

# **OpenCore**

Reference Manual (0.0.4)

[2019.08.04]

# Contents

| 1        | 1.1             | oduction Known defects   | 3               |
|----------|-----------------|--------------------------|-----------------|
|          | 1.2             | Generic Terms            | 3               |
| <b>2</b> | Con             | figuration               | 4               |
|          | 2.1             | Configuration Terms      | 4               |
|          | 2.2             | Configuration Processing | 4               |
|          | 2.3             | Configuration Structure  | 5               |
| 3        | Set             |                          | 6               |
|          | 3.1             | Directory Structure      | 6               |
|          | 3.2             | Installation and Upgrade | 7               |
|          | 3.3             | Contribution             | 7               |
| 4        | $\mathbf{AC}$   | ·I                       | 9               |
|          | 4.1             | Introduction             | G               |
|          | 4.2             | Properties               | 9               |
|          | 4.3             | Add Properties           | 9               |
|          | 4.4             | Block Properties         | 10              |
|          | 4.5             |                          | 10              |
|          | 4.6             | •                        | 11              |
| _        | ъ               |                          | 10              |
| 5        |                 | 1                        | $\frac{13}{13}$ |
|          | 5.1             |                          | 13              |
|          | 5.2             | 1                        | 13              |
|          | 5.3             | Common Properties        | 13              |
| 6        | Ker             |                          | <b>1</b> 4      |
|          | 6.1             |                          | 14              |
|          | 6.2             | 1                        | 14              |
|          | 6.3             | 1                        | 14              |
|          | 6.4             | •                        | 15              |
|          | 6.5             | Emulate Properties       | 15              |
|          | 6.6             | Patch Properties         | 15              |
|          | 6.7             | Quirks Properties        | 16              |
| 7        | Mis             |                          | 19              |
| •        | 7.1             |                          | 19              |
|          | 7.2             |                          | 19              |
|          | 7.3             |                          | 19              |
|          | 7.4             | •                        | $\frac{1}{21}$  |
|          | 7.5             | O I                      | $\frac{-1}{22}$ |
|          | 7.6             | v ·                      | $\frac{-}{24}$  |
| 0        | <b>N.T.T.</b> 7 |                          | ۰.              |
| 8        |                 |                          | 25              |
|          | 8.1             |                          | $\frac{25}{2}$  |
|          | 8.2             | 1                        | $\frac{25}{26}$ |
|          | 8.3             | v                        | $\frac{26}{26}$ |
|          | 8.4             |                          | $\frac{26}{26}$ |
|          | 8.5             | Other Variables          | 26              |
| 9        |                 |                          | 28              |
|          | 9.1             | 1                        | 28              |
|          | 9.2             | 1                        | 29              |
|          | 9.3             | *                        | 30              |
|          | 9.4             | PlatformNVRAM Properties | 31              |

|    | 9.5  | SMBIOS Properties    | 32 |
|----|------|----------------------|----|
| 10 | UEI  |                      | 36 |
|    |      | Introduction         |    |
|    | 10.2 | Properties           | 36 |
|    | 10.3 | Protocols Properties | 37 |
|    | 10.4 | Quirks Properties    | 37 |
| 11 | Tro  | ubleshooting         | 40 |
|    |      | Windows support      |    |
|    | 11.2 | Debugging            | 41 |
|    | 11.3 | Tips and Tricks      | 41 |

### 1 Introduction

This document provides information on OpenCore user configuration file format used to setup the correct functioning of macOS operating system.

### 1.1 Known defects

For OpenCore issues please refer to Acidanthera Bugtracker.

### 1.2 Generic Terms

- plist Subset of ASCII Property List format written in XML, also know 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.

# 2 Configuration

# 2.1 Configuration Terms

- OC config OpenCore Configuration file in plist format named config.plist. It has to provide extensible way to configure OpenCore and is structured to be separated into multiple named sections situated in the root plist dictionary. These sections are permitted to have plist array or plist dictionary types and are described in corresponding sections of this document.
- valid key plist key object of OC config described in this document or its future revisions. Besides explicitly
  described valid keys, keys starting with # symbol (e.g. #Hello) are also considered valid keys and behave as
  comments, effectively discarding their value, which is still required to be a valid plist object. All other plist
  keys are not valid, and their presence yields to undefined behaviour.
- valid value valid plist object of OC config described in this document that matches all the additional requirements in specific plist object description if any.
- invalid value valid plist object of OC config described in this document that is of other plist type, does not conform to additional requirements found in specific plist object description (e.g. value range), or missing from the corresponding collection. Invalid value is read with or without an error message as any possible value of this plist object in an undetermined manner (i.e. the values may not be same across the reboots). Whilst reading an invalid value is equivalent to reading certain defined valid value, applying incompatible value to the host system may yield to undefined behaviour.
- optional value valid value of OC config described in this document that reads in a certain defined manner provided in specific plist object description (instead of invalid value) when not present in OC config. All other cases of invalid value do still apply. Unless explicitly marked as optional value, any other value is required to be present and reads to invalid value if missing.
- fatal behaviour behaviour leading to boot termination. Implementation must stop the boot process from going any further until next host system boot. It is allowed but not required to perform cold reboot or show any warning message.
- undefined behaviour behaviour not prescribed by this document. Implementation is allowed to take any
  measures including but not limited to fatal behaviour, assuming any states or values, or ignoring, unless these
  measures negatively affect system security in general.

### 2.2 Configuration Processing

OC config is guaranteed to be processed at least once if it was found. Depending on OpenCore bootstrapping mechanism multiple OC config files may lead to reading any of them. No OC Config may be present on disk, in which case all the values read follow the rules of invalid value and optional value.

OC config has size, nesting, and key amount limitations. OC config size does not exceed 16 MBs. OC config has no more than 8 nesting levels. OC config has up to 16384 XML nodes (i.e. one plist dictionary item is counted as a pair of nodes) within each plist object.

Reading malformed OC config file leads to undefined behaviour. Examples of malformed OC config cover at least the following cases:

- files non-conformant to plist DTD
- files with unsupported or non-conformant plist objects found in this document
- files violating size, nesting, and key amount limitations

It is recommended but not required to abort loading malformed OC config and continue as if no OC config was present. For forward compatibility it is recommended but not required for the implementation to warn about the use of invalid values. Recommended practice of interpreting invalid values is to conform to the following convention where applicable:

| Type         | Value                              |  |  |  |
|--------------|------------------------------------|--|--|--|
| plist string | Empty string ( <string></string> ) |  |  |  |
| plist data   | Empty data ( <data></data> )       |  |  |  |

| Type   | Value  |
|--|--|
| plist integer<br>plist boolean<br>plist tristate | 0 ( <integer>0</integer> ) False ( <false></false> ) False ( <false></false> ) |

# 2.3 Configuration Structure

OC config is separated into following sections, which are described in separate sections of this document. By default it is tried to not enable anything and optionally provide kill switches with Enable property for plist dict entries. In general the configuration is written idiomatically to group similar actions in subsections:

- Add provides support for data addition.
- Block provides support for data removal or ignorance.
- Patch provides support for data modification.
- Quirks provides support for specific hacks.

Root configuration entries consist of the following:

- ACPI
- DeviceProperties
- Kernel
- Misc
- NVRAM
- PlatformInfo
- UEFI

*Note*: Currently most properties try to have defined values even if not specified in the configuration for safety reasons. This behaviour should not be relied upon, and all fields must be properly specified in the configuration.

# 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, which loads OpenCore.efi unless it was already started as a driver.
- 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.
- Tools
  - Directory used for storing supplemental tools.
- OpenCore.efi

Main booter driver responsible for operating system loading.

Hashes for all files potentially loadable by OC Config.

• config.plist

OC Config.vault.sigSignature for vault.plist.

• vault.plist

• nvram.plist OpenCore variable import file.

 opencore-YYYY-MM-DD-HHMMSS.txt OpenCore log file.

### 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.

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, MacInfoPkg, and OcSupportPkg.

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

git clone https://github.com/acidanthera/EfiPkg

git clone https://github.com/acidanthera/MacInfoPkg

git clone https://github.com/acidanthera/OcSupportPkg

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/EfiPkg
- -I/UefiPackages/EfiPkg/Include
- -I/UefiPackages/EfiPkg/Include/X64
- -I/UefiPackages/AptioFixPkg/Include
- -I/UefiPackages/AppleSupportPkg/Include
- -I/UefiPackages/OpenCorePkg/Include
- $\verb|-I/UefiPackages/OcSupportPkg/Include| \\$
- -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

Listing 2: ECC Configuration

Warning: Tool developers modifying config.plist or any other OpenCore files must ensure that their tool checks for opencore-version NVRAM variable (see Debug Properties section below) and warn the user if the version listed is unsupported or prerelease. OpenCore configuration may change across the releases and the tool shall ensure that it carefully follows this document. Failure to do so may result in this tool to be considered as malware and blocked with all possible means.

### ACPI

#### 4.1 Introduction

ACPI (Advanced Configuration and Power Interface) is an open standard to discover and configure computer hardware. ACPI specification defines the standard tables (e.g. DSDT, SSDT, FACS, DMAR) and various methods (e.g. \_DSM, \_PRW) for implementation. Modern hardware needs little changes to maintain ACPI compatibility, yet some of those are provided as a part of OpenCore.

To compile and disassemble ACPI tables iASL compiler can be used developed by ACPICA. GUI front-end to iASL compiler can be downloaded from Acidanthera/MaciASL.

#### 4.2 **Properties**

1. Add

Type: plist array Failsafe: Empty

**Description**: Load selected tables from OC/ACPI directory.

Designed to be filled with plist dict values, describing each block entry. See Add Properties section below.

Type: plist array Failsafe: Empty

**Description**: Remove selected tables from ACPI stack.

Designed to be filled with plist dict values, describing each block entry. See Block Properties section below.

3. Patch

Type: plist array Failsafe: Empty

**Description**: Perform binary patches in ACPI tables before table addition or removal.

Designed to be filled with plist dictionary values describing each patch entry. See Patch Properties section below.

4. Quirks

Type: plist dict

**Description**: Apply individual ACPI quirks described in Quirks Properties section below.

#### Add Properties 4.3

1. Comment

Type: plist string Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

2. Enabled

Type: plist boolean Failsafe: false

**Description**: This ACPI table will not be added unless set to true.

3. Path

Type: plist string Failsafe: Empty string

Description: File paths meant to be loaded as ACPI tables. Example values include DSDT.aml, SubDir/SSDT-8.aml,

SSDT-USBX.aml, etc.

ACPI table load order follows the item order in the array. All ACPI tables load from OC/ACPI directory.

Note: All tables but tables with DSDT table identifier (determined by parsing data not by filename) insert new tables into ACPI stack. DSDT, unlike the rest, performs replacement of DSDT table.

### 4.4 Block Properties

#### 1. All

Type: plist boolean Failsafe: false

**Description**: If set to true, all ACPI tables matching the condition will be dropped. Otherwise only first matched table.

#### 2. Comment

Type: plist string Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

#### 3. Enabled

Type: plist boolean Failsafe: false

**Description**: This ACPI table will not be removed unless set to true.

#### 4. OemTableId

Type: plist data, 8 bytes

Failsafe: All zero

**Description**: Match table OEM ID to be equal to this value unless all zero.

### 5. TableLength

Type: plist integer

Failsafe: 0

**Description**: Match table size to be equal to this value unless 0.

### 6. TableSignature

Type: plist data, 4 bytes

Failsafe: All zero

**Description**: Match table signature to be equal to this value unless all zero.

### 4.5 Patch Properties

### 1. Comment

Type: plist string Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

### 2. Count

Type: plist integer

Failsafe: 0

**Description**: Number of patch occurrences to apply. 0 applies the patch to all occurrences found.

#### 3. Enabled

Type: plist boolean

Failsafe: false

Description: This ACPI patch will not be used unless set to true.

### $4.\ {\tt Find}$

Type: plist data Failsafe: Empty data

Description: Data to find. Must equal to Replace in size.

### 5. Limit

Type: plist integer

Failsafe: 0

**Description**: Maximum number of bytes to search for. Can be set to 0 to look through the whole ACPI table.

#### 6. Mask

Type: plist data Failsafe: Empty data

Description: Data bitwise mask used during find comparison. Allows fuzzy search by ignoring not masked (set

to zero) bits. Can be set to empty data to be ignored. Must equal to Replace in size otherwise.

#### 7. OemTableId

Type: plist data, 8 bytes

Failsafe: All zero

**Description**: Match table OEM ID to be equal to this value unless all zero.

### 8. Replace

Type: plist data Failsafe: Empty data

**Description**: Replacement data of one or more bytes.

### 9. ReplaceMask

Type: plist data Failsafe: Empty data

Description: Data bitwise mask used during replacement. Allows fuzzy replacement by updating masked (set

to non-zero) bits. Can be set to empty data to be ignored. Must equal to Replace in size otherwise.

### $10.~{\tt Skip}$

Type: plist integer

Failsafe: 0

**Description**: Number of found occurrences to be skipped before replacement is done.

#### 11. TableLength

Type: plist integer

Failsafe: 0

**Description**: Match table size to be equal to this value unless 0.

### 12. TableSignature

Type:

textttplist data, 4 bytes Failsafe: All zero

**Description**: Match table signature to be equal to this value unless all zero.

In the majority of the cases ACPI patches are not useful and harmful:

- Avoid renaming devices with ACPI patches. This may fail or perform improper renaming of unrelated devices (e.g. EC and ECO), be unnecessary, or even fail to rename devices in select tables. For ACPI consistency it is much safer to rename devices at I/O Registry level, as done by WhateverGreen.
- Avoid patching \_OSI to support a higher level of feature sets unless absolutely required. Commonly this enables a number of hacks on APTIO firmwares, which result in the need to add more patches. Modern firmwares generally do not need it at all, and those that do are fine with much smaller patches.
- Try to avoid hacky changes like renaming \_PRW or \_DSM whenever possible.

Several cases, where patching actually does make sense, include:

- Refreshing HPET (or another device) method header to avoid compatibility checks by \_OSI on legacy hardware. \_STA method with if ((OSFL () == Zero)) { If (HPTE) ... Return (Zero) content may be forced to always return 0xF by replacing AO 10 93 4F 53 46 4C 00 with A4 0A 0F A3 A3 A3 A3 A3.
- To provide custom method implementation with in an SSDT, for instance, to report functional key presses on a laptop, the original method can be replaced with a dummy name by patching \_Q11 with XQ11.

Tianocore AcpiAml.h source file may help understanding ACPI opcodes.

### 4.6 Quirks Properties

#### 1. FadtEnableReset

Type: plist boolean

Failsafe: false

**Description**: Provide reset register and flag in FADT table to enable reboot and shutdown on legacy hardware. Not recommended unless required.

# 2. NormalizeHeaders

 $\mathbf{Type}: \mathtt{plist} \ \mathtt{boolean}$ 

Failsafe: false

**Description**: Cleanup ACPI header fields to workaround macOS ACPI implementation bug causing boot crashes. Reference: Debugging AppleACPIPlatform on 10.13 by Alex James aka theracermaster. The issue is fixed in macOS Mojave (10.14).

### 3. RebaseRegions

 $\mathbf{Type} \colon \mathtt{plist} \ \mathtt{boolean}$ 

Failsafe: false

**Description**: Attempt to heuristically relocate ACPI memory regions. Not recommended.

ACPI tables are often generated dynamically by underlying firmware implementation. Among the position-independent code, ACPI tables may contain physical addresses of MMIO areas used for device configuration, usually grouped in regions (e.g. OperationRegion). Changing firmware settings or hardware configuration, upgrading or patching the firmware inevitably leads to changes in dynamically generated ACPI code, which sometimes lead to the shift of the addresses in aforementioned OperationRegion constructions.

For this reason it is very dangerous to apply any kind of modifications to ACPI tables. The most reasonable approach is to make as few as possible changes to ACPI and try to not replace any tables, especially DSDT. When this is not possible, then at least attempt to ensure that custom DSDT is based on the most recent DSDT or remove writes and reads for the affected areas.

When nothing else helps this option could be tried to avoid stalls at PCI Configuration Begin phase of macOS booting by attempting to fix the ACPI addresses. It does not do magic, and only works with most common cases. Do not use unless absolutely required.

#### 4. ResetHwSig

Type: plist boolean

Failsafe: false

Description: Reset FACS table HardwareSignature value to 0.

This works around firmwares that fail to maintain hardware signature across the reboots and cause issues with waking from hibernation.

### 5. ResetLogoStatus

Type: plist boolean

Failsafe: false

Description: Reset BGRT table Displayed status field to false.

This works around firmwares that provide BGRT table but fail to handle screen updates afterwards.

# 5 DeviceProperties

### 5.1 Introduction

Device configuration is provided to macOS with a dedicated buffer, called EfiDevicePropertyDatabase. This buffer is a serialised map of DevicePaths to a map of property names and their values.

Property data can be debugged with gfxutil. To obtain current property data use the following command in macOS:

```
ioreg -lw0 -p IODeviceTree -n efi -r -x | grep device-properties |
  sed 's/.*<//;s/>.*//' > /tmp/device-properties.hex &&
  gfxutil /tmp/device-properties.hex /tmp/device-properties.plist &&
  cat /tmp/device-properties.plist
```

### 5.2 Properties

#### 1. Add

Type: plist dict

**Description**: Sets device properties from a map (plist dict) of deivce paths to a map (plist dict) of variable names and their values in plist metadata format. Device paths must be provided in canonic string format (e.g. PciRoot(0x0)/Pci(0x1,0x0)/Pci(0x0,0x0)). Properties will only be set if not present and not blocked.

*Note*: Currently properties may only be (formerly) added by the original driver, so unless a separate driver was installed, there is no reason to block the variables.

### $2. \ {\tt Block}$

Type: plist dict

**Description**: Removes device properties from a map (plist dict) of deivce paths to an array (plist array) of variable names in plist string format.

### 5.3 Common Properties

Some known properties include:

• device-id

User-specified device identifier used for I/O Kit matching. Has 4 byte data type.

• vendor-id

User-specified vendor identifier used for I/O Kit matching. Has 4 byte data type.

• AAPL,ig-platform-id

Intel GPU framebuffer identifier used for framebuffer selection on Ivy Bridge and newer. Has 4 byte data type.

• AAPL, snb-platform-id

Intel GPU framebuffer identifier used for framebuffer selection on Sandy Bridge. Has 4 byte data type.

• layout-id

Audio layout used for AppleHDA layout selection. Has 4 byte data type.

### 6 Kernel

#### 6.1 Introduction

This section allows to apply different kinds of kernelspace modifications on Apple Kernel (XNU). The modifications currently provide driver (kext) injection, kernel and driver patching, and driver blocking.

### 6.2 Properties

1. Add

Type: plist array Failsafe: Empty

Description: Load selected kernel drivers from OC/Kexts directory.

Designed to be filled with plist dict values, describing each driver. See Add Properties section below. Kernel driver load order follows the item order in the array, thus the dependencies should be written prior to their consumers.

2. Block

Type: plist array Failsafe: Empty

**Description**: Remove selected kernel drivers from prelinked kernel.

Designed to be filled with plist dictionary values, describing each blocked driver. See Block Properties section below.

3. Emulate

Type: plist dict

**Description**: Emulate select hardware in kernelspace via parameters described in Emulate Properties section below.

4. Patch

Type: plist array Failsafe: Empty

**Description**: Perform binary patches in kernel and drivers prior to driver addition and removal.

Designed to be filled with plist dictionary values, describing each patch. See Patch Properties section below.

5. Quirks

Type: plist dict

**Description**: Apply individual kernel and driver quirks described in Quirks Properties section below.

### 6.3 Add Properties

1. BundlePath

Type: plist string Failsafe: Empty string

Description: Kext bundle path (e.g. Lilu.kext or MyKext.kext/Contents/PlugIns/MySubKext.kext).

2. Comment

Type: plist string Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

3. Enabled

Type: plist boolean Failsafe: false

Description: This kernel driver will not be added unless set to true.

4. ExecutablePath

Type: plist string

Failsafe: Empty string

Description: Kext executable path relative to bundle (e.g. Contents/MacOS/Lilu).

5. MatchKernel

Type: plist string Failsafe: Empty string

**Description**: Blocks kernel driver on selected macOS version only. The selection happens based on prefix match with the kernel version, i.e. 16.7.0 will match macOS 10.12.6 and 16. will match any macOS 10.12.x version.

6. PlistPath

Type: plist string Failsafe: Empty string

Description: Kext Info.plist path relative to bundle (e.g. Contents/Info.plist).

### 6.4 Block Properties

1. Comment

Type: plist string Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

2. Enabled

Type: plist boolean Failsafe: false

Description: This kernel driver will not be blocked unless set to true.

3. Identifier

Type: plist string Failsafe: Empty string

Description: Kext bundle identifier (e.g. com.apple.driver.AppleTyMCEDriver).

4. MatchKernel

Type: plist string Failsafe: Empty string

**Description**: Blocks kernel driver on selected macOS version only. The selection happens based on prefix match with the kernel version, i.e. 16.7.0 will match macOS 10.12.6 and 16. will match any macOS 10.12.x version.

### 6.5 Emulate Properties

1. Cpuid1Data

Type: plist data, 16 bytes

Failsafe: All zero

Description: Sequence of EAX, EBX, ECX, EDX values in Little Endian order to replace CPUID (1) call in XNU kernel.

 $2. \ {\tt Cpuid1Mask}$ 

Type: plist data, 16 bytes

Failsafe: All zero

**Description**: Bit mask of active bits in Cpuid1Data. When each Cpuid1Mask bit is set to 0, the original CPU bit is used, otherwise set bits take the value of Cpuid1Data.

### 6.6 Patch Properties

1. Base

Type: plist string Failsafe: Empty string

**Description**: Selects symbol-matched base for patch lookup (or immediate replacement) by obtaining the address of provided symbol name. Can be set to empty string to be ignored.

2. Comment

Type: plist string

Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

#### 3. Count

Type: plist integer

Failsafe: 0

**Description**: Number of patch occurrences to apply. 0 applies the patch to all occurrences found.

#### 4. Enabled

Type: plist boolean Failsafe: false

**Description**: This kernel patch will not be used unless set to true.

### 5. Find

Type: plist data Failsafe: Empty data

Description: Data to find. Can be set to empty for immediate replacement at Base. Must equal to Replace in

size otherwise.

6. Identifier

Type: plist string Failsafe: Empty string

Description: Kext bundle identifier (e.g. com.apple.driver.AppleHDA) or kernel for kernel patch.

### 7. Limit

Type: plist integer

Failsafe: 0

**Description**: Maximum number of bytes to search for. Can be set to 0 to look through the whole kext or kernel.

#### $8. \, {\tt Mask}$

Type: plist data Failsafe: Empty data

**Description**: Data bitwise mask used during find comparison. Allows fuzzy search by ignoring not masked (set to zero) bits. Can be set to empty data to be ignored. Must equal to Replace in size otherwise.

### 9. MatchKernel

Type: plist string Failsafe: Empty string

**Description**: Adds kernel driver to selected macOS version only. The selection happens based on prefix match with the kernel version, i.e. 16.7.0 will match macOS 10.12.6 and 16. will match any macOS 10.12.x version.

### 10. Replace

Type: plist data Failsafe: Empty data

**Description**: Replacement data of one or more bytes.

### 11. ReplaceMask

Type: plist data Failsafe: Empty data

**Description**: Data bitwise mask used during replacement. Allows fuzzy replacement by updating masked (set to non-zero) bits. Can be set to empty data to be ignored. Must equal to Replace in size otherwise.

#### 12. Skip

Type: plist integer

Failsafe: 0

**Description**: Number of found occurrences to be skipped before replacement is done.

### 6.7 Quirks Properties

### $1. \ {\tt AppleCpuPmCfgLock}$

Type: plist boolean

Failsafe: false

**Description**: Disables PKG\_CST\_CONFIG\_CONTROL (0xE2) MSR modification in AppleIntelCPUPowerManagement.kext, commonly causing early kernel panic, when it is locked from writing.

*Note*: This option should avoided whenever possible. Modern firmwares provide CFG Lock setting, disabling which is much cleaner. More details about the issue can be found in VerifyMsrE2 notes.

### $2. \ {\tt AppleXcpmCfgLock}$

Type: plist boolean

Failsafe: false

**Description**: Disables PKG\_CST\_CONFIG\_CONTROL (0xE2) MSR modification in XNU kernel, commonly causing early kernel panic, when it is locked from writing (XCPM power management).

Note: This option should avoided whenever possible. Modern firmwares provide CFG Lock setting, disabling which is much cleaner. More details about the issue can be found in VerifyMsrE2 notes.

### 3. AppleXcpmExtraMsrs

Type: plist boolean

Failsafe: false

Description: Disables multiple MSR access critical for select CPUs, which have no native XCPM support.

This is normally used in conjunction with Emulate section on Haswell-E, Broadwell-E, Skylake-X, and similar CPUs. More details on the XCPM patches are outlined in acidanthera/bugtracker#365.

*Note*: Additional not provided patches will be required for Ivy Bridge or Pentium CPUs. It is recommended to use AppleIntelCpuPowerManagement.kext for the former.

#### 4. CustomSMBIOSGuid

Type: plist boolean

Failsafe: false

Description: Performs GUID patching for UpdateSMBIOSMode Custom mode. Usually relevant for Dell laptops.

#### 5. DisableIoMapper

Type: plist boolean

Failsafe: false

Description: Disables IOMapper support in XNU (VT-d), which may conflict with the firmware implementation.

*Note*: This option is a preferred alternative to dropping DMAR ACPI table and disabling VT-d in firmware preferences, which does not break VT-d support in other systems in case they need it.

#### 6. ExternalDiskIcons

Type: plist boolean

Failsafe: false

Description: Apply icon type patches to AppleAHCIPort.kext to force internal disk icons for all AHCI disks.

Note: This option should avoided whenever possible. Modern firmwares usually have compatible AHCI controllers.

#### 7. LapicKernelPanic

Type: plist boolean

Failsafe: false

**Description**: Disables kernel panic on LAPIC interrupts.

### 8. PanicNoKextDump

Type: plist boolean

Failsafe: false

**Description**: Prevent kernel from printing kext dump in the panic log preventing from observing panic details. Affects 10.13 and above.

### 9. ThirdPartyTrim

Type: plist boolean

Failsafe: false

**Description**: Patch IOAHCIBlockStorage.kext to force TRIM command support on AHCI SSDs.

*Note*: This option should avoided whenever possible. NVMe SSDs are compatible without the change. For AHCI SSDs on modern macOS version there is a dedicated built-in utility called trimforce.

### 10. XhciPortLimit

Type: plist boolean

Failsafe: false

 $\textbf{Description:} \ \ \text{Patch various kexts (AppleUSBXHCI.kext, AppleUSBXHCIPCI.kext, IOUSBHostFamily.kext) to} \\$ 

remove USB port count limit of 15 ports.

*Note*: This option should avoided whenever possible. USB port limit is imposed by the amount of used bits in locationID format and there is no possible way to workaround this without heavy OS modification. The only valid solution is to limit the amount of used ports to 15 (discarding some). More details can be found on AppleLife.ru.

### 7 Misc

#### 7.1 Introduction

This section contains miscellaneous configuration entries for OpenCore behaviour that does not go to any other sections

# 7.2 Properties

1. Boot

Type: plist dict

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

2. Debug

Type: plist dict

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

3. Security

Type: plist dict

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

4. Tools

Type: plist array

**Description**: Add new entries to boot picker.

Designed to be filled with plist dict values, describing each block entry. See Tools Properties section below.

*Note*: Select tools, for example, UEFI Shell or CleanNvram 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.

### 7.3 Boot Properties

1. ConsoleMode

Type: plist string Failsafe: Empty string

**Description**: Sets console output mode as specified with the WxH (e.g. 80x24) formatted string. Set to empty string not to change console mode. Set to Max to try to use largest available console mode.

2. ConsoleBehaviourOs

Type: plist string Failsafe: Empty string

**Description**: Set console control behaviour upon operating system load.

Console control is a legacy protocol used for switching between text and graphics screen output. Some firmwares do not provide it, yet select operating systems require its presence, which is what ConsoleControl UEFI protocol is for.

When console control is available, OpenCore can be made console control aware, and and set different modes for the operating system booter (ConsoleBehaviourOs), which normally runs in graphics mode, and its own user interface (ConsoleBehaviourUi), which normally runs in text mode. Possible behaviours, set as values of these options, include:

- Empty string Do not modify console control mode.
- Text Switch to text mode.
- Graphics Switch to graphics mode.
- ForceText Switch to text mode and preserve it (requires ConsoleControl).
- ForceGraphics Switch to graphics mode and preserve it (require ConsoleControl).

### Hints:

- Unless empty works, firstly try to set ConsoleBehaviourOs to Graphics and ConsoleBehaviourUi to Text.
- On APTIO IV (Haswell and earlier) it is usually enough to have ConsoleBehaviourOs set to Graphics and ConsoleBehaviourUi set to ForceText to avoid visual glitches.

- On APTIO V (Broadwell and newer) ConsoleBehaviourOs set to ForceGraphics and ConsoleBehaviourUi set to ForceText usually works best.
- On Apple firmwares ConsoleBehaviourOs set to Graphics and ConsoleBehaviourUi set to Text is supposed to work best.

*Note*: IgnoreTextInGraphics and SanitiseClearScreen may need to be enabled for select firmware implementations. Particularly APTIO firmwares.

#### 3. ConsoleBehaviourUi

Type: plist string Failsafe: Empty string

**Description**: Set console control behaviour upon OpenCore user interface load. Refer to ConsoleBehaviourOs description for details.

#### 4. 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.

#### 5. 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.

#### 6. Resolution

Type: plist string Failsafe: Empty string

**Description**: Sets console output screen resolution.

- Set to WxH@Bpp (e.g. 1920x1080@32) WxH (e.g. 1920x1080) formatted string to request custom resolution from GOP if available.
- Set to empty string not to change screen resolution.
- Set to Max to try to use largest available screen resolution.

On HiDPI screens APPLE\_VENDOR\_VARIABLE\_GUID UIScale NVRAM variable may need to be set to 02 to enable HiDPI scaling in FileVault 2 UEFI password interface and boot screen logo. Refer to Recommended Variables section for more details.

*Note*: This will fail when console handle has no GOP protocol. When the firmware does not provide it, it can be added with ProvideConsoleGop UEFI quirk set to true.

### 7. ShowPicker

Type: plist boolean Failsafe: false

**Description**: Show simple boot picker to allow boot entry selection.

#### 8. Timeout

Type: plist integer, 32 bit

Failsafe: 0

Description: Timeout in seconds in boot picker before automatic booting of the default boot entry.

### $9. \ {\tt UsePicker}$

Type: plist boolean

Failsafe: false

**Description**: Use OpenCore built-in boot picker for boot management.

UsePicker set to false entirely disables all boot management in OpenCore except policy enforcement. In this case a custom user interface may utilise OcSupportPkg OcBootManagementLib to implement a user friendly boot

picker oneself. Reference example of external graphics interface is provided in ExternalUi test driver.

*Note*: By default OpenCore built-in boot picker loads the default discovered option, this can be changed by setting ShowPicker to true.

### 7.4 Debug Properties

1. 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.

2. DisplayDelay

Type: plist integer

Failsafe: 0

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

3. 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.

4. 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:

```
nvram 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.

#### Security Properties 7.5

#### 1. ExposeSensitiveData

Type: plist integer

Failsafe: 2

**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.

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:

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

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

```
u=$(nvram 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:

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

### 2. 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.

#### 3. RequireSignature

Type: plist boolean

Failsafe: true

Description: Require vault.sig signature file for vault.plist in OC directory.

This file should contain a raw 256 byte RSA-2048 signature from SHA-256 hash of vault.plist. The signature is verified against the public key embedded into OpenCore.efi.

To embed the public key you should do either of the following:

- Provide public key during the OpenCore.efi compilation in OpenCoreVault.c file.
- Binary patch OpenCore.efi replacing zeroes with the public key between =BEGIN OC VAULT= and ==END OC VAULT== ASCII markers.

RSA public key 520 byte format description can be found in Chromium OS documentation. To convert public key from X.509 certificate or from PEM file use RsaTool.

Note: vault.sig is used regardless of this option when public key is embedded into OpenCore.efi. Setting it to true will only ensure configuration sanity, and abort the boot process when public key is not set but was supposed to be used for verification.

#### 4. RequireVault

Type: plist boolean

Failsafe: true

Description: Require vault.plist file present in OC directory.

This file should contain SHA-256 hashes for all files used by OpenCore. Presence of this file is highly recommended to ensure that unintentional file modifications (including filesystem corruption) do not happen unnoticed. To create this file automatically use create\_vault.sh script.

Regardless of the underlying filesystem, path name and case must match between config.plist and vault.plist.

*Note*: vault.plist is tried to be read regardless of the value of this option, but setting it to true will ensure configuration sanity, and abort the boot process.

The complete set of commands to:

- Create vault.plist.
- Create a new RSA key (always do this to avoid loading old configuration).
- Embed RSA key into OpenCore.efi.
- Create vault.sig.

Can look as follows:

```
cd /Volumes/EFI/EFI/OC
/path/to/create_vault.sh .
/path/to/RsaTool -sign vault.plist vault.sig vault.pub
off=$(($(strings -a -t d OpenCore.efi | grep "=BEGIN OC VAULT=" | cut -f1 -d' ')+16))
dd of=OpenCore.efi if=vault.pub bs=1 seek=$off count=520 conv=notrunc
rm vault.pub
```

Note: While it may appear obvious, but you have to use an external method to verify OpenCore.efi and BOOTx64.efi for secure boot path. For this you are recommended to at least enable UEFI SecureBoot with a custom certificate, and sign OpenCore.efi and BOOTx64.efi with your custom key. More details on customising secure boot on modern firmwares can be found in Taming UEFI SecureBoot paper (in Russian).

### 5. ScanPolicy

Type: plist integer, 32 bit

Failsafe: 0xF0103

**Description**: Define operating system detection policy.

This value allows to prevent scanning (and booting) from untrusted source based on a bitmask (sum) of select flags. As it is not possible to reliably detect every file system or device type, this feature cannot be fully relied upon in open environments, and the additional measures are to be applied.

Third party drivers may introduce additional security (and performance) measures following the provided scan policy. Scan policy is exposed in scan-policy variable of 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102 GUID for UEFI Boot Services only.

- 0x00000001 (bit 0) OC\_SCAN\_FILE\_SYSTEM\_LOCK, restricts scanning to only known file systems defined as
  a part of this policy. File system drivers may not be aware of this policy, and to avoid mounting of undesired
  file systems it is best not to load its driver. This bit does not affect dmg mounting, which may have any file
  system. Known file systems are prefixed with OC\_SCAN\_ALLOW\_FS\_.
- 0x00000002 (bit 1) 0C\_SCAN\_DEVICE\_LOCK, restricts scanning to only known device types defined as a part of this policy. This is not always possible to detect protocol tunneling, so be aware that on some systems it may be possible for e.g. USB HDDs to be recognised as SATA. Cases like this must be reported. Known device types are prefixed with OC\_SCAN\_ALLOW\_DEVICE\_.
- 0x00000100 (bit 8) OC\_SCAN\_ALLOW\_FS\_APFS, allows scanning of APFS file system.
- 0x00000200 (bit 9) OC\_SCAN\_ALLOW\_FS\_HFS, allows scanning of HFS file system.
- 0x00000400 (bit 10) 0C\_SCAN\_ALLOW\_FS\_ESP, allows scanning of EFI System Partition file system.
- 0x00010000 (bit 16)  $0C_SCAN_ALLOW_DEVICE_SATA$ , allow scanning SATA devices.
- 0x00020000 (bit 17) 0C\_SCAN\_ALLOW\_DEVICE\_SASEX, allow scanning SAS and Mac NVMe devices.
- 0x00040000 (bit 18)  $0C\_SCAN\_ALLOW\_DEVICE\_SCSI$ , allow scanning SCSI devices.
- 0x00080000 (bit 19) OC\_SCAN\_ALLOW\_DEVICE\_NVME, allow scanning NVMe devices.

- 0x00100000 (bit 20) OC\_SCAN\_ALLOW\_DEVICE\_ATAPI, allow scanning CD/DVD devices.
- 0x00200000 (bit 21) OC\_SCAN\_ALLOW\_DEVICE\_USB, allow scanning USB devices.
- 0x00400000 (bit 22) OC\_SCAN\_ALLOW\_DEVICE\_FIREWIRE, allow scanning FireWire devices.
- 0x00800000 (bit 23) OC\_SCAN\_ALLOW\_DEVICE\_SDCARD, allow scanning card reader devices.

Note: Given the above description, 0xF0103 value is expected to allow scanning of SATA, SAS, SCSI, and NVMe devices with APFS file system, and prevent scanning of any devices with HFS or FAT32 file systems in addition to not scanning APFS file systems on USB, CD, USB, and FireWire drives. The combination reads as:

- OC\_SCAN\_FILE\_SYSTEM\_LOCK
- OC\_SCAN\_DEVICE\_LOCK
- OC\_SCAN\_ALLOW\_FS\_APFS
- OC\_SCAN\_ALLOW\_DEVICE\_SATA
- OC\_SCAN\_ALLOW\_DEVICE\_SASEX
- OC\_SCAN\_ALLOW\_DEVICE\_SCSI
- OC\_SCAN\_ALLOW\_DEVICE\_NVME

### 7.6 Tools Properties

### 1. Comment

Type: plist string Failsafe: Empty string

**Description**: Arbitrary ASCII string used to provide human readable reference for the entry. It is implementation defined whether this value is used.

#### 2. Enabled

Type: plist boolean Failsafe: false

**Description**: This tool will not be listed unless set to true.

#### 3. Name

Type: plist string Failsafe: Empty string

**Description**: Human readable tool name displayed in boot picker.

### 4. Path

Type: plist string Failsafe: Empty string

**Description**: File path to select UEFI tool relative to OC/Tools directory.

### 8 NVRAM

#### 8.1 Introduction

Has plist dict type and allows to set volatile UEFI variables commonly referred as NVRAM variables. Refer to man nvram for more details. macOS extensively uses NVRAM variables for OS — Bootloader — Firmware intercommunication, and thus supplying several NVRAM is required for proper macOS functioning.

Each NVRAM variable consists of its name, value, attributes (refer to UEFI specification), and its GUID, representing which 'section' NVRAM variable belongs to. macOS uses several GUIDs, including but not limited to:

- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14 (APPLE\_VENDOR\_VARIABLE\_GUID)
- 7C436110-AB2A-4BBB-A880-FE41995C9F82 (APPLE\_BOOT\_VARIABLE\_GUID)
- 8BE4DF61-93CA-11D2-AAOD-00E098032B8C (EFI\_GLOBAL\_VARIABLE\_GUID)
- 4D1FDA02-38C7-4A6A-9CC6-4BCCA8B30102 (OC\_VENDOR\_VARIABLE\_GUID)

*Note*: Some of the variables may be added by PlatformNVRAM or Generic subsections of PlatformInfo section. Please ensure that variables of this section never collide with them, as behaviour is undefined otherwise.

### 8.2 Properties

#### 1. Add

Type: plist dict

**Description**: Sets NVRAM variables from a map (plist dict) of GUIDs to a map (plist dict) of variable names and their values in plist metadata format. GUIDs must be provided in canonic string format in upper or lower case (e.g. 8BE4DF61-93CA-11D2-AAOD-00E098032B8C).

Created variables get EFI\_VARIABLE\_BOOTSERVICE\_ACCESS and EFI\_VARIABLE\_RUNTIME\_ACCESS attributes set. Variables will only be set if not present and not blocked. To overwrite a variable add it to Block section. This approach enables to provide default values till the operating system takes the lead.

Note: If plist key does not conform to GUID format, behaviour is undefined.

### $2.\ {\tt Block}$

Type: plist dict

**Description**: Removes NVRAM variables from a map (plist dict) of GUIDs to an array (plist array) of variable names in plist string format.

### 3. LegacyEnable

Type: plist boolean Failsafe: false

Description: Enables loading of NVRAM variable file named nvram.plist from EFI volume root.

This file must have root plist dictionary type and contain two fields:

- Version plist integer, file version, must be set to 1.
- Add plist dictionary, equivalent to Add from config.plist.

Variable loading happens prior to Block (and Add) phases, and will not overwrite any existing variable. Variables allowed to be set must be specified in LegacySchema. Third-party scripts may be used to create nvram.plist file. An example of such script can be found in Utilities. The use of third-party scripts may require ExposeSensitiveData set to 0x3 to provide boot-path variable with OpenCore EFI partition UUID.

**WARNING**: This feature is very dangerous as it passes unprotected data to your firmware variable services. Use it only when no hardware NVRAM implementation is provided by the firmware or it is incompatible.

### 4. LegacySchema

Type: plist dict

**Description**: Allows setting select NVRAM variables from a map (plist dict) of GUIDs to an array (plist array) of variable names in plist string format.

You can use \* value to accept all variables for select GUID.

**WARNING**: Choose variables very carefully, as nvram.plist is not vaulted. For instance, do not put boot-args or csr-active-config, as this can bypass SIP.

To read NVRAM variable value from macOS one could use nvram by concatenating variable GUID and name separated by: symbol. For example, nvram 7C436110-AB2A-4BBB-A880-FE41995C9F82:boot-args.

A continuously updated variable list can be found in a corresponding document: NVRAM Variables.

### 8.3 Mandatory Variables

Warning: These variables may be added by PlatformNVRAM or Generic subsections of PlatformInfo section. Using PlatformInfo is the recommend way of setting these variables.

The following variables are mandatory for macOS functioning:

- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:FirmwareFeatures
  32-bit FirmwareFeatures. Present on all Macs to avoid extra parsing of SMBIOS tables
- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:FirmwareFeaturesMask 32-bit FirmwareFeaturesMask. Present on all Macs to avoid extra parsing of SMBIOS tables.
- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:MLB
  BoardSerialNumber. Present on newer Macs (2013+ at least) to avoid extra parsing of SMBIOS tables, especially in boot.efi.
- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ROM

  Primary network adapter MAC address or replacement value. Present on newer Macs (2013+ at least) to avoid accessing special memory region, especially in boot.efi.

### 8.4 Recommended Variables

The following variables are recommended for faster startup or other improvements:

- 7C436110-AB2A-4BBB-A880-FE41995C9F82:csr-active-config 32-bit System Integrity Protection bitmask. Declared in XNU source code in csr.h.
- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ExtendedFirmwareFeatures

  Combined FirmwareFeatures and ExtendedFirmwareFeatures. Present on newer Macs to avoid extra parsing of SMBIOS tables
- 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 macOS versions, and is thus not recommended.
- 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.

### 8.5 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=0xFFFFFFF
- acpi\_level=0xFFFF5F (implies ACPI\_ALL\_COMPONENTS)
- cpus=VALUE
- debug=VALUE
- io=VALUE
- keepsyms=1
- kextlog=VALUE
- nvda\_drv=1
- lapic\_dont\_panic=1
- slide=VALUE
- -nehalem\_error\_disable
- -no\_compat\_check
- -s
- v
- -x
- 7C436110-AB2A-4BBB-A880-FE41995C9F82:bootercfg

Booter arguments, similar to boot-args but for boot.efi. Accepts a set of arguments, which are hexadecimal 64-bit values with or without 0x prefix primarily for logging control:

- log=VALUE
  - \* 1 AppleLoggingConOutOrErrSet/AppleLoggingConOutOrErrPrint (classical ConOut/StdErr)
  - \* 2 AppleLoggingStdErrSet/AppleLoggingStdErrPrint (StdErr or serial?)
  - \* 4 AppleLoggingFileSet/AppleLoggingFilePrint (BOOTER.LOG/BOOTER.OLD file on EFI partition)
- debug=VALUE
  - \* 1 enables print something to BOOTER.LOG (stripped code implies there may be a crash)
  - \* 2 enables perf logging to /efi/debug-log in the device three
  - \* 4 enables timestamp printing for styled printf calls
- level=VALUE Verbosity level of DEBUG output. Everything but 0x80000000 is stripped from the binary, and this is the default value.
- kc-read-size=VALUE Chunk size used for buffered I/O from network or disk for prelinkedkernel reading and related. Set to 1MB (0x100000) by default, can be tuned for faster booting.
- 7C436110-AB2A-4BBB-A880-FE41995C9F82:bootercfg-once

Booter arguments override removed after first launch. Otherwise equivalent to bootercfg.

- 7C436110-AB2A-4BBB-A880-FE41995C9F82:fmm-computer-name
  - Current saved host name. ASCII string.
- 7C436110-AB2A-4BBB-A880-FE41995C9F82:nvda\_drv

NVIDIA Web Driver control variable. Takes ASCII digit 1 or 0 to enable or disable installed driver.

### 9 PlatformInfo

Platform information is comprised of several identification fields generated or filled manually to be compatible with macOS services. The base part of the configuration may be obtained from MacInfoPkg package, which itself generates a set of interfaces based on a database in YAML format. These fields are written to three select destinations:

- SMBIOS
- Data Hub
- NVRAM

Most of the fields specify the overrides in SMBIOS, and their field names conform to EDK2 SmBios.h header file. However, several important fields reside in Data Hub and NVRAM. Some of the values can be found in more than one field and/or destination, so there are two ways to control their update process: manual, where one specifies all the values (the default), and semi-automatic, where (Automatic) only select values are specified, and later used for system configuration.

To inspect SMBIOS contents dmidecode utility can be used. Version with macOS specific enhancements can be downloaded from Acidanthera/dmidecode.

### 9.1 Properties

#### 1. Automatic

Type: plist boolean Failsafe: false

Description: Generate PlatformInfo based on Generic section instead of using values from DataHub, NVRAM, and SMBIOS sections.

Enabling this option is useful when Generic section is flexible enough. When enabled SMBIOS, DataHub, and PlatformNVRAM data is unused.

#### 2. UpdateDataHub

Type: plist boolean Failsafe: false

Description: Update Data Hub fields. These fields are read from Generic or DataHub sections depending on Automatic value.

#### 3. UpdateNVRAM

Type: plist boolean Failsafe: false

**Description**: Update NVRAM fields related to platform information.

These fields are read from Generic or PlatformNVRAM sections depending on Automatic value. All the other fields are to be specified with NVRAM section.

If UpdateNVRAM is set to false the aforementioned variables can be updated with NVRAM section. If UpdateNVRAM is set to true the behaviour is undefined when any of the fields are present in NVRAM section.

### 4. UpdateSMBIOS

Type: plist boolean

Failsafe: false

**Description**: Update SMBIOS fields. These fields are read from **Generic** or **SMBIOS** sections depending on **Automatic** value.

### 5. UpdateSMBIOSMode

Type: plist string Failsafe: Create

**Description**: Update SMBIOS fields approach:

- TryOverwrite Overwrite if new size is <= than the page-aligned original and there are no issues with legacy region unlock. Create otherwise. Has issues with some firmwares.
- Create Replace the tables with newly allocated EfiReservedMemoryType at AllocateMaxAddress without
  any fallbacks.

- Overwrite Overwrite existing gEfiSmbiosTableGuid and gEfiSmbiosTable3Guid data if it fits new size. Abort with unspecified state otherwise.
- Custom Write first SMBIOS table (gEfiSmbiosTableGuid) to gOcCustomSmbiosTableGuid to workaround firmwares overwriting SMBIOS contents at ExitBootServices. Otherwise equivalent to Create. Requires patching AppleSmbios.kext and AppleACPIPlatform.kext to read from another GUID: "EB9D2D31" "EB9D2D35" (in ASCII), done automatically by CustomSMBIOSGuid quirk.
- 6. Generic

Type: plist dictonary

Optional: When Automatic is false

Description: Update all fields. This section is read only when Automatic is active.

7. DataHub

Type: plist dictonary

Optional: When Automatic is true

Description: Update Data Hub fields. This section is read only when Automatic is not active.

8. PlatformNVRAM

Type: plist dictonary

Optional: When Automatic is true

**Description**: Update platform NVRAM fields. This section is read only when Automatic is not active.

9. SMBIOS

Type: plist dictonary

Optional: When Automatic is true

Description: Update SMBIOS fields. This section is read only when Automatic is not active.

### 9.2 Generic Properties

1. SpoofVendor

Type: plist boolean

Failsafe: false

Description: Sets SMBIOS vendor fields to Acidanthera.

It is dangerous to use Apple in SMBIOS vendor fields for reasons given in SystemManufacturer description. However, certain firmwares may not provide valid values otherwise, which could break some software.

 $2. \ {\tt SystemProductName}$ 

Type: plist string Failsafe: MacPro6,1

Description: Refer to SMBIOS SystemProductName.

 $3. \ {\tt SystemSerialNumber}$ 

Type: plist string Failsafe: OPENCORE\_SN1

 ${\bf Description} \hbox{: Refer to SMBIOS SystemSerialNumber}.$ 

4. SystemUUID

Type: plist string, GUID Failsafe: OEM specified

Description: Refer to SMBIOS SystemUUID.

5. MLB

Type: plist string

Failsafe: OPENCORE\_MLB\_SN11

Description: Refer to SMBIOS BoardSerialNumber.

6. ROM

Type: plist data, 6 bytes

Failsafe: all zero

Description: Refer to 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ROM.

### 9.3 DataHub Properties

#### 1. PlatformName

Type: plist string Failsafe: Not installed

Description: Sets name in gEfiMiscSubClassGuid. Value found on Macs is platform in ASCII.

### 2. SystemProductName

Type: plist string Failsafe: Not installed

Description: Sets Model in gEfiMiscSubClassGuid. Value found on Macs is equal to SMBIOS SystemProductName

in Unicode.

#### 3. SystemSerialNumber

Type: plist string Failsafe: Not installed

Description: Sets SystemSerialNumber in gEfiMiscSubClassGuid. Value found on Macs is equal to SMBIOS

SystemSerialNumber in Unicode.

#### 4. SystemUUID

Type: plist string, GUID Failsafe: Not installed

Description: Sets system-id in gEfiMiscSubClassGuid. Value found on Macs is equal to SMBIOS SystemUUID.

#### 5. BoardProduct

Type: plist string Failsafe: Not installed

Description: Sets board-id in gEfiMiscSubClassGuid. Value found on Macs is equal to SMBIOS BoardProduct

in ASCII.

#### 6. BoardRevision

Type: plist data, 1 byte

Failsafe: 0

**Description**: Sets board-rev in gEfiMiscSubClassGuid. Value found on Macs seems to correspond to internal board revision (e.g. 01).

### 7. StartupPowerEvents

Type: plist integer, 64-bit

Failsafe: 0

**Description**: Sets StartupPowerEvents in gEfiMiscSubClassGuid. Value found on Macs is power management state bitmask, normally 0. Known bits read by X86PlatformPlugin.kext:

- 0x00000001 Shutdown cause was a PWROK event (Same as GEN\_PMCON\_2 bit 0)
- 0x00000002 Shutdown cause was a SYS PWROK event (Same as GEN PMCON 2 bit 1)
- 0x00000004 Shutdown cause was a THRMTRIP# event (Same as GEN PMCON 2 bit 3)
- 0x00000008 Rebooted due to a SYS RESET# event (Same as GEN\_PMCON\_2 bit 4)
- 0x00000010 Power Failure (Same as GEN\_PMCON\_3 bit 1 PWR\_FLR)
- 0x00000020 Loss of RTC Well Power (Same as GEN\_PMCON\_3 bit 2 RTC\_PWR\_STS)
- 0x00000040 General Reset Status (Same as GEN\_PMCON\_3 bit 9 GEN\_RST\_STS)
- Oxffffff80 SUS Well Power Loss (Same as GEN\_PMCON\_3 bit 14)
- 0x00010000 Wake cause was a ME Wake event (Same as PRSTS bit 0, ME\_WAKE\_STS)
- 0x00020000 Cold Reboot was ME Induced event (Same as PRSTS bit 1 ME\_HRST\_COLD\_STS)
- 0x00040000 Warm Reboot was ME Induced event (Same as PRSTS bit 2 ME\_HRST\_WARM\_STS)
- 0x00080000 Shutdown was ME Induced event (Same as PRSTS bit 3 ME\_HOST\_PWRDN)
- 0x00100000 Global reset ME Wachdog Timer event (Same as PRSTS bit 6)
- 0x00200000 Global reset PowerManagment Wachdog Timer event (Same as PRSTS bit 15)

### 8. InitialTSC

Type: plist integer, 64-bit

Failsafe: 0

Description: Sets Initial TSC in gEfiProcessorSubClassGuid. Sets initial TSC value, normally 0.

#### 9. FSBFrequency

Type: plist integer, 64-bit

Failsafe: Automatic

Description: Sets FSBFrequency in gEfiProcessorSubClassGuid. Sets CPU FSB frequency.

### 10. ARTFrequency

Type: plist integer, 64-bit Failsafe: Not installed

Description: Sets ARTFrequency in gEfiProcessorSubClassGuid. Sets CPU ART frequency, Skylake and

newer.

### 11. DevicePathsSupported

Type: plist integer, 32-bit

Failsafe: Not installed

**Description**: Sets DevicePathsSupported in gEfiMiscSubClassGuid. Must be set to 1 for AppleACPIPlatform.kext to append SATA device paths to Boot#### and efi-boot-device-data variables. Set to 1 on all modern Macs.

#### 12. SmcRevision

Type: plist data, 6 bytes Failsafe: Not installed

 $\textbf{Description} : \textbf{Sets} \ \texttt{REV} \ \textbf{in} \ \texttt{gEfiMiscSubClassGuid}. \ \textbf{Custom} \ \textbf{property} \ \textbf{read} \ \textbf{by} \ \texttt{VirtualSMC} \ \textbf{or} \ \textbf{FakeSMC} \ \textbf{to} \ \textbf{generate}$ 

SMC REV key.

#### 13. SmcBranch

Type: plist data, 8 bytes Failsafe: Not installed

Description: Sets RBr in gEfiMiscSubClassGuid. Custom property read by VirtualSMC or FakeSMC to generate

SMC RBr key.

### 14. SmcPlatform

Type: plist data, 8 bytes Failsafe: Not installed

Description: Sets RPlt in gEfiMiscSubClassGuid. Custom property read by VirtualSMC or FakeSMC to

generate SMC RPlt key.

### 9.4 PlatformNVRAM Properties

#### 1. BID

Type: plist string Failsafe: Not installed

Description: Specifies the value of NVRAM variable 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW\_BID.

#### 2. ROM

Type: plist data, 6 bytes Failsafe: Not installed

**Description**: Specifies the values of NVRAM variables 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW\_ROM and 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ROM.

### $3.\ \mathrm{MLB}$

Type: plist string Failsafe: Not installed

**Description**: Specifies the values of NVRAM variables  $4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_MLB$  and  $4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:HW_MLB$ .

#### 4. FirmwareFeatures

Type: plist data, 8 bytes Failsafe: Not installed

Description: This variable comes in pair with FirmwareFeaturesMask. Specifies the values of NVRAM variables:

- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:FirmwareFeatures
- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ExtendedFirmwareFeatures

#### 5. FirmwareFeaturesMask

Type: plist data, 8 bytes Failsafe: Not installed

Description: This variable comes in pair with FirmwareFeatures. Specifies the values of NVRAM variables:

- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:FirmwareFeaturesMask
- 4D1EDE05-38C7-4A6A-9CC6-4BCCA8B38C14:ExtendedFirmwareFeaturesMask

### 9.5 SMBIOS Properties

#### 1. BIOSVendor

Type: plist string Failsafe: OEM specified

**SMBIOS**: BIOS Information (Type 0) — Vendor

Description: BIOS Vendor. All rules of SystemManufacturer do apply.

#### 2. BIOSVersion

Type: plist string Failsafe: OEM specified

**SMBIOS**: BIOS Information (Type 0) — BIOS Version

**Description**: Firmware version. This value gets updated and takes part in update delivery configuration and macOS version compatibility. This value could look like MM71.88Z.0234.B00.1809171422 in older firmwares, and is described in BiosId.h. In newer firmwares it should look like 236.0.0.0.0 or 220.230.16.0.0 (iBridge: 16.16.2542.0.0,0). iBridge version is read from BridgeOSVersion variable, and is only present on macs with T2

### Apple ROM Version

BIOS ID: MBP151.88Z.F000.B00.1811142212

Model: MBP151

EFI Version: 220.230.16.0.0 Built by: root@quinoa

Date: Wed Nov 14 22:12:53 2018

Revision: 220.230.16 (B&I)

ROM Version: F000\_B00

Build Type: Official Build, RELEASE

Compiler: Apple LLVM version 10.0.0 (clang-1000.2.42)

UUID: E5D1475B-29FF-32BA-8552-682622BA42E1
UUID: 151B0907-10F9-3271-87CD-4BF5DBECACF5

#### 3. BIOSReleaseDate

Type: plist string Failsafe: OEM specified

**SMBIOS**: BIOS Information (Type 0) — BIOS Release Date

Description: Firmware release date. Similar to BIOSVersion. May look like 12/08/2017.

### 4. SystemManufacturer

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Information (Type 1) — Manufacturer

**Description**: OEM manufacturer of the particular board. Shall not be specified unless strictly required. Should *not* contain Apple Inc., as this confuses numerous services present in the operating system, such as firmware updates, eficheck, as well as kernel extensions developed in Acidanthera, such as Lilu and its plugins. In addition it will also make some operating systems like Linux unbootable.

### 5. SystemProductName

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Information (Type 1), Product Name

**Description**: Preferred Mac model used to mark the device as supported by the operating system. This value must be specified by any configuration for later automatic generation of the related values in this and other

SMBIOS tables and related configuration parameters. If SystemProductName is not compatible with the target operating system, -no\_compat\_check boot argument may be used as an override.

Note: If SystemProductName is unknown, and related fields are unspecified, default values should be assumed as being set to MacPro6,1 data. The list of known products can be found in MacInfoPkg.

### 6. SystemVersion

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Information (Type 1) — Version

Description: Product iteration version number. May look like 1.1.

### 7. SystemSerialNumber

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Information (Type 1) — Serial Number

Description: Product serial number in defined format. Known formats are described in macserial.

### 8. SystemUUID

Type: plist string, GUID Failsafe: OEM specified

**SMBIOS**: System Information (Type 1) — UUID

**Description**: A UUID is an identifier that is designed to be unique across both time and space. It requires no central registration process.

### 9. SystemSKUNumber

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Information (Type 1) — SKU Number

**Description**: Mac Board ID (board-id). May look like Mac-7BA5B2D9E42DDD94 or Mac-F221BEC8 in older models. Sometimes it can be just empty.

### 10. SystemFamily

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Information (Type 1) — Family **Description**: Family name. May look like iMac Pro.

#### 11. BoardManufacturer

Type: plist string Failsafe: OEM specified

 ${\bf SMBIOS} :$  Baseboard (or Module) Information (Type 2) - Manufacturer

**Description**: Board manufacturer. All rules of SystemManufacturer do apply.

#### 12. BoardProduct

Type: plist string Failsafe: OEM specified

SMBIOS: Baseboard (or Module) Information (Type 2) - Product

**Description**: Mac Board ID (board-id). May look like Mac-7BA5B2D9E42DDD94 or Mac-F221BEC8 in older models.

#### 13. BoardVersion

Type: plist string Failsafe: OEM specified

SMBIOS: Baseboard (or Module) Information (Type 2) - Version

Description: Board version number. Varies, may match SystemProductName or SystemProductVersion.

#### 14. BoardSerialNumber

Type: plist string Failsafe: OEM specified

**SMBIOS**: Baseboard (or Module) Information (Type 2) — Serial Number

**Description**: Board serial number in defined format. Known formats are described in macserial.

#### 15. BoardAssetTag

Type: plist string Failsafe: OEM specified

**SMBIOS**: Baseboard (or Module) Information (Type 2) — Asset Tag

Description: Asset tag number. Varies, may be empty or Type2 - Board Asset Tag.

### 16. BoardType

Type: plist integer Failsafe: OEM specified

**SMBIOS**: Baseboard (or Module) Information (Type 2) — Board Type

Description: Either OxA (Motherboard (includes processor, memory, and I/O) or OxB (Processor/Memory

Module), refer to Table 15 – Baseboard: Board Type for more details.

### 17. BoardLocationInChassis

Type: plist string Failsafe: OEM specified

SMBIOS: Baseboard (or Module) Information (Type 2) — Location in Chassis

Description: Varies, may be empty or Part Component.

### 18. ChassisManufacturer

Type: plist string Failsafe: OEM specified

SMBIOS: System Enclosure or Chassis (Type 3) — Manufacturer

Description: Board manufacturer. All rules of SystemManufacturer do apply.

### 19. ChassisType

Type: plist integer Failsafe: OEM specified

**SMBIOS**: System Enclosure or Chassis (Type 3) — Type

**Description**: Chassis type, refer to Table 17 — System Enclosure or Chassis Types for more details.

### 20. ChassisVersion

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Enclosure or Chassis (Type 3) — Version

Description: Should match BoardProduct.

#### 21. ChassisSerialNumber

Type: plist string
Failsafe: OEM specified

SMBIOS: System Enclosure or Chassis (Type 3) — Version

 ${\bf Description} \hbox{: Should match SystemSerialNumber}.$ 

#### 22. ChassisAssetTag

Type: plist string Failsafe: OEM specified

**SMBIOS**: System Enclosure or Chassis (Type 3) — Asset Tag Number

Description: Chassis type name. Varies, could be empty or MacBook-Aluminum.

### $23. \ {\tt PlatformFeature}$

Type: plist integer, 32-bit

Failsafe: 0xFFFFFFF

SMBIOS: APPLE\_SMBIOS\_TABLE\_TYPE133 - PlatformFeature

**Description**: Platform features bitmask. Refer to AppleFeatures.h for more details. Use <code>OxFFFFFFFF</code> value to not provide this table.

#### 24. SmcVersion

Type: plist data, 16 bytes

Failsafe: All zero

SMBIOS: APPLE\_SMBIOS\_TABLE\_TYPE134 - Version

**Description**: ASCII string containing SMC version in upper case. Missing on T2 based Macs. Ignored when zero.

### 25. FirmwareFeatures

Type: plist data, 8 bytes

Failsafe: 0

 ${\bf SMBIOS: APPLE\_SMBIOS\_TABLE\_TYPE128 - Firmware Features} \ {\bf and} \ {\bf ExtendedFirmware Features}$ 

Description: 64-bit firmware features bitmask. Refer to AppleFeatures.h for more details. Lower 32 bits match

FirmwareFeatures. Upper 64 bits match ExtendedFirmwareFeatures.

#### 26. FirmwareFeaturesMask

Type: plist data, 8 bytes

Failsafe: 0

SMBIOS: APPLE\_SMBIOS\_TABLE\_TYPE128 - FirmwareFeaturesMask and ExtendedFirmwareFeaturesMask Description: Supported bits of extended firmware features bitmask. Refer to AppleFeatures.h for more details.

Lower 32 bits match FirmwareFeaturesMask. Upper 64 bits match ExtendedFirmwareFeaturesMask.

### 27. ProcessorType

Type: plist integer, 16-bit

Failsafe: Automatic

SMBIOS: APPLE\_SMBIOS\_TABLE\_TYPE131 - ProcessorType Description: Combined of Processor Major and Minor types.

### $28.\ {\tt MemoryFormFactor}$

Type: plist integer, 8-bit Failsafe: OEM specified

**SMBIOS**: Memory Device (Type 17) — Form Factor

**Description**: Memory form factor. On Macs it should be DIMM or SODIMM.

### 10 UEFI

### 10.1 Introduction

UEFI (Unified Extensible Firmware Interface) is a specification that defines a software interface between an operating system and platform firmware. This section allows to load additional UEFI modules and/or apply tweaks for the onboard firmware. To inspect firmware contents, apply modifications and perform upgrades UEFITool and supplementary utilities can be used.

### 10.2 Properties

1. ConnectDrivers

Type: plist boolean

Failsafe: false

**Description**: Perform UEFI controller connection after driver loading. This option is useful for loading filesystem drivers, which usually follow UEFI driver model, and may not start by themselves. While effective, this option is not necessary with e.g. APFS loader driver, and may slightly slowdown the boot.

2. Drivers

Type: plist array Failsafe: None

**Description**: Load selected drivers from OC/Drivers directory.

Designed to be filled with string filenames meant to be loaded as UEFI drivers. Depending on the firmware a different set of drivers may be required. Loading an incompatible driver may lead your system to unbootable state or even cause permanent firmware damage. Some of the known drivers include:

- ApfsDriverLoader APFS file system bootstrap driver adding the support of embedded APFS drivers in bootable APFS containers in UEFI firmwares.
- AppleUiSupport Apple-specific user interface support driver. This driver brings the support for FileVault 2 GUI, hotkey parsing (shift, cmd+v, etc.), language collation support, and certain other features important for normal macOS functioning. For hotkey support AppleKeyMapAggregator-compatible driver is required.
- AppleGenericInput user input driver adding the support of AppleKeyMapAggregator protocols on top of different UEFI input protocols. Additionally resolves mouse input issues on select firmwares. This is an alternative to UsbKbDxe, which may work better or worse depending on the firmware.
- AptioMemoryFix a set of quirks for various firmwares. While it primarily targets APTIO firmwares, other firmwares may be compatible as well. Among the resolved issues are hibernation support, KASLR, Lilu NVRAM security enhancements, NVRAM, and UEFI Boot entry preservation.
- EmuVariableRuntimeDxe NVRAM emulation driver from MdeModulePkg. NVRAM is supported by most modern firmwares. For firmwares with macOS incompatible NVRAM implementation an emulated driver may be used. This driver will not preserve NVRAM contents across the reboots.
- EnglishDxe Unicode collation driver from MdeModulePkg. This driver is a lightweight alternative to AppleUiSupport, which contains no Apple-specific code, and only provides unicode collation support. The driver is not recommended for use on any hardware but few original Macs.
- EnhancedFatDxe FAT filesystem driver from FatPkg. This driver is embedded in all UEFI firmwares, and cannot be used from OpenCore. It is known that multiple firmwares have a bug in their FAT support implementation, which leads to corrupted filesystems on write attempt. Embedding this driver within the firmware may be required in case writing to EFI partition is needed during the boot process.
- NvmExpressDxe NVMe support driver from MdeModulePkg. This driver is included in most firmwares starting with Broadwell generation. For Haswell and earlier embedding it within the firmware may be more favourable in case a NVMe SSD drive is installed.
- UsbKbDxe USB keyboard driver adding the support of AppleKeyMapAggregator protocols on top of a custom USB keyboard driver implementation. This is an alternative to AptioInputFix, which may work better or worse depending on the firmware.
- VirtualSmc UEFI SMC driver, required for proper FileVault 2 functionality and potentially other macOS specifics. An alternative, named SMCHelper, is not compatible with VirtualSmc and OpenCore, which is unaware of its specific interfaces. In case FakeSMC kernel extension is used, manual NVRAM variable addition may be needed and VirtualSmc driver should still be used.
- VBoxHfs HFS file system driver with bless support. This driver is an alternative to a closed source

HFSPlus driver commonly found in Apple firmwares. While it is feature complete, it is approximately 3 times slower and is yet to undergo a security audit.

• XhciDxe — XHCI USB controller support driver from MdeModulePkg. This driver is included in most firmwares starting with Sandy Bridge generation. For earlier firmwares or legacy systems it may be used to support external USB 3.0 PCI cards.

To compile the drivers from TianoCore UDK use the same command you do normally use for OpenCore compilation, but choose a corresponding package:

```
git clone https://github.com/tianocore/edk2 -b UDK2018 UDK
cd UDK
source edksetup.sh
make -C BaseTools
build -a X64 -b RELEASE -t XCODE5 -p FatPkg/FatPkg.dsc
build -a X64 -b RELEASE -t XCODE5 -p MdeModulePkg/MdeModulePkg.dsc
```

#### 3. Protocols

Type: plist dict Failsafe: None

Description: Force builtin versions of select protocols described in Protocols Properties section below.

*Note*: all protocol instances are installed prior to driver loading.

#### 4. Quirks

Type: plist dict Failsafe: None

**Description**: Apply individual firmware quirks described in Quirks Properties section below.

### 10.3 Protocols Properties

### 1. AppleBootPolicy

Type: plist boolean Failsafe: false

**Description**: Reinstalls Apple Boot Policy protocol with a builtin version. This may be used to ensure APFS compatibility on VMs or legacy Macs.

#### 2. ConsoleControl

Type: plist boolean Failsafe: false

**Description**: Replaces Console Control protocol with a builtin version.

macOS bootloader requires console control protocol for text output, which some firmwares miss. This option is required to be set when the protocol is already available in the firmware, and other console control options are used, such as IgnoreTextInGraphics, SanitiseClearScreen, and sometimes ConsoleBehaviourOs with ConsoleBehaviourUi).

#### 3. DataHub

Type: plist boolean

Failsafe: false

**Description**: Reinstalls Data Hub protocol with a builtin version. This will drop all previous properties if the protocol was already installed.

### 4. DeviceProperties

Type: plist boolean Failsafe: false

**Description**: Reinstalls Device Property protocol with a builtin version. This will drop all previous properties if it was already installed. This may be used to ensure full compatibility on VMs or legacy Macs.

### 10.4 Quirks Properties

### 1. AvoidHighAlloc

Type: plist boolean

Failsafe: false

**Description**: Advises allocators to avoid allocations above first 4 GBs of RAM.

This is a workaround for select board firmwares, namely GA-Z77P-D3 (rev. 1.1), failing to properly access higher memory in UEFI Boot Services. Not recommended unless required for booting. May cause recovery boot failures on unaffected boards.

# $2. \ \, \underbrace{\texttt{ExitBootServicesDelay}}_{-}$

Type: plist integer

Failsafe: 0

**Description**: Adds delay in microseconds after EXIT\_BOOT\_SERVICES event.

This is a very ugly quirk to circumvent "Still waiting for root device" message on select APTIO IV firmwares, namely ASUS Z87-Pro, when using FileVault 2 in particular. It seems that for some reason they execute code in parallel to EXIT\_BOOT\_SERVICES, which results in SATA controller being inaccessible from macOS. A better approach should be found in some future. Expect 3-5 seconds to be enough in case the quirk is needed.

### 3. IgnoreInvalidFlexRatio

Type: plist boolean

Failsafe: false

**Description**: Select firmwares, namely APTIO IV, may contain invalid values in MSR\_FLEX\_RATIO (0x194) MSR register. These values may cause macOS boot failure on Intel platforms.

*Note*: While the option is not supposed to induce harm on unaffected firmwares, its usage is not recommended when it is not required.

### 4. IgnoreTextInGraphics

Type: plist boolean

Failsafe: false

**Description**: Select firmwares output text onscreen in both graphics and text mode. This is normally unexpected, because random text may appear over graphical images and cause UI corruption. Setting this option to true will discard all text output when console control is in mode different from Text.

*Note*: While the option is not supposed to induce harm on unaffected firmwares, its usage is not recommended when it is not required. This option may hide onscreen error messages. ConsoleControl may need to be set to true for this to work.

### 5. ProvideConsoleGop

Type: plist boolean

Failsafe: false

**Description**: macOS bootloader requires GOP (Graphics Output Protocol) to be present on console handle. This option will install it if missing.

*Note*: Some drivers, like AptioMemoryFix, may provide equivalent functionality. These drivers are not guaranteed to adhere to the same logic, and if a quirk is necessary, this option is preferred.

### 6. ReleaseUsbOwnership

Type: plist boolean

Failsafe: false

**Description**: Attempt to detach USB controller ownership from the firmware driver. While most firmwares manage to properly do that, or at least have an option for, select firmwares do not. As a result, operating system may freeze upon boot. Not recommended unless required.

#### 7. RequestBootVarRouting

Type: plist boolean

Failsafe: false

**Description**: Request NVRAM driver (or AptioMemoryFix) to redirect Boot prefixed variables from EFI\_GLOBAL\_VARIABLE\_C to OC\_VENDOR\_VARIABLE\_GUID.

This will set special boot-redirect variable, which a compatible driver will abide after booter start. The quirk lets default boot entry preservation at times when firmwares delete incompatible boot entries.

#### 8. SanitiseClearScreen

Type: plist boolean

Failsafe: false

**Description**: Some firmwares reset screen resolution to a failsafe value (like 1024x768) on the attempts to clear screen contents when large display (e.g. 2K or 4K) is used. This option attempts to apply a workaround.

Note: ConsoleControl may need to be set to true for this to work. On all known affected systems ConsoleMode had to be set to empty string for this to work.

# 11 Troubleshooting

### 11.1 Windows support

#### Can I install Windows?

While no official Windows support is provided, 64-bit UEFI Windows installations (Windows 8 and above) prepared with Boot Camp are supposed to work. Third-party UEFI installations as well as systems partially supporting UEFI boot, like Windows 7, might work with some extra precautions. Things to keep in mind:

- MBR (Master Boot Record) installations are legacy and will not be supported.
- Installing Windows and macOS on the same drive is currently unsupported but will be addressed later.
- All the modifications applied (to ACPI, NVRAM, SMBIOS, etc.) are supposed to be operating system agnostic, i.e. apply equally regardless of the OS booted. This enables Boot Camp software experience on Windows.
- macOS requires the first partition to be EFI System Partition, and does not support the default Windows layout. While OpenCore does have a workaround for this, it is highly recommend not to rely on it and install properly.
- Windows may need to be reactivated. To avoid it consider leaving SystemUUID field empty, so that the original firmware UUID is used. Be warned, on old firmwares it may be invalid, i.e. not random. In case you still have issues, consider using HWID or KMS38 license. The nuances of Windows activation are out of the scope of this document and can be found online.

### What additional software do I need?

To enable operating system switching and install relevant drivers in the majority of cases you will need Windows support software from Boot Camp. For simplicity of the download process or when configuring an already installed Windows version a third-party utility, Brigadier, can be used successfully. Note, that you may have to download and install 7-Zip prior to using Brigadier.

Remember to always use the latest version of Windows support software from Boot Camp, as versions prior to 6.1 do not support APFS, and thus will not function correctly. To download newest software pass most recent Mac model to Brigadier, for example ./brigadier.exe -m iMac19,1. To install Boot Camp on an unsupported Mac model afterwards run PowerShell as Administrator and enter msiexec /i BootCamp.msi. In case you already have a previous version of Boot Camp installed you will have to remove it first by running msiexec /x BootCamp.msi command. BootCamp.msi file is located in BootCamp/Drivers/Apple directory and can be reached through Windows Explorer.

While Windows support software from Boot Camp solves most of compatibility problems, sometimes you may have to address some of them manually:

- To invert mouse wheel scroll direction FlipFlopWheel must be set to 1 as explained on SuperUser.
- RealTimeIsUniversal must be set to 1 to avoid time desync between Windows and macOS as explained on SuperUser (this one is usually not needed).
- To access Apple filesystems like HFS and APFS separate software may need to be installed. Some of the known tools are: Apple HFS+ driver (hack for Windows 10), HFSExplorer, MacDrive, Paragon APFS, Paragon HFS+, TransMac, etc. Remember to never ever attempt to modify Apple file systems from Windows as this often leads to irrecoverable data loss.

### Why do I see Basic data partition in Boot Camp Startup Disk control panel?

Boot Camp control panel uses GPT partition table to obtain each boot option name. After installing Windows separately you will have to relabel the partition manually. This can be done with many tools including open-source gdisk utility. Reference example:

```
PS C:\gdisk> .\gdisk64.exe \\.\physicaldrive0
GPT fdisk (gdisk) version 1.0.4

Command (? for help): p
Disk \\.\physicaldrive0: 419430400 sectors, 200.0 GiB
Sector size (logical): 512 bytes
Disk identifier (GUID): DEC57EB1-B3B5-49B2-95F5-3B8C4D3E4E12
Partition table holds up to 128 entries
```

Main partition table begins at sector 2 and ends at sector 33 First usable sector is 34, last usable sector is 419430366 Partitions will be aligned on 2048-sector boundaries Total free space is 4029 sectors (2.0 MiB)

| Number | Start (sector) | End (sector) | Size      | Code | Name                 |
|--------|----------------|--------------|-----------|------|----------------------|
| 1      | 2048           | 1023999      | 499.0 MiB | 2700 | Basic data partition |
| 2      | 1024000        | 1226751      | 99.0 MiB  | EF00 | EFI system partition |
| 3      | 1226752        | 1259519      | 16.0 MiB  | 0C01 | Microsoft reserved   |
| 4      | 1259520        | 419428351    | 199.4 GiB | 0700 | Basic data partition |

Command (? for help): c Partition number (1-4): 4 Enter name: BOOTCAMP

Command (? for help): w

Final checks complete. About to write GPT data. THIS WILL OVERWRITE EXISTING PARTITIONS!!

Do you want to proceed? (Y/N): Y OK; writing new GUID partition table (GPT) to  $\.\$  physicaldriveO. Disk synchronization succeeded! The computer should now use the new partition table. The operation has completed successfully.

Listing 3: Relabeling Windows volume

### How to choose Windows BOOTCAMP with custom NTFS drivers?

Third-party drivers providing NTFS support, such as NTFS-3G, Paragon NTFS, Tuxera NTFS or Seagate Paragon Driver break certain macOS functionality, including Startup Disk preference pane normally used for operating system selection. While the recommended option remains not to use such drivers as they commonly corrupt the filesystem, and prefer the driver bundled with macOS with optional write support (command or GUI), there still exist vendor-specific workarounds for their products: Tuxera, Paragon, etc.

### 11.2 Debugging

Similar to other projects working with hardware OpenCore supports auditing and debugging. The use of NOOPT or DEBUG build modes instead of RELEASE can produce a lot more debug output. With NOOPT source level debugging with GDB or IDA Pro is also available. For GDB check OcSupport Debug page. For IDA Pro you will need IDA Pro 7.3 or newer, refer to Debugging the XNU Kernel with IDA Pro for more details.

To obtain the log during boot you can make the use of serial port debugging. Serial port debugging is enabled in Target, e.g. 0xB for onscreen with serial. OpenCore uses 115200 baud rate, 8 data bits, no parity, and 1 stop bit. For macOS your best choice are CP2102-based UART devices. Connect motherboard TX to USB UART GND, and motherboard GND to USB UART RX. Use screen utility to get the output, or download GUI software, such as CoolTerm.

Remember to enable COM port in firmware settings, and never use USB cables longer than 1 meter to avoid output corruption. To additionally enable XNU kernel serial output you will need debug=0x8 boot argument.

# 11.3 Tips and Tricks

### 1. How to debug boot failure?

Normally it is enough to obtain the actual error message. For this ensure that:

- You have a DEBUG or NOOPT version of OpenCore.
- Logging is enabled (1) and shown onscreen (2):  $\texttt{Misc} \to \texttt{Debug} \to \texttt{Target} = 3$ .
- Logged messages from at least DEBUG\_ERROR (0x80000000), DEBUG\_WARN (0x00000002), and DEBUG\_INFO (0x000000040) 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.

#### 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. 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 Recovery tool from OcSupportPkg.

### 4. 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. Another cause may be buggy firmware allocator, which can be worked around with AvoidHighAlloc UEFI quirk.

### 5. 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.

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

For machine code (x86 code) it is not possible to do such 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.