OpenCore

Reference Manual (~~0.0.4~~0.5.0)

[2019.08.25]

1 Introduction

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

1.1 ~~Known defects~~

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

1.1 Generic Terms

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

10.3 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`)
   - `0xffffff80` — 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 `InitialTSC` 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. This value equals to CPU nominal frequency divided by CPU maximum bus ratio and is specified in Hz. Refer to `MSR_NEHALEM_PLATFORM_INFO (CEh)` MSR value to determine maximum bus ratio on modern Intel CPUs.

10. `ARTFrequency`
    Type: `plist integer`, 64-bit
    Failsafe: ~~Not installed~~Automatic
    Description: Sets `ARTFrequency` in `gEfiProcessorSubClassGuid`. ~~Sets~~

    This value contains CPU ART frequency, ~~Skylake~~ also known as crystal clock frequency. Its existence is exclusive to Skylake generation and newer. The value is specified in Hz, and is normally 24 MHz for client Intel segment, 25 MHz for server Intel segment, and 19.2 MHz for Intel Atom CPUs. macOS till 10.15 inclusive assumes 24 MHz by default.

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

10.4 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. `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:MLB`.

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. On these boards this quirk is required for booting entries that need to allocate large memory chunks, such as macOS DMG recovery entries. On unaffected boards it may cause boot failures, and thus strongly not recommended. For known issues refer to `acidanthera/bugtracker#449`.

2. `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. `ReplaceTabWithSpace`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Some firmwares do not print tab characters or even everything that follows them, causing difficulties or inability to use the UEFI Shell builtin text editor to edit property lists and other documents. This option makes the console output spaces instead of tabs.

   Note: `ConsoleControl` may need to be set to `true` for this to work.

6. `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.

7. `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.

8. `RequestBootVarRouting`
   Type: `plist boolean`
   Failsafe: `false`
   Description: Request redirect`Boot` prefixed variables from `EFI_GLOBAL_VARIABLE_GUID` to `OC_VENDOR_VARIABLE_GUID`.

   This quirk requires `OC_FIRMWARE_RUNTIME` protocol implemented in `FwRuntimeServices.efi`. The quirk lets

default boot entry preservation at times when firmwares delete incompatible boot entries. Simply said, you are required to enable this quirk to be able to reliably use Startup Disk preference pane in a firmware that is not compatible with macOS boot entries by design.

9. `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.

10. `ClearScreenOnModeSwitch`
    Type: `plist boolean`
    Failsafe: `false`
    Description: Some firmwares clear only part of screen when switching from graphics to text mode, leaving a fragment of previously drawn image visible. This option fills the entire graphics screen with black color before switching to text mode.

    Note: `ConsoleControl` should be set to `true` for this to work.

- 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. **How to choose the default boot entry?**

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

4. **What is the simplest way to install macOS?**

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

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

   For offline installation refer to How to create a bootable installer for macOS article.

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

   This may be caused by missing HFS+ driver, as all presently known recovery volumes have HFS+ filesystem. Another cause may be buggy firmware allocator, which can be worked around with `AvoidHighAlloc` UEFI quirk.

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

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

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

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

8. **How can I migrate from `AptioMemoryFix`?**

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

   - `ProvideConsoleGop` (UEFI quirk)
   - `AvoidRuntimeDefrag`
   - `DiscardHibernateMap`
   - `EnableSafeModeSlide`
   - `EnableWriteUnprotector`
   - `ForceExitBootServices`
   - `ProtectCsmRegion`
   - `ProvideCustomSlide`
   - `SetupVirtualMap`
   - `ShrinkMemoryMap`