

# ARM® SBSA Architecture Compliance Suite

Revision: r1p0

## Application User Guide

Non-confidential



## ARM®SBSA Architecture Compliance Suite

### Application User Guide

Copyright © 2016, 2017 ARM Limited or its affiliates. All rights reserved.

#### Release Information

The following changes have been made to this document.

#### Change History

| Issue | Date             | Confidentiality  | Change            |
|-------|------------------|------------------|-------------------|
| A     | 30 November 2016 | Non-confidential | Release for alpha |
| B     | 31 March 2017    | Non-confidential | Release for beta  |
| C     | 13 July 2017     | Non-confidential | Release for v1.0  |

#### Proprietary Notice

This document is protected by copyright and other related rights and the practice or implementation of the information contained in this document may be protected by one or more patents or pending patent applications. No part of this document may be reproduced in any form by any means without the express prior written permission of ARM. No license, express or implied, by estoppel or otherwise to any intellectual property rights is granted by this document unless specifically stated.

Your access to the information in this document is conditional upon your acceptance that you will not use or permit others to use the information for the purposes of determining whether implementations infringe any third party patents.

THIS DOCUMENT IS PROVIDED “AS IS”. ARM PROVIDES NO REPRESENTATIONS AND NO WARRANTIES, EXPRESS, IMPLIED OR STATUTORY, INCLUDING, WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY, SATISFACTORY QUALITY, NON-INFRINGEMENT OR FITNESS FOR A PARTICULAR PURPOSE WITH RESPECT TO THE DOCUMENT. For the avoidance of doubt, ARM makes no representation with respect to, and has undertaken no analysis to identify or understand the scope and content of, third party patents, copyrights, trade secrets, or other rights.

This document may include technical inaccuracies or typographical errors.

TO THE EXTENT NOT PROHIBITED BY LAW, IN NO EVENT WILL ARM BE LIABLE FOR ANY DAMAGES, INCLUDING WITHOUT LIMITATION ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, PUNITIVE, OR CONSEQUENTIAL DAMAGES, HOWEVER CAUSED AND REGARDLESS OF THE THEORY OF LIABILITY, ARISING OUT OF ANY USE OF THIS DOCUMENT, EVEN IF ARM HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

This document consists solely of commercial items. You shall be responsible for ensuring that any use, duplication or disclosure of this document complies fully with any relevant export laws and regulations to assure that this document or any portion thereof is not exported, directly or indirectly, in violation of such export laws. Use of the word “partner” in reference to ARM’s customers is not intended to create or refer to any partnership relationship with any other company. ARM may make changes to this document at any time and without notice.

If any of the provisions contained in these terms conflict with any of the provisions of any signed written agreement covering this document with ARM, then the signed written agreement prevails over and supersedes the conflicting provisions of these terms. This document may be translated into other languages for convenience, and you agree that if there is any conflict between the English version of this document and any translation, the terms of the English version of the Agreement shall prevail.

Words and logos marked with ® or ™ are registered trademarks or trademarks of ARM Limited or its affiliates in the EU and/or elsewhere. All rights reserved. Other brands and names mentioned in this document may be the trademarks of their respective owners. Please follow ARM’s trademark usage guidelines at <http://www.arm.com/about/trademark-usage-guidelines.php>

Copyright © 2016, 2017, ARM Limited or its affiliates. All rights reserved.

ARM Limited. Company 02557590 registered in England.

110 Fulbourn Road, Cambridge, England CB1 9NJ.

**Confidentiality Status**

This document is non-confidential.

**Product Status**

The information in this document is for a REL v1.0 product.

**Web Address**

<http://www.arm.com>

# Contents

## ARM® SBSA ACS Application User Guide

|  |           |
|--|-----------|
| ARM® SBSA Architecture Compliance Suite .....      | 6         |
| Application User Guide .....                       | 6         |
| <b>Preface .....</b>                               | <b>6</b>  |
| About this book .....                              | 7         |
| Using this book .....                              | 8         |
| Conventions .....                                  | 9         |
| Typographic conventions .....                      | 9         |
| Numbers .....                                      | 9         |
| Additional reading .....                           | 9         |
| ARM Publications .....                             | 10        |
| Feedback .....                                     | 10        |
| <b>UEFI Shell application .....</b>                | <b>11</b> |
| 1.1 Overview of tests .....                        | 12        |
| 1.2 UEFI Application arguments .....               | 12        |
| 1.3 Memory requirements .....                      | 13        |
| Code .....   | 13        |
| Data .....   | 13        |
| 1.4 Interfaces consumed by Shell Application ..... | 13        |
| Libraries .....                                    | 13        |
| Protocols .....                                    | 13        |
| 1.5 Toolchain .....                                | 14        |
| 1.6 System dependencies .....                      | 14        |
| 1.6.1 PSCI .....                                   | 14        |
| 1.7 Platform override .....                        | 14        |
| 1.8 Test ID .....                                  | 14        |
| 1.9 UEFI implementation of PAL APIs .....          | 15        |
| 1.9.1 Infrastructure APIs .....                    | 15        |
| 1.9.2 Module-specific APIs .....                   | 15        |
| <b>Chapter 2 .....</b>                             | <b>17</b> |
| <b>Linux kernel module and application .....</b>   | <b>17</b> |
| 2.1 Linux Application arguments .....              | 18        |
| 2.1.1 Loading the kernel module .....              | 18        |
| 2.2 SBSA ACS - Linux application .....             | 18        |
| 2.2.1 Source path .....                            | 18        |
| 2.2.2 Kernel module – build .....                  | 18        |
| 2.2.3 SBSA Linux application build .....           | 19        |
| 2.2.4 Target environment setup .....               | 19        |
| 2.2.5 Runtime environment .....                    | 19        |

# Preface

This preface introduces the *ARM® SBSA Architecture Compliance Suite User Guide*. It contains the following sections:

- *About this book* on page x.
- *Using this book* on page xi.
- *Conventions* on page xii.
- *Additional reading* on page xiii.
- *Feedback* on page xiv.

## About this book

This book describes the Architecture Compliance Suite User Guide for the ARM SBSA architecture.

## Intended audience

This book is written for engineers who are specifying, designing, or verifying an implementation of the ARM SBSA architecture.

## Using this book

This book is organized into the following chapters:

**Chapter 1** *UEFI Shell Application*

Read this for information about SBSA Architecture Compliance Suite tests which run as a UEFI Shell Application.

**Chapter 2** *Linux Kernel Module and Application*

Read this for details about SBSA Architecture Compliance Suite tests which run within an Operating System environment.

## Conventions

The following sections describe conventions that this book can use:

- [Typographic conventions](#).
- [Numbers](#).

### Typographic conventions

The typographical conventions are:

|                |  |
|----------------|--|
| <i>italic</i>  | Introduces special terminology, and denotes citations.   |
| <b>bold</b>    | Denotes signal names, and is used for terms in descriptive lists, where appropriate.   |
| monospace      | Used for assembler syntax descriptions, pseudocode, and source code examples. Also used in the main text for instruction mnemonics and for references to other items appearing in assembler syntax descriptions, pseudocode, and source code examples.   |
| SMALL CAPITALS | Used for a few terms that have specific technical meanings.  |
| Colored text   | Indicates a link. This can be: <ul style="list-style-type: none"> <li>• A URL, for example <a href="http://infocenter.arm.com">http://infocenter.arm.com</a>.</li> <li>• A cross-reference, that includes the page number of the referenced information if it is not on the current page, for example, <a href="#">Feedback on this product on page xi</a>.</li> <li>• A link, to a chapter or appendix, or to the section of the document that defines the colored term, for example <a href="#">Appendix A Memory Attributes</a>.</li> </ul> |

### Numbers

Numbers are normally written in decimal. Binary numbers are preceded by 0b, and hexadecimal numbers by 0x. In both cases, the prefix and the associated value are written in a monospace font, for example 0xFFFF0000.

## Additional reading

This document refers to the following external documents.

- <http://www.uefi.org/specifications>
  - ACPI Specification Version 6.1
  - UEFI Specification Version 2.6
  - UEFI Platform Initialization Specification Version 1.4 (Volume 2)
- <http://www.uefi.org/acpi>
  - WDRT
  - MCFG
  - IORT
  - DBG2
- For general introduction and build steps for SBSA ACS, see <https://github.com/ARM-software/sbsa-acs/blob/master/README.md>
- For more details on the Validation Methodology, see <https://github.com/ARM-software/sbsa-acs/tree/master/docs>.

See Infocenter: <http://infocenter.arm.com> for access to ARM documentation



**ARM Publications**

This document refers to the following documents:

- *Server Base System Architecture (ARM-DEN-0029 Version 3.0)*
- *Server Base Boot Requirements (ARM-DEN-0044B Version 1.0)*
- *ARM® Architecture Reference Manual ARMv8, for ARMv8-A architecture profile (ARM DDI 0487).*

**Feedback**

ARM welcomes feedback on its documentation.

# Chapter 1

## UEFI Shell application

This chapter contains the following sections:

- *Overview of tests on page 16*
- *Application arguments on page 16*
- *Memory requirements on page 17*
- *Interfaces consumed by Shell Application on page 17*
- *Toolchain on page 18*
- *System Dependencies on page 18*
- *Platform Override on page 18*
- *Test ID on page 18*
- *UEFI implementation of PAL APIs on page 18*

## 1.1 Overview of tests

The general division of tests between UEFI Shell Application and Linux Application is as follows.

| Test environment   | Components covered                                |
|--------------------|---|
| UEFI Shell         | PE, GIC, Timers, Watchdog, Wakeup, Secure Devices |
| Linux command line | PCIe, SMMU  |

## 1.2 UEFI Application arguments

The application can be run with the following set of arguments:

```
uefi shell> Sbsa.efi [-v <n>] [-l <n>] [-skip <x,y,z>] [-f <file name>] [-s]
```

**Table 1-1 Parameter and its description**

| Parameter | Description  |
|-----------|--|
| v         | Print Level.<br>1 – INFO & above.<br>2 – DEBUG & above.<br>3 – TEST & above.<br>4 – WARN & ERROR.<br>5 – ERROR.  |
| l         | Level of compliance to be tested for (0-3).  |
| skip      | Overrides the suite to skip the execution of a particular test.<br><u>Example</u> 33 skips test case with ID 33.<br>30 skips all tests in module with ID = 30.<br>50 skips all tests in module with ID = 50.<br>(Refer to test ID section for more details on Module IDs)<br>comma separated. Maximum of three values. |
| f         | File name to which the output log is written.  |
| s         | Runs Secure tests before executing Non-secure tests. (Requires Secure firmware code from SBSA ACS to be ported to EL3 FW)<br>Not giving this option runs only Non-secure tests.  |

For example,

```
Shell > sbsa.efi -v 2 -l 3 -f acs.txt -skip 20,36
```

This set of parameters will:

- Print messages with verbosity of 2 and above.
- Test for compliance against SBSA level 3.
- Skip execution of all tests belonging to GIC module and test number 36.
- Store the log messages to file acs.txt.

## 1.3 Memory requirements

### Code

Binary size – 165KB

### Data

#### *EfiBootServicesData*

**Table 1-2 Data Structure and Size**

| <b>Data Structure</b>          | <b>Size (in Bytes)</b> |
|--------------------------------|------------------------|
| PE_INFO_TABLE                  | 8192                   |
| GIC_INFO_TABLE                 | 2048                   |
| TIMER_INFO_TABLE               | 1024                   |
| WD_INFO_TABLE                  | 512                    |
| PCIE_INFO_TABLE                | 64                     |
| PERIPHERAL_INFO_TABLE          | 1024                   |
| IO-Virtualization Table        | 2048                   |
| PE_SHARED_MEMORY               | (num_of_pe) * 16       |
| PE_SECONDARY_STACK             | (num_of_pe) * 256      |
| <b>Total (Assuming 48 PEs)</b> | <b>27,992</b>          |

#### *EfiRuntimeServicesData*

None

## 1.4 Interfaces consumed by Shell Application

### Libraries

- UefiLib
- ShellLib
- BaseMemoryLib
- ShellCEntryLib
- UefiBootServicesTableLib
- UefiRuntimeServicesTableLib

### Protocols

- gEfiAcpiTableProtocolGuid
- gHardwareInterruptProtocolGuid
- gEfiPciIoProtocolGuid

## 1.5 Toolchain

Linaro AArch64 5.3 toolchain was used to develop this application.

The toolchain is located at:

<http://releases.linaro.org/components/toolchain/binaries/5.3-2016.02/aarch64-linux-gnu/>

## 1.6 System dependencies

### 1.6.1 PSCI

The compliance suite makes the following PSCI calls:

**ARM\_SMC\_ID\_PSCI\_CPU\_SUSPEND\_AARCH64** (0xc4000001)

**ARM\_SMC\_ID\_PSCI\_CPU\_OFF** (0x84000002)

**ARM\_SMC\_ID\_PSCI\_CPU\_ON\_AARCH64** (0xc4000003)

## 1.7 Platform override

On certain platforms, the underlying ACPI infrastructure to provide information on the system is not implemented yet. To enable running SBSA ACS on these platforms, override hooks are provided for certain modules which take the relevant hardware information from the override file rather than the underlying UEFI framework.

See `<acs_local_path>/sbsa-acs/platform/pal_uefi/include/platform_override.h` file in the source code for available options.

## 1.8 Test ID

Test ID of each test is generated as an addition of Module ID and Unit Test ID.

For a given module, Unit Test ID begins from 1.

Module IDs are as follows.

**Table 1-3 Module Name and Module ID**

| Module Name    | Module ID |
|----------------|-----------|
| PE             | 0         |
| GIC            | 20        |
| Timer          | 30        |
| Watchdog       | 40        |
| PCIe           | 50        |
| Power & Wakeup | 70        |
| Peripheral     | 80        |
| SMMU           | 90        |
| Secure         | 900       |

## 1.9 UEFI implementation of PAL APIs

The following table lists the UEFI interfaces used for the implementation of the *Platform Abstraction Layer* (PAL) APIs mentioned in the *SBSA Validation Methodology Document*. ([https://github.com/ARM-software/sbsa-acs/tree/master/docs/SBSA\\_Val\\_Methodolgy.pdf](https://github.com/ARM-software/sbsa-acs/tree/master/docs/SBSA_Val_Methodolgy.pdf))

### 1.9.1 Infrastructure APIs

**Table 1-4 PAL APIs and UEFI interfaces**

| PAL API             | UEFI interfaces   |
|---------------------|-------------------|
| Pal_print           | AsciiPrint        |
| Mem_alloc           | gBS->AllocatePool |
| Mem_free            | gBS->FreePool     |
| Mem_alloc_shared    | gBS->AllocatePool |
| Mem_free_shared     | gBS->FreePool     |
| Mem_get_shared_addr | None              |
| Mmio_read           | None              |
| Mmio_write          | None              |

### 1.9.2 Module-specific APIs

**Table 1-5 PAL APIs, UEFI interfaces, and ACPI tables consumed**

| PAL API                 | UEFI interfaces consumed   | ACPI table consumed |
|-------------------------|--|---------------------|
| Pe_create_info_table    | <ul style="list-style-type: none"> <li>gST-&gt;ConfigurationTable</li> <li>CompareGuid</li> <li>IndustryStandard/Acpi61.h</li> </ul>             | MADT Table          |
| Call_smc                | None   | -                   |
| Pe_execute_payload      | None   | -                   |
| Pe_install_esr          | <ul style="list-style-type: none"> <li>gEfiCpuArchProtocolGuid</li> <li>Cpu-&gt;RegisterInterruptHandler</li> </ul>                              | -                   |
| Gic_create_info_table   | <ul style="list-style-type: none"> <li>gST-&gt;ConfigurationTable</li> <li>CompareGuid</li> <li>IndustryStandard/Acpi61.h</li> </ul>             | MADT table          |
| Gic_install_isr         | <ul style="list-style-type: none"> <li>gHardwareInterruptProtocolGuid</li> <li>RegisterInterruptSource</li> <li>EnableInterruptSource</li> </ul> | -                   |
| Timer_create_info_table | <ul style="list-style-type: none"> <li>gST-&gt;ConfigurationTable</li> <li>CompareGuid</li> <li>IndustryStandard/Acpi61.h</li> </ul>             | GTDT Table          |
| Wd_create_info_table    | <ul style="list-style-type: none"> <li>gST-&gt;ConfigurationTable</li> <li>CompareGuid</li> <li>IndustryStandard/Acpi61.h</li> </ul>             | GTDT Table          |
| Pcie_create_info_table  | <ul style="list-style-type: none"> <li>gST-&gt;ConfigurationTable</li> <li>CompareGuid</li> <li>IndustryStandard/Acpi61.h</li> </ul>             | MCFG Table          |
| Pcie_get_mcfg_ecam      | <ul style="list-style-type: none"> <li>gST-&gt;ConfigurationTable</li> </ul>   | MCFG Table          |

| PAL API                      | UEFI interfaces consumed   | ACPI table consumed |
|------------------------------|--|---------------------|
|                              | <ul style="list-style-type: none"> <li>• CompareGuid, IndustryStandard/Acpi61.h</li> <li>• IndustryStandard/MemoryMappedConfigurationSpaceAccessTable.h</li> </ul> |                     |
| Iovirt_create_info_table     | <ul style="list-style-type: none"> <li>• gST-&gt;ConfigurationTable</li> <li>• CompareGuid</li> <li>• IndustryStandard/Acpi61.h</li> </ul>                         | IORT Table          |
| Peripheral_create_info_table | <ul style="list-style-type: none"> <li>• gEfiPciIoProtocolGuid</li> <li>• Pci-&gt;GetLocation</li> <li>• Pci-&gt;Pci.Read</li> </ul>                               | -                   |
| Memory_create_info_table     | gBS->GetMemoryMap  | -                   |

## Chapter 2

# Linux kernel module and application

This chapter contains the following sections:

- [Application Arguments on page 22](#)
- [SBSA ACS - Linux Application on page 22](#)



## 2.1 Linux Application arguments

The application can be run with the following set of arguments:

```
shell> sbsa [--v <n>] [--l <n>] [--skip <x,y,z>]
```

**Table 2-1 Parameter and its description**

| Parameter | Description  |
|-----------|--|
| v         | Print Level.<br>1 – INFO & above<br>2 - DEBUG & above<br>3 – TEST & above<br>4 – WARN & ERROR<br>5 - ERROR       |
| l         | Level of compliance to be tested for. (0 to 3)   |
| skip      | Overrides the suite to skip the execution of a particular test.<br><u>Example</u> 53 skips test case with ID 53. |

For example,

```
shell> sbsa --v 3 --l 3 --skip 57
```

This set of parameters tests for compliance against SBSA level 3 with print verbosity set to 3 and skips test number 57.

### 2.1.1 Loading the kernel module

Before the SBSA ACS Linux application can be run, the SBSA ACS kernel module must be loaded. This can be achieved by using the `insmod` command.

For example,

```
Shell>insmod sbsa_acs.ko
```

## 2.2 SBSA ACS - Linux application

### 2.2.1 Source path

The patch for the kernel tree and the Linux Platform Abstraction Layer are hosted separately on <http://linux-arm.org/git?p=linux-accs.git;a=summary>.

### 2.2.2 Kernel module – build

#### Pre-requisites

1. Linux kernel source version 4.10 or above.
2. Linaro GCC tool chain 5.3 or above.
3. Build environment for AArch64 Linux kernel.

#### Porting steps – Linux kernel

1. `git clone git://linux-arm.org/linux-accs.git <local_dir>/sbsa-accs-drv>`
2. `git clone https://github.com/ARM-software/sbsa-accs.git <local_dir>/sbsa-accs>`
3. Choose a suitable kernel patch (based on your kernel version) from `<local_dir>/kernel/src/` and apply it to your kernel source tree.
4. Build the kernel.

**Build steps – SBSA kernel module**

1. `cd <local_dir>/sbsa-acs-drv/files`
  2. Set the GCC path to the ARM64 toolchain.
  3. `export KERNEL_SRC=<linux kernel path>`
  4. `./setup.sh <local_dir>/sbsa-acs`
  5. `make`
- `sbsa_acs.ko` file is generated.

**2.2.3 SBSA Linux application build**

1. `cd <sbsa-acs path>/linux_app/sbsa-acs-app`
2. Set `CROSS_COMPILE` to the ARM64 toolchain path.  
`export CROSS_COMPILE=<local_dir>/gcc-linaro-5.3-2016.02/bin/aarch64-linux-gnu-`
3. `make`

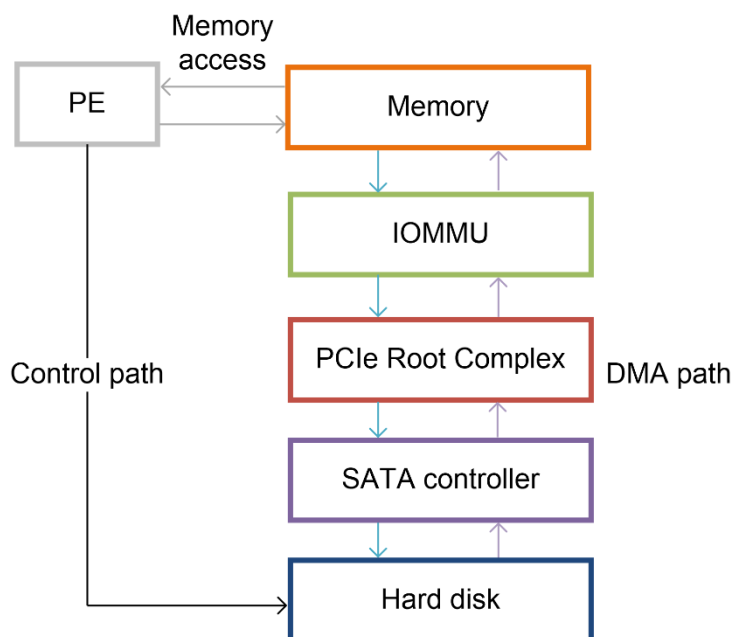
Executable file: `sbsa` is generated.

**2.2.4 Target environment setup**

The set of tests assumes at least one SATA controller behind a PCIe root complex. The SATA controller might or might not be behind an IOMMU.

Before running these tests, at least one SATA hard disk must be connected to the SATA controller.

The test performs read and write operations to the SATA hard disk. Hence, the data on the HDD is overwritten. The SATA drive must not be the boot device for the OS.

**2.2.5 Runtime environment**

**Figure 2-1 Hardware functional blocks**

The PCIe-DMA tests initiate data transfers from a DMA master. By default, the test searches for a SATA controller which is part of the PCIe subsystem.

1. The test writes known data from the PE to main memory.
2. The test programs the DMA master to transfer this known data to its end-point device.
3. The test asks the DMA master to transfer the data back to a different location in the main memory.
4. The test compares the data at both the locations.

Also, if the SATA controller is not behind an IOMMU, during this data transfer, the address that is used by the SATA controller is retrieved and compared with the DMA address that is seen by the PE.

If the DMA master is behind an IOMMU, then the address that is used by the SATA AHCI controller is compared with the address that is seen by the IOMMU. Both these addresses must match.

To enable the export of the addresses that are seen by the SATA AHCI controller and IOMMU, the kernel drivers for these two modules must be patched.