VisWeek 09

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Visual Analysis of Malware Behavior

October 11th, 2009

About Us

- University of Mannheim, Germany

- Laboratory for Dependable Distributed Systems
- Security research:
  - Analysis of malware and spam
  - Honeypots / IT-Forensics

Motivation

- Sandbox Service - *CWSandbox.org*
- Dynamic malware analysis
  - API-Hooking
    - Monitors 121 API-Calls out of 20 sections
    - Detailed Behavior Report (XML)
- Up to 4000 new samples per day
- Manual processing not possible

Motivation

- What are the main Operations?
  - Network activities?
  - Registry access?
  - Filesystem operations?
  - ...
- Which operations do not occur?

Motivation

- What are the main Operations?
  - Network activities?
  - Registry access?
  - Filesystem operations?
  - ...
- Which operations do not occur?

Which samples are of interest?


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1265393.xml

```
<?xml version="1.0"?>
<!-- This analysis was created by CWSandbox (c) CWSE GmbH / Sunbelt Software-->
<analysis cwsversion="2.1.6" time="3/28/2009 10:06:45 PM" file="C:\1265393" md5="a9f6aa1649e6a0f1bfad8a576f0193a0"
sha1="1d13db7f7b57fcc6c715084a20660a464a7aab50" logpath="C:\cwsandbox\log\1265393\run_1\">
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</process_call>
</calltree>
</process_call>
</calltree>
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terminationtime="00:01.172" startreason="AnalysisTarget" terminationreason="NormalTermination" executionstatus="OK" applicationtype="Win32Application">
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Line: 1 Column: 1 XML Tab Size: 4

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<open_key key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor"/>
<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="DisableUNCCheck"/>
<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="EnableExtensions"/>
<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="DelayedExpansion"/>
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```

1265393.xml

```
<open_key key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor"/>
<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="DisableUNCCheck"/>
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<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="CompletionChar"/>
<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="PathCompletionChar"/>
<query_value key="HKEY_CURRENT_USER\Software\Microsoft\Command Processor" value="AutoRun"/>
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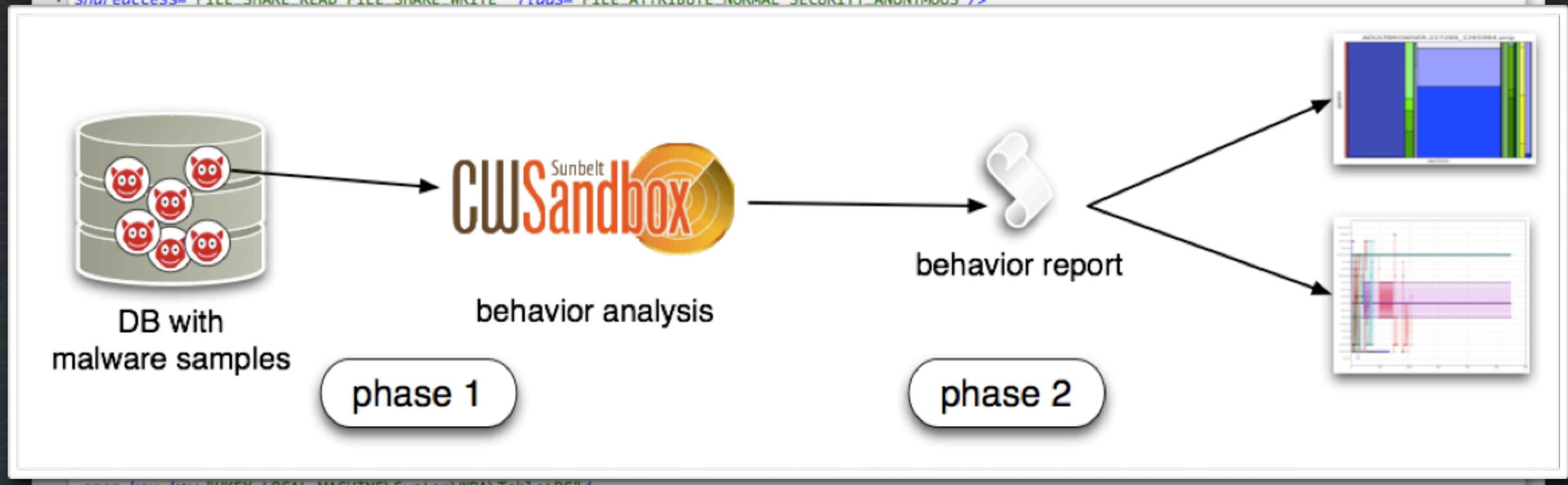


```
<open_key key="HKEY_LOCAL_MACHINE\System\WPA\TabletPC"/>
<open_key key="HKEY_LOCAL_MACHINE\SYSTEM\WPA\MediaCenter"/>
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FILE_WRITE_EA FILE_WRITE_ATTRIBUTES" flags="FILE_ATTRIBUTE_NORMAL SECURITY_ANONYMOUS"/>
<open_file filetype="file" srcfile="C:\WINDOWS\system32\" srcfile_hash="hash_error" desiredaccess="FILE_ANY_ACCESS FILE_READ_ACCESS FILE_READ_DATA
FILE_LIST_DIRECTORY" shareaccess="FILE_SHARE_READ FILE_SHARE_WRITE" flags="SECURITY_ANONYMOUS"/>
<find_file filetype="file" srcfile="C:\WINDOWS\system32\attrib.exe" srcfile_hash="6be7cccf384b1b05b08b7fc5ae5bc3bb3365cc55"
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<open_key key="HKEY_LOCAL_MACHINE\Software\Microsoft\Windows NT\CurrentVersion\AppCompatFlags\Layers"/>
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<load_dll filename="C:\WINDOWS\system32\VERSION.dll" successful="1" address="&#x24;77BD0000" end_address="&#x24;77BD8000" size="32768"
```

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Visualization

- CWSandbox report is “too” detailed
- Use visualization for abstraction
  - Simple to create
  - Comprehensible
- Treemaps and Threadgraphs
- Static version (Python, matplotlib)
- Dynamic version using JavaScript (flot, Jit)

Treemaps

- Quick overview
- Displays the distribution of all operations
- No information about the sequence of operations
- Use case: Malware clustering


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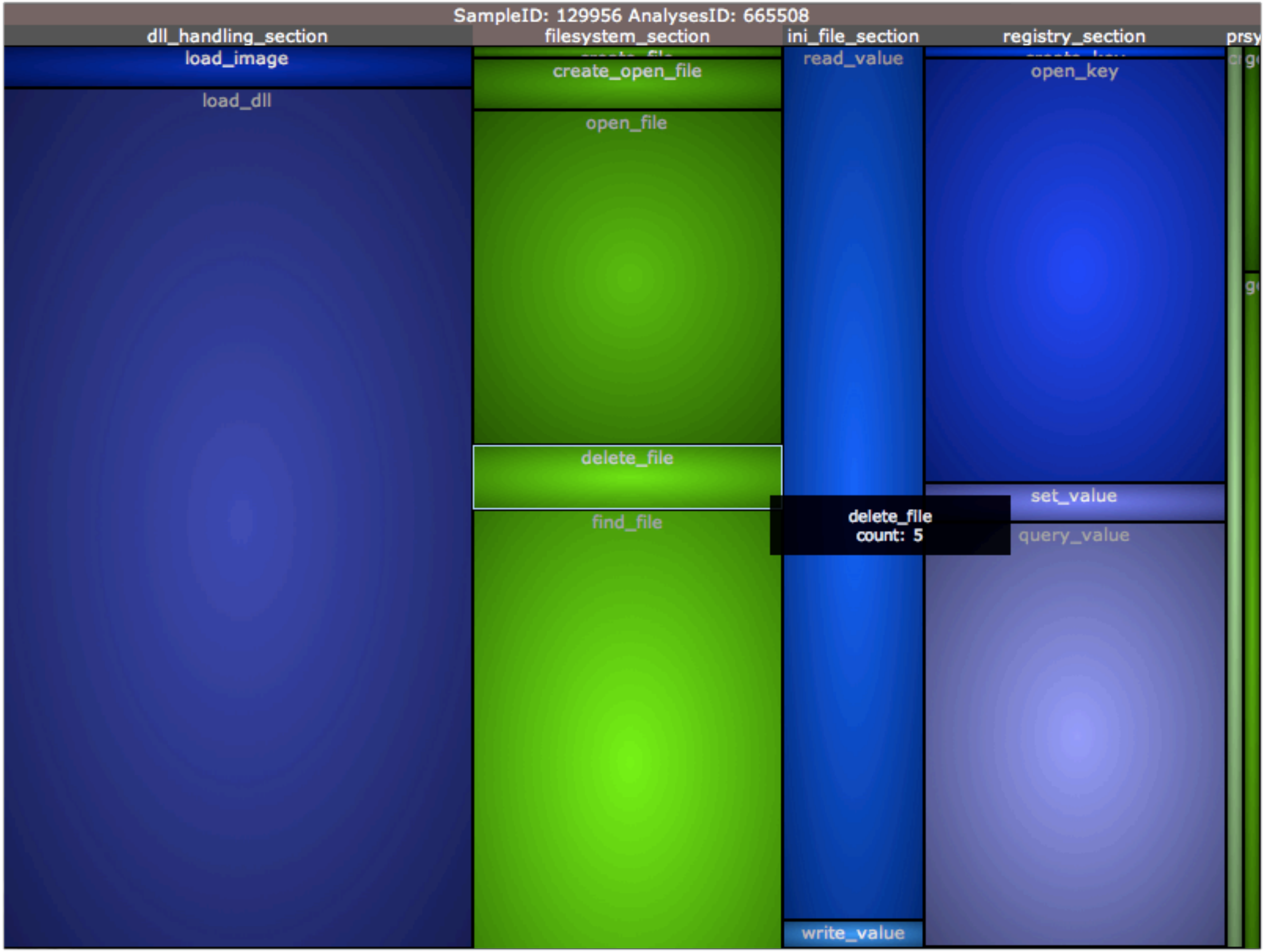

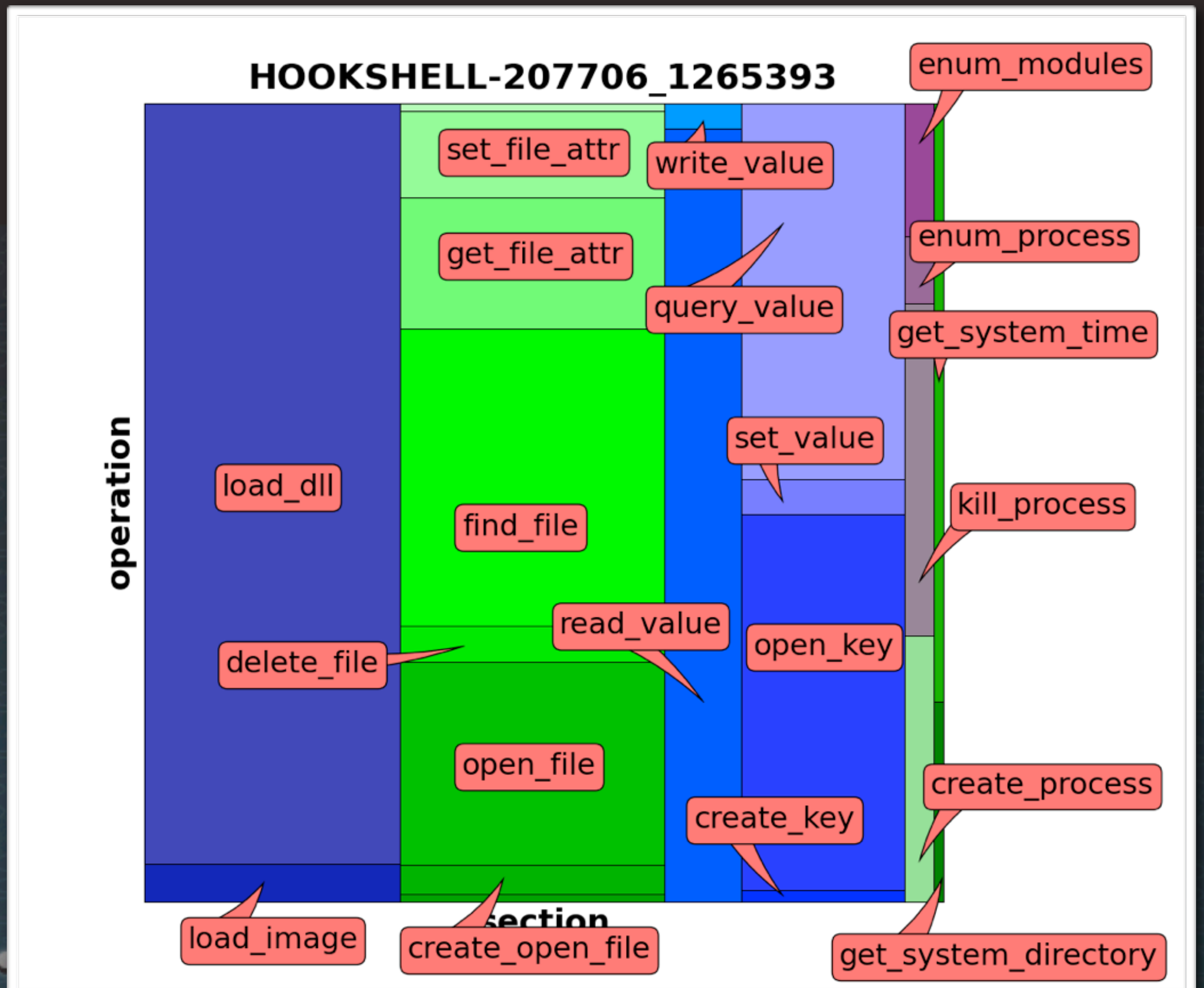
HOOKSHELL-207706_1265393
operation
section
load_dll
set_file_attr
get_file_attr
find_file
delete_file
open_file
load_image
create_open_file
write_value
query_value
read_value
set_value
open_key
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get_system_time
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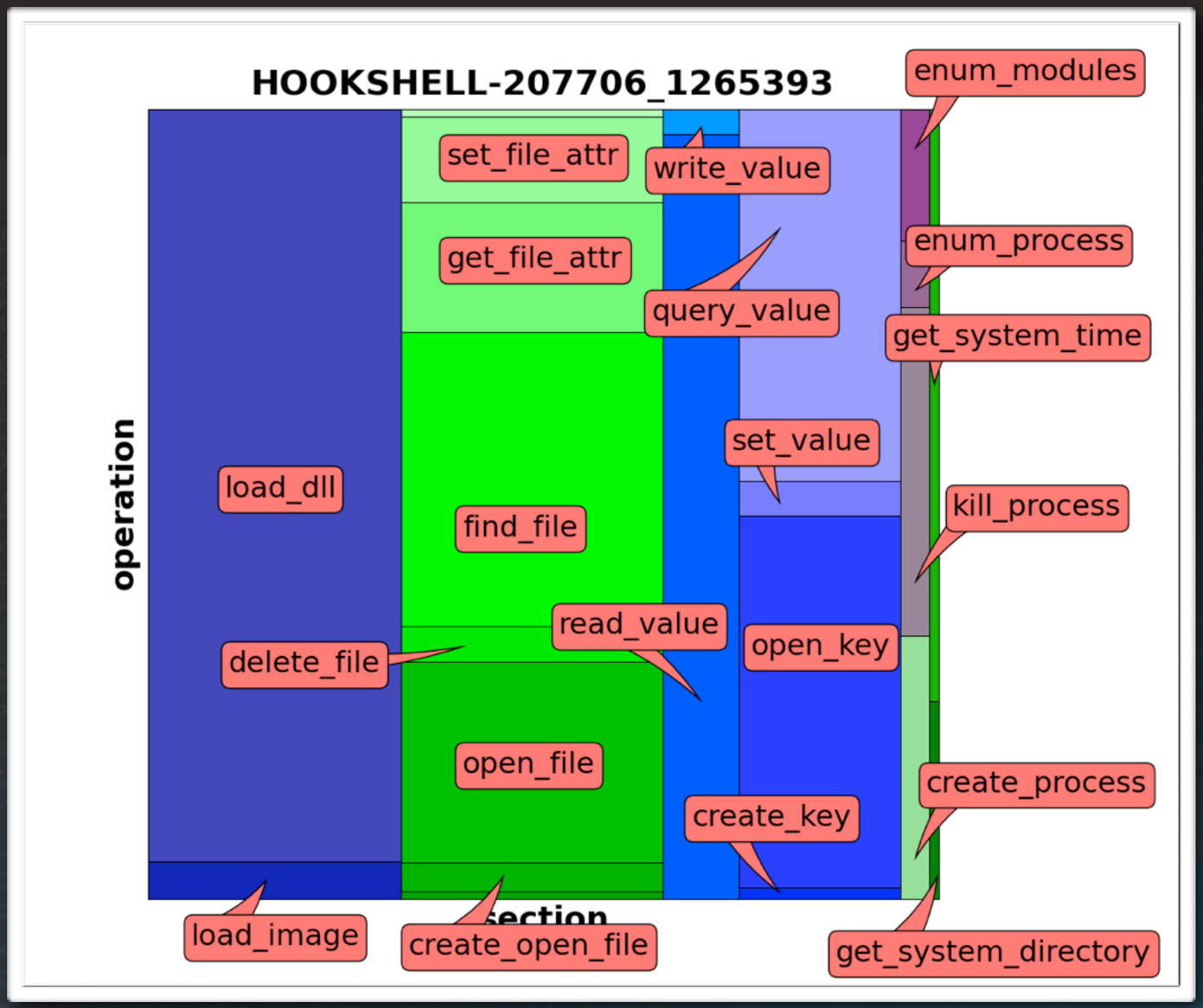
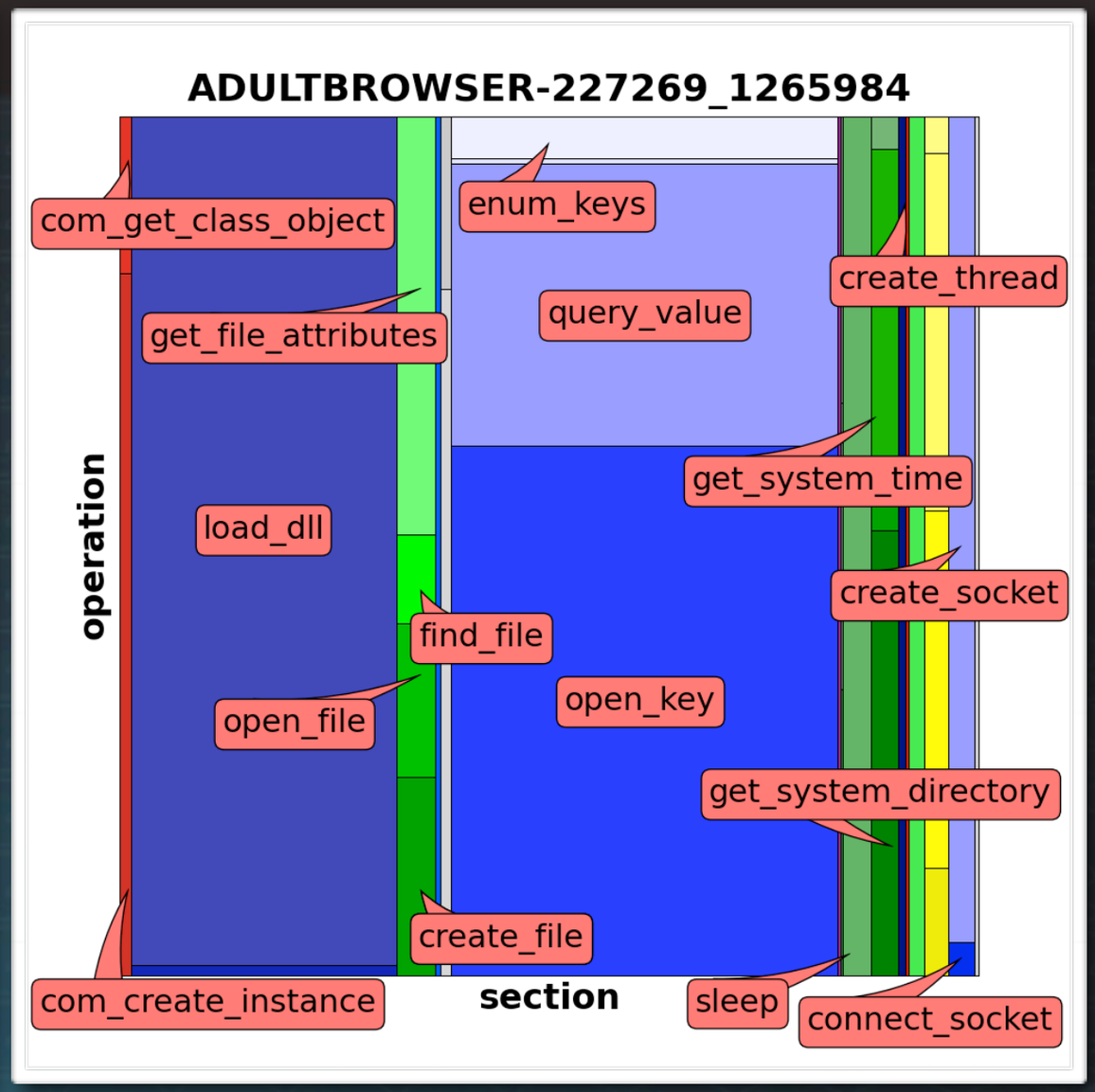
create_process
get_system_directory



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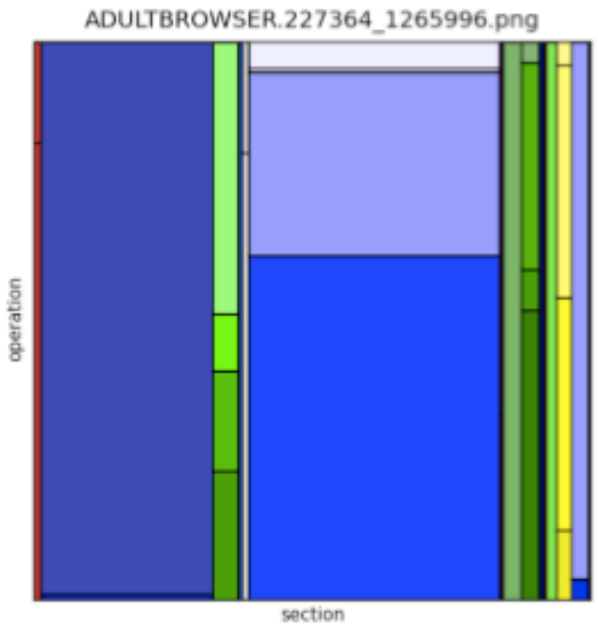
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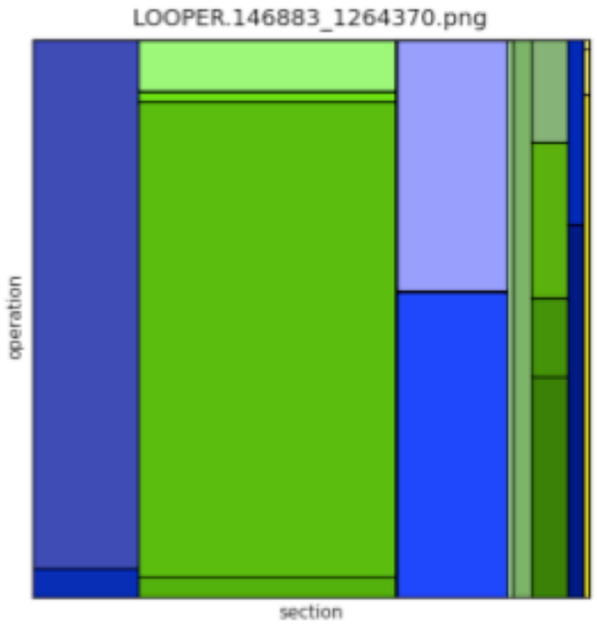
operation
section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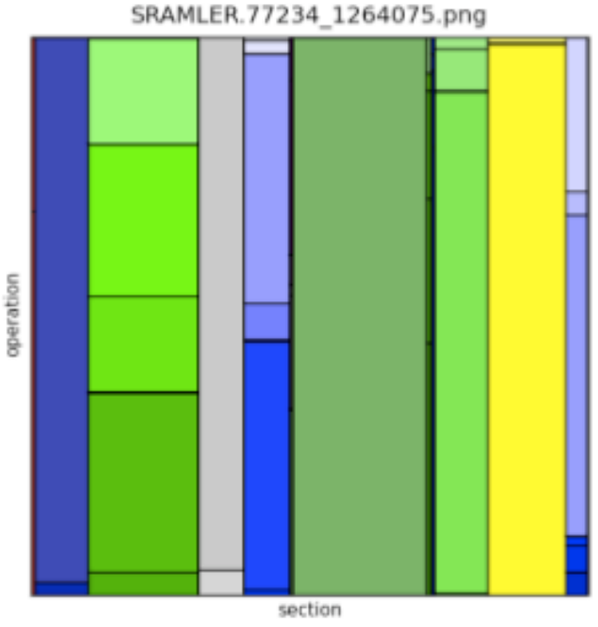
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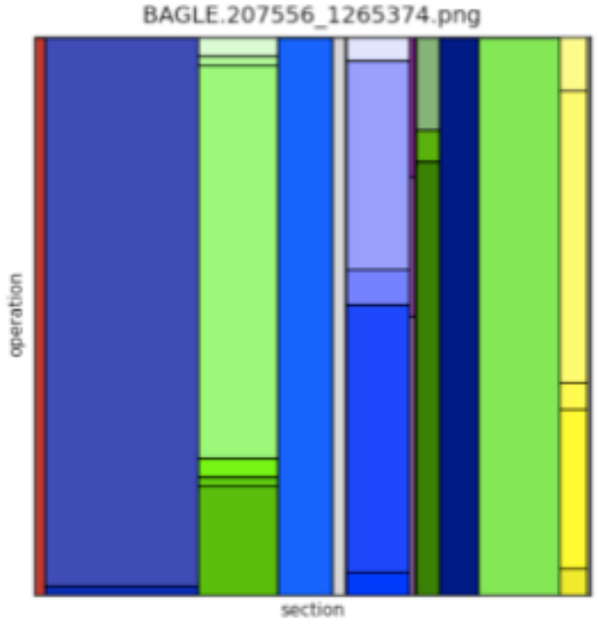
section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operation
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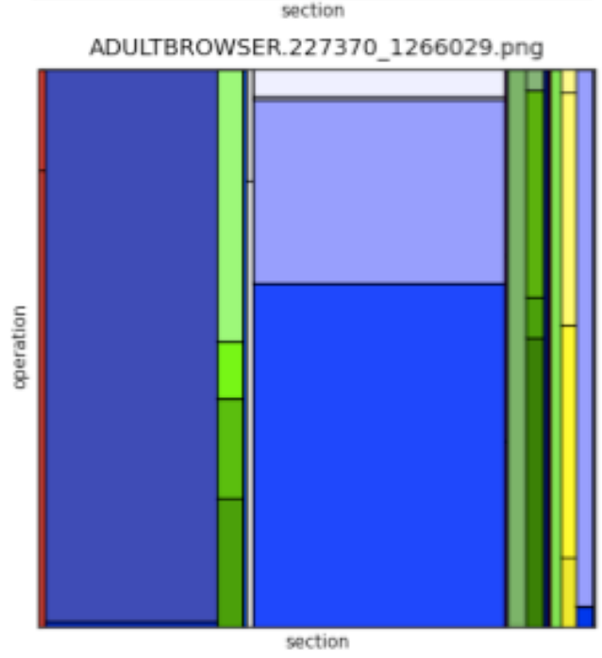
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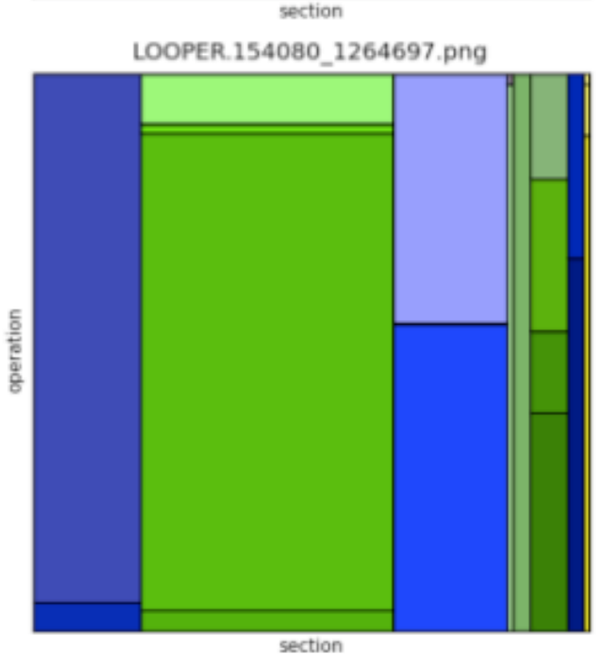
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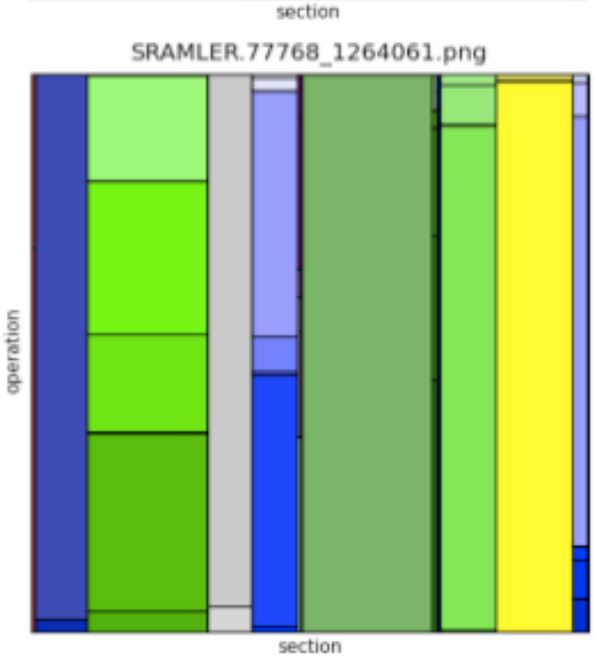
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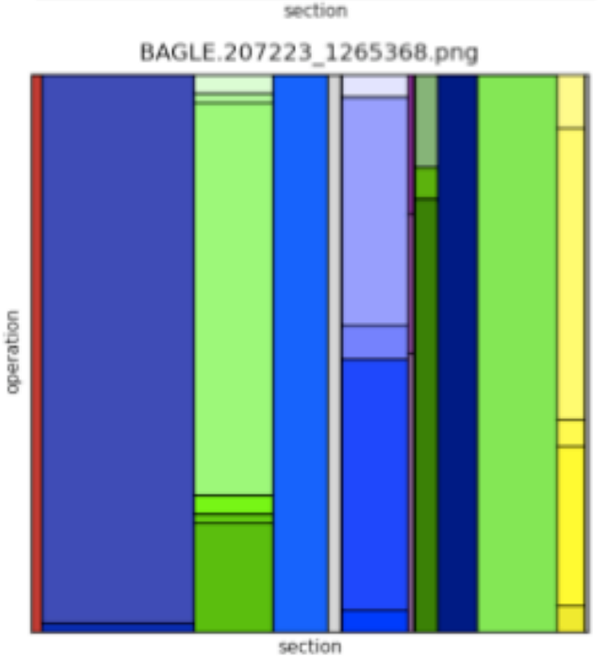
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operation
section

Assignments

Cluster 1 (968 members, 3 prototypes, 23.6% of data, 1 label, 23.6% cumulative)
mist

Cluster 2 (298 members, 8 prototypes, 7.3% of data, 1 label, 30.8% cumulative)
mist

Cluster 3 (184 members, 2 prototypes, 4.5% of data, 1 label, 35.3% cumulative)
mist

Cluster 4 (178 members, 2 prototypes, 4.3% of data, 1 label, 39.6% cumulative)
mist

Cluster 5 (145 members, 1 prototypes, 3.5% of data, 1 label, 43.1% cumulative)
mist

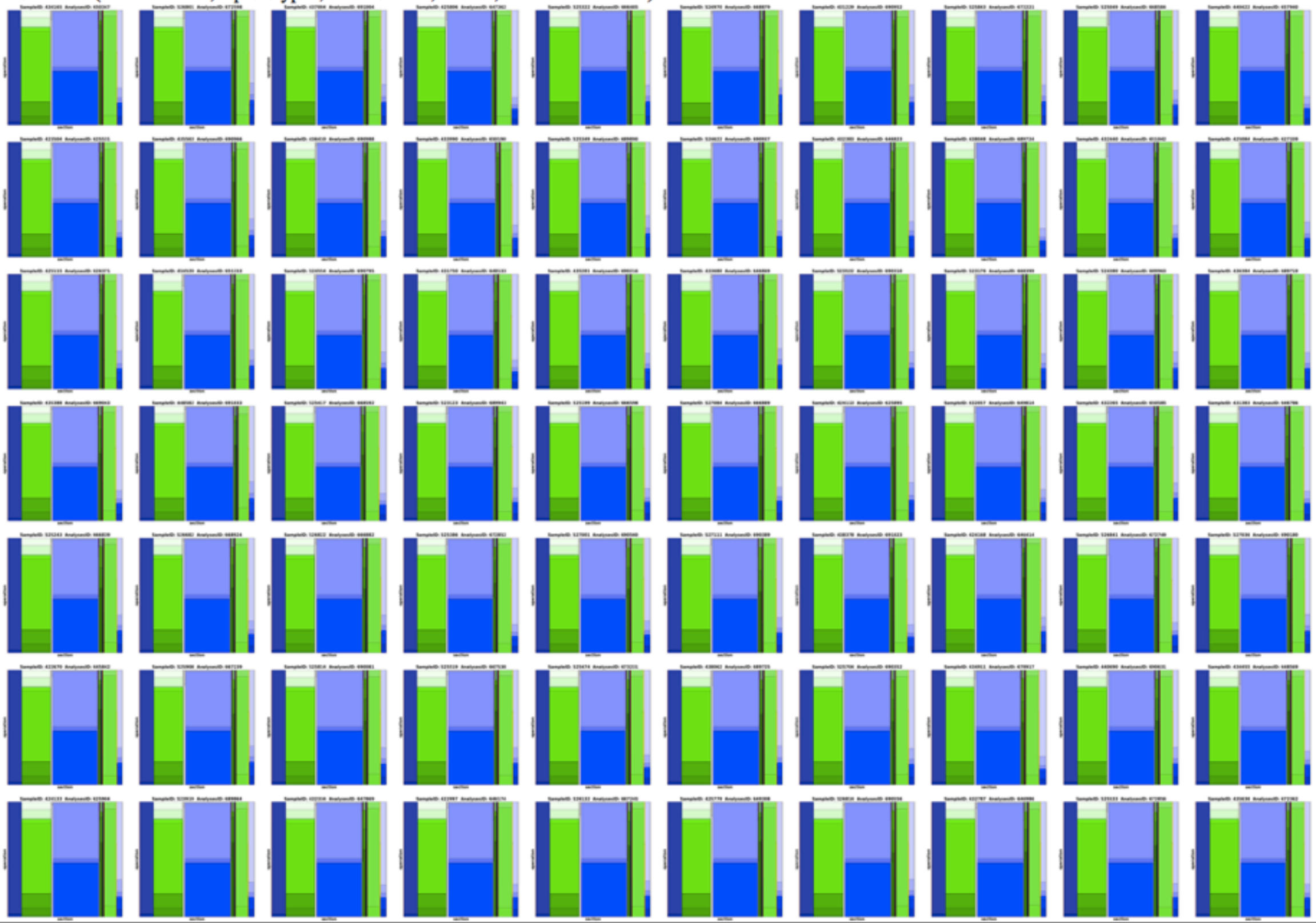
Cluster 6 (134 members, 3 prototypes, 3.3% of data, 1 label, 46.4% cumulative)
mist

Cluster 7 (133 members, 1 prototypes, 3.2% of data, 1 label, 49.6% cumulative)
mist

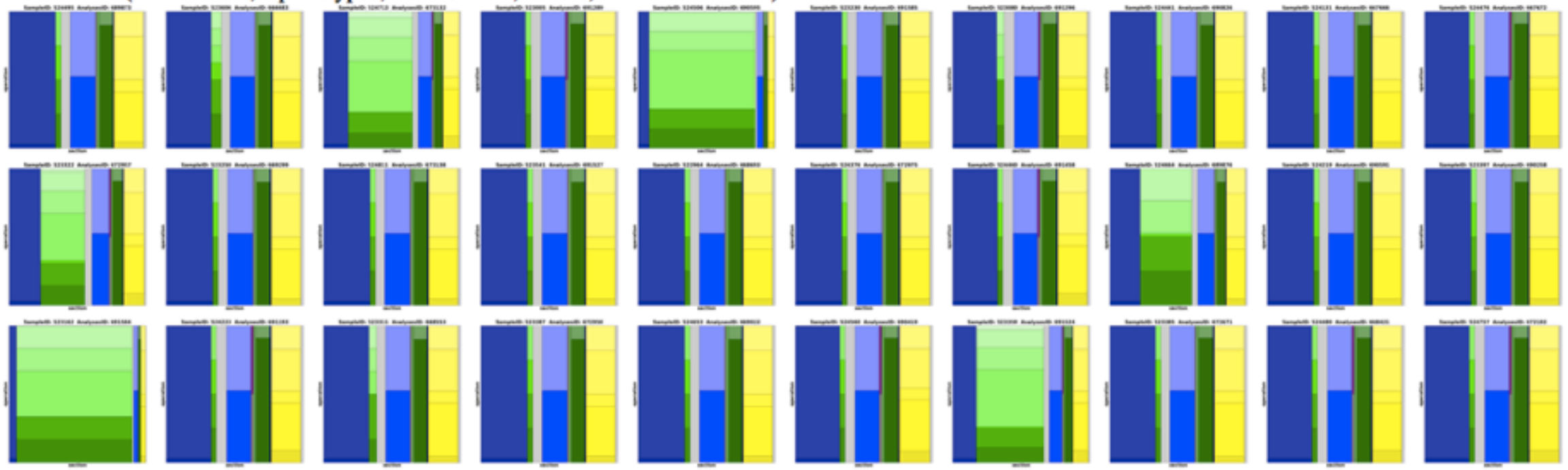
Cluster 8 (123 members, 4 prototypes, 3.0% of data, 1 label, 52.6% cumulative)
mist

Cluster 9 (103 members, 3 prototypes, 2.5% of data, 1 label, 55.1% cumulative)

- Cluster 5 (145 members, 1 prototypes, 3.5% of data, 1 label, 43.1% cumulative)



- Cluster 17 (30 members, 5 prototypes, 0.7% of data, 1 label, 64.6% cumulative)



Threadgraph

- Detailed view of the monitored behavior
- Every monitored operation of all executed threads
- Sequential order preserved

- Truncated Reports only (static version)
- Zoom necessary (JavaScript)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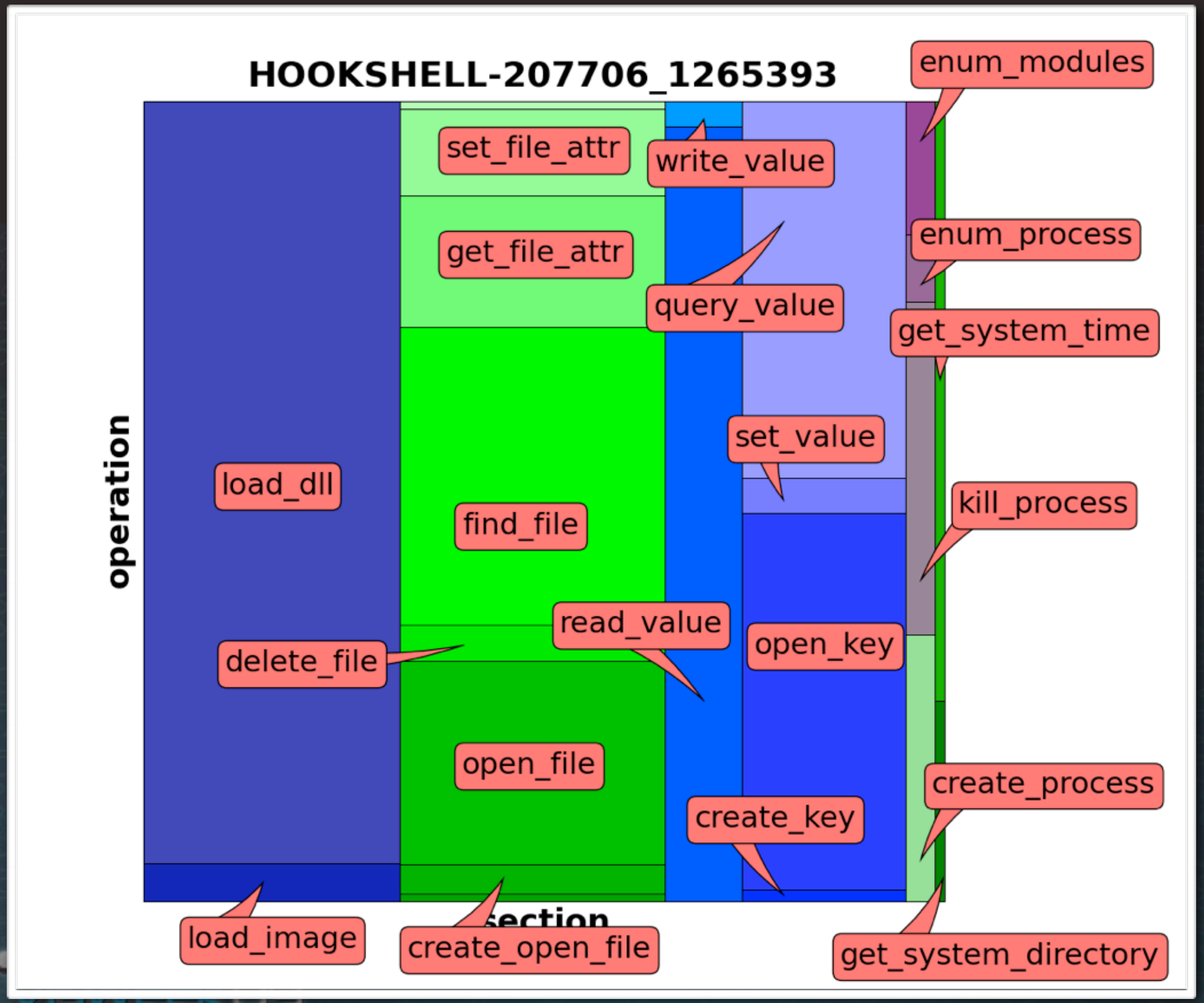
HOOKSHELL-207706_1265393
operation
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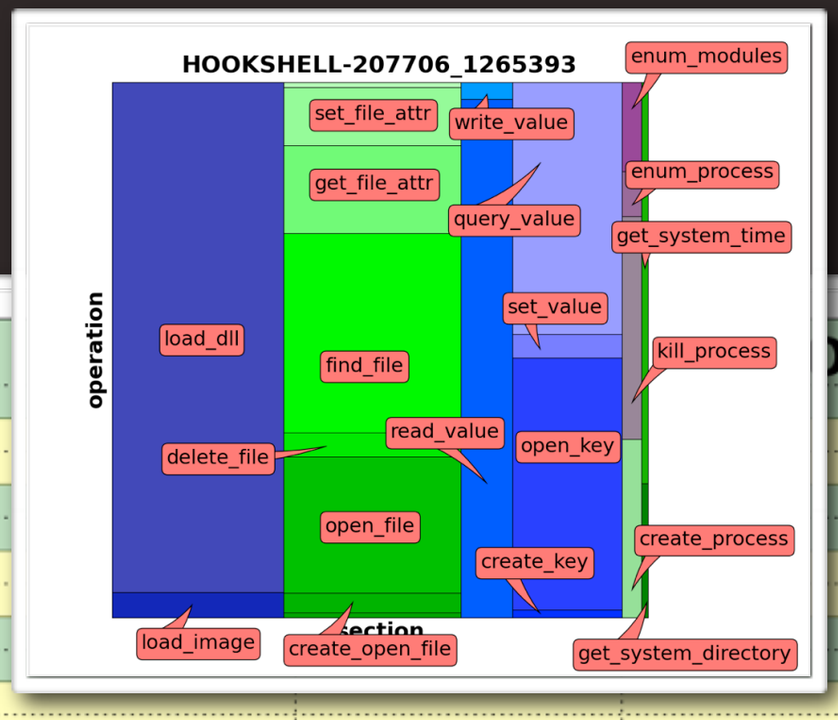
load_dll
set_file_attr
get_file_attr
find_file
delete_file
open_file
load_image
create_open_file
write_value
query_value
read_value
set_value
open_key
create_key
enum_modules
enum_process
get_system_time
kill_process
create_process
get_system_directory



OKSHELL-207706_1265393 (level 1)

api-call sections

windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com

operation on registry

operation on registry

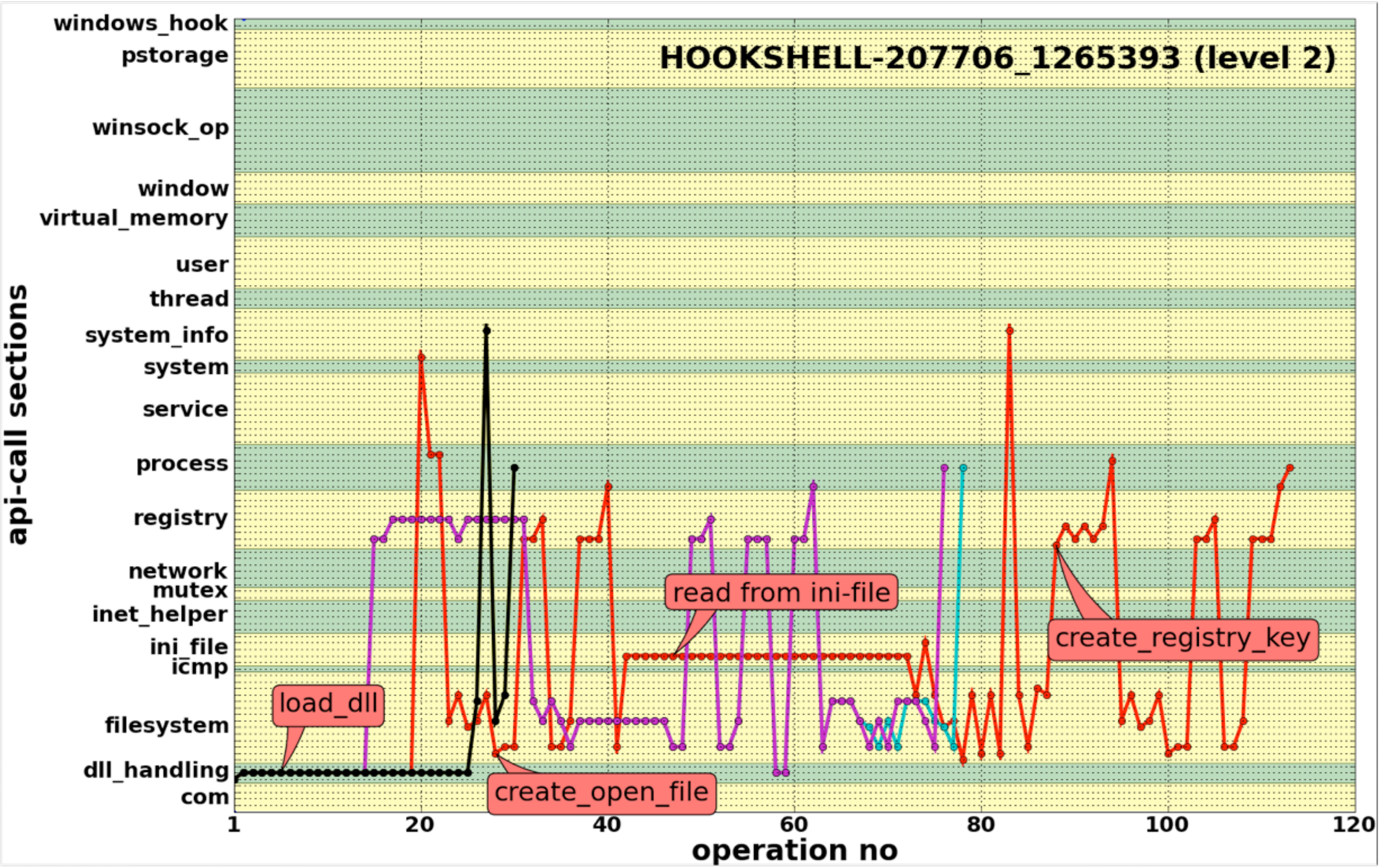
read from ini-file

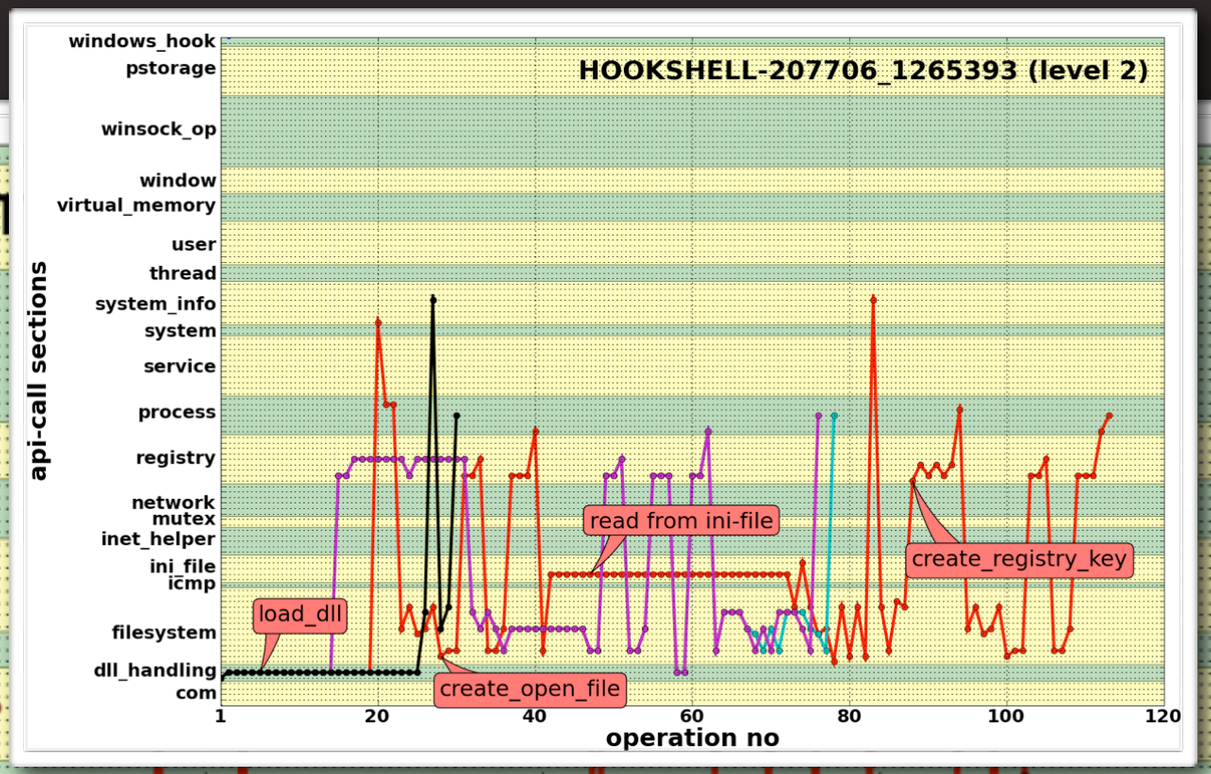
operation on filesystem

load_dll

1 20 40 60 80 100 120

operation no


HOOKSHELL-207706_1265393 (level 2)
api-call sections
windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com
load_dll
read from ini-file
create_registry_key
create_open_file
1
20
40
60
80
100
120
operation no


HOOKSHELL-207706_1265393 (level 2)
windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com
api-call sections
load_dll
create_open_file
read from ini-file
create_registry_key
1
20
40
60
80
100
120
operation no

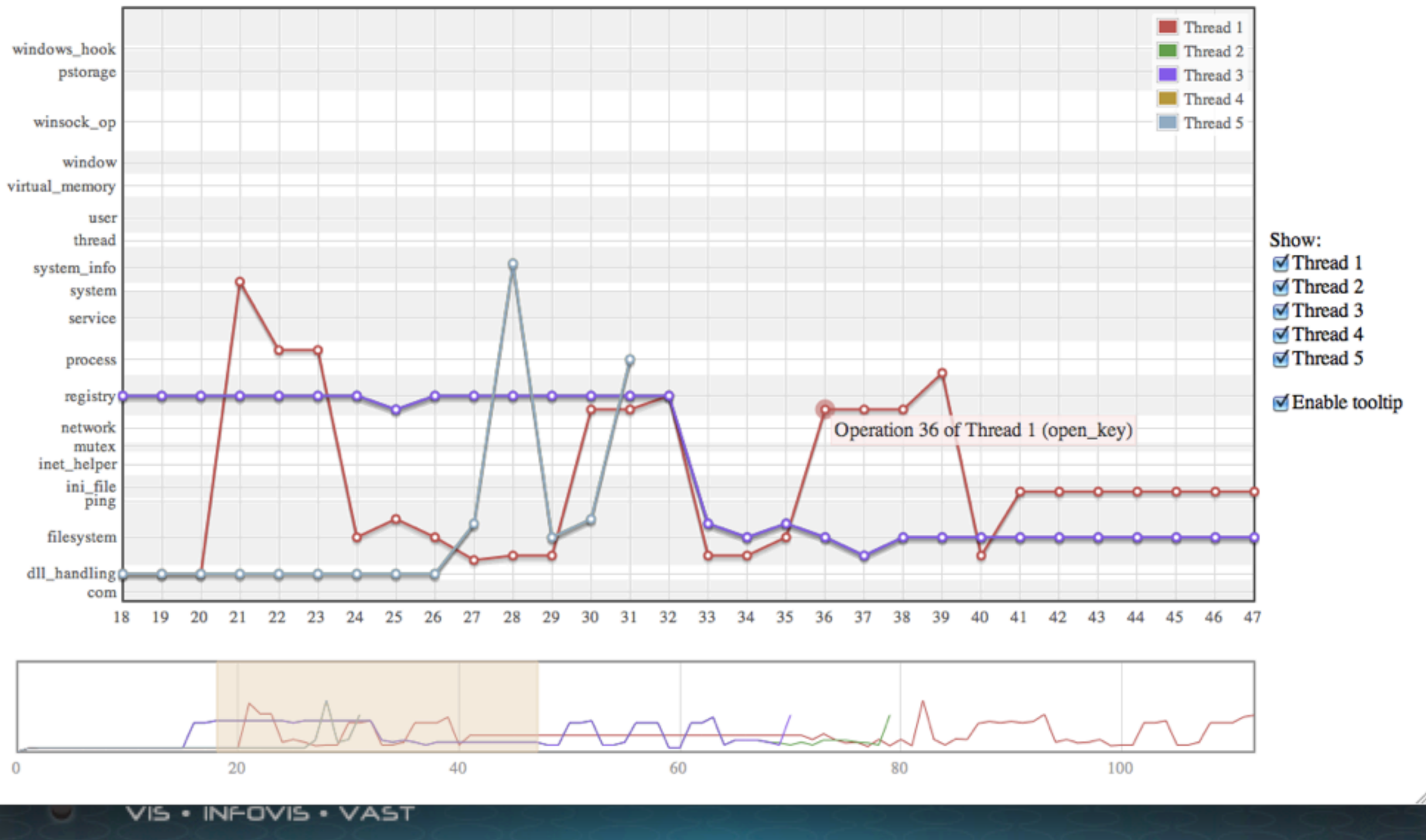
windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com
api-call sections
1
100
200
300
400
500
600
operation no

Threadgraph

Threadgraph

Threadgraph of SampleID: 129956 AnalysesID: 665508 (level2)

< open_key key = HKEY_LOCAL_MACHINE\Software\Microsoft\Windows NT\CurrentVersion\AppCompatFlags\Layers />



Analysis of malicious PDFs

- Monitor Adobe Acrobat Reader within CWSandbox
- Autoupdate disabled

- Short experiment:
  - 200 benign PDFs
  - 17 malicious PDFs

- Two different Treemaps
- Malicious operations are observable at once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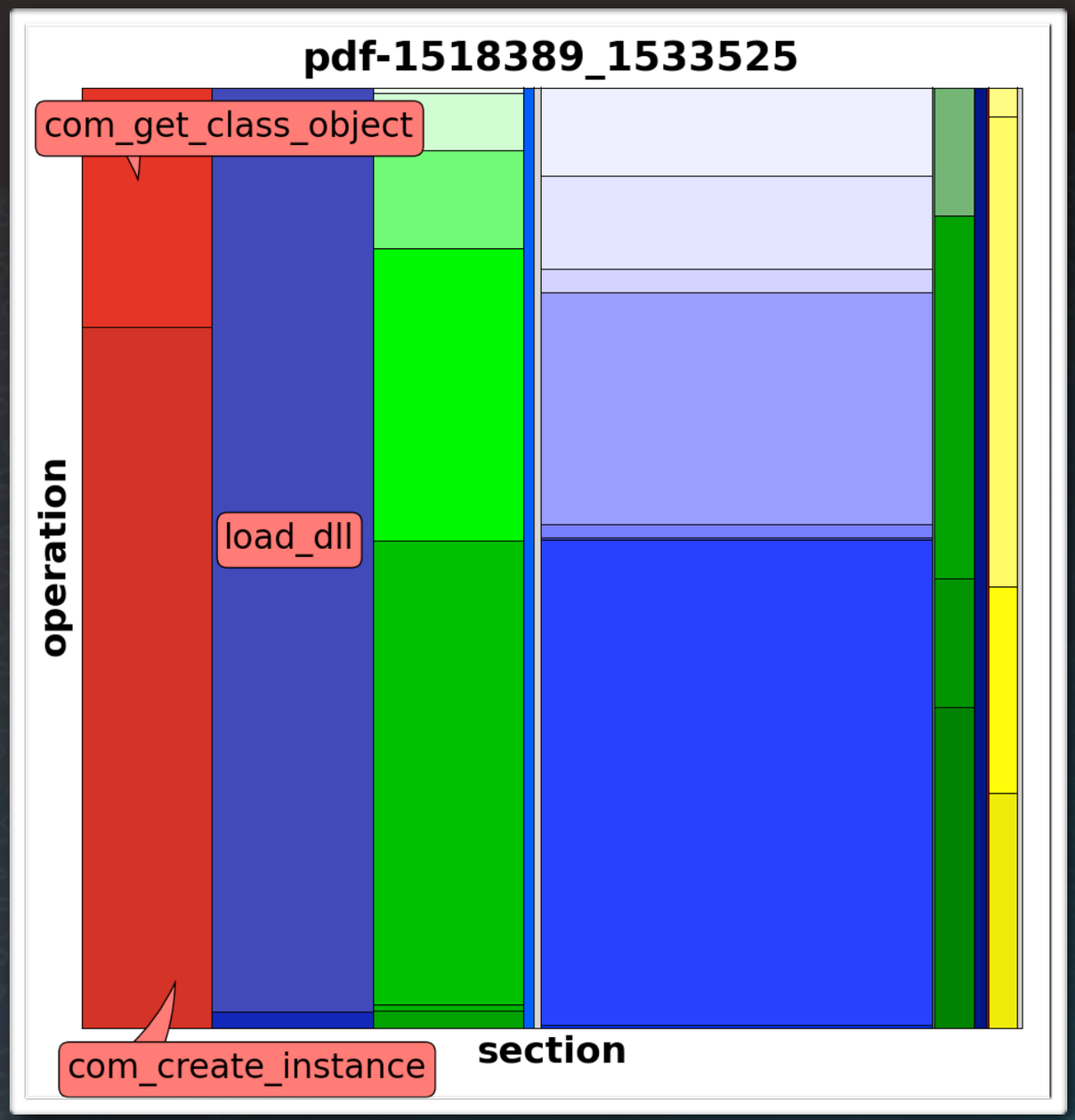
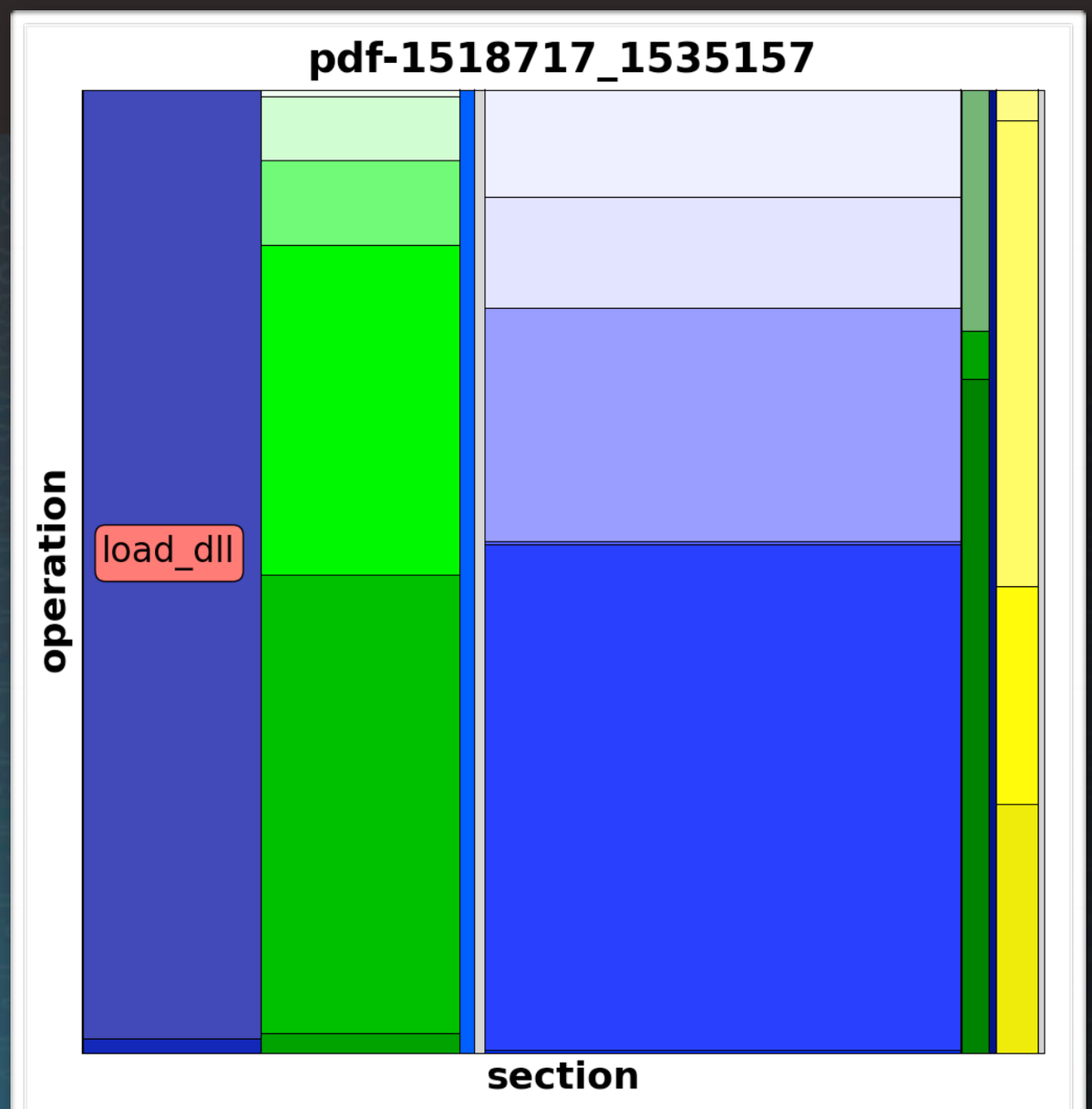
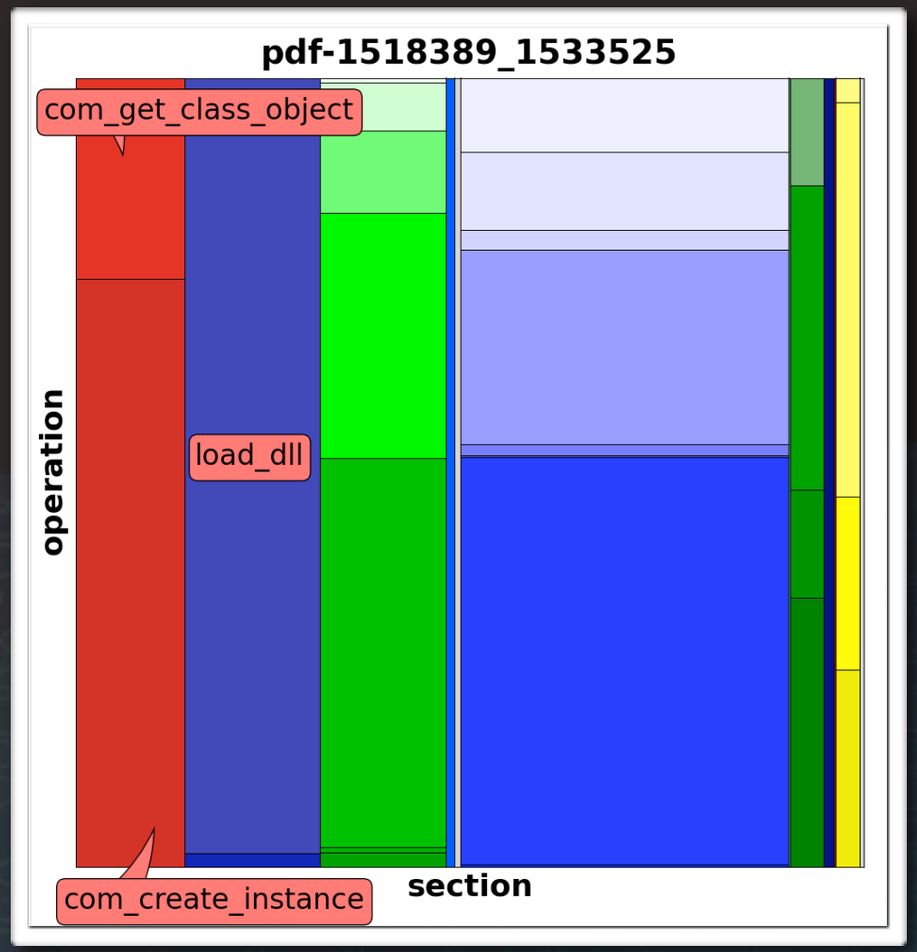
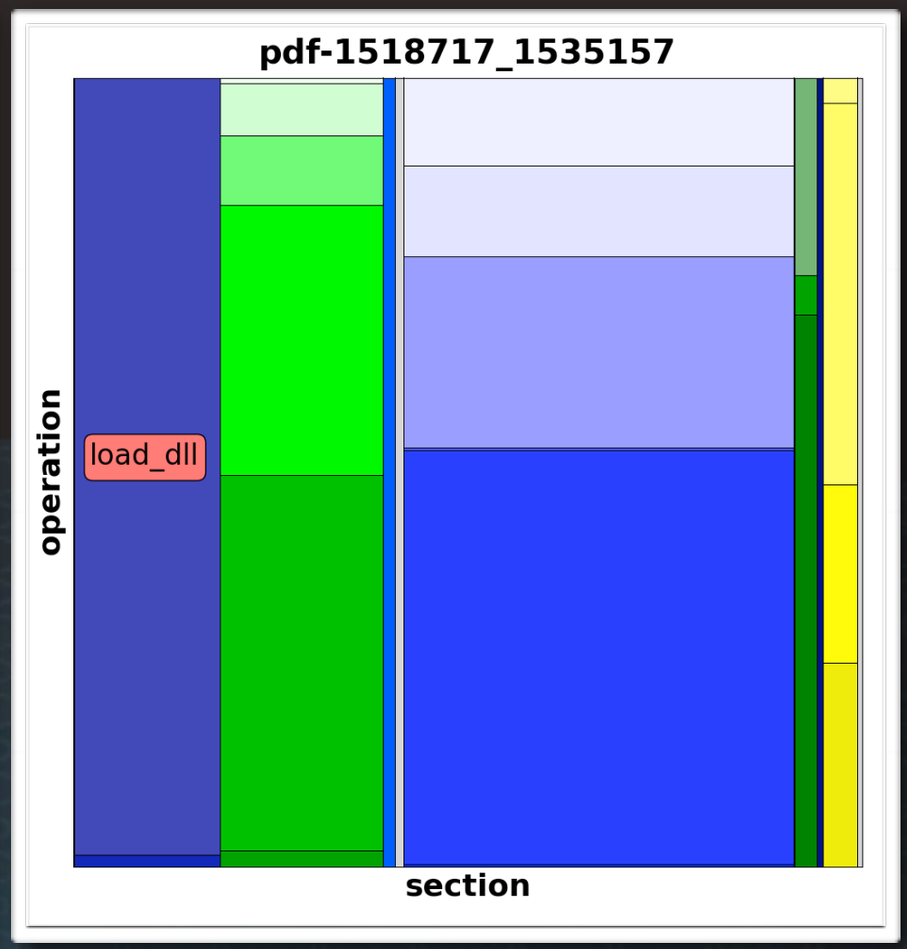
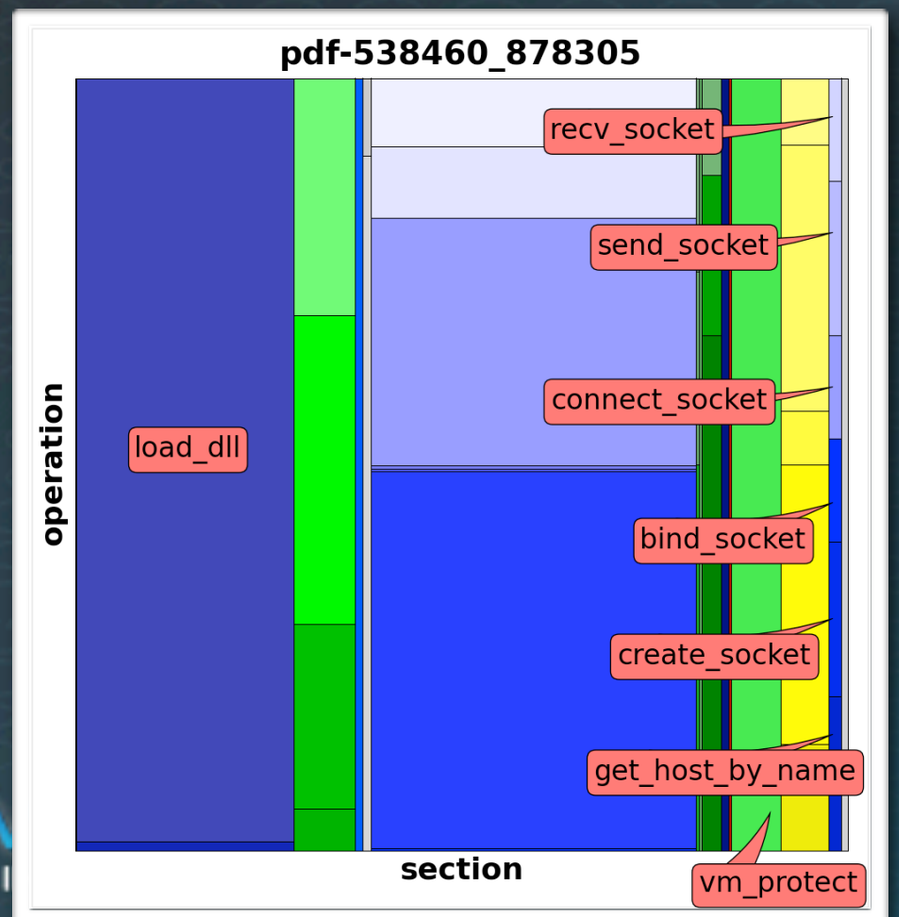
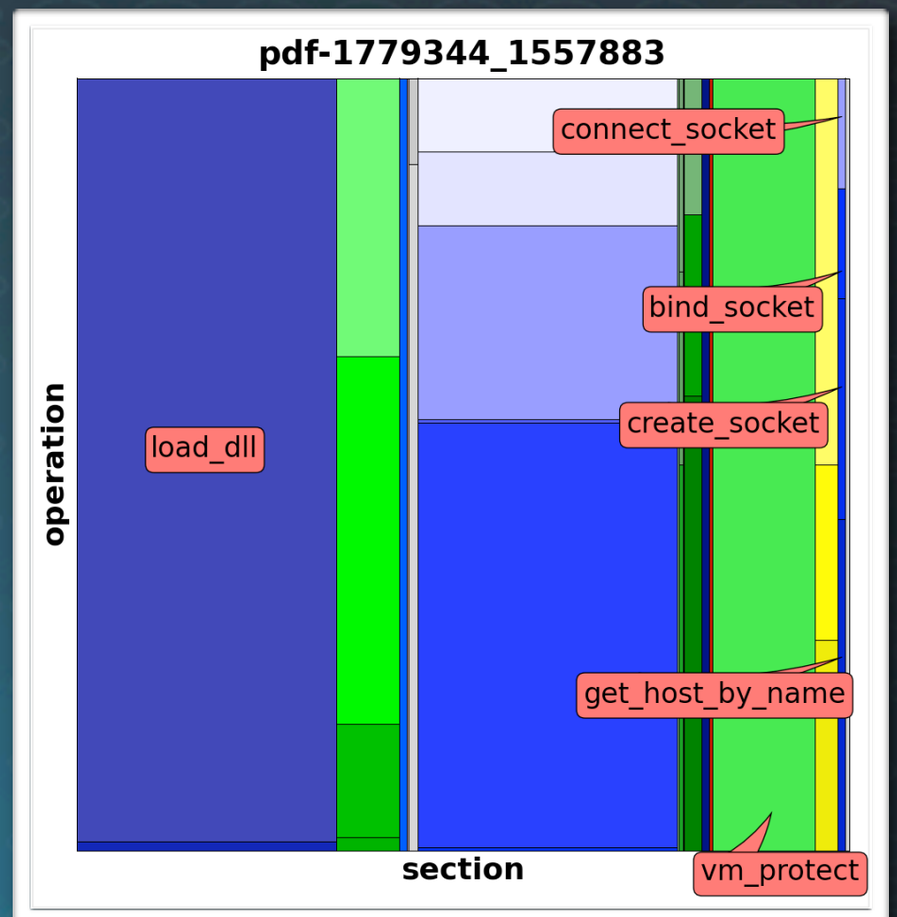


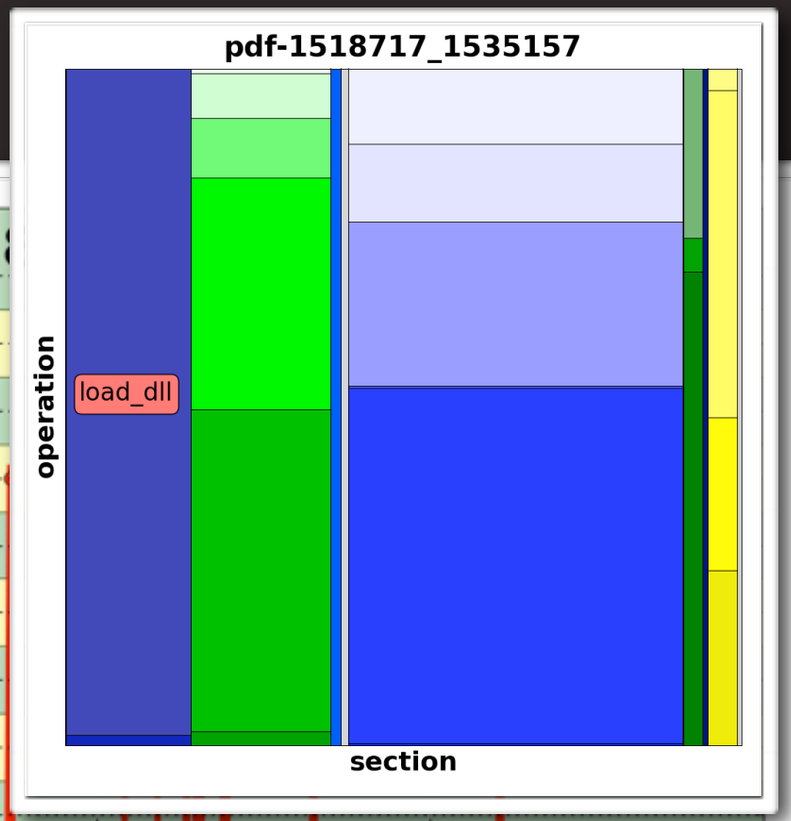



pdf-1518389_1533525
com_get_class_object
load_dll
com_create_instance
operation
section

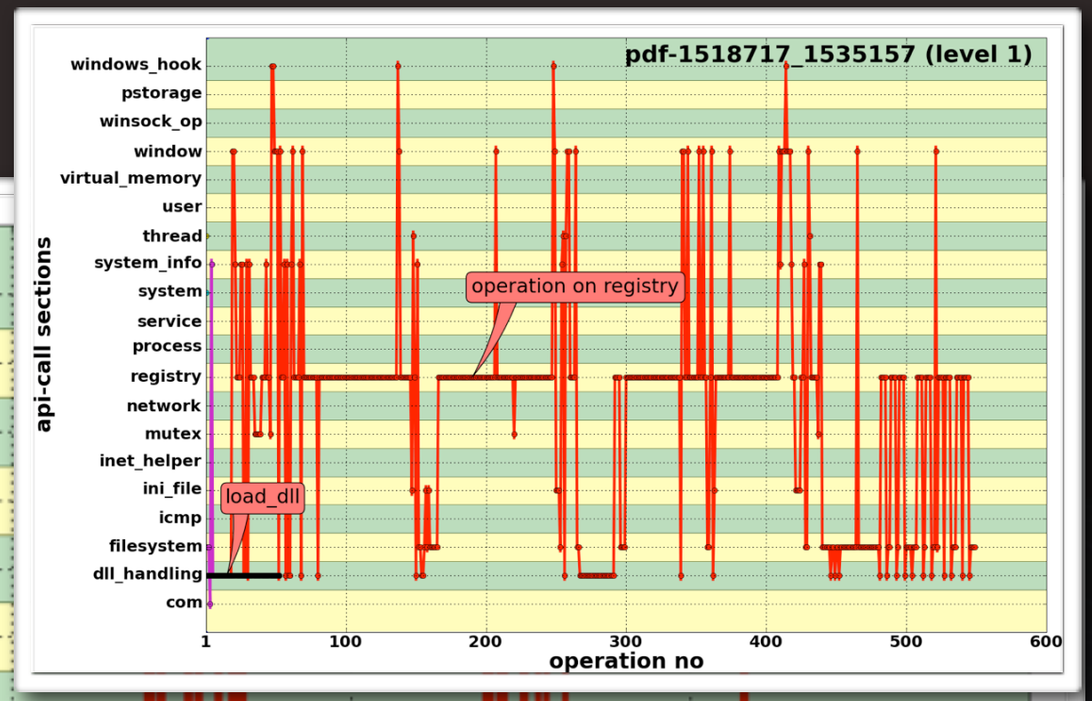

pdf-1518717_1535157
load_dll
operation
section


pdf-538460_878305
recv_socket
send_socket
connect_socket
load_dll
bind_socket
create_socket
get_host_by_name
vm_protect
operation
section


pdf-1779344_1557883
connect_socket
bind_socket
create_socket
load_dll
get_host_by_name
vm_protect
operation
section


pdf-1518717_1535157
operation
load_dll
section

pdf-151
api-call sections
windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com
operation on registry
load_dll
1
100
200
300
400
500
600
operation no


pdf-1518717_1535157 (level 1)
windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com
api-call sections
operation on registry
load_dll
1
100
200
300
400
500
600
operation no

windows_hook
pstorage
winsock_op
window
virtual_memory
user
thread
system_info
system
service
process
registry
network
mutex
inet_helper
ini_file
icmp
filesystem
dll_handling
com
api-call sections
network activity
allocate virtual memory
operation on registry
load_dll
additional load_dll
1
100
200
300
400
500
600
operation no

Conclusion

- First attempt on visualization - need Feedback
- Plots are accessible on *CWSandbox.org*
  - Static + JavaScript version

- Study on image clustering and classification
- Development of further visualization types

http://pi1.informatik.uni-mannheim.de
http://cwsandbox.org

Questions?

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