



OpenCore

Reference Manual (0.5.~~8~~.9)

[2020.05.10]

1 Introduction

This document provides information on OpenCore user configuration file format used to setup the correct functioning of macOS operating system. It is to be read as the official clarification of expected OpenCore behaviour. All deviations, if found in published OpenCore releases, shall be considered documentation or implementation bugs, and are requested to be reported through Acidanthera Bugtracker. All other sources or translations of this document are unofficial and may contain errors.

This document is structured as a specification, and is not meant to provide a step by step algorithm for configuring end-user board support package (BSP). Any third-party articles, tools, books, etc., providing such material are prone to their authors' preferences, tastes, this document misinterpretation, and essential obsolescence. In case you still use these sources, for example, OpenCore Desktop Guide (parent link), please ensure following this document for every made decision and judging its consequences. Regardless of the sources used you are required to fully understand every dedicated OpenCore configuration option and concept prior to reporting any issues in Acidanthera Bugtracker.

1.1 Generic Terms

- **plist** — Subset of ASCII Property List format written in XML, also known as XML plist format version 1. Uniform Type Identifier (UTI): `com.apple.property-list`. Plists consist of **plist objects**, which are combined to form a hierarchical structure. Due to plist format not being well-defined, all the definitions of this document may only be applied after plist is considered valid by running `plutil -lint`. External references: <https://www.apple.com/DTDs/PropertyList-1.0.dtd>, `man plutil`.
- **plist type** — plist collections (**plist array**, **plist dictionary**, **plist key**) and primitives (**plist string**, **plist data**, **plist date**, **plist boolean**, **plist integer**, **plist real**).
- **plist object** — definite realisation of **plist type**, which may be interpreted as value.
- **plist array** — array-like collection, conforms to `array`. Consists of zero or more **plist objects**.
- **plist dictionary** — map-like (associative array) collection, conforms to `dict`. Consists of zero or more **plist keys**.
- **plist key** — contains one **plist object** going by the name of **plist key**, conforms to `key`. Consists of printable 7-bit ASCII characters.
- **plist string** — printable 7-bit ASCII string, conforms to `string`.
- **plist data** — base64-encoded blob, conforms to `data`.
- **plist date** — ISO-8601 date, conforms to `date`, unsupported.
- **plist boolean** — logical state object, which is either true (1) or false (0), conforms to `true` and `false`.
- **plist integer** — possibly signed integer number in base 10, conforms to `integer`. Fits in 64-bit unsigned integer in two's complement representation, unless a smaller signed or unsigned integral type is explicitly mentioned in specific **plist object** description.
- **plist real** — floating point number, conforms to `real`, unsupported.
- **plist metadata** — value cast to data by the implementation. Permits passing **plist string**, in which case the result is represented by a null-terminated sequence of bytes (aka C string), **plist integer**, in which case the result is represented by 32-bit little endian sequence of bytes in two's complement representation, **plist boolean**, in which case the value is one byte: 01 for `true` and 00 for `false`, and **plist data** itself. All other types or larger integers invoke undefined behaviour.

3 Setup

3.1 Directory Structure

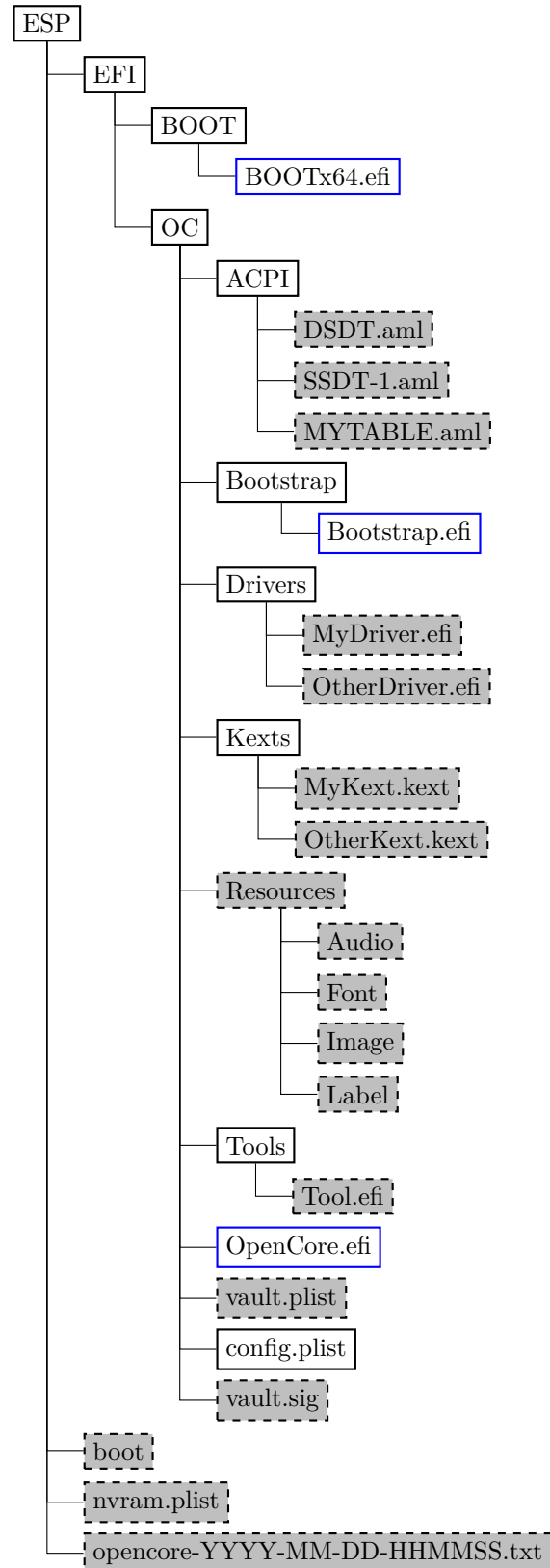


Figure 1. Directory Structure

When directory boot is used the directory structure used should follow the description on Directory Structure figure.

Available entries include:

- `BOOTx64.efi` ~~Initial booter~~ and `Bootstrap.efi`
[Initial bootstrap loaders](#), which loads `OpenCore.efi` unless it was already started as a driver. `BOOTx64.efi` is loaded by the firmware by default according to UEFI specification, and `Bootstrap.efi` can be registered as a custom option to let OpenCore coexist with operating systems using `BOOTx64.efi` as their own loaders (e.g. Windows), see [BootProtect](#) for more details.
- `boot`
[Duet bootstrap loader](#), which initialises UEFI environment on legacy BIOS firmwares and loads `OpenCore.efi` similarly to other bootstrap loaders. Modern Duet bootstrap loader will default to `OpenCore.efi` on the same partition when present.
- `ACPI`
Directory used for storing supplemental ACPI information for `ACPI` section.
- `Drivers`
Directory used for storing supplemental UEFI drivers for `UEFI` section.
- `Kexts`
Directory used for storing supplemental kernel information for `Kernel` section.
- `Resources`
Directory used for storing media resources, such as audio files for screen reader support. See [UEFI Audio Properties](#) section for more details. [This directory also contains image files for graphical user interface. See OpenCanopy section for more details.](#)
- `Tools`
Directory used for storing supplemental tools.
- `OpenCore.efi`
Main booter driver responsible for operating system loading.
- `vault.plist`
Hashes for all files potentially loadable by `OC Config`.
- `config.plist`
`OC Config`.
- `vault.sig`
Signature for `vault.plist`.
- `nvram.plist`
OpenCore variable import file.
- `opencore-YYYY-MM-DD-HHMMSS.txt`
OpenCore log file.

Note: It is not guaranteed that paths longer than `OC_STORAGE_SAFE_PATH_MAX` (128 characters including 0-terminator) will be accessible within OpenCore.

3.2 Installation and Upgrade

To install OpenCore reflect the Configuration Structure described in the previous section on a EFI volume of a GPT partition. While corresponding sections of this document do provide some information in regards to external resources like ACPI tables, UEFI drivers, or kernel extensions (kexts), completeness of the matter is out of the scope of this document. Information about kernel extensions may be found in a separate Kext List document available in OpenCore repository. Vaulting information is provided in Security Properties section of this document.

`OC config`, just like any property lists can be edited with any stock textual editor (e.g. nano, vim), but specialised software may provide better experience. On macOS the preferred GUI application is Xcode. For a lightweight cross-platform and open-source alternative ProperTree editor can be utilised.

For BIOS booting a third-party UEFI environment provider will have to be used. `DuetPkg` is one of the known UEFI environment providers for legacy systems. To run OpenCore on such a legacy system you can install `DuetPkg` with a dedicated tool `BootInstall` (bundled with OpenCore).

For upgrade purposes refer to `Differences.pdf` document, providing the information about the changes affecting the configuration compared to the previous release, and `Changelog.md` document, containing the list of modifications across all published updates.

3.3 Contribution

OpenCore can be compiled as an ordinary EDK II. Since UDK development was abandoned by TianoCore, OpenCore requires the use of EDK II Stable. Currently supported EDK II release (potentially with patches enhancing the experience) is hosted in acidanthera/audk.

The only officially supported toolchain is XCODE5. Other toolchains might work, but are neither supported, nor recommended. Contribution of clean patches is welcome. Please do follow EDK II C Codestyle.

Required external package dependencies include EfiPkg and MacInfoPkg.

To compile with XCODE5, besides Xcode, one should also install NASM and MTOC. The latest Xcode version is recommended for use despite the toolchain name. Example command sequence may look as follows:

```
git clone https://github.com/acidanthera/audk UDK
cd UDK
git clone https://github.com/acidanthera/DuetPkg
git clone https://github.com/acidanthera/EfiPkg
git clone https://github.com/acidanthera/MacInfoPkg
git clone https://github.com/acidanthera/OpenCorePkg
source edksetup.sh
make -C BaseTools
build -a X64 -b RELEASE -t XCODE5 -p OpenCorePkg/OpenCorePkg.dsc
```

Listing 1: Compilation Commands

For IDE usage Xcode projects are available in the root of the repositories. Another approach could be Sublime Text with EasyClangComplete plugin. Add .clang_complete file with similar content to your UDK root:

```
-I/UefiPackages/MdePkg
-I/UefiPackages/MdePkg/Include
-I/UefiPackages/MdePkg/Include/X64
-I/UefiPackages/MdeModulePkg
-I/UefiPackages/MdeModulePkg/Include
-I/UefiPackages/MdeModulePkg/Include/X64
-I/UefiPackages/DuetPkg/Include
-I/UefiPackages/EfiPkg
-I/UefiPackages/EfiPkg/Include
-I/UefiPackages/EfiPkg/Include/X64
-I/UefiPackages/AppleSupportPkg/Include
-I/UefiPackages/OpenCorePkg/Include
-I/UefiPackages/OvmfPkg/Include
-I/UefiPackages/MacInfoPkg/Include
-I/UefiPackages/UefiCpuPkg/Include
-IInclude
-include
/UefiPackages/MdePkg/Include/Uefi.h
-fshort-wchar
-Wall
-Wextra
-Wno-unused-parameter
-Wno-missing-braces
-Wno-missing-field-initializers
-Wno-tautological-compare
-Wno-sign-compare
-Wno-varargs
-Wno-unused-const-variable
-DOC_TARGET_NOOPT=1
-DNO_MSABI_VA_FUNCS=1
```

Listing 2: ECC Configuration

8 Misc

8.1 Introduction

This section contains miscellaneous configuration ~~entries for OpenCore behaviour that does not go to any other sections~~ affecting OpenCore operating system loading behaviour as well as other entries, which do not go to any other section.

OpenCore tries to follow “bless” model also known as “Apple Boot Policy”. The primary specialty of “bless” model is to allow embedding boot options within the file system (and be accessible through a specialised driver) as well as supporting a broader range of predefined boot paths compared to the removable media list found in the UEFI specification.

Each partition will only be used for booting when it corresponds to “Scan policy”: a set of restrictions to only use partitions with specific file systems and from specific device types. Scan policy behaviour is discussed in `ScanPolicy` property description.

Scan process starts with obtaining all the partitions filtered with “Scan policy”. Each partition may produce multiple primary and alternate options. Primary options describe operating systems installed on this media. Alternate options describe recovery options for the operating systems on the media. It is possible for alternate options to exist without primary options and vice versa. Be warned that the options may not necessarily describe the operating systems on the same partition. Each primary and alternate option can be an auxiliary option or not, refer to `HideAuxiliary` for more details. Algorithm to determine boot options behaves as follows:

1. Obtain all available partition handles filtered by “Scan policy” (and driver availability).
2. Obtain all available boot options from `BootOrder` UEFI variable.
3. For each found boot option:
 - Retrieve device path of the boot option.
 - Perform fixups (e.g. NVMe subtype correction) and expansion (e.g. for Boot Camp) of the device path.
 - Obtain device handle by locating device path of the resulting device path (ignore it on failure).
 - Find device handle in the list of partition handles (ignore it if missing).
 - For disk device paths (not specifying a bootloader) execute “bless” (may return > 1 entry).
 - For file device paths check presence on the file system directly.
 - Exclude options with blacklisted filenames (refer to `BlacklistAppleUpdate` option).
 - On OpenCore boot partition exclude all OpenCore bootstrap files by header checks.
 - Mark device handle as *used* in the list of partition handles if any.
 - Register the resulting entries as primary options and determine their types.
The option will become auxiliary for some types (e.g. Apple HFS recovery).
4. For each partition handle:
 - If partition handle is marked as *unused* execute “bless” primary option list retrieval.
In case `BlessOverride` list is set, not only standard “bless” paths will be found but also custom ones.
 - Exclude options with blacklisted filenames (refer to `BlacklistAppleUpdate` option).
 - On OpenCore boot partition exclude all OpenCore bootstrap files by header checks.
 - Register the resulting entries as primary options and determine their types if found.
The option will become auxiliary for some types (e.g. Apple HFS recovery).
 - If partition already has primary options of “Apple Recovery” type proceed to next handle.
 - Lookup alternate entries by “bless” recovery option list retrieval and predefined paths.
 - Register the resulting entries as alternate auxiliary options and determine their types if found.
5. Custom entries and tools are added as primary options without any checks with respect to `Auxiliary`.
6. System entries (e.g. `Reset NVRAM`) are added as primary auxiliary options.

The display order of the boot options in the picker and the boot process are determined separately from the scanning algorithm. The display order as follows:

- Alternate options follow corresponding primary options, i.e. Apple recovery will be following the relevant macOS option whenever possible.
- Options will be listed in file system handle firmware order to maintain an established order across the reboots regardless of the chosen operating system for loading.
- Custom entries, tools, and system entries will be added after all other options.
- Auxiliary options will only show upon entering “Advanced Mode” in the picker (usually by pressing “Space”).

The boot process is as follows:

- Try looking up first valid primary option through `BootNext` UEFI variable.
- On failure looking up first valid primary option through `BootOrder` UEFI variable.
- Mark the option as the default option to boot.
- Boot option through the picker or without it depending on the `ShowPicker` option.
- Show picker on failure otherwise.

Note 1: This process is meant to work reliably only when `RequestBootVarRouting` option is enabled or the firmware does not control UEFI boot options (`DuetPkg` or custom BDS). Without `BootProtect` it also is possible that other operating systems overwrite `OpenCore`, make sure to enable it if you plan to use them.

Note 2: UEFI variable boot options' boot arguments will be dropped if present as they may contain arguments compromising the operating system, which is undesired once secure boot is enabled.

Note 3: Some operating systems, namely Windows, will create their boot option and mark it as top most upon first boot or after NVRAM Reset. When this happens default boot entry choice will update till next manual reconfiguration.

8.2 Properties

1. Boot

Type: plist dict

Description: Apply boot configuration described in Boot Properties section below.

2. BlessOverride

Type: plist array

Description: Add custom scanning paths through bless model.

Designed to be filled with `plist string` entries containing absolute UEFI paths to customised bootloaders, for example, `\EFI\Microsoft\Boot\bootmgfw.efi` for Microsoft bootloader. This allows unusual boot paths to be automatically discovered by the boot picker. Designwise they are equivalent to predefined blessed path, such as `\System\Library\CoreServices\boot.efi`, but unlike predefined bless paths they have highest priority.

3. Debug

Type: plist dict

Description: Apply debug configuration described in Debug Properties section below.

4. Entries

Type: plist array

Description: Add boot entries to boot picker.

Designed to be filled with `plist dict` values, describing each load entry. See Entry Properties section below.

5. Security

Type: plist dict

Description: Apply security configuration described in Security Properties section below.

6. Tools

Type: plist array

Description: Add tool entries to boot picker.

Designed to be filled with `plist dict` values, describing each load entry. See Entry Properties section below.

Note: Select tools, for example, UEFI Shell, are very dangerous and **MUST NOT** appear in production configurations, especially in vaulted ones and protected with secure boot, as they may be used to easily bypass secure boot chain.

8.3 Boot Properties

1. ConsoleAttributes

Type: plist integer

Failsafe: 0

Description: Sets specific attributes for console.

Text renderer supports colour arguments as a sum of foreground and background colors according to UEFI specification. The value of black background and black foreground (0) is reserved. List of colour names:

- 0x00 — EFI_BLACK
- 0x01 — EFI_BLUE
- 0x02 — EFI_GREEN
- 0x03 — EFI_CYAN
- 0x04 — EFI_RED
- 0x05 — EFI_MAGENTA
- 0x06 — EFI_BROWN
- 0x07 — EFI_LIGHTGRAY
- 0x08 — EFI_DARKGRAY
- 0x09 — EFI_LIGHTBLUE
- 0x0A — EFI_LIGHTGREEN
- 0x0B — EFI_LIGHTCYAN
- 0x0C — EFI_LIGHTRED
- 0x0D — EFI_LIGHTMAGENTA
- 0x0E — EFI_YELLOW
- 0x0F — EFI_WHITE
- 0x10 — EFI_BACKGROUND_BLACK
- 0x11 — EFI_BACKGROUND_BLUE
- 0x12 — EFI_BACKGROUND_GREEN
- 0x13 — EFI_BACKGROUND_CYAN
- 0x14 — EFI_BACKGROUND_RED
- 0x15 — EFI_BACKGROUND_MAGENTA
- 0x16 — EFI_BACKGROUND_BROWN
- 0x17 — EFI_BACKGROUND_LIGHTGRAY

Note: This option may not work well with **System** text renderer. Setting a background different from black could help testing proper GOP functioning.

2. HibernateMode

Type: plist string

Failsafe: None

Description: Hibernation detection mode. The following modes are supported:

- None — Avoid hibernation for your own good.
- Auto — Use RTC and NVRAM detection.
- RTC — Use RTC detection.
- NVRAM — Use NVRAM detection.

3. HideAuxiliary

Type: plist boolean

Failsafe: false

Description: Hides auxiliary entries from picker menu by default.

An entry is considered auxiliary when at least one of the following applies:

- Entry is macOS recovery.
- Entry is macOS Time Machine.
- Entry is explicitly marked as **Auxiliary**.
- Entry is system (e.g. **Clean NVRAM**).

To see all entries picker menu needs to be reloaded in extended mode by pressing **Spacebar** key. Hiding auxiliary entries may increase boot performance for multidisk systems.

4. ~~HideSelf~~**Type:** ~~plist boolean~~**Failsafe:** ~~false~~**Description:** ~~Hides own boot entry from boot picker. This may potentially hide other entries, for instance, when another UEFI OS is installed on the same volume and driver boot is used.~~

5. PickerAttributes

Type: plist integer

Failsafe: false

Description: Enable `boot.efi` debug log saving to OpenCore log.

Note: This option only applies to 10.15.4 and newer.

2. [ApplePanic](#)

Type: plist boolean

Failsafe: false

Description: Save macOS kernel panic to OpenCore root partition.

The file is saved as `panic-YYYY-MM-DD-HHMMSS.txt`. It is strongly recommended to have `keepsyms=1` boot argument to see debug symbols in the panic log. In case it was not present `kpdescribe.sh` utility (bundled with OpenCore) may be used to partially recover the stacktrace.

Development and debug kernels produce more helpful kernel panics. Consider downloading and installing `KernelDebugKit` from developer.apple.com when debugging a problem. To activate a development kernel you will need to add a `kcsuffix=development` boot argument. Use `uname -a` command to ensure that your current loaded kernel is a development (or a debug) kernel.

In case OpenCore kernel panic saving mechanism was not used, kernel panics may still be found in `/Library/Logs/Diagnostic` directory. Starting with macOS Catalina kernel panics are stored in JSON format, so they need to be preprocessed before passing to `kpdescribe.sh`:

```
cat Kernel.panic | grep macOSProcessedStackshotData |  
python -c 'import json,sys;print(json.load(sys.stdin)["macOSPanicString"]'
```

3. [DisableWatchDog](#)

Type: plist boolean

Failsafe: false

Description: Select firmwares may not succeed in quickly booting the operating system, especially in debug mode, which results in watch dog timer aborting the process. This option turns off watch dog timer.

4. [DisplayDelay](#)

Type: plist integer

Failsafe: 0

Description: Delay in microseconds performed after every printed line visible onscreen (i.e. console).

5. [DisplayLevel](#)

Type: plist integer, 64 bit

Failsafe: 0

Description: EDK II debug level bitmask (sum) showed onscreen. Unless **Target** enables console (onscreen) printing, onscreen debug output will not be visible. The following levels are supported (discover more in `DebugLib.h`):

- 0x00000002 (bit 1) — `DEBUG_WARN` in `DEBUG`, `NOOPT`, `RELEASE`.
- 0x00000040 (bit 6) — `DEBUG_INFO` in `DEBUG`, `NOOPT`.
- 0x00400000 (bit 22) — `DEBUG_VERBOSE` in custom builds.
- 0x80000000 (bit 31) — `DEBUG_ERROR` in `DEBUG`, `NOOPT`, `RELEASE`.

6. [Target](#)

Type: plist integer

Failsafe: 0

Description: A bitmask (sum) of enabled logging targets. By default all the logging output is hidden, so this option is required to be set when debugging is necessary.

The following logging targets are supported:

- 0x01 (bit 0) — Enable logging, otherwise all log is discarded.
- 0x02 (bit 1) — Enable basic console (onscreen) logging.
- 0x04 (bit 2) — Enable logging to Data Hub.
- 0x08 (bit 3) — Enable serial port logging.
- 0x10 (bit 4) — Enable UEFI variable logging.
- 0x20 (bit 5) — Enable non-volatile UEFI variable logging.

- 0x40 (bit 6) — Enable logging to file.

Console logging prints less than all the other variants. Depending on the build type (RELEASE, DEBUG, or NOOPT) different amount of logging may be read (from least to most).

Data Hub log will not log kernel and kext patches. To obtain Data Hub log use the following command in macOS:

```
ioreg -lw0 -p IODeviceTree | grep boot-log | sort | sed 's/.*<\(.*\)>.*\/1/' | xxd -r -p
```

UEFI variable log does not include some messages and has no performance data. For safety reasons log size is limited to 32 kilobytes. Some firmwares may truncate it much earlier or drop completely if they have no memory. Using non-volatile flag will write the log to NVRAM flash after every printed line. To obtain UEFI variable log use the following command in macOS:

```
nvrw 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:boot-log |  
awk '{gsub(/%0d%0a%00/, ""); gsub(/%0d%0a/, "\n")}'1'
```

Warning: Some firmwares are reported to have broken NVRAM garbage collection. This means that they may not be able to always free space after variable deletion. Do not use non-volatile NVRAM logging without extra need on such devices.

While OpenCore boot log already contains basic version information with build type and date, this data may also be found in NVRAM in `opencore-version` variable even with boot log disabled.

File logging will create a file named `opencore-YYYY-MM-DD-HHMMSS.txt` at EFI volume root with log contents (the upper case letter sequence is replaced with date and time from the firmware). Please be warned that some file system drivers present in firmwares are not reliable, and may corrupt data when writing files through UEFI. Log is attempted to be written in the safest manner, and thus is very slow. Ensure that `DisableWatchDog` is set to `true` when you use a slow drive.

8.5 Security Properties

1. `AllowNvramReset`
Type: plist boolean
Failsafe: false
Description: Allow CMD+OPT+P+R handling and enable showing NVRAM Reset entry in boot picker.
2. `AllowSetDefault`
Type: plist boolean
Failsafe: false
Description: Allow CTRL+Enter and CTRL+Index handling to set the default boot option in boot picker.
3. `AuthRestart`
Type: plist boolean
Failsafe: false
Description: Enable VirtualSMC-compatible authenticated restart.

Authenticated restart is a way to reboot FileVault 2 enabled macOS without entering the password. To perform authenticated restart one can use a dedicated terminal command: `sudo fdesetup authrestart`. It is also used when installing operating system updates.

VirtualSMC performs authenticated restart by saving disk encryption key split in NVRAM and RTC, which despite being removed as soon as OpenCore starts, may be considered a security risk and thus is optional.
4. [BlacklistAppleUpdate](#)
Type: [plist boolean](#)
Failsafe: [false](#)
Description: [Ignore boot options trying to update Apple peripheral firmware \(e.g. MultiUpdater.efi\).](#)
5. `BootProtect`
Type: plist string
Failsafe: None
Description: Attempt to provide bootloader persistence.

Valid values:

- **None** — do nothing.
- **Bootstrap** — create or update top-priority \EFI\OC\Bootstrap\Bootstrap.efi boot option (Boot9696) in UEFI variable storage at bootloader startup. For this option to work RequestBootVarRouting is required to be enabled.

This option provides integration with third-party operating system installation and upgrade at the times they overwrite \EFI\BOOT\BOOTx64.efi file. By creating a custom option in **Bootstrap** mode this file path becomes no longer used for bootstrapping OpenCore.

Note 1: Some firmwares may have broken NVRAM, no boot option support, or various other incompatibilities of any kind. While unlikely, the use of this option may even cause boot failure. Use at your own risk on boards known to be compatible.

Note 2: Be warned that ~~NVRAM reset will also~~ while NVRAM reset executed from OpenCore should not erase the boot option created in **Bootstrap**~~mode~~, executing NVRAM reset prior to loading OpenCore will remove it.

6. ExposeSensitiveData

Type: plist integer

Failsafe: 0x6

Description: Sensitive data exposure bitmask (sum) to operating system.

- 0x01 — Expose printable booter path as an UEFI variable.
- 0x02 — Expose OpenCore version as an UEFI variable.
- 0x04 — Expose OpenCore version in boot picker menu title.
- 0x08 — Expose OEM information as a set of UEFI variables.

Exposed booter path points to OpenCore.efi or its booter depending on the load order. To obtain booter path use the following command in macOS:

```
nvrnm 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:boot-path
```

To use booter path for mounting booter volume use the following command in macOS:

```
u=$(nvrnm 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:boot-path | sed 's/.*GPT,\([^,]*\),.*\/1/'); \
if [ "$u" != "" ]; then sudo diskutil mount $u ; fi
```

To obtain OpenCore version use the following command in macOS:

```
nvrnm 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:opencore-version
```

To obtain OEM information use the following commands in macOS:

```
nvrnm 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:oem-product # SMBIOS Type1 ProductName
nvrnm 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:oem-vendor # SMBIOS Type2 Manufacturer
nvrnm 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102:oem-board # SMBIOS Type2 ProductName
```

7. HaltLevel

Type: plist integer, 64 bit

Failsafe: 0x80000000 (DEBUG_ERROR)

Description: EDK II debug level bitmask (sum) causing CPU to halt (stop execution) after obtaining a message of HaltLevel. Possible values match DisplayLevel values.

8. Vault

Type: plist string

Failsafe: Secure

Description: Enables vaulting mechanism in OpenCore.

Valid values:

- **Optional** — require nothing, no vault is enforced, insecure.
- **Basic** — require vault.plist file present in OC directory. This provides basic filesystem integrity verification and may protect from unintentional filesystem corruption.

- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ExtendedFirmwareFeaturesMask`
Combined `FirmwareFeaturesMask` and `ExtendedFirmwareFeaturesMask`. Present on newer Macs to avoid extra parsing of SMBIOS tables.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_BID`
Hardware `BoardProduct` (e.g. `Mac-35C1E88140C3E6CF`). Not present on real Macs, but used to avoid extra parsing of SMBIOS tables, especially in `boot.efi`.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_MLB`
Hardware `BoardSerialNumber`. Override for `MLB`. Present on newer Macs (2013+ at least).
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_ROM`
Hardware `ROM`. Override for `ROM`. Present on newer Macs (2013+ at least).
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:prev-lang:kbd`
ASCII string defining default keyboard layout. Format is `lang-COUNTRY:keyboard`, e.g. `ru-RU:252` for Russian locale and ABC keyboard. Also accepts short forms: `ru:252` or `ru:0` (U.S. keyboard, compatible with 10.9). Full decoded keyboard list from `AppleKeyboardLayouts-L.dat` can be found here. Using non-latin keyboard on 10.14 will not enable ABC keyboard, unlike previous and subsequent macOS versions, and is thus not recommended in case you need 10.14.
- `7C436110-AB2A-4BBB-A880-FE41995C9F82:security-mode`
ASCII string defining FireWire security mode. Legacy, can be found in `IOFireWireFamily` source code in `IOFireWireController.cpp`. It is recommended not to set this variable, which may speedup system startup. Setting to `full` is equivalent to not setting the variable and `none` disables FireWire security.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:UIScale`
One-byte data defining `boot.efi` user interface scaling. Should be **01** for normal screens and **02** for HiDPI screens.
- `4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:DefaultBackgroundColor`
Four-byte `RGBA` data defining `boot.efi` user interface background colour. Standard colours include **BF BF BF BF** (Light Gray) and **00 00 00 00** (Syrah Black). Other colours may be set at user's preference.

9.5 Other Variables

The following variables may be useful for certain configurations or troubleshooting:

- `7C436110-AB2A-4BBB-A880-FE41995C9F82:boot-args`
Kernel arguments, used to pass configuration to Apple kernel and drivers. There are many arguments, which may be found by looking for the use of `PE_parse_boot_argn` function in the kernel or driver code. Some of the known boot arguments include:
 - `acpi_layer=0xFFFFFFFF`
 - `acpi_level=0xFFFF5F` (implies `ACPI_ALL_COMPONENTS`)
 - `batman=VALUE` (`AppleSmartBatteryManager` debug mask)
 - `batman-nosmc=1` (disable `AppleSmartBatteryManager` SMC interface)
 - `cpus=VALUE` (maximum number of CPUs used)
 - `debug=VALUE` (debug mask)
 - `io=VALUE` (IOKit debug mask)
 - `keepsyms=1` (show panic log debug symbols)
 - `kextlog=VALUE` (kernel extension loading debug mask)
 - `nv_disable=1` (disables NVIDIA GPU acceleration)
 - `nvda_drv=1` (legacy way to enable NVIDIA web driver, removed in 10.12)
 - `npici=0x2000` (legacy, disables `kIOPCIConfiguratorPFM64`)
 - `lapic_dont_panic=1`
 - `slide=VALUE` (manually set KASLR slide)
 - `smcdebug=VALUE` (`AppleSMC` debug mask)
 - `-amd_no_dgpu_accel` (alternative to WhateverGreen's `-radvesa` for new GPUs)
 - `-nehalem_error_disable`
 - `-no_compat_check` (disable model checking)
 - `-s` (single mode)
 - `-v` (verbose mode)
 - `-x` (safe mode)

There are multiple external places summarising macOS argument lists: [example 1](#), [example 2](#).

- `7C436110-AB2A-4BBB-A880-FE41995C9F82:booterconfig`

- **HardDrive** — Generic OS (mandatory).
- **Apple** — Apple OS.
- **AppleRecovery** — Apple Recovery OS.
- **AppleTM** — Apple Time Machine.
- **Windows** — Windows.
- **Other** — Custom entry (see **Entries**).
- **ResetNVRAM** — Reset NVRAM system action or tool.
- **Shell** — Entry with UEFI Shell name (e.g. **OpenShell**).
- **Tool** — Any other tool.

Predefined labels are put to `\EFI\OC\Resources\Label` directory. Each label has `.1b1` or `.12x` suffix to represent the scaling level. Full list of labels is provided below. All labels are mandatory.

- **EFIBoot** — Generic OS.
- **Apple** — Apple OS.
- **AppleRecovery** — Apple Recovery OS.
- **AppleTM** — Apple Time Machine.
- **Windows** — Windows.
- **Other** — Custom entry (see **Entries**).
- **ResetNVRAM** — Reset NVRAM system action or tool.
- **Shell** — Entry with UEFI Shell name (e.g. **OpenShell**).
- **Tool** — Any other tool.

Label and icon generation can be performed with bundled utilities: **disklabel** and **icnspack**. Please refer to sample data for the details about the dimensions. [Font is Helvetica 12 pt times scale factor.](#)

[Font format corresponds to](#) AngelCode binary BMF. [While there are many utilities to generate font files, currently it is recommended to use dpFontBaker to generate bitmap font \(using CoreText produces best results\) and fonverter to export it to binary format.](#)

WARNING: OpenCanopy is currently considered experimental and is not recommended for everyday use. Refer to [acidanthera/bugtracker#759](#) for more details regarding the current limitations.

11.5 OpenRuntime

OpenRuntime is an OpenCore plugin implementing `OC_FIRMWARE_RUNTIME` protocol. This protocol implements multiple features required for OpenCore that are otherwise not possible to implement in OpenCore itself as they are needed to work in runtime, i.e. during operating system functioning. Feature highlights:

- NVRAM namespaces, allowing to isolate operating systems from accessing select variables (e.g. **RequestBootVarRouting** or **ProtectSecureBoot**).
- NVRAM proxying, allowing to manipulate multiple variables on variable updates (e.g. **RequestBootVarFallback**).
- Read-only and write-only NVRAM variables, enhancing the security of OpenCore, Lilu, and Lilu plugins, like VirtualSMC, which implements **AuthRestart** support.
- NVRAM isolation, allowing to protect all variables from being written from an untrusted operating system (e.g. **DisableVariableWrite**).
- UEFI Runtime Services memory protection management to workaround read-only mapping (e.g. **EnableWriteUnprotector**).

11.6 Properties

1. APFS

Type: plist dict

Failsafe: None

Description: Provide APFS support as configured in APFS Properties section below.

2. Audio

Type: plist dict

Failsafe: None

Description: Configure audio backend support described in Audio Properties section below.

- Logging is enabled (1) and shown onscreen (2): Misc → Debug → Target = 3.
- Logged messages from at least DEBUG_ERROR (0x80000000), DEBUG_WARN (0x00000002), and DEBUG_INFO (0x00000040) levels are visible onscreen: Misc → Debug → DisplayLevel = 0x80000042.
- Critical error messages, like DEBUG_ERROR, stop booting: Misc → Security → HaltLevel = 0x80000000.
- Watch Dog is disabled to prevent automatic reboot: Misc → Debug → DisableWatchDog = true.
- Boot Picker (entry selector) is enabled: Misc → Boot → ShowPicker = true.

If there is no obvious error, check the available hacks in Quirks sections one by one. For early boot troubleshooting, for instance, when OpenCore menu does not appear, using [UEFI Shell \(bundled with OpenCore\)](#) may help to see early debug messages.

2. How to customise boot entries?

OpenCore follows standard Apple Bless model and extracts the entry name from `.contentDetails` and `.disk_label.contentDetails` files in the booter directory if present. These files contain an ASCII string with an entry title, which may then be customised by the user.

3. How to choose the default boot entry?

OpenCore uses the primary UEFI boot option to select the default entry. This choice can be altered from UEFI Setup, with the macOS Startup Disk preference, or the Windows Boot Camp Control Panel. Since choosing OpenCore's `BOOTx64.EFI` as a primary boot option limits this functionality in addition to several firmwares deleting incompatible boot options, potentially including those created by macOS, you are strongly encouraged to use the `RequestBootVarRouting` quirk, which will preserve your selection made in the operating system within the OpenCore variable space. Note, that `RequestBootVarRouting` requires a separate driver for functioning.

4. What is the simplest way to install macOS?

Copy online recovery image (`*.dmg` and `*.chunklist` files) to `com.apple.recovery.boot` directory on a FAT32 partition with OpenCore. Load OpenCore Boot Picker and choose the entry, it will have a `(dmg)` suffix. Custom name may be created by providing `.contentDetails` file.

To download recovery online you may use `macrecovery.py` tool from `MacInfoPkg`.

For offline installation refer to How to create a bootable installer for macOS article. Apart from App Store and `softwareupdate` utility there also are third-party tools to download an offline image.

5. Why do online recovery images (*.dmg) fail to load?

This may be caused by missing HFS+ driver, as all presently known recovery volumes have HFS+ filesystem.

6. Can I use this on Apple hardware or virtual machines?

Sure, most relatively modern Mac models including `MacPro5,1` and virtual machines are fully supported. Even though there are little to none specific details relevant to Mac hardware, some ongoing instructions can be found in [acidanthera/bugtracker#377](#).

7. Why do Find&Replace patches must equal in length?

For machine code (x86 code) it is not possible to do differently sized replacements due to relative addressing. For ACPI code this is risky, and is technically equivalent to ACPI table replacement, thus not implemented. More detailed explanation can be found on [AppleLife.ru](#).

8. How can I migrate from AptioMemoryFix?

Behaviour similar to that of `AptioMemoryFix` can be obtained by installing `OpenRuntime` driver and enabling the quirks listed below. Please note, that most of these are not necessary to be enabled. Refer to their individual descriptions in this document for more details.

- `ProvideConsoleGop` (UEFI quirk)
- `AvoidRuntimeDefrag`
- `DiscardHibernateMap`
- `EnableSafeModeSlide`
- `EnableWriteUnprotector`
- `ForceExitBootServices`
- `ProtectMemoryRegions`