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FINEST HACKING

PIC Your Malware!

Whoami

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Syllabus

- Concepts for fileless malware
  - Artifacts popular in memory PE loaders leave (Reflective DLL, Donut)
- Leveraging position independent code (PIC) to avoid these artifacts

- Tool release: Lsass dumping without ProcessAccess event (as PIC)

- Solving some tedious problems of creating PIC
- Protecting tools with self-decrypting PIC
- Pipelining the build process

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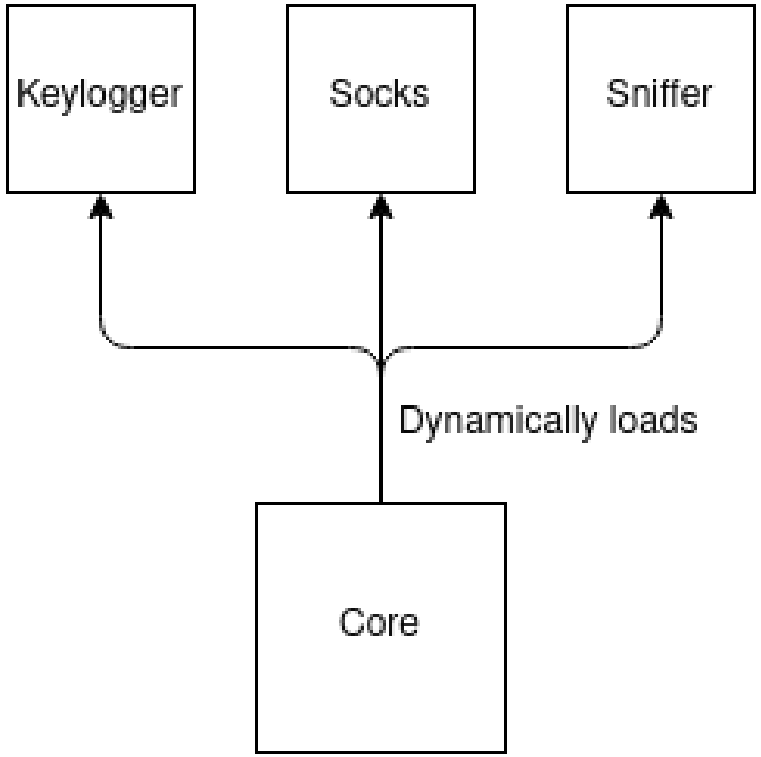
Fileless Malware and Memory Artifacts

Motivation for Fileless Malware

- Development of malware is a complex software project
- If analysts ever find your malware, all hard work is burned
- Therefore, sophisticated malware has a ‘Plug and Play’ concept for most of its capabilities
  - Malware consists of a main module. Capabilities are then loaded on the fly
  - If one module is flagged it is easy to replace / only one module needs to be adapted

Motivation for Fileless Malware



Plug and Play

- Back in the days, an extension was dropped as a DLL and loaded from disk
  - Problem 1: AV heuristics / automatic analysis of dropped files
  - Problem 2: Files left on the filesystem will be forgotten by operators
- Malware authors started looking for ways to load extensions without ever touching disk

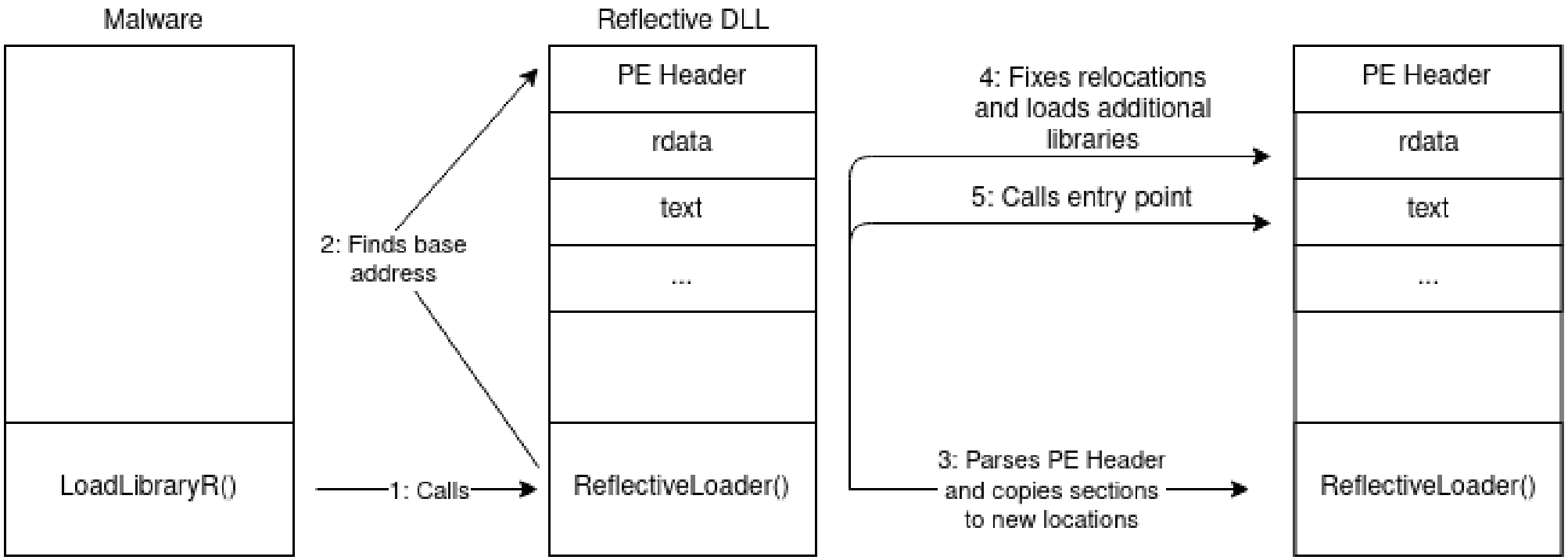
Fileless Malware

- Monitoring of memory operations is prone to false positives and also resource intense.
  - DRM uses similar concepts for legitimate use
- Many concepts for fileless malware: {Reflective DLL, sRDI/Donut, in memory .NET}
  - All of them have their drawbacks which enable analysts and security products to find them

Reflective DLL

- Self loading DLL
  - First implemented by Stephen Fewer in 2011
- Regular DLL with one special export: ReflectiveLoader
  - Implements a PE loader: takes care of fixing IAT, Relocations and so on
  - Loader itself is fully position independent (PIC)
- Malware needs to be able to find the ReflectiveLoader in memory
  - Requires additional code

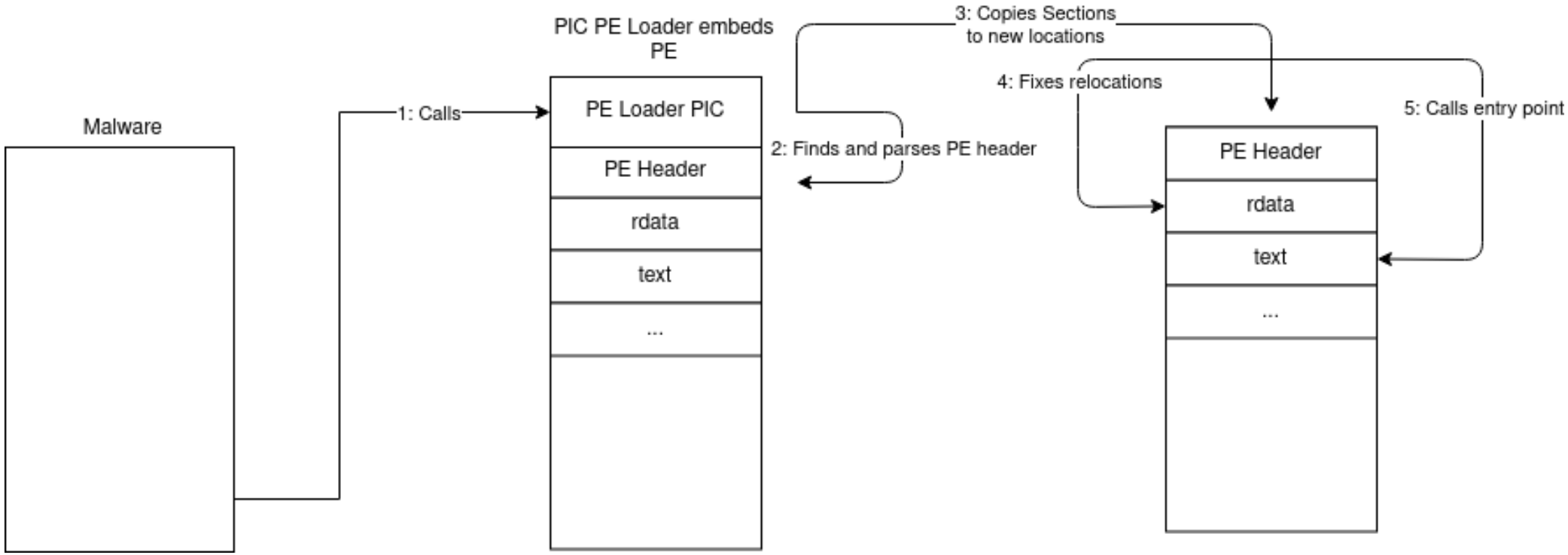
Recap Reflective DLL



PE2Shellcode

- Implementation of a PE Loader as pure PIC
  - PIC embeds a given a PE file which it loads and executes
  - No PE loader or LoadLibraryR has to be compiled into malware
- PE are not actually converted they are just wrapped with a PIC PE loader
- PE loader finds the embedded PE file and loads it in memory
- PE – To – Shellcode - Concept
- Example open source implementations:
  - https://github.com/hasherezade/pe_to_shellcode
  - https://github.com/TheWover/donut
  - https://github.com/monoxgas/sRDI

PIC PE Loader

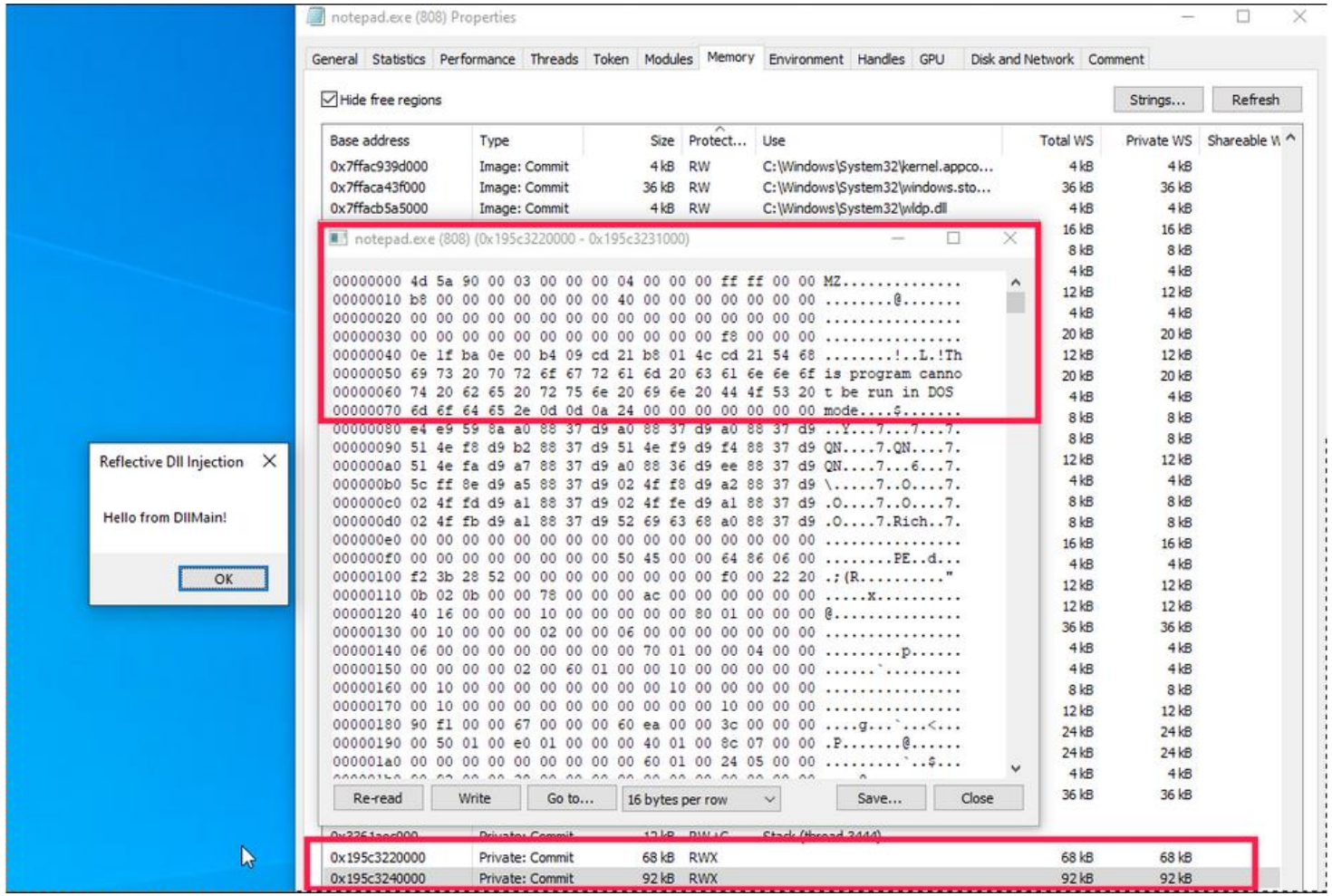


Suspicious Memory Artifacts

- PE loaders need to allocate more memory to load the PE file
  - Some sections need to be executable (.text segment)
- Suspicious Memory Pages such as R(W)X
- Private Committed and Executable Memory
  - VirtualAlloc
  - Not backed by a file on disk
  - R(W)X pages should only exist as part of a PE file
- PE Header in private committed memory

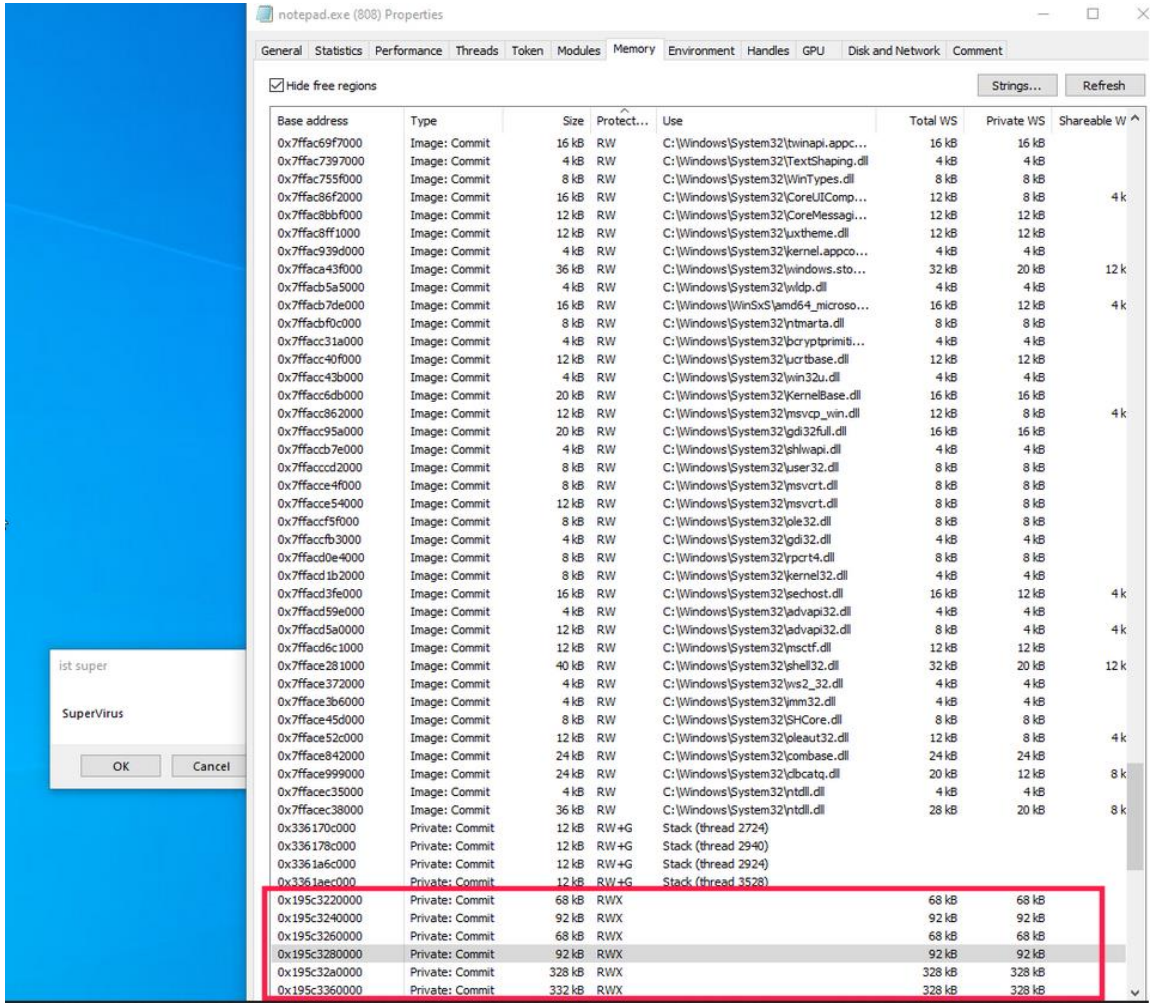
Artifacts Reflective DLL

- PE Header in private committed memory
- Executable and private committed pages



Memory Artifacts Donut

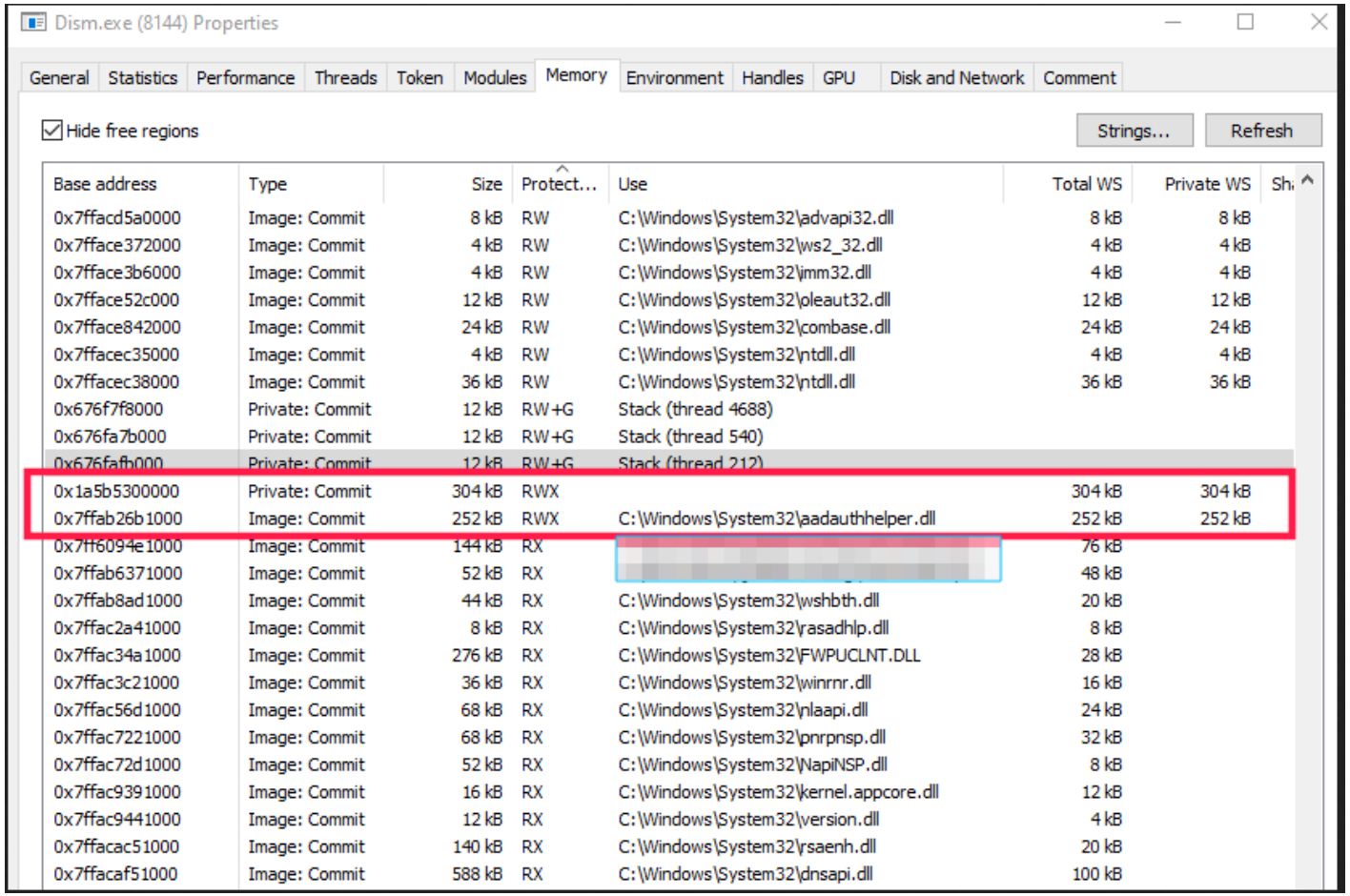
- Executable and private committed memory
- Donut can wipe the PE header from memory
  - Header is in memory during loading
  - Rest of PE structure is still in memory. PESieve can find it [1]



[1] https://github.com/hasherezade/pe-sieve

Artifacts with File Backed Memory

- Try to first copy the PIC to file backed memory
- Donut / RDLL does not stay where it was first copied to
- Breaks concepts, like Phantom DLL Hollowing [1] (Forrest orr)



Base address	Type	Size	Protect...	Use	Total WS	Private WS
0x7ffacd5a0000	Image: Commit	8 kB	RW	C:\Windows\System32\advapi32.dll	8 kB	8 kB
0x7fface372000	Image: Commit	4 kB	RW	C:\Windows\System32\ws2_32.dll	4 kB	4 kB
0x7fface3b6000	Image: Commit	4 kB	RW	C:\Windows\System32\imm32.dll	4 kB	4 kB
0x7fface52c000	Image: Commit	12 kB	RW	C:\Windows\System32\oleaut32.dll	12 kB	12 kB
0x7fface842000	Image: Commit	24 kB	RW	C:\Windows\System32\combase.dll	24 kB	24 kB
0x7ffacec35000	Image: Commit	4 kB	RW	C:\Windows\System32\ntdll.dll	4 kB	4 kB
0x7ffacec38000	Image: Commit	36 kB	RW	C:\Windows\System32\ntdll.dll	36 kB	36 kB
0x676f7f8000	Private: Commit	12 kB	RW+G	Stack (thread 4688)		
0x676fa7b000	Private: Commit	12 kB	RW+G	Stack (thread 540)		
0x676fafb000	Private: Commit	12 kB	RW+G	Stack (thread 212)		
0x1a5b5300000	Private: Commit	304 kB	RWX		304 kB	304 kB
0x7ffab26b1000	Image: Commit	252 kB	RWX	C:\Windows\System32\aadauthhelper.dll	252 kB	252 kB
0x7ff6094e1000	Image: Commit	144 kB	RX		76 kB	
0x7ffab6371000	Image: Commit	52 kB	RX		48 kB	
0x7ffab8ad1000	Image: Commit	44 kB	RX	C:\Windows\System32\wshbth.dll	20 kB	
0x7ffac2a41000	Image: Commit	8 kB	RX	C:\Windows\System32\rasadhlp.dll	8 kB	
0x7ffac34a1000	Image: Commit	276 kB	RX	C:\Windows\System32\FWPUCLNT.DLL	28 kB	
0x7ffac3c21000	Image: Commit	36 kB	RX	C:\Windows\System32\winrnr.dll	16 kB	
0x7ffac56d1000	Image: Commit	68 kB	RX	C:\Windows\System32\nlaapi.dll	24 kB	
0x7ffac7221000	Image: Commit	68 kB	RX	C:\Windows\System32\pnrpnsp.dll	32 kB	
0x7ffac72d1000	Image: Commit	52 kB	RX	C:\Windows\System32\NapiNSP.dll	8 kB	
0x7ffac9391000	Image: Commit	16 kB	RX	C:\Windows\System32\kernel.appcore.dll	12 kB	
0x7ffac9441000	Image: Commit	12 kB	RX	C:\Windows\System32\version.dll	4 kB	
0x7ffacac51000	Image: Commit	140 kB	RX	C:\Windows\System32\rsaenh.dll	20 kB	
0x7ffacaf51000	Image: Commit	588 kB	RX	C:\Windows\System32\dnsapi.dll	100 kB	

[1] https://www.forrest-orr.net/post/malicious-memory-artifacts-part-i-dll-hollowing

Weakness of RDLL / Donut

- In memory PE loaders leave memory artifacts
- Some artifacts can be removed after loading
  - During loading, automated products have a timeframe to work with
- In memory execution of .NET would mean constantly fighting AMSI

- If the whole tool was PIC, there would never be a PE to load …

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PIC Your Malware!

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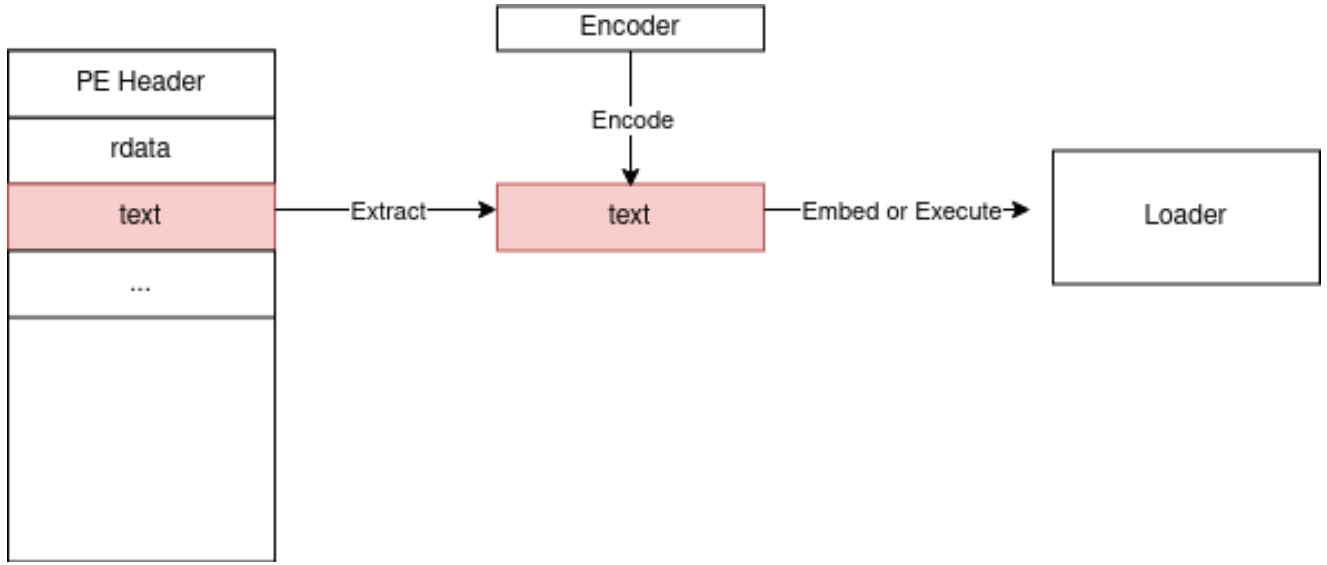
- C code can be compiled to PE files living fully in its .text segment [1]
- **Extracting the .text segment means obtaining PIC**
  - **No need to load it, just place it in memory and jump to it**
- Conditions
  - No relocations
  - No other segments in use than .text
  - Uses string stacking and avoids global / static variables
  - Must be able to parse Dlls for function pointers

- [1] https://vxug.fakedoma.in/papers/VXUG/Exclusive/FromaCprojectthroughassemblytoshellcodeHasherezade.pdf

Position Independent Code

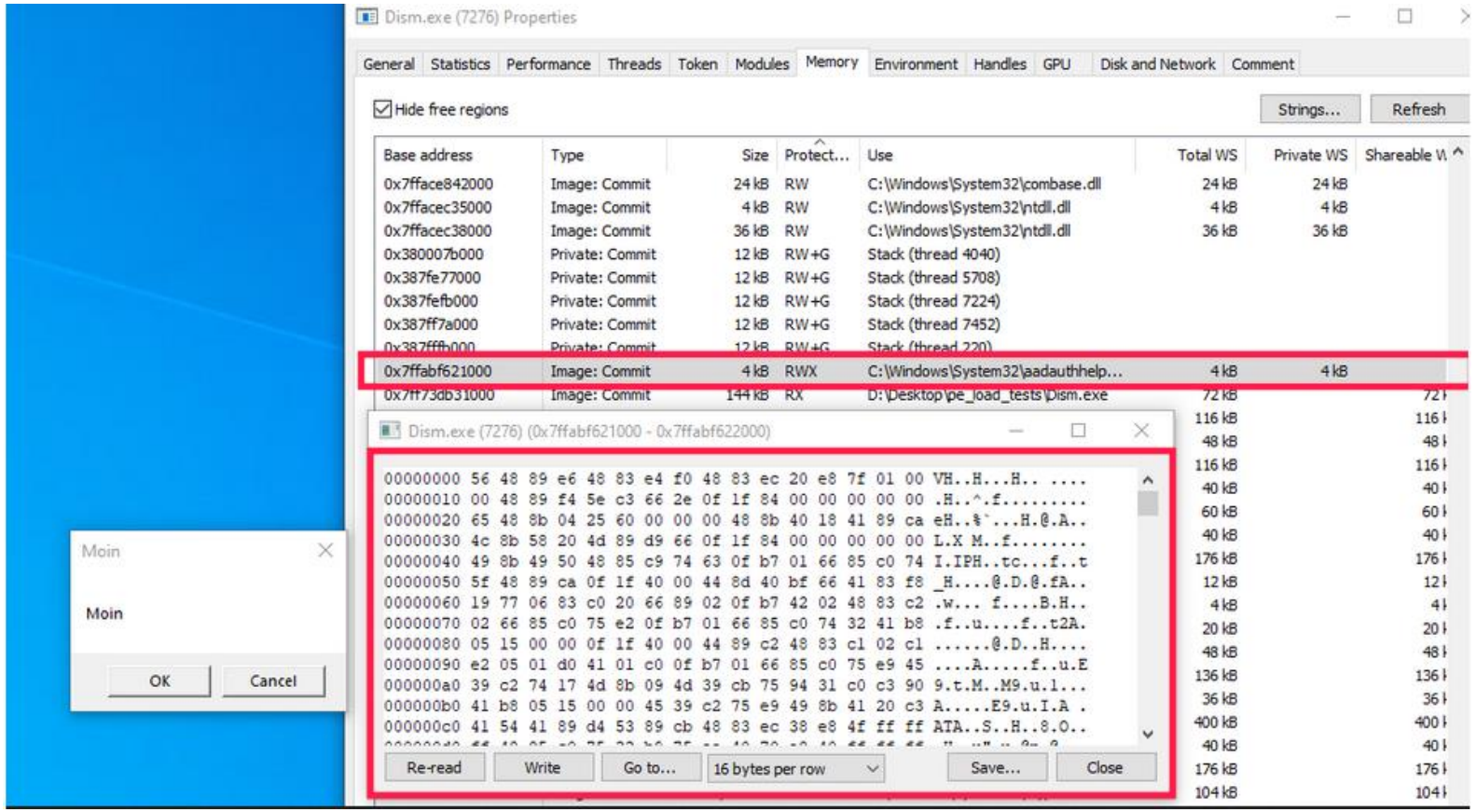


Position Independent Code

- The .text segment of such a program is fully position independent
- Stays where it is copied to
- Can be executed like classic shellcode
  - Needs a host process
- Bonus: can be encoded with any shellcode encoder to break signatures!
  - As long as no parameters are passed and you expect the shellcode to return properly

PIC in File Backed Memory

- PIC stays where it is copied to
- No PE loading necessary
- No new memory allocated
- No additional private committed pages
- No PE header



Nothing is Fully Undetectable

- Also not in memory
- PIC helps reducing memory artifact fingerprint
- Abnormal allocation of file backed memory itself can still be fingerprinted [1]
  - Prone to false positives
- Analysts will still catch malicious behavior of processes

- Let us try to avoid suspicious Sysmon events using PIC!

[1] https://www.forrest-orr.net/post/masking-malicious-memory-artifacts-part-ii-insights-from-moneta

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PIC Lsass Dumper

Lsass Dumper as PIC

- If a process opens Lsass with PROCESS_ALL_ACCESS or PROCESS_VM_READ | PROCESS_QUERY_INFORMATION it is most likely going to dump Lsass
- ProcessAccess event every time a process uses OpenProcess()
- Defenders definitely monitor this event related to Lsass
- What if we never open Lsass?

Avoiding ProcessAccess

- Some benign processes already have a handle to Lsass (HandleHolder)
- PROCESS_QUERY_INFORMATION | PROCESS_DUP_HANDLE
- Clone the existing handle using NtDuplicateObject
- Handle can then be used in a malicious context
- Sysmon only throws ProcessAccess on HandleHolder
- Lsass usually has a handle to itself
  - Open Lsass with access mask not revealing your true intention

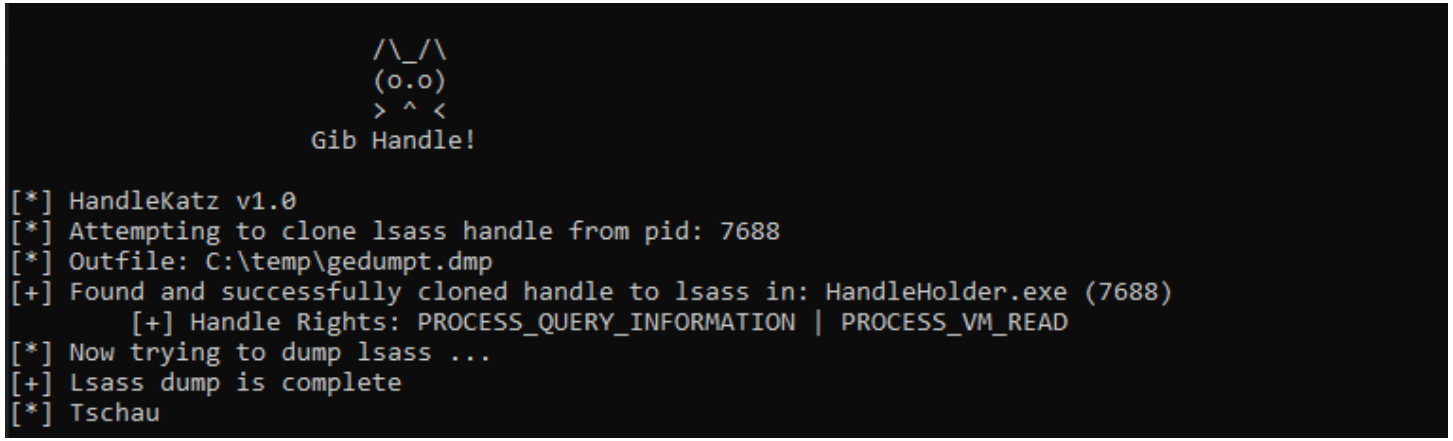
Avoiding ProcessAccess

- MiniDumpWriteDump from DbgHelp internally opens multiple new handles
- *@Rookuu__* [1] demonstrated the usage of ReactOS MiniDumpWriteDump to dump
- However, also this function opens some new handles.
  - Replace EnumerateLoadedModulesW64()
- Using ReactOS MiniDumpWriteDump + ReactOS EnumerateLoadedModulesW64() to dump Lsass using a cloned handle does not appear in Sysmon

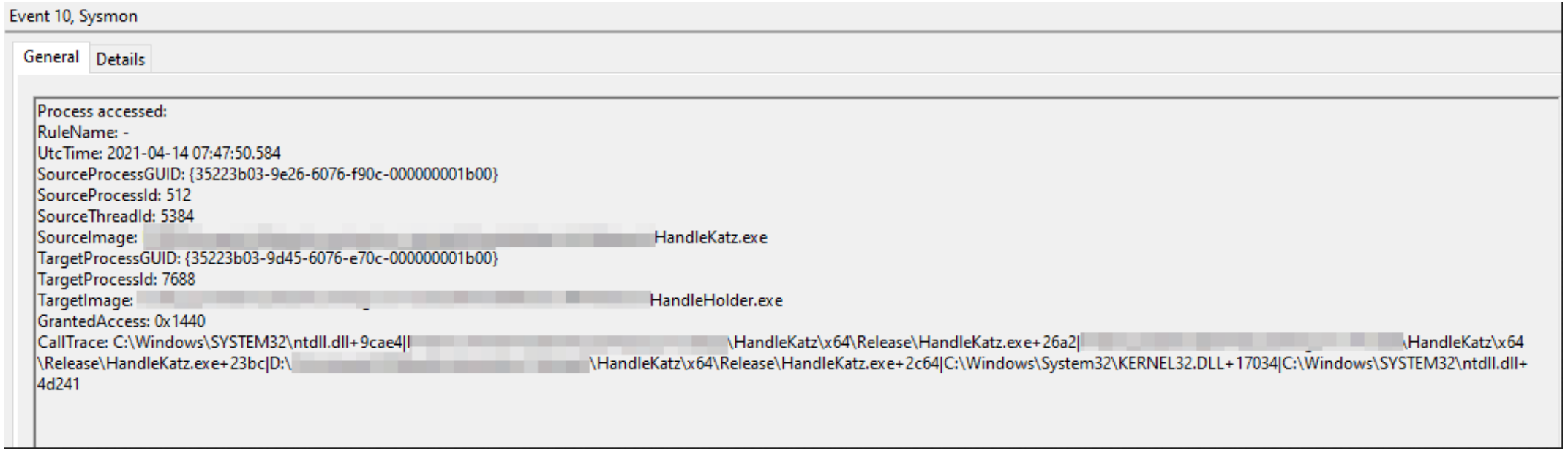
[1] https://github.com/rookuu/BOFs/tree/main/MiniDumpWriteDump

Introducing HandleKatz

- HandleKatz enumerates processes for a suitable handle to dump Lsass
- Clones handle and uses ReactOS Code (MiniDumpWriteDump + EnumerateLoadedModules) to dump the process without opening any new handle to Lsass
- Then writes an obfuscated dump to disk
- Uses direct syscalls
- Fully PIC



HandleKatz


Event 10, Sysmon
General
Details
Process accessed:
RuleName: -
UtcTime: 2021-04-14 07:47:50.584
SourceProcessGUID: {35223b03-9e26-6076-f90c-000000001b00}
SourceProcessId: 512
SourceThreadId: 5384
SourceImage: HandleKatz.exe
TargetProcessGUID: {35223b03-9d45-6076-e70c-000000001b00}
TargetProcessId: 7688
TargetImage: HandleHolder.exe
GrantedAccess: 0x1440
CallTrace: C:\Windows\SYSTEM32\ntdll.dll+9cae4|\HandleKatz\x64\Release\HandleKatz.exe+26a2|\HandleKatz\x64
\Release\HandleKatz.exe+23bc|D:\\HandleKatz\x64\Release\HandleKatz.exe+2c64|C:\Windows\System32\KERNEL32.DLL+17034|C:\Windows\SYSTEM32\ntdll.dll+
4d241

Power of PIC

- Feel free to upload on VT or drop it to disk
- HandleKatz can be encoded with SGN [1]
- Different encoded versions of PIC perform the exact same complex task
  - Yet, they look completely different
- Depending on the encoder, encoded version cannot take arguments or do not return properly

```
ssdeep,1.1--blocksize:hash:hash,filename
384:SojqwXNx2ObrGlgCoQ5DB6+UspgGysl4dF:SyqYNNGlgg96wpgGysKF,"/                                  /HandleKatz.bin.sgn"
384:pAa6V5kHg4lSTUxULthjS5i+MPqbY+Ux2oRzpz8:g5kAnTtEvbHiRZ8,"/                                 /HandleKatz.bin.sgn_1"
384:Q7llcoQv/zR0uidcrsj84Sw9jjNDFxtQeiP02uwe4eAc:Q7llcoQTmuid9/fjNDFLBiLu0u,"/                                  /HandleKatz.bin.sgn_2"
384:BVa8V5nsX7vK1pfvip88iYaAo7ApK3o1Np+OM:BM8VcjKLu88taAiAEAp+OM,"/                                  /HandleKatz.bin.sgn_3"
```

How to integrate HandleKatz

- Comes with a header file for HandleKatz's entry point
- Simply cast pointer to the typedef of HandleKatz
- Easy to integrate into your favorite C2

```
printf("[*] Now executing PIC ... \n");
dw_success = ((HandleKatz*)buf_shellcode)(b_only_recon, path_dump, dw_pid, buf_output);
printf("[*] HandleKatz returned: %d\n", dw_success);
printf(" ============== output ==============\n");
printf("%s\n", buf_output);
```

HandleKatz

- Code + Compiled PIC can be found at https://github.com/codewhitesec/HandleKatz
- Other PIC examples: https://github.com/thefLink/C-To-Shellcode-Examples
- How to build and protect PIC?

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Automating Creation and Protection

Source Files

- 2010 - @nickharbour - Writing Shellcode with a C Compiler
- 2013 - @mattifestation - Writing Optimized Windows Shellcode in C
- 2020 - @hasherezade - From a C project, through assembly, to shellcode
- 2021 - @passthehashbrwn - Dynamic payload compilation with mingw

PE vs. PIC

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Characteristic	PE	PIC
Structure	Structured in sections with different memory characteristics, separation of functions and data	All in one binary blob
Relocation	Yes, will be calculated through the loading process of the OS	No relocations, everything must be called relative to IP
Imports	External function calls are resolved through the loading process of the OS	External functions can only be called after they are manually resolved

Position Independent Problems

- **Imports** – External functions can only be called after they are manually resolved

- **Strings** – Have to be

```
{'s', 't', 'a', 'c', 'k', 's', 't', 'r', 'i', 'n', 'g', 's', 0};
```
[1]

  Hashes are often used to hide imports but are not applicable for other use cases

- **Global Data** – Must be passed from one function to another

→ Especially a problem for our imports

[1] https://www.fireeye.com/blog/threat-research/2016/06/automatically-extracting-obfuscated-strings.html

Position Independent Problems

From MSDN to source code

C++

```
void Sleep(
  DWORD dwMilliseconds
);
```

+ Library Name

Position Independent Problems
From MSDN to source code

C++

```
void Sleep(
  DWORD dwMilliseconds
);
```

+ Library Name

```
python3 GenFunctionPointer.py https://docs.microsoft.com/en-us/windows/win32/api/synchapi/nf-synchapi-sleep

→ typedef void(__stdcall *p_Sleep)(DWORD dwMilliseconds);
```

Position Independent Problems

Script generated code pattern

```
CHAR SleepStr[] = { 0 }; //str: Sleep

DeobfuscateString(SleepStr, SleepStr);

GetProcAddrManMap(Kernel32, SleepStr, &ProcAddress, Api);

Api->_Sleep = p_Sleep(ProcAddress);
```

Position Independent Problems

Script generated code pattern

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GetProcAddrManMap(Kernel32, SleepStr, &ProcAddress, Api);

Api->_Sleep = p_Sleep(ProcAddress);
```

+ Scripted the importing process of external functions
+ Write strings as they are
+ Make function pointers available everywhere → Api struct

Position Independent Problems

Script generated code pattern

Pre-build script *obfuscate.py* for string processing:

1) Find `"INT ObfuscationKey"` in source code and set random key value

2) Parse all files for string patterns, encode them with the obfuscation key and paste encoded version

```
CHAR SleepStr[] = { 0 }; //str: Sleep
→  CHAR SleepStr[] = {18, 93, 21, 83, 66, -1}; //str: Sleep
```

Template Based Shellcode
Gimme Shelter

AVs have different triggers for in-memory scans, for example jumping to the start of an executable region after…

- allocating it (and filling it with data) (RWX)
- changing its characteristics (RW → RX)

Template Based Shellcode
Gimme Shelter

AVs have different triggers for in-memory scans, for example jumping to the start of an executable region after…

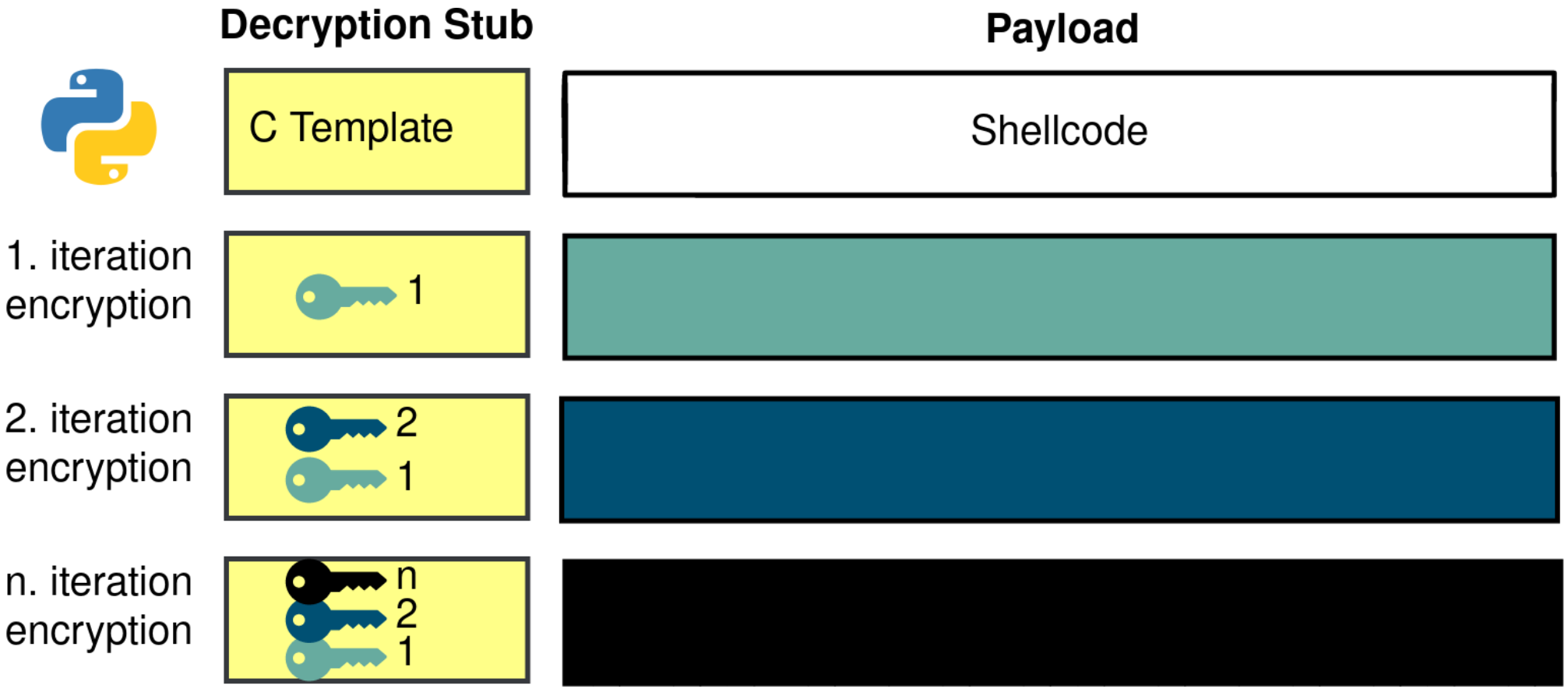
- allocating it (and filling it with data) (RWX)
- changing its characteristics (RW → RX)

Self-decrypting shellcode as a wrapper to protect payloads

1) Place self-decrypting shellcode in RWX memory region
2) Execute it → hides payload (long enough) from memory scanner

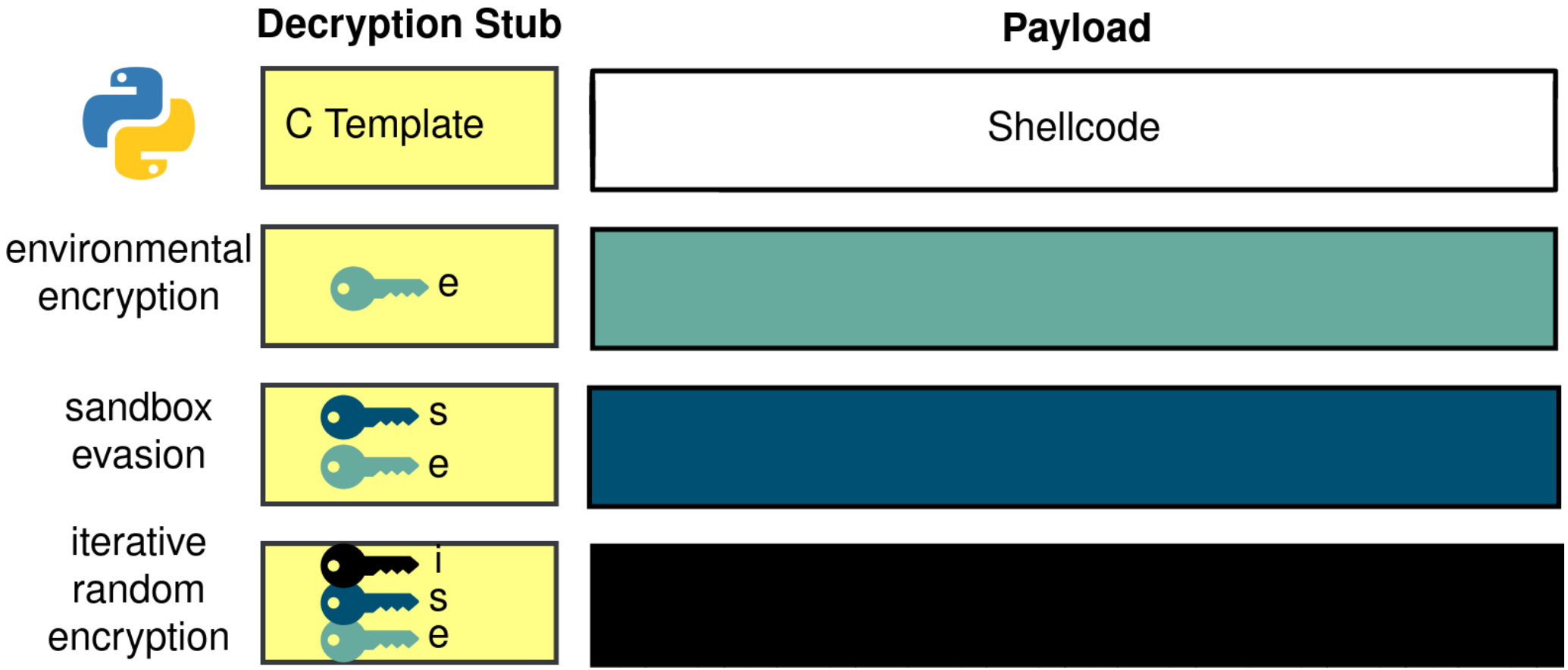
Template Based Shellcode

Self-decrypting shellcode pre-build script



Template Based Shellcode

Self-decrypting shellcode pre-build script



Template Based Shellcode

Self-decrypting shellcode Template

```
#define LOG 1
#define UK 0
#define DK 0
#define HK 0
#define PK 0

#if UK or DK or HK or PK or LOG [Active Preprocessor Block]
#endif

#if UK or DK or HK or PK [Inactive Preprocessor Block]
#endif

#if LOG [Active Preprocessor Block]
#endif
```

Template Based Shellcode

Self-decrypting shellcode Template

```
#define LOG 0
#define UK 1
#define DK 0
#define HK 0
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#if UK or DK or HK or PK or LOG [Active Preprocessor Block]
#endif

#if UK or DK or HK or PK [Active Preprocessor Block]
#endif

#if LOG [Inactive Preprocessor Block]
#endif
```

Template Based Shellcode

Self-decrypting shellcode Template

```
#define Parameter 1
#define _WIN64 1

#if Parameter
    extern"C" VOID prologue(CHAR *Args);
    extern"C" VOID mainAct(CHAR *Args);
    #if _WIN64
       extern"C" VOID AlignRSP(CHAR *Args);
    #endif
#else
    extern"C" VOID prologue();
    extern"C" VOID mainAct();
    #if _WIN64
        extern"C" VOID AlignRSP();
    #endif
#endif
```

Template Based Shellcode

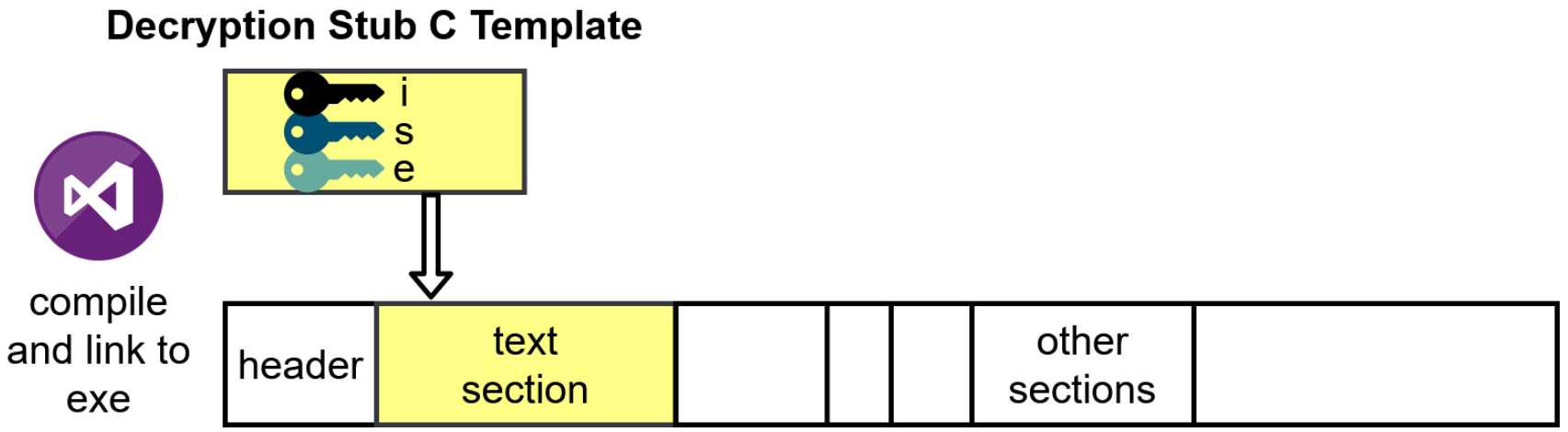
Self-decrypting shellcode Template

```
#define Parameter 0
#define _WIN64 0

#if Parameter
    extern"C" VOID prologue(CHAR *Args);
    extern"C" VOID mainAct(CHAR *Args);
    #if _WIN64
       extern"C" VOID AlignRSP(CHAR *Args);
    #endif
#else
    extern"C" VOID prologue();
    extern"C" VOID mainAct();
    #if _WIN64
        extern"C" VOID AlignRSP();
    #endif
#endif
```

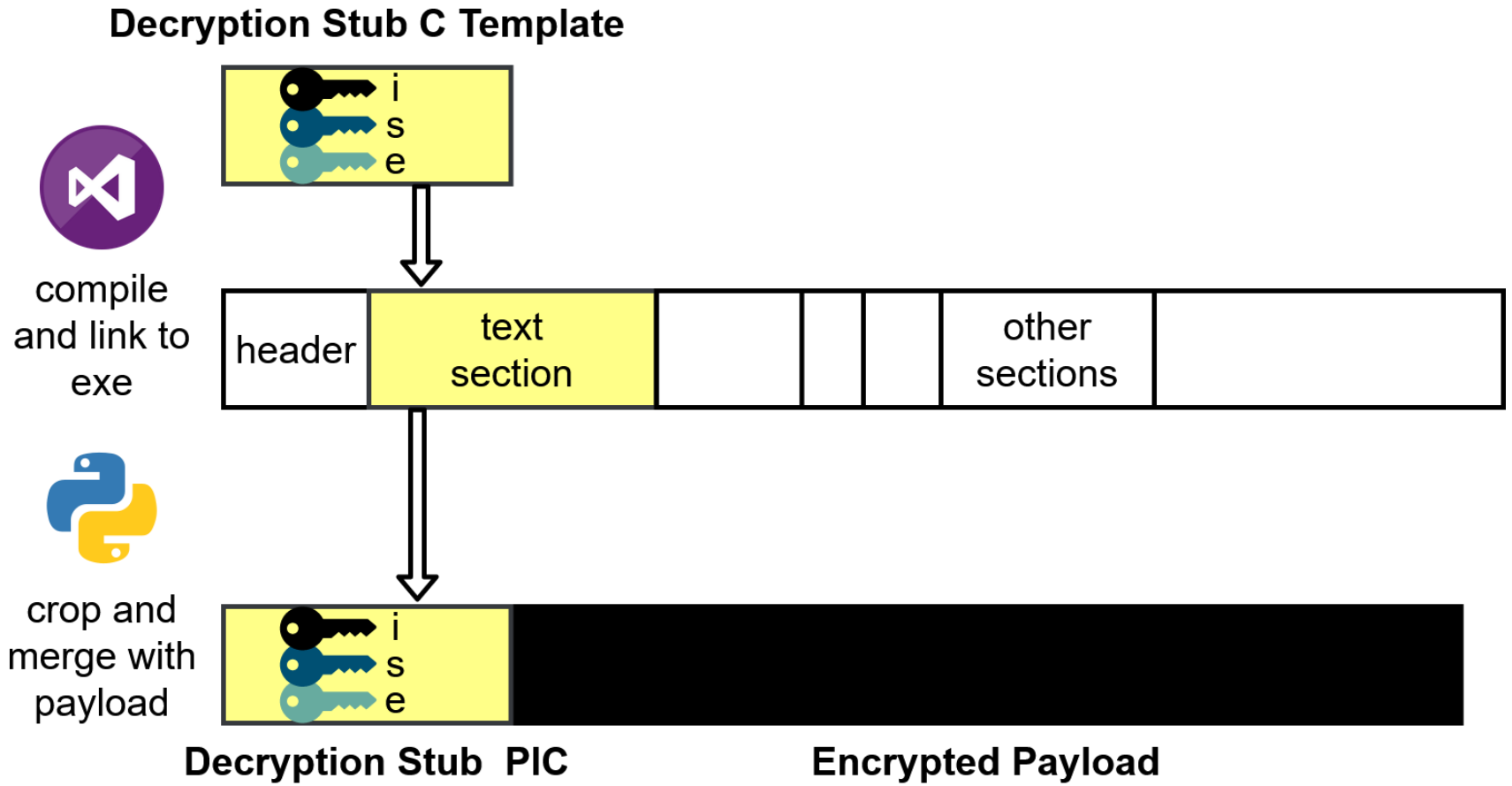
Template Based Shellcode

Self-decrypting shellcode post-build script



Template Based Shellcode

Self-decrypting shellcode post-build script



Template Based Shellcode
Suitable Memory

Suitable memory is needed to run self-decrypting shellcode!
And here we go again: in-memory artifacts ☹

Is this really a problem?

Template Based Shellcode
Suitable Memory

Suitable memory is needed to run self-decrypting shellcode!
And here we go again: in-memory artifacts ☹

Is this really a problem?

Short answer: No! ☺
Long answer: Depends - you must know what you're doing!
→ PIC itself in RWX memory is hard to identify as malicious

Template Based Shellcode
Gimme Suitable Memory

Masking Malicious Memory Artifacts: Part I – III
https://www.forrest-orr.net/blog

- VirtualAlloc
- VirtualProtect
- Create PE with RWX section
- Load DLL with RWX section
- <Something> Hollowing
- You name it
- …

Template Based Shellcode

Express Yourself – Just Say Yes!

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Run shellcode directly

- Link into text section of loader PE
- Execute without prior allocation
- Not feasible for self-modifying code

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Express Yourself – Just Say Yes!

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Run shellcode directly

- Link into text section of loader PE
- Execute without prior allocation
- Not feasible for self-modifying code

Protection?

- Obfuscation by replacing / inserting assembly instructions
  C → ASM → Obfuscation / Mutation → ASM → Binary [1]
- Situational awareness by conditional jumps

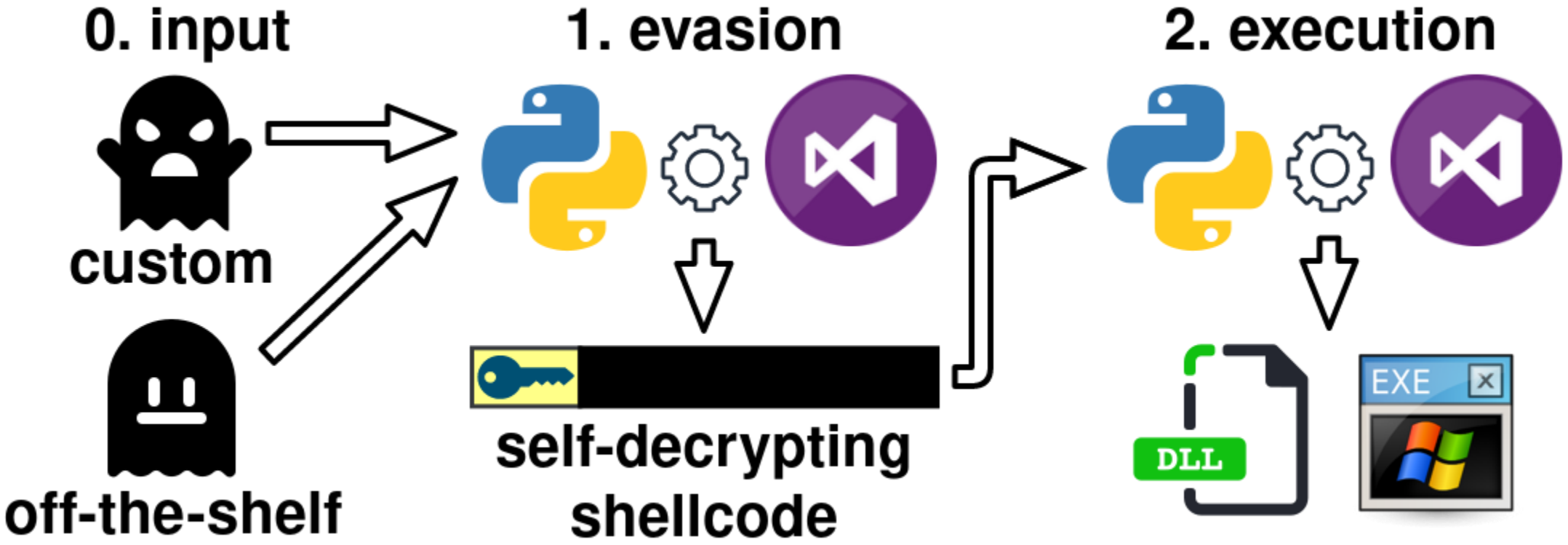
[1] https://vxug.fakedoma.in/papers/VXUG/Exclusive/FromaCprojectthroughassemblytoshellcodeHasherezade.pdf

Template Based Shellcode
Loader PE Templates

MinGW based approaches
https://github.com/phra/PEzor
https://github.com/optiv/ScareCrow

- One MSVS solution, multiple configurations
- Generic loader PE templates, mostly DLLs
- Various exports
- Various functionality (different hijacks / drop)
- Shellcode payload as header
- Some resource files for fun

Git Together



Git Together
Why Gitlab CI/CD

- Modularity
- Flexibility
- Parameterization
- Ubiquitous

Git Together
Gitlab CI/CD Pipelines

CODE WHITE
FINEST HACKING

- **Logic** in YAML files (and Python in our case)
- **Jobs** define what to do
  For example, jobs that compile or process (obfuscate)
- **Stages** define when to run the jobs
  For example, stages run different pre- or post-build evasion jobs after each other

Git Together

.gitlab-ci.yml Example Handlekatz

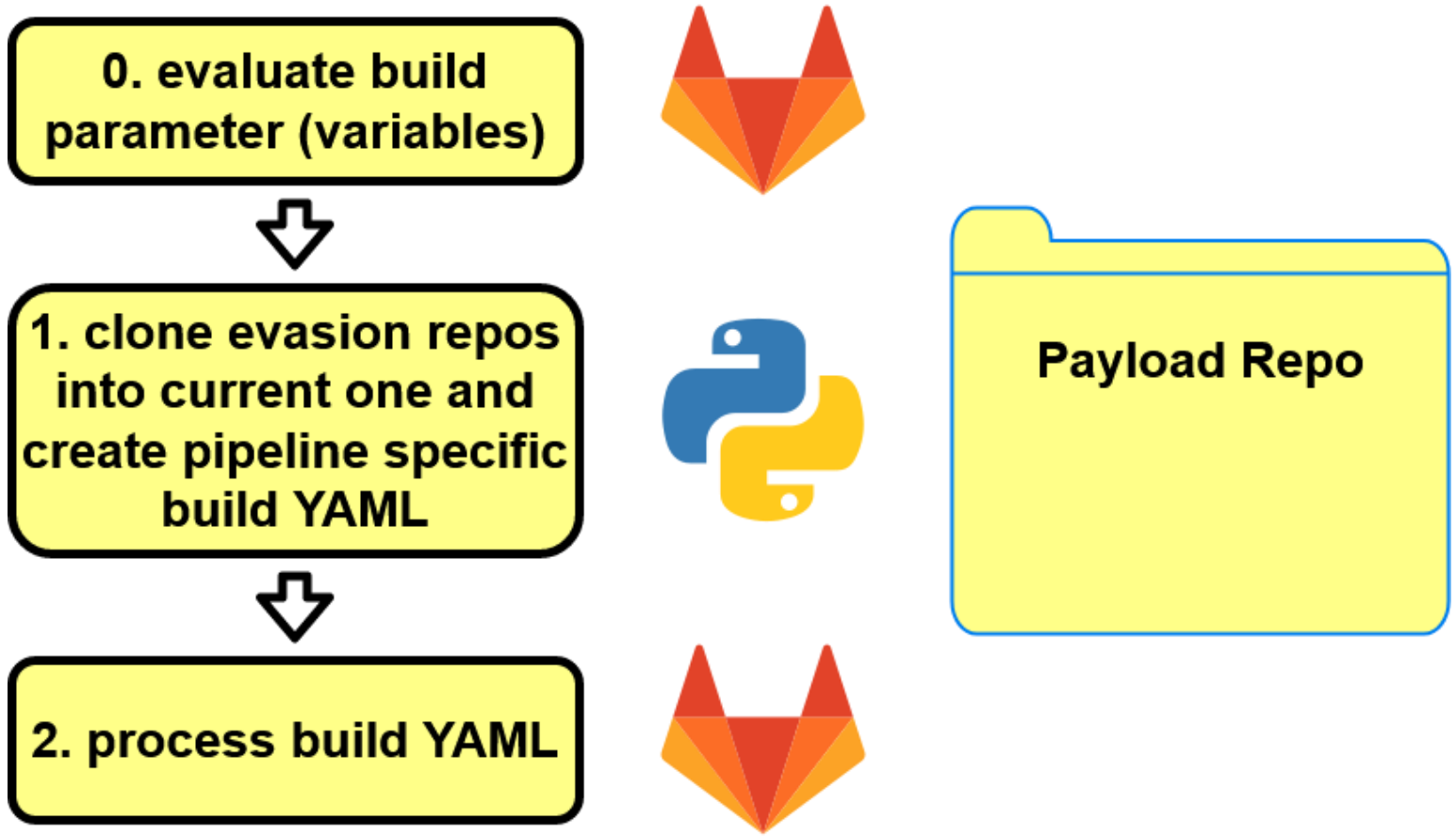
```
variables:
    CW_PROJECT: BruCon
    CW_PARAMETER: --pid 7688
    CW_EVASION: Crypto LoaderGen

    CW_CRYPTO_KEY_USER: KevinSmith
    CW_CRYPTO_SANDBOX: 1
    CW_CRYPTO_ITERATIONS: 100

    CW_LOADER_TEMPLATE: EXE
    CW_LOADER_CONSOLE: 1
```

Git Together

Build Configuration / Preparation



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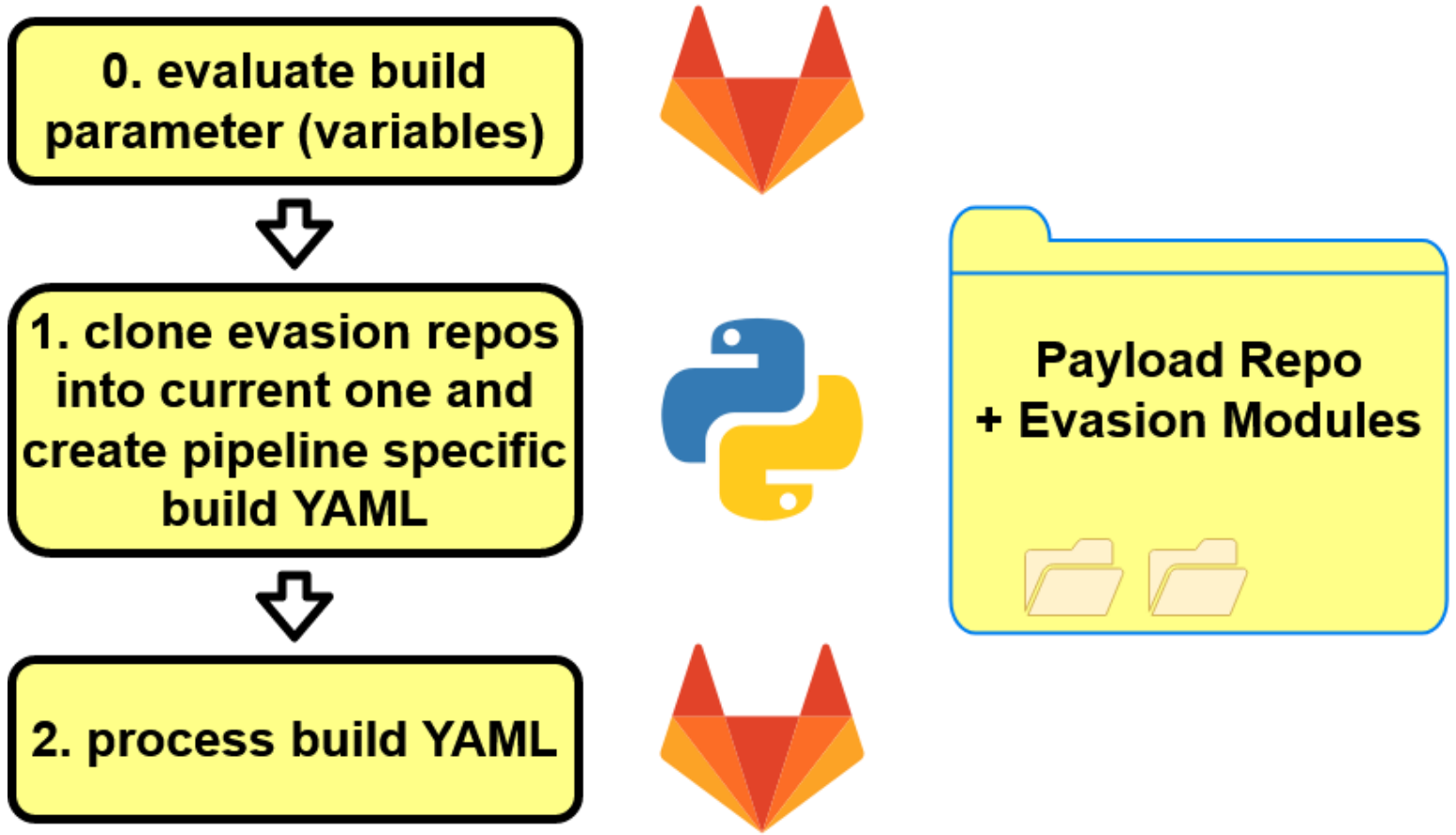
Build Configuration / Preparation



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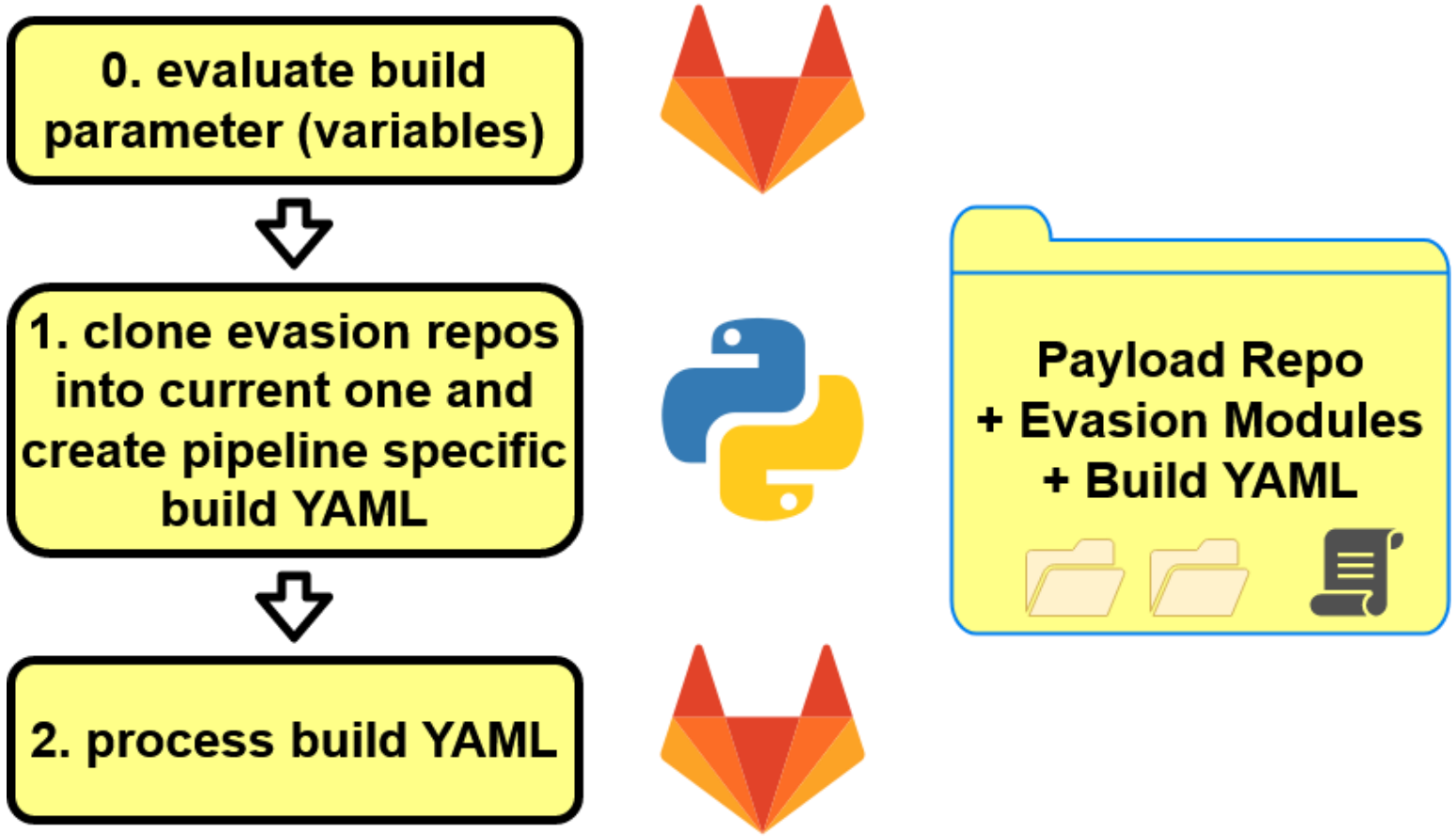
Build Configuration / Preparation



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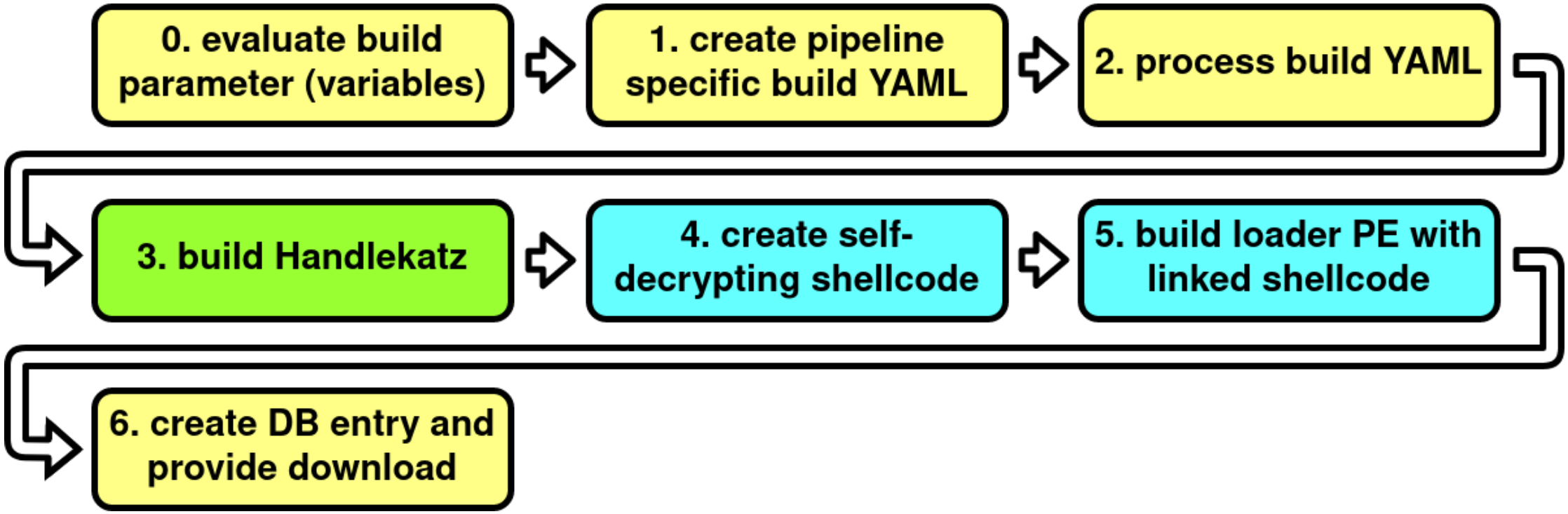
Pipeline Example Handlekatz



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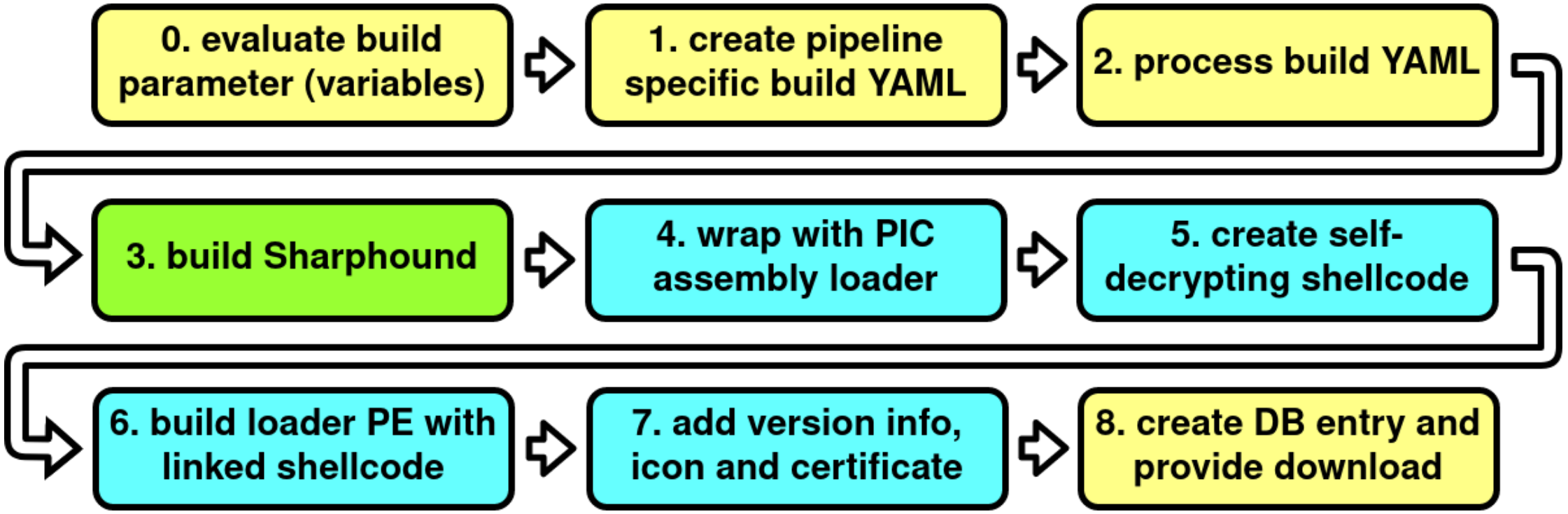
Pipeline Example Sharphound



Git Together
C2 Integration

Great talk about evasion CI/CD
Dominic Chell - Offensive Development: Post Exploitation Tradecraft in an EDR World

- **Agents:** Trigger pipeline process through CobaltStrike UI and download generated loader to your client

- **Tools / Payloads / Red Teaming as Code:** Trigger pipeline process through the CobaltStrike UI and upload artifact to a running Agent

Demo
C2 Integration

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Thank you for your attention!
Questions?

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@niph_
@b00n10