.

Thanks to Luke for contributing.

## 18.213 3.58.0 - 2018-06-13

This adds a new extra `timezones()` strategy that generates `dateutil timezones`.

Thanks to Conrad for contributing.

## 18.214 3.57.0 - 2018-05-20

Using an unordered collection with the `permutations()` strategy has been deprecated because the order in which e.g. a set shrinks is arbitrary. This may cause different results between runs.

## 18.215 3.56.10 - 2018-05-16

This release makes `hypothesis.settings.define_setting` a private method, which has the effect of hiding it from the documentation.

## 18.216 3.56.9 - 2018-05-11

This is another release with no functionality changes as part of changes to Hypothesis's new release tagging scheme.

## 18.217 3.56.8 - 2018-05-10

This is a release with no functionality changes that moves Hypothesis over to a new release tagging scheme.

## 18.218 3.56.7 - 2018-05-10

This release provides a performance improvement for most tests, but in particular users of `sampled_from()` who don't have numpy installed should see a significant performance improvement.

## 18.219 3.56.6 - 2018-05-09

This patch contains further internal work to support Mypy. There are no user-visible changes... yet.

## 18.220 3.56.5 - 2018-04-22

This patch contains some internal refactoring to run `mypy` in CI. There are no user-visible changes.

## 18.221 3.56.4 - 2018-04-21

This release involves some very minor internal clean up and should have no user visible effect at all.

## 18.222 3.56.3 - 2018-04-20

This release fixes a problem introduced in `3.56.0` where setting the hypothesis home directory (through currently undocumented means) would no longer result in the default database location living in the new home directory.

## 18.223 3.56.2 - 2018-04-20

This release fixes a problem introduced in `3.56.0` where setting `max_examples` to 1 would result in tests failing with `Unsatisfiable`. This problem could also occur in other harder to trigger circumstances (e.g. by setting it to a low value, having a hard to satisfy assumption, and disabling health checks).

## 18.224 3.56.1 - 2018-04-20

This release fixes a problem that was introduced in `3.56.0`: Use of the `HYPOTHESIS_VERBOSITY_LEVEL` environment variable was, rather than deprecated, actually broken due to being read before various setup the deprecation path needed was done. It now works correctly (and emits a deprecation warning).

## 18.225 3.56.0 - 2018-04-17

This release deprecates several redundant or internally oriented `settings`, working towards an orthogonal set of configuration options that are widely useful *without* requiring any knowledge of our internals ([issue #535](#)).

- Deprecated settings that no longer have any effect are no longer shown in the `__repr__` unless set to a non-default value.
- `hypothesis.settings.perform_health_check` is deprecated, as it duplicates `suppress_health_check`.
- `hypothesis.settings.max_iterations` is deprecated and disabled, because we can usually get better behaviour from an internal heuristic than a user-controlled setting.
- `hypothesis.settings.min_satisfying_examples` is deprecated and disabled, due to overlap with the `filter_too_much` healthcheck and poor interaction with `max_examples`.
- `HYPOTHESIS_VERBOSITY_LEVEL` is now deprecated. Set `verbosity` through the profile system instead.
- Examples tried by `find()` are now reported at debug verbosity level (as well as `verbose` level).

## 18.226 3.55.6 - 2018-04-14

This release fixes a somewhat obscure condition ([issue #1230](#)) under which you could occasionally see a failing test trigger an assertion error inside Hypothesis instead of failing normally.

## 18.227 3.55.5 - 2018-04-14

This patch fixes one possible cause of [issue #966](#). When running Python 2 with hash randomisation, passing a `bytes` object to `random.seed()` would use `version=1`, which broke `derandomize` (because the seed depended on a randomised hash). If `derandomize` is *still* nondeterministic for you, please open an issue.

## 18.228 3.55.4 - 2018-04-13

This patch makes a variety of minor improvements to the documentation, and improves a few validation messages for invalid inputs.

## 18.229 3.55.3 - 2018-04-12

This release updates the URL metadata associated with the PyPI package (again). It has no other user visible effects.

## 18.230 3.55.2 - 2018-04-11

This release updates the URL metadata associated with the PyPI package. It has no other user visible effects.

## 18.231 3.55.1 - 2018-04-06

This patch relaxes constraints in our tests on the expected values returned by the standard library function `hypot()` and the internal helper function `cathetus`, to fix near-exact test failures on some 32-bit systems used by downstream packagers.

## 18.232 3.55.0 - 2018-04-05

This release includes several improvements to the handling of the `database` setting.

- The `database_file` setting was a historical artefact, and you should just use `database` directly.
- The `HYPOTHESIS_DATABASE_FILE` environment variable is deprecated, in favor of `load_profile()` and the `database` setting.
- If you have not configured the example database at all and the default location is not usable (due to e.g. permissions issues), Hypothesis will fall back to an in-memory database. This is not persisted between sessions, but means that the defaults work on read-only filesystems.

## 18.233 3.54.0 - 2018-04-04

This release improves the `complex_numbers()` strategy, which now supports `min_magnitude` and `max_magnitude` arguments, along with `allow_nan` and `allow_infinity` like for `floats()`.

Thanks to J.J. Green for this feature.

## 18.234 3.53.0 - 2018-04-01

This release removes support for Django 1.8, which reached end of life on 2018-04-01. You can see Django's release and support schedule [on the Django Project website](#).

## 18.235 3.52.3 - 2018-04-01

This patch fixes the `min_satisfying_examples` settings documentation, by explaining that example shrinking is tracked at the level of the underlying bytestream rather than the output value.

The output from `find()` in verbose mode has also been adjusted - see [the example session](#) - to avoid duplicating lines when the example repr is constant, even if the underlying representation has been shrunk.

## 18.236 3.52.2 - 2018-03-30

This release improves the output of failures with *rule based stateful testing* in two ways:

- The output from it is now usually valid Python code.
- When the same value has two different names because it belongs to two different bundles, it will now display with the name associated with the correct bundle for a rule argument where it is used.

## 18.237 3.52.1 - 2018-03-29

This release improves the behaviour of *stateful testing* in two ways:

- Previously some runs would run no steps ([issue #376](#)). This should no longer happen.
- `RuleBasedStateMachine` tests which used bundles extensively would often shrink terribly. This should now be significantly improved, though there is likely a lot more room for improvement.

This release also involves a low level change to how ranges of integers are handles which may result in other improvements to shrink quality in some cases.

## 18.238 3.52.0 - 2018-03-24

This release deprecates use of `@settings(...)` as a decorator, on functions or methods that are not also decorated with `@given`. You can still apply these decorators in any order, though you should only do so once each.

Applying `@given` twice was already deprecated, and applying `@settings(...)` twice is deprecated in this release and will become an error in a future version. Neither could ever be used twice to good effect.

Using `@settings(...)` as the sole decorator on a test is completely pointless, so this common usage error will become an error in a future version of Hypothesis.

## 18.239 3.51.0 - 2018-03-24

This release deprecates the `average_size` argument to `lists()` and other collection strategies. You should simply delete it wherever it was used in your tests, as it no longer has any effect.

In early versions of Hypothesis, the `average_size` argument was treated as a hint about the distribution of examples from a strategy. Subsequent improvements to the conceptual model and the engine for generating and shrinking examples mean it is more effective to simply describe what constitutes a valid example, and let our internals handle the distribution.

## 18.240 3.50.3 - 2018-03-24

This patch contains some internal refactoring so that we can run with warnings as errors in CI.

## 18.241 3.50.2 - 2018-03-20

This has no user-visible changes except one slight formatting change to one docstring, to avoid a deprecation warning.

## 18.242 3.50.1 - 2018-03-20

This patch fixes an internal error introduced in 3.48.0, where a check for the Django test runner would expose import-time errors in Django configuration (issue #1167).

## 18.243 3.50.0 - 2018-03-19

This release improves validation of numeric bounds for some strategies.

- `integers()` and `floats()` now raise `InvalidArgument` if passed a `min_value` or `max_value` which is not an instance of `Real`, instead of various internal errors.
- `floats()` now converts its bounding values to the nearest float above or below the min or max bound respectively, instead of just casting to float. The old behaviour was incorrect in that you could generate `float(min_value)`, even when this was less than `min_value` itself (possible with eg. fractions).
- When both bounds are provided to `floats()` but there are no floats in the interval, such as `[(2**54)+1 .. (2**55)-1]`, `InvalidArgument` is raised.
- `decimals()` gives a more useful error message if passed a string that cannot be converted to `Decimal` in a context where this error is not trapped.

Code that previously **seemed** to work may be explicitly broken if there were no floats between `min_value` and `max_value` (only possible with non-float bounds), or if a bound was not a `Real` number but still allowed in `math.isnan` (some custom classes with a `__float__` method).

## 18.244 3.49.1 - 2018-03-15

This patch fixes our tests for Numpy dtype strategies on big-endian platforms, where the strategy behaved correctly but the test assumed that the native byte order was little-endian.

There is no user impact unless you are running our test suite on big-endian platforms. Thanks to Graham Inggs for reporting [issue #1164](#).

## 18.245 3.49.0 - 2018-03-12

This release deprecates passing `elements=None` to collection strategies, such as `lists()`.

Requiring `lists(nothing())` or `builds(list)` instead of `lists()` means slightly more typing, but also improves the consistency and discoverability of our API - as well as showing how to compose or construct strategies in ways that still work in more complex situations.

Passing a nonzero `max_size` to a collection strategy where the `elements` strategy contains no values is now deprecated, and will be an error in a future version. The equivalent with `elements=None` is already an error.

## 18.246 3.48.1 - 2018-03-05

This patch will minimize examples that would come out non-minimal in previous versions. Thanks to Kyle Reeve for this patch.

## 18.247 3.48.0 - 2018-03-05

This release improves some “unhappy paths” when using Hypothesis with the standard library `unittest` module:

- Applying `@given` to a non-test method which is overridden from `unittest.TestCase`, such as `setUp`, raises a *new health check*. ([issue #991](#))
- Using `subTest()` within a test decorated with `@given` would leak intermediate results when tests were run under the `unittest` test runner. Individual reporting of failing subtests is now disabled during a test using `@given`. ([issue #1071](#))
- `@given` is still not a class decorator, but the error message if you try using it on a class has been improved.

As a related improvement, using `django.test.TestCase` with `@given` instead of `hypothesis.extra.django.TestCase` raises an explicit error instead of running all examples in a single database transaction.

## 18.248 3.47.0 - 2018-03-02

`register_profile` now accepts keyword arguments for specific settings, and the parent settings object is now optional. Using a name for a registered profile which is not a string was never suggested, but it is now also deprecated and will eventually be an error.

## 18.249 3.46.2 - 2018-03-01

This release removes an unnecessary branch from the code, and has no user-visible impact.



## 18.250 3.46.1 - 2018-03-01

This changes only the formatting of our docstrings and should have no user-visible effects.

## 18.251 3.46.0 - 2018-02-26

`characters()` has improved docs about what arguments are valid, and additional validation logic to raise a clear error early (instead of e.g. silently ignoring a bad argument). Categories may be specified as the Unicode ‘general category’ (eg `u'Nd'`), or as the ‘major category’ (eg `[u'N', u'Lu']` is equivalent to `[u'Nd', u'Nl', u'No', u'Lu']`).

In previous versions, general categories were supported and all other input was silently ignored. Now, major categories are supported in addition to general categories (which may change the behaviour of some existing code), and all other input is deprecated.

## 18.252 3.45.5 - 2018-02-26

This patch improves strategy inference in `hypothesis.extra.django` to account for some validators in addition to field type - see [issue #1116](#) for ongoing work in this space.

Specifically, if a `CharField` or `TextField` has an attached `RegexValidator`, we now use `from_regex()` instead of `text()` as the underlying strategy. This allows us to generate examples of the default `User` model, closing [issue #1112](#).

## 18.253 3.45.4 - 2018-02-25

This patch improves some internal debugging information, fixes a typo in a validation error message, and expands the documentation for new contributors.

## 18.254 3.45.3 - 2018-02-23

This patch may improve example shrinking slightly for some strategies.

## 18.255 3.45.2 - 2018-02-18

This release makes our docstring style more consistent, thanks to [flake8-docstrings](#). There are no user-visible changes.

## 18.256 3.45.1 - 2018-02-17

This fixes an indentation issue in docstrings for `datetimes()`, `dates()`, `times()`, and `timedeltas()`.

## 18.257 3.45.0 - 2018-02-13

This release fixes `builds()` so that `target` can be used as a keyword argument for passing values to the target. The target itself can still be specified as a keyword argument, but that behavior is now deprecated. The target should be provided as the first positional argument.

## 18.258 3.44.26 - 2018-02-06

This release fixes some formatting issues in the Hypothesis source code. It should have no externally visible effects.

## 18.259 3.44.25 - 2018-02-05

This release changes the way in which Hypothesis tries to shrink the size of examples. It probably won't have much impact, but might make shrinking faster in some cases. It is unlikely but not impossible that it will change the resulting examples.

## 18.260 3.44.24 - 2018-01-27

This release fixes dependency information when installing Hypothesis from a binary “wheel” distribution.

- The `install_requires` for `enum34` is resolved at install time, rather than at build time (with potentially different results).
- Django has fixed their `python_requires` for versions 2.0.0 onward, simplifying Python2-compatible constraints for downstream projects.

## 18.261 3.44.23 - 2018-01-24

This release improves shrinking in a class of pathological examples that you are probably never hitting in practice. If you *are* hitting them in practice this should be a significant speed up in shrinking. If you are not, you are very unlikely to notice any difference. You might see a slight slow down and/or slightly better falsifying examples.

## 18.262 3.44.22 - 2018-01-23

This release fixes a dependency problem. It was possible to install Hypothesis with an old version of `attrs`, which would throw a `TypeError` as soon as you tried to import `hypothesis`. Specifically, you need `attrs 16.0.0` or newer.

Hypothesis will now require the correct version of `attrs` when installing.

## 18.263 3.44.21 - 2018-01-22

This change adds some additional structural information that Hypothesis will use to guide its search.

You mostly shouldn't see much difference from this. The two most likely effects you would notice are:

1. Hypothesis stores slightly more examples in its database for passing tests.

2. Hypothesis *may* find new bugs that it was previously missing, but it probably won't (this is a basic implementation of the feature that is intended to support future work. Although it is useful on its own, it's not *very* useful on its own).

## 18.264 3.44.20 - 2018-01-21

This is a small refactoring release that changes how Hypothesis tracks some information about the boundary of examples in its internal representation.

You are unlikely to see much difference in behaviour, but memory usage and run time may both go down slightly during normal test execution, and when failing Hypothesis might print its failing example slightly sooner.

## 18.265 3.44.19 - 2018-01-21

This changes how we compute the default `average_size` for all collection strategies. Previously setting a `max_size` without setting an `average_size` would have the seemingly paradoxical effect of making data generation *slower*, because it would raise the average size from its default. Now setting `max_size` will either leave the default unchanged or lower it from its default.

If you are currently experiencing this problem, this may make your tests substantially faster. If you are not, this will likely have no effect on you.

## 18.266 3.44.18 - 2018-01-20

This is a small refactoring release that changes how Hypothesis detects when the structure of data generation depends on earlier values generated (e.g. when using `flatMap` or `composite()`). It should not have any observable effect on behaviour.

## 18.267 3.44.17 - 2018-01-15

This release fixes a typo in internal documentation, and has no user-visible impact.

## 18.268 3.44.16 - 2018-01-13

This release improves test case reduction for recursive data structures. Hypothesis now guarantees that whenever a strategy calls itself recursively (usually this will happen because you are using `deferred()`), any recursive call may replace the top level value. e.g. given a tree structure, Hypothesis will always try replacing it with a subtree.

Additionally this introduces a new heuristic that may in some circumstances significantly speed up test case reduction - Hypothesis should be better at immediately replacing elements drawn inside another strategy with their minimal possible value.

## 18.269 3.44.15 - 2018-01-13

`from_type()` can now resolve recursive types such as binary trees (issue #1004). Detection of non-type arguments has also improved, leading to better error messages in many cases involving **forward references**.

## 18.270 3.44.14 - 2018-01-08

This release fixes a bug in the shrinker that prevented the optimisations in [3.44.6](#) from working in some cases. It would not have worked correctly when filtered examples were nested (e.g. with a set of integers in some range).

This would not have resulted in any correctness problems, but shrinking may have been slower than it otherwise could be.

## 18.271 3.44.13 - 2018-01-08

This release changes the average bit length of values drawn from `integers()` to be much smaller. Additionally it changes the shrinking order so that now size is considered before sign - e.g. -1 will be preferred to +10.

The new internal format for integers required some changes to the minimizer to make work well, so you may also see some improvements to example quality in unrelated areas.

## 18.272 3.44.12 - 2018-01-07

This changes Hypothesis's internal implementation of weighted sampling. This will affect example distribution and quality, but you shouldn't see any other effects.

## 18.273 3.44.11 - 2018-01-06

This is a change to some internals around how Hypothesis handles avoiding generating duplicate examples and seeking out novel regions of the search space.

You are unlikely to see much difference as a result of it, but it fixes a bug where an internal assertion could theoretically be triggered and has some minor effects on the distribution of examples so could potentially find bugs that have previously been missed.

## 18.274 3.44.10 - 2018-01-06

This patch avoids creating debug statements when debugging is disabled. Profiling suggests this is a 5-10% performance improvement ([pull request #1040](#)).

## 18.275 3.44.9 - 2018-01-06

This patch blacklists null characters (`'\x00'`) in automatically created strategies for Django `CharField` and `TextField`, due to a database issue which [was recently fixed upstream](#) (Hypothesis issue [#1045](#)).

## 18.276 3.44.8 - 2018-01-06

This release makes the Hypothesis shrinker slightly less greedy in order to avoid local minima - when it gets stuck, it makes a small attempt to search around the final example it would previously have returned to find a new starting

point to shrink from. This should improve example quality in some cases, especially ones where the test data has dependencies among parts of it that make it difficult for Hypothesis to proceed.

## 18.277 3.44.7 - 2018-01-04

This release adds support for [Django 2](#) in the hypothesis-django extra.

This release drops support for Django 1.10, as it is no longer supported by the Django team.

## 18.278 3.44.6 - 2018-01-02

This release speeds up test case reduction in many examples by being better at detecting large shrinks it can use to discard redundant parts of its input. This will be particularly noticeable in examples that make use of filtering and for some integer ranges.

## 18.279 3.44.5 - 2018-01-02

Happy new year!

This is a no-op release that updates the year range on all of the copyright headers in our source to include 2018.

## 18.280 3.44.4 - 2017-12-23

This release fixes [issue #1044](#), which slowed tests by up to 6% due to broken caching.

## 18.281 3.44.3 - 2017-12-21

This release improves the shrinker in cases where examples drawn earlier can affect how much data is drawn later (e.g. when you draw a length parameter in a composite and then draw that many elements). Examples found in cases like this should now be much closer to minimal.

## 18.282 3.44.2 - 2017-12-20

This is a pure refactoring release which changes how Hypothesis manages its set of examples internally. It should have no externally visible effects.

## 18.283 3.44.1 - 2017-12-18

This release fixes [issue #997](#), in which under some circumstances the body of tests run under Hypothesis would not show up when run under coverage even though the tests were run and the code they called outside of the test file would show up normally.

## 18.284 3.44.0 - 2017-12-17

This release adds a new feature: The `@reproduce_failure` decorator, designed to make it easy to use Hypothesis's binary format for examples to reproduce a problem locally without having to share your example database between machines.

This also changes when seeds are printed:

- They will no longer be printed for normal falsifying examples, as there are now adequate ways of reproducing those for all cases, so it just contributes noise.
- They will once again be printed when reusing examples from the database, as health check failures should now be more reliable in this scenario so it will almost always work in this case.

This work was funded by [Smarkets](#).

## 18.285 3.43.1 - 2017-12-17

This release fixes a bug with Hypothesis's database management - examples that were found in the course of shrinking were saved in a way that indicated that they had distinct causes, and so they would all be retried on the start of the next test. The intended behaviour, which is now what is implemented, is that only a bounded subset of these examples would be retried.

## 18.286 3.43.0 - 2017-12-17

`HypothesisDeprecationWarning` now inherits from `FutureWarning` instead of `DeprecationWarning`, as recommended by [PEP 565](#) for user-facing warnings (issue #618). If you have not changed the default warnings settings, you will now see each distinct `HypothesisDeprecationWarning` instead of only the first.

## 18.287 3.42.2 - 2017-12-12

This patch fixes [issue #1017](#), where instances of a list or tuple subtype used as an argument to a strategy would be coerced to tuple.

## 18.288 3.42.1 - 2017-12-10

This release has some internal cleanup, which makes reading the code more pleasant and may shrink large examples slightly faster.

## 18.289 3.42.0 - 2017-12-09

This release deprecates `faker-extra`, which was designed as a transition strategy but does not support example shrinking or coverage-guided discovery.

## 18.290 3.41.0 - 2017-12-06

`sampled_from()` can now sample from one-dimensional numpy ndarrays. Sampling from multi-dimensional ndarrays still results in a deprecation warning. Thanks to Charlie Tanksley for this patch.

## 18.291 3.40.1 - 2017-12-04

This release makes two changes:

- It makes the calculation of some of the metadata that Hypothesis uses for shrinking occur lazily. This should speed up performance of test case generation a bit because it no longer calculates information it doesn't need.
- It improves the shrinker for certain classes of nested examples. e.g. when shrinking lists of lists, the shrinker is now able to concatenate two adjacent lists together into a single list. As a result of this change, shrinking may get somewhat slower when the minimal example found is large.

## 18.292 3.40.0 - 2017-12-02

This release improves how various ways of seeding Hypothesis interact with the example database:

- Using the example database with `seed()` is now deprecated. You should set `database=None` if you are doing that. This will only warn if you actually load examples from the database while using `@seed`.
- The `derandomize` will behave the same way as `@seed`.
- Using `--hypothesis-seed` will disable use of the database.
- If a test used examples from the database, it will not suggest using a seed to reproduce it, because that won't work.

This work was funded by [Smarkets](#).

## 18.293 3.39.0 - 2017-12-01

This release adds a new health check that checks if the smallest “natural” possible example of your test case is very large - this will tend to cause Hypothesis to generate bad examples and be quite slow.

This work was funded by [Smarkets](#).

## 18.294 3.38.9 - 2017-11-29

This is a documentation release to improve the documentation of shrinking behaviour for Hypothesis's strategies.

## 18.295 3.38.8 - 2017-11-29

This release improves the performance of `characters()` when using `blacklist_characters` and `from_regex()` when using negative character classes.

The problems this fixes were found in the course of work funded by [Smarkets](#).

## 18.296 3.38.7 - 2017-11-29

This is a patch release for `from_regex()`, which had a bug in handling of the `re.VERBOSE` flag (issue #992). Flags are now handled correctly when parsing regex.

## 18.297 3.38.6 - 2017-11-28

This patch changes a few byte-string literals from double to single quotes, thanks to an update in `unify`. There are no user-visible changes.

## 18.298 3.38.5 - 2017-11-23

This fixes the repr of strategies using lambda that are defined inside decorators to include the lambda source.

This would mostly have been visible when using the `statistics` functionality - lambdas used for e.g. filtering would have shown up with a `<unknown>` as their body. This can still happen, but it should happen less often now.

## 18.299 3.38.4 - 2017-11-22

This release updates the reported `statistics` so that they show approximately what fraction of your test run time is spent in data generation (as opposed to test execution).

This work was funded by [Smarkets](#).

## 18.300 3.38.3 - 2017-11-21

This is a documentation release, which ensures code examples are up to date by running them as doctests in CI (issue #711).

## 18.301 3.38.2 - 2017-11-21

This release changes the behaviour of the `deadline` setting when used with `data()`: Time spent inside calls to `data.draw` will no longer be counted towards the deadline time.

As a side effect of some refactoring required for this work, the way flaky tests are handled has changed slightly. You are unlikely to see much difference from this, but some error messages will have changed.

This work was funded by [Smarkets](#).

## 18.302 3.38.1 - 2017-11-21

This patch has a variety of non-user-visible refactorings, removing various minor warts ranging from indirect imports to typos in comments.



## 18.303 3.38.0 - 2017-11-18

This release overhauls *the health check system* in a variety of small ways. It adds no new features, but is nevertheless a minor release because it changes which tests are likely to fail health checks.

The most noticeable effect is that some tests that used to fail health checks will now pass, and some that used to pass will fail. These should all be improvements in accuracy. In particular:

- New failures will usually be because they are now taking into account things like use of `data()` and `assume()` inside the test body.
- New failures *may* also be because for some classes of example the way data generation performance was measured was artificially faster than real data generation (for most examples that are hitting performance health checks the opposite should be the case).
- Tests that used to fail health checks and now pass do so because the health check system used to run in a way that was subtly different than the main Hypothesis data generation and lacked some of its support for e.g. large examples.

If your data generation is especially slow, you may also see your tests get somewhat faster, as there is no longer a separate health check phase. This will be particularly noticeable when rerunning test failures.

This work was funded by [Smarkets](#).

## 18.304 3.37.0 - 2017-11-12

This is a deprecation release for some health check related features.

The following are now deprecated:

- Passing `HealthCheck.exception_in_generation` to `suppress_health_check`. This no longer does anything even when passed - All errors that occur during data generation will now be immediately reraised rather than going through the health check mechanism.
- Passing `HealthCheck.random_module` to `suppress_health_check`. This hasn't done anything for a long time, but was never explicitly deprecated. Hypothesis always seeds the random module when running `@given` tests, so this is no longer an error and suppressing it doesn't do anything.
- Passing non-`HealthCheck` values in `suppress_health_check`. This was previously allowed but never did anything useful.

In addition, passing a non-iterable value as `suppress_health_check` will now raise an error immediately (it would never have worked correctly, but it would previously have failed later). Some validation error messages have also been updated.

This work was funded by [Smarkets](#).

## 18.305 3.36.1 - 2017-11-10

This is a yak shaving release, mostly concerned with our own tests.

While `getfullargspec()` was documented as deprecated in Python 3.5, it never actually emitted a warning. Our code to silence this (nonexistent) warning has therefore been removed.

We now run our tests with `DeprecationWarning` as an error, and made some minor changes to our own tests as a result. This required similar upstream updates to `coverage` and `execnet` (a test-time dependency via `pytest-xdist`).

There is no user-visible change in Hypothesis itself, but we encourage you to consider enabling deprecations as errors in your own tests.

### 18.306 3.36.0 - 2017-11-06

This release adds a setting to the public API, and does some internal cleanup:

- The `derandomize` setting is now documented (issue #890)
- Removed - and disallowed - all ‘bare excepts’ in Hypothesis (issue #953)
- Documented the `strict` setting as deprecated, and updated the build so our docs always match deprecations in the code.

### 18.307 3.35.0 - 2017-11-06

This minor release supports constraining `uuids()` to generate a particular version of UUID (issue #721).

Thanks to Dion Mistic for this feature.

### 18.308 3.34.1 - 2017-11-02

This patch updates the documentation to suggest `builds(callable)` instead of `just(callable())`.

### 18.309 3.34.0 - 2017-11-02

Hypothesis now emits deprecation warnings if you apply `@given` more than once to a target.

Applying `@given` repeatedly wraps the target multiple times. Each wrapper will search the space of possible parameters separately. This is equivalent but will be much more inefficient than doing it with a single call to `@given`.

For example, instead of `@given(booleans()) @given(integers())`, you could write `@given(booleans(), integers())`

### 18.310 3.33.1 - 2017-11-02

This is a bugfix release:

- `builds()` would try to infer a strategy for required positional arguments of the target from type hints, even if they had been given to `builds()` as positional arguments (issue #946). Now it only infers missing required arguments.
- An internal introspection function wrongly reported `self` as a required argument for bound methods, which might also have affected `builds()`. Now it knows better.

## 18.311 3.33.0 - 2017-10-16

This release supports strategy inference for more Django field types - you can now omit an argument for Date, Time, Duration, Slug, IP Address, and UUID fields. ([issue #642](#))

Strategy generation for fields with grouped choices now selects choices from each group, instead of selecting from the group names.

## 18.312 3.32.2 - 2017-10-15

This patch removes the `mergedb` tool, introduced in Hypothesis 1.7.1 on an experimental basis. It has never actually worked, and the new *Hypothesis example database* is designed to make such a tool unnecessary.

## 18.313 3.32.1 - 2017-10-13

This patch has two improvements for strategies based on enumerations.

- `from_type()` now handles enumerations correctly, delegating to `sampled_from()`. Previously it noted that `Enum.__init__` has no required arguments and therefore delegated to `builds()`, which would subsequently fail.
- When sampling from an `enum.Flag`, we also generate combinations of members. Eg for `Flag('Permissions', 'READ, WRITE, EXECUTE')` we can now generate, `Permissions.READ, Permissions.READ|WRITE`, and so on.

## 18.314 3.32.0 - 2017-10-09

This changes the default value of the `use_coverage` setting to True when running on pypy (it was already True on CPython).

It was previously set to False because we expected it to be too slow, but recent benchmarking shows that actually performance of the feature on pypy is fairly acceptable - sometimes it's slower than on CPython, sometimes it's faster, but it's generally within a factor of two either way.

## 18.315 3.31.6 - 2017-10-08

This patch improves the quality of strategies inferred from Numpy dtypes:

- Integer dtypes generated examples with the upper half of their (non-sign) bits set to zero. The inferred strategies can now produce any representable integer.
- Fixed-width unicode- and byte-string dtypes now cap the internal example length, which should improve example and shrink quality.
- Numpy arrays can only store fixed-size strings internally, and allow shorter strings by right-padding them with null bytes. Inferred string strategies no longer generate such values, as they can never be retrieved from an array. This improves shrinking performance by skipping useless values.

This has already been useful in Hypothesis - we found an overflow bug in our Pandas support, and as a result `indexes()` and `range_indexes()` now check that `min_size` and `max_size` are at least zero.

## 18.316 3.31.5 - 2017-10-08

This release fixes a performance problem in tests where the `use_coverage` setting is `True`.

Tests experience a slow-down proportionate to the amount of code they cover. This is still the case, but the factor is now low enough that it should be unnoticeable. Previously it was large and became much larger in 3.30.4.

## 18.317 3.31.4 - 2017-10-08

`from_type()` failed with a very confusing error if passed a `NewType()` (issue #901). These psudeo-types are now unwrapped correctly, and strategy inference works as expected.

## 18.318 3.31.3 - 2017-10-06

This release makes some small optimisations to our use of coverage that should reduce constant per-example overhead. This is probably only noticeable on examples where the test itself is quite fast. On no-op tests that don't test anything you may see up to a fourfold speed increase (which is still significantly slower than without coverage). On more realistic tests the speed up is likely to be less than that.

## 18.319 3.31.2 - 2017-09-30

This release fixes some formatting and small typos/grammar issues in the documentation, specifically the page docs/settings.rst, and the inline docs for the various settings.

## 18.320 3.31.1 - 2017-09-30

This release improves the handling of deadlines so that they act better with the shrinking process. This fixes issue #892.

This involves two changes:

1. The deadline is raised during the initial generation and shrinking, and then lowered to the set value for final replay. This restricts our attention to examples which exceed the deadline by a more significant margin, which increases their reliability.
2. When despite the above a test still becomes flaky because it is significantly faster on rerun than it was on its first run, the error message is now more explicit about the nature of this problem, and includes both the initial test run time and the new test run time.

In addition, this release also clarifies the documentation of the deadline setting slightly to be more explicit about where it applies.

This work was funded by [Smarkets](#).

## 18.321 3.31.0 - 2017-09-29

This release blocks installation of Hypothesis on Python 3.3, which **reached its end of life date on 2017-09-29**.

This should not be of interest to anyone but downstream maintainers - if you are affected, migrate to a secure version of Python as soon as possible or at least seek commercial support.

## 18.322 3.30.4 - 2017-09-27

This release makes several changes:

1. It significantly improves Hypothesis's ability to use coverage information to find interesting examples.
2. It reduces the default `max_examples` setting from 200 to 100. This takes advantage of the improved algorithm meaning fewer examples are typically needed to get the same testing and is sufficiently better at covering interesting behaviour, and offsets some of the performance problems of running under coverage.
3. Hypothesis will always try to start its testing with an example that is near minimized.

The new algorithm for 1 also makes some changes to Hypothesis's low level data generation which apply even with coverage turned off. They generally reduce the total amount of data generated, which should improve test performance somewhat. Between this and 3 you should see a noticeable reduction in test runtime (how much so depends on your tests and how much example size affects their performance. On our benchmarks, where data generation dominates, we saw up to a factor of two performance improvement, but it's unlikely to be that large.

## 18.323 3.30.3 - 2017-09-25

This release fixes some formatting and small typos/grammar issues in the documentation, specifically the page docs/details.rst, and some inline docs linked from there.

## 18.324 3.30.2 - 2017-09-24

This release changes Hypothesis's caching approach for functions in `hypothesis.strategies`. Previously it would have cached extremely aggressively and cache entries would never be evicted. Now it adopts a least-frequently used, least recently used key invalidation policy, and is somewhat more conservative about which strategies it caches.

Workloads which create strategies based on dynamic values, e.g. by using `flatmap` or `composite()`, will use significantly less memory.

## 18.325 3.30.1 - 2017-09-22

This release fixes a bug where when running with the `use_coverage=True` setting inside an existing running instance of coverage, Hypothesis would frequently put files that the `coveragerc` excluded in the report for the enclosing coverage.

## 18.326 3.30.0 - 2017-09-20

This release introduces two new features:

- When a test fails, either with a health check failure or a falsifying example, Hypothesis will print out a seed that led to that failure, if the test is not already running with a fixed seed. You can then recreate that failure using either the `@seed` decorator or (if you are running `pytest`) with `--hypothesis-seed`.

- `pytest` users can specify a seed to use for `@given` based tests by passing the `--hypothesis-seed` command line argument.

This work was funded by [Smarkets](#).

### 18.327 3.29.0 - 2017-09-19

This release makes Hypothesis coverage aware. Hypothesis now runs all test bodies under coverage, and uses this information to guide its testing.

The `use_coverage` setting can be used to disable this behaviour if you want to test code that is sensitive to coverage being enabled (either because of performance or interaction with the trace function).

The main benefits of this feature are:

- Hypothesis now observes when examples it discovers cover particular lines or branches and stores them in the database for later.
- Hypothesis will make some use of this information to guide its exploration of the search space and improve the examples it finds (this is currently used only very lightly and will likely improve significantly in future releases).

This also has the following side-effects:

- Hypothesis now has an install time dependency on the `coverage` package.
- Tests that are already running Hypothesis under coverage will likely get faster.
- Tests that are not running under coverage now run their test bodies under coverage by default.

This feature is only partially supported under `pypy`. It is significantly slower than on CPython and is turned off by default as a result, but it should still work correctly if you want to use it.

### 18.328 3.28.3 - 2017-09-18

This release is an internal change that affects how Hypothesis handles calculating certain properties of strategies.

The primary effect of this is that it fixes a bug where use of `deferred()` could sometimes trigger an internal assertion error. However the fix for this bug involved some moderately deep changes to how Hypothesis handles certain constructs so you may notice some additional knock-on effects.

In particular the way Hypothesis handles drawing data from strategies that cannot generate any values has changed to bail out sooner than it previously did. This may speed up certain tests, but it is unlikely to make much of a difference in practice for tests that were not already failing with `Unsatisfiable`.

### 18.329 3.28.2 - 2017-09-18

This is a patch release that fixes a bug in the `hypothesis.extra.pandas` documentation where it incorrectly referred to `column()` instead of `columns()`.

### 18.330 3.28.1 - 2017-09-16

This is a refactoring release. It moves a number of internal uses of `namedtuple()` over to using attrs based classes, and removes a couple of internal `namedtuple` classes that were no longer in use.

It should have no user visible impact.

### 18.331 3.28.0 - 2017-09-15

This release adds support for testing `pandas` via the `hypothesis.extra.pandas` module.

It also adds a dependency on `attrs`.

This work was funded by [Stripe](#).

### 18.332 3.27.1 - 2017-09-14

This release fixes some formatting and broken cross-references in the documentation, which includes editing doc-strings - and thus a patch release.

### 18.333 3.27.0 - 2017-09-13

This release introduces a `deadline` setting to Hypothesis.

When set this turns slow tests into errors. By default it is unset but will warn if you exceed 200ms, which will become the default value in a future release.

This work was funded by [Smarkets](#).

### 18.334 3.26.0 - 2017-09-12

Hypothesis now emits deprecation warnings if you are using the legacy SQLite example database format, or the tool for merging them. These were already documented as deprecated, so this doesn't change their deprecation status, only that we warn about it.

### 18.335 3.25.1 - 2017-09-12

This release fixes a bug with generating `numpy datetime` and `timedelta` types: When inferring the strategy from the dtype, `datetime` and `timedelta` dtypes with sub-second precision would always produce examples with one second resolution. Inferring a strategy from a time dtype will now always produce example with the same precision.

### 18.336 3.25.0 - 2017-09-12

This release changes how Hypothesis shrinks and replays examples to take into account that it can encounter new bugs while shrinking the bug it originally found. Previously it would end up replacing the originally found bug with the new bug and show you only that one. Now it is (often) able to recognise when two bugs are distinct and when it finds more than one will show both.

## 18.337 3.24.2 - 2017-09-11

This release removes the (purely internal and no longer useful) `strategy_test_suite` function and the corresponding `strategytests` module.

## 18.338 3.24.1 - 2017-09-06

This release improves the reduction of examples involving floating point numbers to produce more human readable examples.

It also has some general purpose changes to the way the minimizer works internally, which may see some improvement in quality and slow down of test case reduction in cases that have nothing to do with floating point numbers.

## 18.339 3.24.0 - 2017-09-05

Hypothesis now emits deprecation warnings if you use `some_strategy.example()` inside a test function or strategy definition (this was never intended to be supported, but is sufficiently widespread that it warrants a deprecation path).

## 18.340 3.23.3 - 2017-09-05

This is a bugfix release for `decimals()` with the `places` argument.

- No longer fails health checks ([issue #725](#), due to internal filtering)
- Specifying a `min_value` and `max_value` without any decimals with `places` places between them gives a more useful error message.
- Works for any valid arguments, regardless of the decimal precision context.

## 18.341 3.23.2 - 2017-09-01

This is a small refactoring release that removes a now-unused parameter to an internal API. It shouldn't have any user visible effect.

## 18.342 3.23.1 - 2017-09-01

Hypothesis no longer propagates the dynamic scope of settings into strategy definitions.

This release is a small change to something that was never part of the public API and you will almost certainly not notice any effect unless you're doing something surprising, but for example the following code will now give a different answer in some circumstances:

```
import hypothesis.strategies as st
from hypothesis import settings

CURRENT_SETTINGS = st.builds(lambda: settings.default)
```



(We don't actually encourage you writing code like this)

Previously this would have generated the settings that were in effect at the point of definition of `CURRENT_SETTINGS`. Now it will generate the settings that are used for the current test.

It is very unlikely to be significant enough to be visible, but you may also notice a small performance improvement.

## 18.343 3.23.0 - 2017-08-31

This release adds a `unique` argument to `arrays()` which behaves the same ways as the corresponding one for `lists()`, requiring all of the elements in the generated array to be distinct.

## 18.344 3.22.2 - 2017-08-29

This release fixes an issue where Hypothesis would raise a `TypeError` when using the datetime-related strategies if running with `PYTHONOPTIMIZE=2`. This bug was introduced in `3.20.0`. (See [issue #822](#))

## 18.345 3.22.1 - 2017-08-28

Hypothesis now transparently handles problems with an internal unicode cache, including file truncation or read-only filesystems ([issue #767](#)). Thanks to Sam Hames for the patch.

## 18.346 3.22.0 - 2017-08-26

This release provides what should be a substantial performance improvement to numpy arrays generated using *provided numpy support*, and adds a new `fill_value` argument to `arrays()` to control this behaviour.

This work was funded by [Stripe](#).

## 18.347 3.21.3 - 2017-08-26

This release fixes some extremely specific circumstances that probably have never occurred in the wild where users of `deferred()` might have seen a `RuntimeError` from too much recursion, usually in cases where no valid example could have been generated anyway.

## 18.348 3.21.2 - 2017-08-25

This release fixes some minor bugs in argument validation:

- `hypothesis.extra.numpy` dtype strategies would raise an internal error instead of an `InvalidArgument` exception when passed an invalid endianness specification.
- `fractions()` would raise an internal error instead of an `InvalidArgument` if passed `float("nan")` as one of its bounds.
- The error message for passing `float("nan")` as a bound to various strategies has been improved.

- Various bound arguments will now raise `InvalidArgument` in cases where they would previously have raised an internal `TypeError` or `ValueError` from the relevant conversion function.
- `streaming()` would not have emitted a deprecation warning when called with an invalid argument.

### 18.349 3.21.1 - 2017-08-24

This release fixes a bug where test failures that were the result of an *@example* would print an extra stack trace before re-raising the exception.

### 18.350 3.21.0 - 2017-08-23

This release deprecates Hypothesis's strict mode, which turned Hypothesis's deprecation warnings into errors. Similar functionality can be achieved by using `simplefilter('error', HypothesisDeprecationWarning)`.

### 18.351 3.20.0 - 2017-08-22

This release renames the relevant arguments on the `datetimes()`, `dates()`, `times()`, and `timedeltas()` strategies to `min_value` and `max_value`, to make them consistent with the other strategies in the module.

The old argument names are still supported but will emit a deprecation warning when used explicitly as keyword arguments. Arguments passed positionally will go to the new argument names and are not deprecated.

### 18.352 3.19.3 - 2017-08-22

This release provides a major overhaul to the internals of how Hypothesis handles shrinking.

This should mostly be visible in terms of getting better examples for tests which make heavy use of `composite()`, `data()` or `flatmap` where the data drawn depends a lot on previous choices, especially where size parameters are affected. Previously Hypothesis would have struggled to reliably produce good examples here. Now it should do much better. Performance should also be better for examples with a non-zero `min_size`.

You may see slight changes to example generation (e.g. improved example diversity) as a result of related changes to internals, but they are unlikely to be significant enough to notice.

### 18.353 3.19.2 - 2017-08-21

This release fixes two bugs in `hypothesis.extra.numpy`:

- `unicode_string_dtypes()` didn't work at all due to an incorrect dtype specifier. Now it does.
- Various impossible conditions would have been accepted but would error when they fail to produced any example. Now they raise an explicit `InvalidArgument` error.

## 18.354 3.19.1 - 2017-08-21

This is a bugfix release for [issue #739](#), where bounds for `fractions()` or floating-point `decimals()` were not properly converted to integers before passing them to the integers strategy. This excluded some values that should have been possible, and could trigger internal errors if the bounds lay between adjacent integers.

You can now bound `fractions()` with two arbitrarily close fractions.

It is now an explicit error to supply a `min_value`, `max_value`, and `max_denominator` to `fractions()` where the value bounds do not include a fraction with denominator at most `max_denominator`.

## 18.355 3.19.0 - 2017-08-20

This release adds the `from_regex()` strategy, which generates strings that contain a match of a regular expression.

Thanks to Maxim Kulkin for creating the `hypothesis-regex` package and then helping to upstream it! ([issue #662](#))

## 18.356 3.18.5 - 2017-08-18

This is a bugfix release for `integers()`. Previously the strategy would hit an internal assertion if passed non-integer bounds for `min_value` and `max_value` that had no integers between them. The strategy now raises `InvalidArgument` instead.

## 18.357 3.18.4 - 2017-08-18

Release to fix a bug where mocks can be used as test runners under certain conditions. Specifically, if a mock is injected into a test via `pytest` fixtures or patch decorators, and that mock is the first argument in the list, hypothesis will think it represents self and turns the mock into a test runner. If this happens, the affected test always passes because the mock is executed instead of the test body. Sometimes, it will also fail health checks.

Fixes [issue #491](#) and a section of [issue #198](#). Thanks to Ben Peterson for this bug fix.

## 18.358 3.18.3 - 2017-08-17

This release should improve the performance of some tests which experienced a slow down as a result of the [3.13.0](#) release.

Tests most likely to benefit from this are ones that make extensive use of `min_size` parameters, but others may see some improvement as well.

## 18.359 3.18.2 - 2017-08-16

This release fixes a bug introduced in [3.18.0](#). If the arguments `whitelist_characters` and `blacklist_characters` to `characters()` contained overlapping elements, then an `InvalidArgument` exception would be raised.

Thanks to Zac Hatfield-Dodds for reporting and fixing this.

## 18.360 3.18.1 - 2017-08-14

This is a bug fix release to fix [issue #780](#), where `sets()` and similar would trigger health check errors if their element strategy could only produce one element (e.g. if it was `just()`).

## 18.361 3.18.0 - 2017-08-13

This is a feature release:

- `characters()` now accepts `whitelist_characters`, particular characters which will be added to those it produces. ([issue #668](#))
- A bug fix for the internal function `_union_interval_lists()`, and a rename to `_union_intervals()`. It now correctly handles all cases where intervals overlap, and it always returns the result as a tuple for tuples.

Thanks to Alex Willmer for these.

## 18.362 3.17.0 - 2017-08-07

This release documents [the previously undocumented phases feature](#), making it part of the public API. It also updates how the example database is used. Principally:

- A `Phases.reuse` argument will now correctly control whether examples from the database are run (it previously did exactly the wrong thing and controlled whether examples would be *saved*).
- Hypothesis will no longer try to rerun *all* previously failing examples. Instead it will replay the smallest previously failing example and a selection of other examples that are likely to trigger any other bugs that will found. This prevents a previous failure from dominating your tests unnecessarily.
- As a result of the previous change, Hypothesis will be slower about clearing out old examples from the database that are no longer failing (because it can only clear out ones that it actually runs).

## 18.363 3.16.1 - 2017-08-07

This release makes an implementation change to how Hypothesis handles certain internal constructs.

The main effect you should see is improvement to the behaviour and performance of collection types, especially ones with a `min_size` parameter. Many cases that would previously fail due to being unable to generate enough valid examples will now succeed, and other cases should run slightly faster.

## 18.364 3.16.0 - 2017-08-04

This release introduces a deprecation of the timeout feature. This results in the following changes:

- Creating a settings object with an explicit timeout will emit a deprecation warning.
- If your test stops because it hits the timeout (and has not found a bug) then it will emit a deprecation warning.
- There is a new value `unlimited` which you can import from `hypothesis.settings` (`settings(timeout=unlimited)` will *not* cause a deprecation warning).

- There is a new health check, `hung_test`, which will trigger after a test has been running for five minutes if it is not suppressed.

## 18.365 3.15.0 - 2017-08-04

This release deprecates two strategies, `choices()` and `streaming()`.

Both of these are somewhat confusing to use and are entirely redundant since the introduction of the `data()` strategy for interactive drawing in tests, and their use should be replaced with direct use of `data()` instead.

## 18.366 3.14.2 - 2017-08-03

This fixes a bug where Hypothesis would not work correctly on Python 2.7 if you had the `typing` module `backport` installed.

## 18.367 3.14.1 - 2017-08-02

This raises the maximum depth at which Hypothesis starts cutting off data generation to a more reasonable value which it is harder to hit by accident.

This resolves ([issue #751](#)), in which some examples which previously worked would start timing out, but it will also likely improve the data generation quality for complex data types.

## 18.368 3.14.0 - 2017-07-23

Hypothesis now understands inline type annotations ([issue #293](#)):

- If the target of `builds()` has type annotations, a default strategy for missing required arguments is selected based on the type. Type-based strategy selection will only override a default if you pass `hypothesis.infer` as a keyword argument.
- If `@given` wraps a function with type annotations, you can pass `infer` as a keyword argument and the appropriate strategy will be substituted.
- You can check what strategy will be inferred for a type with the new `from_type()` function.
- `register_type_strategy()` teaches Hypothesis which strategy to infer for custom or unknown types. You can provide a strategy, or for more complex cases a function which takes the type and returns a strategy.

## 18.369 3.13.1 - 2017-07-20

This is a bug fix release for [issue #514](#) - Hypothesis would continue running examples after a `SkipTest` exception was raised, including printing a falsifying example. Skip exceptions from the standard `unittest` module, and `pytest`, `nose`, or `unittest2` modules now abort the test immediately without printing output.

## 18.370 3.13.0 - 2017-07-16

This release has two major aspects to it: The first is the introduction of `deferred()`, which allows more natural definition of recursive (including mutually recursive) strategies.

The second is a number of engine changes designed to support this sort of strategy better. These should have a knock-on effect of also improving the performance of any existing strategies that currently generate a lot of data or involve heavy nesting by reducing their typical example size.

## 18.371 3.12.0 - 2017-07-07

This release makes some major internal changes to how Hypothesis represents data internally, as a prelude to some major engine changes that should improve data quality. There are no API changes, but it's a significant enough internal change that a minor version bump seemed warranted.

User facing impact should be fairly mild, but includes:

- All existing examples in the database will probably be invalidated. Hypothesis handles this automatically, so you don't need to do anything, but if you see all your examples disappear that's why.
- Almost all data distributions have changed significantly. Possibly for the better, possibly for the worse. This may result in new bugs being found, but it may also result in Hypothesis being unable to find bugs it previously did.
- Data generation may be somewhat faster if your existing bottleneck was in `draw_bytes` (which is often the case for large examples).
- Shrinking will probably be slower, possibly significantly.

If you notice any effects you consider to be a significant regression, please open an issue about them.

## 18.372 3.11.6 - 2017-06-19

This release involves no functionality changes, but is the first to ship wheels as well as an sdist.

## 18.373 3.11.5 - 2017-06-18

This release provides a performance improvement to shrinking. For cases where there is some non-trivial "boundary" value (e.g. the bug happens for all values greater than some other value), shrinking should now be substantially faster. Other types of bug will likely see improvements too.

This may also result in some changes to the quality of the final examples - it may sometimes be better, but is more likely to get slightly worse in some edge cases. If you see any examples where this happens in practice, please report them.

## 18.374 3.11.4 - 2017-06-17

This is a bugfix release: Hypothesis now prints explicit examples when running in verbose mode. ([issue #313](#))

## 18.375 3.11.3 - 2017-06-11

This is a bugfix release: Hypothesis no longer emits a warning if you try to use `sampled_from()` with `collections.OrderedDict`. (issue #688)

## 18.376 3.11.2 - 2017-06-10

This is a documentation release. Several outdated snippets have been updated or removed, and many cross-references are now hyperlinks.

## 18.377 3.11.1 - 2017-05-28

This is a minor ergonomics release. Tracebacks shown by `pytest` no longer include Hypothesis internals for test functions decorated with `@given`.

## 18.378 3.11.0 - 2017-05-23

This is a feature release, adding datetime-related strategies to the core strategies.

`timezones()` allows you to sample `pytz` timezones from the Olsen database. Use directly in a recipe for tz-aware datetimes, or compose with `none()` to allow a mix of aware and naive output.

The new `dates()`, `times()`, `datetimes()`, and `timedeltas()` strategies are all constrained by objects of their type. This means that you can generate dates bounded by a single day (i.e. a single date), or datetimes constrained to the microsecond.

`times()` and `datetimes()` take an optional `timezones=` argument, which defaults to `none()` for naive times. You can use our extra strategy based on `pytz`, or roll your own `timezones` strategy with `dateutil` or even the standard library.

The old `dates`, `times`, and `datetimes` strategies in `hypothesis.extra.datetimes` are deprecated in favor of the new core strategies, which are more flexible and have no dependencies.

## 18.379 3.10.0 - 2017-05-22

Hypothesis now uses `inspect.getfullargspec()` internally. On Python 2, there are no visible changes.

On Python 3 `@given` and `@composite` now preserve **PEP 3107** annotations on the decorated function. Keyword-only arguments are now either handled correctly (e.g. `@composite`), or caught in validation instead of silently discarded or raising an unrelated error later (e.g. `@given`).

## 18.380 3.9.1 - 2017-05-22

This is a bugfix release: the default field mapping for a `DateTimeField` in the Django extra now respects the `USE_TZ` setting when choosing a strategy.

## 18.381 3.9.0 - 2017-05-19

This is feature release, expanding the capabilities of the `decimals()` strategy.

- The new (optional) `places` argument allows you to generate decimals with a certain number of places (e.g. cents, thousandths, satoshis).
- If `allow_infinity` is `None`, setting `min_bound` no longer excludes positive infinity and setting `max_value` no longer excludes negative infinity.
- All of `NaN`, `-NaN`, `sNaN`, and `-sNaN` may now be drawn if `allow_nan` is `True`, or if `allow_nan` is `None` and `min_value` or `max_value` is `None`.
- `min_value` and `max_value` may be given as decimal strings, e.g. `"1.234"`.

## 18.382 3.8.5 - 2017-05-16

Hypothesis now imports `sqlite3` when a SQLite database is used, rather than at module load, improving compatibility with Python implementations compiled without SQLite support (such as BSD or Jython).

## 18.383 3.8.4 - 2017-05-16

This is a compatibility bugfix release. `sampled_from()` no longer raises a deprecation warning when sampling from an `enum.Enum`, as all enums have a reliable iteration order.

## 18.384 3.8.3 - 2017-05-09

This release removes a version check for older versions of `pytest` when using the Hypothesis `pytest` plugin. The `pytest` plugin will now run unconditionally on all versions of `pytest`. This breaks compatibility with any version of `pytest` prior to 2.7.0 (which is more than two years old).

The primary reason for this change is that the version check was a frequent source of breakage when `pytest` change their versioning scheme. If you are not working on `pytest` itself and are not running a very old version of it, this release probably doesn't affect you.

## 18.385 3.8.2 - 2017-04-26

This is a code reorganisation release that moves some internal test helpers out of the main source tree so as to not have changes to them trigger releases in future.

## 18.386 3.8.1 - 2017-04-26

This is a documentation release. Almost all code examples are now doctests checked in CI, eliminating stale examples.



## 18.387 3.8.0 - 2017-04-23

This is a feature release, adding the `iterables()` strategy, equivalent to `lists(...).map(iter)` but with a much more useful repr. You can use this strategy to check that code doesn't accidentally depend on sequence properties such as indexing support or repeated iteration.

## 18.388 3.7.4 - 2017-04-22

This patch fixes a bug in 3.7.3, where using `@example` and a pytest fixture in the same test could cause the test to fail to fill the arguments, and throw a `TypeError`.

## 18.389 3.7.3 - 2017-04-21

This release should include no user visible changes and is purely a refactoring release. This modularises the behaviour of the core `given()` function, breaking it up into smaller and more accessible parts, but its actual behaviour should remain unchanged.

## 18.390 3.7.2 - 2017-04-21

This reverts an undocumented change in 3.7.1 which broke installation on debian stable: The specifier for the hypothesis[django] extra\_requires had introduced a wild card, which was not supported on the default version of pip.

## 18.391 3.7.1 - 2017-04-21

This is a bug fix and internal improvements release.

- In particular Hypothesis now tracks a tree of where it has already explored. This allows it to avoid some classes of duplicate examples, and significantly improves the performance of shrinking failing examples by allowing it to skip some shrinks that it can determine can't possibly work.
- Hypothesis will no longer seed the global random arbitrarily unless you have asked it to using `random_module()`
- Shrinking would previously have not worked correctly in some special cases on Python 2, and would have resulted in suboptimal examples.

## 18.392 3.7.0 - 2017-03-20

This is a feature release.

New features:

- Rule based stateful testing now has an `@invariant` decorator that specifies methods that are run after init and after every step, allowing you to encode properties that should be true at all times. Thanks to Tom Prince for this feature.
- The `decimals()` strategy now supports `allow_nan` and `allow_infinity` flags.

- There are *significantly more strategies available for numpy*, including for generating arbitrary data types. Thanks to Zac Hatfield Dodds for this feature.
- When using the `data()` strategy you can now add a label as an argument to `draw()`, which will be printed along with the value when an example fails. Thanks to Peter Inglesby for this feature.

Bug fixes:

- Bug fix: `composite()` now preserves functions' docstrings.
- The build is now reproducible and doesn't depend on the path you build it from. Thanks to Chris Lamb for this feature.
- `numpy` strategies for the void data type did not work correctly. Thanks to Zac Hatfield Dodds for this fix.

There have also been a number of performance optimizations:

- The `permutations()` strategy is now significantly faster to use for large lists (the underlying algorithm has gone from  $O(n^2)$  to  $O(n)$ ).
- Shrinking of failing test cases should have got significantly faster in some circumstances where it was previously struggling for a long time.
- Example generation now involves less indirection, which results in a small speedup in some cases (small enough that you won't really notice it except in pathological cases).

### 18.393 3.6.1 - 2016-12-20

This release fixes a dependency problem and makes some small behind the scenes improvements.

- The fake-factory dependency was renamed to `faker`. If you were depending on it through `hypothesis[django]` or `hypothesis[fake-factory]` without pinning it yourself then it would have failed to install properly. This release changes it so that `hypothesis[fakefactory]` (which can now also be installed as `hypothesis[faker]`) will install the renamed `faker` package instead.
- This release also removed the dependency of `hypothesis[django]` on `hypothesis[fakefactory]` - it was only being used for emails. These now use a custom strategy that isn't from `fakefactory`. As a result you should also see performance improvements of tests which generated User objects or other things with email fields, as well as better shrinking of email addresses.
- The distribution of code using nested calls to `one_of()` or the `|` operator for combining strategies has been improved, as branches are now flattened to give a more uniform distribution.
- Examples using `composite()` or `.flatmap` should now shrink better. In particular this will affect things which work by first generating a length and then generating that many items, which have historically not shrunk very well.

### 18.394 3.6.0 - 2016-10-31

This release reverts Hypothesis to its old pretty printing of lambda functions based on attempting to extract the source code rather than decompile the bytecode. This is unfortunately slightly inferior in some cases and may result in you occasionally seeing things like `lambda x: <unknown>` in statistics reports and strategy reprs.

This removes the dependencies on `uncompyle6`, `xdis` and `spark-parser`.

The reason for this is that the new functionality was based on `uncompyle6`, which turns out to introduce a hidden GPLed dependency - it in turn depended on `xdis`, and although the library was licensed under the MIT license, it contained some GPL licensed source code and thus should have been released under the GPL.

My interpretation is that Hypothesis itself was never in violation of the GPL (because the license it is under, the Mozilla Public License v2, is fully compatible with being included in a GPL licensed work), but I have not consulted a lawyer on the subject. Regardless of the answer to this question, adding a GPLed dependency will likely cause a lot of users of Hypothesis to inadvertently be in violation of the GPL.

As a result, if you are running Hypothesis 3.5.x you really should upgrade to this release immediately.

## 18.395 3.5.3 - 2016-10-05

This is a bug fix release.

Bugs fixed:

- If the same test was running concurrently in two processes and there were examples already in the test database which no longer failed, Hypothesis would sometimes fail with a `FileNotFoundError` (`IOError` on Python 2) because an example it was trying to read was deleted before it was read. (issue #372).
- Drawing from an `integers()` strategy with both a `min_value` and a `max_value` would reject too many examples needlessly. Now it repeatedly redraws until satisfied. (pull request #366. Thanks to Calen Pennington for the contribution).

## 18.396 3.5.2 - 2016-09-24

This is a bug fix release.

- The Hypothesis pytest plugin broke pytest support for doctests. Now it doesn't.

## 18.397 3.5.1 - 2016-09-23

This is a bug fix release.

- Hypothesis now runs cleanly in `-B` and `-BB` modes, avoiding mixing bytes and unicode.
- `unittest.TestCase` tests would not have shown up in the new statistics mode. Now they do.
- Similarly, stateful tests would not have shown up in statistics and now they do.
- Statistics now print with pytest node IDs (the names you'd get in pytest verbose mode).

## 18.398 3.5.0 - 2016-09-22

This is a feature release.

- `fractions()` and `decimals()` strategies now support `min_value` and `max_value` parameters. Thanks go to Anne Mulhern for the development of this feature.
- The Hypothesis pytest plugin now supports a `--hypothesis-show-statistics` parameter that gives detailed statistics about the tests that were run. Huge thanks to Jean-Louis Fuchs and Adfinis-SyGroup for funding the development of this feature.
- There is a new `event()` function that can be used to add custom statistics.

Additionally there have been some minor bug fixes:

- In some cases Hypothesis should produce fewer duplicate examples (this will mostly only affect cases with a single parameter).
- `pytest` command line parameters are now under an option group for Hypothesis (thanks to David Keijser for fixing this)
- Hypothesis would previously error if you used [PEP 3107](#) function annotations on your tests under Python 3.4.
- The repr of many strategies using lambdas has been improved to include the lambda body (this was previously supported in many but not all cases).

### 18.399 3.4.2 - 2016-07-13

This is a bug fix release, fixing a number of problems with the settings system:

- Test functions defined using `@given` can now be called from other threads ([issue #337](#))
- Attempting to delete a settings property would previously have silently done the wrong thing. Now it raises an `AttributeError`.
- Creating a settings object with a custom `database_file` parameter was silently getting ignored and the default was being used instead. Now it's not.

### 18.400 3.4.1 - 2016-07-07

This is a bug fix release for a single bug:

- On Windows when running two Hypothesis processes in parallel (e.g. using `pytest-xdist`) they could race with each other and one would raise an exception due to the non-atomic nature of file renaming on Windows and the fact that you can't rename over an existing file. This is now fixed.

### 18.401 3.4.0 - 2016-05-27

This release is entirely provided by [Lucas Wiman](#):

Strategies constructed by the Django extra will now respect much more of Django's validations out of the box. Wherever possible, `full_clean()` should succeed.

In particular:

- The `max_length`, blank and choices kwargs are now respected.
- Add support for `DecimalField`.
- If a field includes validators, the list of validators are used to filter the field strategy.

### 18.402 3.3.0 - 2016-05-27

This release went wrong and is functionally equivalent to [3.2.0](#). Ignore it.

## 18.403 3.2.0 - 2016-05-19

This is a small single-feature release:

- All tests using `@given` now fix the global random seed. This removes the health check for that. If a non-zero seed is required for the final falsifying example, it will be reported. Otherwise Hypothesis will assume randomization was not a significant factor for the test and be silent on the subject. If you use `random_module()` this will continue to work and will always display the seed.

## 18.404 3.1.3 - 2016-05-01

Single bug fix release

- Another charmap problem. In `3.1.2` `text()` and `characters()` would break on systems which had `/tmp` mounted on a different partition than the Hypothesis storage directory (usually in home). This fixes that.

## 18.405 3.1.2 - 2016-04-30

Single bug fix release:

- Anything which used a `text()` or `characters()` strategy was broken on Windows and I hadn't updated appveyor to use the new repository location so I didn't notice. This is now fixed and windows support should work correctly.

## 18.406 3.1.1 - 2016-04-29

Minor bug fix release.

- Fix concurrency issue when running tests that use `text()` from multiple processes at once (issue #302, thanks to Alex Chan).
- Improve performance of code using `lists()` with `max_size` (thanks to Cristi Cobzarencu).
- Fix install on Python 2 with ancient versions of pip so that it installs the `enum34` backport (thanks to Donald Stufft for telling me how to do this).
- Remove duplicated `__all__` exports from `hypothesis.strategies` (thanks to Piët Delport).
- Update headers to point to new repository location.
- Allow use of strategies that can't be used in `find()` (e.g. `choices()`) in stateful testing.

## 18.407 3.1.0 - 2016-03-06

- Add a `nothing()` strategy that never successfully generates values.
- `sampled_from()` and `one_of()` can both now be called with an empty argument list, in which case they also never generate any values.
- `one_of()` may now be called with a single argument that is a collection of strategies as well as as varargs.
- Add a `runner()` strategy which returns the instance of the current test object if there is one.

- ‘Bundle’ for RuleBasedStateMachine is now a normal(ish) strategy and can be used as such.
- Tests using RuleBasedStateMachine should now shrink significantly better.
- Hypothesis now uses a pretty-printing library internally, compatible with IPython’s pretty printing protocol (actually using the same code). This may improve the quality of output in some cases.
- Add a ‘phases’ setting that allows more fine grained control over which parts of the process Hypothesis runs
- Add a `suppress_health_check` setting which allows you to turn off specific health checks in a fine grained manner.
- Fix a bug where lists of non fixed size would always draw one more element than they included. This mostly didn’t matter, but it would cause problems with empty strategies or ones with side effects.
- Add a mechanism to the Django model generator to allow you to explicitly request the default value (thanks to Jeremy Thurgood for this one).

### 18.408 3.0.5 - 2016-02-25

- Fix a bug where Hypothesis would now error on `pytest` development versions.

### 18.409 3.0.4 - 2016-02-24

- Fix a bug where Hypothesis would error when running on Python 2.7.3 or earlier because it was trying to pass a `bytearray` object to `struct.unpack()` (which is only supported since 2.7.4).

### 18.410 3.0.3 - 2016-02-23

- Fix version parsing of `pytest` to work with `pytest` release candidates
- More general handling of the health check problem where things could fail because of a cache miss - now one “free” example is generated before the start of the health check run.

### 18.411 3.0.2 - 2016-02-18

- Under certain circumstances, strategies involving `text()` buried inside some other strategy (e.g. `text().filter(...)` or `recursive(text(), ...)`) would cause a test to fail its health checks the first time it ran. This was caused by having to compute some related data and cache it to disk. On travis or anywhere else where the `.hypothesis` directory was recreated this would have caused the tests to fail their health check on every run. This is now fixed for all the known cases, although there could be others lurking.

### 18.412 3.0.1 - 2016-02-18

- Fix a case where it was possible to trigger an “Unreachable” assertion when running certain flaky stateful tests.
- Improve shrinking of large stateful tests by eliminating a case where it was hard to delete early steps.
- Improve efficiency of drawing `binary(min_size=n, max_size=n)` significantly by provide a custom implementation for fixed size blocks that can bypass a lot of machinery.

- Set default home directory based on the current working directory at the point Hypothesis is imported, not whenever the function first happens to be called.

## 18.413 3.0.0 - 2016-02-17

Codename: This really should have been 2.1.

Externally this looks like a very small release. It has one small breaking change that probably doesn't affect anyone at all (some behaviour that never really worked correctly is now outright forbidden) but necessitated a major version bump and one visible new feature.

Internally this is a complete rewrite. Almost nothing other than the public API is the same.

New features:

- Addition of `data()` strategy which allows you to draw arbitrary data interactively within the test.
- New “exploded” database format which allows you to more easily check the example database into a source repository while supporting merging.
- Better management of how examples are saved in the database.
- Health checks will now raise as errors when they fail. It was too easy to have the warnings be swallowed entirely.

New limitations:

- `choices()` and `streaming()` strategies may no longer be used with `find()`. Neither may `data()` (this is the change that necessitated a major version bump).

Feature removal:

- The `ForkingTestCase` executor has gone away. It may return in some more working form at a later date.

Performance improvements:

- A new model which allows `flatmap`, composite strategies and stateful testing to perform *much* better. They should also be more reliable.
- Filtering may in some circumstances have improved significantly. This will help especially in cases where you have lots of values with individual filters on them, such as `lists(x.filter(...))`.
- Modest performance improvements to the general test runner by avoiding expensive operations

In general your tests should have got faster. If they've instead got significantly slower, I'm interested in hearing about it.

Data distribution:

The data distribution should have changed significantly. This may uncover bugs the previous version missed. It may also miss bugs the previous version could have uncovered. Hypothesis is now producing less strongly correlated data than it used to, but the correlations are extended over more of the structure.

Shrinking:

Shrinking quality should have improved. In particular Hypothesis can now perform simultaneous shrinking of separate examples within a single test (previously it was only able to do this for elements of a single collection). In some cases performance will have improved, in some cases it will have got worse but generally shouldn't have by much.

## 18.414 2.0.0 - 2016-01-10

Codename: A new beginning

This release cleans up all of the legacy that accrued in the course of Hypothesis 1.0. These are mostly things that were emitting deprecation warnings in 1.19.0, but there were a few additional changes.

In particular:

- non-strategy values will no longer be converted to strategies when used in `given` or `find`.
- `FailedHealthCheck` is now an error and not a warning.
- Handling of non-ascii reprs in user types have been simplified by using raw strings in more places in Python 2.
- `given` no longer allows mixing positional and keyword arguments.
- `given` no longer works with functions with defaults.
- `given` no longer turns provided arguments into defaults - they will not appear in the `argspec` at all.
- the `basic()` strategy no longer exists.
- the `n_ary_tree` strategy no longer exists.
- the `average_list_length` setting no longer exists. Note: If you're using `using recursive()` this will cause you a significant slow down. You should pass explicit `average_size` parameters to collections in recursive calls.
- `@rule` can no longer be applied to the same method twice.
- Python 2.6 and 3.3 are no longer officially supported, although in practice they still work fine.

This also includes two non-deprecation changes:

- `given`'s keyword arguments no longer have to be the rightmost arguments and can appear anywhere in the method signature.
- The `max_shrinks` setting would sometimes not have been respected.

## 18.415 1.19.0 - 2016-01-09

Codename: IT COMES

This release heralds the beginning of a new and terrible age of Hypothesis 2.0.

It's primary purpose is some final deprecations prior to said release. The goal is that if your code emits no warnings under this release then it will probably run unchanged under Hypothesis 2.0 (there are some caveats to this: 2.0 will drop support for some Python versions, and if you're using internal APIs then as usual that may break without warning).

It does have two new features:

- New `@seed()` decorator which allows you to manually seed a test. This may be harmlessly combined with and overrides the `derandomize` setting.
- `settings` objects may now be used as a decorator to fix those settings to a particular `@given` test.

API changes (old usage still works but is deprecated):

- `Settings` has been renamed to `settings` (lower casing) in order to make the decorator usage more natural.
- Functions for the storage directory that were in `hypothesis.settings` are now in a new `hypothesis.configuration` module.



Additional deprecations:

- the `average_list_length` setting has been deprecated in favour of being explicit.
- the `basic()` strategy has been deprecated as it is impossible to support it under a Conjecture based model, which will hopefully be implemented at some point in the 2.x series.
- the `n_ary_tree` strategy (which was never actually part of the public API) has been deprecated.
- Passing settings or `random` as keyword arguments to `given` is deprecated (use the new functionality instead)

Bug fixes:

- No longer emit `PendingDeprecationWarning` for `__iter__` and `StopIteration` in `streaming()` values.
- When running in health check mode with `non_strict`, don't print quite so many errors for an exception in `reify`.
- When an assumption made in a test or a filter is flaky, tests will now raise `Flaky` instead of `UnsatisfiedAssumption`.

## 18.416 1.18.1 - 2015-12-22

Two behind the scenes changes:

- Hypothesis will no longer write generated code to the file system. This will improve performance on some systems (e.g. if you're using `PythonAnywhere` which is running your code from NFS) and prevent some annoying interactions with auto-restarting systems.
- Hypothesis will cache the creation of some strategies. This can significantly improve performance for code that uses `flatmap` or `composite` and thus has to instantiate strategies a lot.

## 18.417 1.18.0 - 2015-12-21

Features:

- Tests and `find` are now explicitly seeded off the global random module. This means that if you nest one inside the other you will now get a health check error. It also means that you can control global randomization by seeding `random`.
- There is a new `random_module()` strategy which seeds the global random module for you and handles things so that you don't get a health check warning if you use it inside your tests.
- `floats()` now accepts two new arguments: `allow_nan` and `allow_infinity`. These default to the old behaviour, but when set to `False` will do what the names suggest.

Bug fixes:

- Fix a bug where tests that used `text()` on Python 3.4+ would not actually be deterministic even when explicitly seeded or using the `derandomize` mode, because generation depended on dictionary iteration order which was affected by hash randomization.
- Fix a bug where with complicated strategies the timing of the initial health check could affect the seeding of the subsequent test, which would also render supposedly deterministic tests non-deterministic in some scenarios.
- In some circumstances `flatmap()` could get confused by two structurally similar things it could generate and would produce a flaky test where the first time it produced an error but the second time it produced the other value, which was not an error. The same bug was presumably also possible in `composite()`.

- `flatmap()` and `composite()` initial generation should now be moderately faster. This will be particularly noticeable when you have many values drawn from the same strategy in a single run, e.g. constructs like `lists(s.flatmap(f))`. Shrinking performance *may* have suffered, but this didn't actually produce an interestingly worse result in any of the standard scenarios tested.

### 18.418 1.17.1 - 2015-12-16

A small bug fix release, which fixes the fact that the 'note' function could not be used on tests which used the `@example` decorator to provide explicit examples.

### 18.419 1.17.0 - 2015-12-15

This is actually the same release as 1.16.1, but 1.16.1 has been pulled because it contains the following additional change that was not intended to be in a patch release (it's perfectly stable, but is a larger change that should have required a minor version bump):

- Hypothesis will now perform a series of "health checks" as part of running your tests. These detect and warn about some common error conditions that people often run into which wouldn't necessarily have caused the test to fail but would cause e.g. degraded performance or confusing results.

### 18.420 1.16.1 - 2015-12-14

Note: This release has been removed.

A small bugfix release that allows bdist's for Hypothesis to be built under 2.7 - the `compat3.py` file which had Python 3 syntax wasn't intended to be loaded under Python 2, but when building a bdist it was. In particular this would break running `setup.py test`.

### 18.421 1.16.0 - 2015-12-08

There are no public API changes in this release but it includes a behaviour change that I wasn't comfortable putting in a patch release.

- Functions from `hypothesis.strategies` will no longer raise `InvalidArgument` on bad arguments. Instead the same errors will be raised when a test using such a strategy is run. This may improve startup time in some cases, but the main reason for it is so that errors in strategies won't cause errors in loading, and it can interact correctly with things like `pytest.mark.skipif`.
- Errors caused by accidentally invoking the legacy API are now much less confusing, although still throw `NotImplementedError`.
- `hypothesis.extra.django` is 1.9 compatible.
- When tests are run with `max_shrinks=0` this will now still rerun the test on failure and will no longer print "Trying example:" before each run. Additionally `note()` will now work correctly when used with `max_shrinks=0`.

## 18.422 1.15.0 - 2015-11-24

A release with two new features.

- A ‘characters’ strategy for more flexible generation of text with particular character ranges and types, kindly contributed by [Alexander Shorin](#).
- Add support for preconditions to the rule based stateful testing. Kindly contributed by [Christopher Armstrong](#)

## 18.423 1.14.0 - 2015-11-01

New features:

- Add ‘note’ function which lets you include additional information in the final test run’s output.
- Add ‘choices’ strategy which gives you a choice function that emulates `random.choice`.
- Add ‘uuid’ strategy that generates UUIDs’
- Add ‘shared’ strategy that lets you create a strategy that just generates a single shared value for each test run

Bugs:

- Using strategies of the form `streaming(x.flatmap(f))` with `find` or `in` in stateful testing would have caused `InvalidArgument` errors when the resulting values were used (because code that expected to only be called within a test context would be invoked).

## 18.424 1.13.0 - 2015-10-29

This is quite a small release, but deprecates some public API functions and removes some internal API functionality so gets a minor version bump.

- All calls to the ‘strategy’ function are now deprecated, even ones which pass just a `SearchStrategy` instance (which is still a no-op).
- Never documented `hypothesis.extra.entry_points` mechanism has now been removed ( it was previously how `hypothesis.extra` packages were loaded and has been deprecated and unused for some time)
- Some corner cases that could previously have produced an `OverflowError` when simplifying failing cases using `hypothesis.extra.datetimes` (or dates or times) have now been fixed.
- Hypothesis load time for first import has been significantly reduced - it used to be around 250ms (on my SSD laptop) and now is around 100-150ms. This almost never matters but was slightly annoying when using it in the console.
- `hypothesis.strategies.randoms` was previously missing from `__all__`.

## 18.425 1.12.0 - 2015-10-18

- Significantly improved performance of creating strategies using the functions from the `hypothesis.strategies` module by deferring the calculation of their `repr` until it was needed. This is unlikely to have been an performance issue for you unless you were using `flatmap`, `composite` or `stateful testing`, but for some cases it could be quite a significant impact.
- A number of cases where the `repr` of strategies build from lambdas is improved

- Add `dates()` and `times()` strategies to `hypothesis.extra.dates`
- Add new ‘profiles’ mechanism to the settings system
- Deprecates mutability of Settings, both the `Settings.default` top level property and individual settings.
- A Settings object may now be directly initialized from a parent Settings.
- `@given` should now give a better error message if you attempt to use it with a function that uses destructuring arguments (it still won’t work, but it will error more clearly),
- A number of spelling corrections in error messages
- `pytest` should no longer display the intermediate modules Hypothesis generates when running in verbose mode
- Hypothesis should now correctly handle printing objects with non-ascii reprs on python 3 when running in a locale that cannot handle ascii printing to stdout.
- Add a `unique=True` argument to `lists()`. This is equivalent to `unique_by=lambda x: x`, but offers a more convenient syntax.

### 18.426 1.11.4 - 2015-09-27

- Hide modifications Hypothesis needs to make to `sys.path` by undoing them after we’ve imported the relevant modules. This is a workaround for issues cryptography experienced on windows.
- Slightly improved performance of drawing from `sampled_from` on large lists of alternatives.
- Significantly improved performance of drawing from `one_of` or strategies using `|` (note this includes a lot of strategies internally - `floats()` and `integers()` both fall into this category). There turned out to be a massive performance regression introduced in 1.10.0 affecting these which probably would have made tests using Hypothesis significantly slower than they should have been.

### 18.427 1.11.3 - 2015-09-23

- Better argument validation for `datetimes()` strategy - previously setting `max_year < datetime.MIN_YEAR` or `min_year > datetime.MAX_YEAR` would not have raised an `InvalidArgument` error and instead would have behaved confusingly.
- Compatibility with being run on `pytest < 2.7` (achieved by disabling the plugin).

### 18.428 1.11.2 - 2015-09-23

Bug fixes:

- `Settings(database=my_db)` would not be correctly inherited when used as a default setting, so that newly created settings would use the `database_file` setting and create an SQLite example database.
- `Settings.default.database = my_db` would previously have raised an error and now works.
- Timeout could sometimes be significantly exceeded if during simplification there were a lot of examples tried that didn’t trigger the bug.
- When loading a heavily simplified example using a `basic()` strategy from the database this could cause Python to trigger a recursion error.
- Remove use of deprecated API in `pytest` plugin so as to not emit warning

Misc:

- hypothesis-pytest is now part of hypothesis core. This should have no externally visible consequences, but you should update your dependencies to remove hypothesis-pytest and depend on only Hypothesis.
- Better repr for hypothesis.extra.dattetimes() strategies.
- Add .close() method to abstract base class for Backend (it was already present in the main implementation).

## 18.429 1.11.1 - 2015-09-16

Bug fixes:

- When running Hypothesis tests in parallel (e.g. using pytest-xdist) there was a race condition caused by code generation.
- Example databases are now cached per thread so as to not use sqlite connections from multiple threads. This should make Hypothesis now entirely thread safe.
- floats() with only min\_value or max\_value set would have had a very bad distribution.
- Running on 3.5, Hypothesis would have emitted deprecation warnings because of use of inspect.getargspec

## 18.430 1.11.0 - 2015-08-31

- text() with a non-string alphabet would have used the repr() of the the alphabet instead of its contexts. This is obviously silly. It now works with any sequence of things convertible to unicode strings.
- @given will now work on methods whose definitions contains no explicit positional arguments, only varargs (issue #118). This may have some knock on effects because it means that @given no longer changes the argspec of functions other than by adding defaults.
- Introduction of new @composite feature for more natural definition of strategies you'd previously have used flatmap for.

## 18.431 1.10.6 - 2015-08-26

Fix support for fixtures on Django 1.7.

## 18.432 1.10.4 - 2015-08-21

Tiny bug fix release:

- If the database\_file setting is set to None, this would have resulted in an error when running tests. Now it does the same as setting database to None.

## 18.433 1.10.3 - 2015-08-19

Another small bug fix release.

- `lists(elements, unique_by=some_function, min_size=n)` would have raised a `ValidationError` if `n > Settings.default.average_list_length` because it would have wanted to use an average list length shorter than the minimum size of the list, which is impossible. Now it instead defaults to twice the minimum size in these circumstances.
- `basic()` strategy would have only ever produced at most ten distinct values per run of the test (which is bad if you e.g. have it inside a list). This was obviously silly. It will now produce a much better distribution of data, both duplicated and non duplicated.

### 18.434 1.10.2 - 2015-08-19

This is a small bug fix release:

- `star` imports from `hypothesis` should now work correctly.
- example quality for examples using `flatmap` will be better, as the way it had previously been implemented was causing problems where `Hypothesis` was erroneously labelling some examples as being duplicates.

### 18.435 1.10.0 - 2015-08-04

This is just a bugfix and performance release, but it changes some semi-public APIs, hence the minor version bump.

- Significant performance improvements for strategies which are `one_of()` many branches. In particular this included `recursive()` strategies. This should take the case where you use one `recursive()` strategy as the base strategy of another from unusably slow (tens of seconds per generated example) to reasonably fast.
- Better handling of `just()` and `sampled_from()` for values which have an incorrect `__repr__` implementation that returns non-ASCII unicode on Python 2.
- Better performance for `flatmap` from changing the internal morpher API to be significantly less general purpose.
- Introduce a new semi-public `BuildContext/cleanup` API. This allows strategies to register cleanup activities that should run once the example is complete. Note that this will interact somewhat weirdly with `find`.
- Better simplification behaviour for streaming strategies.
- Don't error on lambdas which use destructuring arguments in Python 2.
- Add some better reprs for a few strategies that were missing good ones.
- The `Random` instances provided by `randoms()` are now copyable.
- Slightly more debugging information about `simplify` when using a debug verbosity level.
- Support using `given` for functions with `varargs`, but not passing arguments to it as positional.

### 18.436 1.9.0 - 2015-07-27

Codename: The great bundling.

This release contains two fairly major changes.

The first is the deprecation of the `hypothesis-extra` mechanism. From now on all the packages that were previously bundled under it other than `hypothesis-pytest` (which is a different beast and will remain separate). The functionality remains unchanged and you can still import them from exactly the same location, they just are no longer separate packages.

The second is that this introduces a new way of building strategies which lets you build up strategies recursively from other strategies.

It also contains the minor change that calling `.example()` on a strategy object will give you examples that are more representative of the actual data you'll get. There used to be some logic in there to make the examples artificially simple but this proved to be a bad idea.

## 18.437 1.8.5 - 2015-07-24

This contains no functionality changes but fixes a mistake made with building the previous package that would have broken installation on Windows.

## 18.438 1.8.4 - 2015-07-20

Bugs fixed:

- When a call to `floats()` had endpoints which were not floats but merely convertible to one (e.g. integers), these would be included in the generated data which would cause it to generate non-floats.
- Splitting lambdas used in the definition of `flatmap`, `map` or `filter` over multiple lines would break the repr, which would in turn break their usage.

## 18.439 1.8.3 - 2015-07-20

“Falsifying example” would not have been printed when the failure came from an explicit example.

## 18.440 1.8.2 - 2015-07-18

Another small bugfix release:

- When using `ForkingTestCase` you would usually not get the falsifying example printed if the process exited abnormally (e.g. due to `os._exit`).
- Improvements to the distribution of characters when using `text()` with a default alphabet. In particular produces a better distribution of ascii and whitespace in the alphabet.

## 18.441 1.8.1 - 2015-07-17

This is a small release that contains a workaround for people who have bad reprs returning non ascii text on Python 2.7. This is not a bug fix for Hypothesis per se because that's not a thing that is actually supposed to work, but Hypothesis leans more heavily on repr than is typical so it's worth having a workaround for.

## 18.442 1.8.0 - 2015-07-16

New features:

- Much more sensible reprs for strategies, especially ones that come from hypothesis.strategies. These should now have as reprs python code that would produce the same strategy.
- lists() accepts a unique\_by argument which forces the generated lists to be only contain elements unique according to some function key (which must return a hashable value).
- Better error messages from flaky tests to help you debug things.

Mostly invisible implementation details that may result in finding new bugs in your code:

- Sets and dictionary generation should now produce a better range of results.
- floats with bounds now focus more on ‘critical values’, trying to produce values at edge cases.
- flatmap should now have better simplification for complicated cases, as well as generally being (I hope) more reliable.

Bug fixes:

- You could not previously use assume() if you were using the forking executor.

### 18.443 1.7.2 - 2015-07-10

This is purely a bug fix release:

- When using floats() with stale data in the database you could sometimes get values in your tests that did not respect min\_value or max\_value.
- When getting a Flaky error from an unreliable test it would have incorrectly displayed the example that caused it.
- 2.6 dependency on backports was incorrectly specified. This would only have caused you problems if you were building a universal wheel from Hypothesis, which is not how Hypothesis ships, so unless you’re explicitly building wheels for your dependencies and support Python 2.6 plus a later version of Python this probably would never have affected you.
- If you use flatmap in a way that the strategy on the right hand side depends sensitively on the left hand side you may have occasionally seen Flaky errors caused by producing unreliable examples when minimizing a bug. This use case may still be somewhat fraught to be honest. This code is due a major rearchitecture for 1.8, but in the meantime this release fixes the only source of this error that I’m aware of.

### 18.444 1.7.1 - 2015-06-29

Codename: There is no 1.7.0.

A slight technical hitch with a premature upload means there’s was a yanked 1.7.0 release. Oops.

The major feature of this release is Python 2.6 support. Thanks to Jeff Meadows for doing most of the work there.

Other minor features

- strategies now has a permutations() function which returns a strategy yielding permutations of values from a given collection.
- if you have a flaky test it will print the exception that it last saw before failing with Flaky, even if you do not have verbose reporting on.
- Slightly experimental git merge script available as “python -m hypothesis.tools.mergedbs”. Instructions on how to use it in the docstring of that file.



Bug fixes:

- Better performance from use of filter. In particular tests which involve large numbers of heavily filtered strategies should perform a lot better.
- floats() with a negative min\_value would not have worked correctly (worryingly, it would have just silently failed to run any examples). This is now fixed.
- tests using sampled\_from would error if the number of sampled elements was smaller than min\_satisfying\_examples.

## 18.445 1.6.2 - 2015-06-08

This is just a few small bug fixes:

- Size bounds were not validated for values for a binary() strategy when reading examples from the database.
- sampled\_from is now in \_\_all\_\_ in hypothesis.strategies
- floats no longer consider negative integers to be simpler than positive non-integers
- Small floating point intervals now correctly count members, so if you have a floating point interval so narrow there are only a handful of values in it, this will no longer cause an error when Hypothesis runs out of values.

## 18.446 1.6.1 - 2015-05-21

This is a small patch release that fixes a bug where 1.6.0 broke the use of flatmap with the deprecated API and assumed the passed in function returned a SearchStrategy instance rather than converting it to a strategy.

## 18.447 1.6.0 - 2015-05-21

This is a smallish release designed to fix a number of bugs and smooth out some weird behaviours.

- Fix a critical bug in flatmap where it would reuse old strategies. If all your flatmap code was pure you're fine. If it's not, I'm surprised it's working at all. In particular if you want to use flatmap with django models, you desperately need to upgrade to this version.
- flatmap simplification performance should now be better in some cases where it previously had to redo work.
- Fix for a bug where invalid unicode data with surrogates could be generated during simplification (it was already filtered out during actual generation).
- The Hypothesis database is now keyed off the name of the test instead of the type of data. This makes much more sense now with the new strategies API and is generally more robust. This means you will lose old examples on upgrade.
- The database will now not delete values which fail to deserialize correctly, just skip them. This is to handle cases where multiple incompatible strategies share the same key.
- find now also saves and loads values from the database, keyed off a hash of the function you're finding from.
- Stateful tests now serialize and load values from the database. They should have before, really. This was a bug.
- Passing a different verbosity level into a test would not have worked entirely correctly, leaving off some messages. This is now fixed.
- Fix a bug where derandomized tests with unicode characters in the function body would error on Python 2.7.

### 18.448 1.5.0 - 2015-05-14

Codename: Strategic withdrawal.

The purpose of this release is a radical simplification of the API for building strategies. Instead of the old approach of `@strategy.extend` and things that get converted to strategies, you just build strategies directly.

The old method of defining strategies will still work until Hypothesis 2.0, because it's a major breaking change, but will now emit deprecation warnings.

The new API is also a lot more powerful as the functions for defining strategies give you a lot of dials to turn. See *the updated data section* for details.

Other changes:

- Mixing keyword and positional arguments in a call to `@given` is deprecated as well.
- There is a new setting called 'strict'. When set to True, Hypothesis will raise warnings instead of merely printing them. Turning it on by default is inadvisable because it means that Hypothesis minor releases can break your code, but it may be useful for making sure you catch all uses of deprecated APIs.
- `max_examples` in settings is now interpreted as meaning the maximum number of unique (ish) examples satisfying assumptions. A new setting `max_iterations` which defaults to a larger value has the old interpretation.
- Example generation should be significantly faster due to a new faster parameter selection algorithm. This will mostly show up for simple data types - for complex ones the parameter selection is almost certainly dominated.
- Simplification has some new heuristics that will tend to cut down on cases where it could previously take a very long time.
- `timeout` would previously not have been respected in cases where there were a lot of duplicate examples. You probably wouldn't have previously noticed this because `max_examples` counted duplicates, so this was very hard to hit in a way that mattered.
- A number of internal simplifications to the SearchStrategy API.
- You can now access the current Hypothesis version as `hypothesis.__version__`.
- A top level function is provided for running the stateful tests without the TestCase infrastructure.

### 18.449 1.4.0 - 2015-05-04

Codename: What a state.

The *big* feature of this release is the new and slightly experimental stateful testing API. You can read more about that in *the appropriate section*.

Two minor features that were driven out in the course of developing this:

- You can now set `settings.max_shrinks` to limit the number of times Hypothesis will try to shrink arguments to your test. If this is set to `<= 0` then Hypothesis will not rerun your test and will just raise the failure directly. Note that due to technical limitations if `max_shrinks` is `<= 0` then Hypothesis will print *every* example it calls your test with rather than just the failing one. Note also that I don't consider `settings.max_shrinks` to zero a sensible way to run your tests and it should really be considered a debug feature.
- There is a new debug level of verbosity which is even *more* verbose than `verbose`. You probably don't want this.

Breakage of semi-public SearchStrategy API:

- It is now a required invariant of SearchStrategy that if `u` simplifies to `v` then it is not the case that `strictly_simpler(u, v)`. i.e. simplifying should not *increase* the complexity even though it is not required to decrease it. Enforcing this invariant lead to finding some bugs where simplifying of integers, floats and sets was suboptimal.
- Integers in basic data are now required to fit into 64 bits. As a result python integer types are now serialized as strings, and some types have stopped using quite so needlessly large random seeds.

Hypothesis Stateful testing was then turned upon Hypothesis itself, which lead to an amazing number of minor bugs being found in Hypothesis itself.

Bugs fixed (most but not all from the result of stateful testing) include:

- Serialization of streaming examples was flaky in a way that you would probably never notice: If you generate a template, simplify it, serialize it, deserialize it, serialize it again and then deserialize it you would get the original stream instead of the simplified one.
- If you reduced `max_examples` below the number of examples already saved in the database, you would have got a `ValueError`. Additionally, if you had more than `max_examples` in the database all of them would have been considered.
- `@given` will no longer count duplicate examples (which it never called your function with) towards `max_examples`. This may result in your tests running slower, but that's probably just because they're trying more examples.
- General improvements to example search which should result in better performance and higher quality examples. In particular parameters which have a history of producing useless results will be more aggressively culled. This is useful both because it decreases the chance of useless examples and also because it's much faster to not check parameters which we were unlikely to ever pick!
- `integers_from` and lists of types with only one value (e.g. `[None]`) would previously have had a very high duplication rate so you were probably only getting a handful of examples. They now have a much lower duplication rate, as well as the improvements to search making this less of a problem in the first place.
- You would sometimes see simplification taking significantly longer than your defined timeout. This would happen because timeout was only being checked after each *successful* simplification, so if Hypothesis was spending a lot of time unsuccessfully simplifying things it wouldn't stop in time. The timeout is now applied for unsuccessful simplifications too.
- In Python 2.7, `integers_from` strategies would have failed during simplification with an `OverflowError` if their starting point was at or near to the maximum size of a 64-bit integer.
- `flatmap` and `map` would have failed if called with a function without a `__name__` attribute.
- If `max_examples` was less than `min_satisfying_examples` this would always error. Now `min_satisfying_examples` is capped to `max_examples`. Note that if you have assumptions to satisfy here this will still cause an error.

Some minor quality improvements:

- Lists of streams, flatmapped strategies and basic strategies should now now have slightly better simplification.

## 18.450 1.3.0 - 2015-05-22

New features:

- New verbosity level API for printing intermediate results and exceptions.
- New specifier for strings generated from a specified alphabet.
- Better error messages for tests that are failing because of a lack of enough examples.

Bug fixes:

- Fix error where use of `ForkingTestCase` would sometimes result in too many open files.
- Fix error where saving a failing example that used `flatMap` could error.
- Implement simplification for `sampled_from`, which apparently never supported it previously. Oops.

General improvements:

- Better range of examples when using `one_of` or `sampled_from`.
- Fix some pathological performance issues when simplifying lists of complex values.
- Fix some pathological performance issues when simplifying examples that require unicode strings with high codepoints.
- Random will now simplify to more readable examples.

### 18.451 1.2.1 - 2015-04-16

A small patch release for a bug in the new executors feature. Tests which require doing something to their result in order to fail would have instead reported as flaky.

### 18.452 1.2.0 - 2015-04-15

Codename: Finders keepers.

A bunch of new features and improvements.

- Provide a mechanism for customizing how your tests are executed.
- Provide a test runner that forks before running each example. This allows better support for testing native code which might trigger a segfault or a C level assertion failure.
- Support for using Hypothesis to find examples directly rather than as just as a test runner.
- New streaming type which lets you generate infinite lazily loaded streams of data - perfect for if you need a number of examples but don't know how many.
- Better support for large integer ranges. You can now use `integers_in_range` with ranges of basically any size. Previously large ranges would have eaten up all your memory and taken forever.
- Integers produce a wider range of data than before - previously they would only rarely produce integers which didn't fit into a machine word. Now it's much more common. This percolates to other numeric types which build on integers.
- Better validation of arguments to `@given`. Some situations that would previously have caused silently wrong behaviour will now raise an error.
- Include `+/- sys.float_info.max` in the set of floating point edge cases that Hypothesis specifically tries.
- Fix some bugs in floating point ranges which happen when given `+/- sys.float_info.max` as one of the endpoints... (really any two floats that are sufficiently far apart so that `x, y` are finite but `y - x` is infinite). This would have resulted in generating infinite values instead of ones inside the range.

## 18.453 1.1.1 - 2015-04-07

Codename: Nothing to see here

This is just a patch release put out because it fixed some internal bugs that would block the Django integration release but did not actually affect anything anyone could previously have been using. It also contained a minor quality fix for floats that I'd happened to have finished in time.

- Fix some internal bugs with object lifecycle management that were impossible to hit with the previously released versions but broke hypothesis-django.
- Bias floating point numbers somewhat less aggressively towards very small numbers

## 18.454 1.1.0 - 2015-04-06

Codename: No-one mention the M word.

- Unicode strings are more strongly biased towards ascii characters. Previously they would generate all over the space. This is mostly so that people who try to shape their unicode strings with `assume()` have less of a bad time.
- A number of fixes to data deserialization code that could theoretically have caused mysterious bugs when using an old version of a Hypothesis example database with a newer version. To the best of my knowledge a change that could have triggered this bug has never actually been seen in the wild. Certainly no-one ever reported a bug of this nature.
- Out of the box support for Decimal and Fraction.
- new dictionary specifier for dictionaries with variable keys.
- Significantly faster and higher quality simplification, especially for collections of data.
- New `filter()` and `flatmap()` methods on Strategy for better ways of building strategies out of other strategies.
- New `BasicStrategy` class which allows you to define your own strategies from scratch without needing an existing matching strategy or being exposed to the full horror or non-public nature of the `SearchStrategy` interface.

## 18.455 1.0.0 - 2015-03-27

Codename: Blast-off!

There are no code changes in this release. This is precisely the 0.9.2 release with some updated documentation.

## 18.456 0.9.2 - 2015-03-26

Codename: T-1 days.

- `floats_in_range` would not actually have produced `floats_in_range` unless that range happened to be (0, 1). Fix this.

## 18.457 0.9.1 - 2015-03-25

Codename: T-2 days.

- Fix a bug where if you defined a strategy using map on a lambda then the results would not be saved in the database.
- Significant performance improvements when simplifying examples using lists, strings or bounded integer ranges.

### 18.458 0.9.0 - 2015-03-23

Codename: The final countdown

This release could also be called 1.0-RC1.

It contains a teeny tiny bugfix, but the real point of this release is to declare feature freeze. There will be zero functionality changes between 0.9.0 and 1.0 unless something goes really really wrong. No new features will be added, no breaking API changes will occur, etc. This is the final shakedown before I declare Hypothesis stable and ready to use and throw a party to celebrate.

Bug bounty for any bugs found between now and 1.0: I will buy you a drink (alcoholic, caffeinated, or otherwise) and shake your hand should we ever find ourselves in the same city at the same time.

The one tiny bugfix:

- Under pypy, databases would fail to close correctly when garbage collected, leading to a memory leak and a confusing error message if you were repeatedly creating databases and not closing them. It is very unlikely you were doing this and the chances of you ever having noticed this bug are very low.

### 18.459 0.7.2 - 2015-03-22

Codename: Hygienic macros or bust

- You can now name an argument to @given 'f' and it won't break ([issue #38](#))
- `strategy_test_suite` is now named `strategy_test_suite` as the documentation claims and not in fact `strategy_test_suitee`
- Settings objects can now be used as a context manager to temporarily override the default values inside their context.

### 18.460 0.7.1 - 2015-03-21

Codename: Point releases go faster

- Better string generation by parametrizing by a limited alphabet
- Faster string simplification - previously if simplifying a string with high range unicode characters it would try every unicode character smaller than that. This was pretty pointless. Now it stops after it's a short range (it can still reach smaller ones through recursive calls because of other simplifying operations).
- Faster list simplification by first trying a binary chop down the middle
- Simultaneous simplification of identical elements in a list. So if a bug only triggers when you have duplicates but you drew e.g. `[-17, -17]`, this will now simplify to `[0, 0]`.

## 18.461 0.7.0, - 2015-03-20

Codename: Starting to look suspiciously real

This is probably the last minor release prior to 1.0. It consists of stability improvements, a few usability things designed to make Hypothesis easier to try out, and filing off some final rough edges from the API.

- Significant speed and memory usage improvements
- Add an example() method to strategy objects to give an example of the sort of data that the strategy generates.
- Remove .descriptor attribute of strategies
- Rename descriptor\_test\_suite to strategy\_test\_suite
- Rename the few remaining uses of descriptor to specifier (descriptor already has a defined meaning in Python)

## 18.462 0.6.0 - 2015-03-13

Codename: I'm sorry, were you using that API?

This is primarily a “simplify all the weird bits of the API” release. As a result there are a lot of breaking changes. If you just use @given with core types then you're probably fine.

In particular:

- Stateful testing has been removed from the API
- The way the database is used has been rendered less useful (sorry). The feature for reassembling values saved from other tests doesn't currently work. This will probably be brought back in post 1.0.
- SpecificationMapper is no longer a thing. Instead there is an ExtMethod called strategy which you extend to specify how to convert other types to strategies.
- Settings are now extensible so you can add your own for configuring a strategy
- MappedSearchStrategy no longer needs an unpack method
- Basically all the SearchStrategy internals have changed massively. If you implemented SearchStrategy directly rather than using MappedSearchStrategy talk to me about fixing it.
- Change to the way extra packages work. You now specify the package. This must have a load() method. Additionally any modules in the package will be loaded in under hypothesis.extra

Bug fixes:

- Fix for a bug where calling falsify on a lambda with a non-ascii character in its body would error.

Hypothesis Extra:

**hypothesis-fakefactory: An extension for using faker data in hypothesis. Depends** on fake-factory.

## 18.463 0.5.0 - 2015-02-10

Codename: Read all about it.

Core hypothesis:

- Add support back in for pypy and python 3.2

- @given functions can now be invoked with some arguments explicitly provided. If all arguments that hypothesis would have provided are passed in then no falsification is run.
- Related to the above, this means that you can now use pytest fixtures and mark.parametrize with Hypothesis without either interfering with the other.
- Breaking change: @given no longer works for functions with varargs (varkwargs are fine). This might be added back in at a later date.
- Windows is now fully supported. A limited version (just the tests with none of the extras) of the test suite is run on windows with each commit so it is now a first class citizen of the Hypothesis world.
- Fix a bug for fuzzy equality of equal complex numbers with different reprs (this can happen when one coordinate is zero). This shouldn't affect users - that feature isn't used anywhere public facing.
- Fix generation of floats on windows and 32-bit builds of python. I was using some struct.pack logic that only worked on certain word sizes.
- When a test times out and hasn't produced enough examples this now raises a Timeout subclass of Unfalsifiable.
- Small search spaces are better supported. Previously something like a @given(bool, bool) would have failed because it couldn't find enough examples. Hypothesis is now aware of the fact that these are small search spaces and will not error in this case.
- Improvements to parameter search in the case of hard to satisfy assume. Hypothesis will now spend less time exploring parameters that are unlikely to provide anything useful.
- Increase chance of generating "nasty" floats
- Fix a bug that would have caused unicode warnings if you had a sampled\_from that was mixing unicode and byte strings.
- Added a standard test suite that you can use to validate a custom strategy you've defined is working correctly.

Hypothesis extra:

First off, introducing Hypothesis extra packages!

These are packages that are separated out from core Hypothesis because they have one or more dependencies. Every hypothesis-extra package is pinned to a specific point release of Hypothesis and will have some version requirements on its dependency. They use entry\_points so you will usually not need to explicitly import them, just have them installed on the path.

This release introduces two of them:

hypothesis-datetime:

Does what it says on the tin: Generates datetimes for Hypothesis. Just install the package and datetime support will start working.

Depends on pytz for timezone support

hypothesis-pytest:

A very rudimentary pytest plugin. All it does right now is hook the display of falsifying examples into pytest reporting.

Depends on pytest.

## 18.464 0.4.3 - 2015-02-05

Codename: TIL narrow Python builds are a thing

This just fixes the one bug.



- Apparently there is such a thing as a “narrow python build” and OS X ships with these by default for python 2.7. These are builds where you only have two bytes worth of unicode. As a result, generating unicode was completely broken on OS X. Fix this by only generating unicode codepoints in the range supported by the system.

## 18.465 0.4.2 - 2015-02-04

Codename: O(dear)

This is purely a bugfix release:

- Provide sensible external hashing for all core types. This will significantly improve performance of tracking seen examples which happens in literally every falsification run. For Hypothesis fixing this cut 40% off the runtime of the test suite. The behaviour is quadratic in the number of examples so if you’re running the default configuration this will be less extreme (Hypothesis’s test suite runs at a higher number of examples than default), but you should still see a significant improvement.
- Fix a bug in formatting of complex numbers where the string could get incorrectly truncated.

## 18.466 0.4.1 - 2015-02-03

Codename: Cruel and unusual edge cases

This release is mostly about better test case generation.

Enhancements:

- Has a cool release name
- `text_type` (str in python 3, unicode in python 2) example generation now actually produces interesting unicode instead of boring ascii strings.
- floating point numbers are generated over a much wider range, with particular attention paid to generating nasty numbers - nan, infinity, large and small values, etc.
- examples can be generated using pieces of examples previously saved in the database. This allows interesting behaviour that has previously been discovered to be propagated to other examples.
- improved parameter exploration algorithm which should allow it to more reliably hit interesting edge cases.
- Timeout can now be disabled entirely by setting it to any value  $\leq 0$ .

Bug fixes:

- The descriptor on a `OneOfStrategy` could be wrong if you had descriptors which were equal but should not be coalesced. e.g. a strategy for `one_of((frozenset({int}), {int}))` would have reported its descriptor as `{int}`. This is unlikely to have caused you any problems
- If you had strategies that could produce NaN (which float previously couldn’t but e.g. a `Just(float('nan'))` could) then this would have sent hypothesis into an infinite loop that would have only been terminated when it hit the timeout.
- Given elements that can take a long time to minimize, minimization of floats or tuples could be quadratic or worse in the that value. You should now see much better performance for simplification, albeit at some cost in quality.

Other:

- A lot of internals have been rewritten. This shouldn't affect you at all, but it opens the way for certain of hypothesis's oddities to be a lot more extensible by users. Whether this is a good thing may be up for debate...

### 18.467 0.4.0 - 2015-01-21

**FLAGSHIP FEATURE:** Hypothesis now persists examples for later use. It stores data in a local SQLite database and will reuse it for all tests of the same type.

**LICENSING CHANGE:** Hypothesis is now released under the Mozilla Public License 2.0. This applies to all versions from 0.4.0 onwards until further notice. The previous license remains applicable to all code prior to 0.4.0.

Enhancements:

- Printing of failing examples. I was finding that the pytest runner was not doing a good job of displaying these, and that Hypothesis itself could do much better.
- Drop dependency on six for cross-version compatibility. It was easy enough to write the shim for the small set of features that we care about and this lets us avoid a moderately complex dependency.
- Some improvements to statistical distribution of selecting from small ( $\leq 3$  elements)
- Improvements to parameter selection for finding examples.

Bugs fixed:

- `could_have_produced` for lists, dicts and other collections would not have examined the elements and thus when using a union of different types of list this could result in Hypothesis getting confused and passing a value to the wrong strategy. This could potentially result in exceptions being thrown from within simplification.
- `sampled_from` would not work correctly on a single element list.
- Hypothesis could get *very* confused by values which are equal despite having different types being used in descriptors. Hypothesis now has its own more specific version of equality it uses for descriptors and tracking. It is always more fine grained than Python equality: Things considered `!=` are not considered equal by hypothesis, but some things that are considered `==` are distinguished. If your test suite uses both `frozenset` and `set` tests this bug is probably affecting you.

### 18.468 0.3.2 - 2015-01-16

- Fix a bug where if you specified `floats_in_range` with integer arguments Hypothesis would error in example simplification.
- Improve the statistical distribution of the floats you get for the `floats_in_range` strategy. I'm not sure whether this will affect users in practice but it took my tests for various conditions from flaky to rock solid so it at the very least improves discovery of the artificial cases I'm looking for.
- Improved `repr()` for strategies and `RandomWithSeed` instances.
- Add detection for flaky test cases where hypothesis managed to find an example which breaks it but on the final invocation of the test it does not raise an error. This will typically happen with too much recursion errors but could conceivably happen in other circumstances too.
- Provide a "derandomized" mode. This allows you to run hypothesis with zero real randomization, making your build nice and deterministic. The tests run with a seed calculated from the function they're testing so you should still get a good distribution of test cases.
- Add a mechanism for more conveniently defining tests which just sample from some collection.

- Fix for a really subtle bug deep in the internals of the strategy table. In some circumstances if you were to define instance strategies for both a parent class and one or more of its subclasses you would under some circumstances get the strategy for the wrong superclass of an instance. It is very unlikely anyone has ever encountered this in the wild, but it is conceivably possible given that a mix of namedtuple and tuple are used fairly extensively inside hypothesis which do exhibit this pattern of strategy.

## 18.469 0.3.1 - 2015-01-13

- Support for generation of frozenset and Random values
- Correct handling of the case where a called function mutates its argument. This involved introducing a notion of strategies knowing how to copy their argument. The default method should be entirely acceptable and the worst case is that it will continue to have the old behaviour if you don't mark your strategy as mutable, so this shouldn't break anything.
- Fix for a bug where some strategies did not correctly implement `could_have_produced`. It is very unlikely that any of these would have been seen in the wild, and the consequences if they had been would have been minor.
- Re-export the `@given` decorator from the main hypothesis namespace. It's still available at the old location too.
- Minor performance optimisation for simplifying long lists.

## 18.470 0.3.0 - 2015-01-12

- Complete redesign of the data generation system. Extreme breaking change for anyone who was previously writing their own SearchStrategy implementations. These will not work any more and you'll need to modify them.
- New settings system allowing more global and modular control of Verifier behaviour.
- Decouple SearchStrategy from the StrategyTable. This leads to much more composable code which is a lot easier to understand.
- A significant amount of internal API renaming and moving. This may also break your code.
- Expanded available descriptors, allowing for generating integers or floats in a specific range.
- Significantly more robust. A very large number of small bug fixes, none of which anyone is likely to have ever noticed.
- Deprecation of support for pypy and python 3 prior to 3.3. 3.3 and 3.4. Supported versions are 2.7.x, 3.3.x, 3.4.x. I expect all of these to remain officially supported for a very long time. I would not be surprised to add pypy support back in later but I'm not going to do so until I know someone cares about it. In the meantime it will probably still work.

## 18.471 0.2.2 - 2015-01-08

- Fix an embarrassing complete failure of the installer caused by my being bad at version control

## 18.472 0.2.1 - 2015-01-07

- Fix a bug in the new stateful testing feature where you could make `__init__` a `@requires` method. Simplification would not always work if the `prune` method was able to successfully shrink the test.

## 18.473 0.2.0 - 2015-01-07

- It's alive.
- Improve python 3 support using `six`.
- Distinguish between byte and unicode types.
- Fix issues where `FloatStrategy` could raise.
- Allow stateful testing to request constructor args.
- Fix for issue where test annotations would timeout based on when the module was loaded instead of when the test started

## 18.474 0.1.4 - 2013-12-14

- Make verification runs time bounded with a configurable timeout

## 18.475 0.1.3 - 2013-05-03

- Bugfix: Stateful testing behaved incorrectly with subclassing.
- Complex number support
- support for recursive strategies
- different error for hypotheses with unsatisfiable assumptions

## 18.476 0.1.2 - 2013-03-24

- Bugfix: Stateful testing was not minimizing correctly and could throw exceptions.
- Better support for recursive strategies.
- Support for named tuples.
- Much faster integer generation.

## 18.477 0.1.1 - 2013-03-24

- Python 3.x support via `2to3`.
- Use new style classes (oops).

## 18.478 0.1.0 - 2013-03-23

- Introduce stateful testing.
- Massive rewrite of internals to add flags and strategies.

## 18.479 0.0.5 - 2013-03-13

- No changes except trying to fix packaging

## 18.480 0.0.4 - 2013-03-13

- No changes except that I checked in a failing test case for 0.0.3 so had to replace the release. Doh

## 18.481 0.0.3 - 2013-03-13

- Improved a few internals.
- Opened up creating generators from instances as a general API.
- Test integration.

## 18.482 0.0.2 - 2013-03-12

- Starting to tighten up on the internals.
- Change API to allow more flexibility in configuration.
- More testing.

## 18.483 0.0.1 - 2013-03-10

- Initial release.
- Basic working prototype. Demonstrates idea, probably shouldn't be used.



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## Ongoing Hypothesis Development

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Hypothesis development is managed by me, [David R. MacIver](#). I am the primary author of Hypothesis.

*However*, I no longer do unpaid feature development on Hypothesis. My roles as leader of the project are:

1. Helping other people do feature development on Hypothesis
2. Fixing bugs and other code health issues
3. Improving documentation
4. General release management work
5. Planning the general roadmap of the project
6. Doing sponsored development on tasks that are too large or in depth for other people to take on

So all new features must either be sponsored or implemented by someone else. That being said, the maintenance team takes an active role in shepherding pull requests and helping people write a new feature (see [CONTRIBUTING.rst](#) for details and [pull request #154](#) for an example of how the process goes). This isn't "patches welcome", it's "we will help you write a patch".

### 19.1 Release Policy

Hypothesis releases follow [semantic versioning](#).

We maintain backwards-compatibility wherever possible, and use deprecation warnings to mark features that have been superseded by a newer alternative. If you want to detect this, you can [upgrade warnings to errors in the usual ways](#).

We use continuous deployment to ensure that you can always use our newest and shiniest features - every change to the source tree is automatically built and published on PyPI as soon as it's merged onto master, after code review and passing our extensive test suite.

## 19.2 Project Roadmap

Hypothesis does not have a long-term release plan. However some visibility into our plans for future *compatibility* may be useful:

- We value compatibility, and maintain it as far as practical. This generally excludes things which are end-of-life upstream, or have an unstable API.
- We would like to drop Python 2 support when it reaches end of life in 2020. Ongoing support is likely to depend on commercial funding.



## CHAPTER 20

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### Help and Support

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For questions you are happy to ask in public, the *Hypothesis community* is a friendly place where I or others will be more than happy to help you out. You're also welcome to ask questions on Stack Overflow. If you do, please tag them with 'python-hypothesis' so someone sees them.

For bugs and enhancements, please file an issue on the [GitHub issue tracker](#). Note that as per the *development policy*, enhancements will probably not get implemented unless you're willing to pay for development or implement them yourself (with assistance from me). Bugs will tend to get fixed reasonably promptly, though it is of course on a best effort basis.

To see the versions of Python, optional dependencies, test runners, and operating systems Hypothesis supports (meaning incompatibility is treated as a bug), see *Compatibility*.

If you need to ask questions privately or want more of a guarantee of bugs being fixed promptly, please contact me on [hypothesis-support@drmaciver.com](mailto:hypothesis-support@drmaciver.com) to talk about availability of support contracts.



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## Packaging Guidelines

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Downstream packagers often want to package Hypothesis. Here are some guidelines.

The primary guideline is this: If you are not prepared to keep up with the Hypothesis release schedule, don't. You will annoy me and are doing your users a disservice.

Hypothesis has a very frequent release schedule. It's rare that it goes a week without a release, and there are often multiple releases in a given week.

If you *are* prepared to keep up with this schedule, you might find the rest of this document useful.

### 21.1 Release tarballs

These are available from [the GitHub releases page](#). The tarballs on PyPI are intended for installation from a Python tool such as pip and should not be considered complete releases. Requests to include additional files in them will not be granted. Their absence is not a bug.

### 21.2 Dependencies

#### 21.2.1 Python versions

Hypothesis is designed to work with a range of Python versions. We always support [all versions of CPython with upstream support](#), and plan to drop Python 2 at EOL in 2020. We also support the latest versions of PyPy for Python 3, and for Python 2 until the CPython 2 EOL.

If you feel the need to have separate Python 3 and Python 2 packages you can, but Hypothesis works unmodified on either.

#### 21.2.2 Other Python libraries

Hypothesis has *mandatory* dependencies on the following libraries:

- `attrs`
- `enum34` is required on Python 2.7

Hypothesis has *optional* dependencies on the following libraries:

- `pytz` (almost any version should work)
- `Django`, all supported versions
- `numpy`, 1.10 or later (earlier versions will probably work fine)
- `pandas`, 1.19 or later
- `pytest` (3.0 or greater). This is a mandatory dependency for testing Hypothesis itself but optional for users.

The way this works when installing Hypothesis normally is that these features become available if the relevant library is installed.

## 21.3 Testing Hypothesis

If you want to test Hypothesis as part of your packaging you will probably not want to use the mechanisms Hypothesis itself uses for running its tests, because it has a lot of logic for installing and testing against different versions of Python.

The tests must be run with `pytest >= 3.0`; check the [requirements/](#) directory for details.

The organisation of the tests is described in the [hypothesis-python/tests/README.rst](#).

## 21.4 Examples

- `arch linux`
- `fedora`
- `gentoo`

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## Reproducing Failures

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One of the things that is often concerning for people using randomized testing is the question of how to reproduce failing test cases.

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**Note:** It is better to think about the data Hypothesis generates as being *arbitrary*, rather than *random*. We deliberately generate any valid data that seems likely to cause errors, so you shouldn't rely on any expected distribution of or relationships between generated data. You can read about “swarm testing” and “coverage guided fuzzing” if you're interested, because you don't need to know for Hypothesis!

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Fortunately Hypothesis has a number of features to support reproducing test failures. The one you will use most commonly when developing locally is *the example database*, which means that you shouldn't have to think about the problem at all for local use - test failures will just automatically reproduce without you having to do anything.

The example database is perfectly suitable for sharing between machines, but there currently aren't very good work flows for that, so Hypothesis provides a number of ways to make examples reproducible by adding them to the source code of your tests. This is particularly useful when e.g. you are trying to run an example that has failed on your CI, or otherwise share them between machines.

### 22.1 Providing explicit examples

The simplest way to reproduce a failed test is to ask Hypothesis to run the failing example it printed. For example, if Falsifying example: `test(n=1)` was printed you can decorate `test` with `@example(n=1)`.

`@example` can also be used to ensure a specific example is *always* executed as a regression test or to cover some edge case - basically combining a Hypothesis test and a traditional parametrized test.

```
hypothesis.example(*args, **kwargs)
```

A decorator which ensures a specific example is always tested.

Hypothesis will run all examples you've asked for first. If any of them fail it will not go on to look for more examples.

It doesn't matter whether you put the example decorator before or after given. Any permutation of the decorators in the above will do the same thing.

Note that examples can be positional or keyword based. If they're positional then they will be filled in from the right when calling, so either of the following styles will work as expected:

```
@given(text())
@example("Hello world")
@example(x="Some very long string")
def test_some_code(x):
    assert True

from unittest import TestCase

class TestThings(TestCase):
    @given(text())
    @example("Hello world")
    @example(x="Some very long string")
    def test_some_code(self, x):
        assert True
```

As with `@given`, it is not permitted for a single example to be a mix of positional and keyword arguments. Either are fine, and you can use one in one example and the other in another example if for some reason you really want to, but a single example must be consistent.

## 22.2 Reproducing a test run with `@seed`

`hypothesis.seed(seed)`

seed: Start the test execution from a specific seed.

May be any hashable object. No exact meaning for seed is provided other than that for a fixed seed value Hypothesis will try the same actions (insofar as it can given external sources of non-determinism. e.g. timing and hash randomization).

Overrides the `derandomize` setting, which is designed to enable deterministic builds rather than reproducing observed failures.

When a test fails unexpectedly, usually due to a health check failure, Hypothesis will print out a seed that led to that failure, if the test is not already running with a fixed seed. You can then recreate that failure using either the `@seed` decorator or (if you are running `pytest`) with `--hypothesis-seed`.

The seed will not be printed if you could simply use `@example` instead.

## 22.3 Reproducing an example with `@reproduce_failure`

Hypothesis has an opaque binary representation that it uses for all examples it generates. This representation is not intended to be stable across versions or with respect to changes in the test, but can be used to reproduce failures with the `@reproduce_example` decorator.

`hypothesis.reproduce_failure(version, blob)`

Run the example that corresponds to this data blob in order to reproduce a failure.

A test with this decorator *always* runs only one example and always fails. If the provided example does not cause a failure, or is in some way invalid for this test, then this will fail with a `DidNotReproduce` error.

This decorator is not intended to be a permanent addition to your test suite. It's simply some code you can add to ease reproduction of a problem in the event that you don't have access to the database. Because of this, *no* compatibility guarantees are made between different versions of Hypothesis - its API may change arbitrarily from version to version.

The intent is that you should never write this decorator by hand, but it is instead provided by Hypothesis. When a test fails with a falsifying example, Hypothesis may print out a suggestion to use `@reproduce_failure` on the test to recreate the problem as follows:

```
>>> from hypothesis import settings, given, PrintSettings
>>> import hypothesis.strategies as st
>>> @given(st.floats())
... @settings(print_blob=PrintSettings.ALWAYS)
... def test(f):
...     assert f == f
...
>>> try:
...     test()
... except AssertionError:
...     pass
Falsifying example: test(f=nan)
```

You can reproduce this example by temporarily adding `@reproduce_failure(..., b'AAAA//↵AAAAAAAEAE')` as a decorator on your test case

Adding the suggested decorator to the test should reproduce the failure (as long as everything else is the same - changing the versions of Python or anything else involved, might of course affect the behaviour of the test! Note that changing the version of Hypothesis will result in a different error - each `@reproduce_failure` invocation is specific to a Hypothesis version).

When to do this is controlled by the `print_blob` setting, which may be one of the following values:

#### **class** hypothesis.PrintSettings

Flags to determine whether or not to print a detailed example blob to use with `reproduce_failure()` for failing test cases.

##### **NEVER = 0**

Never print a blob.

##### **INFER = 1**

Make an educated guess as to whether it would be appropriate to print the blob.

The current rules are that this will print if:

1. The output from Hypothesis appears to be unsuitable for use with `example()`, and
2. The output is not too long, and
3. Verbosity is at least normal.

##### **ALWAYS = 2**

Always print a blob on failure.





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