HOW TO GET FROM HERE TO HERE

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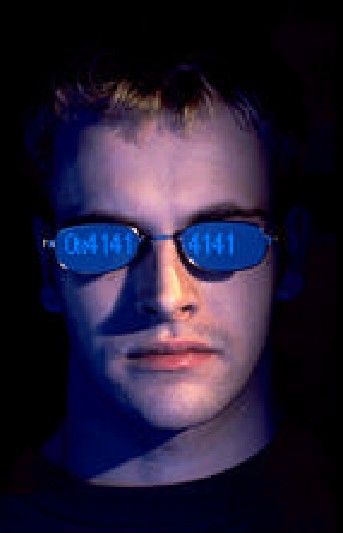
Phenoelit

Halvar

TESO

Agenda

- The Mindset
- Finding vulnerabilities
- Writing exploits
- Exploiting non-standard stuff



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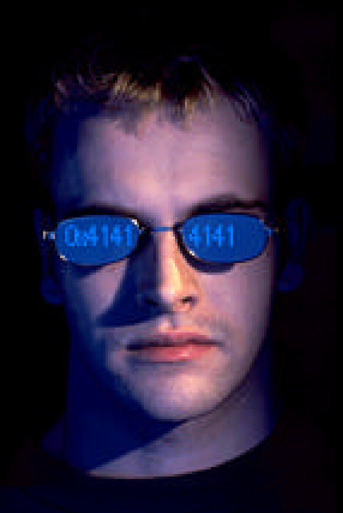
Mindset

1. Understand John von Neumann!
   - For any given computer today, there is no difference between data and code.
   - Where the instruction pointer points to, this is code
   - Where other registers point to, this is data
   - Code can become data
   - Data can become code



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Open your eyes!

- Cheer when things crash
- Don‘t click away Dr. Watson
- Don‘t just delete ‚core‘

Example:

You view a web page with your favorite browser and it crashes.

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Warning

- Make no mistake, this is **work**
- Learning as you go on
- Finding vulnerabilities takes time
- Reliable exploitation needs a lot of testing
- Brain required

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Finding Vulnerabilities

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The goal: 0day

- What we are looking for:
  - Handles network side input
  - Runs on a remote system
  - Is complex enough to potentially contain significant number of vulnerabilities

Testing methods

- Manual testing
- Fuzzing
- Static analysis
- Diff and BinDiff
- Runtime analysis

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Manual Testing

- Using the standard client (or server) to access the target service
- Observing the behavior:
  - States in the target
  - Reaction to valid input
  - Reaction to invalid input
  - Information transmitted before and after authentication
  - Default configuration and misconfiguration issues and environment requirements
  - Logging capabilities

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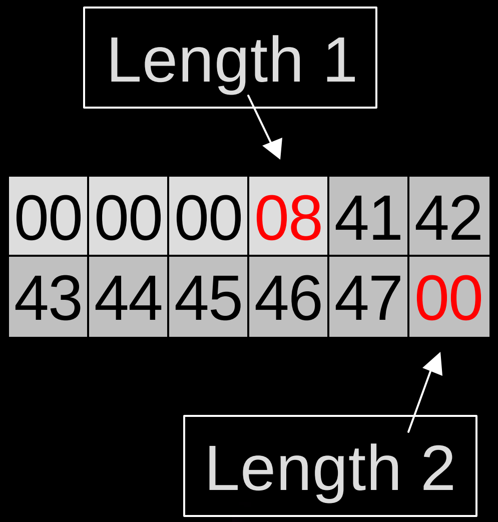
Manual Testing

- Things to look for:
  - Input validation on client side
    - Input in client rejected
    - Input in client accepted but modified before transmission
  - Pre-Authentication client data
    - Hostname
    - Username
    - Certificate content
    - Date/Time strings
    - Version information (Application, OS)

Manual Testing



- More things to look for:
  - Network protocol structure
    - Dynamic or static field sizes
    - Field size determination
    - Information grouping
    - Numeric 32bit fields
  - Timing
    - Concurent connections
    - Fast sequential connections

Manual Testing

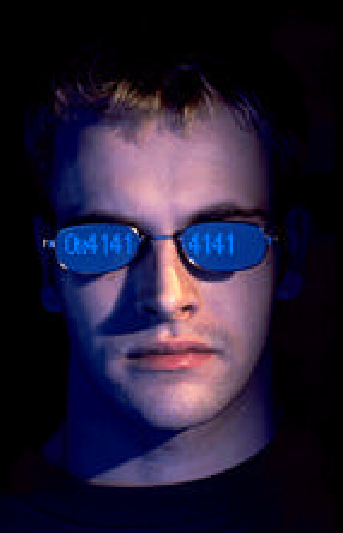
- Advantages:
  - No need for additional tools
  - Becoming familiar with the target
  - Uncovers client side security quickly
  - Easy correlation between user action and network traffic
- Disadvantages:
  - Potentially high learning effort
  - Often provides only clues where vulnerabilities might be found
  - Proving a vulnerability often requires additional efforts (such as code)
  - High dependence on the tester

Manual Testing

- Usual findings:
  - Cross Site Scripting / Code & SQL injections
  - Protocol based overflows and integer issues
  - Application logic failures
- Best suited for:
  - Web applications
  - Java application frameworks
  - Proprietary clients
  - Internet Explorer (and other browsers)

Fuzzing

- Creating rough clients (or counterparts) to generate a wide range of invalid input
  - Attempts to find vulnerabilities by exceeding the possible combinations of malformed input beyond the boundaries of the original client
- Best suited for:
  - Services using documented protocols HTTP, FTP, RPC, DCOM, …
  - Web applications
  - Protocols with many field combinations



Fuzzing

- Semi-Manual fuzzing
  - Writing scripts or short programs acting as rough clients
  - Manually changing the code for each test
  - Running the code and evaluating the response
- Automated fuzzing
  - Writing scripts or programs to iterate through a high number of invalid input
  - Running the code and letting it iterate until the target crashes

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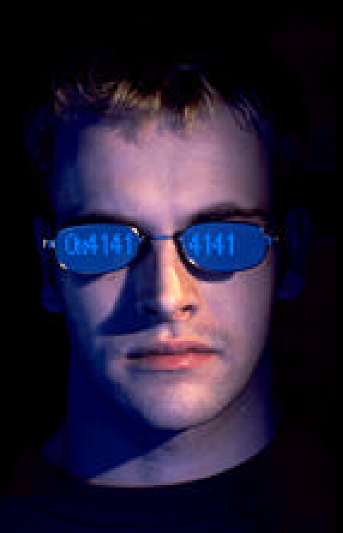
Fuzzing

- What you try to determine
  - Semi-Manual fuzzing
    - Unexpected responses
    - Modified data in the response
    - Changed timing behavior
    - Target crashes
  - Automated fuzzing
    - Target crashes



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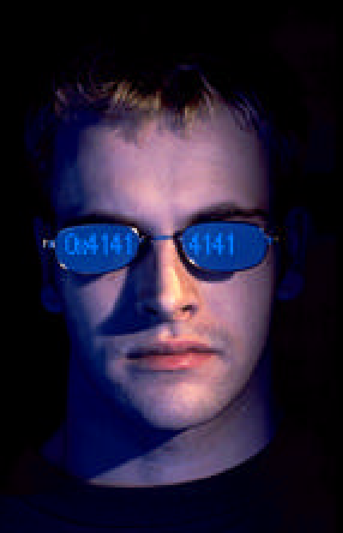
Fuzzing

- Semi-Manual fuzzing procedure
  - Get your script to work normally
  - Change fields one at the time
  - Generate output (send data, create file, ...)
  - Inspect results
  - Change fields again, depending on results
  - Generate output
  - Repeat last two steps



Example:
Symantec PC AnyWhere 10.5

- Timing issue with frequent reconnects and initial handshake
- Fails to synchronize load and unload of a DLL for the tray bar icon
- DoS: connect, handshake and disconnect about 10 times

Fuzzing

- Automated fuzzing procedure
  - Define what vulnerabilities you want to look for
  - Create iterator script/program using a fuzzer framework
    - Output data for every vulnerability type you want to test
    - Output data for multiple/combined vulnerabilities
    - Iterate through all combinations
  - Wait until your target crashes
    - Needs a debugger attached to the target in case the vulnerability is hidden by a SEH handling it
    - Issues with „forking“ processes under Win32

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Fuzzing Frameworks

- SPIKE
  - By Dave Aitel, Immunity Inc
  - Currently version 2.9
  - Block based fuzzer
  - Written in C
  - Fuzzing programs need to be in C too
  - Rudimentary functions for sending and receiving data, strings and iterations
  - Almost no documentation
  - Comes with a number of demo fuzzing programs

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Fuzzing Frameworks

- Peach
  - By Michael Eddington, IOActive
  - Currently pre-release state
  - Written in Python (object oriented)
  - Consists of:
    - **Generators** for static elements or protocol messages
    - **Transformers** for all kinds of en/decoding
    - **Protocols** for managing state over multiple messages
    - **Publishers** for data output to files, protocols, etc.
    - **Groups** for incrementing and changing Generators
    - **Scripts** for abstraction of the per-packet operations
  - Documented fully, including examples

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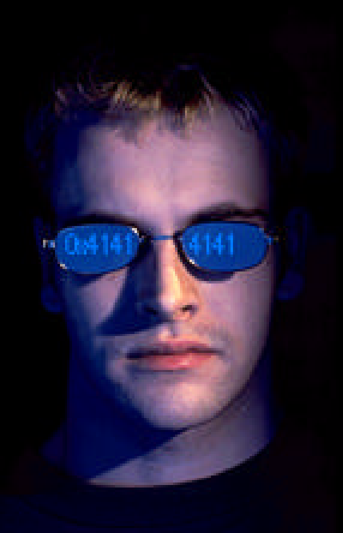
Fuzzing

- Advantages:
  - Semi-Manual fuzzing
    - „Try-Inspect“ Process leads to fast findings
    - Fuzzing script can be promoted to exploit
  - Automated fuzzing
    - Quickly uncovers a wide range of overflow and format string vulnerabilities
    - Effective when many combinations are possible
- Disadvantages:
  - Understanding of the underlying protocol required
  - Tester has to rely on fuzzer
  - Debugger on the target system often required
  - Can hide a bug behind another bug



Static analysis

- Disassembly of the target binary in order to find vulnerabilities.
- Identification of vulnerable code sequences independent of their location
- Often paired with automatic analysis of calls to known library functions with vulnerability potential

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Static analysis

- Always a manual procedure with aid of several tools
- Requirements:
  - Binaries of the target
  - Interactive Disassembler (IDA)
  - Library reference for the target
  - Fluent assembly
  - Fluent C (!)

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Static analysis

- Find *REACHABLE* references to functions with vulnerability potential: strcpy(), sprintf(), ...

  (Testifies to the average quality of COTS ☺
- Check the call arguments for each reference if they suggest a vulnerability

  sprintf(buffer, „%s“, ...
- Check if the data can be influenced

  sprintf(buffer, „%s“, user_input);
- Find potential limiting factors

  sprintf(buffer, „%s“,
      strlen(user_input)>(sizeof(buffer)-
      1)?“big“:user_input);

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Static analysis

- Reverse engineering of lower level protocol handlers
  - Find calls to recv(), recvfrom(), WSArecv(), WSArecvfrom(), read(), ...
  - Determine the buffer holding the data
  - Follow the program flow to eventually find the parsing functions
  - Reverse engineer the parsing functions
  - Identify potential for parsing mistakes

Static analysis

- Things to remember:
  - In order to find bugs, you should know the language better than the programmer: The ANSI C standard should be your Bible. Sleep on it. Read it. Worship it.
  - Knowing „not a whole lot of“ assembly will make you miss „a whole lot“ of bugs
  - Reading diff‘s to open source software will make you a better closed source auditor, too
  - Different compilers react differently, and an astonishing number of them do not implement the ANSI standard correctly
  - The standard itself is often ambiguous ➔ things break

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C trivia question

Signedness of comparison is not always obvious:

```
int             a = 10, c = -1;
unsigned int    b = 10;

if( a + b > c )
```

The above condition evaluates to FALSE

```
int             a = 10, c = -1;
unsigned short  b = 10;

if( a + b > c )
```

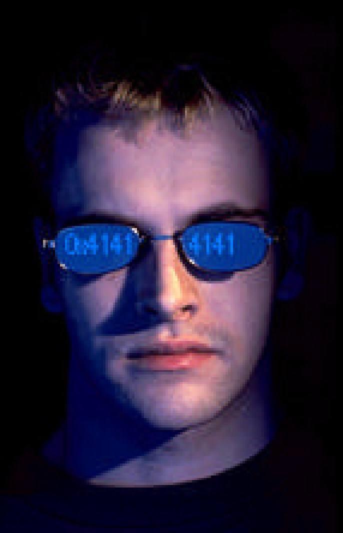
The above condition evaluates to TRUE – Why ?

C trivia question

Quoting from the ANSI/ISO C Standard, Page 57:

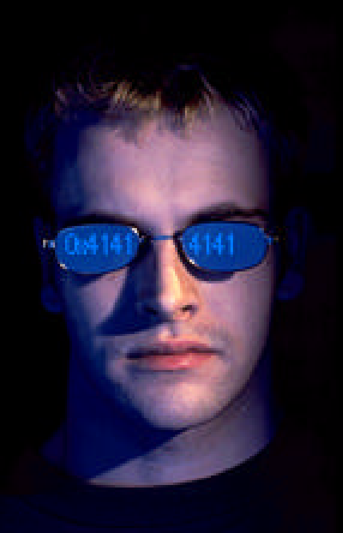
If an int can represent all values of the original type,the value is converted to an int, otherwise, it is converted to an unsigned int. These are called Integer promotions

unsigned int b can not fit all values into a regular int, so a+b ends up being unsigned int. On the other hand, unsigned short b can easily fit all values into a regular int, so a+b ends up being signed.



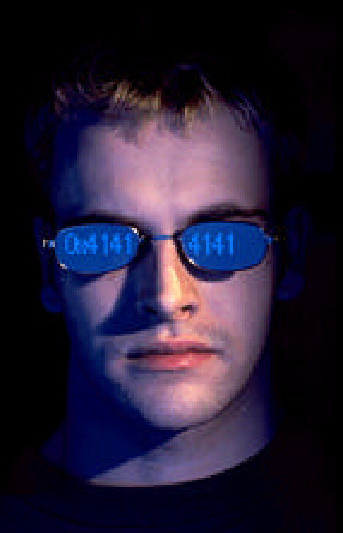
Static analysis

- Advantages:
  - Finds vulnerabilities in code normally not executed
  - Quickly uncovers most format string vulnerabilities
  - Advanced vulnerability identification
- Disadvantages:
  - Needs lots of time, experience and skill
  - Disassembly is almost never complete
    - Library call identification fails
    - C++ and Delphi code hard to read
    - Packed or obfuscated code hard to handle
    - Not usable for ugly stuff (Visual Basic)



Diffing

- Identification of a vulnerability after it has been found and fixed.
  - The goal here is to identify the fix, in order to find the vulnerability.
- Reasons:
  - Most people don‘t patch quickly enough
  - Diffing takes less time than auditing
  - Vendors sometimes fuck up the patch, giving out vulns for free
  - Vendors sometimes tell the public about bugclasses, so they give out vulns for free
  - ➔ No need to audit to break into a system if you can wait for the next update to come out



Diffing

- In patches, one needs to first find out what files are modified
- Filemon from Sysinternals
- Killing the update after the unpacking procedure but before the copy
- Static analysis of the patch program itself

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Diffing

- Comparing two versions of a binary by hand takes very long
  - Find functions that are at the same address
  - Compare the number of functions
  - Compare the size of functions
- Automated binary diffing is far superior
  - Graph based fingerprinting of functions
  - Automated comparison
  - Can also be used to port function names

http://www.sabre-security.com/files/dimva_paper2.pdf

Runtime analysis

- Running the target in a debugging environment and inspecting the code during execution.
- Identification of vulnerable code sequences using disassembly, much like static analysis.
- Observation of the target code rather than completely reverse engineering it.

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Runtime analysis

- Manual process with the aid of debugging tools
- Requirements:
  - *Functioning* version of the target
  - Debugger
  - Fluent assembly
  - Library reference for the target system

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Release!
Phenoelit (dum(b)ug) core

(dumB)
(Bug)

dumb people (write)
dumb debuggers (to find)
dumb bugs

- Complete and fully open source Win32 debugger core
- C++ class architecture
- PE parsing, disassembly, thread handling, breakpoints
- Instant debugger creation using a few lines of code

http://www.phenoelit.de/dumbbug/

Runtime analysis

- Data follow procedure
  - Identify functions that produce „incoming“ data, such as recv() and break there
  - Follow the data through the program flow to identify parsing functions
  - Following the data can be supported by memory breakpoints
  - Reverse engineer the parsing function, looking for mistakes in the programming
  - Craft data to trigger the suspected vulnerability and inspect the results

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Runtime analysis

- Code follow procedure
  - Identify functions with vulnerability potential
  - Break every time such a function is executed and inspect the arguments
  - Check the arguments if they suggest a vulnerability in this case
  - Check the arguments if they are user supplied data or derived from it
- For most functions, this is impractical because of the high number of calls to them
  - Often, only one in 100 calls is relevant

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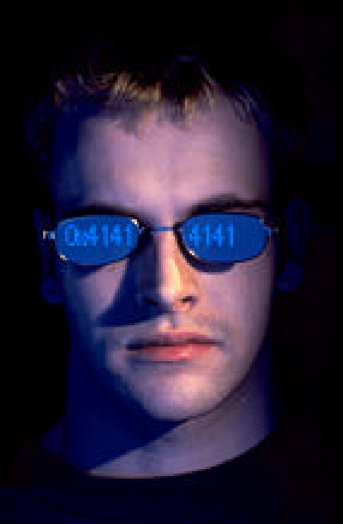
Runtime analysis

- Advantages:
  - Correct disassembly at the time of execution
  - Known state of registers
  - Advanced vulnerability identification
  - Slightly faster than static analysis, due to skipping of uninteresting code
- Disadvantages:
  - Time, skill and experience required
  - „Break-and-Inspect“ not good for library functions
  - Timeout issues
  - Detaching of debugger only on Win2003



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Static and Runtime analysis

- Usual findings:
  - Application and protocol level overflows
  - Format string vulnerabilities
  - Integer vulnerabilities
- Best suited for:
  - All kinds protocol parsers
  - Logging and data processing
  - Code using unsafe functions

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Release!
Phenoelit (dum(b)ug) ltrace

(dumB)
(Bug)

dumb people (write)
dumb debuggers (to find)
dumb bugs

- Ltrace for Windows
- Log calls to any function
- Before and after states
- Call conventions
- Follows „forks“
- Stack analysis
- Format string analysis

http://www.phenoelit.de/dumbbug/

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Trace defs

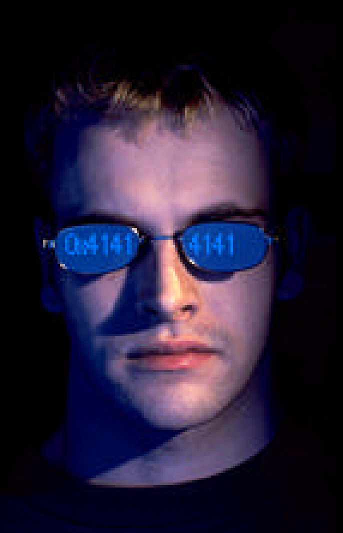
- Trace definitions used to identify arguments of traced functions
- Native C notation
- Argument directions
- Return value or output buffer

```
int __cdecl recv(
       [in] int socket, [both] char * buf,
       [in] int len, [in] int flags );

„haxor“ == int sprintf(
       [out] char * buf,
       [in] fmtchar * format );
```

Function call tracing

- Advantages:
  - Extremely fast
  - No disassembly
  - Recognition of user supplied data
  - Automagic format string vulnerability detection
- Disadvantages:
  - Incomplete: only called functions traced
  - Covers only unsafe functions
  - Does not (yet) identify compiled in incarnations of library functions



Combining forces

- Fuzzing and tracing
  - Fuzzing using Peach and a well designed script
  - Attaching ltrace or (dum(b)ug) tracer to catch exceptions and “forking”
- Semi-Manual fuzzing and static analysis scripts

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Writing Exploits

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C--

- Don‘t write exploits in C
  - Error prone
  - Not portable
  - Ugly
- Connecting and sending data can be done in script languages
  - Perl
  - Python
  - Even Java *urgl*

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Exploit creation process

- Find a vulnerability
- Trigger it
- Get code execution
- Get shellcode there
- Execute shellcode

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Trigger

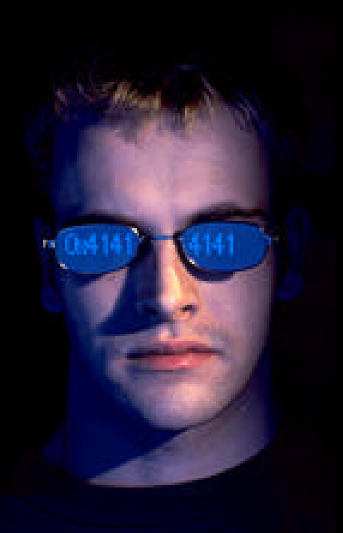
- Make sure you can trigger the vulnerability on more than one computer
- Observe environment requirements

Example:

- Overflow in HTTP server
- Crash: GET /AAAAA.... HTTP/1.0\r\n\r\n
- Concatenation of real path and requested URI: c:\the\buggy\server\AAAAAAA...

Code execution

- Influencing the instruction pointer (eg. EIP) to point at data you influence
  - Use illegal instruction codes (0xFFFF, 0xC0) or 0xCC (debug break)
  - Don‘t limit yourself to the overflowed buffer
- Try to get out of the function as soon as possible
  - Reading of local variables between overflow and return
  - Writing or local variables or function arguments



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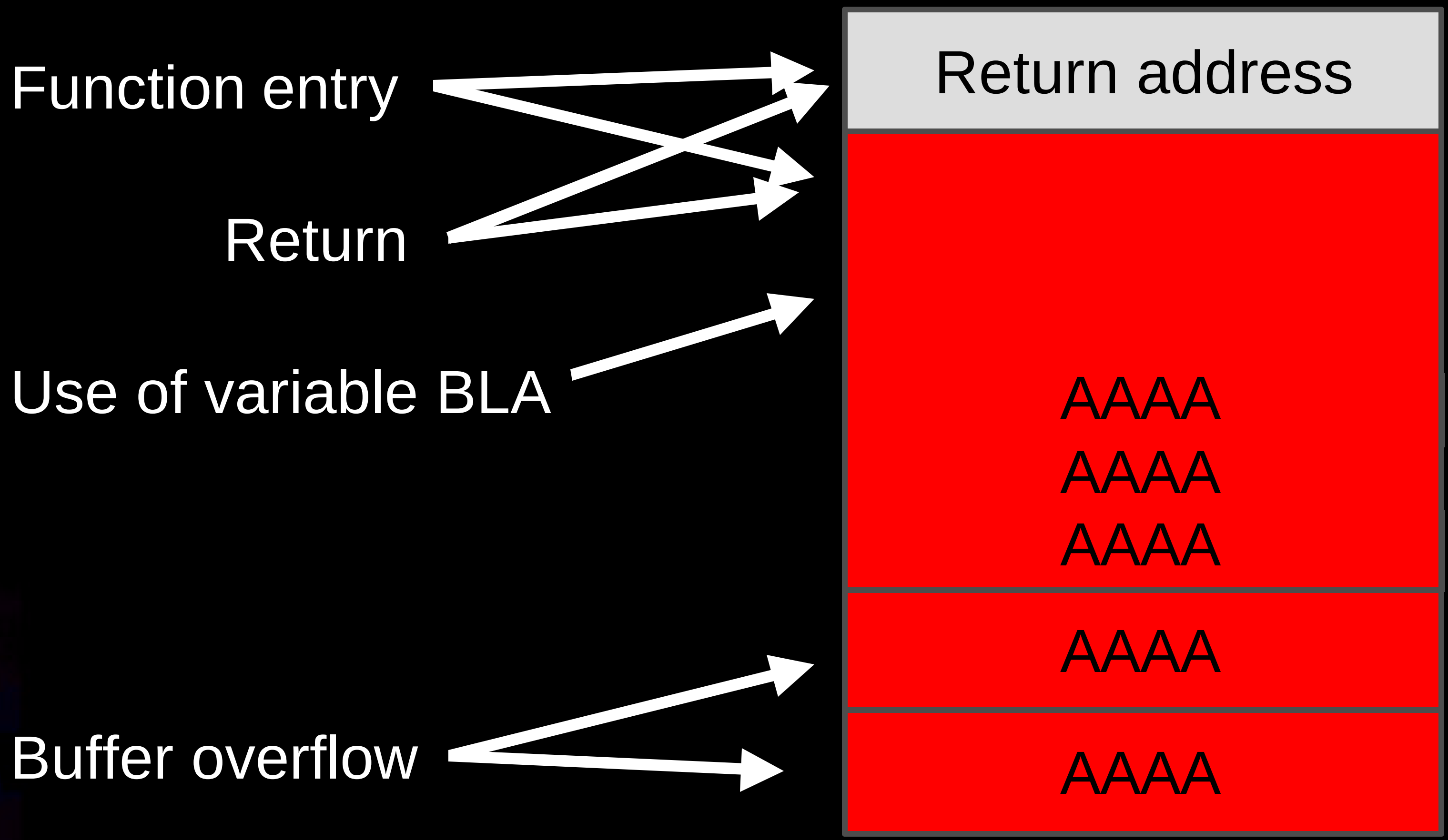
Code execution



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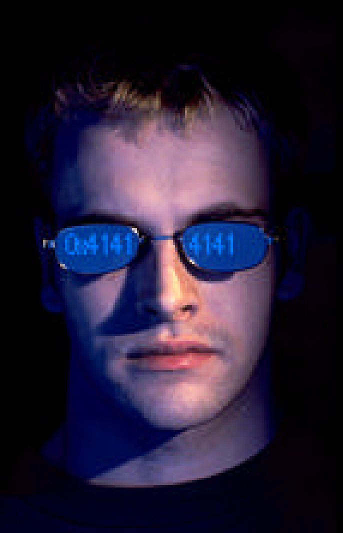
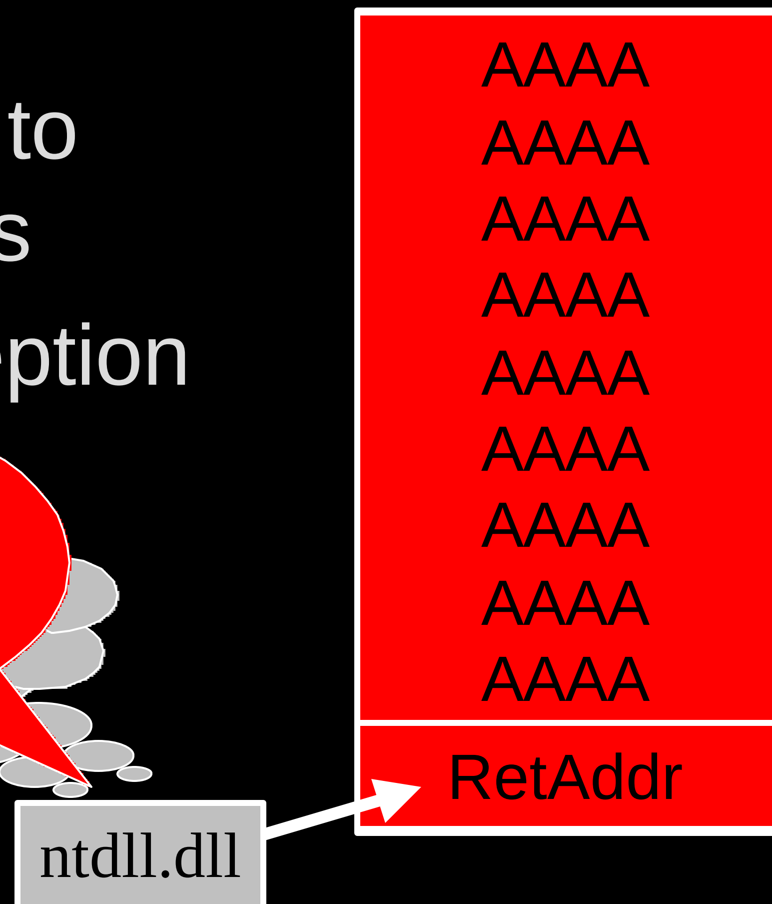
Code execution: Return address

- Direct return into buffer
  - Mostly not reliable
  - Not a good idea with threads
- Return to known code location
  - JMP <Reg>
  - CALL <Reg>
  - POP <Reg>
POP <Reg> ...
RET
  - ADD ESP,0x??
RET
- Structured Exception Handler



SEH in full color

1. Overflow up to SEH address
2. Trigger exception (n)
3.
4. Enjoy



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Return to register - UNICODE

- 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>

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... 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**

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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
```

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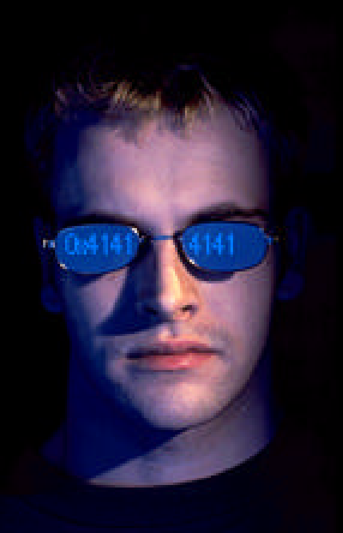
Getting shellcode there

- Shellcode is a general term describing data that became code
- Shellcode creation process:
  - Write a small program that opens a listener with a shell
  - Compile
  - Disassemble
  - Make it position independent
  - Remove forbidden characters



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Getting shellcode there

- When writing your own shellcode...
  - Try to make it flexible
  - Do not rely on libraries
  - Use delta offsets for variable addressing
- Use MosDef
- Use Metasploit
- Use Google

```
EB 20
5D
...
E8 DB FF FF FF
2F 62 69 6E 2F 73 68
```

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Getting shellcode there

- Shellcode can be transported in many ways
  - In overflowed buffer
  - (local) in environment variable
  - In other buffer of the same request
  - In data you sent before (username?)
- Shellcode often gets transformed
  - 0x00 characters in string operations
  - Forbidden characters
  - Encoding (eg. UNICODE transformation)

Unicode Shellcode

- Transformation example: UNICODE

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

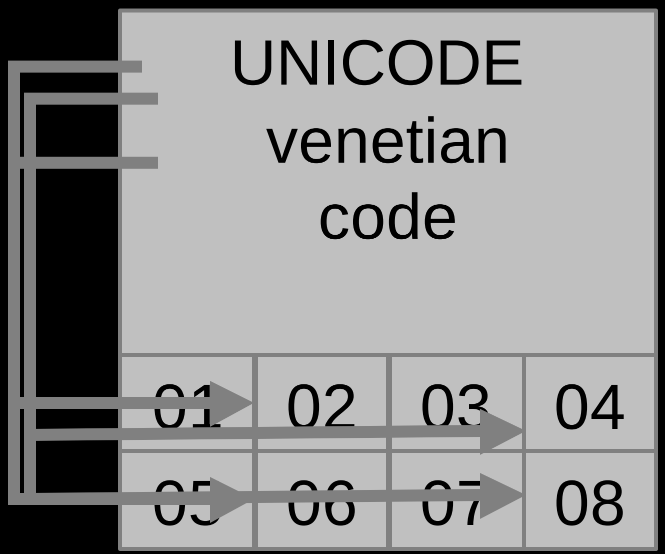
```
E8 00000000     CALL 004015C5
0000            ADD BYTE PTR DS:[EAX],AL
0000            ADD BYTE PTR DS:[EAX],AL
005D 00         ADD BYTE PTR SS:[EBP],BL
64:008B 000D00 ADD BYTE PTR FS:[EBX+D00],CL
0000            ADD BYTE PTR DS:[EAX],AL
0000            ADD BYTE PTR DS:[EAX],AL
0000            ADD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

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
- Implemented as shell code generator
  - Dave Aitel’s makeunicode2.py
  - Phenoelit‘s vense.pl

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



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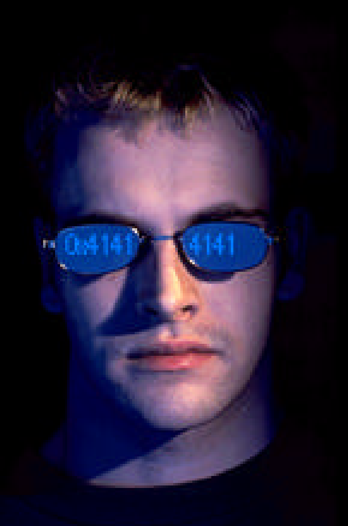
Finalizing the exploit

- Now you can:
  - Trigger the vulnerability
  - Point the instruction pointer to your data (which becomes code, did you pay attention?)
  - Get your code (data ☺) there
- Try it
  - With debugger
  - Without debugger
  - Different OS versions
  - Different OS languages



Exploiting non-standard stuff

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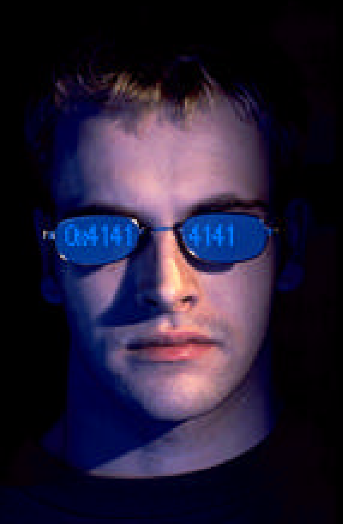
What is the difference?

- Other platforms are von Neumann machines as well
  - They got a CPU
  - They got Random Access Memory
  - They got (some) permanent storage
  - They got network connectivity
- Why not hack ...
  - Routers
  - Printers
  - Cell Phones
  - Hotel Pay-TV sets



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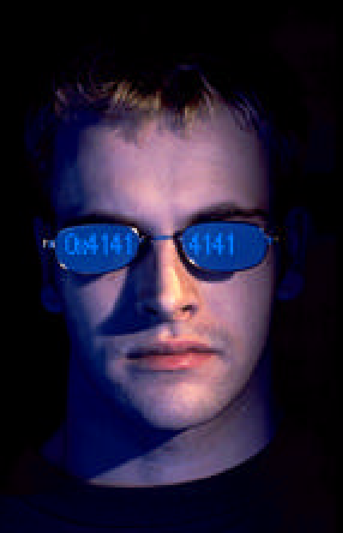
Non-Intel CPUs

- Differences from Intel to non-Intel
  - Often fixed size instructions (32bit)
  - Nicer instruction set
  - Alignment requirements
  - Different condition codes and conditional execution
  - Delayed branches
  - More registers



Exploiting other OSes

- Get a shell
- Get a debugger
- Understand the platform
  - Process management
  - Memory management
  - Privilege mechanism and granularity
- Read, but don‘t believe

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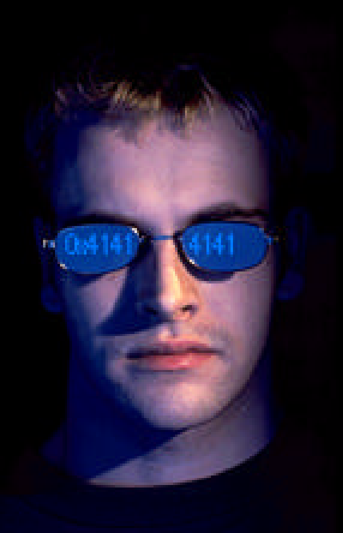
Exploiting black boxes

- Look for undocumented debugging or logging capabilities
  - Hidden functionality in shell
  - Not soldered serial port
  - JTAG interface
- Trail-and-Error will do as well
- Use illegal instructions or infinite loops as „stop“ of your code
- Interpret the results



Summary

- Read
- Think
- Do
- Have fun

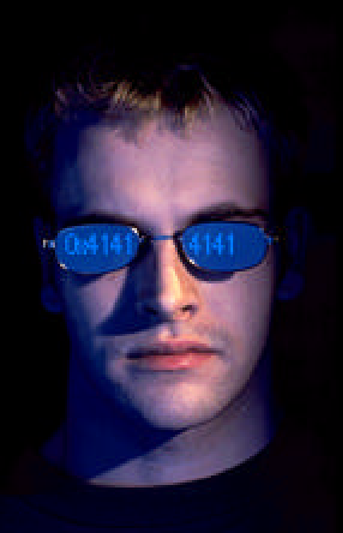
FX Halvar

Halvar‘s greetz:

Too many to list here

FX‘s greetz:

Phenoelit@home, TESO, THC, ADM, Gettohackers, all@ph-neutral, Shmoo, DEFCON goons, EEye, Rocky, HD Moore, cmn, Gera, Rocketgrl, a-few@CCC, c-base



FX Halvar