

Pastelyzer

User manual

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January 9, 2020

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1 Introduction

`pastelyzer` is a tool that analyses text documents and looks for security and privacy related “items” (called *artefacts* in this document). A distinguishing feature of the tool is that embedded binary content (e.g., base64-encoded) is detected and decoded. The decoded content is then recursively processed (see section 4.1).

IMPORTANT: This software is a work-in-progress, and is expected to change. Make sure you consult the documentation that corresponds to the version of `pastelyzer` you’re using.

2 Running `pastelyzer`

`pastelyzer` can be run in two modes:

- interactively as an ordinary command-line utility, and
- as a background service with no user interaction.

Both of these modes are described in the following sections.

2.1 Interesting artefacts

In order to keep the amount of information presented to the user manageable not all discovered artefacts are shown. For example not all groups of four numbers separated with periods are IP addresses — more commonly than not the numbers are actually version numbers. To make the IP address extraction useful there is an option to only show the IP addresses that fall into specific networks (see section `--networks-file` option). In this case we say that the IP addresses that belong to the specified networks are “interesting.” Similarly for top-level domains and bank cards.

There are still some cases hard-coded in the system. The intention is to make the configuration facility flexible enough so that these can be removed from the code and into the configuration.

2.2 Common command-line options

The following options affect artefact extraction and apply in both CLI and standalone mode:

-h, --help Show short usage information.

-v, --version Show version.

--networks-file Path to a file that contains networks (in [CIDR notation](#)), one per line. Empty lines and lines starting with a `#` character are ignored. See <https://nic.lv/local.net> for an example of such a file.

--tlds-file Path to a file containing valid Top Level Domains (e.g., <https://data.iana.org/TLD/tlds-alpha-by-domain.txt>). Empty lines and lines starting with `#` character are ignored. Used to reduce the number of false positives.

--interesting-tlds A comma-separated list of TLDs that should be considered interesting. These are used by comparing the domains from the end, so the period should be included to compare the complete TLD. Example: `.abc,.xyz`.

--important-cc-bins Path to a file containing important bank card [BINs](#). The format of the file is described below.

2.2.1 Important bank card BINs file

Each line of the file can be one of the following:

- A comment line, starting with a # character. There can be multiple consecutive comment lines. The last comment line preceding a BIN specification is used as a note for that BIN.
- An empty line, clears the note.
- A BIN specification. The format is: digit characters followed by number placeholder characters. The number of digit and placeholder characters should match the number of bank card digits corresponding to the bin (e.g., 16 for Visa and Mastercard). Spaces are ignored (in both prefix and placeholder parts).

The following example file defines 5 bins for 2 banks. The first bank uses 16-digit numbers that start with 123456, 424242 and 111122. The second bank uses 15-digit numbers that start with 23 and 32.

```
# This is just an example.
```

```
# National bank
1234 56xx xxxx xxxx
424242 xx xxxx xxxx
111122xxxxxxxxxxx
```

```
# Other bank
23xx xxxxxx xxxxx
32xxxxxxxxxxxxxx
```

Listing 1: Sample important BIN file

2.3 Interactive mode

The simplest way to use **pastelyzer** is to pass it one or more file names. **pastelyzer** will analyze given files and print all detected artefacts in a tree structure (see figure below).

```

~$ curl -s 'https://pastebin.com/raw/33E400e1' | pastelyzer -
STDIN
├─ 0..8143 ENCODED-STRING: UTF-8, JUNPTVNQRUMLIC9iI_MEFDZ0FKQJ36QUNrQU93QT0=
├─ 0..8143 BASE64-BLOB: JUNPTVNQRUMLIC9iI_MEFDZ0FKQJ36QUNrQU93QT0=
├─ 0..6106 ENCODED-STRING: UTF-8, %COMSPEC /b /c s..AGEAcgB0ACgAJABzACKA0wA=
├─ 63..6106 BASE64-BLOB: op -w hidden -e aQ8mACgAWwBJAG4AdABQAHQA..AGEAcgB0ACgAJABzACKA0wA=
├─ 0..4531 ENCODED-STRING: UTF-16LE, if([IntPtr]::Sics.Process]::Start($s);
├─ 389..2040 BASE64-BLOB: mBase64String('H4sIABTd+F0CA7VWaW/b0BD9..+Bqu9KPDvWA+7CCI4gkAAA==')),[System.IO
├─ 0..1236 COMPRESSED-BLOB: GZIP, 1237 -> 2530 bytes
├─ 0..2529 ENCODED-STRING: UTF-8, function ch6z {...0xfffffff) | Out-Null..
├─ 263..276 WINDOWS-INTERNAL: $cZr.GetMethod('GetProcAddress', [Type[]]0([Sy
├─ 494..508 WINDOWS-INTERNAL: $cZr.GetMethod('GetModuleHandle')').Invoke($null
├─ 734..754 WINDOWS-INTERNAL: ::CurrentDomain.DefineDynamicAssembly((New-Object Sys
├─ 1401..1780 BASE64-BLOB: omBase64String('"/OICAAAAYInIMcBki1Aw1IM_UtdoAtnIX//VAcMpxnXuwv==")
├─ 1837..1865 WINDOWS-INTERNAL: vices.Marshal]:GetDelegateForFunctionPointer((ch6z kernel32.
├─ 1886..1897 WINDOWS-INTERNAL: 6z kernel32.dll VirtualAlloc), (pNW 0([IntPt
├─ 2145..2173 WINDOWS-INTERNAL: vices.Marshal]:GetDelegateForFunctionPointer((ch6z kernel32.
├─ 2393..2421 WINDOWS-INTERNAL: vices.Marshal]:GetDelegateForFunctionPointer((ch6z kernel32.
~$

```

Figure 1: Sample CLI usage

Currently in this mode it is only possible to view what and where pastelyzer can detect. In the future it will be possible to control what is extracted (i.e., limit output to a subset of “interesting” artefact classes) and what to do with the results (i.e., write to a file, or generate JSON).

2.4 Standalone mode

In standalone mode pastelyzer receives documents from a feed¹, stores them in database and analyzes them. It is possible to control what to do with the discovered artefacts using filters (see section 3). A sample systemd service file is provided in [support/pastelyzer.service](#) file.

2.4.1 Prerequisites

pastelyzer stores all received documents in a PostgreSQL (version **9.5** or later) database. The database schema is provided in the source distribution [support/schema.sql](#) file.

2.4.2 Options

-c, --config Path to configuration file (see section 3).

-w, --workers Number of threads to use for document processing (default: 4).

¹Currently only CIRCL.LU AIL paste feed is supported.

- server-port** Port number where to expose the dashboard. If the port is not given then the web server is not started.
- server-ext-host, --server-ext-port** Web server host and port to use when generating links to documents in emails. If not specified, links of the form `http://localhost/...` will be generated.
- [no-]process-broken** Process pastes with broken UTF-8 content² (in addition to trying to fix them; defaults to yes). Specific sites can be blacklisted using an environment variable (see `IGNORED_PASTESITES`).

2.4.3 Environment variables

DB_NAME Database name. Default: `pastelyzer`.

DB_USER Database user. Default: `pastelyzer`.

DB_PASS Database password. Default: empty.

DB_HOST Database host. Default: `localhost`.

DB_PORT Database port. Default: `5432`.

CIRCL_ZMQ_ADDRESS Paste feed endpoint³. Default: `tcp://crf.circl.lu:5556`.

IGNORED_PASTESITES Comma-separated list of paste sites to not re-fetch broken pastes from. It is a good idea to have at least `pastebin.com` in this list.

HTTP_USER_AGENT User agent to use when fetching web pages. This will be used verbatim as the HTTP `User-Agent` header value.

2.4.4 Static web server files

The `public` directory in the source distribution is expected to be located in the same directory where the `pastelyzer` binary is run from.

²This will not be necessary once the CIRCL.LU AIL paste feed is fixed.

³You need to contact CIRCL.LU support to whitelist the external IP address of the machine running `pastelyzer`.

3 Configuration

Currently configuration file is used only when running in standalone mode. By default received documents are stored in the database, processed, and the summary of findings (what kind of artefacts and how many) also stored in the database. Sinks are additional destinations where artefacts can be collected, and filters are used to control what artefacts end up in which sinks.

Current sink and filter implementation is good enough to support basic use cases. The implementation is expected to change in the future to accommodate additional use cases.

3.1 Syntax overview

Configuration is written using [S-expressions](#). The most unusual thing about this notation might be the prefix notation, but it can also be thought of as XML simplified (i.e., no need for closing tags). Please refer to [Wikipedia page](#) for a more verbose introduction.

Syntax used in `pastelyzer` configuration file have an extension: square brackets can be used to specify byte-vectors. The elements between opening and closing square brackets are expected to be space-separated hexadecimal 8-bit numbers (case-insensitive). Example: `[7f 45 4c 46]`.

Currently there are two recognized configuration directives (described in following sections): `define-sink` and `define-artefact-filter`. The word `define` in both of them is there to let text editors that have support for lisp-like languages recognize and treat these expressions specially (i.e., for syntax highlighting and automatic indentation).

3.2 Sinks

`define-sink` directive is used to define a sink. The syntax is as follows:

```
(define-sink <name> (<parent>) <attribute>*)
```

`<name>` is the name of sink being defined and will be used to refer to it in filters or as a parent in another sink.

`<parent>` should be either one of the built-in sink implementations (described in the following sections), or another thing that has been defined previously. Even though a sink can only have one parent it has to be specified as a single-element list (i.e., it has to be surrounded by parenthesis).

There can be zero or more `<attribute>` specifications of the following form:

(<name> <parameter>*)

Attribute <name> will usually be a keyword (i.e., a symbol starting with a colon). Each sink implementation has a different set of supported attributes described in corresponding section below.

3.2.1 Specifying values

Attribute values have types. This means that if a `string` value is required, the value must be enclosed in double quotes (i.e., "this is a string").

Values can also be forms:

<string> A string value stands for itself.

yes, true A boolean true value.

no, false A boolean false value.

(env <string>) Returns the value of process environment variable named by given string.

(file-contents <string>) Returns the contents of a file named by the given string.

(or <form>+) Returns the first form from the given list that has a value. For example, the form `(or (env "SOME_VAR" "undefined"))` will return the value of `SOME_VAR` environment variable, or the string `"undefined"` if there is no such environment variable.

3.2.2 Templates

If an attribute is specified to be a template, the value of an attribute will be generated using forms provided in the attribute.

:nl New line: outputs a newline character, unconditionally.

:fl Fresh line: outputs a newline only if the last character was not a newline.

(extract <field>) Extracts `field` from the context variable. See sink and item field extractors below.

(fmt <format-string> <form>+) Formats given parameters using Common-lisp `format` function. For advanced users only.

(unique-count <artefact-class>) Not really a filter function or an extractor, but can be used in sink attribute templates to calculate the number unique artefacts of the given **artefact-class** in a document currently being processed. Note: this is a hack, and most probably will change once we come up with a more general way to access this information.

Sink (document) level field extractors:

source-url Source site of the document being processed. E.g., `pastebin.com`.

remote-url The URL of the document being processed (if available).

remote-raw-url The URL to the raw contents of the document being processed (if available).

local-url The URL to the local copy of the document being processed. See `--server-ext-host` and `--server-ext-port` command line options.

artefact-descriptions Generates a summary of all artefacts collected in a sink, grouped by artefact class, one per line.

artefact-summary-by-class Generates a comma-separated string with artefact class and the number of artefacts with this class collected in the sink.

Item (artefact) level field extractors:

digits The digits of a bank card number with no separators.

note Note associated with an artefact. For `important-card-number` it is the comment associated with the BIN. See `--important-cc-bins` option.

3.2.3 WEB-SINK

This is the simplest sink. It does not have any parameters.

Example:

```
(define-sink dashboard (web-sink))
```

3.2.4 SMTP-SINK

This sink is used to send emails. Attributes:

(:server <string>) Sets the outgoing SMTP server to the given string.

- (:from <string>)** Sets the sender (“From” field) of the outgoing emails.
- (:subject <form>+)** Template attribute to generate subject line of the outgoing email.
- (:body <form>+)** Template attribute to generate the body of the outgoing email.
- (:recipients <string>+)** A list of strings, each being an email address to send the email to.

3.2.5 MISP-SINK

- (:server <string>)** Sets the MISP instance URL.
- (:api-key <string>)** The API key to use when communicating with the instance.
- (:ca-cert <string>)** Path to a custom CA certificate.
- (:user-cert <string>)** Path to PEM-encoded user certificate.
- (:user-key <string>)** Path to PEM encoded private key matching the certificate given in `:user-cert` attribute.
- (:user-key-pass <string>)** Passphrase to use to decrypt the private key specified with `:user-key` attribute.
- (:alert <boolean>)** Boolean value specifying whether this MISP event is or is not an alert.
- (:publish <boolean>)** Boolean value specifying whether to automatically publish this event.
- (:title <form>+)** Template attribute to generate the title of MISP event.
- (:sharing-group <string>)** Currently the only sharing option is a sharing group. Given value should be the name of the sharing group to use (the ID will be automatically looked up using the API).
- (:document-action <form>)** An action to perform once the MISP event is created. Currently the following actions are supported:
 - (add-tags <string>+)** Tag the event with the given tags.

(add-attribute :category <string> :type <string> :value <string> :comment <string>)

Add an attribute to the event with the given *category*, *type*, *value* and *comment* (optional). The subject of the action is sink (document).

(:item-action <form>) An action to perform after the MISP event is created, and all document actions are performed. Each item action is performed once for every artefact collected in the sink. The only supported action is *add-attribute*:

(add-attribute :category <string> :type <string> :value <string> :comment <string>)

Add an attribute to the event with the given *category*, *type*, *value* and *comment* (optional). The subject (context) of the action is an artefact.

3.3 Filters

define-artefact-filter directive is used to define a filter. The syntax is as follows:

(define-artefact-filter <name> <filter-expression> <action>+)

<name> is the name of the filter. Generally unimportant, but useful for debugging. Whenever an artefact is detected, *<filter-expression>* of every filter is executed. If the result is true (i.e., the filter matches), all *<action>* items are executed in order. Currently the only supported action is to collect the artefact into a sink.

Actions have the following syntax: *(collect-into <sink-name>)*.

Filter expressions have an implicit argument: an artefact. The following filter expressions are supported:

(type? <class>) True if the artefact is of the given class. See section 4.

(and <filter-expression>+) True if all enclosed filter expressions are true, false otherwise.

(or <filter-expression>+) True if any of the enclosed filter expressions is true, false otherwise.

(not <filter-expression>) False if the given filter expression is true, false otherwise.

(extract <field>) Extract given field from the current context value, usually an artefact. Extractors applicable to particular artefacts are documented in the corresponding artefact class section.

(-> <filter-expression>+) Replaces the context of each consecutive filter expression with the value of the previous expression. Consider the following example:

```
(and (type? embedded-binary)
      (-> (extract embedded-binary-bytes)
           (or (starts-with? [4D 5A])
               (starts-with? [7f 45 4c 46]))))
```

The `and` expression has two enclosed filter expressions. For it to return true both of them have to be true. So if the class of the artefact is not 4.2.7, the value of `and` will be false (and the second form will not even be considered). But if the context of the filter is indeed an 4.2.7 then the value of `and` will be the value of second form: `->`.

First it calls `(extract embedded-binary-bytes)` (see below), and replaces the current context with returned value. The next form is `or`, and for this form the context is the binary bytes of the current artefact (which we know is an 4.2.7). The forms enclosed in `or` are executed in order; if any of them returns true the value of the `or` form is also true. In any case, the value of `->` form will be the value of the `or` form applied to the byte content of the 4.2.7 artefact.

(length) Returns the length of current context value.

(= <number>) True if the current context value is equal to the given number.

(< <number>) True if the current context value is less than the given number.

(> <number>) True if the current context value is greater than the given number.

(starts-with? <subsequence>) True if the context value is a sequence that starts with the given subsequence.

(ends-with? <subsequence>) True if the context value is a sequence that ends with the given subsequence.

(contains? <subsequence>) True if the context value is a sequence that contains the given subsequence.

3.4 Example configuration

```
(define-sink dashboard (web-sink))

(define-artefact-filter web
  ;; Everything except playlist entries and PNG images.
  (not (or (type? m3u-entry)
            (and (type? embedded-binary)
                  (-> (extract embedded-binary-bytes)
                      (starts-with? [89 50 4E 47])))))
  (collect-into dashboard))

(define-sink local-misp (misp-sink)
  (:server "https://127.0.0.1:5000/")
  (:api-key (env "MISP_API_KEY"))
  (:ca-cert (or (env "MISP_CA_CERT")
                "misp/ca.pem"))
  (:user-cert (or (env "MISP_USER_CERT")
                  "misp/misp.crt.pem"))
  (:user-key (or (env "MISP_USER_KEY")
                  "misp/misp.key.pem"))
  (:user-key-pass (env "MISP_USER_KEY_PASS")))

(define-sink misp-cc-event (local-misp)
  (:alert yes)
  (:publish yes)
  (:title
   (fmt "~@[~A: ~]~A probable card number~:P"
        (extract source-url)
        (unique-count important-card-number)))
  (:sharing-group "Finance")
  (:document-action
   (add-tags "CardFraud" "tlp:amber"))
  (:document-action
   (add-attribute :category "External analysis"
                  :type "url"
                  :value (extract source-url)))
  (:item-action
   (add-attribute :category "Financial fraud"
                  :type "cc-number"))
```

```

        :value (extract digits)
        :comment (extract note))))

(define-sink email (smtp-sink)
  (:server "smtp.your.org")
  (:from "pastelyzer@your.org")
  (:subject (extract artefact-summary-by-class))
  (:body "URL: " (extract local-url) :f1
    "Origin: " (extract remote-url) :f1
    "Origin (raw): " (extract remote-raw-url) :f1
    (extract artefact-descriptions))
  (:recipients "pastelyzer-notifications@your.org"))

(define-artefact-filter important-cc
  (type? important-card-number)
  (collect-into misp-cc-event)
  (collect-into email))

```

4 Artefact classes

The list of artefact classes recognized by **pastelyzer** and their relationships are shown below. These artefact classes are described in the following sections.

4.1 Binary artefacts

BINARY-ARTEFACT is the superclass for artefacts that are represented as binary data (i.e. sequence of 8-bit bytes). If the input data is not known to be text then it is processed as binary data. In most cases this means that the data will be detected as being text in UTF-8 encoding and processed as text.

4.1.1 COMPRESSED-BLOB

Created if the **BINARY-ARTEFACT** bytes can be decompressed using gzip, zlib or deflate methods.

4.1.2 ENCODED-STRING

Created if the **BINARY-ARTEFACT** bytes can be decoded as UTF-8 or UTF-16 (little- or big-endian) string.

```
ARTEFACT
├─ BINARY-ARTEFACT
│  └─ COMPRESSED-BLOB
│  └─ ENCODED-STRING
└─ STRING-ARTEFACT
   ├── BANK-CARD-NUMBER
   │   └─ IMPORTANT-CARD-NUMBER
   ├── CREDENTIAL
   ├── DOMAIN
   │   └─ ONION
   ├── EMAIL
   ├── EMBEDDED-BINARY
   │   ├── BASE64-BLOB
   │   ├── HEX-BLOB
   │   └─ BINARY-BLOB
   ├── IP-ADDRESS
   │   └─ RESOLVED-IP-ADDRESS
   ├── M3U-ENTRY
   ├── URI
   └─ WINDOWS-INTERNAL
```

Listing 2: Artefact relationships

4.2 String artefacts

STRING-ARTEFACT is the superclass of all artefacts represented as text (i.e. most of them, described below).

4.2.1 BANK-CARD-NUMBER

pastelyzer currently recognizes bank card numbers that correspond to the following patterns:

Table 1: Bank card number patterns

Pattern	Description
XXXXXXXXXXXXZ	14 consecutive digits
XXXXXXXXXXXXXZ	15 consecutive digits
XXXXXXXXXXXXXXZ	16 consecutive digits
XXXX-XXXX-XXXX-XXXZ	16 digits in groups of 4
XXXX-XXXXXX-XXXXZ	15 digits in groups of 4-6-5

In the latter two cases the separator can be single or double space or dash. In all cases the first digit is expected to be non-zero, and the last digit is expected to be the checksum digit (according to [Luhn algorithm](#)).

These rules are very lax and are expected to generate false-positives. This is because the [BINs](#) change, and we want to avoid updating the software when they do. In the future we expect to allow specifying the BINs in an external file.

Applicable extractors:

digits A string of all the bank card digits with separators removed.

4.2.2 IMPORTANT-CARD-NUMBER

Artefact class of bank card number (see section 4.2.1) whose BIN (prefix) is listed in the important bank card BIN file (see `--important-cc-bins` option).

Applicable extractors:

digits Inherited from BANK-CARD-NUMBER.

note Comment associated with the bin this artefact has been matched to. See section 2.2.1.

4.2.3 CREDENTIAL

An username/passphrase pair, separated by colon (:), semicolon (;), vertical bar (|), comma (,) or tab character. At the moment regular expressions are used to match both. Even though the character repertoire for passphrases is quite generous, there are some limitations:

- Only credentials with emails (see 4.2.6) as usernames are detected.
- Non-ASCII characters are not matched.
- Space (and tab) characters are not matched.

We plan to improve credential extraction to work around these limitations in the future.

4.2.4 DOMAIN

Everything that looks like words separated with periods, with some additional restrictions (documented in [RFC1035](#)) and other heuristics.

We strongly suggest to provide the valid TLD file (see the `--tlds-file` option) to filter out most false positives.

4.2.5 ONION

A pseudo-domain consisting of two parts separated by a period. The first part being 16 or 56 alphanumeric characters (consistency not checked), the second being onion (see [Wikipedia entry](#)).

4.2.6 EMAIL

Strings of the form `username@domain` are recognized as emails using a simple regular expression. Only alphanumeric characters plus a period (.), underscore (_), percent sign (%), plus (+) and minus (-) are considered in the username part. Period-separated sequences of alphanumeric characters are accepted as domain part.

4.2.7 EMBEDDED-BINARY

All embedded binary artefacts (currently `BASE64-BLOB`, `HEX-BLOB` and `BINARY-BLOB`) are specializations of this artefact class. The textual representation is processed and resulting binary data is available as the `BYTES` field (see section 3.3).

The bytes are processed, and if it turns out they represent text or compressed data, the corresponding **BINARY-ARTEFACT** instance is created.

Applicable extractors:

embedded-binary-bytes The bytes of the artefact after decoding. Note: this will most likely be renamed to just **bytes** in near future.

BASE64-BLOB Base64-encoded (see [Wikipedia](#)) sequence of bytes. Example: TVqQ.

HEX-BLOB A sequence of hexadecimal digit pairs, each pair representing one 8-bit byte. Example: 4D5A90.

This artefact is also created for sequences of bytes written using C-syntax for hexadecimal numbers, separated by comma and optional white-space. Example: 0x4d, 0x5a, 0x90.

BINARY-BLOB Just ones and zeroes in groups of 8 (i.e., the total number of digits must be a multiple of 8). Example: 010011010101101010010000.

4.2.8 IP-ADDRESS

Artefact class for IPv4 addresses. Only addresses that belong to one of the “interesting networks” are considered “interesting” (see `--networks-file` option).

4.2.9 RESOLVED-IP-ADDRESS

A specialization of **IP-ADDRESS** artefact class for IPv4 addresses that are obtained by resolving domain names using system resolver (see **DOMAIN**).

4.2.10 M3U-ENTRY

Titles of playlist entries (lines starting with `#EXTINF:`).

4.2.11 URI

URIs matched using the syntax provided in [RFC3986, appendix A](#).

4.2.12 WINDOWS-INTERNAL

One of the strings from the following table:

Table 2: Low-level Windows functions

CreateProcess	NtUnmapViewOfSection
CreateRemoteThread	NtWriteVirtualMemory
DefineDynamicAssembly	PointFunctionCall
GetDelegateForFunctionPointer	QueueUserAPC
GetModuleHandle	ResumeThread
GetProcAddress	SetThreadContext
GetThreadContext	VirtualAlloc
NtAllocateVirtualMemory	VirtualAllocEx
NtCreateUserProcess	WriteProcessMemory
NtGetContextThread	