"Botnet Battlefield": A Structured Study of Behavioral Interference Between Different Malware Families

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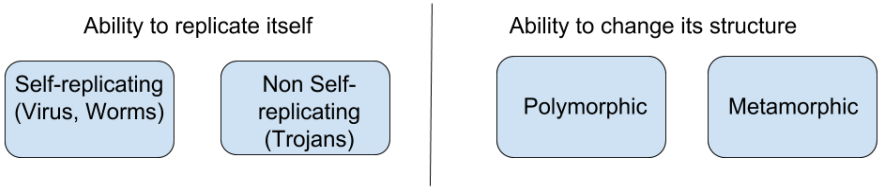
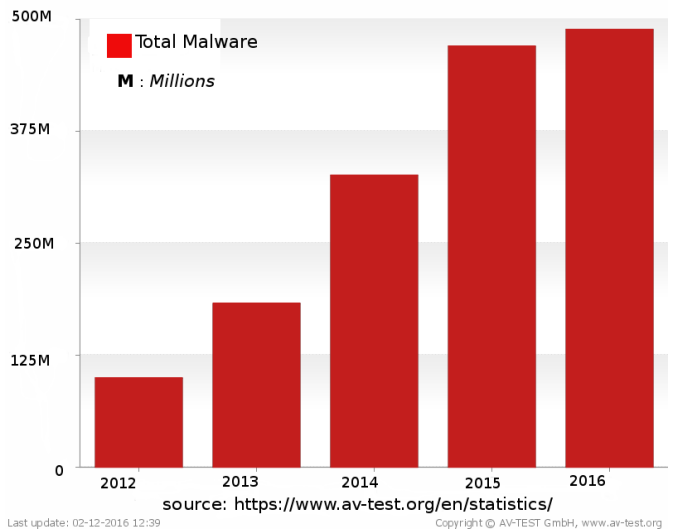
Malware

Malicious software that corrupts or steals data, or disrupt operations with illegitimate access to computer or computer networks





- Hard to detect with signature based
- Static and dynamic analysis (Anubis)

- Monetary profit
- In 2006, 2.8 billion dollars in US and 9.3 billion euros in Europe

Problem Statement

Interference Between Malware Families

- In 2004, NetSky vs Bagle and MyDoom
- In 2010, SpyEye vs Zbot
- In 2015, highly evasive Shifu malware

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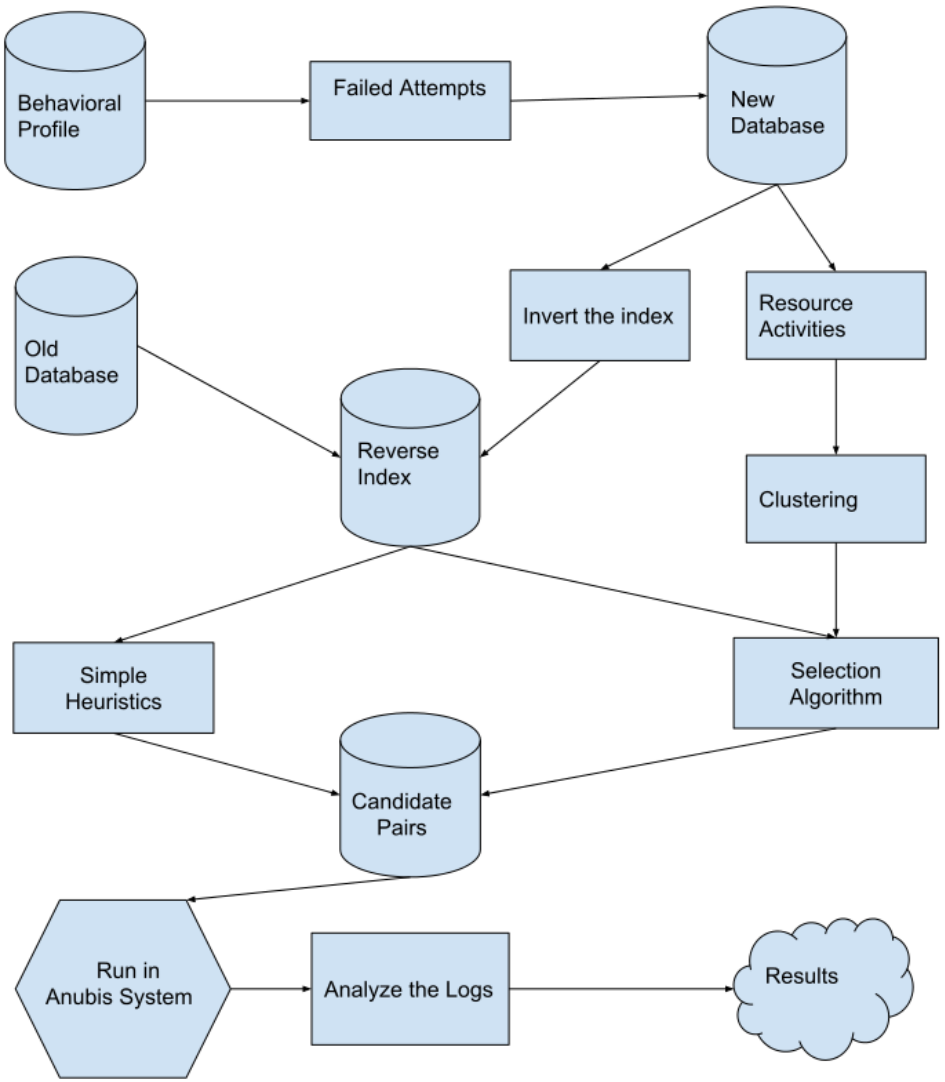
Identify the existence of behavioral interference between the malware families

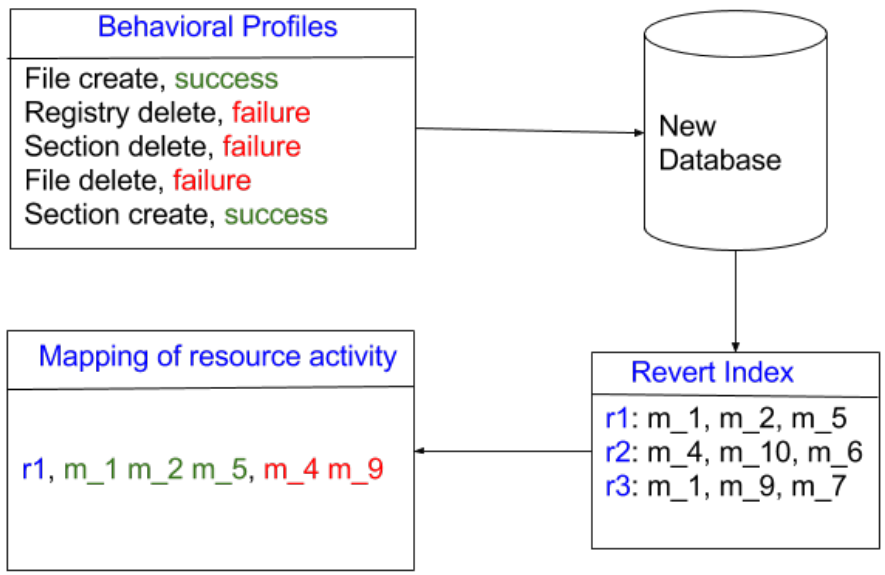
- Dynamic aspect/environment-sensitive malware
- The inter-family relations and their associated underground economy

The Big Picture



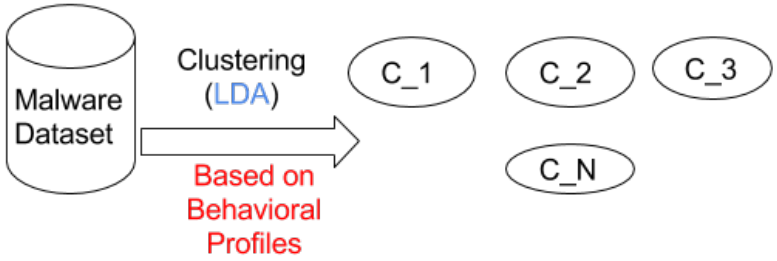
Initial Phase

- Datasets: Millions of malware samples from Anubis
- Behavioral Profile: execution trace
- Resource types: File, Registry, Sync, Section, Process
- Resource activities: Create, Delete, Access
- Modeled the problem into Map-reduce
- N-combination problem



Clustering

- Document Clustering
- **tf-idf**
  $O(\#words \times \#documents)$
- **LDA**
  $O(\#words \times \#topics)$
- Filter extremes:
  no_below 10 and
  no_above 1 Millions
- Large intra-distance and small inter-distance



RESOURCE_CODE = {"file" : "1", "registry" : "2" ...}
OPERATION_CODE = {"access" : "1", " delete" : "2", "modify" : "3"}

A file delete action of filename *"foo.txt"* with file_name_id '789' in our database would be represented as: '1_2_789'

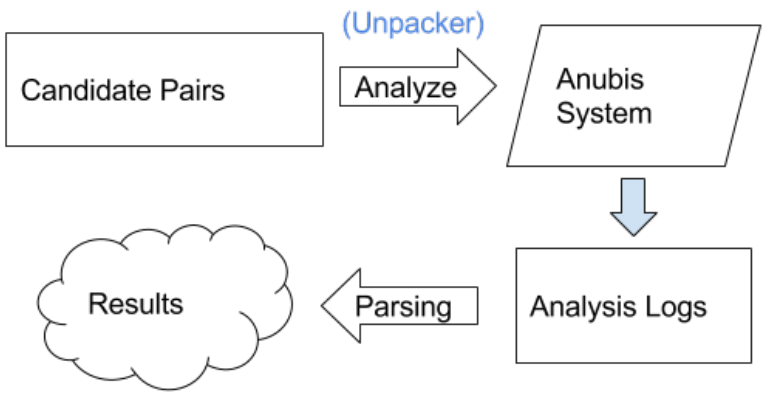
Candidate Selection

1: R = Set of all interesting resource
2: A_r = Set of malware that creates a particular resource 'r'
3: B_r = Set of malware that delete/access (failed) particular resource 'r'
4: N = Maximum number of families to consider
5: E = Set of all probable candidate
6: **function** C (j)
7: c_j = cluster id that malware j belongs to
8: *Return* c_j
9: **end function**
10: **for all** $r \in R$ **do**
11: **if** $|C(x_r) : x \in A_r| > N \vee |C(y_r) : y \in B_r| > N$ **then**
12: **continue**
13: **end if**
14: **for all** $(x_r, y_r) \in A_r \times B_r$ **do**
15: **if** $C(x_r) \neq C(y_r)$ **then**
16: $E \leftarrow (x_r, y_r)$
17: **end if**
18: **end for**
19: **end for**

Candidate Pair Analysis

- Candidate pairs analyzed in Anubis
- Extraneous data appended to binary
- Packer packs candidate pair to Unpacker
- Unpacker self reads and drops
- Logs parsed

Unpacker



Contribution

Our research will provide the following contributions:

- Systematic study of interferences between malware families
- A novel approach to malware clustering based on malware behavior profiles
- An automated system that detects interfering malware samples on a large scale

Results

List of Candidate Pairs

Resource types	#candidate pairs
File	213,171
Registry	39,899
Sync	7,781
Section	2,786
Process	54
Total	263,691

- Value of N (maximum family cutoff) in algorithm chosen to be 10
- '*File*' with the highest number of candidate pair and '*Process*' with the lowest

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Result of Candidate Run

Resource types	# tested pairs	# true positive	prediction accuracy
File	5,000	1032	20.64%
Registry	5,000	731	14.62%
Sync	1,000	119	11.9%
Section	1,000	93	9.3%
Process	54	6	11.11%

- Average prediction accuracy: 14.25%

Threats to Validity

- Different values of N would give different candidate pairs and different results
- Didn't deal with random resource name
- Total execution time 10 minutes
- Sequence of execution
- True semantics of malware

Conclusion and Future Work

Conclusion

- Behavioral interference between malware families exists
- Malware checks for the presence of resource created by other malware and deletes it
- Our system could detect such interfering malware with average accuracy rate of 14.25%
- In our dataset, Files and Registries were the most interfered resource and Process was the least

Future Work

- Make the experiment more efficient
- In depth analysis (static) of positive pair

Questions

QUESTIONS?

Reverse Index

Listing 1 : Sort and join the reverse index

```
LANG=en_EN sort -t, -k 1,1 $file_name
LANG=en_EN join -t , -a1 -a2 $fn1 $fn2
```

Listing 2 : Sample of reverse index created for File activity

```
C:\mbr.exe,189524063,184501719,87504631,86763863
C:/DOCUME~1/ADMINI~1/LOCALS~1/Temp/telnet.exe
    ,178046895,174206059,183601891,89650247
C:/DOCUME~1/ADMINI~1/LOCALS~1/Temp/1.jpg
    ,161552035,116241803
```

Inter and Intra Distance

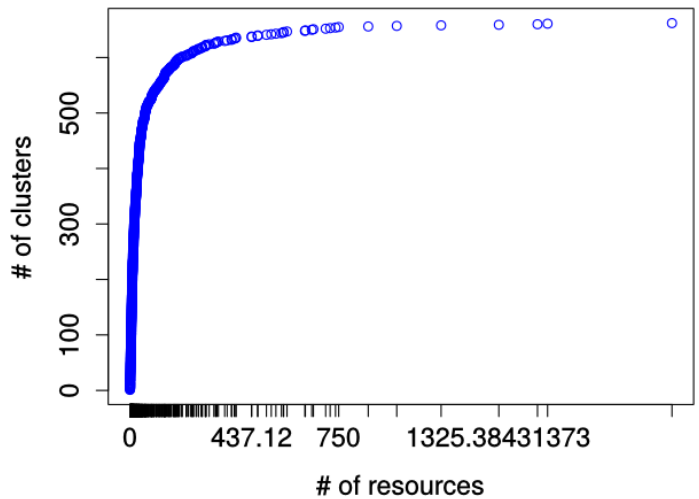

Figure 1 : Graph showing cdf distribution of common resource between same family topic

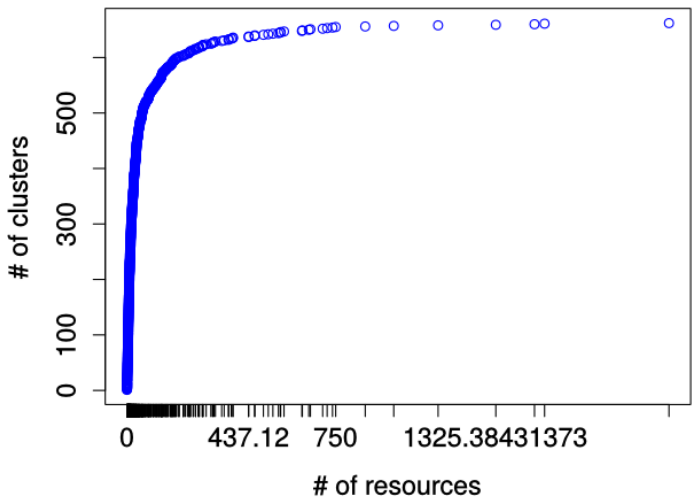

Figure 2 : Graph showing cdf distribution of common resource between same family topic

Max Flow

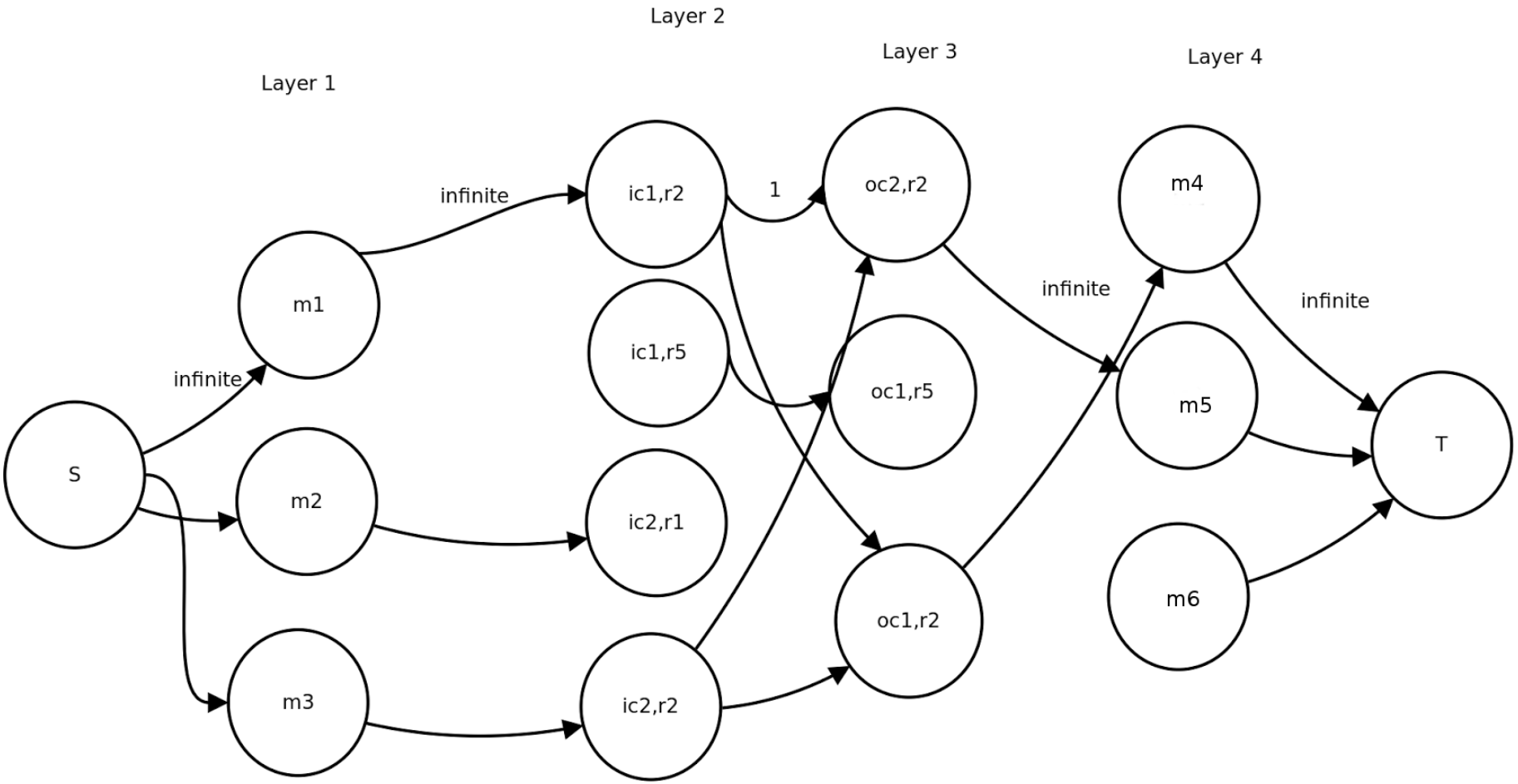

Figure 3 : Graph representing the max flow implementation

Heuristics

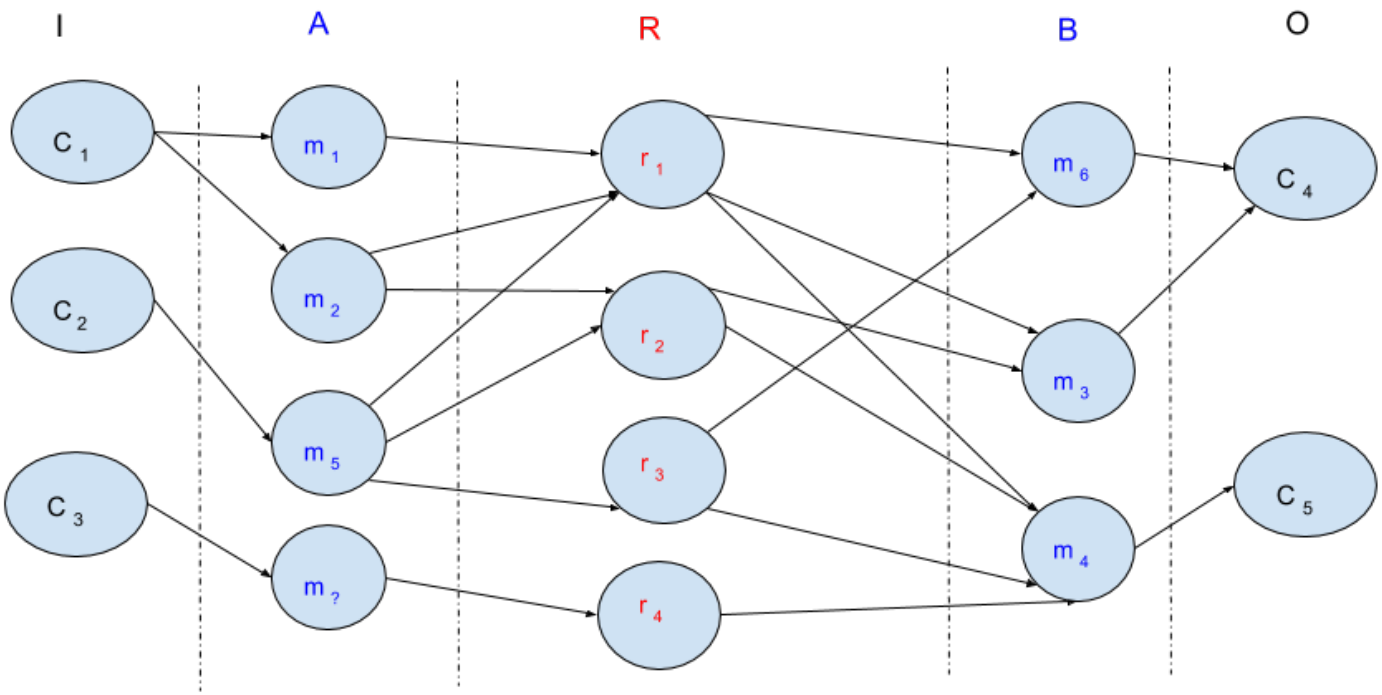

Figure 4 : Heuristics approach to optimal malware pair selection

Experiment Setup

- 7 Anubis instance
- Each instance emulates entire running PC with Windows XP Service Pack 3 as OS
- Uses Qemu and monitors process by invoking callback routine for every basic block executed in virtual processor
- Unpacker and Packer used to run the candidate pair
- 10 minutes as total run time of each candidate pair experiment
- 4 minute for each malware, and 2 minute to boot system

Some Examples

- Artemis! vs Cosmu on resource `C:\Old.exe`
- VB.CB vs Startpage.AI on resource `C:\WINDOWS\window.exe`
- KeyLogger vs OnlineGames on resource `C:\windows\system32\svrchost.exe`