# The Darker Sides of Assembly

We've seen it.

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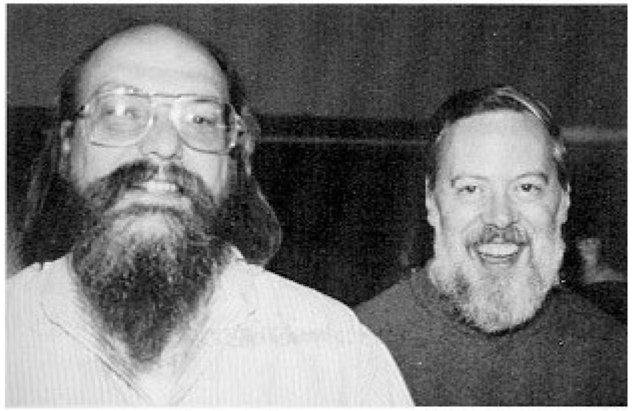
# Moments in History



Thompson's Compiler Backdoor
http://cm.bell-labs.com/who/ken/trust.html

"I am a programmer. On my 1040 form, that is what I put down as my occupation. As a programmer, I write programs. I would like to present to you the **cutest** program I ever wrote. I will do this in three stages and try to bring it together at the end."

## This Script Kitty is more cute, right?

http://www.b3tards.com/v/1f879bbd15d3273880f9/1108.jpg

## Moments in History

On November 2, 1988, Robert Morris, Jr., a graduate student in Computer Science at Cornell, wrote an experimental, self-replicating, self-propagating program called a worm and injected it into the Internet. He chose to release it from MIT, to disguise the fact that the worm came from Cornell

http://groups.csail.mit.edu/mac/classes/6.805/articles/morris-worm.html

# gets() payload in fingerd

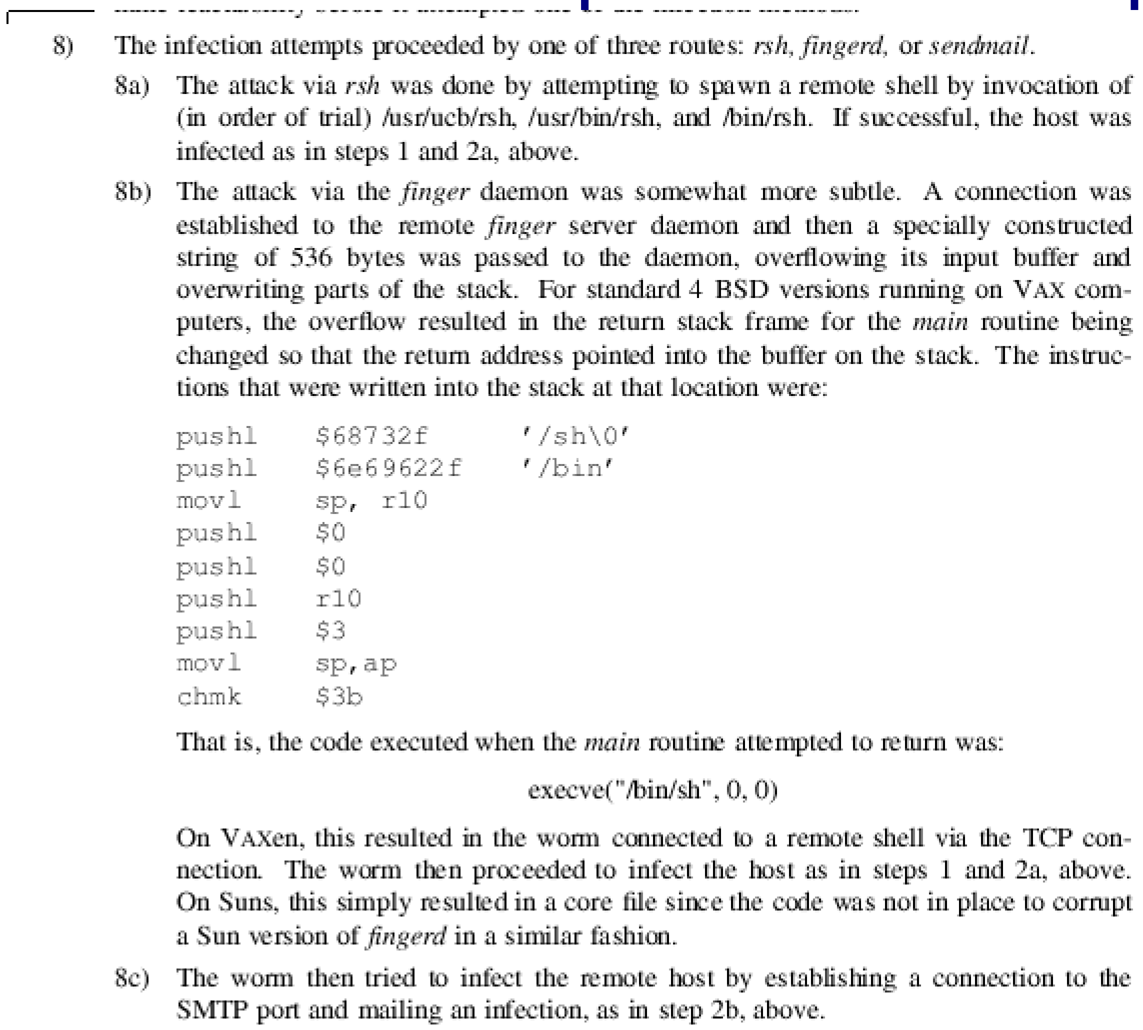
Shellcode spotlight →
Robert Morris, Jr. worm
(Spaf)

```
pushl   $68732f     '/sh\0'
pushl   $6e69622f   '/bin'
movl    sp, r10
pushl   $0
pushl   $0
pushl   r10
pushl   $3
movl    sp,ap
chmk    $3b
```

http://scrapetv.com/News/News%20Pages/Science/Images/dune-sandworm.jpg

# Spaf does it right

- Best analysis ever on The Morris Worm: http://homes.cerias.purdue.edu/~spaf/tech-reps/82



[illegible]

8) The infection attempts proceeded by one of three routes: *rsh*, *fingerd*, or *sendmail*.

8a) The attack via *rsh* was done by attempting to spawn a remote shell by invocation of (in order of trial) /usr/ucb/rsh, /usr/bin/rsh, and /bin/rsh. If successful, the host was infected as in steps 1 and 2a, above.

8b) The attack via the *finger* daemon was somewhat more subtle. A connection was established to the remote *finger* server daemon and then a specially constructed string of 536 bytes was passed to the daemon, overflowing its input buffer and overwriting parts of the stack. For standard 4 BSD versions running on VAX computers, the overflow resulted in the return stack frame for the *main* routine being changed so that the return address pointed into the buffer on the stack. The instructions that were written into the stack at that location were:

```
pushl   $68732f     '/sh\0'
pushl   $6e69622f   '/bin'
movl    sp, r10
pushl   $0
pushl   $0
pushl   r10
pushl   $3
movl    sp,ap
chmk    $3b
```

That is, the code executed when the *main* routine attempted to return was:

execve("/bin/sh", 0, 0)

On VAXen, this resulted in the worm connected to a remote shell via the TCP connection. The worm then proceeded to infect the host as in steps 1 and 2a, above. On Suns, this simply resulted in a core file since the code was not in place to corrupt a Sun version of *fingerd* in a similar fashion.

8c) The worm then tried to infect the remote host by establishing a connection to the SMTP port and mailing an infection, as in step 2b, above.

## Outline of Today's Agenda

- Moments in History
- Basic terminology
- Code injection
  - Shellcode
  - Building a virus
    - The ELF format
    - Injection Schemes
  - ? Surprise us

# Terminology

| | |
|---|---|
| Backdoor | Program allowing remote, covert access |
| Virus | Parasitic program |
| Worm | Self-propagating network-enabled program |
| Rootkit | Tools to covertly maintain high-level system access |
| Malware/Spyware | Harmful software (popups, password/CC sniffers....) |
| Botnet | MMORPG – without the RPG |

http://www.flickr.com/photos/andresrueda/2983149263/

## Code injection we care about

- Runtime Arbitrary Code Execution
  - Privileged Processes
  - Signed/Trusted Code Execution Environments
  - Remote programs
- Program File injection
- ???

# Runtime Code Injection

- Remember all those crashmes?
- Local code injection
  - Command line arguments, environment, pathname, executable interpreter flags, program data (heap,stack,...)
- Remote code injection
  - Program data

# Writing your first shellcode.

- Goal:
  - do not fork bomb anything
  - Print a message to the screen

# asm

```
BITS 32
; nasm -f elf code.asm; ld -o code.bin code.o; ./code.bin
; nasm -f bin code.asm ; ndisasm -u ./code

global _start
_start:
xor eax, eax
mov eax, 4
jmp data

back:
xor ebx, ebx
pop ecx
mov edx, 13
int 0x80

mov eax, 1
int 0x80

data:
call back
db "HI csci4971",0x0a
```

## demO

# Minimization tips

- Data is code is data is code is data is code …

  (von Neumann arch vs Harvard)
- NUL byte safe?
  - Match constants to register sizes
  - Avoid some instructions
  - Use math to get values with NUL
  - Encoder/Decoder

## Minimization Tips (II)

- Size problems?
  - Multi-staged payloads
    - Establish data transfer
    - Receive code
    - Decode it
    - Execute it
- Code crunch:
  - extra credz for shortest, self-contained d/l and execute binary code.

## No shellcode necessary

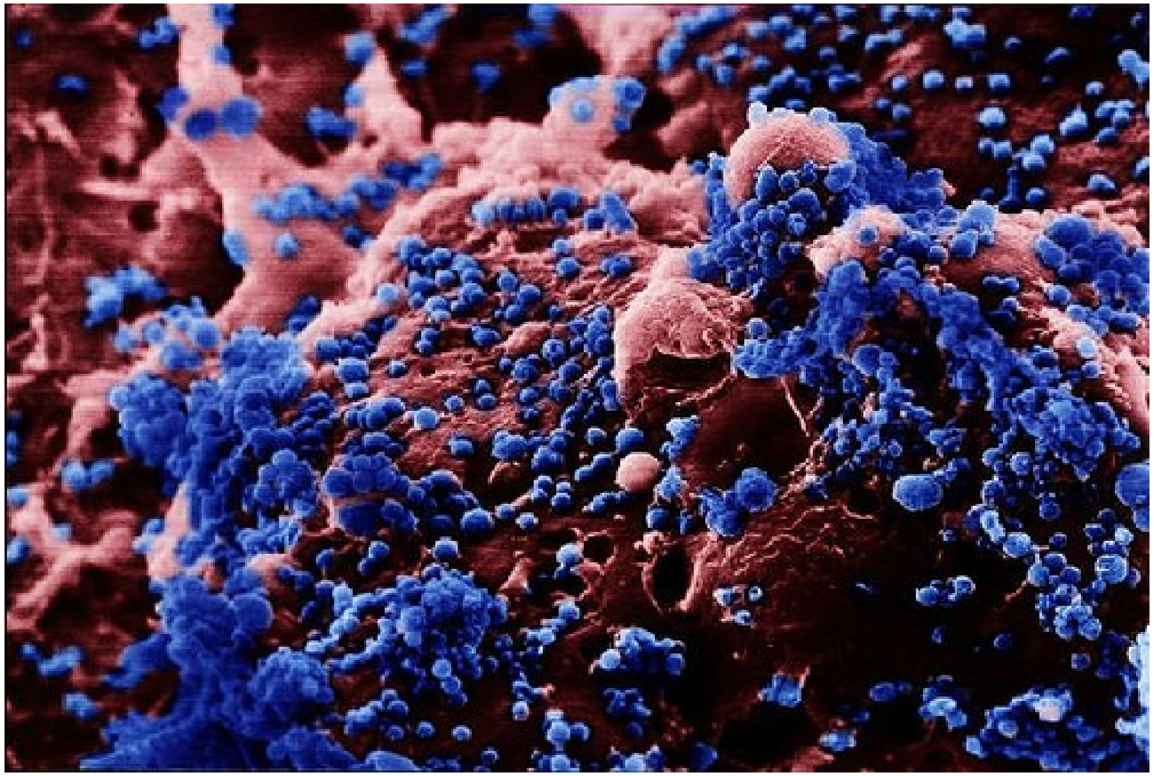
- Ret2libc
  - Solar Designer '97
  - ...

# Memory corruption can be hard, but also very easy

- Linux local bugs:
- Off-by-one on gcc4 main()
  - Truncates frame pointer by one byte
- Bypass ASLR
  - “patched up”
  - Still missing /proc/pid/stat

## Writing a Virus

- Parasitic code
  - Injects into drivers, system code files, executable programs, runtime process memory, …



http://www.flickr.com/photos/guiplash/61424646/in/photostream/

## Plan of Action

- Harmless Linux ELF Infector
    - Open a file
    - Expand size
    - Inject code
    - Update offsets
    - Save to filesystem

## Useful links

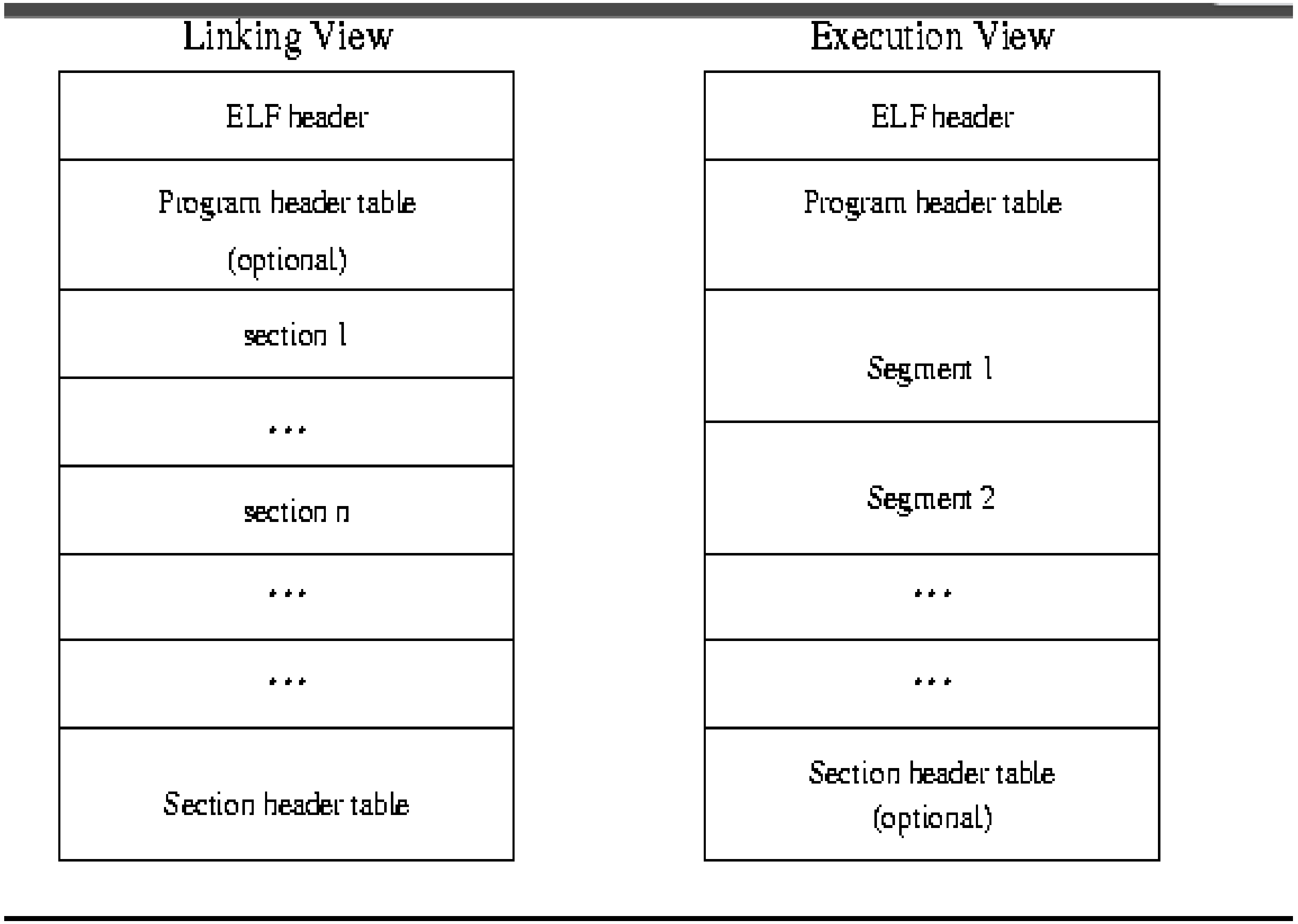
- Cesare's http://vx.netlux.org/lib/static/vdat/tuunix02.htm
- Eresi: http://www.eresi-project.org/
- http://virus.bartolich.at/virus-writing-HOWTO/_html/index.html
- http://felinemenace.org/~mercy/slides/RUXCON2004-ELFfairytale.ppt
- http://www.vx.netlux.org/lib/vrn00.html
- http://www.phrack.com/issues.html?issue=56&id=7&mode=txt
- ...

## The ELF Format

- ELF Header
  - Man 5 elf
- Program Headers
  - Runtime
- Section Headers
  - Link time
- Misc

## More useful links

- http://www.sco.com/developers/gabi/latest/contents.html
  http://www.sco.com/developers/devspecs/abi386-4.pdf



http://users.csc.calpoly.edu/~mhaungs/paper/img7.gif

# ELF Header

```
typedef struct {
    unsigned char e_ident[EI_NIDENT];
    uint16_t      e_type;
    uint16_t      e_machine;
    uint32_t      e_version;
    ElfN_Addr     e_entry;
    ElfN_Off      e_phoff;
    ElfN_Off      e_shoff;
    uint32_t      e_flags;
    uint16_t      e_ehsize;
    uint16_t      e_phentsize;
    uint16_t      e_phnum;
    uint16_t      e_shentsize;
    uint16_t      e_shnum;
    uint16_t      e_shstrndx;
} ElfN_Ehdr;
```

# Program Headers

```
typedef struct {
        uint32_t   p_type;
        Elf32_Off  p_offset;
        Elf32_Addr p_vaddr;
        Elf32_Addr p_paddr;
        uint32_t   p_filesz;
        uint32_t   p_memsz;
        uint32_t   p_flags;
        uint32_t   p_align;
    } Elf32_Phdr;
```

PT_LOAD

PT_INTERP

| | |
|---|---|
| PF_X | An executable segment. |
| PF_W | A writable segment. |
| PF_R | A readable segment. |

# Using readelf/objdump/etc

- Demo

## Some ELF File Infection strategies

- Overwrite existing code
  - Semantic nop injector (bukowski framework)
- Hijack GOT/PLT redirection
- Expand TEXT segment
- Insert new PF_X segment
- Replace Dynamic Interpreter
- Inject malicious shared object file paths

## Simple infector

- >>

## PHDR Injection

- Add a PF_X segment
- Add code
- Hijack entry point / branch

## How do you do it all in asm?

- Need self propagation
- No compiler available (Sorry Ken)

## All you need is...

- Open()
- Mmap()
- asm code

## Infector demo

# ELF Virus Detection

- Tripwire...
- Mismatched Section Headers
- Extra executable segments
- Strange shared libraries/dynamic interpreter
- Unusual entry point
  - Q: Can the entry point be outside of the TEXT segment?
- Linux AVs
- ???