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Live-Forensik: Rootkit

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Scenario

- Investigating an image of a Linux system (CentOS 5.5) infected by a rootkit
- We will use live acquisition of data to gather information on this system
  - Simulated, i.e. we will produce a local file with the output
    - In reality this should be sent by netcat (nc) to a different computer to prevent modifications of the system under investigation!
- We will use various techniques to identify the problem
- The virtual machine is a VMWare image
  - Can also be opened in Virtualbox
- Under /mnt/cdrom there is the script “investigate.sh”
  - You can run it (“/mnt/cdrom/investigate.sh >report.txt”)
- But we are going to do the same (and some elements more) manually!

ATTENTION!

- This is part of a real rootkit, however it has been slightly modified
- It is **part** of a very old rootkit, so it is not that good/well hidden and very limited
  - Note the differences in output compared to the “real” binaries!
  - It has certain limitations which renders in relatively useless on modern systems
- BUT:
  - It is still a real rootkit
  - The source code is NOT available in the image (often it would have been compiled there, so it might still exist, perhaps only in parts of deleted files)
  - The binaries may NEVER be used anywhere else!

This is SOLELY for EDUCATIONAL USE!

Elements of good toolkits for live forensics

- Minimize system impact ✓ (apart from local log file)
  - Don't copy anything to the disk, binaries as small as possible
- Enforce the use of known binaries only
  Not possible: No statically compiled files (too complicated); use files on CD-ROM image for investigation
  - Make sure that no library from the system investigated is used
- Extensive logging and checksums ✓
  - Ensuring that no later modification can occur and that verification is possible
- No drivers needed for installing (→ CD-ROM better than USB!) ✓
  - Can be difficult → Depends on the system investigated
    - If very well secured, this might be difficult (IDS tries to prevent exactly this!)
- Copies data directly to another system (→ Network/Share or USB)
  Local file (too complicated)

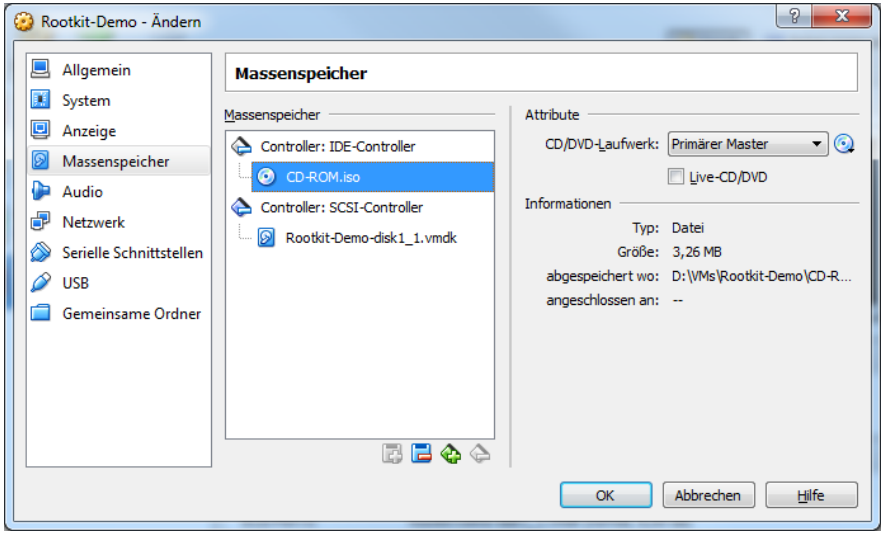
Basic information on the image

- CentOS 5.5 (=RedHat Enterprise Linux 5.5)
  - Basic/minimal installation: Commandline only (no GUI), no special applications installed
- Two users are available:
  - Username “user”, Password “user” (Normal user, no special permissions)
  - Username “root”, Password “root” (Administrator)
- Keyboard: German, but “\” is “shift-ü”
- Investigative tools: /mnt/cdrom/bin (needs to be mounted first!)
  - Perhaps useful: “export PATH=/mnt/cdrom/bin” to ensure to run only “our” programs
    - Note: Libraries will still be loaded from system; the tools are not statically compiled!

The image will be distributed in the class on DVDs/memory stick and can be downloaded from the website (Password for ZIP is disclosed in class)!

Importing the image

- Import the image from the DVD / Memory stick / download directory
- This image is the “original” system
- The forensic tools (not statically compiled; see previous slide) are located on an “external” CD-ROM: CD-ROM.iso
- Necessary process:
  - Import the virtual machine
  - Configure the virtual machine to use the CD image as the CD drive (see →)
  - Start the virtual machine
  - Mount the CD image:
    “mount /dev/cdrom /mnt/cdrom”



What we are not investigating here

- Copying RAM content
  - Difficult to do, investigation is very difficult and out of scope here!
- DNS cache
  - Not interesting here; problematic because of fixed file location
- No recovering deleted files still in use
  - The rootkit doesn't use such files

Basic information

- Generally: Try both commands - from “/mnt/cdrom/bin” as well as from the system - and compare both results!
- Date & time: “date”, “date –u”
  - Documenting the start of the investigation (incl. timezone)
- System: “hostname”, “uname –a”, “whoami”, “id”
  - Where are we? What kind of system is this? Who are we? (Last two not on "CD"!)
- Patch level: “rpm –qa”
  - Normally very late, as this is unlikely to change during the investigation!
- Uptime, logged in users: “w”, “who”
  - Are we alone (logins form network!)?
- Last logged in users: “last –a –i”
  - Including from where they logged in (here not interesting, but in general useful!)

IP/firewall information

- IP addresses: "ip addr"
  - Nothing special: localhost, IPv4 connection
  - sit0: Tunnel for IPV6 → IPv4
- IP devices: "ip link" and IP tunnels: "ip tunnel" show the same information
  - Take note of IP address/subnet → Might be necessary for "nc" (not used here)!
- Firewall configuration (iptables = standard on Linux)
  - "iptables-save":
    - Outgoing: No restrictions
    - Input and forwarding: A few default rules
      - Allowed: Local connections, ICMP (=pinging+…), ESP/AH: IPSec connections, UDP/224.0.0.251/5353 (Zeroconf/Multicast DNS), Port 631 (Internet Printing Protocol) Port 22 (SSH)

Network information

- ARP cache: “ip neigh show”
  - Useless here, as this system probably hasn’t connected anywhere
    - Note: Updates, software installation … might show some other systems
    - Depends also on the kind of network integration of the virtualization environment
- Routing table: “ip route show table all”
  - Current routes (here not very interesting)
- Routing cache: “ip route show cached”
  - Previous routes (here not very interesting)

Process information

- Processes: “ps aux”
  - Please take care: Which “ps” are your executing?
    - “/mnt/cdrom/bin/ps” or “/bin/ps” ?
  - Try both and compare them: What is strange?
    - Visual differences? Yes!
    - Content differences? Difficult because of the visual differences
      - We will come back to this later!
    - Count lines: “ps aux | wc –l” and “/mnt/cdrom/bin/ps aux | wc –l”
      - But: Perhaps the problem is not “ps” but “wc”? We don’t know yet!
        - Which wc did you use ☺?
        - Try “/mnt/cdrom/bin/ps aux | /mnt/cdrom/bin/wc –l”
- Anyway, we have found the first strange result!

Processes/ports (1)

- Listening: “netstat –an”
  - Three ports are open for listening:
    - UDP Port 68: BootP/DHCP (Waiting for info from DHCP server)
      - Does seem normal (depends on configuration!)
      - “cat /etc/sysconfig/network-scripts/ifcfg-eth0” → DHCP is really used/on
    - TCP Port 22: SSH server →Very common to be open on most systems!
      - Especially on commandline systems (otherwise: only console or telnet!)
      - Is a SSH server running? “ps aux | grep ssh”
        - Yes: /usr/sbin/sshd
        - Is this a “real” SSH server (or trojaned → Logging entered passwords)?

          Who knows, we would have to investigate more and in detail!

Processes/ports (2)

- Also open: Port 12345
  - This is a rather strange port: It is above 1024 and so should be a normal application
    - But no such application seems to be running?
  - What does Google say about port 12345?
    - Legitimate: NetBus remote administration tool for Windows
    - Often used for trojans, …
  - This looks very suspicious!
- But: We cannot get any more information out of this listing
  - So we keep it in memory and try to find out more!
    - Or use "netstat –anp"!

http://www.speedguide.net/port.php?port=12345

Open files/ports/…

- Showing all kinds of handles: “lsof –nP”
  - Attention: Very long output!
- So let’ focus a bit: “lsof –nP | grep 12345”
  - So this is the HTTP server running there! That looks a bit strange ….
  - Check whether such a server is really installed (init scripts/rpm are good starts!)
- What else is going on there: “lsof –nP | grep httpd”
  - It is running from the executable ”/usr/bin/httpd” and uses solely the C library
    - Plus the linux loader
  - It doesn’t have any other files open (try repeatedly) beside StdIn/StdOut/StdErr

Remote shell

- Try telneting there: “telnet localhost 12345” and “GET / HTTP/1.0<Ret><Ret>”
  - Doesn’t seem to be a webserver …
  - Try “ls –al;”
- This is a remote shell: If you can telnet there (firewalls!), you can issue any command, which will be executed as root
  - Note: Must be terminated by “;”, always returns an error message (low quality SW!)
  - Exiting the shell: “exit;”
- This is the first part of the rootkit!
- Try at home: Find out how it is started on boot
  - Hint: Check all kinds of init scripts!
- Note: Would this really be a problem here (=reachable from outside?)
  - Hint: See slides before ("iptables-save"!)

Back to ps

- Does “ps” show this program?
  - “ps aux | grep httpd” → No, but it should
- Does “/mnt/cdrom/bin/ps” show this program?
  - Yes it does!
- Result: “/bin/ps” doesn’t work quite all right, it probably was modified (“trojaned”)
  - We cannot trust its output any more

Checking file date/time

- We know the file “/bin/ps” has been modified - Can we find out the date/time?
- Date/times of a file: “stat /bin/ps” (Access omitted from output)
  - Modify: 31.3.2010 6:53
  - Change: 4.11.2011 13:59
- Compare this to the original date/times
    - How would we get at this? Install a “new” one in a virtual machine and check!
  - Modify: 31.3.2010 6:53
  - Change: 4.7.2010 5:42
- Result: The modification date seems to have been copied, but the change date is incorrect → The intrusion probably occurred on 4.11.2011 at about 14 o’clock
  - The rootkit installation program doesn’t work correctly regarding this!

Other information (OS, file system …)

- Kernel modules: “lsmod” and packages “rpm –qa”
  - Not very interesting here
- Mounted file systems: “mount –l”
  - Nothing mounted here apart from the system ones
- Free space: “df –k”
  - Not interesting here
- Scheduled jobs: “atq” → Nothing to show here
- System load: “top –bn 1”
  - Note: “httpd” is shown here → The rootkit doesn’t modify this commands’ output!

Checking the date of the intrusion

- Whet else happened on the system on 4.11.2011 13:59 (change time)?
- One possibility:

  “/mnt/cdrom/bin/find / -printf “%p;%Cx;%CT\n” | grep “11/04/2011;13:”

  — Why not the exact date? We don’t know whether this was the first or last action!

  — Too many results → we can still narrow it down!
- Also changed at about that time (apart from the directories they are in):

  — /bin/ps, /usr/bin/httpd: We already know them!

  — /bin/ls: That’s new! So some files seem to be hidden as well …

  — /usr/bin/chsh: That’s new!

  — Several other files (prelink-related, mails, yum cache, …)

    - Yum might potentially be interesting: Update check or who/what was installed?

/bin/ls: Hidden files

- Compare the output from our “find” commando to “ls” for the root directory
  - In practice this would be done by producing a full dump and automatic comparison
    - “Our” find and the one from the system itself
  - Here just use “ls -al /” and “find / -maxdepth 1”
- Result: “ls” has been “hacked” as it hides a directory otherwise existing!
  - Compare to previous slide – the suspicion there has been confirmed!
- There exists the directory “/rk” which shows up in “find” but not in “ls”
  - Check out its contents!

Rootkit files

- Now we find a different date: 3.11.2011 16:40
  - This could have been the time of the initial intrusion
- Check out the individual files
  - Find out what “fix” is for!
    - Try “strings fix” for a first view
  - Try to identify the content of the “backup” folder
  - What is “ptyp” and “ptyr” there for?
    - What can we learn from its content?
    - These are extremely important files: They show what is hidden!

What is “chsh”?

- Command to change the current/login shell
  - SetUID, modifies /etc/passwd → Very high permissions anyway
  - Main reason for trojans: If you get in as some user, you can become root through this
    - Drawback: You need the root password (NOT in trojaned versions!)
- This version has been modified, but how?
  - Try “strings chsh |more” → Can you see anything interesting?
  - No, the interesting parts (i.e. the “secret password”) has been hidden
    - Not that well, but good enough for this simple approach
  - Try the password (see next slide or the file README) – how is it to be used?
    - Enter it instead of a shell name and you receive a root shell
    - So to really test it, log in as “user” (check your rights with the command “id”)!

Rootkit password – Source code

- /* ROOTKIT_PASSWORD must be 6 letters due to my lame attempts at string hiding... */

  #define ROOTKIT_PASSWORD "rkdemo"

- char MAG[6];

  strcpy(MAG,"");

  MAG[0]=ROOTKIT_PASSWORD[0]; MAG[1]=ROOTKIT_PASSWORD[1];

  MAG[2]=ROOTKIT_PASSWORD[2]; MAG[3]=ROOTKIT_PASSWORD[3];

  MAG[4]=ROOTKIT_PASSWORD[4]; MAG[5]=ROOTKIT_PASSWORD[5];

  MAG[6]='\0';

- Password is stored in executable as separate characters
  - If you know this, you can see it clearly in the output of “strings chsh” as well!
- Practice: Deassembly/Decompilation or Debugging

Conclusions (1)

- Generally the investigation would be more difficult,
  - especially for files:
    - Using external tools and producing a log
    - Using the internal tools and producing a log
    - Comparing those files in a spreadsheet/diff/…
    - Find out date/time of files at the time of intrusion (if known …)
  - and binaries:
    - Install a “new” version in a virtual machine
    - Bring it to exactly the same patch level/software
    - Compare md5 values of files in both VMs to find out which ones were modified
      - Reinstall might be easier!

Conclusions (2)

- What we didn't find out:
  - How the intrusion took place
    - When it took place → We have only some hints, but which are quite good
  - What the attacker was after (but: no interesting content here anyway ☺)
  - Complete list of changes: Have we really found everything?
    - Probably yes, but some parts might also have been hidden better!

Thank you for your attention!

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