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simple + secure

Unveiling the kernel: Rootkit discovery using selective automated kernel memory differencing

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Agenda

- Objective and method
- System design and implementation
  - Running drivers
  - Data extraction
  - Processing the data
  - Reporting and signatures
- And the result is …
  - Experiment A: High profile rootkits
  - Experiment B: Driver files
  - Experiment C: Random set of PE files
- Conclusion
- Future work

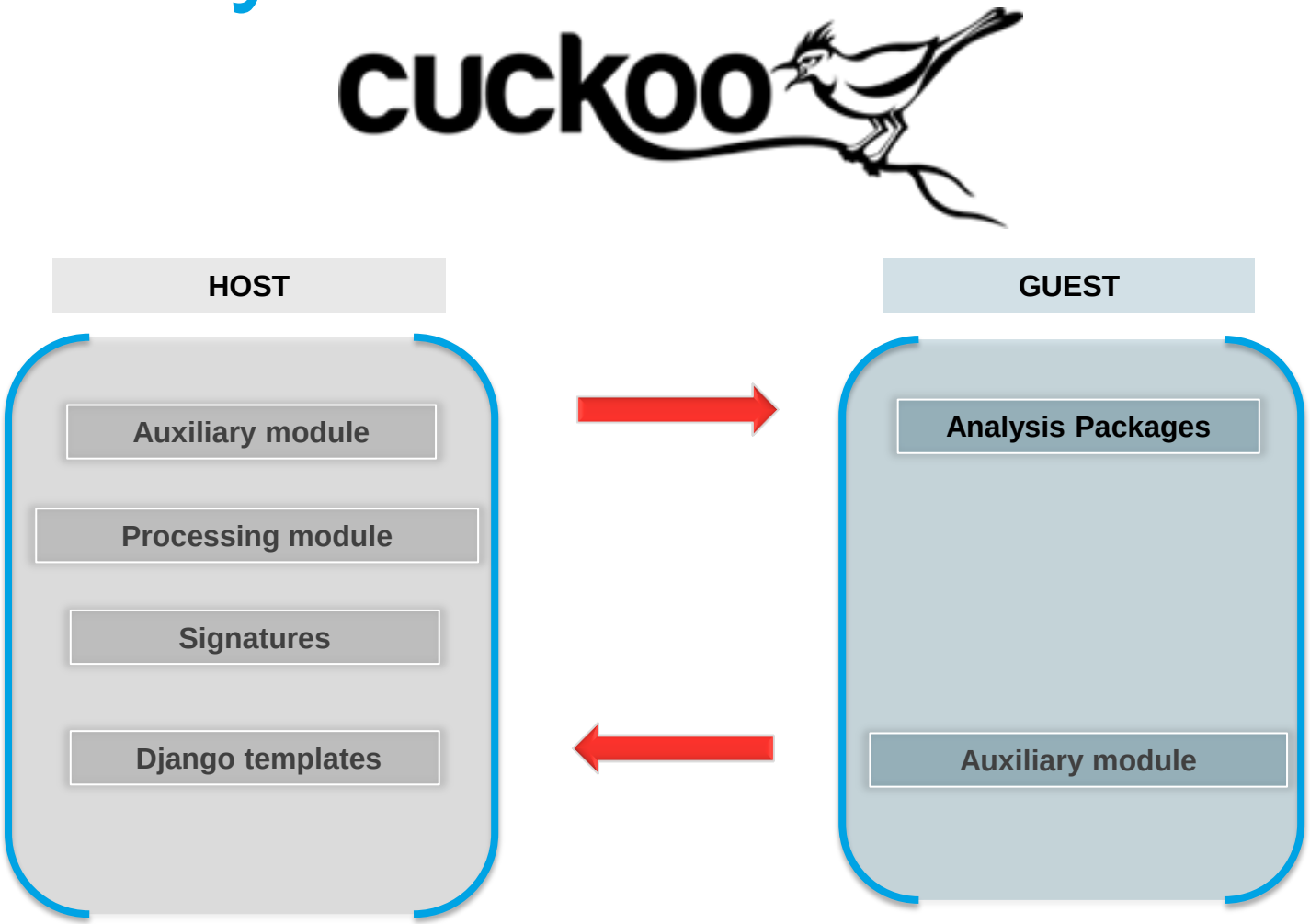
What is the objective?

- Automate the process of finding samples that exhibit kernelmode behaviour
- List the modifications made to the kernel
- Identify the maliciousness of specific modifications
- Import that data into other systems

How do we automate the process?

- Use existing tools
- Build our own
  - Using anti-rootkit tools
  - Using a custom diff based solution

Bird's eye view



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Running Driver files

(Servicename | StartType | ServiceType | LoadMode)

“Register service using scm
If not loadmode then:
  start service using NTLoadDriver
Else:
  start service using loadmode option
If not service is running:
   report FAIL ! “

Usage of the Sophos AV Engine

With the SAV engine we get:

- Existing software that has a presence in the kernel
- The ability to examine/dump areas of kernel memory
- The ability to write to a log file

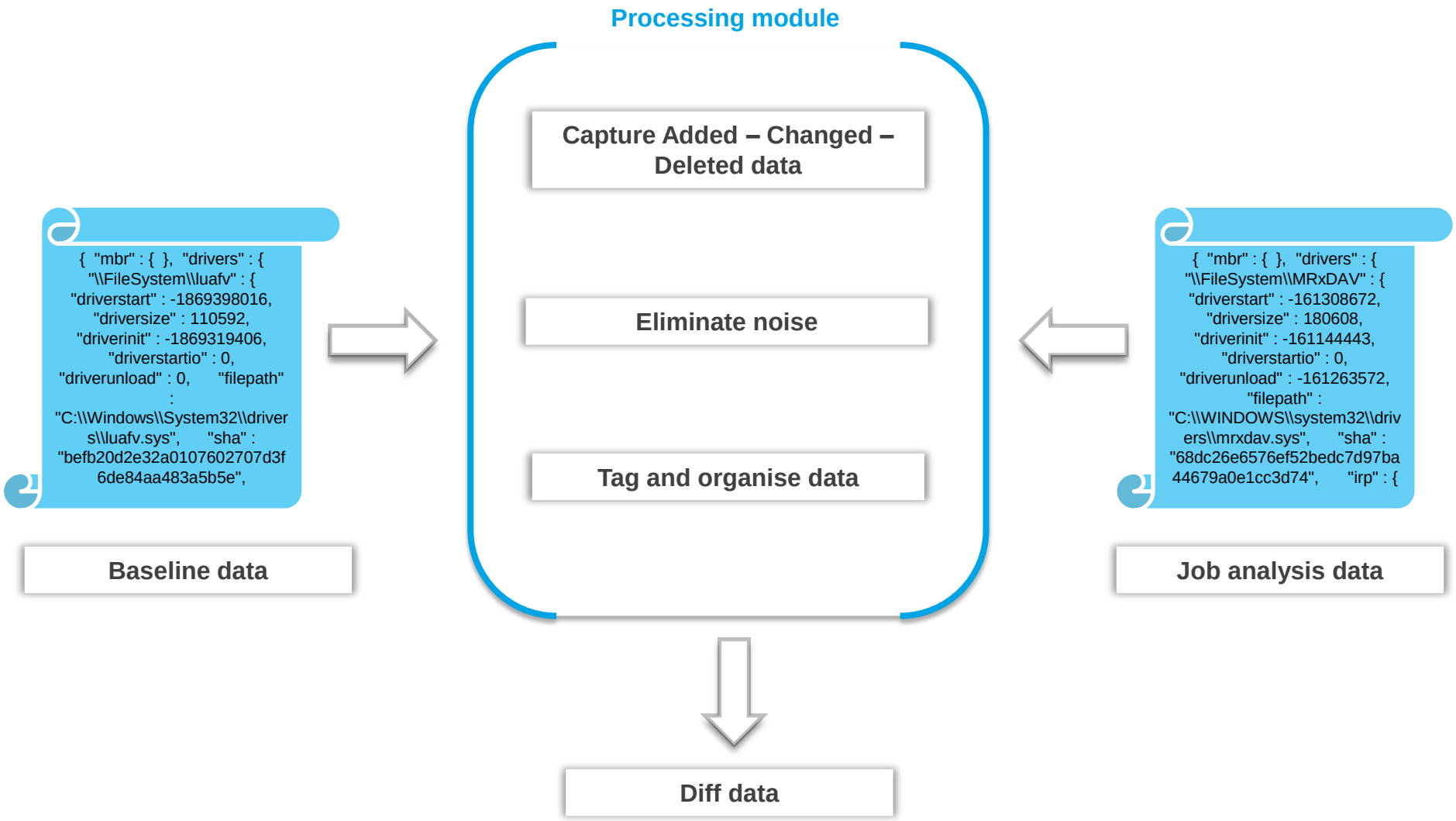
NOTE: Due to modular design we don't *need* to use the Sophos AV engine.

Examining the kernel

What areas are we looking at?

Drivers	Modules	SSDT
IDT	Callbacks	Disk Information

Processing the data



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Processing the data

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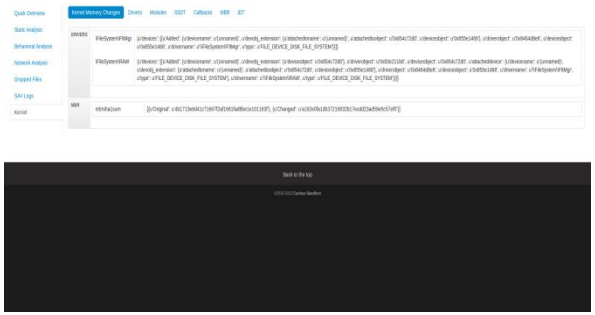
Data flow

Data → Signatures → Reporting


```
{"drivers": {"\\Driver\\4C3553F1":
{"Added": {"driverinit":
"0xf7b97983", "driverunload":
"0xf7b9794a", "irp":
{"IRP_MJ_CREATE_MAILSLOT
": "0xf7b97965",
"IRP_MJ_SET_QUOTA":
"0xf7b97965",
"IRP_MJ_SET_SECURITY":
"0xf7b97965",
"IRP_MJ_SET_VOLUME_INFO
RMATION": "0xf7b97965",
"IRP_MJ_WRITE":
"0xf7b97965", …"
```


generic_new_driver
generic_modified_driver
generic_deleted_driver
generic_new_module
generic_deleted_module
generic_ssdt_hook
generic_idt_hook
generic_new_callback
generic_modifed_callback
generic_attached_device

. . .



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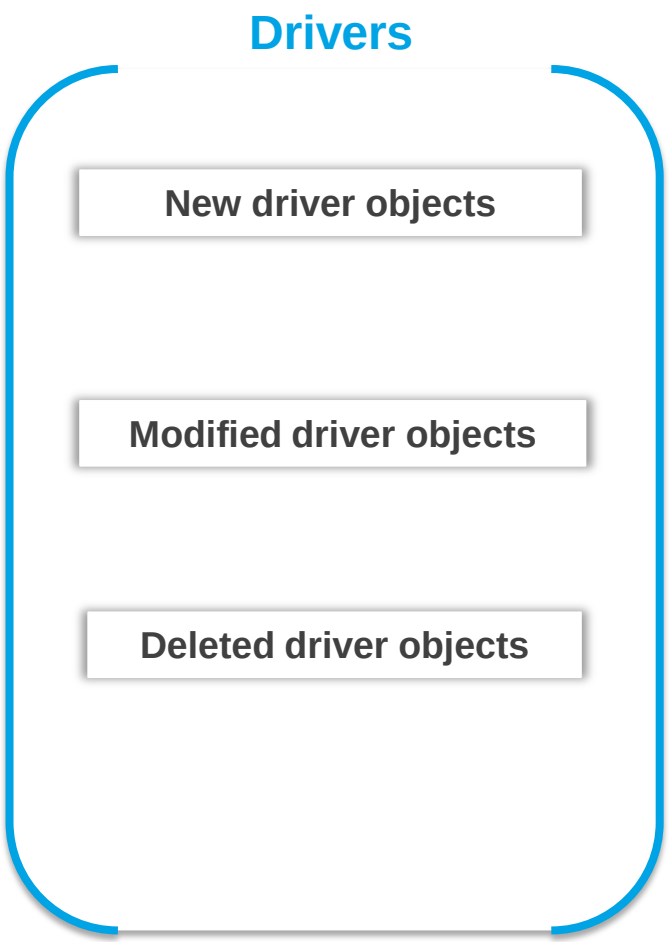
Signatures



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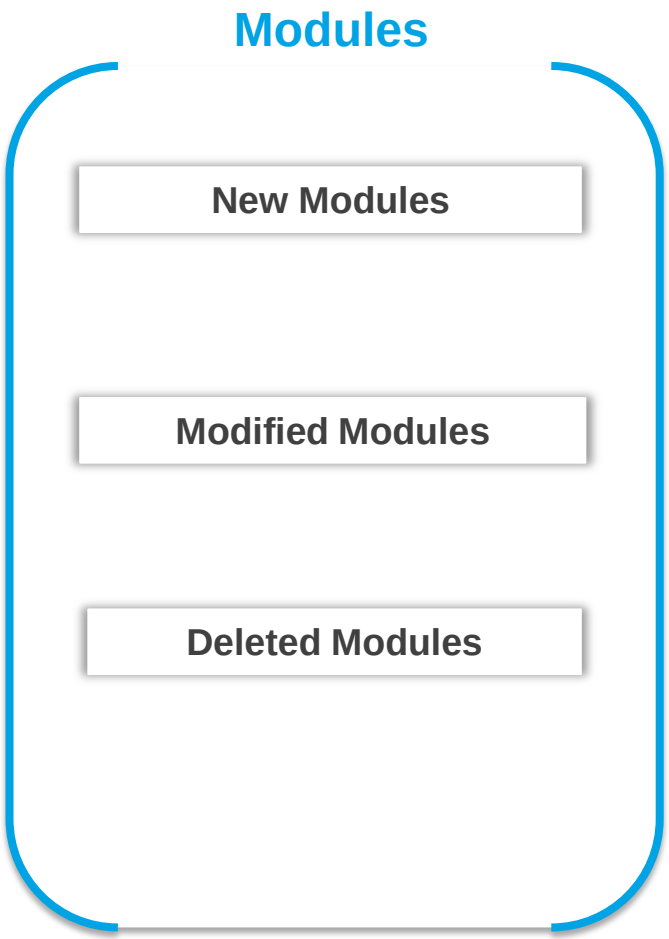
Signatures



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Signatures

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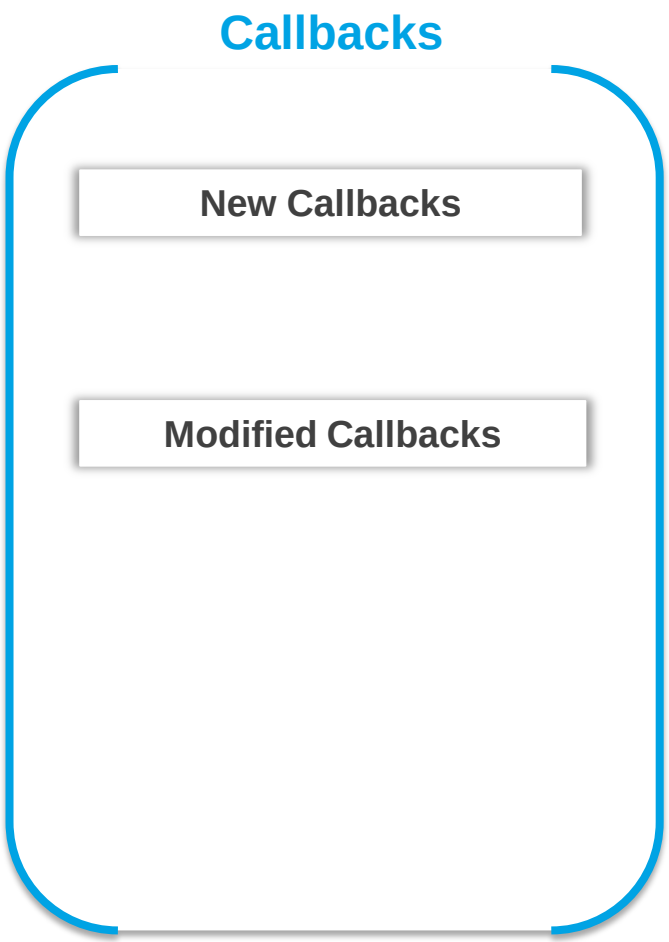
Signatures



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Signatures

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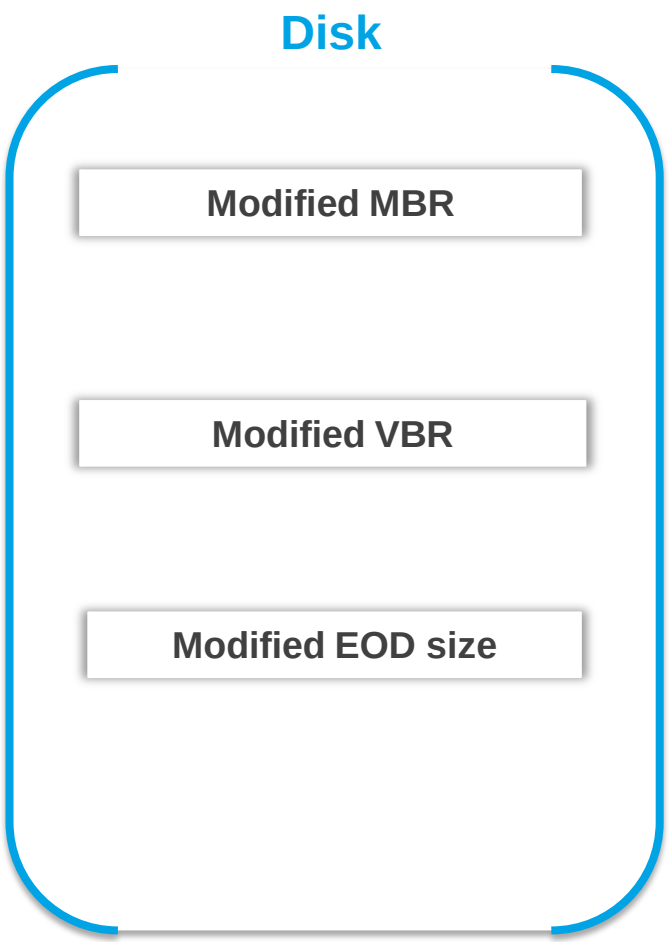
Signatures



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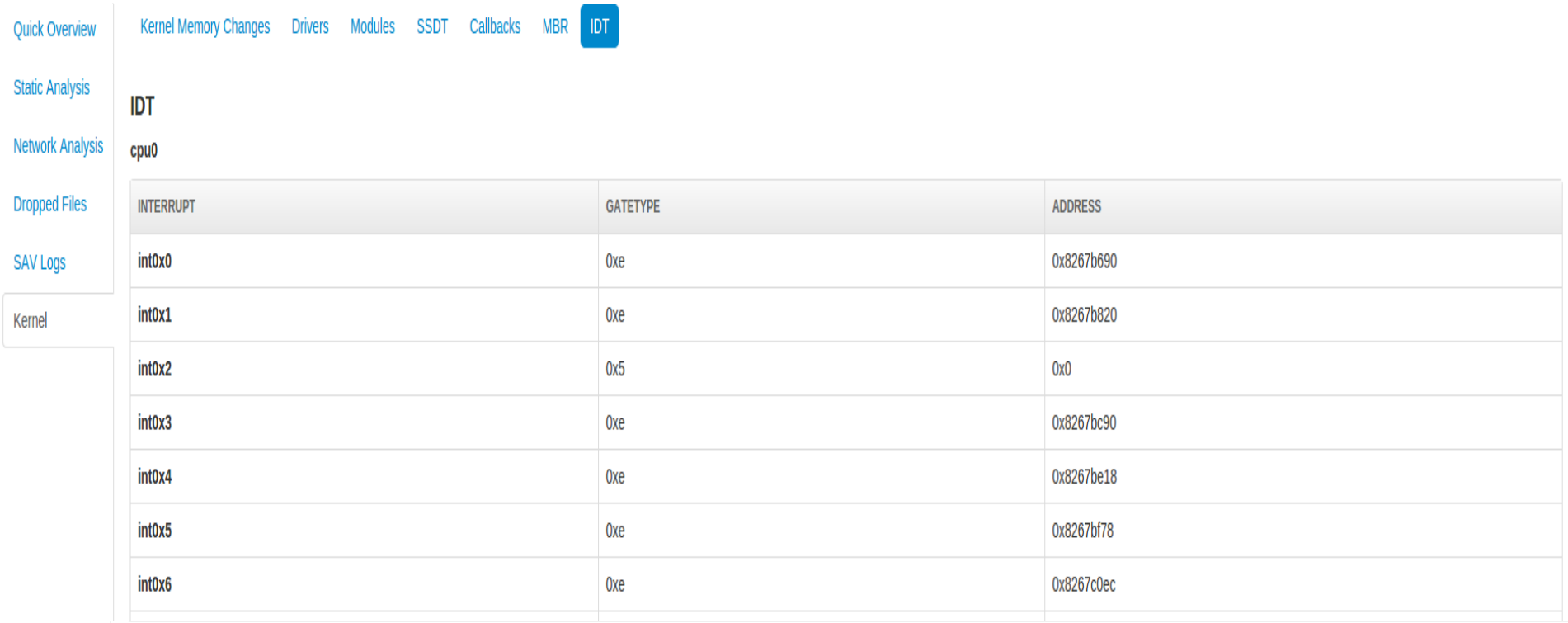
Reports



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YOU SHALL NOT PASS

Tests

- High profile rootkits
  - TDL Derivatives
  - GAPZ
  - Turla
  - Necurs
- Experiment B: Malicious and clean driver set
- Experiment C: Random set of known malicious PE files

TDL Derivatives

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TDL Derivatives

Device Object(s) added

DeviceName: (unnamed)

DeviceObjectAddr: 0x84895710

DeviceType: FILE_DEVICE_DISK_FILE_SYSTEM

Driver: \FileSystem\FltMgr

Driver Object(s) modified

Name: \FileSystem\RAW

Name: \FileSystem\FltMgr

Kernel Memory Changes | Drivers | Modules | SSDT | Callbacks | MBR | IDT

DRIVERS

\FileSystem\RAW	{u'devices': [{u'Added': {u'devicename': u'(unnamed)', u'devobj_extension': {u'deviceobject': u'0x8482c030'}, u'driverobject': u'0x83e1f1b8', u'deviceobject': u'0x8482c030', u'attacheddevice': {u'devicename': u'(unnamed)', u'devobj_extension': {u'attachedtoname': u'(unnamed)', u'attachedtoobject': u'0x8482c030', u'deviceobject': u'0x84895710'}, u'driverobject': u'0x84a41c40', u'deviceobject': u'0x84895710', u'drivername': u'\\FileSystem\\FltMgr', u'type': u'FILE_DEVICE_DISK_FILE_SYSTEM'}, u'drivername': u'\\FileSystem\\RAW', u'type': u'FILE_DEVICE_DISK_FILE_SYSTEM'}}]}
\FileSystem\FltMgr	{u'devices': [{u'Added': {u'devicename': u'(unnamed)', u'devobj_extension': {u'attachedtoname': u'(unnamed)', u'attachedtoobject': u'0x8482c030', u'deviceobject': u'0x84895710'}, u'driverobject': u'0x84a41c40', u'deviceobject': u'0x84895710', u'drivername': u'\\FileSystem\\FltMgr', u'type': u'FILE_DEVICE_DISK_FILE_SYSTEM'}}]}

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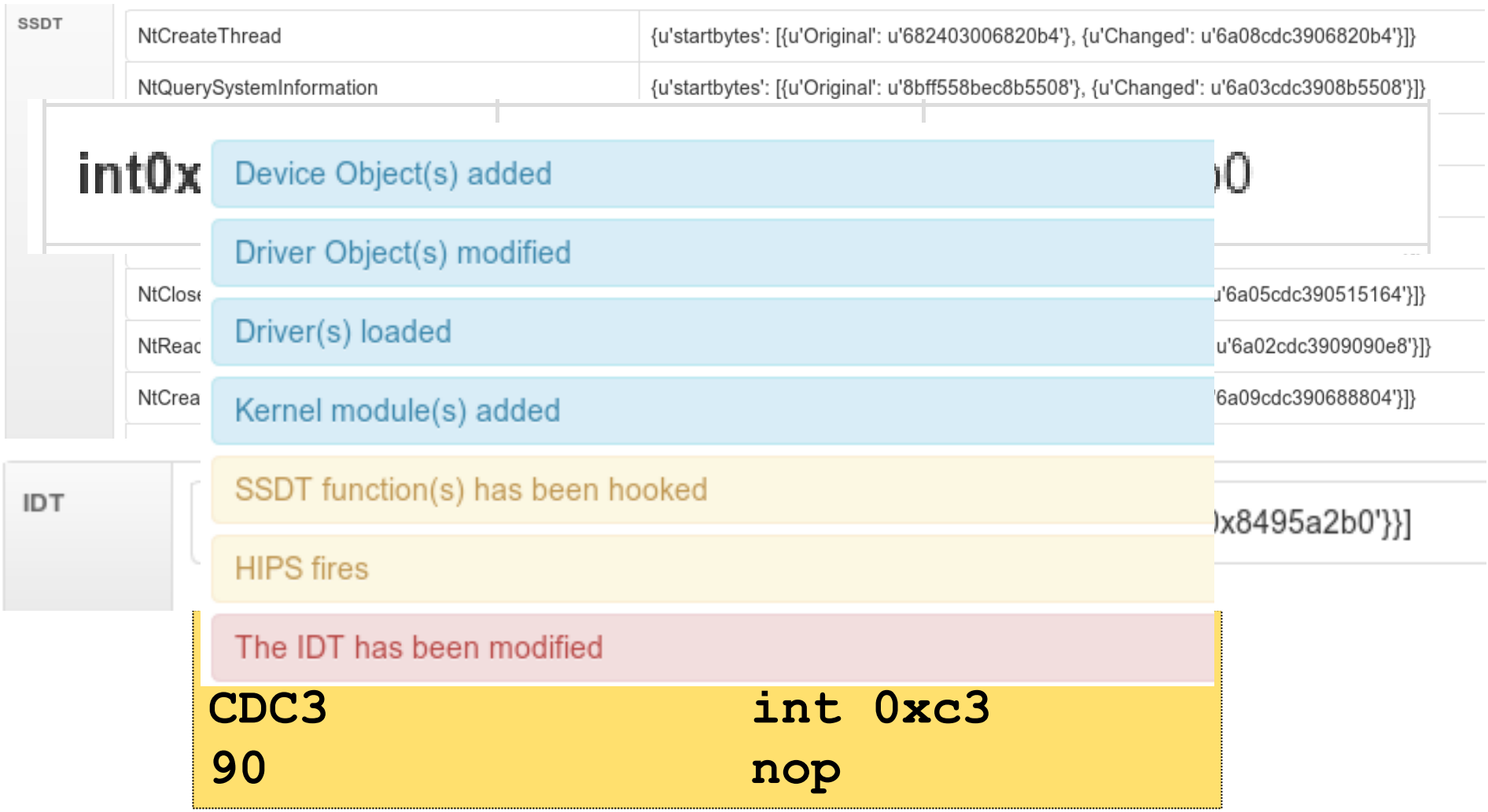
GAPZ

The VBR has been modified

MBR	Partition0	{u'vbrsha1sum': [{u'Original': u'7a781423dbb768786a81633441f8d533594583f5'}, {u'Changed': u'64f08b44562578234af25a1cfef84d2bccf1a5'}]}
SSDT	NtDeletePrivateNamespace	{u'startbytes': {u'Added': u'8bff558bec83ec10', u'PagedIn': 1}}
	NtSaveKey	{u'startbytes': {u'Added': u'8bff558bec83e4f8', u'PagedIn': 1}}
	NtPulseEvent	{u'startbytes': {u'Added': u'6a1468a8e6982e8', u'PagedIn': 1}}

Turla a.k.a Snake, Uroborus



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Necurs

\FileSystem\FltMgr

Device Object(s) added

Driver Object(s) modified

Driver(s) loaded

A callback has been added

tension': {u'attachedtoname': u'0x85765ed8'}, u'driverobject': {u'devicename': u'(unnamed)', ltoobject': u'0x85765ed8', deviceobject': u'0x8581eb68', u'drivername': u'\\Driver\\808a56c5daeb2cc4', u'type': u'FILE_DEVICE_DISK_FILE_SYSTEM'}, ISK_FILE_SYSTEM'}}]}

LoadImageNotify

[{u'Added': {u'filepath': None, u'driver': u'unknown/hidden', u'module': u'\\SystemRoot\\system32\\ntkrnlpa.exe', u'sha': None, u'address': u'0x8289add5', u'type': u'LoadImageNotify'}}, {u'Added': {u'filepath': None, u'driver': u'\\Driver\\808a56c5daeb2cc4', u'module': u'unknown/hidden', u'sha': None, u'address': u'0x84874510', u'type': u'LoadImageNotify'}}]

Name: \Driver\808a56c5daeb2cc4

Sha: None

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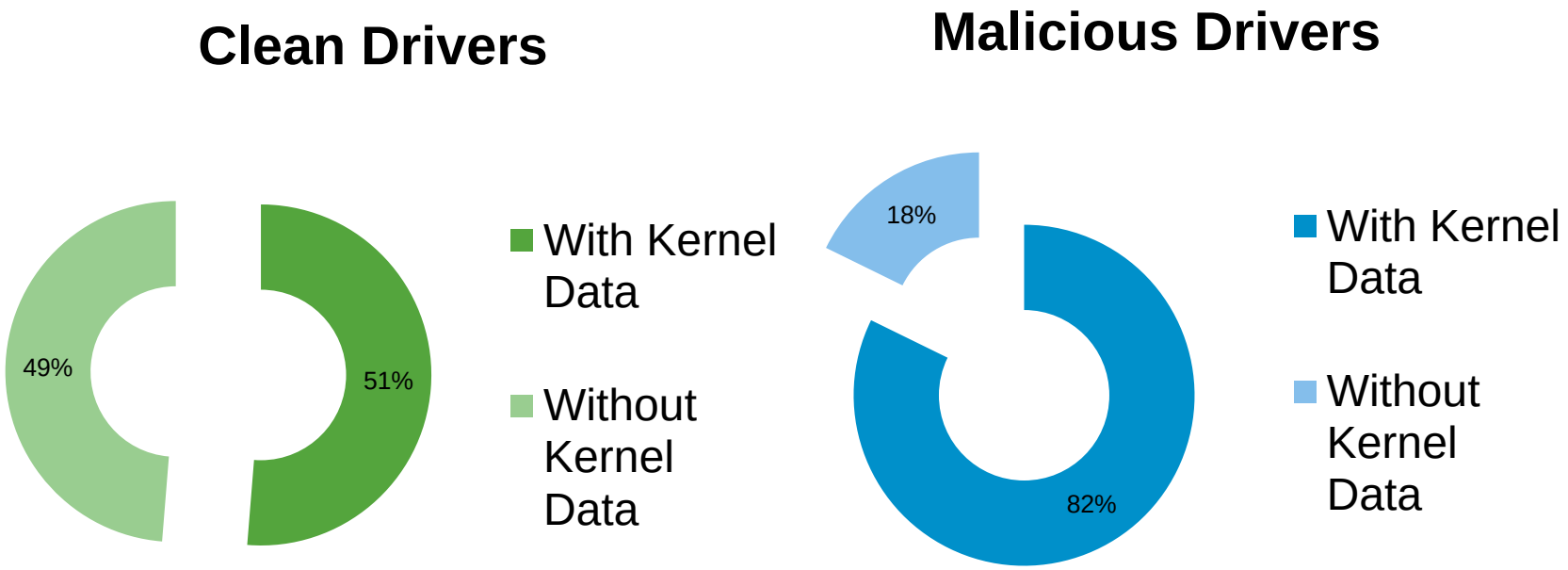
High profile rootkits

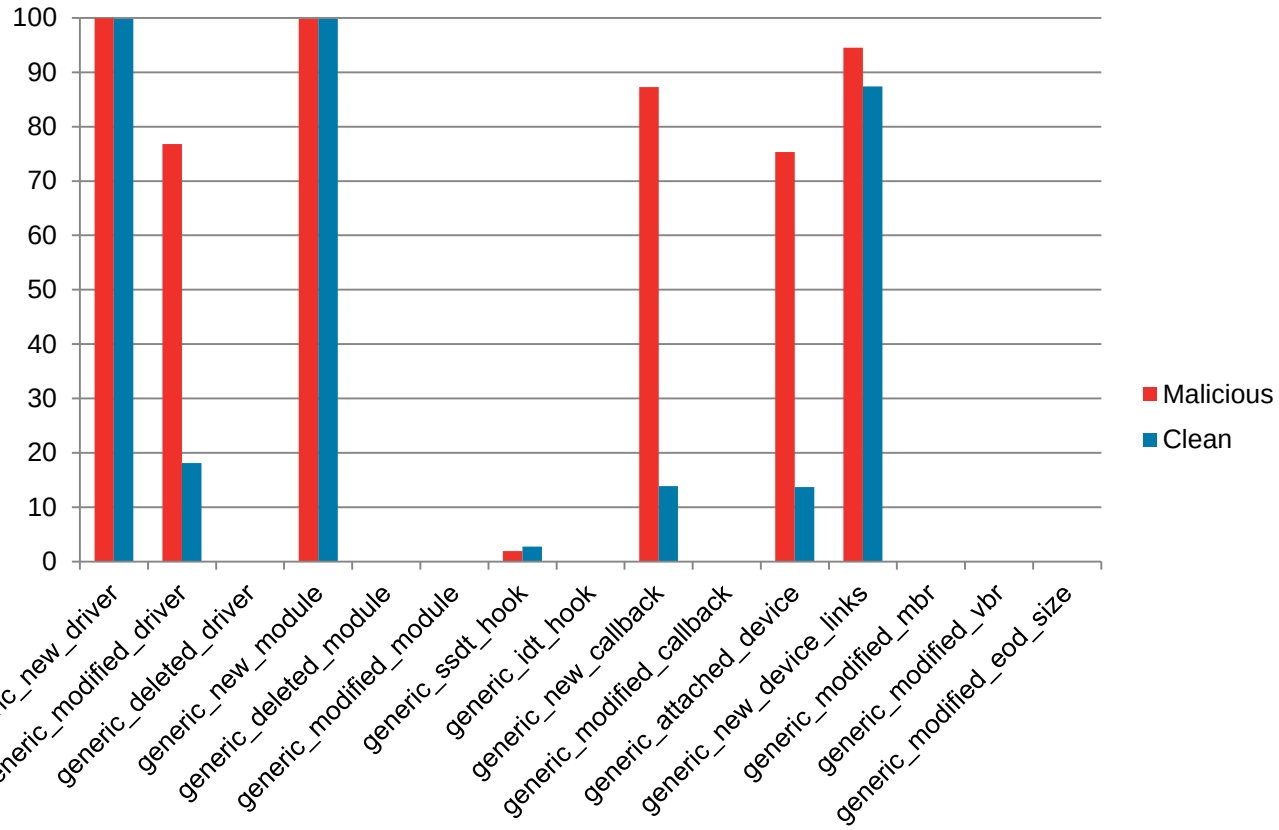
- We do not always get enough information to classify specific families
- We are getting enough information to warrant further investigation by an researcher

Experiment B



- Total number of malicious drivers 1854.
- Total number of clean drivers 1053.
- Insufficient time for the log to be generated was a common reason for failure to get back kernel data. Miss the log by a second or two. It's a trade off.

And the results is



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Callbacks

TYPE	FILEPATH	DRIVER	MODULE
CreateThreadNotify			
	C:\Windows\System32\drivers\savonaccess.sys	\FileSystem\SAVOnAccess	\SystemRoot\system32\DRIVE
CreateProcessNotify			
	None	unknown/hidden	\SystemRoot\system32\ntkrnlp
	C:\Windows\System32\drivers\ksecdd.sys	\Driver\KSecDD	\SystemRoot\System32\Drivers
	C:\Windows\System32\drivers\cng.sys	\Driver\CNG	\SystemRoot\System32\Drivers
	C:\Windows\System32\drivers\tcpip.sys	\Driver\Tcpip	\SystemRoot\System32\drivers
	None	unknown/hidden	\SystemRoot\system32\CI.dll
	C:\Windows\System32\drivers\PEAuth.sys	\Driver\PEAUTH	\SystemRoot\system32\drivers

SSDT	NtEnumerateKey	{u'startbytes': [{u'Original': u'6a6068d88c6982e8'}, {u'Changed': u'e967eaa8186982e8'}]}
	NtFlushInstructionCache	{u'startbytes': [{u'Original': u'6a2c6838206982e8'}, {u'Changed': u'e9badfb6186982e8'}]}

	None	unknown/hidden

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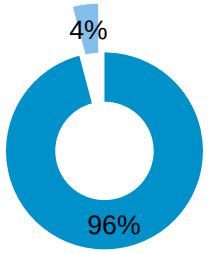
Experiment C

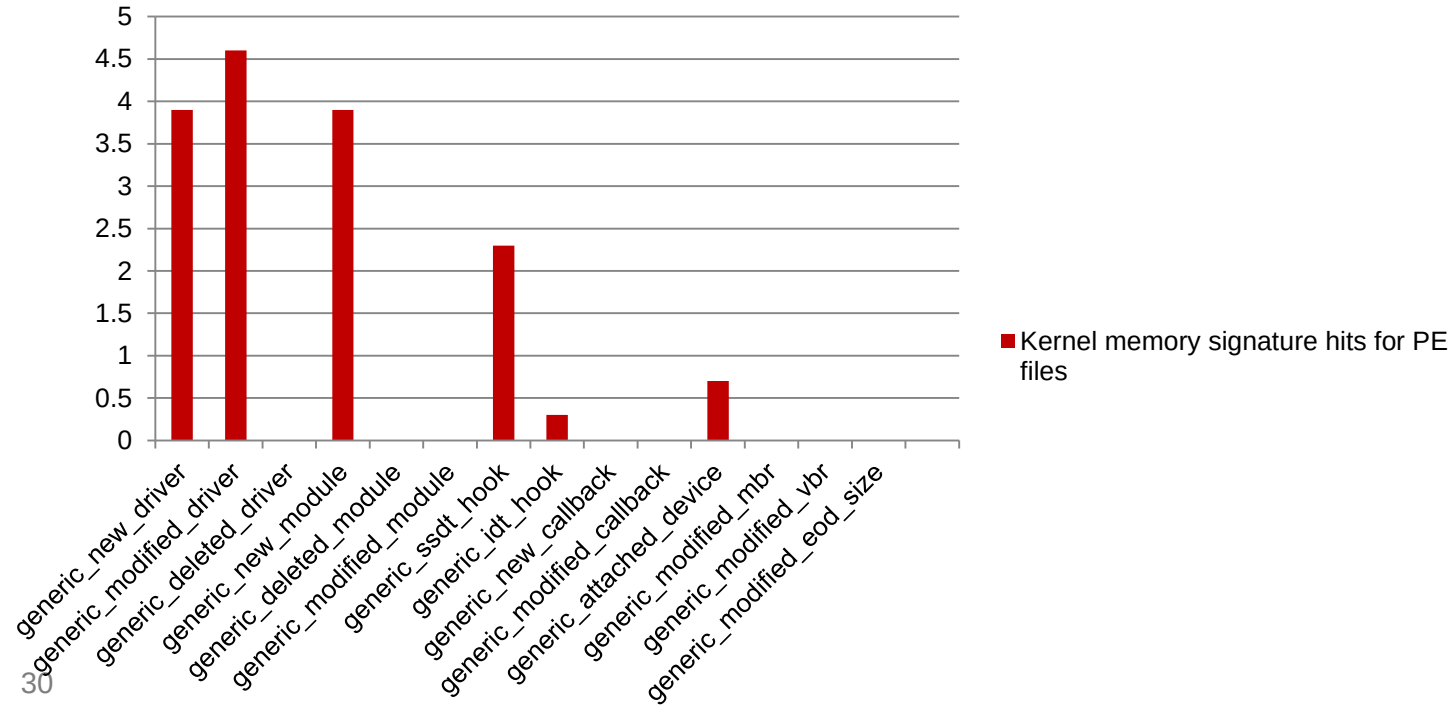
- 319 of known malicious PE files.



Set of PE files

- With Kernel memory
- Without Kernel Data

Kernel memory signature hits for PE files



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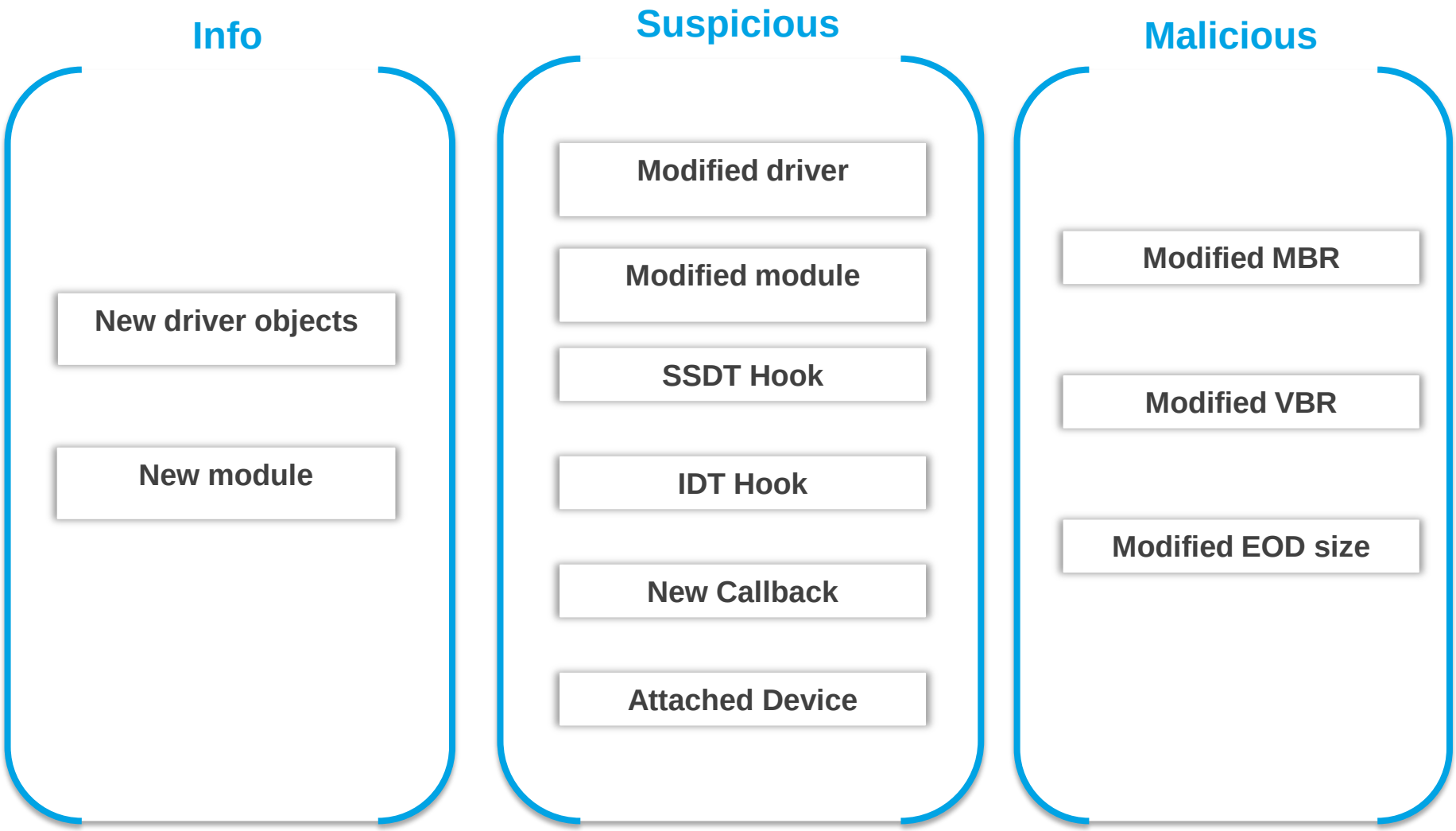
Weighting the signatures



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Conclusion

- Malicious activity can be identified via modifications rather than creation
- Malicious drivers are unlikely to employ anti-sandboxing techniques
- Good enough to identify kernel activity
  - Not exhaustive analysis

Future work

- Exploring other areas of the kernel
  - Object table
  - DKOM
  - 64bit drivers
- Sample clustering
- Usermode rootkits

Questions?