Hacking The Python Import System

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Terms

From python glossary:

- `Module` - An object that serves as an organizational unit of Python code
- `Package` - A Python module which can contain submodules or recursively, subpackages
- `Loader` - An object that loads a module
- `Finder` - An object that tries to find the loader for a module that is being imported

Import Machinery

Finder

```python
class ExampleFinder(importlib.abc.MetaPathFinder):
    def find_spec(self, fullname, path, target = None) -> Optional[ModuleSpec]:
        ...
```

- `fullname` - The full name of the module imported
- `path` - Path of the package the module is imported from
- `return value` - An object that contains the `Loader` that should be used to load the module

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Example:

```
from flask.json import loads
```

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Example:

```
from flask.json import loads
```

- `fullname`: `"flask.json"`
- `path`: `["/Users/loz/env/lib/python3.9/site-packages/flask"]`

Loader

```python
class ExampleLoader(importlib.abc.Loader):
    def create_module(self, spec: ModuleSpec) -> ModuleType:
        ...

    def exec_module(self, module: ModuleType) -> None:
        ...
```

- `spec` - The module spec created by `find_spec`
- `module` - The module object created by `create_module`

Loader

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- `module` - The module object created by `create_module`

The result of the `create_module` is the module returned from the import statement

sys.meta_path

A list of all the Finders that are used in the Import Machinery

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import sys
sys.meta_path
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[<class '_frozen_importlib.BuiltinImporter'>,
 <class '_frozen_importlib.FrozenImporter'>,
 <class '_frozen_importlib_external.PathFinder'>]
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[<class '_frozen_importlib.BuiltinImporter'>,
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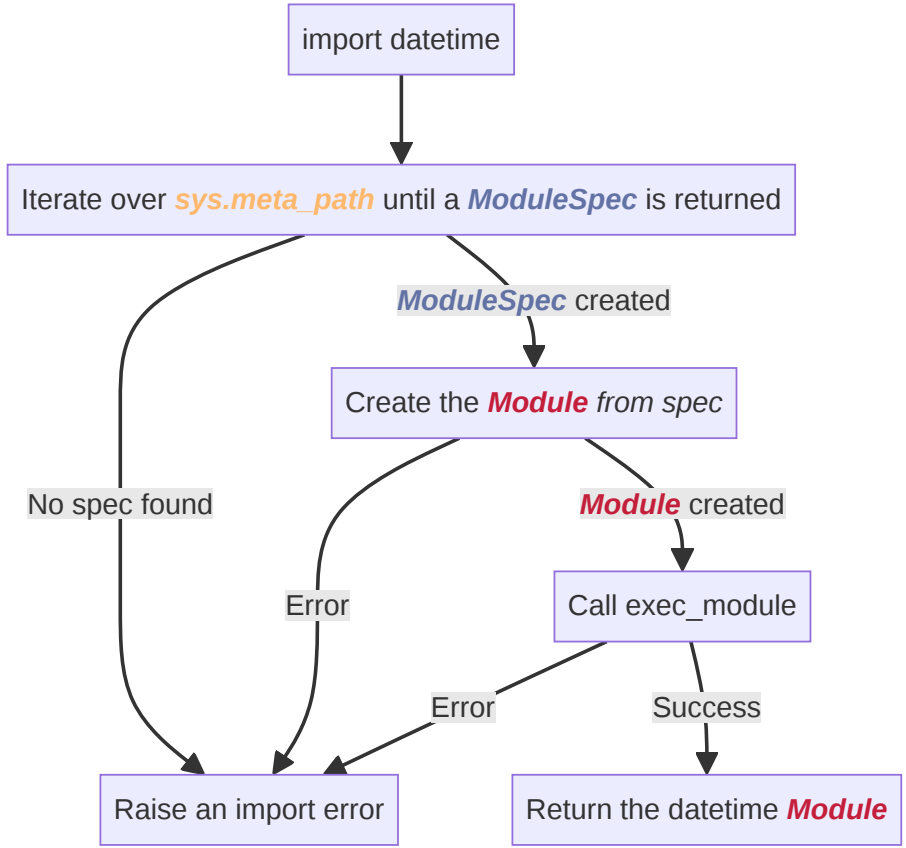
```

- `BuiltinImporter` - For modules like `sys` and `os`
- `FrozenImporter` - For frozen modules
- `PathFinder` - Modules that are located somewhere in the filesystem like `datetime` or `flask`

Import Flow


import datetime
Iterate over sys.meta_path until a ModuleSpec is returned
ModuleSpec created
Create the Module from spec
No spec found
Module created
Error
Call exec_module
Error
Success
Raise an import error
Return the datetime Module

PathFinder

sys.path

Locations where the `PathFinder` searches for packages/modules

Inside a virtual environment

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import sys
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```python
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```
['',
 '/Library/Frameworks/Python.framework/Versions/3.8/lib/python38.zip',
 '/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8',
 '/Library/Frameworks/Python.framework/Versions/3.8/lib/python3.8/lib-dynload',
 '/Users/loz/projects/hacking_import/env/lib/python3.8/site-packages']
```

PYTHONPATH

An environment variable, when the python process starts the contents are appended into `sys.path`

```
export PYTHONPATH=/path/to/foo:/path/to/bar
```

```
sys.path
```

```
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 '/Users/loz/Library/Python/3.8/lib/python/site-packages',
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PathFinder

```python
class PathFinder:

    ...

    @classmethod
    def find_spec(cls, fullname, path=None, target=None):
        """Try to find a spec for 'fullname' on sys.path or 'path'.

        The search is based on sys.path_hooks and sys.path_importer_cache.
        """
        if path is None:
            path = sys.path
        spec = cls._get_spec(fullname, path, target)
        if spec is None:
            return None

        # ommitted code
        return spec
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- Create a Finder with the `find_spec` function
- Create a Loader with the `create_module` and `exec_module` functions
- Add the Finder to `sys.meta_path`

Remote Host Finder

Problem: We have a python package that can only be installed on linux hosts. While production does run on linux, in development some of the developers use MacOS.

Solution: Create a new finder - for packages that are not found with the standard finder, it uses a proxy module from a remote linux host.

RPyC Finder

```python
import rpyc
import sys
import importlib

ALLOWED_MODULES = ['linux_only_package',]
class RPyCFinder(importlib.abc.MetaPathFinder):
    def __init__(self):
        self.host = rpyc.classic.connect('ubuntu-host')

    def find_spec(self, fullname, path):
        if path:
            return None
        if fullname not in ALLOWED_MODULES:
            return None

        spec = importlib.util.spec_from_loader(fullname, RPyCLoader(self.host))
        return spec


sys.meta_path.append(RPyCFinder())
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RPyC Loader

```
1   class RPyCLoader(importlib.abc.Loader):
2       def __init__(self, host):
3           self.host = host
4
5       def create_module(self, spec):
6           proxy_module = getattr(self.host.modules, spec.name)
7           return proxy_module
8
9       def exec_module(self, module):
10          ...
```

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Module Found

Don’t try this at home!

Problem: Python doesn’t find the modules I ask it to. Whether it was not installed, a spelling mistake in the name or the module just doesn’t exist.

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Solution: AI

Use Open AI API to generate module functions as they are being called

AI Finder

No, really... I'm not joking!

```python
DISALLOWED_MODULES = ["apport_python_hook", "sitecustomize", "usercustomize"]
class AiFinder():  # pylint: disable=too-few-public-methods
    def __init__(self, api_key: str) -> None:
        self._loader = AiLoader(api_key)

    def find_spec(self, fullname, path, _target=None):
        if path:
            return None
        if '.' in fullname or fullname in DISALLOWED_MODULES:
            return None
        return importlib.util.spec_from_loader(fullname, self._loader)
```

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AI Loader

For your safety, don't do this...

```python
from module_found.lazy_object import LazyModule

class AiLoader():
    def __init__(self, api_key: str) -> None:
        self._api_key = api_key

    def create_module(self, spec):
        return LazyModule(self._api_key, spec.name)

    def exec_module(self, _module):
        ...
```

AI Loader

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from module_found.lazy_object import LazyModule

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    def create_module(self, spec):
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    def exec_module(self, _module):
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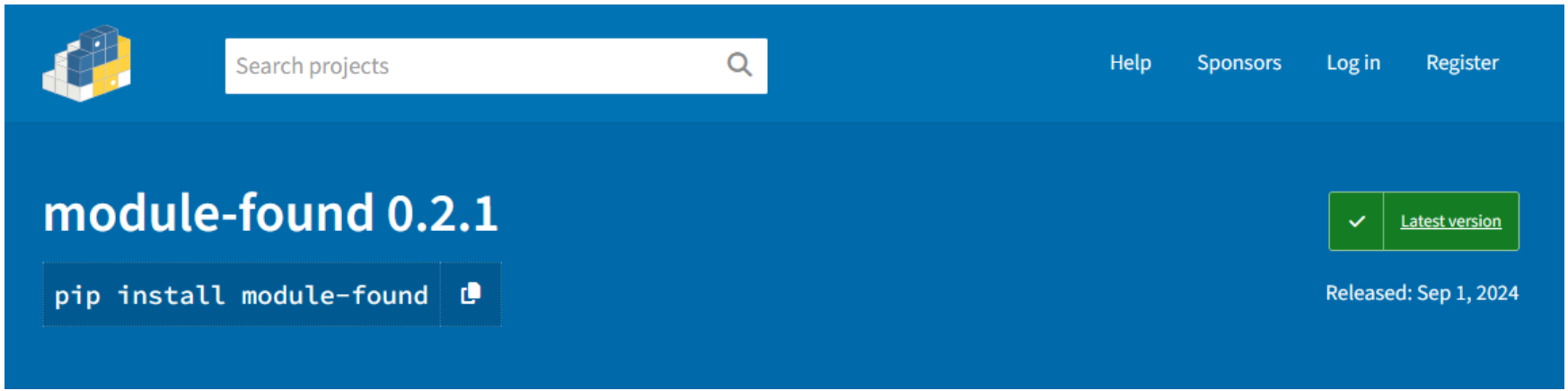
```

Module Found Demo

Seriously, DON’T try this at home… Like, ever!

Module Found on PyPI

Alright, here's how you do it at home...



https://pypi.org/project/module-found/

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But wait, there's more!

- Relative imports - PEP 328
- `sys.path_hooks` - to hook into the PathFinder code
- Lazy imports in Python 3.12 PEP-690