



CFE Bootloader and Flash Memory Structure

CFE BOOTLOADER VERSION 4.16L.01

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Revision History

Revision	Date	Change Description
963XX-AN102-R	02/06/14	Third released
963XX-AN101-R	07/25/05	Second release
963XX-AN100-R	10/13/03	Initial release

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Table of Contents

About This Document	6
Purpose and Audience	6
Acronyms and Abbreviations	6
Document Conventions	6
Technical Support	6
Building the CFE Bootloader	7
Full Binary Rebuild	7
Building NOR Flash CFE ELF Files and cfe.w File.....	7
Building NAND Flash CFE ELF Files	7
Building NAND CFE-only Images	7
Initial Programming of CFE via JTAG Debugger	8
CFE Bootloader Command Line Interface	9
CFE Bootloader Commands	11
CFE Bootloader Command c	12
CFE Bootloader Command Examples	14
Updating the DSL Router Image Using TFTP	14
Updating the DSL Router Image Using HTTP	16
Flash Memory Structure (NOR Flash)	17
Backup PSI Area (NOR Flash only).....	19
Persistent System Log Area.....	19
Dual Linux Image Support	20
Flash Memory Structure (NAND Flash)	20

List of Figures

Figure 1: Flash Memory Map18

Figure 2: Filesystem.....21

Figure 3: Split Filesystem.....22

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List of Tables

Table 1: CFE Bootloader Commands11

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About This Document

Purpose and Audience

This document explains the Common Firmware Environment (CFE) bootloader version 4.16L.01 command-line interface and the flash-memory structure in the BCM963XX DSL router reference platform.

Acronyms and Abbreviations

In most cases, acronyms and abbreviations are defined on first use.

For a comprehensive list of acronyms and other terms used in Broadcom documents, go to:
<http://www.broadcom.com/press/glossary.php>.

Document Conventions

The following conventions may be used in this document:

Convention	Description
Bold	User input and actions: for example, type exit , click OK , press Alt+C
Monospace	Code: <code>#include <iostream></code> HTML: <code><td rowspan = 3></code> Command line commands and parameters: <code>wl [-1] <command></code>
<code>< ></code>	Placeholders for <i>required</i> elements: enter your <code><username></code> or <code>wl <command></code>
<code>[]</code>	Indicates <i>optional</i> command-line parameters: <code>wl [-1]</code> Indicates bit and byte ranges (inclusive): <code>[0:3]</code> or <code>[7:0]</code>

Technical Support

Broadcom provides customer access to a wide range of information, including technical documentation, schematic diagrams, product bill of materials, PCB layout information, and software updates through its customer support portal (<https://support.broadcom.com>). For a CSP account, contact your Sales or Engineering support representative.

In addition, Broadcom provides other product support through its Downloads and Support site (<http://www.broadcom.com/support/>).

Building the CFE Bootloader

The CFE for the BCM63138 device is used in the following examples. The procedure for other devices is identical.

Full Binary Rebuild

To rebuild the full binary, type these commands:

1. `cd cfe/build/broadcom/bcm63xx_rom`
2. `make release`

CFE binaries will be built and copied to the `targets/cfe/` directory.

Building NOR Flash CFE ELF Files and cfe.w File

To build the NOR Flash ELF files and a `cfe.w` file, type these commands:

1. `cd cfe/build/broadcom/bcm63xx_rom`
2. `make BRCM_CHIP=63138`

The ELF file will be in `cfe/build/broadcom/bcm63xx_rom/cfe63138`

The `Cfe.w` file will be in `cfe/build/broadcom/bcm63xx_rom/bcm963138_cfe.w`

Building NAND Flash CFE ELF Files

To build NAND Flash CFE ELF files, type these commands:

1. `cd cfe/build/broadcom/bcm63xx_rom`
2. `make BRCM_CHIP=63138 BLD_NAND=1`

The ELF file will be in `cfe/build/broadcom/bcm63xx_rom/cfe63138`

Building NAND CFE-only Images

To build NAND CFE-only images, follow these steps:

1. Perform the full binary rebuild described in [“Full Binary Rebuild”](#).
2. Change directory back to the top directory.
3. Type `make PROFILE=963138GW nandcfeimage`

Images will be in `targets/963138GW/bcm963138GW_nand_cfeonly.<blocksize>.w`

Initial Programming of CFE via JTAG Debugger

Prerequisites

1. CFE ELF File
2. JTAG debugger with attach script and ddrinit script for the appropriate device.
3. Image file including CFE:
 - For NOR CFE Only, bcm963138_cfe.w
 - For NOR full image, bcm963138GW_cfe_fs_kernel
 - For NAND CFE Only, bcm963138GW_nand_cfeonly.<blocksize>.w
 - For NAND Linux® images, bcm963138GW_nand_fs_image_<blocksize>_<filesystem>.w
4. Serial connection to serial port (115200, 8, N, 1)
5. LAN connection to a PC with a static IP address on subnet 192.168.1.0/24 and an address between 192.168.1.2 and 192.168.1.254. (The example given in [Step 8](#) below assumes the address is 192.168.1.5)
6. Web browser and/or TFTP server on PC with the image file available

Procedure

1. Power on the board.
2. Run the attach script and break into the CPU (usually start.cmm or attach.cmm followed by BREAK).
3. Run the DDR initialization script (usually ddrinit.cmm).
4. Load the CFE ELF file into memory.
5. RUN the ELF file.
6. On the serial console, you should see the flash memory correctly recognized and the CFE will prompt for NVRAM parameters. Select the correct board-id and other parameters. The defaults are appropriate for most parameters.
7. Once the CFE reaches its command prompt, confirm that the PC can ping the CFE.
8. Load the firmware.
 - By HTTP by navigating to http://192.168.1.1 and uploading the image file
 - By TFTP by entering **<w 192.168.1.5: bcm963138GW_nand_cfeonly.128.w>** (or the appropriate filename)
9. Allow the unit to program and reboot.

CFE Bootloader Command Line Interface

The following steps bring up the CFE bootloader console.

1. Connect a serial cable between a PC and the BCM963xx reference board serial console port.
2. Configure and start a serial port terminal emulator program such as Minicom.
Use rate 115200, 8 data bits, no parity, 1 stop bit, and no flow control.
3. Reset the BCM963xx DSL Router.
4. In Minicom, if the NVRAM configuration data section of the flash memory is not valid, enter the board configuration parameters as appropriate for the particular board. If the NVRAM configuration data section is valid, this step is skipped.

```
Board Id Name (0-3)
96358VW          ----- 0
96358VW-16       ----- 1
96358GW          ----- 2
96358GW-16       ----- 3      : 0
Number of MAC Addresses (1-32) : 11
Base MAC Address      : 02:10:18:38:38:01
```

or

```
Board Id Name (0-10)
96348R          ----- 0
96348LV         ----- 1
96348GW         ----- 2
96348W2         ----- 3
96348W3         ----- 4
96348GW-10      ----- 5
96348GW-11      ----- 6
96348SV         ----- 7
96348GW-DualDSP ----- 8
BCMCUST_01      ----- 9
96348M          ----- 10     : 0
Number of MAC Addresses (1-32) : 11
Base MAC Address      : 02:10:18:01:00:01
```

or

```
Board Id Name (0-2)
96338SV         ----- 0
96338L-2M-8M    ----- 1
96338W          ----- 2      : 1
Number of MAC Addresses (1-32) : 11
Base MAC Address      : 02:10:18:38:38:01
```

5. In Minicom, press a key before the one-second countdown completes in order to get a boot prompt. The following messages and CFE> prompt are printed to the screen.

```
CFE version 1.0.37-9.14 for BCM96358 (32bit,SP,BE)
Build Date: Tue Mar 27 18:14:39 PST 2007 (root@dhcp-10-12-160-156)
Copyright (C) 2000-2006 Broadcom Corporation.
```

```
Boot Address 0xbe000000
```

```
Initializing Arena.
```

```
Initializing Devices.
```

```
Parallel flash device: name AM29LV320MT, id 0x2201, size 16384KB
```

```
100 MB Full-Duplex (auto-neg)
```

```
CPU type 0x2A010: 300MHz, Bus: 133MHz, Ref: 64MHz
```

```
CPU running TP0
```

```
Total memory: 33554432 bytes (32MB)
```

```
Total memory used by CFE: 0x80401000 - 0x80527CE0 (1207520)
```

```
Initialized Data: 0x8041D5F0 - 0x8041F500 (7952)
```

```
BSS Area: 0x8041F500 - 0x80425CE0 (26592)
```

```
Local Heap: 0x80425CE0 - 0x80525CE0 (1048576)
```

```
Stack Area: 0x80525CE0 - 0x80527CE0 (8192)
```

```
Text (code) segment: 0x80401000 - 0x8041D5F0 (116208)
```

```
Boot area (physical): 0x00528000 - 0x00568000
```

```
Relocation Factor: I:00000000 - D:00000000
```

```
Board IP address : 192.168.1.1:ffffff00
```

```
Host IP address : 192.168.1.100
```

```
Gateway IP address :
```

```
Run from flash/host (f/h) : f
```

```
Default host run file name : vmlinux
```

```
Default host flash file name : bcm963xx_fs_kernel
```

```
Boot delay (0-9 seconds) : 1
```

```
Board Id (0-8) : 96358VW2
```

```
Number of MAC Addresses (1-32) : 11
```

```
Base MAC Address : 02:10:18:01:00:01
```

```
PSI Size (1-64) KBytes : 24
```

```
Main Thread Number [0|1] : 0
```

```
*** Press any key to stop auto run (1 seconds) ***
```

```
Auto run second count down: 1
```

```
web info: Waiting for connection on socket 0.
```

```
CFE>
```

CFE Bootloader Commands

Table 1: CFE Bootloader Commands

Command	Description	Parameters
b	Set board ID and MAC addresses. 1. Board ID string. 2. Number of MAC address (use default in most cases) 3. Base MAC address 4. Profile Storage Interface (PSI) size 5. Main thread number	—
c	Set/Modify boot line parameters	See “CFE Bootloader Command c” for details.
f	Write image to the flash from remote host. Use c to set the proper host IP address and Default host flash file name. Three examples on how to use this command: 1. f to load an image defined in the default host flash file name from the host IP address. 2. f imageName to load this imageName from the host IP address. 3. f 192.168.1.188:imageName to load imageName from 192.168.1.188.	Image file name stored on the host. Note: This image file is a special formatted nonexecutable file for CFE bootloader to write into the flash. Usage: f [hostip:][image-name]
i	Erase profile storage data from flash	N/A
r	Run program from image on flash or remote host depending on the value in the following configuration in the c command: Run from flash/host (f/h): If the value is h, the bootloader downloads the executable image from the host to the SDRAM. It does not overwrite the image on the flash. Three examples on how to use this command: 1. r to load an image defined in the default host run file name from the host IP address. 2. r imageName to load this imageName from the host IP address. 3. r 192.168.1.188:imageName to load imageName from 192.168.1.188.	Usage: r [hostip:][image-name]
w	Write an image to flash memory starting at the first block. This is useful for overwriting an old version of the CFE with a different TAG structure. For example, w bcm96345_cfe.w or w 192.168.1.100:bcm96348_cfe.w.	The image has a special error checking code and is built by issuing the command hostTools\addvtoken cfe.bin bcm96345_cfe.w Note: cfe.bin is the output from gmake from the CFE build process.
p	Print boot line information.	N/A

Table 1: CFE Bootloader Commands (Cont.)

Command	Description	Parameters
e	Erase flash.	a: erase all flash except bootloader. n: erase NVRAM. usage: e a e n
reset	Reset the modem.	N/A

CFE Bootloader Command c

CFE> c

Board IP address: AAA.BBB.CCC.XXX

This is the IP address for the LAN bridge port shared by the Ethernet and USB ports. The router software running in the CPU bridges packets between Ethernet and USB. Replace AAA.BBB.CCC.XXX or leave it as it is.

Host IP address: AAA.BBB.CCC.YYY

Replace AAA.BBB.CCC.YYY with the host PC's IP address. The host PC is where the image is stored and TFTP server is running.

Gateway IP address

Enter the Gateway IP address only if the host is located in a different subnet. The gateway is a router between the ADSL router and the host. Press the Enter key if there is no gateway between the host and the ADSL router.

Run from flash/host (f/h): h

Type **h** if the image is to be downloaded from the host. Type **f** if the image is already stored on the flash memory and direct boot the image from the local flash memory.

Default host run file name

This is an executable image file name, such as vmlinux, which is stored on the host. This file name is only valid for the run command (r), which loads the executable image to the SDRAM. This parameter is ignored by the f flash-file-name command, which downloads and writes a nonexecutable image file to the flash.

Default host flash file name

This is the default flash image file name, such as bcm96345R_fs_kernel, stored on the host. This file name is only valid for the f (flash) command, which loads the executable image from the host and programs the image to flash. This parameter is ignored by the f flash-file-name command, which downloads from host flash-file-name and programs it to the flash.

Boot delay (0–9 second): 1

Enter the delay time for CFE bootloader to wait for any key input from the serial port in order to enter into command interface. The default value is 1.

Boot image (0=latest, 1=previous): 0

This input is only displayed if there are two Linux router images on the flash. It indicates whether to boot the Linux image that was most recently flashed (value 0) or boot the Linux image that was flashed before the most recent one (value 1). See the [“Dual Linux Image Support”](#) section. The default value is 0.

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CFE Bootloader Command Examples

Updating the DSL Router Image Using TFTP

To update the BCM963xx DSL Router with a new image using TFTP, follow these steps.

1. Verify that a TFTP server is installed and started on your Linux PC and that the desired router image, such as bcm96345R_fs_kernel, bcm96348R_fs_kernel, or bcm96338R_fs_kernel, is in the /tftpboot directory.
2. Configure and start a serial port terminal emulator program such as Minicom.
3. Reset the BCM963xx DSL Router.
4. In Minicom, press a key before the one-second countdown completes in order to get a boot prompt.

```
CFE version 1.0.37-9.14 for BCM96358 (32bit,SP,BE)
Build Date: Tue Mar 27 18:14:39 PST 2007 (root@dhcp-10-12-160-156)
Copyright (C) 2000-2006 Broadcom Corporation.
```

```
Boot Address 0xbe000000
```

```
Initializing Arena.
```

```
Initializing Devices.
```

```
Parallel flash device: name AM29LV320MT, id 0x2201, size 16384KB
100 MB Full-Duplex (auto-neg)
```

```
CPU type 0x2A010: 300MHz, Bus: 133MHz, Ref: 64MHz
```

```
CPU running TP0
```

```
Total memory: 33554432 bytes (32MB)
```

```
Total memory used by CFE: 0x80401000 - 0x80527CE0 (1207520)
```

```
Initialized Data: 0x8041D5F0 - 0x8041F500 (7952)
```

```
BSS Area: 0x8041F500 - 0x80425CE0 (26592)
```

```
Local Heap: 0x80425CE0 - 0x80525CE0 (1048576)
```

```
Stack Area: 0x80525CE0 - 0x80527CE0 (8192)
```

```
Text (code) segment: 0x80401000 - 0x8041D5F0 (116208)
```

```
Boot area (physical): 0x00528000 - 0x00568000
```

```
Relocation Factor: I:00000000 - D:00000000
```

```
Board IP address : 192.168.1.1:ffffff00
```

```
Host IP address : 192.168.1.100
```

```
Gateway IP address :
```

```
Run from flash/host (f/h) : f
```

```
Default host run file name : vmlinux
```

```
Default host flash file name : bcm963xx_fs_kernel
```

```
Boot delay (0-9 seconds) : 1
```

```
Board Id (0-8) : 96358VW2
```

```
Number of MAC Addresses (1-32) : 11
```

```
Base MAC Address : 02:10:18:01:00:01
```

```
PSI Size (1-64) KBytes : 24
```

```
Main Thread Number [0|1] : 0
```

```
*** Press any key to stop auto run (1 seconds) ***
```

```
Auto run second count down: 1
```

```
web info: Waiting for connection on socket 0.
```

```
CFE>
```

5. In Minicom, type **c** to configure a TFTP download similar to the following.

```
Board IP address      : 192.168.1.1:ffffff00
Host IP address       : 192.168.1.100
Gateway IP address    :
Run from flash/host (f/h) : f
Default host run file name : vmlinux
Default host flash file name : bcm96358GW_fs_kernel
Boot delay (0-9 seconds) : 1
```

Replace the IP address values with values that are appropriate for the network that the DSL Router is connected to.

6. In Minicom, type **f** to download the Linux image (root file system and kernel) and write the image to the flash.

```
CFE> f
Loading 192.168.1.100:bcm96358GW_fs_kernel ...
Finished loading 3262458 bytes
```

```
Flashing root file system and kernel at 0xbe020000: .....
```

```
*** Image flash done *** !
```

```
Resetting board...
```

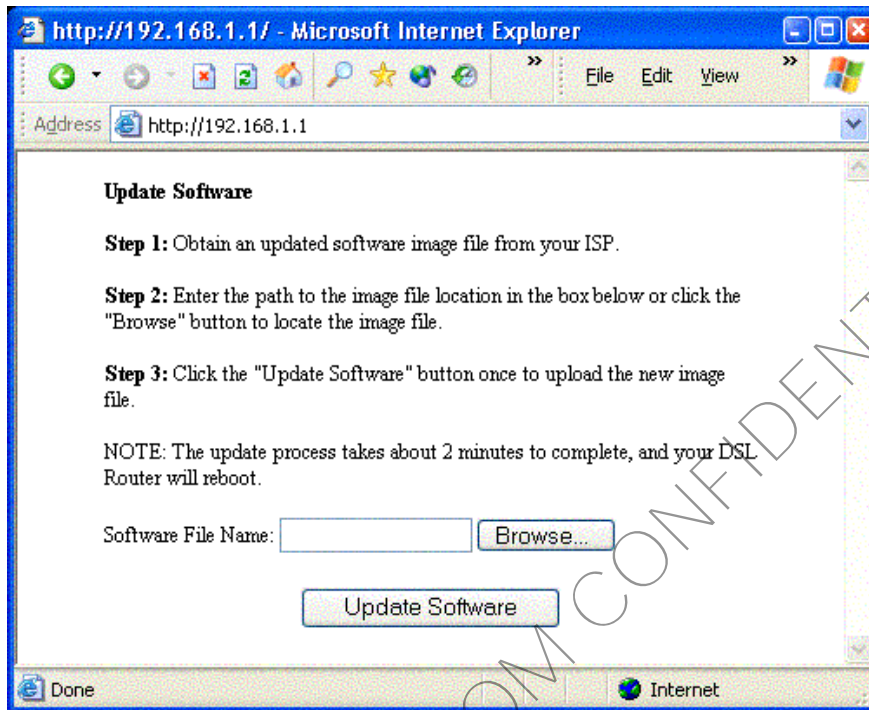
The name of the file to TFTP can also be specified on the command line, for example:

```
CFE> f my_fs_kernel
```

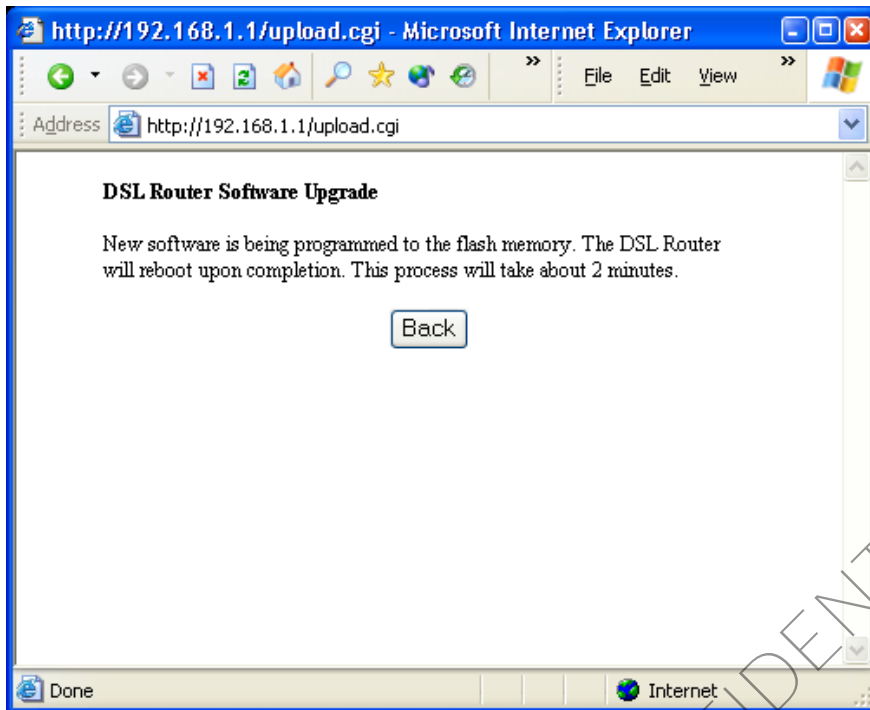
Updating the DSL Router Image Using HTTP

To update the BCM963xx DSL router with a new image using an HTTP Web server without needing a serial port:

1. Press and hold the **reset** button until the DSL LED goes on. It takes about eight seconds.
2. Configure a PC Ethernet connection with a static IP address on subnet 192.168.1.x.
3. Open a Web browser to IP address 192.168.1.1. The following appears.



4. Enter the name of the DSL router image in the **Software File Name** box.
5. Press the **Update Software** button. The following window appears a few seconds after the image is downloaded onto the DSL router.



6. The new image is written to flash memory.

Flash Memory Structure (NOR Flash)

The flash memory consists of entities in the following order:

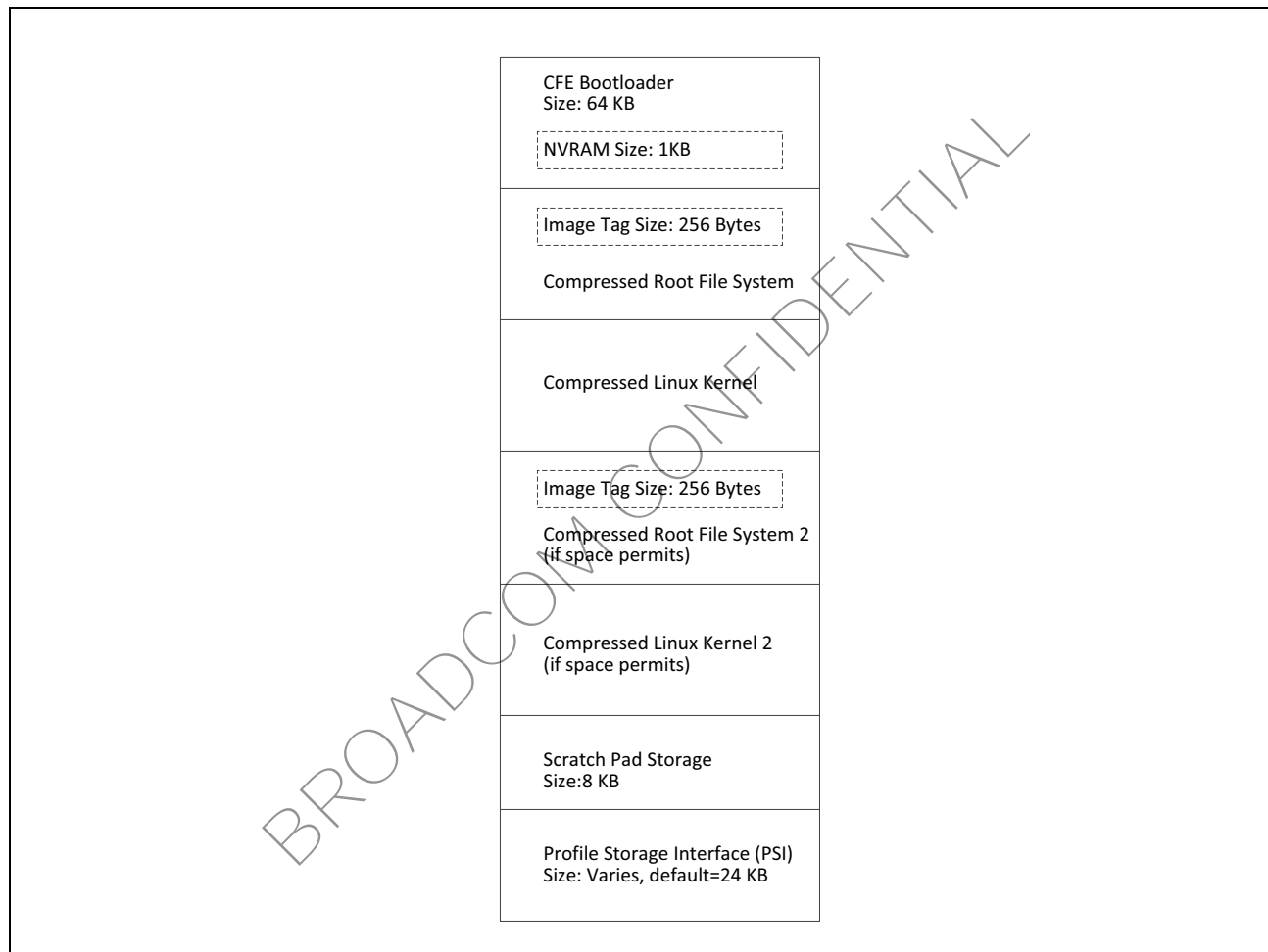
1. CFE bootloader/NVRAM
2. Linux Root File System
3. Linux Kernel
4. Second Linux Root File System, if space permits.
5. Second Linux Kernel, if space permits.
6. Optional persistent system log storage area, size is 0 to 256 KB.
7. Optional backup Profile Storage Interface (PSI) storage area, size is the same as the main PSI.
8. Scratch Pad (temporary data that needs to be stored persistently). It may share the block with the PSI area below it.
9. PSI, profile storage interface for configuration data.

The bootloader size is less than or equal to 64 KB. The size of the Linux root file system, Linux kernel and entities below the Linux kernel may vary. The kernel is not allowed to share a flash block with the entities below it. A second Linux root file system and Linux kernel is included if the size requirements described in the [“Dual Linux Image Support”](#) section are met.

If the boot sector size is 128 KB, then the root file system starts at the second flash sector, offset 0x20000. This adjustment is handled automatically by the CFE bootloader. The Linux router updates the image commands for a Broadcom tagged image such as bcm963xx_fs_kernel image or bcm963xx_cfe_fs_kernel. For a whole flash or a .w image, the sector size must be correctly set in the build target profile field, BRCM_FLASHBLK_SIZE. This field should be set to 128 for a 128 KB flash sector size and 64 for all other flash sector sizes. For an fs_kernel or cfe_fs_kernel image, this field should be set to 64 for all sector sizes.

Note that the flash map shown in [Figure 1](#) does not allocate any space for the backup PSI nor the persistent system log.

Figure 1: Flash Memory Map



Backup PSI Area (NOR Flash only)

By default, this feature is disabled in the CFE.

To enable the Backup PSI area, type **e n** at the CFE prompt. This will erase the NVRAM data and force the user to reenter all the NVRAM parameters. The backup PSI option only takes 0 (disabled) or 1 (enabled). If enabled, the backup PSI area will be the same size as the primary PSI area. The backup PSI feature must also be enabled in the image via make menuconfig. This area can be configured via make menuconfig to behave either as a backup PSI or as a factory PSI.

The Backup PSI area does not share blocks with any other entities. Therefore, if the PSI area is 24 KB and the next block available above the scratch pad is 64 KB, then the backup PSI area will take the entire 64 KB block.

Persistent System Log Area

By default, this feature is disabled in the CFE.

To allocate space to the Persistent System Log area, type **e n** at the CFE prompt. This will erase the NVRAM data and force the user to reenter all the NVRAM parameters. The Persistent System Log area takes a size argument from 0–256. If size is 0, no space is allocated to the Persistent System Log. If 24 is entered, then 24 KB will be allocated to the Persistent System Log. Currently, the userspace management software and Linux kernel do not use the Persistent System Log. Note that despite its name, this area can be used for different purposes, including a JFFS2 filesystem, or storage for other information, etc.

The Persistent System Log area does not share blocks with any other entities. Therefore, if the Persistent System Log area is configured to be 24 KB and the next block available from the bottom is 64 KB, then the Persistent System Log area will take the entire 64 KB block.

Dual Linux Image Support

Two Linux images can reside on the flash if the image size can fit in both the top half of the flash (minus the bootloader) or the bottom half of the flash (minus the various other information that is in the bottom half of the flash.) The CFE bootloader and Linux router update image commands will flash a bcm963xx_fs_kernel image or bcm963xx_cfe_fs_kernel image to the other image location (see the [“Flash Memory Structure \(NOR Flash\)”](#) section) if the size requirement is satisfied. This capability occurs automatically and is not configurable. If the image to be flashed is greater than the maximum size allowed for dual images, all images on the flash memory will be replaced with the single image.

If space at the bottom of the CFE is allocated for Backup PSI and/or Persistent Syslog, the size calculations for dual boot images can become asymmetrical.

Example: A flash has a total of 8 MB with 64 KB sectors throughout the flash, the PSI is 24 KB, and Persistent Syslog is 24 KB. The primary PSI and scratch pad, which are allowed to share a block, will take the bottom 64 KB block. Then the backup PSI, which does not share its block, will take the next 64 KB block. Finally, the Persistent Syslog, which also does not share its block, will take the next 64 KB block. So the total space used at the bottom of the flash is $3 \times 64 = 192$ KB.

Therefore, the maximum dual image size is $4096 - 192 = 3904$ KB.

This limit applies to an image even when it is written to the top part of the flash, where there is actually $4096 - 64 = 4032$ KB available. Applying the minimum size limit to both the top half and bottom half makes the behavior of the dual image writes more predictable.

The CFE bootloader boots the image specified in the Boot Image configuration value (see the [“CFE Bootloader Command c”](#) section), which is either the latest image or the previous image. The bootloader validates the Linux image file tag CRC, the Linux file system CRC and the Linux kernel CRC. If all CRC values are correct, the Linux kernel is decompressed into SDRAM. If the decompression is successful, the program execution jumps to the Linux kernel entry point address and the Linux image starts to execute. If one of the CRC values is not correct or the decompression fails, the same steps are done with the alternate flash image. If the alternate image is also has an invalid CRC or decompression failure, control stops in the CFE bootloader.

Flash Memory Structure (NAND Flash)

The flash memory consists of entities in the following order:

1. CFEROM boot loader/NVRAM located in erase block zero
2. First filesystem image
3. Second filesystem image
4. Data partition
5. Bad block table/correctable error table

The NVRAM contains a partition table identifying the location of the filesystems.

The filesystem images can be recorded to flash using only a SKIPBB (Skip Bad Block) algorithm. The image can be either a JFFS2 image containing CFERAM, the Linux kernel, and the root filesystem or, alternatively, a split filesystem consisting of a JFFS2 bootfs image containing CFERAM and the Linux kernel, followed by a split marker, then a UBIFS containing the root filesystem.

Figure 2: Filesystem

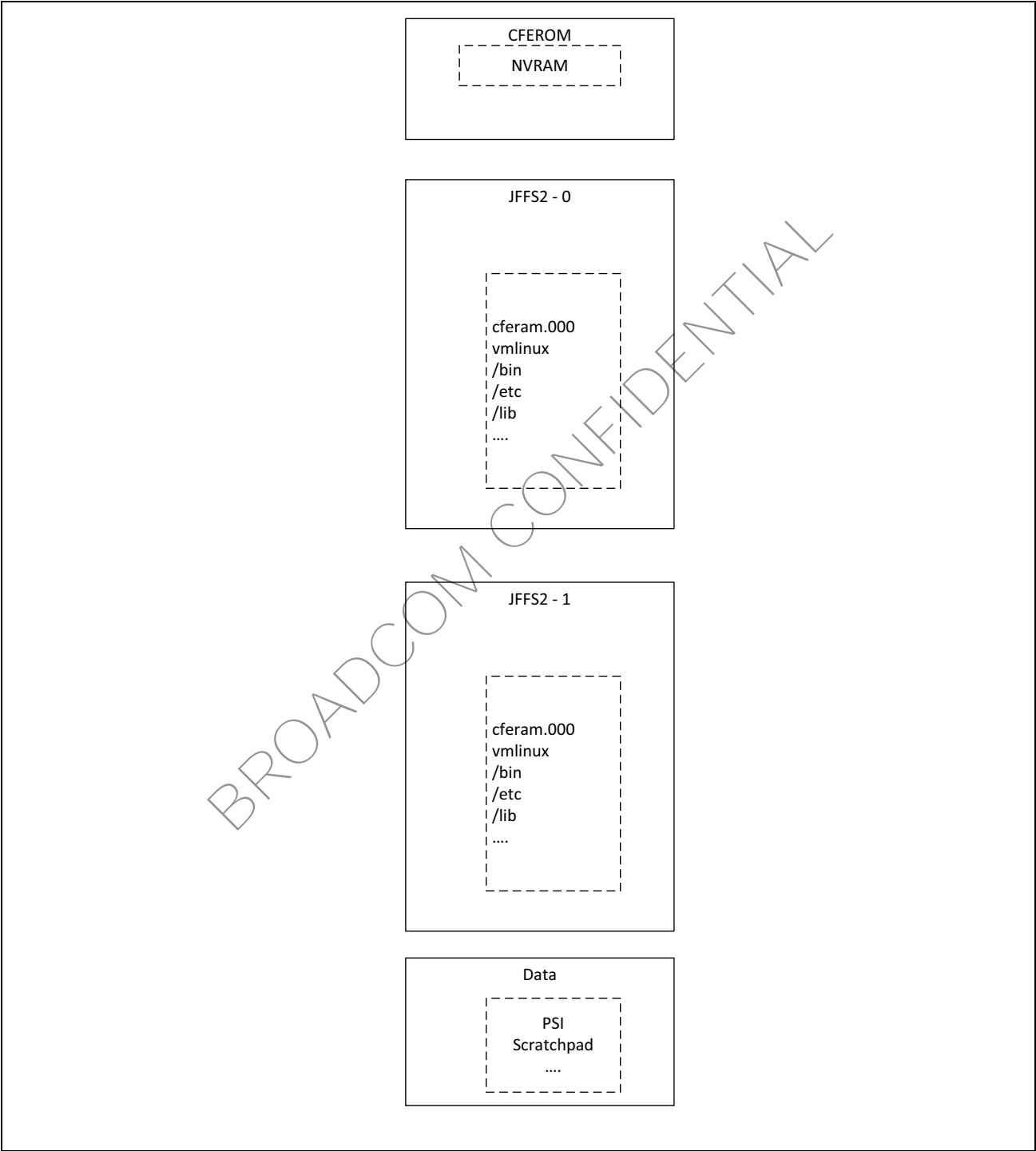
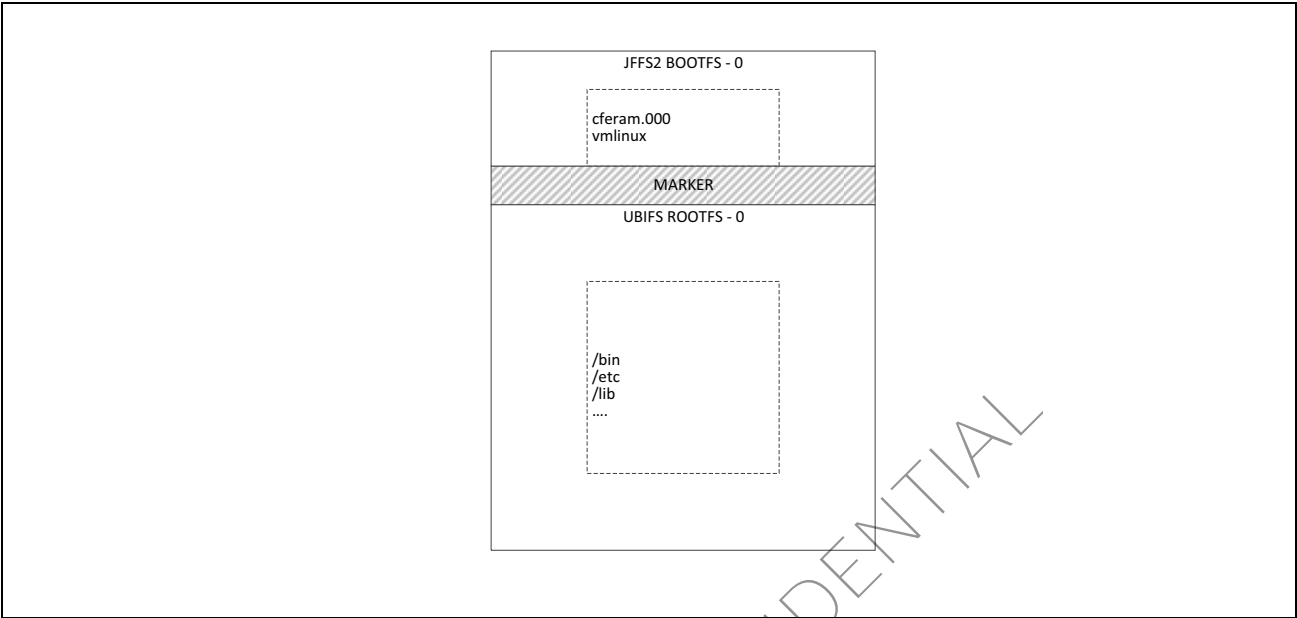


Figure 3: Split Filesystem



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