

THOR / SPARK Log Analysis

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1 Introduction

THOR and SPARK log files are designed to provide as much information on a detected object as possible. However, both scanners are designed to evaluate an object offline without any further data sources aside from the local signature sets. Many log messages must be evaluated by an analyst that has access to other data sources and platforms.

This document is meant for analysts with the task to analyze THOR or SPARK log files. Each chapter contains guidelines to process messages of a certain module.

Please see chapter 5 for a complete overview of tools to evaluate the events generated by THOR.

2 Analyst Profile

The analyst profiles help you to understand which skills are recommended and required to complete a successful log analysis. The scanners actually perform a live forensic analysis on the end systems and highlight elements using the internal signature database. The best possible analyst for these events is someone with experiences in digital forensics, incident response or malware analysis.

The expert in digital forensics knows how to spot and qualify suspicious elements.

The incident responder understands adversary tactics, hack tools, lateral movement methods and the many different ways to achieve persistence on an end system.

And the malware analyst has the right mindset and experience to evaluate at least the elements that involve backdoors and persistence methods.

We recommend a two-tier analysis process in which a second level analyst with the described skill set processes log lines that have been pre-qualified by first level analysts.

2.1.1 Recommended / 2nd Level

- Forensic Analysis
- Incident Response Specialist
- Malware Analyst

2.1.2 Required / 1st Level

- Professional with security background
- Knowledge of Microsoft Windows internals (Administration, Development)
- Security analyst with Antivirus log analysis background

3 Log Analysis

3.1 General Recommendations

This chapter contains general approaches that apply to all findings regardless of the module that reported it.

3.1.1 High Quantity Reduces Relevance

In contrast to firewall log analysis, the high number of a certain event doesn't increase but decrease the relevance of that event. In a nutshell, if a suspicious file has been detected on a high number of end systems within a given network, it is most likely a false positive. Experience showed that the most relevant findings were reported from 1-5 and sometimes up to 30 end systems but suspicious elements reported from 100 end systems and higher are most likely false positives if no strong indicators suggest the opposite.

3.1.2 Analysis by Module or Score

Our analysts prefer two types of approaches that are often combined to analyze big amounts of log data.

First, we recommend using our Analysis Cockpit or the free Splunk App / Add-on to sort the log data by score (descending).

This way analysts are able to see top scoring elements that are often the most urgent ones. It is recommended to process the top scoring events top down to a score of 80 and then switch over to an analysis by module. After selecting a certain module, we recommend selecting the columns (fields) with the most characteristic features. (e.g. "FileScan" module > selected fields "FILE", "MAIN_REASON")

1. Sort by score and analyze events top down to a score of 80
2. Analyze events by module and process the remaining events with an appropriate set of columns

3.1.3 Filters Clear the View

It is crucial to provide a quick and easy way to filter events based on keywords, especially when analyzing events of hundreds or thousands of end points. Log analysis or SIEM systems that do not offer easy and fast ways to filter information from a view make it substantially more difficult to process large amounts of log data.

Typically, false positives are found in great quantities. By providing tools and log management solutions that allow easy filtering the time to complete the analysis of large amounts of log data can be reduced from days to a few hours.

3.1.4 Attribute Evaluation

Many evaluation steps that can be automated have already been implemented in the scanners. This document aims at giving an analyst the best possible support to complete the remaining evaluations.

There is no easy step by step guide to analyze the logs of our forensic scanners. The tables named "Attribute Evaluation", which are part of the following chapters, just support this evaluation process. They do not represent all necessary steps to complete an analysis.

3.2 FileScan

Events reported by the "FileScan" module typically originate from the file system scan. But, due to the "Message Enrichment" feature, other modules that include events with full file path strings may also produce events of this type. (e.g. module "SHIMCache", "Eventlog")

Filescan events are rich in attributes and extra information.

3.2.1 Samples

```
Dec  2 19:29:43 PROMETHEUS/10.0.2.4 THOR: Notice: MODULE: Filescan MESSAGE:
Suspicious file found FILE: C:\Program Files (x86)\HaoZip\HaoZipExt64.dll SCORE:
54 MD5: 60873d6560b29bdb30235e05eda97539 SHA1:
d312157d7c890a68eed85c5a2fd17fdfe6defa87 OWNER: BUILTIN\Administrators SIZE:
513800 TYPE: EXE FIRSTBYTES: 4d5a90000300000004000000ffff0000b8000000 / MZ
COMPANY: ##### DESC: 2345##-Windows##### CREATED: Thu Jul 26 05:20:04 2012
MODIFIED: Thu Jul 26 05:20:04 2012 ACCESSED: Fri Sep 20 12:47:39 2013 REASON_1:
Haozip_SFX / Haozip SFX Compressed Executable Score: +50 Trigger: Specific Rule
Value: Str1: release\pdb\HaoZip
```

3.2.2 Typical False Positives

- Legitimate files matching a filename regular expression IOC
- YARA rules matching THOR reports or clear-text signatures from former scan runs that have been left on the system
- Dual use tools used by administration (e.g. "nmap.exe", "ncat.exe")
- Legitimate tools moved to Recycler and therefore detected with wrong name (e.g. "Psexec" as "\$IR4HB6A.exe")
- Legitimate but very old files that trigger the file size anomaly
- Old and rare versions of legitimate programs that trigger the file signature anomalies (that often happens with "javaw.exe" / "java.exe")

3.2.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
FILE	See chapter 4.1 "File Path Checks"			
MD5 / SHA1 / SHA256	See chapter 4.2 "Hash Checks" for generic checks on hashes			
SIZE	Is the file size 0 bytes? (Probably reset by AV due to a detected infection)	Yes	Bad	Medium
FIRSTBYTES	Do the first bytes contain words in native language – e.g. @ECHO OFFecho "Übertragung"	Yes	Good	High
	Do the first 20 byte already contain executables or command line tools – e.g. "@echo off net user /domain >"	Yes	Bad	Medium
OWNER	Is the owner of the file a typical user account – e.g. DOM\user123	Yes	Good	Low
	Is the owner of the file "BUILTIN\Administrators"	Yes	-	-
	Does the owner string of the file contain "IIS" or another service name – e.g. "IIS_USRS", "tomcat", "apache"	Yes	Bad	Medium

TYPE	Does the type match the extension?	No	Bad	Low
	Is the type EXE and the extension a benign looking one? – e.g. ".txt" or ".pdf"	Yes	Bad	Medium
COMPANY	Does the company string from the PE header match the expected values, e.g. "cmd.exe" contains "Microsoft"	No	Bad	Medium
DESC	Does the description string from the PE header match the expected values, e.g. "sapgui.exe" contains "SAP GUI for Windows"	No	Bad	Low
CREATED / MODIFIED	Has the file been created very far in the past? – e.g. time stamp shows 2010 and older	Yes	Good	Low
	Has the file been modified on a Sunday (note the region in which the admins work: e.g. in Israel Sunday is a work day)	Yes	Bad	Medium

3.2.4 Typical REASONS

REASON_1	Is the only REASON a file name pattern match? (prone to false positives)	Yes	Good	Low
REASON_2				
...				
	Is the file located in a personal user folder and does it look as if the user changed the extension to avoid certain filter mechanisms? (e.g. "Chrome-Portable.exe.txt", "weihnachstkalender.txt")	Yes	Good	Medium
	Does the REASON field report a file anomaly and the file is located in a backup folder from a very old version of Windows or may be an outdated version of the original program? – e.g. "F:\WinNT35\..." or "C:\Program Files\NextGen Software\bin\javaw.exe"	Yes	Good	Medium
	Does the REASON report a suspicious, unsigned javaw.exe and is that file located in a folder of a software product? (Rule: Javaws_Not_Verisign) (e.g. "C:\Program Files\IBM Backup Manager\bin\javaw.exe")	Yes	Good	Medium
	Rule starts with "VUL_" reporting a vulnerability?	Yes	Good	Medium
	Does the rule match on a hack tool that is installed in a typical location on disk or in a backup location? (e.g. "ncat" in "/usr/bin/ncat" or "/backups/sys1/20171113/bin/ncat")	Yes	Good	Medium

3.3 SHIMCache

The SHIM Cache or AppCompatCache is a special Registry cache containing valuable information because the cache tracks metadata for binary files that were executed. It includes the full path to the executable file image and a timestamp, which could be the date of the last execution or the creation time stamp of the file, depending on the Windows version.

3.3.1 References

<https://countuponsecurity.com/2016/05/18/digital-forensics-shimcache-artifacts/>

3.3.2 Samples

```
Aug 26 13:10:21 SRV2345/10.2.0.22 THOR: Warning: MODULE: SHIMCache MESSAGE:
Suspicious file name in Shim Cache Entry detected ELEMENT: SYSVOL\Temp\1.exe
PATTERN: \[01]\.exe AND \[A-Za-z0-9]\.(exe|com|dll|bat|scr|vbs)$ AND \[Tt]emp\[0-
9a-zA-Z]\.(exe|dll) SCORE: 60 DESC: Typical attacker scheme FILE:
SYSVOL\Temp\1.exe DATE: 02/21/17 15:44:32 TYPE: system HIVEFILE: None EXTRAS: N/A
N/A True MD5: - SHA1: - SHA256: -
```

```
Aug 26 12:02:59 SRV1123.internal.net/10.0.0.112 THOR: Warning: MODULE: SHIMCache
MESSAGE: Suspicious file name in Shim Cache Entry detected ELEMENT:
D:\Temp\test\client.exe PATTERN: \client.exe SCORE: 60 DESC: Typical Malware
Names FILE: D:\Temp\test\client.exe DATE: 01/23/17 08:03:37 TYPE: system
HIVEFILE: None EXTRAS: N/A N/A False MD5: 099120aca1c34e7a529b3b390cfdbc1e SHA1:
4ece72b9fa13019a4ce8b4229ca7b6aee09d6982 SHA256:
c3c336a23021b68b026bdf1642b220d88037039aa6d7f8e7d4d576cc38063088
```

3.3.3 Typical false positives

- Legitimate software that uses strange executable locations
- THOR's own scan runs if administrators chose suspicious working directories (e.g. C:\Temp\, C:\thor\)

3.3.4 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
ELEMENT	See chapter 4.1 "File Path Checks"			
MD5 / SHA1 / SHA256	Is the hash field empty? (this means: File was not found during the scan)	Yes	-	-
	See chapter 4.2 "Hash Checks" for all generic checks on hashes			

3.4 Autoruns

The Autoruns module makes use of the command line version of SysInternals Autoruns. It parses the tool's output and integrates the output in each log message.

3.4.1 References

<https://docs.microsoft.com/en-us/sysinternals/downloads/autoruns>

3.4.2 Issues

The hash generation for the SHA1 hash in Autorunsc.exe is not reliable. The reasons for this is unknown. The issue has been reported but hasn't been fixed so far. The value is therefore suppressed.

3.4.3 Samples

```
Aug 26 18:48:28 system.internal.net/10.1.2.50 THOR: Warning: MODULE: Autoruns
MESSAGE: New or changed autoruns element LOCATION:
HKLM\System\CurrentControlSet\Services ENTRY: SymELAM ENABLED: enabled CATEGORY:
Drivers PROFILE: System-wide DESC: Symantec ELAM PUBLISHER: Symantec Corporation
IMAGE_PATH: c:\windows\system32\drivers\sep\0c011b95\19c8.105\x64\symelam.sys
LAUNCH_STRING: system32\Drivers\SEP\0C011B95\19C8.105\x64\SymELAM.sys MD5:
20f758e6339a16f97dd83389d582e09a SHA1: - SHA256:
837016154b7952b645b5545aeb8e2a8878efa8674e6b96471c3db5e458b06960 SCORE: 60
```

```
Aug 26 13:00:55 system.internal.net/10.1.2.50 THOR: Warning: MODULE: Autoruns
MESSAGE: Autoruns element located in a suspicious location MATCH_STRING: \temp\
LOCATION: HKLM\System\CurrentControlSet\Services ENTRY: inject3526 ENABLED:
enabled CATEGORY: Services PROFILE: System-wide DESC: - PUBLISHER: - IMAGE_PATH:
c:\users\markschmitt\AppData\Local\Temp\ inject23.exe LAUNCH_STRING:
C:\Users\markschmitt\AppData\Local\Temp\inject23.exe MD5:
7f9a4835a7a237d2873901bb73d00e7b SHA1: - SHA256:
d21d4ad73b848488890bf7f846daff7455062801d0d86238d99591219878f36a SCORE: 75
```

3.4.4 Typical False Positive

- New entries that are legitimate
- Legitimate software that uses strange autorun locations

3.4.5 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
MESSAGE	Does it contain "New or changed autoruns element" (Note: This is just a change notice and can be relevant on critical systems or under certain circumstances)	Yes	Good	Low
IMAGE_PATH	See chapter 4.1 "File Path Checks"			
PUBLISHER	Is the field empty	Yes	Bad	Low
DESC	Is the field empty	Yes	Bad	Low
MD5 / SHA1 / SHA256	Is the hash field empty? (means: File was not found during the scan)	Yes	-	-
	See chapter 4.2 "Hash Checks" for all generic checks on hashes			

3.5 LogScan

The "LogScan" module processes "*.log" files found in disk line by line (It performs some checks to avoid scanning files that are no ASCII log files but something else that uses the *.log extension).

Each log line is checked with all file name and keyword IOCs and scanned with the "keyword" and "log" type YARA rules.

3.5.1 Samples

```
Aug 26 18:58:32 System23.local.net/10.2.2.14 THOR: Warning: MODULE: LogScan
MESSAGE: Suspicious file name in Log Entry detected ELEMENT: Deleted file -
E:\TEAM-TRANSFER\4Helmut\Tools\PortScan.exe PATTERN: \PortScan.exe SCORE: 65
DESC: PortScanner Names FILE: D:\ scripts\log\TEAM-TRANSFER.CLEANUP.cmd.2015-09-
27.log LINE: 320
```

```
Aug 27 10:40:30 System23.local.net/10.2.2.14 THOR: Warning: MODULE: LogScan
MESSAGE: Suspicious file name in Log Entry detected ELEMENT: /EN/cmd.exe /c+dir
"C:\data\inetpub\wwwroot\EN\cmd.exe" 404 "SW0123" - -2147024864 - - 0 10.10.9.24
443 - "gi.webshop.com" - 09:48:18.024 "HTTP/1.1" "https" 1405 102 PATTERN: ([C-
Zc-z]:|\\).{1,40}\
```

3.5.2 Typical False Positives

- Web vulnerability scans trying to access files that do not exist (HTTP Error 404)
- RoboCopy logs that list hack tools like "nmap.exe" or "ncat.exe"

3.5.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
FILE	Does the path include a timestamp that indicates very old data? (e.g. C:\wwwroot\logs\2003-04-17-access.log)	Yes	Good	Medium
ELEMENT	Does an investigation for the remote IP address return negative or suspicious results? (see chapter 5 for platforms and tools)	Yes	Bad	High
	Does the web server access log line include a response code 404? (404: file not found; see the example above)	Yes	Good	Medium
	Does the element show an Antivirus alert? > Antivirus alerts often go unnoticed / it is recommended to include them in the reports	Yes	Bad	Medium
	Does the element (log line) include a file name / file path? See chapter 4.1 "File Path Checks"			

3.6 GroupsXML

The GroupsXML module is a module that reports on critical security issues related to decryptable passwords in group policy files, that are readable for anyone within a Windows Domain.

3.6.1 References

<https://adsecurity.org/?p=2288>

<http://niiconsulting.com/checkmate/2016/02/hunting-passwords-in-sysvol/>

3.6.2 Samples

```
Aug 28 11:07:24 System32.local.net/10.2.0.7 THOR: Warning: MODULE: GroupsXML  
MESSAGE: Found decryptable password in Groups.xml FILE:  
D:\SYSVOL_DFSR\sysvol\win55.local.net\Policies\{FFABF4BC-8A98-4B3F-AD7D-  
D65A5F4C26C1}\Machine\Preferences\Groups\Groups.xml USER: Administrator (built-  
in) PASSWORD: win***removed*** SCORE: 75
```

3.6.3 Typical False Positives

The only possible false positives for these findings are:

- Old groups.xml files in backup locations that are not active anymore

3.6.4 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
PASSWORD	Does the password start with 3 digits that could indicate password that is easy to guess? (e.g. pas*****, win*****, Def*****)	Yes	Bad	Medium
USER	Is the user name a default user account that attackers could easily use without attracting attention? (e.g. Administrator, Admin)	Yes	Bad	Medium

3.7 Registry

Registry matches can be caused by different signature types: File name IOCs, keywords or YARA signatures matches.

3.7.1 Samples

Aug 29 08:13:37 system123.local.net/10.6.2.10 THOR: Warning: MODULE: Registry
MESSAGE: YARA Rule Match KEY: Registry Key CMI-CreateHive{D43B12C1-09B5-40DB-AFF6-F6DFEB78DAEC}\Software\Microsoft\Windows\CurrentVersion\Run with 1 values and 0 subkeys NAME: Suspicious_Startup_Loc_RegistryKey SCORE: 70 DESCRIPTION: Detects suspicious registry values often used by malware REF: - MATCHED_STRINGS: Str1: CurrentVersion\Run;Google Update;"C:\Users\MSchmitz\AppData\Local\Google\Update\GoogleUpdate.exe

Aug 28 08:17:46 system123.local.net/10.10.1.8 THOR: Warning: MODULE: Registry
MESSAGE: YARA Rule Match KEY: Registry Key CMI-CreateHive{6A1C4018-97AB-4291-A7DC-7AED1C76667C}\Keyboard Layout\Preload with 3 values and 0 subkeys NAME: Chinese_Keyboard_Layout_RDP_Preload SCORE: 70 DESCRIPTION: Chinese Keyboard Layout settings detected - this hive's user used the chinese keyboard layout REF: <http://www.welivesecurity.com/2014/05/20/miniduke-still-duking/> MATCHED_STRINGS: Str1: Keyboard Layout\Preload;2;00000804

3.7.2 Typical False Positives

- Values with system files in rare locations (e.g. backup locations: "\\backupserv\sysbackup20171119\Windows\system32")
- Keyboard layout preloads that are typical for the region of the system (e.g. "Chinese keyboard layout" on a system in Shanghai)
- Values that start with "4d5a" by pure chance

3.7.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
MATCHED_STRINGS	Does the strings match on a suspicious program location and is that location legitimate? (verify via Google search)	Yes	Good	Medium
		No	Bad	Medium
	Does a google search on the strings match show no result at all?	Yes	Bad	Medium
NAME	Does the rule name include the string "RDP_Preload" and the respective keyboard layout is completely implausible on that end system? (e.g. Chinese keyboard layout on system in Italy with Italian admins only)	Yes	Bad	Medium
	Does the rule name include the string "RDP_Preload" and the respective keyboard layout is plausible on that end system? (e.g. Chinese keyboard layout on system in Shanghai)	Yes	Good	High

3.8 WMI Persistence

It is difficult to detect malicious WMI persistence objects. The detection methods are based on white lists and a black list with keywords known from APT reports. The white lists are extended every time our analysts detect false positives in a customer's environment. The black lists are extended every time an APT report states a certain WMI persistence method with specific event filter or event file name.

3.8.1 References

https://github.com/darkquasar/WMI_Persistence

3.8.2 Samples

```
Aug 26 23:16:41 server44.local.net/10.23.3.1 THOR: Warning: MODULE:
WMIPersistence MESSAGE: Suspicious WMI element KEY: Binding 91 FILTERTYPE:
HealthDriverEventConsumer EVENTFILTERNAME: HP_TempSensorFailureEvent
EVENTCONSUMER: Health Event Consumer EVENTFILTER: select * from
HP_TempSensorFailureEvent EVENTCONSUMER: - SCORE: 75
```

```
Aug 26 23:16:41 server44.local.net/1.253.103.134 THOR: Warning: MODULE:
WMIPersistence MESSAGE: Suspicious WMI element KEY: Binding 93 FILTERTYPE:
HealthDriverEventConsumer EVENTFILTERNAME: HP_ASRStateChangeEvent EVENTCONSUMER:
Health Event Consumer EVENTFILTER: select * from HP_ASRStateChangeEvent
EVENTCONSUMER: - SCORE: 75
```

3.8.3 Typical False Positives

- Legitimate entries caused by system management software (e.g. HP services)

3.8.4 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
EVENTFILTER	Does the Eventfilter content related to the EventFilterName? (e.g. "HP_TempSensorFailureEvent" and "select * from HP_TempSensorFailureEvent")	Yes	Good	Medium
		No	Bad	Medium
EVENTFILTERNAME	Does a google search on the EventFilerName show no result at all?	Yes	Bad	Medium
	Does a google search on the EventFilterName result in results that seem legitimate?	Yes	Good	Medium

3.9 VulnerabilityCheck

Vulnerability checks are limited to a few vulnerabilities that are known to be exploited by various threat groups. The vulnerability checks focus on vulnerabilities that are used for lateral movement or weaknesses that allow an attacker to easily achieve persistence without using any kind of software as backdoor.

Note: There are vulnerabilities covered by YARA rules and reported in other modules. The YARA rules that detect vulnerabilities start with "VUL_*".

3.9.1 Samples

```
Aug 29 10:06:58 server44.local.net/10.23.3.1 THOR: Warning: MODULE:
VulnerabilityCheck MESSAGE: Tomcat credential weakness REASON: Password equals
the user name USER: tomcat FILE: F:\apache\tomcat\conf\tomcat-users.xml SCORE: 75
```

3.9.2 Typical False Positives

- Weaknesses in inactive "tomcat-users.xml" files, e.g. in backup locations or tomcats that are only accessible on localhost

3.9.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
REASON	Password equals the user name	Yes	Bad	Medium
	Password is a default password	Yes	Bad	Medium
FILE	Tomcat Vulnerability: Does the folder look like a backup location or an inactive location, not used by a running tomcat process? (e.g. H:\Backup\test_23\conf\tomcat-users.xml) Background: The vulnerability is only relevant if used by an active tomcat process. Local development installations or backups of a default config are not relevant.	Yes	Good	High
MESSAGE	Does the message state "Domain Controller is running since before 11/17/2014"	Yes	Bad	High

3.10 LoggedIn

The "LoggedIn" module analyses all currently logged in users and analyses their names.

3.10.1 Samples

```
Aug 26 12:28:07 server44.local.net/10.7.1.100 THOR: Warning: MODULE: LoggedIn  
MESSAGE: Suspicious logged in user name KEYWORD: ^[0-9a-z]{1,3}$ USER: abc SCORE:  
75
```

3.10.2 Typical False Positives

- Legitimate 3 or less character user accounts

3.10.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
USER	Does the user name look suspicious to a human eye? (e.g. "abc", "123", "adm123", "suser", "bckdr", "master", "access")	Yes	Good	Medium
		No	Bad	Medium

3.11 ProcessCheck

Different checks are performed in the "ProcessCheck" module. Some of them check the process characteristics such as parent/child relations, process priorities and executable file locations for anomalies. Other checks evaluate the processes network connections and YARA checks match on the process memory.

3.11.1 References

<https://sysforensics.org/2014/01/know-your-windows-processes/>

3.11.2 Samples

```
Aug 26 13:02:27 server22.local.net/10.6.19.8 THOR: Warning: MODULE: ProcessCheck
MESSAGE: Process started from a typical attacker / malware location PID: 8336
PPID: 5796 PARENT: C:\temp\ProcessMonitor\Procmon.exe NAME: Procmon64.exe OWNER:
server-ABC123 COMMAND: "C:\Users\SERVER~4\AppData\Local\Temp\2\Procmon64.exe"
/originalpath "C:\temp\ProcessMonitor\Procmon.exe" PATH:
C:\Users\SERVER~4\AppData\Local\Temp\2\Procmon64.exe CREATED: 24.08.2017

Aug 26 13:02:55 server.local.net/10.1.19.2 THOR: Warning: MODULE: ProcessCheck
MESSAGE: Yara rule match on process PID: 32980 PPID: 4104 PARENT: C:\Program
Files\Internet Explorer\iexplore.exe NAME: iexplore.exe OWNER: SYSTEM COMMAND:
"C:\Program Files (x86)\Internet Explorer\IEXPLORE.EXE" SCODEF:4104 CREDAT:275457
/prefetch:2 PATH: C:\Program Files (x86)\Internet Explorer\IEXPLORE.EXE CREATED:
24.08.2017 05:00:02 MD5: e3da77b534d7dff8a2ae6a577a44703b CONNECTION_COUNT: 0
LISTEN_PORTS: - RULE: CN_C2_Domain_HvS_Client_A3 DESCRIPTION: THOR HvS Client A3
- C2 domain in file REFERENCE: - SCORE: 75 STRINGS: Str1: .lookipv6.com
```

3.11.3 Typical False Positives

- Legitimate software started from strange locations
- Old Windows versions (XP, 2003) show abnormal parent/child relation and process priority warnings
- Process end points in suspicious GEO IP regions of the world (e.g. system in China with process connections to other systems in China)
- Process memory scan alerts in processes that may contain clear-text signatures (AV process memory, VMWare tools (copied THOR to the system), GRR, SearchIndexer)

3.11.4 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
COMMAND	Is the executable a well-known SysInternals tool?	Yes	Good	Medium
PATH	See chapter 4.1 "File Path Checks"			
PARENT	Is the parent of the suspicious process a Microsoft Office program?	Yes	Bad	High
OWNER	If the owner of the suspicious process starts with "IWAM_", "IUSR_" or "IIS_"?	Yes	Bad	Medium
MESSAGE	Did the YARA rule match on IEXPLORE.EXE, VMWARE tools process memory? (Note: the Internet Explorer and VMWare tools process memory is prone to false positives)	Yes	Good	Low
	Did the YARA rule match on Antivirus or Security tool process memory? (e.g. CarbonBlack, GRR)	Yes	Good	High

3.12 HotfixCheck

The "HotFixCheck" module analyses the installed hotfixes on the end system.

3.12.1 Samples

```
Sep 4 16:33:27 server11.local/192.168.2.2 THOR: Warning: MODULE: HotfixCheck  
MESSAGE: Outdated System - No hotfixes installed for the last 90 days. Last  
hotfix DATE: 2015/01/09 SCORE: 75
```

3.12.2 Typical False Positives

- THOR failed to evaluate the modules on the system and didn't return a single hotfix. In these cases, THOR reports "No Hotfixes installed or no hotfix information available"

3.13 RunKeyCheck

The "RunKeyCheck" module processes entries in the RUN Key.

3.13.1 Samples

```
Aug 6 11:22:11 server11.local/10.252.8.237 THOR: Warning: MODULE: RunKeyCheck  
MESSAGE: Suspicious file name in value detected ELEMENT: "C:\Program  
Files\Microsoft Security Client\msseces.exe" -hide -runkey PATTERN:  
(?i)\msseces\.exe SCORE: 60 DESC: Executable used by PlugX DLL side-loading in  
non-standard location Run Key Entry NAME: MSC VALUE: "C:\Program Files\Microsoft  
Security Client\msseces.exe" -hide -runkey FILE: C:\Program Files\Microsoft  
Security Client\msseces.exe FIRSTBYTES: 4d5a90000300000004000000ffff0000b8000000  
/ MZ SHA1: 71fac169a5f04af634d06c367e7d832e72c1cdf2
```

3.13.2 Typical False Positives

- Elements matching known system files in suspicious locations (see example with msseces.exe)

3.13.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
USER	Does the user name look suspicious to a human eye? (e.g. "abc", "123", "adm123", "suer", "bckdr", "master", "access")	Yes	Good	Medium
		No	Bad	Medium

3.14 AmCache

The "AmCache" module processes entries in the AmCache of the system. In contrast to the SHIMCache entries, AmCache entries contain a SHA1 hash value that can be used to determine the exact program that was executed on the end system.

3.14.1 References

<http://www.swiftforensics.com/2013/12/amcachehive-in-windows-8-goldmine-for.html>

<https://windowsir.blogspot.de/2017/03/incorporating-amcache-data-into.html>

3.14.2 Samples

```
Aug 26 16:14:22 server33.local/10.1.2.31 THOR: Warning: MODULE: Amcache MESSAGE:
Suspicious file name in Amcache entry detected ELEMENT: C:\temp\1.exe PATTERN:
\\(tmp|temp)\\[a-zA-Z0-1]\\. (exe|com) AND \\[01]\\.exe AND \\[A-Za-z0-
9]\\. (exe|com|dll|bat|scr|vbs)$ AND (temp|tmp)\\[0-9]{1,50}\\.exe$ AND \\[Tt]emp\\[0-
9a-zA-Z]\\. (exe|dll) SCORE: 60 DESC: Typical attacker scheme FILE: C:\temp\1.exe
SHA1: 9cf9c57b0927c45d6712387871dd435053d912b6 SIZE: None DESC: None FIRST_RUN:
2017-05-22 15:41:00.021779 CREATED: 0001-01-01
```

```
Aug 19 13:08:49 server4448.local.net/10.0.10.1 THOR: Warning: MODULE: Amcache
MESSAGE: Suspicious file name in Amcache entry detected ELEMENT:
C:\Users\blueprism\FPipe.exe PATTERN: FPipe.exe AND \\(Users|Documents and
Settings)\\[^\]{1,20}\\[^\]{1,20}\\. (exe|dll|vbs|bat|ps1) SCORE: 75 DESC: Pattern in
Amcache entry FILE: C:\Users\Public\FPipe.exe SHA1:
41d57d356098ff55fe0e1f0bcaa9317df5a2a45c SIZE: 13312 DESC: FPipe FIRST_RUN: 2017-
07-12 14:13:32.823776 CREATED: 2017-07-12 14:13:26.886278 PRODUCT: FPipe COMPANY:
Foundstone
```

3.14.3 Typical False Positives

- Legitimate files in suspicious locations
- Elements matching known system files in suspicious locations

3.14.4 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
ELEMENT	See chapter 4.1 "File Path Checks"			
SHA1	See chapter 4.2 "Hash Checks" for all generic checks on hashes			
FIRST_RUN	Did the file run the first time on a Sunday?	Yes	Bad	Medium
	Did the file run the first time at night between 00:00 and 06:00 am in the early morning?	Yes	Bad	Medium

3.15 Firewall

The "Firewall" module evaluates all local Windows firewall rules and tries to detect suspicious entries by using white- and black-lists.

3.15.1 Samples

Aug 26 17:51:25 server23.local.net/10.19.2.17 THOR: Warning: MODULE: Firewall
MESSAGE: Zeus Local Port defined in Firewall rule SIGNATURE: ZEUS RULE_NAME:
Appsense_Input PORT: 7771 SCORE: 75

Jul 29 11:19:48 serverx-print/10.255.80.56 THOR: Warning: MODULE: Firewall
MESSAGE: Suspicious Trojan/Backdoor Local Port defined in Firewall rule SIGNATURE:
Strange Value RULE_NAME: XXXCloudProxy.exe PORT: 8080 SCORE: 75

3.15.2 Typical False Positives

- Legitimate rules for non-white-listed programs
- Legitimate rules on suspicious ports (e.g. WinSShd on port 60022/tcp, Apache on port 4443/tcp)

3.15.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
RULE_NAME	Does the name look suspicious?	Yes	Bad	Low
PORT	Does the port relate to the rule name? (e.g. "Port 8080" to "Apache", "Port 2222" to "Bitvise SSH Daemon")	Yes	Good	Medium

3.16 ServiceCheck

The "ServiceCheck" module evaluates all registered local Windows services. It detects suspicious service entries by different anomaly checks, black-listed keywords and reports file path anomalies.

3.16.1 Samples

```
Aug 1 15:14:26 server88.localnet/192.168.2.4 THOR: Warning: MODULE: ServiceCheck  
MESSAGE: Service started from typical attacker location KEY: srvany SERVICE_NAME:  
srvany IMAGE_PATH: c:\srvany.exe SHA1: 7c5329229042535fe56e74f1f246c6da8cea3be8  
START_TYPE: unknown USER: LocalSystem SCORE: 75
```

```
Jul 1 11:52:41 server77.local.net/10.10.9.19 THOR: Warning: MODULE: ServiceCheck  
MESSAGE: Service started from suspected attacker location KEY: cpuz139  
SERVICE_NAME: cpuz139 IMAGE_PATH:  
\\??\C:\Users\u23491\AppData\Local\Temp\cpuz139\cpuz139_x64.sys SHA1:  
13df48ab4cd412651b2604829ce9b61d39a791bb START_TYPE: ONDEMAND_START USER: SCORE:  
75
```

```
Nov 20 11:44:52 PROMETHEUS/10.0.2.4 THOR: Warning: MODULE: ServiceCheck MESSAGE:  
YARA Rule Match in service STRING: loadersvc - {993B4A05-7C9E-4DA7-9052-  
4192A3B96F21} - C:\Testing\uixd.exe NAME: Malicious_Keylogger_Service_Driver  
SCORE: 65 DESCRIPTION: Detects malicious keylogger service driver - loadersvc  
REF: - MATCHED_STRINGS: Str1: loadersvc KEY: loadersvc SERVICE_NAME: {993B4A05-  
7C9E-4DA7-9052-4192A3B96F21} IMAGE_PATH: C:\Testing\uixd.exe MODIFIED: 2017-03-  
17T10:53:51.143664 SHA1: - START_TYPE: ONDEMAND_START USER: LocalSystem
```

3.16.2 Typical False Positives

- Legitimate software with service binaries located in suspicious folders (e.g. the user's %AppData% folder)
- Services with matching regular expression file name IOCs
- Services registered by administrators in suspicious locations (e.g. C:\srvany.exe)

3.16.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
IMAGE_PATH	See chapter 4.1 "File Path Checks"			
SHA1	See chapter 4.2 "Hash Checks" for all generic checks on hashes			
SERVICE_NAME	Is the service name a random ID? (e.g. "98ncjs87e", "{993B4A05-7C9E-4DA7-9052-4192A3B96F21}")	Yes	Bad	Medium
START_TYPE	Is the start-type "ONDEMAND*"?	Yes	Good	Low
MODIFIED	Has the service been modified in a suspicious time frame? (Sundays, at night between 00:00 and 06:00 am)	Yes	Bad	Medium
MESSAGE	Does a YARA rule match on the service entry?	Yes	Bad	Medium

3.17 DNSCache

The "DNSCache" module evaluates the entries of the local DNS cache. It compares the entries with known C2 servers and reports suspicious entries based on some regular expression checks.

3.17.1 Samples

```
Aug 19 11:27:08 system444.local.net/172.27.2.7 THOR: Alert: MODULE: DNSCache  
MESSAGE: Malware Domain found in DNS Cache ENTRY: 60.10.1.183.in-addr.arpa IP:  
10.252.8.5 SIGNATURE: 60.10.1. DESC: Graphedt Group SCORE: 100
```

```
Jul 8 11:30:56 system88.local.net/10.10.9.15 THOR: Warning: MODULE: DNSCache  
MESSAGE: Entry with dangerous TLD found TLD: biz ENTRY: altftp.compsys.biz IP:  
10.11.11.40 SCORE: 75
```

3.17.2 Typical False Positives

- Legitimate company domains registered with a black-listed Top Level Domain (TLD) (e.g. vpnaccess.companybranch.info)
- False positives caused by "in-addr.arpa" reversed strings that match on black-listed IP addresses
- Too short domain names from 3rd party IOC sources (e.g. "ipv6.com" matching on "benign-site-ipv6.com")

3.17.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
IP	Is the IP known for malicious activity? (Check the platforms listed in chapter 5)	Yes	Bad	Medium
		No	Good	Medium
ENTRY	Is the FQDN known for malicious activity?	Yes	Bad	Medium
		No	Good	Medium
TLD	Seems the FQDN to be legitimate although it is registered under a suspicious TLD? (e.g. servftp.companyname.biz, www2.companybranch.cn)	No	Bad	Medium
		Yes	Good	High

3.18 Hosts

The "Hosts" module evaluates the entries in the local hosts file.

3.18.1 References

<https://blog.malwarebytes.com/cybercrime/2016/09/hosts-file-hijacks/>

3.18.2 Samples

Aug 26 11:46:14 server555.local.net/10.7.1.14 THOR: Warning: MODULE: Hosts
MESSAGE: New hosts entry - not found during the last run ENTRY: master.comp-a.net
IP: 10.7.10.2 SCORE: 75

Jul 29 12:16:18 server99.local.net/10.1.1.55 THOR: Warning: MODULE: Hosts
MESSAGE: Suspicious entry found in Hosts file ENTRY: ctldl.windowsupdate.com IP:
127.0.0.1 SCORE: 75

3.18.3 Typical False Positives

- Entries on development systems to simulate future DNS resolution (e.g. "www.company-intranet.net 10.0.2.28")
- Some Antivirus tools insert entries into the hosts file to immunize the system (e.g. "Spybot Search & Destroy")

3.18.4 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
MESSAGE	Does a new host file entry look legitimate?	Yes	Good	Medium
ENTRY	Does the FQDN related to a server of a security software like an update server of an Antivirus server? (e.g. update1.f-secure.com)	Yes	Bad	Medium
IP	Is the IP address not an IP address in a local network? (10.0.0.0/8, 192.168.0.0/16, 172.16.0.0/12)	No	Bad	Medium

3.19 WMIStartup

The "WMIStartup" module uses different WMI queries to retrieve information on elements that could be used for persistence. It is very likely that findings by this module also appear in other modules (e.g. "Autoruns") in a different form, because it just uses a different method to look at the same elements.

3.19.1 Samples

```
Aug 23 02:03:12 server55.local.net/10.16.1.44 THOR: Warning: MODULE: WMIStartup  
MESSAGE: Suspicious startup program WMI Run Key Evaluation LOCATION:  
C:\Users\user1\AppData\Local\Temp\1\RarSFX1\OlympUpgrade.exe zInstalu true 0  
C:\OLYMP\ SCORE: 75
```

```
May 20 11:14:52 wks10021/10.1.7.60 THOR: Warning: MODULE: WMIStartup MESSAGE:  
Suspicious startup program WMI Run Key Evaluation LOCATION:  
"C:\Users\user1\AppData\Local\Akamai\netsession_win.exe" SCORE: 75
```

3.19.2 Typical False Positives

- Legitimate software that uses suspicious startup locations

3.19.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
LOCATION	See chapter 4.1 "File Path Checks"			

3.20 CommandCheck

The "CommandCheck" module is a meta module that analyses full command lines (path, executable, parameters) in different modules.

3.20.1 Samples

May 20 12:25:49 server55.local.net/10.1.12.2 THOR: Warning: MODULE: CommandCheck
MESSAGE: Command in suspicious location PATH:
C:\Windows\TEMP\vmw72DE.tmp\guestcustutil.exe SCORE: 75

May 6 11:26:59 server88.local.net/10.10.9.33 THOR: Warning: MODULE: CommandCheck
MESSAGE: Command in suspicious location PATH: d:\temp\aaa.cmd SCORE: 75

3.20.2 Typical False Positives

- Legitimate administrative activity that looks suspicious

3.20.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
PATH	See chapter 4.1 "File Path Checks"			

3.21 ProcessHandles

The "ProcessHandles" module is a sub module of the "ProcessCheck" module that analyses the handles of each process. The module makes use of the SysInternals "handle.exe" tool that can be placed in the "./tools" sub folder.

3.21.1 Samples

```
Jun 24 11:52:08 server77.local.net/10.1.90.18 THOR: Warning: MODULE: ProcessHandles MESSAGE: Suspicious file name in Process Handle detected VALUE: D:\Lotus\Domino\data\mail\htrang.nsf PATTERN: \htran SCORE: 75 DESC: Diverse PID: 1068 COMMAND: D:\Lotus\Domino\server.exe =>D:\Lotus\Domino\notes.ini -j HANDLEID: EF0 HANDLE: File (RW-)
```

```
Aug 4 11:44:08 serv55123/10.2.47.43 THOR: Alert: MODULE: ProcessHandles MESSAGE: Malware file name in Process Handle detected VALUE: G:\Documents\InfoStream\mimikatz-master PATTERN: \mimikatz AND mimikatz SCORE: 145 DESC: Allgemein PID: 4 COMMAND: N/A HANDLEID: 11698 HANDLE: File (RWD)
```

3.21.2 Typical False Positives

- Legitimate administrative activity that looks suspicious

3.21.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
VALUE	See chapter 4.1 "File Path Checks"			
PATTERN	Does it look like a weak pattern matching on legitimate handles?	Yes	Good	Medium

3.22 ProcessConnections

The "ProcessConnections" module checks the network connections of a process and generates alerts and warnings based on C2 signature matches and suspicious GEO IP lookups.

3.22.1 Samples

```
Oct 25 17:33:17 server66.local.net/147.2.20.16 THOR: Notice: MODULE:  
ProcessConnections MESSAGE: Established connection PID: 3012 NAME: dfssvc.exe  
COMMAND: C:\Windows\system32\dfssvc.exe LIP: 147.2.20.16 LPORT: 56513 RIP:  
147.2.21.188 RPORT: 53389
```

```
Oct 25 17:33:17 server66.local.net/10.1.30.2 THOR: Notice: MODULE:  
ProcessConnections MESSAGE: Relevant remote region GEO IP lookup PID: 3012 NAME:  
p.exe COMMAND: C:\Windows\system32\p.exe LIP: 10.1.30.2 LPORT: 56513 RIP:  
14.102.172.144 RPORT: 6022 COUNTRY: PK
```

3.22.2 Typical False Positives

- Legitimate software updaters that receive updates directly from 3rd party systems
- OS or AV telemetry services (often related to Microsoft, Google, Symantec, McAfee etc.)
- Legitimate connections to service providers or branch office servers

3.22.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
COMMAND	See chapter 4.1 "File Path Checks"			
RIP	Is the remote IP known for malicious activity? (Check the platforms listed in chapter 5)	Yes	Bad	Medium
		No	Good	Medium
COUNTRY	Does the remote IP (RIP) lookup point to a service provider or branch office network? (e.g. stock exchange server range in a banking environment, travel data provider network in an aviation environment)	Yes	Good	High
		No	Bad	Medium
RPORT	Does a Google search on the remote port show only suspicious, malware or hacking related results? (e.g. lookup for port "4444")	Yes	Bad	High
		No	Good	Medium
LPORT / RPORT	Does the remote port correspond with the local port and is this form of connection legitimate? (e.g. local port is 22 (ssh) and remote port is 14560, local port is 80 (http) and remote port is 34283)	Yes	Good	Medium
		No	Bad	Medium
LIP / RIP	Is the remote system a system in a public IP range that is not related to the company and the local system an internal system that shouldn't communicate with the Internet directly?	Yes	Bad	High

3.23 WER

The "WER" module analyses program crash files and checks for special crashes caused by exploits and file name IOC signature matches in the application path. Software is broken so applications tend to crash but hack tools and exploits crash too. Even if the attackers completely removed their tools from a system, a crashed exploit code, scanner, password dumper or backdoor will still be visible in the Windows error reports.

(Side note: Microsoft's own IR team makes use of the WER file analysis with their own tool named "WOLF")

3.23.1 Samples

```
Jun Oct 25 21:01:51 server44.local.net/10.216.2.186 THOR: Notice: MODULE: WER
MESSAGE: Error Report - Found AppHang EXE: notepad++.exe DATE: 2011-08-25
07:37:39 FILE:
C:\Users\scadmin\AppData\Local\Microsoft\Windows\WER\ReportArchive\AppHang_notepa
d++.exe_4eafbb67f1329f8691e382b93f71beb6d0fcb99_cfe6cd59_5da093b9\Report.wer
APPPATH: C:\Program Files (x86)\Notepad++\notepad++.exe ERROR: - / -
FAULT_IN_MODULE: not set
```

3.23.2 Typical False Positives

- Software is broken so application tend to crash

3.23.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
APPPATH	See chapter 4.1 "File Path Checks"			
MESSAGE	Does the message contain a CVE number?	Yes	Bad	Medium

3.24 UserAccounts

The "UserAccounts" module analyses the local user database. It checks for suspicious user names, suspicious members in the "Administrators" group, activated guest accounts, user accounts created on Sundays and reports recently logged in users.

It applies the "hot time frame" parameter (-f) if given and reports suspicious account activity on a given set of dates.

3.24.1 Samples

```
Jun Oct 25 21:01:51 server44.local.net/10.216.2.186 THOR: Notice: MODULE:
UserAccounts MESSAGE: Recently logged in USER: sa_backup FULL_NAME: sa_backup
PRIV: 2 LAST_LOGON: 24/10/2017 16:08:22 BADPWCOUNT: 0 SERVER: \* NUM_LOGONS: 9
PASS_AGE: 105.00 days ACTIVE: True NO_EXPIRE: True LOCKED: False
```

```
Oct 23 15:27:12 server44.local.net/10.216.2.186 THOR: Warning: MODULE:
UserAccounts MESSAGE: Last password change of user happened in relevant time
frame USER: Administrator FULL_NAME: PRIV: 2 LAST_LOGON: 23/10/2017 08:03:15
BADPWCOUNT: 0 SERVER: \* NUM_LOGONS: 14 PASS_AGE: 3.00 days ACTIVE: True
NO_EXPIRE: True LOCKED: False SCORE: 75
```

```
Aug 28 12:27:29 PROMETHEUS/10.0.2.4 THOR: Warning: MODULE: UserAccounts MESSAGE:
Suspicious user name in Local Administrators group NAME: Guest SCORE: 75
```

```
Sep 8 12:32:39 PROMETHEUS/10.0.2.4 THOR: Warning: MODULE: UserAccounts MESSAGE:
Suspicious user name KEYWORD: (^[0-9a-
z]{1,3}$|^test$|^sa$|hack|exploit|nopw|temp) USER: neo FULL_NAME: PRIV: 2
LAST_LOGON: 30/08/2017 12:43:41 BADPWCOUNT: 0 SERVER: \* NUM_LOGONS: 352
PASS_AGE: 930.00 days ACTIVE: True NO_EXPIRE: True LOCKED: False SCORE: 75
```

3.24.2 Typical False Positives

- Organizations that use short user names (e.g. "ska", "mba", "jmi")
- User creation on Sunday warning messages in regions in which a Sunday is a work day (e.g. Israel)

3.24.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
MESSAGE	Is the user name suspicious but plausible in the organization?	Yes	Good	Medium
	Is the Guest account active although it shouldn't be?	Yes	Bad	High
	Has the Guest account be added to the local Administrators?	Yes	Bad	High
	Does the account activity happen in the given hot time frame?	Yes	Bad	Medium

3.25 AtJobs

The "AtJobs" module analyses the local user at jobs and just lists them in "Info" level messages and applies the global string check on the command line.

3.25.1 Samples

TBT

3.25.2 Typical False Positives

- Software updaters

3.25.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
JOB	See chapter 4.1 "File Path Checks"			

3.26 ScheduledTasks

The "ScheduledTasks" module analyses the local user at jobs and just lists them in "Info" level messages and applies the global string check on the command line.

3.26.1 Samples

```
Aug 2 14:37:48 server44/192.168.2.4 THOR: Notice: MODULE: ScheduledTasks MESSAGE:  
Noticeable file name in command detected ELEMENT: C:\start1.bat PATTERN:  
\start1\.bat$ SCORE: 50 DESC: Indian Cyber Attack Task NAME: kpistart1 sabato  
COMMAND: C:\start1.bat USER: Webload LASTRUN: 15/05/2010 14:02:00 NEXTRUN:  
30/11/1999 00:00:00 MD5: 666081523aef8d40d53b4f6aeedd851 SHA1:
```

3.26.2 Typical False Positives

- Software updaters
- Administrative jobs

3.26.3 Attribute Evaluation

Attribute	Question	Answer	Indication	Weight
NAME	Does the name look like a random value? (e.g. "jd8slpk8d8")	Yes	Bad	High
	Does the name contain words in the local language? (e.g. "Datensicherung", "copiar-datos-privados")	Yes	Good	High
ELEMENT	See chapter 4.1 "File Path Checks"			

3.27 Rescontrol

The "Rescontrol" (Resource Control) module generates "Warning" level messages in cases in which a resource limit has been reached. In most of the cases, this is caused by very low free main memory levels or false positives that generated many SYSLOG messages.

Resource control is active by default and can be deactivated with (--norescontrol).

Resource control

- Stops the THOR scan if the available free main memory drops below 50MB
- Switches to "reduced syslog mode" (Warnings and Alerts only) if more than 5MB of data has been sent via Syslog

3.27.1 Samples

```
Aug 2 14:37:48 server44/192.168.2.4 THOR: Warning: MODULE: Rescontrol MESSAGE:
Stopping THOR scan in order to avoid a memory outage (use --norescontrol to avoid
this) SCORE: 75
```

```
Aug 2 14:37:48 server44/192.168.2.4 THOR: Warning: MODULE: Rescontrol MESSAGE:
Logged more than 5000000 bytes via SYSLOG. This seems odd. Resource control
activates 'reduced syslog' mode. SCORE: 75
```

3.28 DeepDive

A DeepDive on memory images or disk space cannot be analysed by THOR events alone. You typically need the memory dumps or restored chunks to evaluate the findings. This typically takes a lot more time, know-how and effort to complete.

We recommend the analysis of DeepDive module events only in cases in which other indicators give a sufficient initial suspicion.

3.28.1 Samples

```
Sep 5 17:23:56 server44.local.net/10.16.3.7 THOR: Alert: MODULE: DeepDive
MESSAGE: YARA Score Rule Match TARGET:
C:\WINDOWS\PCHEALTH\ERRORREP\UserDumps\thor.exe.20170904-154909-00.hdump TYPE:
file NAME: HurricanePanda_C2_Server SCORE: 180 DESCRIPTION: Hurricane Panda C2
Server in file http://goo.gl/Fm00Q8 OFFSET: 203423744 MATCHING_STRINGS: S1:
203.135.134.243 IN: 1dns.dubkill.com.in$s2203.135.134.243$s3newss.effers.com$s4
S2: 202.181.133.237 IN:
upport.proxydns.com$s13202.181.133.237MobileDevicesUsedtoExecu S3: 223.29.248.9
IN: e.authorizeddns.org$s11223.29.248.9$s12googlesupport.proxy S4: 61.78.34.179 ...

Aug 26 22:20:18 server44.local.net/10.10.1.4 THOR: Alert: MODULE: DeepDive
MESSAGE: YARA Score Rule Match TARGET: C:\Program Files (x86)\Common
Files\McAfee\TalkBack\Data\RPCSERV(1).dmp TYPE: file NAME:
WindowsCredentialEditor SCORE: 140 DESCRIPTION: Windows Credential Editor OFFSET:
203423744 MATCHING_STRINGS: S1: Windows Credentials Editor IN:
%.2X%.2Xttcawindows Credentials Editor-- by Hernan Ochoa (herna
```

3.28.2 Typical False Positives

- Antivirus signatures in pagefile.sys or in disk surface scans
- Findings in "\McAfee\TalkBack\Data\RPCSERV"
- THOR process dump files

3.29 Other Modules

Messages from other modules like "Rootkit", "SkeletonKey", "ReginFS" should always be considered relevant and handled intensively.

3.29.1 Samples

Aug 23 11:26:26 server44.local.net/10.16.22.2 THOR: Notice: MODULE: SkeletonKey
MESSAGE: Domain Controller supports AES type encryption. No SkeletonKey type
attack detected.

4 Generic Checks

4.1 File Path Checks

The checks listed in the following table apply to any file path string in many different modules.

Attribute	Question	Answer	Indication	Weight
FILE	Is the file located in a temporary directory? (e.g. C:\Temp, C:\Users\user1\AppData\Local\Temp)	Yes	Bad	Medium
	Does the path contain elements in a local language? (e.g. "...\Datensicherung", "C:\Progs\Zeiterfassung\ze.exe)	Yes	Good	High
	Does the file have matches on other systems as well?	Yes, on more than 1	-	-
		Yes, on more than 10	Good	Medium
		Yes, on more than 100	Good	High
	Is the file name known on Google? (results point to goodware or known Windows file names)	Yes	Good	Medium
	Is the file name known on Google and results point to malware or hack tools?	Yes	Bad	Medium
	Does an exact Google search for the program path return no results?	Yes	Bad	Low
	Do sandbox reports and antivirus scan reports show up, when you google the filename or specific path name (e.g. "GoogleMasterUpdate\gm.exe")	Yes	Bad	Medium
	Does the path look like a "backup" directory or user's "home folder" on a server drive e.g. "G:\Backup2007\..." or N:\Home-Folders\user2345\AppData\Local\Temp"	Yes	Good	Medium
	Is the file located in an %AppData% folder in the user profile?	Yes	Bad	Low
	Is the file located in a folder that should not contain executable files? (e.g. C:\Windows\Fonts, C:\PerfLogs, C:\Users\x123\AppData\Roaming\Microsoft\certs, C:\Windows\inf, C:\Users\Public\Documents)	Yes	Bad	Medium
	Does the file name look like a tool used for administration purposes? (e.g. C:\robocopy-migration.exe)	Yes	Good	Low
	Is the path a mounted / shared network drive?	Yes	Bad	Medium

(e.g. \\tsclient\C\$, \\server1\C\$\temp\m.exe)			
Does the path look as if the product is a strange custom software? (e.g. C:\Temp\Arbeitszeitnachweis\AZN-service.exe)	Yes	Good	Medium
Is the program located directly in a folder that is typically empty and only contains sub directories? (e.g. C:\ProgramData\1.exe, C:\Users\user\AppData\Roaming\1.exe)	Yes	Bad	Medium
Does the file look as if it has been modified by a user to circumvent security filters? (e.g. Text file reported as executable: "Weihnachtsgrüße.txt", "ChromePortable.txt")	Yes	Good	Low

4.2 Hash Checks

4.2.1 Manual Hash Checks

We recommend using Virustotal for the analysis of Hash values

<https://www.virustotal.com/en/>

The checks listed in the following table apply to any hash value reported in many different modules.

Attribute	Question	Answer	Indication	Weight
MD5 / SHA1 / SHA256	What does the Virustotal.com check show?	Unknown	-	-
		Suspicious (> 2 matches)	Bad	Medium
		Malicious (> 10 matches)	Bad	High
	Does Virustotal show other suspicious names in the "Additional Information" tab – e.g. file names with ".vir" or ".virobj" extension or file names that are hashes	Yes	Bad	Low
	Is "first submission" on Virustotal very far in the past? (>7 years)	Yes	Good	Low
	Are there any negative votes or comments on Virustotal?	Yes	Bad	Medium
	Does at least one matching AV signature on Virustotal contain one of the following keywords: Hack, Scan, Dump, Password, Webshell	Yes	Bad	High
	Is the file part of the Microsoft software catalogue? (Virustotal shows that on a green bar above the analysis)	Yes	Good	High
	Does Virustotal show the bar "probably harmless"?	Yes	Good	High
	Does the file has a valid software signature from a trusted vendor?	Yes	Good	Medium
	Does the listed "File names" contain only legitimate names? (e.g. javaw.exe, java.exe)	Yes	Good	Low
	Does the listed "File names" contain hash values?	Yes	Bad	Low
	Does the Portable Executable (PE, EXE) file have a very old compilation time stamp?	Yes	Good	Low

	(> 10 years)			
--	--------------	--	--	--

5 Tools for Event Analysis

5.1 VirusTotal

Used for: File Hashes, Domains, IPs, File Names

<https://www.virustotal.com/>

Also search for IPs and Domain Names – Examples:

<https://www.virustotal.com/en/domain/DOMAIN/information/>

<https://www.virustotal.com/en/ip-address/58.158.177.102/information/>

File Name Search – via Google Search:

inurl:virustotal.com filename

5.2 PEStudio

Windows tool that helps in the initial and static assessment of a file Samples (if available)

<https://www.winitor.com/>

5.3 PassiveTotal

Used for: Domains, IPs

<https://www.passivetotal.org/>

5.4 Cymon

Cymon is the largest open tracker of malware, phishing, botnets, spam, and more.

<https://cymon.io/>

5.5 Censys

Censys is a search engine that enables researchers to ask questions about the hosts and networks that compose the Internet.

<https://censys.io/>

5.6 Threat Crowd

ThreatCrowd is a system for finding and researching artefacts relating to cyber threats.

<https://www.threatcrowd.org/>

5.7 APT Custom Search

Custom Search Engine for APT related Sites

<https://cse.google.com/cse/publicurl?cx=003248445720253387346:turlh5vi4xc>

5.8 Hybrid Analysis

Used for: Samples Upload, search for methods and keywords

<https://www.hybrid-analysis.com/>

5.9 Automatic Hash Checks

You can use the Python script "munin.py" to batch process lists of Hash values or even complete THOR log files as the script automatically extracts the relevant values from each line.

The best option is to use the "*.csv" files produced after a THOR run and use them as input for the script.

```
cat *.csv >> all-hashes.csv
```

```
python munin.py -i config.ini -f all-hashes.csv
```

Munin

<https://github.com/Neo23x0/munin>



```

Online Hash Checker for Virustotal and Other Services
Florian Roth - 0.2.1 October 2017

[+] Found results CSV from previous run: check-results_munin-demo.csv
[+] Appending results to file: check-results_munin-demo.csv
[+] Processing 9 lines ...

0 / 9 > Unknown
HASH: 618c68376f8e39c834c7f39a64d676a55b13d6c2 COMMENT: Private File
RESULT: - / -

1 / 9 > Clean
HASH: fabf7d484dfcd08424548325baec494eee4b361de61b9a02607980b10052d29a COMMENT: Windows File
TYPE: Win32 EXE FILENAMES: WindowsDeviceRecoveryToolInstaller.exe, WindowsDeviceRecoveryToolInstaller.exe, WindowsDeviceRecoveryToolInstaller.exe, WindowsDeviceRecoveryToolInstaller (1).exe, setup, WindowsDeviceRecoveryToolInstaller.exe, WindowsDeviceRecoveryToolInstaller.exe, WindowsDeviceRecoveryToolInstaller.exe, Bootstrapper.exe
COPYRIGHT: Copyright (c) Microsoft. All rights reserved. DESCRIPTION: Windows Device Recovery Tool 3.12.24302
ORIGNAME: Bootstrapper.exe SIGNER: Microsoft Corporation
FIRST_SUBMITTED: 2017-09-02 04:56:19 UTC ( 1 month, 3 weeks ago ) LAST_SUBMITTED: 2017-10-14 16:37:02
RESULT: 0 / 54 SIGNED

2 / 9 > Malicious
HASH: 040c0111aef474d8b7bfa9a7caa0e06b4f1049c7ae8c66611a53fc2599f0b90f COMMENT: Nemucod
VIRUS: Microsoft: TrojanDownloader:JS/Swabfex.C / Kaspersky: HEUR:Trojan-Downloader.Script.Generic / McAfee: JS/Nemucod.ho / TrendMicro: JS_NEMUCOD.DLDUH / ESET-NOD32: JS/TrojanDownloader.Nemucod.AEA / F-Secure: Trojan.JS.RLZ / Sophos: JS/Agent-ASEY / GData: Script.Trojan-Downloader.Agent.SS
TYPE: Text FILENAMES: 3257422871.js, PGE_Faktura_018208.js, AGL_bill.js, 071d5c44d21c365c13133d46b93a94bc.js, Remittance_Error.js
FIRST_SUBMITTED: 2016-06-14 01:16:18 UTC ( 1 year, 4 months ago ) LAST_SUBMITTED: 2017-04-24 15:39:14
RESULT: 33 / 56
[!] Sample is on hybrid-analysis.com SCORE: 100 DATE: 2016-06-14 11:35:07 HOSTS: 166.62.109.86, 193.23.244.244

3 / 9 > Suspicious
HASH: ef56bbe29919b042f36ddd784a6cd361d79766e7d492adea255ad96f518550a0 COMMENT: Turla_Copyright_String_Test
TYPE: Win32 EXE FILENAMES: 2B1FCD5F070CCC4175DBC8017F7AFF0C, setup, Microsoft ATA Gateway Setup.exe
COPYRIGHT: Copyright (c) Microsoft Corporation. All rights reserved. DESCRIPTION: Microsoft Advanced Threat Analytics Gateway
ORIGNAME: Microsoft ATA Gateway Setup.exe SIGNER: Microsoft Corporation
FIRST_SUBMITTED: 2017-08-06 20:42:12 UTC ( 2 months, 3 weeks ago ) LAST_SUBMITTED: 2017-09-17 16:19:25
RESULT: 1 / 65 SIGNED
```

Figure 1 - Munin - Online Hash Checker