YARA User's Manual Ver. 1.2

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1. YARA in a nutshell

YARA is a tool aimed at helping malware researchers to identify and classify malware families. With YARA you can create descriptions of malware families based on textual or binary information contained on samples of those families. These descriptions, named rules, consist of a set of strings and a Boolean expression which determines the rule logic.

Let's explain it with an example. Suppose that we have a malware family with two variants, one of them downloads a malicious file from *http://foo.com/badfile1.exe*, the other downloads a file from *http://bar.com/badfile2.exe*, the URLs are hardcoded into the malware code. Both variants drops the downloaded file with the name *win.exe*, which also appears hardcoded into the samples. For this hypothetical family we can create a rule like this:

```
rule BadBoy
{
      strings:
         $a = "win.exe"
         $b = "http://foo.com/badfile1.exe"
         $c = "http://bar.com/badfile2.exe"

      condition:
         $a and ($b or $c)
}
```

The rule above instructs YARA that those files containing the string *win.exe* and any of the two URLs must be reported as BadBoy.

This is just a simple example, but more complex and powerful rules can be created by using binary strings with wild-cards, case-insensitive text strings, regular expressions, and many other features provided by YARA that will be covered in this manual.

2. Writing rules

YARA rules are easy to write and understand, and they have a syntax that resembles in some way a C struct declaration. He here is the simplest rule that you can write for YARA, which does absolutely nothing:

```
rule Dummy
{
      condition:
         false
}
```

Each rule in YARA starts with the keyword `rule` followed by a rule identifier. Identifiers must follow the same lexical conventions of the C programming language, they can contain any alphanumeric character and the underscore character, but the first character can not be a digit. Rule identifiers are case sensitive and cannot exceed 128 characters. The following keywords are reserved and cannot be used as an identifier:

```
all             global          rule
and             is              rva
any             in              section
ascii           int8            strings
at              int16           them
condition       int32           true
entrypoint      nocase          uint8
false           not             uint16
filesize        or              uint32
fullword        of              wide
for             private
```

Rules are generally composed of two sections: strings definition and condition, although the strings definition section can be omitted if the rule doesn't rely on any string. The condition section is always required. The strings definition section is where the strings that will be part of the rule are defined. Each string has an identifier consisting in a $ character followed by a sequence of alphanumeric characters and underscores, these identifiers can be used in the condition section to refer to the corresponding string. Strings can be defined in text or hexadecimal form, as shown in the following example:

```
rule ExampleRule
{
    strings:
        $my_text_string = "text here"
        $my_hex_string = { E2 34 A1 C8 23 FB }

    condition:
        $my_text_string or $my_hex_string
}
```

Text strings are enclosed on double quotes just like in the C language. Hex strings are enclosed by curly brackets, and they are composed by a sequence of hexadecimal numbers that can appear contiguously or separated by spaces. Decimal numbers are not allowed in hex strings.

The condition section is where the logic of the rule resides. This section must contain a Boolean expression telling under which circumstances a file satisfies the rule or not. Generally, the condition will refer to previously defined strings by using the string identifier. In this context the string identifier acts as a Boolean variable which evaluate to true of the string was found in the file, or false otherwise. If the condition is true for a given file, the file matches the rule.

2.1 Comments

You can add comments to your YARA rules just as if it was a C source file, both single-line and multi-line C-style comments are supported.

```
/*
     This is a multi-line comment ...
*/

rule CommentExample    // ... and this is single-line comment
{
     condition:
        false  // just an dummy rule, don't do this
}
```

3. Strings

There are three types of strings in YARA: hexadecimal strings, text strings and regular expressions. Hexadecimal strings are used for defining raw sequences of bytes, while text strings and regular expressions are useful for defining portions of legible text. However text strings and regular expressions can be also used for representing raw bytes by mean of escape sequences as will be shown below.

3.1 Hexadecimal strings

Hexadecimal strings allow three special constructions that make them more flexible: wild-cards, jumps, and alternatives. Wild-cards are just placeholders that you can put into the string indicating that some bytes are unknown and they should match anything. The placeholder character is the question mark (?). Here you have an example of a hexadecimal string with wild-cards:

```
rule WildcardExample
{
     strings:
        $hex_string = { E2 34 ?? C8 A? FB }

     condition:
        $hex_string
}
```

As shown in the example the wild-cards are nibble-wise, which means that you can define just one nibble of the byte and leave the other unknown.

Wild-cards are useful when defining strings whose content can vary but you know the length of the variable chunks, however, this is not always the case. In some circumstances you may need to define strings with chunks of variable content and length. In those situations you can use jumps instead of wild-cards.

```
rule JumpExample
{
    strings:
        $hex_string = { F4 23 [4-6] 62 B4 }

    condition:
        $hex_string
}
```

In the example above we have a pair of numbers enclosed in square brackets and separated by a hyphen, that's a jump. This jump is indicating that any arbitrary sequence from 4 to 6 bytes can occupy the position of the jump. Any of the following strings will match the pattern:

```
F4 23 01 02 03 04 62 B4
F4 23 00 00 00 00 00 62 B4
F4 23 15 82 A3 04 45 22 62 B4
```

The lower bound of a jump (the number before the hyphen) must be greater than or equal to zero and lower than the higher bound (the number after the hyphen), while the higher bound cannot exceed 255. These are valid jumps:

s

```
FE 39 45 [0-8] 89 00
FE 39 45 [23-45] 89 00
FE 39 45 [128-255] 89 00
```

These are invalid:

```
FE 39 45 [10-7] 89 00
FE 39 45 [4-4] 89 00
FE 39 45 [200-300] 89 00
```

A jump can be also specified by a single number enclosed in brackets like this:

```
FE 39 45 [6] 89 00
```

That means that exactly 6 bytes must exist in the place occupied by the jump, and it's equivalent to:

```
FE 39 45 ?? ?? ?? ?? ?? ?? 89 00
```

Of course, wild-cards and jumps can be mixed together in the same string:

```
78 [4] 45 ?? 5F
```

The only limitation to wild-cards and jumps is that they can not appear at the beginning of the string. The follow strings are invalid:

```
5? 00 40 23
[4] 12 35
```

There are also situations in which you may want to provide different alternatives for a given fragment of your hex string. In those situations you can use a syntax which resembles a regular expression:

```
rule AlternativesExample1
{
    strings:
        $hex_string = { F4 23 ( 62 B4 | 56 ) 45 }

    condition:
        $hex_string
}
```

This rule will match any file containing `F42362B445` or `F4235645`.

But more than two alternatives can be also expressed. In fact, there are no limits to the amount of alternative sequences you can provide, and neither to their lengths.

```
rule AlternativesExample2
{
    strings:
        $hex_string = { F4 23 ( 62 B4 | 56 | 45 ?? 67 ) 45 }

    condition:
        $hex_string
}
```

As can be seen also in the above example, strings containing wild-cards are allowed as part of alternative sequences. However you can not include jumps or construct nested alternatives.

3.2 Text strings

As shown in previous sections, text strings are generally defined like this:

```
rule TextExample
{
    strings:
        $text_string = "foobar"

    condition:
        $text_string
}
```

This is the simplest case: an ASCII-encoded, case-sensitive string. However, text strings can be accompanied by some useful modifiers that alter the way in which the string will be

interpreted. Those modifiers are appended at the end of the string definition separated by spaces, as will be discussed below.

Text strings can also contain the following subset of the escape sequences available in the C language:

`\"`	Double quote
`\\`	Backslash
`\t`	Horizontal tab
`\x`*dd*	Any byte in hexadecimal notation

3.2.1 Case-insensitive strings

Text strings in YARA are case-sensitive by default, however you can turn your string into case-insensitive mode by appending the modifier `nocase` at the end of the string definition, in the same line.

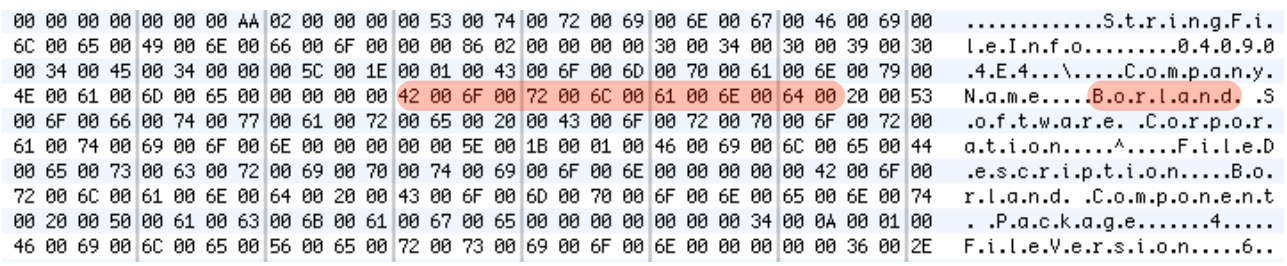
```
rule CaseInsensitveTextExample
{
      strings:
         $text_string = "foobar" nocase

      condition:
         $text_string
}
```

With the `nocase` modifier the string "foobar" will match "Foobar", "FOOBAR", and "fOoBaR".

This modifier can be used in conjunction with any other modifier.

3.2.2 Wide-character strings

The `wide` modifier can be used to search for strings encoded with two bytes per character, something typical in many executable binaries.



In the above figure de string "Borland" appears encoded as two bytes per character, therefore the following rule will match:

```
rule WideCharTextExample
{
      strings:
         $wide_string = "Borland" wide

      condition:
         $wide_string
}
```

However, keep in mind that this modifier just interleaves the ASCII codes of the characters in the string with zeroes, it does not support truly UTF-16 strings containing non-English characters. If you want to search for strings in both ASCII and wide form, you can use the `ascii` modifier in conjunction with `wide`, no matter the order in which they appear.

```
rule WideCharTextExample
{
      strings:
         $wide_and_ascii_string = "Borland" wide ascii

      condition:
         $wide_and_ascii_string
}
```

The `ascii` modifier can appear along, without an accompanying a `wide` modifier, but it's not necessary to write it because in absence of `wide` the string is assumed to be ASCII by default.

3.2.3 Searching for full words

Another modifier that can be applied to text strings is `fullword`. This modifier guarantee that the string will match only if it appears in the file delimited by non-alphanumeric characters. For example the string "domain", if defined as `fullword`, don't matches "www.mydomain.com" but it matches "www.my-domain.com" and "www.domain.com".

3.3 Regular expressions

Regular expressions are one of the most powerful features of YARA. They are defined in the same way as text strings, but enclosed in backslashes instead of double-quotes, like in the Perl programming language. The regular expression syntax is also Perl-compatible.

```
rule RegExpExample1
{
      strings:
         $re1 = /md5: [0-9a-zA-Z]{32}/
         $re2 = /state: (on|off)/

      condition:
         $re1 and $re2
}
```

Regular expressions can be also followed by `nocase`, `ascii`, `wide`, and `fullword` modifiers just like in text strings. The semantics of these modifiers are the same in both cases. For more information about Perl regular expressions please visit:
http://www.pcre.org/pcre.txt

4. Conditions

Conditions are nothing more than Boolean expressions as those that can be found in all programming languages, for example in an "if" statement. They can contain the typical Boolean operators `and`, `or` and `not` and relational operators `>=`, `<=`, `<`, `>`, `==` and `!=`. Also, the arithmetic operators (`+`, `-`, `*`, `\`) can be used on numerical expressions.

String identifiers can be also used within a condition, acting as Boolean variables whose value depends on the presence or not of the associated string in the file.

```
rule Example
{
      strings:
         $a = "text1"
         $b = "text2"
         $c = "text3"
         $d = "text4"

      condition:
         ($a or $b) and ($c or $d)
}
```

4.1 Counting strings

Sometimes we need to know not only if certain string is in the file or not, but how many times the string appears in the file. The number of occurrences of each string is represented by a variable whose name is the string identifier but with a # character in place of the $ character. For example:

```
rule CountExample
{
      strings:
         $a = "dummy1"
         $b = "dummy2"

      condition:
         #a == 6 and #b > 10
}
```

This rules match any file containing the string `$a` exactly six times, and more than ten occurrences of string `$b`.

4.2 String offsets

In the majority of cases, when a string identifier is used in a condition, we are willing to know if the associated string is anywhere within the file, but sometimes we need to know if the string is at some specific offset on the file. In such situations the operator `at` is what we need. This operator is used as shown in the following example:

```
rule AtExample
{
      strings:
         $a = "dummy1"
         $b = "dummy2"

      condition:
         $a at 100 and $b at 200
}
```

The expression `$a at 100` in the above example is true only if string `$a` is found at offset 100 within the file. The string `$b` should appear at offset 200. Please note that both offsets are decimal, however hexadecimal numbers can be written by adding the prefix 0x before the number as in the C language. Also note the higher precedence of the operator `at` over the `and`.

While the `at` operator allows to search for a string at some fixed offset in the file, the `in` operator allows to search for the string within a range of offsets.

```
rule InExample
{
      strings:
         $a = "dummy1"
         $b = "dummy2"

      condition:
         $a in (0..100) and $b in (100..filesize)
}
```

In the example above the string `$a` must be found at an offset between 0 and 100, while string `$b` must be at an offset between 100 and the end of the file. Again the numbers are decimal by default.

As explained in the previous section, we can use the identifier `#a` to get the number of times that string `$a` appears in the file. In a similar way we can use `@a` to obtain the first offset where `$a` is located within the file. Notice that because `@a` returns always the offset of the first occurrence of `$a`, and can exist many of them, the expression `$a at 100` is not equivalent to `@a == 100`. If `$a` appears at offsets 50 and 100 of the file, the former is true while the latter is false.

4.3 File size

String identifiers are not the only variables that can appear in a condition (in fact, rules can be defined without any string definition as will be shown below), there are other special variables that can be used as well. One of these especial variables is `filesize`, which holds, as its name indicates, the size of the file being analyzed. The size is expressed in bytes.

```
rule FileSizeExample
{
    condition:
       filesize > 200KB
}
```

The previous example also demonstrate the use of the KB postfix. This postfix, when attached to a numerical constant, automatically multiplies the value of the constant by 1024. The MB postfix can be used to multiply the value by 2^{20}. Both postfixes can be used only with decimal constants.

4.4 Entry point

Another special variable than can be used on a rule is `entrypoint`. If the file is a Portable Executable (PE), this variable holds the raw offset (not the RVA) of the entry point of the executable. A typical use of this variable is to look for some pattern at the entry point to detect packers or simple PE infectors.

```
rule EntryPointExample1
{
    strings:
       $a = { E8 00 00 00 00 }

    condition:
       $a at entrypoint
}

rule EntryPointExample2
{
    strings:
       $a = { 9C 50 66 A1 ?? ?? ?? 00 66 A9 ?? ?? 58 0F 85 }

    condition:
       $a in (entrypoint..entrypoint + 10)
}
```

The presence of the `entrypoint` variable in a rule implies that only PE files can satisfy that rule. If the file is not a PE any rule using this variable evaluates to false.

4.5 Accessing data from the file

There are many situations in which you may want to write conditions that depends on data stored in the file at a certain offset. In those situations you can use one of the following functions to read from the file at the given offset:

```
int8(<offset>)
int16(<offset>)
int32(<offset>)
uint8(<offset>)
uint16(<offset>)
uint32(<offset>)
```

The `intXX` functions read 8, 16, and 32 bits signed integers from *<offset>*, while functions `uintXX` read unsigned integers. Both 16 and 32 bits integer are considered to be little-endian. The *<offset>* parameter can be any expression returning an unsigned integer, including the return value of one the `uintXX` functions itself. As an example let's see a rule to distinguish PE files:

```
rule IsPE
{
    condition:
        // MZ signature at offset 0 and ...
        uint16(0) == 0x5A4D and
        // ... PE signature at offset stored in MZ header at 0x3C
        uint32(uint32(0x3C)) == 0x00004550
}
```

4.6 Sets of strings

There are circumstances in which is necessary to express that the file should contain a certain number strings from a given set. None of the strings in the set are required to be present, but at least some of them should be. In these situations the operator `of` come into help.

```
rule OfExample1
{
    strings:
        $a = "dummy1"
        $b = "dummy2"
        $c = "dummy3"

    condition:
        2 of ($a,$b,$c)
}
```

What this rule says is that at least two of the strings in the set `($a,$b,$c)` must be present on the file, no matter which. Of course, when using this operator, the number before the `of` keyword must be equal to or less than the number of strings in the set.

The elements of the set can be explicitly enumerated like in the previous example, or can be specified by using wild cards. For example:

```
rule OfExample2
{
      strings:
         $foo1 = "foo1"
         $foo2 = "foo2"
         $foo3 = "foo3"

      condition:

         /* ($foo*) is equivalent to ($foo1,$foo2,$foo3) */

         2 of ($foo*)
}

rule OfExample3
{
      strings:
         $foo1 = "foo1"
         $foo2 = "foo2"
         $foo3 = "foo3"

         $bar1 = "bar1"
         $bar2 = "bar2"

      condition:
         3 of ($foo*,$bar1,$bar2)
}
```

You can even use `($*)` to refer to all the strings in your rule, or write the equivalent keyword `them` for more legibility.

```
rule OfExample4
{
      strings:
         $a = "dummy1"
         $b = "dummy2"
         $c = "dummy3"

      condition:
         1 of them /* equivalent to 1 of ($*) */
}
```

In all the above examples the number of strings have been specified by a numeric constant, but any expression returning a numeric value can be used. The keywords `any` and `all` can be used as well.

```
all of them        /* all strings in the rule */
any of them        /* any string in the rule */
all of ($a*)       /* all strings whose identifier starts by $a */
any of ($a,$b,$c) /* any of $a, $b or $c */
1 of ($*)          /* same that "any of them" */
```

4.7 Applying the same condition to many strings

There is another operator very similar to `of` but even more powerful, the `for..of` operator. The syntax is:

```
for expression of string_set : ( boolean_expression )
```

And its meaning is: from those strings in *`string_set`* at least *`expression`* of them must satisfy *`boolean_expression`*.

In other words: *`boolean_expression`* is evaluated for every string in *`string_set`* and must be at least *`expression`* of them returning True.

Of course, *`boolean_expression`* can be any boolean expression accepted in the condition section of a rule, except for one important detail: here you can (and should) use a dollar sign ($) as a place-holder for the string being evaluated. Take a look to the following expression:

```
for any of ($a,$b,$c) : ( $ at entrypoint  )
```

The `$` symbol in the boolean expression is not tied to any particular string, it will be `$a`, and then `$b`, and then `$c` in the three successive evaluations of the expression.

Maybe you already realized that the `of` operator is an special case of `for..of`. The following expressions are the same:

```
any of ($a,$b,$c)
for any of ($a,$b,$c) : ( $ )
```

You can also employ the symbols `#` and `@` to make reference to the number of occurrences and the first offset of each string respectively.

```
for all of them : ( # > 3 )
for all of ($a*) : ( @ > @b )
```

4.8 Using anonymous strings with "of" and "for..of"

When using the `of` and `for..of` operators followed by `them`, the identifier assigned to each string of the rule are usually superfluous. As we are not referencing any string individually we don't not need to provide a unique identifier for each of them. In those situations you can declare anonymous strings with identifiers consisting only in the $ character, as in the following example:

```
rule AnonymousStrings
{
      strings:
         $ = "dummy1"
         $ = "dummy2"

      condition:
         1 of them
}
```

4.9 Referencing other rules

When writing the condition for a rule you can also make reference to a previously defined rule in a manner that resembles a function invocation of traditional programming languages. In this way you can create rules that depends on others. Let's see an example:

```
rule Rule1
{
      strings:
         $a = "dummy1"

      condition:
         $a
}

rule Rule2
{
      strings:
         $a = "dummy2"

      condition:
         $a and Rule1
}
```

As can be seen in the example, a file will satisfy Rule2 only if it contains the string "dummy2" and satisfy Rule1. Note that is strictly necessary to define the rule being invoked before the one that will make the invocation.

5. More about rules

There are some aspects of YARA rules that has not been covered yet, but still are very important. They are: global rules, private rules and rule tags.

5.1 Global rules

Global rules give you the possibility of imposing restrictions in all your rules at once. For example, suppose that you want all your rules ignoring those files that exceed certain size limit, you could go rule by rule doing the required modifications to their conditions, or just write a global rule like this one:

```
global rule SizeLimit
{
      condition:
         filesize < 2MB
}
```

You can define as many global rules as you want, they will be evaluated before the rest of the rules, which in turn will be evaluated only of all global rules are satisfied.

5.1 Private rules

Private rules are a very simple concept. That are just rules that are not reported by YARA when they match on a given file. Rules that are not reported at all may seem sterile at first glance, but when mixed with the possibility offered by YARA of referencing one rule from another (see section 4.5) they become useful. Private rules can serve as building blocks for other rules, and at the same time prevent cluttering YARA's output with irrelevant information. For declaring a rule as private just add the keyword `private` before the rule declaration.

```
private rule PrivateRuleExample
{
      ...
}
```

You can apply both `private` and `global` modifiers to a rule, resulting a global rule that does not get reported by YARA but must be satisfied.

5.3 Rule tags

Another useful feature of YARA is the possibility of adding tags to rules. Those tags can be used later to filter YARA's output and show only the rules that you are interesting in. You can add as many tags as you want to a rule, they are declared after the rule identifier as shown below:

```
rule TagsExample1 : Foo Bar Baz
{
      ...
}

rule TagsExample2 : Bar
{
      ...
}

rule TagsExample3 : Foo Baz
{
      ...
}
```

Tags must follow the same lexical convention of rule identifiers, therefore only alphanumeric characters and underscores are allowed, and the tag cannot start with a digit. They are also case sensitive.

When using YARA you can output only those rules that are tagged with the tag or tags that you provide. More details on this topic can be found in the following section.

6. Using YARA from command line

In order to invoke YARA you will need two things: the set of rules you want to apply, and the path to the file or folder that you want to scan. The rules can be provided to YARA through one or more plain-text files containing the rules, or through the standard input if no rule file is specified.

```
usage:  yara [ -t tag ] [ -n ] [ -g ] [ -s ] [ -r ] [ -v ] [RULEFILE...] FILE
options:
  -t <tag>          print rules tagged as <tag> and ignore the rest.
  -i <identifier>   print rules named <identifier> and ignore the rest.
  -n                print only not satisfied rules (negate).
  -g                print tags.
  -s                print matching strings.
  -r                recursively search directories.
  -v                show version information.
```

The rules will be applied to the file specified as the last argument to YARA, if this path points to a directory, all the files contained in it will be scanned. By default YARA does not attempt to scan directories recursively, but you can use the `-r` option to do it.

The `-t` option allows you to specify one or more tags that will act as filters to YARA's output. If you use this option, only those rules tagged as you specified will be shown. The `-i` option has a similar behavior, filtering all rules except the one having the given identifier. You can also use the `-n` modifier to print those rules that are not satisfied by the files.

7. Using YARA from Python

YARA can be also invoked from your own Python scripts. The `yara-python` extension is provided in order to make YARA functionality available to Python users. Once `yara-python` is built and installed on your system you can use it as shown below:

```
import yara
```

Then you will need to compile your YARA rules before applying them to your data, the rules can be compiled from a file path:

```
rules = yara.compile(filepath='/foo/bar/myrules')
```

The default argument is *filepath*, so you don't need to explicitly specify its name:

```
rules = yara.compile('/foo/bar/myrules')
```

You can also compile your rules from a file object:

```
fh = open('/foo/bar/myrules')
rules = yara.compile(file=fh)
fh.close()
```

Or you can compile them from a Python string:

```
rules = yara.compile(source='rule dummy { condition: true }')
```

In the three cases `compile` returns an instance of the class `Rules`, which in turn has two methods: `matchfile` and `matchstring`. The first one applies the rules to a file given its path:

```
matches = rules.match('/foo/bar/myfile')
```

The second one applies the rules to a Python string:

```
f = fopen('/foo/bar/myfile', 'rb')

matches = rules.match(data=f.read())
```

Both methods return a list of instances of the class `Match`. The instances of this class can be treated as text strings containing the name of the matching rule. For example you can print them:

```
foreach m in matches:
     print "%s" % m
```

In some circumstances you may need to explicitly convert the instance of `Match` to string, for example when comparing it with another string:

```
if str(matches[0]) == 'SomeRuleName':
     ...
```

The `Match` class have another two attributes: `tags` and `strings`. The `tags` attribute is a list of strings containing the tags associated to the rule. The `strings` attribute is a dictionary whose values are those strings within the data that made the YARA rule match, and the keys are the offsets where those strings were found.