Volatility 3

Public Beta: Insider's Preview

Andrew Case | 15 April 2020 | Volexity Cyber Session

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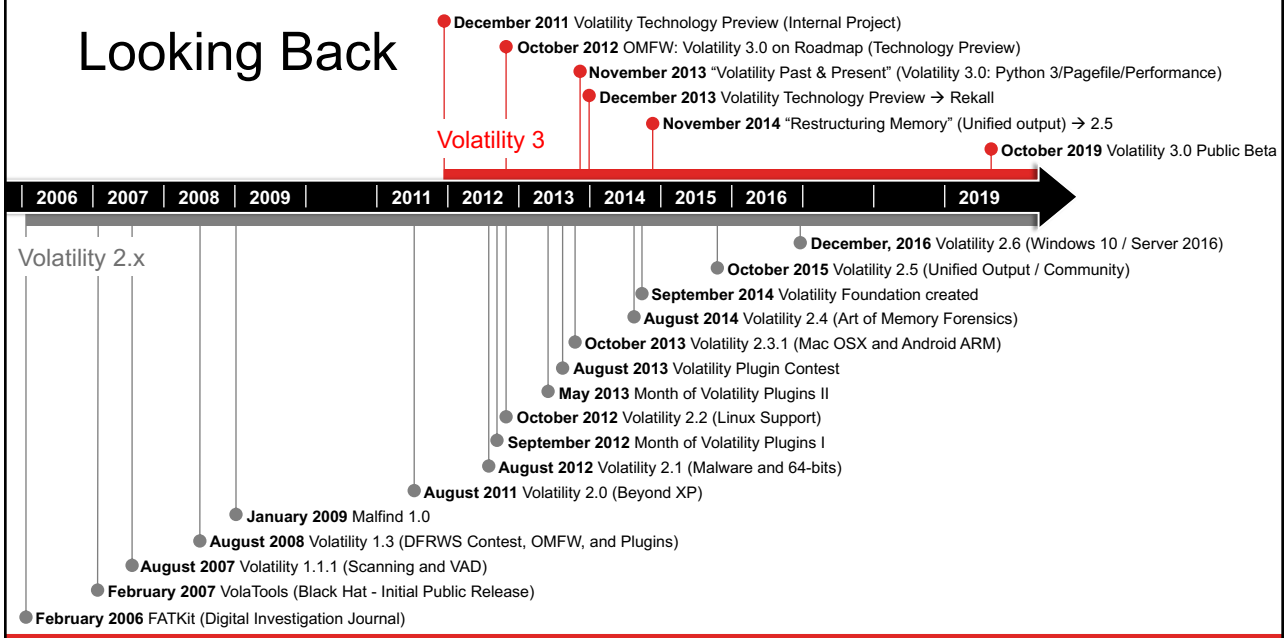
Looking Back



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Memory Forensics: 2006 vs. 2019

SAMPLE SIZE

THEN	NOW
<= 4GB	>= 16GB

>= 128GB common

SAMPLE QUANTITY

THEN	NOW
1	5+

VOLATILITY ANALYSIS TASKS

THEN	NOW
<= 10	>= 50

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Operating System Release Cycles in 2019 [3, 4]

- **Feature updates** will be released twice per year, around March and September. As the name suggests, these will add new features to Windows 10, delivered in bite-sized chunks compared to the previous practice of Windows releases every 3-5 years.

- Linux_5.3 Released Sun, 15 September 2019 (70 days)
- Linux_5.2 Released Sun, 7 July 2019 (63 days)
- Linux_5.1 Released Sun, 5 May 2019 (63 days)
- Linux_5.0 Released Sun, 3 March 2019 (70 days)

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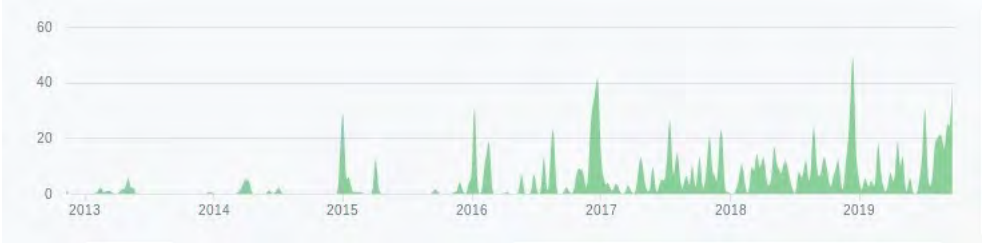
The History of Vol3



- Many novel ideas attempted and refined before being put into the stable code base
- The goal: Meet the needs of the next decade of memory analysis

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What is New in Volatility 3?

- **All** of it
- **Every** line of code
- **Entire framework** (backend, plugins, etc.) was completely rewritten and redesigned

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What is New in Volatility 3? Cont.

- Written in Python 3
- Major performance boost!
  - Natively supports multi-processing and memory caches
- Much simpler integration into other libraries and user interfaces

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What is New in Volatility 3? Cont.

- No more --profile for any OS!
  - Automatic detection of profiles
  - Extraction of known-good data from debug info vs hardcoded
- 32bit apps on 64bit kernels natively supported
  - Proper Wow64 analysis!
- Automated evaluation of in-memory code

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What is New for Developers?

- Extensive API documentation
- Plugins can directly call other plugins
- Plugins are versioned
- Much easier to use custom data structures and symbols

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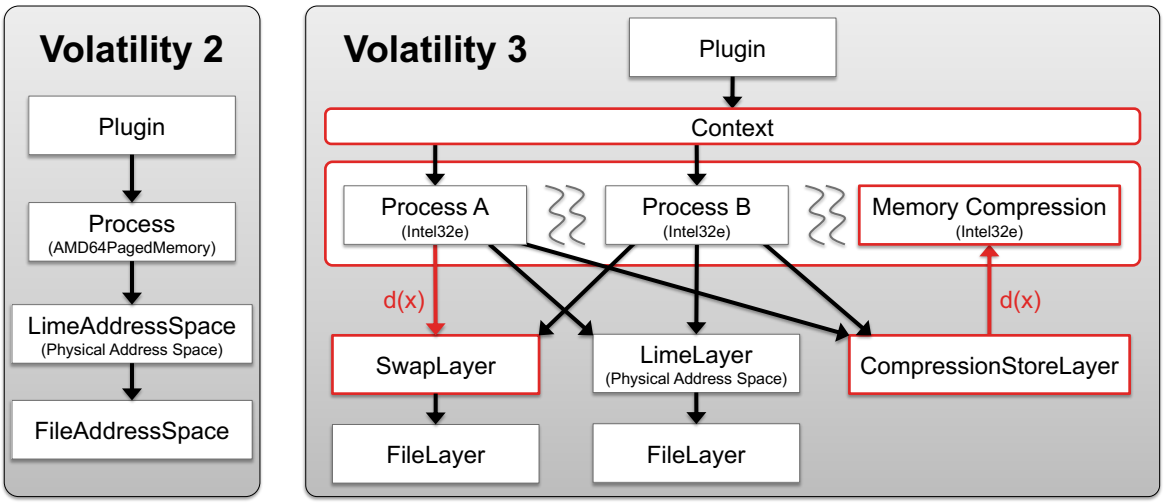

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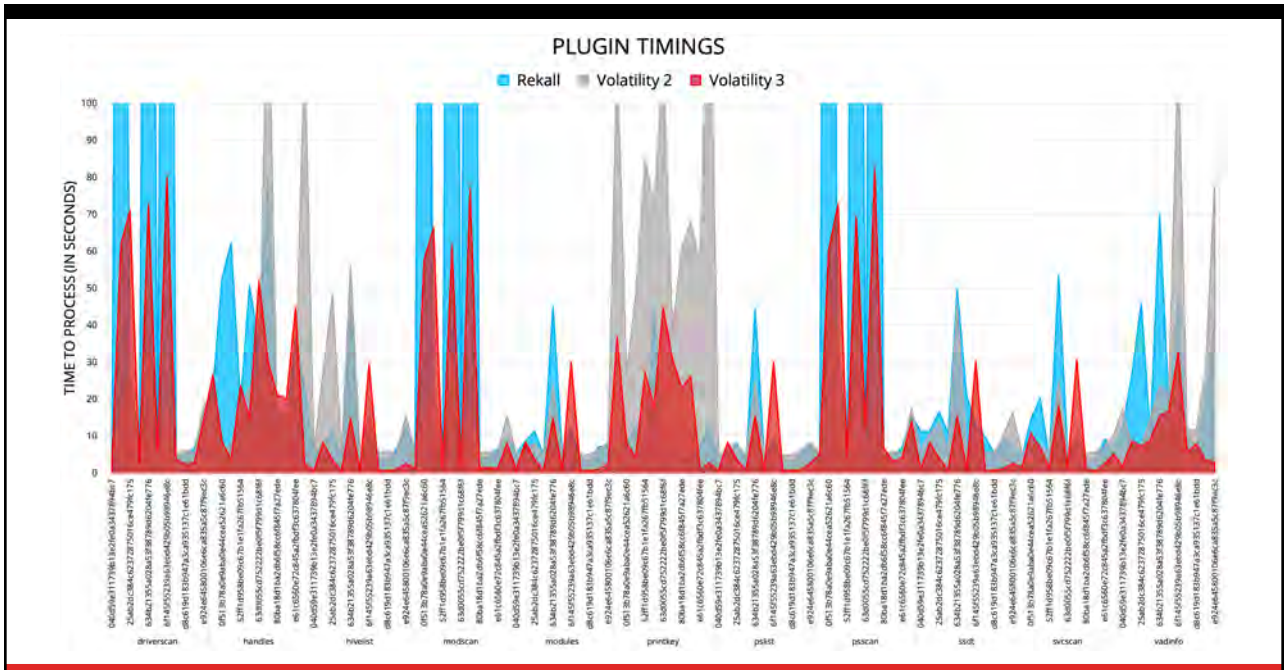

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```
$ time python3 vol.py -f turlanew.raw -r pretty windows.pslist
Volatility 3 Framework 1.0.0-beta.1
  |   PID | PPID |  ImageFileName |      Offset(V) | Threads | Handles | SessionId | Wow64 |                  CreateTime |                      ExitTime
* |     4 |    0 |         System | 0xfa8030eb5840 |      94 |     413 |       N/A | False | 2018-07-31 17:39:31.000000  |                            N/A
* |   276 |    4 |       smss.exe | 0xfa80325e9700 |       2 |      30 |       N/A | False | 2018-07-31 17:39:31.000000  |                            N/A
* |   372 |  360 |      csrss.exe | 0xfa8033185710 |      10 |     553 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |   428 |  360 |    wininit.exe | 0xfa803351e060 |       3 |      79 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |   512 |  428 |   services.exe | 0xfa80335a6060 |       9 |     239 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |   544 |  428 |       lsass.exe | 0xfa80335d3710 |       8 |     585 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |   552 |  428 |        lsm.exe | 0xfa80335d42d0 |      11 |     149 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |   648 |  512 |    svchost.exe | 0xfa8033821a70 |      13 |     372 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |   708 |  512 |   vmacthlp.exe | 0xfa8033856910 |       3 |      56 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |  1004 |  812 |    audiodg.exe | 0xfa8033951630 |       6 |     136 |         0 | False | 2018-07-31 17:39:32.000000  |                            N/A
* |  1632 | 2568 |    notepad.exe | 0xfa803113e7d0 |       2 |      75 |         2 | False | 2019-04-11 19:35:28.000000  |                            N/A
* |  2920 | 2568 |    wordpad.exe | 0xfa8031a66060 |       5 |     132 |         2 | False | 2019-04-11 19:35:31.000000  |                            N/A
* |  3384 | 1448 |        cmd.exe | 0xfa80312b9480 |       0 |       - |         0 | False | 2019-04-11 19:35:36.000000  | 2019-04-11 19:35:36.000000
* |  3960 |  372 |    conhost.exe | 0xfa803104cb30 |       0 |       - |         0 | False | 2019-04-11 19:35:36.000000  | 2019-04-11 19:35:36.000000
* |  3956 | 3384 |   ipconfig.exe | 0xfa80312c9630 |       0 |       - |         0 | False | 2019-04-11 19:35:36.000000  | 2019-04-11 19:35:36.000000

real    0m1.116s
user    0m0.760s
sys     0m0.076s
```


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```
$ python3 volshell.py -f turlanew.raw
Volshell (Volatility 3 Framework) 1.0.0-beta.1
Readline imported successfully  Building linux caches

    Call help() to see available functions

    Volshell mode: Generic
    Current Layer: primary2

(primary2) >>> hh()

Methods:
* dt, display_type
    Display Type describes the members of a particular object in alphabetical order
* db, display_bytes
    Displays byte values and ASCII characters
* dw, display_words
    Displays word values (2 bytes) and corresponding ASCII characters
* dd, display_doublewords
    Displays double-word values (4 bytes) and corresponding ASCII characters
* dq, display_quadwords
    Displays quad-word values (8 bytes) and corresponding ASCII characters
* dis, disassemble
    Disassembles a number of instructions from the code at offset
* cl, change_layer
    Changes the current default layer
* dpo, display_plugin_output
    Displays the output for a particular plugin (with keyword arguments)
* gt, generate_treegrid
    Generates a TreeGrid based on a specific plugin passing in kwarg configuration values
* rt, render_treegrid
    Renders a treegrid as produced by generate_treegrid
* ds, display_symbols
    Prints an alphabetical list of symbols for a symbol table
```


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Supporting Modern and Advanced Analytics

- Automating (where possible) operating system and application support
- Automating analysis decisions beyond simply presenting data structures and raw disassembly listings
- Automating analysis of multiple samples at once

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Automated Kernel Module Analysis – NDIS & Netfilter [5, 6]

With the hooks installed, whenever the network adapter driver attempts to register to NDIS, or whenever there is an attempt to install NDIS intermediate driver or NDIS filter driver, the hook handlers will register Snake's own *MiniportXxx* functions with the NDIS library.

With its own miniport handler functions, it can send/receive data by using a private TCP/IP stack, bypassing all firewall hooks, and making its open ports invisible to scanners.

```
magic_packet_hook_options.hook = (void *)magic_packet_hook;
magic_packet_hook_options.hooknum = 0;
magic_packet_hook_options.pf = PF_INET;
magic_packet_hook_options.priority = NF_IP_PRI_FIRST;
```


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Automated Version Analysis – TrueCrypt vs VeraCrypt [7, 8]

Tuesday, January 14, 2014

TrueCrypt Master Key Extraction And Volume Identification

- ***Windows***:
  - Installer: VeraCrypt Setup 1.24.exe (34.2 MB) (PGP Signature)
  - Portable version: VeraCrypt Portable 1.24.exe (34 MB) (PGP Signature)
  - Debugging Symbols: VeraCrypt_1.24_Windows_Symbols.zip (9.45 MB) (PGP Signature)

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Automatic Symbol Inclusion

```
$ python3 vol.py -f sample.vmem windows.ssdt
Volatility 3 Framework 1.0.0-beta.1
Index  Address          Module    Symbol
0      0xf800034dea50   ntoskrnl  NtMapUserPhysicalPagesScatter
1      0xf800033c40a0   ntoskrnl  NtWaitForSingleObject
2      0xf800030c68a0   ntoskrnl  NtCallbackReturn
3      0xf800033b7210   ntoskrnl  NtReadFile
<snip>

$ python3 vol.py -f sample.vmem windows.callbacks
Volatility 3 Framework 1.0.0-beta.1
Type                            Callback        Module    Symbol                  Detail
PspLoadImageNotifyRoutine       0xf800033ea520  ntoskrnl  EtwpTraceLoadImage      N/A
PspCreateProcessNotifyRoutine   0xf80003099590  ntoskrnl  ViCreateProcessCallback N/A
<snip>
```


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Automated Emulation of In-Memory Hooks [9]

```
Hook mode: Usermode
Hook type: Inline/Trampoline
Process: 3068 (iexplore.exe)
Victim module: ntdll.dll (0x77640000 - 0x7777c000)
Function: ntdll.dll!LdrLoadDll at 0x776a22b8
Hook address: 0x74c601f8
Hooking module: <unknown>
Disassembly(0):
0x776a22b8 e93bdf5bfd       JMP 0x74c601f8
<cut>
Disassembly(1):
0x74c601f8 e9c3daabeb       JMP 0x6071dcc0
<cut>
```

```
3068 iexplore.exe     ntdll.dll!LdrLoadDll at 0x776a22b8
PAGE_EXECUTE_READWRITE <Non-File Backed Region: 0x74c60000
0x74c6afff>
PAGE_EXECUTE_WRITECOPY \Device\HarddiskVolume1\
Program Files\AVG\Antivirus\snxhk.dll (2)
PAGE_EXECUTE_READWRITE <Non-File Backed Region: 0x74c60000
0x74c6afff> (46)
PAGE_EXECUTE_WRITECOPY \Device\HarddiskVolume1\
Program Files\AVG\Antivirus\aswhookx.dll (2)
PAGE_EXECUTE_READWRITE <Non-File Backed Region: 0x6f670000
0x6f67ffff> (4)
PAGE_EXECUTE_WRITECOPY \Device\HarddiskVolume1\Windows\
System32\ntdll.dll (2)
```


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Automatically Analyzing Multiple Samples

Volatility 2

1. Run kdbgscan (or imageinfo)
2. <wait>
3. Set --profile
4. Run plugin

Volatility 3

1. Run plugin

```
$ for sample in $(ls samples/*.mem); do python3 vol.py -f $sample windows.pslist | grep System; done
4     0       System  0x8a13f280      120        -    N/A     False   2019-09-30 03:16:14.000000      N/A
4     0       System  0x86569040      109        -    N/A     False   2019-01-05 02:29:56.000000      N/A
4     0       System  0x8954f040      121        -    N/A     False   2019-07-15 21:29:58.000000      N/A
4     0       System  0x85f6c040      118        -    N/A     False   2019-08-02 00:39:33.000000      N/A
```


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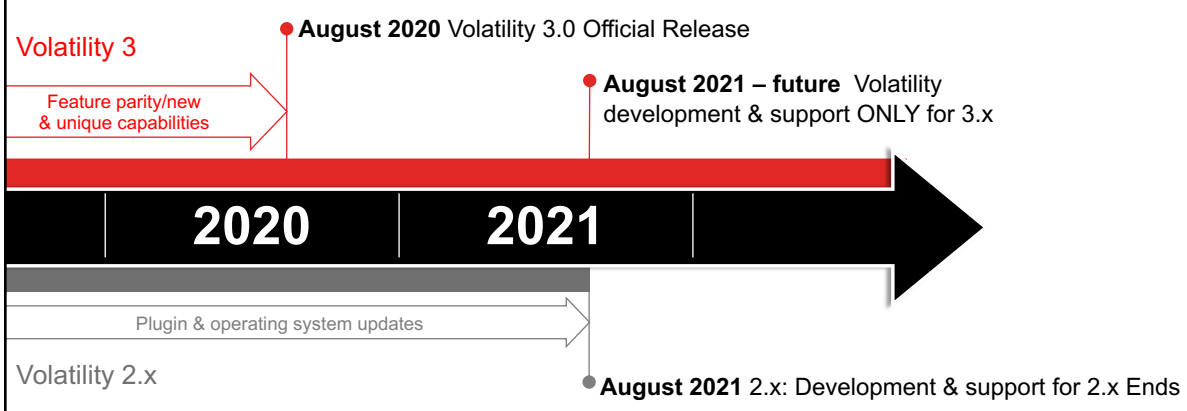
Looking Forward



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Start Using It and Get Involved!

- https://www.github.com/volatilityfoundation/volatility3
- https://volatility3.rtfd.io/
- https://www.volatilityfoundation.org/slack
- https://lists.volatilityfoundation.org/pipermail/vol-users/

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References

[1] https://www.blackhat.com/presentations/bh-dc-07/Walters/Paper/bh-dc-07-Walters-WP.pdf
[2] https://www.volatilityfoundation.org/20
[3] https://docs.microsoft.com/en-us/windows/deployment/update/waas-quick-start
[4] https://www.kernelnewbies.org
[5] https://artemonsecurity.com/snake_whitepaper.pdf
[6] https://github.com/f0rb1dd3n/Reptile/
[7] https://volatility-labs.blogspot.com/2014/01/truecrypt-master-key-extraction-and.html
[8] https://www.veracrypt.fr/en/Downloads.html
[9] http://dfrws.org/conferences/dfrws-usa-2019/sessions/hooktracer-system-automated-and-accessible-api-hooks-analysis

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