When Malware Is Packing Heat

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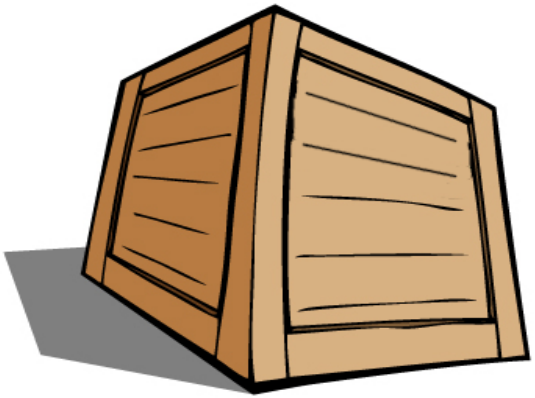

Packing

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AV software often mis-classify benign packed samples as malicious

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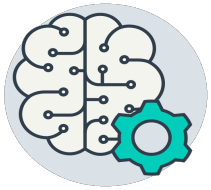
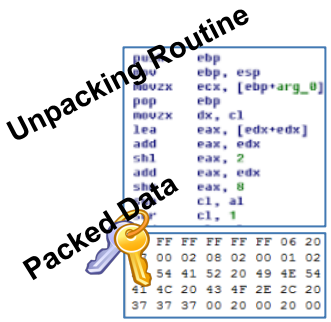
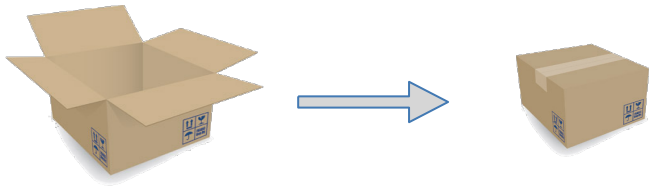
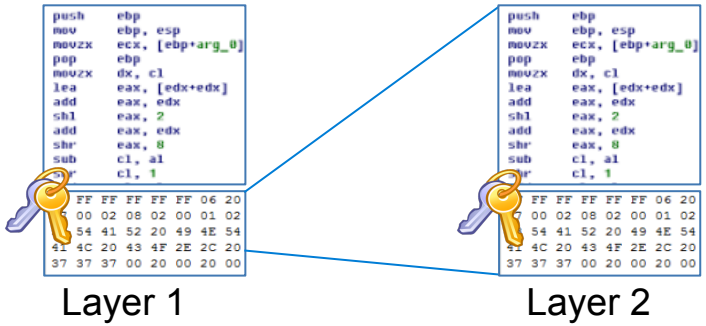


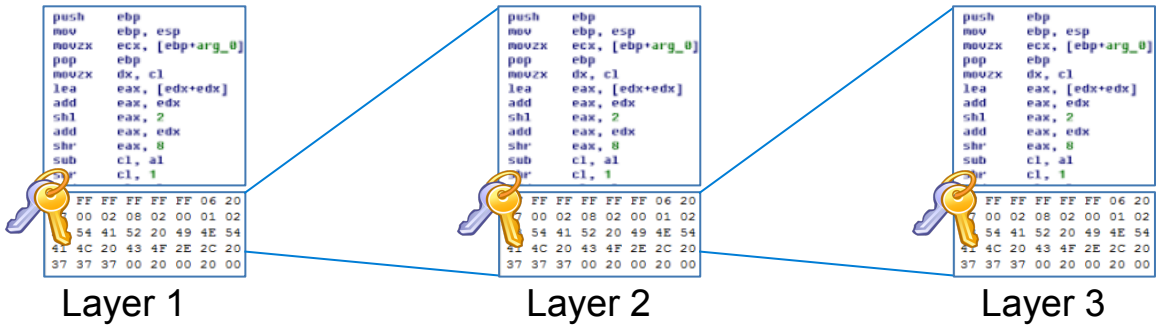
We all love ML, but in the presence of packing it just learns the wrong thing


Unpacking Routine
Packed Data
ebp
ebp, esp
ecx, [ebp+arg_0]
ebp
dx, cl
eax, [edx+edx]
eax, edx
eax, 2
eax, edx
eax, 8
cl, al
cl, 1
FF FF FF FF FF 06 20
00 02 08 02 00 01 02
54 41 52 20 49 4E 54
4C 20 43 4F 2E 2C 20
37 37 37 00 20 00 20 00

Layer 1




push ebp
mov ebp, esp
movzx ecx, [ebp+arg_0]
pop ebp
movzx dx, cl
lea eax, [edx+edx]
add eax, edx
shl eax, 2
add eax, edx
shr eax, 8
sub cl, al
shr cl, 1
FF FF FF FF FF 06 20
00 02 08 02 00 01 02
54 41 52 20 49 4E 54
4C 20 43 4F 2E 2C 20
37 37 37 00 20 00 20 00
Layer 1
Layer 2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add eax, edx
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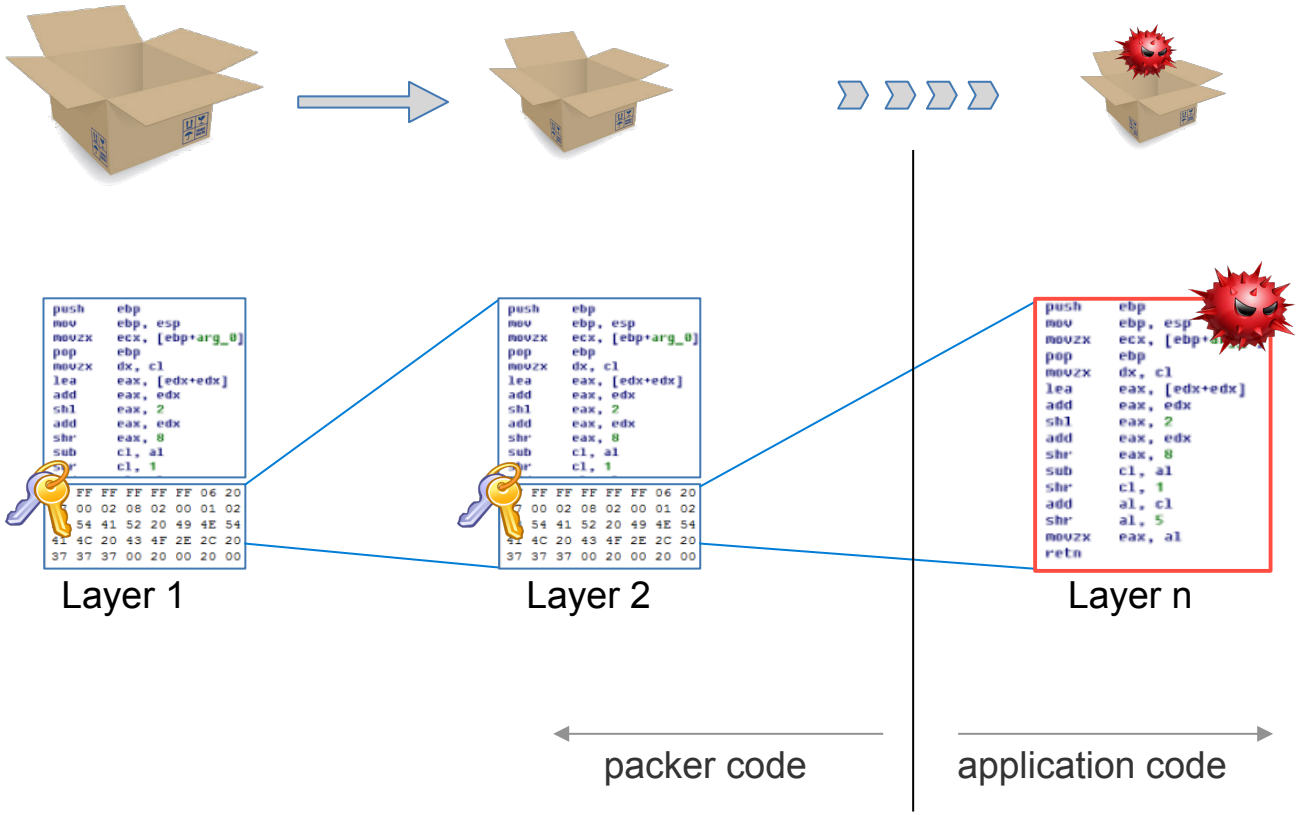
add eax, edx
shr eax, 8
sub cl, al
shr cl, 1
FF FF FF FF FF 06 20
00 02 08 02 00 01 02
54 41 52 20 49 4E 54
4C 20 43 4F 2E 2C 20
37 37 37 00 20 00 20 00
Layer 1
Layer 2
Layer 3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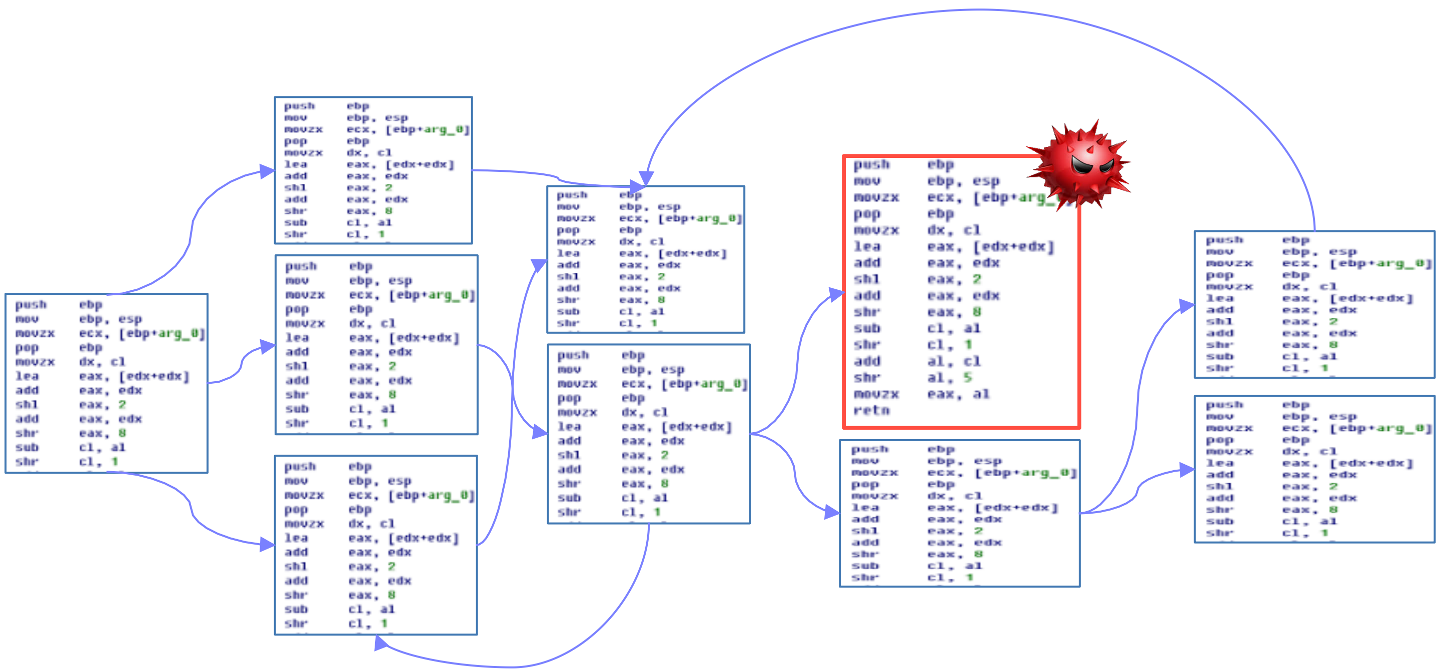
mov ebp, esp
movzx ecx, [ebp+arg_0]
pop ebp
movzx dx, cl
lea eax, [edx+edx]
add eax, edx
shl eax, 2
add eax, edx
shr eax, 8
sub cl, al
shr cl, 1
add al, cl
shr al, 5
movzx eax, al
retn
Layer 1
Layer 2
Layer n
packer code
application code


push ebp
mov ebp, esp
movzx ecx, [ebp+arg_
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sub cl, al
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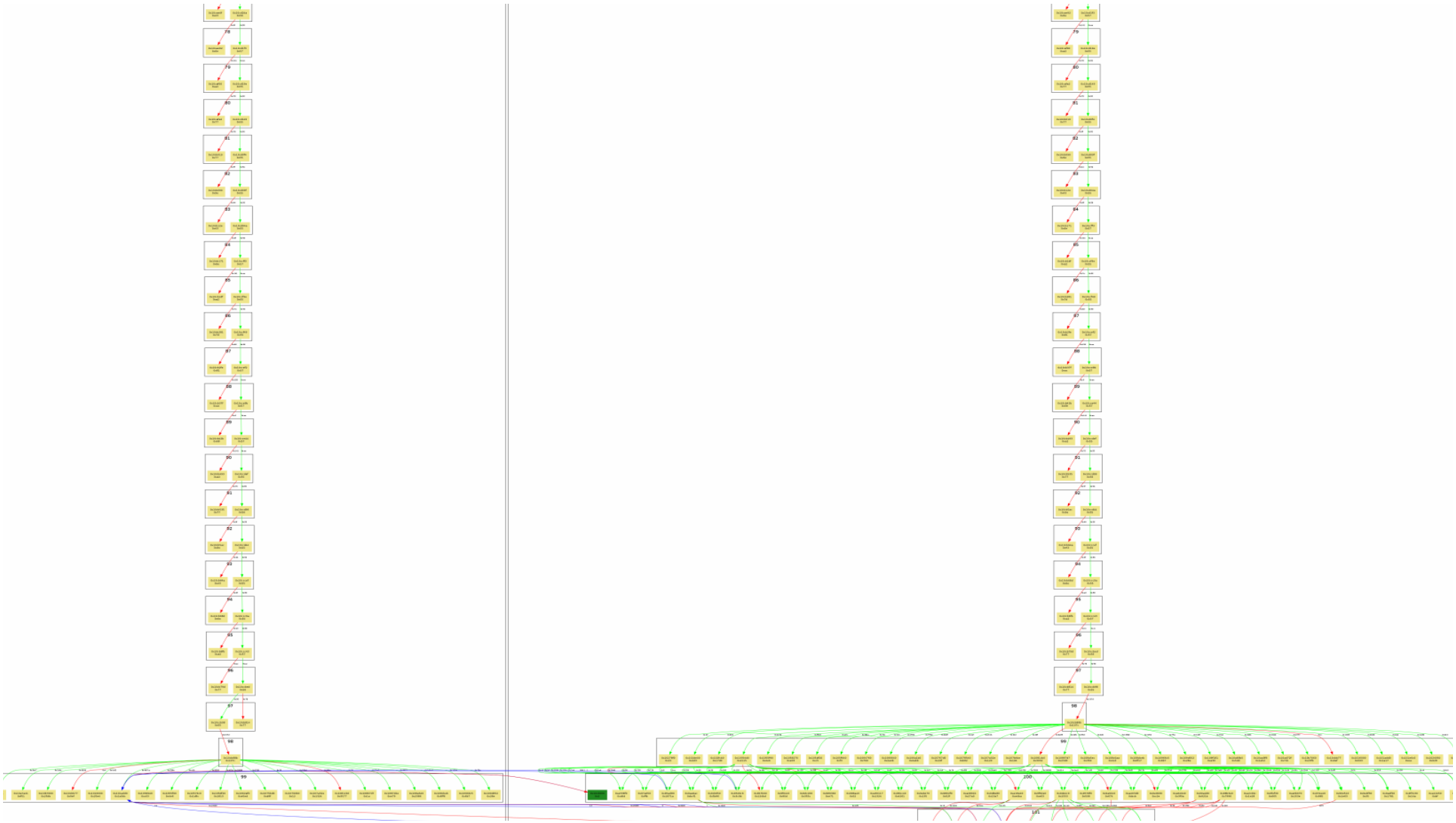
add al, cl
shr al, 5
movzx eax, al
retn



Complexity Classes

[Class I] *a single unpacking routine is executed before transferring the control to the unpacked program*

[Class II] *multiple unpacking layers are executed sequentially and lead to the original code at the end*

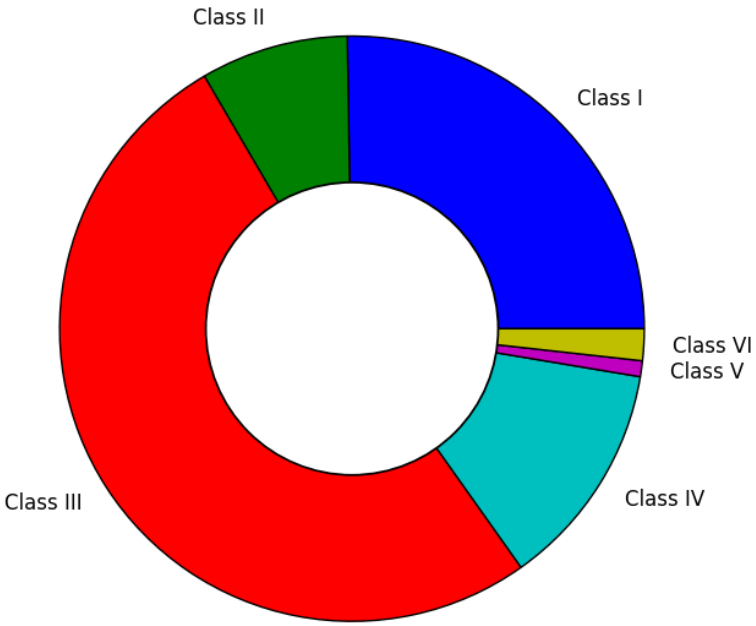
[Class III] *intermediate layers are executed in loops*

[Class IV] *the packer code is interleaved with the execution of the unpacked program*

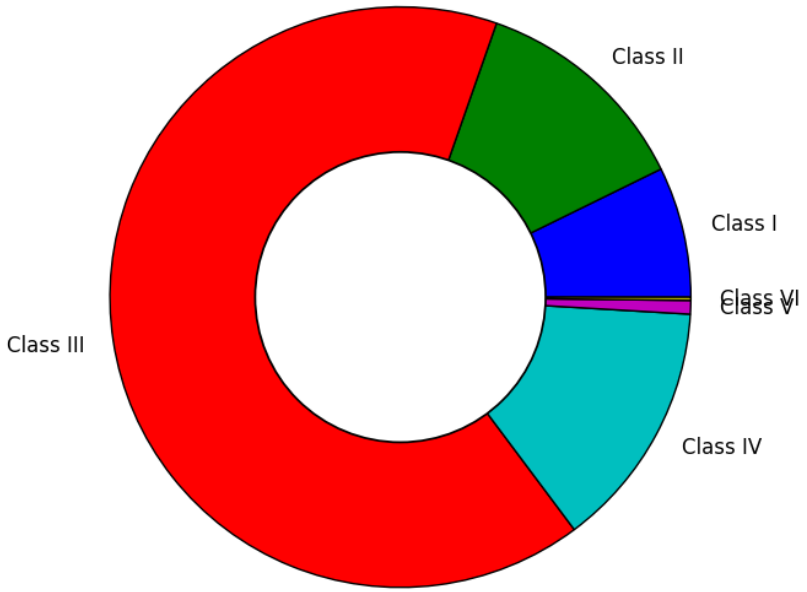
[Class V] *pieces of the original program are unpacked on-demand*

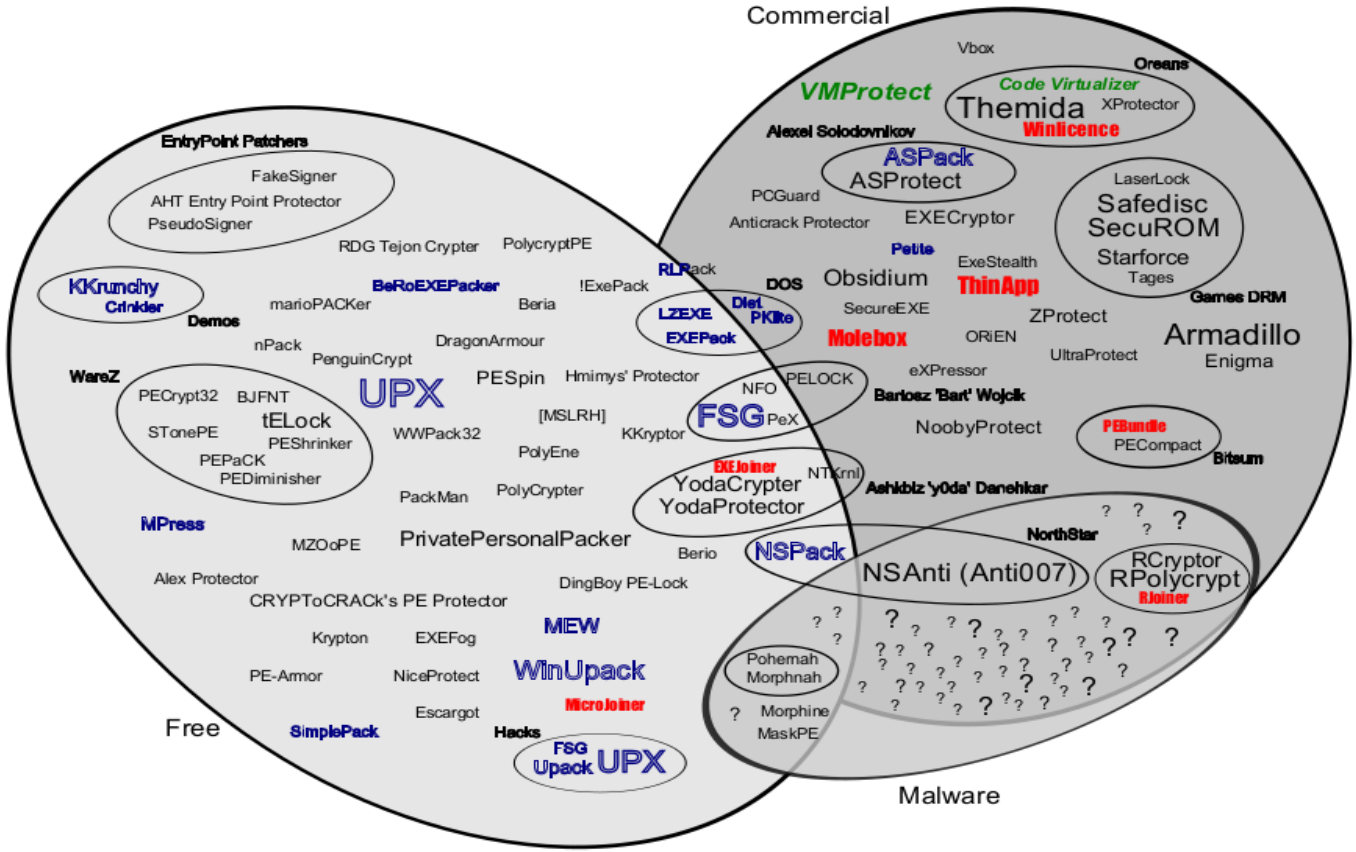
[Class VI] *only a single fragment of the original program (as little as a single instruction) is unpacked in memory at any moment in time*

Off-The-Shelf Packers



Custom Malware Packers





Why Does Packing Matter?

- Dynamic analysis techniques (e.g., sandboxes) have been introduced to deal with packing…
- …but static analysis techniques are more efficient!

An Experiment

- Benign programs from Windows OSs (XP, Vista, 7, NT)
  - 7983 samples
- Packed with 4 different packers
  - 16663 samples
- Submitted to VirusTotal
  - Looking for 10+ detections
- See: http://sarvamblog.blogspot.com/2013/05/nearly-70-of-packed-windows-system.html

Results

- UPX: 0% False Positives 
- BEP: 72.78% False Positives 
- NsPack: 98.72% False Positives 
- Upack: 99.88% False Positives 

Packing = Malware?

- False Positives

- Dataset Pollution

How Did We Get Here?

- Machine Learning has been increasingly used to perform malware detection
- The misclassification of packed binaries is the result of learning the wrong thing…

- Let's take a step back!

What Is Machine Learning?

- “Machine learning explores the study and construction of algorithms that can learn from and perform predictive analysis on data”

https://en.wikipedia.org/wiki/Machine_learning

Why Machine Learning?

- Supports data analysis
- Supports characterization
- Supports classification

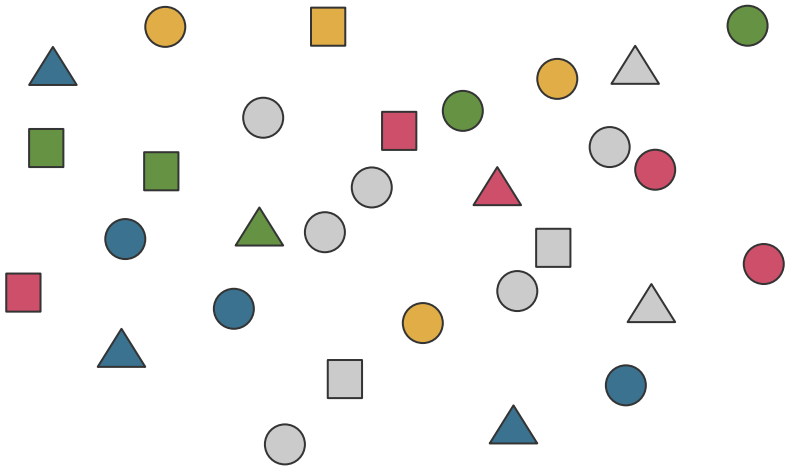
Machine Learning

?

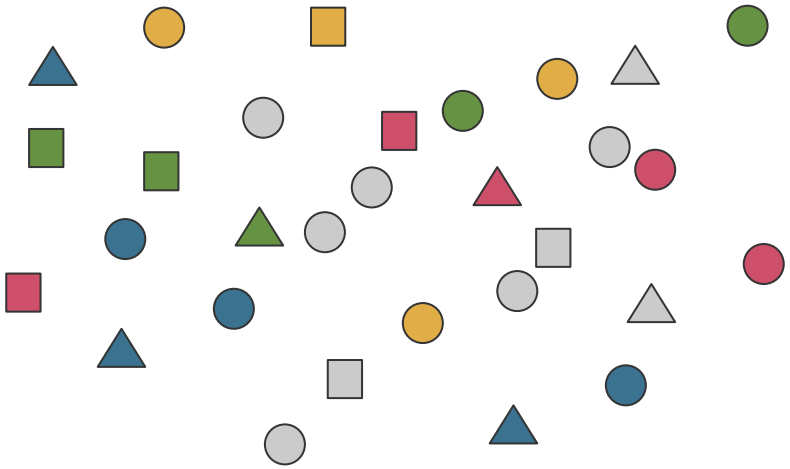
Round?

Has >3 sides?

…



Machine Learning



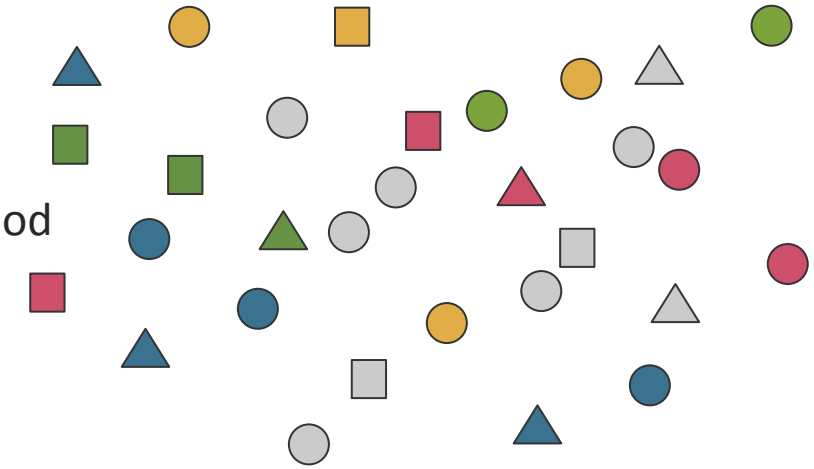
Machine Learning

?

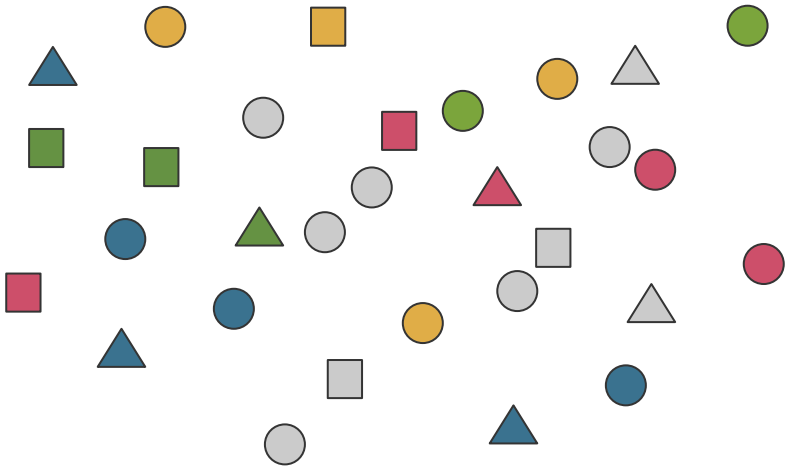
Reds are bad

Blues, greens, oranges are good

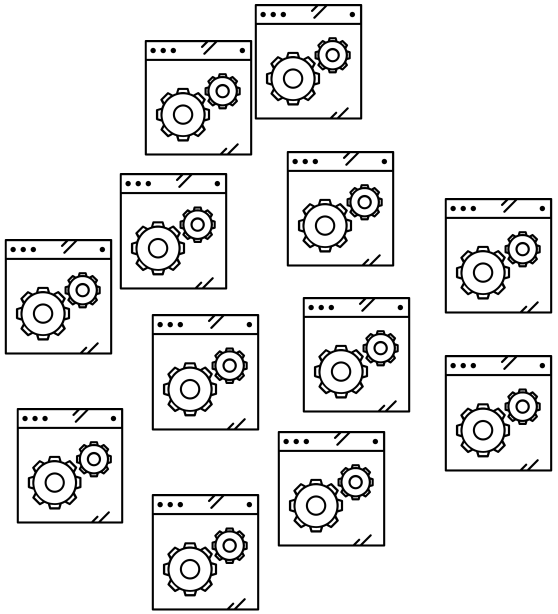
What about greys?

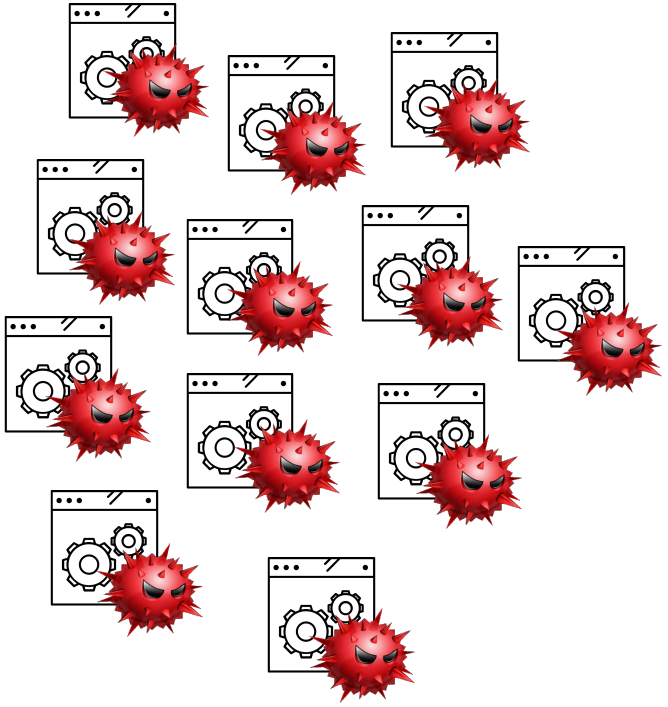


Machine Learning



Pitfalls in Machine Learning





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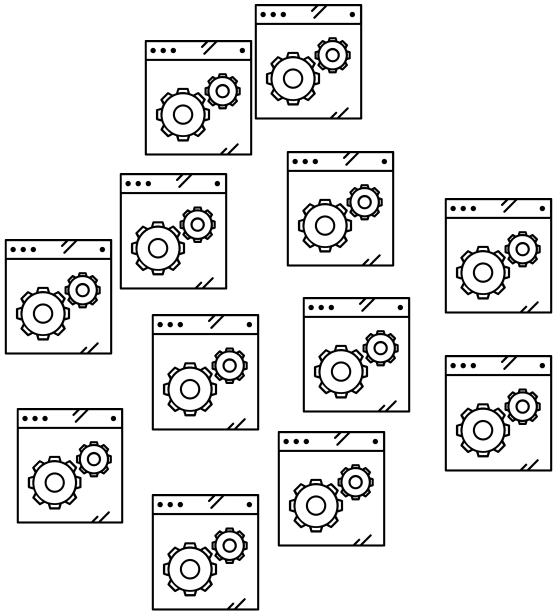

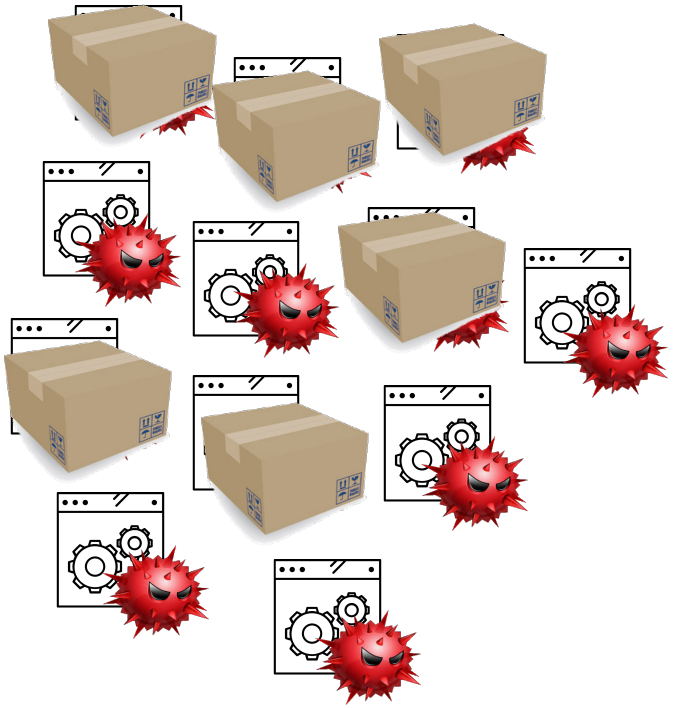

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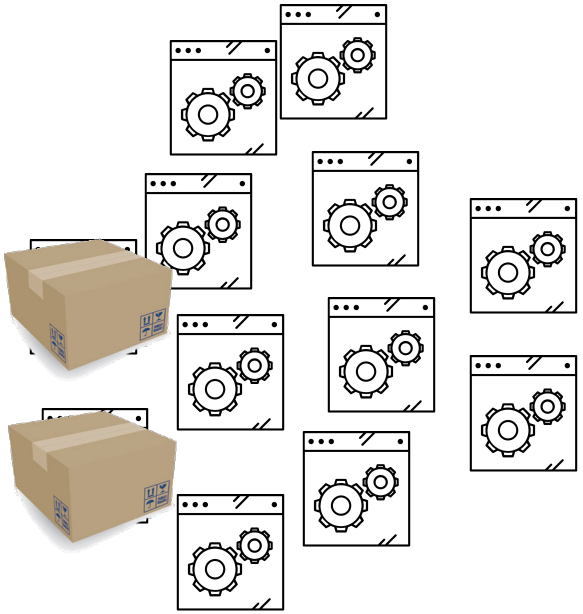

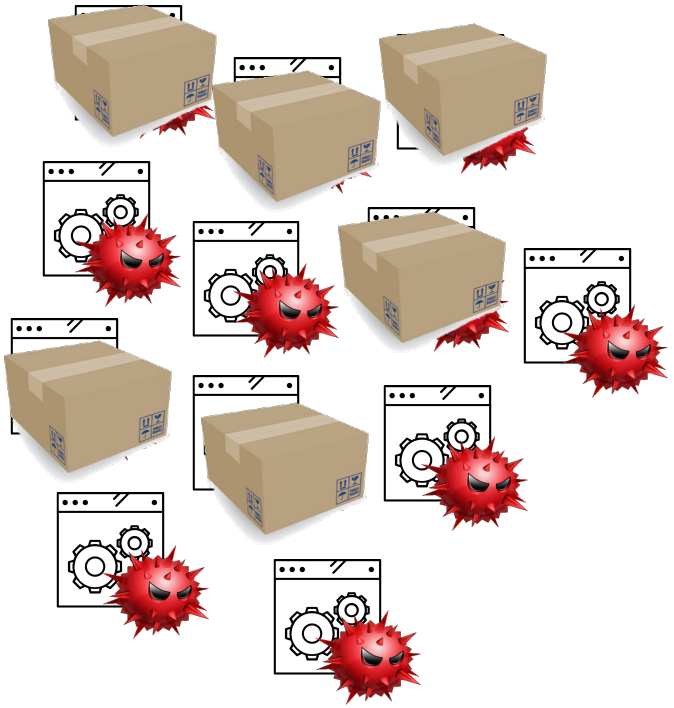

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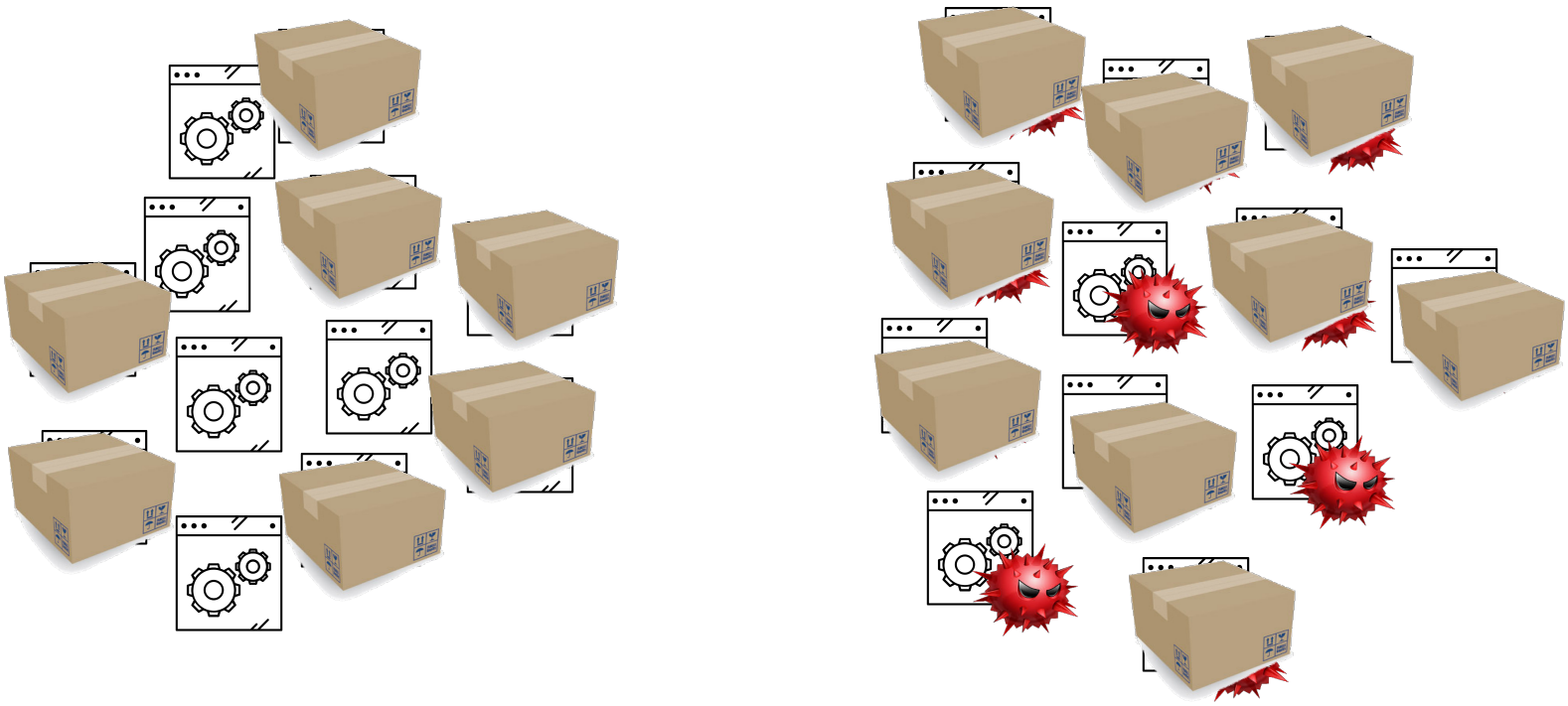
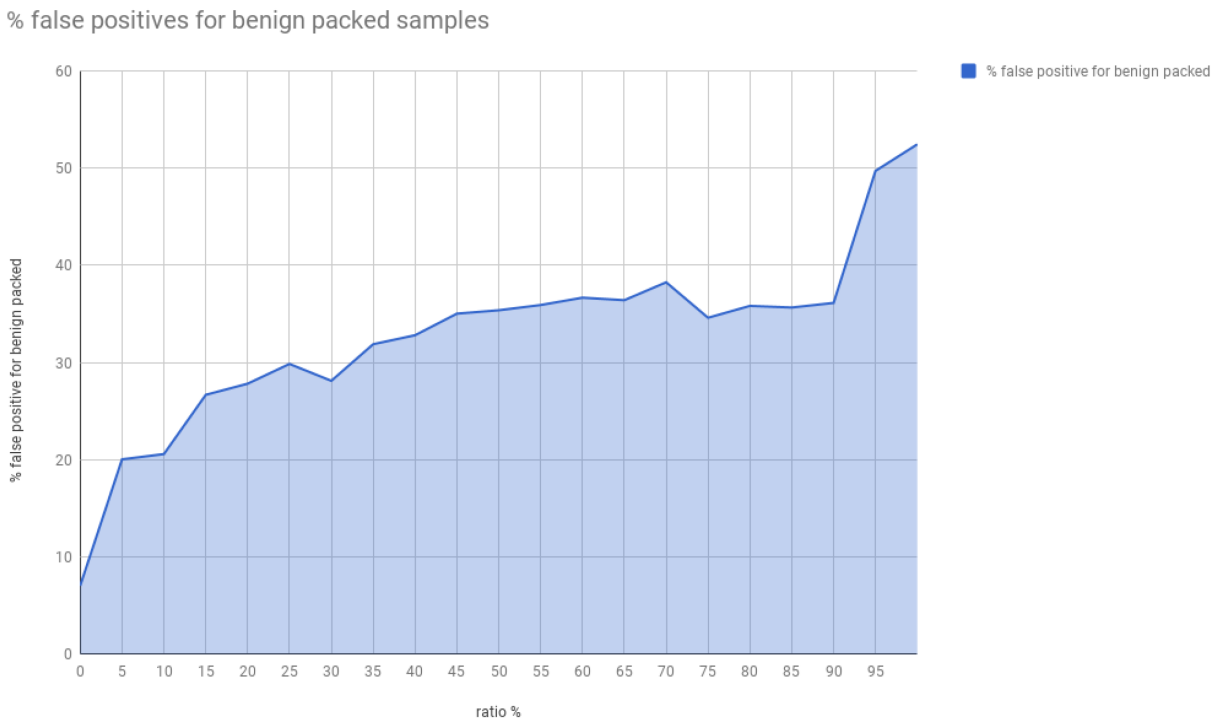


Another Experiment

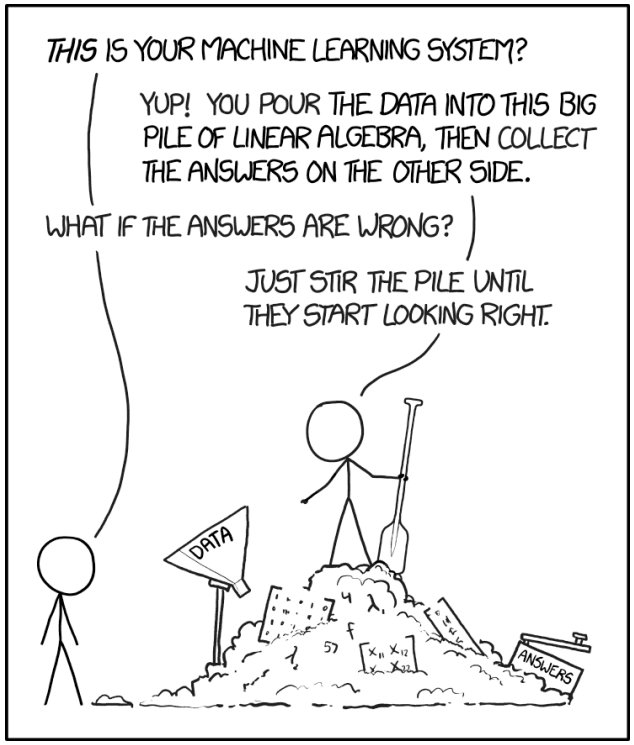


Insight: When most of malware is packed, *packing* is what is actually learned

Conclusions

- Applying machine learning to packed malware might lead to the detection of packing (and not the detection of malicious behavior) resulting in false positives
  - De-sensitization caused by false positives
  - Pollution of datasets
- Sophisticated dynamic unpacking and analysis is necessary

Questions?



process by Roman from the Noun Project
Machine learning picture: https://xkcd.com/1838/