Memory Forensic using Rekall

Abstract

The usage of the Rekall framework gives an insight to a style of memory analysis unlike its predecessors. It allows users to analyze the effects of malware in live time. The memory forensic report encompasses three malware, Coreflood, R2D2, and Cridex. Usage of volatility based framework Rekall is a potent tool. This paper provides critical analysis of three dangerous malware, surveys the tool of memory forensics and provides insight of malware's intricacy.

Table of Contents

Rekall Installation Guide

Windows:

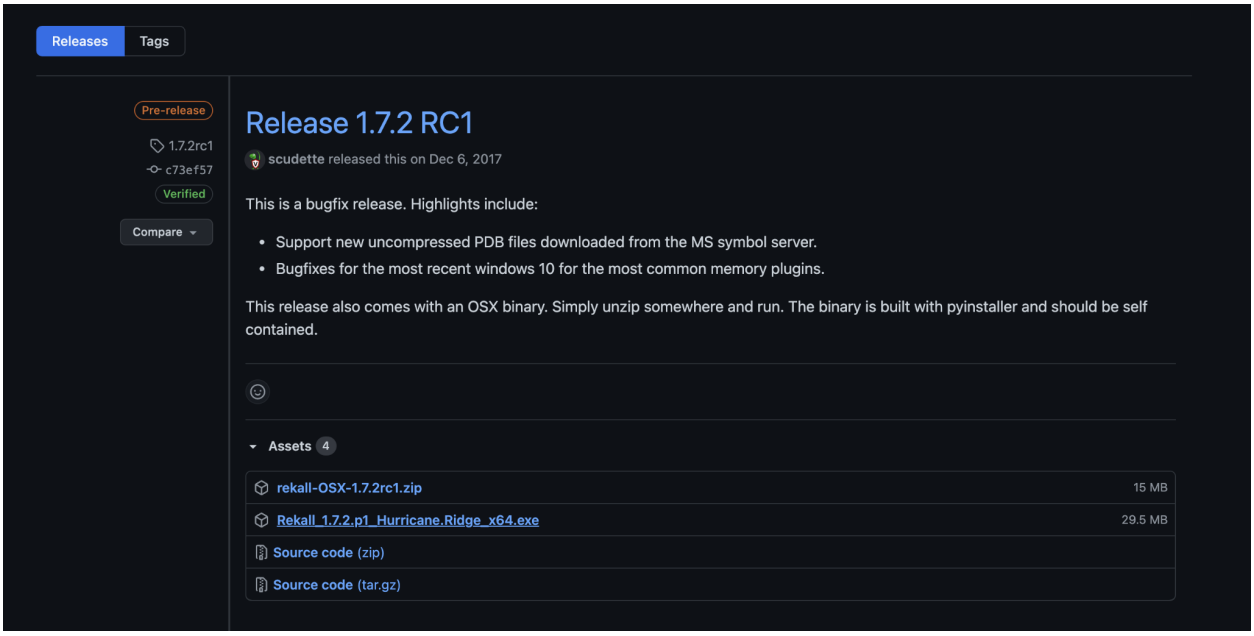
1. Make sure you have python downloaded. Preferably Python 3.6 or below
    a. Link: https://www.python.org/downloads/release/python-360/

2. Your Python should have installed pip as well.

3. If for some reason, you do not have pip, install pip by
    a. Open CMD, type in "curl https://bootstrap.pypa.io/get-pip.py -o get-pip.py"
    b. Once its done, type in "python get-pip.py"

4. Go to https://github.com/google/rekall/releases

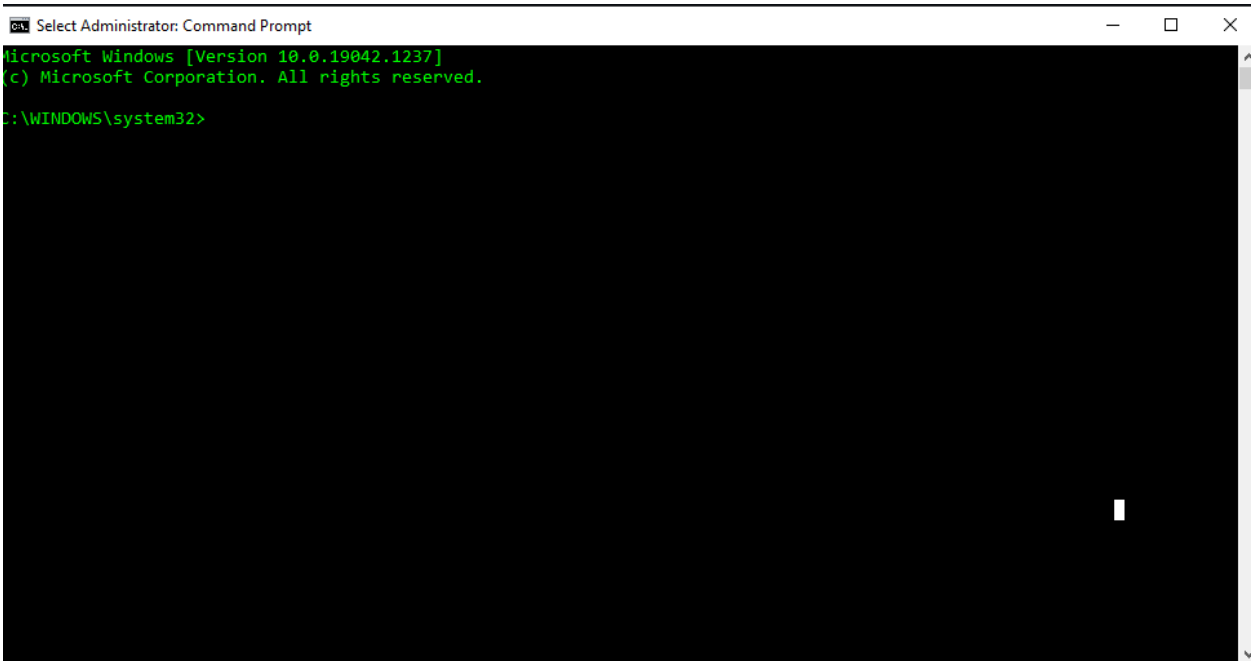
5. Click the drop down menu on “Assets”



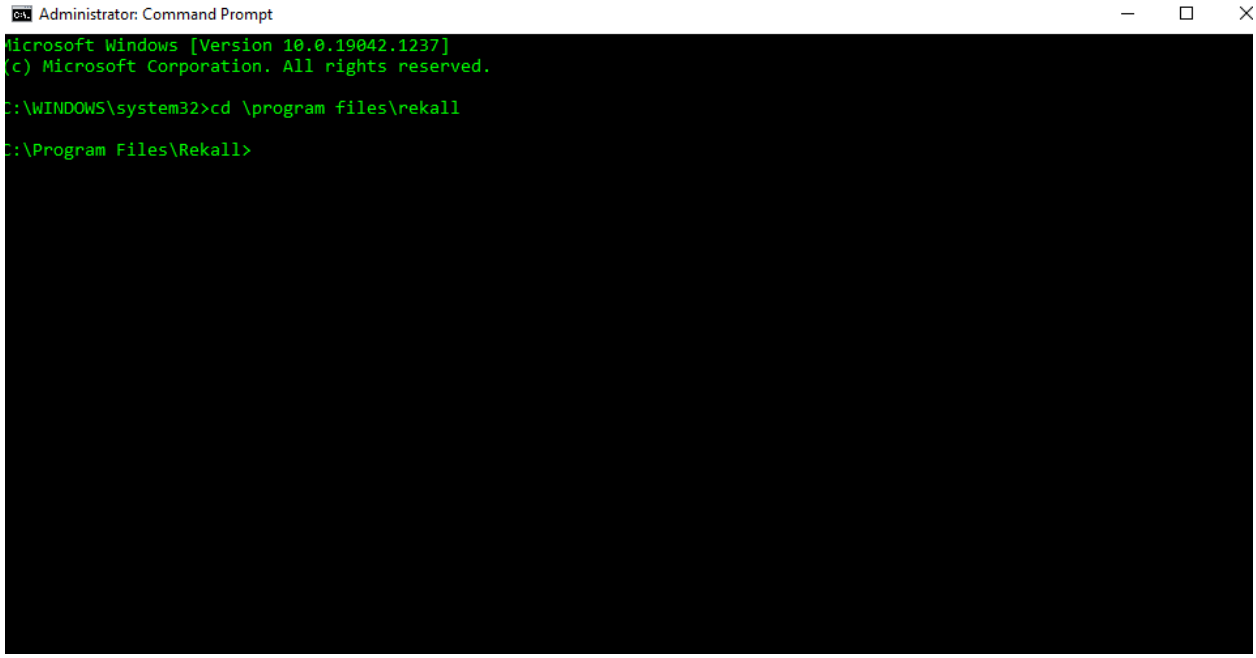
6. Install “Rekall_1.7.2.p1_Hurricane.Ridge_x64.exe”

7. Run through the installation process.
   a. If it lets you choose the download destination, download it under C:\Program Files. NOT C:\Program Files(x86)

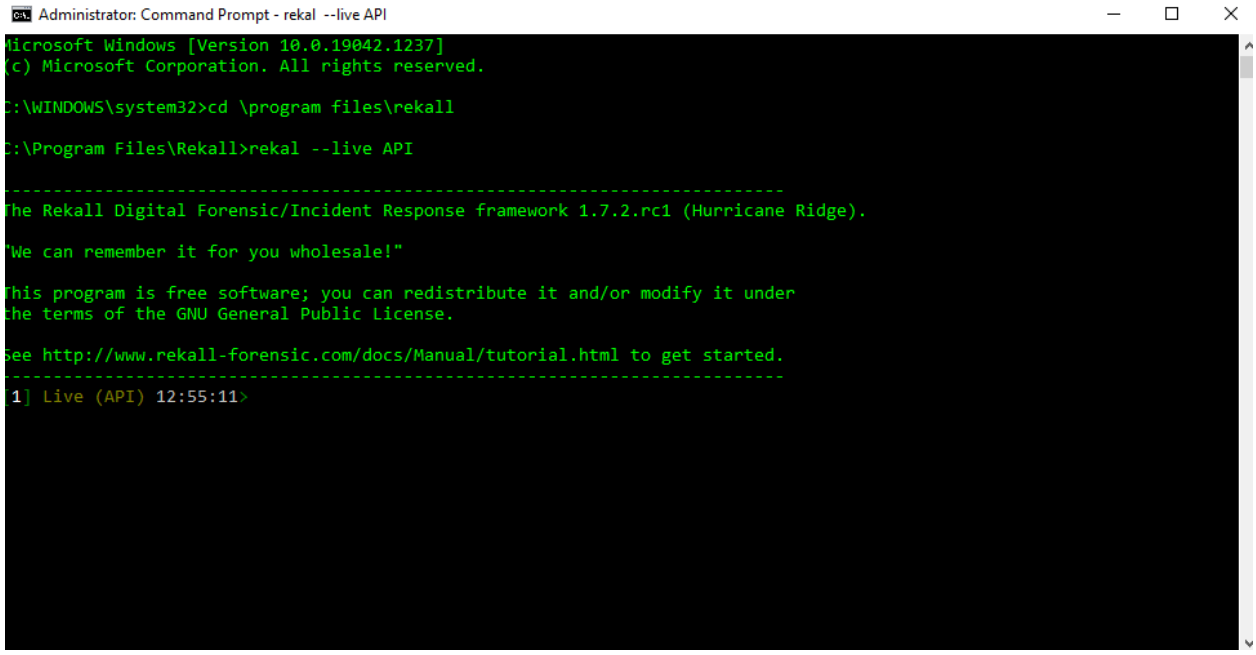
8. Open up your CMD in administrator mode.



9. Type in cd \Program Files\Rekall



10. Type rekal --live API (make sure API is all capital letters)



Initial Failure Documentation

Based on the Rekall official documentation and other sources, they seem to grab a .dmp, .img or .aff4 file to analyze.

Winpmem is required to acquire memory images.

There are multiple versions of Winpmem floating around on the internet. For example, “winpmem_2.0.1”, “winpmem_v3.3.rc3”, “winpmem_mini_x64_rc2.exe”, and “winpmem-2.1.post4.exe”.

Environment Sidenote

- Rekall is located under C:\Program Files\Rekall
- All of the different versions of winpmem is downloaded under C:\Program Files
- All commands are run under administrator privileges

Winpmem_2.0.1

Displaying -h output

Administrator: Command Prompt

```
Microsoft Windows [Version 10.0.19042.1288]
(c) Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>cd c:\program files

c:\Program Files>winpmem_2.0.1.exe -h

USAGE:

   winpmem_2.0.1.exe  [-l] [-u] [--write-mode] [--mode <MmMapIoSpace,
                      PhysicalMemory, PTERemapping>] [--driver <Path to
                      driver.>] [--elf] [-m] [-p </path/to/pagefile>] ...
                      [-V] [-d] [-v] [-t] [-i </path/to/file/or/device>]
                      ...  [--category <string>] [-e <string>] [-o
                      </path/to/file>] [-c <zlib, snappy, none>] [--]
                      [--version] [-h] </path/to/aff4/volume> ...


Where:

   -l,  --load-driver
     Load the driver and exit

   -u,  --unload-driver
     Unload the driver and exit

   --write-mode
     Enable write mode. You must have the driver compiled with write
     support and be on a system with test signing enabled.
```

Attempt to create .aff4 file: Fail

Administrator: Command Prompt

```
c:\Program Files>winpmem_2.0.1.exe -o output.aff4
Driver Unloaded.
E1107 10:23:13.520354 18160 win_pmem.cc:594] Error: StartService(), Cannot start the driver:A device attached to the sys
tem is not functioning.
E1107 10:23:13.520354 18160 pmem_imager.cc:165] Imaging failed with error: -8
```

Attempt to load the driver: Fail

Administrator: Command Prompt

```
c:\Program Files>winpmem_2.0.1.exe -l
Driver Unloaded.
E1107 10:25:00.424062 18140 win_pmem.cc:594] Error: StartService(), Cannot start the driver:A device attached to the sys
tem is not functioning.
E1107 10:25:00.424062 18140 pmem_imager.cc:165] Imaging failed with error: -8

c:\Program Files>
```

Attempt to unload the driver: Success

Administrator: Command Prompt

```
c:\Program Files>winpmem_2.0.1.exe -u
Driver Unloaded.
```

winpmem_v3.3.rc3

Displaying -h output

Administrator: Command Prompt

```
(c) Microsoft Corporation. All rights reserved.

C:\WINDOWS\system32>cd c:\program files

c:\Program Files>winpmem_v3.3.rc3.exe -h

USAGE:

   winpmem_v3.3.rc3.exe  [-L] [-U] [--write-mode] [--mode <MmMapIoSpace,
                         PhysicalMemory, PTERemapping>] [--driver <Path to
                         driver.>] [--format <map, elf, raw>]
                         [--volume_format <aff4, raw>] [-m] [-p
                         </path/to/pagefile>] ...  [-V] [-l] [-d] ...  [-v]
                         [-t] [-i </path/to/file/or/device>] ...
                         [--relative] [-e <string>] [--logfile <string>]
                         [-D <path to directory>] [-o </path/to/file>] [-s
                         <Size (E.g. 100Mb)>] [-c <deflate, zlib, snappy,
                         lz4, none>] [--threads <(default 2)>] [--]
                         [--version] [-h] </path/to/aff4/volume> ...


Where:

   -L,  --load-driver
     Load the driver and exit

   -U,  --unload-driver
     Unload the driver and exit

   --write-mode
     Enable write mode. You must have the driver compiled with write
     support and be on a system with test signing enabled.

   --mode <MmMapIoSpace, PhysicalMemory, PTERemapping>
     Select the acquisition mode. Default is PTERemapping.

   --driver <Path to driver.>
     Use this driver instead of the included one. This option is rarely
     used.

   --format <map, elf, raw>
     Specify the output format of memory streams:
```

Attempt to create .aff4 file: Fail

```
c:\Program Files>winpmem_v3.3.rc3.exe -o output.aff4
2021-11-07 10:31:43 E Error: StartService(), Cannot start the driver: A device attached to the system is not functioning
.

2021-11-07 10:31:43 E Error: StartService(), Cannot start the driver: A device attached to the system is not functioning
.

IO_ERROR: at win_pmem.cc: 695
2021-11-07 10:31:43 E Imaging failed with error: IO_ERROR
```

Attempt to load the driver: Fail

```
Administrator: Command Prompt

c:\Program Files>winpmem_v3.3.rc3.exe --load-driver
2021-11-07 10:32:36 E Error: StartService(), Cannot start the driver: A device attached to the system is not functioning
.

2021-11-07 10:32:36 E Error: StartService(), Cannot start the driver: A device attached to the system is not functioning
.

IO_ERROR: at win_pmem.cc: 695
2021-11-07 10:32:36 E Imaging failed with error: IO_ERROR
```

Attempt to unload the driver: Fail

```
Administrator: Command Prompt

c:\Program Files>winpmem_v3.3.rc3.exe -U
```

winpmem_mini_x64_rc2.exe

Displaying -h output

Administrator: Command Prompt

```
C:\WINDOWS\system32>cd c:\program files

c:\Program Files>winpmem_mini_x64_rc2.exe -h
WinPmem64
Winpmem - A memory imager for windows.
Copyright Michael Cohen (scudette@gmail.com) 2012-2014.

Version 2.0.1 Oct 13 2020
Usage:
  winpmem_mini_x64_rc2.exe [option] [output path]

Option:
  -l    Load the driver and exit.
  -u    Unload the driver and exit.
  -d [filename]
        Extract driver to this file (Default use random name).
  -h    Display this help.
  -w    Turn on write mode.
  -0    Use MmMapIoSpace method.
  -1    Use \\Device\PhysicalMemory method (Default for 32bit OS).
  -2    Use PTE remapping (AMD64 only - Default for 64bit OS).

NOTE: an output filename of - will write the image to STDOUT.

Examples:
winpmem_mini_x64_rc2.exe physmem.raw
Writes an image to physmem.raw
```

Attempt to create .aff4 file: Fail

Administrator: Command Prompt

```
c:\Program Files>winpmem_mini_x64_rc2.exe -o output.aff4
WinPmem64
Winpmem - A memory imager for windows.
Copyright Michael Cohen (scudette@gmail.com) 2012-2014.

Version 2.0.1 Oct 13 2020
Usage:
  winpmem_mini_x64_rc2.exe [option] [output path]

Option:
  -l    Load the driver and exit.
  -u    Unload the driver and exit.
  -d [filename]
        Extract driver to this file (Default use random name).
  -h    Display this help.
  -w    Turn on write mode.
  -0    Use MmMapIoSpace method.
  -1    Use \\Device\PhysicalMemory method (Default for 32bit OS).
  -2    Use PTE remapping (AMD64 only - Default for 64bit OS).

NOTE: an output filename of - will write the image to STDOUT.

Examples:
winpmem_mini_x64_rc2.exe physmem.raw
Writes an image to physmem.raw
```

Administrator: Command Prompt

```
c:\Program Files>winpmem_mini_x64_rc2.exe -l
WinPmem64
Extracting driver to C:\Users\KICHAN~1\AppData\Local\Temp\pmeE8E9.tmp
Driver Unloaded.
Loaded Driver C:\Users\KICHAN~1\AppData\Local\Temp\pmeE8E9.tmp.
Deleting C:\Users\KICHAN~1\AppData\Local\Temp\pmeE8E9.tmp
```

Attempt to unload the driver: Success

Administrator: Command Prompt

```
c:\Program Files>winpmem_mini_x64_rc2.exe -u
WinPmem64
Driver Unloaded.
```

Attempt to create .raw file: Success

```
c:\Program Files>winpmem_mini_x64_rc2.exe physmem.raw
WinPmem64
Extracting driver to C:\Users\KICHAN~1\AppData\Local\Temp\pmeBC13.tmp
Driver Unloaded.
Loaded Driver C:\Users\KICHAN~1\AppData\Local\Temp\pmeBC13.tmp.
Deleting C:\Users\KICHAN~1\AppData\Local\Temp\pmeBC13.tmp
The system time is: 16:41:48
Will generate a RAW image
 - buffer_size_: 0x1000
CR3: 0x00001AD002
 7 memory ranges:
Start 0x00001000 - Length 0x00057000
Start 0x00059000 - Length 0x00046000
Start 0x00100000 - Length 0xA22F1000
Start 0xA23F3000 - Length 0x06ED6000
Start 0xA9611000 - Length 0x00170000
Start 0xAAEFF000 - Length 0x00001000
Start 0x100000000 - Length 0x34F000000
max_physical_memory_ 0x44f000000
Acquitision mode PTE Remapping
Padding from 0x00000000 to 0x00001000
pad
 - length: 0x1000

00% 0x00000000 .
copy_memory
 - start: 0x1000
 - end: 0x58000
```

…

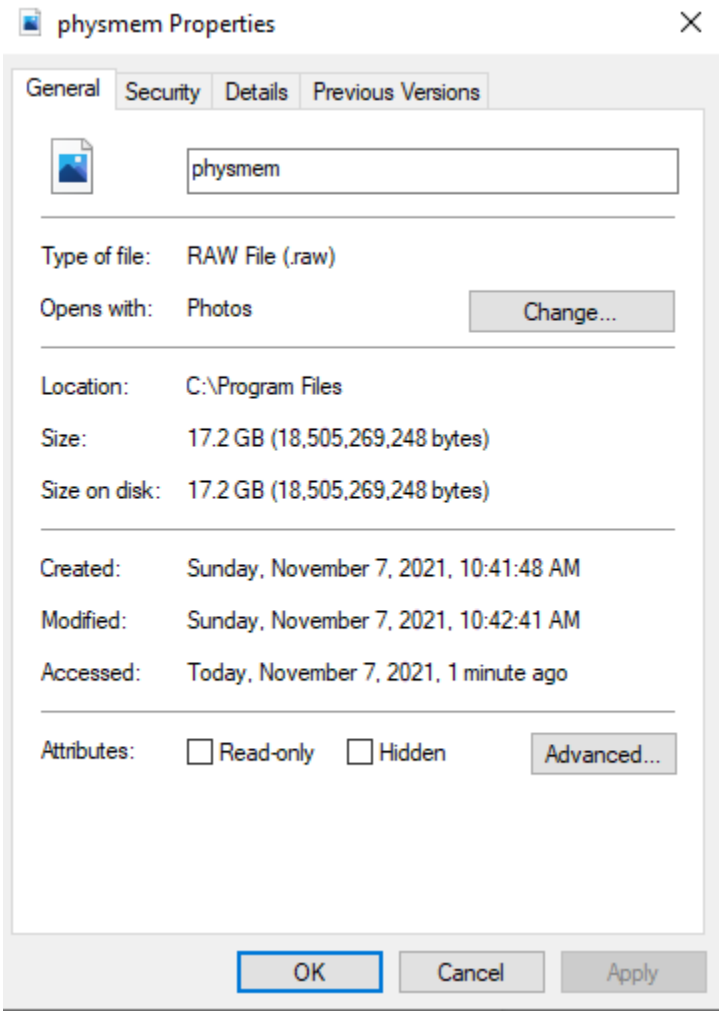
Administrator: Command Prompt

```
Padding from 0xAAF00000 to 0x100000000
pad
 - length: 0x55100000

15% 0xAAF00000 ..................................................
15% 0xAAF00000 ....................................
copy_memory
 - start: 0x100000000
 - end: 0x44f000000

23% 0x100000000 .................xxx..............................
27% 0x132000000 ..................................................
32% 0x164000000 ..................................................
36% 0x196000000 ..................................................
41% 0x1C8000000 ..................................................
45% 0x1FA000000 ..................................................
50% 0x22C000000 ...............x..................................
54% 0x25E000000 ..................................................
59% 0x290000000 ..................................................
54% 0x2C2000000 ..................................................
58% 0x2F4000000 ..................................................
73% 0x326000000 ...............x..................................
77% 0x358000000 ..................................................
82% 0x38A000000 ..................................................
86% 0x3BC000000 ..................................................
91% 0x3EE000000 ..................................................
95% 0x420000000 ......................................x......
The system time is: 16:42:41
Driver Unloaded.
```

Output file of physmem.raw has been created under C:\Program Files



Attempting to analyze physmem.raw with rekall threw back an error because it couldn't find the path of physmem.raw. I moved the physmem.raw file inside of the rekall folder.

Outcome: Partial Success
I ran Rekal -f physmem.raw then netstat then pslist

Administrator: Command Prompt - rekal -f physmem.raw

```
:\Program Files\Rekall>rekal -f physmem.raw

------------------------------------------------------------------------------
he Rekall Digital Forensic/Incident Response framework 1.7.2.rc1 (Hurricane Ridge).

We can remember it for you wholesale!"

his program is free software; you can redistribute it and/or modify it under
he terms of the GNU General Public License.

ee http://www.rekall-forensic.com/docs/Manual/tutorial.html to get started.
------------------------------------------------------------------------------
1] physmem.raw 10:46:08> netstat
021-11-07 10:46:09,598:WARNING:rekall.1:Inventory for repository "http://profiles.rekall-forensic.com" seems malformed.
Are you behind a captive portal or proxy? If this is a custom repository, did you forget to create an inventory? You mu
t use the tools/profiles/build_profile_repo.py tool with the --inventory flag.
021-11-07 10:46:09,599:WARNING:rekall.1:Repository http://profiles.rekall-forensic.com will be disabled.
------------------------> netstat()400000 (0xa00000)
021-11-07 10:48:32,788:CRITICAL:rekall.1:Traceback (most recent call last):
  File "rekall-core\rekall\session.py", line 866, in RunPlugin
  File "rekall-core\rekall\session.py", line 925, in _GetPluginObj
  File "rekall-core\rekall\obj.py", line 153, in __call__
  File "rekall-lib\rekall_lib\registry.py", line 96, in __call__
  File "rekall-core\rekall\plugins\overlays\windows\tcpip_vtypes.py", line 742, in __init__
ttributeError: 'NoneType' object has no attribute 'profile'

---------------------------------------------------------------------------
ttributeError                             Traceback (most recent call last)
ipython-input-1-5c1889516dcf> in <module>()
---> 1 netstat()

:\Program Files\Rekall\rekall\obj.pyc in __call__(self, *args, **kwargs)

:\Program Files\Rekall\rekall\session.pyc in RunPlugin(self, plugin_obj, *args, **kwargs)

:\Program Files\Rekall\rekall\session.pyc in RunPlugin(self, plugin_obj, *args, **kwargs)

:\Program Files\Rekall\rekall\session.pyc in _GetPluginObj(self, plugin_obj, *args, **kwargs)
```

Pslist returned the correct form but no live processors

Administrator: Command Prompt - rekal -f physmem.raw

```
AttributeError: 'NoneType' object has no attribute 'profile'
[1] physmem.raw 10:49:46> pslist
------------------------> pslist()
  _EPROCESS            name          pid   ppid  thread_count handle_count session_id wow64    process_create_time
 process_exit_time
------------- -------------------- ----- ------ ------------ ------------ ---------- ------ ----------------------- --
---------------------
Out<10:49:46> Plugin: pslist (WinPsList)
[1] physmem.raw 10:49:46>
```

winpmem-2.1.post4.exe

Displaying -h output

Administrator: Command Prompt

```
:\WINDOWS\system32>cd c:\program files

:\Program Files>winpmem-2.1.post4.exe -h

SAGE:

  winpmem-2.1.post4.exe  [-l] [-u] [--write-mode] [--mode <MmMapIoSpace,
                         PhysicalMemory, PTERemapping>] [--driver <Path to
                         driver.>] [--format <map, elf, raw>] [-m] [-p
                         </path/to/pagefile>] ...  [-V] [-d] [-v] [-t] [-i
                         </path/to/file/or/device>] ...  [-e <string>] [-o
                         </path/to/file>] [-c <zlib, snappy, none>] [--]
                         [--version] [-h] </path/to/aff4/volume> ...


here:

  -l,  --load-driver
    Load the driver and exit

  -u,  --unload-driver
    Unload the driver and exit

  --write-mode
    Enable write mode. You must have the driver compiled with write
    support and be on a system with test signing enabled.

  --mode <MmMapIoSpace, PhysicalMemory, PTERemapping>
    Select the acquisition mode. Default is PTERemapping.

  --driver <Path to driver.>
    Use this driver instead of the included one. This option is rarely
    used.

  --format <map, elf, raw>
    Specify the output format of memory streams:

    map: An AFF4Map object (Supports compression and sparse).

    elf: An ELF stream. (Supports sparse image).

    raw: A raw padded stream. (Padded with no compression).

    If this option is used together with the --export option it specifies
    the output format of the exported stream.
```

Attempt to create .aff4 file: Fail

```
c:\Program Files>winpmem-2.1.post4.exe -o output.aff4
Driver Unloaded.
E1107 11:00:50.506300  2028 win_pmem.cc:507] Error: StartService(), Cannot start the driver:A device attached to the sys
tem is not functioning.
E1107 11:00:50.506300  2028 pmem_imager.cc:328] Imaging failed with error: -8
```

Attempt to load the driver: Fail

Administrator: Command Prompt

```
c:\Program Files>winpmem-2.1.post4.exe -l
Driver Unloaded.
E1107 11:01:18.272374 18856 win_pmem.cc:507] Error: StartService(), Cannot start the driver:A device attached to the sys
tem is not functioning.
E1107 11:01:18.272374 18856 pmem_imager.cc:328] Imaging failed with error: -8
```

Attempt to unload the driver: Success

Administrator: Command Prompt

```
c:\Program Files>winpmem-2.1.post4.exe -u
Driver Unloaded.
```

Background Information

Rekall is an advanced forensic and incident response framework. While it began life purely as a memory forensic framework, it has now evolved into a complete platform. Rekall implements the most advanced analysis techniques in the field, while still being developed in the open, with a free and open source license.
The Rekall framework is plugin based. This is what makes it so extensible. Developers can add many different plugins to implement different analysis techniques and produce different data.

Single Command Example:

>Rekal -f test.aff4 pslist

Starting an Interactive Session:

>rekal -f test.aff4

Starting an Interactive Session(sends output to specified tool):

>rekal -f test.aff4 --pager=gedit

Key Definitions

Pslist: list all the processes on windows using a variety of methods. Since it is required by all plugins which have process selectors, this plugin will, by default, list processes using all methods.

Psxview: Find hidden processes with various process listings

Pstree: Shows the parent/child relationship between processes. This plugin prints a parent/child relationship tree by walking the task_struct.children and task_struct.sibling members.

Memdump: To dump all addressable memory in a process, use the memdump plugin. This plugin enumerates the process page tables and writes them out into an external file. An index file is also created which can be used to find the virtual address of each byte in the output file.

Connscan: Similar to the [connections](Connections.html) plugin, this plugin searches from _TCP_OBJECT structs. However, it employs pool scanning techniques.

Sockets: This module enumerates the active sockets from tcpip.sys

Cmdscan: searches the memory of csrss.exe on XP/2003/Vista/2008 and conhost.exe on Windows 7 for commands that attackers entered through a console shell (cmd.exe). This is one of the most powerful commands you can use to gain visibility into an attacker's actions on a victim system, whether they opened cmd.exe through an RDP session or proxied input/output to a command shell from a networked backdoor.

Malfind: helps find hidden or injected code/DLLs in user mode memory, based on characteristics such as VAD tag and page permissions.

Hooks_inline: Detect API hooks in process and kernel memory

Analyzing Malwares 1
Coreflood

About: Coreflood is a trojan horse and botnet created by a group of Russian hackers and released in 2010. The FBI included on its list of infected systems “approximately 17 state or local government agencies, including one police department; three airports; two defense contractors; five banks or financial institutions; approximately 30 colleges or universities; approximately 20 hospital or health care companies; and hundreds of businesses.” It is present on more than 2.3 million computers worldwide and as of May 2011 remains a threat.

To start analyzing Coreflood

```
c:\Program Files>cd rekall

c:\Program Files\Rekall>rekal --filename coreflood.vmem
```

```
---------------------------------------------------------------------------
The Rekall Digital Forensic/Incident Response framework 1.7.2.rc1 (Hurricane Ridge).

"We can remember it for you wholesale!"

This program is free software; you can redistribute it and/or modify it under
the terms of the GNU General Public License.

See http://www.rekall-forensic.com/docs/Manual/tutorial.html to get started.
---------------------------------------------------------------------------
[1] coreflood.vmem 10:41:42>
```

We want to enumerate the processes

```
[1] coreflood.vmem 10:42:22> pslist
2021-12-07 10:42:24,083:WARNING:rekall.1:Inventory for repository "http://profiles.rekall-forensic.com" seems malfor
ned. Are you behind a captive portal or proxy? If this is a custom repository, did you forget to create an inventory
? You must use the tools/profiles/build_profile_repo.py tool with the --inventory flag.
2021-12-07 10:42:24,085:WARNING:rekall.1:Repository http://profiles.rekall-forensic.com will be disabled.
--------------------------> pslist()
_EPROCESS          name          pid   ppid  thread_count handle_count session_id wow64    process_create_time
 process_exit_time
--------- -------------------- ----- ------ ------------ ------------ ---------- ------ ----------------------- --
---------------------
0x810b1660 System                  4      0           58          183          - False  -                       -

0x80fdc368 logon.scr             124    632            1           15          0 False  2010-08-15 18:21:28Z    -

0xff25a7e0 alg.exe               216    676            6          105          0 False  2010-08-11 06:06:39Z    -

0xff3667e8 VMwareTray.exe        432   1724            1           49          0 False  2010-08-11 06:09:31Z    -

0xff374980 VMwareUser.exe        452   1724            6          189          0 False  2010-08-11 06:09:32Z    -

0x80f94588 wuauclt.exe           468   1028            4          134          0 False  2010-08-11 06:09:37Z    -

0xff2ab020 smss.exe              544      4            3           21          - False  2010-08-11 06:06:21Z    -

0xff1ecda0 csrss.exe             608    544           10          369          0 False  2010-08-11 06:06:23Z    -

0xff1ec978 winlogon.exe          632    544           20          518          0 False  2010-08-11 06:06:23Z    -

0xff247020 services.exe          676    632           16          269          0 False  2010-08-11 06:06:24Z    -

0xff255020 lsass.exe             688    632           19          344          0 False  2010-08-11 06:06:24Z    -

0xff218230 vmacthlp.exe          844    676            1           24          0 False  2010-08-11 06:06:24Z    -

0x80ff88d8 svchost.exe           856    676           17          199          0 False  2010-08-11 06:06:24Z    -

0xff364310 wscntfy.exe           888   1028            1           27          0 False  2010-08-11 06:06:49Z    -
```

```
0xff217560 svchost.exe           936    676           10          272          0 False  2010-08-11 06:06:24Z    -

0x80fbf910 svchost.exe          1028    676           71         1341          0 False  2010-08-11 06:06:24Z    -

0xff38b5f8 TPAutoConnect.e      1084   1968            1           61          0 False  2010-08-11 06:06:52Z    -

0xff22d558 svchost.exe          1088    676            5           80          0 False  2010-08-11 06:06:25Z    -

0xff125020 cmd.exe              1136   1668            0            -          0 False  2010-08-15 18:24:00Z    20
10-08-15 18:24:00Z
0xff203b80 svchost.exe          1148    676           14          208          0 False  2010-08-11 06:06:26Z    -

0xff1d7da0 spoolsv.exe          1432    676           13          135          0 False  2010-08-11 06:06:26Z    -

0xff1b8b28 vmtoolsd.exe         1668    676            5          221          0 False  2010-08-11 06:06:35Z    -

0xff3865d0 explorer.exe         1724   1708           12          341          0 False  2010-08-11 06:09:29Z    -

0xff1fdc88 VMUpgradeHelper      1788    676            4          100          0 False  2010-08-11 06:06:38Z    -

0xff143b28 TPAutoConnSvc.e      1968    676            5          100          0 False  2010-08-11 06:06:39Z    -

0xff3ad1a8 IEXPLORE.EXE         2044   1724           10          366          0 False  2010-08-15 18:11:17Z    -
```

Everything looks fine, but one thing that stands out is the running internet explorer.
To dive further into the IEXPLORE.EXE, we check its outbound connection.

To check the outbound connection, I used connscan to check out previously terminated and currently active connections.

```
Out<10:45:28> Plugin: pslist (WinPsList)
[1] coreflood.vmem 10:54:45> connscan
---------------------------> connscan()
 tcpip/GUID/9546A8399BAC4717BC41758594EF0D9C2 matched offset 0x4562+0xf3ba9000=0 offset_p      local_net_address
    remote_net_address        pid
---------- ------------------------ ------------------------ ----------
  0xeda590 172.16.176.143:1058       65.54.81.209:80                 2044
 0x1079e70 172.16.176.143:1082       209.234.234.16:80               2044
 0x107c888 172.16.176.143:1059       4.23.40.126:80                  2044
 0x108fcd8 172.16.176.143:1072       65.55.15.124:80                 2044
 0x10fa448 172.16.176.143:1065       65.55.253.21:80                 2044
 0x2214988 172.16.176.143:1092       65.54.81.14:80                  2044
 0x26c68a8 172.16.176.143:1074       65.55.15.243:80                 2044
 0x2ae4bb0 172.16.176.143:1073       65.55.15.123:80                 2044
 0x48b25f0 172.16.176.143:1085       65.55.149.119:80                2044
 0x4a045f8 172.16.176.143:1057       65.54.81.49:80                  2044
 0x4a04e70 172.16.176.143:1095       69.43.160.145:80                2044
 0x4a4a4a0 172.16.176.143:1084       12.120.180.24:80                2044
 0x4be2558 172.16.176.143:1079       65.54.81.22:80                  2044
 0x5536e70 172.16.176.143:1090       65.54.81.14:80                  2044
 0x5802340 172.16.176.143:1062       65.55.18.18:80                  2044
 0x5c9e200 172.16.176.143:1067       65.54.81.14:80                  2044
 0x5deea30 172.16.176.143:1068       65.54.81.14:80                  2044
 0x6015ab0 172.16.176.143:1053       207.46.170.10:80                2044
 0x605f208 172.16.176.143:1086       202.89.231.60:80                2044
 0x6125538 172.16.176.143:1083       65.54.81.79:80                  2044
 0x623a438 172.16.176.143:1066       96.6.41.210:80                  2044
 0x6450720 172.16.176.143:1077       65.55.149.121:80                2044
 0x64509f0 172.16.176.143:1063       64.4.18.73:80                   2044
 0x6497a68 172.16.176.143:1075       65.55.15.124:80                 2044
 0x67bd218 172.16.176.143:1070       65.54.81.209:80                 2044
 0x7c17be0 172.16.176.143:1060       65.55.239.161:80                2044
Out<10:54:47> Plugin: connscan (ConnScan)
```

From what we see, it seems like the host had legitimate communications. All the communication was created by pid 2044 which is iexplorer. There is a chance that it could also be fake IP addresses registered by the hackers.

We use sockets to check the inbound connections.

```
[1] coreflood.vmem 11:04:52> sockets
---------------------------> sockets()
 offset_v   pid    port  proto   protocol      address      create_time
--------- ------ ------ ------ ---------- --------------- -----------
0x80fd1008      4      0     47 GRE        0.0.0.0         2010-08-11 06:08:00Z
0xff158c00   2044   1052     17 UDP        127.0.0.1       2010-08-15 18:11:19Z
0xff258008    688    500     17 UDP        0.0.0.0         2010-08-11 06:06:35Z
0xff2984a0   1088   1078     17 UDP        0.0.0.0         2010-08-15 18:11:23Z
0xff367008      4    445      6 TCP        0.0.0.0         2010-08-11 06:06:17Z
0x80ffc128    936    135      6 TCP        0.0.0.0         2010-08-11 06:06:24Z
0xff225b70    688      0    255 Reserved   0.0.0.0         2010-08-11 06:06:35Z
0xff254008   1028    123     17 UDP        127.0.0.1       2010-08-15 18:24:00Z
0x80fce930   1088   1025     17 UDP        0.0.0.0         2010-08-11 06:06:38Z
0xff127d28    216   1026      6 TCP        127.0.0.1       2010-08-11 06:06:39Z
0xff3a97a0   1088   1061     17 UDP        0.0.0.0         2010-08-15 18:11:21Z
0xff12b580   1148   1900     17 UDP        127.0.0.1       2010-08-15 18:24:00Z
0xff1b8250    688   4500     17 UDP        0.0.0.0         2010-08-11 06:06:35Z
0xff382e98      4   1033      6 TCP        0.0.0.0         2010-08-11 06:08:00Z
0x80fbdc40      4    445     17 UDP        0.0.0.0         2010-08-11 06:06:17Z
Out<11:04:53> Plugin: sockets (Sockets)
```

Next, let's use the malfind function to possibly find injected code inside the process memory.

Some of the outputs have been truncated for viewing ease.

```
[1] coreflood.vmem 11:07:45> malfind
--------------------------> malfind()
**************************************************** of pid 468
Process: csrss.exe Pid: 608 Address: 0x7f6f0000
Vad Tag: Vad  Protection: EXECUTE_READWRITE
Protection: 6

0x7f6f0000 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................ vad_0x7f6f0000
0x7f6f0010 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x7f6f0020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x7f6f0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................

------ vad_0x7f6f0000 ------: 0x7f6f0000
  0x7f6f0000   0x0 0000                 add byte ptr [eax], al
  0x7f6f0002   0x2 0000                 add byte ptr [eax], al
  0x7f6f0004   0x4 0000                 add byte ptr [eax], al
  0x7f6f0006   0x6 0000                 add byte ptr [eax], al
  0x7f6f0008   0x8 0000                 add byte ptr [eax], al
  0x7f6f000a   0xa 0000                 add byte ptr [eax], al
  0x7f6f000c   0xc 0000                 add byte ptr [eax], al
  0x7f6f000e   0xe 0000                 add byte ptr [eax], al
  0x7f6f0010  0x10 0000                 add byte ptr [eax], al
  0x7f6f0012  0x12 0000                 add byte ptr [eax], al
  0x7f6f0014  0x14 0000                 add byte ptr [eax], al
  0x7f6f0016  0x16 0000                 add byte ptr [eax], al
  0x7f6f0018  0x18 0000                 add byte ptr [eax], al
  0x7f6f001a  0x1a 0000                 add byte ptr [eax], al
  0x7f6f001c  0x1c 0000                 add byte ptr [eax], al
  0x7f6f001e  0x1e 0000                 add byte ptr [eax], al
  0x7f6f0020  0x20 0000                 add byte ptr [eax], al
  0x7f6f0022  0x22 0000                 add byte ptr [eax], al
  0x7f6f0024  0x24 0000                 add byte ptr [eax], al
  0x7f6f0026  0x26 0000                 add byte ptr [eax], al
  0x7f6f0028  0x28 0000                 add byte ptr [eax], al
  0x7f6f002a  0x2a 0000                 add byte ptr [eax], al
  0x7f6f002c  0x2c 0000                 add byte ptr [eax], al
  0x7f6f002e  0x2e 0000                 add byte ptr [eax], al
  0x7f6f0030  0x30 0000                 add byte ptr [eax], al
  0x7f6f0032  0x32 0000                 add byte ptr [eax], al
  0x7f6f0034  0x34 0000                 add byte ptr [eax], al
  0x7f6f0036  0x36 0000                 add byte ptr [eax], al
  0x7f6f0038  0x38 0000                 add byte ptr [eax], al
  0x7f6f003a  0x3a 0000                 add byte ptr [eax], al
  0x7f6f003c  0x3c 0000                 add byte ptr [eax], al
  0x7f6f003e  0x3e 0000                 add byte ptr [eax], al
  0x7f6f0040  0x40 0000                 add byte ptr [eax], al
  0x7f6f0042  0x42 0000                 add byte ptr [eax], al
```

```
Process: winlogon.exe Pid: 632 Address: 0x2c930000
Vad Tag: VadS Protection: EXECUTE_READWRITE
CommitCharge: 4, MemCommit: 1, PrivateMemory: 1, Protection: 6

0x2c930000 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................ vad_0x2c930000
0x2c930010 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x2c930020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x2c930030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................

------ vad_0x2c930000 ------: 0x2c930000
  0x2c930000   0x0 0000                 add byte ptr [eax], al
  0x2c930002   0x2 0000                 add byte ptr [eax], al
  0x2c930004   0x4 0000                 add byte ptr [eax], al
  0x2c930006   0x6 0000                 add byte ptr [eax], al
  0x2c930008   0x8 0000                 add byte ptr [eax], al
  0x2c93000a   0xa 0000                 add byte ptr [eax], al
  0x2c93000c   0xc 0000                 add byte ptr [eax], al
  0x2c93000e   0xe 0000                 add byte ptr [eax], al
  0x2c930010  0x10 0000                 add byte ptr [eax], al
  0x2c930012  0x12 0000                 add byte ptr [eax], al
  0x2c930014  0x14 0000                 add byte ptr [eax], al
  0x2c930016  0x16 0000                 add byte ptr [eax], al
  0x2c930018  0x18 0000                 add byte ptr [eax], al
  0x2c93001a  0x1a 0000                 add byte ptr [eax], al
  0x2c93001c  0x1c 0000                 add byte ptr [eax], al
  0x2c93001e  0x1e 0000                 add byte ptr [eax], al
  0x2c930020  0x20 0000                 add byte ptr [eax], al
  0x2c930022  0x22 0000                 add byte ptr [eax], al
  0x2c930024  0x24 0000                 add byte ptr [eax], al
  0x2c930026  0x26 0000                 add byte ptr [eax], al
  0x2c930028  0x28 0000                 add byte ptr [eax], al
  0x2c93002a  0x2a 0000                 add byte ptr [eax], al
  0x2c93002c  0x2c 0000                 add byte ptr [eax], al
  0x2c93002e  0x2e 0000                 add byte ptr [eax], al
  0x2c930030  0x30 0000                 add byte ptr [eax], al
  0x2c930032  0x32 0000                 add byte ptr [eax], al
  0x2c930034  0x34 0000                 add byte ptr [eax], al
  0x2c930036  0x36 0000                 add byte ptr [eax], al
  0x2c930038  0x38 0000                 add byte ptr [eax], al
  0x2c93003a  0x3a 0000                 add byte ptr [eax], al
  0x2c93003c  0x3c 0000                 add byte ptr [eax], al
  0x2c93003e  0x3e 0000                 add byte ptr [eax], al
  0x2c930040  0x40 0000                 add byte ptr [eax], al
  0x2c930042  0x42 0000                 add byte ptr [eax], al
  0x2c930044  0x44 0000                 add byte ptr [eax], al
  0x2c930046  0x46 0000                 add byte ptr [eax], al
```

```
Process: winlogon.exe Pid: 632 Address: 0x37ec0000
Vad Tag: VadS Protection: EXECUTE_READWRITE
CommitCharge: 4, MemCommit: 1, PrivateMemory: 1, Protection: 6

0x37ec0000 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................ vad_0x37ec0000
0x37ec0010 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x37ec0020 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................
0x37ec0030 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00  ................

------ vad_0x37ec0000 ------
  0x37ec0000   0x0 0000                add byte ptr [eax], al
  0x37ec0002   0x2 0000                add byte ptr [eax], al
  0x37ec0004   0x4 0000                add byte ptr [eax], al
  0x37ec0006   0x6 0000                add byte ptr [eax], al
  0x37ec0008   0x8 0000                add byte ptr [eax], al
  0x37ec000a   0xa 0000                add byte ptr [eax], al
  0x37ec000c   0xc 0000                add byte ptr [eax], al
  0x37ec000e   0xe 0000                add byte ptr [eax], al
  0x37ec0010  0x10 0000                add byte ptr [eax], al
  0x37ec0012  0x12 0000                add byte ptr [eax], al
  0x37ec0014  0x14 0000                add byte ptr [eax], al
  0x37ec0016  0x16 0000                add byte ptr [eax], al
  0x37ec0018  0x18 0000                add byte ptr [eax], al
  0x37ec001a  0x1a 0000                add byte ptr [eax], al
  0x37ec001c  0x1c 0000                add byte ptr [eax], al
  0x37ec001e  0x1e 0000                add byte ptr [eax], al
  0x37ec0020  0x20 0000                add byte ptr [eax], al
  0x37ec0022  0x22 0000                add byte ptr [eax], al
  0x37ec0024  0x24 0000                add byte ptr [eax], al
  0x37ec0026  0x26 0000                add byte ptr [eax], al
  0x37ec0028  0x28 0000                add byte ptr [eax], al
  0x37ec002a  0x2a 0000                add byte ptr [eax], al
  0x37ec002c  0x2c 0000                add byte ptr [eax], al
  0x37ec002e  0x2e 0000                add byte ptr [eax], al
  0x37ec0030  0x30 0000                add byte ptr [eax], al
  0x37ec0032  0x32 0000                add byte ptr [eax], al
  0x37ec0034  0x34 0000                add byte ptr [eax], al
  0x37ec0036  0x36 0000                add byte ptr [eax], al
  0x37ec0038  0x38 0000                add byte ptr [eax], al
  0x37ec003a  0x3a 0000                add byte ptr [eax], al
  0x37ec003c  0x3c 0000                add byte ptr [eax], al
  0x37ec003e  0x3e 0000                add byte ptr [eax], al
  0x37ec0040  0x40 0000                add byte ptr [eax], al
  0x37ec0042  0x42 0000                add byte ptr [eax], al
  0x37ec0044  0x44 0000                add byte ptr [eax], al
```

As you can see, the output of malfind function seems to be benign for now.

Next, we call a IAT hook on the iexplore by `hooks_iat 2044`

```
[1] coreflood.vmem 10:41:09> hooks_iat 2044
---------------------------> hooks_iat(2044)
         source                 target         target_func
  -------------------- -------------------- -----------
---------------------------
Process IEXPLORE.EXE (2044)
---------------------------
```

From the function call, I expected to see multiple calls on the hooks further cementing the findings of malware analysis of Coreflood trojan.

Analyzing Malwares 2
R2D2

About: R2D2 is a malicious program belonging to the Crysis/Dharma ransomware family. Systems infected with this malware have their data encrypted and users receive ransom demands for decryption.When encryption is underway, all affected files are renamed according to the following pattern: original filename, unique ID (generated individually for each victim), cyber criminals' email address and ".R2D2 " extension. For example, a file such as "1.jpg" would appear as something similar to "1.jpg.id-1E857D00.[1024back@tuta.io].R2D2" following encryption.After this process is complete, a text file ("FILES ENCRYPTED.txt") is created on the desktop and a pop-up window is displayed.

To start analyzing R2D2

```
c:\Program Files\Rekall>rekal --filename 0zapftis.vmem

----------------------------------------------------------------------------
The Rekall Digital Forensic/Incident Response framework 1.7.2.rc1 (Hurricane Ridge).

"We can remember it for you wholesale!"

This program is free software; you can redistribute it and/or modify it under
the terms of the GNU General Public License.

See http://www.rekall-forensic.com/docs/Manual/tutorial.html to get started.
----------------------------------------------------------------------------
[1] 0zapftis.vmem 10:52:33>
```

Some extra information about R2D2 using imageinfo function

```
[1] 0zapftis.vmem 10:53:09> imageinfo
2021-12-08 10:53:10,526:WARNING:rekall.1:Inventory for repository "http://profiles.rekall-forensic.com" seems malformed
 Are you behind a captive portal or proxy? If this is a custom repository, did you forget to create an inventory? You m
st use the tools/profiles/build_profile_repo.py tool with the --inventory flag.
2021-12-08 10:53:10,528:WARNING:rekall.1:Repository http://profiles.rekall-forensic.com will be disabled.
--------------------------> imageinfo()
        key          value
------------------- -----
Kernel DTB           0x319000
NT Build             2600.xpsp_sp2_rtm.040803-21580000 \
NT Build Ex          -
Signed Drivers       -
Time (UTC)           2011-10-10 17:06:54Z
Time (Local)         2011-10-10 13:06:54-0400
Sec Since Boot       98.21875
NtSystemRoot         C:\WINDOWS
```

Lets enumerate the processes by calling **pslist**

```
[1] 0zapftis.vmem 10:54:30> pslist
--------------------------> pslist()
_EPROCESS          name          pid   ppid  thread_count handle_count session_id wow64    process_create_time       proc
ess_exit_time
---------- -------------------- ----- ------ ------------ ------------ ---------- ------ ----------------------- -------
----------------
0x819cc830 System                  4      0           55          162          - False  -                         -
0x816d63d0 VMwareTray.exe        184   1956            1           28          0 False  2011-10-10 17:04:41Z     -
0x8180b478 VMwareUser.exe        192   1956            6           83          0 False  2011-10-10 17:04:41Z     -
0x818233c8 reader_sl.exe         228   1956            2           26          0 False  2011-10-10 17:04:41Z     -
0x815e7be0 wuauclt.exe           400    964            8          173          0 False  2011-10-10 17:04:46Z     -
0x81945020 smss.exe              536      4            3           21          - False  2011-10-10 17:03:56Z     -
0x817a34b0 cmd.exe               544   1956            1           30          0 False  2011-10-10 17:06:42Z     -
0x816c6020 csrss.exe             608    536           11          355          0 False  2011-10-10 17:03:58Z     -
0x813a9020 winlogon.exe          632    536           24          533          0 False  2011-10-10 17:03:58Z     -
0x816da020 services.exe          676    632           16          261          0 False  2011-10-10 17:03:58Z     -
0x813c4020 lsass.exe             688    632           23          336          0 False  2011-10-10 17:03:58Z     -
0x81772ca8 vmacthlp.exe          832    676            1           24          0 False  2011-10-10 17:03:59Z     -
0x8167e9d0 svchost.exe           848    676           20          194          0 False  2011-10-10 17:03:59Z     -
0x817757f0 svchost.exe           916    676            9          217          0 False  2011-10-10 17:03:59Z     -
0x816c6da0 svchost.exe           964    676           63         1058          0 False  2011-10-10 17:03:59Z     -
0x815daca8 svchost.exe          1020    676            5           58          0 False  2011-10-10 17:03:59Z     -
0x813aeda0 svchost.exe          1148    676           12          187          0 False  2011-10-10 17:04:00Z     -
0x817937e0 spoolsv.exe          1260    676           13          140          0 False  2011-10-10 17:04:00Z     -
0x81754990 VMwareService.e      1444    676            3          145          0 False  2011-10-10 17:04:00Z     -
0x8136c5a0 alg.exe              1616    676            7           99          0 False  2011-10-10 17:04:01Z     -
0x815c4da0 wscntfy.exe          1920    964            1           27          0 False  2011-10-10 17:04:39Z     -
0x813bcda0 explorer.exe         1956   1884           18          322          0 False  2011-10-10 17:04:39Z     -
Out<10:54:31> Plugin: pslist (WinPsList)
[1] 0zapftis.vmem 10:54:31>
```

Right off of the pslist, there are two processes that stand out. **Reader_sl.exe** and **cmd.exe**

Lets see the hierarchy of these processes using **pstree**

```
--------------------------> pstree()
_EPROCESS                                    ppid  thd_count hnd_count       create_time
---------------------------------------- ------ --------- --------- -----------------------
  0x819cc830 System (4)                       0        55       162 -
. 0x81945020 smss.exe (536)                   4         3        21 2011-10-10 17:03:56Z
.. 0x816c6020 csrss.exe (608)               536        11       355 2011-10-10 17:03:58Z
.. 0x813a9020 winlogon.exe (632)            536        24       533 2011-10-10 17:03:58Z
... 0x816da020 services.exe (676)           632        16       261 2011-10-10 17:03:58Z
.... 0x81772ca8 vmacthlp.exe (832)          676         1        24 2011-10-10 17:03:59Z
.... 0x8167e9d0 svchost.exe (848)           676        20       194 2011-10-10 17:03:59Z
.... 0x817757f0 svchost.exe (916)           676         9       217 2011-10-10 17:03:59Z
.... 0x816c6da0 svchost.exe (964)           676        63      1058 2011-10-10 17:03:59Z
..... 0x815e7be0 wuauclt.exe (400)          964         8       173 2011-10-10 17:04:46Z
..... 0x815c4da0 wscntfy.exe (1920)         964         1        27 2011-10-10 17:04:39Z
.... 0x815daca8 svchost.exe (1020)          676         5        58 2011-10-10 17:03:59Z
.... 0x813aeda0 svchost.exe (1148)          676        12       187 2011-10-10 17:04:00Z
.... 0x817937e0 spoolsv.exe (1260)          676        13       140 2011-10-10 17:04:00Z
.... 0x81754990 VMwareService.e (1444)      676         3       145 2011-10-10 17:04:00Z
.... 0x8136c5a0 alg.exe (1616)              676         7        99 2011-10-10 17:04:01Z
... 0x813c4020 lsass.exe (688)              632        23       336 2011-10-10 17:03:58Z
  0x813bcda0 explorer.exe (1956)           1884        18       322 2011-10-10 17:04:39Z
. 0x816d63d0 VMwareTray.exe (184)          1956         1        28 2011-10-10 17:04:41Z
. 0x8180b478 VMwareUser.exe (192)          1956         6        83 2011-10-10 17:04:41Z
. 0x818233c8 reader_sl.exe (228)           1956         2        26 2011-10-10 17:04:41Z
. 0x817a34b0 cmd.exe (544)                 1956         1        30 2011-10-10 17:06:42Z
```

From pstree, we can see that explore.exe is starting reader_sl.exe and cmd.exe. Everything seems benign for now.

Lets run **cmdscan** to search the memory process to gain visibility on possible attackers.

```
[1] 0zapftis.vmem 11:00:43> cmdscan
--------------------------> cmdscan()
**************************************************
CommandProcess: csrss.exe Pid: 608
CommandHistory: 0x11132d8 Application: cmd.exe Flags: Allocated, Reset
CommandCount: 2 LastAdded: 1 LastDisplayed: 1
FirstCommand: 0 CommandCountMax: 50
ProcessHandle: 0x4c4
Cmd  Address   Text
--- ---------- ----
  0 0x004e1eb8 sc query malwar
  1 0x011135e8 sc query malware
```

It shows that csrss.exe is attempting to start a service called malware.

Lets run **connscan** to see if there are any suspicious connections to outside IP addresses.

```
[1] 0zapftis.vmem 11:03:09> connscan
--------------------------> connscan()
tcpip/GUID/9546A8399BAC4717BC41758594EF0D9C2 matched offset 0x4562+0xf11c0000=0 offset_p      local_net_address
emote_net_address        pid
--------- ------------------------ ------------------------ ----------
0x1a25a50 0.0.0.0:1026              172.16.98.1:6666                1956
```

From the function, it is evident that process 1956 is trying to make a connection to 172.16.98.1.

Lets run dlllist on cmd.exe by typing **dlllist proc_regex="cmd.exe"**

```
0x816118d8     4    445     17 UDP        0.0.0.0         2011-10-10 17:03:55Z
Out<11:11:06> Plugin: sockets (Sockets)
[1] 0zapftis.vmem 11:13:03> dlllist proc_regex="cmd.exe"
--------------------------> dlllist(proc_regex="cmd.exe")
     base       size                reason            dll_path
 ---------- ---------- ------------------------------ --------
-------------------------------------------
cmd.exe pid: 544
Command line : "C:\WINDOWS\system32\cmd.exe"
Service Pack 2
-------------------------------------------
 0x4ad00000    0x61000 65535                          C:\WINDOWS\system32\cmd.exe
 0x7c900000    0xb0000 65535                          C:\WINDOWS\system32\ntdll.dll
 0x7c800000    0xf4000 65535                          C:\WINDOWS\system32\kernel32.dll
 0x77c10000    0x58000 65535                          C:\WINDOWS\system32\msvcrt.dll
 0x77d40000    0x90000 65535                          C:\WINDOWS\system32\USER32.dll
 0x77f10000    0x46000 65535                          C:\WINDOWS\system32\GDI32.dll
 0x5cb70000    0x26000 1                              C:\WINDOWS\system32\ShimEng.dll
 0x6f880000   0x1ca000 1                              C:\WINDOWS\AppPatch\AcGenral.DLL
 0x77dd0000    0x9b000 23                             C:\WINDOWS\system32\ADVAPI32.dll
 0x77e70000    0x91000 11                             C:\WINDOWS\system32\RPCRT4.dll
 0x76b40000    0x2d000 2                              C:\WINDOWS\system32\WINMM.dll
 0x774e0000   0x13c000 2                              C:\WINDOWS\system32\ole32.dll
 0x77120000    0x8c000 1                              C:\WINDOWS\system32\OLEAUT32.dll
 0x77be0000    0x15000 1                              C:\WINDOWS\system32\MSACM32.dll
 0x77c00000     0x8000 3                              C:\WINDOWS\system32\VERSION.dll
 0x7c9c0000   0x814000 1                              C:\WINDOWS\system32\SHELL32.dll
 0x77f60000    0x76000 3                              C:\WINDOWS\system32\SHLWAPI.dll
 0x769c0000    0xb3000 1                              C:\WINDOWS\system32\USERENV.dll
 0x5ad70000    0x38000 1                              C:\WINDOWS\system32\UxTheme.dll
 0x10000000    0x59000 1                              C:\WINDOWS\system32\mfc42u1.dll
 0x71ab0000    0x17000 2                              C:\WINDOWS\system32\WS2_32.dll
 0x71aa0000     0x8000 1                              C:\WINDOWS\system32\WS2HELP.dll
 0x71f60000     0x8000 1                              C:\WINDOWS\system32\snmpapi.dll
 0x773d0000   0x102000 1                              C:\WINDOWS\WinSxS\x86_Microsoft.Windows.Common-Controls_6595b64144ccf1df_6.0.2600.2180_x-ww_a84f
1ff9\comctl32.dll
 0x5d090000    0x97000 1                              C:\WINDOWS\system32\comctl32.dll
 0x77b40000    0x22000 1                              C:\WINDOWS\system32\Apphelp.dll
Out<11:13:03> Plugin: dlllist (WinDllList)
[1] 0zapftis.vmem 11:13:03>
```

There is a dll that seemed eye-catching which was the mfc42ul.dll. After googling the dll, it is indeed a malicious dll.

This entry is classified as malware, spyware, adware, or other potentially unwanted software.

If the description states that it is malware, you should immediately run a trusted anti-virus and anti-spyware tool.

Item Details

Type:	AppInit_DLLs
Filename:	%SYSDIR%\mfc42ul.dll
Description:	Backdoor:Win32/R2d2.A

This confirms that we hunted down R2D2 malware.

Analyzing Malwares 3
Cridex

About: Cridex malware, also known as Cridex or W32.Cridex, is a malicious computer worm that spreads to computers by copying itself to removable disks. On each computer it infects, it opens a backdoor and downloads malicious software to the hard disk. The malicious software gathers personal information on the compromised machine, including web session and banking data, and transmits it to a third-party. Cridex-infected machines can also become botnet slaves, participating in behavior such as DDoS attacks.

To start analyzing Cridex

```
c:\Program Files\Rekall>rekal --filename cridex.vmem

-------------------------------------------------------------------------------
The Rekall Digital Forensic/Incident Response framework 1.7.2.rc1 (Hurricane Ridge).

"We can remember it for you wholesale!"

This program is free software; you can redistribute it and/or modify it under
the terms of the GNU General Public License.

See http://www.rekall-forensic.com/docs/Manual/tutorial.html to get started.
-------------------------------------------------------------------------------
[1] cridex.vmem 11:34:33>
```

Some additional information about Cridex can be found using **imageinfo**

```
[1] cridex.vmem 11:35:30> imageinfo
2021-12-08 11:35:32,170:WARNING:rekall.1:Inventory for repository "http://profiles.rekall-forensic.com" seems malformed.
 Are you behind a captive portal or proxy? If this is a custom repository, did you forget to create an inventory? You mu
st use the tools/profiles/build_profile_repo.py tool with the --inventory flag.
2021-12-08 11:35:32,171:WARNING:rekall.1:Repository http://profiles.rekall-forensic.com will be disabled.
------------------------> imageinfo()
        key          value
------------------- -----
Kernel DTB           0x2fe000
NT Build             2600.xpsp.080413-2111s 0xc0000000 \
NT Build Ex          -
Signed Drivers       -
Time (UTC)           2012-07-22 02:45:08Z
Time (Local)         2012-07-21 22:45:08-0400
Sec Since Boot       164.890625
NtSystemRoot         C:\WINDOWS
```

Lets enumerate the processes by calling **pslist** to see all the processes in an infected system

_EPROCESS	name	pid	ppid	thread_count	handle_count	session_id	wow64	process_create_time	process_exit_time
0x823c89c8	System	4	0	53	240	-	False	-	-
0x822f1020	smss.exe	368	4	3	19	-	False	2012-07-22 02:42:31Z	-
0x822a0598	csrss.exe	584	368	9	326	0	False	2012-07-22 02:42:32Z	-
0x82298700	winlogon.exe	608	368	23	519	0	False	2012-07-22 02:42:32Z	-
0x81e2ab28	services.exe	652	608	16	243	0	False	2012-07-22 02:42:32Z	-
0x81e2a3b8	lsass.exe	664	608	24	330	0	False	2012-07-22 02:42:32Z	-
0x820e8da0	alg.exe	788	652	7	104	0	False	2012-07-22 02:43:01Z	-
0x82311360	svchost.exe	824	652	20	194	0	False	2012-07-22 02:42:33Z	-
0x81e29ab8	svchost.exe	908	652	9	226	0	False	2012-07-22 02:42:33Z	-
0x823001d0	svchost.exe	1004	652	64	1118	0	False	2012-07-22 02:42:33Z	-
0x821dfda0	svchost.exe	1056	652	5	60	0	False	2012-07-22 02:42:33Z	-
0x821fcda0	wuauclt.exe	1136	1004	8	173	0	False	2012-07-22 02:43:46Z	-
0x82295650	svchost.exe	1220	652	15	197	0	False	2012-07-22 02:42:35Z	-
0x821dea70	explorer.exe	1484	1464	17	415	0	False	2012-07-22 02:42:36Z	-
0x81eb17b8	spoolsv.exe	1512	652	14	113	0	False	2012-07-22 02:42:36Z	-
0x8205bda0	wuauclt.exe	1588	1004	5	132	0	False	2012-07-22 02:44:01Z	-
0x81e7bda0	reader_sl.exe	1640	1484	5	39	0	False	2012-07-22 02:42:36Z	-

Lets see the hierarchy of these processes using **pstree**

_EPROCESS	ppid	thd_count	hnd_count	create_time
0x823c89c8 System (4)	0	53	240	-
. 0x822f1020 smss.exe (368)	4	3	19	2012-07-22 02:42:31Z
.. 0x822a0598 csrss.exe (584)	368	9	326	2012-07-22 02:42:32Z
.. 0x82298700 winlogon.exe (608)	368	23	519	2012-07-22 02:42:32Z
... 0x81e2ab28 services.exe (652)	608	16	243	2012-07-22 02:42:32Z
.... 0x820e8da0 alg.exe (788)	652	7	104	2012-07-22 02:43:01Z
.... 0x82311360 svchost.exe (824)	652	20	194	2012-07-22 02:42:33Z
.... 0x81e29ab8 svchost.exe (908)	652	9	226	2012-07-22 02:42:33Z
.... 0x823001d0 svchost.exe (1004)	652	64	1118	2012-07-22 02:42:33Z
..... 0x821fcda0 wuauclt.exe (1136)	1004	8	173	2012-07-22 02:43:46Z
..... 0x8205bda0 wuauclt.exe (1588)	1004	5	132	2012-07-22 02:44:01Z
.... 0x821dfda0 svchost.exe (1056)	652	5	60	2012-07-22 02:42:33Z
.... 0x82295650 svchost.exe (1220)	652	15	197	2012-07-22 02:42:35Z
.... 0x81eb17b8 spoolsv.exe (1512)	652	14	113	2012-07-22 02:42:36Z
... 0x81e2a3b8 lsass.exe (664)	608	24	330	2012-07-22 02:42:32Z
0x821dea70 explorer.exe (1484)	1464	17	415	2012-07-22 02:42:36Z
. 0x81e7bda0 reader_sl.exe (1640)	1484	5	39	2012-07-22 02:42:36Z

Reader_sl.exe stands out because it has a parent id of 1484 which is a **explorer.exe**

Lets use **psxview** to see any hidden processes

_EPROCESS	name	pid	PsActiveProcessHead	CSRSS	PspCidTable	Sessions	Handles	PSScan	Thrdproc
0x823c89c8	System	4	True	False	True	False	False	True	True
0x822f1020	smss.exe	368	True	False	True	False	True	True	True
0x822a0598	csrss.exe	584	True	False	True	True	True	True	True
0x82298700	winlogon.exe	608	True	True	True	True	True	True	True
0x81e2ab28	services.exe	652	True	True	True	True	True	True	True
0x81e2a3b8	lsass.exe	664	True	True	True	True	True	True	True
0x820e8da0	alg.exe	788	True	True	True	True	True	True	True
0x82311360	svchost.exe	824	True	True	True	True	True	True	True
0x81e29ab8	svchost.exe	908	True	True	True	True	True	True	True
0x823001d0	svchost.exe	1004	True	True	True	True	True	True	True
0x821dfda0	svchost.exe	1056	True	True	True	True	True	True	True
0x821fcda0	wuauclt.exe	1136	True	True	True	True	True	True	True
0x82295650	svchost.exe	1220	True	True	True	True	True	True	True
0x821dea70	explorer.exe	1484	True	True	True	True	True	True	True
0x81eb17b8	spoolsv.exe	1512	True	True	True	True	True	True	True
0x8205bda0	wuauclt.exe	1588	True	True	True	True	True	True	True
0x81e7bda0	reader_sl.exe	1640	True	True	True	True	True	True	True

So far, the output seems benign.

Next, we want to check for open sockets and tcp connections. To do those, we will use sockets and connscan.

Connscan

Offset(P)	Local Address	Remote Address	Pid
0x02087620	172.16.112.128:1038	41.168.5.140:8080	1484
0x023a8008	172.16.112.128:1037	125.19.103.198:8080	1484

There are two tcp connections from 172.16.112.128 to 41.168.5.140 and 125.19.103.198 by 1484(explorer.exe)

Sockets

Offset(V)	PID	Port	Proto	Protocol	Address	Create Time
0x81ddb780	664	500	17	UDP	0.0.0.0	
0x82240d08	1484	1038	6	TCP	0.0.0.0	
0x81dd7618	1220	1900	17	UDP	172.16.112.128	
0x82125610	788	1028	6	TCP	127.0.0.1	
0x8219cc08	4	445	6	TCP	0.0.0.0	
0x81ec23b0	908	135	6	TCP	0.0.0.0	
0x82276878	4	139	6	TCP	172.16.112.128	
0x82277460	4	137	17	UDP	172.16.112.128	
0x81e76620	1004	123	17	UDP	127.0.0.1	
0x82172808	664	0	255	Reserved	0.0.0.0	
0x81e3f460	4	138	17	UDP	172.16.112.128	
0x821f0630	1004	123	17	UDP	172.16.112.128	
0x822cd2b0	1220	1900	17	UDP	127.0.0.1	
0x82172c50	664	4500	17	UDP	0.0.0.0	
0x821f0d00	4	445	17	UDP	0.0.0.0	

We can see that one of the TCP connections from 1484 is still open.

We can see two open TCP connections to 2 different external IP addresses which bring up suspicion.

Lets create a dmp file using

```
[1] cridex.vmem 12:20:42> memdump 1640, dump_dir="."
```

After we open the dmp file in a notepad and search for 41.168.5.140 which is from the output of the conscan, we see

```
Accept: */*
User-Agent: Mozilla/5.0 (Windows; U; MSIE 7.0; Windows NT 6.0; en-US)
PVñ¿ )Gz¡ E û ]@ €-Û¬p€)¨Œºe]þpÀPDpI8 POST /zb/v_01_a/in/ HTTP/1.1
Host: 41.168.5.140:8080
Content-Length: 229
Connection: Keep-Alive
Cache-Control: no-cache
```

Showing that reader_sl.exe is sending data to 41.168.5.140 via http post.
This concludes the findings of cridex malware.

References

- https://sansorg.egnyte.com/dl/L4hx0pM9y3
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- https://capoo.tistory.com/9
- https://github.com/volatilityfoundation/volatility/wiki/Memory-Samples