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Looking for the perfect signature: an automatic YARA rules generation algorithm in the AI-era

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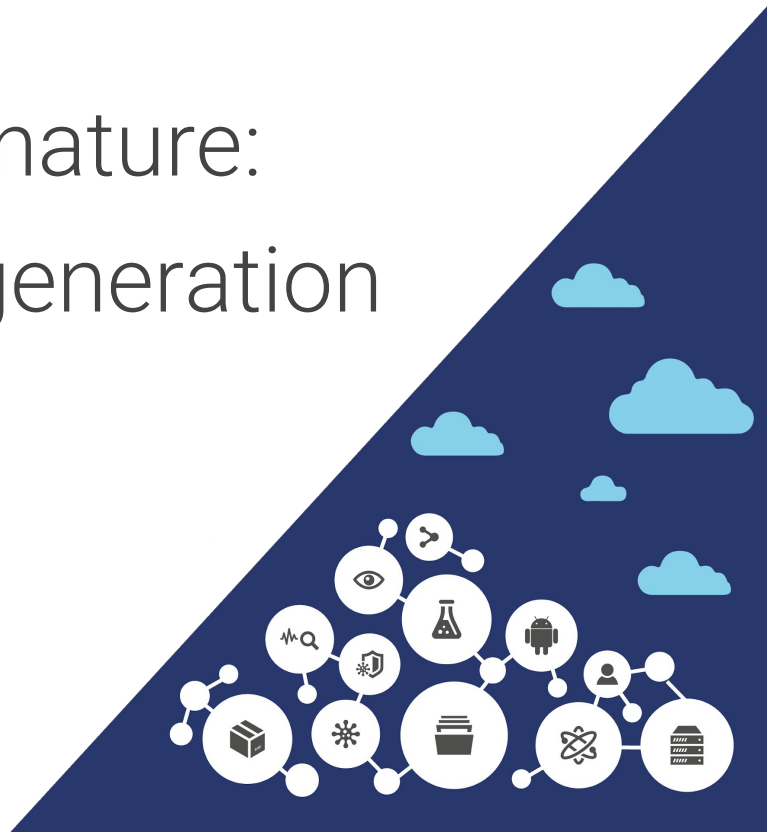

Who I am

PhD Student at Politecnico di Torino

ML, semi-supervised modeling, optimization problem

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Agenda

The signature generation problem

The algorithm

Introducing YaYaGen

Demo

The signature generation problem

What is a malware signature?

A unique pattern that indicates the presence of malicious code

As malware evolves, new signatures need to be generated frequently

Syntactic signatures are based on unique sequences of instructions or strings
* this is where the most of the existing tools and researches focus on

Semantic signatures provides an abstraction of the program behavior

Our target is **Android malware**, although the approach is generic

This is not just another ML classifier.

Work motivations

Reduce
the malware
exposure time

Automate
a repetitive task

20k - 50k SUBMISSIONS
EVERY DAY

100% recall
and high
precision
requirements

Save
a considerable
amount of time
and resources

About YARA

“YARA is to files what Snort is to network traffic”

Designed to be fast

The **de-facto standard** language to write malware signatures

Natively supports **syntactic signatures** (strings + regex + hex)

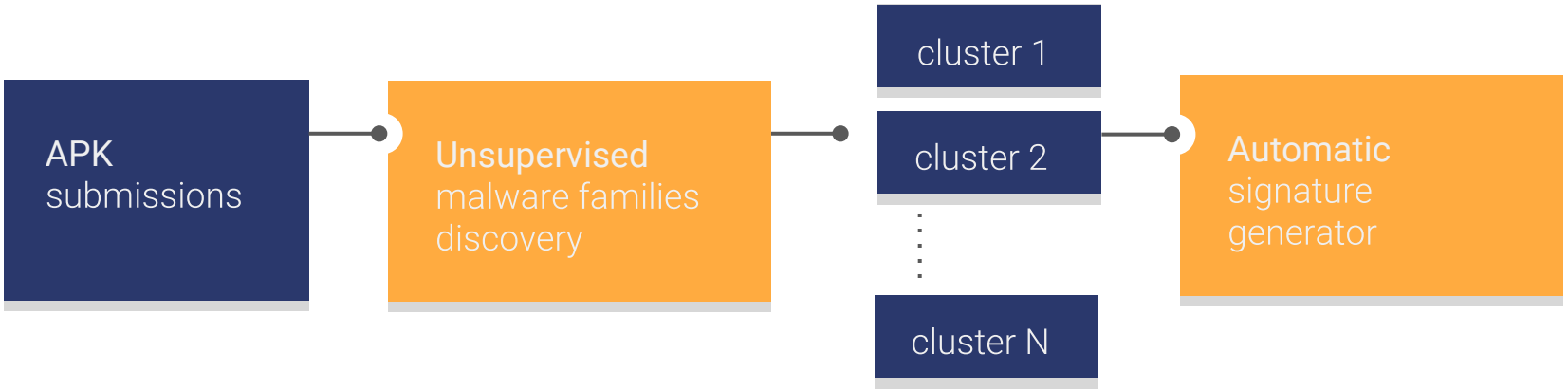
Semantic signatures are defined through custom modules.

An example of YARA rule

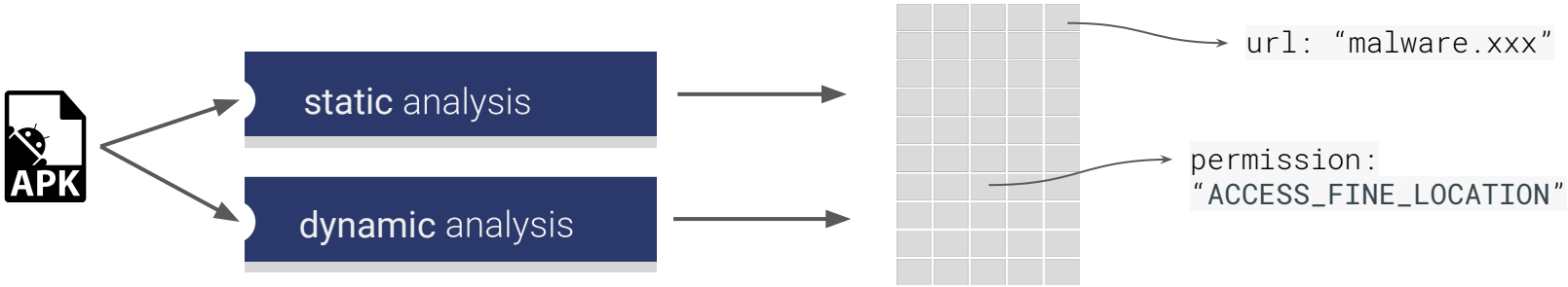
```
rule YaYaSyringe {

    meta:
        author = "DEF CON 26"

    strings:
        $a = “text here”
        $b = { E2 34 A1 C8 23 FB }

    condition:
        $a and $b
        and androguard.filter("action.BATTERYCHECK")
        and androguard.number_of_services == 3
        …
}
```

The algorithm

The detection workflow



The attributes



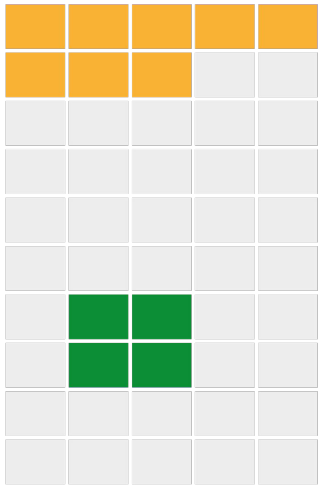
Each block is an attribute extracted through the analysis

*Androguard, *Droidbox, Cockoo are used

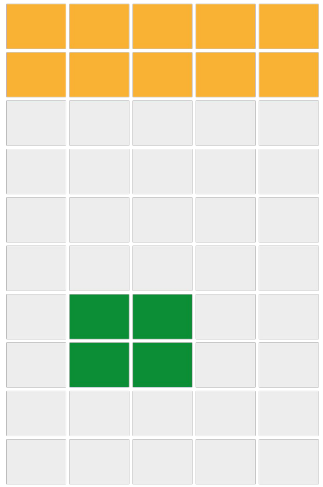
The **quality of the analysis** affects the signature generation process.

* They require a custom YARA module

Sample 1



Sample 2



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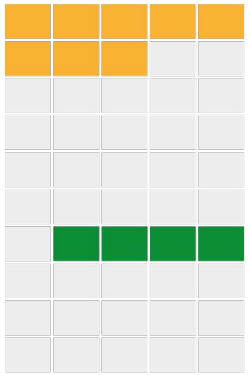
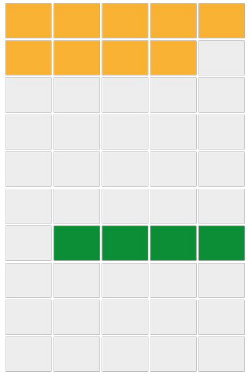
Signature

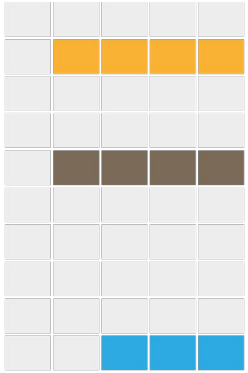
Sample 1



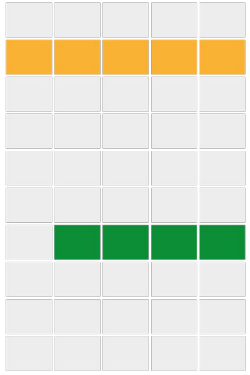
Sample 2



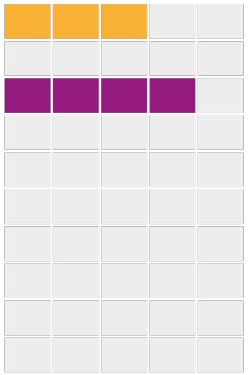
Sample 3



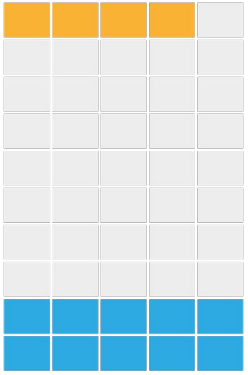
Sample 4



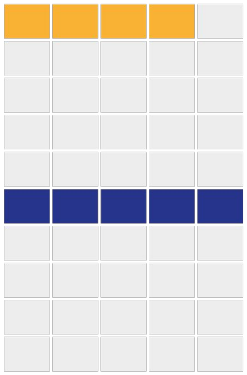
Sample 5



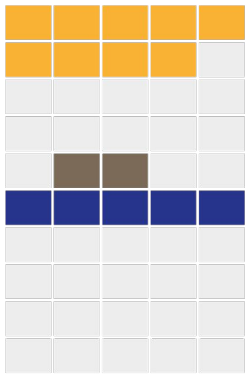
Sample 6



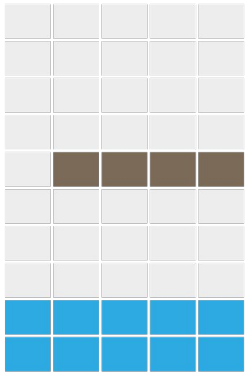
Sample 7



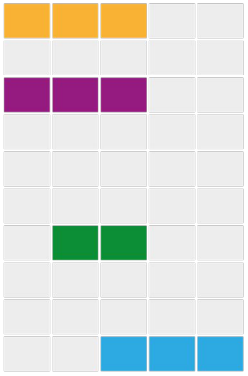
Sample 8



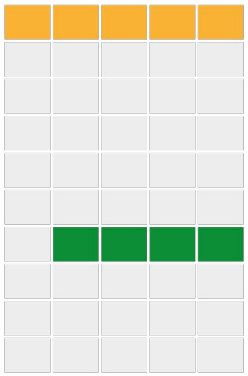
Sample 9



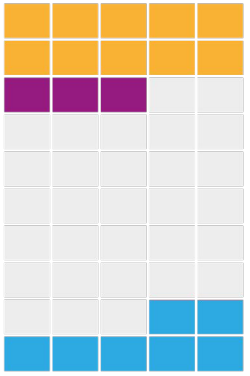
Sample 10



Sample 11



Sample 12



The solution

Finding the optimal attributes subsets is the goal of the signature generation process

The problem can be reduced to a variant of the set cover problem (NP-complete)

A **dynamic greedy algorithm** builds the signature as a disjunction of clauses.

Normal form

$$(l_1 \wedge l_2 \wedge l_3) \vee (l_4 \wedge l_5)$$

clause

literal

Signature anatomy

Each signature can be expressed in **DNF**

$$S = \bigvee_{i=0}^{n} c_i \quad c_i = \bigwedge_{j=0}^{m(i)} l_{i,j}$$

Each **clause** can be **weighed**

$$w(c_i) = \sum_{j=0}^{m(i)} w(l_{i,j})$$

The weight of a signature **is the lowest** among its clauses

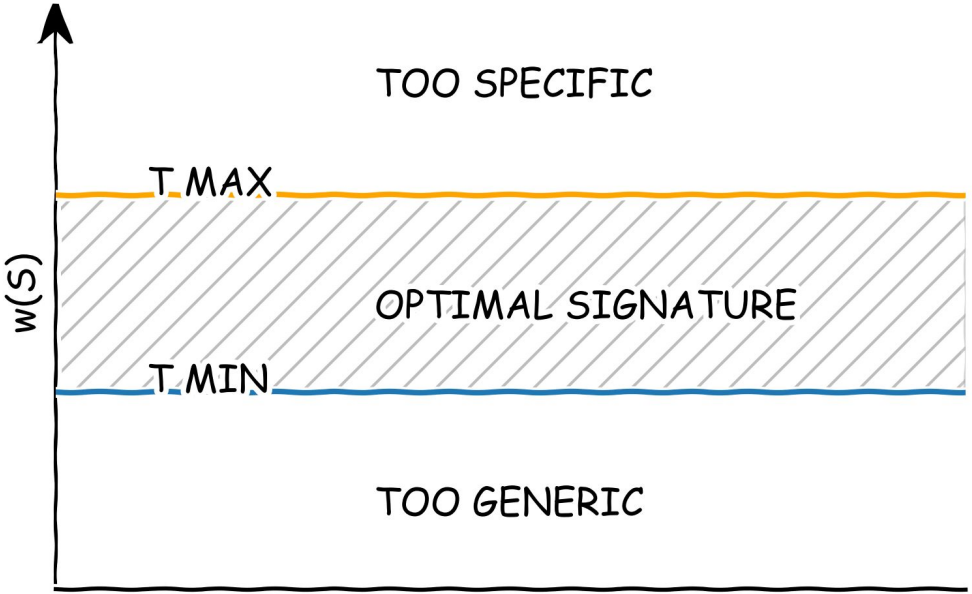
$$w(S) = \min_{\forall i} w(c_i)$$

Generality vs specificity

A **weighting system** evaluates the rules

The higher the weight, the less FP
Possibly more FN

The lower the weight, the more FP
Possibly less FN

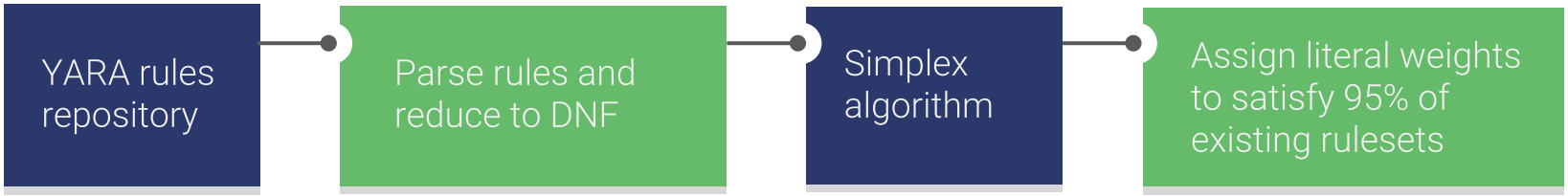


Weighting process

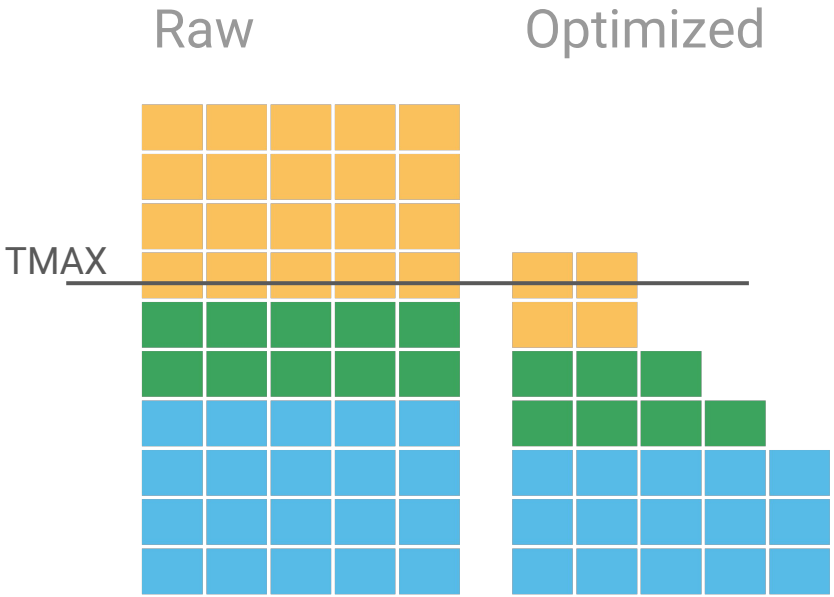
Assign correct weights is the key to guarantee high quality results

The value of **TMIN** and **TMAX** is strongly related to the choice of the weights

The process is designed to be automated



Optimization



Experimental results show that automatically generated rules could be **over-specific**

Two approaches:

- **Basic optimizer** (< 1 min)
  a greedy optimizer
- **Evo optimizer** (~ 5 min)
  based on EA. Encodes the human expert knowledge

Introducing YaYaGen

Yet another YARA rule Generator

*YaYa is grandma in ES

From

a set of **application analysis reports**

to

a set of **YARA rules**

Yet another YARA rule Generator

*YaYa is grandma in ES

2 algorithms (*clot*, *greedy*), **2 optimizers** (*basic*, *evo*) and some **heuristics**

Includes a **YARA rule parser** for attributes weight optimization

Supports **FP exclusion** from rule generation

Written in Python 3

Ready for ***Koodous** (collaborative platform for Android malware research)

* https://koodous.com/

Fork me on GitHub

https://github.com/jimmy-sonny/YaYaGen

Demo

Results

Results

Rule Name	Original	YaYaGen	Improvement
SMSSENDER	539	1,004	+86.3%
SYRINGE	220	315	+43.2%
HUMMINGBAD2	136	257	+89.0%
MARCHER2	559	652	+16.6%
SMSREG	159	172	+8.2%
VOLCMANDROPPER	186	430	+131.2%

Takeaways

Automatically generated rules **perform better** than manual written ones

However, there is still room for improvement

Existing rulesets are used to trim the algorithm

Exploit the expert knowledge

The time required to generate a rule from **100 apps is less 5 minutes**

Ready for real-world applications

Ongoing work

YaYaGenPE

Questions?

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cost
EUROPEAN COOPERATION
IN SCIENCE & TECHNOLOGY

Thank you

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https://github.com/AlienVault-OTX/yabin

https://www.talosintelligence.com/bass