Typing Software Heritage with MyPy

. . . the codebase, not the archive!

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Software Heritage

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Paris, France

Outline

1. Static typing with MyPy
2. Typing the Software Heritage codebase
3. Tips, tricks, FAQs, . . .
4. Outlook

Outline

Credits

Reusing intro slides shamelessly from:

Diego Muñoz
Python static typing with MyPy
Python Madrid Meetup, 2018
https://slides.kartones.net/027.html


Type Hints

Type Hints

- For Python 3

```
from typing import Union


def my_method(an_integer: int, a_float: float) -> Union[None, float]:
    if a_float == 0:
        return None
    the_result: float = an_integer / a_float
    return the_result
```

Stub files

- `.pyi` files
- Code you cannot annotate directly (e.g. external library)
- `stubgen <module>`

```
from typing import Any, List
from django.views.generic import View


class MyLibView(object):

   http_method_names: List

   def __init__(self, **kwargs: Any) -> None: ...

   def as_view(self, cls: View, **initkwargs: Any) -> View: ...

   def sum_values(self, first: int, second: int) -> int: ...
```

- Primitives

```
from typing import Union


def my_method(an_integer: int, a_float: float) -> Union[None, float]:
    if a_float == 0:
        return None
    the_result: float = an_integer / a_float
    return the_result
```

- Unknown type

```
from typing import Any


class MyDjangoView(View):
   def post(self, request: WSGIRequest, **kwargs: Any) -> JsonResponse:
       pass
```

- Lists and Tuples

```
from typing import List, Tuple


def numeric_tuple_to_list(source_tuple: Tuple) -> List:
    return [item for item in source_tuple]


def numeric_tuple_to_list(source_tuple: Tuple[int]) -> List[int]:
    return [item for item in source_tuple]
```

- Dictionaries

```python
from typing import Dict


def my_method(input_data: Dict) -> None:
    for key, value in input_data.items():
        print(f"{key}:{value}")


def my_method_2(input_data: Dict[str, int]) -> None:
    for key, value in input_data.items():
        print(f"{key}:{value}")
```

- Multiple types

```
from typing import Union


def my_method(an_integer: int, a_float: float) -> Union[None, float]:
    if a_float == 0:
        return None
    the_result: float = an_integer / a_float
    return the_result
```

- “Nullable type” (type or `None`)

```python
from typing import Optional


def my_method(an_integer: int, a_float: float) -> Optional[float]:
    if a_float == 0:
        return None
    the_result: float = an_integer / a_float
    return the_result
```

Python 3

- Types can also be specified

```
from typing import Type


def validate_type(a_vehicle_class: Type) -> bool:
    return a_vehicle_class in [Car, Truck]
```

Python 3
- Iterators

```
from typing import Iterator


def find_items() -> Iterator[MyClass]:
    # ...
    yield item
```

Python 3

- Function/Method handlers

```python
from typing import Callable


def my_method1(func: Callable, value: int) -> int:
    return func(value)


def my_method2(func: Callable[[int], int], value: int) -> int:
    return func(value)
```

Python 3
- Type aliases

```
from typing import List

Vector = List[float]
```


MyPy

Annotations not enforced by Python

Left for type checkers to use (**gradual typing)**

Static type checker tool

How to run

- From command line

```
mypy myproj

myproj/models.py:46: error: Function is missing a type annotation for one or
more arguments

myproj/models.py:54: error: Unsupported operand types for >= ("int" and "str")

myproj/tests/models_test.py:253: error: Argument 2 to "my_method" of "MyClass"
has incompatible type "int"; expected "str"
```

Outline

Goal

Minimal Viable Product

- make “mypy swh” pass in every `swh-environment` repository...
- ...with no or minimal type annotations
  - i.e., “only” avoid blatant type errors
- integrate with CI
  - i.e., create a regression-free baseline for incrementally annotating our codebase in the medium/long term

Developer interface

```
cd swh-environment/swh-foo
```

`make typecheck` only run mypy

`make check` will *also* do the above (in addition to `flake8` & `codespell`)

`tox -e mypy` like `make typecheck`, but in `tox`

`tox` all of it + tests, but in `tox`

Current status

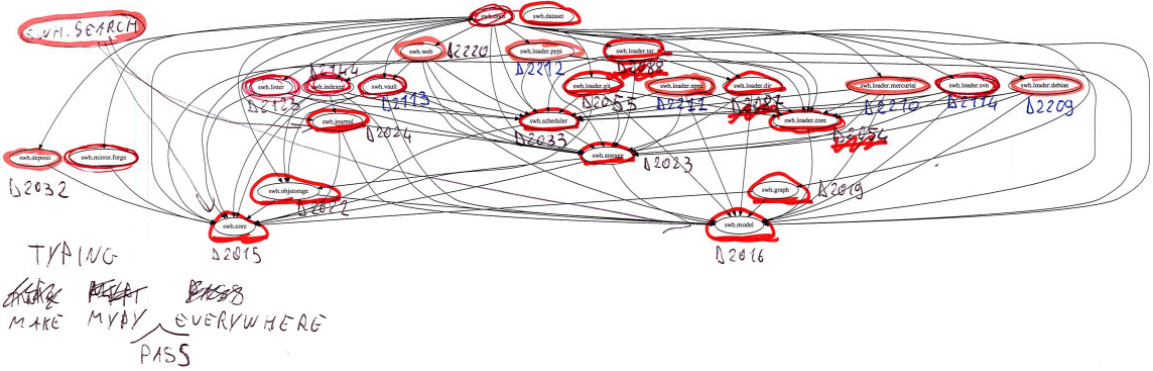
```
~/swh-environment $ make typecheck
make -C swh-core typecheck
make[1]: Entering directory '/home/zack/swh-environment/swh-core'
mypy swh
Success: no issues found in 41 source files
make[1]: Leaving directory '/home/zack/swh-environment/swh-core'

[...]

make[1]: Entering directory '/home/zack/swh-environment/swh-web'
Makefile.local:97: warning: overriding recipe for target 'check-mypy'
../Makefile.python:39: warning: ignoring old recipe for target 'check-mypy'
DJANGO_SETTINGS_MODULE=swh.web.settings.development mypy swh
Success: no issues found in 120 source files
make[1]: Leaving directory '/home/zack/swh-environment/swh-web'

~/swh-environment $ echo $?
0
```

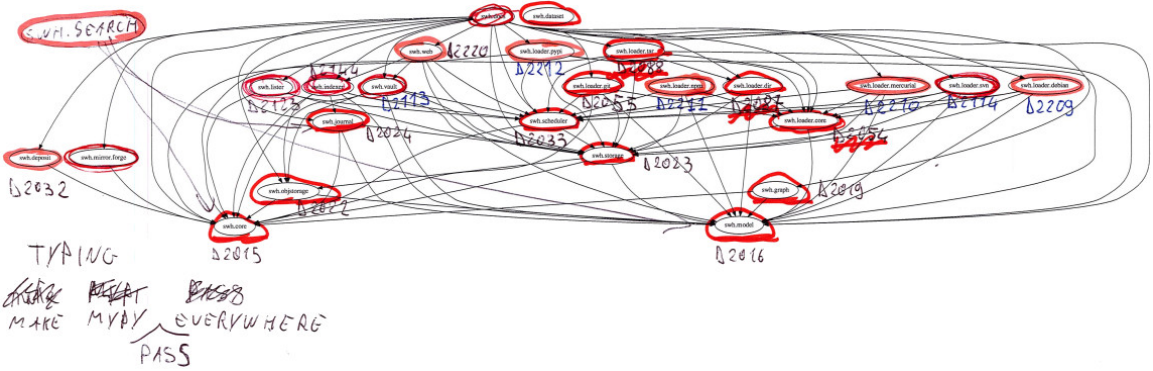
The journey



Elapsed (wall clock) time: 1.5 months

- D2015 (swh-core): submitted 2019-09-20
- D2230 (swh-search): closed 2019-11-07

The journey



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Source tree layout changes

```
diff --git a/mypy.ini b/mypy.ini
new file mode 100644
index 0000000..51a26dc
--- /dev/null
+++ b/mypy.ini
@@ -0,0 +1,18 @@
+[mypy]
+namespace_packages = True
+warn_unused_ignores = True
+
+# 3rd party libraries without stubs (yet)
+
+[mypy-pkg_resources.*]
+ignore_missing_imports = True
+
+[mypy-pytest.*]
+ignore_missing_imports = True
```

...

(more on this later)

Source tree layout changes (cont.)

```
diff --git a/.gitignore b/.gitignore
index b0e734a..3c564c7 100644
--- a/.gitignore
+++ b/.gitignore
@@ -9,3 +9,4 @@ build/
 dist/
 version.txt
 .tox
+.mypy_cache/
```

Source tree layout changes (cont.)

```
diff --git a/swh/search/py.typed b/swh/search/py.typed
new file mode 100644
index 0000000..1242d43
--- /dev/null
+++ b/swh/search/py.typed
@@ -0,0 +1 @@
+# Marker file for PEP 561.

diff --git a/MANIFEST.in b/MANIFEST.in
index 1271b63..8c63402 100644
--- a/MANIFEST.in
+++ b/MANIFEST.in
@@ -3,3 +3,4 @@ include requirements.txt
 include requirements-swh.txt
 include version.txt
 include README.md
+recursive-include swh py.typed
```

Source tree layout changes (cont.)

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```

Source tree layout changes (cont.)

```
diff --git a/tox.ini b/tox.ini
index 7f7bc76..1c535aa 100644
--- a/tox.ini
+++ b/tox.ini
@@ -1,5 +1,5 @@
 [tox]
-envlist=flake8,py3
+envlist=flake8,mypy,py3

@@ -16,3 +16,11 @@ deps =
+
+[testenv:mypy]
+skip_install = true
+deps =
+  .[testing]
+  mypy
+commands =
+  mypy swh
```

Source tree layout changes (cont.)

```
diff --git a/swh/__init__.py b/swh/__init__.py
index 69e3be5..f14e196 100644
--- a/swh/__init__.py
+++ b/swh/__init__.py
@@ -1 +1,4 @@
-__path__ = __import__('pkgutil').extend_path(__path__, __name__)
+from pkgutil import extend_path
+from typing import Iterable
+
+__path__: Iterable[str] = extend_path(__path__, __name__)
```

Bestiary of encountered issues

- missing django kwarg: D2031
- bytes/str mismatch in CRAN lister: D2124
- drop obsolete CLI alaises: D2013, D2000
- click_required=1: D1985, D1986, D1987, D1988, D1989
- missing import json, shadowed by unrelated NoQA marker: D2022
- import loop swh-storage↔swh-journal
- do not explode when TEST_DB_DUMP=None: D2012
- unused format string parameter in SQL query formatting: D2144
- actual dynamic typing of int/str/datetime in default_min_bound of github lister
  - ⇒ swept under the carpet with `type: Any` for now

Outline

When should modules be ignored?

Mypy looks for type information:

- in the `.py` files themselves
  - for third party modules this is so *provided that* the module declares itself to be typed shipping `py.typed` (PEP 561)
- in third party `.pyi` interface files
  - locally installed to annotate 3rd party libraries, e.g., `django-stubs`
  - available from typeshed `https://github.com/python/typeshed/`

```
swh/search/elasticsearch.py:9: error: No library stub file for module 'elasticsearch'
swh/search/elasticsearch.py:10: error: No library stub file for module 'elasticsearch.helpers'
```

⇒

```
diff --git a/mypy.ini b/mypy.ini
--- a/mypy.ini
+++ b/mypy.ini
+[mypy-elasticsearch.*]
+ignore_missing_imports = True
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Docstrings

Do not duplicate type information between docstrings and type hints, sphinx+napoleon will Do The Right Thing™.

```python
def __init__(self, record_size: int, fname: str, mode: str = 'rb',
             length: int = None):
    """open an existing on-disk map

    Args:
        record_size: size of each record in bytes
        fname: path to the on-disk map
        mode: file open mode, usually either 'rb' for read-only maps, 'wb' for
            creating new maps, or 'rb+' for updating existing ones (default: 'rb')
        length: map size in number of logical records; used to initialize
            writable maps at creation time. Must be given when mode is 'wb' and
            the map doesn't exist on disk; ignored otherwise
    """
```

C.f. https://docs.softwareheritage.org/devel/apidoc/swh.graph.pid.html#swh.graph.pid._OnDiskMap

Postel's law & type hints

- Q Should I return `Dict` or `Mapping`?
- Q Should I accept `Sequence` or `List`?

Definition (Robustness principle)

Be conservative in what you send, be liberal in what you accept.

⇓

Return concrete types, accept abstract base classes.

```python
from typing import Any, Dict, Mapping, Sequence
def main_loop(conf: Mapping[str, Any],
              targets: Sequence[str]) -> Dict[str, int]
    pass
```

- note: `Mapping`, `Sequence` (input) v. `Dict` (output)
- keep `https://docs.python.org/3/library/collections.abc.html` handy!

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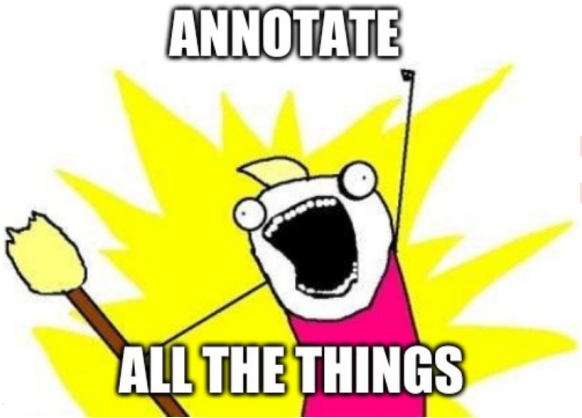
Next steps for typing



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- if so: bottom-up, starting from core interfaces/functionalities and walking our way up towards external modules
- might be a good chance to design more abstract types/clear contracts for our architectural layers

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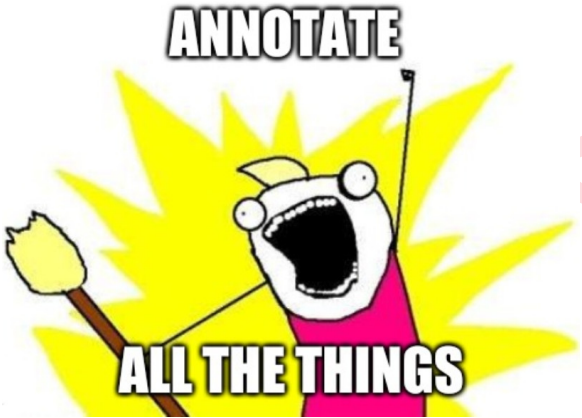

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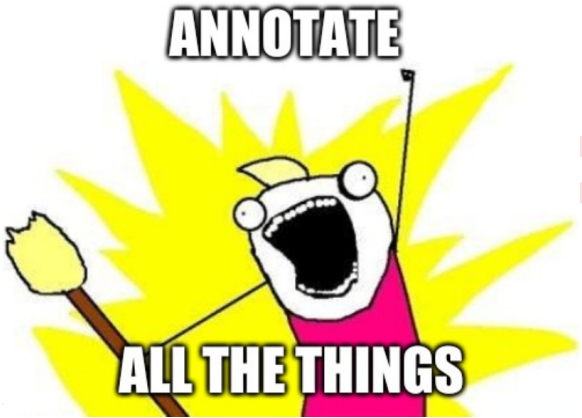

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On doing cross-cutting changes to our codebase

- quite painful
- [short of monorepo] can we do better?
- unclear to me, some ideas
  - CI support for: “test this and all its reverse dependencies”
  - move CI/linting configuration *out* of individual packages, so that we have one central place where to change cross-cutting quality standards
    - price to pay: giving up on independent testability
  - non-uniform pre-commit rules is still a pain (WTH am I the only one hitting `codespell` issue?)
    - ⇒ go ahead with the switch to `https://pre-commit.com/` (T1881)

The good

- CI is a great help
- `git tag` to release is awesome

- (minimally) typing SWH with Mypy has been a positive experience—learned some stuff, squashed some bugs
- my take: we should now go ahead and (maximally) type SWH with Mypy
- it is complementary to current linting & testing and raises opportunities to define clear(er) invariants/contracts across our entire software stack

MyPy
Type hints cheat sheet
https://mypy.readthedocs.io/en/latest/cheat_sheet_py3.html

Dropbox
Our journey to type checking 4 million lines of Python
https://blogs.dropbox.com/tech/2019/09/our-journey-to-type-checking-4-million-lines-of-python/

Bernat Gabor
Type Hints: Inside the Snake Pit
https://gaborbernat.github.io/pycon-us-2019/

about the slides:
available at https://upsilon.cc/~zack/talks/2019/2019-11-20-swh-mypy.pdf