

Grasshopper v2.0.2

User Guide

DRAFT

APPENDIX A:OVERVIEW.....	3
1CONCEPT OF OPERATIONS.....	4
2REFERENCED DOCUMENTS.....	5
APPENDIX B:SYSTEM DESIGN.....	6
1COMPOSITION.....	7
2LOGIC.....	8
2.1BUILD TIME.....	9
2.2RUN TIME.....	10
APPENDIX C:INSTALLATION.....	11
1SYSTEM REQUIREMENTS.....	12
2INSTALLING GRASSHOPPER.....	13
2.1AS DELIVERED.....	14
2.2CUSTOMIZATION.....	15
3INSTALLING COMPONENTS.....	16
3.1COMPONENT NAMES.....	17
3.2AUTO DISCOVERY.....	18
APPENDIX D:UILDER.....	19
1COMMANDS.....	20
1.1COMPONENT COMMANDS.....	21
1.2INSTALLER COMMANDS.....	22
1.3BUILD COMMANDS.....	23
1.4OTHER COMMANDS.....	24
2WORKSPACES.....	25
3USER INTERFACE.....	26
3.1USAGE.....	27



CL BY: 2355679
CL REASON: Section
1.5(c),(e)
DECL ON: 20351003
DRV FRM: COL 6-03

3.2COMMAND LINE VS. CUSTOM SHELL.....28
3.3ENVIRONMENT VARIABLES.....29
4OUTPUT.....30
4.1BUILD DIRECTORY.....31
4.2BUILD RECEIPT.....32
5RULE MANAGEMENT.....33
5.1PATH EVALUATION.....34
5.2INLINE EDITING.....35
APPENDIX E:EXECUTION.....36
1USAGE.....37
1.1DYNAMIC LOAD LIBRARY (DLL).....38
1.2IN-MEMORY CODE EXECUTION (ICE) V3 MODULE.....39
2TRADECRAFT CONSIDERATIONS.....40
APPENDIX F:DECODER.....41
1LOG FILES.....42
2USER INTERFACE.....43
3OUTPUT.....44
APPENDIX G:RULES.....45
1FACTS.....46
1.1GRAMMAR.....47
1.2PRIMITIVES.....48
1.3EVALUATION.....49
2OPERATORS.....50
2.1GRAMMAR.....51
2.2EVALUATION.....52
3MACROS.....53
3.1GRAMMAR.....54
3.2EVALUATION.....55
4IMPORTS.....56
4.1GRAMMAR.....57
4.2EVALUATION.....58
5COMMENTS.....59

CL BY: 2355679
CL REASON: Section
1.5(c),(e)
DECL ON: 20351003
DRV FRM: COL 6-03

5.1 GRAMMAR..... 60

6 RULE SEARCH PATH..... 61

7 EXAMPLE..... 62

APPENDIX H: RULE FACTS..... 63

1 GRASSHOPPER..... 64

 1.1 ARCHITECTURE..... 65

 1.2 ACCESS AT LEAST..... 66

 1.3 LITERAL TRUE..... 67

 1.4 LITERAL FALSE..... 68

2 OPERATING SYSTEM..... 69

 2.1 ARCHITECTURE..... 70

 2.2 RELEASE..... 71

 2.3 FAMILY..... 72

 2.4 AT LEAST..... 73

 2.5 OLDER THAN..... 74

 2.6 ACTIVATED..... 75

3 DIRECTORY..... 76

 3.1 EXISTS..... 77

 3.2 READABLE..... 78

 3.3 WRITABLE..... 79

 3.4 CAN CREATE DIRECTORY..... 80

 3.5 CAN CREATE FILE..... 81

 3.6 EMPTY..... 82

 3.7 CONTAINS..... 83

 3.8 CONTAINS (IGNORE ACCESS DENIED)..... 84

 3.9 OWNED BY..... 85

 3.10 CREATED AFTER..... 86

 3.11 CREATED BEFORE..... 87

 3.12 ACCESSED AFTER..... 88

 3.13 ACCESSED BEFORE..... 89

 3.14 MODIFIED AFTER..... 90

 3.15 MODIFIED BEFORE..... 91

4 FILE..... 92

 4.1 EXISTS..... 93

 4.2 READABLE..... 94

 4.3 WRITABLE..... 95

 4.4 SIZE EQUAL..... 96

 4.5 SIZE GREATER..... 97

 4.6 SIZE LESS..... 98

 4.7 FIND STRING..... 99

 4.8 FIND HEX..... 100

 4.9 MD5..... 101

 4.10 OWNED BY..... 102

 4.11 CREATED AFTER..... 103

 4.12 CREATED BEFORE..... 104

 4.13 ACCESSED AFTER..... 105

 4.14 ACCESSED BEFORE..... 106

 4.15 MODIFIED AFTER..... 107

CL BY: 2355679
CL REASON: Section
1.5(c),(e)
DECL ON: 20351003
DRV FRM: COL 6-03

4.16MODIFIED BEFORE.....108
5PROCESS.....109
5.1EXISTS.....110
5.2HAS LOADED.....111
5.3HAS EXACTLY LOADED.....112
5.4OWNED BY.....113
6REGISTRY KEY.....114
6.1EXISTS.....115
6.2CONTAINS.....116
7REGISTRY VALUE.....117
7.1EXISTS.....118
7.2TYPE.....119
7.3MATCHES STRING.....120
7.4MATCHES INTEGER.....121
7.5FIND STRING.....122
8NETWORK.....123
8.1CONNECT TO.....124
8.2DNS LOOKUP.....125
8.3PROCESS LISTENING.....126
8.4PROCESS LISTENING ON.....127
8.5PORT AVAILABLE.....128

CL BY: 2355679
CL REASON: Section
1.5(c),(e)
DECL ON: 20351003
DRV FRM: COL 6-03

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Appendix A: **Overview**

Grasshopper is a software tool used to build custom installers for target computers running Microsoft Windows operating systems.

1 Concept of Operations

An operator uses Grasshopper to *build* a custom installation executable, *execute* that installation executable on a target computer, and (optionally) *decode* the results of that execution.

Build

An operator uses the Grasshopper builder to construct a custom installation executable.

The operator configures an installation executable to install one or more payloads using a variety of techniques. Each payload installer is built from individually configured components that implement part of the installation procedure.

The operator may designate that installation is contingent on the evaluation of the target environment. Target conditions are described using a custom rule language.

The operator may configure the tool to output a log file during execution for later exfiltration.

Execute

An operator runs the installation executable on a target computer running a Microsoft Windows operating system. The installation executable should be loaded into and executed solely within memory.

The operator is responsible for selecting the appropriate method for gaining on-target execution for the configured Grasshopper tool.

If the executable has output a log file, the operator collects it from the filesystem for later analysis.

Decode

An operator decodes the runtime-generated log file to evaluate detailed execution results.

The execution log stores result codes from each installer component and facts evaluated as part of the target environment validation process.

2 Referenced Documents

Grasshopper complies with the following specifications:

NOD Persistence v1

The Grasshopper executable DLL is compliant with the NOD Persistence specification version 1. It can be safely loaded and executed in process memory.

In-memory Code Execution (ICE) v3

The Grasshopper executable ICE-DLL is compliant with the In-memory Code Execution (ICE) specification version 3. It can be loaded as a module by an ICE-compliant loader using the 'Fire' execution mode.

Appendix B: **System Design**

1 Composition

A Grasshopper *executable* contains one or more *installers*. An installer is a stack of one or more installer *components*. Grasshopper invokes each component of the stack in series to operate on a *payload*. The ultimate purpose of an installer is to persist a payload.

Grasshopper will optionally evaluate *rules* to determine whether to execute an installation. Rules may be set on each installer and/or globally.

Executables

Grasshopper executables contain and run one or more installers on a target system.

An executable may have a global rule that will be evaluated before execution of any installers. If a global rule is provided and evaluates to false the executable aborts operation.

Executables may be constructed for both x86 and x64 architectures and in the following formats:

- DLL* Microsoft Dynamic-Link Library
 - Compliant with NOD Persistence Specification v1
 - Executes in a thread created in the DLL entry point (DllMain)
 - Memory-loadable (compliant with NOD Persistence v1)
- ICE* ICEv3 Module
- DLL* - Compliant with In-memory Code Execution (ICE) Specification v3
 - Supports 'Fire' feature set

If no rules need to be evaluated by the executable, Grasshopper uses an alternate executable, called a Cricket. A Cricket is equivalent to a Grasshopper, but has been stripped of the rule processing engine.

Installers

Installers encapsulate the process used to install a payload on a target system. Installers are constructed from one or more components that each contribute to the installation process.

Installers run by passing a payload through each member of the component stack. An installer may invoke a component at run time or build time, depending on payload availability and the components' execution time requirements. Installers are biased toward build-time execution of components to minimize on-target activity.

An installer may have a rule that will be evaluated before execution. If an installer rule is provided and evaluates to false the associated installer is skipped.

Components

Components form the functional portion of installers. Components may be used to introduce payloads to the installer stack, modify a payload on the stack, install a payload on a target, etc.

Grasshopper users configure components individually before using them to construct installers. Components may be used in multiple installers.

Components may be developed by third-parties and added to an existing Grasshopper build system.

Payloads

Payloads are the software tools that an installer is meant to persist on a target. Payloads are passed through each component on the installer stack.

Payloads are typed by format (EXE, DLL, SYS, PIC), architecture (x86, x64), and interface. The output type of a component must match exactly the input type of the next component on the stack.

Payloads may either be available at build time or run time. The availability of the payload may change based on the function of the components.

Payloads arguments can be added with the optional -a parameter when adding a payload component.

Grasshopper includes a built-in payload component which is used to introduce a payload to the component stack.

Rules

Rules are statements that describe on-target conditions required for the successful operation of an installer or a Grasshopper executable as a whole. Rules use Boolean operators to combine simple facts about the target into complex expressions.

2 Logic

For any given executable, including some number of installers built from some sequence of components, Grasshopper will operate according to the following logic.

2.1 Build Time

At build time, Grasshopper will validate the executable and run the build time components.

Validation

For each installer in an executable, Grasshopper evaluates the payload exchanges between the constituent components. Grasshopper ensures that both the payload types and availabilities between each component are compatible.

Build Time Components

Some components are designed to operate on a payload at build time. For each installer in the executable, Grasshopper will invoke the components to operate on the payload until the first run time component is reached. The output of the last build time component will be the input of the first run time component.

2.2 Run Time

At run time, Grasshopper will evaluate the target environment and run the run time components.

Global Rule

An executable may be configured with a global rule that describes conditions that are required for the executable as a whole. Before executing any components, Grasshopper will evaluate this global rule.

If the global rule does not evaluate to “true”, the Grasshopper aborts operation.

Installer Rules

For each installer in the executable, a rule may be configured that describe required conditions for that particular installer. Before executing any of an installer’s run time components, Grasshopper will evaluate its installer rule.

If the installer rule does not evaluate to “true”, the Grasshopper skips that installer.

Run Time Components

For each installer in the executable, Grasshopper invokes each run time component to operate on the payload. If any component fails, Grasshopper will unwind, calling the components in reverse order to undo whatever actions they had taken.

Appendix C: **Installation**

1 System Requirements

Grasshopper has the following system dependencies:

Python 3.4

The Grasshopper build system was developed and tested for Python 3.4.

zlib

Grasshopper uses zlib through Python for compression. This may require a zlib development package be installed when installing Python 3.4.

readline

Grasshopper uses readline through Python for tab completion and command history. This may require a readline development package be installed when installing Python 3.4.

2 Installing Grasshopper

The Grasshopper build system can be installed on and customized for your workstation. This is optional, as the provided Grasshopper tools may be used as delivered.

2.1 As Delivered

Grasshopper, as delivered, consists of the following:

Application Scripts

The application scripts are executable Python that provide user interfaces to Grasshopper functionality. There are two application scripts: `ghbuild` (described in section Appendix D:: Builder) and `ghdecode` (described in section Appendix F:: Decoder).

The application scripts are dependent on the Grasshopper Python package for all of their functionality.

Grasshopper Package

The `grasshopper` package is a Python package that provides all of the functionality for Grasshopper. It should not be used directly and must be in the Python path whenever using an application script.

Components

The `grasshopper-components` directory contains the Grasshopper component packages that are delivered with Grasshopper.

2.2 Customization

Grasshopper supports a variety of customizations that can make the system fit any operator's workflow.

Components

Grasshopper allows operators to customize where they install component packages. They can use this feature to manage when components are available to the system. For example, an operator may keep components under evaluation separate from components for regular use.

For more information, see section Appendix C:3: Installing Component Packages.

Rules

Grasshopper allows operators to customize where it will search for rule files. They can use this feature to conveniently access rules they have written for reuse or to setup a shared repository of rule files.

For more information, see section Appendix G:6: Rule Search Path.

Filesystem Usage

Operators are able to customize where Grasshopper will store files on the filesystem.

Grasshopper gives the operator several options for customizing where to store information about a build environment. For more information, see section Appendix D:2: Workspaces.

Grasshopper also allows operators to specify where to output build files by default. For more information, see section Appendix D:4: Output.

Text Editor

Grasshopper can open a text editor to allow an operator to make just-in-time file modifications. Operators are able to customize how these text file are opened on their system.

For more information, see section Appendix D:5.2: Inline Editing.

3 Installing Component Packages

Grasshopper component packages are Python packages/modules that define and register component types. Component packages must be installed in a Grasshopper build system

3.1 Component Names

Components are registered with and referenced by the Grasshopper system by name. Component names are case insensitive. If multiple components attempt to register the same name, only the last component to register will be used.

3.2 Auto Discovery

Grasshopper applications will automatically discover component packages at startup. Grasshopper components are installed by placing their package in the component search path.

Grasshopper will search for component packages in the following locations and order:

Local Path

Optional directory co-located with the Grasshopper Python package named "grasshopper-components".

System Path

Optional subdirectory of the Grasshopper system directory named "components". The Grasshopper system directory is `/var/lib/grasshopper` on Linux operating systems and `%PROGRAMDATA%\Grasshopper` on Windows operating systems.

Working Path

Optional subdirectory of the current working directory named "grasshopper-components".

Environment Paths

Directories specified using the `GHCOMPONENTPATH` environment variable.

The value of the variable is delimited by the system-appropriate path separator (':' on Linux, ';' on Windows).

Appendix D: **Builder**

The Grasshopper builder is the tool used to construct Grasshopper installation executables.

1 Commands

The builder provides a set of commands for building a Grasshopper executable. Build commands operate within a workspace to configure components and installers and to build Grasshopper executables.

1.1 Component Commands

The following commands are used to operate on components in a workspace:

add component

```
add component [-i ID] NAME ...
```

Configure a new component and add it to the workspace. The type of component to add is specified by name. Additional arguments are provided to the component for configuration.

The ID for the new component may be set using the `-i/--id` flag. If no ID is set, a unique identifier is generated. The ID is not used within the target-side executable.

rm component

```
rm component ID [ID ...]
```

Remove one or more components from the workspace by ID. The ID argument supports Unix shell-style wild cards.

mv component

```
mv component OLD_ID NEW_ID
```

Rename a component from an old ID to a new ID. If a component with the desired new ID exists, it will be overwritten.

ls component

```
ls component [-v] [ID ...]
```

View components currently in the workspace. If the `-v/--verbose` flag is provided, detailed information about the components is displayed.

Components to display may be selected by IDs. The ID argument supports Unix shell-style wild cards.

1.2 Installer Commands

The following commands are used to operate on installers in a workspace:

add installer

```
add installer [-i ID] [-r RULE_PATH] [-e] COMPONENT [COMPONENT ...]
```

Configure a new installer and add it to the workspace. The components that define the installer are selected using IDs assigned by the `add component` command. The component ID arguments support Unix shell-style wild cards.

The ID for the new component may be set using the `-i/--id` flag. If no ID is set, a unique identifier is generated. The ID is not used within the target-side executable.

The installer may be assigned a rule that describes required on-target conditions. Existing rule files may be added to the installer rule using the `-r/--rule` flag. If the `-e/--edit` flag is provided, the installer's rule files will be opened in a text editor. If neither the `-r` or `-e` flags are used, no rule will be generated for the installer.

rm installer

```
rm installer ID [ID ...]
```

Remove one or more installers from the workspace by ID. The ID argument supports Unix shell-style wild cards.

mv installer

```
mv installer OLD_ID NEW_ID
```

Rename an installer from an old ID to a new ID. If an installer with the desired new ID exists, it will be overwritten.

ls installer

```
ls installer [-v] [ID ...]
```

View installers currently in the workspace. If the `-v/--verbose` flag is provided, detailed information about the installers is displayed.

Installers to display may be selected by IDs. The ID argument supports Unix shell-style wild cards.

1.3 Build Commands

The following commands are used to build or rebuild Grasshopper executables:

build

```
build [-l LOG_PATH] [-o OUTPUT_DIR]
      [--dll] [--ice] [--x86] [--x64]
      [-r RULE_PATH] [-e]
      [INSTALLER ...]
```

Build a new Grasshopper executable. The installers included in the executable are selected using IDs assigned by the `add installer` command. The installer ID arguments support Unix shell-style wild cards.

If no installer IDs are specified, the build will include all installers in the workspace, sorted lexicographically by ID. If there are no installers in the workspace, the build will use an implicit installer consisting of all components in the workspace, sorted lexicographically by ID.

The executable may be configured to generate a log at runtime using the `-l/--log-path` flag. An encoded log file will be saved to a file on target specified by the flag argument.

The output directory may be set using the `-o/--output` flag. The default output directory is the value of the environment variable `'GHBUILDOUTPUT'` or the current working directory if the variable is not set.

The executable format is selected using the `-dll` and `-ice` flags. If none of these flags is used, the builder will produce all of them.

The executable architecture is selected using the `-x86` and `-x64` flags. If none of these flags is used, the builder will produce all of them.

The executable may be assigned a global rule that describes required on-target conditions. Existing rule files may be added to the global rule using the `-r/--rule` flag. If the `-e/--edit` flag is provided, the global rule files will be opened in a text editor. If neither the `-r` or `-e` flags are used, no global rule will be generated for the executable.

rebuild

```
rebuild [-o OUTPUT_DIR] [--dll] [--ice] [--x86] [--x64] RECEIPT
```

Rebuild a Grasshopper executable from the receipt file generated during a previous build.

The output directory may be set using the `-o/--output` flag. The default output directory is the value of the environment variable `'GHBUILDOUTPUT'` or the current working directory if the variable is not set.

The executable format is selected using the `-dll` and `-ice` flags. If none of these flags is used, the builder will produce all of them.

The executable architecture is selected using the `-x86` and `-x64` flags. If none of these flags is used, the builder will produce all of them.

ls receipt

ls receipt RECEIPT [RECEIPT ...]

View the contents of previously generated build receipts. Receipts are selected by paths; globbing is supported.

1.4 Other Commands

The following commands provides other functions for the builder:

env

env

View information about the Grasshopper build environment as key-value pairs.

The environment command will return values for the following keys:

VERSION	Version of the Grasshopper builder
WORKSPACE	Path to the current workspace
OUTPUT_DIR	Path to the default output directory of a build
COMPONENT_PATH	Search Path for component packages, using OS appropriate path delimiters
RULE_PATH	Search Path for rule files, using OS appropriate path delimiters

2 Workspaces

The Grasshopper builder uses workspaces to organize build activities. A workspace is a directory in which Grasshopper stores build information between command invocations. This includes previously configured components and installers, and command history.

The Grasshopper workspace directory may be set using `ghbuild's --workspace` command line option. If the option is not provided, the workspace may be set to the value of the `GHWORKSPACE` environment variable. If the environment variable is not set, the workspace is set to `".grasshopper"` in the current working directory.

If the workspace directory does not exist, it will be created.

3 User Interface

The command line user interface to the Grasshopper builder is accessed using `ghbuild`.

3.1 Usage

```
ghbuild.py [--workspace WORKSPACE] [--color WHEN]
ghbuild.py [--workspace WORKSPACE] [--color WHEN] COMMAND
ghbuild.py --version
```

`ghbuild` provides a command line interface to the Grasshopper build commands.

Build commands can be passed to `ghbuild` directly on the command line. This makes it convenient to perform simple tasks or to script the builder. If no arguments are provided to the command, `ghbuild` will drop the user into a custom shell.

The Grasshopper workspace directory may be selected using the `--workspace` option. If the option is not used, the builder will use the value of the `GHWORKSPACE` environment variable or `“.grasshopper”` in the current working directory.

The builder's use of color may be modified using the `--color` option. The builder has three color modes: `auto`, `always`, and `never`. `“auto”` is the default mode and will use color unless the standard output is not a TTY.

The `--version` flag will cause `ghbuild` to display the Grasshopper version and exit.

3.2 Command Line vs. Custom Shell

The builder UI provides a direct command line interface to the Grasshopper commands. The command line makes it convenient to perform simple tasks or to script the builder.

However, if no arguments are provided to the command line, `ghbuild` will drop the user into a custom shell. The shell provides usability enhancements, including tab completion, command history, and expanded help.

3.3 Environment Variables

The builder recognizes the following environment variables:

GHWORKSPACE	Path to builder workspace directory
GHBUILDOUTPUT	Path to default builder output directory
GHRULEPATH	Paths to include in Rule search path
EDITOR	Default text editing program

4 Output

During operation, the Grasshopper builder produces a build directory and build receipt file in an output directory. The output directory may be specified explicitly by the operator or set using the `GHBUILDOUTPUT` environment variable.

4.1 Build Directory

A build directory contains Grasshopper executables generated by the builders during `build` or `rebuild` commands.

A new build directory is created every time Grasshopper executables are built. The build directory is named “grasshopper_<YYYY>-<MM>-<DD>_<HH>-<MM>-<SS>.build”, based on the current date and time.

The build directory contains all of the executables produced by the builder. The executables are named “<BASE>-<FORMAT>-<ARCH>.<EXT>”. The `BASE` refers to the type of core Grasshopper executable; fully-featured executables are called “Grasshopper”, while executables stripped of the rule engine are called “Cricket”. The `FORMAT` refers to the type of executable and may be `DLL` or `ICE-DLL`. The `ARCH` refers to the architecture of the executable and may be `32 (x86)` or `64 (x64)`. The `EXT` is the file-appropriate extension.

The build directory also contains metadata files required for some formats. Grasshopper executables of the ICE DLL format will have an associated `.META.xml` file in the build directory.

The build directory will include a `build.xml` file containing configuration data for the built executables.

4.2 Build Receipt

A build receipt serves as a record of a Grasshopper build. It contains all of the configuration data and supporting files that were used during `build` or `rebuild` commands.

A new build receipt is created every time Grasshopper executables are built. The build receipt is named “`grasshopper_<YYYY>-<MM>-<DD>_<HH>-<MM>-<SS>.receipt.tgz`”, based on the current date and time.

The contents of the build receipt can be displayed using the `ls receipt` command. Manual inspection is also possible.

5 Rule Management

The builder includes features that make it easier to manage Grasshopper rules.

5.1 Path Evaluation

Grasshopper evaluates paths to rule files relative to the current working directory. If a rule source file is not located, the path is evaluated relative to each directory in the rule search path (see Appendix G:6 Rule Search Path).

5.2 Inline Editing

The Grasshopper builder will open a text editor inline to write original rules or modify existing rules. Changes made to existing rules are not saved to the original source rule.

The builder respects the `EDITOR` environment variable when selecting the editing program to use. If `EDITOR` is not defined, it will default to *notepad* on Windows and *vi* otherwise.

Appendix E: **Execution**

Grasshopper executables are available as either a Dynamic Load Library (DLL) or In-Memory Code Execution (ICE) v3 Module.

For any build, the Grasshopper builder will output either Grasshopper or Cricket executables. Grasshopper executables include code to evaluate the target environment according to user-provided rules; Cricket executables do not.

1 Usage

The operator uses an unspecified tool to run the Grasshopper executable within some Windows process. It is the operator's responsibility to ensure that the process selected has sufficient permissions to accomplish the Grasshopper executable's intended task.

1.1 Dynamic Load Library (DLL)

The Grasshopper DLL is a Windows Dynamic Load Library that executes from a thread created in DIIMain. The DLLs are built in such a way that they can be executed in memory.

1.2 In-Memory Code Execution (ICE) v3 Module

The Grasshopper ICE module is a Windows Dynamic Load Library that implements the In-Memory Code Execution (ICE) v3 Module interface. The module exports its ICE entry point on ordinal 1 and implements the “Fire” feature set. The ICE Module takes no command arguments.

2 Tradecraft Considerations

Grasshopper executables may contain considerable equities, including persistence techniques and any number of payloads. With this in mind, it is important to consider carefully the tradecraft of building and executing a Grasshopper.

Appendix F: **Decoder**

The Grasshopper decoder is the tool used to decode runtime-generated log files.

1 Log Files

Grasshopper installation executables can optionally generate an encoded log file at runtime. The log file contains codes documenting the results of component execution and rule evaluation. The meaning of these log files may only be deciphered using the decoder and a receipt file.

2 User Interface

The decoder uses a simple command line interface accessed using `ghdecode`.

```
ghdecode -l LOG -r RECEIPT [-o OUTPUT]
ghdecode --version
```

Decode a log file generated at runtime by a Grasshopper executable.

The path to the log file is specified using the `-l/--log` flag. The path to the receipt for the executable is specified using the `-r/--receipt` flag. Both the `-l` and `-r` flags are required.

The base path to the output files may be set using the `-o/--output` flag. The output base path is optional and will default to the log path without extension.

The `--version` flag will cause `ghdecode` to display the Grasshopper version and exit.

3 Output

The decoder generates three files from an encoded log: bin, log, and facts.

The output location of the decoder is specified by a base path to which type-appropriate extensions are applied. By default, the log path is used as the output base path.

Binary

A copy of the encoded log file for archival purposes. The log binary is saved in the output location with the extension “.bin”.

Log

A human-readable log file generated from the encoded log and the build receipt. The text log is saved in the output location with the extension “.log”.

Facts

A human readable list of facts evaluated on the target computer. The facts file is saved in the output location with the extension “.facts”.

Appendix G: Rules

Rules are statements declaring what conditions are required on a target to execute an installer or Grasshopper executable. Rules combine simple facts with boolean operators to create complex expressions.

1 Facts

A fact is a simple statement that can be evaluated at run time. A fact consists of a subject (or noun) and a predicate (or verb). A list of all supported facts is provided in Appendix H:: Rule Facts.

1.1 Grammar

Facts are declared with a subject and predicate joined with a period. Subjects and predicates are specified using a key word and arguments that describe them. Arguments are comma-delimited and provided within parenthesis to the keyword.

```
<noun>( <noun_arg>, ... ).<verb>( <verb_arg>, ... )
```

In the following example, the fact declaration states that a directory for the Wireshark program exists on the target machine.

```
directory( "%SYSTEMDRIVE%\Program Files\Wireshark" ).exists
```

1.2 Primitives

Arguments to a fact subject or predicate may have one of three primitive types: integer, string, or sequence.

Integers

Integers may be declared in decimal, hexadecimal, or binary by using the number system appropriate prefix (`0x` for hexadecimal, `0b` for binary).

Strings

Strings may be quoted or unquoted, although unquoted strings may not include the characters right parenthesis, right square bracket, or comma. Argument strings support escape sequences using the backslash character.

Sequences

Sequences are lists of primitive types, enclosed in square brackets and delimited by commas.

1.3 Evaluation

At runtime, facts are evaluated as either `TRUE`, `FALSE`, or `INVALID`. The values `TRUE` and `FALSE` indicate the state of a successfully evaluated fact. `INVALID` is a special case indicating that an issue occurred while gathering data to assess the fact making the result indeterminate.

During execution, Grasshopper will cache the evaluation of each fact. The caching mechanism reduces the cost of reusing facts throughout rules and minimizes the profile of the Grasshopper executable.

2 Operators

An operator is a logical operation that is applied to a series of child facts and operators.

There are three standard operators (`and`, `or`, and `xor`) which take one or more children. There are also three unary operators (`not`, `assume_true`, `assume_false`) which take only one child.

There is an implicit `and` operator that joins all facts and operators at the top-level of the rule.

2.1 Grammar

Operators are declared by keyword. Standard operators follow the keyword with a list of child facts or operators, enclosed in curly braces and delimited by whitespace. Unary operators follow the keyword with a single child fact or operator.

```
<std_operator>{<child> ...}
```

```
<unary_operator> <child>
```

In the following example, the operator states that the target machine is running an operating system that is not Windows 7 or Windows Server 2008 R2.

```
not or{os.family("win7") os.family("win2008r2")}
```

2.2 Evaluation

Operators are evaluated by assessing each of the children in order and combining their values based on the operator type. The behavior of each operator is described below.

AND

and {<child> ...}

States that all of the children of the operator have been evaluated to TRUE.

Truth Table

TRUE	All children evaluate to TRUE
FALSE	At least one child evaluates to FALSE
INVALID	At least one child evaluates to INVALID <u>and</u> no children evaluate to FALSE

Short Circuit

If any children evaluate to FALSE, the operator immediately evaluates to FALSE and the remaining children are skipped.

OR

or {<child> ...}

States that at least one of the children of the operator have been evaluated to TRUE.

Truth Table

TRUE	At least one child evaluates to TRUE
FALSE	All children evaluate to FALSE
INVALID	At least one child evaluates to INVALID <u>and</u> no children evaluate to TRUE

Short Circuit

If any children evaluate to TRUE, the operator immediately evaluates to TRUE and the remaining children are skipped.

XOR

xor {<child> ...}

States that one and only one of the children of the operator have been evaluated to TRUE.

Truth Table

TRUE	One child evaluates to TRUE and no children evaluate to INVALID
------	---

FALSE More than one child evaluates to TRUE or no children evaluate to TRUE OR INVALID

INVALID At least one child evaluates to INVALID and less than two children evaluate to TRUE

Short Circuit

If two children evaluate to TRUE, the operator immediately evaluates to TRUE and the remaining children are skipped.

NOT

not <child>

States that the child has been evaluated to FALSE.

Truth Table

TRUE Child evaluates to FALSE

FALSE Child evaluates to TRUE

INVALID Child evaluates to INVALID

ASSUME TRUE

assume_true <child>

States that if the child evaluates to INVALID, assume that the actual value is TRUE.

Truth Table

TRUE Child evaluates to TRUE OR INVALID

FALSE Child evaluates to FALSE

INVALID n/a

ASSUME FALSE

assume_false <child>

States that if the child evaluates to INVALID, assume that the actual value is FALSE.

Truth Table

TRUE Child evaluates to TRUE

FALSE Child evaluates to FALSE OR INVALID

INVALID n/a

3 Macros

A macro is a simple text substitution assigned to a variable, allowing for value reuse.

3.1 Grammar

Macros are declared by assigning a name to a value string using an equals sign. No whitespace is permitted between the name, equals sign, and value.

```
<name>=<value>
```

In the following example, every instance of `kaspersky_exe` in the file will be replaced by `avp.exe`.

```
kaspersky_exe=avp.exe
```

The macro name is restricted to the characters `a-z`, `A-Z`, `0-9`, and `_`. The macro value is set to all text between the equals sign and the end of the line.

3.2 Evaluation

Macros are expanded during preprocessing of every rule source file. Macros only apply to the rule source file in which they are defined.

4 Imports

An import is a statement that inserts the value of one rule file into the value of another. Import statements allow users to build complex rules composed of simpler rules from a reusable rule library.

4.1 Grammar

Imports are declared using the `import` keyword and a path to the imported rule's source file. The path is enclosed in parenthesis; it cannot contain a right parenthesis character.

```
import(<rule_path>)
```

4.2 Evaluation

Import paths are first evaluated relative to the location of the rule file. If the imported rule's source file is not located, the path is evaluated relative to each of the directories in the rule search path (see 6 Rule Search Path).

5 Comments

A comment is text that is ignored by the rule parser. Comments allow for inline documentation of rule source files.

5.1 Grammar

Line comments are declared using a hash character. Any text following the hash character is ignored by the parser.

```
# <comment goes here>
```

6 Rule Search Path

Grasshopper uses a search path to locate rule source files. The current rule search path can be viewed using `ghbuild's env` command.

The search path is constructed from the following paths:

Environment Paths

Directories specified using the `GHRULEPATH` environment variable.

The value of the variable is delimited by the system-appropriate path separator (':' on Linux, ';' on Windows).

Working Path

Optional subdirectory of the current working directory named "grasshopper-rules".

System Path

Optional subdirectory of the Grasshopper system directory named "rules". The Grasshopper system directory is `/var/lib/grasshopper` on Linux operating systems and `%PROGRAMDATA%\Grasshopper` on Windows operating systems.

Local Path

Optional directory co-located with the Grasshopper Python package named "grasshopper-rules".

7 Example

The following sample rule will check that the target is running Windows 7 or 8, and does not have Kaspersky or Norton installed.

example.rule

```

or { os.family(win7)
      os.family(win8)
}
not import(kaspersky.rule)
not import(norton.rule)

```

kaspersky.rule

```

or { process("avp.exe").exists
      directory("%PROGRAMFILES%\Kaspersky Lab").exists
      directory("%PROGRAMFILES(X86)%\Kaspersky Lab").exists
}

```

norton.rule

```

or { process("ccsvchst.exe").exists
      directory("%PROGRAMFILES%\Norton Internet Security").exists
      directory("%PROGRAMFILES(X86)%\Norton Internet Security").exists
      directory("%PROGRAMFILES%\Norton 360").exists
      directory("%PROGRAMFILES(X86)%\Norton 360").exists
}

```

Appendix H: **Rule Facts**

This appendix documents each of the facts support by Grasshopper rules.

1 Grasshopper

The “grasshopper” noun is used to construct facts about the executing Grasshopper.

The following verbs are supported by grasshopper:

architecture access_at_least true false

1.1 Architecture

The “architecture” verb states that the Grasshopper binary is built for a given processor architecture.

Usage

```
grasshopper.architecture(<arch>)
```

arch Architecture of the grasshopper binary (x86, x64)

Truth Table

TRUE Grasshopper binary built for arch

FALSE Grasshopper built for different arch

INVALID Error occurred while collecting grasshopper information

1.2 Access At Least

The “access_at_least” verb states that the Grasshopper is running in an environment with privileges at or above the specified level.

Usage

```
grasshopper.access_at_least(<access_level>)  
    access_level  Privilege access level (admin, system)
```

Truth Table

TRUE	Running grasshopper has access_level or higher
FALSE	Running grasshopper does not have access_level
INVALID	Error occurred while collecting grasshopper information

1.3 Literal True

The “true” verb is a literal True. It will always evaluate to True.

Usage

grasshopper.true

Truth Table

TRUE	Always
FALSE	Never
INVALID	Never

1.4 Literal False

The “false” verb is a literal False. It will always evaluate to False.

Usage

grasshopper.false

Truth Table

TRUE	Never
FALSE	Always
INVALID	Never

2 Operating System

The “os” noun is used to construct facts about the operating system on the target.

The following verbs are supported by os:

architecture	family	older_than
release	at_least	activated

The OS facts use the following strings to identify Windows OS versions:

winxp-sp0	winxp-sp1	winxp-sp2	winxp-sp3
winxp-x64-sp0	winxp-x64-sp1	winxp-x64-sp2	winxp-x64-sp3
win2003-sp0	win2003-sp1	win2003-sp2	win2003-sp3
vista-sp0	vista-sp1	vista-sp2	
win2008-sp0	win2008-sp1	win2008-sp2	
win7-sp0	win7-sp1		
win2008r2-sp0	win2008r2-sp1		
win8-sp0			
win2012-sp0			
win81-sp0			
win2012r2-sp0			

The OS facts use the following strings to identify Windows OS families:

winxp	
winxp-x64	win2003
vista	win2008
win7	win2008r2
win8	win2012
win81	win2012r2

2.1 Architecture

The “architecture” verb states that the operating system is running on a given processor architecture.

Usage

os.architecture(<arch>)

arch Architecture of the system’s processor (x86, x64)

Truth Table

TRUE	Operating system running on processor(s) with arch
FALSE	Operating system running on processor(s) with different arch
INVALID	Error occurred while collecting OS information

2.2 Release

The “release” verb states that the operating system is a given version.

Usage

```
os.release(<os_version>)
```

os_version Windows operating system version identifier

Truth Table

TRUE	Operating system is os_version
FALSE	Operating system is not os_version
INVALID	Error occurred while collecting OS information

2.3 Family

The “family” verb states that the operating system is from a given family.

Usage

`os.family(<os_family>)`

`os_family` Windows operating system family identifier

Truth Table

TRUE	Operating system is within <code>os_family</code>
FALSE	Operating system is not within <code>os_family</code>
INVALID	Error occurred while collecting OS information

2.4 At Least

The “at_least” verb states that the operating system is a given version or higher.

Usage

```
os.at_least(<os_version>)
```

os_version Windows operating system version identifier

Truth Table

TRUE	Operating system is os_version or higher
FALSE	Operating system is lower than os_version
INVALID	Error occurred while collecting OS information

2.5 Older Than

The “older_than” verb states that the operating system is lower than a given version.

Usage

```
os.older_than(<os_version>)
```

os_version Windows operating system version identifier

Truth Table

TRUE	Operating system is lower than os_version
FALSE	Operating system is os_version or higher
INVALID	Error occurred while collecting OS information

2.6 Activated

The “activated” verb states that the operating system has been activated with Microsoft.

Usage

os.activated

Truth Table

TRUE	Operating system has been activated with Microsoft
FALSE	Operating system has not been activated with Microsoft
INVALID	Error occurred while collecting OS information

3 Directory

The “directory” noun is used to construct facts about a directory on the target file system. The noun takes the path to a directory as a parameter.

The following verbs are supported by `directory`:

<code>exists</code>	<code>can_create_file</code>	<code>owned_by</code>	<code>accessed_before</code>
<code>readable</code>	<code>empty</code>	<code>created_after</code>	<code>modified_after</code>
<code>writable</code>	<code>contains</code>	<code>created_before</code>	<code>modified_before</code>
<code>can_create_dir</code>	<code>contains_ignore</code>	<code>accessed_after</code>	

3.1 Exists

The “exists” verb states that a directory exists.

Usage

```
directory(<dir_path>).exists
```

dir_path Path to directory on target file system

Truth Table

TRUE	dir_path exists and is a directory
FALSE	dir_path does not exist or is not a directory
INVALID	Access denied to dir_path attributes

3.2 Readable

The “readable” verb states that Grasshopper is able to list the contents of the directory.

Usage

```
directory(<dir_path>).readable
```

dir_path Path to directory on target file system

Truth Table

TRUE dir_path is readable

FALSE dir_path is not readable

INVALID dir_path does not exist or is not a directory

3.3 Writable

The “writable” verb states that Grasshopper is able to add files and subdirectories to the directory.

Usage

```
directory(<dir_path>).writable
```

dir_path Path to directory on target file system

Truth Table

TRUE dir_path is writable

FALSE dir_path is not writable

INVALID dir_path does not exist or is not a directory

3.4 Can Create Directory

The “can_create_dir” verb states that Grasshopper is able to add subdirectories to the directory.

Usage

```
directory(<dir_path>).can_create_dir
```

dir_path Path to directory on target file system

Truth Table

TRUE GH can add subdirectories to dir_path

FALSE GH cannot add subdirectories to dir_path

INVALID dir_path does not exist or is not a directory

3.5 Can Create File

The “can_create_file” verb states that Grasshopper is able to add files to the directory.

Usage

```
directory(<dir_path>).can_create_file
```

dir_path Path to directory on target file system

Truth Table

TRUE GH can add files to dir_path

FALSE GH cannot add files to dir_path

INVALID dir_path does not exist or is not a directory

3.6 Empty

The “empty” verb states that a directory does not contain any files or subdirectories.

Usage

```
directory(<dir_path>).empty
```

dir_path Path to directory on target file system

Truth Table

TRUE dir_path contains no files or subdirectories

FALSE dir_path contains files or subdirectories

INVALID dir_path does not exist, is not a directory, or is not readable

3.7 Contains

The “contains” verb states that a directory contains a file or directory of a given name.

A depth is provided to perform a recursive search on subdirectories. A depth of 0 will not search any subdirectories, a depth of 1 will search the first level of subdirectories, etc.

Usage

```
directory(<dir_path>).contains(<file_name>, <depth>)
```

<code>dir_path</code>	Path to directory on target file system
<code>file_name</code>	Name of file or directory within directory
<code>depth</code>	Recursive search depth

Truth Table

TRUE	<code>dir_path</code> contains a file or directory <code>file_name</code> within <code>depth</code> levels
FALSE	<code>dir_path</code> does not contain a file or directory <code>file_name</code> within <code>depth</code> levels
INVALID	Encountered error during search; file was not otherwise found

3.8 Contains (Ignore Access Denied)

The “contains_ignore” verb states that a directory contains a file or directory of a given name, but ignores ACCESS_DENIED errors. If any access errors are encountered, the fact will assume that the target file or directory would not have been located.

A depth is provided to perform a recursive search on subdirectories. A depth of 0 will not search any subdirectories, a depth of 1 will search the first level of subdirectories, etc.

Usage

```
directory(<dir_path>).contains_ignore(<file_name>, <depth>)
```

dir_path	Path to directory on target file system
file_name	Name of file within directory
depth	Recursive search depth

Truth Table

TRUE	dir_path contains a file or directory file_name within depth levels
FALSE	dir_path does not contain a file or directory file_name within depth levels
INVALID	Encountered error (excluding ACCESS_DENIED) during search; file was not otherwise found

3.9 Owned By

The “owned_by” verb states that a directory is owned by a specified user.

Usage

```
directory(<dir_path>).owned_by(<user_name>)
```

dir_path Path to directory on target file system

user_name Windows username (does not include DOMAIN)

Truth Table

TRUE dir_path is owned by user_name

FALSE dir_path is not owned by user_name

INVALID dir_path does not exist, is not a directory, or access was denied

3.10 Created After

The “created_after” verb states that a directory was created after a given time.

Usage

```
directory(<dir_path>).created_after(<time>)
```

<code>dir_path</code>	Path to directory on target file system
<code>time</code>	Time (in UTC) to compare against the directory timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>dir_path</code> was created after <code>time</code>
FALSE	<code>dir_path</code> was created before <code>time</code>
INVALID	<code>dir_path</code> does not exist, is not a directory, or access was denied

3.11 Created Before

The “created_before” verb states that a directory was created before a given time.

Usage

```
directory(<dir_path>).created_before(<time>)
```

<code>dir_path</code>	Path to directory on target file system
<code>time</code>	Time (in UTC) to compare against the directory timestamp
	Provided in one of the following formats
	- yyyy-mm-ddThh:mm:ss (ISO 9601)
	- yyyy-mm-dd

Truth Table

TRUE	<code>dir_path</code> was created before <code>time</code>
FALSE	<code>dir_path</code> was created after <code>time</code>
INVALID	<code>dir_path</code> does not exist, is not a directory, or access was denied

3.12 Accessed After

The “accessed_after” verb states that a directory was last accessed after a given time.

Usage

```
directory(<dir_path>).accessed_after(<time>)
```

<code>dir_path</code>	Path to directory on target file system
<code>time</code>	Time (in UTC) to compare against the directory timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>dir_path</code> was last accessed after <code>time</code>
FALSE	<code>dir_path</code> was last accessed before <code>time</code>
INVALID	<code>dir_path</code> does not exist, is not a directory, or access was denied

3.13 Accessed Before

The “accessed_before” verb states that a directory was last accessed before a given time.

Usage

```
directory(<dir_path>).accessed_before(<time>)
```

<code>dir_path</code>	Path to directory on target file system
<code>time</code>	Time (in UTC) to compare against the directory timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>dir_path</code> was last accessed before <code>time</code>
FALSE	<code>dir_path</code> was last accessed after <code>time</code>
INVALID	<code>dir_path</code> does not exist, is not a directory, or access was denied

3.14 Modified After

The “modified_after” verb states that a directory was last modified after a given time.

Usage

```
directory(<dir_path>). modified_after(<time>)
```

<code>dir_path</code>	Path to directory on target file system
<code>time</code>	Time (in UTC) to compare against the directory timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>dir_path</code> was last modified after <code>time</code>
FALSE	<code>dir_path</code> was last modified before <code>time</code>
INVALID	<code>dir_path</code> does not exist, is not a directory, or access was denied

3.15 Modified Before

The “modified_before” verb states that a directory was last modified before a given time.

Usage

```
directory(<dir_path>).modified_before(<time>)
```

<code>dir_path</code>	Path to directory on target file system
<code>time</code>	Time (in UTC) to compare against the directory timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>dir_path</code> was last modified before <code>time</code>
FALSE	<code>dir_path</code> was last modified after <code>time</code>
INVALID	<code>dir_path</code> does not exist, is not a directory, or access was denied

4 File

The “file” noun is used to construct facts about a file on the target file system. The noun takes the path to a file as a parameter.

The following verbs are supported by `file`:

<code>exists</code>	<code>size_greater</code>	<code>md5</code>	<code>accessed_after</code>
<code>readable</code>	<code>size_less</code>	<code>owned_by</code>	<code>accessed_before</code>
<code>writable</code>	<code>find_string</code>	<code>created_after</code>	<code>modified_after</code>
<code>size_equal</code>	<code>find_hex</code>	<code>created_before</code>	<code>modified_before</code>

4.1 Exists

The “exists” verb states that a file exists.

Usage

```
file(<file_path>).exists
```

file_path Path to file on target file system

Truth Table

TRUE	file_path exists and is a file
FALSE	file_path does not exist or is not a file
INVALID	Access denied to file_path attributes

4.2 Readable

The “readable” verb states that Grasshopper is able to read the contents of the file.

Usage

```
file(<file_path>).readable
```

file_path Path to file on target file system

Truth Table

TRUE file_path is readable

FALSE file_path is not readable

INVALID file_path does not exist or is not a file

4.3 Writable

The “writable” verb states that Grasshopper is able to modify the contents of the file.

Usage

```
file(<file_path>).writable
```

file_path Path to file on target file system

Truth Table

TRUE file_path is writable

FALSE file_path is not writable

INVALID file_path does not exist or is not a file

4.4 Size Equal

The “size_equal” verb states that the size of the file is equal to a specified size.

Usage

```
file(<file_path>).size_equal(<file_size>)
```

file_path Path to file on target file system

file_size Size value to compare against the file

Supports complex file size numbers (e.g., 5m == 5,242,880)

Truth Table

TRUE file_path is exactly file_size bytes

FALSE file_path is not file_size bytes

INVALID file_path does not exist or is not a file

4.5 Size Greater

The “size_greater” verb states that the size of the file is greater than a specified size.

Usage

```
file(<file_path>).size_greater(<file_size>)
```

file_path Path to file on target file system

file_size Size value to compare against the file

Supports complex file size numbers (e.g., 5m == 5,242,880)

Truth Table

TRUE file_path is larger than file_size bytes

FALSE file_path is smaller than file_size bytes

INVALID file_path does not exist or is not a file

4.6 Size Less

The “size_less” verb states that the size of the file is less than a specified size.

Usage

```
file(<file_path>).size_less (<file_size>)
```

file_path Path to file on target file system

file_size Size value to compare against the file

Supports complex file size numbers (e.g., 5m == 5,242,880)

Truth Table

TRUE file_path is smaller than file_size bytes

FALSE file_path is larger than file_size bytes

INVALID file_path does not exist or is not a file

4.7 Find String

The “find_string” verb states that a file contains the given string. Grasshopper will search for the ASCII-encoded string in the contents of the file.

Usage

```
file(<file_path>).find_string(<string>)
```

file_path Path to file on target file system

string Target string to locate

Truth Table

TRUE file_path contains the value string

FALSE file_path does not contain string

INVALID file_path does not exist, is not a file, or access was denied

4.8 Find Hex

The “find_hex” verb states that a file contains the given hex-encoded data.

Usage

```
file(<file_path>).find_hex(<hex_string>)
```

file_path	Path to file on target file system
hex_string	Target data to locate, provided as a sequence of hexadecimal characters

Truth Table

TRUE	file_path contains the value hex_string
FALSE	file_path does not contain hex_string
INVALID	file_path does not exist, is not a file, or access was denied

4.9 MD5

The “md5” verb states that the MD5 hash of the contents of the file equals a provided MD5 sum.

Usage

```
file(<file_path>).md5(<md5_sum>)
```

<code>file_path</code>	Path to file on target file system
<code>md5_sum</code>	Expected MD5 sum value, provided as a sequence of 32 hexadecimal characters

Truth Table

TRUE	MD5 sum of <code>file_path</code> contents equals <code>md5_sum</code>
FALSE	MD5 sum of <code>file_path</code> contents does not equal <code>md5_sum</code>
INVALID	<code>file_path</code> does not exist, is not a file, or access was denied

4.10 Owned By

The “owned_by” verb states that a file is owned by a specified user.

Usage

```
file(<file_path>).owned_by(<user_name>)
```

file_path Path to file on target file system

user_name Windows username (does not include DOMAIN)

Truth Table

TRUE file_path is owned by user_name

FALSE file_path is not owned by user_name

INVALID file_path does not exist, is not a file, or access was denied

4.11 Created After

The “created_after” verb states that a file was created after a given time.

Usage

```
file(<file_path>).created_after(<time>)
```

file_path	Path to file on target file system
Time	Time (in UTC) to compare against the file timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	file_path was created after time
FALSE	file_path was created before time
INVALID	file_path does not exist, is not a file, or access was denied

4.12 Created Before

The “created_before” verb states that a file was created before a given time.

Usage

```
file(<file_path>).created_before(<time>)
```

<code>file_path</code>	Path to file on target file system
<code>time</code>	Time (in UTC) to compare against the file timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>file_path</code> was created before <code>time</code>
FALSE	<code>file_path</code> was created after <code>time</code>
INVALID	<code>file_path</code> does not exist, is not a file, or access was denied

4.13 Accessed After

The “accessed_after” verb states that a file was last accessed after a given time.

Usage

```
file(<file_path>).accessed_after(<time>)
```

<code>file_path</code>	Path to file on target file system
<code>time</code>	Time (in UTC) to compare against the file timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>file_path</code> was last accessed after <code>time</code>
FALSE	<code>file_path</code> was last accessed before <code>time</code>
INVALID	<code>file_path</code> does not exist, is not a file, or access was denied

4.14 Accessed Before

The “accessed_before” verb states that a file was last accessed before a given time.

Usage

```
file(<file_path>).accessed_before(<time>)
```

<code>file_path</code>	Path to file on target file system
<code>time</code>	Time (in UTC) to compare against the file timestamp Provided in one of the following formats <ul style="list-style-type: none"> - yyyy-mm-ddThh:mm:ss (ISO 9601) - yyyy-mm-dd

Truth Table

TRUE	<code>file_path</code> was last accessed before <code>time</code>
FALSE	<code>file_path</code> was last accessed after <code>time</code>
INVALID	<code>file_path</code> does not exist, is not a file, or access was denied

4.15 Modified After

The “modified_after” verb states that a file was last modified after a given time.

Usage

```
file(<file_path>). modified_after(<time>)
```

<code>file_path</code>	Path to file on target file system
<code>time</code>	Time (in UTC) to compare against the file timestamp Provided in one of the following formats <ul style="list-style-type: none">- <code>yyyy-mm-ddThh:mm:ss</code> (ISO 9601)- <code>yyyy-mm-dd</code>

Truth Table

TRUE	<code>file_path</code> was last modified after <code>time</code>
FALSE	<code>file_path</code> was last modified before <code>time</code>
INVALID	<code>file_path</code> does not exist, is not a file, or access was denied

4.16 Modified Before

The “modified_before” verb states that a file was last modified before a given time.

Usage

```
file(<file_path>).modified_before(<time>)
```

<code>file_path</code>	Path to file on target file system
<code>time</code>	Time (in UTC) to compare against the file timestamp Provided in one of the following formats <ul style="list-style-type: none"> - <code>yyyy-mm-ddThh:mm:ss</code> (ISO 9601) - <code>yyyy-mm-dd</code>

Truth Table

TRUE	<code>file_path</code> was last modified before <code>time</code>
FALSE	<code>file_path</code> was last modified after <code>time</code>
INVALID	<code>file_path</code> does not exist, is not a file, or access was denied

5 Process

The “process” noun is used to construct facts about a process on the target file system. The noun takes the name of a process as a parameter; “*” is used to refer to all/any process.

The following verbs are supported by process:

exists

has_loaded

has_exactly_loaded

owned_by

5.1 Exists

The “exists” verb states that a process exists.

Usage

```
process(<process_name>|*).exists
```

process_name Name of process running on target system

Truth Table

TRUE process_name exists

FALSE process_name does not exist

INVALID Error occurred while collecting process information

5.2 Has Loaded

The “has_loaded” verb states that a process has loaded a set of modules (DLLs). Additional modules may be loaded into the process.

Usage

```
process(<process_name>|* ).has_loaded([<module_name>, ...])
```

process_name Name of process running on target system

module_name Name of module loaded into process

Truth Table

TRUE	A process named process_name has loaded all of the module_name DLLs
FALSE	No processes named process_name have loaded all of the module_name DLLs
INVALID	Error occurred while collecting process information

5.3 Has Exactly Loaded

The “has_exactly_loaded” verb states that a process has exactly loaded a set of modules (DLLs). No additional modules may be loaded into the process

Usage

```
process(<process_name>|*).has_exactly_loaded([<module_name>, ...])
```

process_name Name of process running on target system

module_name Name of module loaded into process

Truth Table

TRUE	A process named process_name has loaded exactly the module_name DLLs
FALSE	No processes named process_name have loaded exactly the module_name DLLs
INVALID	Error occurred while collecting process information

5.4 Owned By

The “owned_by” verb states that a process is owned by a specified user.

Usage

```
process(<process_name>|* ).owned_by(<user_name>)
```

process_name Name of process running on target system

user_name Windows username (does not include DOMAIN)

Truth Table

TRUE process_name is owned by user_name

FALSE process_name is not owned by user_name

INVALID process_name does not exist or an error occurred while collecting
process info

6 Registry Key

The “reg_key” noun is used to construct facts about a registry key on the target system. The noun takes the hive name and key path as parameters.

The following verbs are supported by reg_key:

exists

contains

6.1 Exists

The “exists” verb states that a registry key exists.

Usage

```
reg_key(<hive_name>, <key_path>).exists
```

hive_name Name of registry hive

key_path Path of registry key within the hive

Truth Table

TRUE Registry key at key_path within hive_name exists

FALSE No registry key at key_path within hive_name found

INVALID Error occurred while collecting registry information

6.2 Contains

The “contains” verb states that a registry key contains a key or value of a given name.

A depth is provided to perform a recursive search on subkeys. A depth of 0 will not search any subkeys, a depth of 1 will search the first level of subdirectories, etc.

Usage

```
reg_key(<hive_name>, <key_path>).contains(<val_name>, <depth>)
```

hive_name	Name of registry hive
key_path	Path of registry key within the hive
val_name	Name of value or subkey within key
depth	Recursive search depth

Truth Table

TRUE	hive_name\key_path contains a value or key val_name within depth levels
FALSE	hive_name\key_path does not contain a value or key val_name within depth levels
INVALID	Key does not exist or error occurred while collecting registry information

7 Registry Value

The “reg_value” noun is used to construct facts about a registry value on the target system. The noun takes the hive name, key path, and value name as parameters.

The following verbs are supported by reg_value:

exists	matches_string	find_string
type	matches_integer	

7.1 Exists

The “exists” verb states that a registry value exists in a given hive and key.

Usage

```
reg_value(<hive_name>, <key_path>, <val_name>).exists
```

hive_name	Name of registry hive
key_path	Path of registry key within the hive
val_name	Name of registry value within the key

Truth Table

TRUE	Registry value named val_name exists at hive_name\key_path
FALSE	No registry value named val_name exists at hive_name\key_path
INVALID	Error occurred while collecting registry information

7.2 Type

The “type” verb states that a registry value is a given type.

Usage

```
reg_value(<hive_name>, <key_path>, <val_name>).type(<reg_type>)
```

hive_name	Name of registry hive
key_path	Path of registry key within the hive
val_name	Name of registry value within the key
reg_type	Type of registry value

Truth Table

TRUE	hive_name\key_path\val_name is the type reg_type
FALSE	hive_name\key_path\val_name is not the type reg_type
INVALID	Value does not exist or error occurred while collecting registry information

7.3 Matches String

The “matches_string” verb states that a registry value is the provided string.

Usage

```
reg_value(<hive_name>, <key_path>, <val_name>).matches_string(<string>)
```

hive_name	Name of registry hive
key_path	Path of registry key within the hive
val_name	Name of registry value within the key
string	String to compare to registry value

Truth Table

TRUE	hive_name\key_path\val_name value matches the string
FALSE	hive_name\key_path\val_name value does not match the string
INVALID	Value does not exist or error occurred while collecting registry information

7.4 Matches Integer

The “matches_integer” verb states that a registry value is the provided integer.

Usage

```
reg_value(<hive_name>, <key_path>, <val_name>).matches_integer(<integer>)
```

hive_name	Name of registry hive
key_path	Path of registry key within the hive
val_name	Name of registry value within the key
number	Number to compare to registry value

Truth Table

TRUE	hive_name\key_path\val_name value matches the integer
FALSE	hive_name\key_path\val_name value does not match the integer
INVALID	Value does not exist or error occurred while collecting registry information

7.5 Find String

The “find_string” verb states that a registry value contains the provided string.

Usage

```
reg_value(<hive_name>, <key_path>, <val_name>).find_string(<string>)
```

hive_name	Name of registry hive
key_path	Path of registry key within the hive
val_name	Name of registry value within the key
string	String to locate within the registry value

Truth Table

TRUE	hive_name\key_path\val_name value contains the string
FALSE	hive_name\key_path\val_name value does not contain the string
INVALID	Value does not exist or error occurred while collecting registry information

8 Network

The “network” noun is used to construct facts about network communications and status.

The following verbs are supported by network:

connect_to	process_listening	port_available
dns_lookup	process_listening_on	

8.1 Connect To

The “connect_to” verb states that the target can connect to via TCP to a given host and port. Grasshopper checks connectivity by establishing and closing a socket connection.

Usage

```
network.connect_to(<host>, <port>)
```

host	Host name or IPv4 address
port	TCP port number

Truth Table

TRUE	Target can connect to host on port
FALSE	Target cannot connect to host on port
INVALID	Error occurred while attempting connection

8.2 DNS Lookup

The “dns_lookup” verb states that the target can resolve the host and service port. Grasshopper checks resolution by performing a DNS lookup.

Usage

```
network.dns_lookup(<host>, <port>)
```

host Host name or IPv4 address

port TCP port number

Truth Table

TRUE Target can resolve service at host on port

FALSE Target cannot resolve service at host on port

INVALID Error occurred while attempting lookup

8.3 Process Listening

The “process_listening” verb states that a process with a given name is listening.

Usage

```
network.process_listening(<process_name>)
```

process_name Name of process running on target system

Truth Table

TRUE	Process with process_name is listening
FALSE	No process with process_name is listening
INVALID	Error occurred while enumerating listening processes

8.4 Process Listening On

The “process_listening_on” verb states that a process with a given name is listening on a specific port.

Usage

```
network.process_listening_on(<process_name>, <port>)
```

process_name Name of process running on target system

port TCP port number

Truth Table

TRUE Process with process_name is listening on port

FALSE No process with process_name is listening on port

INVALID Error occurred while enumerating listening processes

8.5 Port Available

The “port_available” verb states that a specified TCP port is available.

Usage

```
network.port_available(<port>)
```

port TCP port number

Truth Table

TRUE TCP port is available for use

FALSE TCP port is not available for use

INVALID Error occurred while enumerating listening processes