Registry Analysis and Memory Forensics: Together at Last

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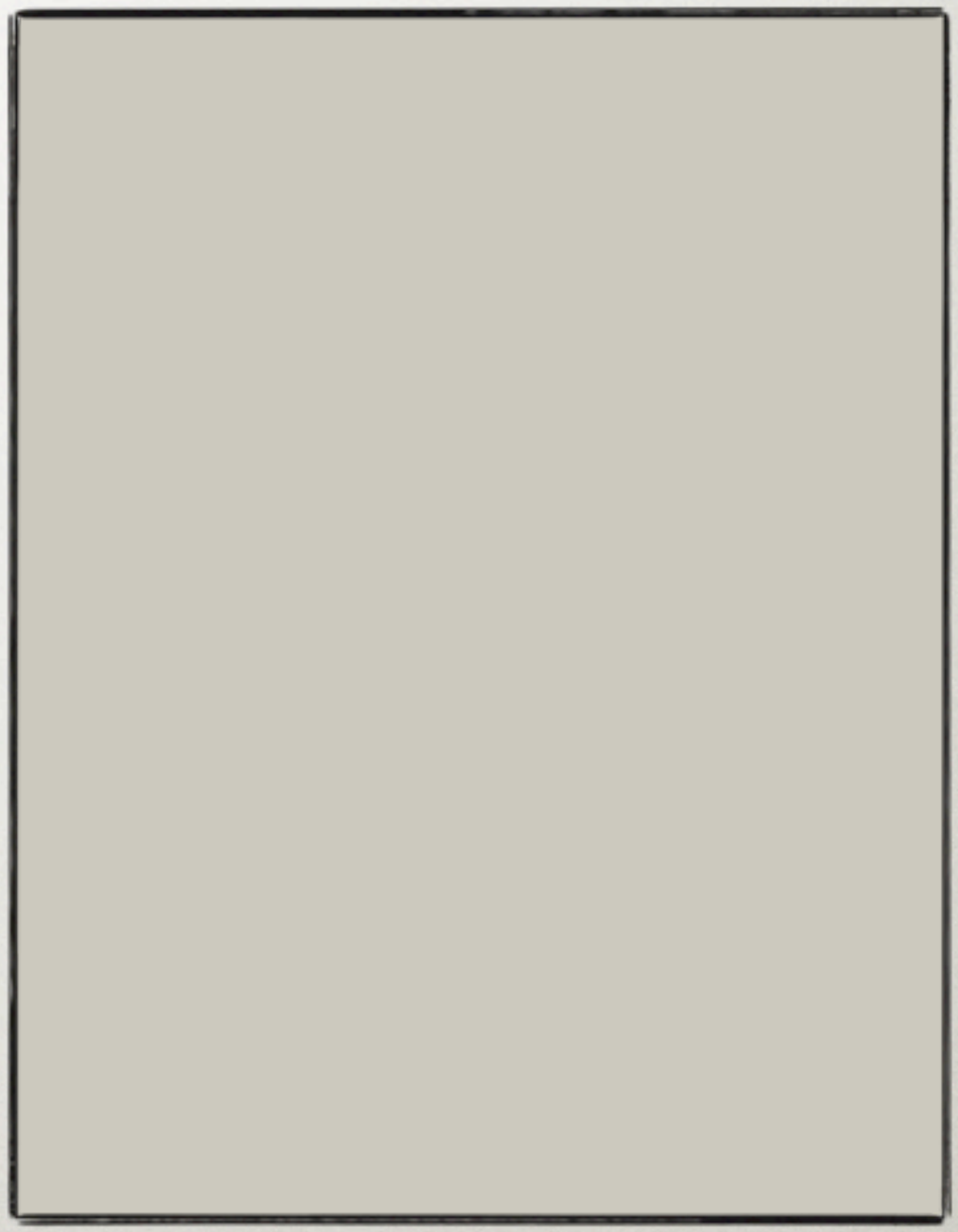
Who I Am

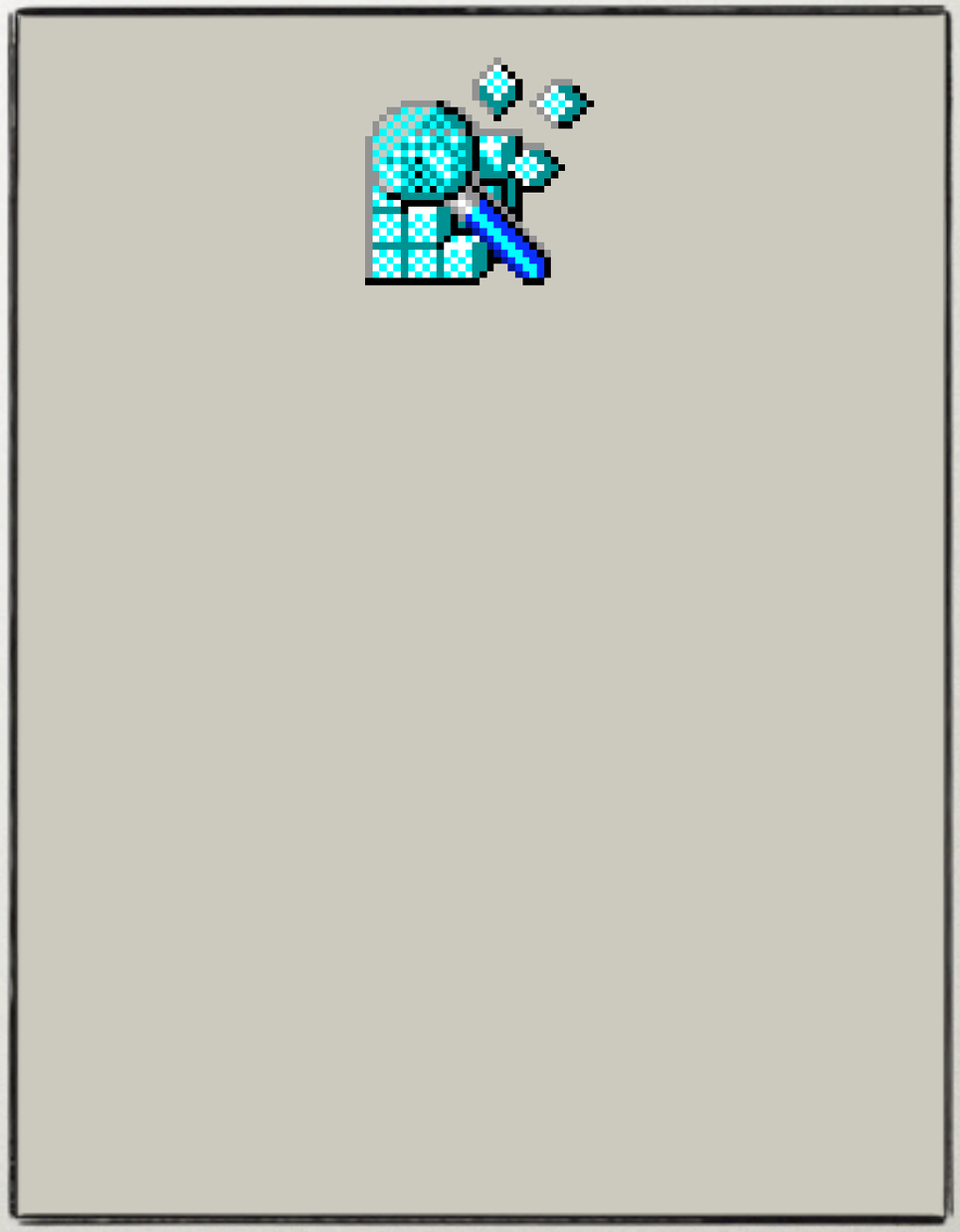
- Developer on Volatility project
- Grad student and researcher at Georgia Tech
- Author of “Push the Red Button” blog

Overview



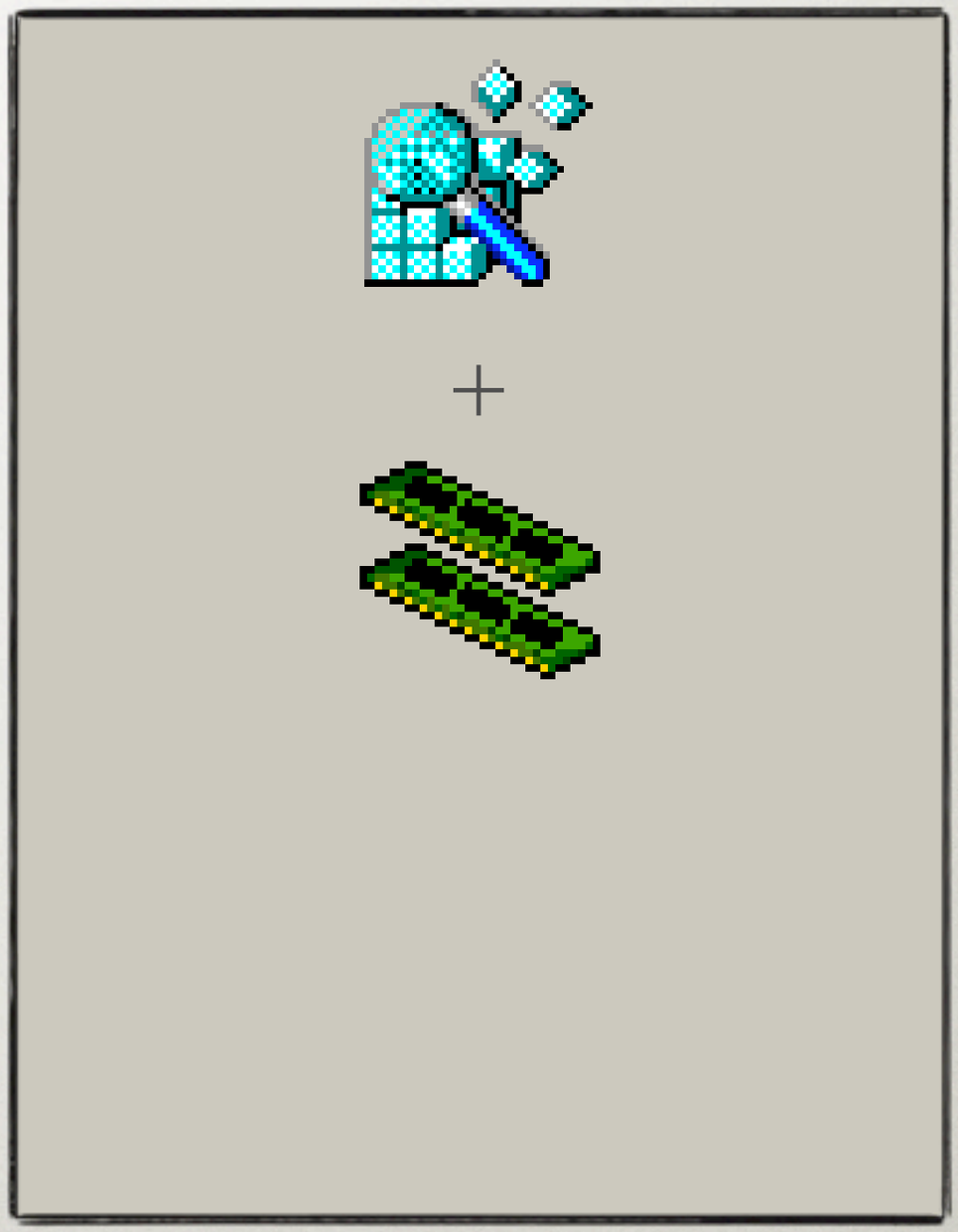
Overview

- Registry Analysis



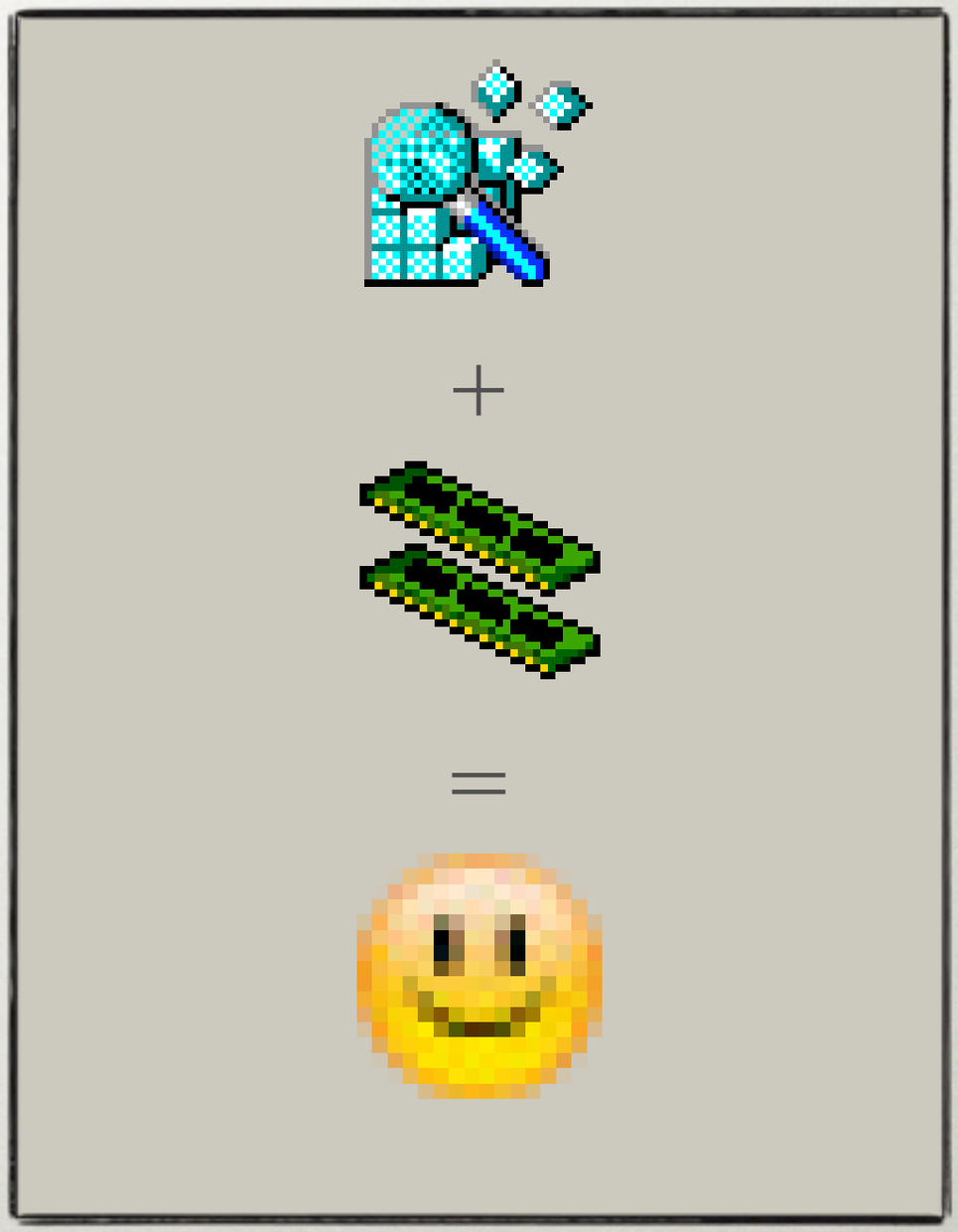
Overview

- Registry Analysis
- Memory Forensics



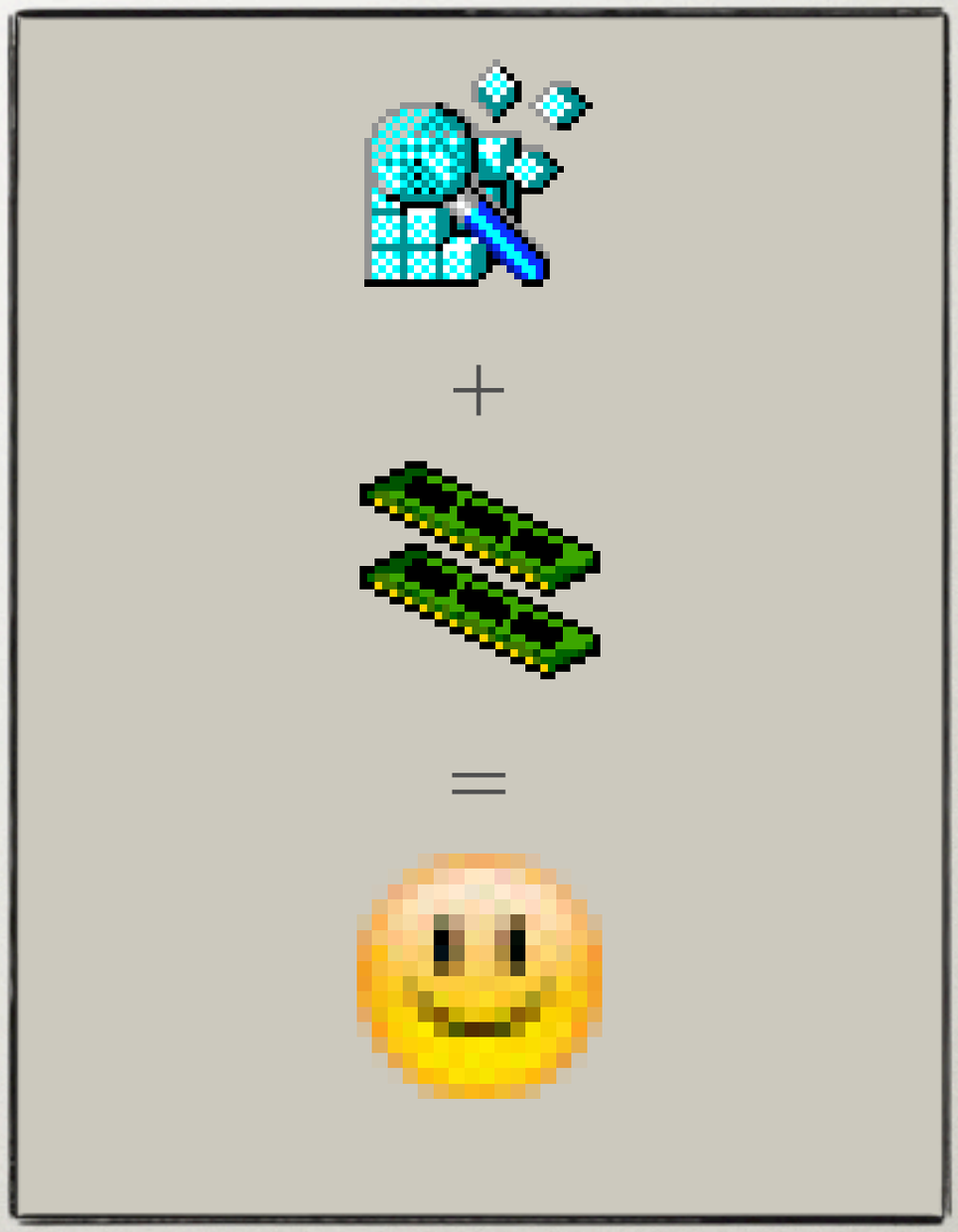
Overview

- Registry Analysis
- Memory Forensics
- Combining the fields



Overview

- Registry Analysis
- Memory Forensics
- Combining the fields
- Lots of examples throughout



Windows Registry

- Centralized, hierarchical configuration database
- Structured like a filesystem
  - Keys = Directories, Values = Files
- Rich source of forensic information

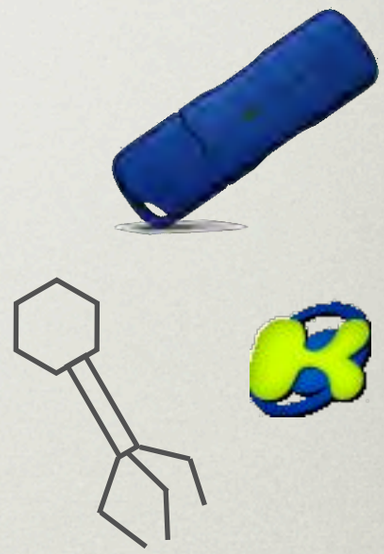
Windows Registry (cont.)

- Registry appears as unified tree, but is made up of distinct *hives*

- Standard set of systemwide hives, as well as per-user hives
- Note: Registry contains some *volatile* data available only at runtime

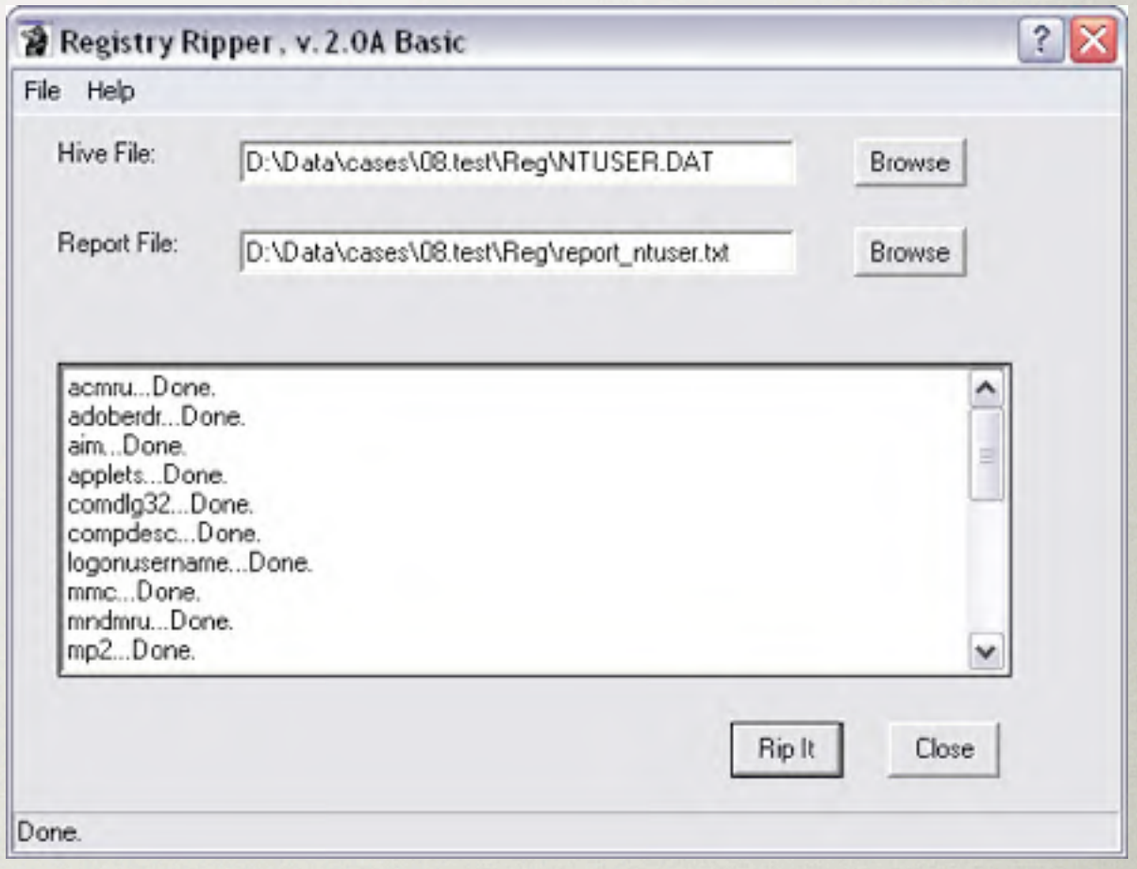
Registry Data

- Removable media / USB keys
- Artifacts from P2P programs
- Malware persistence artifacts
- Password hashes (encrypted)



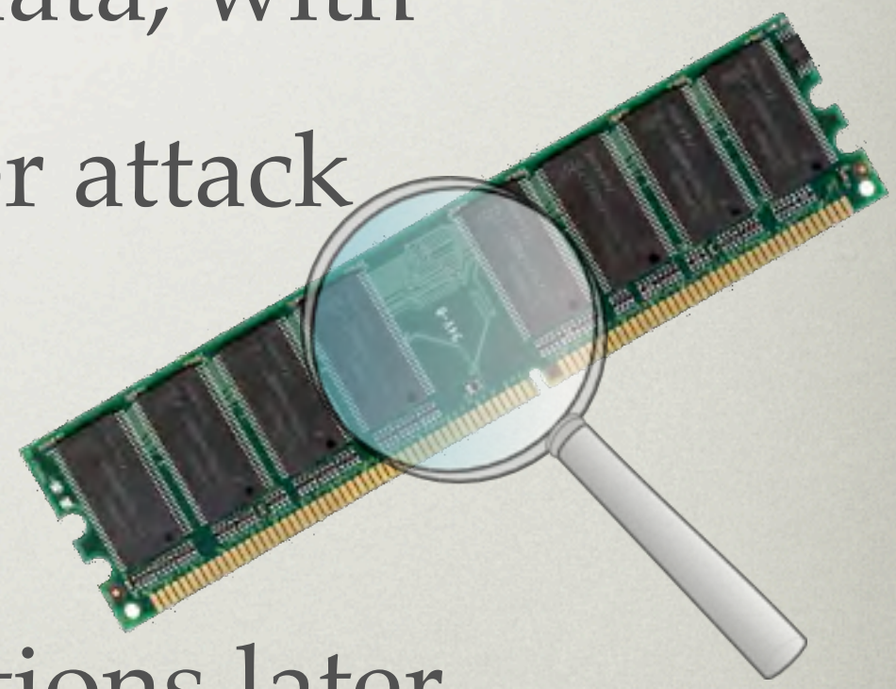
Registry Forensics Tools

- RegLookup
  - Fast, robust registry parser
- Parse::Win32Registry
  - Lower level perl module
  - Good for rolling your own tools
- RegRipper
  - Undisputed king of registry analysis
  - Produces reports of forensic info



Memory Forensics

- Analysis of volatile data based on memory snapshots
- Allows extraction of *live* data, with
  - Higher integrity (smaller attack surface)
  - Repeatable results
  - Ability to ask new questions later



Memory Forensics Tools

- Memoryze
- HBGary Responder
- Volatility
  - GPL, collaborative development
  - Supports plugins
  - My favorite ;)

Data in Memory

- Current tools can extract a ton of information from memory images

- Processes
- Threads
- Drivers
- Open files
- Loaded DLLs
- Rootkit behavior
- Injected code
- Encryption keys

Combining Registry and Memory Analysis

- Windows keeps registry data in memory
- By figuring out the internals of the Windows Configuration Manager...
- We can combine these two fields!

Design Goals

- Access *stable* registry data
- Access *volatile* registry data
- Speed up incident response
- Apply existing registry analyses

Solution: VolReg

- Suite of plugins for Volatility 1.3
- Provides API to access registry data from XPSP2 memory images
- Adds new commands for:
  - Showing keys / values
  - Dumping registry as CSV
  - Extracting password hashes

VolReg: Hivescan

- Hivescan: finds raw offsets in memory image of registry hives
- Not very useful by itself, but needed for other plugins
- Once we have one hive offset, we can get a nicer list of all hives in memory

```
$ volatility hivescan \
  -f image.dd
Offset             (hex)
42168328           0x2837008
42195808           0x283db60
47598392           0x2d64b38
155764592          0x948c770
155973608          0x94bf7e8
208587616          0xc6ecb60
208964448          0xc748b60
234838880          0xdff5b60
243852936          0xe88e688
251418760          0xefc5888
252887048          0xf12c008
256039736          0xf42db38
269699936          0x10134b60
339523208          0x143cb688
346659680          0x14a99b60
377572192          0x16814b60
```

VolReg: Hivelist

- Given one of the offsets from hivescan, finds all other hives in memory
- Keep this list around!
- The addresses in this list are what we will use for the other registry plugins

Hivelist Example

```
$ volatility hivelist -f image.dd -o 0x2837008
Address      Name
0xe2610b60   \Documents and Settings\S----\Local Settings\[...]\UsrClass.dat
0xe25f0578   \Documents and Settings\S----\NTUSER.DAT
0xe1d33008   \Documents and Settings\LocalService\Local Settings\[...]\UsrClass.dat
0xe1c73888   \Documents and Settings\LocalService\NTUSER.DAT
0xe1c04688   \Documents and Settings\NetworkService\Local Settings\[...]\UsrClass.dat
0xe1b70b60   \Documents and Settings\NetworkService\NTUSER.DAT
0xe1658b60   \WINDOWS\system32\config\software
0xe1a5a7e8   \WINDOWS\system32\config\default
0xe165cb60   \WINDOWS\system32\config\SAM
0xe1a4f770   \WINDOWS\system32\config\SECURITY
0xe1559b38   [no name]
0xe1035b60   \WINDOWS\system32\config\system
0xe102e008   [no name]
```

VolReg: Printkey

- Given a hive address and a key, prints the key and its subkeys and values
- Shows last modified time, formats values according to type
- Includes *volatile* keys & values as well
- Good for just looking around

Printkey Example

```
$ volatility printkey -f image.dd -o 0xe1035b60
Key name: $$$PROTO.HIV (Stable)
Last updated: Mon Jul  4 18:16:59 2005

Subkeys:
   ControlSet001 (Stable)
   ControlSet002 (Stable)
   LastKnownGoodRecovery (Stable)
   MountedDevices (Stable)
   Select (Stable)
   Setup (Stable)
   WPA (Stable)
   CurrentControlSet (Volatile)

Values:

$ volatility printkey -f image.dd -o 0xe1035b60 CurrentControlSet
Key name: CurrentControlSet (Volatile)
Last updated: Mon Jul  4 18:16:59 2005

Subkeys:

Values:
REG_LINK  SymbolicLinkValue : \Registry\Machine\System\ControlSet001 (Volatile)
```

Volatile data!

VolReg: Hashdump

- Local account password hashes are stored in the registry (encrypted)
- Hashdump module decrypts and prints these hashes
- If LanMan hash is in use, rainbow tables can recover password in minutes
- Use this power for good :)

Hashdump Example

System hive

SAM hive

```
$ volatility hashdump -f image.dd -y 0xe1035b60 -s 0xe165cb60

Administrator:500:08f3a52bdd35f179c81667e9d738c5d9:ed88cccbc08d1c18bcded317112555f4:::
Guest:501:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
HelpAssistant:1000:ddd4c9c883a8ecb2078f88d729ba2e67:e78d693bc40f92a534197dc1d3a6d34f:::
SUPPORT_388945a0:1002:aad3b435b51404eeaad3b435b51404ee:8bfd47482583168a0ae5ab020e1186a9:::
phoenix:1003:07b8418e83fad948aad3b435b51404ee:53905140b80b6d8cbe1ab5953f7c1c51:::
ASPNET:1004:2b5f618079400df84f9346ce3e830467:aef73a8bb65a0f01d9470fadc55a411c:::
S----:1006:aad3b435b51404eeaad3b435b51404ee:31d6cfe0d16ae931b73c59d7e0c089c0:::
```

Hashes can now be cracked using
John the Ripper, rainbow tables, etc.

Others (not shown)

- Cachedump: dumps cached domain credentials
- Lsadump: dumps LSA protected storage (can contain passwords)
- Hivedump: dumps CSV of all keys and (optionally) values

Design Goals

- Access *stable* registry data [✓]
- Access *volatile* registry data [✓]
- Speed up incident response [?]
- Apply existing registry analyses [X]

Solution: VolRip

- Python→Perl interface that makes VolReg look like Parse::Win32Registry
- Now we can run RegRipper against memory!
- Existing analysis plugins just work

VolRip Setup

- Linux only (sorry!)
- Requirements: Inline::Python, VolReg
- Extract VolRip tarball into Volatility directory
- Run rip.pl with the memory image and address of the hive:

```
perl rip.pl -r image.dd@0xe1035b60 -f system
```

VolRip Example: Tracking USB Keys

```
$ perl rip.pl -r image.dd@0xe1035b60 -p usbstor
Launching usbstor v.20080418
USBStor
ControlSet001\Enum\USBStor

Disk&Ven_Generic&Prod_STORAGE_DEVICE&Rev_0.01 [Sun Jun 27 05:58:42 2004]
  S/N: 6&a344881&0 [Wed Jun 30 00:23:07 2004]
    FriendlyName  : Generic STORAGE DEVICE USB Device
    ParentIdPrefix: 7&192c45c3&0

Disk&Ven_LEXAR&Prod_JUMPDRIVE_SPORT&Rev_1000 [Sat Jun 25 16:50:48 2005]
  S/N: 0A4F10111801321308O4&0 [Mon Jul  4 18:17:50 2005]
    FriendlyName  : LEXAR JUMPDRIVE SPORT USB Device
    ParentIdPrefix: 7&2930a404&0


$ perl rip.pl -r image.dd@0xe1035b60 -p usbstor2
SPLATITUDE,Disk&Ven_Generic&Prod_STORAGE_DEVICE&Rev_0.01,6&a344881&0,
  1088554987,Generic STORAGE DEVICE USB Device,7&192c45c3&0,\DosDevices\E:
SPLATITUDE,Disk&Ven_LEXAR&Prod_JUMPDRIVE_SPORT&Rev_1000,0A4F10111801321308O4&0,
  1120501070,LEXAR JUMPDRIVE SPORT USB Device,7&2930a404&0,\DosDevices\D:
```

Design Goals

- Access *stable* registry data [✓]
- Access *volatile* registry data [✓]
- Speed up incident response [✓]
- Apply existing registry analyses [✓]

Caveats

- Since analysis is done on memory, some things might be missing
- Can be especially annoying with hash dumping -- both System and SAM must be in memory
- Possible future direction: dump all available registry data, then use fragment recovery

Conclusions

- Applying registry analysis to memory can give you powerful new tools!
- Some existing registry tools can be coaxed into working with memory
- Still need tools to analyze *volatile* registry data (new RegRipper plugins?)

Thanks!

- To you all, for listening
- To AAron Walters and the folks in #volatility
- To Harlan Carvey, Tim Morgan, and many others for their work and insight on all matters registry-related

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? ? ? ...any questions? ? ? ?