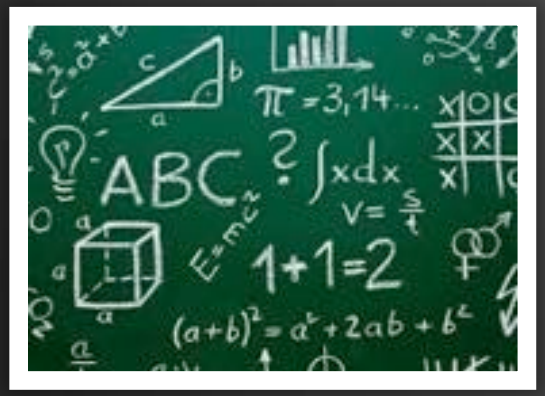
I am packer and so can you

Mike Sconzo

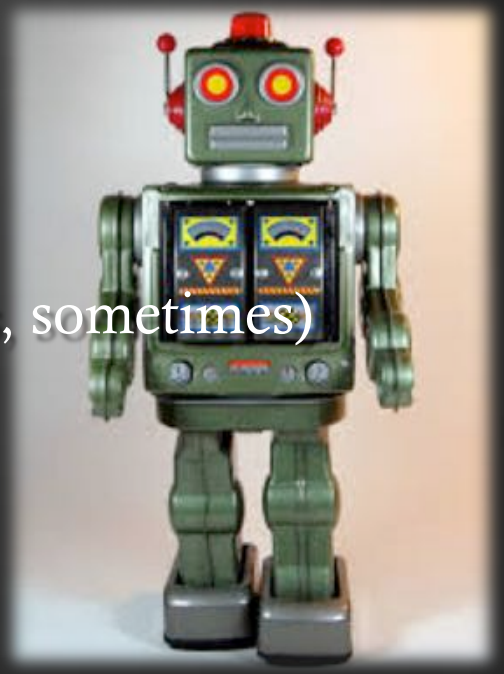


Agenda*

*Powered by business synergy

It's all about me!

- Threat Research at Bit9 + Carbon Black
- Enjoy static analysis, machine learning, network forensics, and eating BBQ and pie (yes, I live in TX)
- SecRepo.com
- @sooshie
- Member of MLSec Project (I contribute things, sometimes)



What's the problem?

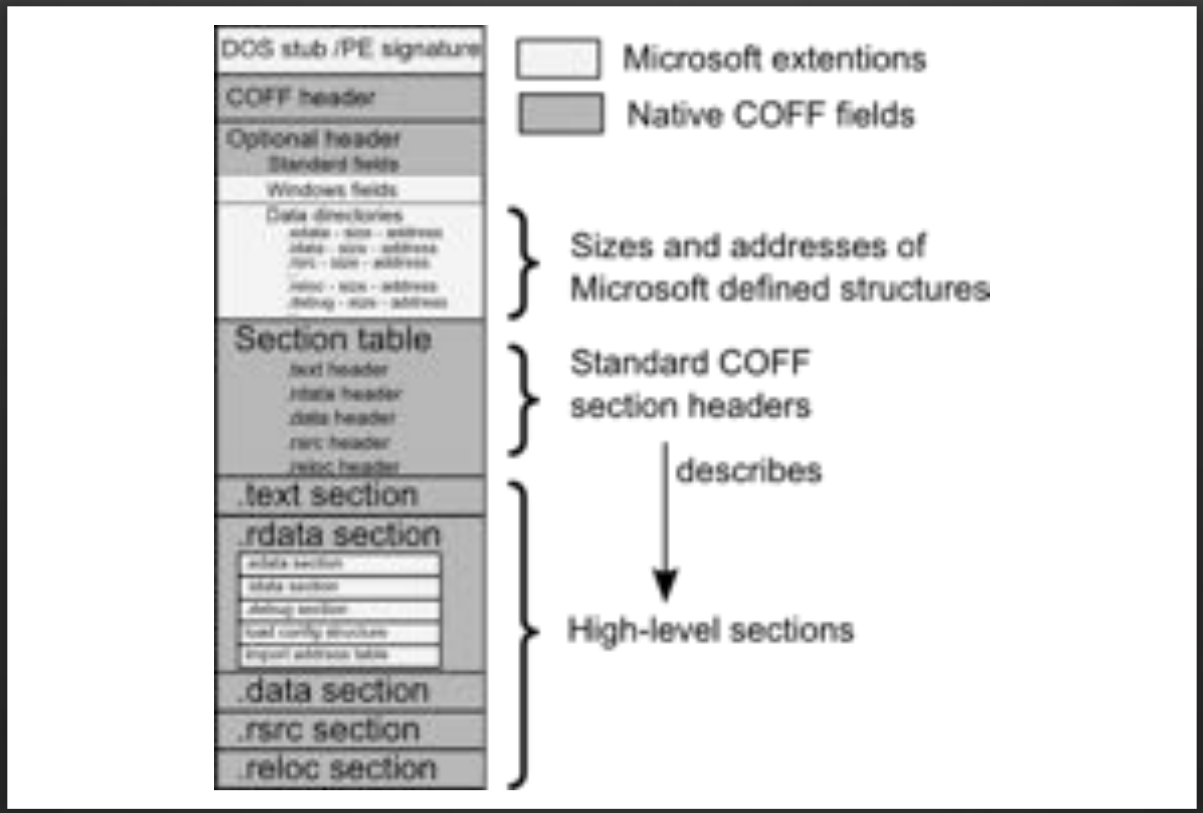
Detecting packers, compilers and various artifacts from the development cycle can be really useful when looking at malware or files in general. However, the de facto standard (PEiD) was created over 10 years ago, and there are very few recent signature updates. Is it time for something new and different?

Moar?

- Zero (or near zero) trust in prior solutions
  - Approach this from a clustering perspective
- Easy to generate signatures
  - Non-experts want to play too
- Cross platform
  - <Insert Mac Fanboi Statement>
- Simple to understand and extend
- Fuzzy Matching (similarity)
  - Understand signature overlap
  - Percent of each signature matched

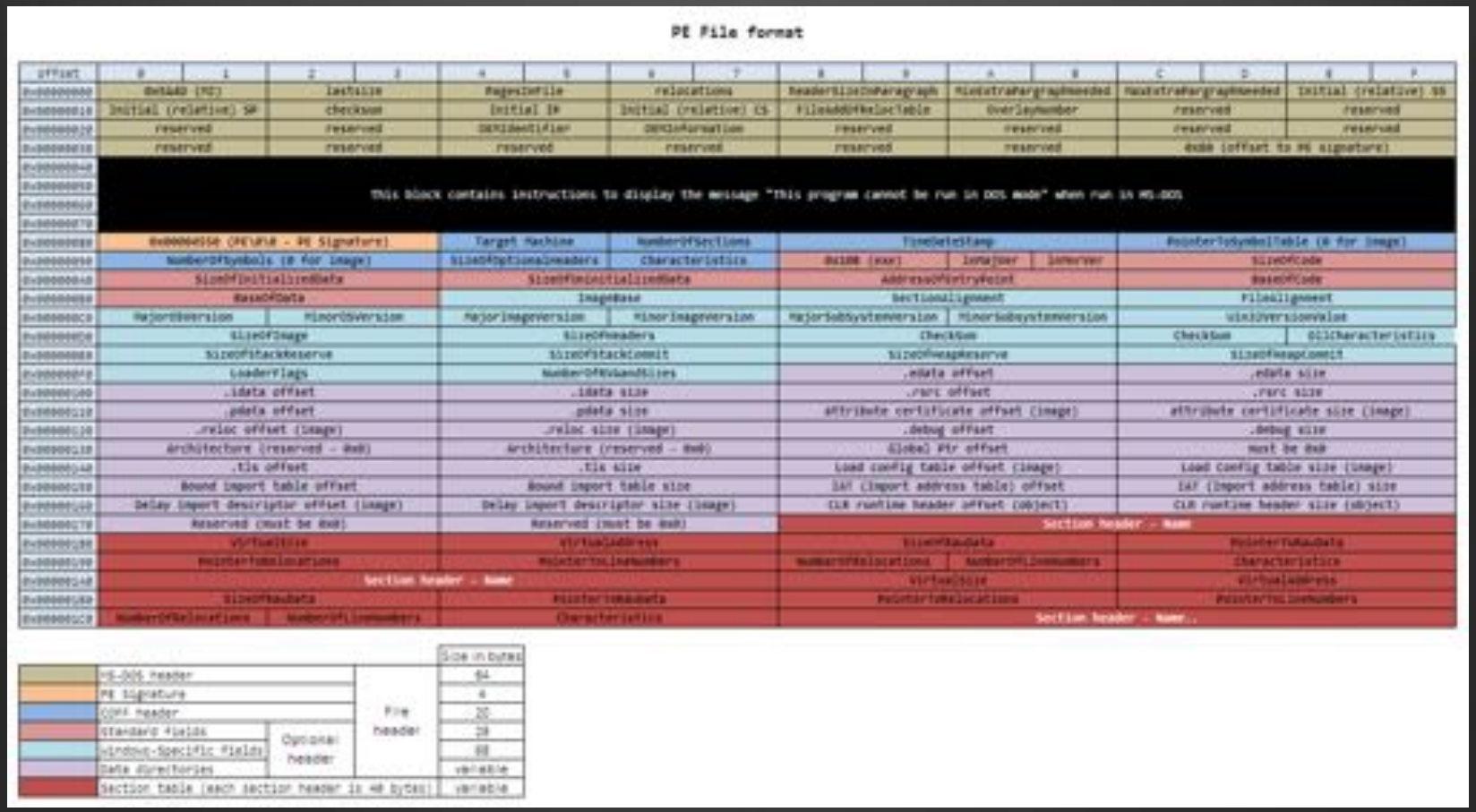
Refresher

Terms, File Structure, 101



PE Simplified

PE format

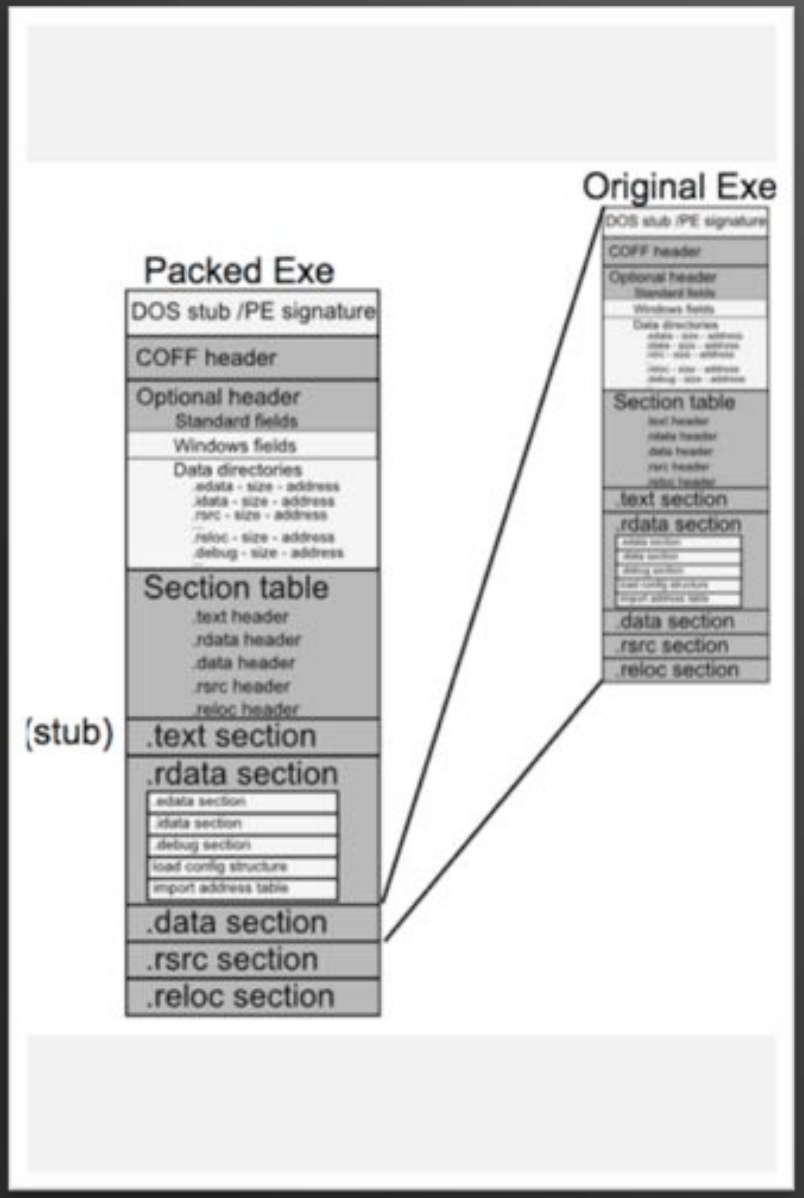

PE File format
This block contains instructions to display the message "This program cannot be run in DOS mode" when run in MS-DOS
Target Machine
NumberOfSections
TimeDateStamp
PointerToSymbolTable (0 for image)
SizeOfCode
SizeOfInitializedData
SizeOfUninitializedData
AddressOfEntryPoint
BaseOfCode
BaseOfData
ImageBase
SectionAlignment
FileAlignment
MajorOperatingSystemVersion
MinorOperatingSystemVersion
Win32VersionValue
SizeOfImage
SizeOfHeaders
CheckSum
DllCharacteristics
SizeOfStackReserve
SizeOfStackCommit
SizeOfHeapReserve
SizeOfHeapCommit
LoaderFlags
NumberOfRvaAndSizes
.edata offset
.edata size
.idata offset
.idata size
.rsrc offset
.rsrc size
.pdata offset
.pdata size
Attribute certificate offset (image)
Attribute certificate size (image)
.reloc offset (image)
.reloc size (image)
.debug offset
.debug size
Architecture (reserved - 0x0)
Architecture (reserved - 0x0)
Global Ptr offset
must be 0x0
.tls offset
.tls size
Load Config table offset (image)
Load Config table size (image)
Bound Import table offset
Bound Import table size
IAT (Import address table) offset
IAT (Import address table) size
Delay Import descriptor offset (image)
Delay Import descriptor size (image)
CLR runtime header offset (object)
CLR runtime header size (object)
Reserved (must be 0x0)
Reserved (must be 0x0)
Section header - Name
VirtualSize
VirtualAddress
SizeOfRawData
PointerToRawData
PointerToRelocations
PointerToLinenumbers
NumberOfRelocations
NumberOfLinenumbers
Characteristics
Section header - Name
VirtualSize
VirtualAddress
SizeOfRawData
PointerToRawData
PointerToRelocations
PointerToLinenumbers
NumberOfRelocations
NumberOfLinenumbers
Characteristics
Section header - Name...
MS-DOS header
PE signature
COFF header
Standard fields
Windows-Specific Fields
Data directories
Section table (each section header is 40 bytes)
File header
Optional header
Size in bytes
64
4
20
28
88
variable
variable

Header features we care about (today)

- LinkerMajorVersion
- LinkerMinorVersion
- NumberOfSections

Tool chain

- Set of tools used to develop software
  - IDE
  - Compiler
  - Linker
  - Etc…
- This talk will touch on compiler/build environment detection
  - Information provided by the linker, etc… will also be used



Packer

- "Program within a program"
- Generally used to compress or obfuscate PE information
  - Evade AV
  - Make static analysis harder

Packers, their parts.

- Packer
  - Compresses/obfuscates the original executable and creates a new executable complete with decompression/deobfuscation code
- Unpacker
  - A.k.a Stub
  - Run when the new executable is executed and is responsible for producing the original executable

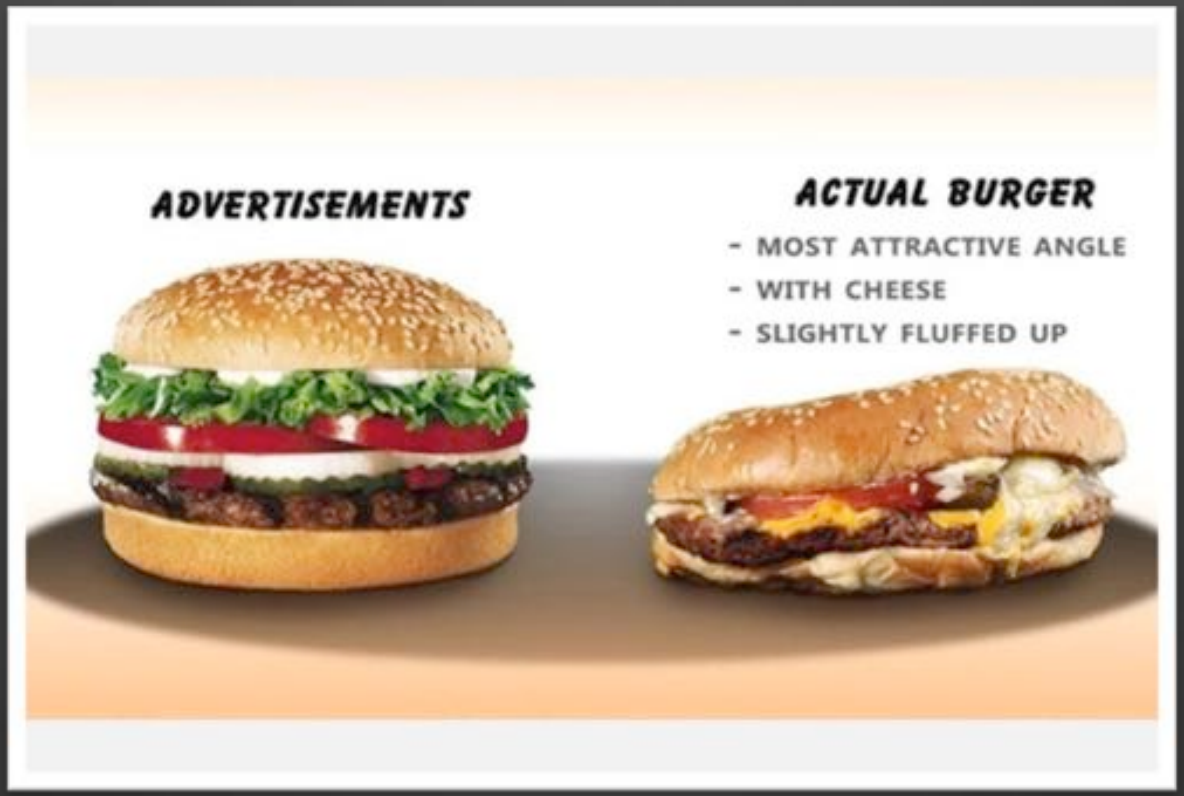
Unpackers, how do they work?

- Take control of AddressOfEntryPoint
- Run the unpacking routine
  - Find the packed data
  - Restore the data contents
  - Perform relocation fixes
  - Resolve imports since the original executable isn't being loaded by the Windows loader
  - Jump into the original program

http://www.stonedcoder.org/~kd/lib/61-267-1-PB.pdf

The popular kids

- PEiD
  - “PEiD detects most common packers, cryptors, and compilers for PE files.”
- YARA
  - “YARA is a tool aimed at (but not limited to) helping malware researchers to identify and classify malware samples”
- RDG Packer Detector
  - “RDG Packer Detector is a detector of packers, cryptors, Compilers, Packers Scrambler, Joiners, Installers”



Back to Reality (Data)

Now on to the more exciting stuff, even though it's ugly at times.

Data

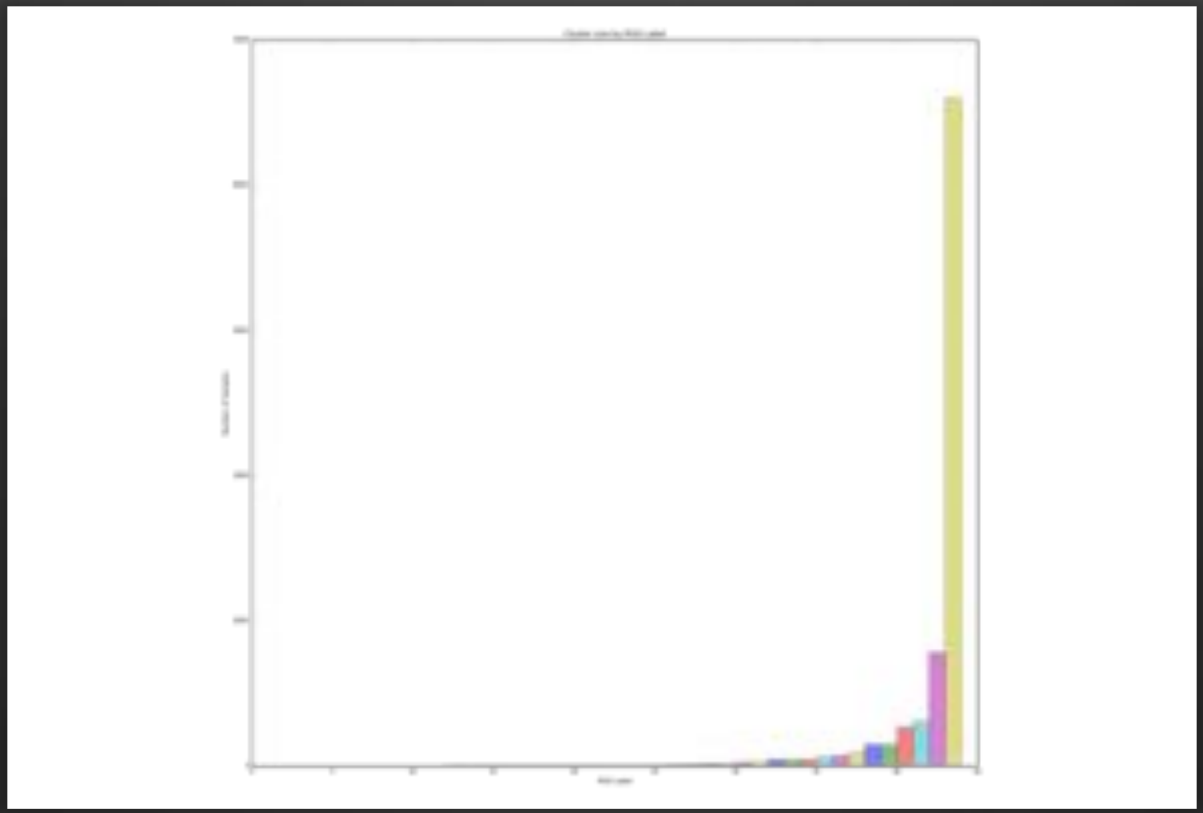
- 3977 PEiD signatures used for testing
- File sets
  - Sony – 9 Samples
  - Chthonic – 11 Samples
  - Backoff – 22 Samples
  - Volatile Ceader – 36 Samples
  - Carbanak – 74 Samples
  - APT1 – 281 Samples
  - ZeuS – 6774 Samples
  - Random – 411340 Samples

Data analysis

- Basic exploration of the ZeuS dataset
- Some of the possible attributes/features we can look at
- Clustering

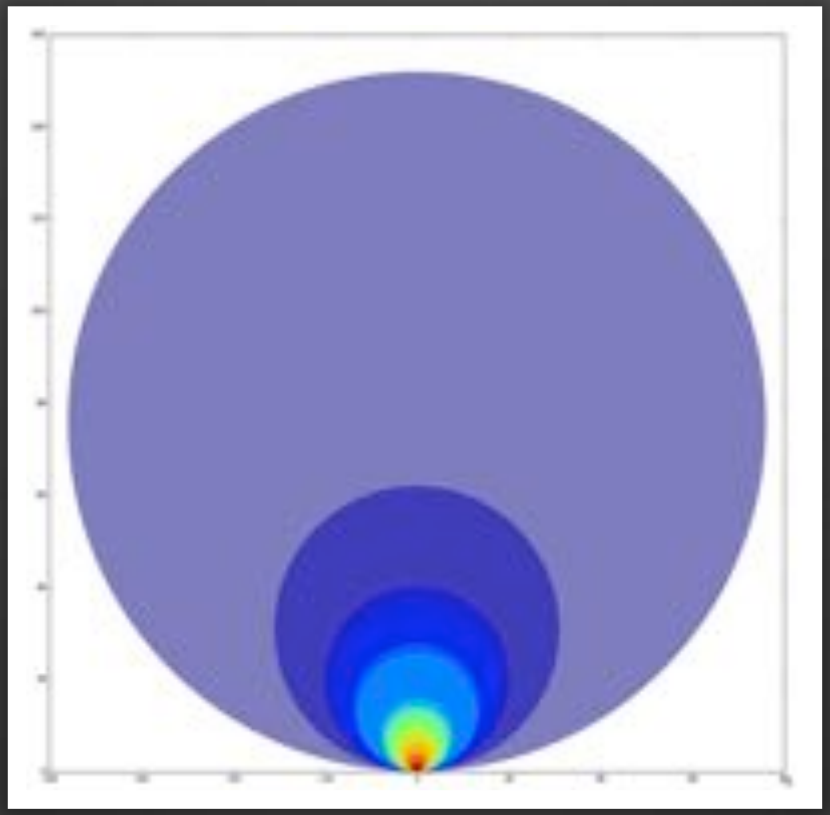
ZeuS + PEiD

PEiD Label	Count
None	4600
UPX v0.89.6 - v1.02 / v1.05 -v1.24 -> Markus & Laszlo [overlay]	781
UPX 2.90 [LZMA] -> Markus Oberhumer, Laszlo Molnar & John Reiser	318
PureBasic 4.x -> Neil Hodgson	267
Microsoft Visual Basic v5.0/v6.0	166
Armadillo v1.71	164
Microsoft Visual C++ 8	148
UPX 2.93 - 3.00 [LZMA] -> Markus Oberhumer, Laszlo Molnar & John Reiser	61
MingWin32 v?.? (h)	45
Microsoft Visual C++ 7.0 MFC	44



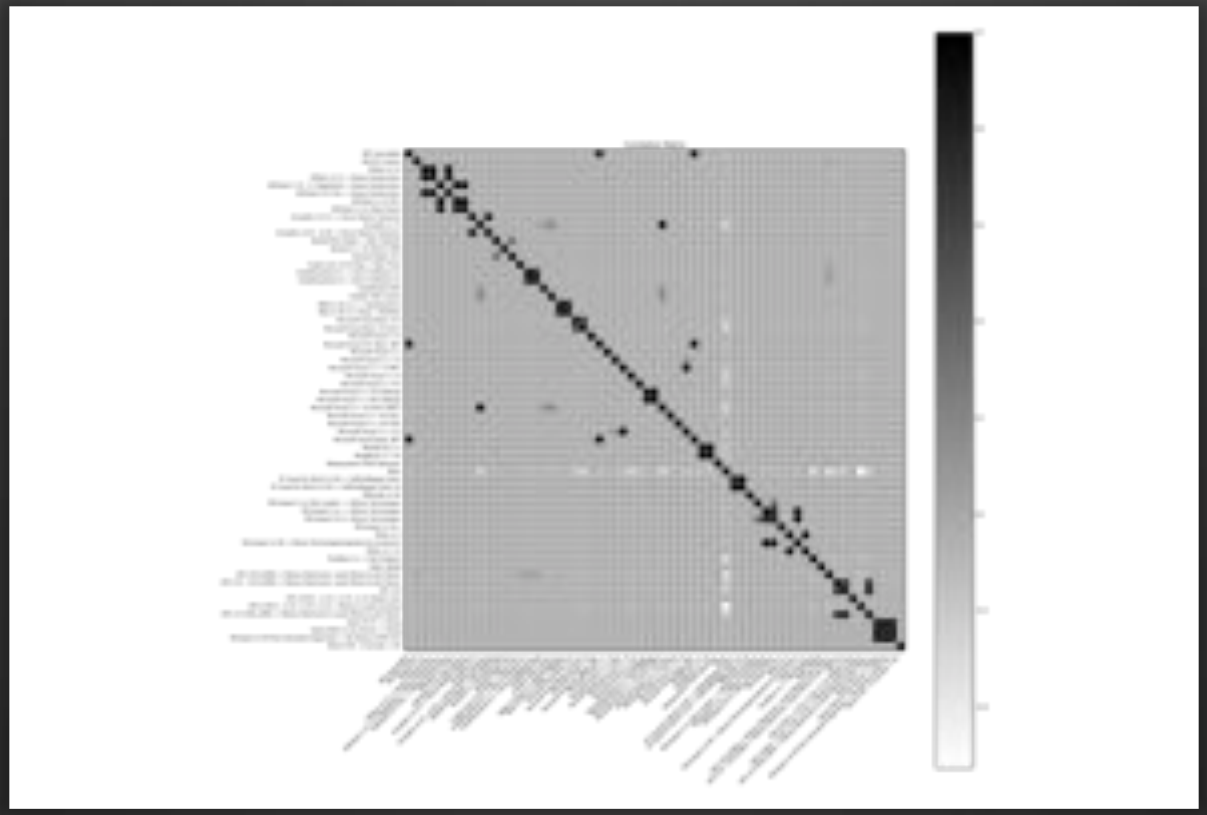
ZeuS + PEiD

Samples per PEiD signature



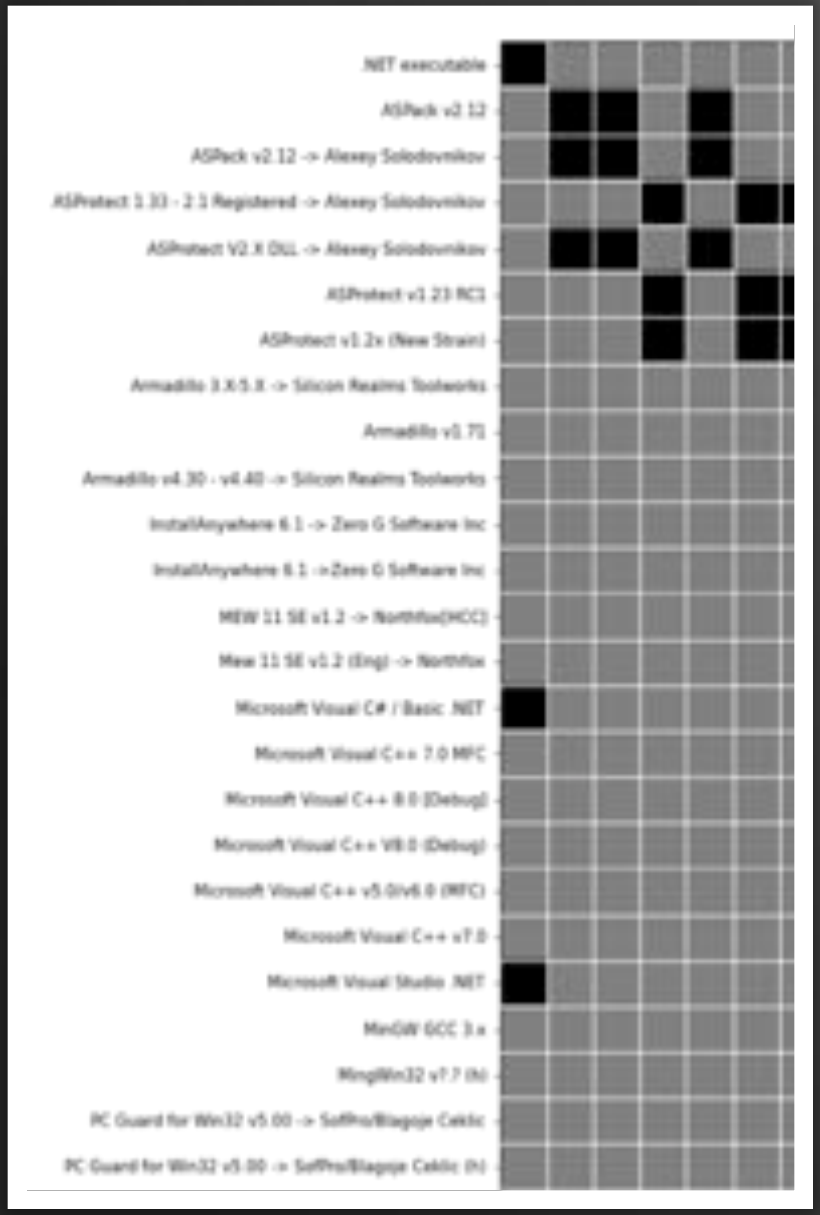
ZeuS + PEiD

Samples per PEiD signature



ZeuS + PEiD

Correlation between the PEiD signatures



Highly correlated

ASPack v2.12	ASPack v2.12 -> Alexey Solodovnikov	1.0
ASPack v2.12	ASProtect V2.X DLL -> Alexey Solodovnikov	1.0

PDB strings

- C:\Users\Samim\Desktop\Stab\stb\Release\stb.pdb
- Y:\DnijJVgd\pitWxRX\ctoerrwx\RtpjVeb.pdb
- H:\RJmq\HYkAuHH\lsvyudBS\yMgpHF\obzwwn.pdb
- C:\answer\record\These\Answer\Dry\Lay\since\Since\mean\Tree\Music.pdb
- X:\DEVELOPMENT\VC++\Cryptor_Evolution_old\release\main.pdb
- c:\temp\debug.pdb
- F:\zmapHjyf\tGQkckQ\UrmgircgraBwwX\nAjaGbB.pdb
- C:\Users\M4x\Documents\Programmieren\PECRYPT\Client\EXECUTABLE\Stub\Release\Stub.pdb

Linker versions

Major.Minor Linker Versions	Count
2.50	2067
10.0	1064
9.0	793
6.0	717
5.0	235
5.12	231
8.0	201
7.10	155
0.0	85
1.1	73

Number of Sections

Number of sections	Count
3	2917
5	1153
4	798
6	576
7	443
8	396
10	127
12	109
9	87
11	72

ASM mnemonics

Symbolic name for a machine instruction

- add
- mov
- nop
- xor
- …

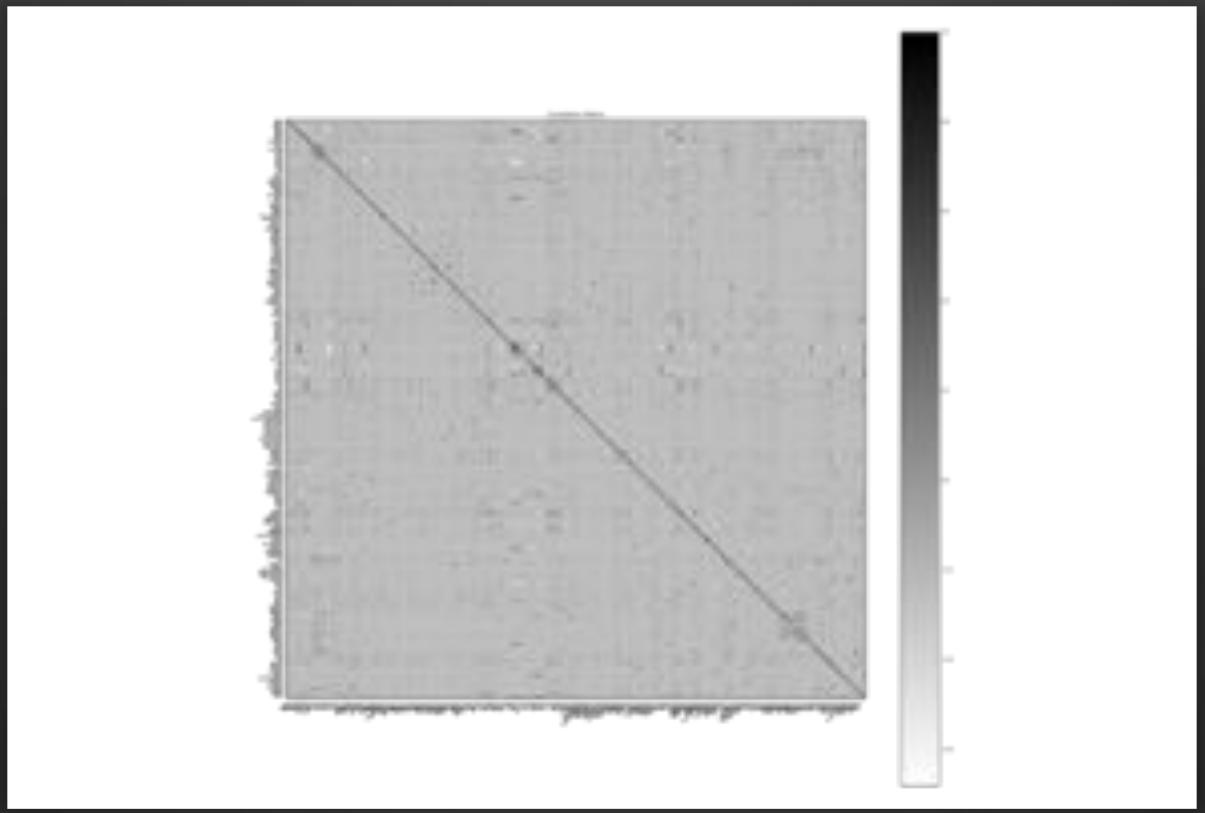
All mnemonics are treated equally from this point forward

Johnny 5 is alive!

Yes. Disassemble.

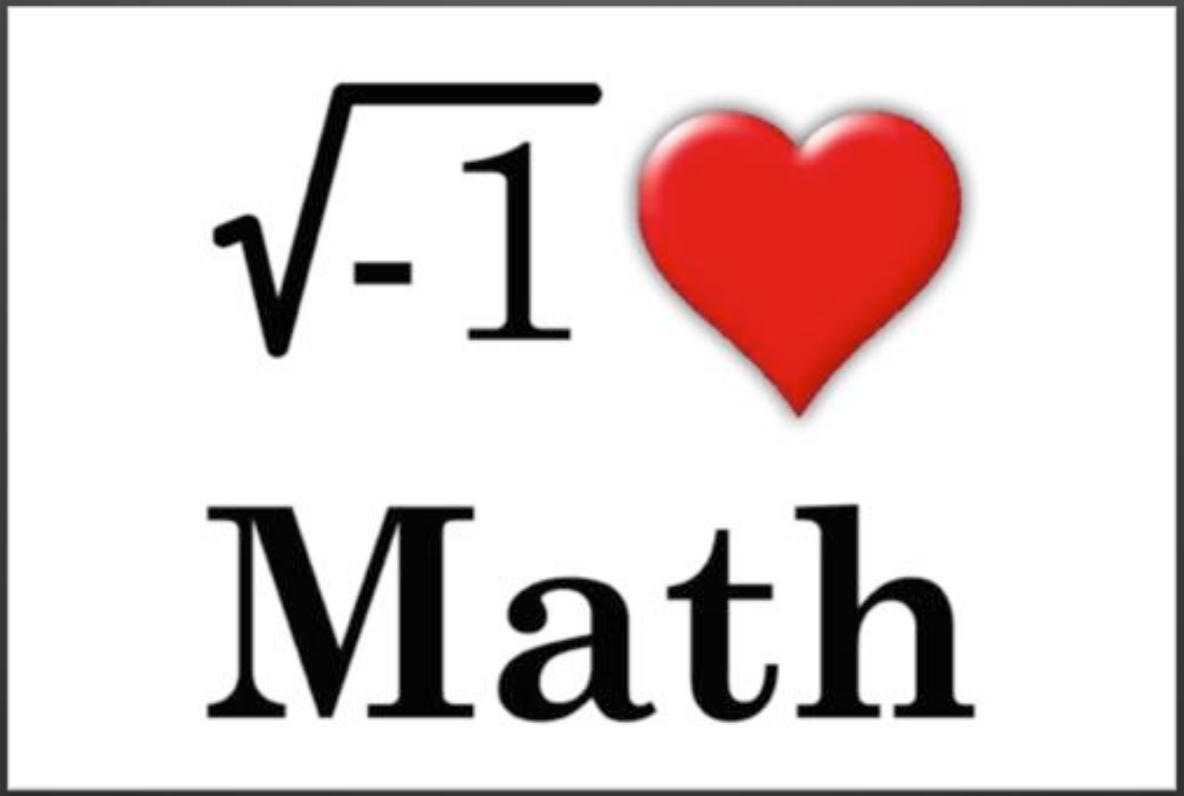
Capstone Engine

- Standardize on one disassembler for consistent results
- Free
- Awesome
- Multi-Language support
- Cross Platform



ZeuS + ASM

Just because we can, doesn't mean we should



It's important

ASM

- Mnemonics describe program behavior
- Mnemonics at AddressOfEntryPoint describe initial program behavior
  - Compiler setup
  - Unpacker stub
- Use this as the basis for a signature

Sets

- Correlation
  - Doesn't take order into account
  - Doesn't really help with distance or similarity
- Jaccard Distance
  - Doesn't take order into account
  - Distance is based on set membership
- Levenshtein Distance
  - Edits determine distance
  - Position is important

Jaccard

['pushal', 'mov', 'lea', 'push', 'jmp', 'nop', 'mov', 'inc', 'mov', 'inc']

['push', 'mov', 'add', 'push', 'mov', 'call', 'mov', 'mov', 'call', 'mov']

Total #of shared elements/Total # of unique elements

[mov push] / [pushal mov lea jump nop inc push add call]

2/8 = .25

Levenshtein

['pushal', 'mov', 'lea', 'push', 'jmp', 'nop', 'mov', 'inc', 'mov', 'inc’]

['push', 'mov', 'add', 'push', 'mov', 'call', 'mov', 'mov', 'call', 'mov']

How many things have to change to make the bottom into the top.

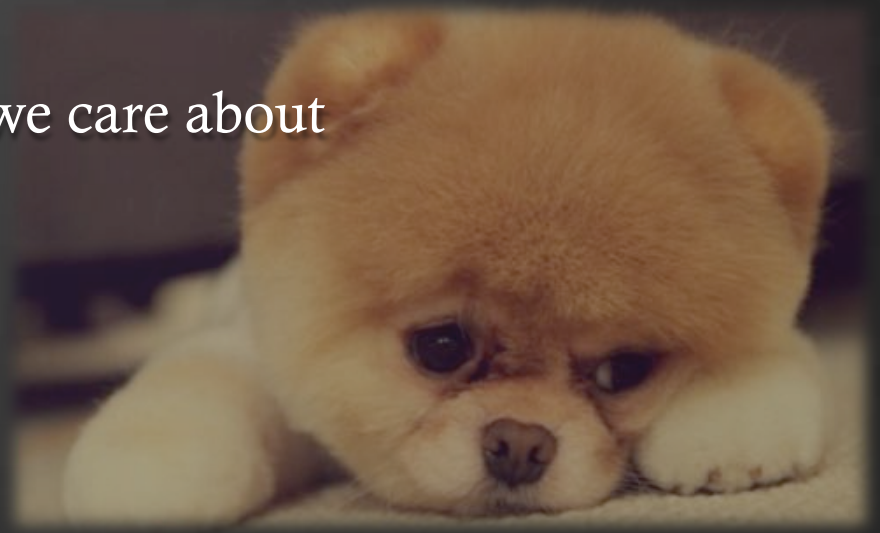
[yes no yes no yes yes no yes yes yes]

yes = 7

Distance = 7

But…

- Code is executed in order
- There might be branches
- Shouldn't the ASM mnemonics to the 'left' be worth more than the ones on the 'right'
- Where's the cutoff
- How many instructions should we care about
- What's the size of the stub



Enter our superhero

(Tapered Levenshtein)

Tapered levenshtein

Position dependent, left edits have a higher weight than right edits

['pushal', 'mov', 'lea', 'push', 'jmp', 'nop', 'mov', 'inc', 'mov', 'inc'

['push', 'mov', 'add', 'push', 'mov', 'call', 'mov', 'mov', 'call', 'mov']

1 - (position/len(set))

1, 0, .8, 0, .6, .5, 0, .3, .2, .1

3.5 (vs. 7 on the non-tapered version)

Tapered levenshtein similarity

['pushal', 'mov', 'lea', 'push', 'jmp', 'nop', 'mov', 'inc', 'mov', 'inc'

['push', 'mov', 'add', 'push', 'mov', 'call', 'mov', 'mov', 'call', 'mov']

Distance = 3.5

Similarity = 1 – Distance/max(len(seq1), len(seq2))

1 – 3.5/10 = 65% similar

Now we're ready to science

- PE files
- MajorLinkerVersion
- MinorLinkerVersion
- Assembly mnemonics
- Fancy algorithms

Workflow

1. Gather samples
2. Static analysis
    1. PEiD
    2. Disassemble
    3. Header features
3. Cluster
4. Closeness according to distance metric (> 90% similar)
    1. Use banded minhash for < $O(n^2)$ comparisons
5. Analyze based on cluster groups using 30 mnemonics
    1. 30 mnemonic chain length is based on prior research and exploration
6. Create Signatures

Why signatures

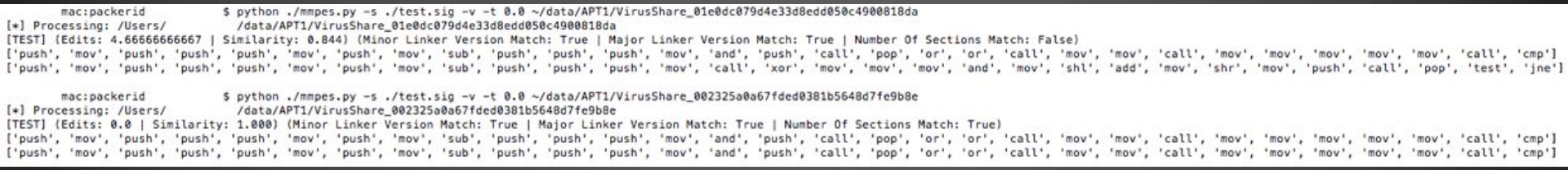
- Sometimes using a full ML model is overkill
  - Have to worry about model drift
  - Model will vary based on training data source
  - Can be intimidating to people just wanting to get started with the hacking
    - That's right, this slide says 'the hacking'

Signatures

- [Microsoft Visual Basic v5.0]
  - mnemonics = push,call,add,add,add,xor,add,inc,add,add,add,add,adc,dec,mov,adc,add,add,add,add,or,imul,push,and,and
- File
  - mnemonics = push,call,add,add,add,xor,add,inc,add,add,add,add,jmp,dec,mov,xor,add,add,add,add,add,add,dec,jnp,add
- Results
  - [Microsoft Visual Basic v5.0] (Edits: 2.93333333333 | Similarity: 0.902)

Demo

Please accept our chicken sacrifice, Demo Gods.




```
mac:packerid XXXX$ python ./mmpes.py -s ./test.sig -v -t 0.0 ~/data/APT1/
VirusShare_01e0dc079d4e33d8edd050c4900818da
[*] Processing: /Users/XXX/data/APT1/VirusShare_01e0dc079d4e33d8edd050c4900818da
[TEST] (Edits: 4.66666666667 | Similarity: 0.844) (Minor Linker Version Match: True | Major Linker
Version Match: True | Number Of Sections Match: False)
['push', 'mov', 'push', 'push', 'push', 'mov', 'push', 'mov', 'sub', 'push', 'push', 'push',
'mov', 'and', 'push', 'call', 'pop', 'or', 'or', 'call', 'mov', 'mov', 'call', 'mov', 'mov',
'mov', 'mov', 'mov', 'call', 'cmp']
['push', 'mov', 'push', 'push', 'push', 'mov', 'push', 'mov', 'sub', 'push', 'push', 'push',
'mov', 'call', 'xor', 'mov', 'mov', 'mov', 'and', 'mov', 'shl', 'add', 'mov', 'shr', 'mov',
'push', 'call', 'pop', 'test', 'jne']

mac:packerid XXX$ python ./mmpes.py -s ./test.sig -v -t 0.0 ~/data/APT1/
VirusShare_002325a0a67fded0381b5648d7fe9b8e
[*] Processing: /Users/XXX/data/APT1/VirusShare_002325a0a67fded0381b5648d7fe9b8e
[TEST] (Edits: 0.0 | Similarity: 1.000) (Minor Linker Version Match: True | Major Linker Version
Match: True | Number Of Sections Match: True)
['push', 'mov', 'push', 'push', 'push', 'mov', 'push', 'mov', 'sub', 'push', 'push', 'push',
'mov', 'and', 'push', 'call', 'pop', 'or', 'or', 'call', 'mov', 'mov', 'call', 'mov', 'mov',
'mov', 'mov', 'mov', 'call', 'cmp']
['push', 'mov', 'push', 'push', 'push', 'mov', 'push', 'mov', 'sub', 'push', 'push', 'push',
'mov', 'and', 'push', 'call', 'pop', 'or', 'or', 'call', 'mov', 'mov', 'call', 'mov', 'mov',
'mov', 'mov', 'mov', 'call', 'cmp']
```

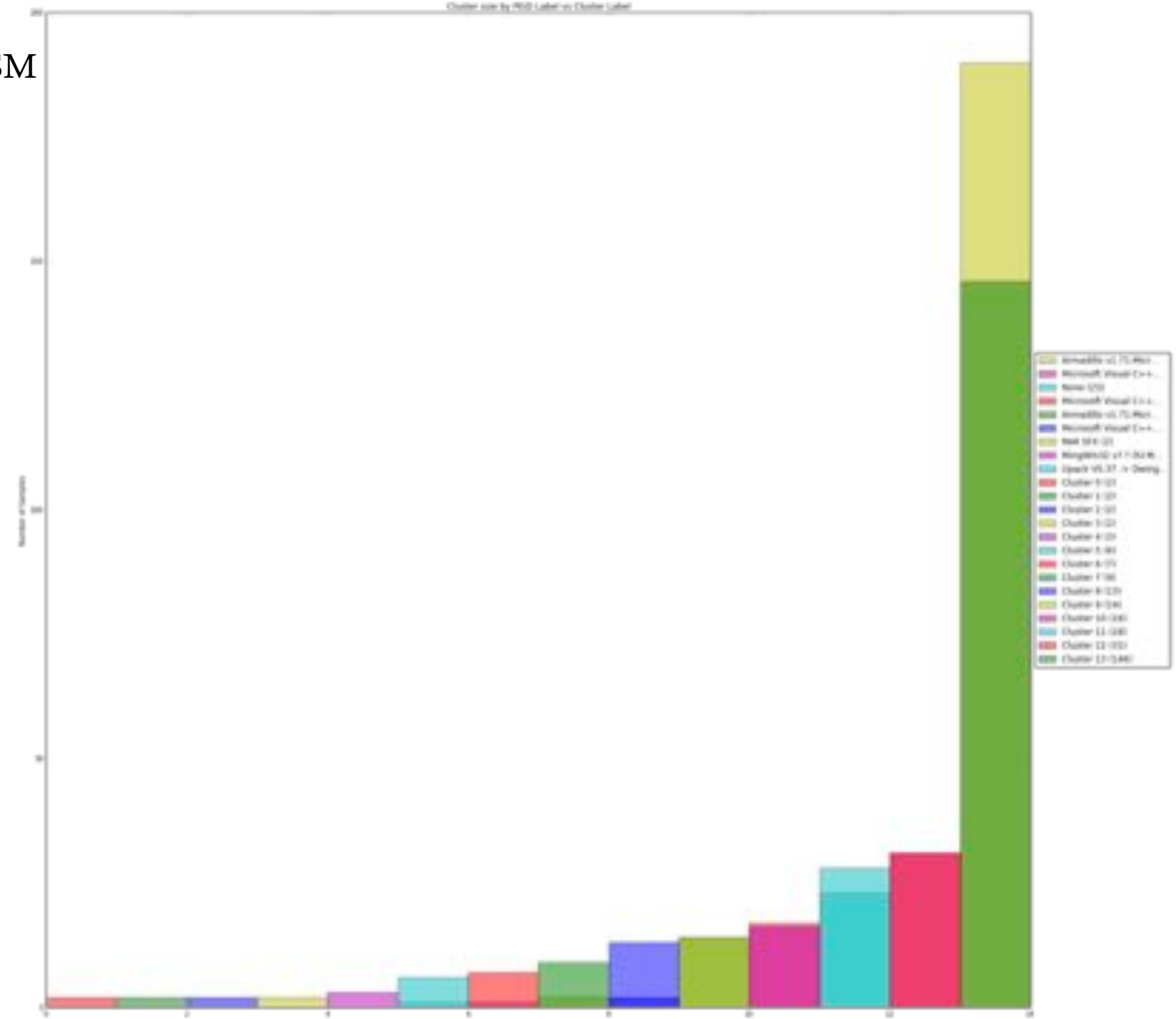

```
mac:packerid XXXX$ python ./generate_mmpes_sig.py -t "Example Rule" -l -s
~/data/zeroaccess/exe/
f7259c32f4048e7fafa138362f85c505712c8c6f2b29e173f442505d2d9bccbb

[Example Rule]
major_linker = 9
minor_linker = 0
numberofsections = 4
mnemonics =
push,mov,and,sub,push,push,push,mov,lea,push,push,push,mov,push,call,test
,jl,mov,push,lea,push,push,push,call,test,jl,mov,cmp,jne,lea
```

https://blog.kaspersky.com/files/2013/06/apt_title.jpg

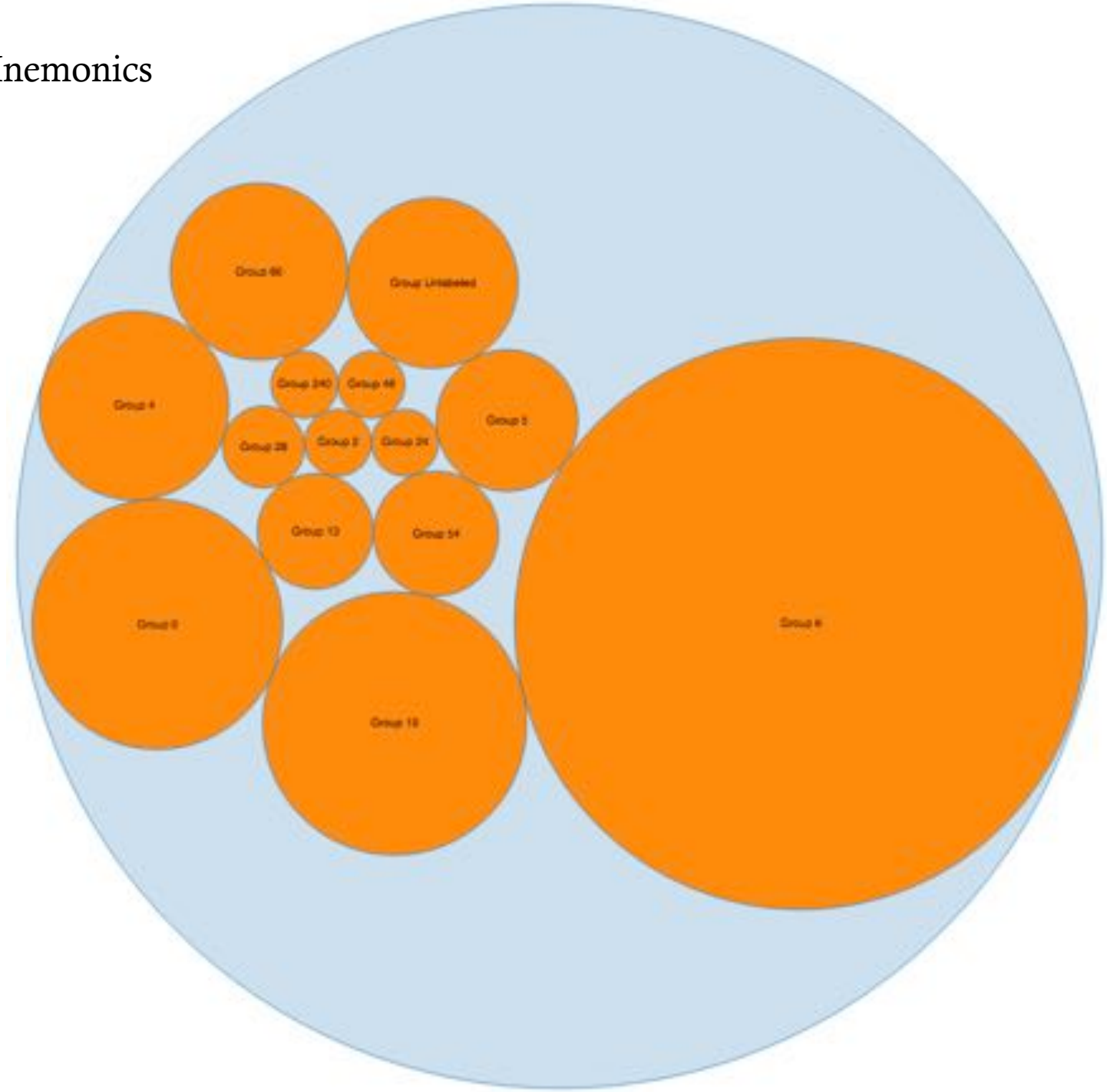
APT1

Because first APT is best APT

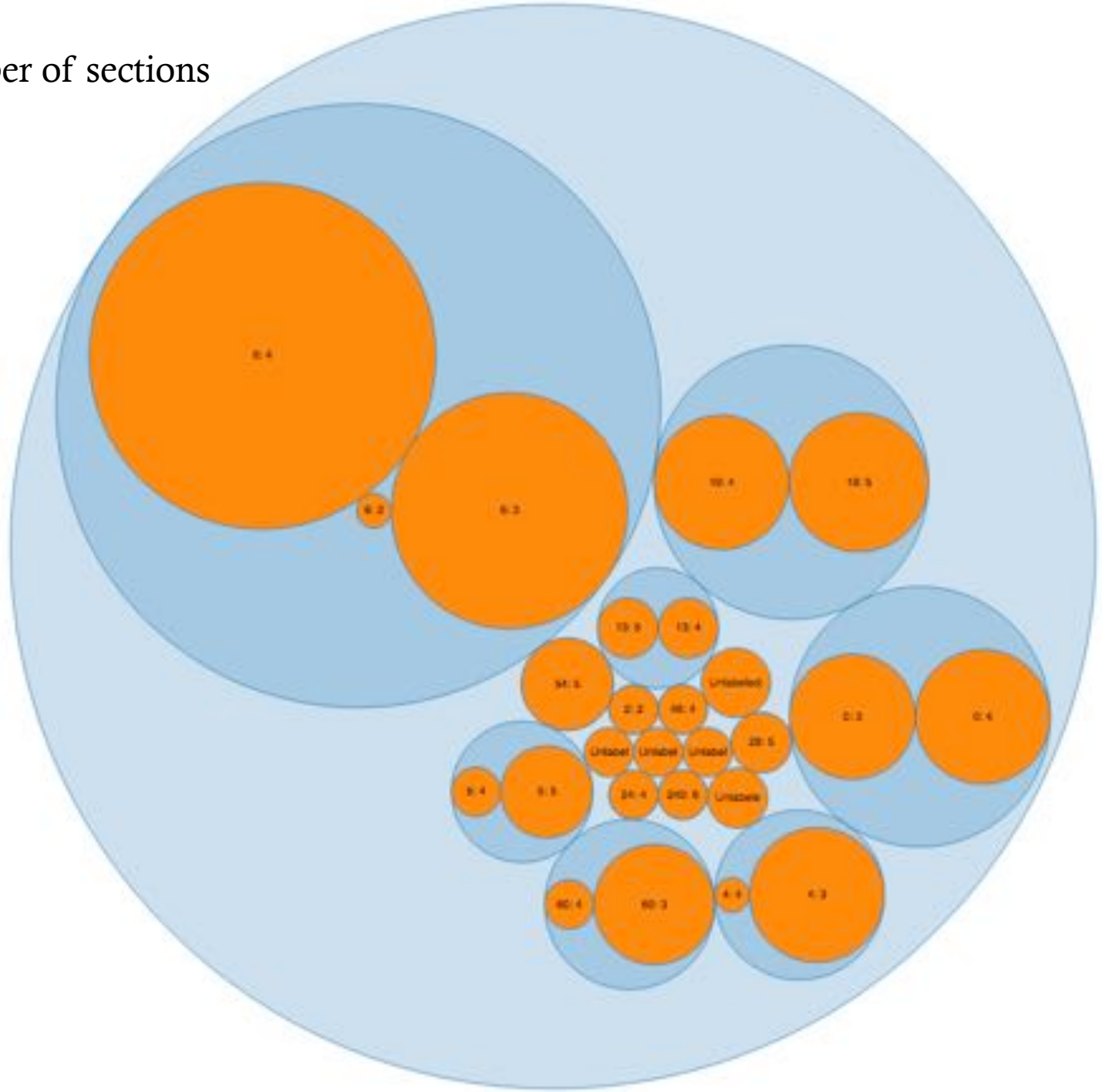
APT 1
PEiD vs. ASM



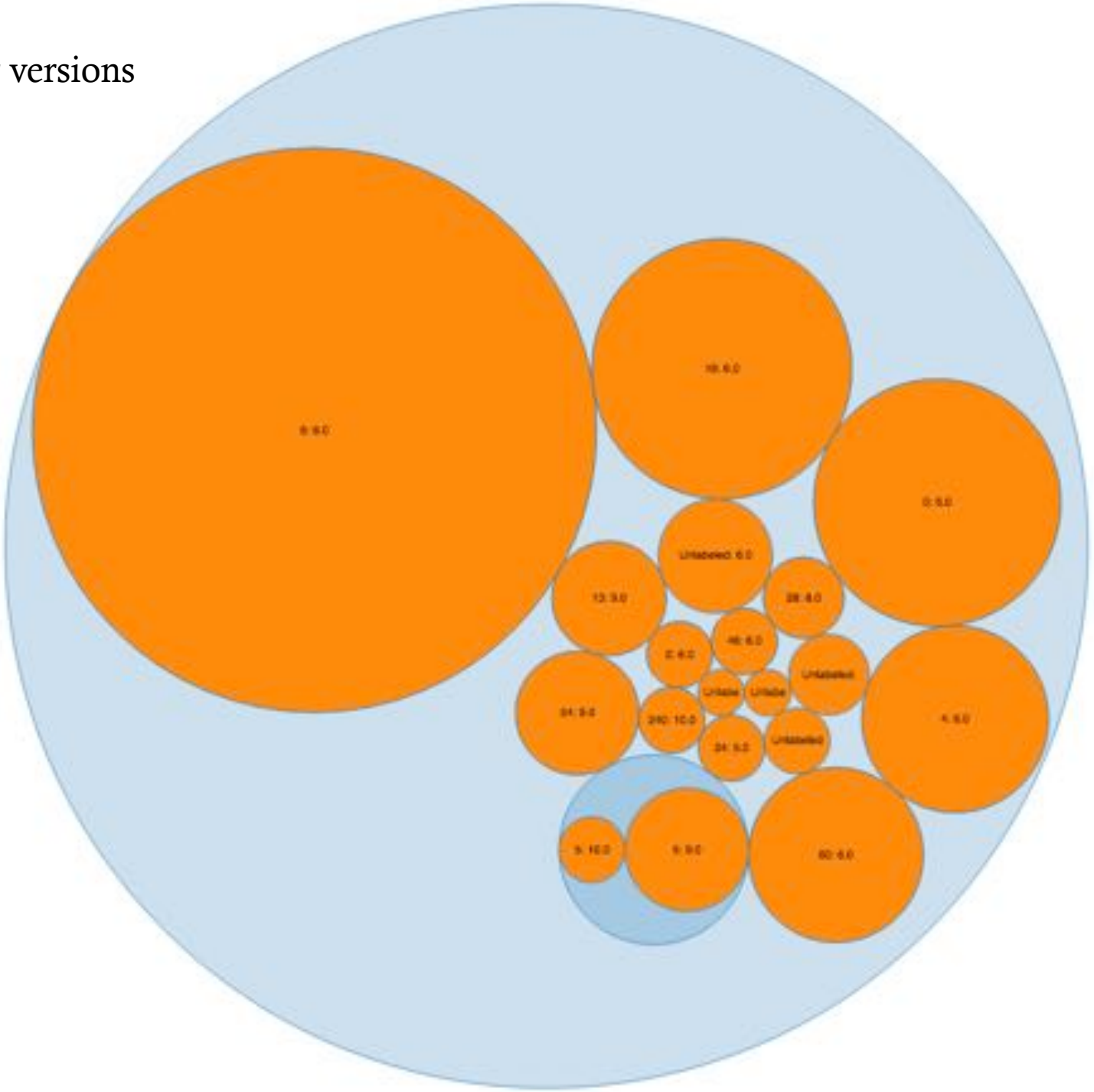
APT 1
Cluster on 30 ASM Mnemonics



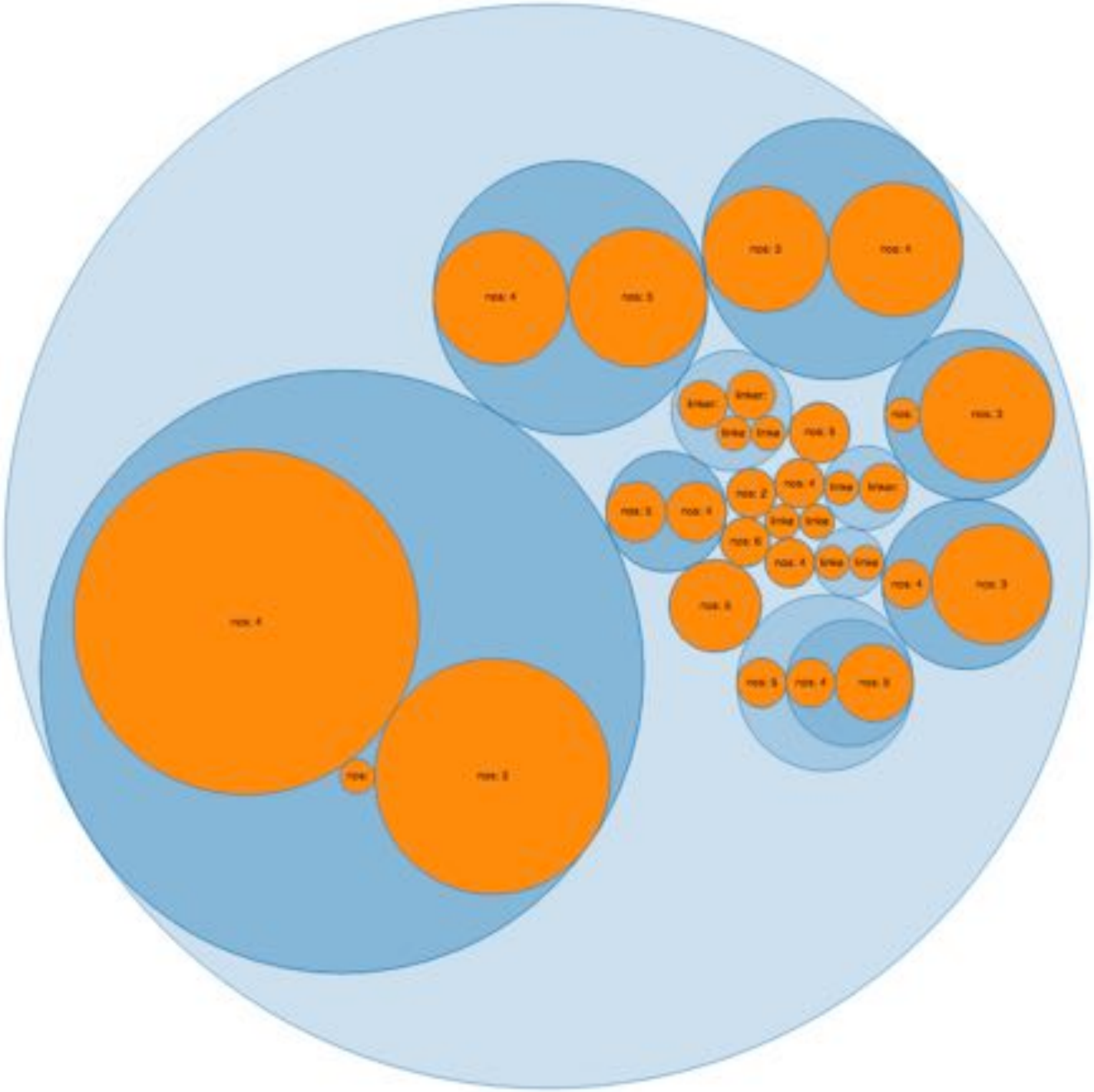
APT 1
Sub-clustered on number of sections



APT 1
Sub-clustered on linker versions



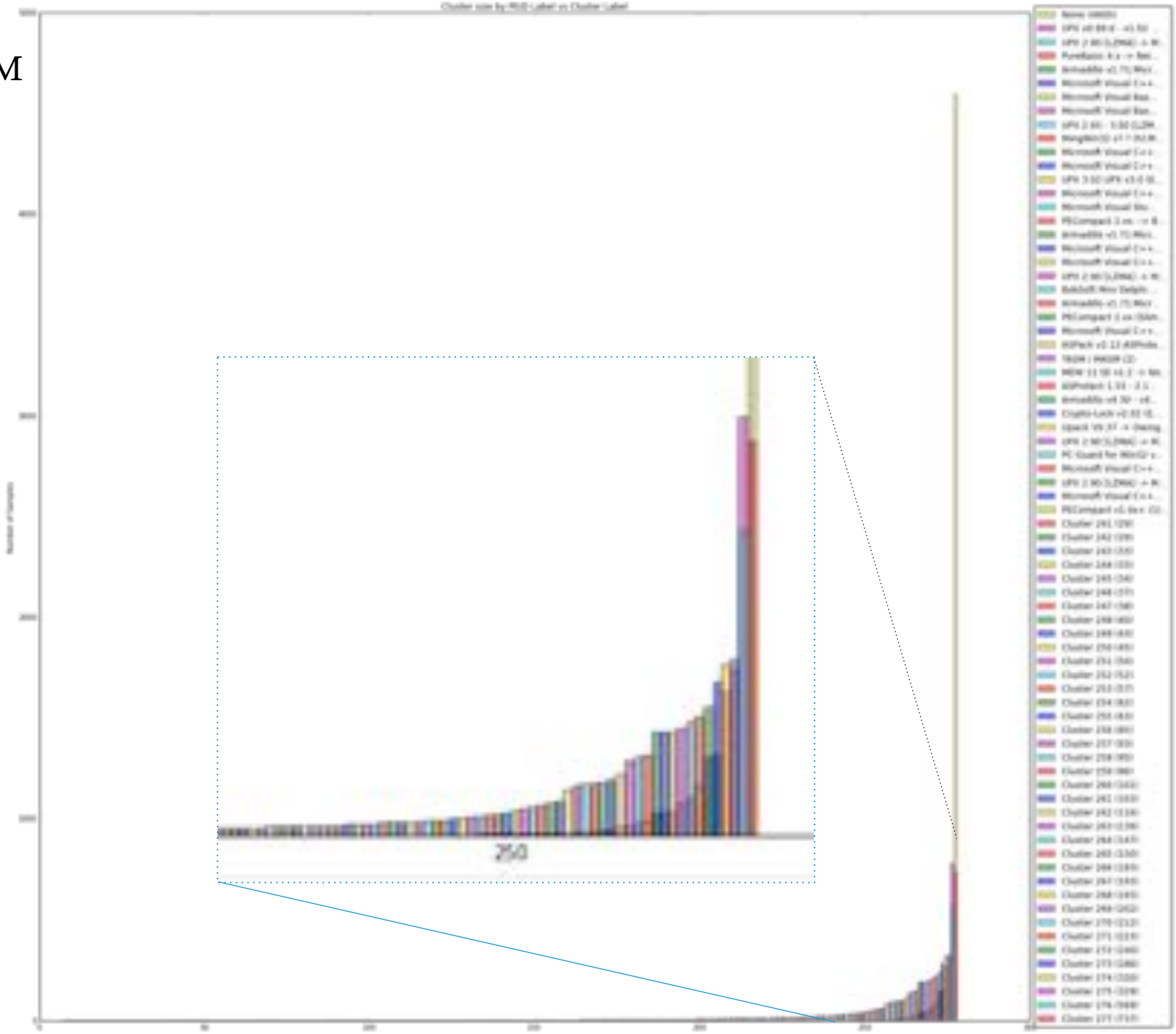
APT 1
Sub-clustered on both



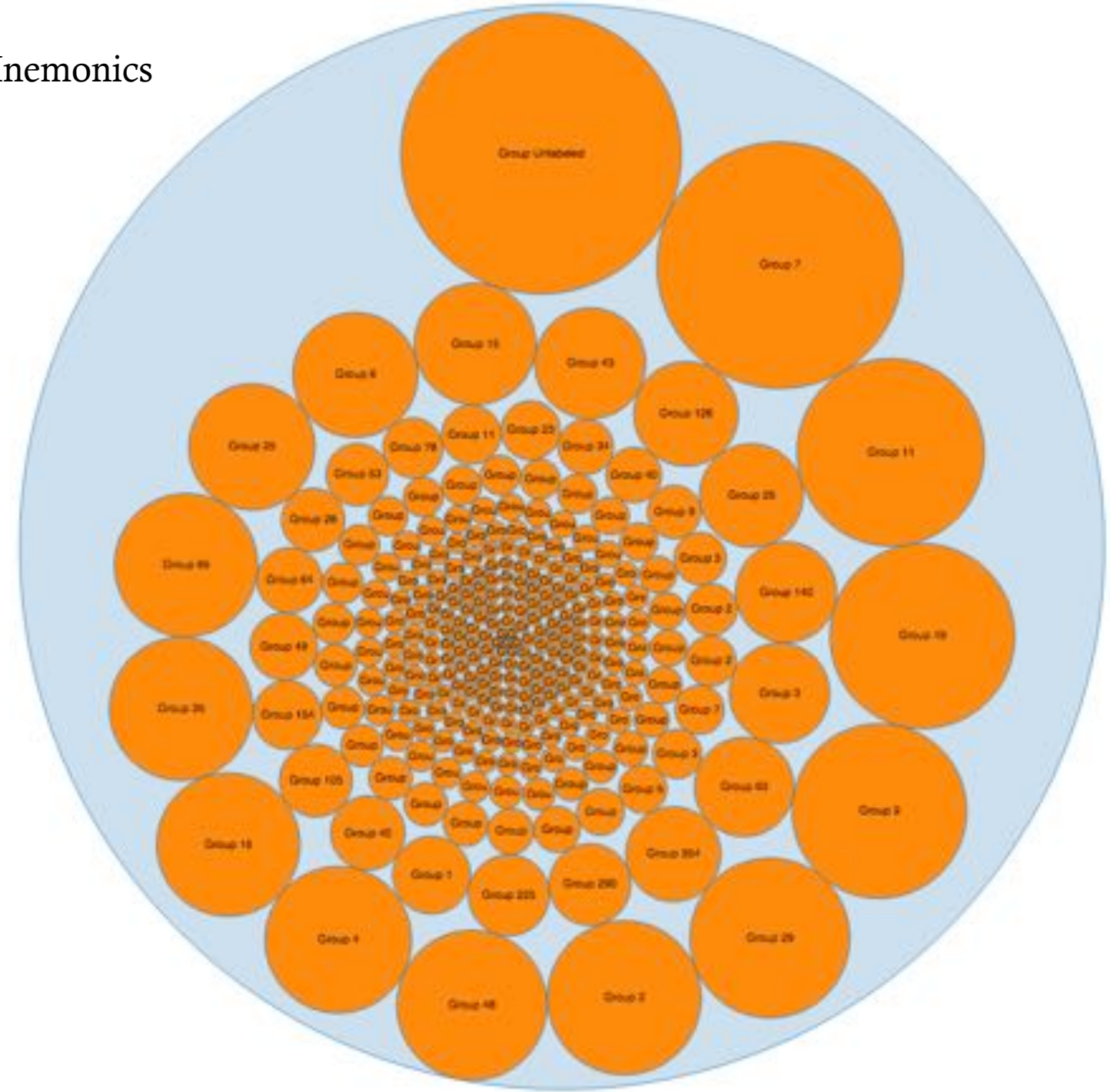
ZeuS

Malware or Greek God?

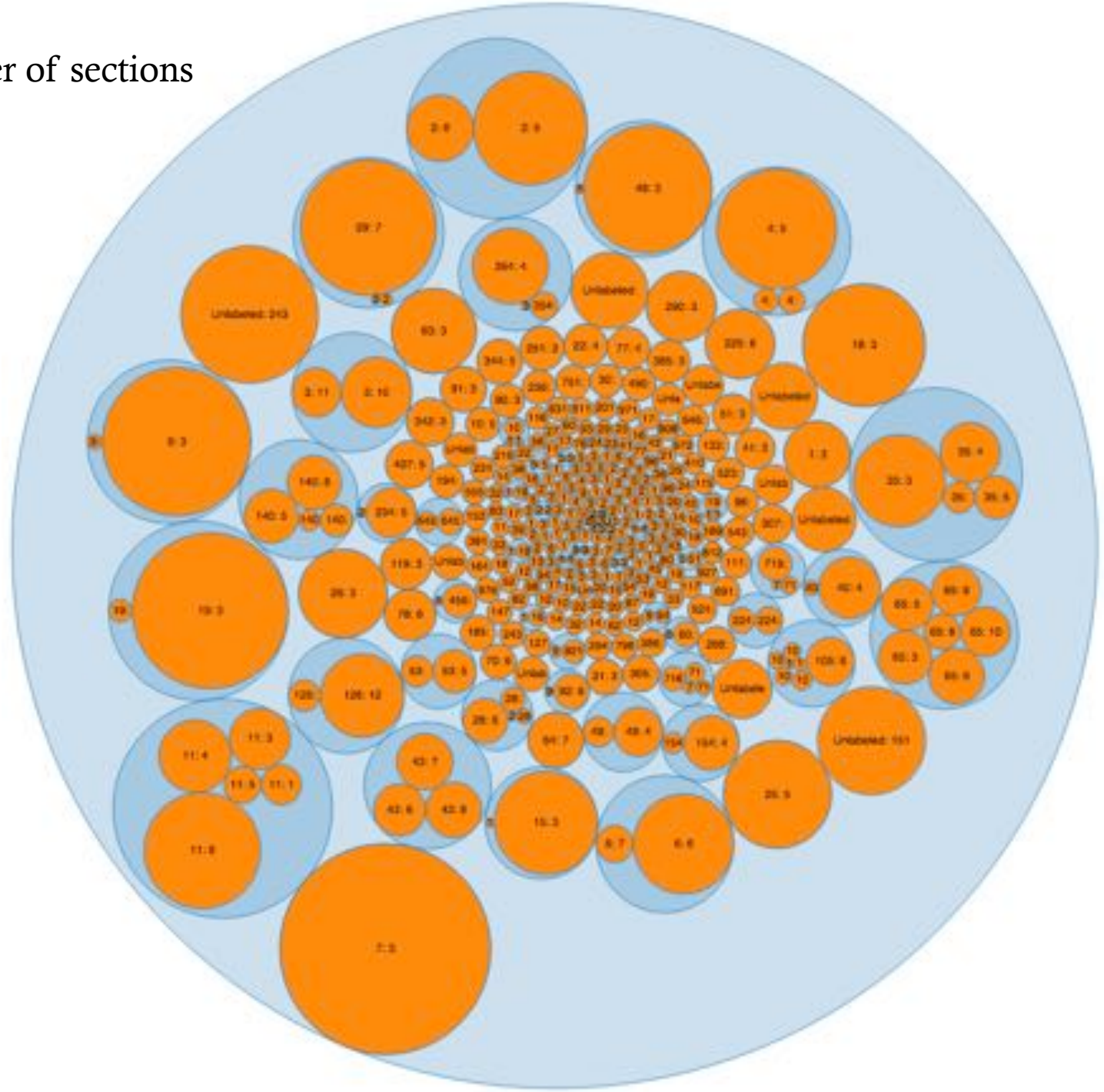
ZeuS
PEiD vs. ASM



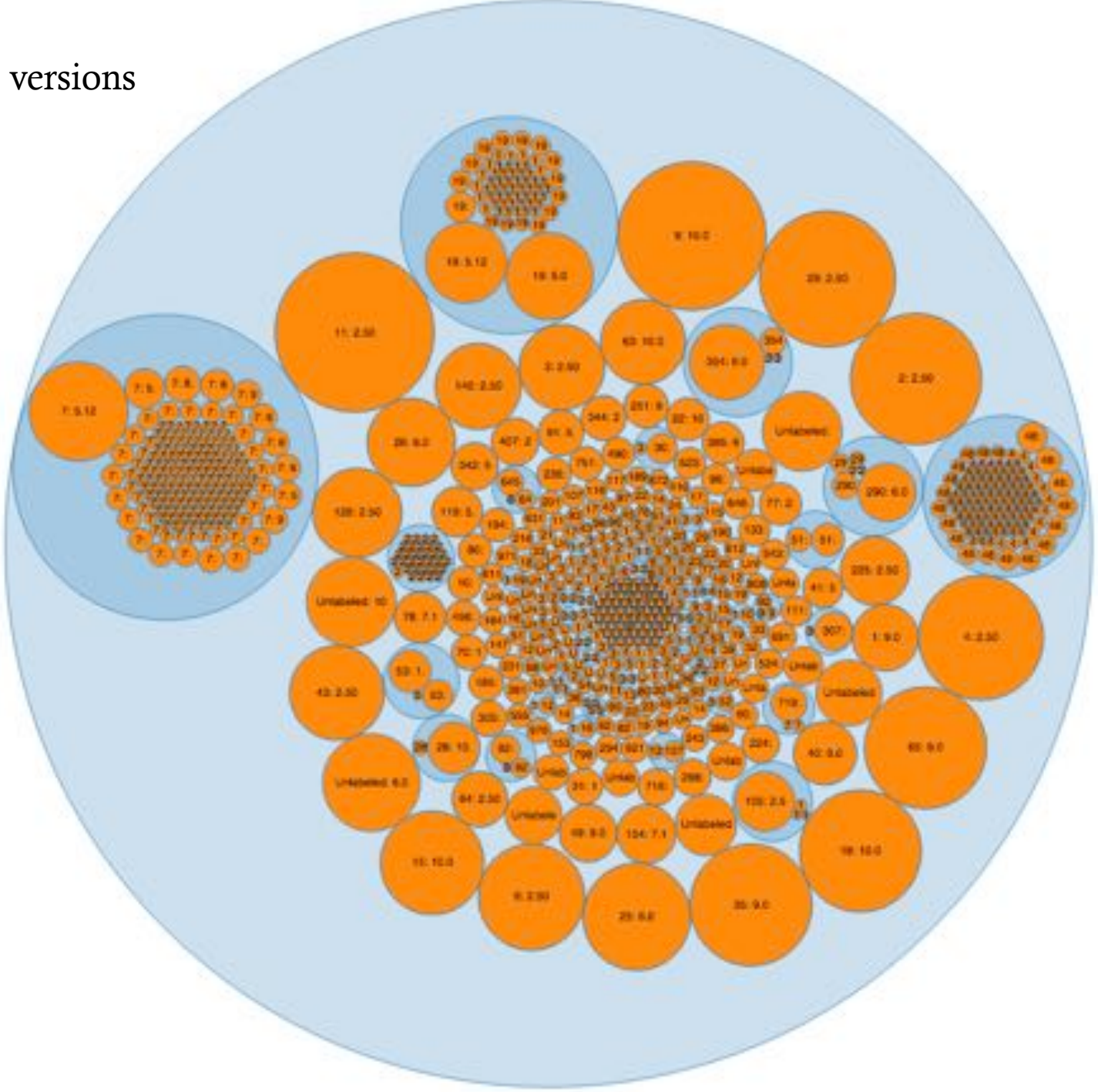
ZeuS
Cluster on 30 ASM Mnemonics



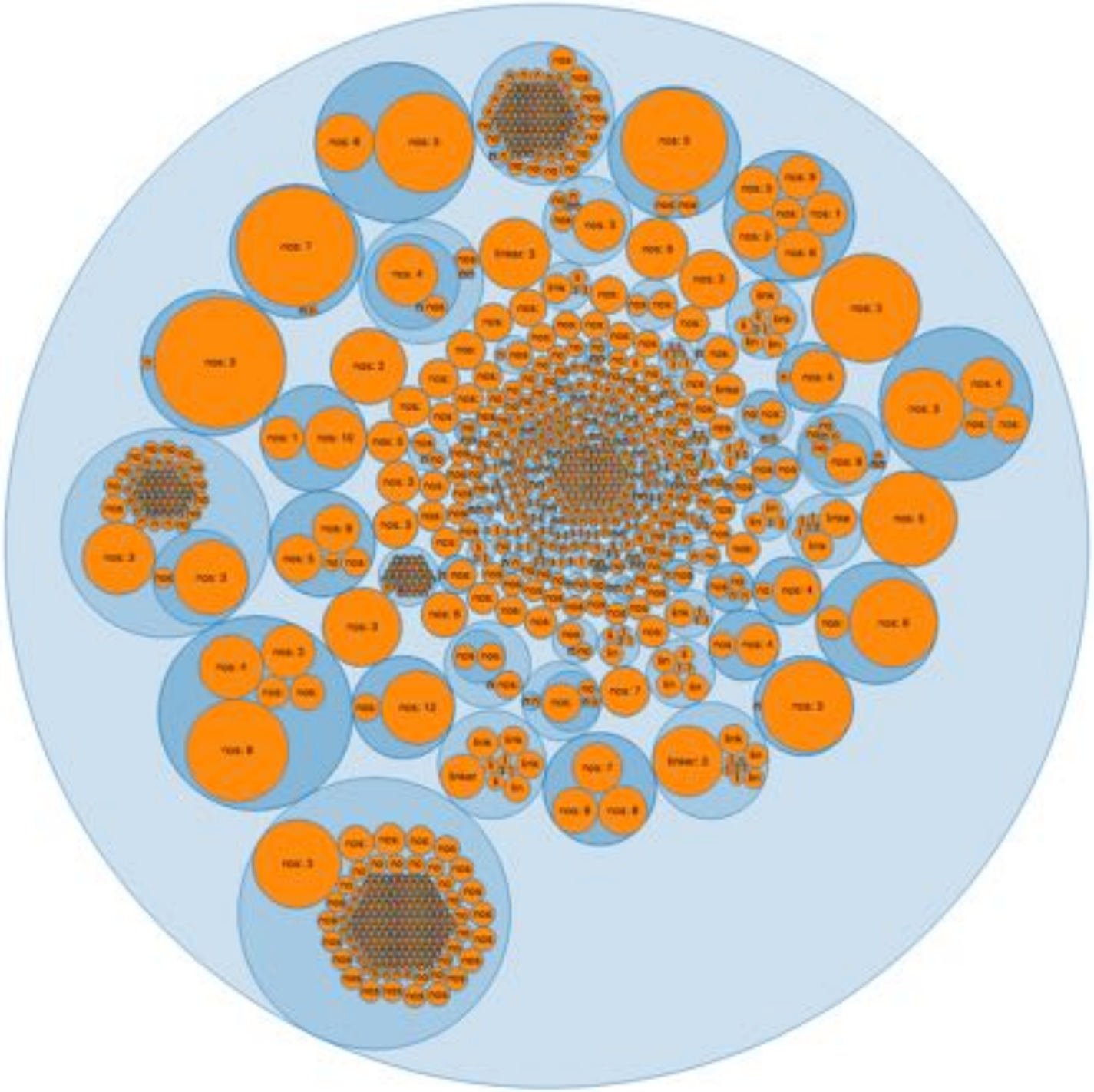
ZeuS
Sub-clusters on number of sections



ZeuS
Sub-clustered on linker versions



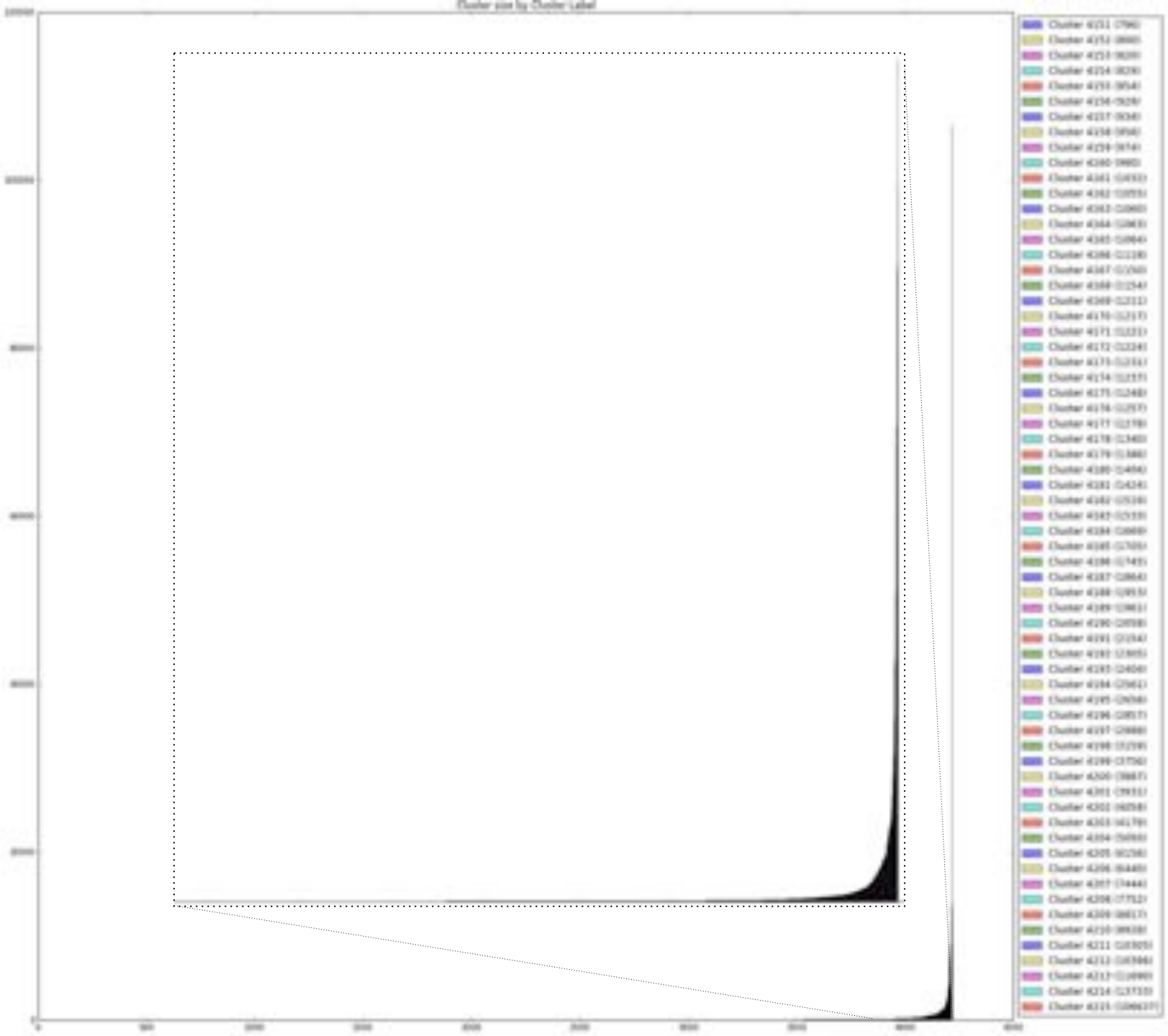
ZeuS
Sub-clustered on both



Random files

Are random

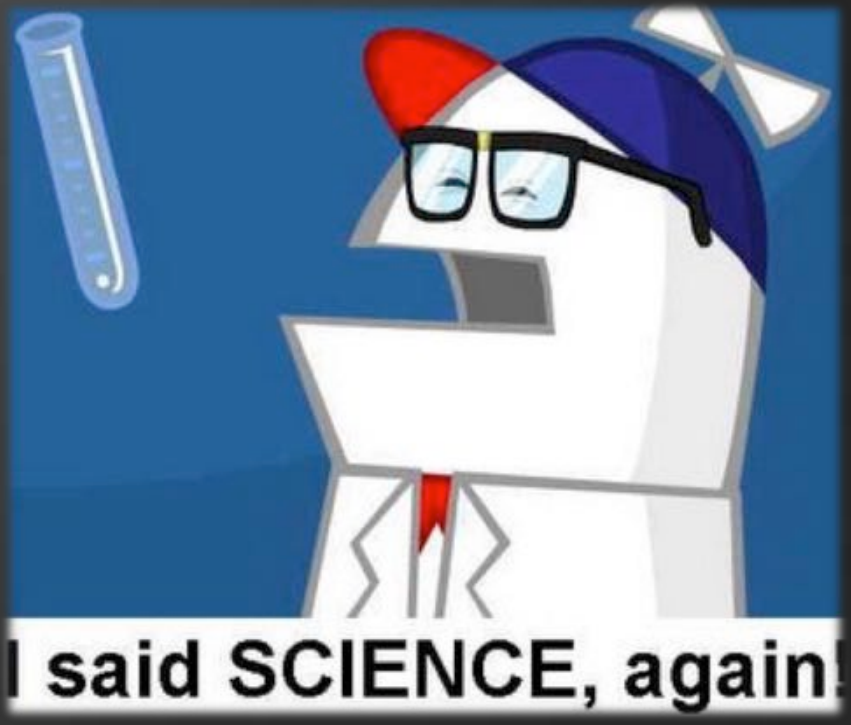
Random
ASM



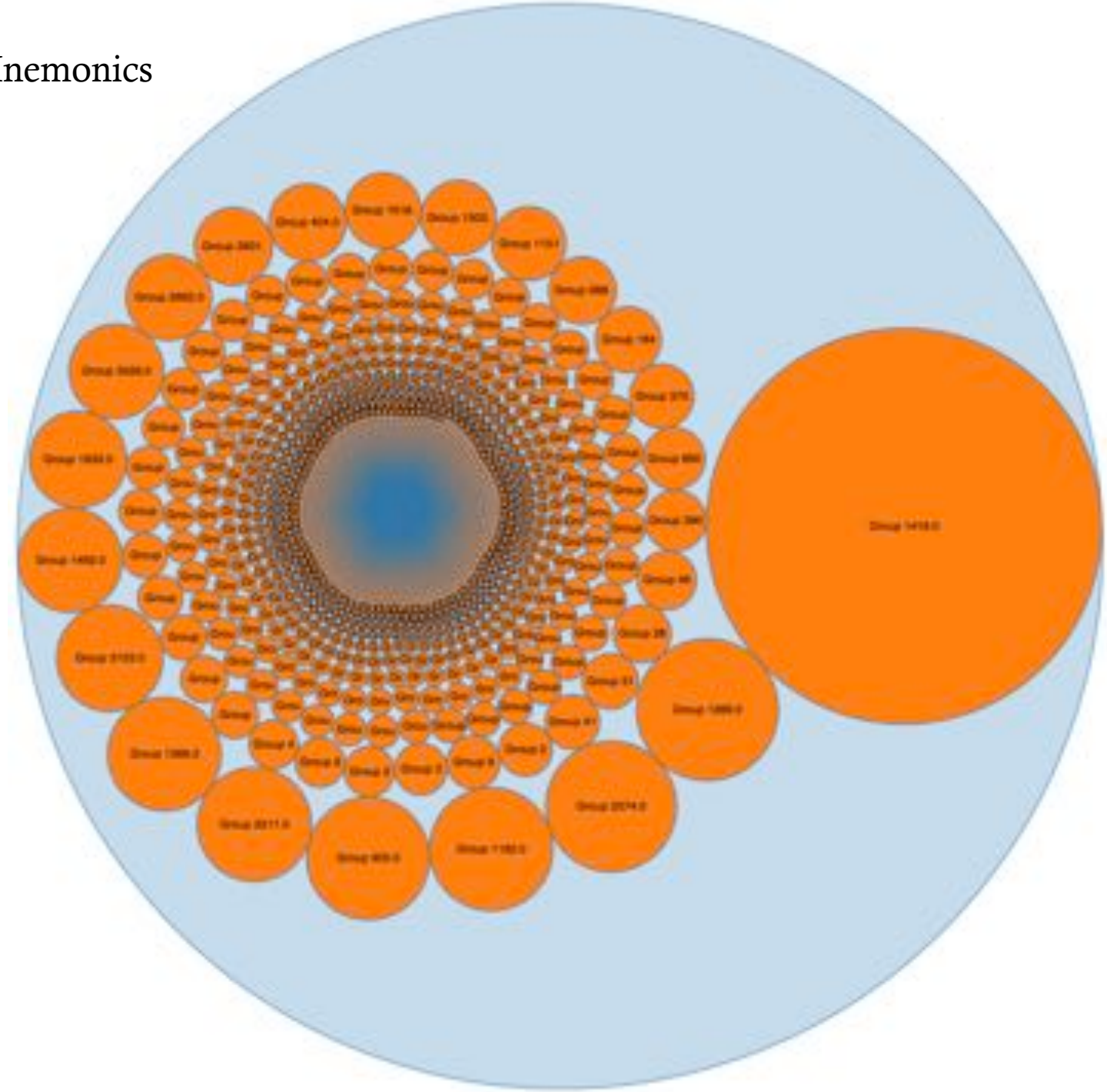
Fun fact

- 5821 out of 411340 files don't meet the similarity requirement*
  - They are not at least 90% to any other file

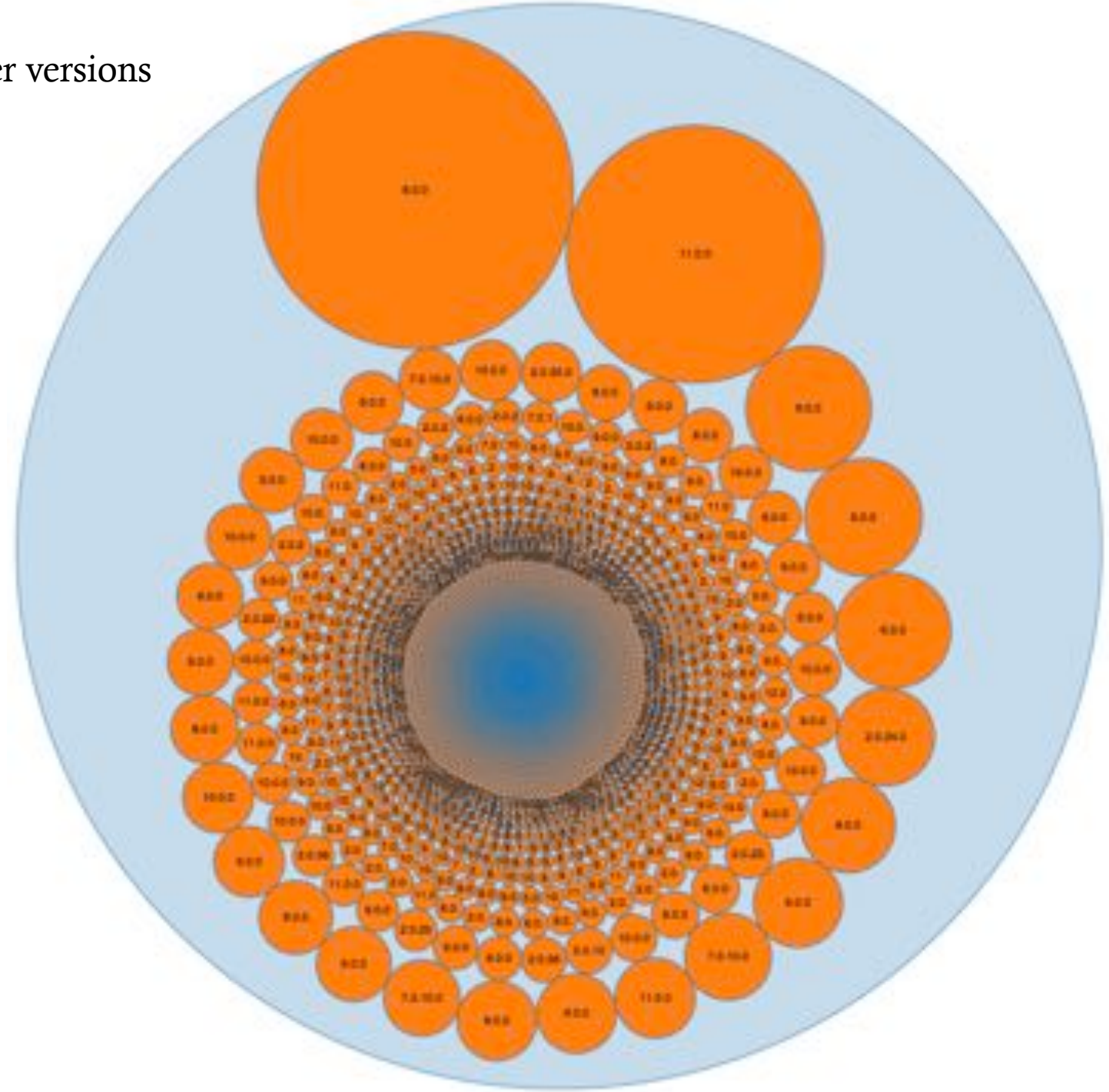
*Actual number may be lower



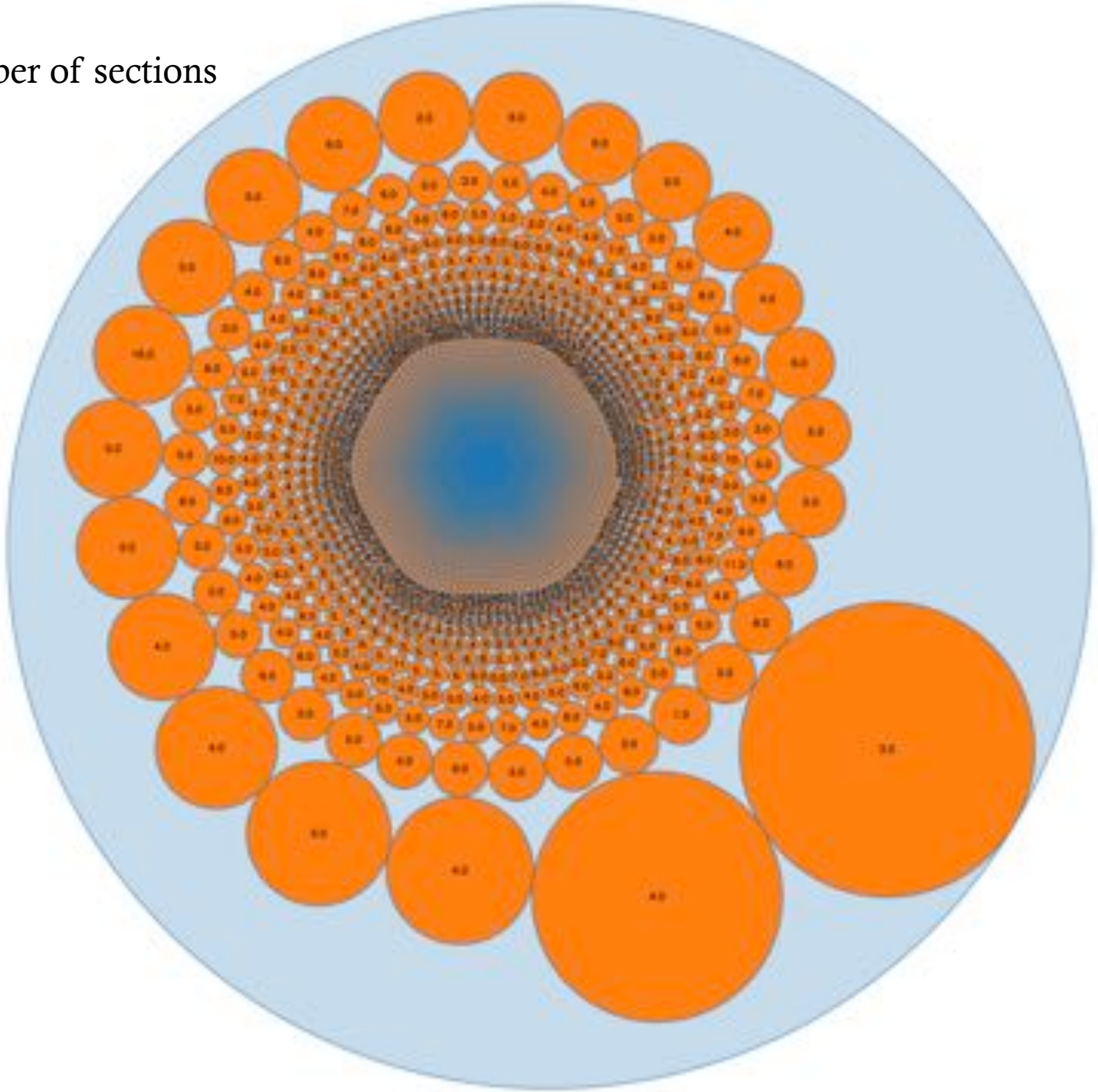
Random
Cluster on 30 ASM Mnemonics



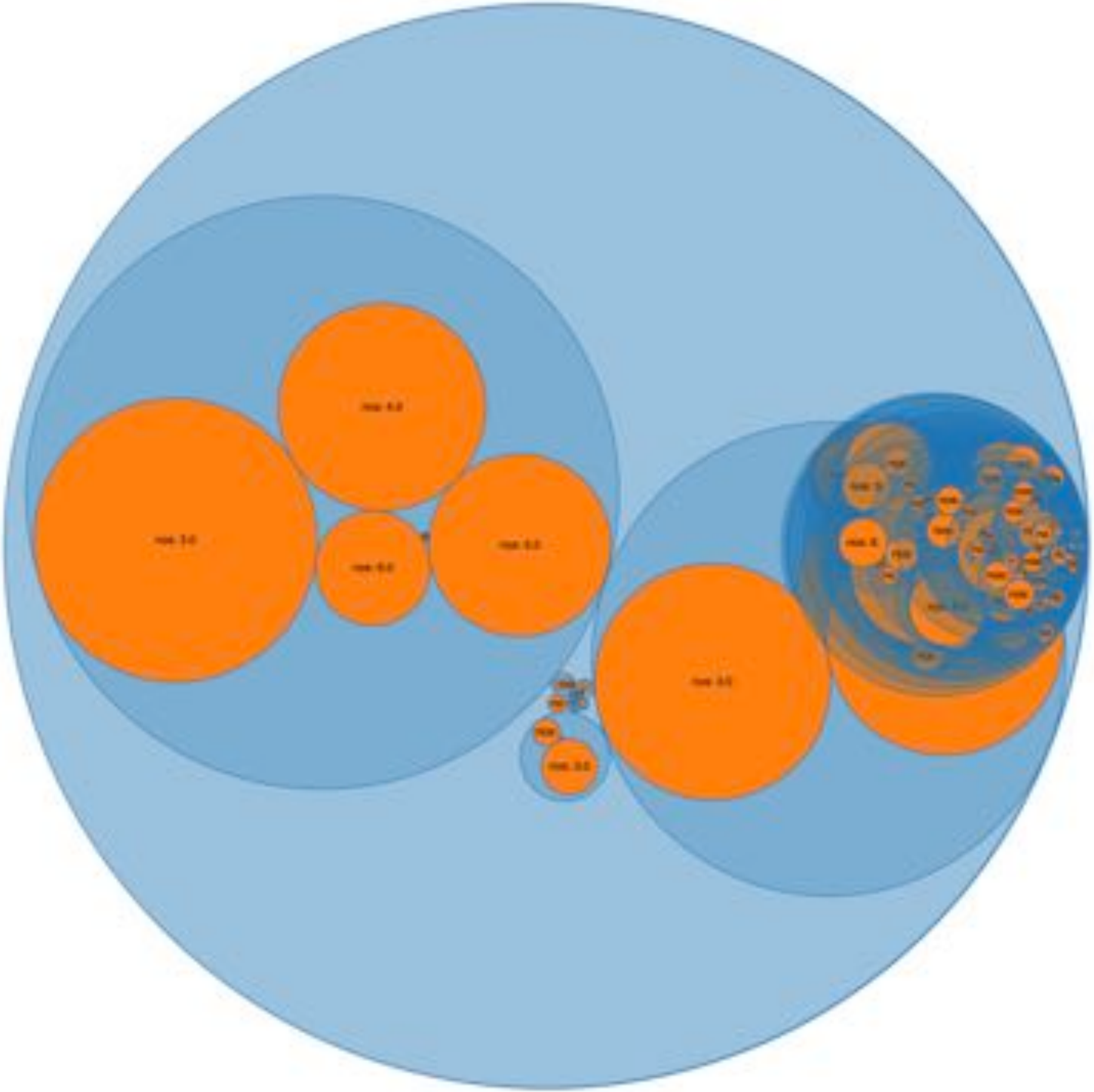
Random
Sub-clustered on linker versions



Random
Sub-clustered on number of sections



Random
Sub-clustered on both



Google Chrome

AKA Why linkers and sections are important

- 97 files match the ASM signature
  - ['call', 'jmp', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'int3', 'cmp', 'jae', 'cmp', 'jae', 'shrd', 'shr', 'ret', 'mov', 'xor', 'and', 'shr', 'ret', 'xor', 'xor', 'ret', 'int3']
- 95 have the same linker version: 10.0
  - 2 have a linker version of 11.0
- 94 have the same number of sections: 6
  - Two have 4 sections, one has 5 sections
- 94 binaries have BOTH a linker version of 10.0 AND 6 sections
  - All 94 are signed Google Chrome binaries

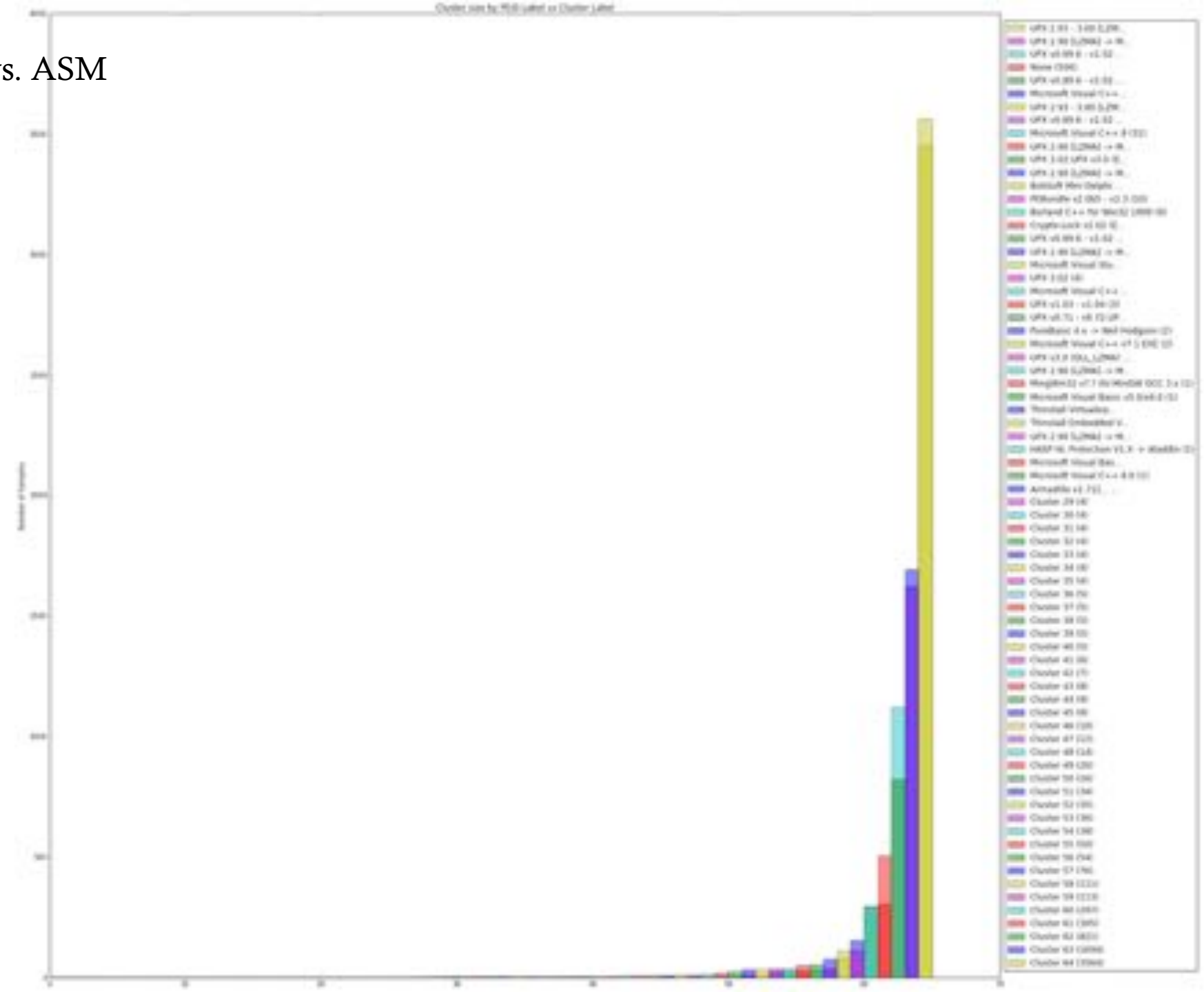
UPX

Because somebody was going to ask

- 7469 files packed with UPX (looked for UPX0, UPX1, or UPX! in the file)
- 65 different groups identified
  - Includes everything that didn't match anything else (catch all) – 76 samples
- 31 unique linker versions
- 13 unique number of sections
  - 6902 have 3 sections

Group Label	Count
2	3564
1	1694
0	821
25	305
24	297
83	113
123	111

UPX
PEiD vs. ASM



UPX numbers

PEiD Label	Count
UPX 2.93 - 3.00 [LZMA] -> Markus Oberhumer, Laszlo Molnar & John Reiser:UPX 3.02:UPX v3.0 (EXE_LZMA) -> Markus Oberhumer & Laszlo Molnar & John Reiser	3453
UPX 2.90 [LZMA] -> Markus Oberhumer, Laszlo Molnar & John Reiser	1626
UPX v0.89.6 - v1.02 / v1.05 -v1.24 -> Markus & Laszlo [overlay]	1121
None	506
UPX v0.89.6 - v1.02 / v1.05 -v1.22 (Delphi) stub	297

Group Label	Count
2	3564
1	1694
0	821
25	305
24	297

Solution recap

- Easy to generate signatures
  - Python script with minimal dependencies
- It involves Math, who doesn't love Math?
- Cross platform.
  - Python works everywhere, right?
- Easy to understand…ish
- It Works!

Questions

I’m done