# PYTHON VS MODERN DEFENSES

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DEFCON30 – Adversary Village

# whoami

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# Python vs Modern Defenses

- Modern Defenses – Basic Concepts
- A Bypass Strategy
- Leveraging Python

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# MODERN DEFENSES

Basic concepts

# MODERN DEFENSES – Basic concepts

- EDR Visibility
- Memory Scanning
- ML-based detection
- IoC and IoA-based detection

# EDR VISIBILITY

To Detect and Respond you must first see what's happening on a system. EDRs get data from optics available on target OS and also employ proprietary techniques.

# EDR VISIBILITY

Two common ways of increasing visibility on Windows

- Using Kernel Callbacks to:
  - Inject EDR's dll into new processes
  - Getting process tree information
  - Getting image loading events

- Using Usermode Hooks to:
  - Inspect Windows API calls

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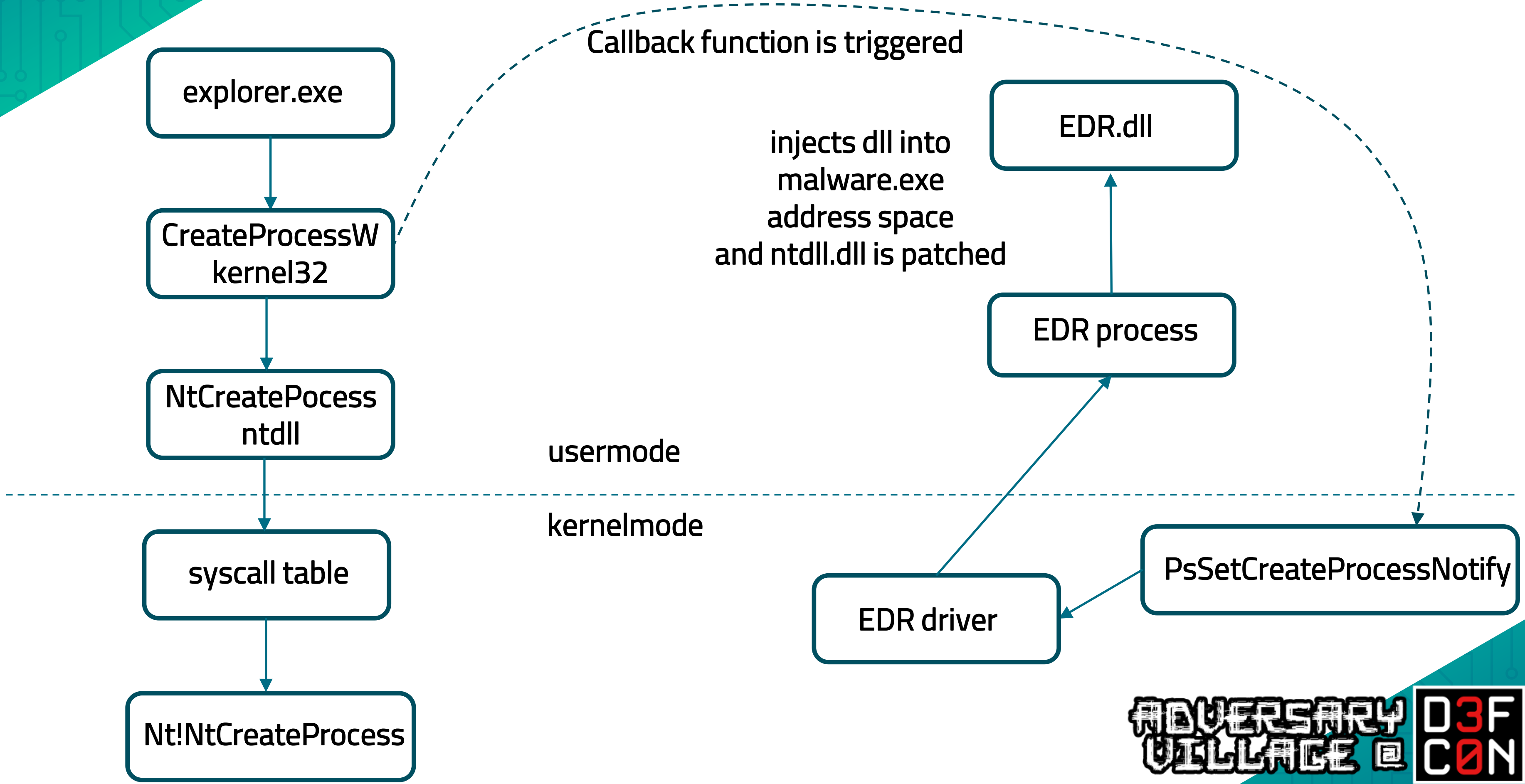
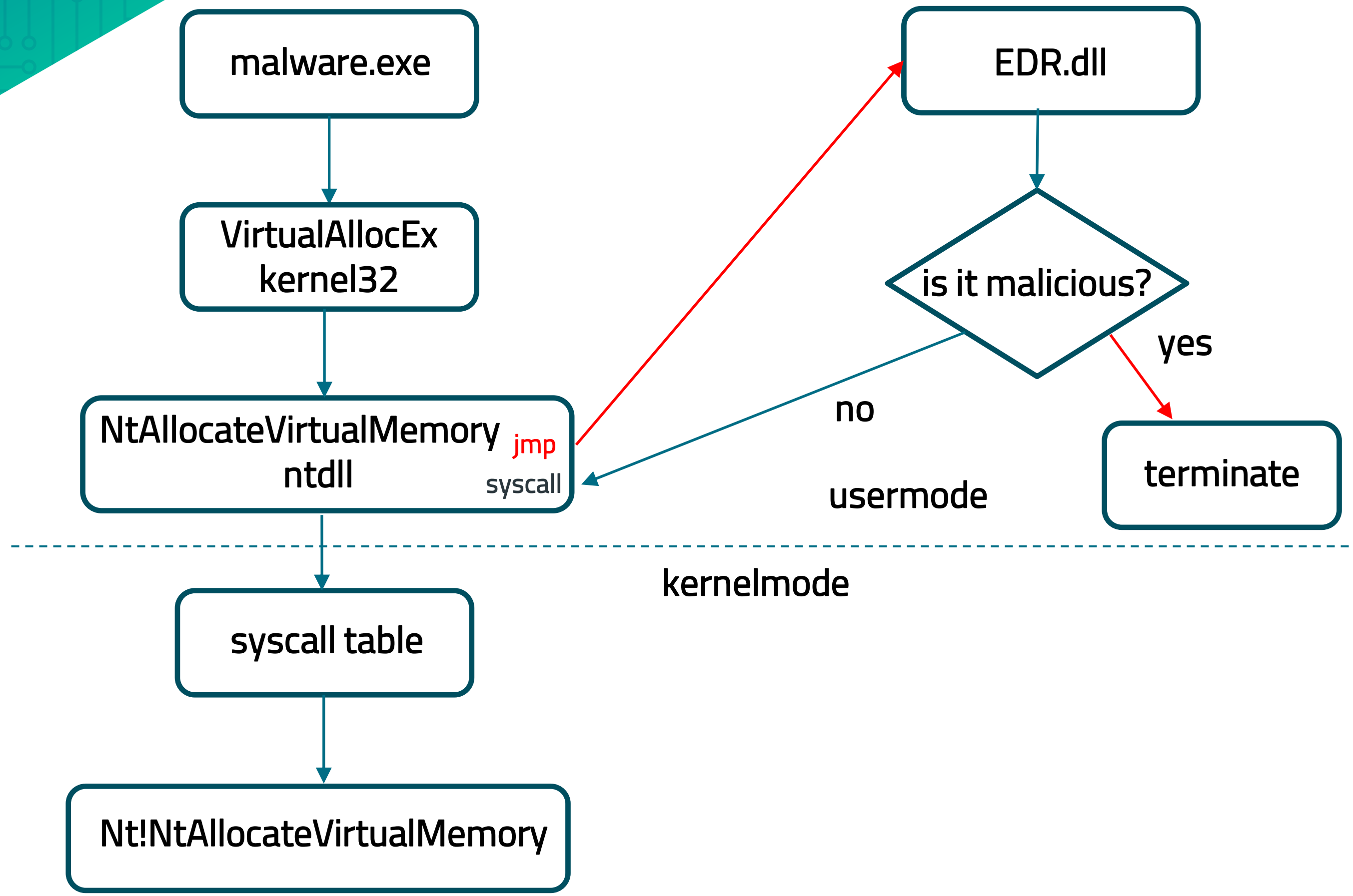
# EDR VISIBILITY – Kernel callbacks



# EDR VISIBILITY – Usermode Hooks

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# MEMORY SCANNING

In-memory scanning techniques look for patterns in the code and data of processes. Scanning is resource intensive and could be periodic or triggered by events/conditions/analysts.

# MEMORY SCANNING

- Inner workings of AV/EDR are undisclosed
- Examples of triggered scans:
  - Unusual process-tree
  - Suspicious binary (ML detection)
  - Unusual sequence of API-calls
  - Unusual access to files/process handles
  - Suspicious traffic (amount, type, reputation)

https://www.artstation.com/artwork/vBJx6

# MEMORY SCANNING

- Common malicious indicators detected by memory scanning:
  - Known-bad signature-based IoC
  - Reflectively loaded Dlls
  - Injected threads
  - RWX permissions
  - Inline/IAT/EAT hooking
  - modules with modified/unmatching PE header
  - implanted PE files (manually loaded, not corresponding to any legitimate module)
- Great tools: @hasherazade's PeSieve @forestorr's Moneta

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# ML-based Detection

Machine Learning can detect variant malware files that can evade signature-based detection. Malware possesses several "features" that can be used for training machine learning models.

Moon et al. - Compact feature hashing for machine learning based malware detection

# ML-based Detection

Essentially, the workflow we follow to build any machine learning-based detector, including a decision tree, boils down to these steps:

- Collect example of malware and benignware [...]
- Extract features from each training example to represent the example as an array of numbers[...]
- Train the ML system to recognize malware using the features we extracted
- Test the approach [...]

Malware Data Science: Attack Detection and Attribution (2018) - Joshua Saxe

# ML-based Detection

Some features used to determine wether a file is good or bad:

- Wether it's digitally signed
- The presence of malformed headers
- The presence of encrypted data
- Wether it has been seen on more than 100 network workstations

**Lots** of different features are used in ML detection

Malware Data Science: Attack Detection and Attribution (2018) - Joshua Saxe

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“ What if a binary commonly classified as benignware is used maliciously?

What if it’s also widely used for legit custom applications?

# IoC and IoA-based detection

An Indicator of Compromise (IoC) is digital evidence that a cyber incident has occurred. An Indicator of Attack (IOA) is digital or physical evidence that a cyberattack is likely to occur.

IoC is static, IoA is dynamic.

# IoC and IoA-based detection

IoC is retroactive


IoC provides forensic intelligence but can't help detect an attack attempt. Signatures also generates instances of false positives.

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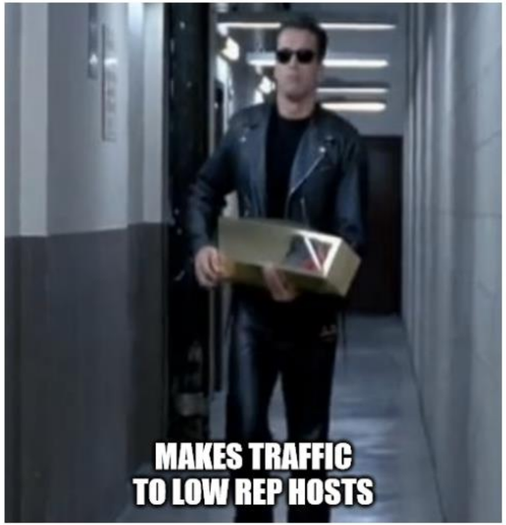
# IoC and IoA-based detection

IoA is proactive



IoA can detect a threat not characterized by static signatures.

Does not provide sufficient forensic intelligence.

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"What if an attacker is directly launching a widely used signed binary and operations are done natively from that process?

# 2

# A BYPASS STRATEGY

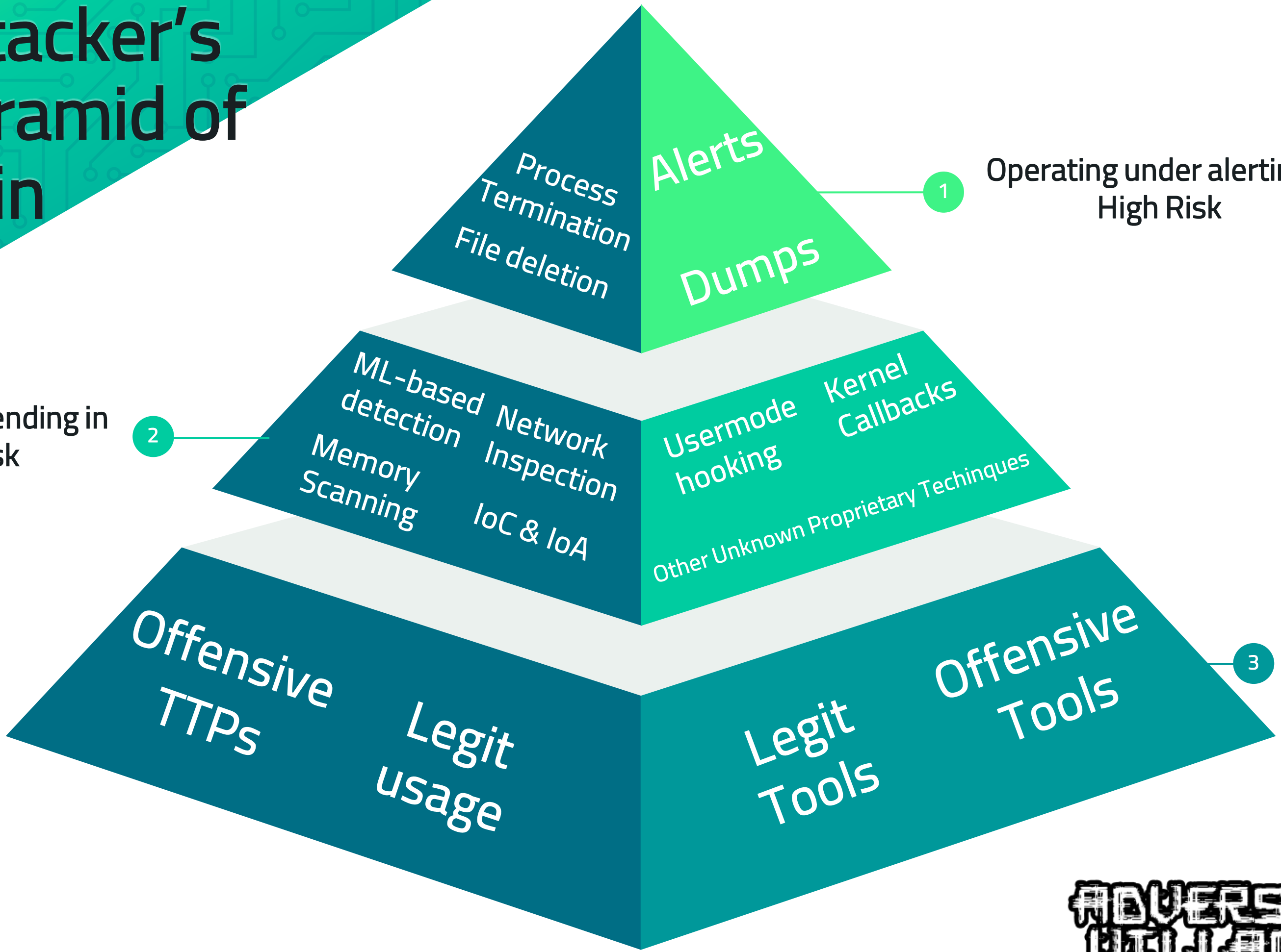
# A BYPASS STRATEGY

- Main Categories of EDR Evasion
- Constraints
- Strategy

# Main Categories of EDR evasion

- Avoiding the EDR
  - proxying traffic or pure avoidance
- Blending into the environment
- EDR tampering
- Operating in blind spots
  - Exploiting lack of visibility

# Attacker's Pyramid of Pain




1 Operating under alerting
High Risk

2 Operating by blending in
Medium Risk

3 Operating in blind spots
Low Risk

4 Operating avoiding EDRs
No risk

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# Constraints

- Operational Scenario/limitations:
  - Operations done from an EDR-equipped box
  - No remote process Injections
  - No dropping on disk custom/unknown artifacts
  - C2 agent execution is a last resort
- Desired capabilities:
  - Dynamic module loading
  - Compatibility with community-driven tools
  - Traffic tunneling without spawning new processes

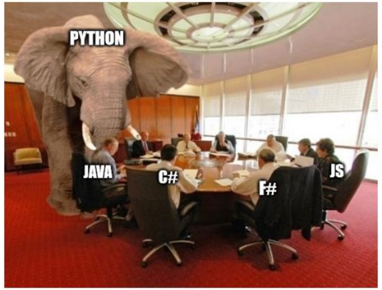
# Strategy

Choosing the language

- Operating in EDR's blind spots
  - Choose a set of common non-native languages
  - Exclude languages that can natively provide optics to EDRs.
  - embeddable packages are desirable
  - how much existing tooling can be reused?
  - Check if capabilities can be developed

# Strategy

## Choosing the language




- Python language has several benefits:
  - Python >3.7 comes with an «Embeddable zip package»
  - Signed interpreter
  - Limited visibility of python code execution for EDRs
  - Lots of offensive tooling available
  - The interpreter natively runs API calls AKA "lot of different telemetry coming from the same binary"

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# LEVERAGING PYTHON

# LEVERAGING PYTHON

https://github.com/naksyn/Pyramid

- Execution Method
- Dynamically Importing Python Modules
  - Bloodhound-python and impacket
- Using BOFs with Python
  - Dumping lsass with nanodump
- In-process tunneling
  - Listen, I really need to run an agent!

# Execution Method

- Dropping "Python Embeddable Package" and running python.exe (or pythonw.exe) directly.
  - less probability of triggering IoAs and IoCs – no uncommon process tree patterns.
  - less probability of triggering ML detection - signed files
  - No visibility for dynamic code execution for stock python.exe - ref. PEP-578 – Python Runtime Audit Hooks

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# Execution Method

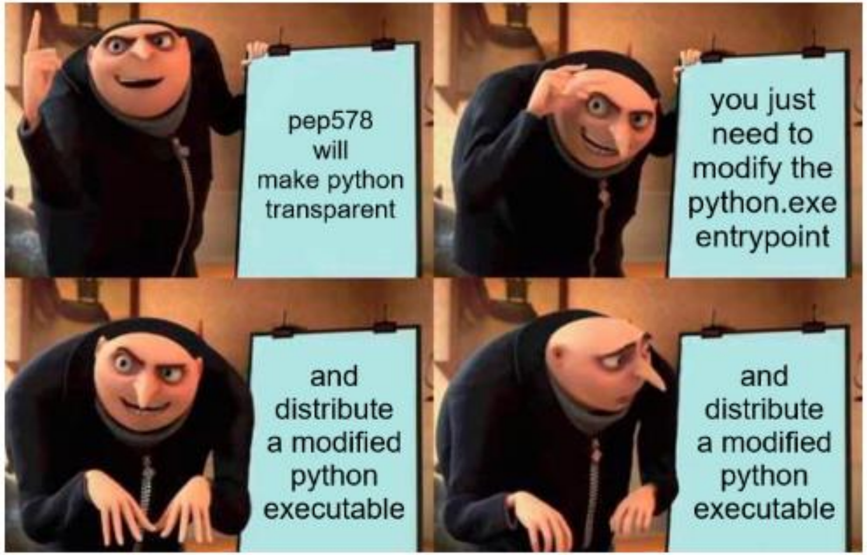
- Lack of visibility
- PEP-578 Runtime Audit Hooks – introduced to "solve" the limited context for Python code

| API Function | Event Name | Arguments | Rationale |
|---|---|---|---|
| `compile`, `exec`, `eval`, `PyAst_CompileString`, `PyAST_obj2mod` | `compile` | `(code, filename_or_none)` | Detect dynamic code compilation, where `code` could be a string or AST. Note that this will be called for regular imports of source code, including those that were opened with `open_code`. |
| `exec`, `eval`, `run_mod` | `exec` | `(code_object,)` | Detect dynamic execution of code objects. This only occurs for explicit calls, and is not raised for normal function invocation. |
| `import` | `import` | `(module, filename, sys.path, sys.meta_path, sys.path_hooks)` | Detect when modules are imported. This is raised before the module name is resolved to a file. All arguments other than the module name may be `None` if they are not used or available. |

# Execution Method

## Why no visibility?

- PEP-578 audit hooks are not enabled in stock python.exe
- deploying PEP-578 is complex



# Dynamically Importing Python Modules

- Been around for quite some time
- Amazing prior work done by **@scythe_io** (in-memory Embedding of CPython), **@xorrior** (Empyre), **@n1nj4sec** (pupy), **@ajpc500** (Medusa)
  - Each project has its own goals and design choices

# Dynamically Importing Python Modules

## PEP 302 – New Import Hooks

- import hooks allow you to modify the logic in which Python modules are located and how they are loaded.
- involves defining a custom "Finder" class and either adding finder objects to sys.meta_path
- sys.meta_path holds entries that implement Python's default import semantics

```
sound/                          Top-level package
      __init__.py               Initialize the sound package
      formats/                  Subpackage for file format conversions
              __init__.py
              wavread.py
              wavwrite.py
              aiffread.py
              aiffwrite.py
              auread.py
              auwrite.py
              ...
      effects/                  Subpackage for sound effects
              __init__.py
              echo.py
              surround.py
              reverse.py
```

# Dynamically Importing Python Modules

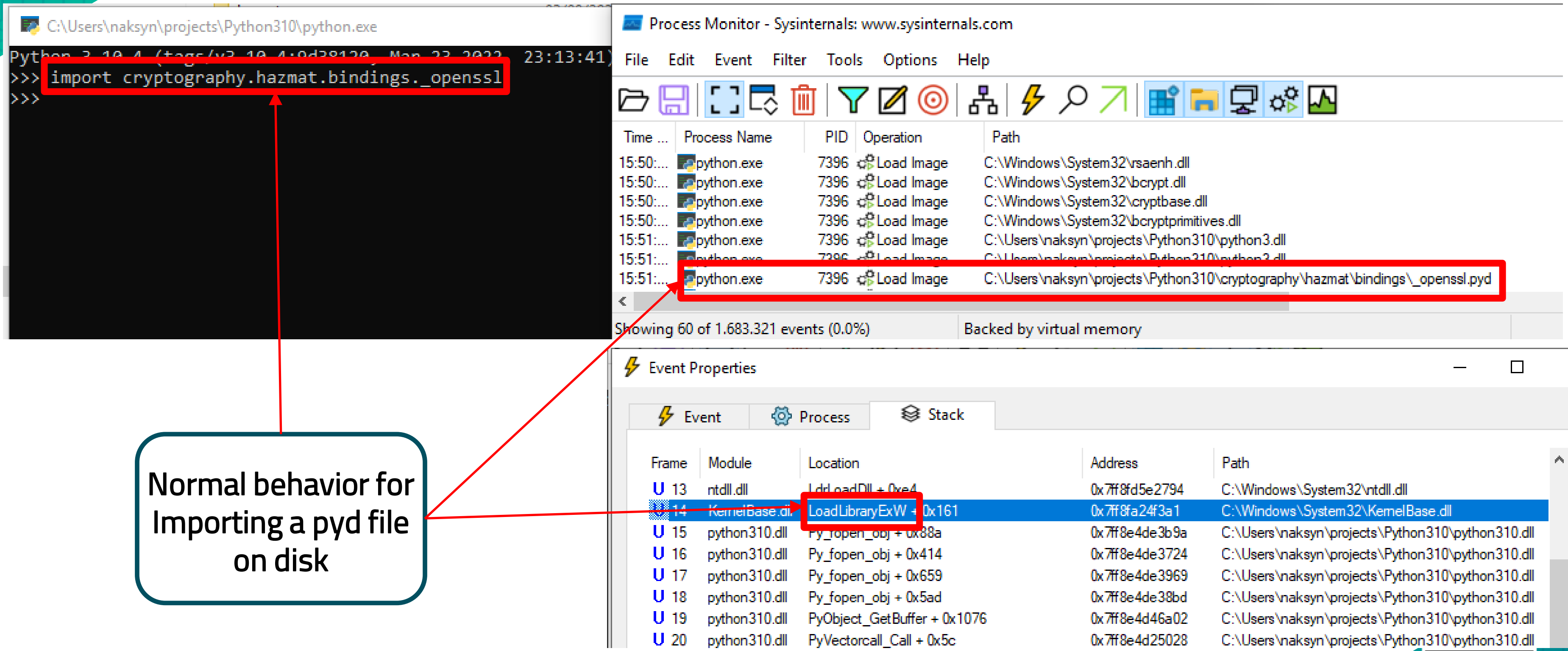
- Using Import Hooks we can:
  - Use a custom Finder class
  - In-memory download a Python package as a zip
  - Add the zip file finder object to sys.meta_path
  - Import the zip file in memory

- Problems:
  - Python module dependencies nightmare
  - In-memory Dynamic loading of *.pyd extensions is not natively supported

# Dynamically Importing Python Modules

- Dynamic Loading used in Pyramid:
  - Based on @xorrior Empyre Finder class
  - uses fixed packages dependencies to in-memory import impacket, bloodhound-python and paramiko

# Dynamically Importing Python Modules



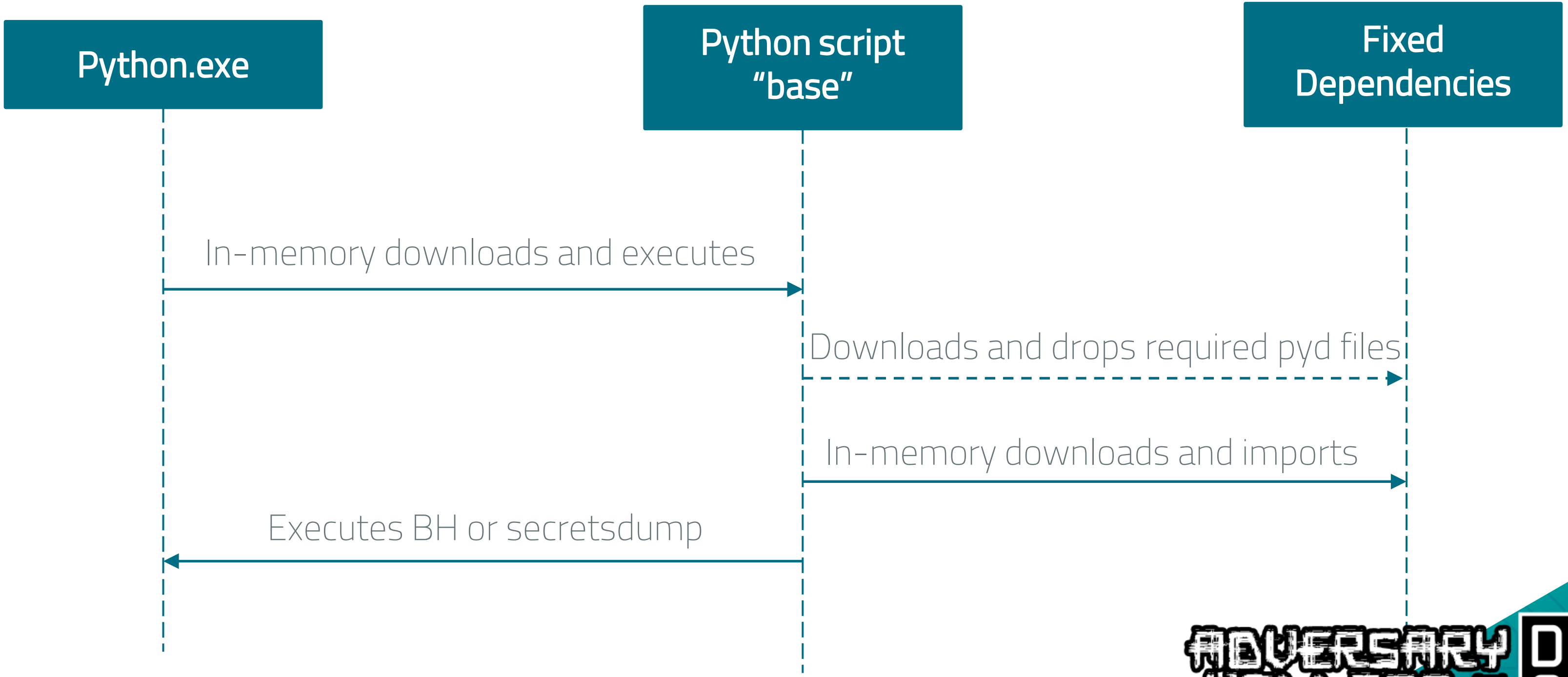

Normal behavior for Importing a pyd file on disk

# Dynamically Importing Python Modules

- How the problems were solved in Pyramid:
  - Python module dependencies nightmare : solved by providing fixed dependencies packages
  - *.pyd In-memory loading would require re-engineering the CPython interpreter losing its digital signature. An acceptable solution – per our scenario – would be dropping on-disk the official Pypy Wheels containing the needed pyd files and maintain normal loading behaviour.

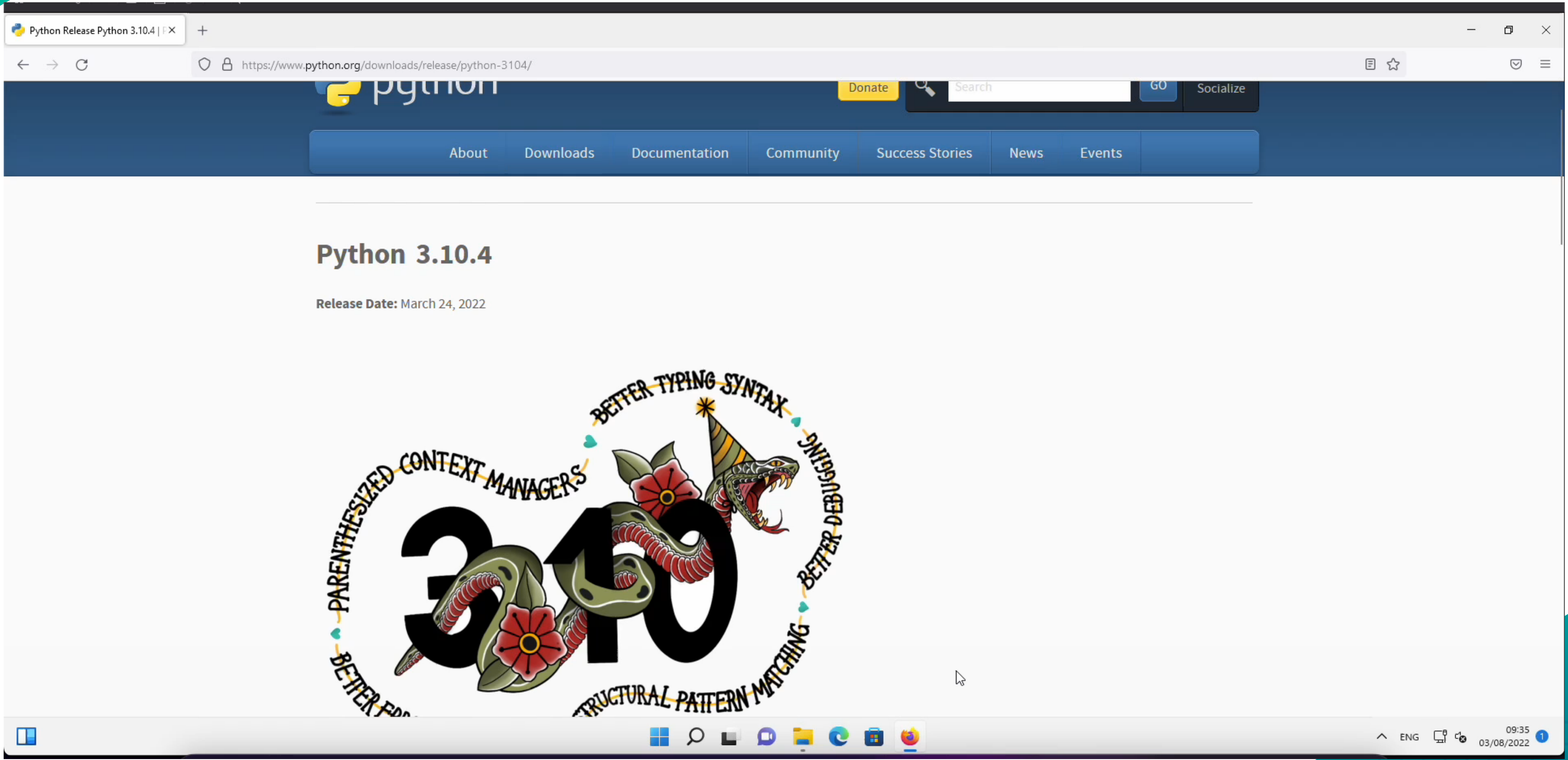
# Demo

## Dynamically importing and executing BloodHound-Python



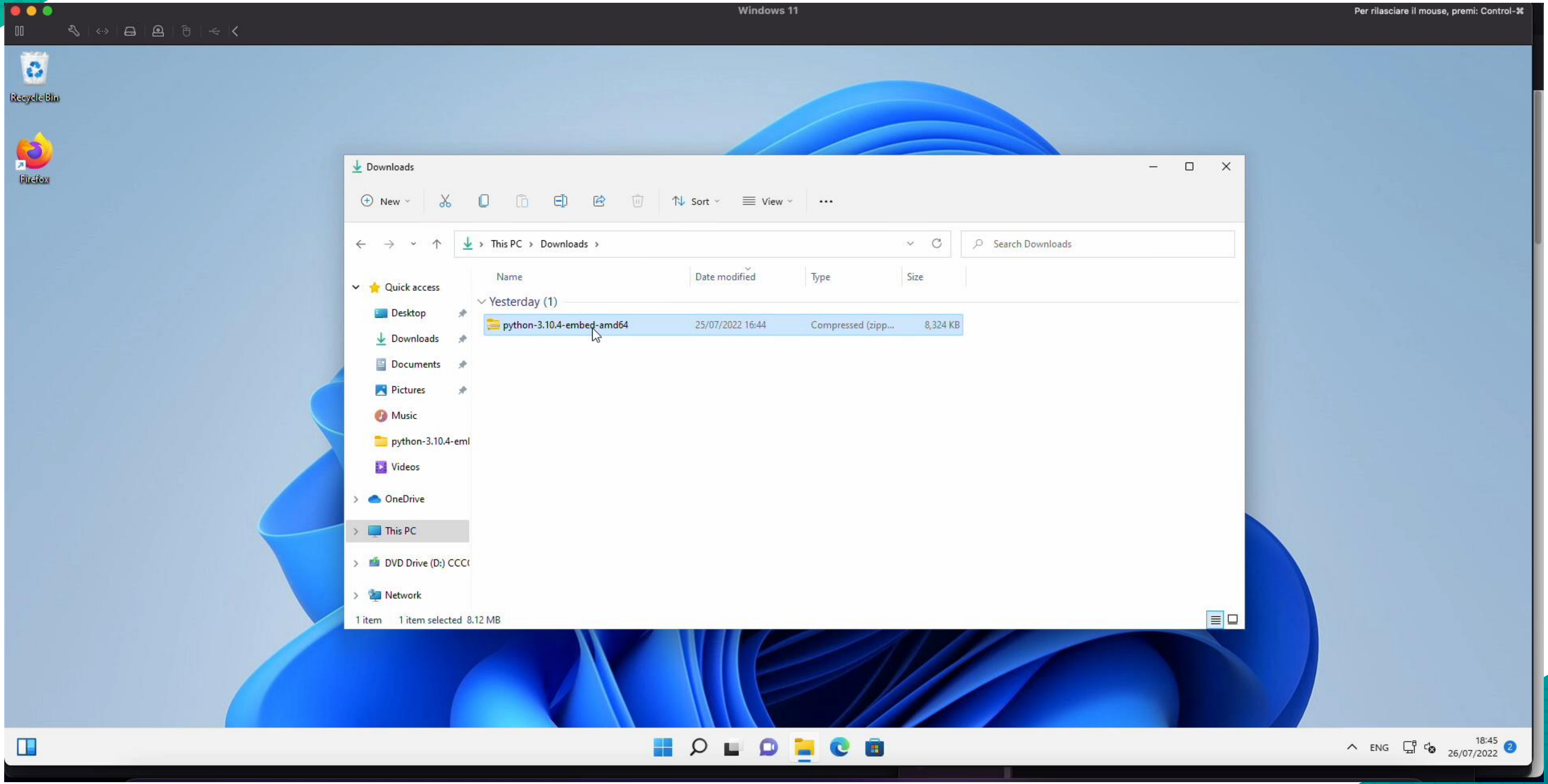
# Demo

Dynamically importing and executing BloodHound-Python

# Demo

Dynamically importing and executing Impacket secretsdump

# Using Beacon Object Files with Python

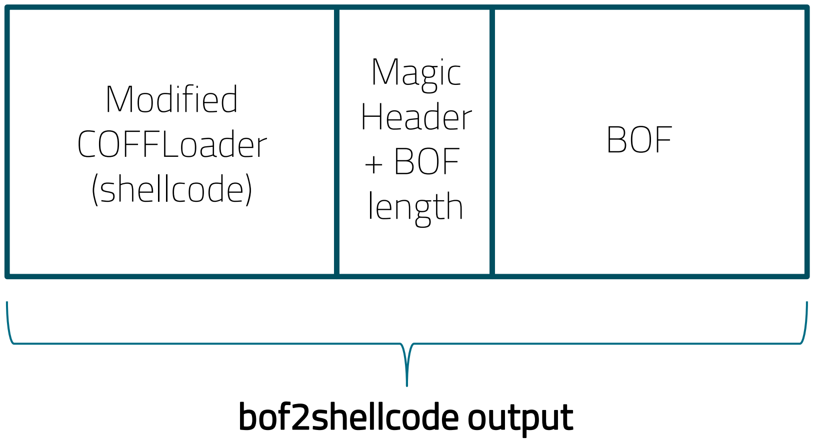
- BOFs are a way to rapidly extend the Cobalt Strike's Beacon agent with new post-exploitation features by executing a compiled C program withing the Beacon process.
- Lot of amazing community-driven BOFs are available
- Achieving a way to execute BOFs with one's own technique or C2 is a great way to augment capabilities.

# Using Beacon Object Files with Python

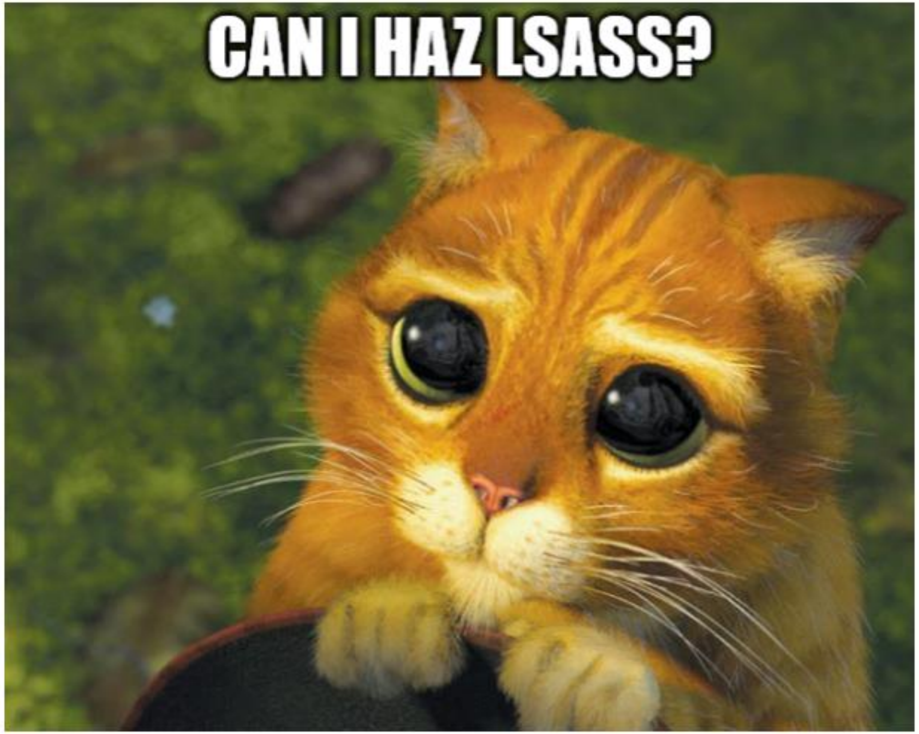
- Feature implemented in Pyramid tool:
  - leverages **@trustedsec** COFFloader and **@falconforce** bof2shellcode
  - Complex BOFs such as nanodump should be modified to be compatible
  - COFF loader is converted to shellcode and BOF is appended
  - resulting shellcode can be dynamically injected with Python into python.exe achieving in-process BOF execution.

# Using Beacon Object Files with Python

- COFFloader (shellcode) looks for the BOF in memory via the magic header and 4-byte integer length.
- BOF is then fed to COFFLoader
- command line arguments are parsed (can be unstable)




# Using Beacon Object Files with Python

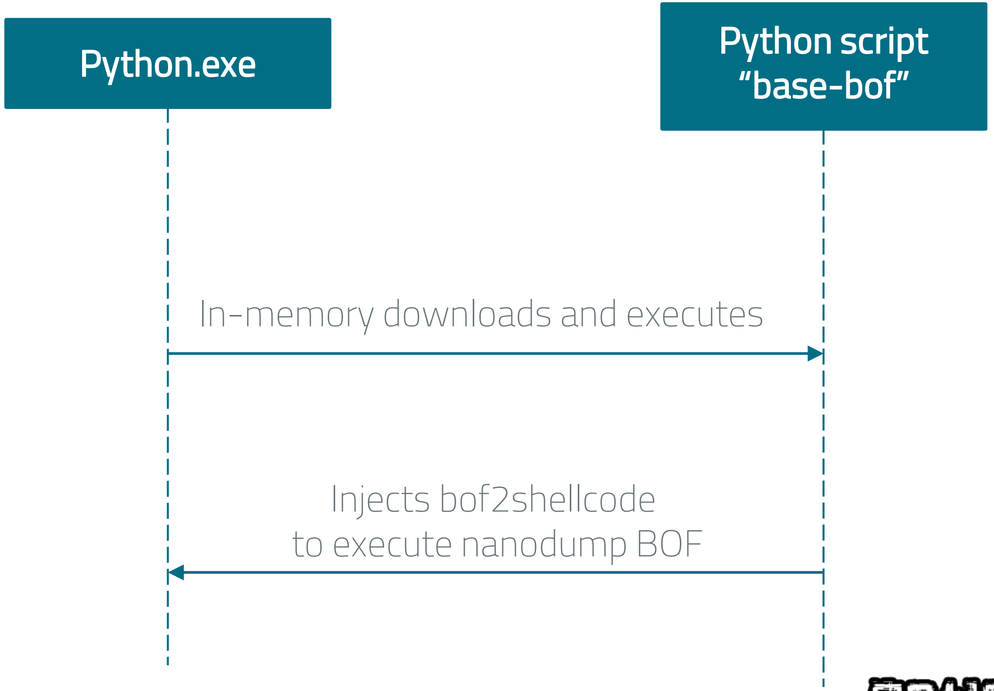


# Using Beacon Object Files with Python

- We can dump lsass using @helpsystems nanodump but we need to modify the BOF by:
  - Stripping internal Beacon API calls
  - Hardcoding command line parameters to increase stability
  - Stripping cmd line parsing functions
- Compile the BOF, then use bof2shellcode
- Inject the shellcode blob into python.exe natively using Python

# Demo

Injecting shellcode within python.exe to achieve BOF execution and dumping lsass Using process forking

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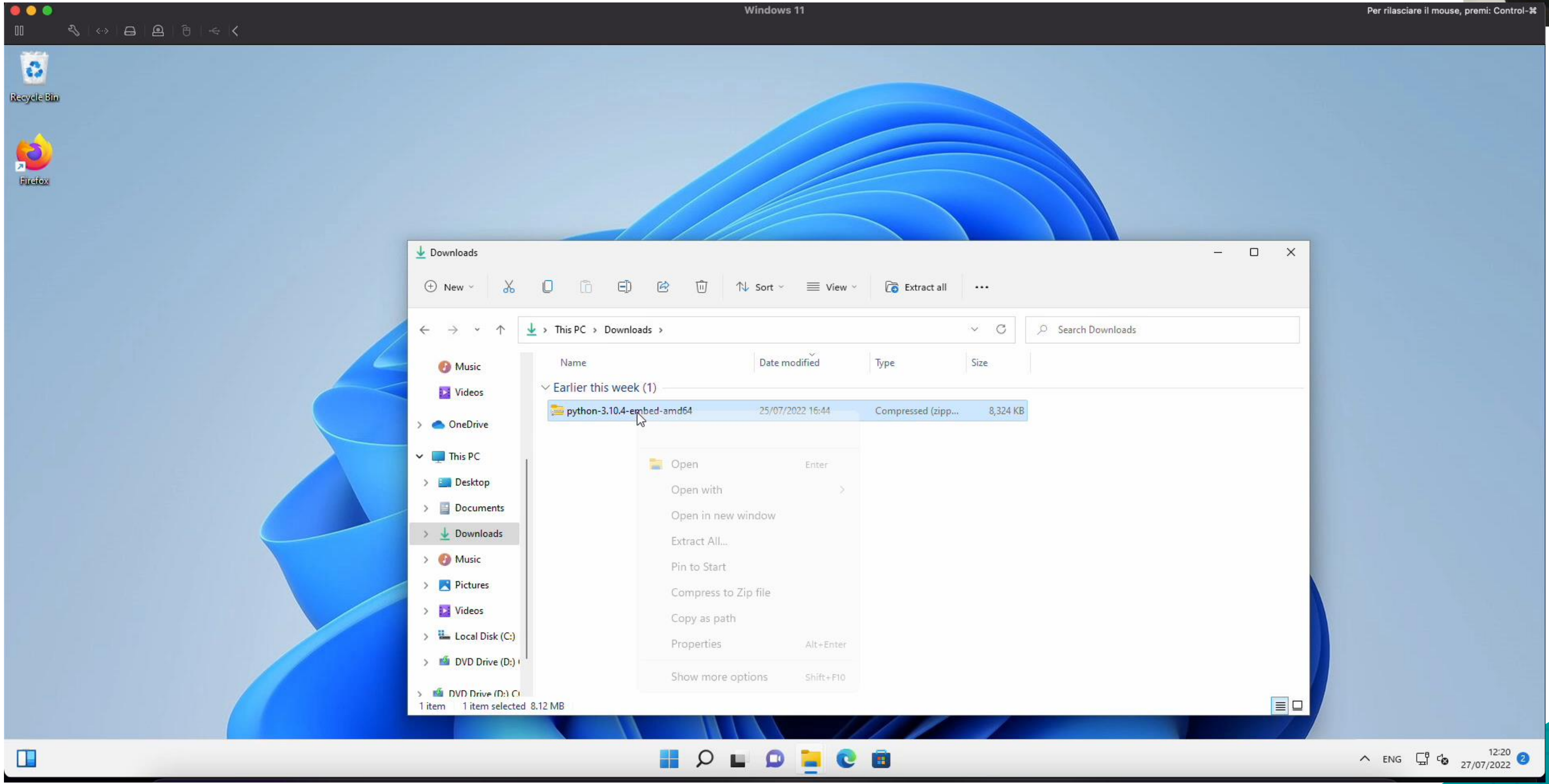
# Demo

Injecting shellcode within python.exe to achieve BOF execution and dumping lsass Using process forking

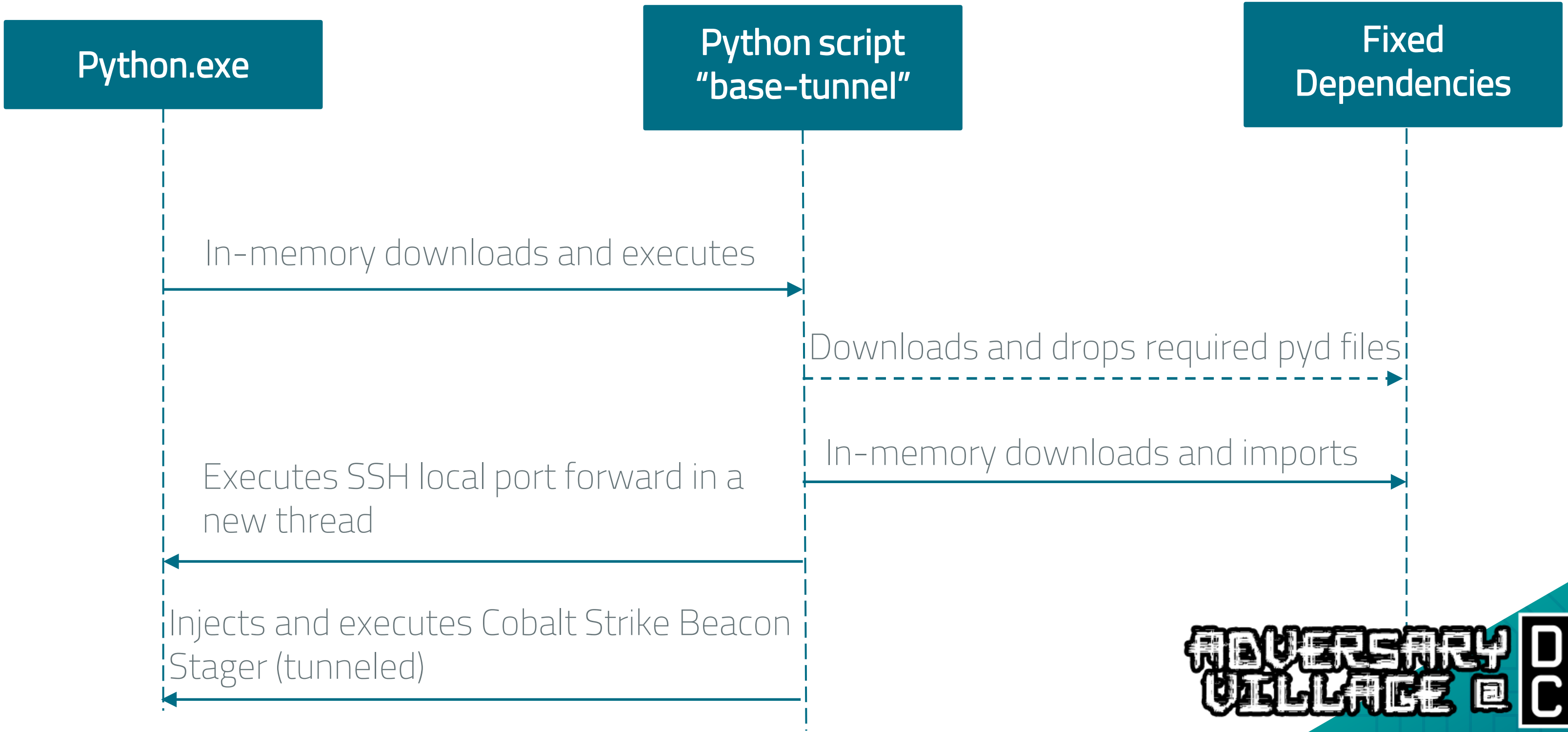



# In-process agent tunneling

- Agent tunneling can be useful to:
  - Decouple agent communications with real C2
  - Blend-in with SSH instead of HTTP/S or DNS
  - Exploit the signed python.exe context to mask C2
  - Create reusable agent payloads with 127.0.0.1 as C2 host
  - Make C2 server not easily reachable from the internet
- Mind your OPSEC
  - SSH credentials are stored in python.exe memory – use at least burnable-temporary creds and whitelist IPs on SSH server

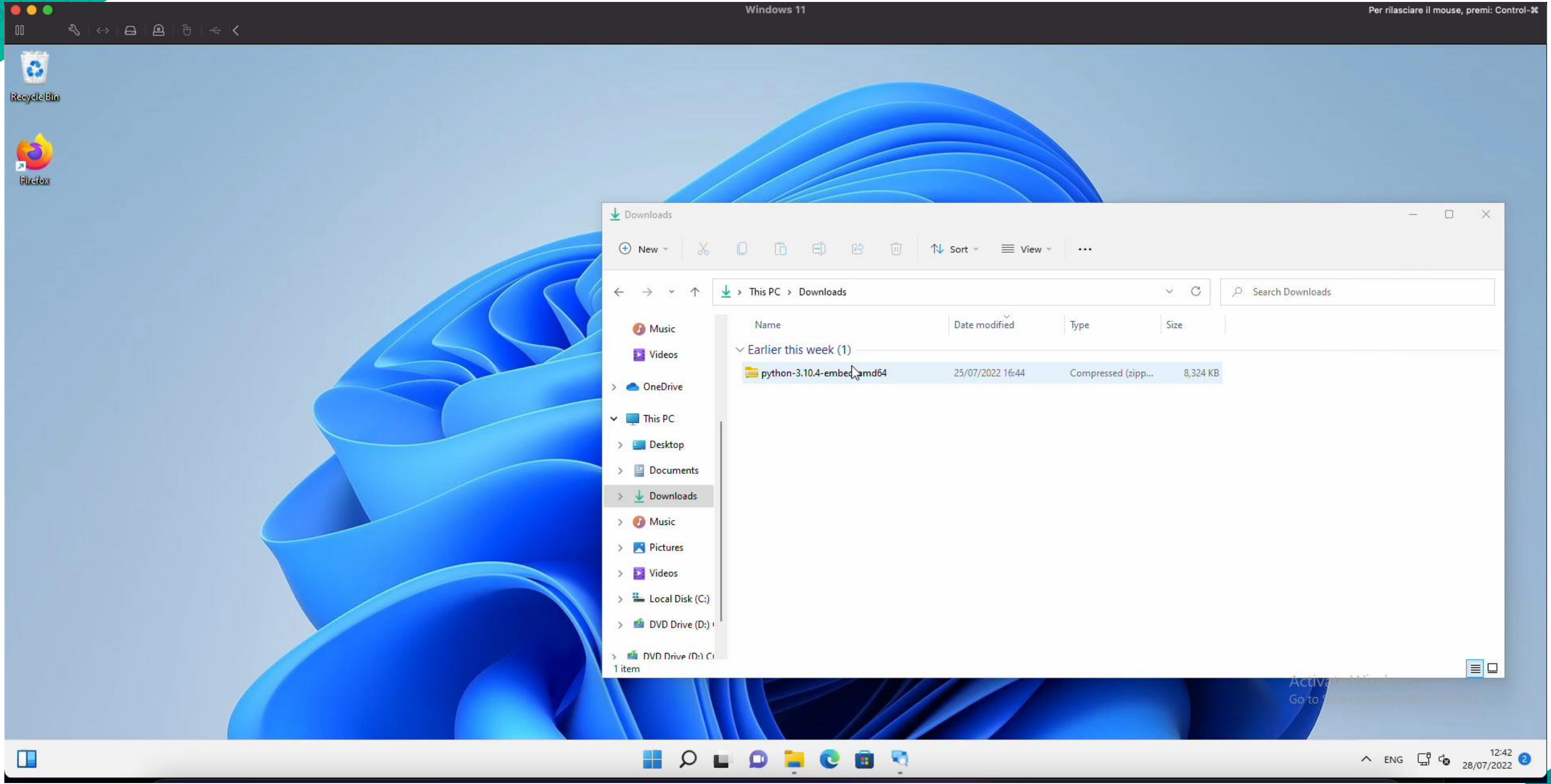
# Demo

In-process tunneling a Cobalt Strike Beacon with Python



# Demo

In-process tunneling a Cobalt Strike Beacon with Python




# Conclusions

- The main takeaways for the talk are:
  - You can use Python Language to dynamically execute Python tools without falling into EDR visibility.
  - Python Embeddable package provide an "attack avenue" with a signed context under which an attacker can operate.
  - Python interpreter has a huge "telemetry fingerprint" so it can be difficult for EDRs to spot anomalies coming from it.
  - You can execute BOFs, dynamic code and in-process tunneling from within python.exe increasing the chances of not being detected.

# THANKS!

## Any questions?

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# References


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