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

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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?
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

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

Phenoetic
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## Windows transformation tables

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What can be addressed?

- With 2 out of 4 bytes to influence, one gets 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
Return address selection

- Blowing up the heap
  - Doesn't always work
  - Is unreliable since it’s unpredictable
  - Might 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
1. Overflow up to SEH address
2. Trigger exception (not hard 😊)
3. Get code from ntdll.dll
4. Enjoy

Ahaha!
ntdll.dll
0800-CALLSEH

AAAA
AAAA
AAAA
AAAA
AAAA
AAAA
AAAA
AAAA
RetAddr

Missbrauch Nutzbar
Misuse will be rewarded
Return to register, but how?

- Useful 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 occurs
    - Print result if JMP/CALL <reg> is found
    - Recourse 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
OllyUni finding example

- UNICODE return addresses that are not directly reachable:

0x00420153 is addressable by the sequence 0x429C in the ANSI table.

0x0042015D is not Unicode addressable, but contains CALL EBX.
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 minimum 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
Format strings in color

- User input:
  ```
  AAAA_A_ % x
  ```

- Wide char by ANSI:
  ```
  A A A A A _ % x
  ```

- `*printf()` call: ""
  - 0x00 byte encountered, end of string

- `*wprintf()` call: "AAAA_23FEFE23"
  - Format argument is wide char
The shell code dilemma

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

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

```assembly
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
- Only (to me) known public implementation from Dave Aitel in makeunicode2.py
  - Unfortunately it needs a lot of fixing (sorry ;)
  - A commercial version is included in CANVAS and might be working better.
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
  00 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
Venetian Shellcode [4]

- The size of the venetian 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 (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 realignment 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 256 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
- Some 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 ...
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
- (relatively) easy to install, runs on Windows NT/2000 or Linux
- Directly connected to the existing SAP R/3
This installation type is appropriate for production systems 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**

- HTTP
- HTTPS Generic Firewall
- SNC Encryption SAP router Firewall
- TCP/IP
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
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:
    ```php
    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 architecture 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...)

Phenoelit
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/